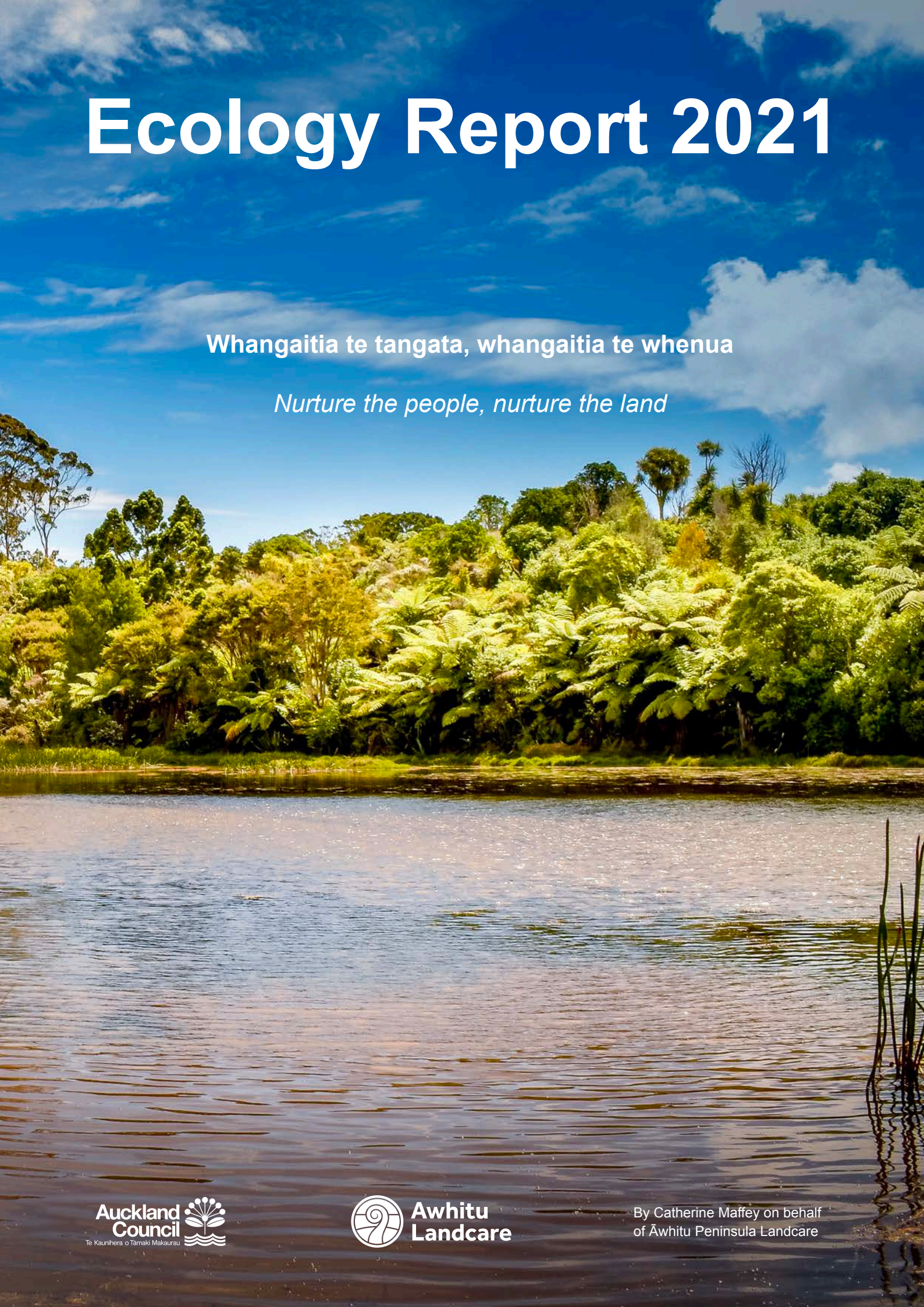
Ecology Report 2021

Whangaitia te tangata, whangaitia te whenua

Nurture the people, nurture the land



Auckland Council
Te Kaunihera o Tāmaki Makaurau

Awhitu Landcare

By Catherine Maffey on behalf
of Āwhitu Peninsula Landcare

Photo by Catherine Maffey

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Introduction

Āwhitu Peninsula Landcare was established in 1994 and is a community led, not for profit initiative that promotes, leads and supports the regeneration and sustainability of indigenous ecosystems on the Āwhitu Peninsula (hereafter referred to as the Peninsula).

Āwhitu Peninsula Landcare, in partnership with Auckland Council and Ngāti Te Ata, has recently initiated a revegetation programme called Te Korowai o Papatūānuku. This programme is funded from the Ministry for Primary Industries One Billion Trees Fund. The Āwhitu Peninsula Landcare community nursery will grow approximately 40,000 native plants in 2021, increasing to 75,000 plants over the following three years and potentially beyond this.

A variety of plants native to the Peninsula are eco-sourced locally and grown from seed from multiple ecosystems including broadleaf and podocarp forests, wetlands and dunes. An estimated 22,000 hectares of land (figure 1) is covered in the Āwhitu Peninsula Landcare focus area, that is approximately 40km long by 8-10km wide [1].

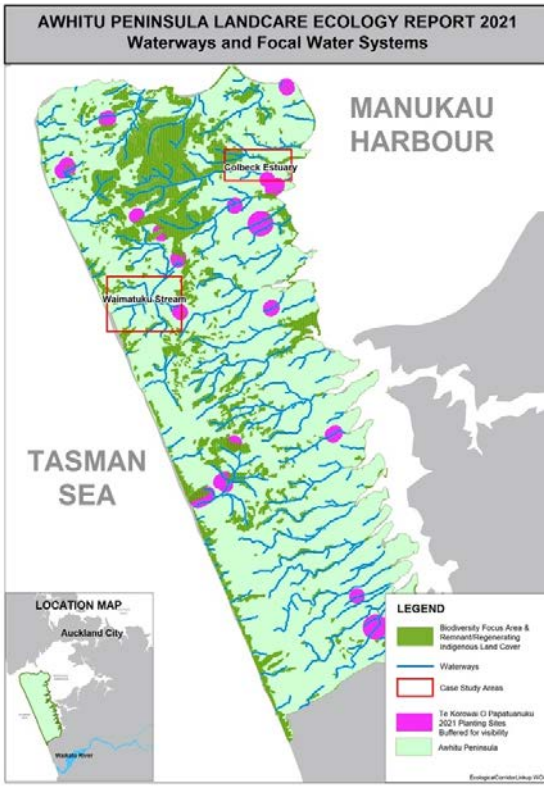

Figure 1: Map of the Āwhitu Peninsula. Waterways are a prominent feature of the Āwhitu Peninsula landscape.

Volunteers working in the Nursery. Photo by Sigrid Sharplin.

The Peninsula is predominantly sand dunes that have accumulated over more than 400,000 years, between 1,000,000 to 600,000 years ago [1] and are prone to sand blows. The west coast of the Peninsula is comprised of steep 200 meter plus cliffs,

that dramatically transcend down to black iron-rich sand. The west coast is prone to high wave action that accelerates erosion of the exposed cliff edge (figure 3). The eastern and northern sides of the Peninsula envelop the Manukau Harbour and are comprised of calm, white-sand beaches.

Sedimentation is apparent in the Manukau Harbour and the water systems leading into it, mangroves are therefore prominent.

The Peninsula encompasses an array of ecosystems including fragmented native forest, exotic forest (pine, gum), agricultural exotic pasture, wetlands, tidal estuaries, streams and lakes located on both private and public land spaces.

Since human settlement there has been a significant loss of indigenous land cover across Aotearoa. Large scale deforestation has resulted in an estimated decline of 14 million hectares of mature forest, 71% of the original forest of Aotearoa [15]. More recently, between 1996 and 2012 there was a net loss of 31,000 hectares of native tussock grassland, 24,000 hectares of native shrubland and approximately 16,000 hectares of native forest as a direct result from conversion of land use and development [30].

The subsequent regeneration of cleared landcover has resulted in a significant change of community assemblages of plant species, resulting in predominantly early-successional coloniser species. This is further emphasised by the selected logging of mature enrichment species typical in early European settlement that is distinctive in mature native forest fragments. Mature enrichment tree species that are representative of prehuman settlement are not commonly seen in native forest, which has a substantial negative impact on the biodiversity and functionality of the ecosystem and the forest canopy structure [17].

Due to habitat loss and threats from introduced predators, many indigenous flora and fauna species are threatened and/or at-risk of extinction and rely on conservation management. Approximately 83% of indigenous land-based vertebrates in Aotearoa are either threatened or are at-risk of extinction [30]. It is estimated that 90% of seabird and shorebird species and subspecies in Aotearoa are threatened with, or at-risk of, extinction [29].

The loss of indigenous landcover has resulted in a fragmented native landscape across the Peninsula. Habitat fragmentation is defined as when a larger, continuous habitat is broken up into smaller and isolated fragments with less overall area. Fragmentation is known to have adverse ecological effects resulting from the loss of overall habitat size, isolation and the creation of habitat edges. Negative effects include reduced abundance of birds, mammals, insects and plants. More specifically, it is estimated that habitat fragmentation reduces biodiversity by 13% to 75% [21]. As well as a reduction in overall species richness, the entire composition of communities is often changed and a reduced retention of carbon and nitrogen [21]. Fragmentation also negatively effects the survivorship and growth of the endemic canopy tree tawa (*Beilschmiedia tawa*) [32]. It has been found that the migration of one individual per generation between habitat patches will ensure the necessary genetic diversity is maintained [27].

Enabling connectivity of habitats supports migration and therefore gene flow and re colonisation of areas with populations under threat [20,40]. Ecological corridors provide a continuous pathway, or stepping stones, to enable the movement of plants and wildlife. Corridors are a prevalent method for connecting fragmented habitats and mitigating the negative impacts of isolated ecosystems [13,20]. Riparian planting along streams, rivers, lakes, wetlands and estuaries can be an effective corridor [20, 25]. Ecological corridors have also been found to increase the movement of species between fragmented habitats by approximately 50% [19].

The vision for the Peninsula

Āwhitu Peninsula Landcare envisions the Peninsula to become a biodiverse and thriving ecological hub within Tāmaki Makaurau/Auckland. Clear and clean waterways will give rise to a flourishing and dense network of indigenous forest, wetlands, lakes and streams, home to an abundance of generalist and vulnerable species. Native birds will dominate the skyline and native reptiles and invertebrates in the forest understory. A clear, thorough and strategic pest management system will enable the Peninsula to be an exemplar of pest-free models within mainland Aotearoa. With the addition of a predator fence at the entrance to the Peninsula, the Peninsula would be used as a model for further research on pest eradication, ecological regeneration and reintroduction of vulnerable and threatened species. The local community will band together and take pride in supporting their local environment.

Āwhitu Peninsula Landcare, in partnership with Ngāti Te Ata, is in a prime position within the community to facilitate and drive the ecological restoration and conservation on the Peninsula, in cohesion with supporting community groups. The plant nursery will continue to expand to provide an array of plants native to the Peninsula. A purpose-built facility will become an education and training nucleus with Āwhitu Peninsula Landcare at the helm. Regular guest speakers and workshops will continue to be held to enable the continued growth and experience of local experts and community members.

Report objectives

The purpose of this report is to aid in the strategic direction of Āwhitu Peninsula Landcare to:

1. Increase the ecological health and connectivity of indigenous ecosystems;
2. Increase the overall health and biodiversity of waterways;
3. Provide potential for re-introduction of threatened species;
4. Increase community ecological awareness, information and support; and
5. Enable strategic planning and plantings.

Key initiatives

Fencing around established native forest blocks on private land

Fragmented native forest is located on private and public land throughout the Peninsula and some blocks are at-risk of herbivory by grazing domestic livestock, predominantly cattle (*Bos taurus*) and sheep (*Ovis aries*), due to the lack of fencing. These remnant blocks are propagule sources of genetic lines and it's vital they are protected by eliminating grazing to ensure natural succession in the area. It's important to retain and effectively protect the indigenous ecosystems that are left and manage them well [35]. Initial consultation with some landowners indicates that some are supportive of fencing and regeneration of these areas however, the financial implications of funding the fencing costs results in it being economically impractical of them to do so. In addition, it has also been identified that local knowledge on the damaging consequences of domestic livestock in the forest seems to be limited.

Figure 2: Exclusion of domestic livestock (Sheep *Ovis aries* and Cattle *Bos taurus,* left of fence) is essential to sustain native biodiversity in forest remnants, East Cape (Photo credit David Norton).

Fencing around native forest fragments is a widespread management tool to limit the effects of herbivores. Studies have shown that having livestock, including cattle, sheep, deer or horses openly graze in the forest leads to significant degradation of the ecological system [5,11,12,43]. A depleted understory and groundcover has been documented in a block of native forest, Taitua, on the Peninsula due to grazing by domestic livestock, wild goats and deer [6]. Livestock typically forage on regenerating seedlings and significantly decrease the initial number of tree and shrub recruitment [43]. The occurrence of livestock in forest remnants alters soil chemistry, vegetation composition and litter mass when comparing to fenced forest reserves [12]. Fenced areas generally had an increase of overall density of leaf dwelling invertebrates and a reduction of dissimilarity of community composition between fenced forest blocks [12]. Excluding herbivory can result in an increase of density of indigenous leaf-litter dwelling invertebrates [12] and higher successful recruits and survivorship of indigenous seedlings, when compared to unfenced areas [5,43].

However, findings also show that fencing as a single management strategy is insufficient to restore indigenous species' richness and density to reference, untouched forest levels [5,12,32,43]. Successful recruitment of mature enrichment tree species is often prevented by dispersal, environmental implications and competition, which results in changes to the forest canopy structure when compared to pre-human settlement [17]. Another study which researched forest fragmentation management in a pastoral landscape, found that fencing led to a high-density pulse of woody seedlings within 10 years that then thinned out. Most woody seedlings that established following fencing were of short-lived subcanopy species leading to changes in canopy replacement probabilities. Densities of seedlings and saplings of canopy species were uniformly low and too few to ensure replacement of existing canopy trees [5].

Morales *et al.* 2016 found that fencing did not consistently increase the survivorship or growth of tawa (*Beilschmiedia tawa*) seedlings. It was concluded that water availability, the history and spatial context of the fragmented forest is as important as the restoration activities [32]. Factors such as local climate conditions, site specific factors (light availability for emerging seedlings for example, history of fragmentation) and the community dynamics of the flora and fauna also have a significant impact [5,43].

In conclusion, fencing around indigenous forest fragments is an important first step to facilitate the regeneration process, to slow the degradation and prevent further loss of species. However, additional management tools such as water management (e.g. planting in the wet season and dense planting), pest and weed control and replacement enrichment planting is necessary, to ensure regeneration to reference forest structures is achieved.

Connectivity through waterways

The Peninsula has a vast network of springs feeding into streams, lakes and wetlands, which drain into the Manukau Harbour or the west coast. There is a real opportunity to utilise this network to create ecological connectivity between the fragmented indigenous landscape. Rivers, streams and riparian areas can be effective habitat corridors [41,42].

Excluding livestock from waterways

Many dairy farmers on the Peninsula have fenced off waterways for a number of years in accordance with the Sustainable Dairying Water Accord 2013, which set out national benchmarks for farmers and included the exclusion of livestock from waterways. The Resource Management (stock exclusion) Regulations 2020 came into effect on 3 September 2020 and intends to stop further degradation of our waterways and promote the waterways and ecosystems returning to a healthy state [34]. All farmed cattle (beef and dairy), deer and pigs must be excluded from waterways outlined in the Regulations. The Regulations apply to any lake (as defined in the Resource Management Act), natural wetland (as defined in the Regulations), and any river that is wider than one meter anywhere in the land parcel (measured as the bed width bank-to-bank). There must be a three meter set back from the bank [28,34]. There are exclusions which are likely to result in a limiting impact to the Āwhitu Peninsula ecological landscape however. This includes exclusions for land that is not low slope and wetlands that are smaller than 500m^2, unless the wetland is identified in regional plans.

Fencing and planting of waterways

There is increasing worldwide attention and focus on human impacts on our environment, in particular freshwater and marine ecosystems. A recent study of global rivers found that half of all river systems have been heavily affected by humans. The greatest impact was found in temperate rivers, where changes to biodiversity were principally due to river fragmentation and introduction of non-native species [45].

Significant changes to riparian ecosystems in Aotearoa over the last century due to changes in land use have resulted in the degradation of habitat and this has consequently had negative effects on the indigenous flora and fauna [30]. A recent report identified the degradation of our coastal ecosystems to be one of the top issues to our marine environment in Aotearoa [29]. Excess sedimentation and nutrient run off are significant contributors to the deteriorating trend.

Estuaries provide a critical link between our rivers, streams and the sea. They are transitional zones where the freshwater from streams and rivers, meet the saltwater of the ocean. This creates a unique environment for its inhabitants such as a nursery ground for many fishes and a home for a multitude of endemic invertebrates, vertebrates and crustaceans. This unique environment is also consequently a catchment for contaminants such as soil and nutrients from agriculture and other chemicals [29]. The sedimentation, evident in the Manukau Harbour, is a direct consequence of soil run off from cleared land and as a result, it smothers bottom dwelling plants and animals. With it, the sedimentation carries nutrients from farming and urban practices including pesticides and fertilisers. A buildup of nutrients triggers

algal blooms which in turn reduces the amount of dissolved oxygen in the water and thus, has negative effects on the freshwater and marine life [29].

Wetlands are an important feature of the ecological landscape. They provide protection against flooding, water filtration and are a home to many indigenous plants and wildlife. It is estimated that 90% of wetlands in New Zealand have been lost since European settlement, primarily from the convergence of land for settlement and farming practices [30]. Only 4% of Auckland's original wetlands remain [26]. High proportions of threatened species are found in wetlands, including an estimated 13% of nationally threatened plant species [7].

Riparian buffer strips not only provide an aesthetic value to the surrounding community but also provide biodiversity and ecological protection, water filtration and, in some cases, mitigate flooding effects [9,38]. Water temperature plays a significant role in the overall health of waterways, ensuring they are habitable for indigenous flora and fauna. Having a riparian buffer strip comprised of riparian plants and generalist native forest trees and shrubs will aid in providing shelter across the waterway and keeping the temperature within acceptable ranges required for invertebrate communities [38]. Riparian planting has shown to help mitigate the negative impacts on waterways and promote a healthy ecological system. However, it is important to ensure riparian planting is part of a wider environmental management plan as riparian buffer strips, under high nutrient loadings, can become oversaturated with pollutants, limiting their effectiveness and increasing greenhouse gas emissions [8]. Ensuring the responsible use of agricultural chemicals is essential.

During consultation with landowners, there is a general positive attitude towards environmental causes and protection of waterways. However, losing further grazing from paddocks to facilitate effective planting along buffer strips does prove to be a hinderance for some. The Auckland Council recommends that a riparian buffer strip of a minimum 10 meters either side of the water's edge [2], which would require the loss of further grazing land for some landowners. Consultation and collaboration with landowners are essential to ensure the best positive outcome environmentally that is also sustainable for landowner's land practices.

Actively promoting and encouraging landowners to establish new native forest blocks

Āwhitu Peninsula Landcare has an active public communication platform that could be further enhanced to expand the local awareness of ecological knowledge, pest control and eco-sourced plant availability. Through consulting with landowners, it became evident that although some were aware of the availability of information and resources, there was an apparent gap where some knew very little of what was available. Broadening the general knowledge to landowners on the Peninsula would in turn foster a cohesive, broader ecological management approach. In particular, actively promoting the conversion of unproductive grazing land, particularly steep hillsides and boggy areas, to biodiverse regenerating bush would, from an ecological point of view, be a better use of the land. It would increase the abundance of indigenous landcover and facilitate movement of species. Planting the steep hillsides would also assist in reducing the amount of erosion and sedimentation in the streams that ultimately lead into the Manukau Harbour and the west coast.

Erosion control

The west coast of the Peninsula is dominated by 200m sand dunes that cascade down to the black sand beach (figure 3). The dunes are prone to sand blows and the cliff edges regularly landslide. Across Aotearoa 192 million tonne of land is estimated to be lost each year into waterways and the ocean from erosion. Of which, 44% is from farming pasture [30]. Aotearoa makes up an estimated 0.1% of the global land mass, yet it contributes 1-2% of annual average yields of ocean sedimentation. The naturally high occurrence of erosion is due to high levels of rainfall, geology, tectonic activity and topography [22].

Figure 3: Photo of the western coastline. The erosion of the cliff edge is evident. Photo by Peninsula Helicopters.

Until recently, the recommended dune restoration approach by Āwhitu Peninsula Landcare was to plant the exotic marram grass (*Ammophila arenaria*) as a means to stabilise exposed dunes, which has proven effective at establishing in the harsh conditions and forms a matting. The Auckland Council however, promotes the use of native dune species such as spinifex (*Spinifex sericeus*) and pīngao (*Ficinia spiralis*), which is outlined in Auckland Council's Dune Restoration Guide. Marram grass is now classified as a pest plant and from 1 September 2021 is prohibited to propagate or plant. Marram grass is known to displace native dune species and therefore, the use of it is no longer supported by the Auckland Council. Native dune plants are now recognised as the most effective at restoring dune ecosystems [3]. It is imperative that erosion prone land is fenced off, restricting access from animals and vehicles to ensure further degradation is minimised.

Pest and weed control

Appropriate pest and weed control are essential to ensure the long-term success of any supported ecosystem and new plantings [35].

Āwhitu Peninsula Landcare has an established pest management plan and actively promotes pest control through social media platforms, trap building workshops and information stalls at local events. Free possum bait (Brodifacoum), traps and bait stations are available for the community from the Landcare Resource Centre (through an Auckland Council contract). A baiting and trapping network managed by Āwhitu Landcare's pest control contractor targets possums (and rats at selected hot spots) across the Peninsula.

In addition to animal pests, new plantings need to be routinely released from weeds for approximately the first three to five years until they are established.

Wild deer, goats, pigs, mustelids and cats are prominent on the Peninsula and the ecological damage is evident. To fully support the regeneration and potentially reintroduction of threatened species and ecosystems, a wider scoped pest management plan is required that incorporates these pests. Further funding and guidance from pest eradication specialists would need to be sourced and appropriate funding allocated to cover the associated costs, which is currently hindering progress in this area.

Plants such as agapanthus (*Agapanthus praecox*), tradescantia (*Tradescantia fluminensis*), and pampas (*Cortaderia selloana and C. jubata*) are common on the Peninsula and the identification and effects are not necessarily known to private land owners. Pest plants are also prominent on the roadsides and public reserves. These are typically self-set, spreading by natural dispersal methods. Further development to Āwhitu Peninsula Landcare's public awareness strategy regarding pest plants, would help locals to appreciate the effects they have on our indigenous environment and promote the eradication of these plants. Communication and collaboration with Auckland Council is needed to establish an effective management plan for combating pest plants on road sides and public reserves. This would assist in preventing further dispersal.

Potential revegetation site case studies

The Peninsula boasts a vast network of streams, wetlands and estuaries that flow out to the west coast and into the Manukau Harbour. The number of waterways that are of ecological significance to the Peninsula community are vast.

Āwhitu Peninsula Landcare selected two waterways that run through multiple properties as case studies for potential strategic revegetation sites[1]. Our research focused on a) ensuring the long-term viability of the indigenous flora and fauna in these ecosystems and b) enhancing connectivity between ecosystems.

The catchments are:

1. Waimatuku waterway and wetlands
2. Colbeck Estuary

As with all regeneration projects, complete support of landowners is required. When a waterway runs through multiple properties, collaboration between landowners is essential to ensure a complete catchment management approach is taken to ensure the overall health of the waterway is effectively managed and achieved.

Waimatuku waterway and wetlands

Historically, the Waimatuku valley was likely to be predominantly inhabited by marshland [1]. With the more recent introduction of farming, man-made drains have been developed to manage the water flow across the landscape and thus, making it more desirable for pasture.

The Waimatuku waterway network is now comprised of both natural streams, wetlands and man-made drains. The network runs through multiple properties, including five dairy farms and eventuates at a stream that flushes across the west coast beach, Hamilton's Gap (figure 4) and out into the Tasman Sea. The beach is a popular destination for both locals and visitors. The stream itself is a popular swim spot with children on the beach.

For the purpose of this report two farming properties in the valley were visited and consulted with in February and November 2021. Both of the properties are dairy farms and the paddocks in the valley are prone to flooding in the wetter months of the year. The streams and drains observed, had a sandy and muddy bottom and erosion of the banks and sand dune (at the beach end) was evident. Algal growth was prominent in some areas and there was generally little shelter over the waterways. Mostly exotic grass was present along the water's edge with some self-set native flora.

[1] The case studies depicted in this report do not reflect their suitability to meeting funding criteria. For these projects to commence and funding to be sourced, a full site and project assessment would need to be conducted and the required application criteria fulfilled.

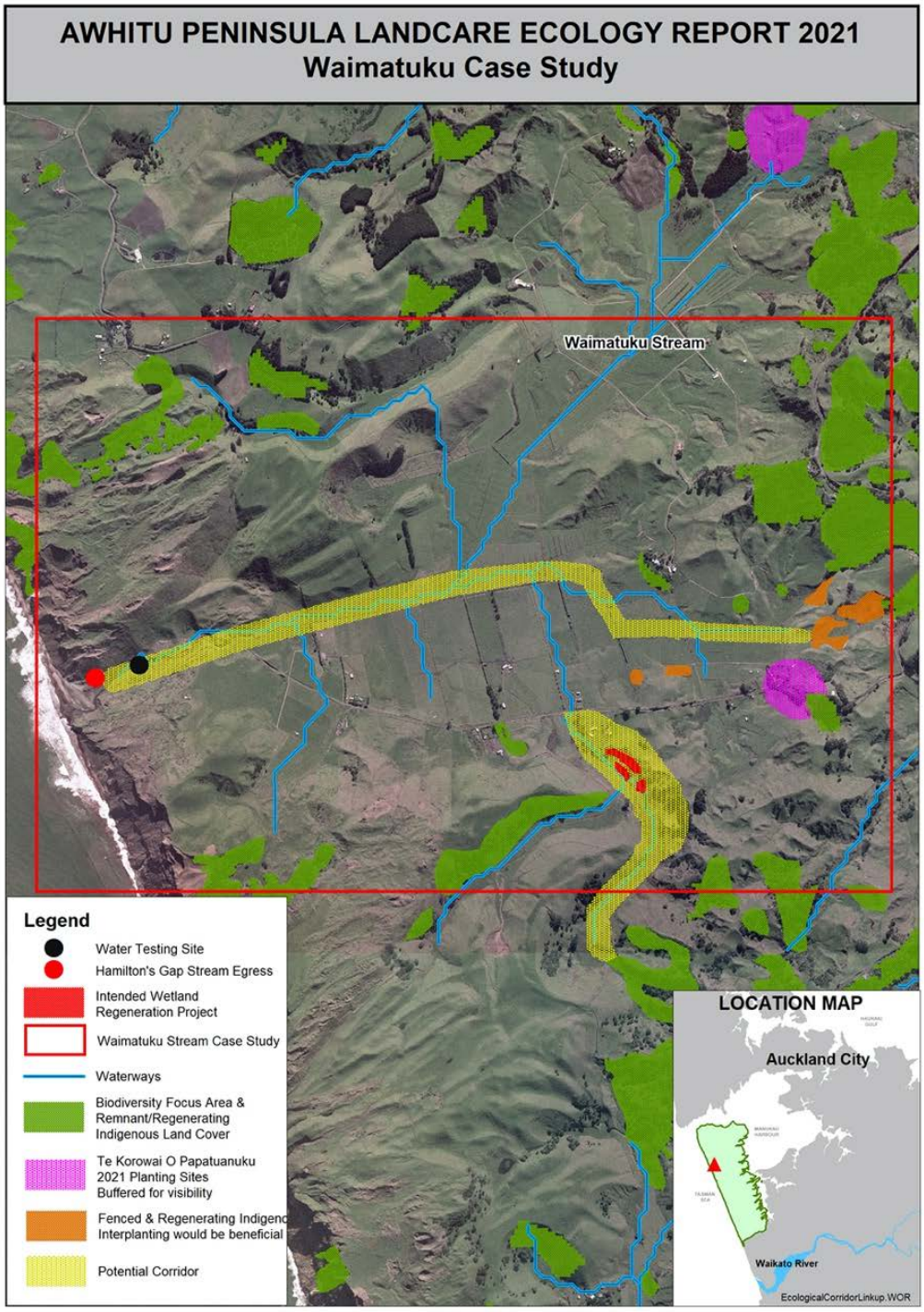

Figure 4: Aerial view of the Waimatuku waterway.

The drains and streams in the valley have been fenced to exclude cattle in accordance with the requirements specified in the Sustainable Dairying Water Accord 2013. The fencing was installed with the intention of excluding cattle from the waterway and not necessarily to improve riparian planting. Therefore, to provide an effective ecological corridor, the fences would need to move to allow the recommended minimum of 10 meters by Auckland Council either side of the water's edge [2]. Consequently, this would remove a significant amount of grazing for the farmers and therefore, may not be a realistic option. An alternative option would be

to utilise the space there currently is along the waterways to the best advantage. This would in turn, provide some level of filtration leading into the waterway. Due to the natural topography, there is some variation in the distance between the fence and the waterway. In some areas there will be larger areas for planting providing a greater level of diversity of flora.

Figure 5: An area that has been fenced off and would benefit from being planted with riparian plants and would connect to established native forest.

At the head of the valley, extensive work by the landowner has been undertaken to fence off multiple riparian areas to exclude stock and the areas are now naturally regenerating (figure 5). There is also a step hillside that is prone to erosion that has been fenced off and planted with Mānuka (*Leptospermum* scoparium). These sights are a fantastic first steps to improve the connectivity to established native forest and would benefit from further interplanting to improve the diversity and to speed up the recovery.

Figure 6: View from private land owner's property looking at stream running through a dairy farm, alongside a sand dune and out to the west coast beach.

Water testing at the current sampling site (figure 4) has been conducted on Waimatuku Stream since July 2019 (Appendix 1). The sampling location is strategically positioned so it encompasses run off from all five dairy farms and therefore, gives an accurate reflection of the health of the stream prior to its expulsion into the Tasman Sea. Sampling and testing are done under the direction of Wai Care to ensure appropriate methodology is conducted and maintained.
The sampling results for this stream illustrates further regeneration work is required to ensure the ecological health and suitability of the stream for indigenous flora and fauna. In particular, the levels of nitrates (NO_3) and phosphorus (P) are concerning. The results are depicted below and are referenced to the Data Interpretation Table (appendix 2) provided on the Wai Care website. The methodologies used by Wai Care community groups provide a simplified (but less accurate) way for community groups to get an indication of nutrient concentrations and overall ecological health. A more thorough and detailed analysis conducted by a specialist laboratory would provide more accurate results and interpretation that are able to be referenced to acceptable levels depicted in The National Policy Statement for Freshwater Management 2020 (NPSFM) [33].

pH
The pH of the stream typically lies between 6 and 7 and has an annual median of 6.5 for the period April 2020 to April 2021 (this will be the period reflected in annual medians depicted in this report). Wai Care states that a pH of between 5 to 9 is acceptable. **Therefore, this stream is within an acceptable range.**

Water clarity
The clarity at this site varies between 40 to 65cm and has an annual median of 49cm. Wai Care states that this median is within the range of orange (fair). Readings above 60cm are classified as good or excellent (green). **The water clarity is therefore, often below the level of good or excellent (green).**

Dissolved Oxygen (DO)
The dissolved oxygen in this stream varies between 4 and 9. The annual median of dissolved oxygen is 5mg/L, which is classified as fair (orange) by Wai Care. Levels above 6 mg/L are classified as green (good or excellent). **This stream is often below the level of good or excellent (green).**

Nitrates (NO_3)
The nitrates levels in this stream vary between 2 and 5.5mg/L. The annual median for nitrate is 4mg/L. Wai Care classifies levels below 1mg/L as good or excellent (green). All recorded results for this stream are either fair (orange) or of concern (red). Therefore, this stream **does not sit within an acceptable range for nitrate content**.

Phosphorus (P)
The phosphorus levels in this stream vary between 0.03 and 0.40mg/L. The annual median of phosphorus is 0.20mg/L. Wai Care classifies levels below 0.025mg/L as good or excellent (green). All recorded results for this stream are fair (orange) and therefore, **this stream does not sit within an acceptable range for phosphorus content.**

Total WIMP score

The Wai Care Invertebrate monitoring Protocol (WIMP) was designed to allow an assessment of stream health based on simplified invertebrate identification. A bush covered stream has an average WIMP score of 104, where as a stream running through pasture typically has an average of 80 across Aotearoa. This stream has an average of 95 and there this stream **has a WIMP score within an acceptable range.**

A potential ecological corridor for this area is depicted in figure 4. The corridor in the main Waimatuku valley, would connect to established native forest and would encompass the restoration work already underway at the head of the valley and the main waterway leading to the beach. In time, this would support the natural filtration of nutrients leading into the waterway, protect the ecosystem for indigenous flora and fauna and provide connectivity, allowing movement of species.

Across the public road there is another smaller valley containing three wetlands that are partially fenced (figures 4 and 7) by the landowner. The fencing needs to be finished, weeds managed and then it is ready for riparian planting. The landowner intends to implement this by 2024. If the wetlands are protected and enhanced with riparian planting, it would provide an effective stepping-stone connectivity for generalist fauna and wetland species. A potential corridor is depicted in figure 4 that would further enhance the connectivity to established native bush further up the valley.

Figure 7: View from private land owner's property looking a wetland that has been fenced with electric wires ready for weed control and planting.

Colbeck Estuary

Colbeck estuary is situated on the eastern coast of the Peninsula and feeds into the Manukau Harbour (figures 1 and 8). It is an important ecological system that endemic, native and threatened species are known to inhabit, including Matuku hūrepo (Australasian Bittern). Tūturiwhatu (NZ Dotterel) have a nesting site on the Colbeck beach where the estuary emerges (figure 8 and 10). The estuary is dominated by extensive mangroves with some native planting along the edges, predominantly on the upper branch. There are some self-set native trees and wetland plants that are interspersed throughout the area also. The estuary itself is largely a mud bottom, reflective of the high level of sedimentation common in the Manukau Harbour.

There are four properties that directly border on to the estuary, which all practice farming and/or horticulture. Most of the estuary is fully fenced with wire and batten fences, with a range of two to seven wires.

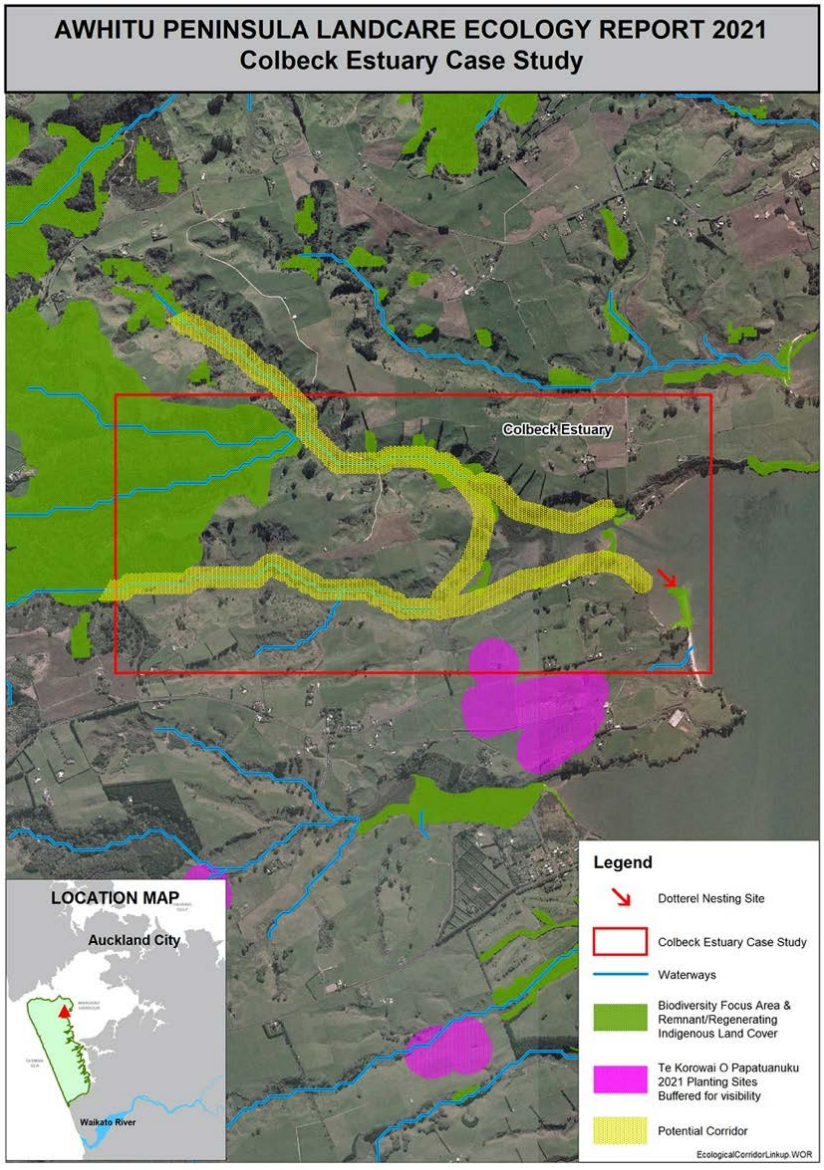

Figure 8: Aerial view of Colbeck estuary.

Figure 9: View from private land owner's property looking out towards the entrance of the Colbeck estuary. Extensive numbers of mangroves are evident.

Planting around this site would provide greater habitat for native wetland species, better filtration of run off and sedimentation from the neighboring properties and increase connectivity to current planting and remanent native forest sites. Reducing nutrient and sediment run off will in turn, slow the expansion of mangroves that are threatening to envelop the shell spit that is a nesting site for Tūturiwhatu (NZ Dotterel) (figure 10).

Tūturiwhatu (NZ Dotterel). Photo by Shaun Lee.

Figure 8 depicts a potential ecological corridor through enhancing the current regeneration work and also expanding on this to connect to larger native bush sites.

Figure 10: Photo of the where the Colbeck estuary meets Manukau Harbour with nesting NZ Dotterel on the shell spit.

Through consultation with landowners around this case study site, it became apparent the damaging impacts of pūkeko (*Porphyrio melanotus*) on young plants. To ensure the successful establishment of future plantings, a management plan for pūkeko will be required that is inclusive of all landowners bordering on the estuary. Pūkeko, although a native species, are permitted to be shot during the shooting season as they are abundant and widespread and there is no concern for their long-term survival [10]. An alternative pūkeko management tool would be the inclusion of biodegradable plant sleeves to protect the young plants until they are established.

Across both case studies, initial consultation with landowners signalled a positive attitude towards regeneration and protection of the waterways. For all, a lack of resources for fencing and planting is limiting progress with protecting and enhancing these ecosystems.

Vulnerable flora and fauna

The Peninsula is home to an abundance of wildlife and unique plant species such as the moss *Altrichum androgynum,* the orchid *Nematoceras rivularis* and the liverwort *Dumortiera hirsute* [1]. There are isolated patches of king fern (*Ptisana salicina*) that are currently threatened by herbivory by wild goats and pigs.

Forest dwelling birds typically seen on the Peninsula include the ruru (morepork), kererū (wood pigeon), tūī, pīwakawaka (fantail) and kākā (parrot) in the older established forest blocks. There is a known presence of the *Powelliphanta* snail in native forest blocks on the Peninsula.

The wetlands provide a home for at-risk birds including pūweto, mioweka, matuku hūrepo, tūturiwhatu and mātātā and due to various factors, typically including habitat loss and predation, are all in various levels of decline. It is expected that with increased connectivity, a greater rate of dispersal of indigenous flora and fauna will be achieved.

Pūweto photo by Oscar Thomas

Pūweto (spotless crake)

Pūweto (spotless crake) *Porzana tabuensis* is native to New Zealand and is known to inhabit freshwater wetlands on the Peninsula and has a conservation status of ‘Declining’. They have a patchy distribution across the North Island and are rare in the South Island. Their declining status is considered a result of habitat loss, typically due to the conversion of land for agriculture. Pūweto are omnivorous and typically feed on seeds, fruit and leaves of riparian plants as well as invertebrates [16]. During a recent acoustic distribution survey, two individuals were detected. One at the Āwhitu Campground and another at Kauritutahi Creek [44].

Mioweka photo by Shaun Lee

Mioweka (banded rail)

Mioweka (banded rail) *Gallirallus philippensis* is typically found in coastal wetlands in the upper North Island (around 80-90% of total population) and has a conservation status of ‘Declining’. Small numbers of the native bird are also known to inhabit Marlborough and Nelson, Great Barrier Island, Three Kings Islands and four islands off Stewart Island. They generally stay in dense vegetation of wetland rushes and mangroves and feed on crustaceans, invertebrates, seeds, fruit and dead fish. Habitat loss, typically as a result of wetland draining for agriculture is considered to be the driving force with their decline in numbers [4].


Tūturiwhatu photo by Shaun Lee

Tūturiwhatu (NZ dotterel)

Tūturiwhatu (NZ dotterel) *Charadrius obscurus* is endemic to New Zealand and has a conservation status as 'Recovering'. There are two subspecies, the Northern NZ dotterel and the Southern NZ dotterel, which is now only found on Stewart Island. The Northern NZ dotterel is in higher abundance and typically inhabits sandy beaches across the North Island. They are most at-risk from human activities and development on beaches (e.g. standing on nests), predation and loss of nests from big tides. They consume a variety of terrestrial and marine species including small fish, sandhoppers, small mussels, crabs and worms [14]. Northern NZ dotterel currently inhabit and nest on a sandy spit at Colbeck Beach on the Peninsula (figures 8 and 10) and although there is signage, they are at-risk of their nest being trampled by dogs and/or humans.


Matuku hūrepo photo by Oscar Thomas

Matuku hūrepo (Australasian bittern)

Matuku hūrepo (Australasian bittern) *Botaurus poiciloptilus* is native to New Zealand and their conservation status is 'Nationally Critical', the highest level of concern and risk of extinction. The population is estimated to be around 900 individuals. They inhabit and forage in wetlands across New Zealand, typically consuming fish, eels, spiders, insects, molluscs, worms, koura, frogs and lizards. They are highly secretive individuals and are difficult to locate. Thus, they are extremely sensitive to disturbances [50]. A recent acoustic survey of populations across Tāmaki Makaurau/Auckland, further highlighted that they are at immediate risk of local extinction due to observed reduced numbers. The Auckland region has substantially lower numbers of abundance than neighbouring regions. Three matuku hūrepo were detected in Āwhitu during the survey. Two at Rangiriri Creek and one at Big Bay [44].


Mātātā photo by Shaun Lee

Mātātā (fernbird)

There are five subspecies of mātātā (fernbird) *Bowdleria punctata* that are all endemic to New Zealand. The North Island subspecies *B. p. vealeae* has a conservation status of 'Declining' [31] and was detected on the Peninsula at Kauritutahi Creek during a recent acoustic survey. It was unclear if the calls detected were from a single or multiple individuals [44]. Mātātā typically inhabit shrubland and tussock but are also known to occur in dense wetland vegetation. They are a small sparrow-sized bird that are more often heard than seen and are excellent at camouflaging into the surrounding environment. They are at-risk due to the loss of wetland habitat from draining for agricultural purposes and also predation. They are poor fliers, predominantly flying just above the vegetation where they are most at-risk to mammalian predators. They mostly feed on insects, spiders and other small invertebrates [31].


Elegant gecko photo by Shaun Lee


Copper skink photo by Shaun Lee

Gecko and skinks

Two endemic species of gecko have recently been confirmed to inhabit the Peninsula. A female elegant gecko (*Naultinus elegans*) was found in early 2021 inhabiting kanuka bush (*Kunzea ericoides*) [46]. A pacific gecko (*Hoplodactylus pacificus*) was also confirmed to be located on the Peninsula in early 2021[46]. Both of these species are endemic to Aotearoa and the elegant gecko has a conservation status of 'At-Risk: Declining' and the pacific gecko as 'At-Risk: Relicts' [23]. The endemic copper skink (*Oligosoma aeneum*) has been found on the Peninsula and is widespread across the North Island and is currently considered 'Not-threatened' [23].

Lizards play an integral part of a healthy ecosystem as they pollinate native plants and disperse plant seeds via eating the fruit. Lizards are most under threat by mammalian predators (cats, rats and mustelids). Loss of habitat and/or fragmentated habitat also contribute to the threat on sustainable populations of lizards. Habitat degradation by foraging mammals including wild pigs, deer, goats and possums as well as livestock is also a significant influence [39].

Reintroduction of vulnerable species

Āwhitu Peninsula Landcare envisage that with the development of greater indigenous landcover and connectivity, there will be the potential to repopulate ecologically significant and threatened species. Potential species for reintroduction that warrant further investigation of suitability are the endemic kiwi (*Apteryx sp.*) and pekapeka (bats). Recent reintroduction attempts of pekapeka have proved to be unsuccessful and further research is needed in this area [37].

There are two endemic Pekapeka (bat) species in Aotearoa. The lesser short- tailed bat (*Mystacina tuberculata*) and the long-tailed bat (*Chalinolobus tuberculatus*). The greater short-tailed bat (M*ystacina robusta*) is presumed extinct. Once widely distributed throughout forested areas across Aotearoa, they are now in varying levels of decline due to a combination of significant threats. Their decline is primarily resulting from habitat loss and predation from introduced stoats (*Mustela erminea*), rats (*Rattus* spp.), possums (*Trichosurus vulpecula*) and cats (*Felis catus*) [36].
Bats are not known to currently inhabit the Peninsula. An acoustic bat survey conducted in 2016 reported no audio recordings for bats on the Peninsula. The closest known population of bats was recorded in native forest situated between Waiuku and Pukekohe [47]. A further, more extensive survey of the Peninsula would provide greater assertion that they are not currently inhabiting the Peninsula. If no known occurrences are confirmed, with a comprehensive pest management plan there is the potential to reintroduce bats to our forested areas. Further investigation and consultation with subject matter experts will be required to put this into action and ensure the greatest chance of success.

What to plant

Current best practice for regeneration is to plant a diverse range of native and eco-sourced species to provide habitat for a wider range of flora and fauna. Greater diversity of planting will ensure greater resilience to disease and climate variations and also provide a year-round food supply for birds and invertebrates to ensure visitation by these species is consistent [35].

Eco-sourcing seed that is native to the Peninsula is recommended to ensure genetic integrity (that they are suited to the local environmental conditions) and provide the best chance of success [35]. This is the current ethos and practice of Āwhitu Peninsula Landcare.

Volunteers. Photo by Anna White.

Table 1 below provides an outline of the varieties of plants that are currently eco-sourced and propagated at the Āwhitu Peninsula Landcare nursery and their associated habitat type. Further and more detailed information on these varieties and their habitats can be found on the Auckland Council website. There are approximately 42 species propagated at the Āwhitu Peninsula Landcare nursery.

When approached by landowners, the Āwhitu Peninsula Landcare planting experts visit the site and establish a planting plan that includes the variety of suitable species, the abundance of each species and the recommended spacing and location/zone of each species. Information on site preparation, pest and weed control is also offered. However, there is the opportunity for the information and support provided to be more extensive.

Māori name/common name	**Scientific name**	**Plant type (Coloniser (C), Enrichment (E), Sandy dunes (D), Riparian-edges (R-E), Riparian-swampy (R-S), Riparian-Standing water (R-SW), Riparian- Saline (R-Sal)**
Kauri	*Agathis australis*	E
Tītoki	*Alectryon excelsus*	E
Oioi/Jointed wire rush	*Apodasmia similis*	R-Sal, D
Toetoe (small)	*Austraderia fulvida*	C, D, R-E
Toetoe	*Austraderia splendens*	C, D, R-E
Taraire	*Beilschmiedia tarairi*	E
Rautahi	*Carex geminata*	R-E, R-S,
Māori Sedge	*Carex maorica*	R-S, R-SW
Mākura/Purei	*Carex secta*	R-S, R-SW
Mākura/Purei	*Carex virgata*	R-E, R-S, R-SW
Mākaka/NZ Broom	*Carmichaelia australis*	D
Karamū	*Coprosma robusta*	C, R-E
Tī kōuka/Cabbage tree	*Cordyline australis*	C, R-E
Karaka	*Corynocarpus laevigatus*	C, E
Upoko tangata/Giant umbrella sedge	*Cyperus ustulatus*	R-SW
Kahikatea	*Dacrydium dacrydioides*	E, R-E, R-S
Kohekohe	*Dysoxylum spectabile*	E
Whau	*Entelea arborescens*	C
Wiwi/Knobby club rush	*Ficinia nodosa*	C, R-E, R-S
Pīngao/Golden sand spiralis	*Ficinia spiralis*	D
Koromiko	*Hebe stricta*	C, R-E
Pigeonwood	*Hedycarya arborea*	E
Rewarewa	*Knightia excelsa*	C, E
Kānuka	*Kunzea robusta*	C
Pukatea	*Laurelia novae-zelandiae*	R-E, R-S
Mānuka	*Leptospermum scoparium*	C, R-E, R-S, R-Sal
Kawakawa	*Macropiper excelsum*	E, R-E
Pōhutukawa	*Metrosideros excelsa*	E, D
Wharangi	*Melicope ternata*	E
Māhoe	*Melicytus ramiflorus*	C, R-E
Mātipo	*Myrsine australis*	C
Cottonwood	*Ozothamnus leptophyllus*	D
Whaririki/Mountain flax	*Phormium cookianum*	C, R-E
Harakeke/Flax	*Phormium tenax*	C, R-E, R-S, R-Sal, D
Tōtara	*Podocarpus totara*	E
Houpara/Forest five finger	*Pseudopanax arboreus*	C
Houpara/Coastal five finger	*Pseudopanax lessoni*	C, E, D
Kōwhai	*Sophora microphylla (inland)*	C, R-E
Kōwhangatara/Spinafex	*Spinifex sericeus*	D
Maire tawake/Swamp Maire	*Syzygium maire*	R-S
Nikau palm	*Rhopalostylis sapida*	E
Pūriri	*Vitex lucens*	C, E

Table 1: A list of the varieties of plants eco sourced and propagated at the Āwhitu Peninsula Landcare nursery.

Arbuscular Mycorrhizal Fungi (AMF) symbiosis

Arbuscular mycorrhizal fungi (AMF) play a significant role in the community dynamics of ecosystems [18,24,48,49] and more specifically, in the stress tolerance of exposed coastal dune environments [24].

Forest sourced AMF has shown to increase the growth of thin-barked tōtara (*Podocarpus cunninghamii*) when growing in competition with the exotic grass *Agrostis capillaris.* However, AMF sourced from ex-agricultural land decreased growth. Accordingly, it was recommended that plants are inoculated with native forest AMF when regenerating ex-agricultural land to forest [48].

There is an increasing interest in the use of AMF as a commercially available inoculation product in restoration and conservation projects. However, commercially made products in New Zealand are often made of exotic species of AMF. Williams *et al.* 2013 found that exotic species of AMF had no effect, or a negative effect on thin-barked tōtara growth and tissue concentrations of nitrogen and phosphorus [49]. Species of AMF native to New Zealand were found to induce positive growth and nutrient responses.

If inoculating with AMF, it is therefore recommended that native AMF is sourced from the corresponding environment, for example sourcing from a mature forest or coastal dune.

Dune planting. Photo by Anna White.

Conclusion and recommendations

In summary, Āwhitu Peninsula Landcare intends to continue to support and promote the community to plant and protect biodiverse, eco-sourced plant stock. To achieve the desired outcomes of this report, the following recommendations are provided.

Recommended next steps:

1. A communications specialist to work with Āwhitu Peninsula Landcare to establish the best approach for achieving the desired audience and outcomes.

2. Wide scale information provided to the community on the effects of grazing livestock in native forest and targeted support provided to private landowners to fence around native forest.

3. Once a native forest area is fully fenced following stock grazing, an assessment of the area to ascertain what interplanting should be undertaken.

4. Actively promote and support the revegetation and fencing of streams, wetlands, and lakes. Information provided to the community on recommended buffers (10m min) prior to fencing being built and the importance of biodiverse native planting.

5. Actively promote and support establishment of new biodiverse forest blocks on the Peninsula. In particular, the conversion of unproductive land (e.g. steep hillsides and boggy areas) to native forest.

6. Āwhitu Peninsula Landcare needs to establish a clear approach in dune restoration and erosion prevention. Prioritise consultation with local community members and dune planting experts to strategise a clear management and implementation pathway, drawing from local knowledge and experience in addition to the recommendations of Auckland Council. It is imperative that the erosion prone land is retired from grazing to ensure further degradation and the risk reduced. A clear and far-reaching public awareness campaign is recommended to promote ecologically safe practices on erosion prone land. Such recommendations include restricting access to animals, people and specifically vehicles. Private landowners should be encouraged to fence off erosion prone land and given targeted support to do so. Once an area is secure and protected, it is recommended that a restorative planting plan is put in place.

7. Integrate a wider scoped pest management plan that is inclusive of wild deer, goats, pigs, mustelids and cats across the Peninsula. This could incorporate local expertise to establish a volunteer pest hunting team and target specific areas and move through the Peninsula. Utilising local hunting experts may foster a more supportive and trusted relationship with landowners on the Peninsula.

8. Conduct a wide scoped bat survey on the Peninsula using acoustic detectors to ascertain whether they inhabit forested areas on the Peninsula. The results from the survey could inform Landcare's pest management strategy (if they are found) or warrant further investigation for the feasibility of reintroduction.

9. Communication and collaboration with Auckland Council to establish a thorough and effective management plan for combating pest plants on road sides and Council owned land.

10. Investigate the feasibility of inoculating plantings with native arbuscular mycorrhizal fungi (AMF) from a corresponding ecosystem.
11. Establish a management plan for pūkeko and integrate into all planting plans for relevant sites. This needs to be a high priority for upcoming wetland plantings.
12. Incorporate a detailed supportive information pack with landowners at the beginning of ordering plants from Āwhitu Peninsula Landcare, alongside the planting plan. Inclusive of site preparation information, pest plant and animal control, high-risk disease identification (e.g., myrtle rust, kauri dieback) and ongoing maintenance guidance.

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Appendix 1: Stream testing results for Waimatuku stream, Āwhitu. Results procured from the WaiCare website (for Hamilton's Gap): https://waicare.org.nz/Resources/ExportRawData.aspx

SampleDate	AirTemp (°C)	WaterTemp (°C)	WaterClarity (cm)	pH	DissolvedOxygen (mg/L DO)	Nitrate (mg/L NO3)	Phosphorous (mg/L P)	Wimp Score	Fish	Macroinvertebrates
31/07/19	13.00	12.80	41	6.00	9.00	5.00	0.03	94		Swimming Mayfly, Flat Mayfly, Damselfly, Water Flea, Mite, Shrimp, Other rounded/pointed snails, Midge
22/10/19	16.00	16.20	50	7.00	8.00	5.00	0.05	103	Inanga	Swimming Mayfly, Water Flea, Mite, Shrimp, Other rounded/pointed snails
20/01/20	23.00	18.80	50	6.00	4.00	5.50	0.15	84		Flat Mayfly, Amphipods/isopods, Water Flea, Shrimp, Other rounded/pointed snails, Mosquito Larva, Midge
19/04/20	19.00	18.10	40	7.00	5.00	5.50	0.07	91		Flat Mayfly, Amphipods/isopods, Shrimp, Other rounded/pointed snails, Mosquito Larva
19/07/20	15.00	14.80	45	6.00	7.00	5.00	0.40	95		Swimming Mayfly, Water Flea, Shrimp, Flat/spiral Snail, Mosquito Larva
25/10/20	21.00	17.90	65		6.00	4.00	0.20	104		Swimming Mayfly, Water Flea, Shrimp, Other rounded/pointed snails
17/01/21	23.70	17.00	62	7.00	5.00	2.00	0.10	88		Swimming Mayfly, Dolomedes Spider, Amphipods/isopods, Mite, Shrimp, Other rounded/pointed snails, Mosquito Larva, Midge
25/04/21	18.40	14.00	49	6.00	4.00	2.00	0.30	105		Swimming Mayfly, Dolomedes Spider, Pondskater, Amphipods/isopods, Water Flea, Shrimp, Other rounded/pointed snails, Mosquito Larva
ANNUAL MEDIAN	**19.00**	**17**	**49**	**6.50**	**5.00**	**4.00**	**0.20**	**95**		

Appendix 2: Data interpretation table for stream testing. Sourced from the WaiCare website: https://waicare.org.nz/Files/Data%20Interpretation%20Table.pdf

Test	Excellent	Good	Fair	Of concern
Water temperature:	below 14.9°C	15 - 17.9°C	18 - 21°C	above 21°C
Water clarity:	80 - 100cm	60 - 79.9cm	30 - 59.9cm	0-29.9 cm
pH:		5 to 9		below 5; 9 or above
Dissolved Oxygen:	9 mg/L and above	6 - 8.9 mg/L	3 - 5.9mg/L	below 3 mg/L
Nitrate:	0 - 0.5 mg/L	0.51 - 1mg/L	1.01 - 5mg/L	above 5 mg/L
Nitrite:	0 - 0.075 mg/L	0 - 0.075 mg/L	0.076 - 0.15 mg/L	above 0.16mg/L
Phosphorous:	0 - 0.0125 mg/L	0.0126 - 0.025mg/L	0.026 - 0.8 mg/L	Above 0.8mg/L


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