# Forest Ecological Integrity in Tāmaki Makaurau 2009-2024

State of the Environment Reporting

Georgianne J. K. Griffiths, Grant Lawrence

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# Executive summary


This report assesses forest ecological integrity in Tāmaki Makaurau / Auckland, with a focus on forest extent and configuration using data from the Landcover database from 1996-2018 with a provisional update to 2023, and forest composition, structure and function using plant and bird data from Auckland Council's Terrestrial Biodiversity Monitoring Programme (TBMP) 2009 to 2024. Ecological integrity is defined as the extent to which an ecosystem is able to support and maintain its composition, structure and functions, in comparison to its natural or historical range of variation and in response to natural or anthropogenic change.

## Forest extent

Indigenous forest and scrub account for 27% of land cover in Tāmaki Makaurau, up from 26% in 2018. Indigenous forest covers 16.8% (81,161 ha) and indigenous scrub/shrubland 11.3% (57,999 ha). Across the 27-year monitoring timeframe, the largest expansion in forested land cover was observed 2018-2023, with net gains of 1,021 hectares of indigenous forest and 4,534 hectares of indigenous scrub/shrubland.

The primary driver of forest expansion is conversion from exotic grassland (1,839 ha for forest, 4,680 ha for scrub/shrubland), with additional gains from exotic forest (439 ha to forest, 697 ha to scrub/shrubland). Gains arise from active replanting associated with pastoral conversion to lifestyle blocks and greenfield developments, active replanting in regional parks, and natural regeneration on marginal farmland. Approximately 84% of gains occurred on private land, with the 10 largest patches accounting for 7% of total gain and often associated with rural subdivisions and lifestyle development.

A mixture of Auckland Unitary Plan policies are driving these changes, including rural subdivision rules (E39), vegetation management and biodiversity provisions (E15) particularly when developments impact existing ecological features or require ecological offsets, planting to protect water quality (E3), and Significant Ecological Areas overlay (D9). Public land gains were concentrated in regional and local parks, with Te Muri Regional Park recording the largest increase (approximately 75 ha).

Gains and losses are not equivalent for biodiversity. All indigenous forest ecosystems in Tāmaki Makaurau are classified as Threatened according to International Union for Conservation of Nature (IUCN) criteria. Forest losses result from direct conversions to urban expansion (187 ha) and infrastructure development, or from incremental infill that crosses classification thresholds. There will be considerable time-lag before new plantings can compensate for loss of biodiverse habitats when existing forest is removed. The ecological outcomes of large-scale planting programmes depend on the quality of initial planting and maintenance. Low-diversity plantings on private land may fall short of supporting diverse, self-sustaining indigenous ecosystems without careful planning

of diverse species mixtures, and ongoing monitoring. Despite recent gains, Tāmaki Makaurau remains well below the national average of 33% indigenous forest cover.

### Plants

TBMP data reveals clear differences in native plant biodiversity. Large, continuous forest blocks consistently support higher indigenous plant species richness, including plants with a conservation status of threatened, at-risk or data-deficient. Threatened, at-risk and data-deficient species were found in all sub-regions, highlighting the biodiversity value of protecting a variety of habitats, across a wide range of environmental contexts, including those that may be considered of more limited value. These species showed signs of poor regeneration (they represent 8.5% of basal area but only 3.5% of seedling density) undermining their long-term survival.

Urban forest patches support fewer indigenous plant species and more pest plants (averaging 8.9 pest species per plot versus 3.3 regionally), highlighting their exposure to pest plant propagules from human settlements including private gardens. Declining seedling densities was observed regionally, across Te Wao Nui ā Tiriwa / Waitākere Ranges, Ark in the Park and the Kōkako Management Area which may be caused by multiple drivers including pest mammals, drought impacts or forest dynamics and warrants further investigation.

Forest condition scores identify concerning patterns at Te Korowai-o-Te-Tonga / South Kaipara Peninsula, where deer browse has halted regeneration under senescing kānuka canopies, including impacts on the nationally threatened *Kunzea amathicola* and regionally threatened *Coprosma crassifolia*. These forest patches are at risk of canopy collapse.

### Birds

All six deep endemic bird species (endemic at family taxonomic rank) recorded in the TBMP were observed on Te Hauturu-o-Toi highlighting the value of mammalian pest-free offshore islands to species most vulnerable to mammalian pests. The TBMP data showed that coupled with bird translocations to safe environments, there appeared to be a hierarchy of outcomes in the indigenous bird response to mammalian pest control. Greatest outcomes for deep endemic birds and indigenous birds more generally were observed where mammalian pests are eradicated, on the offshore islands of Te Hauturu-o-Toi and Ōtata, followed by pest exclusion to zero density, in the fenced mainland islands of Tāwharanui and Shakespear Open Sanctuaries. Sustained mammalian pest suppression including the use of broad scale application of toxic bait, such as that used at the Kōkako Management Area, was more effective than mammalian pest suppression without the use of broad scale toxic bait, such as that used at Ark in the Park, especially when pest control operations were targeted to protect a specific indigenous bird, the kōkako. It is important to remember that all sites are continually vulnerable to mammalian pest incursions, as illustrated by the stoat incursion at Tāwharanui in 2016, and require sustained and indefinite mammalian pest control to maintain biodiversity outcomes.

## The Terrestrial Biodiversity Monitoring Programme

The Terrestrial Biodiversity Monitoring Programme (TBMP) provides long-term, systematic quantitative data on forest plant and bird composition and structure, plus qualitative assessments of forest condition and pest signs. This enables tracking of forest ecology and biodiversity across regions and sub-regions with varying landscape configurations, ecosystems, histories and conservation management approaches.

Recent improvements include tree tagging to monitor recruitment, growth and mortality of trees, and recce plots for better ecosystem mapping and to improve observations of non-woody and pest plants. Budget constraints over the 15-year programme have reduced plot numbers and remeasurement frequency, impacting regional coverage and change-detection sensitivity. The Natural Environment Targeted Rate (NETR) now provides funding to remeasure some existing plots and establish new ones at key Biodiversity Focus Areas, enabling outcome monitoring of NETR-funded conservation management. Previously "parked" plots remain available for remeasurement.

TBMP data supports diverse analytical approaches, particularly valuable when combined with functional plant or bird traits to understand ecosystem functioning. However, the programme only monitors plants and birds, lacking systematic monitoring of other indigenous biodiversity such as invertebrates, which are declining globally and drive critical ecosystem functions including decomposition, nutrient recycling and pollination. This report also identified the value of monitoring of restoration planting, ideally on public and private land, to better understand restoration quality.

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# 1 Introduction

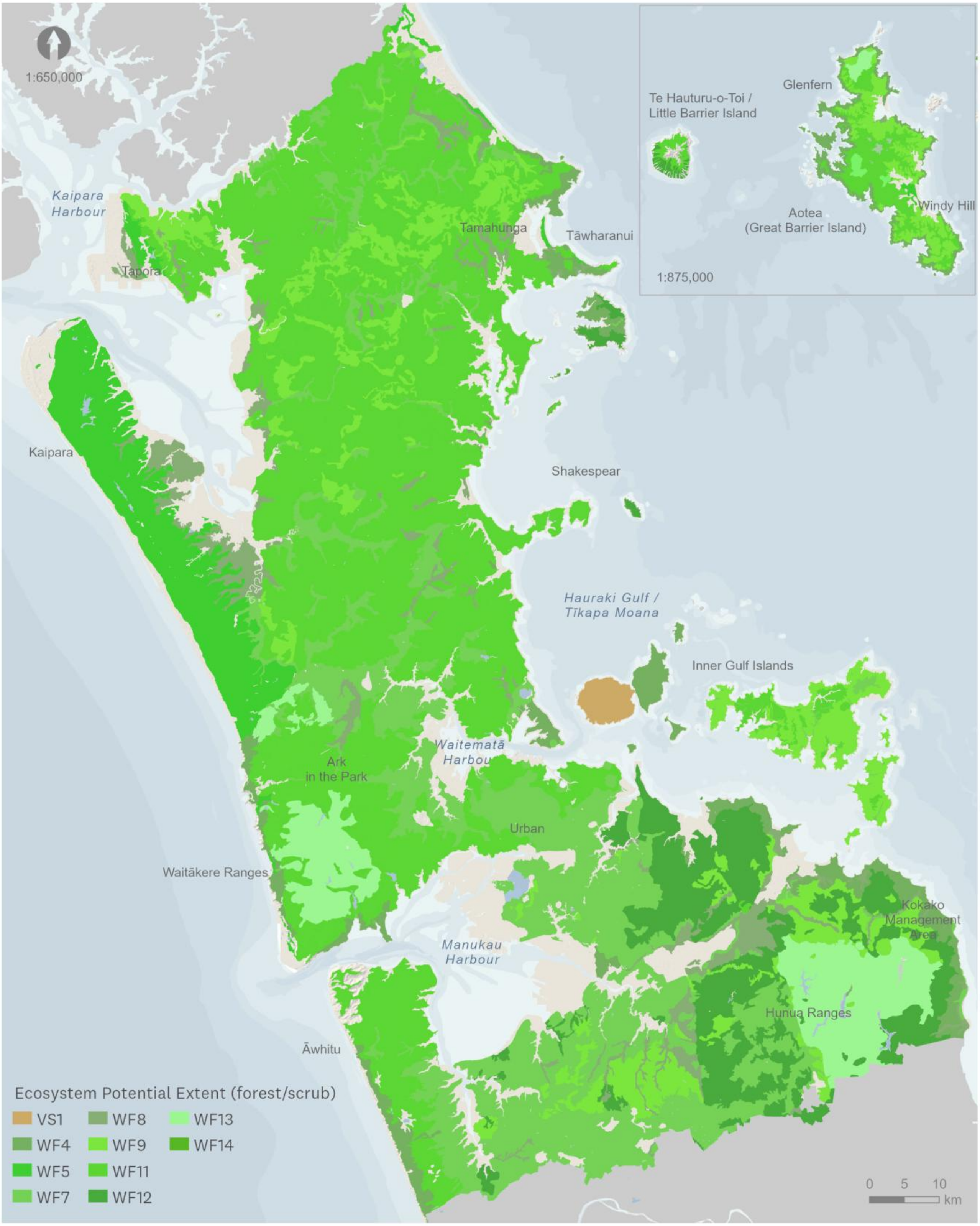
Ecological integrity is defined as the extent to which an ecosystem is able to support and maintain its composition, structure and functions, in comparison to its natural or historical range of variation and in response to natural or anthropogenic change (MfE 2024, Tierney et al 2009). Ecological integrity can be examined at multiple scales (McGlone et al 2020). This report assesses forest ecological integrity in Tāmaki Makaurau / Auckland, with a focus on forest extent and configuration using data from the Landcover database from 1996-2018 with a provisional update to 2023, and forest composition, structure and function using plant and bird data from Auckland Council's Terrestrial Biodiversity Monitoring Programme (TBMP) 2009 to 2024.

## 1.1 Forest in Tāmaki Makaurau

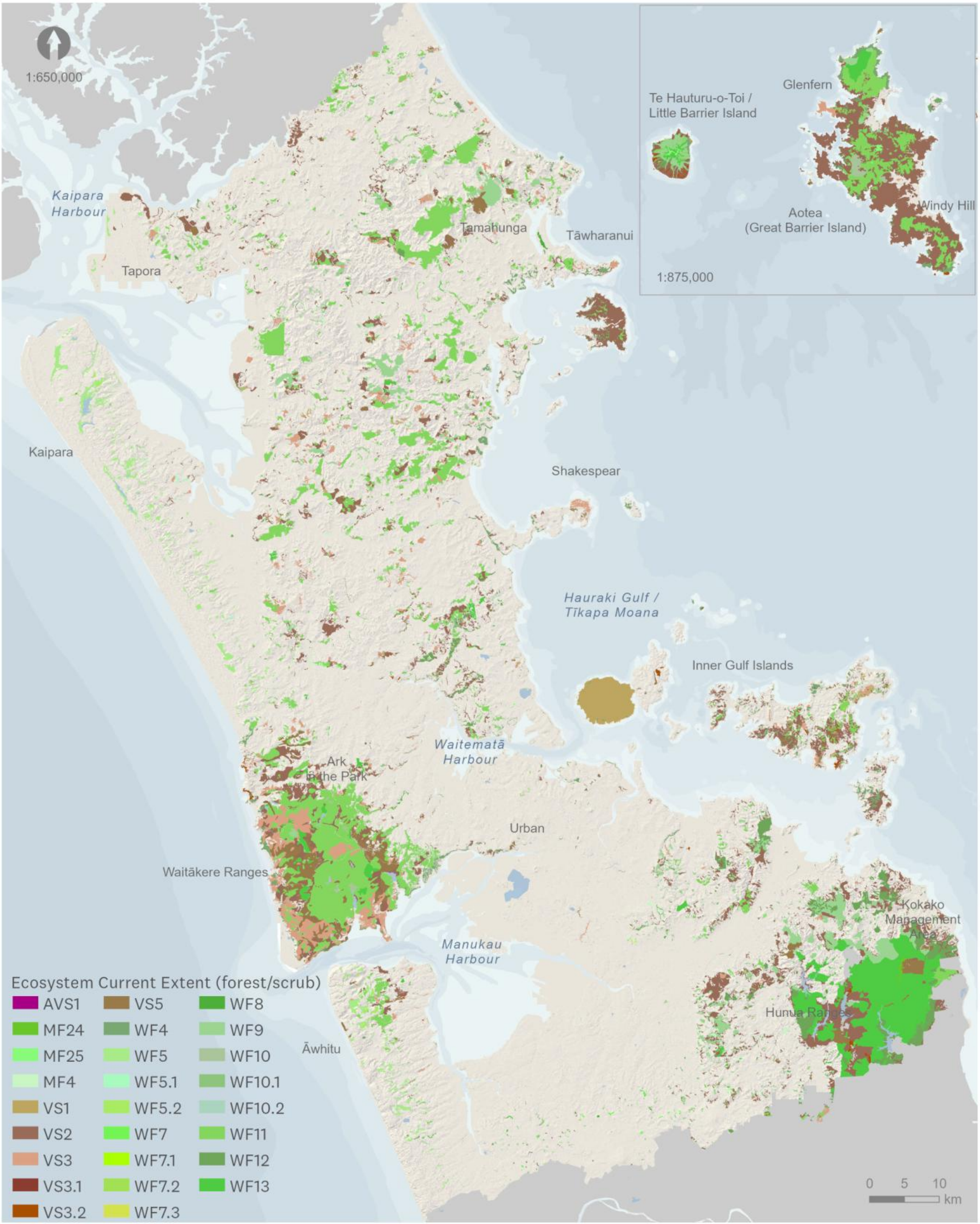
Indigenous forest and scrub/shrubland composes 26% of the land cover in Tāmaki Makaurau, exotic forest and scrub/shrubland covers a further 10% (Griffiths et al 2021).

Singers et al (2017) mapped the indigenous terrestrial and wetland ecosystem types in Tāmaki Makaurau and identified twelve mature and four regenerating scrub/forest ecosystems, along with a number of anthropogenic and novel forest and scrub ecosystems. These ecosystems were mapped to show the potential (predicted pre-human, Map 1) and current (Map 2) distribution of forest and scrub ecosystems. Comparison of these two distributions show the impact of human colonisation on forest extent, fragmentation and composition. The distribution of indigenous forest and scrub ecosystems has severely reduced, representing a massive loss of habitat for forest dwelling flora and fauna, especially given the high rates of endemism in Aotearoa New Zealand's birds (~71%) and plants (82.2%, McGlone et al 2001). Since (predicted) pre-human times there has been a massive reduction in the extent of previously dominant forest ecosystems, especially those typical of lowland areas. Indigenous forest types that have declined by more than 80% of their original extent include Pūriri (WF7), Kahikatea, pukatea (WF8), Tōtara, kānuka, broadleaf (WF5), Kauri, podocarp, broadleaf, beech (WF12), Kauri, podocarp, broadleaf (WF11), Taraire, tawa, podocarp (WF9) and Pōhutukawa, pūriri, broadleaf (WF4). Kahikatea, pukatea (WF8) has been reduced to 2% of its original extent, Pūriri (WF7) forest to 0.3% of its original extent (Griffiths et al 2021). As a result, all indigenous forest ecosystems in Tāmaki Makaurau are classed as Threatened according to International Union for Conservation of Nature (IUCN) criteria (Singers et al 2017). A large proportion of remaining forest (37%) has been disturbed and degraded to such an extent it has been reclassified as regenerating forest and scrub ecosystem types (Kānuka VS2, Mānuka/kānuka VS3 and Broadleaved species VS5) or converted to anthropogenic or novel forest and scrub ecosystems such as exotic forest and scrub, planted forest/scrub, treeland and anthropogenic tōtara (14%, Griffiths et al 2021).

Most regenerating forest and scrub will develop into mature forest ecosystems in the absence of repeated disturbance (e.g. fires, landslides, etc). Forest development goes through several




Map 1. Potential pre-human (predicted) extent of forest and scrub ecosystems in Tāmaki Makaurau (Singers et al 2017). Ecosystem names for each code are listed in Appendix 5.




Map 2. Current extent of forest and scrub ecosystem types in Tāmaki Makaurau (Singers et al 2017). Ecosystem names for each code are listed in Appendix 5.

successional stages following disturbance (Wyse et al 2018). Early successional stages are defined by seedling recruitment, followed by a building phase characterised by a high density of small tree stems. Once the sub-canopy closes, mid-successional stages are defined by intense competition for light during which there is high mortality, or competitive thinning of smaller tree stems and growing basal area of larger tree stems. As trees continue to grow in maturing forest this self-thinning leads to a largely stable stand basal area (Weiner & Freckleton 2010). Late successional stage mature forest is characterised by high structural complexity with understorey, sub-canopy, canopy, and emergent trees. Emergent trees are typically kauri or podocarp conifers and the hemi-epiphytic northern rātā. Once forest stands mature, senescence leads to canopy thinning, providing more light for seedlings and saplings to establish.

Despite intensive urbanisation, Tāmaki Makaurau retains several large continuous tracts of indigenous forest on the mainland in Te Wao Nui ā Tiriwa / Waitākere Ranges and Te Ngāherehere o Kohukohunui / Hūnua Ranges and on the offshore island of Aotea / Great Barrier Island. These areas have been logged for kauri (*Agathis australis*) and other timber trees and parts repeatedly burned or cleared for farming, but significant regeneration and consolidation has occurred (Perry et al 2010; Griffiths et al 2023). These large, continuous forested areas now represent a complex and diverse mosaic of mature and successional forest vegetation (Denyer et al 1993). Smaller in area, but one of the most intact indigenous forested areas in Tāmaki Makaurau is the offshore island of Te Hauturu-o-Toi (Little Barrier Island), where there has been only limited logging and farming.

A large proportion of Auckland's forest habitat (>60%), however, is found in smaller and more isolated forest fragments, often surrounded by rural or urban land. Examples include unique remnants of swamp forest at Omaha and Pakiri and indigenous sand dune forest along the Awhitu and Te Korowai-o-Te-Tonga peninsulas. Even urban areas of Tāmaki Makaurau contain examples of rare forest types. These include remnants of lowland taraire forest, such as Kirk's Bush near Papakura, indigenous lava forest at Otuataua and Maungawhau (Mt. Eden, a nationally uncommon vegetation type), hard beech-kauri forest in the Birkenhead-Chatswood area and the best example of gumland in Tāmaki Makaurau at Waikumete Cemetery.

The current patchy forest and scrub distribution reflects the history of burning, logging, forest clearance, farming and urban development activities since human colonisation, especially in lowland areas. Destruction of forest habitat is responsible in large part for declines in native biodiversity, with forest loss considered to have a greater impact on bird communities than invasive mammals in areas of high deforestation such as lowland Auckland (Innes et al 2009; Ruffell and Didham, 2017). As forest patches become smaller and more isolated, they are less able to provide the conditions and resources necessary for indigenous forest species to persist and are less likely to be recolonised by forest species when they go locally extinct (Fahrig 2003). Smaller forest patches have a greater edge to area ratio, and edge effects can be detrimental to forest communities (Norton 2002; Ewers and Didham 2008), although these transition zones can also be highly diverse. Adjacent land-uses vary in their ability to provide resources, support movement of native species between forest patches or expose forest patches to further pressures. Within highly modified landscapes however, recommendations for optimal distribution of forest cover include maintaining a few large areas of continuous forest cover (approximately 25%), necessary for more specialist species, and many smaller forest patches covering a wider range of environmental contexts (Arroyo-Rodriguez et al 2020). Such forest configuration across the landscape would support the many indigenous forest bird species with limited ability to disperse between forest patches (Innes et al 2022).

Previous analyses of the TBMP forest data showed landscape structure had a significant impact on indigenous plant and bird species richness; more native species occurred in larger and more connected forest patches, regardless of the surrounding land cover (Griffiths et al 2021). It is important to note that small, poorly connected urban habitat patches with low species richness are still highly valuable for biodiversity. The plot at Kirk's bush for example, records only 20 native species, but is a rare example of a taraire dominated forest in an urban context.

## 1.2 Pest plants and animals

Considerable degradation of Auckland's forests is driven by problematic non-native species. Disturbed and fragmented forests become more exposed and susceptible to pest plants, plant pathogens and pest animals (Hobbs 2000; Jeschke & Starzer 2018). Previous analyses of the TBMP forest data showed pest plant abundance was strongly driven by landcover, with more weeds occurring in forests surrounded by urban land cover (Griffiths et al 2021). Exotic pest plants are known to be more common in forest fragments close to human settlements (Sullivan et al 2005) and ornamental plants are disproportionately listed as environmental pest plants (Hulme 2020). Garden escapees will continue to be a major source of pest plants in the future as the time-lag between plants entering the horticultural market to becoming naturalised and problematic can be >100 years (Hulme 2020).

In Auckland Council's *Regional Pest Management Plan 2020-2030* (Auckland Council 2020), 226 species are listed as problematic. The Department of Conservation's (DOC) revised list of environmental weeds occurring nationally includes 386 species, a large number of which occur in Tāmaki Makaurau (MacAlpine & Howell 2024). These weeds are considered capable of having serious adverse effects on the environment or people. Pest plants harm indigenous forest and scrub ecosystems by outcompeting native species for resources (e.g. space, light), hybridising with native species, promoting fire, altering hydrology or altering the nutrient or chemical profile of soil, resulting in reduced species richness and disruption to functioning in indigenous ecosystems (Toft et al 2001, McAlpine et al 2015, Perry et al 2014). Invasive pest plants pose a threat to more than half of Aotearoa New Zealand's critically endangered ecosystems and are the main threat to one third of threatened plant species (de Lange et al 2009, Wiser et al 2013, Hulme 2020). In forest interiors, pest plants are often those that can survive in a wide range of light levels and often initially colonise disturbed land such as tree fall gaps, landslides and regenerating forests.

The plant pathogens causing kauri dieback disease (*Phytophthora agathidicida*) and myrtle rust (*Austropuccinia psidii*) threaten some of the most iconic and abundant tree species in Tāmaki Makaurau, namely kauri, pōhutukawa, rātā trees and vines. Extensive kauri population health surveys showed no evidence of kauri dieback in Te Ngāherehere o Kohukohunui / Hūnua Ranges (Froud et al 2025). In Te Wao Nui ā Tiriwa / Waitākere Ranges, *P. agathidicida* and symptomatic kauri trees were more prevalent around the periphery of the parkland and along tracks, with signs of infectious disease spread from kauri tree to kauri tree, but less common in the forest interior (Froud et al 2022). In the Te Wao Nui ā Tiriwa / Waitākere Ranges, only 53.2% of sampled kauri trees were observed to be healthy. Kauri dieback disease is known to occur in various kauri stands throughout Tāmaki Makaurau and work is continuing to better understand how kauri can be managed and protected, including the forthcoming 'Kauri ora' survey on Aotea.

The wind-dispersed myrtle rust, specific to Myrtaceae, arrived in Aotearoa New Zealand in 2017 and has spread rapidly, leading to the decline and death of multiple indigenous Myrtaceae species. Myrtle rust infects at least 12 of the 18 species in the Myrtaceae plant family (McCarthy et al 2024), especially vulnerable are two species of the endemic genus *Lophomyrtus*, ramarama (*L. bullata*) and rōhutu (*L. obcordata*) along with maire tawake (*Syzygium maire*, Prasad 2022), which have now been classed as nationally and regionally threatened (de Lange et al 2024; Simpkins et al 2025). The woody family Myrtaceae has the second highest mean relative cover and basal area in forests nationally and are particularly dominant in regenerating forests (Jo et al 2021). In Tāmaki Makaurau, 37% of forested land cover is composed of early successional scrub/shrubland which is most vulnerable to myrtle rust (McCarthy et al 2024).

In Aotearoa New Zealand, 32 mammal species have been introduced, mostly deliberately (Goldson et al 2015). In Tāmaki Makaurau, severe impacts on indigenous ecosystems are observed from rats (ship rat *Rattus rattus,* Norway rat *Rattus norvegicus,* kiore *Ratus exulans)*, mice (*Mus musculus*), mustelids (ferrets *Mustela furo*, stoats *M. erminea*, weasels *M. nivalis*), hedgehog (*Erinaceus europaeus*), rabbits (*Oryctolagus cuniculus*), hare (*Lepus europaeus*), cats (*Felis catus*), dogs (*Canis lupus familiaris*), possum (*Trichosurus vulpecula*), deer (*Cervus, Axis, Dama, Odocoileus* and *Elaphurus* species), goat (*Capra hircus*), pigs (*Sus scrofa*) and wallaby (*Macropus, Petrogale* and *Wallabia* species). As a result of its isolation from the rest of the world, many of New Zealand's endemic birds have evolved in the absence of mammalian predators. Birds that are deeply endemic (i.e. birds endemic at a higher taxonomic rank such as family or order) may have evolved traits that make them more susceptible to mammalian pests than more recent endemics (i.e. birds endemic at a lower taxonomic rank such as species or genus). This vulnerability is mostly attributed to absence of a mammalian-predator escape response, including flightlessness, but may also be linked with associated traits such as ground-nesting, cavity nesting, large body size and mobility (Binny et al 2020; Walker et al 2021). While all mammalian pest-control regimes benefited indigenous bird populations, Binny et al (2020) found that deeply endemic species had the strongest population responses to mammalian pest eradication compared to more recent endemics or introduced birds in fenced ecosanctuaries. In areas managed for mammalian pest suppression, recent natives and introduced species may be advantaged by combined low pest densities, and competitive release from more highly specialised endemics. As a result, many predator-sensitive native species such as korimako (bellbird), hihi (stitchbird), toutouwai (North Island robin), North Island kōkako, kākā and pōpokatea (whitehead) can only survive in predator-free offshore or mainland islands (Ruffell and

Didham 2017). Lizards and invertebrates are also highly vulnerable to mammalian pests (St Clair 2011; Norbury et al 2014), as well as exotic birds and wasps (*Vespula* and *Polistes* species).

Predatory mammals have been shown to impact forest ecosystem functioning by disrupting bird-mediated pollination and seed dispersal (Pattemore & Anderson 2012; Anderson et al 2011), but also through direct impacts on indigenous plants. Mammalian pests including omnivorous rats and possums and browsing and grazing herbivores consume the seeds, seedlings, flowers, buds, leaves, stems and new growth of indigenous plant species, altering forest composition and regeneration dynamics (Husheer 2007). For example, analysis of forest plots in Te Urewera concluded that deer grazing on palatable broadleaved canopy species lead to arrested succession in fire-induced communities dominated by kānuka (*Kunzea* species), treeferns, rewarewa (*Knightia excelsa*) and kāmahi (*Weinmannia racemosa*) which all showed minimal compositional change over 30 years, especially of canopy species (Payton et al 1984, Richardson et al 2014). Deer-browsing can lead to non-reversible ecosystem impacts (Coombes et al 2003). In Te Wao Nui ā Tiriwa / Waitākere Ranges, populations of possum in the 1990s were high enough to have caused significant damage to canopy and seedling populations of northern rātā and other indigenous species (Denyer et al 1993, Buddenhagen et al 1995). Terrestrial Biodiversity Monitoring Programme (TBMP) data from Te Wao Nui ā Tiriwa / Waitākere Ranges since 2009, showed that despite possum control (< 6.6% RTC) no saplings, seedlings or epiphytes have been recorded of several preferred species including northern rātā (*Metrosideros robusta*), pōhutukawa (*Metrosideros excelsa*), whauwhaupaku (*Pseudopanax arboreus*) and mamaku (*Cyathea medullaris,* Griffiths et al 2023). A review of the biodiversity benefits of possum control however, showed that it benefited indigenous vegetation by increasing foliage and fruit production and by reducing tree mortality (Byrom et al 2016).

Less well documented are the impacts of invasive invertebrates such as wasps and paper wasps. Where these species are abundant they are known to consume and seriously deplete invertebrate fauna, particularly butterflies and moths (Beggs et al 2011; Lefort et al 2020a; Lefort et al 2020b). The disappearance of the forest ringlet butterfly from Tāmaki Makaurau since the 1990s has in part been attributed to predation by invasive wasps (Wheatley 2017).

## 1.3 Climate change

The National Climate Change Risk Assessment for New Zealand identifies the priority risk of climate change for indigenous forest ecosystems will come from the 'enhanced spread, survival and establishment of invasive species' (MfE 2020). Climate change will expand the range and impact of existing invasive species and provide opportunities for new naturalisations, driving biodiversity losses (Sheppard et al 2016; Bishop et al 2018; Macinnis-Ng et al 2021). Forest flora and fauna that already have a reduced distribution and population size from habitat loss and fragmentation will have limited resilience to changes in climate (McGlone and Walker 2011).

Predictions from NIWA for the Auckland region include increased temperatures, including the number of hot days (>25°C) per year (Pearce et al 2018). Changes in temperature can impact the phenology or timing of species and their interactions, such as the timing and intensity of synchronised mast-seeding events across multiple plant species (Schauber et al 2002). The length and intensity of both droughts and extreme rainfall events is expected to increase. Elevated stress from prolonged low soil moisture will impact native forest flora and fauna. There are few predictive traits for drought-induced mortality; but small trees are considered more susceptible than larger trees, and forest on steeper ridges and slopes are more susceptible, which is where much of the least disturbed forest is more likely to be found (Russo et al 2010; O'Brien et al 2017). In the Auckland region, species such as tawa (*Beilschmiedia tawa)* and kanono (*Coprosma autumnalis*) are considered drought sensitive (Knowles and Beveridge 1982), but there is little comprehensive research. Droughts will increase wildfire hazard, impacting forest ecosystems that are already highly fragmented (McGlone and Walker 2011), and potentially changing successional trajectories to favour fire-adapted non-native taxa (Perry et al 2014), such as Hakea species.

Increasing frequency and severity of drought and high rainfall events cause shrinking and swelling in Auckland's clay-rich soils leading to progressive weakening, and increased likelihood of landslides (Tichavský et al 2019, Brown et al 2003). Landslides are a natural disturbance process that can lead to compositional changes in the vegetation of our indigenous forests. However, landslides are increasing in frequency and scale in response to climate change as evidenced by the number and coverage of landslides following extreme storm events in March 2017 (Lee 2020), September 2020 (Griffiths et al 2023) and January 2023 (McLelland and Roberts 2025). While landslides may provide opportunities for natural forest regeneration processes, they also can destroy mature forest and provide opportunities for infestation by pest plants.

## 1.4 Terrestrial Biodiversity Monitoring Programme (TBMP)

Auckland Council's Terrestrial Biodiversity Monitoring Programme (TBMP) was established in 2009 in response to State of the Environment monitoring requirements under Section 35 of the Resource Management Act 1991 (RMA), legislation currently undergoing reform. The programme is designed to monitor the biodiversity of forests, wetlands and dunes across Tāmaki Makaurau. The National Policy Statement for Indigenous Biodiversity 2023 (NPSIB, MfE 2024) is a regulatory statement under the RMA (1991) that aims to maintain terrestrial indigenous biodiversity across Aotearoa New Zealand and requires regional councils to monitor indigenous biodiversity (Subpart 3.25). Auckland Council's TBMP will form part of this monitoring.

The TBMP is partly supported by dedicated funding mechanisms within Auckland Council. The Natural Environmental Targeted Rate (NETR) provides a dedicated and significant funding stream for environmental initiatives, including pest control operations articulated through the Regional Pest Management Plan (RPMP 2020, mandated by the Biosecurity Act 1993), biodiversity protection prioritised through Biodiversity Focus Areas (BFAs) and biodiversity outcome monitoring. BFAs are areas of ecological significance selected to protect a representative range of indigenous species and ecosystems across the region and used to prioritised conservation management (Auckland Council 2025a). Part of the biodiversity outcome monitoring of BFAs is to use existing and establish new permanent forest plots as part of the TBMP.

The Auckland Unitary Plan (AUP) implements the RMA for Tāmaki Makaurau to promote sustainable management of resources. It provides rules, policies and objectives to guide land use and development and minimise adverse effects on indigenous vegetation and significant habitats of indigenous fauna. A key mechanism within the AUP is the identification of Significant Ecological Areas (SEAs), which are Auckland's regional equivalent of the Significant Natural Areas (SNAs) referred to in the NPSIB 2023. The TBMP was not designed to report on the NPSIB or the AUP directly but was designed to examine the overall state and trends in forest ecological integrity across the region, to which all these instruments will contribute.

# 2 Methods

## 2.1 Land cover

The New Zealand Land Cover Database (LCDB) is a comprehensive classification of New Zealand's land cover over time at national and regional scales. The LCDB is derived from remote sensing and continually refined with each version while maintaining backwards compatibility, the latest version available (LCDBv5) has five timestamps in 1996/97, 2001/02, 2008/09, 2012/13, 2018/19 (Landcare Research Ltd, 2020). In addition, this study used a sixth provisional LCDB update for the Auckland Region for 2023/24 (Auckland Council, 2025b). This regional update provided a contemporary assessment of land cover for Auckland for inclusion in Auckland Council's State of the Environment 2025 reporting, given that the forthcoming national LCDBv6 was not yet available. See Appendix 2 for a summary of methods and limitations associated with the development of Auckland's provisional land cover database update 2023/24.

Land cover data used in this analysis includes the mainland of Tāmaki Makaurau and islands in the Tīkapa Moana / Hauraki Gulf, including Aotea / Great Barrier island. Land cover data includes onshore and offshore classifications, such as mangrove and coastal waterbodies, as defined by their spatial relationship to the coastline. LAWA (Land, Air, Water Aotearoa) medium land cover classes are used to describe land cover patterns and changes in Tāmaki Makaurau (www.lawa.org.nz). Two medium land cover classes, Indigenous forest and Indigenous scrub/shrubland, are used to assess extent and changes in extent of forest cover. These medium cover classes are made up of detailed LCDB classes; Indigenous forest is composed of the detailed classes 'Indigenous Forest' and 'Broadleaf indigenous hardwoods'. Indigenous scrub/shrubland is composed of detailed classes 'Manuka and/or Kanuka', 'Fernland', 'Mangrove' and 'Matagouri or Grey Scrub'. See Appendix 3 for land cover statistics for all land cover classes including LAWA medium groupings and detailed classes.

## 2.2 Terrestrial Biodiversity Monitoring Programme (TBMP)

### 2.2.1 The forest plot network

The Terrestrial Biodiversity Monitoring Programme (TBMP) forest plot network uses a grid-based systematic sampling approach centred around permanent 20 x 20m vegetation plots, and the national 8km grid used for the Department of Conservation Tier One monitoring programme (MacLeod et al 2024). To generate a regional sample for Tāmaki Makaurau (Tier 1), alternate squares of a nested 4km grid were used to identify plot locations. Plots were located in the nearest suitable patch of forest closest to the centre of each grid cell. For each plot, a randomly selected plot corner had to be at least 20m from any forest edge, this limited the minimum patch size suitable for sampling to around one hectare. Where forest patches occurred on public land, permission to establish a permanent plot was granted. Permission to establish a permanent vegetation plot on private land could not always be obtained. If this was the case, the next nearest suitable forest patch for which permission could be obtained was used. On occasion, no other suitable patches of forest occurred, or no permission was granted, in which case no plots could be established in that grid cell. In total 134 permanent forest plots have been established forming the Regional Tier 1 monitoring network, designed to monitor regional forest ecological integrity across a range of environment contexts in Tāmaki Makaurau (Map 3).

The TBMP network contains nested tiers of plots at increasing spatial resolution to understand forest ecological integrity regionally (Tier 1) and within specific sub-regions (Tier 2 and 3, Map 3). Tier 2 plots were established using a 2km grid across three large continuous blocks of indigenous forest on Aotea, Te Wao Nui ā Tiriwa / Waitākere Ranges and Te Ngāherehere o Kohukohunui / Hūnua Ranges, in urban forest patches and rural forest patches at Tapora, Te Korowai-o-Te-Tonga / South Kaipara Peninsula and Awhitu. A small number of plots were also established on Waiheke and Motuihe islands.

Tier 3 plots were established in sub-regions with intensive conservation management, many of which are located in Biodiversity Focus Areas for species or ecosystems (Map 3). Conservation management activities may include but are not limited to pest animal plant control, revegetation and bird translocations. Sanctuary type, BFA designation, specific mammalian pest control strategy and numbers of ongoing or successful bird species translocation are described for each sub-region in Table 1. More detailed descriptions of the history, management and forest ecosystem of Regional Tier 1 and sub-regions can be found in Appendix 1.

In Tier 4, six plots were established for experimental reasons and not analysed further here.

Plots in the Regional Tier 1 sample are evenly distributed between public (51.5%) and private (48.5%) land, whereas across the other sub-regions tenure is strongly skewed towards public land (81%). Public land includes mostly regional parks, local and scenic reserves. Forty-five percent of the Regional Tier 1 sample are in Biodiversity Focus Areas (BFA), or sites identified by Auckland Council as areas of representative or unique biodiversity for targeted conservation management, whereas 86% of plots in the remaining sub-regions are in BFA. Only 22% of the Regional Tier 1 plots and 27% of plots in the other sub-regions are located in a Protected Area Network site.

The indigenous forest and scrub ecosystems represented in the Regional Tier 1 network are broadly representative of ecosystem types regionally (Griffiths et al 2021), with the majority in Kānuka scrub/forest (VS2) and Kauri, podocarp, broadleaf forest (WF11). Plots in Tier 2 and Tier 3 sub-regions had proportionately fewer anthropogenic forest types (e.g. Exotic forest EF and Exotic scrub ES), and because of the density of plots in the KMA, a higher proportion of Tawa, kohekohe, rewarewa, hīnau, podocarp forest (WF13). For a breakdown of ecosystem types Regionally and by sub-region see Appendix 5.


Map 3. The network of Tier 1 - 4 permanent forest plots in the Terrestrial Biodiversity Monitoring Programme (TBMP).

Table 1. Sanctuary type, Biodiversity Focus Area, mammalian pest control strategy and numbers of ongoing or successful bird species translocation Regionally (Tier 1) and for each sub-region (Tier 2 and 3).

| Tier | SubRegion | Mainland / Island | BFA | Sanctuary type | Mammalian pest control strategy | Ongoing/ successful bird translocations |
|---|---|---|---|---|---|---|
| 1 | Regional | Mixed | Mixed | | | |
| 2 | Te Wao Nui ā Tiriwa / Waikakere Ranges | Mainland | BFA | | Extra site-led control of pigs, mustelids, rats, feral cat. Extra progressive containment of deer, goat, possum & sulphur-crested cockatoo. | 3 |
| 2 | Te Ngāherehere o Kohukohunui / Hūnua Ranges | Mainland | BFA | | Extra site-led control of pigs, mustelids, rats, feral cat. | 3 |
| 2 | Aotea | Island | BFA | | | 1 |
| 2 | Urban | Mainland | Mixed | | | 0 |
| 2 | Te Korowai-o-te-Tonga / South Kaipara Peninsula | Mainland | Mixed | | | 0 |
| 2 | Tapora | Mainland | Mixed | | | 0 |
| 2 | Awhitu | Mainland | Mixed | | | 0 |
| 2 | Motuihe Island | Island | BFA | Offshore island | Eradication | 3 |
| 2 | Waiheke Island | Island | Mixed | | | 1 |
| 3 | Shakespear | Mainland | BFA | Fenced mainland island | Pest exclusion to zero density | 7 |
| 3 | Tāwharanui | Mainland | BFA | Fenced mainland island | Pest exclusion to zero density | 7 |
| 3 | Ark in the Park | Mainland | BFA | Unfenced mainland island | Pest supression | 3 |
| 3 | KMA | Mainland | BFA | Unfenced mainland island | Sustained pest suppression | 0 |
| 3 | Tamahunga Ecological Area | Mainland | BFA | Unfenced mainland island | Pest supression | 1 |
| 3 | Kotuku Peninsula, Aotea | Island | | Fenced mainland island | Pest supression | 0 |
| 3 | Windy Hill, Aotea | Island | BFA | Unfenced mainland island | Pest supression | 0 |
| 3 | Te Hauturu-ō-Toi | Island | BFA | Offshore island | Eradication | 3 |
| 3 | Rangitoto Island | Island | BFA | Offshore island | Eradication | 3 |
| 3 | Motutapu Island | Island | BFA | Offshore island | Eradication | 4 |
| 3 | Ōtata, Noises Islands | Island | BFA | Offshore island | Eradication | 0 |

The TBMP started in 2009, with the intention to visit all plots on a five-year rotation (Rotation 1: 2009 and 2013; Rotation 2: 2014 and 2018; Rotation 3: 2019 – 2023; Rotation 4: 2024 – 2028). Budget constraints and reprioritisations have resulted in many changes to the plot network since 2009. For each rotation, the number of plots visited Regionally (Tier 1) and in each sub-region are shown in Table 4. Tier 1 and Tier 2 plots are now visited on a 10-year rotation in line with DOC's Tier One national monitoring programme (MacLeod et al 2024), with the exception of Tier 2 plots inside the Waitākere Ranges Heritage Area that are monitored on a 5-year rotation to meet the statutory monitoring requirements of the Waitākere Ranges Heritage Area Act (2008). Most Tier 3 plots were parked in 2017 due to budget constraints. Since 2023, several sub-regions in Tier 3 located in Biodiversity Focus Areas are monitored on a 5-year rotation with funding from the Natural

Environment Targeted Rate (NETR) to monitor outcomes of NETR-funded conservation management.

### 2.2.2 The forest plot protocol

At each permanent plot, a standardised protocol is followed based on the standard 20m x 20m permanent plot protocol (Hurst et al 2022). The aim of the protocol is to capture as complete a snapshot of the forest structure, composition and life stages as feasible, given limited resources. At each plot visit, the 20 x 20m permanent plot is marked out, and sub-divided into 16 5 x 5m subplots (labelled A - P) using measuring tapes and 24 1m$^2$ understorey plots (labelled 1 - 24, Figure 1).

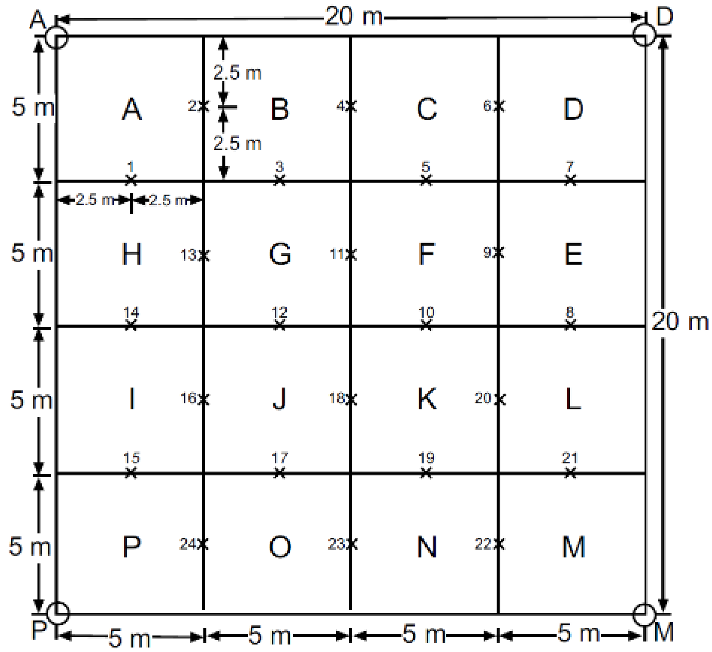



Figure 1. Permanent forest plot layout, showing subplots (A - P) and understorey plots (1 - 24).

Permanent 20 x 20 m plots are established or remeasured between October and December. Once the 20 x 20m plot is laid out, plants are measured in standardised ways as described in Table 2. Species-abundance data is collected for woody species in three size-classes: trees (>1.35m height and >2.5cm diameter at 1.35m height or DBH), saplings (>1.35m height and <2.5cm DBH) and seedlings (<1.35m height and <2.5cm DBH). The presence of all other species >15 cm tall is recorded. Birds are monitored at each plot using three 10-minute bird counts with a detection probability and a distance sampling component (Landers et al 2021). Full details of the current TBMP forest plot protocol are available on request (Environmentaldata@aklc.govt.nz). Since monitoring started in 2009, there have been several changes to the protocol. In 2016, tree tagging started at all plots according to Hurst et al (2022). Tree tagging enables monitoring of tree recruitment, growth and mortality and ensures greater accuracy in plot layout and tree diameter remeasurements. In 2025, the relevé or recce protocol was introduced to measure percent cover classes of all vascular plants in seven height tiers according to Hurst et al (2022). The relevé is used for ecosystem mapping and better captures non-woody vascular plants including pest plants.

Table 2. Data recorded at each plot visit.

| Measure | Description |
|---|---|
| Meta-data | Record plot corner coordinates, slope, aspect, physiography, drainage, % ground cover (soil, bedrock, rock, vascular and non-vascular foliage, leaf litter, bare ground), altitude, average canopy height (m), average canopy cover (%), site history, evidence of fire, logging, clearance, mining, tracks, horizon angles and soil depth. |
| Forest condition | Estimate condition scores for the plot interior and immediate surrounding forest (<20m from plot edge). Conditions measured include canopy dieback, understorey vegetation, weeds, fencing or stock access, mammalian pests and whether the plot is representative of the surrounding forest. See Appendix 2 for Forest Condition Scoring. |
| Animal signs | Animal signs observed while measuring the plot, or while accessing or leaving the plot. Animals include cattle, deer, goat, sheep, hedgehog, mustelid, pig, possum, rabbit/hare, cat, rat, mouse or other. Signs may be canopy browse, understorey browse, footprints, rooting, stem damage/rubbing, stools/pellets or sighting of an animal. If the sign is related to vegetation, the plant species is recorded. The severity of the animal impact is scored as 1. Major impact, 2. Moderate impact, 3. Minor impact, 4. Low impact, 5. No impact. |
| Tree DBH | The species and DBH or diameter at breast height (1.35m) of individual trees is measured per subplot, for tree ≥1.35m tall and ≥2.5 cm diameter. All trees meeting these criteria are tagged. This measure gives both the diameter and number of trees per subplot. Tree diameter is used to calculate tree basal area per plot. |
| Sapling count | For saplings ≥1.35m tall and <2.5cm diameter, count the number of each species per subplot. |
| Understorey count | Count the number, species and height tier of woody seedlings <1.35m tall within 24 seedling plots. Height is recorded in fixed height tiers <15cm, 15-30cm, 31-45cm, 46-75cm, 76-105cm and 106-135cm. |
| Understorey presence | Record the presence, species and height tier of non-woody plants (e.g. ferns, herbaceous, liana, grass) <1.35m tall within 24 seedling plots. Height is recorded in fixed height tiers <15cm, 15-30cm, 31-45cm, 46-75cm, 76-105cm and 106-135cm. These data were not used in this report. |
| Vicinity DBH | Record species, DBH and tag trees >60cm DBH that are outside the plot but within a 20m radius of the plot centre. These data were not used in this report. |
| Birds | Three 10 minute bird counts are conducted at the plot P-corner. During the first 5 minutes, each bird seen or heard is counted with associated distance bands, in the second five minutes only the presence of birds not recorded in the first five minutes are recorded. Bird counts are conducted between the first hour after sunrise and before 1300 hours, at least one hour apart. |

## 2.3 Measures used to infer ecological integrity

A number of measures are used to infer ecological integrity (Table 3). The extent (hectares) of indigenous forest and scrub/shrubland across Tāmaki Makaurau is compared between five LCDB timestamps 1996/97, 2001/02, 2008/09, 2012/13, 2018/19 (Landcare Research Ltd, 2020), and the provisional update for Tāmaki Makaurau to 2023.

Forest patch size, connectivity and dominant land cover were estimated from LCDB 2018 data for each forest plot within the TBMP. The LCDB 2018 was selected as a mid-point in the 15-year TBMP monitoring period. The patch size (ha) of the habitat in which a plot is located was based on the total area of continuous indigenous vegetation represented by classified polygons. Of the 29 land cover classes found in Auckland, nine classes were used to define habitat patches (broadleaved indigenous hardwoods, fenland, flaxland, herbaceous freshwater vegetation, herbaceous saline vegetation, indigenous forest, mangrove, manuka and/or kanuka, matagouri or greyscrub). The habitat patch size was calculated by merging contiguous polygons of the specified classes and retrieving the sum area of the final polygon for each plot, in some cases multiple plots are located in the same habitat patch. The proportion of indigenous land cover within a 1000m radius of the plot centre was used as an area-based proxy for connectivity. This measure has been shown to perform better than several other measures including distance to nearest neighbour (Bender et al 2003). Finally, a categorical variable describing the dominant land cover (indigenous, exotic, rural, urban or coastal) was devised based on the dominant land cover within a 1000m radius of the plot centre (a land-use was dominant when it covered ≥0.45 of the landcover by proportion, Ruffell & Didham 2017). To classify dominant land cover, LAWA landcover classes were further combined to create Indigenous (Indigenous forest and scrub), Exotic (Exotic forest and scrub), Rural (Exotic grassland, cropping and horticulture), Urban (Urban built and artificial bare surfaces), Coastal (Sea water) land cover types. Dominant land cover type was assigned to each plot. Where multiple dominant land cover types existed in a sub-region this was described as 'Mixed'.

The TBMP forest plot data is used to calculate a number of measures at the plot level (Table 7). All vascular plants recorded in a plot are used to estimate species richness. Woody species data collected in three size-classes (trees, saplings and seedlings) are used to calculate four abundance metrics.

1. Basal area or the summed cross-sectional area of trees at 1.35m height ($m^2$ $plot^{-1}$)
2. Count of tree stems ($plot^{-1}$)
3. Count of sapling stems ($plot^{-1}$)
4. Count of seedling stems ($plot^{-1}$)

For plants, metrics were calculated for three functional groups:

1. Indigenous or native species
2. Pest plants (according to the RPMP 2020 and MacAlpine & Howell 2024)
3. Threatened, at-risk and data-deficient species (according to de Lange et al 2024 and Simpkins et al 2025).

All bird species detected during the ten-minute bird count were used to estimate bird species richness. Mean bird abundance was the average count of the three five-minute bird counts per plot.

For birds, metrics were calculated for the bird endemicity functional group composed of five levels, introduced, native non-endemic, endemic species, endemic genus and endemic family. Species endemic at a higher taxonomic rank, such as family or order, are deep endemics, species endemic at lower taxonomic ranks are recent endemics. No species endemic at the order level (e.g. kiwi or kakapo) were detected in the TBMP.

A summary of forest condition scores are presented regionally (Tier 1) and for sub-regions (Tiers 2 and 3). Scoring is based on signs seen or heard during the plot visit. Scores represent a subjective estimate of condition that is sensitive to observer bias from different field teams but may provide a general picture of forest health.

Table 3. Measures used to infer ecological integrity of forests in Tāmaki Makaurau.

| Measure | Description | Data |
|---|---|---|
| Forest extent (ha) | Extent of indigenous forest and scrub/shrubland between 1996 and 2023. | LCDB 1996, LCDB 2018, LCDB provisional 2023 |
| Patch size (ha) | The continuous area (ha) of indigenous land cover in which a plot was located. | LCDB 2018 |
| Connectivity | Percentage of indigenous land cover within a 1000m radius of plot centre. | |
| Dominant landcover | Dominant landcover (>45%) type within a 1000m radius buffer centred on each plot. Dominant landcover types and the constituent LAWA medium landcover classes were: Indigenous (Indigenous forest, Indigenous scrub/shrubland), Exotic (Exotic forest, Exotic scrub/shrubland), Rural (Exotic grassland, Cropping/horticulture), Urban (Urban area, artificial bare surfaces), Coastal (Sea water). | |
| Plant species richness | Number of species of Native trees, Threatened, At-risk and data-deficient trees and Pest trees | TMBP forest plot network 2009 - 2024 |
| Canopy height m | Average top height of vegetation in the top forest tier | |
| Canopy cover % | Average canopy cover above 1.35m | |
| Basal area m$^2$ plot$^{-1}$ | Calculated for Native trees, Threatened, At-risk and data-deficient trees and Pest trees | |
| Tree count plot$^{-1}$ | | |
| Sapling count plot$^{-1}$ | | |
| Seedling count plot$^{-1}$ | | |
| Bird species richness | Bird endemicity | |
| Bird abundance | Bird endemicity | |

## 2.4 Terrestrial Biodiversity Monitoring Programme (TBMP) data

There were large variations in sampling effort i.e. the number of unique plots and the number of plot visits, between sub-regions and rotations which make comparisons between sub-regions and rotations (timestamps) complicated. Sub-regions with fewer than five plots were omitted from further analyses, including Waiheke, Motuihe and Awhitu.

To make most use of the available information, data from Rotation 3 and Rotation 4 were used to describe the current state for the Regional (Tier 1) sample and seven sub-regions in Tier 2 and Tier 3 for which there was sufficient data, Te Wao Nui ā Tiriwa / Waitākere Ranges, Te Ngāherehere o Kohukohunui / Hūnua Ranges, Te Korowai-o-te-Tonga / South Kaipara Peninsula and Urban in Tier 2, Shakespear Open Sanctuary, Ark in the Park, the Kōkākō Management Area and Ōtata Island in Tier 3 (Table 4). Data from Rotation 1 and Rotation 2 were used to describe the current state for eight sub-regions in Tier 2, and Tāwharanui, Tamahunga, Kotuku Peninsula, Windy Hill, Te Hauturu-o-Toi, Rangitoto island and Motutapu Island in Tier3. Forest described using data from Rotations 1 and 2 may have changed considerably in the intervening years, especially for regenerating forest, and these ‘states' must be treated as indicative of the time at which they were monitored only.

Changes over time were examined by rotation for Regional Tier 1 plots and all sub-regions with at least three rotations (timestamps), including Te Wao Nui ā Tiriwa / Waitākere Ranges, Te Ngāherehere o Kohukohunui / Hūnua Ranges, Urban, Ark in the Park, Kōkākō Management Area, Shakespear, Tāwharanui and Tapora.

Formal hypothesis testing to compare sub-regions was not used for several reasons. Firstly, sampling effort across the forest plot network is unbalanced, geographic resolution is variable, sub-regions are often nested, and plots have been remeasured inconsistently, mostly due to budget constraints and variable intentions around the purpose of the TBMP. Secondly, because the magnitude of differences that occur across the region and sub-regions precludes any single hypothesis. For example, areas are sampled from different parts of the region and with different geographical extents, from forests that vary in their history of logging or disturbance, past and present management, soil and ecosystem type, local climate, age, proximity to indigenous forest, exposure to invasive species, surrounding land cover, etc. All these variables will contribute to current ecological integrity in ways that may be confounding or hard to unpick (Lee et al 2005). When examining patterns amongst sub-regions, there were insufficient degrees of freedom to formally account for variation in sampling, climate, soils or ecosystem types.

Data manipulation and graphs were performed using R software version 4.3.3 including tidyverse and ggplot2 packages, and Python 3.13 including Pandas, Scikit-Bio, Matplotlib and Seaborn.

Table 4. Plot data from each timestamp or rotation used to describe the current state in forest ecological integrity regionally (Tier 1) and in the sub-regions (Tiers 1 and 2).

| Tier | SubRegion | R1 | R2 | R3 | R4 | Unique plots | State timeframe | State |
|---|---|---|---|---|---|---|---|---|
| 1 | Regional | 124 | 53 | 103 | 12 | 134 | 2019 - 2024 | R34 |
| 2 | Te Wao Nui ā Tiriwa / Waitākere Ranges | 20 | 24 | 21 | 7 | 24 | 2019 - 2024 | |
| 2 | Te Ngāherehere o Kohukohunui / Hūnua Ranges | 12 | 2 | 9 | 3 | 12 | 2019 - 2024 | |
| 2 | Urban | 19 | 4 | 20 | 4 | 20 | 2019 - 2024 | |
| 2 | Te Korowai-o-te-Tonga / South Kaipara Peninsula | 6 | 0 | 0 | 4 | 6 | 2019 - 2024 | |
| 2 | Tapora | 9 | 2 | 5 | 0 | 11 | 2019 - 2024 | |
| 3 | Ark in the Park | 19 | 4 | 4 | 16 | 19 | 2019 - 2024 | |
| 3 | Kōkako Management Area | 26 | 4 | 20 | 6 | 26 | 2019 - 2024 | |
| 3 | Shakespear | 20 | 20 | 8 | 12 | 20 | 2019 - 2024 | |
| 3 | Ōtata Island | 0 | 0 | 6 | 0 | 6 | 2019 - 2024 | |
| 2 | Aotea | 6 | 13 | 0 | 0 | 21 | 2009 - 2018 | R12 |
| 3 | Tāwharanui | 20 | 20 | 4 | 0 | 20 | 2009 - 2018 | |
| 3 | Tamahunga | 0 | 14 | 0 | 0 | 14 | 2009 - 2018 | |
| 3 | Kotuku Peninsula | 10 | 6 | 0 | 0 | 16 | 2009 - 2018 | |
| 3 | WindyHill | 6 | 9 | 0 | 0 | 15 | 2009 - 2018 | |
| 3 | Te Hauturu-o-Toi | 20 | 4 | 0 | 0 | 20 | 2009 - 2018 | |
| 3 | Rangitoto Island | 5 | 0 | 0 | 0 | 5 | 2009 - 2018 | |
| 3 | Motutapu Island | 5 | 0 | 0 | 0 | 5 | 2009 - 2018 | |

## 2.5 Data caveats

The TBMP forest plot network is designed to monitor broad patterns or trends in forest regionally and sub-regionally. It is not designed to monitor changes in uncommon species, highly localised species or species with a clustered distribution pattern. For example, many common pest plants are shade intolerant and tend to be concentrated on forest edges or tracks and are less likely to be detected in forest plots. Forest plots will capture pest plants in the forest interior.

The forest plot network requires that sufficient plots are monitored to give a representative snapshot of forest ecology. Sub-regions with fewer than five plots were omitted from further analysis in this report but for larger or highly heterogenous areas, five plots will still be insufficient. Analysis has been contracted from Manaaki Whenua Landcare Research to quantify the sensitivity of the TBMP to detect changes based on a five-year and ten-year rotation.

It is important to note that the ten-minute bird counts record a sample of birds at a location on a particular day and do not provide a complete inventory of bird species at a location.

# 3 Results and Discussion

## 3.1 Forest extent

This section describes analysis of land cover data across multiple LCDB timestamps, using the LAWA medium cover classes with a special focus on the dynamics of indigenous forest and indigenous scrub/shrubland within Tāmaki Makaurau from 1996 to 2023. Land cover includes mainland Tāmaki Makaurau and Tīkapa Moana / Hauraki Gulf Islands.

### 3.1.1 Patterns in land cover

The most recent measure of land cover data, derived from the provisional Auckland LCDB update for 2023 (Auckland Council, 2025), reveals that indigenous forest and indigenous scrub/shrubland together now account for 27% of land cover in Tāmaki Makaurau, up from 26% in 2018 (LCDBv5, Table 5). Indigenous forest covers 16% (81,161 ha) and indigenous scrub/shrubland accounts for 11% (57,999 ha). These native woody vegetation classes are distributed across both upland and lowland areas, frequently occurring in fragmented patches. Although these classes represent native vegetation, many areas have been modified, with indigenous forest including mature and secondary growth, and scrub/shrubland largely consisting of early successional vegetation regenerating on previously cleared or disturbed land.

Exotic grassland is the dominant land cover class in Tāmaki Makaurau, occupying 43% (220,907 ha) of the region. This class is particularly widespread in lowland and hill country areas, reflecting the extensive historical modification of the landscape for pastoral agriculture. Urban areas account for 12% (61,742 ha) of Tāmaki Makaurau, typically concentrated around the urban core, major settlements and transport corridors. These developed areas frequently overlap with locations that historically supported rich lowland forest ecosystems. Exotic forest plantations cover 9.8% (50,317 ha), including both actively planted and harvested areas, and generally occur in consolidated blocks across a range of elevations. Other land cover classes, including cropping and horticulture (2.6%), inland and coastal water bodies (2.8%), and natural bare or lightly vegetated surfaces (combined 2.1%), along with smaller areas of exotic scrub/shrubland, other herbaceous vegetation, and artificial bare surfaces, collectively contribute to the region's complex land cover mosaic and exhibit varied spatial distributions and extents.

Table 5. Area (ha and %) of provisional 2023 LAWA Medium land cover classes in Tāmaki Makaurau.

| LAWA Medium Land Cover Classes | Area (ha) | % of total |
|---|---|---|
| Exotic grassland | 220,907 | 43% |
| Indigenous forest | 81,161 | 16% |
| Urban area | 61,742 | 12% |
| Indigenous scrub/shrubland | 57,999 | 11% |
| Exotic forest | 50,317 | 10% |
| Water bodies | 14,260 | 3% |
| Cropping/horticulture | 13,143 | 3% |
| Natural bare/lightly-vegetated surfaces | 4,283 | 0.8% |
| Other herbaceous vegetation | 3,889 | 0.8% |
| Exotic scrub/shrubland | 3,403 | 0.7% |
| Artificial bare surfaces | 2,353 | 0.5% |
| Total | 513,458 | 100% |

### 3.1.2 Temporal trends in indigenous vegetation cover

While the extent of indigenous forest and scrub/shrubland cover was relatively stable between 1996 and 2018, a notable increase became apparent between 2018 and 2023. Table 6 provides a detailed summary of gains, losses, and net change in hectares for indigenous forest and indigenous scrub/shrubland across five distinct periods: 1996-2001, 2001-2008, 2008-2012, 2012-2018, and 2018-2023.

Indigenous forest showed fluctuating gains and losses throughout the 27-year period, with modest gains of 180 ha in 1996-2001, peaking in the most recent period at 1,214 ha between 2018 and 2023. Losses declined from 326 ha (1996-2001) to 54 ha (2008-2012), then rose slightly to 193 ha in the most recent period (2018-2023). Crucially, indigenous forest consistently demonstrated a positive net change across most periods, indicating overall expansion, with the largest net gain of 1,021 ha occurring in the most recent 2018-2023 period suggesting accelerated processes contributing to indigenous forest expansion.

Indigenous scrub/shrubland consistently gained area throughout all periods, culminating in a substantial increase of 4,688 ha in the latest 2018-2023 period. Losses remained comparatively low relative to gains, fluctuating from 69 ha (2008-2012) to 246 ha (2001-2008). Because of these dynamics, indigenous scrub/shrubland consistently exhibited a positive net change across the entire time series, culminating in a net gain of 4,534 ha from 2018 to 2023. This sustained and accelerating net gain demonstrates expansion of early successional native vegetation in the region.

Table 6. Area (ha) of indigenous forest and scrub/shrubland gained and lost across each LCDB change period. Gains and losses for each change period represent gross transitions during each transition and should not be summer across the timeseries as this would overstate total change due to repeated transitions. In contrast, net change can be summed across periods as they represent cumulative change from initial to final state.

| LAWA Medium Classes | | 1996 to 2001 | 2001 to 2008 | 2008 to 2012 | 2012 to 2018 | 2018 to 2023 |
|---|---|---|---|---|---|---|
| Indigenous forest | Gains | 180 | 497 | 456 | 268 | 1,214 |
| | Losses | - 326 | - 233 | - 54 | - 141 | - 193 |
| | Net Change | - 146 | 263 | 402 | 127 | 1,021 |
| Indigenous scrub/shrubland | Gains | 370 | 442 | 258 | 498 | 4,688 |
| | Losses | - 135 | - 246 | - 69 | - 161 | - 154 |
| | Net Change | 235 | 196 | 189 | 338 | 4,534 |

### 3.1.3 Cumulative change by land cover class (1996 to 2023)

Table 7 details the cumulative gains and losses (in hectares) for indigenous forest and indigenous scrub/shrubland from and to other LAWA medium land cover classes over the entire 1996-2023 period. This cross-classification analysis provides critical insight into the drivers of land cover change for native woody vegetation. Indigenous forest recorded cumulative gains of 2,473 ha and lost 806 ha, resulting in a net gain of 1,667 ha. Most gains for indigenous forest originated from exotic grassland (1,839 ha) and exotic forest (439 ha), indicating conversion and replanting of pastoral land and exotic plantations. Losses from indigenous forest were primarily to urban area (187 ha) and artificial bare surfaces (107 ha), indicating direct impacts from urbanisation and infrastructure development. Exotic forest also accounted for 240 ha of losses, suggesting conversion of native forest to exotic forestry.

Indigenous scrub/shrubland gained 6,123 ha and lost 633 ha, yielding a net gain of 5,490 ha. Gains were predominantly from exotic grassland (4,680 ha), and exotic forest (697 ha). Mangrove expansion contributed to gains from water bodies reflecting gradual growth overtime. Losses from indigenous scrub/shrubland were mainly to artificial bare surfaces (50 ha), urban area (40 ha), natural bare/lightly-vegetated surfaces (29 ha), and indigenous forest (39 ha).

### 3.1.4 Ownership pattern of indigenous forest and scrub/shrubland gains

Ownership patterns of the 5,902 ha of indigenous forest and scrub/shrubland gained between 2018 and 2023 are shown in Table 8. Gain-polygons were spatially intersected (centroid-based) with a composite public land layer comprising Auckland Council Parks Extents (Auckland Council, 2025c), Department of Conservation (DOC) Estate (Department of Conservation, 2025), and other publicly owned land (including education, transport, and community facilities, Auckland Council, 2025d). All remaining areas were classified as ‘private’ by default.

Approximately 84% of indigenous forest and scrub/shrubland gains occurred on private land, with the 10 largest patches accounting for 7% of the total gain. These were often associated with rural subdivisions and lifestyle development, with aerial imagery showing increased buildings and

Table 7. Area (ha) of indigenous forest and scrub lost and gained between LAWA Medium Land Cover Classes between 1996 and 2023

| LAWA Medium Land Cover Classes | Gains and losses (ha) between 1996 and 2023 | | | |
|---|---|---|---|---|
| | Indigenous forest | | Indigenous scrub/shrubland | |
| | Gains | Losses | Gains | Losses |
| Artificial bare surfaces | | 107 | 5 | 50 |
| Cropping/horticulture | 27 | 8 | 16 | 8 |
| Exotic Forest | 439 | 240 | 697 | 128 |
| Exotic grassland | 1,839 | 197 | 4,680 | 210 |
| Exotic scrub/shrubland | 46 | 10 | 99 | 15 |
| Indigenous forest | | | 29 | 39 |
| Indigenous scrub/shrubland | 39 | 29 | | |
| Natural bare/lightly-vegetated su | 2 | 26 | 7 | 29 |
| Other herbaceous vegetation | 2 | 1 | 46 | 60 |
| Urban area | 42 | 187 | 2 | 40 |
| Water bodies | 37 | 2 | 542 | 55 |
| Total | 2,473 | - 806 | 6,123 | - 633 |
| Net change | 1,667 | | 5,490 | |

infrastructure. Plantings often buffered existing indigenous vegetation and replaced exotic grassland and land previously under exotic plantation forestry. These observations were further corroborated through visual assessment of resource consent data and changes in Auckland Council property parcel boundaries over the same period. Examples include revegetation planting on former exotic forest land on the southern slopes of Dome Valley Forest in Rodney, on former pastoral land at Cowans Bay in Mahurangi, and riparian planting on former pastoral land in Pukekohe East (see Appendix 4 for examples).

Public land gains were concentrated in regional and local parks. Te Muri Regional Park recorded the largest increase (approximately 75 ha), followed by substantial gains at Waitawa and Ātiu Creek Regional Parks (each exceeding 40 ha). Several local parks also experienced planting activity, with Totara Park showing the most significant gain (approximately 29 ha). Smaller plantings in local parks (<1 ha) may be underrepresented due to spatial resolution limitations.

Table 8. Area (ha and %) of indigenous forest and scrub/shrubland gained between 2018 and 2023. Public land includes Parks, Regional Parks, Department of Conservation (DOC) estate, and other publicly owned land (e.g., education, transport). All remaining land is considered private by default.

| Ownership Class | Indigenous forest and indigenous scrub/shrubland gains | |
|---|---|---|
| | Area (ha) | % of total |
| Public | 924 | 16% |
| Private (outside public land) | 4,979 | 84% |
| Total | 5,902 | 100% |

Analysis of changes in forest and scrub/shrubland cover reveals a complex mosaic of gains and losses, reflecting both expansion processes and the nuances of classification methodology. Gross gains in native woody vegetation cover are largely attributable to active replanting, in lowland areas, within riparian margins, and across hill country, and to lesser extent attributable to natural successional processes such as encroachment and regeneration on marginal farmland. As demonstrated by the examples of gains associated with private and public land, these changes are often associated with broad land use transitions, such as the planting coinciding with conversion of pastoral agriculture and exotic forestry to lifestyle blocks (created through rural subdivisions), indigenous planting associated with large urban greenfield developments or the implementation of conservation management planting within parks. Vegetation gains on farms have also been identified in areas where indigenous species are gradually expanding into exotic grassland. Although these changes typically occur slowly across multiple time periods, they have met the threshold for inclusion in this update (e.g. property at Kawakawa Bay Coast Road, Clevedon).

In contrast, losses in native forest and scrub/shrubland cover are more nuanced in their interpretation. Some losses represent direct land cover conversions, such as the clear-felling of vegetation for urban expansion or large-scale infrastructure development (e.g., Mahurangi Penlink, a new transport connection between the Whangaparāoa Peninsula and SH1 at Redvale). Forest and scrub/shrubland losses were also observed on farms in areas where indigenous scrub/shrubland is encroaching into exotic grassland. One example (Bays Road, Orere Point) appears to coincide with efforts to maintain pasture extent, potentially through vegetation control measures such as spraying, although the exact cause cannot be confirmed from the available data (e.g., at Orere Point, Te Ngāherehere o Kohukohunui / Hūnua Ranges). These direct conversions are relatively straightforward to interpret as clear impacts.

Many apparent losses in forest and scrub/shrubland however, are the result of more subtle shifts in the dominant land cover classification within heterogeneous mosaics. For example, a patch of land previously dominated by indigenous forest may now be classified as urban due to incremental infill development that crossed a classification threshold, even if the underlying forest vegetation had not substantially changed (observed near Glenbrook Reserve on Waiheke Island). Other changes reflect gradual, cumulative disturbances, such as piecemeal vegetation clearance or progressive urban encroachment, that, over time, accumulate to cross a classification threshold.

Typical of spatial change analysis using multi-temporal remotely sensed maps, it is important to acknowledge that a small number of observed changes may stem from actual changes associated with previous misclassifications or apparent change resulting from the correction of historical mapping errors. For instance, areas formerly mapped as indigenous scrub/shrubland that should have been mapped as exotic scrub/shrubland, particularly when associated with an actual change to grassland, may misleadingly appear as a loss of indigenous cover. These findings collectively underscore the critical importance of interpreting land cover change data within the broader context of classification methodology, inherent landscape dynamics, and historical land use patterns to accurately understand forest representation.

### 3.1.5 Ecological quality and restoration limitations

The statistics presented here reflect changes in the spatial extent of indigenous forest and scrub/shrubland cover, but do not account for ecological integrity or biodiversity value. While increases in native vegetation cover are encouraging, they may not always equate to ecological restoration success. Large-scale planting programmes, particularly on private land, may rely on low-diversity species mixes, limited maintenance, and variable planting success. These factors can lead to canopy gaps, pest plant invasion, and reduced ecological function. Such plantings will fall short of supporting diverse and self-sustaining indigenous ecosystems. Norton et al. (2018) emphasise that successful restoration in Aotearoa New Zealand depends on careful planning, eco-sourcing of native species, and ongoing monitoring. Their work highlights that low-diversity plantings, while visually effective in increasing cover, may not deliver meaningful biodiversity outcomes or ecosystem services. Field-based ecological monitoring of revegetated areas would provide an understanding of their ecological and biodiversity value and help guide planting design on public and private land, resource consents or plan changes to the Auckland Unitary Plan to support genuine ecological restoration.

## 3.2 Dominant land cover, patch-size and connectivity

LCDB (2018) data is used to describe the dominant land cover, patch size and connectivity (proportion of indigenous land cover within a 1000m radius) at the location where a TBMP forest plot is located (Figure 2). Dominant land cover, patch size and connectivity were all highly correlated. Patch size increased with connectivity, and both were highest in areas dominated by indigenous forest/scrub. In the Regional Tier 1 sample, the dominant land covers were mixed and reflected the distribution of landcovers regionally, with a mixture of rural, indigenous forest/scrub, urban, exotic forest/scrub and coastal covers (in decreasing order). On average, patch size and connectivity were intermediate for the regional Tier 1 sample.

Sub-region plots were located in a single continuous forest patch for Aotea, Te Wao Nui ā Tiriwa / Waitākere Ranges, Te Ngāherehere o Kohukohunui / Hūnua Ranges, Ark in the Park, Kōkako Management Area, Tamahunga Ecological Area, Rangitoto, Kotuku Peninsula, Windy Hill and Te Hauturu-o-Toi. Of these continuous extents of forest, Rangitoto, Te Hauturu-o-Toi and Tamahanga Ecological Area were smaller. The Kotuku Peninsula was the only one of these sub-regions with lower connectivity to indigenous land cover.

Forest patches for Urban plots were all small and poorly connected, with a low proportion of indigenous land cover nearby. Sub-regions in predominately rural areas were Te Korowai-o-Te-Tonga, Tapora and Motutapu island. Forest cover in Te Korowai-o-te-Tonga is largely dominated by exotic pine plantation. Indigenous forest patch size in these sub-regions was small and the forest was poorly connected to other indigenous land cover. Shakespear and Tāwharanui forest plots were located in a mixture of Rural, Indigenous and Coastal dominant land covers, with low patch size and connectivity. Ōtata was strongly influenced by its island location. There were no sub-regions predominately surrounded by exotic forest/scrub land cover.

Previous analyses of the TBMP forest plot data showed landscape structure had a significant impact on indigenous plant and bird communities. More indigenous plant species occurred in larger and more connected forest patches, regardless of the surrounding landcover, while native bird communities were most species-rich in forest surrounded by indigenous dominated land cover (Griffiths et al 2021). The optimal distribution of forest cover in highly modified landscapes is complicated, but recommendations include maintaining a few large areas of continuous forest cover (approximately 25%), necessary for more specialist species, and many smaller forest patches covering a wider range of environmental contexts (Arroyo-Rodriguez et al 2020).

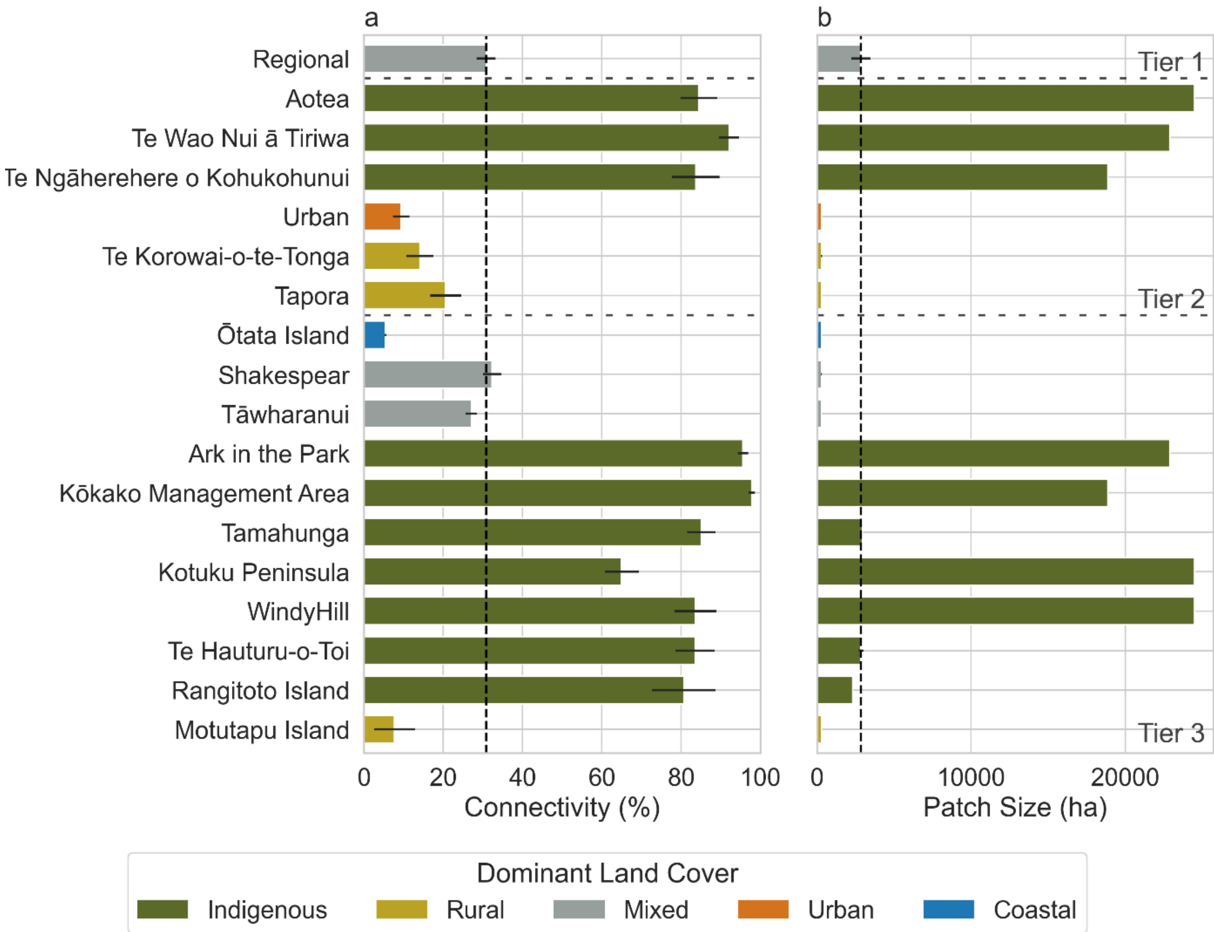



Figure 2. Dominant land cover (shading) (a) connectivity (%, mean ± s.e) and (b) patch size (ha, mean ± s.e.) for the most recent Regional Tier 1 sample and each sub-region using LCDB (2018) data.

## 3.3 Canopy height and cover

Mean canopy height and canopy cover are summarised from the most recent set of plot measures (either Rotation3 and 4, R34 or Rotation1 and 2, R12) for each sub-region (Figure 3). For sub-regions where the most recent measure was in R12, especially for those with pioneer, regenerating or early successional forest types, there could have been large changes in the intervening years.

In the Regional Tier 1 sample, mean canopy height was 13.7 m (±0.6) but ranged between 0 and 35m, and mean canopy cover was 68.2% (±1.6) but ranged between 10% and 100%. Mean canopy height was highest at Ark in the Park at 16.7 m (±2.0) and the Kōkako Management Area at 15m (±0.9) where mature forest ecosystems are dominant and some remnants of unlogged forest remain.

Mean canopy height was low at Shakespear Regional Park (5.7 ± 0.6m), reflecting the early successional stage of the Mānuka, kānuka scrub that dominates the forest. Canopy height (3.6 ± 0.9m) and canopy cover (14.4 ± 1.7%) were lowest on Rangitoto Island, reflecting the Pōhutukawa scrub/forest that grows on the incipient soils. Canopy cover was generally low in sub-regions dominated by regenerating forest types Kānuka scrub/forest (VS2) and Mānuka, kanuka scrub (VS3) such as Shakespear, Aotea, Kotuku Peninsula, Windy Hill and Tapora. The canopy cover at Te Korowai-o-Te-Tonga Peninsula was exceptionally low (37.5 ± 8.5 %), especially given the canopy height (12.5 ± 2.5m), and may be cause for concern.

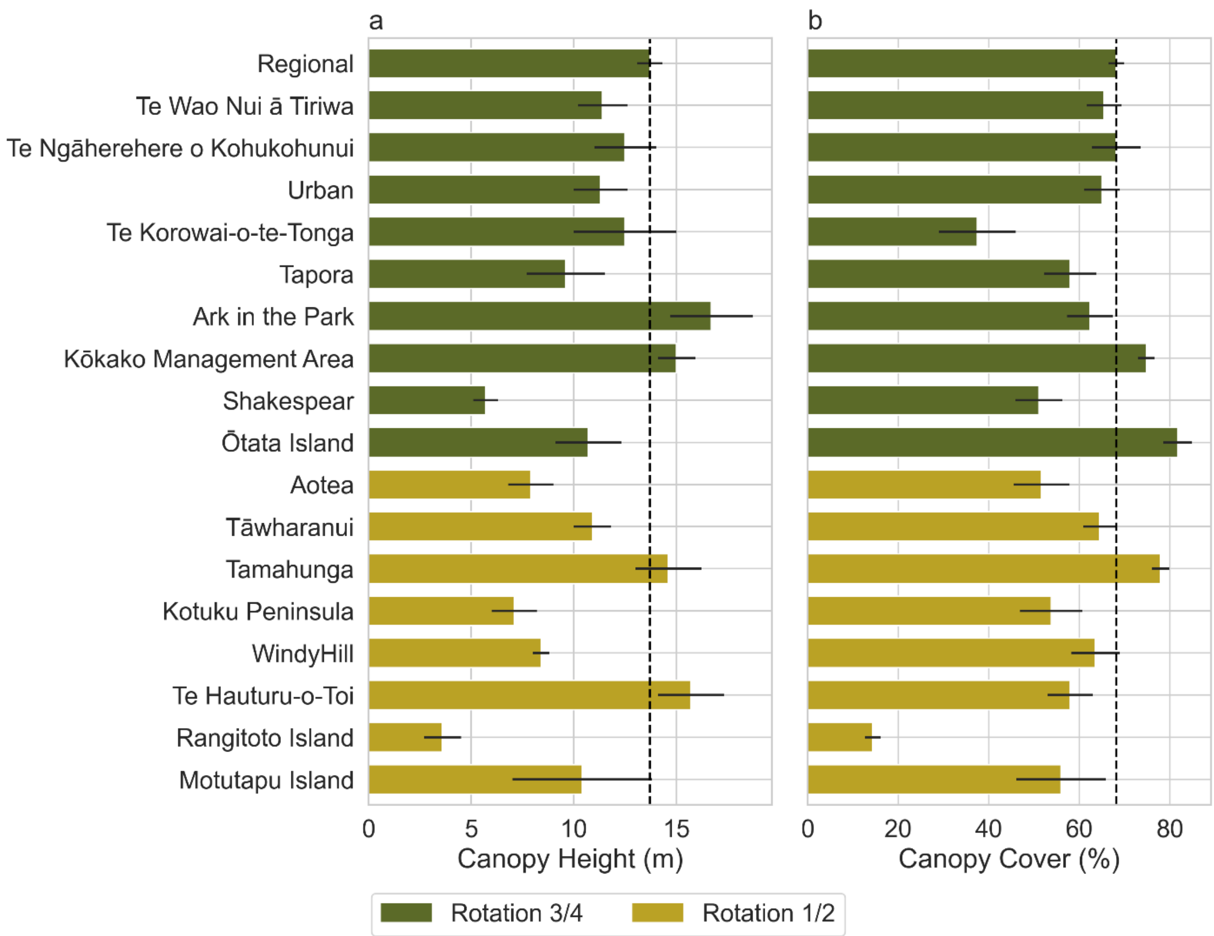



Figure 3. (a) Canopy height (m, mean ± s.e) and (b) canopy cover (%, mean ± s.e.) for the most recent Regional Tier 1 sample and each sub-region. The most recent plot measures were either from Rotations 3/4 (2019 – 2024) or Rotations 1/2 (2009 – 2018).

## 3.4 Forest condition

Forest condition scores were summarised from the most recent plot measures. For the Regional Tier 1 sample and nine sub-regions this was Rotation3 and Rotation4, for eight sub-regions this was Rotation1 and Rotation2. Only five conditions are shown which showed most variation across sub-regions (Figures 4 and 5).

The Regional Tier 1 sample showed a low to moderate impact of pest animals (e.g. ungulate, goat, peer, possum, pig, rat, mouse, mustelid, hedgehog, rabbit, hare) during plot visits (Animal pest score of 3.8 ± 0.1). Stock access was generally restricted (4.5 ± 0.1) even though fencing was 'mostly incomplete' (2.4 ± 0.2. i.e. stock were absent from most sites). On average the canopy interior score (3.9 ± 0.1) indicated the foliage was sparse in some areas, with canopy gaps and dead crowns covering 5 – 25%. The average understorey interior (3.4 ± 0.1) was indicative of moderate seedling and sapling regeneration (25 – 50% cover of the site) regionally.

Te Korowai-o-Te-Tonga showed some of the lowest forest condition scores. The mean score for Animal pests was 2.0 ± 0.4 indicating moderate to major pest impacts. Te Korowai-o-Te-Tonga Peninsula plots showed considerable canopy interior dieback with sparse foliage, canopy gaps and dead crowns covering 25 – 50% of the site. In the understorey interior there was only scattered seedling and sapling regeneration covering 5 – 25% of the site. The canopy and understorey edge scores were very similar. Plot data also showed a species poor and sparse sub-canopy and understorey layer. Multiple deer signs were recorded at five of six plots measured on Te Korowai-o-te-Tonga in rotation 1 and 2, and in three of the four plots measured in rotations 3 and 4. Signs included deer footprints, pellets and understorey browse, including on the regionally threatened *Coprosma crassifolia* which is strongly associated with sandy, coastal areas. Signs for feral pig, rabbit/hare, sheep and cattle were also observed at forest plots on Te Korowai-o-te-Tonga. Forest plots in Te Korowai-o-te-Tonga did vary in their condition scores and further monitoring would be required to understand which forest patches were most vulnerable.

Forest patches on Te Korowai-o-Te-Tonga Peninsula with poor forest condition scores appear to be severely impacted by deer browse, with very little regeneration possible. The vast majority of basal area at these plots is contributed by rawirinui (*Kunzea robusta*) and rawiritoa (*K. amathicola*), a regionally and nationally threatened plant species. Given the average canopy height (12.5m) and cover (37.5%) for these plots, and static or decreasing basal area for both kānuka species between plot remeasures, the evidence suggests these forests are starting to senesce. In the absence of regeneration, these forests are at risk of canopy collapse. Further ecological assessments or establishment of forest plots at additional forested areas across Te Korowai-o-te-Tonga will help to understand how widespread the risk of canopy collapse is, but pest mammal exclusion or suppression, especially of deer, may be necessary to enable forest regeneration.

Forest condition scores for the Kōkako Management Area indicate ongoing pest animal (3.6 ± 0.2) and herbivore pressure on understorey regeneration (2.7 ± 0.2) despite intensive pest suppression operations in this area to support kōkako breeding. Mammalian pest animal signs observed at these plots were canopy browse by possum, rooting by pigs, understorey browse by rabbit/hare and rat stools. This was different from previous plot measures in Rotations 1 and 2 when goat, deer and cattle understorey browse, canopy browse, footprints and pellets were also commonly observed.

No condition data were collected for Rangitoto and Motutapu.

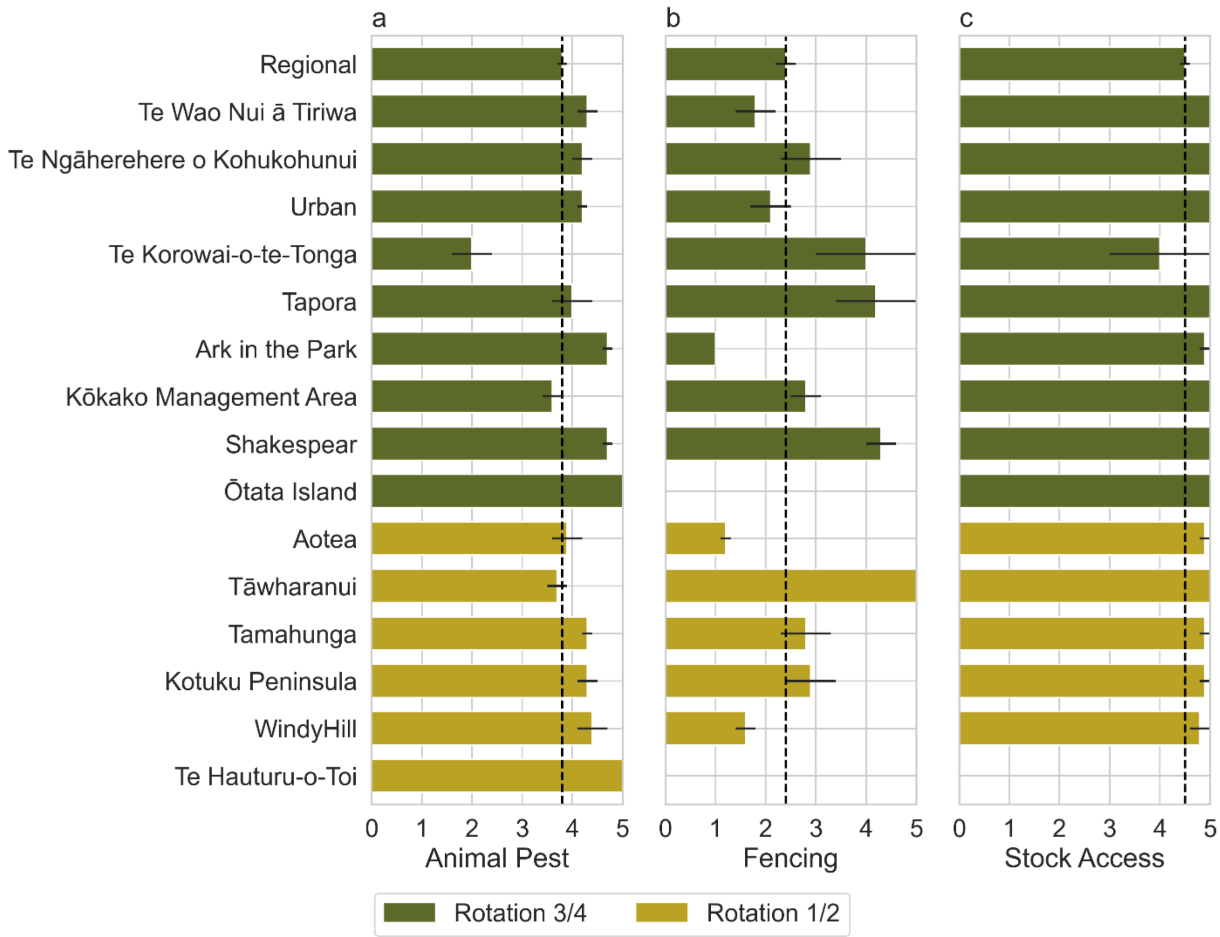



Figure 4. Forest condition scores (mean ± s.e.) for the most recent Regional Tier 1 sample and each sub-region for (a) Animal Pest, (b) Fencing and (c) Stock Access. The most recent plot measures were either from Rotations 3/4 (2019 – 2024) or Rotations 1/2 (2009 – 2018).

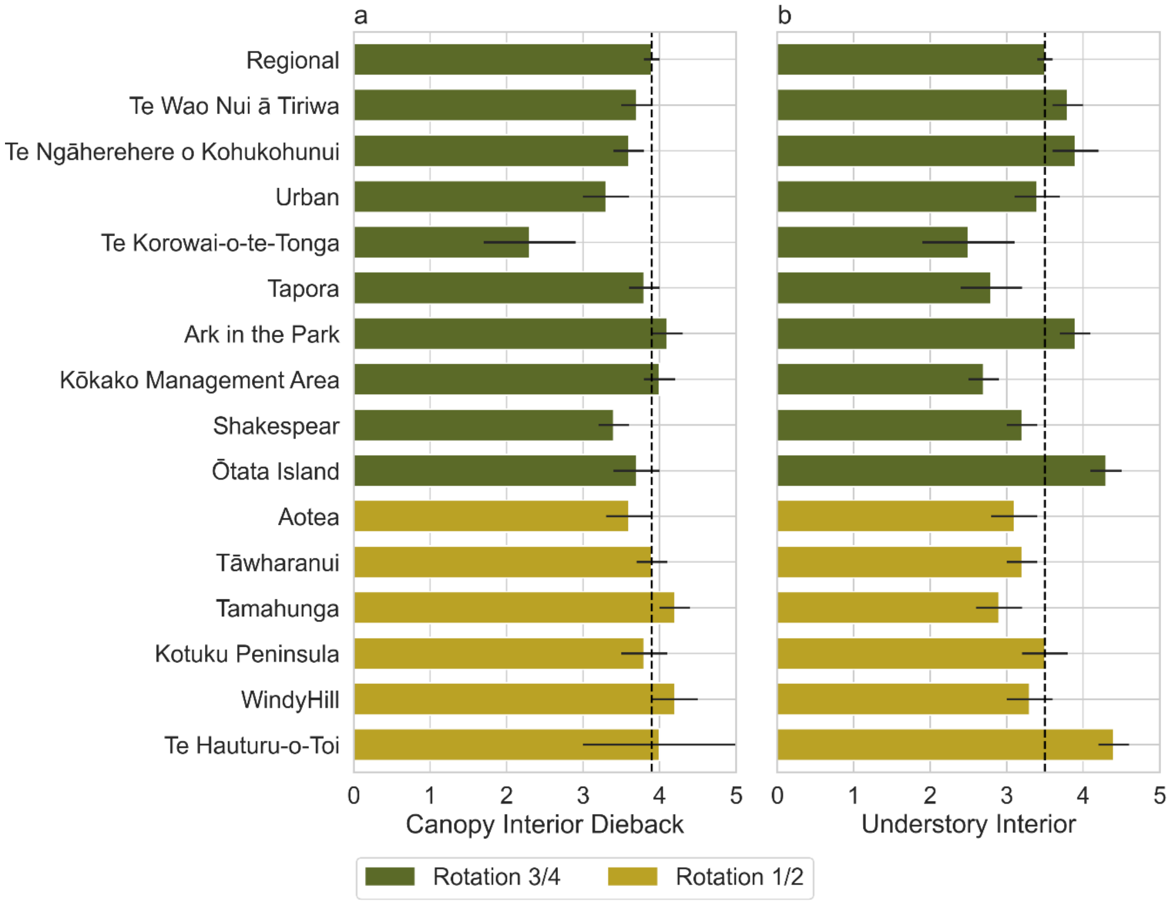



Figure 4. Forest condition scores (mean ± s.e.) for the most recent Regional Tier 1 sample and each sub-region for (a) Canopy Interior Dieback and (b) Understorey Interior. The most recent plot measures were either from Rotations 3/4 (2019 – 2024) or Rotations 1/2 (2009 – 2018).

## 3.5 Plant species richness

Across the Regional Tier 1 forest samples there were 32.7 (± 1.1) native or indigenous species per plot on average (Figure 5a). Indigenous plant species richness was highest in Te Wao Nui ā Tiriwa / Waitākere Ranges, Te Ngāherehere o Kohukohunui / Hūnua Ranges, the mainland islands contained within them, Ark in the Park and the Kōkako Management Area, and Tamahunga Ecological Area.

Urban forest plots and those on Te Korowai-o-Te-Tonga Peninsula had the lowest species richness of any mainland sub-region. Urban forests are small and isolated in the landscape, so there is less opportunity for indigenous species to recolonise when they go locally extinct. Indigenous forest at Te Korowai-o-Te-Tonga Peninsula occurs as small, isolated patches, surrounded by pine plantation or exotic grassland. Some of it is clearly under severe pressure from browsing deer, to the extent that there is little or no woody sapling regeneration (see Figure 4 and 5).

Many island forests (e.g. Ōtata, Aotea, Kotuku Peninsula, Windy Hill, Rangitoto, Motutapu and even Te Hauturu-o-Toi) had lower indigenous plant species richness than many of the mainland sub-regions. All of these islands have large areas of secondary forest recovering from past clearance, fire or other disturbance. For example, on Ōtata a forest fire cleared much of the mature pōhutukawa dominated Coastal broadleaf forest (WF4) on the eastern side of the island where several plots are located, that is now in regenerating scrub dominated by young stands of houpara (*Pseudopanax lessonii*), red mapou (*Mysrine australis*) and karo (*Pittosporum crassifolium*). All predominately bird-dispersed species. At Kotuku Peninsula, there was very little forest cover in the 1960s apart from small remnants in the gullies and on the southern slopes, where only a small number of plots are located. For smaller islands or those more distant from the mainland, there may be fewer propagules for recolonisation when species go locally extinct.

An average of 3.2 (± 0.2) threatened, at-risk and data-deficient species were recorded in plots Regionally (Figure 2c). Te Wao Nui ā Tiriwa / Waitākere Ranges, Ark in the Park, Tamahunga Ecological Area and Te Hauturu-o-Toi are clearly refuges for these vulnerable species. A list of threatened, at-risk and data-deficient species found in the most recent measure of plots Regionally and in the sub-regions can be found in Appendix 6.

Regionally, there were 3.3 (± 0.4) pest plant species per plot, but pest plants were most species rich by far in Urban forest plots where they averaged 8.9 (± 1.3) weeds per plot (Figure 2c). No pest plant species were recorded in plots on Te Hauturu-o-Toi or at the Tamahunga Ecological Area, although both forests are known to contain pest plants.

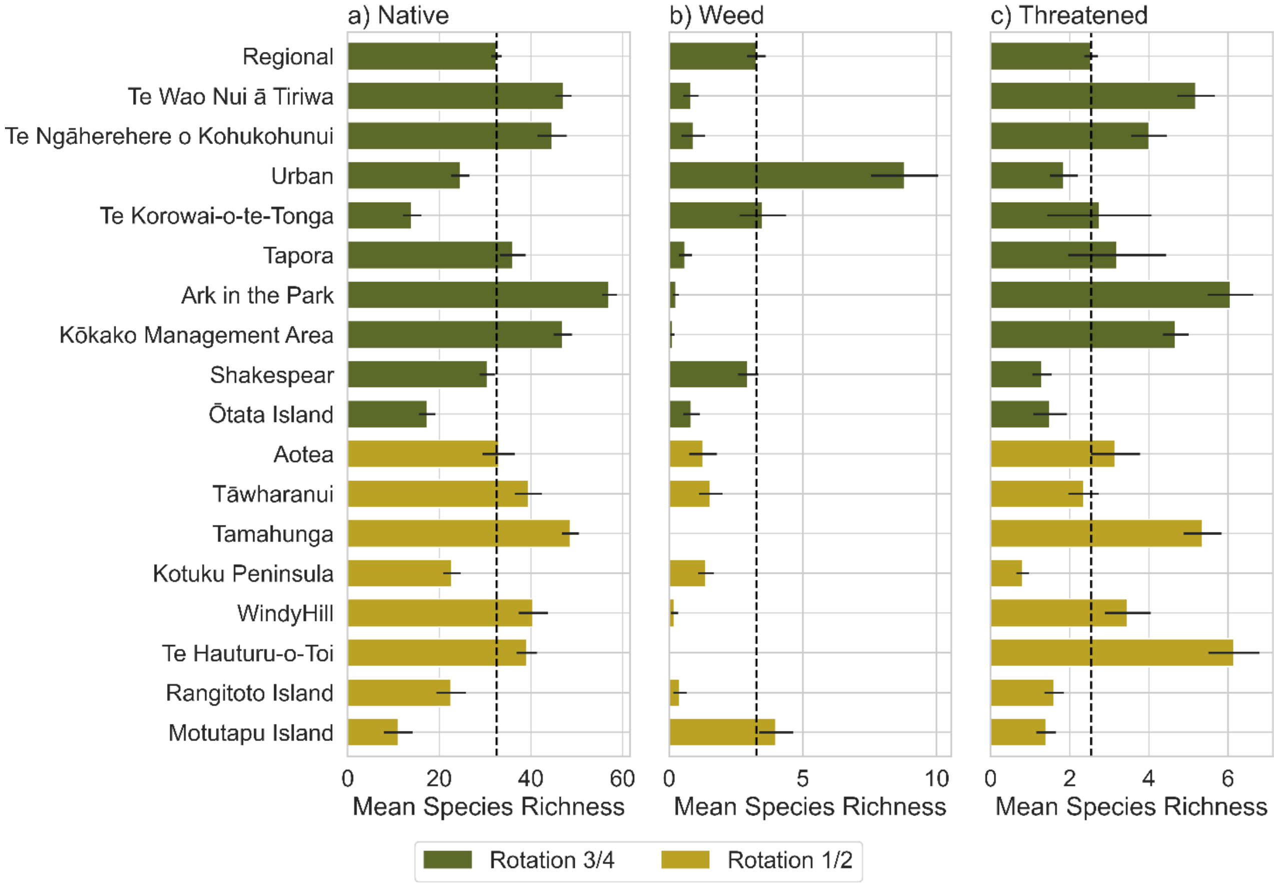



Figure 5. Species richness (mean ± s.e.) of (a) Indigenous plants, (b) Pest plants, and (c) Threatened, At-risk and Data-deficient plants for the most recent Regional Tier 1 sample and each sub-region. The most recent plot measures were either from Rotations 3/4 (2019 – 2024) or Rotations 1/2 (2009 – 2018).

Increases in indigenous species richness over the 15-year monitoring period were observed for Shakespear (20.3 ± 1.5 in rotation1 to 33.1 ± 1.6 in rotation3) and Ark in the Park (48.5 ± 2.7 in rotation1 to 59.2 ± 2.1 in rotation 3. It would be valuable to unpick the mechanisms driving these patterns. Natural regeneration processes could lead to new plant species colonising as the regenerating forest attracts seed-dispersing birds, especially in Shakespear where bird translocations have resulted in a greater diversity of indigenous bird fauna. In addition, more effective control of both pest plants and mammalian pest animals, such as possum in Ark in the Park, could permit further plant species to recolonise or spread.

Threatened, at-risk and data-deficient species showed no trends, showing neither systemic nor sub-region-specific changes in species richness across the three rotations. Pest plant species increased in Urban forest (5.3 ± 1.1 to 8.3 ± 1.3) and at Shakespear Regional Park (1.3 ± 0.2 to 3.3 ± 0.5).

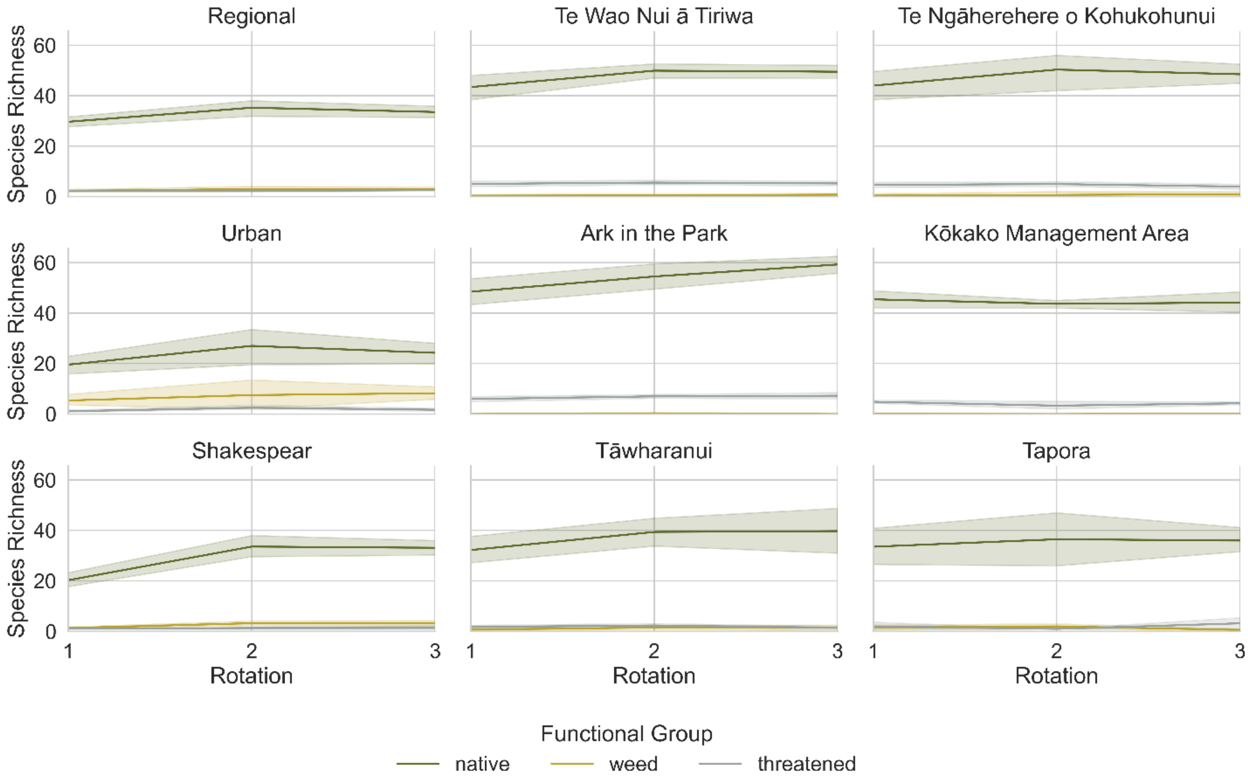



Figure 6. Trends in species richness (mean ± s.e.) of Indigenous species, Weed species, and Threatened, At-risk and Data-deficient species for Regional Tier 1 plots and eight sub-regions with plots in three or more rotations.

## 3.6 Plant abundance

Indigenous woody basal area was highest at Ark in the Park, the Kōkako Management Area and Tamahunga Ecological Area, consistent with later-successional stage, mature forest (Figure 7). This is further supported by the tall mean canopy height (Figure 3a) recorded for these sub-regions and that there are several small patches of primary forest in these locations.

Indigenous tree density was highest in areas of regenerating forest at Shakespear, Ōtata Island and Kotutu Peninsula on Aotea. This is indicative of mid-successional stage forest before competitive thinning starts to reduce tree density. It may also reflect some early revegetation practises at Shakespear where kānuka were planted too densely.

Sapling and seedling density was highest at Shakespear, Ōtata Island and Tamahunga Ecological Area and lowest at Te Korowai-o-Te-Tonga Peninsula and the Kōkako Management Area.

Higher seedling and sapling density would be expected in areas of effective pest animal control, as has been observed following goat and pig control at Tamahanga Ecological Area (Auckland Council 2025e). Higher seedling and sapling density would also be associated with early-successional forest typical of much forest at Ōtata island and Shakespear.

Low sapling and seedling density at Te Korowai-o-Te-Tonga Peninsula is likely to be caused by deer browse as indicated by low pest animal condition scores and animal signs observed. Forests at Te Korowai-o-Te-Tonga Peninsula had the lowest basal area, tree density and sapling density of all sub-regions, providing further evidence of poor regeneration and the start of canopy collapse in these deer-browsed forests.

At the Kōkako Management Area moderate pest animal condition scores and animal signs indicate ongoing herbivory impacts from possum, pig, rabbit/hare and rats, but reduced herbivory impacts from deer, goat and cattle. Previous reporting on the TBMP forest plot data indicated poor seedling and sapling regeneration of this predominately Tawa, kohekohe, rewarewa, hīnau, podocarp forest (WF13, Griffiths et al 2021). Forest at these plots forms a dense canopy (74.8 ± 1.8%) that could shade out less shade tolerant species, but tawa seedlings and saplings are highly shade-tolerant and can survive for decades until a tree gap or thinning tree crown increase light intensity and allow seedling and sapling growth (Smale et al 1986). Tawa seedling densities are probably insufficient for tawa forest regeneration (Smale et al 2008), and seedlings were recorded in fewer plots in the most recent plot remeasure. Tawa pollination is predominately by insects and wind (Smale et al 2008) and Kelly et al (2010) found little evidence of dispersal limitation from native birds. Tawa seeds are however, consumed by possum and pigs and are highly sensitive to desiccation; reduced humidity from a depleted ground vegetation (due to browsing, disturbance or fragmentation) may be sufficient to prevent germination (Knowles & Beveridge 1982, Smales et al 1986).

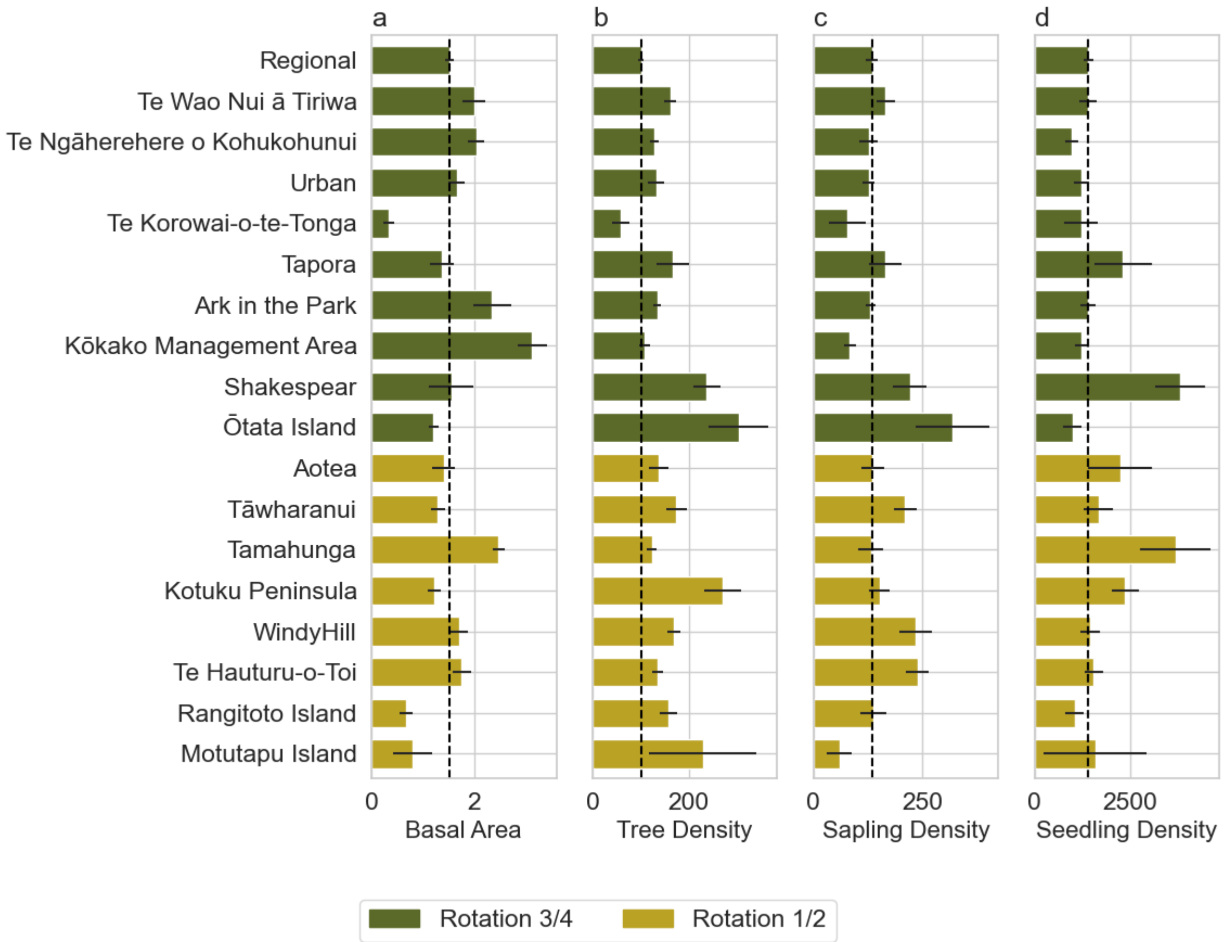



Figure 7. Forest structure abundance metrics (mean ± s.e.) for indigenous woody species in the most recent Regional Tier 1 sample and each sub-region. (a) Basal area ($m^2$ $plot^{-1}$) of native trees, (b) Native tree count ($plot^{-1}$), (c) Native woody sapling count ($plot^{-1}$), (d) Native woody seedling count ($plot^{-1}$). The most recent plot measures were either from Rotations 3 & 4 (2019 – 2024) or Rotations 1 & 2 (2009 – 2018).

Threatened, at-risk and data-deficient plant species were typically uncommon, but were recorded from all sub-regions including small urban and rural forest patches (e.g. Te Korowai-o-te-Tonga, Tapora, Figure 8). Regionally threatened, at-risk and data-deficient species composed a diminishing percentage of the total woody abundance by size-class, representing 8.5% of the basal area, 4.5% of the tree density, 3.3% of the sapling density and 3.5% of the seedling density on average per plot. This highlights one of the main vulnerabilities of these species, that many threatened, at-risk and data-deficient species are present as mature trees but are not regenerating.

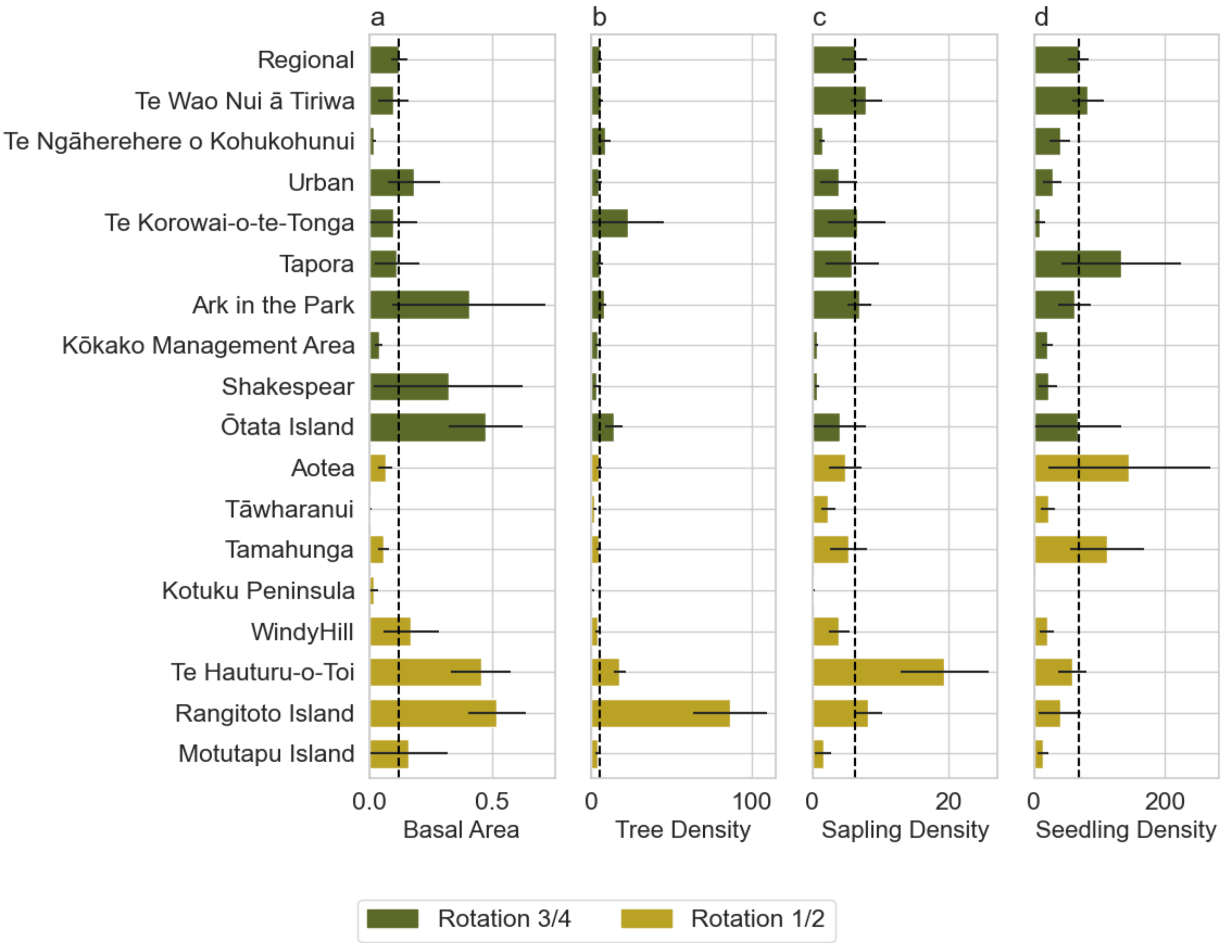



Figure 8. Forest structure abundance metrics (mean ± s.e.) for threatened, at-risk and data-deficient woody species in the most recent Regional Tier 1 sample and each sub-region. (a) Basal area ($m^2$ $plot^{-1}$), (b) Tree count ($plot^{-1}$), (c) Woody sapling count ($plot^{-1}$), (d) Woody seedling count ($plot^{-1}$). The most recent plot measures were either from Rotations 3 & 4 (2019 – 2024) or Rotations 1 & 2 (2009 – 2018).

Regionally, pest plant species composed only a small percentage of the total woody abundance by size-class, representing 6.4% of the basal area, 4.7% of the tree density, 5.5% of the sapling density and only 3.8% of the seedling density on average per plot. From 2025, the adoption of the recce plot into the TBMP forest plot protocol will better capture pest plants in the understorey. Future analysis of this data would benefit from a functional approach to understand the shade-tolerance of pest plant species occurring in the forest interior and their potential risk of spread.

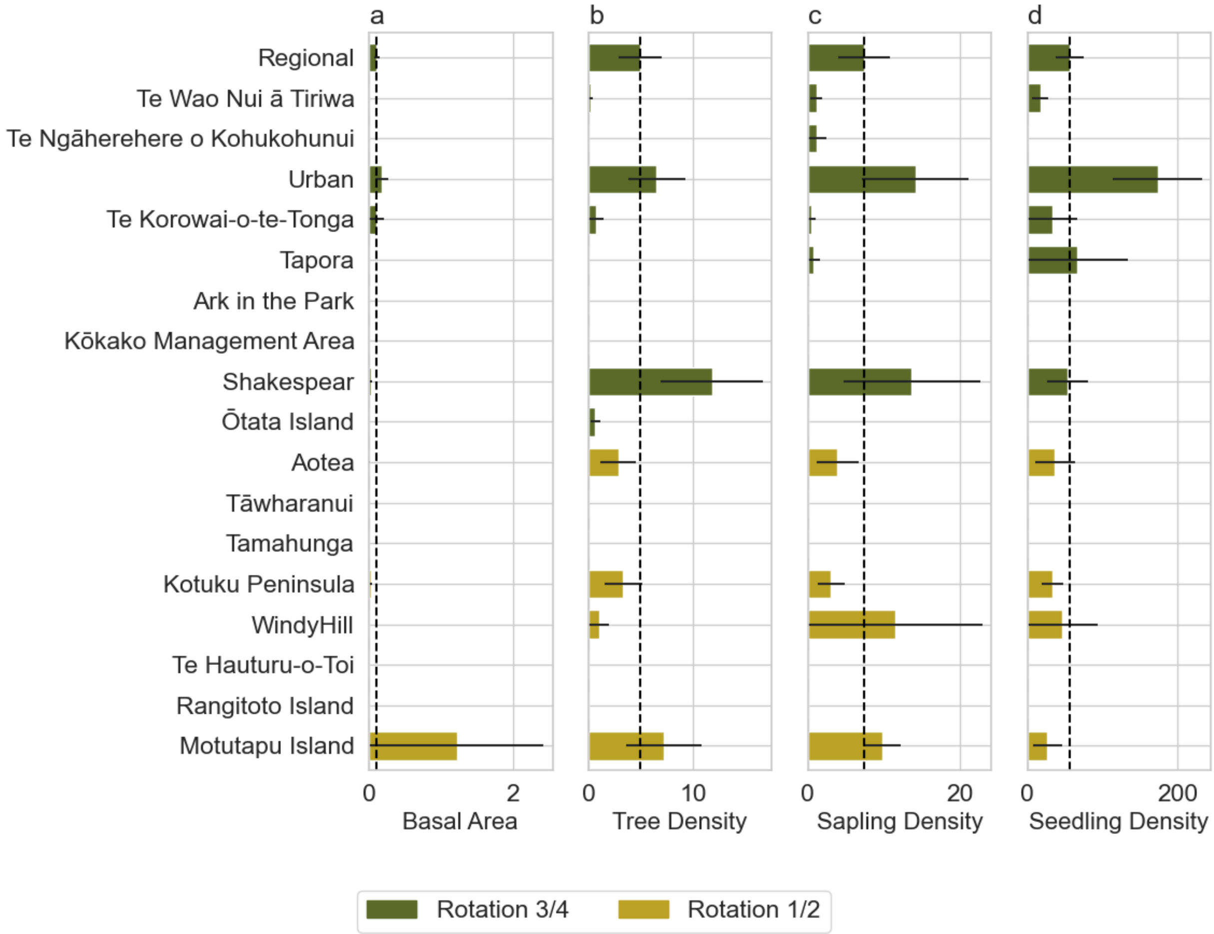



**Figure 9. Forest structure abundance metrics (mean ± s.e.) of pest plant woody species in the most recent Regional Tier 1 sample and each sub-region. (a) Basal area ($m^2$ $plot^{-1}$) of pest trees, (b) Pest tree count ($plot^{-1}$), (c) Pest sapling count ($plot^{-1}$), (d) Pest seedling count ($plot^{-1}$). The most recent plot measures were either from Rotations 3 & 4 (2019 – 2024) or Rotations 1 & 2 (2009 – 2018).**

Across the 15-year monitoring period, there was a decline in the number of seedlings observed in plots Regionally and across a number of sub-regions (Te Wao Nui ā Tiriwa / Waitākere Ranges, Ark in the Park and Kōkako Management Area) which may be driven by pest mammals, drought impacts or increasing canopy closure (Figure 10, Griffiths et al 2021, 2023). Seedling densities can change rapidly in response to different stimuli and more targeted research is required to understand trends in seedling densities and possible mechanisms.

Large changes in all abundance metrics in Shakespear Regional Park over the 15-year monitoring period are consistent with maturing forest; there was an increase in basal area, coupled with a decrease in tree and sapling density. Seedling density at Shakespear showed a net gain over the 15-year sampling period although it peaked in rotation 2. At both Ark in the Park and Shakespear there was huge variability in the forest structure between plots, indicating that the forest habitat in these sub-regions is variable.

Threatened, at-risk and data-deficient species abundance was highest for basal area in Ark in the Park, mostly due to the presence of large, mature kauri trees. The pattern of diminishing percentages of threatened, at-risk and data-deficient species in basal area through to seedling density was apparent for all sub-regions. The density of tree, sapling and seedling weeds declined significantly at Shakespear Regional Park, indicative of the effectiveness of pest plant management at that site but had changed little elsewhere.

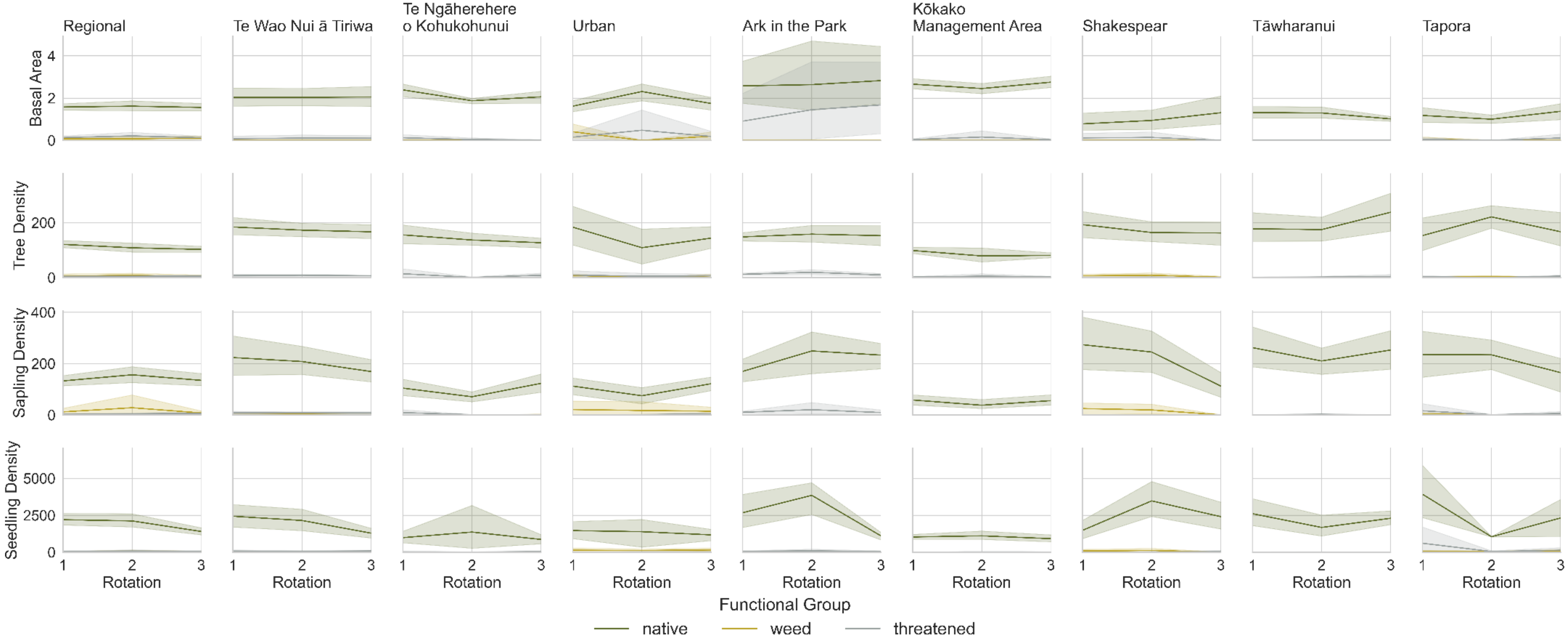



Figure 10. Trends in forest structure abundance metrics (mean and s.e.) for Indigenous species, pest plant species and Threatened, At-risk and data-deficient species for Regional Tier 1 plots and eight sub-regions with plots in three or more rotations. Forest structure metrics are Basal area ($m^2$ $plot^{-1}$), Tree count ($plot^{-1}$), Sapling count ($plot^{-1}$) and Seedling count ($plot^{-1}$).

## 3.7 Bird endemicity

A total of six deep endemic species (those endemic at the family taxonomic rank) were recorded in the TBMP forest data using ten-minute bird counts. Species richness of deep endemics was highest on Te Hauturu-ō-Toi island and in Tāwharanui Open Sanctuary (Figure 11). Both sub-regions also supported a high richness of species endemic at the genus and species taxonomic rank. All six deep endemics were recorded on Te Hauturu-ō-Toi including kākā (*Nestor meridionalis*), tīeke (*Philesturnus rufusater*, North Island saddleback), kōkākō (*Callaeas wilsoni*), hihi (*Notiomystis cincta*, stitchbird), pōpokatea (*Mohoua albicilla*, whitehead) and tītiponamu (*Acanthisitta chloris,* North Island rifleman). Of all mammalian pests in Aotearoa New Zealand, only kiore and feral cats reached Te Hauturu-ō-Toi and both were eradicated in 2004. With the exception of tīeke that were translocated to Te Hauturu-ō-Toi, all these deep endemic species are extant or surviving populations. Populations of deep endemics on Te Hauturu-ō-Toi represent the national stronghold for kākā (together with Aotea) and regional stronghold for korimako (Woolly et al 2024). Te Hauturu-ō-Toi also has the largest regional populations of hihi, tīeke and pōpokotea. The population of tītipounamu on Te Hauturu-ō-Toi was reported to have declined following eradication of cats and kiore, but in the absence of further monitoring the current trend is unknown (Woolly et al 2024).

Three deep endemic species recorded at Tāwharanui included kākā, tīeke and pōpokatea. Pōpokatea were reintroduced in 2007 and tīeke in 2012 following pest mammal exclusion to zero density at Tāwharanui Open Sanctuary for all mammalian pests with the exception of mice and rabbits. Kākā have naturally recolonised from Te Hauturu-ō-Toi.

For all other sites with deep endemic species present, these species were either kākā, kōkākō, tīeke, pōpokatea or hihi. Tītipounamu were not recorded outside of Te Hauturu-ō-Toi.

Indigenous bird species richness was above the regional mean at the offshore island of Te Hauturu-ō-Toi, the fenced mainland islands of Tāwharanui and Shakespear Open Sanctuaries and the unfenced mainland island at the Kōkako Management Area. All four sites have intensive mammalian pest control. Mammalian pests have been eradicated on Te Hauturu-ō-Toi, excluded to zero density at Tāwharanui (with the exception of mice and rabbit), excluded to zero density at Shakespear (with the exception of mice), and suppressed at the Kōkako Management Area with an intensive array of pest control measures including landscape scale aerial application of toxic bait containing 1080 (or sodium fluoroacetate) in response to mast years (years when trees produce large amounts of seed resulting in increased pest mammal populations). In addition, there have been successful translocations of seven indigenous bird species each to Tāwharanui and Shakespear. Bird translocation to the Kōkako Management Area have been unsuccessful to date.

Although Tāwharanui and Shakespear Open Sanctuaries both have predominately regenerating forest ecosystems with low canopy cover, the combination of effective mammalian pest exclusion and bird translocations has made these fenced mainland islands a refuge for many indigenous bird species. Following intensive pest suppression, the mainland island in the Kōkako Management Area now has one of the largest mainland populations of kōkako in the North Island, but the population is dependent on ongoing and sustained mammalian pest control (Woolly et al 2024). Unlike the Kōkako

Management Area, it is notable that indigenous bird species richness at Ark in the Park did not exceed the regional average. Individuals of kōkako have been translocated to Ark in the Park but their numbers remain low. The mammalian pest suppression activity at Ark in the Park does not include the use of broad scale aerial application of toxic bait as has been used over the Kōkako Management Area.

It should be reiterated that for all sub-regions including Te Hauturu-o-Toi and Tāwharanui that are positioned below the dotted line in Figure 8 and Figure 9, bird data comes from plots remeasured in rotation 1 and rotation 2, representing bird species richness and abundance in the period 2014 – 2018. The numbers of introduced species are provided for context. Complete analyses of bird data from the TBMP can be found in Fessardi et al (2025) in this State of Environment 2025 reporting series on Knowledge Auckland (www.knowledgeauckland.org.nz).

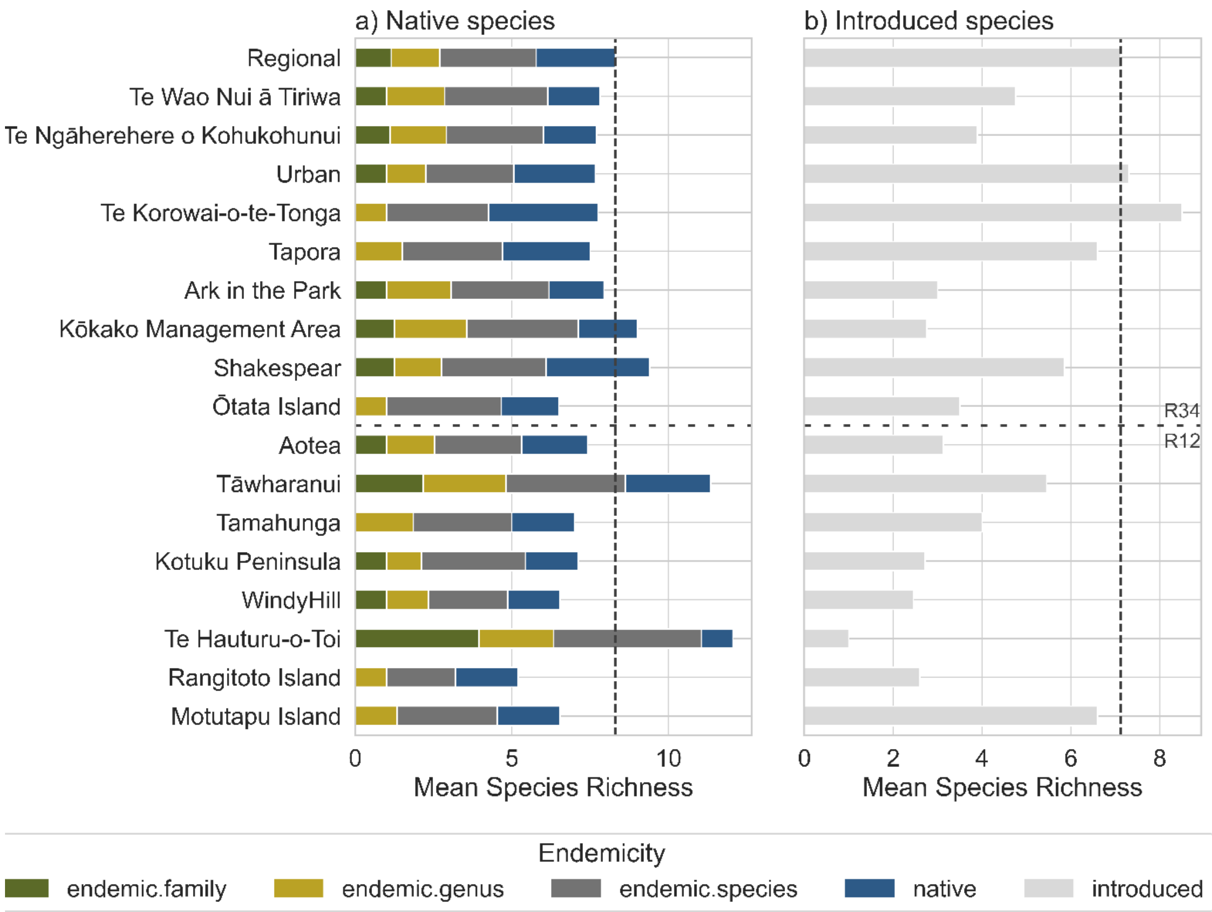



Figure 11. Bird species richness (mean ± s.e.) for (a) Indigenous species, broken down into endemicity level, and (b) Introduced species, for the most recent Regional Tier 1 sample and each sub-region. The most recent plot measures were either from Rotations 3 & 4 (2019 – 2024) or Rotations 1 & 2 (2009 – 2018).

Indigenous bird abundance (endemics and indigenous non-endemics) was above the regional average on Te Hauturu-ō-Toi, Shakespear and Tāwharanui Open Sanctuaries and Ōtata island (Figure 12). High indigenous bird abundance in these sub-regions can be largely attributed to effective pest control, with mammalian pests eradicated from Te Hauturu-ō-Toi and Ōtata island and excluded to zero density at both Shakespear and Tāwharanui Open Sanctuaries (with the exception of mice and rabbit). The indigenous bird fauna on Te Hauturu-o-Toi was both more abundant and hugely dominated by species that are endemic rather than indigenous non-endemic species. In the complete absence of pest mammals (i.e. pest eradication), many endemic species have a competitive advantage over native non-endemics which can decline in abundance as deep endemics increase (Binny et al 2020).

There are several possible reasons to explain the absence of bird species endemic at the family level on Ōtata, deep endemic bird species may have been unable to naturally recolonise, there have been no bird translocations, or pest control may be insufficiently effective.

The abundance of indigenous birds did not exceed the regional average at the unfenced mainland islands of Kōkako Management Area or Ark in the Park. Indigenous bird numbers in these two sub-regions remain low, despite intensive pest suppression. At the Kōkako Management Area, the use of broad scale aerial application of toxic bait in sustained pest suppression, targeted at protecting breeding kōkako populations, has been effective and kōkako numbers have increased (Woolly et al 2023). Time lags in population responses to restoration activity are expected, with indigenous bird populations requiring several generations to build up population densities. If this is the case, and intensive pest suppression including the use of broad scale aerial applications of toxic bait continue in response to mast years, future monitoring at the Kōkako Management Area may show improvements in indigenous bird populations. There is some evidence that pest suppression at the Kōkako Management Area remains insufficient, or has not been going for long enough, since the Animal pest condition score for this sub-region indicated minor impacts (3.6 ± 0.2) and signs of possum, pig, rabbit/hare and rat were observed. In contrast, Animal pest condition scores for Ark in the Park indicated no or very low impacts (4.7 ± 0.1) and no animal signs were observed when the plots were remeasured. These data highlight the value of quantitative mammalian pest animal monitoring to track pest numbers alongside bird population responses. This would demonstrate where there are causal relationships (i.e. between mammalian pest animal declines and indigenous bird population increases), or where other factors may be inhibiting indigenous bird population responses.

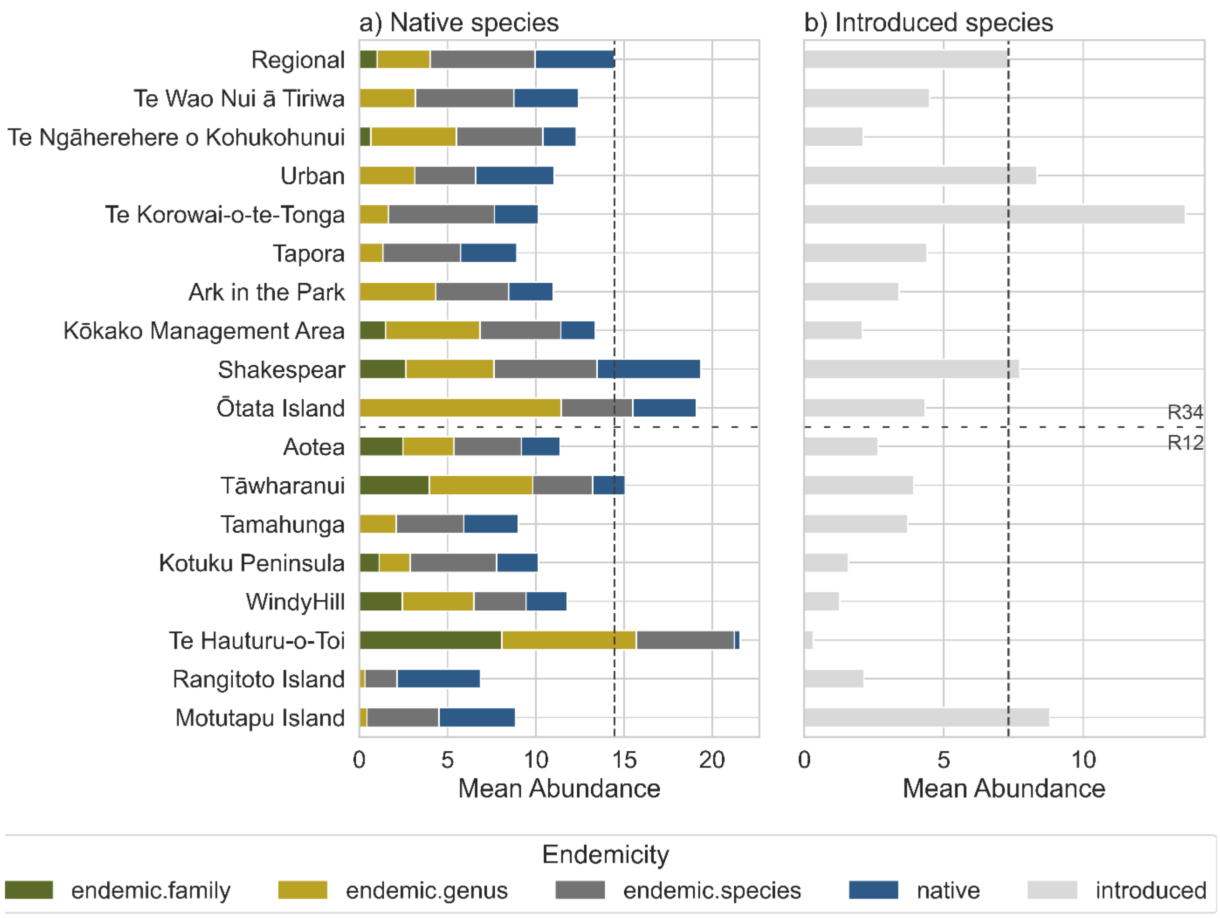



Figure 12. Bird abundance (mean ± s.e.) for (a) Indigenous species, broken down into endemicity level and (b) Introduced species, for the most recent Regional Tier 1 sample and each sub-region. The most recent plot measures were either from Rotations 3 & 4 (2019 – 2024) or Rotations 1 & 2 (2009 – 2018).

Across the nine sub-regions with three sets of plot measures (2009 -2023) for trend analysis, there were no significant trends in the species richness of different indigenous and endemic groups (Figure 13). In the absence of trend data from Te Hauturu-ō-Toi, the species richness of all indigenous and endemic groups was highest at Tāwharanui Open Sanctuary, and species endemic at the species taxonomic rank were the most species rich group.

At Tāwharanui, analysis of bird trends use data from 20 plots in rotations 1 and rotation 2, but only four plots were remeasured in rotation 3 (due to budget constraints). All Tāwharanui plots will be remeasured in rotation 4 (2024 – 2028) using NETR funding to allow a more complete trend analysis. Trends for only the four plots remeasured in rotation 3 showed the same pattern as the full data set, mean indigenous bird species richness increased between rotation 1 and rotation 2 from 9 to 11.8, and remained constant at 11.8 species for rotation 3.

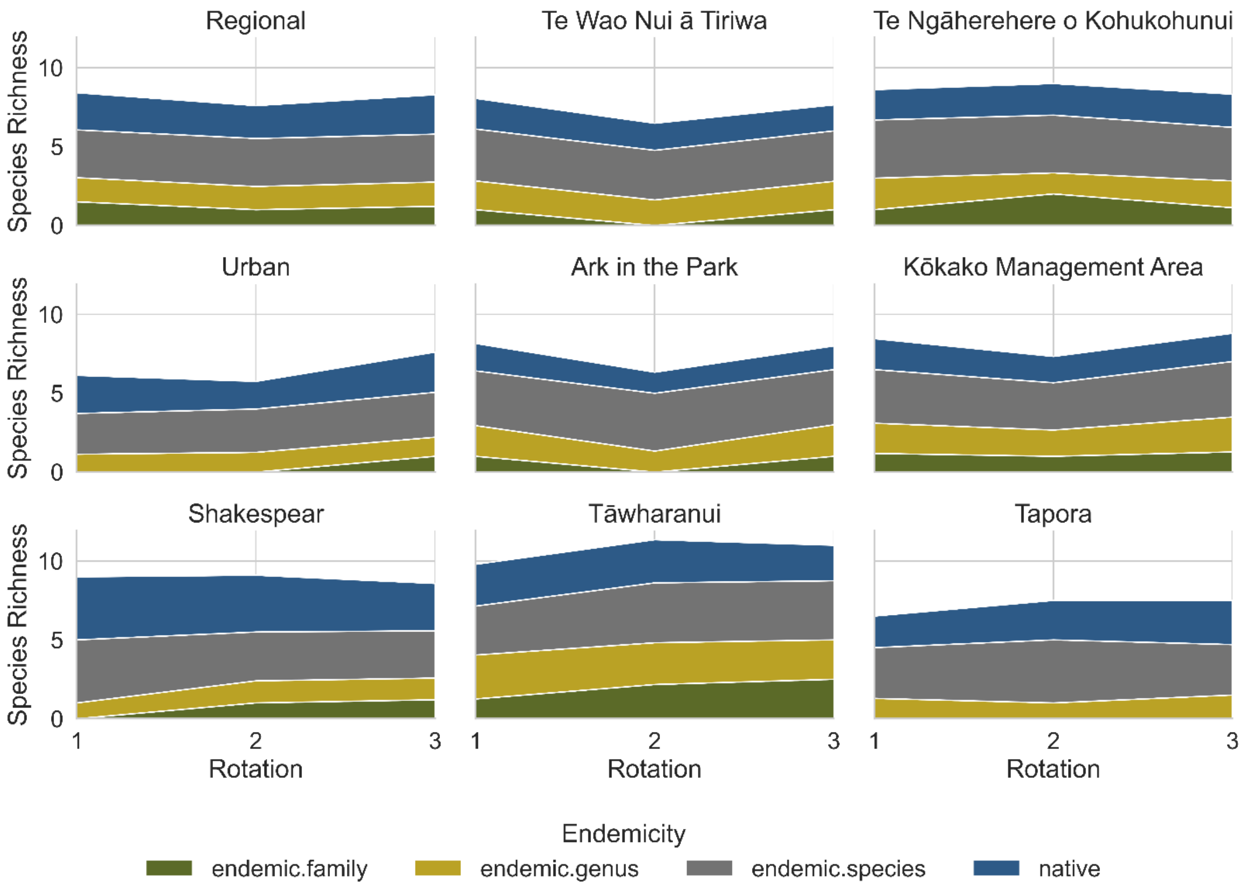



Figure 13. Trends in bird species richness (mean ± s.e.) for indigenous species, broken down into native (non-endemic), and birds endemic at the species, genus and family taxonomic rank. Data are shown for the Regional Tier 1 plots and eight sub-regions with plots in three or more rotations.

Across the nine sub-regions with three sets of plot measures (2009 -2023) for trend analysis, indigenous bird abundance was highest in Tāwharanui Open Sanctuary (Figure 14). Despite largely regenerating forest at Tāwharanui, this fenced mainland island acts as a refuge to many indigenous bird species as a result of effective mammalian pest exclusion to zero density (with the exception of rabbits and mice) and multiple bird translocations. A significant decline in indigenous bird abundance in rotation 2 (2014 – 2018, most plots were remeasured in 2018) was predominately driven by declines in kererū and korimako, birds endemic at the genus taxonomic rank. Overall indigenous bird abundance at Tāwharanui increased again by rotation 3, although korimako numbers continued to decline. A stoat incursion in 2016 was known to impact several bird populations, particularly tīeke, before it was trapped. Three of the four plots remeasured in rotation 3 recorded a lower number of tīeke compared to rotation 2, the fourth plot recorded the same number.

Regionally (Tier 1) there was a decline in the abundance of deep endemics, although overall there was a net gain in indigenous bird abundance across the 15-year monitoring period. Plots in Te Wao Nui ā Tiriwa / Waitākere Ranges, Te Ngāherehere o Kohukohunui / Hūnua Ranges, Ark in the Park, Kōkako Management Area and Tāwharanui all showed an increase in indigenous bird abundance between rotations 2 and 3. For Te Wao Nui ā Tiriwa / Waitākere Ranges and Ark in the Park this was driven by increases in species endemic at the species taxonomic rank, for Te Ngāherehere o Kohukohunui / Hūnua Ranges there were small increases across all endemicity levels, for the Kōkako Management Area there were increases at the family and genus levels of endemicity. In the Kōkako Management Area, kōkako, endemic at the family taxonomic rank, increased in numbers and were observed at more plots in rotation 3. Shakespear Open Sanctuary showed an increase in abundance of deep endemics only.

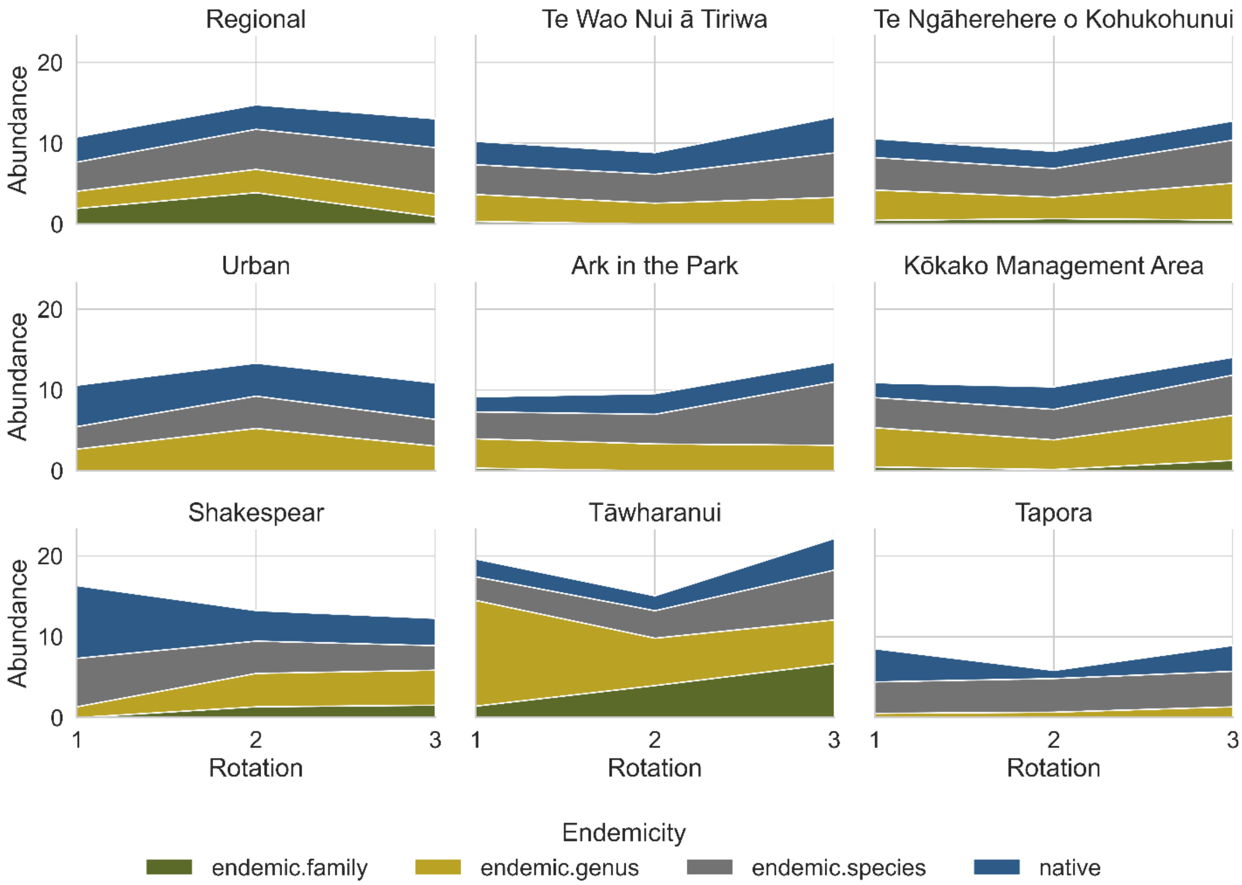



Figure 14. Trends in bird abundance (mean ± s.e.) for indigenous species, broken down into native (non-endemic), and birds endemic at the species, genus and family taxonomic rank. Data are shown for the Regional Tier 1 plots and eight sub-regions with plots in three or more rotations.

# 4 Conclusions

This report describes the state and trends in forest ecological integrity in Tāmaki Makaurau from 2009 – 2024, focussing on composition, structure and function as they relate to forest extent, plants and bird endemicity. Two sources of data are used, the Landcover database (1996 – 2018) with a provisional update for Tāmaki Makaurau to 2023, and data from the Terrestrial Biodiversity Monitoring Programme (2009 – 2024) forest plot network.

## 4.1 Forest extent

The analysis of land cover change indicates a shift in forest extent trends in recent years. The period from 2018-2023 recorded net gains of 1,511 hectares of indigenous forest and 4,043 hectares of indigenous scrub/shrubland (LCDB 2023 provisional). These increases represent the largest recorded expansions during the 27-year monitoring period (1996 – 2023). The primary driver of forest expansion is conversion from exotic grassland to native vegetation, accounting for 1,839 hectares of new indigenous forest and 4,680 hectares of scrub/shrubland. Gains in native woody vegetation cover arise from active replanting associated with pastoral conversion to lifestyle blocks and greenfield developments, active replanting in regional parks and natural regeneration processes on marginal farmland (in decreasing order of magnitude). Forest losses result from direct conversions to urban expansion and infrastructure development, or from many small accumulated losses, for example from incremental infill, that have crossed a classification threshold.

These changes highlight the contribution private landowners can make towards forest restoration (assisting the recovery of ecosystems that have been damaged, degraded, destroyed or disturbed, Auckland Council, 2023). They also highlight how the planning framework can support or incentivise this restoration through targeted policies. Within the AUP, a combination of provisions may contribute to this, although the specific impacts are difficult to quantify without detailed review of the individual resource consents. Key mechanisms include rural subdivision rules (E39), vegetation management and biodiversity provisions (E15), particularly when developments impact existing ecological features or when ecological offsets are required, planting to protect water quality and aquatic ecosystems (E3), and Significant Ecological Areas (D9 Overlay). A planned Section 35 review of the effectiveness of biodiversity provisions in the Auckland Unitary Plan will examine these relationships in greater detail.

Private land ownership encompasses much of the region's remaining lowland areas and represents a valuable opportunity for protecting and restoring some of the most threatened and depleted forest ecosystems. Some of the most severely depleted forest types are those typical of lowland areas (e.g. Pūriri forest depleted to 0.3% of original extent, Kahikatea, pukatea forest depleted to 2% of original extent). Furthermore, rare plants in Aotearoa New Zealand are disproportionately represented in lowland areas (Rogers & Walker 2002). International research demonstrates that private land conservation can achieve significant biodiversity outcomes when appropriate mechanisms are in place (Perfecto & Vandermeer 2008). New indigenous ecosystems will also provide added benefits for erosion control, improved water quality in streams, increased habitat connectivity and climate resilience.

The ecological and biodiversity outcomes of large-scale planting programmes are dependent on the quality of the initial planting and subsequent maintenance. There is a risk that large-scale planting programmes on private land may rely on low-diversity species mixes without infill or enrichment planting and with limited maintenance. Such plantings can lead to low diversity scrub/shrubland with arrested successional development to mature forest ecosystem and pest plant invasion and spread, falling short of the ultimate goal of restoration planting to support diverse and self-sustaining indigenous ecosystems (Auckland Council 2023). Norton et al. (2018) emphasise that successful restoration in Aotearoa New Zealand depends on careful planning, eco-sourcing of native species, and ongoing monitoring. Their work highlights that low-diversity plantings, while visually effective in increasing cover, may not deliver meaningful biodiversity outcomes or ecosystem services. Ecological restoration guidance from Ngā Iwi Mana Whenua o Tāmaki Makaurau and Te Kaunihera o Tāmaki Makaurau (Auckland Council 2023) advise limiting kānuka and mānuka to no more than 50% of plants in forest restoration replanting and including fleshy-fruited species to attract seed-dispersing birds to increase diversity over time. In addition, most newly revegetated areas on private land lack mammalian pest control and formal long-term protection. There is a clear value in ecological monitoring of replanting programmes on private and public land to assess the ecological and biodiversity outcomes, implement adaptive management where necessary, inform new replanting efforts and guide Auckland Unitary Plan provisions through Section 35 assessments.

Changes in landcover classification resulting from incremental infill development illustrate cumulative impacts on forest ecological integrity. Increasing proportion of non-forest cover affects forest structural attributes such as fragmentation and connectivity, edge effects and biotic and abiotic conditions in the forest interior. Indigenous forest close to residential developments are also increasingly exposed to pest plants, with private gardens the dominant source of weeds in adjacent indigenous forest (Sullivan et al 2005).

It is important to remember that gains and losses in forest extent are not equivalent for biodiversity, especially since all indigenous forest ecosystems in Tāmaki Makaurau are classed as Threatened according to IUCN criteria. There will be a considerable time-lag before new plantings on exotic grassland can compensate for the loss of biodiverse habitats when existing forest or scrub/shrubland is removed (e.g. Reay & Norton 1999, Toft et al 2018). Furthermore, loss of existing forest and scrub/shrubland will contribute to further fragmentation, isolation and exposure to human activity of extant forest patches. Despite the recent gains observed in indigenous forest and scrub cover to 27%, Tāmaki Makaurau still remains well below the national average of 33% cover for New Zealand (MfE 2021).

## 4.2 Plants

Data from the Terrestrial Biodiversity Monitoring Programme (TBMP) indicates clear differences in indigenous plant biodiversity between sub-regions and in response to forest landscape structure. Highly diverse, mature, structurally complex forest can be found in the large continuous forest blocks of the Te Wao Nui ā Tiriwa / Waitākere Ranges and Te Ngāherehere o Kohukohunui / Hūnua Ranges, in the unfenced mainland islands of Ark in the Park and the Kōkako Management Area, in Tamahunga Ecological Area and on Te Hauturu-o-Toi. These large, continuous forest blocks consistently support more biodiverse indigenous plant communities (Griffiths et al 2021).

Large, continuous forest blocks, but especially in Te Wao Nui ā Tiriwa / Waitākere Ranges, Ark in the Park, Tamahunga Ecological Area and Te Hauturu-o-Toi are clearly refuges for species that are threatened, at-risk and data-deficient. But populations of threatened, at-risk and data-deficient species were observed in all sub-regions including small urban and rural forest patches (e.g. Te Korowai-o-te-Tonga). Rare plant species may be disproportionately common in lowland areas, particularly since that is where most forest ecosystem has been lost (Rogers & Walker 2002, Singers et al 2017). This highlights the biodiversity value of protecting a variety of habitats, across a wide range of environmental contexts, including those that may be considered of more limited value (Griffiths et al 2007, Richarson et al 2014, Arroyo-Rodriguez et al 2020). Protecting, restoring and increasing forest patches across rural and urban landscapes would also support populations of indigenous forest birds with limited dispersal ability (Innes et al 2022). There were no trends in the abundance of threatened, at-risk and data-deficient species but the diminishing abundance of these plants in each size-class (representing 8.5% of basal area to 3.5% of seedlings) illustrates a pattern of poor regeneration. This undermines their long-term survival and calls for deeper understanding of the causes of rarity and how these species can be better managed and protected (Duncan & Young 2000, Monks & Barrows 2014, Hare et al 2019, Wyse et al 2023).

Two quite different sub-regions, Ark in the Park and Shakespear Open Sanctuary showed increasing trends in indigenous plant species richness. More indigenous plant species were recorded in Ark in the Park than any other sub-region and the steady increase in species does not appear to be saturating. A number of mechanisms might be behind this pattern. Natural regeneration and successional processes and more effective control of both pest plants and mammalian pest animals would result in new species colonising or spreading, while more abundant and diverse bird communities, especially in response to bird translocations, would increase the potential for seed dispersal.

Smaller urban forest patches that are both more isolated from indigenous vegetation and more exposed to human activity, supported fewer indigenous plant species and more pest plants throughout the forest structure from seedlings to large trees. Private gardens are one of the dominant sources of pest plants in adjacent indigenous forest (Sullivan et al 2005). Low indigenous plant species richness was also observed in forest patches at Te Korowai-o-te-Tonga. Condition scores, animal signs and plot data for these forest patches at Te Korowai-o-te-Tonga describe a pattern where kānuka canopies are senescing, but sustained herbivore browse has limited forest regeneration, leading to the risk of canopy collapse. This pattern is consistent with research from other forest sites in Aotearoa New Zealand where deer browsing prevents regeneration (Husheer 2007). The nationally and regionally threatened rawiritoa (*K. amathicola*) and regionally threatened *Coprosma crassifolia*, both associated with sandy, coastal areas, grow at these sites. Further monitoring would be required to understand how widespread this pattern is in Te Korowai-o-te-Tonga.

Declining seedling densities was observed Regionally and across Te Wao Nui ā Tiriwa / Waitākere Ranges, Ark in the Park and Kōkako Management Area which may be caused by multiple drivers including pest mammals consuming seeds, drought impacts affecting germination or forest dynamics affecting competition and light levels (Griffiths et al 2021, 2023). Seedling densities can change rapidly in response to different stimuli and these patterns will not be picked up though monitoring on a five- or ten-year return time. Consequently, more targeted research would be required to understand trends in seedling density, possible mechanisms and how they will impact our future forests. At the Kōkako Management Area for example, there are signs of effective pest suppression of deer and goat which could be expected to release seedling and sapling densities from herbivory, similar to that observed at Tamahunga Ecological Area, but seedling densities continue to decline including those of one of the dominant canopy tree species, tawa (*Beilschmiedia tawa*). Maturing forest at the Kōkako Management Area has increasing canopy cover (68% in 2014 – 2018 and 74.8% in 2024 – 2028) that would shade out many species, but tawa seedlings and saplings are highly shade-tolerant. Given the observation of ongoing pest impacts and signs (of possum, pig, rabbit/hare and rat) at the Kōkako Management Area, it is possible seed and seedlings are consumed by pigs, possums and/or rats. Alternatively, desiccation driven by climate change could be affecting seed survival and germination.

The TBMP is not designed to monitor pest plants *per se* but will detect those pest plants able to colonise and persist in the forest interior, whether they are shade-tolerant species that can colonise under the canopy, or invasive species that colonise areas disturbed by tree-fall gaps or landslides (e.g. Griffiths et al 2023). The TBMP data suggest a decline in pest plant abundance at sites with pest plant control operations including Shakespear Open Sanctuary, Te Hauturu-o-Toi, Ark in the Park, Kōkako Management Area and Tāwharanui Open Sanctuary, although additional pest plant species also arrived at Shakespear. While not monitored here, it should be noted that the plant pathogens causing kauri dieback disease (*Phytophthora agathicida*) and myrtle rust (*Austropuccinia psidii*) remain an existential threat for many of the forested landscapes in Tāmaki Makaurau and highlight the vulnerability of even our large forest blocks to major compositional and ecosystem change. Many of the most vulnerable species to these two pathogens, kauri, pōhutukawa, rātā trees and vines, compose a large proportion of the biomass, are integral to forest ecosystem functioning and are culturally important.

## 4.3 Bird endemicity

All six deep endemic bird species (endemic at family taxonomic rank) recorded in the TBMP were observed on Te Hauturu-o-Toi highlighting the value of mammalian pest-free offshore islands to species most vulnerable to mammalian pests. The TBMP data showed that coupled with bird translocations to safe environments, there appeared to be a hierarchy of outcomes in the indigenous bird response to mammalian pest control. Greatest outcomes (for deep endemics and indigenous birds more generally) were observed for mammalian pest eradication, on the offshore islands of Te Hauturu-o-Toi and Ōtata, followed by pest exclusion to zero density, in the fenced mainland islands of Tāwharanui and Shakespear Open Sanctuaries. Mammalian pest suppression including the use of broad scale application of toxic bait, such as that used at the Kōkako Management Area, was more effective than mammalian pest suppression without the use of broad scale toxic bait, such as that used at Ark in the Park, especially when pest control operations were targeted to protect a specific indigenous bird, the kōkako. It is important to remember that all sites are continually vulnerable to mammalian pest incursions, as illustrated by the stoat incursion at Tāwharanui in 2016, and require sustained and indefinite mammalian pest control to maintain biodiversity outcomes. Given the limited dispersal ability of many indigenous forest birds to cross 'gaps' between forest patches (Innes et al 2022), bird translocations to 'safe' environments are a valuable conservation management tool.

## 4.4 Terrestrial Biodiversity Monitoring Programme (TBMP)

The Terrestrial Biodiversity Monitoring Programme, TBMP provides long-term, systematically collected and quantitative data on forest plant and bird composition, structure and function, and qualitative assessments on forest condition and mammalian pest signs. Analysis of TBMP data allows us to track forest ecology and biodiversity regionally and at a range of sub-regions with different forest-landscape configurations, forest ecosystems, history and conservation management. There have been recent improvements to the forest plot protocol, through the introduction of tree tagging to monitor tree recruitment, growth and mortality and better track forest dynamics including of vulnerable species (e.g. those species vulnerable to drought, plant pathogens, etc), and the introduction of the recce plot for use in ecosystem mapping and to better capture understorey plants including non-woody and pest plants.

Since the TBMP started 15-years ago, both the number of plots remeasured and the frequency of remeasurements have been reduced in response to budget constraints. This impacts the regional coverage of the forest plot network, the sensitivity of the network to detect changes and the ability to use the data that is collected in a meaningful way. With 15 years of data it is now timely to review the TBMP and check that it is fit for purpose for the next 15-plus years. A review of the TBMP is underway with trend and power analyses planned for a subset of indicators. Consistent, long-term funding is essential to maintain the value of this long-term biodiversity dataset for Tāmaki Makaurau (Lindenmayer et al 2022). The introduction of the Natural Environment Targeted Rate (NETR) has provided funding to start remeasuring some existing plots and establish new permanent forest plots at key Biodiversity Focus Areas. NETR-funded outcome monitoring at BFAs will be invaluable to quantify biodiversity outcomes and adapt conservation management operations across Tāmaki Makaurau funded by rate payers through NETR. Many other plots that were 'parked' in rotation 1 and 2 pending further funding are in rural areas (e.g. Te Korowai-o-te-Tonga, Awhitu, Tapora) where forest patches are essential to maintain connectivity and biodiversity. These forest plots remain available to be remeasured where the need is perceived and funding available.

The TBMP data can be used to calculate a wide variety of metrics, not limited to those used in this report. Especially valuable are examinations of the data in combination with functional plant or bird traits (e.g. palatability to herbivores, shade-tolerance of plant species, bird seed dispersers, bird dispersal ability, etc) to understand forest ecosystem functioning.

Finally, the TBMP monitors plants and birds only. There is no systematic monitoring of other indigenous biodiversity, such as invertebrates, which have been declining globally, and are a driving force of many ecosystem functions including decomposition, nutrient recycling, pollination, and providing a valuable food source for many fauna. It is generally only those flora and fauna that we monitored that we actively protect. This report also identified the value of monitoring of restoration planting, ideally on public and private land, to better understand restoration quality.

# 5 Acknowledgements

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# Appendix 1: Regional and sub-regional monitoring areas

## Tier 1: Regional forest

Regional Tier I plots are distributed in forest and scrub across the Auckland region, representing the full range of elevations, forest patch sizes, history, management, surrounding land uses and ecosystem types. Plots are located in kānuka scrub/forest (VS2, 26 plots), kauri, podocarp, broadleaf forest (WF11, 26 plots), tōtara, kānuka, broadleaf forest (WF5, 12 plots), taraire, tawa, broadleaf forest (WF9, 10 plots), exotic forest (EF, 9 plots), pōhutukawa, pūriri broadleaf (WF4, 7 plots) and other less common ecosystem types, including 20 unclassified plots (the Singers et al 2017 geospatial layer of current ecosystem type is a living document that is continually updated as new habitats are surveyed and more information comes available, ultimately all habitat patches across the Auckland region will be classified).

## Tier 2: Aotea (Great Barrier Island)

Aotea (Great Barrier Island) in the outer Tīkapa Moana / Hauraki Gulf is New Zealand's sixth largest island (28,500ha). Aotea is of international, national and regional significance for its biodiversity, has high cultural value to mana whenua, and the Auckland public. Much of Aotea was logged for kauri from c.1850-1940 and farming was later attempted on the more gently sloping and warmer landforms. However, the relative isolation, ruggedness of the terrain and nutrient deficiencies in the soil meant that most of these farmed areas have long since reverted to indigenous scrub and forest. Only a small proportion of the island is dominated by exotic pasture and residential 'urban' areas. The remainder of the island comprises indigenous forest and scrub and indigenous freshwater and saline wetlands. Nearly two thirds of the island is in public ownership, with the expectation to be managed for conservation.

Several mammalian pest species have never made it to Aotea including deer, stoats, ferrets, weasels, possums, hedgehogs and Norway rats, or for goats, have been eliminated from the island through active control . Aotea is the second largest area of possum free habitat in New Zealand after Campbell Island. In 2022, a large-scale, mana whenua-led initiative Tū Mai Taonga, began on Aotea to eradicate feral cats and ship rats. Most feral cats have been removed from the northern part of the island, Te Paparahi, and insights will be used to inform their work to the south. Meanwhile, rats have been removed from two nearby outer islands.

There are many environmental protection and restoration projects around the island. Glenfern Sanctuary, initially a private sanctuary but now owned by Auckland Council forms part of the Kotuku Peninsula, a 240ha pest managed peninsula. The land comprises five land owners including a Department of Conservation Scenic reserve, an Auckland Council Regional Park and three private landowners. In Rosalie Bay, the privately owned Windy Hill Sanctuary covers 800ha of which 300ha have intensive predator control. The Oruawharo Medlands Ecovision and Okiwi Community Ecology project lead by the community, focus on reducing predator numbers, improving breeding grounds for native birds and restoring waterways, sand-dunes and wetlands. The Great Barrier Island Environmental Trust work with the community to reduce feral cats and rats across the island, with the vision to bring back kokako to Aotea. The Ecology Vision also supports the community to protect, enrich and restore ecosystems.

Aotea plots are predominately located in kānuka scrub/forest (VS2, 12 plots) and kauri, podocarp, broadleaf forest (WF11, 4 plots), with one plot each of taraire, tawa, broadleaf forest (WF9, 1 plots) and tawa, kohekohe, rewarewa, hīnau, podocarp forest (WF13, 1 plot).

### Tier 2: Hūnua Ranges

The Hūnua Ranges comprise 17,000ha of native forest in south-east Auckland with the highest point at Mt Kohukohunui (688m). Areas of the Hūnua Ranges were settled by Māori and early Europeans and from the 1890s the foothills (up to about 250m) and alluvial flats were logged for kauri and other timber and cleared for farming (Silvester 1964). Severe damage to the forest has been caused by high populations of goats and pigs. There has been substantial regeneration since the 1930s. At higher altitudes, tawa, broadleaf and podocarps dominate, on northern slopes taraire and pūriri are common, in lowland areas kauri and hard beech are found (Silvester 1964). From the 1950s to 1970s five reservoirs were built in the Hūnua Ranges, four of which currently supply water to Auckland, the last is due to be connected to the Auckland supply network in 2021. Auckland Council regularly control feral pigs, goats, deer, possums and mustelids within parkland and buffer land surrounding the park. Deer are considered absent from the Hūnua Ranges. Weed control activities are highly restricted within or near reservoir water catchments, but at least 36 weed species are controlled regularly in specified blocks across the Hūnua Ranges.

Plots in the Hūnua Ranges are spread across tawa, kohekohe, rewarewa, hīnau, podocarp forest (WF13, 7 plots), taraire, tawa, broadleaf forest (WF9, 5 plots), kānuka scrub/forest (VS2, 4 plots), kauri, podocarp, broadleaf forest (WF11, 1 plot) and one unclassified plot.

### Tier 2: Waitākere Ranges

The Waitākere Ranges Regional Park covers 17,000ha of public land, but a wider area of public and private land is recognised under the Waitākere Ranges Heritage Area Act 2008 which seeks to protect the ecological and cultural significance of the area, as well recognising its role in water catchment and supply to the Auckland region. The most common forest type, accounting for 45% of all native ecosystems, is kauri, podocarp, broadleaf forest (WF11), followed by mānuka, kānuka scrub (VS3, 17%), broadleaf scrub/forest (VS5, 13%) and kānuka scrub/forest (VS2, 12%). Forest composition and structure has been severely impacted by the brushtail possum (*Trichosurus vulpecula*), rats, mustelids, cats and pigs. Possum browse and seed consumption have seriously affected Northern rātā, Hall's tōtara, tōtara, maire tawake, pōhutukawa, mamaku, broadleaf, pūriri, kohekohe, large-leaved māhoe and whauwhaupaku, with reports of tree mortality (Barton & McClure 1990; Ogden & Carlaw 1997). Forest health surveys conducted in the 1990s demonstrated considerable impacts on the forest canopy and seedling populations, with consequences for forest regeneration. Operation Forestsave started in 1997. This Waitākere-wide possum control programme effectively maintained possum numbers below 7% of the residual trap catch (a measure of their abundance, Lovegrove and Parker, 2023). In addition, Auckland Council regularly controls pigs, which are vectors of the pathogen causing kauri dieback. There has been ongoing work by Auckland Council to understand and control the spread of kauri dieback. Local iwi Te Kawerau a Maki placed a rāhui on the Waitākere Ranges in December 2017 to prevent further spread of the kauri dieback and this was followed by a Controlled Area Notice imposed by Auckland Council to close the majority of the regional park to public access. Increased public access to specific tracks has occurred as tracks are checked and upgraded to minimise risk of kauri dieback spread.

TBMP plots in the Waitākere Ranges are predominately located in kauri, podocarp, broadleaf forest (WF11, 10 plots), mānuka, kānuka scrub (VS3, 5 plots), broadleaved species scrub/forest (VS5, 4 plots), kānuka scrub/forest (VS2, 2 plots) and one plot each of pōhutukawa, pūriri broadleaf (WF4) and tawa, kohekohe, rewarewa, hīnau, podocarp forest (WF13).

### Tier 2: Awhitu

The Awhitu peninsula covers ~22,000 ha of predominately rural land. The Awhitu Landcare group supports pest and weed control on public and private land across the peninsula, and Auckland Council provide possum control. The community group has an active replanting programme on public land.

All Awhitu plots are in tōtara, kānuka, broadleaf forest (WF5, 4 plots).

### Tier 2: Te Korowai-o-Te-Tonga Peninsula / Southhead

Six South Kaipara plots are in tōtara, kānuka, broadleaf forest (WF5, 6 plots), and one each in kānuka scrub/forest (VS2, 1 plots) and spinifex/pingao grassland/sedgeland (DN2, 1 plot).

### Tier 2: Tapora

Tapora/Otamatea plots are spread across kānuka scrub/forest (VS2, 4 plots), kauri, podocarp, broadleaf forest (WF11, 2 plots), and one plot each of pōhutukawa, pūriri broadleaf (WF4, 1 plot), exotic scrub (ES, 1 plot) and unclassified.

### Tier 2: Tamahunga (Department of Conservation)

The Tamahunga Ecological Area near Matakana includes Mt Tamahunga peak at 437m and is approximately 230 ha administered by the Department of Conservation. An active community group monitor 150 DOC predator traps across the site and a neighbouring section of 270ha of privately owned bush. Yearly catches average 30-40 stoats, 5 weasels, 200 rats. Auckland Council and DOC have eradicated goats and continue to target pigs, possums and weeds on an annual basis. Monitoring is undertaken to detect goat and deer. The first of three kiwi translocations from Motuora to Tamahunga occurred in March 2023 with 10 North Island Brown kiwi released. Further releases were planned for 2024 and 2025.

Much of the forest is taraire-dominated with emergent northern rātā, rimu, kahikatea, and rewarewa, and a mature canopy of taraire, pūriri, kānuka, tawa, pukatea and other native species. There is an abundance of vines and epiphytes. A dense and diverse understorey is re-establishing following the removal of large numbers of goats and ongoing pig control. Small kiokio, raukawa and *Astelia microsperma* – native species typically found at high elevations or with a more southern distribution, occur high up on Mount Tamahunga. The majority of Tamahunga plots are in taraire, tawa, broadleaf forest (WF9, 12 plots), with two plots in broadleaved species scrub/forest (VS5, 2 plots).

### Tier 2: Urban forests

The 21 plots in urban forest represent a wide range of ecosystem types, with varied histories and management. The sampling area lies within Auckland's Metropolitan Urban Limits (MUL) and includes most of Tamaki (c. 76%), Manukau (c.12%), Inner Gulf Islands (c.8%), Waitākere (c.5%), Rodney (c.2.5%) and Hūnua (c.1%) ecological districts. Represented in decreasing order are pōhutukawa, pūriri broadleaf (WF4, 3 plots), kānuka scrub/forest (VS2, 2 plots), pūriri, taraire forest (WF7.2, 2 plots), kauri, podocarp, broadleaf forest (WF11, 2 plots), and one plot each of mānuka, kānuka scrub (VS3), broadleaved species scrub/forest (VS5), pūriri forest (WF7), taraire, tawa, broadleaf forest (WF9), tawa, kohekohe, rewarewa, hīnau, podocarp forest (WF13), planted native scrub/forest <20 years old (PL1), exotic forest (EF), treeland (TL). Four plots are unclassified.

### Tier 3: Te Hauturu-o-Toi

One of the most intact indigenous forest communities in the Auckland region is found on the offshore island of Te Hauturu-o-Toi (Little Barrier Island), where there has been only limited logging and farming since human colonisation and minimal pest animal and weed incursions. Cats have been eradicated since 1980 and kiore since 2004 (Wade & Veitch 2019). Ongoing pest control focusses on detecting any new incursions through pest stations across the island and strict biosecurity checks for Department of Conservation approved visitors. Systematic control of climbing asparagus began in 1996 and continues with an annual search of 175ha per year. Systematic control of pampas began in 2004, mostly by spraying cliffs from a helicopter with the aim to search and treat about 50% of cliff and slip faces each year. Other weeds are controlled as they are encountered, including an infestation of panic veldt grass that requires ongoing surveillance. The aim for weed control is eradication or control to zero-density. The bird community on Te Hauturu-o-Toi continues to fulfil the ecosystem functions of pollination and seed dispersal that many indigenous forest species depend on (Pattemore & Anderson 2012; Anderson et al 2011).

TBMP forest plots on Te Hauturu-o-toi are located in Kānuka scrub/forest (VS2, 6 plots), Taraire, tawa, broadleaf forest (WF9, 3 plots), Kauri, podocarp, broadleaf, beech forest (WF12, 3 plots), Tawa, kohekohe, rewarewa, hīnau, podocarp forest (WF13, 2 plots), and one plot each of Mānuka, kānuka scrub (VS3), Kauri, podocarp, broadleaf forest (WF11) and the rare for Auckland Kauri, towai, rata, montane podocarp forest (MF25). One forest plot is classified as exotic grassland (EG). Forest on Te Hauturu-o-Toi however, reflects marine influences, not least the impacts of burrowing seabirds that can change plant community structure (Orwin et al 2015).

### Tier 3: Kōkako Management Area, Hunuas

The combined effects of habitat loss, habitat degradation and invasive pests are reported to have had a profound impact on the bird fauna of the Hūnua Ranges (McKenzie 1979). In the 1990s the kōkako population was estimated to have been reduced to 22 males and 1 female bird (Nature Space 2020). In response, the Kōkako Management Area was established on 1500ha of native forest dominated by mature tawa (*Beilschmiedia tawa*), and including northern rātā (*Metrosideros robusta*), rewarewa (*Knightia excelsa*), rimu (*Dacrydium cupressinum*) and tāwheowheo (*Quintinia serrata*). Intensive pest control within the Kōkako Management Area targets rats and possums using 2777 bait stations and a range of trap types to target mustelids and rats. Rat monitoring is used to assess control effectiveness and determine whether targets are met. A series of 1080 drops in 2015, 2018 and 2022 in the Hunuas were highly effective at controlling pest animals. Yearly average control levels were achieved for the 2019-20 reporting year, but rat numbers exceeded targets for the kōkako breeding season (Morrison 2020). Despite that, six pairs of kōkako successfully bred. The Kōkako Management Area is considered to have goats at zero density (boundary and hotspot checks are conducted annually), deer are not in the Hūnua Ranges and there is a buffer control programme to protect the parkland.

The majority of plots in the Kōkako Management Area are in tawa, kohekohe, rewarewa, hīnau, podocarp forest (WF13, 21 plots). The remainder are in taraire, tawa, broadleaf forest (WF9, 5 plots) and kānuka scrub/forest (VS2, 1 plot).

### Tier 3: Ark in the Park, Waitākeres

Ark in the Park is a volunteer based collaborative project with Forest and Bird and Auckland Council. It is an unfenced sanctuary covering approximately 2100ha. The main activities are predator control which started in 2002, and there is a dense network of traps and bait stations run by volunteers to control rats and stoats. In total there are 4780 bait stations and 550 traps, with over 400 volunteers who dedicate more than 10,000 hours to conservation every year. Pigs and possum are also targeted by Auckland Council employed contractors. There have been reintroductions of toutouwai (North Island robin), pōpokatea (whitehead), hihi (stitchbird) and kōkako (North Island kōkako). Volunteers regularly control pest plants in the forest. Weed incidence within intact forest is typically low but incursions are common around borders, tracks and waterways. The main weed targets have been ginger species, bamboo species, woolly nightshade, blackberry and gorse. The Ark in the Park buffer zone includes some 200 neighbouring properties where land-owners are encouraged to control pest animals.

Plots in Ark in the Park are dominated by kauri, podocarp, broadleaf forest (WF11, 14 plots) and kānuka scrub/forest (VS2, 4 plots). There is one plot of mature kauri forest (WF10.1).

### Tier 3: Shakespear Regional Park

A predator proof fence was built around the peninsula in 2011 and pest eradication successfully removed nine of ten target species (Norway rat, ship rat, possum, cat, hedgehog, weasel, stoat, ferret, rabbit) with only mice persisting. New incursions of these pest species are eradicated. Weed control undertaken by Auckland Council and community groups has mostly limited spread. There have been many reintroductions of missing fauna including the kiwi pukupuku (little spotted kiwi), toutouwai (North Island robin), pōpokatea (whitehead), pāteke (brown teal), kākāriki (red-crowned kakariki), tieke (North Island saddleback), takahē (South Island takahe) and Duvaucel's gecko. There have also been natural or assisted natural colonisation by korimako (bellbird), ōi (grey faced petrel), kuaka (diving petrel) and pakahā (fluttering shearwater) and a few individual records of hihi (stitchbird), mātātā (fernbird) and tītīpounamou (rifleman). In addition, a number of extant reptiles have been discovered, the moko skink, shore skink, pacific gecko and forest gecko. Plant reintroductions include pirita (green mistletoe), *Pomaderris hamiltonii*, hinarepe (sand tussock) and *Hibiscus richardsonii*. Revegetation at Shakespear includes 2000-5000 plants per year up until 2010 and then approximately 15,000 plants (1.5ha) per year from 2010 to the present. Plantings have been in retired pasture areas unsuitable for grazing with a focus on increasing the size of key forest remnants.

Shakespear Regional Park plots are dominated by mānuka, kānuka scrub (VS3, 10 plots), pōhutukawa, pūriri broadleaf (WF4, 5 plots) and planted native scrub/forest <20 years old (PL1, 3 plots). One plot is unclassified.

### Tier 3: Tāwharanui Regional Park

A predator proof fence was built around the peninsula in 2004 and pest eradication successfully removed eight of ten target species (Norway rat, ship rat, possum, cat, hedgehog, weasel, stoat and ferret) with only rabbit and mice persisting. New incursions of these pest species are eradicated. Weed control undertaken by Auckland Council and community groups has mostly limited spread, with one weed species eradicated. There have been many reintroductions of missing fauna including the North Island Brown kiwi, toutouwai (North Island robin), pōpokatea (whitehead), pāteke (brown teal), kākāriki (red-crowned kakariki), tieke (North Island saddleback), takahē (South Island takahe), forest, green and Duvaucel's gecko. There have also been natural or assisted natural colonisation by korimako (bellbird), ōi (grey faced petrel), kuaka (diving petrel) and pakahā (fluttering shearwater) and a few individual records of miromiro (tomtit), hihi (stitchbird), titi (cooks petrel) and weka (woodhen). Plant reintroductions include pirita (green mistletoe), *Pomaderris hamiltonii*, hinarepe (sand tussock) and *Hibiscus richardsonii*. Revegetation at Tāwharanui included 2000-5000 plants per year between 2005-2008, and approximately 20,000 plants (2ha) per year from 2008 to the present.

The plots in Tāwharanui are predominately located in pōhutukawa, pūriri broadleaf forest (WF4, 12 plots) and mānuka, kānuka scrub (VS3, 5 plots). There is one plot each of kānuka scrub/forest (VS2) and kauri, podocarp, broadleaf forest (WF11). One plot is unclassified.

### Tier 3: Inner Gulf Islands

Plots in the Inner Gulf Islands represent a diverse range of ecosystem types across four very different islands of Rangitoto, Motutapu, Motuihe and Waiheke.

Rangitoto only formed 600 years ago during a series of volcanic eruptions, as such it is the youngest land mass in the Auckland region. It now forms 2311ha of mostly pōhutukawa scrub forest, reaching 260m in elevation. Uniquely, it has never been permanently inhabited. There have been occasional forest fires, but no official records of logging exist. The island has been goat free since the 1880s and deer free since the 1980s. Brushtail possums and the brush-tailed rock wallabies were eradicated in the 1990s and DOC eradicated all other mammalian pests (rats, cats, stoats, mice, rabbits, and hedgehogs) by 2009. Rangitoto and neighbouring Motutapu, between which there is a land bridge, were declared pest-free in 2011. Following forest regeneration, native species previously not seen on the islands began to arrive on their own, including kākāriki, bellbird, tūi and kākā to join existing species fantail, grey warbler, silvereye and ruru. Translocations of saddleback and whitehead have taken place. Rangitoto forest is dominated by pōhutukawa with a rich diversity of native trees and flowering plants including ferns, orchids, epiphytes and northern rātā. Management interventions have since focussed on removing or controlling weeds (especially maurandya vine, mile a minute, panic veldt grass, boneseed) on the island. The island has a large number of exotic plants, though not all of them are problematic. Control of evergreen buckthorn proved impossible and has been abandoned.

Motutapu, linked to Rangitoto by a land-bridge, has had a very different history. Most of the original forest on the island was removed during Māori occupation and by the eruption of Rangitoto. It was settled by Māori from the 1300s, and the fertile land from ash fall used for horticulture. The removal of pests from Motutapu follows the same timeline as Rangitoto. Restoration, undertaken by the Motutapu Restoration Trust, aims to replant 500ha of forest, or about one third of the island. The remainder is farmed for sheep and beef under a concession recently taken over by Ngāi Tai ki Tāmaki following Treaty settlement in 2018. Weed control is undertaken by the Motutapu Restoration Trust and Motutapu Outdoor Education Centre. Since 2011, a number of native bird species have been translocated to Motutapu, the takahē, tieke and North Island brown kiwi.

Motoihe Island (179ha) has had a long history of Māori and then European settlement. Most of the forest has been removed apart from c.18ha of remnant coastal forest. The island is controlled by DOC and administered by the Motuihe Trust which formed in 2000. Motuihe island was declared mammalian pest free in 2005. The Motuihe Trust has undertaken replanting, weed control and species reintroductions including the red-crowned parakeet, tieke, little spotted kiwi and tuatara. The main weed species on the island are evergreen buckthorn, moth plant and pampas.

Waiheke Island is the second largest island in the Hauraki Gulf after Aotea and is the most densely populated. A large proportion of the land is owned privately. Reserve land is managed by Auckland Council, DOC and Forest and Bird with regular control undertaken against a wide range of weed plants. The island has a plan to become pest free by 2050.

At 15 ha, Ōtata Island is the largest of the Noises island group in Tīkapa Moana / Hauraki Gulf. Ōtata has never been cleared or farmed and has always had some forest cover, though there was a major fire between 1925 and 1931. Forest on Ōtata is dominated by pōhutukawa (*Metrosideros excelsa)*, red matipo *(Myrsine australis),* coastal karamu (*Coprosma macrocarpa)*, karo (*Pittosporum crassifolium)*, houpara (*Pseudopanax lessonii)* and māhoe (*Melicytus ramiflorus)*. Ōtata has had rabbits and stoats, but rabbits died out between 1944-45 and stoats have not been seen since the 1950s. Norway rats arrived on Ōtata around 1956-57. In 1976 the Noises island group became a study site for the Wildlife Service to gather information on the ecology of Norway rats on small islands and to test eradication methods. Six eradication attempts were made, but rats continued to reinvade from nearby Rakino island. The Noises and Rakino island were all declared rodent free (successful eradication of Norway rat) in 2002. The Noises island group, including Ōtata, are an important breeding ground for many seabirds in the Hauraki Gulf. There have been translocations of wetapunga (*Deinacrida heteracantha*) to Ōtata.

The only examples of pōhutukawa scrub/forest (VS1, 5 plots) in the plot network occur on Rangitoto. Other ecosystem types represented are kānuka scrub/forest (VS2, 3 plots), exotic grassland (EG, 2 plots), and one plot each of mānuka, kānuka scrub (VS3), broadleaved species scrub/forest (VS5), pōhutukawa, pūriri broadleaf (WF4), pōhutukawa treeland/flaxland/rockland and native/amenity planting (PL3).

### Tier 3: Glenfern Sanctuary, Aotea

Glenfern started as a private sanctuary in 1994 and was purchased by Auckland Council in 2017. It forms part of the Kotuku Peninsula Sanctuary on the western side of Aotea, together with privately owned and Department of Conservation land. A predator proof fence was built around the peninsula in 2008. Aerial eradication of pests occurred in 2009 with intensive monitoring for incursions. Glenfern sanctuary covers 83ha, most of which is under QEII covenant, and is actively managed with replanting and restoration, bird reintroductions, monitoring of endangered and threatened species (e.g. tāiko (black petrel), tītī (cooks petrel), pāteke (brown teal), kākā, chevron skink), and environmental education.

Historically, much of the area was cleared for agriculture during European settlement, and parts were cleared by fire multiple times during the first few decades of the 20th century and until as recently as 1965 (Perry et al 2010). Since the 1950s it has been gradually reverting to forest. The main forest type is relatively young kānuka scrubland with exotic woody species such as prickly hakea on drier north-facing slopes. Small patches of remnant forest are found in some gullies, kauri pole stands (rickers) are common on ridges and pōhutukawa in coastal areas. Plots on Glenfern are mostly in kānuka scrub/forest (VS2, 15 plots), with one plot in pōhutukawa, pūriri broadleaf (WF4). More information is available from the Glenfern archives on the website, https://www.glenfern.org.nz/archives.

### Tier 3: Windy Hill private sanctuary, Aotea

Windy Hill private sanctuary covers 800ha on the southern part of Aotea, with intensive predator control across 300ha (Ogden & Gilbert 2009) including 6000 trap and bait stations. Weeds are regularly monitored and removed, especially key species (pampas, jasmine, plectranthus, Mexican devilweed, hakea, aristea, pine trees). There is regular monitoring of endangered and threatened species. This community-based restoration project was started in 2000. More information is available on their website (https://www.windyhillsanctuary.nz)

Historically, this land has been partially cleared including multiple times by fire during the first few decades of the 20th century, and as recently as c.1940 (Perry et al 2010). It has since reverted back to relatively young mānuka and kānuka scrubland, with remnant kauri, podocarp, broadleaf forest in gullies, and pōhutukawa forest on cliffs. Permanent forest plots on Glenfern are in kānuka scrub/forest (VS2, 11 plots) and kauri, podocarp, broadleaf forest (WF11, 5 plots).

# Appendix 2: Forest condition scores

| Condition | Score | Description |
|---|---|---|
| Canopy Edge | | Dieback <20m from the site margin. |
| | 1 | 75-100% canopy dieback. |
| | 2 | 50-75% canopy dieback. |
| | 3 | 10-50% canopy dieback. |
| | 4 | <10% canopy dieback. |
| | 5 | No canopy dieback. |
| Canopy Interior | | Dieback >20m from the site margin. Canopy gaps include holes from past human disturbances (logging/clearing/animal) but not natural tree fall events. |
| | 1 | Very sparse foliage or many large canopy gaps or dead crowns that collectively cover >50% of the site. |
| | 2 | Sparse foliage or canopy gaps or dead crowns are common and collectively cover 25-50% of the site. |
| | 3 | Foliage is sparse in some areas, canopy gaps and dead crowns cover 5-25% and are concentrated in one location or geographical feature (e.g. along ridgelines). |
| | 4 | Foliage sparse in some areas, canopy gaps and dead crowns cover 5-25% and are spread throughout the site. |
| | 5 | Foliage mostly dense, only occasional sparse areas. Canopy gaps rare (<5% of site). Abundant dense foliage over whole canopy. |
| Understorey Edge | | Understorey habitat <20m from the site margin. |
| | 1 | Understorey almost completely absent (<5% cover). |
| | 2 | Some (5-25% cover) understorey, occasional seedlings near edge of canopy. |
| | 3 | Average cover (25-50%) of understorey vegetation, including a good density of seedlings near the edge of canopy. |
| | 4 | Considerable (50-75%) understorey, many seedling and saplings near edge of canopy. |
| | 5 | Vigorous, abundant (>75%) understorey extending out from canopy edge. |
| Understorey Interior | | Interior includes habitat >20m from the site margin. Understorey cover is a combination of plant growth in the browse (30cm-2m) and ground (<30cm) tiers. |
| | 1 | Understorey almost completely bare of all species (<5% cover). |
| | 2 | Scattered seedling & sapling regeneration (5-25% cover). |
| | 3 | Moderate seedling & sapling regeneration (25-50% cover). |
| | 4 | Good seedling & sapling regeneration (50-75% cover). |
| | 5 | Vigorous, abundant seedling & sapling regeneration (>75% cover). |
| Fence | | Fencing around site |
| | 1 | No fencing. |
| | 2 | Some fencing but mostly incomplete. |
| | 3 | Most of boundary fenced, but some areas with potential for stock access (due to missing sections or stream access etc.). |
| | 4 | Most of boundary fenced, but some areas with potential for stock access (due to gates allowing access if the site is used as a bush paddock or similar). |
| | 5 | Secure, intact fencing around entire area. |
| Stock | | Stock Access |
| | 1 | Abundant fresh sign (droppings, major tracks, hoof prints) or stock heard/seen throughout (>50% of) site. |
| | 2 | Common fresh sign throughout (>50% of) site, sometimes scattered or occasional stock heard/seen. |
| | 3 | Common fresh sign and animal noise, etc. Restricted to smaller (i.e. <50%) parts of the site, with sign uncommon in the balance of the site. |
| | 4 | Sign uncommon or old. No stock heard/seen. |
| | 5 | No sign. |
| Weed edge | | Total cover of all exotic species around the site margin (within c.20m of the edge). |
| | 1 | Very common, cover >50%. |
| | 2 | Common, 10-50%. |
| | 3 | Occasional 1-10% |
| | 4 | Rare <1%. |
| | 5 | None present. |
| Weed Interior | | Total cover of all exotic species in the 'core' of the site (>20m from the margin). |
| | 1 | Very common, cover >50%. |
| | 2 | Common, 10-50%. |
| | 3 | Occasional 1-10%. |
| | 4 | Rare <1%. |
| | 5 | None present. |
| Animal pests | | Identify presence of feral (i.e. not domestic) animal pests (ungulate, goat, deer, possum, pig, cat, rat, mouse, mustelid, hedgehog, rabbit/hare) and indicate level of pest impact. Record specific pest signs. |
| | 1 | Major impact. |
| | 2 | Moderate impact. |
| | 3 | Minor impact. |
| | 4 | Low impact |
| | 5 | No impact. |
| Represent-ativeness of plot | | Assess the representativeness of the plot in relation to the surrounding vegetation. |
| | 1 | Poor: 50+% of plot area is characterised by vegetation that is a completely different structural class (e.g. forest vs. scrub; forest vs. treeland or pasture) to the majority of the vegetation surrounding the plot (i.e. within c.100m of the plot on all sides). |
| | 2 | Low: 25-50% of the plot area characterised by vegetation that is a completely different structural class to the majority of the vegetation surrounding the plot. |
| | 3 | Medium: 5-25% of the plot area characterised by vegetation that is a completely different structural class to the majority of the vegetation surrounding the plot. |
| | 4 | High: Very similar species composition and structure to surrounding vegetation. |

# Appendix 3: Auckland provisional land cover database update 2023/24 – Methods summary

1. Overview

This section summarises the methodology and key considerations behind the provisional 2023/24 update to the Auckland region's segment of the New Zealand Land Cover Database (LCDB). Since the forthcoming LCDBv6 was not yet available for inclusion in Auckland Council's State of the Environment (SOE) 2025 state and trends reporting, a region-specific update was undertaken to provide a contemporary assessment of land cover.

Auckland Council's Environmental Evaluation and Monitoring Unit (EEMU) carried out this update to better assess land cover change across the region. It provides both a current snapshot of land cover and changes since the previous SOE, thereby supporting relevant themes in the 2025 synthesis report and domain-specific state and trends reports.

It is used to analyse land cover distributions, dominance, and associated pressures, as well as land cover change, and specific indigenous vegetation indicators (cover and change). At domain level, the LCDB supports reporting by serving as a predictor of pressures and drivers of change and categorising sites into broad urban, rural, or indigenous classes at scales ranging from site and plot level to catchments and buffers.

Beyond its regional significance, this update also represents an opportunity to contribute valuable regional input to the national land cover mapping effort, supporting continued improvements in classification accuracy. While developed with the intention of integrating into LCDBv6, the Auckland dataset may not be fully incorporated into the national LCDBv6 update scheduled for release in late 2025. Consequently, analyses based on this dataset may yield different results.

This provisional 2023/24 land cover update for the Auckland region was created using a desktop-based manual mapping approach. Land cover changes since 2018/19 (in LCDBv5) were identified and polygons reclassified (many changes also required delineation) following a 5x5km grid overlaid on the region in ArcPro. This involved visual interpretation of multiple optical imagery sources, including recent Sentinel-2 (2023/24), Maxar (2023), and high-resolution aerial imagery (2023/2024), alongside a Sentinel-based NDVI difference model to highlight potential areas of change.

Identified land cover changes were recorded in a geodatabase structured to mirror the LCDBv5 schema, with additional attributes for the 2023/24 update. Existing LCDBv5 data was used to guide interpretation, ensuring consistency in classification and mapping standards. Polygon delineation in the updated dataset followed the established LCDB specifications (including a minimum mapping unit of 1 hectare and a minimum polygon width of 30 metres) supporting backward compatibility and alignment with national mapping conventions. Land cover features are described by polygon boundaries and a land cover classification for each nominal time step: 1996/97, 2001/02, 2008/09, 2012/13, 2018/19, and now 2023/24.

In undertaking this work, the existing LCDBv5 dataset served as a valuable contextual layer that informed our interpretation and delineation decisions. While the original dataset broadly adheres to published mapping standards, some inconsistencies were observed, particularly in the application of classification rules and spatial delineation, which occasionally posed challenges in maintaining strict alignment with those standards. To support consistency and improve the reliability of long-term land cover change assessments within the Auckland region, targeted classification refinements were applied to previous timestamps (dating back to 1996/97), especially in areas that have undergone significant land cover transitions. These refinements aimed to enhance thematic and spatial coherence across time while remaining faithful to the intent and structure of the national dataset.

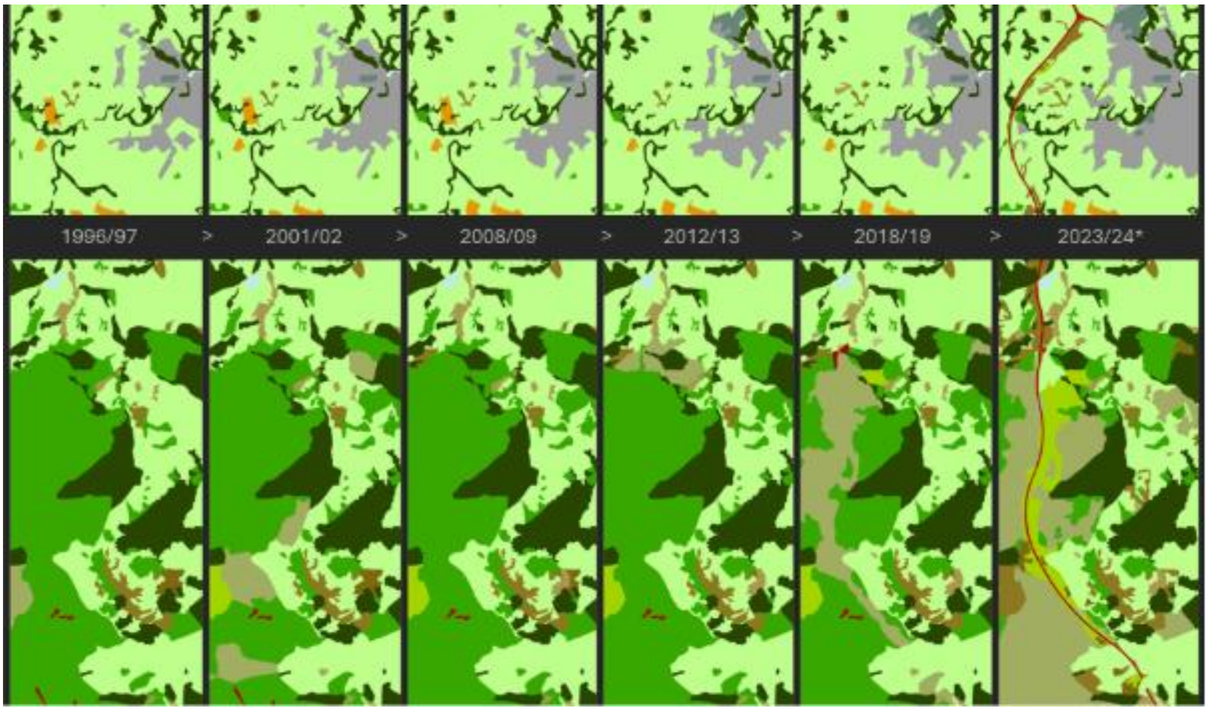



*Figure 1: Progressive changes in land cover mapping are shown across each timestamp in the LCDB. The example above illustrates land cover changes associated with the Puhoi to Warkworth state highway development, Rodney, North Auckland.*

Key findings from the update:

- A comparison between the updated dataset and the original LCDBv5 demonstrates a significant increase in detected land cover changes. Despite adherence to LCDB methodology, the number of detected changes rose to 4,889 for 2018-2023, compared to an average of ~1,000 per period in LCDBv5. This increase may be partially driven by an increase in actual changes, but also due to methodological factors.

- The adoption of a systematic manual mapping approach has resulted in a more consistent application of the national classification schema and spatial scale. While these refinements improve accuracy, they may introduce moderate inconsistencies when compared to the national methodology overall.

This dataset is intended for internal use to inform State of the Environment reporting by providing monitoring site characterisations (at various spatial scales) and change. Independent verification is strongly recommended before applying it in any decision-making processes.

## 2. Update Methodology

### 2.1 Mapping Approach and Data Processing

The 2023/24 land cover update was conducted using a desktop-based manual approach, ensuring consistency with national LCDB methodologies while maintaining backward compatibility, spatial integrity, and adherence to classification schema. Land cover changes were mapped and classified directly into a copy of the LCDBv5 dataset, with new attributes representing 2023/24 applied during processing.

#### 2.1.1 Key methodological components include:

Systematic Grid-Based Manual Change Detection

- Land cover changes were assessed using ArcPro with a split-screen and grid (5x5km search grid), allowing for consistent, detailed visual evaluation across the dataset. Changes were edited manually.

Adherence to LCDB Documentation and Precedent in LCDBv5

- The update followed LCDB classification definitions and mapping scale standards (minimum mapping unit size of 1 ha, polygons greater than 30m wide) as published by MWLR on the LRIS portal in addition to using the LCDBv5 mapping as a guide in when mapping changes under similar conditions
- Classification consistency in the original LCDBv5 for Auckland showed variability, especially in areas undergoing change or with diffuse boundaries. Examples of these inconsistencies include:
  - Transitional Land Cover: The classification of areas undergoing change lacked uniformity. For instance, lifestyle developments within fragmented pasture or forest were inconsistently mapped. A clear density threshold was absent to differentiate between grassland/forest and urban settlement.
  - Low-Density Vegetation: The mapping of sparse indigenous vegetation (e.g., Manuka and/or Kanuka) within pasture landscapes transitioning towards native cover was also inconsistent. Again, clear density thresholds for inclusion were lacking.
  - Shrubland-Forest Transition: The transition between shrub and forest classes was also inconsistently applied, due to subjective interpretation in its classification.
  - Sub-Minimum Mapping Unit polygons: polygons below the 1 ha minimum mapping threshold were present, not only in areas of change but also across broader landscapes.
- Despite variability in methodology over past LCDB versions and regional classification inconsistencies, every effort was made to align with the existing Auckland LCDBv5 dataset while improving classification reliability.

Targeted Classification Refinements

- Minor adjustments were made in historical timestamps where necessary, particularly in areas undergoing significant transformation. For instance, around 160ha of Manuka/Kanuka across Auckland in the LCDBv5 dataset for 2018/19 was corrected in the updated dataset from a misclassification as Exotic Forest – this misclassification likely resulted from the interpretation of the uniform structure of the native revegetation plantings, which can visually resemble exotic conifer plantings – many of these areas have continued to be planted and were detected in the 2023/24 update.

Optical Imagery Sources for Detection and Delineation

- Multiple imagery sources were utilised to support the 2023/24 change detection, delineation, and land cover classification:
  - Sentinel 2023/24 10m RGB mosaic
  - Sentinel-Based NDVI difference model (used for 2018/19-2023/24 change detection)
  - Maxar multi-sensor mosaic (March-April 2023, post-Cyclone Gabrielle)
  - Fine-scale aerial RGB imagery, varying by location:
    - West Coast (Rural): 0.25m resolution, March-May 2024
    - Urban Auckland: 0.075m resolution, February-May 2024
    - Nearmap Image Service (Urban), 2023-2024

- Additional reference imagery sources were used for 2018/19 as the reference set for contemporary change detection, and additional imagery used for comparison with and backdating historical timestamps, including:
  - Maxar WorldView mosaic (2017)
  - Sentinel 2018/19 10m RGB mosaic
  - Auckland historical aerial imagery catalogue (1990-2017), varying in resolution and extent

## 2.2 Comparative Analysis with LCDBv5

### Change Detection Rates Across Timestamps and Versions

A comparison with the original LCDBv5 (clipped to the Auckland region) highlights a marked increase in detected land cover changes. This is defined as polygons with a classification change between two timestamps and does not include polygons that were edited but remained the same class.

- The 2018-2023 change count increased to 4,889 in the update from an average of 1,000 across 1996-2018 in the original LCDBv5, reflecting a significant increase in detected changes.
- Historical change periods in the update also showed an increase to an average of ~1,500 changes, largely due to minor corrections incorporated into the update.
- Although the proportion of change polygons below the 1 ha minimum mapping unit increased in the updated dataset (26% for 1996-2018, compared to 16% in the original LCDBv5 for the same period), the similar tight spread of this proportion across all timestamps in both the

update (8% difference) and original (7% difference) datasets indicates a consistent application of including these smaller changes throughout the respective time series.
- However, the average size of change polygons decreased in the updated periods (6ha 2018-2023, average: 8ha 1996-2018) compared to the original LCDBv5 average before the update (11ha, 1996-2018). The decreasing change polygon size is not unexpected due to continual fragmentation of landscapes undergoing change, however, the above represents a more significant decrease than expected.

Despite adherence to LCDB methodology and precedent set by mapped change polygons in LCDBv5, the methodology used for this update was more comprehensive than previous LCDB iterations, with more consistent identification and delineation of change areas, aided by availability of higher resolution aerial imagery. The precedent set by LCDBv5 also indicated that similar types of changes would have been detected but at a significantly lower rate due to historical methodology constraints.

Whilst methodological improvements and higher-resolution imagery have undoubtedly contributed to the increased detection of change polygons, it is also possible that actual land cover changes during the update period (2018-2023) have increased relative to historical periods (1996-2018) and driven part of the increase. Recognising this interplay is essential to contextualise the observed trends and ensure an accurate interpretation of the dataset changes.

### 2.3 Caveats and Limitations

While quality control measures were employed throughout the update process, the following caveats and limitations must be considered:

- Minimum Mapping Unit: Features smaller than 1 hectare (e.g., narrow riparian strips, small wetlands) may be omitted or generalised, limiting fine-scale analysis.
- "Dominant Cover" Rule: Classification typically reflects the majority land cover, potentially masking significant but sub-dominant features (e.g., scattered wetlands in pasture, areas for transport and infrastructure within built-up urban settlements).
- Challenges in Transitional Areas: Classifying areas with mixed or changing land cover (e.g., fragmented rural-urban fringes, shrub encroachment in pasture) relies on potentially subjective thresholds.
- Temporal Resolution: The 5-7 year intervals between timestamps may not capture rapid or cyclical changes (e.g., forestry harvest cycles) or seasonal variations effectively.
- Change Detection Complexity: Detecting land cover change over time is complex, and errors from past versions can affect current analyses. Gradual changes may also be underestimated.
- Manual Editing and Versioning: Despite protocols to backdate mapping improvements, Inconsistencies can arise due to evolving mapping techniques across LCDB versions, affecting boundary details and complex areas.
- Potential National LCDBv6 Divergence: This regional dataset's alignment with the upcoming national LCDBv6 is not guaranteed, potentially leading to differing analysis results.

- Historical Corrections (Limited): Historical misclassifications were corrected only when coinciding with recent changes, not through a systematic review.
- Recommendation for Independent Verification: Users should validate this dataset independently before critical operational or policy use, as local knowledge may reveal additional nuances.

While this LCDB update provides a valuable wall-to-wall, thematic view of land cover across the Auckland region, users requiring a higher degree of accuracy for specific land cover classes are advised to consult supplementary datasets, such as detailed ecosystem maps. It is important to note that the accuracy of this dataset will naturally vary across different land cover classes and historical timestamps. Apparent recent errors may, in some instances, reflect inconsistencies or limitations inherent in earlier LCDB versions.

### Further information

The Air Land and Biodiversity Team (ALB) within the Environmental Evaluation and Monitoring Unit (EEMU) is well placed to assist with custom data order requests or general enquiries.

The provisional Auckland land cover database update (2023/24) can be made available upon request. If it is not needed prior to mid-2025, we recommend waiting for release of the national LCDBv6 update.

Links to the national Land Cover Database (LCDBv5) and references to national indicators can be found at https://catalogue.data.govt.nz/dataset/land-cover-1996-to-2018

For the full LCDBv5 dataset and documentation, visit https://lris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/

# Appendix 4: Auckland provisional land cover database update 2023/24 – Regional result tables and examples

Table 1: Total area (ha) for LAWA Medium land cover classes and original detailed LCDB classes from the provisional LCDB update for the Auckland region

| Medium Classes (LAWA) | Detailed Land Cover Classes | Total Area (ha) | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1996 | 2001 | 2008 | 2012 | 2018 | 2023 |
| Artificial bare surfaces | Surface Mine or Dump | 581 | 589 | 591 | 629 | 778 | 1,141 |
| | Transport Infrastructure | 882 | 889 | 969 | 1,003 | 1,016 | 1,212 |
| Total | | 1,463 | 1,478 | 1,560 | 1,632 | 1,794 | 2,353 |
| Cropping/horticulture | Orchard, Vineyard or Other Perennial Crop | 2,866 | 2,956 | 3,293 | 3,291 | 3,308 | 4,252 |
| | Short-rotation Cropland | 8,716 | 8,764 | 9,028 | 8,971 | 8,719 | 8,891 |
| Total | | 11,582 | 11,720 | 12,321 | 12,262 | 12,028 | 13,143 |
| Exotic forest | Deciduous Hardwoods | 539 | 543 | 547 | 545 | 542 | 569 |
| | Exotic Forest | 46,620 | 47,383 | 50,049 | 50,496 | 46,022 | 40,244 |
| | Forest - Harvested | 2,390 | 6,032 | 3,526 | 1,552 | 4,961 | 9,504 |
| Total | | 49,550 | 53,958 | 54,122 | 52,594 | 51,525 | 50,317 |
| Exotic grassland | High Producing Exotic Grassland | 241,121 | 235,220 | 231,893 | 231,685 | 229,379 | 218,406 |
| | Low Producing Grassland | 3,358 | 1,997 | 1,803 | 2,322 | 2,721 | 2,501 |
| Total | | 244,478 | 237,217 | 233,696 | 234,007 | 232,100 | 220,907 |
| Exotic scrub/shrubland | Gorse and/or Broom | 1,450 | 1,474 | 1,633 | 1,748 | 1,676 | 2,622 |
| | Mixed Exotic Shrubland | 639 | 638 | 728 | 732 | 719 | 780 |
| Total | | 2,089 | 2,112 | 2,362 | 2,480 | 2,395 | 3,403 |
| Indigenous forest | Broadleaved Indigenous Hardwoods | 15,626 | 15,548 | 15,833 | 16,246 | 16,406 | 17,363 |
| | Indigenous Forest | 63,868 | 63,801 | 63,779 | 63,768 | 63,734 | 63,798 |
| Total | | 79,494 | 79,348 | 79,612 | 80,013 | 80,140 | 81,161 |
| Indigenous scrub/shrubland | Fernland | 7 | 12 | 12 | 12 | 7 | 17 |
| | Mangrove | 8,885 | 8,888 | 8,903 | 8,902 | 8,842 | 9,332 |
| | Manuka and/or Kanuka | 43,597 | 43,822 | 44,006 | 44,196 | 44,599 | 48,633 |
| | Matagouri or Grey Scrub | 20 | 20 | 17 | 17 | 17 | 17 |
| Total | | 52,509 | 52,743 | 52,939 | 53,128 | 53,465 | 57,999 |
| Natural bare/lightly-vegetated surfaces | Gravel or Rock | 110 | 110 | 120 | 120 | 120 | 126 |
| | Landslide | 2 | 2 | 171 | 175 | 189 | 240 |
| | Sand or Gravel | 3,922 | 3,947 | 3,815 | 3,813 | 3,855 | 3,917 |
| Total | | 4,034 | 4,059 | 4,106 | 4,108 | 4,164 | 4,283 |
| Other herbaceous vegetation | Flaxland | 26 | 26 | 26 | 26 | 26 | 54 |
| | Herbaceous Freshwater Vegetation | 1,325 | 1,324 | 1,350 | 1,352 | 1,351 | 1,485 |
| | Herbaceous Saline Vegetation | 2,090 | 2,089 | 2,108 | 2,084 | 2,119 | 2,350 |
| Total | | 3,441 | 3,439 | 3,485 | 3,462 | 3,496 | 3,889 |
| Urban area | Built-up Area (settlement) | 41,357 | 44,231 | 46,046 | 46,449 | 49,091 | 52,741 |
| | Urban Parkland/Open Space | 8,646 | 8,390 | 8,474 | 8,582 | 8,503 | 9,001 |
| Total | | 50,003 | 52,621 | 54,520 | 55,030 | 57,594 | 61,742 |
| Water bodies | Estuarine Open Water | 13,250 | 13,244 | 13,222 | 13,222 | 13,248 | 12,797 |
| | Lake or Pond | 1,274 | 1,228 | 1,235 | 1,241 | 1,266 | 1,270 |
| | River | 157 | 157 | 171 | 171 | 171 | 172 |
| | Not Land | 132 | 132 | 109 | 109 | 73 | 21 |
| Total | | 14,813 | 14,761 | 14,736 | 14,742 | 14,757 | 14,260 |
| **Grand Total** | | **513,457** | **513,457** | **513,457** | **513,457** | **513,457** | **513,458** |

Table 2: Total area (as a percentage of total land area) for LAWA Medium land cover classes and original detailed LCDB classes from the provisional LCDB update for the Auckland region

| Medium Classes (LAWA) | Detailed Land Cover Classes | Percentage of Total Area 1996 | 2001 | 2008 | 2012 | 2018 | 2023 |
|---|---|---|---|---|---|---|---|
| Artificial bare surfaces | Surface Mine or Dump | 0% | 0% | 0% | 0% | 0% | 0% |
| | Transport Infrastructure | 0% | 0% | 0% | 0% | 0% | 0% |
| Total | | 0% | 0% | 0% | 0% | 0% | 0% |
| Cropping/horticulture | Orchard, Vineyard or Other Perennial Crop | 1% | 1% | 1% | 1% | 1% | 1% |
| | Short-rotation Cropland | 2% | 2% | 2% | 2% | 2% | 2% |
| Total | | 2% | 2% | 2% | 2% | 2% | 3% |
| Exotic forest | Deciduous Hardwoods | 0% | 0% | 0% | 0% | 0% | 0% |
| | Exotic Forest | 9% | 9% | 10% | 10% | 9% | 8% |
| | Forest - Harvested | 0% | 1% | 1% | 0% | 1% | 2% |
| Total | | 10% | 11% | 11% | 10% | 10% | 10% |
| Exotic grassland | High Producing Exotic Grassland | 47% | 46% | 45% | 45% | 45% | 43% |
| | Low Producing Grassland | 1% | 0% | 0% | 0% | 1% | 0% |
| Total | | 48% | 46% | 46% | 46% | 45% | 43% |
| Exotic scrub/shrubland | Gorse and/or Broom | 0% | 0% | 0% | 0% | 0% | 1% |
| | Mixed Exotic Shrubland | 0% | 0% | 0% | 0% | 0% | 0% |
| Total | | 0% | 0% | 0% | 0% | 0% | 1% |
| Indigenous forest | Broadleaved Indigenous Hardwoods | 3% | 3% | 3% | 3% | 3% | 3% |
| | Indigenous Forest | 12% | 12% | 12% | 12% | 12% | 12% |
| Total | | 15% | 15% | 16% | 16% | 16% | 16% |
| Indigenous scrub/shrubland | Fernland | 0% | 0% | 0% | 0% | 0% | 0% |
| | Mangrove | 2% | 2% | 2% | 2% | 2% | 2% |
| | Manuka and/or Kanuka | 8% | 9% | 9% | 9% | 9% | 9% |
| | Matagouri or Grey Scrub | 0% | 0% | 0% | 0% | 0% | 0% |
| Total | | 10% | 10% | 10% | 10% | 10% | 11% |
| Natural bare/lightly-vegetated surfaces | Gravel or Rock | 0% | 0% | 0% | 0% | 0% | 0% |
| | Landslide | 0% | 0% | 0% | 0% | 0% | 0% |
| | Sand or Gravel | 1% | 1% | 1% | 1% | 1% | 1% |
| Total | | 1% | 1% | 1% | 1% | 1% | 1% |
| Other herbaceous vegetation | Flaxland | 0% | 0% | 0% | 0% | 0% | 0% |
| | Herbaceous Freshwater Vegetation | 0% | 0% | 0% | 0% | 0% | 0% |
| | Herbaceous Saline Vegetation | 0% | 0% | 0% | 0% | 0% | 0% |
| Total | | 1% | 1% | 1% | 1% | 1% | 1% |
| Urban area | Built-up Area (settlement) | 8% | 9% | 9% | 9% | 10% | 10% |
| | Urban Parkland/Open Space | 2% | 2% | 2% | 2% | 2% | 2% |
| Total | | 10% | 10% | 11% | 11% | 11% | 12% |
| Water bodies | Estuarine Open Water | 3% | 3% | 3% | 3% | 3% | 2% |
| | Lake or Pond | 0% | 0% | 0% | 0% | 0% | 0% |
| | River | 0% | 0% | 0% | 0% | 0% | 0% |
| | Not Land | 0% | 0% | 0% | 0% | 0% | 0% |
| Total | | 3% | 3% | 3% | 3% | 3% | 3% |
| **Grand Total** | | **100%** | **100%** | **100%** | **100%** | **100%** | **100%** |

Table 3: Change area (ha) for LAWA Medium land cover classes and original detailed LCDB classes from the provisional LCDB update for the Auckland region

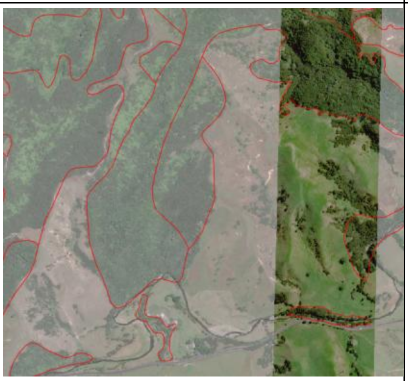
| Medium Classes (LAWA) | Detailed Land Cover Classes | Change in Area (ha) 1996 to 2001 | 2001 to 2008 | 2008 to 2012 | 2012 to 2018 | 2018 to 2023 |
|---|---|---|---|---|---|---|
| Artificial bare surfaces | Surface Mine or Dump | 8 | 1 | 38 | 149 | 362 |
| | Transport Infrastructure | 7 | 80 | 34 | 13 | 196 |
| Total | | 15 | 82 | 72 | 162 | 559 |
| Cropping/horticulture | Orchard, Vineyard or Other Perennial Crop | 90 | 338 | -3 | 18 | 944 |
| | Short-rotation Cropland | 48 | 264 | -57 | -252 | 171 |
| Total | | 138 | 601 | -59 | -234 | 1,115 |
| Exotic forest | Deciduous Hardwoods | 3 | 5 | -2 | -4 | 28 |
| | Exotic Forest | 763 | 2,666 | 447 | -4,474 | -5,778 |
| | Forest - Harvested | 3,642 | -2,507 | -1,974 | 3,409 | 4,543 |
| Total | | 4,408 | 164 | -1,528 | -1,069 | -1,207 |
| Exotic grassland | High Producing Exotic Grassland | -5,901 | -3,327 | -208 | -2,306 | -10,973 |
| | Low Producing Grassland | -1,360 | -194 | 519 | 399 | -220 |
| Total | | -7,261 | -3,521 | 311 | -1,907 | -11,192 |
| Exotic scrub/shrubland | Gorse and/or Broom | 24 | 160 | 115 | -72 | 946 |
| | Mixed Exotic Shrubland | -1 | 90 | 4 | -13 | 61 |
| Total | | 23 | 250 | 118 | -85 | 1,007 |
| Indigenous forest | Broadleaved Indigenous Hardwoods | -78 | 286 | 413 | 160 | 957 |
| | Indigenous Forest | -68 | -22 | -11 | -33 | 64 |
| Total | | -146 | 263 | 402 | 127 | 1,021 |
| Indigenous scrub/shrubland | Fernland | 5 | - | - | -5 | 10 |
| | Mangrove | 4 | 15 | -1 | -60 | 490 |
| | Manuka and/or Kanuka | 225 | 184 | 190 | 403 | 4,034 |
| | Matagouri or Grey Scrub | - | -3 | - | - | - |
| Total | | 235 | 196 | 189 | 338 | 4,534 |
| Natural bare/lightly-vegetated surfaces | Gravel or Rock | - | 10 | - | - | 6 |
| | Landslide | - | 170 | 4 | 14 | 51 |
| | Sand or Gravel | 25 | -132 | -2 | 42 | 63 |
| Total | | 25 | 48 | 1 | 56 | 120 |
| Other herbaceous vegetation | Flaxland | - | - | - | - | 28 |
| | Herbaceous Freshwater Vegetation | -1 | 26 | 2 | -1 | 134 |
| | Herbaceous Saline Vegetation | -1 | 19 | -24 | 35 | 232 |
| Total | | -2 | 45 | -22 | 33 | 394 |
| Urban area | Built-up Area (settlement) | 2,874 | 1,815 | 403 | 2,642 | 3,650 |
| | Urban Parkland/Open Space | -256 | 83 | 108 | -79 | 498 |
| Total | | 2,618 | 1,899 | 511 | 2,564 | 4,148 |
| Water bodies | Estuarine Open Water | -6 | -22 | - | 26 | -451 |
| | Lake or Pond | -46 | 7 | 5 | 25 | 4 |
| | River | - | 14 | - | - | 2 |
| | Not Land | - | -24 | - | -36 | -52 |
| Total | | -52 | -25 | 5 | 15 | -497 |

Table 4: Change area (as a proportion of total class area) for LAWA Medium land cover classes and original detailed LCDB classes from the provisional LCDB update for the Auckland region

| Medium Classes (LAWA) | Detailed Land Cover Classes | Change in Area (%) 1996 to 2001 | 2001 to 2008 | 2008 to 2012 | 2012 to 2018 | 2018 to 2023 |
|---|---|---|---|---|---|---|
| Artificial bare surfaces | Surface Mine or Dump | 1% | 0% | 6% | 24% | 47% |
| | Transport Infrastructure | 1% | 9% | 4% | 1% | 19% |
| Total | | 1% | 6% | 5% | 10% | 31% |
| Cropping/horticulture | Orchard, Vineyard or Other Perennial Crop | 3% | 11% | 0% | 1% | 29% |
| | Short-rotation Cropland | 1% | 3% | -1% | -3% | 2% |
| Total | | 1% | 5% | 0% | -2% | 9% |
| Exotic forest | Deciduous Hardwoods | 1% | 1% | 0% | -1% | 5% |
| | Exotic Forest | 2% | 6% | 1% | -9% | -13% |
| | Forest - Harvested | 152% | -42% | -56% | 220% | 92% |
| Total | | 9% | 0% | -3% | -2% | -2% |
| Exotic grassland | High Producing Exotic Grassland | -2% | -1% | 0% | -1% | -5% |
| | Low Producing Grassland | -41% | -10% | 29% | 17% | -8% |
| Total | | -3% | -1% | 0% | -1% | -5% |
| Exotic scrub/shrubland | Gorse and/or Broom | 2% | 11% | 7% | -4% | 56% |
| | Mixed Exotic Shrubland | 0% | 14% | 0% | -2% | 8% |
| Total | | 1% | 12% | 5% | -3% | 42% |
| Indigenous forest | Broadleaved Indigenous Hardwoods | -1% | 2% | 3% | 1% | 6% |
| | Indigenous Forest | 0% | 0% | 0% | 0% | 0% |
| Total | | 0% | 0% | 1% | 0% | 1% |
| Indigenous scrub/shrubland | Fernland | 80% | 0% | 0% | -44% | 141% |
| | Mangrove | 0% | 0% | 0% | -1% | 6% |
| | Manuka and/or Kanuka | 1% | 0% | 0% | 1% | 9% |
| | Matagouri or Grey Scrub | 0% | -15% | 0% | 0% | 0% |
| Total | | 0% | 0% | 0% | 1% | 8% |
| Natural bare/lightly-vegetated surfaces | Gravel or Rock | 0% | 9% | 0% | 0% | 5% |
| | Landslide | 0% | 11110% | 2% | 8% | 27% |
| | Sand or Gravel | 1% | -3% | 0% | 1% | 2% |
| Total | | 1% | 1% | 0% | 1% | 3% |
| Other herbaceous vegetation | Flaxland | 0% | 0% | 0% | 0% | 107% |
| | Herbaceous Freshwater Vegetation | 0% | 2% | 0% | 0% | 10% |
| | Herbaceous Saline Vegetation | 0% | 1% | -1% | 2% | 11% |
| Total | | 0% | 1% | -1% | 1% | 11% |
| Urban area | Built-up Area (settlement) | 7% | 4% | 1% | 6% | 7% |
| | Urban Parkland/Open Space | -3% | 1% | 1% | -1% | 6% |
| Total | | 5% | 4% | 1% | 5% | 7% |
| Water bodies | Estuarine Open Water | 0% | 0% | 0% | 0% | -3% |
| | Lake or Pond | -4% | 1% | 0% | 2% | 0% |
| | River | 0% | 9% | 0% | 0% | 1% |
| | Not Land | 0% | -18% | 0% | -33% | -71% |
| Total | | 0% | 0% | 0% | 0% | -3% |

## Auckland provisional land cover database update 2023/24 – indigenous forest and scrub/shrubland change examples

| | | |
|---|---|---|
|  |  | Kaipara Flats Rd, Streamlands (Southern slopes Dome Valley Forest)<br><br>Example: planting associated with subdivision of rural production land (conversion: exotic forest to indigenous scrub/shrubland)<br><br>Left: 2018/19 LCDBv5 Outlines, 2014-16 imagery (Northland 0.4m Rural Aerial Photos)<br><br>Right: 2023/24 provisional LCDB outlines, 2024 imagery (Auckland 0.075m Urban Aerial Photos) |
|  |  | Cowan Bay, Pohuehue<br><br>Example: planting associated with subdivision of coastal rural land (conversion: exotic grassland to indigenous scrub/shrubland)<br><br>Left: 2018/19 LCDBv5 Outlines, 2017 imagery (WorldView2)<br><br>Right: 2023/24 provisional LCDB outlines, 2024 imagery (Auckland 0.075m Urban Aerial Photos) |
|  |  | Runciman Road, Ramarama (Pukekohe East)<br><br>Example: riparian planting associated with subdivision of rural countryside living land (conversion: exotic grassland to indigenous scrub/shrubland)<br><br>Left: 2018/19 LCDBv5 Outlines, 2017 imagery (WorldView2)<br><br>Right: 2023/24 provisional LCDB outlines, 2024 imagery (Auckland 0.075m Urban Aerial Photos) |
|  |  | Totara Park, Manukau<br><br>Example: planting associated within local park (conversion: exotic grassland to indigenous scrub/shrubland)<br><br>Left: 2018/19 LCDBv5 Outlines, 2017 imagery (WorldView2)<br><br>Right: 2023/24 provisional LCDB outlines, 2024 imagery (Auckland 0.075m Urban Aerial Photos) |

| | | |
|---|---|---|
|  |  | Motuihe Island, Hauraki Gulf<br><br>Example: planting associated with Department of Conservation estate (conversion: exotic grassland to indigenous scrub/shrubland)<br><br>Left: 2018/19 LCDBv5 Outlines, 2017 imagery (WorldView2)<br><br>Right: 2023/24 provisional LCDB outlines, 2024 imagery (Auckland 0.075m Urban Aerial Photos) |
|  |  | Atiu Regional Park, Tapora<br><br>Example: planting associated with Regional Park (conversion: exotic grassland to indigenous scrub/shrubland)<br><br>Left: 2018/19 LCDBv5 Outlines, 2014-16 (Northland 0.4m Rural Aerial Photos)<br><br>Right: 2023/24 provisional LCDB outlines, 2024 imagery (Auckland 0.075m Urban Aerial Photos) |
|  |  | Kawakawa-Orere Road, Clevedon<br><br>Example: expansion and increase in vegetation cover and density – no clear association with planting activity (conversion: exotic grassland to indigenous scrub/shrubland)<br><br>Left: 2018/19 LCDBv5 Outlines, 2017 imagery (WorldView2)<br><br>Right: 2023/24 provisional LCDB outlines, 2024 imagery (Auckland 0.075m Urban Aerial Photos) |

# Appendix 5: Current ecosystem types Regionally (Tier 1) and by sub-region

| | | Tier1 | | | | Tier 2 | | | | | | Tier3 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Code | Ecosystem name | Regional | Te Wao Nui ā Tiriwa | Te Ngāherehere o Kohukohuui | Aotea | Urban | Te Korowai-o-te-Tonga | Tapora | Shakespear | Tāwharanui | Ark in the Park | Kōkako Management Area | Tamahunga | Motutapu Island | Rangitoto Island | Ōtata Island | Kotuku Peninsula | Windy Hill | Te Hauturu-o-Toi |
| VS1 | Pōhutukawa scrub / forest | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 |
| VS2 | Kānuka scrub / forest | 25 | 2 | 2 | 12 | 2 | 1 | 4 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 15 | 11 | 6 |
| VS3 | Mānuka, kānuka scrub | 2 | 4 | 0 | 0 | 1 | 0 | 0 | 11 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| VS3.2 | Mānuka dominated scrub | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| VS5 | Broadleaved scrub / forest | 3 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| WF4 | Coastal broadleaved forest | 6 | 0 | 0 | 0 | 3 | 0 | 1 | 4 | 12 | 0 | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 |
| WF5 | Dune forest | 12 | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WF7 | Pūriri forest | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WF7.2 | Pūriri, taraire forest | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WF8 | Kahikatea, pukatea forest | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WF9 | Taraire, tawa, podocarp forest | 10 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 12 | 0 | 0 | 0 | 0 | 0 | 3 |
| WF10 | Kauri forest | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WF11 | Kauri, podocarp, broadleaved forest | 27 | 10 | 0 | 5 | 2 | 1 | 2 | 0 | 1 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 |
| WF12 | Kauri, podocarp, broadleaved, beech forest | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| WF13 | Tawa, kohekohe, rewarewa, hīnau podocarp forest | 4 | 1 | 8 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| MF4 | Kahikatea forest | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MF25 | Rimu, tōwai forest | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| MF24 | Kauri, tōwai, rātā, montane podocarp forest | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DN2 | Spinifex, pīngao grassland / sedgeland | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CL1 | Pōhutukawa treeland / flaxland / rockland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| WL1.1 | Gumland heath | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PL | Planted vegetation | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TL | Native and or amenity plantings | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PL.3 | Treeland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| EF | Exotic forest | 8 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ES | Exotic scrub | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| EG | Exotic grassland | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 1 |
| UC | Unclassified | 21 | 0 | 0 | 0 | 3 | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Appendix 6: Threatened, At Risk and Data Deficient species

| Species | National Threat Status | Regional Treat Status |
|---|---|---|
| Agathis australis | At Risk - Declining | At Risk - Declining |
| Alseuosmia quercifolia | | At Risk - Uncommon |
| Archeria racemosa | | Threatened - Endangered |
| Asplenium hookerianum | | Threatened - Vulnerable |
| Astelia fragrans | | Data Deficient |
| Carex breviculmis | | At Risk - Declining |
| Carex ochrosaccus | | At Risk - Declining |
| Carex spinirostris | | At Risk - Relict |
| Carmichaelia australis | At Risk - Declining | At Risk - Declining |
| Ceodes brunoniana | At Risk - Relict | At Risk - Relict |
| Clematis cunninghamii | | At Risk - Declining |
| Clematis foetida | | Data Deficient |
| Clematis forsteri | | At Risk - Uncommon |
| Coprosma crassifolia | | Threatened - Vulnerable |
| Coprosma dodonaeifolia | At Risk - Uncommon | At Risk - Uncommon |
| Coprosma repens | | At Risk - Declining |
| Coprosma rotundifolia | | Threatened - Endangered |
| Corokia cotoneaster | | Threatened - Vulnerable |
| Cyathea cunninghamii | | At Risk - Uncommon |
| Dianella haematica | | At Risk - Declining |
| Dracophyllum sinclairii | | At Risk - Declining |
| Dracophyllum traversii | | At Risk - Uncommon |
| Drosera binata | | At Risk - Declining |
| Echinopogon ovatus | At Risk - Declining | At Risk - Declining |
| Entelea arborescens | | At Risk - Declining |
| Epilobium pallidiflorum | | At Risk - Declining |
| Fuchsia excorticata | | At Risk - Declining |
| Fuscospora truncata | | At Risk - Declining |
| Galium propinquum | | At Risk - Declining |
| Geranium solanderi | At Risk - Declining | Threatened - Vulnerable |
| Gleichenia microphylla | | At Risk - Declining |
| Griselinia littoralis | | Threatened - Endangered |
| Halocarpus kirkii | At Risk - Uncommon | At Risk - Relict |
| Helichrysum lanceolatum | | At Risk - Declining |
| Hydrocotyle heteromeria | | At Risk - Uncommon |
| Hymenophyllum cupressiforme | At Risk - Uncommon | At Risk - Uncommon |
| Hymenophyllum lyallii | | At Risk - Uncommon |
| Hypolepis rufobarbata | | At Risk - Uncommon |
| Ixerba brexioides | | At Risk - Uncommon |
| Kunzea amathicola | At Risk - Declining | Threatened - Vulnerable |
| Kunzea linearis | At Risk - Declining | Threatened - Endangered |
| Lagenophora stipitata | At Risk - Uncommon | Threatened - Vulnerable |
| Lagenophora sublyrata | At Risk - Uncommon | At Risk - Declining |
| Leionema nudum | At Risk - Declining | Threatened - Vulnerable |
| Lepidium oleraceum | Threatened - Endangered | Threatened - Critical |
| Leptolepia novae-zelandiae | | Threatened - Critical |
| Libocedrus plumosa | | At Risk - Declining |
| Litsea calicaris | | At Risk - Declining |

| Species | National Threat Status | Regional Treat Status |
|---|---|---|
| Lophomyrtus bullata | Threatened - Critical | Threatened - Vulnerable |
| Machaerina arthrophylla | | At Risk - Uncommon |
| Machaerina tenax | | At Risk - Declining |
| Melicope simplex | | Threatened - Endangered |
| Melicope ternata | | Threatened - Vulnerable |
| Melicytus macrophyllus | | At Risk - Uncommon |
| Melicytus micranthus | | Threatened - Vulnerable |
| Metrosideros carminea | At Risk - Declining | At Risk - Declining |
| Metrosideros diffusa | | At Risk - Declining |
| Metrosideros excelsa | | At Risk - Declining |
| Metrosideros fulgens | | At Risk - Declining |
| Metrosideros perforata | | At Risk - Declining |
| Metrosideros robusta | At Risk - Declining | At Risk - Declining |
| Metrosideros umbellata | | Threatened - Endangered |
| Mida salicifolia | At Risk - Declining | At Risk - Declining |
| Myoporum laetum | | At Risk - Declining |
| Myrsine divaricata | | Threatened - Vulnerable |
| Myrsine salicina | | At Risk - Declining |
| Nestegis cunninghamii | | Threatened - Endangered |
| Nestegis montana | | Threatened - Vulnerable |
| Olearia allomii | At Risk - Uncommon | Threatened - Vulnerable |
| Olearia solandri | At Risk - Declining | At Risk - Declining |
| Ozothamnus leptophyllus | | At Risk - Declining |
| Paspalum orbiculare | Threatened - Vulnerable | Threatened - Vulnerable |
| Pennantia corymbosa | | Threatened - Endangered |
| Pimelea longifolia | At Risk - Declining | Threatened - Endangered |
| Pittosporum cornifolium | At Risk - Declining | At Risk - Declining |
| Pittosporum ellipticum | At Risk - Uncommon | At Risk - Declining |
| Pittosporum eugenioides | | Data Deficient |
| Pittosporum huttonianum | At Risk - Uncommon | At Risk - Uncommon |
| Pittosporum kirkii | At Risk - Declining | At Risk - Uncommon |
| Pittosporum umbellatum | | At Risk - Declining |
| Planchonella costata | At Risk - Uncommon | Threatened - Vulnerable |
| Poa pusilla | | At Risk - Declining |
| Pomaderris kumeraho | | At Risk - Declining |
| Pseudopanax discolor | At Risk - Declining | At Risk - Uncommon |
| Pseudowintera axillaris | | Threatened - Critical |
| Ptisana salicina | At Risk - Declining | At Risk - Declining |
| Quintinia serrata | | At Risk - Uncommon |
| Raukaua anomalus | | At Risk - Uncommon |
| Raukaua edgerleyi | At Risk - Declining | Threatened - Vulnerable |
| Schizaea dichotoma | At Risk - Uncommon | |
| Senecio diaschides | | At Risk - Declining |
| Sophora fulvida | At Risk - Uncommon | At Risk - Uncommon |
| Sophora microphylla | | Threatened - Vulnerable |
| Stellaria parviflora | | Threatened - Vulnerable |
| Streblus banksii | At Risk - Relict | Threatened - Endangered |
| Syzygium maire | Threatened - Vulnerable | Threatened - Critical |
| Tetragonia tetragonoides | At Risk - Uncommon | Threatened - Endangered |
| Thelymitra aemula | Threatened - Vulnerable | Threatened - Endangered |
| Tmesipteris sigmatifolia | | At Risk - Uncommon |
| Toronia toru | | At Risk - Declining |
| Wahlenbergia violacea | | At Risk - Declining |
| Zoysia pauciflora | | At Risk - Declining |

Find out more:
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