

AVIFAUNA OF MOUNT TOMAH BOTANIC GARDENS AND UPPER STOCKYARD GULLY IN THE BLUE MOUNTAINS, NEW SOUTH WALES

G. R. FULTON

c/- Egretta R. S. D., Narrung Road, Meningie, South Australia 5264

Received: 6 September 2000

A survey of diurnal and nocturnal birds of Mount Tomah Botanic Gardens, New South Wales and adjacent native forests was undertaken on one day and night in most months between November 1996 and March 1999. Birds were recorded within the Gardens and along a transect passing through rainforest to open forest at the adjacent Stockyard Gully. Listening, playback and spotlighting were undertaken on this transect at night and a resident Sooty Owl *Tyto tenebricosa* was detected. More than one-third (27) of the species detected showed habitat preferences; 14 species were more frequently detected inside the Botanic Gardens, while five were more frequently detected along the Stockyard Gully transect. The presence of permanent water at the Botanic Gardens Dam has increased the abundance and diversity of waterfowl. The New Holland Honeyeater *Phylidonyris novaehollandiae* has increased in abundance in the study area since Brenton's (1987) checklist; whilst corvid and artamid abundances may have increased following the 1994 fires. Archaeological and historical records indicate that the Emu *Dromaius novaehollandiae* may be extirpated from the area.

INTRODUCTION

Urbanization and fragmentation modifies the native habitat replacing it with a degraded habitat (Hoskin *et al.* 1991; Major *et al.* 1996; Matthews *et al.* 1999). The new habitat is frequently more suitable for exotic species (e.g. House Sparrow *Passer domesticus*), or other endemic species, which have benefited from the change (e.g. Pied Currawong *Strepera graculina* and Noisy Miner *Manorina melanocephala*) (Recher 1999). Whilst there is a general lack of rigorously quantified supporting data, there is general agreement that habitat fragmentation and degradation contribute to species decline (Recher and Lim 1990; Woinarski and Braithwaite 1990; Garnett 1993; Ford *et al.* 1995; Robinson and Traill 1996; Reid 1999; Ford *et al.* 2001). In the absence of quantitative information, records contained in the historical literature can be used to deduce changes in the avifauna or species status at local or regional levels. For example, Recher (1999) cites numerous examples including Heron (1973) regarding changes in abundance and bird species composition in the Orange district on the Central Tablelands of New South Wales and Hoskin *et al.* (1991) has done the same in the Sydney area. In addition, nocturnal birds have frequently been overlooked in surveys, which generally have concentrated on daylight observations, particularly away from the higher altitude forests, and often fail to monitor the colder winter months (Debus 1995). Subsequently, our understanding of the status of these birds may be hindered because of a lack of data resulting from a lack of investigation.

Within the Blue Mountains, farmland, towns and timber plantations contribute to habitat fragmentation. Degrading

factors include the introduction of ornamental exotic fruiting trees and shrubs, orchards, permanent water reservoirs and introduced grasses associated with parklands and clearings. However, the degradation is not as extensive as it is in the modified areas of urban Sydney to the east and cleared grazing country of the Central Tablelands to the west.

Changes to the avifauna can occur at either local and or regional levels. Smith and Smith (1990) point out the association between the Common Koel *Eudynamis scolopacea*, the Channel-billed Cuckoo *Scythrops novaehollandiae* and introduced fruit. Furthermore, they state that these species are seldom encountered in the broader area of the Blue Mountains bushland, except around towns. Recher (1999) highlighted that change in avian community composition occurs as either increases or decreases in species numbers or groups of species, and that both increases and decreases can be viewed as an environmental dysfunction.

The current study (1996–1999) was designed to:

1. Determine habitat preference of birds between the newly developed Mount Tomah Botanic Gardens and the relatively undisturbed neighbouring native habitats;
2. Detect changes to bird species present now compared to historical records.

MATERIALS AND METHODS

Study area

Mount Tomah (33°33'S, 150°25'E) is situated in the Blue Mountains National Park approximately 120 kilometres west of Sydney and 1 000

metres above sea level. The mountain has a mixture of semi-urban and light rural development, interspersed with native and exotic plant communities.

Mount Tomah Botanic Gardens is an annex of the Royal Botanic Gardens Sydney, thematically planted with cool climate and Gondwanan plants. There are a number of habitats in the gardens. The Botanic Gardens are located on the northern end of the mountain's basaltic cap and retains two remnants of native rainforest vegetation. One remnant is overplanted with exotic and native Gondwanan trees and shrubs, such as *Nothofagus* spp. Both have walking tracks for public access. The Botanic Gardens' rainforest is similar to the rainforest and tall forest in Stockyard Gully, except that its fringes include many young trees often forming thickets. However, light penetration to the forest floor is generally greater in these two remnants (80%–50%) because the surrounding areas have been cleared for gardens.

The open forest habitat in the gardens is a mosaic of local native sclerophyllous forest remnants and botanical gardens, which include *Rhododendron*, conifer collections and lawns. Two small remnants of open eucalypt forest are retained within the Botanic Gardens. One adjoins the north-west border of the Gondwanan Rainforest, the other is narrower and is isolated on the northern face. The Rock (heath) Garden on the exposed northern face is comprised of various exotics and natives with a significant proportion of the nectar-rich Proteaceae. It contains several ponds and a calcium tolerant plant section. The Botanic Gardens are relatively young with most development commencing in 1988. However, the botanical garden has many mature trees planted during its history of settlement by Europeans from the earlier part of the 1900s (Hungerford 1987). These plants, along with the local native vegetation add floristic and structural diversity, increasing the range of habitats. Ingram (1987) gives a detailed floristic description of Mount Tomah.

Upper Stockyard Gully is situated on the western side of the Botanic Gardens and drains into Mill Creek to the north. The gully and the gardens are bisected by Bell's Line of Road, the main east-west arterial road in the northern Blue Mountains. The Stockyard Gully transect begins in rainforest below the Botanic Gardens Dam and parallels Bell's Line of Road and the Botanic Gardens boundary for 0.5 kilometres. In the north and east, the transect becomes increasingly distant from Stockyard Creek and closest to the main road at its northern extremity. The substrate changes along the transect from Tomah (Tertiary) Basalt in the south to Ashfield Shale centrally and Hawkesbury Sandstone at the northern end, and the vegetation changes with substrate.

Stockyard Gully native plant communities

These communities consist of rainforest, tall forest and open forest. Stockyard Gully rainforest, occurs on basaltic soil on basalt bed rock and on soils occurring on shale and sandstone bedrock improved from the washing down of basaltic soils and nutrients. Shading on the forest floor exceeds 80 per cent. Dominant trees include Sassafras *Doryphora sassafras* and Coachwood *Ceratopetalum apetalum*. The rainforest is fringed and interspersed with Brown Barrel *Eucalyptus fastigata*, the rainforest canopy consists of smaller trees, tall tree ferns and lianas.

Stockyard Gully tall forest (wet sclerophyll forest) occurs on Ashfield Shale substrate. Shading, varies from 70 per cent to 50 per cent. Dominant trees are *E. fastigata* up to 50 metres in height, with an understorey of *Acacia* spp., and Native Indigo *Indigofera australis*, which are densely entwined with climbers. Both rainforest and tall forest have been grouped together as one habitat in this study and are designated as Stockyard Gully rainforest.

Stockyard Gully open forest occurs on Ashfield Shale and Hawkesbury Sandstone substrate. Shading of the forest floor is variable, from 50 per cent to 30 per cent. Dominant trees include open forest *Eucalyptus* spp. and *Angophora* spp. The understorey includes *Acacia* spp., *Leptospermum* spp., proteaceous shrubs and grasses.

Climate

Average annual rainfall at Mount Tomah is 1541 millimetres. Precipitation is generally highest in January and February when coastally derived moist warm air mixes with cool mountain air. In addition, mist frequently covers the mountain, keeping habitats damp for extended periods. During winter the prevailing winds come from

the west and rainfall is lower. Temperatures are cool in winter and some snow is recorded, which generally melts by midday. Minimum and maximum average temperatures are: for summer, 13°C, 24°C; and winter 3°C, 10°C (Rodd 1987).

During the study period temperatures ranged from -3°C with snow and sleet in June 1997, to 35°C with smoke filled air from surrounding bushfires in December 1997. There was an unusually hot and long autumn in 1998, followed by unusually prolonged winter rains. Fire reshaped much of the surrounding landscape prior to the study period, in 1994, but did not enter the study area. General weather conditions were noted each day data was collected and annotated with temperatures from radio and television broadcasts taken from the Bureau of Meteorology.

Data collection

Abundance and distribution data for birds and nests were gathered from November 1996 to March 1999. Nocturnal birds were often surveyed on the same study day as diurnal birds. Surveys were completed on 21 nights and 22 days in both the Botanic Gardens and Stockyard Gully. In addition, infrequent and opportunistic records have been collected since 1991 within the Botanic Gardens. Observations of diurnal birds were obtained primarily from visual observations while nocturnal data were obtained primarily from calls. A single observation represents seeing or hearing a single bird. Thus, the numbers of birds counted are the numbers of observations. The maximum number of individuals detected per study day was dependent on either seeing or hearing a number of the birds simultaneously, or by identifying characteristic marks such as: a missing eye, a bird with worn feathers versus another bird with new feathers or age plumage variations. In addition, four bird observations and six nest records were taken from senior Botanic Gardens personnel who were familiar with the birds. In one instance Welcome Swallows *Hirundo neoxena* were identified by me but the nest was detected in the Gardens' Residence by the Botanic Gardens Curator/Manager. Red-browed Finch *Neochmia temporalis* and Grey Fantail *Rhipidura fuliginosa* nests were collected by gardeners, subsequently the location of the collected nest was confirmed and the nests were identified.

Efforts were made to visit as many of the habitat types as possible in the Botanic Gardens on each study day. However, during the first three months of the study the Botanic Gardens southern face and Gondwanan Rainforest were visited less frequently than other parts of the gardens. The Stockyard Gully transect was systematically surveyed twice each afternoon by walking in both directions along the transect, two hours and one hour before sunset and occasionally on some mornings. Transect width varies from approximately 50 metres in open forest to 15 metres in dense rainforest.

Owls were surveyed in the first 12 months November 1996 to October 1997; following protocols suggested by Debus (1995), except that a five minute spotlight sweep followed a five minute broadcast for each species. Playback for owls commenced one hour after sunset following Debus (1995). This playback took place at two points on the Stockyard Gully transect, firstly on the rainforest edge in wet sclerophyll forest and secondly at the northern end in open forest. From November 1996 to October 1997, playback targeted the owls, Southern Boobook *Ninox novaeseelandiae*, Grass Owl *Tyto capensis*, Barn Owl *T. alba*, Masked Owl *T. novaehollandiae*, Barking Owl *N. connivens*, Sooty Owl and Powerful Owl *N. strenua* in that order, smaller to larger. Following this only listening for the birds calls was employed until March 1999 to avoid conditioning the owls to the playback and to detect their roost sites from unsolicited calls. Owls will frequently give territorial calls from their roost sites in the evening (Rod Kavanagh; pers. com.); whereas playback can attract the owls to the playback site and they will then call from there. However, playback for the Southern Boobook was recommenced in June 1998 and continued throughout winter until their 'morepork' calls resumed in September 1998. A shorter playback survey was conducted from November 1996 to March 1997 for the Australian Owllet-nightjar *Aegotheles cristatus*, White-throated Nightjar *Eurostopodus mystacalis*, Tawny Frogmouth *Podargus strigoides* and Pheasant Coucal *Centropus phasianinus*. This playback was performed prior to sunset and later in the night after the owl census. All calls were taken from Buckingham and Jackson (1990). A Sony Walkman Professional WM-D6C Stereo Cassette-recorder with a TOA Transistor Megaphone ER-66 (16 watts maximum output) were used at three quarter volume to transmit the calls.

Changes to the avifauna were to be detected by comparison to the previous Mount Tomah Checklist of Brenton (1987), which was compiled during the 1950s to 1980s prior to the establishment of the Botanic Gardens and before much of Mount Tomah's residential development. In addition, other historical literature was searched to detect bird records prior to Brenton's Checklist; and the NSW Parks and Wildlife Service Aboriginal Sites Register was searched to detect any evidence of bird species present prior to European settlement.

Sequence and nomenclature of birds follows Christidis and Boles (1994), mammals follow Strahan (1988), plants follow Ingram (1987) and the Dharug inland or mountain dialect bird-names follow Kohen (1993). The latter are included to preserve them through usage and to promote them as potential colloquial regional names (or sub-species epithets), much the same way as Mountain Lowry is sometimes used for the Crimson Rosella *Platycercus elegans*. Notably, Wonga Wonga is currently used as the preferred common name for the Wonga Pigeon *Leucosarcia melanoleuca*.

Statistical analysis

A Mann-Whitney two-tailed test was used to detect if there was an overall significant difference between summer and winter. Summer and winter were tested as six-month seasons October–March and April–September respectively. Nocturnal birds were excluded from this analysis because the frequency of nocturnal surveys is one less than that of diurnal birds. This statistical test was taken from Zar (1999).

RESULTS

Overall, 72 species were recorded from 1881 observations during the study period (Appendices 1 and 2). Overall species abundance was not significantly different ($P > 0.05$) between 'summer' October–March and 'winter'

April–September. However, the following diurnal migratory species were not detected during the colder months: Black-faced Monarch *Monarcha melanopsis*, Rufous Fantail *Rhipidura rufifrons*, Welcome Swallow, Tree Martin *H. nigricans* and Silvereeye *Zosterops lateralis*. In addition, the Yellow-faced Honeyeater *Lichenostomus chrysops*, a passage migrant (Brenton 1987), was only detected in the months of April, July and August. (Appendix 3).

Habitat preference

In total, 27 species (more than one third of the total species detected) showed evidence of habitat preferences (Table 1). For example, the Golden Whistler *Pachycephala pectoralis* showed a preference for Stockyard Gully rainforest; the Grey Fantail for Stockyard Gully open forest; Australian Magpie *Gymnorhina tibicen* for the Botanic Gardens open forest; the Australian Wood Duck *Chenonetta jubata* for the Botanic Gardens Dam; and the New Holland Honeyeater *Phylidonyris novaehollandiae* for the Botanic Gardens Rock Garden (proteaceous heath). Fourteen species, particularly the exotic and honeyeater species remained predominantly within the Botanic Garden's boundaries, avoiding native habitats. Three native insectivorous species (White-throated Treecreeper *Cormobates leucophaeus*, Buff-rumped Thornbill *Acanthiza reguloides* and Grey Fantail) showed a preference for Stockyard Gully.

TABLE 1

Species showing evidence of a habitat preference. Numbers of individuals detected, by habitat, of 27 species that showed evidence of a habitat preference. Bold typeface indicates evidently preferred habitat. Abbreviations OF – open forest; RF – rainforest; RG – rock garden (analogous to heath).

Species and habitats	Stockyard Gully		Botanic Gardens			
	RF	OF	RF	OF	RG	Dam
Stockyard Gully rainforest species						
Wonga Pigeon <i>Leucosarcia melanoleuca</i>	12		2			
Golden Whistler <i>Pachycephala pectoralis</i>	25	7	5	3		
Rainforest species						
Australian King Parrot <i>Alisterus scapularis</i>	19		18	1	2	
Yellow-throated Scrubwren <i>Sericornis citreogularis</i>	9	1	7			
Superb Lyrebird <i>Menura novaehollandiae</i>	6	1	6	1		
Eastern Whipbird <i>Psophodes olivaceus</i>	29		41	2		
Black-faced Monarch <i>Monarcha melanopsis</i>	5	1	3			
Bassian Thrush <i>Zoothera lunulata</i>	2		7	2		
Stockyard Gully open forest						
White-throated Treecreeper <i>Cormobates leucophaeus</i>		14	1	3		
Buff-rumped Thornbill <i>Acanthiza reguloides</i>		9				
Grey Fantail <i>Rhipidura fuliginosa</i>	6	16		4	1	
Open forest species						
Laughing Kookaburra <i>Dacelo novaeguineae</i>	4	16	1	18		
Silvereeye <i>Zosterops lateralis</i>		5		11		
Botanic Garden species						
Eastern Rosella <i>Platycercus eximius</i>	1	3		13		
Superb Fairy-wren <i>Malurus cyaneus</i>		3				
Red Wattlebird <i>Anthochaera carunculata</i>			12	49	11	1
Lewin's Honeyeater <i>Meliphaga lewinii</i>				7		27
New Holland Honeyeater <i>Phylidonyris novaehollandiae</i>	3	6	30	19	7	
Eastern Spinebill <i>Acanthorhynchus tenuirostris</i>		1	5	21	83	
Australian Magpie <i>Gymnorhina tibicen</i>		6	7	40	24	
Pied Currawong <i>Strepera graculina</i>		8		52		
Australian Raven <i>Corvus coronoides</i>		1		92		
Satin Bowerbird <i>Ptilonorhynchus violaceus</i>	1	5		60	6	
Welcome Swallow <i>Hirundo neoxena</i>	8	5	13	30		
Red-wiskered Bulbul <i>Pycnonotus jocosus</i>		2		7		62
Common Blackbird <i>Turdus merula</i>	2	1		5	4	
Botanic Garden dam species		3	4	31		1
Australian Wood Duck <i>Chenonetta jubata</i>				4		

Artamid and Corvid abundances

Numbers of Australian Magpie, Pied Currawong and Australian Raven *Corvus coronoides* all increased substantially following the 1994 bush fires (pers. obs). Australian Raven numbers declined in June 1998 from a mean 4.3 individuals per study day, to one individual per study day. However, Australian Magpie and Pied Currawong numbers have remained consistently high throughout the study period with a mean of 2.8 and 4.3 birds per study day, respectively.

Comparisons with Brenton's 1987 checklist

In the current study 12 species were recorded that were not listed in Brenton (1987), although four of these 12 are mentioned in his supplementary notes. All 12 are annotated with an asterisk in the Systematic List (Appendix 1), which includes some species detected outside the study period.

Waterfowl, exotic species, Red Wattlebirds *Anthochaera carunculata*, New Holland Honeyeaters and the Australian King Parrot *Alisterus scapularis* have increased in number compared to the previous checklist. Variegated Fairy-wrens

Malurus lamberti and Pilotbirds *Pycnoptilus floccosus* may have decreased in number. Brenton (1987) reported the latter two species as common to moderately common respectively. However, Variegated Fairy-wrens were not detected and only one Pilotbird was detected during the survey. Satin Flycatchers *Myiagra cyanoleuca* were reported uncommon by Brenton (1987) and were not detected during this study. Casual observations (commencing in 1991) suggest that Eastern Spinebills *Acanthorhynchus tenuirostris* may have been replaced as the most conspicuous honeyeater within the Botanic Gardens by the larger honeyeaters Red Wattlebirds and New Holland Honeyeaters.

Data from the NSW Parks and Wildlife Service Aboriginal Sites Register

Emu *Dromaius novaehollandiae* tracks have been detected engraved into rocks at two sites close to the study area. Both sites are at the same altitude (approximately 1 000 m a.s.l.). One site contains at least 150 individual engravings and is located in a sandstone overhang, situated in open forest within 2.75 kilometres of the study site,

TABLE 2

Nocturnal survey results. The nocturnal surveys commenced in November 1996. Playback or listening only was carried out one night per month, over 21 months. Playback was used from November 1996 to March 1997 for all species and continued until October 1997 for the Owls. Playback recommenced in June 1998 for the Southern Boobook only and continued until September 1998. Numbers refer to the number of individuals identified as present on the night. The '-' symbol denotes that no playback or listening was undertaken in that month, a zero denotes no calls were heard in that month.

Months	J	F	M	A	M	J	J	A	S	O	N	D
1996											N	D
Tawny Frogmouth										-	0	0
White-throated Nightjar										-	0	0
Powerful Owl										-	0	0
Barking Owl										-	0	0
Southern Boobook										-	0	1
Sooty Owl										-	0	0
1997												
Tawny Frogmouth	0	1	0	1	-	0	0	0	0	0	0	0
White-throated Nightjar	1	1	0	0	-	0	0	0	0	0	0	0
Powerful Owl	0	1	0	0	-	0	0	0	0	0	0	0
Barking Owl	0	0	0	0	-	0	0	0	0	0	0	1
Southern Boobook	0	0	3	1	-	0	0	0	0	0	3	3
Sooty Owl	0	0	1	1	-	0	1	0	1	0	0	0
1998												
Tawny Frogmouth	0	-	-	-	-	0	0	1	1	-	-	-
White-throated Nightjar	0	-	-	-	-	0	0	0	0	-	-	-
Powerful Owl	0	-	-	-	-	0	0	0	0	-	-	-
Barking Owl	0	-	-	-	-	0	0	0	0	-	-	-
Southern Boobook	1	-	-	-	-	0	0	0	1	-	-	-
Sooty Owl	0	-	-	-	-	0	0	0	0	-	-	-
1999												
Tawny Frogmouth	0	1	1	-								
White-throated Nightjar	0	0	0	-								
Powerful Owl	0	0	0	-								
Barking Owl	0	0	0	-								
Southern Boobook	2	0	0	-								
Sooty Owl	1	0	1	-								
Totals												
Tawny Frogmouth	0	2	1	1	-	0	0	1	1	0	0	0
White-throated Nightjar	1	1	0	0	-	0	0	0	0	0	0	0
Powerful Owl	0	1	0	0	-	0	0	0	0	0	0	0
Barking Owl	0	0	0	0	-	0	0	0	0	0	0	1
Southern Boobook	3	0	3	1	-	0	0	0	1	0	3	4
Sooty Owl	1	0	2	1	-	0	1	0	1	0	0	0

Tawny Frogmouth *Podargus strigoides*, White-throated Nightjar *Eurostopodus mystacalis*, Powerful Owl *Ninox strenua*, Barking Owl *Ninox connivens*, Southern Boobook *Ninox novaeseelandiae*, Sooty Owl *Tyto tenebricosa*.

whilst the other with a 75 centimetres × 75 centimetres engraved area, is situated 6.75 kilometres from the study site in a heathland habitat.

Nocturnal birds

Nocturnal birds detected were the Powerful Owl, Barking Owl, Southern Boobook, Sooty Owl, Tawny Frogmouth and White-throated Nightjar. Generally, nocturnal birds were quiet or absent during winter, except for the Sooty Owl (Table 2). At least one Sooty Owl was detected on six of the 21 study nights of the nocturnal survey. Three calls were unsolicited and three solicited by playback. The study also revealed that at least three Southern Boobooks could be heard simultaneously from the northern end of the Stockyard Gully transect. One was on the mountain, sometimes within the Botanic Gardens, another was calling from the Mount Wilson area approximately five kilometres to the north-west and another from about the same distance in Bowen Creek Valley to the north. All three called from the same roost areas on at least three occasions during the study. Southern Boobook calls were not heard or evoked by playback from June to August. Playback failed to elicit a response from the Australian Owlet-nightjar, Masked Owl, Barn Owl, Grass Owl and Pheasant Coucal. Furthermore, these species were not detected on any night, when playback was not used.

DISCUSSION

Overall seasonal abundance

Mount Tomah's climate is mild in comparison to higher regions to the south (pers. obs.). For example, the Brindabella Ranges (near Canberra) and Kosciusko National Park, where annual seasonal migrations have been reported by Lamm and Wilson (1965), and Gall and Longmore (1978) respectively. This study did not detect any significant seasonal change in overall bird abundance between summer October-March and winter April-September. Five species previously identified as migratory species by Blakers *et al.* (1985) Black-faced Monarch, Rufous Fantail, Welcome Swallow, Tree Martin and Silvereye were not detected in the colder months. However, there is one unconfirmed report that the Welcome Swallow overwintered in 1998 (see Systematic List). In addition, the Yellow-faced Honeyeater was identified as a passage migrant and was only detected in April, July and August (for nocturnal birds see later discussion).

Habitat preferences

Habitat preferences are difficult to interpret precisely because most of the Botanic Gardens open forests are exotic gardens mixed with endemic eucalypts and are only analogous to the natural open eucalypt dominated forest of Stockyard Gully. There are however, two small remnants of open eucalypt forest remaining in the Botanic Gardens. In addition, the Botanic Gardens rainforests are either overplanted with Gondwanan exotics or direct comparison is inhibited by the difference in patch size between the relatively small remnants in the Botanic Gardens and the larger rainforest in Stockyard Gully. Nevertheless, habitat preferences were detected for more than one-third of the species present some more distinctly than others and some

were clearly related to habitat change. For example, the Australian Wood Duck showed a close association with the Botanic Gardens dam and surrounding lawns that are favoured for grazing. Notably, the Wonga Pigeon and Golden Whistler were more frequently detected in Stockyard Gully rainforest. However, other rainforest species were detected at approximately equal frequencies in the Botanic Garden's and Stockyard Gully's rainforests. Three native insectivores (White-throated Treecreeper, Buff-rumped Thornbill and Grey Fantail) were also more frequently detected in Stockyard Gully open forest. However, the Laughing Kookaburra *Dacelo novaeguineae* and Silvereye were detected at approximately equal frequencies in Stockyard Gully open forest and the Botanic Garden's open habitats.

Artamid and Corvid abundances

In 1994, bush fires burnt much of the Mount Tomah's surrounding habitat. Since then increased numbers of corvids and large artamids moved into the area, perhaps in search of food. Pied Currawongs and Australian Magpies have probably maintained an increased presence in the Botanic Gardens since that time by utilising food from human sources. For example, Pied Currawongs take exotic fruits and Australian Magpies feed in soil under the extensive lawns for invertebrates (see Floyd 1979). Pied Currawongs have been identified as significant avian nest predators in the Australian National Botanic Gardens and adjacent Black Mountain native forest, in the Australian Capital Territory (Prawiradilaga 1996), in urban environments (Major *et al.* 1996), and in fragmented woodlands (Fulton and Ford 2000; Fulton and Ford 2001). Along with other avian nest predators, their consistently high numbers in and around the Mount Tomah Botanic Gardens may have an adverse impact on other nesting species, in both the gardens and the native forest. Future avifaunal structural change may be driven by increased avian predation; particularly by breeding Pied Currawongs preying on species with overlapping breeding seasons (see Prawiradilaga 1996; Wood 1998; Fulton and Ford 2000; Fulton and Ford 2001). Some species such as the Satin Flycatcher, which was uncommon prior to this survey and was not detected during the study period 1996–1999 (but detected in October 1991), may be more vulnerable to increased nest predation and may have become locally endangered.

Comparisons with Brenton's 1987 checklist

Harold Brenton compiled his checklist from casual observations collected from 1953 into the 1980s. He was a life-long amateur bird observer and bird-bander. He would often patiently sit for hours and draw the birds and associated plants (Jean Ingram 1997 pers. comm.). Brenton's list was compiled prior to the establishment of the Botanic Gardens and before much of Mount Tomah's residential development. Brenton (1987), identified and ascribed a status for 118 avian species, and suggested another eight species in its supplementary notes. The current survey identified 72 species. However, a direct comparison between the two sets of data is limited because Brenton collected data from the entire mountain, which encompassed a greater area and variety of habitats.

Nevertheless, some changes that have occurred over time can be detected by comparing the two studies. Some of these changes are clearly associated with the development and maturation of the Botanic Gardens and possibly with the increased residential development on Mount Tomah.

The new bird species detected fall into three groups: waterfowl associated with permanent water available at the Botanic Gardens dam; introduced species, which may be vagrant occurrences or they may have expanded their ranges; and nocturnal birds (see later discussion). The latter may have been present during previous surveys but are now more readily detected using playback.

Waterfowl were previously considered rare, but have increased in numbers with reliable water now at the Botanic Gardens Dam. Brenton (1987) reported the Australian Wood Duck as rare; his only record was a pair with young seen in 1982 (near the Botanic Gardens Dam). This species increased in number prior to and during the study period, with six resident pairs recorded in June 1997. Other waterfowl, grebes, cormorants, herons and the Straw-necked Ibis *Threskiornis spinicollis* are occasional visitors. Major bush fires at Lithgow, Mountain Lagoon and Mount Irvine (the latter approximately 7 km from Mount Tomah) coincided with the one-off occurrence of the two Pacific Black Ducks *Anas superciliosa*, two Australasian Grebes *Tachybaptus novaehollandiae* and approximately 100 Fairy Martins *Hirundo ariel* at the dam in December 1997. At this time the air was full of smoke making it difficult to breathe and glowing ash was falling into the study area. This may highlight the dam's potential as a refuge for these birds during or after fires.

Two of the new bird species detected were exotic pigeons the Spotted Turtle-Dove *Streptopelia chinensis*, which was detected in January 1999 and Rock Dove *Columba livia*. Both occurrences of the Rock Dove in the Botanic Gardens corresponded with the release of 'racing pigeons'. The first was identified from a collection of feathers in June 1997 and the second a dead bird (with bands that were not collected) in July 1998. At least three pairs of Common Myna *Acridotheres tristis* have been detected breeding adjacent to and just below the study area at Berambing. Brenton (1987) reported the species as uncommon but recorded it to peak of the mountain. However, it has not been detected in the study area.

The honeyeater assemblage may have changed since Brenton's Checklist, because of an increase in nectar-rich heathland plants introduced into the Botanic Gardens. However, outside the Botanic Gardens, in native forest, no change in honeyeater numbers has been detected. Brenton (1987) reported, New Holland Honeyeaters as rather rare, and Red Wattlebirds as winter nomads. Red Wattlebirds are now detected throughout the year and it seems improbable that New Holland Honeyeaters would be rare in the rich Proteaceous heath of the surrounding sandstones. However, on the basaltic capped mountain in rainforest habitat with less nectar providing plants, honeyeater abundance could be lower. Currently, New Holland Honeyeaters are the second most abundant species in the Botanic Gardens, particularly on the northern face in the Rock Garden. The overwhelming preference demonstrated by this species for

the Botanic Gardens compared to Stockyard Gully, agrees with its rare status given by Brenton (1987), prior to the Botanic Gardens establishment.

Brenton (1987) also reported the Australian King Parrot as a rather rare resident. This seems surprising, as it is moderately common to common throughout the Blue Mountains, especially in wet sclerophyll forest and rainforest. This survey found this species' probability of detection was 0.64 on any given day and that it prefers native rainforest to exotic garden or open forest environments. Variegated Fairy-wrens were considered common residents in heathlands by Brenton (1987). However, they were not detected during the survey. Pilotbirds were also reported as moderately common residents by Brenton (1987) and at least one bird was commonly seen in the Botanic Gardens after the bush fires in 1994. However, only one observation of this species was made during the study period. Satin Flycatchers were reported as uncommon by Brenton (1987) but as moderately common breeding residents in the upper Blue Mountains by Smith and Smith (1990). However, this species was detected only once (in October 1991) when both male and female birds were recorded in the Botanic Gardens.

The Emu

The Emu has not been detected in the area since early European settlement. Blaxland (1813) reported Emu calls during the night in the lower Blue Mountains and he found Emu tracks in morning frost, in the upper Blue Mountains. In addition, engravings of Emu tracks originating from the indigenous Australians of the area have been found throughout the mountains, and close to the study site. These artefacts indicate that the local Dharug people were familiar with this species. Furthermore, eggs of the Emu have been used as a food source by the Wiradjuri people who bordered the Dharug on the west (McCarthy, 1964). McCarthy (1964) excavated a Wiradjuri site (Noola rock shelter) less than 50 kilometres north of Mount Tomah with a similar landscape to Stockyard Gully, close to a water source (approx. 80 m) and situated below Tavan Pic, a basaltic peak. The site contained Emu eggshells in several layers of a 1.78 metre excavation, indicating a long history with this food source.

Nocturnal birds

The Southern Boobook may be an altitudinal migrant at Mount Tomah. Although Southern Boobooks are considered to be quiet during the winter months, its call may be given at any time of year (Schodde and Mason, 1980). Fleay (1968) reported that Boobooks emit calls similar to the Barking Owl's scream through the autumn and winter months, the 'morepork' call beginning in late July. Debus (1995) found playback more than doubled the detection rate for larger forest owls and Redpath (1994), obtained responses within 30 minutes in 94 per cent of cases for Tawny Owls *Strix aluco*. However, playback over two consecutive winters at Mount Tomah failed to elicit a single response from the Southern Boobook. Seasonal migration has previously been encountered in Southern Boobooks crossing Bass Strait (Schodde and Mason 1980).

In addition, Clancy (1977) identified individuals regularly wintering in Sydney, predominantly from March to August. Other individuals regularly returned to winter in a barn at Richmond, arriving March-April and departing July-August. (Richmond is situated between Mount Tomah and Sydney, at the foot of the Blue Mountains). These observations suggest a seasonal altitudinal movement to the warmer lowlands and or better feeding grounds. The cooler climate of the upper Blue Mountains may inhibit much of the predominantly insect diet of the Southern Boobook.

The Sooty Owl is considered a specialised rainforest resident (Debus 1994; Schodde and Mason 1980). However, at least one individual radio-tracked at Engadine, New South Wales, had a 30 square kilometre territory, which contained less than 1 per cent rainforest (Jackson and Kavanagh 1997). The Australian subspecies (*Tyto t. tenebricosa*) is listed as rare with inappropriate forestry management considered its greatest threat by reducing nest sites, roost sites and prey availability (Garnett 1993). This 'rarity' has also been linked to a lack of observers in its preferred habitat at night and to its secretive roosting habits, in tree hollows, caves and dense foliage during the day (Schodde and Mason 1980; Hollands 1991; Debus 1994).

The Mount Tomah area provides two basic habitat types for the Sooty Owl; rainforest on basaltic soils and open eucalypt forest on sandstone and shale substrates. The Botanic Gardens, agricultural clearings and residential development represent a smaller proportion of the available habitat. The following evidence suggests that the Sooty Owl at Mount Tomah may prefer the basaltic rainforest rather than the greater area of surrounding open forest country. On three occasions, white-tipped mammal tails approximately 18 centimetres long (not collected or identified), have been located in Botanic Gardens rainforest, wedged between lianas and tree stems. In addition, a Sugar Glider *Petaurus breviceps* was found dead, but uneaten in the fork of a large Rhododendron in the Botanic Gardens. While this prey may have been taken by other owls in the area, the Sooty Owl was detected more frequently closer to the Botanic Gardens than other large owls, excluding the Southern Boobook. Moreover, all three of the playback responses occurred in rainforest at the first playback site in Stockyard Gully rainforest and of the three unsolicited calls one was heard in Stockyard Gully rainforest directly above my tent in the middle of the night. The other two unsolicited calls were heard from the open forest playback site and were too distant to ascribe a habitat, given the mosaic of rainforest and eucalypt forest present.

Of the owls not detected by the initial 12-month playback survey or subsequent years of listening, the Barn Owl is considered an irruptive breeding nomad. Barn Owls are listed by Brenton (1987), which includes a sighting of an immature bird, and they are reported by residents during mouse plagues. The Masked Owl was also not detected in the survey. There is only a single record for the upper Blue Mountains at Kings Tableland (33°28'S, 150°15'E), February 1997 (Morris 2000). There are four records for greater Blue Mountains and surrounding areas. Blue Gum

Swamp, Winmalee, 1981 (Smith and Smith 1990); Central Colo, December 1992 (Morris and Burton 1994); Gees Lagoon, Central Colo, May and November 1993 (Morris and Burton 1995). A search of the Australian Museum data base also failed to detect this species in the Blue Mountains area. However, they are considered widespread around Sydney and on the entire east coast inland to the forested edge of the tablelands (Debus and Rose 1994). The Masked Owl is a very cryptic and under-recorded species, there is no logical reason why it should be absent from the Blue Mountains (Stephen Debus, pers. comm.).

Future research and conclusion

Future research regarding the Sooty Owl could investigate its habitat preference and use. Firstly, through identifying roosts and nest sites then by pellet collection and analysis. Further insights into its range and habitat utilization and preference could be advanced by radio-tracking individual birds. Increases in abundance of nest predators such as the Pied Currawong could be investigated and the effects on the nesting success of a target species or species groups (open-cup and enclosed nesters) could be undertaken. This could be done in association with artificial nests experiments where the nests are monitored with cameras to identify the nest predator. Furthermore, Pied Currawong pellet analysis may reveal more detail about its diet and if the increased availability of exotic fruits helps to maintain its high abundance in the Botanic Gardens. Point counts with equal sampling effort and colour banding could be used to gather more reliable abundance data when monitoring future avifaunal structure at this site.

In conclusion, some changes have occurred to the avifauna by the establishment of the Mount Tomah Botanic Gardens at the study site. These have been primarily brought about through the substantive increase in nectar rich plants, the addition of berry-bearing trees and shrubs, and the addition of a permanent water supply at the Botanic Gardens dam. In addition, some species have shown habitat preferences for the Botanic Gardens particularly the exotic species and large artamids, while three native insectivorous species were detected more frequently in Stockyard Gully, perhaps avoiding the Botanic Gardens. The increased abundance of potential bird-nest predators such as the Pied Currawong (see Priddel and Carlile 1995; Major *et al.* 1996; Prawiradilaga 1996; Wood 1998; Fulton and Ford 2000; Fulton and Ford 2001) may be reducing the numbers of other breeding birds in the area.

ACKNOWLEDGMENTS

I would like to acknowledge the Australian Museum for the loan of playback equipment used throughout the nocturnal study and for the use of their library. The Mount Tomah Botanic Gardens for allowing access to their property and the NSW Parks and Wildlife Service for access to the Aboriginal Sites Register. This paper benefited from comments on early drafts provided by Richard Major, Hugh Ford and then on the final draft from Corella's reviewers. I would like to thank Geordie Fulton and my wife Mercedes for their help in the field, Leif Rosengard for his enthusiasm, and particularly Pat O'Carroll for the warm-hearted lodgings given in the concluding months of the study. In addition, the author recognizes that this study was carried out in the traditional lands of the Dharug people.

REFERENCES

- Atkinson, L. (1861). A voice from the country. Mount Tomah. *SMH*: January 28th.
- Blaxland, G. (1813). 'A journal of a tour of discovery across the Blue Mountains, New South Wales, in the year 1813.' (Gibbs, Shailard, and Co.: Sydney.)
- Blakers, M., Davies, S. J. J. F. and Reilly, P. N. (1985). 'The Atlas of Australian Birds.' (Royal Australian Ornithologists Union: Melbourne.)
- Brenton, H. E. (1987). Checklist of the birds of Mount Tomah. In 'The Mount Tomah Book, Second Edition.' (The Mount Tomah Society and the Royal Botanic Gardens: Sydney.)
- Buckingham, R. and Jackson, L. (1990). 'A field guide to Australian birdsong.' (Bird Observers Club of Australia: Nunawading.)
- Coleman, A. (1971). Bird day observation count. *Aust. Birds* 78: 39.
- Christidis, L. and Boles, W. E. (1994). 'The Taxonomy and Species of Australia and its Territories.' (RAOU Monograph 2. Royal Australian Ornithologists Union: Melbourne.)
- Clancy, G. P. (1977). Boobook Owls in the Sydney district. *Aust. Birds* 12: 12-13.
- Debus, S. J. S. (1994). The Sooty Owl *Tyto tenebricosa* in New South Wales. *Aust. Birds* 28: Suppl. 4-19.
- Debus, S. J. S. (1995). Surveys of large forest owls in northern New South Wales: Methodology, calling behaviour and owl responses. *Corella* 19: 38-50.
- Debus, S. J. S. and Rose, A. B. (1994). The Masked Owl *Tyto novaehollandiae* in New South Wales. *Aust. Birds* 28: Suppl. 39-59.
- Ford, H., Barrett, G. and Recher, H. (1995). Birds in a degraded landscape — safety nets for capturing regional biodiversity. In 'Nature Conservation 4: The Role of Networks.' (Eds. D. A. Saunders, J. L. Craig and E. M. Mattiske.) Pp. 40-50. (Surrey Beatty & Sons: Sydney.)
- Ford, H. A., Barrett, G., Saunders, D. and Recher, H. (2001). Why have birds in woodlands of Southern Australia declined? *Biol. Conserv.* 97: 71-88.
- Fleay, D. (1968). 'Nightwatchmen of bush and plain.' (Jacaranda Press: Brisbane.)
- Floyd, R. B. (1979). Localization of Scarab larvae by the Black-backed Magpie (*Gymnorhina tibicen*). (B.Sc. Honours thesis, University of New England: Armidale.)
- Fulton, G. R. and Ford, H. A. (2000). Avian nest predation and the role of territorial Pied Currawongs (*Strepera graculina*): an artificial nest experiment. In 'Birds Australia Report Series 9. The 2nd Southern Hemisphere Ornithological Congress. (Abstracts)'. (Eds. L. B. Astheimer and M. F. Clarke.) Pp. 87. (Griffith University: Brisbane.)
- Fulton, G. R. and Ford, H. A. (2001). The Pied Currawong's (*Strepera graculina*) role in avian nest predation: an artificial nest and predator removal experiment. *Pac. Cons. Bio.* 7: 154-160.
- Gall, B. C. and Longmore, N. W. (1978). Avifauna of the Thredbo Valley, Kosciusko National Park. *Emu* 78: 189-196.
- Garnett, S. (1993). 'Threatened and Extinct Birds of Australia.' (2nd edition). (RAOU Report Number 82. Royal Australian Ornithologists Union: Moonee Ponds.)
- Heron, S. J. (1973). Birds of the Orange district. NSW. *Emu* 73: 1-8.
- Hollands, D. (1991). 'Birds of the night.' (Reed: Sydney.)
- Hoskin, E. S., Hindwood, K. A. and McGill A. R. (1991). 'The birds of Sydney County of Cumberland New South Wales 1770-1989.' (2nd Edition.) (Surrey Beatty & Sons: Chipping Norton.)
- Hungerford, M. (1987). History of Mount Tomah. In 'The Mount Tomah Book'. (2nd Edition.) (The Mount Tomah Society and the Royal Botanic Gardens: Sydney.)
- Ingram, C. K. (1987). Plants. In 'The Mount Tomah Book'. (2nd Edition.) (The Mount Tomah Society and the Royal Botanic Gardens: Sydney.)
- Jackson, R. and Kavanagh, R. (1997). Against all odds supper sooty survives suburbia. *Geo.* 19: 51-56.
- Kohen, J. (1993). A Dictionary of the Dharug Language: The inland dialect. In 'Blue Mountains Dreaming The Aboriginal Heritage'. (E. Stockton, Ed.) (Three Sisters Publication: Winmalee.)
- Lamm, D. W. and Wilson, S. J. (1965). Seasonal fluctuations of birds in the Brindabella Range, Australian Capital Territory. *Emu* 65: 183-205.
- Major, R. E., Gowing, G. and Kendal, C. E. (1996). Nest predation in Australian urban environments and the role of the Pied Currawong, *Strepera graculina*. *Aust. J. Ecol.* 21: 399-409.
- Matthews, A., Dickman, C. R. and Major, R. E. (1999). The influence of fragment size on nest predation in urban bushland. *Ecography* 22: 349-356.
- McCarthy, F. D. (1964). Archaeology of the Capertee Valley, New South Wales. *Records of the Australian Museum* 26: 197-246.
- Morris, A. K. and Burton, A. (1994). New South Wales annual bird report 1992. *Aust. Birds* 27: 97-150.
- Morris, A. K. and Burton, A. (1995). New South Wales annual bird report 1993. *Aust. Birds* 28: 81-128.
- Morris, A. K. and Burton, A. (1997). New South Wales annual bird report 1995. *Aust. Birds* 30: 81-149.
- Morris, A. K. (2000). New South Wales annual bird report 1997. *Aust. Birds* 32: 1-64.
- Prawiradilaga, D. M. (1996). Foraging ecology of Pied Currawongs *Strepera graculina* in recently colonised areas of their range. (PhD thesis, Australian National University: Canberra.)
- Priddel, D. and Carlile, N. (1995). Mortality of adult Gould's Petrels *Pterodroma leucoptera* at the nesting site on Cabbage Tree Island, New South Wales. *Emu* 95: 259-264.
- Recher, H. F. (1999). The state of Australia's avifauna: a personal opinion and prediction for the new millennium. *Aust. Zool.* 31: 11-27.
- Recher, H. F. and Lim, L. (1990). A review of current ideas of the extinction, conservation and management of Australia's terrestrial vertebrate fauna. *Proc. Ecol. Soc. of Aust.* 16: 287-301.
- Redpath, S. M. (1994). Censusing Tawny Owls *Strix aluco* by the use of imitation calls. *Bird Study* 41: 192-198.
- Reid, J. R. W. (1999). 'Threatened and declining birds in the NSW sheep-wheat belt: 1 diagnosis, characteristics and management.' (Consultancy report to New South Wales National Parks and Wildlife Service. CSIRO Wildlife and Ecology: Canberra.)
- Robinson, D. and Trail, B. J. (1996). Conserving woodland birds in the wheat and sheep belts of southern Australia. RAOU Conservation statement No. 10. *Supp., to Wingspan* 6: No. 2.
- Rodd, N. W. (1987). Weather. In 'The Mount Tomah Book', (2nd Edition). (The Mount Tomah Society and the Royal Botanic Gardens: Sydney.)
- Schodde, R. and Mason, I. (1980). 'Nocturnal birds of Australia.' (Lansdowne Editions: Melbourne.)
- Slater, P., Slater, P. and Slater, R. (1989). 'The Slater Field Guide to Australian Birds.' (Weldon Publishing: Australia.)
- Smith, J. and Smith, P. (1990). 'Fauna of the Blue Mountains.' (Kangaroo Press: Kenthurst.)
- Strahan, R. (1988). 'Complete book of Australian Mammals.' (Angus and Robertson: North Ryde.)
- Vellenga, R. (1968). 'Some birds of the City of the Blue Mountains.' Unpublished (ms).
- Woinarski, J. C. Z. and Braithwaite, R. W. (1990). Conservation foci for Australian birds and mammals. *Search* 21: 65-68.
- Wood, K. A. (1998). Seasonal changes in the diet of Pied Currawongs *Strepera graculina* at Wollongong, New South Wales. *Emu* 98: 157-170.
- Zar, J. H. (1999). 'Biostatistical analysis' (4th Ed.) (Prentice Hall: New Jersey.)

APPENDIX 1

Systematic list

Species below were recorded in the study area during the study period, unless otherwise stated. Probability of detection (PD) is the proportion of study days on which the species was detected (diurnal n = 22, nocturnal n = 21). Probability of detection (PD**) indicates no detection during the study period but records were obtained at other times. Dates of observations outside the survey period are given by month and year. The asterisk '*' following the scientific names signifies a species not recorded in the previous checklist by Brenton (1987). Some (where known) Dharug inland or mountain dialect bird-names are given in brackets following the English common name.

- Dromaius novaehollandiae* Emu (Biribain and Murriong) PD = 0; possibly locally extirpated.
Chenonetta jubata * Australian Wood Duck PD = 0.86; juveniles seen each year.
Anas superciliosa * Pacific Black Duck (Yuranyi or Yurungai) PD = 0.05
Tachybaptus novaehollandiae * Australasian Grebe PD = 0.05
Poliiocephalus poliocephalus * Hoary-headed Grebe PD = 0.05
Phalacrocorax melanoleucos * Little Pied Cormorant PD = 0.05
Egretta novaehollandiae White-faced Heron PD** single record prior to study period 2–94.
Threskiornis spinicollis * Straw-necked Ibis PD = 0.05
Accipiter cirrocephalus Collared Sparrowhawk PD = 0.05
Vanellus miles Masked Lapwing (Burranjurung) PD = 0.05; also recorded Botanic Gardens 2–94.
Columba livia * Rock Dove PD = 0.09; two dead birds recovered in Botanic Gardens 6–97 and 7–98 coincident with racing pigeon releases near Tomah Trig.
Streptopelia chinensis * Spotted Turtle-Dove PD = 0.05
Macropygia amboinensis Brown Cuckoo-Dove PD = 0.09
Leucosarcia melanoleuca Wonga Pigeon (Wonga Wonga) PD = 0.50
Calyptorhynchus funereus Yellow-tailed Black-Cockatoo PD = 0.23
Callocephalon fimbriatum Gang-gang Cockatoo PD = 0.09; also recorded 2–94.
Alisterus scapularis Australian King Parrot PD = 0.64
Platycercus elegans Crimson Rosella PD = 0.95
Platycercus eximius Eastern Rosella PD = 0.27
Cacomantis flabelliformis Fan-tailed Cuckoo PD = 0.14
Cacomantis variolosus Brush Cuckoo PD = 0.05
Eudynamis scolopacea Common Koel PD = 0.05
Scythrops novaehollandiae Channel-billed Cuckoo PD = 0.05; harassed in flight over Stockyard Gully rainforest by several noisy Pied Currawongs.
Ninox strenua * Powerful Owl PD = 0.05
Ninox connivens * Barking Owl PD = 0.05
Ninox novaeseelandiae Southern Boobook (Binnit) PD = 0.43
Tyto tenebricosa * Sooty Owl PD = 0.29
Podargus strigoides Tawny Frogmouth PD = 0.29
Eurostodopus mystacalis * White-throated Nightjar PD = 0.10
Dacelo novaeguineae Laughing Kookaburra (Kogunda or Kukundi) PD = 0.82
Menura novaehollandiae Superb Lyrebird PD = 0.50; two nests found in Stockyard Gully winter 1995.
Cormobates leucophaeus White-throated Treecreeper PD = 0.50
Malurus cyaneus Superb Fairy-wren PD = 0.91; nested in Botanic Gardens 1–97 and 10–98.
Pardalotus striatus ornatus Striated Pardalote PD = 0.09
Pycnophilus floccosus Pilotbird PD = 0.05
Sericornis citreogularis Yellow-throated Scrubwren PD = 0.32; two nests in Stockyard Gully rainforest 11–98, one suspended over walking track abandoned, the other over water with three eggs, attended by both sexes though neither were seen incubating.
Sericornis frontalis White-browed Scrubwren PD = 0.86; three nests detected in Botanic Gardens rainforest 11 and 12–98.
Sericornis magnirostris Large-billed Scrubwren PD = 0.18
Gerygone mouki Brown Gerygone PD = 0.05
Acanthiza pusilla Brown Thornbill PD = 0.82
Acanthiza reguloides Buff-rumped Thornbill PD = 0.18
Acanthiza nana Yellow Thornbill PD = 0.14
Acanthiza lineata Striated Thornbill PD = 0.32; no records for May–September inclusive.
Anthochaera carunculata Red Wattlebird PD = 0.86; juvenile in Rock Garden 11–96.
Meliphaga lewinii Lewin's Honeyeater PD = 1.0; nested in 'Gondwanan Rainforest' 2–97.
Lichenostomus chrysops Yellow-faced Honeyeater PD = 0.14; passage migrant.
Melithreptus lunatus White-naped Honeyeater PD = 0.05
Phylidonyris novaehollandiae New Holland Honeyeater PD = 0.95
Acanthorhynchus tenuirostris Eastern Spinebill PD = 0.95; nest collected Botanic Gardens open forest 6–97.
Petroica phoenicea Flame Robin PD = 0.05
Petroica rosea Rose Robin PD = 0.05; single record male and female 2–97.
Eopsaltria australis Eastern Yellow Robin PD = 0.82; seen with juvenile in Botanic Gardens 12–98.
Psophodes olivaceus Eastern Whipbird PD = 0.82
Falcunculus frontatus Crested Shrike-tit PD = 0.05
Pachycephala pectoralis Golden Whistler PD = 0.68; nest detected 1–97, cup-shaped of twigs and grass lined with greener leaves, 1.5 m above ground, three eggs similar to Brown Thornbill in Slater *et al.* (1989), all hatched. Male seen perched at night beside the empty nest a month later.
Pachycephala rufiventris Rufous Whistler PD = 0.05. Rare, single record two birds in Stockyard Gully open forest 11–97.
Colluricincla harmonica Grey Shrike-thrush PD = 0.27
Monarcha melanopsis Black-faced Monarch PD = 0.23; adult feeding juvenile Botanic Gardens rainforest 2–99.
Myiagra cyanoleuca Satin Flycatcher PD** single record both sexes in Botanic Gardens 10–91.
Rhipidura rufifrons Rufous Fantail PD = 0.23
Rhipidura fuliginosa Grey Fantail PD = 0.55; nest detected Stockyard Gully open forest 2–98.
Rhipidura leucophrys Willie Wagtail PD = 0.09
Coracina novaehollandiae Black-faced Cuckoo-shrike PD = 0.09

Appendix 2 — continued

Species	ST OF	ST RF	BG RFs	Habitats BG RG	BG OF	BG dam/ other	Total observations
Tawny Frogmouth		4	2				6
White-throated Nightjar		2					2
Laughing Kookaburra	16	4	1		18		39
Superb Lyrebird	1	6	6		1		14
White-throated Treecreeper	14		1		3		18
Superb Fairy-wren	3		12	11	49	1	76
Striated Pardalote					2		2
Pilotbird	1					1	
Yellow-throated Scrubwren	1	9	7				17
White-browed Scrubwren	2	3	14	6	72		97
Large-billed Scrubwren	2	1			2		5
Brown Gerygone	1						1
Brown Thornbill	13	6	13	1	37		70
Buff-rumped Thornbill	9						9
Yellow Thornbill	4		2				6
Striated Thornbill	3	2	2		6		13
Red Wattlebird	10	1		27	7		45
Lewin's Honeyeater	6	3	30	7	19		65
Yellow-faced Honeyeater	1				17		18
White-naped Honeyeater					1		1
New Holland Honeyeater	1		5	83	21		110
Eastern Spinebill	6		7	24	40		77
Flame Robin					3		3
Rose Robin		2					2
Eastern Yellow Robin	9	3	13		18		43
Eastern Whipbird		29	41		2		72
Crested Shrike-tit			1				1
Golden Whistler	7	27	5		3		42
Rufous Whistler	2						2
Grey Sbrike-thrush	3	1			6		10
Black-faced Monarch	1	5	3				9
Rufous Fantail		11					11
Grey Fantail	16	6		1	4		27
Willie Wagtail					2		2
Black-faced Cuckoo-shrike					2		2
Australian Magpie	8				52	2	62
Pied Currawong	1		2		92		95
Australian Raven	5	1		6	60		72
Satin Bowerbird	5	8	13		30		56
Red-browed Finch	10	13	12		29		64
Welcome Swallow	2			62	7		71
Tree Martin				5			5
Fairy Martin						100	100
Red-whiskered Bulbul	1	2		4	5		12
Silvereye	5				11		16
Bassian Thrush	1	3	5		4		13
Common Blackbird	3		4		31		38
Total	190	212	277	241	735	226	1 881

APPENDIX 3

Mean abundance of each species by month. The mean numbers of birds detected for each month of the study period and the number of surveys for each month during the study period are recorded. A zero indicates that the species was not detected in that month during the study period. However, October was not surveyed for diurnal birds during the study period. A total of 22 months were surveyed.

Month	J	F	M	A	M	J	J	A	S	O	N	D
Number of surveys for each month	3	3	2	2	1	2	1	1	1	0	3	3
Species	Mean numbers of observations											
Australian Wood Duck	8.3	2	2.5	4.5	0	6.5	8	6	6		1.3	8.3
Pacific Black Duck	0	0	0	0	0	0	0	0	0		0	0.7
Australasian Grebe	0	0	0	0	0	0	0	0	0		0	0.7
Hoary-headed Grebe	0	0.3	0	0	0	0	0	0	0		0	0
Little Pied Cormorant	0	0.3	0	0	0	0	0	0	0		0	0
Straw-necked Ibis	0	0	0	2.5	0	0	0	0	0		0	0
Collared Sparrowhawk	0	0	0	0	0	0	0	0	0		0	0.3
Masked Lapwing	0	0	0	0	0	0.5	0	0	0		0	0

Appendix 3 -- continued

Month	J	F	M	A	M	J	J	A	S	O	N	D
Number of surveys for each month	3	3	2	2	1	2	1	1	1	0	3	3
Species	Mean numbers of observations											
Rock Dove	0	0	0	0	0	0.5	1	0	0	0	0	0
Spotted Turtle-Dove	0.3	0	0	0	0	0	0	0	0	0	0	0
Brown Cuckoo-Dove	1	0	0	0	0	0	0	0	0	0	0	0
Wonga Pigeon	1	0.7	0	0	0	0.5	2	1	1	0	0.7	0.7
Yellow-tailed Black-Cockatoo	0	0	3.5	3	0	0	0	0	0	0	0.7	1.3
Gang-gang Cockatoo	0.7	0	0.5	0	0	0	0	0	0	0	0	0
Australian King Parrot	3.7	3.3	2	3	0	0.5	2	1	1	0	0.7	0.7
Crimson Rosella	5	6.7	4.5	5.5	6	5.5	1	8	4	0	4.7	4
Eastern Rosella	0.7	0	1	0	0	3	0	3	0	0	0.7	0.7
Brush Cuckoo	0.3	0	0	0	0	0	0	0	0	0	0	0
Fan-tailed Cuckoo	0.3	0	0	0	0	0	1	0	1	0	0	0
Common Koel	0	0.3	0	0	0	0	0	0	0	0	0	0
Channel-billed Cuckoo	0.3	0	0	0	0	0	0	0	0	0	0	0
Powerful Owl	0	0.3	0	0	0	0	0	0	0	0	0	0
Barking Owl	0	0	0	0	0	0	0	0	0	0	0	0.3
Southern Boobook	1	0	1.5	0.5	0	0	0	1	0	1	1	1.3
Sooty Owl	0.3	0	1	0.5	0	0	1	0	1	0	0	0
Tawny Frogmouth	0	0.7	0.5	0.5	0	0	1	1	0	0	0	0
White-throated Nightjar	0.3	0.3	0	0	0	0	0	0	0	0	0	0
Laughing Kookaburra	3.3	1.7	1.5	1	0	1.5	3	1	2	0	0.7	2.7
Superb Lyrebird	0.7	0.7	0	0	0	1	3	1	0	0	0.7	0.7
White-throated Treecreeper	1	2	1	1	0	0	1	2	0	0	0.3	0.3
Superb Fairy-wren	3.3	1.7	0.5	3.5	8	6.5	1	4	8	0	2.3	4
Striated Pardalote	0	0	0	0	1	0.5	0	0	0	0	0	0
Pilotbird	0	0	0	0	0	0	0	0	0	0	0.3	0
Yellow-throated Scrubwren	1	0.3	0	0	0	1	3	1	0	0	2	0.3
White-browed Scrubwren	4.7	4.7	0	2.5	1	4.5	5	5	6	0	6.3	6.3
Large-billed Scrubwren	0	0.7	0.5	1	0	0	0	0	0	0	0	0
Brown Gerygone	0	0	0.5	0	0	0	0	0	0	0	0	0
Brown Thornbill	5	3.7	3	1.5	0	2.5	5	5	2	0	1.3	4.7
Buff-rumped Thornbill	0.3	0.7	0	1.5	0	1.5	0	0	0	0	0	0
Yellow Thornbill	0	0	0	0	0	1.5	0	2	0	0	0	0.3
Striated Thornbill	0.7	1.3	0	1.5	0	0	0	0	0	0	0.7	0.7
Red Wattlebird	1	3	1	2	2	1.5	1	3	1	0	1.3	1.3
Lewin's Honeyeater	2.3	2.7	1.5	2	2	5.5	6	5	5	0	2.3	2.3
Yellow-faced Honeyeater	0	0	0	4	0	0	2	8	0	0	0	0
White-naped Honeyeater	0	0	0	0	0	0	1	0	0	0	0	0
New Holland Honeyeater	3.3	4	5.5	5	6	5.5	2	4	5	0	6.3	6.7
Eastern Spinebill	4.3	5	2	4	1	2	2	1	6	0	2	5.7
Flame Robin	0	0	0	0	0	0	0	0	3	0	0	0
Rose Robin	0	0.7	0	0	0	0	0	0	0	0	0	0
Eastern Yellow Robin	3	2.7	1	3	2	2	2	0	3	0	0.3	2
Eastern Whipbird	5	3.3	2.5	3	1	2.5	2	5	4	0	1.7	4.7
Crested Shrike-tit	0	0.3	0	0	0	0	0	0	0	0	0	0
Golden Whistler	3	3.7	1.5	1.5	2	3.5	0	1	0	0	0.7	1.3
Rufous Whistler	0	0	0	0	0	0	0	0	0	0	0.7	0
Grey Shrike-thrush	0.3	1	1	0.5	0	0.5	0	2	0	0	0	0
Black-faced Monarch	0.7	1	1	0	0	0	0	0	0	0	0.7	0
Rufous Fantail	0.7	2.3	1	0	0	0	0	0	0	0	0	0
Grey Fantail	2.3	1	1	5	0	0.5	2	0	0	0	0	0.7
Willie Wagtail	0	0	0	0.5	0	0.5	0	0	0	0	0	0
Black-faced Cuckoo-shrike	0	0	0	0	1	0.5	0	0	0	0	0	0
Australian Magpie	5.7	1	3	2.5	3	4	6	3	3	0	2	0.7
Pied Currawong	3.3	3.7	4	5	3	4	8	5	0	0	6.3	4.3
Australian Raven	2.3	2	3	5	6	5.5	4	1	6	0	1	4
Satin Bowerbird	3.7	2.7	3	2	1	1.5	0	5	5	0	1.3	3
Red-browed Finch	1	2.3	3	6	0	5	10	6	10	0	0	0
Welcome Swallow	7.7	7	3.5	3	2	1	0	0	0	0	2.7	0.7
Tree Martin	0.7	0.3	1	0	0	0	0	0	0	0	0	0
Fairy Martin	0	0	0	0	0	0	0	0	0	0	0	33
Red-whiskered Bulbul	0	0	0	1	0	0	2	0	0	0	1	1.7
Silvereye	1	0	1	1.5	0	0	0	0	8	0	0	0
Bassian Thrush	1.3	0.3	0	1	0	0.5	1	0	1	0	0.3	0.7
Common Blackbird	2.3	0.3	1	1	1	0.5	2	4	0	0	2.7	3.3