

## RELATIVE ABUNDANCE OF BIRD SPECIES IN ROADSIDE VEGETATION AT MARBURG, SOUTH-EAST QUEENSLAND

G. J. LEACH

P.O. Box 568, Kenmore, Queensland 4069

*Received 16 August, 1994*

Nine transects in south-east Queensland were censused eight times over two years to determine relative abundance of bird species and their distribution between roadside softwood scrub remnants and eucalypt associations. Eighty-eight species were observed; 80 in the softwood scrub and 56 in the eucalypt associations, with 48 common to both habitats. On average, 50 individual birds ( $42 \text{ ha}^{-1}$ ) were observed in each census of the softwood scrub remnants and 21 ( $18 \text{ ha}^{-1}$ ) in the eucalypt associations.

Silvereye, Double-barred Finch, Superb Fairy-wren, Willie Wagtail and Lewin's Honeyeater were the most frequently observed species in the softwood scrub, with Double-barred Finch (mean of 8.9 individuals per census), Zebra Finch (6.5), Silvereye (5.2), Superb Fairy-wren (3.4) and Lewin's Honeyeater (1.6) most abundant. In the eucalypt associations, Noisy Miner, Black-faced Cuckoo-shrike, Grey Butcherbird, Rufous Whistler and Lewin's Honeyeater were most frequently observed, with Noisy Miner (7.4), Scaly-breasted Lorikeet (1.5), Grey Butcherbird (1.0), Pale-headed Rosella (0.8) and Rufous Whistler (0.6) most abundant.

### INTRODUCTION

Distribution of Australian bird species is relatively well-documented at the  $1^\circ$  grid square scale (Blakers *et al.* 1984), and for several regions at a finer scale, e.g. Victoria (Emison *et al.* 1987), Richmond River (Gosper 1986) and New England (Ford and McFarland 1992). However, information on abundance within regions or habitats, e.g. New England woodland (Ford *et al.* 1985) and Richmond Valley forest (Gosper 1992), is sparse and inadequate for determining continental status of species. A major objective of the Australian Bird Count (ABC) is to strengthen this data base (Ambrose 1989).

The birdlife of the Marburg district of south-east Queensland has been monitored since 1977, leading to an appraisal of species presence (Leach and Hines 1987, 1993), but providing little information on their relative abundance. Information was derived from frequency of observation of species in a standard survey (Leach and Hines 1993) and from Rolling Bird Surveys (Cullen 1980; Leach 1995). Additionally, censuses over a year determined the impact of diurnal changes in detectability of birds on census outcomes in

softwood scrub remnants and eucalypt open forest (Leach and Watson 1994) and in another summer determined relative abundance in roadside softwood scrub (Leach and Recher 1993).

This paper reports censuses undertaken over a two-year period to determine relative abundance of species associated with roadside softwood scrub and eucalypt associations, and especially to determine those with localized distribution between habitats. The censuses provide new information for the sub-coastal subtropics, complementing information which will emerge from the ABC, and facilitating the better understanding of species status required for effective habitat management.

### METHODS

#### *Site*

The study was undertaken in the Marburg district ( $27^\circ 35'S$ ,  $152^\circ 35'E$ ) of south-east Queensland (Leach and Hines 1987, 1993). Briefly, the landscape comprises low hills and broad valleys and is used for agriculture and rural residential occupation. Fertile clay soils predominated and supported low closed forest, occasionally including Brigalow *Acacia harpophylla*, or forest dominated by Brigalow. These vegetation types are collectively referred to as softwood scrub and are represented by degraded remnants and galleries along creeks, fencelines

and roadsides. Solodic soils support eucalypt open forest (commonly Spotted Gum *Eucalyptus maculata*, with ironbarks *E. crebra* and *E. melanophloia*, and occasional Blue Gum *E. tereticornis* and Moreton Bay Ash *E. tessellaris*). Brigalow and eucalypts are up to about 20 m tall and low closed forest remnants about 8 m.

Six transects (1, 2, 4–7) were along Schuman's Road and three (3, 8, 9) along Woolshed Creek Road (see maps in Leach and Hines 1993 and/or Leach and Recher 1993). Transects 1 to 6 traversed softwood scrub remnants and 7 to 9 traversed eucalypt associations (Table 1). Each transect was 300 m in length and extended 20 m on both sides of the road.

### Weather

Climate is sub-tropical with 70 per cent of rainfall received in October through March (Cook and Russell 1983). Annual rainfall was near the long-term mean (780 mm) in 1980–81 and slightly greater in 1981–82, with high summer/early autumn rainfall in both years and low winter rainfall in the first year (Table 2). Maximum temperatures on census days

were within 2°C of monthly means, except in September 1981 (2.9°C below) and November 1981 (5.8°C above).

### Survey procedures

Land birds were censused on eight days by three teams (A, B and C; 3 to 6 observers per team) (Table 2). Three transects were censused concurrently, commencing on Schuman's Road. Each team censused the same two softwood scrub transects and one eucalypt transect each day. Birds seen or heard were counted as the group walked along transects over a 40-minute period. Birds flying within the first 20 m above ground, i.e. to the height of the tallest trees, were also included. Species names follow RAOU (1978); scientific names are included in Table 3.

Censuses through the day (Leach and Watson (1994) indicated that the intensity of censusing would ensure a near-complete inventory of species. However, because results of censuses are sensitive to differences in detectability of species, and within species between seasons and through the day, (Recher 1988; Wiens 1989; Leach and Watson 1994), comparisons between species need to be made with caution.

TABLE 1

Habitats along the nine roadside transects and in adjacent paddocks, intervals during which censuses were completed and team of observers.

Habitat		Time of census	Team
Roadside	Adjacent paddocks		
1. Softwood scrub, nw (some mw), md to dd.	Open farmland.	08:15–09:30	B
2. Softwood scrub, nw, od.	Open farmland.	09:15–10:20	A
3. Softwood scrub, mw (nw to ww), md to dd.	Farmland, remnants of softwood scrub, especially along creek 50 m south.	10:45–12:00	C
4. Softwood scrub, nw to mw, od (some md).	Farmland, with small softwood scrub remnants, eucalypts nearby (see transect 7).	08:20–09:30	A
5. Softwood scrub, nw to mw, mostly od to md (some dd).	Farmland with a few small softwood scrub remnants.	09:20–10:30	C
6. Brigalow-softwood scrub, mw to ww, mostly md to dd.	Brigalow remnant, softwood scrub remnants and open farmland.	09:15–10:30	B
7. Open eucalypt woodland (mainly ironbarks, some Blue Gum), with patches of softwood scrub, nw, od.	As roadside. An "island" (6 ha approx.) in open farmland with remnant softwood scrub.	08:20–09:30	C
8. Open eucalypt forest (mainly Spotted Gum), ew, md.	As roadside, > 500 ha. forest.	11:00–12:00	A
9. Open eucalypt forest (Spotted Gum, ironbarks, some Blue Gum and Moreton Bay Ash), ew, md.	As roadside, > 500 ha. forest.	10:55–12:00	B

Notes: Roadside habitat, woody vegetation — nw, narrow, 5 m or less width; mw, medium, 5–10 m width; ww, wide, >10 m width; ew, extensive through adjacent paddocks; od, open density, widely spaced clumps and/or thin stands; md, medium density, more or less continuous stand; dd, dense, with low light penetration and mainly broad-leaved shade species in the herb layer.

TABLE 2

Temperature and wind run on census days and preceding rainfall.

	1980		1981				1982	
	10 Aug.	21 Dec.	29 Mar.	21 June	6 Sep.	29 Nov.	21 Mar.	23 May
Temperature (°C):								
09:00	14.4	26.0	22.3	12.0	n.a. <sup>1</sup>	27.5	23.0	12.5
Daily max.	23.2	30.9	27.7	21.7	21.8	35.6	27.3	22.0
Wind run (km)	59	120	90	37	n.a.	123	82	90
Rain <sup>2</sup> (mm):								
5-day	0.0	7.6	0.0	0.3	0.0	45.6	3.2	0.0
Between censuses	42	207	353	191	73	189	552	30

<sup>1</sup>n.a. — not available. Note that min. temperature for 6 Sept. 1981, earlier in the morning, was 10.2°C.<sup>2</sup>Rainfall totals are for the 5 days preceding censuses and for the interval since the previous census (since 1 June 1980 for the first census). Note that the 45.6 mm 5-day total fell on 26 Nov. 1981.

## RESULTS

Eighty-eight species were observed (Table 3); Black-faced Cuckoo-shrike, Lewin's Honeyeater and Silvereye were observed on all transects and on all days. Another 10 species were observed on all days but only on seven or eight transects.

Silvereye was the most commonly observed species, in 49 censuses, while Noisy Miner, Double-barred Finch, Superb Fairy-wren and Lewin's Honeyeater were also observed in more than half of the censuses (Table 3). In contrast, 32 species were observed on no more than two days or two transects, 20 of them only once. Seven species averaged more than one individual observation per census.

Over all censuses, from 34 to 55 species were observed on eight transects but only 14 species on transect 8 (Table 4). Eighty species were observed on transects traversing roadside softwood scrub (transects 1 to 6) and 56 on those traversing eucalypt associations (7 to 9), with 48 common to both habitats (Table 3). Mean number of individual observations per transect per day ranged from 12 to 93 (Table 4).

Among common species, at least 90 per cent of species and individual observations of Silvereye, Double-barred Finch, Willie Wagtail and White-browed Scrubwren were made on softwood scrub transects (Table 5), with about the same number

from each softwood scrub transect (Fig. 1). Over 90 per cent of observations of Superb Fairy-wren, Yellow Thornbill, Bar-shouldered Dove and Zebra Finch were also made in softwood scrub but the number of observations from each softwood scrub transect was more variable.

In eucalypt associations, Noisy Miner had the most species and individual observations (Table 5) and was evenly represented over the three transects (Fig. 1). However, only 59 per cent and 77 per cent of species and individual observations of Noisy Miners were made in the habitat (cf. common species in softwood scrub — see above). Furthermore, only three other species in Table 5 had over 50 per cent of observations made on eucalypt transects.

Similarity Indices (SI) were used to indicate species overlap between transects, with  $SI = 2c / (a + b)$  where 'a' is the number of species on one transect, 'b' the number on the other and 'c' the number common to both (Krebs 1985). Transects in softwood scrub had quite similar avifauna ( $SI \geq 0.56$ ). Transects 5 and 6 were most similar ( $SI = 0.79$ ), while pairs 1 and 4, 2 and 5, and 3 and 4, had  $SI \geq 0.72$ . Transect 8 (Spotted Gum, Table 1) had low similarity with all other transects ( $SI = 0.29$  to  $0.39$ ) except transect 7 ( $SI = 0.54$ ). Transect 9 had low similarity with transects 1 to 5 ( $SI = 0.46$  to  $0.58$ ), but high similarity with transect 6 ( $SI = 0.67$ ).

TABLE 3

The number of transects (max = 9) and days (max = 8) on which species were observed, the total number of observations of species (max = 72) and individuals, and habitats in which species were observed (S, one or more of transects 1–6 (softwood scrub); E, one or more of transects 7–9 (eucalypt associations)).

Species name	Species			Individuals	Habitats
	No. of transects	No. of days	Total no.	Total no.	
Pacific Baza <i>Aviceda subcristata</i>	2	2	3	4	E
Brown Goshawk <i>Accipiter fasciatus</i>	2	2	2	2	SE
Brown Falcon <i>Falco berigora</i>	1	1	1	1	S
Brown Quail <i>Coturnix australis</i>	4	4	4	10	SE
Spotted Turtle-Dove <i>Streptopelia chinensis</i>	4	4	8	13	SE
Brown Cuckoo-Dove <i>Macropygia amboinensis</i>	1	1	1	1	S
Peaceful Dove <i>Geopelia placida</i>	7	8	16	33	SE
Bar-shouldered Dove <i>G. humeralis</i>	7	7	24	55	SE
Emerald Dove <i>Chalcophaps indica</i>	1	1	1	1	S
Common Bronzewing <i>Phaps chalcoptera</i>	3	3	3	3	SE
Crested Pigeon <i>Ocyphaps lophotes</i>	5	6	10	17	SE
Galah <i>Cacatua roseicapilla</i>	2	2	2	2	S
Rainbow Lorikeet <i>Trichoglossus haematodus</i>	3	3	3	18	SE
Scaly-breasted Lorikeet <i>T. chlorolepidotus</i>	6	5	13	62	SE
Little Lorikeet <i>Glossopsitta pusilla</i>	2	2	2	9	SE
Cockatiel <i>Nymphicus hollandicus</i>	1	1	1	2	S
Pale-headed Rosella <i>Platycercus adscitus</i>	6	7	16	42	SE
Brush Cuckoo <i>Cuculus variolosus</i>	1	1	1	1	S
Shining Bronze-Cuckoo <i>Chrysococcyx lucidus</i>	1	1	1	1	S
Common Koel <i>Eudynamis scolopacea</i>	1	1	1	1	S
Channel-billed Cuckoo <i>Scythrops novaehollandiae</i>	2	2	2	3	S
Pheasant Coucal <i>Centropus phasianinus</i>	4	3	4	5	S
Laughing Kookaburra <i>Dacelo novaeguineae</i>	6	7	10	14	SE
Sacred Kingfisher <i>Halcyon sancta</i>	4	3	6	7	SE
Rainbow Bee-eater <i>Merops ornatus</i>	6	7	15	60	SE
White-backed Swallow <i>Cheramoeca leucosternum</i>	1	7	7	51	S
Welcome Swallow <i>Hirundo neoxena</i>	2	2	2	3	S
Fairy Martin <i>Cecropis ariel</i>	1	1	1	4	S
Black-faced Cuckoo-shrike <i>Coracina novaehollandiae</i>	9	8	24	35	SE
Cicadabird <i>C. tenuirostris</i>	1	1	1	1	E
Ground Cuckoo-shrike <i>C. maxima</i>	1	1	1	4	S
Varied Triller <i>Lalage leucomela</i>	4	7	10	13	S
Rose Robin <i>Petroica rosea</i>	2	2	2	2	S
Scarlet Robin <i>P. multicolor</i>	1	1	1	1	E
Eastern Yellow Robin <i>Eopsaltria australis</i>	4	6	9	9	SE
Jacky Winter <i>Microeca leucophaea</i>	2	2	2	2	S
Golden Whistler <i>Pachycephala pectoralis</i>	6	5	10	12	SE
Rufous Whistler <i>P. rufiventris</i>	8	8	25	45	SE
Little Shrike-thrush <i>Colluricincla megarrhyncha</i>	1	1	1	1	S
Grey Shrike-thrush <i>C. harmonica</i>	5	5	10	12	SE
Black-faced Monarch <i>Monarcha melanopsis</i>	1	1	1	2	S
Leaden Flycatcher <i>Myiagra rubecula</i>	3	4	4	6	SE
Restless Flycatcher <i>M. inquieta</i>	1	1	1	1	S
Rufous Fantail <i>Rhipidura rufifrons</i>	6	5	12	16	SE
Grey Fantail <i>R. fuliginosa</i>	8	5	23	70	SE
Willie Wagtail <i>R. leucophrys</i>	8	8	35	55	SE
Eastern Whipbird <i>Psophodes olivaceus</i>	2	3	4	5	S
Grey-crowned Babbler <i>Pomatostomus temporalis</i>	1	1	1	2	E
Golden-headed Cisticola <i>Cisticola exilis</i>	3	6	9	24	S
Superb Fairy-wren <i>Malurus cyaneus</i>	7	8	37	165	SE

Table 3 — continued

Species name	Species			Individuals	Habitats
	No. of transects	No. of days	Total no.	Total no.	
Variegated Fairy-wren <i>M. lamberti</i>	5	5	8	24	S
White-browed Scrubwren <i>Sericornis frontalis</i>	7	8	21	22	SE
Speckled Warbler <i>S. sagittatus</i>	7	8	17	33	SE
Weebill <i>Smicronis brevirostris</i>	1	1	1	2	E
White-throated Gerygone <i>Gerygone olivacea</i>	4	4	5	8	SE
Yellow-rumped Thornbill <i>Acanthiza chrysorrhoa</i>	6	6	8	26	SE
Yellow Thornbill <i>A. nana</i>	7	7	25	77	SE
Varied Sittella <i>Daphoenositta chrysoptera</i>	2	2	2	4	SE
White-throated Treecreeper <i>Climacteris leucophaea</i>	1	1	1	1	E
Striped Honeyeater <i>Plectorhyncha lanceolata</i>	6	7	10	11	SE
Noisy Friarbird <i>Philemon corniculatus</i>	1	1	1	1	S
Noisy Miner <i>Manorina melanocephala</i>	8	8	41	230	SE
Lewin's Honeyeater <i>Meliphaga lewinii</i>	9	8	37	85	SE
Yellow-faced Honeyeater <i>Lichenostomus chrysops</i>	4	3	6	13	SE
Fuscous Honeyeater <i>L. fuscus</i>	1	1	1	1	E
White-throated Honeyeater <i>Melithreptus albogularis</i>	1	5	5	10	E
Brown Honeyeater <i>Lichmera indistincta</i>	5	5	11	36	S
Eastern Spinebill <i>Acanthorhynchus tenuirostris</i>	2	1	2	4	S
Scarlet Honeyeater <i>Myzomela sanguinolenta</i>	4	4	8	12	SE
Mistletoebird <i>Dicaeum hirundinaceum</i>	8	5	17	27	SE
Spotted Pardalote <i>Pardalotus punctatus</i>	2	2	3	6	SE
Striated Pardalote <i>P. striatus</i>	9	6	23	46	SE
Silvereye <i>Zosterops lateralis</i>	9	8	49	261	SE
Red-browed Firetail <i>Emblema temporalis</i>	4	4	5	7	S
Zebra Finch <i>Poephila guttata</i>	5	8	23	310	S
Double-barred Finch <i>P. bichenovii</i>	7	8	38	431	SE
Chestnut-breasted Mannikin <i>Lonchura castaneothorax</i>	3	5	5	21	S
Nutmeg Mannikin <i>L. punctulata</i>	2	3	3	65	S
Common Starling <i>Sturnus vulgaris</i>	2	2	2	2	S
Olive-backed Oriole <i>Oriolus sagittatus</i>	7	5	12	21	SE
Figbird <i>Sphecotheres viridis</i>	5	6	11	36	SE
Spangled Drongo <i>Dicrurus hottentottus</i>	6	4	10	21	SE
Australian Magpie-lark <i>Grallina cyanoleuca</i>	4	5	8	22	SE
Grey Butcherbird <i>Cracticus torquatus</i>	7	8	16	30	SE
Pied Butcherbird <i>C. nigrogularis</i>	6	5	8	16	SE
Australian Magpie <i>Gymnorhina tibicen</i>	8	8	17	31	SE
Pied Currawong <i>Strepera graculina</i>	1	1	1	2	S
Torresian Crow <i>Corvus orru</i>	8	7	19	43	SE

TABLE 4

Number of species observed on each transect on each day and the total number over all days, and mean number of individual observations.

Day	Transect									Total
	1	2	3	4	5	6	7	8	9	
1	24	9	18	15	19	10	7	7	13	54
2	17	10	10	15	14	16	13	3	7	43
3	13	7	20	9	20	6	9	4	6	43
4	18	6	15	20	15	9	8	3	15	47
5	9	14	11	19	19	15	9	1	9	49
6	13	11	12	13	13	15	9	4	11	42
7	15	8	12	15	9	8	8	2	12	39
8	18	17	14	23	18	21	11	3	12	51
Species	48	34	48	55	40	41	34	14	40	88
Indivs.	40	42	43	51	93	30	32	12	20	40

TABLE 5

The number of species and individual observations of species observed at least twice per transect, on average, in softwood scrub remnants and eucalypt associations. Total number of species observations, mean number of individual observations per census and percentage of species and individual observations within each habitat are presented.

Species	Species observations		Individual observations	
	No.	%	No.	%
<b>Softwood scrub</b>				
Silvereye	45	92	5.17	95
Double-barred Finch	37	97	8.92	99
Superb Fairy-wren	36	97	3.42	99
Willie Wagtail	32	91	1.06	93
Lewin's Honeyeater	29	78	1.56	88
Yellow Thornbill	24	96	1.54	96
Bar-shouldered Dove	23	96	1.12	98
Zebra Finch	23	100	6.46	100
Grey Fantail	19	83	1.31	90
White-browed Scrubwren	19	90	0.42	91
Striated Pardalote	19	83	0.88	91
Rufous Whistler	17	68	0.62	67
Noisy Miner	17	41	1.10	23
Black-faced Cuckoo-shrike	15	62	0.48	66
Peaceful Dove	14	88	0.58	85
Speckled Warbler	14	82	0.52	76
Torresian Crow	14	74	0.58	65
<b>Eucalypt associations</b>				
Noisy Miner	24	59	7.38	77
Black-faced Cuckoo-shrike	9	38	0.50	34
Grey Butcherbird	9	56	0.96	77
Rufous Whistler	8	32	0.62	33
Lewin's Honeyeater	8	22	0.42	12
Mistletoebird	8	47	0.50	44
Scaly-breasted Lorikeet	7	54	1.54	60
Pale-headed Rosella	6	38	0.83	48
Laughing Kookaburra	6	60	0.33	57
Australian Magpie	6	35	0.33	26

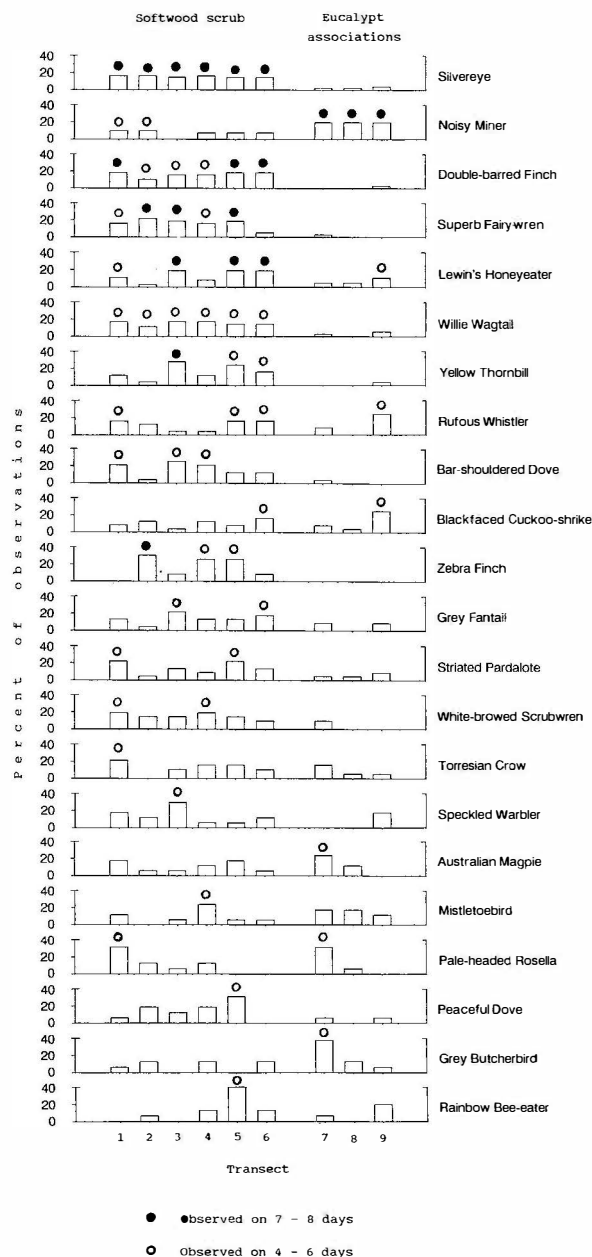


Figure 1. Percentage of the total number of individual observations of each species that were observed on each transect. Information for species observed in 15 or more censuses is shown; species are displayed in descending order of frequency of observation (see Table 3). Transects 1 to 6 were through roadside remnants of softwood scrub and transects 7 to 9 through eucalypt associations (see text). Species observed on individual transects on 7 to 8 days, and 4 to 6 days, are labelled; other observations on individual transects were on 1 to 3 days only.

## DISCUSSION

### *Species observed*

Censuses were in a 10' Grid Square where 157 species of land bird were observed over 10 years (Leach and Hines 1987), and 99 in five years of a standard survey through nearby farmland (Leach and Hines 1993). The 88 species observed in present censuses thus represent a substantial component of the Marburg land bird fauna.

The 80 species observed in roadside softwood scrub were fewer than the 154 in 18 dry rainforest sites (50–3 000 ha) through subtropical subcoastal Queensland (Horsup *et al.* 1993), although more species (87) were observed at only one individual site (3 000 ha). Thirty species at six or more sites which were not observed at Marburg included four observed in other Marburg roadside censuses, four on the eucalypt transects and three nocturnal species. The remaining 19 species included Australian Brush-turkey, fruit pigeons, Noisy Pitta, monarchs, Brown Gerygone, Large-billed Scrubwren and Regent Bowerbird — most require large patches of closed forest (Howe 1986; Leach and Recher 1993) and would be unlikely to occur in small roadside remnants. The total of 80 species is comparable with 81 in dry rainforest in north-east New South Wales (Gosper 1992), although only half the species were common to both studies. Annual rainfall (Gosper 1986) is at least 50 per cent higher in north-east New South Wales, and the forest taller and more extensive, than at Marburg. The 20 most abundant north-east New South Wales species included Topknot Pigeon, Sulphur-crested Cockatoo, Australian King Parrot, Large-billed Scrubwren, Brown Gerygone, Brown Thornbill and Regent Bowerbird, all commonly observed by Horsup *et al.* (1993) but absent from, or seldom observed in, the Marburg District (Leach and Hines 1987).

The numbers of species observed in Spotted Gum associations by Gosper (1992) (87 and 96) were higher than on present eucalypt transects. About half the species in north-east New South Wales were also at Marburg. Striated Thornbill, Noisy Friarbird, Fuscous Honeyeater and Red-browed Firetail, abundant in north-east New South Wales, were virtually absent from Marburg. In contrast, Noisy Miner, abundant in the Marburg eucalypt associations, was insignificant in north-east New South Wales, probably reflecting higher rainfall and greater growth of woody understorey.

### *Relative abundance of species*

In softwood scrub, Superb Fairy-wren, Yellow Thornbill and Silvereye were always among the six species with most individual observations in present censuses (Tables 3 and 5) and those of Leach and Recher (1993) and Leach and Watson (1994), while Bar-shouldered Dove, Willie Wagtail, Lewin's Honeyeater, Striated Pardalote and Double-barred Finch were always among the first 16 species. Noisy Miner had most individual observations in all censuses of the eucalypt associations, with Rufous Whistler the only other always among the first six.

The censuses provide an indication of density of birds, though subject to limitations through differences in detectability between species and environments (Recher 1988; Wiens 1989; Leach and Watson 1994). Densities in eucalypt forest (Keast *et al.* 1985; see especially chapters by Gilmore; Milledge and Recher; Recher and Holmes; and Shields *et al.*), collated by Recher (1985), indicate predominant densities of 10 to 20 birds per hectare with a maximum around 35. Densities in drier woodlands on the New England Tablelands were lower at 8 to 11 ha<sup>-1</sup> (Ford *et al.* 1985). Mean density for Marburg eucalypt transects (18 ha<sup>-1</sup>) is thus within the range observed in New South Wales studies. The mean density among the softwood scrub transects (42 ha<sup>-1</sup>) is similar to the 38 ha<sup>-1</sup> for a recently selectively logged closed-forest in New South Wales (Shields *et al.* 1985), in both instances probably reflecting increased presence of edge species.

Double-barred Finch had a mean density of 5 ha<sup>-1</sup> at Marburg, with Superb Fairy-wren, Noisy Miner, Silvereye and Zebra Finch also exceeding 1 ha<sup>-1</sup>. Generally these densities overlap the highest in Keast *et al.* (1985) and are higher than for all species except Fuscous Honeyeater (2.5 ha<sup>-1</sup>) in eucalypt associations censused by Ford *et al.* (1985). Superb Fairy-wren, for example, among the commonest species in both studies, was over three times as abundant at Marburg as on the New England Tablelands (1.9 cf. 0.5 ha<sup>-1</sup>).

### *Differences in avifauna between transects*

Land bird species are commonly, though loosely, associated with particular habitats (e.g. see Kikkawa 1968; Recher *et al.* 1991). Differences in proportions of the more abundant Marburg species (Fig. 1) generally showed substantial

preference for either softwood scrub (e.g. Silvereye, Double-barred Finch, Superb Fairy-wren) or eucalypt associations (e.g. Noisy Miner), confirming earlier inferences (Leach and Hines 1993; Leach 1995).

Within softwood scrub, avifaunas were similar on all transects and there was little difference in vegetation between transects (Table 1). In contrast, similarity indices were low in eucalypt associations. Transect 8 was dominated by Spotted Gum with sparse shrub and herb layers, whereas other eucalypts, shrubs and grass were more conspicuous along transect 9. Sparse understorey probably contributed to absence of small passerines. Similarity in avifaunas between transect 9 and transect 6 probably reflected structural convergence between eucalypt forest and tall brigalow, respectively. The open eucalypt woodland, with some softwood scrub, on transect 7 and location within farmlands with softwood scrub remnants, is likely to have ensured that the avifauna was similar to that on softwood scrub transects — for example Bar-shouldered Dove, Superb Fairy-wren and White-browed Scrubwren were observed (Fig. 1).

White-backed Swallow and White-throated Honeyeater, observed on five or more days but only on one transect, appeared to be strongly dependent on availability of quarry nest sites and layered eucalypt forest, respectively.

### *General discussion and conclusions*

Understanding changes in abundance of bird species in response to changes in land use is essential for effective conservation, and increasing emphasis is being given to remnant vegetation in agricultural landscapes (e.g. Howe *et al.* 1981; Saunders 1989; Arnold and Weeldenberg 1990; Leach and Recher 1993). Present censuses provide new information on relative abundance of birds in the remnant vegetation of subtropical, sub-coastal, Queensland. Information may be compared with that from relatively undisturbed habitats in the ABC (Ambrose 1989), or other censuses, to provide insights into how changes in land use have affected, and will affect, abundance. Results also confirm that frequency of observation of species in a standard survey (Leach and Hines 1993), which can be determined with less resources, is a valid surrogate for abundance of most species.

Avifaunas of the eucalypt and softwood scrub remnants were distinct, although the distinction diminished as structure converged. The softwood scrub remnants were consistently occupied by a diverse abundance of birds. In contrast, the avifauna of the eucalypt transects ranged from poor to rich and suggested that richness and abundance declined with increasing dominance of Spotted Gum (see Table 1). In combination, the vegetation associations substantially determined the land bird fauna of the district and hence need to be adequately retained in land management plans.

### ACKNOWLEDGMENTS

Teams were led by A. Lloyd (1 day), C. Lloyd (3), V. Sampson (8), D. Watson (4), A. Webb (1), C. Wingate (2) and P. Woodall (5), with A. Webb also a team member on three other days. Other members were: A. Barnaart (5 days), A. Boardman (2), B. Gill (3), P. Grice (5), the late M. Hawken (5), T. Murphy (4), G. Nye (4), A. Pyle (3), M. Sampson (8), D. Sullivan (7), G. Watson (6), J. Webb (4), L. Woodall (2) and another 16 individuals who participated on only one day. All are generously thanked for making the censuses possible, especially V. and M. Sampson who participated in every one. The Division of Tropical Crops and Pastures, CSIRO, is thanked for weather records from Lawes, B. Hines for computer graphics for Figure 1, and R. Major, P. Woodall and anonymous referees for helpful comments on an earlier version of the manuscript.

### REFERENCES

- Ambrose, S. (1989). The Australian Bird Count — have we got your number? *RAOU Newsletter* 80: 1.
- Arnold, G. W. and Weeldenburg, J. (1990). Factors determining the number and species of birds in road verges in the wheatbelt of Western Australia. *Biological Conservation* 53: 295–315.
- Blakers, M., Davies, S. J. J. F. and Reilly, P. N. (1984). 'The Atlas of Australian Birds.' (RAOU and Melbourne University Press: Melbourne.)
- Cook, S. J. and Russell, J. S. (1983). 'The Climate of Seven CSIRO Field Stations in Northern Australia.' (Division of Tropical Crops and Pastures Technical Paper No. 25. CSIRO: Australia.)
- Cullen, M. (1980). After the Atlas. I. Rolling Bird Survey. (RAOU) *Atlas Newsletter* 16: 1.
- Emison, W. B., Beardsell, C. M., Norman, F. I., Loyn, R. H. and Bennett, S. C. (1987). 'Atlas of Victorian Birds.' (Department of Conservation, Forests and Lands/RAOU: Melbourne.)
- Ford, H. A., Bridges, L. and Noske, S. (1985). Density of birds in eucalypt woodland near Armidale, north-eastern New South Wales. *Corella* 9: 97–107.
- Ford, H. A. and McFarland, D. (1991). Fauna survey of New England. III. Birds. *Memoirs of the Queensland Museum* 30: 381–432.



- Gosper, D. G. (1986). Birds in the Richmond River District, New South Wales, 1973–1983. 1. Distribution. *Corella* 10: 1–16.
- Gosper, D. G. (1992). Forest bird communities of the Richmond River District, New South Wales. *Corella* 16: 78–88.
- Horsup, A., James, C. and Porter, G. (1993). Vertebrates of dry rainforest of south and mideastern Queensland. *Memoirs of the Queensland Museum* 34: 215–228.
- Howe, R. W. (1986). Bird distributions in forest islands in North-eastern New South Wales. In 'The Dynamic Partnership. Birds and Plants in Southern Australia.' (Eds H. A. Ford and D. C. Paton.) pp. 119–129 (The Flora and Fauna of South Australia Handbooks Committee: Adelaide.)
- Howe, R. W., Howe, T. D. and Ford, H. A. (1981). Bird distributions on small rainforest remnants in New South Wales. *Australian Wildlife Research* 8: 637–651.
- Keast, A., Recher, H. F., Ford, H. and Saunders, D. (Eds) (1985). 'Birds of Eucalypt Forests and Woodlands: Ecology, Conservation and Management.' (Surrey Beatty & Sons: Chipping Norton).
- Kikkawa, J. (1968). Ecological association of bird species and habitats in eastern Australia: similarity analysis. *Journal of Animal Ecology* 37: 143–165.
- Krebs, C. J. (1985). 'Ecology. The Experimental Analysis of Distribution and Abundance.' Third Edition. (Harper and Row: New York.)
- Leach, G. J. (1995). Changes in populations of bird species in roadside softwood scrub remnants/farmland and open eucalypt forest in south-east Queensland, 1981–1993. *Pacific Conservation Biology* 2: in press.
- Leach, G. J. and Hines, H. B. (1987). Birds of the Marburg District, South-east Queensland. *Sunbird* 17: 65–95.
- Leach, G. J. and Hines, H. B. (1993). Frequency of observation of bird species in sub-coastal farmland in South-east Queensland. *Memoirs of the Queensland Museum* 33: 259–275.
- Leach, G. J. and Recher, H. F. (1993). Use of roadside remnants of softwood-scrub vegetation by birds in South eastern Queensland. *Wildlife Research* 20: 233–249.
- Leach, G. J. and Watson, D. J. (1994). Detectability of birds through the day in softwood scrub remnants and open eucalypt forest along roadsides at Tallegalla, South-east Queensland. *Corella* 18: 155–161.
- RAOU (1978). Recommended English Names for Australian Birds. *Emu* 77 (Supplement): 245–307.
- Recher, H. F. (1985). Synthesis: a model of forest and woodland bird communities. In 'Birds of Eucalypt Forests and Woodlands: Ecology, Conservation and Management.' (Eds A. Keast, H. F. Recher, H. Ford and D. Saunders.) pp. 129–135. (Surrey Beatty & Sons: Chipping Norton.)
- Recher, H. F. (1988). Counting terrestrial birds: use and application of census procedures in Australia. *Australian Zoology Reviews* 1: 25–45.
- Recher, H. F., Kavanagh, R. P., Shields, J. M. and Lind, P. (1991). Ecological association of habitats and bird species during the breeding season in south-eastern New South Wales. *Australian Journal of Ecology* 16: 337–352.
- Saunders, D. A. (1989). Changes in the avifauna of a region, district and remnant as result of fragmentation of native vegetation: the wheatbelt of Western Australia. A case study. *Biological Conservation* 50: 99–135.
- Shields, J. M., Kavanagh, R. P. and Rohan-Jones, W. G. (1985). Forest avifauna of the Upper Hastings River. In 'Birds of Eucalypt Forests and Woodlands: Ecology, Conservation and Management.' (Eds A. Keast, H. F. Recher, H. Ford and D. Saunders.) pp. 55–64. (Surrey Beatty & Sons: Chipping Norton.)
- Wiens, J. A. (1989). 'The Ecology of Bird Communities. Vol. 1. Foundations and Patterns.' (Cambridge University Press: Cambridge.)