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## USE OF RIPARIAN AREAS BY TERRESTRIAL BIRDS OF THE MULGA LANDS - SOUTH WEST QUEENSLAND

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### ABSTRACT

The total abundance of individuals and species richness of terrestrial birds were found to be significantly higher in riparian habitat compared to surrounding non-riparian habitat in the Mulga Lands of south west Queensland. Ninety eight sites in riparian and upslope areas were sampled during two winters and one summer from July 1997 to August 1998.

The extent of the differences varied with time and was greatest during winter 1997, when rainfall was below average, and least during winter 1998, when rainfall was well above average. Nearly half of the 65 species analysed were at least 50% more abundant in riparian than in upslope areas and approximately one third were at least 50% more abundant in upslope areas. Very few species were recorded exclusively in one habitat or the other. The results suggest that the ecological importance of riparian areas to terrestrial birds of the Mulga Lands may be most acute during extended dry periods.

### INTRODUCTION

Vegetation adjacent to waterways (riparian areas) may support a disproportionately high component of total terrestrial biodiversity and, in addition, is important to the functioning of adjacent habitats (Szaro & Jakle, 1985; Risser, 1990; Gregory *et al.*, 1991; Catterall 1993). Substantial research into this issue has been conducted in temperate North America,

where riparian areas are considered important habitat for both migratory and resident bird populations, particularly in arid and semi-arid regions.

Studies of bird communities within the eucalypt forests of eastern Australia have also demonstrated total abundance and species richness are significantly higher in riparian areas. Gregory & Pressey (1982) noted 43 species of birds as being specifically associated with riparian areas in the eastern highlands of Australia. Recher *et al.* (1991) and Loyn (1985) observed that moist riparian areas dominated by wet sclerophyll and rainforest vegetation in south east Australia supported a richer and more abundant avifauna than adjacent drier forests associated with the slopes and ridges. Chan (1995) reported similar findings from eucalypt woodlands of the New South Wales northern tablelands.

In riparian areas of subtropical coastal lowlands in south east Queensland, Bentley & Catterall (1997) and Catterall *et al.* (2000), respectively, observed higher densities of migratory insectivorous birds, and higher bird abundances and species richness than in corresponding adjacent habitats. In the tropical savannas of northern Australia Woinarski *et al.* (2000) make similar findings and note that the riparian avifauna appeared most distinct from avifauna in adjacent habitats in regions of lower rainfall.

In the more arid regions of Australia, Nix (1993) proposed that riparian areas are of critical importance in maintaining bird populations during dry periods, and that their degradation since European settlement is a likely cause of species decline. According to Wilson (1999) the semi-arid Mulga Lands of south west Queensland are widely recognised as the State's most degraded bioregion. Wilson (1999) noted that land degradation in the form of soil erosion and major alterations to vegetation communities occurs across most land types within the region but is most severe within mulga and alluvial (riparian) land zones. However there is a scarcity of information regarding the implications of this for the region's fauna.

Here we examine the importance of riparian areas to terrestrial birds within the Mulga Lands of south west Queensland. Specifically we measure the extent to which bird densities and diversity vary between riparian and adjacent habitats

## METHODS

### *Study area*

Data for the study were collected between July 1997 and August 1998 from 98 sites distributed throughout the Mulga Lands biogeographic region (Thackway & Cresswell 1995; Wilson 1999) of south west Queensland. The

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study area is bounded by latitudes 25° - 29°S and longitudes 144° - 149°E, and contains major portions of the Maranoa/Balonne, Warrego, Paroo, and Bulloo River catchments, and the townships of St. George, Charleville, Cunnamulla and Quilpie.

The climate of the area is semi-arid with 60% to 70% of the annual average rainfall of between 270mm and 570mm occurring during the summer months (October to March). Average monthly temperatures exceed 35°C during summer and fall below 5°C during winter (Neldner 1984).

Mulga *Acacia aneura*, the dominant canopy species, occurs widely throughout the study area and its distribution is closely related to extensive areas of weathered Tertiary land surfaces supporting loamy sandy or gravelly red earths (Neldner 1984; Wilson 1999). Vegetation structure ranges from forest and woodland in the less arid eastern parts of the region to shrublands in the west. The riparian component of the landscape is much more limited in extent, and occurs on alluvial clays of Quaternary origin as forest or woodland formations throughout the region (Neldner 1984; Wilson 1999).

#### **Study Sites and Data Collection**

Birds were counted repeatedly on Riparian (n = 42) and Upslope (n = 56) sites over three sampling periods (Winter 1997, Summer 1997/8, Winter 1998). A subset of 90 (of the 98) sites were sampled during Winter 1997 and Summer 1997/8, and 89 sites were sampled during Winter 1998. The winter surveys were conducted in July and August in both years and the summer survey was undertaken from mid November to early February.

Riparian sites contained woodland or forest vegetation associated with major permanent or ephemeral watercourses. Riparian vegetation was typically dominated by: river red gum *Eucalyptus camaldulensis*, coolibah *E. coolibah*, and/or yapunyah *E. ochrophloia*. Upslope sites were located at least 200m distant from riparian areas (or known permanent water sources) and approximately half of the sites were located more than two kilometres away. These sites generally supported woodlands and/or shrublands dominated by mulga *Acacia aneura* and/or poplar box *E. populnea*. Grasslands, clay pans and cleared pastures were not sampled. Bore drains and areas in their vicinity were also excluded from the study. Apart from these differences both the Riparian and Upslope sites sampled a broad range of environmental conditions (e.g vegetation structure, disturbance, proximity to water etc.) present within the Bioregion.

At each site measurements of bird species density, using standardised area counts, were obtained. Three evenly spaced circular plots (25m radius) were located within a 300m long by 50m wide rectangular site. Each site was visited on two separate mornings by an observer who recorded the species and number of individuals (group size) of all birds seen during a 10 minute sample of each circular plot. Thus, the total time spent per site-sampling period was; 10 mins X 3 plots X 2 days, or 60 mins. Statistical analyses were conducted at this resolution by combining bird counts from all 6 individual 10 minute plots. Sites within 500m of drainage lines were positioned parallel to them. Riparian sites were positioned immediately adjacent to drainage lines. Data collection took place between 0.5 hrs and 3.5 hrs after sunrise, and rainy or very windy days were avoided.

Weather conditions during the survey periods were assessed by comparing the average monthly rainfall (from 14 locations throughout the bioregion) during, and one month prior, to each period, with the long-term average for the same months (BOM 1999). These calculations confirmed that conditions varied among the sampling periods. Rainfall during the Winter 1997 sampling period was well below average (6.4 mm/month vs. 21.4 mm/month long-term), while both Summer 1997/8 and Winter 1998 experienced rainfall well above average (60.2 mm/month vs. 43.6 mm/month long-term, and 56.7 mm/month vs. 21.4 mm/month long-term, respectively).

### ***Analyses***

Differences in total abundance and species richness between Riparian and Upslope site types were analysed using Analysis of Variance (ANOVA; Zar 1984). Separate single factor ANOVAs were carried out on these variables using data derived from each individual sampling period. To examine differences between riparian and upslope areas over all three sampling periods, two factor ANOVAs were used based on Riparian Status (two levels: Riparian, Upslope) and Sampling Period (three levels; Winter 1997, Summer 1997/8, Winter 1998). The effect of sampling period was regarded as a random factor (block) and as a result, seasonal effects are excluded here but will be examined in a separate publication.

Prior to data analyses all records of water birds, and birds flying over the study plots (direct flights greater than ten metres above the emergent vegetation layer) were excluded from the data set. To improve statistical assumptions associated with normality and heterogeneity of variance, all abundance data was log transformed prior to analyses. Presented means and standard errors are back-transformed.

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To measure the magnitude of the difference in abundance between riparian and upslope habitats, a riparian index was calculated for each species recorded at five or more sites, and for total abundance and species richness. The Riparian Index was calculated as a simple ratio of the mean Riparian density divided by the mean Upslope density. Indices exceeding one indicate proportionally more observations from riparian treatments. The reverse is true for indices of less than one. For example, a species with a Riparian Index of 2.0 was on average twice as abundant in Riparian sites as Upslope sites. Species recorded exclusively at five or more Riparian or Upslope sites were allocated a Riparian Index of "High" or "Low" respectively.

## RESULTS

A total of 4156 bird records was obtained, accounting for 8549 individuals of 104 species. During the Summer 1997/8 sampling period 2292 individuals (81 species) were counted. The Winter 1997 and Winter 1998 sampling periods yielded 3261 individuals (71 species), and 2996 individuals (84 species) respectively. The Appendix (pp13-16) contains a list of all 104 species and their frequency of occurrence. Sixty five species were present at five or more sites and given a Riparian Index.

Of the 65 species, 43% had abundances at least 50% higher in Riparian habitats (Riparian Index > 1.5), while 29% exhibited the reverse trend (Riparian Index < 0.66). Prominent species of Riparian sites included: White-plumed Honeyeater, Willie Wagtail, Grey Shrike-thrush, Yellow-throated Miner, Red-winged Parrot, Brown Treecreeper, Magpie-lark, Black-faced Cuckoo-shrike, Little Friarbird, Laughing Kookaburra, Whistling Kite, White-browed Treecreeper, Australian Ringneck, Sacred Kingfisher, Peaceful Dove and Restless Flycatcher. Prominent Upslope species included: Rufous Whistler, Weebill, Chestnut-rumped Thornbill, Jacky Winter, Crested Bellbird, Striated Pardalote, Red-capped Robin, Singing Honeyeater, Mistletobird, Yellow-rumped Thornbill, Hooded Robin, Striped Honeyeater and Splendid Fairy-wren.

Very few species were recorded exclusively in either in Riparian or Upslope zones areas. Only four species had greater than 95 % of individuals within Upslope treatments (Riparian Index > 0.05; Appendix): Splendid Fairy-wren, Yellow-rumped Thornbill, Chestnut-rumped Thornbill and Jacky Winter. Similarly, three species had more than 95% of individuals in Riparian areas (Riparian Index >20.0; Appendix): Pied Currawong, Laughing Kookaburra and Fairy Martin.

**Table 1. Results of Analyses of Variance (ANOVA) examining differences in Riparian Status for Total Abundance.**

Results are shown for each individual sampling period and over all sampling periods. Analyses based on Log (x+1) transformed values. Probability levels: \* =  $P < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\* =  $p < 0.001$ ; ns = not significant. Riparian Index = mean Riparian abundance/mean Upslope abundance.

Variable	No. of Site-Times	Riparian Index	ANOVA Results (F value; Probability level)		
			Riparian Status (df = 1)	Sampling Time (df = 2)	Interaction (df = 2)
Winter 1997 Abundance	90	3.82	52.17***	N/A	N/A
Summer 97/8 Abundance	90	2.30	42.12***	N/A	N/A
Winter 1998 Abundance	89	1.55	12.59**	N/A	N/A
Total Abundance	269	2.38	102.68***	8.83***	6.15**

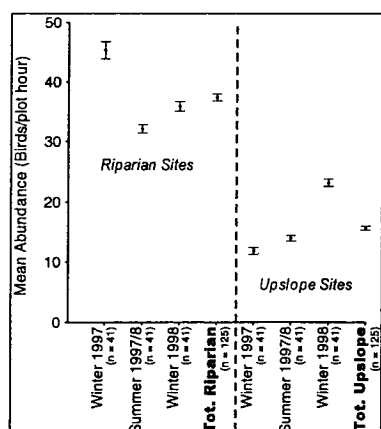
**Table 2. Results of Analyses of Variance (ANOVA) examining differences in Riparian Status for Species Richness.**

Results are shown for each individual sampling period and over all sampling periods. Analyses based on Log (x+1) transformed values. Probability levels: \* =  $P < 0.05$ ; \*\*  $P < 0.01$ ; \*\*\* =  $p < 0.001$ ; ns = not significant. Riparian Index = mean Riparian richness/mean Upslope richness.

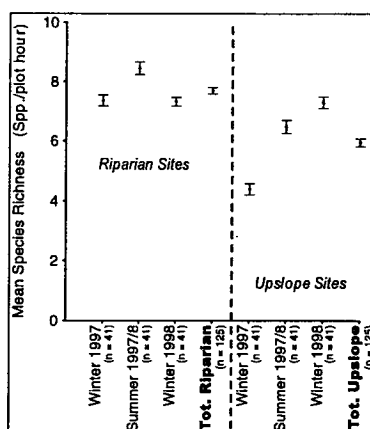
Variable	No. of Site-Times	Riparian Index	ANOVA Results (F value; Probability level)		
			Riparian Status (df = 1)	Sampling Time (df = 2)	Interaction (df = 2)
Winter 1997 Species Richness	90	1.26	21.15***	N/A	N/A
Summer 97/8 Species Richness	90	1.12	6.62*	N/A	N/A
Winter 1998 Species Richness	89	1.00	0.00 <sup>ns</sup>	N/A	N/A
Species Richness	269	1.29	19.76***	4.46*	9.17***

Riparian habitats supported significantly ( $p < 0.001$ ) higher overall densities than adjacent Upslope habitats (Table 1; Figure 1). Over the three sampling periods and all 104 species, the average bird density was more than twice as high in Riparian areas compared with Upslope habitats. The most dramatic differences were evident during Winter 1997 when nearly four times as many birds were recorded from Riparian areas compared with Upslope habitats (Table 1). During Winter 1998 there were approximately 50 percent more observations from Riparian areas, while more than twice as many birds were observed in Riparian habitats during the Summer 1997/8 sampling period (Table 1).

Broadly similar patterns are evident for species richness (Table 2; Figure 2), although there was less difference between Riparian and Upslope habitats. Species richness was significantly higher in Riparian habitats during Winter 1997 and Summer 1997/8, and over all three Sampling Periods. However, no difference could be detected for Winter 1998, because of an increase in the number of species recorded within Upslope habitats.



**Figure 1:** Riparian and upslope differences in total bird abundance (mean and standard error) over three sampling periods



**Figure 2:** Riparian and upslope differences in species richness (mean and standard error) over three sampling periods

## DISCUSSION

The results clearly demonstrate that riparian areas supported a greater number of birds and bird species than adjacent upslope habitats. Although the magnitude of total abundance was obviously influenced by a few highly abundant species (e.g. White-plumed Honeyeater, Yellow-throated Miner), the observation that nearly half of all species analysed were at least 50% more abundant in riparian areas indicates that these habitats provide important resources for many species. The further observation that such species come from a wide range of genera, feeding guilds, and other life history characteristics indicates that such resources have widespread benefits to terrestrial birds.

A variety of environmental factors may underlie the important role that riparian areas play in providing habitat for birds. These include: 1) the presence of more water in riparian areas; 2) increased structural complexity of the vegetation in riparian areas; and/or 3) higher levels of primary and secondary production arising from enhanced nutrient status of riparian areas (see Thomas *et al.* 1979; Riding & Carter 1992). While this study does not attempt to test the role of these related factors it is noteworthy that during Summer 1997/8 and Winter 1998 there was abundant free-standing water at locations many kilometres from riparian areas. On the other hand when rainfall was below average during Winter 1997, a much larger proportion of total abundance came from riparian sites. This observation is consistent with the findings of Woinarski *et al.*

(2000) that report higher contributions to total abundance and species richness from riparian habitats toward the end of the dry season and at locations with lower annual average rainfall. This suggests that even when there was ample water in upslope areas, riparian areas continued to support higher numbers of individuals and species, and that during adverse seasons the role of riparian areas may be further enhanced.

While many species appear to show a definite preference for either upslope or riparian areas, very few species were found exclusively in one or other. This indicates that a wide range of species utilised riparian habitats for at least part of their needs. Therefore, these habitat types should be viewed as a habitat complex rather than independent entities. The suggestion from these data that seasonal variation in rainfall affects the strength of the riparian/upslope relationship is further support for this view. Management strategies must therefore consider the habitats of both riparian and adjacent upslope areas. Strategies aimed exclusively at the riparian habitats without regard for conditions in upslope areas may not be completely successful. However, the fact that riparian areas occupy such a small proportion of the landscape (often < 1%; see Knopf *et al.* 1988; Hewitt 1990) suggests the possibility that relatively minor improvements in riparian management may have widespread benefits to terrestrial bird populations across the landscape.

The results are broadly consistent with the findings of other studies within arid and semi-arid climates overseas (see for example Knopf *et al.* 1988; Szaro & Jakle 1985; Johnson & Haight 1985; Holstein 1984), and are also similar to comparable work in northern Australia (Woinarski *et al.* 2000) and the more mesic south east Queensland (Bentley & Catterall 1997; Catterall *et al.* 2000). Of particular note are comparisons of the community indices: total abundance and species richness. This study records Riparian Indices of 2.38 and 1.29 for total abundance and species richness, respectively, when averaged across all three sampling periods. In eucalypt forests of south east Queensland, calculations from Bentley & Catterall (1997) suggest values of 1.86 and 1.83 respectively (over two seasons and one year), while Kingston & Catterall (unpublished) also recorded 1.86 for total abundance, but 1.5 for species richness during the same three sampling periods as the present study. Calculations from Woinarski *et al.* (2000) suggest values of 1.36 and 1.45 respectively. While there are minor differences in the design of these studies, comparisons with the results of the present study suggest that semi-arid riparian areas, may be characterised by less separation of species, but greater concentrations of individuals especially during dry periods.

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### REFERENCES

- BENTLEY, J.,M. & CATTERALL, C.,P. (1997) The use of bushland, corridors, and linear remnants by birds in southeastern Australia. *Cons. Biol.* **11**, 1173-1189.
- BOM (1999) Monthly Precipitation Data for the following locations: Adavale (1985-1999), Bollon (1885-1999), Charleville Aero (1942-1999), Cunnamulla P.O. (1879-1999), Tinnenburra (1907-1998), Eulo P.O. (1886-1998), Hungerford P.O. (1884-1999), Idalia N.P. (1989-1999), Emmet Downs (1897-1998), Milo Station (1888-1998), Mitchell P.O. (1884-1999), Quilpie Airport (1917-1999), St George (1881-1999), Thargomindah P.O. (1879-1999). Prepared by Climate and Consultancy Section of the Queensland Regional Office of the Bureau of Meteorology.
- CATTERALL, C.P. (1993) The importance of riparian zones to terrestrial wildlife. In: BUNN, S.E., PUSEY, B.J. & PRICE, P. (Eds) *Ecology and Management of Riparian Zones in Australia*. LWRRDC Occasional Paper No 05/93.
- CATTERALL, C.P., PIPER, S.D., BUNN, S.E., & ARTHUR, J.M. (2000) Flora and fauna assemblages vary with local topography in a subtropical eucalypt forest. *Austral Ecology* **26**, 59-69.

- CHAN, K. (1995) Bird community patterns in fragmented vegetation zones around streambeds of the Northern Tablelands, New South Wales. *Aust. Bird Watcher* 16, 11-20.
- CHRISTIDIS, L. & BOLES, W.E. (1994) *The Taxonomy and Species of Birds of Australia and its Territories*. Royal Australasian Ornithologists Union Monograph 2, RAOU, Melbourne.
- GREGORY, B. & PRESSEY, B. (1982) River improvement. *Wildlife in Australia* 19, 52-55.
- GREGORY, S.V., SWANSON, F.J., MCKEE, W.A., & CUMMINS, K.W. (1991) An ecosystem perspective of riparian zones. *Bioscience* 41, 540-551.
- HOLSTEIN, G. (1984) Californian riparian forests: Deciduous islands in an evergreen sea. In: WARNER, R.E. & HENDRIX, K.M. (Eds) *California Riparian Systems: Ecology, Conservation, and Management*. Californian Riparian Systems Conference; Davis, CA (USA) 17-19 Sept 1981.
- HEWITT, M.J. (1990) Synoptic inventory of riparian ecosystems: The utility of Landsat Thematic Mapper data. *For. Ecol. Man* 33/34, 605-620.
- JOHNSON, R.R. & HAIGHT, L.T. (1985) Avian use of xeroriparian ecosystems in the North American warm deserts. In: JOHNSON, R.R., ZIEBELL, C.D., PATTEN, D.R., FFOLLIOT, P.F., & HAMRE, R.H. (Eds) *Riparian ecosystems and their management: reconciling conflicting uses*. USDA For. Serv. Gen. Tech. Rep. RM -120.
- KNOFF, F.L., JOHNSON, R.R., RICH, T., SAMSON, F.B. & SZARO, R.C. (1988) Conservation of riparian ecosystems in the United States. *Wilson Bull.* 100, 272-284.
- LOYN, R.H. (1985) Ecology, distribution and density of birds in Victorian forests. In: KEAST, A., RECHER, H.F., FORD, H.A. & SAUNDERS, D. A. (Eds) *Birds of Eucalypt Forest and Woodlands: Ecology, Conservation, Management*. RAOU & Surrey Beatty & Sons, Chipping Norton.
- NELDNER, V.J. (1984) *Vegetation Survey of Queensland - South Central Queensland* Queensland Botany Bulletin No. 3. Dept. of Primary Industries. Brisbane.
- NIX, H.H. (1993) Bird distributions in relation to imperatives for habitat conservation in Queensland. In: Catterall, C.P., Driscoll, P., Hulsman, K.A. & Taplin, A. (eds) *Birds and Their Habitats: Status and Conservation in Queensland*. Qld. Ornith. Soc.
-

- RECHER, H.F., KAVANAGH, R.P., SHIELDS, J.M., & LIND, P. (1991) Ecological association of habitats and bird species during the breeding season in southeastern New South Wales. *Aust. J. Ecol.* **16**, 337-352.
- RIDING, T. & CARTER, R. (1992) *The Importance of the Riparian Zone in Water Resource Management: A Literature Review*. Water Resources NSW.
- RISSER, P.G. (1990) The ecological importance of land-water ecotones. In: NAIMAN, R.J. & DECAMPS, H. (Eds). *The Ecology and Management of Aquatic - Terrestrial Ecotones*. UNESCO, Paris; Parthenon Publishing Group. Man and the Biosphere Series, No. 4, 7-21.
- SZARO, R.C. & JAKLE, M.D. (1985) Avian use of a desert riparian island and its adjacent scrub habitat. *The Condor* **87**, 511-519.
- THACKWAY, R. & CRESSWELL, I.D. (1995) (Eds). *An Interim Biogeographic Regionalisation for Australia: a framework for establishing the national system of reserves, version 4.0* Australian Nature Conservation Agency, Canberra.
- THOMAS, J.W., MASER, C., & RODIEK, J.E. (1979) Riparian Zones. In: THOMAS, J.W. (ed) *Wildlife Habitats in Managed Forests: the Blue Mountains of Oregon and Washington*. USDA For. Serv. Agriculture Handbook No. 553.
- WILSON, B.A. (1999) Mulga Lands. In: SATTLER, P.S. & WILLIAMS, R.D. (eds) (1999) *The Conservation Status of Queensland's Bioregional Ecosystems*. Environmental Protection Agency. Brisbane.
- WOINARSKI, J.C.Z., BROCK, C., ARMSTRONG, M., HEMPEL, C., CHEAL, D., & BRENNAN, K. (2000) Bird distribution in riparian vegetation in the extensive natural landscape of Australia's tropical savanna: a broad-scale survey and analysis of a distributional data base. *J. Biogeog.* **27**, 843-868.
- ZAR, J.H. (1984) *Biostatistical Analysis*. (2nd ed.) Prentice-Hall Inc. New Jersey.

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**Appendix: Mean abundance of all species at Riparian and Upslope sites.**

Taxonomy and order of species follow Christidis & Boles (1994). Analyses based on  $\log(x+1)$  transformed values. Presented means are back-transformed. Riparian Index = mean Riparian abundance/mean Upslope abundance. Species with riparian indices denoted as "High" or "Low" indicate those observed exclusively in Riparian or Upslope sites respectively.

Species	Mean Species Abundance (Number of Sites over all three sampling periods in brackets)			Riparian Index (for species recorded at 5 or more sites only)
	Riparian (n = 125)	Upslope (n = 144)	Total (n=269)	
Emu <i>Dromaius novaehollandiae</i>	0.009 (1)	0.026 (3)	0.018 (4)	
Stubble Quail <i>Coturnix novaezealandiae</i>	0.009 (1)	0 (0)	0.004 (1)	
Australian Wood Duck <i>Chenonetta jubata</i>	0.046 (4)	0 (0)	0.021 (4)	
Pacific Baza <i>Aviceda subcristata</i>	0.006 (1)	0 (0)	0.003 (1)	
Black-breasted Buzzard <i>Hamirostra melanosternon</i>	0.006 (1)	0 (0)	0.003 (1)	
Black Kite <i>Milvus migrans</i>	0.006 (1)	0 (0)	0.003 (1)	
Whistling Kite <i>Haliastur sphenurus</i>	0.105 (11)	0.008 (1)	0.052 (12)	13.58
Wedge-tailed Eagle <i>Aquila audax</i>	0 (0)	0.015 (3)	0.008 (3)	
Little Button-quail <i>Turnix velox</i>	0 (0)	0.005 (1)	0.003 (1)	
Common Bronzewing <i>Phaps chalcoptera</i>	0.138 (15)	0.148 (19)	0.143 (34)	0.93
Crested Pigeon <i>Ocyphaps lophotes</i>	0.260 (13)	0.245 (19)	0.252 (32)	1.06
Peaceful Dove <i>Geopelia striata</i>	0.116 (16)	0.023 (4)	0.065 (20)	5.12
Galah <i>Cacatua roseicapilla</i>	0.404 (20)	0.307 (21)	0.352 (41)	1.32
Little Corella <i>Cacatua sanguinea</i>	0.164 (9)	0.010 (2)	0.079 (11)	16.69
Major Mitchell's Cockatoo <i>Cacatua leadbeateri</i>	0.083 (7)	0.019 (2)	0.049 (9)	4.33
Sulphur-crested Cockatoo <i>Cacatua galerita</i>	0.036 (4)	0.023 (3)	0.029 (7)	1.58
Cockatiel <i>Nymphicus hollandicus</i>	0.103 (7)	0.091 (6)	0.097 (13)	1.14
Red-winged Parrot <i>Aprosmictus erythropterus</i>	0.339 (24)	0.134 (13)	0.226 (37)	2.52
Pale-headed Rosella <i>Platycercus adscitus</i>	0.075 (8)	0.050 (5)	0.062 (13)	1.49
Australian Ringneck <i>Barnardius zonarius</i>	0.807 (25)	0.266 (21)	0.495 (46)	3.03
Blue Bonnet <i>Northiella haematogaster</i>	0.018 (2)	0.011 (1)	0.014 (3)	
Red-rumped Parrot <i>Psephotus haematonotus</i>	0.042 (4)	0.008 (1)	0.024 (5)	5.46
Mulga Parrot <i>Psephotus varius</i>	0.092 (8)	0.104 (11)	0.098 (19)	0.88
Budgerigar <i>Melopsittacus undulatus</i>	0.018 (1)	0 (0)	0.008 (1)	
Pallid Cuckoo <i>Cuculus pallidus</i>	0 (0)	0.013 (2)	0.007 (2)	
Fan-tailed Cuckoo <i>Cacomantis flabelliformis</i>	0 (0)	0.005 (1)	0.003 (1)	
Horsfield's Bronze-Cuckoo <i>Chrysococcyx basalis</i>	0 (0)	0.005 (1)	0.003 (1)	
Laughing Kookaburra <i>Dacelo novaeguineae</i>	0.187 (20)	0.005 (1)	0.087 (21)	38.31
Sacred Kingfisher <i>Todiramphus sanctus</i>	0.255 (22)	0.041 (7)	0.136 (29)	6.26
Rainbow Bee-eater <i>Merops ornatus</i>	0.076 (12)	0.081 (11)	0.078 (23)	0.94

Species	Mean Species Abundance			Riparian Index
	Riparian (n = 125)	Upslope (n = 144)	Total (n=269)	
Dollarbird <i>Eurystomus orientalis</i>	0.052 (8)	0.015 (3)	0.032 (11)	3.54
White-browed Treecreeper <i>Climacteris affinis</i>	0.117 (10)	0.015 (2)	0.061 (12)	7.91
Brown Treecreeper <i>Climacteris picumnus</i>	0.397 (25)	0.104 (11)	0.233 (36)	3.83
Superb Fairy-wren <i>Malurus cyaneus</i>	0.020 (2)	0.034 (3)	0.028 (5)	0.59
Splendid Fairy-wren <i>Malurus splendens</i>	0 (0)	0.117 (9)	0.061 (9)	Low
Variegated Fairy-wren <i>Malurus lamberti</i>	0.074 (5)	0.099 (9)	0.087 (14)	0.75
Spotted Pardalote <i>Pardalotus punctatus</i>	0 (0)	0.005 (1)	0.003 (1)	
Red-browed Pardalote <i>Pardalotus rubricatus</i>	0.013 (1)	0.005 (1)	0.009 (2)	
Striated Pardalote <i>Pardalotus striatus</i>	0.044 (4)	0.139 (14)	0.093 (18)	0.32
Weebill <i>Smicromis brevirostris</i>	0.172 (7)	0.584 (32)	0.376 (39)	0.29
Western Gerygone <i>Gerygone fusca</i>	0.013 (1)	0 (0)	0.006 (1)	
Inland Thornbill <i>Acanthiza apicalis</i>	0.009 (1)	0.010 (1)	0.009 (2)	
Chestnut-rumped Thornbill <i>Acanthiza uropygialis</i>	0.011 (1)	0.611 (32)	0.295 (33)	0.02
Yellow-rumped Thornbill <i>Acanthiza chrysorrhoa</i>	0 (0)	0.144 (12)	0.074 (12)	Low
Yellow Thornbill <i>Acanthiza nana</i>	0 (0)	0.034 (3)	0.018 (3)	
Southern Whiteface <i>Aphelocephala leucopsis</i>	0 (0)	0.011 (1)	0.006 (1)	
Spiny-cheeked Honeyeater <i>Acanthagenys rufogularis</i>	0.678 (25)	0.583 (41)	0.627 (66)	1.16
Striped Honeyeater <i>Plectorhyncha lanceolata</i>	0.006 (1)	0.089 (10)	0.049 (11)	0.06
Noisy Friarbird <i>Philemon corniculatus</i>	0.051 (5)	0.039 (6)	0.044 (11)	1.31
Little Friarbird <i>Philemon citreogularis</i>	0.448 (24)	0.060 (8)	0.227 (32)	7.43
Blue-faced Honeyeater <i>Entomyzon cyanotis</i>	0.051 (4)	0.044 (3)	0.047 (7)	1.15
Noisy Miner <i>Manorina melanocephala</i>	0.410 (9)	0.058 (2)	0.211 (11)	7.05
Yellow-throated Miner <i>Manorina flavigula</i>	1.308 (24)	0.622 (25)	0.913 (49)	2.10
Singing Honeyeater <i>Lichenostomus virescens</i>	0.030 (3)	0.155 (11)	0.095 (14)	0.19
Grey-headed Honeyeater <i>Lichenostomus keartlandi</i>	0 (0)	0.011 (1)	0.006 (1)	
White-plumed Honeyeater <i>Lichenostomus penicillatus</i>	9.631 (40)	0.989 (40)	3.360 (80)	9.73
Brown Honeyeater <i>Lichmera indistincta</i>	0.023 (2)	0.021 (3)	0.022 (5)	1.14
Painted Honeyeater <i>Grantiella picta</i>	0.006 (1)	0.008 (1)	0.007 (2)	
White-fronted Honeyeater <i>Phylidonyris albigularis</i>	0 (0)	0.010 (2)	0.005 (2)	
Black Honeyeater <i>Certhionyx niger</i>	0.006 (1)	0 (0)	0.003 (1)	
Crimson Chat <i>Ephthianura tricolor</i>	0 (0)	0.005 (1)	0.003 (1)	
Jacky Winter <i>Microeca fascians</i>	0.006 (1)	0.229 (22)	0.119 (23)	0.02
Red-capped Robin <i>Petroica goodenovii</i>	0.011 (2)	0.133 (16)	0.074 (18)	0.08
Hooded Robin <i>Melanodryas cucullata</i>	0.009 (1)	0.061 (10)	0.036 (11)	0.14
Eastern Yellow Robin <i>Eopsaltria australis</i>	0.034 (4)	0.005 (1)	0.018 (5)	6.91
Grey-crowned Babbler <i>Pomatostomus temporalis</i>	0.029 (3)	0.106 (9)	0.069 (12)	0.27
White-browed Babbler <i>Pomatostomus superciliosus</i>	0.021 (1)	0 (0)	0.010 (1)	
Hall's Babbler <i>Pomatostomus halli</i>	0.051 (2)	0.097 (8)	0.075 (10)	0.52

Species	Mean Species Abundance			Riparian Index
	Riparian (n = 125)	Upslope (n = 144)	Total (n=269)	
Cinnamon Quail-thrush <i>Cinclosoma cinnamomeum</i>	0 (0)	0.008 (1)	0.004 (1)	
Varied Sittella <i>Daphoenositta chrysoptera</i>	0 (0)	0.023 (2)	0.012 (2)	
Crested Bellbird <i>Oreoica gutturalis</i>	0.035 (5)	0.109 (14)	0.074 (19)	0.32
Golden Whistler <i>Pachycephala pectoralis</i>	0.006 (1)	0 (0)	0.003 (1)	
Rufous Whistler <i>Pachycephala rufiventris</i>	0.107 (12)	0.301 (31)	0.206 (43)	0.36
Grey Shrike-thrush <i>Colluricincla harmonica</i>	0.397 (29)	0.157 (21)	0.263 (50)	2.53
Restless Flycatcher <i>Myiagra inquieta</i>	0.117 (11)	0.015 (3)	0.061 (14)	7.90
Magpie-lark <i>Grallina cyanoleuca</i>	0.314 (23)	0.106 (13)	0.199 (36)	2.96
Grey Fantail <i>Rhipidura fuliginosa</i>	0.045 (5)	0.070 (8)	0.058 (13)	0.64
Willie Wagtail <i>Rhipidura leucophrys</i>	0.574 (25)	0.262 (28)	0.400 (53)	2.19
Black-faced Cuckoo-shrike <i>Coracina novaehollandiae</i>	0.231 (23)	0.069 (12)	0.142 (35)	3.32
White-bellied Cuckoo-shrike <i>Coracina papuensis</i>	0.022 (2)	0 (0)	0.010 (2)	
Ground Cuckoo-shrike <i>Coracina maxima</i>	0 (0)	0.008 (1)	0.004 (1)	
White-winged Triller <i>Lalage sueurii</i>	0.028 (4)	0.023 (4)	0.025 (8)	1.24
Olive-backed Oriole <i>Oriolus sagittatus</i>	0.014 (2)	0.013 (1)	0.014 (3)	
White-breasted Woodswallow <i>Artamus leucorhynchus</i>	0.028 (2)	0 (0)	0.013 (2)	
Masked Woodswallow <i>Artamus personatus</i>	0.017 (3)	0.008 (1)	0.012 (4)	
White-browed Woodswallow <i>Artamus superciliosus</i>	0.150 (7)	0.021 (1)	0.080 (8)	7.03
Black-faced Woodswallow <i>Artamus cinereus</i>	0.013 (1)	0 (0)	0.006 (1)	
Little Woodswallow <i>Artamus minor</i>	0.011 (1)	0.026 (3)	0.019 (4)	
Grey Butcherbird <i>Cracticus torquatus</i>	0.035 (5)	0.069 (9)	0.053 (14)	0.50
Pied Butcherbird <i>Cracticus nigrogularis</i>	0.035 (4)	0.044 (6)	0.040 (10)	0.78
Australian Magpie <i>Gymnorhina tibicen</i>	0.138 (14)	0.115 (14)	0.126 (28)	1.20
Pied Currawong <i>Strepera graculina</i>	0.051 (5)	0 (0)	0.023 (5)	High
Australian Raven <i>Corvus coronoides</i>	0.174 (19)	0.130 (14)	0.150 (33)	1.34
Little Crow <i>Corvus bennetti</i>	0.013 (1)	0 (0)	0.006 (1)	
White-winged Chough <i>Corcorax melanorhamphos</i>	0.124 (5)	0.031 (3)	0.074 (8)	4.07
Apostlebird <i>Struthidea cinerea</i>	0.414 (13)	0.403 (15)	0.408 (28)	1.03
Spotted Bowerbird <i>Chlamydera maculata</i>	0.075 (9)	0.083 (13)	0.079 (22)	0.91
Richard's Pipit <i>Anthus novaeseelandiae</i>	0 (0)	0.020 (4)	0.010 (4)	
Zebra Finch <i>Taeniopygia guttata</i>	0 (0)	0.051 (4)	0.027 (4)	
Double-barred Finch <i>Taeniopygia bichenovii</i>	0.029 (4)	0.055 (7)	0.043 (11)	0.53
Mistletoebird <i>Dicaeum hirundinaceum</i>	0.006 (1)	0.091 (13)	0.050 (14)	0.06
Fairy Martin <i>Hirundo ariel</i>	0.112 (7)	0.005 (1)	0.054 (8)	22.87
Rufous Songlark <i>Cinclorhamphus mathewsi</i>	0.050 (7)	0.020 (4)	0.034 (11)	2.52
Brown Songlark <i>Cinclorhamphus cruralis</i>	0.009 (1)	0 (0)	0.004 (1)	