The Effectiveness of a Variable Circular-Plot Census Procedure for Estimating Bird Density in the Karri *Eucalyptus diversicolor* F.V. Muell. Forest of South-Western Australia

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SUMMARY

A variable circular-plot census procedure was used to obtain estimates of density of birds in karri forest in south-western Australia in spring 1982 and summer 1983. Birds were also mistnetted and colour-banded to help interpret census results in the four study sites.

Five resident species (White-breasted Robin, White-browed Scrub-wren, Inland Thornbill, Grey Fantail and Red-winged Fairy-wren) dominate the understorey of the forest, although their densities were over estimated. Slash-lines and tracks may have attracted these species thus changing the micro-distribution of the birds within the dense understorey. Estimates of density of species living in the overstorey but not forming flocks were consistent between sites. Tracks are unlikely to affect the censusing of these species.

Differences in estimates of density between seasons may be due to seasonal changes in activity by some species and by a response to the disturbance caused by the construction of the census lines. Some compaction of these sites occurred during summer. Differences in the estimates of density between sites are more likely to be due to site characteristics that affect the census procedure than to real differences. A comparison of diversity indices and density distance curves between sites suggests that the bird communities of the four sites are similar.

INTRODUCTION

Concern has been expressed about the possible negative effect of various forestry management practices on the fauna within the karri forest (Routley and Routley, 1975). The avifauna is the most obvious and probably the most sensitive to gross changes in the structure of the habitat. The practices likely to be of greatest consequence to the avifauna within that part of the karri forest managed by the Forests Department are cutting and burning. Clear felling (removal of all trees in a stand of forest and regenerating the area by planting or by seed from trees cut in the clearing operation) was the method of cutting practised prior to the 1940s and since 1967. Group selection cutting (removal of small groups of mature trees from a stand of forest) was employed between the 1940s and 1967. A prescribed burning programme was introduced in the karri forest in the early 1970s to enable the control of wildfires and to reduce the likelihood of damage to regeneration by fire (Bradshaw and Lush, 1981). A study has been established to examine the effects of these three operations on the avifauna of the karri forest. A knowledge of the density of the bird species in the community and their variability between sites is required prior to the implementation of the operations.

This paper reports on the use of a variable circular-plot procedure (Reynolds *et al*, 1980) in the censusing of birds in two seasons during the first of two years prior to the implementation of operations. Birds were mistnetted and colour-banded to assess the accuracy of this census procedure in the karri forest. Bird detections and detectability were used to assess the similarity of the avian communities of the four study areas.

AREAS AND FIELD METHODS

The four study sites are situated within tall, open, unlogged karri forest, 32 km south west of Manjimup (34°18′, 115°49′) in Gray Forest Block.

The karri forest in the area of this study has two major components (Fig. 1), a dense understorey up to 10 m in height (depending on the time since previous burn) and an open overstorey of sparsely foliaged trees to 70 m in height. A minor component of the forest in this area is a secondary storey of karri saplings ranging in height from 10–35 m.

The dominant understorey of the study area is in two age classes (7 and 15 yeas). Fifteen year old understorey is dominated by one or both of two species, *Bossiaea laidlawiana* Tovey and Morris (netic) and *Trymalium spathulatum* (Labill.) Ostf (hazel), leading to a characteristic but homogenous structure of the understorey of the sites. Different understorey types within the karri forest are consistent in their structure for a given age class (Sneeuwjagt, 1971). The understorey of study site 1 is dominated by open (30–70% cover) 15 year old hazel, site 2 by dense (>70% cover) 15 year old hazel and netic, and site 3 by dense (>70% cover) 15 year old hazel. Site 4 exhibits a range of dense (>70% cover) understorey types in two age classes (7 and 15 years).

The overstorey is dominated by two species, karri and marri *Eucalyptus calophylla* R.Br. ex-Lindl occurring in approximately equal proportions. Karri by virtue of its height is the dominant element in all sites. Fig. 1 shows a profile diagram for study site 2. This represents the structural components of the forest typical of the four study sites.

A variable circular-plot procedure was used to census birds eight times in spring 1982 from 18 points in each nine-hectare site. The census stations were established in a grid to maintain the maximum distance from the edge of planned operations. Points are 120 m apart in lines 60 m apart. Points are 85 m diagonally between lines. Lines include hand slashed and bulldozer tracks. Points are located at the edge of these lines to enable sighting of birds within the overstorey.

Two teams of two people made the census, one person observing and one recording. Observers in the teams alternated between sites to prevent personal bias from influencing the total counts. Various aspects of the birds behaviour when first detected were also recorded although are not discussed in this paper. Each bird seen or heard during a 5 minute interval at each point was counted and the horizontal distance to its location when first encountered was estimated within one of six distance categories (0–50 m, 5–10 m, 10–20 m, 20–30 m, 30–60 m, over 60 m). All counts were carried out within four hours after sunrise.

A second census was carried out in February 1983 to assess the seasonal effects of the marri and some karri flowering within the sites. Five counts were made over a two week period using 9 of the 18 points used in the spring counts.

Results of the counts were analysed using the methods explained by Ramsey and Scott (1981). This method of analysis is easily used and does not preclude accurate estimation of population density in cases of birds reacting to the presence of an observer (Ramsey and Scott, 1981). Estimates of density were derived by plotting the cumulative number of detections against the cumulative area surveyed. The basal radius (Reynolds *et al*, 1980) for each species was determined as the distance from the points where the density (slope of cumulative curve) was highest. The density was then calculated from the total number of birds within the circles of basal radius.

Plots of the derived functions of bird detections (per 45 point counts) versus distance from the observer were used to guage the relation between the sites and the two seasons' counts. This density should decline with increasing distance because the ability to detect birds declines with distance. Observer interaction, behavioural changes or other factors may cause these functions to vary between sites or seasons and to have a low value close to the observer.

Table 1 lists all species recorded during the two seasons' surveys in each site. Tables 1 and 2 provide a list of total numbers of

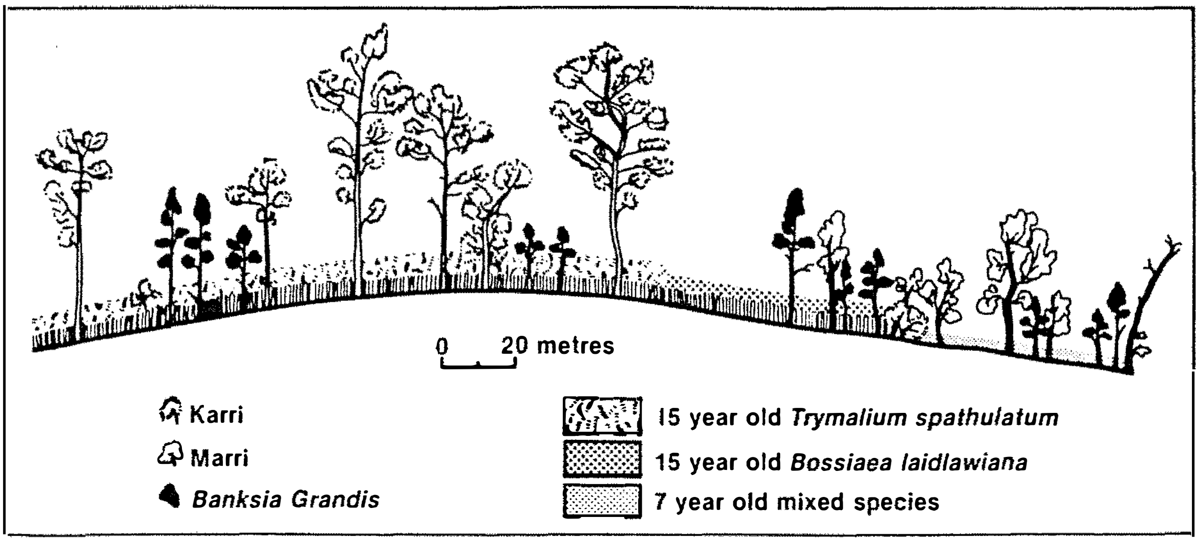

Figure 1: A profile drawing of Karri forest in study site 2 in Gray Forest Block near Manjimup, Western Australia.

TABLE 1

Number of bird detections during 144†, 5 minute point census counts in Spring 1982 within each of 4 study areas in karri forest in Gray Forest Block

SPECIES	SITE 1	SITE 2	SITE 3	SITE 4
Whistling Kite (*Haliastur sphenurus*)				2
Brown Goshawk (*Accipiter fasciatus*)		1		
Collared Sparrowhawk (*Accipiter cirrhocephalus*)	1			
Wedge-tailed Eagle (*Aquila audax*)		1		
Common Bronzewing (*Phaps chalcoptera*)			2	
Red-tailed Black-Cockatoo (*Calyptorhynchus magnificus*)	+	8		
White-tailed Black-Cockatoo (*Calyptorhynchus baudinii*)ns	28	22	17	18
Purple-crowned Lorikeet (*Glossopsitta porphyrocephala*)	9	3	4	5
Red-capped Parrot (*Purpureicephalus spurius*)	10	20	16	12
Western Rosella (*Platycercus icterotis*)ns	37	33	21	32
Port Lincoln Ringneck (*Barnardius zonarius*)ns	18	15	8	22
Fan-tailed Cuckoo (*Cuculus pyrrophanus*)ns	27	25	26	16
Horsfield's Bronze-Cuckoo (*Chrysococcyx basalis*)	1		1	+
Shining Bronze-Cuckoo (*Chrysococcyx lucidus*)	4	12	4	+
Southern Boobook (*Ninox novaeseelandiae*)	+			
Laughing Kookaburra (*Dacelo novaeguineae*)	6	11	2	12
Sacred Kingfisher (*Halcyon sancta*)	+			
Tree Martin (*Cecropis nigricans*)***	40	18	48	21
Black-faced Cuckoo-shrike (*Coracina novaehollandiae*)	13	9	13	16
Scarlet Robin (*Petroica multicolor*)	+	+		
White-breasted Robin (*Eopsaltria georgiana*)***	37	91	78	52
Crested Shrike-tit (*Falcunculus frontatus*)	+	1		
Golden Whistler (*Pachycephala pectoralis*)ns	53	72	63	60
Grey Shrike-thrush (*Colluricincla harmonica*)ns	14	20	22	13
Restless Flycatcher (*Myiagra inquieta*)	2	3	1	2
Grey Fantail (*Rhipidura fuliginosa*)ns	58	68	48	54
White-browed Babbler (*Pomatostomus superciliosus*)	10	3	26	14
Red-winged Fairy-wren (*Malurus elegans*)ns	62	56	48	43
White-browed Scrub-wren (*Sericornis frontalis*)ns	61	70	69	69
Western Gerygone (*Gerygone fusca*)***	26	17	3	8
Inland Thornbill (*Acanthiza apicalis*)*	14	35	21	29
Western Thornbill (*Acanthiza inornata*)				
Rufous Treecreeper (*Climacteris rufa*)	3	+	10	6
Red Wattlebird (*Anthochaera carunculata*)	12	19	17	9
Little Wattlebird (*Anthochaera chrysoptera*)		3		
White-naped Honeyeater (*Melithreptus lunatus*)ns	161	158	142	134
New Holland Honeyeater (*Phylidonyris novaehollandiae*)*	57	31	52	39
Western Spinebill (*Acanthorhynchus superciliosus*)				
Spotted Pardalote (*Pardalotus punctatus*)ns	47	56	56	60
Striated Pardalote (*Pardalotus striatus*)ns	90	84	92	79
Silvereye (*Zosterops lateralis*)	5	28	1	15
Red-eared Firetail (*Emblema oculata*)	1	+	+	
Dusky Woodswallow (*Artamus cyanopterus*)	5	5	5	7
Australian Raven (*Corvus coronoides*)	5	9	2	5
Diversity Index; 144 point counts (H)	1.27	1.30	1.26	1.28
Diversity Index; 45 points counts (H)	1.17	1.21	1.24	1.25

Chi square test for numbers of detections for species between sites within 60 m of observer for total counts.

ns not significant
* $P<0.05$
** $P<0.01$
*** $P<0.001$
\+ species detected during census but not from above counts
† 128 counts were conducted at site 4.

detections in each site in each season. A chi squared test was used to test the significance of the differences in the numbers of bird detections within 60 m of the observer for species between sites for spring and summer.

Mist nets were set in cleared areas at six points, 60 m apart in each of the two central lines in each study site. Two mist nets (13 m long, 2.5 m high in three shelves) were operated at each of the twelve points for two consecutive mornings. Due to inclement weather three consecutive mornings were used for sites three and four in February. Nets were unfurled for five hours from dawn. All netted birds were banded under the Australian Bird Banding Scheme, weighed, measured and released at the capture point.

TABLE 2

Number of birds detections during 45, 5 minute point census counts in Summer 1983 within each of 4 study areas in karri forest in Gray Forest Block

SPECIES	SITE 1	SITE 2	SITE 3	SITE 4
Red-tailed Black-Cockatoo		3		
White-tailed Black-Cockatoo*	51	25	7	8
Purple-crowned Lorikeet**	37	24	67	40
Red-capped Parrot *ns*	4	9	2	8
Western Rosella *ns*	89	56	55	38
Port Lincoln Ringneck**	10	4	1	6
Fan-tailed Cuckoo *ns*		3		1
Laughing Kookaburra	6			1
Tree Martin***	15	5	23	56
Black-faced Cuckoo-shrike	2			
White-breasted Robin**	16	38	28	42
Golden Whistler***	2	12	4	18
Grey Shrike-thrush	5	1	1	1
Grey Fantail**	49	27	9	14
White-browed Babbler	11		4	3
Red-winged Fairy-wren *ns*	14	30	19	17
White-browed Scrub-wren *ns*	7	5	11	8
Western Gerygone	3	4	2	
Inland Thornbill*	2	9	4	5
Western Thornbill				1
Rufous Treecreeper	3	17	3	4
Red Wattlebird***	41	29	21	66
Little Wattlebird *ns*	97	64	64	63
White-naped Honeyeater *ns*	31	50	44	52
New Holland Honeyeater *ns*	134	123	173	125
Western Spinebill	1	4	3	
Spotted Pardalote**	8	17	25	16
Striated Pardalote		5		
Silvereye		2		
Red-eared Firetail	4		1	1
Dusky Woodswallow	8	1		
Australian Raven	6	1		
Diversity Index ($\hat{H}$)	1.12	1.17	1.02	1.11

Chi square test for numbers of detections for species between sites within 60 m of observer for total counts.

ns not significant
* $P<0.05$
** $P<0.01$
*** $P<0.001$

Banding studies were carried out as a check of the estimates of density for species dwelling in the understorey. The White-breasted Robin was chosen for study because of high numbers of captures in mist nets and because it is one of the more easily observed bird species dwelling in the understorey. A standard capture/recapture formula (Loyn, pers. comm.) has been used to provide an estimate of the population of White-breasted Robins impinging on the mist nets in each site in each season;

$$p = \frac{\Sigma wx^2}{\Sigma xz}$$

where p = population
w = number caught on any one day
x = cumulative total of birds marked at the end of that day
z = the number of birds caught on that day which had already been marked.

A separate estimate of the population impinging on the mist nets was derived based on mist net captures only and using mist net captures combined with colour-band observations. An approximate guide to the area of mist net coverage for White-breasted Robins during the February mist net session was made. The percentage of birds sighted with colour-bands was plotted against distance from the mist net line. It was assumed that;

(1) The effective area surveyed by the mist nets was the same in all areas.
(2) The numbers of White-breasted Robins with colour-bands declined as a linear function with distance from the mist net lines.

Diversity Indices were used to examine the similarity of the bird communities in the four study sites. Diversity of each of the bird communities was calculated using the Shannon Diversity Index

$$(\hat{H} \text{ where } \hat{H} = \frac{\Sigma}{J} \frac{Ni}{N} \log_{10} \frac{Ni}{N})$$

Diversity was calculated for all sites using all detections within 60 m of the observer in each of the spring and summer counts. Diversity was also calculated from 45 point counts in spring to enable a direct comparison between spring and summer data. A measure of the diversity of birds in the understorey was derived by using the first capture of each individual in each mist net session as the input data.

RESULTS

Species Dwelling in the Understorey

Tables 3 and 4 show high total estimates of density in both seasons. They are consistently highest in spring. Much of this high estimate is accounted for by five species of passerines dwelling within the understorey. Estimates of density are high for the Grey Fantail, White-breasted Robin, Inland Thornbill, White-browed Scrub-wren and Red-winged Fairy-wren in all sites during spring. All species dwelling in the understorey had consistent densities between sites. Estimates of density in summer (Table 4) for the Grey Fantail, Inland Thornbill and White-browed Scrub-wren although high are considerably lower than spring estimates. Few other passerines were recorded in the understorey and none of these were found to have high estimates of density.

Table 5 shows that the same five passerines found in the census to have high estimates of density are the most frequently netted and recaptured species. Mist netting however does not support the census results of lower densities in summer of Inland Thornbills, Red-winged Fairy-wrens and White-browed Scrub-wrens. Capture rates of each of these five dominant passerines are consistent between seasons. However mist netting supports the census observations that low numbers of other species living in the understorey are present within the study sites. Mist netting did not detect any species not recorded by censusing.

Observations of colour-banded birds in summer 1983 showed that 56.7% (37) of sightings of White-breasted Robins along the mist net lines were of colour-banded birds. Of sightings in adjacent lines (60 m distant), 16.7% (4) were of colour-banded birds. The effective area surveyed was calculated to be 10.81 ha. Table 6 shows that estimates of density of White-breasted Robins derived from observations of colour-banded birds combined with recaptures in mist nets are considerably less than those obtained through censusing.

TABLE 3

Densities of birds per ha derived from 144, 5 minute point census counts in Spring 1982 within each of 4 study areas in karri forest in Gray Forest Block

SPECIES	SITE 1	SITE 2	SITE 3	SITE 4
Red-tailed Black-Cockatoo		1.11		
White-tailed Black-Cockatoo	.39	-	.11	.11
Purple-crowned Lorikeet	.44	.07	.10	.08
Red-capped Parrot	.33	.25	.33	.51
Western Rosella	1.77	.88	1.55	1.76
Port Lincoln Ringneck	1.76	.20	.20	.63
Fan-tailed Cuckoo	.66	.24	.88	.13
Horsfield's Bronze-Cuckoo			.02	-
Shining Bronze-Cuckoo	.07	.17	.09	-
Laughing Kookaburra	.02	.09	-	.19
Tree Martin	2.43	.88	5.31	4.04
Black-faced Cuckoo-shrike	.66	.17	.22	.42
White-breasted Robin	6.19	9.06	8.40	7.58
Crested Shrike-tit			.22	-
Golden Whistler	1.77	1.99	1.71	2.78
Grey Shrike-thrush	.10	.12	.37	.14
Restless Flycatcher	.22	.06	.02	.01
Grey Fantail	5.53	9.73	6.19	3.54
White-browed Babbler	.50	.66	1.10	.20
Red-winged Fairy-wren	7.07	6.63	3.98	4.80
White-browed Scrub-wren	6.41	6.41	8.84	8.84
Western Gerygone	.54	.44	.05	.25
Inland Thornbill	1.77	4.42	2.65	4.04
Rufous Treecreeper	.11	.44	.33	.06
Red Wattlebird	.44	.27	.27	.06
Little Wattlebird		.06	-	
White-naped Honeyeater	6.19	4.20	5.97	6.06
New Holland Honeyeater	6.19	.94	2.43	1.77
Spotted Pardalote	1.11	4.42	1.25	2.02
Striated Pardalote	4.42	3.54	2.65	2.02
Silvereye	.88	.72	.06	2.27
Red-eared Firetail	.22			
Dusky Woodswallow	.06	.07	.22	.25
Australian Raven		.22	.22	-
Total Density (Birds/ha)	58.25	58.46	55.74	54.56

TABLE 4

Densities of birds per ha derived from 45, 5 minute point census counts in Summer 1983 within each of 4 study areas in karri forest in Gray Forest Block

SPECIES	SITE 1	SITE 2	SITE 3	SITE 4
Red-tailed Black-Cockatoo		.06	-	
White-tailed Black-Cockatoo	.28	.35	.04	.47
Purple-crowned Lorikeet	1.73	.35	3.71	1.49
Red-capped Parrot	.08	.14	.04	.35
Western Rosella	2.12	1.26	3.54	2.12
Port Lincoln Ringneck	.24			.35
Fan-tailed Cuckoo		.04	-	.08
Tree Martin	.88	.24	.86	2.59
Black-faced Cuckoo-shrike	.08	-		
White-breasted Robin	1.95	3.54	5.66	6.37
Golden Whistler	.04	.31	.31	.86
Grey Shrike-thrush	1.41	.02	.02	-
Grey Fantail	.71	2.12	.47	1.41
White-browed Babbler	.63		2.83	2.30
White-browed Scrub-wren	.71	.53	1.24	1.06
Western Gerygone	.08	.08	.04	-
Inland Thornbill	.16	1.41	.71	.88
Western Thornbill				.02
Rufous Treecreeper	.16	2.12	-	
Red Wattlebird	.86	.63	.31	1.65
Little Wattlebird	1.65	1.02	2.04	1.26
White-naped Honeyeater	1.65	1.89	2.52	2.67
New Holland Honeyeater	10.61	4.48	9.90	5.42
Western Spinebill	.02	1.41	.53	-
Spotted Pardalote	.04	.20	.37	.39
Striated Pardalote		.08	-	
Red-eared Firetail	2.12	-	.08	.08
Dusky Woodswallow	.31	.02	-	
Australian Raven	.02	-		
Total Density (Birds/ha)	29.78	25.84	35.3	32.06

Species Dwelling in the Mid and Upper Storeys

High estimates of density were obtained for two species of Honeyeater (White-naped and New Holland) in both spring and summer. Estimates are consistently higher for the New Holland and lower for the White-naped Honeyeater in summer than in spring. Data from mist netting support these estimates of density for honeyeaters. White-naped Honeyeaters were caught more often than New Holland Honeyeaters in November and vice-versa in February. No nectar-eating species were detected by mist netting and not by censusing. Those species which were detected were found to be abundant. Wattlebirds (Red and Little) were found to be confined to the upper storey canopy and gave high estimates of density in summer. Populations of two other species, the Western Rosella and Purple-crowned Lorikeet were more dense in summer than in spring. Both inhabit the upper storey.

Most species occurring in the mid and upper storeys gave higher spring than summer estimates of density. Golden Whistler, Spotted and Striated Pardalotes, Western Gerygone and Port Lincoln Ringneck all have consistently higher estimates of density in spring than in summer.

Several species dwelling in the upper storey, White-tailed Black-Cockatoo, Purple-crowned Lorikeet and New Holland Honeyeater are active flocking species. The Tree

TABLE 5

Mist net bird capture data [Total captures; total recaptures (individuals recaptured)] from 240* net hrs in each of 4 study areas in karri forest in Gray Forest Block November 1982 and *February 1983*

SPECIES	SITE 1		SITE 2		SITE 3		SITE 4	
Western Rosella	1	*2*				*1*		
Fan-tailed Cuckoo	1		1	*1*	2	*2;1(1)*	1	
Shining Bronze-Cuckoo			1				1	
Tree Martin		*1*				*1*	2	
Scarlet Robin								*1*
White-breasted Robin	14;3(3)	*12;2(2)*	19;4(4)	*16;5(3)*	40;7(5)	*34;20(14)*	40;17(11)	*31;15(10)*
Crested Shrike-tit			1			*1*		
Golden Whistler	6	*5;2(2)*	6	1	11;1(1)	*2;1(1)*	20;1(1)	*7;2(2)*
Grey Shrike-thrush		*2*			1			*1*
Grey Fantail	4	*5;1(1)*	7	*10;1(1)*	10;1(1)	*9*	11;1(1)	*9;2(2)*
White-browed Babbler		*2*		*6*			5	
Red-winged Fairy-wren	3	*8*	7;1(1)	*4;1(1)*	7	*10;3(3)*	3	*12*
White-browed Scrub-wren	21;3(3)	*3;1(1)*	11	*11;4(3)*	16;2(1)	*19;7(6)*	25;5(4)	*19;8(7)*
Inland Thornbill	7;1(1)	1	5	*2*	8	*4;2(1)*	4	*8*
Western Thornbill								*1*
Rufous Treecreeper							2	*1*
White-naped Honeyeater	17;1(1)		8		6	*13*	21;1(1)	*9;3(3)*
New Holland Honeyeater	16;1(1)	*17*	2	*6*	3	*27*	7	*44;4(4)*
Western Spinebill								1
Spotted Pardalote	2		3		5		3	
Striated Pardalote	4	*3*	7	*2;1(1)*	3		5	
Silvereye	3		19;1(1)		5		10	
Red-eared Firetail		*2*	2			*1*		*7*
Dusky Woodswallow					2		2	
Diversity Index (H)	.99	*.96*	1.04	*.90*	.98	*.94*	1.05	*.95*

* 360 net hrs in sites 3 & 4 *February 1983*

TABLE 6

Density per area surveyed of White-breasted Robins dervied from mistnet data (supplemented with colour-band observations) within 4 study sites in karri forest in Gray Forest Block

	SITE 1	SITE 2	SITE 3	SITE 4
Spring	26.45	26.94	101.07	74.90
Summer		28.29 (19.05)	37.39 (30.63)	30.58 (24.66)
Summer Population Estimate (birds/ha)		2.62 (1.76)	3.46 (2.83)	2.83 (2.28)

Martin and White-browed Babbler are active communal species. All five species gave variable estimates of density between sites.

Seasonal and Site Differences

Thirty-nine species of birds were detected in the 144 point counts of the spring census (Table 1). Thirty-two species were detected from 45 point counts in summer (Table 2). Fewer species were found to have significant differences in numbers of detections between sites in spring, than in summer. The spring data collected from the 9 points used during the summer census were extracted and compared with the summer data. Thirty-two species were detected during these counts. Five species were recorded in each season which were not recorded during the other season.

Estimates of total density were consistently high in all sites in both seasons despite lower detection/densities within 5 m of the observer (Fig. 2). The detection/density curves for total bird detections were consistent between sites but not between the two seasons despite being low close to the observer in both seasons. The detection/density curves reached a maximum value farther from the observer in summer than in spring.

The detection/density curves for individual species were also inconsistent between seasons. Many species dwelling in the overstorey (e.g. White-naped Honeyeater and Striated and Spotted Pardalotes) had highest detection/densities within 5 m of the observer in spring and 10 m of the observer in summer. Grey Fantails are one of the few species dwelling in the understorey which consistently had the highest detection/densities within 5 m of the observer in spring. No species dwelling in the understorey and few others had highest detection/densities within 5 m of the observer during summer.

Indices of diversity were similar for each site within seasons. Indices of diversity differed between seasons being higher in spring than summer for each site (Tables 1 and 2). Indices of diversity in the understorey derived from mistnetting were similar both within and between seasons.

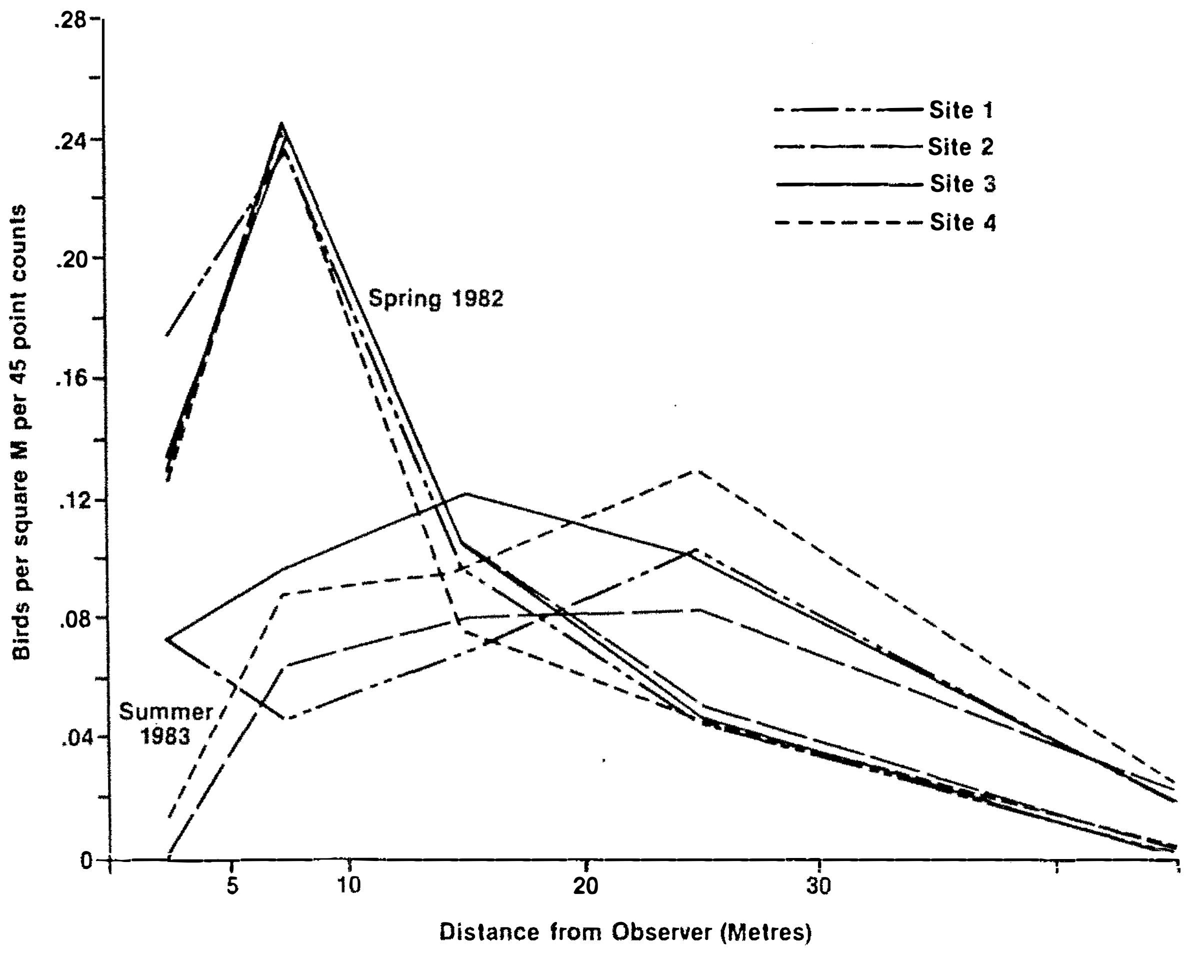

Figure 2: The density/distance functions for bird detections per 45, 5 min. point census counts in Spring 1982 and Summer 1983 within each of 4 study sites in Karri forest in Gray Forest Block.

DISCUSSION

Species Dwelling in the Understorey

Five resident passerines dominate the understorey in each of the study sites. White-breasted Robin, White-browed Scrub-wren, Inland Thornbill, Red-winged Fairy-wren and Grey Fantails account for much of the estimate of total density for each of the study sites, particularly in spring. Few other passerines are resident within the understorey. Nevertheless it is likely that the densities of each of these species has been considerably over-estimated, particularly in spring despite low detection/densities within the closest census band (0-5 m). Mistnetting results suggest little variation in population levels of species dwelling within the understorey between spring and summer. Variable estimates of density between spring and summer obtained through censusing suggest either changes in activity of the birds or stabilization of the tracks. These results suggest that censusing from newly constructed lines or tracks leads to changes in the micro-distribution of the species in the community and hence affects the estimation of density for these species. The line of sight created by tracks may also preclude reliable estimates of density for species dwelling in the understorey.

The White-breasted Robin because of the nature of its feeding strategy (aerial perch, ground prey) and social behaviour (ill defined territories) is likely to be the species most favoured by small openings created by slash lines and tracks. Estimates of density (particularly those including observations of colour-banded birds) of White-breasted Robins obtained through mistnetting are likely to be close to the actual density of this species in each site. Although reliable knowledge of densities has been derived only for White-breasted Robins, the residential status of other species dwelling in the understorey with variable estimates of density between seasons suggest that the total estimates of density obtained in summer are more accurate (despite being more variable) than those obtained in spring. The differences in total estimates of density between the seasons is largely due to the estimates of density of species dwelling in the understorey.

Species Dwelling in the Mid and Upper Storeys

Many species dwelling in the upper storey show consistent estimates of density between sites during spring. Consistent estimates are likely for such species provided they do not flock because slash lines or tracks used for censusing aid in the census of them without affecting their behaviour. Estimates of density appear to be most variable for species living in the upper storey and forming flocks. This may explain high and variable estimates for the Purple-crowned Lorikeet and New Holland Honeyeater during February. The lower number of counts in summer than in spring may also have led to greater variability in estimates of density and numbers of detections in summer. Fewer counts in summer led to fewer species being recorded.

High estimates of densities and total numbers of detections suggest that several itinerant species living in the upperstorey are supported at times by flowering of either the marri or karri. The high estimates of density for the wattlebirds, lorikeets and honeyeaters during summer coincided with flowering in the upper storey. Reduced summer populations of White-naped Honeyeaters may be due to a competitive advantage of the New Holland Honeyeater and the two species of wattlebird at the time of flowering of the upper storey trees. Censusing and mist netting results suggest that both of these honeyeaters have high resident populations. The high estimates of density of Western Rosellas during summer are likely to be due to the hazel seeding at this time.

Seasonal and Site Differences

A high proportion of detections during spring were of resident species dwelling within the understorey. This accounts for much of the skew in the detection/density functions at the 5-10 m interval. Many understorey dwelling species were attracted to the edges of the small openings created by the tracks and slash lines during spring. Some stabilization of the tracks and slash lines may have led to a lowering of the estimate of density during summer for some species. Defence of territory associated with breeding activity was found to be highest in spring. Hence edge effects and observer interaction are also likely to be greatest in spring during periods of highest activity.

The greater skew in the density/distance functions during summer may be caused by less attraction of understorey birds to tracks and a high proportion of detections being of active flocking species in the overstorey. There may be some difficulty in assigning the correct distance category to detections of these species.

Caution is required in making seasonal comparisons between estimates of density where density/distance functions vary between seasons. Nevertheless the technique of density estimation used in this paper can account for variable detectability between different species or sites (Ramsey and Scott, 1981). Hence the detection/density curves need not be highest closest to the observer. However one needs to distinguish between actual detectability and errors in the determination of distance.

The similarity of diversity indices and density/distance functions between sites during seasons suggest that overall, the avian communities are similar within each of the four study sites. The differences in diversity indices between seasons may be partially explained by the different density/distance functions. In addition a few species living in the overstorey were found to dominate counts during February. The low indices of diversity in the understorey may be due to the dominance of this storey by a few species. The close correspondence of indices of diversity in the understorey between seasons is likely to be due to a high proportion of the birds within this storey being of resident species.

The two main vegetation layers forming the forest in the study area provide different environments and support different communities of birds. Censusing the two storeys may therefore be best done on separate occasions or at separate sites. Slash lines and tracks appear to be suitable sites from which to census species living in the overstorey but have led in this study to over-estimates of some of those living in the understorey. Sites within undisturbed forest adjacent to current census points may be suitable for the censusing of birds dwelling in the understorey. If observations made over two or more years from such sites are compared, the extent to which tracks or slash lines modify sites for censusing birds dwelling in the understorey can be determined. The extent to which small openings affect the behaviour of the birds of the karri forest may also be determined. This will aid in the understanding of the effects of forest operations on the bird communities of the karri forest.

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REFERENCES

BRADSHAW, F.J. and A.R. LUSH 1981. Conservation of the Karri Forest. Forests Department of Western Australia. 59p.

RAMSEY, F.L. and J.M. SCOTT 1981. Analysis of bird survey data using a modification of Emlen's method. Stud. in Avian Biol. 6: 483-487.

REYNOLDS, R.T., J.M. SCOTT and R.A. NUSSBAUM 1980. A variable circular-plot method for estimating bird numbers. Condor 82: 309-313.

ROUTLEY, R. and ROUTLEY, C. 1975. The fight for the forests: The Takeover of Australian Forests for Pines, Woodchips and Intensive Forestry. A.N.U. Res. School of Soc. Sci., Canberra, 2nd ed.

SNEEUWJAGT, R.J. 1973. Measuring Forest Fuels. Forests Department of Western Australia, Research Paper No. 9.