



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

June 2018



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This report was prepared by Wildlife Management International Limited for Greater Wellington Regional Council in fulfilment of the Contract for Services dated 20th October 2017.

26th June 2018

Citation:

This report should be cited as:

McArthur, N.; Flux, I.; Harvey, A. and Ray, S. 2018. State and trends in the diversity, abundance and distribution of birds in Wellington City. Client report prepared for Greater Wellington Regional Council. Wildlife Management International Ltd, Blenheim.

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Cover Image: Shining cuckoo (*Chrysococcyx lucidus*). Photo credit: Rob Lynch/New Zealand Birds Online (<http://nzbirdsonline.org.nz/>).

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 2017. The aim of these surveys is to monitor trends in the diversity, abundance and distribution of native forest birds throughout Wellington City's reserve network, to provide a measure of local biodiversity management outcomes.

Since 2011 there has been a significant increase in the average number of native forest bird species encountered per bird count, likely caused by increases in the abundance and distribution of a number of resident bird species. Encounter rates for tūī, kākā and red-crowned parakeet have all increased significantly since 2011, and no decreases in encounter rates have been detected for any other native species.

These results suggest that the presence of Zealandia, and the increasing levels of predator control being carried out in parks, reserves and suburban areas throughout the city are creating improved opportunities for local residents and visitors to encounter a wider range of New Zealand's native forest bird species in the heart of New Zealand's capital city.

Local residents are becoming increasingly engaged as 'citizen scientists', helping to build an ever more detailed picture of changes in bird distribution in the city by contributing to a number of citizen science databases and projects. The New Zealand eBird database is the leading repository of such citizen science data for Wellington City, and we recommend that Wellington City Council takes further steps to encourage the use of this database by local citizen scientists.

We recommend that Wellington City Council continues to carry out these five-minute bird counts on an annual basis, to create the opportunity to monitor further improvements in the city's native bird communities as the council works towards achieving a Predator Free Wellington. We also provide a number of additional recommendations aimed at filling gaps in our existing knowledge of the abundance and distribution of native forest birds in Wellington City, and the threats that they face.

Keywords: Wellington City, five-minute bird count, bird abundance, encounter rate, Zealandia, citizen science, eBird, NatureWatch.

Wellington City forest reserves bird health check

Low Concern

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

Tūī, Silvereye, Grey warbler, Fantail, Shining cuckoo, Kingfisher



Moderate Concern

Small, localised or sparse populations. Moderate predator risk.

Falcon, Hihi, Kākā, Kākāriki, Kererū, Robin, Saddleback, Whitehead



High Concern

Tiny populations. High predator risk.

Bellbird



Data Deficient

Population size and trends poorly known.

Morepork



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1. INTRODUCTION

Over the past decade there has been a conspicuous increase in the diversity, abundance and distribution of native forest bird species in Wellington City (Miskelly et al, 2005). These changes are likely to be a consequence of two improvements in the management of indigenous forest habitats in and around Wellington City. Firstly, a series of species re-introductions 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 (Miskelly & Powlesland, 2013). These species include kākā (*Nestor meridionalis*), red-crowned parakeet (*Cyanoramphus novaezelandiae*) whitehead (*Mohoua albicilla*) and bellbird (*Anthornis melanura*) (Miskelly et al, 2005; Froude, 2009; McLaughlin & Harvey, 2013). Secondly, ongoing multi-species 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) and is creating an opportunity for recently re-introduced species to establish functional populations away from their original re-introduction sites.

Further improvements in efforts to protect and restore Wellington City's indigenous habitats that are now underway are likely to result in significant changes to the abundance and distribution of local native bird populations in the near future. Over 100 community-led conservation groups are now active in Wellington City and in 2014 these groups contributed a combined total of 34,611 volunteer hours towards local environmental restoration activities (WCC, 2015). Predator Free Wellington, a project co-funded by Wellington City Council, Greater Wellington Regional Council and the NEXT Foundation plans to build on the proliferation of pest-free suburb projects and aims to eradicate rats, mustelids and possums from Wellington City, beginning with a trial eradication project on Miramar Peninsula (Bell & Bell, 2017). If successful, these efforts will result in further dramatic improvements in the distribution and abundance of native bird species that are currently locally rare or extinct in Wellington City.

Monitoring ongoing changes 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 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 across the entire network of Wellington City parks and reserves, rather than a selected subset of reserves (McArthur et al, 2012). Tūī were chosen as a key focal species for this survey design due to their conspicuousness and popularity with the general public. Based on a power analysis of the pre-2011 Wellington City bird survey data, a sample size of 200 five-minute bird counts carried out at 100 locations across the city's parks and reserves network was chosen to ensure that this new design had sufficient statistical power to detect a 10% or more change in the relative abundance of tūī in Wellington City reserves from one year to the next.

These counts have now been carried out each year since 2011, and have demonstrated the important influence that Zealandia has on the native forest bird community in the wider Wellington City. Around 33% 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, 2012; 2013a; 2015; 2016). Many of these species were found to have very localised distributions beyond Zealandia's predator-proof fence however, indicating that mammalian predators are likely to still be significantly limiting the ability of these species to colonise other native forest habitats in the city's parks and reserves (McArthur et al, 2015).

Another key result from this work is that mean encounter rates for tūī, kākā and red-crowned parakeet have increased significantly between 2011 and 2017, suggesting that these species have increased in abundance and/or conspicuousness in Wellington City parks and reserves over this time (McArthur et al, 2017). This suggests that ongoing improvements in the intensity and spatial coverage of mammalian predator control in the city are benefitting these bird species.

In November 2017, an additional 77 five-minute bird count stations were established on a 320m x 320m grid overlaid across Miramar Peninsula in order to collect robust baseline measures of bird distribution and abundance on the peninsula prior to the proposed eradication of rats and mustelids (Bell & Bell, 2017; Ray & McArthur, 2017). These counts found that the peninsula supported a lower diversity and lower numbers of native forest birds compared to the rest of Wellington City, and that the local bird community is currently dominated by a relatively small number of introduced bird species (Ray & McArthur, 2017).

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 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, 2015).

This report provides an update on the emerging trends in the diversity, abundance and distribution of birds throughout Wellington City, by analysing and reporting a seventh year of five-minute bird counts and another year of citizen-science data collected since the publication of the previous bird monitoring report in June 2017.

2. METHODS

2.1 Five-minute bird count data collection

One hundred bird count stations were established at random locations in forest habitat in Wellington City parks and reserves in November 2011 and have been surveyed annually between 2011 and 2017 (Figure 2.1). Bird count stations were established at a minimum distance of 200 metres from one another and no less than 50 metres from the nearest forest edge. Each station was 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 were carried out at each station each year, with each count being carried out on a different day. All counts were carried out in November or early December 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 were employed to conduct the counts each year, with each observer surveying approximately half of the bird count stations.

Bird conspicuousness can vary in response to a number of 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 more likely 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.

Observer-related variation 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 conspicuous 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 six 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 established in Wellington City parks and reserves in 2011.

2.2 Five-minute bird count data analysis

The Wellington City five-minute bird count data were entered into a Microsoft Excel spreadsheet and then used to calculate the mean number of birds of each species detected per five-minute bird count each year, in order to examine temporal patterns in bird encounter rates (Dawson & Bull, 1975). For the purposes of this analysis, we defined a “native forest bird” as any native species capable of maintaining a functional population entirely within native forest habitat, and therefore likely to be a resident rather than transitory species in this habitat.

Because these raw data consist of relatively low counts which are naturally truncated at zero, the data is too skewed to conform to a normal distribution, a key assumption for many parametric tests for statistical significance. To deal with this, we first added a value of 1.0 to the number of species and individuals recorded during each count in order to remove zero values from the dataset, then applied an *a priori* square root transformation to the data to ensure that they were approximately normally distributed and with approximately equal sample variances before we proceeded with any further

analyses. Once we were satisfied that our transformed data met these assumptions, we used one-way analyses of variance (ANOVA) to test for statistically-significant differences in mean bird encounter rates between years (Fowler & Cohen, 1995). Performing these statistical tests is important because a statistically significant result indicates that any difference between the two or more means being compared is very unlikely to have occurred due to chance sampling error, so instead is assumed to represent a real difference in the abundance and/or conspicuousness of native forest birds between years.

Patterns in the distribution of native birds among Wellington City reserves were examined by mapping the relative frequency at which each native forest bird species was detected at each bird count station using QGIS version 3.0.3. Although this technique does not explicitly take into account relative differences in abundance (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 (less conspicuous species will also be less likely to be detected), it should be sufficient to detect relatively large changes in species' distributions (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 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. Since 2011, residents and visitors to the Wellington region have contributed almost 180,000 bird observations to online databases and citizen science projects such as the New Zealand eBird database, NatureWatch, the NZ Garden Bird Survey and the Great Kererū Count.

The New Zealand eBird database is the largest source of such citizen science data. The 164,564 bird observation records submitted to the eBird database for the Wellington region since 2011 accounts for around 91% of citizen science bird data available for the region. The New Zealand eBird database (<http://ebird.org/content/newzealand/>) 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 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 410,000 unique users having so far contributed over 500 million bird records describing the distribution of 98% of the world's bird species (Sullivan et al, 2014; <http://ebird.org/content/ebird/news/millions0417/>, accessed 30/06/2017).

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 2018 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 2018. 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) before adding these records to the distribution maps created from the five-minute bird count data.

The NatureWatch NZ database is the second-largest online source of citizen science bird data for the Wellington region. NatureWatch 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. Naturewatch NZ (<http://naturewatch.org.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. The 15,405 bird observation records submitted to NatureWatch for the Wellington region since 2011 account for around 8% of citizen science bird data available for the region. Within this dataset, 9060 records (58%) are bird observations submitted directly to NatureWatch. A further 4389 records (28%) are bird observations collected by people participating in Landcare Research's New Zealand Garden Bird Survey¹, which have subsequently been uploaded to NatureWatch. An additional 1956 records (13%) are kererū observations submitted by people participating in the Kererū Discovery Project's Great Kererū Count², which have likewise been uploaded to NatureWatch.

Within the NatureWatch 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 original species identifications have been verified by another NatureWatch user. Because most bird observations submitted to NatureWatch aren't accompanied by photographs, the majority of records are "casual grade" records. We used the search tool on the NatureWatch website to download all bird observations recorded in Wellington City between 2011 and 2018. We formatted this dataset using Microsoft Excel, 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. NatureWatch automatically obscures the locations of taxa that have been given a conservation status of "Near Threatened" or higher on the IUCN Red List of threatened species (<http://naturewatch.org.nz/pages/help#obscured>; accessed 30/06/2017). As a result, any records for these taxa are assigned a random set of coordinates that are within a ca. 20x 20 km cell containing the true coordinates. Because the locations of these observations are obscured in such a way, several hundred observations for a number of threatened or 'At Risk' bird taxa had to be discarded due to inaccurate location data, as there is no clear guidance on the NatureWatch website regarding how researchers can go about accessing the original, true locations of these records.

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.

3. RESULTS

3.1 Species diversity

The total number of bird species detected during these five minute bird counts has varied little between 2011 and 2017, with between 29 and 34 bird species detected each year (Figure 3.1). Between 10% and 19% of these species detected each year are native species ranked as either Nationally Threatened or 'At Risk' under the New Zealand Threat Classification System and a further 30% to 41% are native species ranked as Not Threatened (Robertson et al, 2013; 2017). Between 42% and 52% of species detected are listed as Introduced and Naturalised (see Appendix). Two new species

¹ <http://www.landcareresearch.co.nz/science/plants-animals-fungi/animals/birds/garden-bird-surveys>; accessed 30/06/2017

² <https://kererudiscovery.org.nz/great-kereru-count-2016/>

were detected in 2017 that hadn't been detected during counts carried out in the preceding six years, little penguin (*Eudyptula minor*) and spotted shag (*Stictocarbo punctatus*). Both species maintain large breeding colonies on Mātīu/Somes, Mokopuna and Makaro/Ward Islands in Wellington Harbour, and are frequently observed in the harbour and on the adjacent Wellington City coastline (Bull et al, 2000; Waugh et al, 2013; eBird, 2017).

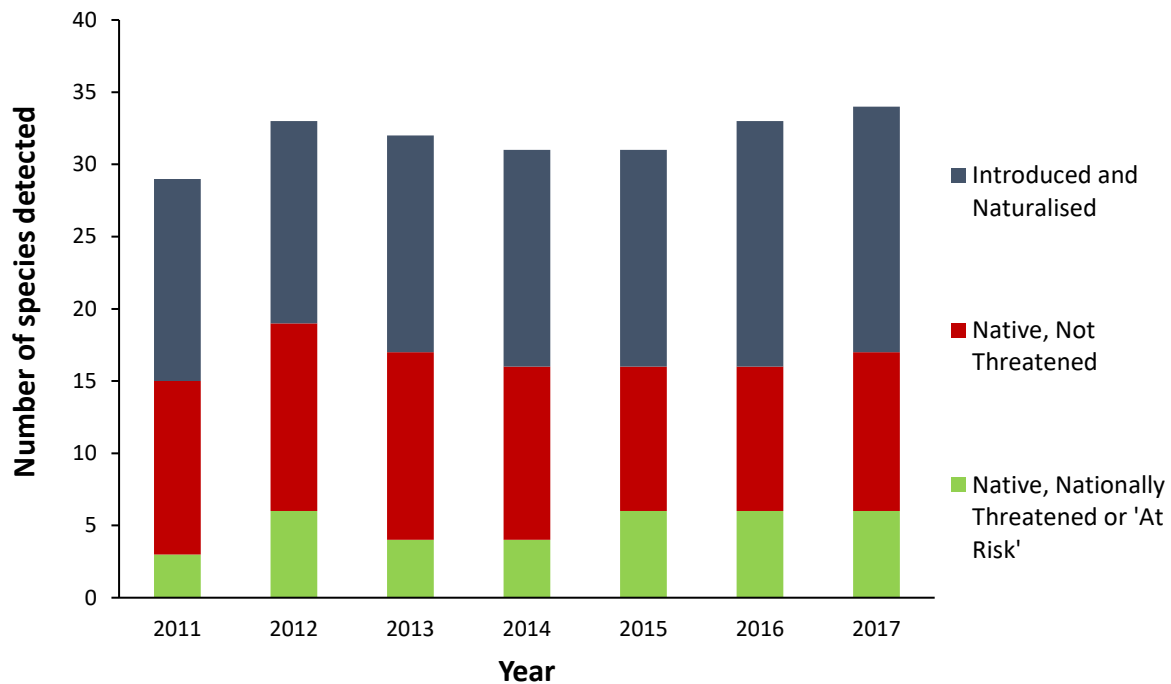


Figure 3.1: Total number of bird species detected during five-minute bird counts carried out in Wellington City parks and reserves, 2011-2017.

Eighteen of the native bird species detected between 2011 and 2016 were species that are typically found in native forest habitat and it is these species for which trends in relative abundance and distribution have been reported below. The remaining nine native species recorded were either open-country or coastal species such as Australasian harrier (*Circus approximans*), paradise shelduck (*Tadorna variegata*) or red-billed gull (*Larus novaehollandiae*) and are not included in any further analyses. A full list of all of the bird species detected during these counts can be found in the Appendix at the end of this report.

Between 2011 and 2017 there has been significant year-to-year variation in the mean number of native forest bird species detected per bird count station in Wellington City reserves ($F_{6,1393} = 10.24$, $p = 4.13 \times 10^{-11}$; one-way ANOVA). Over the seven years of bird counts, there has been a gradual upward trend in the mean number of native forest birds detected per station (Figure 3.2).

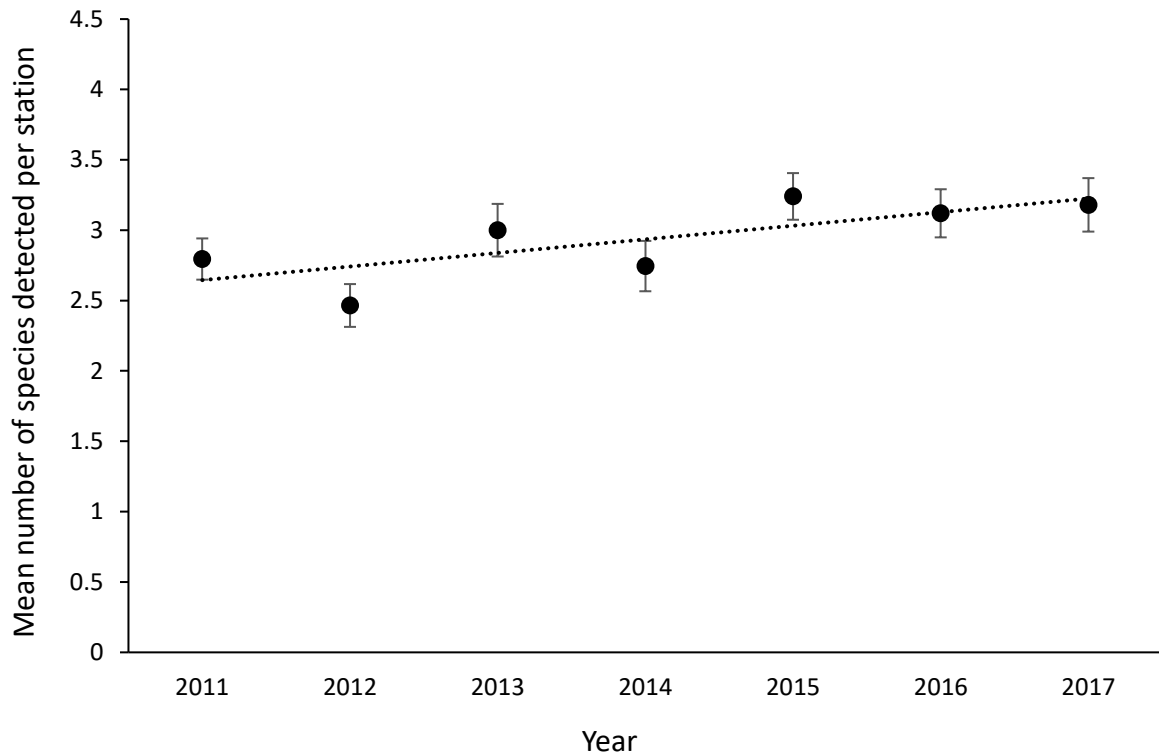


Figure 3.2: Mean number of native forest bird species recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

Mean species richness also varied spatially across Wellington City. The mean number of native forest bird species detected per bird count station tends to be higher in forest habitat within 1-2 km of Zealandia’s boundary, and in remaining areas of original native forest habitat including Otari-Wilton Bush and Khandallah Park. In contrast, lower numbers of native forest species tend to be detected in smaller patches of regenerating native forest, forest habitat on more exposed slopes or those areas of habitat that are less well connected to one another (Figure 3.3).

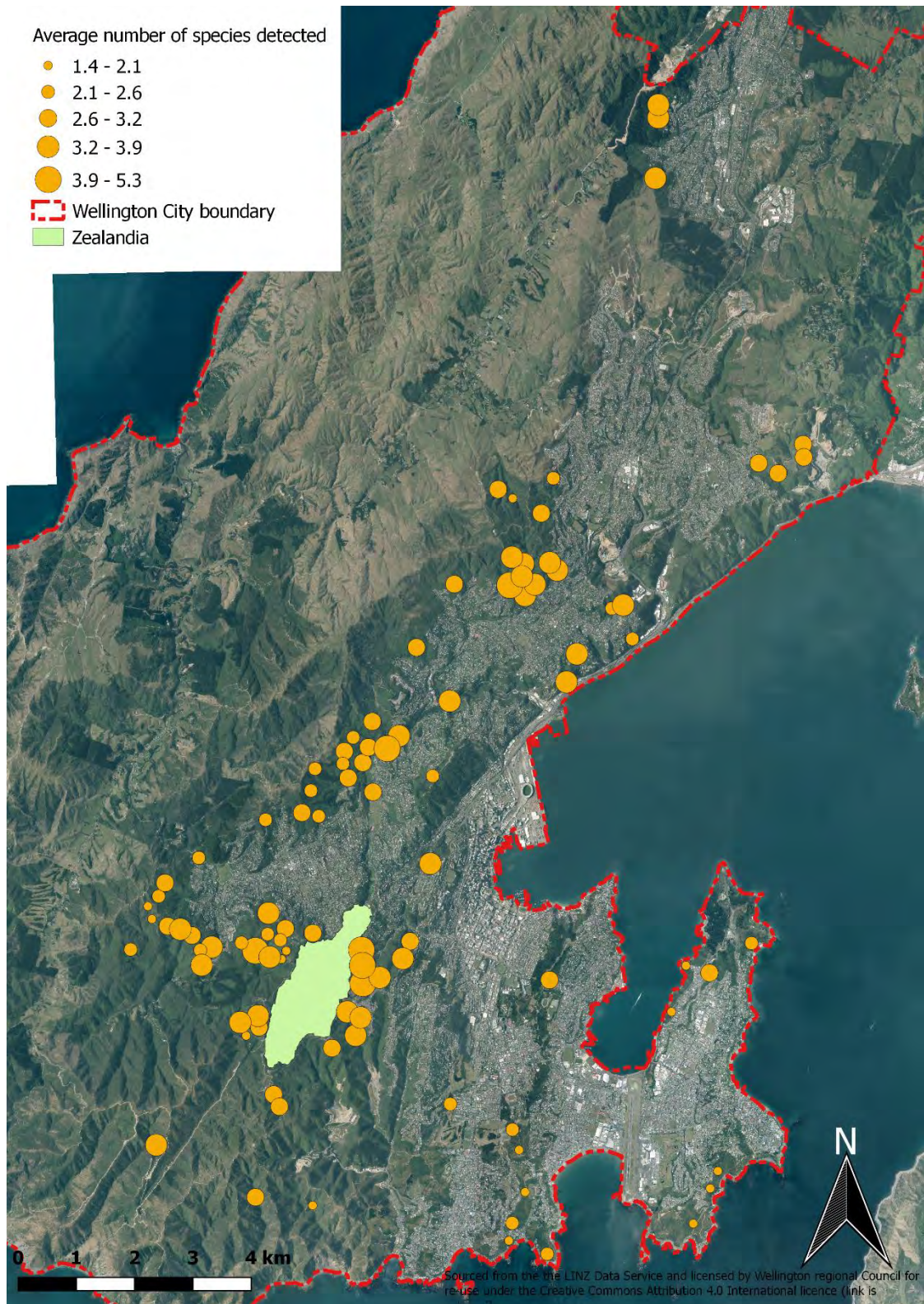


Figure 3.3: Mean number of native forest bird species detected at each five-minute bird count station in Wellington City between 2011 and 2017.

3.2 Abundance and distribution of native forest bird species

The following species accounts are listed in approximate order of decreasing 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.

3.2.1 Tūī (*Prosthemadera novaeseelandiae*)

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

Regional conservation status: Not Threatened (GWRC/DoC, unpublished data).

Tūī encounter rates have increased significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 28.93$, $p = 9.16 \times 10^{-33}$; one-way ANOVA; Figure 3.4). Tūī are common and widespread in Wellington City, and are recorded from the majority of five-minute bird count stations each year. Tūī are also the bird species most frequently reported by local citizen scientists, with 4573 tūī observations reported within Wellington City limits since 2011 (Figure 3.5).



Image courtesy of Tony Whitehead/NZ Birds Online

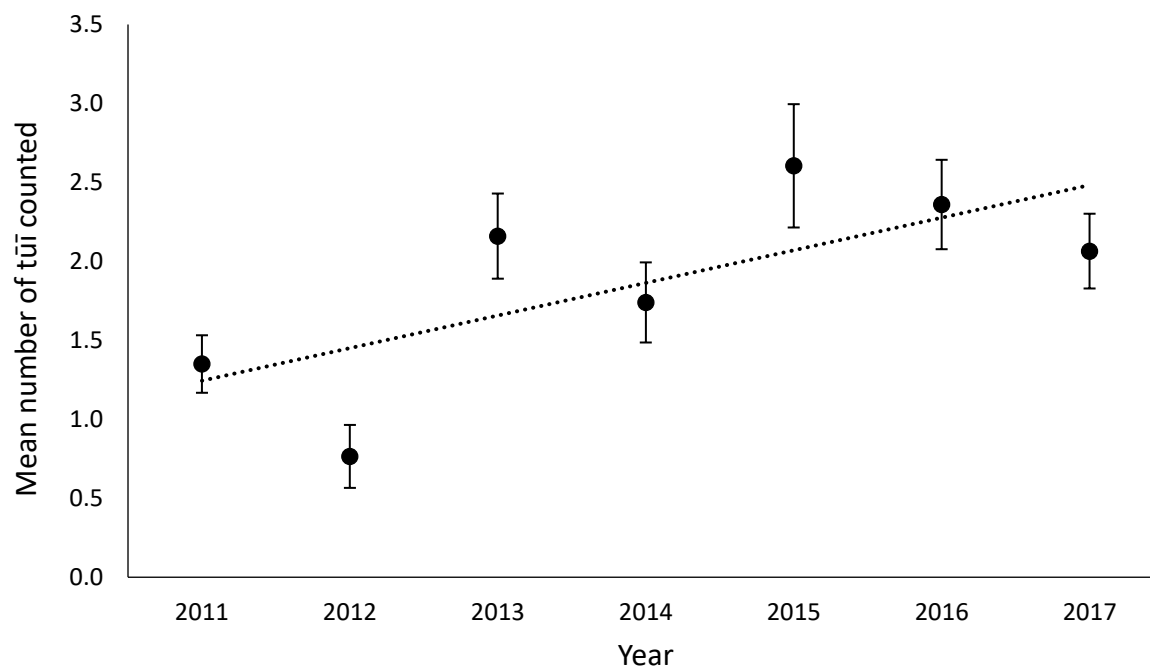


Figure 3.4: Mean number of tūī recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

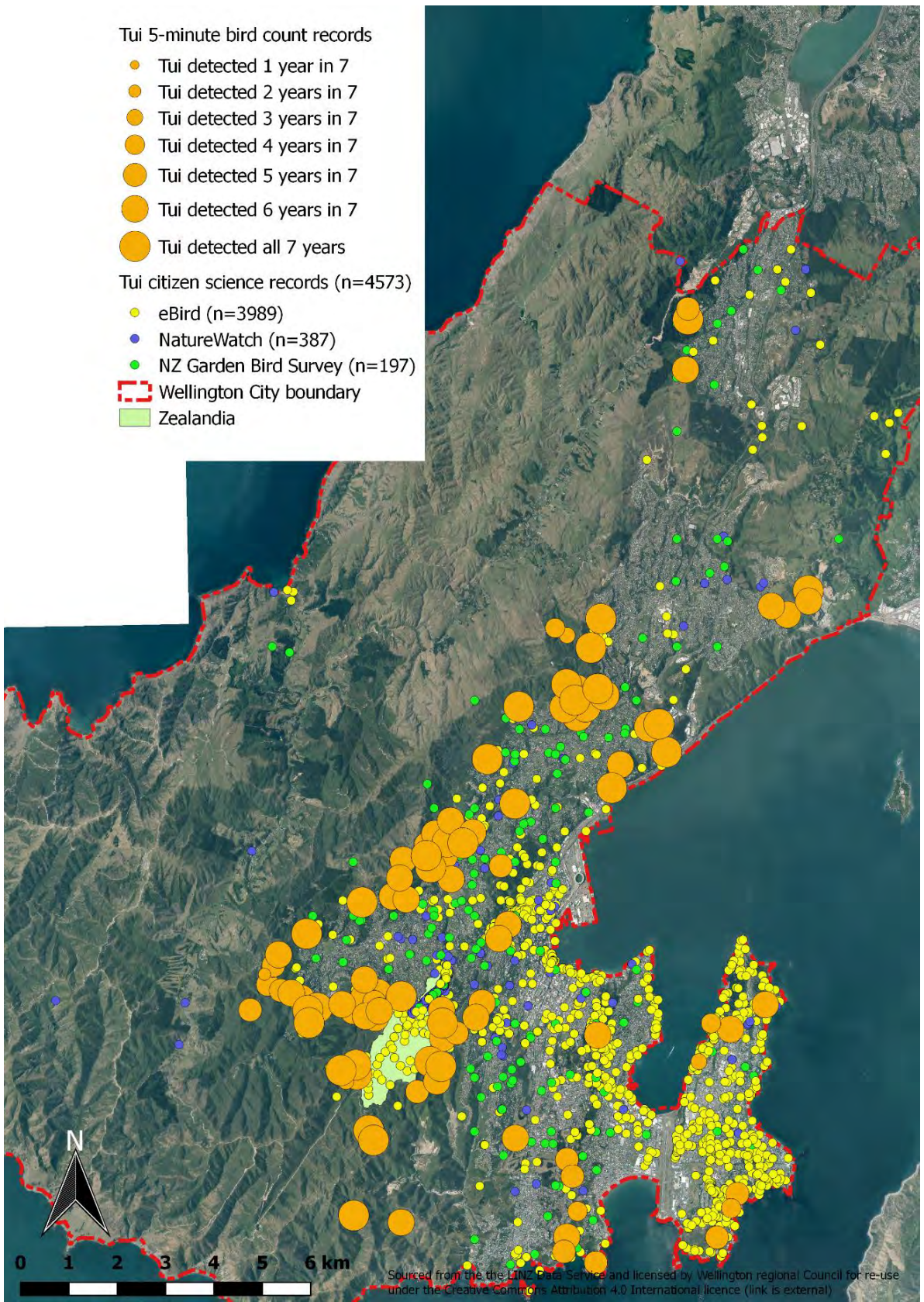


Figure 3.5: Distribution of tūi in Wellington City between 2011 and 2018. Orange circles represent tūi detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent tūi observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.2 Silvereye (*Zosterops lateralis*)

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

Regional conservation status: Not Threatened (GWRC/DoC, unpublished data).

Silvereye encounter rates have not changed significantly in Wellington City between 2011 and 2017, and are relatively consistent from one year to the next ($F_{6,1393} = 1.50, p = 0.17$; one-way ANOVA; Figure 3.6). Silvereyes are common and widespread in Wellington City, and are recorded from the majority of five-minute bird count stations each year. Silvereyes are also the third most frequently observed bird species reported by local citizen scientists, with 2367 silvereye observations reported within Wellington City limits since 2011 (Figure 3.7).



Image courtesy of Ormond Torr/NZ Birds Online

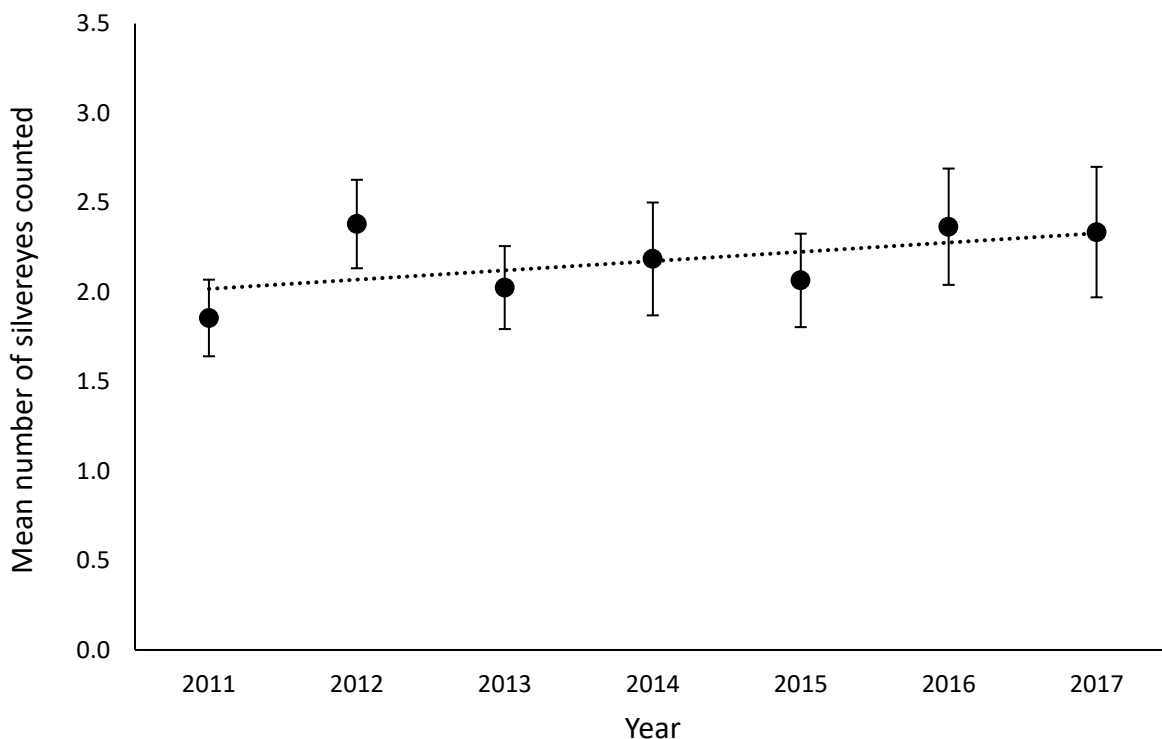


Figure 3.6: Mean number of silvereyes recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

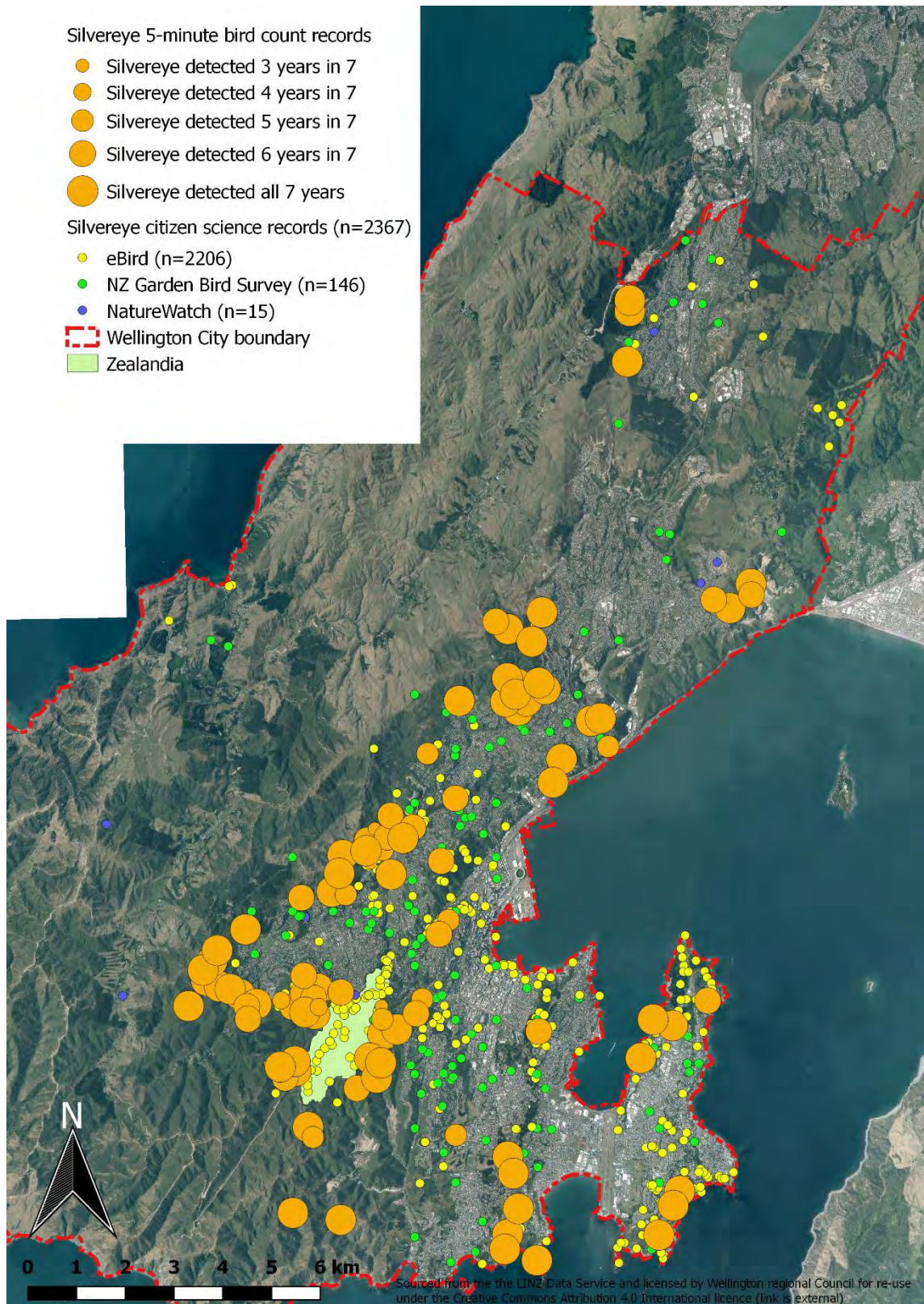


Figure 3.7: Distribution of silvereye in Wellington City between 2011 and 2018. Orange circles represent silvereye detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent silvereye observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.3 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 (GWRC/DoC, unpublished data).

Grey warbler encounter rates have not changed significantly in Wellington City between 2011 and 2017, however there have been some statistically-significant fluctuations in encounter rates from year to year ($F_{6,1393} = 7.73$, $p = 3.41 \times 10^{-8}$; one-way ANOVA; Figure 3.8). Grey warblers are common and widespread in Wellington City, and are recorded from the majority of five-minute bird count stations each year. Grey warblers are also the fourth most frequently observed bird species reported by local citizen scientists, with 2177 grey warbler observations reported within Wellington City limits since 2011 (Figure 3.9).

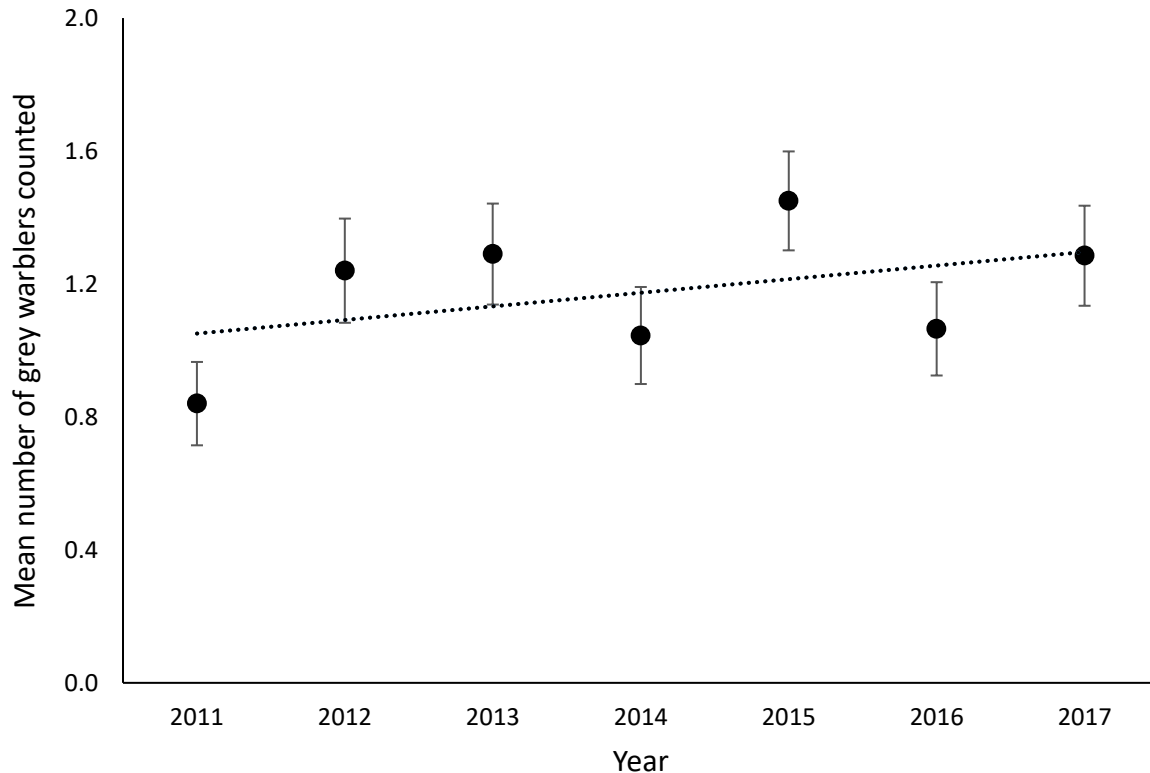


Figure 3.8: Mean number of grey warblers recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

- Grey warbler 5-minute bird count records
- Grey warbler present 2 years in 7
 - Grey warbler present 3 years in 7
 - Grey warbler present 4 years in 7
 - Grey warbler present 5 years in 7
 - Grey warbler present 6 years in 7
 - Grey warbler present all 7 years
- Grey warbler citizen science records (n=2177)
- eBird (n=2088)
 - NZ Garden Bird Survey (n=63)
 - NatureWatch (n=26)
- ▭ Wellington City boundary
- ▭ Zealandia

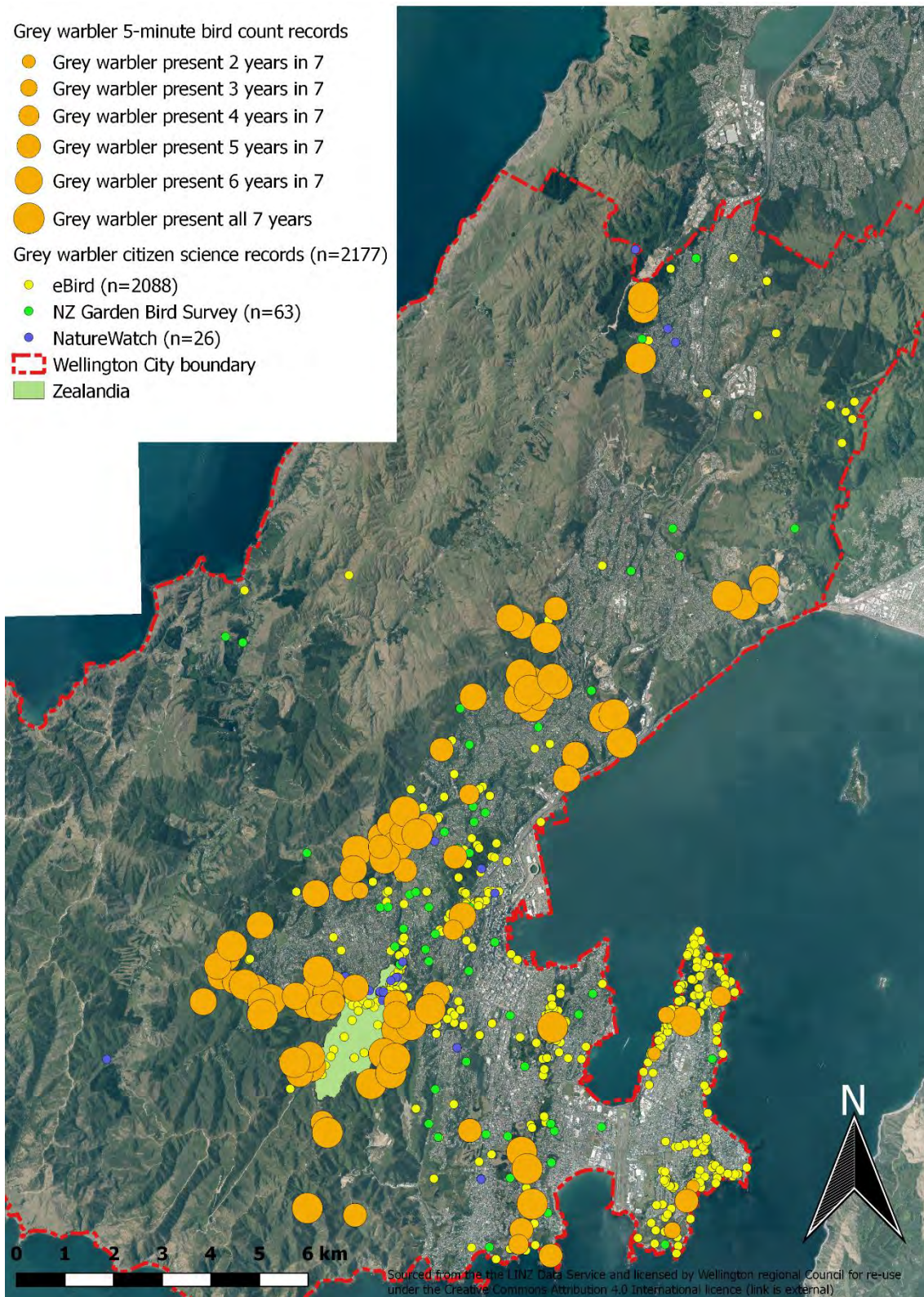


Figure 3.9: Distribution of grey warbler in Wellington City between 2011 and 2018. Orange circles represent grey warbler detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent grey warbler observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.4 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 (GWRC/DoC, unpublished data).

Fantail encounter rates have not changed significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 1.99$, $p = 0.06$; one-way ANOVA; Figure 3.10). Fantails are common and widespread in Wellington City, though are less frequently encountered at five-minute bird count stations in the southern parts of the city. Fantails are also the sixth most frequently observed bird species reported by local citizen scientists, with 1362 fantail observations reported within Wellington City limits since 2011 (Figure 3.11).

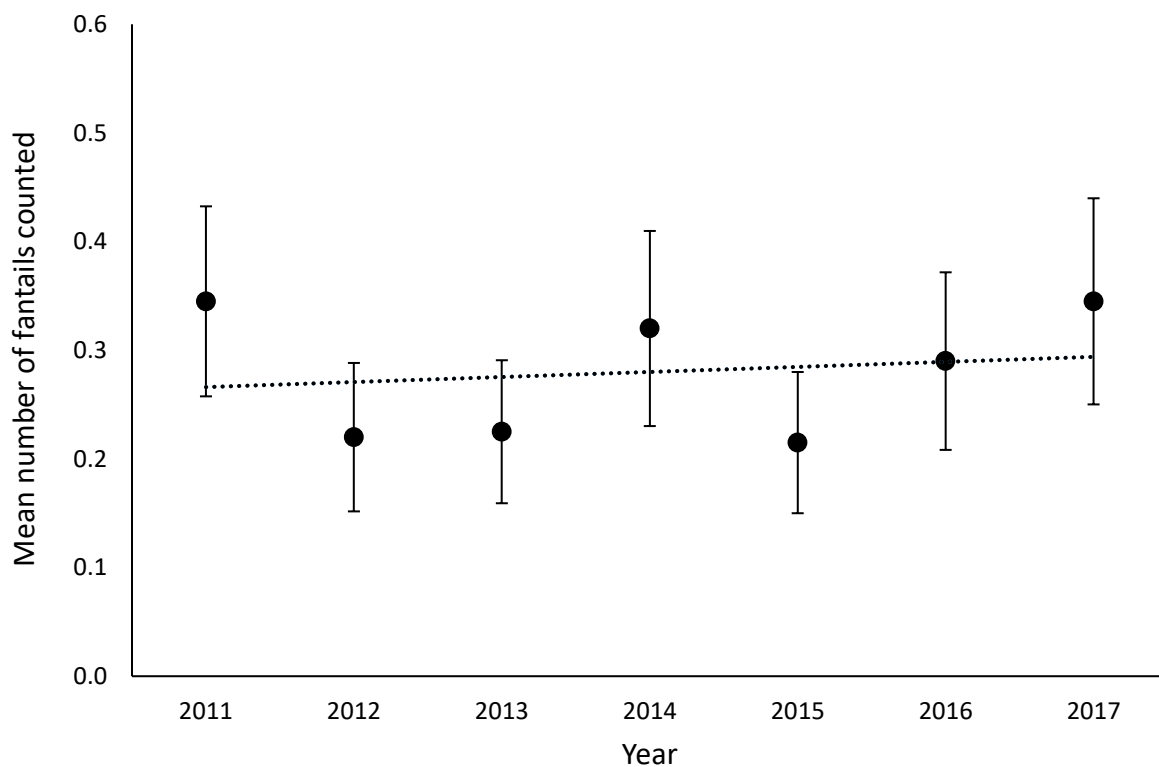


Figure 3.10: Mean number of fantails recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

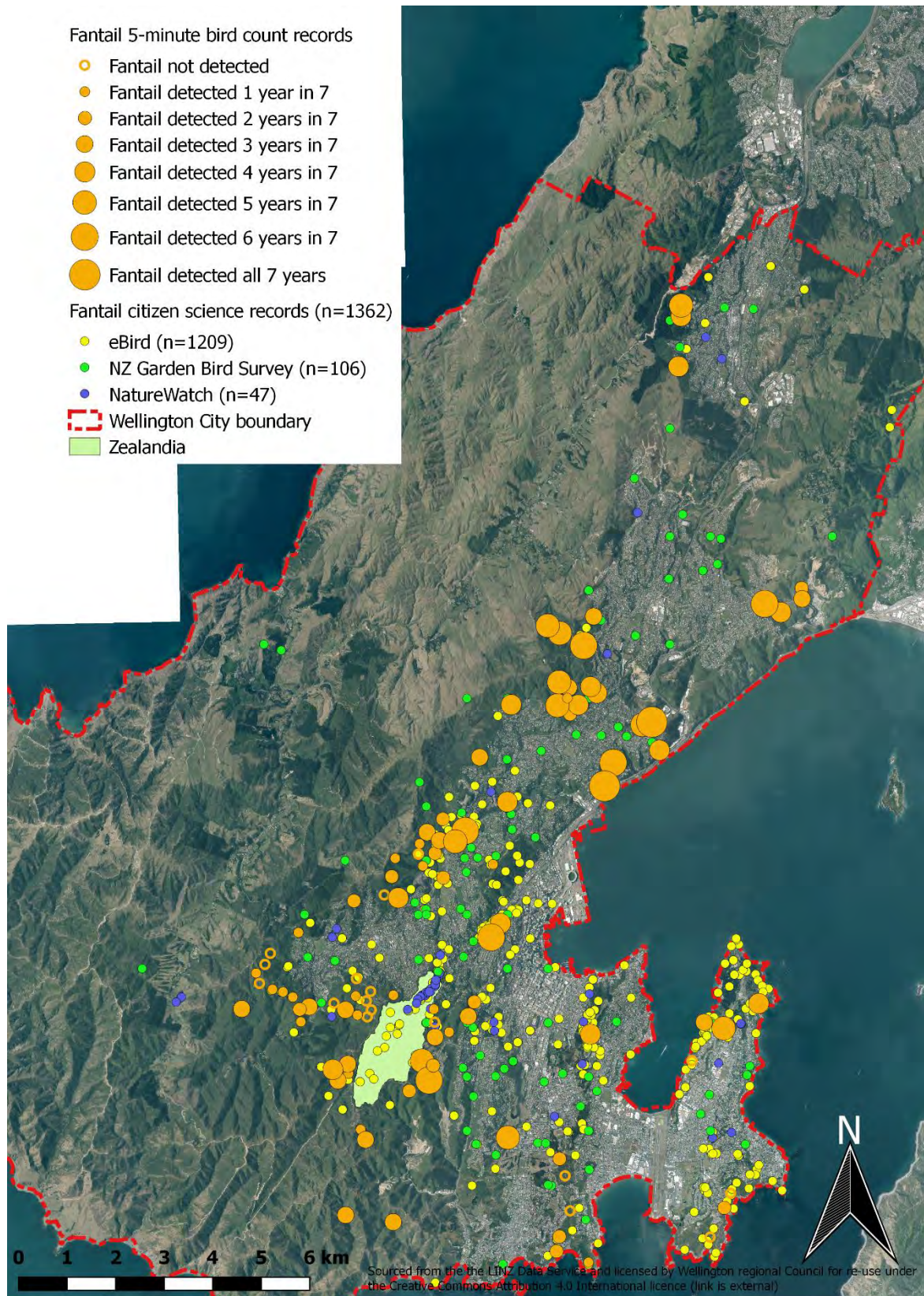


Figure 3.11: Distribution of fantail in Wellington City between 2011 and 2018. Orange circles represent fantail detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent fantail observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.5 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 (GWRC/DoC, unpublished data).

Shining cuckoo encounter rates have not changed significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 0.74$, $p = 0.62$; one-way ANOVA; Figure 3.12). Shining cuckoos are sparsely distributed throughout Wellington City, though encounter rates appear to be highest in forest habitat within 1km of Zealandia and in Khandallah Park. Shining cuckoos are also the eleventh most frequently observed bird species reported by local citizen scientists, with 437 shining cuckoo observations reported within Wellington City limits since 2011 (Figure 3.13).

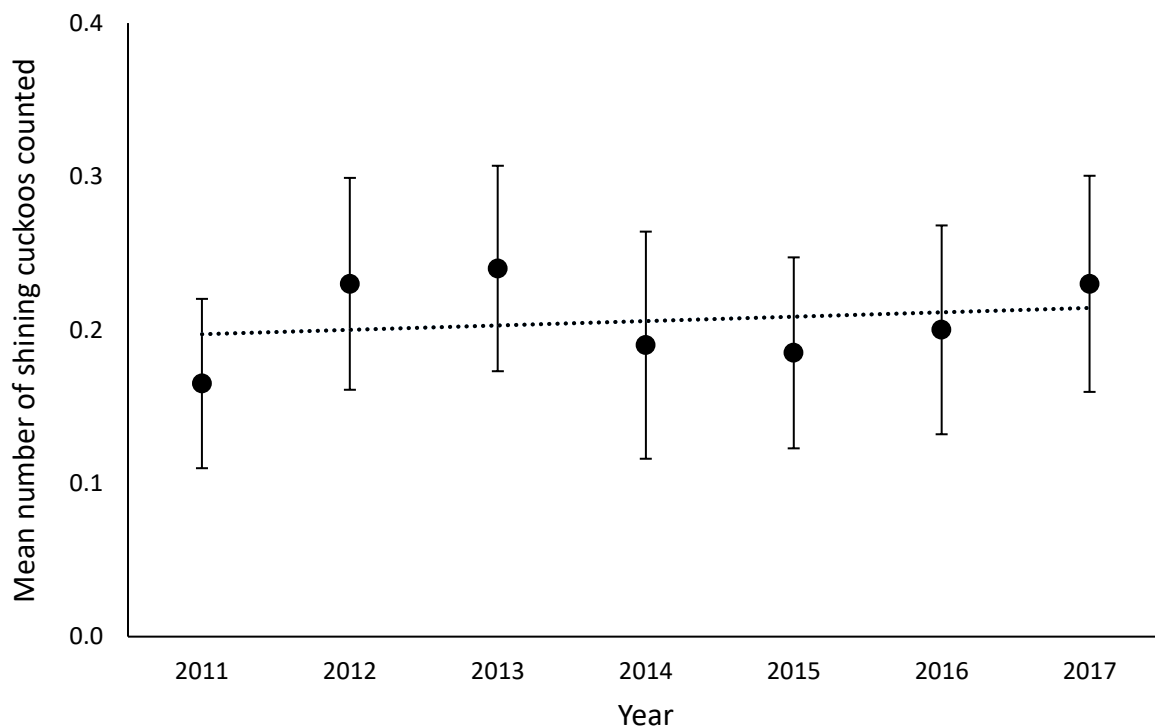


Figure 3.12: Mean number of shining cuckoos recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

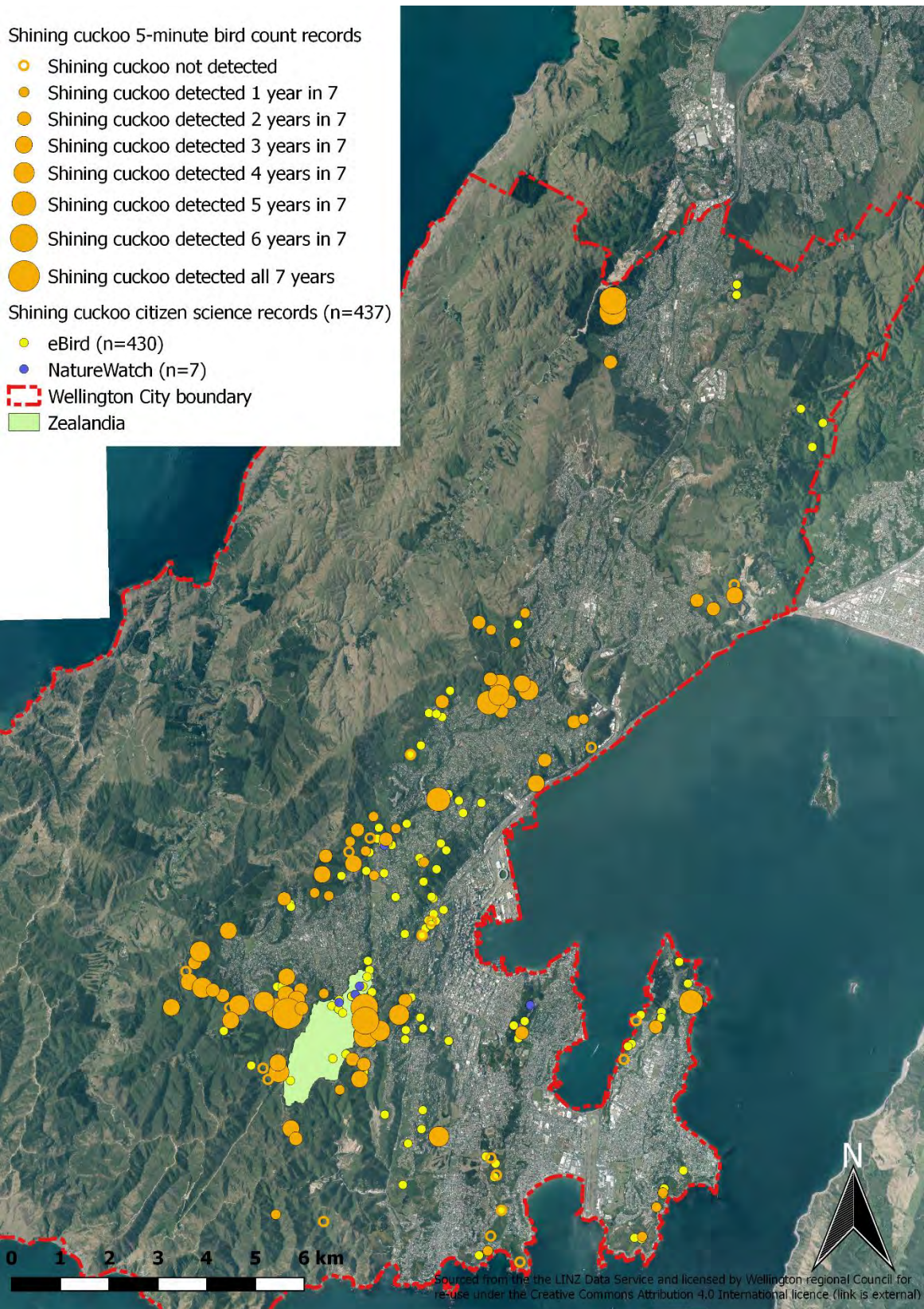


Figure 3.13: Distribution of shining cuckoo in Wellington City between 2011 and 2018. Orange circles represent shining cuckoo detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent shining cuckoo observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.6 kākā (*Nestor meridionalis*)

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

Regional conservation status: Regionally Vulnerable (GWRC/DoC, unpublished data).

Kākā encounter rates have increased significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 3.09$, $p = 0.005$; one-way ANOVA; Figure 3.14). Kākā are now commonly encountered in central Wellington, particularly in the suburbs of Karori, Wadestown, Ngaio, Kelburn, Te Aro and Brooklyn. They are also continuing to extend their range into more northern suburbs such as Johnsonville, and more eastern suburbs such as Miramar. Kākā are also the fifth most frequently observed bird species reported by local citizen scientists, with 1737 kākā observations reported within Wellington City limits since 2011 (Figure 3.15).



Image courtesy of Jean-Claude Stahl/NZ Birds Online

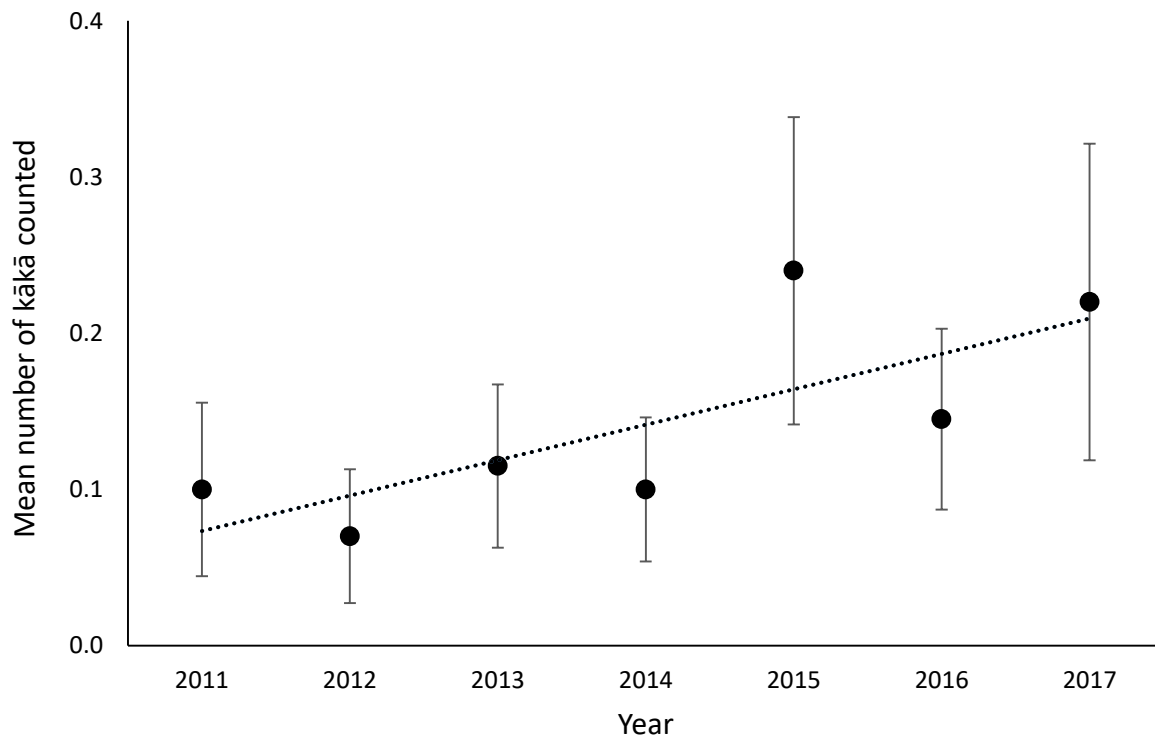


Figure 3.14: Mean number of kākā recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

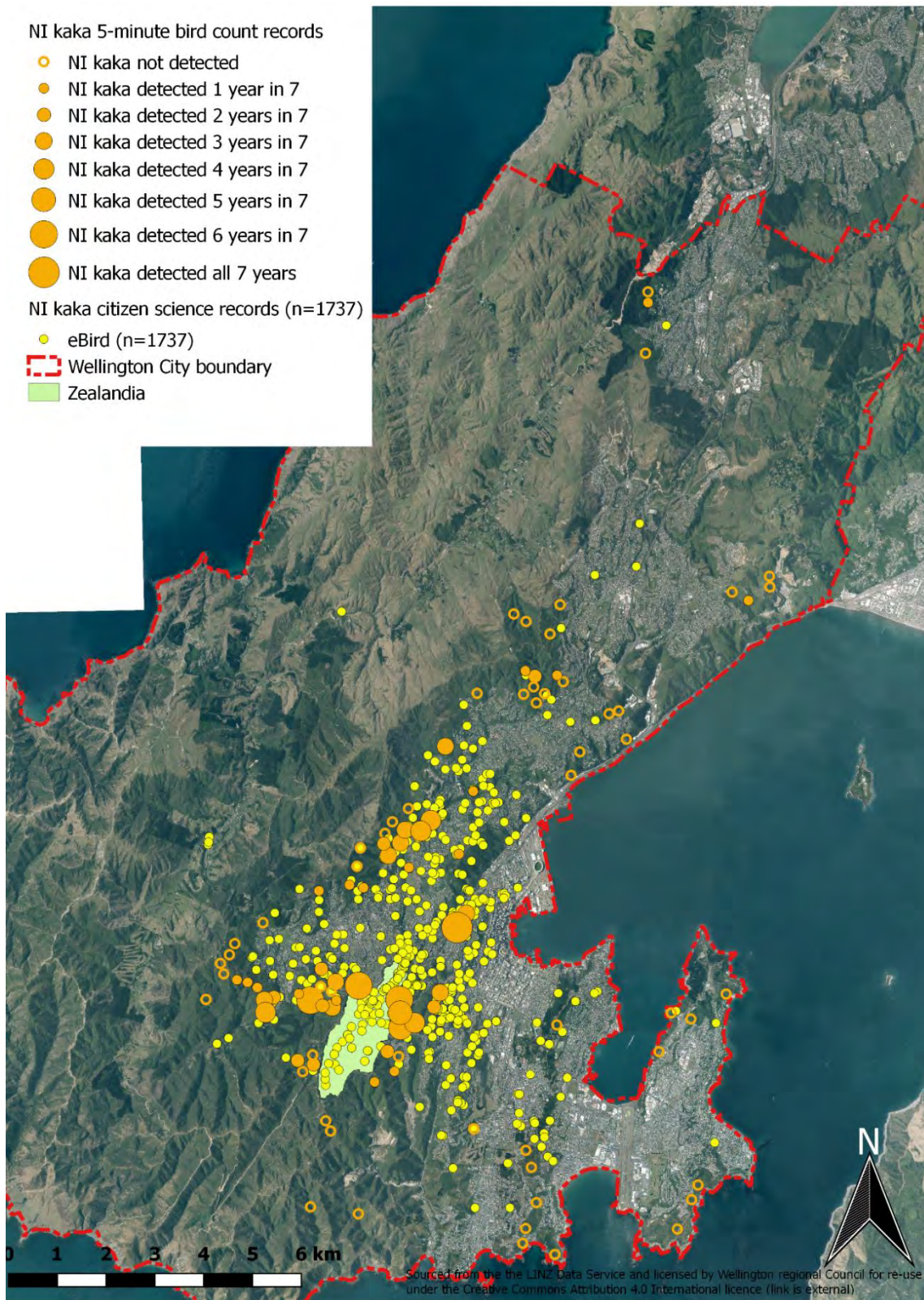


Figure 3.15: Distribution of kākā in Wellington City between 2011 and 2018. Orange circles represent kākā detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent kākā observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.7 Kererū (*Hemiphaga novaeseelandiae*)

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

Regional conservation status: Not threatened (GWRC/DoC, unpublished data).

Kererū encounter rates have increased significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 3.57$, $p = 0.0016$; one-way ANOVA; Figure 3.16). Much of this increase has been between 2015 and 2017 however, so further monitoring will be required to determine whether this increase is part of a long-term trend, or simply inter-annual variation in encounter rates caused by a change in distribution or habitat use. Kererū encounter rates are highest in reserves containing original native forest habitat, such as Otari-Wilton Bush and Khandallah Park, but they are also frequently observed in adjacent suburban areas. Kererū are the second most frequently observed bird species reported by local citizen scientists, with 2597 kererū observations reported within Wellington City limits since 2011 (Figure 3.17).



Image courtesy of Arindam Bhattacharya/NZ Birds Online

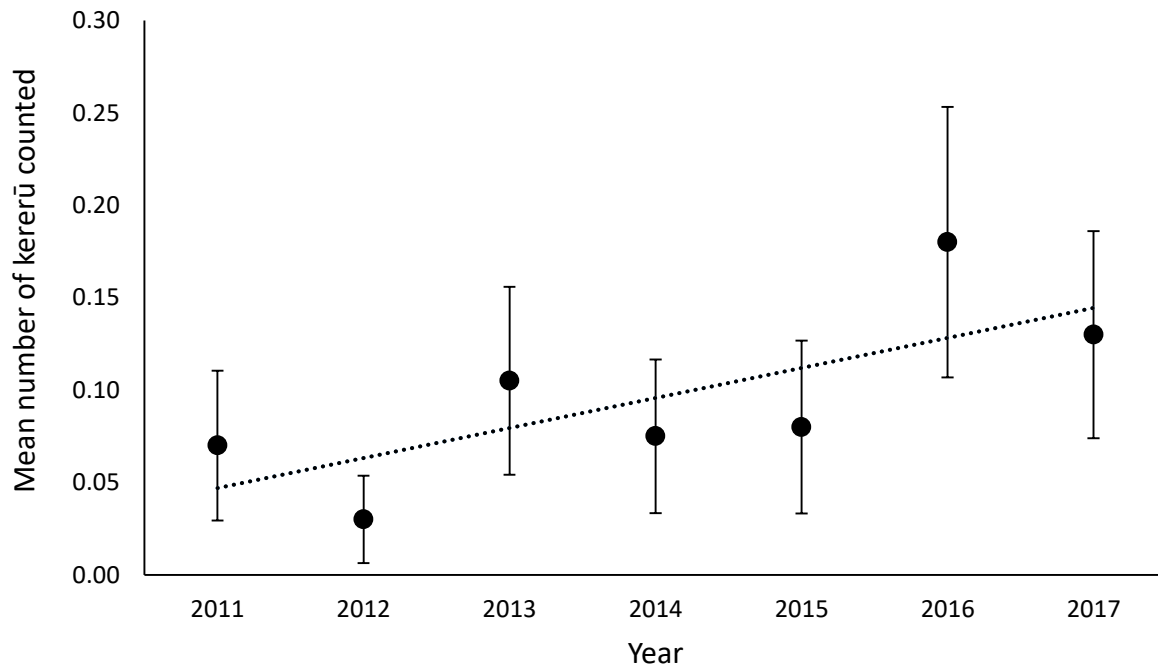


Figure 3.16: Mean number of kererū recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

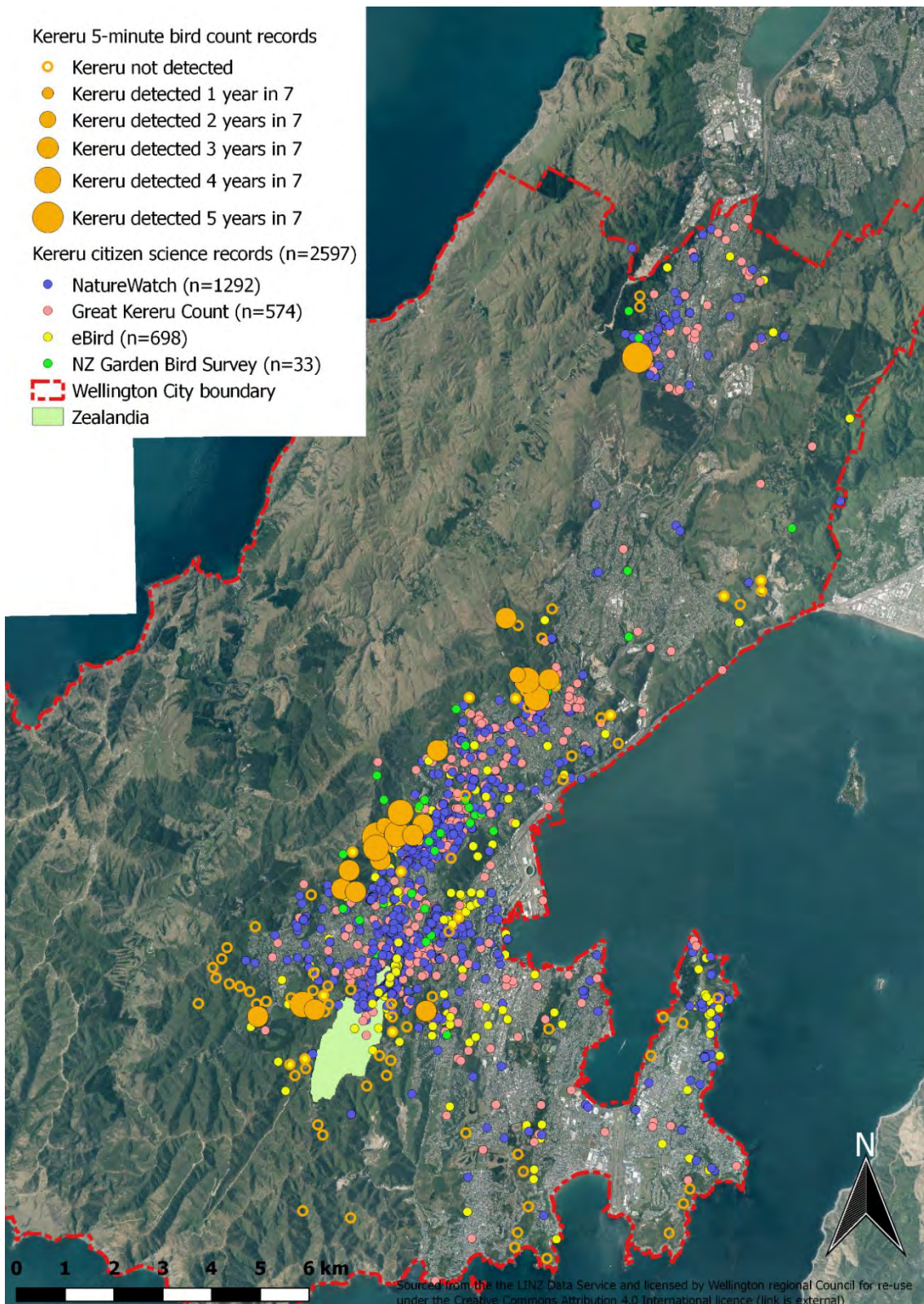


Figure 3.17: Distribution of kererū in Wellington City between 2011 and 2018. Orange circles represent kererū detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent kererū observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.8 North Island saddleback (*Philesturnus rufusater*)

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

Regional conservation status: Regionally Endangered (GWRC/DoC, unpublished data).

North Island saddleback encounter rates have varied significantly from year to year between 2011 and 2017 ($F_{6,1393} = 3.02, p = 0.006$; one-way ANOVA; Figure 3.18). It appears that encounter rates have increased significantly since 2012, suggesting that ongoing improvements to mammalian pest control in the city are beginning to benefit this species. NI saddleback are largely restricted to Zealandia or forested reserves less than 1-2 km from Zealandia's pest-proof boundary fence. NI saddleback are the ninth most frequently observed bird species reported by local citizen scientists, with 458 NI saddleback observations reported within Wellington City limits since 2011 (Figure 3.19).



Image courtesy of Rob Lynch/NZ Birds Online

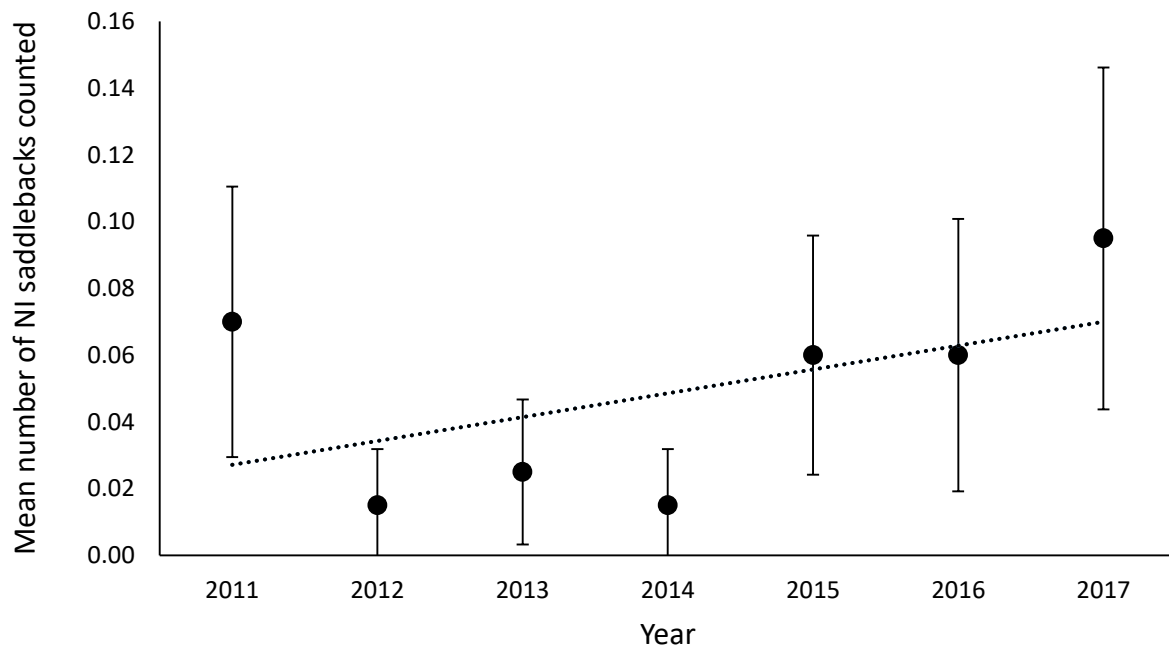


Figure 3.18: Mean number of NI saddlebacks recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

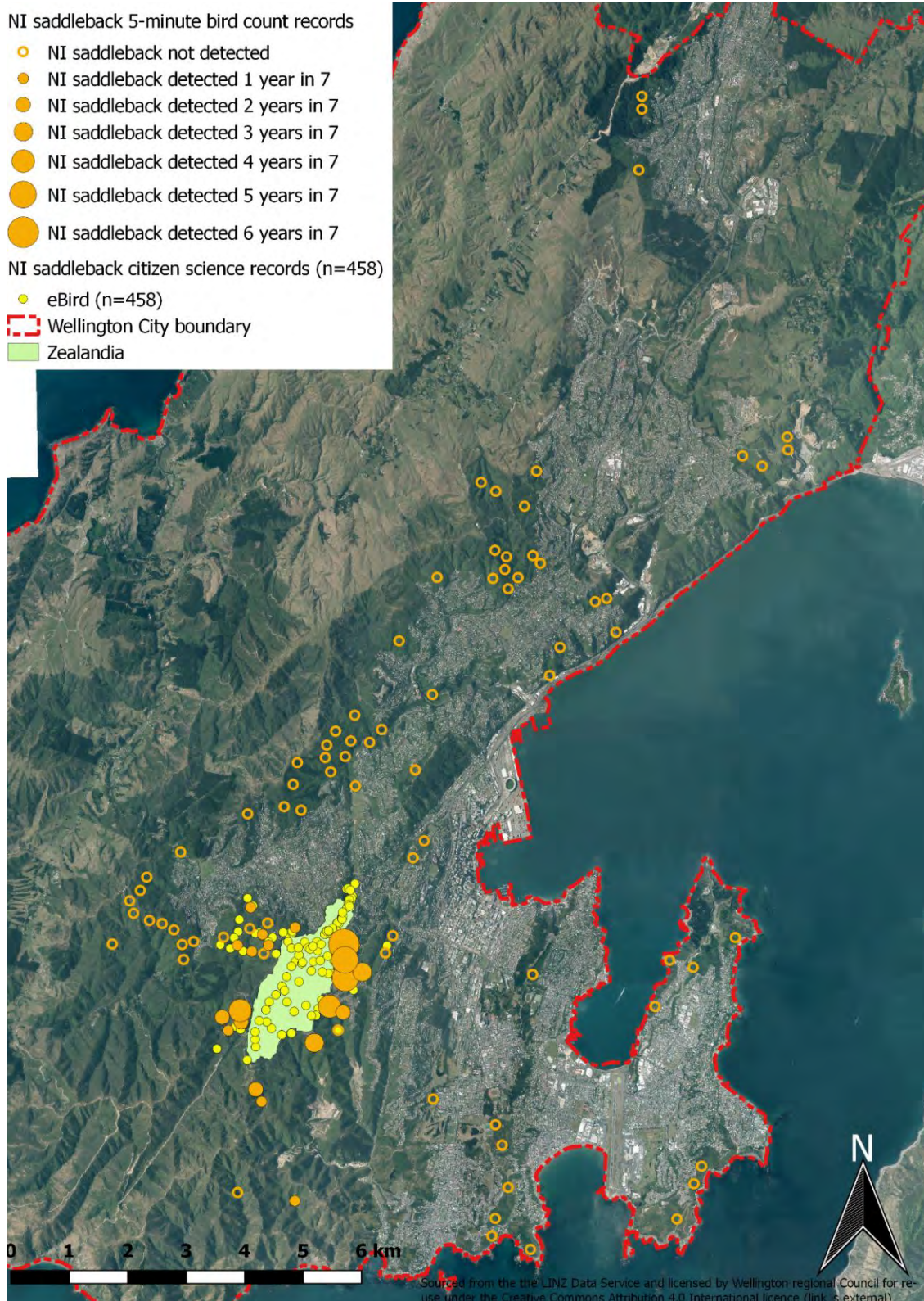


Figure 3.19: Distribution of NI saddleback in Wellington City between 2011 and 2018. Orange circles represent NI saddleback detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent NI saddleback observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.9 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 (GWRC/DoC, unpublished data).

Whitehead encounter rates have not changed significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 0.42$, $p = 0.867$; one-way ANOVA; Figure 3.20). Whiteheads are largely restricted to Zealandia and to forest reserves within 1-2 km of Zealandia's boundary fence, however they may also have recently colonised Trelissick Park and Prince of Wales Park. Whiteheads are the thirteenth most frequently

observed bird species reported by local citizen scientists, with 364 whitehead observations reported within Wellington City limits since 2011 (Figure 3.21).

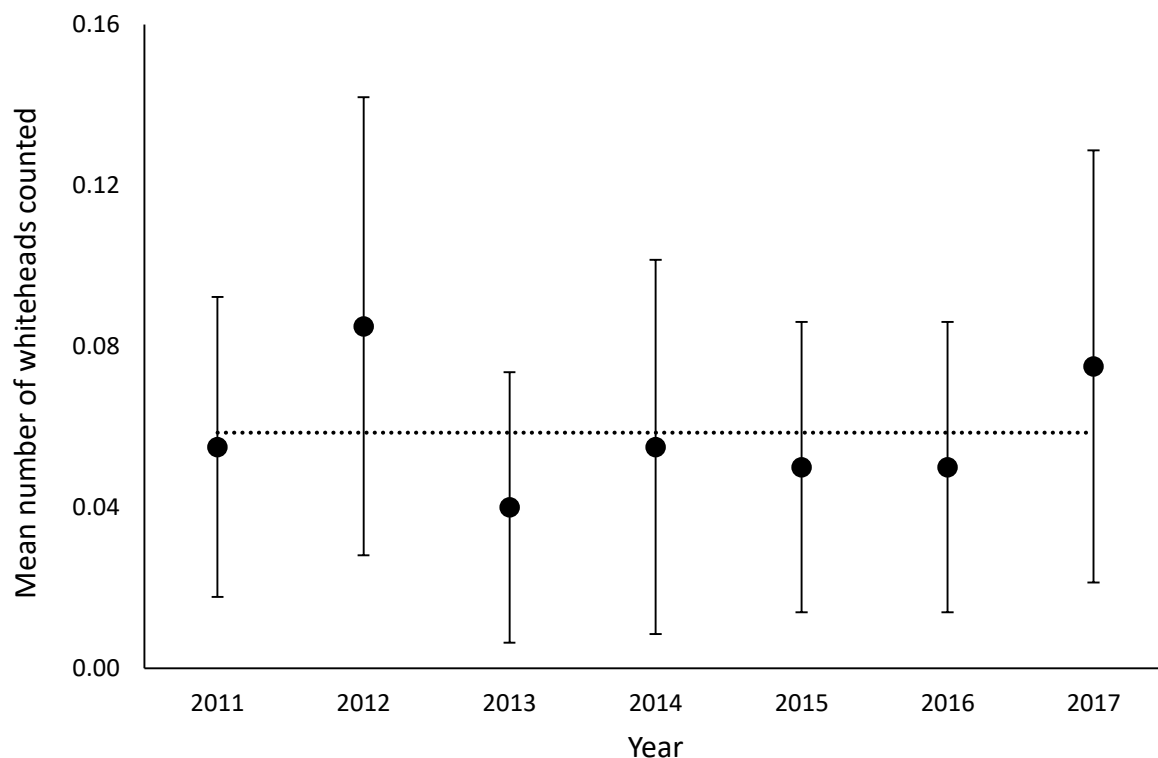


Figure 3.20: Mean number of whiteheads recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

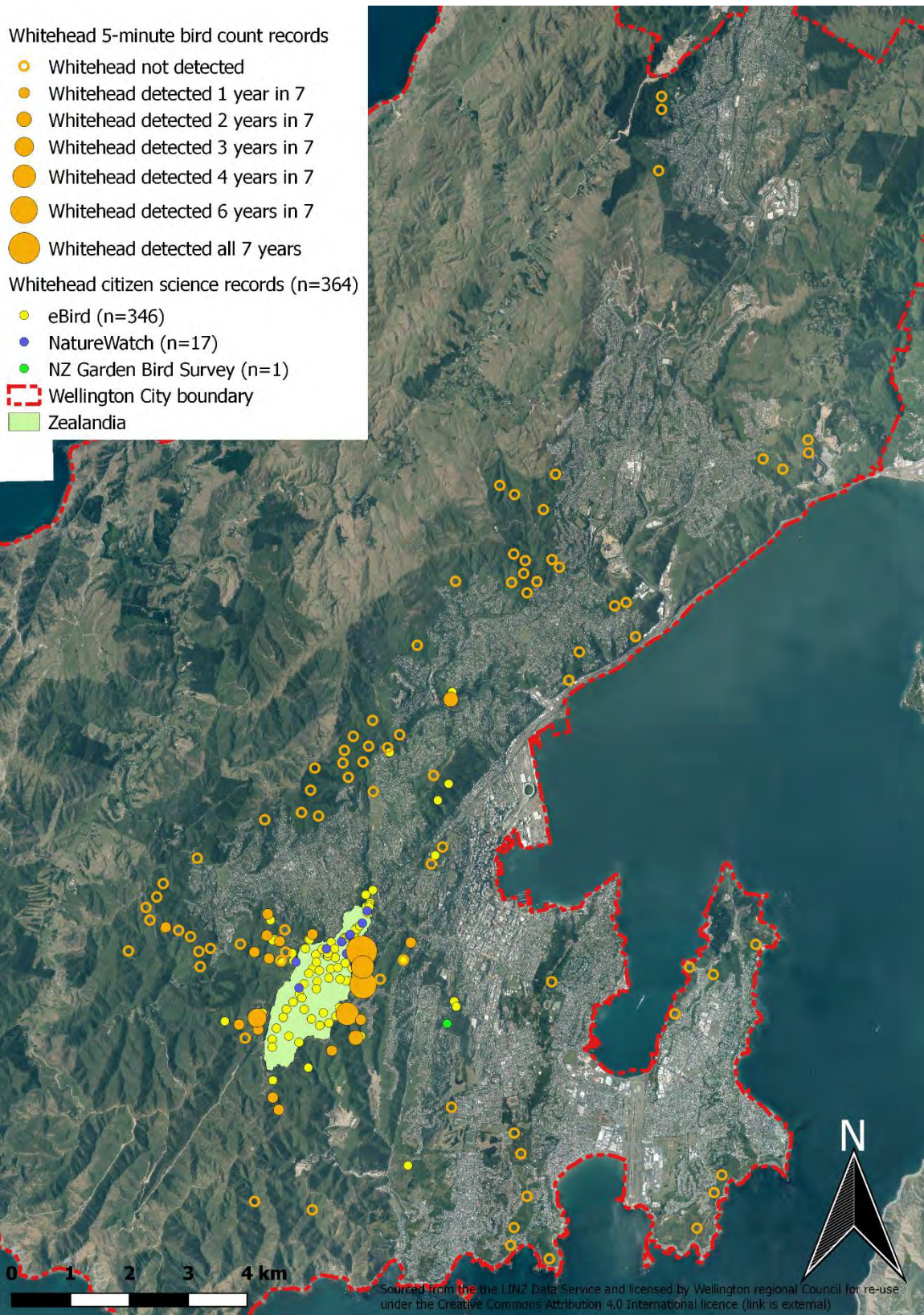


Figure 3.21: Distribution of whitehead in Wellington City between 2011 and 2018. Orange circles represent whitehead detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent whitehead observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.10 New Zealand 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 (GWRC/DoC, unpublished data).

New Zealand kingfisher encounter rates have not changed significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 0.39$, $p = 0.885$; one-way ANOVA; Figure 3.22). NZ kingfisher encounter rates are higher in reserves with original native forest habitat, namely Otari-Wilton Bush, Wellington Botanical Gardens and Khandallah Park. However, NZ kingfishers are sparsely distributed throughout Wellington City. NZ kingfishers are the tenth most frequently observed bird species reported by local citizen scientists, with 461 kingfisher observations reported within Wellington City limits since 2011 (Figure 3.23).

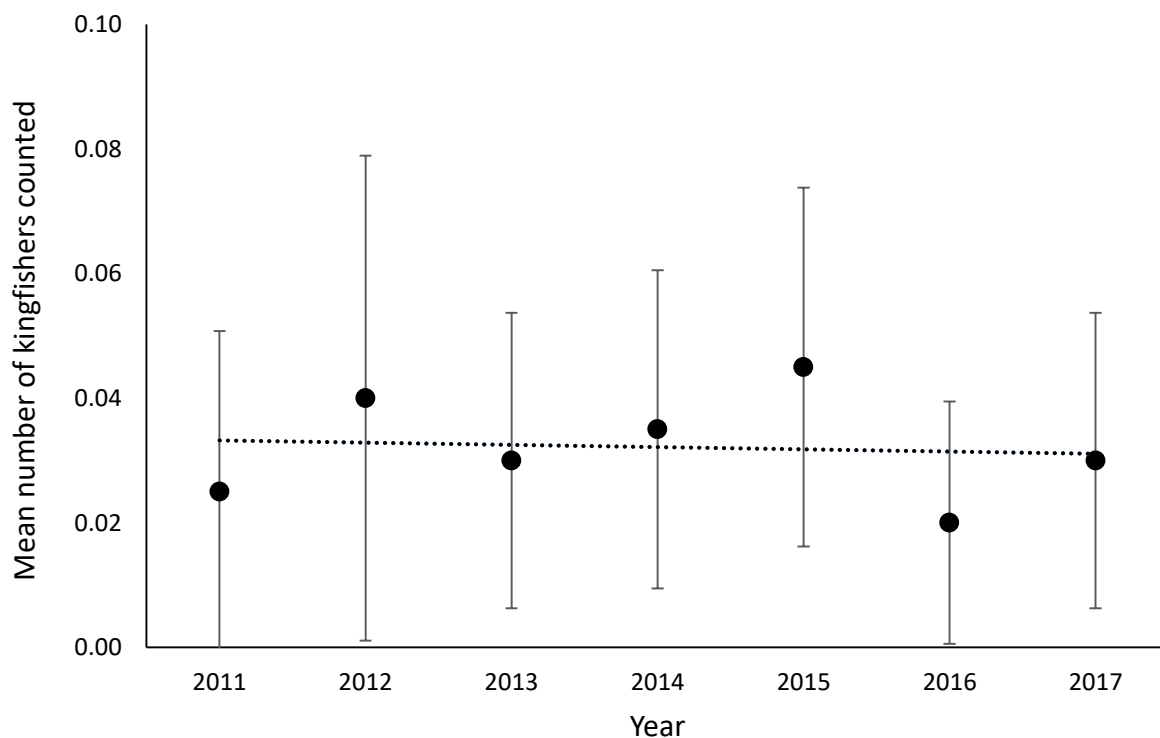


Figure 3.22: Mean number of NZ kingfishers recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

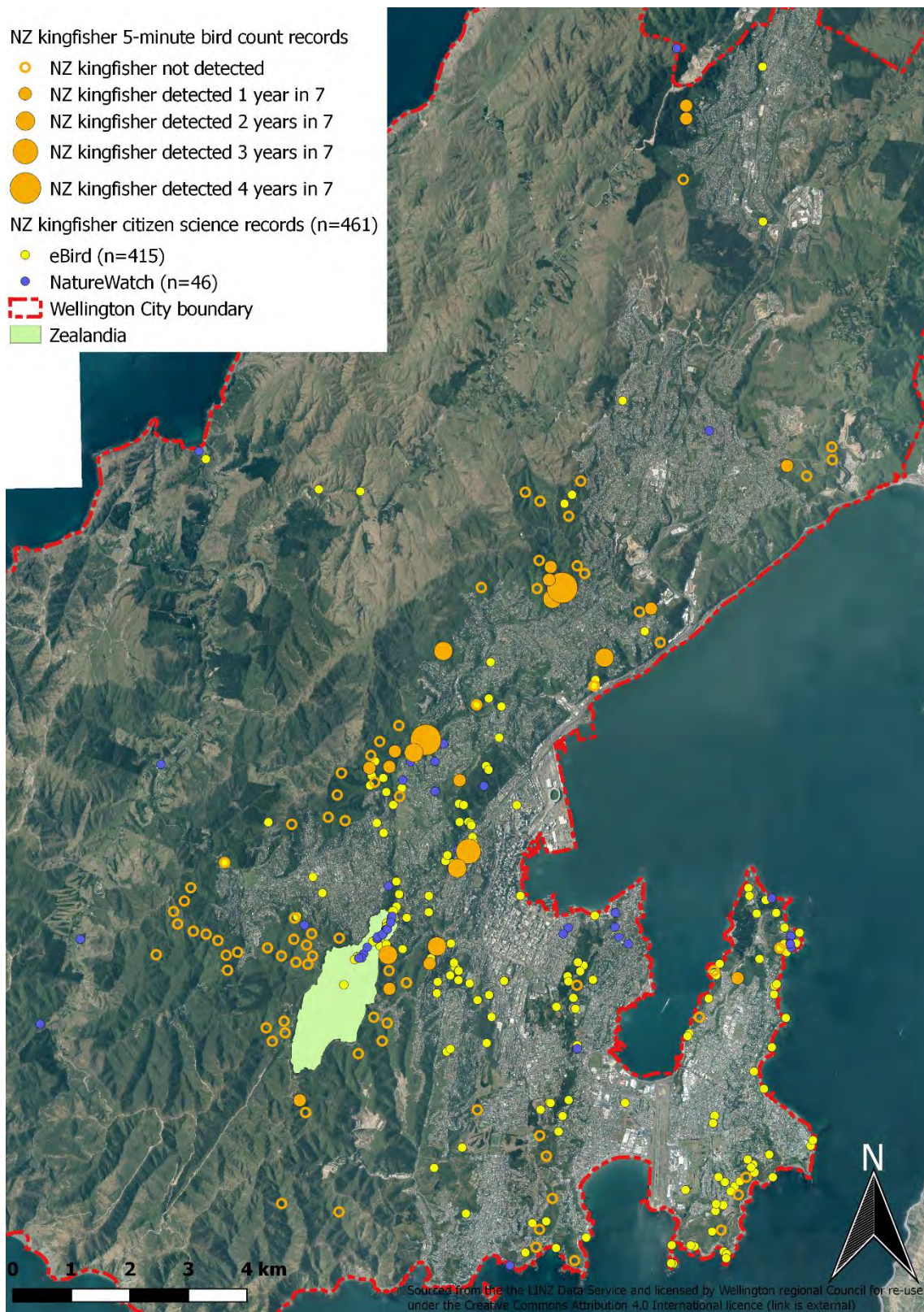


Figure 3.23: Distribution of NZ kingfisher in Wellington City between 2011 and 2018. Orange circles represent NZ kingfisher detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent NZ kingfisher observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.11 Red-crowned parakeet (*Cyanoramphus novaezealandiae*)



Image courtesy of Laurie Ross/NZ Birds Online

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

Regional conservation status: At Risk, Recovering (GWRC/DoC, unpublished data).

Red-crowned parakeet encounter rates have increased significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 4.38, p = 0.0002$; one-way ANOVA; Figure 3.24). Beyond Zealandia, red-crowned parakeets are now established in Wright's Hill reserve, Otari-Wilton Bush and Khandallah Park, Huntleigh Park and possibly also the Wellington Botanic Gardens. Red-crowned parakeets are sparsely distributed throughout Wellington City, in both native forest and suburban habitats and are the twelfth most frequently observed bird species reported by local citizen scientists, with 431 observations reported within Wellington City limits since 2011 (Figure 3.25)

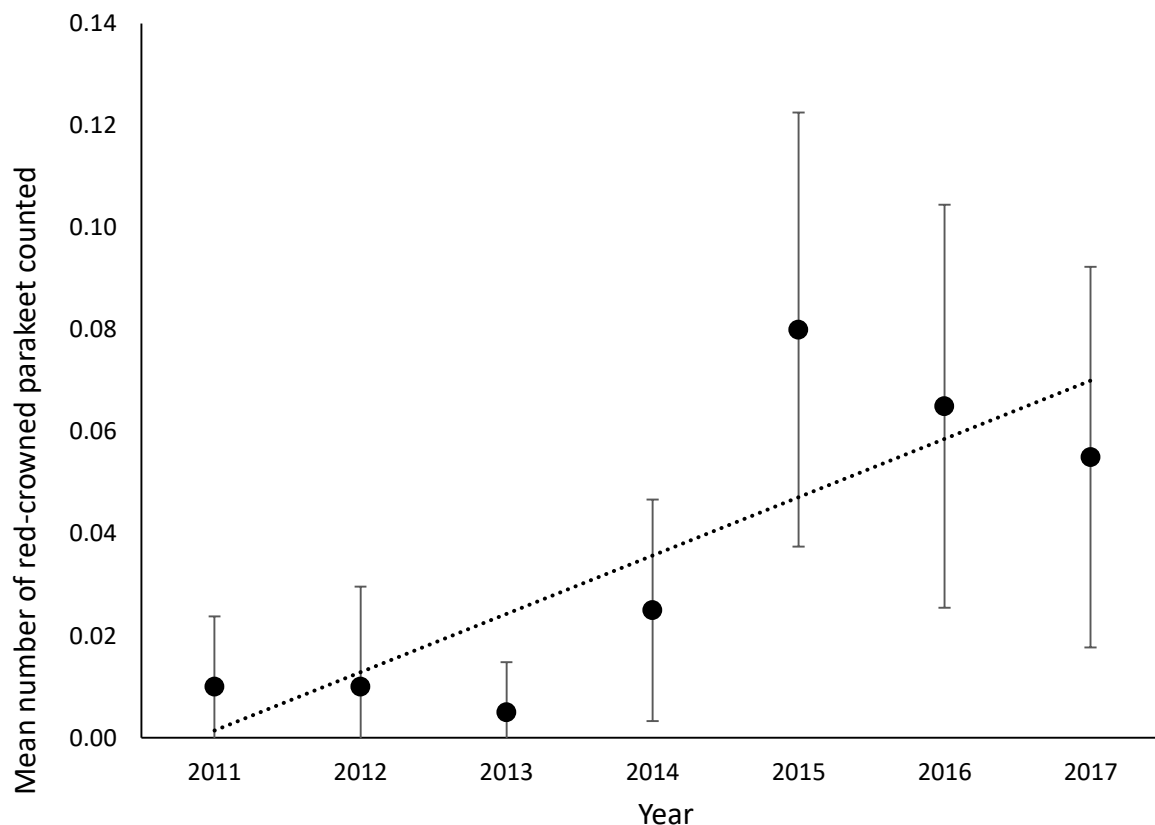


Figure 3.24: Mean number of red-crowned parakeets recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

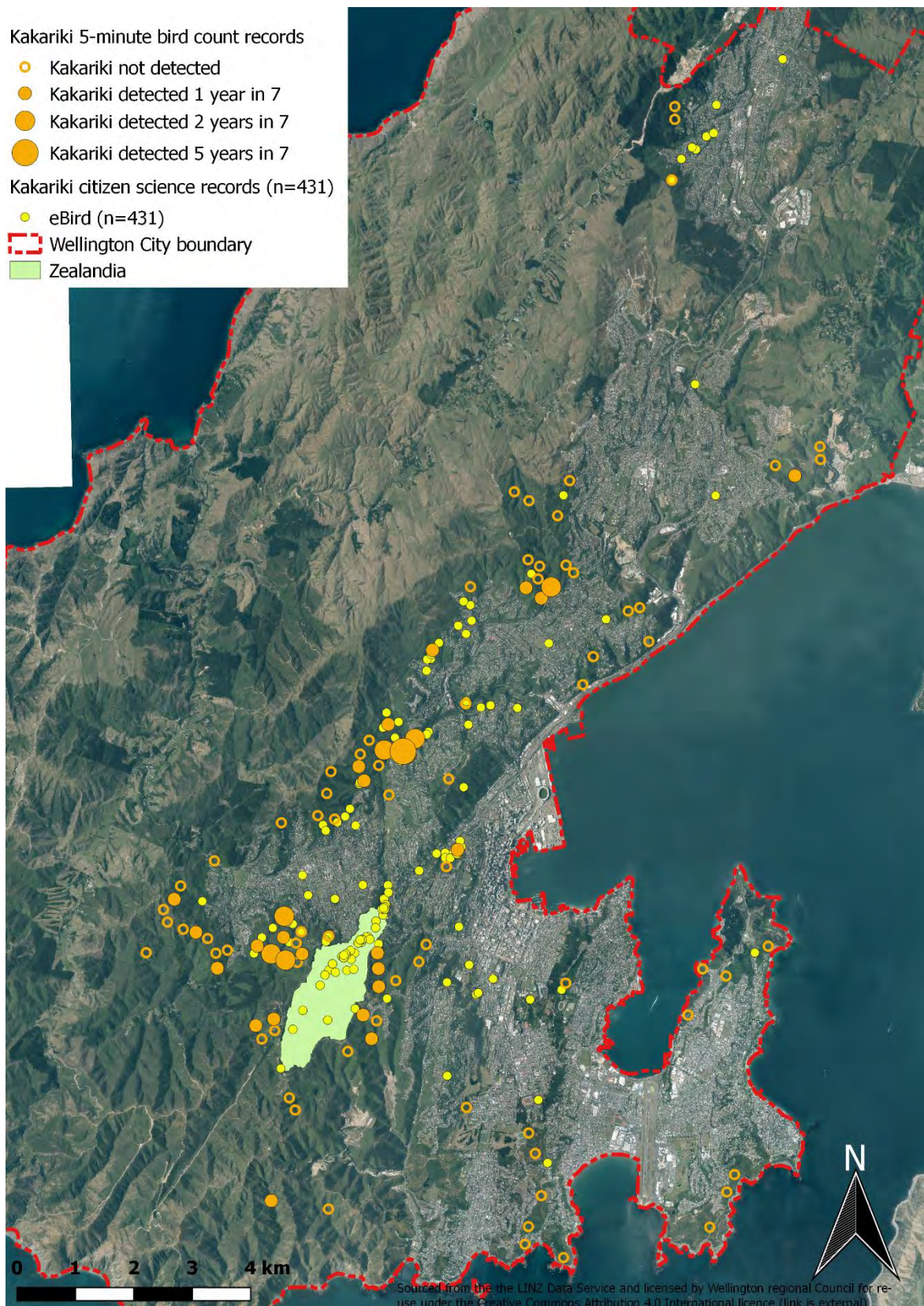


Figure 3.25: Distribution of red-crowned parakeet in Wellington City between 2011 and 2018. Orange circles represent red-crowned parakeet detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent red-crowned parakeet observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.12 North Island robin

(*Petroica longipes*)

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

Regional conservation status: Not Threatened (GWRC/DoC, unpublished data).

North Island robin encounter rates are exceedingly low in Wellington City parks and reserves, and have not changed significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 0.55$, $p = 0.772$; one-way ANOVA; Figure 3.26). NI robins are largely restricted to Zealandia and to native forest habitats within 1-2 km of Zealandia's pest-proof boundary fence. NI robins are the eighth most frequently observed bird species reported by local citizen scientists, with 531 robin observations reported within Wellington City limits since 2011 (Figure 3.27).



Image courtesy of Neil Fitzgerald/NZ Birds Online

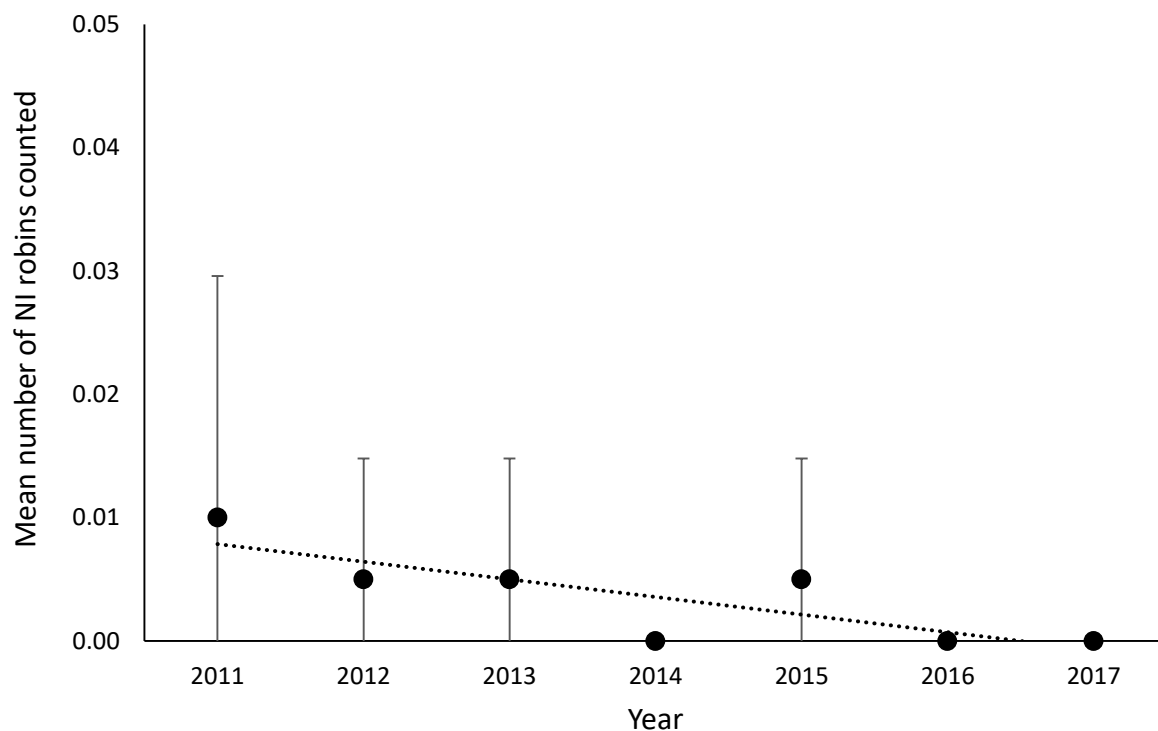


Figure 3.26: Mean number of NI robins recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

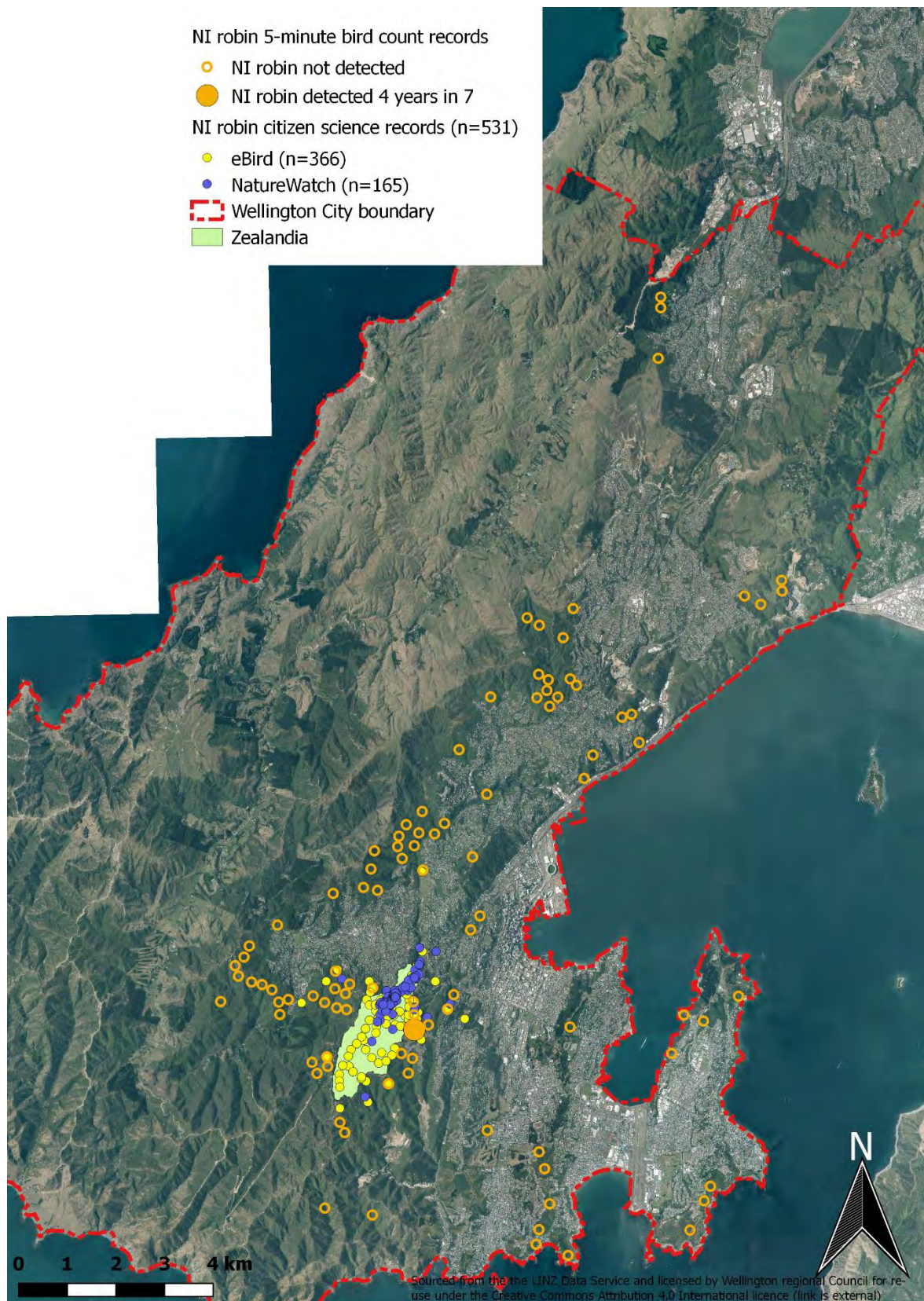


Figure 3.27: Distribution of NI robin in Wellington City between 2011 and 2018. Orange circles represent NI robin detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent NI robin observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.13 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 (GWRC/DoC, unpublished data).

Bellbird encounter rates have varied significantly from year to year in Wellington City between 2011 and 2017 ($F_{6,1393} = 2.34$, $p = 0.030$; one-way ANOVA; Figure 3.28). However these changes appear to be a result of inter-annual fluctuations in abundance and/or distribution, rather than forming part of a longer-term trend in abundance. Bellbirds are very sparsely distributed across Wellington City, with a small breeding population established in Zealandia, and possibly also in the Wellington Botanic Gardens and Khandallah Park. Bellbirds are the seventh most frequently observed bird species reported by local citizen scientists, with 547 bellbird observations reported within Wellington City limits since 2011

(Figure 3.27).

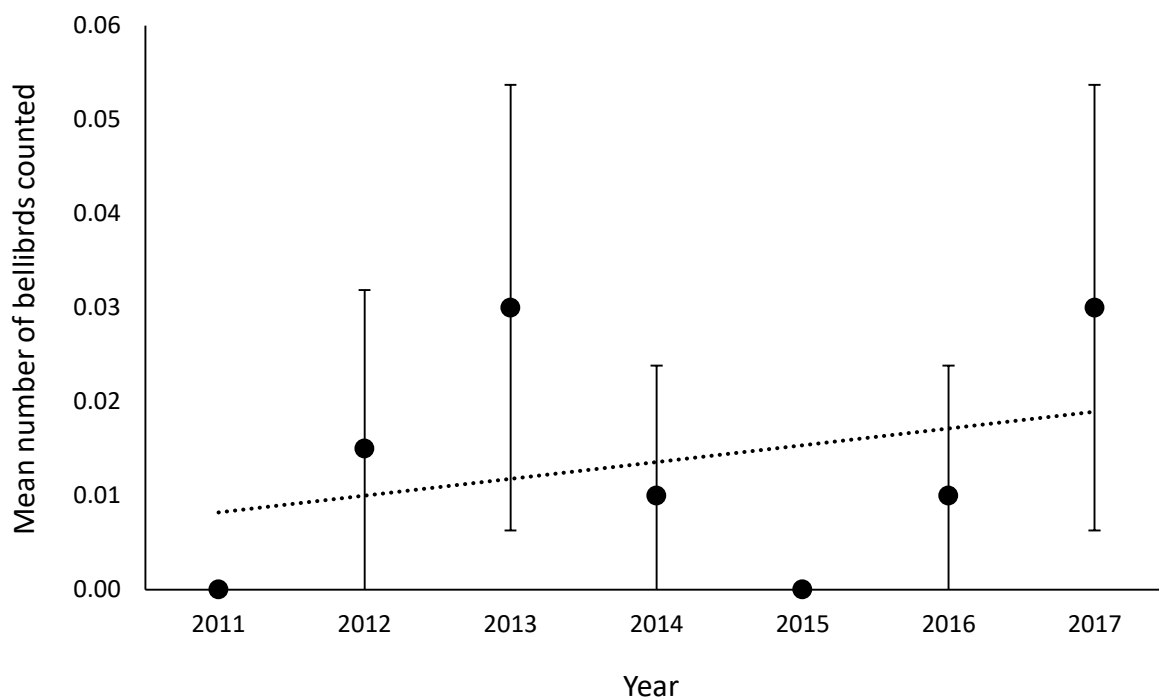


Figure 3.28: Mean number of bellbirds recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

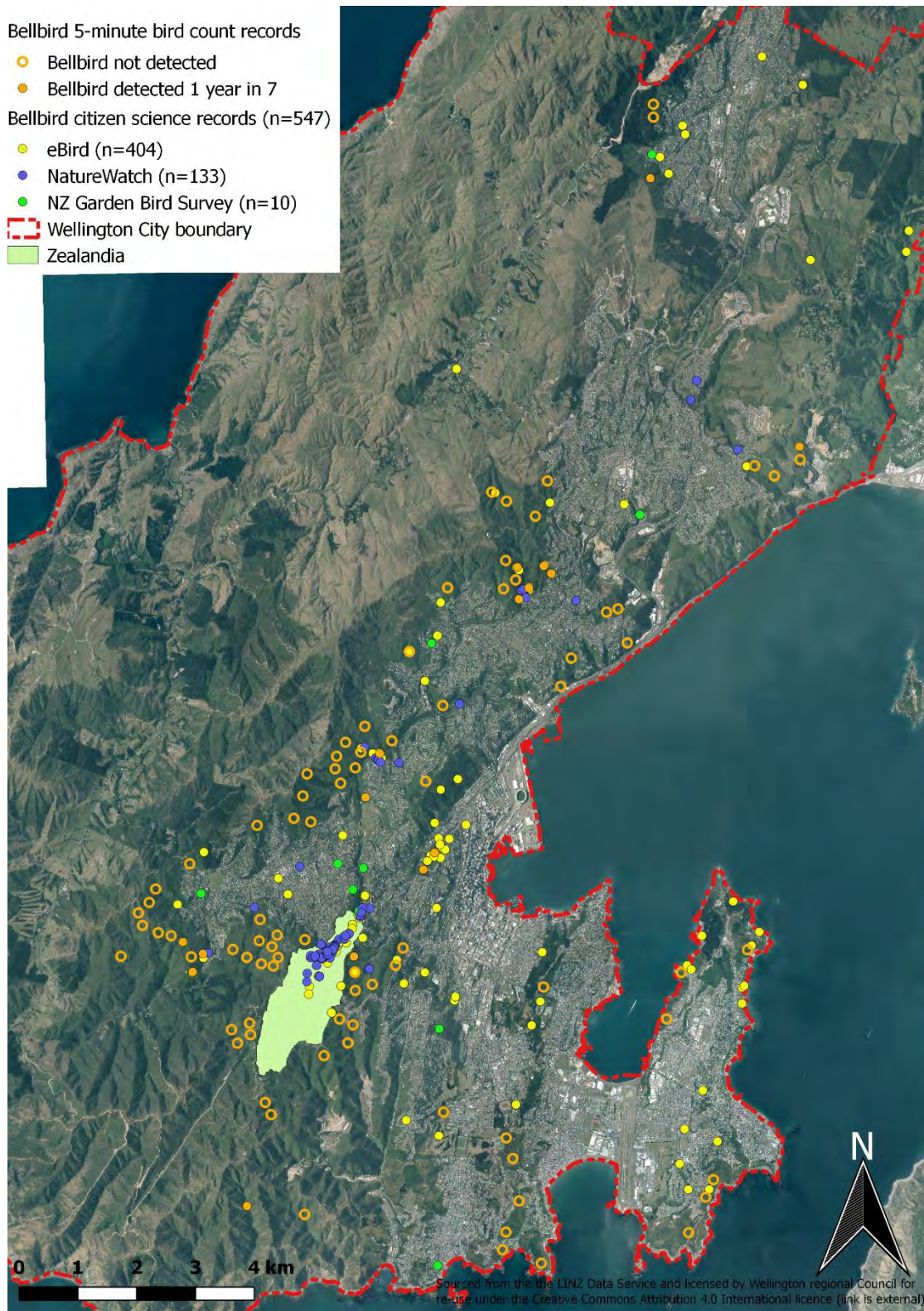


Figure 3.29: Distribution of bellbird in Wellington City between 2011 and 2018. Orange circles represent bellbird detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent bellbird observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.14 New Zealand 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 (GWRC/DoC, unpublished data).

New Zealand falcon encounter rates have not changed significantly in Wellington City between 2011 and 2017 ($F_{6,1393} = 0.67$, $p = 0.68$; one-way ANOVA; Figure 3.30). NZ falcons are sparsely distributed across Wellington city, in both native forest and suburban habitats. There is likely to be only a handful of pairs of birds present, at sites such as Zealandia and Otari-Wilton Bush. NZ falcons are the fourteenth most frequently observed bird species reported by local citizen scientists, with 283 falcon observations reported within Wellington City limits since 2011 (Figure 3.31).

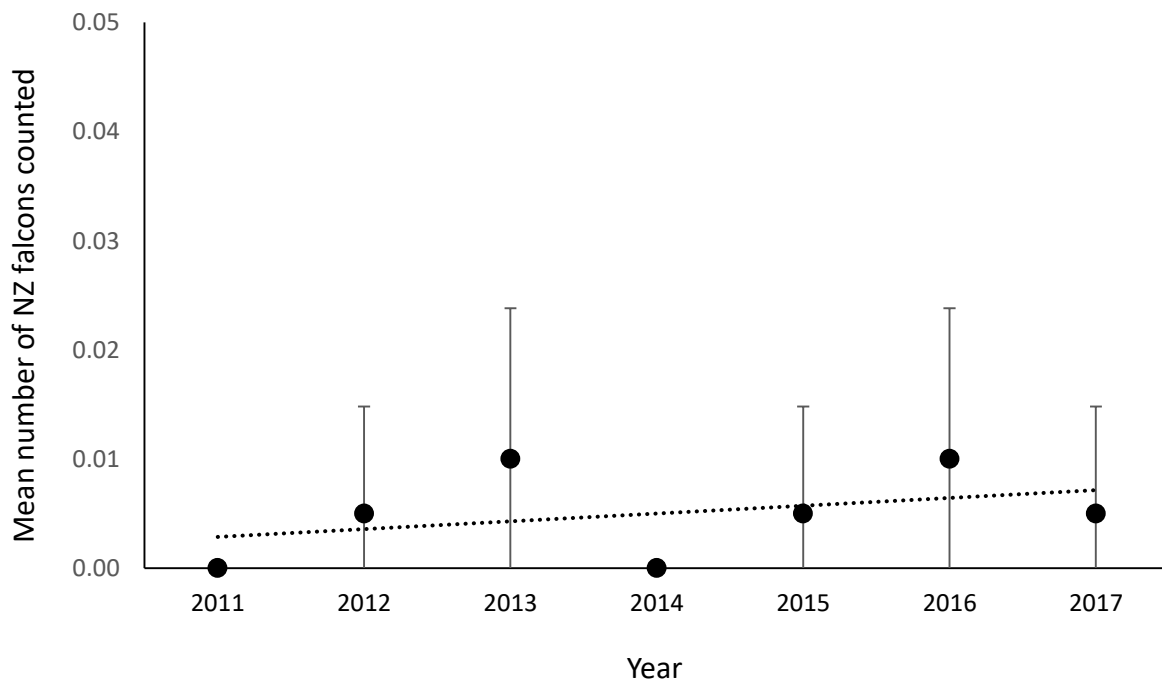


Figure 3.30: Mean number of NZ falcons recorded per five-minute bird count station in Wellington City between 2011 and 2017 (error bars represent 95% confidence limits).

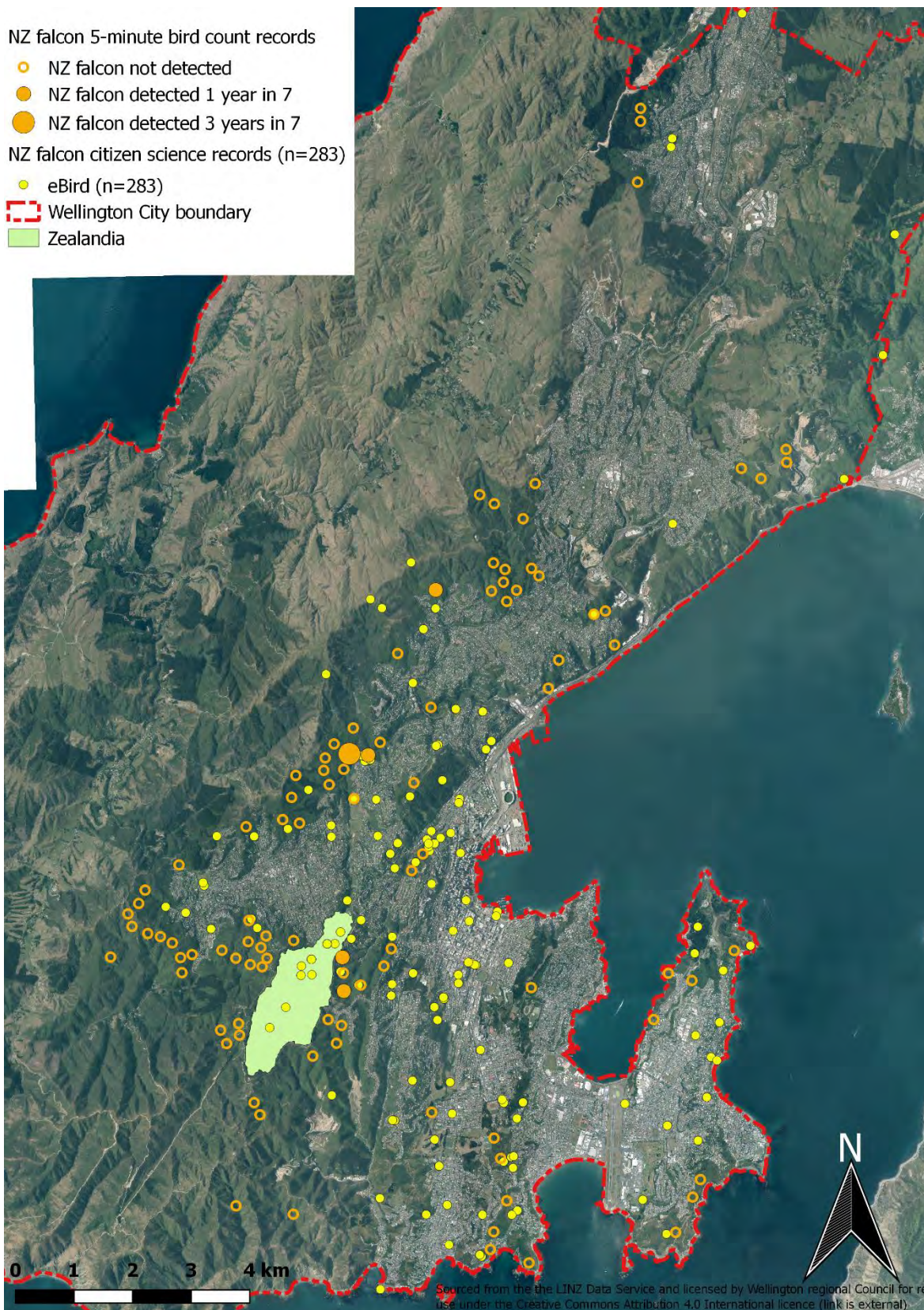


Figure 3.31: Distribution of NZ falcon in Wellington City between 2011 and 2018. Orange circles represent NZ falcon detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent NZ falcon observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.15 Tomtit (*Petroica macrocephala*)

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

Regional conservation status: Not Threatened (GWRC/DoC, unpublished data).

Tomtits are a vagrant (irregular visitor) to Wellington City at the present time, with no local self-sustaining population known to exist within Wellington City boundaries. A single tomtit was recorded for the first time during this five-minute bird count project in 2016, at a count station in Khandallah Park. Prior to this, the only other known tomtit record since 2011 was a single bird observed by Peter Hodge on Tinakori Hill in 2015 (Figure 3.32; Hodge, 2015). Over the past 12 months however, tomtits have been recorded in the city on two further occasions, another record on Tinakori Hill, and one in Otari-Wilton Bush. Tomtit populations did occur in Wellington City historically, R.H.D. Stidolph noted their presence in both Otari-Wilton Bush and Khandallah Park in the mid-1920s (Stidolph, 1924; 1925). Tomtits were also reintroduced to Zealandia between 2001 and 2014, however these re-introduction attempts did not result in the establishment of a self-sustaining population (Empson and Fastier, 2013).



Image courtesy of Paul Shaw/NZ Birds Online

3.2.16 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 (GWRC/DoC, unpublished data).

Moreporks have not yet been detected during these five-minute bird counts, due to the fact that moreporks are largely nocturnal, and these counts are carried out during daylight hours. Nonetheless, moreporks are the sixteenth most frequently observed bird species reported by local citizen scientists, with 210 morepork observations reported within Wellington City limits since 2011 (Figure 3.33). The distribution of these records suggest that morepork are likely to be widespread in Wellington City, and are found in both native forest and suburban habitats.

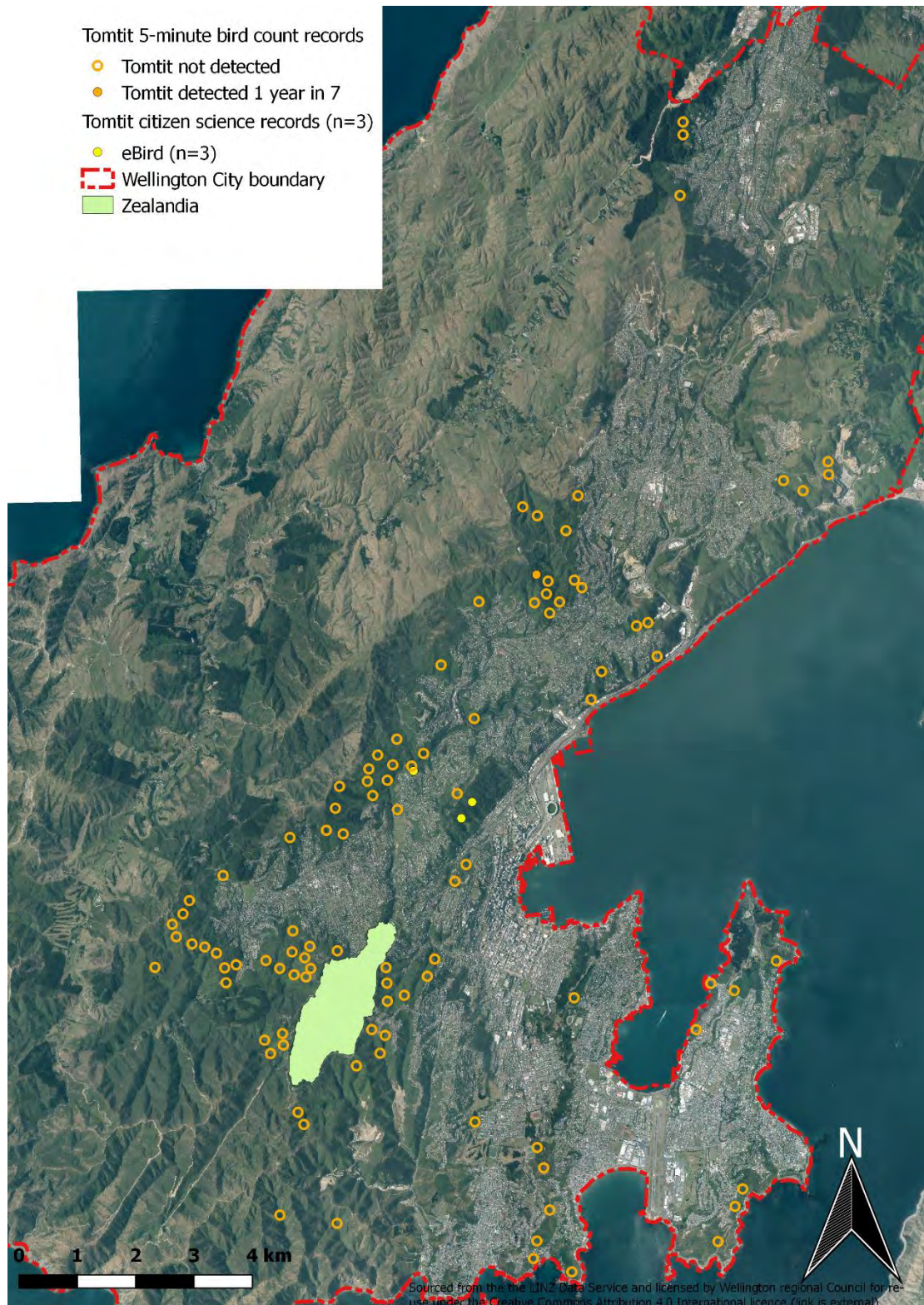


Figure 3.32: Distribution of tomtit in Wellington City between 2011 and 2018. Orange circles represent tomtit detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent tomtit observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.



Figure 3.33: Distribution of morepork in Wellington City between 2011 and 2018. Orange circles represent morepork detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent morepork observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

3.2.17 Hihi (*Notiomystis cincta*)

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

Regional conservation status: Regionally Critical (GWRC/DoC, unpublished data).

Hihi have not yet been detected during these five-minute bird counts, despite the fact that a small resident population is now established in Zealandia. Nonetheless, hihi are the fifteenth most frequently observed bird species reported by local citizen scientists, with 256 hihi observations reported within Wellington City limits since 2011 (Figure 3.34). The majority of these observations are from within Zealandia or within a few hundred metres of Zealandia’s pest proof fence. This suggests that hihi either don’t usually stray far from Zealandia, or if they do, that they don’t persist for long in adjacent reserves.



Image courtesy of Paul Le Roy/NZ Birds Online

3.2.18 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 (GWRC/DoC, unpublished data).

Long-tailed cuckoos are a vagrant (irregular visitor) to Wellington City at the present time, which means that Wellington City’s whitehead population is likely to be largely free of brood-parasitism by long-tailed cuckoos. Long-tailed cuckoos have not yet been recorded during five-minute bird counts carried out as part of this project, and have only been recorded by citizen scientists on three occasions since 2011 (Figure 3.35).

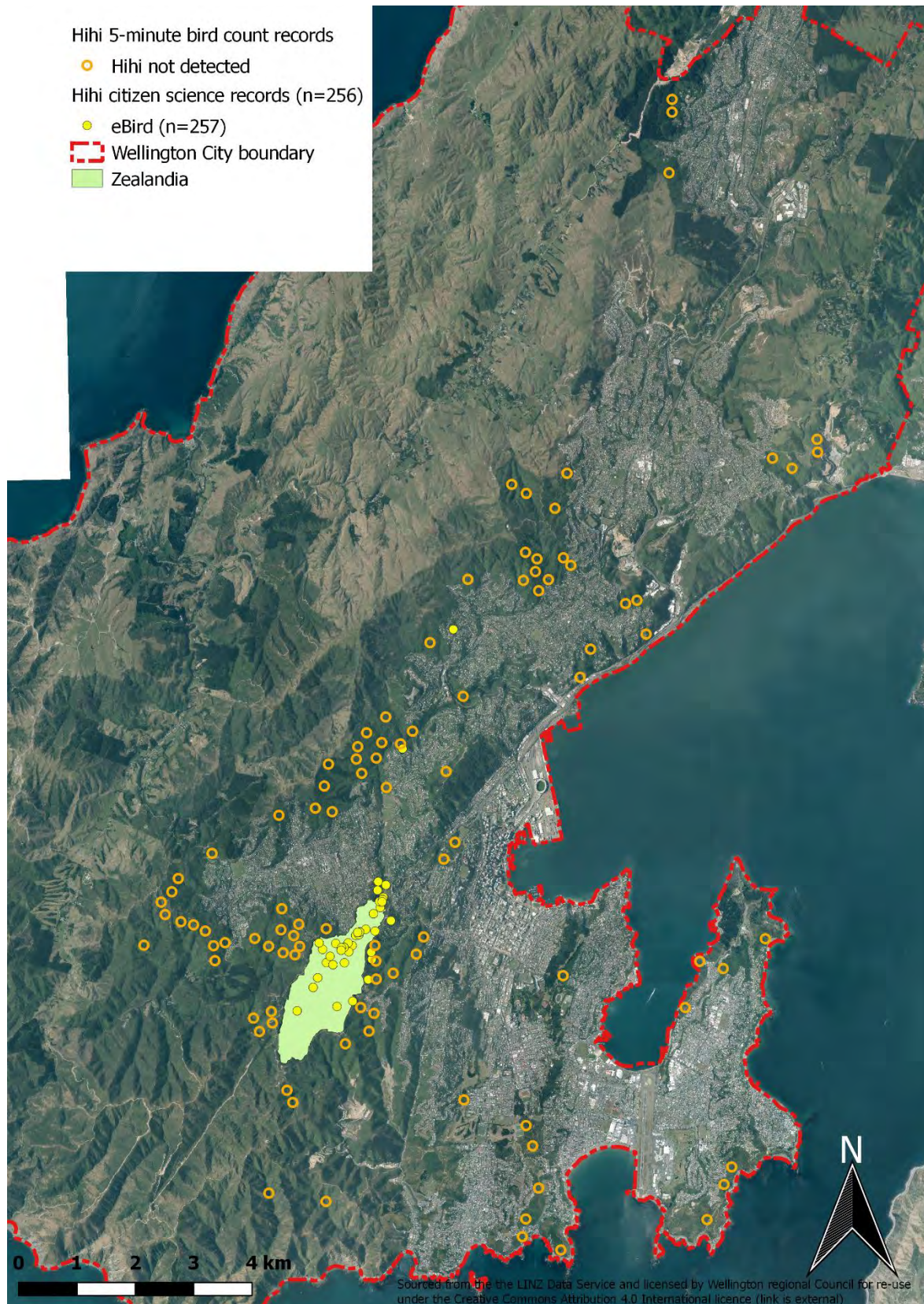


Figure 3.34: Distribution of hihi in Wellington City between 2011 and 2018. Orange circles represent hihi detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent hihi observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

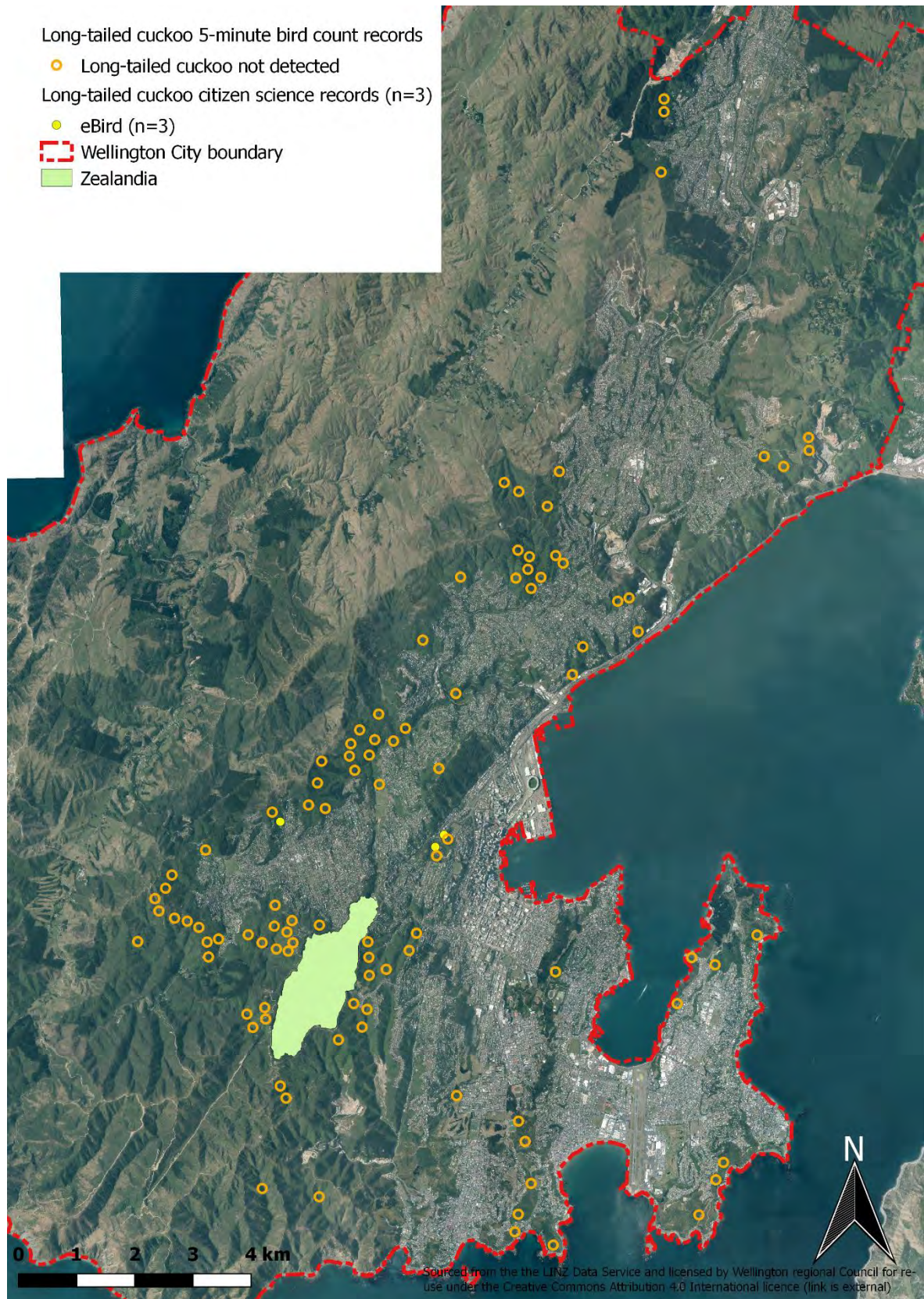


Figure 3.35: Distribution of long-tailed cuckoo in Wellington City between 2011 and 2018. Orange circles represent long-tailed cuckoo detections at five-minute bird count stations, with the size of the circle corresponding to the relative detection frequency. Smaller coloured circles represent long-tailed cuckoo observations reported by local citizen scientists via eBird, NatureWatch or the NZ Garden Bird Survey.

4. DISCUSSION

4.1 Bird diversity, abundance and distribution

One trend that is emerging from these counts is that the average number of native forest bird species being encountered per five-minute bird count is slowly increasing over time. Because only one new native forest bird species (tomtit) has been detected since 2011, much of this increase in average species richness is likely a result of ongoing range expansions of bird species already present in Wellington City. In particular, the ongoing dispersal of species that have been re-introduced to Zealandia, and their establishment in other forested reserves in the city, is driving these improvements in local species richness in some parks and reserves. Given how vulnerable some of these species are to depredation by mammalian predators, it's unlikely that these improvements would be occurring were it not for the presence of Zealandia, and for the widespread implementation of mammalian predator control throughout Wellington City's parks, reserves and suburban areas. The results of these five-minute bird counts therefore demonstrate that these initiatives are leading to a gradual improvement in bird species richness in parts of Wellington City, and are creating more opportunities for local residents and visitors to encounter a wider range of New Zealand's native forest bird species in the heart of New Zealand's capital city.

Of the eighteen native forest bird species currently present in Wellington City outside of Zealandia's predator-proof fence, encounter rates for three species, namely tūī, kākā and red-crowned parakeet, have increased significantly since 2011. 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 these three species has increased in Wellington City since 2011. All three species are vulnerable to depredation by mammalian predators, so the presence of Zealandia, and the widespread mammalian predator control now in place throughout Wellington City is almost certainly the cause for the ongoing increase in encounter rates for these three species.

One further key result from these counts is that no long-term declines in encounter rates for any native forest bird species have been detected between 2011 and 2017. This means that as well as leading to the improvements in encounter rates for species such as tūī, kākā and red-crowned parakeet, the establishment of Zealandia, coupled with the instigation of city-wide predator control has successfully prevented any decrease in the abundance and/or conspicuousness of native forest birds in Wellington City since 2011.

Against the backdrop of these successes, there are several vulnerable species that have been reintroduced to Zealandia, but have not expanded their distribution very far beyond Zealandia's predator-proof fence. For example, NI robins have been well established in Zealandia for at least 15 years (McGavin, 2009; Empson & Fastier, 2013), yet have only been detected at a single five-minute bird count station between 2011 and 2017, and are seldom reported by citizen scientists at distances greater than around 1 km from Zealandia (Figure 3.27). 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. A mark-recapture study of NI robins and NI saddleback in reserves adjacent to Zealandia appears to be confirming that poor adult and juvenile survival rates is limiting the ability of these species to colonise forest habitat outside of Zealandia. Wellington City Council contractors have been catching and colour-banding both robins and saddleback in reserves adjacent to Zealandia, and resighting data is suggesting local survival rates are extremely low (Annette Harvey, personal

communication). Given this evidence, the most likely factor limiting the distribution and survival rates of these species beyond the boundaries of Zealandia is the presence of mammalian predators including both domestic and wild cats (*Felis catus*), rats (*Rattus* spp.), possums (*Trichosurus vulpecula*), hedgehogs (*Erinaceus europaeus*) and mustelids (*Mustela* spp.). Although considerable effort is being invested in reducing populations of a number of these species in Wellington City, cats are typically not targeted due to the risks that existing control methods pose to domestic pets. Recent 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 they occur at relatively high densities in the parks and reserves that were sampled.

To determine which introduced predators are limiting the establishment of native birds emigrating from Zealandia, further research quantifying the nest success rates and causes of nest failure of these bird species in reserves adjacent to Zealandia would be useful. Identifying causes of nest failure events by filming nests with digital trail cameras would be particularly useful to inform decisions regarding future pest control priorities aimed at improving the abundance and distribution of these more vulnerable native forest bird species in Wellington City reserves. We suggest that these research efforts should continue to be focussed on NI robins and NI saddleback, as the nests of these two species are relatively easy to locate and monitor, yet are particularly vulnerable to mammalian predators (e.g. Powlesland, 1997).

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 18,797 verified observations of native forest birds have been contributed by citizen scientists in Wellington City between 2011 and 2017, and are included on the distribution maps in this report. 83%, or 15,508 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 (Figure 4.1). A further 11% (2159 observations) were submitted via the NatureWatch NZ database, making this the second-most preferred database used by Wellington-based citizen scientists³. An additional 3% of records (556 and 574 observations) were sourced from the New Zealand Garden Bird Survey and Great Kererū Count respectively, via the NatureWatch NZ website.

³ Note: This number is likely to underestimate NatureWatch usage among Wellington-based citizen scientists, for two reasons. Firstly, a much larger proportion of NatureWatch observations was discarded during data analysis due to location and/or species identification errors, compared to the eBird database. This suggests that either the data validation process used by NatureWatch is not as effective at picking up errors in comparison to eBird’s data validation processes, or that there is a difference in skill level between the average NatureWatch and eBird user. Secondly, location data for any NatureWatch 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.

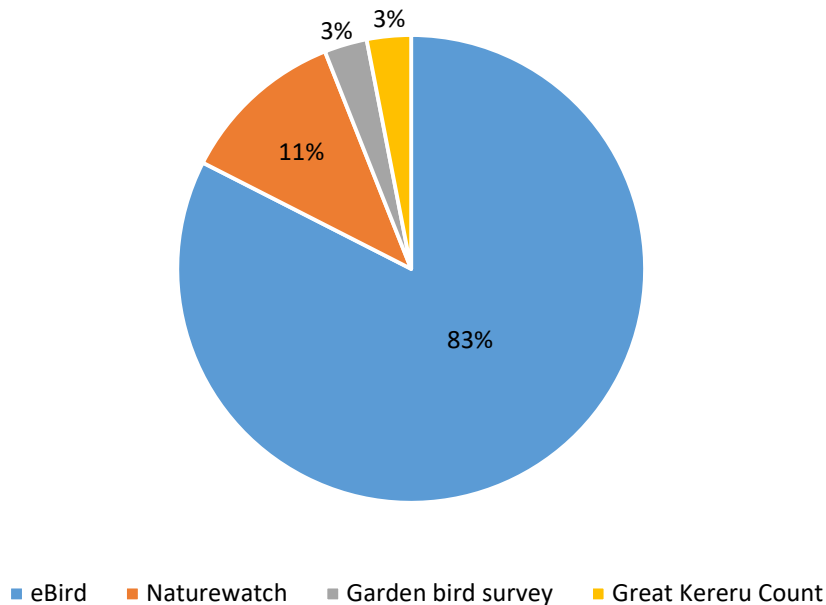


Figure 4.1: Relative volume of bird observation data available from the four major citizen science datasets used in this report. These data represent bird observations reported from Wellington City between 2011 and 2018.

A comparison of the number of observations of each native forest bird species submitted to both eBird and NatureWatch reveals some interesting differences. Total numbers of observations submitted to eBird are closely correlated to the average encounter rate for each species in our five-minute bird count dataset (Figure 4.2), suggesting that eBird users have few species-specific biases in reporting rates. This in turn indicates that eBird users are generally able to identify all native forest birds present in Wellington City correctly, and tend to structure their observations into complete species checklists, recording all of the bird species that they see or hear. This latter point is particularly significant, as it creates the opportunity to use this data to build detailed spatio-temporal models of species occupancy once a sufficient quantity of such data has accumulated (Sullivan et al, 2014). In contrast, NatureWatch users appear to under-report relatively common and/or inconspicuous species such as grey warblers, silvereyes and fantails, suggesting that NatureWatch users either have less expertise in identifying these species, or less interest in reporting relatively common species (Figure 4.2). Furthermore, NatureWatch users tend to report their observations as one-off independent records, rather than structuring them into complete species checklists, limiting the potential to use this data to build more robust species occupancy models in the future.

The very large number of kererū observations that have been submitted to NatureWatch between 2011 and 2018 may provide evidence of the valuable role that single-species citizen science projects can play in galvanizing more widespread and sustained citizen science effort. Kererū have been the subject of a “Great Kererū Count” project run each year since 2011, wherein people are encouraged to record the presence or absence of Kererū in gardens or local parks and reserves. Great Kererū Count participants are asked to submit their records via the NatureWatch NZ database, and this in turn appears to have driven a much higher subsequent rate of kererū reporting to NatureWatch than would otherwise be expected (Figure 4.2).

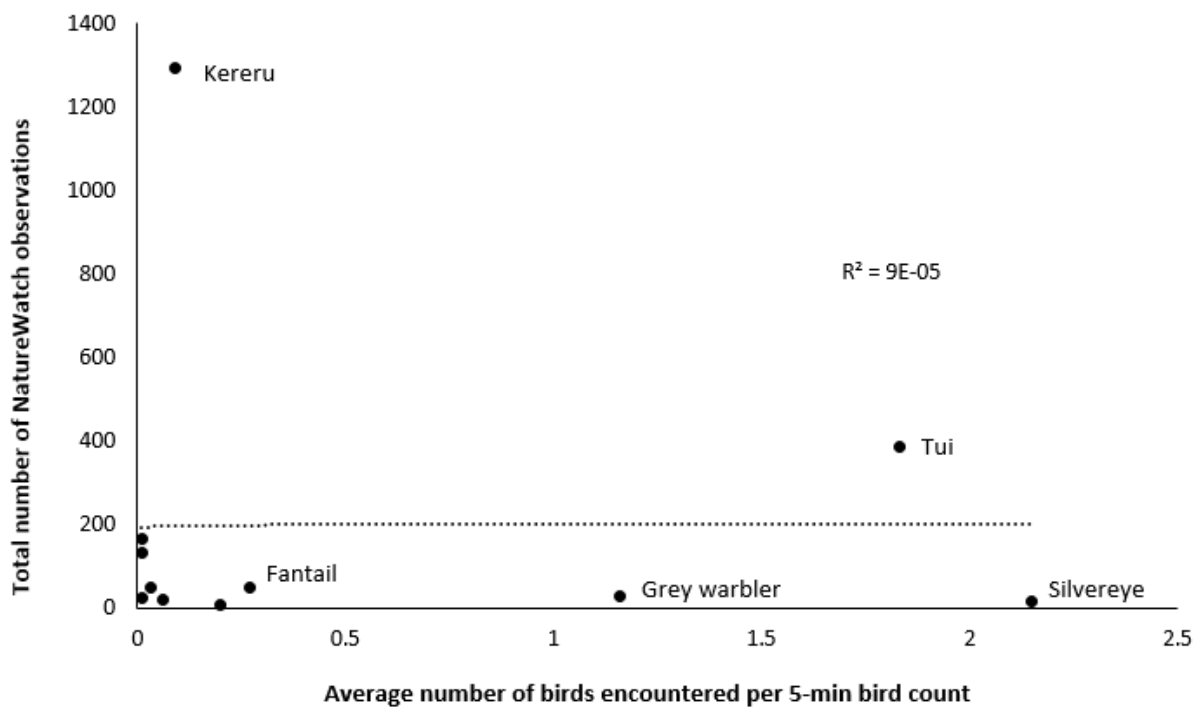
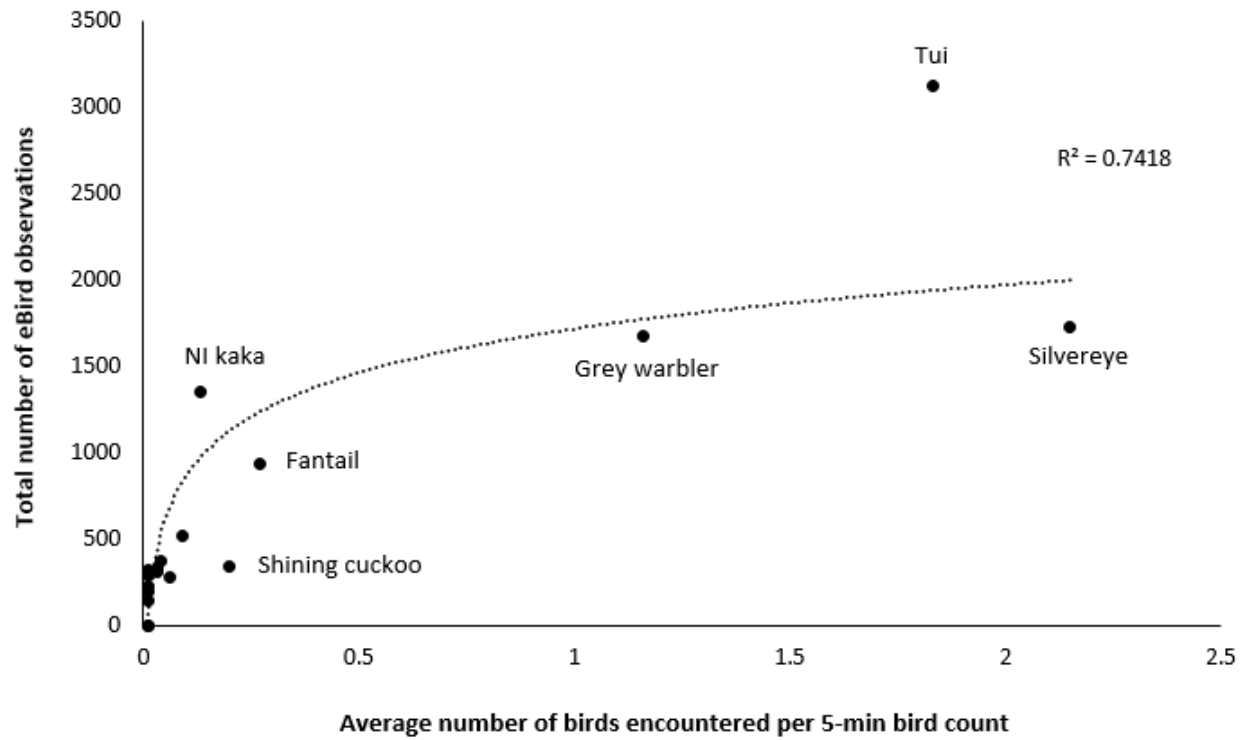


Figure 4.2: Relationship between the average number of birds recorded per five-minute bird count station, and the total number of citizen science records submitted for each species in Wellington City between 2011 and 2018, for eBird (top graph) and NatureWatch (bottom graph).

Although our knowledge of the distribution of diurnal, or day-active bird species in Wellington City has improved substantially over the past five years, the distribution of our one relatively widespread nocturnal species is very poorly understood. 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 morepork in Wellington City and quantifying encounter rates as an indirect measure of abundance. We suggest that such a project could be modelled on the 2011 Hamilton City 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 the Council continues to undertake this five-minute bird count monitoring programme on an ongoing, 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 and/or Predator Free Wellington considers initiating an investigation aimed at identifying the environmental factors currently limiting the establishment of vulnerable native forest bird species recently re-introduced to Zealandia in suitable habitat beyond Zealandia's predator-proof fence, to inform future biodiversity management decision-making (objective 1.2.2c of WCC's Biodiversity Strategy and Action Plan (WCC, 2015). Such an investigation should focus on locating and monitoring the outcomes of nesting attempts by forest bird species with restricted distributions in Wellington City, including NI saddleback, and NI robin. A crucial element of this investigation would involve filming monitored nests with trail cameras to identify and quantify the causes of nest failure events.
- That Wellington City Council reviews its support and promotion of available citizen science databases and projects, to ensure that local citizen science effort is being utilised in the most efficient way possible (objective 4.3.3a of WCC's Biodiversity Strategy and Action Plan (WCC, 2015). In light of the differences in usage & data quality between the eBird and NatureWatch datasets, we recommend that Wellington City Council adopts the New Zealand eBird database as the primary repository for high-quality citizen science bird data for the city, and that the Council encourages those local citizen scientists with relatively good bird identification skills to submit their observations to eBird. We further recommend that WCC continues to use NatureWatch NZ as an engagement tool, and encourages beginner-level citizen scientists to submit their data to this database. This approach should not only maximise the quantity of high-quality citizen science data being accumulated in a single, central location (eBird), but will also minimise the quantity of erroneous observations being submitted, given that less

experienced users will be using an alternative user-friendly database with less robust data validation processes (NatureWatch).

- That Wellington City Council and/or Predator Free Wellington considers designing and carrying out a citizen science project aimed at mapping the distribution of morepork in Wellington City in 2018 (objective 3.3.4b of WCC's Biodiversity Strategy and Action Plan (WCC, 2015). Such a project could involve public requests for morepork sightings during a particular month of the year (e.g. November, 2018), much like the Great Kererū Count, 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 morepork distribution in local parks and reserves.

6. ACKNOWLEDGMENTS

This work was instigated by Myfanwy Emeny, Open Space and Parks Manager at Wellington City Council and by Philippa Crisp, Team Leader, Terrestrial Ecosystems and Quality, Greater Wellington Regional Council. We would like to thank Mark McAlpine for assisting with data collection in Wellington City reserves in 2011. We also extend our thanks to Raewyn Empson (former Conservation Manager at Zealandia) for providing us with access to bird distribution data held by the Karori Sanctuary Trust, and to the growing group of dedicated & skilled Wellington-based citizen scientists collecting and sharing high-quality bird observations via the New Zealand eBird database, the Zealandia website or via other citizen-science bird monitoring projects. Local resident Peter Hodge in particular has contributed a very high proportion of the citizen science bird records that appear on the maps in this report. Thanks also to Li Loo, Richard Farrell, Luke Crouch, Grant Redvers and Roger Uys for assisting with data entry and management, and thanks also to Mike Bell (WMIL), Roger Uys (GWRC) and Daniela Biaggio (WCC) for providing useful comments on earlier drafts of this report.

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8. APPENDIX

This appendix contains a list of all of the bird species encountered in Wellington City parks and reserves during five-minute bird counts carried out between 2011 and 2017 (P = species present). Species names and taxonomic order are those listed in Gill et al (2010). Threat classification rankings are those listed in Robertson et al (2017): DE = At Risk, Declining; RC = At Risk, Recovering; RE = At risk, Relict; NT = Not threatened; I = Introduced and Naturalised; N/A = Not applicable.

Scientific Name	Common Name	Threat Ranking	2011	2012	2013	2014	2015	2016	2017
<i>Eudyptula minor</i>	little penguin	DE							P
<i>Callipepla californica</i>	California quail	I	P	P	P	P	P	P	P
<i>Gallus gallus</i>	feral chicken	N/A ⁴	P	P	P	P	P	P	P
<i>Tadorna variegata</i>	paradise shelduck	NT		P	P				P
<i>Anas platyrhynchos</i>	mallard	I					P	P	
<i>Phalacrocorax varius</i>	pieb shag	RC					P		
<i>Stictocarbo punctatus</i>	spotted shag	NT							P
<i>Egretta novaehollandiae</i>	white-faced heron	NT			P				
<i>Circus approximans</i>	swamp harrier	NT	P	P		P			
<i>Falco novaeseelandiae</i>	New Zealand falcon	RC		P	P		P	P	P
<i>Haematopus unicolor</i>	variable oystercatcher	RC		P		P	P	P	
<i>Vanellus miles</i>	spur-winged plover	NT				P			
<i>Larus dominicanus</i>	southern black-backed gull	NT	P	P	P	P	P	P	P
<i>L. novaehollandiae</i>	red-billed gull	DE		P	P				
<i>Columba livia</i>	rock pigeon	I						P	P
<i>Hemiphaga novaeseelandiae</i>	New Zealand pigeon (kererū)	NT	P	P	P	P	P	P	P
<i>Nestor meridionalis</i>	kākā	RC	P	P	P	P	P	P	P
<i>Platycercus eximius</i>	eastern rosella	I	P	P	P	P	P	P	P
<i>Cyanoramphus novaeseelandiae</i>	red-crowned parakeet	RE	P	P		P	P	P	P

⁴ 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).

Scientific Name	Common Name	Threat Ranking	2011	2012	2013	2014	2015	2016	2017
<i>Chrysococcyx lucidus</i>	shining cuckoo	NT	P	P	P	P	P	P	P
<i>Todiramphus sanctus</i>	New Zealand kingfisher	NT	P	P	P	P	P	P	P
<i>Philesturnus rufusater</i>	North Island saddleback	RC	P	P	P	P	P	P	P
<i>Gerygone igata</i>	grey warbler	NT	P	P	P	P	P	P	P
<i>Anthornis melanura</i>	bellbird	NT		P	P	P		P	P
<i>Prothemadera novaeseelandiae</i>	tūtī	NT	P	P	P	P	P	P	P
<i>Mohoua albicilla</i>	whitehead	DE	P	P	P	P	P	P	P
<i>Gymnorhina tibicen</i>	Australian magpie	I	P		P	P	P	P	P
<i>Rhipidura fuliginosa</i>	New Zealand fantail	NT	P	P	P	P	P	P	P
<i>Petroica macrocephala</i>	tomtit	NT						P	
<i>P. longipes</i>	North Island robin	DE	P	P	P		P		
<i>Alauda arvensis</i>	skylark	I	P	P	P	P	P		P
<i>Zosterops lateralis</i>	silveryeye	NT	P	P	P	P	P	P	P
<i>Hirundo neoxena</i>	welcome swallow	NT	P					P	P
<i>Turdus merula</i>	Eurasian blackbird	I	P	P	P	P	P	P	P
<i>T. philomelos</i>	song thrush	I	P	P	P	P	P	P	P
<i>Sturnus vulgaris</i>	common starling	I	P	P	P	P	P	P	P
<i>Passer domesticus</i>	house sparrow	I	P	P	P	P	P	P	P
<i>Prunella modularis</i>	dunnock	I	P	P	P	P	P	P	P
<i>Fringilla coelebs</i>	chaffinch	I	P	P	P	P	P	P	P
<i>Carduelis chloris</i>	greenfinch	I	P	P	P	P	P	P	P
<i>C. carduelis</i>	goldfinch	I	P	P	P	P	P	P	P
<i>C. flammea</i>	common redpoll	I		P	P	P	P	P	P
<i>Emberiza citrinella</i>	yellowhammer	I	P	P	P	P	P	P	P