Landbirds on Lord Howe Island, NSW

Survey report 5

September 2018



Prepared for the Lord Howe Island Board

by the Canberra Ornithologists Group

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March 2019

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Summary

This report describes a survey in September 2018 of landbirds on Lord Howe Island conducted by the Canberra Ornithologists Group (COG). The survey was the fifth 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 2019 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. Plot 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 six 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, four teams of two observers surveyed all paired plots in three days with all of the plots resurveyed over the following three days.

The mean abundance, mean reporting rate, frequency and group size for each of the 22 species recorded during the plot survey were calculated. In addition, the 13 species were analyzed using generalized linear mixed models, 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, 2014, 2016 and 2017.

From the 2013, 2014, 2016, 2017 and 2018 surveys, 26 bird species have been recorded from the plot counts. The White-faced Heron, Woodhen, Buff-banded Rail, Swamphen, Masked Lapwing, Emerald Dove, Sacred Kingfisher, Pied Currawong, Golden Whistler, Magpie-lark, Silvereye, Blackbird and Song Thrush have been reported from the counts for each of the survey years. Feral Duck and Feral Pigeon were not reported for 2014. Whimbrel has been reported in 2016, 2017 and 2018. Starling was reported only for 2013 and 2018, Bar-tailed Godwit for 2014 and 2018, Cattle Egret for 2016 and 2017 with Red-necked Stint for 2014 only and Golden Plover and Double-banded Plover new for 2018.

Comparing the reporting rate of the more common species between 2017 and 2018 there appears to have been an increase in many species including the Woodhen, Buff-banded Rail, Masked Lapwing, Emerald Dove, Sacred Kingfisher, Golden Whistler, Silvereye and Blackbird, with a decrease in the Welcome Swallow and little change for the remaining species. The Golden Whistler followed by the Silvereye continues to be the most common species.

In general, where the habitat influences are included in the generalized linear mixed models they appear to be sensible and generally reflect what we know about the biology of the species. In comparison to the previous reports, and with additional data, there is less potential difference between years than was noted for last year's report. Additional modelling may be necessary to clarify if this is a general result.

For the transect surveys, and with the additional year of survey, of the six species reported here four, Emerald Dove, Sacred Kingfisher, Song Thrush and Woodhen now show evidence of differences between the years of survey and the models suggest that the current survey effort is able to detect changes over time. The interpretation of the apparent influence of the direction of travel along the transects needs further analysis but would appear to be driven by the period of the traverse relative to sunset. Emerald Dove and Sacred Kingfisher abundances are significantly higher for the return traverse compared to the outward count. This is in contrast to the Blackbird where the outwards count yields large number of individuals recorded. For the 2018 survey an additional observer surveyed all transects in reverse, with two observers starting at opposite ends of the transect. Also, the additional observer surveyed transects in the early morning on six days.

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 2019.

Introduction

This report describes a survey in September 2018 of landbirds on Lord Howe Island (latitude 31° 33´S and longitude 159° 05´E). The survey was the fifth 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, 2014, 2016 and 2017 have been reported (Fullagar *et al*., 2014, Fullagar *et al*., 2015, Fullagar *et al*., 2017, Fullagar *et al*., 2018).

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 2019.

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 land-based visitors. 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. Plot 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

As previously this report clarifies some terms used in some past reports by renaming them and by defining the term ‘survey’:

- **count –** data collected by a single observer from a single plot or traverse of a 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, a minimum of 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 or traverse of a transect and the number present (seen/heard).
- **survey** – recorded observations for a given period on the island; usually seven days.

Choice of 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).

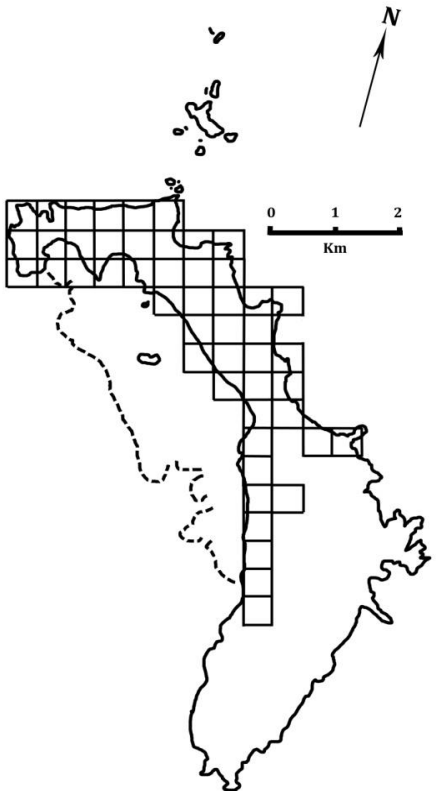


Figure 1. Grid cells, based on plot counts, used for surveying distribution of landbirds on LHI, September 2018

The same 48 grid cells (see Figure 1) used in 2013, 2014, 2016 and in 2017 were surveyed again in 2018, and each grid cell was allocated two count plots. The 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 Appendix A. 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 rodent eradication took place.

Plot count protocol

Our protocol involved four teams of two observers surveying over six days. Surveying was restricted to between sunrise and late morning and, as in 2014, 2016 and 2017, each team surveyed eight plots per day. All 96 plots were surveyed in three days with a repeat of all plots over the following three days. Due to windy conditions on 16 September not all plots were surveyed resulting in 3 plots being surveyed on 3 occasions and 4 plots on 2 occasions giving a total of 373 plot counts.

The paired plots were a minimum of 100 m apart and similar in topography and vegetation. See Appendix B for plot details of geolocation, vegetation and habitat type and number of surveys for each of the 96 surveyed plots.

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.

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 plot count at the exact pre-determined point. Observers were requested to plot count as near as they could to the allocated point. On arrival a waypoint reading was taken of the actual point of the plot and subsequently compared with the allocated central point of the plot. The average distance between these two locations was seven metres, a slight improvement compared with the 2017 survey, so the plot count 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 (373).
- Mean reporting rate (R). Defined as the number of recorded occurrences divided by the total number of observations (373).
- 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 of plot counts

A generalized linear mixed model was the starting point for the analysis of the combined (2013, 2014, 2016, 2017 and 2018) data. We have accounted 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 Appendix A), year and starting time (the recorded time of the start of the plot count), primarily to test if there has been any detectable change over the 12-month intervals between surveys. The random effects include plot, observer and day when the survey was performed. In previous years we have included zone as a random factor but current advice is that factors with few levels could be better treated as a fixed effect. This course of action has been followed here.

All models were fitted using the R software (R Core Team, 2015) and the package 'lme4' (Bates *et al.*, 2014). Where possible, confidence intervals were derived from the models using functions from the 'lme4' package. In some 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 Silvereye, 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, 2014, 2016, 2017 and 2018 of variable length (ranging from 570 to 970 metres) were walked at a slow pace by a single observer twice – in one direction (out) and then return (in) – in the evening on six days. As with 2013 and 2014, seven observers were available for the transect surveys. See Fullagar *et al.* 2017 for details of the 2016 transect survey and Fullagar *et al*. 2018 for the 2017 transect survey. For the 2018 survey an additional observer surveyed all transects in reverse, with two observers starting at opposite ends of the transect. Also, the additional observer surveyed transects in the early morning on six days. 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.

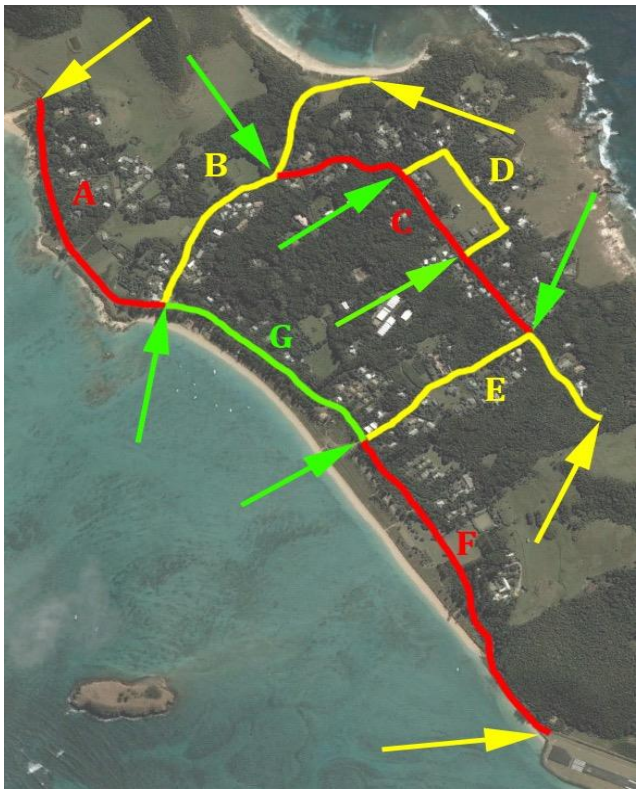


Figure 2. Map of core settlement area, LHI, with location of transects (A–G)

None of the observers walked the same transects twice, with seven observers covering six of the seven transects (see Table 1). An additional observer covered six transects in both evening and morning. 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 1. Allocation of observers to transects, LHI core settlement, September 2018

Observer	*Transects*						
	A	B	C	D	E	F	G
Ob1	1	1	0	1	1	1	1
Ob2	1	1	1	0	1	1	1
Ob3	1	1	1	1	0	1	1
Ob4	1	1	1	1	1	0	1
Ob5	1	1	1	1	1	1	0
Ob6	0	1	1	1	1	1	1
Ob7	1	0	1	1	1	1	1
Ob8*	1	1	1	1	0	1	1
Ob8**	1	1	1	1	0	1	1
Length (m)	*750*	*970*	*900*	*570*	*820*	*970*	*670*

Note: Observers not necessarily the same for 2013, 2014, 2016 and 2017.
* Additional observer (see page 4 for details).
** Additional observer for morning count (see page 4 for details).

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 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 generalized linear mixed models 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, 2015) and the package 'lme4' (Bates *et al.*, 2014). 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 flight from Sydney to Lord Howe Island was cancelled for 24 hours due to high winds on the island. The start of the survey was delayed for one day but a spare morning on the 17 September before the afternoon departure flight allowed both the point count and the transect surveys to be completed.

The 2018 plot counts were surveyed between 12 and 17 September with the transect surveys conducted between 11 and 16 September, and the final morning transect survey conducted on 17 September. For the point count surveys, teams were in the field soon after dawn each day and ready to start by about 06:00. 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 evening transect surveys, however, started at 17:00 each day with the morning surveys starting at 6:30.

The weather for the point counts was generally cool with slight winds clearing to sunny conditions on most days. On the morning of the 16th there was a frontal passage which brought windy conditions resulting in 11 of the 384 plots not being surveyed.

For the evening transect counts the weather was generally fine but with breezy to strong winds at times on all days. The passage of the front on the 16th produced windy conditions on all transects. Some weather observations for the week are shown in Table 2.

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Table 2. Selected daily weather observations, LHI, 11–17 September 2018

Date	*Day*	*Min °C*	*Max °C*	*Rain (mm)*	*Wind Direction*	*Max. wind speed (km/h)*
11	Tue	15.5	19.4	23.0	SSW	59
12	Wed	12.7	19.4	0.0	ENE	33
13	Thu	15.9	20.8	0.0	NNE	37
14	Fri	16.0	20.6	0.0	NE	33
15	Sat	17.3	21.8	0.0	NNE	48
16	Sun	18.4	21.6	0.0	SSW	57
17	Mon	13.4	18.1	0.0	SSW	52

Source: Bureau of Meteorology website

Results and discussion

Plot counts

The maximum number of times that any one species could be recorded was 373: the sum of 88 plots with four plot counts, 3 plots with 3 counts and 4 plots with 2 counts. Table 3 shows the distribution of the counts in the vegetation groups and habitat zones.

Table 3. No. of counts undertaken in 3 vegetation groups in 5 habitat zones, LHI, 2018

Vegetation group	*Habitat zone*					***Total counts***
	1	*2*	*3*	*4*	*5*	
Lowland forest	93	24	32	16	32	**197**
Palm forest	8	56	8	0	32	**104**
Open	0	32	4	32	4	**72**
Total surveys	**101**	**112**	**44**	**48**	**68**	**373**

Note: For definitions of vegetation group and habitat zone, see Appendix A.

Abundance, reporting rate, frequency and group size

Table 4 shows the abundance, reporting rate, frequency and group size, irrespective of vegetation group or habitat zone, for 22 birds recorded in 96 plots on Lord Howe Island during the 2018 Survey. The species are listed in decreasing order of reporting rate.

As occurred in 2013, 2014, 2016 and again in 2017, the most common bird in terms of reporting rate and abundance was the Golden Whistler. The number of Silvereye individuals on a plot was difficult to estimate given their flocking behaviour, their often quick passage through the 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, 2016, 2017 and 2018 surveys, 26 bird species have been recorded from the plot counts. The White-faced Heron, Woodhen, Buff-banded Rail, Swamphen, Masked Lapwing, Emerald Dove, Sacred Kingfisher, Pied Currawong, Golden Whistler, Magpie-lark, Silvereye, Blackbird and Song Thrush have been reported from the counts for each of the survey years. Feral Duck and Feral Pigeon were not reported for 2014. Whimbrel has been reported in 2016, 2017 and 2018. Starling was reported for 2013 and 2018 only, Bar-tailed Godwit for 2014 and 2018, Cattle Egret for 2016 and 2017 with Red-necked Stint for 2014 only and Golden Plover and Double-banded Plover new for 2018.

Comparing the reporting rate of the more common species between 2017 and 2018 there appears to have been an increase in many species including the Woodhen, Buff-banded Rail, Masked Lapwing, Emerald Dove, Sacred Kingfisher, Golden Whistler, Silvereye and Blackbird, with a decrease in the Welcome Swallow and little change for the remaining species.

Table 4. Abundance, reporting rate, frequency and group size for 22 bird species recorded at 96 plots, LHI, 2018

Species name	*Abundance*	*Reporting rate*	*Frequency*	*Group size*
Golden Whistler	1.78	0.75	0.89	2.38
Silvereye		0.70	0.88	
Pied Currawong	0.55	0.30	0.56	1.83
Blackbird	0.59	0.29	0.52	2.02
Magpie-lark	0.41	0.20	0.32	2.04
Welcome Swallow	0.62	0.19	0.31	3.32
Sacred Kingfisher	0.17	0.14	0.36	1.23
Emerald Dove	0.16	0.13	0.34	1.30
Buff-banded Rail	0.17	0.10	0.25	1.64
Woodhen	0.07	0.08	0.17	1.17
Masked Lapwing	0.06	0.04	0.07	1.71
Golden Plover	0.25	0.03	0.05	7.08
Song Thrush	0.03	0.03	0.08	1.08
White-faced Heron	0.03	0.02	0.07	1.11
Starling	0.06	0.02	0.06	2.63
Feral Duck	0.03	0.02	0.04	1.86
Swamphen	0.05	0.01	0.03	4.25
Feral Pigeon	0.02	0.01	0.03	2.00
Whimbrel	0.01	<0.01	0.01	4.00
Bar-tailed Godwit	0.01	<0.01	0.01	2.00
Kestrel	<0.01	<0.01	0.01	1.00
Double-banded Plover	<0.01	<0.01	0.01	1.00

Table 5 shows the 2018 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 5. Reporting rate, abundance and frequency for the Golden Whistler, Woodhen and Pied Currawong, defined by vegetation group and habitat zone, LHI, 2018

Golden Whistler

	Reporting rate			*Abundance*			*Frequency*		
Vegetation group	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Habitat zone									
1	0.90	0.63		2.20	1.38		0.27	0.02	
2	1.00	0.82	0.09	2.75	1.75	0.09	0.06	0.15	0.03
3	0.94	0.88	0.25	2.44	2.25	0.25	0.08	0.02	0.01
4	0.94		0.22	2.38		0.25	0.04		0.04
5	0.94	0.88	0.00	2.31	2.06	0.00	0.08	0.07	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	0.04	0.00	0.00	0.04	0.00	0.00	0.02	0.00
3	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.01
4	0.25		0.28	0.25		0.38	0.02		0.06
5	0.09	0.13	0.00	0.09	0.16	0.00	0.02	0.03	0.00

Pied Currawong

	Reporting rate			*Abundance*			*Frequency*		
Vegetation group	*1*	*2*	*3*	*1*	*2*	*3*	*1*	*2*	*3*
Habitat zone									
1	0.30	0.00		0.38	0.00		0.18	0.00	
2	0.13	0.11	0.00	0.13	0.23	0.00	0.03	0.05	0.00
3	0.53	0.38	0.00	0.78	0.63	0.00	0.07	0.01	0.00
4	0.63		0.16	1.81		0.53	0.04		0.02
5	0.44	0.78	0.00	0.78	1.59	0.00	0.07	0.08	0.01

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 groups 1 (*Drypetes, Cassinia-poa*) and 2 (Pasture*/Howea forsterana, Syzygium fullagarii*), and habitat zone 2 (Settlement) c.f. 2017 habitat zone 3 (Transit Hill).

For the Woodhen there were no sightings in habitat zone 1 (North Hills), with the highest reporting rate and abundance in vegetation group 1 (*Drypetes/Cryptocarya*) and vegetation group 3 (Drypetes/Cryptocarya exposed variant) and habitat zone 4 (Suburban). Similar to last year the highest reporting rate and abundance for the Pied Currawong was in habitat zone 5 (South Hills) within vegetation group 2 (*Pasture/Howea forsterana, Syzygium fullagarii*) and in habitat zone 4 (Suburban), vegetation group 1 (*Drypetes/Crypyocarya*).

Generalized linear mixed models

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 fifth survey in 2018 some of these difficulties remain.

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, 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 more complex models possible.

Data from the five surveys, 2013, 2014, 2016, 2017 and 2018 were combined 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 models are summarized as follows:

- the significant fixed effects are listed for each species,
- the magnitude of the random effects are described,
- the estimated abundances and where possible the confidence intervals derived from the appropriate model are graphically presented and
- species specific information on issues is described with the fitting and interpretation of the model.

The fixed effects, zone and vegetation group, are significantly associated with five of the 13 species for which generalized linear mixed models were fitted and tested. No species showed significant differences between years. The abundance of these species were associated with the starting time of the plot count, with three – Buff-banded Rail, Swamphen, Emerald Dove - showing reduced abundances as the interval from sunrise increased.

The magnitude of the random effects describe the variability of the observations with respect to plot (also accounts for repeat observation on the same plot), observer, the day on which the count was undertaken (can account for conditions that are otherwise unrecorded, e.g. weather conditions) and zone (which can account for environmental influences not captured by the fixed effect of vegetation group). The two largest sources of variation are plot (largest for five of the 13 species) and zone (largest for the other six species).

Woodhen

There were no significant fixed effects. The observed mean abundance was 0.08 and the estimated abundance from the null model was 0.08 (95% confidence interval 0.004 – 0.65).

Buff-banded Rail

The fixed effect starting time shows a strong decline in numbers observed as a function of the time of day (see Figure 3).

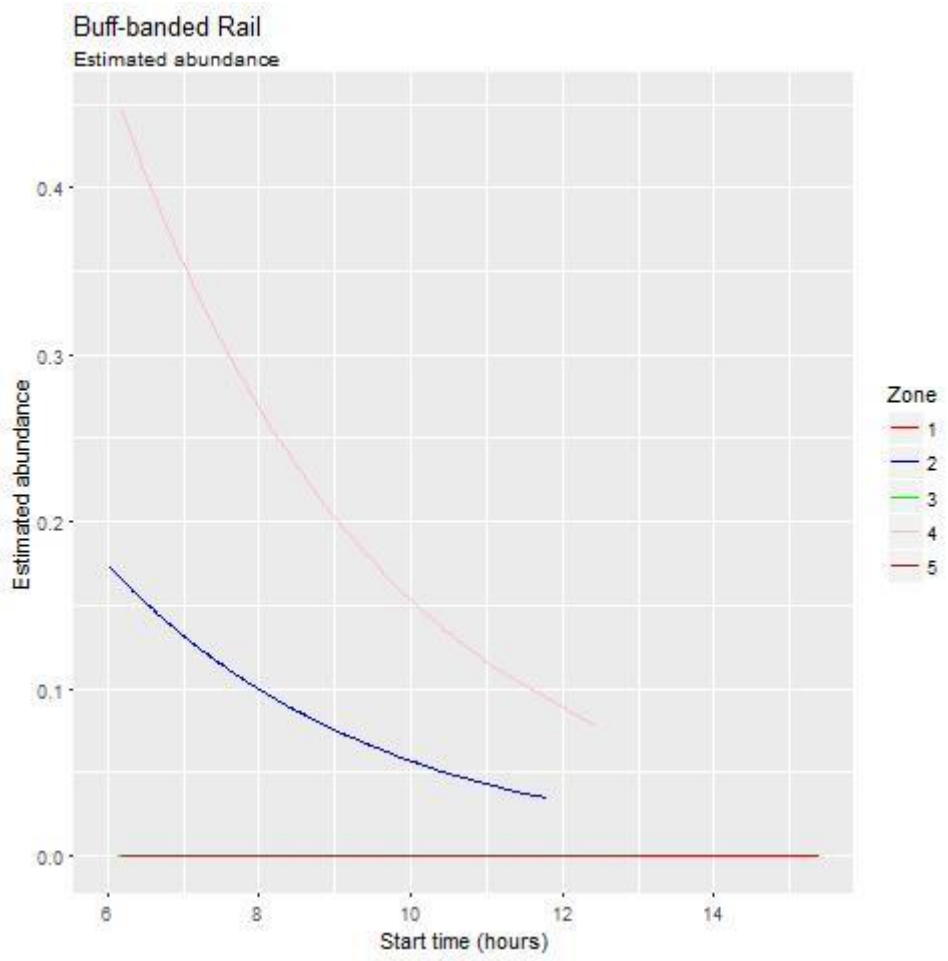


Figure 3. Estimated number of Buff-banded Rail as a function of the zone in which the plot exists

Swamphen

While a model has been fitted to the available data it should be noted that the reporting rate is close to the critical value that Cunningham and Olsen (2009) used to eliminate species from their analysis, so interpreting the fitted model needs caution. The fixed effect zone is significant. Five years data now hides some of the earlier effects, particularly vegetation group. The vegetation group effect is driven by the almost total absence of this species from the forests.

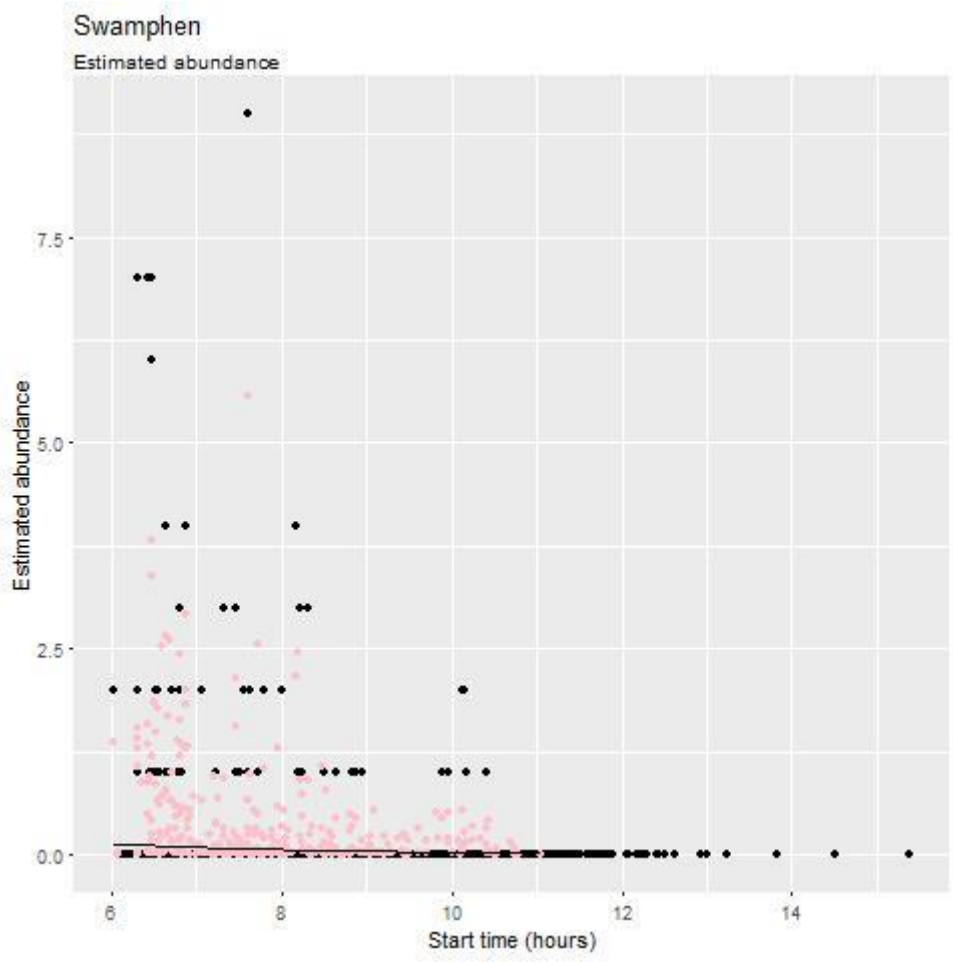


Figure 4. Estimated number of Swamphen observed as a function of count starting time. The observed counts are shown (black dots) and the estimated abundances accounting for the random effects (pink dots)

Masked Lapwing

Fifty-five records of Masked Lapwing have been made. The majority (52) were from open vegetation.

Emerald Dove

The fixed effects zone, vegetation and starting time were significant. The Emerald Dove is estimated to be very much more abundant in the forest vegetation groups and apparent abundance declines with increasing interval from sunrise (see Figure 5).

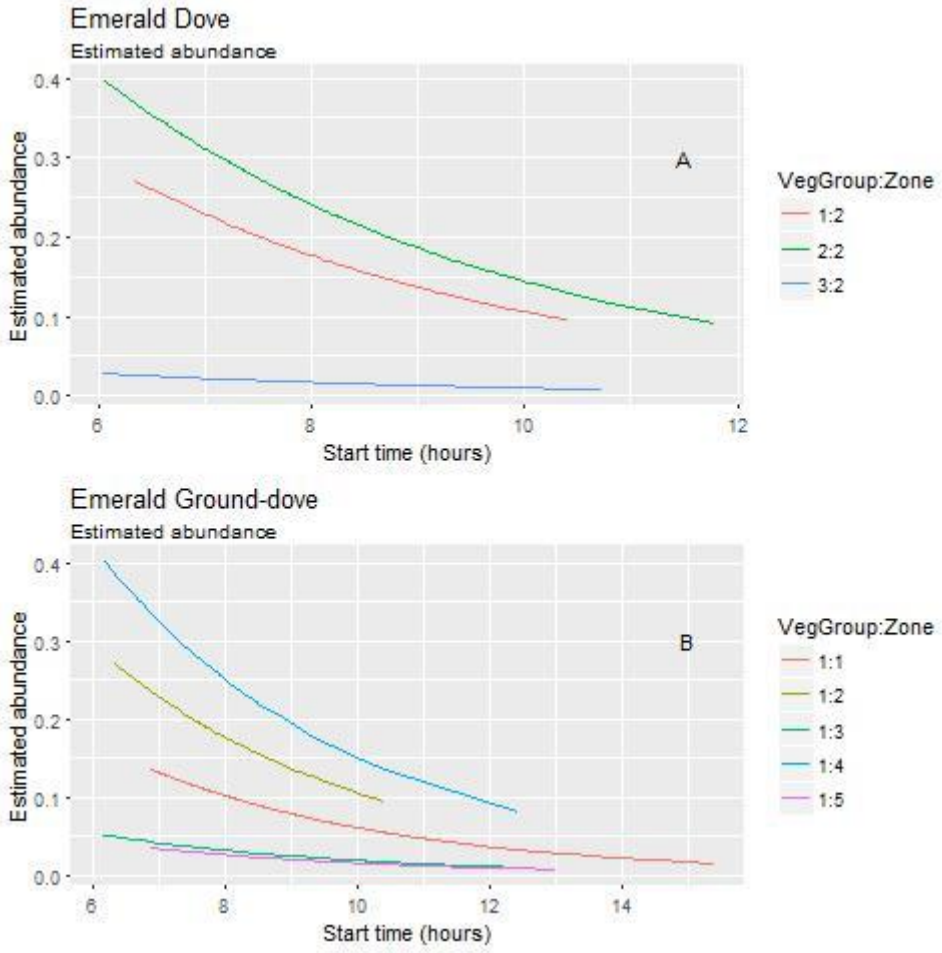


Figure 5. Estimated number of Emerald Dove as a function of count starting time and plot vegetation group and zone. Graphic A illustrates the impact of vegetation group within a zone (2) and graphic B illustrates the impact of zone within a vegetation group (1)

Sacred Kingfisher

There was one significant fixed effect for this species, zone. The observed abundance per zone is plotted in Figure 6.

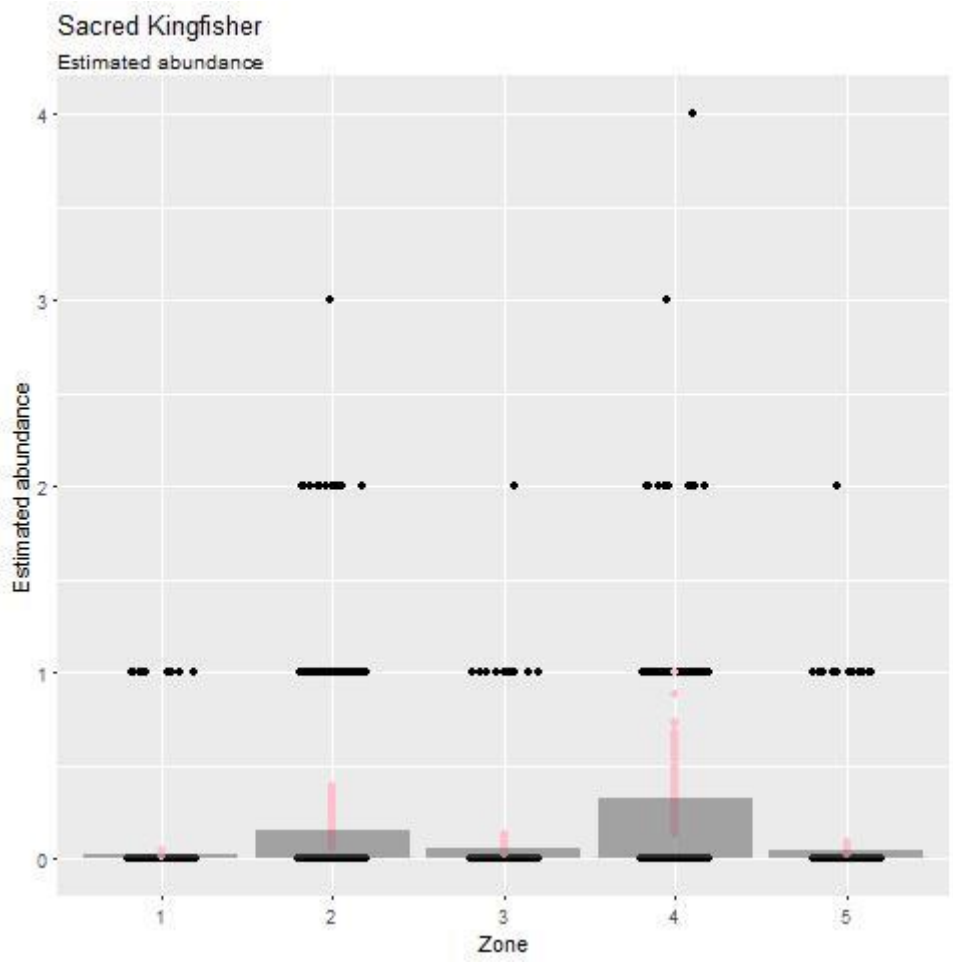


Figure 6. Estimated number of Sacred Kingfisher as a function of the zone of the plot observed. The Observed abundances are show (black dots) and the estimated abundances accounting for the random effects (pink dots)

Pied Currawong

Pied Currawong was recorded across all vegetation groups but not abundantly in the open vegetation group (see Figure 7).

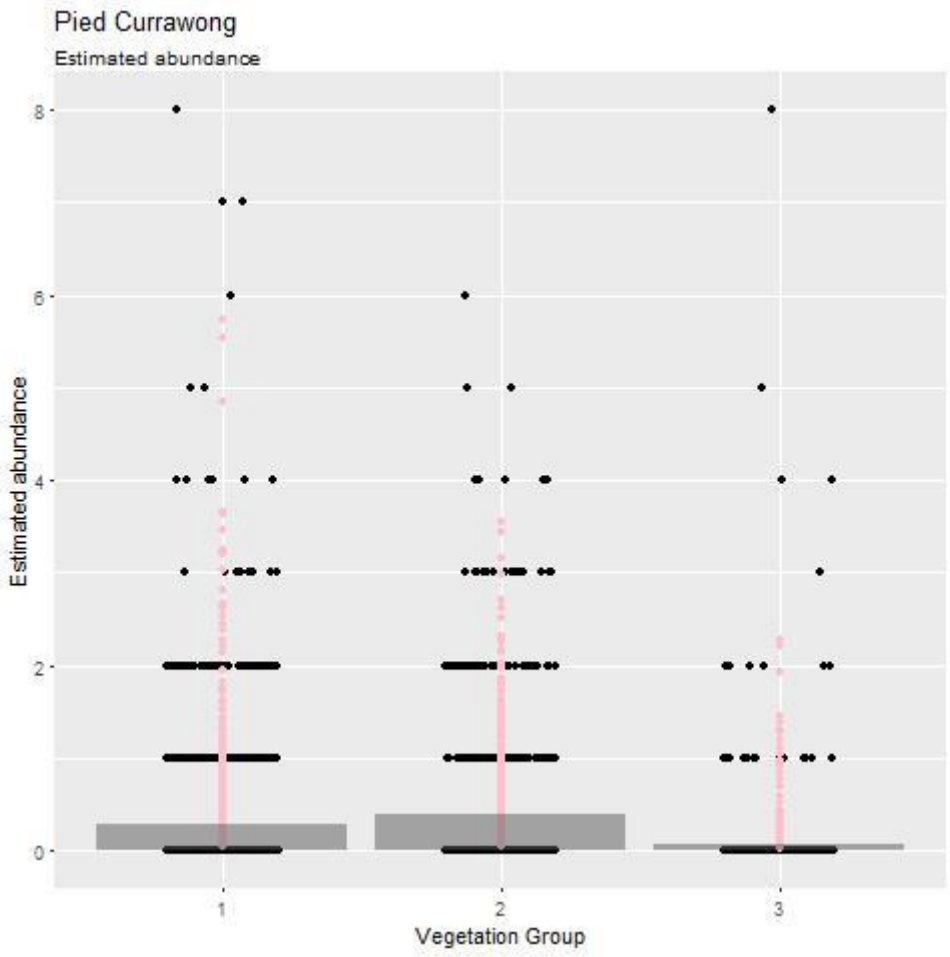


Figure 7. Estimated number of Pied Currawong as a function of the vegetation group. The observed counts (black dots) and estimated abundances after accounting for the random effects (pink dots) are shown

Golden Whistler

The fixed effect vegetation group is highly significant. The observed data and predicted abundance are show in Figure 8 as a function of the fixed effect vegetation group. Note that the observed data have been jittered to allow display.

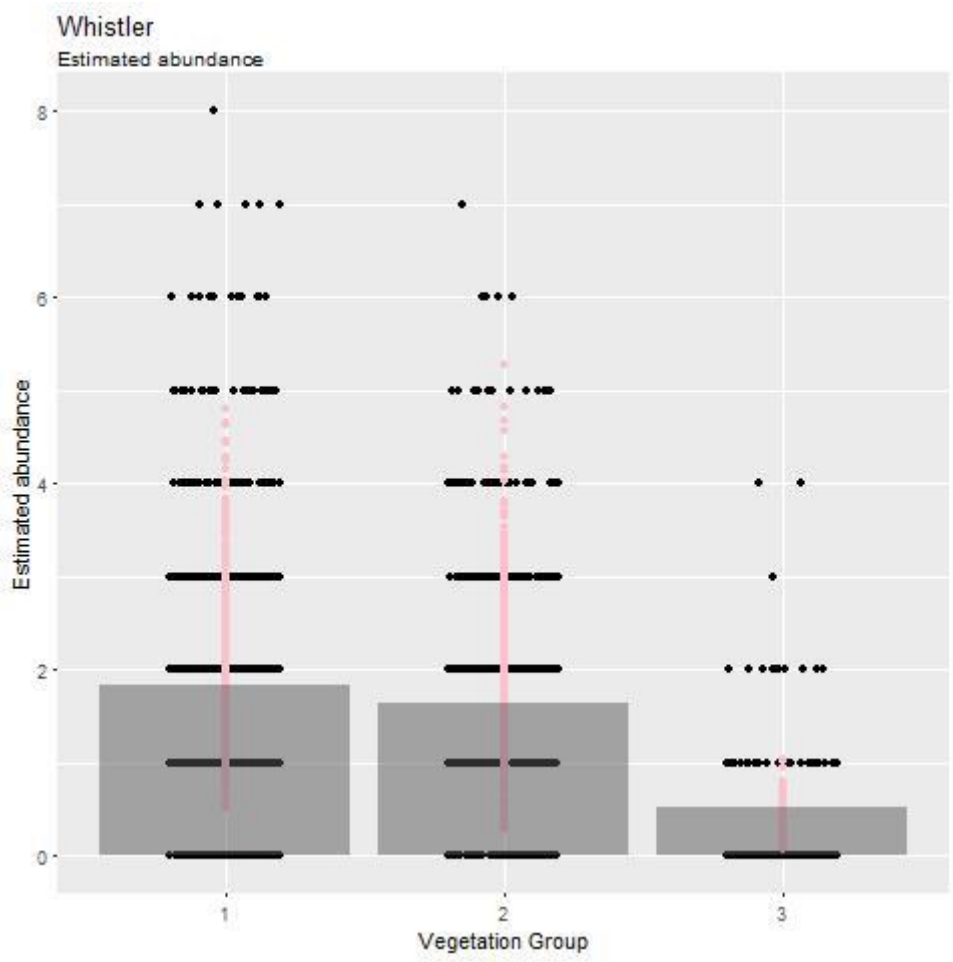


Figure 8. Estimated number of Golden Whistler as a function of vegetation group. The observed (black dots) and estimated (pink dots) after accounting for the random effects. Bars are also shown

Magpie-lark

The fixed effect zone is significant (see Figure 9).

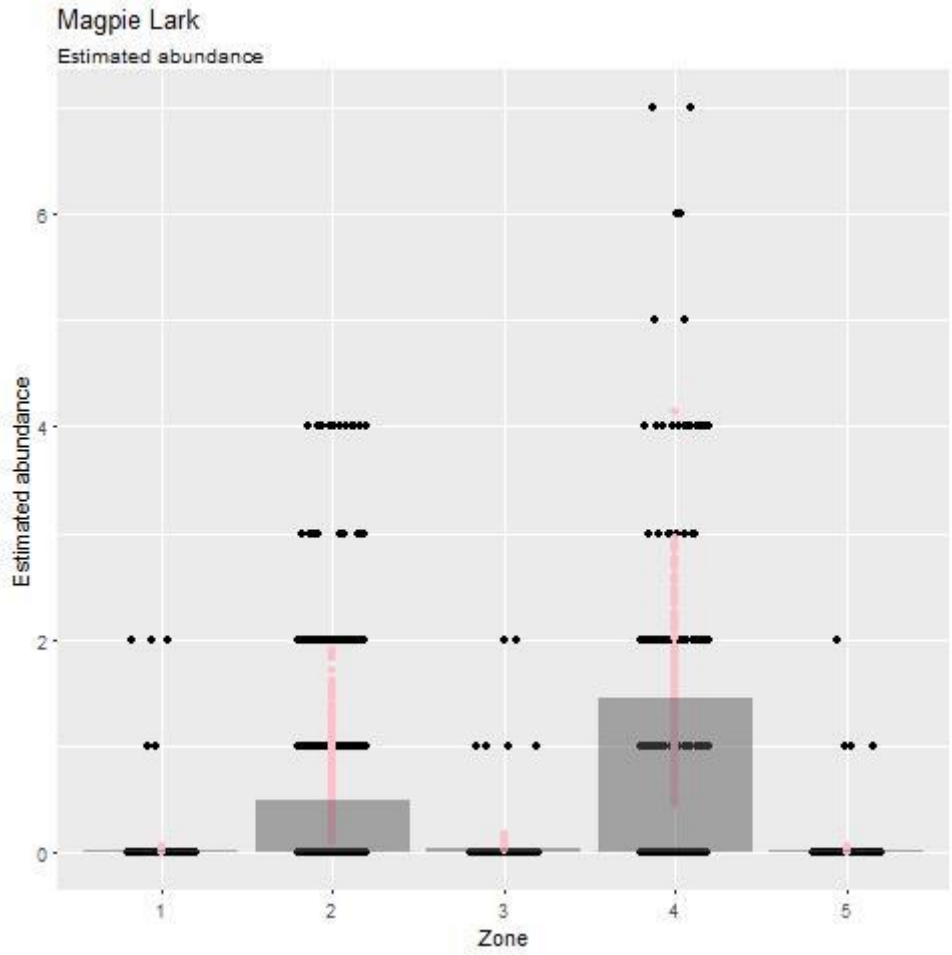


Figure 9. Estimated number of Magpie-lark as a function of zone. The observed abundances (black dots) and estimated abundances (pink dots) after accounting for the random effects are also shown

Welcome Swallow

The fixed effect vegetation group is significant (see Figure 10).

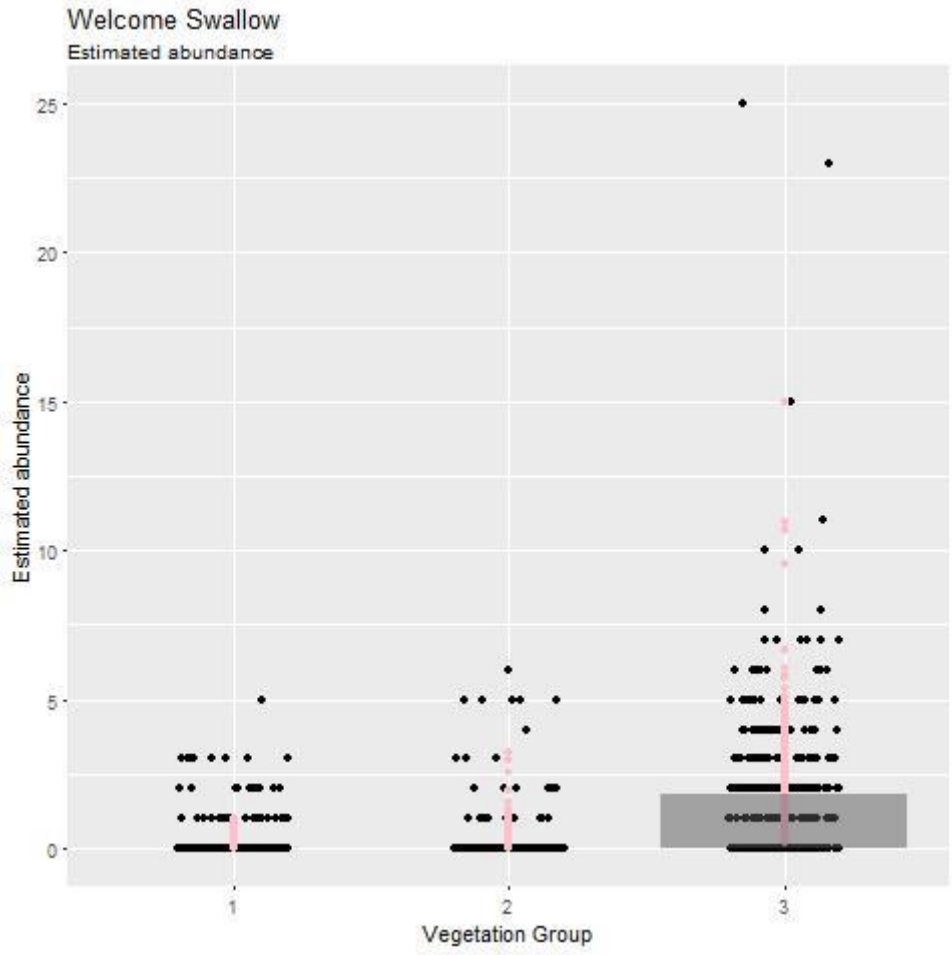


Figure 10. Estimated number of Welcome Swallow as a function of vegetation group. The observed abundances (black dots) and estimated abundances (pink dots) after accounting for the random effects are also shown

Silvereye

Note that a different mixed model is fitted to the Silvereye data; due to the difficulty of recording abundance the data were converted to presence or absence. The fixed effect vegetation group was significant. The probability of recording Silvereye in the forest is approximately three times that of recording it in open vegetation (see Figure 11). Note that for this simpler model there is very little change in the parameters for this model compared with the model fitted on the data from four years.

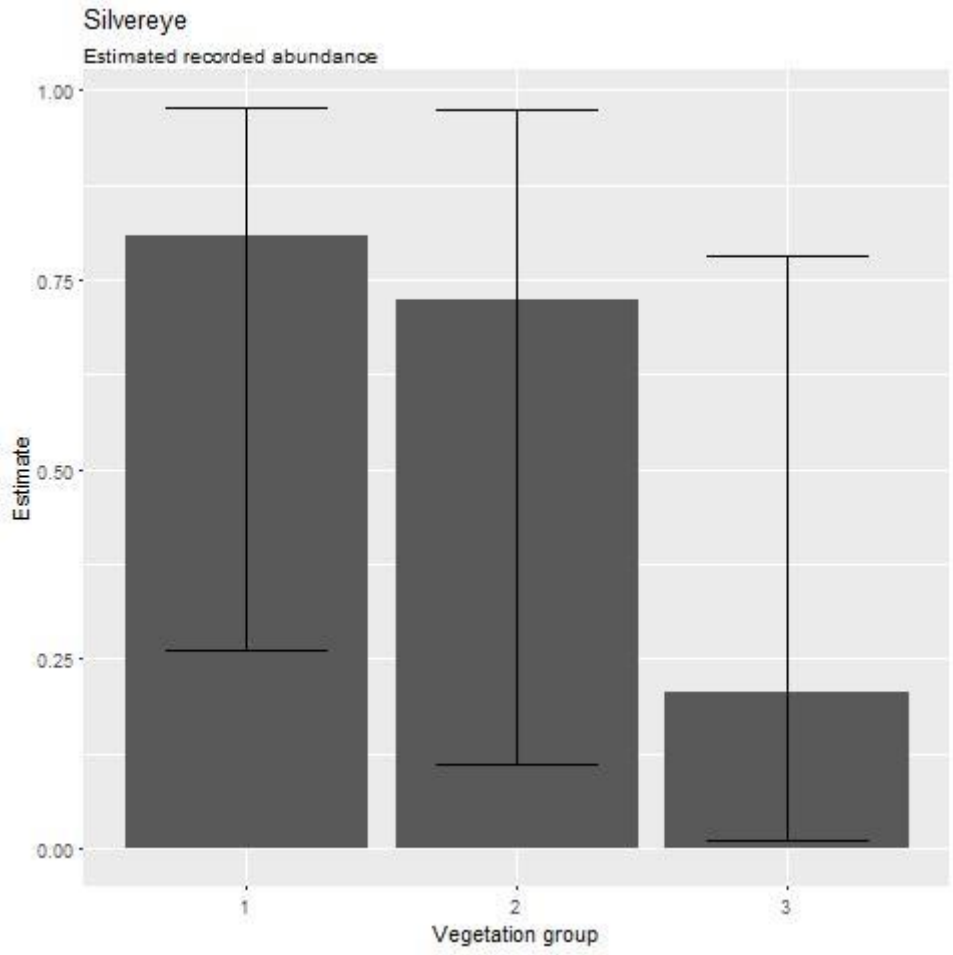


Figure 11. Probability of occurrence of Silvereye as a function of plot vegetation group

Blackbird

There was a significant fixed effect of zone, being larger in zone 2 relative to the others. (see Figure 12).

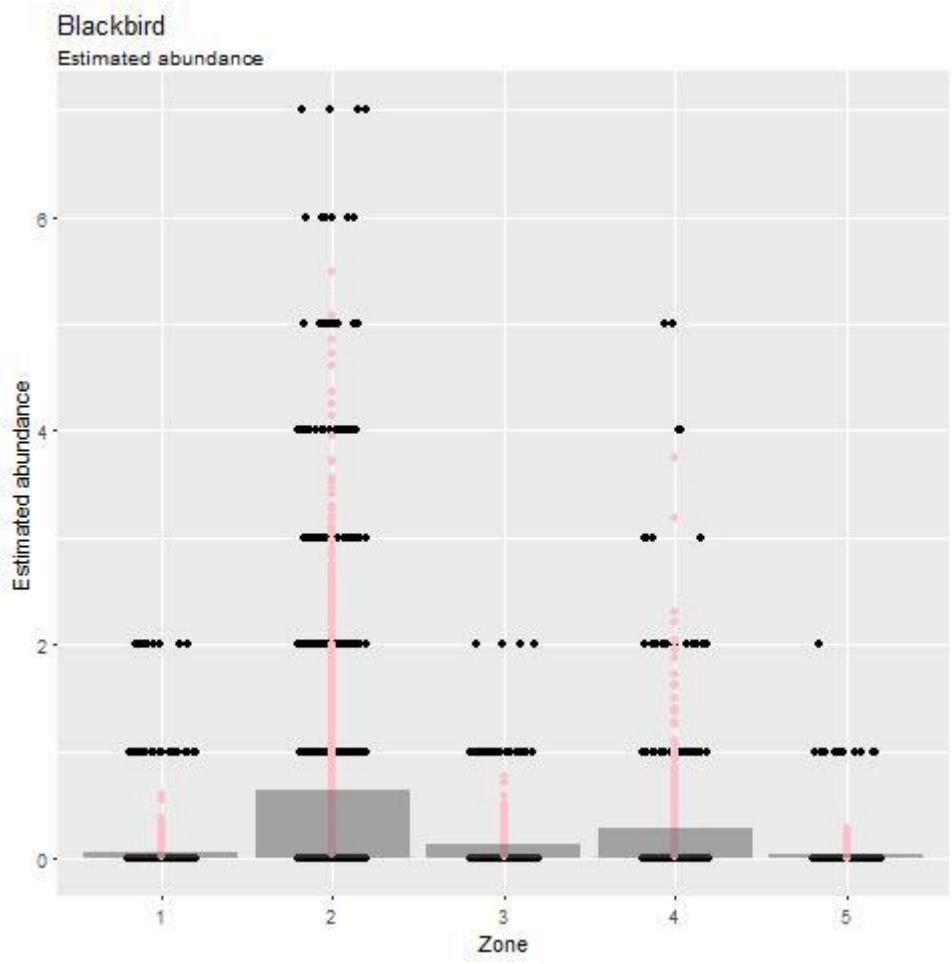


Figure 12. Estimated number of Blackbird observed as a function of the zone in which the plots exists

Song Thrush

Only 55 records of Song Thrush have been made from plot observations over all surveys. Consequently no model has been fitted. The majority of these records (50) are from the Palm forest.

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 fifth survey in 2018 some of these difficulties remain.

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

In general, where the habitat influences are included in the models they appear to be sensible and generally reflect what we know about the biology of the species. In comparison to the previous reports, and with additional data, there is less potential difference between years than was noted for last year's report. Additional modelling may be necessary to clarify if this is a general result.

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, 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 more complex models possible.

Species distribution

Figures 13–16 show the 2018 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 fewer than eight counts were made in the cell.

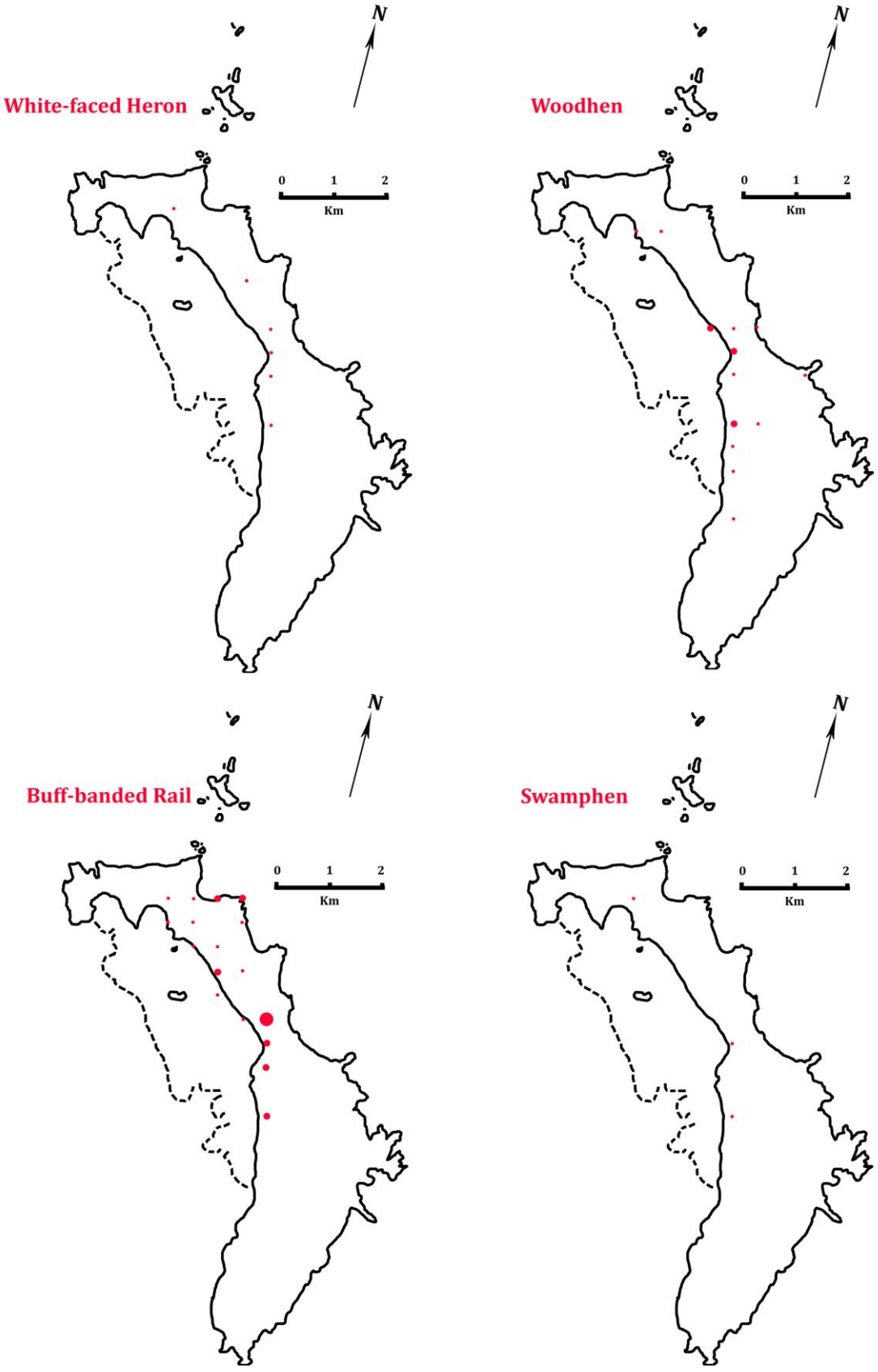


Figure 13. Distribution of White-faced Heron, Woodhen, Buff-banded Rail and Swamphen, September 2018, northern LHI, by frequency of occurrence at plots

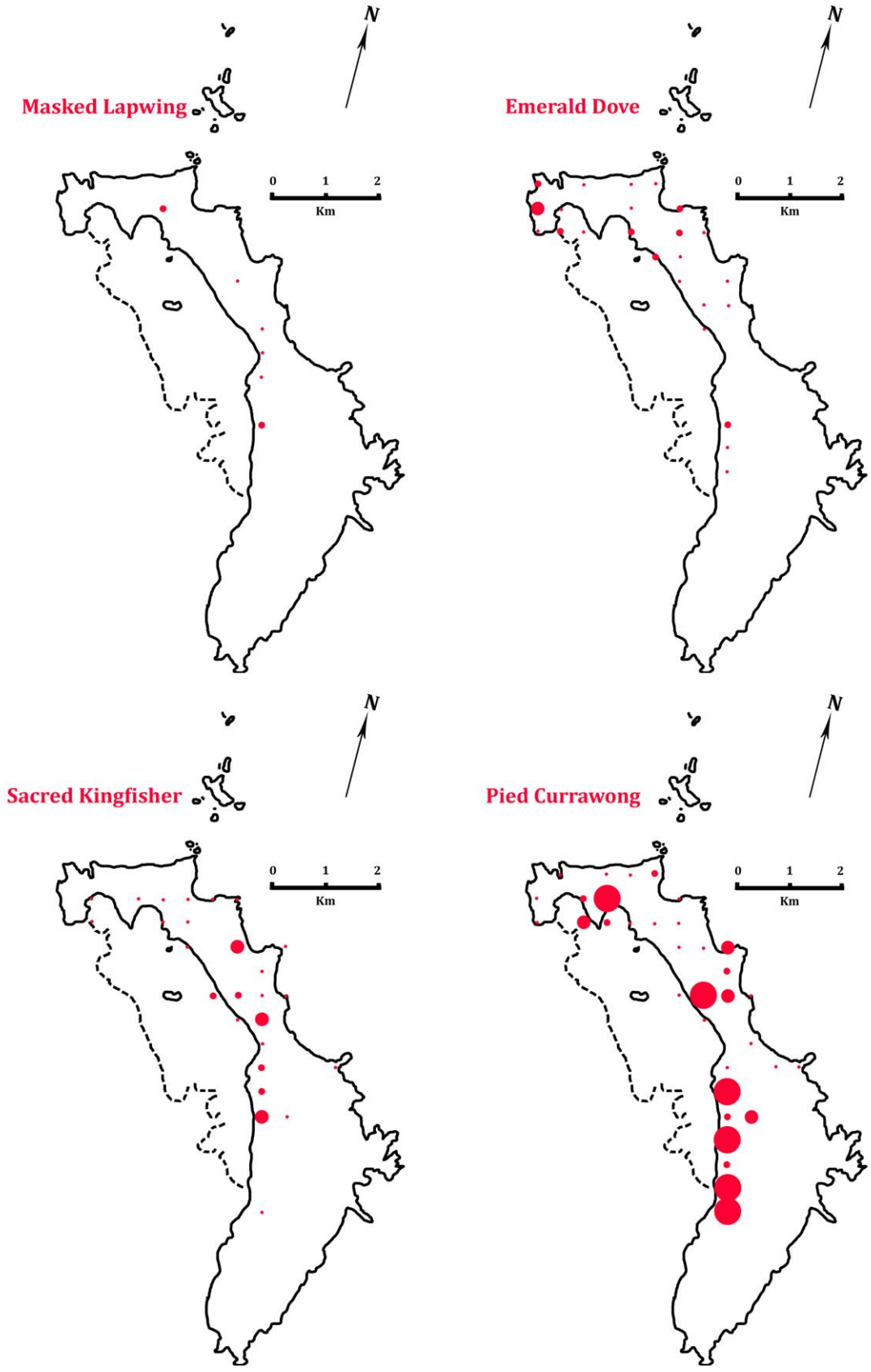


Figure 14. Distribution of Masked Lapwing, Emerald Dove, Sacred Kingfisher and Pied Currawong, September 2018, northern LHI, by frequency of occurrence at plots

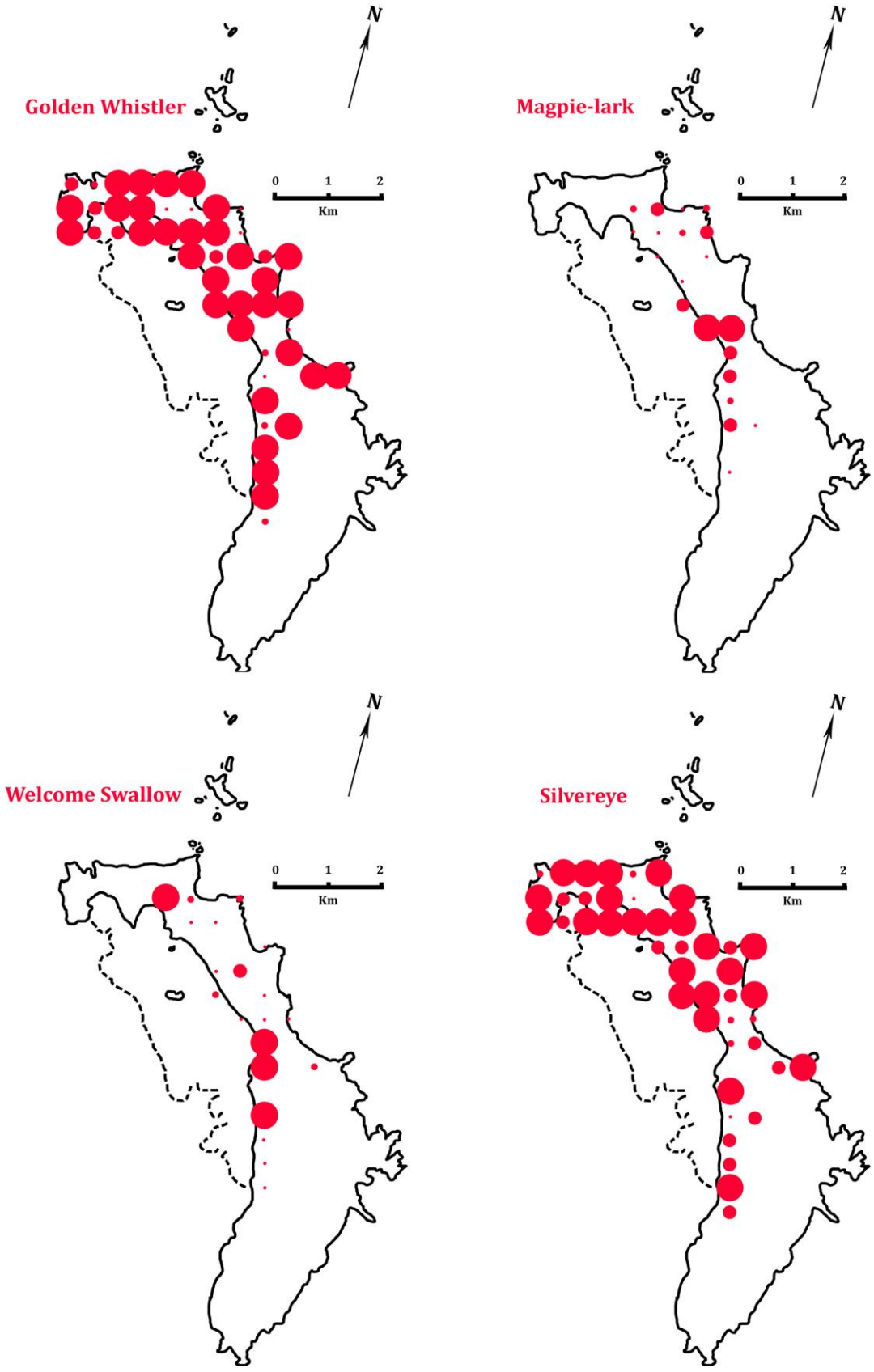


Figure 15. Distribution of Golden Whistler, Magpie-lark, Welcome Swallow and Silvereye, September 2018, northern LHI, by frequency of occurrence at plots

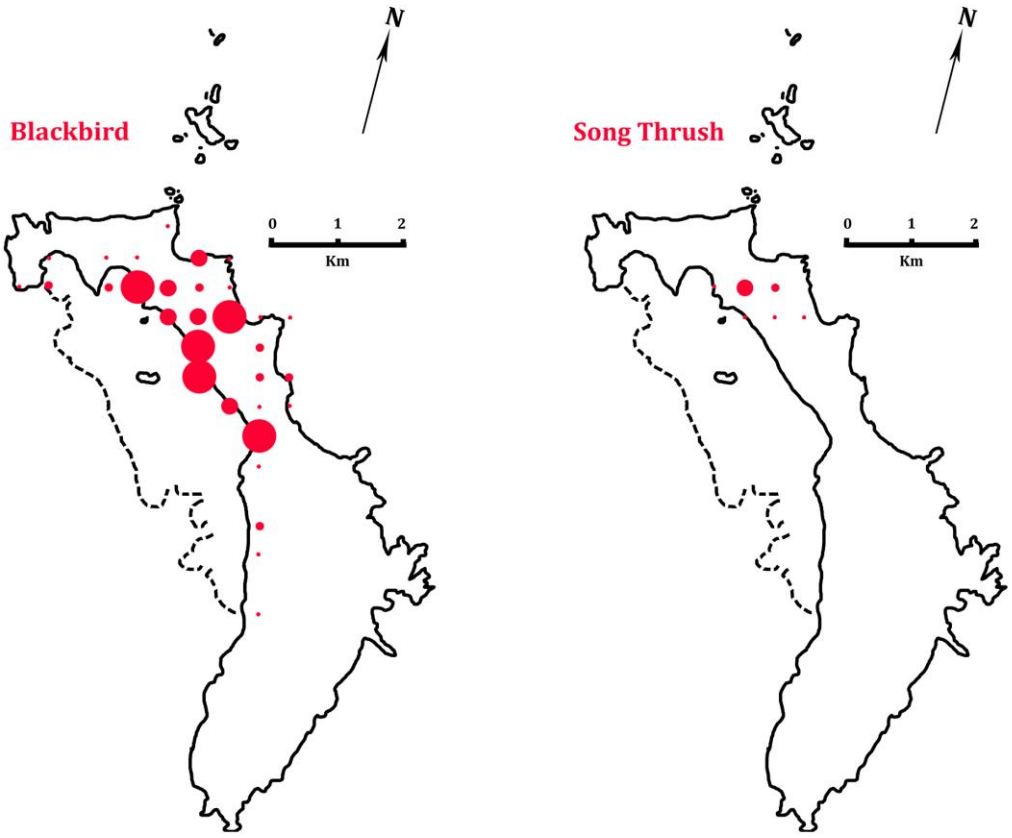


Figure 16. Distribution of Blackbird and Song Thrush, September 2018, northern LHI, by frequency of occurrence at plots

Transect counts

In six days, seven observers recorded 84 observations with an additional observer also surveying on these days in the opposite direction – resulting in a total of 90 counts for the numbers of six species on these transects (see Table 1). The additional observer also counted on six mornings from shortly after sunrise following exactly the protocol of the standard evening transect (that is to say not in the reverse direction as that observer had done with evening counts). This gave another 12 counts of numbers of the same six species to compare with the evening counts. The speed of travel for all transect counts was standardized to 2 km/hr in 2014 and has been adhered to ever since.

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, 2017 and 2018 was similar to that in 2014.

Differences between counts on transects carried out in opposing directions and a comparison of evening counts with morning counts will be examined when more surveys have been completed.

Woodhen

There is no evidence that direction is associated with the number of Woodhen recorded, but the combined data do suggest that the transect length and year are associated with the number of individuals recorded (see Figure 17). The observed data have been jittered to allow display of the data. It appears that there has been a substantial increase in the number of Woodhen recorded in 2018 compared with 2017.

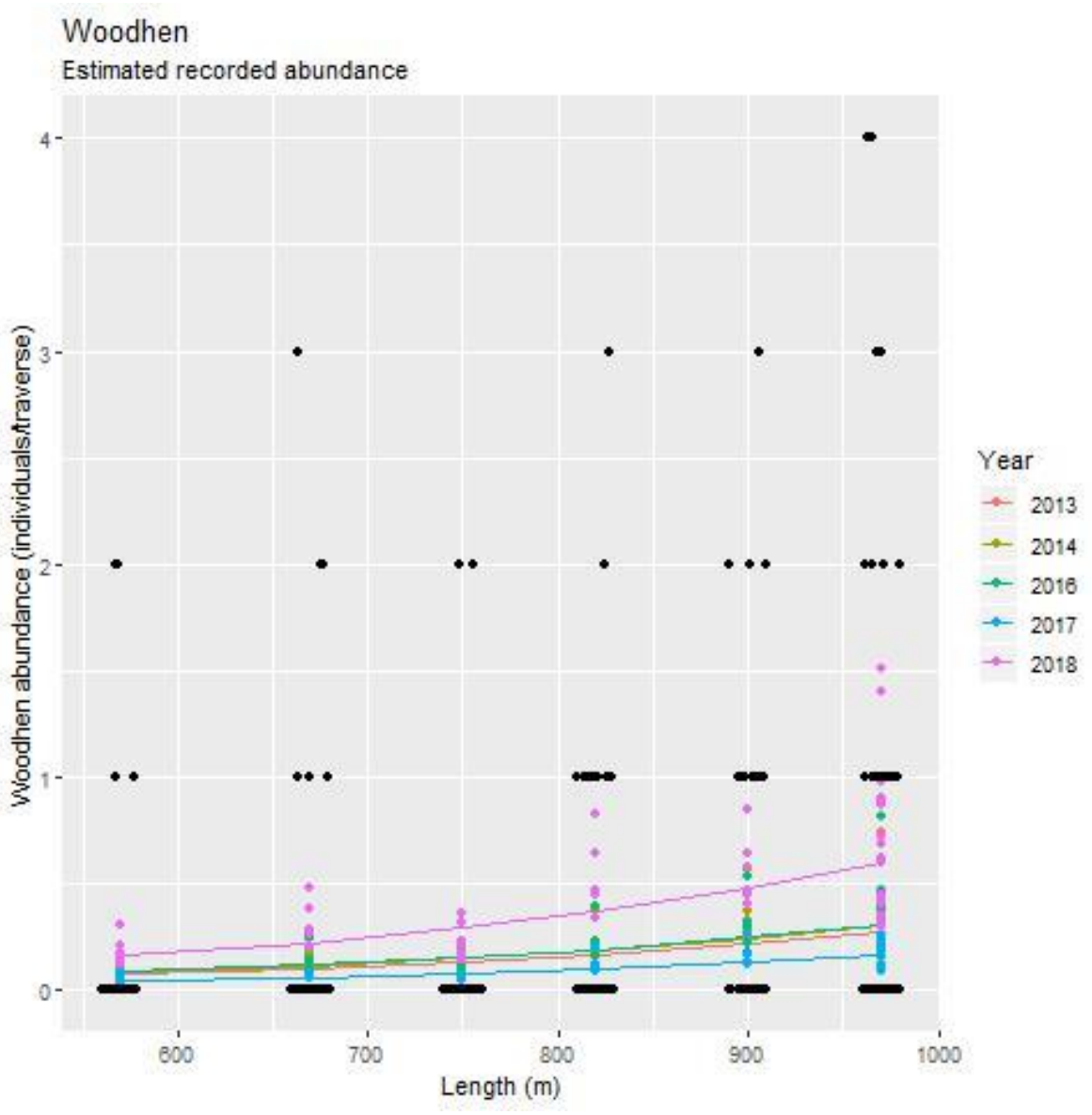


Figure 17. Observed number of Woodhen (black dots) and estimated abundance as a function of transect length with random effects (pink dots) and without random effects (coloured lines) in calculating the estimates

Buff-banded Rail

In contrast to previous years there is limited support for more complex models for this species. The best model is one with year of survey and direction of travel as predictors, but the level of support is low (around 30%). Figure 18 shows the predicted values and estimates of the 95% confidence intervals, which are wide and in themselves would suggest that there is no difference between the years or travel.

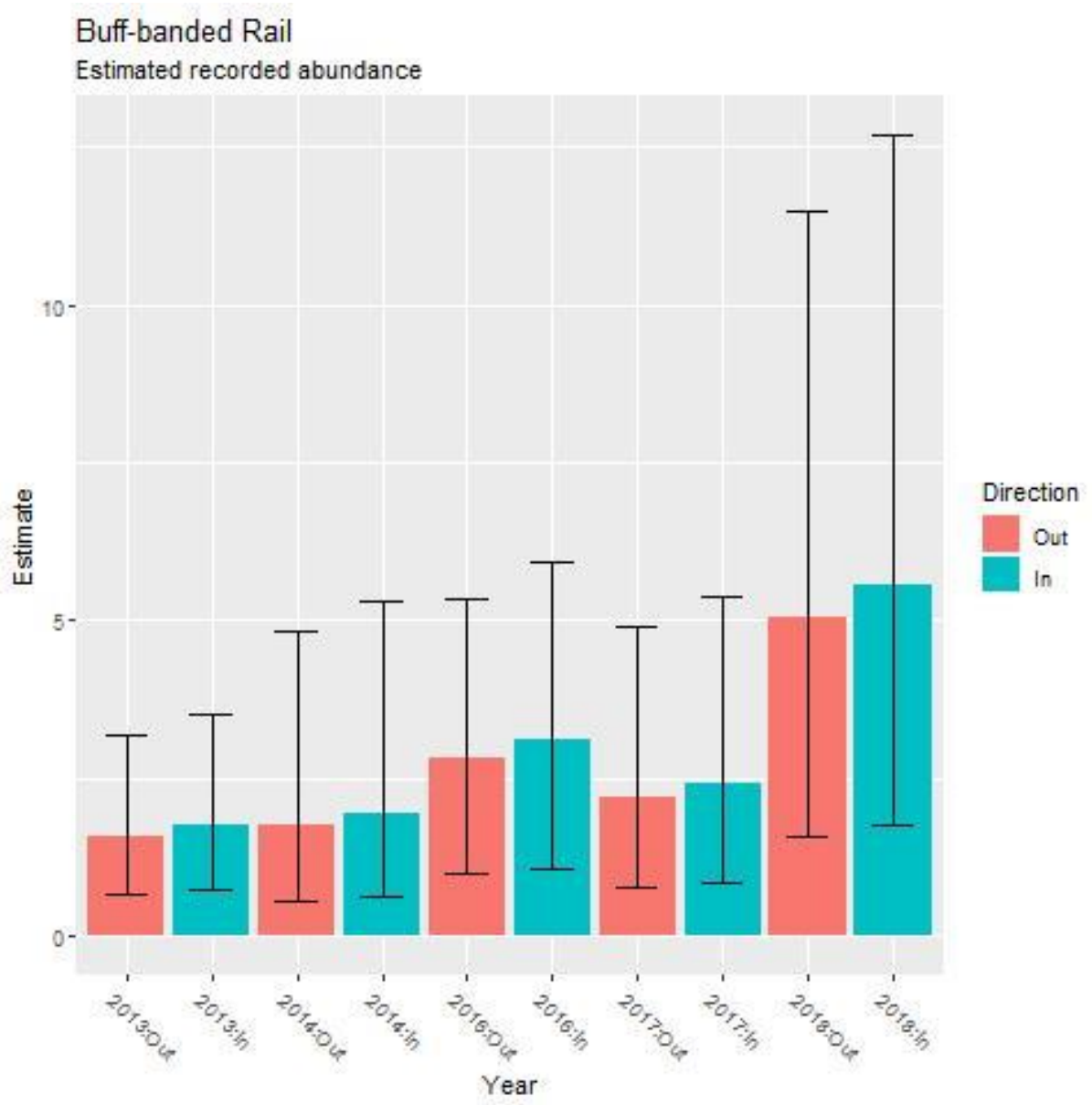


Figure 18. Estimated abundance of Buff-banded Rail as a function of survey year and direction of travel along transect together with estimates of 95% confidence intervals

Emerald Dove

The fixed effects year and direction are significant. The return traverse (i.e. closer to sunset) yields approximately double the number of individuals compared to the outward traverse (see Figure 19)

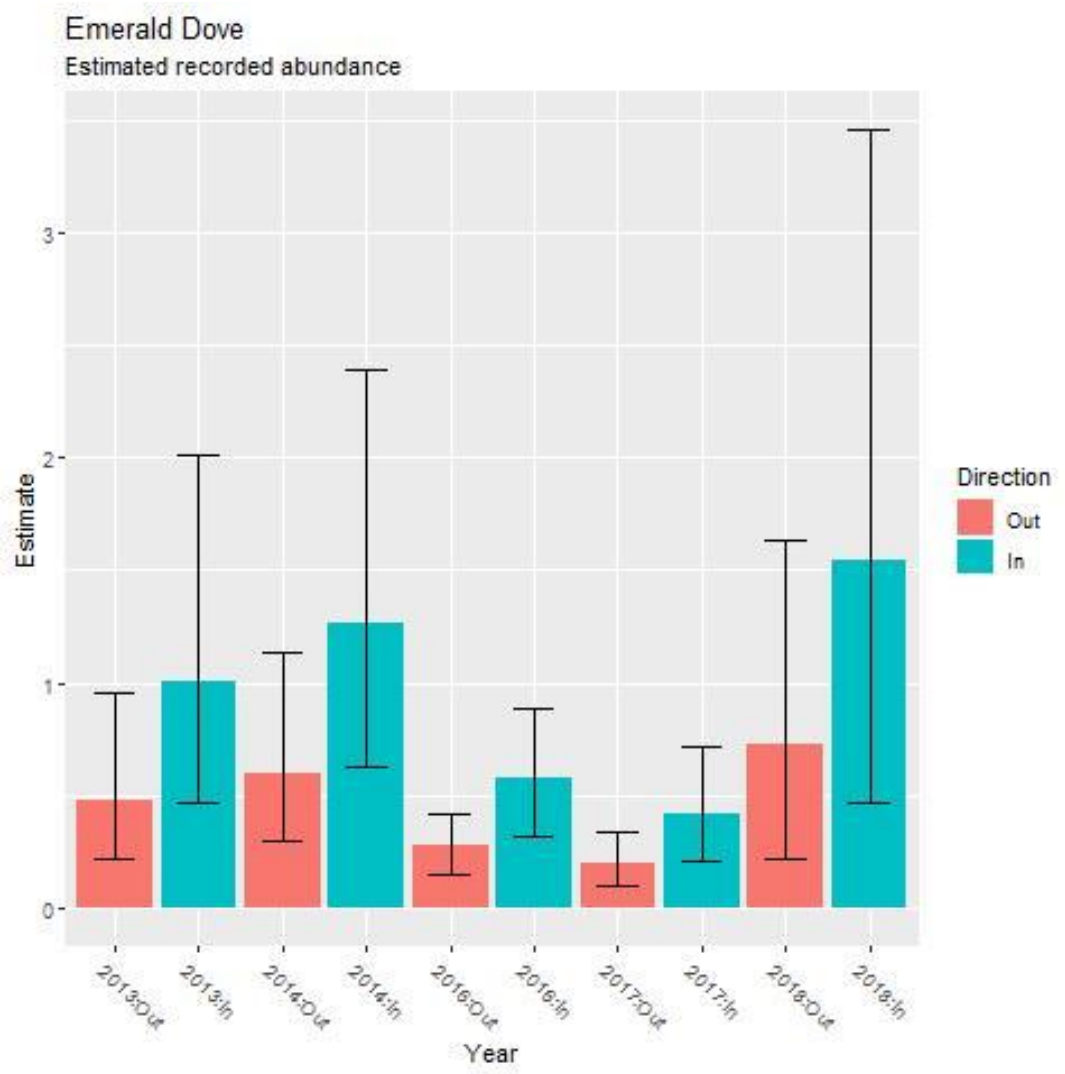


Figure 19. Estimated abundance of Emerald Dove as a function of survey year and direction of travel along transect together with estimates of 95% confidence intervals

Sacred Kingfisher

There is evidence that year has an effect on the number of individuals observed and in contrast to earlier years the direction of travel is also important. It appears that the number of Sacred Kingfisher have continued to increase from the low seen in first survey in 2013 (see Figure 20).

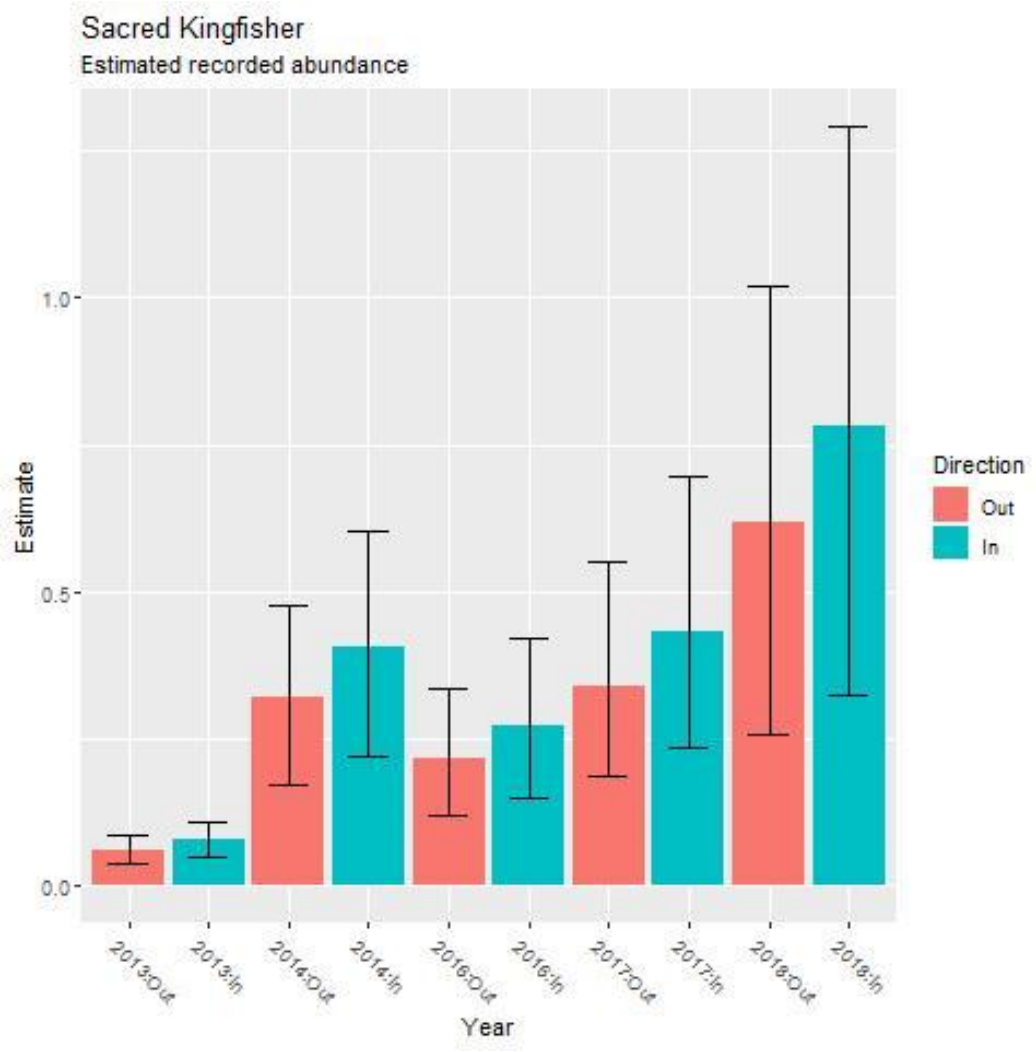


Figure 20. Estimated number of Sacred Kingfisher as a function of survey year and direction of travel together with estimates of 95% confidence intervals

Common Blackbird

There are significant differences in the observed abundances due to the direction of travel and the year of survey. The direction of travel is undoubtedly due to the return traverse being closer to sunset and the birds settling into their roosts. The differences between years is not strong. The confidence intervals suggest that the differences are not important in contrast to the AIC ranking of the candidate models which suggests that the differences between years may be real (see Figure 21).

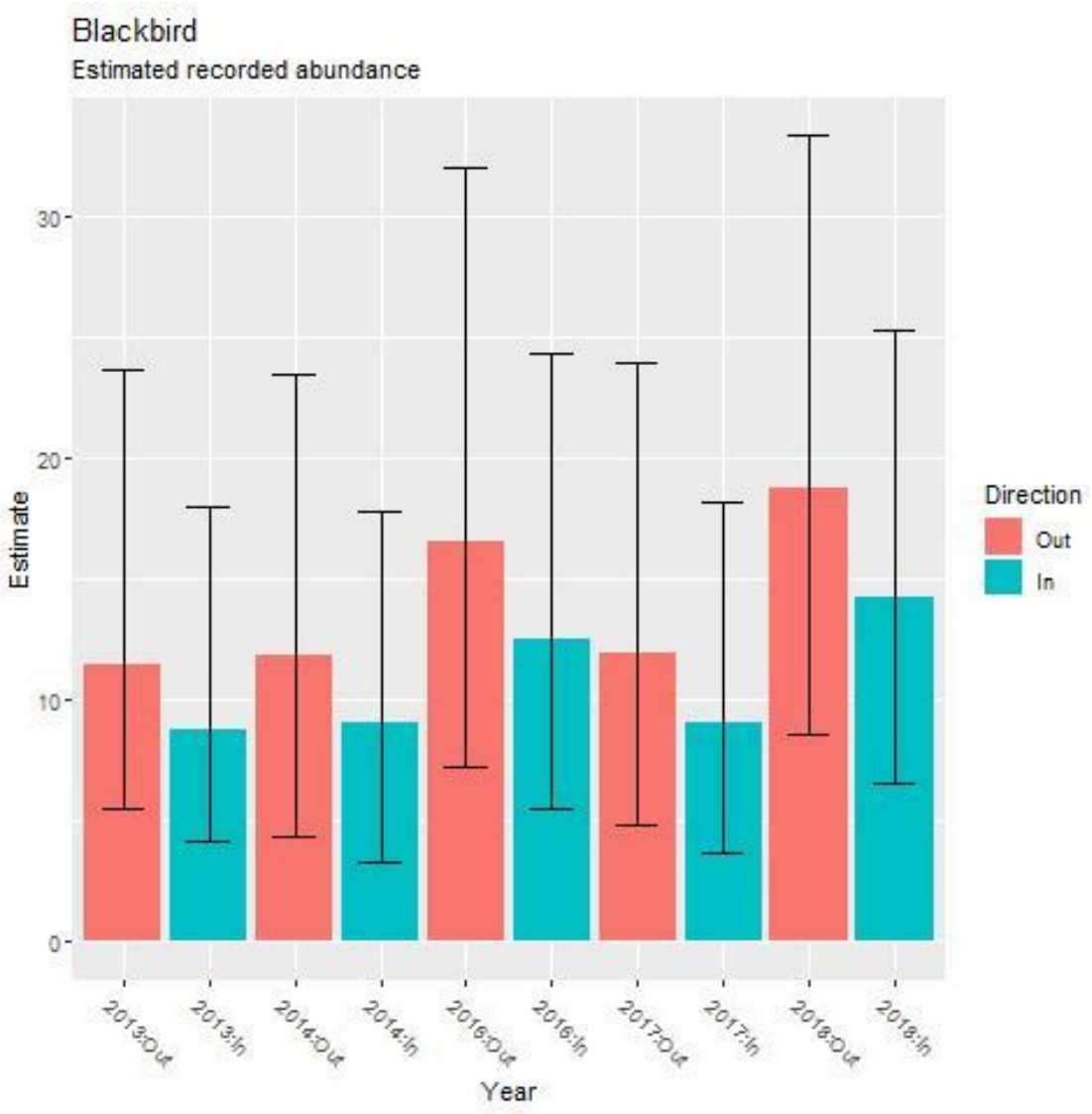


Figure 21. Estimated number of Blackbird as a function of survey year and direction of travel along transect together with estimates of 95% confidence intervals

Song Thrush

With more data the complexity of the best model has increased from one with length of transect to having different intercepts for year of survey and direction of travel (Figure 22). This figure also shows the observed data and the estimated abundances that incorporates the random effects within the model. The observed data points have been jittered to allow display.

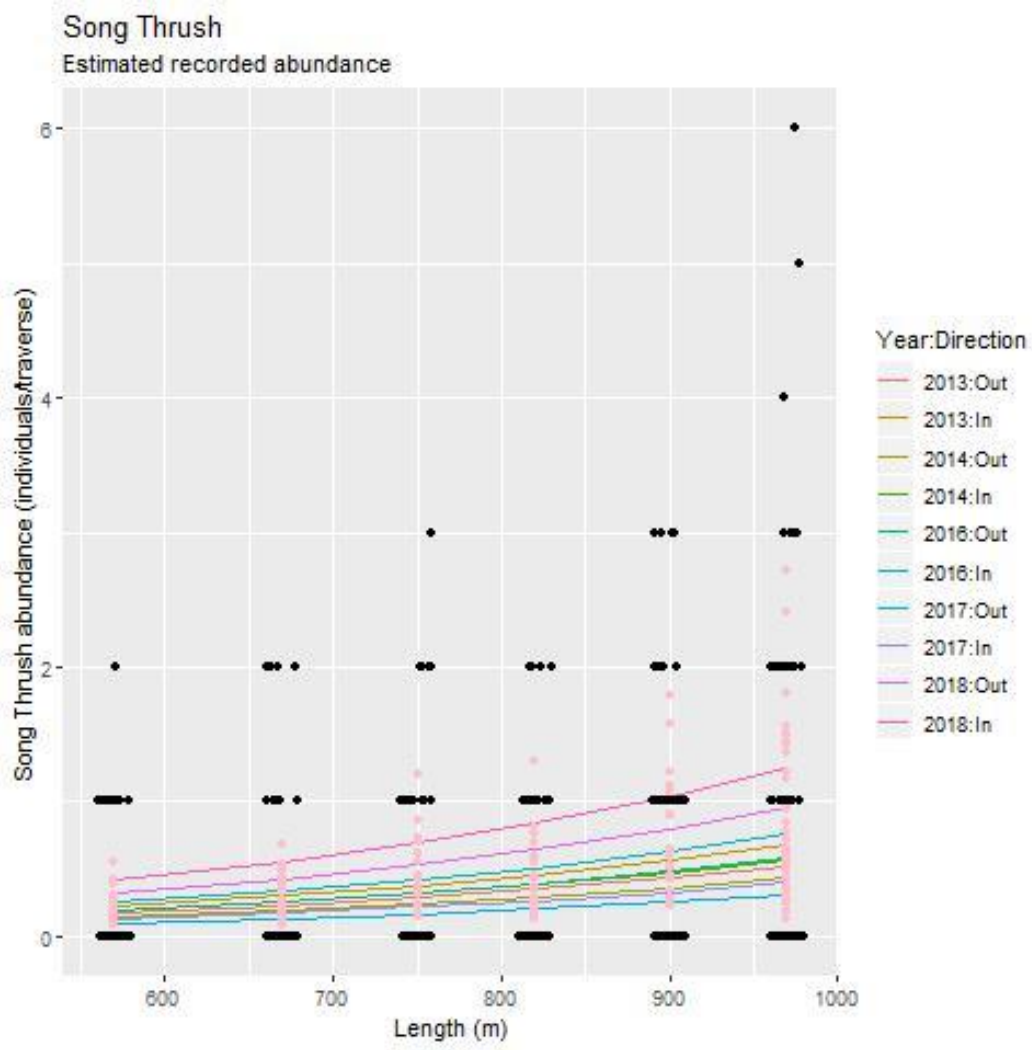


Figure 22. Observed Song Thrush abundance (black dots) and estimated abundance as a function of transect length, with random effects (red dots) and colour coded lines for the year of survey and direction of travel

One of the important reasons for the pre-rodent baiting program monitoring was to establish some background estimates of selected avian species abundances. We now have five surveys spread over the period 2013 to 2018.

With the additional year of survey of the six species reported here four, Emerald Dove, Sacred Kingfisher, Song Thrush and Woodhen now show evidence of differences between the years of survey and the models suggest that the current survey effort is able to detect changes over time. The interpretation of the apparent influence of the direction of travel along the transects needs further analysis but would appear to be driven by the period of the traverse relative to sunset. Emerald Dove and Sacred Kingfisher abundances are significantly higher for the return traverse compared to the outward count. This is in contrast to the Blackbird where the outwards count yields large number of individuals recorded.

It would be easy to attribute the observed apparent influence of transect length to be a reflection of survey effort. Longer transects yield more individuals than shorter transects; we suspect, however, that the transect locations may also be of importance. This may be worth further exploration but certainly highlights the need to maintain the existing survey protocol in the years post the rodent baiting program.

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

Acknowledgements

The survey was conducted under an arrangement between the Lord Howe Island Board and the Canberra Ornithologists Group. The report was compiled by Peter Fullagar and Chris Davey with statistical input from A O Nicholls. With his intimate knowledge of the flora and fauna of the island, Ian Hutton was responsible for the arrangements and logistical support on the island and he provided invaluable input. The survey teams consisted of David and Kathy Cook, Michael Robbins, Harvey Perkins, David Rees, Noel Luff, Ian Hutton, Peter Fullagar and Chris Davey. All, apart from Ian Hutton, are members of the Canberra Ornithologists Group.

We thank Duncan McCaskill for providing an EXCEL routine that defined the distance from the actual waypoint to the intended waypoint for each plot.

We thank Nicholas Carlile from the Office of Environment and Heritage, NSW Department of Premier and Cabinet, and the Lord Howe Island Board for their support.

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APPENDIXES

Appendix A. Vegetation and habitat classifications of all 96 surveyed plots, LHI, 2018

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

Notes:

1. Calcarenite and exposed variants are treated as one type, giving a total of four paired plots
2. Name changed in this report from *Cleistocalyx fullageri* to *Syzygium fullagarii* (see Craven, 1998)

Habitat zones	*Habitat zone code*	*No. of plots*
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, 2018

	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	4
2	31 31 06.7	159 02 25.2	1	1	1	4
3	31 31 16.8	159 02 31.0	1	1	1	3
4	31 31 12.8	159 02 31.0	1	1	1	4
5	31 31 05.8	159 02 21.4	1	1	1	3
6	31 31 04.3	159 02 24.7	1	1	1	4
7	31 31 00.4	159 02 24.8	4	1	1	4
8	31 30 56.9	159 02 23.0	4	1	1	4
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	4
18	31 31 02.9	159 03 09.0	1	1	1	4
19	31 31 00.1	159 02 52.7	1	1	1	4
20	31 31 02.4	159 02 55.7	1	1	1	3
21	31 31 02.0	159 03 03.4	1	1	1	4
22	31 30 59.3	159 03 01.0	1	1	1	4
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	2
26	31 30 49.3	159 03 25.8	1	1	1	2
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	4
34	31 31 18.7	159 03 30.1	5	2	2	4
35	31 31 23.8	159 03 44.6	5	2	2	4
36	31 31 21.3	159 03 47.0	5	2	2	4
37	31 31 09.8	159 04 04.7	1	1	2	4
38	31 31 07.1	159 04 09.1	1	1	2	4
39	31 31 08.9	159 04 19.2	10	2	2	4
40	31 31 12.1	159 04 16.3	10	2	2	4

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	4
50	31 31 35.6	159 04 23.8	5	2	2	4
51	31 31 42.3	159 04 39.5	5	2	3	4
52	31 31 40.1	159 04 44.2	5	2	3	4
53	31 31 51.2	159 04 33.4	1	1	3	4
54	31 31 53.3	159 04 36.4	1	1	3	4
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	4
64	31 32 24.7	159 04 34.6	1	1	4	4
65	31 32 18.5	159 04 40.1	6	3	4	4
66	31 32 20.2	159 04 45.1	6	3	4	4
67	31 31 59.9	159 04 37.7	3	1	3	4
68	31 32 03.4	159 04 38.6	3	1	3	4
69	31 32 07.8	159 04 49.6	3	1	3	4
70	31 32 10.8	159 04 53.1	2	1	3	4
71	31 32 17.2	159 04 50.3	7	3	3	4
72	31 32 32.4	159 04 59.4	7	3	5	4
73	31 33 05.1	159 04 32.3	6	3	4	4
74	31 33 03.1	159 04 37.5	6	3	4	4
75	31 33 09.8	159 04 58.1	9	2	5	4
76	31 33 09.4	159 04 54.4	9	2	5	4
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	4
88	31 32 43.4	159 04 41.5	8	3	4	4
89	31 32 52.0	159 04 42.0	1	1	4	4
90	31 32 55.1	159 04 39.7	1	1	4	4
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

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: Woodhen, Buff-banded Rail, Emerald Dove, Sacred Kingfisher, 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 but 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, 2018

Species nomenclature and names follow those recommended by the latest IOC listing. See Gill, F & D Donsker (Eds), 2018, IOC World Bird List (v8.1). doi:10.14344/IOC.ML.8.1. 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*	*novaehollandiae*
Golden Plover	Pacific Golden Plover	*Pluvialis fulva*	
Double–banded Plover		*Charadrius bicinctus*	
Whimbrel		*Numenius phaeopus*	*variegatus*
Bar-tailed Godwit		*Limosa lapponica*	*baueri*
Feral Pigeon	Rock Dove	*Columba livia*	
Emerald Dove	Pacific Emerald Dove	*Chalcophaps longirostris*	*rogersi*
Sacred Kingfisher		*Todiramphus sanctus*	*vagans*
Pied Currawong		*Strepera graculina*	*crissalis*[2]
Golden Whistler	Australian Golden Whistler	*Pachycephala pectoralis*	*contempta*[2]
Magpie-lark		*Grallina cyanoleuca*	*cyanoleuca*
Welcome Swallow		*Hirundo neoxena*	*neoxena*
Silvereye		*Zosterops lateralis*	*tephropleurus*[2]
Blackbird	Common Blackbird	*Turdus merula*	
Song Thrush		*Turdus philomelos*	

Note:
1. Includes hybrids with Pacific Black Duck, *Anas superciliosa*. 2. Endemic subspecies