

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

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Cover Image: North Island kaka (*Nestor meridionalis*) feeding on kowhai nectar, Kelburn, Wellington (August 2013). Image courtesy of David Brooks/NZ Birds online (www.nzbirdsonline.org.nz)

ABSTRACT

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 2014. 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.

Between 29 and 33 bird species were detected during these bird counts each year, with approximately half of these species being native species and half being introduced and naturalised species. On average, a lower number of native forest bird species were recorded per bird count station in Wellington City reserves compared to Upper Hutt City reserves. This is because around 25% of the native forest bird species recorded in Wellington City reserves had very localised distributions (typically centred on Zealandia), whereas almost all species detected in Upper Hutt reserves had fairly widespread distributions.

The abundance of most native forest bird species recorded in Wellington City reserves has varied little between 2011 and 2014. Numbers of tui detected per bird count station have fluctuated substantially from year to year however, from a low of 0.8 birds counted per station in 2012 to a high of 2.2 birds per station in 2013. These large, short-term fluctuations appear to be caused by local changes in tui distribution in response to changes in local food supply. The abundance of blackbirds has increased by approximately 30% in Wellington City reserves over the past four years, from a mean of 2.3 birds per station in 2011 to 3.0 birds per station in 2014. Blackbirds are the most abundant bird species in Wellington City reserves and this ongoing increase in numbers may suggest that this species is benefitting from local efforts to control populations of mammalian predators.

The incorporation of bird distribution data collected by local 'citizen scientists' has allowed us to map the distribution of birds in Wellington City in much greater detail than previously. Many of the native forest bird species recently re-introduced to Zealandia or other predator-free sites near the city continue to have fairly localised distributions within Wellington City, suggesting that mammalian predators are still likely to be limiting the establishment of populations beyond these original re-introduction sites. Nonetheless, these distribution maps indicate that some natural re-colonisation events have occurred in recent years, including whiteheads and red-crowned parakeets colonising Trelissick Park, bellbirds and red-crowned parakeets colonising Khandallah Park and red-crowned parakeets also colonising Otari-Wilton Bush.

We recommend that these counts be continued on an annual basis to provide a consistent, repeatable measure of trends in bird diversity, abundance and distribution in Wellington City. We also recommend that Wellington City Council considers investing additional resources towards further amalgamating existing Wellington City citizen science bird datasets and to provide additional training and support to improve local citizen scientists' ability to record and report bird observation data that can be used to supplement this more systematic bird monitoring programme.

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

1 INTRODUCTION

In recent years 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 recent 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 (the Karori Wildlife Sanctuary), 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 kaka (*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 tui (*Prosthemadera novaeseelandiae*) (Bell, 2008; Froude, 2009; Brockie & Duncan, 2012) and is improving the likelihood that recently re-introduced species will establish functional populations away from their original re-introduction sites.

Ongoing improvements in efforts to protect and restore Wellington City's indigenous habitats are likely to result in further changes in the abundance and distribution of local native bird populations in the near future. Over 100 community restoration 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). Initiatives such as the "Enhancing the Halo" project¹ and a long-term goal of Wellington City Council to create New Zealand's first pest-free urban area on Miramar Peninsula (WCC, 2015) will likely result in further improvements in the distribution and abundance of currently locally-rare or locally-extinct native bird species in the 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 tui 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). Tui were chosen as a key focal species for this survey design and a sample size of 200 five-minute bird counts carried out at 100 locations across the city's reserve network was chosen to ensure the design had sufficient statistical power to detect a 10% or greater change in the relative abundance of tui in Wellington City reserves from one year to the next. These new bird count stations were surveyed in both 2011 and 2012 and showed that the dispersal of birds re-introduced to Zealandia into surrounding reserves accounted for 33% of the native forest bird species detected. Many of these species were found to

¹ A joint initiative between the Morgan Foundation, Wellington City Council, Department of Conservation and Greater Wellington Regional Council (<http://halo.org.nz/>)

have very localised distributions in Wellington City however, indicating that one or more factors were limiting the ability of these species to colonise habitats beyond Zealandia's predator-proof fence (McArthur et al, 2013a).

Another key result from these first two surveys was that the average number of tui recorded per count station declined substantially between 2011 and 2012, with much of this decline resulting from tui being largely absent from eastern and southern parts of the city in late 2012. This was considered to have been caused by movements of tui into other habitats in the city or surrounding landscape, probably in response to changes in locally-available food resources (McArthur et al, 2013a). This result demonstrates that changes in the spatial pattern of food availability in Wellington City has the potential to drive large and conspicuous changes in local bird abundance and distribution over relatively short time periods.

These five-minute bird counts were repeated again in both 2013 and 2014 and this report provides a summary of the results of these more recent bird counts and makes comparisons with the results of the earlier 2011 and 2012 surveys.

Although this existing network of five-minute bird count stations is only designed to sample native birds in Wellington City's parks and reserves, this report also attempts for the first time to incorporate local 'citizen science' bird distribution data to provide additional information on the distribution of native birds in adjacent urban and suburban habitats in the city. Thanks to the availability of biodiversity reporting tools such as the New Zealand eBird and NatureWatch databases, Zealandia's "report a bird" webpage and citizen science projects such as the Great Kereru Count and New Zealand Garden Bird Survey, there is rapidly growing interest among Wellington City residents in collecting and sharing high-quality bird observations from around the city. These observations have the potential to complement the existing Wellington City five-minute bird count dataset by providing distribution data from habitats not currently being sampled as part of this existing monitoring programme.

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 2014 (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 each.

Bird conspicuousness can vary in response to a number of variable 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.

Due to unforeseen circumstances, one of the observers employed to carry out these bird counts in 2011 was not available from 2012 onwards, so was replaced by a new observer. A third observer has carried out these counts for all four years. Many of the apparent changes in bird detection rates observed between 2011 and 2012 appeared to be a consequence of this change in one of the observers rather than an actual change in bird abundance (McArthur et al, 2013a). This result highlighted the substantial impact observer-related variation can have on five-minute bird count results and illustrates the importance of retaining the same observers from one year to the next. During the four years of surveys carried out so far, the aim has been to minimise the number of different observers involved in carrying out these surveys, in order to keep these observer-related effects to a minimum. During three of the four years completed so far, the same two observers (AH and IF) have carried out these five-minute bird counts each year.

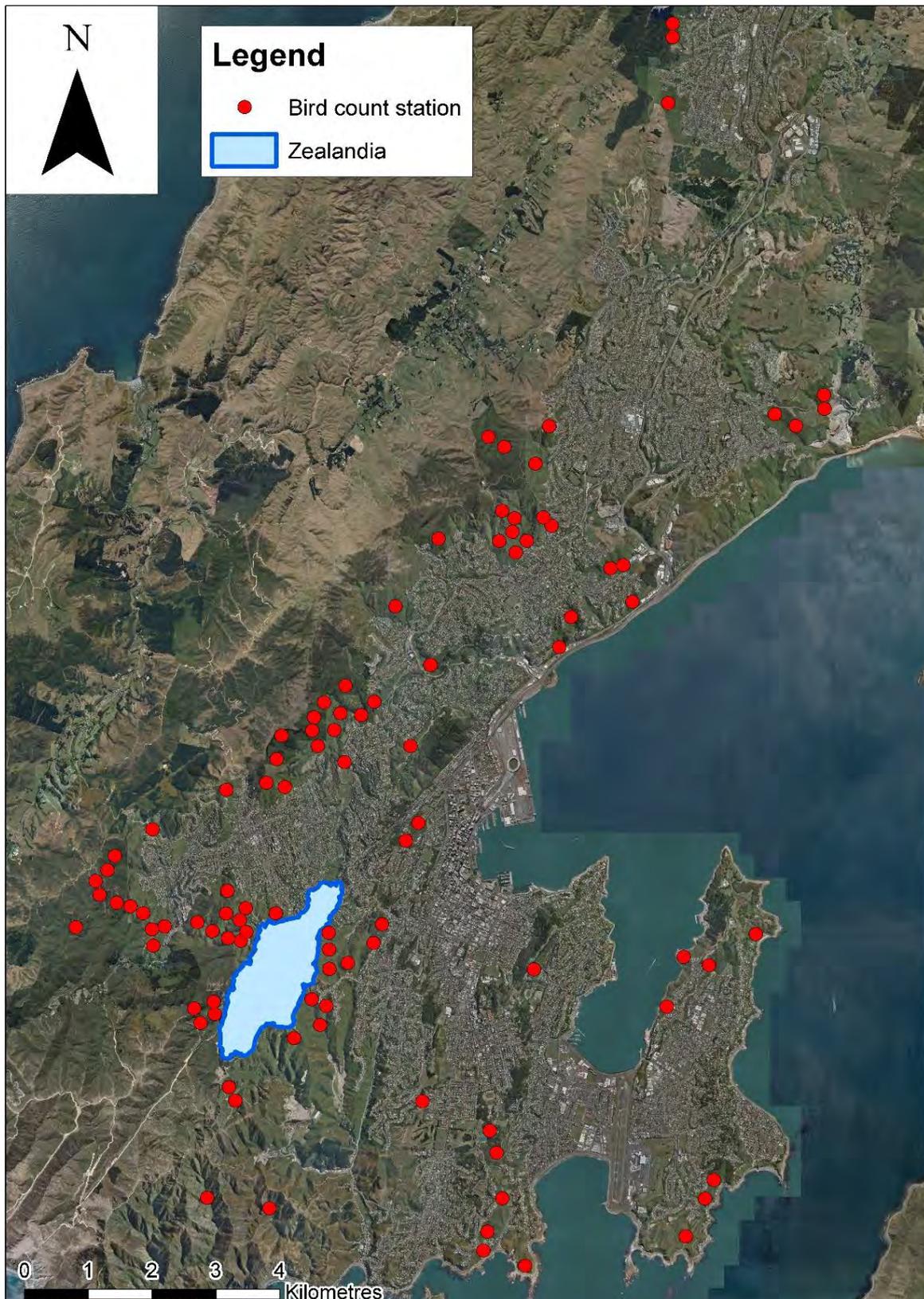


Figure 2.1: Locations of five-minute bird count stations established in Wellington City parks and reserves in 2011

2.2 Five-minute bird count data analysis

The Wellington City five-minute bird count data were entered into a Microsoft Excel spreadsheet, along with five-minute bird count data collected from Upper Hutt (n=90) and south Wairarapa (n=45) reserves as well as Porirua Scenic Reserve (n=45), all of which were also surveyed between 2011 and 2014. Details of the survey design, location and number of reserves sampled in Upper Hutt can be found described in McArthur et al, 2013b). The south Wairarapa reserves sampled included O'Connor's Bush in Greytown Memorial Park, Tauherenikau Bush at the Tauherenikau Racecourse and Waihora Bush (Waihora Stream on NW boundary of Aorangi Forest Park).

Once entered, these bird count data were used to calculate the mean number of native forest bird species detected per five-minute bird count for each reserve network and each year, in order to examine temporal and spatial patterns in the diversity of resident native species. 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. We also used these data to calculate the mean number birds of each species recorded per count for each network and year, to create indices of the relative abundance and/or conspicuousness of each bird species in the Wellington City reserves network (Dawson & Bull, 1975).

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 species diversity values and abundance indices in Wellington City between years. To test for differences in mean values between years and reserve networks, we used two-way ANOVAs. However, because two-way ANOVAs require sample sizes to be equal, we performed the test on a random sub-sample of 90 Wellington City bird counts in order to compare mean values with those calculated from the Upper Hutt City bird count data. In cases where the results of our ANOVAs did indicate that mean values varied significantly, we then applied two-tailed z-tests to the transformed dataset to determine which of the mean values in each group varied significantly from each other (Fowler & Cohen, 1995). Both the ANOVAs and z-tests are 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 diversity or abundance of native forest birds between years, or between one or more of the four reserve networks/sites that we surveyed.

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 ArcMap version 10.3.1. 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

The New Zealand eBird database (<http://ebird.org/content/newzealand/>) is a citizen science enterprise run by the Cornell Lab of Ornithology in partnership with Birds New Zealand (formerly the Ornithological Society of New Zealand). The eBird database provides a facility for recreational birdwatchers to permanently record their bird observation in a standard format and in one centralised location and to make 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 150 000 unique users having already contributed over 250 million bird records describing the distribution of 98% of the world's bird species (Sullivan et al, 2014).

The New Zealand eBird database now contains in excess of 100 000 bird records recorded by citizen scientists in the Wellington region. Automated data filters and an expert review process ensures that these data are of relatively high quality and accuracy (Sullivan et al, 2014). We used eBird's "download data" tool to access the August 2015 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 2015. 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 tab-delimited text files so that they could be imported into ArcMap. 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.

A key difference between these eBird datasets and the five-minute bird count data is that the temporal and spatial distribution of search effort spent by citizen scientists contributing to the EBD varies unpredictably from year to year, whereas this search effort is standardised during these five-minute bird counts. Nonetheless, verified bird records submitted to eBird 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 2014, with between 29 and 33 bird species detected each year² (Figure 3.1). Between 10% and 18% 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 39% to 41% are native species ranked as Not Threatened (Robertson et al, 2013). Between 42% and 48% of species detected are listed as Introduced and Naturalised² (see Appendix).

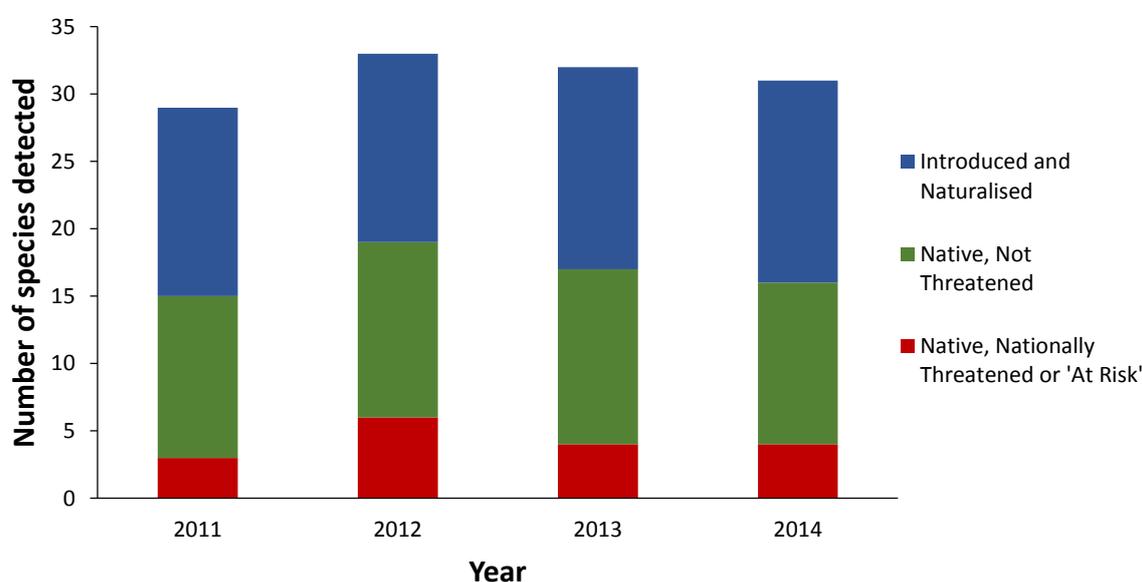


Figure 3.1: Total number of bird species detected during five-minute bird counts carried out in Wellington City parks and reserves, 2011-2014.

Fourteen of the native bird species detected between 2011 and 2014 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 eight 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.

Between 2011 and 2014 there has been no consistent change in the mean number of native forest bird species detected per bird count station in Wellington City reserves, despite some statistically significant year-to-year fluctuations ($F_{3,796} = 6.18$, $p = 0.000375$; one-way ANOVA). For example, there was a significant decline from a mean of 2.8 species recorded per station in 2011 to 2.5 species in 2012 ($z = 1.96$, $p = 0.0015$; two-tailed z-test), followed by a subsequent increase to 3.0 species per station in 2013 ($z = 1.96$, $p = 3.28 \times 10^{-5}$; two-tailed z-test) (Figure 3.2). The mean number of native forest bird

² Note, feral chicken (*Gallus gallus*) has been included in these species totals for the first time in this report (lumped in with Introduced and Naturalised species in Figure 3.1). These totals therefore vary slightly from those previously reported in McArthur et al, 2012 and McArthur et al, 2013a).

species detected at count stations in Wellington City and south Wairarapa reserves, and in Porirua Scenic Reserve have not differed significantly between each other during most years (Figure 3.2). In contrast, the number of native forest bird species detected per count station in Upper Hutt reserves has been significantly higher than those recorded in Wellington City each year between 2011 and 2014 ($F_1 = 154.72$, $p = 2.78 \times 10^{-32}$; two-way ANOVA).

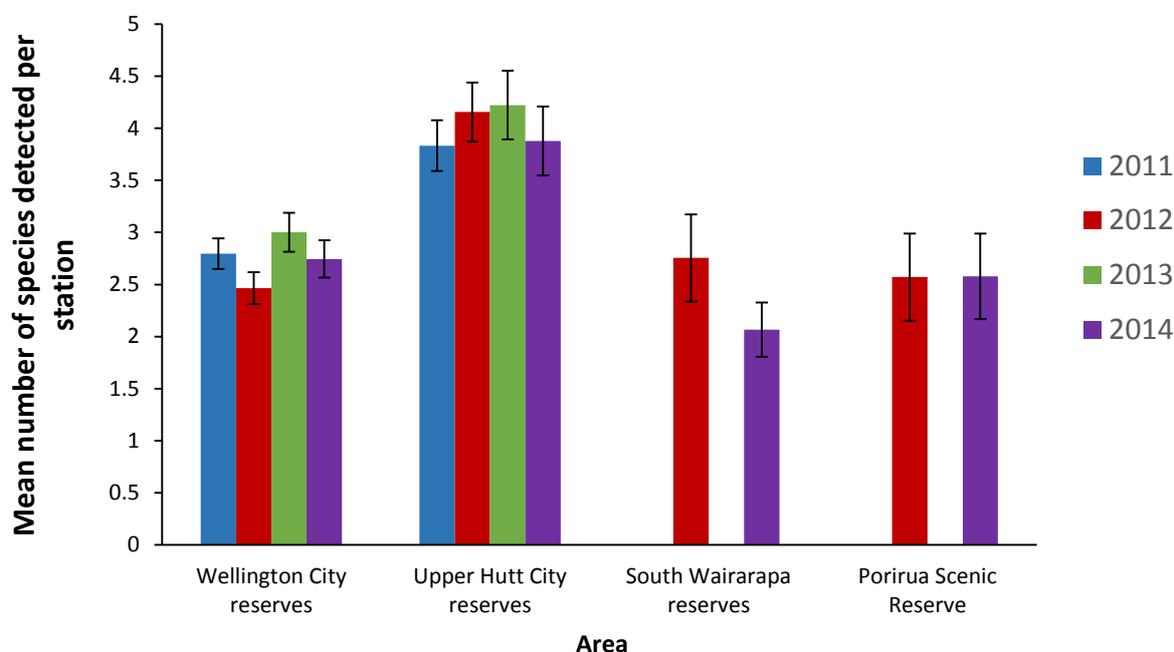


Figure 3.2: Mean number of native forest bird species recorded per count station in Wellington City (n=200), Upper Hutt City (n=90), south Wairarapa (n=45) reserves and in Porirua Scenic Reserve (n=45) between 2011 and 2014 (error bars represent 95% confidence limits). NB: south Wairarapa reserves and Porirua Scenic Reserve weren't monitored in 2011 or 2013.

3.2 Bird abundance

Silvereeye (*Zosterops lateralis*), tui, grey warbler (*Gerygone igata*), fantail (*Rhipidura fuliginosa*) and shining cuckoo (*Chrysococcyx lucidus*) have been the five most frequently-encountered native forest bird species recorded in Wellington City reserves each year between 2011 and 2014. Silvereeye has been the most frequently encountered species each year, with between 1.9 and 2.4 individuals recorded per count station between 2011 and 2014. A significant increase in the silvereeye encounter rate observed between 2011 and 2012 ($z = 1.96$, $p = 0.0028$; two-tailed z-test) was likely to be a consequence of a change in observer between these two surveys (McArthur et al, 2013a) and no further changes in silvereeye abundance have been detected during subsequent years (Figure 3.3). Tui was the second most frequently-encountered species during three of the four previous years and encounter rates have fluctuated substantially over the past four years, from a low of 0.8 individuals recorded per count station in 2012 to a high of 2.2 individuals recorded per station in 2013 ($F_{3,796} = 32.37$, $p = 9.44 \times 10^{-20}$; one-way ANOVA). Numbers of grey warblers encountered per station have been less variable, with between 0.8 and 1.3 individuals encountered per bird count station each year. A significant increase in the grey warbler encounter rate between 2011 and 2012 ($z = 1.96$, $p = 0.00015$; two-tailed z-test) was also likely to be due to the change in observer between these two surveys (McArthur et al, 2013a) and no further changes in abundance have been detected in subsequent years. No significant variation in the abundance of fantails ($F_{3,796} = 2.41$, $p = 0.065$; one-way ANOVA) or

shining cuckoos ($F_{3,796} = 1.18$, $p = 0.317$; one-way ANOVA) have been detected between 2011 and 2014, with 0.2-0.3 and 0.2 birds counted per station for these respective species each year.

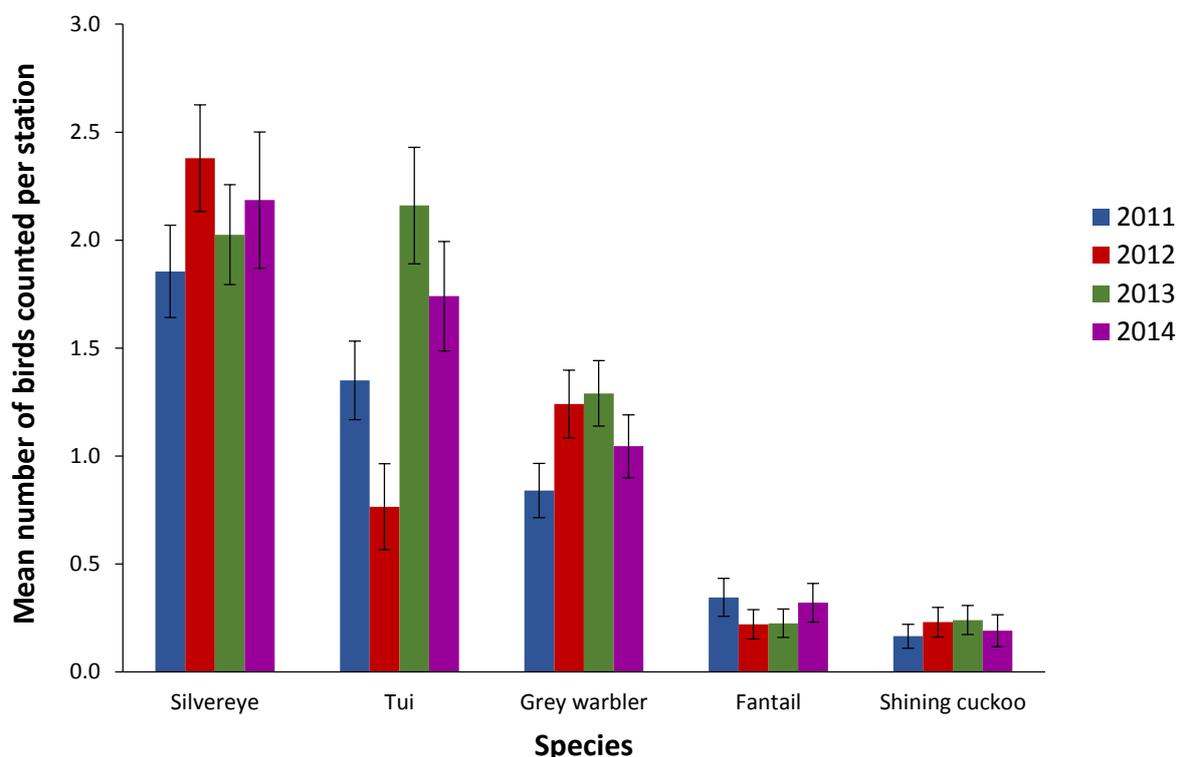


Figure 3.3: Mean number of birds recorded per count station for relatively common or conspicuous native forest bird species recorded in Wellington City reserves between 2011 and 2014 (error bars represent 95% confidence limits).

The nine remaining native forest bird species have all been encountered at a rate of less than 0.2 birds per count station each year (Figure 3.4). Of these, only North Island saddleback (*Philesturnus rufusater*) has shown significant variation between years, with numbers of saddleback encountered per station significantly lower during the years 2012-2014 than in 2011 ($F_{3,796} = 3.84$, $p = 0.0095$; one-way ANOVA). Several other species have not been detected during all four annual surveys. North Island robins (*Petroica longipes*) weren't detected during five minute bird counts in 2014 despite being recorded each year between 2011 and 2013. Conversely, both bellbird and New Zealand falcon (*Falco novaeseelandiae*) weren't detected in 2011 but have been recorded during five-minute bird counts in subsequent years.

Several native forest bird species have not yet been detected during these five-minute bird counts, despite being resident or regular visitors to Wellington City parks and reserves. Morepork (*Ninox novaeseelandiae*) have not yet been encountered despite the fact that this species is likely to be resident and breeding in many of Wellington's parks and reserves. Being a nocturnal species however, moreporks are fairly unlikely to be detected during these daytime counts. According to citizen science records submitted to the New Zealand eBird database, both long-tailed cuckoos (*Eudynamys taitensis*) and hihi (*Notiomystis cincta*) are also likely to be regular visitors to Wellington City reserves, but have not yet been recorded during these five-minute bird counts. (NZ eBird database, <http://ebird.org/content/newzealand/>; accessed 18/09/2015).

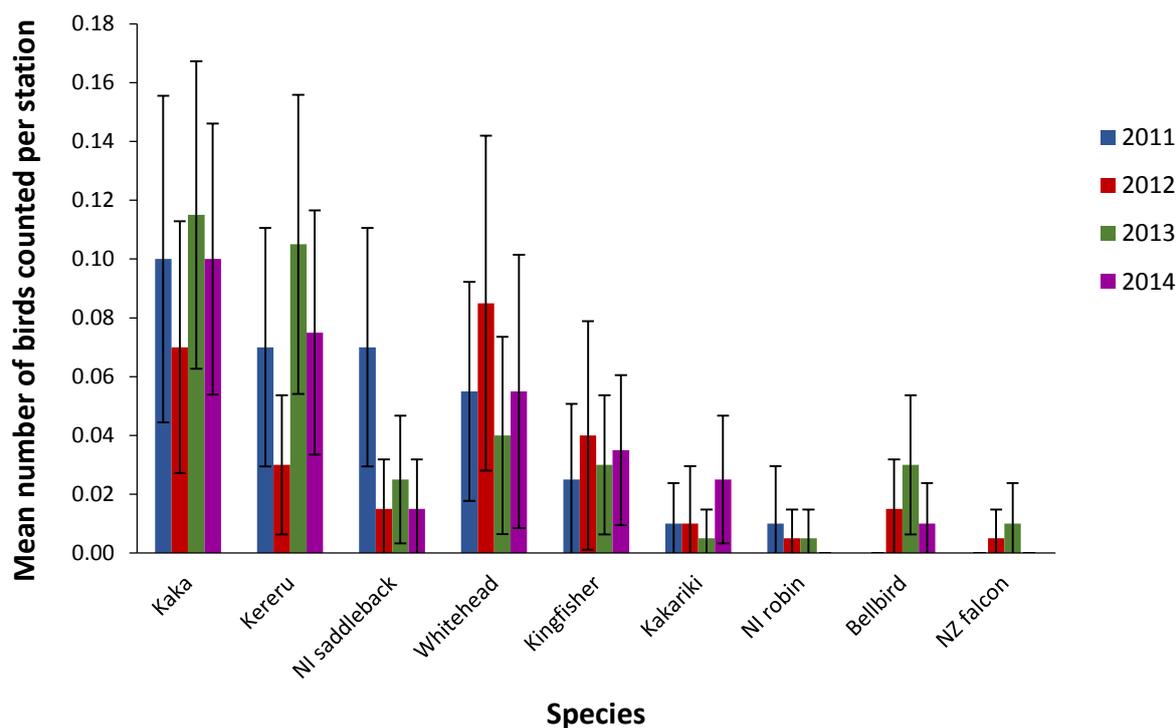


Figure 3.4: Mean number of birds recorded per count station for relatively rare or inconspicuous native forest bird species recorded in Wellington City reserves between 2011 and 2014 (error bars represent 95% confidence limits).

Blackbird (*Turdus merula*), chaffinch (*Fringilla coelebs*), starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*) and dunnock (*Prunella modularis*) have been the five most frequently-encountered introduced bird species recorded in Wellington City reserves between 2011 and 2014. Blackbird has been the most abundant species, with encounter rates exceeding those of even the most common native bird species detected during these surveys. Moreover, the mean number of blackbirds encountered per bird count station has increased by 30% between 2011 and 2014, from 2.3 birds counted per station in 2011 to 3.0 bird per station in 2014 ($F_{3,796} = 5.24$, $p = 0.0014$; one-way ANOVA). Encounter rates for chaffinch have not changed significantly between 2011 and 2014, with a mean of 0.9 – 1.0 birds detected per count each year ($F_{3,796} = 0.66$, $p = 0.5758$; one-way ANOVA). Starlings on the other hand varied from 0.2 – 0.4 birds per count each year, with a significant decrease in encounter rate observed between 2012 and 2013 ($z = 1.96$, $p = 0.00173$; two-tailed z-test). Both house sparrow and dunnock encounter rates have been significantly and consistently higher in 2012-2014 than in 2011, however this is likely to be a consequence of the change in observers that occurred between the 2011 and 2012 counts (McArthur et al, 2013a).

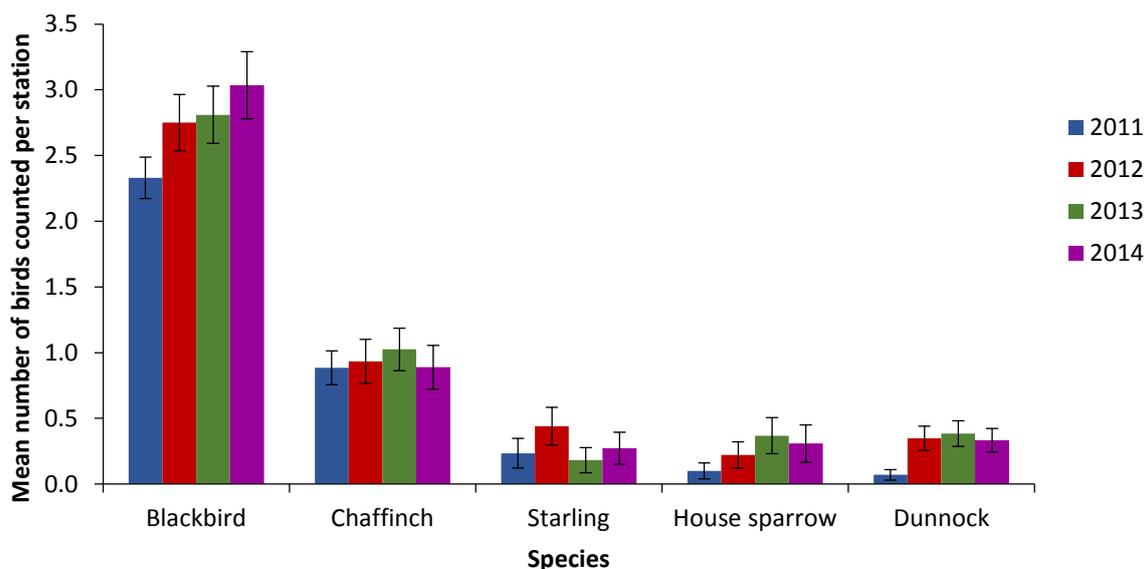


Figure 3.5: Mean number of birds recorded per count station for relatively common or conspicuous introduced bird species recorded in Wellington City reserves between 2011 and 2014 (error bars represent 95% confidence limits).

The remaining introduced bird species that have been recorded between 2011 and 2014 were all encountered at a rate of less than 0.6 birds per count station (Figure 3.6). Mean encounter rates for goldfinch (*Carduelis carduelis*) and yellowhammer (*Emberiza citrinella*) remained significantly higher in 2012-2014 than in 2011, likely to be a result of the previously-described observer effect (McArthur et al, 2013a). Redpolls (*C. flammea*) and feral chickens (*Gallus gallus*) continued to be encountered each year between 2012 and 2014, despite neither species having been detected during the 2011 counts.

No crimson rosellas (*Platycercus elegans*) have been detected during any of the five-minute bird counts carried out over the past four years. A small population of crimson rosellas became established in western and north-western suburbs of Wellington City around 1963, with credible sightings of birds occurring as recently as the mid-1990s (Galbraith, 2013; Heather & Robertson, 2015; New Zealand eBird database, <http://ebird.org/content/newzealand/>; accessed 18/09/2015). This result provides additional confirmation that this crimson rosella population has now apparently either died out or has become absorbed into the local eastern rosella (*P. eximius*) population.

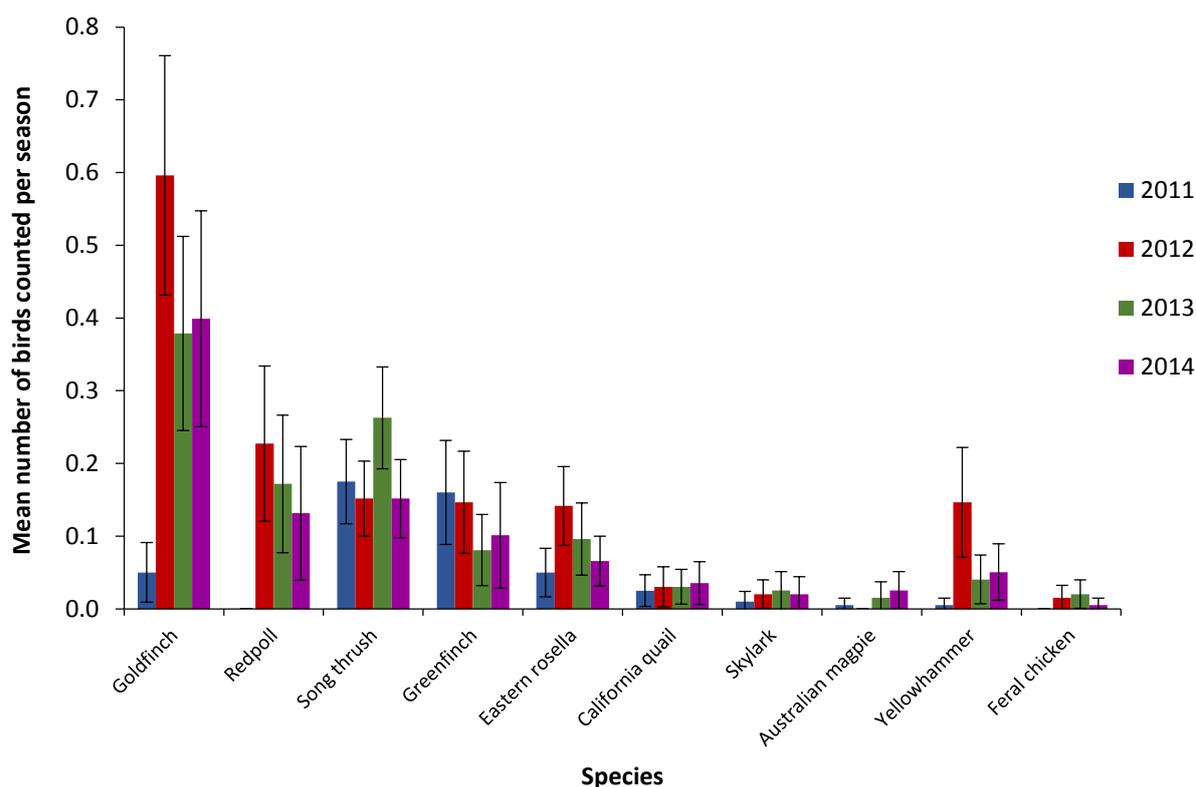


Figure 3.6: Mean number of birds recorded per count station for relatively rare or inconspicuous introduced bird species recorded in Wellington City reserves between 2011 and 2014 (error bars represent 95% confidence limits).

3.3 Native bird distribution

Tui are now widespread across Wellington City, despite being a relatively rare and infrequent visitor to many parts of the city as recently as 10 - 15 years ago (Figure 3.7; Bell, 2008). Tui have been detected at every one of the 100 five-minute bird count stations that have been surveyed between 2011 and 2014. The proportion of counts during which tui have been detected has generally been higher at count stations in western and northern suburbs of the city, and at stations within 1 km of Zealandia's predator-proof fence. In contrast, detection rates have tended to be lower in eastern suburbs and on Miramar Peninsula, although the large number of tui records submitted by citizen scientists from these eastern suburbs suggest that tui are resident or regular visitors to this part of the city as well (Figure 3.7). The combination of five-minute bird count records and citizen science observations show that tui are utilizing a range of habitats in Wellington City, including forest and shrub land habitats in Wellington's parks and reserve network as well as adjacent urban and suburban habitats.

In contrast, bellbirds remain much more sparsely distributed and have only been detected at 10% of the five-minute bird count stations surveyed between 2011 and 2014 (Figure 3.8). A concentration of bellbird detections at count stations in Khandallah Park suggests that a small population may now be established in this reserve. Bellbird detections in George Denton Park, the Wellington Botanical Gardens and at Makara Peak are perhaps most likely to be birds dispersing from Zealandia, whereas several records in Tawa may represent birds dispersing south from the source population in Porirua Scenic Reserve.

Several other native species such as silvereye, grey warbler and fantail are also relatively widespread in Wellington City and have been detected at a large proportion of the five-minute bird count stations

between 2011 and 2014 (e.g. Figure 3.9). As with tui, the proportion of counts during which fantails are detected appears to be higher at count stations situated in western and northern suburbs and within 1 km of the Zealandia boundary fence.

In contrast, kereru appear to be much more patchily distributed in Wellington City and have only been detected at around 30% of the five-minute bird count stations surveyed between 2011 and 2014 (Figure 3.10). Kereru appear to be mainly restricted to patches of relatively mature native forest, including Otari-Wilton Bush, Khandallah Park and Zealandia and are sparse or absent from reserves with shorter, shrubby vegetation such as Wright's Hill and Makara Peak.

Of the several native species that have been re-introduced to Zealandia, North Island kaka have been the most successful at utilizing habitats in surrounding parts of Wellington City (Figure 3.11). NI kaka have been detected at 30% of the five-minute bird count stations surveyed between 2011 and 2014, most of which are either within 1 – 2 km of Zealandia, or situated in areas of relatively mature native forest such as Otari-Wilton, the Wellington Botanical Gardens and Trelissick Park. Being such a conspicuous and recognisable species, NI kaka are frequently reported by local citizen scientists, with several thousand records now having been submitted either to the Zealandia "report a bird" webpage, to the New Zealand eBird database, NatureWatch or to Birds New Zealand. These observations demonstrate that kaka are regular visitors to suburban habitats in western and southern parts of Wellington City, although they apparently do not yet regularly occur in suburbs north of the Ngaio Gorge or on Miramar Peninsula.

A number of other species that have been re-introduced to Zealandia remain largely restricted to Zealandia itself or to adjacent parks and reserves. Whitehead for instance are seldom recorded more than 1 – 2 km from the Zealandia boundary fence, although they do appear to have now colonised Trelissick Park, some 3.8 km to the north (Figure 3.12). North Island saddleback show a similar pattern, typically only encountered in reserves such as George Denton Park and Wright's Hill, immediately adjacent to Zealandia. One NI saddleback was recorded at a five-minute bird count station in Te Kopahou Reserve 2.4 km south of the boundary fence in 2012, however (Figure 3.13).

Despite having been well-established in Zealandia for a relatively long time, North Island robins have not yet spread very far beyond the boundary fence. Robins have only been detected at one of the Wellington City five-minute bird count stations (in George Denton Park) and have only been reported by local citizen scientists from locations within 1 km of Zealandia's boundary (Figure 3.14).

In contrast, red-crowned parakeets are a relatively recent re-introduction to Zealandia, but have already been detected at six of the 100 five-minute bird count stations (Figure 3.15). Although still a relatively rare bird in Wellington City, red-crowned parakeets have been reported by citizen scientists from many locations across the city, particularly in the western suburbs. Clusters of records from Otari-Wilton Bush, Khandallah Park and Trelissick Park and in forested reserves in the Tawa area suggest that small resident populations may now be established at these locations. While many of these more southern 'satellite' populations are likely to have been founded by birds dispersing from Zealandia, some of these populations may also be receiving immigrants from Matiu/Somes Island. Red-crowned parakeet populations in the Tawa area may similarly be receiving immigrants from the apparently healthy source population now established in Porirua Scenic Reserve.

Several other native forest species are still sufficiently rare in Wellington City that they have barely been detected (if at all) during the five-minute bird counts carried out between 2011 and 2014. New Zealand falcons have only been detected at three of the 100 bird count stations surveyed over the past four years, but being relatively conspicuous and distinctive birds they are regularly reported by local citizen scientists at locations throughout Wellington City (Figure 3.16). Similarly, hihi have not yet been detected at any Wellington City five-minute bird count stations, but have been reported visiting reserves adjacent to Zealandia by citizen scientists on a number of occasions (Figure 3.17).

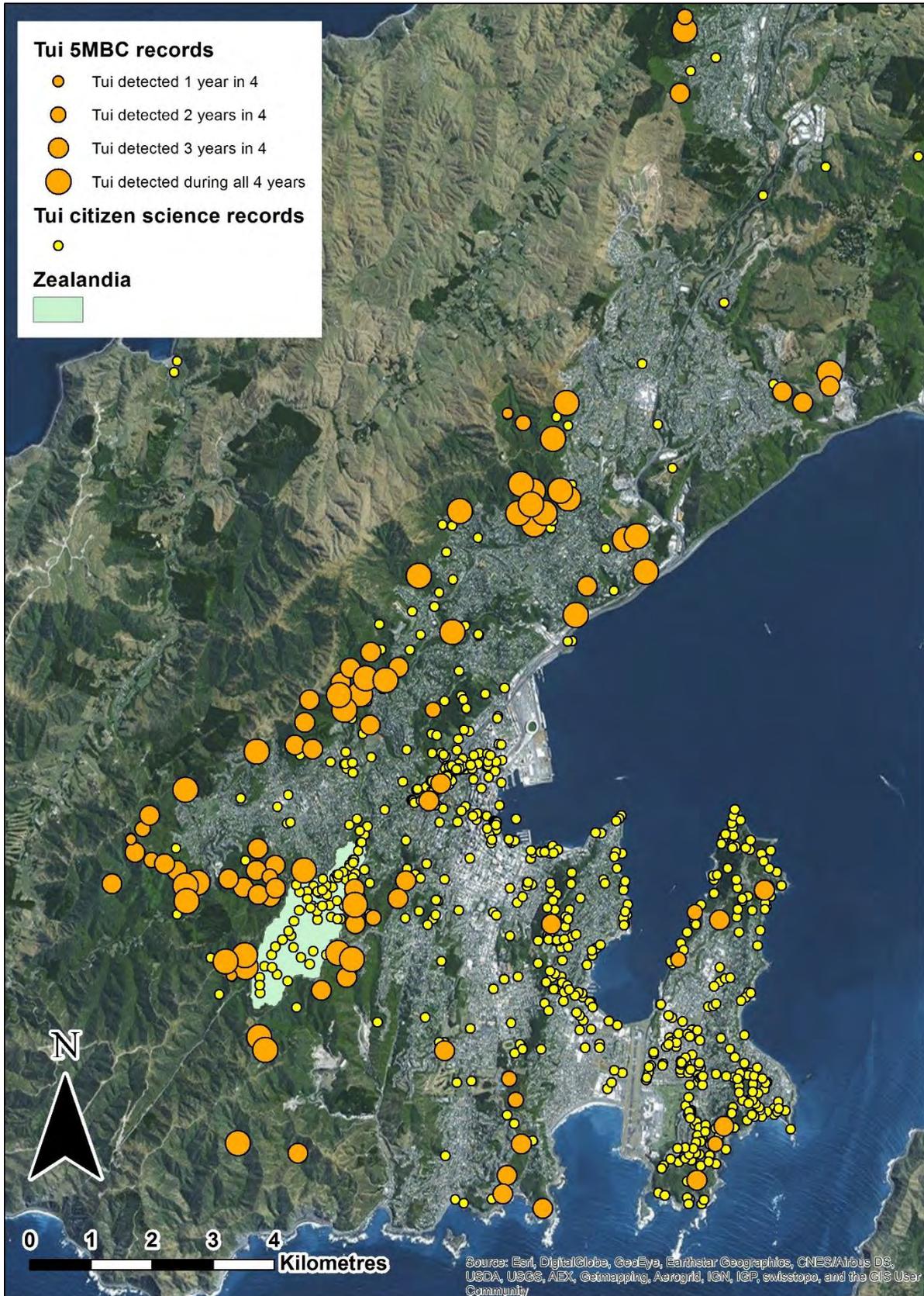


Figure 3.7: Distribution of tui in Wellington City between 2011 and 2014. Orange circles represent tui detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent tui observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

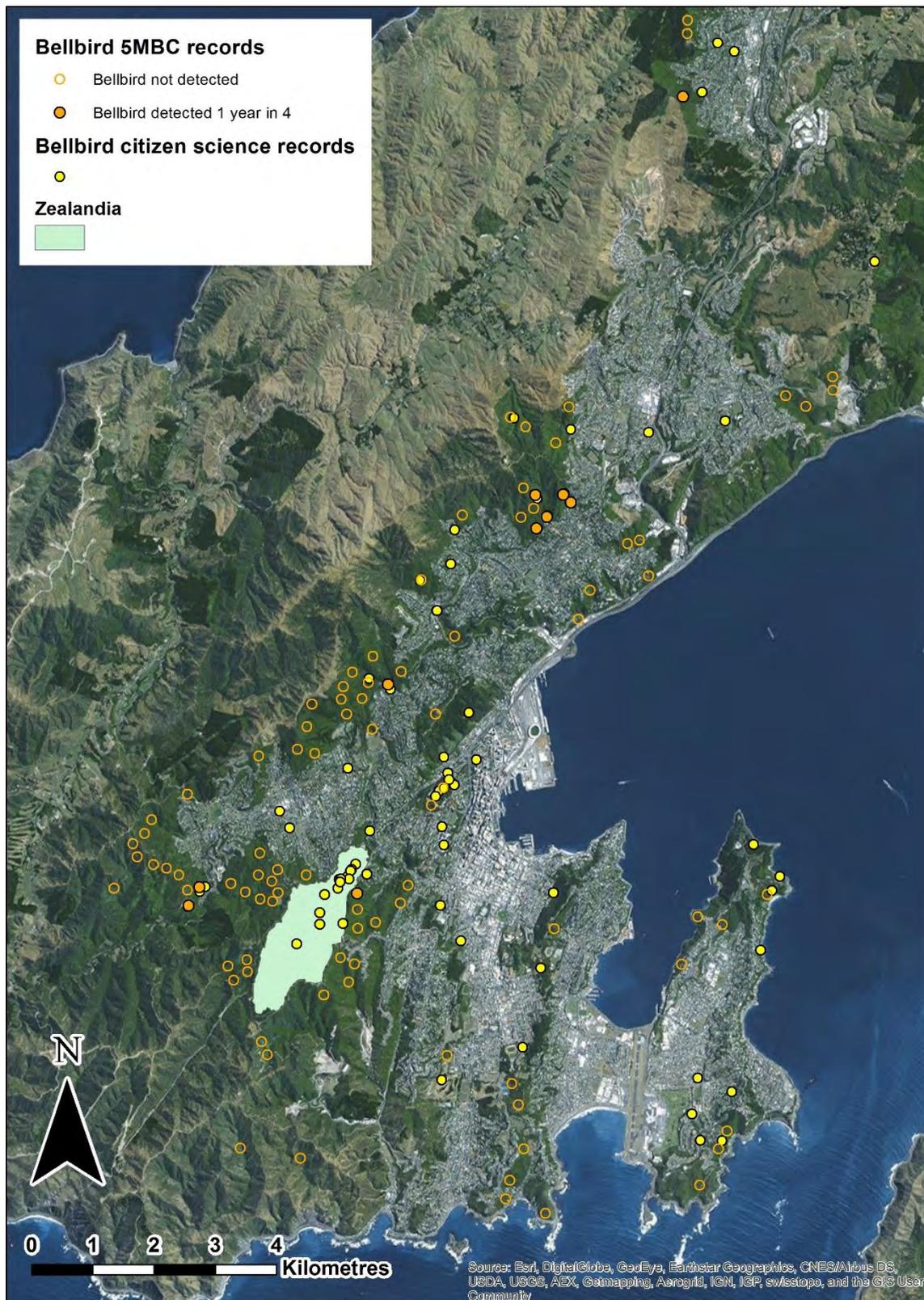


Figure 3.8: Distribution of bellbird in Wellington City between 2011 and 2014. Orange circles represent bellbird detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent bellbird observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

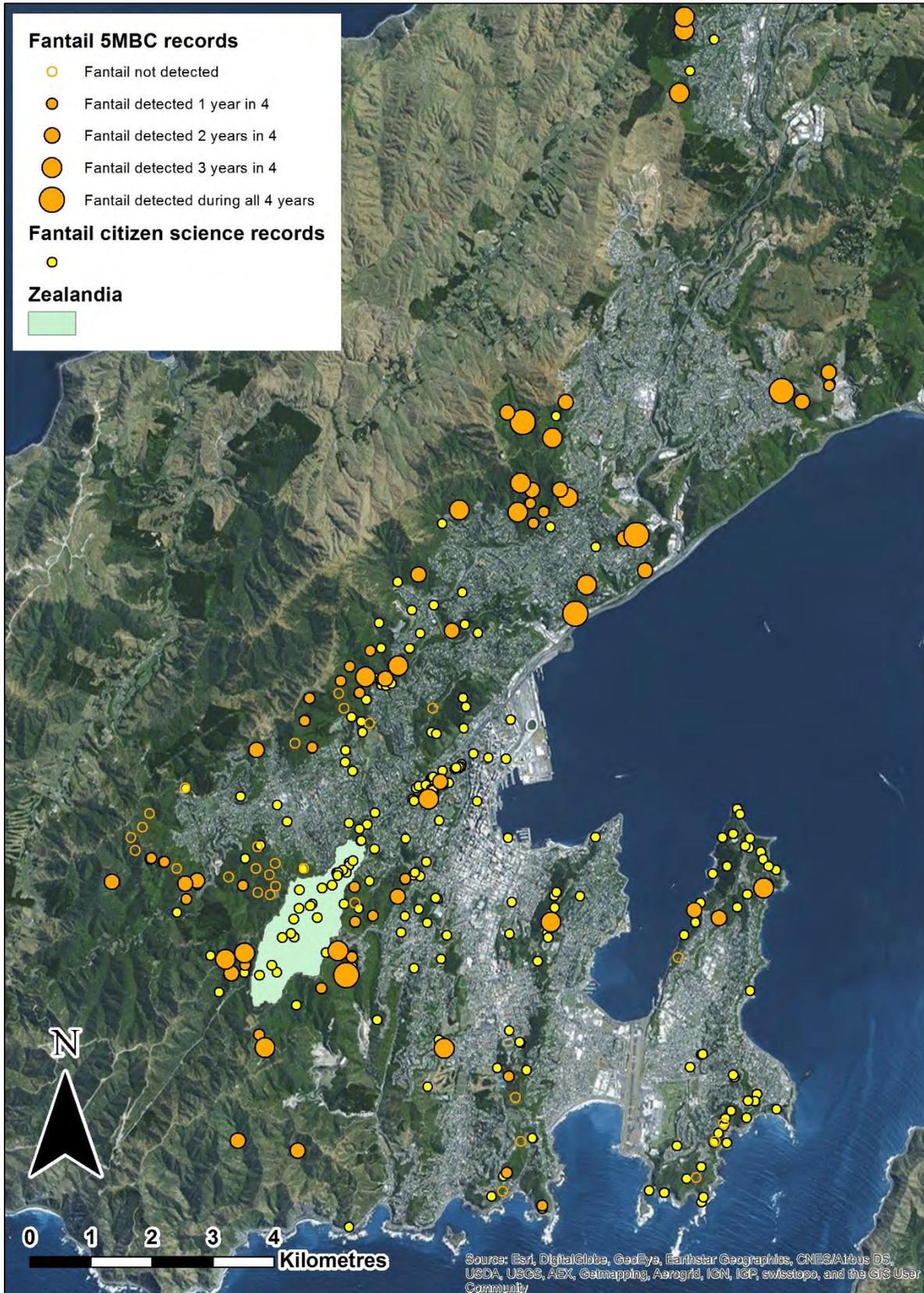


Figure 3.9: Distribution of fantail in Wellington City between 2011 and 2014. Orange circles represent fantail detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent fantail observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

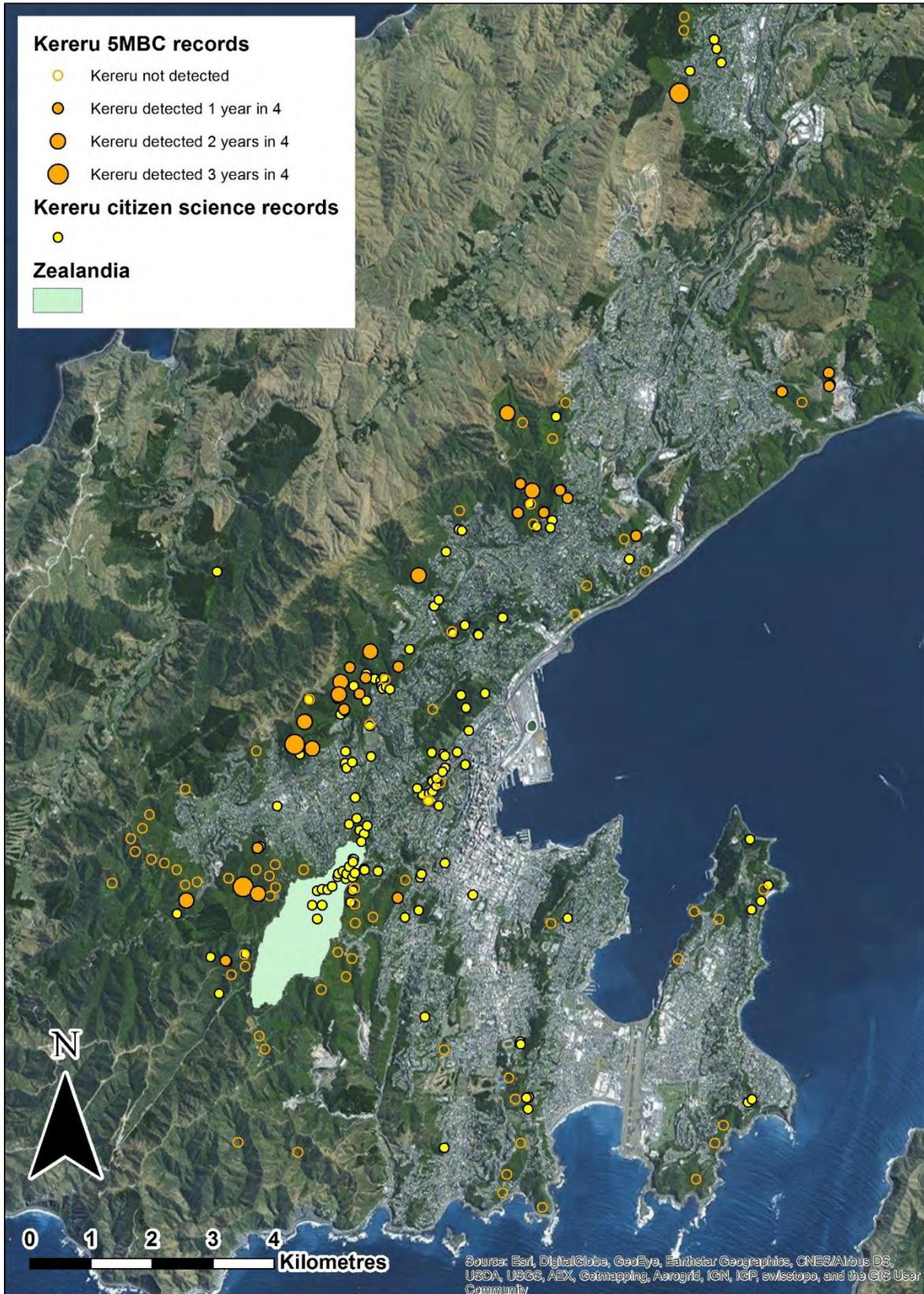


Figure 3.10: Distribution of kereru in Wellington City between 2011 and 2014. Orange circles represent kereru detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent kereru observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

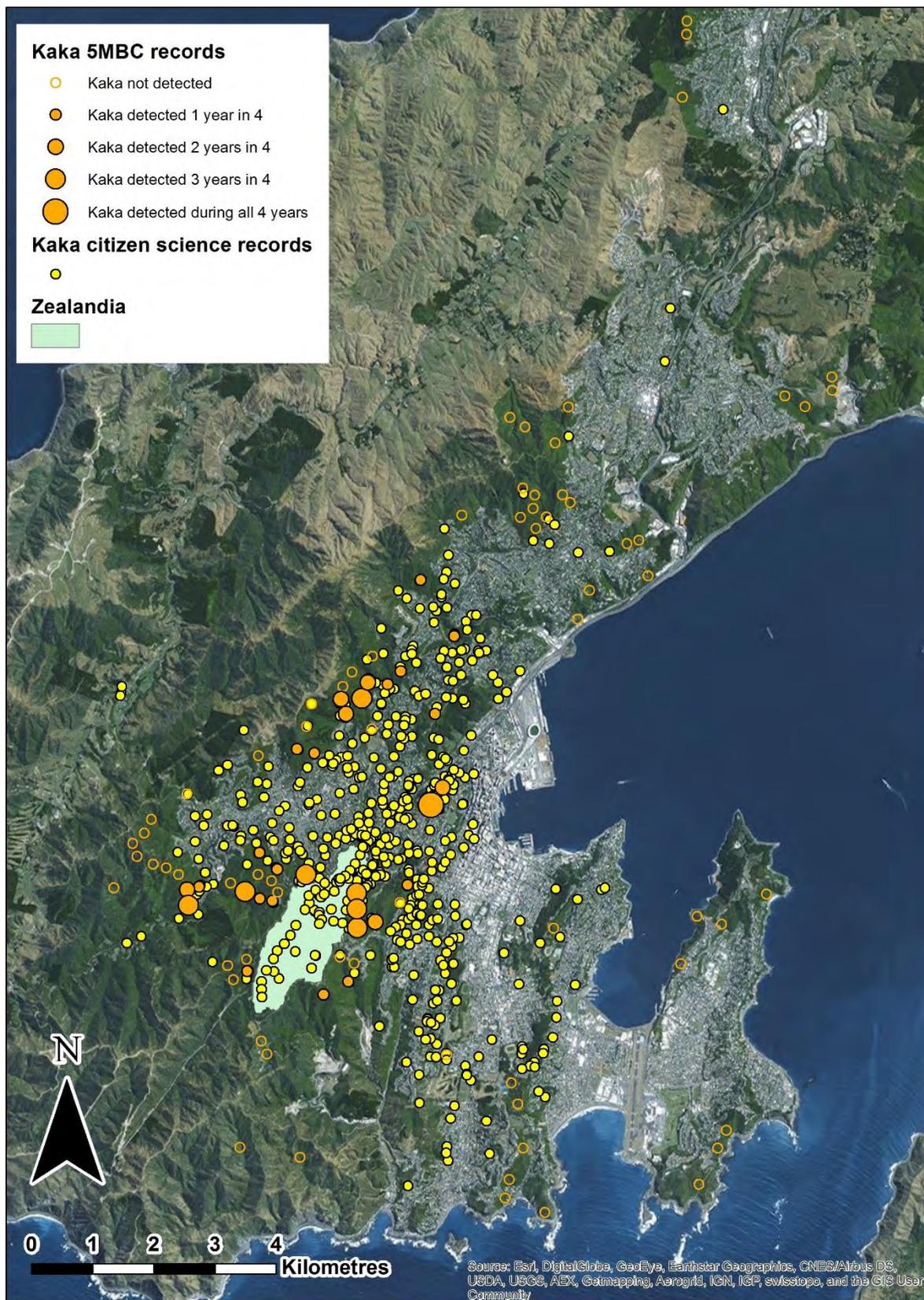


Figure 3.11: Distribution of kaka in Wellington City between 2011 and 2014. Orange circles represent kaka detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent kaka observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

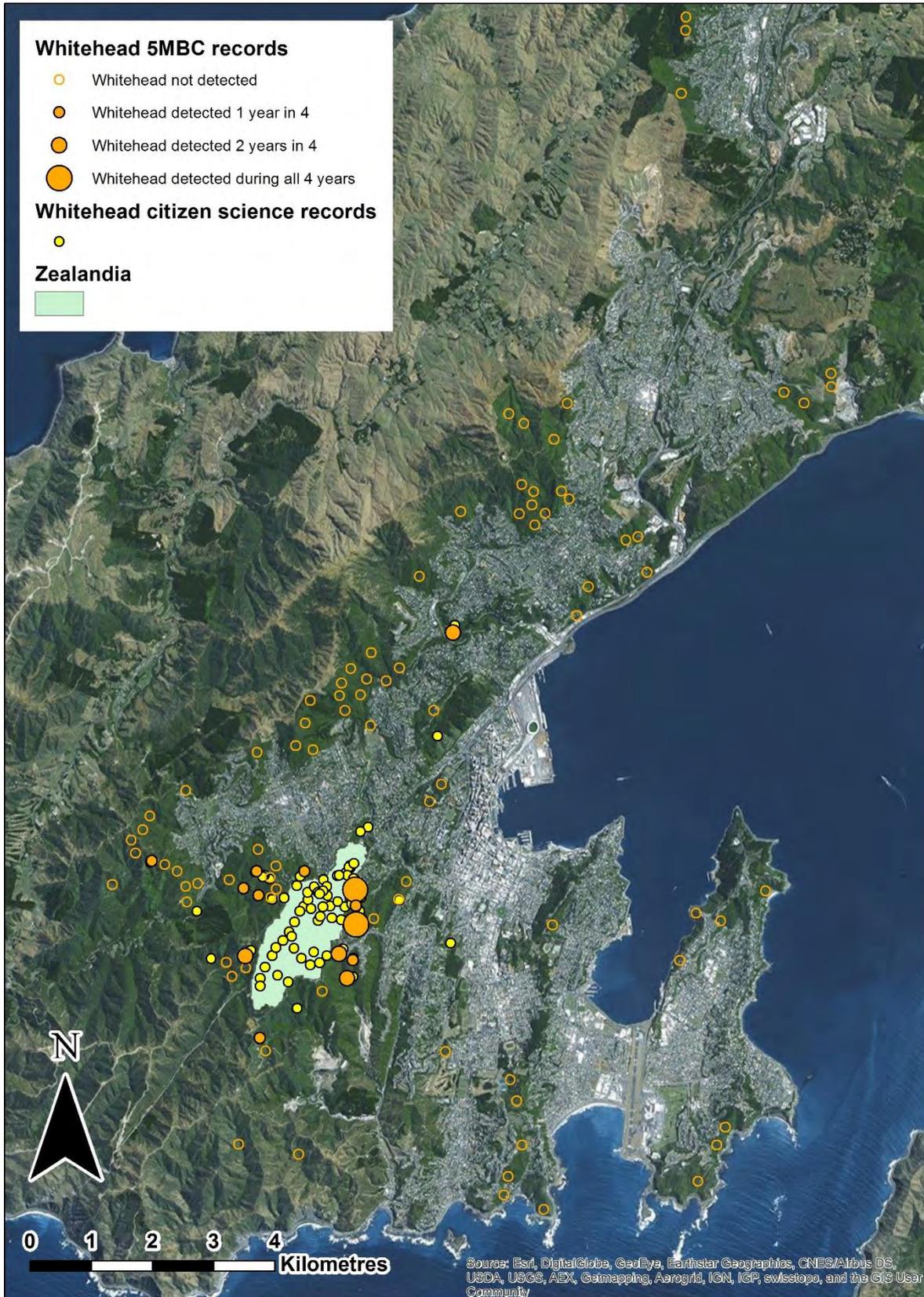


Figure 3.12: Distribution of whitehead in Wellington City between 2011 and 2014. Orange circles represent whitehead detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent whitehead observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).



Figure 3.13: Distribution of NI saddleback in Wellington City between 2011 and 2014. Orange circles represent NI saddleback detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent NI saddleback observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

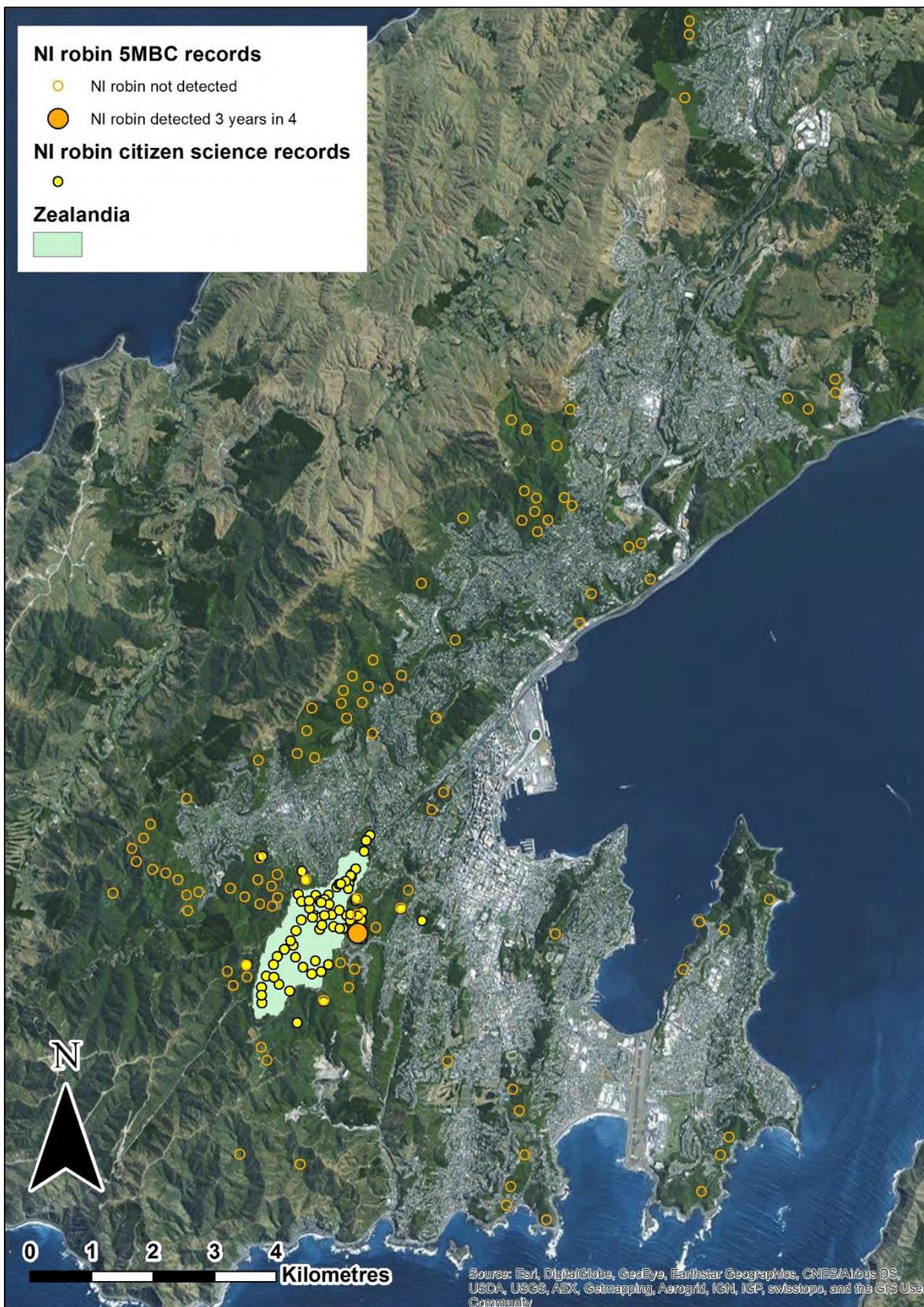


Figure 3.14: Distribution of NI robin in Wellington City between 2011 and 2014. Orange circles represent NI robin detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent NI robin observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).



Figure 3.15: Distribution of red-crowned parakeet in Wellington City between 2011 and 2014. Orange circles represent red-crowned parakeet detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent red-crowned parakeet observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

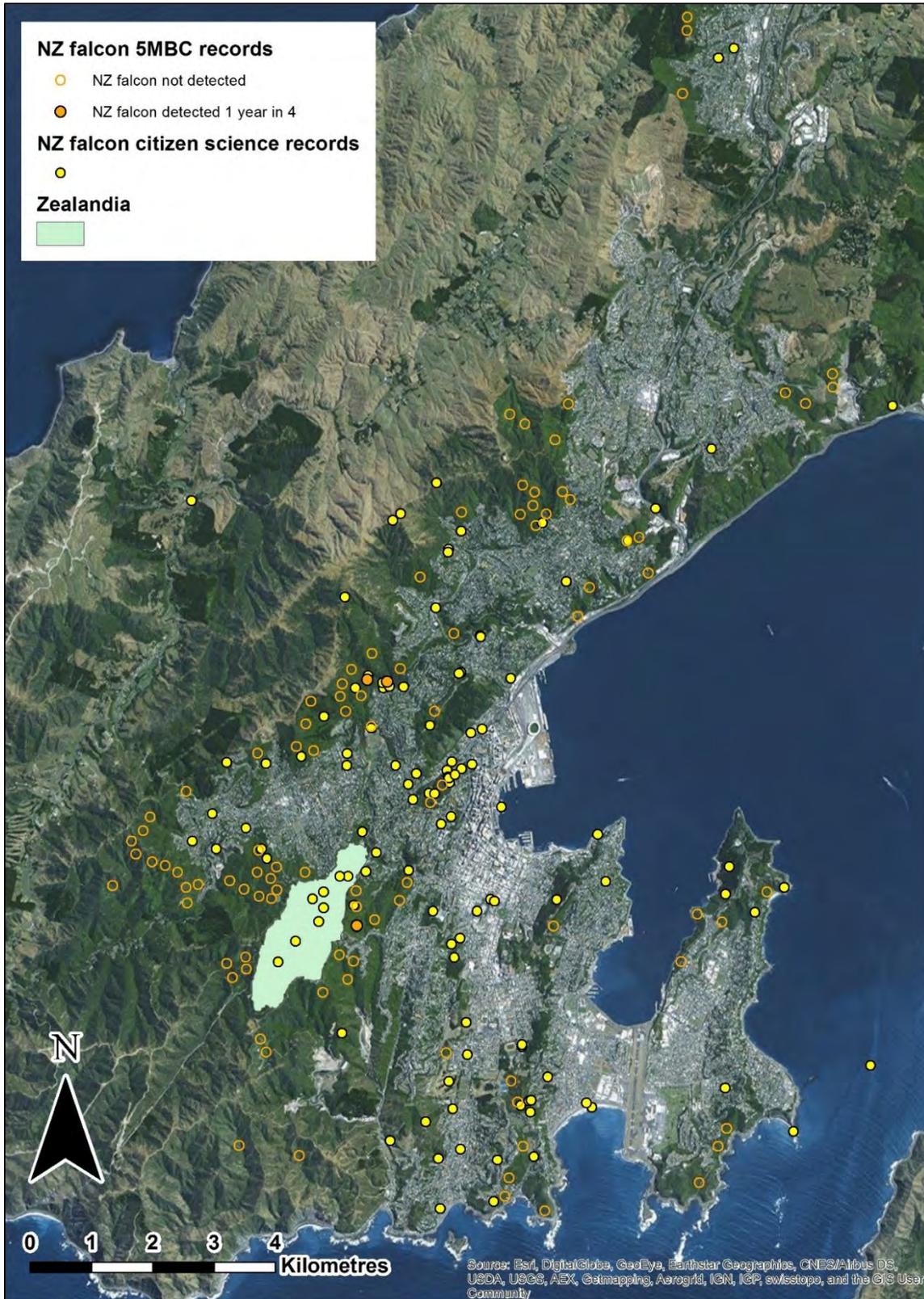


Figure 3.16: Distribution of NZ falcon in Wellington City between 2011 and 2014. Orange circles represent NZ falcon detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent NZ falcon observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015). NB: the falcon record in Wellington Harbour to the east of Miramar Peninsula is a valid record – this was a falcon spotted flying across the harbour by a passenger on a Cook Strait ferry.

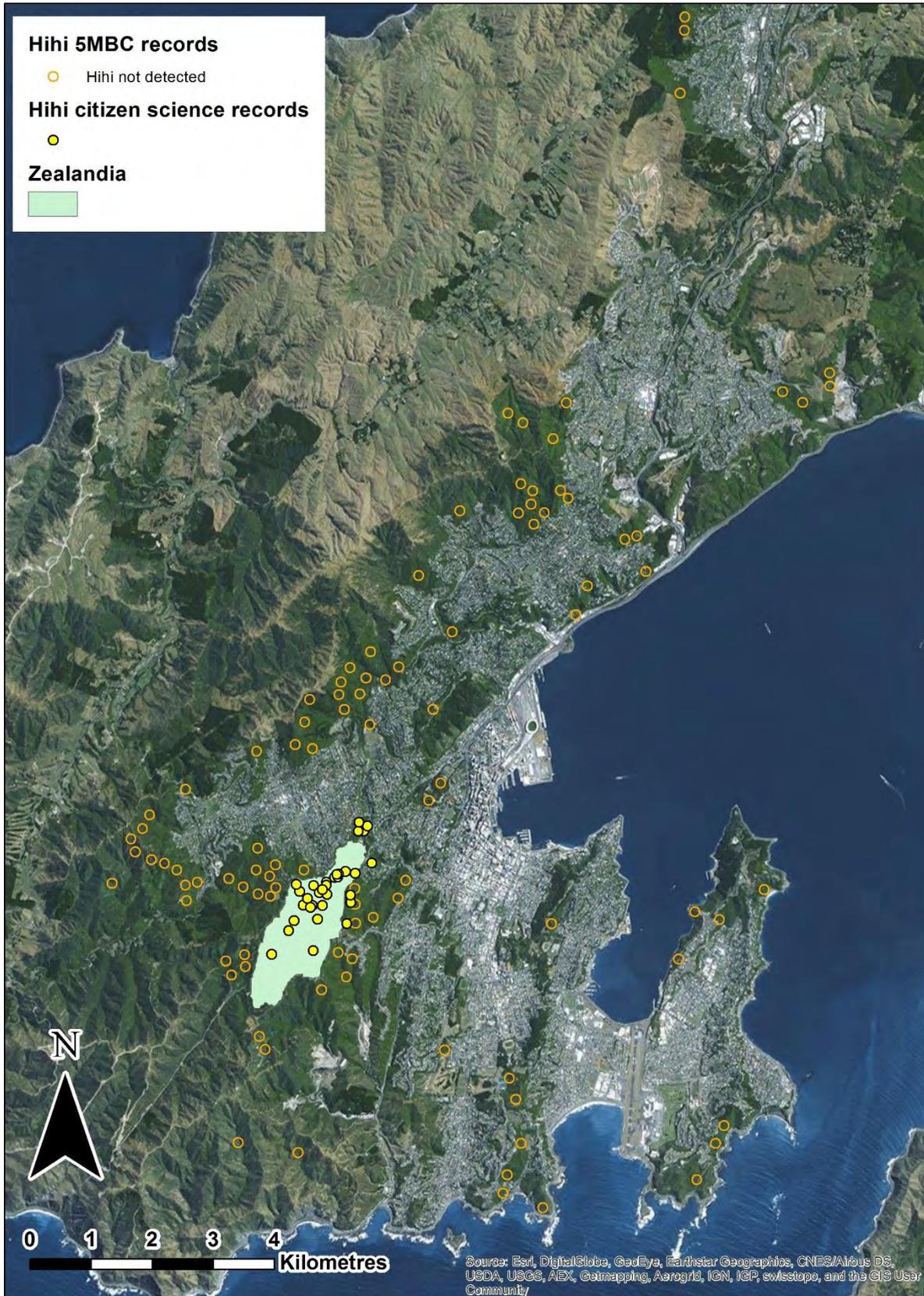


Figure 3.17: Distribution of hihi in Wellington City between 2011 and 2014. Orange circles represent hihi detections at five-minute bird count stations, with the size of the circle corresponding to relative detection frequency. Yellow circles represent hihi observations sourced from the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

4 DISCUSSION

4.1 Species diversity

Zealandia continues to have an important influence on the diversity of native forest bird species present in Wellington City. Around one third of the native forest bird species detected during the five-minute bird counts carried out between 2011 and 2014 were present largely as a consequence of birds dispersing from source populations in Zealandia. These species include North Island robin, whitehead (both re-introduced to Zealandia in 2001), kaka and North Island saddleback (both re-introduced in 2002) (Miskelly & Powlesland, 2013).

Both kaka and whitehead have been recorded in Wellington City prior to their re-introduction to Zealandia (Miskelly et al, 2005). However, the current distributions of these two species (centred on Zealandia; see Figures 3.11 and 3.12) suggest that the majority of the birds encountered during these bird counts have originated from this predator-free sanctuary. In the case of kaka, many of the birds recorded in Wellington City parks and reserves over the past decade appear to be birds that breed within Zealandia, but have home ranges that extend across Wellington City that enable the birds to exploit locally-available food sources (Zealandia, unpublished data). In more recent years however kaka have been recorded nesting elsewhere in Wellington City, including a pair that successfully fledged a chick in Prince of Wales Park (Mt Cook) in January 2013 (M. Booth, pers. comm.) and a fledgling caught and killed by a dog in Huntleigh Park (Ngaio) in February 2015 (<http://wellington.govt.nz/your-council/news/2015/02/dog-kills-kaka-in-huntleigh-park>; accessed 28/09/2015).

Two further species recorded during these bird counts (bellbird and red-crowned parakeet) appear to be present as a result of a combination of birds dispersing from source populations within Zealandia as well as from source populations from nearby inshore islands and other mainland reserves. Radio-tracking data together with sightings of banded birds have confirmed that bellbirds disperse readily from Zealandia to other parts of the city, including the Wellington Botanical Gardens, hampering efforts to re-establish a self-sustaining population in the sanctuary (R. Empson pers. comm). However, both bellbird and red-crowned parakeet have also been recorded in Wellington City prior to their re-introduction to Zealandia in 2001 and 2010 respectively (Miskelly et al, 2005; Froude, 2009). This, together with their relatively strong dispersal abilities suggests that both species may also be dispersing into Wellington City from other nearby source populations such as Mana Island (bellbird), Matiu/Somes Island (red-crowned parakeet) and Kapiti Island (both species). Indeed, several colour-banded bellbirds transferred from Kapiti Island to Mana Island in July 2012 were subsequently re-sighted in Wellington City, including one female that made several attempts to breed at Zealandia (McLaughlin & Harvey, 2013; M. Booth pers. comm.). This demonstrates that under certain (albeit artificial) circumstances, bellbirds are capable of dispersing from these islands and into Wellington City.

Between 2011 and 2014, the mean number of native forest bird species recorded per bird count station was significantly lower in Wellington City than in Upper Hutt reserves, and was not significantly different from the mean number of species recorded per station in south Wairarapa reserves or Porirua Scenic Reserve. This pattern is most likely caused by the fact that at least a quarter of the bird species recorded in Wellington City reserves continue to have very localised distributions (centred on Zealandia), so are only recorded at a relatively small proportion of the bird count stations surveyed. In contrast, almost all of the species recorded in Upper Hutt and south Wairarapa reserves, and in Porirua Scenic Reserve were widely distributed and were recorded at a large proportion of the bird count stations surveyed.

4.2 Bird abundance

The mean number of tui encountered per five-minute bird count has varied substantially from year to year between 2011 and 2014. These varying encounter rates are often matched by large changes in the distribution of tui in Wellington City reserves from one year to the next, so are likely to represent year-to-year difference in habitat use by tui in Wellington City, probably reflecting annual differences in the local availability of food resources. In 2012, for instance relatively high numbers of tui encountered at bird count stations in southern and western parts of the city appeared to be linked to the prolific fruiting of Darwin's barberry (*Berberis darwinii*) at the time (McArthur et al, 2013a).

The mean number of blackbirds encountered per five-minute bird count has increased by around 30% between 2011 and 2014. Because these counts are carried out in consistent weather conditions, at the same time of year and usually by the same observers, this increase in encounter rate likely represents a true increase in the abundance of this species in Wellington City parks and reserves between 2011 and 2014 (Bibby et al, 2000). This result may indicate that local blackbird populations are benefitting from ongoing improvements in the extent and intensity of mammalian pest control efforts in the city.

In contrast, these counts suggest that there has been no significant change in the abundance of bird species recently re-introduced to Zealandia in surrounding parks and reserves. This result indicates that one or more factors continue to limit these species' ability to establish functional populations beyond Zealandia's predator-proof fence. For example, NI robins are known to be relatively strong dispersers, with juvenile birds capable of dispersing up to 11 km from their natal territories in forested habitat (Oppel & Beaven 2004; Richard 2007). Despite this, and despite the fact that a large and highly productive NI robin population has been present in Zealandia since at least 2003 (McGavin 2009; Empson & Fastier 2013), NI robins were not detected at any five-minute bird count stations in 2014 and are seldom reported by local citizen scientists at distances greater than around 1 km from Zealandia (Figure 3.14).

The most likely factor limiting the establishment 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), suggesting that they occur at relatively high densities in the parks and reserves that were sampled.

To determine whether or not introduced predators are continuing to limit the establishment of native birds emigrating from Zealandia, further research quantifying the survival and reproductive rates of these bird species in reserves adjacent to Zealandia and identifying causes of adult mortality and nest failure would be useful. Identifying any causes of adult mortality (in particular detecting the identity of predators from DNA samples collected from freshly-dead birds) and nest failure (through the use of trail cameras) will help inform decisions regarding future pest control priorities aimed at improving the abundance and distribution of native forest birds in Wellington City reserves. We suggest that these research efforts should be focussed on NI robins, NI saddleback and kaka, as each of these three species are relatively easy to monitor, yet fairly susceptible to the impacts of mammalian predators (e.g. Powlesland, 1997).

4.3 Native bird distribution

The distribution of native forest birds in Wellington City parks and reserves has not changed substantially from that reported previously (McArthur et al, 2012; McArthur et al, 2013a). Those species with the strongest dispersal abilities, or those that are least susceptible to the impacts of mammalian predators (including silvereye, tui, grey warbler and fantail) continue to have the most widespread distributions in Wellington City parks and reserves. Those species with more limited dispersal abilities, or greater susceptibility to depredation by mammalian predators (including NI robin and NI saddleback) have more localised distributions, typically centred on key source populations now established in predator-free Zealandia.

The accumulation of four years of five-minute bird count data combined with an increasing quantity of citizen science bird data has allowed us to detect several species re-colonisation events that have occurred in Wellington City reserves within the last 4-5 years. Both whiteheads and red-crowned parakeets for example now appear to be resident in Trelissick Park, some 3.8 km north of the nearest source populations in Zealandia. Similarly, resident populations of both bellbirds and red-crowned parakeets now appear to have established in Khandallah Park, 5.7 km north of Zealandia and red-crowned parakeets are now well established in Otari-Wilton Bush, 1.7 km north of Zealandia.

The incorporation of bird observation data collected by local citizen scientists into the distribution maps provided in this report has enabled bird distribution in Wellington City to be mapped in much greater detail than in previous reports. In this particular case, the Wellington City five-minute bird count dataset and local citizen science bird distribution datasets appear to be highly complementary. The original aim of this Wellington City five-minute bird count monitoring programme was to sample bird populations in forested habitats in Wellington City's parks and reserve network, so it isn't designed to provide any information on bird distribution in other habitats in the city such as suburban backyards. The majority of bird observations reported by local citizen scientists however are from these suburban habitats, so combining these two datasets provides a much more detailed and complete picture of bird distribution in Wellington City than either of these datasets can provide on their own.

The use of this citizen science data to complement a more systematic bird monitoring programme provides a good local example of the contribution that local citizen scientists can make towards monitoring trends in bird populations in Wellington City, particularly when it comes to reporting the outcomes of species re-introductions and other local ecological restoration efforts. Indeed, in some instances this citizen science data alone can be sufficient to detect large-scale changes in the distribution of particularly distinctive or conspicuous bird species, in the absence of any systematic monitoring. For example since 2004 staff at Zealandia have actively encouraged Wellington residents to report sightings of North Island kaka and other bird species re-introduced to Zealandia via a "report a bird" webpage on the Zealandia website (<http://www.visitzealandia.com/contact-us/report-a-bird/>; accessed 24/09/2015). Furthermore since 2008 Birds New Zealand (formerly the Ornithological Society of New Zealand) has administered a New Zealand portal to the global eBird database, a web-based reporting system designed specifically for birdwatchers to enter bird checklist data from any location in the world. Between these two reporting mechanisms, Wellington-based citizen scientists have reported over 3000 observations of North Island kaka in Wellington City over the past decade, effectively mapping the re-establishment of kaka in the city in real-time following their re-introduction to Zealandia in 2002 (Figure 4.1).

Although the incorporation of citizen science data sourced from the New Zealand eBird and Zealandia databases into this monitoring programme has already substantially improved our ability to describe the distribution of birds in Wellington City, further work could be done to improve this picture even more. Firstly, not all of the locally-available citizen science data has been incorporated into the maps contained in this report yet, due to time constraints and the fact that this data is currently scattered across a number of databases and reporting platforms. Further work could be done therefore to

amalgamate bird distribution data we've already sourced from the New Zealand eBird and Zealandia databases with additional data available from the NatureWatch NZ website, Garden Bird Survey dataset and Great Kereru Count dataset.

Furthermore, it's our impression that the rate at which bird observations are being reported by Wellington-based citizen scientists hasn't yet reached its upper limit. Instead, we believe that current reporting rates are being limited by the degree to which the various biodiversity reporting tools are being promoted and the limited training opportunities available to local citizen scientists to learn how to use these tools effectively. For example, only 5-10% of local Birds New Zealand members submit their bird observations to the New Zealand eBird database on a regular basis (N. McArthur pers. obs.). Developing a more coordinated and systematic approach towards improving local citizen scientists' awareness of the value of their observations, the tools available to record and share their observations and the training they need to use these tool effectively would increase both the quality and quantity of citizen science data available to local agencies for environmental reporting.

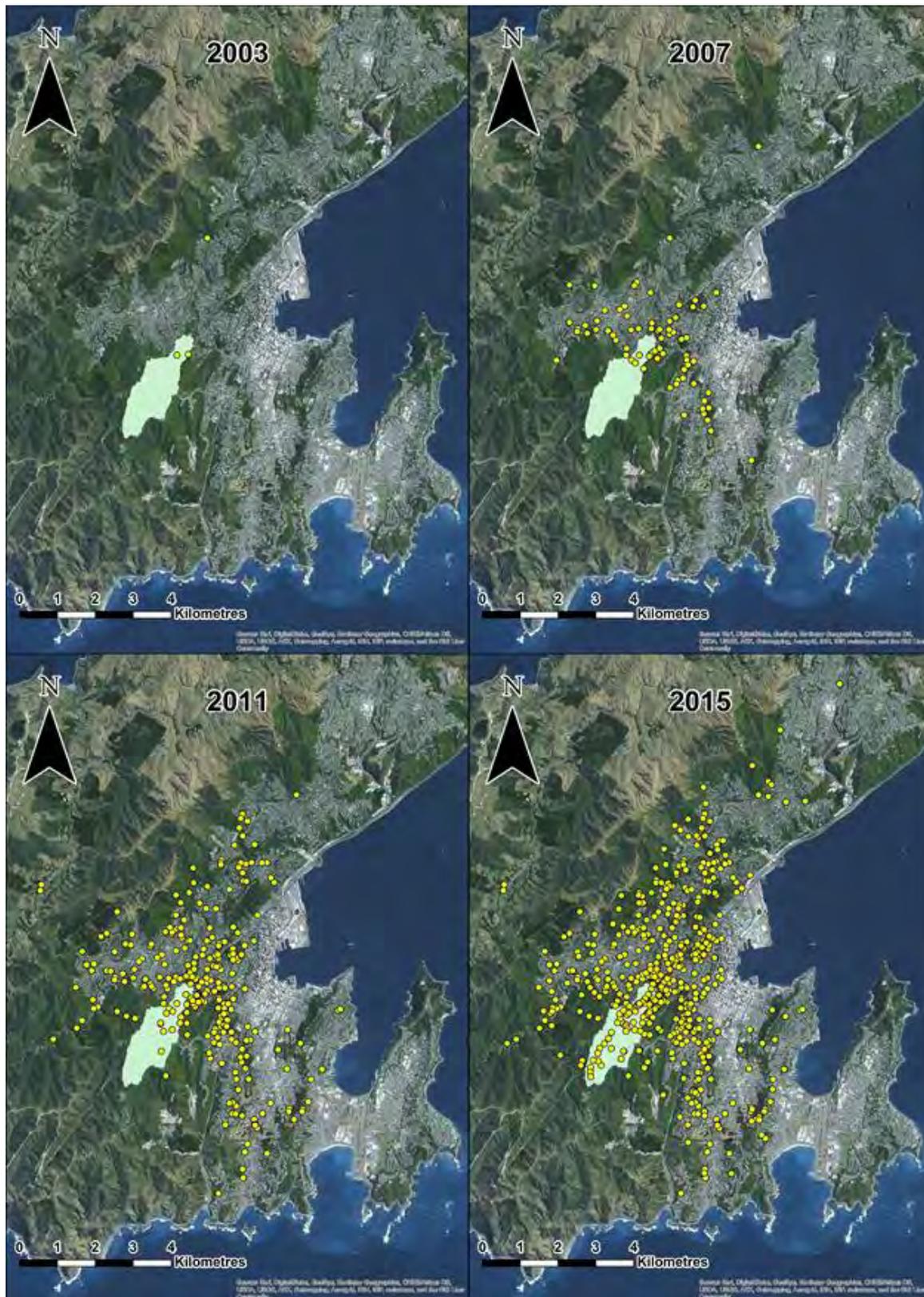


Figure 4.1: Range expansion of North Island Kaka in Wellington City between 2003 and 2015. Each yellow dot represents a single kaka sighting reported to Zealandia’s “report a bird” webpage or the New Zealand eBird database (<http://ebird.org/content/newzealand/>; accessed 18/09/2015).

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 the Council considers investing additional resources into further enabling citizen scientists to take a greater role in monitoring and reporting trends in the distribution of birds in Wellington City, in order to complement and add value to the systematic five-minute bird count programme currently being carried out. Potential work-streams for a Wellington City citizen science bird monitoring programme include the ongoing amalgamation of existing citizen science datasets, targeted investigations to fill knowledge-gaps (e.g. morepork distribution in Wellington City) and the development of a more coordinated and strategic approach towards promoting the use of fit-for-purpose reporting tools by Wellington-based citizen scientists.
- That Wellington City Council considers initiating an investigation aimed at identifying the environmental factors currently limiting the establishment of 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).

6 Acknowledgements

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8 APPENDIX

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 2014 (P = present). Species names and taxonomic order are as per Gill et al (2010). Threat classification rankings are as per Robertson et al (2013): NV – Nationally Vulnerable; 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
<i>Callipepla californica</i>	California quail	I	P	P	P	P
<i>Gallus gallus</i>	feral chicken	N/A ³		P	P	P
<i>Tadorna variegata</i>	paradise shelduck	NT		P	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	NV		P	P	
<i>Haematopus unicolor</i>	variable oystercatcher	RC		P		P
<i>Vanellus miles</i>	spur-winged plover	NT				P
<i>Larus dominicanus</i>	southern black-backed gull	NT	P	P	P	P
<i>L. novaehollandiae</i>	red-billed gull	NV		P	P	
<i>Hemiphaga novaeseelandiae</i>	New Zealand pigeon (kereru)	NT	P	P	P	P
<i>Nestor meridionalis</i>	kaka	NV	P	P	P	P
<i>Platycercus eximius</i>	eastern rosella	I	P	P	P	P
<i>Cyanoramphus novaeseelandiae</i>	red-crowned parakeet	RE	P	P		P
<i>Chrysococcyx lucidus</i>	shining cuckoo	NT	P	P	P	P
<i>Todiramphus sanctus</i>	New Zealand kingfisher	NT	P	P	P	P
<i>Philesturnus rufusater</i>	North Island saddleback	RC	P	P	P	P
<i>Gerygone igata</i>	grey warbler	NT	P	P	P	P
<i>Anthornis melanura</i>	bellbird	NT		P	P	P
<i>Prothemadera novaeseelandiae</i>	tui	NT	P	P	P	P

³ 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, 2013).

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

<i>Mohoua albicilla</i>	whitehead	NT	P	P	P	P
<i>Gymnorhina tibicen</i>	Australian magpie	I	P		P	P
<i>Rhipidura fuliginosa</i>	New Zealand fantail	NT	P	P	P	P
<i>Petroica longipes</i>	North Island robin	NT	P	P	P	
<i>Alauda arvensis</i>	skylark	I	P	P	P	P
<i>Zosterops lateralis</i>	silvereeye	NT	P	P	P	P
<i>Hirundo neoxena</i>	welcome swallow	NT	P			
<i>Turdus merula</i>	Eurasian blackbird	I	P	P	P	P
<i>T. philomelos</i>	song thrush	I	P	P	P	P
<i>Sturnus vulgaris</i>	common starling	I	P	P	P	P
<i>Passer domesticus</i>	house sparrow	I	P	P	P	P
<i>Prunella modularis</i>	dunnock	I	P	P	P	P
<i>Fringilla coelebs</i>	chaffinch	I	P	P	P	P
<i>Carduelis chloris</i>	greenfinch	I	P	P	P	P
<i>C. carduelis</i>	goldfinch	I	P	P	P	P
<i>C. flammea</i>	common redpoll	I		P	P	P
<i>Emberiza citrinella</i>	yellowhammer	I	P	P	P	P