

When more is less: Urban remnants support high bird abundance but diversity varies

JAMES A. FITZSIMONS^{1,2}, MARK J. ANTOS^{1,3} and GRANT C. PALMER^{1,4}

Urban remnant vegetation, especially where it occurs in public parks, allows for relatively easy access for ongoing biodiversity monitoring. However, relatively little baseline information on bird species distribution and abundance across a range of *identifiable* urban remnants appears in the published literature. We surveyed the relative abundance and distribution of birds across urban and suburban remnant vegetation in Melbourne, Australia. One hundred and six species were recorded, of which 98 were indigenous. Red wattlebirds had the highest mean relative abundance with 2.94 birds/ha, followed by rainbow lorikeets (2.51), noisy miners (1.93), brown thornbills (1.75) and spotted doves (0.96). There was no obvious trend between overall relative abundance and the size of the remnant, in contrast to species richness which was positively correlated with remnant size. The data revealed that some species were either totally restricted to, or more abundant in, larger remnants and generally absent from smaller remnants. Some of the more common birds (crimson rosella, superb fairy-wren, spotted pardalote and black-faced cuckoo-shrike) recorded during this study were detected at similar densities to those found in comparable vegetation to the east of Melbourne within a largely forested landscape. Other species occurred at much lower densities (e.g., white-browed scrubwren, brown thornbill, eastern yellow robin and grey fantail) or had habitat requirements or ecological characteristics that could place them at risk of further decline or local extinction in the urban area. We identify a suite of bird species of potential conservation concern within Melbourne's urban landscape. The establishment of repeatable, fixed-point, and long-term monitoring sites will allow for repeat surveying over time and provide an early warning of population declines, or conversely an indication of population increase for other species.

Key words: urbanization, avifauna, relative abundance, remnant vegetation, urban parks, baseline monitoring

INTRODUCTION

IN response to predictions of future climate change and the potentially significant repercussions this is predicted to have on species populations (e.g., Mac Nally *et al.* 2009), there has been increased interest in tracking changes in species distributions over time as well as assessing the viability of populations at local and landscape scales. In Australia, continental-scale atlases (Blakers *et al.* 1984; Barrett *et al.* 2003) and state-based or city-wide surveys (e.g., Aston and Balmford 1978; Woodall, 1995, 2002; Veerman 2003) have documented changes over time in both bird distribution and abundance. These comparisons used a variety of techniques and examined a range of habitats and timescales but did not provide information at a local or patch-level.

Most remnant vegetation patches in urban areas are relatively small compared to those outside of the urban area and many occur within parks and reserves, although significant linear stands can occur along railway corridors, roads and easements. Nonetheless, remnants in urban areas are considered important as they contain species that may not be found in the surrounding urban matrix (Parsons *et al.* 2003; White *et al.* 2005). Urban remnants, and the biodiversity within them, face a number of threats from clearing and fragmentation, weed encroachment, pressures from domestic animals and disturbance from high levels of recreational

use (e.g., Densmore and French 2005; Weston *et al.* 2009). On the other hand, there are often considerable resources spent on maintaining or improving vegetation in urban areas. As remnants are both highly identifiable and the majority occur in some form of publicly accessible park or reserve, they allow easy access for ongoing monitoring and may be important for promoting conservation more broadly.

Unfortunately, relatively little baseline information on species distribution and abundance across a wide range of *identifiable* urban remnants over the same time period appears in the published literature (White *et al.* 2009) (although see Mason 1985; van Polanen Petel and Lill 2004). Accurate and up to date baseline information is important for documenting the rate and extent of increases or declines of species through time and in response to various management actions or disturbances (e.g., Jones 1983; Recher and Serventy 1991; Keast 1995; Jones and Wieneke 2000; Smith 2002; Recher 2004; Burgin and Saunders 2007; Major and Parsons 2010). While some bird species in urban areas have shown marked and obvious increases in the last couple of decades (e.g., lorikeets: Fitzsimons *et al.* 2003; Burgin and Saunders 2007; Smith and Lill 2007) or declines (e.g., grey-crowned babbler: Lockwood and Robinson 1997), other changes are likely to be more subtle. As urban areas continue to expand, there is an increasing need to monitor biodiversity,

¹ School of Life and Environmental Sciences, Deakin University, 221 Burwood Highway, Burwood VIC 3125, Australia

² The Nature Conservancy, Suite 3-04, 60 Leicester Street, Carlton VIC 3053, Australia. Email james.fitzsimons@deakin.edu.au

³ Parks Victoria, Level 10, 535 Bourke Street, Melbourne VIC 3000, Australia. Email mantos@parks.vic.gov.au

⁴ Centre for Environmental Management, School of Science, Information Technology and Engineering, University of Ballarat, PO Box 663, Ballarat VIC 3353, Australia. Email g.palmer@ballarat.edu.au

especially in recently developed suburbs where remnant vegetation may have been recently fragmented. The lack of awareness and understanding of the natural values of some of these urban remnants can be an impediment to their effective conservation and management.

We have previously reported a strong correlation between species richness of native birds and remnant vegetation size in urban areas (Palmer *et al.* 2008). This present paper documents the occurrence and abundance of birds in remnant vegetation of Melbourne, a relatively large and expanding city in south-eastern Australia. Its purpose is threefold. Firstly, it presents a current analysis of species abundance and distribution in remnant vegetation in Melbourne. Secondly, it analyses whether abundance of birds is correlated with remnant size. Thirdly, it presents site-specific records to enable future research and monitoring of change in distribution and abundance.

METHODS AND STUDY AREA

Study area

Research was conducted in Melbourne, Victoria, Australia (37°50'S, 44°58'E). A wide range of natural vegetation types occurred prior to settlement including forests, woodlands, heathlands, wetlands and grasslands. Remnants of many of these habitats may still be found within parks embedded in the urban matrix. Study sites were located within the urban matrix of the Gippsland Plain bioregion, mainly in the eastern and southeastern suburbs, within a 30 km radius of the Melbourne Central Business District (Fig. 1, Appendix 1). Thirty-nine remnants were selected based on size and availability and were at least 2 km apart. Remnants were divided into three size-classes – small (1–5 ha) ($n = 15$), medium (6–15 ha) ($n = 14$) and large (>15 ha) ($n = 10$).

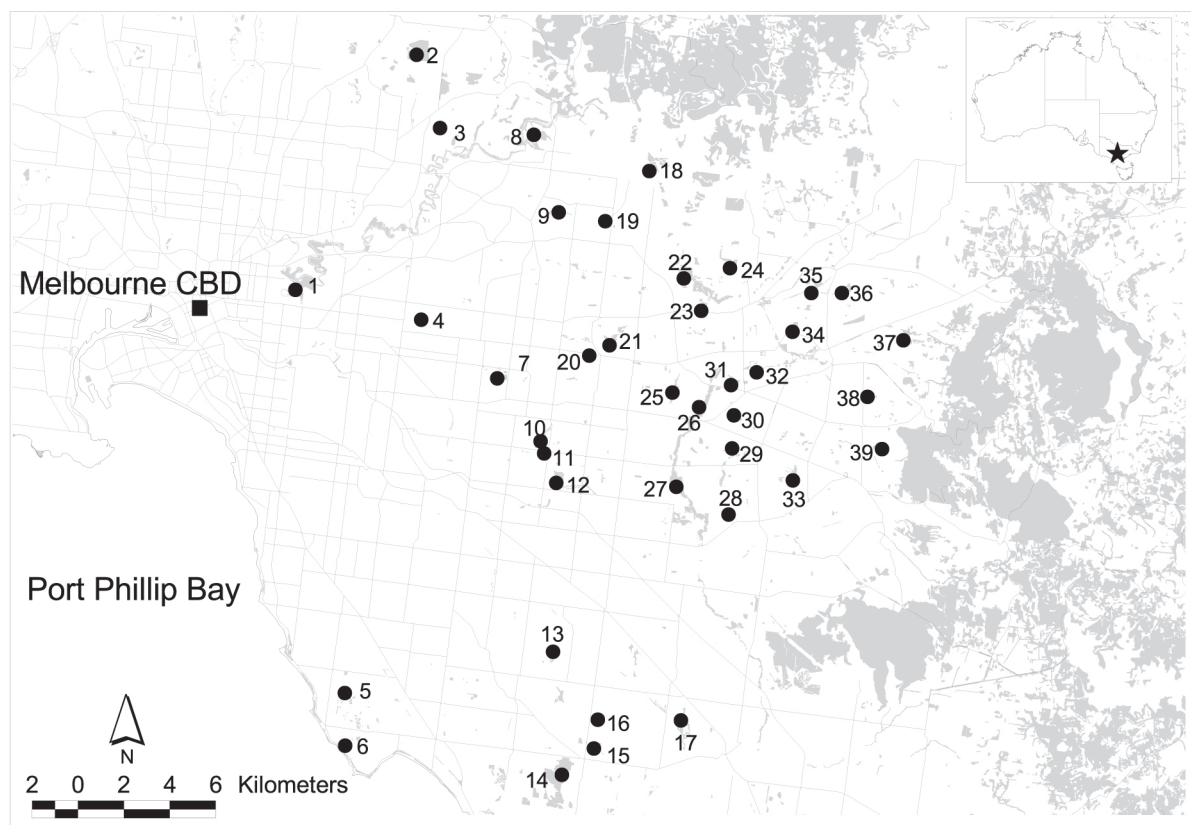


Fig. 1. Location of remnant vegetation patches surveyed. Grey shading represents native vegetation. Key to remnants: 1 Yarra Bend Park; 2 Gresswell Forest Wildlife Reserve; 3 Banyule Creek Reserve; 4 Belmont Park; 5 George St Reserve; 6 Donald McDonald Reserve; 7 Wattle Park; 8 Westerfolds Park; 9 Ruffey Lake Reserve; 10 Dampier Creek Reserve; 11 Bellbird Corner; 12 The Valley Reserve; 13 The Grange Reserve; 14 Braeside Park; 15 Coomoora Rd Reserve; 16 Alex Wilkie Reserve; 17 Yarraman Creek; 18 Currawong Bush Park; 19 Zerbes Reserve; 20 Wandinong Reserve; 21 Blackburn Lake Reserve; 22 Hillcrest Forestway; 23 Antonio Park; 24 BJ Hubbard Reserve; 25 Bellbird Dell Reserve; 26 Koomba Park; 27 Shepherd's Bush; 28 Redcourt Reserve; 29 Flamingo Reserve; 30 William Morris Reserve; 31 Bateman St Reserve; 32 JW Mason Reserve; 33 Lakewood Reserve; 34 Wombalano Park; 35 Cheong Wildflower Reserve; 36 Eastfield Park; 37 Bungalook Conservation Area; 38 Old Joes Creek Reserve; 39 Koolunga Native Reserve

Surveys

Fixed width transects of 1 ha (200 m × 50 m) were used to assess relative abundance and species richness of native and introduced birds. Habitats and transects chosen targeted native terrestrial diurnal species and not aquatic or nocturnal species. While some aquatic species were recorded, it should not be interpreted that the results represent a thorough account of aquatic species in surveyed parks or reserves where aquatic habitats were present. One transect was used to survey small remnants, two transects were used in medium remnants and three transects were used in large remnants. Twenty-minute surveys were conducted during the non-breeding season (April–July) of 2003 and breeding season (October–February) of 2003/04. Each transect was surveyed four times in each season, on different days, between dawn and mid-day during favourable conditions (days of high wind or rain were avoided). Overall relative abundance of each species was calculated by dividing the total number of records by the number of transects and the number of visits. At the remnant scale, relative abundance of each species (expressed as individuals per hectare) was calculated by dividing the total number of records by the number of transects in the remnant and the number of visits.

Data analysis

The relative abundance, species richness and diversity of bird assemblages occurring in remnant size classes were compared using analysis of variance (ANOVA). The SNK multiple range test was used as a post-hoc test to determine where the differences occurred between remnant size classes. Species diversity was calculated using the Shannon Wiener Index. Spearman rank correlation was used to test the relationship between remnant size and the relative abundance and species richness of bird assemblages.

ANOSIM and SIMPER procedures were conducted using PRIMER v 5 software package (Clarke and Gorley 2001) to test for differences in species composition between the three size classes of remnants (i.e., large, medium or small) and to identify the species contributing most to the similarity within each size class of remnant and the dissimilarity between the size classes.

RESULTS

One hundred and six species were recorded in vegetation remnants in urban Melbourne, of which 98 were indigenous, six introduced and two presumed avicultural escapees (Appendix 2). The red wattlebird was recorded in all remnants surveyed, Australian magpie, eastern rosella and rainbow lorikeet in 37 of the 39 remnants, and

spotted pardalote, common blackbird and spotted dove in 35–36 remnants (see Appendix 2 for scientific names). In terms of mean relative abundance across all the remnants surveyed, red wattlebird had the highest with 2.94 birds/ha, followed by rainbow lorikeet (2.51), noisy miner (1.93), brown thornbill (1.75) and spotted dove (0.96). Koomba Park had the highest number of species recorded (49), followed by Braeside (48), Gresswell (46), Bungalook (46) and Shepherd's Bush (41). Some small remnants had considerably fewer species recorded, such as Zerbes, Redcourt and Flamingo Reserves (13, 12, 11 species, respectively) (Appendix 2).

Remnants with the highest overall relative abundance of birds were those in Koomba Park (36.85 birds/ha), Bellbird Dell Reserve (33.50), The Grange Reserve and Coomoora Rd Reserve (31.79 each) and Yarraman Creek Reserve (30.21) (Appendix 2). For each of these parks a small number of abundant bird species contributed substantially to the overall bird abundance but the species mix of these abundant birds differed from remnant to remnant (i.e., Bellbird Dell — red wattlebird, brown thornbill; Koomba Park — superb fairywren, white-browed scrubwren, brown thornbill, rainbow lorikeet; The Grange Reserve — little raven, white-plumed honeyeater, white-browed scrubwren; Coomoora Rd Reserve — noisy miner, red wattlebird; and Yarraman Creek Reserve — red wattlebird, noisy miner).

There was no difference in the mean relative abundance of birds between the remnant size-classes ($F_{2,36} = 1.116$, $p = 0.339$) and there was no relationship between relative abundance of birds and remnant size ($r = 0.096$, $p = 0.560$; Fig. 2). The mean relative abundance of birds was 22.67 birds/ha (sd = 6.81) in large remnants, 24.28 birds/ha (sd = 7.02) in medium remnants and 20.91 birds/ha (sd = 4.37) in small remnants.

There was a significant difference in the richness of bird assemblages between the remnant sizes ($F_{2,36} = 36.231$, $p < 0.001$), with species richness increasing as remnant size increased (Fig. 2). Species richness in large remnants was 39.2 species (sd = 8.84) compared to 27.7 species (sd = 4.01) in medium remnants and 18.2 species (sd = 5.22) in small remnants. The positive relationship between species richness and remnant size ($r = 0.791$, $p < 0.001$) is shown in Fig. 2.

The diversity of bird assemblages was significantly different between the remnant size classes ($F_{2,36} = 13.275$, $p < 0.001$). Large remnants supported more diverse bird assemblages (mean $H' = 2.91$, sd = 0.35) than medium remnants (mean $H' = 2.76$, sd = 0.17) and small remnants (mean $H' = 2.34$, sd = 0.34).

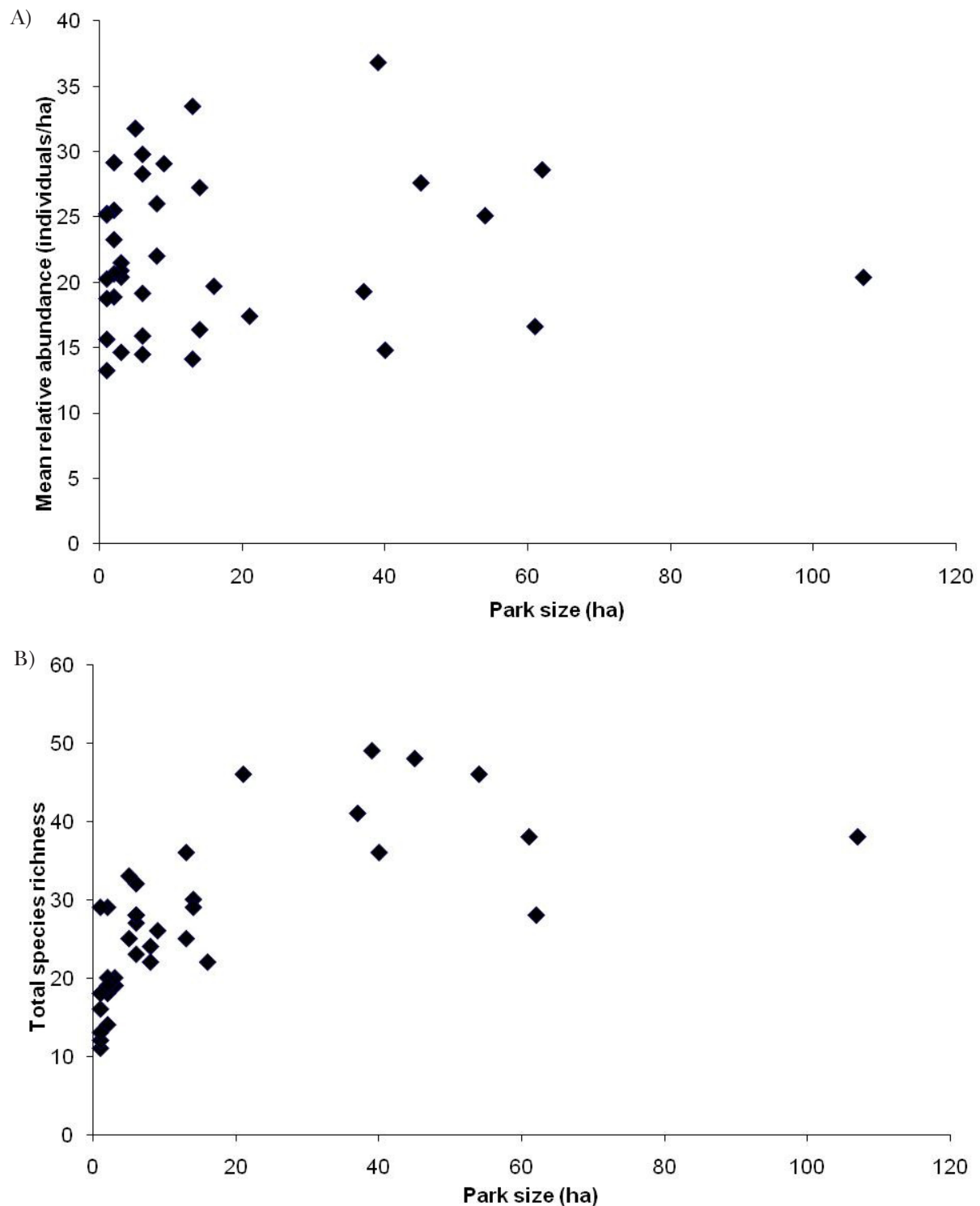


Fig. 2. a) Relative abundance and b) species richness of birds in urban remnants in Melbourne.

There were significant differences in the composition of bird assemblages in large remnants when compared to those in small remnants ($R = 0.268$, $p < 0.01$) and medium remnants ($R = 0.387$, $p < 0.01$) (Table 1). As most species contributing to dissimilarities were observed in all remnant sizes, differences in abundance between different sized remnants were the main drivers of differences in the

composition of assemblages between size classes, rather than the presence or absence of individual species (Table 1).

Some species were far more abundant in large remnants than in small or medium remnants (e.g., rainbow lorikeet, superb fairy-wren, white-browed scrubwren and white-plumed honey-eater). Other species were more abundant in

Table 1. Dissimilarity (%) in assemblage composition between large, medium and small remnants in urban Melbourne. Remnant size: L = large, M = medium, S = small; Results: D = average dissimilarity, C = contribution percentage.

Species	Mean Abundance			L v S (62.83)		L v M (58.20)		S v M (55.72)	
	L	M	S	D	C	D	C	D	C
Noisy miner	1.62	1.16	2.65	6.01	9.57	4.04	6.95	5.90	10.58
Rainbow lorikeet	3.39	1.78	2.50	5.94	9.45	5.65	9.70	4.43	7.94
Red wattlebird	1.57	3.67	3.22	4.87	7.76	4.84	1.30	4.61	8.27
Brown thornbill	1.51	2.41	1.43	3.57	5.69	3.56	6.12	4.14	7.44
Superb fairy-wren	1.44	0.33	0.29	3.08	4.92	2.86	4.91		
White-browed scrubwren	1.13	0.65	0.70	2.48	3.94	2.04	3.50	1.78	3.20
Eastern rosella	0.72	0.41	1.27	2.36	3.76	1.18	2.03	2.44	4.38
Common myna	1.00	1.06	0.49	2.04	3.25	1.90	3.26	2.08	3.74
Spotted dove	0.37	1.33	1.04	1.86	2.95	2.20	3.78	2.19	3.93
White-plumed honeyeater	0.70	0.12	0.32	1.76	2.80	1.46	0.96		
Common blackbird	0.36	1.05	0.92	1.76	2.80	1.64	2.82	1.72	3.09
Musk lorikeet	0.48	0.61	0.71	1.71	2.71	1.44	2.48	1.85	3.32
Spotted pardalote	0.80	0.71	0.69	1.68	2.68	1.67	2.87	1.41	2.52
Australian magpie	0.53	0.97	0.78	1.50	2.39	1.62	2.78	1.53	2.75
Little raven	0.38	0.87	0.63	1.29	2.06	1.32	2.27	1.55	2.78
Silvereye	0.37		0.33	1.24	1.98				
Striated thornbill	0.36	1.18	0.20	1.20	1.91	2.38	4.10	2.68	4.81
Crimson rosella	0.12	0.73				1.50	2.58	1.73	3.10

small remnants than in large or medium remnants (e.g., noisy miner and eastern rosella). Several species showed no clear trend or were more abundant in medium remnants (e.g., red wattlebird, brown thornbill and striated thornbill). The data revealed that some species were totally restricted to (e.g., crested shrike-tit and rufous whistler) or more abundant in (e.g., striated pardalote, eastern yellow robin and golden whistler) larger remnants. There did not appear to be any species that showed an exclusive preference for either medium or small sized remnants.

Our data indicate that the aggressive noisy miner, which is often regarded as being abundant in fragmented and disturbed landscapes (Catterall 2004), was widespread across reserves of all size classes and was quite abundant in some of the largest remnants (e.g., Westerfolds Park) as well as within the smaller remnants. The bell miner was relatively uncommon, being only detected at four different sites, three of which were large remnants.

The distribution and abundance of introduced bird species did not show any clear patterns. Although spotted dove occurred at relatively high abundances, the common blackbird, common starling and common myna tended to occur at low to moderate abundances in many remnants, irrespective of their size.

The surveys detected several species that are listed as threatened in Victoria (DSE 2007), such as the swift parrot, powerful owl and Latham's snipe. These species were typically located at only one or two sites and at very low densities. Our surveys may have under-represented the occurrence of these species, given that many are cryptic and/or require specialized survey techniques (e.g., nocturnal surveys, wetland surveys).

DISCUSSION

This paper documents bird abundance and distribution data for birds in remnant vegetation across a large part of Melbourne. Remnant vegetation in the urban landscape provides valuable habitat for native birds, including a high proportion of the species found in assemblages in large, relatively intact areas of native vegetation in surrounding regions (particularly eucalypt forests and woodlands, e.g., Mac Nally 1996; Hewish *et al.* 2006; Palmer and Bennett 2006). The bird assemblages present in remnant vegetation in the urban landscape are known to be influenced by patch size (Palmer *et al.* 2008), the composition and arrangement of vegetation (White *et al.* 2005; Antos *et al.* 2006; Palmer *et al.* 2008) and the presence of riparian habitats (Palmer *et al.* 2008).

The size of a remnant was found to be particularly important for woodland bird diversity with a significant positive correlation with increasing remnant patch size (Palmer *et al.* 2008). However, there appeared to be no obvious trend between overall relative abundance and remnant size. This can be explained by the fact that many of the species detected in smaller remnants can often form large feeding flocks around favoured food sources (e.g., red wattlebird, lorikeets), are co-operative breeders that live in family groups (e.g., noisy miner, white-browed scrubwren, brown thornbill) or are generally gregarious, at least at certain times of the year (e.g., little raven, common myna). Our findings are in contrast to those of Chiari *et al.* (2010) who found a significant positive relationship between bird species richness and assemblage abundance for the whole urban area of Florence, Italy. However, Chiari *et al.* (2010) also found less of a relationship in highly

urbanized landscapes suggesting the intensity of urbanization at local scales might be important.

The most widely distributed species found in our survey are similar to those found by van Polanen Petel and Lill (2004) in Melbourne remnants (i.e., red wattlebird, Australian magpie, eastern rosella, rainbow lorikeet), although we found spotted pardalotes to be much more widely distributed. Likewise red wattlebird, noisy miner, brown thornbill and spotted dove were on average the most abundant in our study and van Polanen Petel and Lill's (2004) study (although a number of these species were recorded in higher abundances in some remnants in the latter study; whereas we recorded significantly higher relative abundances of rainbow lorikeets). The relative abundance of musk lorikeets (0.68 birds/ha) was lower than that in a previous study of lorikeets in Melbourne in 2002 where this species averaged 1.56 birds/ha in urban remnants (Fitzsimons *et al.* 2003). The seasonal variation in presence and abundance of this species is further demonstrated by the findings of van Polanen Petel and Lill (2004) of it only occurring in one remnant in the 1999–2000 breeding season (1 bird/ha). However, rainbow lorikeets were found to be slightly more abundant in the present study (2.5 birds/ha) compared with that of Fitzsimons *et al.* (2003) who recorded 2.04 birds/ha in urban remnants. Sample size and duration is likely to be an important determinant of relative abundance estimates. For example we found 106 species in the 39 remnants surveyed during the non-breeding season of 2003 and breeding season of 2003–04 whereas van Polanen Petel and Lill (2004) found 50 species in 15 remnants in the breeding season of 1999–2000.

Some of the more common woodland birds encountered during this study were detected at similar abundances to those in comparable vegetation to the east of Melbourne within a largely forested landscape (Palmer and Bennett 2006; Palmer 2007). These included species such as the crimson rosella, superb fairy-wren, spotted pardalote and black-faced cuckoo-shrike. Others occurred at much lower abundances. For instance, our study detected much lower abundances than the riparian sites of Palmer and Bennett (2006) of white-browed scrubwrens (0.8 vs. 2.75 birds/ha), brown thornbills (1.75 vs. 5.61 birds/ha), eastern yellow robins (0.1 vs. 0.98 birds/ha) and grey fantails (0.18 vs. 1.84 birds/ha). One of the few species that occurred at higher densities within our urban remnants was the grey butcherbird, a nest predator, at a mean density of 0.44 birds/ha compared with 0.03 birds/ha in sites examined by Palmer and Bennett (2006).

Although our survey detected a rich bird assemblage within the urban area with over 100 species recorded, the data also revealed that some species were either very rare or absent, despite the presence of apparently suitable habitat. Some of the species that appeared to be under-represented within urban remnants include the cuckoos (only one remnant had more than one species), some migratory species, such as the sacred kingfisher and rufous whistler; robins (scarlet and eastern yellow) and many of the honeyeaters (e.g., yellow-faced, white-eared, white-naped). Species that forage on bark and tree trunks (crested shrike-tit, white-throated treecreeper, varied sittella) were recorded in a small number of remnants despite the presence of apparently suitable habitat in the majority of sites. Some of these species groups have been shown to be susceptible to habitat fragmentation in other areas of Australia or overseas (Ambuel and Temple 1983; Walters *et al.* 1999). It may therefore be possible that some of these species will be lost from urban remnants with time even though habitat quality is maintained.

Historical records indicate that a number of species that were formerly recorded within the greater Melbourne area are now either regionally extinct or very scarce. These include species such as the king quail, ground parrot, regent honeyeater and grey-crowned babbler (Wheelwright 1861; Chisholm 1942, 1943, 1949; Ward 1966; Norris *et al.* 1995). Our study found a range of species to be rare within the urban remnants; some of these remain common and widespread in adjoining areas (e.g., Palmer and Bennett 2006; Palmer 2007), while others have experienced significant declines in southeastern Australia (Barrett *et al.* 2003). We believe several species may be at risk from further decline and local extinction within the urban area because they display a range of characteristics that put them at higher risk, including: occupation of a small number of remnants; being confined to the larger patches of remnant vegetation in the urban landscape; have undergone declines elsewhere in their range; and, have ecological requirements that make them vulnerable to decline in the urban landscape (e.g., bark foragers and ground-nesting birds) (Table 2).

Many urban areas have a range of historical records, publications and studies which document the flora and fauna and allow for some assessment of the changes that have occurred over time. However, in the case of Melbourne, many of these mostly relate to the presence or absence of species rather than relative abundance and they can lack precise location information (e.g., Warringal Conservation Society 1981; Norris *et al.* 1995; Kloot 2000). By gathering data on the relative abundance of species from defined localities using standardized

methods, quantitative assessments of change can be made. We advocate the establishment of repeatable, fixed-point, long-term monitoring sites such as those initiated by Birds Australia's Atlasing project (Anon. 2008) which will allow for repeat surveying over time by different observers while allowing public access to the data. Such data will allow a better understanding of whether certain species are continuing to decline and whether other species (e.g., crested pigeon, red-rumped parrot) are increasing in numbers.

Table 2. Bird species considered to be at risk of declines and local extinctions in the urban landscape of Melbourne. "Reason for concern" codes: 1 = Species occurs in small number of surveyed remnants (<5 remnants); 2 = Species mostly confined to large remnants; 3 = Species only present in outer suburban remnants; 4 = Species known to be declining in south-eastern Australia due to landscape scale processes including habitat loss and fragmentation (e.g., Robinson and Traill 1996; Barrett *et al.* 2003; Mac Nally *et al.* 2009).

Risk species	Reason for concern
Painted button-quail [#]	1,2,4
Swift parrot	1,4
Shining bronze-cuckoo	1,2,3
Pallid cuckoo	1,2,3,4
Fan-tailed cuckoo	1,2,3
Powerful owl	1,4
Sacred kingfisher	1,2,3
White-throated treecreeper	1,2
Yellow-faced honeyeater	1,2,3
White-eared honeyeater	1,2,3
White-naped honeyeater	1,2,3
Brown-headed honeyeater	1,4
Varied sittella	1,2,3
Crested shrike-tit	1,3
Rufous whistler	1,2,3
Dusky woodswallow	1,2,3,4
Scarlet robin	1,2,4
Bassian thrush	1,2,3

[#]Painted button-quail *Turnix varius* not recorded during surveys but known to occur at one or more sites.

As remnants within urban areas are often subject to a wide range of environmental pressures and changes that can occur within comparatively short time frames, and because they can support diverse assemblages of native fauna, they require careful management. This is particularly true for Melbourne, a city with over 4 million residents but also now the most rapidly growing in Australia (Colebatch 2010). To effectively manage such areas, knowledge of the presence and abundance of flora and fauna species and how these respond to environmental pressures and management actions is necessary. We present a tangible example of how this can be achieved over a large geographic area using birds, a taxonomic group widely regarded as good potential environmental indicators (Pearson 1995). Ease of access, close proximity to a pool of professional and volunteer surveyors and a diversity of suitable study species make urban remnants especially suited to long term study

and monitoring to help better understand the impacts of urbanization on biodiversity as well as other ecological processes.

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REFERENCES

- Ambuel, B. and Temple, S. A., 1983. Area dependent changes in the bird communities and vegetation in southern Wisconsin forest. *Ecology* **64**: 1057–1068.
- Anon., 2008. A new way of atlasing (1). *Atlas News* **10**: 5.
- Antos, M. J., Fitzsimons, J. A., Palmer, G. C. and White, J. G., 2006. Introduced birds in urban remnant vegetation: Does remnant size really matter? *Austral Ecology* **31**: 254–261.
- Aston, H. I. and Bamford, R. A., 1978. A Bird Atlas of the Melbourne Region. Victorian Ornithological Research Group, Melbourne.
- Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R., 2003. The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Melbourne.
- Blakers, M., Davies, S. J. J. F. and Reilly, P. N., 1984. The Atlas of Australian Birds. Melbourne University Press, Carlton.
- Burgin, S. and Saunders, T., 2007. Parrots of the Sydney region: population changes over 100 years. Pp 185–194. *in* Pest or Guest: The Zoology of Overabundance. ed by D. Lunney, P. Eby, P. Hutchings and S. Burgin. Royal Zoological Society of New South Wales, Mosman.
- Catterall, C. P., 2004. Birds, garden plants and suburban bushlots: where good intentions meet unexpected outcomes. Pp. 21–31. *in* Urban Wildlife: More than Meets the Eye ed by D. Lunney and S. Burgin. Royal Zoological Society of New South Wales, Mosman.
- Chiari, C., Dinetti, M., Licciardello, C., Licitra, G. and Pautasso, M., 2010. Urbanization and the more-individuals hypothesis. *Journal of Animal Ecology* **79**: 366–371.
- Chisholm, A. H., 1942. Birds of a Melbourne park. *Victorian Naturalist* **59**: 75–80.
- Chisholm, A. H., 1943. Further notes on birds of a Melbourne park. *Victorian Naturalist* **59**: 204–207.
- Chisholm, A. H., 1949. Salute to the birds of a Melbourne park. *Victorian Naturalist* **66**: 14–19.
- Christidis, L. and Boles, W. E., 2008. Systematics and Taxonomy of Australian Birds. CSIRO Publishing, Collingwood.
- Clarke, K. R. and Gorley, R. N., 2001. PRIMER v5: User Manual/Tutorial. Plymouth Marine Laboratory, PRIMER-E Ltd, Plymouth.
- Colebatch, T., 2010. Victoria's population growth fastest in nation. *The Age* 26 March 2010, p. 3. Available: <http://www.theage.com.au/victoria/victorias-population-growth-fastest-in-nation-20100325-qzvl.html> [Accessed 28 March 2010].
- Densmore, P. and French, K., 2005. Effects of recreation areas on avian communities in coastal New South Wales' parks. *Ecological Management & Restoration* **6**: 182–189.

- DSE, 2007. Advisory List of Threatened Vertebrate Fauna in Victoria — 2007. Department of Sustainability and Environment, Melbourne.
- Emison, W. B., Beardsell, C. M., Norman, F. I., Loyn, R. H. and Bennett, S. C., 1987. Atlas of Victorian Birds. Department of Conservation Forests and Lands and RAOU, Melbourne.
- Fitzsimons, J. A., Palmer, G. C., Antos, M. J. and White, J. G., 2003. Refugees and residents: densities and habitat preferences of lorikeets in urban Melbourne. *Australian Field Ornithology* **20**: 2–7.
- Garden, J., McAlpine, C., Peterson, A., Jones, D. and Possingham, H., 2006. Review of the ecology of Australian urban fauna: A focus on spatially explicit processes. *Austral Ecology* **31**: 126–148.
- Green, R. J., 1984. Native and exotic birds in a suburban habitat. *Australian Wildlife Research* **11**: 181–190.
- Hewish, M., Ward, R., Bugg, R. and Munday, D., 2006. Birds of the Long Forest 1889–2005. Friends of Werribee Gorge and Long Forest Mallee Inc, Bacchus Marsh.
- Jones, D. N., 1983. The suburban bird community of Townsville, a tropical city. *Emu* **83**: 12–18.
- Jones, D. N. and Wieneke, J., 2000. The suburban bird community of Townsville revisited: Changes over a 17 year period. *Corella* **24**: 53–60.
- Keast, A., 1995. Habitat loss and species loss: the birds of Sydney 50 years ago and now. *Australian Zoologist* **30**: 3–25.
- Kloot, T., 2000. Birds of Box Hill in the City of Whitehorse. Victorian Ornithological Research Group, Melbourne.
- Lockwood, D. and Robinson, D., 1997. The Grey-crowned Babbler *Pomatustos temporalis* on the Mornington Peninsula — going, going, gone? *Victorian Naturalist* **114**: 269–277.
- Mac Nally, R., 1996. A winter's tale: Among-year variation in bird community structure in a southeastern Australian forest. *Australian Journal of Ecology* **21**: 280–291.
- Mac Nally, R., Bennett, A. F., Thomson, J. R., Radford, J. Q., Unmack, G., Horrocks, G. and Vesk, P. A., 2009. Collapse of an avifauna: climate change appears to exacerbate habitat loss and degradation. *Diversity and Distributions* **15**: 1–11.
- Major, R. E. and Parsons, H., 2010. What do museum specimens tell us about the impact of urbanisation? A comparison of the recent and historical bird communities of Sydney. *Emu* **110**: 92–103.
- Mason, P., 1985. The impact of urban development on bird communities of three Victorian towns — Lilydale, Coldstream and Mt. Evelyn. *Corella* **9**: 14–21.
- Melway Publishing, 2007. Greater Melbourne 2008 Street Directory. Melway Publishing, Melbourne.
- Norris, M., Cornwell, G., Longden, M., Parsons, I. and Stewart, F. (Eds.) 1995. Local Birds of Bayside. Bayside City Council, Sandringham.
- Palmer, G. C., 2007. Ecological value of riparian zones to birds in forest landscapes. PhD thesis, School of Life and Environmental Sciences, Deakin University, Melbourne.
- Palmer, G. C. and Bennett, A. F., 2006. Riparian zones provide for distinct bird assemblages in forest mosaics of south-east Australia. *Biological Conservation* **130**: 447–457.
- Palmer, G. C., Fitzsimons, J. A., Antos, M. J. and White, J. G., 2008. Determinants of native avian richness in suburban remnant vegetation: Implications for conservation planning. *Biological Conservation* **141**: 2329–2341.
- Parsons, H., French, K. and Major, R. E., 2003. The influence of remnant bushland on the composition of suburban bird assemblages in Australia. *Landscape and Urban Planning* **66**: 43–56.
- Pearson, D., 1995. Selecting indicator taxa for the quantitative assessment of biodiversity. Pp 75–80 in *Biodiversity: Measurement and Estimation* ed by D. L. Hawksworth. Chapman & Hall and the Royal Society, London.
- Platt, A. and Lill, A., 2006. Composition and conservation value of bird assemblages of urban “habitat islands”: Do pedestrian traffic and landscape variables exert an influence? *Urban Ecosystems* **9**: 83–97.
- Recher, H. F., 2004. The King's Park avifauna: keeping birds in the city. Pp. 8–20 in *Urban Wildlife: More Than Meets the Eye* ed by D. Lunney and S. Burgin. Royal Zoological Society of New South Wales, Mosman.
- Recher, H. F. and Serventy, D. L., 1991. Long term changes in the relative abundances of birds in Kings Park, Perth, Western Australia. *Conservation Biology* **5**: 90–102.
- Robinson, D. and Traill, B. J., 1996. Conserving woodland birds in the wheat and sheep belts of southern Australia. *RAOU Conservation Statement* 10. [supplement to *Wingspan* **6**(2)].
- Smith, J. and Lill, A., 2008. Importance of eucalypts in exploitation of urban parks by Rainbow and Musk Lorikeets. *Emu* **108**: 187–195.
- Smith, V. W., 2002. Avian population changes in a developing urban area in Western Australia over an eighteen year period. *Corella* **26**: 79–84.
- Tait, C. J., Daniels, C. B. and Hill, R. S., 2005. Changes in species assemblages within the Adelaide metropolitan area, Australia, 1836–2002. *Ecological Applications* **15**: 346–359.
- van Polanen Petel, T. and Lill, A., 2004. Bird communities of some urban bushland fragments: Implications for conservation. *Australian Field Ornithology* **21**: 21–32.
- Veerman, P., 2003. Canberra Birds: A Report on the First 21 Years of the Garden Bird Survey. Canberra Ornithologists Group, Canberra.
- Walters, J. R., Ford, H. A. and Cooper, C. B., 1999. The ecological basis of sensitivity of brown treecreepers to habitat fragmentation: a preliminary assessment. *Biological Conservation* **90**: 13–20.
- Ward, G. M., 1966. Once in the suburbs. *Victorian Naturalist* **83**: 157–167.
- Warrigal Conservation Society, 1981. Birds of Heidelberg and the Yarra Valley. Warrigal Conservation Society, Rosanna.
- Weston M. A., Antos M. J. and Glover H. K., 2009. Birds, buffers and bicycles: a review and case study of wetland buffers. *Victorian Naturalist* **126**: 79–85.
- Wheelwright H. W., 1861. Bush Wanderings of a Naturalist or Notes on the Field Sports and Fauna of Australia. Routledge, Warne and Routledge, London.
- White, J. G., Antos, M. J., Fitzsimons, J. A. and Palmer, G. C., 2005. Non-uniform bird assemblages in urban environments: The influence of streetscape vegetation. *Landscape and Urban Planning* **71**: 123–135.
- White, J. G., Fitzsimons, J. A., Palmer, G. C. and Antos, M. J., 2009. Surviving urbanization: Maintaining bird species diversity in urban Melbourne. *Victorian Naturalist* **126**: 73–78.
- Wood, K. A., 1995. Temporal and spatial variations in density of landbirds at an urban bushland reserve. *Corella* **19**: 7–11.
- Woodall, P. F., 1995. Results of the QOS garden survey, 1979–1980, with particular reference to South-east Queensland. *Sunbird* **25**: 1–17.
- Woodall, P. F., 2002. The Birds Queensland garden bird survey, 1999. *Sunbird* **32**: 37–51.

Appendix 1. Location, size and vegetation types in vegetation remnants surveyed

Park/reserve name	Size of remnant surveyed (ha)	Size category*	Suburb	Melway (2008) map reference	Ecological Vegetation Classes in remnants#
Yarra Bend Park	65.6	L	Kew	44 H5	Floodplain Riparian Woodland, Riparian Woodland, Basalt Escarpment Shrubland, Plains Grassy Woodland, Aquatic Hermland, Valley Grassy Forest, Box Ironbark Forest, Grassy Woodland
Gresswell Forest Wildlife Reserve	53.6	L	Macleod	20 B4	Plains Grassy Woodland
Braeside Park	45.0	L	Braeside	88 E8	Heathy Woodland, Creekline Grassy Woodland
Currawong Bush Park	39.8	L	Warrandyte	34 G6	Riparian Forest, Grassy Dry Forest, Herb-rich Foothill Forest, Creekline Herb-rich Woodland
Shepherd's Bush	36.5	L	Wantirna South	71 K2	Swampy Riparian Woodland, Valley Grassy Forest, Valley Heathy Forest
Koonba Park	31.1	L	Wantirna	63 C7	Swampy Riparian Woodland
Bungalo Conservation Area	21.5	L	Kilsyth South	51 F12	Swampy Riparian Woodland, Swamp Scrub, Plains Grassy Wetland, Wetland Formation, Valley Heathy Forest
Hillcrest Forestway	19.7	L	Donvale	49 B5	Valley Heathy Forest, Swampy Riparian Complex, Riparian Forest
Westerfolds Park	19.7	L	Templestowe	33 E2	Valley Grassy Forest
Wattle Park	15.7	L	Burwood	60 K3	Valley Grassy Forest
Blackburn Lake Sanctuary	13.7	M	Blackburn	48 C12	Valley Heathy Forest, Swampy Riparian Complex
The Valley Reserve	13.6	M	Mount Waverley	70 F2	Swampy Riparian Complex, Aquatic Hermland
Bellbird Dell Reserve	13.3	M	Vermont South	62 J5	Valley Heathy Forest, Creekline Herb-rich Woodland
Bateman Street Reserve	12.7	M	Wantirna	63 F4	Valley Heathy Forest
Eastfield Park	7.9	M	Croydon	50 J7	Valley Heathy Forest, Swampy Riparian Woodland
Wombalano Park	7.7	M	Ringwood East	50 C10	Valley Heathy Forest
Antonio Park	6.5	M	Mitcham	49 C8	Valley Heathy Forest
Lakewood Reserve	6.4	M	Knoxfield	73 C2	Creekline Herb-rich Woodland, Valley Heathy Forest
Yarraman Creek (Fotheringham) Reserve	6.1	M	Dandenong	89 K4	Floodplain Riparian Woodland, Plains Grassy Woodland, Plains Grassy Wetland
BJ Hubbard Reserve	5.9	M	Ringwood North	49 G4	Valley Heathy Forest, Grassy Forest, Valley Grassy Forest, Swampy Riparian Woodland
The Grange Reserve	5.4	S	Clayton South	79 F8	Swamp Scrub, Heathy Woodland
Coomoora Rd Reserve	5.1	S	Keysborough	88 K6	Plains Grassy Woodland, Heathy Woodland
Damper Creek Reserve	4.6	M	Mount Waverley	61 D10	Valley Grassy Forest
Koolunga Native Reserve	3.4	S	Fernree Gully	65 C11	Valley Heathy Forest
Alex Wilkie Nature Reserve	3.3	S	Springvale South	88 K4	Wet Heathland, Heathy Woodland
William Morris Reserve	2.8	S	Wantirna	63 F7	Valley Heathy Forest
George St Reserve	2.7	S	Sandringham	77 B12	Sand Heathland
Old Joes Creek Reserve	2.7	M	Boronia	65 A6	Valley Heathy Forest, Swampy Riparian Complex
Cheong Wildflower Sanctuary	2.0	S	Croydon	50 E7	Valley Heathy Forest
Donald McDonald Reserve	1.9	S	Beaumaris	86 B6	Sand Heathland
JW Mason Reserve	1.9	S	Wantirna	63 J4	Valley Grassy Forest, Riparian Woodland
Bellbird Corner	1.6	S	Mount Waverley	61 E11	Creekline Herb-rich Woodland
Wandinong Reserve	1.5	S	Blackburn	61 K1	Valley Heathy Forest
Flamingo Reserve	1.4	S	Wantirna South	63 F11	Valley Heathy Forest
Belmont Park	1.3	S	Canterbury	46 B8	Plains Grassy Woodland
Banyule Creek Reserve	1.2	S	Rosanna	20 D12	Plains Grassy Woodland
Redcourt Reserve	1.2	S	Scoresby	72 F6	Valley Heathy Forest
Rufley Lake Reserve	1.0	S	Templestowe	33 G9	Valley Grassy Forest
Zerbes Reserve	1.0	S	Doncaster East	34 B10	Valley Heathy Forest

Notes: *Area relates to the vegetation remnant surveyed and does not necessarily equal the entire size of the park/reserve. #Size category: S: Small = 1-5 ha; M: Medium = 6-15 ha; L: Large = >15 ha. # Based on 2003 Ecological Vegetation Class mapping (Department of Sustainability and Environment).

Appendix 2. Relative abundance (individuals/ha) of bird species in remnant vegetation areas in urban Melbourne.

(^ Note remnant size relates to the vegetation remnant surveyed and does not necessarily equal the entire size of the reserve;

* = Introduced; # = Suspected aviary escapee). Cells with no entry represent no records for that remnant.

		Yarra Bend Park	Westerfolds Park	Hillcrest Forestway	Gresswell Forest Wildlife Reserve	Braeside Park	Currawong Bush Park	Koomba Park	Shepherd's Bush	Bungaloek Conservation Area	Wattle Park	Blackburn Lake	The Valley Reserve	Belbird Dell Reserve	Bateman St Bushland	Damper Creek Reserve	Eastfield Park	Wombolano Park	Antonio Park	Old Joe's Creek Reserve	Lakewood Nature Reserve	Yarraman Creek Reserve
Remnant size (ha)^		107	62	61	54	45	40	39	37	21	16	14	14	13	13	9	8	8	6	6	6	6
Total relative abundance		20.41	28.64	16.65	25.13	27.64	14.84	36.85	19.32	17.44	19.73	16.41	27.28	33.5	14.16	29.11	26.05	22.04	14.52	19.19	15.93	30.21
Richness		38	28	38	46	48	36	49	41	46	22	30	29	36	25	26	22	24	23	32	27	28
Black swan	<i>Cygnus atratus</i>	0.13																				
Australian wood duck	<i>Chenonetta jubata</i>	0.21	0.42		0.13	0.29	0.08	0.29	0.13		0.75		0.44			0.25	0.25			0.13	0.25	
Grey teal	<i>Anas gracilis</i>								0.08	0.21												
Chestnut teal	<i>Anas castanea</i>							0.21			0.13											
Pacific black duck	<i>Anas superciliosa</i>	0.17	0.04		0.21	0.08	0.17	1.25	0.21	0.08	0.38	0.19	0.13	0.19		1.13			0.13		0.13	
Rock dove*	<i>Columba livia</i>	0.42				0.04																
Spotted dove*	<i>Streptopelia chinensis</i>	0.17		0.25	0.71	0.29	0.29	0.83	0.42	0.63	0.06	0.38	1.00	1.38	0.25	2.13	2.63	1.06	1.13	1.13	1.50	1.88
Common bronzewing	<i>Phaps chalcoptera</i>		0.25		0.13	0.13	0.21			0.04	0.13								0.06			
Crested pigeon	<i>Ocyphaps lophotes</i>																					
Tawny frogmouth	<i>Podargus strigoides</i>										0.44					0.25						
Little pied cormorant	<i>Microcarbo melanoleucos</i>				0.08			0.04			0.13											
Great cormorant	<i>Phalacrocorax carbo</i>						0.08															
Australian pelican	<i>Pelecanus conspicillatus</i>					0.13																
White-faced heron	<i>Egretta novaehollandiae</i>							0.13														
White-necked heron	<i>Ardea pacifica</i>							0.04														
Eastern great egret	<i>Ardea modesta</i>							0.04														
Australian white ibis	<i>Threskiornis molucca</i>									0.29				0.94								
Straw-necked ibis	<i>Threskiornis spinicollis</i>																				0.06	
Whistling kite	<i>Haliastur spheurnus</i>																					
Brown goshawk	<i>Accipiter fasciatus</i>			0.08		0.17		0.04	0.13			0.06						0.06		0.19		
Collared sparrowhawk	<i>Accipiter cirrocephalus</i>				0.04								0.06				0.13					
Little eagle	<i>Hieraaetus morphnoides</i>					0.04																
Nankeen kestrel	<i>Falco cenchroides</i>		0.08																			
Australian hobby	<i>Falco longipennis</i>					0.04															0.06	
Purple swamphen	<i>Porphyrio porphyrio</i>							0.29														
Dusky moorhen	<i>Gallinula tenebrosa</i>							0.17														
Masked lapwing	<i>Vanellus miles</i>																					
Latham's snipe	<i>Gallinago hardwickii</i>							0.17														
Pacific gull	<i>Larus pacificus</i>					0.08																
Silver gull	<i>Larus novaehollandiae</i>	0.13																				1.50
Yellow-tailed black-cockatoo	<i>Calyptorhynchus funereus</i>			0.08					0.08					0.19								
Gang-gang cockatoo	<i>Callocephalon fimbriatum</i>										0.19											
Galah	<i>Eolophus roseicapillus</i>		1.42	0.08	0.08		0.42	0.04	0.42		0.38	0.13	0.31	0.13		1.00				0.13		
Long-billed corella	<i>Cacatua tenuirostris</i>		0.25			0.08	0.08															
Little corella	<i>Cacatua sanguinea</i>									0.38												
Sulphur-crested cockatoo	<i>Cacatua galerita</i>	0.21	0.67	0.08	0.71	0.08	0.04	0.54	0.92	0.04				0.13						0.31		0.13
Rainbow lorikeet	<i>Trichoglossus haematodus</i>	4.79	9.42	4.21	0.83	0.67	2.42	3.58	2.04	0.42	5.50	2.63	1.56	2.31	0.19	4.75	0.63	1.25	2.13	0.38	0.88	0.63
Musk lorikeet	<i>Glossopsitta concinna</i>		1.92	0.08	1.08	0.25		0.83	0.25	0.13	0.25	0.50	1.44	0.19		1.19		0.13	0.25	0.63	0.19	2.75
Little lorikeet	<i>Glossopsitta pusilla</i>																					0.38
Australian king-parrot	<i>Alisterus scapularis</i>		0.38							0.13										0.19		
Superb parrot#	<i>Polytelis swainsonii</i>																					
Crimson rosella	<i>Platycercus elegans</i>		0.08		0.04		0.08	0.25		0.54	0.25	0.38	0.13	1.00		0.94	1.63	2.56		1.13	0.25	
Eastern rosella	<i>Platycercus eximius</i>	0.21	1.75	0.54	0.17	0.54	0.67	0.96	0.42	0.54	1.38	0.13	0.56	0.31	0.06	0.75	0.75	0.31	1.38	0.31	0.25	0.13
Swift parrot	<i>Lathamus discolor</i>											0.19										
Red-rumped parrot	<i>Psephotus haematonotus</i>	1.50	0.42		0.17																	
Budgerigar#	<i>Melopsittacus undulatus</i>				0.04																	
Shining bronze-cuckoo	<i>Chalites lucidus</i>					0.04																
Pallid cuckoo	<i>Cacomantis pallidus</i>					0.08																
Fan-tailed cuckoo	<i>Cacomantis flabelliformis</i>			0.04		0.13																
Powerful owl	<i>Ninox strenua</i>														0.06	0.06						

	BJ Hubbard Reserve	The Grange Reserve	Coomoora Rd Reserve	Koolunga Native Reserve	Alex Wilkie Nature Reserve	William Morris Reserve	George St Reserve	Cheong Wildflower Reserve	Donald McDonald Reserve	JW Mason Reserve	Belbird Corner	Wandinong Reserve	Flamingo Reserve	Belmont Park	Banyule Creek Reserve	Redcourt Reserve	Ruffey Lake Reserve	Zerbes Reserve	Mean relative abundance	Number of sites recorded	Percent of sites recorded
Remnant size (ha)^	6	5	5	3	3	3	3	2	2	2	2	2	1	1	1	1	1	1			
Total relative abundance	28.33	31.81	31.79	14.68	21.53	20.43	20.68	23.3	25.55	29.19	20.43	18.91	13.28	25.3	25.19	20.29	15.67	18.79			
Richness	28	33	25	19	19	19	20	18	20	29	19	14	11	16	29	12	18	13			
Black swan	<i>Cygnus atratus</i>																		0.00	1	2.6
Australian wood duck	<i>Chenonetta jubata</i>			0.25	0.25				0.25					0.13	0.25				0.12	18	46.2
Grey teal	<i>Anas gracilis</i>																		0.01	2	5.1
Chestnut teal	<i>Anas castanea</i>																		0.01	2	5.1
Pacific black duck	<i>Anas superciliosa</i>								2.50						0.25				0.19	17	43.6
Rock dove*	<i>Columba livia</i>					0.25								0.13					0.02	4	10.3
Spotted dove*	<i>Streptopelia chinensis</i>	1.50	1.50	0.50	0.63	3.50	0.63	1.00	0.63	2.63	2.25	0.75	1.63		0.88	0.63	0.50		0.96	35	89.7
Common bronzewing	<i>Phaps chalcoptera</i>		0.25				0.13												0.03	9	23.1
Crested pigeon	<i>Ocyphaps lophotes</i>			0.50		0.38	0.25											0.13	0.03	4	10.3
Tawny frogmouth	<i>Podargus strigoides</i>				0.25														0.02	3	7.7
Little pied cormorant	<i>Microcarbo melanoleucos</i>																		0.01	3	7.7
Great cormorant	<i>Phalacrocorax carbo</i>																		0.00	1	2.6
Australian pelican	<i>Pelecanus conspicillatus</i>																		0.00	1	2.6
White-faced heron	<i>Egretta novaehollandiae</i>																		0.00	1	2.6
White-necked heron	<i>Ardea pacifica</i>																		0.00	1	2.6
Eastern great egret	<i>Ardea modesta</i>																		0.00	1	2.6
Australian white ibis	<i>Threskiornis molucca</i>		0.88	1.13															0.08	4	10.3
Straw-necked ibis	<i>Threskiornis spinicollis</i>																0.38		0.01	2	5.1
Whistling kite	<i>Haliastur sphenurus</i>		0.19																0.00	1	2.6
Brown goshawk	<i>Accipiter fasciatus</i>		0.19		0.25				0.13	0.13					0.13				0.04	12	30.8
Collared sparrowhawk	<i>Accipiter cirrocephalus</i>																		0.01	3	7.7
Little eagle	<i>Hieraaetus morphnoides</i>																		0.00	1	2.6
Nankeen kestrel	<i>Falco cenchroides</i>																		0.00	1	2.6
Australian hobby	<i>Falco longipennis</i>																		0.00	2	5.1
Purple swamphen	<i>Porphyrio porphyrio</i>																		0.01	1	2.6
Dusky moorhen	<i>Gallinula tenebrosa</i>																		0.00	1	2.6
Masked lapwing	<i>Vanellus miles</i>										0.13								0.00	1	2.6
Latham's snipe	<i>Gallinago hardwickii</i>																		0.00	1	2.6
Pacific gull	<i>Larus pacificus</i>		0.13	0.63															0.02	3	7.7
Silver gull	<i>Larus novaehollandiae</i>		0.44	0.38															0.06	4	10.3
Yellow-tailed black-cockatoo	<i>Calyptorhynchus funereus</i>														0.50				0.02	4	10.3
Gang-gang cockatoo	<i>Callocephalon fimbriatum</i>																		0.00	1	2.6
Galah	<i>Eolophus roseicapillus</i>													0.63	0.13		1.25		0.17	15	38.5
Long-billed corella	<i>Cacatua tenuirostris</i>		0.19	0.13	0.25										0.50		0.13	1.00	0.07	9	23.1
Little corella	<i>Cacatua sanguinea</i>																		0.02	2	5.1
Sulphur-crested cockatoo	<i>Cacatua galerita</i>	0.25		1.00					0.13					2.63					0.20	16	41
Rainbow lorikeet	<i>Trichoglossus haematodus</i>	4.00	0.75		1.00	2.13	1.63	1.13	2.00	4.13	2.25	7.38	1.75	4.38	5.75	3.13	1.00	4.13	2.51	37	94.9
Musk lorikeet	<i>Glossopsitta concinna</i>		3.25	0.50		1.13		2.13		0.75				1.50	0.25	0.13	1.38	1.00	0.62	27	69.2
Little lorikeet	<i>Glossopsitta pusilla</i>																		0.01	1	2.6
Australian king-parrot	<i>Alisterus scapularis</i>																		0.02	3	7.7
Superb parrot#	<i>Polytelis swainsonii</i>														0.13				0.00	1	2.6
Crimson rosella	<i>Platycercus elegans</i>	0.75		2.50	0.63				0.13				0.63	1.00		0.88	0.13		0.41	22	56.4
Eastern rosella	<i>Platycercus eximius</i>		1.75	0.38	0.88	1.00	0.25	0.38	0.13	2.13	0.13	1.13	0.25	5.88	0.50	2.00	1.25	3.50	0.86	37	94.9
Swift parrot	<i>Lathamus discolor</i>														0.50				0.02	2	5.1
Red-rumped parrot	<i>Psephotus haematonotus</i>		0.75											0.13			0.50		0.09	6	15.4
Budgerigar#	<i>Melopsittacus undulatus</i>																		0.00	1	2.6
Shining bronze-cuckoo	<i>Chalites lucidus</i>																		0.00	1	2.6
Pallid cuckoo	<i>Cacomantis pallidus</i>																		0.00	1	2.6
Fan-tailed cuckoo	<i>Cacomantis flabelliformis</i>		0.06																0.01	3	7.7
Powerful owl	<i>Ninox strenua</i>																		0.00	2	5.1

		Yarra Bend Park	Westerfolds Park	Hillcrest Forestway	Gresswell Forest Wildlife Reserve	Braeside Park	Currawong Bush Park	Koomba Park	Shepherd's Bush	Bungaloek Conservation Area	Wattle Park	Blackburn Lake	The Valley Reserve	Bellbird Dell Reserve	Batemans St Bushland	Dampier Creek Reserve	Eastfield Park	Wombolano Park	Antonio Park	Old Joe's Creek Reserve	Lakewood Nature Reserve	Yarraman Creek Reserve
Laughing kookaburra	<i>Dacelo novaeguineae</i>	0.17	0.29	0.08	0.04	0.04	0.38	0.17	0.17	0.08	0.25	0.06		0.63		0.38	0.75	0.38	0.25			0.38
Sacred kingfisher	<i>Todiramphus sanctus</i>				0.04	0.08																
White-throated treecreeper	<i>Corombates leucophaeus</i>			0.33						0.33												
Superb fairy-wren	<i>Malurus cyaneus</i>	0.13		0.67	1.58	5.17	0.46	4.08	1.54	0.75		0.25			1.38			0.06		0.63		
White-browed scrubwren	<i>Sericornis frontalis</i>	0.29	0.08	0.13	1.33	2.13	0.96	3.88	1.67	0.79		0.38	1.88	1.25	0.13	0.38	0.75	0.88		0.75	0.56	
White-throated gerygone	<i>Gerygone albogularis</i>	0.04																				
Striated thornbill	<i>Acanthiza lineata</i>			1.71	0.29		0.96		0.13	0.46		0.56	0.13	2.06	2.13		1.38	1.38	0.31	0.88	0.25	0.50
Yellow thornbill	<i>Acanthiza nana</i>				0.25			0.08														
Brown thornbill	<i>Acanthiza pusilla</i>			1.63	2.71	2.17	0.79	3.75	2.88	1.17		1.63	4.00	3.69	2.44	1.31	3.25	4.31	0.94	1.13	1.5	1.38
Spotted pardalote	<i>Pardalotus punctatus</i>	0.92	0.17	0.71	0.88	3.63	0.54	0.79	0.08	0.17	0.13	0.50	1.44	2.13	0.56	0.69	0.25	0.13	0.31	0.25	0.25	1.63
Striated pardalote	<i>Pardalotus striatus</i>		0.29	0.29	0.04	0.04	0.08	0.04		0.29	0.06			0.06	0.13					0.25	0.13	
Eastern spinebill	<i>Acanthorhynchus tenuirostris</i>			0.25	0.25	0.17	0.04		0.04	0.08		0.25	0.69	0.94	0.19	0.25	0.38		0.19	0.13		
Lewin's honeyeater	<i>Meliphaga lewinii</i>									0.04												
Yellow-faced honeyeater	<i>Lichenostomus chrysops</i>			0.08				0.08														
White-eared honeyeater	<i>Lichenostomus leucotis</i>			0.17						0.13												
White-plumed honeyeater	<i>Lichenostomus penicillatus</i>	2.13			0.79	1.79		1.29	0.63	0.38		0.19	0.19	0.13	0.06					0.44	0.38	
Noisy miner	<i>Manorina melanocephala</i>	0.17	4.46		0.29	3.63	1.63	1.08	0.08	0.08	4.81	0.69	3.19	0.19		4.88	0.13		0.81	0.06	4.00	
Bell miner	<i>Manorina melanophrys</i>						0.08	3.08		1.79												
Little wattlebird	<i>Anthochaera chrysoptera</i>													0.19	0.06						0.38	
Red wattlebird	<i>Anthochaera carunculata</i>	2.21	0.08	0.54	2.79	1.54	1.33	2.33	1.46	1.63	1.75	2.75	2.56	5.44	1.94	2.19	5.25	4.06	2.56	3.13	5.25	7.25
New Holland honeyeater	<i>Phylidonyris novaehollandiae</i>							0.21		0.42				0.25								
Brown-headed honeyeater	<i>Melithreptus brevirostris</i>																					
White-naped honeyeater	<i>Melithreptus lunatus</i>			0.25					0.63	0.42									1.06			
Varied sittella	<i>Daphoenositta chrysoptera</i>									0.25												
Black-faced cuckoo-shrike	<i>Coracina novaehollandiae</i>	0.33		0.17	0.42	0.25	0.13		0.08			0.19	0.13	0.06		0.13		0.13	0.06	0.06		0.25
Crested shrike-tit	<i>Falcunculus frontatus</i>	0.08		0.08		0.04		0.04		0.08												
Golden whistler	<i>Pachycephala pectoralis</i>	0.29		0.17	0.13	0.04	0.08	0.25	0.17	0.46			0.31	0.25	0.19	0.19	0.13	0.13	0.19	0.13	0.06	
Rufous whistler	<i>Pachycephala rufiventris</i>	0.08		0.21				0.04														
Grey shrike-thrush	<i>Colluricincla harmonica</i>	0.29		0.29	0.25	0.33	0.04	0.08	0.21	0.04		0.06		0.38						0.06		
Olive-backed oriole	<i>Oriolus sagittatus</i>	0.04		0.08		0.04		0.04										0.25			0.25	
Dusky woodswallow	<i>Artamus cyanopterus</i>	0.38				0.08																
Grey butcherbird	<i>Cracticus torquatus</i>		0.63		0.29	0.46	0.08	0.04	0.04	0.08	0.69	0.06	0.94	0.75		1.00	1.00	0.13	0.63		0.06	1.13
Australian magpie	<i>Cracticus tibicen</i>	0.21	1.17	0.17	0.46	0.17	0.42	0.04	0.08	0.92	1.63	1.50	1.06	1.13	1.13	1.44	0.50	1.75	1.63	0.19	0.25	0.38
Pied currawong	<i>Strepera graculina</i>			0.04			0.08		0.13			0.13	0.38	0.63	0.19	0.38		0.13	0.31	0.06		0.13
Grey currawong	<i>Strepera versicolor</i>	0.04			0.75			0.13						0.19	0.06			0.25		0.13		
Rufous fantail	<i>Rhipidura rufifrons</i>											0.06										
Grey fantail	<i>Rhipidura albiscapa</i>	0.08		0.83	0.67	0.17	0.13	0.50	0.33	0.46		0.19	0.31	0.19		0.50	0.38		0.25		0.13	
Willie wagtail	<i>Rhipidura leucophrys</i>	0.29			0.21			0.04														
Australian raven	<i>Corvus coronoides</i>			0.08																		
Little raven	<i>Corvus mellori</i>	0.79	0.92		0.79	0.46	0.08	0.21	0.33	0.17		1.00	1.00	1.25	0.56	1.25	1.38	0.25	0.44	1.19	0.81	0.50
Satin flycatcher	<i>Myiagra cyanoleuca</i>			0.04																		
Magpie-lark	<i>Grallina cyanoleuca</i>	0.04	0.08		0.04	0.13	0.17		0.04	0.04	0.31	0.06		0.13		0.13			0.06			1.63
Scarlet robin	<i>Petroica boodang</i>	0.13			0.13							0.19										
Rose robin	<i>Petroica rosea</i>																		0.06			
Eastern yellow robin	<i>Eopsaltria australis</i>	0.04		0.46	0.04	0.75	0.04	0.17	0.54	0.21				0.06						0.13		
Australian reed-warbler	<i>Acrocephalus australis</i>							0.04														
Silvereye	<i>Zosterops lateralis</i>	0.04		0.79	1.54	0.08		0.83	0.17	0.29			0.81	1.06	1.13		0.50	0.44		0.06		
Welcome swallow	<i>Hirundo neoxena</i>	0.63	1.33	0.17		0.04	0.38	0.71	0.25	0.21		0.38		0.06					0.13	0.06	0.25	
Tree martin	<i>Petrochelidon nigricans</i>																					
Bassian thrush	<i>Zoothera lunulata</i>			0.08				0.17														
Common blackbird*	<i>Turdus merula</i>	0.21	0.04	0.25	0.92	0.38	0.25	0.67	0.58	0.25		0.31	1.44	1.69	0.88	1.06	0.88	1.63	0.25	1.19	0.56	1.00
Song thrush*	<i>Turdus philomelos</i>							0.04	0.08			0.06										
Common starling*	<i>Sturnus vulgaris</i>	0.67	0.13		0.08	0.17	0.38	0.04	0.33	0.13				0.06						0.31	0.25	
Common myna*	<i>Sturnus tristis</i>	1.75	1.83	0.08	2.17	0.13	0.79	1.38	0.75	1.00	0.13	0.81	1.06	1.88	0.13	1.00	3.00		0.50	1.50	1.31	1.00
Mistletoebird	<i>Dicaeum hirundinaceum</i>		0.04		0.04																	0.13
Red-browed finch	<i>Neochmia temporalis</i>			0.54	0.38	0.33		1.08	0.63	0.33									1.38			

		BJ Hubbard Reserve	The Grange Reserve	Coomoora Rd Reserve	Koolunga Native Reserve	Alex Wilkie Nature Reserve	William Morris Reserve	George St Reserve	Cheong Wildflower Reserve	Donald McDonald Reserve	JW Mason Reserve	Bellbird Corner	Wandinong Reserve	Flamingo Reserve	Belmont Park	Banyule Creek Reserve	Redcourt Reserve	Ruffey Lake Reserve	Zerbes Reserve	Mean relative abundance	Number of sites recorded	Percent of sites recorded
Laughing kookaburra	<i>Dacelo novaeguineae</i>	0.06		0.88				0.25	0.50		0.25		0.25		0.25		0.13			0.17	24	61.5
Sacred kingfisher	<i>Todiramphus sanctus</i>																			0.00	2	5.1
White-throated treecreeper	<i>Corombates leucophaeus</i>																			0.02	2	5.1
Superb fairy-wren	<i>Malurus cyaneus</i>	1.63	1.75	3.00					0.25											0.60	16	41
White-browed scrubwren	<i>Sericornis frontalis</i>	0.88	3.19	0.63	0.38		0.25	2.88	0.25	1.38	1.63	0.88				0.50				0.80	29	74.4
White-throated gerygone	<i>Gerygone albogularis</i>																			0.00	1	2.6
Striated thornbill	<i>Acanthiza lineata</i>	4.63						2.75	0.63											0.54	18	46.2
Yellow thornbill	<i>Acanthiza nana</i>	1.38																		0.04	3	7.7
Brown thornbill	<i>Acanthiza pusilla</i>	3.38	2.06	0.75	2.50		2.25	3.88	3.25	5.5	1.25	1.63	0.5			0.75				1.75	30	76.9
Spotted pardalote	<i>Pardalotus punctatus</i>	0.38	1.19	2.38	0.25	0.25	1.38	1.00	0.88	0.88	1.00	0.63		0.38	0.75	0.50		0.25		0.72	36	92.3
Striated pardalote	<i>Pardalotus striatus</i>													0.13						0.05	13	33.3
Eastern spinebill	<i>Acanthorhynchus tenuirostris</i>	0.25	0.13				0.25	0.13	0.63			0.25				0.38	0.13			0.15	22	56.4
Lewin's honeyeater	<i>Meliphaga lewinii</i>																			0.00	1	2.6
Yellow-faced honeyeater	<i>Lichenostomus chrysops</i>																			0.00	2	5.1
White-eared honeyeater	<i>Lichenostomus leucotis</i>																			0.01	2	5.1
White-plumed honeyeater	<i>Lichenostomus penicillatus</i>	3.63	1.00				0.25		0.25	0.13								0.13		0.35	18	46.2
Noisy miner	<i>Manorina melanocephala</i>	0.75	7.25		8.00		0.75		0.63	0.88	4.75	2.75	0.13	6.63		3.75	3.00	5.75		1.93	30	76.9
Bell miner	<i>Manorina melanophrys</i>					1.25														0.16	4	10.3
Little wattlebird	<i>Anthochaera chrysoptera</i>	0.44	0.25		0.13		0.75		1.00	0.25										0.09	9	23.1
Red wattlebird	<i>Anthochaera carunculata</i>	1.63	2.50	3.50	2.00	2.50	5.38	2.00	4.88	4.13	3.50	0.88	2.38	6.38	0.75	3.88	6.63	3.38	0.13	2.94	39	100
New Holland honeyeater	<i>Phylidonyris novaehollandiae</i>	2.50																		0.09	4	10.3
Brown-headed honeyeater	<i>Melithreptus brevirostris</i>						0.75													0.02	1	2.6
White-naped honeyeater	<i>Melithreptus lunatus</i>																			0.06	4	10.3
Varied sittella	<i>Daphoenositta chrysoptera</i>																			0.01	1	2.6
Black-faced cuckoo-shrike	<i>Coracina novaehollandiae</i>	0.13	0.19		0.13		0.13		0.25							0.13				0.09	20	51.3
Crested shrike-tit	<i>Falcunculus frontatus</i>																			0.01	5	12.8
Golden whistler	<i>Pachycephala pectoralis</i>	0.25	0.25		0.13		0.13		0.38	0.13										0.11	23	59
Rufous whistler	<i>Pachycephala rufiventris</i>																			0.01	3	7.7
Grey shrike-thrush	<i>Colluricincla harmonica</i>	0.25	0.13						0.25	0.25										0.07	15	38.5
Olive-backed oriole	<i>Oriolus sagittatus</i>																			0.02	6	15.4
Dusky woodswallow	<i>Artamus cyanopterus</i>																			0.01	2	5.1
Grey butcherbird	<i>Cracticus torquatus</i>		1.13	0.13	0.63	0.63	0.88		0.63	0.25	0.88	1.25	0.75	0.63	0.38	1.00				0.44	30	76.9
Australian magpie	<i>Cracticus tibicen</i>	0.63	0.19		0.88	0.75	0.75		0.75	0.25	0.50	1.63	0.75	2.25	0.75	1.25	1.25	0.50	0.88	0.77	37	94.9
Pied currawong	<i>Strepera graculina</i>					0.63		0.13			0.88	0.13				0.13				0.12	17	43.6
Grey currawong	<i>Strepera versicolor</i>	0.13																		0.04	8	20.5
Rufous fantail	<i>Rhipidura rufifrons</i>																			0.00	1	2.6
Grey fantail	<i>Rhipidura albiscapa</i>	0.63	0.25		0.13		0.13	0.13	0.25	0.13		0.13								0.18	23	59
Willie wagtail	<i>Rhipidura leucophrys</i>	0.06																		0.02	4	10.3
Australian raven	<i>Corvus coronoides</i>																			0.00	1	2.6
Little raven	<i>Corvus mellori</i>	0.75	3.13		0.50	0.25	0.5	1.38	1.75	0.50	0.88	0.75	0.13	0.38	0.50	0.13				0.64	33	84.6
Satin flycatcher	<i>Myiagra cyanoleuca</i>																			0.00	1	2.6
Magpie-lark	<i>Grallina cyanoleuca</i>	0.13	0.25							0.25	0.63				0.88	0.13		1.38		0.17	20	51.3
Scarlet robin	<i>Petroica boodang</i>																			0.01	3	7.7
Rose robin	<i>Petroica rosea</i>																			0.00	1	2.6
Eastern yellow robin	<i>Eopsaltria australis</i>	0.38	1.19																	0.10	12	30.8
Australian reed-warbler	<i>Acrocephalus australis</i>																			0.00	1	2.6
Silvereye	<i>Zosterops lateralis</i>	1.13	0.25	0.25				2.88	1.75							0.50				0.37	19	48.7
Welcome swallow	<i>Hirundo neoxena</i>	0.13	0.19	0.25	0.13					0.25						0.25		1.25	0.38	0.19	21	53.8
Tree martin	<i>Petrochelidon nigricans</i>		0.13																	0.00	1	2.6
Bassian thrush	<i>Zoothera lunulata</i>																			0.01	2	5.1
Common blackbird*	<i>Turdus merula</i>	1.75	0.56	1.00	0.88	1.25	1.88	1.13	1.50	1.00	1.75	2.25	0.25			2.00		0.13	0.13	0.82	35	89.7
Song thrush*	<i>Turdus philomelos</i>	0.13																		0.01	4	10.3
Common starling*	<i>Sturnus vulgaris</i>	0.25	0.25		0.38		0.88		0.25	0.13			0.25			0.38	0.13	0.38		0.15	21	53.8
Common myna*	<i>Sturnus tristis</i>	0.50	0.88		0.88		0.38	0.25		2.88		0.25		0.63	1.63	0.38	0.25			0.80	31	79.5
Mistletoebird	<i>Dicaeum hirundinaceum</i>	0.13								0.13										0.01	5	12.8
Red-browed finch	<i>Neochmia temporalis</i>	0.50	2.63																	0.20	9	23.1