CHAPTER 1

GENERAL INTRODUCTION : TREES, INSECTS, BIRDS AND THE FUSCOUS HONEYEATER

In Australia, the predominant family of birds in most habitats are honeyeaters (Meliphagidae). They are dominant in three ways. Firstly, the family has many species (67 species in Australia, Blakers *et al.* 1984), of which six or more can regularly co-occur in the one area (see, for example, references in Keast *et al.* 1985). Secondly, honeyeaters can be extremely numerous within a habitat - Loyn (1985) found honeyeaters to make up 0-48% of the bird community, and other workers have found even higher values (for example, Paton 1979, 1985, Rooke 1979, Ford and Pursey 1982, Wykes 1982, 1985 etc.). Thirdly, honeyeaters can dominate their communities aggressively (see, for example, Dow 1977b, Smith and Robertson 1978, Loyn *et al.* 1983). The family is also diverse in its foraging behaviour, with species feeding on insects, nectar, fruit and alternative carbohydrates (such as manna, lerp and honeydew, Paton 1980, Pyke 1980). Most previous studies on honeyeaters have concentrated on nectarivorous species (for example, Ford and Paton 1977, 1982, Ford 1979, Paton 1979, Rooke 1979, McFarland 1985a). With the exception of miners (Genus *Manorina*), few insectivorous species of honeyeaters have been studied to any extent (but see Wykes 1982, 1985), and for the miners, research has concentrated on breeding systems rather than food (Dow 1977a, Clarke 1984a etc.).

Just as honeyeaters dominate the Australian avifauna, eucalypts (Family Myrtaceae) are the prevalent tree genus. The domination by both these taxonomic groups is probably interrelated as they have co-evolved as the major components of a unique Australian biota. Eucalypts occur throughout Australia, with the exception of in rainforests, heaths or arid shrub-steppe areas. Eucalypts are evergreen and sclerophyllous, have the capacity to produce new growth in any or all seasons, and produce large amounts of secondary chemicals but contain low nutrient levels (Pryor 1976, Florence 1981, Lambert and Turner 1983, Landsberg 1986). These are characteristics of plants adapted to poor soils, and Australian soils are generally impoverished (Kelly and Turner 1978, Lindsay 1985).

Relationships between vegetation types and the distribution of birds have been frequently noted (see, for instance, Keast *et al.* 1985) and the type of vegetation is considered one of the major cues used by birds in habitat selection (Cody 1985 and references therein). Vegetation is used for cover from predators and weather and for nesting sites, but also as foraging substrates. Many birds are not herbivorous, though, and so use the vegetation type as a guide to available and preferred invertebrates to eat. Studies on nectarivorous birds have frequently shown that they respond to changes in available food, by increasing in numbers when nectar is abundant and declining in abundance through emigration/nomadism or switching to other food sources when nectar is unavailable. Work in Australia (Ford 1979, Paton 1979, Rooke 1979, McFarland 1985a but see Pyke 1983) and overseas (Feinsinger 1976, Wolf *et al.* 1976, Carpenter 1978, Gass 1979, Paton and Carpenter 1984, Carpenter 1987 etc.) have described how changes in the abundance of nectar (or, in some cases, alternative carbohydrates such as manna, lerp and honeydew, see Paton 1979, 1980) affected the defence of food resources by the birds. Briefly, if nectar was very abundant or extremely sparse, it was not economic for the birds to defend a territory (Brown 1964, and see Davies and Houston 1984 and references therein for the concept of economic defensibility). At intermediate food abundance, the benefits of holding a territory outweighed the costs of defending it, and so birds were territorial (Carpenter and MacMillen 1976, McFarland 1985a, 1986d). The relationships between insectivorous birds and their food have been less frequently examined (Wykes 1982, 1985, Bell 1983aa, 1985b, Pyke 1983, 1985, Woinarski 1984a, 1985a etc.), presumably because it is harder to work on insects.

A wide range of herbivorous insects are adapted to feeding on eucalypts, despite the plants' low nutritional status. The abundance of the insects will affect the numbers of predatory arthropods, which will prey upon the herbivorous insects. A few studies have investigated the ecology of insects on eucalypts (Ohmart *et al.* 1983, Woinarski and Cullen 1984, Bell 1985a, Landsberg 1986 etc.). Generally speaking, there can be large differences in numbers and types of insects within individual trees between branches and over time, between trees of the same species, and between species. Major differences in type and abundance of arthropods, and in seasonal patterns, appear to exist between eucalypts in the sub-genus *Monocalyptus* (stringybarks) and those in the sub-genus *Symphyomyrtus* (gums, boxes and peppermints, see Woinarski and Cullen 1984 and Woinarski 1985a). *Symphyomyrtus* eucalypts usually have more nutrients, particularly nitrogen, and less secondary chemicals than eucalypts in the sub-genus *Monocalyptus* (Journet and Cochrane 1978, Lambert and Turner 1983, Landsberg 1986 etc.), and this influences the numbers and types of insects on plants (Morrow and Fox 1980, Ohmart *et al.* 1985 etc.). As the major vegetation type available for insects to consume, eucalypts have a large impact on the distribution of insectivorous birds.

That birds are influenced in distribution and behaviour by the availability of their food sources is obvious and fundamental. Conversely, birds may have an impact on their food. This can influence behaviour such as territoriality and competition, but depletion of food is rarely tested. There have been few studies that examined if insectivorous birds were, in fact, depleting their food resources (that is, that food was in short supply), mostly by exclusion of birds from areas which were then compared to uncovered control areas (Askenmo *et al.* 1977, Holmes *et al.* 1979, Gradwohl and Greenberg 1982). Others have manipulated the birds, for instance by removing a dominant species (Loyn *et al.* 1983), and monitoring the changes in food and bird species.

Recher (1985) suggested that soil nutrient levels may affect plant nutrient levels, which affect the numbers and types of insects which, in turn, will influence the abundance and species of insectivorous birds. However, at a community level, interactions between birds, both intra- and interspecific, will also profoundly influence the distribution of birds. For a complete picture, therefore, it is necessary to examine the relationships at all these levels. With the exception of soil/plant dynamics, the work of Holmes and others (Holmes and Sturges 1975, Holmes and Robinson 1981, Robinson and Holmes 1982, Holmes *et al.* 1979a and b, 1986) is one example of a community level bird study. In Australia, few studies have taken this approach (but see Wykes 1982, 1985).

The present study took a broad community view, but concentrated on the Fuscous Honeyeater (*Lichenostomus fuscus*). The Fuscous Honeyeater is a small (*ca.* 17g), largely insectivorous honeyeater (Pyke 1980, Blakers *et al.* 1984, Ford *et al.* 1986), and is common (Ford and Bell 1982, Ford *et al.* 1985) and present all year at the study site, Eastwood State Forest, near Armidale on the Northern Tablelands of New South Wales. This species occurs along the south-eastern ranges and slopes of Australia, to the coast in some areas, from mid-Queensland to southern Victoria (17° S to 39° S), and from the Victorian-South Australian border to the most easterly extent of Australia (140° E to 154° E). It is most common on the tablelands and upper western slopes (Blakers *et al.* 1984) and breeds throughout the main part of its range. The Fuscous is partially migratory in the south and sedentary or locally nomadic throughout the rest of its range. The Fuscous Honeyeater can occur at locally high densities (present study, Blakers *et al.* 1984 and Ford *et al.* 1985). The closest relative of the Fuscous is probably the Yellow-tinted Honeyeater (*Lichenostomus flavescens*) which replaces the Fuscous in the eucalypt woodlands of northern Australia and, although it has been suggested that these are sub-species (Salomonsen 1967), I followed Ford (1986) in considering the Fuscous to be distinct.

Early work on the Fuscous Honeyeater was mainly about its distribution (for example, see Hindwood 1949 and Gannon 1962). Liddy (1966) and Keast

(1968) mentioned the movements of the Fuscous, noting that the species was occasionally seen migrating in association with other honeyeaters or was trapped in areas in which it did not usually occur. Several short papers from 1967 to 1975 were reports of banding studies on the longevity of the Fuscous or discussed the change of gape and eye-ring colour. Initially it was thought there might be two varieties, one with a yellow gape and eye-ring and the other with these parts being black, or that these were juvenile or adult birds respectively. It was confirmed by Dow (1973, 1975b), Lane (1974) and Morris (1974) that most Fuscous regularly changed from yellow soft parts in the non-breeding season to black gape and eye-ring during breeding. More recently, Wykes (1982, 1985) studied several species of honeyeaters including the Fuscous, at 3 sites in Victoria. He concentrated on aspects of distribution with respect to habitat, food and other honeyeaters.

The main aim of this thesis was:- TO INVESTIGATE THE ROLE OF THE FUSCOUS HONEYEATER IN EUCALYPT WOODLAND.

More specifically, the aims were:-

1. What is the distribution of birds within Eastwood State Forest? (see Chapter 3)

2. What environmental features affect the distribution of the Fuscous in particular, and the bird community as a whole? (see Chapter 3)

3. Is the distribution of birds modified by interactions between species? (see Chapter 3).

4. What is the distribution of foliage arthropods on eucalypts and how are they affected by tree type? (see Chapters 4 and 5)

5. How do birds affect arthropods? (see Chapter 5)

6. What is the foraging behaviour and diet of the Fuscous Honeyeater? (see Chapter 6)

7. What is the social behaviour of Fuscous Honeyeaters? (see Chapter 7)

In order to determine the role of this species in the bird community at Eastwood, it was necessary to explain the observed distribution of Fuscous in terms of its food (the plant/insect and insect/bird relationships and foraging behaviour) and its intraspecific interactions (including breeding and aggression) and interspecific interactions (including aggression and associations between species).

CHAPTER 2

SITE DESCRIPTION

2.1 LOCATION

The study was carried out at Eastwood State Forest (30° 35' S, 151° 44' E) 12km southeast of Armidale, New South Wales, from July, 1984 to July, 1988. This Forest consists of 200ha of woodland (see Figure 2.1) and is surrounded by partly-cleared grazing land. Eastwood has a generally sparse understorey (see Plates 2.1, 2.2 and Section 2.32) and is lightly grazed by cattle and kangaroos. Forestry operations are limited to the extraction of timber for firewood by locals.

The site was chosen as it is one of the few remaining patches of uncleared woodland in the Armidale area and the major bird species studied, the Fuscous Honeyeater (*Lichenostomus fuscus*), is both common and resident all year. Eastwood has been used as a study site by Ford and others for many years, and data exist on its vegetation, insect and bird species (Williams pers. comm., Lowman unpublished data, Ford and Bell 1982, Ford *et al.* 1985, Ford *et al.* 1986 etc.).

2.2 CLIMATE

The usual climatic pattern for the Armidale area is warm, wet summers and cool, dry winters (see Figure 2.2 and Table 2.1, data from Commonwealth Bureau of Meteorology recorded at 2AD in Armidale for temperature and for rainfall from J. Smith at Selwyn's Wood, 5km SE of Armidale). The long term average rainfall for Armidale is 792mm. Heavy falls are associated usually with summer thunderstorms. 1984 had above average rainfall total (see Figure 2.2), 1985 was slightly below normal and 1987 was average. 1986 was a very dry year (only 514mm) with above average rainfall in only 3 months falling in winter, when it is too cold for extensive plant growth. 1988 was also dry, except for January and April.

Temperatures are warm (maxima of 25°- 30°C) in summer and cool to cold in winter (minima 0° - 5°C). There is an average of 65 frosts per year occurring mostly in June to August but 1987 was a mild year with only 54 frosts. Wind may affect nest success (see Chapter 7) and so storms were noted, in addition to daily wind runs provided by the Meteorology Department (see Table 2.1, also includes other breeding season weather data).

FIGURE 2.1: Map of Eastwood State Forest (30° 35' S, 151° 44' E) showing location of points (x) used for vegetation analysis and bird censusing. Contour interval is 20m. Numbers 1 to 4 indicate exclusion experiment sites 1 to 4 (Chapter 5).

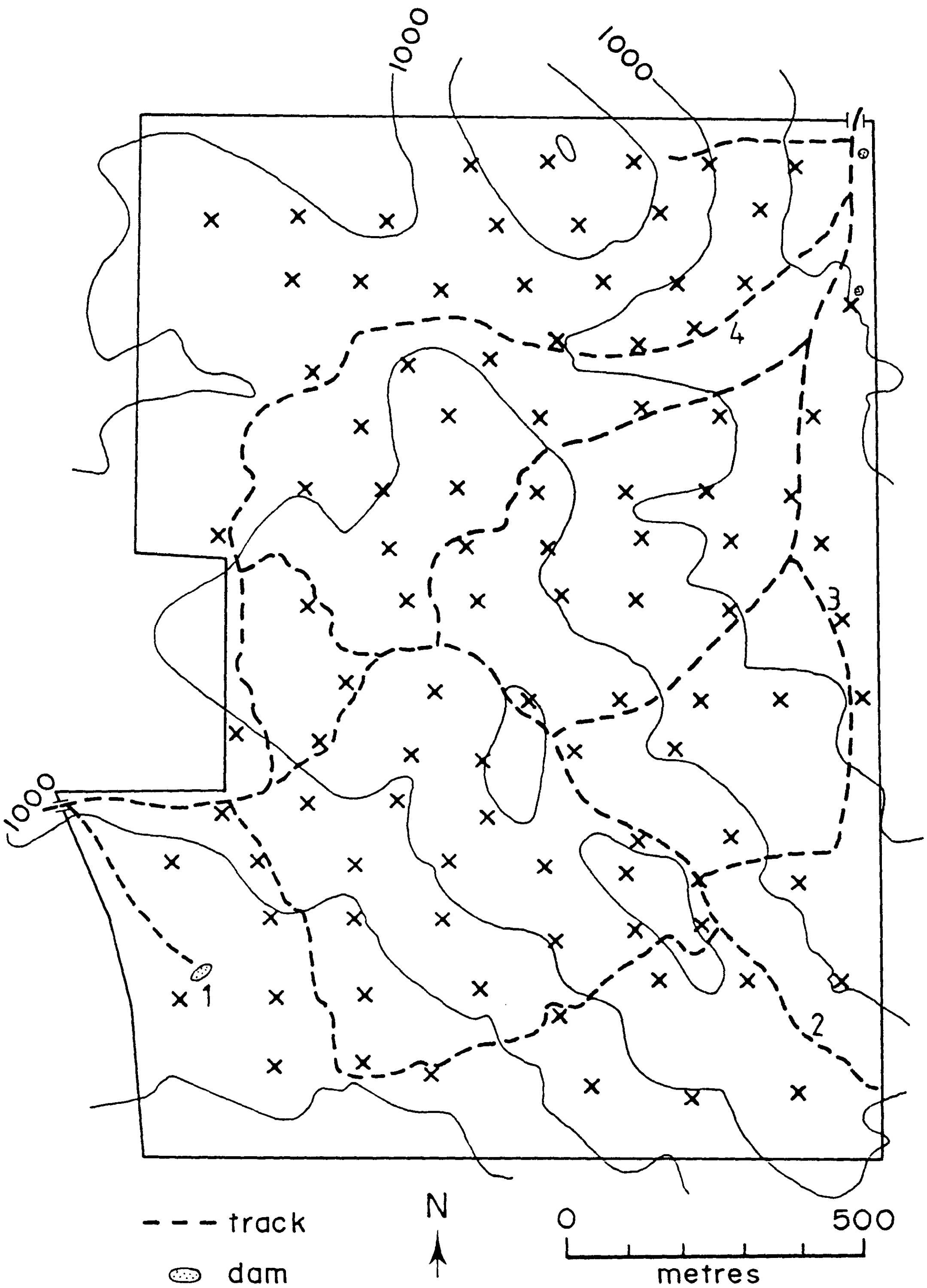

1000
1000
1000
0
4
3
2
1
track
dam
N
0
500
metres

PLATE 2.1: View of Eastwood State Forest on ridge-top looking approximately south. Taken in early 1988, when little rain had fallen recently. Note mixed eucalypts with stringybarks (*E. caliginosa*) predominating and general lack of understorey.

PLATE 2.2: View of Eastwood near the large dam in the south-west corner (see map for location) looking south-east. Taken in 1984, during a period of above average rainfall. Note that all trees are smooth-barked gums (*E. viminalis* and *blakelyi*). An area of regrowth and the main dam are seen in the background.

FIGURE 2.2: Temperature and rainfall patterns from near Armidale, July 1984 to July 1988. Data supplied by Commonwealth Bureau of Meteorology for temperature as recorded at 2AD in Armidale, and for rainfall, by J. Smith at Selwyn's Wood, 5km south-east of Armidale. Long-term average rainfall of Armidale is added to rainfall graph.

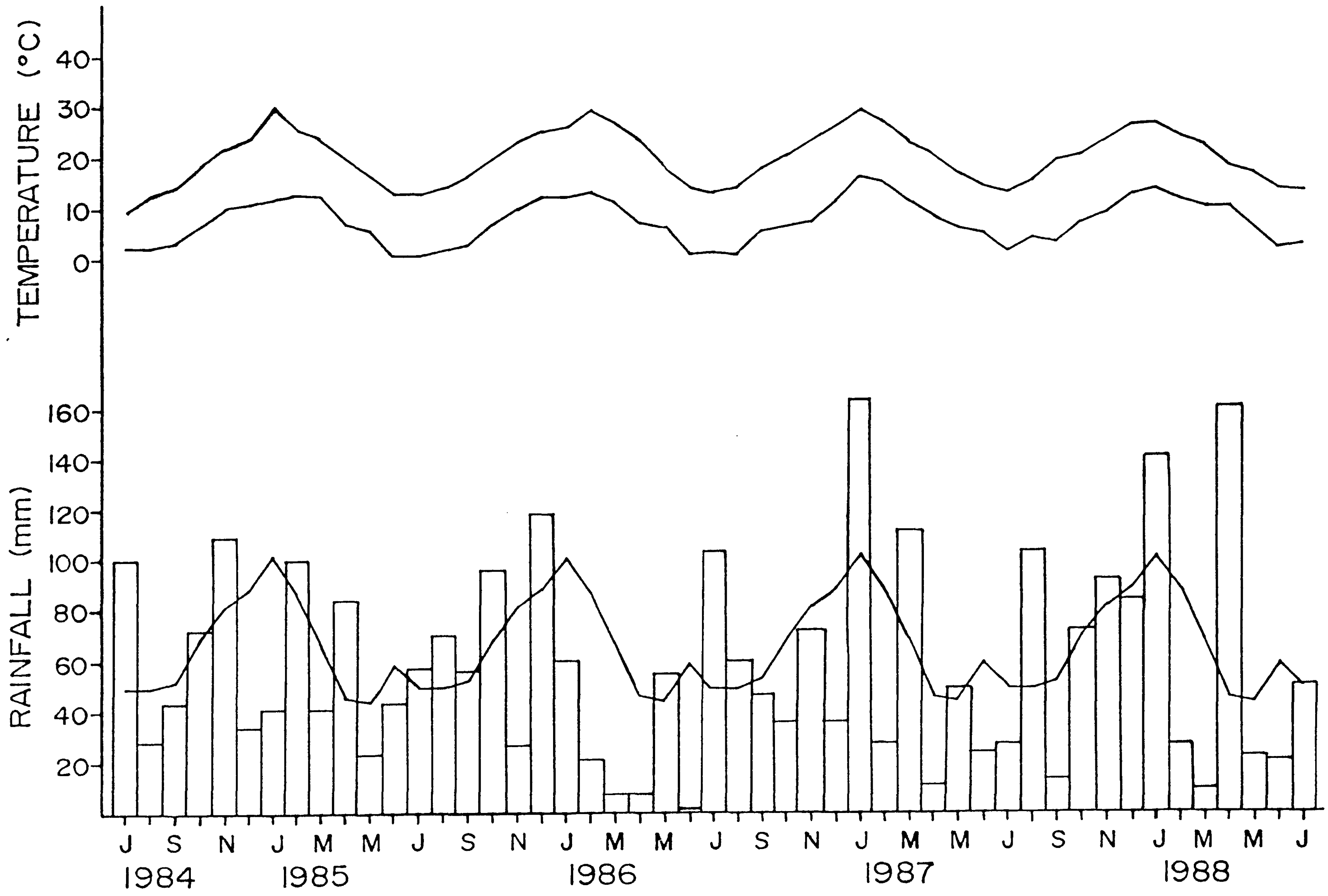

TEMPERATURE (°C)
40
30
20
10
0
RAINFALL (mm)
160
140
120
100
80
60
40
20
J S N J M M J S N J M M J S N J M M J S N J M M J
1984
1985
1986
1987
1988

TABLE 2.1: Weather during the breeding season of Fuscous Honeyeaters (see Chapter 7). From Commonwealth Bureau of Meteorology data, taken at Armidale. Months are A August, S September, O October, N November, D December and J January. Columns are RAINFALL in mm, RAIN is the number of rainy days that month, THUNDER is the number of days that had thunderstorms that month, FROST is the number of days that recorded overnight temperatures of below 0°C that month and WIND is the average daily wind run in km for that month (data not obtained for 1984 or 1988). Numbers in bold text indicate figures greater than the long-term average.

YEAR	MONTH	RAINFALL	RAIN	THUNDER	FROST	WIND
1984	A	27.5	6	0	5	
	S	43.0	8	0	1	
	O	**72.0**	7	2	2	
	N	**108.5**	**13**	**6**	0	
	D	34.0	7	2	0	
1985	J	41.4	9	**9**	0	175.8
	A	**70.4**	9	0	14	192.2
	S	**56.4**	**12**	**3**	**9**	189.7
	O	**95.8**	**13**	3	1	171.9
	N	26.6	**10**	2	0	160.2
	D	**118.0**	**15**	**8**	0	181.8
1986	J	60.0	**13**	**7**	0	171.9
	A	**60.4**	**11**	0	**16**	177.2
	S	46.8	7	3	7	186.0
	O	35.8	**10**	**5**	**3**	209.1
	N	72.2	**12**	**5**	0	200.6
	D	35.8	7	3	0	196.5
1987	J	**162.8**	**11**	**11**	0	163.7
	A	**102.6**	**17**	0	10	182.7
	S	13.4	6	2	**10**	174.5
	O	**72.0**	**14**	2	2	203.4
	N	**91.6**	9	4	0	181.8
	D	84.0	**13**	6	0	195.4
1988	J	**141.2**	**11**	**8**	0	

2.3 VEGETATION

2.3.1 Methods

It was decided to use the point-quarter method of vegetation analysis (Cottam *et al.* 1953) for the tree species as this method related well to the points used for bird-censusing (see Chapter 3). It is considered a suitable technique in communities where individual plants are widely spaced and where the dominant plants are not inter-connected. The alternative methods, quadrats and transects, are very time-consuming and percentage cover, the usual measure derived from these methods, was not considered an appropriate measure to relate to numbers of birds. In addition, there is a problem with the selection of plot size for the quadrats, with some areas at Eastwood being quite densely covered with trees and others being sparsely covered.

The point-quarter method involves locating a number of random points to be sampled. In this study, data were needed to cover most of the forest, so 100 points were spaced throughout, at 150m intervals along a series of east-west transects (see Figure 2.1). The points were marked by plastic surveying tape around the nearest tree or sapling and were numbered 1 to 20 in each of 5 sub-areas for convenience of location (see Figure 2.1).

The area around each point was then divided into four equal quadrants, north to east, east to south, south to west and west to north. The individual tree (greater than 5m in height) closest to the point in each quadrant was located and the distance between the centre of its rooted base and the point was measured to the nearest 10cm. The species of tree was noted, the circumference (to nearest cm) at breast height (1.3m from the ground) was measured and the height of the tree estimated visually to the nearest metre.

The distance to the nearest mistletoe in each quadrant was estimated (to nearest m) up to a distance of 50m from the point and its height of attachment noted. Quadrants with no mistletoe seen up to 50m from the point were taken to have a mistletoe at 75m, half the distance to the next point. Flowering status was noted also with trees and mistletoe given a score of 1 (approximately 1/4 of the flowers present are open), 2 (about 1/2 of the flowers are out), etc. This was done monthly throughout the bird-censusing as well (see Chapter 3).

The percentage cover of the major types of understorey plants (30cm to 5m in height) and the ground cover (less than 30cm in height) was estimated visually in a 10m x 10m quadrat centered on the sampling point.

In the point-quarter analysis, first the mean point-to-plant distance is calculated and squared to give the mean area per plant, that is, the area that one plant occupies. The total density is calculated by the following equation.

$$\text{Total density of all species/ha} = \frac{\text{Unit area}}{(\text{Mean point-to-plant distance})^2}$$

In this case, 'unit area' is the factor to convert square metres to hectares (10,000). Numbers of individuals of each species and their basal areas (from the circumference data) were calculated next, and the basal areas were summed and divided by the number of that species to give the average dominance values (a measure of size of the tree). Densities, relative densities, the relative dominance, relative frequencies and the importance values for each species were determined from the following equations.

$$\text{Relative density} = \frac{\text{No. individuals of a species}}{\text{Total individuals of all species}} \times 100$$

$$\text{Density} = \frac{\text{Relative density of a species}}{100} \times \text{Total density of all species}$$

Dominance = Density of a species x Average dominance value for species

$$\text{Relative dominance} = \frac{\text{Dominance for a species}}{\text{Total dominance for all species}} \times 100$$

$$\text{Frequency} = \frac{\text{No. of points at which species occurs}}{\text{Total no. of points sampled}}$$

$$\text{Relative frequency} = \frac{\text{Frequency for each species}}{\text{Total frequency for all species}} \times 100$$

Importance = Mean of (relative density, relative dominance and relative frequency)

2.32 Results

The total tree density was 245 individuals per hectare. The predominant tree species was *Eucalyptus caliginosa* (Broad-leaved or New England Stringybark) with a relative density of 57.5% (see Table 2.2, see Appendix 1 for complete plant list). It occurred at 92 out of 100 points and individuals were generally of a large size (high dominance value, 15.04). It was most abundant along the ridges of the forest (see Plate 2.1 and Figure 2.3) and was significantly correlated with altitude ($r=0.23$, $n=100$, $P<0.05$).

The next most abundant tree types were *Eucalyptus viminalis* (Manna Gum) and *E. blakelyi* (Blakely's Red Gum, see Table 2.2). *E. viminalis* occurred mainly in the lower areas whereas *E. blakelyi* was more scattered in distribution (see Plates 2.1 and 2.2). *E. viminalis* was slightly less frequent than *E. blakelyi* (35 vs 41 of 100 points) but trees were larger in the former (higher dominance value, 3.76 vs 1.72).

Two species of box also occurred (see Table 2.2) - *Eucalyptus melliodora* (Yellow Box) and *E. bridgesiana* (Long-leaved Box). Both tended to be scattered throughout the forest (Plate 2.2). Although individuals of *E. bridgesiana* were larger (dominance value higher), they were only about half as common (density and frequency).

Other tree species encountered were *Acacia* spp. (mostly the bipinnate *filicifolia* but some *implexa*) both occurring more usually as shrubs, *Angophora floribunda* (Rough-barked Apple), a few unidentified eucalypts and a *Casuarina littoralis.*

Bridges (1980) found higher densities (384 plants/ha) than those reported here. She worked in a restricted area of Eastwood that had a large number of small trees but Ford and Bell (1982) described the same area and their figures were comparable to those found here for the whole forest (260 plants/ha vs 245 plants/ha). Bridges used circular quadrats of diameter 24.6m and Ford and Bell used 10m x 10m quadrats.

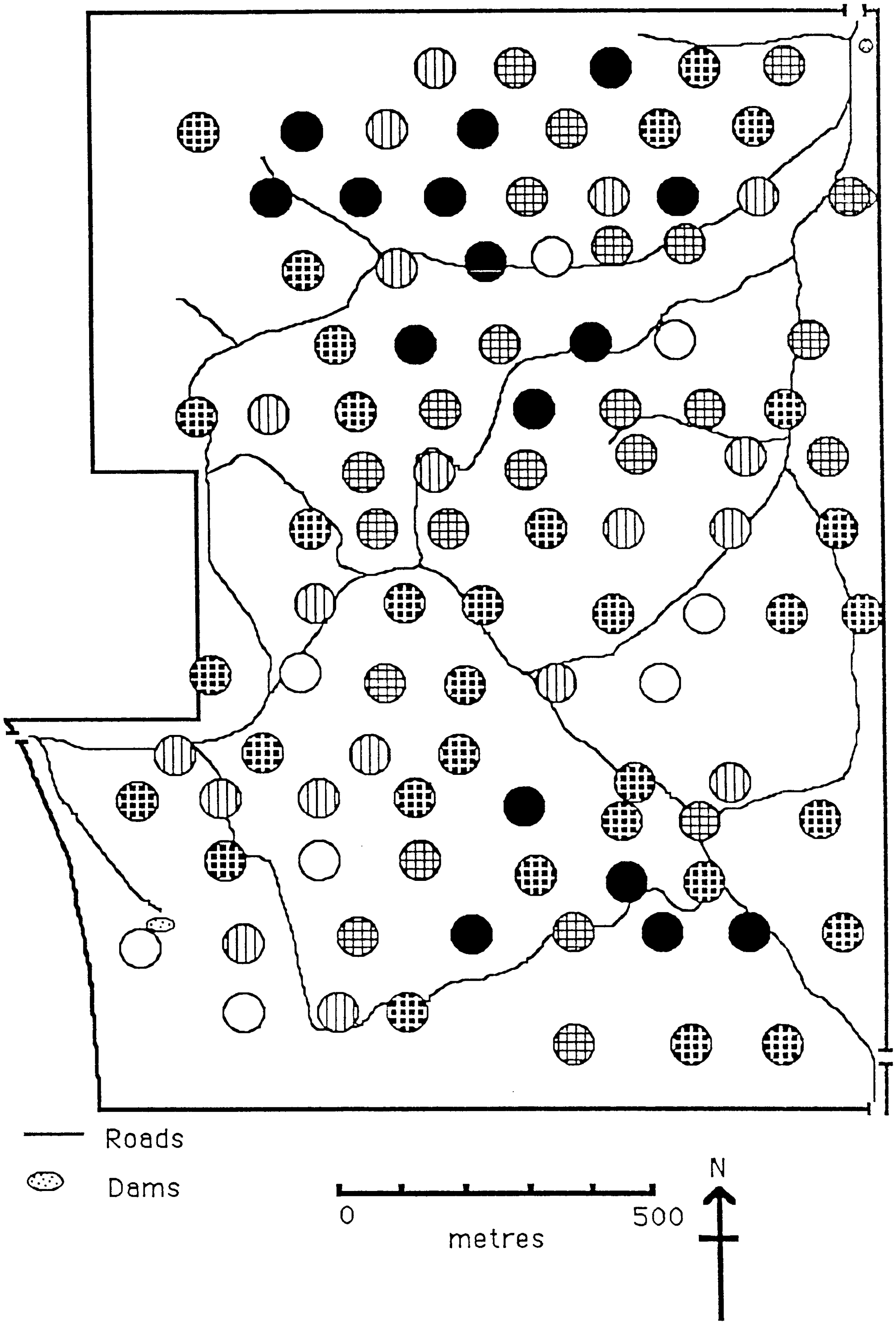
Mistletoe (*Amyema* spp.) was patchy in distribution, with the northern and eastern parts of the forest having quite high numbers of plants (see Figure 2.4). The average density was calculated to be 4.8 plants/ha. Mistletoes were attached to the host plant at an average height of 14.7m (standard error of 0.4m, $n= 228$).

Table 2.3 shows the times of flowering of the major tree species and mistletoe, as recorded during the vegetation analysis (January to March 1986) and the bird censusing (April 1986 to April 1987, see Chapter 3). As mentioned before, 1986 was a dry year and this could be the reason for the lack of flowering of *E. melliodora* and *E. blakelyi*, the very limited flowering of *E. viminalis* and the abnormal flowering time of *E. caliginosa* (usually flowers in winter). It could be also that *E. melliodora* and *E. blakelyi* were in their vegetative growth year - many eucalypt species have a two-year cycle of mainly vegetative growth one year and mostly reproductive

TABLE 2.2: Results of tree layer (>5m height) analysis at Eastwood. Analysis at 100 points. Abbreviations as follows: NO. number of individual trees, HT mean height (in m) of that species, ADV average dominance value (see text for explanation), DEN density in numbers/ha, RDEN relative density (where 100 is total density), DOM dominance value (reflects the size of individual trees), RDOM relative dominance (where 100 is combined total), FREQ frequency, RFREQ relative frequency (number of points at which the species occurred) and IMP importance value, mean percentage of RDEN, RDOM and RFREQ.

SPECIES	NO.	HT	ADV	DEN	RDEN	DOM	RDOM	FREQ	RFREQ	IMP
Eucalyptus caliginosa	230	20.4	0.107	140.6	57.5	15.04	63.57	0.92	41.63	54.2
E. viminalis	55	20.4	0.112	33.6	13.75	3.76	15.89	0.35	15.84	15.2
E. blakelyi	53	15.7	0.053	32.4	13.25	1.72	7.27	0.41	18.55	13.0
E. melliodora	27	19.7	0.083	16.5	6.75	1.37	5.79	0.24	10.86	7.8
E. bridgesiana	15	16.9	0.169	9.2	3.75	1.55	6.55	0.13	5.88	5.4
Acacia spp.	13	8.4	0.008	7.9	3.25	0.06	0.25	0.10	4.52	2.7
Angophora floribunda	3	9.7	0.032	1.8	0.75	0.06	0.25	0.02	0.90	0.6
Gum (misc.)	3	13.3	0.044	1.8	0.75	0.08	0.34	0.03	1.36	0.8
Casuarina littoralis	1	12.0	0.030	0.6	0.25	0.02	0.09	0.01	0.45	0.3
TOTAL	400		0.638	244.5	100.00	23.66	100.00	2.21	100.00	100.0

FIGURE 2.3: Map showing distribution of stringybarks in Eastwood. Four trees were identified at each point. Densities of stringybarks are 0 (empty circle), 1 (vertical lines in circle), 2 (black grid on white circle), 3 (white grid on black circle) and 4 (black circle).



Roads
Dams
0
500
metres
N

FIGURE 2.4: Map showing distribution of mistletoe in Eastwood. Note that the index is the mean distance of the four nearest mistletoe plants to each point, with a value of 75m if there are no mistletoe visible. Hence, the mistletoes are most common where the mean distance is shortest (see text for further explanation). Mean distance to nearest mistletoe is 75m (empty circle), <60m (vertical lines in circle), <45m (black grid on white circle), <30 (white grid on black circle) and <15m (black circle).

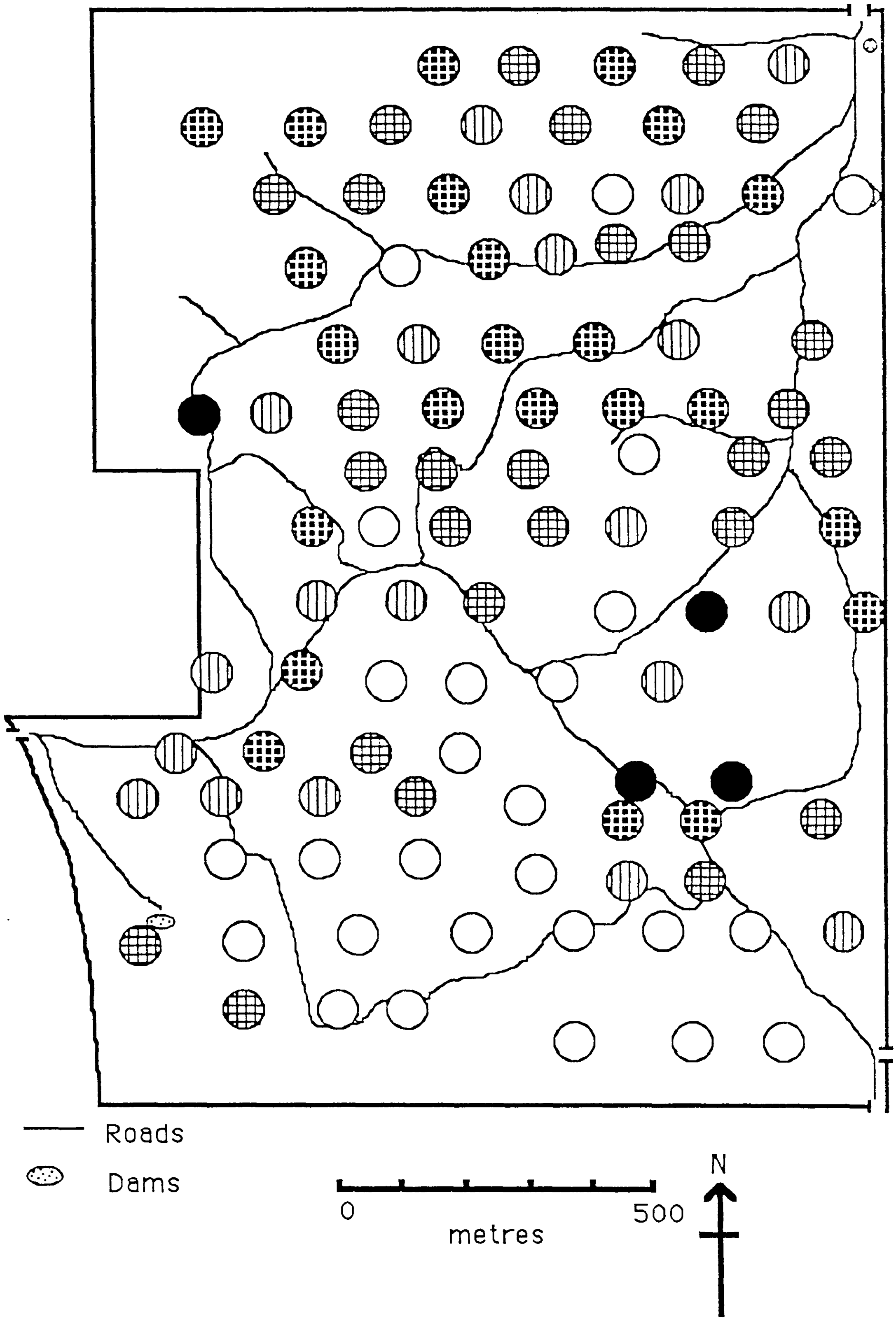

Roads
Dams
0
metres
500
N

TABLE 2.3: Flowering times of main tree species and mistletoe, as recorded during the vegetation sampling (January to March 1986) and bird censusing (April 1986 to April 1987). Values are percentage of points at which flowering was seen. Mean indices are given when a month was sampled more than once. Lines indicate 'normal' flowering times (as observed by Ford and Williams pers. comm.).

SPECIES	MONTH											
	J	F	M	A	M	J	J	A	S	O	N	D
E. caliginosa	22	3	2							2	27	67
E. viminalis				13	2							
E. blakelyi	--									--	--	--
E. melliodora								--	--	--	--	
Mistletoe	0	24.5	21	23	43	53	52	52	52	40	28	2

flowering and seed production the next (Nadolny and Ford pers. comm.). Certainly, these two species were flowering abundantly in 1987 and poorly in 1988, although the former was a wetter year. Mistletoe were seen to flower for most of the year peaking in winter. There are at least two species of mistletoe (*Amyema pendula* and *A. miquelii*) at Eastwood and they peak in flowering at different times but overlap considerably.

The understorey layer was generally sparse (mean of 7.6% coverage with 0.8% standard error, see Figure 2.5). Eucalypt saplings and *Acacia filicifolia* and *A. implexa* occurred most frequently, with some small areas of *Cassinia quinquefaria, Olearia viscidula, Indigofera australis* and other species (see Appendix 1 for complete plant list). Dead wood, brambles and wild roses (*Rubus* spp.) made up the rest of the understorey. The percentage cover was generally higher at lower altitudes, that is in the valleys (percentage cover *vs* altitude, $r=-0.263$, $n=100$, $P<0.01$, see Figure 2.5).

Ground cover was also significantly associated with altitude ($r=-0.551$, $n=100$, $P<0.01$) with less cover by plants at higher altitudes. Mean plant ground cover was 59.6% (standard error 2.9%) but this varied from 100% on the lower parts to 0-5% along the ridges and slopes. The mean agrees well with the value of 52% found by Bridges (1980) for a smaller area of the forest. Ford and Bell (1982) assessed the ground cover to be 42% in the same area. There was a complex mix of plant species with grasses, members of the Asteraceae, small woody plants and monocots present (see Appendix 1). The species composition at any particular point was not noted except for some virtually pure coverage by *Goodenia hederacea*, a creeper in higher, rocky areas. Leaf litter and dead wood covered most of the rest of the ground layer, with some small areas of rock or gravel (the latter associated mostly with the tracks).

See Appendix 1 for a complete plant list (Williams unpublished data).

In summary:-

1. The point-quarter method was used to analyse the tree types, and assessment of the understorey and ground layers were by a 10m x 10m quadrat.

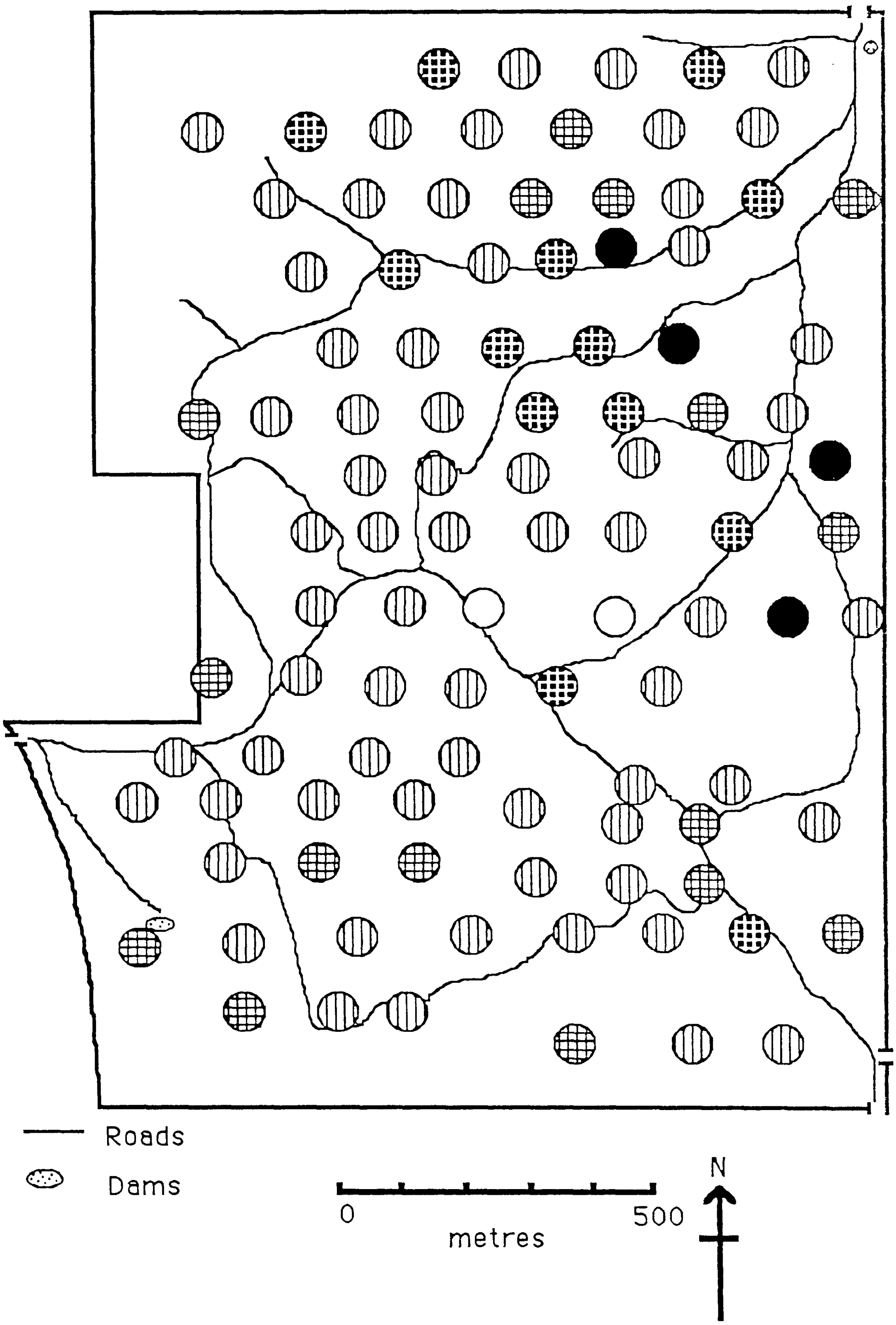
2. The main tree types, in order of importance, were *Eucalyptus caliginosa* (54.2%), *E. viminalis* (15.2%), *E. blakelyi* (13.0%), and *E. melliodora* (7.8%). Total tree density was 245 individuals per hectare. There were more stringybarks (*E. caliginosa*) at higher altitudes.

3. Mistletoe density was 4.8 plants per hectare.

4. Most tree and mistletoe species flowered during the study, but poorly for the trees.

5. Understorey coverage was 7.6% and plants occupied 59.6% of the ground layer. In both these layers, coverage was higher at lower altitudes.

FIGURE 2.5: Map showing percentage cover by understorey (30cm to 5m in height), from a 10m by 10m quadrat at each point. Note generally sparse cover. Percentage cover is 0 (empty circle), >0-5 (vertical lines in circle), >5-10 (black grid on white circle), >10-20 (white grid on black circle) and >20 (black circle).


Roads
Dams
0
500
metres
N

CHAPTER 3

THE BIRD COMMUNITY

3.1 INTRODUCTION

The composition of a bird community is the result of many interacting factors. Birds will select a particular habitat or range of habitats on the basis of distribution of necessary resources, and, through time, will show behavioural, physiological and morphological adaptations to these habitats. This will tend to re-inforce the process of habitat selection. The choice of habitat of any bird species may be subject to modification by competition, co-operation or predation by the same and/or other species of birds (Wiens 1985). Any habitat examined will have a suite of bird species present, but these may not necessarily form a highly integrated community. Some species will be present consistently, others may frequent the habitat on a seasonal basis, and some birds may be vagrant or erratic in occurrence. It is only in the two former categories that a degree of integration can be expected.

There has been considerable debate whether availability of resources or competition is the major force in the formation of a bird community (MacArthur 1972, Cody 1974, 1985, Diamond 1978, Wiens and Rotenberry 1981, Wiens 1985 etc.). In particular, the degree of variability in distribution and abundance of the required resources seems to affect the relative importance of resources and competition. Where resources are relatively predictable, a large number of species may be present, for example, in Northern Hemisphere temperate forests in summer (Cody 1978, Rabenold 1978, Alatalo 1982, Morse 1985, Holmes *et al.* 1986 etc.) and tropical forests (Karr 1976, Bell 1982, references in Keast and Morton 1980 etc. although data are limited). In these communities, birds appear to have specialized feeding techniques, that is, a narrow niche or may occur in different habitats. Domination of the community by one, or only a few species, is comparatively rare. Competition may have a major structuring role, although the evidence for this is mostly inferential rather than experimental (see Wiens 1983 for commentary). Where resources are more unpredictable, there may be fewer, more generalized, species of birds (such as in irruptions Zach and Falls 1975, Sealy 1979, Folse 1982, or in grassland communities Wiens 1977, 1985 etc.). Obviously, these will be communities in the loosest sense, and the suite of species present will be determined not only by the available resources but also by the ability of birds to locate areas of resource abundance and the availability of resources elsewhere. No community should be regarded as totally static, and the composition of the bird community will vary seasonally, between years and from place to place.

The bird species present, and their numbers are usually measured by censusing. There are many techniques available, all being subject to particular biases and errors (see Ralph and Scott 1981 and Davies 1984 for reviews). The most commonly used methods are mist-netting, mapping, transects and point counts. Mist-netting is time-consuming (Shields and Recher 1984) and is based on the erroneous assumption that all bird species are equally catchable. Mapping also takes much time, and is less reliable when birds are wide-ranging or non-territorial (see references in Ralph and Scott 1981). Neither of these methods is useful in sampling a large area, although the latter can give very accurate estimates of bird numbers. Transects and point counts, using either fixed or variable distances, seem to be the most frequently used techniques for sampling larger areas. Both are considered to give reasonably reliable estimates of the relative densities of birds (although cryptic species may be overlooked) but they usually under-estimate the actual numbers present (references in Ralph and Scott 1981, Davies 1984, Shields and Recher 1984). This may not matter where relative abundance is all that is required. Transects are more efficient for covering a large area, but the movement of the observer may cause errors in counting and may involve crossing habitat boundaries. In this study, point counts were thought to be the most appropriate method of censusing, as it related well to the method of vegetation sampling (see Chapter 2), was easy to do (the observer was not initially familiar with the bird community) and permitted extensive coverage of the large study area and comparisons within this area between habitats.

All censusing is biased. Errors can be caused by variability between observers, differences in weather and time of day, differences in detectability of the birds within and between species (behaviour may change seasonally or with age), and counting technique used (birds may be attracted or repelled during counting, duration and numbers of counts may affect species and numbers detected). Some of these sources of error can be standardised, for example, in this study there was only one observer, and counting was carried out at similar times of day and in similar weather, and where other factors are thought to influence the results, they have been mentioned (see Section 3.3).

In Australia, few bird communities have been studied, and these have been mostly in eucalypt-dominated forests and woodlands (Paton 1979, Rooke 1979, Wykes 1982, Recher *et al.* 1983, McFarland 1985a, 1986a, Ford and Paton 1985 and studies reported in Keast *et al.* 1985). Widespread similarities in community structure were found, especially between northern and southern forests and woodlands in eastern Australia. Most birds that have been studied in detail have been found to be quite generalized in foraging techniques (Bell 1983a, 1985b, Woinarski 1984a, 1985a, Noske 1985, Recher *et al.* 1983, 1985, Ford *et al.* 1986). Species tend to be separated by habitat rather than by within-habitat specializations such as food-type, height and method of foraging or morphology, although many bird species specialize on different substrates (Recher *et al.* 1985, Ford 1985, Ford *et al.* 1986). So communities, where they were not composed of the same species of birds, tended to consist of closely-related replacement species. In many communities, honeyeaters tended to be predominant (Rooke 1979, Wykes 1982, Recher *et al.* 1983, McFarland 1985a, references in Keast *et al.* 1985) and their abundance and species composition were often determined by the availability of food resources (Wykes 1982, 1985, Ford and Paton 1982, Paton 1979, 1985c, McFarland 1985a, Pyke 1985, Collins and Newland 1986 etc.). Many species, particularly the honeyeaters, are aggressive and/or territorial (Dow 1977b, Smith and Robertson 1978, Paton 1979, Loyn *et al.* 1983, Woinarski 1984b, McFarland 1985a, 1986b and d) and this suggests that competition may be important in structuring these communities (Ford 1979, Rooke 1979, Ford and Paton 1982).

In the present study I was interested in how the community of birds at Eastwood State Forest was constructed. The specific questions I address are:-

1. What is the distribution of Fuscous and other species of birds within Eastwood State Forest and how does this distribution change seasonally?

2. How is the distribution of birds related to certain environmental variables?

3. Are there positive or negative associations among species of birds, especially between other species and Fuscous?

3.2 METHODS

Bird censusing was carried out at Eastwood State Forest. Counts were made each month from April 1986 to April 1987 inclusive, and again in March and April/May 1988. Analyses of trial bird censuses indicated no consistent day or time effects although, in the warmer months, activity of the birds decreased after 09.30 - 10.00 (Eastern Summer Time). Therefore, censuses were started earlier in summer, and most censuses were commenced about 2 hours after sunrise and completed by mid- to late-morning. Originally, the censuses were to be carried out on 5 consecutive days per month, however birds were not counted when the weather was cloudy or windy and, on some days, deteriorating weather meant that a census was terminated on that day, to be continued when conditions improved. Hence, no censuses were actually on 5 consecutive days.

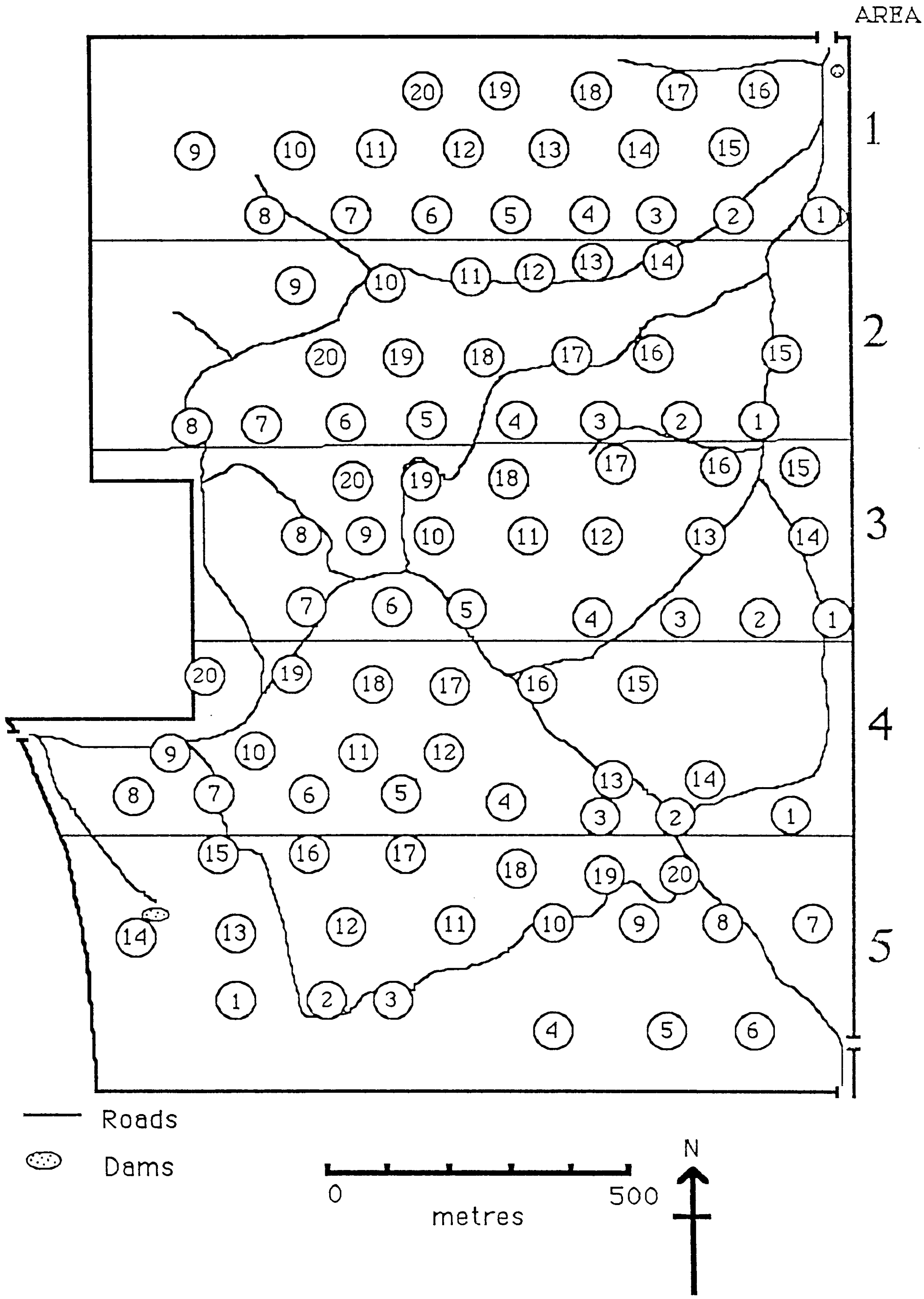
One hundred points were located throughout the Forest and these were divided, for convenience, into 5 areas of twenty points each, with area 1 being the northernmost area down to area 5 in the south (see Figure 3.1).

Sixty points were censused each month, that is, up to 12 points were counted per day, selected from two areas, for instance areas 1 and 4 might be counted on one day, 2 and 3 on the next day etc. Thus, each area had some of its points counted twice a month. An attempt was made to count birds at each point at least once every two months. The twelve points counted per day during censusing of birds were selected according to the number of stringybarks (ranging from 0 to 4, see Chapter 2) at each point, and were stratified to represent the proportion of stringybarks that existed in the Forest as a whole. So, 1 point per day was sampled that had no stringybarks, 2 points per day that had 1 stringybark, 3 that had 2 stringybarks, 4 that had 3 stringybarks and 2 that had 4 stringybarks. Neighbouring points were censused in the quickest order to minimize the time spent walking between them. In addition, areas were reversed in order of counting every second day, so on one day points in area 1 might be counted first then those in area 4 and the next day, points in area 3 might be censused before those in area 2. This should have reduced biases in counts between days or time of day.

During censusing, all birds seen or heard (up to a distance of about 50m for the larger species) during 5 minutes were counted. Birds that were flying above the canopy, waterbirds and raptors (all seen infrequently) were not included. Eastwood has a fairly open canopy and little understorey (see Chapter 2) so visibility is good, and similar between points. An effort was made to avoid counting a bird more than once during the 5 minutes. Small birds high in the canopy e.g. thornbills were difficult to count accurately, especially in mixed-species flocks. In these cases, the minimum number detected was used with no attempt to separate this group into species. Therefore, many counts were underestimates. Behaviours of the birds that were seen during censusing were noted, such as chases (for all species of birds), corroborrees and territorial calls (for Fuscous Honeyeaters, see Chapter 7 for description of these behaviours).

The amount of flowering of trees and mistletoe was assessed at each point. In this index, each flowering tree or mistletoe within 30m was given a rating of 1 to 4 depending on a visual estimate of the numbers of flowers present that were open e.g. if about one half of the flowers present were open then that tree or mistletoe was given a rating of 2. Although relative, this method was used because counting the number of flowers on a tree is very difficult and time-consuming. Then the rating was multiplied by the number of trees or mistletoe within 30m that had that number of

FIGURE 3.1: Map of Eastwood State Forest, showing location and numbers of census points.


AREA
1
2
3
4
5
Roads
Dams
0
500
metres
N

flowers open and the total scores summed for each point, with trees and mistletoe added separately.

This gave an index ranging from 0 (no flowering) to 11 (for trees) and 28 (for mistletoe). There is no suggestion intended in this index that a flowering mistletoe with, say, 20 flowers represents an equal food source to a tree that might have thousands of flowers, although they might both have the same index value.

During most months, only the mistletoes were flowering. In these censuses, an inverse index of mistletoe density was calculated as an average of the distance from the point of the nearest mistletoe in each of 4 quadrants (from the vegetation analysis, see Chapter 2). In this index, a high mistletoe density produces a low average distance from the point. Mistletoe distance ranged from 12m up to 68m. At points where no mistletoe were seen, a default value of 75m, which equals half the distance to the next point, was used. Mistletoes were densest, that is, had the smallest distance at points 2.8, 3.3, 4.13 and 4.14, and were generally more common in the northern two-thirds of the Forest.

Trees were seen flowering in four months (April, November and December 1986 and January 1987). A similar index of tree distance was calculated, except for April 1986 where distances were not recorded. In these cases, however, the mean was calculated of the actual distances of the flowering trees from the sampling point. The default distance when there were no trees in flower was 30m, considered to be the maximum distance at which a tree could have the extent of flowering accurately assessed.

Correlation and regression analyses were used to examine the relationships among the types of birds and with the environmental variables. Average numbers of the different bird species per point were obtained by dividing the number of a particular bird species seen by the number of points counted that season. These figures were converted to density estimates by multiplying the number per point by an area factor to express results as numbers per hectare. The area conversion factor was obtained by estimating the maximum distance at which a bird of a particular species could be reliably detected (by sight and/or sound), converting this radius to an area, and multiplying this area up to a hectare. The detection radius of most small species was considered to be 20m; for Fuscous Honeyeaters, treecreepers, rosellas and Sacred Kingfishers to be 30m; for whistlers, Black-faced Cuckoo-shrikes, Grey Shrike-thrushes, Grey Butcherbirds, Noisy Miners, currawongs and ravens to be 40m; and for Red Wattlebirds, Noisy Friarbirds, magpies, choughs and kookaburras to be 50m (see Appendix 2 for scientific names). So each point count represented the number of birds on approximately one eighth of a hectare for small birds, a quarter hectare for Fuscous etc., a half hectare for the 40m birds and 3/4 of a hectare for the most easily detected species. Relative frequencies were calculated from the number of points at which a bird species was recorded, divided by the total number of points in that season and multiplied by 100. This approximates the number of points out of the hundred census points at which each species might have occurred.

The censuses were analysed on a monthly, later seasonal, basis by canonical correlation analysis (program MANOVA, SPSS^X 1986). In this analysis, the bird counts were related to a number of environmental variables, to see which factors explained the most variability in the numbers of birds. Analyses were performed for total numbers of birds and total numbers of species of birds, and for birds grouped into feeding guilds (see Recher *et al.* 1985, Ford *et al.* 1986). This was done as most species singly had too few records to be analysed separately. Groups of birds with less than 6 records per month (10% of total points) were not included. The groups used were Fuscous Honeyeaters, other insectivorous honeyeaters, nectarivorous honeyeaters (division on the basis of diet from observations on foraging behaviour, see Pyke 1980, Ford *et al.* 1986), small, non-honeyeater leaf-gleaners (includes thornbills, pardalotes etc.), bark-feeders (treecreepers and sittellas), larger insectivores (Grey Shrike-thrushes, Black-faced Cuckoo-shrikes and Crested Shrike-tits), whistlers, robins, aerial feeders (included fantails, Willie Wagtails and woodswallows), parrots and large birds (such as choughs, magpies, ravens and currawongs). These groups are indicated in Table 3.1. The environmental variables used in the analyses were number of stringybarks (see above and Figure 2.3), altitude, flowering tree index and distance or flowering mistletoe index and distance (see above) and percentage cover of the understorey vegetation (see Figure 2.4, understorey layer was thickest in the north-east quarter, particularly at points 2.13, 2.16, 3.2 and 3.15). These variables were chosen as previous observations indicated that they may be important in the distribution of some of the bird species, in particular the honeyeaters and small insectivores (thornbills, pardalotes etc.).

3.3 RESULTS

Results will be presented on a seasonal basis. The seasons were autumn (April and May), winter (June, July and August), spring 1986 (September, October and November), summer 1986/87 (December, January and February), autumn 1987 (March and April) and autumn 1988 (March and April/May).

TABLE 3.1: A. Mean number of birds per 5 minute point count (n = 100 points), presented seasonally. B. Relative frequency of birds per 100 points. Seasons are: AUT'86, AUT' 87 and AUT'88 includes the months March to May, WIN is June to August, SPR is September to November inclusive, and SUM is December to February. MEAN is all seasons combined. Birds are arranged in guilds (see Section 3.2, and Ford *et al.* 1986). In the bird species column, abbreviations are as follows: HE honeyeater, GST Grey Shrike-thrush, BFCS Black-faced Cuckoo-shrike, CrST Crested Shrike-tit. See Appendix 2 for scientific names. Thornbills and flycatchers include 3 species each, pardalotes, treecreepers, whistlers, cuckoos and rosellas include 2 species each. For miscellaneous species (mean in A. 0.018, B. 1.4), see Section 3.3.12.

A.

SPECIES	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88	MEAN
Fuscous Honeyeater	0.96	1.02	1.32	0.83	0.92	0.76	0.97
White-naped HE	0.15	0.48	0.20	0.18	0.48	0.57	0.34
Yellow-faced HE	0	0.01	0	0.006	0.01	0.05	0.02
Brown-headed HE	0	0.04	0	0.006	0.01	0.05	0.02
Noisy Miner	0	0	0	0.006	0.03	0.08	0.02
Red Wattlebird	0.47	0.17	0.24	0.30	0.14	0.08	0.23
Noisy Friarbird	0	0	0.12	0.33	0.04	0	0.08
Eastern Spinebill	0.02	0.02	0.006	0	0.007	0	0.01
Thornbills	0.43	0.62	0.33	0.39	0.63	0.85	0.54

SPECIES	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88	MEAN
Pardalotes	0.12	0.07	0.08	0.006	0.11	0	0.06
White-throated Gerygone	0	0	0.03	0.04	0.02	0.008	0.02
Silvereye	0.03	0	0	0	0.007	0	0.01
Treecreepers	0.27	0.43	0.27	0.44	0.29	0.51	0.37
Varied Sittella	0.02	0.07	0.06	0.02	0.06	0.16	0.06
Whistlers	0.08	0.10	0.19	0.20	0.14	0.17	0.14
GST	0.04	0.14	0.22	0.10	0.18	0.15	0.14
BFCS	0.02	0.006	0.11	0.18	0.17	0.13	0.10
CrST	0.02	0.02	0.02	0.006	0.03	0.06	0.02
Mistletoebird	0.02	0.006	0.006	0.01	0	0.03	0.01
Speckled Warbler	0.03	0.01	0.02	0	0.02	0.02	0.02
Superb Fairy-wren	0.05	0.07	0.07	0.06	0.08	0.06	0.06
Grey Fantail	0.03	0.01	0.04	0.05	0.30	0.23	0.11
Willie Wagtail	0.03	0.03	0.08	0.05	0.04	0	0.04

SPECIES	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88	MEAN
Flycatchers	0.008	0.006	0.05	0.10	0.01	0.03	0.03
Dusky Woodswallow	0	0	0.08	0.03	0	0.03	0.02
Eastern Yellow Robin	0.02	0.07	0.03	0.03	0.007	0.02	0.03
Scarlet Robin	0.03	0.06	0.04	0.006	0.02	0.08	0.04
Rose Robin	0	0.006	0	0	0.007	0.008	0.004
Cuckoos	0.03	0.006	0	0.006	0.02	0	0.01
Rosellas	0.23	0.13	0.22	0.22	0.28	0.25	0.22
Red-rumped Parrot	0	0	0	0.04	0	0.04	0.01
White-winged Chough	0.12	0.16	0.26	0.62	0.52	0.16	0.31
Australian Magpie	0.03	0.09	0.27	0.54	0.31	0.32	0.26
Grey Butcherbird	0	0	0.006	0.01	0.03	0.03	0.01
Pied Currawong	0	0.01	0.08	0.04	0.02	0.03	0.03
Australian Raven	0.06	0.03	0.01	0	0.03	0.02	0.02
Laughing Kookaburra	0.008	0.03	0.04	0.08	0	0.008	0.03
Sacred Kingfisher	0	0	0.04	0.05	0	0	0.02

B.

SPECIES	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88	MEAN
Fuscous Honeyeater	31.7	30.0	31.7	20.5	32.6	30.0	29.4
White-naped HE	5.8	20.0	12.8	11.5	21.5	26.7	16.4
Yellow-faced HE	0	0.6	0.6	0.6	0.7	6.7	1.5
Brown-headed HE	0	1.7	0	0.6	0.7	1.7	0.8
Noisy Miner	0	0	0	0.6	0.7	3.3	0.8
Red Wattlebird	23.3	10.0	18.0	18.6	9.7	5.8	15.1
Noisy Friarbird	0	0	8.9	19.9	3.5	0	5.4
Eastern Spinebill	1.7	1.1	0.6	0	0.7	0	0.7
Thornbills	13.3	20.0	13.9	13.5	16.7	23.3	16.8
Pardalotes	8.3	6.7	5.6	0.6	10.4	0	5.3
White-throated Gerygone	0	0	2.8	3.9	2.1	0.8	1.6
Silvereye	0.8	0	0	0	0.7	0	0.3
Treecreepers	24.2	32.8	22.2	32.0	25.7	40.8	29.6
Varied Sittella	0.8	2.8	1.7	0.6	1.4	2.5	1.6

SPECIES	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88	MEAN
Whistlers	5.8	8.9	13.9	16.7	12.5	12.5	11.7
GST	4.2	12.2	15.0	9.0	14.6	12.5	11.2
BFCS	0.8	0.6	6.7	12.8	10.4	10.0	6.9
CrST	1.7	1.1	1.7	0.6	1.4	3.3	1.6
Mistletoebird	0.8	0.6	0.6	1.3	0	2.5	1.0
Speckled Warbler	1.7	0.6	1.1	0	1.4	1.7	1.1
Superb Fairy-wren	1.7	2.2	3.9	2.6	2.8	1.7	2.5
Grey Fantail	2.5	1.1	2.8	4.5	15.3	16.7	7.1
Willie Wagtail	2.5	1.7	4.4	4.5	2.1	0	2.6
Flycatchers	0.8	0.6	3.9	10.3	1.4	2.5	3.2
Dusky Woodswallow	0	0	5.0	1.9	0	0.8	1.3
Eastern Yellow Robin	1.7	5.6	1.7	1.3	0.7	0.8	1.9
Scarlet Robin	1.7	4.4	2.2	0.6	1.4	5.8	2.7
Rose Robin	0	0.6	0	0	0.7	0.8	0.3

SPECIES	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88	MEAN
Cuckoos	2.5	0.6	0	0.6	2.1	0	1.0
Rosellas	8.3	6.7	12.8	10.3	9.7	14.2	10.3
Red-rumped Parrot	0	0	0	1.9	0	0.8	0.5
White-winged Chough	1.7	1.7	5.6	9.0	6.9	2.5	4.5
Australian Magpie	1.7	5.6	14.4	22.4	12.5	11.7	11.4
Grey Butcherbird	0	0	0.6	1.3	2.1	3.3	1.2
Pied Currawong	0	1.7	6.1	3.2	1.4	1.7	2.3
Australian Raven	3.3	3.3	1.1	0	2.1	1.7	1.9
Laughing Kookaburra	0.8	2.2	3.3	3.8	0	0.8	1.8
Sacred Kingfisher	0	0	3.3	4.5	0	0	1.3

TABLE 3.2: Density of birds at Eastwood, in numbers/ha. 1986-88 data collected during present study, that during 1978 by Bell, that in 1979 by Ford (see Ford and Bell 1982) and that during 1981-82 by Ford *et al.* (1985). Densities in the present study were calculated from the mean relative densities for the whole census. Species and abbreviations as before. Approximate numbers of species of thornbills, pardalotes, treecreepers and rosellas are given for 1986-1988 study, according to identified percentage composition of these groups (see Section 3.3). The high values for miscellaneous species in 1978 and 1979 are mostly due to large numbers of finches (see text).

SPECIES	1986-88	1978	1979	1981-82
Fuscous Honeyeater	3.88	3.07	5.46	3.43
White-naped Honeyeater	2.72	4.63	1.00	0.37
Yellow-faced Honeyeater	0.24	0.16	0	0.02
Brown-headed Honeyeater	0.16	0.65	0.38	0.08
Noisy Miner	0.04	0	0	0
Red Wattlebird	0.31	0.05	0.21	0.14
Noisy Friarbird	0.11	0	0.08	0.10
Eastern Spinebill	0.08	0.11	0.08	0.01
Buff-rumped Thornbill	3.03	1.54	0.92	0.14
Striated Thornbill	0.86	1.58	0.25	0.06
Yellow-rumped Thornbill	0.43	0	0	0
Brown Thornbill	0	0.31	0	0.01
Spotted Pardalote	0.41	0.33	0	0.12
Striated Pardalote	0.07	1.66	0.04	0.53
White-throated Gerygone	0.08	0.12	0.46	0.01
Silvereye	0.08	0.36	0.88	0.01
White-throated Treecreeper	0.88	1.07	1.13	0.49
Brown Treecreeper	0.23	0.10	0.04	0.14
Varied Sittella	0.48	0.20	0.20	0.25
Whistlers	0.28	0.58	1.50	0.28

	1986-88	1978	1979	1981-82
GST	0.28	0.55	0.50	0.19
BFCS	0.20	0.09	0.21	0.10
CrST	0.16	0	0.29	0.20
Mistletoebird	0.08	0.10	0.21	0.16
Speckled Warbler	0.16	0.49	0.54	0.26
Superb Fairy-wren	0.48	1.03	1.41	0.72
Grey Fantail	0.88	0.92	0.21	0.09
Willie Wagtail	0.32	0.02	0.25	0.12
Flycatchers	0.24	0.04	0.37	0.05
Dusky Woodswallow	0.16	0.01	0.17	0.16
Eastern Yellow Robin	0.24	0.68	0.67	0.26
Scarlet Robin	0.32	0.65	0.04	0.03
Rose Robin	0.03	0.06	0	0
Cuckoos	0.08	0.04	0.50	0
Eastern Rosella	0.76	0.17	0.25	0.60
Crimson Rosella	0.12	0.06	0	0.01
White-winged Chough	0.41	0.09	0.63	0.14
Australian Magpie	0.35	0.03	0.08	0.19
Grey Butcherbird	0.02	0	0	0
Pied Currawong	0.06	0.02	0.13	0.10
Australian Raven	0.04	0.20	0	0.02
Laughing Kookaburra	0.04	0.01	0.08	0.03
Sacred Kingfisher	0.08	0	0.17	0.04
Miscellaneous (approximate)	0.07	2.04	0.99	0.12
Total	19.95	23.82	20.33	9.78

A total of 4035 individuals, from 56 species, were recorded during the census and, of these, 10 species were detected only once or twice. Only 17 species made up 83.6% of the sample by number (see Tables 3.1, 3.2, scientific names in Appendix 2) - these were Fuscous Honeyeaters, White-naped Honeyeaters, Red Wattlebirds, thornbills (3 species, Buff-rumped, Striated and Yellow-rumped Thornbills), White-throated and Brown Treecreepers, whistlers (2 species, Rufous and Golden Whistlers), Grey Shrike-thrushes, Black-faced Cuckoo-shrikes, Grey Fantails, Eastern and Crimson Rosellas, White-winged Choughs and Australian Magpies. The same species make up 78.2% of the sample by frequency (see Table 3.1). Fuscous Honeyeaters were the most common species (Tables 3.1 and 3.2), Buff-rumped Thornbills were probably nearly as numerous (as most identified thornbills were of this species), then White-naped Honeyeaters, White-throated Treecreepers and Grey Fantails, with White-napes and the fantails being more variable between seasons. Total density was calculated to be nearly 20 birds/ha. Table 3.2 also includes densities from previous censuses (Ford and Bell 1981, Ford *et al.* 1985).

Table 3.3 shows the structure of the bird community by feeding guild (see Ford *et al.* 1986). Fuscous Honeyeaters make up the largest contribution of any single species and, taken together, insectivorous honeyeaters dominate the avifauna. Birds that are mostly insectivorous and feed mainly on leaf arthropods, in fact, represent the majority (54% by number and 48% by frequency). Most of the other species present are insectivorous (or omnivorous) to some degree, with only a small percentage (less than 15%, including nectarivorous honeyeaters and rosellas) relying on nectar to any extent, reflecting the lack of reliable nectar sources. Fuscous Honeyeaters, other leaf-gleaning species such as thornbills, and choughs can occur in locally high numbers (frequency is less than number). Nectarivorous honeyeaters, species that forage on bark, large insectivores and whistlers tend to be spread out (low number and high frequency).

Distribution maps are given for Fuscous Honeyeaters, other insectivorous honeyeaters and other small insectivores (see Figures 3.2 to 3.4). See Appendix 3 for distribution maps of other birds.

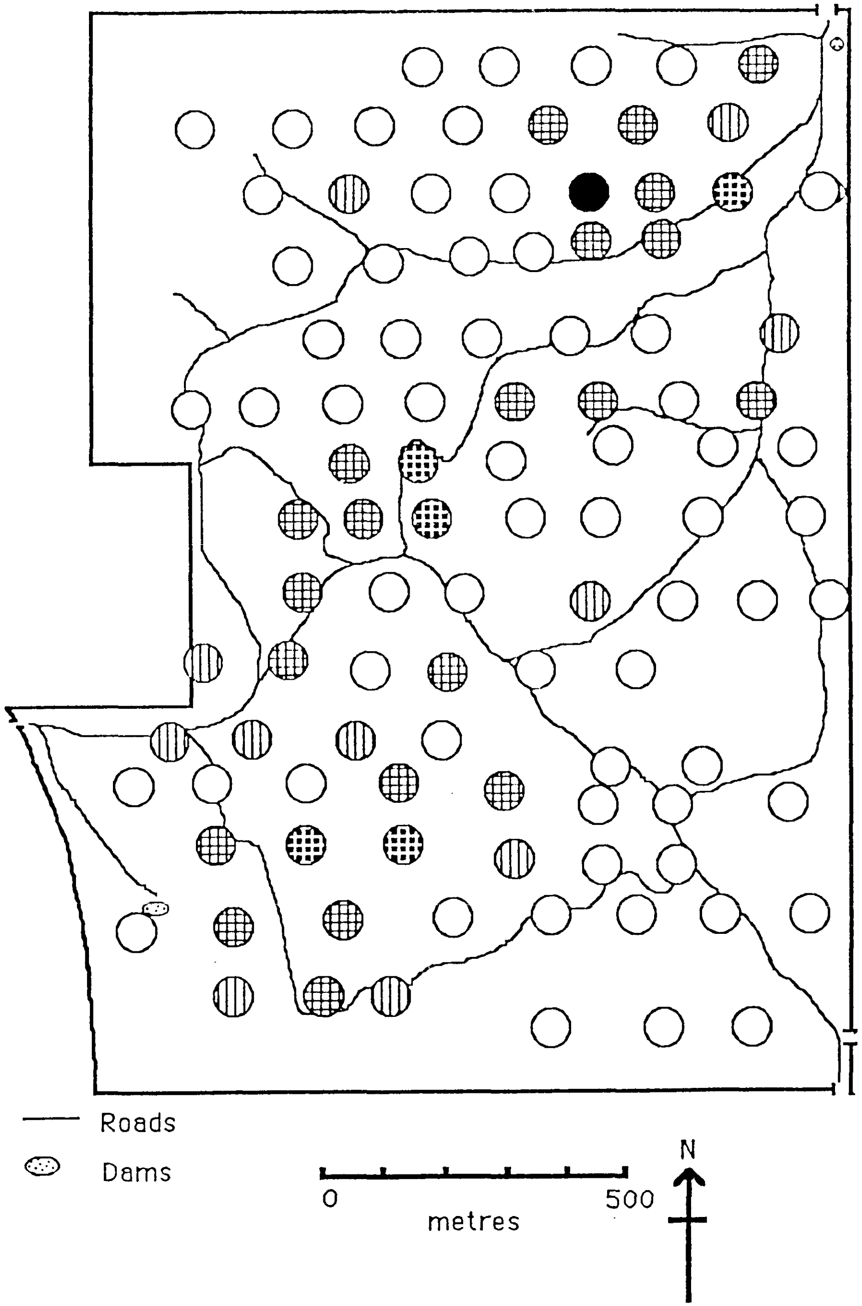
3.3.1 Fuscous Honeyeaters

Fuscous occurred in a broad band from the north-eastern corner to the south-western corner, with the highest numbers concentrated in the south-west quarter (see Figure 3.2). They were more dipersed in winter and spring 1986, and less in autumn 1988. The most notable change in distribution throughout the census was their decline in the north-east, to almost none in autumn 1988. There were small increases at points 4.2 and 4.14. A similar distribution change was noticed before the start of censusing,

TABLE 3.3: Composition of the bird community by foraging guild (see text and Ford *et al.* 1986). Percentages by number and by frequency from mean of all seasons combined (see Table 3.1). Groups are Fuscous Honeyeaters, other insectivorous honeyeaters (OIHE, includes White-naped, Yellow-faced, Brown-headed and White-eared Honeyeaters and Noisy Miners), nectarivorous honeyeaters (NHE, Red Wattlebirds, Noisy Friarbirds and Eastern Spinebills), other leaf-gleaners (OLG, thornbills, pardalotes, Silvereyes and White-throated Gerygones), bark feeders (treecreepers and Varied Sittellas), large insectivores (GST, BFCS and CrST), whistlers, aerial feeders (Grey Fantails, Willie Wagtails, flycatchers, Dusky Woodswallows), robins, small ground feeders (Speckled Warblers and Superb Fairy-wrens), cuckoos, frugivores (Mistletoebird), rosellas, large (choughs, magpies, butcherbirds, currawongs, ravens) and kingfishers (kookaburras and Sacred Kingfishers). NHEs and rosellas were considered to be mostly nectarivores and the last two groups were considered to be mixed invertebrate/vertebrate feeders.

GUILD	% BY NUMBER	% BY FREQUENCY
Fuscous Honeyeater	21.74	13.48
OIHE	9.19	8.97
Total insectivorous HEs	30.93	22.45
NHE	7.17	9.68
Total honeyeaters	38.10	32.13
OLG	14.12	10.95
Bark feeders	9.64	14.95
Large insectivores	5.83	9.05
Whistlers	3.14	5.37
Aerial feeders	4.49	6.54
Robins	1.66	2.29
Small ground feeders	1.80	1.62
Cuckoos	0.22	0.44
Total insectivores	71.83	73.04
Frugivores	0.22	0.44
Rosellas	5.15	4.94
Total nectarivores	12.32	14.68
Large	14.12	9.80
Kingfishers	1.12	1.44
Total mixed feeders	15.24	11.24
Miscellaneous	0.39	0.60
Total	100.0	100.0

FIGURE 3.2: Map of Eastwood showing seasonal distribution of Fuscous Honeyeaters. For this, and other figures in this chapter, seasons are, in order, autumn 1986, winter, spring, summer, autumn 1987 and autumn 1988. Relative densities of Fuscous are: 0 (empty circle), <2 (vertical lines in circle), <4 (black grid on white in circle), <6 (white grid on black in circle) and 6+ (black circle).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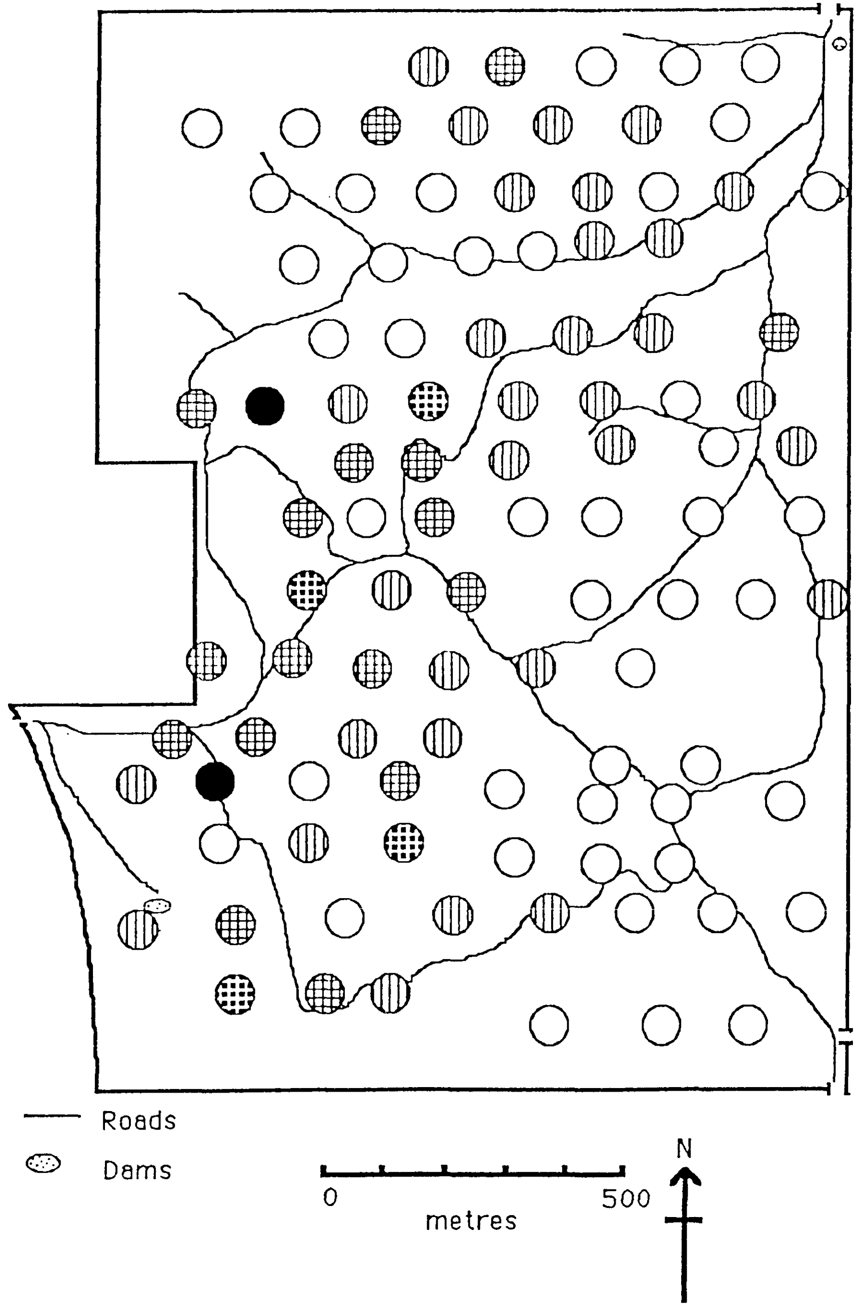
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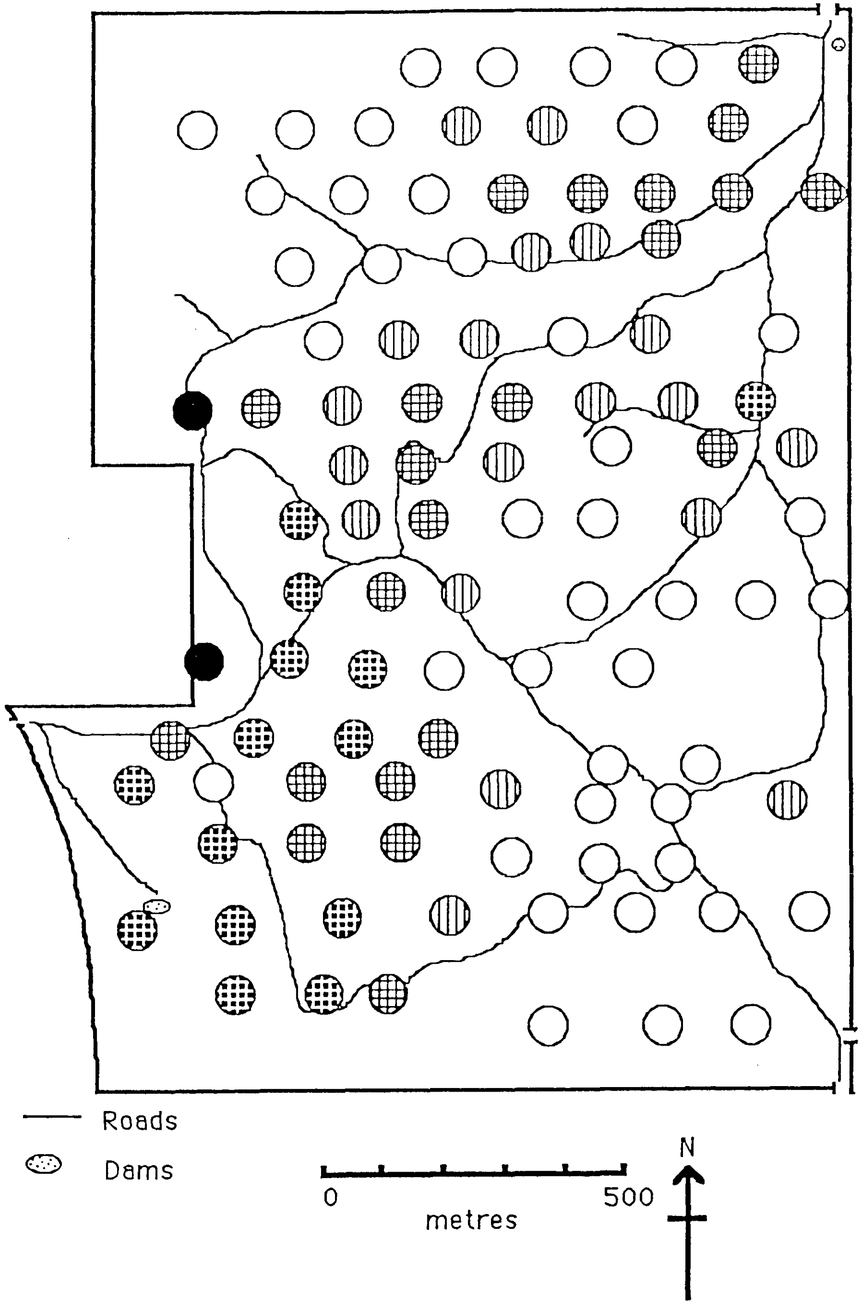
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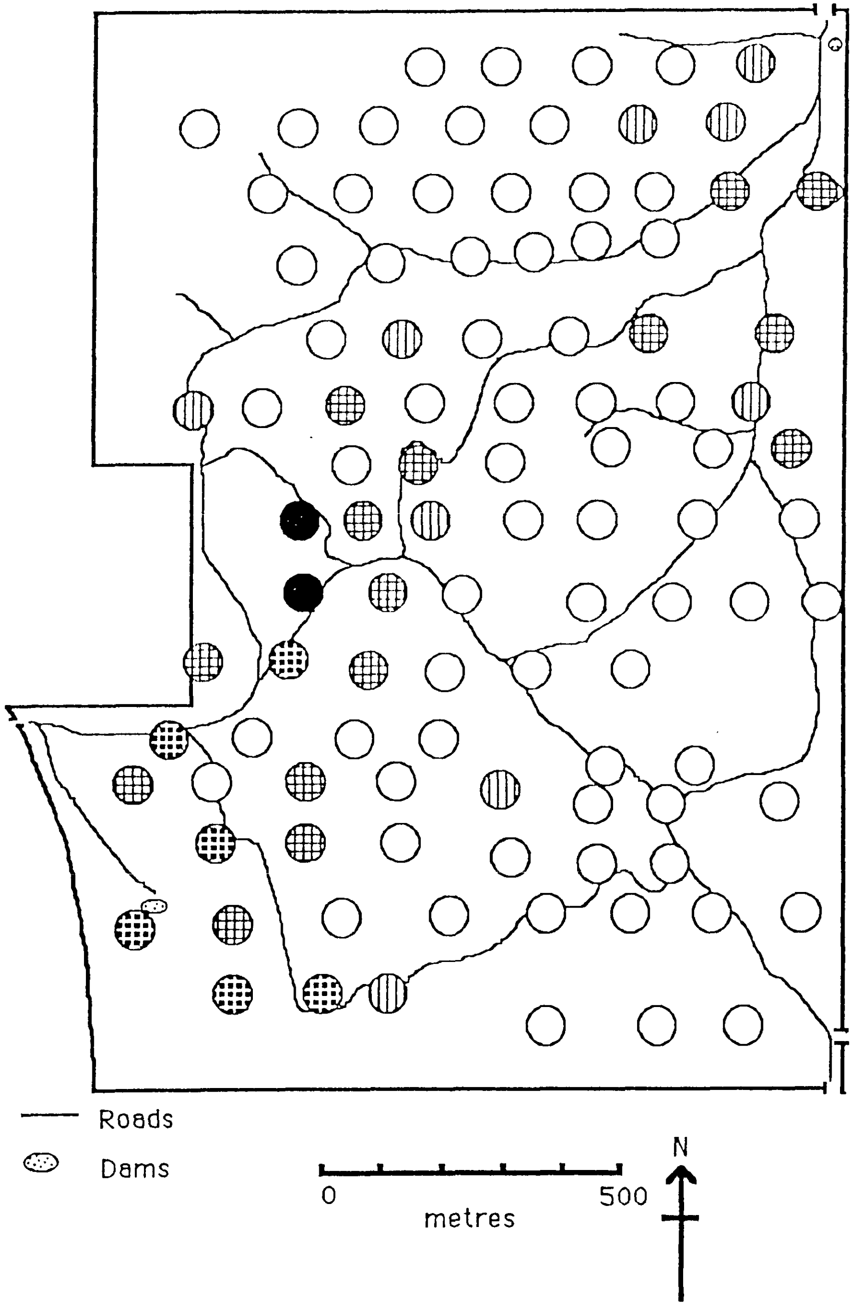
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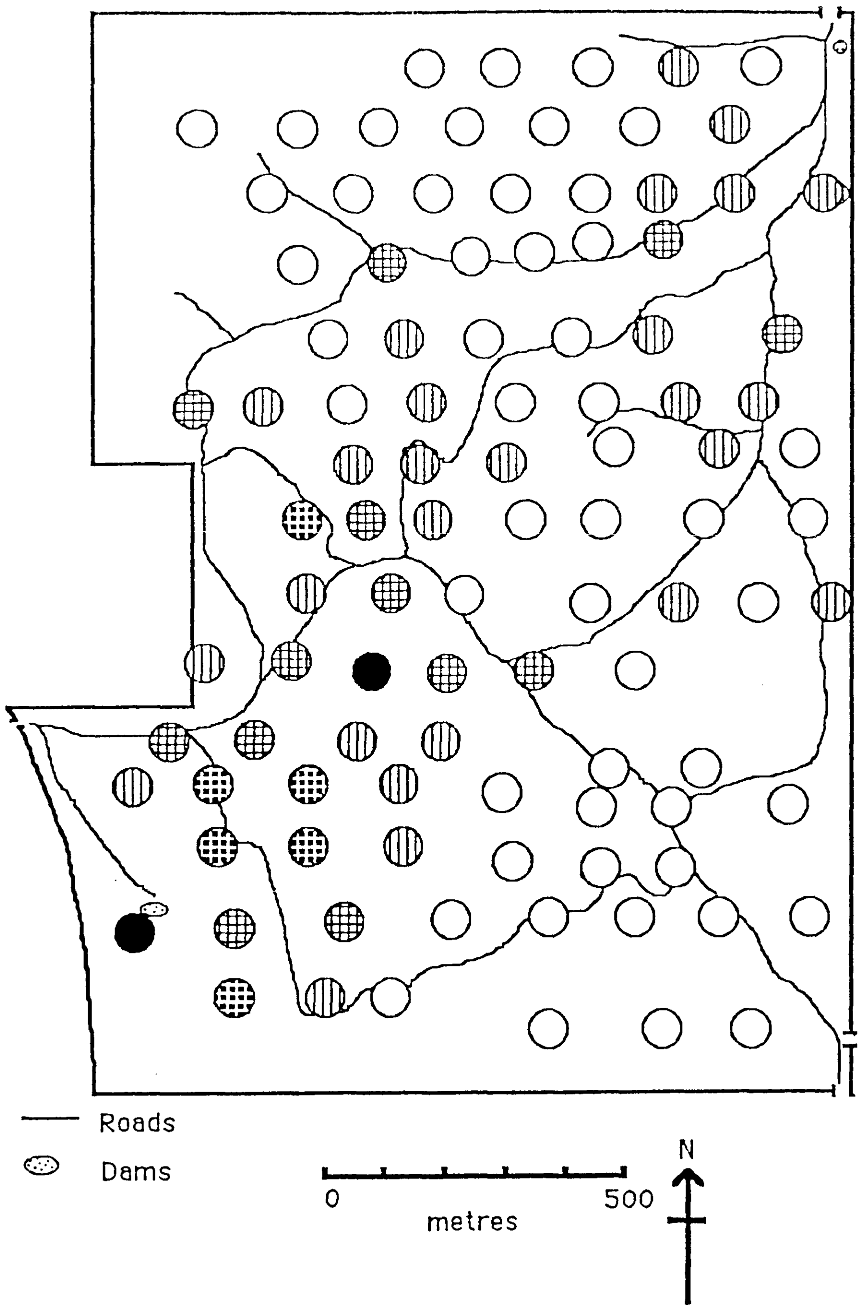
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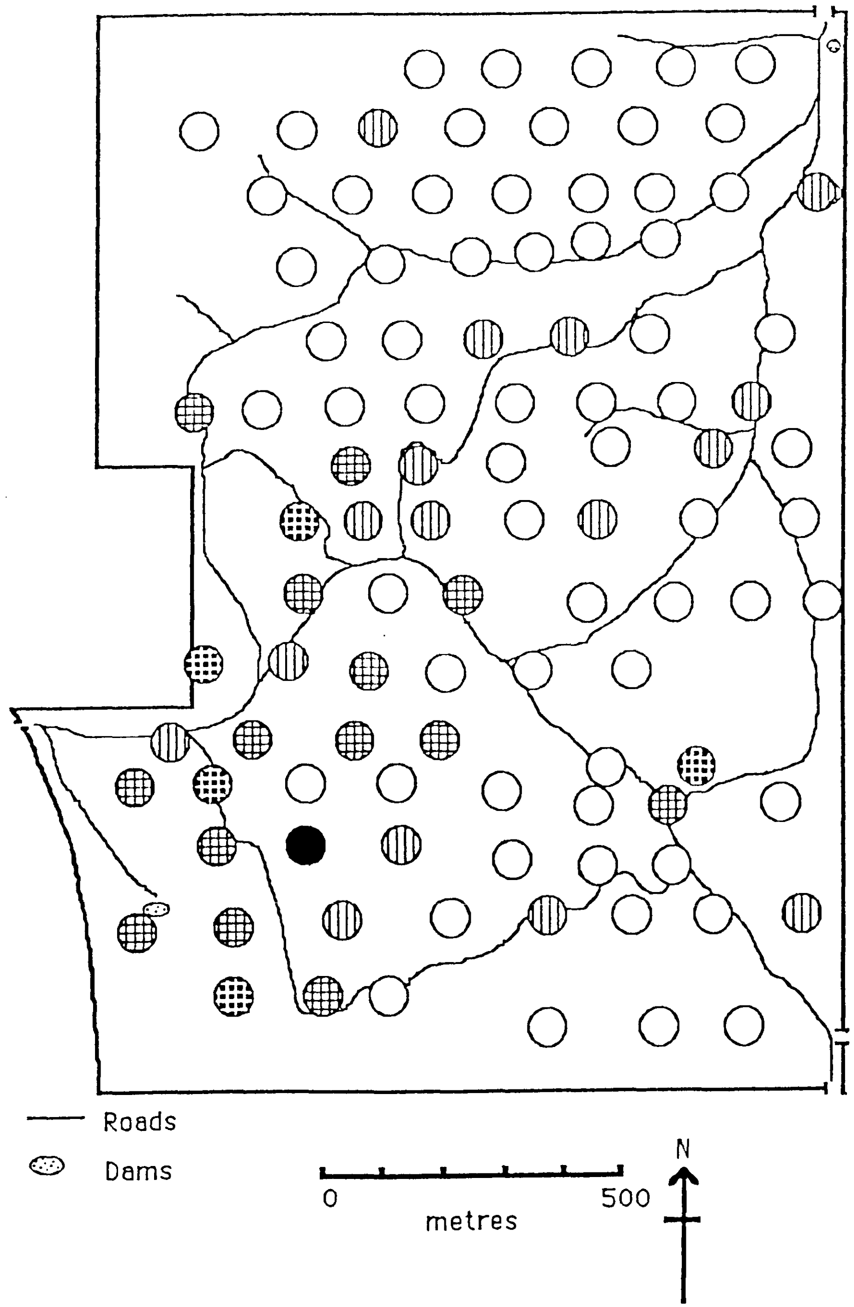
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with birds being abundant (around 3 counted in 5 minutes, and Ford pers. comm.) in the area 4.3, 4.13-4.15 in mid- to late- 1984. By the start of censusing, however, there were very few Fuscous in this area.

The results of the canonical correlation and multiple regression analyses are shown in Table 3.4. There were no significant canonical correlations in autumn 1986. In all other seasons, the Fuscous Honeyeater dominated the avifauna, as shown by the very high weightings on this species in the analysis. Fuscous Honeyeaters were most numerous in habitats with few stringybarks (and therefore, many gums), at low altitudes (the numbers of gums were significantly correlated with low altitude) and where the understorey was sparse. They also congregated where mistletoe was common, especially when the mistletoe was flowering. The regressions suggested a similar habitat description.

3.3.2 Other insectivorous honeyeaters

White-naped Honeyeaters made up most (82% by number) of this group. They occurred at lower densities than the Fuscous, but were more dispersed, particularly in autumn 1987, 1988 and winter. They appeared to be very rare in autumn 1986, but this was a result of my not learning their calls until winter and having to rely on visual detection. Their density was probably higher than that calculated as they were one of the species that was often in mixed-species feeding flocks (hereafter known as MSF's), and it was difficult therefore to count all individuals. MSF's were much more frequent in autumn and winter (see later) and so White-naped Honeyeaters were most apparent at these times.

Other species of mostly insect-feeding honeyeaters seen were Yellow-faced Honeyeaters (average of 0.03 per point), Brown-headed Honeyeaters (0.02 per point), Noisy Miners (0.02 per point) and a single White-eared Honeyeater. The first two species occurred most of the time (67% and 63% of detections respectively) in association with White-naped Honeyeaters, in MSF's. There were small resident populations (the White-naped was seen in all seasons, the Brown-headed in most) of these species in Eastwood, however the high count of Yellow-faced Honeyeaters in autumn 1988 was probably due to an influx of migrant birds (this may also be the case for the higher counts of the Brown-headed Honeyeater at this time). Noisy Miners increased throughout the survey, becoming more numerous in the extreme north-eastern and south-western corners. There had always been resident colonies of Noisy Miners in more open country outside the Forest near these corners, thus the increase represented an extension of the range of this species.

These other insectivorous honeyeaters (hereafter known as OIHE) rarely had significance in explaining the distribution of birds in Eastwood (see Table 3.4,

TABLE 3.4: Results of canonical correlation analyses and regressions. Significance given if P<0.05, else given as NS. In any season, the results of the canonical variates are given first, then those of the regressions (indicated REG). Most important species (column SPECIES) and environmental (column ENVIRONMENT) variables are those with weightings in the canonical analysis greater than 0.5, ( ) indicates borderline cases. There were no significant canonical correlations in autumn 1986, the first two sets of canonical variates were significant in winter (indicated by 1 and 2), and in all other seasons, only the first set of variates were significant (indicated by 1). All abbreviations as before, but also FHE (Fuscous Honeyeater), Th (small insectivores), TC (bark feeders), GST (in this Table includes GST, BFCS and CrST), Wh (Whistlers), Ae (aerial feeders) and Large (mixed feeders) for bird species/groups. Habitat variables are NO. STR (number of stringybarks), ALT (altitude), FL MIST (index of flowering mistletoe), MD (mistletoe distance, inverse index of density) and %U (percentage cover by understorey). Associations are positive unless indicated (by - sign).

SEASON		SIGNIFICANCE	SPECIES	ENVIRONMENT
AUTUMN'86		NS	OIHE	- NO. STR
			- LARGE	- %U
	REG	P<0.047	OIHE	MD
WINTER	1	P<0.001	FHE	- NO. STR
			NHE	FL MIST
				- %U
	2	P<0.049	FHE	- NO. STR
			- NHE	- ALT
				- %U
	REG	P<0.001	FHE	- NO. STR
		P<0.004	FHE	- %U
		P<0.018	OIHE	%U
		P<0.018	NHE	ALT
		P<0.001	NHE	FL MIST
		P<0.029	GST	%U
		P<0.014	Wh	- ALT
SPRING	1	P<0.001	FHE	- ALT
				- NO. STR
				- %U

SEASON		SIGNIFICANCE	SPECIES	ENVIRONMENT
	REG	P<0.003	FHE	- NO. STR
		P<0.001	FHE	- ALT
		P<0.001	FHE	FL MIST
		P<0.033	FHE	MD
		P<0.001	FHE	- %U
		P<0.047	Th	ALT
		P<0.012	GST	MD
		P<0.001	Wh	- NO.STR
SUMMER	1	P<0.005	FHE	- ALT
			(Ae)	
	REG	P<0.001	FHE	- NO. STR
		P<0.006	FHE	- ALT
		P<0.047	TC	ALT
		P<0.001	Ae	- ALT
		P<0.027	Ae	- %U
AUTUMN'87	1	P<0.006	FHE	- NO. STR
				- %U
				(- ALT)
	REG	P<0.001	FHE	- NO. STR
		P<0.012	FHE	- ALT
		P<0.006	FHE	- %U
		P<0.043	OIHE	%U
		P<0.017	Wh	%U
		P<0.011	LARGE	MD
AUTUMN'88	1	P<0.033	FHE	- NO. STR
			(- OIHE)	- MD
				- %U
	REG	P<0.012	FHE	- NO. STR
		P<0.007	FHE	- %U
		P<0.004	Th	MD
		P<0.031	GST	- ALT
		P<0.015	LARGE	FL MIST

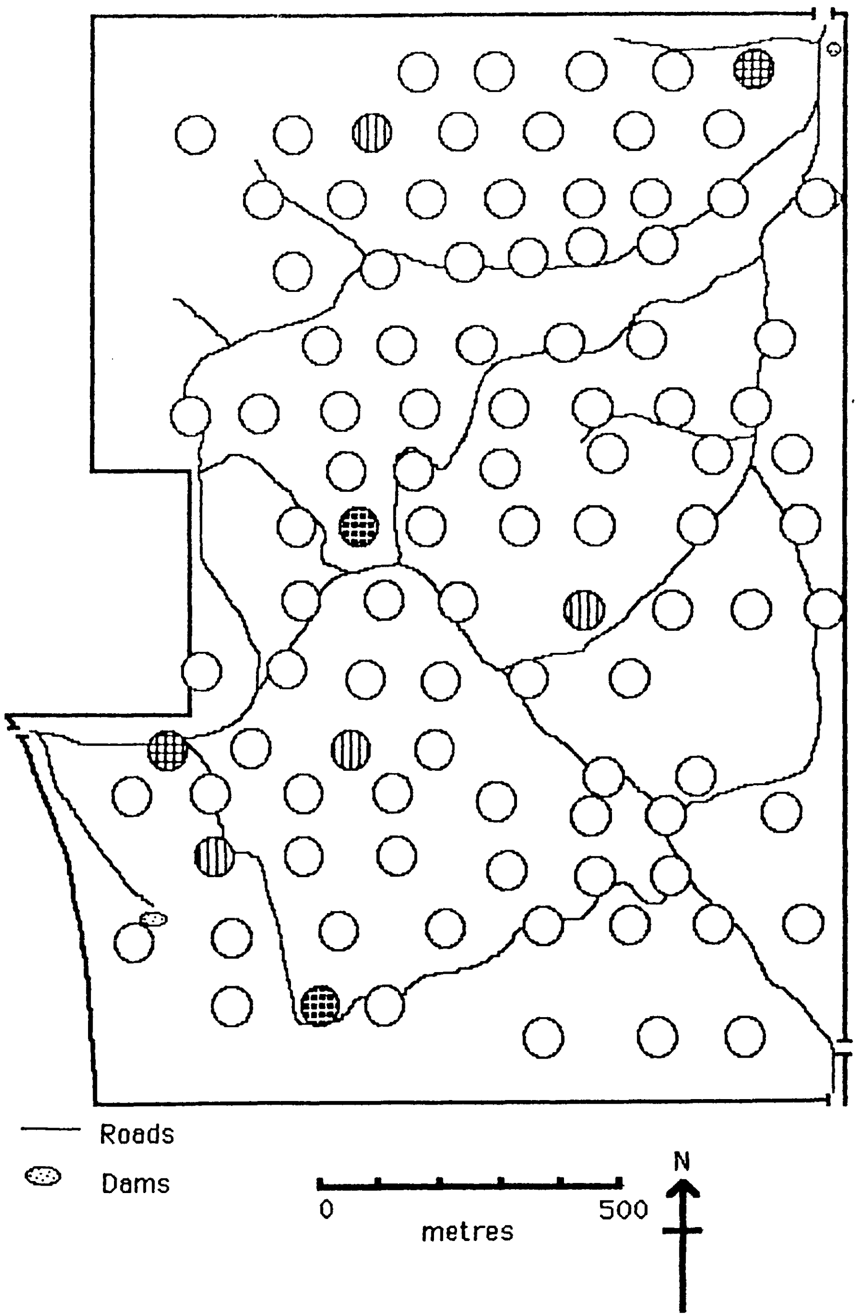
this group had low weightings in the canonical correlation analysis except in autumn 1988). The analyses suggested that these honeyeaters were found in areas where mistletoe was sparse, and where there was more understorey and, in autumn 1988, where stringybarks were common. This habitat description is the opposite to that of the Fuscous and suggests that these two groups of honeyeaters were found in somewhat different areas. A comparison of the distribution maps (see Figures 3.2 and 3.3) confirms this.

3.3.3 Nectarivorous honeyeaters

Three species of honeyeaters were considered to have largely nectarivorous diets; these were, in order of abundance, Red Wattlebirds (see Tables 3.1, 3.2, mean of 0.23 birds per point), Noisy Friarbirds (mean of 0.08 per point) and Eastern Spinebills (0.01 per point). Red Wattlebirds (see Appendix 3) were scattered throughout the Forest, occurring in the highest numbers in the central third. Small aggregations (up to 10 birds) were seen at flowering eucalypts. They were recorded least in winter, and were most evenly spaced in summer. They declined in numbers during the census (comparison between the three autumns). Eastern Spinebills, similarly, seemed to have decreased in abundance during counting, although they were never present in large numbers. Spinebills were most often seen feeding in flowering mistletoe (86% of sightings). Noisy Friarbirds were summer breeding migrants (first recorded during census on 22/9/86, last sighting was on 24/3/87). Like the Red Wattlebirds, they were well dispersed throughout the study site (Appendix 3), but tended not to be in high numbers where the wattlebirds were most abundant.

Table 3.4 shows the results of the canonical and regression analyses. Nectarivorous honeyeaters were most strongly weighted in the canonical analysis in winter, when they were correlated, in the first set, with few stringybarks, where mistletoe was flowering and understorey was sparse, similar to habitats where Fuscous occurred. The second (just significant) set of correlates and the regressions suggest that the nectarivorous honeyeaters (at this time mostly Red Wattlebirds) also occurred at higher altitudes (and hence, because the factors were correlated, where there were more stringybarks). The results were probably disproportionally affected by the aggregations of wattlebirds at a few flowering trees in areas where stringybarks were quite common (see Appendix 3).

FIGURE 3.3: Map of Eastwood showing the distribution of insectivorous honeyeaters excluding Fuscous. Seasons as in Figure 3.2. Relative densities of honeyeaters are: 0 (empty circle), <2 (vertical lines in circle), <4 (black grid on white in circle), <6 (white grid on black in circle) and 6+ (black circle).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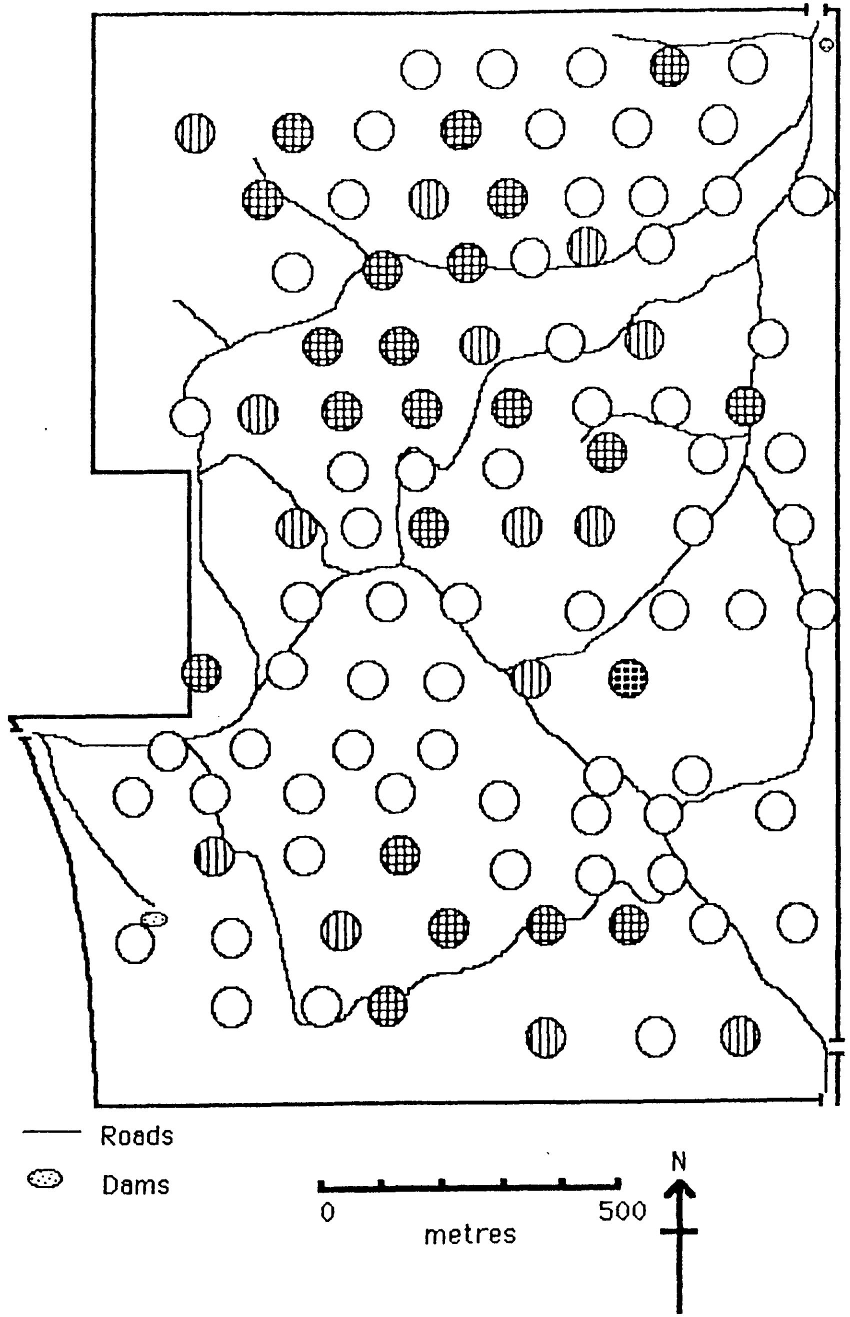
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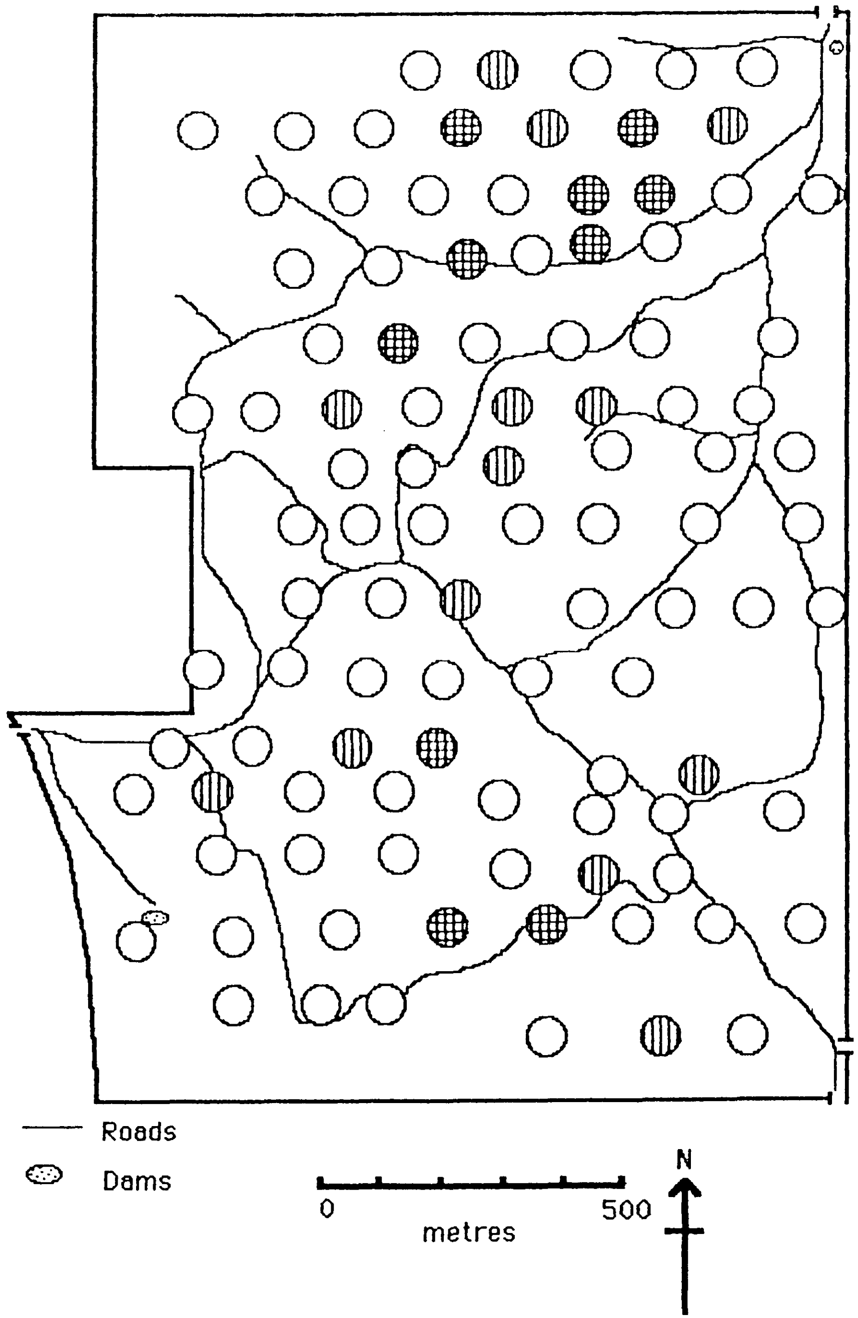
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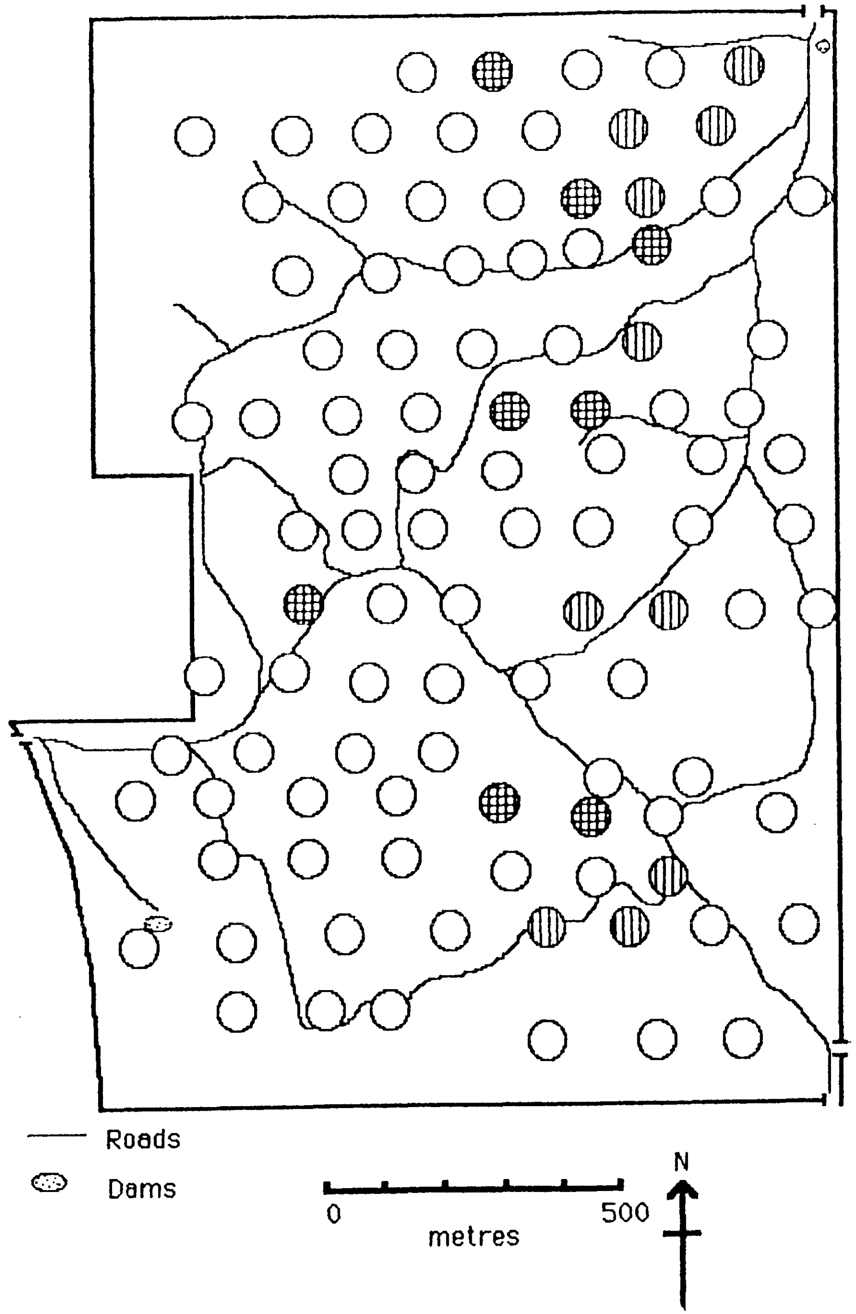
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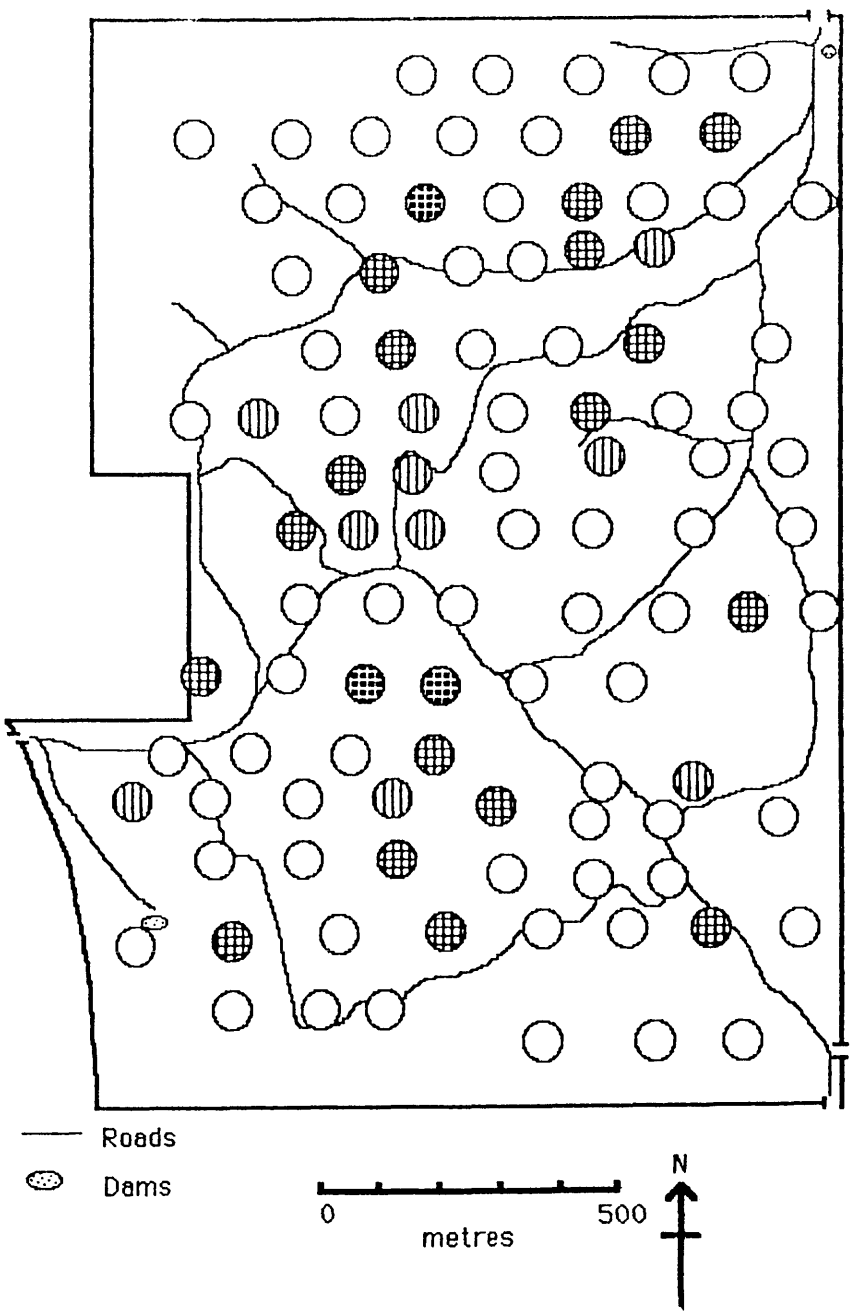

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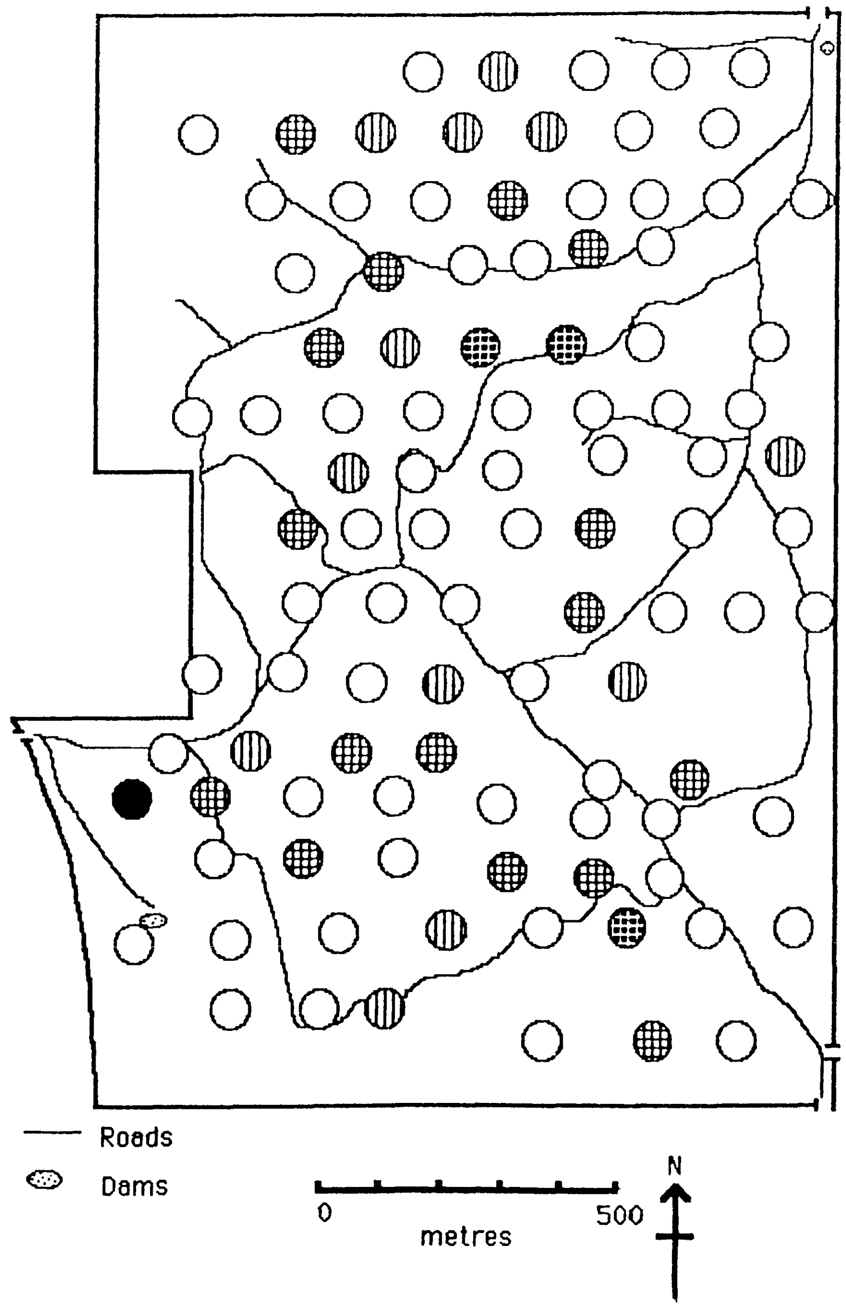

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3.3.4 Small insectivores

This guild of small, mostly leaf-gleaning insectivorous birds was composed of 7 species, many of whom were seen most frequently in MSF's. Therefore, they tend to be underestimated in numbers but not in distribution.

Thirty-seven percent of the thornbills were not identified to species, of the rest, 70% were Buff-rumped Thornbills, 20% were Striated Thornbills and 10% were Yellow-rumped Thornbills. Collectively, they were common (Tables 3.1, 3.2) although, when not forming flocks in spring and summer, appeared to be much less numerous.

Pardalotes were also included in this group. Sixty-two percent of pardalotes were detected only by sound and were not identified to species. Of those that were, 86% were Spotted Pardalotes and the rest were Striated Pardalotes. Ford and Bell (1982) found that Striated Pardalotes were the more common species in 1978, but were less numerous by 1979. Pardalotes were seen rarely, or not at all, in summer and autumn 1988. In the other seasons, although not common (mean of 0.06 birds per point, see Table 3.1), they were well dispersed (see Appendix 3). An initial impression, that they were seen most often in MSF's, was found not to be the case (only 47% of sightings were with MSF's).

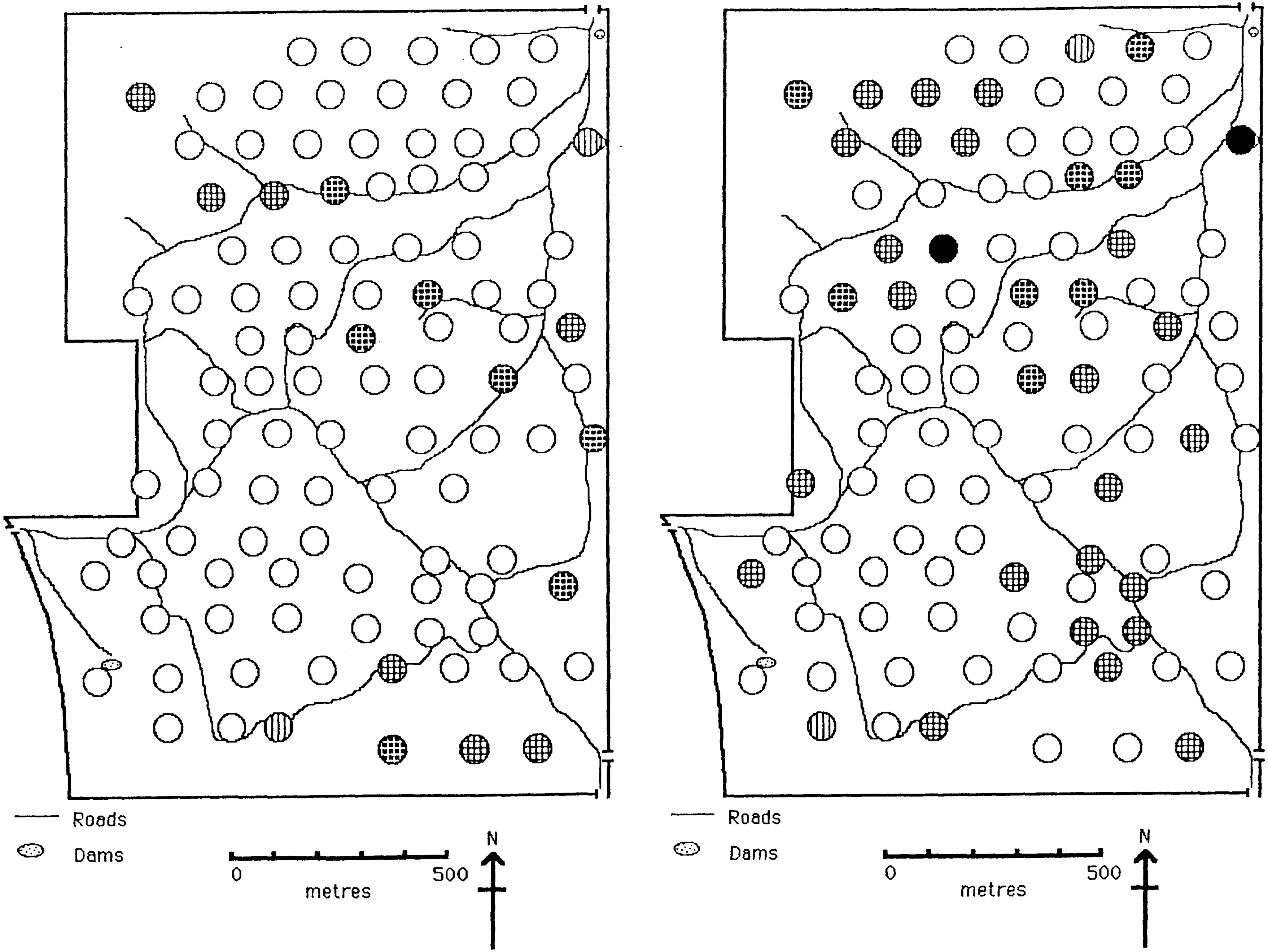
Silvereyes occurred infrequently (mean of 0.01 birds per point) in autumn, associated with MSF's. White-throated Gerygones were present during spring to autumn, but were uncommon (see Table 3.1, mean of 0.02 per point).

This group rarely helped explain the distribution of birds in Eastwood, as shown by the low weightings in the canonical correlation analysis (see Table 3.4). The regressions showed that, in spring and autumn 1988, these species occurred at higher altitudes and where the mistletoe was sparse. Their distribution was almost completely complementary to that of the Fuscous Honeyeater, occurring in the north-west and south-east of the Forest (compare Figures 3.2 and 3.4).

3.3.5 Bark-feeders

Three species were included in this group; these were White-throated and Brown Treecreepers and Varied Sittellas. Treecreepers, especially White-throated, were common (see Table 3.1, mean of 0.37 birds per point) and occurred in small groups or individually, so were very widespread (Table 3.1 and Appendix 3). Forty-six percent of treecreepers were not identified to species, as I could not distinguish the calls but of the rest, 79% were White-throated and 21% were Brown Treecreepers. Ford and Bell (1982) and Ford *et al.* (1985) found similar relative abundance of these species. Sittellas were probably under-represented in the sample, as they were identified by sight only. Treecreepers were most concentrated in spring

FIGURE 3.4: Map of Eastwood showing the distribution of thornbills (3 species, see Section 3.3.4). Seasons as in Figure 3.2. Relative densities of thornbills are: 0 (empty circle), <2 (vertical lines in circle), <4 (black grid on white in circle), <6 (white grid on black in circle) and 6+ (black circle).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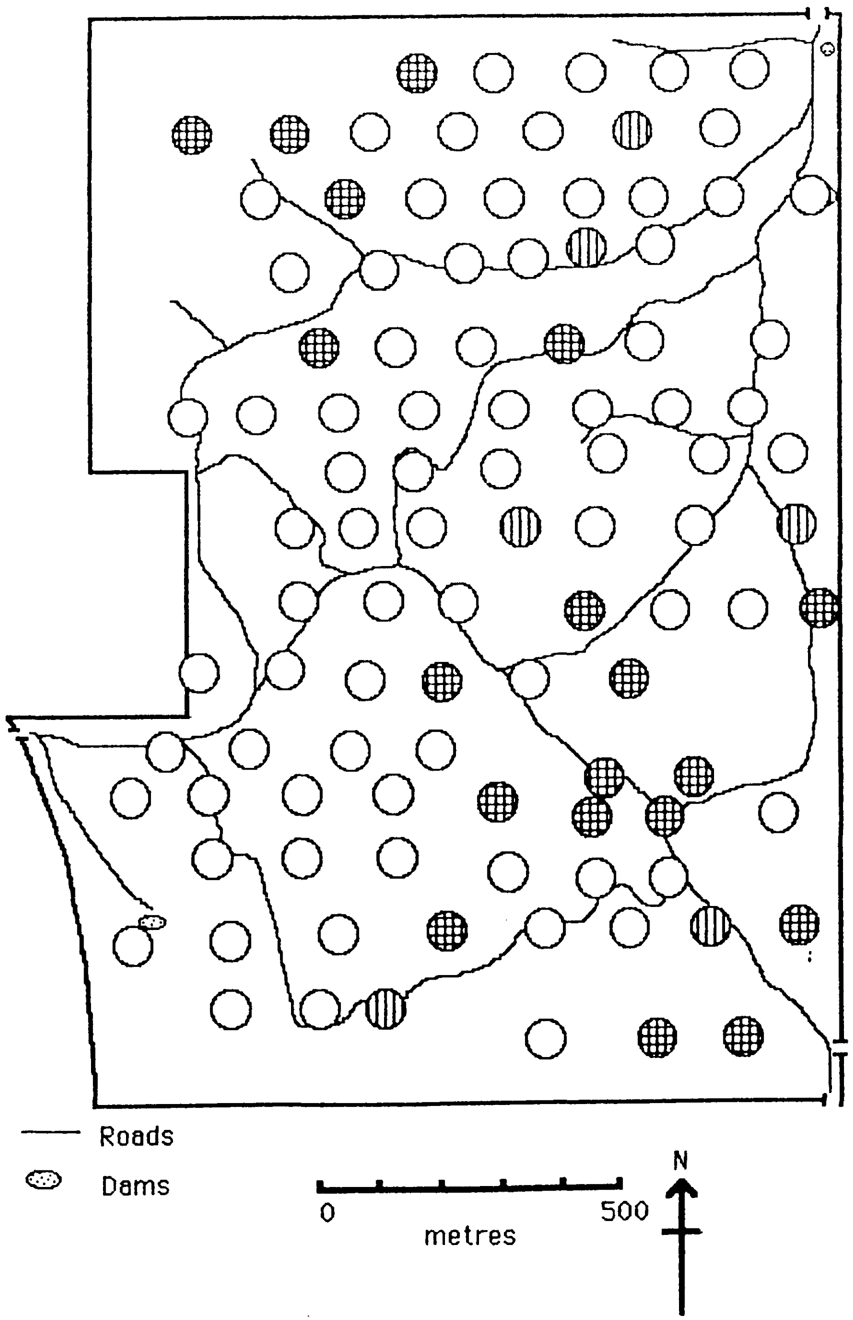
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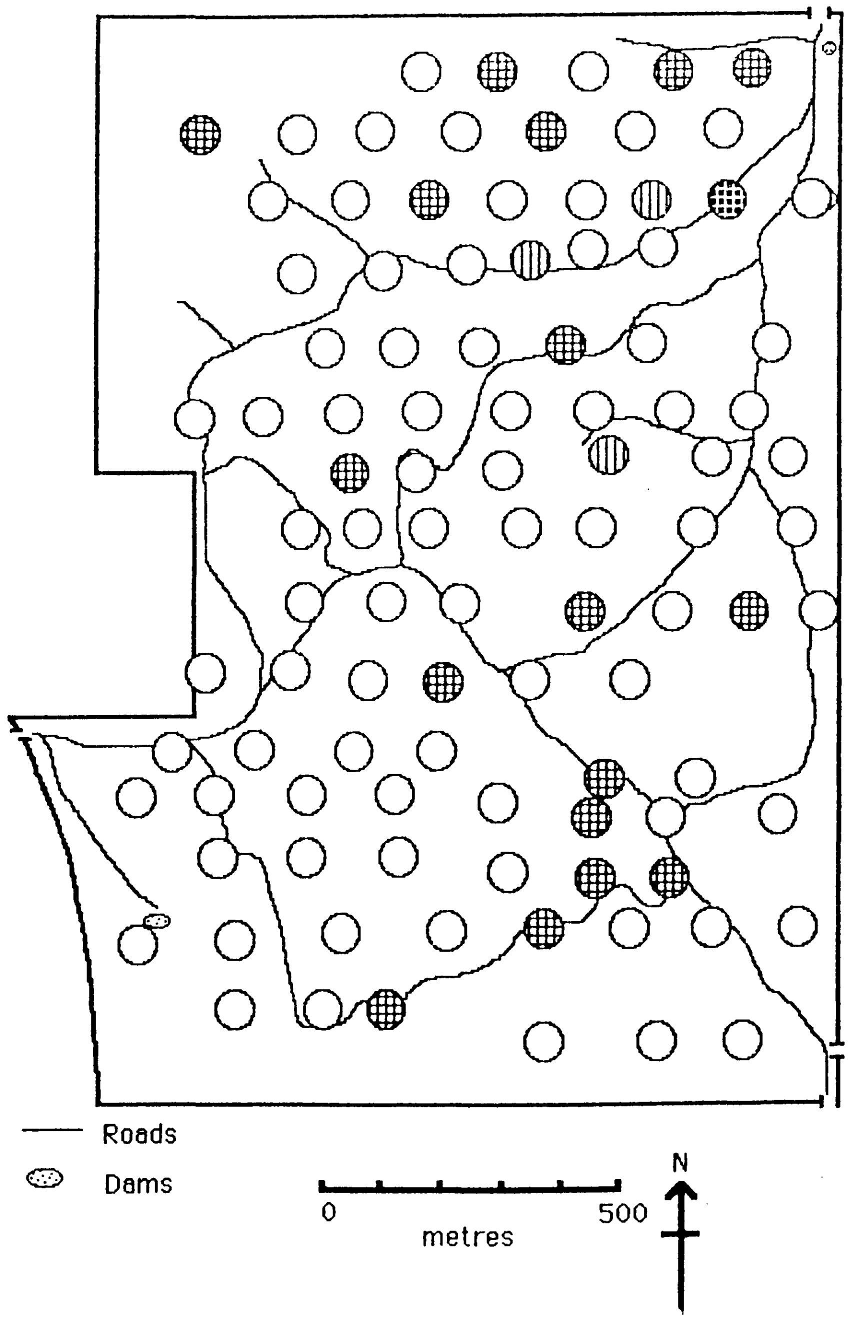
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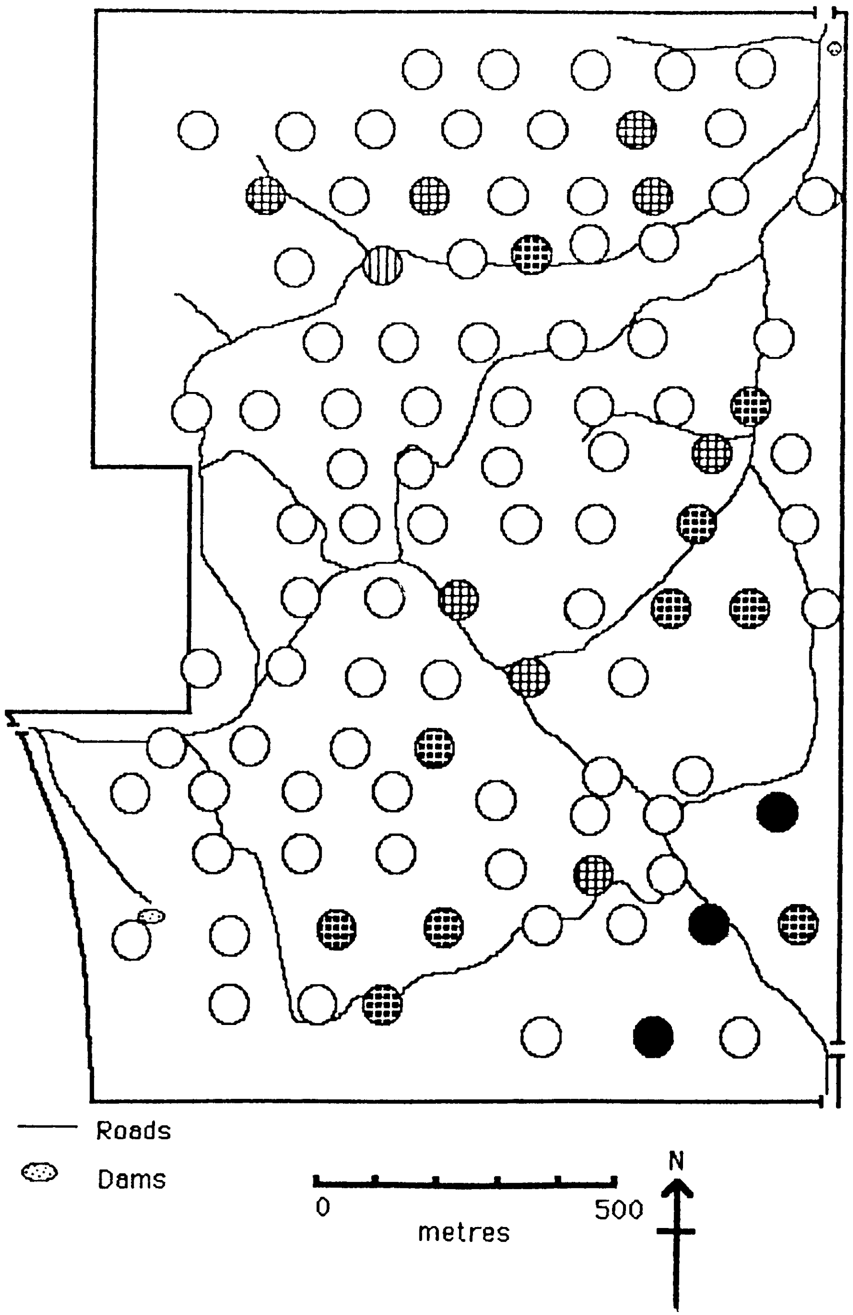

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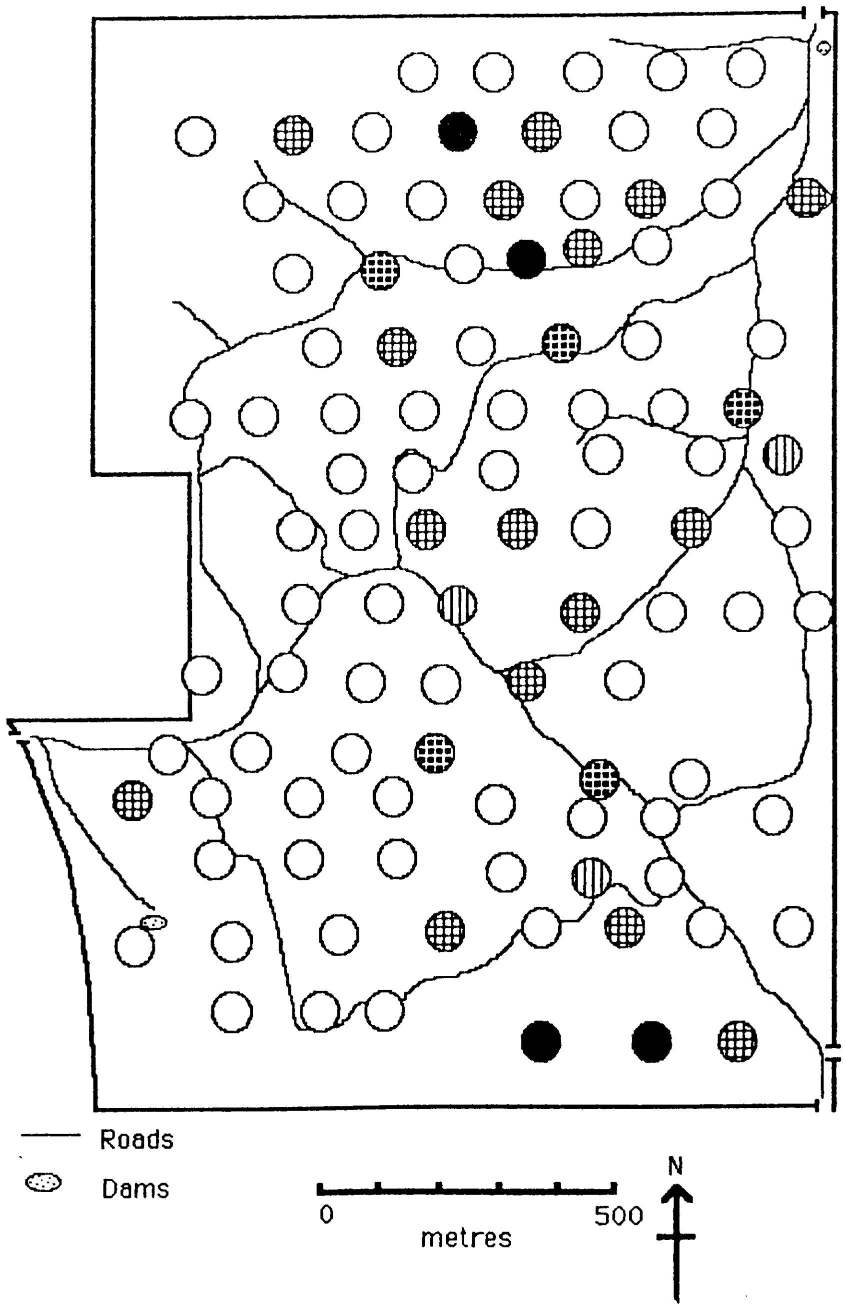

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when they were territorial and breeding, sittellas were least obvious in summer when they were not in MSF's.

Although common, this group appeared to have little influence on the distribution of species in the Forest, as shown by their consistently low weightings in the canonical analysis (see Table 3.4). They were rarely related to any of the environmental variables that were tested, with only one significant regression in summer, when they were found at higher altitudes.

3.3.6 Whistlers

Two species of whistlers appeared in Eastwood; they were Rufous Whistlers, breeding migrants in spring to autumn, and Golden Whistlers, overwintering migrants that were present in autumn to spring. Rufous Whistlers were territorial, and most common in the north-west corner (see Appendix 3 though not well covered by the census points, this was the main study area for Bridges working on Rufous Whistlers). Golden Whistlers were usually seen associated with MSF's (53% of sightings in autumn and winter), and were in lower numbers than the Rufous (see Table 3.1).

Whistlers were not highly weighted in the canonical correlation analysis (Table 3.4), but the regressions found that they were found at low altitudes in winter, with few stringybarks in spring and where understorey was denser in autumn 1987. This apparent flexibility may be the result of different behaviour and habitat choices by the two species of whistler.

3.3.7 Large insectivores

Three species were included in this group of larger, insectivorous birds that feed mostly off leaves and branches (see Ford *et al.* 1986); these were Grey Shrike-thrushes, Black-faced Cuckoo-shrikes and Crested Shrike-tits. The last species was the least common (mean of 0.02 birds per point, see Table 3.1) and occurred most frequently in the south-west quarter of the Forest (see Appendix 3). Grey Shrike-thrushes were spread throughout the Forest in autumn and winter, often associating with MSF's (49.3% of sightings in these seasons), but were more concentrated in the south-west quarter during the breeding season. Black-faced Cuckoo-shrikes were spread throughout the forest in all seasons, though most obvious in summer (Appendix 3 and Table 3.1).

Although this group was not strongly influencing the distribution of birds (low weighting in the canonical analysis, see Table 3.4), their numbers were related to some of the measured environmental variables. In winter and autumn 1988 they were most numerous in areas at low altitude and in spring where mistletoe was sparse.

3.3.8 Robins

Robins were fairly rare (total mean of 0.074 birds per point, see Table 3.1). Three species occurred at Eastwood; these were, in order of decreasing abundance, Scarlet Robins, Eastern Yellow Robins and Rose Robins. Scarlet and Rose Robins occurred most frequently in MSF's (74.3% and 66.7% of all sightings respectively) and this was reflected in their distribution (see Appendix 3), where they were seen throughout the northern half and in the south-eastern corner. Eastern Yellow Robins rarely were associated with MSF's (only 30% of sightings) and were most abundant in the south-west. All three species were recognised by sight only in autumn 1986, so their abundance appears to be low then.

Ford (Ford and Bell 1982, Ford *et al.* 1985) found that Eastern Yellow Robins were far more abundant than Scarlet Robins, but the Yellow Robins had drastically declined in numbers by the present study. None of the environmental variables measured in this study appeared to influence their distribution (Table 3.4), but this is partly the result of the different species having varying habitat requirements and partly because they were in such low numbers.

3.3.9 Aerial feeders

Six species were considered to take insects mostly in the air or to be flying while hunting. These were Grey Fantails, Willie Wagtails, Dusky Woodswallows and three species of flycatchers (Restless, Leaden and Satin). See Appendix 3 for the distribution of Willie Wagtails and Grey Fantails. The latter occurred throughout the Forest, usually in association with MSF's (69% of sightings) and so was most common in the south-eastern and north-western parts of Eastwood. It was very abundant in autumn 1987 and 1988 - probably these were mostly passage migrants. Grey Fantails were seen in all seasons so there was almost certainly a breeding population as well. Willie Wagtails were confined almost exclusively to the south-western quarter of Eastwood. They were most abundant in spring and summer, but may have declined in numbers as none was recorded in autumn 1988. Dusky Woodswallows were present for the spring/summer breeding season, and were seen only in the south-west corner. The flycatchers were also most abundant in spring and summer, but were widely dispersed, often appearing with MSF's in autumn and winter. Restless Flycatchers were the species recorded most often (52.4% of identified birds) but 36.4% of birds were not identified to species (heard, not seen).

The distribution of this group partly explained the relationship between the birds and the environmental variables in summer (Table 3.4). In this season, aerial feeders were most common at low altitudes, and where the understorey was sparse.

3.3.10 Parrots

Twenty-eight percent of rosellas were not identified to species but, of the rest, 87% were Eastern Rosellas and the rest were Crimson Rosellas. They were found throughout the Forest (see Appendix 3), although Ford (pers. comm.) found the Crimson Rosellas to be more common in the stringybark areas (see Chapter 2). Their numbers were not related to any of the measured environmental variables (Table 3.4). There were few seasonal effects in numbers or dispersion. Other parrots seen rarely were Red-rumped Parrots and a Galah. Both were common in the open country around Eastwood.

3.3.11 Large birds

Five species were included in this group; these were, in order of decreasing abundance, White-winged Choughs, Australian Magpies, Pied Currawongs, Australian Ravens and Grey Butcherbirds (see Table 3.1 for abundance of these species). Flocks of choughs (mean size 6.5 birds, n=43, s.d. 3.73) were seen in most areas (see Appendix 3), with the smallest group size and most dispersion occurring in summer. Magpies (see Appendix 3) occurred in much smaller groups (average 2.0 birds, n=114, s.d. 1.19). Both these species were most obvious in summer, and tended not to co-occur (the two species were seen to interact aggressively when together, see later). Ravens and currawongs were recorded infrequently, but were seen throughout Eastwood; butcherbirds were rare but appeared to increase during the census (see Table 3.1).

The measured environmental factors generally did not appear to influence the observed distribution of this group (Table 3.4). They appeared to be most numerous in the southern half of the Forest in autumn 1987, corresponding to sparse mistletoe, and to amount of flowering mistletoe in autumn 1988, although my observations, and those of Ford *et al.* (1986), suggested that mistletoe was a substrate never used by these species.

3.3.12 Other birds

All the above species were included in the analyses, and comprised nearly 96% of the birds counted. Other species that were seen regularly, but in small numbers, were Superb Fairy-wrens (in groups associated with brambles, see Nias 1984, 1987), Speckled Warblers (throughout the area, often with MSF's in autumn and winter), Laughing Kookaburras (most heard in autumn, unrecorded in summer), Sacred Kingfishers (a spring and summer breeding migrant), cuckoos (Fan-taileds were seen in autumn 1986 and winter, and Horsefield's Bronze-cuckoo in summer and autumn 1987), Mistletoebirds (seen in mistletoes but occasionally with MSF's), Rufous Songlarks (a regular summer breeder but highly variable in numbers) and White-winged Trillers (similarly a summer breeder). Species recorded very rarely or as vagrants were Dollarbirds (which appeared to increase in numbers during the census), Australian Magpie-larks (a pair nested near the large dam in the south-west), Painted Button-quails (seen once, present in very low numbers) and Olive-backed Orioles (one seen). Diamond Firetails had drastically declined in numbers from 1984 and were only seen once; similarly Red-browed Firetails had declined and were not seen during the census, but were occasionally observed at other times. Other species that occurred in spring and summer in Eastwood but were not recorded in the census, were Welcome Swallows and Tree Martins as both were above the canopy. White-browed Woodswallows were usually vagrants in the area but hundreds bred in Eastwood during the 1987/88 season. Peaceful Doves, Yellow-tailed Black-cockatoos, Scarlet Honeyeaters and Regent Honeyeaters were very rarely recorded and not during the census.

3.3.13 Mixed Species Feeding Flocks

Many species have been mentioned above as joining MSF's. Tables 3.5 and 3.6 show the incidence and percentage composition of these flocks. MSF's were seen in all months, however they were most common in early-autumn through to late-winter. Flock sizes were largest in autumn 1988 and smallest in autumn 1986 (fewer birds identified due to my inexperience), with an overall average of nearly 7 birds per flock (see Table 3.6). Twenty-nine species were recorded as being in association as a MSF; 5 of these were considered to be nuclear species, that is, species that formed the flock, which other birds then joined (see Bell 1983a, Ford 1989). These were three species of thornbills (Buff-rumped, Striated and Yellow-rumped), White-naped Honeyeaters and Varied Sittellas. All flocks contained at least one of these five species. Nine other species (Grey Fantails, Scarlet and Rose Robins, Yellow-faced, Brown-headed and White-eared Honeyeaters, White-throated Gerygones, Golden Whistlers and Silvereyes) were seen almost exclusively in MSF's. Fuscous Honeyeaters were rather problematic; they were often seen in the same area as a MSF, but frequently displayed aggressive behaviour towards other species in the flock. It is possible that they were attracted to the presence of other birds, which they tried to exclude, rather than feeding with the flock (more data would need to be collected on their activity patterns while with the flock to distinguish between these alternatives). For this reason, data are presented with and without Fuscous Honeyeaters.

TABLE 3.5: Incidence and size of mixed-species foraging flocks, from bird censusing. Flocks per day (FLOCKS/DAY) are means, calculated monthly. Mean size of flocks (SIZE) include sample size (n) and standard deviation (sd). Percentage of points with mixed-species flocks (% POINTS) are calculated from mean frequency occurrence of a mixed-species flock at points. April to December are in 1986, January to May are in 1987 and March to May are in 1988.

MONTH	FLOCKS/DAY	SIZE	n	sd	% POINTS
APRIL	1.2	4.5	6	1.05	10.0
MAY	2.6	5.2	13	2.79	21.7
JUNE	2.5	7.3	15	3.75	25.0
JULY	2.5	6.9	14	2.46	23.3
AUGUST	2.6	7.5	13	3.07	21.7
SEPTEMBER	1.8	5.6	9	2.88	18.8
OCTOBER	0.5	7.0	1	0	1.4
NOVEMBER	0.4	8	2	2.83	3.3
DECEMBER	1.0	5.2	5	1.30	8.3
JANUARY	1.3	5.4	8	2.39	13.3
FEBRUARY	1.0	5.6	5	3.78	13.9
MARCH	2.1	9.6	16	3.66	19.0
APRIL	1.3	5.8	5	1.30	16.7
MAY	2.7	7.5	8	5.63	26.7
MARCH	1.7	10.4	5	5.41	13.9
APRIL	3.8	5.6	14	2.47	29.2
MAY	3.7	10.3	9	5.26	25.0

TABLE 3.6: Composition of mixed-species flocks, by mean number per flock (MEAN, sample size 148 flocks) and percentage (% TOTAL). Percentage composition without Fuscous Honeyeaters is also given (% NO FHE, see text). Core species are thornbills, White-naped Honeyeaters and Varied Sittellas. Abbreviations for species as before, except that GST is only Grey Shrike-thrush (does not include BFCS and CrST).

SPECIES	MEAN	% TOTAL	% NO FHE
Thornbills	2.7	38.8	41.7
White-naped Honeyeater	1.1	15.8	17.0
Varied Sittella	0.2	2.9	3.1
FHE	0.5	7.2	-
Yellow-faced Honeyeater	0.1	1.4	1.5
Brown-headed Honeyeater	0.1	1.4	1.5
White-eared Honeyeater	0.02	0.3	0.3
Pardalotes	0.2	2.9	3.1
White-throated Gerygone	0.1	1.4	1.5
Silvereye	<0.01	0.1	0.2
White-throated Treecreeper	0.5	7.2	7.7
Brown Treecreeper	0.1	1.4	1.5
Whistlers	0.4	5.7	6.2
GST	0.1	1.4	1.5
CrST	0.02	0.3	0.3
Mistletoebird	0.02	0.3	0.3
Speckled Warbler	0.03	0.4	0.5
Superb Fairy-wren	0.04	0.6	0.6

	MEAN	% TOTAL	% NO FHE
Grey Fantail	0.4	5.7	6.2
Flycatchers	0.2	2.9	3.1
Scarlet Robin	0.1	1.4	1.5
Rose Robin	<0.01	0.1	0.2
Eastern Yellow Robin	0.03	0.4	0.5
Mean Total	6.98		
Without FHE	6.48		

3.3.14 Associations and interactions between species

From the distribution maps (see Figures 3.2 to 3.4 and Appendix 3) and the canonical correlation analyses and regressions (see Table 3.4), it is obvious that while some species occur together frequently and react similarly to the same environmental factors, other bird species rarely or never do so.

There were distinct differences in the species composition of birds in the areas dominated by Fuscous Honeyeaters and those areas with few Fuscous (see Table 3.7). The areas with many Fuscous had more species and more individuals than those with few or no Fuscous. Fuscous Honeyeaters made up between 35% (in autumn) and 52% (in spring) of birds in their areas. Several other species of birds were most common, or only occurred in the Fuscous areas. Correlations between species (Table 3.8) show that Fuscous were most often associated with rosellas (in most seasons), nectarivorous honeyeaters in winter, aerially-feeding species in winter and summer (Willie Wagtails in both, and Restless Flycatchers and Dusky Woodswallows in summer, see Table 3.7) and larger insectivores (Grey Shrike-thrushes, Black-faced Cuckoo-shrikes and Crested Shrike-tits) in spring and summer. These are all species that were rarely, if ever, chased by Fuscous (see Table 3.9) or, because of their large size, were relatively unaffected by Fuscous aggression. Fuscous were significantly negatively associated with thornbills and other small insectivores in spring and summer. Rufous Whistlers occurred with Fuscous in spring (Table 3.8), but Golden Whistlers, as mentioned above, most frequently associated with species that formed mixed-species flocks in autumn and winter.

The other suite of species occurred in areas where the Fuscous was rare. It consisted of species that were chased by Fuscous and, because they were smaller, were subordinant to the Fuscous. Species such as thornbills and the small honeyeaters avoided the areas where Fuscous were common. These species associated together to form mixed-species feeding flocks, particularly in autumn and winter (Table 3.8). Species involved included, apart from the small honeyeaters and the thornbills, Scarlet Robins, Grey Fantails and treecreepers and sittellas. Grey Shrike-thrushes accompanied these mixed-species flocks in autumn and winter but were significantly associated with Fuscous Honeyeaters in spring and summer.

Table 3.9 shows the aggressive interactions that were recorded. The vast majority of these interactions were intra-specific (80.8%), with most of these being between Fuscous Honeyeaters (69.8% of the total encounters). Fuscous Honeyeaters chased one another significantly more than expected during the breeding season (chi^2 test, n=130, P<0.05); this was the season that the Fuscous were most closely associated with one another and had nests to defend (see also Chapter 7). Fuscous Honeyeaters also chased other species of birds more during the breeding season

TABLE 3.7: Relative abundance of birds in areas where Fuscous Honeyeaters are common (FHE) and areas where they are rare (nonF). Data from bird census presented seasonally. Taken from 4 points at two locations for each density of Fuscous, some of which were resampled within a season (total of 19 points for winter, 18 points for spring, 18 points for summer and 27 points in high-Fuscous area and 24 in low-Fuscous area for autumn). Small ground feeders includes Superb Fairy-wrens (in FHE areas) and Speckled Warblers (in nonF areas). Miscellaneous includes Dollarbirds, cuckoos and Diamond Firetails.

SPECIES	WINTER		SPRING		SUMMER		AUTUMN	
	FHE	nonF	FHE	nonF	FHE	nonF	FHE	nonF
Fuscous Honeyeater	2.79	0.16	4.17	0.11	3.83	0	2.85	0.04
White-naped Honeyeater	0.32	0.63	0	0.28	0.11	0.06	0.33	0.38
Other insectivorous HE	0.16	0	0	0	0	0.11	0	0.17
Red Wattlebird	0.53	0	0.50	0.17	0.11	0.22	0.19	0
Thornbills	0.05	1.00	0	0.44	0	0.67	0.07	1.25
Pardalotes	0.11	0.11	0.06	0	0	0	0.04	0.08
Other small insectivores	0	0	0	0	0	0	0.37	0.03
Treecreepers	0.11	0.53	0.06	0.22	0.50	0.44	0.30	0.33
Varied Sittella	0	0.16	0	0.28	0	0	0.19	0

SPECIES	WINTER		SPRING		SUMMER		AUTUMN	
	FHE	nonF	FHE	nonF	FHE	nonF	FHE	nonF
Whistlers	0.05	0.16	0.06	0.17	0.39	0.11	0.15	0.08
Grey Shrike-thrush	0.26	0.11	0.67	0.06	0.44	0.06	0.22	0.13
Black-faced Cuckoo-shrike	0	0	0.06	0	0.39	0	0.22	0.08
Crested Shrike-tit	0	0	0	0	0.06	0	0.22	0
Mistletoebird	0	0.05	0	0	0.06	0	0	0.04
Small ground feeders	0.21	0	0.33	0	0.17	0	0.30	0.14
Grey Fantail	0	0	0	0.11	0	0	0.19	0.42
Willie Wagtail	0.32	0	0.50	0	0.28	0	0.11	0
Restless Flycatcher	0	0	0.06	0	0.06	0	0.07	0
Leaden Flycatcher	0	0	0	0.06	0	0.11	0	0
Dusky Woodswallow	0	0	0.39	0	0.28	0	0	0
Eastern Yellow Robin	0.16	0	0	0	0	0.06	0.04	0
Scarlet Robin	0	0.05	0	0	0	0.06	0.04	0.21

SPECIES	WINTER		SPRING		SUMMER		AUTUMN	
	FHE	nonF	FHE	nonF	FHE	nonF	FHE	nonF
Rosellas	0.37	0	0.56	0	0.33	0	0.48	0.13
Other parrots	0	0	0	0	0.06	0.28	0	0
White-winged Chough	0.32	0.53	0	0.61	0	0.89	0.41	0.75
Australian Magpie	0.05	0.26	0.28	0.06	0.72	0.28	0.89	0.21
Other large	0	0.05	0.17	0.11	0	0.06	0.07	0.17
Kingfishers	0.05	0	0.06	0	0.06	0.28	0	0
Miscellaneous	0	0	0	0	0.33	0	0	0
Mean Total	6.05	3.79	8.00	2.67	8.05	3.78	8.07	4.62
Total without FHE	3.26	3.63	3.83	2.56	4.22	3.78	5.22	4.58
Total nonF leaf-gleaners	0.63	1.74	0.06	0.72	0.11	0.83	0.81	1.92

TABLE 3.8: Correlations between groups of birds, data from bird censusing, presented seasonally. SPECIES PAIRS indicates the correlation is between those bird groups/species. Seasons are AUT'86 (autumn 1986), WIN (winter), SPR (spring), SUM (summer), AUT'87 (autumn 1987) and AUT'88 (autumn 1988). Abbreviations are FHE (Fuscous Honeyeater), OIHE (other insectivorous honeyeaters, see text), NHE (nectarivorous honeyeaters), Th (small insectivores), TC (bark feeders), Wh (whistlers), GST (large insectivores), Ae (aerial feeders), Rob (robins), Ros (rosellas) and Large (mixed feeders). ns indicates correlation is not significant, ( ) indicates P=0.05, correlation in plain text indicates P<0.05, correlation in **bold** text indicates P<0.01. All correlations are positive unless indicated (by - sign). Sample size for autumns is 120, for other seasons n = 180.

SPECIES PAIR	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88
FHE & NHE	(0.178)	**0.331**	ns	ns	ns	ns
F & Th	ns	ns	**-0.242**	**-0.163**	ns	ns
F & GST	ns	ns	**0.286**	**0.270**	ns	ns
F & Wh	ns	ns	**0.236**	ns	ns	ns
F & Ae	ns	**0.195**	ns	**0.246**	ns	ns
F & Ros	**0.242**	0.155	0.157	ns	ns	ns
OIHE & Th	ns	**0.340**	ns	**0.203**	ns	**0.238**
OIHE & TC	ns	**0.238**	ns	ns	ns	ns
OIHE & Wh	ns	ns	ns	ns	ns	**0.296**
OIHE & GST	ns	0.154	ns	ns	ns	ns
OIHE & Ae	ns	ns	**0.307**	ns	**0.238**	ns

SPECIES PAIR	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88
OIHE & Rob	ns	**0.253**	ns	ns	**0.271**	0.196
NHE & Th	ns	-0.148	ns	ns	ns	ns
Th & TC	ns	**0.369**	ns	ns	0.183	ns
Th & Wh	ns	0.182	ns	ns	**0.609**	**0.284**
Th & GST	ns	**0.256**	ns	ns	ns	ns
Th & Ae	ns	ns	0.164	**0.247**	ns	ns
Th & Rob	0.183	**0.307**	ns	ns	**0.286**	**0.299**
TC & Wh	ns	ns	0.170	ns	**0.401**	ns
TC & GST	**0.257**	0.192	ns	ns	ns	ns
TC & Ae	**0.254**	ns	ns	ns	**0.383**	ns
TC & Rob	ns	**0.247**	ns	ns	0.225	0.197
Wh & GST	ns	**0.196**	ns	ns	ns	ns
Wh & Ae	ns	**0.219**	ns	ns	ns	ns
Wh & Rob	ns	ns	ns	ns	**0.444**	**0.294**

SPECIES PAIR	AUT'86	WIN	SPR	SUM	AUT'87	AUT'88
GST & Ae	**0.273**	ns	ns	ns	ns	ns
GST & Rob	**0.313**	0.154	ns	ns	ns	ns
GST & Large	**0.354**	ns	ns	ns	ns	ns
Ae & Rob	ns	0.184	ns	ns	ns	ns
Ae & Ros	ns	0.186	ns	ns	ns	ns
Ae & Large	0.217	ns	ns	ns	ns	ns
Rob & Ros	ns	ns	ns	ns	ns	**0.244**

TABLE 3.9: Aggressive interactions (chases and mobbings) between birds. Data from census and observations during whole study, given as numbers and percentages of total. ATTACKED SPECIES (may be groups) are Fuscous Honeyeater, other insectivorous honeyeaters (White-naped, Yellow-faced and Brown-headed Honeyeaters), nectarivorous honeyeaters (Red Wattlebird and Noisy Friarbird), thornbills and pardalotes, treecreepers and sittellas, whistlers, large insectivores (GST, BFCS and CrST), aerial feeders (Grey Fantail, Willie Wagtail and flycatchers), woodswallows (Dusky and White-browed Woodswallows), robins (Eastern Yellow and Scarlet), Superb Fairy-wren, Fan-tailed Cuckoo, miscellaneous (White-winged Triller and Rufous Songlark), Large (choughs, magpies, currawongs and butcherbirds),Boobook Owl and Tawny Frogmouth, raptors (sparrowhawk and Australian Goshawk) and kingfishers (kookaburras and Sacred Kingfisher). Chases and mobbings by Fuscous given separately in column FHE, but are included in the column INTRASP (intra-specific interactions) and totals, where indicated. Column INTERSP (inter-specific interactions) includes chases directed at Fuscous but all others in this column are interactions not involving Fuscous.

	ATTACKING SPECIES:					
ATTACKED SPECIES	FHE		INTRASP		INTERSP	
	NO.	%	NO.	%	NO.	%
Fuscous Honeyeater	565	69.8	565	69.8	8	1.1
Other insectivorous honeyeaters	12	1.5	19	2.4	5	0.6
Nectarivorous honeyeaters	16	2.0	6	0.7	3	0.4
Thornbills & pardalotes	4	0.5	3	0.4	3	0.4
Treecreepers and sittellas	11	1.4	1	0.1	4	0.5
Whistlers	3	0.4	0	0	1	0.1

ATTACKED SPECIES	ATTACKING SPECIES: FHE		INTRASP		INTERSP	
	NO.	%	NO.	%	NO.	%
Large insectivores	13	1.6	14	1.7	3	0.4
Aerial feeders	8	1.0	20	2.5	2	0.2
Woodswallows	3	0.4	11	1.4	1	0.1
Robins	2	0.2	0	0	2	0.2
Superb Fairy-wren	3	0.4	0	0	0	0
Fan-tailed Cuckoo	1	0.1	0	0	0	0
Miscellaneous	2	0.2	0	0	0	0
Rosellas	0	0	9	1.1	2	0.2
Large	6	0.7	5	0.6	13	1.6
Boobook Owl and Tawny Frogmouth	5	0.6	0	0	3	0.4
Raptors	0	0	0	0	2	0.2
Kingfishers	3	0.4	1	0.1	11	1.4
Total Aggression by Fuscous	657	81.2				
Total Aggression including Fuscous			654	80.8	155	19.2
Total Aggression excluding Fuscous			89	11.0	63	7.8
Overall total					809	100.0

(chi^2 test, n=26, P<0.05). At first glance, Fuscous aggression looks indiscriminate (Table 3.9). If species that were not present all year are excluded, then 6 species of birds were chased only during the breeding season (see also Chapter 7), in nest or territory defence - these were Red Wattlebirds, Grey Shrike-thrushes, Black-faced Cuckoo-shrikes, Superb Fairy-wrens and Willie Wagtails, all species that occur with Fuscous at this time but are not in the same feeding guild (Ford *et al.* 1986). Mobbing of predators was also significantly more common during the breeding season (t-test, n=17, P<0.05). Chases by Fuscous Honeyeaters of other species made up 11.4% of the total, whereas Fuscous were only chased by other species in 1% of observed encounters. The majority of interspecific encounters not involving Fuscous were smaller birds mobbing potential nest predators (29 out of 55 interactions, 52.7%). Interspecific non-Fuscous chases accounted for 6.8% of the total observed interactions. Species of birds that were chased by Fuscous all year round were White-throated Treecreepers, White-naped and Yellow-faced Honeyeaters, Yellow Robins and whistlers. Pardalotes and Grey Fantails were attacked more frequently in the non-breeding season. All these species are tree-using insectivores and some (honeyeaters and pardalotes) probably extensively utilize the same food. Cuckoos, flycatchers, Crested Shrike-tits and Brown Treecreepers were rarely interfered with by Fuscous. Thornbills were recorded as chased only in the breeding season, however, few aggressive interactions were noted while birds were in mixed-species feeding flocks because of problems in detection. Species other than Fuscous were less aggressive during the breeding season (chi^2 test, n=66, P<0.05) probably because they interacted less when separated on territories, as opposed to being together in mixed-species flocks.

3.4 DISCUSSION

Three previous censuses have been carried out at Eastwood, during winter and spring 1978, spring to summer 1979, and throughout 1981 (Ford and Bell 1981, Ford *et al.* 1985, see Table 3.2 for a summary of results). All but the first census were in a restricted area of Eastwood, corresponding to the area outlined by the points 3.15-3.13-3.4-4.16-4.2-4.1, the earliest was more wide-ranging. The birds were mostly counted along fixed-width transects.

The densities of birds found in Eastwood were 23.5 (1978) and 21.1 (1979) birds/ha, closely comparable to the total density found in the present study (20.0 birds/ha). The 1981 census was done towards the end of a severe drought (1980-81) and the total density of birds was reduced (only 9.7 birds/ha were recorded). The drought appeared to affect small birds most, with thornbills, Speckled Warblers, White-throated Gerygones, Brown-headed and White-naped Honeyeaters, Superb Fairy-wrens, and possibly Grey Shrike-thrushes and whistlers declining in numbers (all insectivorous species). Finches and Eastern Spinebills also decreased in abundance, the former being seed-eaters (grasses failed to produce seed) and the latter being nectarivorous. Both Eastern Spinebills and Red Wattlebirds declined throughout the present census, possibly because of the dry conditions in 1986/87 and poor flowering of eucalypts (see Chapter 2). Interestingly, Brown Treecreepers were little affected by drought and White-throated Treecreepers were greatly reduced in numbers, this probably reflects the differences in their ecology - the White-throated Treecreeper is a generalist and opportunist with a small home-range and breeds in pairs whereas the Brown Treecreeper is more specialized and forms stable family groups on large home-ranges (Noske 1982, 1985), the latter factors might be predicted to assist survival under conditions of reduced food.

Some of these species seem to have suffered long-term declines to the present day, for instance Superb Fairy-wrens and finches. Conditions, after the 1980-81 drought, were reasonably good up to 1986 and finches (Red-browed and Diamond Firetails) were quite common in 1984-85 (personal observations), but by the time censusing had begun, they were declining in numbers and had virtually disappeared by the end of the study. Neither species were seen in 1988 (Ford pers. comm.). The decrease in density of Superb Fairy-wrens can probably be related most to the reduction in area and quality of brambles after spraying. Brambles are their preferred and successful breeding sites (Nias 1984, 1987). Rosellas (Eastern and Crimson) and the Australian Magpie have shown long-term increases in abundance, and during the present study Grey Butcherbirds and Noisy Miners became more common. This may be due to a reduction in thickness of the understorey and possibly the canopy. Frequent dry conditions and grazing meant the understorey never really recovered from the 1980-81 drought, and fire-wood harvesting continues in the Forest and has caused localised thinning of the canopy, especially near tracks.

Migratory and nomadic species such as White-naped, Brown-headed and Yellow-faced Honeyeaters, pardalotes, Silvereyes, Grey Fantails, some of the robins and flycatchers, cuckoos and White-throated Gerygones show generally larger fluctuations in abundance than the sedentary species, as might be expected. The exceptions to this are the seasonal migrants Noisy Friarbirds and Dusky Woodswallows, which show little change from year to year. The White-winged Chough is sedentary and long-lived (Heinsohn pers. comm.), but shows marked variations in numbers from 1978 to the present, and during this study, probably due to their seasonal changes in flocking habits (Heinsohn 1987).

Some of the differences between the results of this study and those found previously are due to the restricted sampling and different methods of the earlier studies, either seasonally (the 1978 and 1979 censuses were only for part of the year) or regionally (most of the earlier work was done in the mid-eastern part of the Forest). There are quite major differences in the species-mix throughout the Forest and seasonally (see Figures 3.2 to 3.4, Appendix 3 and Tables 3.7 and 3.8). Many of these differences relate to the distribution of resources and consequent habitat-selection by particular species, and to inter-specific interactions, both positive (associations) and negative (aggression/competition).

The canonical correlation analyses (Table 3.4) indicated that the abundance and distribution of many species could be related to various features of the environment. Fuscous Honeyeaters were associated with areas of gums (mostly *Eucalyptus viminalis* and *E. blakelyi*, see Chapter 2) rather than stringybarks (*E. caliginosa*). They also tended to occur in areas of sparse understorey, and at low altitude. Gums grow most abundantly in the deeper soils in the valleys and are associated with grass cover rather than shrubs (see Chapter 2). Fuscous were attracted to flowering mistletoe and eucalypts. So too were Red Wattlebirds, Noisy Friarbirds and Eastern Spinebills, the former two being dominant to the Fuscous and the latter subordinate. These species were present in rather low numbers, apart from the Fuscous. In winter, when the mistletoe were flowering most (see Chapter 2), Red Wattlebirds and the spinebills were significantly correlated with it and with one another (Tables 3.4 and 3.8).

Aggregations of honeyeaters at sources of nectar have been frequently noted (Paton 1980, Collins and Briffa 1982, Loyn 1985, Pyke 1985, Recher *et al.* 1983 etc.). Species such as White-naped, Yellow-faced and Brown-headed Honeyeaters are attracted to flowering trees and shrubs, although not in this study due to the poor flowering of eucalypts and the lack of major alternative nectar-rich plants. Here, these species were most often associated with areas of denser understorey (Table 3.4) which may be partly due to avoidance of Fuscous areas. These small, mostly insectivorous honeyeaters were subordinate to Fuscous Honeyeaters (Table 3.9). Their distribution was most different to that of the Fuscous in winter (Figures 3.2 and 3.3, Tables 3.7 and 3.8) when they were associated with MSF's, and in summer when they occurred most in areas of denser undergrowth.

Rosellas were significantly associated with Fuscous in most seasons (Tables 3.7 and 3.8). Although unrelated to any of the measured environmental variables, Eastern Rosellas feed on the ground in grassy areas (Wyndham and Cannon 1985, Ford *et al.* 1986). These areas occur at low altitudes along the valley floors (see Chapter 2), where gums are dense and hence Fuscous are common. There were no interspecific interactions noted between these species.

The group of birds containing Grey Shrike-thrushes, Black-faced Cuckoo-shrikes and Crested Shrike-tits sometimes co-occurred with Fuscous (in spring and summer, Tables 3.7 and 3.8) and in the rest of the year, were associated with groups forming MSF's (thornbills, other insectivorous honeyeaters etc.). The Grey Shrike-thrushes were the most abundant species in the group and followed the MSF's, the other two species did not change their distribution much through the year. Their numbers correlated with several of the environmental variables measured (Table 3.4), although not consistently with any particular factor, and they have been recorded as using the tree species in roughly the proportions at which the trees occur (Ford *et al.* 1986). A possible reason why they associate with Fuscous during the breeding season is that by nesting in the areas of high Fuscous density, these species, particularly the Grey Shrike-thrush, benefit from the protective effects of Fuscous vigilance and mobbing (see also Chapter 7). Grey Shrike-thrushes were rarely chased by Fuscous, except when close to the nest (Table 3.9 and Chapter 7). Fuscous were found to have higher nesting success in the areas of many Fuscous (see Chapter 7). Such protective associations have been noted previously between grebes and gulls (Burger 1984), several species and Fieldfares (*Turdus pilaris,* Slagsvold 1980a and b, Wiklund 1979 and Wiklund and Andersson 1980) and among waders (Dyrcz 1981). A similar association possibly exists between the Australian species, Leaden Flycatchers and Noisy Friarbirds (Marchant 1983).

There was a similar positive correlation between whistlers and Fuscous during the breeding season (Tables 3.7 and 3.8) where the species involved was the Rufous Whistler, and associations with MSF's in winter by Golden Whistlers. Neither species showed any consistent relationship with the measured environmental factors. Both species are chased by Fuscous (Bridges pers. comm. and Table 3.9). The result during the breeding season may be incorrect as the main breeding concentration of Rufous Whistlers was located in the extreme north-western corner of the Forest, an area not well covered by the census points but where Fuscous are uncommon.

Robins and the aerial feeders similarly included species that were associated with Fuscous (Eastern Yellow Robins, Willie Wagtails, Dusky Woodswallows and, to a lesser extent, Restless Flycatchers) in summer, and those that often occurred in MSF's (Scarlet Robins and Grey Fantails). The correlations shown by the robins (Table 3.8), in particular, ought not to be too strongly regarded as robins were rather infrequently recorded. The aerially-feeding species were only significantly related to low altitude and less understorey in summer. Their foraging method requires more open habitat (Cameron 1985, Recher and Holmes 1985, Ford *et al.* 1986). All these species were infrequently chased by Fuscous, except the fantail (Table 3.9).

Treecreepers were rarely significantly associated with the environmental variables and were not associated strongly with any species group. White-throated Treecreepers were the more numerous species and tended to occur frequently with MSF's in winter (Table 3.6). They prefer rough-barked tree species as foraging substrates (Noske 1985, Ford *et al.* 1986) and were consequently most common in areas of many stringybarks and this was perhaps re-inforced by Fuscous aggression, although the treecreepers were possibly so numerous that they were widespread and evenly dispersed. The Brown Treecreepers were seen most often in the more open areas (Ford pers. comm. and my observations).

Thornbills were the major core species in the formation of MSF's. They were not obviously related to any variable, although the Striated Thornbill has been found to prefer stringybarks slightly over gums (Bell 1983a, 1985b, Woinarski 1985a, Ford *et al.* 1986). Other small leaf-gleaning birds, such as the pardalotes and White-throated Gerygones and other thornbill species, have been found to prefer feeding on lerps (Woinarski 1984a, 1985a) which were more common on gums (Woinarski 1985a, Woinarski and Cullen 1984). All these species were, however, attacked by honeyeaters (Woinarski 1984b, 1985a and present study) and may avoid their preferred tree species or habitat. In this study, the distribution of these species was almost completely complimentary to that of the Fuscous. It would be necessary to remove or reduce the Fuscous to test properly if these small leaf-gleaners were being excluded from areas by the Fuscous. This would be virtually impossible with the large and continuous populations of Fuscous found here. Loyn *et al.* (1983) removed Bell Miners (*Manorina melanophrys*), which even more extremely exclude other birds, from a psyllid-infested area. They found that several small insectivorous species (honeyeaters, thornbills, pardalotes, treecreepers and sittellas) moved into the area and reduced the outbreak to low levels. In the present study, an area in the mid-north of the Forest (points 1.4,5,11-14,19 and 20) was occupied by Fuscous in winter and had few thornbills. By summer, the area had few Fuscous and was widely used by thornbills, and the trend continued to the end of the study, with no Fuscous and many thornbills in autumn 1988. The same situation prevailed in spring 1988 (Ford pers. comm.).

Many of the bird species discussed above participated in MSF's, particularly during the non-breeding season. The formation of MSF's is a common phenomenon, and has been noted from many parts of the world (Morse 1970, 1978, Krebs 1973, Grieg-Smith 1978, Diamond 1981, Bell 1983b Barnard and Thompson 1985, etc.) including in eucalypt forests and woodlands (Bell 1980, 1983a, Hermes 1981). Two main hypotheses have been proposed to account for the formation of these flocks (see Barnard and Thompson 1985 and references therein). One suggests that there are protective benefits in flocking against predators, partly because of reduced individual vigilance (which means an individual can spend more time foraging), but increased overall watchfulness as there are 'more eyes on the job' and partly because of the confusion effect to predators of multiple targets. The other hypothesis suggests that the main benefit is a more efficient exploitation of a limited and clumped food supply, because the food concentrations are more readily found with more birds searching and partly because recently exploited areas can be avoided. The flocks may also form in Australia to enable areas dominated by aggressive, but non-predatory species, like the larger honeyeaters to be 'swamped' by smaller species to gain access to food. There is evidence to support both hypotheses, which are not mutually exclusive but will differ in importance between populations. In the present study, the latter effects were probably most influential, as the number of predators was low. Also, insects may have been sparse because conditions were dry (Chapter 2, 4 and 5) and this could have initiated the earlier formation of MSF's (which were quite frequently encountered from January in 1987, but in other years were not seen before March). An earlier incidence of MSF's during dry conditions was noted also by Bell (1983a).

Finally, the Large category was numerically dominated by magpies and choughs, which had fairly similar mean densities but different group sizes. These species showed no close relationship to any other groups of birds as they were much larger birds with different feeding ecologies, or to any of the measured environmental variables. The distribution of choughs and magpies tended to be mutually exclusive, and violent fights were quite common between them (see also Rowley 1978). Other species in this category such as currawongs and butcherbirds, although not abundant, were the major nest predators of the smaller birds and were frequently mobbed by several species in the breeding season.

The organization of this community of birds changed between the breeding and non-breeding seasons. There were more species and individuals present in the breeding season, with the regular arrival of several migrant species, although 'passage' migrants could increase the autumnal totals. Most species arriving were ecologically similar to species already present (eg. Noisy Friarbirds and Red Wattlebirds, Rufous Whistlers replacing Golden Whistlers, Sacred Kingfishers and kookaburras?), the major exceptions being the seasonal influx of aerial insectivores such as woodswallows, swallows and martins, and some flycatchers. These species presumably were following the warm weather increases of flying insects (see Chapters 4 and 5, Wykes 1982, Recher *et al.* 1983, Pyke 1985 etc.). Yellow-faced Honeyeaters and Grey Fantails had small resident populations, which increased enormously in some autumns. Most other species were fairly rare and nomadic, or resident and quite stable in numbers.

Co-incident with the changing species composition, there were changes in associations throughout the year. In autumn and winter, mixed species feeding flocks were seen regularly, and many of the species in Eastwood participated in these. The flocks occurred mostly in the areas not dominated by Fuscous Honeyeaters, which were aggressively superior to most of the species in the MSF's. Hence the flocks were seen frequently in areas with many stringybarks, where the Fuscous was in low numbers. The species that associated with Fuscous changed seasonally, although rosellas and Red Wattlebirds were often found in the same areas. The former were never attacked by Fuscous possibly because of their large size and dissimilar foraging habits. Red Wattlebirds were mobbed by Fuscous during the breeding season (see also Chapter 7) but did not appear to be seriously restricted in their foraging by this aggression. A few species were often found in MSF's in winter but preferred to nest in sites where Fuscous were common. The community, therefore, had species of birds that were responding mostly to the distribution of resources such as food, nesting sites and foraging opportunities (Fuscous Honeyeaters, rosellas, Superb Fairy-wrens, treecreepers, Red Wattlebirds and large ground-feeding birds) whereas other species seemed to be influenced more by the presence and absence of aggressive species (thornbills, pardalotes, small honeyeaters) or by positive associations (possible nesting association of Grey Shrike-thrushes with Fuscous, all species participating in MSF's).

The dominance of the community by honeyeaters is not unusual in Australia, and not unexpected due to their abundance and aggressive behaviour. Most of the communities that have been described (see references in Keast *et al.* 1985) in eucalypt-dominated forests and woodlands seem to be so organized, with 40-60% of the individuals present being meliphagids. Some communities in areas of high nectar productivity are dominated by a seasonal influx of nectarivorous species (Paton 1979, Rooke 1979, McFarland 1985a, 1986a etc.). Where carbohydrate production is low or erratic, the community is dominated by more insectivorous honeyeaters which also take carbohydrates such as lerp or honeydew (Wykes 1982, Loyn 1985, this study). Insectivores generally comprise most of the avifauna (here 72%), probably reflecting more the lack of other food sources (such as fruits, seeds, carbohydrates) than any great abundance of arthropods.

Comparisons with studies of bird communities in temperate habitats on other continents suggests that Australian bird communities are to some extent different in structure. Few overseas bird communities in forests or woodlands seem to be dominated by one, or a few species (Herrera 1978, Rabenold 1978, Holmes *et al.* 1986 etc.). Migratory birds tend to make up a much higher percentage of an avifauna in the Northern Hemisphere (around 30% in this study vs up to 80% in northern America and Europe, Willson 1976, Rabenold 1978, Nilsson 1979, Gauthreaux 1982, Holmes *et al.* 1986 etc.), with consequent extreme variation in numbers and species richness between seasons. Nectarivorous species, with the exception of a few hummingbird-rich communities in south-western U.S., tend to be less well represented than in Australia (references in Ford 1989). Insectivores tend to make up the greatest component of the avifauna in all forests and woodlands that have been studied, but in Europe and North America many insectivores will also take fruits (Holmes and Recher 1985, Ford *et al.* 1986). Australian communities seem to possess rather few seed-eating passerines and pigeons (although parrots fill this role). These differences reflect the distribution and abundance of food resources between the regions.

In summary:-

1. Birds were censused monthly at Eastwood State Forest from April 1986 to April 1987, and during autumn 1988. Environmental variables such as tree type, amount of flowering, altitude and percentage understorey, and aggressive interactions between birds, were recorded concurrently.

2. Canonical and regular correlations and regressions were used to analyse the distribution and abundance of birds.

3. Fifty-six species were detected, with 17 species comprising nearly 80% of sightings. Fuscous Honeyeaters were the most common species.

4. Fuscous Honeyeaters occurred in areas of few stringybarks, at low altitudes and where the understorey was sparse. Nectarivorous honeyeaters congregated in areas where plants were flowering. Other insectivorous honeyeaters and small insectivores occurred in areas where there were no Fuscous. Most other species were not strongly related to the measured environmental variables.

5. Most interactions between bird species were intraspecific (80.8%). Fuscous chased many species, some during nest defence and others that had similar foraging behaviour. No other species were as aggressive. Some bird species occurred together in flocks particularly in autumn and winter, and others may nest in association with Fuscous.

6. It is suggested that Fuscous aggression caused avoidance of Fuscous-dominated areas by small insectivores. The Fuscous therefore considerably influenced the distribution of some species. Other species were probably responding to the distribution of required resources (nesting sites, foraging sites).

7. Comparisons with other Australian communities suggest that numerical domination of the community by honeyeaters is fairly typical. Overseas communities are seldom similarly dominated by one, or a few, species.

Since the Fuscous Honeyeater has such an impact upon many species, and the community organization generally, it was thought necessary to account for this species' distribution. The following chapters will investigate the distribution and abundance of tree-foliage arthropods, the impact of birds on these, and the diet and the social organization of the Fuscous in an attempt to explain its observed distribution .