An evaluation of the Great Kererū Count 2015

Photo: *Tony Stoddard 2014/Kererū Discovery*

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TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI VICTORIA UNIVERSITY OF WELLINGTON

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EXECUTIVE SUMMARY

The Great Kererū Count (GKC) is an annual nationwide citizen science project organised by the Worldwide Fund for Nature (WWF) New Zealand and Forest & Bird with support from the Kiwi Conservation Club (KCC), Kererū Discovery, Wellington City Council (WCC), Victoria University of Wellington (VUW), Wildland Consultants and Nature Watch NZ. The GKC 2015 took place nationwide from the 19th to the 27th of September 2015. During the duration of the count, 9 days in total, people were encouraged to report the presence or absence of kererū (a New Zealand pigeon) and other details about the sighting.

Organising a citizen science project focused on kererū has many potential benefits, including increased public awareness of: the significance of kererū in New Zealand ecosystems; threats to kererū, what actions can be taken to help kererū; as well as the potential to gain early indications of population increase or decline. Over a number of years, it is intended that data from the GKC will develop a picture of changes in kererū numbers and distribution, as well as some aspects of behaviour. The main purpose of this report is to summarise information from GKC 2015 on the abundance and distribution of the New Zealand pigeon.

The public could provide data over three channels: the NatureWatch website, the iNaturalist mobile application, as well as a bespoke web interface that collects and feed data into a NatureWatch database. The latter web interface was the main channel for participants who were not registered with NatureWatch. The GKC 2015 dataset was manually cleaned, and then analysed using ArcGIS 10.2.2, R for spatial analysis and Excel for data summaries. Some of the main findings were:

- 7,372 reports submitted, totalling 15, 840 kererū observed (excludes incomplete (n=1611) and offshore (n=463) observations).
- 7,131 of the submitted reports detailed the presence of kererū and 241 detailed the absence of kererū.
- The most popular plant and food sources associated with kererū were kowhai (671), followed by planted fruit trees (305) and pūriri (105).
- The rate for reporting was not proportional to (human) population or the number of households. Some areas, such as the Tasman region, had a higher number of reports submitted per household than others. It is unclear whether the higher number is due to the region having more kererū, and/or greater publicity for the GKC 2015 in the region, and/or any other reasons that might influence people's propensity to participate in the project.
- In Wellington City, most of the reports of kererū presence were made in Urban/Suburban land cover (77%), with native land cover recording 18% of observations.

Based on the evaluation of the GKC 2015, a number of recommendations for future GKCs were developed. The main recommendations are:

1. It is important to clearly understand in advance who will use the data, how it will be analysed and how results will be communicated back to the citizen scientists.
2. The data collection app should have a prompt that encourages participants to enable their location to be gathered.
3. The GKC and NatureWatch should encourage its citizen scientists to collect absence data. By collecting absence data in addition to actual sightings, we will be able to create a dataset that is more useful for ecological modeling.
4. Willow trees and various planted fruit trees (plum, pear etc.) should be included as a possible answers for the question *"If feeding from a tree or shrub, what type of tree?"*

There is a lot of potential in a nationwide kererū presence- absence dataset, for example the data gathered could benefit local councils by providing information on kererū distribution and relative abundance, suitable habitats, and by providing evidence of effective pest control efforts. Meaningful analysis must take into account the distribution of the human population of observers and how this influences the perception of kererū distribution.

1. INTRODUCTION

Citizen science is one of the fields of Public Participation in Scientific Research (PPSR). Shirk et al. (2012) define PPSR "as intentional collaborations in which members of the public engage in the process of research to generate new science-based knowledge". One of the pioneers in the field of citizen science and PPSR in ecological and conservation studies is the Cornell Lab of Ornithology (CLO), a unit of Cornell University and a non-profit environmental organisation. On their citizen science website, CLO (Cornell Lab of Ornithology, 2014) describe PPSR and citizen science as follows: "The growing field of PPSR includes citizen science, volunteer monitoring, and other forms of organized research in which members of the public engage in the process of scientific investigations: asking questions, collecting data, and/or interpreting results". Projects involving PPSR may be driven by different goals, such as education or management of social-ecological systems, but what defines PPSR projects is the aim to contribute to scientific research and/or monitoring (Shirk et al., 2012).

The Great Kererū Count (hereafter referred to as the GKC) is an annual citizen science project organised by Kererū Discovery Project (a partnership between WWF New Zealand and Wellington City Council) and Forest & Bird's Kiwi Conservation Club. The aim of this report is to summarise findings form the 2015 GKC and to create recommendations for future GKCs. This report is produced as part of a summer scholarship project, funded by the Wellington City Council (WCC) and Victoria University of Wellington (VUW). The two main questions that WCC are interested in were:

- What are kererū feeding on in Wellington?
- What land characteristics determine kererū distribution?

This report consists of four components:

- A literature review of the principles of citizen science, biases, limitations of crowdsourcing data and the use of pseudo-absences.
- Data analysis of the Great Kererū Count 2015.
- Recommendations for future GKCs.
- Conclusion.

2. LITERATURE REVIEW

In recent years, volunteer participation has become one of the pillars of ecological studies concerning conservation of biodiversity (Dickinson et al., 2010). It is likely that the number of citizen science projects has increased in recent years not only because of the wide availability of new technologies, such as mobile applications (apps), wireless sensor networks, and online computer/video gaming (Newman et al., 2012), but also because the scientific community has recognised the potential of citizen science to gather data on a large geographic scale and over a long time period for minimal cost (Cohn, 2008). Mass data collection, and the potential gains it can offer to scientists, only represents one side of citizen science. Citizen science can also provide an efficient way to engage the public with science. For example, participating in a citizen science project may encourage participants to engage in the scientific thinking processes (Trumbull et al., 2000), improve scientific literacy of the participants (Cronje et al., 2011), and increase the participants' knowledge or change their behaviour (Evans et al., 2005). This report uses the term *participant* for a volunteer citizen scientist, and the term *citizen science* is used throughout the report to describe a project that involves mass data collection by volunteer participants.

Many of the principles behind planning and organising a citizen science project are general to all of science. For example, the methods of data collection must be well designed and standardised and the data collected by the public must be validated (Silvertown, 2009). Shirk et al. (2012) created a framework (Fig. 1) that considers how public and scientific interests can be negotiated in order to create a successful citizen science project, i.e. to enhance the outcomes for individuals, science and social-ecological systems. Cornell Laboratory for Ornithology (CLO) has used data collected by volunteer citizen scientists in a variety of projects over the past two decades, and during this time, CLO developed a model (Fig. 2) for building and operating citizen science projects (Bonney et al., 2009).

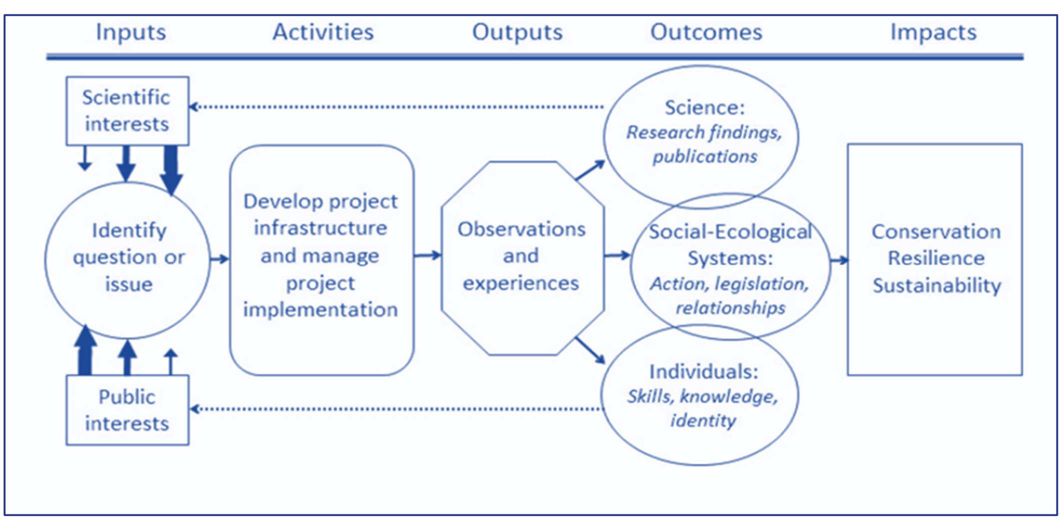


Figure 1: Framework for public participation in scientific research projects (Shirk et al., 2012).

Model for developing a citizen science project (Bonney et al., 2009):

1. Choose a scientific question.
2. Form a scientist/educator/technologist/evaluator team.
3. Develop, test, and refine protocols, data forms, and educational support materials.
4. Recruit participants.
5. Train participants.
6. Accept, edit, and display data.
7. Analyse and interpret data.
8. Disseminate results.
9. Measure outcomes.

Figure 2: Model for developing a citizen science project (Bonney et al., 2009).

The scope of past and existing citizen science projects varies enormously, ranging from projects such as volunteers classifying images of galaxies (Galaxy Zoo, http://www.galaxyzoo.org/#/) to citizens scientists searching through old ships' log books for weather observations (Weather Detective, http://www.weatherdetective.net.au/). Many of the citizen science initiatives are conservation and environment related. A book dedicated to environmental citizen science (edited by Janis L. Dickinson and Rick Bonney, 2012) and a recent report made for the European Union (University of the West of England, 2013) provide overviews of environmental citizen science.

Probably one of the best known examples of citizen science projects in New Zealand is the annual Garden Bird Survey. The annual survey has been carried out since 2007 for the purpose of monitoring the distribution and population trends of common garden birds in New Zealand, in the hope that the survey could potentially act as an early-warning system if currently common native species start declining (Landcare Research, 2014). Spurr (2012) analysed the first four years of the Garden Bird survey, and concluded that despite some methodology and data issues, the Garden Bird survey has the potential to detect changes in the distribution and abundance of species that may require a management response. The survey cannot identify the reasons for population changes, but it can alert authorities to investigate potential reasons for declines, such as disease outbreaks (Spurr, 2012). Also, the results of the Garden Bird survey could provide local council and other biodiversity management authorities with circumstantial evidence regarding the effect of their pest control and restoration planting efforts (Spurr, 2012).

2.1 Biases

Due to the often unstructured or undirected nature of citizen science sampling, survey effort is likely to result in bias and data quality issues (Tulloch et al., 2013). Lack of quality assurance and potential bias increase the risk of inaccurate trend estimation and this data collection method makes it difficult to distinguish between changes in population size and spatio-temporal shifts in distribution (Wilson et al. 2013). According to Matsuoka et al. (2011), sampling biases arise when particular areas are more likely to be sampled than others. Historically, the location and intensity of collecting is heavily influenced by accessibility. Bird studies, in particular, are shown to be more located in areas that are accessible (McCaffrey, 2005). Sampling areas typically show dense, significant aggregation around city limits, along rivers, roads and walking tracks (Reddy & Dávalos, 2003). Other biases identified in the literature include climate, season and attractiveness of site, i.e. designated conservation areas. Studies have shown that by understanding the source, magnitude and pattern of sampling biases and errors researchers can specifically target under-sampled areas (Tulloch & Szabo, 2012).

2.2 Modelling using pseudo-absences

In order to gain an understanding of spatial patterns and species distribution, it is important for studies to obtain information on where a species is absent. Absence data allows for the effective ecological modelling of the species. However, such data is difficult to obtain, making it statistically challenging to predict species' distribution with presence-only data (Wisz & Guisan 2009). To solve this problem, numerous studies have proposed the use of pseudo-absences. However, there is little consensus on how and where to select pseudo-absences. Some of the techniques identified are a) pseudo-absences selected randomly from the background, b) pseudo-absences selected from low suitability areas predicted by either Ecological Niche Factor Analysis (ENFA) or BIOCLIM (Wisz & Guisan 2009), or c) select pseudo-absences from areas in proportion to the distribution of potential observers (Warton et al. 2013).

2.3 Limitations of crowd sourcing

There are three main limitations to crowd sourcing. The first limitation is poor data quality. According to Li and Hongjuan (2011), poor data quality can occur when crowd sourcing facilitators fail to give clear instructions to the crowd. Second, because participants are unpaid or paid less than professionals, the end product is usually viewed as less credible in comparison to something produced by professional. Finally, crowdsourcing requires significant management of the contributions and queries associated with participation (Li & Hongjuan, 2011). To overcome these limitations, Brabham (2010) suggests ensuring that expectations are defined; the project and its facilitators are transparent, focus on quality and value and reward participants.

3. THE GREAT KERERŪ COUNT 2015

3.1 Background

The fourth annual Great Kererū Count (GKC), organised by Kererū Discovery Project (a partnership between WWF New Zealand and WCC) and Forest & Bird's Kiwi Conservation Club, took place from the 19th to 27th of September 2015 nationwide (WWF, 2014).

The general aims of the GKC are:

- To gain the New Zealand public's participation in a meaningful science project.
- To gather scientific data about the nationwide distribution and population of kererū.
- To educate New Zealanders about the ecological importance of the kererū.
- To show New Zealanders that science is fun, achievable and rewarding.

During the duration of the count, 9 days in total, people were encouraged to record their kererū reports, alongside observations such as:

- Bird microhabitat
- Survey area description

There were four major changes compared to the previous two years' counts:

1. Instead of using the Thundermaps website, a new website interface was developed. This interface included a bespoke data entry page. In addition, participants were given the option to enter data directly via the crowd-sourcing site Nature Watch (http://naturewatch.org.nz/).
2. iNaturalist mobile application was used (as a way of entering data into NatureWatch), whereas in 2014, the Thundermaps mobile application was used.
3. Some new questions were added to the survey, and other questions were restructured, e.g. so that answers could be selected from drop-down menus.
4. Instead of 14 days, the duration of the count reduced to 9 days in total (two weekends and the intervening weekdays).

3.2 Why kererū?

Kererū, also known as native pigeon or wood pigeon, is the more common of the two subspecies of the endemic *Hemiphaga novaeseelandiae*, the New Zealand pigeon (Heather & Robertson, 2005). Kererū is currently considered to be common and widespread in native forests and increasingly in urban areas throughout the North/South Islands, Stewart Island/Rakiura and large offshore island however, due to illegal hunting kererū is becoming rare in some parts of New Zealand (Scofield & Stephenson, 2013). Other threats to kererū include habitat loss through forest clearance, predation by rats, stoats, possums and cats, and competition for food (leaves, flowers, and fruit) with possums (Department Of Conservation, 2014).

Photo: Tony Stoddard 2014/ Kererū Discovery

Kererū is not currently classified as threatened, but its conservation is considered important, not only for its intrinsic value but also because its decline creates a serious threat to New Zealand's native forests. Kererū provide effective dispersal by moving most seeds away from the parent tree and enhancing seed and seedling survival, and it has been shown that both dispersal failure and introduced mammals negatively affect the regeneration of large-seeded trees in New Zealand (Wotton, 2007). In their report 'Monitoring and management of Kererū (*Hemiphaga novaeseelandiae*)', Mander at al. (1998) outline the need for monitoring kererū populations:

- Kererū is a keystone species of native mixed podocarp-broad-leaf forests – kererū are one of the most important seed dispersing bird species in New Zealand because of their widespread distribution, mobility and the wide range of fruit they eat, and they are the only common bird capable of dispersing large-fruited species, such as karaka (*Corynocarpus laevigatus*), tawa (*Beilschmiedia tawa*), tarairi (*Beilschmiedia taraire*) and pūriri (*Vitex lucens*);
- Kererū have a relatively low reproductive rate, and are vulnerable to predation by introduced mammals. Therefore, they can be useful as an *indicator species* to assess the effectiveness of mainland island management programmes and other restoration projects;
- Kererū populations are declining in Northland, and are widely perceived to be declining other parts of the country, partly because of illegal harvesting;
- The development and implementation of a nationally coordinated monitoring programme is a necessary first step in the development of a kererū conservation strategy (Mander at al., 1998).

Based on these factors, a citizen science project focused on kererū has many potential benefits, including increased public awareness of the threats to kererū, its significance in New Zealand ecosystems, what actions can be taken to help kererū, and the potential to gain early warning if the populations appear to be in decline in some parts of the country. By taking action to help kererū, other native and endemic species may be also helped as a result. Furthermore, kererū is an excellent target species for a citizen science project, as it is widespread, relatively common, and large and distinguishable, making it easy to easy to identify.

3.3 Data collection

Data was collected via three channels; the NatureWatch and Great Kererū Count websites, and the iNaturalist app. The user drags and drops a pin on a Google map to add a location of the Kererū observation. A street address is then generated from the recorded latitude and longitude coordinates. If the marked location was in a non-residential area, such as park or forest, the system pulls through the nearest possible street address, or a non-street location. If the marked location was too far from an address, e.g. in the sea, then no address was applied. The user could then add more information by using dropdown boxes and an open comment fields.

The first questions asked were 'What did you see?', 'When did you see it?', and 'Where were you?'. Answers to these questions provide the core minimum information required for an observation to be included in analyses. Participants had the option of changing the geoprivacy between open, obscured and private. In addition to these intial questions, participants could also add a description, photo or sound.

The second stage of the questionaire consisted of the following questions. Answering these was encoraged, but considered optional.

a) How many kererū did you see?
b) Where did you first see the birds(s)?
c) What kind of place were you in when you made the observation?
d) Was this a premeditated timed survey or a chance observation?
e) How long did you spend looking for kererū this time (in minutes)?
f) How far away were you when you first observed it?
g) While observing, were you primarily sitting/standing, walking or something else?
h) How frequently have you seen them at this location before?
i) In your opinion, have kereru become more abundant, less abundant or stayed about the same in this area over the past three years?
j) Were any NZ pigeon display flights observed? In these distinctive displays the bird gains altitude with noisy wingbeats, stalls with its body vertical and wings and tail spread, then tilts forwards or sometimes sideways to glide silently down again.
k) Was the kererū feeding?
l) If feeding from a tree or shrub, what type of tree?

The final stage consisted of a comment section and the option to subscribe to the GKC project email.

3.4 Data analysis and methods

After the initial data cleaning by the Kererū Discovery, the total figures showed 7,372 reports submitted and 15,840 kererū observed. This figure is an increase from the 2014 survey in which 7,099 reports were submitted and 14,194 kererū observed.

The kererū presence-absence dataset was affected by a number of questionable geographical locations (e.g. located offshore or invalid X-Y coordinates), several incomplete reports and the inability to verify the reports due to a lack of participant contact information.

The following steps were taken to prepare the dataset for analysis:

Geocoding

Records with appropriate spatial information, but lacking an assigned geographic location were assigned to a specific location by the following method.

- Contextual information was extracted from the address provided in the comment field. The quality for this information was categorised as either '*Excellent'* (number, street/road and town included), '*Good'* (Road), and '*Bad'* (general area only, i.e. near Hutt River).
- *Excellent* and *Good* data were geocoded using Google sheets App "Geocoded by Awesome Table", overall 32 observations were successfully geocoded.
- These coordinates were added to the "KereruPts_NZTM" excel file.

New Categories

- The field on time spent looking for kererū was cleaned. Text, such as "1 minute", was replaced with a numeric value "1".
- A numeric field for "h) opinion of change' was created using the following classification; More abundant = 1, About the same = 0, and Less abundant = -1.
- A numeric field for the "I) frequency of previous encounter" was created based on midpoints: Never (0), Seldom (5.5), Sometimes (18), Often (37.5), Regularly (70.5), Very Frequently (95).
- A presence/absence field was added.
- Added a field to distinguish geocoded observations.

Empty fields

- A new 'Presence/Absence' column was added: Absence = 0, Presence = 1. All 'Blanks' checked and changed to '1' or '0' based on comments and the number of kererū observed.

While kererū have been tracked crossing from Invercargill to Stewart island and back (Powlesland, Moran, & Wotton, 2011), the chances of people actually seeing a kererū flying over open water is negligible, hence

reports greater than 200m from land or offshore islands were removed. This removal reduced the number of reports from 7835 to 7516. Land cover data (using the Land Cover Database (LCDB) v3 created by Landcare Research New Zealand Ltd.) was obtained from the LRIS portal and the land cover classes were reduced from 32 to 4. Spatial analysis was completed using ArcGIS 10.2.2.

Conversion used to aggregate LCDB land cover classes into one of four more general categories

LCDB Class Number and Name	**GKC Class Name**
1 Built-up Area (settlement) Exotic	Urban/suburban
2 Urban Parkland / Open Space Exotic	Open space non woody
5 Transport Infrastructure Exotic	Open space non woody
6 Surface Mines and Dumps Exotic	Open space non woody
10 Coastal Sand and Gravel Indigenous	Open space non woody
12 Landslide Indigenous	Open space non woody
14 Permanent Snow and Ice Indigenous	Open space non woody
15 Alpine Grass / Herbfield Indigenous	Open space non woody
16 Gravel and Rock Indigenous	Open space non woody
20 Lake and Pond Indigenous	Open space non woody
21 River Indigenous	Open space non woody
22 Estuarine Open Water Indigenous	Open space non woody
30 Short-rotation Cropland Exotic	Open space non woody
33 Orchard Vineyard and Other Perennial Crops Exotic	Exotic woody vegetation
40 High Producing Exotic Grassland Exotic	Open space non woody
41 Low Producing Grassland Exotic	Open space non woody
43 Tall-Tussock Grassland Indigenous	Open space non woody
44 Depleted Grassland Indigenous	Open space non woody
45 Herbaceous Freshwater Vegetation Indigenous	Open space non woody
46 Herbaceous Saline Vegetation Indigenous	Open space non woody
47 Flaxland Indigenous	Native woody vegetation
50 Fernland Indigenous	Open space non woody
51 Gorse and/or Broom Exotic	Exotic woody vegetation
52 Mānuka and/or Kānuka Indigenous	Native woody vegetation
54 Broadleaved Indigenous Hardwoods Indigenous	Native woody vegetation
55 Sub-Alpine Shrubland Indigenous	Native woody vegetation
56 Mixed Exotic Shrubland Exotic	Exotic woody vegetation
58 Matagouri or Grey Scrub Indigenous	Native woody vegetation

64 Forest – Harvested Exotic	Exotic woody vegetation
68 Deciduous Hardwoods Exotic	Exotic woody vegetation
69 Indigenous Forest Indigenous	Native woody vegetation
70 Mangrove Indigenous	Native woody vegetation
71 Exotic Forest	Exotic woody vegetation

In order to create map surfaces the following tools were used, point density, inverse distance weighted and the symbology properties. Before each map was created, the geoprocessing environment was set. All outputs were restricted to the land area (NZ Coastlines and Islands Polygons-dataset). The point density tool was used to calculate the magnitude-per-unit area from point features that fall within a neighbourhood around each cell. The observer effort map was created using this method, kererū reports shapefile was the input and since the aim was to display the density of all of the reports, no specific population field was selected. The default values were chosen and the tool was run. Symbology and classification were used to make the map easier to visualize, yellow and red were chosen to represent hot and cold spots. The IDW tool was used to create the perceived frequency map, this tool outputs a raster surface from the kererū report shapefile. As before, the shapefile was the input and the search radius was set to variable. This selection uses a variable search radius in order to find a specified number of input sample points for the interpolation. In addition, the number of points in the search radius setting was set to 12. To create the relative density and opinion of change maps, the AU2015 meshblock was used to create a spatial join with the kererū reports based on spatial location. This aggregated all the reports by area unit and allowed for the use of symbology in order to visualize changes between each area unit.

Finally, Excel was used to create complementary graphs and tables. Most spatial datasets used were obtained from WCC and Land Information New Zealand (LINZ). A New Zealand Coastlines and Islands dataset was obtained from LINZ (https://data.linz.govt.nz/layer/1153-nz-coastlines-and-islands-polygons-topo-150k/). A land cover dataset was obtained from the Land Resource Information Systems (LRIS) portal (https://lris.scinfo.org.nz/layer/304-lcdb-v30-deprecated/), and was then modified in ArcGIS.

For analysis, the area of interest (New Zealand) was divided into 16 regions according to New Zealand Government Regional Council classification (Figure 3), so that figures could be compared with New Zealand census data (Statistics New Zealand).

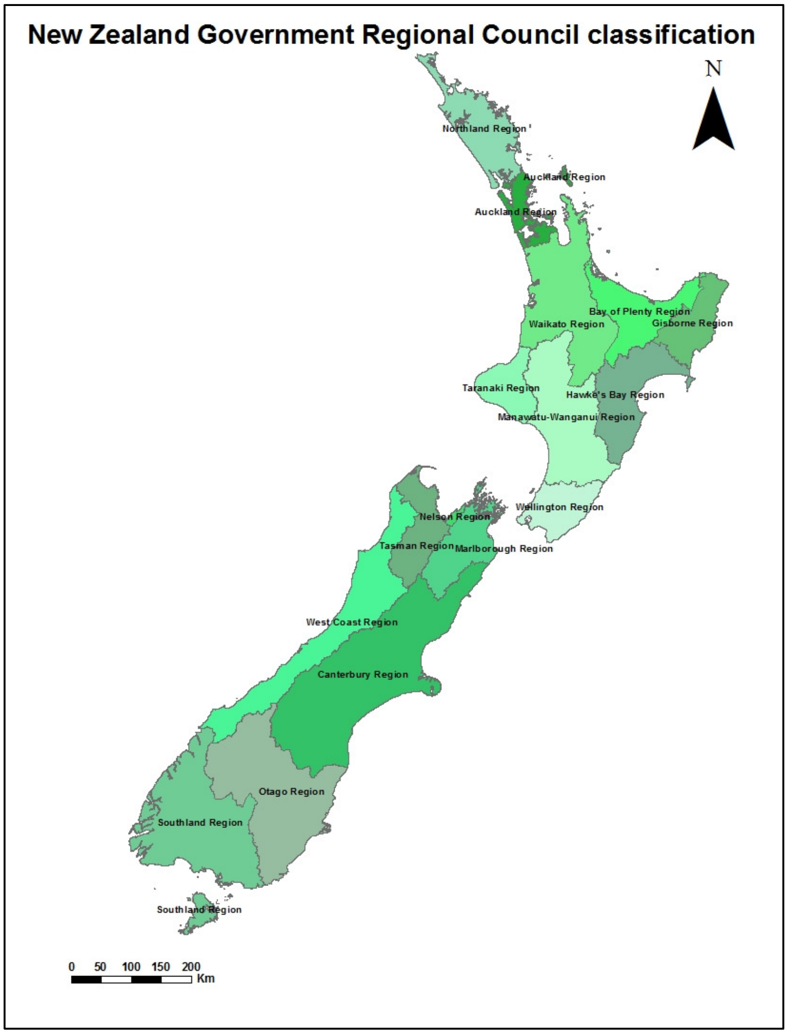


Figure 3: Regions of analysis (to facilitate comparison with census datasets).

The report numbers made in each region were compared against the national household numbers based on the latest (2013) household census data from Statistics New Zealand.

- The kererū point locations were intersected with the census region polygons, and then summed in Excel based on exported attribute tables. Using this method, the total report figures were 7372 kererū reports for a total of 15,840 observed (i.e. an average of 2.15 birds per report).

Excluded from these numbers are:

- Approximately 2,074 incomplete reports (reports without reliable spatial location data).
- 463 reports made outside the 16 regional areas, of which 72 (23.53%) points were determined 'off-shore points', with 11 of these having no identifiable location based on the comment/address section. The number of 'off-shore points' was determined by selecting all the points outside 200 metres range from either the mainland or islands by using the buffer tool.

4. RESULTS OF THE GKC 2015

Over seven-thousand reports (7,372) were submitted amounting to 15,840 kererū observed, excluding incomplete records (1,611) and offshore observations (463). Of these, 7,131 of the reports recorded the presence of kererū and 241 reports recorded absences. There is a slight increase on 2014 when 7,099 reports were made in total, and 14,194 kererū were observed. Furthermore, the 2014 Great Kereru Count extended over 14 days, whereas the 2015 Count was for 9 days (many of which were rainy over large areas of the country).

Participants were encouraged to undertake timed surveys and to submit a report, even if they did not see any kererū. Forty-four percent of participants spent under 30 minutes looking for kererū, while 31% spent 30-60 minutes looking (Figure 4). Overall (combining timed surveys and casual records), two hundred and forty-one (3.37%) reports reported an absence of kererū and the remaining 7,131 (96.63%) reported presence of kererū. Twenty-seven percent of absence reports were made after people had spent 15-30 minutes looking for kererū (Figure 5), in comparison to the 2014 results which showed that a large majority of absences were reported after 5 – 10 minutes.

4.1 Participant observations and behaviour

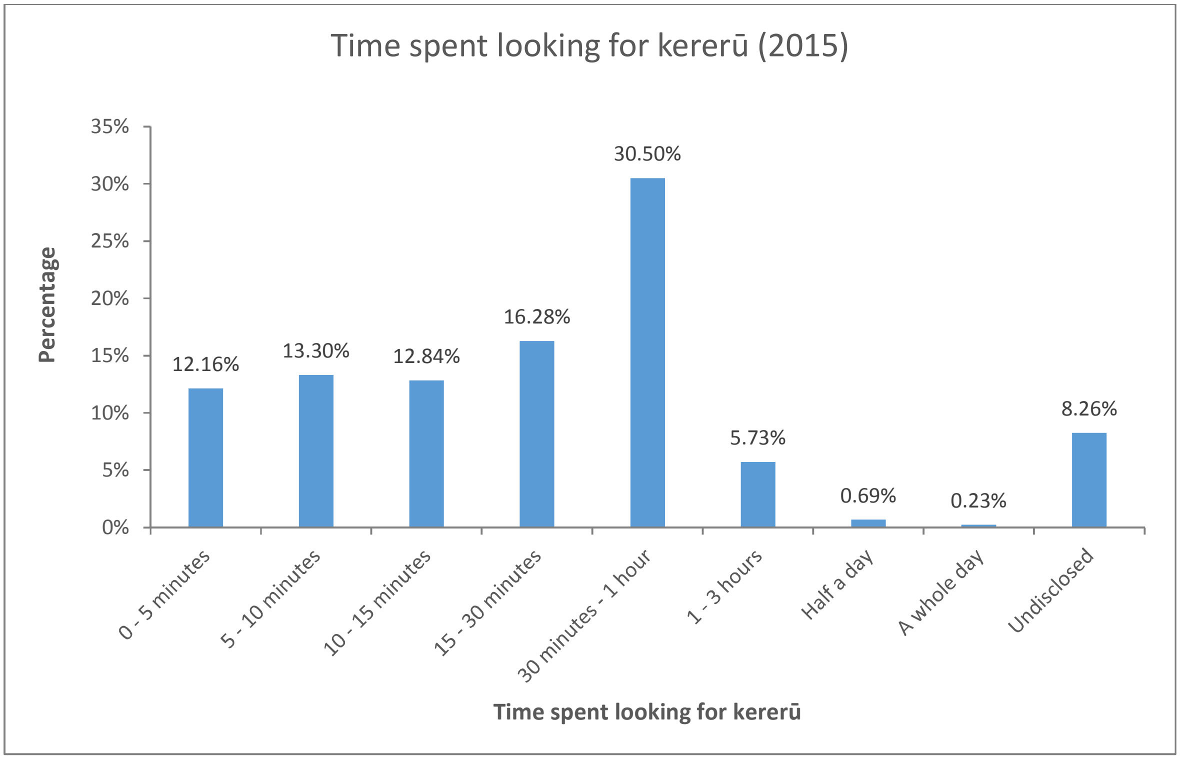


Figure 4: Time spent looking for kererū in a timed survey, combining both absence and presence (n = 437).

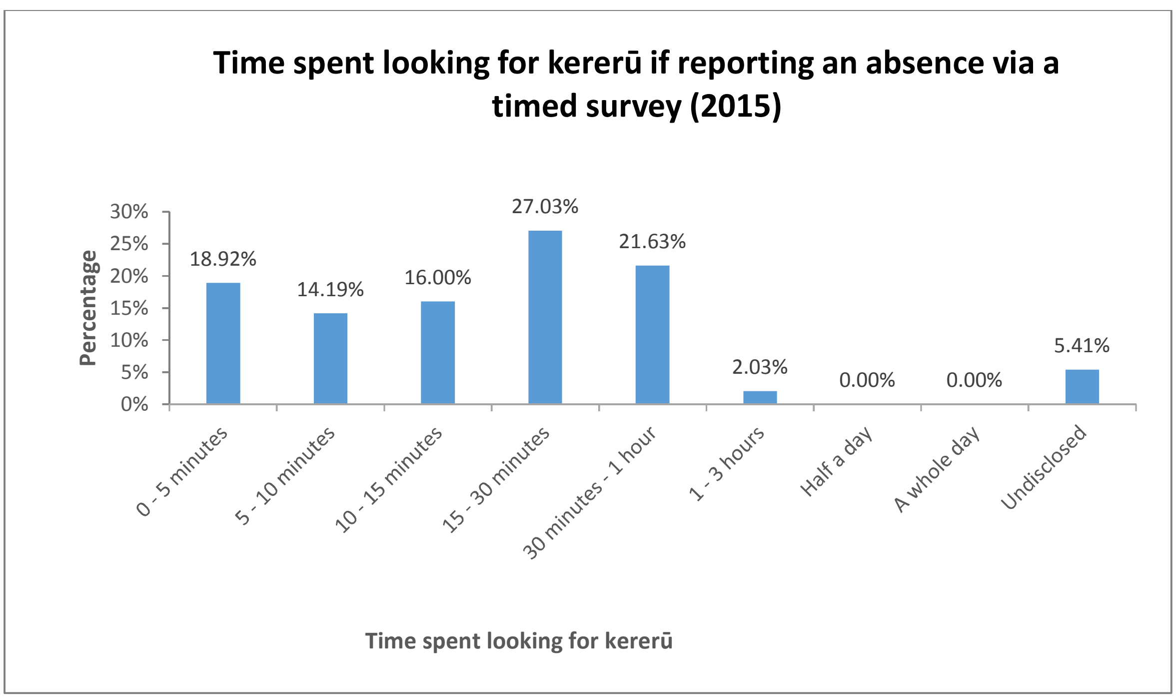


Figure 5: Time spent looking for kererū if the absence of kererū was reported, for example '5-10 minutes' means that the participant was looking for kererū for five to ten minutes, but did not see one. If the participant did not add any information on how long they spent looking for kererū, the report is categorised as 'Undisclosed' (n=92).

In addition to the time spent looking for kererū, the distance from kererū and survey mode of each observation were recorded. Figure 6 shows that most individuals were 5 – 20m from kererū. In terms of survey mode, most of the reports were made by people either sitting or standing (Figure 7).

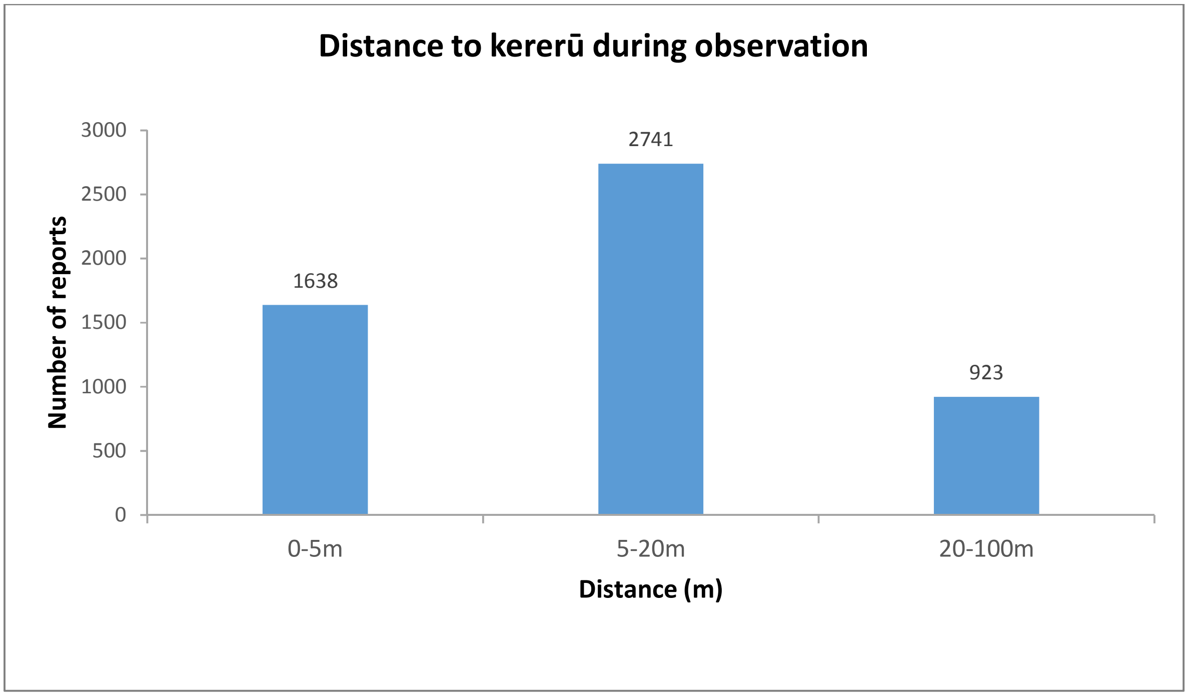


Figure 6: The distance of the observer from the kererū during observation.

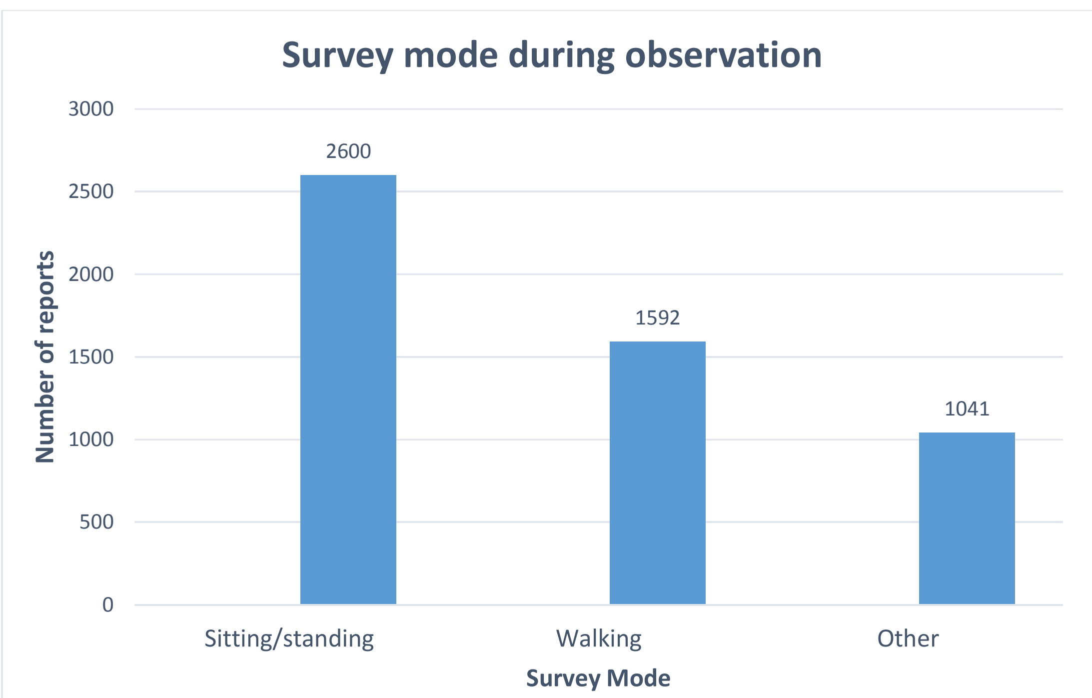


Figure 7: Observer survey mode during observation.

Opinion of change and frequency will be useful in future to determine changes in kererū distribution. In 2015, observers state that kererū abundance has remain more-or-less the same in a large majority of areas around New Zealand (Figure 8). While, the frequency with which participants have seen kererū in particular places, such as Kaitaia, Westport and Nelson, is very high (Figure 9).

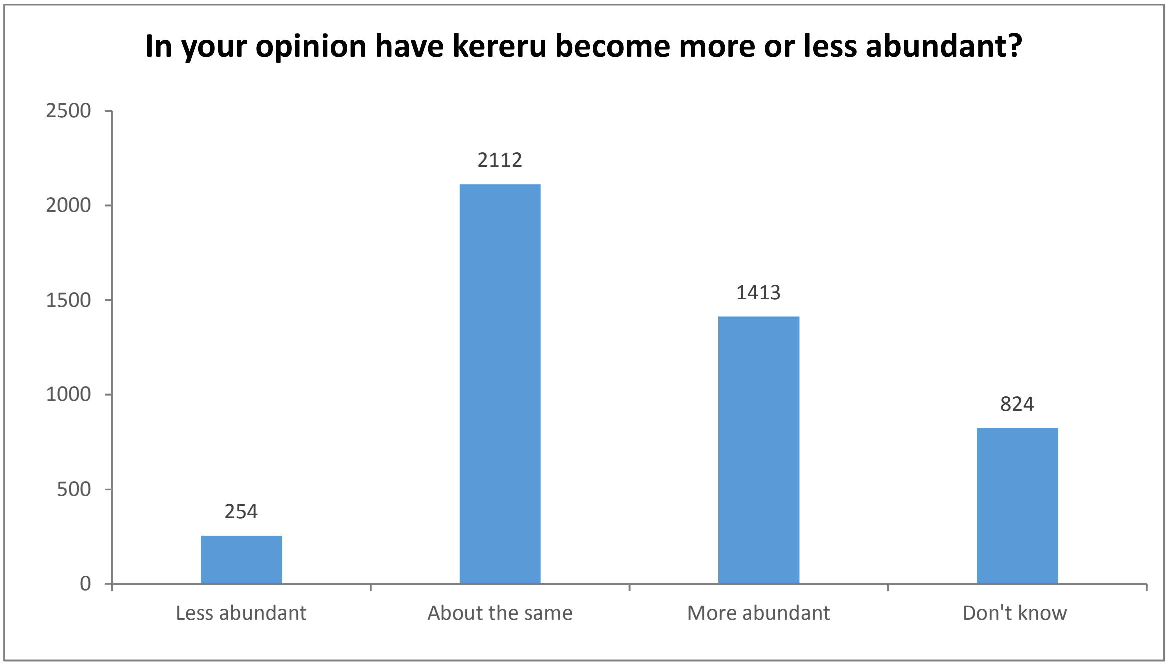


Figure 8: Participant's opinion of change in kererū abundance.

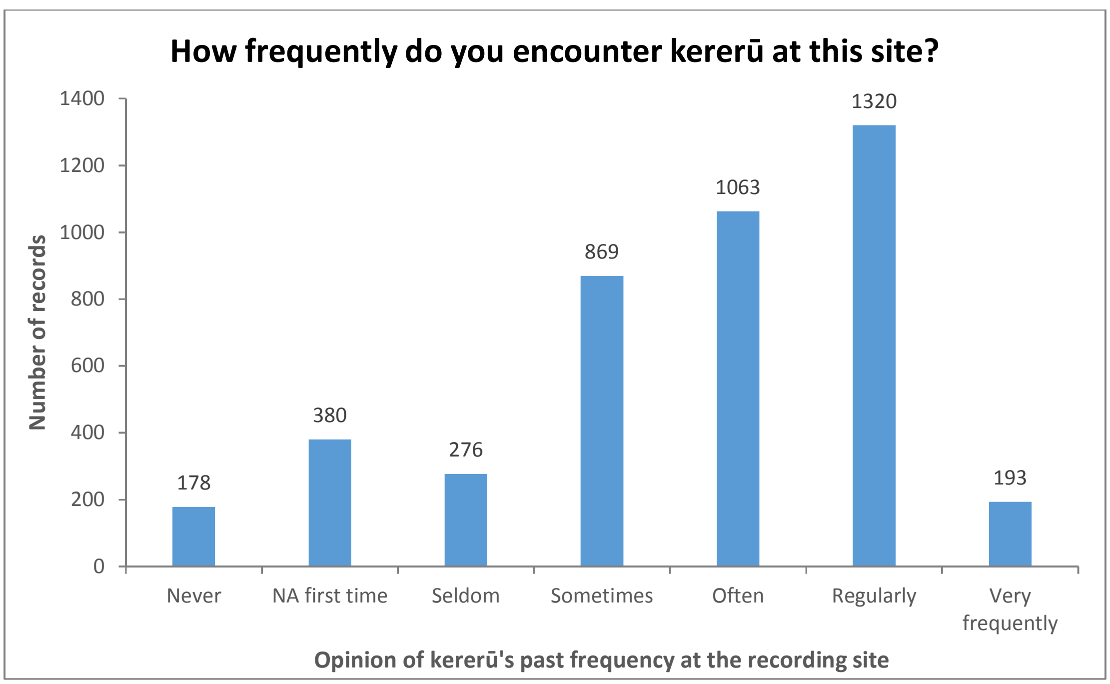


Figure 9: Participant's opinion of frequency of kererū encounter at the location for which the record was submitted. Indicative percentages: Never (0%), Seldom (1-10%), Sometimes (11-25%), Often (26-50%), Regularly (51-90%), Very Frequently (90-100%).

4.2 Kererū observations and behaviour

This section of the report explorers the behaviour and preferences of kererū. Figure 10 illustrates the microhabitat where the kererū was seen, the most common category selected was “perched in tree/shrub” (48.35 %), this result is a change from last year’s report which showed a high proportion of “flying” kererū (36.10%).

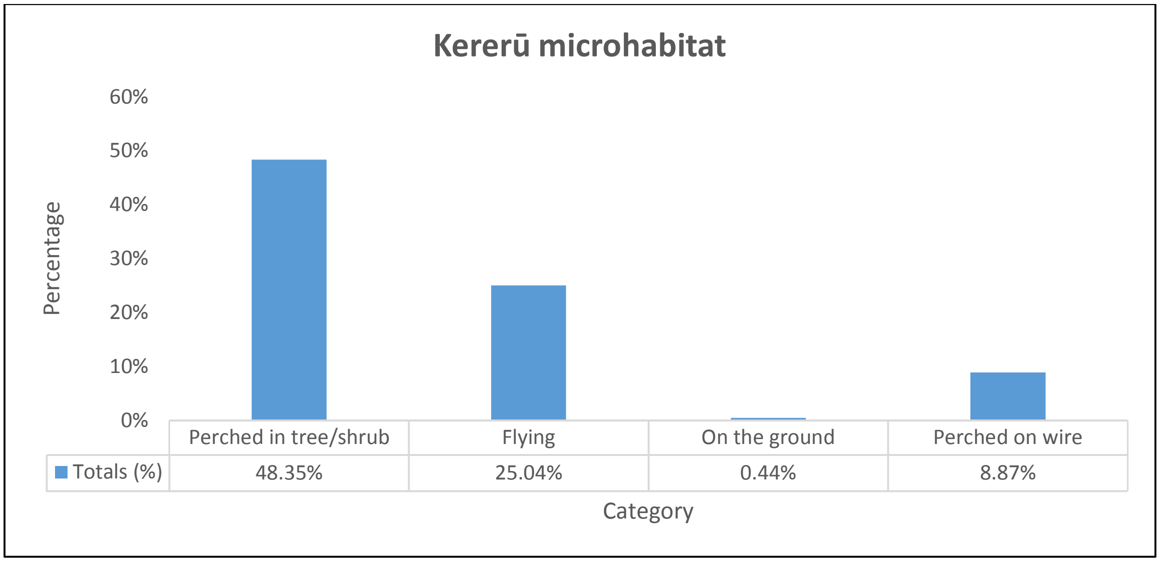


Figure 10: Location of bird when observed.

GKC participants were asked if they had observed any kererū display flights. Results show that a large majority of participants did not answer the question (Figure 11). This choice may mean participants are unsure of what display flight is and future counts could include video footage or include a more comprehensive description. It is advisable to test these questions and supporting information (such as a video) prior to rolling out the survey in 2016.

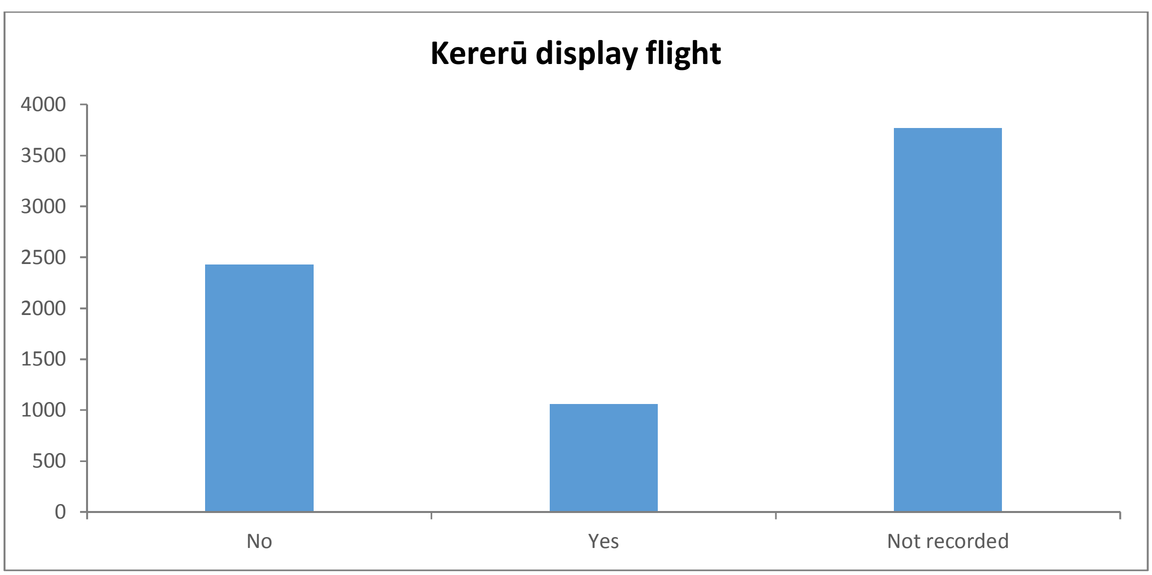


Figure 11: Occurrence of kererū display flight.

The type of area where the kererū was located was also noted (Figure 12). Urban gardens were found to have the highest number of kererū reports, with rural gardens following closely behind. Knowing this, local councils can encourage their citizens to plant more trees in schools and parks.

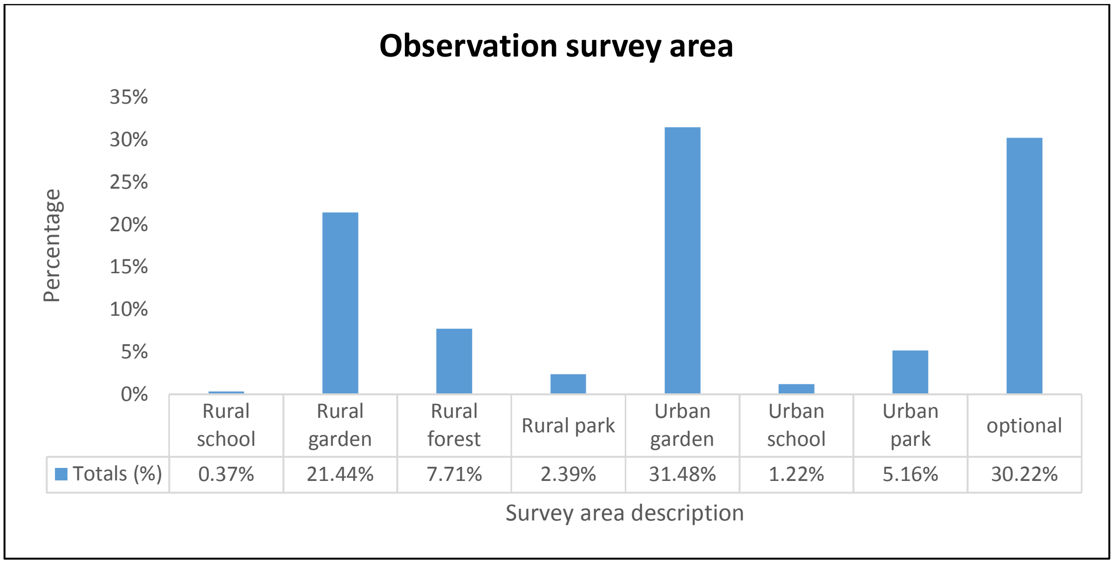


Figure 12: Description of report survey area ("optional" means the question was not answered).

If the kererū was reported to be eating, the participant could then choose a food category. Two thousand one hundred and fifty-seven reports made in the 'Eating' category had information on the type of food the kererū was eating. The majority of people reported the kererū was eating either flowers or leaves (Table 1). The type of plants that contained these fruit and leaves varied widely. Nationally, kererū were mostly found feeding on Kowhai. The second most common food category was planted fruit tree and then tree Lucerne.

Food category	Number of reports made	Percentage (%)	Number of Kererū observed	Percentage
Flowers	600	27.82	1314	20.80
Leaves & buds	1050	48.70	3850	60.80
Fruit	223	10.32	433	6.80
Other	57	2.64	149	2.40
Unsure what	227	10.52	587	9.30
Total	**2157**	**100**	**6333**	**100**

Table 1. Table showing the food items recorded if 'Eating' category was selected when submitting a report

Region	Number of reports made	Kowhai	Planted fruit tree	Tree lucerne	Puriri	Nikau	Gum/Eucalyptus	Cabbage tree	Manuka	Tawa	Karaka	Ngaio	Kahikatea	Miro	Totara
Wellington	2114	201	61	63	4	0	3	2	1	2	3	1	1	0	1
Auckland	1724	155	73	7	51	39	6	5	9	0	4	0	1	2	1
Otago	813	40	44	28	0	0	10	2	1	0	1	1	0	0	0
Northland	311	17	18	0	22	7	1	0	2	0	2	0	3	1	1
Bay of Plenty	252	29	7	31	1	0	1	2	0	0	1	0	1	0	0
Waikato	319	46	20	18	13	3	0	1	0	0	1	0	1	1	1
Taranaki	251	38	3	3	4	0	0	0	0	3	1	0	0	0	0
Manawatu	297	24	17	21	2	0	5	0	0	0	0	0	1	0	1
Canterbury	228	11	13	17	0	0	0	1	0	0	0	0	0	0	0
Tasman	243	25	12	26	0	0	2	0	1	0	1	0	0	0	0
Marlborough	83	15	0	4	0	1	1	2	0	0	0	0	0	0	0
Southland	112	10	7	2	1	0	1	1	0	0	0	0	0	0	1
Hawke's bay	119	14	4	7	1	0	3	0	0	0	1	0	1	0	1
Gisborne	52	5	10	2	0	0	3	1	0	1	0	0	0	0	0
West Coast	130	19	6	2	0	0	2	0	1	0	0	0	1	0	0
Nelson	180	20	8	20	3	0	1	0	0	0	0	0	0	0	0
Totals	**7228**	**669**	**303**	**251**	**102**	**50**	**39**	**17**	**15**	**6**	**15**	**2**	**10**	**4**	**7**

Table 2. The plant type kererū were found feeding on by region

Some participants added additional information in the comment section on the type of planted fruit tree the bird was eating. The search function on Excel was used to identify the most common plants eaten by kererū in these comments. Exotic and native plant species in Project kererū documents (available on http://www.projectkererū.org.nz/how-can-you-help) were interrogated. The most popular comment was "Plum" followed by "Pear".

4.3 Nationwide kererū report distribution

Spatial analysis was completed as detailed in section 3.4. 7,341 reports were submitted and 15,781 kererū observed. Map 1 shows the nationwide distribution of all these reports. Note that reports recorded outside of New Zealand land area have been excluded for all the figures and tables in this section.

The GKC reports per region were compared against national (human) population numbers. The kererū report numbers are not proportional to household numbers, as can be seen from Figure 13 and Table 3a. The Canterbury Region is the second largest region nationally after Auckland with 13.22% of the total households, but only accounted for 3.20% of kererū reports (Figure 13), and the least number of reports compared to human population numbers (0.41 reports made per 1000 inhabitants) (Table 3a). On the other hand, Wellington Region has only (11.36%) of the total households, but 29.15% of all the reports were made in the Wellington Region. The greatest number of reports per 1000 people were made in the West Coast region (20.21), followed by Tasman (15.30) and Wellington (9.19). The average number of reports made per 1000 people was 1.63 (Table 3a).

In comparison to data from the 2014 GKC (Table 3b), the average number of kererū reports per 1000 people remained relatively stable (1.63 compared to 1.42). Wellington retained its position for the most number of reports made, and increased from 24.49% to 29.15%. Unlike 2014, the most reports per capita were made in the Tasman and not Otago. The Nelson region saw a large increase in the number of reports made, jumping from 75 to 180, the change in the total number of kereru recorded in Nelson was even greater, from 91 to 345 (a 279% increase, Table 3a).

region	Human population[1]	No. of GKC report (2015)	No. of kererū recorded	Kererū per report	Reports per 1000 humans	Kererū recorded per 1000 humans	Percent change from 2014[2]
Northland	166000	319	669	2.10	1.92	4.03	-2%
Auckland	1526900	1746	2807	1.61	1.14	1.84	33%
Waikato	430800	325	995	**3.06**	0.75	2.31	53%
Bay of Plenty	282300	252	528	2.10	0.89	1.87	-6%
Gisborne	47100	66	298	**4.52**	1.40	6.33	-32%
Hawke's Bay	158900	120	319	2.66	0.76	2.01	2%
Taranaki	114800	253	403	1.59	2.20	3.51	-18%
Manawatu-Wanganui	232500	300	859	2.86	1.29	3.69	**65%**
Wellington	491400	2140	4514	2.11	**4.35**	**9.19**	38%
Tasman	49100	246	751	3.05	**5.01**	**15.30**	47%
Nelson	49300	180	345	1.92	3.65	7.00	**279%**
Marlborough	44800	83	213	2.57	1.85	4.75	-40%
West Coast	32800	131	663	**5.06**	**3.99**	**20.21**	**130%**
Canterbury	574300	235	529	2.25	0.41	0.92	-4%
Otago	211600	831	1618	1.95	3.93	7.65	4%
Southland	96500	114	270	2.37	1.18	2.80	-30%
TOTAL	4509100	7341	15781	2.15	1.63	3.50	23%

Table 3a. Regional breakdown of the number of kererū reports submitted in 2015. [1]Human population numbers from NZ statistics (2014). [2]Percent change in number of kererū recorded in 2015 relative to 2014. The top three values in the final four columns have been highlighted in bold.

region	No. of GKC reports (2014)	No. of kererū recorded	Kererū per report	Reports per 1000 humans	Kererū recorded per 1000 humans
Northland	398	686	1.72	2.40	4.13
Auckland	1,362	2,118	1.56	0.89	1.39
Waikato	278	649	2.33	0.65	1.51
Bay of Plenty	278	562	2.02	0.98	1.99
Gisborne	128	440	**3.44**	2.72	**9.34**
Hawke's Bay	134	313	2.34	0.84	1.97
Taranaki	260	492	1.89	2.26	4.29
Manawatu-Wanganui	236	520	2.20	1.02	2.24
Wellington	1,569	3,269	2.08	3.19	6.65
Tasman	200	511	2.56	**4.07**	**10.41**
Nelson	75	91	1.21	1.52	1.85
Marlborough	157	355	2.26	**3.50**	7.92
West Coast	110	288	**2.62**	3.35	**8.78**
Canterbury	204	553	**2.71**	0.36	0.96
Otago	873	1,560	1.79	**4.13**	7.37
Southland	146	383	**2.62**	1.51	3.97
TOTAL	6408	12790	2.00	1.42	2.84

Table 3b. Regional breakdown of the number of kererū reports submitted in 2014. The top three values in the final three columns have been highlighted in bold.

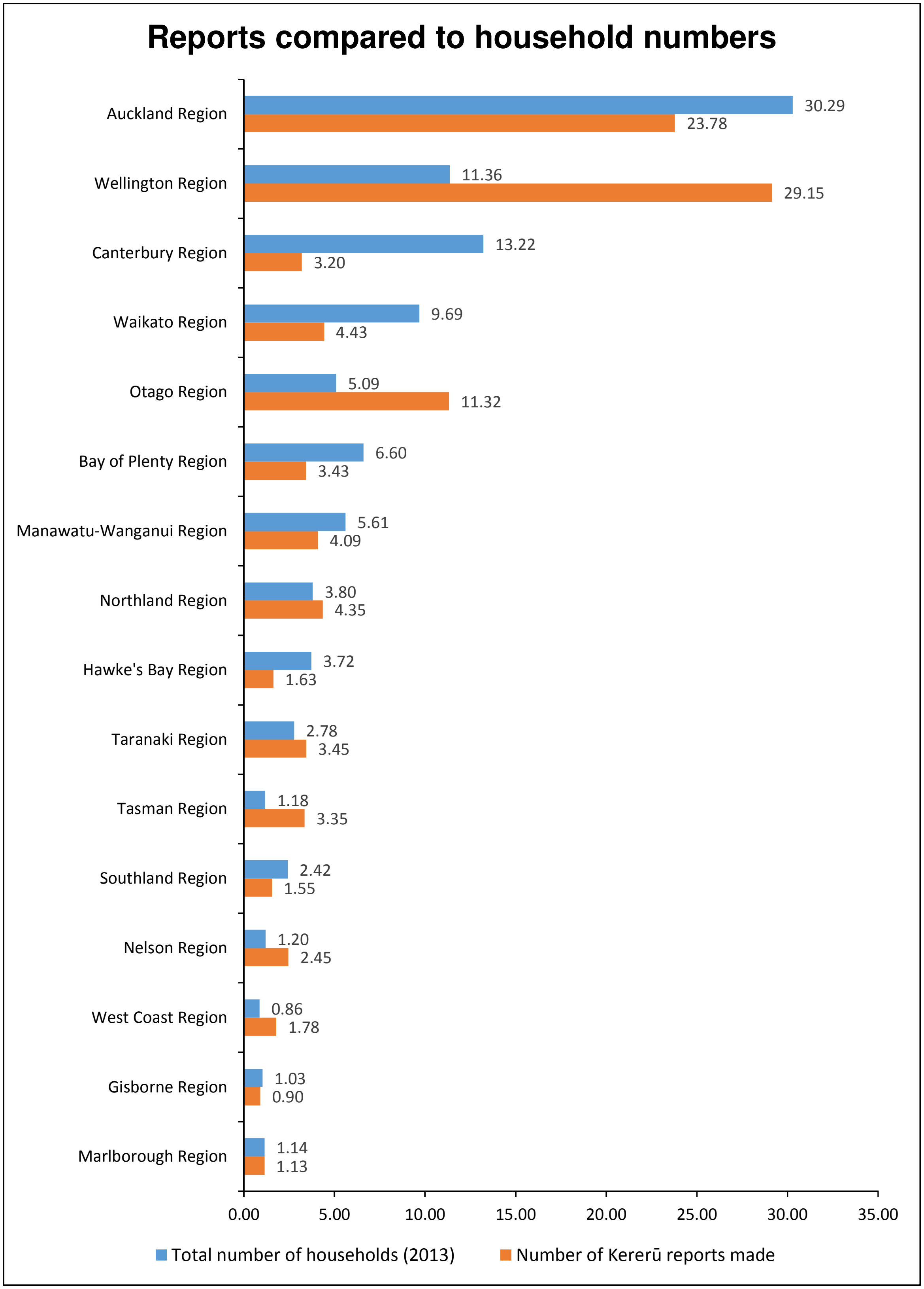
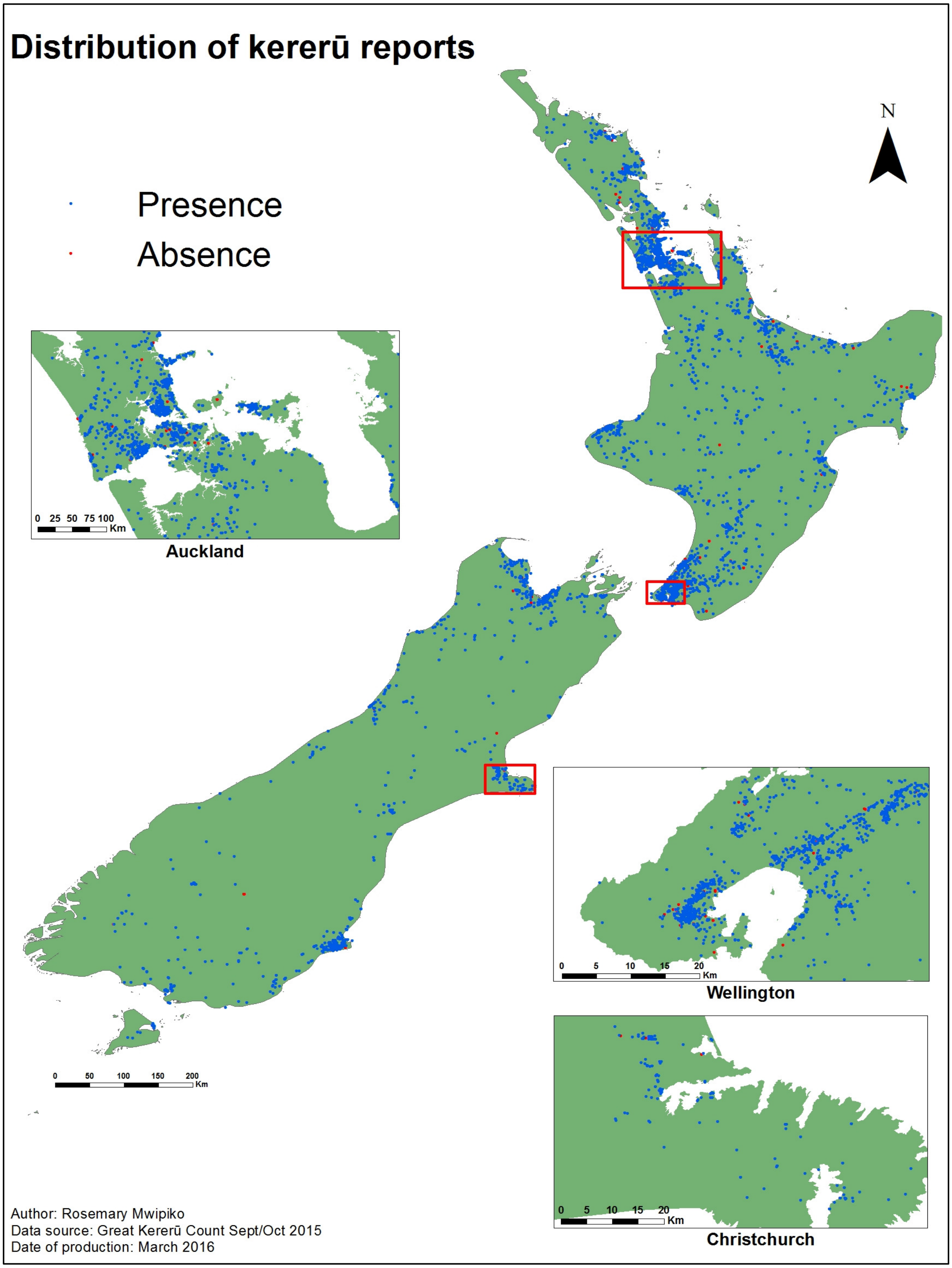
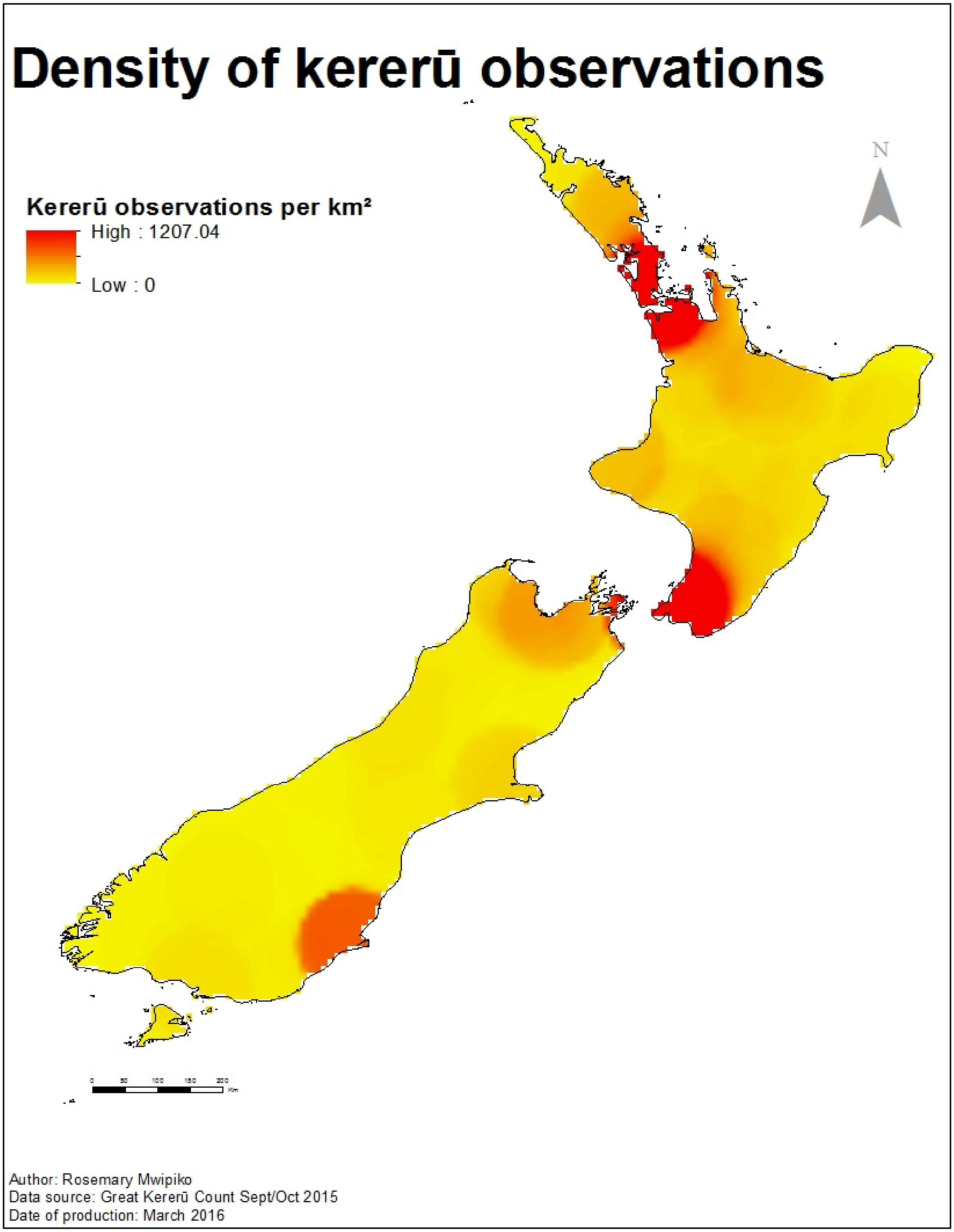


Figure 13: A comparison of the frequency of kererū reporting (2015) against the percentage of nationwide households in each region. E.g. Wellington contains 11.37% of the nation's households, but recorded 24.49% of the kererū sightings submitted to the GKC 2015. The household percentage for each region is taken from 2013 Census, the total household number in occupied private dwellings being 1,549,635.

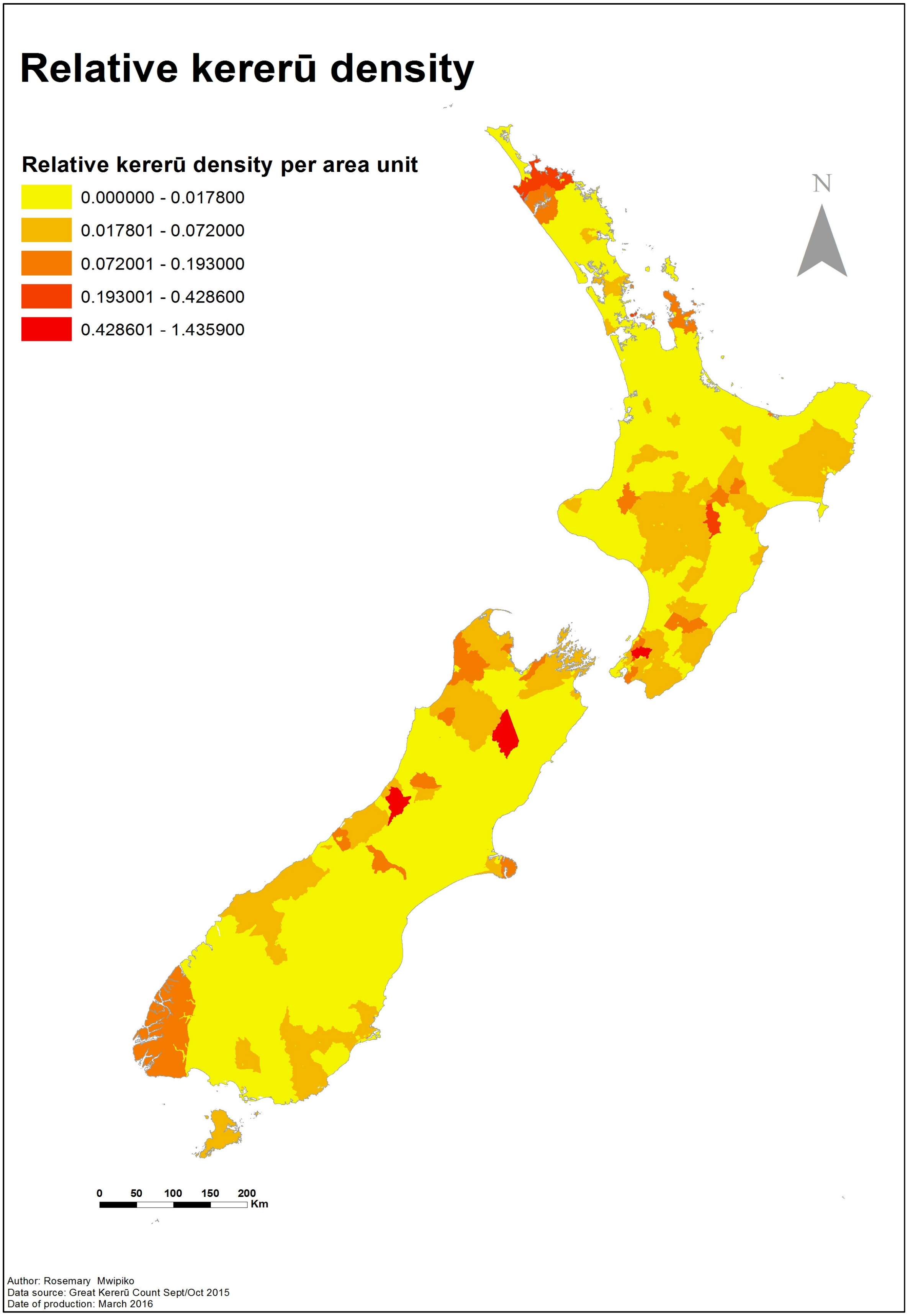
4.4 Nationwide observations



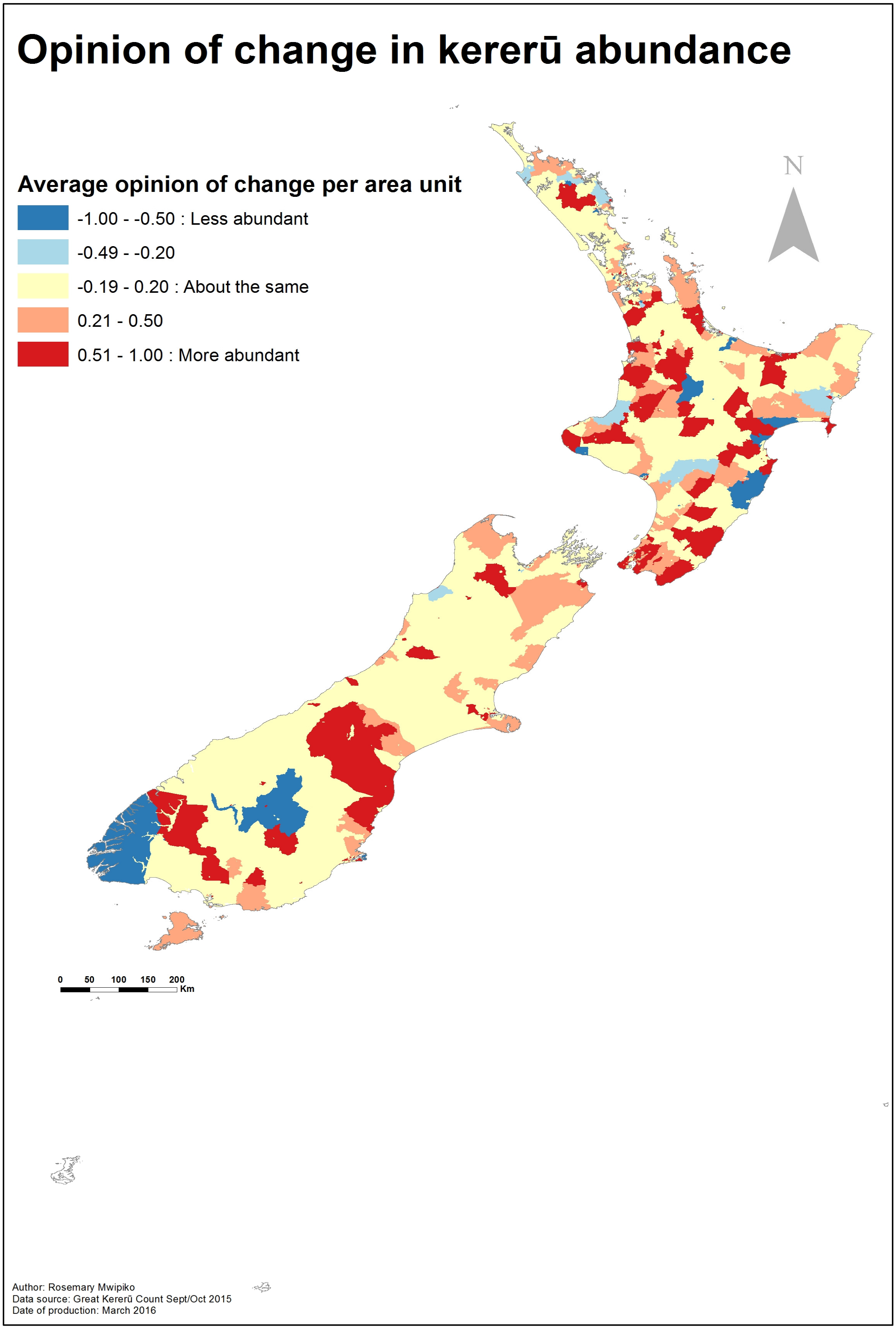
Map 1. Distribution of Great Kererū Count records (2015). Presence = blue points, absences = red points



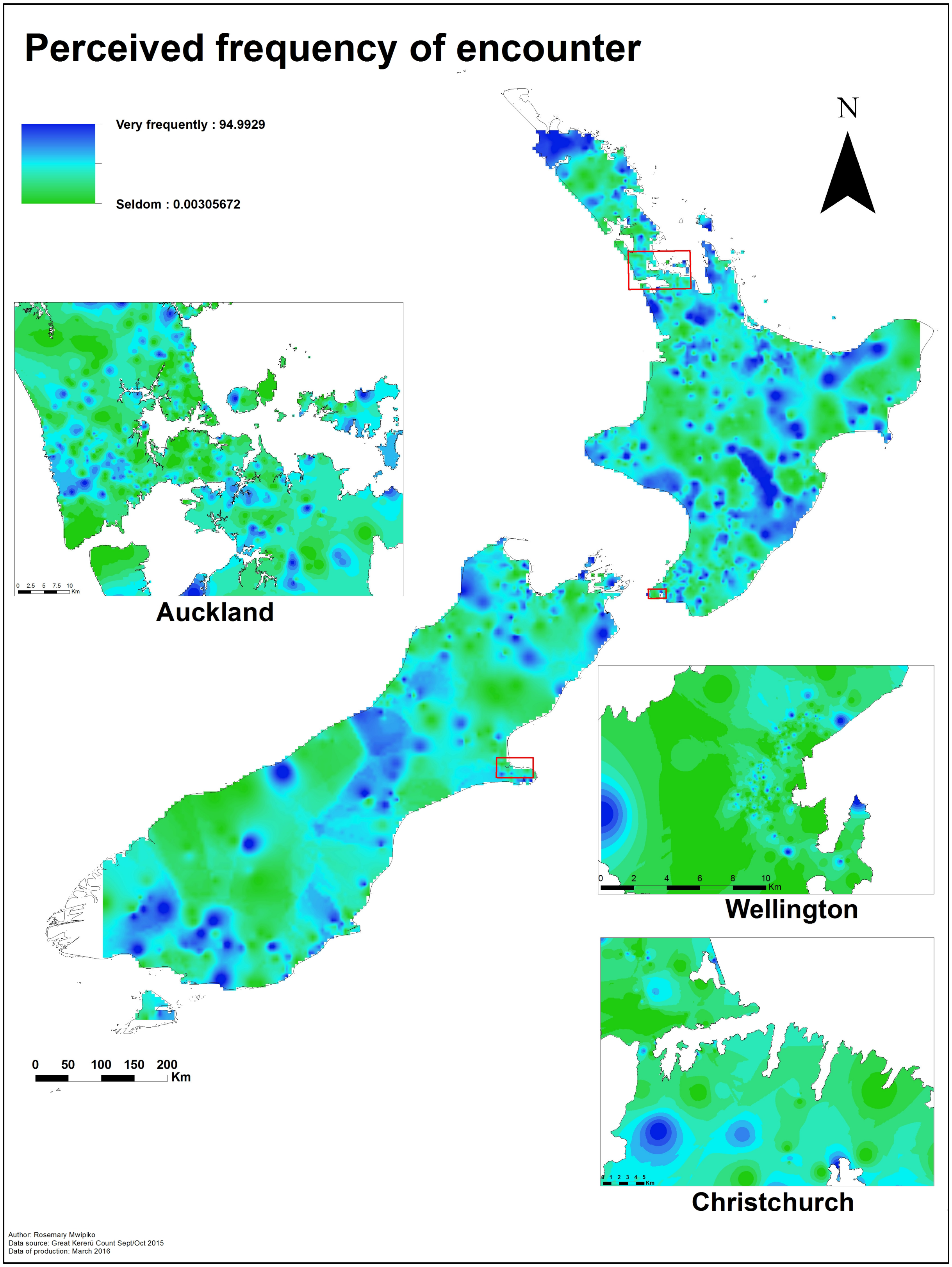
Map 2: Number of records submitted per square kilometre. Point density has been smoothed at a national scale to emphasise broad trends. Auckland and Wellington regions contributed the most records, in part because they have the highest density of observers (humans). Christchurch has a similar human population to Wellington, but submitted many fewer records (*cf* Table 3 and Figure 13).



Map 3. Relative kererū density: Number of kereru presences per human, calculated at the resolution of the national census "area unit meshblocks" (GIS operation = *spatial join* created between *area unit density, population, kererū presence* and *area unit meshblock*)



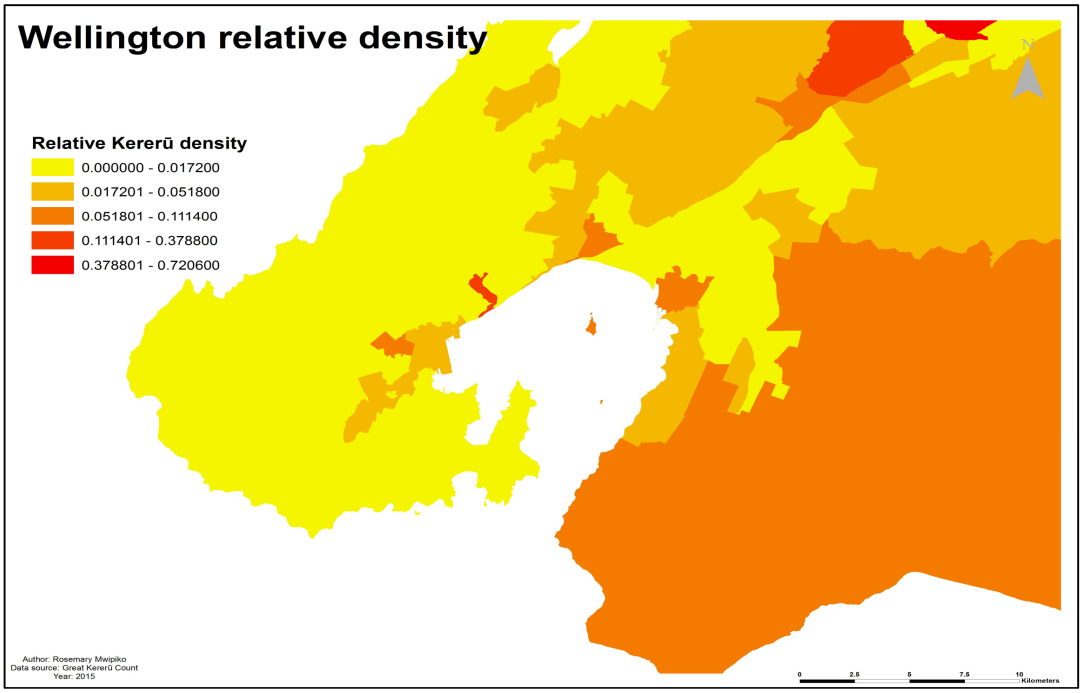
Map 4. Average opinion of change in kererū abundance per area unit. Many more areas report an average increase in kererū abundance (red shades) compared to a decrease (blues shades) over the past few years. See also Appendix Figures A1 and A2.



Map 5. Perceived frequency of kererū encounter at different locations. Possible values range from '0' (Never see them here [green]) to '100' (Always see them here [blue]). The GIS operation used inverse distance weighting with a variable radius that adapts to include 12 points per average. See also Appendix Figure 3 for an alternative representation.

4.5 Wellington Region

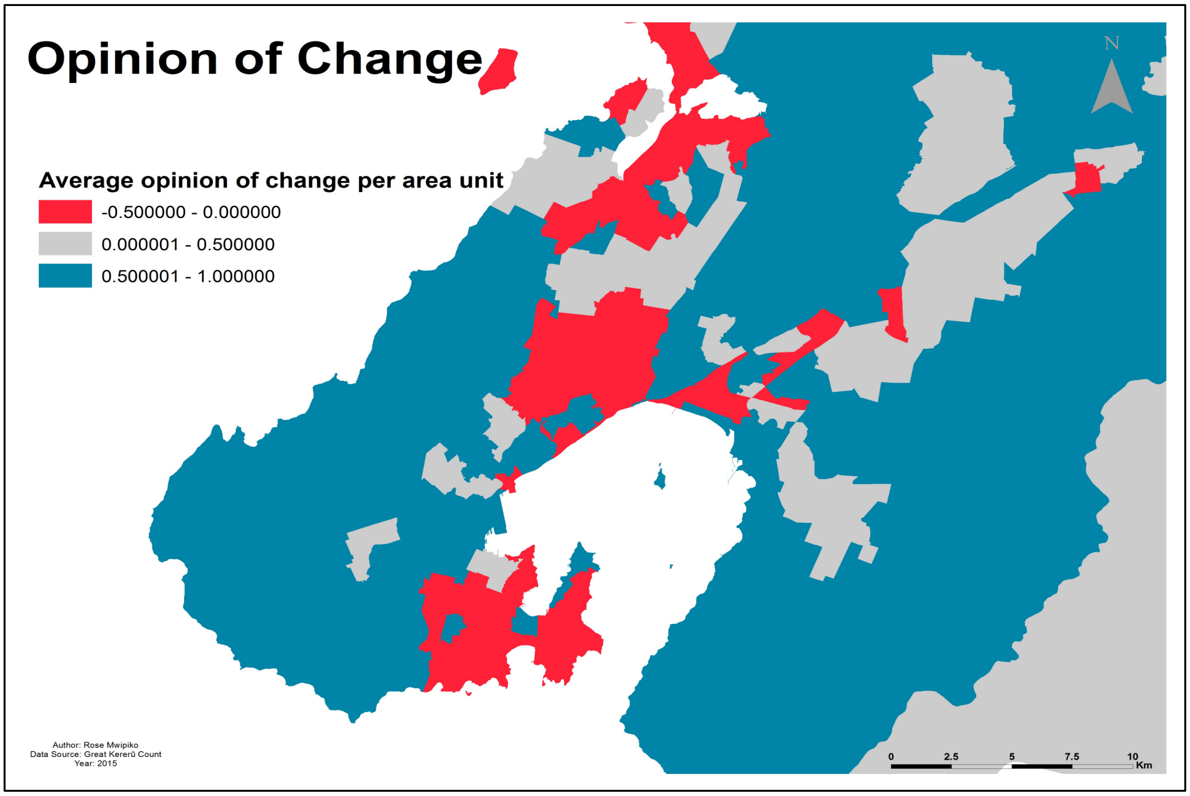
Spatial analysis of the kererū reports made in the Wellington City area was completed as described in section 3.4. Six hundred and ninety four reports were submitted from Wellington City, and 1,078 kererū were observed. Thirty seven reports were of absences and 657 detailed presences.



Map 6. Relative density of kererū reports in the Wellington Region (Calculated as total number of kererū reports/ total human population in each area unit).

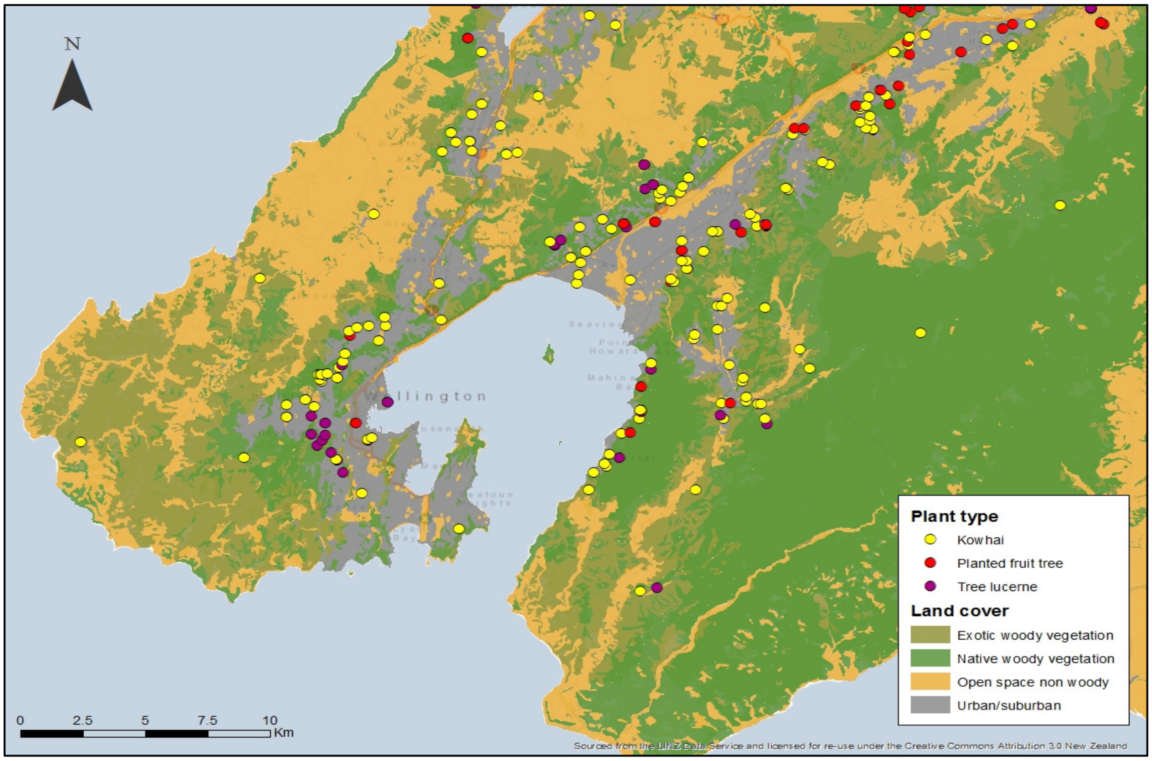
When human population is taken into account, the density of kererū in Wellington city is more even than might first appear. The map above shows that a large majority of Wellington has a relatively low density of kererū. The area units (census administrative areas) that show relatively high densities are Wilton and Ngauranga West, followed by Karori East, Kelburn, Mitchelltown, Thorndon-Tinakori Road, Wadestown and Kaiwharawhara. These areas are expected as numerous parks and reserves are located in these suburbs within close proximity of human observers. These parks include Zealandia, the Town Belt - Te Ahumairangi and Queens Park, Otari Wilton's Bush and Tyers Stream Reserve/Homebush Park and Play Area.

Also of note on this map, is the Pencarrow/Eastbourne area which shows the highest densities of kererū in the region. This higher density is to be expected due to the large amount of native forest cover in that area. Kererū are naturally forest birds (Lyver, Taputu, Kutia & Tahi, 2008) therefore we would expect them to be more common in areas well-endowed with forest (refer forward to Map 8).



Map 7. Average opinion of change in kererū abundance per area unit in Wellington. Many more areas report an average increase in kererū abundance (blue and grey shades) compared to a decrease (red), over the past few years. N.B. the colour scheme and break point in this map differ from those in the national view, Map 4

Opinion of change in kererū abundance in Wellington City suggests that kererū abundance is decreasing in the Urban/Suburban areas, while abundance is increasing in in the outer regions. The outer regions have greater forest cover and so will attract more kererū. See also map figures A1 and A2 in the Appendix for a comparison between Wellington and Auckland.



Map 8. Records of kererū feeding on three specific plants (kowhai, fruit trees and tree lucerne), viewed against a backdrop of land cover,

The map above shows that across the Wellington region kererū were predominantly found feeding on kowhai, followed by planted fruit trees (plums, pears etc.) and tree lucerne. Kererū were found feeding on other plant types but these were the top three. In terms of distribution, kowhai and tree lucerne reports are relatively evenly distributed around the Wellington region, while reports of feeding on planted fruit trees are mostly from the Lower Hutt and Upper Hutt areas.

The majority of the kererū presence reports were made in Urban/Suburban areas (76.56%). 18.11% of the reports were made in Native/ woody/ Vegetation areas and 3.35% in Open Space/ Non-woody (Table 4, Figure 14).

Vegetation/ Land cover	Number of reports made	Percentage (%)	Number of kererū observed	Percentage (%)
Urban / Suburban	503	76.56	822	76.25
Native woody vegetation	119	18.11	201	18.65
Open space / Non-woody	22	3.35	33	3.06
Exotic woody vegetation	13	1.98	22	2.04
Total	657	100	1078	100

Table 4. Number of kererū reports made and the number of kererū observed in different vegetation and land cover areas the Wellington City area.

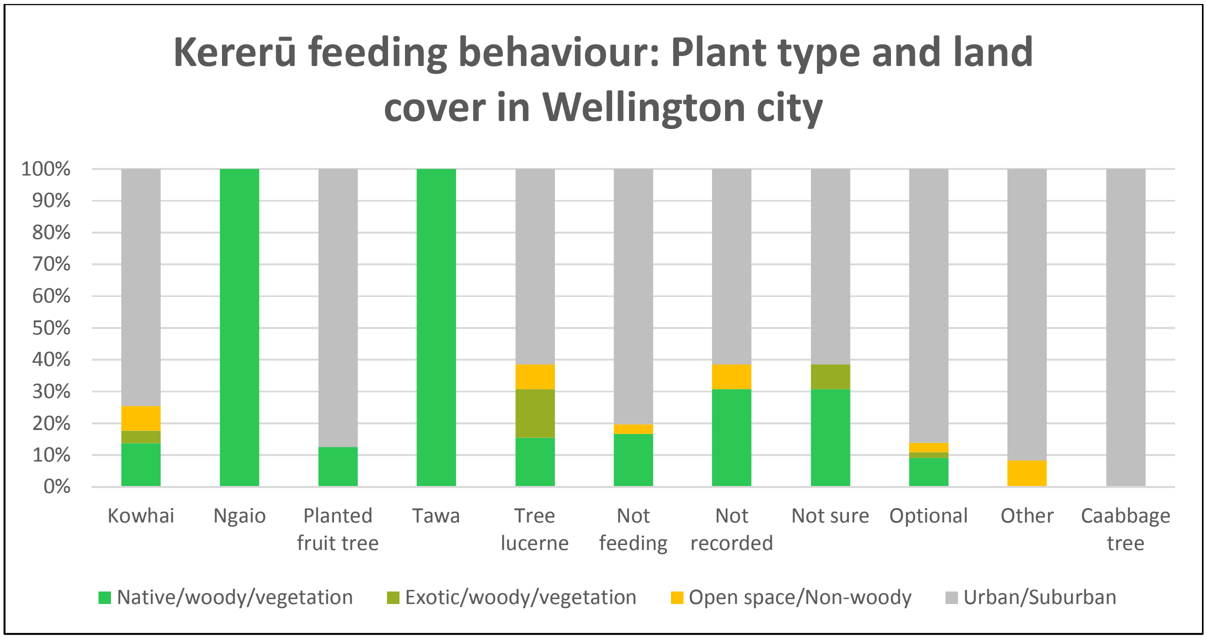
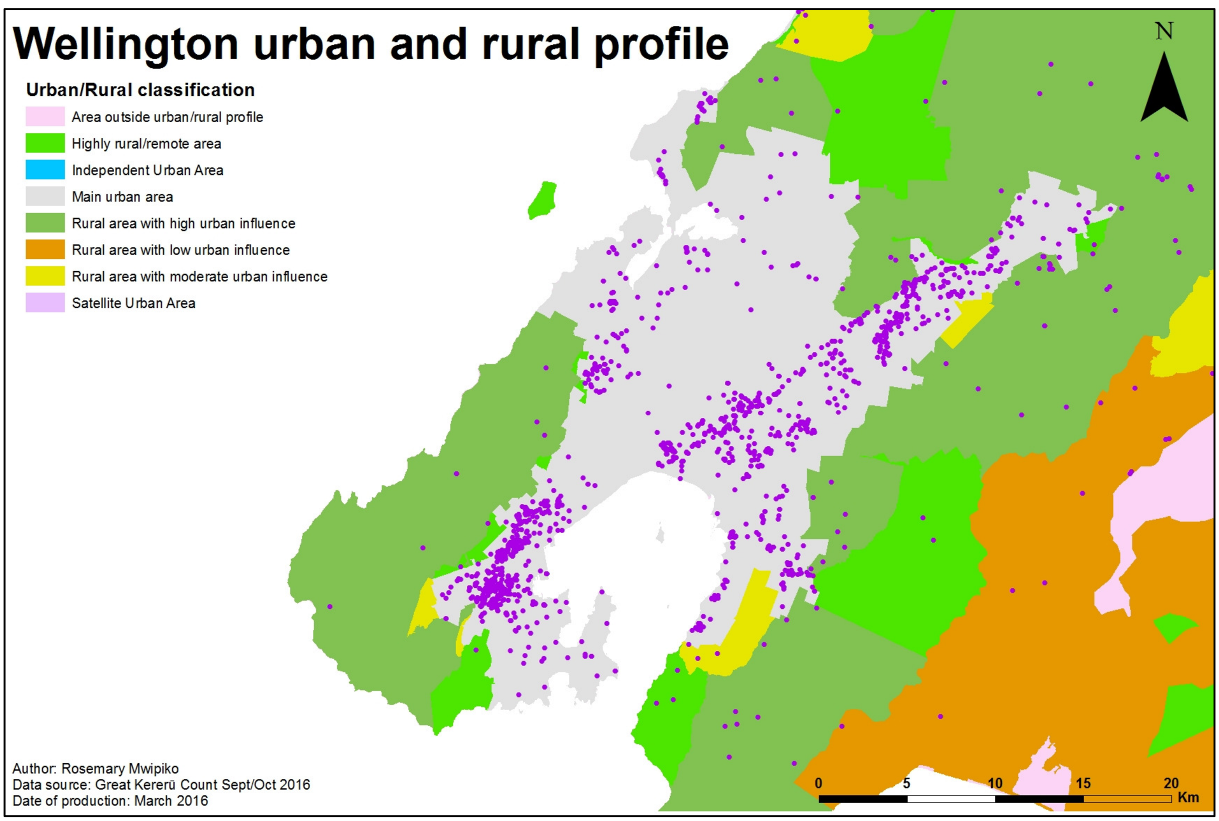


Figure 14: Kererū feeding by species and land cover. For example, all records of kererū feeding on ngaio and tawa plants came from areas dominated by native woody vegetation. Conversely, kererū feeding on cabbage trees were only reported from urban /suburban areas.



Map 9. Submitted records (purple points) against a backdrop of the urban/ rural profile categories defined in the Statistics NZ 2006 census.

Human population density and accessibility has a significant effect on the distribution of kererū reports. A large majority of the reports are located in the main urban area and in rural areas with high urban influence. These areas are easily accessible in terms of roads, track, rivers, etc.

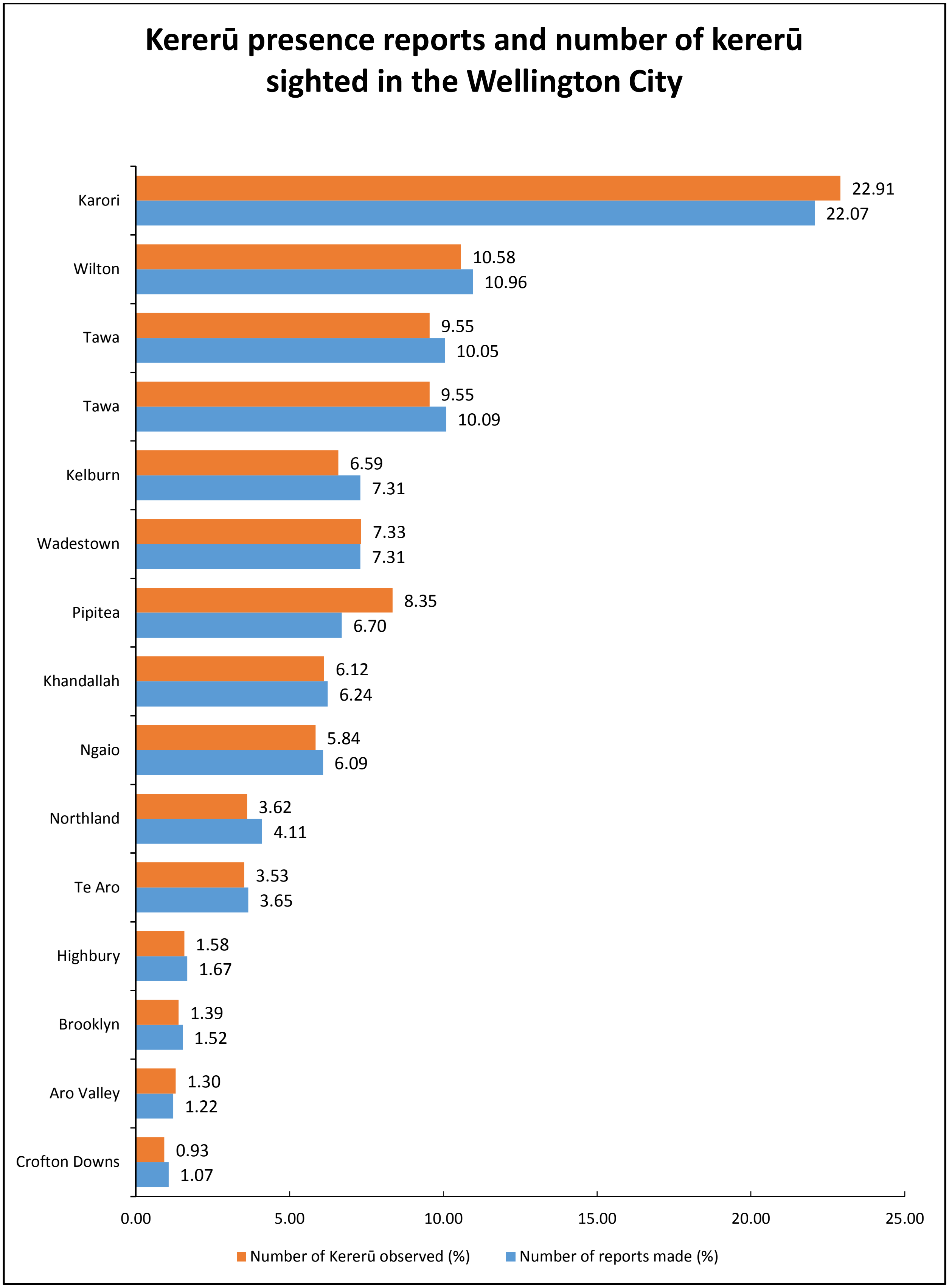


Figure 15: Number of kererū presence reports and total number of kererū sighted across suburbs of Wellington City, per human population density.

5. DISCUSSION AND EVALUATION OF THE GREAT KERERŪ COUNT 2015

This discussion and evaluation of the GKC 2015 is based on feedback and discussion with GKC partners, the analysis of the GKC results and comments submitted by participants.

Understanding the spatial patterns and distribution of kererū in New Zealand is critical to the conservation of the species. In map 1, it is evident that observations of kererū are clustered around urban centres. This clustering can also be seen in the observer effort map 2, which shows high concentrations of observations in the Wellington, Auckland, Nelson and Otago regions. As mentioned in the literature review (section 2), the often unstructured nature of citizen science projects lends itself to a high degree of spatial biases. According to Reddy and Dávalos (2003) sampling areas are likely to show dense, significant aggregation around city limits, along river, roads and walking tracks. This situation appears to be true for the Great Kererū Count.

After the GKC 2014, it was identified that the objectives and goals of the count should be more refined (The Great Kererū Count, 2013). Therefore, one of the research questions in this year's GKC was "what is the relative density of kererū across the country?" To answer this question, spatial bias had to be taken into account. By taking into account human population per area unit, we are able to get a better idea of the underlying distribution of kererū. In the national map, area units in close proximity to the Southern Alps, Nelson Lakes National Park (South Island), Aorangi forest park, Rimutaka forest and Waipoua Kauri Forest (North Island), show relatively high densities of kererū after accounting for human population density. This higher density is to be expected as kererū are naturally forest birds, therefore we would expect them to be more common in areas well-endowed with forest. Native forest in New Zealand has become fragmented because much has been converted to pasture and exotic plantations, especially in the lowlands back (Powlesland, Moran, & Wotton, 2011). This may explain why reports from Christchurch (3.2%) are relatively low in comparison to other major urban centres such as Auckland (23.78%), Otago (11.32%) and Wellington (29.15%).

A comparison between the North and South Islands shows that the North has a more even distribution of Kererū observations than the South. While the South Island is the larger of the two major islands, the North has three to four times the human population. Therefore, we would expect a greater amount of kererū observations in this area.

According to the literature, predation and interspecific competition with introduced species, variability in food supply, and loss of habitat are the principal biophysical mechanisms to have caused declines in kererū

abundance. A comparison between 2014 and 2015 observation figures shows that the number of kererū reported has increased slightly (from 14,194 to 15,840). This could be due to greater publicity of the GKC in 2015. However, when participants were asked if kererū abundance was decreasing, increasing or about the same a large proportion of participants said that abundance had increased over the past few years (Map 4). What is causing this apparent increase is difficult to determine, but as mentioned before, food supply, pest control and forest cover are important factors in determining kererū abundance. It should be remembered that most of the records come from cities. It is possible that increased levels of pest control in urban areas over the past decade have led to an increase in kererū densities in urban areas. Whether there is a similar upward trend in back-country forested areas is much less certain, and other analyses of OSNZ surveys (by Susan Timmons of Landcare Research) have suggested a nationwide decline in kererū numbers. This is supported by map 5, which shows participants perceived frequency of encounter with kererū. Areas with higher frequencies of encounter tend to be located on the fringes of urban areas and in proximity to forested regions. Kererū are naturally forest birds, therefore we would expect to encounter them more in areas of high habitat suitability.

5.1 Wellington Region

Most kererū presence reports in the Wellington City were made in Karori (Figure 15). Notably, the Zealandia sanctuary is situated in Karori, but Karori is also Wellington's largest suburb (Wellington City Library, 2014). Kererū have historically been sighted around Otari-Wilton's Bush and were re-introduced to Zealandia sanctuary in years 2002-2005, since then their numbers have increased to the extent that they are often seen foraging outside the sanctuary in the neighbouring suburbs (Zealandia, 2014). In a paper by McCaffrey (2005) the author concludes that results from studies based on citizen science data can be invaluable in identifying key areas of ecological importance within a city. While these areas have already been identified as key areas of ecological importance, this study helped to reaffirm what had been recorded by others and justifies the importance of these areas.

Kererū feed on leaves, flowers and fruits, including buds of these, from a wide variety of species, both native and exotic (Higgins & Davies 1996). However, when available, fruit is preferred over other food types (Clout 1990; Mander et al. 1998). Table 1 results show that kererū were observed predominately feeding on leaves and buds (1,050 reports) and flowers (600 reports). Table 2 shows that it was mostly flowers, leave and buds from the Kowhai tree (45 % of reports). In addition to this data, comments in the data also show that some kererū were found feeding on Willow trees. Plum and pear trees were also identified as the type of fruit tree that kererū were predominately found on. A large portion of kererū reports are made in people's backyards and suburban areas, and the information on what kererū are feeding on could be used to encourage people to plant natives in their gardens.

5.2 Data quality and the user interface

Before any data analysis was undertaken, the dataset had to be cleaned to validate the reports. Manual cleaning was done as detailed in the Data analysis and methods section. Many of the issues with invalid or incomplete data, discussed in section 3.4, appear to have arisen because of unclear instructions, or issues related to the website and/or mobile application user interface. To improve the data quality, some steps for data validation should be taken. Based on a case study of Project FeederWatch, Bonter and Cooper (2012) suggest a data validation process flow (Figure 16). An automated way to validate data, via a 'smart filter' and warnings to the user, would be the first step, followed by an expert reviewer if some issues with the data appear (Bonter & Cooper, 2012). The Great Koala Count uses a photo as a data validation tool, i.e. to ensure the entered observation is valid (University of South Australia, 2012). But using a photo as a validation is more difficult for bird observations. For kererū, a photo validation is not necessarily required, as kererū can be easily distinguished from most other bird species, nonetheless it may be useful to include some information on the GKC website on how to distinguish kererū from the feral rock pigeon the species that is most likely to cause confusion.

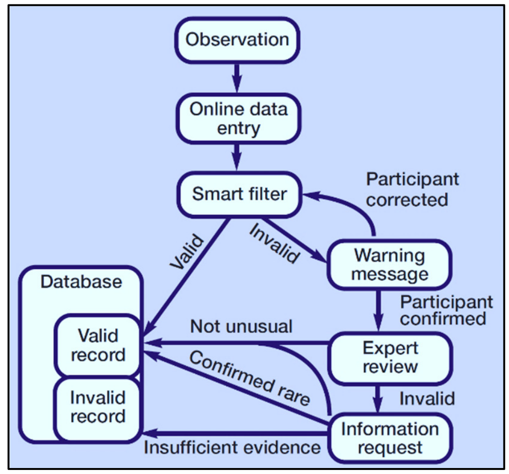


Figure 16: Data validation process diagram (Bonter & Cooper, 2012).

Issues related to the user-interface may have been identified if the system had been tested by naive users prior to the count. Along with user-interface testing, it may be beneficial to run a pilot prior to going live to get an idea of how the user-interface works and what the data will look like, and to identify if something could be changed to create a better user experience, or increase the quality of the data. Automated data validation and data review are only one part of the process – another issue is the need for more precise reporting instructions, perhaps a detailed description with photos or a short video, would reduce the number of invalid or incomplete reports.

As discussed in the data analysis and methods section, a significant number of reports were incomplete due to a lack of coordinates. 1611 incomplete reports (reports without reliable spatial location data) were not included in the data analysis. A further 306 reports made were determined as 'off-shore points'. Another way to increase the accuracy of the data and reduce data clean up time could be a buffer around the mainland and islands, i.e. the participant could not add a report location further than 200 metres from landmass.

6. RECOMMENDATIONS FOR FUTURE KERERŪ COUNTS

The following recommendations are based on the preliminary analysis of the GKC data, meeting minutes (involving all the GKC Partners), discussion with key GKC people, literature cited in the report, and GKC participant comments. These steps are discussed in more detail in this report.

Questionnaire and data entry

1. Anonymous reporting should be discouraged. Participants should at least leave a name and email so that they can be contacted if there is something unclear about their report.

2. While submitting a kererū report, it should not be possible to move forward without confirming:
    a. That the report location is correct.
    b. That the time and date when the observation was made is correct.
    c. That all the required fields have been filled.
    It should also be possible for participants to go back and edit their report at any time in case they realise they have made an error.

3. The instructions for adding reports need to be clearer in order to avoid inconsistent, invalid and/or incomplete reports, to minimise manual data cleaning, and to ensure all reports are submitted to the same database. To increase participants' confidence in the accuracy of their reports and to gain full educational benefits, the instructions should be clear and detailed, and they could be accompanied with videos and photos.

4. Include the type of planted fruit tree (apple, pear, apricot etc.) and willow in the options for food plants

5. There should be only one designated entry point, or if there are several entry points that should be made clear to both the participants and the GKC partners.

6. Support data such as details about plants, feeding patterns, or other observations of relevance to the research question needs to be included in a defined manner (not as an open text field), such as multiple answer or checkbox, e.g. list of plants with images. There should only be one open text field at the end of the survey for additional comments and feedback.

7. Ensure that time spent looking for kererū figures are in the same units (minutes), the manual check was time consuming.

Data analysis

8. Perhaps there could be different questions associated with an absence that would reflect the nature of the absence report more appropriately, and also emphasize the importance of these observations within the whole data set

9. Search effort should be more standardised to provide more accurate absence data. For example, the period of searching for kererū should always be the same length. Or, there should be clear categories to reflect the nature of the absence report, as not seeing kererū for five minutes or not seeing one for three hours are not equal observations.

10. Encouraging participants to record other plant or animal observations could be used as a way to ascertain where people are active participants, but not observing kererū.

11. Data validation needs to be automated, at least the very first step of it (rather than manually going through every observation). Any data flagged 'incomplete' by the automated process could then be manually checked.

12. Data should be monitored during the count to identify incomplete reports and potential real-time issues as well as to contact participants (if they have granted permission for this) about suspected data errors. This could also be coupled with a real-time discussion forum where participants can submit queries during the project.

Communication

13. Communications and documenting the process must be clear when there are multiple partners involved in the project. To ensure maximum efficiency and reliability of the data, it may be beneficial to hire a primary investigator/data analyst, who is involved in all the steps of the data collection, clean up and analysis.

14. As it is important for the participants that the data will be used for science, the data and outcomes from the study should be reported back to the participants as a standard part of the programme –

this provides an additional incentive for participants to provide contact details, to demonstrate the scientific process and scientific validity of the project, to share research outcomes, and to recruit observers for future studies.

15. Collaboration with a range of scientists (including social scientists and eductionalists) will enable input into the research design, delivery, analysis and communication. Universities can utilise student capacity (e.g. honours research projects, summer scholars, master's students) to carry out initial data analysis within a larger research framework.

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8. APPENDIX

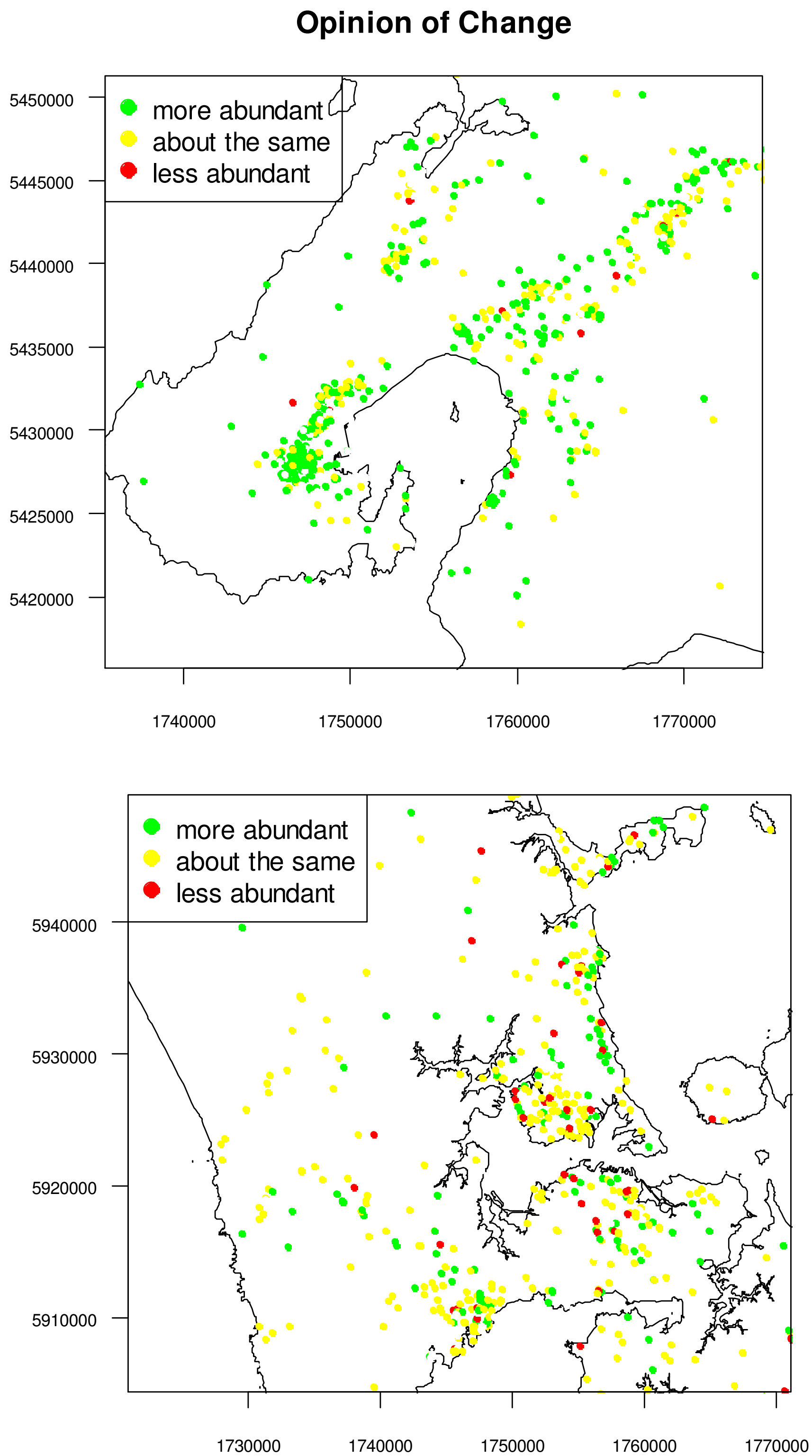


Figure A1. Opinion of change for records submitted in the Wellington and Auckland areas. The three colours represent the answer to the question "In your opinion, over the past three years, have kereru become more abundant, less abundant or stayed about the same, in this locality?" **The general consensus suggests an increase of kererū numbers in Wellington and relative static numbers in Auckland**. See also map A2 overleaf.

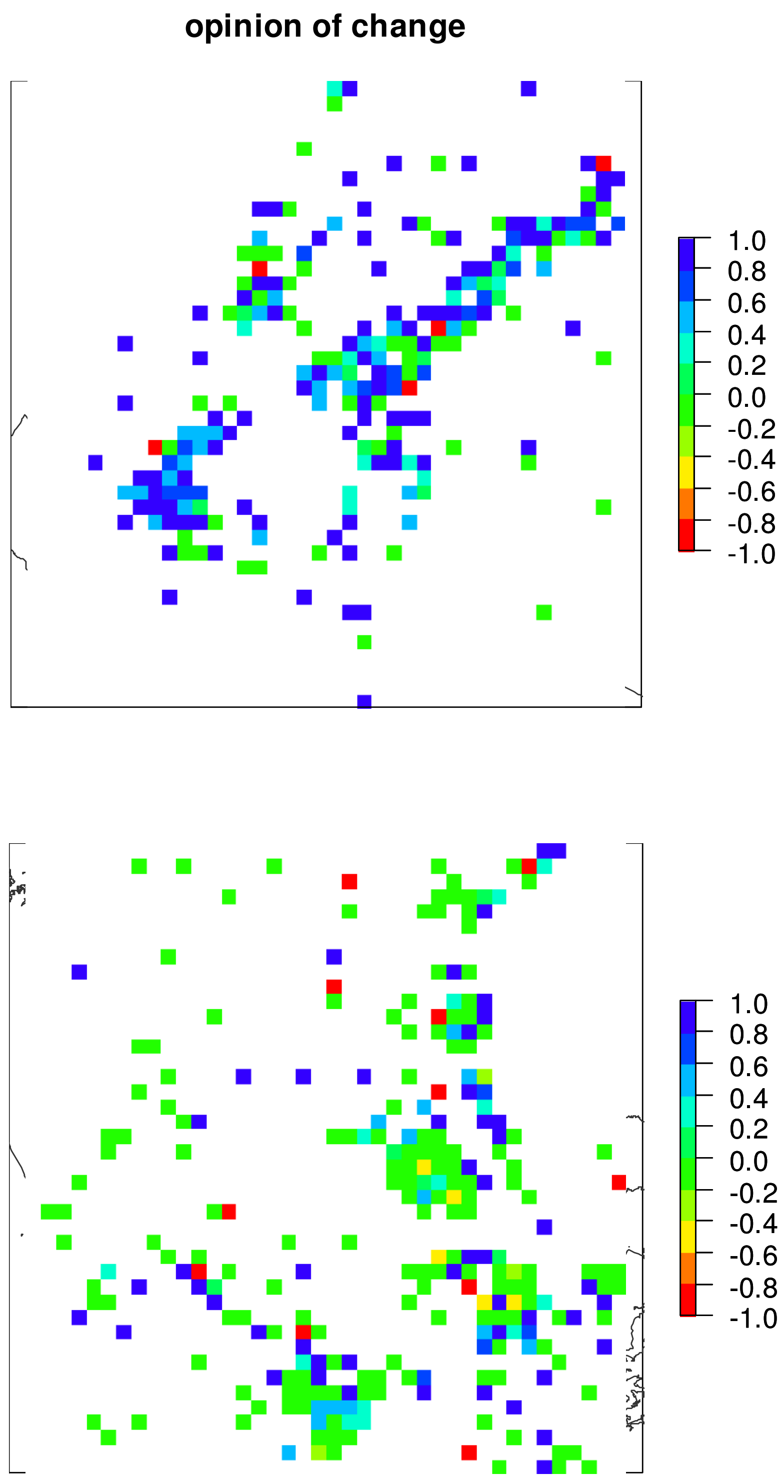
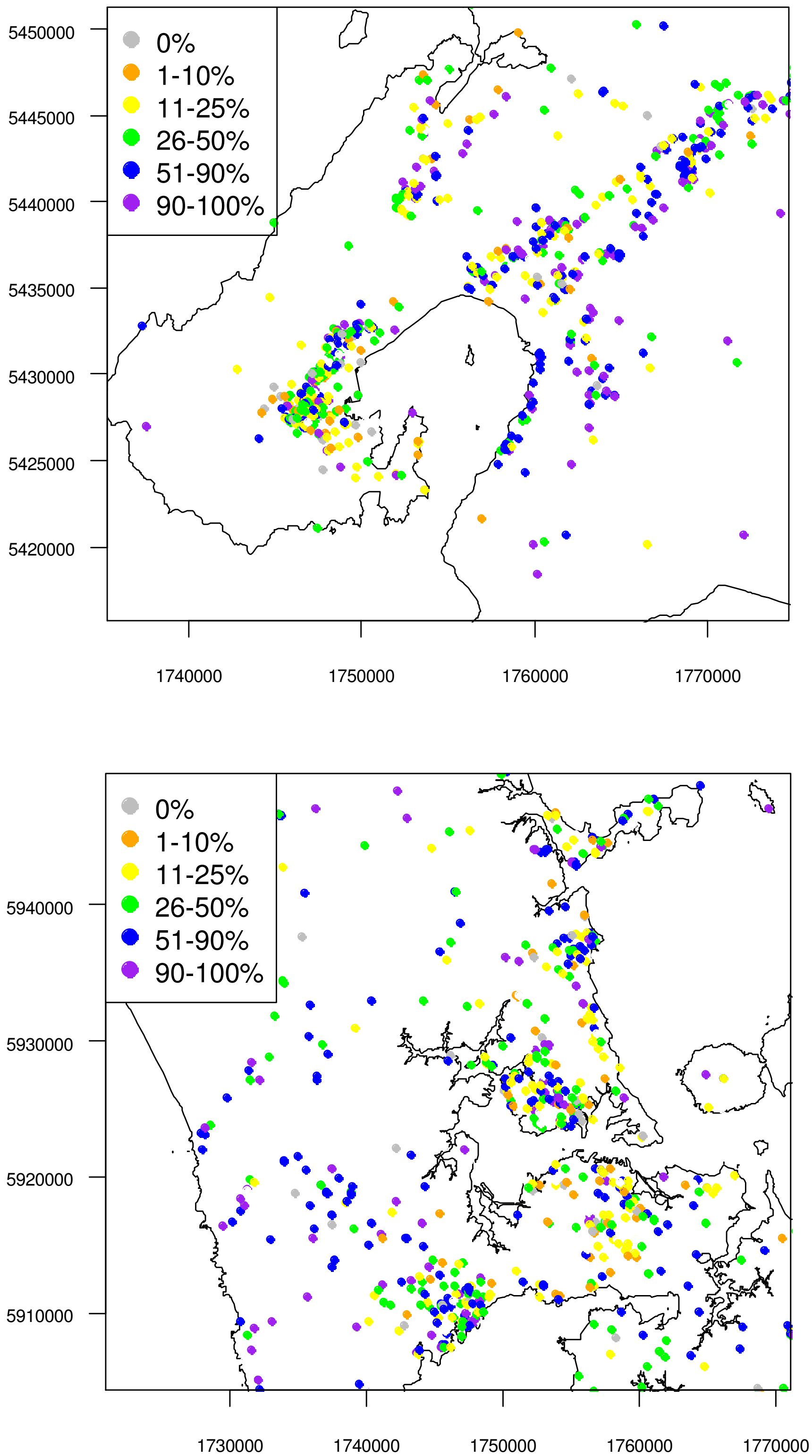


Figure A2. Average opinion of change per 1x1 km grid-cell for the Wellington and Auckland areas (top and bottom respectively). A value of +1 (purple) indicates all observers in that gridcell were of the opinion that kererū numbers were increasing in that locality, a value of negative one (red) indicates decrease and 0 (green) represents no change on average. Number of records per gridcell varies from 1 to ~10. White = no records submitted for that gridcell.

Perceived frequency



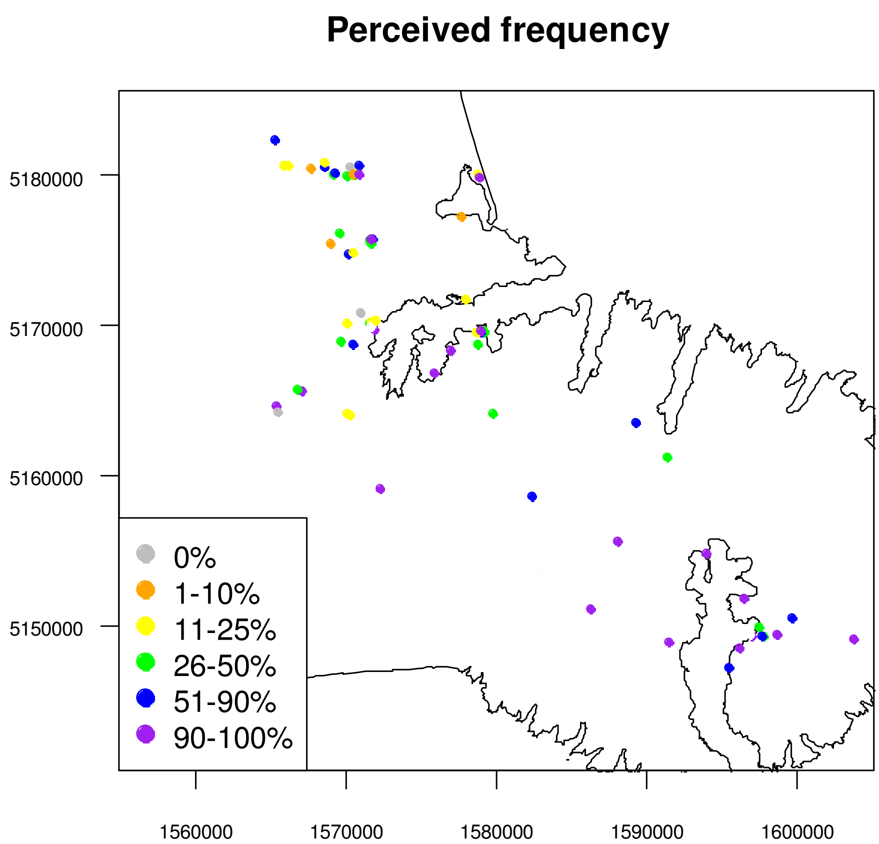


Figure A3. Perceived frequency of previous encounter with kereru for records submitted in the Wellington, Auckland and Christchurch areas. The colours represent the answer to the question "How frequently have you seen kereru at this location before? [never (0%), seldom (1-10%), sometimes (11-25%), often (25-50%), more often than not (51-90%), almost always (91-100%)]?" **The general trend is that kererū are seen at a higher frequency, further away from the city centres.**