# Aotea Bird Count

## Results from the December 2022 survey

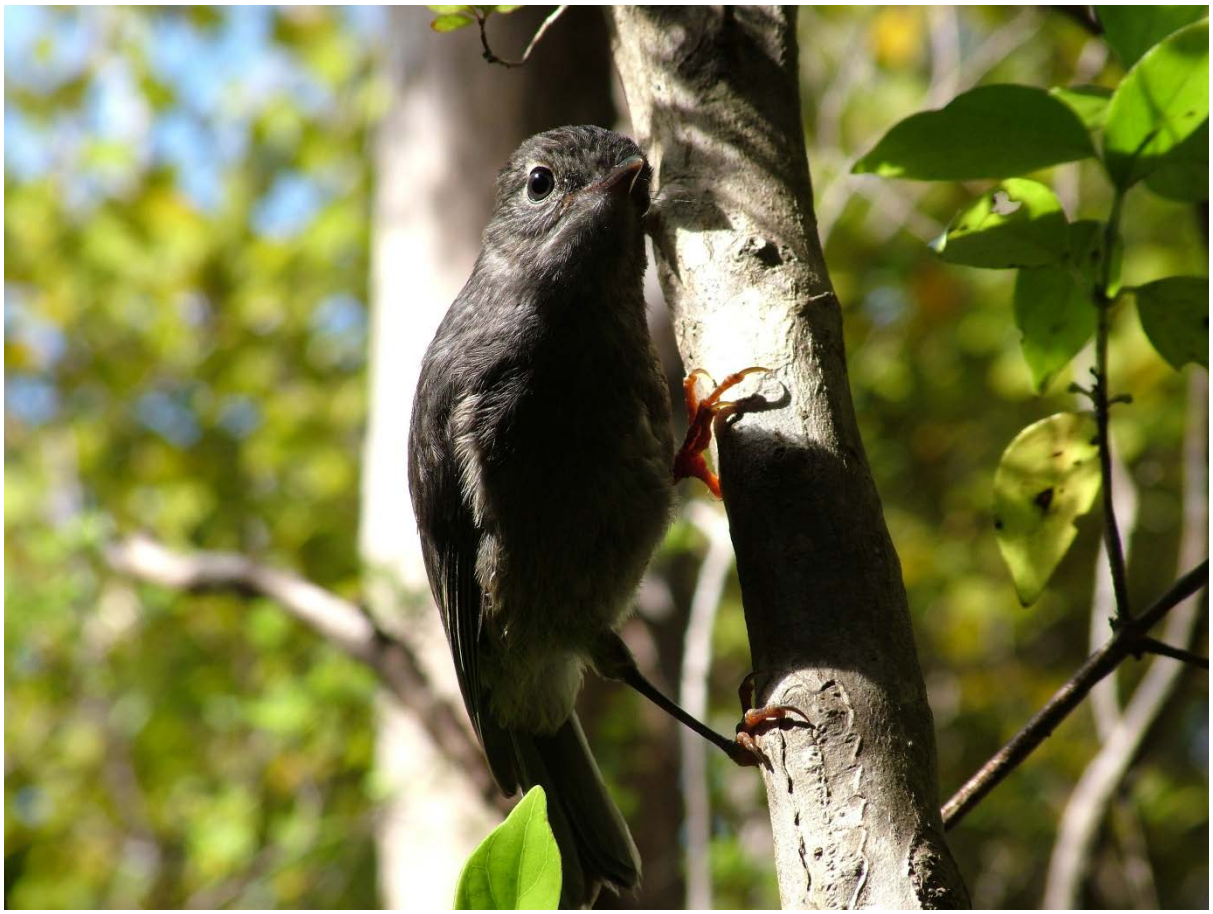

Image from the Windy Hill Sanctuary Collection

Prepared by George Perry, June 2023

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# Acknowledgements

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Thanks in particular to the hard work from Hannah Smith as 2022 co-ordinator, and Thomas Daly, Kate Waterhouse, Judy Gilbert, John Ogden, Jacqueline Beggs, the Aotea staff of the Department of Conservation and Annamarie Clough, of Auckland Council, for ensuring the Aotea Bird Count continues each year. John Ogden and Kate Waterhouse provided comments on a draft of the report. The text and analyses presented here draw on the 2019-2021 reports compiled by Serena Simmonds, Quinn Asena and George Perry, respectively, with the assistance of the late Emma Waterhouse.

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# Summary

This report presents an analysis of the Aotea Bird Count (ABC) data collected in 2022, the fourth iteration of this project. The bird count is organised by the Aotea Great Barrier Environmental Trust, Auckland Council, and the sanctuaries located on Aotea, and is carried out by community volunteers. The objective of the ABC is to provide longitudinal monitoring of species abundances in response to management interventions and pressures. The ABC employs a standard five-minute bird count method as widely employed across New Zealand. In this report, the analysis of the bird count data focus on:

- Island-wide species abundances (the number of times species were recorded at sites and frequencies (the number of sites species were observed at).
- Site-level species abundance, frequency, richness and diversity.
- Site-level abundances of four key target species (kākāriki, kākā, tūī and kererū).
- Differences in species composition among sites over time.

Analysis of the data highlight some key patterns in bird abundance (number of observations) across Aotea-Great Barrier Island:

- The most frequently observed species on the island in the 2022 survey were kākā, tūī, kingfisher (kōtare), grey warbler (riroriro), and fantail (pīwakawaka). This is the same suite of species as in 2021. These five species were also those seen most consistently across sites.
- The number of individuals observed (seen and heard) among sites ranged between 31 at Cooper's Castle and 203 at Medlands. Species richness (number of species observed) ranged from 5 (Cooper's Castle) to 28 (Medlands), and species diversity ranged between 1.21 (Cooper's Castle) and 2.81 (Medlands). These numbers are remarkably similar to previous years' surveys.
- Of the four target species, kākā and tūī were observed widely across Aotea. Kererū were present in low abundances at 11 / 18 (61.1%) sites, and kākāriki were observed at Okiwi (in 2021 they were also recorded at Glenfern).
- The birds observed varies across the sites, but there is little statistical evidence for discrete communities associated with specific habitats.
- A graphical comparison of changes in species richness and diversity from 2019-2022 is shows no consistent trends; however, looking at the four target species suggests a possible decline in the abundance and frequency of observation of kereru (with some caveats outlined in the text).

Data from the ABC are an invaluable source of information on the bird populations and communities of Aotea. As these data expand through time, they will provide the basis for tracking species occurrences and abundances, especially of vulnerable endemic species such as kākāriki. Additionally, such data can inform management interventions such as the iwi-lead Tū Mai Taonga project, which aims to restore lost species such as kōkako and tīeke and promote the recovery of species, including black petrel (tākoketai) and pāteke.

# Contents

# 1 – Introduction

This report is the fourth in a series describing the outcomes of the Aotea Bird Count (ABC) survey, mainly based on the data collected in 2022. In structure, it is intentionally similar to previous reports (Asena, 2021; Simmonds, 2020) and it uses the reproducible workflow developed by Asena (2021). While this report concentrates on the data from 2022, it includes some comparisons with previous surveys. In the longer term, the ABC will be a valuable dataset describing changes in the abundance and distribution of the birds of Aotea. In addition, data from the ABC can contribute to the development and evaluation of management interventions designed to, for example, increase the abundance of key species in managed areas of the island.

## 1.1 – Aotea, Great Barrier Island

Aotea, Great Barrier Island (henceforth Aotea, c. 27,761 ha) is located approximately 17 km northeast from the North Island of New Zealand (Figure 1). It includes many small surrounding islands, two of which – Rakitū and Motu Kaikoura – were included in the 2021 and 2022 surveys. A range of habitats are present on Aotea, including wetlands, coastal cliffs, forests, paddocks and cleared land, and dunes, making it home to diverse animal and plant life including some species at risk on or absent from the mainland (Armitage, 2001; Ogden, 2001). A central ridge of mountains reaching an elevation of 627 m.a.s.l (Hirakimata) runs down the centre of the island. Aotea is the largest area of Aotearoa free of mustelids, ungulates, and possums.

Predator control projects have been implemented on Aotea, with Glenfern sanctuary (83 ha; part of the larger managed area on the Kotuku Peninsula) established as a restoration area in the late 1990s, and Windy Hill sanctuary (800 ha), established in 2000 (Ogden & Gilbert, 2009, 2011). In addition, the Tū Mai Taonga project, lead by the Ngāti Rehua Ngātiwai ki Aotea Trust has begun in the north of Aotea, with the intent to remove feral cats and reduce rat numbers, with the goal of eradicating them from the whole of Aotea. The project's vision is for our mokopuna to hear the birdsong their tupuna once heard. Community projects control rats in some locations, including Okiwi, Awana, Okupu, Windy Hill Sanctuary and Oruawharo Medlands, and Auckland Council and the Department of Conservation carry out feral cat control on roadsides, on Hirakimatā and in the Whangapoua basin. Private landowners control rats on some large land blocks, and the Aotea Trap Library supports residents with free traps, boxes, and advice.

## 1.2 – Birds of Aotea

Aotea is home to many native and endemic bird species, including seabirds, waders, wetland species, species that favour open country, and forest species. Notable species include the tākoketai (black petrel), blue penguins (kororā), Australasian gannets (tākapu), pāteke, banded rails (moho pererū), tomtits (miromiro), Australasian bittern (mātuku), NZ Dotterel (tūturiwhatu) and the iconic tūī, kākā and kākāriki (Armitage, 2001). This diverse group of species is key to both the cultural heritage and biological importance of Aotea. Our knowledge of the birds of the island is summarised in the Birds of Aotea report by Ogden (2023).

Fortunately, some of the worst predatory mammals, such as the Norway rat (*Rattus norvegicus*) and mustelids (weasels, stoats and ferrets) brought to New Zealand by Europeans, never became established on Aotea (Armitage, 2001). The absence of mustelids on Aotea is essential to the

persistence of species such as pāteke, kākā and banded rail, which are now largely much reduced on the mainland. Cats (*Felis catus*) and ship rats (*Rattus rattus*) are believed to have been rare or absent from Aotea in the mid-19th century. Thus, species vulnerable to mammalian predation, such as kākāriki, persisted on Aotea more successfully than on the two main islands of New Zealand after European arrival (Armitage, 2001). However, while many introduced vertebrate pests did not establish on Aotea, a suite of invasive mammals – two species of rat (*Rattus rattus* and *Rattus exulans*), mice (*Mus musculus*), rabbits (*Oryctolagus cuniculus*), feral cats (*Felis catus*), and pigs (*Sus scrofa*) – threatens the island's birdlife (Ogden & Gilbert, 2009, 2011). The last remaining kōkako on Aotea were translocated to nearby predator-free Hauturu (Little Barrier) in 1994, and several bird species, including the tomtit and kākāriki are at risk of local extinction (Russell & Taylor, 2017). Much of the loss of the native and endemic birdlife was probably due to the introduction of the Polynesian rat (*Rattus exulans*) and dogs (*Canis familiaris*) that accompanied the first human settlers of Aotea, and the loss of forest due to fire and logging during Māori (since the late 13th / early 14th century) and European settlement periods (Ogden et al., 2006; Perry et al., 2010).

## 1.3 – Key target species

Stakeholders on Aotea have identified four bird species as focus species for the ABC (Simmonds, 2020): kākā (*Nestor meridionalis*), kererū (*Hemiphaga novaeseelandiae*), kākāriki (*Cyanoramphus novaezelandiae*), and tūī (*Prosthemadera novaeseelandiae*).

Kākāriki are a small (75 g) endemic parrot now almost absent from New Zealand's two main islands. The kākāriki has a national conservation status of a 'relict' population with no change in status since the 2017 assessment (Robertson et al., 2021). Okiwi is the sole confirmed breeding population on Aotea (Simmonds, 2020). Kākāriki are vulnerable to rat predation because they nest in cavities in old trees such as pūriri, so their presence is an indicator of sustained low rat densities.

Kererū are an endemic pigeon, widespread throughout New Zealand. They are the fifth heaviest pigeon in the world (c. 650 g), and feed on fruits, flowers, and leaves (Wotton & Kelly, 2012). Kererū are considered 'keystone' seed dispersers feeding on at least 70 different plant species (McEwen, 1978) and, due to their large size, they can swallow large fruits and have a long seed retention time (Clout & Hay, 1989; Kelly et al., 2010). Kererū inhabit a variety of forest types and are important to native forest regeneration as the germination of seeds of species such as taraire, tawa and miro may be enhanced by passing through the stomach of kererū.

The North Island kākā is an endemic hole-nesting parrot (c 360 g) that is frequently observed throughout Aotea, although at the national-level they are classed as an at risk, recovering species (Robertson et al., 2021). Kākā now occupy only a fraction of their former range due to predation and habitat loss (Moorhouse et al., 2003). Their abundance on Aotea is likely due to the absence of stoats (*M. erminea*) and Norway rats (*R. norvegicus*), to which their nests are vulnerable (Armitage, 2001).

The tūī (c. 100 g) is an endemic species that is widespread across New Zealand other than Canterbury. Tūī are honeyeaters feeding primarily on nectar, fruit and invertebrates (Stewart & Craig, 1985). Windy Hill bird count data collected over two decades showed tūī benefit from lower rat densities, making them a good indicator species for the effectiveness of rat control measures (Ogden 2019).

## 1.4 – Objectives of the Aotea Bird Count

The ABC is a collaborative citizen-science project intended to provide an island-wide assessment of the abundance and distribution of bird species on Aotea. It is envisaged that the ABC will be repeated biannually or annually, building a dataset that provides information and context about changes in species abundance and distribution over time. This supports sanctuaries, community projects, iwi, Department of Conservation and Auckland Council projects by providing long term monitoring of the outcomes of their management effort to protect Aotea's birds.

Such information will be invaluable in informing and evaluating management interventions (e.g., pest control), changes in bird populations across the island, and tracking the abundance of four focus species. Although concerns are sometimes raised about the 'reliability' of such citizen projects, when conducted carefully and appropriately analysed they can provide robust and reliable information (Kosmala et al., 2016).

# 2 – Methods

## 2.2 – Data collection

Eighteen sites across Aotea (Figure 1) were surveyed using the five-minute bird count method (Hartley, 2012). Each survey site comprised five survey locations, approximately 200 metres apart, each of which was surveyed twice with at least a one-hour interval between replicates. Groups of up to three observers undertook the surveys with at least one person (the lead) experienced in bird identification, and all members receiving basic bird count training. At each location at a site, the species, number of birds seen or heard, and distance from the observers (inside or outside of a 25-metre radius) were recorded for five minutes. Counting started after two minutes of silence to reduce the disturbance caused by the observers; additional data on birds flying overhead or observed between the survey locations were also recorded. Finally, the group noted the local conditions (wind, rain, noise, and temperature) at each station.

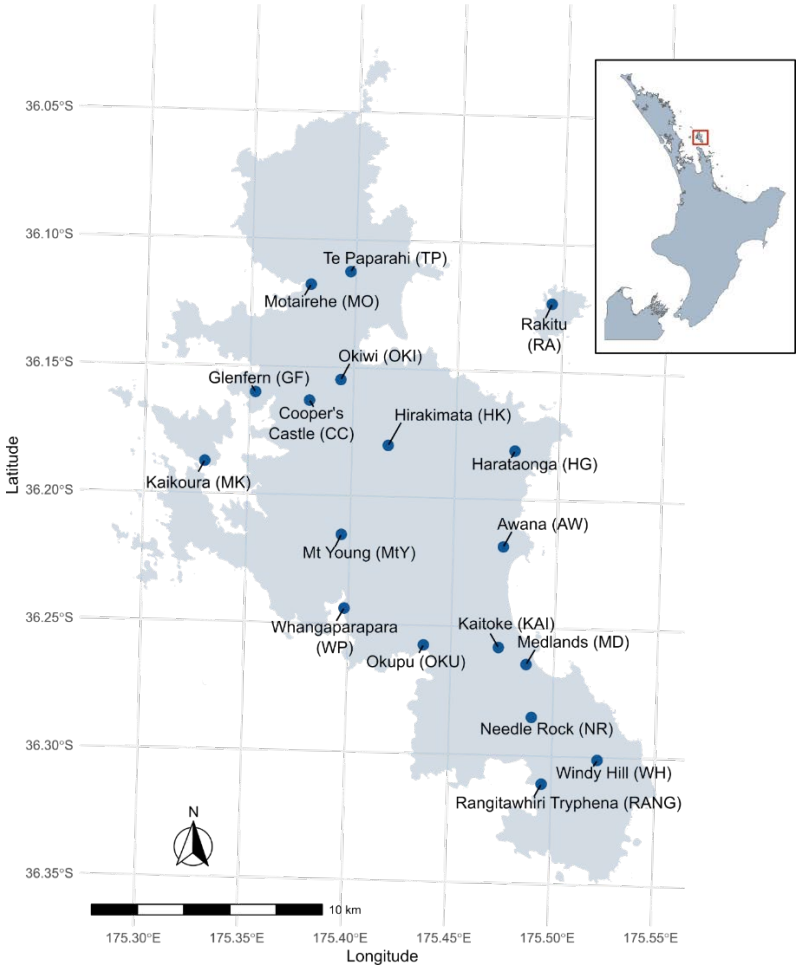


*Figure 1: Locations of the 18 sites surveyed in 2022 on Aotea, Great Barrier Island. Abbreviations are used in some subsequent illustrative material.*

A list of birds observed including their te reo Māori, Latin, and European names is provided in Appendix A.

## 2.3 – Analysis

The main goal of the analyses was to describe patterns in the distribution of bird species across the island and differences in richness and composition among sites. Observations including the seen and heard birds identified by the surveyors were used in the analyses. Some records of unknown species or species not identified to the species level (e.g., 'finch', which could be one of several potential species) were filtered from the data and excluded from analysis. Data were analysed at the island-level, site-level, and for differences among sites:

- First, total bird counts were calculated across the island by summing the counts of each species across all sites. Frequency – the proportion of sites a species was observed at – was also calculated.

- Second, bird counts were analysed at the site-level by calculating species richness and diversity. Additionally, the occurrence and abundance of the four target species (kākāriki, kākā, tūī and kererū) are shown for each site.
- Finally, the sites similarity in bird composition and how this changed over time were calculated from differences in their species composition.

All analyses were conducted in R version 4.3.0 (R-Development-Core-Team, 2023). The vegan package version 2.6-2 (Oksanen et al., 2022) was used to calculate the Bray-Curtis index and Shannon's diversity index (described below). The data and scripts used in this report are reproducible and stored on a public repository (available at: http://dx.doi.org/10.17608/k6.auckland.23805588)

### Richness and diversity

For each of the 18 sites, the richness and diversity of species present were calculated. Species richness is the number of species present (and is a fundamental descriptor of biodiversity), while species diversity describes the species relative abundances. For example, if 100 individuals across ten species were observed, richness would be 10; diversity would vary from highest if all ten species had ten individuals or lowest if one species accounted for 91 individuals and the other nine just one. We calculated species diversity as Shannon's *H* index (Magurran, 2004). Species richness and diversity were mapped to visualise the tends across the island. Additionally, a visual comparison of species richness and diversity between previous surveys data is shown for all species and the four focus species.

### Total count and target species

For each of the 18 sites, the total bird count (i.e., number of individuals observed) and the counts of the four target species (kākāriki, kākā, tūī and kererū) were calculated. Count data mapped onto Aotea provides an overall picture of the bird abundance at each site, complementing richness and diversity measures.

### Ordination trajectory analysis

We used multivariate statistical analysis to assess whether the surveyed bird communities are changing consistently. First, we used non-metric multidimensional scaling ordination to evaluate patterns in the bird communities in the 2021 data; basically, this analysis asks whether there are groups of sites that are similar to each other based on the birds observed at them. We then extend this to the whole dataset to explore whether there are consistent patterns in the direction or rate of change across all the sites that have been surveyed. We used the trajectory analysis method described by de Caceres et al. (2019). For these analyses, we used the site-level frequency values for each species: the proportion of stations at each site where a species was recorded.

# 3 – Results

## 3.1 – Overall observations 2022

In total, 2268 observations were made across 37 species (excluding some unknown or unidentified to the species level). Of the 37 species, the majority were either native or endemic (18 of the top 25; 72%), with the most frequently observed species being kākā, tūī, kōtare, riroriro, and pīwakawaka (Figure 2). The five most frequently observed species were recorded at all 18 sites (Figure 3). Chaffinch was the most frequently observed exotic species, and blackbird the exotic species that occurred at most sites (13/18; 72.2%). Counts and frequencies for all species are given in Appendix B

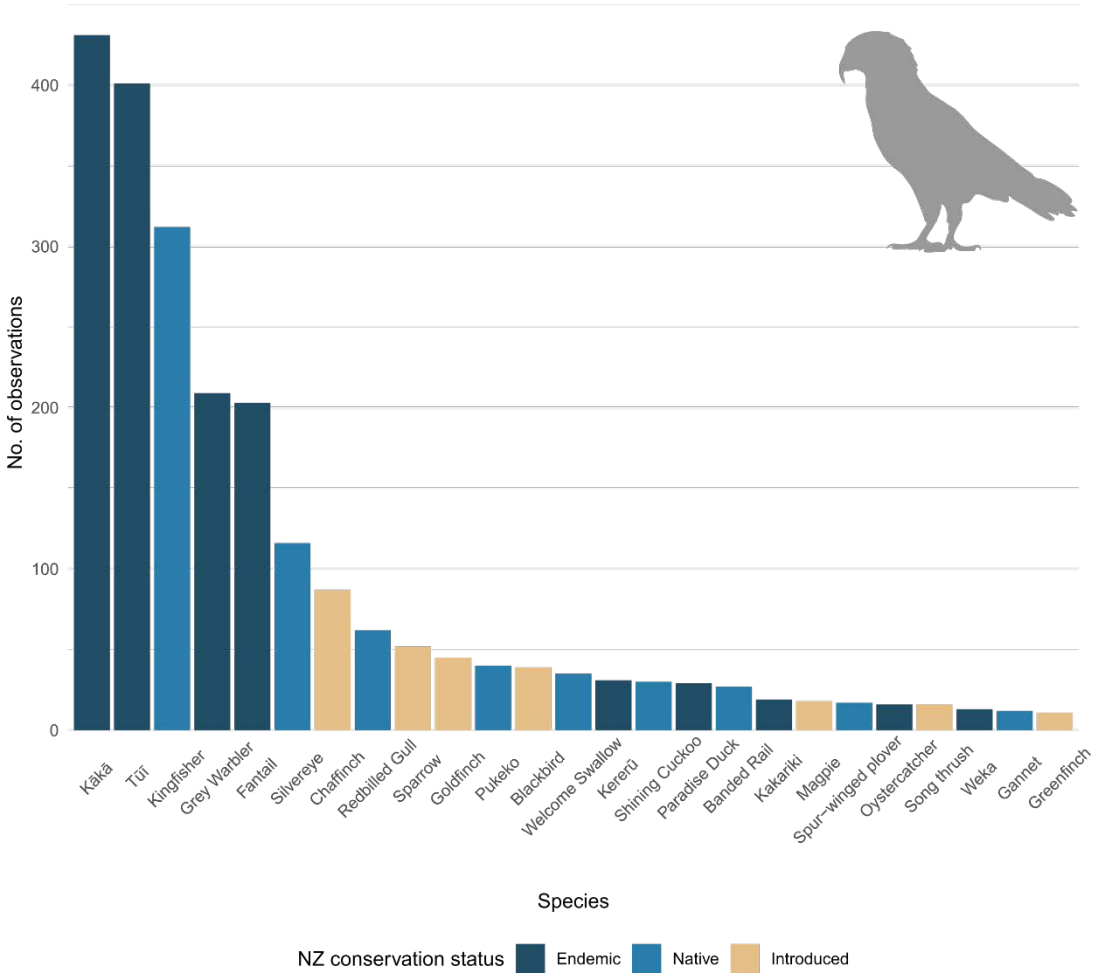


*Figure 2: Total counts of the 25 most frequently observed (seen or heard) species across all 18 sites. Thirty-seven species were observed across 2268 individuals.*

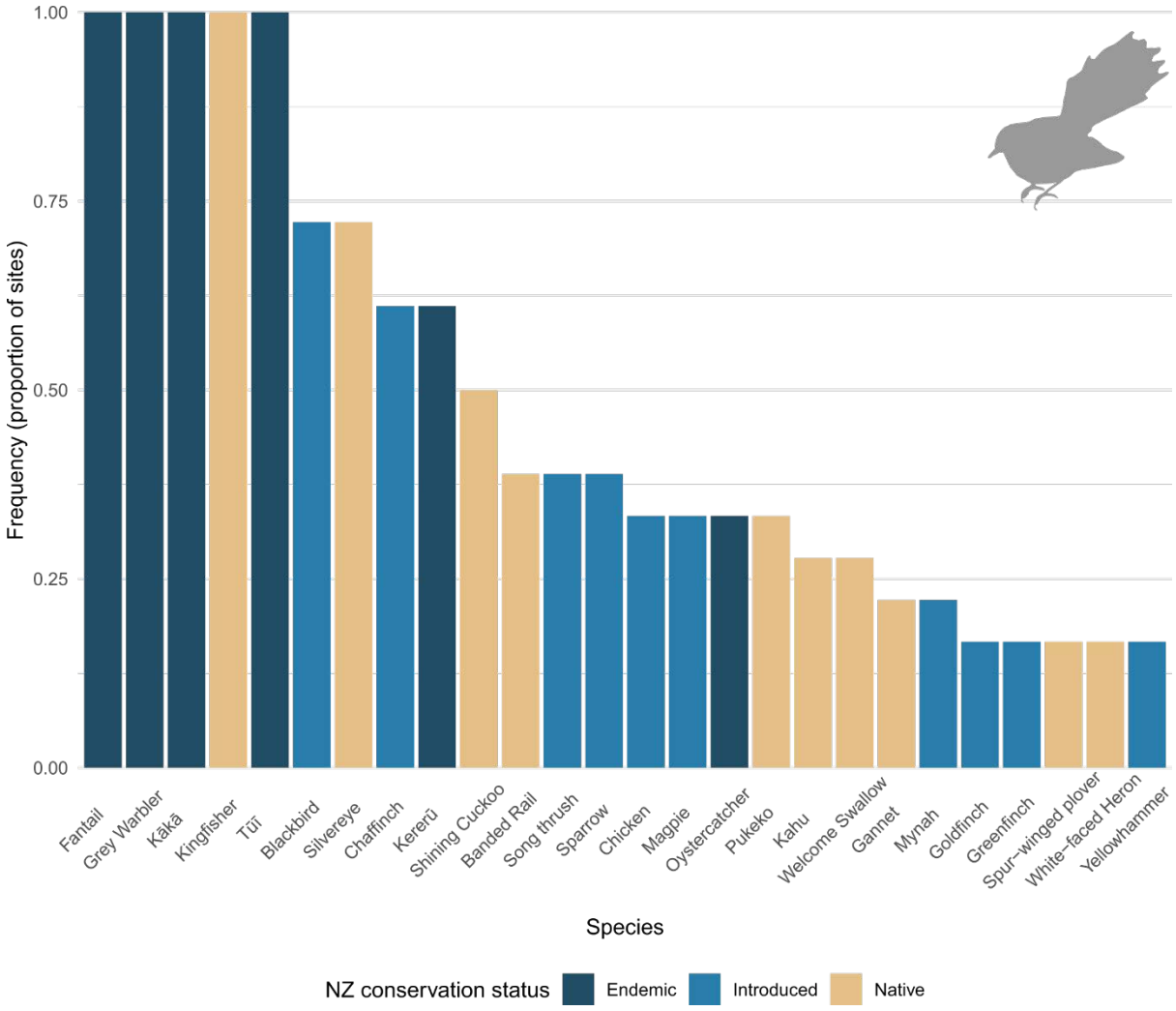


*Figure 3: Total counts of the 25 most frequently observed (seen or heard) species across all 18 sites. Thirty-seven species were observed across 2268 individuals.*

## 3.2 – Richness and diversity

Species richness varies nearly fourfold across the 18 sites, and diversity is predicted by richness (Figures 4 and 5). The highest species richness was observed at the Medlands site, followed by Whangaparapara, and Motu Kaikoura; the highest diversity occurred at Medlands, followed by Okiwi, Kaitoke, and Motu Kaikoura (Figure 5 and Table 1; see Figure 1 for mapped site names). The lowest levels of richness and diversity was observed at Cooper's Castle (mirroring the 2020 and 2021 surveys).

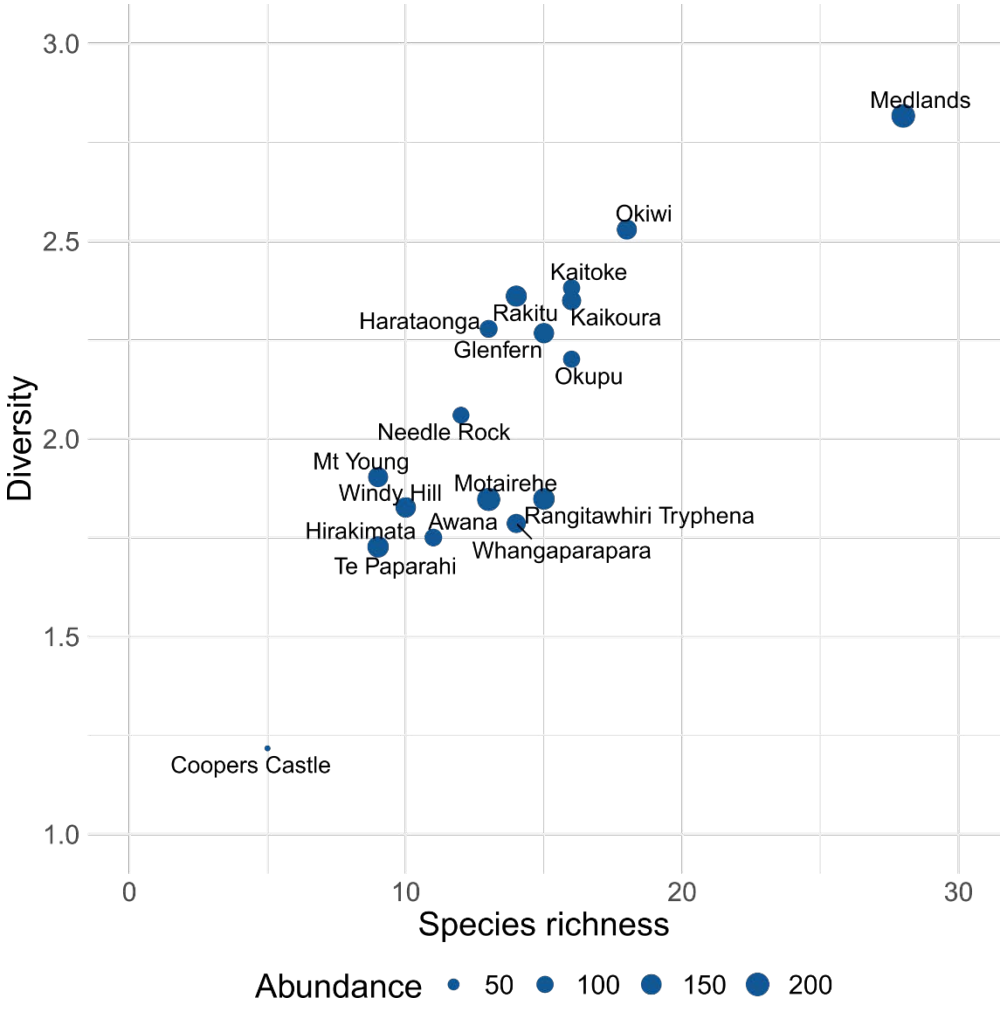


*Figure 4: The relationship between richness and diversity across the 18 sites surveyed in the 2022 ABC. Circle size denotes number of observations at the site.*

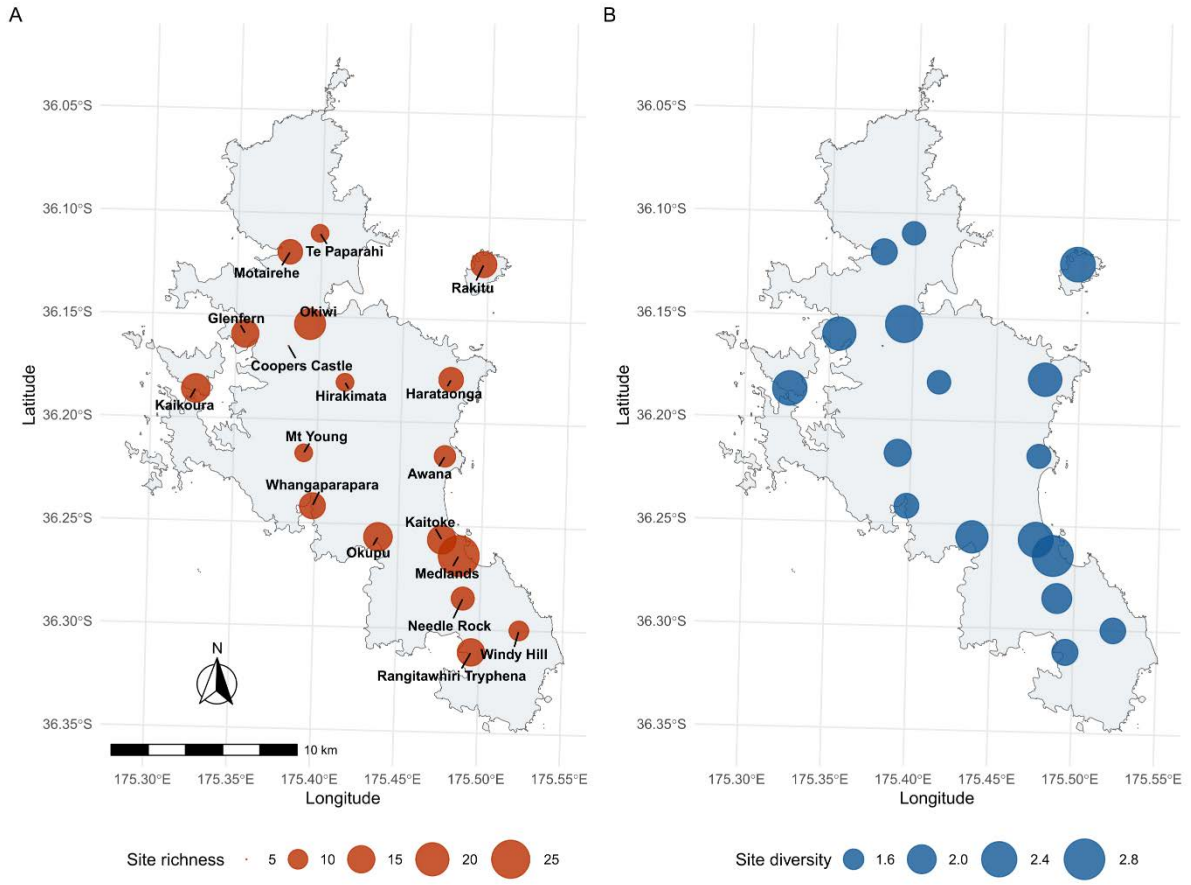


*Figure 5: The species richness (A) and diversity (B) of the 18 sites across Aotea. The size of the data points is scaled by richness and diversity, respectively, with larger points indicating a higher value.*

The number of observations, species richness, diversity and total counts vary across sites with ranges of [31, 203], [5, 28], and [1.21, 2.81], respectively (values inside the square brackets indicating the minimum and maximum; Table 1). Of course, some variation is expected due to local conditions during the bird counts and among observer groups. Species richness is likely to increase with the number of individuals counted at a given site; while statistical tools such as rarefaction can, to some extent, correct for this, we did not use them here.

*Table 1: Species richness, diversity, and count for the 18 sites.*

| Site | Richness | Diversity | No. observations |
|---|---|---|---|
| **Awana** | 11 | 1.75 | 106 |
| **Coopers Castle** | 5 | 1.22 | 31 |
| **Glenfern** | 15 | 2.27 | 145 |
| **Harataonga** | 13 | 2.28 | 109 |
| **Hirakimata** | 9 | 1.73 | 163 |
| **Kaikoura** | 16 | 2.35 | 127 |
| **Kaitoke** | 16 | 2.38 | 101 |
| **Medlands** | 28 | 2.82 | 203 |
| **Motairehe** | 13 | 1.85 | 193 |

| Site | Richness | Diversity | No. observations |
|---|---|---|---|
| **Mt Young** | 9 | 1.90 | 140 |
| **Needle Rock** | 12 | 2.06 | 96 |
| **Okiwi** | 18 | 2.53 | 141 |
| **Okupu** | 16 | 2.20 | 100 |
| **Rakitū** | 14 | 2.36 | 157 |
| **Rangitawhiri Tryphena** | 15 | 1.85 | 165 |
| **Te Paparahi** | 9 | 1.72 | 87 |
| **Whangaparapara** | 14 | 1.79 | 127 |
| **Windy Hill** | 10 | 1.83 | 147 |

## 3.3 – Total counts

The highest total number of observations was at Medlands (203; Figure 6 A and Table 1), which also had the highest richness and diversity (as in 2021).

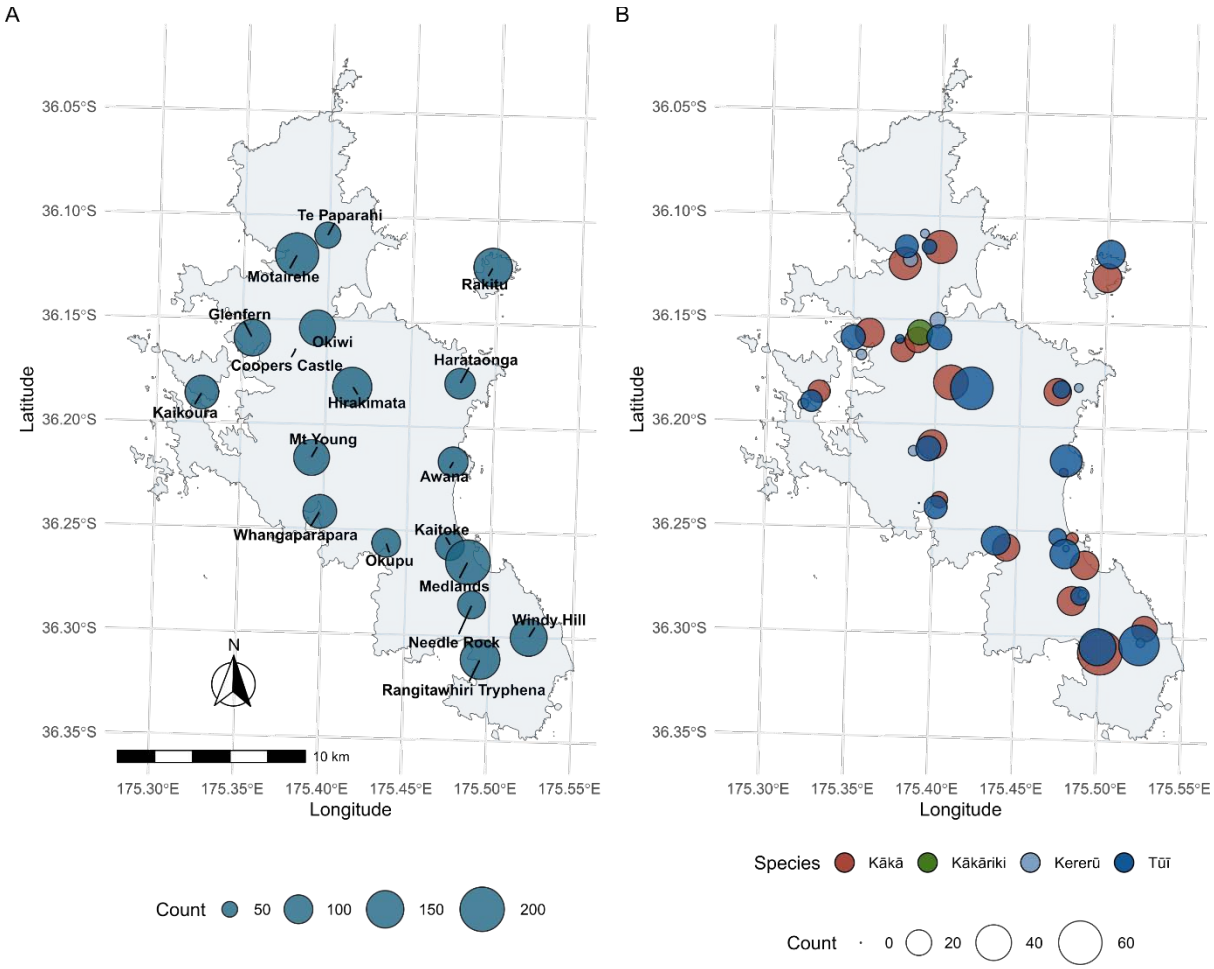


*Figure 6: Total number of observations by site (A) and total number of observations of the four target species (kākāriki, kākā, tūī and kererū) by site (B).*

Of the four target species (kākāriki, kākā, tūī and kererū), kākā and tūī were observed at almost every site, except for Kaitoke, where no kākā were observed (Figures 6 and 7 and Table 2). Kererū were observed at 11 of the 18 sites, although in lower numbers than kākā or tūī. Kākāriki were observed at the Okiwi site, where a breeding population is established (Asena, 2021; Simmonds, 2020). There has been a substantial investment in predator control at Okiwi to maintain the existing kākāriki population (Simmonds, 2018). There is no trend apparent in the number of observations of the four target species over the four surveys, apart from a possible decline in kererū abundance (Figure 7 A and B).

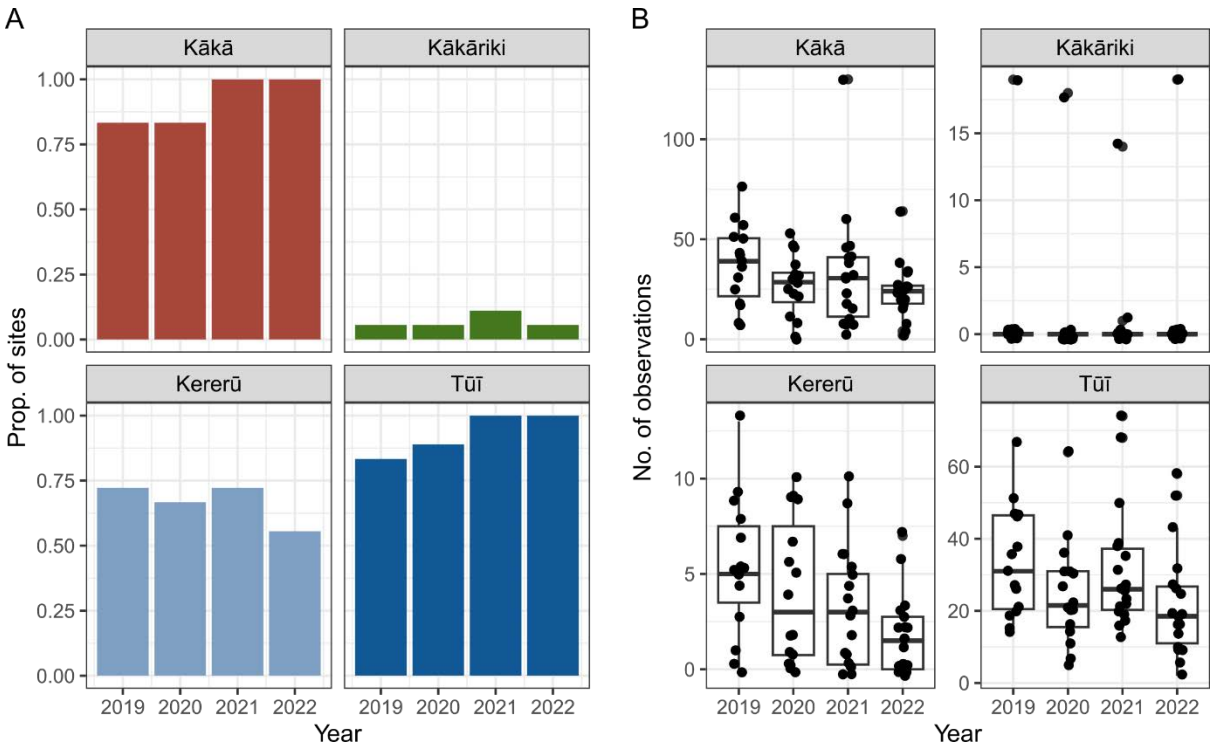


*Figure 7: Proportion of sites that the four focal species were observed at (A) and number of observations for the four species in 2019, 2020, 2021, and 2022 (B). Note that the number and identity of sites surveyed varied slightly between the surveys.*

Tūī and kākā were observed frequently at Windy Hill and Haratonga; Okiwi had high abundances and frequencies of all four species (Figure 6B and Table 2).

*Table 2: Total counts and site-level frequencies (number of stations recorded at per site) of the four target species.*

| | Kākā | | Kākāriki | | Kererū | | Tūī | |
|---|---|---|---|---|---|---|---|---|
| **Site** | Count | Freq | Count | Freq | Count | Freq | Count | Freq |
| **Awana** | 2 | 0.1 | | | | | 32 | 0.8 |
| **Coopers Castle** | 17 | 0.7 | | | | | 2 | 0.2 |
| **Glenfern** | 26 | 1 | | | 3 | 0.1 | 18 | 1 |
| **Harataonga** | 23 | 0.8 | | | 2 | 0.1 | 9 | 0.7 |
| **Hirakimata** | 38 | 1 | | | | | 58 | 1 |
| **Kaikoura** | 15 | 0.6 | | | 3 | 0.2 | 14 | 0.8 |
| **Kaitoke** | 4 | 0.3 | | | | | 9 | 0.7 |
| **Medlands** | 25 | 0.9 | | | 1 | 0.1 | 27 | 1 |
| **Motairehe** | 33 | 1 | | | 6 | 0.3 | 16 | 0.9 |
| **Mt Young** | 27 | 1 | | | 3 | 0.2 | 19 | 0.8 |
| **Needle Rock** | 26 | 0.9 | | | 2 | 0.2 | 10 | 0.8 |
| **Okiwi** | 20 | 0.9 | 19 | 0.6 | 7 | 0.5 | 19 | 0.9 |
| **Okupu** | 23 | 0.9 | | | | | 26 | 1 |
| **Rakitū** | 26 | 0.8 | | | | | 25 | 0.9 |
| **Rangitawhiri Tryphena** | 64 | 1 | | | | | 43 | 1 |
| **Te Paparahi** | 34 | 1 | | | 2 | 0.1 | 6 | 0.5 |
| **Whangaparapara** | 8 | 0.6 | | | | 0.1 | 16 | 0.9 |
| **Windy Hill** | 20 | 0.7 | | | 2 | 0.2 | 52 | 1 |

## 3.4 – Comparison with past surveys

In the long term, the bird count data from the ABC surveys can be used to monitor the trajectory of populations and specific species across Aotea. In aggregate (Figure 9), there are no clear temporal trends in number of observation species richness or diversity, especially in the face of high site and year-level variability.

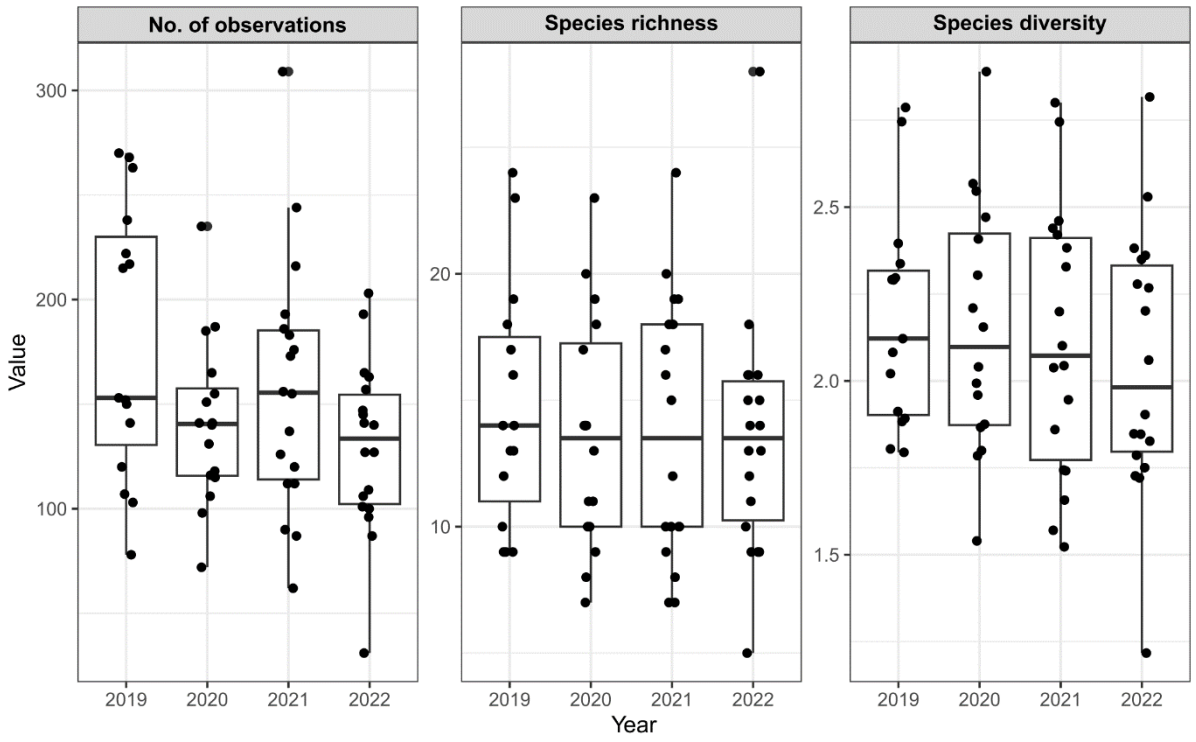


*Figure 10: Aggregate change in number of observations, species richness from 2019-2022. Colours organised to show highest (yellow) to lowest (purple) median count over the four survey periods.*

Graphical comparisons of the change in species richness and the number of observations (Figures 10 and 11) show some differences in sites over the three surveys; however, differences in site conditions and observers will also contribute to this variation. Medlands has consistently increased and is the most species-rich site, while Cooper's Castle has been consistently low in richness. The number of observations shows a mix of increases and decreases among sites between years (Figure 10). These patterns need to be interpreted with caution because trends based on short-term data are inherently uncertain.

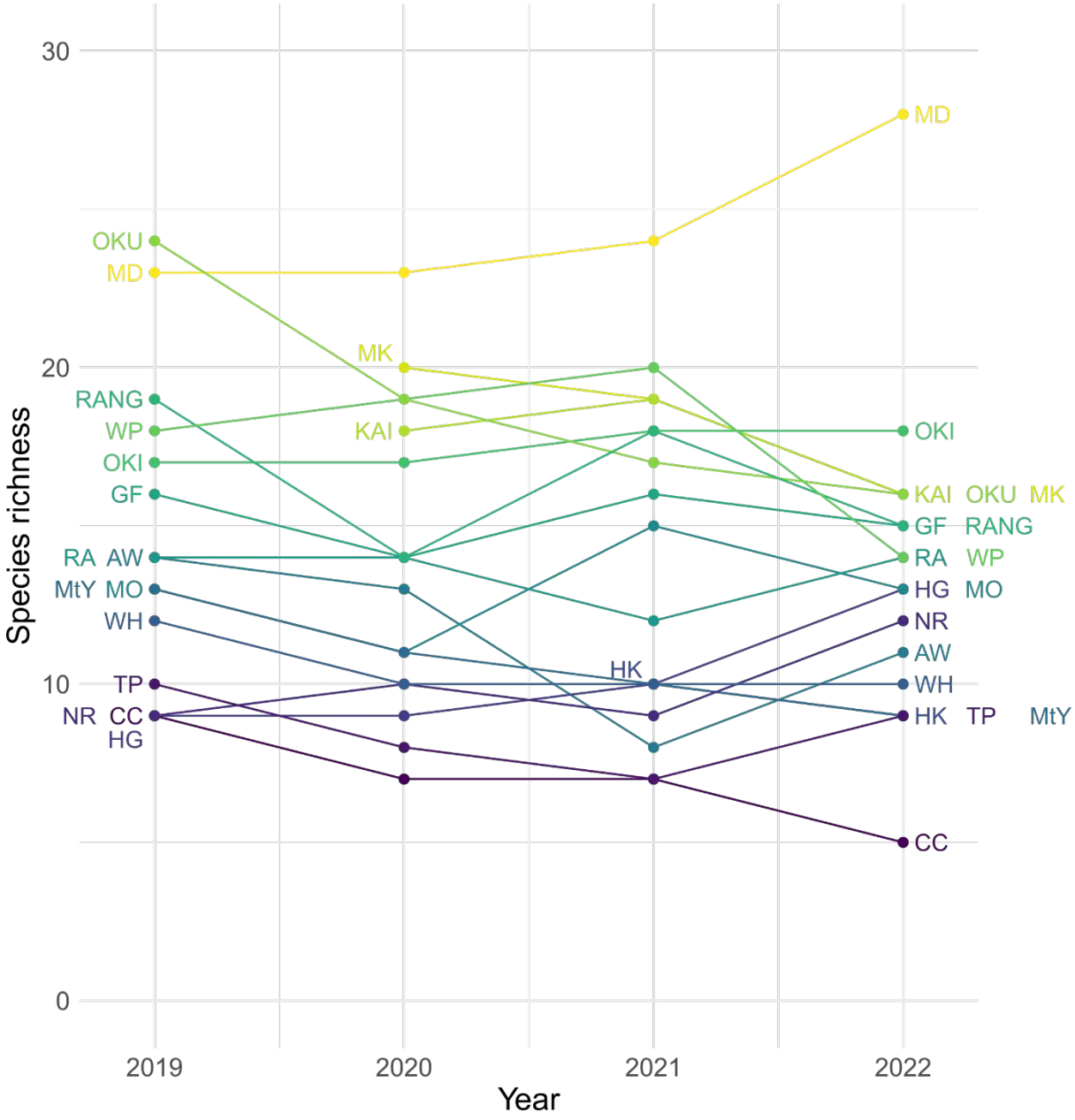


*Figure 11: Bump plot of the change in species richness from 2019-2022. Colours organised to show highest (yellow) to lowest (purple) median count over the four survey periods.*

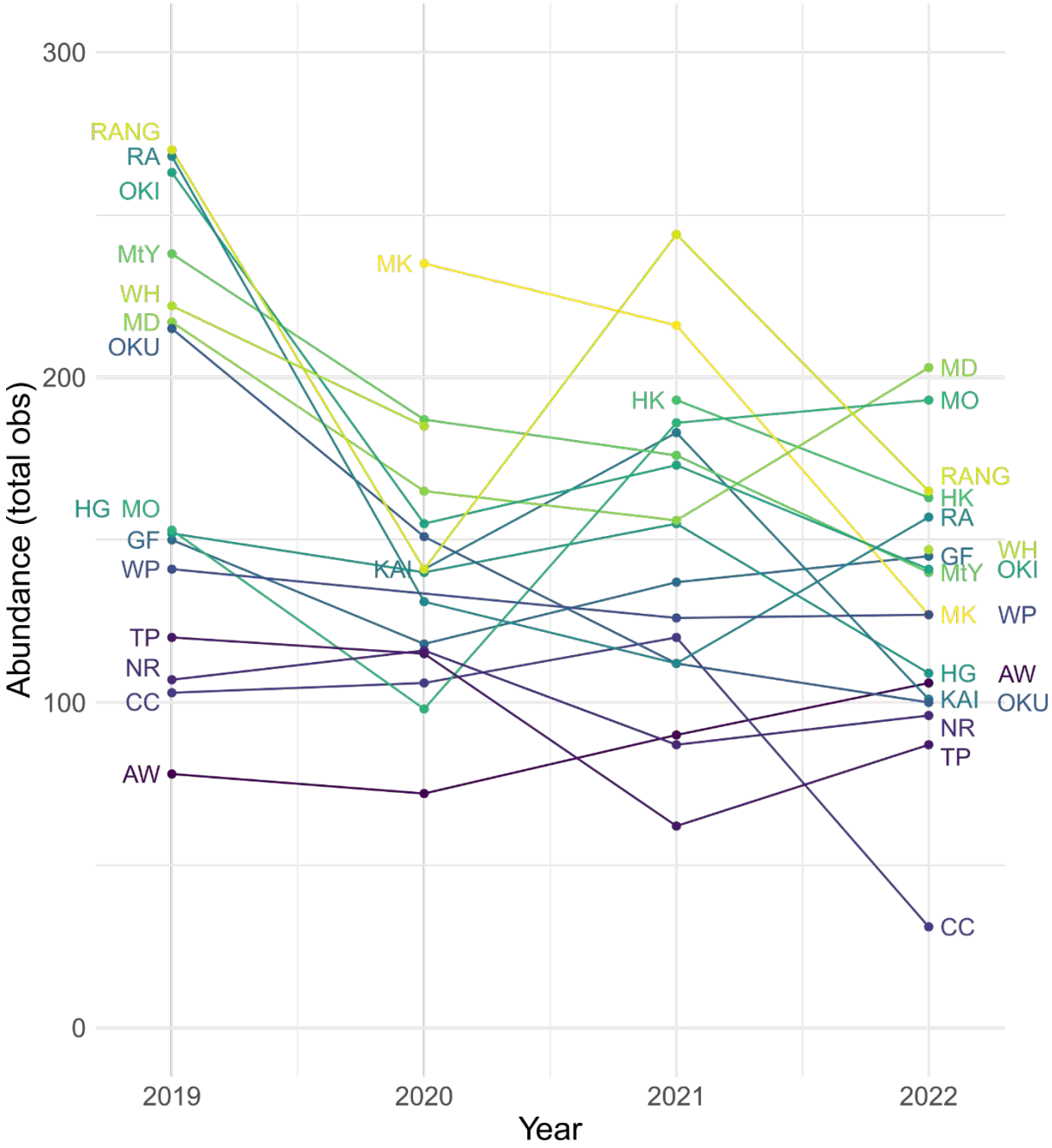


*Figure 12 Bump plot of the change in number of observations 2019-2022. Colours organised to show highest (yellow) to lowest (purple) median count over the four survey periods. See Figure 1 for site abbreviations.*

Focusing on the four target species (kākā, kakariki, kereru, and tūī) again shows a range of responses across the sites (Figure 13). There was a dramatic increase in kākā observations at Windy Hill in 2021, but otherwise the number of kākā observations has been reasonably consistent. As commented on the in 2021 report, there is a decline in the number of sites that kererū were observed at and the number of observations of kererū since 2019. However, this is (i) (at this stage) a relatively short-term trend and (ii) the sedentary nature of kererū can make them difficult to detect. The temporal trend in the number of observations of tūī changes across sites, but they have been observed at all sites in the last two surveys (2021 and 2022).

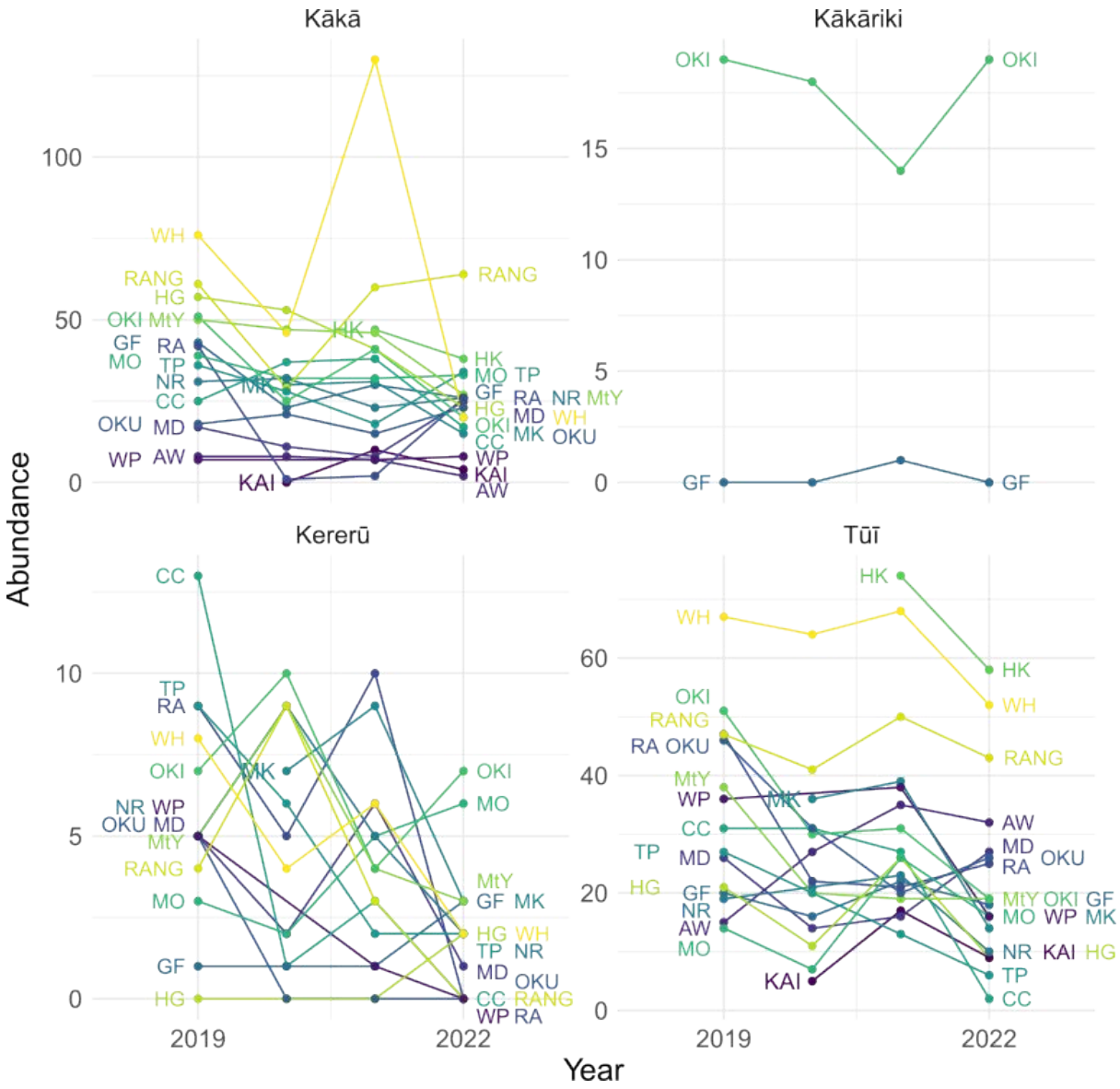


*Figure 13: Bump plot of the change in number of observations for the four focal species, 2019-2022. The figure includes only those sites surveyed in all three years and where the species of interested was recorded at least once. Colours organised to show highest (yellow) to lowest (purple) median count over the four survey periods.*

## 3.5 Community structure and trajectory analysis

One of the benefits of accumulating ecological data over time (i.e., longitudinal studies) is that it allows assessment of changes in ecosystem composition. One statistical tool suitable for this is 'trajectory analysis', which enables assessment of how a collection of sites has shifted over time in terms of direction of change (i.e., across multiple sites have the same species appeared or disappeared over time?) and the rate of change (i.e., are sites changing at the same rate)?

Previous reports describing the ABC have suggested that there is no evidence for strong geographic structuring of the bird community on Aotea, and analysis of the 2022 data is no different (Figure 14 A); in other words, although there are differences in the birds observed at different sites, this is not clearly predicted by habitat. The ordination suggests a core of sites with similar bird communities (e.g., Te Paparahi, Needle Rock, and Windy Hill), with a handful of more distinctive ones (e.g., Cooper's Castle, Medlands, and Awana). Perhaps unsurprisingly, trajectory analysis (Figure 14B) does not show a consistent trend in the direction or rate of change across the survey sites. This lack of consistency is *not* an indicator of any 'problem': the length of the record is still short, there are considerable site-level and year-level variations, and many birds are highly mobile. Nevertheless, such analyses highlight the potential utility of long-term data as are collected through the ABC process.

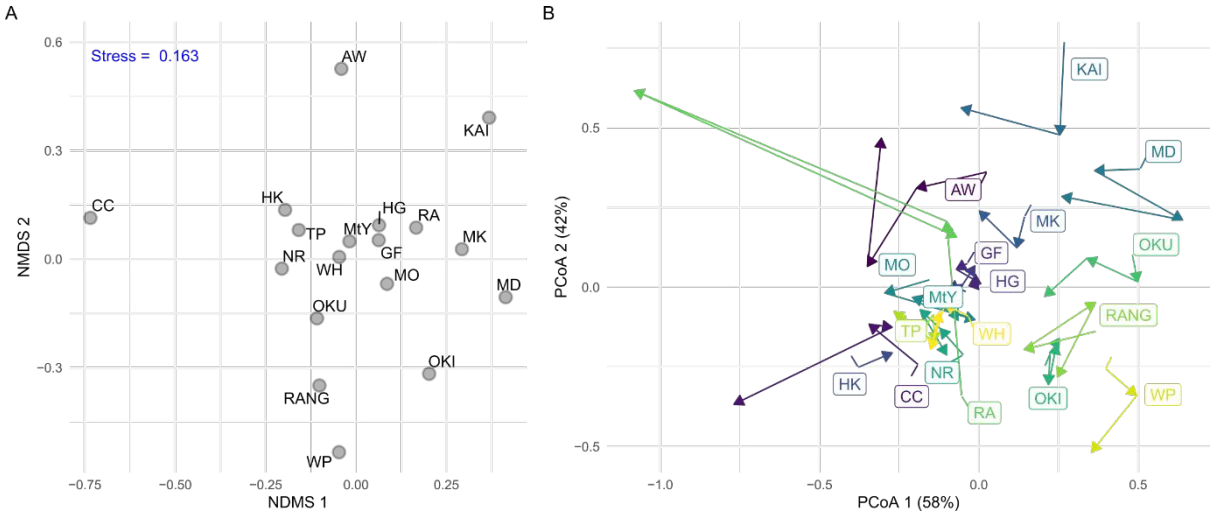


*Figure 14 Analysis of community structure across Aotea based on (a) the 2022 ABC using ordination (here the distance between points [sites] is proportional to their similarity) and (b) trajectory of change at sites over the survey periods (arrows show the trajectory of change from the earliest to most recent survey and the length of the arrow the amount of change between surveys).*

## 4 – Discussion

We analysed the ABC data for the primary, island-wide patterns of abundance and frequency; site-specific patterns of abundance, richness, and diversity; and site dissimilarity. Analysis of the aggregated data shows the most frequently observed species on Aotea during the ABC-2022 were kākā, kōtare, tūī, grey warbler, and fantail (Figure 2). While bird species are not uniformly distributed across the island, this variation is difficult to predict. Ordination analysis (Figure 14) suggests the bird community composition across sites is not geographically structured, but it is also not spatially uniform. As noted previously (see 2021 report), data describing the habitat at each survey point would be informative for future analysis.

Although present at most sites, lower counts of kererū than in previous years were recorded across Aotea, with highest counts and frequencies at Okiwi (Table 2); in 2021 values were highest at Rakitū and Motu Kaikoura highlighting the need to trend this trend cautiously. There is some evidence of consistent decline in the frequency and abundance (based on number of observations) of kereru, although this species is notoriously difficult to detect in five-minute bird counts. Kākāriki were only recorded at Okiwi where there presence is a function of the intensive pest management at that site. Comparisons of species richness and diversity between previous surveys must be interpreted cautiously since there are both site- and year-level sources of variability. However, these analyses show how the data can be used to highlight trends if repeat surveys are conducted biannually or annually.

In the interests of reproducible data analyses and use for the analyses of future bird counts, both the data and the scripts are archived in an online repository. Data can be found at: http://dx.doi.org/10.17608/k6.auckland.23805588

## 4.2 – Limitations

Some sources of uncertainty exist in the data collection methods that must be accounted for during analysis and interpretation (see MacLeod et al., 2012 for a detailed comparison of methods). The primary limitations (noting these are inherent and not reducible) in the data are:

- *Location bias*: survey locations are typically along a track or accessway. Bird counts from such locations may not be representative of the true abundance of a given area. It would be useful to supplement the ABC points with more detailed habitat and vegetation information to contextualise them more effectively.

- *Detection bias*: bird species are not all equally likely to be observed due to size, sound and behavioural differences. Some birds, such as tūī and kākā, are conspicuous and loud, while others, such as the tomtit, are small and inconspicuous. Kererū, in particular, can be hard to detect meaning the possible decline in the number of observations needs to be treated with caution.

- *Identification bias*: not all bird species are equally identifiable visually or audibly. For example, some species such as the kererū are visually easy to identify but may be difficult to detect, while ones such as the yellowhammer are visible but may be easily confused with another such as the goldfinch.

While some limitations exist (as with any observational ecological data), some can be mitigated. For example, survey groups should continue to have at least one trained observer to reduce identification error, and statistical methods exist to correct observation bias in data analysis. Thus, despite sources of uncertainty, important patterns can be derived from the data.

## 4.3 – Conclusion

Counts from the ABC offer valuable insights into patterns of species richness, diversity and abundance. As in previous reports we recommend that the ABC is repeated at regular intervals to build a reliable long-term dataset. Not only does the ABC yield valuable data but it also has an important role in the community on Aotea. Three other recommendations are:

- To supplement the ABC points with vegetation / habitat information – the PCQ method described by Perry et al. (2010) or standard recce methods (Hurst & Allen, 2007) could be used for this purpose
- Explore supplementing survey point data with island-wide rodent monitoring data as a measure of rodent densities at each point, and the type of control methods in place (eg eradicated, low densities, some control, no control)
- To continue to maintain continuity of counting team members at individual sites as far as practical and to ensure counters are trained in the ABC observations recording process

It is also important that data and code used in analysis are archived so that they are easily accessible to interested stakeholders and researchers. This process was started in 2021 and the data and code used in this report are available at: http://dx.doi.org/10.17608/k6.auckland.23805588. Such data can help track changes in the abundance of species (especially endemic declining species such as the pāteke) and the success of management interventions.

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# Appendix A

*Table 3: List of names and conservation status of birds observed in the 2022 ABC survey, including their te reo Māori, Latin, and European names. Note some species have multiple Māori or European names that are not included. Names are sourced from New Zealand Birds Online (New Zealand Birds Online, 2013).*

| Te reo name | Latin name | European name | Conservation status | Biogeographic status |
|---|---|---|---|---|
| **Greenfinch** | Chloris chloris | European greenfinch | Introduced and Naturalised | Introduced |
| **Kāhu** | Circus approximans | Harrier Hawk | Not Threatened | Native |
| **Kaireka** | Alauda arvensis | Skylark | Introduced and Naturalised | Introduced |
| **Kākā** | Nestor meridionalis | Brown Parrot | Recovering | Endemic |
| **Kākāriki** | Cyanoramphus novaezelandiae | Redcrowned parakeet | Relict | Endemic |
| **Kererū** | Hemiphaga novaeseelandiae | Wood Pigeon | Not Threatened | Endemic |
| **Kōtare** | Todiramphus sanctus | Sacred Kingfisher | Not Threatened | Native |
| **Kāruhiruhi** | Phalacrocorax varius | Pied shag | Recovering | Native |
| **Makipae** | Gymnorhina tibicen | Magpie | Introduced and Naturalised | Introduced |
| **Manu Pango** | Turdus merula | Blackbird | Introduced and Naturalised | Introduced |
| **Mioweka** | Gallirallus philippensis | Banded Rail | Declining | Native |
| **Mātātā** | Poodytes punctatus | Fernbird | Declining | Endemic |
| **Ngirungiru** | Petroica macrocephala | Tomtit | Not Threatened | Endemic |
| **Pahirini** | Fringilla coelebs | Chaffinch | Introduced and Naturalised | Introduced |
| **Pāteke** | Anas chlorotis | Brown teal | Recovering | Endemic |
| **Pipiwharauroa** | Chrysococcyx lucidus | Shining Cuckoo | Not Threatened | Native |
| **Pīwakawka** | Rhipidura fuliginosa | Fantail | Not Threatened | Endemic |
| **Pūkeko** | Porphyrio melanotus | Purple Swamphen | Not Threatened | Native |
| **Pūtangitangi** | Tadorna variegata | Paradise Duck | Not Threatened | Endemic |
| **Riroriro** | Gerygone igata | Grey Warbler | Not Threatened | Endemic |
| **Ruru** | Ninox novaeseelandiae | Morepork | Not Threatened | Native |
| **Tākapu** | Morus serrator | Gannet | Not Threatened | Native |
| **Tarāpuka** | Chroicocephalus bulleri | Black-billed gull | Declining | Endemic |
| **Tarapunga** | Larus novaehollandiae | Redbilled Gull | Declining | Native |
| **Tauhou** | Zosterops lateralis | Silvereye | Not Threatened | Native |
| **Tiu** | Passer domesticus | Sparrow | Introduced and Naturalised | Introduced |
| **Tōrea Pango** | Haematopus unicolor | Oystercatcher | Recovering | Endemic |
| **Toutouwai** | Petroica longipes | NI robin | Declining | Endemic |
| **Tūī** | Prosthemadera novaeseelandiae | Parson Bird | Naturally Uncommon | Endemic |
| **Warou** | Hirundo neoxena | Swallow | Not Threatened | Native |
| **Weka** | Gallirallus australis | Woodhen | Not Threatened | Endemic |

| Te reo name | Latin name | European name | Conservation status | Biogeographic status |
|---|---|---|---|---|
| - | Turdus philomelos | Song Thrush | Introduced and Naturalised | Introduced |
| - | Emberiza citrinella | Yellowhammer | Introduced and Naturalised | Introduced |
| - | Chicken | Chicken | Introduced | Introduced |
| - | Carduelis carduelis | Goldfinch | Introduced and Naturalised | Introduced |
| - | Vanellus miles | Spurwinged Plover | Not Threatened | Native |
| - | Streptopelia chinensis | Spotted dove | NA | Introduced |
| - | Acridotheres tristis | Mynah | Introduced and Naturalised | Introduced |
| - | Sturnus vulgaris | Starling | Introduced and Naturalised | Introduced |

*Table 4 Total number of observations, number of counts, and number of sites for each species observed in the 2022 ABC.*

| Species | Status | Total counts | No. observations | No. sites |
|---|---|---|---|---|
| **Banded Rail** | Native | 27 | 18 | 7 |
| **Black-billed Gull** | Endemic | 1 | 1 | 1 |
| **Blackbird** | Introduced | 39 | 34 | 13 |
| **Chaffinch** | Introduced | 87 | 49 | 11 |
| **Chicken** | Introduced | 9 | 8 | 6 |
| **Fantail** | Endemic | 203 | 84 | 18 |
| **Fernbird** | Endemic | 1 | 1 | 1 |
| **Gannet** | Native | 12 | 7 | 4 |
| **Goldfinch** | Introduced | 45 | 14 | 3 |
| **Greenfinch** | Introduced | 11 | 11 | 3 |
| **Grey Warbler** | Endemic | 209 | 120 | 18 |
| **Kāhu** | Native | 5 | 5 | 5 |
| **Kākā** | Endemic | 431 | 142 | 18 |
| **Kākāriki** | Endemic | 19 | 6 | 1 |
| **Kererū** | Endemic | 31 | 21 | 11 |
| **Kōtare** | Native | 312 | 149 | 18 |
| **Magpie** | Introduced | 18 | 15 | 6 |
| **Mynah** | Introduced | 7 | 6 | 4 |
| **Oystercatcher** | Endemic | 16 | 11 | 6 |
| **Paradise Duck** | Endemic | 29 | 6 | 2 |
| **Pāteke** | Endemic | 7 | 2 | 2 |
| **Pied Shag** | Native | 2 | 2 | 2 |
| **Pūkeko** | Native | 40 | 15 | 6 |
| **Red-billed Gull** | Native | 62 | 9 | 2 |
| **Ruru** | Native | 1 | 1 | 1 |
| **Shining Cuckoo** | Native | 30 | 25 | 9 |
| **Silvereye** | Native | 116 | 58 | 13 |
| **Skylark** | Introduced | 2 | 2 | 1 |

| Species | Status | Total counts | No. observations | No. sites |
|---|---|---|---|---|
| **Song thrush** | Introduced | 16 | 13 | 7 |
| **Starling** | Introduced | 7 | 5 | 2 |
| **Tomtit** | Endemic | 4 | 3 | 1 |
| **Toutouwai** | Endemic | 9 | 5 | 1 |
| **Tūī** | Endemic | 401 | 149 | 18 |
| **Weka** | Endemic | 13 | 6 | 1 |
| **Welcome Swallow** | Native | 35 | 14 | 5 |
| **White-faced Heron** | Native | 5 | 3 | 3 |
| **Yellowhammer** | Introduced | 6 | 4 | 3 |

# Appendix B

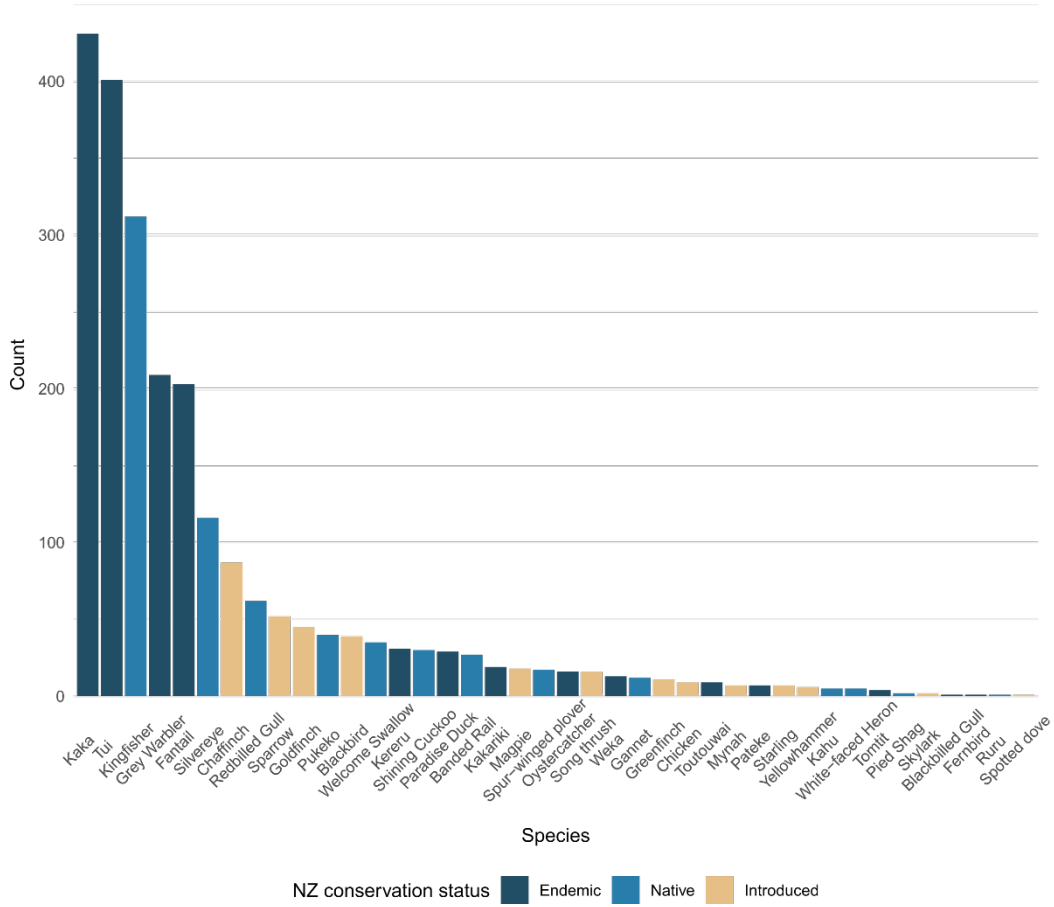


*Figure 15 - Number of observations of each of the species recorded in the ABC 2022 (excluding unambiguous observations). Colours indicate their New Zealand conservation status (native, endemic, introduced species level).*

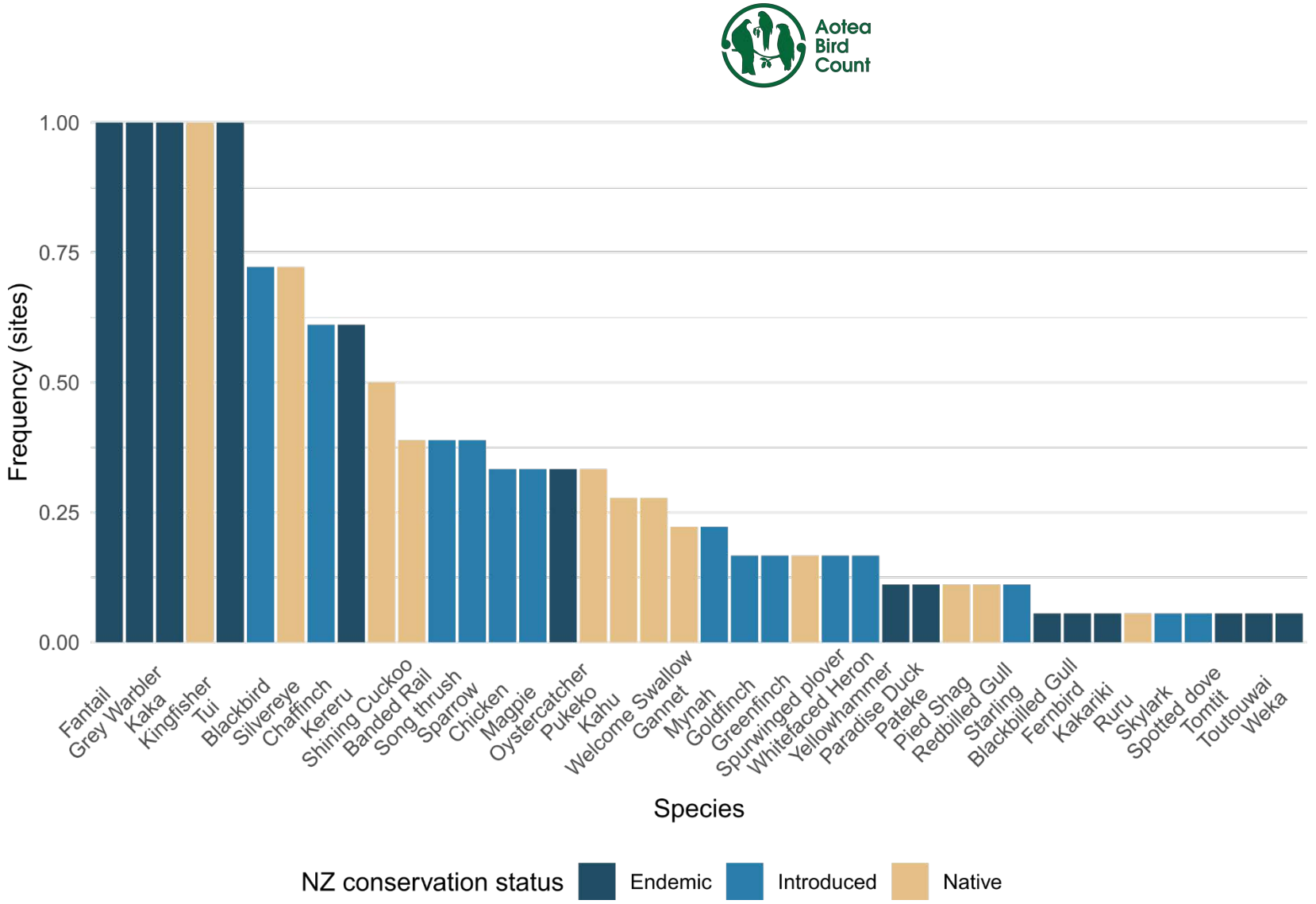


*Figure 16 - Frequency (proportion sites observed at) of each of the species recorded in the ABC 2022 (excluding unambiguous observations). Colours indicate their New Zealand conservation status (native, endemic, introduced species* level).

# Appendix C

The data and scripts used in the 2020, 2021, and 2022 reports are reproducible and stored on a public repository:

- 2020 data and scripts - https://doi.org/10.17608/k6.auckland.14865372
- 2021 data and scripts - https://doi.org/10.17608/k6.auckland.20523765.v1
- 2022 data and scripts - http://dx.doi.org/10.17608/k6.auckland.23805588