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Bird Communities of Some Urban Bushland Fragments: Implications for Conservation

TAMARA VAN POLANEN PETEL[1] and ALAN LILL [1,2] *

[1]Wildlife Ecology Research Group, School of Biological Sciences, Monash University, Clayton Campus, Victoria, 3800 (present address of first author: School of Zoology, University of Tasmania, G.P.O. Box 252-05, Hobart, Tasmania 7001)

[2]Psychology Department, School of Psychology, Psychiatry and Psychological Medicine, Monash University, Clayton Campus, Victoria 3800

* Corresponding author

Summary

Bushland fragments have potential for the conservation of native bird species diversity in suburban Australia, where exotic birds are particularly successful. We surveyed the birds in 15 bushland fragments 1.3 to 22.4 ha in area in suburban Melbourne, Victoria, during the 1999–2000 breeding season to determine whether the fragments were dominated by native or exotic birds. Bird species richness and size of the fragment were positively correlated. Ninety per cent of the species recorded were native and 83% of the sightings were also of native birds, which numerically dominated all fragments and were mainly typical forest or open-woodland birds. A high incidence of native, tree-hollow-nesting species suggested that old, hollow-bearing trees might still be common in the fragments or nearby. However, all fragments contained at least one exotic bird species, and three such species were common and widely distributed among the fragments. The widespread Red Wattlebird *Anthochaera carunculata*, Common Blackbird *Turdus merula*, Spotted Turtle-Dove *Streptopelia chinensis* and Brown Thornbill *Acanthiza pusilla* were particularly responsible for similarities among the avian communities of the suite of fragments. We conclude that fragments of native bushland in eastern suburban Melbourne have some conservation potential for native birds, although this is circumscribed by the fact that the native species which were most abundant in the fragments are also common in residential areas.

Introduction

Eighty per cent of the human population of the world's industrialised countries lives in cities, but urban ecosystems have received substantial attention from ecologists and conservation biologists only recently (Uhl 1998). Significant research on the bird communities of Australian cities began only about 20 years ago. This research has shown that these communities generally have a lower species richness, a higher total bird abundance and a greater proportion of exotic birds than avian communities in rural native bushland (Sewell & Catterall 1998). One reason for the relative paucity of native birds in suburbia is thought to be the relatively small proportion of native vegetation (Green 1984). However, most Australian cities have preserved in their parks and reserves some remnants of the original, native bushland that dominated the site pre-urbanisation and some also have native bushland of more recent origin created through habitat restoration. These fragments and remnants could potentially play a key role in conserving native bird species diversity in the urban environment, provided that they are not simply dominated by exotic birds in the way that much of suburbia that is dominated by high-density housing has been, particularly in our temperate-zone cities. The value of preserving this diversity stems from its important role in urban ecosystems, its aesthetic appeal to city-dwellers and its possible economic value (Barbier *et al.* 1994, Fernandez-Juricic & Jokimaki 2001).

This study quantitatively documents the bird communities in a suite of variable bushland fragments in eastern suburban Melbourne, Victoria, during one breeding season. The aim was to determine whether the fragments provided significant habitat for native birds in the urban environment. An obvious limitation of this investigation is its short duration; bird species richness would undoubtedly have been higher in many fragments if surveying had been extended (Slater 1995, Mac Nally 1996). However, with respect to the main question addressed in this study, namely the extent to which the fragments provide habitat for native birds, the trend in the data is so strong that temporally more extended sampling would have been unlikely to change it significantly.

Method

Study sites

We studied 15 bushland (as defined by Sewell & Catterall 1998) fragments in the eastern suburbs of Melbourne (37°45'S, 144°58'E). The selection deliberately incorporated variability in characteristics such as area, degree of isolation from other bushland, degree of dissimilarity between the fragment and its surrounding matrix, and vegetation. Except for fragment area, no statistical analysis of the influence of these variables on parameters of avian community composition such as species richness was made, because the sample size of fragments required to do so adequately was prohibitive.

Fragment area was measured from aerial photographs with the software program *Tablet II* (produced by Monash University) and a WACOM 1212R Digitiser. Degree of isolation from other bushland was defined in terms of the percentage of bushland (i.e. all areas >1 ha composed of trees and/or shrubs) within a circle of 1 km radius around the fragment and was measured by the same technique as that used for area. The degree of dissimilarity between the vegetation in a fragment and in its surrounding matrix, the Dissimilarity Index, was determined from measurements of percentage vegetation cover (by the method of Kent & Coker 1992) in the fragment and in a 200 m band around it. Vegetation structural and floristic attributes were measured in 20 m^2 quadrats situated adjacent to established paths and at random intervals along them. The number of plots was proportional to the area of the fragment, with one plot being analysed per 3 ha of bushland. The measures taken were: categorical visual estimates of percentage cover (± 10%) in the various horizontal vegetation layers (herb 0–1 m, shrub 1.1–3 m, sub-canopy 3.1–6 m and canopy >6 m), the identity of plant species providing at least 20% of the cover in each layer, and tree density.

Bird surveys

The fixed-width strip transect method (Bibby *et al.* 2000) was used to estimate the bird populations. Larger fragments must be searched for longer to detect most of the species, so we surveyed fragments in proportion to their area by establishing one 60 m × 20 m transect per ha of fragment. A known drawback of this is exaggeration of the relative occurrence of rare species in larger fragments (Mac Nally & Horrocks 2002). The number of transects per fragment ranged from one to 20 and all followed established footpaths. It took about 5 minutes to walk each transect and record all birds visible, excluding those flying high over it. To increase independence of the observations, transects within a fragment were at least 35 m apart. Each fragment was surveyed seven times from October 1999 to January 2000. Surveys were conducted in the first four hours after sunrise in fine, dry conditions. On average, surveys in a fragment were 11 days apart.

From the survey data, we calculated species richness (the number of species recorded in a fragment during the entire study) and estimated the mean density (individuals per ha) of each species and all species combined for each fragment. Saturation curves (i.e. plots of species richness as a function of the number of surveys conducted) were calculated to ascertain whether the surveying adequately estimated species richness; they mostly began to reach an asymptote (plateau) towards the end of the study period, suggesting that sampling was adequate. A Native Bird Rarity Index (NRI) was calculated for each fragment. Each native bird species was given a rarity score (RS), which was the inverse of the number of fragments in which it occurred and could therefore range from 0.067 (present in all fragments) to 1 (present in only one fragment). The NRI for each fragment was then calculated as the sum of all RS values

divided by native bird species richness. A species was regarded as being 'dominant' in a fragment if it contributed more than 5% of the total bird sightings during the study and 'rare' if it contributed less than 1% (Huhtalo & Jarvinen 1977). Each species was also categorised according to the type of nest it typically uses, based on Beruldsen (1980) and Pizzey & Knight (2000): cup or platform nest built in vegetation, domed nest in vegetation, tree-hollow, and burrow. For convenience, bird species are referred to in the text by their common names; scientific names are given in Table 2.

Data analysis

Statistical analyses were performed with the software programs *Systat 9.0* and *Primer* (Carr 1994). A chi-square goodness-of-fit test was used to determine whether the 15 fragments differed in bird species richness. Variation among the fragments in the estimated mean density of all birds was examined with a single-factor analysis of variance (ANOVA) based on the density scores obtained in each census. We used randomisation tests based on chi-square analysis of frequencies (Manly 1991) to determine whether the fragments varied significantly in the percentages of species and individuals that were native and the percentages of species and individuals that used the four different types of nest. Non-metric multi-dimensional scaling (MDS) (Clarke 1993) was employed to examine graphically whether particular subsets of fragments shared a distinct avian community structure in terms of the bird species present and their densities. The SIMPER procedure (percentage similarity) (Carr 1994) was used to determine the species that contributed most to the observed similarities among fragment bird communities.

Results

Variation in fragment characteristics

The fragments varied 17-fold in area (range 1.3–22.4 ha) and 2.7-fold in the Dissimilarity Index (range 12–31), whereas the degree of isolation ranged from 0 (highly isolated) to 16% (moderately isolated) (Table 1). The mean percentage cover in the four horizontal vegetation layers was herb 57% (range 10–100%), shrub 24% (5–50%), sub-canopy 21% (5–60%) and canopy 41% (0–60%). Tree density averaged 7 trees per 20 m^2 (range 0–13). In terms of their contributions to total percentage cover, eight different plant species collectively dominated the herb layers of the suite of fragments (Thatch Saw-sedge *Gahnia radula*, Austral Bracken *Pteridium esculentum*, Panic Veldt-grass *Ehrharta erecta*, Large Quaking-grass *Briza maxima*, Kangaroo Grass *Themeda triandra*, Common Maidenhair *Adiantum aethiopicum*, Sweet Vernal-grass *Anthoxanthum odoratum* and Spiny-headed Mat-Rush *Lomandra longifolia*), five species dominated the shrub layers (Hedge Wattle *Acacia paradoxa*, Swamp Paperbark *Melaleuca ericifolia*, Sweet Bursaria *Bursaria spinosa*, Button Everlasting *Helichrysum scorpioides* and Woolly Tea-tree *Leptospermum lanigerum*), two dominated the sub-canopies (Black Wattle *Acacia mearnsii* and Blackwood *A. melanoxylon*) and five eucalypt species (Mealy Stringybark *Eucalyptus cephalocarpa*, Messmate Stringybark *E. obliqua*, Red Stringybark *E. macrorhyncha*, Snow Gum *E. pauciflora* and Manna Gum *E. viminalis pryoriana*) dominated the canopies. The salient finding in the present context was that the fragments were clearly heterogeneous with respect to all the physical and vegetation features measured.

Avifauna of the fragments

Collectively, Tables 1 and 2 summarise key aspects of bird community structure in the fragments and list the bird species recorded and their distribution among, and estimated mean density in, the fragments. Fifty bird species (in 22 families) were recorded in the fragments, 90% of which were native. There was a significant, but moderate, correlation between the number of fragments occupied by a native

Table 1

Physical variables and bird community structure of the bushland fragments studied in Melbourne, 1999–2000. NRI = native bird rarity index, Species richness = number of species (including exotics) recorded in a fragment during the study. See text for further details. Fragment locations: 1 Antonio Park, Mitcham (Melway reference page 49 C8), 2 Blackburn Lake Sanctuary, Blackburn (48 C11), 3 Bradshaw Park, Mordialloc (87 E10–11), 4 Braeside Park Conservation Reserve, Braeside (88 G8), 5 Bushland Reserve, Frankston (102 D–E9), 6 Coomoora Woodland, Keysborough (88 K6), 7 Reserve on Corio Road, Dingley (88 F1), 8 Joseph St Reserve, Blackburn North (47 J5), 9 Loughies Bushland Reserve, Ringwood North (49 E–F3), 10 Valley Reserve, Mount Waverley (70 F–G2), 11 William Morris Reserve, Wantirna (63 F7), 12 Wandinong Sanctuary, Blackburn (61 K1), 13 Warrien Reserve, Croydon (36 K10), 14 Wombolano Park, Ringwood East (50 C11), 15 'Yarra Valley' Bush, Ringwood North (36 E12).

Physical variables of fragments				*Bird community structure*				
No.	*Area (ha)*	*Isolation (%)*	*Dissimilarity index (%)*	*Species richness*	*% native species*	*% native individuals*	*Mean native birds/ha*	*Fragment NRI*
1	6.6	16	17	14	79	84	16	0.158
2	19.1	3	12	31	90	79	62	0.31
3	1.7	0	17	9	78	68	6	0.287
4	22.4	5	15	32	88	91	78	0.339
5	5.1	5	23	20	86	87	28	0.272
6	4.8	2	16	18	72	87	26	0.208
7	5.6	1	15	16	83	83	22	0.259
8	1.3	1	19	5	67	86	3	0.16
9	4.0	10	29	14	79	89	9	0.204
10	5.3	1	22	14	81	71	15	0.14
11	3.1	1	31	10	88	95	11	0.134
12	1.8	4	30	6	57	91	12	0.113
13	5.1	7	19	14	85	81	10	0.213
14	8.2	3	19	15	80	76	21	0.149
15	6.8	0	19	12	85	81	20	0.15
Mean	6.7	4	20	15	80	81	23	0.206

species and its estimated mean density in the suite of fragments as a whole ($r_{(43)} = +0.429$, $P<0.01$). Thus the only native species recorded in all fragments, the Red Wattlebird, had the highest overall mean density (8.6 individuals/ha) and the equal third most widely distributed native species, the Brown Thornbill (11 fragments), had the sixth highest density (2.2 individuals/ha). However, six other native species occurred in more than half the fragments (RS 0.083–0.125), but had mean densities ranging from 0.2 to 1.3 individuals/ha. The 14 native species that were the least widely distributed among the fragments (RS 1) included four members of the order Psittaciiformes (Gang-gang Cockatoo, Galah, Sulphur-crested Cockatoo and Musk Lorikeet), and they had estimated mean densities of 0.1 to 5.7 individuals/ha. The Noisy Miner, which is thought to strongly influence bird community composition in fragmented rural box–ironbark habitats in Victoria (Grey *et al.* 1998), was recorded in 47% of fragments (RS 0.143) and had a high overall estimated mean density (7.9 birds/ha). However, this was largely a product of its prolific numbers just in the Braeside Park Conservation Reserve remnant (Table 2).

Table 2

Occurrence and estimated mean density of bird species in the bushland fragments. Fragment identities are as in Table 1; mean density (in parentheses) is in individuals per ha. Nest types shown in superscript are: C cup or platform, D domed, H tree-hollow and B burrow. BP indicates brood parasite, * indicates exotic species and F = fragment.

Species	*Rarity score*	*Fragment identity (mean density)*
[H]Australian Wood Duck *Chenonetta jubata*	0.333	F2 (0.7); F4 (0.4); F15 (0.4)
[CH]Pacific Black Duck *Anas superciliosa*	0.5	F2 (0.3); F4 (0.6)
[C]Nankeen Night Heron *Nycticorax caledonicus*	1	F4 (0.3)
[C]Australian White Ibis *Threskiornis molucca*	1	F4 (0.4)
[C]Spotted Turtle-Dove* *Streptopelia chinensis*	0.077	F1 (1.1); F2 (5.7); F3 (1.9); F4 (3); F5 (1.7); F6 (2); F8 (0.3); F9 (1.3); F11 (0.1); F12 (1); F13 (2.7); F14 (1.6); F15 (3.3)
[C]Common Bronzewing *Phaps chalcoptera*	0.333	F1 (0.4); F4 (0.1); F14 (0.1)
[C]Crested Pigeon *Ocyphaps lophotes*	0.5	F4 (0.1); F7 (0.1)
[H]Gang-gang Cockatoo *Callocephalon fimbriatum*	1	F13 (0.1)
[H]Galah *Cacatua roseicapilla*	1	F2 (0.1)
[H]Sulphur-crested Cockatoo *Cacatua galerita*	1	F4 (0.7)
[H]Rainbow Lorikeet *Trichoglossus haematodus*	0.111	F1 (0.4); F2 (0.9); F4 (0.9); F5 (0.7); F9 (3.3); F11 (0.4); F12 (4.9); F13 (0.3); F14 (0.3)
[H]Musk lorikeet *Glossopsitta concinna*	1	F6 (1)
[H]Crimson Rosella *Platycercus elegans*	0.2	F2 (0.3); F11 (0.3); F13 (0.7); F14 (0.4); F15 (0.3)
[H]Eastern Rosella *Platycercus eximius*	0.091	F1 (1); F2 (2); F4 (2.7); F5 (0.9); F6 (1); F9 (0.3); F10 (0.4); F11 (0.6); F13 (0.3); F14 (0.3); F15 (0.4)
[BP]Pallid Cuckoo *Cuculus pallidus*	1	F2 (0.1)
[BP]Fan-tailed Cuckoo *Cacomantis flabelliformis*	1	F4 (0.1)
[C]Tawny Frogmouth *Podargus strigoides*	0.25	F1 (0.1); F8 (0.4); F11 (0.9); F15 (0.3)
[H]Laughing Kookaburra *Dacelo novaeguineae*	0.167	F2 (0.6); F3 (0.1); F4 (0.1); F5 (0.6); F10 (0.1); F15 (0.1)
[H]Sacred Kingfisher *Todiramphus sanctus*	0.5	F2 (0.3); F4 (0.1)
[D]Superb Fairy-wren *Malurus cyaneus*	0.167	F2 (0.9); F4 (10.3); F5 (0.4); F6 (0.6); F7 (5.4); F10 (0.6)
[B]Spotted Pardalote *Pardalotus punctatus*	0.2	F2 (0.4); F3 (0.4); F4 (0.1); F5 (0.3); F10 (0.6)
[D]White-browed Scrubwren *Sericornis frontalis*	0.125	F2 (2.3); F3 (0.4); F4 (0.7); F6 (1.7); F7 (2.1); F10 (0.4); F13 (0.1); F14 (0.1); F15 (0.7)

Table 2 continued

Species	*Rarity score*	*Fragment identity (mean density)*
[D]Brown Thornbill *Acanthiza pusilla*	0.091	F2 (4.9); F3 (1.4); F4 (4); F5 (1.4); F6 (0.9); F7 (0.6); F9 (1.4); F10 (1.3); F13 (1.3); F14 (3.3); F15 (4)
[D]Yellow Thornbill *Acanthiza nana*	1	F3 (0.1)
[C]Red Wattlebird *Anthochaera carunculata*	0.067	F1 (11.1); F2 (26.7); F3 (3.1); F4 (11.1); F5 (8.4); F6 (7.9); F7 (3.4); F8 (3); F9 (1.6); F10 (7.7); F11 (7.7); F12 (4.4); F13 (6); F14 (15.6); F15 (11.1)
[C]Little Wattlebird *Anthochaera chrysoptera*	0.083	F1 (0.1); F2 (1.7); F3 (0.6); F4 (0.4); F5 (1); F6 (1.4); F7 (0.6); F10 (0.6); F11 (0.3); F13 (0.7); F14 (0.3); F15 (0.6)
[C]Noisy Miner *Manorina melanocephala*	0.143	F1 (1.4); F2 (6.9); F4 (34.1); F6 (4.4); F7 (4.3); F10 (2.3); F12 (2)
[C]White-eared Honeyeater *Lichenostomus leucotis*	1	F5 (0.6)
[C]White-plumed Honeyeater *Lichenostomus penicillatus*	0.2	F2 (4.4); F4 (6.9); F5 (0.9); F6 (6.1); F7 (2.9)
[C]White-naped Honeyeater *Melithreptus lunatus*	0.333	F4 (1.1); F5 (5.9); F7 (0.3)
[C]New Holland Honeyeater *Phylidonyris novaehollandiae*	1	F5 (5.7)
[C]Eastern Spinebill *Acanthorhynchus tenuirostris*	0.25	F1 (0.1); F2 (0.1); F10 (0.1); F14 (0.1)
[C]Pink Robin *Petroica rodinogaster*	1	F2 (0.1)
[C]Hooded Robin *Melanodryas cucullata*	1	F7 (0.1)
[C]Eastern Yellow Robin *Eopsaltria australis*	0.25	F4 (0.6); F5 (0.4); F7 (0.1); F9 (0.1)
[C]Grey Shrike-thrush *Colluricincla harmonica*	0.333	F4 (0.3); F5 (0.4); F9 (0.3)
[C]Magpie-lark *Grallina cyanoleuca*	0.167	F1 (0.3); F2 (1); F4 (0.4); F6 (0.3); F7 (0.3); F10 (0.4)
[C]Grey Fantail *Rhipidura fuliginosa*	0.167	F2 (1); F4 (0.3); F5 (0.3); F6 (0.1); F9 (0.1); F14 (0.3)
[C]Willie Wagtail *Rhipidura leucophrys*	0.5	F2 (1.6); F7 (0.9)
[C]Black-faced Cuckoo-shrike *Coracina novaehollandiae*	0.125	F1 (0.3); F2 (0.1); F4 (0.3); F5 (0.1); F7 (0.1); F9 (0.3); F10 (0.1); F12 (0.3)
[C]Olive-backed Oriole *Oriolus sagittatus*	0.333	F2 (0.1); F9 (0.1); F13 (0.1)
[C]Grey Butcherbird *Cracticus torquatus*	0.167	F2 (0.4); F6 (1); F9 (1.3); F11 (0.9); F13 (0.6); F14 (0.3); F15 (1.3)
[C]Australian Magpie *Gymnorhina tibicen*	0.125	F1 (0.9); F2 (4.1); F4 (0.1); F6 (0.1); F10 (0.1); F13 (0.1); F14 (0.1); F15 (0.6)
[C]Pied Currawong *Strepera graculina*	0.5	F2 (0.1); F9 (0.1)
[D]Red-browed Finch *Neochmia temporalis*	0.333	F4 (0.7); F5 (0.1); F7 (0.4)
[C]Silvereye *Zosterops lateralis*	1	F2 (0.1)

Table 2 continued

Species	*Rarity score*	*Fragment identity (mean density)*
[C]Common Blackbird* *Turdus merula*	0.067	F1 (1.4); F2 (3.9); F3 (1.1); F4 (2.7); F5 (2.3); F6 (1.6); F7 (0.6); F8 (0.4); F9 (2.7); F10 (0.6); F11 (0.6); F12 (1.4); F13 (1.6); F14 (4.9); F15 (1.3)
[C]Song Thrush* *Turdus philomelos*	1	F6 (0.1)
[H]Common Starling* *Sturnus vulgaris*	0.5	F4 (0.4); F6 (0.1)
[H]Common Myna* *Acridotheres tristis*	0.1	F1 (0.6); F2 (7.1); F4 (1.4); F5 (0.3); F6 (0.3); F8 (0.4); F9 (2.1); F11 (0.4); F13 (0.3); F14 (0.3)

Records of a few waterbirds mainly reflected the presence of wetlands close to one fragment (Braeside Park Conservation Reserve). Only two typically open-country native species occurred in the fragments, Australian Magpie (8 fragments) and Magpie-lark (6 fragments), but both were at low densities. Most other native species recorded are typically forest or open-woodland dwellers. The single record for the Hooded Robin is unusual for the Melbourne area, but the species has sometimes been recorded this far south (Emison *et al.* 1987).

Five exotic bird species were recorded in the suite of fragments and at least one of these occurred in each fragment. RS values for exotic species ranged from 0.067 to 1. The most widespread exotic species, the Common Blackbird, occurred in all fragments at densities of 0.4 to 4.9 (overall mean 1.8) individuals/ha. The Spotted Turtle-Dove occupied 13 fragments at densities of 0.1 to 5.7 (overall mean 2.0) individuals/ha and the Common Myna ten fragments at densities of 0.3 to 7.1 (overall mean 1.3) individuals/ha. The Common Starling and the Song Thrush were recorded in only two and one fragment(s), respectively. All these exotic species, except the Thrush, are common in residential suburbs in eastern Melbourne (Green 1984) and are predominantly ground-foragers.

In all, 2857 bird sightings were recorded, 84% of which were of native birds. There were five 'dominant' species (>5% of sightings) in the suite of fragments as a whole (Red Wattlebird, Brown Thornbill, Noisy Miner, Common Blackbird and Spotted Turtle-Dove), three of which are native. Sixty-six per cent of species in the fragments were 'rare' (<1% of sightings). The two cuckoo species recorded are brood parasites, and the Pacific Black Duck has variable nesting habits (Beruldsen 1980). Twenty-nine (62%) of the other 47 species build cup or platform nests in vegetation, 12 (26%) use tree-hollows, 5 (11%) build domed nests in vegetation, and one (2%), the Spotted Pardalote, is a burrow-nester.

Variation in the bird communities of the fragments

The 15 fragments varied in bird species richness from five to 32 species ($\chi^2_{(14)} = 54.409$, $P<0.001$). Fragment area and bird species richness were positively correlated ($r_{(13)} = 0.921$, $P<0.001$). There was also variation among the fragments in the density of native birds ($F_{(14, 90)} = 43.594$, $P<0.001$), which ranged from an estimated three to 78 individuals/ha. However, the percentages of species and individuals that were native did not differ significantly among the fragments ($\chi^2_{(14)} = 7.658$ and 12.081, respectively, $P>0.05$ in both cases).

The percentage of native species that use the four different types of nest did not vary among the fragments ($\chi^2_{(42)} = 22.409$, $P>0.05$), but the percentage of

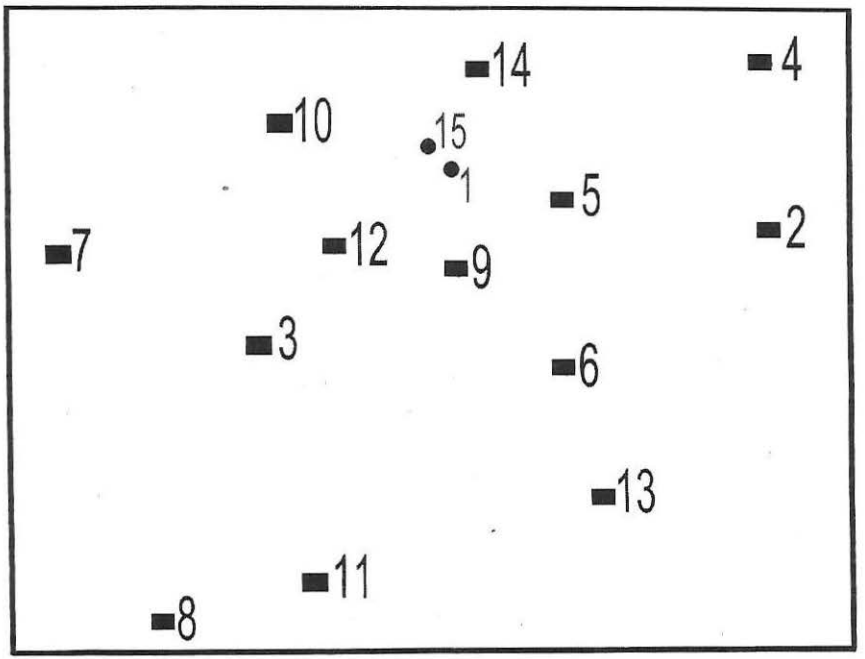

Figure 1. Two-dimensional non-metric multi-dimensional scaling (MDS) plot of fragments based on bird community composition during the 1999–2000 breeding season: Fragment numbers are as listed in Table 1 legend. Relative distance apart of the fragments reflects relative similarity in the composition of their bird communities. Fragments 1 and 15 (shown as solid circles) thus had particularly similar bird communities.

native individuals did ($\chi^2_{(42)}$ = 369.943, P<0.001). Cup- or platform-nesters comprised a mean of 62% (range 29–100%) of the native species and 75% (range 44–100%) of the native individuals in the fragments. Tree-hollow-nesters comprised an average of 21% (range 0–43%) of native species and 12% (range 0–42%) of native individuals. Domed-nest-users comprised a mean of 15% (range 0–43%) of native species and 13% (range 0–39%) of native individuals, and burrow-nesters comprised an average of 2% (range 0–14%) of native species and less than 1% (range 0–4%) of native individuals. The NRI varied 3-fold among fragments, from 0.113 in the Wandinong Sanctuary, which had only four native species, to 0.339 in the Braeside Conservation Reserve, which had 28.

On the basis of their bird communities, seven of the bushland fragments (Wombolano Park, The Valley Reserve, Bushland Reserve, Loughies Bushland Reserve, Wandinong Sanctuary, Antonio Park and 'Yarra Valley' Bush) formed a loose cluster in the non-metric MDS plot (Figure 1), i.e. they had fairly similar bird communities that were relatively distinct from those in the other fragments. Of these seven, Antonio Park and 'Yarra Valley' Bush (Fragments 1 and 15, indicated by solid circles in Figure 1) were particularly similar in area, vegetation structure and Dissimilarity Indices and not surprisingly had very similar bird communities. SIMPER analysis indicated that overall the species that contributed most to similarity among the bird communities of the fragments were the Red

Wattlebird, Common Blackbird, Spotted Turtle-Dove and Brown Thornbill, which variously accounted for 7–55% of the similarity. All four species were widely distributed in the suite of fragments and had high estimated mean densities. In contrast, the species that contributed least to similarity among fragment bird communities (<1%), the Sacred Kingfisher, Common Starling, Crested Pigeon, Silvereye and Pacific Black Duck, occurred in only one or two fragments and at low estimated mean densities. Although the Noisy Miner was the second most abundant species in the suite of fragments, it accounted for only 4% of the similarity among fragment bird communities because its distribution was very uneven.

Discussion

Native bird dominance

Collectively, the urban bushland fragments had a relatively high bird species richness and were strongly dominated by native birds during this single breeding season. This contrasts markedly with the relatively low species richness and greater proportion of introduced birds typically reported for the residential suburbs of Australian towns and cities (Jones 1981, Green 1984, Mason 1985, Catterall *et al.* 1989, Munyenyembe *et al.* 1989, Lenz 1990). However, our findings are consistent with observations that native bird dominance is usually greater in the least than in the most developed residential suburbs in Australian and other cities (Jones 1981, Green 1984, Mason 1985, Blair 1996, Sewell & Catterall 1998). Each of the four exotic species that are particularly common in eastern suburban Melbourne (Common Blackbird, Spotted Turtle-Dove, Common Myna and Common Starling) occurred in at least one of the bushland fragments studied, and two of them, the dove and the blackbird, were among the most abundant species recorded in the suite of fragments. Nonetheless, the bird communities of the fragments more closely resembled those of sclerophyll forest and woodland on Melbourne's outer perimeter than those of adjacent, developed suburbs. Green (1980), for example, found that 89% of species in bushland on the north-eastern outskirts of the city were native, whereas only 77% were native in an adjacent residential area. Lill (unpublished data) also found that 96% of species in Sherbrooke Forest, an 821-ha wet-sclerophyll forest in the Dandenong Ranges on Melbourne's eastern fringe, were native.

Studies of fragmented bushland habitats in rural Australia have shown that variables such as area, shape, isolation and vegetation characteristics influence bird community structure (Loyn 1985, 1987; Lynch & Saunders 1991; Barrett *et al.* 1994). The extent to which these variables exert a similar influence on bird community structure in urban bushland fragments is less well known. The urban fragments investigated in this study varied considerably in both the bird community composition and most of these physical and vegetation characteristics, but we did not examine the influence of these traits on breeding bird community structure statistically because of the limited sample size of fragments. Nonetheless, at least the constant proportions of native species and individuals did not appear to be influenced by any of these factors. Some authors argue that similar ecological patterns and processes are evident in urban and natural environments (Fernandez-Juricic & Jokimaki 2001). However, the factors determining bird community composition in urban and rural native bushland fragments could potentially be somewhat different, because the nature of the surrounding habitat and the extent to which fragments are linked by intervening vegetation which birds can use are often very different in these two situations (Catterall *et al.* 1991).

Nest types used by all bird species

Our investigation was conducted during a single breeding season, but we did not systematically establish the breeding status of most species. However, some species resident consistently in the larger fragments during the study period were definitely breeding there and others may have been. As in most other terrestrial bird communities, except those of the central business districts of towns and cities, cup- and platform-nests built in vegetation were estimated to be the most common type of nest in the bushland fragments. The most interesting finding was that 12 exclusive tree-hollow-nesters were recorded in the fragments; four of the native tree-hollow-nesters occurred in at least one third of the fragments, and the Rainbow Lorikeet occurred in 60% of them and at high densities. This may indicate that in these fragments and nearby there are still many trees of sufficient age to contain hollows suitable for nesting. In the fragments, these nest-sites would have been available to native hollow-nesters, because two of the three exotic hollow-nesting bird species that are common in suburban Melbourne, Common Starling and House Sparrow *Passer domesticus*, were uncommon in, or absent from, these bushland fragments. However, it is also possible that many individuals of some of the highly mobile, hollow-nesting species, such as the lorikeets, may have been using the fragments primarily for feeding.

Conservation implications

A sizeable suite of bushland fragments in urban Melbourne with highly varying physical and vegetation characteristics had breeding-season bird communities that, unlike those of highly developed suburbs, were dominated by native birds (see also van Polanen Petel 2000). Therefore such fragments, if appropriately managed, could potentially play an important role in maintaining native bird species diversity in urban Melbourne, as Grover & Slater (1994) argued for *Melaleuca* remnants in Brisbane. This is important, because invasive species constitute the second most significant threat to biodiversity globally (Ewel *et al.* 1999). However, it needs to be borne in mind that the native species that were most common in the bushland fragments examined here are also common in residential suburban Melbourne, which lessens the fragments' conservation value.

Some studies have been conducted in other countries to identify the factors that determine native bird community structure in urban bushland fragments and remnants (Gavareski 1976, Tilghman 1987, Fernandez-Juricic 2000, Crooks *et al.* 2001). However, more research of this sort is required for Australian cities before optimal conservation and management strategies can be devised. Amateur and professional ornithologists should be encouraged to publish their bird survey data for urban bushland fragments to facilitate such analyses.

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Stephen Debus — A Tribute

This issue of *AFO* marks the completion of Stephen's twentieth year as editor of *The Australian Bird Watcher/AFO*. The first issue he edited was volume 10 part 6 published in June 1984 and for most of the time since he has handled all submitted papers. It is only in the last few years that the editorial team has been expanded with the addition of sub-editors for particular bird groups. Stephen remains co-ordinating editor and personally handles papers on predatory birds, one of his major ornithological interests. Anyone who has been associated with a publication such as *ABW/AFO* will appreciate what a mighty effort he has put in over two decades. His commitment is all the more noteworthy since he has, during the same period, raised a family and also completed MSc and PhD degrees in ornithology. On behalf of the Bird Observers Club of Australia and the *AFO* Editorial Board I thank Stephen for his contribution and look forward to a continuing association with him and the journal.

Alan Lill, Chair, *AFO* Editorial Board