Manaaki Whenua
Landcare Research

Trends in bird species occurrence and abundance in Taranaki

Prepared for: Predator Free Taranaki

June 2021

Trends in bird species occurrence and abundance in Taranaki

Contract Report: LC3990

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Contents

Summary

Project and client

- Manaaki Whenua – Landcare Research was commissioned by Taranaki Regional Council (TRC) to analyse 5-minute bird count (5MBC) data collected as part of the Towards Predator-Free Taranaki - Taranaki Taku Tūranga project.

Objective

- To detect temporal trends in the probability of occurrence or relative abundance of selected bird species, and in bird species richness, for each of three predator control programmes (Urban, Rural, and Zero Possums).

Methods

- We fitted mixed-effects models to the 5MBC data to assess whether time (year of monitoring) was a statistically significant predictor of the probability of observing an indicator bird species (logistic regression), or the number of individuals of an indicator species (Poisson regression) observed at a monitoring station, from three distinct predator control programmes. We also used Poisson regression models to assess whether bird species richness (number of bird species) showed a relationship with time.

Results

- There was an increased probability of observing fantails, silvereyes and grey warblers at the Urban sites over time. An increase in the number of silvereyes at the Urban sites, an increase in the number of kererū at the Zero Possums sites, and a decreased number of blackbirds at the Urban sites was also suggested. Native bird species richness appeared to increase across all three programmes, although this was not statistically significant for the Rural sites.

Conclusions

- These trends suggest predator control is having a positive effect on native bird species occurrence and relative abundance, particularly at the Urban sites. However, it is unwise to make any firm inferences about trends due to the very short time series and, in some cases, poorly fitting models resulting from an excess of zero observations.

Recommendations

- Bird monitoring should continue for another 3 to 5 years to enable robust identification of temporal trends, and to give bird populations time to respond to reduced predator numbers. Ideally, bird monitoring should continue for as long as predator control is conducted to demonstrate any positive biodiversity outcomes from predator reductions. However, this will depend on the TRC’s budget, especially given the expanding nature of the Rural programme.

1 Introduction

Manaaki Whenua – Landcare Research was commissioned by Taranaki Regional Council (TRC) to analyse 5-minute bird count (5MBC) data collected as part of the Towards Predator-Free Taranaki - Taranaki Taku Tūranga project to assess trends in bird species occurrence and abundance following predator control.

2 Background

Towards Predator-Free Taranaki – Taranaki Taku Tūranga is a large-scale project launched in 2018 which aims to extirpate key predator species in the Taranaki region to help restore the native biodiversity and mauri of the region. The project is led by Taranaki Regional Council (TRC), which has three predator control programmes in progress: Urban Predator Control, Zero-Density Possums, and Rural Landscape Predator Control (henceforth Urban, Zero Possums, and Rural).

The Urban part of the project builds on the council's existing voluntary possum- and rat-trapping programmes on public and private land, which began in New Plymouth and Ōakura then expanded in 2019 to additional towns in the region (Figure 1A). The Zero Possums programme is focused on possum eradication in the Kaitake Range and surrounding land (Figure 1A). It is now in the mop-up phase using a remote-reporting leg-hold trap network following initial large-scale predator control in 2018. The Rural predator control programme is based on a high-tech trapping network targeting mustelids across large swathes of private rural land surrounding the maunga (mountain). It has been rolled out over successive years, beginning with Zone 1 in 2018 through to Zone 3 in 2020 (Figures 1A and 1B).

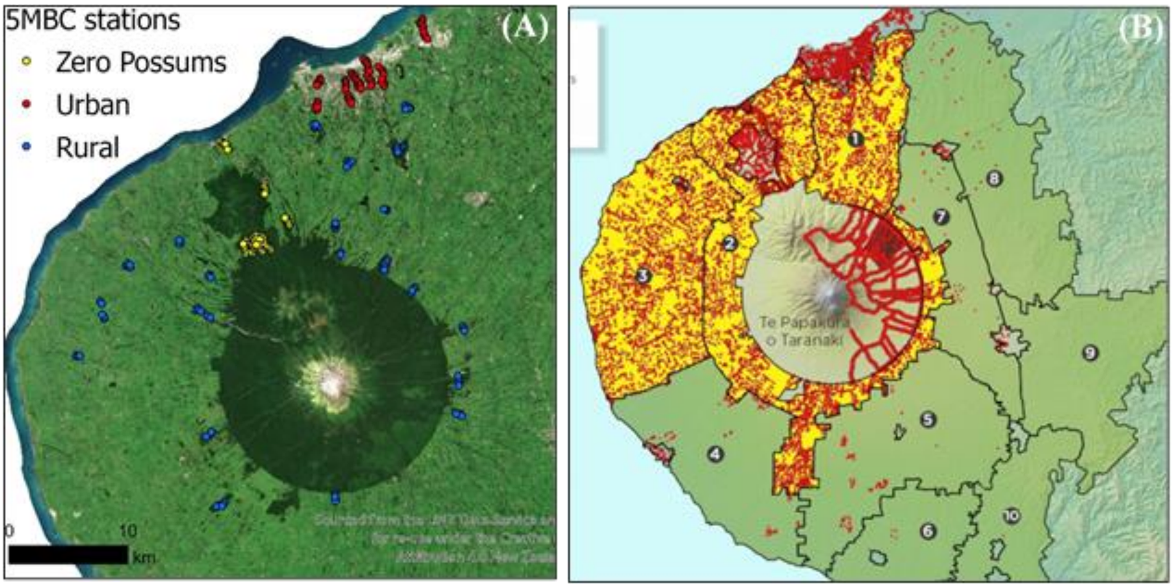

Figure 1. (A) 5-minute bird count stations in the three predator control programmes.
(B) Roll-out zones in the Rural predator control programme; the red dots in zones 1, 2 and 3 and in the maunga indicate predator traps.

To assess the impacts of predator control on desired biodiversity outcomes, a bird monitoring network has been set up across the three predator control programmes. Monitoring consists of 5MBCs at designated stations according to the protocol of Dawson and Bull (1975), with 3 to 10 stations per monitoring line and 10 to 21 monitoring lines per predator control programme (Appendix 1). Each station is surveyed twice a year, with both surveys occurring less than 1 week apart and under similar weather conditions. During the survey, all species of birds and the number of individuals of each species seen and heard are recorded.

TRC is interested in whether bird species have begun to show a measurable response to predator control. To assess this, we fitted statistical models to the 5MBC data for each of the three programmes to test whether the relative abundance or occurrence of indicator bird species has changed over time. We also investigated whether total bird species richness and the subsets of native and exotic species richness changed over time.

3 Objectives

To detect temporal trends in the probability of occurrence or relative abundance of selected bird species, or bird species richness, for each of the three predator control programmes conducted by TRC.

4 Methods

Analyses were done separately for each of the three programmes (Urban, Rural, and Zero Possums). Nine indicator bird species were included for the Urban and Rural analyses: blackbird (*Turdus merula*); chaffinch (*Fringilla coelebs*); North Island fantail (*Rhipidura fuliginosa placabilis*); New Zealand kingfisher (*Halcyon sancta vagans*); Indian myna (*Acridotheres tristis*); kererū/kukupa/New Zealand woodpigeon (*Hemiphaga novaeseelandiae novaeseelandiae*); silvereye (*Zosterops lateralis lateralis*); tūī (*Prosthemadera novaeseelandiae novaeseelandiae*); and grey warbler (*Gerygone igata*). For the Zero Possums analyses, an extra three indicator species were included: mainland bellbird (*Anthornis melanura melanura*); North Island rifleman (*Acanthisitta chloris granti*), and North Island tomtit (*Petroica macrocephala toitoi*). Bird count data were available for 3 years (2018–2020) for all three programmes, with an additional 4 years provided for the Urban programme (2014–2017). This data set was used in a separate set of analyses for the Urban programme over the extended period (2014–2020).

For each indicator species, the probability of occurrence (whether it was seen and/or heard at a monitoring station) was modelled using logistic regression (a binomial distribution being suitable for the binary nature of the response data). Time (i.e. year) was included as a continuous fixed-effect predictor, and survey as a random effects predictor (first or second survey within a year was nested within station, which was nested within monitoring line). Poisson regression was used to model bird counts (the total number of individuals of a given bird species seen and/or heard at a station) as a function of the set of predictor variables described above (summarised as time + line>station>survey). A trend in the probability of occurrence or number of birds over time was indicated if the 'year' predictor was statistically significant (Wald test, p-value < 0.05). Analyses were done in R (R Core Team 2019) using the lme4 package (Bates et al. 2015) to fit the models.

Another set of Poisson regression models was fitted to assess whether there was a trend in bird species richness over time for each of the three programmes. The response variable was either the total bird species richness (total number of species), exotic species richness, or native species richness detected at a monitoring station, with year as a fixed predictor and survey nested within station nested within monitoring line as random effects predictors. We also compared native species richness between two areas within the Zero Possums programme: Pukeiti versus the Kaitake 'Plus' (which comprised the Department of Conservation lines in the Kaitake Range plus the Matekai Park, Surrey Hill, and Carrington A monitoring lines). To do this, we added the categorial predictor 'area' (Pukeiti or Kaitake Plus), as a fixed effect, to the same native species richness model as above, and to a reduced model (with no year predictor) to assess whether there were significant differences between areas (Wald test, $p < 0.05$).

For ease of interpretation, results from logistic and Poisson regression models are presented as 'strength of the temporal trend'; this is the odds ratio for logistic regression or the rate ratio for Poisson regression. For both regression types, the strength is calculated by exponentiating the regression coefficient, where values less than 1 indicate a decreasing temporal trend, values equal to 1 indicate no change, and values greater than 1 indicate an increasing temporal trend. Finally, given the large number of analyses performed, we make inferences mainly for those species for which we obtained a significant temporal trend.

5 Results

The probability of observing one or more fantails, silvereyes or grey warblers in the Urban sites increased over the 3 years of monitoring (2018–2020), with the odds of detecting each of these species approximately doubling each year (Table 1; Figures 2C, 2G, 2I). The odds of observing a blackbird at a monitoring station approximately halved each year (Table 1; Figure 2A). Likewise, the number of silvereyes or grey warblers counted at the Urban monitoring stations increased by approximately 68 and 35% per annum (p.a.), respectively, but the number of blackbirds decreased by about 13% p.a. (Table 2; Figure 3). A small decrease (10% p.a.) in the number of tūī observed was detected (Table 2), although this was not obvious from the plots (Figure 3H) and was of marginal statistical significance ($p = 0.03$). In the Urban area, native species richness increased by approximately 20% (Table 3; Figure 4), which drove a similar increase in total species richness.

For the extended Urban data set (2014–2020) there was a decline in the probability of observing chaffinches over time, and a 14% decrease in the number of chaffinches observed each year (Tables 1 & 2; Supplementary Figures 1B & 2B). Kingfishers also showed a declining trend in the probability of occurrence and in the numbers observed; this trend appeared to be a function of the numerous zero observations in 2018 and 2019 (Table 1; Supplementary Figures 1D & 2D). Small decreases in the number of silvereyes and tūī observed (4 and 3% p.a., respectively) were indicated (Table 1; Supplementary Figures 2G, 2H). A small (<3% p.a.) decrease in exotic bird species richness was found, which drove a similar decrease in total species richness (Table 3).

In the Rural programme there was a large increase in the probability of observing an Indian myna, and in the number of Indian mynas observed each year (Tables 1 & 2; Figures 2E & 3E). However, this trend appeared to be driven by no observations in the first year of the study (2018), followed by a few observations in 2019 and 2020. A higher probability of observing a tūī was found each year (Table 1; Figure 2H), although there was no detectable change in the number of tūī observed (Table 2; Figure 3H). There was a small increasing trend in the number of kingfishers observed over time (4% p.a.: Table 2; Figure 3D) and a decreasing trend in the number of blackbirds (21% p.a.: Table 2; Figure 3A). No statistically significant trends in species richness over time were detected in the Rural programme (Table 3; Figure 4).

In the Zero Possums sites there was an increased probability of observing a chaffinch, kingfisher, grey warbler or rifleman over time (Table 1; Figure 2). There was also an increasing trend in the number of kingfishers, kererū and riflemen observed over the years at the Zero Possums sites. The estimated increase for riflemen in both probability of occurrence and numbers was very large, but should be viewed with caution due to the large number of zeros in the data. All measures of bird species richness (total, native, and exotic) increased over the years, although the relative increase in exotic species richness was larger (Table 3; Figure 4). Despite the number of native species observed being higher at the Pukeiti sites in one year (2019: Figure 5), there was no consistent difference in bird species richness between the Pukeiti and Kaitake Plus monitoring lines.

Table 1. Strength of the temporal trend in the probability of an indicator bird species being observed at a monitoring station for each of the three monitoring programmes. The value shown is the change in the odds of observing a given bird species with each successive year of monitoring (odds is the probability of an event occurring divided by the probability of it not occurring).

Bird species	Urban 2018–2020	Urban 2014–2020	Rural 2018–2020	Zero Possums 2018–2020
Blackbird	0.45	NS	NS	NS
Chaffinch	NS	**<u>0.876</u>**	NS	1.34
North Is. fantail	**1.75**	NS	NS	NS
NZ kingfisher	NS	0.894	NS	1.45
Indian myna	NS	NS	16.51	NS
NZ pigeon/ kererū/kukupa	NS	NS	NS	NS
Silvereye	**<u>2.36</u>**	NS	NS	NS
Tūī	NS	NS	**2.02**	NS
Grey warbler	**<u>2.14</u>**	NS	NS	**1.94**
Mainland bellbird	–	–	–	NS
North Is. rifleman	–	–	–	**4.39**
North Is. tomtit	–	–	–	NS

Notes: NS indicates no significant trend; values in normal text are marginally statistically significant ($0.01 \le p < 0.05$); values in bold are moderately significant ($0.001 \le p < 0.01$); and values in bold and underlined are highly significant ($p < 0.001$). A dash indicates the analysis was not performed for that bird species in that monitoring programme.

Table 2. Strength of the temporal trend in the number of individuals of each bird species observed at a monitoring station for each of the three monitoring programmes. The value shown is the multiplicative change in the number of individuals observed per station with each successive year (a value of 1.2 would indicate a 20% increase per annum, whereas a value of 0.8 would indicate a 20% decrease per annum).

Bird species	Urban 2018–2020	Urban 2014–2020	Rural 2018–2020	Zero Possums 2018–2020
Blackbird	**0.87**	NS	**0.79**	NS
Chaffinch	NS	**<u>0.86</u>**	NS	NS
North Is. fantail	NS	NS	NS	NS
NZ kingfisher	1.28	**0.92**	**<u>1.04</u>**	**<u>1.37</u>**
Indian myna	NS	NS	3.19	NS
NZ pigeon/ kererū/kukupa	NS	NS	NS	1.19
Silvereye	**<u>1.68</u>**	**0.96**	NS	NS
Tūī	0.9	**0.97**	NS	NS
Grey warbler	**1.35**	NS	NS	NS
Mainland bellbird	–	–	–	NS
North Is. rifleman	–	–	–	**<u>5.56</u>**
North Is. tomtit	–	–	–	NS

Notes: NS indicates no significant trend; values in normal text are marginally statistically significant ($0.01 \leq p < 0.05$); values in bold are moderately significant ($0.001 \leq p < 0.01$); and values in bold and underlined are highly significant ($p < 0.001$). A dash indicates the analysis was not performed for that bird species in that monitoring programme.

Table 3. Strength of the temporal trend in species richness (number of bird species) observed at a monitoring station for each of the three monitoring programmes. The value shown is the multiplicative change in the number of bird species observed per station with each successive year (a value of 1.2 would indicate a 20% increase per annum, a value of 0.8 would indicate a 20% decrease per annum).

Richness measure	Urban 2018–2020	Urban 2014–2020	Rural 2018–2020	Zero Possums 2018–2020
All species	**1.09**	**<u>0.977</u>**	NS	**1.08**
Native species	**<u>1.19</u>**	NS	NS	1.060
Exotic species	NS	**0.972**	NS	1.16

Notes: NS indicates no significant trend; values in normal text are marginally statistically significant ($0.01 \leq p < 0.05$); values in bold are moderately significant ($0.001 \leq p < 0.01$); and values in bold and underlined are highly significant ($p < 0.001$).

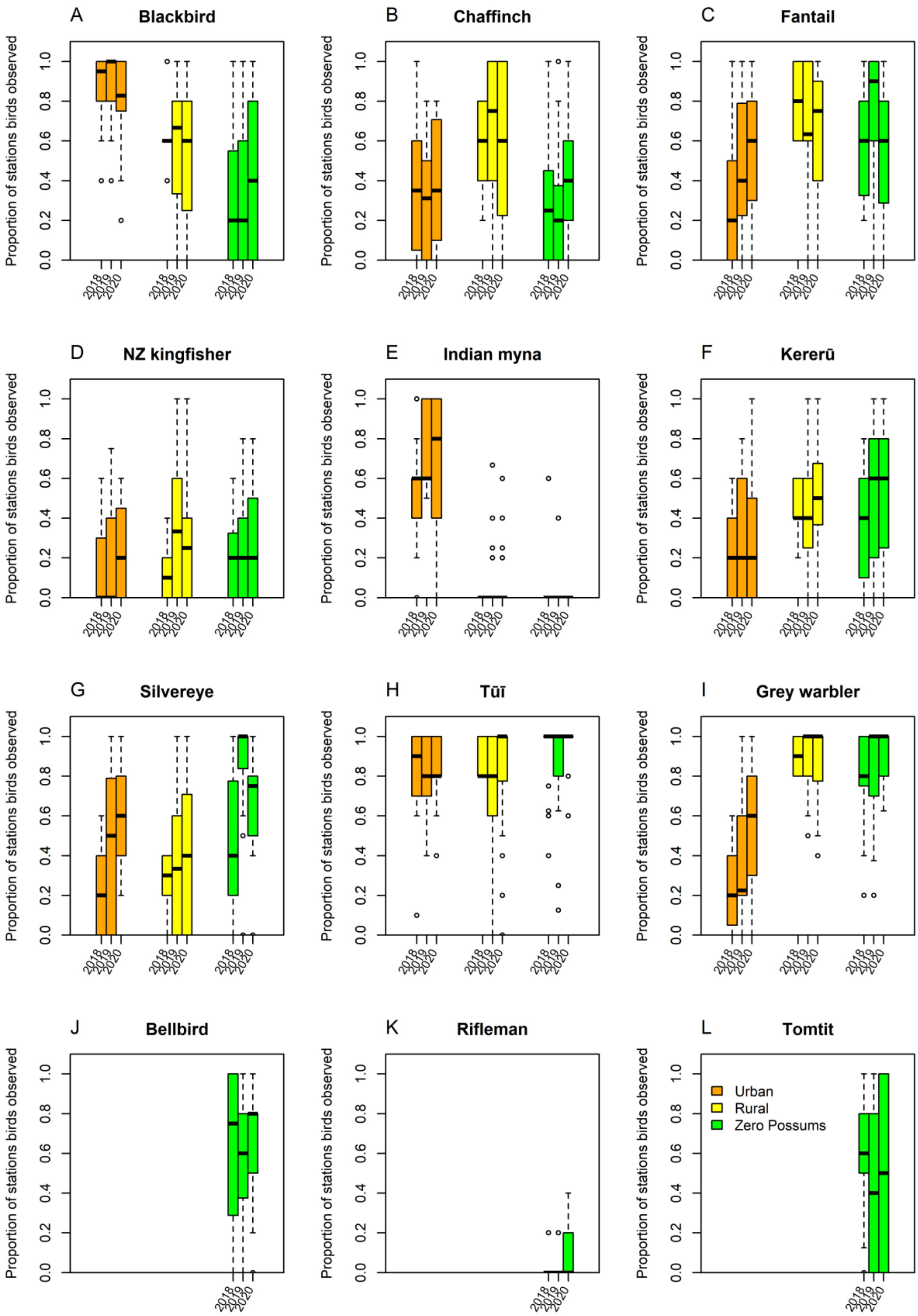

Figure 2. The proportion of stations in a monitoring line where one or more of each indicator species were observed for the years 2018–2020. Notes: Orange bars depict the Urban sites, yellow bars the Rural sites, and green bars the Zero Possums sites. The coloured bars encompass the interquartile range, the bold horizontal line indicates median values, the whiskers indicate the upper and lower extremes, and the points represent outliers.

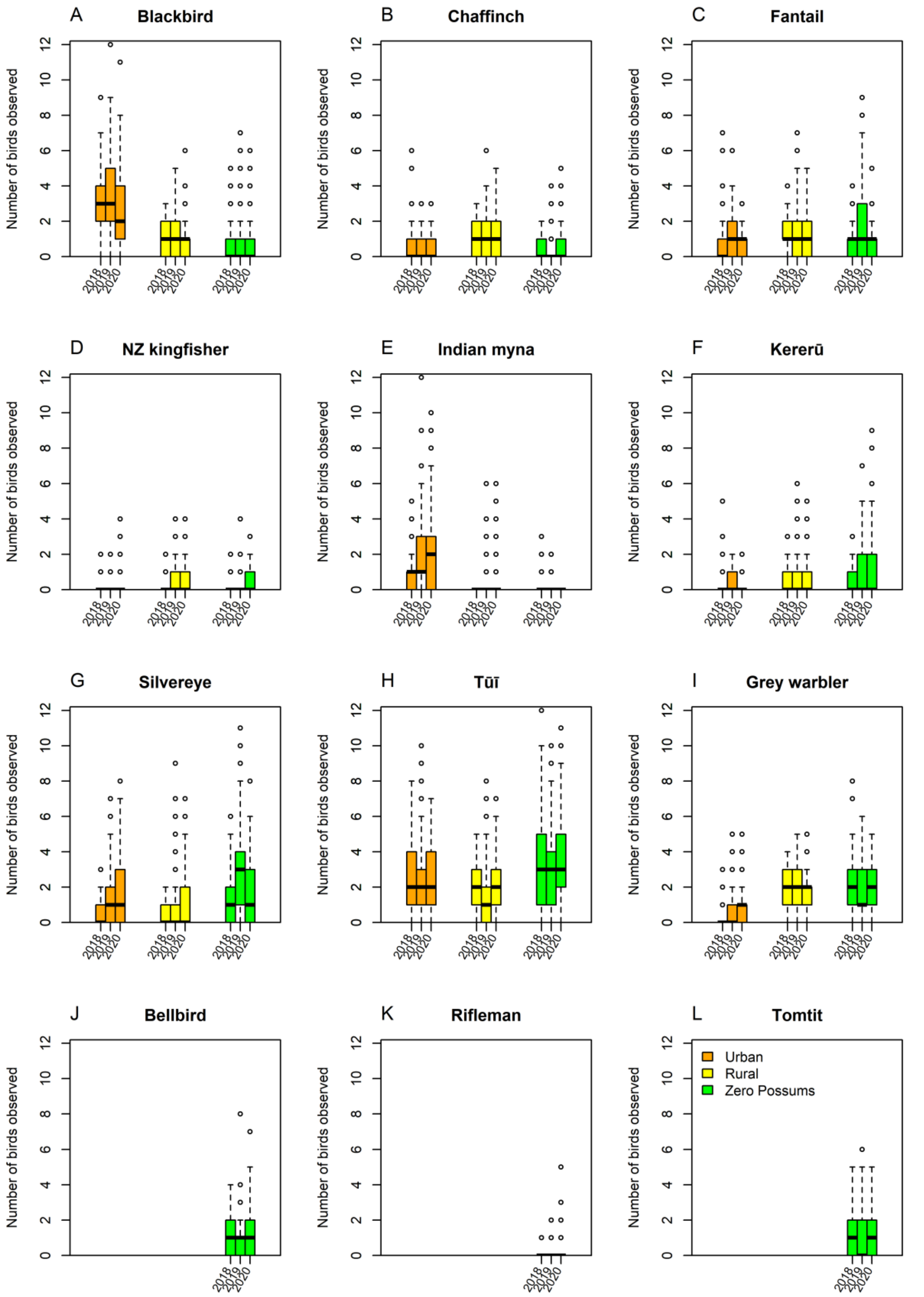

Figure 3. The number of birds for each indicator species observed per monitoring station for the years 2018–2020. Orange bars depict the Urban sites, yellow bars the Rural sites, and green bars the Zero Possums sites. The coloured bars encompass the interquartile range, the bold horizontal line indicates median values, the whiskers indicate the upper and lower extremes, and the points represent outliers.

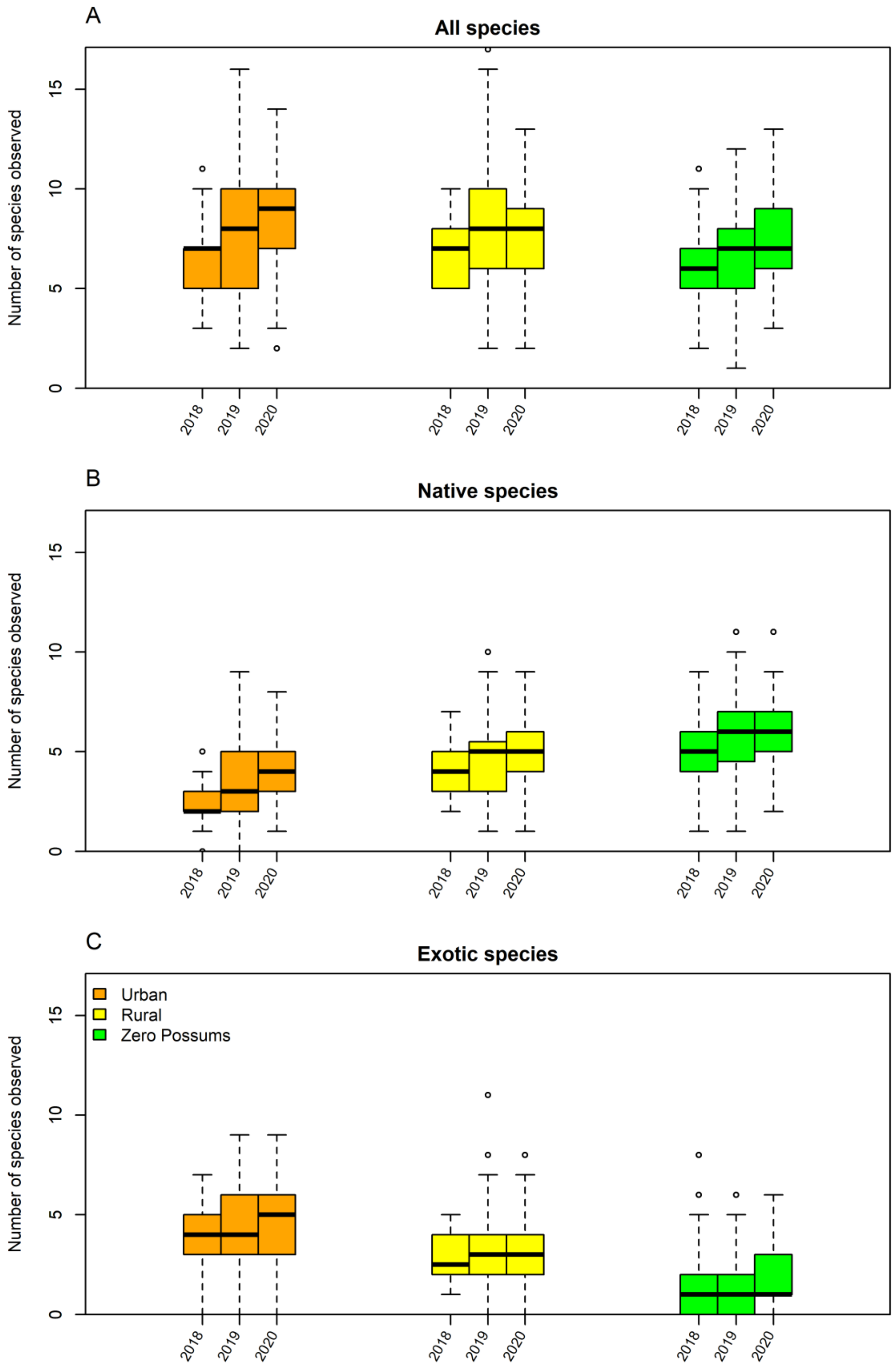

Figure 4. Species richness (number of bird species) observed per monitoring station for the years 2018–2020, where A shows total species richness, B native species richness, and C exotic species richness. Notes: Orange bars depict the Urban sites, yellow bars the Rural sites, and green bars the Zero Possums sites. The coloured bars encompass the interquartile range, the bold horizontal line indicates median values, the whiskers indicate the upper and lower extremes, and the points represent outliers.

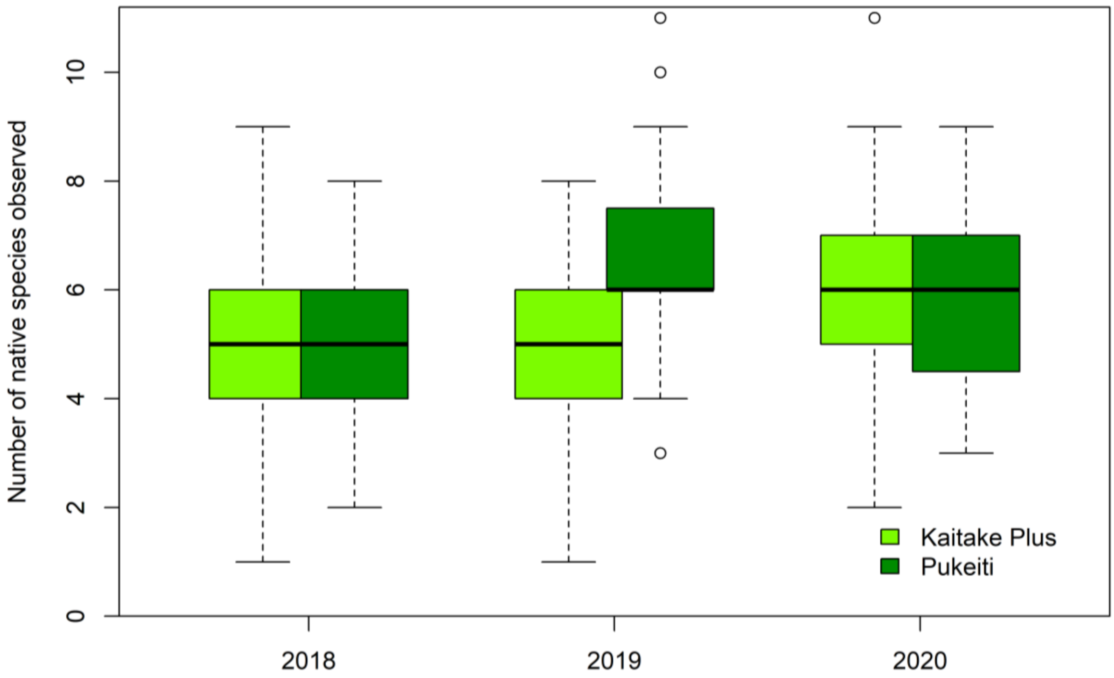

Figure 5. Native bird species richness per monitoring station for the years 2018–2020 for two sub-areas of the Zero Possums programme. Notes: Dark green bars depict Pukeiti monitoring lines and light green bars the Kaitake Range plus the Matekai Park, Surrey Hill, and Carrington A monitoring lines. The coloured bars encompass the interquartile range, the bold horizontal line indicates median values, the whiskers indicate the upper and lower extremes, and the points represent outliers.

6 Conclusions

Some of the trends identified here are reasonably compelling, notably the increased probability of observing fantails, silvereyes, and grey warblers at the Urban sites. There was also evidence for increases in the mean number of silvereyes at the Urban sites and of kererū at the Zero sites, and for a decreased number of blackbirds at the Urban sites. There was some indication that kingfisher numbers were increasing across all of the programme areas, although when seen in the context of the extended Urban data this was because of two poor years in 2018 and 2019 followed by a recovery in 2020. Native bird species richness appeared to increase across all three programmes, although this was not statistically significant for the Rural sites.

These trends suggest predator control is having a positive effect on native bird species occurrence and relative abundance, particularly at the Urban sites. However, for a number of reasons we are hesitant to make any firm inferences about the effects of predator control on bird species occurrence and numbers.

First, the time series is too short to reliably identify a trend. A good or bad year at the start or end of a 3-year data set can have undue influence on the fitted regression slope (e.g. the number of kererū observed at the Zero Possum sites). This is probably best illustrated by how trends identified in the short-term Urban data (2018–2020) were negated or reversed when looking at the longer-term data (2014–2020). Admittedly, the earlier data (2014–2017) were from before the coordinated predator control programme began, when trapping was sporadic and sparse, so we cannot make any inferences about the effect of predator control, but it does show how trends can be non-existent or non-linear when assessed over a longer time scale. Inference is most limited for the Rural programme areas, where the time and monitoring line effects were confounded because predator control was rolled out across different areas and new monitoring lines were added each year.

A second important limitation for making robust inferences is the lack of experimental controls. Monitoring 5MBC stations in areas of equivalent habitat but where predator control does not take place would permit differences in bird population trends to be unequivocally attributed to reduced predator numbers.

Third, many of the models were not a particularly good fit due to overdispersion: the variation observed in the data was greater than that assumed by the models fitted. The models we fitted had observation-level random effects (OLREs), which can account for extra variation (e.g. where a particular monitoring station or line is consistently poor for observing birds). These effects can also account for any correlations in the response due to sampling structure (stations located within lines) and the repeated surveys of the stations. However, OLREs are not very good at accounting for extra variation caused by an excess of zeros (Harrison 2014, 2015). Excess zeros were prevalent in these data and appeared to be the cause of the poor model fits. Zeros in 5MBCs can arise from two sources: there are no birds present at the monitoring station, or there were birds present but they were not detected. Developing complex models to fit both sources of zeros found in 5MBC data was outside the scope of this investigation but is something to be considered for future work.

In conclusion, there are indications of a positive response at the Urban sites, but it is too soon to identify overall bird population responses to predator control, in terms of both time elapsed for bird responses (particularly in the Rural sites, where initiation of predator control has been staggered), and sufficient data points to properly identify a temporal trend.

7 Recommendations

- Bird monitoring should continue for another 3 to 5 years to enable robust identification of temporal trends, and to give bird populations time to respond to reduced predator numbers. Ideally, bird monitoring should continue for as long as predator control is conducted, in order to demonstrate any positive biodiversity outcomes from predator reductions. However, this will depend on the TRC’s budget, especially given the expanding nature of the Rural programme.

8 Acknowledgements

We thank Halema Jamieson at the Taranaki Regional Council for cheerful assistance with data queries and identifying the bird indicator species. We also thank Dr G. Norbury, Manaaki Whenua – Landcare Research, for useful comments on an earlier draft of this report.

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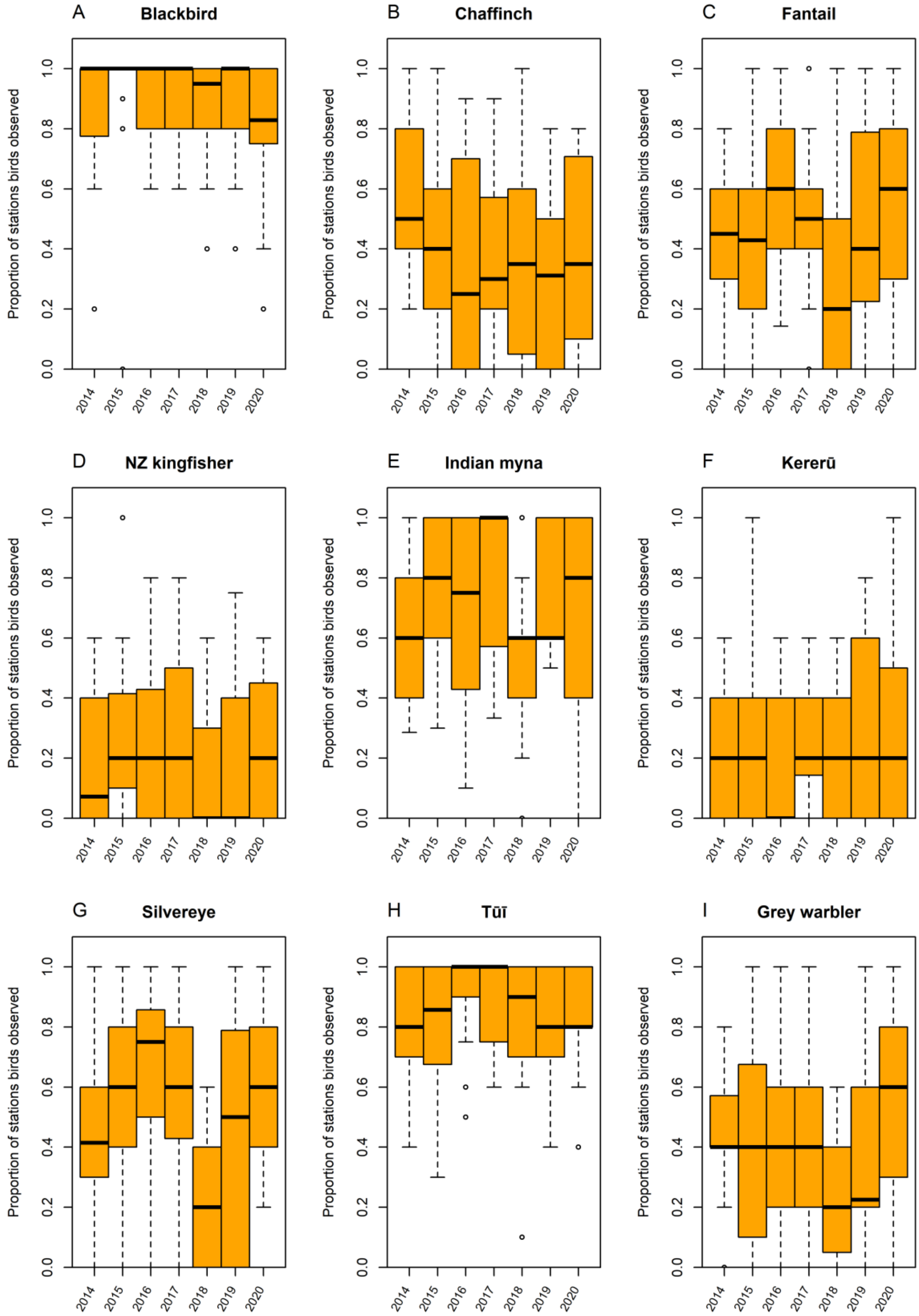
Appendix 1 – List of 5MBC monitoring lines and number of stations monitored for each of the three predator control programmes for the period 2018–2020

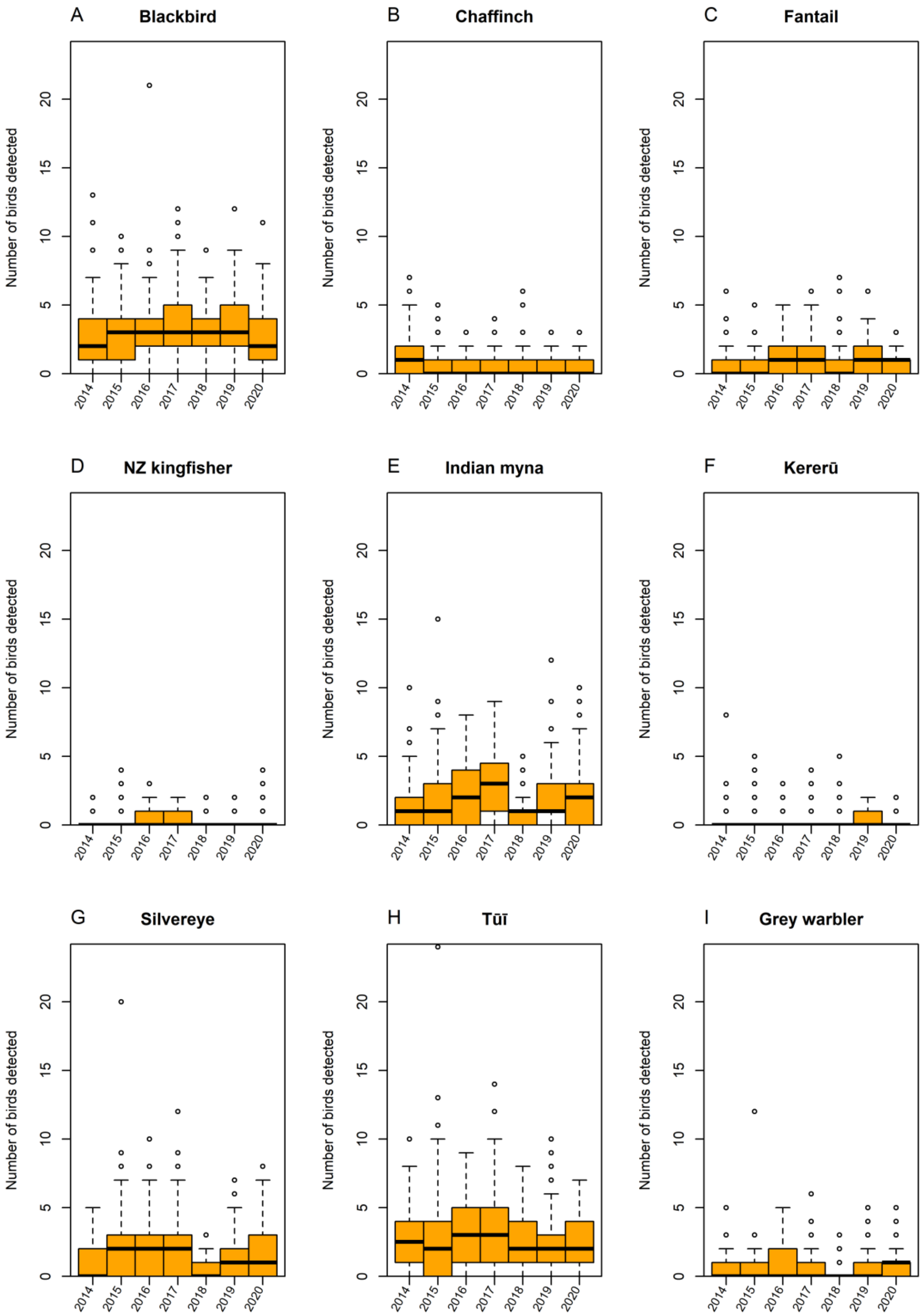
Programme	Line name	Number of stations 2018	Number of stations 2019	Number of stations 2020
Urban	Mangati Walkway	10	10	10
Urban	Pukekura Park / Brooklands	0	9	10
Urban	Mangaotuku	5	5	5
Urban	Barrett's Domain	5	5	5
Urban	Te Henui North	7	7	7
Urban	Te Henui South	5	5	5
Urban	Huatoki North	5	5	5
Urban	Huatoki South	5	5	5
Urban	Wawhakaiho North	0	5	5
Urban	Waiwhakaiho South	0	4	5
Urban	King Edward Park	0	0	5
Urban	Joe Gibbs and P.G. Nops Reserves	0	0	2
Zero	Carrington A	5	5	5
Zero	Matekai Park	5	5	5
Zero	Surrey Hill	5	5	0
Zero	Pukeiti	5	5	5
Zero	Pukeiti	5	5	5
Zero	Pukeiti	0	5	5
Zero	Pukeiti	5	5	5
Zero	Pukeiti	0	5	5
Zero	Pukeiti	5	5	5
Zero	Pukeiti	5	5	5
Zero	Pukeiti	5	5	5
Zero	Kaitake Ranges DOC	8	8	8
Zero	Kaitake Ranges DOC	8	8	8
Zero	Kaitake Ranges DOC	8	8	8
Rural	Umutekai	5	5	5
Rural	Halls KNE	0	3	3
Rural	Mangorei Rd Brent Cathie	0	4	4
Rural	Quintus	5	5	5
Rural	Lake Mangamahoe	5	5	5
Rural	Ratapihipihi	0	5	5
Rural	Mahood-Lowe	0	5	5

Programme	Line name	Number of stations 2018	Number of stations 2019	Number of stations 2020
Rural	Korito Rd	0	2	2
Rural	BlueRata	0	5	5
Rural	Muschamp	0	4	4
Rural	Pembroke Rd DOC	0	5	5
Rural	Denbigh Rd	0	5	5
Rural	Derby Rd N Cooper	0	3	3
Rural	NPDC water	0	4	4
Rural	Dover Rd George Julian	0	3	0
Rural	Arawhata Rd Phillip Field	0	4	4
Rural	Kaweora	0	5	5
Rural	STDC Pungarehu	0	3	3
Rural	Puniho Rd Butler	0	5	5
Rural	Tapunikau Pa / Donalds	0	5	5
Rural	Tom and Dons	0	3	3

Appendix 2 – Supplementary figures for the extended Urban data set



Supplementary Figure 1. The proportion of stations in a monitoring line where one or more individuals of each indicator species were observed at the Urban programme sites for the period 2014–2020. The coloured bars encompass the interquartile range, the bold horizontal line indicates median values, the whiskers indicate the upper and lower extremes, and the points represent outliers.



Supplementary Figure 2. The number of individuals of each indicator species observed per monitoring station at the Urban programme sites for the period 2014-2020.
Notes: The coloured bars encompass the interquartile range, the bold horizontal line indicates median values, the whiskers indicate the upper and lower extremes, and the points represent outliers.