Yaraandoo - How many birds on my patch?

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Birds were monitored regularly at Yaraandoo, a lightly grazed property near Paterson in the Hunter Valley of NSW, over a three-year period from 2011 to 2014. The property, located in a high rainfall area, was bounded on two sides by intact forest with dense understorey vegetation. The property had approximately 20% vegetation cover and an irrigated olive grove.

Surveys, typically of 3.5 hours, were replicated by the same observer at monthly intervals using a constant survey route. Approximately 18 ha was searched during the surveys, which is almost one fifth of the property size. Count data were used to identify seasonal and between-year variations in bird abundance.

The results demonstrated the presence of a diverse and abundant bird population with 104 species recorded and an estimated mean population of 1330 individual birds. Of these, 27 species were regularly present, each being recorded on more than 80% of surveys. The Yellow-faced Honeyeater *Caligavis chrysops* was the most abundant species with a mean count of 21.1 birds/survey. Two species, Speckled Warbler *Pyrrholaemus sagittatus* and Varied Sittella *Daphoenositta chrysoptera,* both classified as Vulnerable in NSW, were recorded intermittently.

Count data (numbers of individual birds) were a more sensitive indicator than presence data (frequency of species occurrence) of seasonal and annual population differences. For example, Jacky Winter *Microeca fascinans*, although regularly present throughout the year, were significantly more numerous in winter when they formed flocks in open areas.

Population densities, estimated from count data, were consistent with the ranges found in other studies. There were no Hunter Region estimates for comparison.

Densities are essential for estimating the size of regional and national bird populations. This paper demonstrates how counting birds in regularly repeated standardised surveys can provide new information on bird populations to the benefit of the national conservation effort. It also highlights the existence of neglected data sets at other locations in the Hunter Region, and potentially elsewhere in Australia, that can quantify the extent to which bird populations have declined during the last 25 years.

INTRODUCTION

The initial focus of terrestrial bird monitoring in Australia involved mapping bird distributions (Blakers *et al*. 1984). Subsequent objectives were broader, including documenting changes in distribution and trends in the abundance of bird populations (Barrett *et al*. 2003). However, there are few reliable estimates of global, or even regional populations of Australian birds, other than for threatened species (Garnett & Baker 2021).

The two Australian Bird Atlases (Blakers *et al*. 1984; Barrett *et al*. 2003) focused on the presence of birds and their abundance was implied by changes in the frequency at which they were recorded (Reporting Rate - RR). The Australian Bird Atlases were inspired by the British Trust for Ornithology's atlases of the UK (Gibbons *et al.* 1993) but fell short of the UK's goal of estimating the population sizes of every breeding species. This ambitious objective requires a link between bird distributions and the numbers of birds. This requires counting birds and relating regional RRs to their population density.

The second Australian Bird Atlas and its subsequent bird monitoring phase Birdata, provided the option for counting birds, but its promotion and use of count data received little focus, particularly for woodland birds. Despite this, some participants counted the numbers of woodland birds.

The protection of birds under Australia's environmental laws requires knowledge of the size and the rates at which populations change. In the recent Action Plan for Australia's Birds 2020 (Garnett & Baker 2021), Birdata was used to establish population estimates using a combination of species distributions and population density estimates, primarily drawing on data involving BirdLife Australia's standardised Birdata 2-ha 20-minute survey protocol. In this paper we explore an alternative approach to estimating species' population densities using standardised Birdata 5-km area search surveys. Our analysis utilised field work conducted between 2011 and 2014 at Yaraandoo (32.63º S, 151.66º E), a rural property lightly grazed by cattle near Paterson in the Hunter Valley, NSW.

We assess the credibility of the species-specific density estimates in this study by comparison with those found in other studies. Finally, we reflect on the importance of rural properties, such as Yaraandoo, in sustaining local bird populations.

METHODS

Twenty-nine 5-km area search surveys (https://birdata.birdlife.org.au/) were conducted between June 2011 and February 2014. Each survey followed the same 3 km route, taking approximately 3.5 h to complete. Surveys were conducted by the same observer (MN) in the morning, typically commencing about 1 h after sunrise. All birds seen and heard were counted. Three standard 2-ha 20-minute surveys (https://birdata.birdlife.org.au/) were conducted as part of the 5-km area search and contributed to the total survey data.

In order to calculate the density of each species, we assumed that an area 30 m either side of the route was sampled; a total area of 0.18 km². A correction was made for species that were not recorded on every survey by decreasing the computed densities in proportion to the fraction of surveys during which they were recorded.

Analysis of results

Survey statistics were summarised as mean count numbers and standard deviations for all species. The total population size for Yaraandoo was estimated from the mean number of individuals/survey assuming that the 0.18 km^2 area surveyed was representative of the entire 1 km^2 property. The minimum and maximum population estimates were based on the upper and lower bounds of the mean count indicated by the standard deviation. All population estimates were rounded to the nearest integer.

A comparison of the fit of the count data with normal and log-normal distributions suggested that a normal distribution was the preferred option for assessment of the count data. Results were analysed as mean count numbers and standard errors. Differences in the sub-sets of survey counts by season or year were assessed using Analysis of Variance (when testing across >2 groups) or Student's *t* test (when testing across 2 groups). Variations in occurrence were analysed using RRs (the percentage of surveys that a species was present).

Seasonal variations were assessed based on three arbitrarily defined periods: breeding (Aug to Dec) 14 surveys, post-breeding (Jan to Apr) eight surveys, and winter (May to Jul) seven surveys. Inter-annual comparisons were based on July to June years.

Habitat

Yaraandoo, area *c* 1 km^2, was split into two properties shortly before these surveys commenced. The survey route sampled habitat in both of the subdivided sections. Surveys commenced from the entrance to the house at the north-western corner of the cleared area (**Figure 1**).

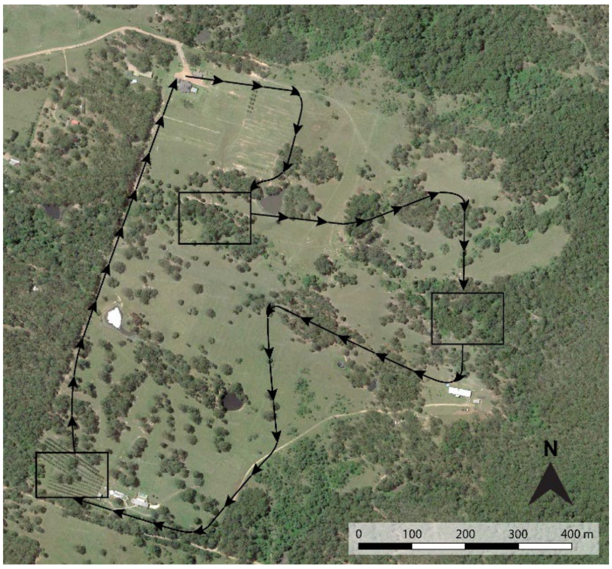

Figure 1. The route used for the 5-km area surveys at Yaraandoo and the locations of the 2-ha 20-minute survey sites.

The route then descended through a recently-cleared olive grove to a small dam above an area of riparian vegetation surrounding a creek, where a 2-ha 20-minute survey was conducted. From there the route ascended to the eastern edge of the cleared area, sampling several copses of retained vegetation. It then descended along a fence line, beyond which there was dense forest, to a creek within a small amphitheatre of grassland surrounded by rainforest vegetation. A 2-ha 20-minute survey was conducted there. The route then descended along a fence line to an area of lightly-timbered pasture, before turning left past a dam and onto the road leading to the property in the south-western corner. A third 2-ha 20-minute survey was conducted in the olive grove adjacent to the house. Finally, the route returned to the starting point, sampling the area adjacent to the fence line and passing another large dam.

RESULTS

One hundred and four species were recorded; a complete list of them is in the on-line **Appendix** (available at https://www.hboc.org.au/the-whistler/the-whistler-volume-16/). From 42-55 species were recorded per survey, with an average of 46 species. Many species were recorded regularly, with 27 species (26% of the total) having RRs of more than 80% of the surveys. In contrast, 34 species (33%) had RRs below 20% (**Figure 2**).

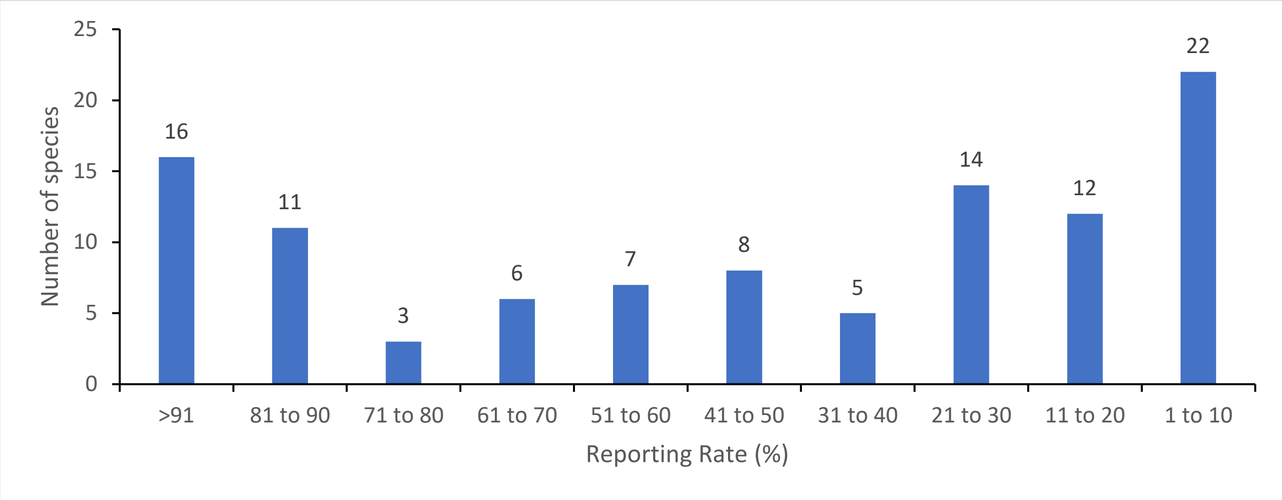

Figure 2. Histogram quantifying the frequency at which species were recorded during surveys at Yaraandoo near Paterson between 2011 and 2014.

Population size

The mean number of birds recorded/survey was 240 (**Table 1**). There were no statistically significant differences between seasons despite seasonal variations for some species (e.g., breeding summer visitors).

Table 1. Statistics for the total number of birds recorded.

Mean number of birds/survey	240
Standard Deviation	56
Mean density (birds/km²)	1330
Maximum density (birds/km²)	1650
Minimum density (birds/km²)	1020

Count statistics and density estimates

Count statistics and density estimates for the 27 most frequently recorded species (those with RR >80%) are shown in **Table 2**. The most abundant species (Yellow-faced Honeyeater *Caligavis chrysops*: 21.1 birds/survey) was recorded 11 times more frequently than the least abundant (Pied Butcherbird *Cracticus nigrogularis*: 1.9 birds/survey). The 27 most regularly recorded species contribute on average 166 birds/survey or 67% of the mean number of birds counted.

Seasonal differences

Six species were found to have statistically significant differences between seasons in the mean number of species per survey (**Table 3** and **Figure 3**). Four species were most abundant in winter - Noisy Friarbird *Philemon corniculatus*, Black-faced Cuckoo-shrike *Coracina novaehollandiae*, Jacky Winter *Microeca fascinans* and Red-browed Finch *Neochmia temporalis*. The increased spread of winter count magnitudes was consistent with the formation of variable sized flocks, as opposed to the presence of territorial pairs in the breeding season (**Figure 3**). In contrast, Rufous Whistler *Pachycephala rufiventris* and Golden Whistler *P. pectoralis* were most numerous in the breeding season.

Table 2. Summary of count statistics and density estimates for the 27 most frequently recorded species ranked in order of decreasing abundance for 5-km area search surveys at Yaraandoo between 2011 and 2014.

Common Name	**Scientific Name**	**Reporting Rate (%)**	**Mean No. of birds**	**Standard deviation**	**Estimated density (birds/km²)**
Yellow-faced Honeyeater	*Caligavis chrysops*	96.6	21.1	19.2	114
Superb Fairy-wren	*Malurus cyaneus*	100	15.6	6.8	87
Red-browed Finch	*Neochmia temporalis*	89.7	11.3	15.1	55
Grey Fantail	*Rhipidura albiscapa*	100	11.1	6.8	62
Lewin's Honeyeater	*Meliphaga lewinii*	100	8.2	2.9	46
Jacky Winter	*Microeca fascinans*	96.6	7.9	6.3	43
Australian Magpie	*Gymnorhina tibicen*	100	6.1	2.3	34
Eastern Whipbird	*Psophodes olivaceus*	100	5.6	2.0	31
Yellow Thornbill	*Acanthiza nana*	86.2	6.6	5.6	32
Striated Thornbill	*Acanthiza lineata*	86.2	6.5	4.4	31
Brown Gerygone	*Gerygone mouki*	89.7	6.0	3.6	30
Noisy Miner	*Manorina melanocephala*	96.6	5.3	2.6	28
Golden Whistler	*Pachycephala pectoralis*	96.6	5.3	2.4	28
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	82.8	5.2	5.0	24
Australian Raven	*Corvus coronoides*	89.7	5.0	4.2	25
Eastern Rosella	*Platycercus eximius*	93.1	4.8	2.7	25
Eastern Yellow Robin	*Eopsaltria australis*	93.1	4.8	2.7	25
Brown Thornbill	*Acanthiza pusilla*	100	4.2	2.4	23
Bar-shouldered Dove	*Geopelia humeralis*	89.7	3.4	1.4	17
Willie Wagtail	*Rhipidura leucophrys*	89.7	3.7	1.6	19
Eastern Spinebill	*Acanthorhynchus tenuirostris*	82.8	3.6	2.3	16
Laughing Kookaburra	*Dacelo novaeguineae*	93.1	3.1	1.5	16
Grey Shrike-thrush	*Colluricincla harmonica*	89.7	3.0	1.8	15
Magpie-lark	*Grallina cyanoleuca*	93.1	2.5	1.5	13
Wonga Pigeon	*Leucosarcia melanoleuca*	89.7	2.4	1.6	12
Grey Butcherbird	*Cracticus torquatus*	93.1	2.3	1.0	12
Pied Butcherbird	*Cracticus nigrogularis*	93.1	1.9	0.8	10

Table 3. Mean numbers and standard errors (SE) for species with statistically significant seasonal differences ($p<0.05$) in the number of individual birds recorded at Yaraandoo between 2011 and 2014.

	RR (%)	**Breeding season means (and SE)**	**Post-breeding means (and SE)**	**Winter means (and SE)**	**Probability (*p*)**
Noisy Friarbird	65.5	3.2 (0.9)	3.4 (0.9)	11.0 (0.6)	0.007
Black-faced Cuckoo-shrike	82.8	3.5 (0.5)	3.8 (1.6)	10.0 (3.2)	0.017
Rufous Whistler	48.3	7.2 (0.8)	1.8 (0.4)	0	0.001
Golden Whistler	96.6	6.3 (0.5)	3.8 (0.6)	5.0 (1.2)	0.047
Jacky Winter	96.6	7.6 (0.8)	5.8 (1.1)	11.0 (1.5)	0.012
Red-browed Finch	89.7	16.8 (2.9)	6.8 (1.4)	25.9 (9.0)	0.044

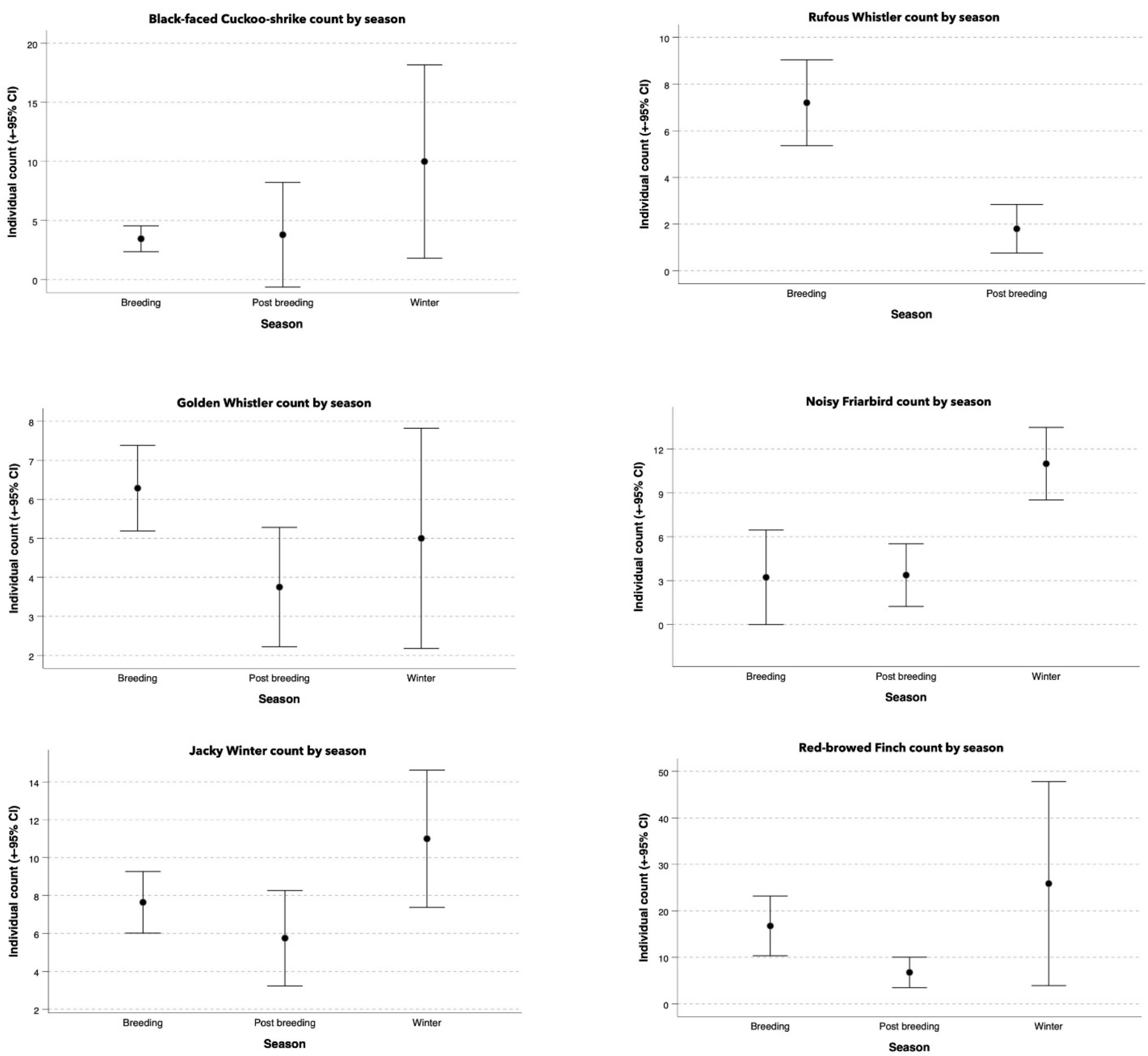

Figure 3. Species with statistically significant differences in seasonal abundance for 5-km area search surveys conducted at Yaraandoo between 2011 and 2014.

Inter-year differences

The number of birds recorded across years was statistically homogeneous except for three species – Yellow Thornbill *Acanthiza nana*, Australian Magpie *Gymnorhina tibicen* and Pied Currawong *Strepera graculina*; their differences are elucidated in **Table 4** and **Figure 4**.

Table 4. Mean numbers and standard errors (SE) for species with statistically significant differences (p<0.05) in the number of individual birds recorded year-on-year at Yaraandoo between 2011 and 2014.

Species	RR (%)	2011/2012 means (and SE)	2012/2013 means (and SE)	2013/2014 means (and SE)	Probability (p)
Yellow Thornbill	86.2	3.2 (1.1)	12.1 (2.4)	4.5 (0.8)	0.001
Australian Magpie	100	8.7 (1.1)	5.7 (0.7)	5.3 (0.4)	0.005
Pied Currawong	65.5	13.5 (3.0)	2.8 (0.6)	1.4 (0.2)	<0.001

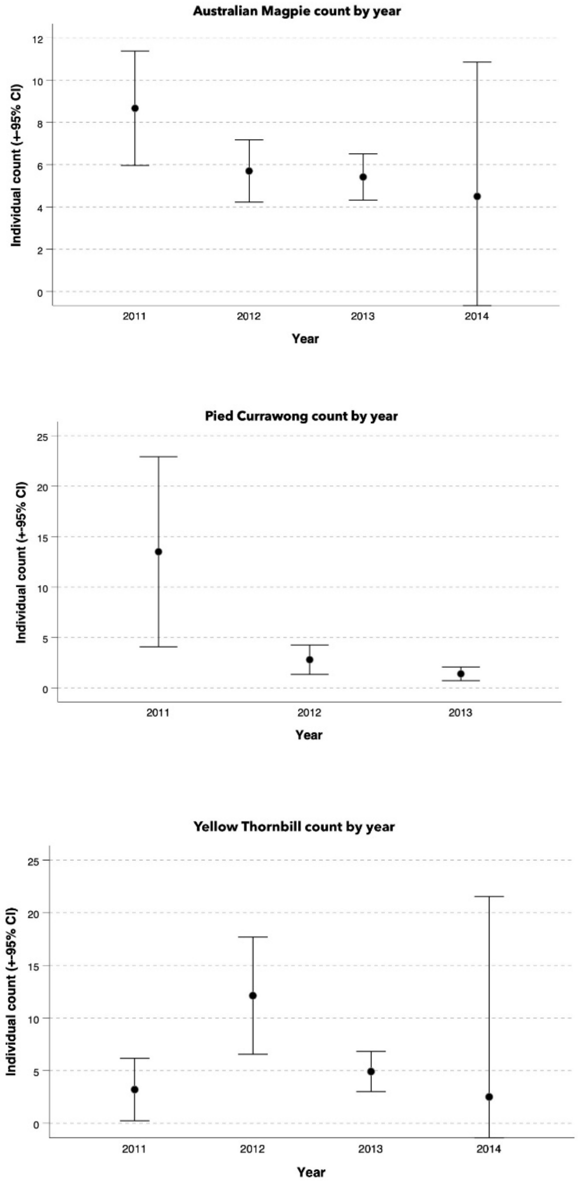

Figure 4. Species with statistically significant inter-year differences in surveys at Yaraandoo 2011-2014.

Threatened Species

Two woodland species listed as threatened in NSW (Roderick & Stuart 2016) were recorded at Yaraandoo. The Varied Sittella *Daphoenositta chrysoptera,* classified as Vulnerable, was recorded on six surveys (RR 20.7%) with a mean count of 4.17 birds/survey and an estimated density of 5 birds/km^2. The Speckled Warbler *Pyrrholaemus sagittatus* occurred on almost half the surveys (RR 48.3%) with a mean count of 2.13 birds/survey and an estimated density of 6 birds/km^2. The attraction of Speckled Warbler to the artificial habitat provided by an irrigated olive grove may have affected these statistics (Newman 2012a).

DISCUSSION

Yaraandoo supported a diverse and abundant bird community with 104 species recorded at the time of these surveys, plus another ten species recorded during surveys not used in this analysis (see the **Appendix**). The total population for the 100 ha (1 km^2) property was estimated to be 1330 birds. To put the magnitude of this estimate into perspective, Loyn (1985) observed populations of 2850, 1450 and 664 birds/km^2 in rainforest gullies, foothill gullies and foothill ridges of forest in Victoria, a rare example of quantified magnitudes of local bird populations.

Twenty-seven regularly occurring species (RR > 80%) contributed two thirds of the total number of birds, suggesting that Yaraandoo provides important habitat (e.g., food availability and in some instances breeding opportunities) for these species. This conclusion also applies to a small number of seasonal visitors such as the Rufous Whistler. Yaraandoo also provides regional connectivity between patches of remnant woodland for many other species that were intermittently recorded.

Abundance

The computed densities are conservative estimates because not all species or individual birds were detected, with small species foraging in the canopy and skulking species being examples. The detectability of species will be variable. For instance, large and highly vocal species (e.g., Australian Magpie) will be more efficiently detected and minimum density based on a 100 m wide sampling zone may provide superior estimates to that based on a 60 m wide sample zone. Conversely, for small skulking species like the White-browed Scrub-wren, the maximum density estimates based on a 40 m wide sampling zone may be more realistic. These estimates of the size of the sampling zone take into account the open nature of the habitat as described below.

The densities estimated in this study, based on whole-of-year survey data, were compared with published values summarized in the Handbook of Australian New Zealand and Antarctic Birds (HANZAB) (e.g., volume 5 for the honeyeater species; Higgins *et al*. 2001) to benchmark the Yaraandoo estimates. HANZAB also provided information on habitat preferences that were used to assess the suitability of Yaraandoo to each species.

The density comparisons in **Table 5** were limited to species that occurred regularly at Yaraandoo, or were of special interest (e.g., threatened species). Species were selected to provide a range of contrasting life-style traits (e.g., ground and canopy feeding specialist species, highly territorial and locally nomadic species etc.). For many species the densities listed in HANZAB were extremely variable. This reflects differences in survey methodology and studies in modified habitat. For example, involving small area (3 ha) survey sites to investigate bird populations in forest communities (Loyn 1985). The ranges shown in **Table 5** excluded apparently anomalous values.

Table 5. Comparison of estimated densities at Yaraandoo with ranges typically recorded in other studies (species listed in order discussed).

	Yaraandoo (birds/km^2)	Other studies (birds/km^2)
Yellow-faced Honeyeater	113	1-100
Lewin's Honeyeater	46	1-20
Noisy Miner	28	80-100
Red-browed Finch	62	10-20
Eastern Rosella	25	5-61
Eastern Whipbird	31	3-45
Superb Fairy-wren	76	20-900
Grey Fantail	62	2-104
Striated Thornbill	31	100-200
Yellow Thornbill	32	10-200
Australian Magpie	34	10-100
Eastern Yellow Robin	25	20 -80
Rufous Whistler	40 [1]	20-200
Golden Whistler	28	20-100
Grey Shrike-thrush	15	10-100
Jacky Winter	43	20-50
Willie Wagtail	19	10-100
Speckled Warbler	6	10-60
Varied Sittella	5	10-60

[1] The breeding season (Aug-Dec) population density at Yaraandoo.

The three most frequently recorded honeyeater species have very different life styles. The Yellow-faced Honeyeater, the most abundant species, predominantly forages in the canopy and is a partial migrant to the Hunter Region. Hence, Yaraandoo supports a combination of locally nomadic birds seeking food resources and passage migrants. Its population probably predominantly involves a constant flux of birds moving through the area, as opposed to resident territorial birds. The estimated density is within the very broad range of densities found in other studies.

In contrast, Lewin's Honeyeater *Meliphaga lewinii* is considered to be a sedentary species with little evidence of local movement throughout its range. Its higher density at Yaraandoo compared to other studies is attributed to the near-coastal location in a high-rainfall locality where forest and riparian vegetation have dense understorey, providing ideal habitat. This proposition is supported by the regular presence of Lewin's Honeyeater at the 2-ha sites in the creekside vegetation and the uncleared forest at the perimeters of the property, whereas it was infrequently recorded at the more open 2-ha site in the olive grove.

The third honeyeater, the Noisy Miner *Manorina melanocephala*, is a despotic species that displaces most other species from its colonies. The Yaraandoo estimate is at the lower end of the range of published densities, which were as high as 80 to 100 birds/km^2 in areas dominated by miners. At Yaraandoo, although they were regularly encountered, it was mainly in habitat that they were unable to dominate because of understorey vegetation. As the survey route did not pass through any breeding colonies of Noisy Miner, the estimated density primarily involved birds foraging away from adjacent miner-dominated colonies.

Red-browed Finch are often found in modified habitats, especially where disturbance creates grassy habitat within or bordering the edges of forest or woodland. Not surprisingly, it was abundant at Yaraandoo with an estimated density of 62 birds/km^2, which is above that recorded in other studies in NSW.

The Eastern Rosella *Platycercus eximius* inhabits open woodland and lightly wooded grassland, including partly-cleared farmland, where they often cohabit with Noisy Miner (Newman 2013). They were a regular feature of Yaraandoo's bird population with an estimated density of 25 birds/km^2 which corresponds to the range of densities (17 – 61 birds/km^2) recorded in studies near Armidale in NSW (Ford 1985).

The Eastern Whipbird *Psophodes olivaceus* is another sedentary species, which like Lewin's Honeyeater, has a preference for dense understorey vegetation. Although having a skulking nature, it is regularly vocal, and hence easily recorded. The estimated density of 31 birds/km^2 compares well with densities ranging from 3 to 45 birds/km^2 found in other studies.

Superb Fairy-wren *Malurus cyaneus*, a widespread and numerous territorial species, had an estimated density of 76 birds/km^2. This is typical of the magnitude of many published values, but well below some (e.g., 900 birds/km^2). The area surveyed contained open areas that were unsuitable for Superb Fairy-wren, which predominantly forage near shrub-layer vegetation that provides shelter.

Grey Fantail *Rhipidura albiscapa*, a common species at Yaraandoo, is a partial migrant in the Hunter Region (Newman 2012c). Hence, the presence of passage birds in spring and autumn, although less obvious than in the case of migrating Yellow-faced Honeyeater, may temporarily increase the overall numbers. Its estimated density of 62 birds/km^2 was central to the broad range of published densities, ranging from 2 to 104 birds/km^2.

Striated Thornbill *Acanthiza lineata* mainly inhabits eucalypt forests and woodland with a well-developed shrub layer, including wet and dry forests and riparian associations. At Yaraandoo its estimated density was 31 birds/km^2. This is towards the lower end of the range of published values with a number of studies involving densities in the range 100 to 200 birds/km^2 and some higher. Yellow Thornbill, which has similar habitat requirements, was slightly less numerous with an estimated density of 32 birds/km^2, typical of the values found in other studies.

The Australian Magpie prefers open country and Yaraandoo provides ideal habitat, with an estimated density of 34 birds/km^2 which is towards the upper end of the published values.

The Eastern Yellow Robin *Eopsaltria australis*, a ground-foraging species, was usually encountered in small numbers at the edges of forests with understorey vegetation. Its estimated density was 25 birds/km^2, lower than many published records, which ranged from 20 to 80 birds/km^2. This difference reflects the lack of suitable habitat at Yaraandoo, other than at the edges of the property where it abuts uncleared forest.

During the breeding season Rufous and Golden Whistlers co-existed at Yaraandoo at similar densities (40 and 28 birds/km^2 respectively). The Rufous Whistler was a spring-summer visitor, while the Golden Whistler, a species that frequents a variety of timbered habitats including rainforests, was present throughout the year at a mean density of 28 birds/km^2, at the lower end of the range of published range of 20-100 birds/km^2. Seasonal variations in the occurrence of these species are discussed further in the next section. Grey Shrike-thrush *Colluricincla harmonica*, another vocal species with similar habitat preferences to the whistler species, was less numerous (15 birds/km^2). This is a relatively low density for this species, further emphasising the limited amount of timbered habitat in the area surveyed.

In contrast, the density of 43 birds/km^2 for the Jacky Winter was at the upper end of that found in other studies. As discussed in the next section, this was associated with the presence of winter flocks in grazed areas at Yaraandoo (Newman 2012b). Willie Wagtail, another species of lightly timbered and open habitats, although regularly recorded, had a density of 19 birds/km^2, at the lower end of the published range.

The two threatened species, Speckled Warbler and Varied Sittella, were present at densities lower than those found in other studies. Their status is discussed in a later section.

The above examples suggest that when birds are counted the 5-km-area survey methodology provides credible density estimates. With hindsight, the methodology could be improved by assessing the typical distance from the nominal survey route at which species were detected, allowing species-specific estimates.

Seasonal Differences

Jacky Winter was more abundant in winter, forming small flocks that foraged in cleared areas (Newman 2012b). The winter density of 61 birds/km^2 was statistically significantly higher than the breeding and post-breeding season densities of 42 and 32 birds/km^2 respectively.

Similarly, there were statistically significant increases in the abundance of the Noisy Friarbird, Black-faced Cuckoo-shrike and Red-browed Finch in winter. These increases may reflect the local movements of flocks formed after the breeding season, but also movements of some populations from higher altitudes towards the coast in the case of the Noisy Friarbird (Higgins *et al.* 2001).

Golden Whistler was another species in which seasonal differences were apparent. In this case the breeding season density of 35 birds/km^2 was statistically significantly higher than in the post-breeding season, 21 birds/km^2, with the winter density at an intermediate level of 28 birds/km^2.

These differences may reflect a seasonal difference in detectability as opposed to an actual decrease in numbers during the post-breeding season. The Golden Whistler is highly vocal in the breeding season when advertising its territories, and this results in a high detection rate. Rufous Whistler, an equally vocal summer visitor, was slightly more abundant, 40 birds/km^2, than the Golden Whistler in the breeding season. Its post-breeding season was significantly lower at 10 birds/km^2, probably reflecting a combination of decreased detectability and the departure of migrating birds. There were no winter records.

The deafening noise of cicadas in timbered areas adversely impacted on the aural detection of all bird species, especially at the beginning of the post-breeding season in January and February.

Inter-year differences

The ability to detect statistically significant inter-year differences in the abundance of three species further emphasises the advantage of count data over presence data in evaluating the dynamics of bird populations. The reasons for the differences are unknown.

Threatened species

The intermittent presence of Speckled Warbler and Varied Sittella demonstrates the importance that rural properties like Yaraandoo have in sustaining them within fragmented landscapes. In the case of the Speckled Warbler, artificial habitat provided by an irrigated olive grove was exploited opportunistically (Newman 2012a).

The case for density estimation options

In the Action Plan for Australian Birds 2020 (Garnett & Baker 2021), 2-ha 20-minute surveys were used to estimate the densities and population sizes of threatened species. An advantage of this approach which uses small area survey data for population estimation is that the survey sites can be related to specific habitat types. As the densities of many species are strongly dependent on habitat type, this knowledge is important when estimating the populations of species at the landscape scale. Hence, the selection of survey sites in uniform habitat is encouraged in many investigations. However, as indicated earlier the 2-ha 20-minute survey approach is data-intensive and for many species data deficiency necessitated the use of inexact expert elicitation methods to estimate densities. A further issue is the preference of many bird species for habitat ecotones, the interface between habitat types.

In this study we took the alternative approach of surveying an area approximately ten times larger than the standard 2-ha survey, in a fragmented landscape involving a variety of habitat types in which ecotones were dominant. In studies of this type, the habitat matrix sampled may be unique, which limits its applicability to the estimation of regional population size. Nevertheless, such studies have an important role as an adjunct to other approaches to landscape scale population estimation. As discussed above, estimation methodologies based on 2-ha surveys have limitations, particularly for sparse species. Studies like Yaraandoo provide a method of testing the credibility of the predictions of more fundamental approaches. The Yaraandoo approach has other benefits, such as the consistency of results when long-term monitoring is conducted using a single observer or observer team.

In this study, significant differences in seasonal and year-on-year population densities were identified using count data, which was a superior indicator of change than was presence data (RRs). Counting woodland birds is difficult because the results are subject to observer bias (sources of bias include the observer's knowledge of calls and their hearing range) and the familiarity of the observer with a survey site. These are valid limitations with respect to the analysis of citizen science data sets involving multiple observers and to comparing studies involving different observers. However, when a single observer is involved, as in this study, the 'observer' becomes a variable that is a systematic as opposed to a random source of error. This increases the reliability of relative measures such as seasonal differences in abundance.

The Yaraandoo survey design was based on the Royal Australasian Ornithologists Union (now BirdLife Australia) Birds on Farms project, which was initiated in 1996. Hence, there is potentially a wealth of historical data that could provide valuable insights into the extent that bird abundance has changed over the last 25 years. For example, MN conducted similar surveys to those at Yaraandoo at other locations near Paterson, including monthly surveys at Green Wattle Creek from mid-1996 to early 2014 (Newman 2009).

CONCLUSIONS

During the period 2011-2014, Yaraandoo, a property lightly grazed by cattle, supported a diverse and abundant bird community. The property was approximately 1 km^2 in size with an estimated 20% remnant vegetation and partially surrounded by uncleared forest.

Count data were used to identify seasonal and year-on-year differences in the abundance of species. Count data were a more sensitive indicator than presence data (i.e. Reporting Rates). The Jacky Winter is an example of a species that, although present throughout the year, was more abundant in winter.

The total species density for the property, and the densities of individual species, were consistent with magnitudes reported in other studies.

There are relatively few estimates of the size of regional bird populations in Australia, or of the species-specific densities that are necessary to estimate the size of bird populations. Consequently, the numbers of a common species such as the Superb Fairy-wren inhabiting either the Hunter Region, NSW or all of Australia, are unknown.

The approach used in this study, involving the same observer regularly searching a relatively large area of diverse habitat types in a systematic manner, has merit as an adjunct to other methods of estimating bird populations using small area habitat-specific surveys (e.g., 2-ha 20-minute). There are similar historical data sets to the Yaraandoo study for other Hunter Region locations, and probably elsewhere, that include count data suitable for this type of analysis. Collectively, such data sets may be capable of providing insights into how the abundance of woodland bird species has changed during the past 25 years. These neglected data sources provide a unique opportunity to inform bird conservation and they require urgent identification and evaluation.

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