

HABITAT USE AND ABUNDANCE OF DRYLAND BIRDS IN HERITAGE AREAS IN THE UPPER SOUTH EAST OF SOUTH AUSTRALIA

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ABSTRACT

Birds in 13 heritage areas in the Upper South East of S.A. were surveyed in the spring of 1994 using variable-strip transects and casual observations. There are no conservation parks in the surveyed region and its avifauna has not been well documented. This paper presents: details of the survey methods and its effectiveness; a full list of the species recorded; quantitative data on the habitat use and abundance of dryland birds in the region; a comparison with data from *The atlas of Australian birds*; and some discussion of the significance and future of the region's avifauna.

One hundred and twelve dryland bird species were recorded during the survey; and the inclusion of RAOU Atlas records takes the total dryland bird richness of the region to 139 species. This reflects the diversity of habitats in the region: dry sclerophyll woodland; mallee; heathland; and open savannah. Analysis by habitat shows that two habitats in the region, woodland (blue gum *Eucalyptus leucoxylon* plus blue gumpink gum *E. fasciculosa*) and heath, are particularly important. The woodland is important to 27 species with eight being highly dependent. The heath is important to 10 species with five being highly dependent including the Rufous Fieldwren *Calamanthus campestris* and the Mallee Emu-wren *Stipiturus mallee*; the former is considered rare and the latter threatened by extinction, in South Australia.

Abundance is expressed both as the probability of a species being recorded in one hectare of habitat in six minutes of observation time, and as the species sightings per hour. A probability greater than 6% is used to determine the characteristic species of the various habitats.

We believe that the study region, despite a high extant species richness, has lost a significant number of dryland bird species. In addition, species restricted to native vegetation are under threat because only a very small proportion of the original vegetation remains. There is an urgent need to determine species loss from small habitat fragments in this and other regions of S.A. This repeatable survey provides baseline data for a study of the long term trends in bird abundance in the region which will be needed to support conservation proposals.

INTRODUCTION

The Nature Conservation Society of S.A. (NCSA) conducted an ecological survey of

¹ Heritage areas (DENR nd) are blocks of native bushland under a *Heritage Agreement* which is a contract between a landholder and the State Government for the protection of a particular area of native vegetation. When a heritage agreement is placed over a block of bushland, it indicates that the main purpose of that land is the conservation of native animals and plants. The landholder retains ownership of the property, and there is no right of public access without landholder agreement.

heritage areas¹ in the Upper South East (USE) of S.A. during Aug.–Oct. 1994. The region covered is roughly bounded by Ngarkat Conservation Park in the north, the Bordertown–Keith road in the south-west and the S.A.–Victoria border in the east (see Figure 1). The primary purpose of the survey was to collect ecological data to assist with the development of management proposals for heritage areas in the region, particularly the use or prevention of fire. Field data were collected on birds, mammals, reptiles and vegetation on 13 privately owned heritage areas (hereafter usually termed "sites"). The area of these sites varies from about 30 ha to 1200 ha, the average being 330 ha. The survey was jointly organised by the NCSA and the South Australian Farmers Federation and funded by grants from Save the Bush and the National Estate Grants Program.

Little is known about the birds of the region, although data exist from Ngarkat Conservation Park (NCP) to the north (Hatch 1977; Close 1982) and the Bangham district to the south (Stokes 1997; Reid *et al.* 1985). Also, we suspected that *The atlas of Australian birds* (Blakers *et al.* 1984a), hereafter called the Atlas, did not cover the region fully because of the lack of conservation parks and limited public access to privately owned heritage areas and scrub blocks.

This paper presents:

1. A description of the transect method used during the survey and a discussion of its effectiveness.
2. Documentation of the avifauna of the region, firstly by listing the species recorded and secondly by characterising the bird populations of the key habitats through the calculation of abundance measures.
3. A comparison of bird observations from this survey with data listed in the Atlas for the study region.
4. A discussion of regional conservation issues, such as lost species, habitat fragmentation and key habitats, and arising from the data on dryland birds and how these issues affect the

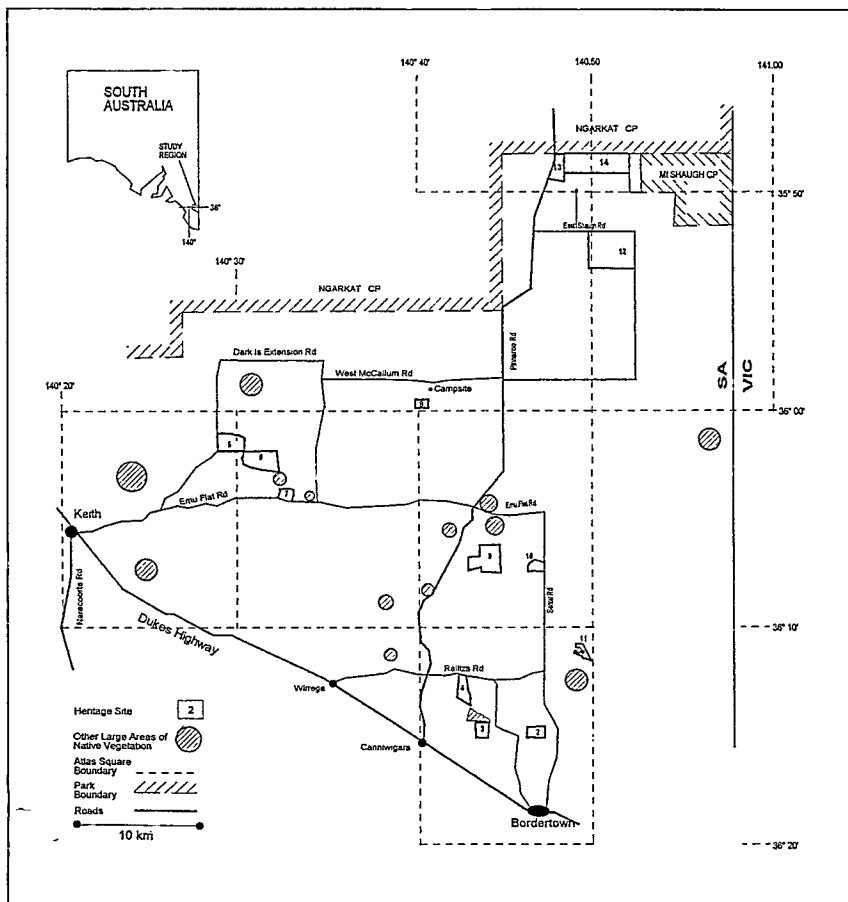


Figure 1. The study region.

formulation of management practices for heritage and other areas of natural habitat in the region.

Variable-strip transects (Emlen 1971; Franzreb 1980; Bell and Ferrier 1985) and casual observations were used to collect the bird data. The common names and the taxonomic order for birds used in this paper follow Christidis and Boles (1994). A more extensive report on this bird survey is published in Possingham and Possingham (in prep.) which provides a benchmark for measuring the success of future management of native habitats, as well as a baseline for studies of changes in bird abundance in this region.

METHODS

Thirty two 500 m transects were laid out in the 13 heritage sites, numbered 2 to 14 on Figure 1. Most transects were laid out in relatively uniform habitat similar to and near that used for the vegetation quadrats and fauna trap lines. Observations of the birds were recorded on pre-printed observer sheets while an observer walked along the transect in 30 minutes. Estimates of the number of each species seen utilising the habitat, the number heard, and the number flying through or over, were recorded using the codes 'u', 'h' and 'fo' respectively. An estimate of the perpendicular distance of each bird from the transect line was recorded; up to 50 m, birds were grouped into 10 m intervals, while more distant birds were grouped into 50–100 m and greater than 100 m categories. The transect was divided into 5 x 100 m sections with the observers required to spend six minutes in each section; flagging tape was used to mark the 100 m sections. Observers usually worked in pairs with the more experienced responsible for identification.

During the survey period, observations made outside the transects were termed 'casual' and coded 'c'. Some casual observations are from the heritage sites and others from roadsides, paddocks and towns. For these observations, the distance from the observer was not recorded, but map reference, vegetation type, patch size, date, time and bird numbers were recorded. Casual records were collected from 40 locations in addition to the heritage sites.

The collection, analysis and reporting of bird data were by voluntary labour; the authors, and 10 other observers listed in the Acknowledg-

ments, spent 69 observer-days on the survey totalling 180 observer-hours collecting data from the 32 transects. Overall, 259 transects were walked during the survey.

The data were keyed into a Microsoft ACCESS database, which contains 5355 species sightings totalling 10 579 birds. A copy of this database is available on a diskette supplied with the full report (Possingham and Possingham in prep.).

Problems associated with differing observer skills (Kavanagh and Recher 1983), as well as the requirement for observers to adhere to the survey procedure, precluded the validation of unusual species or the separation of difficult species pairs. Hence, observers were given specific instructions for recording certain species and there were some subsequent modifications to the basic data before processing. Specifically:

- When separation of species pairs was difficult under survey conditions, e.g. between Superb Fairy-wren *Malurus cyaneus* and Variegated Fairy-wren *M. lamberti*, the observers simply recorded Fairy-wren sp. The same procedure was used for Australian Raven *Corvus coronoides* and Little Raven *C. mellori*, Elegant Parrot *Neophema elegans* and Blue-winged Parrot *N. chrysostoma* and Little Corella *Cacatua sanguinea* and Long-billed Corella *C. tenuirostris*. Where this affects the analysis, the observations listed as sp. were allocated to one or other of the species in the proportion that those species recorded. When calculating species richness of a site or region, a sp. entry will increase the tally from one to two, but not from two to three.
- Because of identification difficulties, most observers recorded Brown Thornbill *Acanthiza pusilla* and Inland Thornbill *A. apicalis* as Brown Thornbill. Although some Inland Thornbill were recorded, all were changed to Brown Thornbill for the subsequent analysis. We suspect that the boundary between these two species occurs in the study region and there may well be overlap.
- The Chestnut-rumped Heathwren *Hylacola pyrrhopygia* may extend into the study region from the south, and therefore co-exist with the Shy Heathwren *H. cauta*. Although some Chestnut-rumped Heathwren were recorded, the records are doubtful; however many Shy Heathwren were identified so, for the analysis, all Heathwren records were changed to the latter species. This does not mean that the

authors believe that Chestnut-rumped Heathwren do not live in the study region.

- Although it is possible that the Spotted Pardalote *Pardalotus punctatus* may occur in the region, only a few birds were recorded under this name and these were unconfirmed. In general, observers recorded this bird as the Yellow-rumped sub-species. However, because of the uncertainty of the taxonomic status of these two, Spotted Pardalote is used in the analysis.
- Although observations of Tree Martin *Hirundo nigricans*, Welcome Swallow *H. neoxena*, White-browed Woodswallow *Artamus superciliosus*, and Masked Woodswallow *A. personatus* were invariably coded 'fo', these species were considered to be 'overhead foragers' and were re-coded as 'utilising' the habitat. Other records coded as 'fo', for species such as Common Starling *Sturnus vulgaris*, White-backed Magpie *Gymnorhina tibicen leuconota* and raptors, were considered to be 'overhead transients' and not associated with the habitat being surveyed.
- Some uncertain observations, i.e. Crimson Rosella *Platycercus elegans* and White-throated Treecreeper *Cormobates leucophaeus* were deleted from the analysis after discussion with the relevant observer. Both may well have been present.

RESULTS AND DISCUSSION

General

Table 1 lists the numbers of all bird species as recorded by the observers during the survey, and it shows that the region has a very high dryland bird species richness with 112 species being recorded. In addition, there were eight water birds and two uncertain observations, giving a total of 122 species for the survey. A comparison with species listed in the Atlas for the seven 10' squares (Blakers *et al.* 1984b) that contain the study sites, see Figure 1, shows that nearly 30 additional dryland bird species may occasionally occur there, confirming the high species richness. Ignoring wetlands and dams, habitat diversity is high and includes dry sclerophyll forest, woodland, mallee, heathland, grassland, and open country (see also Stokes 1997; Mowling and Barritt 1980; Reid *et al.* 1985).

The species list from the Atlas for the four 1° squares that contain the study sites (centred on

36°S, 141°E) is considerably larger than that for the seven 10' squares mentioned above; it extends the region by 50 to 100 km and adds a further 47 dryland species and 38 wetland species. Possingham and Possingham (in prep.) list these species. It also lists the numbers and species of birds recorded during the survey.

Comparison with Atlas

The following discussion refers to the species list from the Atlas for the seven 10' squares defined above. The most significant discrepancy between the study region and these Atlas squares is the extension of the two northern squares into NCP. Site 8 is considered to be in the same square as sites 9 and 10.

(a) Birds listed in the Atlas for this region, but not recorded during survey

One hundred and sixty-seven species are listed in the Atlas for these seven squares and, reducing this total by 34 water birds and waders, and one uncertain observation (Crimson Rosella) noted in the survey, leaves 132 dryland species. The 112 species recorded during the survey represents a surprisingly efficient effort considering the restricted area surveyed and the short survey time. The 27 species recorded in the Atlas, but not during the survey are noted in Table 1.

A number of reasons account for the additional species in the Atlas records; they are:

- The survey did not include any sites in NCP and those sites near NCP had relatively few visits. This accounted for seven of the additional species, noted with (a) in Table 1.
- The presence of 11 nomadic/migratory species (noted with (b) in Table 1) that were not recorded on the survey due to its timing in late winter/early spring.
- The presence of two species from the Atlas (noted with (c) in Table 1) that are considered rare or vagrant.

This leaves seven species (noted with (d) in Table 1): Swamp Harrier *Circus approximans*; Rainbow Lorikeet *Trichoglossus haematodus*; Mulga Parrot *Psephotus varius*; Barn Owl *Tyto alba*; Yellow Thornbill *Acanthiza nana*; Spotted Nightjar *Eurostopodus argus*; and Australian Owllet-nightjar *Aegotheles cristatus* that may have been expected but were not recorded during the survey. More extensive surveys might record these species.

Table 1. List of bird species from *The atlas of Australian birds* and survey as recorded by observers. A species listed in the Atlas is indicated by the number of 10' squares (out of 7) for which that species was recorded, and a species listed for the survey is indicated by the number of birds recorded from the 259 visits to the 32 transects and from the casual observations. Note:

1. Dryland species recorded in the Atlas but not on the survey are indicated by: (a) sites near NCP not well covered; (b) nomadic or migratory species; (c) rare or vagrant species; or (d) likely to occur but not observed.
2. * = non-dryland species.
3. Habitats where species were observed on-site: BG = blue gum; BPG = blue gum and pink gum; MA = mallee with or without broombush; SB = stringybark/banksia; LH = low heath; MX = mixed; NP = native pine; E = edge; A = agricultural savannah; and C = casual, i.e. observed off-site.
4. The following species were always recorded as the indicated sub-species: Australian Ringneck as Mallee Ringneck; and Australian Magpie as White-backed Magpie.

Species	Atlas	Survey	Habitat	Species	Atlas	Survey	Habitat
Emu	1	7	BG, SB, NP, C.	White-faced Heron	*	3	3 C.
<i>Dromaius novaehollandiae</i>				<i>Egretta novaehollandiae</i>			
Malleefowl	(a)	1	-	White-necked Heron	*	3	-
<i>Leipoa ocellata</i>				<i>Ardea pacifica</i>			
Stubble Quail	-	1	LH.	Nankeen Night Heron	*	1	-
<i>Coturnix pectoralis</i>				<i>Nycticorax caledonicus</i>			
Blue-billed Duck	*	1	-	Glossy Ibis	*	1	-
<i>Oxyura australis</i>				<i>Plegadis falcinellus</i>			
Musk Duck	*	1	-	Australian White Ibis	*	1	-
<i>Biziura lobata</i>				<i>Threskiomys molucca</i>			
Black Swan	*	1	-	Straw-necked Ibis	*	1	-
<i>Cygnus atratus</i>				<i>Threskiomys spinicollis</i>			
Australian Shelduck	*	3	11 BG.	Yellow-billed Spoonbill	*	2	1 C.
<i>Tadorna tadornoides</i>				<i>Platalea flavipes</i>			
Australian Wood Duck	*	1	107 C.	Black-shouldered Kite	4	14	MA, SB, LH, C.
<i>Chenonetta jubata</i>				<i>Elanus axillaris</i>			
Mallard	*	1	-	Whistling Kite	3	3	BG, C.
<i>Anas platyrhynchos</i>				<i>Haliastur sphenurus</i>			
Pacific Black Duck	*	-	5 C.	Spotted Harrier	1	7	SB, E, C.
<i>Anas superciliosa</i>				<i>Circus assimilis</i>			
Australasian Shoveler	*	1	-	Swamp Harrier	(d)	1	-
<i>Anas rhynchotis</i>				<i>Circus approximans</i>			
Grey Teal	*	5	-	Brown Goshawk	2	6	BG, BPG, MA, C.
<i>Anas gracilis</i>				<i>Accipiter fasciatus</i>			
Chestnut Teal	*	1	-	Collared Sparrowhawk	1	2	SB, C.
<i>Anas castanea</i>				<i>Accipiter cirrhocephalus</i>			
Pink-eared Duck	*	1	-	Wedge-tailed Eagle	3	15	MX, MA, SB, E, C.
<i>Malacorhynchus membranaceus</i>				<i>Aquila audax</i>			
Hardhead	*	1	-	Little Eagle	4	3	BPG, MA, E.
<i>Aythya australis</i>				<i>Hieraetus morphnoides</i>			
Australasian Grebe	*	2	-	Brown Falcon	5	15	BG, BPG, MA, SB, E, C.
<i>Tachybaptus novaehollandiae</i>				<i>Falco berigora</i>			
Hoary-headed Grebe	*	3	-	Australian Hobby	-	2	BG.
<i>Poliocephalus poliocephalus</i>				<i>Falco longipennis</i>			
Little Pied Cormorant	*	1	-	Peregrine Falcon	1	5	BG, MX, C.
<i>Phalacrocorax melanoleucus</i>				<i>Falco peregrinus</i>			
Pied Cormorant	*	1	-	Nankeen Kestrel	6	6	BG, LH, E.
<i>Phalacrocorax varius</i>				<i>Falco cuculoides</i>			
Little Black Cormorant	*	1	-	Dusky Moorhen	*	-	4 E, C.
<i>Phalacrocorax sulcirostris</i>				<i>Gallinula tenebrosa</i>			
Great Cormorant	*	1	-	Black-tailed Native-hen	2	108	C.
<i>Phalacrocorax carbo</i>				<i>Gallinula ventralis</i>			
Australian Pelican	*	1	1 C.	Eurasian Coot	*	2	-
<i>Pelecanus conspicillatus</i>				<i>Fulica atra</i>			

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Table 1 continued

Species	Atlas Survey	Habitat	Species	Atlas Survey	Habitat
Painted Button-quail <i>Turnix varia</i>	— 1	BG.	Red-rumped Parrot <i>Psephotus haematototus</i>	4 283	BG, BPG, MX, MA, SB, E, A, C.
Common Greenshank <i>Tringa nebularia</i>	* 1 — —		Mulga Parrot <i>Psephotus varius</i>	(d) 1 — —	
Bush Stone-curlew <i>Burhinus grallarius</i>	(c) 1 — —		Budgerigar <i>Melopsittacus undulatus</i>	(b) 1 — —	
Black-winged Stilt <i>Himantopus himantopus</i>	* 1 — —		Blue-winged Parrot <i>Neophema chrysostoma</i>	1 3	MA.
Red-capped Plover <i>Charadrius ruficapillus</i>	* 1 — —		Elegant Parrot <i>Neophema elegans</i>	— 2	MA, SB.
Black-fronted Dotterel <i>Elsayornis melanops</i>	* 2 — —		<i>Neophema sp.</i>	NA 2	SB
Red-kneed Dotterel <i>Erythronyx cinctus</i>	* 1 — —		Pallid Cuckoo <i>Cuculus pallidus</i>	4 12	BG, SB, E, C.
Banded Lapwing <i>Vanellus tricolor</i>	(b) 2 — —		Fan-tailed Cuckoo <i>Cacomantis flabelliformis</i>	1 5	BG, MA, SB, C.
Masked Lapwing <i>Vanellus miles</i>	* 6 13	C.	Horsfield's Bronze-Cuckoo <i>Chrysococcyx basalis</i>	2 41	BG, BPG, MA, SB, LH, C.
Silver Gull <i>Larus novaehollandiae</i>	* 2 — —		Shining Bronze-Cuckoo <i>Chrysococcyx lucidus</i>	(b) 1 — —	
Crested Tern <i>Sterna bergii</i>	* 7 — —		Southern Boobook <i>Ninox novaeseelandiae</i>	2 4	BG, BPG, MA, SB.
Rock Dove <i>Columba livia</i>	4 1	SB, C.	Barn Owl <i>Tyto alba</i>	(d) 1 — —	
Common Bronzewing <i>Phaps chalcoptera</i>	7 68	BG, BPG, MX, MA, SB, LH, E, A, C.	Tawny Frogmouth <i>Podargus strigoides</i>	3 2	C.
Brush Bronzewing <i>Phaps elegans</i>	(a) 2 — —		Spotted Nightjar <i>Eurostopodus argus</i>	(d) 1 — —	
Crested Pigeon <i>Ocyphaps lophotes</i>	7 43	MA, SB, E, A, C.	Australian Owlet-nightjar <i>Aegotheles cristatus</i>	(d) 3 — —	
Peaceful Dove <i>Geopelia striata</i>	2 4	C.	White-throated Needletail <i>Hirundopus caudacutus</i>	(b) 1 — —	
Yellow-tailed Black-Cockatoo <i>Calyptorhynchus funereus</i>	4 51	BG, BPG, MA, SB, C.	Laughing Kookaburra <i>Dacelo novaeguineae</i>	2 32	BG, MA, MX, E, C.
Galah <i>Cacatua roseicapilla</i>	7 518	BG, BPG, MX, MA, SB, LH, E, A, C.	Sacred Kingfisher <i>Tohiramphus sanctus</i>	(b) 2 — —	
Long-billed Corella <i>Cacatua tenuirostris</i>	2 54	BG, MX, MA, C.	Rainbow Bee-eater <i>Merops ornatus</i>	1 11	BG, MX.
Little Corella <i>Cacatua sanguinea</i>	2 3	MA, C.	White-throated Treecreeper <i>Comobates leucophaeus</i>	— 4	SB.
Sulphur-crested Cockatoo <i>Cacatua galerita</i>	3 55	BG, MX, MA, E, C.	Brown Treecreeper <i>Climacteris picumnus</i>	1 30	BG, BPG, MX.
Cockatiel <i>Nymphicus hollandicus</i>	(b) 2 — —		Superb Fairy-wren <i>Malurus cyaneus</i>	7 363	BG, BPG, MA, SB, LH, MX, E, A, C.
Rainbow Lorikeet <i>Trichoglossus haematodus</i>	(d) 1 — —		Splendid Fairy-wren <i>Malurus splendens</i>	(a) 2 — —	
Musk Lorikeet <i>Glossopsitta concinna</i>	3 120	BG, BPG, MA, SB, LH, E, C.	Variegated Fairy-wren <i>Malurus lamberti</i>	6 104	BG, MA, SB, LH, MX, E, C.
Purple-crowned Lorikeet <i>Glossopsitta porphyrocephala</i>	5 187	BPG, MX, MA, SB, LH, E, A, C.	Fairy Wren sp.	NA 224	
Crimson Rosella <i>Platycercus elegans</i>	1 2	SB.	Mallee Emu-wren <i>Stipiturus mallee</i>	2 4	LH.
Eastern Rosella <i>Platycercus eximius</i>	4 232	BG, BPG, MA, SB, E, A, C.	Striated Grasswren <i>Anytomis striata</i>	(a) 1 — —	
Australian Ringneck <i>Banardius zonarius</i>	7 177	BG, BPG, MX, MA, SB, E, A, C.	Spotted Pardalote <i>Pardalotus punctatus</i>	1 2	E.
Blue Bonnet <i>Northiella haematogaster</i>	(c) 1 — —		Spotted Pardalote (Yellow-rumped sub-species)	4 178	BG, BPG, MA, SB, MX, NP, E, A, C.

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Table 1 continued

Species	Atlas Survey	Habitat	Species	Atlas Survey	Habitat
Striated Pardalote	6 111	BG, BPG, MA, SB, MX, E, A, C.	White-fronted Honeyeater	4 10	MA, SB.
<i>Pardalotes striatus</i>			<i>Phylidonyris albifrons</i>		
Chestnut-rumped Heathwren	— 3	MA, SB, E.	Tawny-crowned Honeyeater	4 225	BPG, MA, SB, LH, NP, E, C.
<i>Hylacola pyrrhopygia</i>			<i>Phylidonyris melanops</i>		
Shy Heathwren	2 41	BPG, MA, SB, LH, NP, E, C.	Black Honeyeater	— 2	MA.
<i>Hylacola cauta</i>			<i>Certhionyx niger</i>		
Rufous Fieldwren	2 12	SB, LH.	White-fronted Chat	7 208	BPG, MA, SB, LH, E, C.
<i>Calamanthus fuliginosus</i>			<i>Ephianura albifrons</i>		
Weebill	7 242	BPG, MA, SB, MX, NP, E, A, C.	Jacky Winter	1 47	BG, BPG, MA, MX, E, A, C.
<i>Smicromis brevicastris</i>			<i>Microeca fascians</i>		
Brown Thornbill	1 39	BPG, MA, SB, NP, E, C.	Scarlet Robin	2 3	BG, E.
<i>Acanthiza pusilla</i>			<i>Petroica multicolor</i>		
Inland Thornbill	3 17	MA, SB, E, C.	Red-capped Robin	2 10	MA, SB, MX, A.
<i>Acanthiza apicalis</i>			<i>Petroica goodenovii</i>		
Chestnut-rumped Thornbill (a)	1 —	—	Hooded Robin	5 42	BG, BPG, SB, MX, E.
<i>Acanthiza uropygialis</i>			<i>Melanodryas cucullata</i>		
Buff-rumped Thornbill	4 64	BG, BPG, MA, SB, LH, NP, E, A, C.	Southern Scrub-robin	6 154	BG, MA, SB, MX, E, C.
<i>Acanthiza reguloides</i>			<i>Drymodes brunneopygia</i>		
Slender-billed Thornbill	1 2	MA.	White-browed Babbler	7 324	BG, BPG, MA, SB, LH, MX, E, A, C.
<i>Acanthiza iredalei</i>			<i>Pomatostomus superciliosus</i>		
Yellow-rumped Thornbill	7 294	BG, BPG, MA, SB, E, A, C.	Chestnut Quail-thrush (a)	1 —	
<i>Acanthiza chrysorrhoa</i>			<i>Cinlosoma castaneotus</i>		
Yellow Thornbill (d)	2 —	—	Varied Sitella	3 32	BPG, MA, SB, C.
<i>Acanthiza nana</i>			<i>Daphoenositta chrysoptera</i>		
Striated Thornbill	2 6	MA, A.	Crested Bellbird	3 2	MA.
<i>Acanthiza lineata</i>			<i>Oreocia gutturalis</i>		
Southern Whiteface	2 14	E, SB.	Red-lored Whistler (a)	3 —	—
<i>Aphelocephala leucopsis</i>			<i>Pachycephala rufogularis</i>		
Red Wattlebird	7 251	BG, BPG, MA, SB, LH, MX, E, A, C.	Golden Whistler	4 84	BG, BPG, MA, SB, MX, E, C.
<i>Anthochaera carunculata</i>			<i>Pachycephala pectoralis</i>		
Little Wattlebird	3 1	E.	Rufous Whistler	3 3	MA, SB.
<i>Anthochaera chrysoptera</i>			<i>Pachycephala rufiventris</i>		
Spiny-cheeked Honeyeater	7 102	BG, BPG, MA, SB, LH, MX, E, A, C.	Grey Shrike-thrush	7 170	BG, BPG, MA, SB, LH, MX, NP, E, A, C.
<i>Acanthagenys rufogularis</i>			<i>Colluricincla harmonica</i>		
Blue-faced Honeyeater	2 1	C.	Restless Flycatcher	2 13	BG, BPG, MA, E.
<i>Entonyzian cyanotis</i>			<i>Myiagra inquieta</i>		
Noisy Miner	5 210	BG, BPG, MA, SB, MX, E, A, C.	Maggie-lark	7 33	BG, MA, SB, MX, E, A, C.
<i>Manorina melanocephala</i>			<i>Grallina cyanoleuca</i>		
Yellow-throated Miner	3 8	BG, MA, A, C.	Grey Fantail	5 48	BG, BPG, MA, SB, MX, E, C.
<i>Manorina flavigula</i>			<i>Rhipidura fuliginosa</i>		
Yellow-faced Honeyeater (b)	1 —	—	Willie Wagtail	7 152	BG, BPG, MA, SB, LH, MX, E, A, C.
<i>Lichenostomus chrysops</i>			<i>Rhipidura leucophrys</i>		
Singing Honeyeater	4 14	MA, MX, E, C.	Black-faced Cuckoo-shrike	5 28	BG, BPG, MA, SB, LH, E, A, C.
<i>Lichenostomus virescens</i>			<i>Coracina novaehollandiae</i>		
White-eared Honeyeater	6 144	BG, BPG, MA, SB, MX, E, A, C.	White-winged Triller	2 5	A, C.
<i>Lichenostomus leucotis</i>			<i>Lalage sueurii</i>		
Purple-gaped Honeyeater	3 19	MA, SB, E.	White-breasted Woodswallow (b)	1 —	—
<i>Lichenostomus cratitius</i>			<i>Artamus leucorhynchus</i>		
Yellow-plumed Honeyeater	2 44	BG, MA, MX, E, A, C.	Masked Woodswallow	1 151	BG, BPG, MA, SB, C.
<i>Lichenostomus ornatus</i>			<i>Artamus personatus</i>		
White-plumed Honeyeater	2 121	BG, BPG, MX, E, C.	White-browed Woodswallow	5 427	BG, BPG, MA, SB, MX, E, C.
<i>Lichenostomus penicillatus</i>			<i>Artamus superciliosus</i>		
Brown-headed Honeyeater	6 275	BG, BPG, MA, SB, LH, MX, NP, E, A, C.	Black-faced Woodswallow (b)	1 —	—
<i>Melithreptus brevirostris</i>			<i>Artamus cinereus</i>		
White-naped Honeyeater	1 5	BG, MA.	Dusky Woodswallow	7 52	BG, BPG, MA, SB, LH, MX, E, C.
<i>Melithreptus lunatus</i>			<i>Artamus cyanopterus</i>		
New Holland Honeyeater	7 1400	BG, BPG, MA, SB, LH, MX, NP, E, C.	Grey Butcherbird	5 47	BPG, MA, SB, LH, A, C.
<i>Phylidonyris novaehollandiae</i>			<i>Cracticus torquatus</i>		

continues...

Table 1 continued

Species	Atlas Survey	Habitat	Species	Atlas Survey	Habitat
White-backed Magpie <i>Gymnorhina tibicen leuconota</i>	7 604	BG, BPG, MA, SB, LH, MX, E, A, C.	Mistletoebird <i>Dicaeum hirundinaceum</i>	— 3	BG, C.
Grey Currawong <i>Strepera versicolor</i>	5 125	BG, BPG, MA, SB, LH, MX, E, A, C.	White-backed Swallow <i>Cheramoeca leucosternus</i>	3 2	SB.
Australian Raven <i>Corvus coronoides</i>	6 50	BG, MA, SB, LH, MX, E, A.	Welcome Swallow <i>Hirundo neoxena</i>	7 43	BG, BPG, MA, SB, MX, E, C.
Little Raven <i>Corvus mellori</i>	3 208	BG, BPG, MA, SB, LH, MX, E, A, C.	Tree Martin <i>Hirundo nigricans</i>	4 127	BG, BPG, MA, SB, MX, E, C.
Raven sp.	NA 100		Fairy Martin <i>Hirundo ariel</i>	(b) 1 —	—
White-winged Chough <i>Corcorax melanorhamphos</i>	3 24	C.	Rufous Songlark <i>Cincloramphus mathewsi</i>	4 3	SB.
Skylark <i>Alauda arvensis</i>	4 14	MA, EB, LH, E.	Brown Songlark <i>Cincloramphus cruralis</i>	5 2	LH, E.
Richard's Pipit <i>Anthus novaeseelandiae</i>	7 36	BG, SB, LH, E, C.	Silvereye <i>Zosterops lateralis</i>	5 89	BG, MA, SB, LH, NP, E.
House Sparrow <i>Passer domesticus</i>	6 9	C.	Common Blackbird <i>Turdus merula</i>	3 12	MX
Zebra Finch <i>Taeniopygia guttata</i>	(b) 1 —	—	Common Starling <i>Sturnus vulgaris</i>	6 252	BG, BPG, MA, SB, LH, MX, E, A, C.
European Goldfinch <i>Carduelis chloris</i>	5 2	MA, E.			

(b) Birds not listed in the Atlas for this region, but recorded during the survey

The survey recorded only five species not recorded in the seven 10' Atlas squares, namely: Australian Hobby *Falco longipennis*; Stubble Quail *Coturnix pectoralis*; Painted Button-quail *Turnix varia*; Black Honeyeater *Certhionyx niger*; and Mistletoebird *Dicaeum hirundinaceum*. However analysis of the data for each square shows that for all seven Atlas squares the survey reported species not listed in the Atlas and in many cases the reporting rate was high. Reporting rate for the survey is defined as the proportion of 30 minute visits that resulted in a sighting.

- Survey data recorded an additional 33 and 28 species from two Atlas squares² 36°00'S, 140°40'E and 36°00'S, 140°30'E respectively, see Figure 1. Other squares recorded 16, 12, 10, 4 and 3 additional species.
- Survey data recorded *Neophena* sp., Fan-tailed Cuckoo *Cacomantis flabelliformis*, Red-capped Robin *Petroica goodenovii*, Brown Thornbill, Buff-rumped Thornbill *Acanthiza reguloides*, Yellow-plumed Honeyeater *Lichenostomus ornatus*, Tawny-crowned Honeyeater *Phylidonyris melanops*, and Masked Woodswallow *Artamus personatus* in three of the seven squares as additional species;

² Atlas 10' squares are identified by the latitude and longitude of the north western corner.

Horsfield's Bronze-Cuckoo *Chrysococcyx basalis* in four of the seven squares; and Sky Heathwren in five of the seven squares.

- Some of the survey reporting rates for these additional species were high. Species with high survey reporting rates were:
 - In Atlas square 36°00'S, 140°40'E, the rates were: Tree Martin, 0.14; Southern Scrub-robin *Drymodes brunneopygia*, 0.39; Golden Whistler *Pachycephala pectoralis*, 0.35; and Spotted Pardalote, 0.47.
 - In Atlas square 36°00'S, 140°30'E: Golden Whistler, 0.24; White-eared Honeyeater *Lichenostomus leucotis*, 0.57; Brown-headed Honeyeater *Melithreptus brevirostris*, 0.29; Spotted Pardalote, 0.49; and Grey Butcherbird *Cracticus torquatus*, 0.17
 - In Atlas square 36°10'S, 140°40'E: Jacky Winter *Microeca fascians*, 0.21; and Grey Currawong *Strepera versicolor*, 0.36.

The above indicates that the Atlas field work was not able to cover blocks of privately owned native vegetation in the region which harbour common species such as Southern Scrub-robin, Golden Whistler, White-eared Honeyeater, Brown-headed Honeyeater and Spotted Pardalote. It also may indicate that these species do not inhabit roadside vegetation. Jacky Winter, Spotted Pardalote and Grey Currawong are notable omissions from the Atlas square

Table 2. Dryland bird species of conservation significance recorded during the survey. Note: ¹ = listed by DENR (1993); ² = listed by Garnett (1992); NL = not listed as threatened in Australia by Garnett (1992); and # = restricted to intact native vegetation.

Bird Species	Status in S.A. ¹	Status in Australia ²	Comments
Malleefowl <i>Leipoa ocellata</i>	# Endangered	Vulnerable	Seen between sites 5 and 6 (pers. comm. by Mr Brokus, manager, site 5). Old reports exist for the study region but possibly now close to local extinction. Where birds or active mounds are found, fox control is recommended.
Peregrine Falcon <i>Falco peregrinus</i>	Vulnerable	NL	Nesting in site 4.
Painted Button-quail <i>Turnix varia</i>	# Vulnerable	NL	Flushed at site 3, this species probably still occurs throughout the area.
Yellow-tailed Black-Cockatoo <i>Calyptorhynchus funereus</i>	Vulnerable	NL	Mainly casual records away from sites; of the others, three only were perched in site 3.
Blue-winged Parrot <i>Neophema chrysostoma</i>	Vulnerable	NL	Neophemas were seen at sites 5, 8 and 13, and at six other spots in the study area.
Elegant Parrot <i>Neophema elegans</i>	Insufficiently known	NL	Both species were definitely recorded but we suspect most are Elegant Parrots.
Mallee Emu-wren <i>Stipiturus mallee</i>	# Endangered	Vulnerable	One pair at site 5 in low dwarf sheoak <i>Allocasuarina pusilla</i> heath. Full details to be reported elsewhere.
Spotted Pardalote (Yellow-rumped variant) <i>Pardalotus punctatus xanthopygus</i>	Vulnerable	NL	Recorded on many sites. The authors suggest that this species is not threatened.
Shy Heathwren <i>Hylacola cauta</i>	# Vulnerable	NL	Particularly common at sites 5, 7 and 10.
Rufous Fieldwren <i>Calamanthus campestris</i>	# Rare	NL	Only in heath at site 5 where it was recorded 10 times.
Slender-billed Thornbill <i>Acanthiza iredalei hedleyi</i>	# Vulnerable	Insufficiently known	One record from site 12, see Matthew (1994) for a summary of other records.
Blue-faced Honeyeater <i>Entomyzon cyanotis</i>	Rare	NL	One in Bordertown.
White-winged Chough <i>Corcorax melanorhamphos</i>	Vulnerable	NL	Casual observations in roadside vegetation only.

covering Bordertown.

Species of Conservation Significance

Those species of national or state conservation significance (Garnett 1992; DENR 1993 respectively) that were recorded during the survey are listed in Table 2. Conservation efforts should focus on these species, especially those that are nationally threatened, and their habitats.

Table 3 lists additional threatened dryland species which were not recorded during the survey, but which we consider may utilise the region. The basis for selecting these species is that they are listed for the South East of South Australia by either Garnett (1992) or DENR

(1993) and as well are listed by the Atlas as present in the four 1° squares covering the study region. This list would be a useful check-list for future surveys.

Other species, not listed in the Atlas for these four squares but listed as endangered in the South East by DENR (1993), are King Quail *Coturnix chinensis*, Square-tailed Kite *Lophoictinia isura*, White-bellied Sea-Eagle *Haliaeetus leucogaster*, Gang-gang Cockatoo *Callocephalon fimbriatum*, Rufous Bristlebird *Dasyornis broadbenti whitei*, Regent Honeyeater *Xanthomyza phrygia*, Olive Whistler *Pachycephala olivacea*, Satin Flycatcher *Myiagra cyanoleuca*, Olive-backed Oriole *Oriolus sagittatus*, and Bassian Thrush

Table 3. Other dryland bird species of conservation significance not recorded during the survey but which possibly utilise the study region. Note: ¹ = listed by DENR (1993); ² = listed by Garnett (1992); and NL = not listed as threatened in Australia by Garnett (1992).

Bird Species	Status in S.A. ¹	Status in Australia ²	Comments
Brown Quail <i>Coturnix ypsilophora</i>	Vulnerable	NL	Usually in moist areas.
Cape Barren Goose <i>Cereopsis novaehollandiae</i>	Vulnerable	NL	Usually in moist areas.
Letter-winged Kite <i>Elanus scriptus</i>	Rare	Of concern	Occasionally irrupts to the south east.
Brolga <i>Grus rubicunda</i>	Vulnerable	NL	Usually in moist areas.
Australian Bustard <i>Ardeotis australis</i>	Vulnerable	Of concern	Atlas has records to the east, north and south of the study region.
Bush Stone-curlew <i>Burhinus grallarius</i>	Endangered	Of concern	Apparently still occurs at Mundulla (pers. comm. by owner, Mr Killicoat). There are Atlas records from near Bordertown.
Red-tailed Black-Cockatoo <i>Calyptorhynchus banksii graptogyne</i>	Endangered	Endangered	Atlas has records to the south.
Major Mitchell's Cockatoo <i>Cacatua leadbeateri</i>	Vulnerable	Of concern	Atlas has records from NCP.
Little Lorikeet <i>Glossopsitta pusilla</i>	Vulnerable	NL	Atlas has records to the south.
Regent Parrot <i>Polytelis anthopeplus</i>	Vulnerable	Vulnerable	Atlas has records from NCP.
Swift Parrot <i>Lathamus discolor</i>	Vulnerable	Vulnerable	Atlas has records to the south and east.
Shining Bronze-Cuckoo <i>Chrysococcyx lucidus</i>	Rare	NL	Atlas has records to the south
Barking Owl <i>Ninox connivens</i>	Vulnerable	NL	Atlas has records to the south and east.
Striated Grasswren <i>Amytornis striatus</i>	Uncertain	Insufficiently known	Atlas has records from NCP.
Chestnut-rumped Heathwren <i>Hylacola pyrrhopygia</i>	Vulnerable	NL	Possibly at site 7, a record well north of other non-survey records in the region.
White-throated Gerygone <i>Gerygone olivacea</i>	Rare	NL	Atlas has records to the south and east.
Black-eared Miner <i>Manorina melanotis</i>	Endangered	Endangered	Atlas has records from NCP, but it is now unlikely to occur in the region.
Fuscous Honeyeater <i>Lichenostomus fuscus</i>	Rare	NL	Atlas has records to the south and east.
Black-chinned Honeyeater <i>Meliphreptus gularis</i>	Rare	NL	Occurs further south and may occur in woodland in the south of the study region.
Flame Robin <i>Petroica phoenicea</i>	Rare	NL	Atlas has records from all four 1° squares.
Eastern Yellow Robin <i>Eopsaltria australis</i>	Vulnerable	NL	Atlas has records to the south.
Grey-crowned Babbler <i>Pomatostomus temporalis</i>	Endangered	NL	Now probably extinct in S.A. May still visit Bangham area (Reid <i>et al.</i> 1985).
Western Whipbird <i>Psophodes nigrogularis</i>	Vulnerable	Vulnerable	Occurred here in the past (pers. comm.), now probably extinct in study area.
Chestnut Quail-thrush <i>Cinelosoma castanotus</i>	Vulnerable	NL	Atlas has records from NCP.

continues...

Table 3 continued

Bird Species	Status in S.A. ¹	Status in Australia ²	Comments
Crested Shrike-tit <i>Falcunculus frontatus</i>	Vulnerable	NL	Occurs further south and may occur in woodland in the south of the study region.
Red-lored Whistler <i>Pachycephala rufogularis</i>	Vulnerable	Vulnerable	Atlas has records from NCP.
Gilbert's Whistler <i>Pachycephala inornata</i>	Rare	NL	Atlas has records from all four 1° squares.
White-bellied Cuckoo-shrike <i>Coracina papuensis</i>	Vulnerable	NL	Atlas has records to the south.
Diamond Firetail <i>Stagonopleura guttata</i>	Vulnerable	NL	Possibly still occurs; seen several years ago near site 2 (pers. comm., Mr Killicoat, owner).
Beautiful Firetail <i>Stagonopleura bella</i>	Vulnerable	NL	Atlas has records to the south and west.
Golden-headed Cisticola <i>Cisticola exilis</i>	Rare	NL	Atlas has records to the south.

Zoothera lunulata.

When considering regional conservation issues, data are required on bird species that are mainly restricted to large blocks of relatively intact native vegetation and do not live in small fragments such as long narrow strips of roadside vegetation. The authors feel that the survey results indicate that a number of bird species are in this category and are regionally threatened, i.e. are already reduced to small populations. Those marked with # in Table 2 certainly meet these criteria; they are particularly vulnerable to habitat loss, habitat fragmentation, and/or destruction of entire blocks of vegetation, e.g. by a single fire. See Garnett (1992) for comments regarding fire and Mallee Emu-wren *Stipiturus mallee* (p. 128), Slender-billed Thornbill *Acanthiza iredalei* (p. 152) and Malleefowl *Leipoa ocellata* (p. 42). In addition, those in Table 4 are likely to meet these criteria and need further study, particularly of their ability to live in small fragments of native vegetation, and ability to repopulate.

Based on their ecology, abundance and distribution, the most threatened of these are: Malleefowl, Painted Button-quail *Turnix varia*; Crested Bellbird *Oreoica gutturalis*; Mallee Emu-wren; Rufous Fieldwren; and Brown Treecreeper *Climacteris picumnus*. The authors predict they are likely to become regionally extinct within the next 50 years and should be carefully monitored.

Analysis by Habitat

This section discusses the characteristic

avifauna of the different vegetation categories surveyed. The 32 transects were classified into 8 vegetation categories (habitats) based on the data from the NCSSA survey (NCSSA in prep.). The remainder of this section introduces the two measures of abundance we use to describe bird abundance.

All the records of dryland birds within 50 m of the 500 m transect lines (excluding birds flying over), totalling over 2000 species sightings, were analysed to give an estimate of the probability (expressed as a percentage) of recording a species in a hectare of that habitat in six minutes. An alternative measure of abundance is the number of sightings of each species while walking through

Table 4. Dryland bird species recorded on the survey that are largely restricted to intact native vegetation, may not live in roadside vegetation and are therefore vulnerable to local extinction.

Bird Species	Observed in this survey (no. of sites)
Brown Treecreeper	2
Brown Thornbill	4
Inland Thornbill	4
Southern Whiteface	2
Purple-gaped Honeyeater	4
Scarlet Robin	1
Red-capped Robin	5
Southern Scrub-robin	10
Crested Bellbird	2

the habitat in one hour. In calculating this latter measure all types of record from the transects, i.e. utilising the habitat (u), heard (h) and flying over (fo), were used.

The probability is computed from the number of 1 ha blocks within which a species was sighted divided by the number of 1 ha blocks visited. Each 100 m section of a transect defines a six minute visit to a 1 ha block when the records are restricted to sightings within 50 m of the transect line. The number of sightings per hour is computed from all records within 200 m of the transect line divided by the total observer hours. The above calculations are repeated for each habitat surveyed.

These measures of abundance are preferred when designing a survey to study changes because there are no special requirements on the nature of the data, i.e. quite simple rules are used to determine what data should be included. In brief, the method is easy to repeat. In contrast, estimates of density ideally require records that measure the (assumed) uniform distribution of birds in the habitat. However, bird detectability does decrease with distance from observer (see p. 158) and overcoming this difficulty, as well as sample size problems, is based on either a subjective decision about which data to include or one of a variety of transect estimators involving complex calculations (Burnham *et al.* 1980).

Within each of the following sub-sections (a-h) on habitat, a table lists those species which have a percentage probability greater than 6% of being recorded in one hectare in six minutes of observation or are highly dependent on that habitat. This percentage probability is the first number for a species. The second number is the sightings of the species while observing in the habitat for one hour. Species marked with an * are considered to be strongly dependent on the habitat in this region.

(a) Blue Gum Open Woodland (BG) - 2 transects, 15 visits, 50 spp.

This habitat is characterised by the highest apparent abundance of birds, particularly parrots. In terms of species richness and conservation value, this habitat rates very highly. Characteristic species are:

* Galah	31	5.0
Eastern Rosella	15	2.6

* Australian Ringneck	38	5.2
Red-rumped Parrot	16	2.2
* Laughing Kookaburra	7	1.0
* Brown Treecreeper	18	1.8
Superb Fairy-wren	42	2.2
Striated Pardalote	27	2.8
* White-plumed Honeyeater	47	6.6
New Holland Honeyeater	25	2.8
Jacky Winter	9	1.4
Hooded Robin	9	0.6
Southern Scrub-robin	20	2.0
* White-browed Babbler	25	3.4
Grey Shrike-thrush	15	1.8
Grey Fantail	11	1.0
Willie Wagtail	18	3.0
* White-browed Woodswallow	13	1.2
Australian Magpie	22	3.0
Tree Martin	13	1.6
Common Starling	16	2.0

(b) Blue Gum/Pink Gum Low Open Woodland (BPG) - 2 transects, 16 visits, 50 spp.

This habitat has lower trees and more understorey than the blue gum open woodland. The characteristic species are similar to those in the blue gum open woodland, but with the addition of some mallee species:

Galah	7	1.6
Eastern Rosella	8	1.2
Australian Ringneck	10	1.1
Red-rumped Parrot	17	2.0
Superb Fairy-wren	8	0.62
Spotted Pardalote	15	1.5
Striated Pardalote	18	1.6
* Weebill	33	2.8
White-eared Honeyeater	13	1.4
Brown-headed Honeyeater	8	0.76
New Holland Honeyeater	57	8.4
Hooded Robin	7	0.62
White-browed Babbler	8	0.88
Grey Shrike-thrush	10	1.0
Grey Fantail	8	0.62
Grey Currawong	12	1.1
Tree Martin	17	2.0
Common Starling	10	2.3

(c) Mallee with or without Broombush (MA) - 8 transects, 51 visits, 65 spp.

This is probably the dominant habitat of the study region and varied considerably from site to site with respect to tree and understorey species. The abundance of broombush *Melaleuca uncinata* and other large shrubs in the understorey appears to make a significant difference to the abundance

of many species. Characteristic species are:

Superb Fairy-wren	13	0.94
Spotted Pardalote	18	1.8
Weebill	26	2.7
Red Wattlebird	14	1.1
Spiny-cheeked Honeyeater	7	0.74
White-eared Honeyeater	20	2.5
New Holland Honeyeater	42	7.0
Tawny-crowned Honeyeater	15	2.1
Southern Scrub-robin	23	2.4
Golden Whistler	10	0.9
Grey Shrike-thrush	11	1.5

The Southern Scrub-robin is especially common where there is a well-developed shrub layer. Although the Purple-gaped Honeyeater *Lichenostomus ornatus* was not recorded at a high probability (5%), possibly because most of the mallee areas surveyed were small, it is considered to be very dependent on the one large mallee block, site 9, where it was most often recorded.

(d) Stringybark/Banksia Low Open Woodland (SB) – 6 transects, 41 visits, 49 spp.

This habitat occurs on sand ridges throughout the study area and varies in composition from sites that could be regarded as stringybark low woodland to some that are banksia heath. Characteristic species are:

Eastern Rosella	17	2.0
Superb Fairy-wren	10	0.58
Variiegated Fairy-wren	7	0.48
Shy Heathwren	7	0.58
Weebill	10	0.82
Red Wattlebird	15	2.04
Noisy Miner	9	1.2
New Holland Honeyeater	61	11.8
Tawny-crowned Honeyeater	18	2.0
Golden Whistler	8	0.78
Spotted Pardalote	10	0.98
Australian Magpie	8	1.76

The Heathwrens appear to prefer heath where there is more banksia.

(e) Low Heath (LH) – 2 transects, 12 visits, 33 spp.

Two transects of low heath dominated by dwarf sheoak *Allocasuarina pusilla* were used at site 5. They represent a distinct habitat for birds. Characteristic species are:

Horsfield's Bronze-Cuckoo	10	1.16
Superb Fairy-wren	10	0.5
* Variiegated Fairy-wren	14	0.84
* Shy Heathwren	14	1.34
* Rufous Fieldwren	12	1.26
New Holland Honeyeater	86	17.6
Tawny-crowned Honeyeater	34	4.2
Australian Magpie	10	0.5
Grey Butcherbird	12	1.8
Richard's Pipit	8	1.0

Four species are strongly dependent on this habitat, including the Mallee Emu-wren which was recorded only four times.

(f) Mixed Habitat (MX) – 2 transects, 14 visits, 46 spp.

Two transects contained a mixture of three habitats, namely mallee, stringybark and low open gum woodland. The characteristic species are a mixture of the those from the purer habitats:

Australian Ringneck	7	1.9
Superb Fairy-wren	25	1.3
Spotted Pardalote	11	1.1
Striated Pardalote	16	1.7
Weebill	18	1.9
Red Wattlebird	9	1.3
White-eared Honeyeater	20	1.9
White-plumed Honeyeater	16	2.4
New Holland Honeyeater	18	2.1
Southern Scrub-robin	27	2.6
White-browed Babbler	13	1.3
Golden Whistler	7	0.72
Grey Shrike-thrush	15	1.6
Grey Fantail	24	1.9
Willie Wagtail	9	1.0

(g) Edge Habitat (E) – 7 transects, 40 visits, 63 spp.

Six edge transects were surveyed. They bordered a variety of habitats so the bird assemblage is fairly mixed. Characteristic species of this habitat are listed below (# indicates those that could be at least as common on edges as in the natural habitat):

# Superb Fairy-wren	34	2.6
# Spotted Pardalote	15	1.4
Weebill	13	1.4
Yellow-rumped Thornbill	17	2.5
# Red Wattlebird	12	1.56
White-eared Honeyeater	10	1.1
White-plumed Honeyeater	7	0.66
New Holland Honeyeater	35	5.7

Southern Scrub-robin	12	1.4
White-browed Babbler	8	0.86
Golden Whistler	7	0.56
# Grey Shrike-thrush	17	1.56
# Willie Wagtail	20	2.36
# Australian Magpie	15	3.6
# Grey Currawong	8	1.0

broombush, stringybark/banksia and dense mallee formed by sites 5, 6 and 7 is valuable for the conservation significance and diversity of the 81 species recorded.

EFFECTIVENESS OF THE DATA COLLECTION METHOD

(h) Agricultural Savannah (A) – 2 transects, 10 visits, 33 spp.

Only two sites were surveyed in areas where there were scattered trees over grazed grassland. The purpose of surveying these sites was to gain some impression of which species tolerated the removal of the native understorey. Characteristic species of this habitat are listed below (# indicates those that could be at least as common in agricultural savannah as in the natural habitat):

Eastern Rosella	8	0.8
# Spotted Pardalote	15	1.4
# Weebill	25	2.4
# * Yellow-rumped Thornbill	28	4.0
# Red Wattlebird	8	2.0
# * Noisy Miner	28	4.2
# Brown-headed Honeyeater	8	1.0
White-browed Babbler	10	0.8
Grey Shrike-thrush	8	0.8
Willie Wagtail	8	1.0
# Grey Butcherbird	13	1.0
# Australian magpie	20	2.4
# Grey Currawong	8	1.2

Significant sites

Sites 3 and 4 (Figure 1) which both contain blue gum woodland *Eucalyptus leucoxylon*, are regionally important due to the high species richness (combined total of 77 species). Site 9 is a large block of dense mallee with a significant population of Purple-gaped Honeyeater and some Crested Bellbird (one heard). Crested Bellbird, Slender-billed Thornbill and Black Honeyeater *Certhionyx niger* were recorded at site 12, mallee heath, which almost certainly contains more species of significance but was not thoroughly surveyed; it is valuable for its size. Site 5 (mainly low heath) is regionally important in that it is possibly the only site in the survey region suitable for key heathland birds, like the Mallee Emu-wren and Rufous Fieldwren.

On a national basis, the most significant species recorded were the Mallee Emu-wren at site 5, the Malleefowl between sites 5 and 6 and the Slender-billed Thornbill site 12. The complex of native vegetation consisting of heath, mallee/

Recher *et al.* (1983); Shields *et al.* (1984) and Bell and Ferrier (1985) discuss a number of methods for determining bird densities, e.g. transect, point count, territory mapping, nest searching and mist-netting. Although the transect method in its various forms is judged to be the best available, there are various sources of variability in the data, e.g.:

- Observer variability (Kavanagh and Recher 1983).
- Bird detectability, which depends on: its activity (hence its movement); the nature of the terrain and vegetation; and distance from the observer. Bird activity, in turn, depends on the nature of the species, the time of day, the weather and the season (e.g. breeding).
- Transect design, i.e. transect length and width, and time of traverse; and the number of visits to the transects.

Depending on a number of factors, Recher *et al.* (1983) concluded that bird densities calculated using transect methods are sometimes in agreement with densities from colour banding data and sometimes up to 50% lower. However, most workers accept that, while transect methods are not suitable for determining absolute densities, they are suitable for relative density calculations, particularly if many of the factors, e.g. season and survey patch, are constant.

The items in the above list will introduce some level of variability into the results of surveys such as this, which are intended to obtain measures of abundance, so the survey conditions must be chosen to reduce this variability as much as possible. Only the variability from transect design and number of visits, is under precise control and its effect can be assessed using the species accumulation rate, i.e. the additional species recorded for an additional visit (Recher *et al.* 1983). The accumulation rate is obtained by plotting the cumulative species count against the number of visits for each vegetation type and calculating the slope of the curve. Table 5 gives the accumulation rates for two habitat groups, those with a relatively high number of visits and

Table 5. Species Accumulation Rates (AR). Of the eight habitat groups, five had a low number of visits and three a high number. Note: averages are italicised.

No. of Visits	No. of Habitat Groups	Total Species (species/visit)	Initial AR (species/visit)	Final AR
10 to 16, <i>13</i>	5	34 to 55, <i>43</i>	6 to 18, <i>11</i>	0.44 to 1.1, <i>0.83</i>
40 to 47, <i>43</i>	3	60 to 67, <i>63</i>	4 to 11, <i>7</i>	0.18 to 0.36, <i>0.27</i>

those with a low number. The data in the table show that the accumulation rate is high for the initial visits to a transect (up to 11 species per visit on average), and low for the final visits (down to less than 1 species per visit). This indicates that the survey design is satisfactory in that very few of the species present during the survey were missed.

CONCLUSIONS

If we are to manage bird populations we need to determine trends in abundance and distribution. Data from this survey have been obtained by an explicit and repeatable method that gives quantitative measures of bird abundance. The results provide benchmark data on the abundance of dryland birds that occur in blocks of native vegetation in the study region. The data provide a valuable link between that to the north from Ngarkat Conservation Park (Close 1982; Hatch 1977) and that to the south from the Bangham district (Reid *et al.* 1985). The prior lack of information from the study region can possibly be attributed to the lack of Conservation Parks and difficulty of access to privately owned native vegetation by bird watchers.

The analysis by habitat shows that two in the region are particularly important. They are the blue gum open woodland and blue gum/pink gum low open woodland formations, each with high species richness, (about 20 species each and 27 when combined). These woodlands also support eight bird species that are highly dependent on this habitat type. Another important habitat for the study region is the low heath which, while being important to only 10 species, has five that are highly dependent, including the Mallee Emu-wren and Rufous Fieldwren. The other five habitats have 10 to 15 species making use of each of them, with three species overall being highly dependent.

These data indicate the conservation signific-

ance of woodland and heath habitats for the avifauna of the region. However, it should be mentioned that a good number of the species dependent on blue gum woodland, such as the parrots and honeyeaters, are not threatened in S.A. (DENR 1993). In contrast, the Mallee Emu-wren and Rufous Fieldwren in the low heath are classed as threatened in S.A. There would be serious consequences if any of these key blocks of isolated habitat were devastated by a single fire; the vegetation would likely recover in time, but these isolated bird species would probably not.

Several species appear to have become locally extinct in the study region, or will soon be so. Many of these are ground nesters, or near ground nesters, i.e. Malleefowl, Chestnut Quail-thrush, Bush Stone-curlew and Painted Button-quail. Some of the lost species probably only occurred in woodland on the more fertile soils along the southern part of the region, e.g. Black-chinned Honeyeater, Grey-crowned Babbler, White-bellied Cuckoo-shrike and Little Lorikeet. Other regionally extinct species persist in larger tracts of mallee in NCP, e.g. Western Whipbird, Striated Grasswren and Red-lore Whistler. These species are unlikely to recover in the absence of broad-scale revegetation and/or predator control.

Of immediate concern are the species listed in Table 4. They now persist only in blocks of native vegetation and no single block may be sufficient to support a population that is viable in the long term, although some may be capable of surviving in roadside vegetation. In particular, we predict that some of these will be locally extinct in the next few decades. Because of being restricted to native vegetation, these species are particularly threatened by fires that completely burn a single block of scrub. The possibility of such fires needs to be minimised.

As most of South Australia's mallee habitat is fragmented, it is essential that we embark on some research that monitors the distribution and

abundance of species in these fragments. The main questions are:

- How fast are species being lost from the region?
- Do any species have the ability to recolonise blocks from which they are absent?
- Do Heritage Agreements improve the situation?

If future surveys record local extinctions in heritage areas, further conservation measures must be initiated. A paper by Ford and Howe (1980) on the decline of bird species in the Mount Lofty Ranges has a number of suggestions for minimising species loss. The alternative is that we will only be passive and uninformed observers of the gradual decline of our avifauna. This paper, together with Possingham and Possingham (in prep.), provide baseline data and lists of threatened and non-threatened species that should be targeted by future surveys. It is clear that interest and active support by the local landholders is the key to halting the decline in bird and other native species. Education and hence appreciation of the natural flora and fauna is a major factor in developing this support.

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REFERENCES

- Bell, H. L. and Ferrier, S. 1985. The reliability of estimates of density from transect counts. *Corella*, 9, 3-13.
- Blakers, M., Davies, S. J. J. F. and Reilly, P. N. 1984a. *The atlas of Australian birds*. RAOU and Melbourne University Press, Melbourne.
- Blakers, M., Davies, S. J. J. F. and Reilly, P. N. 1984b. Unpublished extract of 10' data for southern South Australia from *The atlas of Australian birds*. RAOU and Melbourne University Press, Melbourne.
- Burnham, H. L., Anderson, D. R. and Laake, J. L. 1980. *Estimation of density from line transect sampling of biological populations*. Wildlife Monograph 72, Published by the Wildlife Society.
- Christidis, L. and Boles, W. E. 1994. *The taxonomy and species of birds of Australia and its territories*. RAOU Monograph 2, Melbourne.
- Close, D. 1982. Birds of the ninety mile desert. In *The ninety mile desert of South Australia*. C. R. Harris, A. R. Reeves and D. C. Symon (eds). Nature Conservation Society of South Australia, Adelaide, pp. 81-86.
- DENR (nd). *Outline of the heritage agreement scheme for the conservation of native bushland*. Brochure, issued by the Department of Environment and Natural Resources, South Australia.
- DENR 1993. *Threatened Species Strategy for South Australia*. Draft Report prepared for the Minister of Environment and Natural Resources by the Threatened Species Strategy Steering Committee. November 1993.
- Emlen, J. T. 1971. Population densities of birds derived from transect counts. *Auk*, 88, 323-342.
- Ford, H. and Howe, R. 1980. The future of birds in the Mount Lofty Ranges. *South Australian Ornithologist*, 28, 85-89.
- Franzreb, K. E. 1980. The determination of avian densities using the variable-strip and fixed-width transect surveying methods. In *Estimating numbers of terrestrial birds*. C. J. Ralph and J. M. Scott (eds). Studies in Avian Biology No. 6. A publication of The Cooper Ornithological Society, pp. 139-145. More references are included in this document.
- Garnett, S. 1992. *Threatened and extinct birds of Australia*. RAOU Report 92. RAOU and Australian NPWS, Melbourne.
- Hatch, J. H. 1977. The Birds of Comet Bore (Ninety-mile Plain). *South Australian Ornithologist*, 23, 163-172.
- Kavanagh, R. and Recher, H. F. 1983. Effects of observer variability on the census of birds. *Corella*, 7, 93-99.
- Mathew, J. 1994. The status, distribution and habitat of the Slender-billed Thornbill, *Acanthiza irredalei*, in South Australia. *South Australian Ornithologist*, 32, 1-19.
- Mowling, F. A. and Barritt, M. K. 1980. *The natural vegetation of the South-East*. Nature Conservation Society of South Australia, Adelaide.
- NCSA (in prep.). *Upper South-East heritage vegetation and fire management study*. Nature Conservation Society of South Australia, Adelaide.
- Possingham, M. L. and Possingham, H. P. (in prep.). *Distribution and abundance of dryland birds in heritage blocks in the Upper South East of South Australia*. Nature Conservation Society of South Australia, Adelaide.
- Recher, H. F., Milledge, D. R., Smith, P. and Rohan-Jones, W. G. 1983. A transect method to count birds in eucalypt forest. *Corella*, 7, 49-53.
- Reid, J. R. W., Barritt, M. K. and Houston, C. 1985. *Birds and habitats of the Bangham district*. Nature Conservation Society of South Australia, Adelaide.
- SAOA 1996. List of English names and scientific names, recommended for use in papers submitted to the South Australian Ornithologist. *South Australian Ornithologist*, 32, pp. i-vii.
- Shields, J. M. and Recher, H. F. 1984. Breeding bird censuses: an evaluation of four methods for use in sclerophyll forest. *Corella*, 8, 29-41.
- Stokes, A. 1997. *Biological survey of box and buloke grassy woodland in the Upper South East of South Australia*. DENR, Adelaide.
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