

SPECIES RICHNESS AND ABUNDANCE OF BIRDS IN MT LOFTY RANGES GUM WOODLAND HABITAT: YEAR 2000 SURVEY

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ABSTRACT

As a part of the on-going bird survey of the Mt Lofty Ranges of South Australia we visited 61 sites in 46 patches of gum woodland in the spring and summer of year 2000. Each patch contained one or more 2-hectare sites that were visited for three 1-hour periods on different days. Each 1-hour visit was divided into three consecutive 20-minute sampling periods providing a total of nine samples for each site and 549 20-minute samples overall. This paper provides the data for the public record with some basic analysis and discussion.

Three lists summarise the data and categorise the records by species, site and sample. Overall, 98 species were recorded; this is 26 more than for the concurrent survey of the stringybark habitat (Possingham, Field and Possingham 2006). We calculate two measures of abundance for each species, probability of recording and density. Comparing the relative abundance of species from the two concurrent surveys, 22 show a preference for gum woodland and seven for stringybark.

Basic statistical analysis of the records predicts that there is a 90% probability that the average number of species recorded during a single 20-minute sample of a 2-ha site is 10.3–11.5. This is an estimate of species richness of the gum woodland habitat in the Mt Lofty Ranges. These figures contrast with 9.11–9.95 for the stringybark woodland. Aggregating the records from all nine 20-minute samples to form a 3-hour sample of 2-ha sites results in a species richness of 24.4–26.4 with 90% probability. The equivalent figures for stringybark are 20.3–22.5. These differences between gum and stringybark woodland are highly significant statistically and show that the gum woodland is more diverse.

We used the accumulation model presented in Possingham, Field and Possingham (2004) to obtain better estimates of total species richness in the habitat for the region. Supporting the previous paragraph, an analysis of the 20-minute visits gave an estimated 90% confidence interval for species richness for gum woodland of 79.6–83.3, being significantly greater than the equivalent results of 58.7–71.3 for stringybark woodland from Possingham *et al.* (2006). More samples may be needed, however, to explain the species richness of 122 obtained by analysing the 1-hour samples of gum woodland.

The accuracy of the relationship between probability of recording a species and its density has been improved by the inclusion of a flocking factor. This factor separates the species recorded during a 20-minute sample of a 2-ha site into three groups. These groups are defined by the number of birds recorded per visit being greater than four, between two and four, and less than two. The improvement is illustrated by the root-mean-square error reducing to 0.0072 compared with 0.934 when a flocking factor is not used.

Statistical analysis is used to show that observer, wind and site all had a significant effect on the number of species recorded. The changes are from 16.5 to 6.0 over the nine observers, from 11.6 to 7.3 caused by strong wind and, by between seven and eight over the 61 sites.

The basic data and this report are available from <www.ecology.uq.edu.au> and the authors.

INTRODUCTION

During spring and summer, year 2000, the second year of the long-term bird survey of the

Mt Lofty Ranges, we covered the stringybark and gum woodland habitats. This paper reports the results from a survey of the gum woodland habitat which consists of an upper-storey of mainly South Australian blue gum *Eucalyptus leucoxylon* and/or pink gum *E. fasciculosa* sometimes with a few long-leaf box *E. gonicalyx* and/or southern cypress pine *Callitris gracilis* and/or drooping sheoak *Allocasuarina verticillata*. A more or less sparse mid-storey mixture of acacia species, cup gum *E. cosmophylla*, native cherry *Exocarpos cupressiformis*, sweet bursaria *Bursaria spinosa*, hop-bush *Dodonaea viscosa* is over a mixed low shrub layer and grassy understorey. The report is similar in content to the previous two reports on surveys of stringybark woodland (Possingham, Field and Possingham 2004; Possingham, Field and Possingham 2006). Those two surveys were termed SB99–00 and SB00–01 respectively. This survey is referred to as the GUM00–01 survey and it uses the same design as the SB00–01 survey.

The results of this survey extend the baseline data from this series of yearly surveys of the Mt Lofty Ranges to cover the gum woodland habitat and provide a comparison with the stringybark habitat. In particular, this paper includes:

- (i) records, listed by species, giving the numbers of birds recorded and the number of times a species is sighted under various headings and listed by site, giving the species counts under another set of headings;
- (ii) a comparison of the records from this gum woodland survey with those from the previous and concurrent stringybark surveys;
- (iii) a continuation of the investigation of species accumulation plots across sites and visits as a means of estimating species richness; and
- (iv) for selected species, two estimates of bird abundance, i.e. the probability of recording a species and bird density in birds per hectare.

The Web version of the report contains an additional table of on-site, overhead-transient and off-site bird numbers for each species and for

each of the nine 20-minute samples of each site.

It is important to note that the data presented in this paper refer to a specific set of conditions, i.e. gum woodland in spring and early summer, particular observers and time-of-day, see Possingham and Possingham (1997) for discussion of these and other factors that affect bird observations.

METHODS

From early-November to mid-December 2000, nine observers visited 61 sites in 46 patches of gum woodland, see Figure 1. Birds were recorded for three 1-hour periods on different days, with each period consisting of three consecutive 20-minute periods in the five hours following sunrise. The 1-hour visits to each site are termed 'sessions', with each of the three consecutive 20-minute visits in a session termed a 'sample'.

Nine observers made the required 183 1-hour visits using an unstructured plan. The 1-hour visits to each site were, as far as possible, by different observers on different days. However, the three consecutive 20-minute samples to each site that comprised each 1-hour visit were by the same observer. The techniques for observing and recording on-site, overhead-transient and off-site

birds from each sample and the 'record sheet' were the same as reported in Possingham *et al.* (2004 and 2006) for the SB99-00 and SB00-01 surveys.

RESULTS AND ANALYSIS

The nine observers completed 549 record sheets and contributed 183 hours observation time plus much more travelling time. The observations resulted in 5,975 on-site, 3,646 off-site and 616 overhead-transient entries on the record sheets. All the analyses, except simple lists, ignore overhead-transient and off-site records. Most of the analysis is based on the presence-absence nature of the records, i.e. a species sighting during a sample, rather than the number of birds observed.

The number of on-site, overhead transient and off-site birds of each species that were observed and any breeding activity during each sample, together with other survey parameters, were entered into a *Microsoft Access 2000* database for analysis. Copies of this database in *Access 97* format and this report in *Word 97* format are available from the authors and from <www.ecology.uq.edu.au>.

Three tables summarise the records for all species from this survey for all nine samples of the 61 sites: Table 1 summarises the bird numbers by species and sample; Table 5 summarises the species counts by site and sample; and Table 1.1 in the Appendix describes a list of all the data on the record sheets in an *Excel* spreadsheet (only available from the Web version of this report).

Species lists

Table 1 summarises the records for all species from the nine samples of the 61 sites; scientific names for these species may be obtained from Christidis and Boles (1994); a copy of this information appears in SAOA (1996). The table shows the:

- (i) total number of birds for each species recorded on-site, off-site and as overhead-transients;
- (ii) number of birds for each of the nine samples;
- (iii) total number of sightings for each session and overall for all three sessions; and
- (iv) probability of recording on-site species, including for comparison the probability of recording on-site species from the SB00-01 survey.

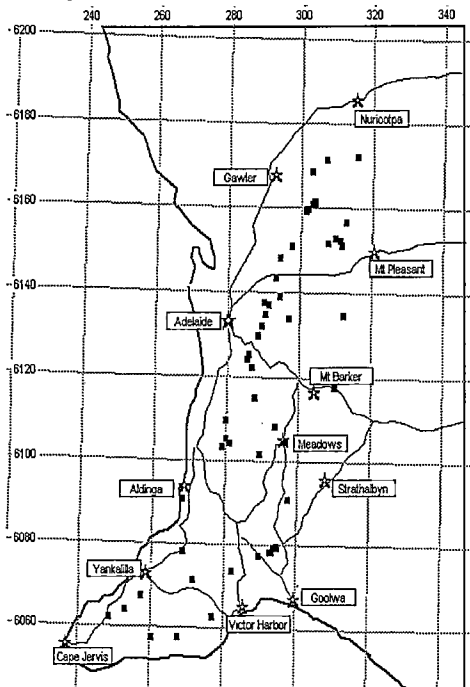


Figure 1. Gum woodland sites for the year 2000 survey (datum AGD66).

Note that in this table the Total Sightings for each session is the sum taken over the three samples. So, for each session, a species could be sighted a maximum of 183 times (61 sites x 3 samples) and 549 times for all three sessions (61 sites x 9 samples).

Overall, 98 species were recorded, 83 on-site, 45 overhead-transients and 85 off-site. This compares with 72, 62, 31 and 57 respectively for the concurrent SB00–01 survey of 48 stringybark sites using the same survey design.

Of the 98 species recorded overall, 15 were recorded as not occupying a site; seven of these (marked + in Table 1) were obviously associated with a nearby wetland or grassland. Another two (marked ++) could be classed as not being bush-birds, five (marked +++) are bush-birds that could have been recorded on-site, i.e. using a 2-ha site of the gum woodland habitat. The remaining one species (marked +++) could be considered as vagrant in this habitat although it was recorded in reasonable numbers (20 overhead-transients and 14 off-site). An additional two species, marked \$, although recorded as occupying a site, are wetland species and are not considered in any analysis. Seven introduced species were recorded; they are Rock Dove *Columba livia*, Spotted Turtle-Dove *Streptopelia chinensis*, House Sparrow *Passer domesticus*, Skylark *Alauda arvensis*, European Goldfinch *Carduelis carduelis*, Blackbird *Turdus merula* and Common Starling *Sturnus vulgaris*.

The probability of recording a species in a 2-ha site during a 20-minute sample, P_{re} (second last column of Table 1), has been computed directly from the number of sightings for each of the 75 species with records from Sample 1. It is computed from the total number of sightings for these 75 species divided by the total number of samples, i.e. 183. See the SB99–00 survey report for a discussion of the precision of P_{re} . These three samples are independent in that they are by different observers on different days and at different times past sunrise. Note that combining all on-site records from the nine samples gave a species count of eight more, i.e. 83.

On the basis of P_{re} , we divided 74 of these species (Grey Teal *Anas gracilis* omitted) into three groups: commonly recorded; uncommonly recorded; and rarely recorded. The three species marked # in Table 1 are commonly recorded in this habitat; during the 183 visits they were sighted more than 110 times, $P_{re} > 0.6$. At the other end of the scale, are the 48 species with

sightings less than 23, $P_{re} < 0.13$, that are rarely recorded, marked ### in Table 1. The 23 species marked ## are uncommonly recorded with sightings from 23 to 110. Seven additional species recorded on-site, marked ####, were not in those used to compute P_{re} as there are no records for Sample 1. Because of the lack of a P_{re} value these seven species are discussed below using the total number of on-site sightings.

Core species

Based on the criterion used to define core species for the SB00–01 survey, the 26 species marked # and ## in Table 1 are considered to be the core species in the gum woodland habitat; they have a P_{re} value greater than 0.13. This figure is similar to the 25 core species for the two previous stringybark woodland surveys combined.

Species in the Mt Lofty Ranges gum woodland habitat of conservation interest

The seven species mentioned above (####) were seldom recorded and in this habitat could be considered as vagrant (Cockatiel *Nymphicus hollandicus*) or very rare (Painted Button-quail *Turnix varia*, Black-chinned Honeyeater *Melithreptus gularis*, Jacky Winter *Microeca fascinans*, Diamond Firetail *Stagonopleura guttata*, Rufous Songlark *Cincloramphus mathewsi* (summer visitor) and Bassian Thrush *Zoothera lunulata*). At most they were sighted five times during the 549 20-minute samples. Combining these with 13 of the 48 species rarely recorded (###) that were recorded at most 29 times (nine species at most eight times) results in a list of 19 (ignoring Cockatiel) that are of conservation interest in gum woodland habitat, see Table 2. Most of these species, considered rare or very rare in the Mt Lofty Ranges gum woodland habitat, are wide-ranging and not endangered in Australia or South Australia. New (2000: 95–98) discusses how factors such as geographic restriction, ecological specialisation and abundance over normal range need to be considered in assessing rarity for conservation purposes. See also Garnett and Crowley (2000) for a more thorough method of determining conservation status.

Therefore the low abundance of most of these species in the Mt Lofty Ranges gum woodland habitat is of little national concern, but local interest in this habitat may warrant concern for these species. Comparing these with the 19

Table 1. All birds recorded on all samples of 61 gum woodland sites: year 2000 survey. The data given are for on-site records, except where denoted as overhead transients or off-site. Note that one sighting means that one or more single birds or several groups of birds were recorded during one single 20-minute sample of a 2-hectare site. The probability of recording a species P_{re} for the GUM00-01 survey is the total on-site sightings for the three independent samples (Sessions 1, 2 and 3, Sample 1) divided by the number of samples (i.e. $61 \times 3 = 183$). The total on-site sightings for these three visits are not given in this table, but can be obtained from $183 \times P_{re}$. The species marked #, ## and ### indicate species commonly, uncommonly and rarely recorded respectively; values of P_{re} equal to 0.60 and 0.13 are used for these divisions. Species marked ##### were not recorded in any of the three independent samples, so P_{re} is not computed. Species marked \$ are wetland on-site species and are ignored in the analyses. Of the 14 species recorded not occupying a site, seven (marked +) are waterbirds, two (++) could be classed as not bush-birds, and four (++++) are bush-birds that could have been recorded on-site. The remaining species (+++++) could be considered as vagrant in this habitat. Thirty-five records of bronzewing species and nine records of corella species have been deleted from this table.

Common name	Session 1				Session 2				Session 3				Totals				Probability of recording	
	Total sightings	Sample 1 birds	Sample 2 birds	Sample 3 birds	Total sightings	Sample 1 birds	Sample 2 birds	Sample 3 birds	Total sightings	Sample 1 birds	Sample 2 birds	Sample 3 birds	On-site sightings	On-site birds	Overhead birds	Off-site birds	GUM00-01	SB00-01
Emu	29	43	46	49	30	47	39	53	23	37	39	42	82	395	301	199	0.158	0.132
Australian Wood Duck	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Pacific Black Duck	+	-	-	-	-	-	-	-	-	-	-	-	-	-	1	20	-	-
Grey Teal	\$	-	-	-	-	-	-	-	3	3	3	3	3	9	10	2	0.005	-
Little Pied Cormorant	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Australian Pelican	+	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-
White-faced Heron	+	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
Straw-necked Ibis	+	-	-	-	-	-	-	-	-	-	-	-	-	6	6	1	-	-
Brown Goshawk	###	1	1	3	3	1	1	1	3	1	-	2	11	11	4	4	0.016	-
Collared Sparrowhawk	###	1	1	-	2	-	-	-	-	-	-	-	3	3	2	-	0.005	0.007
Wedge-tailed Eagle	++	-	-	-	-	-	-	-	-	-	-	-	1	1	4	5	-	0.007
Painted Button-quail	#####	-	-	1	-	-	-	-	-	-	-	1	1	1	1	1	-	0.007
Black-fronted Dotterel	\$	-	-	-	-	-	-	-	2	-	1	1	2	2	-	1	-	-
Masked Lapwing	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Rock Dove	++++	-	-	-	-	-	-	-	-	-	-	-	-	-	1	4	-	-
Spotted Turtle-Dove	###	-	-	-	-	-	-	-	2	2	-	-	2	2	-	3	0.011	-
Common Bronzewing	###	3	4	-	10	6	1	5	14	9	7	3	29	38	1	32	0.071	0.097
Brush Bronzewing	###	3	3	-	4	1	1	-	4	2	1	3	8	10	2	4	0.022	0.007
Crested Pigeon	###	1	1	-	2	2	1	-	2	1	-	1	5	6	1	-	0.005	-
Peaceful Dove	###	3	2	2	2	3	1	-	3	1	3	-	8	11	1	44	0.011	-
Yellow-tailed Black-Cockatoo	###	2	10	2	3	4	2	-	5	4	7	2	10	31	39	82	0.027	0.167
Galah	###	27	20	30	16	10	9	15	14	10	20	10	57	145	258	231	0.104	0.153
Little Corella	++++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
Sulphur-crested Cockatoo	###	2	-	1	1	-	-	-	2	2	-	-	4	4	24	95	0.011	0.125
Cockatiel	####	2	-	2	-	-	-	-	-	-	-	-	2	4	5	8	-	-
Rainbow Lorikeet	##	29	43	46	49	30	47	39	53	37	39	42	82	395	301	199	0.158	0.132

Musk Lorikeet	##	20	20	25	18	13	8	11	11	8	10	11	16	41	130	182	87	0.055	0.014
Purple-crowned Lorikeet	###	6	2	8	8	2	-	1	2	-	2	4	1	10	26	53	26	0.005	-
Crimson Rosella	#	119	158	144	136	103	125	118	129	107	116	121	135	329	1182	63	294	0.645	0.813
Eastern Rosella	###	4	4	2	5	2	2	-	1	-	-	-	-	6	14	-	1	0.011	-
Red-rumped Parrot	###	7	8	6	9	13	6	8	11	8	10	2	8	28	68	13	18	0.055	0.007
Budgerigar	++++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	14	-	-
Elegant Parrot	###	5	4	5	5	6	3	1	5	4	4	2	7	15	32	33	6	0.027	0.007
Fan-tailed Cuckoo	###	16	6	7	4	5	1	2	2	7	4	2	3	28	31	-	63	0.055	0.035
Horsfield's Bronze-Cuckoo	###	14	4	7	4	19	6	6	10	20	8	5	7	53	57	-	73	0.093	0.007
Shining Bronze-Cuckoo	###	2	-	1	1	3	2	-	-	5	2	2	1	10	10	-	33	0.022	0.035
Southern Boobook	###	3	-	3	2	-	-	-	-	1	1	-	-	4	6	-	-	0.005	-
Australian Owl-nightjar	###	3	1	1	1	-	-	-	-	-	-	-	-	3	3	1	-	0.005	-
Laughing Kookaburra	###	3	1	2	4	3	1	2	2	12	7	5	5	18	27	-	113	0.027	0.090
Sacred Kingfisher	###	9	2	6	4	11	5	3	4	13	6	5	7	33	42	-	53	0.055	0.063
Rainbow Bee-eater	###	-	-	-	-	4	2	2	1	1	1	-	-	5	6	-	10	0.011	-
White-throated Treecreeper	###	35	14	16	13	19	6	8	10	26	13	12	11	80	103	-	150	0.137	0.646
Brown Treecreeper	###	10	7	7	8	2	2	1	-	8	11	4	5	20	45	-	14	0.038	-
Superb Fairy-wren	#	138	228	261	254	138	225	243	234	130	209	219	234	406	2107	-	285	0.710	0.688
Spotted Pardalote	##	30	19	27	18	24	14	17	18	24	10	14	15	78	152	-	101	0.142	0.063
Striated Pardalote	#	132	138	139	139	137	152	154	175	137	174	170	185	406	1426	-	210	0.721	0.576
White-browed Scrubwren	##	35	27	28	23	28	18	22	26	22	21	23	17	85	205	-	42	0.142	0.438
Chestnut-rumped Heathwren	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.007	-
Weebill	###	20	21	18	15	16	13	15	7	8	9	6	5	44	109	-	67	0.082	-
Brown Thornbill	##	37	29	32	38	40	28	35	52	27	24	13	18	104	269	-	21	0.208	0.451
Buff-rumped Thornbill	###	54	52	49	65	43	39	53	65	42	69	49	63	139	504	-	34	0.224	0.097
Yellow-rumped Thornbill	###	1	2	-	-	1	1	-	-	7	4	8	16	9	31	-	6	0.016	-
Yellow Thornbill	###	13	14	7	19	16	25	20	13	6	2	8	2	35	110	-	2	0.066	-
Striated Thornbill	##	96	137	146	163	85	121	103	133	71	116	127	96	252	1142	-	61	0.437	0.667
Red Wattlebird	##	65	57	65	46	75	59	61	70	70	43	54	51	210	506	42	287	0.404	0.278
Little Wattlebird	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Noisy Miner	###	-	-	-	-	1	3	-	-	-	-	-	-	1	3	-	21	0.005	-
Yellow-faced Honeyeater	##	98	86	95	84	105	106	109	110	100	86	98	104	303	878	22	245	0.530	0.451
White-plumed Honeyeater	###	16	10	14	18	14	8	13	15	15	13	14	19	45	124	-	23	0.082	-
Black-chinned Honeyeater	###	2	-	4	4	-	-	-	-	-	-	-	-	2	8	-	4	-	-
Brown-headed Honeyeater	###	19	26	34	19	23	13	24	21	12	11	7	9	54	164	10	25	0.098	0.014
White-naped Honeyeater	##	43	34	47	47	32	25	34	40	36	33	27	33	111	320	21	94	0.197	0.056
Crescent Honeyeater	##	92	93	91	97	88	63	73	73	80	62	68	60	260	680	-	130	0.454	0.333
New Holland Honeyeater	##	94	160	174	161	91	106	124	145	79	91	105	102	264	1168	8	93	0.481	0.042
Eastern Spinebill	##	82	61	57	66	66	36	36	39	79	64	51	54	227	464	-	133	0.432	0.146
Jacky Winter	####	-	-	-	-	-	-	-	-	2	-	1	1	2	2	-	3	-	-
Scarlet Robin	###	8	6	4	4	12	4	4	7	9	5	4	7	29	45	-	18	0.044	0.215
Red-capped Robin	###	-	-	-	-	-	-	-	-	1	1	-	-	1	1	-	-	0.005	-
Hooded Robin	###	-	-	-	-	3	2	2	1	-	-	-	-	3	5	-	3	0.005	-
White-browed Babbler	###	13	14	21	11	9	4	11	13	4	2	6	2	26	84	-	48	0.033	-
Varied Sittella	###	14	14	12	16	12	8	11	22	8	14	7	3	34	107	4	5	0.055	0.049
Crested Shrike-tit	###	1	1	-	-	-	-	-	-	3	1	1	1	4	4	-	8	0.011	-
Golden Whistler	#	59	26	19	28	61	35	30	25	66	21	31	36	186	251	-	136	0.328	0.313

continues...

Table 1 (continued)

Common name	Session 1				Session 2				Session 3				Totals				Probability of recording	
	Total sightings	Sample 1 birds	Sample 2 birds	Sample 3 birds	Total sightings	Sample 1 birds	Sample 2 birds	Sample 3 birds	Total sightings	Sample 1 birds	Sample 2 birds	Sample 3 birds	On-site sightings	On-site birds	Overhead birds	Off-site birds	GUM00-01	SB00-01
Rufous Whistler	##	10	15	12	25	8	10	12	41	18	22	19	87	126	-	109	0.137	0.035
Grey Shrike-thrush	##	26	16	22	80	31	35	41	79	34	32	28	208	265	5	343	0.404	0.299
Magpie-lark	###	-	-	-	-	-	-	-	2	2	-	-	2	2	2	48	0.011	0.007
Grey Fantail	##	61	71	58	114	67	73	76	98	62	67	72	320	607	-	217	0.585	0.667
Willie Wagtail	###	2	2	3	9	3	7	4	6	3	2	2	19	28	-	15	0.033	0.014
Black-faced Cuckoo-shrike	###	6	5	7	14	6	6	4	15	6	4	6	46	50	26	58	0.093	0.049
White-winged Triller	###	-	1	2	5	2	3	3	3	2	-	2	11	15	-	3	0.011	-
Dusky Woodswallow	###	4	3	9	8	7	6	3	5	6	4	4	21	46	1	9	0.038	0.014
Australian Magpie	##	9	5	7	25	16	15	18	27	24	15	9	66	118	19	417	0.148	0.118
Grey Currawong	##	25	27	21	36	15	22	18	49	20	22	24	133	194	57	288	0.251	0.194
Little Raven	###	12	12	2	22	17	6	12	15	14	5	5	56	85	93	322	0.126	0.028
White-winged Chough	###	2	2	2	3	6	5	8	2	12	-	-	8	37	-	36	0.022	-
Skylark	++	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-
House Sparrow	+++	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-
Red-browed Finch	###	12	22	13	16	20	22	25	14	12	18	39	51	183	-	14	0.082	0.069
Diamond Firetail	###	-	-	1	2	-	1	3	2	-	3	2	5	10	-	7	-	-
European Goldfinch	###	5	4	8	5	2	7	3	1	-	1	1	13	30	36	15	0.016	0.014
Mistletoebird	##	27	32	42	87	61	53	64	67	33	39	34	214	385	4	81	0.372	-
Welcome Swallow	###	-	-	-	2	1	-	2	-	-	-	-	2	3	-	15	0.005	-
Tree Martin	##	81	75	77	50	78	109	94	46	101	111	102	141	828	11	24	0.268	0.007
Rufous Songlark	####	-	-	-	-	-	-	-	2	-	1	1	2	2	-	-	-	-
Brown Songlark	###	59	54	38	45	32	26	43	41	32	30	40	147	354	31	112	0.005	0.333
Silvereye	###	-	-	-	-	-	-	-	3	-	1	4	3	5	-	-	0.251	0.007
Bassian Thrush	####	25	26	28	42	24	19	26	40	18	15	21	139	202	5	128	0.268	0.285
Common Blackbird	##	12	19	18	11	8	13	7	7	4	4	12	35	97	61	41	0.055	0.083
Common Starling	###	17	12	19	11	8	13	7	7	4	4	12	35	97	61	41	0.055	0.083
Species counts	Totals 98	70	62	62	68	63	62	60	73	65	62	64	83	83	45	85	75	55

Table 2. Rare species ($P_{re} < 0.13$) and the seven very rare (#### in Table 1) of possible interest in Mt Lofty Ranges gum woodland habitat. The number of sightings data are from the nine 20-minute samples (the maximum is 549). Diurnal and nocturnal birds of prey and wetland birds are ignored. National status: NT = Near Threatened (Garnett and Crowley 2000). Mt Lofty Ranges status: V = Vulnerable (Carpenter and Reid 2000).

Common name	Number of sightings	National status	Mt Lofty Ranges status	Sites where recorded (see Table 5 for site names and coordinates)
Painted Button-quail	1	NT	V	54811.
Peaceful Dove	8	–	V	50901, 51101, 52201, 52301, 52701, 54810, 54812.
Eastern Rosella	6	–	–	51201, 52301.
Rainbow Bee-eater	5	–	–	50901, 51101.
Brown Treecreeper	20	–	–	15201, 15202, 15204, 15205.
Yellow Thornbill	35	–	–	50901, 51101, 52401, 54802, 54803, 54805, 54808, 54810, 54811.
Black-chinned Honeyeater	2	NT	V	15205.
Jacky Winter	2	–	V	15202.
Scarlet Robin	29	–	–	15201, 15202, 22201, 52001, 52901, and 9 sites from 54802 to 54812, inclusive.
Red-capped Robin	1	–	–	50901.
Hooded Robin	3	–	V	52701.
White-browed Babbler	26	–	–	15202, 15204, 15205, 50901, 51101, 52701, 52901, 53301, 54701, 54803, 54811.
Crested Shrike-tit	4	–	V	51101, 52501.
White-winged Triller	11	–	–	50202, 50901, 51101, 51301, 52501, 54801, 54809.
White-winged Chough	8	–	V	54804, 54805, 54806.
Diamond Firetail	5	NT	V	51101.
Rufous Songlark	2	–	–	52501.
Brown Songlark	2	–	–	50201.
Bassian Thrush	3	NT	V	50501, 52801.

listed for the Mt Lofty Ranges stringybark habitat in the SB00–01 survey (see Table 3 in Possingham *et al.* 2006) results in at least 36 species of conservation interest in the Mt Lofty Ranges (with Painted Button-quail and Bassian Thrush common to both lists). Monitoring the abundance of these 36+ species for any change may be justified.

Comparison of gum woodland and stringybark species lists

There were 51 species recorded on-site in both gum and stringybark woodland habitats in the year 2000 survey. Using the ratio of P_{re} values greater than 2.0 as the criterion, Table 3 separates those more likely in the two habitats. The top section lists 16 species characteristic of gum woodland and the bottom section, seven species

characteristic of stringybark woodland. The 27 species in the middle are at a similar abundance in both habitats. As one might expect the 16 of the 27 species with similar abundance in both habitats are core species in one or the other habitat, the other 11 being rare in both habitats.

Table 4 gives bird numbers for 30 more species for which P_{re} is not available for both surveys. The figures show that all the stringybark species are very rare (less than five records for the 432 samples) and most of gum species were rare (less than 12 records for the 549 samples). These figures are too small to form conclusions about species preferences for either habitat. However, the remaining six species Brown Treecreeper *Climacteris picumnus*, Weebill *Smicrornis brevirostris*, Yellow Thornbill *Acanthiza nana*, White-plumed Honeyeater *Lichenostomus*

Table 3. Comparison of the probability of recording a species, P_{re} , in both gum and stringybark woodland: year 2000 survey.

Common name	P_{re} for SB (48 sites)		P_{re} for GUM (61 Sites)		Ratio GUM/SB	Ratio GUM/SB	Ratio SB/GUM
Tree Martin	###	0.007	##	0.268	38.6		
Horsfield's Bronze-Cuckoo	###	0.007	###	0.093	13.4		
New Holland Honeyeater	###	0.042	##	0.481	11.5		
Red-rumped Parrot	###	0.007	###	0.055	7.9		
Brown-headed Honeyeater	###	0.014	###	0.098	7.1		
Little Raven	###	0.028	###	0.126	4.5		
Rufous Whistler	###	0.035	##	0.137	3.9		
Elegant Parrot	###	0.007	###	0.027	3.9		
Musk Lorikeet	###	0.014	###	0.055	3.9		
White-naped Honeyeater	###	0.056	##	0.197	3.5		
Brush Bronzewing	###	0.007	###	0.022	3.1		
Eastern Spinebill	##	0.146	##	0.432	3.0		
Dusky Woodswallow	###	0.014	###	0.038	2.8		
Willie Wagtail	###	0.014	###	0.033	2.4		
Buff-rumped Thornbill	###	0.097	##	0.224	2.3		
Spotted Pardalote	###	0.063	##	0.142	2.3		
Black-faced Cuckoo-shrike	###	0.049	###	0.093		1.9	
Magpie-lark	###	0.007	###	0.011		1.6	
Fan-tailed Cuckoo	###	0.035	###	0.055		1.6	
Red Wattlebird	##	0.278	##	0.404		1.5	
Crescent Honeyeater	##	0.333	##	0.454		1.4	
Grey Shrike-thrush	##	0.299	##	0.404		1.4	
Grey Currawong	##	0.194	##	0.251		1.3	
Striated Pardalote	##	0.576	#	0.721		1.3	
Australian Magpie	###	0.118	##	0.148		1.2	
Rainbow Lorikeet	##	0.132	##	0.158		1.2	
European Goldfinch	###	0.014	###	0.016		1.2	
Red-browed Finch	###	0.069	###	0.082		1.2	
Yellow-faced Honeyeater	##	0.451	##	0.530		1.2	
Varied Sittella	###	0.049	###	0.055		1.1	
Golden Whistler	##	0.313	##	0.328		1.0	
Superb Fairy-wren	#	0.688	#	0.710		1.0	
Common Blackbird	##	0.285	##	0.268		0.9	
Grey Fantail	#	0.667	##	0.585		0.9	
Sacred Kingfisher	###	0.063	###	0.055		0.9	
Crimson Rosella	#	0.813	#	0.645		0.8	
Collared Sparrowhawk	###	0.007	###	0.005		0.8	
Silvereye	##	0.333	##	0.251		0.8	
Common Bronzewing	###	0.097	###	0.071		0.7	
Galah	##	0.153	###	0.104		0.7	
Striated Thornbill	#	0.667	##	0.437		0.7	
Common Starling	###	0.083	###	0.055		0.7	
Shining Bronze-Cuckoo	###	0.035	###	0.022		0.6	
Brown Thornbill	##	0.451	##	0.208			2.2
White-browed Scrubwren	##	0.438	##	0.142			3.1
Laughing Kookaburra	###	0.090	###	0.027			3.3
White-throated Treecreeper	#	0.646	##	0.137			4.7
Scarlet Robin	##	0.215	###	0.044			4.9
Yellow-tailed Black-Cockatoo	##	0.167	###	0.027			6.1
Sulphur-crested Cockatoo	##	0.125	###	0.011			11.4

penicillatus, White-browed Babbler *Pomatostomus superciliosus* and Mistletoebird *Dicaeum hirundinaceum* show preference for gum woodland. This adds to the 16 species listed in Table 3, bringing the total to 22 preferring gum woodland.

Species richness from site lists

Table 5 shows how the number of species recorded for several combinations of the nine samples of 20-minutes vary in space (different sites) and time (different samples). The following analysis concerns the on-site species only. As for the SB99-00 and SB00-01 surveys, a single 20-minute sample of a single 2-ha site is not sufficient

to obtain an adequate measure of species richness (estimated by species count) of the avifauna of this habitat. The species count for a single 20-sample varies from one (Site 50801, Session 2, Sample 1) to 23 (Site 15205, Session 1 Sample 2). Figure 2 shows the distribution of species count over the 549 samples of 20 minutes. Increasing the species count to the total given over the nine samples offers little improvement as estimates of species richness, e.g. Scott Conservation Park (Site Numbers 15204 and 15205) and Altona (Site 51101) gave the highest count of on-site species with 37. Mosquito Hill Road (Site 52901) and Montacute Road (Site 51501) gave the least with 18 and three others

Table 4. Bird numbers of on-site species not covered in Table 2 because P_{re} was unavailable for both surveys. Records of two on-site wetland species, three birds of prey and three nocturnal birds are omitted (the method used for this survey is not suitable for nocturnal birds). The bird numbers listed are from all nine samples of all sites.

Common name	Recorded on GUM00-01 survey (549 samples)	Recorded on SB00-01 survey (432 samples)
Painted Button-quail	1	1
Spotted Turtle-Dove	2	—
Crested Pigeon	5	—
Peaceful Dove	8	—
Cockatiel	2	—
Purple-crowned Lorikeet	10	—
Eastern Rosella	6	1
Rainbow Bee-eater	5	—
Brown Treecreeper	20	—
Chestnut-rumped Heathwren	—	4
Weebill	44	—
Yellow-rumped Thornbill	9	—
Yellow Thornbill	35	—
Little Wattlebird	—	1
Noisy Miner	1	—
Black-chinned Honeyeater	2	—
White-plumed Honeyeater	45	1
Jacky Winter	2	—
Red-capped Robin	1	—
Hooded Robin	3	—
White-browed Babbler	26	—
Crested Shrike-tit	4	2
White-winged Triller	11	—
White-winged Chough	8	—
Diamond Firetail	5	—
Mistletoebird	214	2
Welcome Swallow	2	2
Rufous Songlark	2	—
Brown Songlark	2	—
Bassian Thrush	3	3

Table 5 Species Counts for all samples of all 61 gum woodland sites: Year 2000 survey. OHT = Overhead Transient. CP = Conservation Park. HA = Heritage Agreement. RP = Recreation Park.

Site number and name	Patch data		Session 1			Session 2			Session 3			All Sample 1 (3)		All nine samples							
	Site coordinates AGD66		Sample			Sample			Sample			Average	Total	Average	On-site	Off-site					
	North	East	1	2	3	Total	1	2	3	Total	1	2	3	Average	On-site	Off-site					
15201	6078930	294210	25	21	20	19	25	17	14	17	21	17	10	15	19.0	28	16.9	32	11	36	
15202	6079200	294775	20	17	14	14	18	16	13	7	7	25	20	18	20	17.7	27	15.4	33	6	14
15203	6078950	294875	17	10	14	13	12	10	8	10	15	10	10	11	10.0	14	10.7	21	9	24	
15204	6077600	293025	26	19	20	20	21	17	14	16	24	20	15	18	18.7	31	17.7	37	5	16	
15205	6077600	293600	29	17	23	22	17	14	15	15	24	18	19	17	16.3	28	17.8	37	8	29	
22201	6152430	309920	20	13	11	14	18	13	11	12	18	12	12	16	12.7	21	12.7	29	3	20	
50001	6147785	294701	20	11	16	11	21	16	15	13	13	10	9	11	12.3	21	12.7	29	10	30	
50101	6133620	297480	13	7	11	8	21	13	15	17	23	16	16	18	12.0	23	13.4	29	5	26	
50201	6134120	312490	17	12	9	12	23	16	19	18	18	16	13	11	14.7	27	14.0	31	12	29	
50301	6150320	297960	13	10	10	9	16	12	8	7	12	8	9	11	10.0	18	9.33	23	4	26	
50501	6151970	311400	10	8	6	7	7	5	6	7	7	15	7	10	6.67	13	7.56	19	3	14	
50601	6150830	304580	13	10	10	8	8	5	5	5	13	6	7	11	7.00	13	7.44	20	6	27	
50701	6150890	311960	13	11	10	11	17	8	9	10	16	13	9	9	10.7	20	10.0	22	18	18	
50801	6151410	308020	12	6	8	11	5	1	3	4	15	9	10	8	5.33	12	6.67	19	5	14	
50901	6168080	303440	19	13	14	13	20	10	16	14	18	9	13	11	10.7	19	12.6	30	3	31	
51001	6156350	313180	16	8	11	14	12	8	11	8	19	16	15	13	10.7	18	11.6	23	2	29	
51101	6170950	307400	26	13	18	19	26	16	18	17	17	14	12	13	14.3	25	15.6	37	5	36	
51201	6125130	286450	15	11	9	11	14	7	8	12	10	8	9	8	8.67	15	9.22	23	8	27	
51301	6134360	290900	19	15	16	13	11	8	9	10	20	15	13	13	12.67	19	12.4	24	5	21	
51401	6136480	291860	14	13	6	7	13	8	10	10	13	11	5	5	10.7	20	8.33	25	9	32	
51501	6137080	290380	12	7	8	9	13	11	9	10	12	10	12	9	9.33	13	9.44	18	10	21	
51601	6142990	293740	14	6	11	11	15	12	13	11	14	7	11	10	8.33	16	10.2	21	4	17	
51701	6131660	289770	19	13	13	11	17	13	8	13	9	5	5	8	10.3	16	9.89	21	9	24	
51801	6129530	288970	15	9	7	10	19	13	13	14	14	9	12	8	10.3	15	10.6	27	6	26	
51901	6101440	289700	19	12	15	15	16	11	4	7	11	14	7	11	5.33	9	7.44	19	3	25	
52001	6108090	293790	9	5	6	5	11	4	7	11	14	7	11	11	5.33	9	7.44	19	3	25	
52101	6123990	285970	18	11	13	10	12	7	10	9	11	9	8	8	9.00	16	9.44	21	5	18	
52102	6121920	287220	15	10	9	10	15	11	10	8	16	14	11	13	11.7	18	10.7	24	5	27	
52201	6105170	280430	11	7	6	4	17	13	10	12	15	9	10	10	9.67	20	9.11	26	8	24	
52301	6103050	279180	17	13	11	17	13	10	9	10	5	4	4	5	9.00	15	9.22	20	9	20	
52401	6117410	310170	15	9	10	9	15	14	7	10	14	13	13	10	12.0	21	10.6	27	6	18	
52501	6090516	268580	13	6	7	8	13	10	9	9	19	13	11	12	9.7	21	9.44	29	9	22	
52601	6103720	281350	14	8	6	10	15	10	14	11	12	9	6	11	9.00	14	9.44	22	11	34	
52701	6090670	297900	16	12	13	9	24	13	16	19	13	12	10	7	12.3	21	12.3	27	7	31	
52801	6070920	271800	24	17	19	15	13	9	12	10	23	13	14	16	13.0	24	13.9	32	7	26	
52901	6076820	290110	11	9	8	7	15	11	12	12	12	5	8	6	8.33	14	8.67	18	8	20	
53001	6073090	282480	23	17	18	15	14	10	12	9	20	13	13	11	13.3	23	13.1	30	6	23	
53101	6077650	269110	15	12	8	10	12	9	7	8	10	5	6	5	8.67	15	7.78	21	4	26	

53301	Onkaparinga Gorge	6109180	280190	21	16	13	17	20	15	13	14	14	19	14	15	12	15.0	26	14.3	30	9	33
53401	Corkscrew Rd	6138600	294850	13	10	11	6	13	10	10	9	9	13	10	6	8	10.0	16	8.89	20	7	28
53701	Bullaparinga Hill	6061680	248910	16	14	9	11	7	4	6	5	5	13	6	8	11	8.00	17	8.22	23	3	21
53801	Meadows	6104250	295690	13	11	9	9	15	13	10	13	17	16	11	12	11	11.7	19	11.0	21	6	19
53901	Springs Rd Sanctuary	6063730	253280	19	17	13	14	21	18	14	17	14	14	10	11	10	15.0	22	13.8	26	8	20
54001	Mt Hayfield Track	6067076	257802	21	15	19	13	22	11	14	14	18	14	14	12	14	13.3	24	14.0	32	8	21
54101	Mt Scarb Rd	6057160	267810	13	8	12	11	18	10	10	10	10	14	11	8	10	9.67	18	10.0	22	11	20
54201	Taylor Rd	6056980	260660	13	10	10	8	16	11	11	11	11	13	7	11	7	9.33	14	9.56	21	8	16
54301	Tugwell Rd	6062190	277530	13	12	12	11	17	8	15	14	13	13	8	8	6	11.0	17	11.0	22	10	17
54701	Kaisersuhl Sanctuary	6171840	316060	18	14	15	13	15	13	13	13	21	21	14	15	16	13.7	23	14.0	28	7	29
54801	Parra Wirra Site 1	6160960	304430	11	5	7	9	17	10	12	13	10	4	5	10	6.33	12	8.33	24	7	27	
54802	Parra Wirra Site 2	6160550	304500	10	7	4	3	19	12	13	10	12	11	10	10	10.0	17	8.89	22	7	16	
54803	Parra Wirra Site 3	6161110	304120	20	12	16	16	21	17	12	13	13	13	7	9	8	12.0	22	12.2	27	6	31
54804	Parra Wirra Site 4	6160350	303540	12	8	9	7	16	8	5	6	6	10	4	5	6	6.67	14	6.44	22	5	19
54805	Parra Wirra Site 5	6160380	303180	15	12	12	13	11	7	7	8	8	16	9	10	9	9.33	18	9.67	23	4	28
54806	Parra Wirra Site 6	6160810	303260	15	10	11	9	16	13	12	9	16	12	9	8	8	11.7	20	10.3	26	4	21
54807	Parra Wirra Site 7	6159400	302120	13	7	8	8	10	8	4	7	9	9	7	5	7	7.33	15	6.78	19	3	25
54808	Parra Wirra Site 8	6159710	302210	23	14	17	13	21	9	13	16	14	14	11	11	8	11.3	19	12.4	28	3	15
54809	Parra Wirra Site 9	6159410	302420	15	9	11	9	20	9	7	15	14	14	11	9	11	9.67	19	10.1	28	6	19
54810	Parra Wirra Site 10	6158940	302380	22	13	13	13	17	12	12	14	14	8	8	8	11	11.0	17	11.6	29	3	11
54811	Parra Wirra Site 11	6159160	302000	18	12	9	9	17	11	10	11	16	11	11	11	12	11.3	19	10.7	29	8	29
54812	Parra Wirra Site 12	6158920	301940	18	10	11	10	12	9	8	10	10	13	7	6	10	8.67	16	9.00	25	5	5
54901	Scott Creek, Almanda Mine	6114830	288230	15	10	10	10	11	7	7	7	7	11	9	8	6	8.67	17	8.22	23	7	28
		Average species count		16.5	11.2	11.6	11.2	15.8	10.8	10.8	11.2	15.0	10.6	10.2	10.6	10.9	18.7	10.9	25.4	6.41	23.5	
		SD of species count		4.43	3.55	4.10	3.80	4.47	3.61	3.44	3.45	4.13	3.83	3.27	3.37	3.66	4.54	3.61	4.87	2.46	6.34	
		90% CI of species count		±7.40	±5.94	±6.86	±6.35	±7.46	±6.03	±5.74	±5.76	±6.89	±6.40	±5.46	±5.63	±4.91	±7.58	±4.48	±8.13	±4.14	±10.7	
		90% CI of average species count		±0.95	±0.76	±0.88	±0.81	±0.95	±0.77	±0.73	±0.74	±0.88	±0.82	±0.70	±0.72	±0.63	±0.97	±0.57	±1.04	±0.53	±1.36	

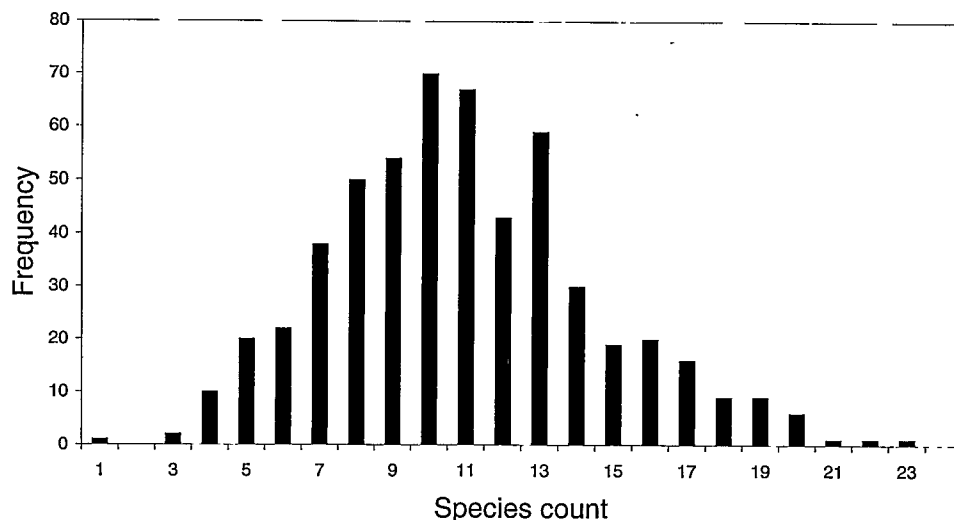


Figure 2. Frequency of species count for 549 20-minute samples of 2-ha sites of gum woodland: year 2000 survey.

are close with 19.

Other measures are the species counts over the 61 sites; located on the bottom row of Table 1, e.g. 98 (total species), 83 (on-site species) and 75 (P_{re} computed) are all estimates of species richness related to different measurement conditions. One condition very different from those relevant to the figures above is that they are from a 183 person-hour survey over 61 sites rather than one or nine samples of a single site.

Measures of species richness that are based on more precisely defined survey conditions are those from an analysis of the 549 samples of 20 minutes over 2 ha, given in Table 5. The most statistically robust are the average species counts from independent samples, i.e. one from each of the three sessions using different observers on different days. These averages vary from 10.2 to 11.6 and the probability of the difference between these two being real and not caused by random variation is less than 5%. Stretching statistical correctness a little, by including all nine samples in the calculation, one can conclude that the average species count for a single 20-minute sample of 2 ha is 10.9 with a 90% confidence interval (CI) of ± 0.25 . An illustration of the variation of the 549 samples of 20 minutes is given in Figure 2 from which the average is 10.9 with a 90% CI of ± 0.25 . So one can conclude that from 10.35 to 11.5 species will be recorded on 90% of repeated 20-minute samples of 2-ha sites of gum woodland. However, note that the

species count for individual visits will vary as shown by Figure 2.

If the records are accumulated over the three independent 20-minute samples (Sample 1 from Sessions 1, 2 and 3) the average species count increases to 18.7 with a 90% CI of ± 0.97 . If all the records from the 549 samples of 20 minutes are accumulated, the average is 25.3 with a 90% CI of ± 1.04 . These two statistically significant increases from the 10.9 for a single 20-minute sample show the effect of increasing the survey effort to 1 hour and 3 hours respectively. Note that 83 on-site species were recorded during this 183-hour survey.

An analysis based on 1-hour surveys can be made by accumulating the records for the three contiguous 20-minute periods for each session. The data for the three independent 1-hour samples were obtained by accumulating the records from the relevant 20-minute samples and averaged over the 61 sites giving total species counts of 15, 15.8 and 16.5 (see Table 5). Again there is no significant difference between these results, so the average of 15.8 is valid with a 90% CI of ± 0.53 . This is significantly higher than the average of 10.9 for the 20-minute samples showing the effect of an increase in survey time to 1 hour based on three contiguous 20-minute samples. However, note that this figure is statistically lower than the 18.7 obtained by using the 1-hour effort for three independent 20-minute visits.

Species Richness from accumulation plots

Possingham *et al.* (2004 and 2006) discuss how accumulation plots are used to estimate species richness. The same method is used for this GUM00–01 survey, making changes appropriate to the changed survey design. Data for the three time-independent 20-minute samples of the 61 sites, i.e. Sample 1 from Sessions 1, 2 and 3, were used to compute the plots. Five different time sequences, combined with four different site sequences were used.

In addition, plots were obtained for the three time-independent 1-hour samples of the 61 sites (Samples 1, 2 and 3 combined) from Sessions 1, 2 and 3. Three different time sequences, combined with four different site sequences, were used. Table 6 shows the results of this analysis of the GUM00–01 records compared with those from the SB99–00 and SB00–01 surveys reported previously.

For the 20-minute samples, the estimated species richness for the GUM00–01 survey is 18 species higher (83 versus 65) than that from the SB99–00 and SB00–01 surveys. Considering the two 90% CIs, this is a significant difference. Note that the GUM00–01 survey provides 16 more (70 versus 54) on-site species used to compute species richness, than the stringybark woodland.

The difference between the estimated species richness for the 1-hour surveys is also significant with a 39 species increase for gum woodland; note that 22 more species were used (83 versus 61). Some doubt must be placed on the 122 species richness figure from the analysis of the 1-hour GUM00–01 data. The relatively high 90% CI of 16 for the 122 indicates that more than 16 samples (four different site sequences and four time sequences) may be needed. Comparisons

with results from future gum woodland surveys need to be examined.

Possingham *et al.* (2004) use the data in SAOA (1985), to estimate that 85 species are likely to be recorded in the Mt Lofty Ranges, increasing to 93 if summer visitors are included. This gives some support to the 83 obtained from the 20-minute data but not to the 122 from the 1-hour data. Possingham *et al.* (2006: 253) also suggested 24 species listed in SAOA (1985) as common in the Mt Lofty Ranges, but not recorded on the SB00–01 survey, and this would explain the low prediction of 65 for species richness from the SB00–01 survey. It is worth noting that the GUM00–01 survey recorded 13 of the 24.

Bird density and probability of recording

As discussed in the report on the SB00–01 survey in Possingham *et al.* (2006), the flocking nature of some species, as one might expect, increases the density for a given probability of recording. We have examined this situation by dividing the 26 core species into three groups: Group A with the average number of birds per visit greater than 3.9; Group B between 3.5 and 2.0; and Group C less than 1.9. Table 7 lists these 26 species in order of P_{re} and the relevant quantities for these three groups including the species in each group. A least square fit of

$$D = \frac{\log_e (1 - P_{re})}{k}$$

to the three sets of data gave fit parameters, k , equal to 0.649, 1.101 and 1.698 for Groups A, B and C respectively (Figure 3). The normalising factor, k , on density, D , allows for the flocking nature of the three groups of species. The total root-mean-square error between fit and data for

Table 6. Comparison of species richness estimates from the two stringybark surveys and one gum survey. Refer to Possingham *et al.* (2004: Appendix 2) for definition of the symbols used.

	SB99–00 survey			SB00–01 survey			GUM00–01 survey				
	20-minute visits (38 sites, 54 species)			20-minute visits (48 sites, 54 species)		1-hour visits (48 sites, 61 species)		20-minute visits (61 sites, 70 species)		1-hour visits (61 sites, 83 species)	
	Mean	90% CI		Mean	90% CI	Mean	90% CI	Mean	90% CI	Mean	90% CI
S_m	65	±4.2		65	±6.3	83	±5.8	83	±3.4	122	±16.0
\bar{M}	5.6	±0.8		4.8	±1.2	4.5	±0.43	5.4	±0.56	5.3	±0.91
j	0.68	±0.1		0.64	±0.08	0.51	±0.05	0.70	±0.055	0.53	±0.057
k	0.63	±0.1		0.45	±0.07	0.46	±0.05	0.53	±0.061	0.45	±0.069
k/j	0.92	±0.1		0.71	±0.1	0.94	±0.12	0.77	±0.084	0.84	±0.078

the three fits is 0.072. A fit to all the data (without normalising) gave a fit parameter of 0.934 and a root-mean-square error of 0.208. Note that $k = 1.101$ for Group B, the middle of the three groups, which is similar to 0.934 for the overall fit, and the overall root-mean-square error is much lower, indicating a much better representation of the data.

The effect of survey design factors on species count

The initial report on the Mt Lofty Bird Survey (Possingham *et al.* 2004) gave the background to the analysis of survey design factors on species count. The same method was used to analyse the results of this gum woodland survey. Tables 8, 9 and 10 show how the average and standard deviation of species count depend on observer, wind and sample start time. The P-values give a

measure of the significance of the dependence. They indicate that observers and wind have significant effects and start time does not. Inspection of the variation caused by temperature and cloud level indicated no significant effect. An inspection of Table 5 indicates that site does have an effect with a Regression Analysis showing an average change in species count between seven and eight species over the 61 sites.

DISCUSSION

It is probably well known by local experienced birdwatchers that, in general, the gum woodland habitat in the Mt Lofty Ranges supports more bird species than stringybark woodland. The year 2000 survey results provide some supporting facts. Below is a summary of the findings from the simple analyses detailed in this report.

Table 7. Density and probability of recording the core species for 61 gum woodland sites: year 2000 survey.

Common name	Number of visits when sighted	Average number of birds per visit when sighted	Probability of recording	Density (birds/ha)	Fit to Density
Group A, high Average Number of birds					
Rainbow Lorikeet	29	4.38	0.16	0.35	0.27
Buff-rumped Thornbill	41	3.90	0.22	0.44	0.39
Tree Martin	49	5.31	0.27	0.71	0.48
Striated Thornbill	80	4.68	0.44	1.02	0.89
New Holland Honeyeater	88	4.06	0.48	0.98	1.01
Superb Fairy-wren	131	5.08	0.72	1.82	1.94
Group B, medium Average Number of birds					
White-browed Scrubwren	26	2.54	0.14	0.18	0.15
White-naped Honeyeater	36	2.46	0.20	0.25	0.22
Brown Thornbill	38	2.13	0.21	0.22	0.23
Silveryeye	46	2.67	0.25	0.34	0.29
Red Wattlebird	74	2.15	0.40	0.43	0.51
Eastern Spinebill	80	2.03	0.44	0.44	0.57
Crescent Honeyeater	83	2.63	0.45	0.60	0.60
Yellow-faced Honeyeater	97	2.87	0.53	0.76	0.75
Crimson Rosella	118	3.38	0.64	1.09	1.02
Striated Pardalote	132	3.52	0.72	1.27	1.26
Group C, low Average Number of birds					
White-throated Treecreeper	25	1.32	0.14	0.09	0.086
Spotted Pardalote	26	1.85	0.14	0.12	0.090
Rufous Whistler	26	1.37	0.14	0.10	0.090
Australian Magpie	27	1.81	0.15	0.13	0.094
Grey Currawong	46	1.30	0.25	0.16	0.171
Common Blackbird	49	1.37	0.27	0.18	0.183
Golden Whistler	60	1.37	0.33	0.22	0.234
Mistletoebird	69	1.77	0.38	0.33	0.279
Grey Shrike-thrush	74	1.23	0.40	0.25	0.305
Grey Fantail	108	1.77	0.59	0.52	0.525

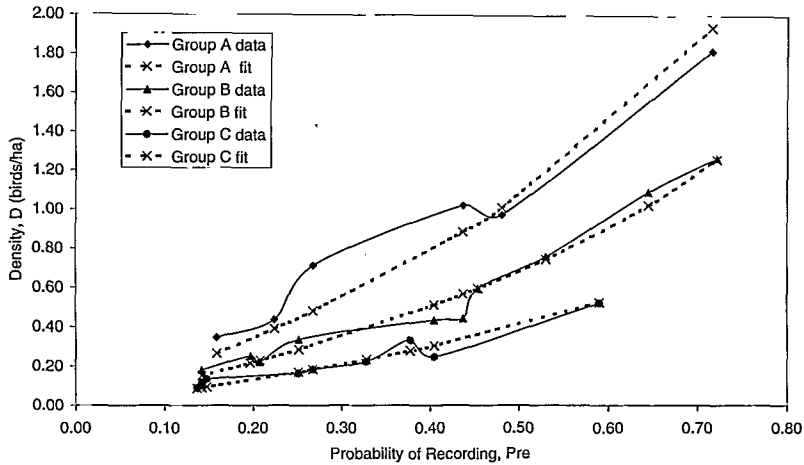


Figure 3. P_{re} versus density, D , for gum woodland: year 2000 survey (reference Table 7).

Table 8. The effect of observer on species count over three 20-minute samples of 61 gum woodland sites, year 2000 survey. $P^1 = 2 \times 10^{-7}$ (highly significant).

Analysis of species count	Observer code								
	1	2	3	4	5	6	7	8	9
Number of samples	2	13	66	31	14	35	10	11	1
Average	16.5	16.3	11.2	11.0	9.93	9.29	9.20	8.82	6.00
SD	0.71	4.01	3.30	3.40	3.00	2.79	2.94	2.68	—

¹If it is assumed that there is no effect of this factor, then the P-value is the probability of the difference in average species count being due to random variation. A P-value less than 0.05 is usually considered to indicate a significant factor and less than 0.01, a highly significant factor.

Table 9. The effect of wind on species counts over three 20-minute samples of 61 gum woodland sites, year 2000 survey. $P^1 = 0.0007$ (highly significant).

Analysis of species count	Wind strength			
	Calm	Light	Medium	Strong
Number of samples	75	59	45	4
Average	11.5	11.1	9.80	7.25
SD	3.24	3.59	4.17	2.75

Table 10. The effect of visit time on species count over three 20-minute visits to 61 gum woodland sites, year 2000 survey. $P^1 = 0.8$ (not significant).

Analysis of species count	Starting times after sunrise in 1-hour periods					
	0	1	2	3	4	5
Number of samples	14	38	46	50	31	4
Average	11.6	11.5	10.0	10.1	11.9	13.5
SD	2.74	4.11	3.16	3.56	3.44	3.11

For the basic species counts, there were more overall, on-site, core, uncommon and rare species recorded in the gum woodland habitat. However, two species were common in both habitats: Superb Fairy-wren *Malurus cyaneus* and Crimson Rosella *Platycercus elegans*. The Striated Pardalote *Pardalotus striatus* was specific to gum woodland and White-throated Treecreeper *Cormobates leucophaeus*, Striated Thornbill *Acanthiza lineata* and Grey Fantail *Rhipidura fuliginosa* were specific to stringybark. Both habitats contributed equally to the species of

conservation importance. Sixteen species preferred the gum woodland to the stringybark habitat and seven *vice versa*.

The variety of figures for species richness estimates under the heading 'Species richness' in Table 11 shows the variety of values obtainable from field surveys and illustrates the importance of the parameters of such surveys and the analysis used. The differences between the estimates of species richness for gum and stringybark are highly significant ($P^1 < 0.001$) and indicate an ornithological difference between these two habitats.

Table 11. Summary of species count (species richness) comparison for the gum and stringybark woodland: year 2000 survey. Where averages are displayed, the 90% confidence interval of that average is provided. Data for the stringybark woodland were obtained from Possingham *et al.* (2006). Note that some of the figures from that reference are in error and have been corrected, e.g. in item 4 of species richness, the figure 16.3 is the corrected version of 21.4 in the year 2000 stringybark report.

Data	Gum	Stringybark	Additional information
Overall species	98	72	104 total species, 60 species common to both habitats.
On-site species	83	61	87 total species, 57 species common to both habitats.
Core species	26	22	29 total species, 19 species common to both habitats.
Common species	3	5	6 total species, 2 species common to both habitats.
Uncommon species	23	17	28 total species, 12 species common to both habitats.
Rare species	48	32	47 total species, 23 species common to both habitats.
Species of conservation importance	19	19	37 total species, 1 species common to both habitats.
Number of species preferring one habitat	16	7	—
Species richness:			
1. Average of nine dependent 20-minute samples, i.e. three hours of survey effort	10.9 ±0.57	9.4 ±0.24	All the differences in items 1 to 7 in the species richness rows are highly significant. Any difference greater than the sum of the two 90% CIs has a probability of less than 0.0001% of being caused by random variation.
2. Total of nine dependent 20-minute samples, i.e. three hours of survey effort	25.4 ±1.04	21.4 ±1.01	
3. Average of three independent 20-minute samples, i.e. one hour of survey effort	10.9 ±0.63	9.5 ±0.42	
4. Total of three independent 20-minute samples, i.e. one hour of survey effort	18.7 ±0.97	16.3 ±1.1	
5. Average of three independent 1-hour samples	15.8 ±0.53	13.8 ±0.51	
6. Accumulated 20-minute samples (see Table 6)	83 ±3.4	65 ±6.3	
7. Accumulated 1-hour samples (see Table 6)	122 ±16.0	83 ±5.8	
8. Species count for Mt Lofty Ranges		85 to 93	
Total species count of nine on-site samples	Maximum = 37 Minimum = 18 Average = 25.4 ±1.04 Highly significant	Maximum = 31 Minimum = 12 Average = 21.4 ±1.05 Significant	Extracted from SAOA (1985). Significant difference for the average species count.
Effect of observer on species count	Highly significant	Significant	P for Gum = 2×10^{-7} ; P for Stringybark = 0.007.
Effect of wind on species count	Highly significant	Nearly significant	P for Gum = 0.0007; P for Stringybark = 0.08.
Effect of starting time on species count	Not significant	Not significant	P for Gum = 0.8; P for Stringybark = 0.11.
Effect of site on species count	7–8 species	8 species	—

Species richness estimates based on accumulation plots show better agreement with the Mt Lofty Ranges birds listed in a field list of South Australian birds (SAOA 1985) and this method is more reliable for monitoring change. The figure of 122 species derived from accumulation plots for 1-hour visits to gum woodland sites is suspect and the analysis needs to be repeated in reports of later surveys.

Observer and wind had a significant effect on species count for gum woodland compared with only observer for stringybark woodland (although wind was marginally significant with a P-value of 0.08). The time of observation was not significant in either habitat, provided it was before four or five hours after sunrise. The effect of site on species count is significant for both habitats and there needs to be some investigation of the site habitat properties causing this effect

The relationship developed here for gum woodland between probability of recording a species and the density of that species is much better if the flocking nature of the species is incorporated. A parameter for three levels of flocking has been determined.

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APPENDIX

Table 1.1 (in the Web version only) provides bird numbers for all 61 gum woodland sites and all nine 20-minute samples: year 2000 survey, in three parts:

Table 1.1a. On-Site;

Table 1.1b. Overhead-transient; and

Table 1.1c. Off-Site.

These tables give the bird numbers recorded for each species and each of the nine 20-minute samples of each site. The tables include, for each species, the species count, number of birds, probability of recording and density as well as the species sightings for each sample. Probability of recording and density are not included for overhead-transient and off-site records. Survey parameters such as site name and location, date and time, weather and observer are included. This table represents the most detailed presentation of the survey records and is only available as an *Excel* spreadsheet on the Web site.