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Effectiveness of transects, point counts and area searches for bird surveys in arid *Acacia* shrubland

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Several different survey techniques are commonly used to assess the richness and abundance of birds. These methods can vary with respect to the likelihood of detecting species with different habits or characteristics and their effectiveness in different vegetation structures. It is advisable, therefore, to test the effectiveness of different methods for specific vegetation types and the bird assemblages associated with them before deciding on the most appropriate technique. We tested the effectiveness of three of the most commonly used bird survey methods – interval point counts, strip transect counts and timed area searches – in a replicated study in arid *Acacia* shrubland in central Australia. Timed area searches produced the highest estimates of species richness and abundance, and point counts were the least effective method. Timed area counts are probably more effective in the relatively dense vegetation structure characteristic of *Acacia* shrublands because they allow the observer to examine thicker patches of vegetation more closely than with the other methods, thereby enabling the observer to locate more cryptic species. Timed area searches may increase survey effectiveness in sites with thicker vegetation.

INTRODUCTION

Developing effective methods to assess species richness and relative abundance of specific plant and animal groups is a fundamental aspect of biological surveying and monitoring. The choice of appropriate methods is an important starting point in designing surveys and monitoring programmes. For most groups of animals and plants, multiple survey methods are available, each with strengths and weaknesses. Understanding the limitations of alternative methods and choosing the method that best matches the questions being addressed by the study and the variables that are being measured will dictate the success, or otherwise, of the research programme.

Birds are a very commonly encountered and active class of vertebrates that are relatively easy to identify. Consequently, bird surveying is usually conducted visually, and a variety of techniques has been developed to assess avian species richness and relative abundance across space and time (Krebs 1999). A wide range of methods developed in the Northern Hemisphere has been applied, sometimes with modifications, to survey Austral avifaunas. Among the commonly used methods are transect counts, point counts, area mapping, area searches and mark-recapture studies (Pyke and Recher 1984). The most appropriate method for a particular study will depend not only on the project's objectives, but also on the suite of species comprising the avian community and the vegetation structure of the habitat (Martin *et al*. 2017). Given such variation, survey methodology should ideally be tested prior to the commencement of larger research projects (Totterman 2015) with the aim of determining which method will achieve the most complete survey (i.e. the highest number of species and most accurate measure of abundance) for the least effort (Watson 2003; Witmer 2005). Such methodological testing has not previously been undertaken in arid *Acacia* shrubland, despite this being one of the most widespread vegetation types in inland Australia (Nano *et al*. 2017).

Transects, point counts and area searches are among the most common methods used for bird surveying in Australia. These methods all give measures of relative abundance (birds observed per unit of time and area), rather than absolute densities. Transects involve an observer moving along a set route (usually a line) for a set distance at a measured pace, while recording all birds detected. Line transects may involve the observer estimating the distance from the line to each bird detected, thus enabling density estimates to be calculated (Buckland *et al*. 1993). An alternative is to use strip or fixed-width transects where boundaries of the search area are marked and the observer walks along the centre line of the strip, with only birds within the marked areas being included (Bell and Ferrier 1985). Transects are normally long and narrow, because few birds are detected more than 30m from the transect line and most detection has been reported to occur within 20m (Recher 1984). Point counts are undertaken by a stationary observer who records all birds detected from the location over a set period. As with line transects, point counts can involve an estimate of the distance to each individual observed, or can be made within a set radius. Interval point counts are a series of point counts made at set intervals, normally along a transect line. These intervals need to be far enough apart for each count to be independent, but close enough to ensure that the area covered is similar to that in other methods (Pyke and Recher 1984). Area searches differ from transect and point counts in that the observer can move freely about the designated locale, for a fixed amount of time. When this method was first initiated, 20-minute area searches were undertaken on unmarked areas of approximately three hectares; 2 ha has been used as the standard in most subsequent studies and marked areas are also sometimes used (Loyn 1986).

Comparisons have been carried out to ascertain the most efficient survey technique in different Australian conditions. Loyn (1986) found that estimates of density from transect counts were less than those arrived at from area mapping, a technique that relies on mapping nest locations or individual territories. He reported that area searches are more effective for cryptic species, but birds may be counted more than once if care is not taken by the observer when moving through the plot. Bell and Ferrier (1985) found that all transect procedures tended to underestimate the densities of birds on plots. Davies (1982) found that point counts gave higher estimates of density than transects. Hermes (1977) compared estimates of bird populations obtained by transect counts, interval point counts, area searches and mapping. He found that each method gave a different estimate for density, as did Arnold (1984), who found transects to be more effective than point counts at locating inconspicuous species. Recher (1984) reported that surveying conducted on transects was the only method among four (mapping, nest searches and mist netting being the others) that would adequately sample the complete avifauna of an area. Harden *et al*. (1986) found that estimates of birds in strip transects are affected by the rate of observer movement and strip width.

Some of the variation among the studies outlined above may have been caused by factors independent of the survey method, including observer bias and differences in how each method was applied. Kavanagh and Recher (1983) found that results could differ significantly even when several observers, each with extensive experience, used the same method on the same survey plot. As birds are highly mobile, the presence of the observer can affect their detectability (Pyke and Recher 1984), and movement by both birds and the observer can result in individuals being counted more than once, a likelihood that increases the longer an observer is in a plot. Weather, season and time of day will also affect survey results (Keast 1984). All these factors need to be considered in study design.

The aim of this study was to determine which method, out of strip transect counts, fixed radius interval point counts and timed area searches, would be the most cost-effective, delivering the highest estimates of species richness and abundance of birds in *Acacia* shrubland for the least effort.

METHODS

Study site

This study was undertaken in *Acacia* shrubland at the Alice Springs Desert Park (23.7066° S, 133.8326° E), a 1300ha reserve on the western boundary of Alice Springs, Northern Territory, Australia. The environment is dominated by Mulga *Acacia aneura* and Witchetty Bush *A. kempeana* and characterised by a generally open structure, with scattered shrubs and grasses interspersed with clumps of dense vegetation along small drainage lines. The shrub layer is one to two metres tall in open areas and up to six metres along drainage lines.

Study Design

To eliminate as many sources of bias as possible and by reference to the literature, the following survey guidelines were established:

1. Only one observer familiar with the central Australian avifauna carried out surveys (Kavanagh and Recher 1983).
2. Procedures were fully defined prior to undertaking surveys (Kavanagh and Recher 1983).
3. The various methods were trialled at the same sites to minimize differences resulting from location (Recher 1988).
4. Procedures were conducted during periods of maximum detectability (the first three hours after sunrise) and were not undertaken in high wind or rain (Keast 1984).
5. Survey plots were narrow to allow maximum visibility for differing methods, noting that few birds are detected more than 20m from the point of observation (Recher 1984).
6. Sites were surveyed on multiple occasions to maximise the chances of achieving a complete sample of avifauna present during the survey period (Dobkin and Rich 1998; Watson 2004).
7. Sites were surveyed only once per day to increase the probability of counting species that moved in and out of the plots (Field *et al*. 2002).
8. Surveys were limited to 30 or fewer minutes to allow for effective surveying whilst limiting the risk of double counting (Loyn 1986; Craig and Roberts 2001).

Three two-hectare sites were marked out as 400m x 50m transects using flagging tape. The centre line of each site was also marked. The sites were surveyed between December 2007 and February 2008. Each site was surveyed using each method six times. Weather permitting, sites were surveyed on consecutive days between 06:00 and 09:00 hours ACST (the hot weather in central Australia limits peak activity of birds to the early morning in summer). Only one site was surveyed per day, using all three methods.

Each site was surveyed using the three different methods consecutively (i.e. interval point count, strip transect and area search); the active sampling time for each method was 30 minutes, with a 10-minute interval between surveys to limit the impact of disturbance by the observer. The order in which survey methods were used was changed each day. All birds identified by sight or sound were recorded. Observations were made using Canon 8 x 40 binoculars.

When conducting transect counts, the centre line of the plot was walked at a measured pace, taking 30 minutes to cover the 400m without leaving the centre line. Interval point counts were conducted at eight points marked down the centre line of the plot. This number was chosen to maximize coverage of the whole plot within a viewing radius of about 50 m. The observer walked to each point, waited for five minutes to allow for effects of the disturbance to subside, and then recorded all birds seen by scanning the area for 3.75 minutes. For area searches, the observer moved through the plot without a fixed path and actively searched for birds without going over area already covered. Thicker patches of vegetation were studied closely.

Data Analysis was conducted using *Primer v7* (Clarke and Gorley 2015) and *Permanova+ for Primer* (Anderson *et al*. 2008). For each variable of interest, data were square-root transformed prior to analyses, and Bray-Curtis similarities were calculated between samples. We then used permutational analysis of variance to test whether estimates of bird species richness, total abundance or community composition differed among survey methods using a two-factor model with survey method as a fixed factor and site as a random factor. We used the total number of species detected and the mean abundance over the six surveys at a site as our response variable (i.e. there was no replication within sites). Non-metric multi-dimensional scaling plots (nMDS) were also generated from the Bray-Curtis similarities to enable visual representation of the species composition of each site as estimated by each survey method.

RESULTS

Four hundred and ninety-six bird sightings of twenty-two species were recorded during the surveys. The number of species detected differed significantly depending on the survey method used (Pseudo-$F_{(2, 8)} = 11.1$, $P = 0.035$). Similar numbers of species were identified at each site using the transect and the area search methods, whereas consistently fewer species were detected using point counts (Table 1). There was a significant difference among sites in the number of species detected (Pseudo-$F_{(2, 8)} = 15.1$, $P = 0.022$), with site 2 having the lowest number of species detected regardless of the survey method used (Table 1).

More species were located more rapidly using the area search method compared to the other two methods (Figure 1). The cumulative species richness for the area search method may have begun to plateau after six surveys, but additional surveys would be required to test this possibility. There was also a significant difference in the abundance of birds detected by the different methods (Pseudo-$F_{(2, 4)} = 14.84$, $P = 0.001$). Abundance also varied across sites (Pseudo-$F_{(2, 4)} = 41.52$, $P = 0.034$). Many more individual birds were seen at each site using the area search method compared to point counts or transects, and the fewest birds were detected using point counts (Table 2).

Indices of relative abundance for each species were calculated (separately for each survey method) as the mean number of individuals observed per survey (six surveys at each of three sites) (Table 3). The comparisons suggest that point counts gave the lowest or equal-lowest estimates of abundance for most species. Area searches and transects resulted in the highest estimates of abundance for the most species (12 of 22 species in each case). The estimates of abundance based on the area search method tended to be higher for smaller species (i.e. those with body mass ≤10g). Six of the seven species with a body mass <10g were recorded most often during surveys conducted with the area search method.

An nMDS plot and a PERMANOVA representing the relative similarity in species composition among sites as estimated by the different survey methods (Figure 2) revealed clumping by site rather than by survey method. Indeed, the composition of the bird assemblage differed significantly among sites (Pseudo-$F_{(2, 4)} = 7.42$, $P = 0.007$), consistent with the detected differences in species richness and abundance among sites. However, no significant differences in assemblage composition were detected with different survey methods (Pseudo-$F_{(2, 4)} = 1.76$, $P = 0.053$).

Table 1

The number of bird species recorded at three Acacia shrubland sites using three survey methods over six surveys at each site.

Site	Area search	Point count	Transect	Total
Site 1	11	7	11	14
Site 2	8	6	8	9
Site 3	14	9	10	16
Total	19	12	19	22

Table 2

Numbers of individuals of all species surveyed at three Acacia shrubland sites using three survey methods over six surveys at each site.

	Point count	Transect	Area search	Total
Site 1	55	68	98	221
Site 2	18	22	37	78
Site 3	43	61	93	197
Total	116	151	229	496

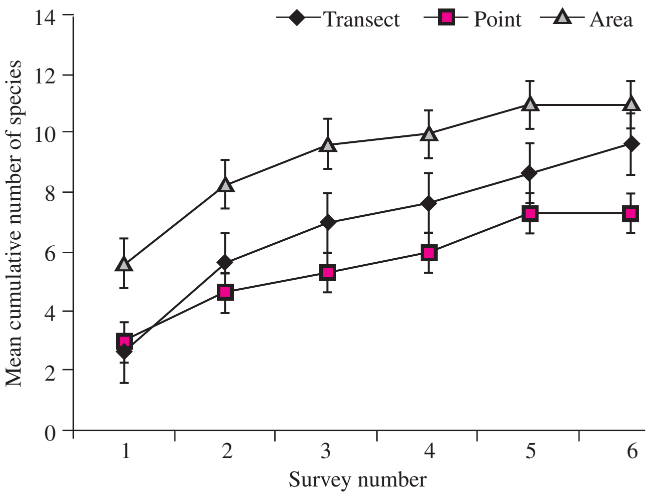

Figure 1. *Cumulative species richness of birds at three Acacia shrubland sites using three survey methods over six surveys at each site.*

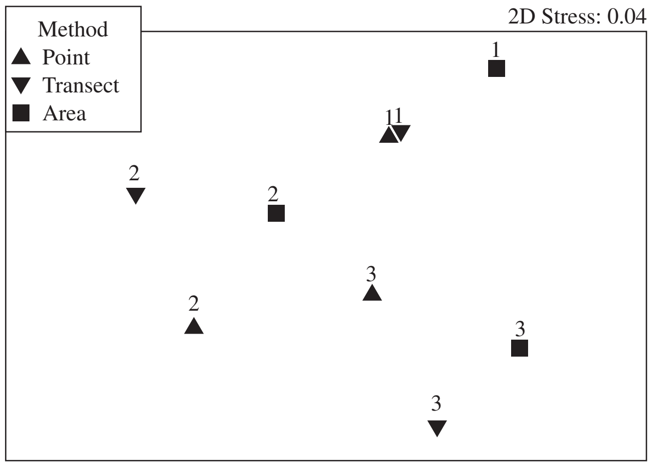

Figure 2. *Non-metric multi-dimensional scaling plot representing the relative similarity among avian communities at different sites as assessed by different survey methods. The nMDS was conducted using Bray-Curtis similarities between sites and methods, calculated from species composition and abundance data averaged over 6 survey periods.*

Table 3

Index of relative abundance (average individuals observed per survey) of bird species across all sites based on each method. Body mass taken from the Handbook of Australian New Zealand and Antarctic Birds (Marchant and Higgins, 1993; Higgins and Davies, 1996; Higgins, 1999; Higgins *et al.*, 2001; Higgins and Peter, 2002; Higgins *et al.*, 2006) Volumes 2-7. Species are arranged in descending order of body mass. The method/s that resulted in the highest or equal highest abundance estimates for each species are shown in bold.

English name	Scientific name	Body mass (g)	Relative abundance Transect	Point count	Area search
Crested Pigeon	*Ocyphaps lophotes*	150-250	**0.16**	0.05	0.05
Australian Ringneck	*Barnardius zonarius*	150-175	**0.05**	0	0
Western Bowerbird	*Ptilonorhynchus guttatus*	140	**0.05**	0	0
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	115	0	0	**0.05**
Grey Shrike-thrush	*Colluricincla harmonica*	65	**0.11**	0	0
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	50	2	2.17	**2.34**
Little Button-Quail	*Turnix velox*	35-50	**1.22**	0	0.5
White-browed Babbler	*Pomatostomus superciliosus*	40	**0.27**	0.11	0.17
Diamond Dove	*Geopelia cuneata*	33	**0.05**	0	**0.05**
Singing Honeyeater	*Lichenostomus virescens*	28	0.44	**0.55**	**0.55**
Rufous Whistler	*Pachycephala rufiventris*	25	**1.05**	0.2	1
Horsfield's Bronze-cuckoo	*Chalcites basalis*	23	0	0	**0.05**
Willie Wagtail	*Rhipidura leucophrys*	18	**0.17**	0.05	0.16
Zebra Finch	*Taeniopygia guttata*	12	0.11	0.11	**0.61**
Red-browed Pardalote	*Pardalotus rubricatus*	11	**0.16**	0	0.11
Splendid Fairy-wren	*Malurus splendens*	9	3.5	3.39	**5.66**
Mistletoebird	*Dicaeum hirundinaceum*	9	**0.33**	**0.33**	**0.33**
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	9	0	0	**0.11**
Red-capped Robin	*Petroica goodenovii*	9	0.16	0.22	**0.67**
Variegated Fairy-wren	*Malurus lamberti*	8	**0.11**	**0.11**	0.05
Inland Thornbill	*Acanthiza apicalis*	7	0.28	0.28	**1.61**
Western Gerygone	*Gerygone fusca*	6	0.05	0	**0.11**

DISCUSSION

In this study, we compared estimates of species composition and relative abundance in an arid *Acacia* shrubland bird assemblage using three commonly used survey methods. Area search and transect methods yielded higher estimates of species richness than did interval point counts. Nearly twice as many individual birds were observed when using the area search method compared to the other methods. The high number of individuals detected partly explains why the number of species detected accumulated most rapidly when using area searches. Although we did not detect significant differences in overall species composition using different survey methods, area searches appeared to be more effective at detecting some species (Table 3), particularly the smaller ones. Nevertheless, no method was completely successful in sampling all the bird species in the area.

The species detected most often using the transect method included several large, conspicuous, mobile birds, such as the Western Bowerbird *Chlamydera guttata*, Australian Ringneck *Barnardius zonarius* and Grey Shrike-thrush *Colluricincla harmonica*. If these species were present at a site during an area search, a competent observer would be expected to locate them; therefore, it seems likely that these species were either absent from the sites during the area surveys or that disturbance by the observer caused them to leave. In contrast, of the seven smallest (< 10 g) species recorded, five were estimated as being most abundant based on area searches. The larger, but cryptic, Horsfield's Bronze-cuckoo *Chalcites basalis* was also only recorded during area searches, but on just one occasion. These findings are consistent with the conclusion of Hewish and Loyn (1989) that area search methods are more effective at locating smaller, more cryptic species. The area search method allows increased detection of more cryptic or non-calling species because of the observer's freedom to carry out closer examination of denser vegetation and to pursue identification of smaller species (Craig 2004). This is supported by our observations in the *Acacia* shrublands of central Australia, where close examination of dense clumps of Witchetty Bush and Mulga was often fruitful, and area searches provided a more complete representation of the bird assemblage than either point counts or transects.

Although there is an increased probability of counting birds more than once when using area searches, we do not think that this can fully account for the increased abundance of birds recorded during such searches. Higher abundances were recorded principally among a suite of small, relatively inconspicuous species, such as the Inland Thornbill *Acanthiza apicalis*, Splendid Fairy-wren *Malurus splendens* and Red-capped Robin *Petroica goodenovii*. For these species, up to twice as many individuals were found with the area search method than with each of the other two methods. Larger and more conspicuous species, such as Rufous Whistler *Pachycephala* *rufiventris* and Spiny-cheeked Honeyeater *Acanthagenys rufogularis*, were recorded more evenly across methods. This suggests that improved detection in large part accounts for the differences in abundance that we observed. Even if the likelihood of double counting was higher during area searches and abundance estimates consequently were slightly elevated, it is generally considered that this risk is outweighed by the tendency of other methods, such as transects, to underestimate relative abundance (Hermes1977; Arnold 1984; Bell and Ferrier 1985; Hewish and Loyn 1989). Craig (2004) stated that area searches produce higher density estimates than point counts and transects because they take longer to conduct. However, this was not true in this study, where the time spent actively surveying birds was identical for all methods; nor was it valid in a study in Wandoo woodland in south-west Western Australia, which also found that the highest density estimates were derived from area searches (Arnold 1984).

Our aim was to determine which of the three trialled survey methods would provide the highest species richness and abundance for the least effort. Based on our results, we conclude that timed area searches are the most suitable survey technique for arid *Acacia* shrublands, primarily due to the ability of the observer to search for the more cryptic species that make up a considerable proportion of the central Australian avifauna in denser, shrubby areas. Point counts were the least effective and efficient survey method in this vegetation type.

REFERENCES

Anderson, M. J., Gorley, R. N. and Clarke, K. R.(2008). *Permanova+ for Primer: Guide to software and statistical method.,* Primer-E. Ltd., Plymouth, UK.

Arnold, G. W. (1984). Comparison of numbers and species of birds in wandoo woodland obtained by two census methods. In: *Methods of Censusing Birds in Australia.* pp. 15-18. Royal Australian Ornithologists Union, Perth.

Bell, H. L. and Ferrier, S. (1985). The reliability of estimates of density from transect counts. *Corella* **9**: 3-13.

Buckland, S. T., Anderson, D. R., Burnham, K. P. and Laake, J. L. (1993). *Distance sampling*: *estimating abundance of biological populations.* Chapman and Hall, London.

Clarke, K. R. and Gorley, R. N. (2015). *Primer v7: User Manual/ Tutoria.* Primer-E, Plymouth, UK.

Craig, M. (2004). A comparison of species counts and density estimates derived from area searches, line transects and point counts in the Jarrah forest of south-western Australia. . *Corella* **28**: 55-59.

Craig, M. D. and Roberts, J. D. (2001). Evaluation of the impact of time of day, weather, vegetation density and bird movements on outcomes of area searches for birds in eucalypt forests of south-western Australia. *Wildlife Research* **28**: 33-39.

Davies, S. J. J. F. (1982). *Counting bush birds at Eyre*. Eyre Bird Observatory Report 1979-1981: 43-48.

Dobkin, D. S. and Rich, A. C. (1998). Comparison of line-transect, spot map and point count surveys for birds in riparian habitats of the great basin. *Journal of Field Ornithology* **69**: 430-443.

Field, S. A., Tyre, A. J. and Possingham, H. P. (2002). Estimating bird species richness: how should repeat surveys be organized in time? *Austral Ecology* **27:** 624-629.

Harden, R., Muir, R. and Milledge, D. (1986). An evaluation of the strip transect method for censusing bird communities in forests. *Wildlife Research* **13**: 203-211.

Hermes, N. (1977). *A comparative study of some methods of censusing birds.* Australian National University, ACT.

Hewish, M. and Loyn, R. (1989). *Popularity and effectiveness of four survey methods for monitoring populations of Australian land birds*. RAOU Report 55, Royal Australian Ornithologists Union, Melbourne.

Higgins, P. J. (ed.) (1999). *Handbook of Australian, New Zealand and Antarctic Birds Volume 4 Parrots to Dollarbird.* Oxford University Press, Melbourne.

Higgins, P. J. and Davies, S. J. J. F. (eds.) (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 3 Snipe to Pigeons.* Oxford University Press, Melbourne

Higgins, P. J. and Peter, J. M. (eds.) (2002). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 6 Pardalotes to Shrike-thrushes.* Oxford University Press, Melbourne.

Higgins, P. J., Peter, J. M. and Cowling, S. J. (eds.) (2006). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 7 Boatbill to Starlings.* Melbourne, Oxford University Press.

Higgins, P. J., Peter, J. M. and Steele, W. K. (eds.) (2001). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 5 Tyrant Flycatchers to Chats.* Oxford University Press, Melbourne.

Kavanagh, R. and Recher, H. F. (1983). Effects of observer variability on the census of birds. *Corella* **7**: 93-100.

Keast, A. (1984). Assessment of community composition and species richness in contrasting habitats. In: *Methods of censusing birds in Australia*. pp. 19-24. Royal Australian Ornithologists Union, Perth.

Loyn, R. H. (1986). The 20 minute search - A simple method for counting forest birds. *Corella* **1**: 58-60.

Marchant, S. and Higgins, P. J. (eds.) (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 Raptors to Lapwings.* Oxford University Press, Melbourne.

Martin, T. E., Nightingale, J., Baddams, J., Monkhouse, J., Kaban, A., Sastranegara, H., Mulyani, Y., Blackburn, G. A. and Simcox, W. (2017). Variability in the effectiveness of two ornithological survey methods between tropical forest ecosystems. *PLoS ONE* **12**: 1-15.

Pyke, G. H. and Recher, H. F. (1984) Censusing Australian birds: a summary of procedures and a scheme for standardisation of data presentation and storage. In: *Methods of Censusing Birds in Australia*. pp. 55-63. Royal Australian Ornithologists Union, Perth.

Recher, H. F. (1984). Use of bird census procedures in Australia: a review. In: *Methods of Censusing Birds in Australia*. pp. 3-14. Royal Australian Ornithologists Union, Perth.

Recher, H. F. (1988). Counting terrestrial birds: use and application of census procedures in Australia. *Australian Zoological Reviews* **1**: 25-45.

Totterman, S. L. (2015). A comparative evaluation of transect, point count and 2-hectare search methods for bird abundance estimates in dry sclerophyll forest and rainforest. *Corella* **39**: 1-7.

Watson, D. M. (2003). The 'standardized search': an improved way to conduct bird surveys. *Austral Ecology* **28**: 515-525.

Watson, D. M. (2004). Comparative evaluation of new approaches to survey birds. *Wildlife Research* **31**: 1-11.

Witmer, G. W. (2005). Wildlife population monitoring: some practical considerations. *Wildlife Research* **32**: 259-263.