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

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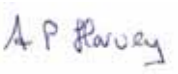
Report prepared by:	A Harvey	Biodiversity Officer	
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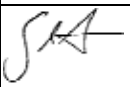
Report approved for release by:	G Sevicke-Jones	Manager, Environmental Science	 Date: May 2014

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Cover photo: North Island Saddleback (*Philesturnus rufusater*) (Photo courtesy of N McArthur)

Executive Summary

Five-minute bird counts have been carried out in 2011 and 2012 at 100 bird count stations randomly distributed in Wellington City parks and reserves. The aim of these surveys is to monitor trends in the diversity, abundance and distribution of native forest birds throughout Wellington City's parks and reserves network.

In November and December each year two bird counts were carried out by an experienced observer at each of the 100 stations, providing a sufficient sample size to detect a 10% or more change in the Wellington City tui population. Tui have been chosen as a focal species for this survey because they are a relatively common and distinctive species in Wellington City, they have a high public profile and they have shown strong responses in the past to changes in native forest habitat management in Wellington City.

Thirty-three species of birds were recorded during the 2012 bird counts, including 19 native and 14 introduced species. On average, a lower number of native forest bird species was recorded at each bird count station in Wellington City reserves compared to Upper Hutt reserves in both 2011 and 2012. This is because 25-30% of the forest bird species recorded in Wellington City reserves had very localised distributions whereas almost all species in Upper Hutt reserves had fairly widespread distributions.

The average number of tui recorded per bird count station in Wellington City declined between 2011 and 2012 and much of this decline resulted from tui being mostly absent from eastern and southern parts of the city in 2012. This is most likely to have been caused by movements of tui into other habitats in the city or surrounding landscape that aren't sampled as part of this survey, probably in response to changes in locally-available food resources.

The detection rate for North Island saddleback also declined between 2011 and 2012, and likely reflects a true decline in the apparent abundance and/or conspicuousness of saddleback in reserves within 1-2 km of Zealandia's boundary fence.

Detection rates for silvereye, grey warbler, blackbird, goldfinch, starling, house sparrow, dunnock, eastern rosella and yellowhammer all increased between 2011 and 2012. This appears to have been caused by a change in observers between these two surveys rather than any real change in the apparent abundance and/or conspicuousness of these nine species. This result highlights the importance of maintaining a high level of consistency between observers when carrying out five-minute bird counts and the usefulness of retaining the same observers from one year to the next.

Zealandia continues to have an important influence on species' distributions in Wellington City. Twenty-nine percent of the native forest bird species recorded during these surveys have distributions centred on the pest-free habitat contained within Zealandia's predator-resistant boundary fence. Several of these species, particularly North Island robin, NI saddleback and whitehead continue to have more localised distributions than we might expect given the number of years since they were successfully re-introduced to Zealandia. This suggests that one or more factors continue to limit the re-establishment of these species in non-fenced Wellington City reserves.

Contents

1. Introduction

In recent years there has been a conspicuous increase in the diversity, abundance and distribution of native bird species in Wellington City parks and reserves (Miskelly et al. 2005). These changes have likely occurred as a result of two processes. Firstly, 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). Secondly, re-introductions of bird species to predator-free sites such as Zealandia (the Karori Wildlife Sanctuary), Matiu/Somes Island and Mana Island have successfully established source populations from which previously locally-extinct or near-extinct 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).

In order to monitor these ongoing changes in the abundance of native birds in Wellington City it is important to carry out regular, standardised monitoring of bird populations at sites throughout the city. Such monitoring allows early detection of species' declines that may require remedial action and enables the identification of new high-priority sites for management in response to the spread and re-establishment of previously extinct or locally-rare species.

Five-minute bird counts were carried out in nine selected parks and reserves in Wellington City by Pacific Eco-Logic Ltd between 2001 and 2009 (Froude 2009). These counts were successful in detecting substantial local increases in the apparent abundance of tui at a key time during which a large expansion in pest control efforts across the 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 new survey design and a sample size of 200 five-minute bird counts was chosen to ensure sufficient statistical power to detect a 10% or more change in the relative abundance of tui from one year to the next. These bird count stations were surveyed for the first time in 2011 and showed that the dispersal of birds re-introduced to Zealandia accounted for 33% of the native forest bird species recorded in Wellington City reserves. Many of these species were found to have very localised distributions however, indicating that one or more factors are currently limiting the ability of these species to colonise nearby parks and reserves (McArthur et al, 2012).

These bird counts were repeated again in 2012, and this report provides a summary of the results of these bird counts and makes comparisons with the results of the 2011 counts reported in McArthur et al (2012).

2. Methods

2.1 Field technique

One hundred bird count stations were established at random locations in forest habitat in Wellington City parks and reserves in November 2011 and were surveyed in both 2011 and 2012 (Figure 2.1). Bird count stations were situated a minimum distance of 200m apart, and no less than 50m 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, with each count being carried out on a separate 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 bird 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 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 either standardise or sample the range of variation in each of these factors so that we could be confident that any changes in the mean number of birds counted from one year to the next would more likely reflect changes in 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 occurs during the day.

Due to unforeseen circumstances one of the observers employed to carry out these bird counts in 2011 (hereafter referred to as observer one) was not available in 2012, so was replaced by a new observer (observer two). A third observer carried out counts during both years. This change between observers one and two has had a substantial impact on the observed detection rates for several bird species between 2011 and 2012, and this is discussed further below. These changes highlight the importance of retaining the same observers whenever possible from one year to the next, and reinforce our intention to keep any future changes in observers to a minimum.

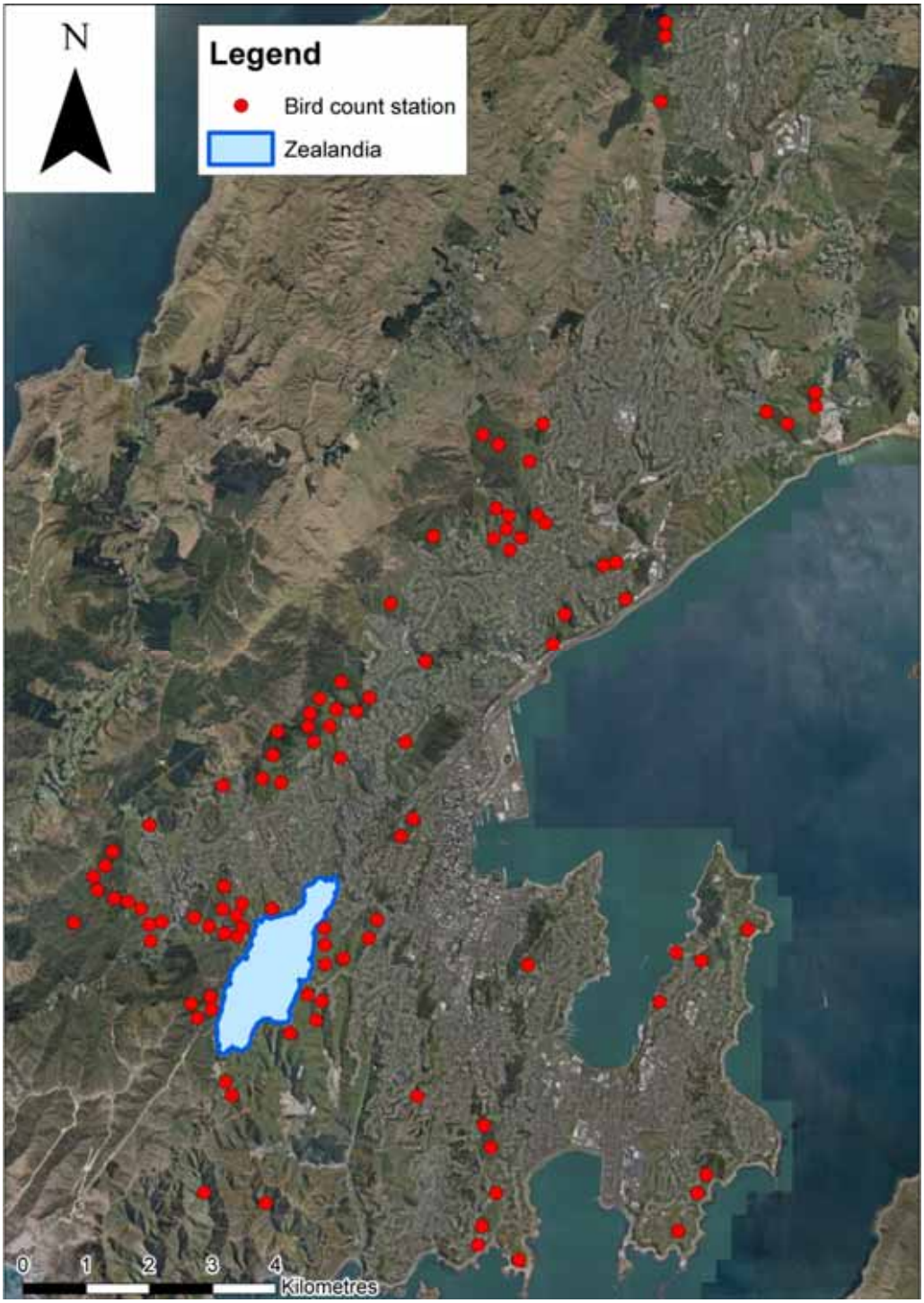

Figure 2.1: Locations of bird count stations established in Wellington City parks and reserves in 2011

2.2 Data analysis

Bird count data were entered into an excel spreadsheet using a standard five-minute bird count data template. This spreadsheet was then used to calculate the mean number of native forest bird species recorded per count station in the Wellington City reserves network and this was compared to the mean number of species recorded in Upper Hutt and Wairarapa reserves that were also surveyed in 2011 and 2012. We first used two-tailed *F*-tests to check that the variances of each sample were approximately equal; then used two-tailed

z-tests to assess whether any differences in the mean number of species recorded per station in Wellington City, Upper Hutt or Wairarapa reserves were statistically significant (Fowler & Cohen, 1995). This latter test is important because a statistically significant result indicates that any difference between two means is very unlikely to have occurred due to chance sampling error, so instead is assumed to represent a real difference in the species diversity of native forest bird communities between the three reserve networks.

The bird count data were also used to calculate the mean number of birds of each species recorded per count station across the Wellington City reserves network in 2011 and 2012. This mean number of birds recorded provides an index of the relative abundance and/or conspicuousness of each bird species (Dawson & Bull, 1975) in the Wellington City reserves network. Two-tailed *F*-tests were again used to check that the variances of each sample were approximately equal; then two-tailed *z*-tests were used to assess whether the mean number of birds recorded per station in Wellington City reserves differed significantly between 2011 and 2012 (Fowler & Cohen, 1995).

Data for any species for which the mean number of birds recorded differed significantly between 2011 and 2012 were further analysed by grouping counts according to observer. Estimates of the mean number of birds of each species recorded per count station by each observer were then generated and compared using two-tailed *z*-tests. This was done to evaluate whether changes in species' detection rates recorded between 2011 and 2012 were more likely to have been caused by the change in observers between the two surveys, or by a change in the apparent abundance or conspicuousness of the birds themselves. Differences in detection rates were assumed to be more likely to have been influenced by the change in observer if differences were recorded between counts carried out by observer one in 2011 and observer two in 2012, but not between counts carried out by observer 3 in 2011 & 2012. On the other hand, differences in detection rates were assumed to be a result of apparent changes in the abundance or conspicuousness of the birds themselves if a significant difference was recorded between counts made by observer three in 2011 and 2012, irrespective of whether there was a difference in detection rates between counts made by observers one and two.

Patterns in the distribution of native birds among Wellington City reserves were examined by mapping the presence or absence of each native forest bird species at each count station using Arcmap version 9.3.1. Although this technique does not take into account changes in abundance (less common species present within sight or earshot of a bird count station are less likely to be recorded) or variation in detection probabilities between species (less conspicuous species will also be less likely to be recorded); it should be sufficient to detect relatively large changes in species' distributions.

3. Results

3.1 Species diversity

Thirty-three species of birds were recorded in Wellington City parks and reserves during the 2012 bird counts, five more than were recorded in 2011 (see appendix). Of these 33 species, 19 were native and 14 introduced, a similar ratio to the 15 native and 13 introduced species recorded in 2011. Fourteen of the native bird species recorded in 2012 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 five native species recorded were either open-country or coastal species such as Australasian harrier (*Circus approximans*), paradise shelduck (*Tadorna variegata*) and black-backed gull (*Larus dominicanus*) and are not included in any further analyses. Of the native forest bird species recorded, two (kaka and NZ falcon) are ranked as "Nationally Vulnerable" under the New Zealand threat classification system; two further species (NI saddleback and red-crowned parakeet) are ranked as "At Risk" and the remainder ranked as "Not threatened" (Miskelly et al, 2008).

Between 2011 and 2012 there was a significant reduction in the mean number of bird species recorded per bird count station in Wellington City reserves, from 2.8 species recorded per station in 2011 to 2.5 species in 2012 (z = 3.06, p =0.002; two-tailed z-test). In 2012 the 2.5 native forest bird species recorded per count station in Wellington City reserves was once again significantly lower than the 4.2 species recorded per station in Upper Hutt City reserves (z = 10.29, p =0.000; two-tailed z-test). In contrast, there was no significant difference between the number of bird species recorded per count station in the Wellington City and Wairarapa reserve networks in 2012 (z =1.29, p =0.201; two-tailed z-test).

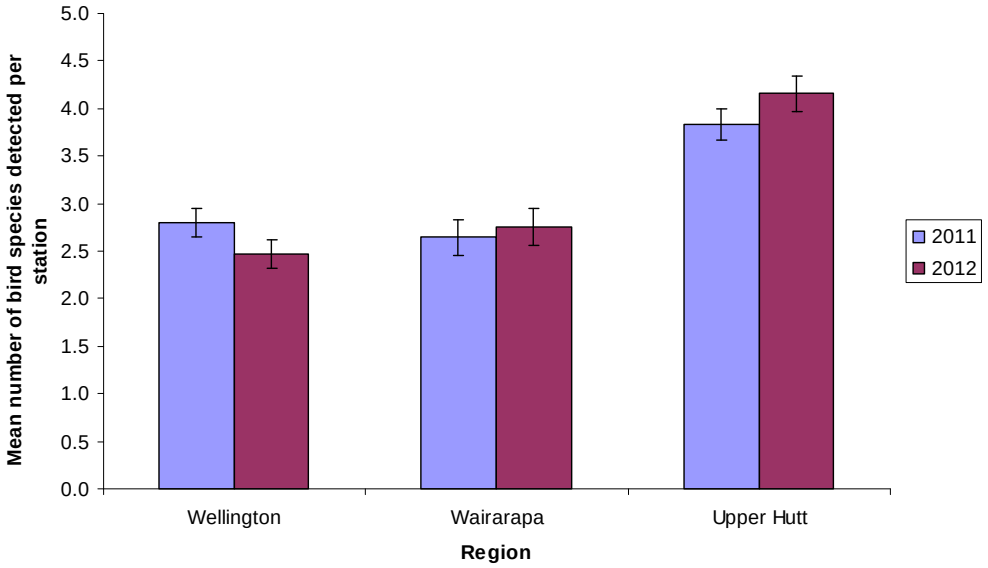

Figure 3.1: Mean number of native forest bird species recorded per count station in Wellington City (n=200), Wairarapa (n=45) and Upper Hutt (n=90) reserves, 2011-2012 (error bars represent 95% confidence limits)

3.2 Index of bird abundance

Silvereye (*Zosterops lateralis*), tui and grey warbler (*Gerygone igata*) were once again the three most frequently recorded native forest bird species recorded in Wellington City reserves in 2012. Silvereye was the most frequently recorded species with a mean of 2.4 birds per count station in 2012; a significant increase from the 1.9 birds recorded per station in 2011 (z =3.15, p =0.002; two-tailed z-test). Grey warbler was the second most frequently recorded species in 2012, with a mean of 1.2 birds per station; a significant increase from the 0.8 birds recorded per station in 2011 (z =3.91, p =9.38x10^{-5}; two-tailed z-test). Tui was the third most frequently recorded bird species in 2012, with a mean of 0.8 birds per count station; significantly fewer than the 1.3 tui recorded per bird count station in 2011 (z =4.25, p =2.17x10^{-5}; two-tailed z-test) (Figure 3.2).

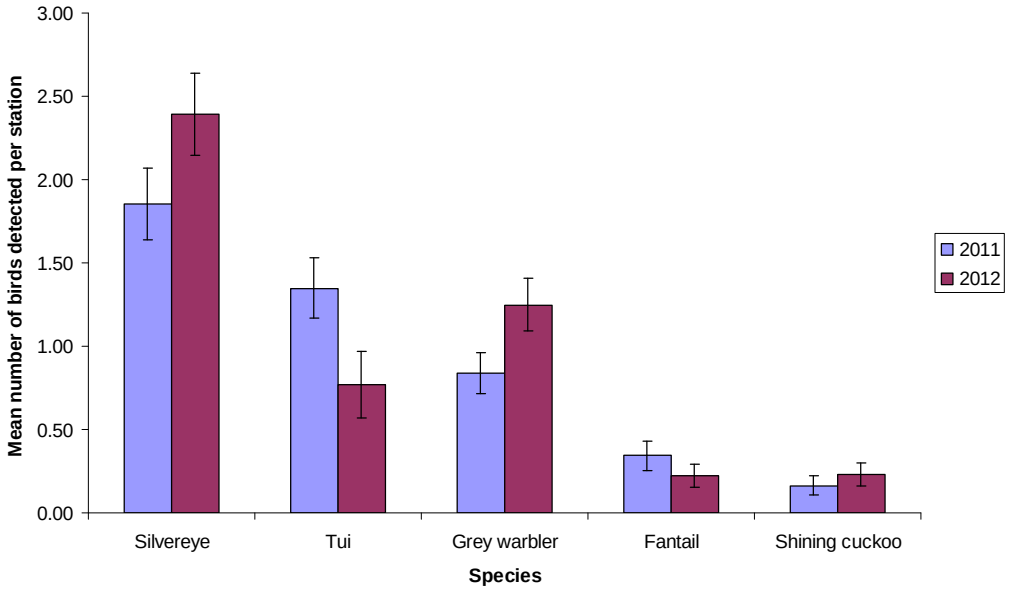

Figure 3.2: Mean number of birds recorded per count station for relatively common or conspicuous native forest bird species recorded in Wellington City reserves, 2011-2012 (error bars represent 95% confidence limits)

The 11 remaining native forest bird species were all recorded at a rate of less than 0.5 birds per bird count station (Figures 3.2 and 3.3). Of these, only NI saddleback (*Philesturnus carunculatus*) showed a significant change between 2011 and 2012; the detection rate for this species declining from 0.07 birds per count station in 2011 to 0.02 birds per station in 2012 (z =2.45, p =0.014; two-tailed z-test). Both bellbird and New Zealand falcon (*Falco novaeseelandiae*) were recorded at bird count stations for the first time in 2012, neither species having been recorded the previous year.

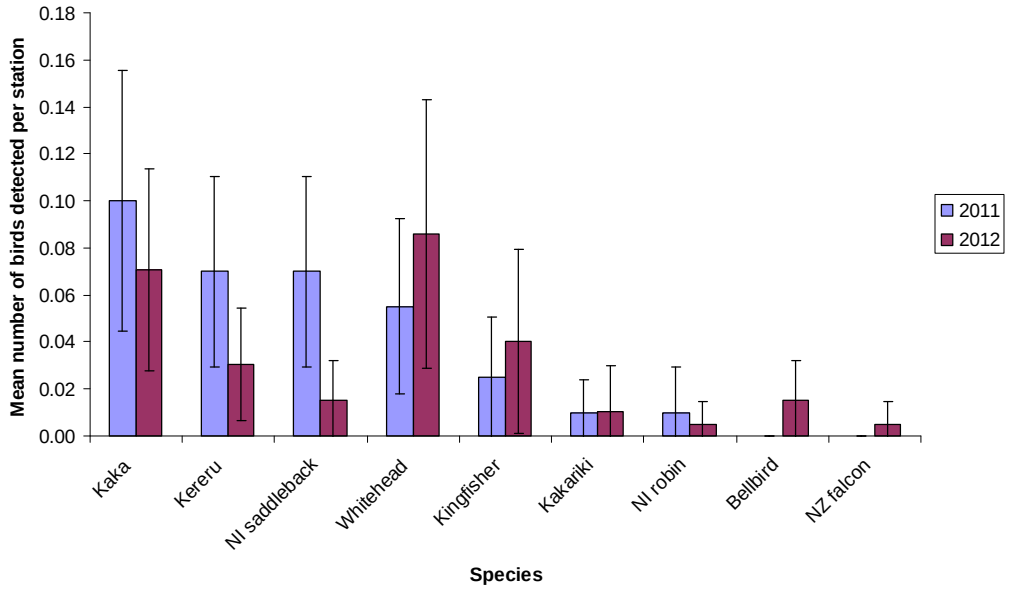

Figure 3.3: Mean number of birds recorded per count station for relatively rare or inconspicuous native forest bird species recorded in Wellington City reserves, 2011-2012 (error bars represent 95% confidence limits)

Of the 14 introduced bird species recorded during the 2012 bird counts, blackbird (*Turdus merula*), chaffinch (*Fringilla coelebs*) and goldfinch (*Carduelis carduelis*) were the three most frequently recorded species. Blackbird was by far the most frequently recorded species with an average of 2.7 birds per count station in 2012; a significant increase from the 2.3 birds recorded per station in 2011 (z =3.09, p =0.002; two-tailed z-test). Chaffinch was once again the second most frequently recorded species, with 0.9 birds per station in both 2011 and 2012. Goldfinch was the third most frequently recorded species in 2012 with 0.6 birds per station; significantly higher than the 0.05 birds recorded per count station in 2011 (z =6.26, p =3.78x10^{-10}; two-tailed z-test) (Figure 3.4).

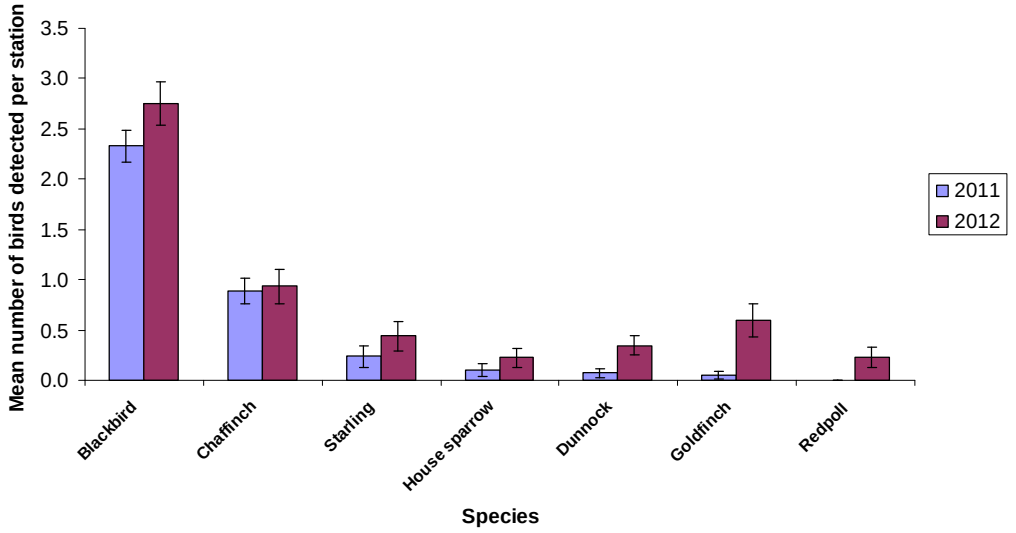

Figure 3.4: Mean number of birds recorded per count station for relatively common or conspicuous introduced bird species encountered in Wellington City reserves, 2011-2012 (error bars represent 95% confidence limits)

The remaining introduced bird species recorded in 2012 were all recorded at a rate of less than 0.5 birds per count station (Figures 3.4 and 3.5). Mean detection rates for starling (*Sturnus vulgaris*), house sparrow (*Passer domesticus*), dunnock (*Prunella modularis*), eastern rosella (*Platycercus eximius*) and yellowhammer (*Emberiza citrinella*) were all significantly higher in 2012 than in 2011 (Table 3.1), whereas all remaining species showed no significant change over the same time period. Both redpoll (*Carduelis flammea*) and feral chicken (*Gallus domesticus*) were recorded at bird count stations for the first time in 2012, whereas Australian magpie (*Gymnorhina tibicen*) was recorded in 2011 but not in 2012.

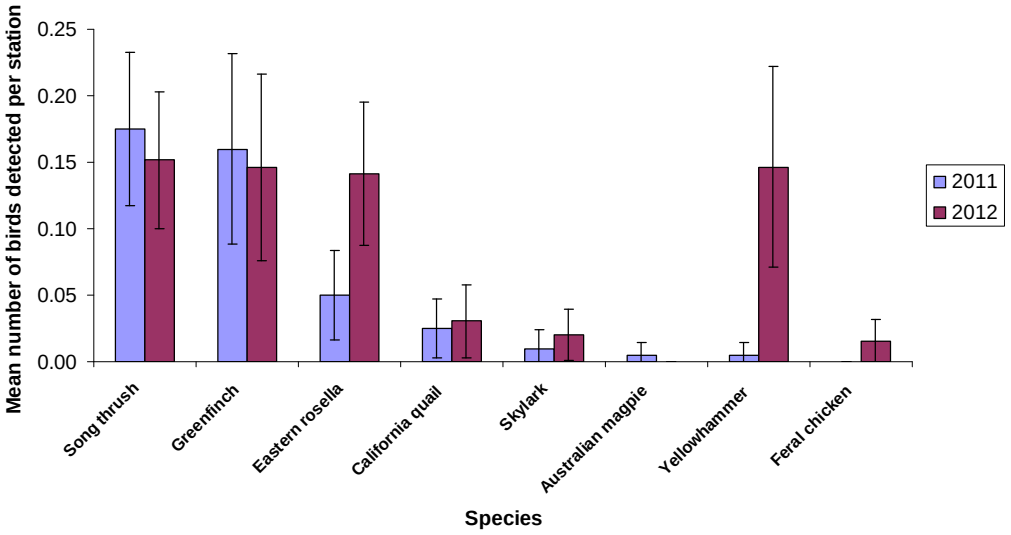

Figure 3.5: Mean number of birds recorded per count station for relatively rare or inconspicuous introduced bird species recorded in Wellington City reserves, 2011-2012 (error bars represent 95% confidence limits)

Table 3.1: Two-tailed *z*-test results for five introduced bird species for which detection rates differed significantly between 2011 than 2012

Species	Mean number of birds counted per station		*z*-value	*p*-value
	2011	2012		
Starling	0.24	0.44	2.16	0.031
House sparrow	0.10	0.22	2.02	0.043
Dunnock	0.07	0.35	5.37	7.69×10^{-8}
Eastern rosella	0.05	0.14	2.78	0.005
Yellowhammer	0.01	0.15	3.61	3.04×10^{-4}

Detection rates for 11 species (four native and seven introduced species) varied significantly between 2011 and 2012. Differences in the detection rates for 10 of these species were explained by differences between counts carried out by observer one (in 2011) and observer two (2012); with no significant differences appearing in counts of these species carried out by observer three in 2011 & 2012. In contrast, encounter rates for tui varied significantly between 2011 and 2012 for observer three as well as for observers one and two (Table 3.2).

Table 3.2: Two-tailed *z*-test results for eleven bird species for which detection rates differed significantly between 2011 & 2012; separated by observer

Species	Observer 1 (2011) and Observer 2 (2012)			Observer 3 (2011 & 2012)		
	Significant change between 2011 & 2012?	*z*-value	*p*-value	Significant change between 2011 & 2012?	*z*-value	*p*-value
Silvereye	Yes	3.48	0.000	No	1.13	0.260
Grey warbler	Yes	4.58	4.64×10^{-6}	No	0.86	0.390
Tui	Yes	2.02	0.043	Yes	10.44	0.000
NI saddleback	Yes	2.03	0.042	No	1.51	0.131
Blackbird	Yes	4.18	2.87×10^{-5}	No	0.81	0.421
Goldfinch	Yes	6.45	1.09×10^{-10}	No	1.83	0.068
Starling	Yes	3.79	0.000	No	1.21	0.225
House sparrow	Yes	2.73	0.006	No	0.02	0.981
Dunnock	Yes	5.66	1.52×10^{-8}	No	1.11	0.268
Eastern rosella	Yes	N/A	N/A	No	0.73	0.465
Yellowhammer	Yes	3.69	0.000	No	N/A	N/A

3.3 Native bird distribution

The distribution of native birds in Wellington City in 2012 was broadly similar to that found in 2011; however the proportion of bird count stations "occupied" by many species was lower during the 2012 survey.

Tui was once again widespread across the reserves network in 2012, but few were recorded from bird count stations in eastern and southern parts of the city including Miramar Peninsula and Houghton Bay. At Makara Peak, observer 2 recorded very high counts of tui at most count stations; indeed at some stations tui call-frequency was so great that it was sometimes difficult for the observer to fully resolve numbers. Both tui and blackbird were observed feeding on the abundant fruit of Darwin's barberry (*Berberis darwinii*) in this reserve. In contrast, in 2011 tui were recorded at most of the count stations in eastern and southern suburbs, but were not recorded at the majority of the bird count stations in Makara Peak Reserve (Figure 3.6).

Bellbirds were recorded at two locations during the 2012 bird counts, at Makara Peak and Otari-Wilton's Bush (Figure 3.7). In contrast, bellbirds were not recorded at any of the count stations in 2011 despite having been recorded during surveys carried out in several Wellington City reserves between 2001 and 2009 (Froude, 2009).

Fantails (*Rhipidura fuliginosa*) were relatively widespread through the Wellington City reserves network and don't appear to have undergone any major changes in distribution between 2011 and 2012 (Figure 3.8). In contrast, kereru (*Hemiphaga novaeseelandiae*) were again localised in distribution, with most records in 2012 concentrated in Otari-Wilton's Bush and Johnston Hill reserve (Figure 3.9).

Several species continue to have distributions centred on the pest-free habitat enclosed within Zealandia's predator-resistant fence. The distribution of kaka in Wellington City has remained very similar in 2011 and 2012, although birds were recorded at fewer locations in 2012 compared to the preceding year (Figure 3.10). The majority of whitehead sightings were at count stations within 1 km of Zealandia's boundary fence in 2012, with the exception of one record from Trelissick Park, 3.8 km from Zealandia (Figure 3.11). North Island saddleback were recorded at far fewer count stations in 2012 in comparison to the previous year, however one bird was recorded 2.4 km south of the sanctuary fence in 2012 (Figure 3.12). NI robin was again recorded at only one count station within a few hundred metres of the Zealandia fence, the very same count station at which this species was recorded in 2011 (Figure 3.13).

Red-crowned parakeets were only recorded at one bird count station in Khandallah Park in 2012. This species was not recorded at either Makara Peak or Otari-Wilton's Bush which were the two locations at which this species was recorded during the 2011 counts (Figure 3.14).

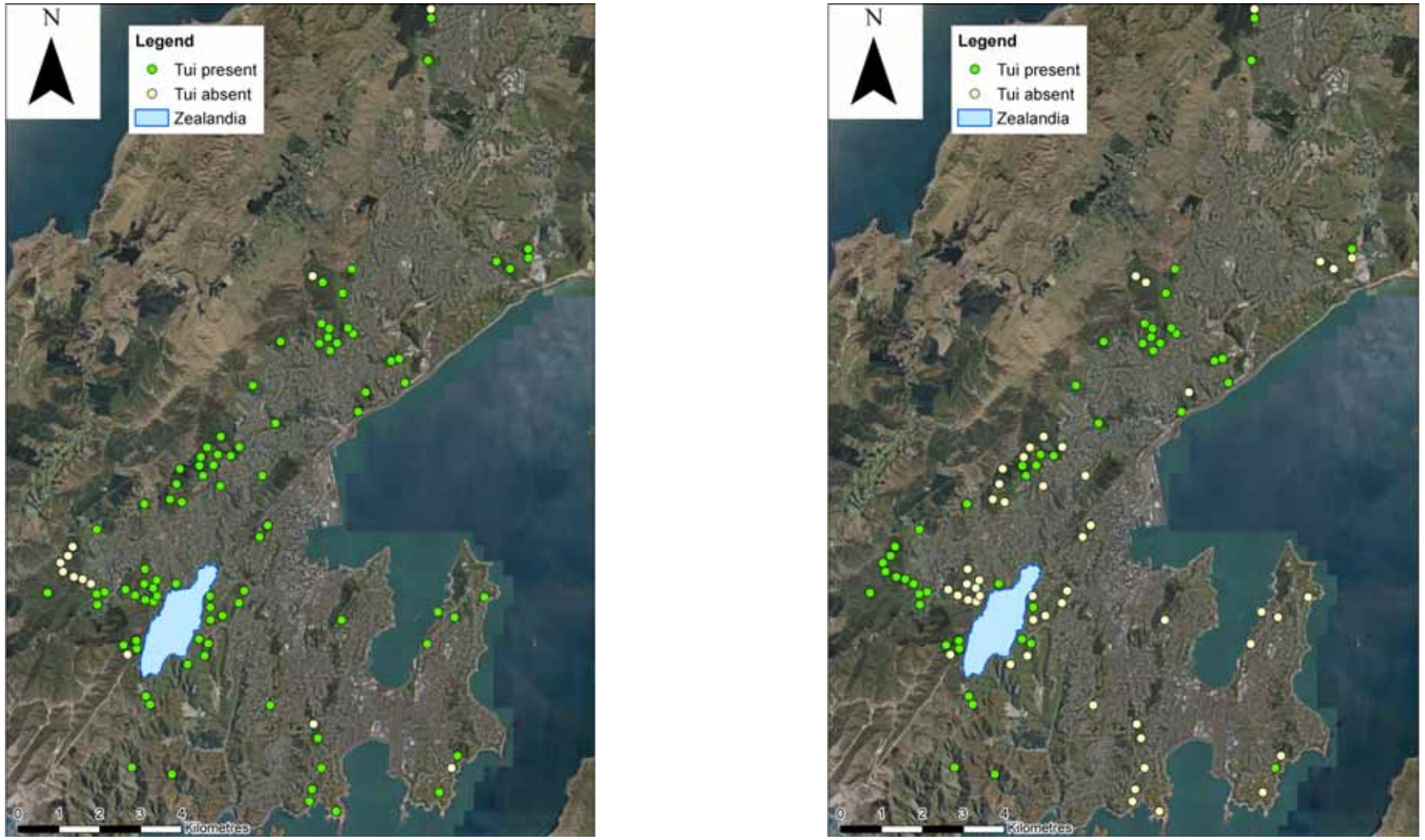

Figure 3.6: Distribution of tui in Wellington City reserves in 2011 (left) and 2012 (right)

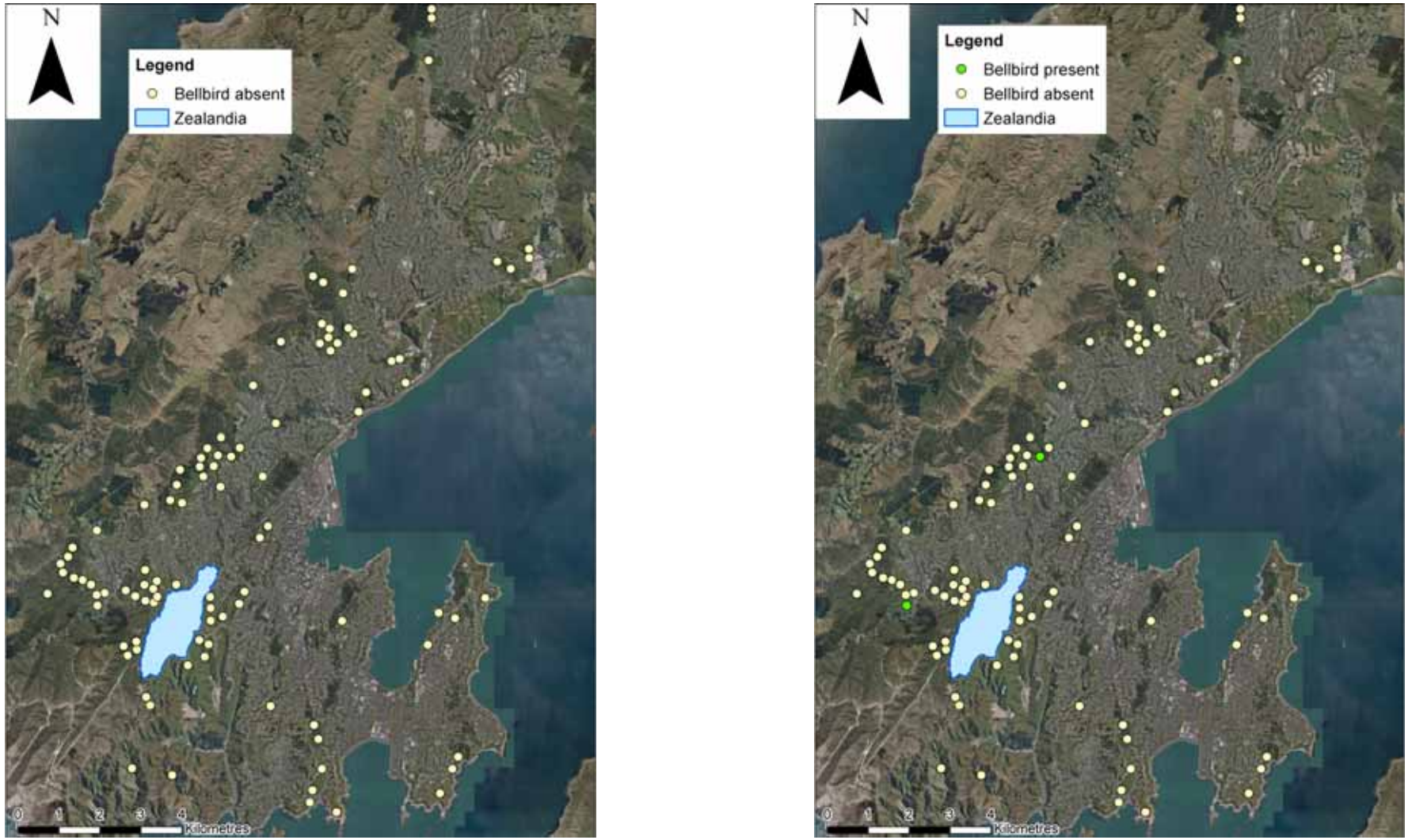

Figure 3.7: Distribution of bellbird in Wellington City reserves in 2011 (left) and 2012 (right)

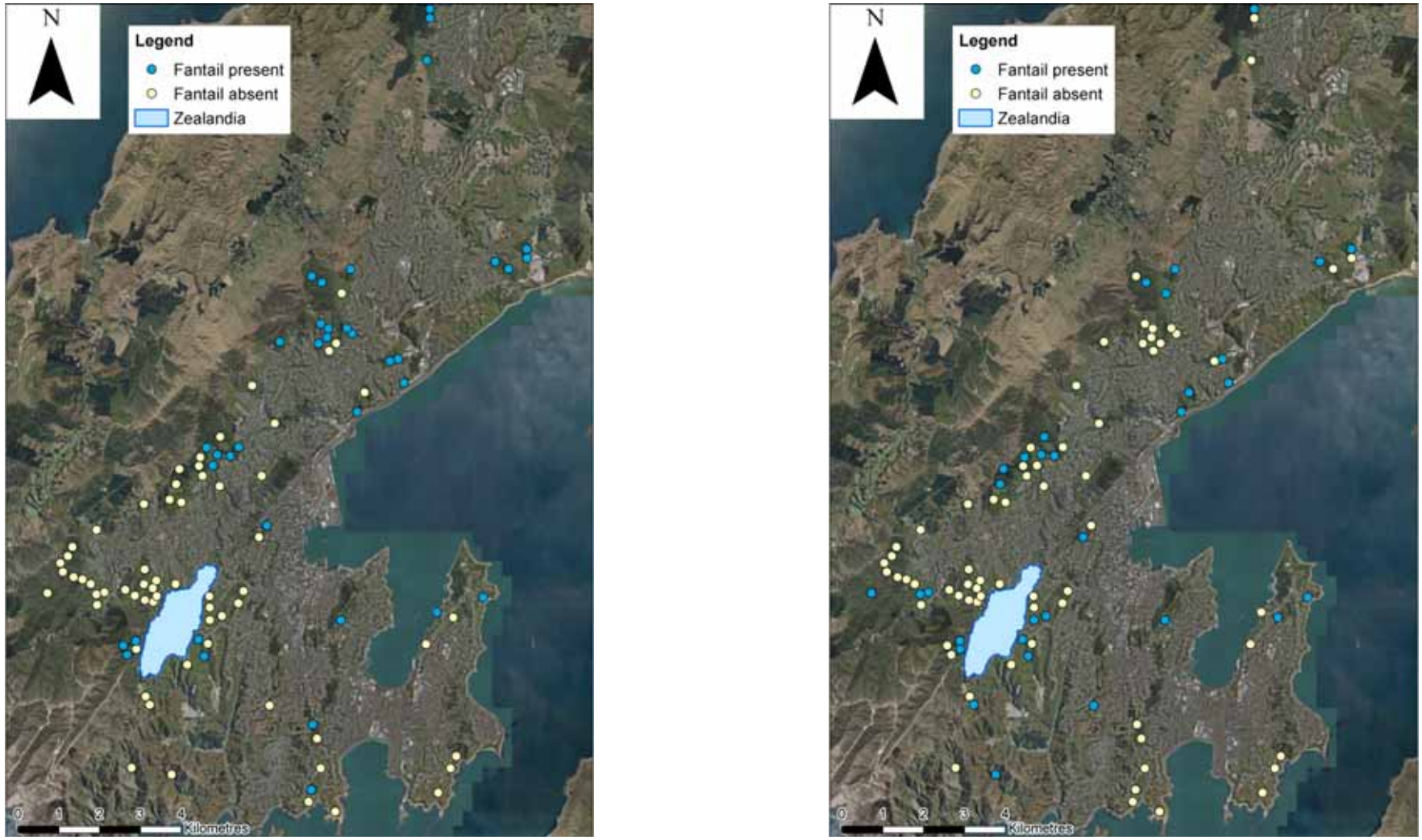

Figure 3.8: Distribution of fantail in Wellington City reserves in 2011 (left) and 2012 (right)

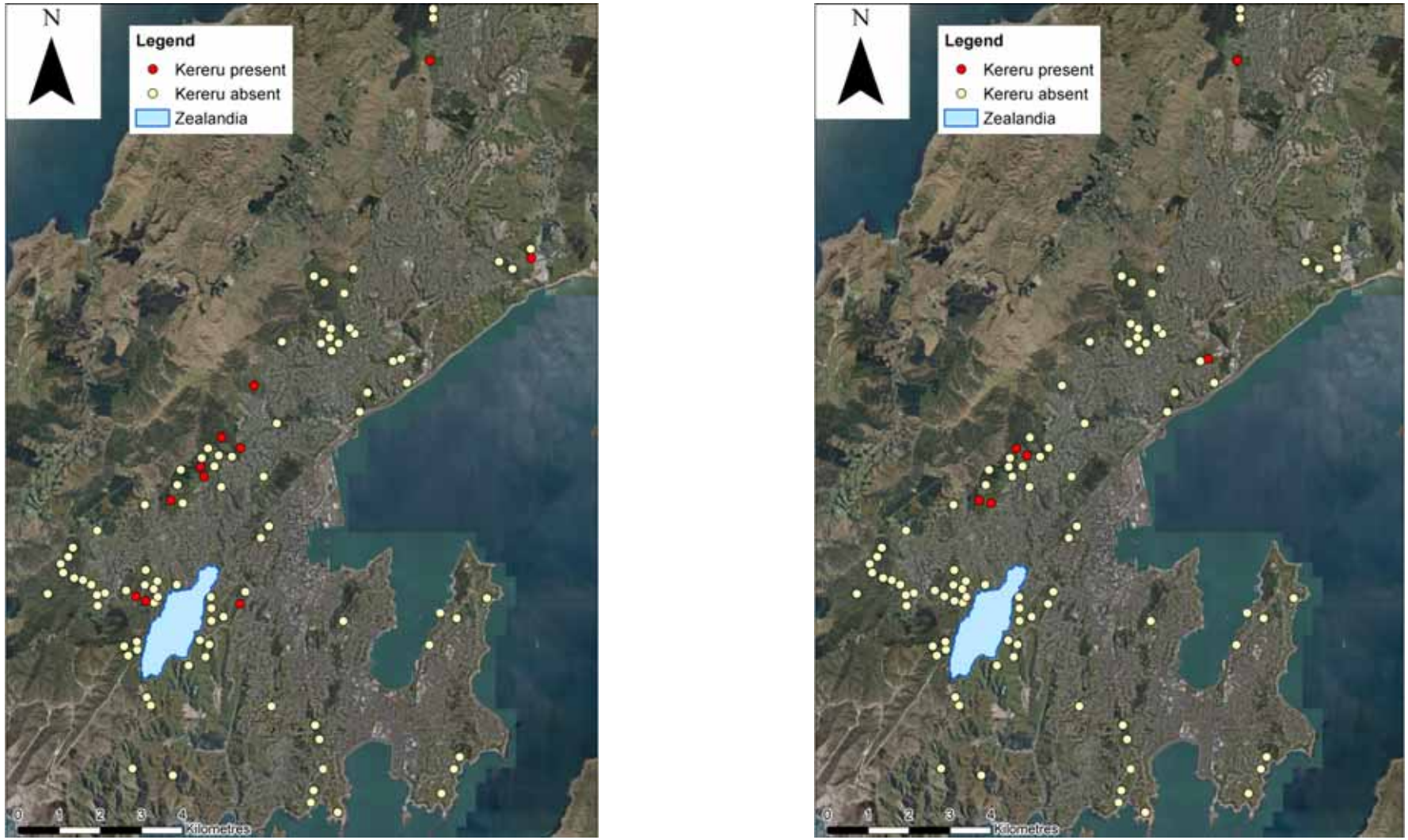

Figure 3.9: Distribution of kereru in Wellington City reserves in 2011 (left) and 2012 (right)

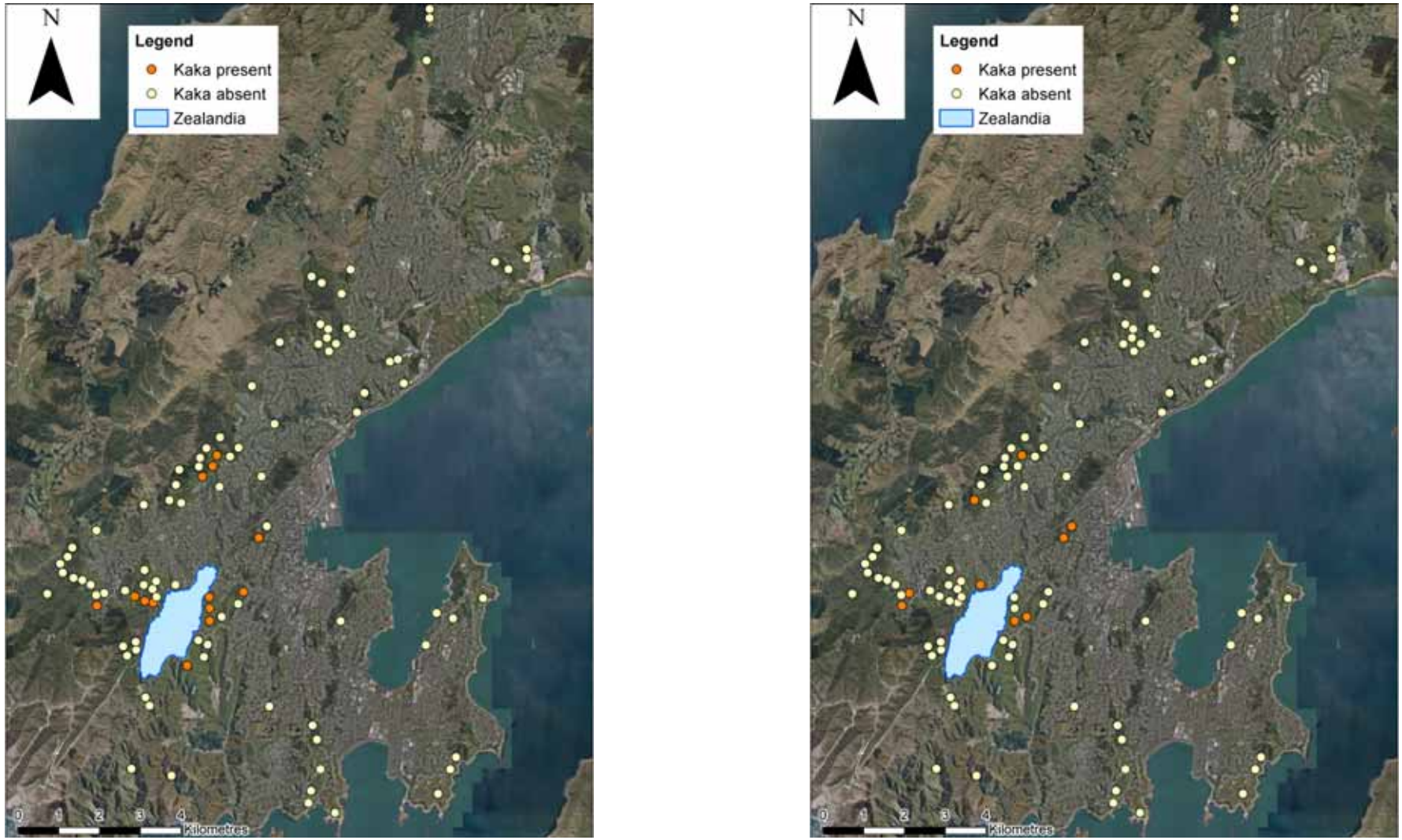

Figure 3.10: Distribution of kaka in Wellington City reserves in 2011 (left) and 2012 (right)

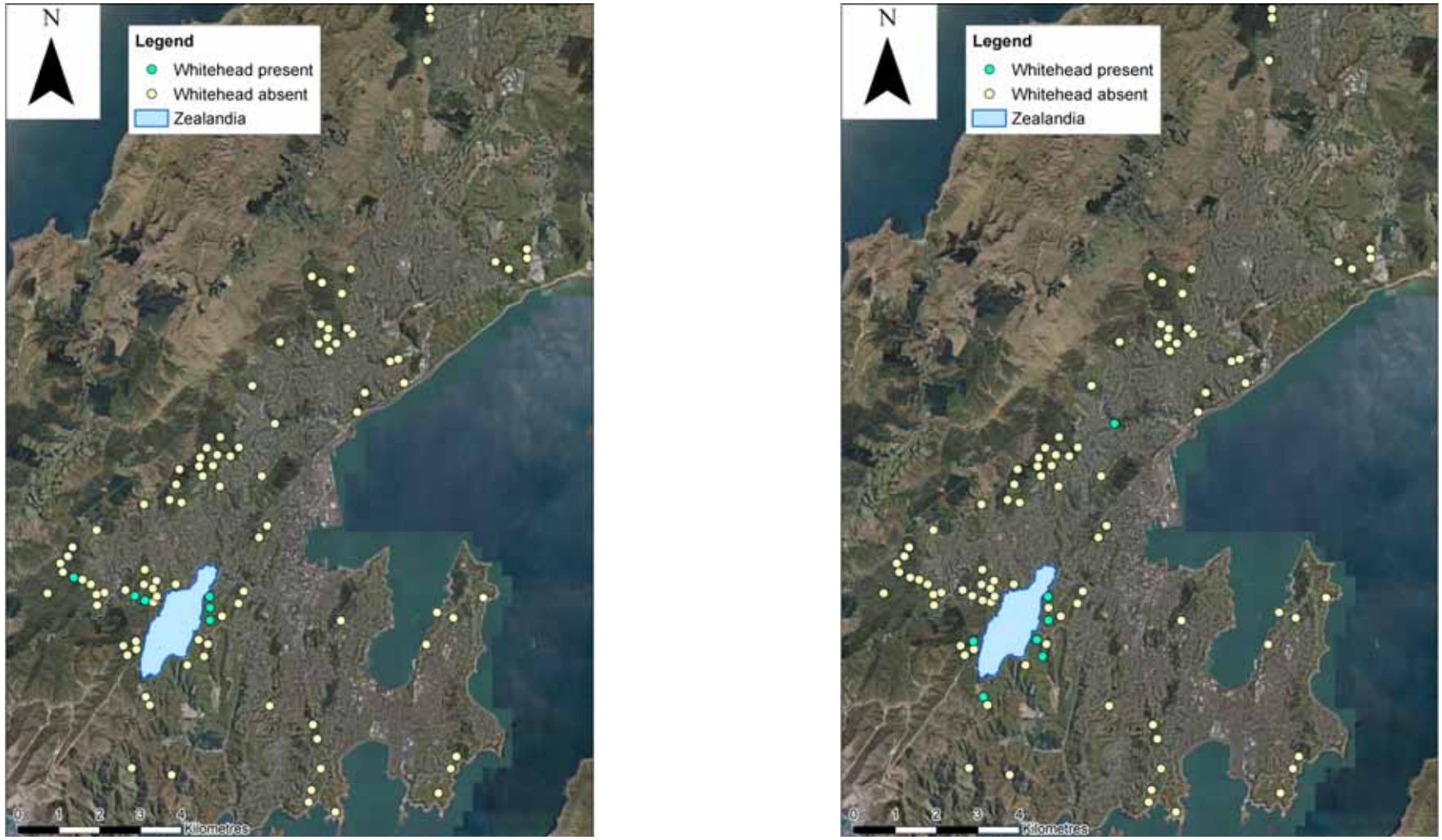

Figure 3.11: Distribution of whitehead in Wellington City reserves in 2011 (left) and 2012 (right)

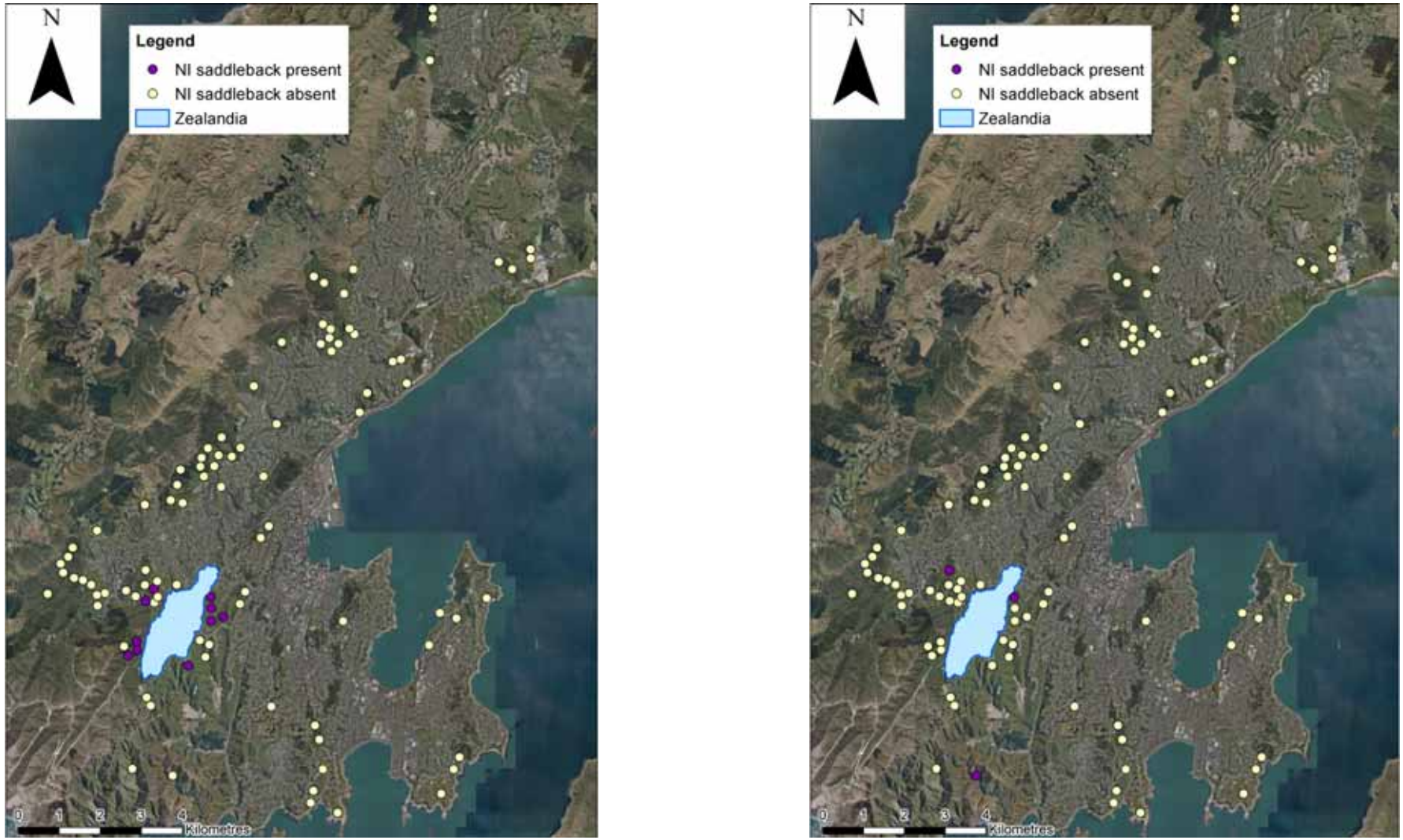

Figure 3.12: Distribution of NI saddleback in Wellington City reserves in 2011 (left) and 2012 (right)

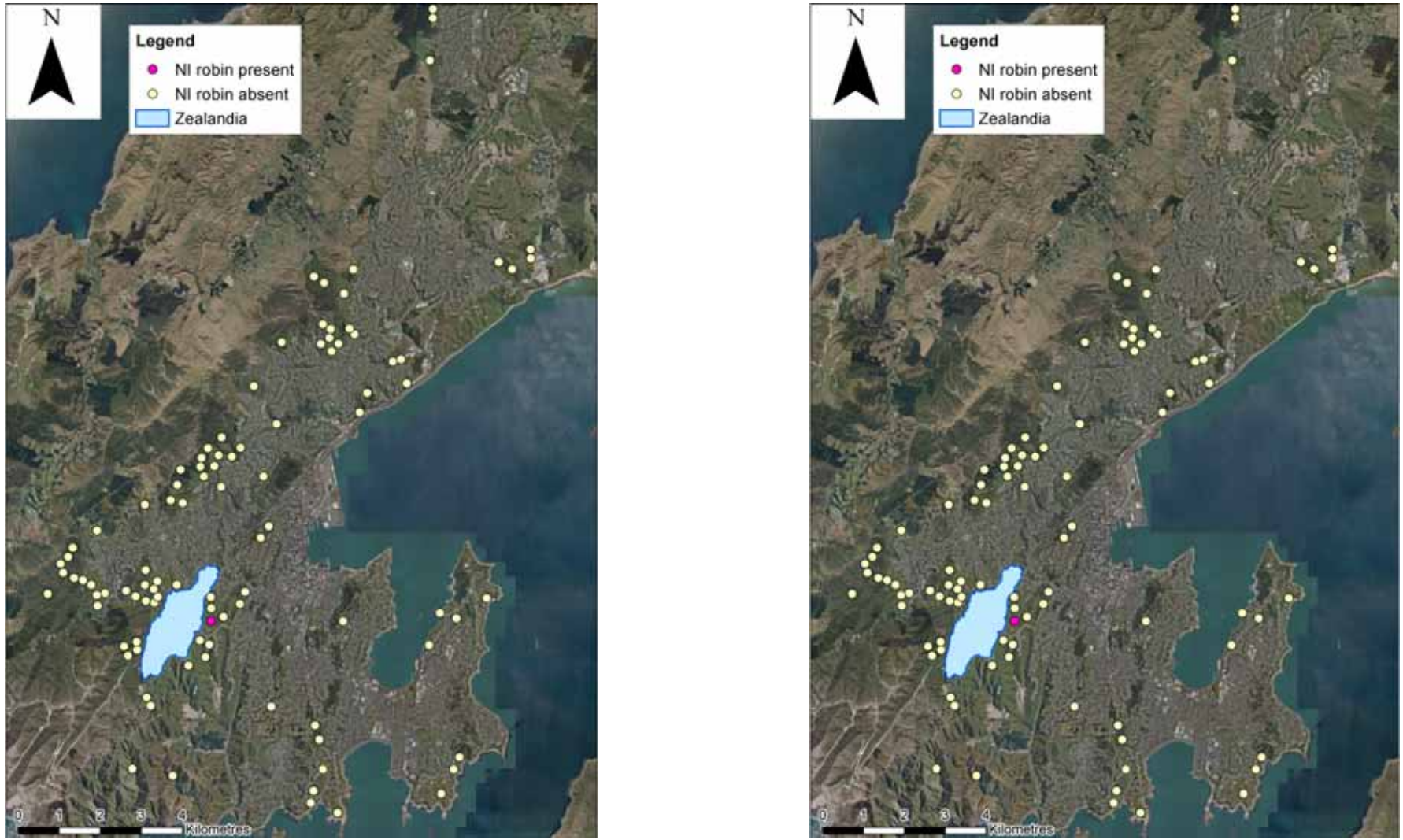

Figure 3.13: Distribution of NI robin in Wellington City reserves in 2011 (left) and 2012 (right)

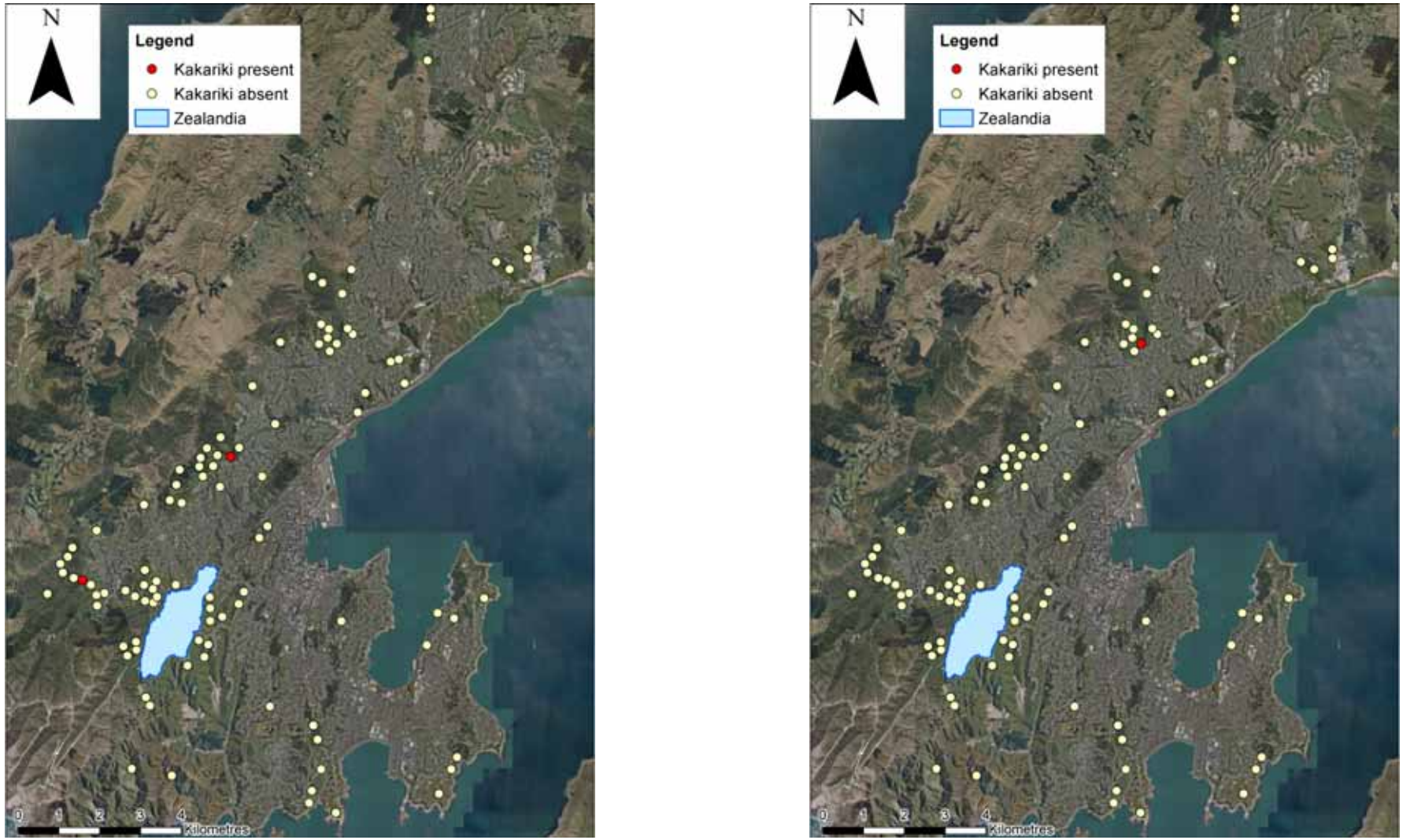

Figure 3.14: Distribution of red-crowned parakeet in Wellington City reserves in 2011 (left) and 2012 (right)

4. Discussion

4.1 Native species diversity

Zealandia continues to have an important influence on the diversity of native forest bird species present in Wellington City parks and reserves. Four of the 14 native forest bird species recorded during the 2012 surveys (29%) were present largely as a consequence of birds dispersing from source populations in Zealandia. These species are North Island robin, whitehead (both re-introduced to Zealandia in 2001), kaka and North Island saddleback (both re-introduced in 2002).

Both kaka and whitehead had been recorded in Wellington City prior to their re-introduction to Zealandia (Miskelly et al. 2005). However, the current distribution of these species (concentrated around the boundary of Zealandia) suggests that the majority of birds encountered during this survey have originated from this predator-free sanctuary. In the case of kaka, many of the birds recorded in Wellington City parks and reserves appear to birds that breed within Zealandia, but have home ranges that extend across Wellington City which enable the birds to exploit locally-available food sources (Zealandia, unpublished data).

Two further species recorded during the 2012 survey (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 on nearby islands. Radio tracking data together with sightings of banded birds have confirmed that bellbirds disperse readily from Zealandia, hampering efforts to re-establish a self-sustaining population in the sanctuary (M. Booth 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.

A total of 14 native forest bird species were recorded in the Wellington City reserve network in 2012, whereas only 10 species were recorded in the Upper Hutt City reserve network (McArthur et al, 2014). This difference can be at least partially explained by differences in "search effort" between the two surveys; whereas 200 bird counts are carried out in Wellington, only 90 are done in Upper Hutt each year. When this search effort is standardised between cities (by calculating the mean number of native forest birds recorded per bird count station), a different picture emerges. In both 2011 and 2012 the mean number of birds species recorded per station was significantly lower in Wellington City than in Upper Hutt reserves. This pattern is most likely caused by the fact that at least a quarter of the bird species recorded in

Wellington City reserves had very localised distributions, 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 reserves were widely-distributed and were recorded at a large proportion of the bird count stations surveyed.

The mean number of native forest bird species recorded per count station in Wellington City also underwent a significant decline between 2011 and 2012. This change appears to reflect a decrease in the abundance, conspicuousness and/or distribution of several bird species in Wellington City, rather than any overall decrease in species diversity. Indeed, in 2012 a total of 14 native forest bird species were recorded at Wellington City count stations whereas only 12 species were recorded in 2011 (McArthur et al, 2012), suggesting an apparent *increase* in species diversity between the two surveys. Both measures of species diversity will also be affected by the fact that naturally rare or inconspicuous species such as New Zealand falcon and bellbird may or may not be recorded during five-minute bird counts due to chance more than any other factor. These chance effects will explain some of the apparent variation in species diversity we observe from one year to the next.

4.2 Index of bird abundance

The mean number of tui recorded per bird count station in Wellington City dropped significantly between 2011 and 2012. This was entirely due to a large decline in the mean number of tui counted per station by observer three. In contrast, there was a small, but significant increase in tui detection rates between counts carried out in 2011 by observer one and counts carried out in 2012 by observer two. Because we have no reason to suspect that the methodology or abilities of observer three have changed between 2011 and 2012, we believe that the significant overall reduction in detection rates for tui between 2011 and 2012 represents either a decline in the overall abundance of this species, or a change in foraging behaviour between years caused by changes in local food availability in Wellington City. Apparent declines appear to have occurred in southern and eastern suburbs including Miramar Peninsula and Houghton Bay, suggesting birds resident in reserves in this part of the city had moved elsewhere, likely in response to changes in local food availability. Prolific fruiting of barberry during the 2012 counts appears to have been a particular influence.

Detection rates for NI saddleback declined significantly between counts carried out by observer one in 2011 and observer two in 2012, but not between counts carried out by observer three in 2011 & 2012. Despite this, we consider it more likely that the overall significant reduction in the detection rate for this species observed between 2011 & 2012 reflects a real reduction in the abundance or conspicuousness of this species, rather than being caused by the change in observer. The reason for this is because the direction of change in NI saddleback detection rates for observers 1 & 2 and observer 3 was the same between 2011 & 2012 and in the case of observers one and two the direction of change is in the opposite to what we would expect an observer-related change to be given the relative skill levels of these observers. For these reasons we suspect the overall significant reduction in detection rates for NI saddleback

between 2011 and 2012 represents a real decline in the abundance or conspicuousness of this species in Wellington City reserves over this time.

Many of the significant changes in detection rates for individual bird species observed between 2011 and 2012 appear to have been caused by the replacement of observer one in 2011 with observer two in 2012. Detection rates for silvereye, grey warbler, blackbird, goldfinch, starling, house sparrow, dunnock, eastern rosella and yellowhammer all varied significantly between observer one (2011) and observer two (2012), but not between counts carried by observer three in 2011 & 2012. The most likely explanation for this is that the change in observer was the cause of these changes in detection rates, rather than any real change in the abundance or conspicuousness of these bird species themselves. These changes illustrate the strong influence that changes in observer can have on the results of five-minute bird count studies, highlighting the importance of considering this source of variation when analysing and interpreting the results of 5-minute bird counts. Ideally, we aim to minimise further changes in observers as much as possible. Where this is unavoidable, we will seek to minimise impacts on the data by ensuring there is an overlap between outgoing and incoming observers, and/or by ensuring all observers possess a similar level of skill & experience (Bibby et al. 2000).

4.3 Native bird distribution

The significant reduction in the tui detection rate in Wellington City parks and reserves between 2011 and 2012 was accompanied by a large change in the distribution of tui across Wellington City reserves over this period. The most likely explanation for this is that large numbers of tui had moved out (or were foraging outside) of the southern and eastern reserves in 2012 and were instead occupying (or visiting) habitats in the surrounding landscape that were not sampled as part of this survey. Tui is a highly mobile species known to travel up to 10 km per day during the breeding season in order to exploit seasonally- or locally-available food resources (Stewart & Craig 1985; Heather & Robertson 2005; Robertson 2013). For this reason, the distribution of tui in Wellington City is likely to vary both between and within years in response to changes in the seasonal and local availability of nectar and fruit in the city.

This interaction between the apparent abundance and distribution of bird species in Wellington City is due to the fact that the probability that an observer will detect a bird species when it is present in the vicinity of a bird count station will seldom be 100%. Instead, this detection probability will vary according to several factors including the true (or absolute) abundance of the species in the vicinity of the bird count station (Bibby et al. 2000; Mackenzie et al. 2006). While many of the factors affecting detectability have been standardised in this survey, true abundance will vary, often unpredictably, from year to year. Survey methods do exist which allow detection probabilities to be modelled and therefore enable unbiased estimates of occupancy to be generated. However, these require multiple repeat visits to each survey station over a short period of time in order to build up “encounter histories” for each species at each count station (Mackenzie et al. 2006). Unfortunately, it isn’t practical to do this given the time and resource constraints placed on this

project; instead care will need to be taken when interpreting changes in species distributions whenever these are accompanied by changes in abundance.

A lack of any significant change in the abundance or distribution of fantails between 2011 and 2012 was surprising. McArthur et al. (2012) assumed the relatively low encounter rate and sparse distribution of this species recorded during the 2011 bird counts was a consequence of heavy local mortality in the local fantail population during two severe snowfall events that occurred in the Wellington Region in July and August 2011 (NIWA 2012). Fantails are known to be particularly susceptible to sudden declines and even local extinction following severe weather events (Miskelly & Sagar 2008) and large declines in fantail abundance were recorded between November 2010 and November 2011 in bird surveys carried out in Upper Hutt City reserves and the Wainuiomata Water Collection Area. In both areas this has been followed by a marked recovery in numbers between 2011 and 2012 (McArthur et al. 2014; Greater Wellington Regional Council, unpublished data). The lack of a similar increase in fantail abundance and distribution in Wellington City over this time suggests that fantails in Wellington City were not as severely affected by these weather events as at sites further inland, despite snow having fallen to sea-level in Wellington City for the first time since 1970 (NIWA 2011).

The dispersal of bird species recently re-introduced to Zealandia into surrounding parks and reserves continues to have an important influence on species' distributions observed in Wellington City in 2012. Four of the 14 native forest bird species recorded during the 2012 counts had distributions that clustered around the boundary of Zealandia, radiating out varying distances into surrounding parks and reserves. The distributions of these four species have changed little between 2011 and 2012, however kaka and NI saddleback were recorded at fewer count stations in 2012 compared to 2011, whereas the occupancy rates for whitehead and NI robin have remained unchanged. Some "pulsing" of the apparent abundance of these species may occur as a result of mortality (outside the fence) interacting with annually varying levels of reproductive success (and corresponding emigration) from within Zealandia. This may, for example, explain the changes in apparent distribution and abundance observed for kaka and NI saddleback between 2011 and 2012.

Irrespective of whether such "pulsing" occurs, these clustered species distributions do indicate that one or more factors are continuing to limit these species' ability to recolonise Wellington City reserves. 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 only recorded at a single count station within a few hundred metres of Zealandia's boundary fence during this bird survey. Sighting of NI robins reported by members of the public on the New Zealand eBird database or Zealandia's "Report a bird" webpage also indicate that robins are rarely encountered more than 1-2 km from Zealandia's boundary fence (R. Empson pers. comm.; http//ebird.org/content/newzealand: accessed 13/06/2013).

Given that natal dispersal of species such as NI robin and NI saddleback away from the large source populations within Zealandia's predator-proof fence is almost certainly occurring, their present distribution suggests that those birds that settle in surrounding parks and reserves are experiencing low survival and/or reproductive rates. If this is the case, it will be unlikely that we will observe any significant increase in the distribution or abundance of these species in Wellington City reserves until the cause(s) of this low survival and/or productivity are identified and managed. Until causes of mortality and/or reproductive failure are better understood and managed, opportunities for Wellington City ratepayers to encounter and interact with species such as NI robins in Wellington City parks and reserves will be restricted to visits to those reserves immediately adjacent to Zealandia.

We recommend that this bird monitoring programme be continued on an annual basis so that on-going changes in the diversity, abundance and distribution of native forest bird species in Wellington City can be monitored. This could be particularly useful for gauging the success or otherwise of any additional management that may be implemented in selected reserves or in surrounding suburban areas as part of an urban halo project (http://halo.org.nz/: accessed 13/06/2013). An opportunity also exists to expand the coverage of this bird survey to monitor native birds in additional habitats in Wellington City, for example to assess how successful suburban pest control initiatives are at improving the abundance and distribution of native birds in Wellington residents' own backyards.

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Appendix

This appendix contains a list of all bird species encountered in Wellington City reserves during the 2011 & 2012 bird counts (P=present). Threat classification rankings are as per Miskelly et al. (2008). (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
Alauda arvensis	skylark	I	P	P
Anthornis melanura	bellbird	NT		P
Callipepla californica	California quail	I	P	P
Carduelis carduelis	goldfinch	I	P	P
C. chloris	greenfinch	I	P	P
C. flammea	redpoll	I		P
Chrysococcyx lucidus	shining cuckoo	NT	P	P
Circus approximans	Australasian harrier	NT	P	P
Cyanoramphus novaezelandiae	red-crowned parakeet	RE	P	P
Emberiza citrinella	yellowhammer	I	P	P
Falco novaeseelandiae	New Zealand falcon	NV		P
Fringilla coelebs	chaffinch	I	P	P
Gallus gallus	feral chicken	N/A[1]		P
Gerygone igata	grey warbler	NT	P	P
Gymnorhina tibicen	Australian magpie	I	P	
Haematopus unicolor	variable oystercatcher	RC		P
Hemiphaga novaeseelandiae	kereru	NT	P	P
Hirundo neoxena	welcome swallow	NT	P	
Larus dominicanus	black-backed gull	NT	P	P
L. novaehollandiae	red-billed gull	NV		P
Mohoua albicilla	whitehead	NT	P	P
Nestor meridionalis	kaka	NV	P	P
Passer domesticus	house sparrow	I	P	P
Petroica longipes	North Island robin	NT	P	P
Philesturnus rufusater	North Island saddleback	RC	P	P
Platycercus eximius	eastern rosella	I	P	P
Prosthemadera novaeseelandiae	tui	NT	P	P
Prunella modularis	dunnock	I	P	P
Rhipidura fuliginosa	fantail	NT	P	P

[1] Feral chicken is not recognised as a naturalised species in New Zealand (Gill et al, 2010) and therefore does not have a NZ Threat Classification System ranking (Miskelly et al, 2008)

Scientific Name	Common Name	Threat Ranking	2011	2012
Sturnus vulgaris	starling	I	P	P
Tadorna variegata	paradise shelduck	NT		P
Todiramphus sanctus	New Zealand kingfisher	NT	P	P
Turdus merula	blackbird	I	P	P
T. philomelos	song thrush	I	P	P
Zosterops lateralis	silvereye	NT	P	P

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