Landbirds on Lord Howe Island, NSW

Survey report 3

September 2016



Prepared for the Lord Howe Island Board

by the Canberra Ornithologists Group

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Contents

Summary iii

Introduction 1

Methods 1

Choice of plots 2

Plot count protocol 3

Statistical treatment of plot counts 4

Statistical model 4

Transect surveys 5

Statistical analysis of transect data 6

Species names 7

Survey dates and weather conditions 7

Results and Discussion 8

Plot counts 8

Abundance, reporting rate, frequency and group size 9

Generalized linear mixed model 12

Species distribution 17

Transect counts 22

Bird atlas data 24

Acknowledgements 24

References 25

Appendixes 26

Appendix A. Vegetation and habitat classifications of all 96 surveyed plots, LHI 26

Appendix B. Geolocation, vegetation code, vegetation group, habitat zone and number of counts for all 96 surveyed plots, LHI 27

Appendix C. Description of start point and turning point for all transects (A–G) 30

Appendix D. Bird species recorded at 96 surveyed plots, LHI, 2016 31

Tables

Table 1. No. of surveys for 96 plots, LHI 3

Table 2. Allocation of observers to transects, LHI core settlement, September 2016 6

Table 3. Selected daily weather observations, LHI, 4–11 September 2016 8

Table 4. No. of counts undertaken in 3 vegetation groups in 5 habitat zones, LHI, 2016 8

Table 5. Abundance, reporting rate, frequency and group size for 21 bird species recorded at 96 plots, LHI, 2016 10

Table 6. Reporting rate, abundance and frequency for the Golden Whistler, Woodhen and Pied Currawong, defined by vegetation group and habitat zone, LHI, 2016 11

Table 7. Significance of fixed effects 12

Table 8. Variance estimates for random effects. 13

Table 9. Estimated no. of individuals derived from the final fitted model. 14

Table 10. Significance of fixed effects on the no. of individuals of target species observed on transects 25

Figures

Figure 1. Grid cells, based on plot counts, used for surveying distribution of landbirds on LHI, September 2016 2

Figure 2. Map of core settlement area, LHI, with location of transects A–G 5

Figure 3. Distribution of Swamphen, Buff-banded Rail, Woodhen and Masked Lapwing, September 2016, northern LHI, by frequency of occurrence at count plots 18

Figure 4. Distribution of Emerald Dove, Sacred Kingfisher, Magpie-lark and Pied Currawong, September 2016, northern LHI, by frequency of occurrence at count plots 19

Figure 5. Distribution of Golden Whistler, Silvereye, Blackbird and Song Thrush, September 2016, northern LHI, by frequency of occurrence at count plots 20

Figure 6. Distribution of White-faced Heron and Welcome Swallow, September 2016, northern LHI, by frequency of occurrence at count plots 21

Summary

This report describes a survey in September 2016 of landbirds on Lord Howe Island conducted by the Canberra Ornithologists Group (COG). The survey was the third of what is intended to be an annual assessment of the status of landbirds on the island. The survey will be repeated each September until at least 2017 with a view to further surveys. This and any further surveys have been commissioned by the Lord Howe Island Board as part of the necessary monitoring processes associated with a plan to eradicate rodents from the island.

The purpose of the survey is to provide baseline information on the numbers and distribution of landbirds on Lord Howe Island. Point counts were chosen as the preferred method for the island survey. The data collecting protocol used is one we believe best fits the limitations of time and effort available in the field. Transects surveys were conducted on five evenings, concentrating on the most important ground feeding species present in the settlement area.

As for the earlier surveys, 48 paired plots were selected across the survey area. The plots were stratified to represent various vegetation types and habitat zones with seven transects selected within the settlement area. From experience gained during the 2013 survey, three teams of two observers surveyed all paired plots in four days with half of the plots resurveyed over the following two days.

The mean abundance, mean reporting rate, frequency and group size for each of the 21 species recorded during the survey was calculated. In addition, the 21 species were analyzed using a generalized linear mixed model allowing both fixed and random effects to be taken into account. Maps of species distribution for 14 species with sufficient data are presented and can be compared with similar maps prepared in 2013 and 2014.

The most common bird was the Golden Whistler followed by the Silvereye. A noticeable reduction in all indices occurred for the next four most frequently reported species – Pied Currawong, Blackbird, Welcome Swallow and Magpie-lark. The remaining 15 species occurred at much lower abundance.

Comparing the indices of the more common species between the three surveys there appears to be little change for the Golden Whistler, Silvereye, Blackbird, Welcome Swallow, Magpie-lark, Emerald Dove, Song Thrush or White-faced Heron. There does appear to be an increase in the indices of Pied Currawong, and Woodhen and a decline in Swamphen and possibly Masked Lapwing. There was a decrease in the abundance and reporting rate in 2014 for the Buff-banded Rail but these indices returned to 2013 levels in 2016. There appeared to be a decline with the Sacred Kingfisher in 2016.

The two random effects that generally contribute least variation, *Observer* and *Day*, are factors that with time and more resources could be manipulated in contrast to *Plot* and *Habitat Zone*, which reflect the environmental variation present across the Island and hence is beyond the control of the survey team. We see two positive features from these two facts: first, that *Observer* differences are generally not large (perhaps reflecting the generally high level of competency of the selected observers) and, second, that potential effects of weather have not been sufficiently large to impact on the ability to undertake the surveys.

In general, the habitat influences appear to be sensible and generally reflect what we know about the biology of the species. In comparison to the previous report and with further data there is a suggested potential difference between years for Welcome Swallow and Emerald Dove with less reliable suggested differences between Buff-banded Rail, Blackbird and Woodhen. All require further exploration and additional observations before it can be suggested that we have detected truly significant differences between years.

The protocol for the surveys provides a rigorous method for obtaining statistically sound measures of significant changes in population numbers and distribution of species over time – particularly changes occurring before and after the proposed rodent eradication. The eradication is set for mid 2018, pending all the approvals being given.

Introduction

This report describes a survey in September 2016 of landbirds on Lord Howe Island (latitude 31° 33´S and longitude 159° 05´E). The survey was the third of intended annual assessments of the status of landbirds on the island conducted before the proposed rodent eradication program occurs. Previous surveys, conducted in 2013 and 2014, have been reported (Fullagar *et al*., 2014, Fullagar *et al*., 2015).

These and the future surveys have been commissioned by the Lord Howe Island Board as part of the necessary monitoring processes associated with a plan to eradicate rats and mice from the island. This eradication is now scheduled for mid 2018.

The purpose of the surveys is to provide baseline information on the numbers and distribution of landbirds on Lord Howe Island. Landbirds are here defined as those species that are either breeding residents on the island or visitors that are land-based. Specifically, all seabirds are excluded but shorebirds are not.

A rigorous survey method was required to provide data that can give a statistically sound measure of significant changes in population numbers and distribution – if they occur.

As indicated in the first report (Fullagar *et al.*, 2014) point counts were chosen as the preferred method for the island survey. Much of the vegetation is dense and often difficult to access; repeated line transects would have been difficult to follow in such circumstances. Point counts are easier to incorporate in a formally designed study, easier to locate and lay out, and they provide a more reproducible data set. As well, point counts are more efficient than transect counts because they allow for more data points (Bibby *et al.*, 1997).

We investigated the power of available statistical analyses achievable with this method of population assessment (Nicholls unpublished) and adopted the data collecting protocol we believe best fitted the limitations of time and effort available in the field. As an additional data set we did, however, use a simple transect procedure to assess the abundance of six species within the most closely settled area of the island. These transects were walked at dusk using the network of sealed roadways.

For a review of the historical records of birds on Lord Howe Island see Fullagar *et al.*, 2014.

Methods

This report clarifies some terms used in previous reports by renaming them and by defining the term ‘survey’:

- **count –** data collected by a single observer from a single plot or transect on a single occasion
- **grid** – a group of cells 500 m x 500 m within which a pair of plots is located

- **paired plot –** replaces paired site
- **plot** – replaces site; a location defined by vegetation group and habitat zone, covering an area of 50 m radius; plots are paired, 100 m apart and within the same vegetation group, habitat zone and grid cell
- **plot count** – a method of recording observed species
- **record** – a documented observation of a single species defined by date, plot and number present (seen/heard)
- **survey** – recorded observations for a given period on the island; usually seven days

Choice of survey plots

For practical reasons, determined by the time available for surveying and the number of teams we could muster, only the northern part of Lord Howe Island was included.
Mt Lidgbird and Mt Gower were excluded, as were Erskine Valley and any of the mountain slopes below the peaks beyond Mutton Bird Point and Little Island (see Figure 1).

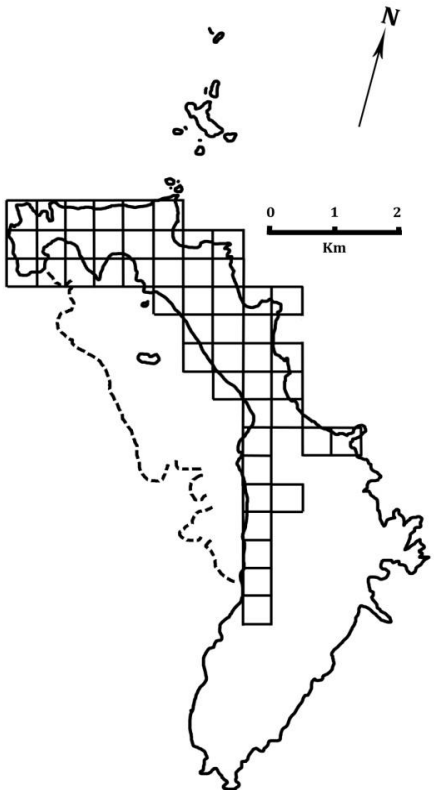


Figure 1. Grid cells, based on plot counts, used for surveying distribution of landbirds on LHI, September 2016

The same 48 grid cells (see Figure 1) used in 2013 and in 2014 were surveyed again in 2016, and each grid cell was allocated two count plots. The count plots were stratified to represent the various vegetation types and habitat zones. For a description of paired plots

defined by vegetation and habitat classification (see Fullagar *et al.*, 2014). There was no survey in 2015 because all field monitoring projects were put on hold by the Lord Howe Island Board while community consultation regarding the eradication took place.

Plot count protocol

Due to unforeseen circumstances two volunteers had to pull out of the survey at the last minute, so the survey was reduced from four to three teams. Our protocol therefore involved three teams of two observers surveying over six days. Surveying was restricted to between sunrise and late morning and, as in 2014, each team surveyed eight plots per day. All 96 plots were surveyed in four days with a repeat of 48 plots over the following two days. The final day was not required.

The paired plots were a minimum of 100 m apart and similar in topography and vegetation. Plot 20 was repositioned to allow for easier access but the plot remained in the same vegetation and habitat classification. See Appendix B for plot details of geolocation, vegetation and habitat type and number of surveys for each of the 96 surveyed plots.

Twenty-four of the paired plots were visited twice while the remaining 24 paired plots were visited four times. This gives a total of 288 counts (see Table 1). No plot was resurveyed by the same observer. Repeatability of counts at a plot could be tested by comparing counts at plots on the same day and on different days. Such analyses have not been undertaken to date.

Table 1. Number of surveys for 96 plots, LHI

Plot numbers	*Number of plots*	*Number of counts*
1–8	8	16
9–16	8	32
17–24	8	16
25–32	8	32
33–40	8	16
41–48	8	32
49–54	6	12
55–62	8	32
63–76	14	28
77–86	10	40
87–90	4	8
91–96	6	24
Total	**96**	**288**

The count protocol at each plot was to record the abundance of each species seen or heard within a 50-metre radius over a 10-minute period, with observers moving within the plot area if required. Team members would survey a pair of plots independently and simultaneously before swapping plots and again counting for 10 minutes.

Only experienced observers were chosen for the field work. All team members were well-trained, expert bird watchers with considerable previous involvement with similar style field work.

In the field the location of the paired plots was determined by GPS. Due to difficulties of terrain and differences in vegetation it was often not possible to survey the exact pre-determined point. Observers were requested to survey as near as they could to the allocated point. On arrival a waypoint reading was taken of the actual point surveyed and subsequently compared with the allocated central point of the plot. The average distance between these two locations was nine metres so the surveyed plot was still well within the appropriate vegetation group and habitat zone.

Statistical treatment of plot counts

Several summary parameters were used as population indices and these will become useful for comparison with data collected in future.

- *Mean abundance* (A). The average number of individuals of a species seen per observation and defined as the sum of the number of individuals reported divided by the total number of observations (288).
- *Mean reporting rate* (R). Defined as the number of recorded occurrences divided by the total number of observations (288).
- *Frequency* (F). The plot occupancy rate or incidence rate defined as the number of plots on which a particular species was recorded divided by the total number of plots (96).
- *Group size* (G). Defined as the sum of the number of individuals divided by the number of observations in which a species was recorded.

Statistical model

A generalized linear mixed model was the starting point for the analysis of the combined (2013, 2014 and 2016) data. We need to account for the non-normal distribution of the counts and the structural components of the survey design. We assume that the counts are drawn from Poisson distributions. The fixed effects explored are *Vegetation Group* (a three-level factor) derived from the *Vegetation type* (see Table 1, Fullagar *et al.*, 2014) and *Year* to test if there has been any detectable change over the 12-month interval between surveys. The random effects include, *Plot*, *Zone*, *Observer* and *Day*, when the survey was performed.

All models were fitted using the R software (R Core Team, 2014) and the packages 'lme4' (Bates *et al.*, 2014) and 'glmmADMB" (Fournier *et al*., 2012; Skaug *et al*., 2013). Confidence intervals were derived from the models using functions from the packages 'lme4', 'glmmADMB' and 'boot' (Canty and Ripley, 2014). In many cases numerical instability of the

parameter estimation prevented fitting of complete models with all fixed terms. In these cases simpler models were fitted.

Due to the difficulty in collecting reliable abundance data for Silvereyes, only presence or absence data are available. Appropriate models fitted to these data assume a binomial error structure and a logit link function.

Transect surveys

The same seven transects covered in September 2013 and 2014 of variable length (ranging from 570 to 970 metres) were walked at a slow pace by a single observer twice (in one direction and then return) on six days. Compared with 2013 and 2014, the number of observers available for the transect surveys was reduced from seven to five. To ensure that all transects were surveyed over at least four days it was necessary to survey over a six-day period. In addition, for two days of the survey one of the team members, who is a resident on the island and not normally available to help with the transects surveys, was able to participate. The transects followed sealed roads. To reduce the variability of speed of travel, each transect was set a specific duration for survey with a walking pace set at 2 km/hr.

Figure 2 provides a map of the Lord Howe Island core settlement area, showing the location of transects A–G. The green pointers indicate junctions, where more than one transect starts or finishes. The yellow pointers indicate transect end points. See Appendix C for a description of the start and finish points for each transect.

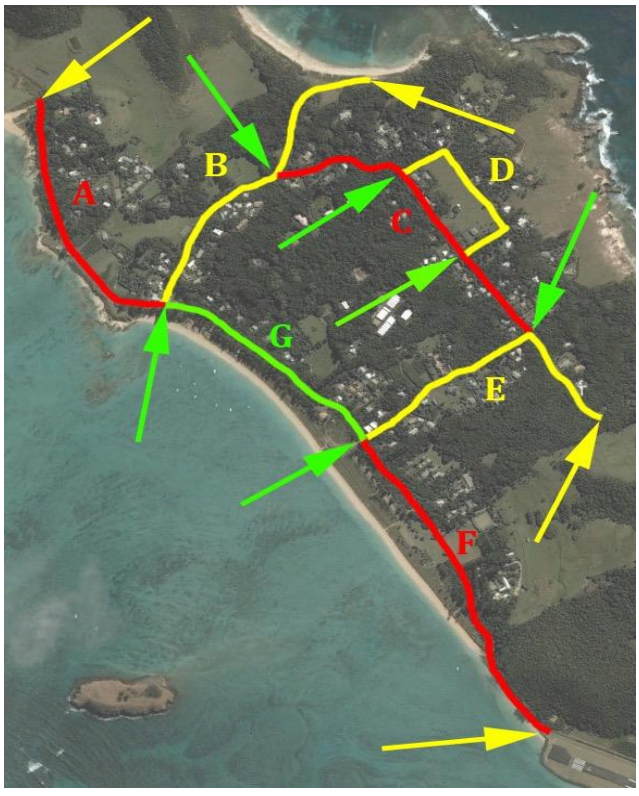


Figure 2. Map of core settlement area, LHI, with location of transects A–G

None of the observers walked the same transects twice, with five observers covering six and one covering two of the seven transects (see Table 2). For practical purposes only six species were targeted for the transect counts. The purpose of the transact counts was to survey most of the ground-feeding species present in the settlement area.

Table 2. Allocation of observers to transects, LHI core settlement, September 2016

Observer	*Transects*						
	A	B	C	D	E	F	G
Ob1	1	1	1	1	0	1	1
Ob2	0	1	1	1	1	1	1
Ob3	1	1	1	1	1	0	1
Ob4	1	0	1	1	1	1	1
Ob5	1	1	1	0	1	1	1
Os6	1	0	0	1	0	0	0
Length (m)	*750*	*970*	*900*	*570*	*820*	*970*	*670*

Note: Observers not necessarily the same for 2013, 2014 and 2016.

Statistical analysis of transect data

There are two groups of potential predictors of the abundance of the observed species. The first group characterizes the observations in terms of physical characteristics of the transect (*Length*), the direction of the traverse (*Out* or *In*) and the duration of the count (*Duration*) or the average speed of travel (*Speed*). These physical characteristics are all connected.

More individuals would be expected to be observed on longer transects, or during longer travel times or slower speeds of travel; there is no *a priori* reason to think that direction of travel should influence the number of individuals observed. Also, in this group is the *Year of observation* which potentially reflects changes over time scales of a year or more. The second group of predictors includes *Observer identity*, *Transect identity* and *Date of observation*.

It is recognized that there are observer differences in terms of ability to detect individuals of different species. It is also recognized that transect differences will favour more individuals on some transects relative to other transects and some days will be better than others for making observations.

We are not primarily interested in the effects of the second group of predictors but may need to account for the variability in observations that can be attributed to these factors.

We do this by considering *Observer identity, Transect identity* and *Date of observation* as random effects. Of the first group *Year of observation* is of primary interest; the others may need to be accounted for to reduce the unexplained variation.

The response variable – the number of individuals per species observed per transect survey – can be considered a Poisson variable where the variance is equal to the mean. To model the observed data we need to fit a Generalized Linear Mixed Model to account for the variance structure of the residuals and the presence of both random and fixed effects. Models were fitted using R (R Core Team, 2014) and the package "lme4" (Bates *et a*l., 2014) and 'glmmADMB" (Fournier *et al*., 2012; Skaug et al., 2013). As for the point data, estimates of the mean number of individuals observed per transect and confidence intervals were derived from parametric bootstrapping techniques based on functions supplied with the package "lme4" and the package "boot" (Canty and Ripley, 2014).

Species names

Species names used in this report follow current preferred internationally accepted nomenclature (see Appendix D). For simplicity, some of the common names have been shortened to conform with island usage.

Survey dates and weather conditions

The 2016 point count survey was conducted between 5 and 10 September with the transect surveys conducted between 4 and 9 September. For the point count surveys, teams were in the field soon after dawn each day and ready to start by about 0600. Teams often worked through until late morning. The time to complete a set of counts varied mostly due to the time taken to reach all allotted count plots. The transect surveys, however, started at 1700 each day.

The weather for both point count and transect surveys was generally ideal with fine and warm conditions and little cloud. Most mornings started cool and overcast but soon cleared to sunny conditions with a light breeze. On 6 and 7 September, conditions remained overcast all day with an occasional light drizzle on the morning of 6 September. On some evenings the higher elevated transects experienced a stronger breeze than the lower transects but this did not interfere with the observations. Some weather observations for the week are shown in Table 3.

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Table 3. Selected daily weather observations, LHI, 4–11 September 2016

Date	*Day*	*Min °C*	*Max °C*	*Rain (mm)*	*Wind Direction*	*Max. wind speed (km/h)*
4	Sun	18.5	20.9	0.0	WSW	44
5	Mon	15.0	20.1	33.4	SSW	43
6	Tue	15.3	20.2	0.4	E	33
7	Wed	16.1	20.4	0.4	E	37
8	Thu	15.8	19.3	0.2	E	41
9	Fri	15.2	18.9	0.0	ENE	56
10	Sat	15.7	20.0	0.0	NNE	44
11	Sun	17.5	21.4	0.0	NNE	57

Source: Bureau of Meteorology website

Results and discussion

Plot counts

The maximum number of times that any one species could be recorded was 288: the sum of 48 count plots with two visits and 48 plots with four visits. Table 4 shows the distribution of the counts in the vegetation groups and habitat zones.

Table 4. No. of counts undertaken in 3 vegetation groups in 5 habitat zones, LHI, 2016

Vegetation group	*Habitat zone*					***Total counts***
	1	*2*	*3*	*4*	*5*	
Lowland forest	72	20	20	8	32	**152**
Palm forest	8	40	4	0	28	**80**
Open	0	32	2	20	2	**56**
Total surveys	**80**	**92**	**26**	**28**	**62**	**288**

Note:
1. For definitions of vegetation group and habitat zone, see Appendix A.
2. Column total for habitat zone 2, Table 3, 2014, should read 112, not 12.

Abundance, reporting rate, frequency and group size

Table 5 shows the abundance, reporting rate, frequency and group size, irrespective of vegetation group or habitat zone, for 21 birds recorded in 96 count plots on Lord Howe Island. The reporting rate is given in descending order.

As occurred in 2013 and again in 2014, the most common bird in terms of reporting rate and abundance was the Golden Whistler. The number of Silvereye individuals in a surveyed plot was difficult to estimate given their flocking behaviour, their often quick passage through the surveyed plots and the fact that they were usually detected only by calls. For the Silvereye, only occurrence was analyzed and no estimate of abundance or group size was possible.

For the 2013, 2014 and 2016 surveys, 24 bird species have been recorded from the plot counts. The Golden Whistler, Silvereye, Blackbird, Magpie-lark, Pied Currawong, Emerald Dove, Buff-banded Rail, Sacred Kingfisher, Swamphen, Woodhen, Masked Lapwing, Song Thrush, and White-faced Heron have been reported from the point counts for each of the three survey years. Welcome Swallow was not observed in 2013 and Feral Pigeon and Feral Duck were not reported in 2014. Starling was reported for 2013 only, Bar-tailed Godwit and Red necked Stint for 2014 only and White Tern, Sooty Tern, Cattle Egret, Kestrel and Whimbrel for 2016 only.

Comparing the indices of the more common species between the three surveys, there appears to be little change for the Golden Whistler, Silvereye, Blackbird, Welcome Swallow, Magpie-lark, Emerald Dove, Song Thrush or White-faced Heron. There does appear to be an increase in the indices of Pied Currawong, and Woodhen and a decline in Swamphen and possibly Masked Lapwing. There was a decrease in the abundance and reporting rate in 2014 for the Buff-banded Rail but these returned to 2013 levels in 2016. There appeared to be a decline in the Sacred Kingfisher in 2016.

Table 5. Abundance, reporting rate, frequency and group size for 21 bird species recorded at 96 plots, LHI, 2016

Species name	*Abundance*	*Reporting rate*	*Frequency*	*Group size*
Golden Whistler	1.49	0.68	0.79	2.17
Silvereye		0.63	0.84	
Pied Currawong	0.43	0.26	0.54	1.62
Blackbird	0.51	0.25	0.42	2.01
Welcome Swallow	0.47	0.20	0.34	2.34
Magpie-lark	0.40	0.19	0.35	2.07
Emerald Dove	0.14	0.13	0.31	1.14
Buff-banded Rail	0.19	0.12	0.22	1.57
Sacred Kingfisher	0.07	0.07	0.17	1.00
Woodhen	0.12	0.07	0.14	1.79
Masked Lapwing	0.05	0.04	0.09	1.36
Swamphen	0.06	0.03	0.05	1.60
Song Thrush	0.04	0.03	0.08	1.10
White Tern	0.08	0.02	0.06	3.67
White-faced Heron	0.01	0.01	0.03	1.00
Feral Duck	0.02	0.01	0.04	1.75
Sooty Tern	1.25	0.01	0.02	120.00
Cattle Egret	0.03	0.01	0.03	3.00
Feral Pigeon	0.01	0.00	0.01	3.00
Kestrel	0.01	0.00	0.01	2.00
Whimbrel	0.01	0.00	0.01	4.00

Table 6 shows the 2016 reporting rate, abundance and frequency for the most commonly reported species – the Golden Whistler, and the two species of greatest concern: the Woodhen and the Pied Currawong. The three indices for observations within the plots are defined by vegetation and habitat zone.

Table 6. Reporting rate, abundance and frequency for the Golden Whistler, Woodhen and Pied Currawong, defined by vegetation group and habitat zone, LHI, 2016

Golden Whistler

	Reporting rate			*Abundance*			*Frequency*		
Vegetation group	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Habitat zone									
1	0.85	0.88		1.49	1.13		0.26	0.02	
2	0.80	0.75	0.00	1.65	2.33	0.00	0.06	0.11	0.00
3	0.95	1.00	0.50	2.10	2.50	1.00	0.08	0.02	0.01
4	0.88		0.25	2.25		0.25	0.04		0.03
5	0.88	0.68	0.00	2.34	1.21	0.00	0.08	0.06	0.00

Woodhen

	Reporting rate			*Abundance*			*Frequency*		
Vegetation group	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Habitat zone									
1	0.00	0.00		0.00	0.00		0.00	0.00	
2	0.00	0.05	0.03	0.00	0.08	0.03	0.00	0.02	0.01
3	0.05	0.00	0.00	0.05	0.00	0.00	0.01	0.00	0.00
4	0.38		0.45	0.88		0.85	0.02		0.04
5	0.03	0.04	0.50	0.03	0.04	1.50	0.01	0.01	0.01

Pied Currawong

	Reporting rate			*Abundance*			*Frequency*		
Vegetation group	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Habitat zone									
1	0.18	0.38		0.24	0.75		0.11	0.02	
2	0.25	0.18	0.06	0.25	0.40	0.06	0.05	0.04	0.02
3	0.50	0.25	0.50	0.70	0.25	1.00	0.05	0.01	0.01
4	0.50		0.10	1.13		0.15	0.04		0.02
5	0.34	0.61	0.00	0.44	1.21	0.00	0.07	0.08	0.00

Note: Empty cells indicate that no vegetation group exists for that habitat zone.

For the Golden Whistler, the highest reporting rate and abundance was in vegetation group 2 (Pasture*/Howea forsterana, Cleistocalyx fullageri*), habitat zone 3 (Transit Hill).

For the Woodhen, the highest reporting rate and abundance was in habitat zone 4 (Suburban) irrespective of vegetation group. The highest reporting rate and abundance for

the Pied Currawong was in habitat zone 5 (South Hills) within vegetation group 2 (*Pasture/Howea forsterana, Cleistocalyx fullageri*).

Generalized linear mixed model

Data from the 2013 and 2014 surveys have been combined with the 2016 data and analyzed. Note that the model for Silvereye is fitted to the presence–absence data while for all other species the model is fitted to the abundance data. The results of the generalized linear mixed model are presented as follows:

- the significance of the fixed effects *Vegetation group* and *Year* and the interaction between these two variables
- the magnitude of the random effects
- the estimated abundances and confidence intervals derived from the appropriate model
- species specific information on issues with the fitting and interpretation of the model.

Table 7 shows the significance of the fixed effects *Vegetation group* and *Year* and their interaction for each of the species for which there are sufficient non-zero observations.

Table 7. Significance of fixed effects Vegetation Group and Year

Species	*Vegetation Group*	*Year*	*Interaction*
Golden Whistler			0.05
Silvereye	<0.001	0.59	0.90
Blackbird			<0.005
Pied Currawong	0.002	0.18	0.11
Magpie-lark	0.64	0.25	019
Welcome Swallow			<0.0001
Sacred Kingfisher	0.56	0.54	0.55
Emerald Dove	<0.001	0.79	NF
Woodhen			0.006
Buff-banded Rail			0.03

Note:
1. NF indicates that the term could not be fitted.
2. An empty cell represents fixed effects that are part of a significant interaction.

The random effects included in the individual species model are summarized in Table 8. Generally two of the random effects, *Plot* and *Habitat Zone,* are larger than the other two sources of variation, *Observer* and *Day*. For example, for the Golden Whistler the largest source of variation from the four random factors is *Habitat Zone*, with *Plot* contributing the next largest amount of variation (Table 8). This pattern is similar for Blackbird, Magpie Lark and Woodhen.

For the other species the pattern tends to be reversed. The two factors that generally contribute least variation, *Observer* and *Day*, are factors that with time and more resources could be manipulated in contrast to *Plot* and *Habitat Zone,* which reflect the environmental variation present across the island and hence are beyond the control of the survey team.

From these two factors, we see two positive features: first, that *Observer* differences are generally not large (perhaps reflecting the generally high level of competency of the selected observers) and, second, that potential effects of weather *(Day)* have not been sufficiently large to impact on the ability to undertake the surveys.

Table 8. Variance estimates for random effects

Species	*Plots*	*Habitat zone*	*Observer*	*Day*
Golden Whistler	0.5009	2.79	0.01861	0.02139
Silvereye	1.989	0.4173	0.8397	0.04516
Blackbird	0.7019	1.698	0.09671	0.06997
Pied Currawong	0.5991	0.1729	0.1374	0.06937
Magpie-lark	0.41908	3.23010	0.09740	0.03512
Welcome Swallow	1.782		0.1111	0.1478
Sacred Kingfisher	0.6301	0.9256	0.1823	0.1132
Emerald Dove	0.3567	0.7839	0.1685	0.1576
Woodhen	0.5009	2.79	0.01861	0.02139
Buff-banded Rail	1.661	44.54	0.07271	0.1118

Note: The empty cell represents an estimate of the variance component that is close to zero.

Table 9 provides an estimated number of individuals found at plots for three vegetation types. For five species, data are significantly different between years. For Silvereye, the estimated values are the probability of observing Silvereye not the number of individuals.

Table 9. Estimated no. of individuals derived from the final fitted model

Species	*Year*	*Vegetation type*		
		Lowland forest	*Palm forest*	*Open*
Golden Whistler	2013	1.93 (1.49 – 2.49)	1.75 (1.18 – 2.59)	0.35 (0.19 – 0.65)
	2014	2.06 (1.49 – 2.83)	1.79 (1.12 – 2.85)	0.18 (0.07 – 0.48)
	2016	1.68 (1.17 – 2.40)	1.68 (1.03 – 2.72)	0.11 (0.03 – 0.41)
Silvereye		0.91 (0.79 – 0.96)	0.88 (0.65 – 0.97)	0.15 (0.04 – 0.44)
Blackbird	2013	0.15 (0.04 – 0.56)	0.17 (0.04 – 0.72)	0.03 (0.01 – 0.14)
	2014	0.19 (0.04 – 0.97)	0.21 (0.04 – 0.97)	0.04 (0.01 – 0.19)
	2016	19 (0.05 – 0.78)	0.21 (0.05 – 1.00)	0.04 (0.01 – 0.19)
Pied Currawong		0.30 (0.17 – 1.42)	0.42 (0.19 – 0.89)	0.05 (0.02 – 0.15)
Magpie-lark		0.10 (0.02 – 0.53)	0.10 (0.02 – 0.53)	0.10 (0.02 – 0.53)
Welcome Swallow	2013	0.02 (0.01 – 0.06)	0.00 (0.00 – 0.04)	1.36 (0.38 – 4.88)
	2014	0.02 (0.00 – 0.09	0.02 (0.00 – 0.56)	1.21 (0.24 – 6.13)
	2016	0.08 (0.02 – 0.30)	0.05 (0.00 – 0.87)	1.44 (0.30 – 6.83)
Sacred Kingfisher		0.04 (0.02 – 0.12)	0.04 (0.02 – 0.12)	0.04 (0.02 – 0.12)
Emerald Dove		0.09 (0.04 – 0.24)	0.13 (0.04 – 0.38)	0.01 (0.00 – 0.03)
Woodhen	2013	0.02 (0.00 – 0.14)	0.05 (0.01 – 0.42)	0.01 (0.00 – 0.09)
	2014	0.03 (0.01 – 0.23)	0.08 (0.01 – 0.99)	0.01 (0.00 – 0.16)
	2016	0.03 (0.00 – 0.25)	0.03 (0.00 – 0.68)	0.05 (0.00 – 0.54)
Buff-banded Rail	2013	0.00 (0.00 – 3.14)	0.00 (0.00 – 1.37)	0.00 (0.00 – 3.60)

	2014	0.00 (0.00 – 1.93)	0.00 (0.00 – 1.64)	0.00 (0.00 – 1.96)
	2016	0.00 (0.00 – 2.05)	0.00 0.00 – 2.29)	0.00 (0.00 – 9.82)

Note: For Silvereye the entries are the probability of recording Silvereye.

Golden Whistler

The interaction between *Year* and *Vegetation group* appears to be significant (see Table 7), but there are numerical issues with the parameter estimation of competing models.

Silvereye

Note that a different mixed model is fitted to the Silvereye data due to the recording of presence or absence, not *Abundance*. The fixed effects interaction and the main effect *Year* were not significant (see Table 7). The probability of recording Silvereye in the forest is nearly four times that of recording it in *Open* vegetation (see Table 9).

Blackbird

There was a significant fixed effect interaction so the two main effects, *Vegetation group* and *Year*, are retained in the model (see Table 7). The predicted number of Blackbird is higher in the forests compared to open country (see Table 9). There appears to have been a slight increase from 2013 to 2014 but no difference between the 2014 and 2016 surveys.

Pied Currawong

Pied Currawong were recorded across all vegetation groups and less abundantly or frequently in the *Open* group (see Table 9). The interaction is not significant and the differences between the three survey years were not significant (see Table 7). The recorded abundance is positively associated with forests compared to that recorded in *Open* habitat.

Magpie-lark

In contrast to the previous report no fixed effects were significant (see Table 7).

Welcome Swallow

The interaction between *Year* and *Vegetation group* is significant (see Table 7). The interaction appears to be driven by the decrease in abundance recorded in *Open* vegetation in 2014 relative to other survey years (see Table 9).

Sacred Kingfisher

The fixed effects appear insignificant (see Table 7) and the overall abundance low across all years and vegetation groups (see Table 9).

Emerald Dove

The interaction and the fixed effect *Year* are significant (see Table 7). The abundance of Emerald Dove in *Open* vegetation is approximately one tenth of that in the forests (see Table 9).

Woodhen
The fixed effects interaction was significant (see Table 7), but the abundances are low and the confidence intervals for the predicted abundances are large (see Table 9). The significant interaction appears to be driven by the observations in 2014 relative to the other years.

Buff-banded Rail

The fixed effects interaction is significant (see Table 7). While it appears that there might be sufficient instances of positive counts of this species, the predicted abundances of zero with varying upper limits suggests that the model does not fully reflect the limited data (see Table 9).

Swamphen
There has been a total of 43 records across the three surveys and consequently no model has been fitted. All records are from *Open* vegetation.

Song Thrush
Only 32 records of Song Thrush have been made from plot observations. No model has been fitted. The vast majority of these records (27) are from the *Palm Forest*.

Masked Lapwing
Thirty-four records of Masked Lapwing have been made. The majority (31) were from *Open* vegetation.

It is recognized that generalized linear mixed models can be difficult to fit even with well-designed and generally balanced surveys. In the present study the number of random effects contributes to the complexity of the models. The small number of individuals recorded at each plot also adds difficulties to the parameter estimation. For some species the estimated confidence intervals are clearly very wide and appear to be well outside the observed data. This reflects some of the complexities of these models. Even with the additional data from the third survey some of these difficulties remain.

A Poisson distribution has been assumed for the error structure. This is a reasonable first approximation. Additional work is needed to explore some alternative error structures and alternative random effects specifications.

In general, the habitat influences appear to be sensible and generally reflect what we know about the biology of the species. In comparison to the previous report and with further data there is a suggested potential difference between years for Welcome Swallow and Emerald Dove with less reliable suggested differences between Buff-banded Rail, Blackbird and Woodhen. All require further exploration and additional observations before it can be suggested that we have detected truly significant differences between years.

To allow for a statistical comparison of the survey data pre- and post-rodent eradication, fixed effects such as vegetation type and year of survey together with random effects such

as plot count, zone, observer and day differences will need to be taken into account. The development of increasingly powerful software for fitting generalized linear mixed models is making the fitting of complex models possible.

Species distribution

Figures 3–6 show the 2016 frequency distribution of 14 species across the lowlands of Lord Howe Island. These distribution maps are based on the relative occurrence of each species derived from the accumulated plot counts. Plot counts have been distributed within a grid pattern extending across the survey area (see Figure 1).

The size of each dot corresponds to the number of times each species is recorded as present within each grid cell. In each cell there are two count plots, giving a possible score of eight if the species is seen on every count in the cell. The smallest dot indicates one or two occurrences, with increasing dot size (doubling in size with each increment) for three or four and five or six occurrences. The largest dot indicates a maximum of seven or eight out of the possible eight counts. An adjusted score was used when only four counts were made in the cell.

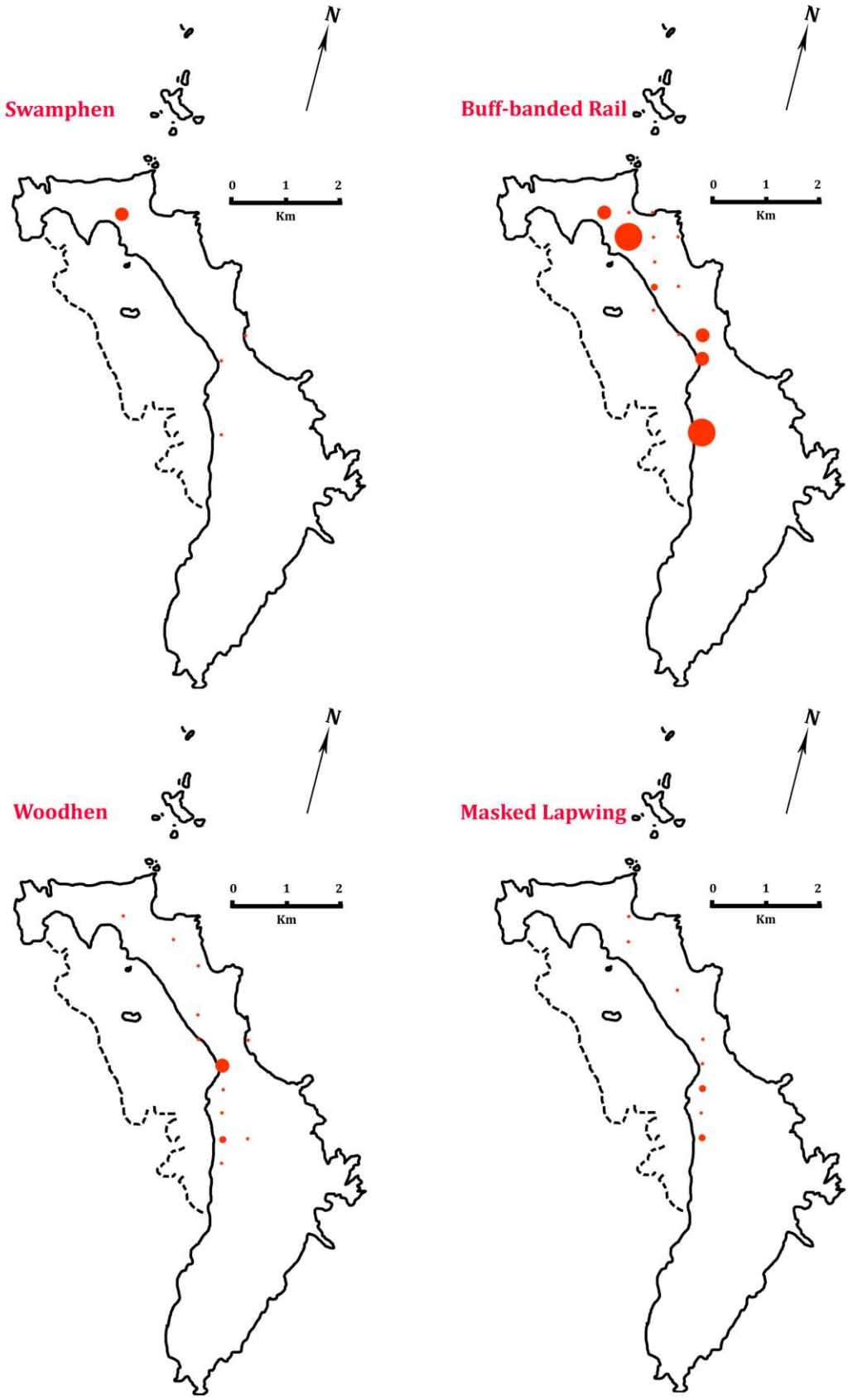


Figure 3. Distribution of Swamphen, Buff-banded Rail, Woodhen and Masked Lapwing, September 2016, northern LHI, by frequency of occurrence at count plots

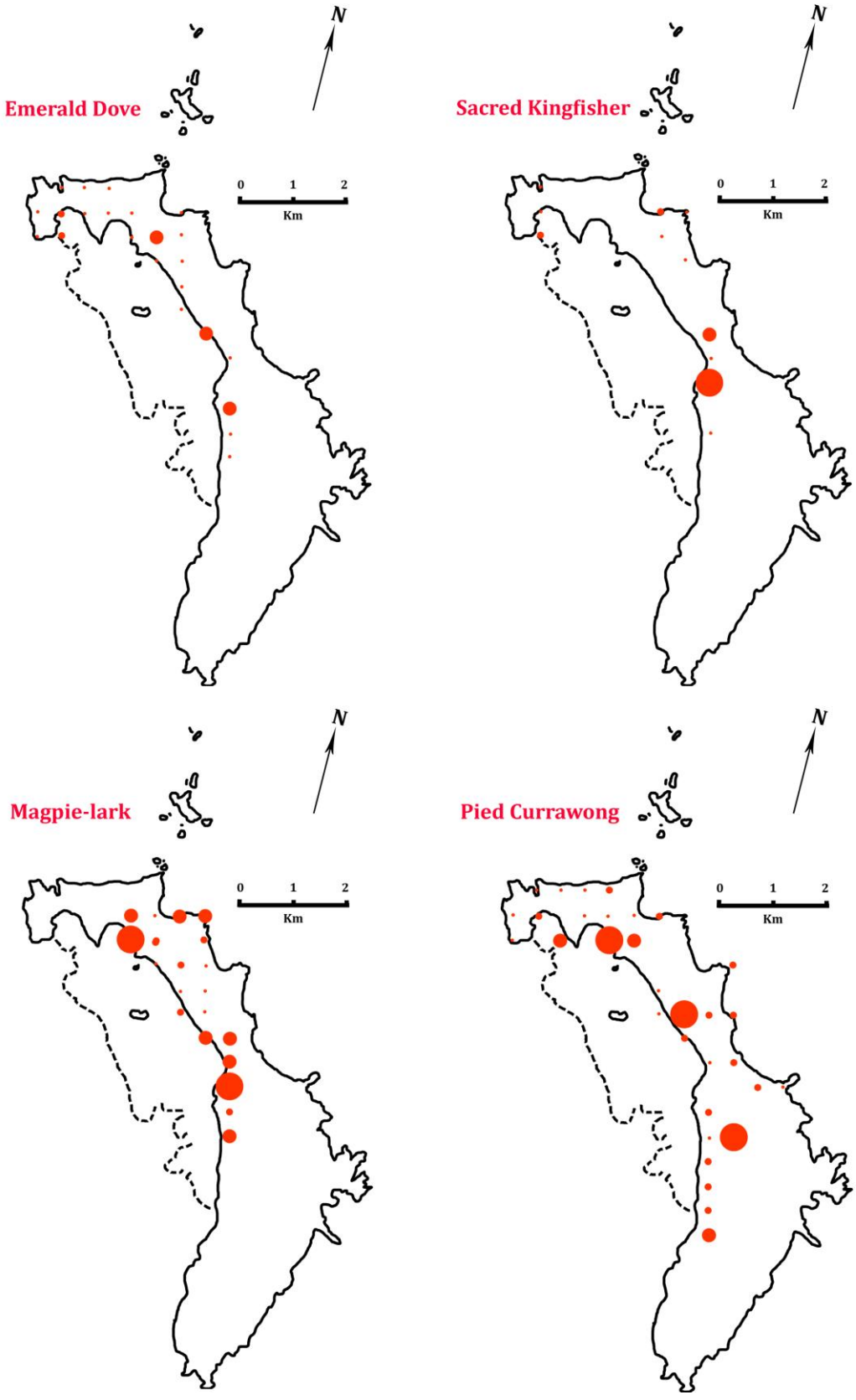


Figure 4. Distribution of Emerald Dove, Sacred Kingfisher, Magpie-lark and Pied Currawong, September 2016, northern LHI, by frequency of occurrence at count plots

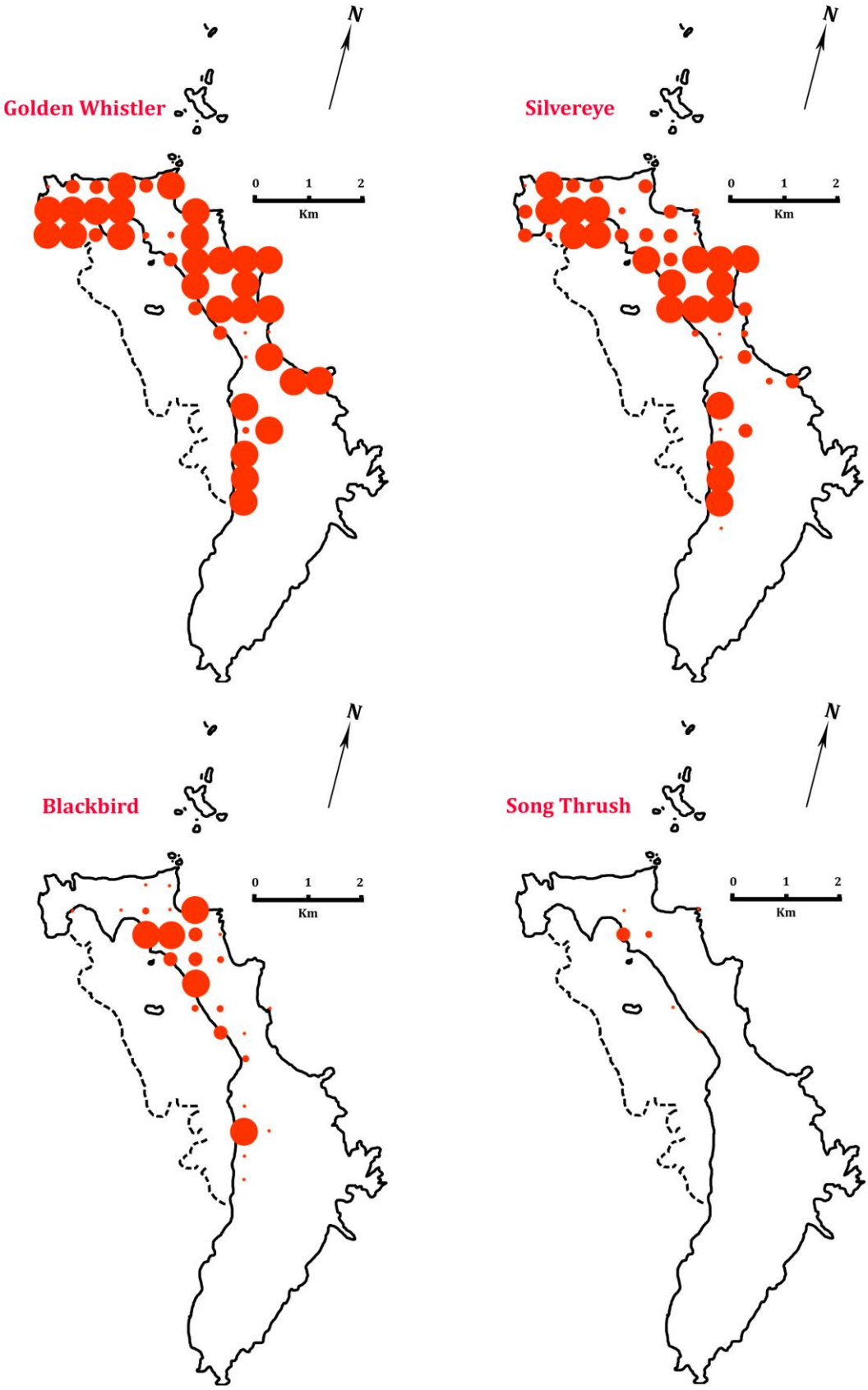


Figure 5. Distribution of Golden Whistler, Silvereye, Blackbird and Song Thrush, September 2016, northern LHI, by frequency of occurrence at count plots

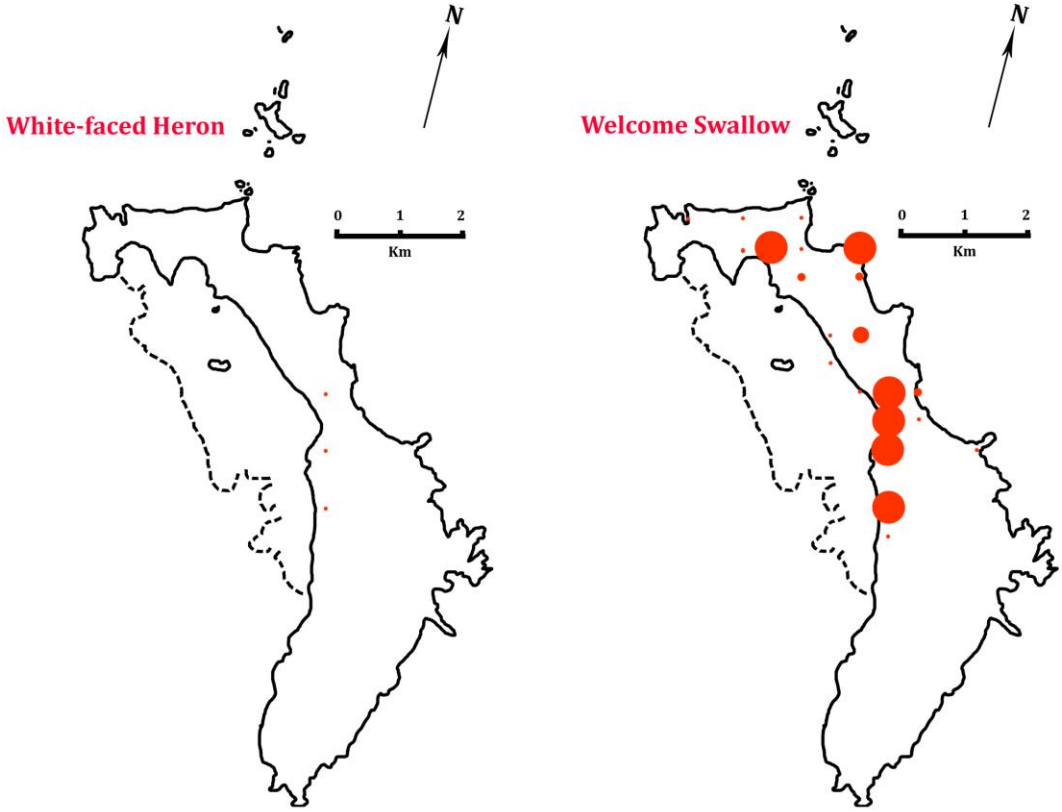


Figure 6. Distribution of White-faced Heron and Welcome Swallow, September 2016, northern LHI, by frequency of occurrence at count plots

Transect counts

In six days, five observers recorded 60 observations with an additional observer surveying on two days giving a total of 64 observations of the numbers of six species on the transects. As the speed of travel may influence the number of individuals counted – the faster the speed the fewer the number observed – the speed of travel for each transect was standardized to 2 km/hr in 2016.

In 2013, before standardization was applied, the average speed was 3.21 km/hr (range 1.94–4.47). In 2014, however, the average speed was 1.90 km/hr (range 1.54–2.16). Consequently, the variance in the speed of travel was significantly reduced (2013 variance 0.42, SD $\pm$ 0.64; 2014 variance 0.01, SD $\pm$ 0.11). The speed of travel in 2016 was similar to that in 2014.

Song Thrush

No main fixed effects are significant (see Table 10). The null model estimates the mean number of individuals per transect as 0.34 (95% confidence interval is 0.19 to 0.62).

Common Blackbird

In contrast to previous years it appears that there are significant differences in the direction of travel and the year of survey (Table 10). Differences between 2013 and 2014 are very small and are consistent with the conclusion in the 2014 report (Fullagar *et al.* 2015) that only direction of travel was significant. However, there was an approximately 50% increase in the numbers of Blackbird seen in 2016 compared to previous surveys (10.3 and 7.5 for the outward and return travel respectively in 2013 and 2014 compared with 15.5 and 11.4 in 2016).

Sacred Kingfisher

There is evidence that *Year* has an effect on the number of individuals observed (see Table 10). The zero number of individuals seen on the outward traverse in 2013 makes fitting of models difficult, and the low number of individuals seen adds to the numerical instability of the parameter estimation. We would be cautious about drawing conclusions about changes over time for this species.

Woodhen

There is no evidence that *Year* or *Direction* are associated with the number of Woodhen recorded (see Table 10). Based on the null model the estimated number of Woodhen per transect is 0.12 (0.04 to 0.32) individuals.

Buff-banded Rail

There is no evidence that *Year* or *Direction* are associated with the number of Buff-banded Rail recorded (see Table 10). The estimated number of individuals per transect is 1.7 (1.0 to 2.8).

Emerald Dove

On their own both *Year* and *Direction* are significant but when both are added to the model parameter estimation is unstable. Direction of travel is very much more significant than the year effects (Table 10). The estimated number of individuals seen per transect on the outward count was 0.87 (0.50 – 1.51) and on the return count 0.35 (0.22 – 0.57) individuals.

Table 10 provides details of the significance of the fixed effects on the number of individuals of target species observed on the transects. The fixed effects were *Year* (2013, 2014, 2016) and *Direction* (out, in).

Table 10. Significance of fixed effects on the no. of individuals of target species observed on transects

Effect	*Song Thrush*	*Common Blackbird*	*Sacred Kingfisher*	*Woodhen*	*Buff-banded Rail*	*Emerald Dove*
Year	0.77	0.03	0.039	0.99	0.80	0.024
Direction	0.82	<0.001	0.062	0.26	0.18	<0.001

For most species there appears to be little difference in the abundance of the primary species recorded on the transects. The notable exception is the Sacred Kingfisher – more individuals were observed in 2014 compared with 2013. It remains one of the least abundant species recorded and, as such, it would be judicious to note the change but not draw inferences about annual variation at this stage.

The dense vegetation over much of the island makes it difficult to see and hence record the abundance of many species of birds. Many observations are therefore based on assessing bird presence through their vocalizations, whether these be calls or song. Vocalisations can vary with the season and time of day. Although the breeding season can vary slightly from year to year we allow for this variation by surveying at the same time each year. This variation may account for some of the small changes in the summary indices from survey to survey.

Bird atlas data

Between 29 January 2015 and 30 September 2016 there were 549 records entered on the Birdlife Australia database. These observations comprised 58 surveys from 23 sites. None of the 25 official BLA surveyed sites (LHI01-LHI25) were surveyed by our teams. The survey protocol for the non-official sites is unknown, with many counts simply designated “Lord Howe Island”. The average number of surveys per site was 2.5 with the highest from Lord Howe Island/Somerset House (*n*=14).

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References

Bates D, Maechler M, Bolker B and Walker S. (2014). lme4: Linear mixed-effects models using Eigen and S4. R package version 1.1-7, URL: http://CRAN.R-project.org/ package=lme4'.

Bibby, C J, Burgess, N D & Hill, D A (1997). *Bird Census Techniques*. Academic Press: Sydney.

Canty, A & Ripley, B (2014). boot: Bootstrap R (S-Plus) Functions. R package version 1.3-11.

Cunningham, R & Olsen, P (2009). A statistical methodology for tracking long-term change in reporting rates from volunteer-collected presence-absence data. *Biodiversity and Conservation*, **18**, 1305-1327.

Fournier D A, Skaug H J, Ancheta J, Ianelli J, Magnusson A, Maunder M, Nielsen A and Sibert J (2012). AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optim. Methods Softw., 27, 233-249.

Fullagar, P J, Davey, C, Nicholls, A O & Hutton, I (2014). Landbirds on Lord Howe Island, NSW Survey report 1, September 2013. Unpublished report, Canberra Ornithologists Group.

Fullagar, P J, Davey, C, Nicholls, A O & Hutton, I (2015). Landbirds on Lord Howe Island, NSW Survey report 2, September 2014. Unpublished report, Canberra Ornithologists Group.

Gill, F & Wright, M (2006). *Birds of the World. Recommended English Names*. Christopher Helm: London. [latest version: Gill, F & D Donsker (Eds). 2013. IOC World Bird List (v 3.5). doi : 10.14344/IOC.ML.3.5 on line at: http://www.worldbirdnames.org]

Skaug H, Fournier D, Nielsen A, Magnusson A and Bolker B (2013). Generalized Linear Mixed Models using AD Model Builder. R package version 0.7.7. ($Date: 2013-07-16 13:52:38 -0400 (Tue, 16 Jul 2013) $).

R Core Team. (2015). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: http://www.R-project.org/.

APPENDIXES

Appendix A. Vegetation and habitat classifications of all 96 surveyed plots, LHI

Vegetation type	*Vegetation code*	*Vegetation group*	*No. of sites*
Drypetes australasica/Cryptocarya triplinervis	1	1	42
Drypetes australasica/Cryptocarya triplinervis (calcarenite variant)	2	1	1
Drypetes australasica/Cryptocarya triplinervis (exposed variant)	3	1	7
Cassinia tenuifolia-Poa poiformis	4	1	2
Howea forsterana	5	2	22
Pasture	6	3	14
Dune	7	3	2
Golf course	8	3	2
Cleistocalyx fullageri	9	2	2
Pasture/*Howea forsterana*	10	2	2

Note: Calcarenite and exposed variants are treated as one type – giving a total of four paired sites.

Habitat zones	*Habitat zone code*	*No. of sites*
North Hills	1	28
Settlement	2	28
Transit Hill	3	11
Suburban	4	12
South Hills	5	17

Appendix B. Geolocation, vegetation code, vegetation group, habitat zone and number of counts for all 96 surveyed plots, LHI

	Geolocation		*Vegetation*	*Vegetation*	*Habitat*	*No. of*
Plot number	*Latitude*	*Longitude*	*code*	*group*	*zone*	*counts*
1	31 31 09.2	159 02 27.8	1	1	1	2
2	31 31 06.7	159 02 25.2	1	1	1	2
3	31 31 16.8	159 02 31.0	1	1	1	2
4	31 31 12.8	159 02 31.0	1	1	1	2
5	31 31 05.8	159 02 21.4	1	1	1	2
6	31 31 04.3	159 02 24.7	1	1	1	2
7	31 31 00.4	159 02 24.8	4	1	1	2
8	31 30 56.9	159 02 23.0	4	1	1	2
9	31 31 01.2	159 02 31.7	5	2	1	4
10	31 31 00.3	159 02 37.3	5	2	1	4
11	31 30 57.4	159 02 39.8	1	1	1	4
12	31 30 54.7	159 02 37.3	1	1	1	4
13	31 30 56.1	159 02 56.5	1	1	1	4
14	31 30 52.9	159 02 57.7	1	1	1	4
15	31 30 52.2	159 03 04.4	1	1	1	4
16	31 30 50.1	159 03 01.6	1	1	1	4
17	31 30 58.3	159 03 05.2	1	1	1	2
18	31 31 02.9	159 03 09.0	1	1	1	2
19	31 31 00.1	159 02 52.7	1	1	1	2
20	31 31 02.4	159 02 55.7	1	1	1	2
21	31 31 02.0	159 03 03.4	1	1	1	2
22	31 30 59.3	159 03 01.0	1	1	1	2
23	31 31 08.1	159 03 11.3	3	1	1	2
24	31 31 11.0	159 03 09.1	3	1	1	2
25	31 30 49.1	159 03 21.5	1	1	1	4
26	31 30 49.3	159 03 25.8	1	1	1	4
27	31 30 52.9	159 03 39.6	3	1	1	4
28	31 30 49.6	159 03 39.7	3	1	1	4
29	31 31 08.1	159 03 46.4	6	3	2	4
30	31 31 10.9	159 03 44.0	6	3	2	4
31	31 31 06.0	159 03 34.4	6	3	2	4
32	31 31 05.8	159 03 30.4	6	3	2	4
33	31 31 15.7	159 03 29.5	5	2	2	2
34	31 31 18.7	159 03 30.1	5	2	2	2
35	31 31 23.8	159 03 44.6	5	2	2	2
36	31 31 21.3	159 03 47.0	5	2	2	2
37	31 31 09.8	159 04 04.7	1	1	2	2
38	31 31 07.1	159 04 09.1	1	1	2	2
39	31 31 08.9	159 04 19.2	10	2	2	2
40	31 31 12.1	159 04 16.3	10	2	2	2

41	31 31 17.1	159 04 18.9	6	3	2	4
42	31 31 21.3	159 04 18.9	6	3	2	4
43	31 31 19.1	159 04 01.0	5	2	2	4
44	31 31 22.4	159 03 59.4	5	2	2	4
45	31 31 29.0	159 04 06.3	5	2	2	4
46	31 31 32.2	159 04 10.4	5	2	2	4
47	31 31 33.6	159 03 51.2	5	2	2	4
48	31 31 28.1	159 03 50.3	5	2	2	4
49	31 31 32.1	159 04 21.7	5	2	2	2
50	31 31 35.6	159 04 23.8	5	2	2	2
51	31 31 42.3	159 04 39.5	5	2	3	2
52	31 31 40.1	159 04 44.2	5	2	3	2
53	31 31 51.2	159 04 33.4	1	1	3	2
54	31 31 53.3	159 04 36.4	1	1	3	2
55	31 31 52.2	159 04 22.9	6	3	2	4
56	31 31 53.9	159 04 18.5	6	3	2	4
57	31 31 58.8	159 04 10.6	1	1	2	4
58	31 31 55.4	159 04 07.2	1	1	2	4
59	31 31 48.6	159 04 04.5	1	1	2	4
60	31 31 45.4	159 04 01.5	1	1	2	4
61	31 32 07.3	159 04 20.4	1	1	3	4
62	31 32 07.6	159 04 23.4	1	1	3	4
63	31 32 21.0	159 04 29.5	1	1	4	2
64	31 32 24.7	159 04 34.6	1	1	4	2
65	31 32 18.5	159 04 40.1	6	3	4	2
66	31 32 20.2	159 04 45.1	6	3	4	2
67	31 31 59.9	159 04 37.7	3	1	3	2
68	31 32 03.4	159 04 38.6	3	1	3	2
69	31 32 07.8	159 04 49.6	3	1	3	2
70	31 32 10.8	159 04 53.1	2	1	3	2
71	31 32 17.2	159 04 50.3	7	3	3	2
72	31 32 32.4	159 04 59.4	7	3	5	2
73	31 33 05.1	159 04 32.3	6	3	4	2
74	31 33 03.1	159 04 37.5	6	3	4	2
75	31 33 09.8	159 04 58.1	9	2	5	2
76	31 33 09.4	159 04 54.4	9	2	5	2
77	31 33 19.0	159 04 43.9	1	1	5	4
78	31 33 23.4	159 04 40.5	1	1	5	4
79	31 33 30.9	159 04 36.9	5	2	5	4
80	31 33 34.5	159 04 35.8	5	2	5	4
81	31 33 43.6	159 04 34.2	5	2	5	4
82	31 33 40.6	159 04 35.3	5	2	5	4
83	31 33 58.0	159 04 32.9	5	2	5	4
84	31 34 03.2	159 04 31.5	5	2	5	4
85	31 32 33.6	159 04 40.9	6	3	4	4

86	31 32 33.2	159 04 45.6	6	3	4	4
87	31 32 46.7	159 04 40.5	8	3	4	2
88	31 32 43.4	159 04 41.5	8	3	4	2
89	31 32 52.0	159 04 42.0	1	1	4	2
90	31 32 55.1	159 04 39.7	1	1	4	2
91	31 32 37.4	159 04 54.2	1	1	5	4
92	31 32 37.7	159 04 57.7	1	1	5	4
93	31 32 42.3	159 05 06.2	1	1	5	4
94	31 32 43.9	159 05 10.7	1	1	5	4
95	31 32 49.3	159 05 26.8	1	1	5	4
96	31 32 52.7	159 05 27.4	1	1	5	4

Note: Plot 19 was moved for the 2014 survey due to access problems but, because of an oversight, plot 20 was not moved, leaving a distance of 223 metres between plots. For the 2016 survey, plot 20 was moved to allow a distance of approximately 100 metres between paired plots.

Appendix C. Description of start point and turning point for all transects (A–G)

See Figure 2 for a map of the Lord Howe Island settlement area showing the seven transects. The protocol for these transect counts is included below.

Description of each transect location

A. Intersection of Neds Beach Road and Lagoon Road to the bridge at Old Settlement Creek.

B. Intersection of Neds Beach Road and Lagoon Road to Neds Beach bathing huts.

C. Intersection of Anderson Road and Neds Beach Road to the corner at the top of Middle Beach Road.

D. Intersection of Anderson Road and Muttonbird Drive up to and along Skyline Drive down McGees Parade to the intersection with Anderson Road.

E. Intersection of Middle Beach Road and Lagoon Road up Middle Beach Road to Anderson Road turning right (S) and down Anderson Road to Bowker Avenue walking track (which is a little difficult to see but is on the W or right hand side of the road and marked by a small triangular trail marker).

F. Intersection of Middle Beach Road and Lagoon Road to the gate at the corner of the air-field at Windy Point.

G. Intersection of Neds Beach Road with Lagoon Road to the intersection of Middle Beach Road and Lagoon Road (beside the LHI Museum).

Protocol for transect counts

1. Count only the six species of birds (Buff-banded Rail, Woodhen, Sacred Kingfisher, Emerald Dove, Blackbird and Song Thrush). Include all seen or heard on a slow walk from the defined start point to the defined finish point (outward count) and, as a new count, on the return walk to the start point (return count). Keep these two counts separate.

2. Count in the evening not before 17:00 in September.

3. Indicate which transect you have counted and include your name and the date.

4. Record the start and finish time for your outward count and your return count.

5. Count all individuals you detect both sides of the road. There is no particular limit on distance but it would be reasonable not to include calls from birds or sightings that are, say, more than 25 metres from the roadside. Do not worry that you might count the same individual or individuals that could have been be seen on another transect at the transect intersections. Just include them as part of your transect count, if you spot them.

Appendix D. Bird species recorded at 96 surveyed plots, LHI, 2016

Species nomenclature and names follow those recommended by the latest IOC listing (see Gill and Wright, 2006, revised 2013 as version 3.5). For some species we use a simplified alternative in this report.

Name used in this report	*IOC recommended name, if different*	*Scientific name*	*Subspecies*
Feral Duck[1]	[Mallard]	*Anas platyrhynchos*	
Cattle Egret	Eastern Cattle Egret	*Bubulcus coromandus*	
White-faced Heron		*Egretta novaehollandae*	
Woodhen	Lord Howe Woodhen	*Gallirallus sylvestris*	
Buff-banded Rail		*Gallirallus philippensis*	
Swamphen	Australasian Swamphen	*Porphyrio melanotus*	
Masked Lapwing		*Vanellus miles*	*novaehollandi-ae*
Bar-tailed Godwit		*Limosa lapponica*	
Whimbrel		*Numenius phaeopus*	
Red-necked Stint		*Calidris ruficollis*	
White Tern[2]		*Gygis alba*	*candida*
Sooty Tern[2]		*Onychprion fuscatus*	*kermadeci*
Feral Pigeon	[Rock Dove]	*Columba livia*	
Emerald Dove	Pacific Emerald Dove	*Chalcophaps longirostris*	*rogersi*
Sacred Kingfisher		*Todiramphus sanctus*	*vagans*
Kestrel	Nankeen Kestrel	*Falco cenchroides*	*cenchroides*
Pied Currawong		*Strepera graculina*	*crissalis*[3]
Golden Whistler	Australian Golden Whistler	*Pachycephala pectoralis*	*contempta*[3]
Magpie-lark		*Grallina cyanoleuca*	*cyanoleuca*
Welcome Swallow		*Hirundo neoxena*	*neoxena*
Silvereye		*Zosterops lateralis*	*tephropleurus*[3]
Starling	Common Starling	*Sturnus vulgaris*	
Blackbird	Common Blackbird	*Turdus merula*	
Song Thrush		*Turdus philomelos*	

Note:
1. Includes hybrids with Pacific Black Duck, *Anas superciliosa*
2. Seabirds, so not analysed
3. Endemic subspecies