The Forest Ecosystems of Te Kawau Tūmaro ō Tōi

A Baseline Assessment 2025

Craig Simpkins and Ange Chaffe

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Craig Simpkins

Emergent Data Analytics

Ange Chaffe

Environmental Services, Auckland Council

Auckland Council
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Forest monitoring plot, Te Kawau Tūmaro ō Tōi / Kawau Island. Photograph by Andrew Marshall.

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Executive summary

Te Kawau Tūmaro ō Tōi / Kawau Island's forest ecosystems, like many throughout Aotearoa / New Zealand have been severely degraded by introduced mammalian pest species. Though there are several pest mammals on the island, this primarily refers to four surviving species of wallabies introduced by Sir George Grey in the mid- to late-1800s. Te Kaunihera o Tāmaki Makaurau/Auckland Council's Regional Pest Management Plan (RPMP) identifies Te Kawau Tūmaro ō Tōi / Kawau Island as a strategic priority management area, aimed specifically at eradicating wallabies from the island to mitigate the risk they pose to ecosystems and primary industries across the region. The RPMP recognises that removing wallabies alone may cause unintended foodweb impacts and mandates a multi-species eradication programme which aims to remove these species from the island.

Referred to in this report as the pest free Kawau Island programme, the multi-species eradication programme is a collective effort, led by Te Kaunihera o Tāmaki Makaurau/Auckland Council with support of partners the Manuhiri Kaitiaki Charitable Trust and Te Papa Atawhai/Department of Conservation, and in collaboration with members of the community. To enable progressive implementation the programme has been split into two separate stages, the first of which commenced in Autumn 2025 and focuses on wallaby and possum browser removal. The second stage will focus on the removal of the island’s mammalian predators; however, future implementation is subject to feasibility assessment, approvals, community engagement and funding. If successful, the pest free Kawau Island programme would make Kawau the largest permanently inhabited island in Tīkapa Moana / Hauraki Gulf to become free of pest mammals.

A forest monitoring network was established on Te Kawau Tūmaro ō Tōi / Kawau Island and will provide pivotal benefits to the pest free Kawau Island programme. This includes establishing a critical baseline of forest ecological integrity, highlighting current ecological issues, identifying trends associated with programme outcomes and informing adaptive management to improve overall success of the programme. This report describes a baseline snapshot of the current condition of dominant forest ecosystems on the island prior to the implementation of the pest eradication programme.

Overall, it is evident that the browsing pressure from wallabies and other mammalian pests has degraded the forest ecosystems, creating a recruitment bottleneck and arrested forest succession across much of Te Kawau Tūmaro ō Tōi / Kawau Island. The successful eradication of pest mammals shows strong potential to release these forests from their current degraded state. Positive signs, such as high indigenous dominance, high numbers of seedlings, and relatively intact bird communities, suggest a robust chance of forest recovery over time; however, recovery trajectories will likely vary significantly between ecosystem types, with kānuka-dominated areas and exotic forests potentially being slower to diversify than areas with existing broadleaved forest components. In addition, close monitoring of weed species will be essential, as the removal of browsing pressure may allow rapid expansion of exotic plants which are currently suppressed. The baseline data collected through this assessment provides a foundational snapshot of forest ecosystem health on Te Kawau Tūmaro ō Tōi

/ Kawau Island, allowing for future monitoring and adaptive management to ensure successful ecological outcomes from the ‘working towards a pest free Kawau Island’ programme.

Plot remeasures will be required over time to understand the outcomes of the pest free Kawau Island programme. It is recommended that in the short-term remeasures occur every two to three years post eradication to enable emerging pressures to be identified and mitigated; followed by a five-year frequency in the long term. Species-level population monitoring should also be considered to better understand outcomes of the pest free Kawau Island programme on the populations of high-value native species on the island.

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1 Introduction

1.1 Background

The evolutionary history of Aotearoa / New Zealand, particularly its separation from Gondwanaland 65-80 million years ago, led to the development of very unique biota exhibiting high levels of endemism across most taxa groups (Clout & Saunders, 1995). This separation occurred prior to the evolution of mammals, and with the exception of three species of bat, terrestrial fauna in Aotearoa / New Zealand evolved in the absence of mammalian predation pressure. Flightless birds and insects evolved to be larger and occupy niches which would have been filled by mammals elsewhere. The behavioural evolution of these species was influenced by the prevailing need to avoid diurnal avian predators rather than nocturnal mammals (Clout & Russell, 2006; Clout & Saunders, 1995; Russell et al., 2015). Similarly, the dominance of birds influenced the form and distribution of trees and shrubs across the landscape, with plants evolving features to protect them against browsing birds rather than mammals (Clout & Saunders, 1995). These characteristics have made Aotearoa / New Zealand's indigenous (endemic and native) species vulnerable to disturbance and the introduction of exotic species.

The arrival of humans on Aotearoa / New Zealand has drastically changed the natural landscape through ecosystem and species loss, with causal agents generally being hunting, land use change, habitat loss and fragmentation, as well as predation and competition from introduced species (Clout & Russell, 2006; Clout & Saunders, 1995; Craig et al. 2000). When early Māori arrived approximately 1,000 years ago, they brought with them companion dogs (*Canis familiaris*), kiore/pacific rat (*Rattus exulans*) and six food plants (Clout & Russell, 2006; Craig et al. 2000). Though less destructive than more recent introductions, it is thought that kiore/pacific rats are likely to have caused the extinction of various small animals across several taxa groups, including frogs, small flightless birds, and large flightless insects (Clout & Russell, 2006). It is estimated that this first wave of human settlement resulted in the extinction of 26 land and four sea bird species as a direct result of hunting alone, with the extinction of a further eight land birds as a result of ecosystem loss or species introductions (Clout & Russell, 2006; Clout & Saunders, 1995; Craig et al. 2000). During this time, many other species suffered from range contraction or were eliminated from some areas completely.

European arrival in the mid to late 1700s resulted in more rapid ecosystem loss, with timber industries and farming leading to large scale landscape change, effectively reducing the original forest cover from 78 per cent of the country's land area to 53 per cent by 1840 (Clout & Saunders, 1995; Craig et al. 2000). In addition, Europeans introduced over 80 additional vertebrate species, including 34 mammals, some of which have become widespread. Predatory mammals, such as rats (*Rattus spp.*) and cats (*Felis catus*), have had a severe impact on indigenous fauna including those that provide pollination and seed dispersal services.

European settlement also brought several plant introductions, both intentionally and unintentionally. The number of exotic vascular plant species (approximately 30,000 species) now far exceeds the 2,522 indigenous species present in Aotearoa / New Zealand (McAlpine & Howell, 2024; New Zealand

Plant Conservation Network [NZPCN], 2025). At least 2,600 of these exotic species have become naturalised in the wild, with 386 identified as environmental weeds (McAlpine & Howell, 2024). Once invasive, exotic plant species can pose a significant threat to indigenous biodiversity. They effectively outcompete and smother indigenous plant species, suppressing regeneration in the understorey and disrupting natural gap-regenerating processes within indigenous forest ecosystems; ultimately altering habitats and damaging natural ecosystem functions (Craig et al. 2000; Ministry for the Environment [MfE] & Stats NZ, 2025).

This second wave of human settlement has resulted in the loss of at least 12 more indigenous vertebrate species, most of which are birds, with many other indigenous plant and animal species suffering severe declines and range contraction (Clout & Russell, 2006; Craig et al. 2000). Since the deliberate and large-scale destruction of ecosystems and species habitats has largely come to a halt, the impacts of introduced pest species, particularly mammals, remains a significant threat to indigenous biodiversity in Aotearoa / New Zealand (Clout & Saunders, 1995). By 2021, more than 75 per cent of extant indigenous reptile, bird, bat and freshwater fish species were threatened with extinction or at risk of becoming threatened nationally (MfE & Stats NZ, 2025). While regional-level assessments for Tāmaki Makaurau / Auckland (Melzer et al., 2022; Bloxham et al., 2023; Simpkins et al., 2025; Woolly et al., 2023; 2024) indicate that 45 per cent of extant indigenous vascular plants, 100 per cent of extant indigenous reptile and bat species, and 68 per cent of indigenous birds and fish are regionally threatened or at risk[1].

As awareness of the adverse impacts of introduced mammals on indigenous wildlife and ecosystems has risen, conservationists have looked upon various options to enhance ecological restoration and the recovery of vulnerable species and ecosystems in Aotearoa / New Zealand. With the occurrence and influence of mammalian species on indigenous biodiversity now widespread across the mainland, management of this key pressure is largely limited to control; however, offshore islands represent a unique opportunity to achieve significant conservation gains (Horn et al., 2022; Mortimer et al., 1996; Clout & Saunders, 1995). Compared to management interventions on the mainland, conservation efforts on islands generally achieve better results. Islands are easier to defend against reinvasion and often a one-off investment will achieve notable, long-term gains in the enhancement or re-establishment of indigenous biodiversity (Aley & Russell, 2019; Clout & Saunders, 1995; Horn et al., 2022).

The eradication of mammals from island ecosystems in Aotearoa / New Zealand has been occurring for over 100 years. The first recorded eradication was in 1912 with the removal of rabbits (*Oryctolagus cuniculus*) from Ngawhiti Island (5ha) in the Marlborough Sounds, followed by the removal of goats (*Capra hircus*) from South East Island (219ha) of the Chatham Islands in 1915 (Clout & Russell, 2006). In the early years, island eradication programmes focused on large to medium sized mammals; however, technological advances since the 1960s have enabled the removal of smaller mammals, such as rats and mice (Bassett et al., 2016; Clout & Russell, 2006; Clout and Saunders, 1995). By 2015, all introduced mammals, both predators and herbivores, had been successfully eradicated from over

[1] Figures exclude non-resident native or regionally vagrant species.

100 offshore islands: however, progress is slow, with as little as 10 per cent of offshore island area classified as being free of pest mammals (Russell et al., 2015).

1.2 The pest free Kawau Island programme

Kawau is located in Ko te Pataka kai o Tikapa Moana Te Moananui a Toi / Hauraki Gulf Marine Park. The park covers an ocean area of 1.2 million hectares between Mangawhai Heads in the north and Homunga Bay in Waikato, and was established to protect the natural and historic features of Tikapa Moana / Hauraki Gulf. The park includes 30 major island groups and over 400 discrete 'islands', 62 per cent of which are free of pest mammal species (Bassett et al., 2016). Due to their pest mammal free status, these islands have amongst the highest diversities of seabirds in the world and provide refuges for threatened indigenous terrestrial birds, reptiles, invertebrates and plants (Aley & Russell, 2010; Bassett at al., 2016; Gaskin & Rayner 2013).

Previous eradication programmes in Ko te Pataka kai o Tikapa Moana Te Moananui a Toi / Hauraki Gulf Marine Park recognise the adverse impacts pest species have on biodiversity and the positive outcomes their removal can have on indigenous biota. Te Kawau Tūmaro ō Tōi / Kawau Island represents an opportunity to increase the portfolio of predator free islands, both within Tikapa Moana / Hauraki Gulf and across the country as a whole. The proximity of Kawau to sanctuaries, such as Tāwharanui, Shakespear, Tiritiri Matangi and Hauturu-ō-Toi / Little Barrier Island (refer to Section 2.1) further supports the potential for natural reintroduction by indigenous species and overall revitalisation of the Island.

This is reflected in Te Kaunihera o Tāmaki Makaurau/Auckland Council's Regional Pest Management Plan (RPMP) (Auckland Council, 2020) which gives effect to Tāmaki Makaurau / Auckland's Indigenous Biodiversity Strategy (Auckland Council, 2012), in part by identifying strategic priority areas for comprehensive and integrated pest management, particularly in areas of high biodiversity value. Subsequently, Te Kawau Tūmaro ō Tōi / Kawau Island is identified as a priority area under Sections 4.2.3 and 7.3 of the RPMP, with the aim of eradicating the region's only wallaby population from the island to mitigate the risk they pose to ecosystems, both on the island and mainland, as well as primary industries. The RPMP recognises that wallaby eradication alone may prove advantageous for competing pest mammal species on the island and as such mandates a multi-species eradication programme which aims to remove wallabies, possums, rodents (rats/mice) and stoats (if present) from the Island. Not only will the eradication result in ecological and cultural gains, as seen in other sites of significant pest control (Griffiths & Lawrence, 2025), but it will be the largest permanently inhabited island in Tikapa Moana / Hauraki Gulf to become free of pest mammals. This would represent a nationally significant milestone in Aotearoa / New Zealand's bid to be predator free by 2050 (Auckland Council, 2020; Department of Conservation [DOC], 2020; Griffiths & Alach, 2023).

The multi-species eradication programme on Te Kawau Tūmaro ō Tōi / Kawau Island has been split into two separate stages, or projects, to allow for progressive implementation and are subject to their own approval process. The first stage was approved in early 2025 following a feasibility assessment and community engagement, and refers to the focused removal of wallaby and possum browsers from the island. This commenced in May 2025, primarily using ground-based hunting methods supported by thermal drones and trained detection dogs to monitor wallaby and possum occurrence

and distribution. Where monitoring reveals higher wallaby and possum presence, targeted ground-based toxin (1080 and Feratox) application will be used to support the hunting (Auckland Council, 2025).

The first stage is expected to occur over approximately 24 months, starting in the southern half of the island, progressing through to the north, followed by a six-month monitoring period to ensure eradication success. Once this stage is completed, steps will be taken to consider options for the second stage which aims to focus on the removal of mammalian predators. This largely refers to rodents (rats/mice), but may also include stoats if they found to be present[2]. Significant groundwork has already been undertaken for this next stage of the programme; however, feasibility assessment and execution are subject to further approvals, community engagement and funding.

At the time of publication, the eradication programme had yet to be formally named and was operating under the working title 'working towards a pest free Kawau Island' programme. The intention is to work with partners and stakeholders to confirm an official name during summer 2026; however, for the purposes of this report the programme will be referred to as the 'pest free Kawau Island programme'. It is a collective effort, led by Te Kaunihera o Tāmaki Makaurau/Auckland Council with support from partners the Manuhiri Kaitiaki Charitable Trust and Te Papa Atawhai/Department of Conservation (DOC), and in collaboration with members of the community. Funding for the first stage of the programme has been provided through a mix of local and central government funding, as well as a generous contribution of over $802,500[3] from Kawau community residents.

1.3 Monitoring and report purpose

A series of forest monitoring plots were established on Te Kawau Tūmaro ō Tōi / Kawau Island to form a long-term forest monitoring network which aims to provide critical benefits to the pest free Kawau Island programme, including establishing a baseline of forest ecological integrity, identifying trends associated with programme outcomes and informing adaptive management to improve overall success of the programme. The methods associated with this network focus specifically on forest vegetation and bird community structure and composition as a measure of ecosystem health and align with similar networks established throughout Tāmaki Makaurau / Auckland to allow for further comparison.

This report describes initial setup of the forest monitoring network which is designed to deliver on long-term monitoring throughout the life of the pest free Kawau Island programme and beyond. This report analyses novel data collected from 21 permanent forest monitoring plots during network setup in 2024 and 2025. Outputs from this analysis will be used to describe a baseline snapshot of the current condition of dominant forest ecosystems on the island prior to eradication using described ecological indicators as a measure of ecosystem health, providing a benchmark from which future change and outcomes from the programme can be measured.

[2] A predator detection dog survey was undertaken in 2024 to detect the presence of stoats on Te Kawau Tūmaro-ō-Tōi/Kawau Island. While the surveys provided no evidence that suggests stoats are on the island, they may still be present at abundances that are currently below detection.
[3] True sum at the time of publication.

2 Te Kawau Tūmaro ō Tōi / Kawau Island

2.1 Location

Te Kawau Tūmaro ō Tōi (the sentinel cormorant of Toi) or Kawau Island (35.42°S, 174.85°E), referred to as Kawau henceforth, is located in Tikapa Moana / Hauraki Gulf, approximately 48km northeast of Tāmaki Makaurau / Auckland's central business district (CBD). Situated in the Inner Gulf Islands Ecological District, Kawau is within relative proximity to various islands and sanctuaries that are largely free of pest mammals, including Te Kaunihera o Tāmaki Makaurau/Auckland Council's Tāwharanui (1.5km north) and Shakespear (16.0km south) open sanctuaries to the north and south (Figure 1).

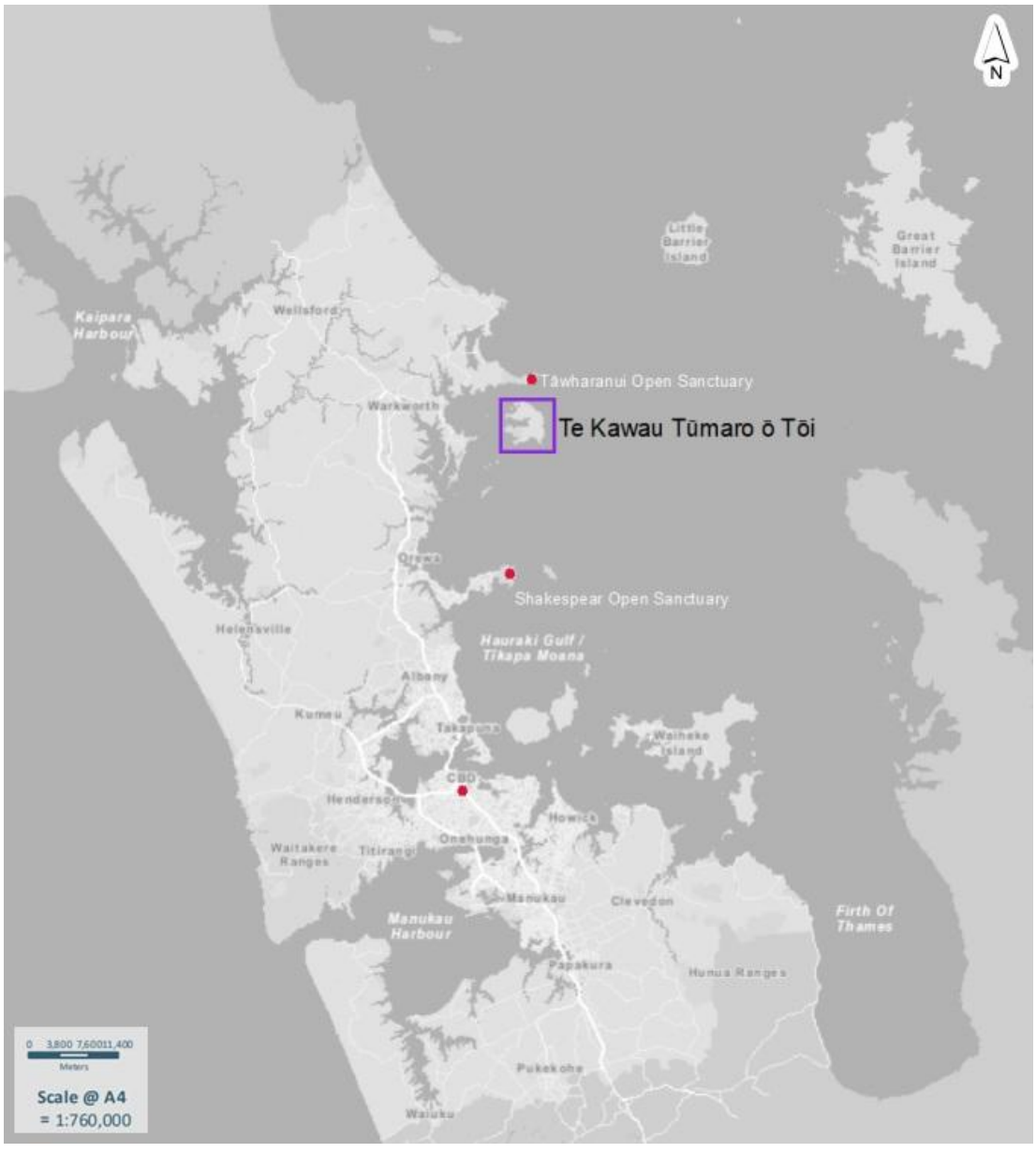

Figure 1: Location of Te Kawau Tūmaro ō Tōi / Kawau Island (purple square) in relation to Auckland CBD, and Tāwharanui and Shakespear open sanctuaries (red dots).

2.2 Physical environment

Kawau covers an area of approximately 2,058 ha. Its topography can be described as hilly to steep, with some relatively flat or gently sloping areas occurring in valleys and at higher elevations (Kalsia et al., 2025). The exposed eastern coast is characterised by steep cliffs, while gentler slopes are present along the more sheltered western coastline (Griffiths & Alach, 2023). The geology is predominantly Waipapa Group greywacke sandstones and argillite, with exposed areas of overlying Waitemata Group sandstone in coastal areas between Mansion House and Bostaquet Bay in the south, and between Vivian Bay and Wells Hill in the northeast (Heron, 2014; Hopgood, 1961). The island has a relatively mild climate, with few extreme conditions, mean monthly temperatures ranging between 15°C in July and 24°C in February, and an annual rainfall of approximately 1,210mm (Griffiths & Alach, 2023).

2.3 History

Kawau has a long history of Māori occupation and is of major significance to Ngāti Manuhiri, with long associations with their Te Kawerau relatives. It is reputed that Kawau was first settled by the early ancestor Toi te Huatahi from whom the island gets its traditional name, followed by descendants of the crews of the Arawa and Tainui canoes. For three centuries the island was occupied by the Ngāti Tai people until their defeat by Te Kawerau iwi, specifically Ngāti Manuhiri, during the battle of Huruhuruwaea in the late 17th century (Griffiths & Alach, 2023; Ngāti Manuhiri & the Crown, 2011).

Kawau was valued for its rich fishing grounds and was an area of conflict during the 18th century as resident Kawerau clashed with iwi of the Marutūahu confederation. Ngāti Manuhiri, however, maintained occupation until the musket war raids led by Ngāpuhi forced them from the island in the 1820s. Kawau remained unoccupied until the 1830s, during which time Ngāti Manuhiri returned to areas adjoining the island (Griffiths & Alach, 2023; Ngāti Manuhiri & the Crown, 2011). After a protracted debate over ownership, Kawau was sold to a W.T. Fairburn on behalf of James Forbes Beattie of the North British Australasian Loan and Investment Company in the 1840s (Griffiths & Alach, 2023). Over the next 18 years the island changed hands several times, supporting industry ventures, including manganese and copper mining, as well as farming, until it was bought by Sir George Grey, the then Governor of New Zealand.

Governor Grey had a grand vision of transforming the island into his concept of an “earthly paradise” and introduced a variety of exotic plants and animal species from his previous postings and elsewhere in the world (Druett, 1983). This included plant species from South America, Japan, India, the Mediterranean and Mauritius. Along with animals, such as emu (*Dromaius novaehollandiae*), cape sheep (*Ovis spp.*), antelopes (*Bovidae*), kangaroos and wallabies (*Macropodidae*), kookaburras (*Dacelo novaeguineae*), possums (*Trichosurus vulpecula*), zebras (*Equus spp.*) and monkeys (*Cebidae*). Some of these failed to establish or were exterminated, but some legacy species, including wallabies, possums and kookaburra, still remain on the island and/or surrounding area.

In 1888, Governor Grey sold Kawau through private sale. The island changed hands several times during subsequent years until it was subdivided in 1910. Currently, 88 per cent of the island is

privately owned, with publicly owned land restricted to relatively small areas in the west of the island and coastal fringes (Griffiths & Alach, 2023; Sutherland & Woolly, 2019). This includes the Kawau Island Historic Reserve in Mansion House Bay managed by DOC and small areas of Te Kaunihera o Tāmaki Makaurau/Auckland Council-owned conservation and coastal esplanade reserve.

2.4 Pest mammals

There are a range of pest mammal species present on Kawau. Many of these were deliberately introduced during Governor Grey's tenure, but others arrived via other means or were self-introduced. The most notable are four species of wallaby: dama (*Notamacropus eugenii eugenii*), parma (*N. parma*), swamp (*Wallabia bicolor*), and brush-tailed rock wallabies (*Petrogale penicillata*); brush-tailed possums, ship rats (*R. rattus*) and Norway rats (*R. norvegicus*). Kiore/pacific rat, mice (*Mus musculus*) and stoats (*Mustela erminea*) may also be present on the island; however, the current status of these species is uncertain (Baber et al., 2008; Griffiths & Alach, 2023; Sutherland & Woolly, 2019). These species have a wide range of ecological impacts on the island including predation of seeds and indigenous fauna, browsing of vegetation and interspecific competition.

The four species of wallaby on the island are perhaps the most influential on island vegetation and generally occupy different niches and areas of the island (Shaw & Pierce, 2002; Wilcox et al., 2004). Dama wallabies, historically recognised as most numerous, particularly in the southern end of the island, and are primarily grazers with grasses being their main diet. Parma and swamp wallabies are now considered prominent island-wide. Like the dama, parma wallabies mainly graze on grasses and herbs, while swamp wallabies are browsers and feed on the leaves of palatable seedlings. Brush-tailed rock wallabies frequent cliff faces and rocky ground on eastern parts of the island, feeding on grasses as well as the leaves of palatable plants.

Possums were once widespread on the island and had a serious impact on canopy trees through the severe defoliation and mortality of palatable species, such as pōhutukawa (*Metrosideros excelsa*). Though possums have been extensively controlled on the island and some trees have been able to recover, the vegetation in some areas of the island are still in relatively poor state as a result (Wilcox et al., 2004). Both possums and rats are known to feed on the fruits, flowers and seeds of palatable indigenous plants species, competing with indigenous birds and insects, and limiting the potential of indigenous regeneration (Brown & Sherley, 2002; Singers, 2023). They also pose a direct threat to indigenous animals and insects through the predation of invertebrates, lizards, eggs, chicks and adult birds, subsequently altering the structure and function of indigenous communities (Brown & Sherley, 2002).

2.5 Environmental weeds

There are a variety of environmental weed species present on Kawau, several of which are also a legacy of Governor Grey and are now widespread across the island. One of the most prominent is bone seed (*Chrysanthemoides monilifera*) which tolerates infertile soils, drought, and salt spray, and produces large numbers of seeds that can be spread by both birds and possums (Wilcox et al., 2004). Other species include honey flower (*Melianthus major*) and sweet pea shrub (*Polygala myrtifolia*) which are common on coastal fringes, agapanthus (*Agapanthus praecox*) along cliffs and in clearings,

stinking iris (*Iris foetidissima*) on the margins of clearings, and arum lily (*Zantedeschia aethiopica*) within wetlands and seeps.

Environmental weeds can smother indigenous vegetation or form large infestations that outcompete indigenous tree species and ground cover plants from establishing. Some of the more common weed species present on the island, such as arum lily and stinking iris, are relatively unpalatable to pest mammalian browsers; however, others, such as buttercup bush (*Senna septemtrionalis*) and climbing dock (*Rumex sagittatus*), are highly palatable to wallabies and are relatively contained as a result (Singers, 2023). Governor Grey also introduced other exotic plant species, such as yellow ginger (*Hedychium flavescens*) and kahili ginger (*H. gardnerianum*), which currently have limited distributions on the island, but are serious and widespread weeds on the mainland (Singers, 2023).

The current composition and distribution of environmental weeds on Kawau indicates that wallabies, in particular, are playing a significant role in suppressing the extent to which weeds occur across the island's landscape. Singers (2023) estimates that wallabies are restricting the spread of at least 50 environmental weed species and found strong evidence to suggest wallabies are currently containing highly invasive species, such as wild ginger and tree privet (*Ligustrum lucidum*), to restricted areas. Release of browsing pressure raises the potential for increases in the abundance and spread of environmental weeds on Kawau, which may in turn act as a source of invasion to other high value areas in and around Tikapa Moana / Hauraki Gulf if the risks are not mitigated.

2.6 Forest ecology

Prior to Māori arrival it is thought that Kawau was covered by a rich mosaic of indigenous forest ecosystems comprised of kauri, podocarp, broadleaved forest (WF11), pōhutukawa-pūriri, broadleaved forest (WF4) and coastal pōhutukawa tree and flaxland (CL1) (Singers et al., 2017; Singers, 2014). It is estimated CL1 ecosystems would have been common on coastal cliffs, with a canopy dominated by pōhutukawa and understories of harakeke/flax (*Phormium tenax*) (CL1). More sheltered areas and gently sloping hillsides would have been comprised of the WF4 ecosystem type, containing a diverse range of broadleaved species including taraire (*Beilschmiedia tarairi*), pūriri (*Vitex lucens*), and kohekohe (*Didymocheton spectablilis*), grading into WF11 ecosystems on more exposed slopes and ridges. This ecosystem type would have contained emergent kauri (*Agathis australis*) and podocarps, such as rimu (*Dacrydium cupressinum*) and tōtara (*Podocarpus totara*), over a broadleaved canopy of taraire, tawa (*B. tawa*) and kohekohe (Singers, 2023). Together these forest ecosystem types (WF4 and WF11) would have dominated most of the island. A pocket of kahikatea-pūriri forest (WF7: Singers et al., 2017) may have also been present in a low-lying area adjacent to Bon Accord Harbour and dominated by pūriri with occasional kahikatea (*D. dacrydioides*), kohekohe and nīkau (*Rhopalostylis sapida*). It is likely these ecosystems would have supported an array of indigenous land-based species, such as kākā (*Nestor meridionalis*), kererū (*Hemiphaga novaeseelandiae*), whitehead (*Mohoua albicilla*), huia (*Heteralocha acutirostris*), saddleback (*Philesturnus* rufusater), tuatara (*Sphenodon punctatus*) and various skinks and geckos (Singers et al., 2017), as well as a variety of seabird species.

Forest cover on Kawau has changed dramatically since the arrival and settlement of humans. Following periods of land use change, including extensive clearance for pasture, much of the original ecosystem coverage has gone. Secondary kānuka (*Kunzea robusta*) forest (VS2) is now the dominant ecosystem type on the island, covering approximately 1,525ha. Areas of exotic forest and residential development are present near the coast, with small pockets of remnant ecosystem types found in the gullies and on coastal edges (Singers, 2014; Singers, 2023). The kānuka forest is relatively even-aged and is the result of regeneration following the cessation of farming around the 1930s (approximately 80-90 years), with a canopy height of 8-14m (Wilcox et al., 2004).

Possums and rats have likely had some impact on the structure and composition of vegetation communities as a result of browse and seed predation; however, wallabies have had the most significant impact on understorey growth and regeneration (Kalsia et al. 2025; Shaw & Pierce, 2002; Singers, 2023), with heavy browsing pressure preventing the regeneration of many naturally occurring tree species. The once diverse understorey is now largely devoid of palatable understorey plant species and it is estimated that hundreds of indigenous plant species have been eliminated from Kawau over the years (Kalsia et al. 2025). Wilcox et al. (2002) noted a clear lack of understorey tiers, particularly in the kānuka forest where the understorey is often dominated by diverse carpets of moss and the occasional bushes of less palatable mingimingi (*Leucopogon fasciculatus* and *Leptocophylla juniperina*) and patches of ponga (*Cyathea dealbata*). Kānuka forest ecosystems across the island have also been found to have lower moisture and organic carbon content than soil in the remnant patches of primary forest (WF4 and WF11); likely as a result of depleted leaf litter inputs and undergrowth associated with wallaby browse (Kalsia et al., 2025; Shaw & Pierce, 2002).

Kawau supports a reduced suite of indigenous animal species, as well as introduced species. This includes more common forest bird species, such as tūī (*Prosthemadera novaeseelandiae*), pīwakawaka/fantail (*Rhipidura fuliginosa*), ruru/morepork (*Ninox novaeseelandiae*), blackbird (*Turdus merula*) and chaffinch (*Fringilla coelebs*). There have been more recent sightings of kākā and kōmako/bellbird (*Anthornis melanura*); however, these are likely visiting from neighbouring Tāwharanui and the establishment on the island is uncertain. Various seabirds, including kororā/little blue penguin (*Eudyptula minor*), petrels and shearwaters (*Puffinus* and *Pterodroma spp.*) have also been observed in coastal and offshore areas around the island (Sutherland & Woolly, 2019).

Kawau is also a nationally important site for North Island weka (*Gallirallus australis greyi*) and supports populations of kiwi-nui/North Island brown kiwi (*Apteryx mantelli*) and Kāruhiruhi/pied shag (*Phalacrocorax varius*). At the time of publication, the island, or parts thereof, were identified as a Biodiversity Focus Area (BFA) for these bird species; as well as threatened plant species including sneezeweed (*Centipeda minima susp. Minima*), adder's tongue (*Ophioglossum coriaceum*) and the herbaceous plant *Lagenophora sublyrata*. BFAs are used by Te Kaunihera o Tāmaki Makaurau/Auckland Council to identify ecologically important sites in the region and aim to guide the protection of their biodiversity values. The BFAs present on Kawau signify the regional importance of the island in maintaining these species and aim to help support restoration and enhancement efforts on the island.

3 Methodology

3.1 Network design

The network design used to establish forest ecosystem monitoring on Kawau was based on the methods underlying Te Kaunihera o Tāmaki Makaurau/Auckland Council's Terrestrial Biodiversity Monitoring Programme (TBMP) which uses a network of unbiased, systematic and spatially stratified permanent 20x20m forest plots to monitor state and trends in forest ecological integrity across Tāmaki Makaurau / Auckland (Griffiths et al., 2021). Although slightly different in its objectives[4], the approach emulates aspects of methods used in the design of the TBMP's Tier 3 outcome monitoring network, including plots in nearby Tāwharanui and Shakespear Open Sanctuaries. There is an assumption that this will allow for comparison with regional TBMP datasets, as well as at the national scale if required.

The number or replication of plots in the monitoring network was based on methods used in the design of the TBMP's existing Tier 3 outcome monitoring network and expert opinion, and adopted a 1x1km grid-based sampling approach to determine how many plots would be required to gain a representative sample of Kawau's land area (2,058ha or 20.5km^2). This identified a minimum requirement of 21 plots to ensure adequate coverage across the island and assumed sufficient statistical power. Plot locations were randomly selected and stratified by ecosystem type. Secondary kānuka scrub/forest (VS2: Singers et al, 2017) is the dominant ecosystem type (1,525ha) (Singers, 2023) on Kawau and by design comprised much of the monitoring network; however, additional weighting was given to rarer warm forest ecosystem types (WF4, WF11 and WF12; refer to **Table 1**) to ensure proportional representation across the network. Plot locations were further constrained by various rules (i.e., a minimum separation distance of 100m between plots) and excluded the cliff pōhutukawa treeland ecosystem type (CL1) due to health and safety risks associated with field sampling (G. Lawrence, personal communications, February 13, 2024). The exotic secondary scrub ecosystem was also excluded due to its composition of predominantly exotic species and relatively low occurrence.

Further adjustments were made to assigned plot locations if landowner permission was unobtainable or due to unforeseen practical access challenges in the field. It is acknowledged that this has the potential to introduce bias and error into the sample design; however, the representation of nominated ecosystem types in the plot network is consistent with their relative current extent (http://www.aucklandcouncil.govt.nz/geospatial/geomaps), so this is considered acceptable and unlikely to influence reporting. The final allocation of monitoring plots across forest ecosystem types on Kawau is provided in **Table 1**.

[4] Te Kaunihera o Tāmaki Makaurau/Auckland Council's TBMP forest network was designed to be spatially representative of the region and targeted study areas, not of the ecosystem types present (Griffiths et al., 2021).

Table 1: Final allocation of forest monitoring plots on Kawau across forest ecosystem types as described in Singers et al. (2017).

Code	Ecosystem type descriptor	Ecosystem area (ha)	No. plots
EF	Exotic forest (>50% exotic species cover in the canopy)	191	2
VS2	Kānuka scrub/forest	1,525	11
WF4	Pōhutukawa, pūriri, broadleaved forest [coastal broadleaved forest]	107	4
WF11	Kauri, podocarp, broadleaved forest	88	3
WF12	Kauri, podocarp, broadleaved, beech forest	13	1
CL1	Pōhutukawa treeland/flaxland/rockland	6	0
ES	Exotic secondary scrub (>50% cover/biomass of exotic species)	7	0

3.2 Plot data collection

3.2.1 Vegetation

Using nationally standardised methods ensures forest monitoring follows best practice and is comparable with forest data across the region and New Zealand (Griffiths et al., 2023). Permanent 20x20m forest plots are widely accepted as the benchmark vegetation plot methodology, with over 45,000 plots recorded nationally (Handford, 2000; McNutt, 2012). Their permanent nature allows the repeated measurement of individuals in the forest overstorey (tree stems) and understorey (saplings, seedlings), enabling estimations of growth, mortality and recruitment within a stand and supporting the long-term monitoring of structural and compositional changes in shrubland and forest ecosystems in New Zealand (Allen, 1993; Hurst et al., 2022; McNutt, 2012). In this instance, the 20x20m permanent plot method, along with accompanying bird count data, aims to enable the assessment of short-term changes in understorey forest tiers and bird communities in response to pest mammalian browser and predator species removal, as well as longer-term changes in forest structure, dynamics, and overall ecological integrity.

All plots were sampled in October and November 2023 and 2024[5] in accordance with the standardised 20x20m permanent plot method (Hurst et al., 2022), with inclusion of TBMP protocol adaptations (Griffiths et al., 2021). Once located, plots were laid out in a quadrat 20×20m square and subdivided into 16 5x5m sublots by measuring tapes (Figure 2). Plots were established with the 'P' and 'M' boundary following the predominant slope contour, unless on flat terrain. In which case, the 'P' and 'M' boundary was established lying north to south. Plot corners (A, D, M, P) and understorey subplots (1 – 24) were permanently marked with aluminium stakes to enable future relocation and measure.

[5] This time period was selected to align with Te Kaunihera o Tāmaki Makaurau/Auckland Council's TBMP forest monitoring season and to avoid disruption to visitors during the peak summer season.

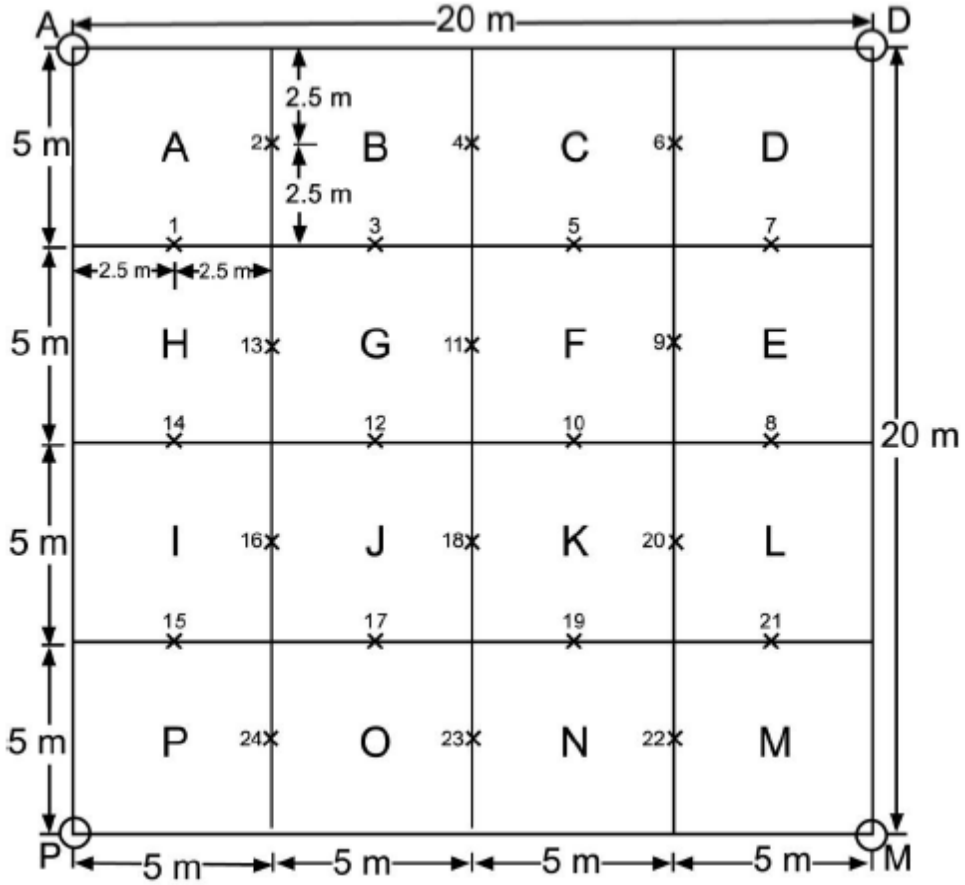

Figure 2: Layout of permanent 20x20m plot showing location of tapes, corner pegs (A, D, M, P), 5x5m subplots (A-P) and understory subplots (1 – 24) (Hurst et al., 2022).

Subplots 'A' through 'P' (Figure 2) were sampled systematically, recording tree stem and sapling data. Tree stem data can be used for a variety of analyses, including providing information on the size structure of tree species and calculations of recruitment, growth, and mortality (Hurst et al., 2022). All tree stems (≥2.5cm DBH) and tree ferns (stem ≥1.35m tall) were identified, tagged and the diameter at breast height (DBH; 1.35m) measured. Sapling data provides information on the regeneration of tree and shrub species. All woody saplings (1.35m tall but <2.5cm DBH) and tree fern saplings (stem <1.35m tall, fronds >1.35m) were identified and counted.

Seedling data provides an indication of recruitment potential, as well as structural changes in understorey vegetation, and is collected from 24 circular plots (49cm radius or 0.75 m^2); labelled 1 to 24; refer to Figure 2. All woody seedlings <15cm tall were identified and recorded as 'present' only, forgoing other measurements. While larger woody species and tree ferns seedlings were identified and counted according to four height classes: 16–45cm, 46–75cm, 76–105cm and 106–135cm. Nonwoody species were recorded as present in each of the five height tiers in which the occurred.

Site access notes and metadata, including reconnaissance (recce) site descriptions (Allen, 1992; Hurst et al., 2022), were recorded for each plot. Additional vegetation data was also collected, including the presence of weed species, vines, climbers and lianes, non-woody species, and any additional species not recorded elsewhere in the data.

3.2.2 Birds

Bird monitoring data provides information on forest bird population trends, including changes in community composition and abundance. Three 10-minute bird counts (10MBC) were undertaken at the 'P' corner of each of the 21 permanent 20x20m plots (Figure 2). Sampling occurred during vegetation data collection in accordance with the TBMP methodologies (Landers et al., 2021) and following standardised methods (Dawson & Bull, 1975; Hartley, 2012; MacLeod et al., 2012).

Observers maintained two minutes of silence prior to each count and then, standing in a stationary position, recorded all bird species seen and heard. These were recorded according to seven horizontal radial distance classes: 0-10m, 11-20m, 21-40m, 41-60m, 61-100m, 101-150m and ≥151m, and one class for individuals observed flying overhead. During the first five-minute period of the 10MBC, observers recorded all individuals detected. During the second five-minute period (minutes six to 10), observers recorded only new bird species not previously detected in the initial five minutes. No individual bird was knowingly counted twice. All counts were undertaken by personnel experienced in bird species identification and were completed a minimum of one hour apart between 0700 and 1300 hours, during settled weather.

3.3 Indicators of ecological integrity

Ecological integrity is the integrating concept underpinning DOC's Biodiversity Assessment Framework (Lee et al., 2005), as well as objectives 1, 6 and 7 of Tāmaki Makaurau / Auckland's Indigenous Biodiversity Strategy (Auckland Council, 2012), and is described in the Environmental Reporting Act 2015 as "the full potential of indigenous biotic and abiotic features and natural processes, functioning in sustainable communities, habitats, and landscapes" (McGlone et al., 2020). Definitions of ecological integrity based on community ecology are related to the concept of biodiversity and refers to the variability among living organisms and the ecological complexes which they are part of. It often refers to the extent of deviation from a prehuman natural reference state; however, biodiversity and hence ecological integrity in the Aotearoa / New Zealand context has been subject to intensive land use, habitat modification and extinctions meaning this state is unattainable (Lee et al., 2005; McGlone et al., 2020; Schallenberg et al, 2011).

Lee et al. (2005) suggest ecological integrity exists when all the indigenous plants and animals typical of a region are present along with the key ecosystem processes that help sustain the functional links between all components. This would suggest an ecosystem is impaired if the species that should be present are absent; however, ecological integrity is scale sensitive (Lee et al., 2005; McGlone et al., 2020). It is unlikely that all species typical of a region will be detected, or even present, at smaller spatial scales. In this sense, McGlone et al. (2020) argues that good ecological integrity exists at smaller scales when indigenous biota typical of a region dominates sustainable, healthy ecosystems.

Describing ecological integrity as a component of ecosystem health is inherently difficult due to the complexity of interactions occurring between an ecosystem's living and non-living components. As a result, ecological practitioners often resort to the use of more easily interpreted surrogates, or indicators, which look to separate key aspects of an ecosystem from an overwhelming array of

potential descriptors (Niemi & McDonald, 2004). Niemi and McDonald (2004) define ecological indicators as: the measurable characteristics of the structure (e.g., habitat and spatial arrangement), composition (e.g., species and communities), or function (e.g., ecosystem and disturbance processes) of ecological systems. Ecological indicators are commonly used to monitor and report on changes in ecological integrity and the pressures affecting biological communities. They help to present complex ecosystem information in a more simplified way and are useful for communicating changes in the state, or condition, of ecosystems to a wider audience.

A set of ecological indicators have been used in this report to describe the state of forest ecosystems on Kawau (Table 2). They are described in terms of the positive conservation outcomes which may be expected as a result of the pest free Kawau Island programme and may be used as a base for future reporting.

Table 2: List of ecological indicators used to measure the baseline state of forest ecosystems on Kawau.

Outcome	Ecological indicator	Measure
Restore forest habitat	Forest ecosystem composition	Canopy and understory species richness and abundance, grouped by age classes
		Plant species occurrences
		Species richness and abundance of plant species with known conservation statuses
	Vegetation structure	Size-class distribution of mature trees and seedlings
	Indigenous plant dominance	Proportion of indigenous versus exotic plant species richness and abundance, grouped by age classes
	Vegetation functional diversity	Proportion of woody versus non-woody species abundance, grouped by age classes
		Proportion and density of palatable plants, grouped by age classes
		Proportion of flammable plant species
Reduce exotic and weed species	Pest plant distribution	Listed pest plant species occurrences and frequency
	Pest plant dominance	Proportion of weed, exotic, and indigenous species abundance
		Density of weed, exotic, and indigenous species, grouped by age classes
Maintain and restore forest bird species	Bird community composition	Bird species richness and abundance
		Bird species occurrences
		Species richness and abundance of bird species with known conservation statuses
		Bird species densities
	Indigenous bird dominance	Proportion of indigenous versus exotic bird species richness and abundance
	Bird functional guild structure	Proportion of bird species and abundance within each foraging guild
		Proportion of bird species and abundance within each habitat guild

3.4 Data analysis

Both vegetation and bird data were analysed at varying spatial scales from plot level to the entirety of Kawau; however, the primary scale of analysis was at the ecosystem level. To facilitate statistical analyses and comparisons, the single WF12 (Kauri, podocarp, broadleaved, beech forest) plot was grouped with the WF11 (Kauri, podocarp, broadleaved forest) plots (Singers et al., 2017). The data collected for all plants was grouped into the three age classes described in Section 2.2.1. (seedlings, saplings, and mature trees), with any tree stems greater than 1.35m in height but missing DBH measures assumed to be saplings. Bird observations were filtered to only include forest species, thus excluding recorded observations of matuku moana/white-faced heron (*Egretta novaehollandiae*), tōrea pango/variable oystercatcher (*Haematopus unicolor*), and karoro/southern black-backed gull (*Larus dominicanus*).

Plant and bird data were further grouped into subcategories to describe compositional attributes. Both plant and bird species were classified based on their regional conservation status (Simpkins et al., 2025; Woolly et al., 2024), as well as whether the species is classified as endemic or native (indigenous), or exotic. Birds were also classified based on their habitat and foraging guilds to allow for clearer understanding on community composition (Binny et al., 2020; O'Donnell & Dilks, 1994). Lists of plants and birds encountered during monitoring are provided in Appendix B.

Plant species were classified according to positional classes: either canopy (i.e., emergent trees and species typically forming the top of layer of the forest canopy, such as large podocarps) or sub-canopy species (i.e., smaller trees, shrubs and ferns, which when mature form the layer of vegetation below the main canopy, as well as groundcover species, within the mid or understorey), based on their typical position in the forest when mature. This classification is independent of whether an individual is currently fulfilling that positional role in forest structure. For example, a kauri (*Agathis australis*) seedling is classed as a canopy species independent of its size or the size of surrounding plants. For the purposes of analysis kānuka is considered a sub-canopy species.

Plant species were additionally grouped as being a listed pest species (weeds) in the RPMP (Auckland Council, 2020), as either woody or non-woody based on the species structural class (refer to Table B.1) and where applicable, were also classified of low, moderate, or high palatability to browsing mammals when data was available. As there are limited data available on the palatability of Aotearoa / New Zealand plant species, particularly for wallabies, data for wallabies, possums and ungulates were combined to give a single palatability value (DOC, 2014; Forsyth et al., 2002; Sweetapple, 2002; Sweetapple and Burns, 2002; Wright and Ranger, 2017). In most instances, combined values were based on the highest known palatability identified across the three mammal species and stated as the reported palatability rating of the given plant species. In others, a mid-range (i.e., moderate) value was selected to account for preferential differences between browsing species. Lastly, plants were classified as high, moderate, or low flammability (Fire and Emergency New Zealand [FENZ], 2025).

Species richness was calculated for both plants and birds as the sum of the unique species which had at least one observed presence or count at the scale of interest. Abundance was calculated as the sum of counts for all unique species at the scale of interest. For cases where only presence was

recorded, a count of one was assumed. This produces a conservative estimate of counts producing abundance estimates at the lower end of probability.

Plant and bird species occupancy was calculated as the number of plots in which at least one observed presence or count occurred. The frequency of observation was calculated, for plants only, as the mean ratio of the number of subplots in which a plant was observed over the total number of subplots within a plot.

Plant species densities were calculated separately for each age class due to the differences in sapling area. Density was calculated as:

$$D = \frac{\sum N_s}{A}$$

Where D is the density in individuals per metre squared, N_s is the total number of individual plants of species s, and A is the total area sampled, 400m^2 for mature trees and saplings and 18m^2 for seedlings.

As the area of detectability for birds could only be estimated, along with the unknown differences in detectability of each bird species, a distance sampling modelling methodology was implemented (Newson et al., 2008). The distance sampling was implemented using the Distance package in R (Miller et al., 2019; R Core Team, 2024). This method accounts for imperfect detection by modelling the probability of observing an individual as a function of the estimated distance from the observer. The probability of observing an individual was modelled as a hazard-rate model which was fit to the observed distances to estimate the mean probability of detection. Density was calculated as:

$$\overline{D} = \frac{n}{A \times \overline{P_a}}$$

Where $\overline{D}$ is the estimated mean density in individuals per metre squared, n is the count of detected individuals, A is the estimated area surveyed based on estimated distances of counts and $\overline{P_a}$ is the mean probability of detection. This approach assumes that all individuals are detected at distance zero and that all individuals are only detected at their initial location before any subsequent movement in response to the observer. Due to this modelling approach birds with less than five total observations were excluded from the analysis.

Significance testing was conducted on key metrics using one-way analysis of variance (ANOVA), where possible. The assumptions for ANOVA were checked for all data and any data failing these assumptions were transformed as required. If transformations were not able to fulfil the ANOVA assumptions, a non-parametric Kruskal-Wallis test was run. A significance value of $\alpha = 0.05$ was used for all tests. In cases of significance, a Tukey HSD or a Dunn's test were conducted as post-hoc tests to determine significant factor pairs for the ANOVA and Kruskal-Wallis tests respectively. All statistical tests and analyses were conducted using R v.4.4.2 (R Core Team, 2024).

4 Results

4.1 Forest condition and structure

A total of 4,816 individual plants were recorded across all plots, consisting of 167 species. The majority (48 per cent) of these species were endemic, with approximately a quarter (23 per cent) of all species being exotic; making up less than 10 per cent of all plants counted (Table 3). Most of the endemic and native species (65 per cent) were not threatened regionally, with only 11 per cent of species (comprising 41 per cent of the total count) being classified as at risk or greater and one species, poroporo (*Solanum aviculare*), identified as regionally critical (Simpkins et al., 2025). The top 10 most abundant recorded species were all endemic or native, with the most common species being kānuka with 1,213 individuals recorded. The most abundant exotic species was Scotch thistle (*Cirsium vulgare*) as the 14th most abundant species, making up approximately one per cent of all counts (Table 5).

Table 3: Status of vegetation species recorded at the 21 permanent 20x20m plots across Kawau.

Status	Species richness	Proportion of total species	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
Endemic	80	0.48	3,537	0.73	8.58 ± 0.93
Native	48	0.29	875	0.18	3.92 ± 0.46
Exotic	39	0.23	404	0.08	2.91 ± 0.37

Table 4: Regional conservation status (Simpkins et al., 2025) of indigenous (endemic and native) vegetation species recorded at the 21 permanent 20x20m plots across Kawau.

Conservation status	Species richness	Proportion of total species	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
Not threatened	108	0.65	2,426	0.50	4.65 ± 0.42
At risk	13	0.08	1,907	0.40	18.51 ± 2.99
Threatened	4	0.02	71	0.01	14.20 ± 11.53
Regionally critical	1	0.01	4	0.00	4.00
Data deficient	2	0.01	4	0.00	1.00

Table 5: **Abundance of the 20 most abundant vegetation species recorded across all permanent 20x20m plots on Kawau. Bold** indicates exotic species. * indicates listed pest species in the Auckland Regional Pest Management Plan (RPMP) (Auckland Council, 2020). See Appendix A for all recorded species.

Scientific name	Common name	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
Kunzea robusta	Kānuka	1213	0.25	63.84 ± 9.88
Cyathea dealbata	Ponga	625	0.13	32.89 ± 6.99
Lagenophora sublyrata	Lagenophora	262	0.05	13.79 ± 2.07
Metrosideros perforata	Akatea	248	0.05	31.00 ± 8.22
Oplismenus hirtellus imbecillis	Basket grass	184	0.04	10.22 ± 2.14
Myrsine australis	Red māpou	151	0.03	7.55 ± 2.19
Microlaena stipoides	Meadow rice grass	135	0.03	11.25 ± 4.18
Beilschmiedia tarairi	Taraire	105	0.02	8.75 ± 2.71
Leucopogon fasciculatus	Mingimingi	85	0.02	5.00 ± 1.58
Veronica plebeia	Speedwell	74	0.02	4.11 ± 0.91
Leptospermum scoparium	Mānuka	68	0.01	34.00 ± 26.00
Schoenus tendo	Kauri sedge	66	0.01	16.50 ± 5.92
Senecio diaschides	Fireweed	61	0.01	5.08 ± 1.90
Cirsium vulgare	**Scotch thistle**	59	0.01	4.54 ± 2.41
Leptecophylla juniperina	Prickly mingimingi	56	0.01	5.60 ± 2.25
Microsorum scandens	Mokimoki/Fragrant fern	54	0.01	7.71 ± 3.13
Pinus radiata	**Radiata pine**	50	0.01	12.50 ± 6.09
Gonocarpus incanus	Piripiri	44	0.01	6.29 ± 1.36
Acianthus sinclairii	Heart-leaved orchid	41	0.01	3.15 ± 1.13
Chrysanthemoides monilifera*	**Boneseed**	40	0.01	2.86 ± 0.64

The most widely observed plant species was red māpou (*Mysine australis*), present at all but one plot (Figure 3a), despite having a somewhat moderate abundance. The two most abundant plant species (kānuka and ponga respectively; refer to Table 5) were widely dispersed, each occurring at 19 out of the 21 plots. Boneseed, a listed pest plant species in Tāmaki Makaurau / Auckland's RPMP (Auckland Council, 2020), while only having 40 total observations was fairly widely distributed across plots, being present at 14 out of the 21 plots. Interestingly, while having a relatively high abundance akatea (*Metrosideros perforata*) was only observed at eight plots, indicating a higher density, but lower distribution structure. The opposite was true for rewarewa (*Knightia excelsa*), which had a low total abundance but was observed at 11 of the 21 plots. The herbaceous (non-woody) Lagenophora (*Lagenophora sublyrata*), a highly abundant species, was also widely dispersed, being observed at 19 plots (Figure 3b). This same wide dispersal for relatively high abundance non-woody plants was seen by both basket grass (*Oplismenus hirtellus imbecillis*) and speedwell (*Veronica plebeia*), with both observed at 18 plots.

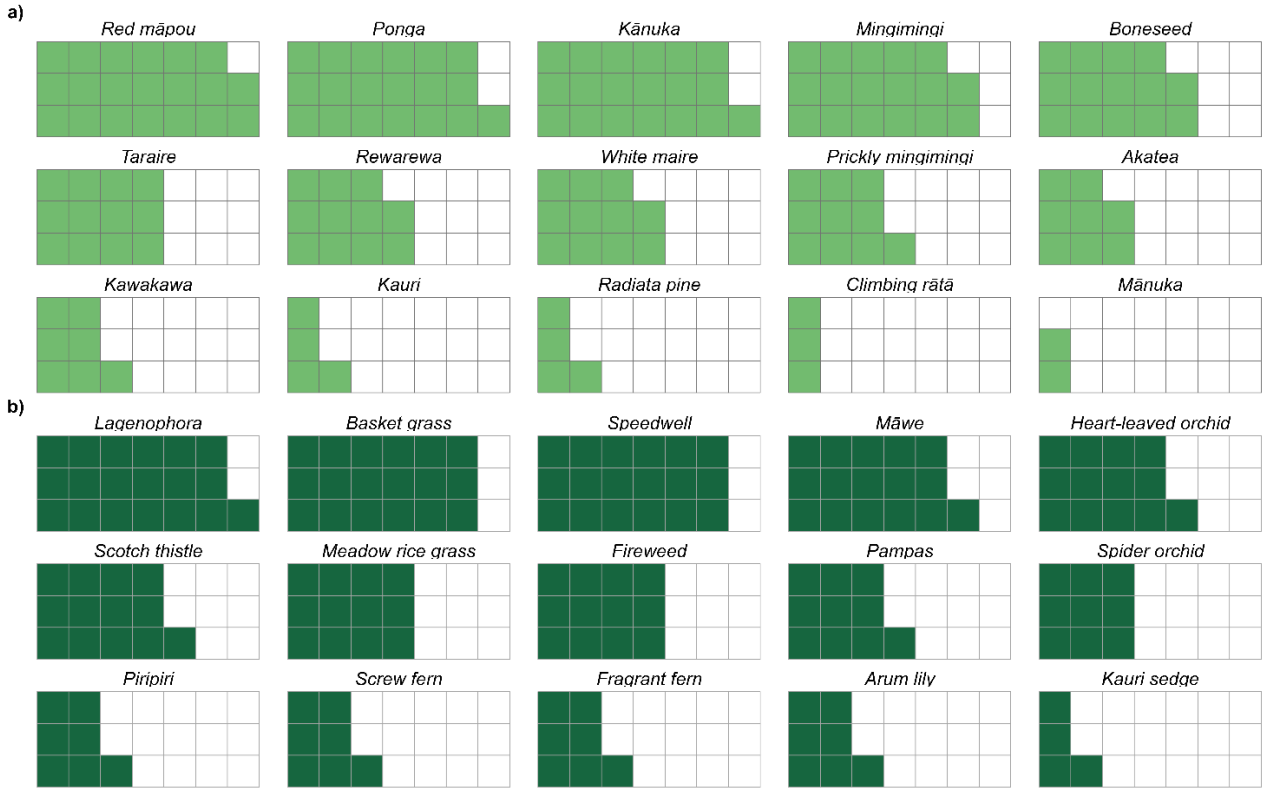

Figure 3: Occurrences of the most dispersed woody and non-woody (herbaceous) vegetation species across the 21 permanent 20x20m plots on Kawau. Each square represents a single plot with a filled square indicating a species was present at that plot: a) woody species (light green), b) non-woody species (dark green).

In general, there was no large difference in the species richness observed between ecosystem types. This was true for both canopy species and sub-canopy species recorded in the mature tree and sapling classes, noting that positional class is defined as a species-specific trait not a functional trait of the sampled individual[6] (Figure 4). While there was no significant difference in the number of canopy species occurring in the seedling class between ecosystem types, there was a significantly higher number of sub-canopy species in the seedling class in the VS2 (Kānuka scrub/forest) ecosystem type compared to the other ecosystem types.

[6] Canopy species refers to tree species, which once mature form the uppermost layer (canopy) of forest ecosystems. Sub-canopy species refers to small tree and shrubs species that generally form the layer of vegetation below the main canopy; as well as lower lying/groundcover species, such as ferns, sedges and herbs.

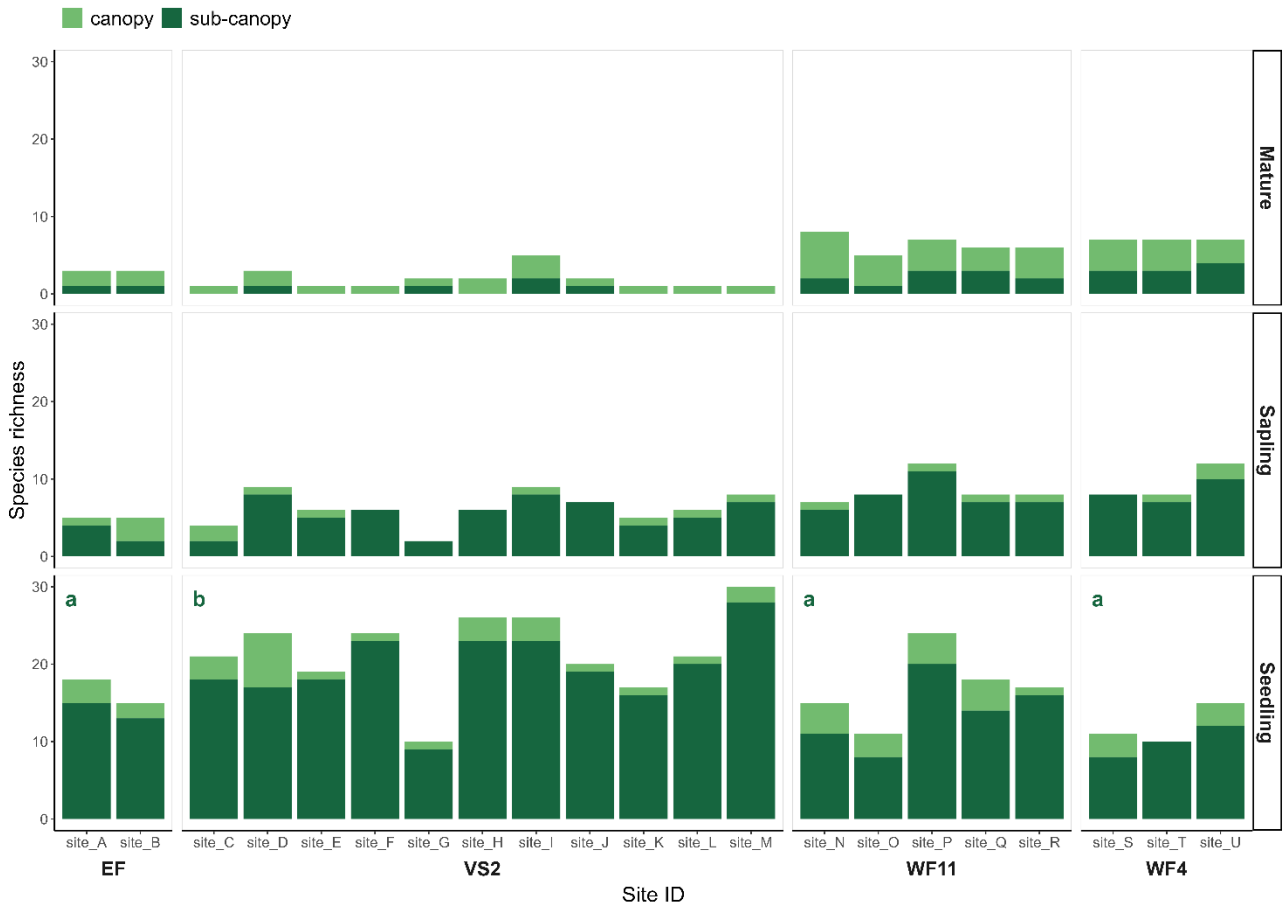

Figure 4: Number of vegetation species recorded at each permanent 20x20m plot on Kawau across the three age classes (seedling, sapling, mature trees) and two positional classes (canopy and sub-canopy), grouped by ecosystem type. The lowercase letters in the seedling panel indicate significant differences in sub-canopy species between the ecosystem types. No significant differences were found for sapling and mature age classes, or for any age class for canopy species.

Clear differences in the proportion of indigenous species richness were observed between the different ecosystem types (Figure 5), with WF11 (Kauri, podocarp, broadleaved forest) and WF4 (Coastal broadleaved forest) having significantly higher proportions of indigenous (endemic and native) species in the sapling age class compared to the other ecosystem types. VS2 sites, in particular, had a high proportion of exotic species in the sapling age class, with most of these sites recording greater than 50% of all species as exotic. In the mature tree age class, all ecosystem types had complete indigenous dominance except for EF (exotic forest) in which radiata pine (*Pinus radiata*) was present, representing a third of the total species richness across this age class in EF ecosystems. No statistically significant differences in indigenous dominance were observed in the seedlings age class.

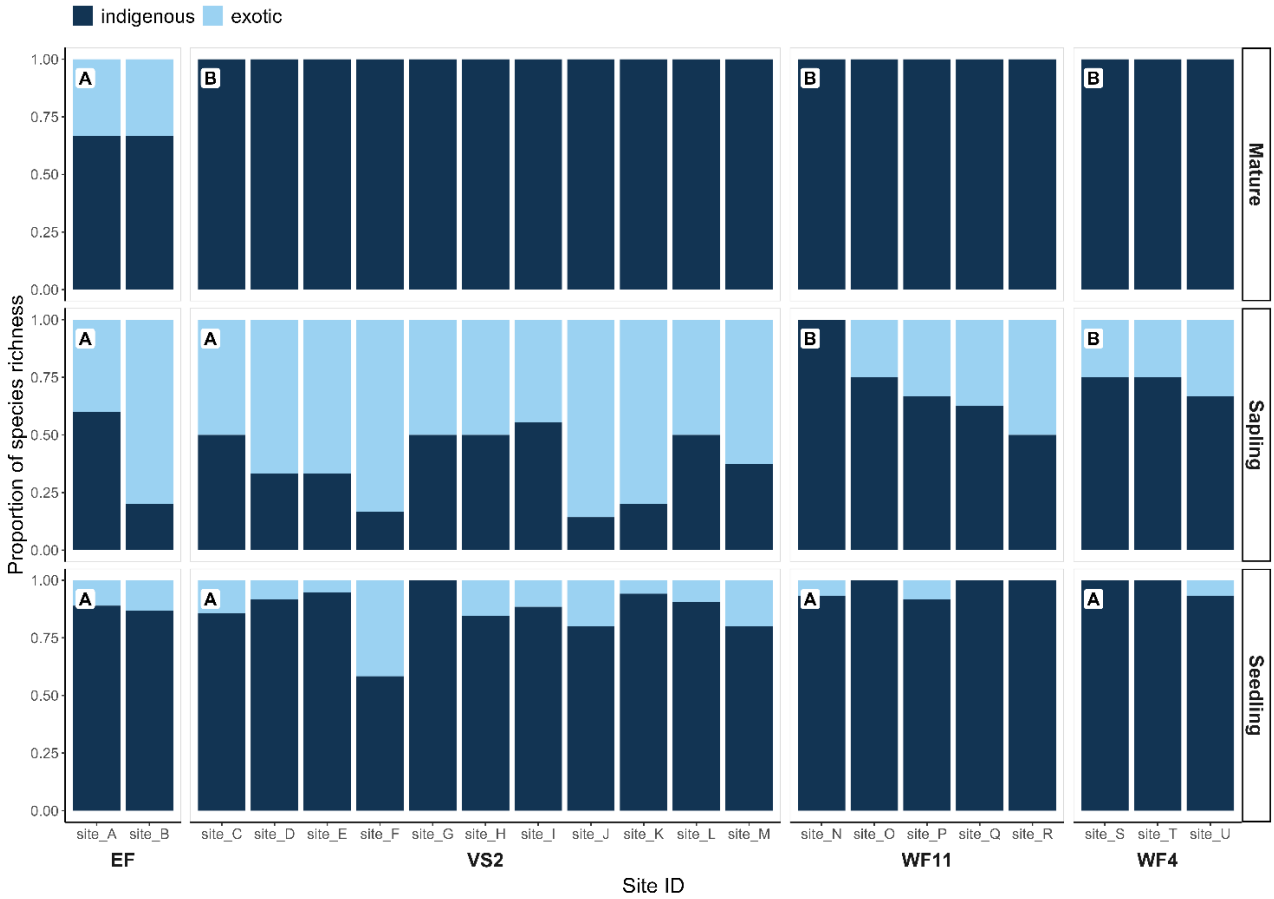

Figure 5: Proportion of indigenous and exotic vegetation species richness recorded at each permanent 20x20m plot on Kawau across the three age classes (seedling, sapling, mature trees), grouped by ecosystem type. The letters indicate significant differences between the ecosystem types within each age class; they do not represent differences between age classes.

The pattern observed in the total abundance of plants reflects that seen in the total species richness, with a far higher number of species occurring in the seedling class than either the sapling or mature tree classes (Figure 6). This difference is attributed to the large number of sub-canopy species recorded in the seedling class, with the number of canopy species being similar across all three age classes. The VS2 ecosystem type was the most significantly different group compared to the other ecosystem types, with significantly more sub-canopy species recorded in the seedling class, especially the herbaceous *Lagenophora* which made up 14 per cent of all species. The mature canopy trees in the VS2 ecosystem were dominated by kānuka, with the canopy of many plots made up solely of this species. This contrasts with the greater mix of species observed in both the WF11 and WF4 ecosystem types. There were no significant differences observed in any of the sapling counts between the ecosystems.

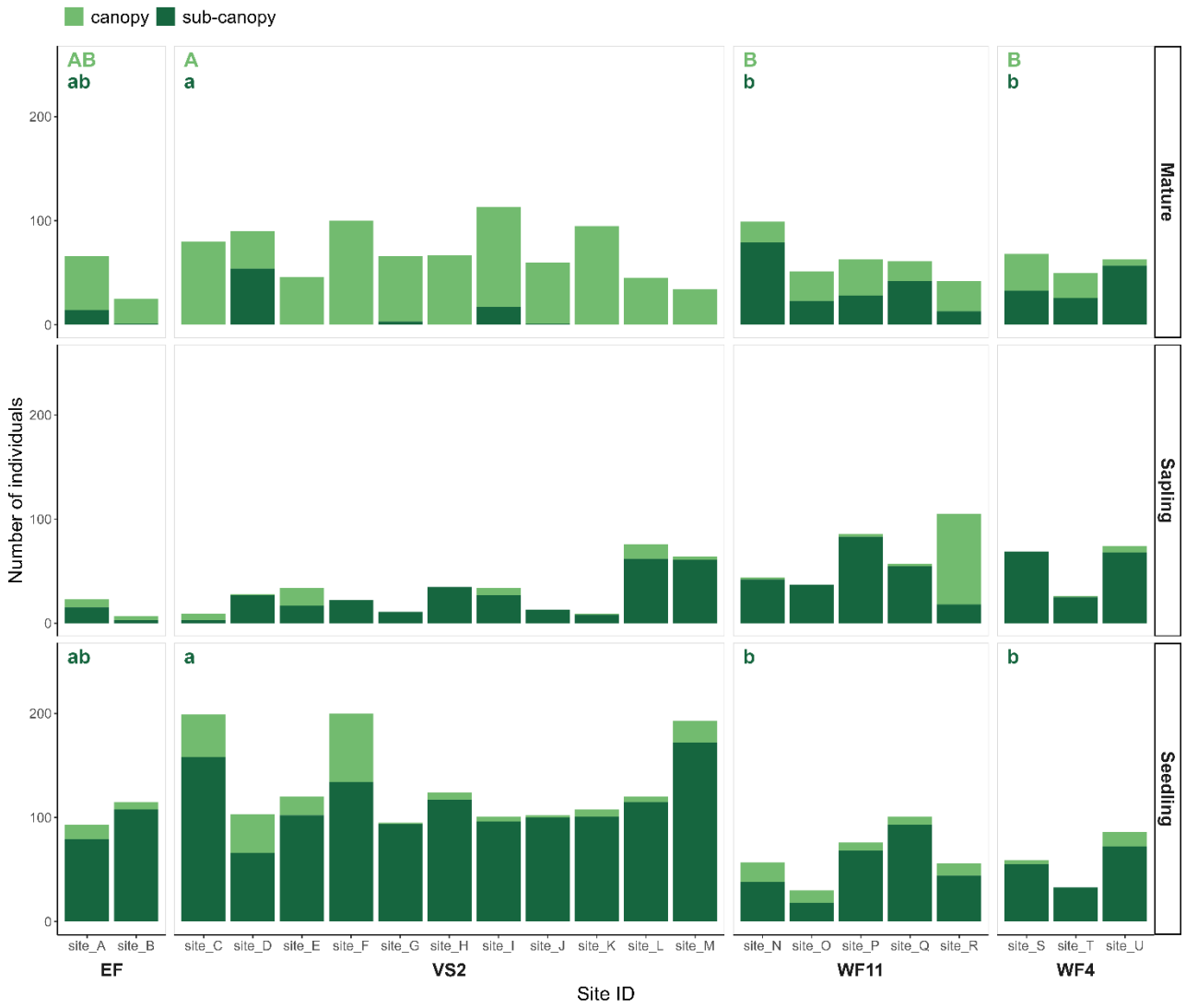

Figure 6: Number of canopy and sub-canopy vegetation species recorded at each permanent 20x20m plot on Kawau across the three age classes (seedling, sapling, mature trees), grouped by ecosystem type. The letters indicate significant differences between the ecosystem types within each age class; they do not represent differences between age classes. Uppercase letters indicate significant differences between the number of canopy species, while lowercase letters indicate differences between sub-canopy species within each age class. No significant differences in either canopy or sub-canopy species were found in the sapling age class.

There was a significantly lower relative abundance of indigenous species in the VS2 ecosystem compared to the WF11 and WF4 ecosystems for both seedling and sapling classes (Figure 7). The EF ecosystem also had a significantly lower relative abundance of indigenous species in the sapling class than that of WF11, and significantly lower relative abundance of mature indigenous tree species than any other ecosystem, noting that this was driven by notably high proportion of exotic saplings in a single EF plot (site B). Though it should be noted that indigenous species were still, overall, the most abundant species in the EF ecosystem, caused by high abundance of kānuka making up 65 per cent of all recorded mature trees.

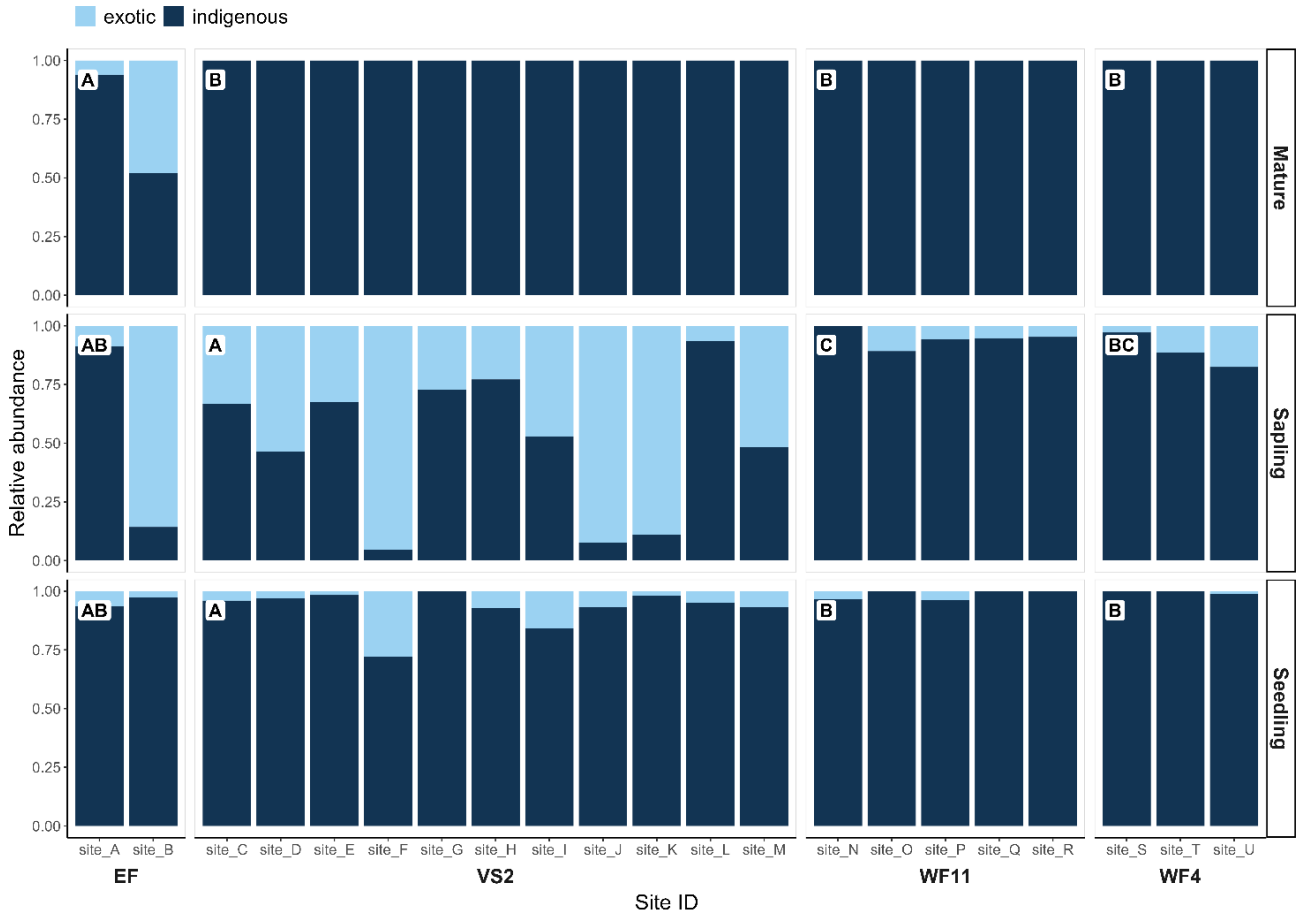

Figure 7: The relative proportional abundance of indigenous and exotic vegetation species recorded at each permanent 20x20m plot on Kawau across the three age classes (seedling, sapling, mature trees), grouped by ecosystem type. The letter labels indicate significant differences between the ecosystem types within each age class; they do not represent differences between age classes.

When looking at the mean abundance of observed species within each plot across age classes, there were far higher numbers of individual per species in mature tree than either seedling or sapling classes (Figure 8). This trend is led by the VS2 ecosystem type, indicating a higher tendency to single species (kānuka) dominance in these kānuka scrub plots than in any of the other ecosystem types. Notably, the seedling and sapling classes show consistently low mean abundance across all ecosystem types, suggesting that few species are successfully establishing and regenerating even when high numbers of mature trees are present.

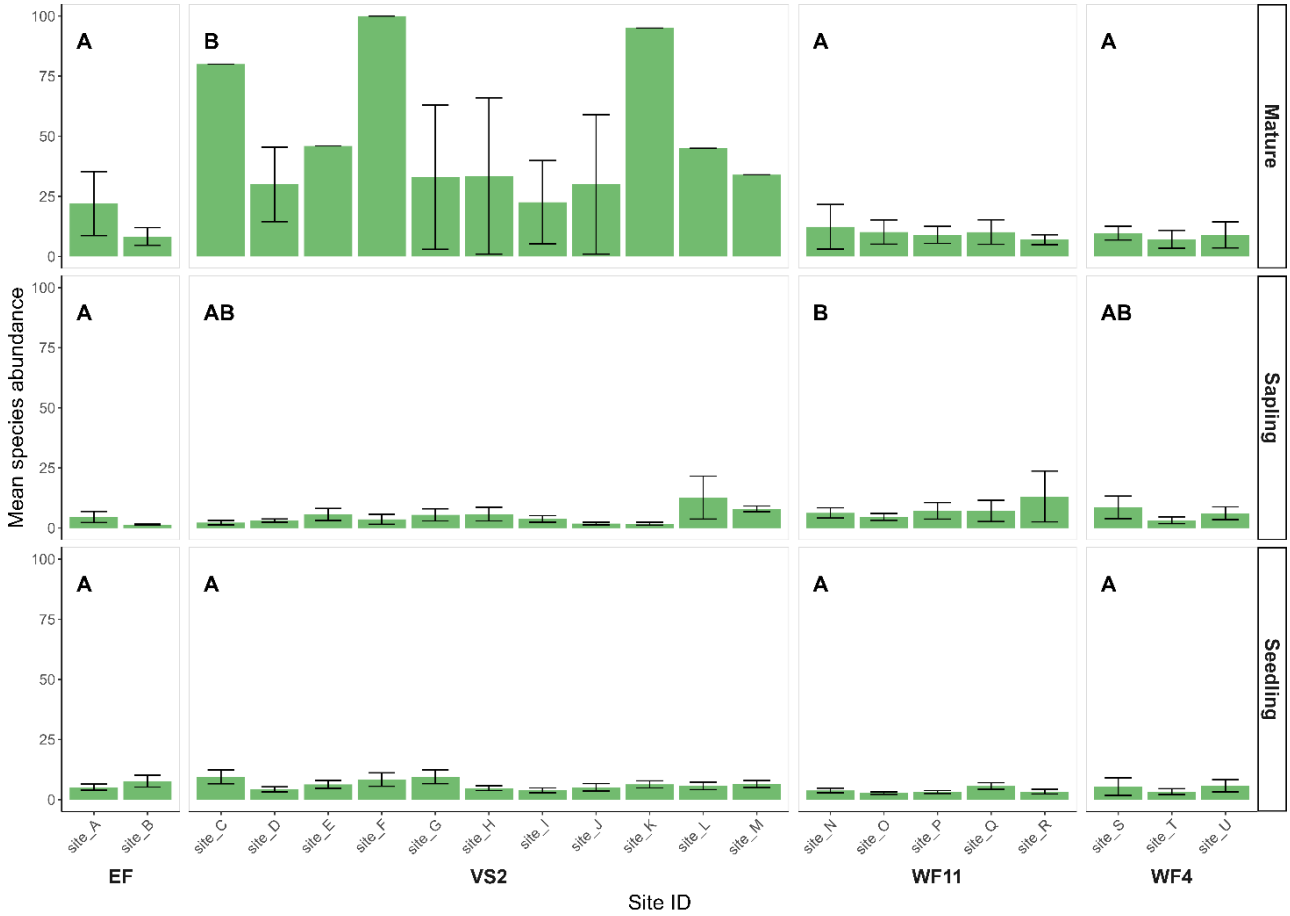

Figure 8: Mean abundance of each vegetation species recorded at each permanent 20x20m plot on Kawau across the three age classes (seedling, sapling, mature trees), grouped by ecosystem type. The letters indicate significant differences between the ecosystem types within each age class; they do not represent differences between age classes

The dominance of kānuka is supported by the significant negative correlation observed between mean species abundance and species richness for the mature tree class (R^2 = 0.55, P < 0.001). Again, this is largely led by the VS2 ecosystem type (Figure 9), with the mature tree cohort in later successional ecosystems (WF4 and WF11) exhibiting higher diversity spread amongst fewer individuals and those in the earlier succession forest (VS2) comprised of a single species at much high abundance. In contrast, no significant correlation was found within either the seedling or sapling classes, with species richness and mean abundance remaining fairly uniform across plots. The absence of any correlation indicates that regeneration patterns are unstructured and suppressed.

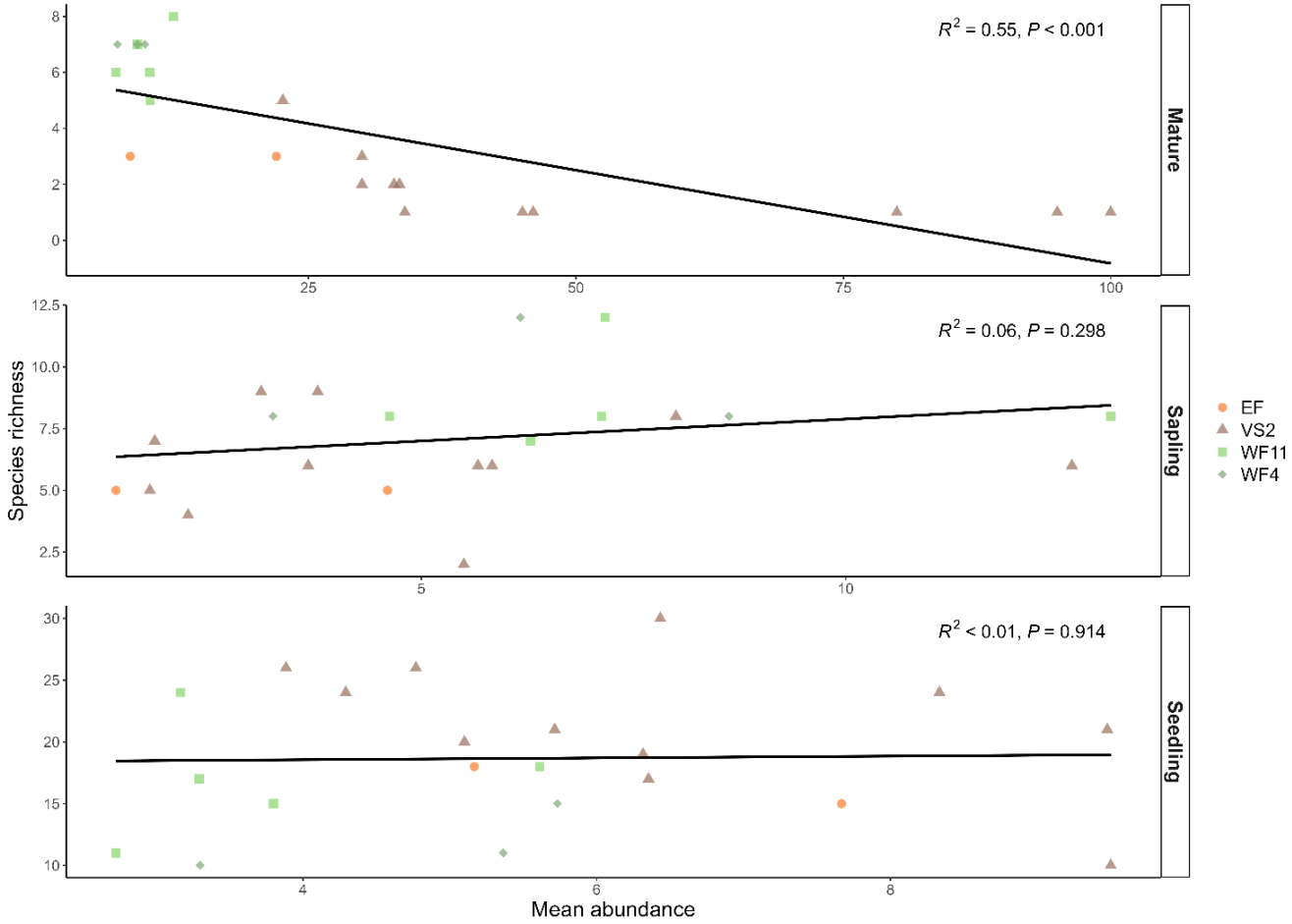

Figure 9: Relationship between mean abundance and species richness of vegetation species recorded at each permanent 20x20m plot on Kawau across the three age classes (seedling, sapling, mature trees), grouped by ecosystem type.

No significant differences in the proportional abundance of woody and non-woody species were found between the ecosystem types across the three age classes (Figure 10). There appeared to be a trend of increasing abundance of woody species between seedling to sapling classes across all ecosystem types; however, this change was only significant in the WF4 ecosystem type between the seedling and mature tree classes (p = 0.001) VS2 and WF11 ecosystem types (p < 0.001 and p = 0.004 respectively).

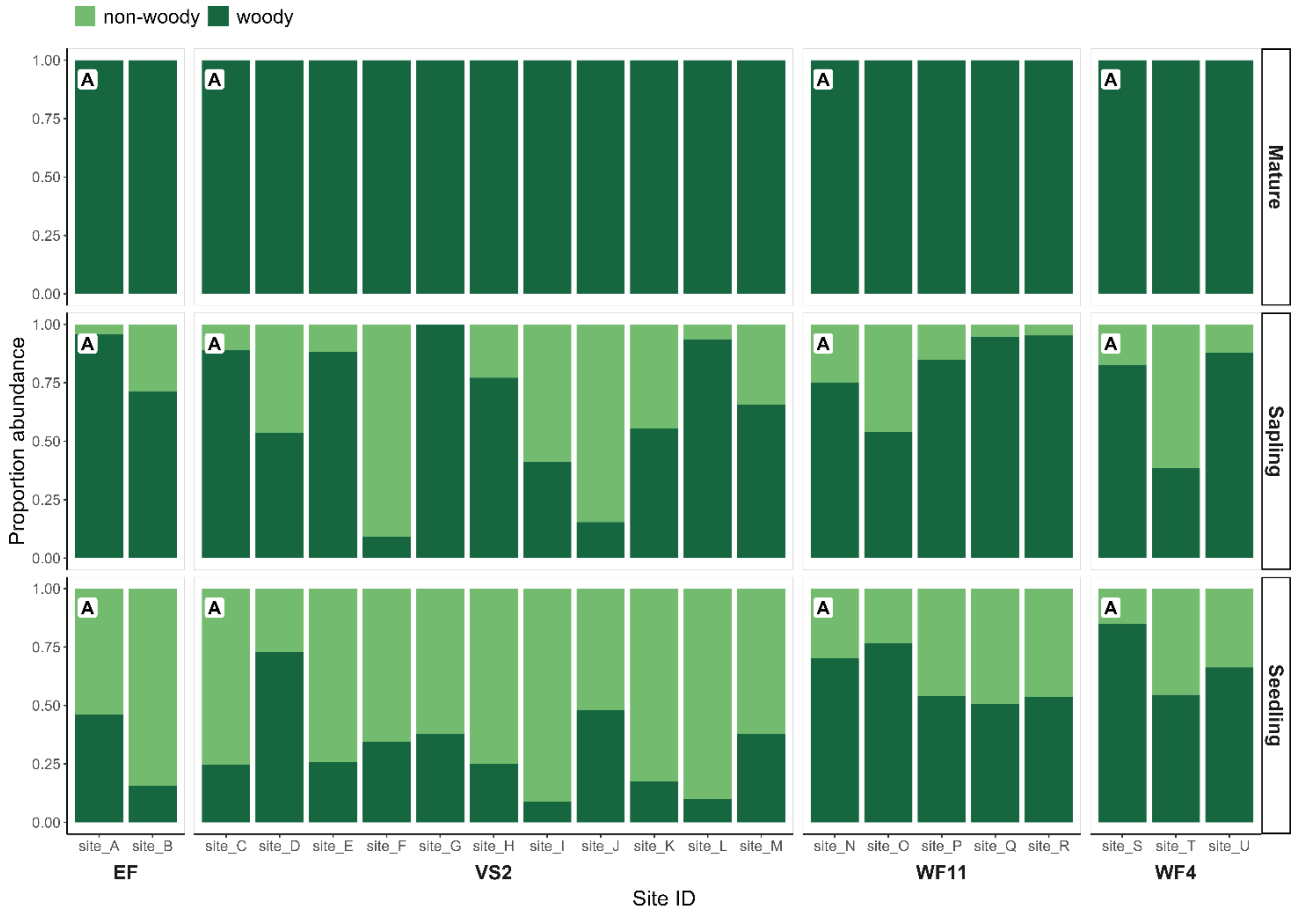

Figure 10: Proportional abundance of woody and non-woody vegetation species recorded at each permanent 20x20m plot on Kawau across the three age classes (seedling, sapling, mature trees), grouped by ecosystem type. The letters indicate significant differences between the ecosystem types within each age class, they do not represent differences between age classes

There was a strong left skew (more smaller individuals) in the size distribution of individuals in both the mature tree and seedling age classes across all ecosystem types (Figure 11; Figure 12). Both age classes (mature trees and seedling) also showed a very rapid drop off in the number of individuals as sizes increase, with only sporadic presences of larger individuals. While this type of negative exponential size distribution is seen in regenerating forests, the substantial lack of large trees and drastic rate of decline is beyond that commonly seen in healthy New Zealand forests beyond the initial competitive thinning phase (Coomes & Allen, 2006; Jo et al., 2024).This was particularly pronounced in the VS2 ecosystem, especially for mature trees, and almost certainly due to the dominance of kānuka and its smaller DBH compared to other canopy species. The size distribution of individuals in the seedling class is notable as almost all observed seedlings are less than 10cm in height, a distribution identified in other New Zealand forests which have experienced prolonged heavy herbivore pressure (Husheer et al., 2002; Wright et al., 2012), suggesting very limited recruitment especially for more palatable species.

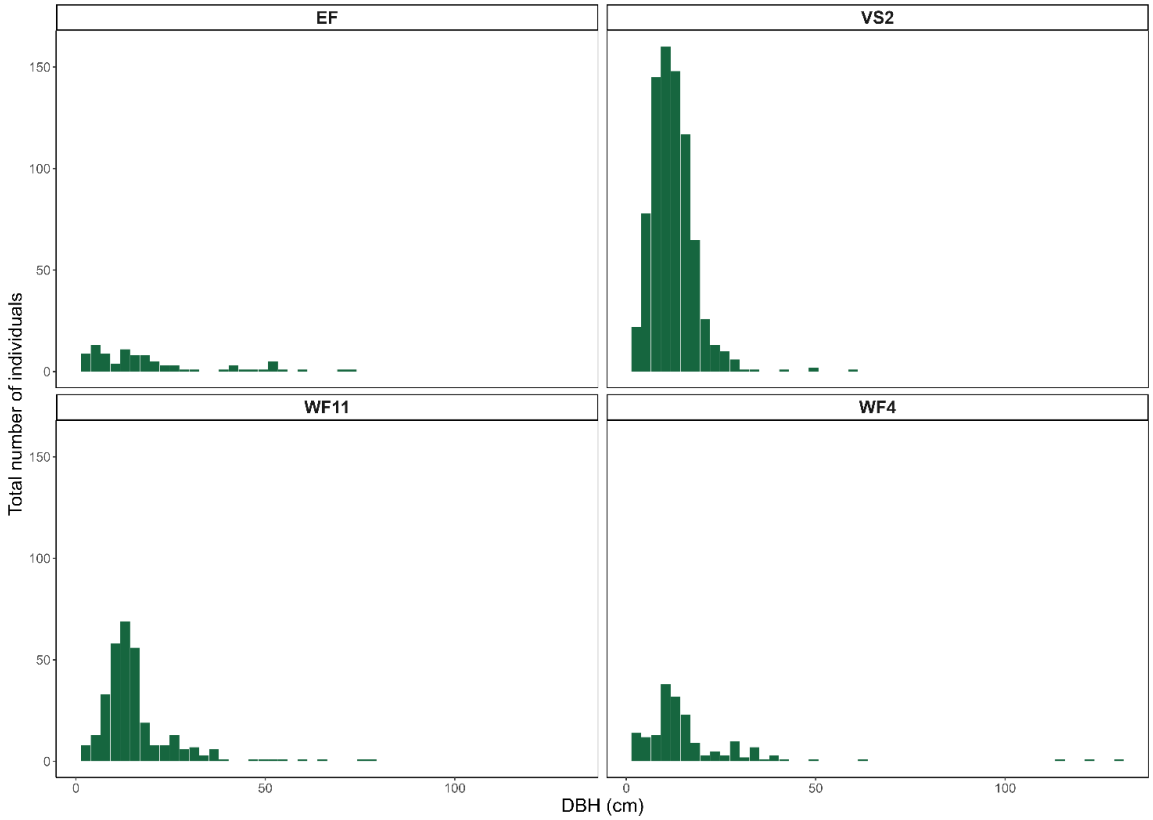

Figure 11: Size (diameter at breast height) distribution of indigenous abundance recorded in the mature tree age class across all permanent 20x20m plots on Kawau, presented by ecosystem type.

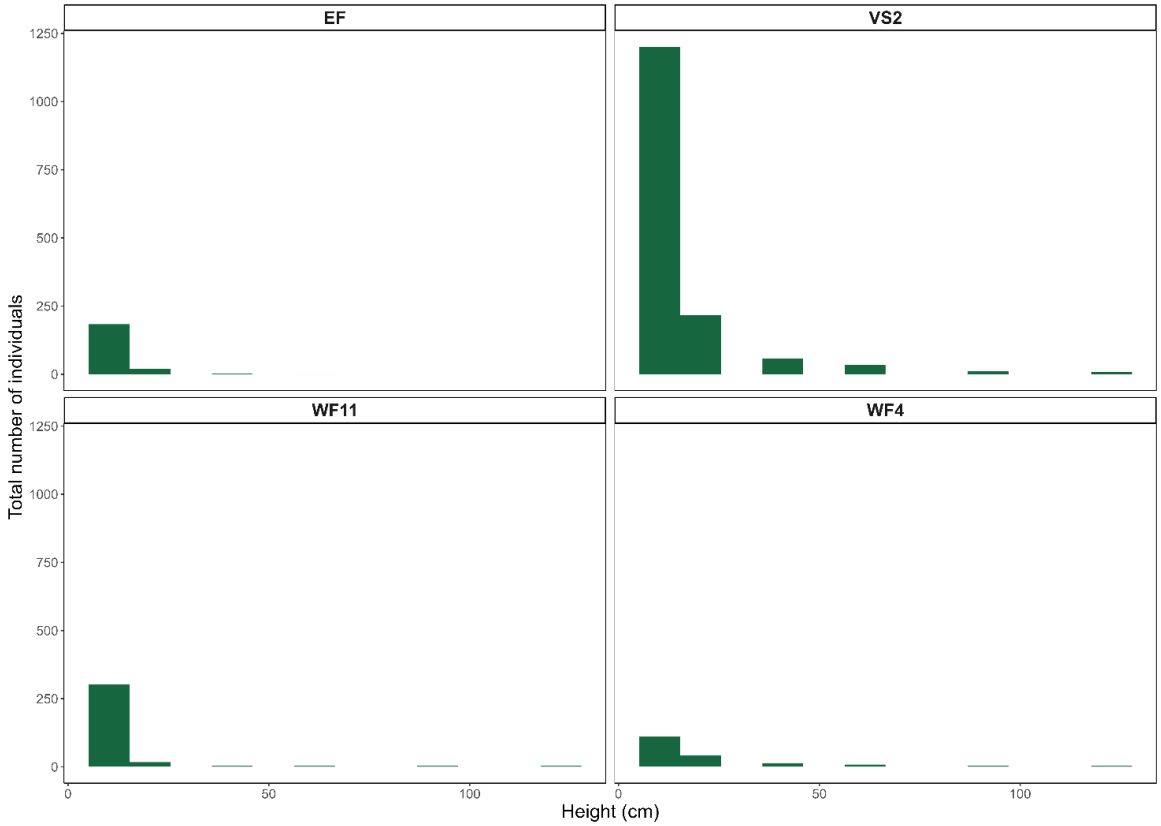

Figure 12: Size (height) distribution of indigenous abundance recorded in the seedling age class across all permanent 20x20m plots on Kawau, presented by ecosystem type.

4.1.1 Exotic vegetation species

A total of 39 exotic species were recorded across all plots accounting for 404 individuals. Of these, 156 individuals across 13 species are listed as pest weeds in the RPMP (Auckland Council, 2021). An additional eight species are identified as environmental weeds; however, these are not actively regulated in the region (McAlpine & Howell, 2024). The most abundant exotic species were Scotch thistle (*n* = 59), with the most abundant listed weed species being boneseed (*n* = 40; see Table 5 in Section 3.1). Boneseed was also the most dispersed listed weed species, being found at 14 of the 21 plots (Figure 13), This was followed by pampas (*Cortaderia spp.*), with individuals recorded at 10 of the 21 plots.

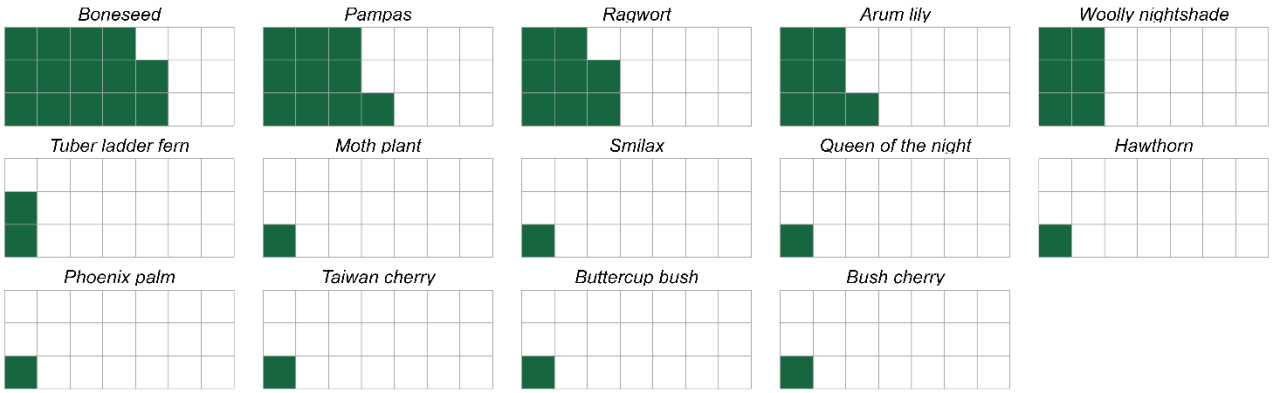

Figure 13: Occurrences of the RPMP listed weed species (Auckland Council, 2020) across the 21 permanent 20x20m plots on Kawau. Each square represents a single site with a filled square indicating a species was present at that site.

The remaining listed weed species were notably less dispersed, with none found at more than half of all plots and most species being found at only one plot. The mean frequency of occurrence for the listed weed species was 0.06 (± 0.01 SE) (Figure 14). Only boneseed, pampas and arum lily occurred with a mean frequency equal to or greater than that of the average frequency of all weed species identified across all plots, and this was only within the VS2 ecosystem type.

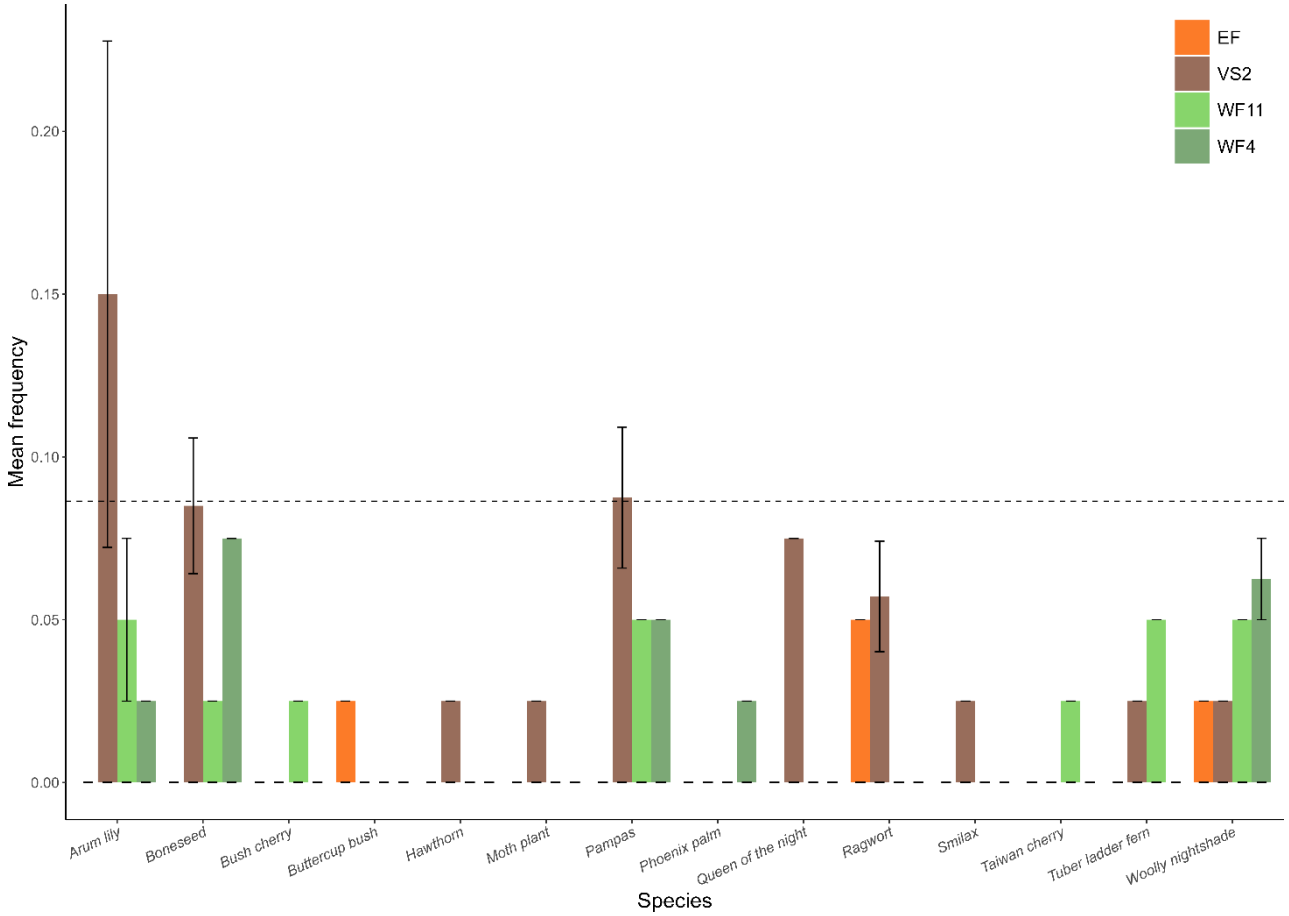

Figure 14: Mean frequency (number of subplots within each plot) for each of the RPMP listed weed species (Auckland Council, 2020) observed across all 21 permanent 20x20m plots on Kawau. The dashed line indicates the mean frequency of all weed species recorded across all sites.

The relative abundance of exotic and weed species was also generally lower than indigenous species (including both native and endemic species) across most ecosystems and age classes (Figure 15); however, VS2 had a significantly higher relative abundance of exotic species (including weeds) in the sapling class than either WF11 or WF4 (p = 0.004 and p = 0.04 respectively). EF also had significantly higher relative abundance of exotic species in the sapling class than WF11 (p = 0.04). EF was also the only ecosystem to record any abundance of exotic species in the mature age class.

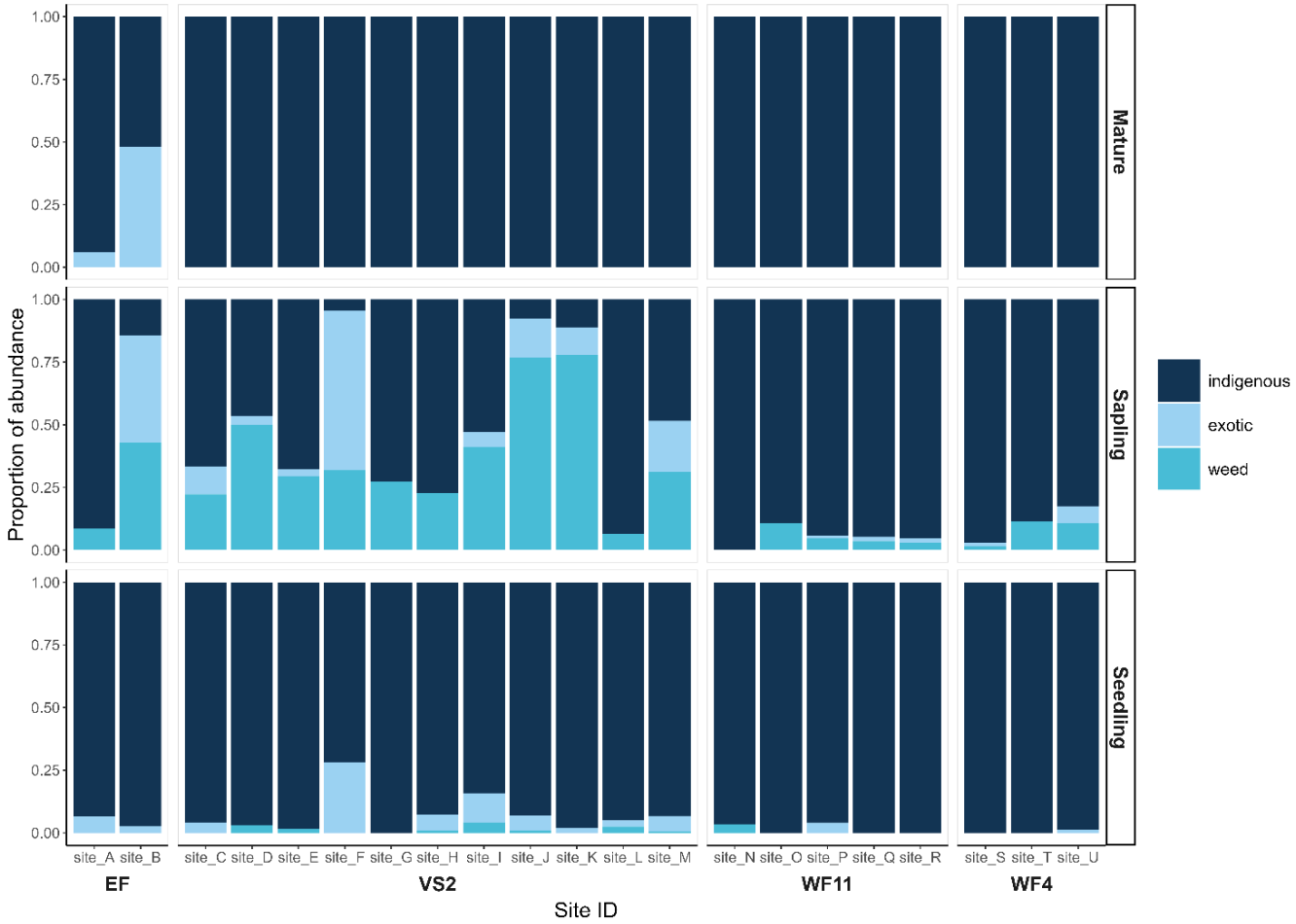

Figure 15: Proportion of abundance of indigenous, exotic and weed species recorded across all permanent 20x20m plots on Kawau compared to total abundance across the three age tiers (seedling, sapling, mature trees), grouped by ecosystem type.

The density of weeds and exotic species was also considerably lower than indigenous species across all ecosystems and age classes, with no significant differences observed between ecosystems (Figure 16). The sapling age class had the highest relative density of weeds and exotic species, with numbers being higher than indigenous species in at least six plots, all within the VS2 ecosystem. Nonetheless, individuals in the sapling class showed a greater density of indigenous species across most plots.

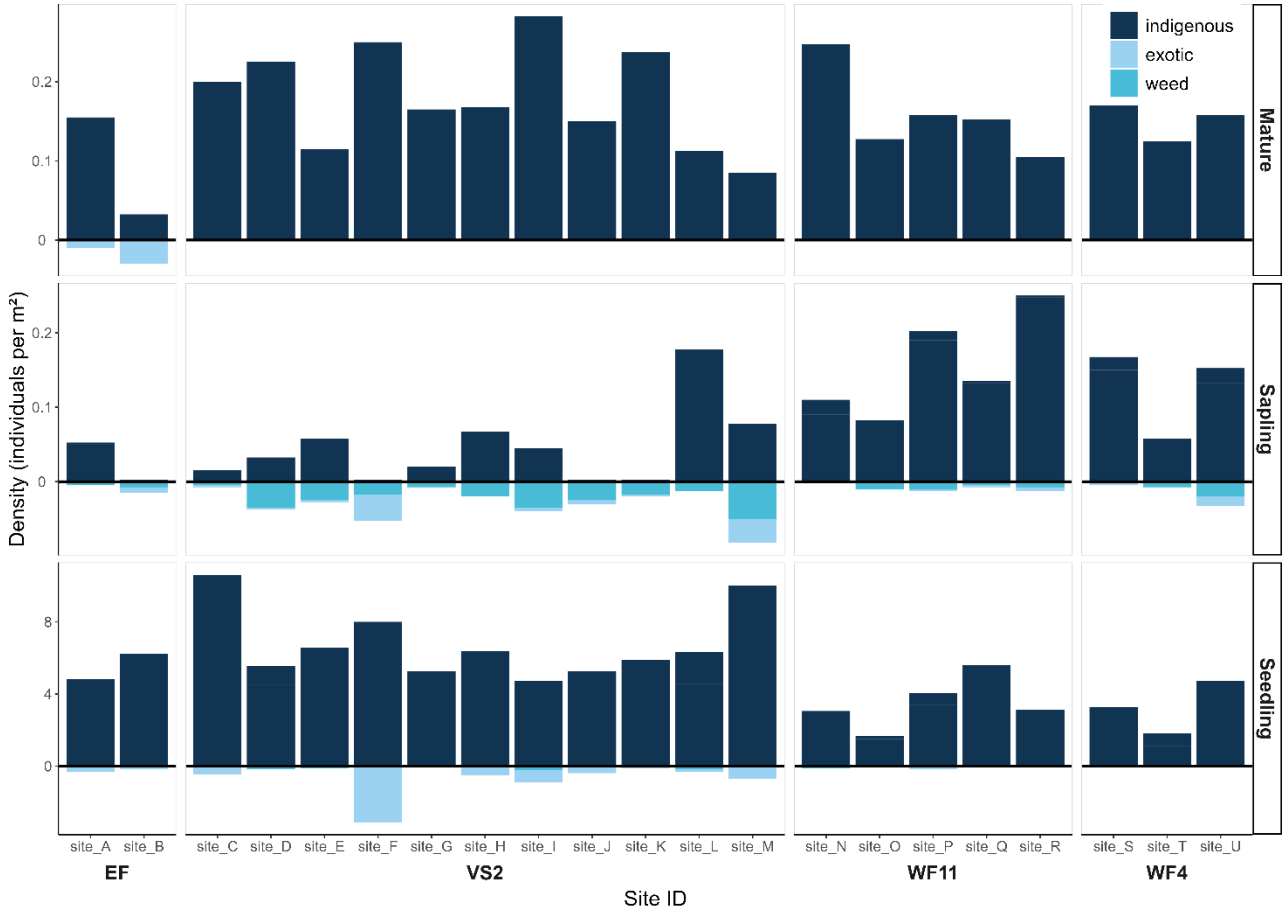

Figure 16: Density (individuals per m²) of indigenous, exotic, and weed species recorded at each permanent 20x20 plot on Kawau across the three age classes (seedling, sapling, mature trees), grouped by ecosystem type.

4.1.2 Palatable vegetation

There was a total of 73 (out of 167) species with known mammalian palatability ratings recorded across all plots (refer to Appendix C), with a total abundance of 3,026 individuals (Table 6). Most of this abundance was contributed by two indigenous low palatability species, kānuka and ponga. Species with moderate or high palatability to mammals had a total abundance of 608 individuals, with the most abundant species being red māpou (n = 151). Of these, nine species were recorded with a high palatability, with a total abundance of 315. The three most abundant high palatability species were red māpou, taraire, and hangehange (*Geniostoma ligustrifolium*), all of which were relatively highly dispersed, occurring at more than half the plots surveyed. Red māpou and taraire were also found to occur at a comparatively high frequency in the plots in which they occurred, with a mean frequency of 0.14 (± 0.03) and 0.15 (± 0.04) respectively.

Table 6: Total abundance and level of palatability for vegetation species with known mammal palatability ratings recorded across all permanent 20x20m plots on Kawau. Bold indicates exotic species. * indicates listed pest species in the Auckland Regional Pest Management Plan (RPMP) (Auckland Council, 2020).

Scientific name	Common name	Palatability	Total count	Occurrence	Mean frequency
Myrsine australis	Red māpou	high	151	20	0.14 ± 0.03
Beilschmiedia tarairi	Taraire	high	105	12	0.15 ± 0.04
Geniostoma ligustrifolium	Hangehange	high	19	14	0.01 ± 0.01
Coprosma arborea	Tree coprosma	high	11	8	0.02 ± 0.01
Coprosma rhamnoides	Twiggy Coprosma	high	11	8	0.02 ± 0.01
Griselinia lucida	Puka	high	11	3	0.02 ± 0.01
Coprosma lucida	Shining karamū	high	3	3	0.01 ± 0.01
Coprosma macrocarpa	Large-seeded coprosma	high	3	3	0.00 ± 0.00
Coprosma robusta	Glossy karamū	high	1	1	0.00 ± 0.00
Leptospermum scoparium	Mānuka	moderate	68	2	0.09 ± 0.04
Microsorum scandens	Fragrant fern	moderate	54	7	0.18 ± 0.07
Asplenium flaccidum	Coastal spleenwort	moderate	26	10	0.00 ± 0.00
Vitex lucens	Pūriri	moderate	25	9	0.05 ± 0.02
Metrosideros fulgens	Climbing rātā	moderate	24	3	0.18 ± 0.11
Microsorum pustulatum	Hound's tongue	moderate	23	10	0.06 ± 0.01
Clematis paniculata	White clematis	moderate	15	3	0.12 ± 0.09
Asplenium polyodon	Sickle spleenwort	moderate	11	5	0.00 ± 0.00
Corynocarpus laevigatus	Karaka	moderate	7	5	0.02 ± 0.01
Elaeocarpus dentatus	Hīnau	moderate	7	1	0.15 ± 0.00
Astelia hastata	Tank lily	moderate	5	2	0.00 ± 0.00
Metrosideros excelsa	Pōhutukawa	moderate	5	3	0.02 ± 0.01
Rubus cissoides	Bush lawyer	moderate	5	3	0.02 ± 0.02
Rhopalostylis sapida	Nīkau	moderate	4	4	0.00 ± 0.00
Hedycarya arborea	Pigeonwood	moderate	3	3	0.02 ± 0.01
Asplenium oblongifolium	Shining spleenwort	moderate	2	1	0.00 ± 0.00
Beilschmiedia tawa	Tawa	moderate	2	1	0.05 ± 0.00
Dacrycarpus dacrydioides	Kahikatea	moderate	2	1	0.05 ± 0.00
Ripogonum scandens	Supplejack	moderate	2	1	0.02 ± 0.00
Astelia solandri	Perching lily	moderate	1	1	0.00 ± 0.00
Blechnum novae-zelandiae	Kiokio	moderate	1	1	0.02 ± 0.00
Brachyglottis repanda	Rangiora	moderate	1	1	0.00 ± 0.00
Kunzea robusta	Kānuka	low	1213	19	0.47 ± 0.04
Cyathea dealbata	Ponga	low	625	19	0.25 ± 0.04
Leucopogon fasciculatus	Mingimingi	low	85	17	0.09 ± 0.03
Cirsium vulgare	Scotch thistle	low	59	13	0.10 ± 0.05
Leptecophylla juniperina	Prickly mingimingi	low	56	10	0.12 ± 0.05
Nestegis lanceolata	White maire	low	38	11	0.07 ± 0.03
Piper excelsum	Kawakawa	low	36	7	0.09 ± 0.05

Scientific name	Common name	Palatability	Total count	Occurrence	Mean frequency
Pyrrosia eleagnifolia	Leatherleaf fern	low	34	11	0.05 ± 0.01
Corybas trilobus	Spider orchid	low	31	9	0.08 ± 0.03
Hydrocotyle tripartita	Australian hydrocotyle	low	28	8	0.08 ± 0.03
Knightia excelsa	Rewarewa	low	28	11	0.06 ± 0.01
Hymenophyllum sanguinolentum	Filmy fern	low	21	8	0.03 ± 0.02
Jacobaea vulgaris*	Ragwort	low	20	8	0.06 ± 0.01
Hydrocotyle moschata	Hairy pennywort	low	19	10	0.04 ± 0.01
Carex inversa	Creeping lawn sedge	low	16	7	0.03 ± 0.01
Histiopteris incisa	Water fern	low	14	2	0.05 ± 0.00
Solanum mauritianum*	Woolly nightshade	low	12	6	0.04 ± 0.01
Hymenophyllum demissum	Drooping filmy fern	low	10	3	0.06 ± 0.04
Hymenophyllum nephrophyllum	Kidney fern	low	9	3	0.07 ± 0.02
Corybas acuminatus	Spider orchid	low	6	1	0.15 ± 0.00
Corybas cheesemanii	Helmet orchid	low	6	4	0.03 ± 0.01
Hydrocotyle heteromeria	Waxweed	low	6	4	0.03 ± 0.02
Carex breviculmis	Grassland sedge	low	5	5	0.00 ± 0.00
Dianella nigra	Turutu	low	5	3	0.02 ± 0.02
Hymenophyllum rarum	Filmy fern	low	4	3	0.00 ± 0.00
Pteris macilenta	Sweet fern	low	4	3	0.02 ± 0.01
Solanum aviculare	Poroporo	low	4	1	0.07 ± 0.00
Juncus effusus	Soft rush	low	3	3	0.00 ± 0.00
Notogrammitis billardierei	Common strap fern	low	3	3	0.01 ± 0.01
Prumnopitys ferruginea	Miro	low	3	2	0.02 ± 0.00
Carex flagellifera	Glen Murray tussock	low	2	2	0.01 ± 0.01
Corybas oblongus	Spider orchid	low	2	2	0.01 ± 0.01
Solanum pseudocapsicum	Jerusalem cherry	low	2	2	0.01 ± 0.01
Adiantum cunninghamii	Common maidenhair	low	1	1	0.00 ± 0.00
Carex virgata	Swamp sedge	low	1	1	0.00 ± 0.00
Gahnia setifolia	Razor sedge	low	1	1	0.00 ± 0.00
Hydrocotyle bowlesioides	Water pennywort	low	1	1	0.00 ± 0.00
Hymenophyllum flexuosum	Filmy fern	low	1	1	0.00 ± 0.00
Hypolepis dicksonioides	Giant hypolepis	low	1	1	0.00 ± 0.00
Juncus planifolius	Grass-leaved rush	low	1	1	0.00 ± 0.00
Juncus usitatus	Common rush	low	1	1	0.00 ± 0.00
Veronica stricta	Koromiko	low	1	1	0.00 ± 0.00

There were clear differences in the recruitment ratios (mature tree class abundance/seedling class abundance) between palatable and non-palatable species at most sites (Figure 17). There was an overall significant difference between palatable and non-palatable species, with palatable species generally having more negative ratios (i.e. higher number of seedlings relative to adult trees; $p < 0.001$). This difference is likely the result of palatable seedling browse by wallabies, and other mammalian herbivores, reducing the number of individuals reaching more mature life stages. The differences between palatable and non-palatable recruitment ratios also differed substantially between ecosystem types, with EF and VS2 having significantly lower recruitment ratios for palatable species than non-palatable species ($p < 0.001$ for both ecosystem types). No such significant difference was observed for WF11 and WF4 ($p = 0.2$ and $p = 0.4$ respectively). This lack of difference may indicate either that more palatable seedlings are reaching maturity in these ecosystems or perhaps given the lower overall seedling abundances in these ecosystems there may be greater seed predation preventing seedlings from developing. This difference would need further surveys to parse.

While not the majority, there were significantly higher densities of mature palatable trees in WF11 and WF4 compared to the other ecosystems primarily due to higher abundance of taraire, a species which is highly palatable to possums (Figure 18). A strong trend of increasing proportions of non-palatable species with age classes was seen in the density of palatable and non-palatable species, though given the uncertainty brought in due to the high number of unknown palatability species this should be viewed cautiously. No statistically significant differences between ecosystems were observed for the density of palatable or non-palatable species in any of the age classes.

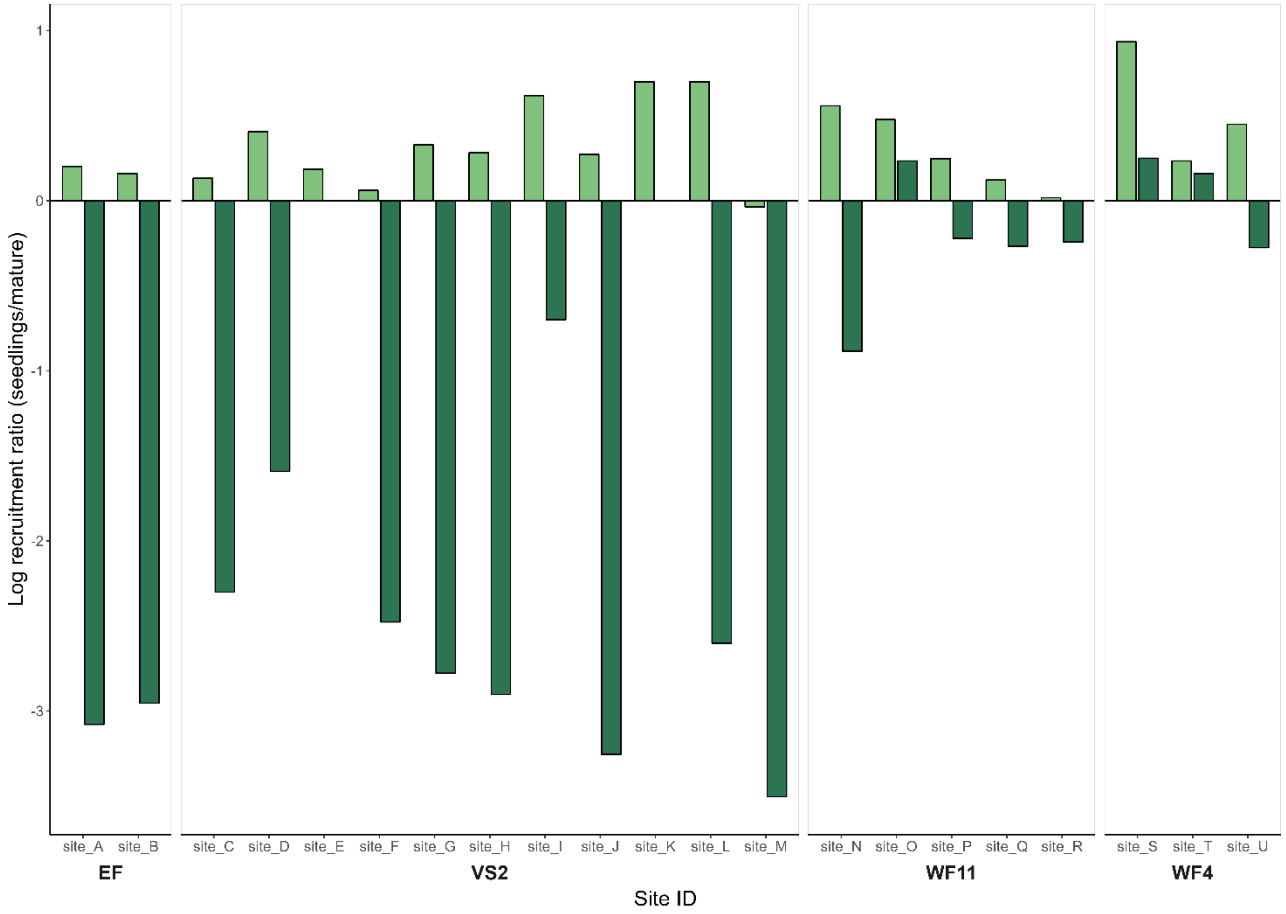

Figure 17: The log of the ratio of adult and seedlings of palatable and non-palatable species across each permanent 20x20m plot on Kawau, grouped by ecosystem type. Lighter green bars represent non-palatable species with darker green bars representing palatable species. Negative values indicate a greater number of seedlings than mature trees, while positive values indicate more mature trees than seedlings.

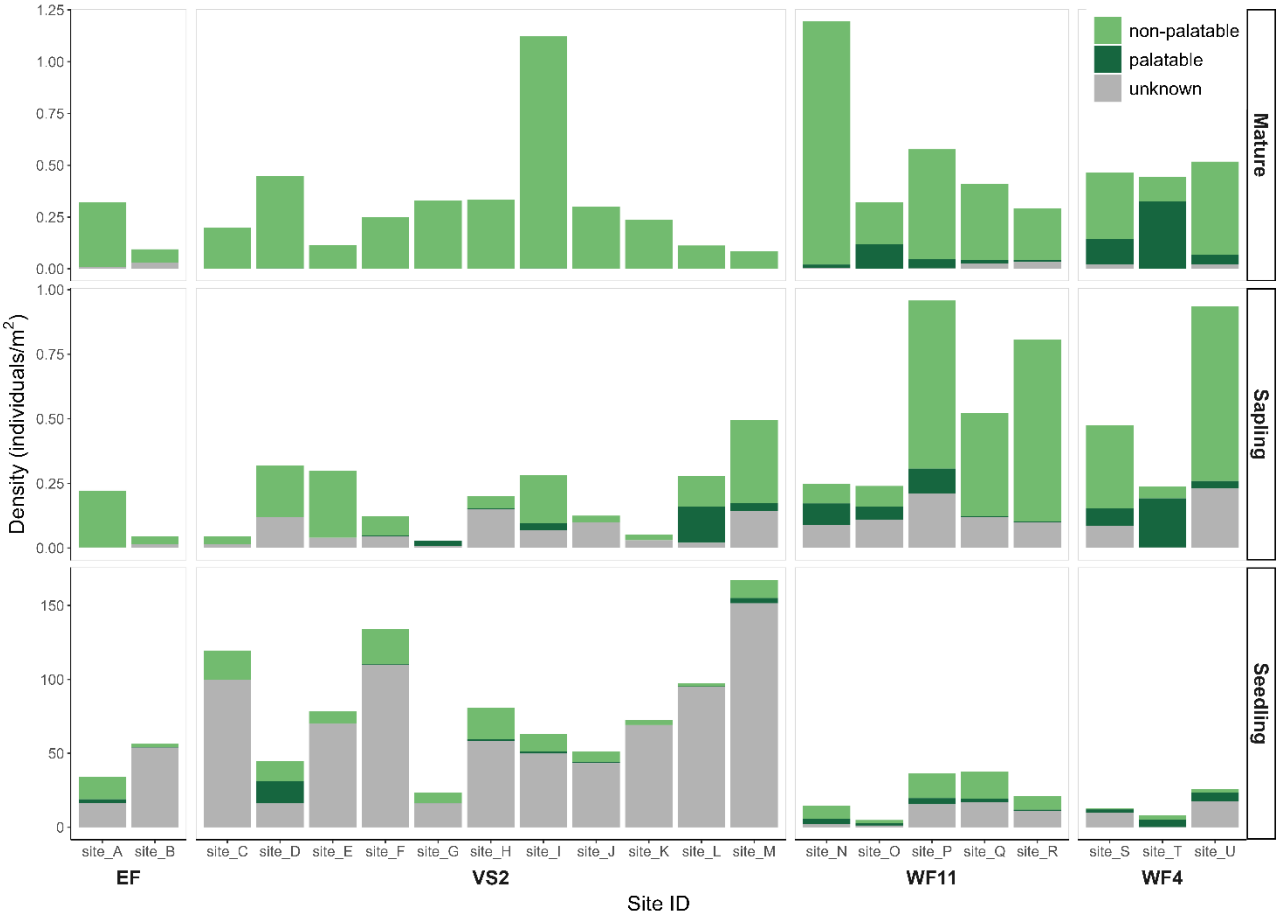

Figure 18: The density of palatable, non-palatable vegetation species, and species with unknown palatability ratings recorded at each permanent 20x20m plot on Kawau across the three age classes (seedling, sapling, mature trees), grouped by ecosystem type.

4.1.3 Vegetation flammability

There was a total of 18 species with known flammability ratings recorded across all plots: four high flammability, five moderate flammability, and nine low flammability. These accounted for 2,092 observations, with the majority being of species with high flammability (1,981), followed by low and then moderate flammability (86 and 25 observations respectively). The large number of observations of high flammability species was caused largely by occurrences of kānuka and ponga. There was no significant difference observed in the proportion of abundance of high flammability species between the ecosystem types when assessed overall (i.e., seedling, sapling and mature trees age classes together); however, a significant difference was seen in the proportion of abundance of high flammability mature plants ($p < 0.01$), with the VS2 ecosystem having significantly higher proportion of high flammability plants than EF ($p = 0.04$), WF11 ($p < 0.001$), or WF4 ($p < 0.001$) ecosystems. This difference is caused by the high proportion of mature kānuka present in the VS2 ecosystem.

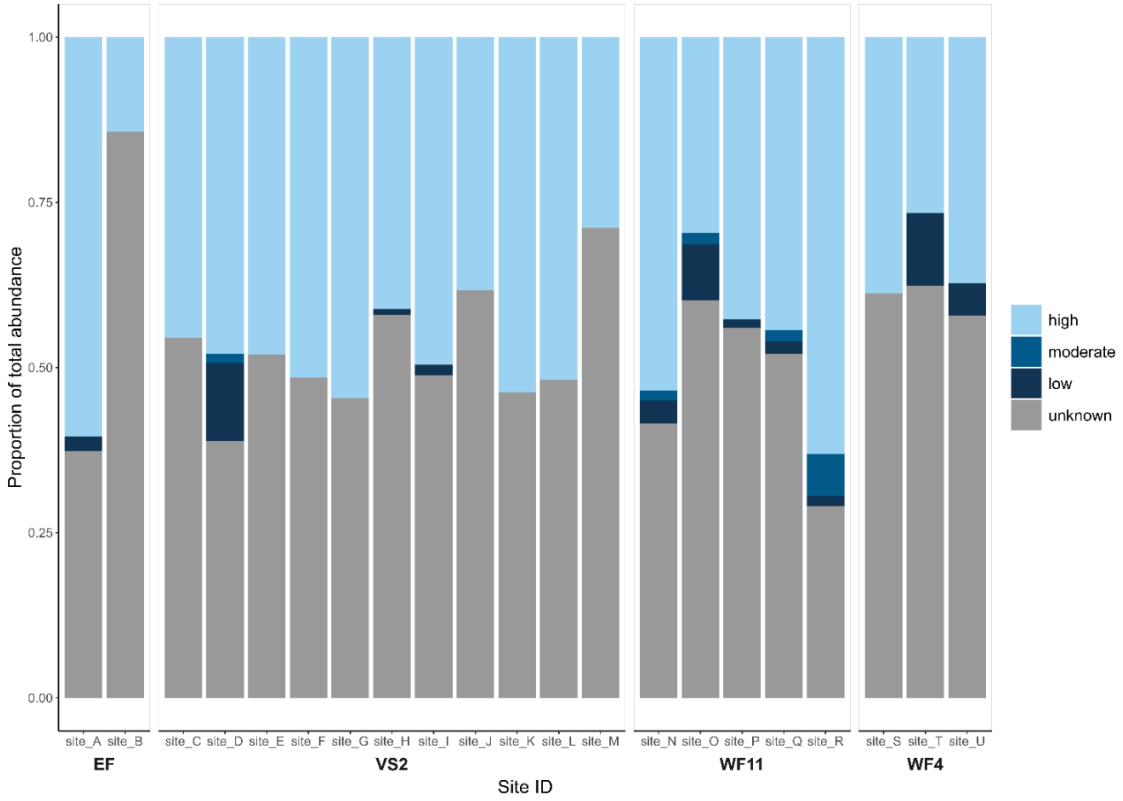

Figure 19: Proportion of total abundance made up by vegetation species of the different flammability ratings recorded at each permanent 20x20m plot on Kawau, grouped by ecosystem type.

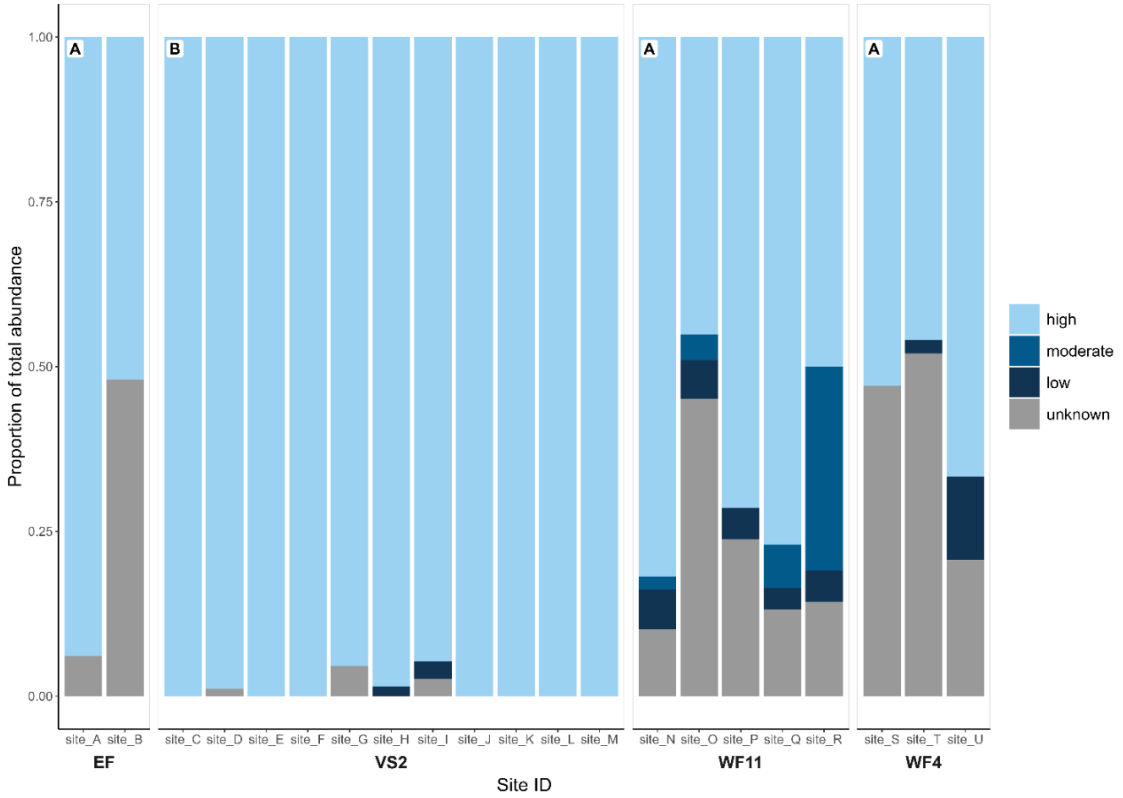

Figure 20: Proportion of the mature tree abundance made up by species of the different flammability ratings recorded at each permanent 20x20m plot on Kawau, grouped by ecosystem type. The letters indicate statistically significant differences between the ecosystem types.

4.2 Bird counts

A total of 734 individual birds were detected across all plots, consisting of 19 species. Most detected species were endemic or native (indigenous), with just over a third comprised of exotic species (Table 7). Most of the species were not threatened regionally, with only two native species being of a higher threat status: weka, At Risk – Regionally Relict and kākā, At Risk – Regionally Recovering (Table 8). Riroriro/grey warbler (*Gerygone igata*) and tūī, two conspicuous endemic species, had particularly high abundance making up approximately a fifth of the total detected abundance each, a trend common throughout Auckland forests (Table 9; Griffiths & Lawrence, 2025).

Table 7: Status of bird species recorded at the 21 permanent 20x20 plots across Kawau.

Status	Species richness	Proportion of total species	Total count	Proportion of total count	Mean abundance per species per site (± SE)
Endemic	7	0.37	490	0.67	1.15 ± 0.05
Native	5	0.26	141	0.19	1.14 ± 0.06
Exotic	7	0.37	103	0.14	1.03 ± 0.01

Table 8: Regional conservation status (Woolly et al., 2024) of bird species recorded at the 21 permanent 20x20 plots across Kawau.

Conservation status	Species richness	Proportion of total species	Total count	Proportion of total count	Mean abundance per species per site (± SE)
Not Threatened	10	0.53	558	0.76	1.14 ± 0.05
Introduced & Naturalised	7	0.37	103	0.14	1.03 ± 0.01
At Risk – Recovering	1	0.05	55	0.07	1.22 ± 0.08
At Risk – Relict	1	0.05	18	0.02	1.12 ± 0.09

Table 9: Abundance for all recorded bird species across all permanent 20x20 plots on Kawau. Bold indicates exotic species.

Species	Common name	Total count	Proportion of total count	Mean abundance per species per site (± SE)
Gerygone igata	Riroriro/grey warbler	165	0.22	1.09 ± 0.02
Prosthemadera novaeseelandiae	Tūī	142	0.19	1.17 ± 0.04
Zosterops lateralis	Tauhou/silvereye	94	0.13	1.68 ± 0.21
Rhipidura fuliginosa	Pīwakawaka/fantail	66	0.09	1.10 ± 0.04
Fringilla coelebs	**Chaffinch**	61	0.08	1.22 ± 0.08
Nestor meridionalis	Kākā	55	0.07	1.22 ± 0.08
Hemiphaga novaeseelandiae	Kererū	41	0.06	1.32 ± 0.10
Todiramphus sanctus	Kōtare/kingfisher	34	0.05	1.03 ± 0.03
Gallirallus australis	Weka	18	0.02	1.12 ± 0.09
Acridotheres tristis	**Myna**	14	0.02	1.00 ± 0.00
Turdus merula	**Blackbird**	13	0.02	1.00 ± 0.00
Chrysococcyx lucidas	Pīpīwharauroa/shining cuckoo	7	0.01	1.00 ± 0.00
Carduelis carduelis	**Goldfinch**	6	0.01	1.00 ± 0.00
Circus approximans	Kāhu/swamp harrier	5	0.01	1.00 ± 0.00
Platycercus eximius	**Eastern rosella**	5	0.01	1.00 ± 0.00
Petroica macrocephala	Miromiro/tomtit	3	0.00	1.00 ± 0.00
Gymnorhina tibicen	**Magpie**	2	0.00	1.00 ± 0.00
Pavo cristatus	**Peafowl**	2	0.00	1.00 ± 0.00
Ninox novaeseelandiae	Ruru/morepork	1	0.00	1.00 ± 0.00

Riroriro/grey warbler and tūī were also detected at all plots surveyed (Figure 21). The next three most abundant species, tauhou/silvereye (*Zosterops lateralis*), pīwakawaka/fantail and chaffinch (*Fringilla coelebs*), were also very widely dispersed, occurring at a minimum of 19 of the 21 plots surveyed. Other than chaffinches, the remaining introduced species had very limited distributions, being found in only a third or less of the plots surveyed. The modelled species density shows similar trends to those observed by abundance, with grey warbler and tūī having notably higher mean densities than the other species, and the top 10 most abundant species also being the 10 species with the highest densities. (Figure 22).

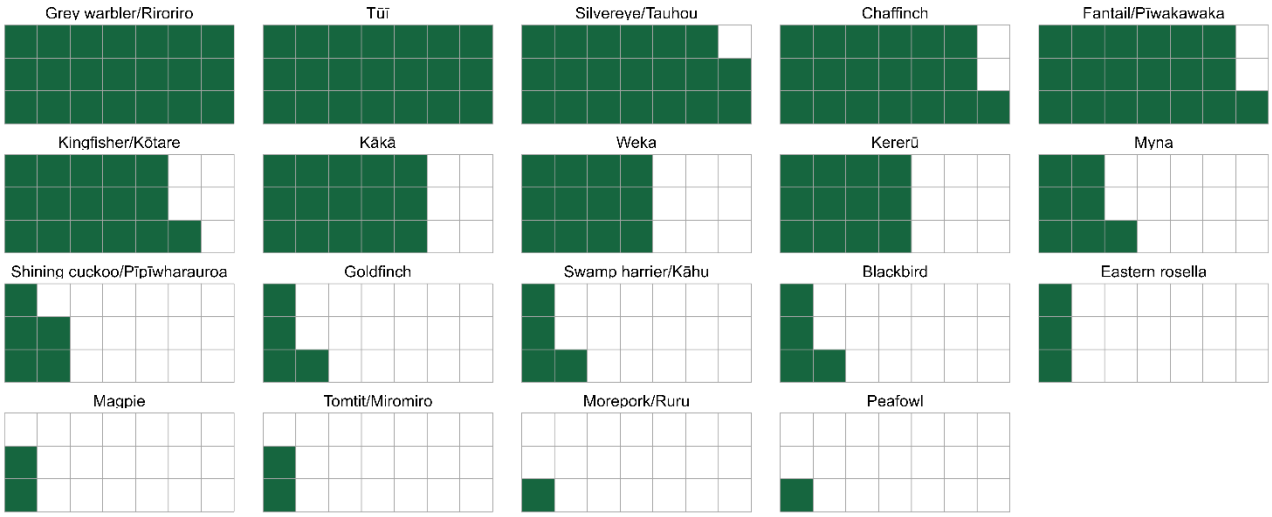

Figure 21: Occupancy of bird species across the 21 permanent 20x20m plots on Kawau. Each square represents a single site with a filled square indicating a species was present at that site.

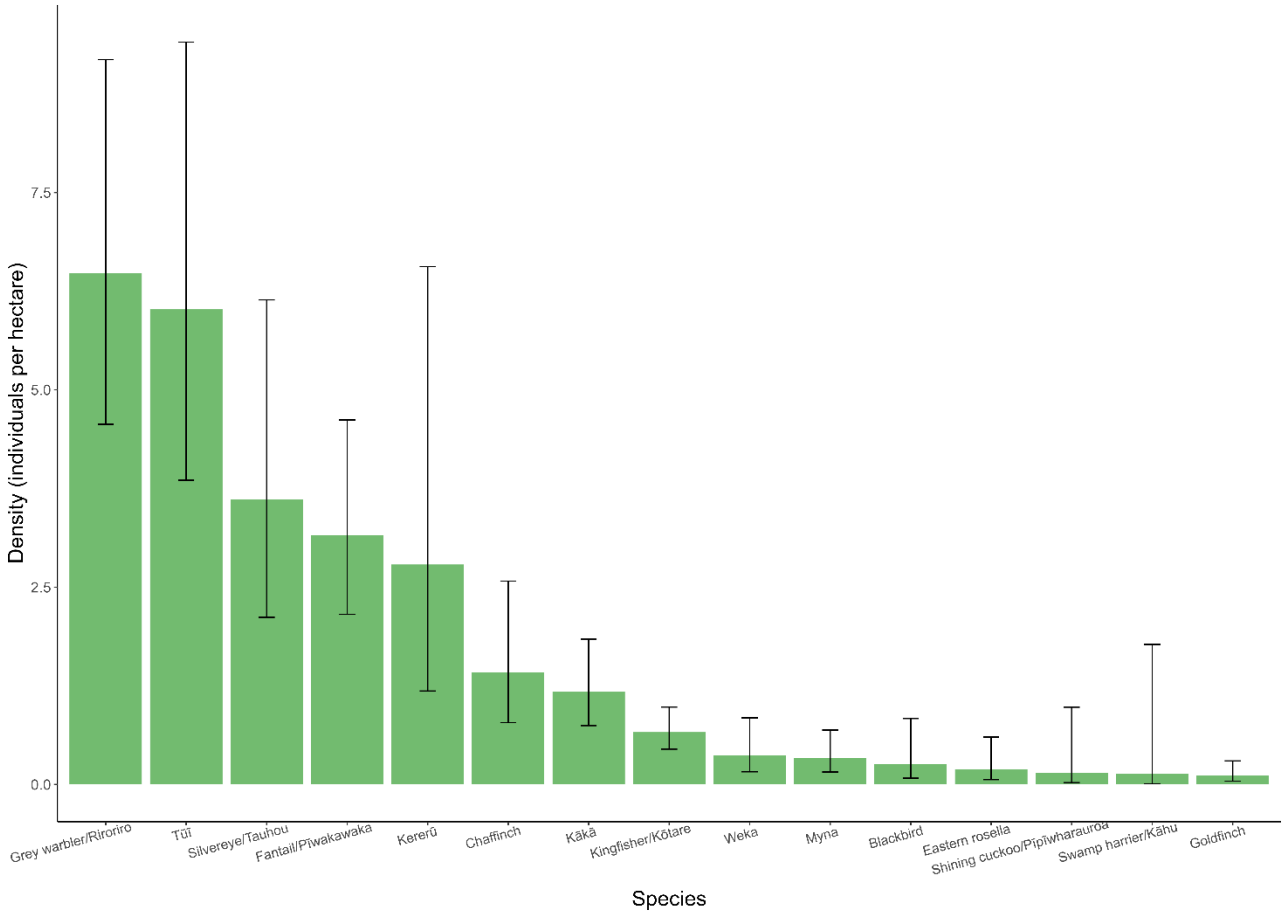

Figure 22: Density of the detected bird species across all permanent 20x20m plots on Kawau. The density is calculated as the number of individuals per hectare. Error bars represent the 95% confidence intervals. Note that very rare species are not shown.

There were no significant differences in the species richness of indigenous and exotic birds across the four described ecosystem types on Kawau (Figure 23). Though, while not statistically significant, all plots with higher exotic species richness occurred within EF and VS2, with all the plots in WF11 and WF4 having at most one detected exotic species. The abundance of indigenous birds was significantly higher in WF11 and WF4 compared to that observed in EF, though no significant differences in exotic species were observed (Figure 24). There was also no significant difference detected in the total abundance of birds across any of the ecosystem types (p = 0.92).

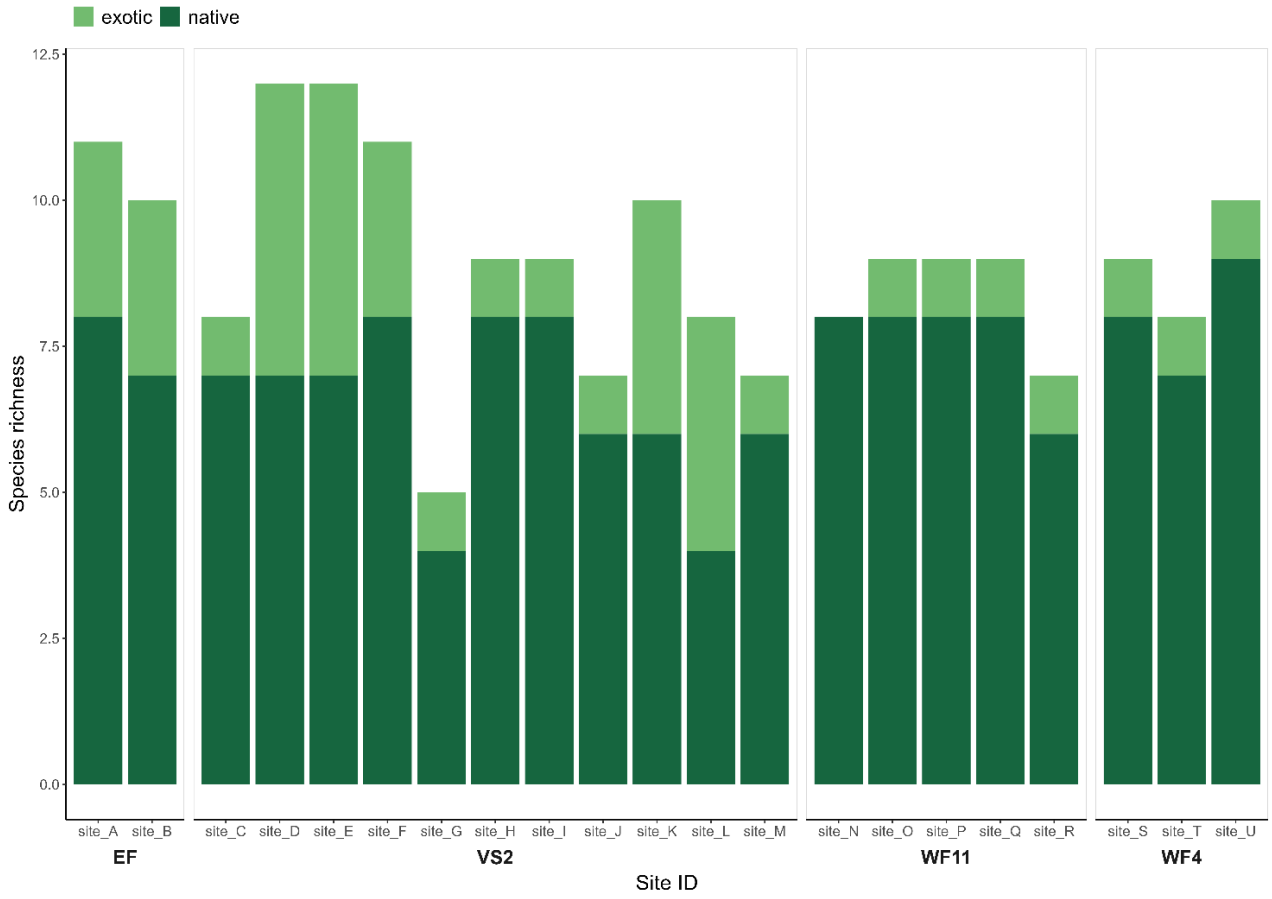

Figure 23: Species richness of native (indigenous) and exotic birds across the 21 permanent 20x20m plots on Kawau, grouped by ecosystem type.

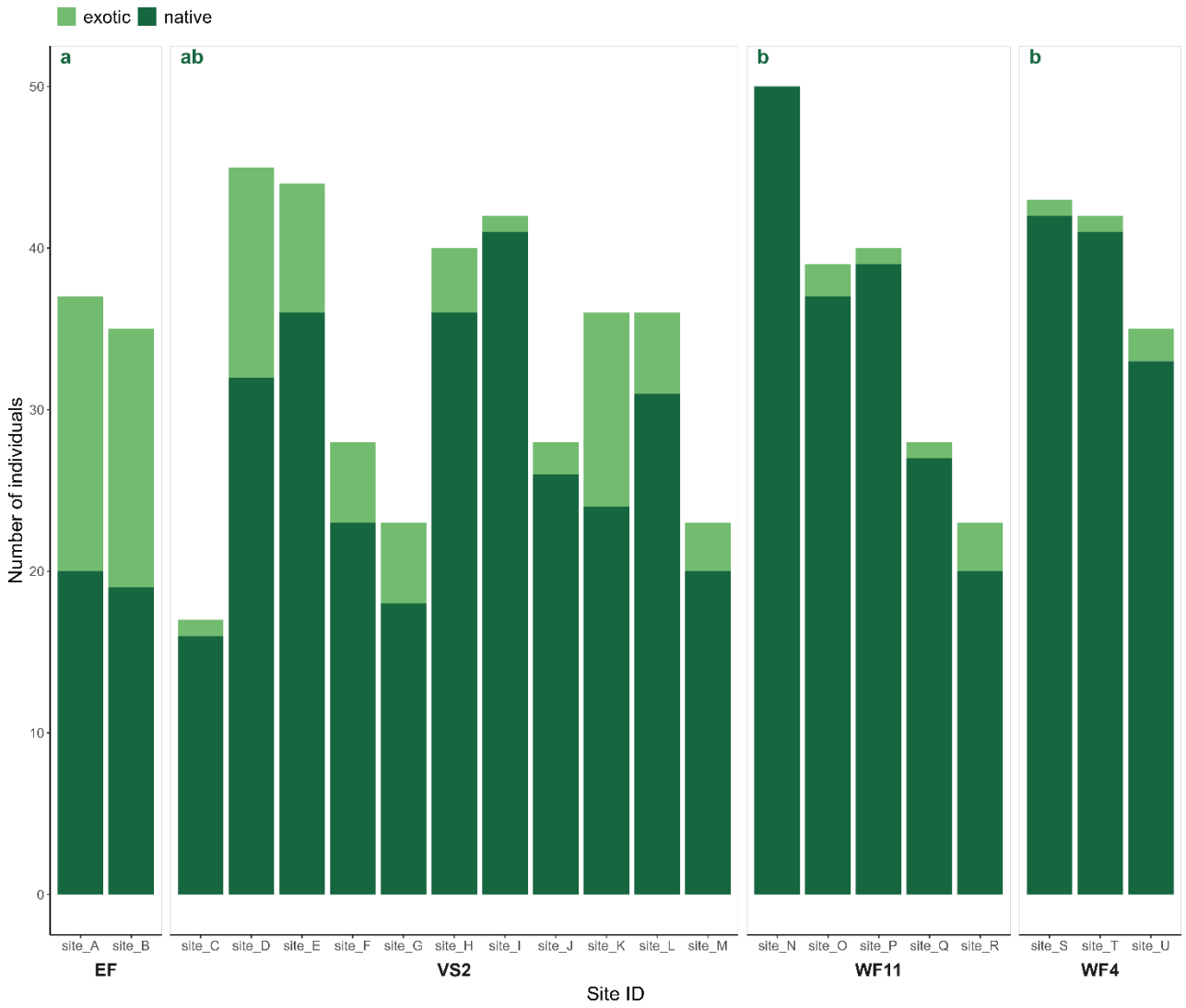

Figure 24: Total number of native (indigenous) and exotic birds detected across the 21 permanent 20x20m plots on Kawau, grouped by ecosystem type. Letters indicate significant differences between native species. No significant differences in exotic species were found.

There was no significant difference in the number of species within each foraging guild observed across the four ecosystem types, other than carnivores only being observed in VS2 and WF4 (Figure 25). This sporadic detection of carnivores is likely a reflection of the low number of species in this guild and the low number recorded, only of kāhu/swamp harrier (*Circus approximans*) and ruru/morepork, along with the cryptic nature of ruru/morepork during the day. In general, there were more insectivores and omnivores species observed than frugivores within all ecosystem types. There was significantly higher relative abundance of omnivores observed in EF than in VS2 ($p = 0.04$), WF11 ($p = 0.01$), or WF4 ($p < 0.01$; Figure 26). While WF4 had significantly higher relative abundance of frugivores than EF ($p = 0.04$) or VS2 ($p = 0.02$).

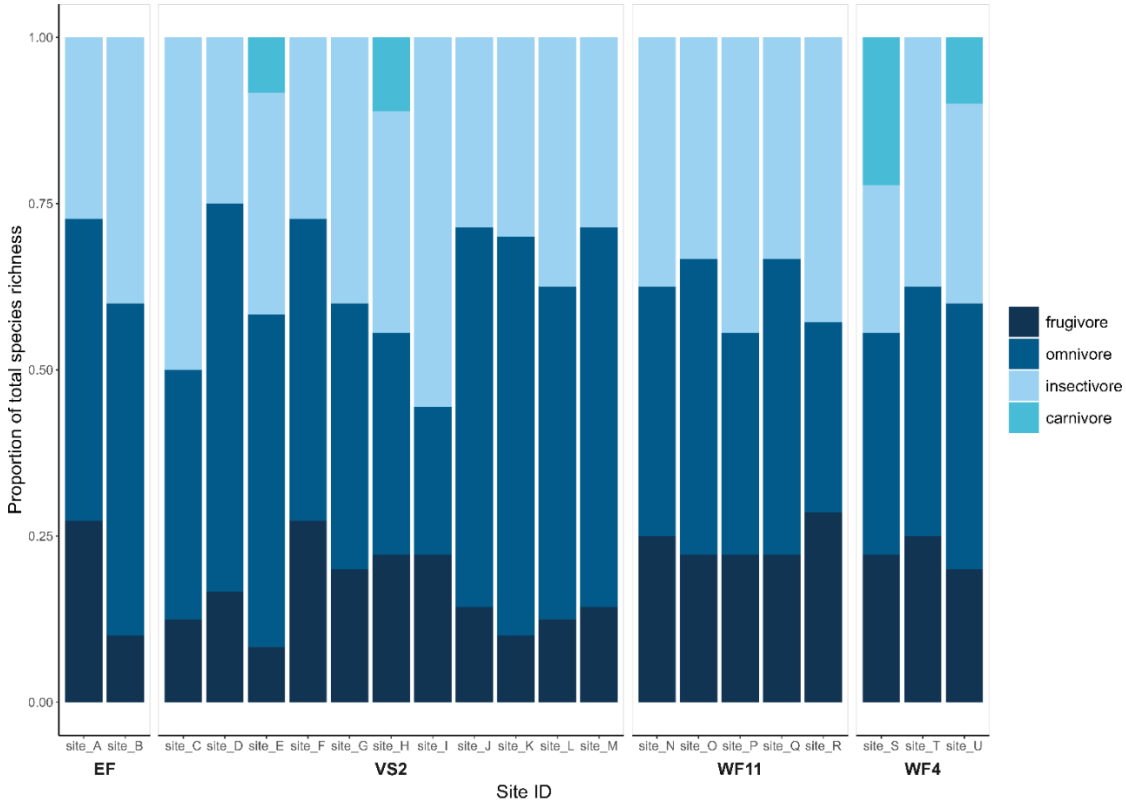

Figure 25: Number of species of birds within each foraging guild observed across the 21 permanent 20x20m plots on Kawau, grouped by ecosystem type.

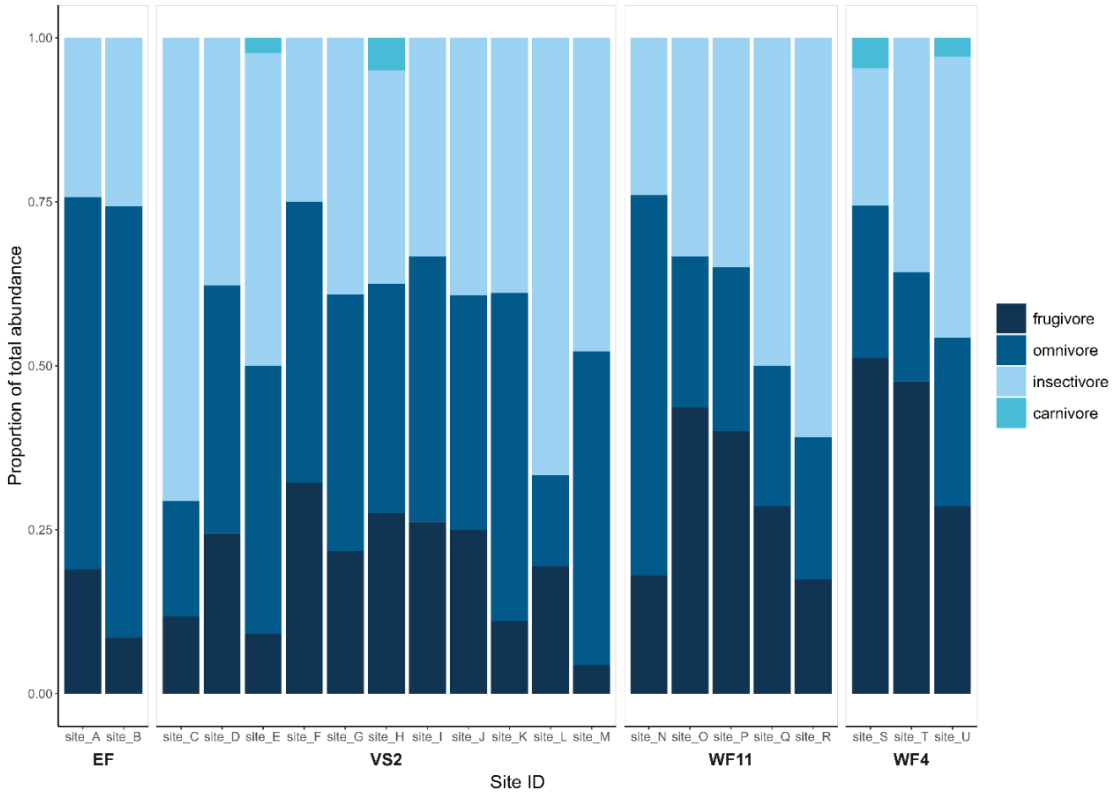

Figure 26: Number of individual birds within each foraging guild observed across the 21 permanent 20x20m plots on Kawau, grouped by ecosystem type.

Most detected bird species were canopy species, followed by understorey and finally ground species (Figure 27). There were no significant differences in the number of species of each habitat guild observed across the four ecosystem types. The relative abundance of canopy birds was significantly lower in VS2 than in either EF ($p < 0.01$) or WF4 ($p = 0.01$), though EF had a significantly lower number of understorey birds than VS2 ($p < 0.01$; Figure 28). There were no significant differences in the abundance of ground species across the four ecosystem types.

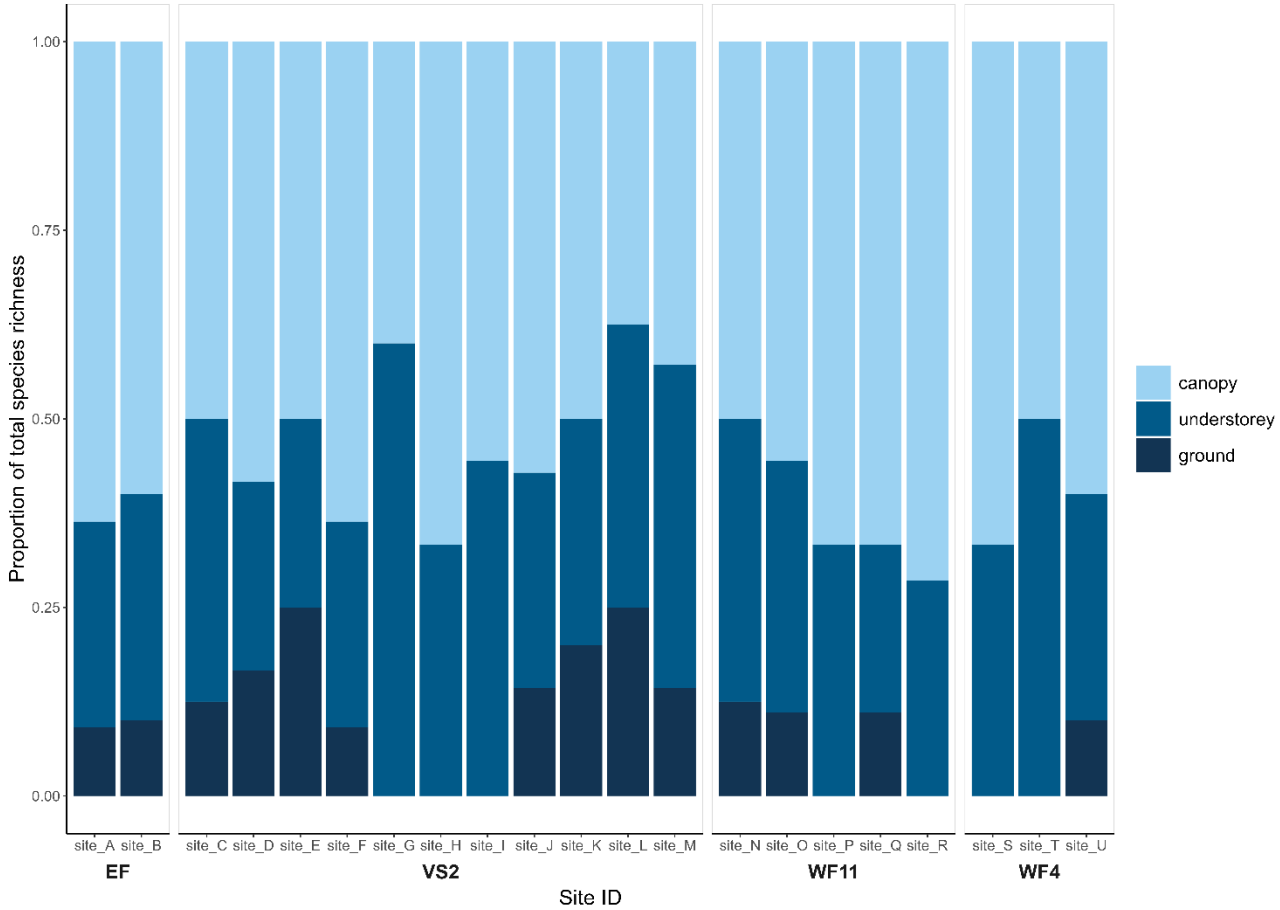

Figure 27: Number of bird species within each habitat guild observed across the 21 permanent 20x20m plots on Kawau, grouped by ecosystem type.

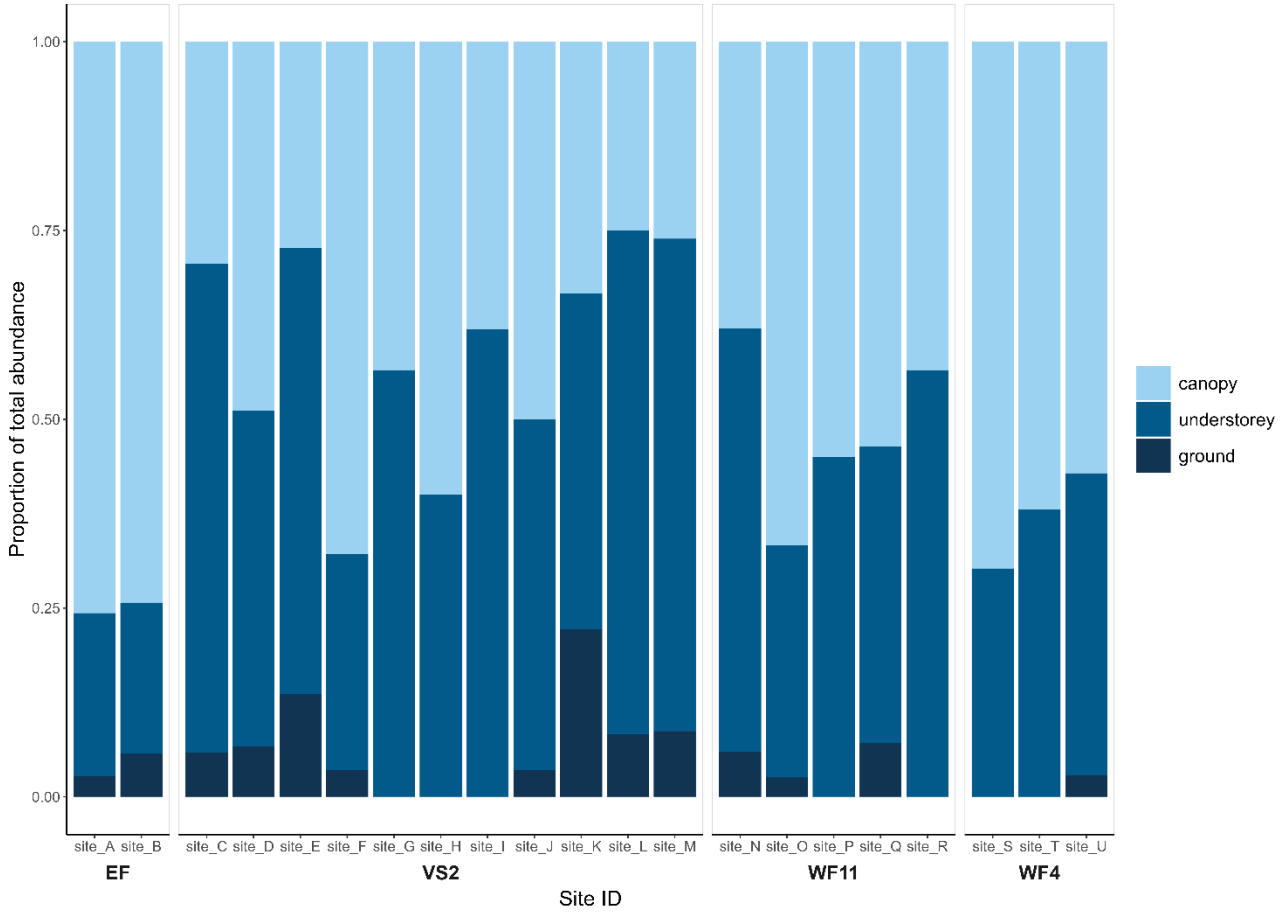

Figure 28: Number of individual birds within each habitat guild observed across the 21 permanent 20x20m plots on Kawau, grouped by ecosystem type.

5 Discussion

5.1 Forest structure and dynamics

The baseline monitoring results show that there are notable issues in forest ecosystem functionality on Kawau. Key amongst these is the highly limited seedling recruitment observed across all plots. Most seedlings were seen to be smaller than 10cm in height, with a rapid drop-off in the number of individuals as sizes increase. This signal may be extremely strong due to the springtime sampling, though the absence of larger individuals is still notable. In well-established forests, size distribution usually follows a shallower reverse-J curve, though the steepness of this curve increases as thinning processes (i.e., mortality) increase (Coomes and Allen, 2006). This more extreme curve and absence of larger trees is observed at other New Zealand forests that have been exposed to high levels of mammalian herbivory (Coomes & Allen, 2006; Jo et al., 2024) This strongly suggests that herbivory (browsing), from the wallabies and possums present on Kawau, may be preventing seedlings from establishing beyond the initial germination stage.

The very reduced abundance seen in the sapling age class also suggests a recruitment bottleneck which is limiting the ability of the forest to regenerate into an ecosystem with higher diversity. There is also evidence of some selective filtering of plant species due to wallaby browse, with saplings and mature trees generally having lower proportions of palatable species than that observed for seedlings (Figure 17). This type of recruitment bottleneck and selective filtering of seedlings is expected for forests under browsing pressures. Where this browser pressure has been removed, such as with mammalian pest management plans similar to that planned for Kawau, forests have been shown to regenerate with increased diversity and native composition (Allen et al., 2023). If a restoration of natural regeneration is not allowed to occur, the forest ecosystems on Kawau will be at an ever-increasing risk of forest collapse, possibly leading to the loss of such ecosystems from the island.

The reduced recruitment has resulted in a forest with an arrested successional pattern. This pattern is especially obvious in the VS2 and EF ecosystem types, which both show significant single species canopy dominance and a depauperate sub-canopy resulting in very limited structural complexity, even when compared to similar ecosystem types throughout Auckland (Griffiths & Lawrence, 2025). The high correlation between kānuka abundance and low species richness (Figure 8 and Figure 9), along with the similar sizes of mature trees with no emergent species, suggests that these are likely a cohort of a similar age (approximately 80-90 years; Wilcox et al., 2004) that has failed to transition into a later successional diverse forest as recruitment has not been sufficient. This failure for forest succession from early pioneer species, such as kānuka, to later successional species to form more diverse forests is a common finding in North Island forests exposed to mammalian browsing pressure (Richardson et al. 2014).

The very high abundance of adult trees in kānuka scrub/forest (VS2) ecosystems, matches similar over-planted early successional forests (kānuka) within Auckland, and along with the high

flammability of these forest types, presents a notable disturbance risk on the island, with no evident mechanism for forest regrowth following such a disturbance. This higher risk of fire disturbance may become an increasing issue with Aotearoa / New Zealand likely to become more at risk of fires under changing climatic conditions, exacerbated by mammalian pests (Pearce. 2018; Perry et al., 2015). This can lead to forests falling into fire traps where shifts in the fire regime drive previously wet forests into an alternate dry, high flammability stable state (Lindenmayer et al., 2011) The higher weed and exotic species load present in VS2 and EF ecosystems are likely to further reduce the recruitment and thus successional pathways of these ecosystems. Such regeneration failure can further arrest succession into a more flammable and less biodiverse state (Perry et al., 2015).

Browsing pressures have effectively locked these ecosystems into a pseudo-stable state that may be slow to change even after their removal (Poorter et al., 2023). The forest can only be in this psuedo-stable state while adult mortality is limited and as the forests age this mortality will increase leading to canopy collapse. This arrested forest succession will have impacts beyond the plant communities themselves, as has been found in the recent kiwi-nui/North Island brown kiwi survey on the island (Donovan & Joustra, 2025). This survey found the Kawau kiwi population to be in relatively poor health, with limited evidence of successful breeding; findings which are linked to the poor foraging resources available to them as a result of the sparse and degraded understorey across much of the island. The WF11 (including WF12) and WF4 ecosystems show greater indigenous dominance and diversity at all stages. These ecosystems are acting as refugia for many native plant species on the island and will be acting as key resources for many of the bird species on the island, as well as a seed source which may enable the expansion of native forests on the island.

The WF11 and WF4 ecosystems may provide refugia for seed sources from which indigenous plant species could spread from, once pressures are sufficiently removed. This type of forest spread from gully refugia has been shown to occur within other areas within Tāmaki Makaurau / Auckland, such as Shakespear Open Sanctuary, following sufficient pest management (Griffiths & Lawrence, 2025). The widespread distribution of some indigenous plants, such as red māpou and taraire, will also provide seed sources for a wider area of the island. In fact, the relatively high number and diversity of seedlings, including shrubs such as tuahinu (*Pomaderris amoena*), climbing vines such as akatea and trees such as pūriri (*Vitex lucens*), suggests that there is still either an active seedbank or functional seed supply, which should allow for the re-establishment of high diversity forests with minimal requirements for active replanting or similar, once pest mammals are removed. This process of increased native sapling densities resulting from active seedbanks has been found to be rapid within other parts of Aotearoa / New Zealand following browser removal (Wright et al., 2012). Though it should be reiterated that changes in forest composition and structure may take longer in areas of a single species canopy, such as those observed in VS2 plots.

The currently observed weedy and exotic plant species levels are relatively low. This finding is consistent with previous work suggesting wallaby browse may be suppressing many invasive weed species on the island (Singer, 2023). It is likely that these species are being supressed by browsing pressure in the same way as many of the native species. Release of this pressure following mammalian pest removal may result in a wider spread and higher abundance of some weed species.,

which would likely have an interaction with native species altering the trajectory of the forest recovery.

This will be especially prevalent in VS2 as it already has higher levels of established weed species, particularly in the sapling age class. This likely will be compounded by the largely absent understorey limiting competition for weedy species. Though it has been found that as browser densities reduce, they may have preferential selection for more highly palatable species, both weedy and indigenous, which may delay these species spread until all browsers are eliminated (Wright et al., 2012). To avoid a large expansion in weedy species, these need to be carefully monitored and will likely require active management at least in the short-term. This may include site-led management, such as species-led containment (or eradication) of weed species occurring at very low levels on the island, in parallel with mammalian pest eradication (Singer, 2023). If weeds are sufficiently suppressed for a period long enough to allow for native forest ecosystems to expand and diversify, these ecosystems will become more robust to weed incursion further inhibiting weed expansion (Singer, 2023)

5.2 Birds

There was a relatively high indigenous dominance in the island's bird community, being notably higher than the Auckland regional average (Griffiths & Lawrence, 2025). This may, in part, be due to the overall coverage of native ecosystems on the island (compared to fully urbanised areas for instance), but the island's proximity areas with higher native avian diversity, such as Tāwharanui and Shakespear Open Sanctuaries, and Te Hauturu-o-Toi, is likely to also have an influence. Results suggest that the forest, or at least the indigenous ecosystems, such as WF11 and WF4, on Kawau still have sufficient functionality for intact animal-plant interactions: however, there was a limited number of frugivores observed, suggesting that seed dispersal for some plant species may be constrained. This has the potential of slowing or skewing forest recovery, though it is difficult to predict in isolation whether this is likely given the current abundance of frugivores.

The removal of pest mammals from the island may have a high impact on the birds as it has a two-fold effect. First, the restoration of forest habitat as the forest recovers will increase habitat and food resources. This may shift the bird community towards higher levels of understorey species as this element of the forest is currently highly reduced. The additional habitat and associated resources will also support a larger bird population which may benefit surrounding areas due to dispersal. Second, the removal of predatory species, such as possums and rats, will have a direct reduction in the mortality rate of the birds, or their eggs. Though it is possible that native predatory species, such as weka, may increase, limiting this impact for susceptible species (Carpenter et al., 2021). It should be noted that both the effects of increasing habitat and lower predation pressure, while generally found to improve bird populations can have varying sizes of effects and certain species may show disproportionate improvements compared to other species, changing the overall composition of the bird community (Ruffell & Didham, 2016).

6 Future monitoring

This report describes a baseline snapshot of ecosystem health within dominant forest ecosystems on Kawau and provides an indication of the impact mammalian pest species have had on overall ecological integrity. The plot network established on the island will need to be remeasured over time to understand the outcomes of the pest free Kawau Island programme, and at a frequency which enables adaptive management. Similar forest monitoring undertaken by DOC under the national tier one (DOC, 2019) monitoring programme on public conservation land is undertaken on a five-year cycle, with a recent review indicating that this measurement frequency provides high power to detect rapid to moderate change in a range of plant and avian guilds, including palatable saplings (MacLeod et al., 2025). It is recommended that the forest plot remeasures are implemented at this five-year frequency in the long-term; however, the required frequency is likely to be higher in the short-term (10-15 years post completion of the pest free Kawau Island programme stages) to enable adaptive management.

It is anticipated that the initial response to pest mammal removal, particularly browsers, in the forest understorey will happen rapidly. Therefore, it is recommended that remeasures in the short-term occur at a frequency of every two to three years to enable emerging pressures (i.e., invasive weeds) to be identified and mitigated. This should be reviewed once data indicates a decline in seedling establishment and peaks in sapling density. The point at which first, and subsequent remeasures, will occur depends upon the timing at which the programme's first stage is completed, meaning wallabies and possums have been successfully eradicated, and the timing at which the second stage (mammalian predators) is implement, if at all, and the associated timeframes for completion. It is anticipated the initial remeasures will be undertaken at least the year following completion of the programme; however, consideration should be given to capturing potential interim responses should there be a lag period between eradication of browsers and implementation of the second stage of the programme.

It is important to note that the forest monitoring network described in this report is specifically targeted towards measuring structure and compositional changes in forest vegetation and bird communities as a measure of overall ecosystem health and integrity. It does not adequately capture species-level responses. Kawau is known to support a variety of indigenous species, including kiwi-nui/North Island brown kiwi and weka, and may also provide habitat for less conspicuous species, such as native lizards. Although some species-level monitoring, such as kiwi call count monitoring (Craig, 2021), is undertaken on the island, it is recommended that further monitoring is considered to better understand outcomes of the pest free Kawau Island programme on high-value native species populations on the island.

7 Conclusion

The forest monitoring network described in this report was established on Kawau to support the pest free Kawau Island programme by establishing a baseline of forest ecological integrity to help identify trends associated with programme outcomes and inform adaptive management. This report assesses forest vegetation and bird community data recorded on the island to describe a baseline snapshot of the current condition of dominant forest ecosystems on the island prior to eradication and provide a benchmark from which future change and outcomes from the programme can be measured.

The browsing pressure from wallabies and other mammalian pests has created a recruitment bottleneck that has halted forest succession, particularly in the exotic forest (EF) and kānuka scrub/forest ecosystems (VS2), resulting in simplified forest structure and reduced biodiversity. However, the broadleaved forest ecosystems (WF11, WF12 and WF4), have widespread distribution of key indigenous species, and presence of viable seedlings indicate that the fundamental components for ecosystem recovery remain present. The successful eradication of mammalian pest species should, in essence, allow for a release of these forests from their current degraded state, restoring critical habitat for fauna, such as kiwi-nui/North Island brown kiwi, though the trajectory and timing of recovery will likely vary between ecosystem types.

The data collected through this monitoring network provides essential baseline metrics against which future ecosystem recovery can be measured, enabling adaptive management responses and success monitoring. In order to capture this, it is recommended that network remeasures in the short-term occur every two to three years post eradication to enable emerging pressures to be identified and mitigated; followed by a five-year frequency in the long term. Species-level population monitoring should be considered to better understand the impact of the pest free Kawau Island programme on high-value native species on the island.

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Appendix A. Supplemental materials

Table A.1: Abundance for all recorded vegetation species across all permanent 20x20m plots on Kawau. **Bold** indicates exotic species. * indicates listed pest species in the Auckland Regional Pest Management Plan (RPMP) (Auckland Council, 2020).

Scientific name	Common name	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
Kunzea robusta	Kānuka	1213	0.25	63.84 ± 9.88
Cyathea dealbata	Ponga	625	0.13	32.89 ± 6.99
Lagenophora sublyrata	Lagenophora	262	0.05	13.79 ± 2.07
Metrosideros perforata	Akatea	248	0.05	31.00 ± 8.22
Oplismenus hirtellus imbecillis	Basket grass	184	0.04	10.22 ± 2.14
Myrsine australis	Red māpou	151	0.03	7.55 ± 2.19
Microlaena stipoides	Meadow rice grass	135	0.03	11.25 ± 4.18
Beilschmiedia tarairi	Taraire	105	0.02	8.75 ± 2.71
Leucopogon fasciculatus	Mingimingi	85	0.02	5.00 ± 1.58
Veronica plebeia	Speedwell	74	0.02	4.11 ± 0.91
Leptospermum scoparium	Mānuka	68	0.01	34.00 ± 26.00
Schoenus tendo	Kauri sedge	66	0.01	16.50 ± 5.92
Senecio diaschides	Fireweed	61	0.01	5.08 ± 1.90
Cirsium vulgare	**Scotch thistle**	59	0.01	4.54 ± 2.41
Leptecophylla juniperina	Prickly mingimingi	56	0.01	5.60 ± 2.25
Microsorum scandens	Fragrant fern	54	0.01	7.71 ± 3.13
Pinus radiata	Radiata pine	50	0.01	12.50 ± 6.09
Gonocarpus incanus	Piripiri	44	0.01	6.29 ± 1.36
Acianthus sinclairii	Heart-leaved orchid	41	0.01	3.15 ± 1.13
Chrysanthemoides monilifera*	**Boneseed**	40	0.01	2.86 ± 0.64
Nestegis lanceolata	White maire	38	0.01	3.45 ± 1.15
Piper excelsum	Kawakawa	36	0.01	5.14 ± 2.87
Cortaderia spp. (jubata or selloana)*	**Pampas**	34	0.01	3.40 ± 0.78
Galium propinquum	Māwe	34	0.01	2.12 ± 0.35
Pyrrosia eleagnifolia	Leatherleaf fern	34	0.01	3.09 ± 0.65

Scientific name	Common name	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
*Zantedeschia aethiopica**	Arum lily	34	0.01	4.86 ± 2.28
Agathis australis	Kauri	31	0.01	7.75 ± 3.84
Corybas trilobus	Spider orchid	31	0.01	3.44 ± 0.93
Lindsaea linearis	Screw fern	31	0.01	4.43 ± 1.54
Dichondra repens	Mercury Bay weed	28	0.01	3.11 ± 1.20
Hydrocotyle tripartita	Australian hydrocotyle	28	0.01	3.50 ± 1.20
Knightia excelsa	Rewarewa	28	0.01	2.55 ± 0.49
Asplenium flaccidum	Coastal spleenwort	26	0.01	2.60 ± 0.43
Hypochaeris radicata	Catsear	25	0.01	1.79 ± 0.28
Thelymitra longifolia	White sun orchid	25	0.01	6.25 ± 2.69
Vitex lucens	Pūriri	25	0.01	2.78 ± 0.89
Metrosideros fulgens	Climbing rātā	24	0.00	8.00 ± 4.73
Microsorum pustulatum	Hound's tongue	23	0.00	2.30 ± 0.68
Cyrtostylis oblonga	Winter orchid	21	0.00	5.25 ± 3.92
Hymenophyllum sanguinolentum	Filmy fern	21	0.00	2.62 ± 0.65
*Jacobaea vulgaris**	Ragwort	20	0.00	2.50 ± 0.57
Geniostoma ligustrifolium	Hangehange	19	0.00	1.36 ± 0.20
Hydrocotyle moschata	Hairy pennywort	19	0.00	1.90 ± 0.46
Erigeron sumatrensis	Broad-leaved fleabane	18	0.00	2.00 ± 0.58
Carex inversa	Creeping lawn sedge	16	0.00	2.29 ± 0.97
Hypericum pusillum	Swamp hypericum	16	0.00	1.78 ± 0.55
Clematis paniculata	White clematis	15	0.00	5.00 ± 3.51
Earina mucronata	Bamboo orchid	15	0.00	2.14 ± 0.26
Pomaderris amoena	Tuahinu	15	0.00	2.14 ± 0.86
Sonchus asper	Prickly sow thistle	15	0.00	7.50 ± 6.50
Drosera auriculata	Sundew	14	0.00	2.33 ± 0.80
Histiopteris incisa	Water fern	14	0.00	7.00 ± 3.00
Centella uniflora	Centella	13	0.00	2.17 ± 0.98
Schoenus maschalinus	Dwarf bog rush	12	0.00	1.33 ± 0.24
*Solanum mauritianum**	Woolly nightshade	12	0.00	2.00 ± 0.37
Asplenium polyodon	Sickle spleenwort	11	0.00	2.20 ± 0.20
Coprosma arborea	Tree coprosma	11	0.00	1.38 ± 0.37
Coprosma rhamnoides	Twiggy Coprosma	11	0.00	1.38 ± 0.18
Griselinia lucida	Puka	11	0.00	3.67 ± 1.67

Scientific name	Common name	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
Senecio bipinnatisectus	Australian fireweed	11	0.00	1.22 ± 0.22
Hymenophyllum demissum	Drooping filmy fern	10	0.00	3.33 ± 1.86
Bulbophyllum pygmaeum	Pygmy tree orchid	9	0.00	2.25 ± 0.25
Callitriche muelleri	Mueller's starwort	9	0.00	1.29 ± 0.18
Hymenophyllum nephrophyllum	Kidney fern	9	0.00	3.00 ± 0.58
Melicytus ramiflorus	Māhoe	8	0.00	1.60 ± 0.60
Corynocarpus laevigatus	Karaka	7	0.00	1.40 ± 0.40
Elaeocarpus dentatus	Hīnau	7	0.00	7.00
Galium divaricatum	**Slender bedstraw**	7	0.00	3.50 ± 2.50
Lysimachia arvensis	**Pimpernel**	7	0.00	3.50 ± 2.50
Senecio minimus	Fireweed	7	0.00	1.40 ± 0.40
Corybas acuminatus	Spider orchid	6	0.00	6.00
Corybas cheesemanii	Helmet orchid	6	0.00	1.50 ± 0.29
Gamochaeta simplicicaulis	**Simple-stem cudweed**	6	0.00	1.00 ± 0.00
Hydrocotyle heteromeria	Waxweed	6	0.00	1.50 ± 0.50
Lindsaea trichomanoides	Oval-wedge fern	6	0.00	2.00 ± 1.00
Pterostylis alobula	Greenhood	6	0.00	1.50 ± 0.50
Schizaea fistulosa	Comb fern	6	0.00	1.50 ± 0.50
Astelia hastata	Tank lily	5	0.00	2.50 ± 0.50
Blechnum parrisiae	Rasp fern	5	0.00	1.67 ± 0.67
Carex breviculmis	Grassland sedge	5	0.00	1.00 ± 0.00
Dianella nigra	Turutu	5	0.00	1.67 ± 0.67
Lygodium articulatum	Mangemange	5	0.00	2.50 ± 0.50
Metrosideros excelsa	Pōhutukawa	5	0.00	1.67 ± 0.33
Phytolacca octandra	**Inkweed**	5	0.00	5.00
Rubus cissoides	Bush lawyer	5	0.00	1.67 ± 0.67
Blechnum filiforme	Thread fern	4	0.00	4.00
Cestrum nocturnum*	**Queen of the night**	4	0.00	4.00
Crepis capillaris	**Hawksbeard**	4	0.00	1.00 ± 0.00
Dendrobium cunninghamii	Winika	4	0.00	2.00 ± 0.00

Scientific name	Common name	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
Euchiton japonicus	Creeping cudweed	4	0.00	1.33 ± 0.33
Hymenophyllum rarum	Filmy fern	4	0.00	1.33 ± 0.33
Lobelia anceps	NZ lobelia	4	0.00	1.33 ± 0.33
Nephrolepis cordifolia*	Tuber ladder fern	4	0.00	2.00 ± 1.00
Paesia scaberula	Lace fern	4	0.00	1.33 ± 0.33
Pteris macilenta	Sweet fern	4	0.00	1.33 ± 0.33
Rhopalostylis sapida	Nīkau	4	0.00	1.00 ± 0.00
Solanum aviculare	Poroporo	4	0.00	4.00
Sonchus arvensis	Perennial sow thistle	4	0.00	4.00
Tmesipteris lanceolata	Fork fern	4	0.00	2.00 ± 0.00
Caladenia minor	Finger orchid	3	0.00	1.00 ± 0.00
Coprosma lucida	Shining karamū	3	0.00	1.00 ± 0.00
Coprosma macrocarpa	Large-seeded coprosma	3	0.00	1.00 ± 0.00
Cordyline australis	Cabbage tree	3	0.00	1.00 ± 0.00
Drymoanthus adversus	Fleshy tree orchid	3	0.00	1.50 ± 0.50
Hedycarya arborea	Pigeonwood	3	0.00	1.00 ± 0.00
Juncus effusus	Soft rush	3	0.00	1.00 ± 0.00
Lagenophora pumila	Papataniwhaniwha	3	0.00	1.50 ± 0.50
Notogrammitis billardierei	Common strap fern	3	0.00	1.00 ± 0.00
Oxalis corniculata	Horned oxalis	3	0.00	3.00
Poa pusilla	Poa	3	0.00	1.50 ± 0.50
Prumnopitys ferruginea	Miro	3	0.00	1.50 ± 0.50
Pteris tremula	Australasian bracken	3	0.00	1.00 ± 0.00
Adiantum hispidulum	Rosy maidenhair	2	0.00	1.00 ± 0.00
Asplenium oblongifolium	Shining spleenwort	2	0.00	2.00
Beilschmiedia tawa	Tawa	2	0.00	2.00
Carex flagellifera	Glen Murray tussock	2	0.00	1.00 ± 0.00
Corybas oblongus	Spider orchid	2	0.00	1.00 ± 0.00
Cyperus ustulatus	Coastal cutty grass	2	0.00	2.00
Dacrycarpus dacrydioides	Kahikatea	2	0.00	2.00
Deparia petersenii	Japanese lady fern	2	0.00	1.00 ± 0.00
Leontodon saxatilis	Hawkbit	2	0.00	1.00 ± 0.00
Microtis unifolia	Onion-leaved orchid	2	0.00	1.00 ± 0.00
Nertera dichondrifolia	Nertera	2	0.00	2.00

Scientific name	Common name	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
Notogrammitis ciliata	Strap fern	2	0.00	1.00 ± 0.00
Phoenix canariensis*	Phoenix palm	2	0.00	2.00
Ripogonum scandens	Supplejack	2	0.00	2.00
Solanum pseudocapsicum	Jerusalem cherry	2	0.00	1.00 ± 0.00
Sonchus oleraceus	Sow thistle	2	0.00	1.00 ± 0.00
Tmesipteris elongata	Fork fern	2	0.00	2.00
Wahlenbergia violacea	Violet hairbell	2	0.00	1.00 ± 0.00
Acacia melanoxylon	Australian blackwood	1	0.00	1.00
Adiantum cunninghamii	Common maidenhair	1	0.00	1.00
Araujia sericifera*	Moth plant	1	0.00	1.00
Asparagus asparagoides*	Smilax	1	0.00	1.00
Astelia solandri	Perching lily	1	0.00	1.00
Blechnum membranaceum	Hard fern	1	0.00	1.00
Blechnum novae-zelandiae	Kiokio	1	0.00	1.00
Brachyglottis repanda	Rangiora	1	0.00	1.00
Carex virgata	Swamp sedge	1	0.00	1.00
Coprosma robusta	Glossy karamū	1	0.00	1.00
Crataegus monogyna*	Hawthorn	1	0.00	1.00
Cyperus eragrostis	Umbrella sedge	1	0.00	1.00
Diplazium australe	Austral Lady Fern	1	0.00	1.00
Gahnia setifolia	Razor sedge	1	0.00	1.00
Geranium homeanum	Cranesbill	1	0.00	1.00
Helminthotheca echioides	Oxtongue	1	0.00	1.00
Hydrocotyle bowlesioides	Water pennywort	1	0.00	1.00
Hymenophyllum flexuosum	Filmy fern	1	0.00	1.00
Hypericum japonicum	Matted St John's wort	1	0.00	1.00
Hypolepis dicksonioides	Giant hypolepis	1	0.00	1.00
Iris foetidissima	Stinking iris	1	0.00	1.00
Isolepis inundata	Swamp club rush	1	0.00	1.00
Isolepis reticularis	Club rush	1	0.00	1.00
Juncus planifolius	Grass-leaved rush	1	0.00	1.00

Scientific name	Common name	Total count	Proportion of total count	Mean abundance per species per plot (± SE)
Juncus usitatus	Common rush	1	0.00	1.00
Myosotis discolor	**Grassland forget-me-not**	1	0.00	1.00
Ophioglossum coriaceum	Adder's tongue	1	0.00	1.00
Parapolystichum glabellum	Smooth shield fern	1	0.00	1.00
Phormium tenax	Flax	1	0.00	1.00
Prunus campanulata*	**Taiwan cherry**	1	0.00	1.00
Pterostylis trullifolia	Trowel-leaved orchid	1	0.00	1.00
Senecio biserratus	Fireweed	1	0.00	1.00
Senna septemtrionalis*	**Buttercup bush**	1	0.00	1.00
Symphyotrichum subulatum	**Bushy starwort**	1	0.00	1.00
Syzygium australe*	**Bush cherry**	1	0.00	1.00
Taraxacum officinale	**Dandelion**	1	0.00	1.00
Veronica stricta	Koromiko	1	0.00	1.00

Appendix B. Species lists

Table B.1: List of plant species identified across all permanent 20x20m plots on Kawau, including scientific and common names, biostatus, structural class and regional threat status (Simpkins et al., 2025). **Bold** text indicates species listed as pests in the Auckland Regional Pest Management Plan (Auckland Council, 2020).

Scientific name	Common name	Biostatus	Structural class	Regional conservation status
Acacia melanoxylon	Australian blackwood	Exotic	Trees & Shrubs	n/a
Acianthus sinclairii	Heart-leaved orchid	Endemic	Orchids	Not threatened
Adiantum cunninghamii	Common maidenhair	Endemic	Ferns	Not threatened
Adiantum hispidulum	Rosy maidenhair	Native	Ferns	Not threatened
Agathis australis	Kauri	Endemic	Trees & Shrubs	At risk – declining
Araujia sericifera	**Moth plant**	Exotic	Lianes & Trailing Plants	n/a
Asparagus asparagoides	**Smilax**	Exotic	Lianes	n/a
Asplenium flaccidum	Coastal spleenwort	Endemic	Ferns	Not threatened
Asplenium oblongifolium	Huruhuruwhenua /shining spleenwort	Endemic	Ferns	Not threatened
Asplenium polyodon	Sickle spleenwort	Native	Ferns	Not threatened
Astelia hastata	Tank lily	Native	Herbs	Not threatened
Astelia solandri	Kōwharawhara/perching lily	Native	Herbs	Not threatened
Beilschmiedia tarairi	Taraire	Endemic	Trees & Shrubs	Not threatened
Beilschmiedia tawa	Tawa	Endemic	Trees & Shrubs	Not threatened
Blechnum filiforme	Thread fern	Endemic	Trees & Shrubs	Not threatened
Blechnum membranaceum	Hard fern	Endemic	Ferns	Not threatened
Blechnum novae-zelandiae	Kiokio	Endemic	Ferns	Not threatened
Blechnum parrisiae	Rasp fern	Native	Ferns	Not threatened
Brachyglottis repanda	Rangiora	Endemic	Trees & Shrubs	Not threatened
Bulbophyllum pygmaeum	Pygmy tree orchid	Endemic	Orchids	Not threatened
Caladenia minor	Finger orchid	Endemic	Orchids	n/a
Callitriche muelleri	Mueller's starwort	Native	Herbs	Not threatened
Carex breviculmis	Grassland sedge	Native	Sedges	Not threatened
Carex flagellifera	Glen Murray tussock	Endemic	Sedges	Not threatened
Carex inversa	Creeping lawn sedge	Native	Sedges	Not threatened
Carex virgata	Pukio/swamp sedge	Endemic	Sedges	Not threatened
Centella uniflora	Centella	Native	Herbs	Not threatened
Cestrum nocturnum	**Queen of the night**	Exotic	Trees & Shrubs	n/a
Chrysanthemoides monilifera	**Boneseed**	Exotic	Trees & Shrubs	n/a
Cirsium vulgare	Scotch thistle	Exotic	Herbs	n/a

Scientific name	Common name	Biostatus	Structural class	Regional conservation status
Clematis paniculata	Puawananga/white clematis	Endemic	Lianes & Trailing Plants	Not threatened
Coprosma arborea	Māmāngi /tree coprosma	Endemic	Trees & Shrubs	Not threatened
Coprosma lucida	Karamū/shining karamū	Endemic	Trees & Shrubs	Not threatened
Coprosma macrocarpa	Large-seeded coprosma	Endemic	Trees & Shrubs	Not threatened
Coprosma rhamnoides	Twiggy Coprosma	Endemic	Trees & Shrubs	Not threatened
Coprosma robusta	Karamū/glossy karamū	Endemic	Trees & Shrubs	Not threatened
Cordyline australis	Tī kōuka/cabbage tree	Endemic	Trees & Shrubs	Not threatened
Cortaderia jubata/selloana	**Pampas**	Exotic	Grasses	n/a
Corybas acuminatus	Spider orchid	Endemic	Orchids	Not threatened
Corybas cheesemanii	Helmet orchid	Endemic	Orchids	Not threatened
Corybas oblongus	Spider orchid	Endemic	Orchids	Not threatened
Corybas trilobus	Spider orchid	Endemic	Orchids	Not threatened
Corynocarpus laevigatus	Karaka	Endemic	Trees & Shrubs	Not threatened
Crataegus monogyna	**Hawthorn**	Exotic	Trees & Shrubs	n/a
Crepis capillaris	Hawksbeard	Exotic	Herbs	n/a
Cyathea dealbata	Ponga	Endemic	Ferns	Not threatened
Cyperus eragrostis	Umbrella sedge	Exotic	Sedges	n/a
Cyperus ustulatus	Coastal cutty grass	Endemic	Sedges	Not threatened
Cyrtostylis oblonga	Winter orchid	Endemic	Orchids	Not threatened
Dacrycarpus dacrydioides	Kahikatea	Endemic	Trees & Shrubs	Not threatened
Dendrobium cunninghamii	Winika	Endemic	Orchids	Not threatened
Deparia petersenii	Japanese lady fern	Native	Ferns	Not threatened
Dianella nigra	Turutu	Endemic	Herbs	Not threatened
Dichondra repens	Mercury Bay weed	Native	Herbs	Not threatened
Diplazium australe	Austral Lady Fern	Native	Ferns	Not threatened
Drosera auriculata	Sundew	Native	Herbs	Not threatened
Drymoanthus adversus	Fleshy tree orchid	Endemic	Orchids	Not threatened
Earina mucronata	Peka-a-waka/bamboo orchid	Endemic	Orchids	Not threatened
Elaeocarpus dentatus	Hīnau	Endemic	Trees & Shrubs	Not threatened
Erigeron sumatrensis	Broad-leaved fleabane	Exotic	Herbs	n/a
Euchiton japonicus	Creeping cudweed	Native	Herbs	Not threatened
Gahnia setifolia	Māpere/razor sedge	Endemic	Sedges	Not threatened
Galium divaricatum	Slender bedstraw	Exotic	Herbs	n/a
Galium propinquum	Māwe	Endemic	Herbs	At risk – declining
Gamochaeta simplicicaulis	Simple-stem cudweed	Exotic	Herbs	n/a
Geniostoma ligustrifolium	Hangehange	Endemic	Trees & Shrubs	Not threatened
Geranium homeanum	Cranesbill	Native	Herbs	Not threatened
Gonocarpus incanus	Piripiri	Endemic	Herbs	Not threatened

Scientific name	Common name	Biostatus	Structural class	Regional conservation status
Griselinia lucida	Puka	Endemic	Trees & Shrubs	Not threatened
Hedycarya arborea	Porokaiwhiri/ pigeonwood	Endemic	Trees & Shrubs	Not threatened
Helminthotheca echioides	Oxtongue	Exotic	Herbs	n/a
Histiopteris incisa	Mātātā/water fern	Native	Ferns	Not threatened
Hydrocotyle bowlesioides	Water pennywort	Exotic	Herbs	n/a
Hydrocotyle heteromeria	Waxweed	Endemic	Herbs	Not threatened
Hydrocotyle moschata	Hairy pennywort	Endemic	Herbs	Not threatened
Hydrocotyle tripartita	Australian hydrocotyle	Exotic	Herbs	n/a
Hymenophyllum demissum	Irirangi/Drooping filmy fern	Endemic	Ferns	Not threatened
Hymenophyllum flexuosum	Filmy fern	Endemic	Ferns	Not threatened
Hymenophyllum nephrophyllum	Konehu/kidney fern	Endemic	Ferns	Not threatened
Hymenophyllum rarum	Filmy fern	Native	Ferns	Not threatened
Hymenophyllum sanguinolentum	Piripiri/filmy fern	Native	Ferns	Not threatened
Hypericum japonicum	Matted St John's wort	Native	Herbs	n/a
Hypericum pusillum	Swamp hypericum	Native	Herbs	At risk – declining
Hypochaeris radicata	Catsear	Exotic	Herbs	n/a
Hypolepis dicksonioides	Giant hypolepis	Native	Ferns	At risk – naturally uncommon
Iris foetidissima	Stinking iris	Exotic	Herbs	n/a
Isolepis inundata	Swamp club rush	Native	Sedges	Threatened – regionally vulnerable
Isolepis reticularis	Club rush	Endemic	Sedges	Not threatened
Jacobaea vulgaris	Ragwort	Exotic	Herbs	n/a
Juncus effusus	Soft rush	Exotic	Rushes & Allies	n/a
Juncus planifolius	Grass-leaved rush	Native	Rushes & Allies	Not threatened
Juncus usitatus	Common rush	Native	Rushes & Allies	Not threatened
Knightia excelsa	Rewarewa	Endemic	Trees & Shrubs	Not threatened
Kunzea robusta	Kānuka	Endemic	Trees & Shrubs	At risk – declining
Lagenophora pumila	Papataniwhaniwha	Endemic	Herbs	Not threatened
Lagenophora sublyrata	Lagenophora	Endemic	Herbs	At risk – declining
Leontodon saxatilis	Hawkbit	Exotic	Herbs	n/a
Leptecophylla juniperina	Prickly mingimingi	Endemic	Trees & Shrubs	Not threatened
Leptospermum scoparium	Mānuka	Native	Trees & Shrubs	Threatened – regionally vulnerable
Leucopogon fasciculatus	Mingimingi	Endemic	Trees & Shrubs	Not threatened
Lindsaea linearis	Screw fern	Endemic	Ferns	Not threatened

Scientific name	Common name	Biostatus	Structural class	Regional conservation status
Lindsaea trichomanoides	Oval-wedge fern	Native	Ferns	Not threatened
Lobelia anceps	NZ lobelia	Native	Herbs	Not threatened
Lygodium articulatum	Mangemange	Endemic	Ferns	Not threatened
Lysimachia arvensis	Pimpernel	Exotic	Herbs	n/a
Melicytus ramiflorus	Māhoe	Endemic	Trees & Shrubs	Not threatened
Metrosideros excelsa	Pōhutukawa	Endemic	Trees & Shrubs	At risk – declining
Metrosideros fulgens	Climbing rātā	Endemic	Lianes & Trailing Plants	At risk – declining
Metrosideros perforata	Akatea	Endemic	Trees & Shrubs	At risk – declining
Microlaena stipoides	Meadow rice grass	Native	Grasses	Not threatened
Microsorum pustulatum	Kōwaowao/hound's tongue	Native	Ferns	Not threatened
Microsorum scandens	Mokimoki/Fragrant fern	Native	Ferns	Not threatened
Microtis unifolia	Onion-leaved orchid	Native	Orchids	Not threatened
Myosotis discolor	Grassland forget-me-not	Exotic	Herbs	n/a
Myrsine australis	Red māpou	Endemic	Trees & Shrubs	Not threatened
Nephrolepis cordifolia	Tuber ladder fern	Exotic	Ferns	n/a
Nertera dichondrifolia	Nertera	Endemic	Herbs	Not threatened
Nestegis lanceolata	White maire	Endemic	Trees & Shrubs	Not threatened
Notogrammitis billardierei	Common strap fern	Native	Ferns	Not threatened
Notogrammitis ciliata	Strap fern	Endemic	Ferns	Not threatened
Ophioglossum coriaceum	Adder's tongue	Native	Ferns	Threatened – regionally vulnerable
Oplismenus hirtellus imbecillis	Basket grass	Native	Grasses	Not threatened
Oxalis corniculata	Horned oxalis	Exotic	Herbs	n/a
Paesia scaberula	Lace fern	Endemic	Ferns	Not threatened
Parapolystichum glabellum	Smooth shield fern	Endemic	Ferns	Not threatened
Phoenix canariensis	Phoenix palm	Exotic	Trees & Shrubs	n/a
Phormium tenax	Flax/harakeke	Endemic	Herbs	Not threatened
Phytolacca octandra	Inkweed	Exotic	Trees & Shrubs	n/a
Pinus radiata	Radiata pine	Exotic	Trees & Shrubs	n/a
Piper excelsum	Kawakawa	Endemic	Trees & Shrubs	Not threatened
Poa pusilla	Poa	Endemic	Grasses	At risk – declining
Pomaderris amoena	Tuahinu	Endemic	Trees & Shrubs	Not threatened
Prumnopitys ferruginea	Miro	Endemic	Trees & Shrubs	Not threatened
Prunus campanulata	Taiwan cherry	Exotic	Trees & Shrubs	n/a
Pteris macilenta	Sweet fern	Endemic	Ferns	Not threatened
Pteris tremula	Australasian bracken	Native	Ferns	Not threatened

Scientific name	Common name	Biostatus	Structural class	Regional conservation status
Pterostylis alobula	Greenhood	Native	Orchids	Not threatened
Pterostylis trullifolia	Trowel-leaved orchid	Endemic	Orchids	Not threatened
Pyrrosia eleagnifolia	Leatherleaf fern	Endemic	Ferns	Not threatened
Rhopalostylis sapida	Nīkau	Endemic	Trees & Shrubs	Not threatened
Ripogonum scandens	Kareao/supplejack	Endemic	Lianes	Not threatened
Rubus cissoides	Tātarāmoa/bush lawyer	Endemic	Trees & Shrubs	Not threatened
Schizaea fistulosa	Comb fern	Native	Ferns	Not threatened
Schoenus maschalinus	Dwarf bog rush	Native	Sedges	Not threatened
Schoenus tendo	Kauri sedge	Endemic	Sedges	Not threatened
Senecio bipinnatisectus	Australian fireweed	Native	Herbs	n/a
Senecio biserratus	Fireweed	Native	Herbs	Threatened – regionally vulnerable
Senecio diaschides	Fireweed	Native	Herbs	At risk – declining
Senecio minimus	Fireweed	Native	Herbs	At risk – declining
Senna septemtrionalis	**Buttercup bush**	Exotic	Trees & Shrubs	n/a
Solanum aviculare	Poroporo	Native	Trees & Shrubs	Threatened – regionally critical
Solanum mauritianum	**Woolly nightshade**	Exotic	Trees & Shrubs	n/a
Solanum pseudocapsicum	Jerusalem cherry	Exotic	Trees & Shrubs	n/a
Sonchus arvensis	Perennial sow thistle	Exotic	Herbs	n/a
Sonchus asper	Prickly sow thistle	Exotic	Herbs	n/a
Sonchus oleraceus	Sow thistle	Exotic	Herbs	n/a
Symphyotrichum subulatum	Bushy starwort	Exotic	Herbs	n/a
Syzygium australe	**Bush cherry**	Exotic	Trees & Shrubs	n/a
Taraxacum officinale	Dandelion	Exotic	Herbs	n/a
Thelymitra longifolia	Māikuku/white sun orchid	Native	Orchids	Not threatened
Tmesipteris elongata	Fork fern	Native	Ferns	Not threatened
Tmesipteris lanceolata	Fork fern	Native	Ferns	Not threatened
Veronica plebeia	Speedwell	Native	Herbs	Not threatened
Veronica stricta	Koromiko	Endemic	Trees & Shrubs	Not threatened
Vitex lucens	Pūriri	Endemic	Trees & Shrubs	Not threatened
Wahlenbergia violacea	Violet hairbell	Native	Herbs	At risk – declining
Zantedeschia aethiopica	**Arum lily**	Exotic	Herbs	n/a

Table B.2: List of bird species identified during 10-minute bird counts at all permanent 20x20m plots on Kawau, including scientific and common names, biostatus, foraging and habitat guilds (Binny et al., 2020; O'Donnell & Dilks, 1994) and regional threat status (Woolly et al., 2024).

Scientific name	Common name	Biostatus	Foraging guild	Habitat guild	Regional conservation status
Acridotheres tristis	Myna	Exotic	Omnivore	Canopy	Introduced and Naturalised
Carduelis carduelis	Goldfinch	Exotic	Omnivore	Canopy	Introduced and Naturalised
Chrysococcyx lucidas	Pīpīwharauroa/shining cuckoo	Native	Insectivore	Canopy	Not threatened
Circus approximans	Kāhu/swamp harrier	Native	Carnivore	Canopy	Not threatened
Fringilla coelebs	Chaffinch	Exotic	Omnivore	Canopy	Introduced and Naturalised
Gallirallus australis	Weka	Endemic	Omnivore	Ground	At risk – regionally relict
Gerygone igata	Riroriro/grey warbler	Endemic	Insectivore	Understorey	Not threatened
Gymnorhina tibicen	Magpie	Exotic	Insectivore	Ground	Introduced and Naturalised
Hemiphaga novaeseelandiae	Kererū	Endemic	Frugivore	Canopy	Not threatened
Nestor meridionalis	Kākā	Endemic	Omnivore	Canopy	At risk – regionally recovering
Ninox novaeseelandiae	Ruru/morepork	Native	Carnivore	Canopy	Not threatened
Pavo cristatus	Peafowl	Exotic	Omnivore	Ground	Introduced and Naturalised
Petroica macrocephala	Miromiro/tomtit	Endemic	Insectivore	Understorey	Not threatened
Platycercus eximius	Eastern rosella	Exotic	Frugivore	Canopy	Introduced and Naturalised
Prosthemadera novaeseelandiae	Tūī	Endemic	Frugivore	Canopy	Not threatened
Rhipidura fuliginosa	Pīwakawaka/fantail	Endemic	Insectivore	Understorey	Not threatened
Todiramphus sanctus	Kōtare/kingfisher	Native	Insectivore	Canopy	Not threatened
Turdus merula	Blackbird	Exotic	Omnivore	Ground	Introduced and Naturalised
Zosterops lateralis	Tauhou/silvereye	Native	Omnivore	Understorey	Not threatened

Appendix C. Palatability and flammability ratings

Table C.1: List of plant palatability ratings used to describe plant species identified across all permanent 20x20m plots on Kawau, based on previously reported palatability for wallabies (Wright & Ranger, 2017), ungulates (Forsythe et al., 2002; Sweetapple, 2022; Sweetapple & Burns, 2002) and possums (DOC, 2014; Sweetapple & Burns, 2002). ^ indicates palatability of fruits or flower buds only * Indicates where the palatability rating used in this report was determined as the midway point between previously reported values.

Scientific name	Common name	Previously reported rating			Rating – this report
		Wallaby	Ungulate	Possum	
Adiantum cunninghamii	Common maidenhair		Low		Low
Asplenium flaccidum	Coastal spleenwort	Low	Moderate	Moderate	Moderate
Asplenium oblongifolium	Shining spleenwort/huruhuru whenua		Moderate		Moderate
Asplenium polyodon	Sickle spleenwort		Moderate		Moderate
Astelia hastata	Tank lily		High	Low	Moderate*
Astelia solandri	Perching lily/kōwharawhara		High	Low	Moderate*
Beilschmiedia tarairi	Taraire			High ^	High
Beilschmiedia tawa	Tawa	Low	Low	Mod-high	Moderate*
Blechnum novae-zelandiae	Kiokio	Low	Moderate		Moderate
Brachyglottis repanda	Rangiora	Low	Moderate		Moderate
Carex breviculmis	Grassland sedge	Low	Low	Low	Low
Carex flagellifera	Glen Murray tussock	Low	Low	Low	Low
Carex inversa	Creeping lawn sedge	Low	Low	Low	Low
Carex virgata	Swamp sedge/pukio	Low	Low	Low	Low
Cirsium vulgare	Scotch thistle	Low			Low
Clematis paniculata	White clematis/puawananga		High	Low	Moderate*
Coprosma arborea	Tree coprosma/māmāngi	High		High	High
Coprosma lucida	Shining karamū/karamū	High	High	High	High
Coprosma macrocarpa	Large-seeded coprosma	High			High
Coprosma rhamnoides		High	Moderate	High	High
Coprosma robusta	Glossy karamū/karamū	High	High		High
Corybas acuminatus	Spider orchid		Low		Low
Corybas cheesemanii	Helmet orchid		Low		Low
Corybas oblongus	Spider orchid		Low		Low
Corybas trilobus	Spider orchid		Low		Low
Corynocarpus laevigatus	Karaka			Moderate ^	Moderate

Scientific name	Common name	Previously reported rating			Rating – this report
		Wallaby	Ungulate	Possum	
Cyathea dealbata	Ponga		Low		Low
Dacrycarpus dacrydioides	Kahikatea		Low	High ^	Moderate*
Dianella nigra	Turutu		Low		Low
Elaeocarpus dentatus	Hīnau	High	Moderate	Low	Moderate*
Gahnia setifolia	Razor sedge/māpere		Low	Low	Low
Geniostoma ligustrifolium	Hangehange	High	High	High	High
Griselinia lucida	Puka	High	High		High
Hedycarya arborea	Pigeonwood/porokaiwhiri	Low	High	Low ^	Moderate*
Histiopteris incisa	Water fern/mātātā		Low	Low	Low
Hydrocotyle bowlesioides	Water pennywort			Low	Low
Hydrocotyle heteromeria	Waxweed			Low	Low
Hydrocotyle moschata	Hairy pennywort			Low	Low
Hydrocotyle tripartita	Australian hydrocotyle			Low	Low
Hymenophyllum demissum	Drooping filmy fern/Irirang	Low	Low	Low	Low
Hymenophyllum flexuosum	Filmy fern	Low	Low	Low	Low
Hymenophyllum nephrophyllum	Kidney fern/konehu	Low	Low	Low	Low
Hymenophyllum rarum	Filmy fern	Low	Low	Low	Low
Hymenophyllum sanguinolentum	Filmy fern/piripiri	Low	Low	Low	Low
Hypolepis dicksonioides	Giant hypolepis		Low		Low
Jacobaea vulgaris	Ragwort		Low		Low
Juncus effusus	Soft rush		Low		Low
Juncus planifolius	Grass-leaved rush		Low		Low
Juncus usitatus			Low		Low
Knightia excelsa	Rewarewa	Low		Low-Mod ^	Low
Kunzea robusta	Kānuka	Low	Low		Low
Leptecophylla juniperina	Prickly mingimingi		Low		Low
Leptospermum scoparium	Mānuka	Moderate	Low		Moderate
Leucopogon fasciculatus	Mingimingi	Low	Low		Low
Metrosideros excelsa	Pōhutukawa			Moderate	Moderate
Metrosideros fulgens	Climbing rātā		Moderate	Moderate	Moderate
Microsorum pustulatum	Hound's tongue/kōwaowao	Low	High		Moderate*
Microsorum scandens	Fragrant fern/mokimoki		Moderate		Moderate
Myrsine australis	Red mapou	High	High	Moderate	High
Nestegis lanceolata	White maire		Low	Low	Low
Notogrammitis billardierei	Common strap fern		Low		Low

Scientific name	Common name	Previously reported rating			Rating – this report
		Wallaby	Ungulate	Possum	
Piper excelsum	Kawakawa	Low			Low
Prumnopitys ferruginea	Miro		Low	Low	Low
Pteris macilenta	Sweet fern		Low		Low
Pyrrosia eleagnifolia	Leatherleaf fern	Low	Low		Low
Rhopalostylis sapida	Nīkau			Yes	Moderate*
Ripogonum scandens	Supplejack/kareao	Low	High	High	Moderate*
Rubus cissoides	Bush lawyer/tātarāmoa	Low	Moderate	Moderate	Moderate
Solanum aviculare	Poroporo	Low			Low
Solanum mauritianum	Woolly nightshade	Low			Low
Solanum pseudocapsicum	Jerusalem cherry	Low			Low
Veronica stricta	Koromiko		Low		Low
Vitex lucens	Pūriri			Moderate ^	Moderate

Table C.2: List of plant flammability ratings ([FENZ, 2025). used to describe plant species identified across all permanent 20x20m plots on Kawau.

Scientific name	Common name	Flammability rating
Agathis australis	Kauri	moderate
Beilschmiedia tawa	Tawa	moderate
Coprosma robusta	Glossy karamū/karamū	low
Cordyline australis	Cabbage tree/tī kōuka	moderate
Corynocarpus laevigatus	Karaka	low
Cyathea dealbata	Ponga	high
Dacrycarpus dacrydioides	Kahikatea	moderate
Geniostoma ligustrifolium	Hangehange	low
Griselinia lucida	Puka	low
Knightia excelsa	Rewarewa	low
Kunzea robusta	Kānuka	high
Leptospermum scoparium	Mānuka	high
Leucopogon fasciculatus	Mingimingi	high
Melicytus ramiflorus	Māhoe	low
Phormium tenax	Flax/harakeke	moderate
Piper excelsum	Kawakawa	low
Solanum aviculare	Poroporo	low
Veronica stricta	Koromiko	low

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