State and trends in the diversity, abundance and distribution of birds in Wellington City

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Cover Image: Male hihi (*Notiomystis cincta*) at Zealandia. Image credit: Rob Brown/photonewzealand.

Executive Summary

Five-minute bird counts have been carried out at 100 bird count stations in forest habitat throughout Wellington City's parks and reserves network each year between 2011 and 2020. The aim of these surveys is to monitor trends in the diversity, abundance and distribution of native forest birds throughout Wellington City's parks and reserves network, in order to provide a measure of local biodiversity management outcomes.

Since 2011, the mean number of native bird species being counted during each bird count has risen by 50%, and the mean number of introduced bird species being counted per count has increased by 61%. Between 2011 and 2020, mean annual counts for kākā have increased by 250%, mean counts for kererū have increased by 186%, mean counts for tūī have increased by 121%, mean counts for tīeke / NI saddleback have increased by 29% and mean counts for pīwakawaka / NZ fantail have increased by 20%.

The predator-free Zealandia sanctuary is having a measurable 'halo' effect on native forest bird communities throughout Wellington City. The mean number of native bird species recorded per five-minute bird count station declines with increasing distance from Zealandia's predator-proof fence. A mean of 6.5 native bird species has been recorded at count stations closest to Zealandia's boundary between 2011 and 2020, whereas only 3.2 native bird species on average was recorded at those count stations situated furthest from Zealandia's boundary over the same period. In contrast, the mean number of introduced species recorded per five-minute bird count station increases with increasing distance from Zealandia's predator-proof fence. A mean of 2.2 introduced bird species has been recorded at count stations closest to Zealandia between 2011 and 2020, whereas an average of 2.4 introduced bird species was recorded at count stations situated furthest away from the sanctuary over the same period.

These results suggest that the presence of large 'source' populations of native forest birds in Zealandia, together with the increasing extent and intensity of mammalian predator control being carried out in Wellington City, is driving spectacular recoveries in several previously rare or locally extinct native forest bird species in Wellington City. As a consequence, bird communities in native forest habitats in Wellington City parks and reserves are becoming more diverse and increasingly dominated by native species, creating improved opportunities for local residents and visitors alike to encounter a wider range of New Zealand's native forest bird species in the heart of New Zealand's capital city. One clear sign of this increasing level of engagement is the large number of citizen science bird records that are being collected in Wellington City, with a total of 47,332 observations of native forest birds having been reported to date by local residents and visitors since 2011.

It is recommended that Wellington City Council continues to carry out these five-minute bird counts on an annual basis, to monitor further improvements in the city's native bird communities as Wellington continues on its journey towards becoming the world's first predator-free capital city.

Keywords: Citizen science, eBird, encounter rate, five-minute bird count, generalised linear mixed-effect models, iNaturalist, New Zealand Bird Atlas, Predator Free Wellington, Wellington City, Zealandia

Wellington City forest reserves bird health check

Low Concern

Large, stable or increasing populations. Low to moderate predator risk.

Tūī, Tauhou / Silvereye, Riroriro / Grey warbler, Pīwakawaka / NZ fantail, Kākā, Kererū, Kōtare / NZ kingfisher

Moderate Concern

Small, localised or sparse populations. Moderate predator risk.

Pīpīwharauroa / Shining cuckoo, Tīeke / NI saddleback, Kākāriki / Red-crowned parakeet, Pōpokotea / Whitehead, Korimako / Bellbird, Kārearea / NZ falcon, Tōtōwai / NI robin, Hihi

High Concern

Tiny or declining populations. Moderate to high predator risk.

Tītitipounamu / Rifleman

Data deficient

Population size and trends poorly known.

Ruru / Morepork

Image credits: NZ Birds Online (http://nzbirdsonline.org.nz/)

1. Introduction

Over the past twenty years there has been a conspicuous increase in the species richness, abundance and distribution of native forest birds in Wellington City (Miskelly et al, 2005; McArthur et al, 2019). These changes are likely to be due to two improvements in the management of indigenous forest habitats in and around the city that have occurred in recent decades. Firstly, a series of species reintroductions to local predator-free sites such as Zealandia, Matiu/Somes Island and Mana Island have successfully established healthy source populations from which previously locally extinct or near-extinct bird species have been dispersing into nearby forested reserves in the city (Miskelly & Powlesland, 2013; McArthur et al, 2017). These species include kākā (*Nestor meridionalis*), kākāriki / red-crowned parakeet (*Cyanoramphus novaezelandiae*), pōpokotea / whitehead (*Mohoua albicilla*) and korimako / bellbird (*Anthornis melanura*) (Miskelly et al, 2005; Froude, 2009; McLaughlin & Harvey, 2013; Miskelly, 2018). Secondly, ongoing multi-species mammalian predator control being carried out by Wellington City Council, Greater Wellington Regional Council and community conservation groups in many Wellington City parks and reserves has resulted in local increases in resident native bird species such as tūī (*Prosthemadera novaeseelandiae*) (Bell, 2008; Froude, 2009; Brockie & Duncan, 2012; McArthur et al, 2019) and is creating an opportunity for recently reintroduced species to establish functional populations away from their original reintroduction sites.

Within Zealandia itself, eleven endemic forest bird species have been reintroduced to the sanctuary since the eradication of mammalian predators in 2000, and a further two species have recolonised of their own accord (Miskelly 2018[1]). This has led to the re-establishment of a diverse and abundant endemic forest bird community within Zealandia's predator-proof fence, which in turn has led to substantial declines in the abundance of three of the four native forest bird species that had been resident in Zealandia prior to the eradication of mammalian predators, namely tauhou / silvereye (*Zosterops lateralis*), riroriro / grey warbler (*Gerygone igata*) and pīwakawaka / fantail (*Rhipidura fuliginosa*) (Miskelly, 2018). At least six introduced bird species have also experienced similar, substantial declines within Zealandia over this time period, including pahirini / chaffinch (*Fringilla coelebs*), dunnock (*Prunella modularis*) and song thrush (*Turdus philomelos*) (Miskelly, 2018). These changes to Zealandia's bird community over the past two decades may foreshadow the changes that may occur in forest habitats in other Wellington City parks and reserves, as efforts to control and/or eradicate mammalian predators continue to expand and intensify.

Mammalian predator control and eradication efforts in Wellington City are continuing to grow in both intensity and coverage. Dozens of community groups across Wellington City are now participating in predator control activities, and in recent years the concept of creating 'predator free suburbs' has emerged. Following central government's announcement in July 2016 to work towards the goal of a Predator Free New Zealand by 2050, these Wellington City predator control efforts have further crystallised into the Predator Free Wellington initiative. Predator Free Wellington is being co-funded by Wellington City Council, Greater Wellington Regional Council and the NEXT Foundation and plans to build on the proliferation of pest-free suburb projects with the aim of eradicating rats, mustelids

[1] Miskelly (2018) lists 10 forest bird species reintroduced to Zealandia. In March 2019, an 11th species, tītitipounamu / rifleman (*Acanthsitta chloris*) was also reintroduced to the sanctuary (https://www.facebook.com/ZEALANDIA/posts/10156377249456401; accessed 04/04/2021).

and possums from Wellington City. The first stage of this project commenced in July 2019 with an effort to eradicate rats and mustelids from Miramar Peninsula, and preparations are now underway to begin an eradication of rats, possums and mustelids from an additional 19 suburbs from Island Bay to the CBD (https://www.pfw.org.nz/; accessed 04/04/2021). If successful, these efforts could result in further dramatic improvements in the distribution and abundance of several native bird species that are currently locally rare or extinct in Wellington City.

Monitoring the ongoing changes that are occurring to native bird populations in the city provides a useful means by which the outcome of the considerable time and effort being spent on improving Wellington City's biodiversity can continue to be measured. For this reason, Wellington City Council has identified a need to monitor local bird populations to provide one measure of the success or otherwise of their recently adopted Biodiversity Strategy & Action Plan (WCC, 2015). Goal 4.2.2a of this Biodiversity Strategy involves setting up a "consistent terrestrial outcome monitoring framework…incorporating existing monitoring work in a collaborative approach with other key organisations" (WCC, 2015).

Five-minute bird count monitoring has been carried out between 2001 and 2009 in nine selected parks and reserves in Wellington City by Pacific Eco-Logic Ltd (Froude, 2009). These counts were successful in detecting substantial increases in the local abundance of tūī at a key time during which a large expansion in pest control efforts in Wellington City was underway. These counts also provided some of the earliest evidence that bird species re-introduced to Zealandia were dispersing and settling in nearby reserves (Froude, 2009). In 2011 this bird monitoring programme was replaced with a new survey designed to monitor changes in the distribution and abundance of native forest birds in forest habitats across the entire network of Wellington City parks and reserves, rather than only a selected subset of reserves (McArthur et al, 2012).

These counts have now been carried out each year since 2011 and have demonstrated the important influence that Zealandia has had on the native forest bird community in the wider Wellington City. Approximately a third of the native forest bird species detected in Wellington City parks and reserves each year are species that have been re-introduced to Zealandia and have subsequently expanded their range to include a number of other parks and reserves in the city (McArthur et al, 2019). Many of these species were found to have very localised distributions beyond Zealandia's predator-proof fence however, indicating that mammalian predators are continuing to limit the ability of these species to colonise other native forest habitats in the city's parks and reserves (McArthur et al, 2019). Another key result from this work is that mean encounter rates for tūī, kākā, kākāriki / red-crowned parakeet, kererū and tīeke / NI saddleback have increased significantly since 2011, suggesting that these species have increased in abundance and/or conspicuousness in Wellington City parks and reserves over this time (McArthur et al, 2019). This suggests that the expansion and intensification of mammalian predator control efforts over this time have led to measurable improvements in the population health of these particular bird species.

The incorporation of bird observations collected by local 'citizen scientists' into the distribution maps created as part of this bird monitoring programme has allowed us to map the distribution of native birds in Wellington City in unprecedented detail. These maps have helped document the range expansion of recently re-introduced species such as kākā and kākāriki / red-crowned parakeet in Wellington City virtually in real time and have documented a number of local re-colonisation events that have occurred in recent years in several individual parks and reserves (McArthur et al, 2019).

This report provides an update on the emerging trends in the diversity, abundance and distribution of birds in forest habitats in parks and reserves throughout Wellington City, by analysing and reporting a

tenth year of five-minute bird count data, together with additional citizen-science data collected since the publication of the previous bird monitoring report in June 2020.

2. Methods

2.1 Five-minute bird count data collection

One hundred bird count stations were established at randomly selected locations in forest habitat in Wellington City parks and reserves in November 2011 and have been surveyed annually between 2011 and 2020 (Figure 2.1). Bird count stations were established at a minimum distance of 200 metres from one another and each station has been marked with either a blue triangle affixed to a living tree, or with pink flagging tape if situated in plantation forest.

Two five-minute bird counts have been carried out at each station each year, with the two counts at each station being carried out on a different day. All counts were carried out between early November and early January each year and counts were made only on fine, calm days between 1.5 hours after sunrise and 1.5 hours before sunset (approximately 7.30 am to 6.30 pm). At each station, an observer spent five minutes recording the number of individuals of all species seen or heard from the count station (i.e., an unbounded count as per Dawson & Bull, 1975 and Hartley & Greene, 2012). Care was taken not to record the same bird twice during a count. Two experienced observers conducted the counts each year, with each observer surveying approximately half of the bird count stations.

Bird conspicuousness can vary in response to external variables such as time of year, weather, time of day and change in observer (Bibby et al, 2000). Because of this, every effort was made to standardise or sample the range of variation in each of these factors to ensure that as much as possible any changes in the mean number of birds counted per station from one year to the next would be more likely to reflect changes in bird abundance rather than conspicuousness. Precautions taken include carrying out these counts during the same months each year and in similar weather conditions. Counts were carried out throughout the day, so sampled any variation in bird conspicuousness that occurred during the day.

Variation in the methods and abilities of observers can have a substantial impact on five-minute bird count results and can sometimes either mask or be mistaken for true changes in bird abundance or conspicuousness from one survey to the next (McArthur et al, 2013a). For this reason, we've endeavoured to minimise the number of observers used to collect this five-minute bird count data, with only two changes being made so far during the ten-year duration of this project. In each case, when one observer has been replaced with another, the second observer has remained the same across both years, thus providing us with some ability to differentiate observer-related variation in bird encounter rates from those caused by true changes in bird conspicuousness or abundance from one year to the next.

Figure 2.1: Locations of five-minute bird count stations surveyed annually in Wellington City parks and reserves between 2011 and 2020.

2.2 Five-minute bird count data analysis

The Wellington City five-minute bird count data were first entered into a Microsoft Excel spreadsheet and then imported into the statistical package R (R Core Team 2021) for statistical analysis. Three separate analyses were carried out, the first of which looked at overall trends in the encounter rates of native and introduced birds over time; the second of which investigated temporal trends in the encounter rates of any individual species that occurred in at least 2.5% of counts (i.e., there were at least 50 individual detections during counts carried out between 2011 and 2020); and the third of which investigated the influence that Zealandia's proximity has on the diversity of native and introduced bird species recorded at a bird count station.

For all three analyses, generalised linear mixed-effects models with a Poisson error were used to investigate temporal and spatial trends in bird encounter rates. For each analysis, we compared models from a candidate set to determine which of the plausible relationships between the number of birds encountered and time best explained the data. The model that fitted the data best was selected using Akaike's Information Criterion corrected for small sample size (AICc; Burnham and Anderson, 2002), with the model with the lowest AICc value providing the best fit to the data using the lowest number of model parameters. We then used our preferred models to assess whether trends in bird encounter rates were increasing or decreasing over time by calculating estimates of slope, and 95% confidence intervals (CIs) around estimates. Positive estimates of slope indicated increases in bird encounter rates, while negative estimates of slope indicated decreases in bird encounter rates. We used the 'lme4' package (Bates et al, 2015) in the statistical package R (R Core Team 2021) for all three analyses.

2.2.1 Trends in the encounter rates of native versus introduced species

To analyse overall trends in the encounter rates of native versus introduced birds over time, three plausible models were considered:

1. **No change**: Bird encounter rates have not changed between 2011 and 2020 but encounter rates of native and introduced species have differed. This model included the number of individuals of all species detected during a count in a given year as a response variable, and the status of each species (native or introduced) as a predictor variable.

2. **Same population trend for both native and introduced species**: Bird encounter rates have changed between 2011 and 2020, at the same rate for both native and introduced species. This model consisted of the same response variable as the "no change" model above, but included both species status and year as predictor variables.

3. **Different population trends for native versus introduced species:** Bird encounter rates have changed between 2011 and 2020, but at different rates for native versus introduced species. This model consisted of the same response and predictor variables as the "same population trend" model above, but included an additional interaction term between the status and year predictor variables to allow for the slope of the relationship with time to vary between native and introduced species.

For each of these three models, a random intercept term was included for each station to account for the repeated-measures design. We did not include observer in the model because observer was partly confounded with station. However, only four observers have been used over the ten-year series of counts, and generally at least five levels of a random effect (in this case, the observer) are required to achieve robust estimates of variance (Gelman & Hill, 2007).

2.2.2 Trends in the encounter rates of individual native forest bird species

To analyse trends in the encounter rates of individual bird species between 2011 and 2020, two plausible models were considered:

1. **No trend**: Bird encounter rates have not changed between 2011 and 2020.

2. **Trend over time**: Bird encounter rates have either increased or decreased between 2011 and 2020.

Both models included the number of individuals of each species detected during a count in a given year as a response variable, an intercept term and a random intercept term for each station to account for the repeated-measures design. The "trend over time" model also included year as a predictor variable. As with the first analysis, observer was not included as a random effect. Where it was necessary, an observation-level random effect was also included to account for overdispersion, i.e., a higher error variance than assumed by the Poisson error distribution for these models (Harrison, 2014).

2.2.3 Zealandia's influence on native and introduced species richness

To analyse how proximity to Zealandia influences the number of native or introduced species recorded at a bird count station, three plausible models were considered:

1. **No spatial trend:** Differences in species richness occur between native and introduced species at any given location, but show no relationship with distance from Zealandia.

2. **Same spatial trend for native and introduced species**: Differences in species richness occur between native and introduced species at any given location, and these differences vary in relation to the distance of the count station from Zealandia at the same rate for both native and introduced species.

3. **Different spatial trends for native versus introduced species:** Differences in species richness occur between native and introduced species at any given location, and these differences vary in relation to the distance of the count station from Zealandia but at different rates for native and introduced species.

All three models contained species richness (i.e., the mean number of species detected at each station) as a response variable, an intercept term, and a random intercept term for each station (to account for the repeated-measures design) and for year (to account for variation between years). All models also included a log-transformed offset term consisting of the number of native and introduced

species included, to account for there being more native than introduced species included in the analysis. A linear relationship between species richness and distance to Zealandia was also assumed. Model one (no spatial trend) included status (whether a species is native or introduced) as a predictor variable. Model 2 (same spatial trend for native and introduced species) included status and distance to the nearest point of Zealandia's boundary as predictor variables. Model three (different spatial trends for native and introduced species) included the same predictor variables as model two, but also included an interaction term between status and distance to Zealandia as an additional predictor variable to allow for the spatial trend in species richness to vary between native and introduced species.

Patterns in the distribution of native birds among Wellington City reserves were also examined by mapping the relative frequency at which each native forest bird species was detected at each bird count station using ArcMap version 10.8.1. Although this technique does not explicitly take into account relative differences in abundance (e.g., less common species present within sight or earshot of a bird count station are less likely to be detected) or variation in detection probabilities between species (e.g., less conspicuous species will also be less likely to be detected), it should be sufficient to detect relatively conspicuous patterns in species' distributions and habitat use (Mackenzie et al, 2006).

2.3 Citizen science data analysis

As a result of the increasing popularity of citizen science, there is a rapidly growing pool of bird observation data collected by citizen scientists available online which can be combined with our more systematic five-minute bird count data to help detect changes in bird distribution in Wellington City over time. To date, residents and visitors to the Wellington region have contributed over 384,000 bird observations to online databases and citizen science projects such as the New Zealand eBird database, the New Zealand Bird Atlas, iNaturalist and the Great Kererū Count.

The New Zealand eBird database (http://ebird.org/content/newzealand/), which in turn hosts the New Zealand Bird Atlas dataset, is run by the Cornell Lab of Ornithology in partnership with Birds New Zealand (formerly the Ornithological Society of New Zealand). It provides a facility for recreational birdwatchers and professional ornithologists to permanently record their bird observations in a standard format and in one centralised location and makes these observations available to researchers, conservation managers and environmental policy makers (Scofield et al, 2012). Globally, the eBird database is now the largest and fastest growing biodiversity database in the world, with over 668,000 unique users having so far contributed over 915 million bird records describing the distribution of 98% of the world's bird species (Sullivan et al, 2014; https://ebird.org/news/2020-year-in-review, accessed 01/04/2021).

Within the eBird database, automated data filters and an expert review process ensure that these data are of high quality and accuracy (Sullivan et al, 2014). We used eBird's "download data" tool to access the February 2021 release of the eBird Basic Dataset (EBD) and to build custom datasets containing citizen science records of all native forest bird species recorded in Wellington City between 2011 and 2021. We formatted these datasets using Microsoft Excel, including removing any extraneous data fields and converting latitude/longitude coordinates to NZTM coordinates. We then saved these files as .csv files so that they could be imported into ArcMap and converted into shapefiles. Once in ArcMap, we visually inspected these eBird records to locate and remove any records containing obvious location errors (e.g., records placed offshore, or for which location descriptions didn't match the coordinates provided) or absence records, before adding these records to the distribution maps created from the five-minute bird count data. A total of 44,397 records of native forest birds observed in Wellington City was retrieved from eBird using this process, representing 94% of all of the citizen science bird observations included in this report.

The iNaturalist database is the second-largest online source of citizen science bird data for the Wellington region. iNaturalist is a database that allows citizen scientists to submit, share and store natural history observations online, and unlike eBird it is designed to accept records for almost any taxon of plant or animal rather than just birds. iNaturalist (https://inaturalist.nz/) is run by a charitable trust called the New Zealand Bio-recording Network Trust and was established using funding from the New Zealand Government's Terrestrial Freshwater Biodiversity Information System Fund.

Within the iNaturalist database, a community peer-review process is used to validate records, with records tagged as either "research grade" or "casual grade" depending on whether or not the original species identifications have been verified by another iNaturalist user. Because most of the bird observations submitted to iNaturalist are not accompanied by photographs, the majority of records cannot be verified and remain tagged as "casual grade" records. We used the search tool on the Global Biodiversity Information Facility website (https://www.gbif.org/) to download all bird observations recorded in Wellington City between 2011 and 2021. We formatted this dataset using Microsoft Excel, including extracting records of all native forest bird species recorded in Wellington

City, then saved the resulting file as a .csv file so that it could be imported into ArcMap and converted to a shapefile. We then displayed the data on a map and visually inspected them and removed records with obvious location errors, before adding these records to the distribution maps created from the five-minute bird count data. A total of 2,360 records of native forest birds observed in Wellington City were retrieved from iNaturalist using this process, representing 5% of all of the citizen science bird observations included in this report.

Kererū Discovery's Great Kererū Count project is the third-largest source of citizen science bird data available for Wellington. The Great Kererū Count is billed as New Zealand's "largest citizen science project" and is a nationwide kererū survey that takes place over a 10-day period in September each year (Hartley, 2017). Observers from around the country are encouraged to record the presence or absence of kererū at locations of their choosing over a 10-day period. In 2020, a total of 10,279 reports were received nationwide, with a total of 21,509 kererū counted (https://www.greatkererucount.nz/; accessed 05/04/2021). We made a request for access to the Great Kererū Count data from Kererū Discovery and received a .csv file containing 574 observations for the city. We imported this .csv file into ArcMap and visually inspected the records to locate and remove any records containing obvious location errors before adding these records to the distribution maps created from the five-minute bird count data. The 574 kererū observations sourced from the Great Kererū Count dataset represents 1% of all of the citizen science bird observations included in this report.

A key difference between these citizen science datasets and the five-minute bird count data is that the temporal and spatial distribution of search effort spent by citizen scientists varies unpredictably from year to year, whereas this search effort is standardised during these five-minute bird counts. Nonetheless, accurate bird observations submitted by citizen scientists have the potential to complement distribution data derived from our five-minute bird count dataset by providing information describing the presence of native forest birds at locations and in habitats not sampled by these five-minute bird counts. By collecting bird observation data all year round, local citizen scientists are also better placed to record local colonisation events, prior to the colonising species being detected during these five-minute bird counts.

3. Results

3.1 Species diversity

Forty-seven bird species have been detected during five-minute bird counts carried out in Wellington City parks and reserves between 2011 and 2020, including one species (kawau paka / little shag, *Phalacrocorax melanoleucos*) that was detected for the first time in 2020. A full list of the 47 bird species detected, along with their current national and regional New Zealand Threat Classification rankings, can be found in Appendix One of this report.

Of these 47 bird species, 23 are typically found in native forest habitats, including 16 native or endemic species and seven introduced and naturalised species. The remaining 24 bird species recorded during these counts are marine, coastal or open country species such as kororā / little penguin (*Eudyptula minor*), tōrea tai / variable oystercatcher and kāhu / swamp harrier (*Circus approximans*) and are not included in any of the individual species analyses reported below. Among the 16 native or endemic bird species recorded during these counts, one is ranked as 'Nationally Vulnerable', two are ranked as 'At Risk Declining', one is ranked as 'At Risk Relict', three are ranked as 'At Risk Recovering', and nine are ranked as 'Not Threatened' under the New Zealand Threat Classification Scheme (Appendix One; Robertson et al, 2017).

The best model to describe the overall trends in encounter rates of native versus introduced birds in native forest habitat in Wellington City parks and reserves over time was the model that assumed that population trends would differ between native versus introduced species. This model had a considerably lower AICc value compared to the next closest model considered (ΔAICc = 8.63). According to this model, the mean number of native birds encountered per count has increased between 2011 and 2020 (the coefficient of year on log abundance was 0.04; 95% CI 0.04 - 0.22). Fifty percent more native birds were encountered in 2020 than in 2011, with a mean of 7.3 (± 0.3 SE) native birds encountered per bird count in 2020 compared to 4.9 (± 0.2 SE) native birds per count in 2011. The mean number of introduced birds encountered per count has also increased between 2011 and 2020 (the coefficient of year on log abundance was 0.02; 95% CI 0.01–0.03). Sixty-one percent more introduced birds were counted in 2020 than in 2011, with a mean of 6.2 (± 0.3 SE) introduced birds encountered per bird count in 2020 compared to 3.8 (± 0.1 SE) introduced birds per count in 2011. Over the entire period between 2011 and 2020, native species have increased in abundance at a faster rate than introduced species, as the coefficient of year on log abundance was larger for native species (0.04) than it was for introduced species (0.02) (Figure 3.1.1).

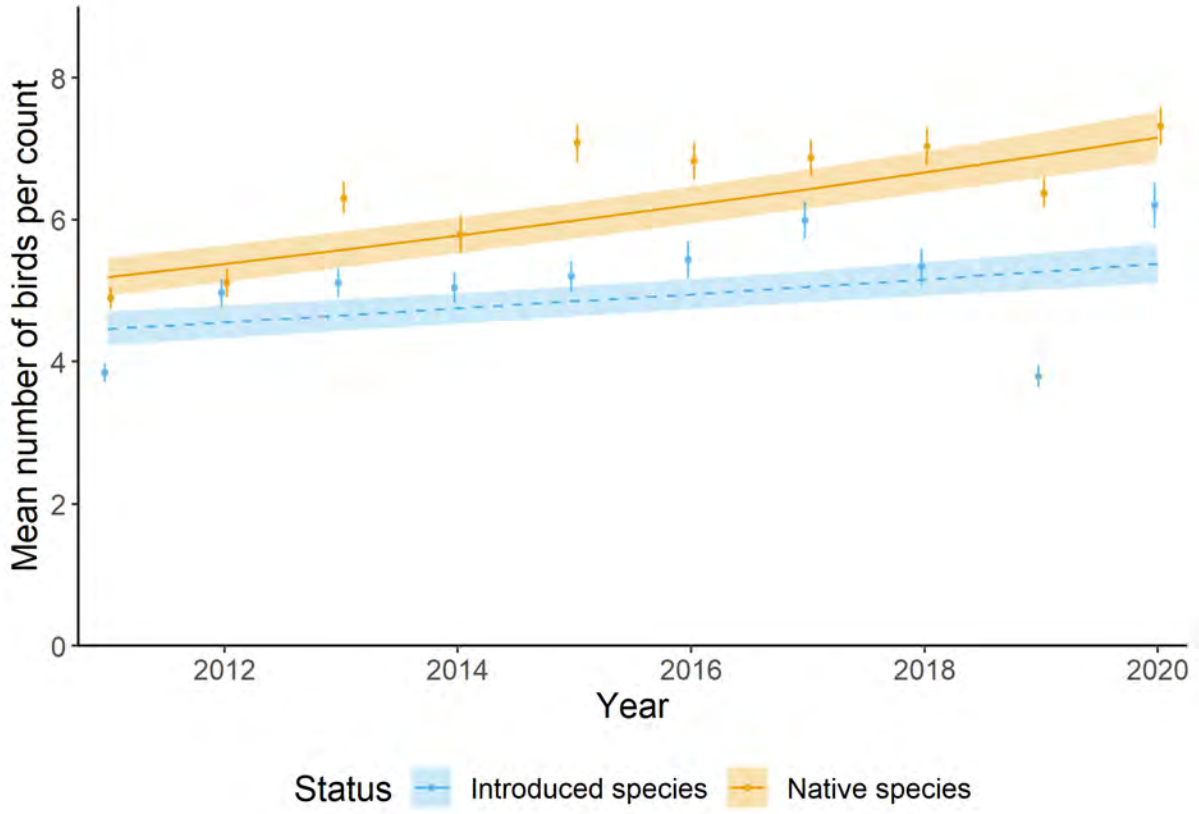

Figure 3.1.1: Trends in the mean number of native and introduced birds encountered per bird count in Wellington City parks and reserves between 2011 and 2021. Individual data points (± standard error) represent the mean number of native and introduced bird species detected per count each year. Solid orange and dashed blue lines (± 95% Confidence Intervals) represent the modelled trend in the number of native and introduced bird species recorded per count each year.

3.2 Abundance and distribution of native forest bird species

Of the 19 native forest bird species that have been recorded in Wellington City since 2011 (comprising 16 recorded during these five-minute bird counts and a further three species reported by citizen scientists), 11 species were encountered on at least 50 occasions during these five-minute bird counts (2.5% of all counts). Based on the lowest AICc values of the two candidate models, seven of these 11 species showed trends over time, whereas four species showed no trend. For species where year has an effect on mean encounter rates, a coefficient estimate >0 indicates an increase in encounter rates over time, with greater coefficient estimates indicating faster rates of increase. Conversely, a negative coefficient estimate indicates a decrease in encounter rates over time. Based on the coefficient estimates for the seven native forest bird species that showed trends over time, six of these species (tūī, pīwakawaka / fantail, kākā, kererū (*Hemiphaga novaeseelandiae*), tīeke / NI saddleback (*Philesturnus rufusater*) and kākāriki / red-crowned parakeet) showed an increase in mean encounter rates over time, and one species (pīpīwharauroa / shining cuckoo (*Chrysococcyx lucidus*) showed a decrease in encounter rates (Table 3.2.1).

The following individual species accounts are listed in decreasing order of their current or recent abundance in Wellington City. Species that are most frequently encountered during the five-minute bird counts are covered first, and the species that are only seldom encountered, or not encountered at all during these five-minute bird counts are treated last. Every species of native forest bird that has been observed in Wellington City outside of Zealandia since 2011 is included in this section of the report. A separate summary table of annual native forest bird encounter rates can be found in Appendix Two of this report.

Table 3.2.1: Summary of models of population change in 11 native forest bird species detected on at least 50 occasions in Wellington City parks and reserves since 2011, and trend if detected. The 'selected model' column indicates which model was selected for each species. The 'trend' column indicates if the change in abundance was increasing, decreasing, or if no trend was detected ('-') based on estimates of slope.

Species	AICc model 1	AICc model 2	Δ AICc	Selected model	Trend	Coefficient estimate (95% CIs)
Tūī	7043.02	6848.52	194.49	Model 2 (Trend over time)	Increasing	0.084 (0.071 – 0.094)
Pīwakawaka NZ fantail	2779.04	2765.06	13.98	Model 2 (Trend over time)	Increasing	0.058 (0.030 – 0.086)
Kākā	1619.26	1563.35	55.92	Model 2 (Trend over time)	Increasing	0.156 (0.116 – 0.200)
Kererū	1343.03	1315.46	27.57	Model 2 (Trend over time)	Increasing	0.146 (0.088 – 0.196)
Tīeke NI saddleback	621.69	617.68	4.02	Model 2 (Trend over time)	Increasing	0.083 (0.008 – 0.143)
Kākāriki Red-crowned parakeet	521.95	520.91	1.04	Model 2 (Trend over time)	Increasing?	0.178 (-0.385 – 0.697)
Tauhou Silvereye	7392.30	7393.88	1.58	Model 1 (No change over time)	-	-
Riroriro Grey warbler	5309.00	5310.57	1.57	Model 1 (No change over time)	-	-
Pōpokotea Whitehead	611.09	612.00	0.91	Model 1 (No change over time)	-	-
Kōtare NZ kingfisher	512.07	513.78	1.71	Model 1 (No change over time)	-	-
Pīpīwharauroa Shining cuckoo	1528.33	1518.89	9.44	Model 2 (Trend over time)	Decreasing	-0.070 (-0.114 - -0.027)

3.2.1 Tūī (*Prosthemadera novaeseelandiae*)

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

Image courtesy of Tony Whitehead/NZ Birds Online

The tūī is the native forest bird species that is most frequently encountered during these five-minute bird counts. Tūī encounter rates have increased by 121% since 2011, from a mean of 1.35 tūī recorded per five-minute bird count in 2011 to a mean of 2.98 tūī per count in 2020 (the coefficient of year on log abundance was 0.084; 95% CI 0.071–0.094; Figure 3.2.1). Tūī is the native forest bird species most commonly reported by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 16,236 encounters with tūī, demonstrating that this species is now common and widespread in native forest, suburban and urban habitats throughout the city (Figure 3.2.2).

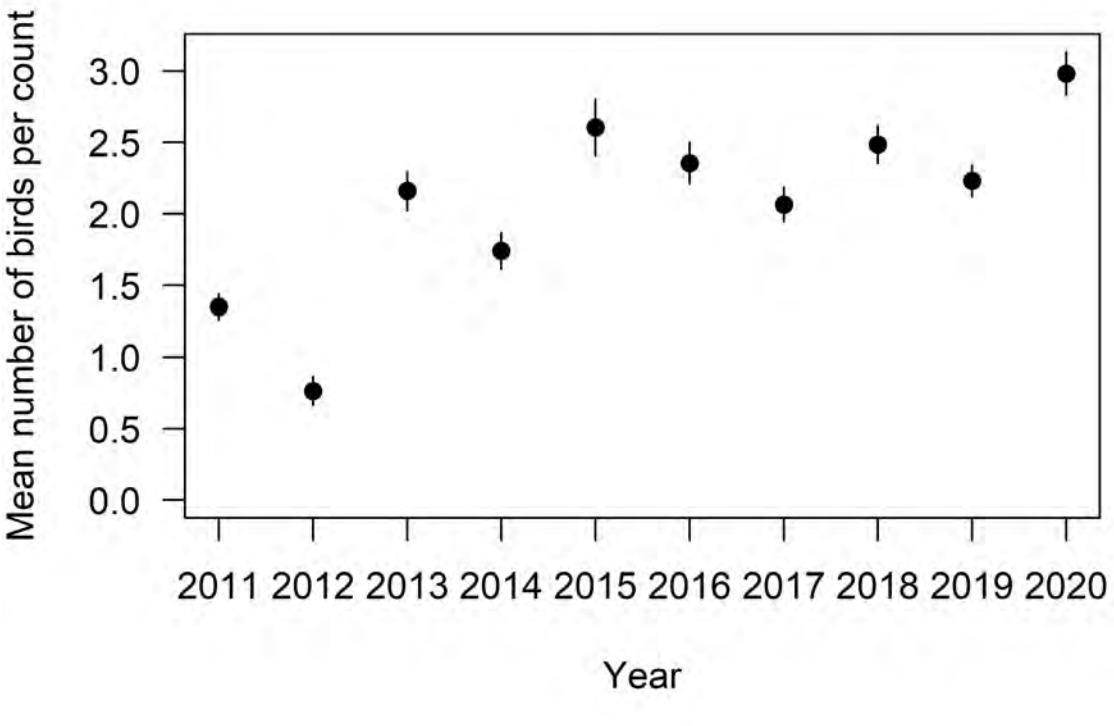

Figure 3.2.1: Mean (±SE) number of tūī recorded per five-minute bird count station in Wellington City between 2011 and 2020.

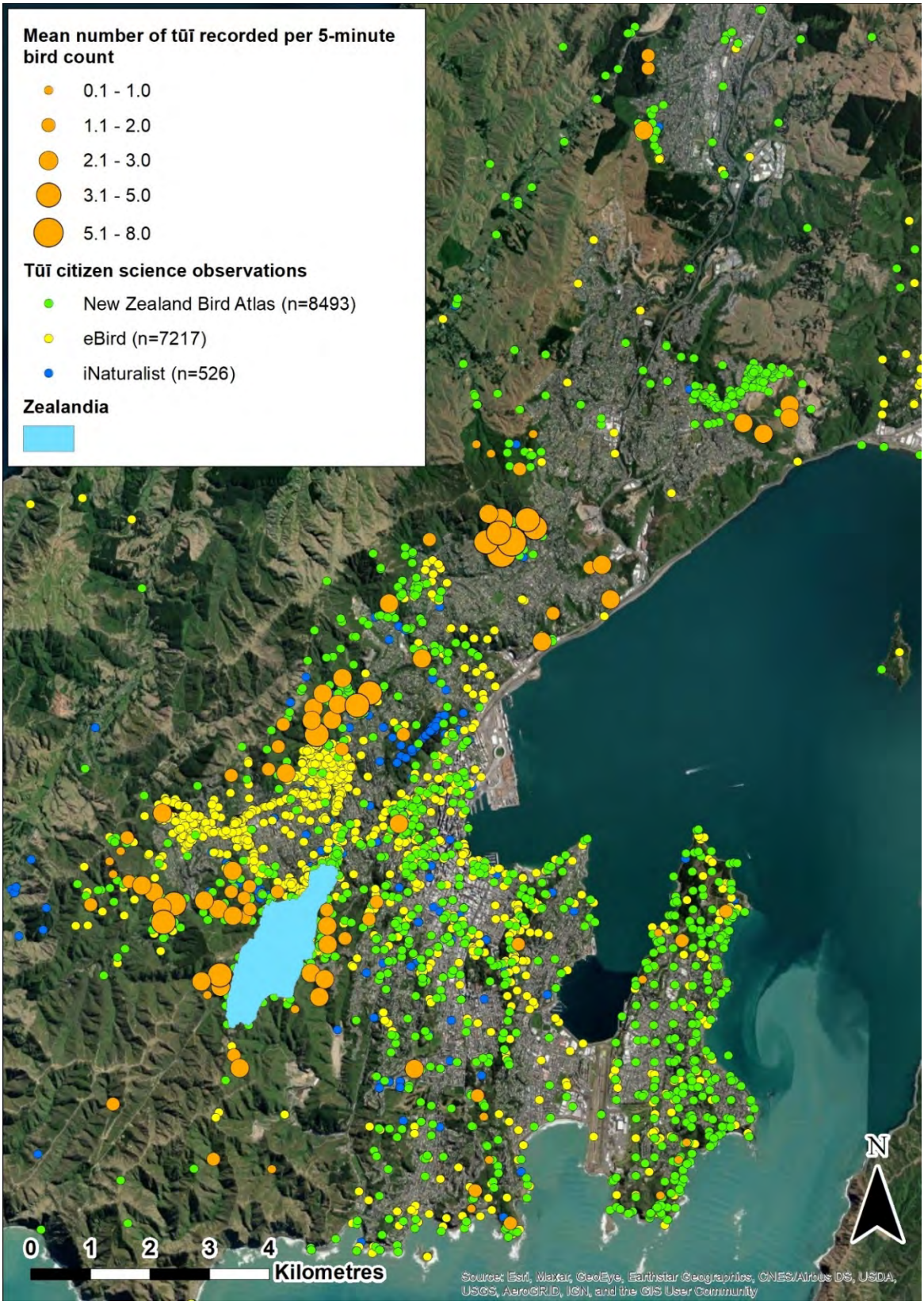

Figure 3.2.2: Distribution of tūī in Wellington City between 2011 and 2021. Orange circles represent tūī detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of tūī detected per station between 2011 and 2020. Yellow, green and blue circles represent tūī observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.2 Tauhou / Silvereye (*Zosterops lateralis*)

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

Image courtesy of Ormond Torr/NZ Birds Online

The tauhou / silvereye is the second most frequently encountered native forest bird species in these five-minute bird counts. Despite some minor year-to-year fluctuations, tauhou / silvereye encounter rates have not changed significantly between 2011 and 2020. Tauhou / silvereye encounter rates have varied between a low of 1.86 tauhou / silvereyes per count in 2011 and a high of 2.40 per count in 2016 (Figure 3.2.3). Tauhou / silvereye is the second most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 5,027 encounters with tauhou / silvereyes, demonstrating that this species is common and widespread in native forest, suburban and urban habitats throughout the city (Figure 3.2.4).

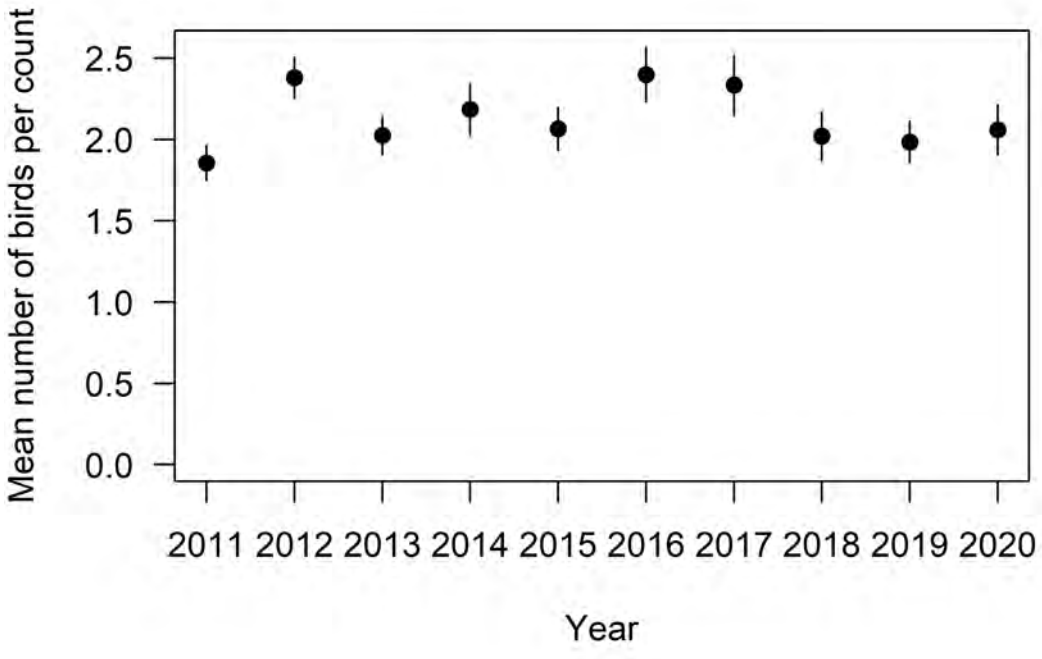

Figure 3.2.3: Mean (±SE) number of tauhou / silvereyes recorded per five-minute bird count station in Wellington City between 2011 and 2020.

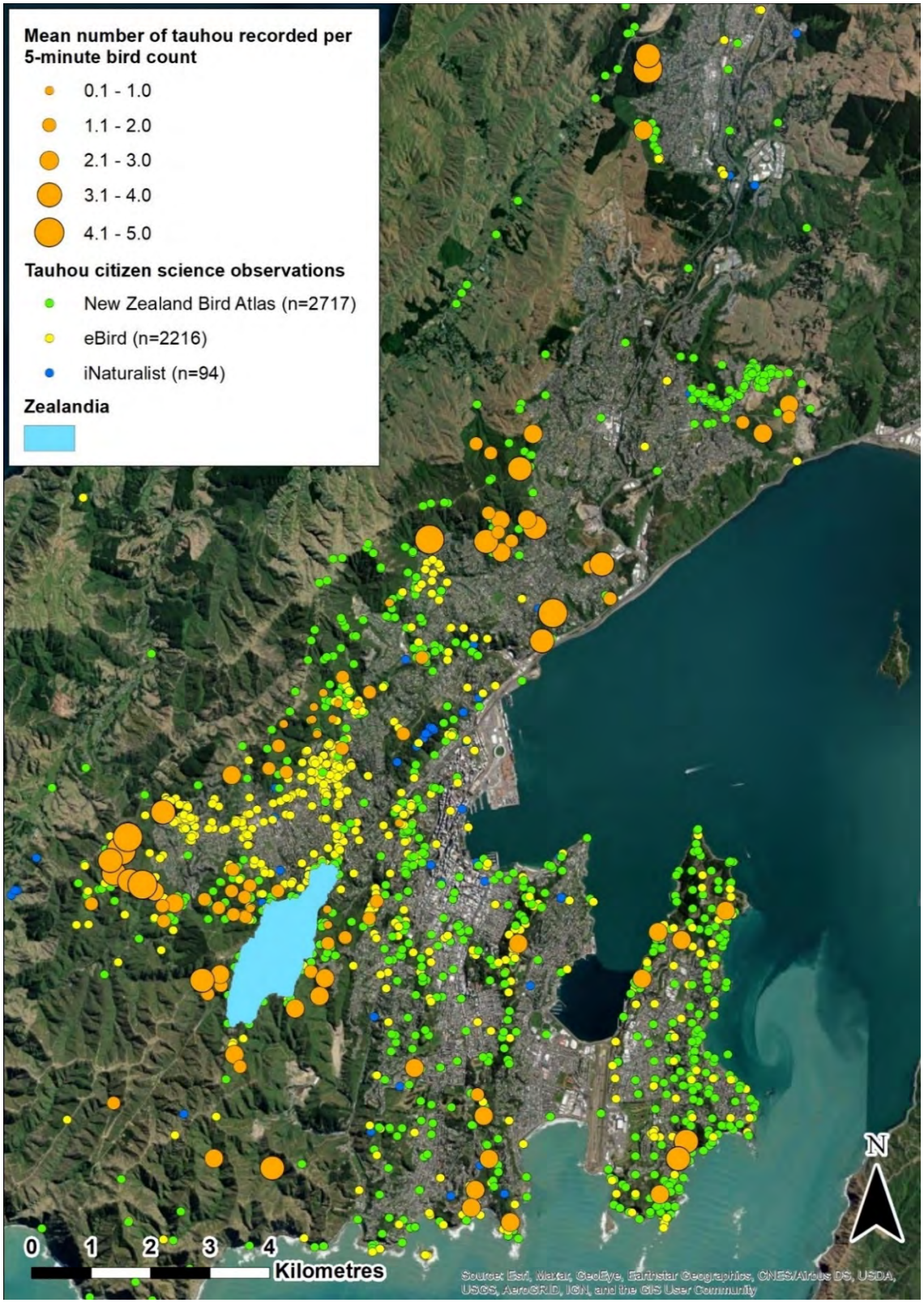

Figure 3.2.4: Distribution of tauhou / silvereyes in Wellington City between 2011 and 2021. Orange circles represent tauhou / silvereye detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of tauhou / silvereyes detected per station between 2011 and 2020. Yellow, green and blue circles represent tauhou / silvereye observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.3 Riroriro / Grey warbler (*Gerygone igata*)

Image courtesy of Bartek Wypych/NZ Birds Online

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

The riroriro / grey warbler is the third most frequently encountered native forest bird species in these five-minute bird counts. Despite some minor year-to-year fluctuations, riroriro / grey warbler encounter rates have not changed significantly between 2011 and 2020. Riroriro / grey warbler encounter rates have varied between a low of 0.84 riroriro / grey warblers per count in 2011 and a high of 1.45 per count in 2015 (Figure 3.2.5). Riroriro / grey warbler is the fifth most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 4,240 encounters with riroriro / grey warblers, demonstrating that this species is common and widespread in native forest and suburban habitats, but is largely absent from urban habitats throughout the city (Figure 3.2.6).

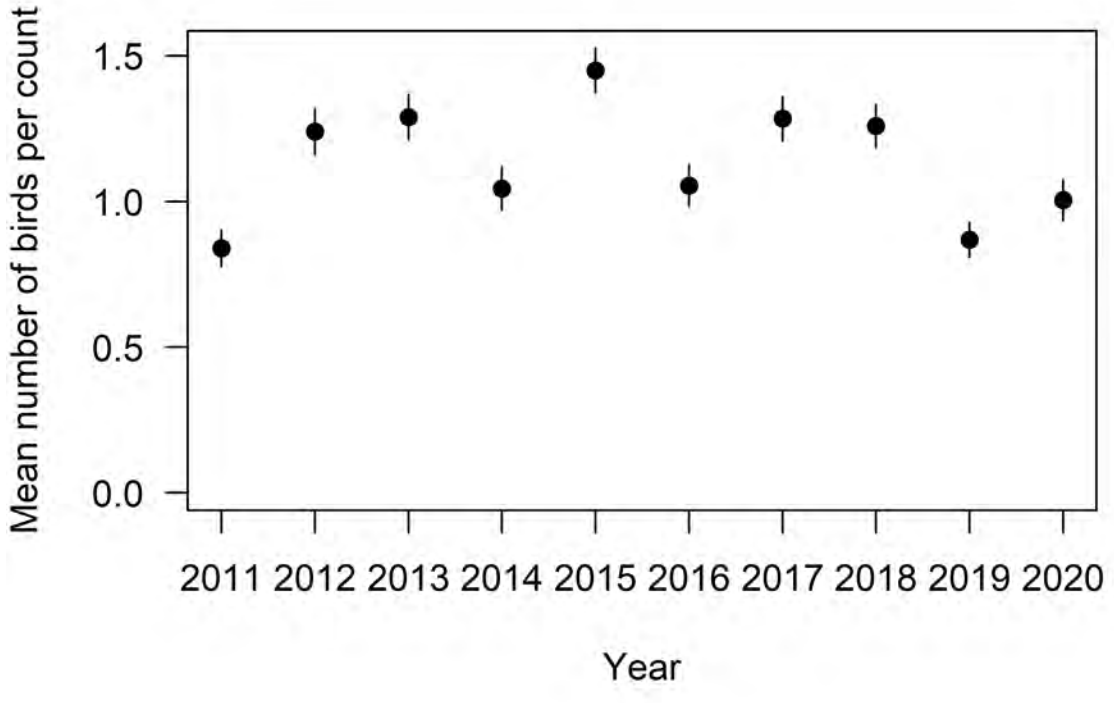

Figure 3.2.5: Mean (±SE) number of riroriro / grey warblers recorded per five-minute bird count station in Wellington City between 2011 and 2020.

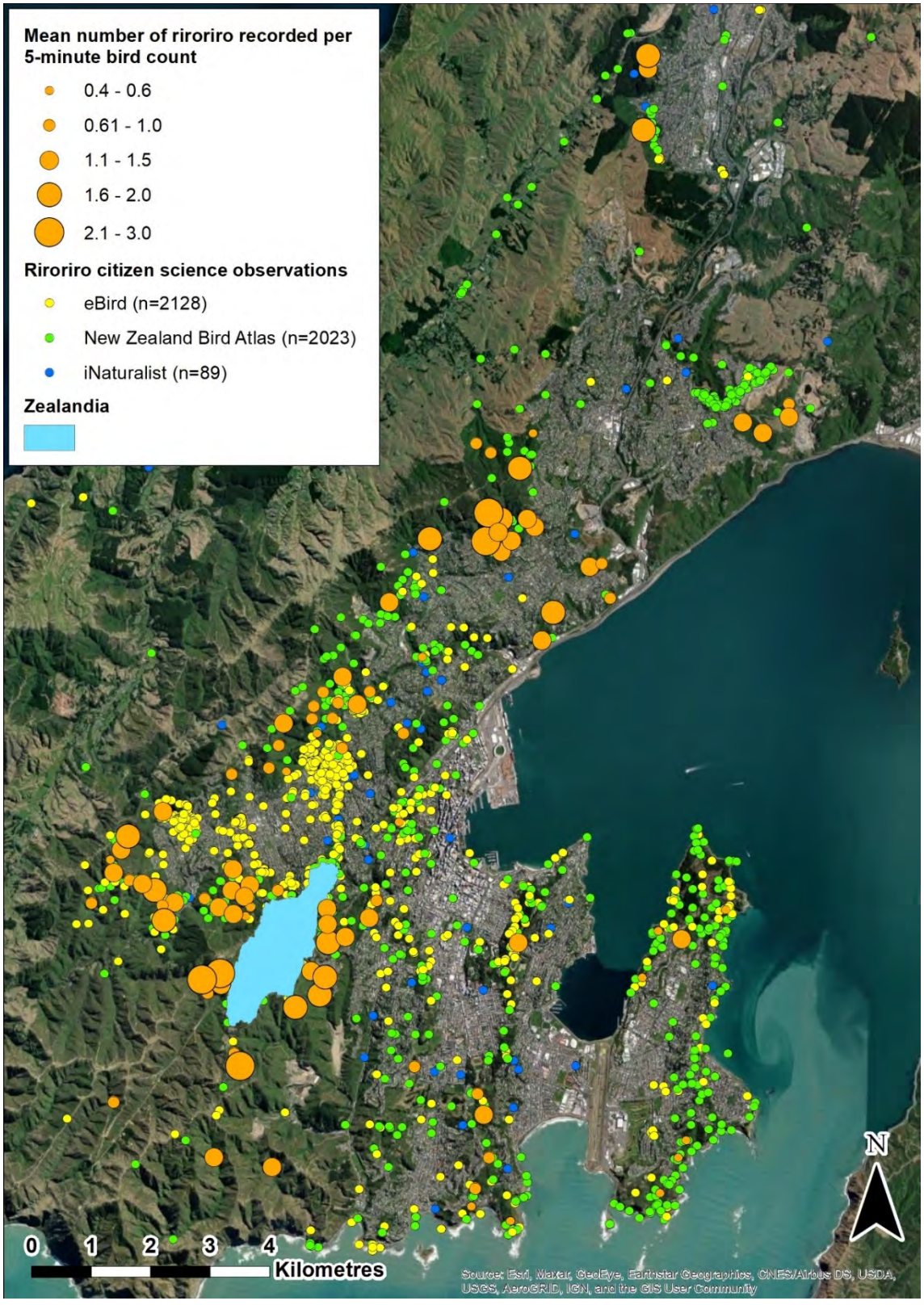

Figure 3.2.6: Distribution of riroriro / grey warblers in Wellington City between 2011 and 2021. Orange circles represent riroriro / grey warbler detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of riroriro / grey warblers detected per station between 2011 and 2020. Yellow, green and blue circles represent riroriro / grey warbler observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.4 Pīwakawaka / NZ fantail (*Rhipidura fuliginosa*)

Image courtesy of Cheryl Marriner/NZ Birds Online

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

The pīwakawaka / NZ fantail is the fourth most frequently encountered native forest bird species in these five-minute bird counts. Pīwakawaka / NZ fantail encounter rates have increased by 20% since 2011, from a mean of 0.35 pīwakawaka / NZ fantails recorded per five-minute bird count in 2011 to a mean of 0.42 pīwakawaka / NZ fantails per count in 2020 (the coefficient of year on log abundance was 0.058; 95% CI 0.030–0.086; Figure 3.2.7). Moreover, pīwakawaka / NZ fantails have increased by 100% over the past five years, from a low of 0.21 bird per count in 2015, to 0.42 birds per count in 2020 (Figure 3.2.7). Pīwakawaka / NZ fantail is the sixth most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 3,942 encounters with pīwakawaka / NZ fantails, demonstrating that this species is common and widespread in native forest, suburban and urban habitats throughout the city (Figure 3.2.8).

During New Zealand's March-April 2020 Covid-19 national lockdown, reports in the media suggested that native forest birds such as pīwakawaka / NZ fantails were occurring more frequently in urban habitats in Wellington's CBD as a result of reduced levels of human disturbance during lockdown[2]. Citizen science records collected in Wellington City over the past ten years however show that pīwakawaka / fantails had been regularly recorded in Wellington's CBD for a number of years, so it's more likely that these birds had become more conspicuous to the general public during the lockdown, rather than more numerous.

[2] https://www.stuff.co.nz/environment/120828367/native-birds-explore-empty-wellington-during-coronavirus-lockdown; accessed 04/04/2021.

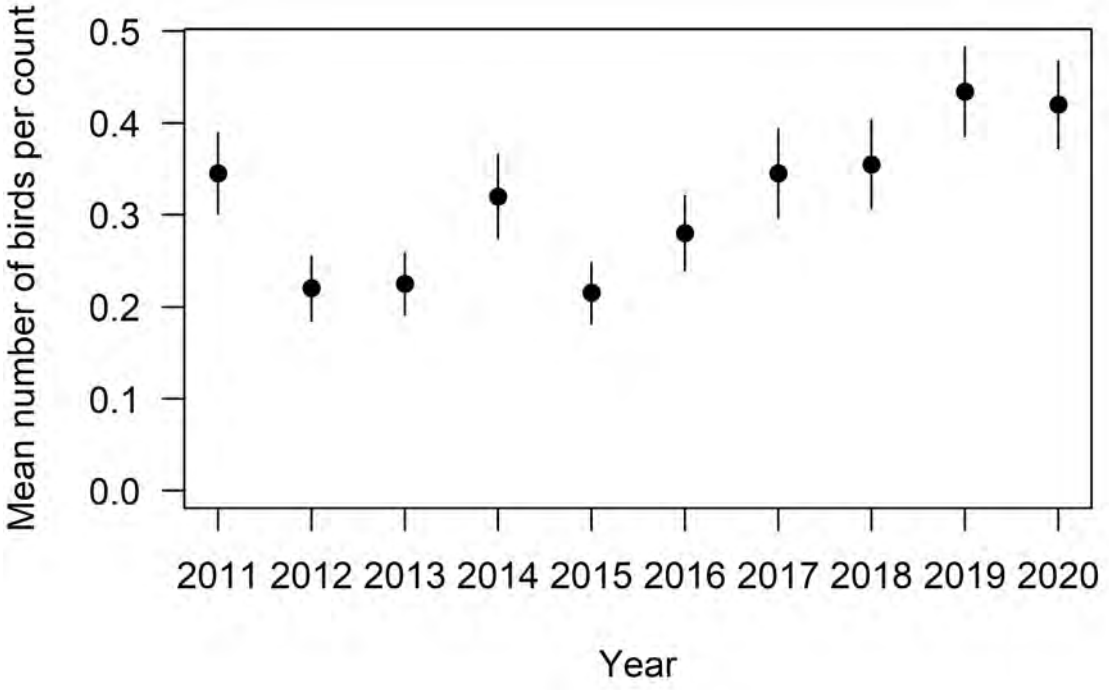

Figure 3.2.7: Mean (±SE) number of pīwakawaka / fantails recorded per five-minute bird count station in Wellington City between 2011 and 2020.

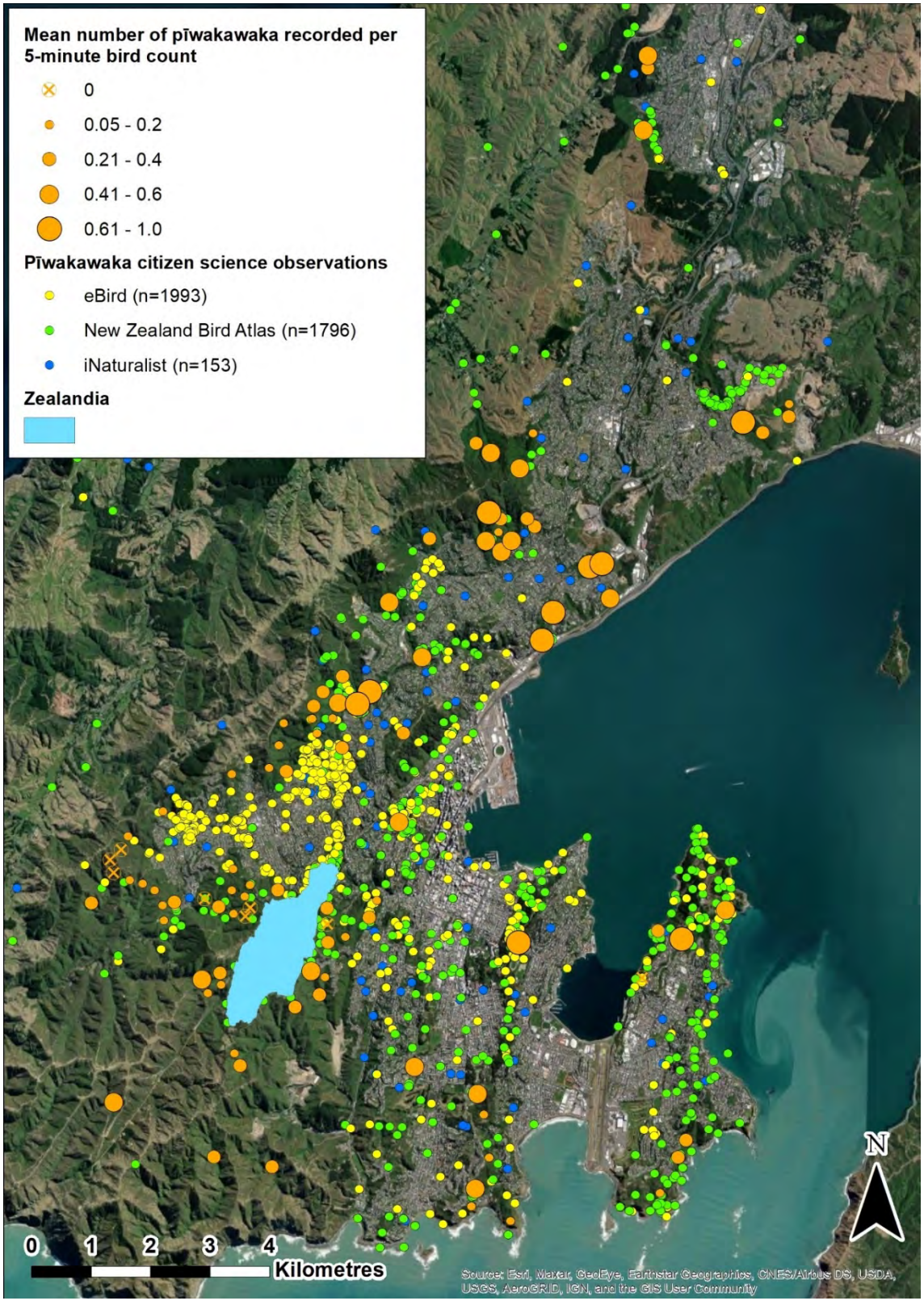

Figure 3.2.8: Distribution of pīwakawaka / fantails in Wellington City between 2011 and 2021. Orange circles represent pīwakawaka / fantail detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of pīwakawaka / fantails detected per station between 2011 and 2020. Yellow, green and blue circles represent pīwakawaka / fantail observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.5 Kākā (*Nestor meridionalis*)

National conservation status:
At Risk, Recovering (Robertson et al, 2017).

Regional conservation status:
At Risk, Recovering (Crisp, 2020).

Image courtesy of Jean-Claude Stahl/NZ Birds Online

The kākā was reintroduced to Zealandia between 2002 and 2007 (Miskelly, 2018) and is now the fifth most frequently encountered native forest bird species in these five-minute bird counts. Kākā encounter rates have increased by 250% since 2011, from a mean of 0.10 kākā recorded per five-minute bird count in 2011 to a mean of 0.35 kākā per count in 2020 (the coefficient of year on log abundance was 0.156; 95% CI 0.116–0.200; Figure 3.2.9). Kākā is now the third most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 4,680 encounters with kākā, demonstrating that this species is now common and widespread in native forest and suburban habitats in the central and southern suburbs of Wadestown, Ngaio, Karori, Te Aro, Brooklyn, Newtown and Island Bay. Kākā are also continuing to spread gradually northwards into Khandallah, and eastwards onto Miramar Peninsula (Figure 3.2.10).

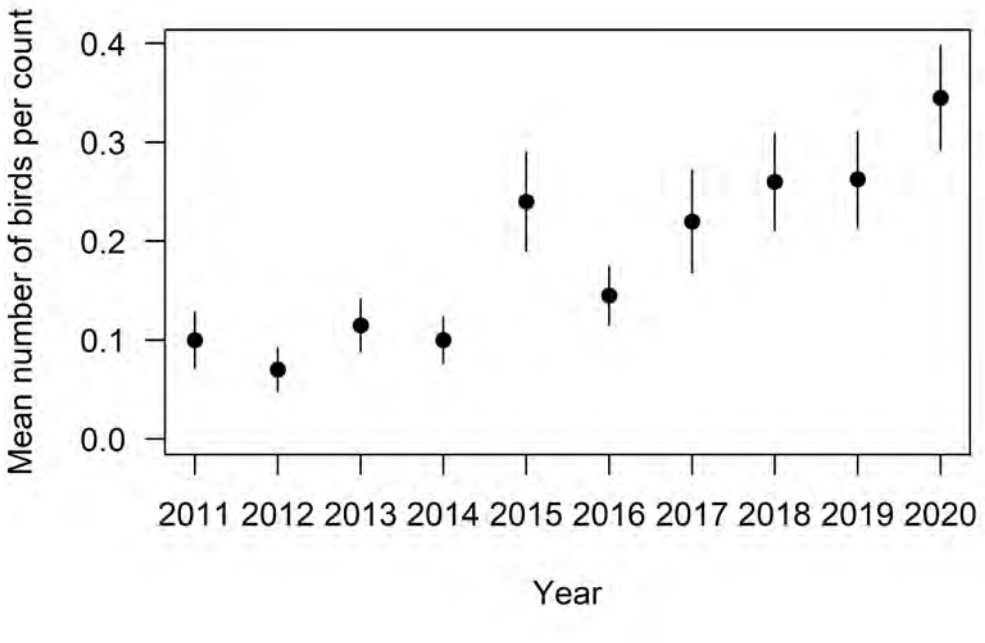

Figure 3.2.9: Mean (±SE) number of kākā recorded per five-minute bird count station in Wellington City between 2011 and 2020.

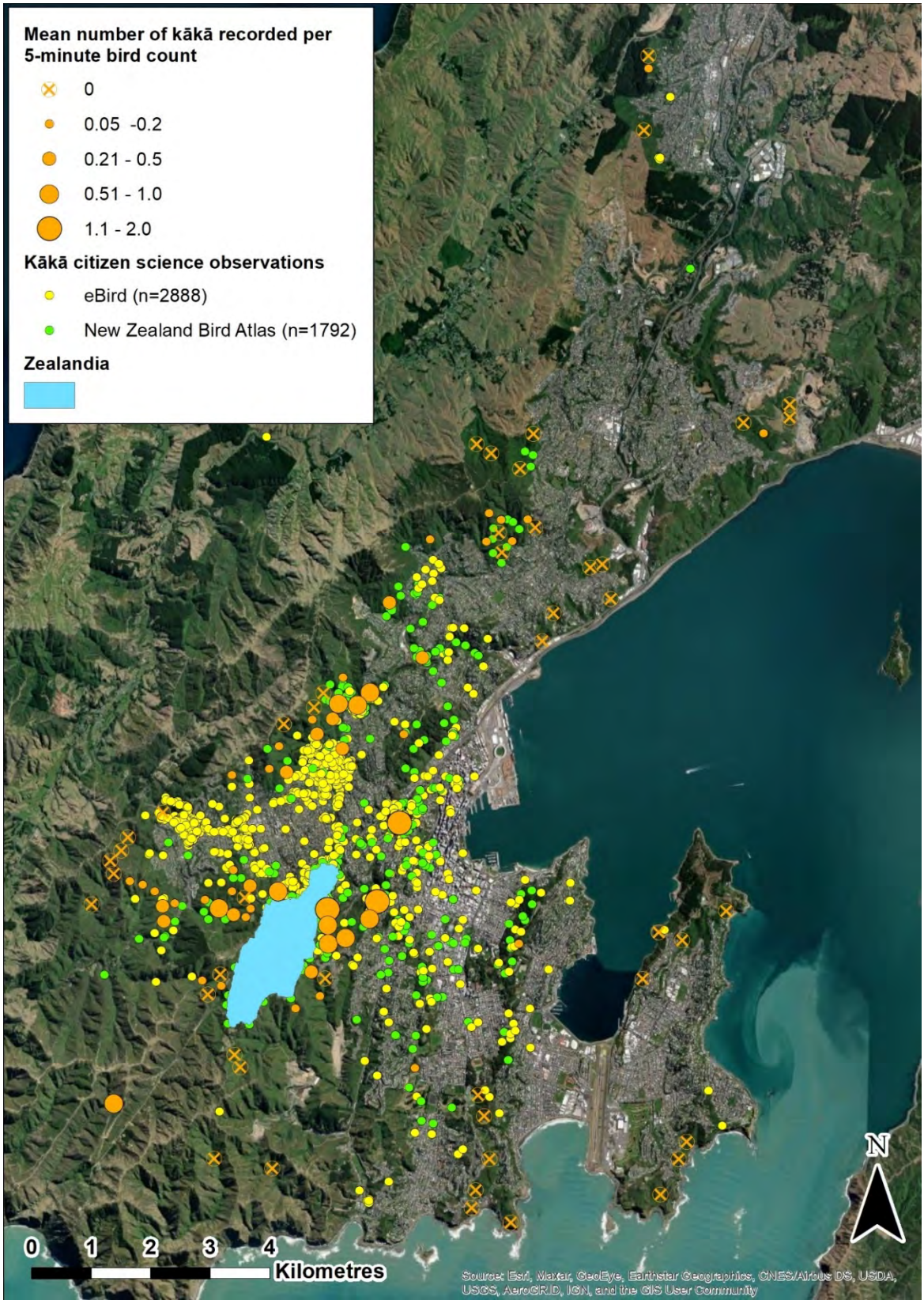

Figure 3.2.10: Distribution of kākā in Wellington City between 2011 and 2021. Orange circles represent kākā detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of kākā detected per station between 2011 and 2020. Yellow and green circles represent kākā observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

3.2.6 Kererū (*Hemiphaga novaeseelandiae*)

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: At Risk, Recovering (Crisp, 2020).

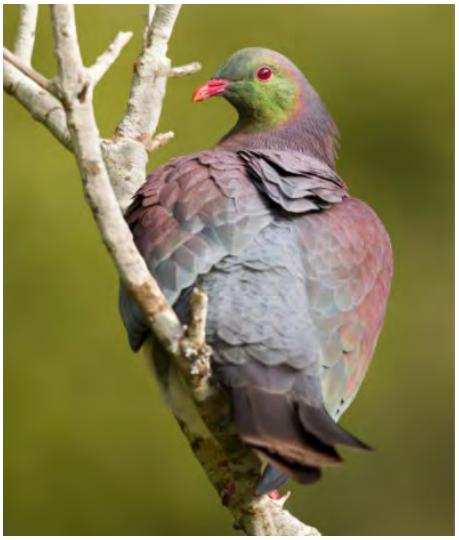

Image courtesy of Arindam Bhattacharya NZ Birds Online

The kererū is the sixth most frequently encountered native forest bird species in these five-minute bird counts. Kererū encounter rates have increased by 186% since 2011, from a mean of 0.07 kererū recorded per five-minute bird count in 2011 to a mean of 0.20 kererū per count in 2020 (the coefficient of year on log abundance was 0.146; 95% CI 0.088–0.196; Figure 3.2.11). Significant 'hotspots' in kererū encounter rates occur in Ōtari-Wilton's Bush and in Khandallah Park, two Wellington City reserves that contain areas of old-growth native forest (Figure 3.2.12). Kererū is the fourth most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 4,275 encounters with kererū, demonstrating that kererū are widespread in areas of native forest habitat in the city, and in adjacent suburban habitats (Figure 3.2.12).

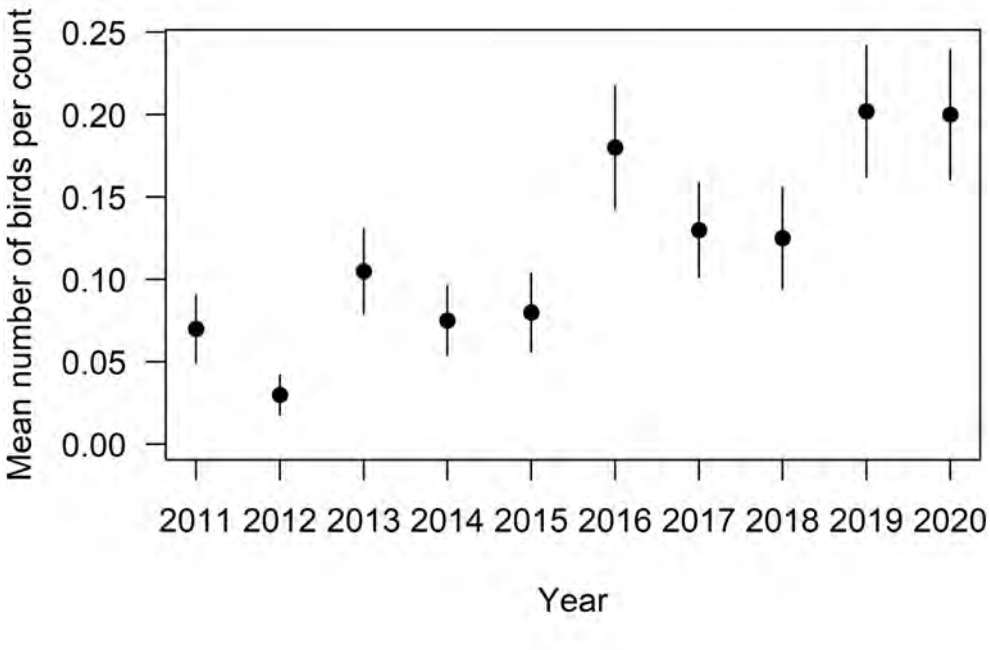

Figure 3.2.11: Mean (±SE) number of kererū recorded per five-minute bird count station in Wellington City between 2011 and 2020.

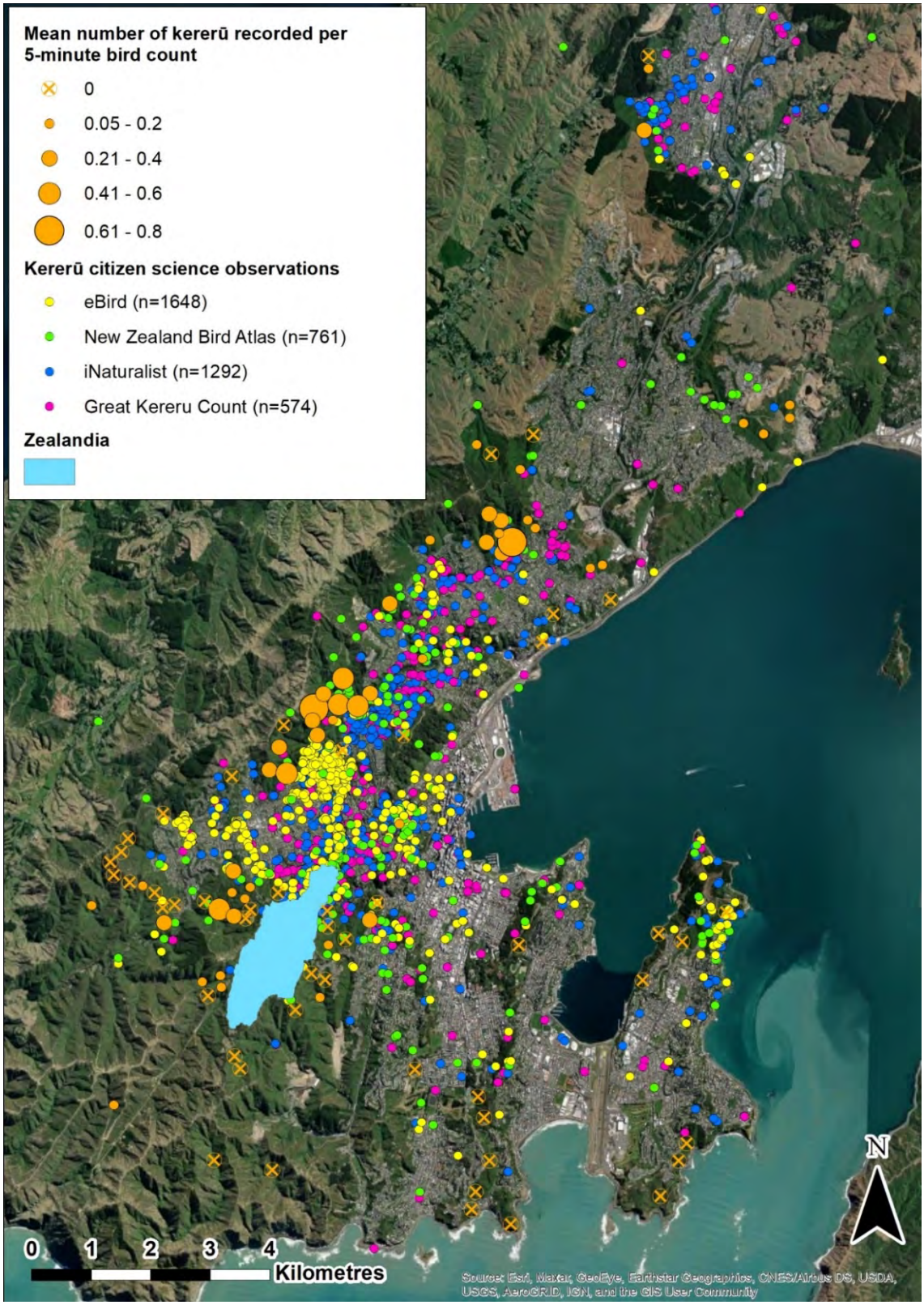

Figure 3.2.12: Distribution of kererū in Wellington City between 2011 and 2021. Orange circles represent kererū detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of kererū detected per station between 2011 and 2020. Yellow, green, blue and purple circles represent kererū observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas, iNaturalist or the Great Kererū Count between 2011 and 2021.

3.2.7 Pīpīwharauroa / Shining cuckoo (*Chrysococcyx lucidus*)

Image courtesy of Rob Lynch/NZ Birds Online

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

The pīpīwharauroa / shining cuckoo is the seventh most frequently encountered native forest bird species in these five-minute bird counts. Pīpīwharauroa / shining cuckoo encounter rates have declined by 53% since 2011, from a mean of 0.17 pīpīwharauroa / shining cuckoos recorded per five-minute bird count in 2011 to a mean of 0.08 pīpīwharauroa / shining cuckoos per count in 2020 (the coefficient of year on log abundance was -0.070; 95% CI -0.114 - -0.027; Figure 3.2.13). The majority of this decline occurred between 2018 and 2019, with encounter rates during the 2019 and 2020 counts significantly lower than encounter rates recorded between 2011 and 2018. Up until 2018, these bird counts were typically carried out between early November and early December each year, whereas the 2019 and 2020 counts extended into late December and early January. Pīpīwharauroa / shining cuckoo call rates are known to decline steadily from December onwards (Heather & Robertson, 2015), so the decline in pīpīwharauroa / shining cuckoo encounter rates observed during these five-minute bird counts almost certainly reflects differences in the conspicuousness of pīpīwharauroa / shining cuckoos between the 2011-2018 and 2019-2020 counts, rather than a decline in numbers over this time.

Pīpīwharauroa / shining cuckoos are sparsely distributed throughout Wellington City, though 'hotspots' in encounter rates appear to occur in forested reserves adjacent to Zealandia, and in Khandallah Park (Figure 3.2.14). Pīpīwharauroa / shining cuckoo is the sixteenth most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 386 encounters with pīpīwharauroa / shining cuckoos, demonstrating that these birds are sparsely distributed in native forest and surburban habitats throughout the city (Figure 3.2.14).

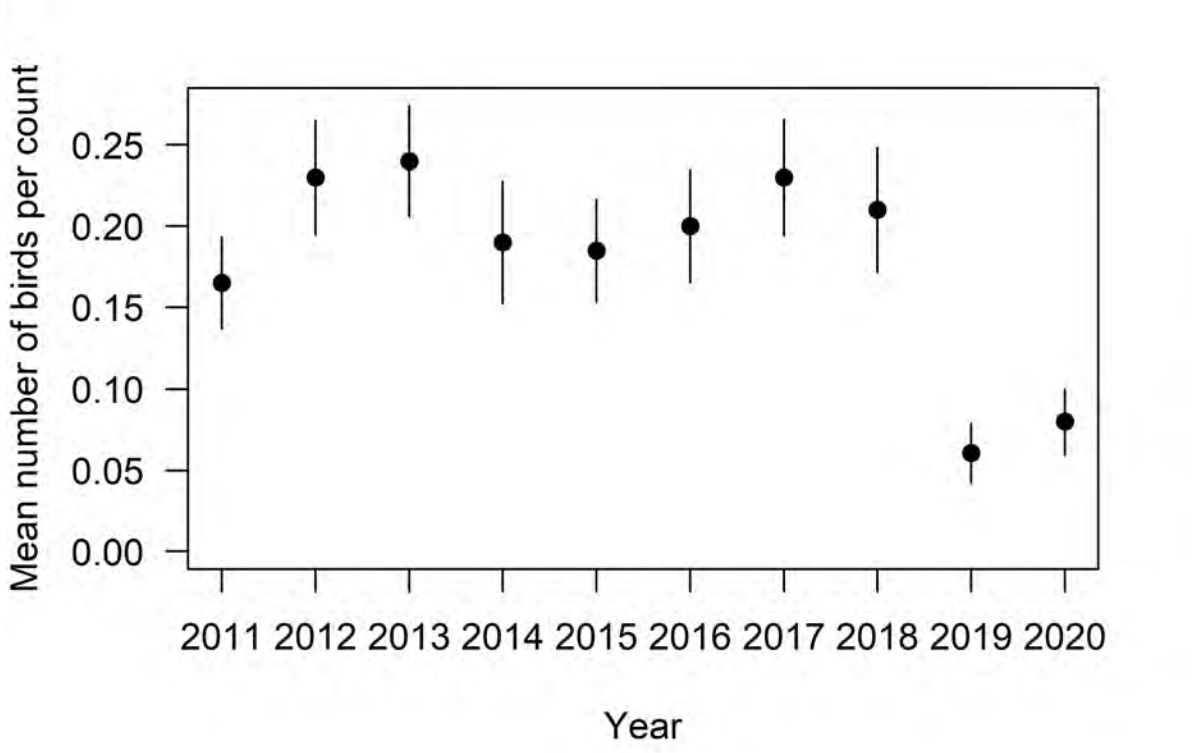

Figure 3.2.13: Mean (±SE) number of pīpīwharauroa / shining cuckoos recorded per five-minute bird count station in Wellington City between 2011 and 2020.

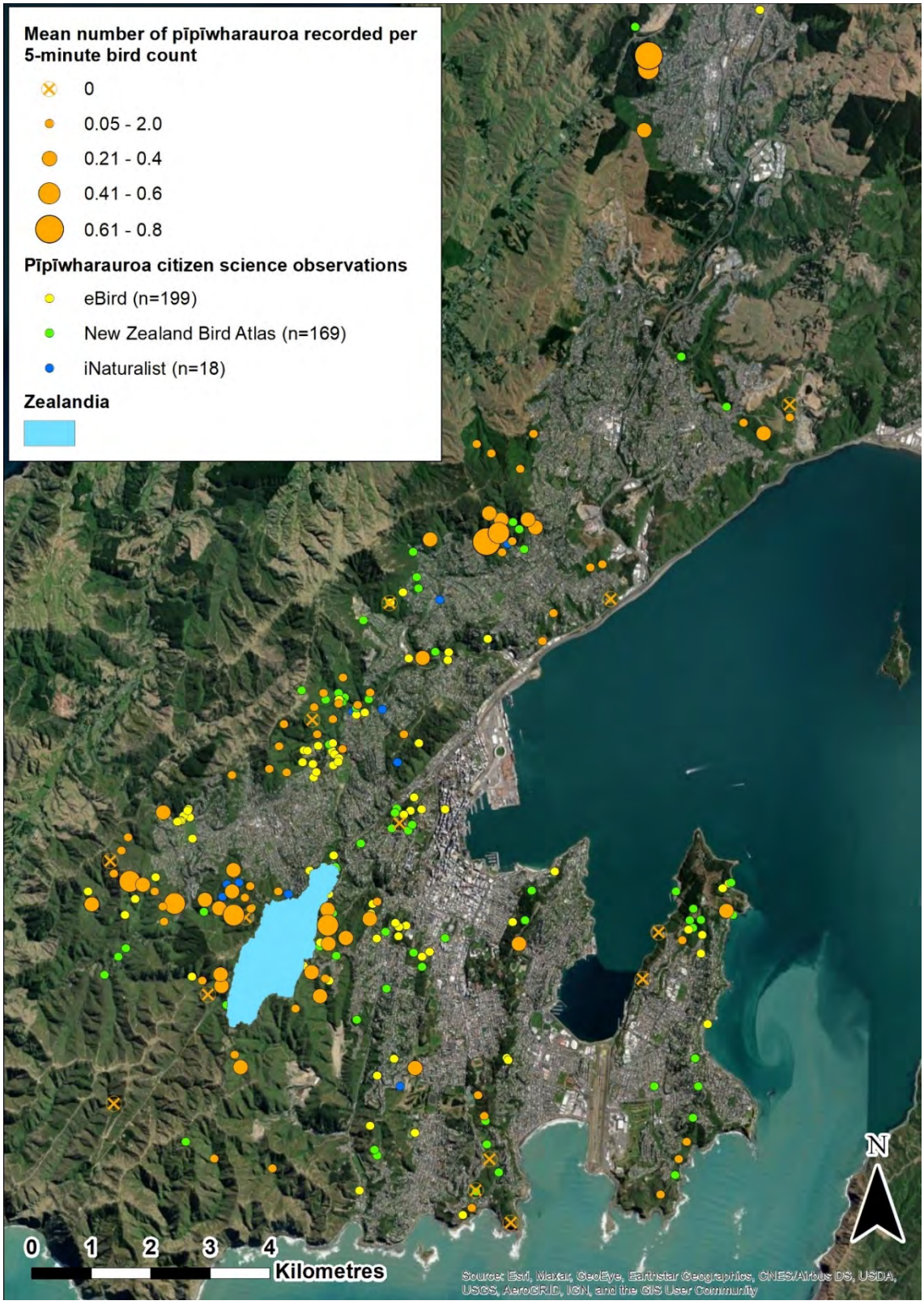

Figure 3.2.14: Distribution of pīpīwharauroa / shining cuckoos in Wellington City between 2011 and 2021. Orange circles represent pīpīwharauroa / shining cuckoo detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of pīpīwharauroa / shining cuckoos detected per station between 2011 and 2020. Yellow, green and blue circles represent pīpīwharauroa / shining cuckoo observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.8 Tīeke / North Island Saddleback (*Philesturnus rufusater*)

National conservation status:
At Risk, Recovering (Robertson et al, 2017).

Regional conservation status:
Regionally Vulnerable (Crisp, 2020).

Image courtesy of Rob Lynch/NZ Birds Online

The tīeke / NI saddleback was reintroduced to Zealandia between 2002 and 2003 (Miskelly, 2018) and is now the eighth most frequently encountered native forest bird species in these five-minute bird counts. Tīeke / NI saddleback encounter rates have increased by 29% since 2011, from a mean of 0.07 tīeke / NI saddleback recorded per five-minute bird count in 2011 to a mean of 0.09 tīeke / NI saddleback per count in 2020 (the coefficient of year on log abundance was 0.083; 95% CI 0.008 - 0.143; Figure 3.2.15). Tīeke / NI saddleback are largely restricted to Zealandia and to forested reserves less than 1-2 km from Zealandia's pest-proof boundary fence, so this increase in encounter rates may be an indication that the recent intensification of mammalian predator control efforts in Polhill Reserve is benefitting this species. Tīeke / NI saddleback is the seventh most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 1465 encounters with tīeke / NI saddlebacks and the majority of these sightings were reported from native forest habitats within 1 km of Zealandia's boundary fence (Figure 3.2.16). This localised distribution of tīeke / NI saddleback observations strongly suggests that one or more environmental factors are severely limiting the ability of this species to colonise forest habitats beyond Zealandia's predator-proof fence.

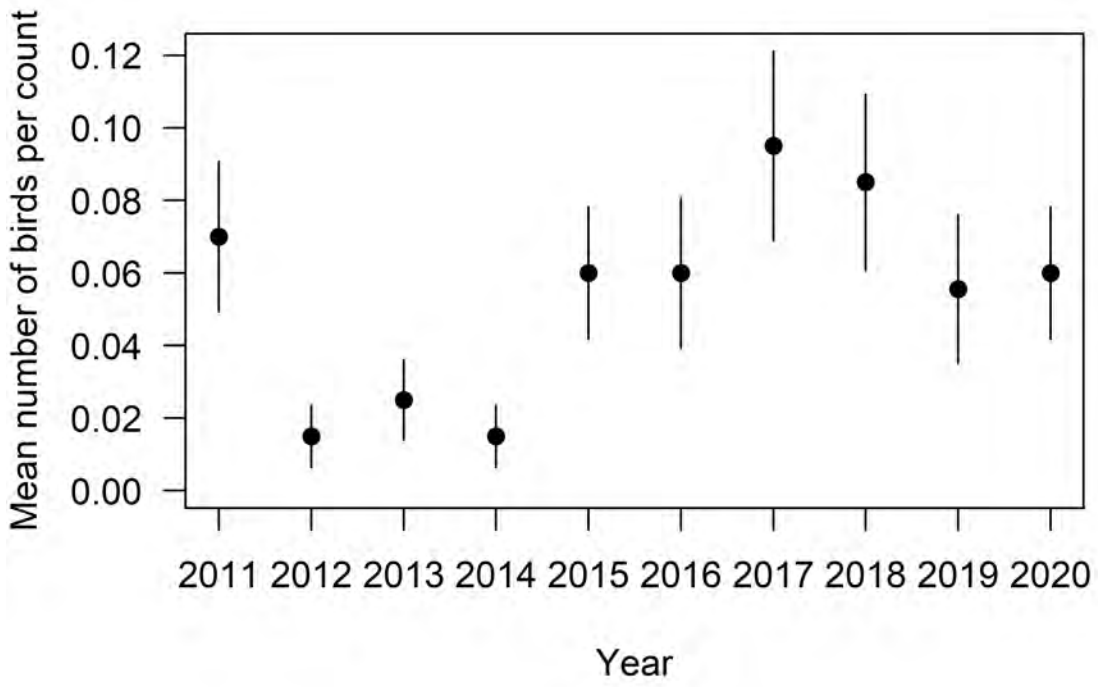

Figure 3.2.15: Mean (±SE) number of tīeke / NI saddlebacks recorded per five-minute bird count station in Wellington City between 2011 and 2020.

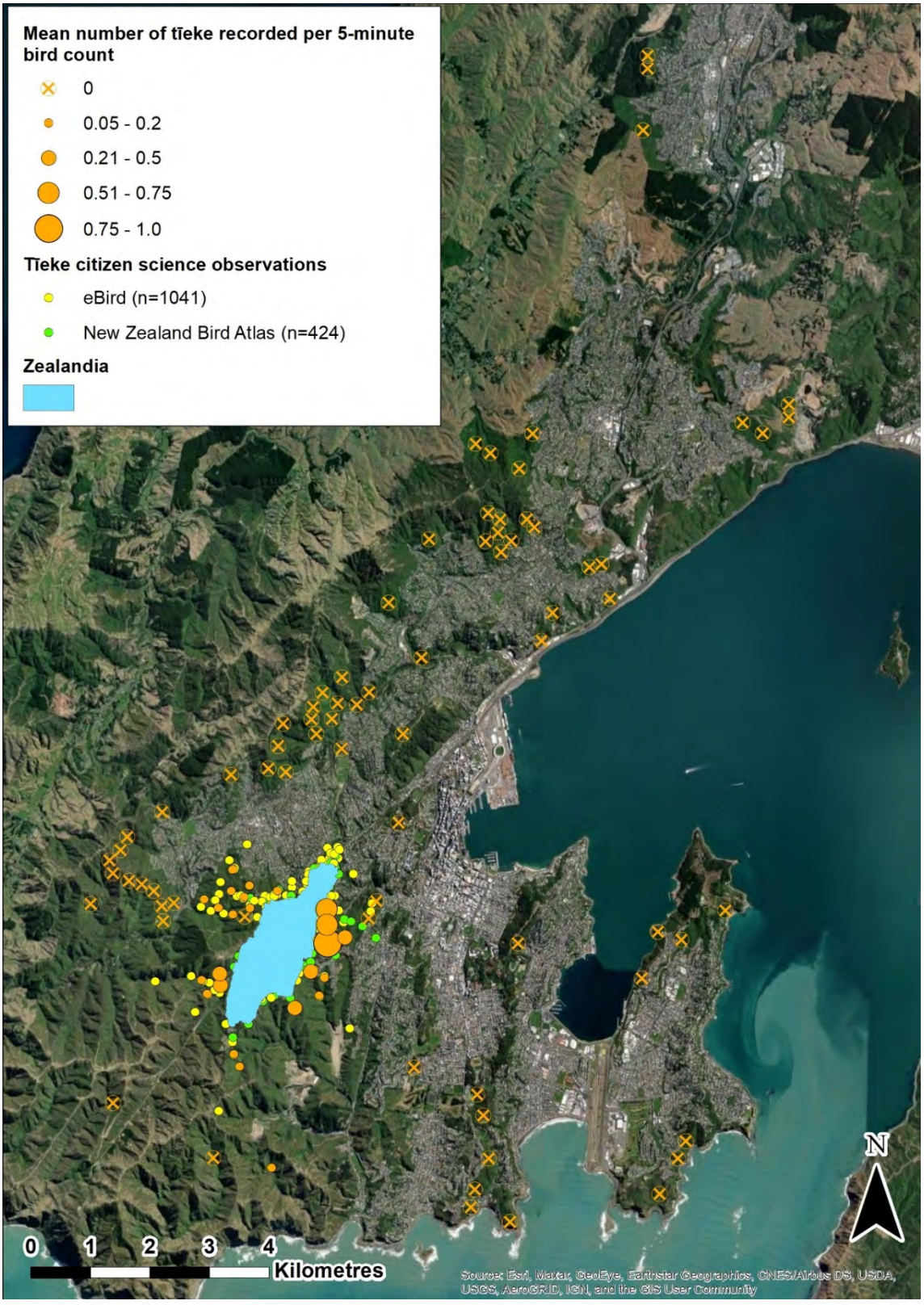

Figure 3.2.16: Distribution of tīeke / NI saddlebacks in Wellington City between 2011 and 2021. Orange circles represent tīeke / NI saddleback detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of tīeke / NI saddlebacks detected per station between 2011 and 2020. Yellow and green circles represent tīeke / NI saddleback observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

3.2.9 Kākāriki / Red-crowned parakeet (*Cyanoramphus novaezelandiae*)

Image courtesy of Laurie Ross/NZ Birds Online

National conservation status: At Risk, Relict (Robertson et al, 2017).

Regional conservation status: At Risk, Recovering (Crisp, 2020).

The kākāriki / red-crowned parakeet was reintroduced to Zealandia between 2010 and 2011, although it is likely that this species has been colonising Wellington City since at least 1999, following the eradication of rats from Kāpiti Island in 1996, and the introduction of kākāriki / red-crowned parakeets to Matiu/Somes Island in 2003 (Miskelly et al, 2005). Kākāriki / red-crowned parakeets are now the ninth most frequently encountered native forest bird species in these five-minute bird counts. Kākāriki / red-crowned parakeet encounter rates have increased by 500% since 2011, from 0.01 kākāriki / red-crowned parakeets recorded per bird count in 2011 to 0.06 kākāriki / red-crowned parakeets per count in 2020 (the coefficient of year on log abundance was 0.178; 95% CI -0.385 – 0.697; Figure 3.2.17). The confidence limits around the coefficient estimate for this estimate are very large and include a lower CI <0 however, so the certainty around this increase is currently low. Beyond Zealandia, kākāriki / red-crowned parakeets now appear to be well established in several forested reserves in the city, including in Wright's Hill Reserve, Polhill Reserve, Ōtari-Wilton's Bush, Khandallah Park, Huntleigh Park and possibly the Wellington Botanic Gardens. Kākāriki / red-crowned parakeets are the thirteenth most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 815 encounters with kākāriki / red-crowned parakeets demonstrating that this species is sparsely distributed in both native forest and suburban habitats in central and western Wellington suburbs and is now an occasional visitor to forest habitats on Miramar Peninsula (Figure 3.2.18).

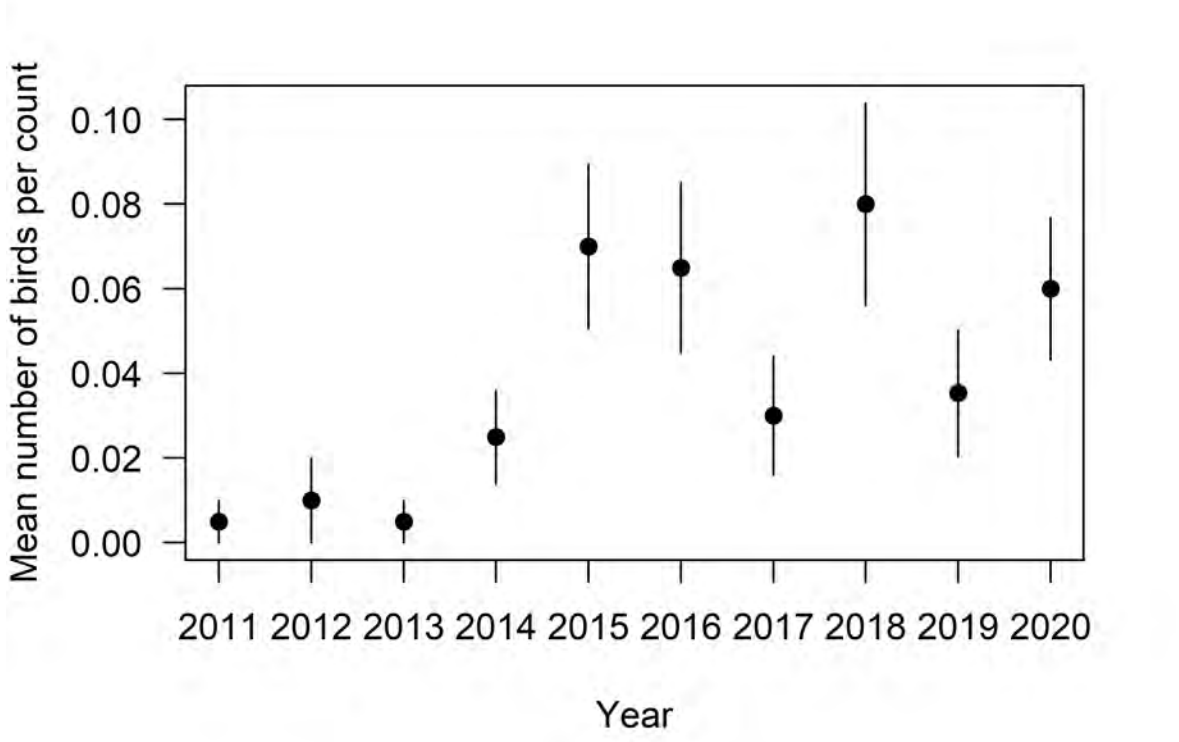

Figure 3.2.17: Mean (±SE) number of kākāriki / red-crowned parakeets recorded per five-minute bird count station in Wellington City between 2011 and 2020.

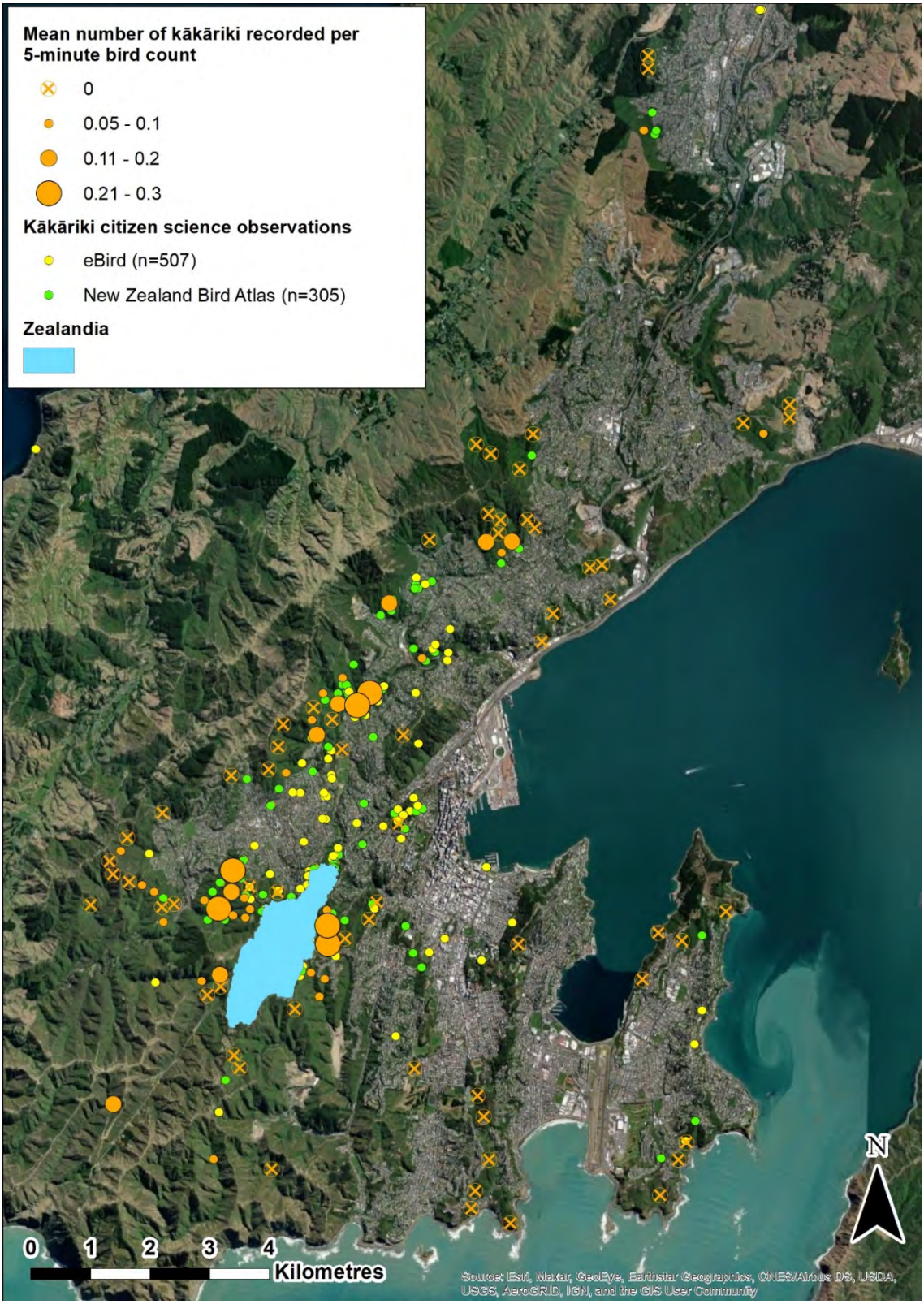

Figure 3.2.18: Distribution of kākāriki / red-crowned parakeets in Wellington City between 2011 and 2021. Orange circles represent kākāriki / red-crowned parakeet detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of kākāriki / red-crowned parakeets detected per station between 2011 and 2020. Yellow and green circles represent kākāriki / red-crowned parakeet observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

3.2.10 Pōpokotea / Whitehead (*Mohoua albicilla*)

Image courtesy of Tony Whitehead/NZ Birds Online

National conservation status: At Risk, Declining (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

The pōpokotea / whitehead was reintroduced to Zealandia between 2001 and 2002 (Miskelly, 2018) and is now the tenth most frequently encountered native forest bird species in these five-minute bird counts. Despite some minor year-to-year fluctuations, pōpokotea / whitehead encounter rates have not changed significantly between 2011 and 2020. Pōpokotea / whitehead encounter rates have varied between a high of 0.09 pōpokotea / whiteheads per count in 2012 and a low of 0.04 per count in 2013 (Figure 3.2.19). Pōpokotea / whitehead is the ninth most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 1057 encounters with pōpokotea / whiteheads. These records show that whiteheads are largely restricted to Zealandia and to forest reserves within 1-2 km of Zealandia's boundary fence, however they have been recorded further afield on occasions, including in Trelissick Park, Ōtari-Wilton's Bush, Tinakori Hill, Wellington Botanical Gardens, Mākara Peak and Prince of Wales Park (Figure 3.2.20). This localised distribution of pōpokotea / whitehead observations strongly suggests that one or more environmental factors are severely limiting the ability of this species to colonise forest habitats beyond Zealandia's predator-proof fence.

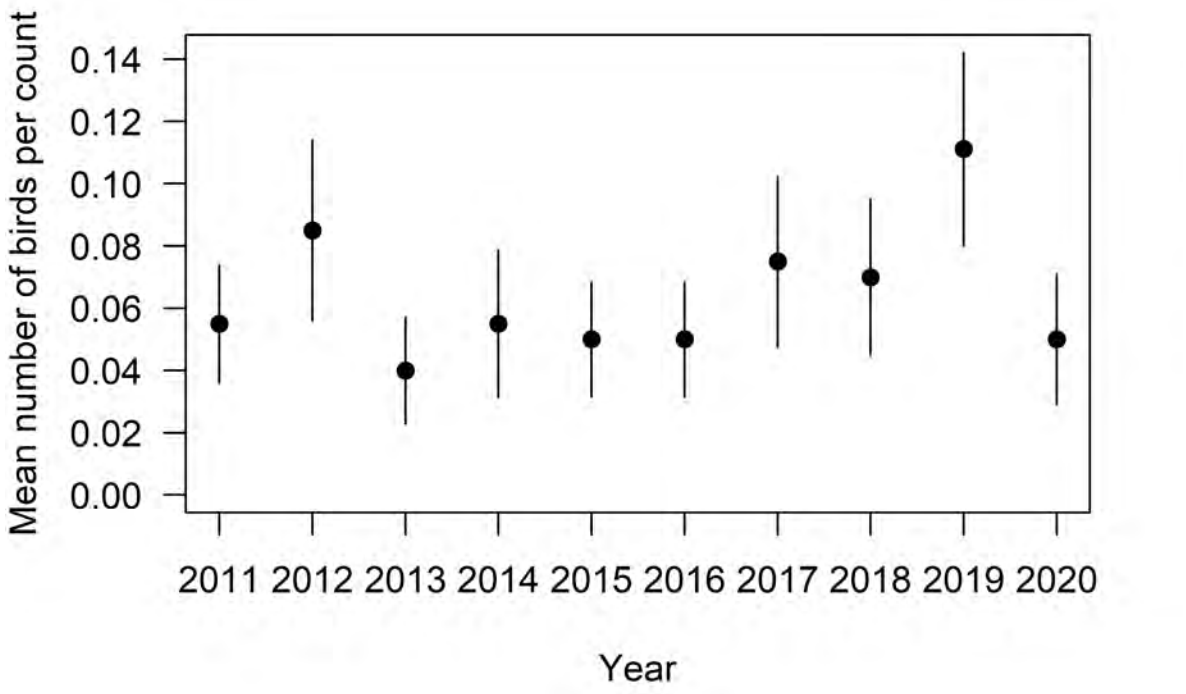

Figure 3.2.19: Mean (±SE) number of pōpokotea / whiteheads recorded per five-minute bird count station in Wellington City between 2011 and 2020.

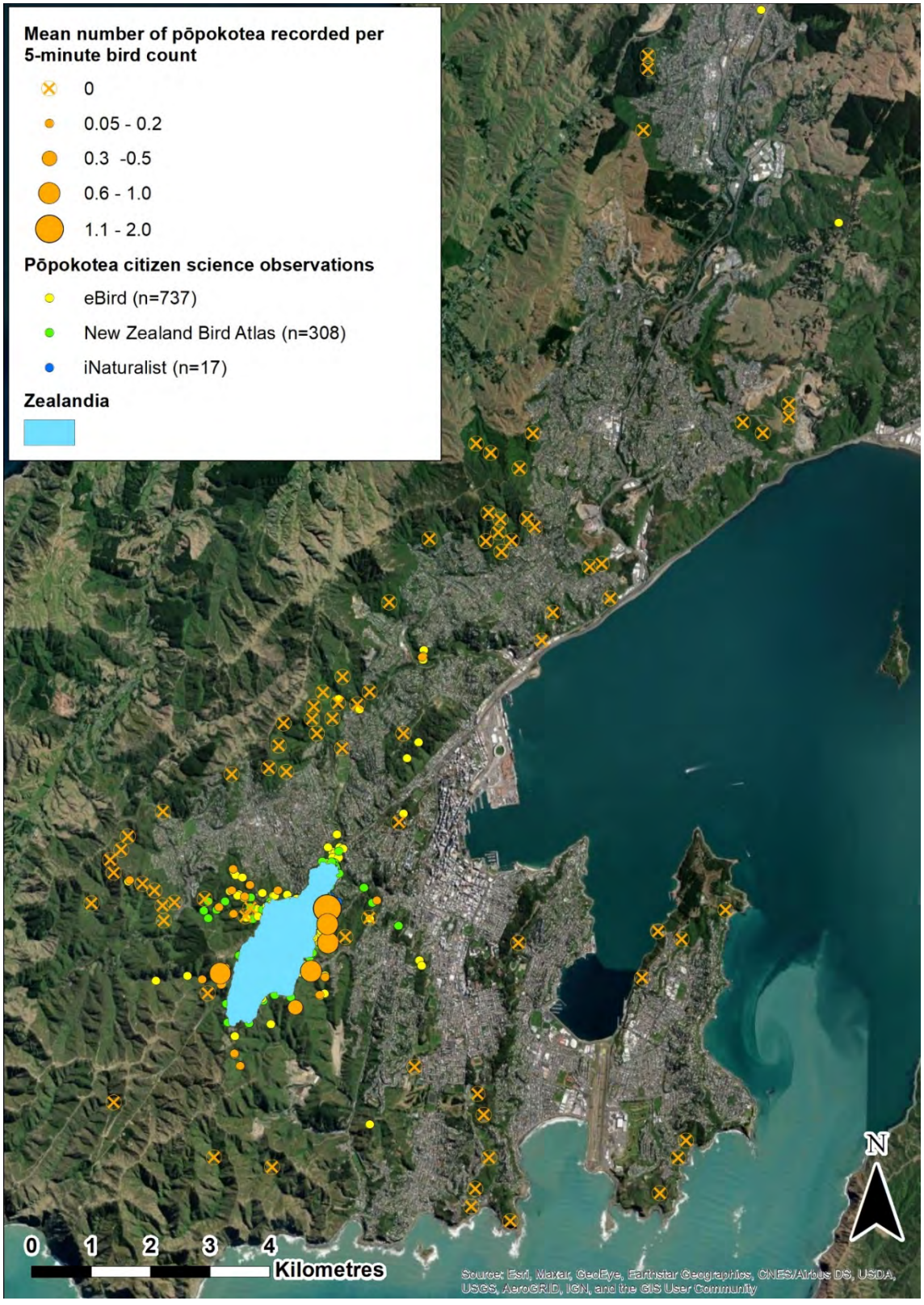

Figure 3.2.20: Distribution of pōpokotea / whiteheads in Wellington City between 2011 and 2021. Orange circles represent pōpokotea / whitehead detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of pōpokotea / whiteheads detected per station between 2011 and 2020. Yellow, green and blue circles represent pōpokotea / whitehead observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.11 Kōtare / NZ kingfisher (*Todiramphus sanctus*)

Image courtesy of Bartek Wypych/NZ Birds Online

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

The kōtare / NZ kingfisher is the eleventh most frequently encountered native forest bird species in these five-minute bird counts. Despite minor year-to-year fluctuations, kōtare / NZ kingfisher encounter rates have not changed significantly between 2011 and 2020. Kōtare / NZ kingfisher encounter rates have varied between a low of 0.02 kōtare / NZ kingfishers per count in 2016 and a high 0.06 per count in 2018 and 2019 (Figure 3.2.21). Kōtare / NZ kingfisher is the eleventh most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 858 encounters with kōtare / NZ kingfishers, demonstrating that kingfishers are sparsely distributed in native forest, suburban and coastal habitats throughout the city (Figure 3.2.22).

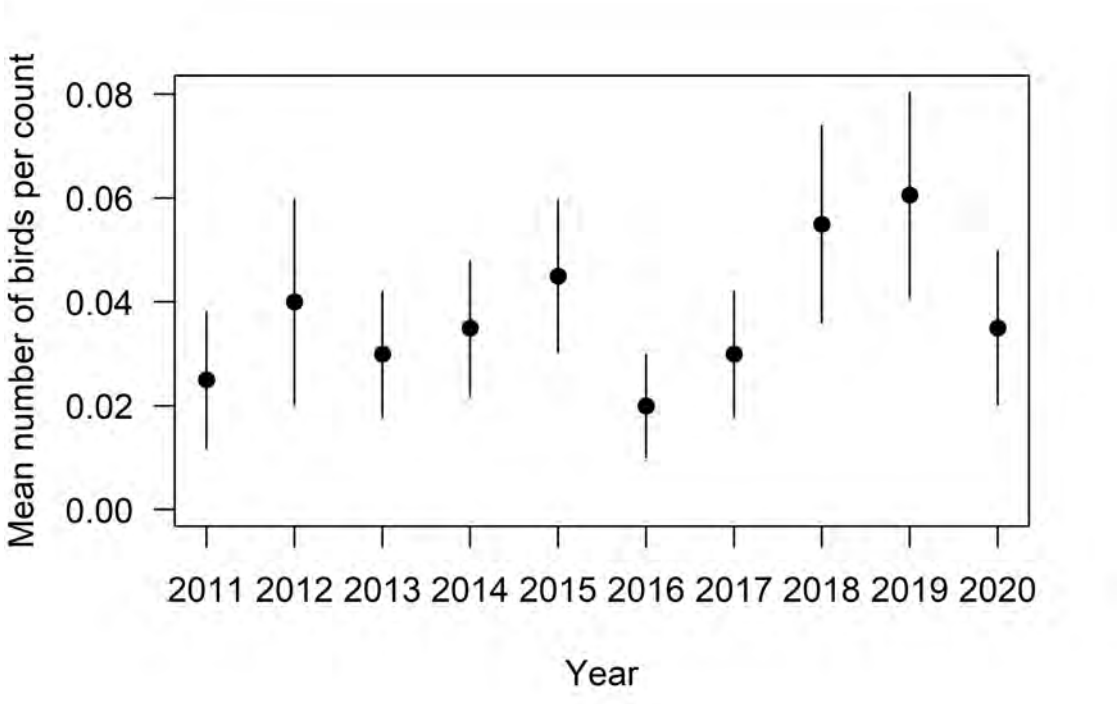

Figure 3.2.21: Mean (±SE) number of kōtare / NZ kingfishers recorded per five-minute bird count station in Wellington City between 2011 and 2020.

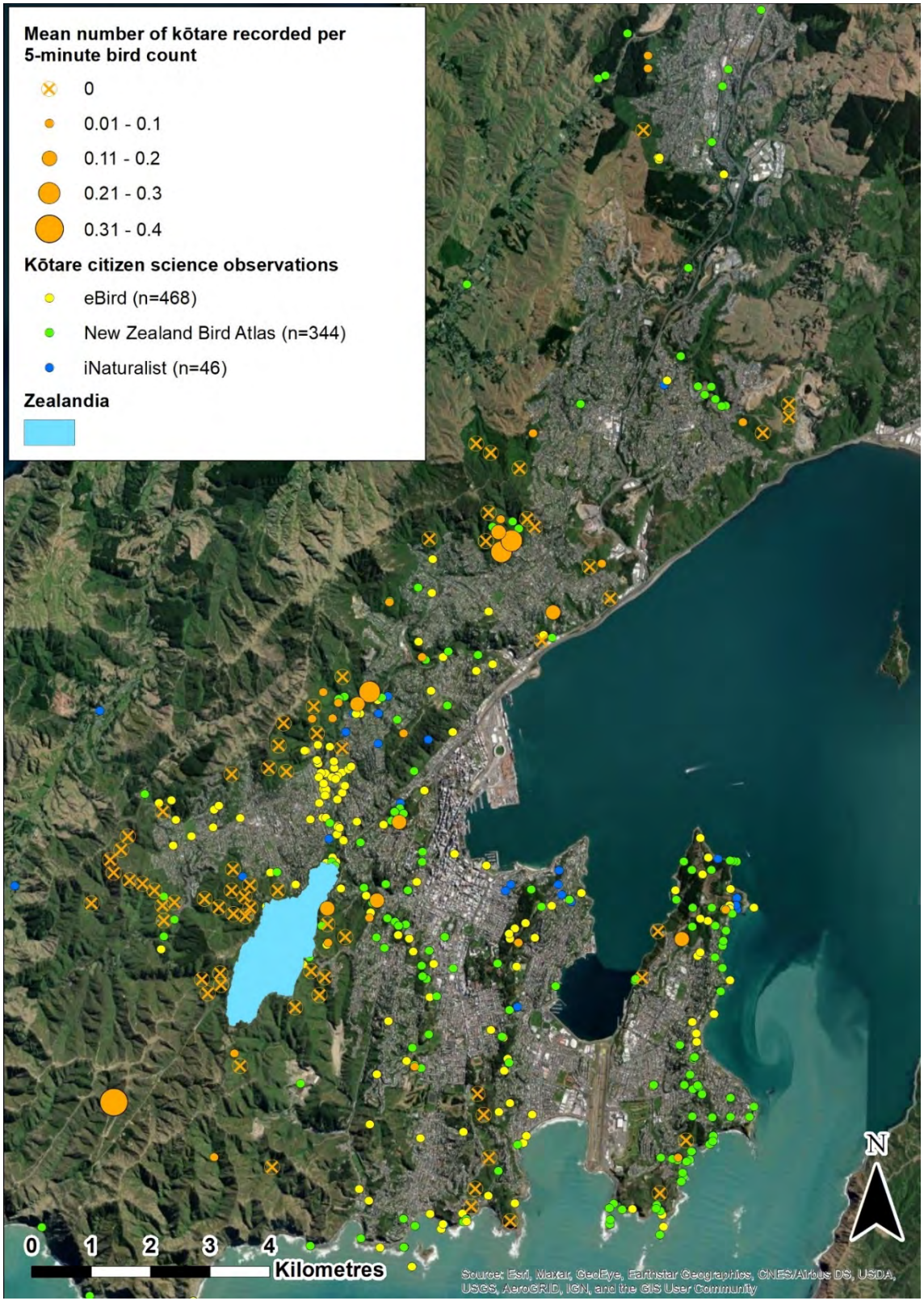

Figure 3.2.22: Distribution of kōtare / New Zealand kingfishers in Wellington City between 2011 and 2021. Orange circles represent kōtare / New Zealand kingfisher detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of kōtare / New Zealand kingfishers detected per station between 2011 and 2020. Yellow, green and blue circles represent kōtare / New Zealand kingfisher observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.12 Korimako / Bellbird (*Anthornis melanura*)

Image courtesy of Craig McKenzie/NZ Birds Online

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

The korimako / bellbird was reintroduced to Zealandia between 2001 and 2011 (Miskelly 2018), although at least two individuals were present in the suburb of Karori during 1999 and 2000 (Miskelly et al, 2005). The korimako / bellbird is now the twelfth most frequently encountered native forest bird species in these five-minute bird counts. Korimako / bellbirds have only been detected on 34 occasions during these five-minute bird counts, providing too few detections to allow trends in encounter rates to be modelled. Korimako / bellbird encounter rates have fluctuated from year to year between 2011 and 2020, from zero birds recorded in 2011 and 2015, to a mean of 0.05 birds encountered per bird count in 2019. Despite these year-to-year fluctuations, there does not appear to have been any overall trend in bellbird encounter rates between 2011 and 2020 (Figure 3.2.23). Korimako / bellbird is the tenth most frequently reported native forest bird species by citizen scientists in Wellington City. Between 2011 and 2021, citizen scientists reported a total of 992 encounters with korimako / bellbirds, demonstrating that bellbirds are very sparsely distributed in native forest and suburban habitats across Wellington City. A resident population is now established in Zealandia (Miskelly, 2018) and possibly also in the Wellington Botanic Gardens, Ōtari-Wilton's Bush and in Khandallah Park (Figure 3.2.24).

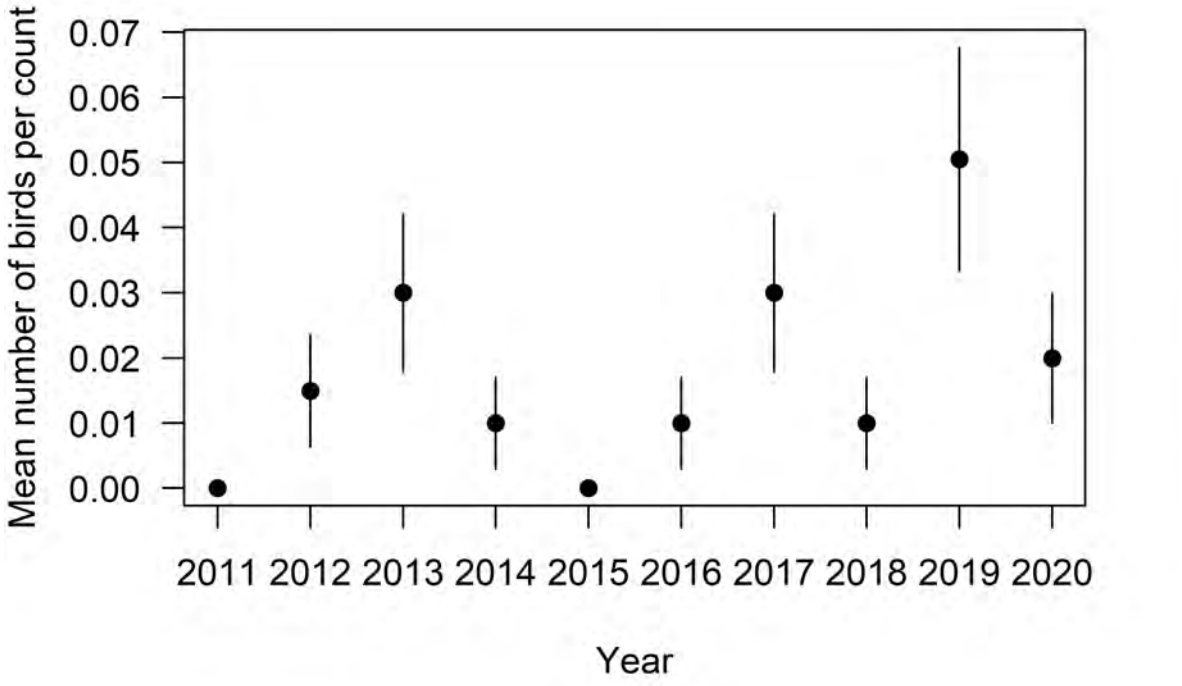

Figure 3.2.23: Mean (±SE) number of korimako / bellbirds recorded per five-minute bird count station in Wellington City between 2011 and 2020.

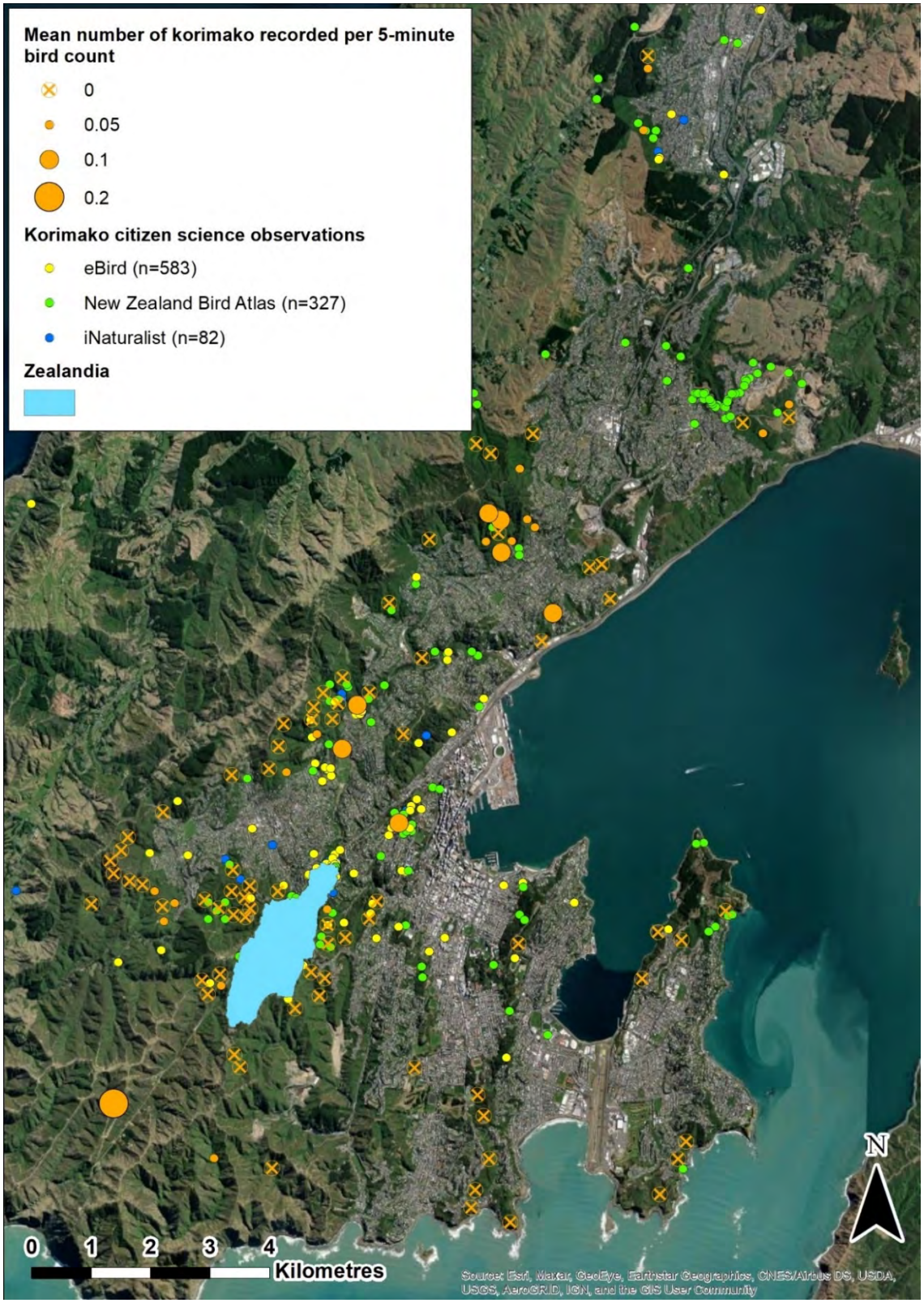

Figure 3.2.24: Distribution of korimako / bellbirds in Wellington City between 2011 and 2021. Orange circles represent korimako / bellbird detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of korimako / bellbirds detected per station between 2011 and 2020. Yellow, green and blue circles represent korimako / bellbird observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.13 Kārearea / NZ falcon (*Falco novaeseelandiae*)

Image courtesy of Steve Attwood/NZ Birds Online

National conservation status: At Risk, Recovering (Robertson et al, 2017).

Regional conservation status: Regionally Critical (Crisp, 2020).

The kārearea / NZ falcon is the thirteenth most frequently encountered native forest bird species in these five-minute bird counts. Kārearea / NZ falcons have only been detected on ten occasions during these five-minute bird counts, providing too few detections to allow trends in encounter rates to be modelled. Kārearea / NZ falcon encounter rates have fluctuated from year to year between 2011 and 2020, from zero birds recorded in 2011, 2014 and 2019 to a mean of 0.01 birds encountered per bird count station in 2013, 2016 and 2018. Despite these year-to-year fluctuations, there does not appear to have been any overall trend in kārearea / NZ falcon encounter rates between 2011 and 2020 (Figure 3.2.25). Kārearea / NZ falcon is the fourteenth most frequently reported native forest bird species by citizen scientists in Wellington City, with 706 encounters recorded between 2011 and 2021 (Figure 3.2.26). These reports have a remarkably uniform distribution across the city, which suggests that these reports represent a relatively small number of highly mobile individuals ranging freely in native forest, suburban and urban habitats throughout the city. Several pairs of kārearea / NZ falcons are known to breed in Wellington City, at locations including Zealandia, Ōtari-Wilton's Bush, Tinakori Hill and on Miramar Peninsula (eBird, 2021). Kārearea / NZ falcon typically occur at fairly low densities and are known to be highly mobile (Heather & Robertson, 2015), so are not expected to undergo any dramatic increases in Wellington City in response to local conservation management efforts.

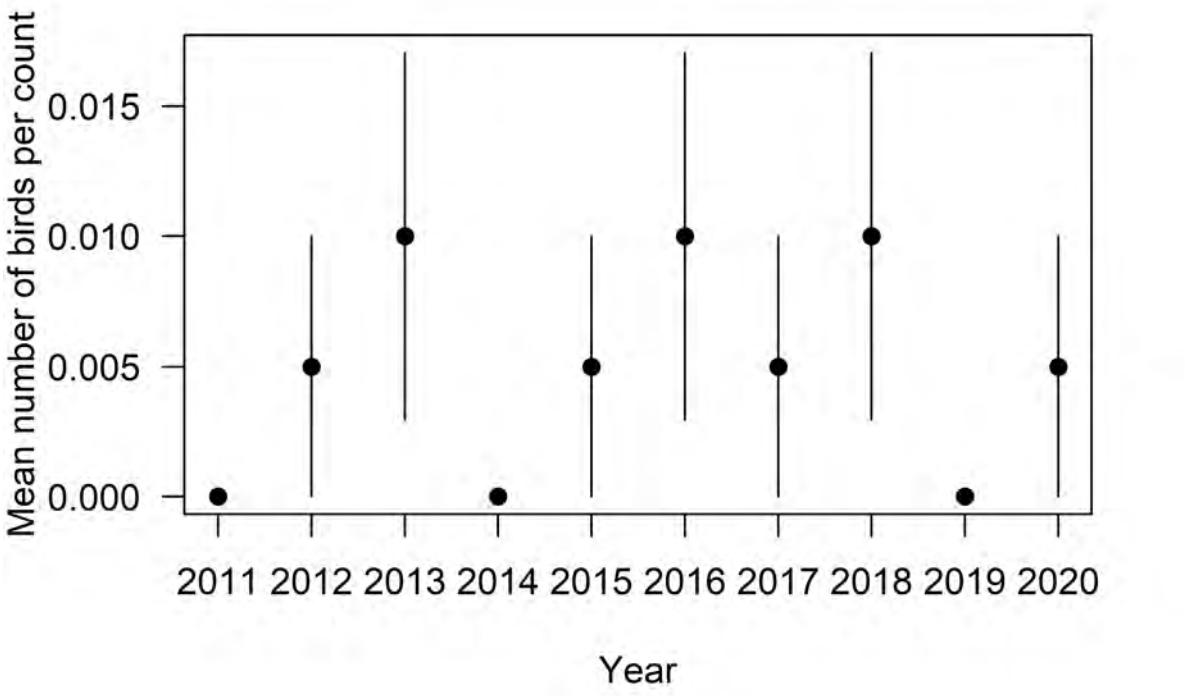

Figure 3.2.25: Mean (±SE) number of kārearea / NZ falcons recorded per five-minute bird count station in Wellington City between 2011 and 2020.

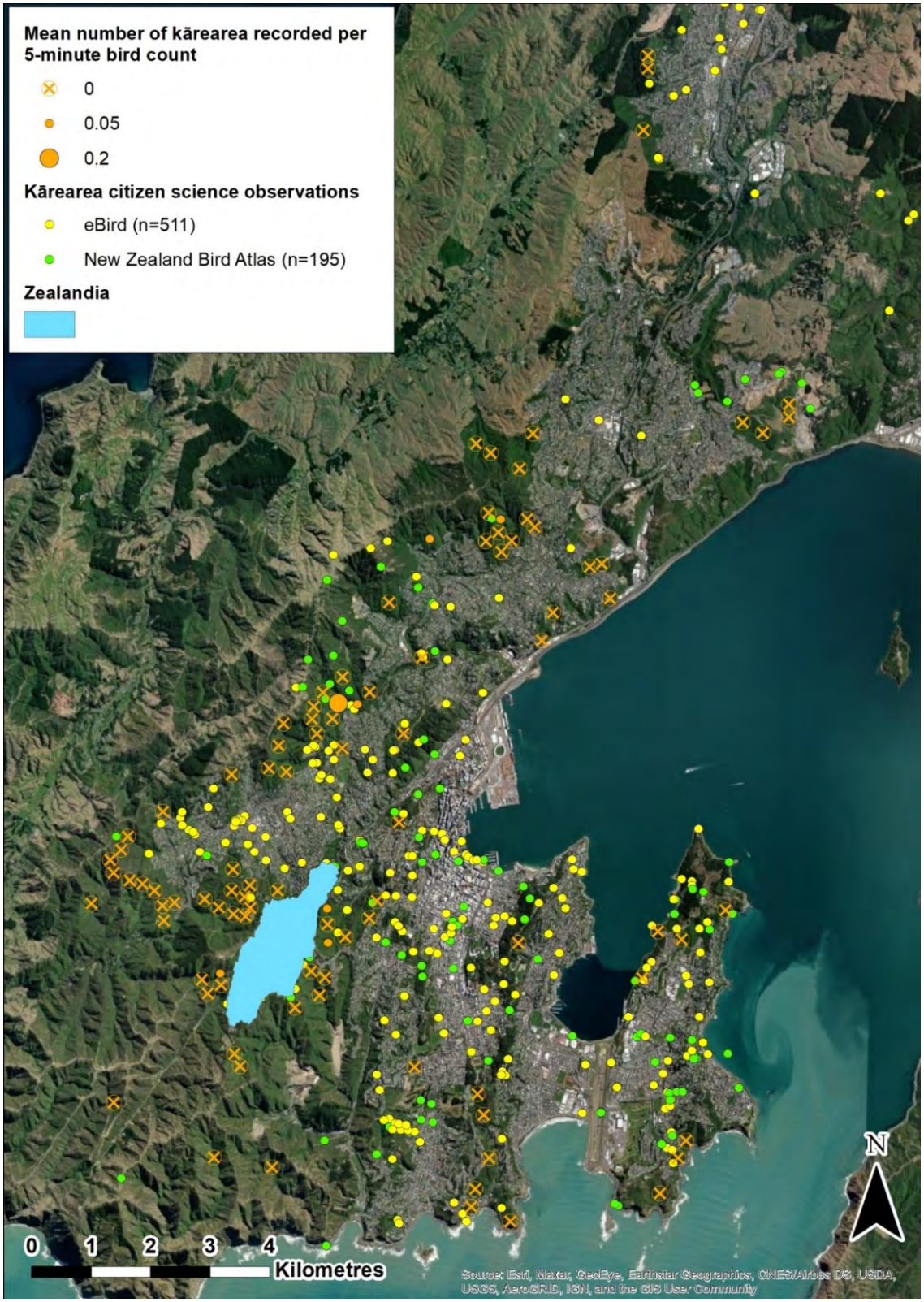

Figure 3.2.26: Distribution of kārearea / NZ falcons in Wellington City between 2011 and 2021. Orange circles represent kārearea / NZ falcon detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of kārearea / NZ falcons detected per station between 2011 and 2020. Yellow and green circles represent kārearea / NZ falcon observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

3.2.14 Tōtōwai / North Island robin (*Petroica longipes*)

National conservation status: At Risk, Declining (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

Image courtesy of Neil Fitzgerald NZ Birds Online

The tōtōwai / NI robin was reintroduced to Zealandia between 2001 and 2002 (Miskelly, 2018) and is now the fourteenth most frequently encountered native forest bird species in these five-minute bird counts. Tōtowai / NI robins have only been detected on eight occasions during these five-minute bird counts, providing too few detections to allow trends in encounter rates to be modelled. Tōtōwai / NI robin encounter rates have fluctuated from zero to a mean of 0.015 birds recorded per bird count each year, with no overall trend in encounter rates between 2011 and 2020 (Figure 3.2.27). Tōtōwai / NI robin is the eighth most frequently reported native forest bird species by citizen scientists in Wellington City with 1163 encounters recorded between 2011 and 2021, the majority of which are from within Zealandia. Of those reports from outside of Zealandia's predator-proof fence, the majority have occurred at locations within 500m of the fence, with only occasional records from forested reserves further afield, including in Ōtari-Wilton's Bush, Tinakori Hill, the Wellington Botanical Gardens and Prince of Wales Park (Figure 3.2.28). In March and April 2021, NI robins were also observed in Makara Peak[3], although these sightings have not yet been submitted to eBird. This localised distribution of tōtōwai / NI robin observations in and around Zealandia suggests that one or more environmental factors are severely limiting the ability of this species to colonise forest habitats beyond Zealandia's predator-proof fence.

[3] https://www.facebook.com/makarapeak/posts/5572064889500977; accessed 13/04/2021.

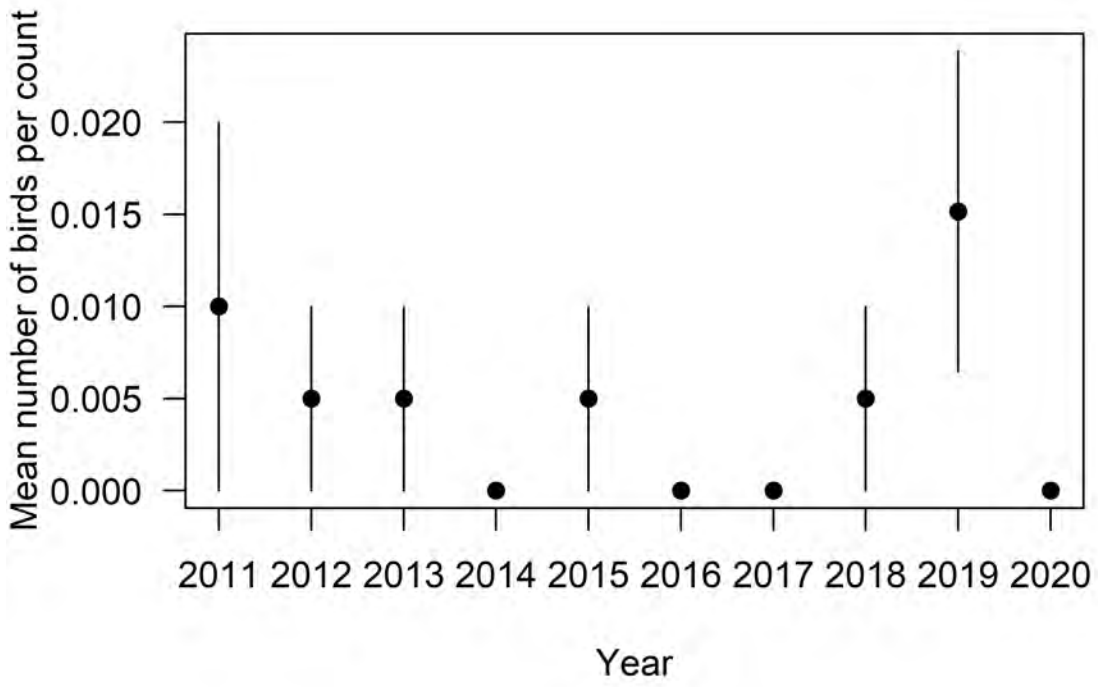

Figure 3.2.27: Mean (±SE) number of tōtōwai / NI robins recorded per five-minute bird count station in Wellington City between 2011 and 2020.

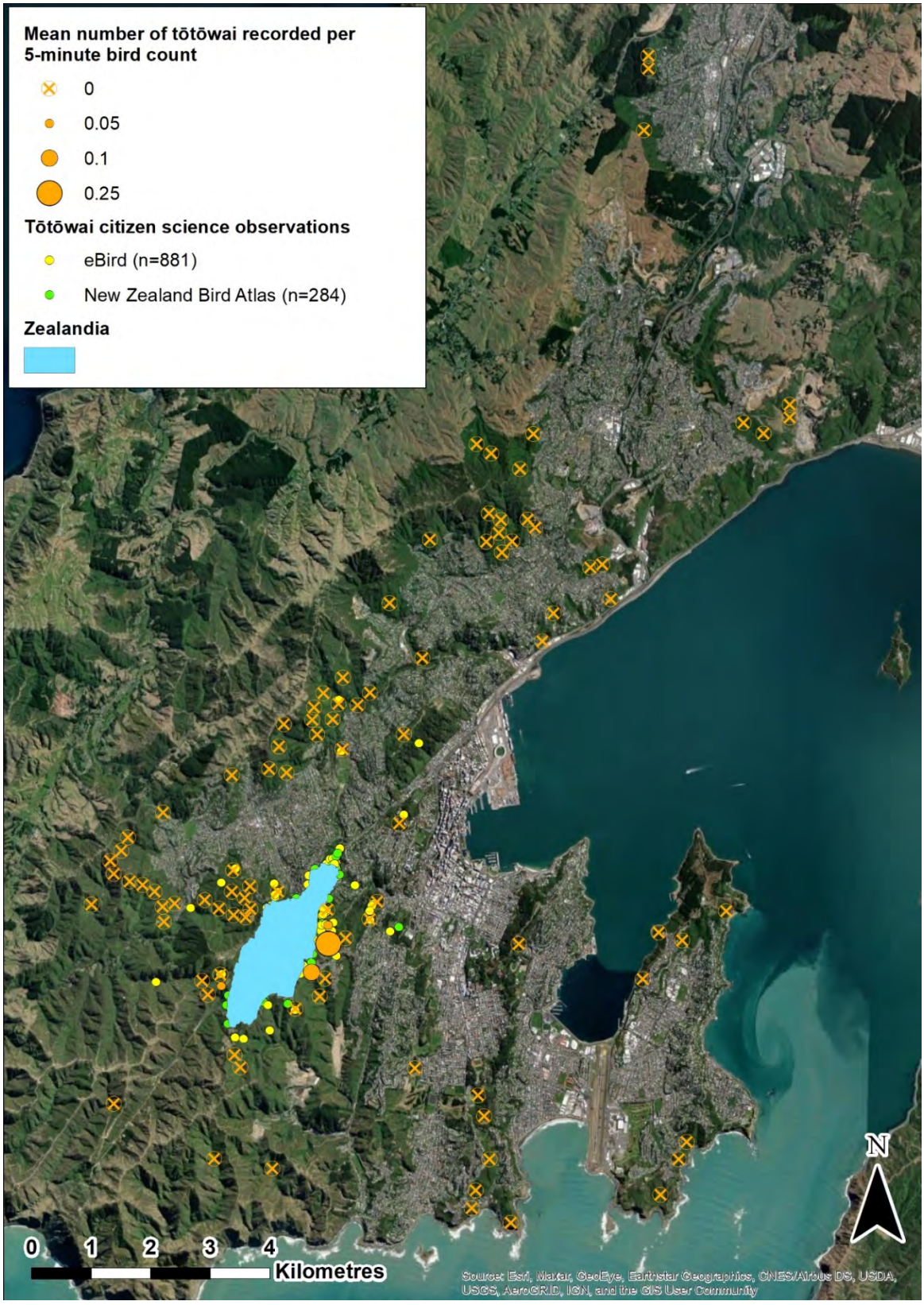

Figure 3.2.28: Distribution of tōtōwai / NI robins in Wellington City between 2011 and 2021. Orange circles represent tōtōwai / NI robin detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of tōtōwai / NI robins detected per station between 2011 and 2020. Yellow and green circles represent tōtōwai / NI robin observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

3.2.15 Hihi / Stitchbird (*Notiomystis cincta*)

National conservation status:
Nationally Vulnerable (Robertson et al, 2017).

Regional conservation status:
Regionally Critical (Crisp, 2020).

Image courtesy of Paul Le Roy/NZ Birds Online

Hihi were reintroduced to Zealandia between 2005 and 2010, and a population is now being maintained in the sanctuary with an ongoing programme of supplementary feeding (Heather & Robertson, 2015; Miskelly, 2018). Hihi were detected during these five-minute bird counts for the first time in 2019, with a single bird being seen and heard at each of two count stations in Wrights Hill Reserve, 390 and 605 metres from the nearest point of Zealandia's boundary fence respectively.

Hihi is the twelfth most frequently reported native forest bird species by citizen scientists in Wellington City, with 843 records submitted since 2011. The majority of these records have been from within Zealandia, however there have been several dozen reports of birds seen or heard in native forest habitats up to 600m from Zealandia's boundary fence (Figure 3.2.29). In May 2016, a single hihi was reported from Orleans Recreational Reserve in Ngaio, 4.5 km NNE of Zealandia (Birds New Zealand, 2016). With this single exception, it appears that hihi are largely confined to Zealandia, and either experience very low emigration rates from the sanctuary, or very low survival rates once they leave the sanctuary.

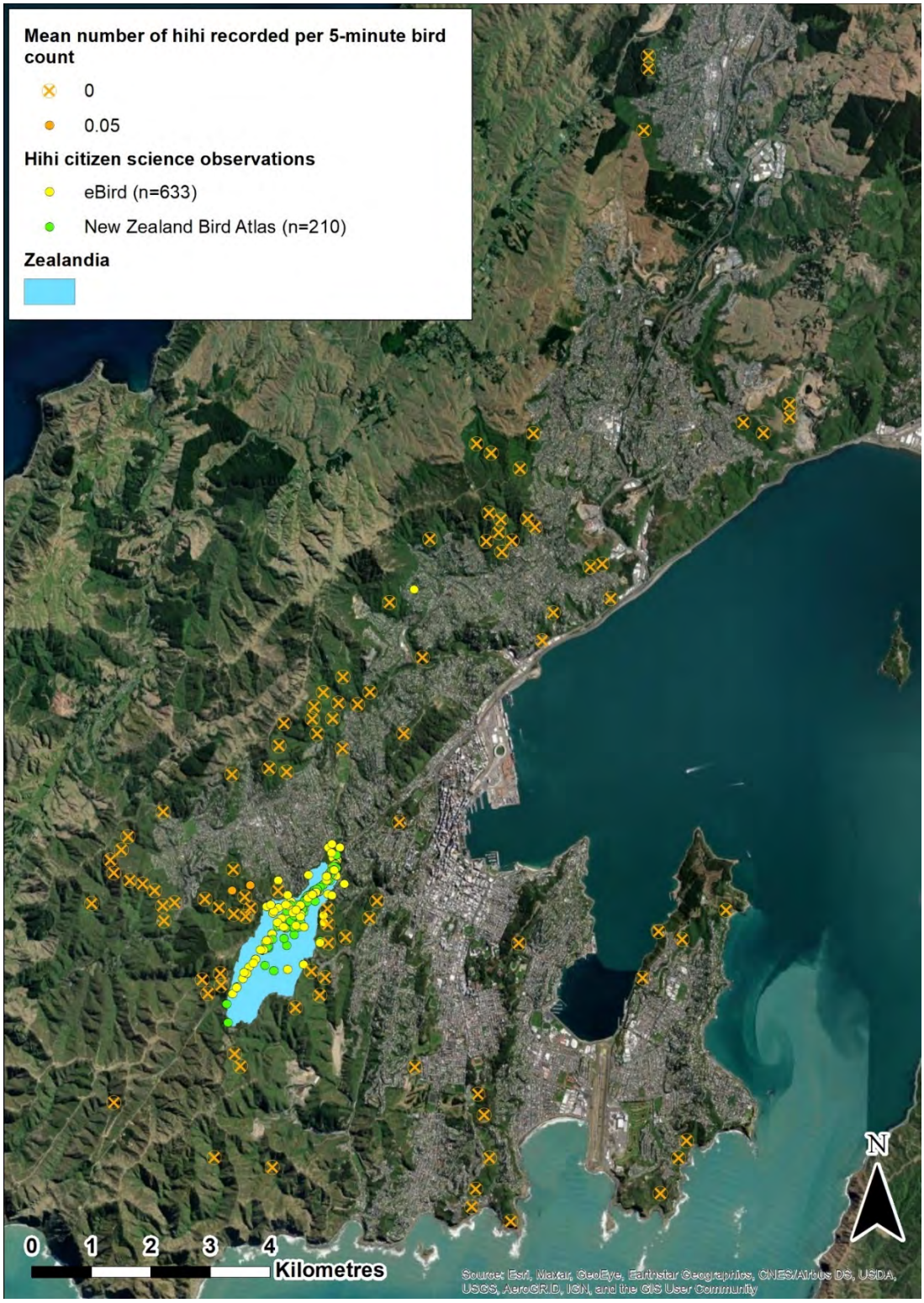

Figure 3.2.29: Distribution of hihi / stitchbirds in Wellington City between 2011 and 2021. Orange circles represent hihi / stitchbird detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of hihi / stitchbirds detected per station between 2011 and 2020. Yellow and green circles represent hihi / stitchbird observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

3.2.16 Miromiro / tomtit (*Petroica macrocephala*)

Image courtesy of Paul Shaw/NZ Birds Online

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

The miromiro / tomtit is a vagrant (i.e., irregular visitor) to Wellington City at the present time, with no local self-sustaining population known to currently exist within Wellington City boundaries. A single miromiro / tomtit was recorded for the first time during this five-minute bird count project in 2016, at a count station in Khandallah Park (Figure 3.2.30; McArthur et al, 2017). In January 2021, at least one tomtit was recorded in Ōtari-Wilton's Bush by New Zealand Bird Atlas surveyors (Milius, 2021). The nearest miromiro / tomtit breeding populations to Wellington City currently occur in Belmont and East Harbour Regional Parks, approximately 13 and 14 km from Wellington City respectively (eBird, 2021). Miromiro / tomtits are known to have strong dispersal abilities, including over open water (Parker et al, 2004), so it is likely that these recent Wellington City observations represent birds that have dispersed into the city from one of these nearby source populations.

Miromiro / tomtits were present in native forest habitats within Wellington City limits historically and persisted in both Ōtari-Wilton's Bush and Khandallah park until at least as late as the mid-1920s (Stidolph, 1924; 1925). An attempt was made to reintroduce miromiro / tomtits to Zealandia between 2001 and 2004 and some successful local breeding subsequently occurred both inside and outside of Zealandia's predator proof-fence between 2003 and 2006. However, this population suffered from high rates of emigration, possibly caused by interspecific competition with an already well-established tōtōwai / NI robin population. As a result, miromiro / tomtits failed to establish in Zealandia and had become locally extinct again by 2007 (Empson and Fastier, 2013).

3.2.17 Ruru / Morepork (*Ninox novaeseelandiae*)

Image courtesy of Adam Clarke NZ Birds Online

National conservation status: Not Threatened (Robertson et al, 2017).

Regional conservation status: Not Threatened (Crisp, 2020).

The ruru / morepork is the most common native forest bird species present in Wellington City that has not yet been detected during these five-minute bird counts, owing to its nocturnal habits and the fact that these counts are carried out during daylight hours. They have been reported on 540 occasions in Wellington City by citizen scientists since 2011. These records suggest that ruru / moreporks are relatively common and widespread in both native forest and suburban habitats throughout the city (Figure 3.2.32).

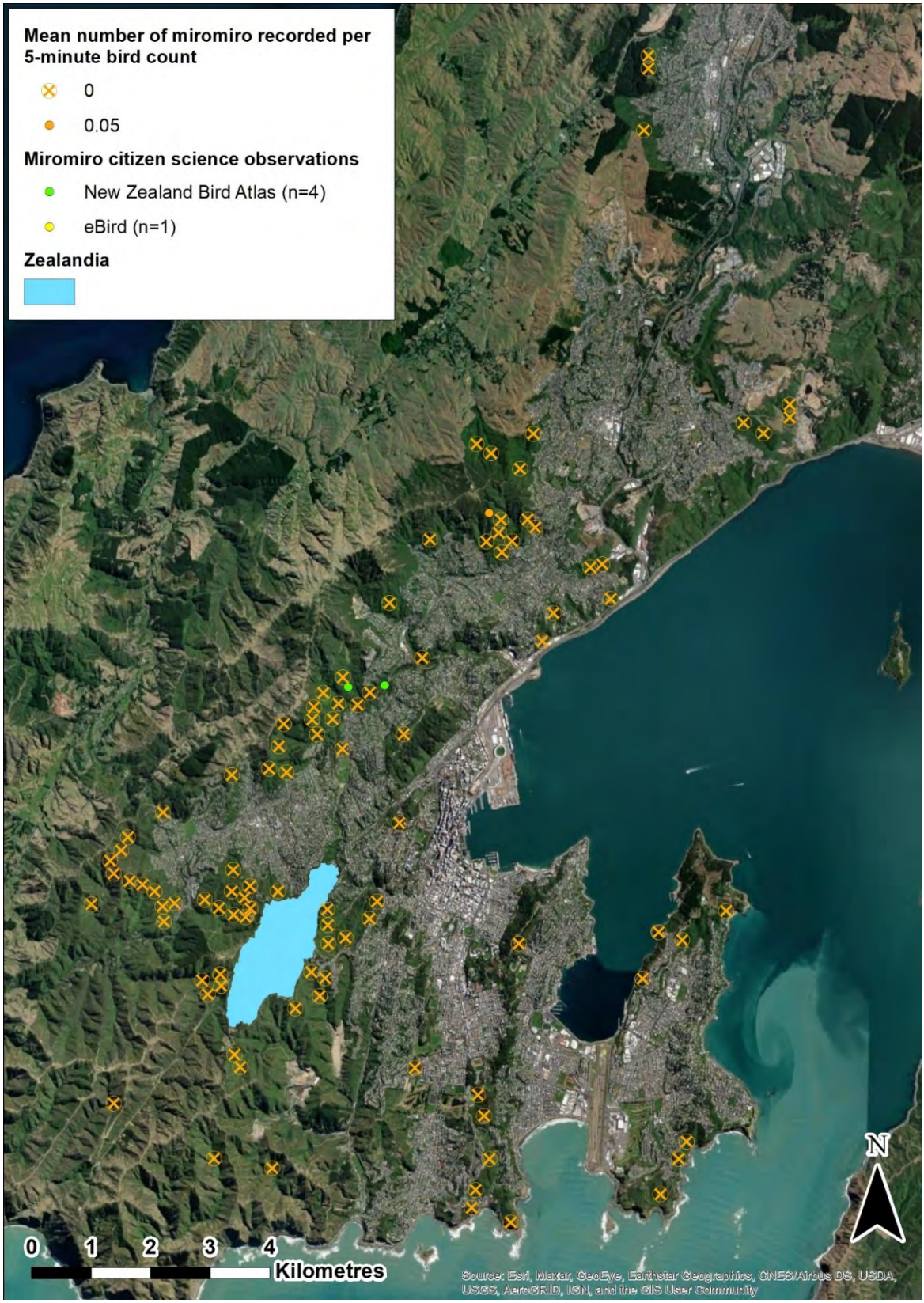

Figure 3.2.30: Distribution of miromiro / tomtits in Wellington City between 2011 and 2021. Orange circles represent miromiro / tomtit detections at five-minute bird count stations, with the size of the circle corresponding to the mean annual number of miromiro / tomtits detected per station between 2011 and 2020. Yellow and green circles represent miromiro / tomtit observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

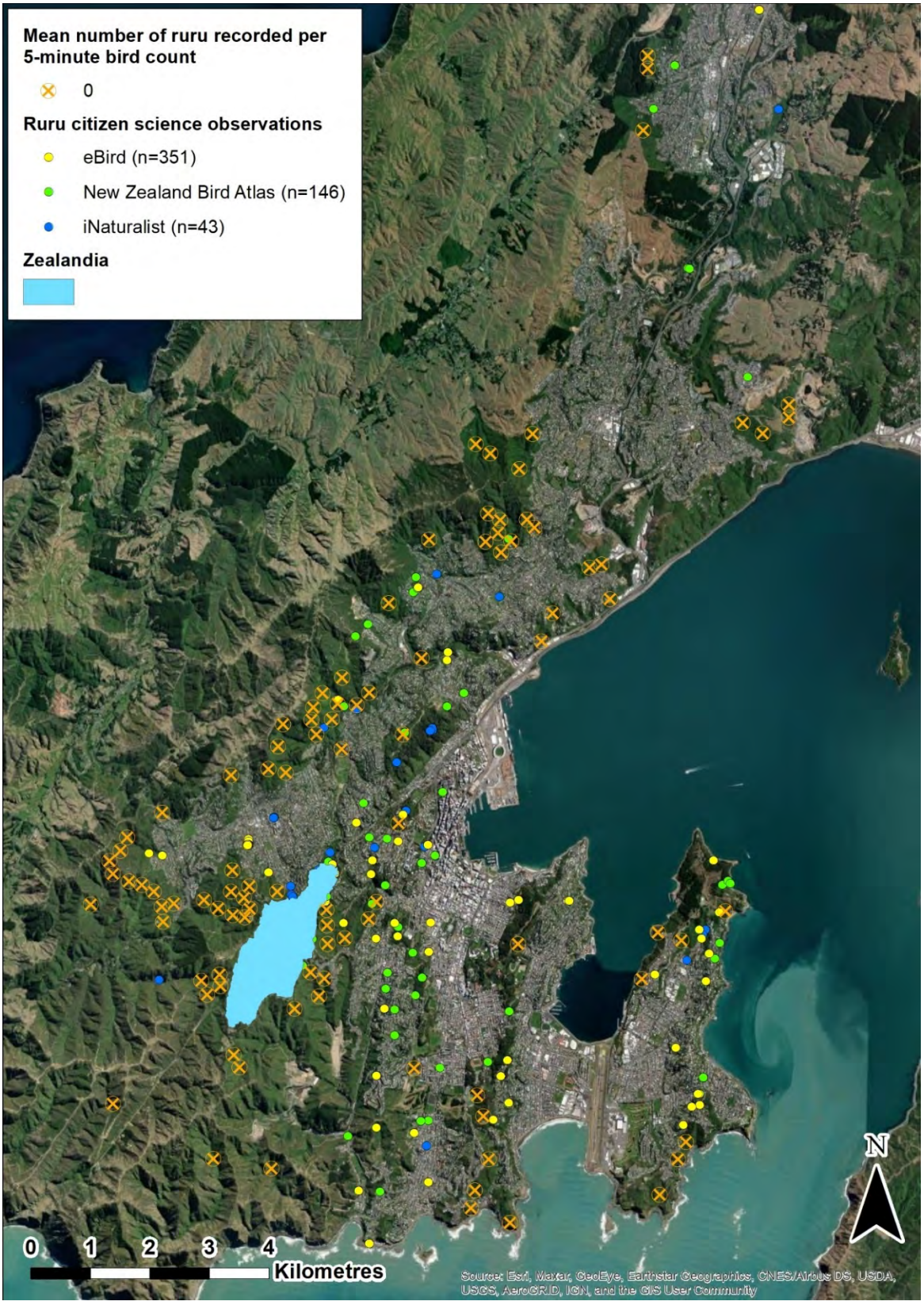

Figure 3.2.32: Distribution of ruru / moreporks in Wellington City between 2011 and 2021. Orange circles represent ruru / morepork non-detections at five-minute bird count stations between 2011 and 2020. Yellow, green and blue circles represent ruru / morepork observations reported by local citizen scientists via eBird, the New Zealand Bird Atlas or iNaturalist between 2011 and 2021.

3.2.18 Tītitipounamu / Rifleman (*Acanthisitta chloris*)

Image courtesy of Glenda Rees NZ Birds Online

National Conservation status: At risk, declining (Robertson et al, 2017)

Regional conservation status: At risk, declining (Crisp, 2020).

Tītitipounamu / riflemen apparently occurred in Wellington City until at least the mid-19th Century, as Oliver (1955) reports that the species was collected by P. Earle at Port Nicholson 'about 1840'. Tītitipounamu / riflemen were either extremely rare or extinct in the area by 1938 however, as Secker (1958) did not encounter them during extensive explorations made in the area between 1938 and 1956. Tītitipounamu / riflemen were reintroduced to Zealandia in March 2019 when 59 birds were transferred from the Wainuiomata/Orongorongo Water Collection Area. These birds have bred successfully within Zealandia with 58 fledglings recorded during the 2020/2021 breeding season[4]. Tītitipounamu / riflemen have not yet been recorded during these five-minute bird counts, however they have been reported on 97 occasions by citizen scientists since 2019, including several observations of birds occurring beyond Zealandia's predator-proof fence, in Central Park (Brooklyn) and in native forest adjacent to Waiapu Road (Figure 3.2.33).

3.2.19 Koekoeā / Long-tailed cuckoo (*Eudynamys taitensis*)

Image courtesy of Adam Clarke/NZ Birds Online

National conservation status:At Risk, Naturally Uncommon (Robertson et al, 2017).

Regional conservation status: At Risk, Naturally Uncommon (Crisp, 2021).

Koekoeā / long-tailed cuckoos appear to be a rare passage migrant in Wellington City at the present time. Koekoeā / long-tailed cuckoos have not yet been recorded during these five-minute bird counts and have only been recorded by citizen scientists in Wellington City on five occasions since 2011 (Figure 3.2.31). Given the current scarcity of koekoeā / long-tailed cuckoos in Wellington City, the local population of pōpokotea / whiteheads present in forest habitats in and adjacent to Zealandia is likely to be the only pōpokotea / whitehead population in the Wellington region that does not experience brood parasitism by koekoeā / long-tailed cuckoos.

[4] https://www.facebook.com/ZEALANDIA/posts/10157605617536401; accessed 04/04/2021.

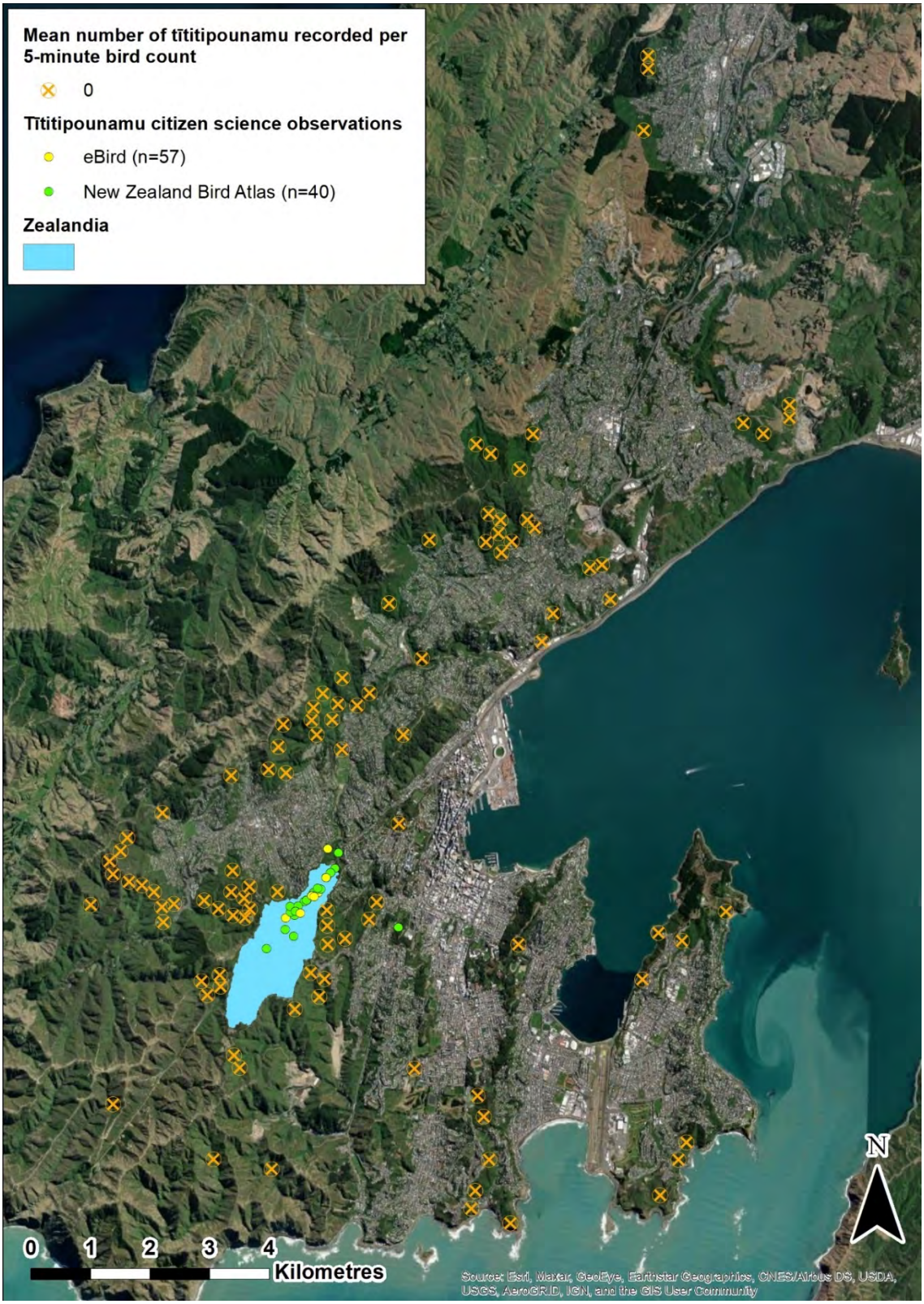

Figure 3.2.33: Distribution of tītitipounamu / riflemen in Wellington City between 2011 and 2021. Orange circles represent tītitipounamu / rifleman non-detections at five-minute bird count stations, between 2011 and 2020. Yellow and green circles represent tītitipounamu / rifleman observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

Figure 3.2.31: Distribution of koekoeā / long-tailed cuckoos in Wellington City between 2011 and 2021. Orange circles represent koekoeā / long-tailed cuckoo non-detections at five-minute bird count stations between 2011 and 2020. Yellow and green circles represent koekoeā / long-tailed cuckoo observations reported by local citizen scientists via eBird or the New Zealand Bird Atlas between 2011 and 2021.

3.3 The Zealandia 'halo effect'

The best model to describe how the proximity of a bird count station to Zealandia influences the diversity of native and introduced species at that station was the model that assumed different spatial trends for native versus introduced species. This model had a lower AICc value (ΔAICc = 1.28) than the next best model, which was the model that assumed that native and introduced species would show the same spatial trend.

According to this model, the species richness of native birds was higher at count stations closer to Zealandia, suggesting that the predator-free sanctuary is exerting a measurable 'halo' effect on forest bird communities beyond the predator-proof fence (the coefficient of distance on log number of native forest bird species was -0.04; 95% CI -0.13 - 0.05). On average, a mean of 6.5 (± 0.3 SE) native forest bird species were detected at count stations closest to Zealandia's boundary, whereas a mean of 3.2 (± 0.4 SE) native forest bird species were detected at the stations situated farthest away from Zealandia (a distance of approximately 10 km).

In contrast, the species richness of introduced bird species increased slightly with increasing distance from Zealandia (the coefficient of distance on log number of introduced bird species was 0.02; 95% CI -0.02 - 0.06). On average, a mean of 2.2 (± 0.3 SE) introduced bird species were detected at count stations closest to Zealandia's boundary, whereas a mean of 2.4 (± 0.3 SE) introduced species were detected at the stations situated farthest away from Zealandia (Figure 3.3.1).

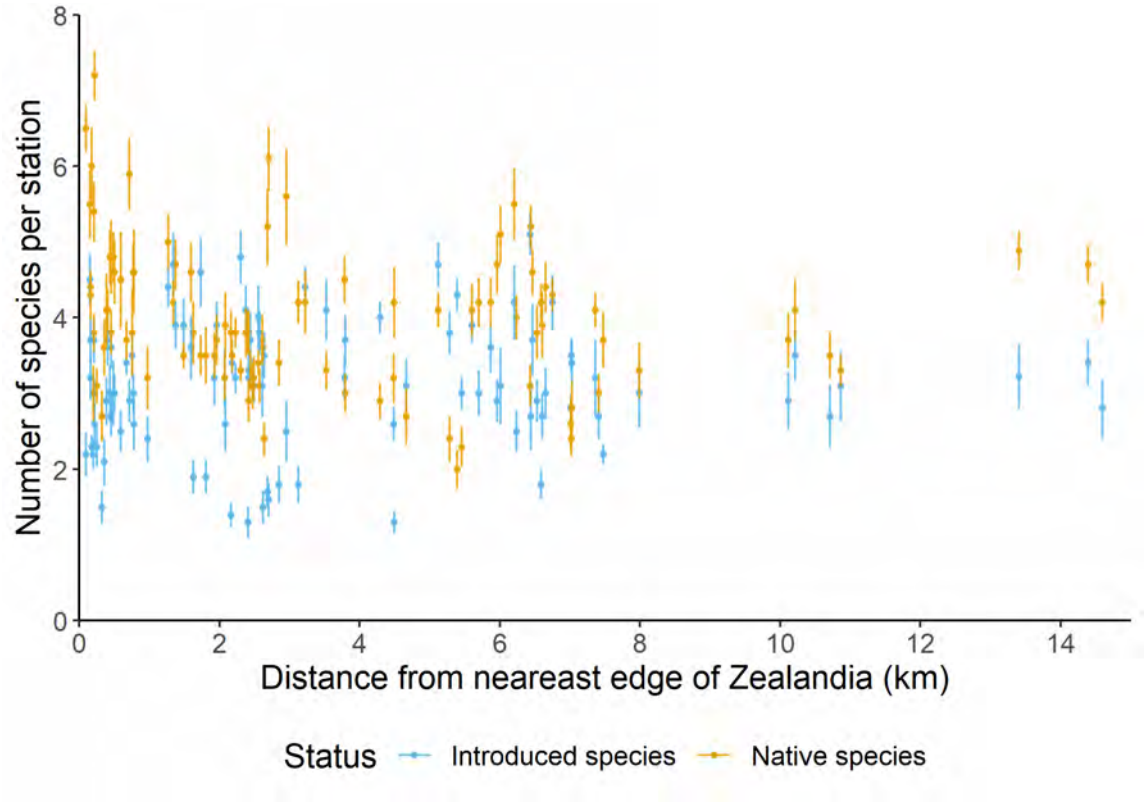

Figure 3.3.1: mean number of native and introduced bird species detected per station between 2011 and 2020, in relation to each station's distance from Zealandia.

4. Discussion

4.1 Changes in bird community composition, abundance and distribution

The mean number of native forest birds being counted per five-minute bird count has increased by 50% since 2011, and this has been driven by substantial increases in the mean number of tūī, pīwakawaka / NZ fantail, kākā, kererū, tīeke / NI saddleback and possibly kākāriki / red-crowned parakeet being counted each year. Three of these species were absent from Wellington City prior to being reintroduced to the predator-free Zealandia sanctuary during the early 2000s, and all of these species are vulnerable to varying degrees to depredation by mammalian predators (Innes et al, 2010; Fea & Hartley, 2018). Given that these five-minute bird counts are carried out at the same time each year, in the same weather conditions and usually by the same observers, these trends are providing ever-strengthening evidence that the abundance of at least five of these species has increased in Wellington City since 2011. This being the case, it is clear that these increases in native forest bird abundance are being driven by both the establishment of large source populations of these species within Zealandia, and the steady expansion and intensification of mammalian predator control efforts across Wellington City.

Although mean annual counts for native forest birds have increased in native forest habitats in Wellington City parks and reserves between 2011 and 2020, mean annual counts for introduced species have similarly increased, albeit at a slower rate. This suggests that the native forest bird communities in forested parks and reserves outside of Zealandia have not yet recovered to the point where interspecific competitive exclusion is reducing the abundance and conspicuousness of introduced bird species, as has occurred within Zealandia (Miskelly, 2018). One local exception to this pattern currently exists, however. Mean annual counts of introduced birds at five-minute bird count stations within a few hundred metres of Zealandia's predator-proof fence are lower than those stations situated furthest away from this predator-free sanctuary. This indicates that the interspecific competitive exclusion of introduced bird species that is occurring within Zealandia is also extending some distance beyond Zealandia's predator-proof fence, into surrounding forest habitats in adjacent parks and reserves, part of what is colloquially known as Zealandia's 'halo' effect.

Zealandia's 'halo' effect is not confined to introduced species, however. On average, over twice as many native bird species have been recorded annually at those five-minute bird count stations situated closest to Zealandia's boundary than at those situated furthest away. These higher levels of native bird species richness at stations in proximity to Zealandia are being driven by the emigration of birds from the large source populations now established within Zealandia. This measurable 'halo' effect demonstrates the key role that Zealandia is playing in driving increases in the diversity, abundance and distribution of native forest birds in Wellington City's parks and reserves.

This in turn raises the question of the relative contributions that Zealandia's 'halo' effect and city-wide mammalian predator control initiatives are making towards the improvements in native forest bird populations observed in Wellington City since 2011. Brudvig et al (2009) for instance report that biodiversity 'spillover' in a landscape is largely a function of processes occurring within the source population rather than in the surrounding landscape, suggesting that some of the increases in native forest bird diversity, abundance and distribution observed in Wellington City may have occurred irrespective of the extent or intensity of mammalian predator control occurring beyond Zealandia's

predator-proof fence. Indeed, it has long been recognised that species occupancy and density is a poor predictor of habitat quality and that even relatively poor-quality habitats can support high population densities due to immigration alone (e.g., McArthur et al, 2019).

In the case of Wellington City, the distribution maps included in this report suggest that the relative importance of conservation management initiatives both within and beyond Zealandia's predator-proof fence is likely to be species specific. Based on these distribution maps, Wellington City's resident native forest bird species can be divided into two broad categories: those species with relatively widespread distributions, and those with very localised distributions. Several widespread species, including tūī, pīwakawaka / fantail and kererū, are now frequently observed breeding successfully in native forest and suburban habitats beyond Zealandia's predator-proof fence, so are more likely to be benefitting from city-wide reductions in mammalian predator densities in addition to being supplemented by emigration from Zealandia.

A number of other species continue to have very localised distributions centred on Zealandia, including tōtōwai / NI robin, and tīeke / NI saddleback. The presence of these species in native forest habitats adjacent to Zealandia appears to be largely a result of the emigration of birds from Zealandia, rather than of improvements in local predator control efforts. For example, tōtōwai / NI robins have been well established in Zealandia for at least 15 years (McGavin, 2009; Empson & Fastier, 2013), yet have only been detected on eight occasions during these five-minute bird counts between 2011 and 2020 and are seldom reported by citizen scientists at distances greater than around 1 km from Zealandia (Figure 3.2.28). Tōtōwai / NI robins are known to have relatively strong dispersal capabilities through habitats dominated by woody vegetation, with juvenile birds capable of dispersing up to 11 km from their natal territories in forested habitat (Oppel & Beaven 2004; Richard 2007), so habitat connectivity is unlikely to be the factor limiting the expansion of this species in Wellington City. Mark-resighting and nest monitoring of tōtōwai / NI robins in reserves adjacent to Zealandia in recent years has confirmed that although these reserves provide suitable breeding habitat for robins, poor adult and juvenile survival rates are limiting the ability of this species to colonise forest habitats outside of Zealandia. Of 37 adult tōtōwai / NI robins banded in forested reserves adjacent to Zealandia in the winter of 2017, only eleven birds were still present on their territories by the beginning of the following breeding season, and only four were still present in the winter of 2018. During the 2017-18 breeding season, a total of ten nesting attempts were monitored. Eight of these successfully fledged young, with 11 young subsequently reaching independence. However, only three of these 11 offspring were detected subsequently, and only one appeared to survive long enough to attempt to breed (unsuccessfully) the following season. Of the two nests that failed, one was depredated by a cat, and the other by a stoat (Shaw and Harvey, 2018). Adult survival rates were similarly low during the 2018-19 breeding season. Of 16 adult birds known to be present on breeding territories in September 2018, only one was still present by March 2019. Breeding success during this second season was substantially worse than the previous year. Of seven nests monitored during the 2018-19 season, only one successfully fledged young (MacKinlay, unpublished data).

Given this evidence, the most likely factor limiting the establishment of tōtōwai / NI robins (as well as other species with localised Wellington City distributions, including tīeke / NI saddleback and pōpokotea / whitehead) beyond the boundaries of Zealandia is depredation of both adult and juvenile birds by mammalian predators, particularly both domestic and wild cats (*Felis catus*) and mustelids (*Mustela* spp.). Although considerable effort is being invested in reducing populations of a number of mammalian predators in Wellington City including rats, possums and mustelids, cats are currently not being targeted. Camera trapping work carried out by researchers at Victoria University of Wellington has shown that cats accounted for a relatively large proportion of the approximately 22,000 animal

'detections' collected from several Wellington City reserves over a five-month period in 2014 (http://identifyanimals.co.nz/; accessed 24/09/2015; Anton et al, 2018), suggesting that cats occur in relatively high densities in the parks and reserves that were sampled. Further camera trapping work carried out in 2016 confirmed that cats were likely to be present across most of the total area of Polhill Reserve (one of the forested reserves adjoining predator-free Zealandia), and that the majority of these cats appeared to be domestic pets (Woolley & Hartley, 2019).

This being the case, we agree with the conclusion drawn by Shaw & Harvey (2018), that if Wellington City Council and Predator Free Wellington wish to create "a natural city that flourishes with native wildlife and a dawn chorus that will be the envy of other cities" (https://www.pfw.org.nz/; accessed 25/06/2019), then progress will need to be made to manage the risk to wildlife posed by feral, stray and free-roaming domestic cats. Until this occurs, further increases in the diversity, abundance and distribution of native forest birds in Wellington City will be constrained by the city's large cat population. Specifically, creating healthy, productive populations of native forest birds such as tōtōwai / NI robin, tīeke / NI saddleback and pōpokotea / whitehead in forest habitats outside of Zealandia's predator-proof fence is unlikely to be attainable, irrespective of the degree to which other mammalian predators such as rats, possums, mustelids and hedgehogs are controlled or eradicated.

4.2 The role of citizen scientists in monitoring Wellington City's bird fauna

Citizen scientists are playing an increasingly important role in providing bird observation data that complement this Wellington City five-minute bird count dataset, enabling us to map the distribution of birds in Wellington City to a level of detail never done before. A total of 47,332 verified observations of native forest birds have been contributed by citizen scientists in Wellington City between 2011 and 2020 and are included on the distribution maps in this report. 94%, or 44,397 observations, have been contributed via the New Zealand eBird database, making eBird by far the most preferred, and most popular database used by Wellington-based citizen scientists that have an interest in birds. A further 5% (2360 observations) were submitted via the iNaturalist NZ database, making this the second most preferred database used by Wellington-based citizen scientists[5]. An additional 1% of records (574 observations) were sourced from the Great Kererū Count.

The contribution that citizen scientists have made to this bird monitoring programme has provided at least two benefits. Firstly, because citizen scientists are collecting observations from a large number of locations not being sampled as part of this project, the resulting bird distribution maps are considerably more detailed than if they had been derived from the 5-minute bird count data alone. These distribution maps have provided insights into the habitat use of native bird species in Wellington City, and have greatly improved our ability to map the steadily expanding ranges of species such as kākā and kākāriki / red-crowned parakeets as they colonise native forest habitats beyond Zealandia's predator-proof fence. The second benefit is the role that citizen scientists play in detecting rare,

[5] Note: This number is likely to underestimate iNaturalist usage among Wellington-based citizen scientists, for two reasons. Firstly, a much larger proportion of iNaturalist observations was discarded during data analysis due to location and/or species identification errors, compared to the eBird database. This suggests that the data validation process used by iNaturalist is not as effective at picking up errors in comparison to eBird's data validation processes. Secondly, location data for any iNaturalist records of species classified as Threatened or Near Threatened on the IUCN Red List is withheld from users, meaning that their locations could not be mapped accurately. These erroneous and 'obscured' records (ca. 200-300 records in total) were all discarded from our analysis and are not included in the numbers of observations reported here.

cryptic or re-colonising bird species in Wellington City. Because citizen scientists are collecting bird observations year-round, they are much better placed to detect colonising species or those species which are naturally rare, cryptic or nocturnal. Indeed, our knowledge of the presence and distribution of three native forest bird species that occur in Wellington City (ruru / morepork; koekoeā / long-tailed cuckoo and tītitipounamu / rifleman), is entirely derived from citizen science data at present, as none of these species have yet been detected during a five-minute bird count.

Although our knowledge of the abundance and distribution of diurnal, or day-active bird species in Wellington City has improved substantially over the past ten years, the abundance and distribution of the one relatively widespread nocturnal forest bird species present in Wellington City is very poorly understood. Ruru / morepork may well be relatively common in Wellington City, and trends in morepork encounter rates or distribution over time could provide an additional measure of the outcomes of local pest control efforts. An opportunity exists therefore to fill this knowledge gap by running a citizen science project specifically aimed at mapping the distribution of ruru / morepork in Wellington City and quantifying encounter rates as an indirect measure of abundance. Such a project could be modelled on the 2011 Hamilton City ruru / morepork survey, whereby volunteers were assigned to a pre-defined set of survey locations over a period of five consecutive nights (Morgan & Styche, 2012). This project would also serve a secondary purpose of providing Wellington City residents with an additional opportunity to engage with their surrounding natural environment, learn more about the birds around them and improve their skills as citizen scientists.

5. Recommendations

Based on the results described in this report, we suggest that Wellington City Council considers adopting the following recommendations:

- That Wellington City Council continues to undertake this five-minute bird count monitoring programme on an annual basis, to provide a consistent, repeatable measure of the state and trends in the diversity, distribution and abundance of birds in Wellington City parks and reserves, in order to contribute towards objective 4.2.2a of WCC's Biodiversity Strategy and Action Plan (WCC, 2015).

- That Wellington City Council takes steps to encourage local citizen scientists to submit their bird observations in the form of complete bird checklists to the New Zealand eBird database (objective 4.3.3a of WCC's Biodiversity Strategy and Action Plan; WCC, 2015). By doing so, local citizen scientists will be submitting their Wellington City bird observation data to a single, centralised database, providing researchers and conservation managers with easy access to a large and fast-growing dataset of high quality Wellington City bird observations.

- That Wellington City Council works with local communities to educate local residents on the risk that domestic cats pose to the city's wildlife, and to explore cat management options to reduce the risk that domestic, stray and feral cats pose to native and endemic birds in Wellington City.

- That Wellington City Council considers designing and carrying out a citizen science project aimed at mapping the distribution of ruru / morepork in Wellington City during the summer of 2021/2022 (objective 3.3.4b of WCC's Biodiversity Strategy and Action Plan; WCC, 2015). Such a project could involve public requests for ruru / morepork sightings during a pre-defined time period (e.g., the month of November), coupled with recruiting a pool of local volunteers to carry out night-time surveys of a pre-determined network of locations throughout the city to determine ruru / morepork distribution in local parks and reserves.

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Appendix One

This appendix contains a list of all bird species encountered in Wellington City parks and reserves during five-minute bird counts carried out between 2011 and 2020 (P = species detected). Māori bird names have been sourced from the Māori Dictionary Project (https://maoridictionary.co.nz/) and from Gill et al (2010). Scientific names, common names and taxonomic order have been sourced from Gill et al (2010). The national threat rankings used are those New Zealand Threat Classification System rankings listed in Robertson et al (2017) and the regional threat rankings are those listed in Crisp (2020).

Māori Name	Common Name	Scientific Name	National Threat Ranking	Regional Threat Ranking	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
koera	California quail	*Callipepla californica*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
heihei	feral chicken	*Gallus gallus*	Not Applicable[6]	Not Applicable[1]	P	P	P	P	P	P	P			P
pūtangitangi	paradise shelduck	*Tadorna variegata*	Not Threatened	Not Threatened		P	P				P	P		
rakiraki	mallard	*Anas platyrhynchos*	Introduced and Naturalised	Introduced and Naturalised					P	P				
kororā	little penguin	*Eudyptula minor*	At Risk, Declining	Regionally Vulnerable							P			
kawau paka	little shag	*Phalacrocorax melanoleucos*	Not Threatened	Regionally Vulnerable										P

[6] The feral chicken is not recognised as a naturalised species in New Zealand (Gill et al, 2010) and therefore does not have a New Zealand Threat Classification System ranking (Robertson et al, 2017).

Māori Name	Common Name	Scientific Name	National Threat Ranking	Regional Threat Ranking	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
kawau	black shag	*Phalacrocorax carbo*	At Risk, Naturally Uncommon	Regionally Critical								P		
kāruhiruhi	pied shag	*P. varius*	At Risk, Recovering	Regionally Vulnerable					P					
kawau tikitiki	spotted shag	*Stictocarbo punctatus*	Not Threatened	Regionally Endangered							P			
matuku moana	white-faced heron	*Egretta novaehollandiae*	Not Threatened	Not Threatened			P							
kāhu	swamp harrier	*Circus approximans*	Not Threatened	Not Threatened	P	P		P						
kārearea	New Zealand falcon	*Falco novaeseelandiae*	At Risk, Recovering	Regionally Critical		P	P		P	P	P	P		P
tōrea tai	variable oystercatcher	*Haematopus unicolor*	At Risk, Recovering	Regionally Vulnerable		P		P	P	P		P	P	
	spur-winged plover	*Vanellus miles*	Not Threatened	Not Threatened				P				P		
karoro	southern black-backed gull	*Larus dominicanus*	Not Threatened	Not Threatened	P	P	P	P	P	P	P	P	P	P
tarāpunga	red-billed gull	*L. novaehollandiae*	At Risk, Declining	Regionally Vulnerable		P	P					P		P
tara	white-fronted tern	*Sterna striata*	At Risk, Declining	Regionally Endangered								P		P
	rock pigeon	*Columba livia*	Introduced and Naturalised	Introduced and Naturalised						P	P			

Māori Name	Common Name	Scientific Name	National Threat Ranking	Regional Threat Ranking	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
kererū	kererū	*Hemiphaga novaeseelandiae*	Not Threatened	At Risk, Recovering	P	P	P	P	P	P	P	P	P	P
kākā	kākā	*Nestor meridionalis*	At Risk, Recovering	At Risk, Recovering	P	P	P	P	P	P	P	P	P	P
	eastern rosella	*Platycercus eximius*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
kākāriki	red-crowned parakeet	*Cyanoramphus novaezelandiae*	At Risk, Relict	At Risk, Recovering	P	P		P	P	P	P	P	P	P
pīpīwharauroa	shining cuckoo	*Chrysococcyx lucidus*	Not Threatened	Not Threatened	P	P	P	P	P	P	P	P	P	P
kōtare	New Zealand kingfisher	*Todiramphus sanctus*	Not Threatened	Not Threatened	P	P	P	P	P	P	P	P	P	P
tīeke	North Island saddleback	*Philesturnus rufusater*	At Risk, Recovering	Regionally Vulnerable	P	P	P	P	P	P	P	P	P	P
hihi	stitchbird	*Notiomystis cincta*	Nationally Vulnerable	Regionally Critical									P	
riroriro	grey warbler	*Gerygone igata*	Not Threatened	Not Threatened	P	P	P	P	P	P	P	P	P	P
korimako	bellbird	*Anthornis melanura*	Not Threatened	Not Threatened		P	P	P		P	P	P	P	P
tūī	tūī	*Prosthemadera novaeseelandiae*	Not Threatened	Not Threatened	P	P	P	P	P	P	P	P	P	P
pōpokotea	whitehead	*Mohoua albicilla*	At Risk, Declining	Not Threatened	P	P	P	P	P	P	P	P	P	P

Māori Name	Common Name	Scientific Name	National Threat Ranking	Regional Threat Ranking	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
makipai	Australian magpie	*Gymnorhina tibicen*	Introduced and Naturalised	Introduced and Naturalised	P		P	P	P	P	P	P		P
pīwakawaka	New Zealand fantail	*Rhipidura fuliginosa*	Not Threatened	Not Threatened	P	P	P	P	P	P	P	P	P	P
miromiro	tomtit	*Petroica macrocephala*	Not Threatened	Not Threatened						P				
tōtōwai	North Island robin	*P. longipes*	At Risk, Declining	Not Threatened	P	P	P		P			P	P	
	skylark	*Alauda arvensis*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P		P	P	P	P
tauhou	silvereye	*Zosterops lateralis*	Not Threatened	Not Threatened	P	P	P	P	P	P	P	P	P	P
warou	welcome swallow	*Hirundo neoxena*	Not Threatened	Not Threatened	P					P	P			
manu pango	Eurasian blackbird	*Turdus merula*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
	song thrush	*T. philomelos*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
tāringi	common starling	*Sturnus vulgaris*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P

Māori Name	Common Name	Scientific Name	National Threat Ranking	Regional Threat Ranking	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
tiu	house sparrow	*Passer domesticus*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
	dunnock	*Prunella modularis*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
pahirini	chaffinch	*Fringilla coelebs*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
	greenfinch	*Carduelis chloris*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
	goldfinch	*C. carduelis*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P
	common redpoll	*C. flammea*	Introduced and Naturalised	Introduced and Naturalised		P	P	P	P	P	P	P	P	P
	yellowhammer	*Emberiza citrinella*	Introduced and Naturalised	Introduced and Naturalised	P	P	P	P	P	P	P	P	P	P

Appendix Two

This table provides a summary of the annual mean number of birds detected per bird count for each native forest bird species that has been recorded in Wellington City since 2011. Species are ordered from the most to least frequently encountered, with the most conspicuous and/or abundant species listed first. Green rows denote species for which mean encounter rates have increased significantly since 2011; yellow rows denote species with stable encounter rates between 2011 and 2020 and red rows represent those species for which encounter rates have declined since 2011. Section 3.2 of this report provides a more detailed picture of the temporal trends in encounter rates for each individual species on this list.

Species	Average number of birds observed at each station									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Tūī	1.35	0.77	2.16	1.74	2.60	2.36	2.07	2.49	2.23	2.98
Tauhou / silvereye	1.86	2.38	2.03	2.20	2.05	2.40	2.34	2.02	1.98	2.06
Riroriro / grey warbler	0.84	1.24	1.29	1.05	1.45	1.06	1.29	1.26	0.87	1.01
Pīwakawaka / NZ fantail	0.35	0.22	0.23	0.32	0.21	0.28	0.35	0.36	0.43	0.42
Kākā	0.10	0.07	0.12	0.10	0.24	0.15	0.22	0.26	0.26	0.35
Kererū	0.07	0.03	0.11	0.08	0.08	0.18	0.13	0.13	0.20	0.20
Pīpīwharauroa / shining cuckoo	0.17	0.23	0.24	0.19	0.18	0.20	0.23	0.21	0.06	0.08
Tīeke / NI saddleback	0.07	0.02	0.03	0.02	0.06	0.06	0.10	0.09	0.06	0.06
Kākāriki / red-crowned parakeet	0.01	0.01	0.01	0.03	0.09	0.07	0.06	0.09	0.04	0.06
Pōpokotea / whitehead	0.06	0.09	0.04	0.06	0.05	0.05	0.08	0.07	0.11	0.05
Kōtare / NZ kingfisher	0.03	0.04	0.03	0.04	0.04	0.02	0.03	0.06	0.06	0.04

Species	Average number of birds observed at each station									
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Korimako / bellbird	0.00	0.02	0.03	0.01	0.00	0.01	0.03	0.01	0.05	0.02
Kārearea / NZ falcon	0.00	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.01
Tōtōwai / NI Robin	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.00
Hihi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Miromiro / tomtit	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Koekoeā / long-tailed cuckoo	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ruru / morepork	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tītitipounamu / rifleman	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00