A Survey of Vegetation and its Relationship to Vertebrate Fauna Present in Winter on Road Verges in the Kellerberrin District, W.A.

Report to Roadside Vegetation Conservation Committee

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ABSTRACT

Twenty-two sections of road verge 1 km long in the Kellerberrin district were surveyed in the winter of 1986 to determine what vegetation existed and what vertebrate fauna were to be found in it. The sites selected ranged in width from 3.8 m to 46.2 m and the vegetation types were heath, mallee-heath and woodland. More than 100 plant species were found. All sites were heavily invaded by non-native dicots and many by non-native grasses.

Very few small mammals, reptiles and amphibians were found in the wide road verges, and the narrow ones were not surveyed for non-avian vertebrates. Evidence of echidnas and kangaroos was found in most sites.

Forty one species of birds were recorded. More species were seen in wide than in narrow verges, and verges of mallee-heath and heath had more species than woodland verges because small passerines were found in them but not in woodland verges. Using regression analysis, it was shown how the numbers of birds in different groupings of species were influenced by vegetation structure. For example, the numbers of small passerines increased as canopy and tree density decreased and shrub cover and number of shrub species increased.

INTRODUCTION

In the wheatbelt of Western Australia most (>90 per cent) of the native vegetation has been cleared leaving small remnants (mostly <30 ha) on alienated land and in reserves designated for various uses, including conservation of flora and fauna. In addition, many of the roads still have native vegetation. The conservation of flora and fauna in the wheatbelt depends on both. While the Western Australian Museum has conducted detailed surveys of flora and fauna on reserves in the wheatbelt (e.g. Kitchener 1976; Kitchener *et al.* 1980a, b, 1982; Muir *et al.* 1978), there have been none on the road verges apart from preliminary work by Scott (1981). Information currently available on roadside vegetation is summarised by Hobbs (1987).

This work was done at the request of the Roadside Vegetation Conservation Committee to provide initial information on how the flora and fauna in roadside verges varied in one district. A limitation was the availability of funds and staff, and this meant that the survey was restricted to 22 sites and one season. The timing of the survey was a compromise since the various faunal groups present would be active at different times of the year. The survey for small vertebrates was in June, and the bird censuses were done in June and July 1986.

The Kellerberrin, Trayning Shire area was chosen for the study because the CSIRO Division of Wildlife and Rangelands Research had already surveyed the area, and had research facilities there.

METHODS

Choice of Survey Sites

The twenty-two sites shown in Figure 1 were chosen to represent the major plant communities found in the roadside vegetation and different road verge widths. The major communities are: open woodland dominated by wandoo *Eucalyptus wandoo* and gimlet *E. salubris* with little shrub understorey; mallee woodland with or without a shrub understorey; and heath with no tree species. There are a number of different heath communities, with various species being dominant.

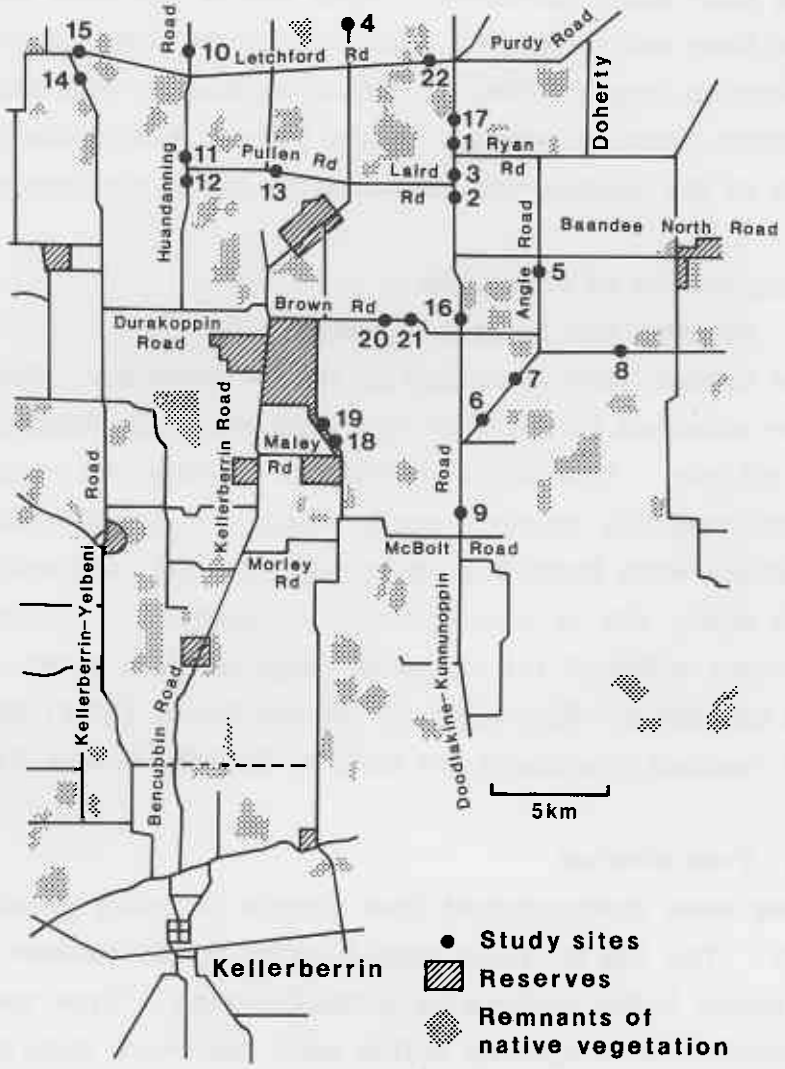

Figure 1
Location of study sites. The remnants of native vegetation were mapped from 1985 aerial photographs.

Road verges fall into two main sizes. The narrow ones have from 2 to 10 m of vegetation either side of the road. The wide ones have 24 to 30 m of vegetation either side of the road; some have all the vegetation on one side of the road giving a single width of 50 m or more.

Survey methods

(1) Choice of sites

Sites were chosen to be 1 km long and as homogeneous in vegetation as possible. However, a basic characteristic of the vegetation is that the floristics and structure change frequently even over short distances. Thus few of the sites were uniform over their entire length. Sites varied in their degree of separation from patches of native vegetation, and the area of remnant native vegetation within 1 km of both sides and the ends of the section was measured on aerial photographs.

(2) Measurements of vegetation

(a) Floristic and habitat variables

Tree species were examined in 100 m^2 quadrats. Shrub species were examined in ten 1 m^2 quadrats randomly located within each 100 m^2 plot. The linear dimensions of each plot varied according to the available roadside verge width. Four plots and associated quadrats were located at distances 150, 300, 450 and 600 m along each study site to allow for site variability. At each of these locations width of the roadside verge on both sides of the road was measured. Nomenclature follows Green (1985) throughout, and voucher specimens are held at CSIRO, Helena Valley.

(b) Tree stratum

Trees were distinguished from shrubs as being greater than 3 m high. The 100 m^2 plots were pegged at the corners, the perimeter being defined by a flexible tape. Tree species' presence and frequency within each plot were recorded. The circumference of trees having a diameter greater than 4.0 cm at breast-height was measured and summed to give a value of tree

stem density within the plot. Canopy cover was measured using a densitometer (Lemmon 1956); measurements were taken at the corners of each plot.

(c) Shrub stratum

A 1 m x 1 m metal-sided frame, divided into 10 cm x 10 cm squares, was used for examining shrub and herbaceous species. Within each quadrat species' presence and abundance was recorded. Annual herbs and grasses, and perennial grasses were combined into their three respective groups because of difficulties in individual species' identification at that time of the year.

Differences in species' size and growth forms precluded the use of the number of individuals as a measure of abundance within a quadrat. Instead, a standard measure of cover (the vertical projection of above-ground parts onto the ground) was used to record species' abundance. Cover was subjectively assessed as the number of 100 cm^2 squares (i.e. 1 per cent cover) that an individual species covered. If a species was present, but its total cover was less than 100 cm^2, its abundance was recorded as 1 per cent. Average species' abundance across the plot was then calculated. Leaf litter cover and percentage bare ground were assessed in the same way. Species' frequency was recorded as the percentage of quadrats occupied within the plot. An importance value (relative cover and relative frequency summed and divided by two, Mueller-Dombois and Ellenberg 1974) was calculated for each species.

The horizontal density component of cover was measured in each plot using a vegetation profile board (Nudds 1977), 3.0 m high and 0.3 m wide, marked in 50 cm intervals. The board was read in the centre of each plot every 15 m along each side of the plot. The proportion of each interval covered by vegetation was recorded as a single digit 'density score' and graded 0 to 10 (1 = 1 to 10 per cent, 10 = 91 to 100 per cent). Horizontal

density was calculated as the average cover for the respective intervals in each plot.

(3) Survey of animals

Ten sites having the widest verges were selected and these included the range of roadside vegetation associations present. The plan was to extend the sampling to narrow verges if many animals were found in the wide verges. There was no point in surveying narrow verges if species' presence was minimal in wider verges.

(a) Trapping survey

Three trap types were used at each site to maximize species' capture. At distances of 200, 400, 600 and 800 m along each site a 'trap set', consisting of four standard elliot traps and a cage trap (dimensions 45 x 30 x 30 cm), were located midway along the roadside verge width. The traps were set in a pattern of two elliots, one cage, two elliots, each trap being located at a distance of 10 m adjacent to the next trap. At distances of 250 and 750 m along each study site, a set of three pit traps (diameter 15 cm, depth 40 cm) were installed 5 m apart. A drift fence 22 cm high was run between pit traps and extended come 5 m past the two end traps.

Trapping was carried out for four days starting 3 June 1986. Cage traps and elliots were baited with 'universal bait' (mixture consisting of peanut paste, rolled oats and bacon fat). Tissue paper was placed in all elliots to prevent 'cold shock' in captured animals. Traps were examined approximately two hours after sunrise each day. Captured animals were recorded and released at the point of capture.

(b) Search survey

Some species of animals could not be trapped and so, following the trapping survey, a 100 m section of each study site was thoroughly searched for species' presence. Animals captured on

the Search Survey were recorded and released at the point of capture. Sightings of animals, species' tracks and scats were also recorded for each site.

(c) Survey within Durokoppin Reserve

The interpretation of the data from the above survey requires information on the numbers of animals to be found in similar habitats within a large reserve. Thus seven such sites were chosen within the 1 100 ha Durakoppin Nature Reserve. Descriptions of these sites are given in Appendix 2.

Each trap line consisted of four trap sets (as above) and a line of six pit traps. Pit traps were not used in Site 2 because of the hardness of the ground, nor at Site 6 because the density of vegetation prevented erection of the drift fence.

Trapping was carried out for four days commencing 8 June 1986. A search survey was not conducted in Durokoppin Reserve because it was felt destruction of habitat was unwarranted.

(4) Survey of birds

Within each site an 800 m section was marked with plastic tapes. Two observers walked slowly along the site recording each bird seen. In narrow verges, one observer counted birds on one side of the road and the second the other side. In wide verges, the two observers counted one side, walking 10 m apart within the verge, and then counted the other side. To minimise errors, care was taken to note when birds flew across the road or moved ahead of the observers.

An estimate was made for each bird seen of the height in the canopy at which it was first observed and the density of the vegetation at that point. Density was on a visual scale of 0 (bird in full view) to 5 (bird invisible). The activities of the birds were not recorded because many were seen only when they moved as the observers approached. However, the presence of

birds in the verges is attributable to either sheltering or feeding. The majority of large birds (ravens, magpies, mudlarks, Port Lincoln Ringneck parrots and Galahs) used the verges for shelter, while the small passerines foraged in the verges.

RESULTS

Data Analysis

Correspondence analysis was used to examine the similarity of the sites in terms of structure and bird communities. Regression analyses were done to relate the numbers of birds of a species (or group of species) seen in each site to the structures of the sites.

Survey Results

(1) Vegetation

(a) Structure

Table 1 gives the mean values for structural measurements for each site. Although the sites have been grouped into woodland, mallee-heath and heath this is too simple a classification because some woodland sites (8 and 10) had shrub understoreys.

Table 1: Structural attributes of sites

	Site	Canopy cover above 2 m (%)	Number of tree stems	Number of tree species	Horizontal density 0-1 m	Horizontal density 1-2 m	Horizontal density 2-3 m	Canopy cover of shrubs (%)	Index of shrub density	Number of shrub species
WOODLAND										
Wide	1	19.0	15.0	1.0	6.3	6.3	8.8	0.1	2.5	0.3
	3	18.3	5.8	0.8	6.0	2.9	0.6	0.3	2.5	0.3
	9	25.5	7.5	1.5	15.7	6.0	2.2	1.6	12.5	1.0
	10	45.5	4.0	1.0	45.2	33.8	27.2	5.7	22.5	1.8
Narrow	4	23.8	7.8	1.5	1.3	3.1	2.8	1.4	10.0	1.5
	8	31.8	6.3	1.5	22.2	13.8	14.1	4.6	15.0	1.3
	22	14.3	3.3	1.0	0.6	2.2	5.0	5.0	5.0	0.5
MALLEE/HEATH										
Wide	1	17.0	7.5	1.3	5.4	19.7	7.8	11.3	22.5	1.3
	18	12.8	14.0	1.0	35.6	19.7	15.3	26.9	70.0	4.8
	19	15.0	11.5	1.0	32.5	40.3	33.5	20.1	55.0	2.8
Narrow	5	7.0	6.5	0.8	18.4	31.0	12.2	20.4	57.5	3.0
	7	27.8	6.8	1.0	27.5	15.9	14.4	4.4	22.5	1.8
	14	3.8	1.0	0.5	64.1	36.6	20.3	33.4	65.0	4.0
	20	13.0	1.5	1.0	47.2	31.3	31.3	30.8	40.0	2.3
	21	19.5	6.0	1.0	33.5	18.8	33.5	10.7	25.0	1.8
HEATH										
Wide	11	28.3	0.0	0.0	87.8	58.8	52.2	41.1	75.0	5.3
	12	0.5	0.0	0.0	81.0	53.5	28.1	41.0	85.0	4.8
	16	1.3	0.8	0.3	78.8	61.3	12.2	54.5	77.5	5.5
	17	37.5	0.0	0.0	39.1	45.5	34.3	56.0	77.5	2.5
Narrow	6	15.0	0.0	0.0	63.3	58.8	49.4	60.5	80.0	4.8
	13	1.3	0.0	0.0	76.8	32.2	11.3	62.6	87.5	7.0
	15	4.3	0.0	0.0	67.2	27.5	27.5	17.2	60.0	3.5

The correspondence analysis (Figure 2) gives a better picture of how the sites group structurally. This analysis locates sites in relation to one another according to their similarity, overall, in structural attributes. The sites are shown as numbers. Overlaid on this is the relationship between attributes, shown as letters. The woodland elipse has sites with little understorey at the top, and those with understorey at the bottom close to mallee and heath sites with tall shrubs. The mallee-heath sites lie in the centre of the Figure and heath sites to the left. Heaths, such as Site 13, with little vegetation above 2 m are at the top of the Figure, and Site 11 with most vegetation in the 2-3 m height is at the bottom.

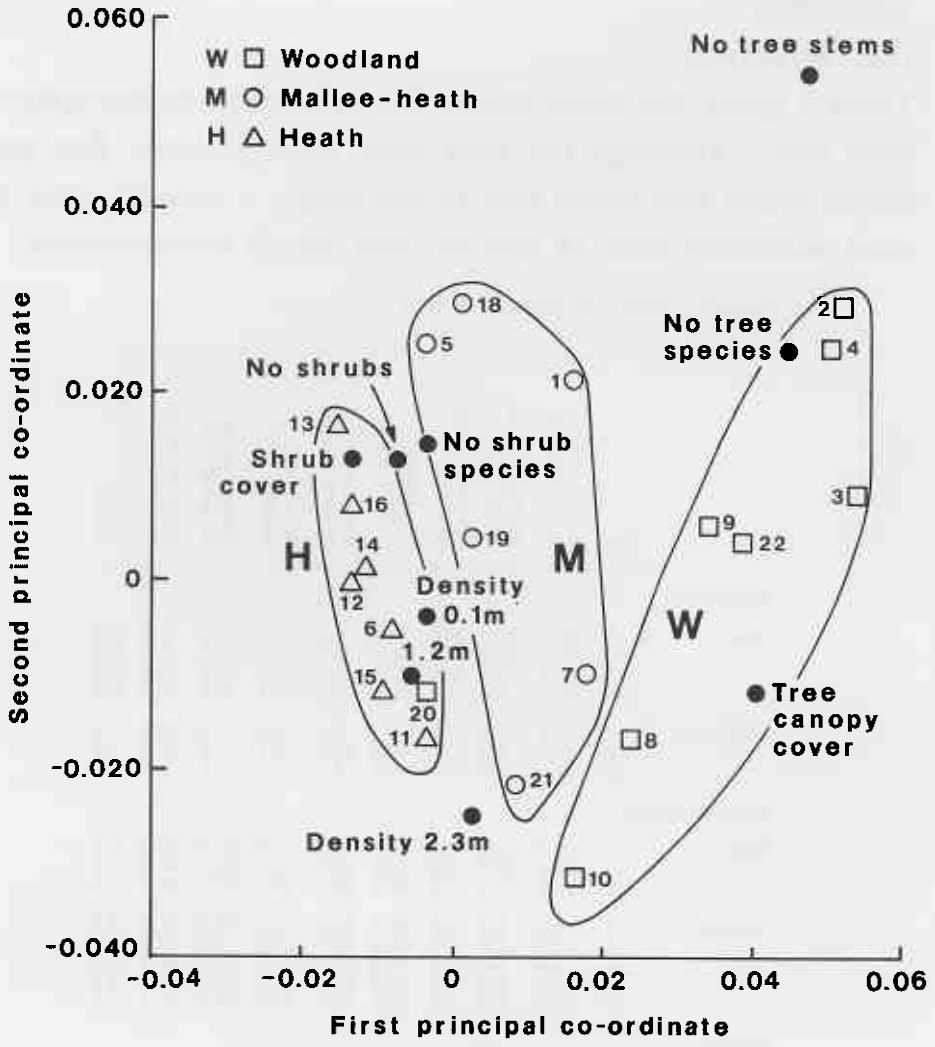

Figure 2
Ordination of sites on vegetation structure.

(b) Floristics

The floristic descriptions of the sites given in Appendix 1 illustrate the diversity of the road verge vegetation. Diversity was greater in the heath sites than in the woodland sites. More than 100 species were recorded.

(c) Weed invasion

Nearly all sites were invaded by weeds from surrounding farmland. The major species were *Hordeum leporinum* (barley grass), *Lolium rigidum* (annual ryegrass), *Avena* spp. (wild oats), *Bromus diandrus* (tall brome), *Arctotheca calendula* (capeweed), *Sisymbrium orientale* (wild mustard), *Brassica tournefortii* (wild turnip) and *Hypochoeris glabra* (flatweed).

Estimates of the area covered by these weeds (Table 2), show that only a few sites had little or no grasses but all sites were heavily invaded by dicotyledonous weeds. However, this Table includes native annuals which could not be differentiated at this time of year, but these probably contribute little to the biomass of annuals.

(2) Non-avian Vertebrates

(a) Trapping survey

Species and number of individuals captured in each study site, during the trapping period, are presented in Table 3 and a species list is given in Appendix 3.

A total of 1 040 trap nights resulted in the capture of 50 animals. Captures of the house mouse (*Mus musculus*) accounted for 88 per cent of this total. The lizard species *Tiliqua rugosa* and *Menetia greyii* are common species over a widespread area as is the only frog species captured (*Pseudophryne guentheri*). However, captures of the common dunnart (*Sminthopsis dolichura*) were of significance. The animals captured were collected in the wide roadside verge connecting the two major reserves in the area (Durokoppin and Kodj Kodjin).

Table 2: Percentage of ground covered by weeds

	Site	Annual grasses	Annual forbs
WOODLAND			
Wide	2	15	43
	3	38	36
	9	17	36
	10	20	42
Narrow	4	41	49
	8	39	51
	22	37	42
MALLEE-HEATH			
Wide	1	26	55
	18	2	29
	19	6	48
Narrow	5	27	57
	7	38	37
	14	30	28
	20	46	29
	21	32	31
HEATH			
Wide	11	7	35
	12	0	16
	16	1	48
	17	0	40
Narrow	6	13	31
	13	5	63
	15	38	28

Table 3: Numbers of each non-avian vertebrate species trapped at each site over four nights

Species	Site No. 1	2	3	5	9	11	12	16	18	19
Pseudophryne guentheri								1		
Menetia greyii				1						
Tiliqua rugosa		1								
Sminthopsis dolichura									3	
Mus musculus				2		28		6	3	5
Total captures	0	1	0	3	0	28	0	7	6	5

Tiliqua rugosa was the only animal captured in the woodland sites. All other animals were collected in the heath and mallee vegetation associations.

The small number of reptile and amphibian species collected during the trapping period was a reflection of climatic conditions. The mean maximum temperature was 19°C and the mean minimum temperature was 4°C. Significant winter rainfall had not occurred prior to the trapping period in early June. A number of reptile species are commonly observed in roadside areas during the warmer months, and amphibian species following rains (local landowner's personal communication).

(b) Search survey

During this limited survey three additional reptile species (*Rhinoplocephalus gouldii*, *Tiliqua occipitalis* and *Diplodactylus maini*) were collected (Table 4). All animals captured were located in heath and mallee sites, indicating the importance of these types of vegetation for small animals.

The presence of larger species was recorded for all but two woodland sites. The western grey kangaroo (*Macropus fuliginosus*) and euro (*M. robustus*) utilized the roadside verges extensively. Evidence of echidna (*Tachyglossus aculeatus*) activity was recorded at four sites. The introduced rabbit (*Oryctologus cuniculus*), fox (*Vulpes vulpes*) and cat (*Felis catus*) were widespread.

Table 4: Non-avian vertebrate search survey results

Site No.	Species: Capture	Species: Sightings (including tracks and scats)
1	Tiliqua rugosa	Euro, echidna, rabbit, fox, cat
2	-	-
3	-	Western grey kangaroo, rabbit, fox
5	-	Western grey kangaroo, echidna, rabbit, fox, cat
9	-	-
11	Tiliqua occipitalis Diplodactylis maini House mouse	Euro, rabbit, fox, cat, echidna
16	Tiliqua rugosa (2) Rhinoplocephalus gouldii House mouse	Rabbit, fox, cat, euro, echidna
18	Menetia greyii (2) Rhinoplocephalus gouldii (2) House mouse	Western grey kangaroo, rabbit, cat
19	Tiliqua rugosa House mouse	Western grey kangaroo, rabbit, fox, cat
20	Tiliqua rugosa (2)	Euro, echidna, rabbit, fox

(c) Survey on Durokoppin Nature Reserve

Species of non-avian vertebrates and number of individuals captured in each study site, during the trapping period, are presented in Table 5.

A total of 680 trap nights resulted in the capture of 90 animals. The onset of heavy rain at the beginning of the trapping period in late June was responsible for the large number of frog captures. Ash-grey mice (*Pseudomys albocinereus*) and common dunnarts were collected at Site 3 only. Although only one feral cat was caught in the traps, nine others were caught in fox traps.

Table 5: Number of animals captured at each site on the Durokoppin Nature Reserve over four nights

Species	Site No. 1	2	3	4	5	6	7
Frogs							
Heleioporus albopunctatus	3		1	1	3		
Neobatrachus kunapalari	2		5	3	1		6
N. pelobatoides							1
Pseudophryne guentheri	3		1	1	5	1	2
Limnodynastes dorsalis				1			
Mammals							
Sminthopsis dolichura			3				
Pseudomys albocinereus			7				
Mus musculus		5	5	9	2	7	11
Felis catus				1			
Total captures	8	5	22	16	11	8	20

(d) Discussion

This survey shows that shrub cover in roadside verge vegetation associations is essential for non-avian vertebrate species. The presence of understorey cover is of consequence as shelter from the vagaries of weather and in avoidance of predation.

The majority of animals utilizing roadside verges were introduced species. Of the native species, the reptiles and amphibians collected are relatively common and widespread in their distribution and thus in little danger from a conservation viewpoint.

Use of roadside verges by echidnas and particularly western grey kangaroos and euros suggests their importance to the survival of dispersing animals between the fragmented reserves in the area. Detailed studies of movement patterns of these species, using radio-tracking techniques, are now required to evaluate the degree of importance of such areas.

Two small native mammal species, ash-grey mouse (*Pseudomys albocinereus*) and the common dunnart (*Sminthopsis dolichura*), were collected during a biological survey of Durokoppin and Kodj Kodjin Nature Reserves (Muir *et al.* 1978). This survey of roadside verges indicated the presence of the common dunnart was restricted to the wide corridor connecting the above reserves (Sites 18 and 19); the ash-grey mouse was not collected in any verge. The apparent absence of these species from seemingly suitable study sites suggest that either their area is too small, or that predation pressure from the local fox and cat populations had caused local extinctions. On the other hand, a bigger trapping effort may be required to detect animals at very low densities.

Results of this initial survey suggested it was not worthwhile to conduct further small vertebrate surveys along roadside verges of narrower width and varying degrees of degradation because of

the limited number of captures in wide verges. However, evidence of kangaroo presence was found in three of the eleven narrow verges.

The limited survey in Durokoppin Nature Reserve showed that the common dunnart and ash-grey mouse were not widespread in the Reserve. Thus the wide verges cannot be said to be poorer in small non-avian vertebrates without more extensive survey work.

(3) Birds

(a) General

Forty-one species of birds were recorded but many of these were seen only once or twice in one or two sites. The species seen in each site are listed in Appendix 4. The most ubiquitous species was the Port Lincoln Ringneck which was seen in every site whilst the singing honeyeater was the commonest small passerine, being seen in 17 sites.

The survey was completed over six weeks in June and July. During that period the number of sites in which the commoner species were seen did not change except for Red-capped Robins which were seen in ten sites during the first set of observations and in none during the fifth set (Figure 3). This decline, and a smaller one in Thornbills, (Inland, Chestnut-rumped and Yellow-rumped) suggests that these species left the verges progressively to begin breeding in more suitable locations.

(b) Relationships between birds and vegetation

These relationships were examined on a subset of the data which represents the commonest birds. In two cases birds were grouped: ravens, magpies and mudlarks were considered to make the same use of the verges (shelter only) and were grouped, as were the three species of thornbills which often foraged in groups of mixed species. Although a number of the small insectivores were considered as separate species, a combined class was used in some analyses.

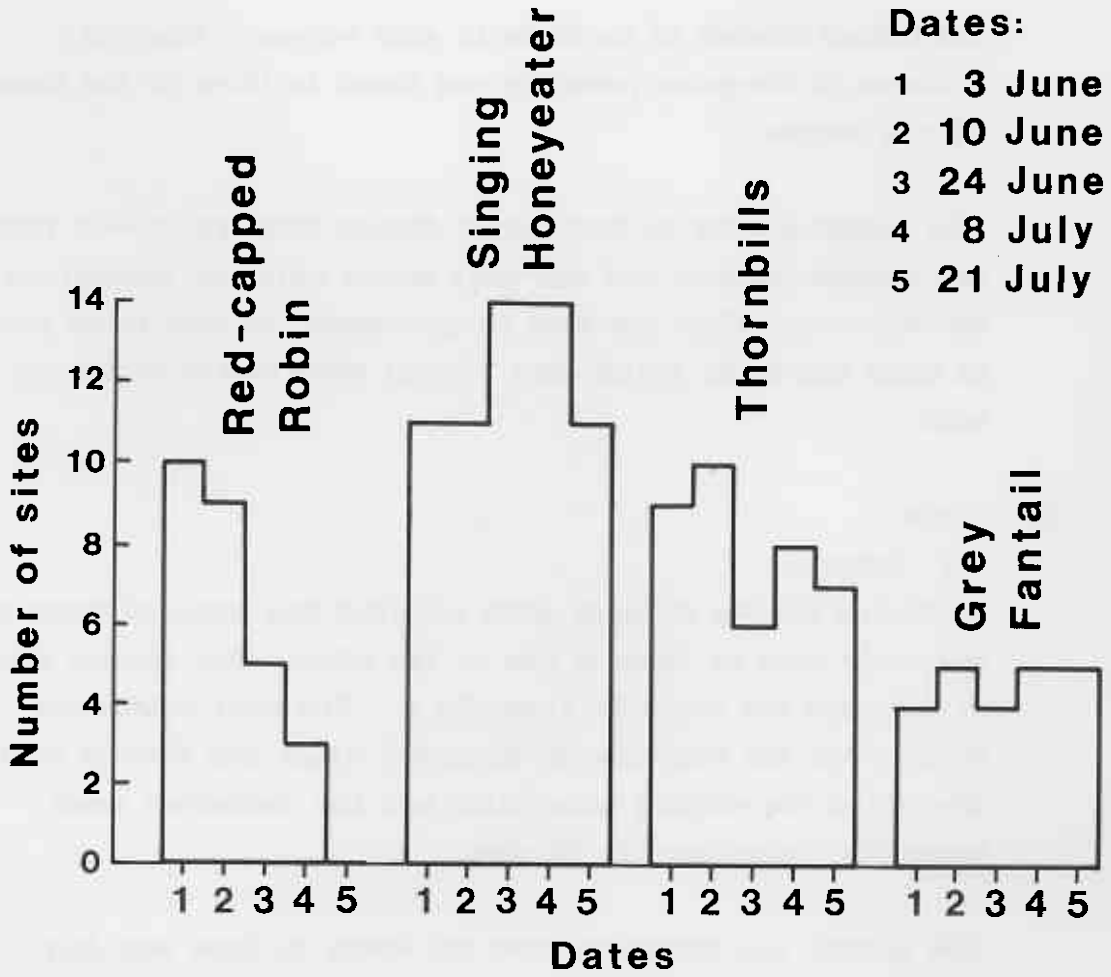

Figure 3
Changes with time in number of birds seen.

Table 6 gives the birds in each site, with the sites grouped into classes according to vegetation type and width; some data on habitat structure are also given. Some associations are obvious. Wide mallee/heath and heath verges had more species than narrow verges, but this was not so with woodland. Galahs were seen mainly in wide woodland verges. Site 10 was the exception, but it had a dense canopy and a considerable understorey of shrubs. Woodland attracted few small insectivores, again with the exception of Site 10.

Table 6: Numbers of birds seen in each site

SITES WOODLAND	WIDTH (m)	BUSH (m) *	No. birds species seen	No. Ravens, Magpies Mudlarks	No. Galahs	No. Port Lincoln Ring-neck Parrots	No. Yellow-throated Miners	No. White-fronted Chats	No. Thornbills	No. Grey Fantails	No. Red-capped Robins	No. Singing Honeyeaters	No. Willie Wagtails	No. small insectivores	Tree stem density	Canopy cover+ (%)	Shrub frequency	Shrub canopy cover (%)
2	50	18	9	15	23	46	7	0	0	0	1	0	0	1	15	19	3	0
3	42	10	10	28	26	41	5	0	0	0	0	0	0	0	18	18	3	0
9	46	3	7	11	30	46	4	0	0	0	0	0	0	0	8	26	13	2
10	45	11	14	18	0	30	10	8	0	0	3	7	5	29	4	46	23	6
4	21	33	10	13	0	32	19	0	0	0	0	5	2	7	15	24	10	1
8	8	3	8	13	3	10	11	2	0	0	0	0	0	0	6	32	15	5
22	8	84	6	3	7	16	0	0	1	0	1	2	1	5	3	14	5	5
MALLEE/ HEATH																		
1	47	7	19	14	2	35	6	0	8	3	2	7	6	28	8	17	23	11
18	51	100	17	5	0	15	0	2	22	6	3	7	0	48	14	13	70	27
19	51	50	13	4	6	23	0	0	23	1	2	2	2	36	12	15	55	20
5	9	16	17	17	4	19	5	3	22	7	0	14	6	52	7	7	58	21
7	7	30	6	4	0	10	13	1	2	0	0	0	0	2	7	28	23	4
14	5	44	8	0	0	11	25	7	23	0	4	31	0	38	1	4	65	33
20	11	7	8	8	0	14	13	1	0	0	0	2	1	3	2	13	40	31
21	9	9	8	4	0	14	0	0	3	0	2	11	4	22	6	20	25	11
HEATH																		
11	47	12	19	15	2	7	13	8	15	7	3	19	7	63	0	28	75	41
12	52	31	14	6	0	2	10	0	8	2	0	12	2	36	0	28	75	41
16	46	67	18	8	0	17	0	0	12	7	0	14	2	53	1	1	78	55
17	46	38	17	1	0	23	0	0	14	2	5	9	3	62	0	38	78	56
6	11	7	8	3	0	2	0	0	7	0	0	9	4	20	0	15	80	61
13	11	5	8	0	0	7	14	4	0	0	0	8	3	11	0	1	88	63
15	11	69	5	6	0	3	0	0	5	0	0	3	1	9	0	4	60	17

* Area of bush in the 6 km^2 around the site

\+ Canopy cover above 2 m

Correspondence analysis was used to examine the relationships between bird communities on the different sites. The result is shown in Figure 4. Sites close together have similar bird communities and those far apart have different bird communities. Woodland sites do not all group together, nor do the other two types of vegetation. Thus, classification into such broad categories is a poor index of likely bird communities.

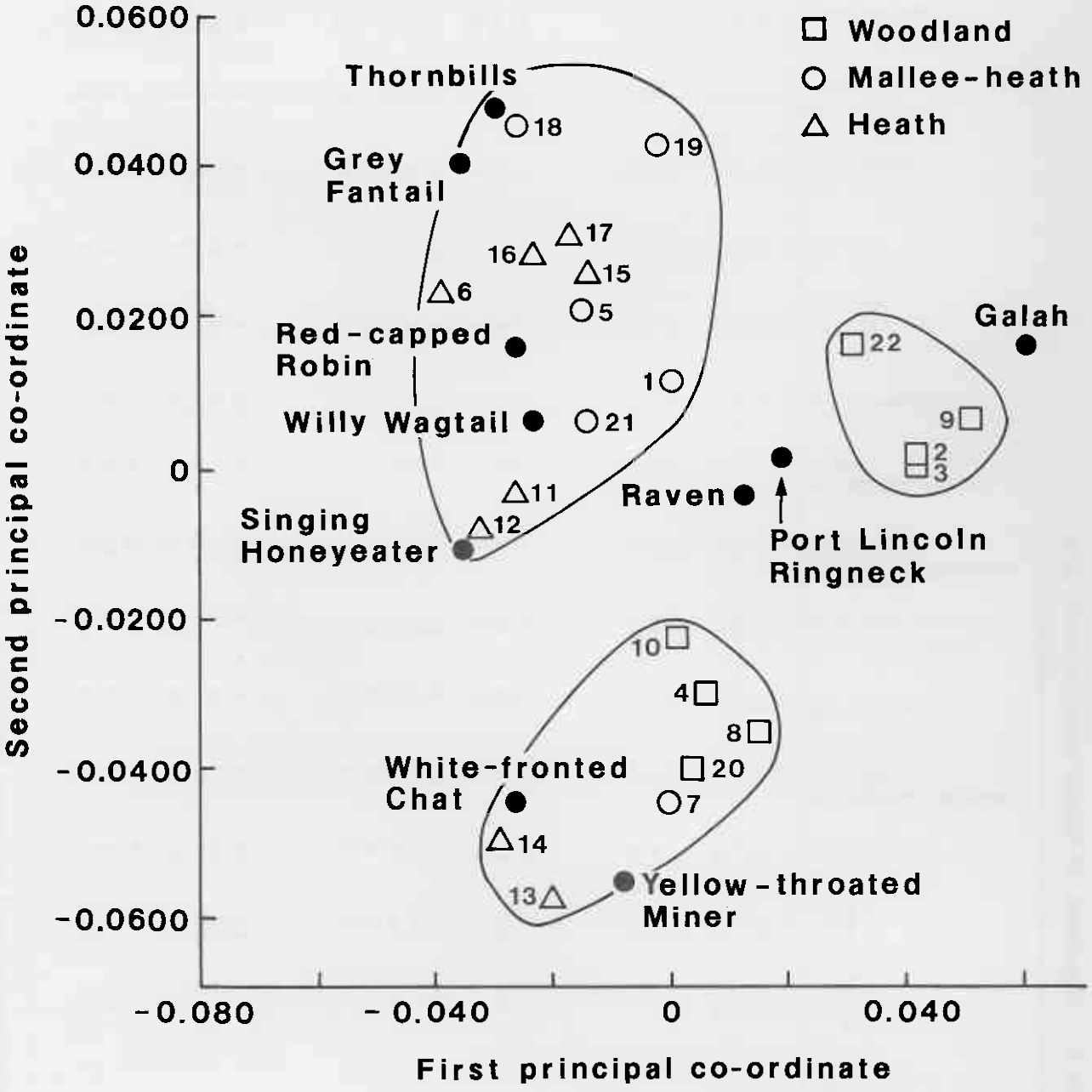

Figure 4
Ordination of sites by bird groups.

The spatial distribution of the bird species allows us to interpret the spatial distribution of the sites. Thus Galahs are clearly separated on one side from the small passerines on the other, which means that these species rarely occurred together. Galahs are also well separated from the White-fronted Chats and Yellow-throated Miners. Reference to Table 6 shows that woodland Site 10 had a high number of White-fronted Chats and small insectivores and these are the reasons for the Site's location on the Figure. On the other hand, Sites 4, 7, 8 and 20 had few insectivores and large numbers of miners, hence their location on the Figure. Heath Sites 13 and 14 are closely located with the other plots because they also had high numbers of these two species.

The area of remnant native vegetation near to mallee and heath, but not woodland, sites had a strong influence on the numbers of small insectivores present in the sites, and this is shown in Figure 5. There were two exceptions, Sites 5 and 11, which attracted large numbers of insectivores but had little remnant native vegetation nearby. These sites contained *Grevillea* species, and it was noticed when recording the birds that these attracted birds even though they were not flowering. Thus the floristics as well as the structure of the vegetation influence the numbers of small insectivores present. Their numbers were also influenced by road width as Table 6 shows. Site 14 was an exception being narrow but attracting a lot of thornbills and singing honeyeaters. Most of these were seen when *Hakea scoparia* was flowering only at this site, and this illustrates the fact that even narrow verges may be important for some bird species at certain times of the year.

Regressions were calculated relating the numbers of birds in each group to road verge width, area of woodland nearby and vectors of scores from principal component analysis (PCA) of the habitat structural variables. The PCA was used to obtain linear combinations of these variables that were not correlated.

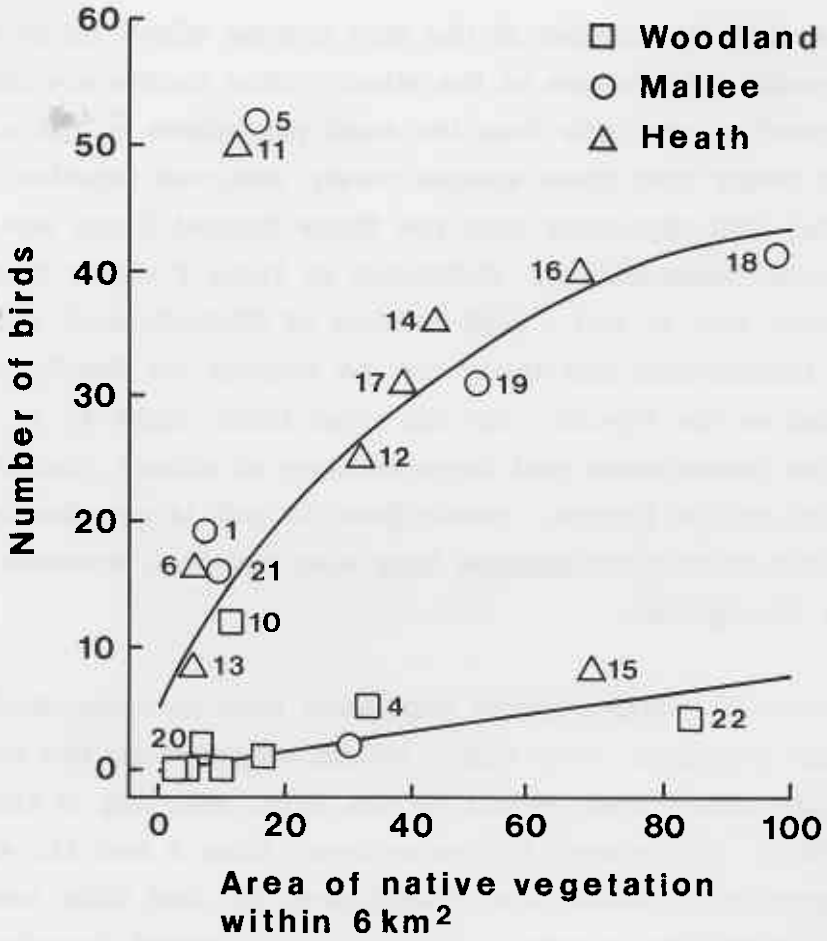

Figure 5
Relationships between numbers of insectivores and area of remnant native vegetation within 6 km².

Significant regressions were obtained for all but Yellow-throated Miners. The number of species found was related only to road verge width. The numbers in the species' groups were related to the structure of the habitats. Two vectors contributed to the regressions, both were contrasts: PCA 1 (interpretable as tree canopy cover v shrub canopy) and PCA 3 (interpretable as number of tree stems versus number of shrub species). The numbers of ravens, magpies, mudlarks and butcherbirds increased with greater tree canopy and less shrub cover (R^2 = 21.6, $P<0.05$). The same was true for Galahs, but road verge width was also important (R^2 = 40.7, $P<0.01$). The numbers of Port Lincoln Ringnecks also increased with road verge width and with numbers of tree stems (R^2 = 77.9,

$P<0.001$). By contrast, the numbers of small passerines increased as tree canopy and tree density decreased and shrub cover and number of shrub species increased ($R^2 = 49.3$, $P<0.001$).

(c) Discussion

The road verges fall clearly into two categories so far as their use by birds. The woodland verges provided shelter for large birds that forage on farmland, and also provided breeding sites. However, small insectivorous passerines were virtually absent. They were found only in verges with shrub understorey. For these birds the important elements were the number and density of the shrubs at 2 m and below. There was insufficient time to study the influence of the shrub floristics on the distribution of these small insectivores, but observational evidence pointed to their greater densities in areas with *Grevillea* species present. Presumably this was because of better food sources in these areas at that time of year. However, it should be stressed that the survey was limited to the winter period, and these conclusions cannot be generalised to the whole year.

Another feature of the distribution of small insectivores was that numbers increased with an increase in the area of native vegetation nearby. It seems, and this aspect warrants detailed study, that the road verges were used for foraging and temporary residence outside the breeding season. The dynamics of species movement between remnants of native vegetation and road verges needs to be examined. It may be that from a conservation viewpoint the most important verges to maintain are those near remnants of native vegetation. However, evidence is still needed to prove this.

CONCLUSION

This initial survey of a wide range of road verges indicates that they are probably of no significance to conservation of small native mammals in this particular area. Their value in conservation of amphibians and reptiles needs further examination. However, they do have considerable value for small birds.

Road verges are also important in terms of flora conservation, for instance, in the wheatbelt tree species such as salmon gum are probably more abundant along roadsides than they are in reserves. Our study indicated that road verges covered virtually the full range of vegetation communities found in reserves in the area and thus represent an important additional resource in flora conservation.

The extent of weed invasion in the road verges is of major concern since we saw little evidence of regeneration of native species in weedy areas. The other area of concern is the apparent lack of regeneration of shrub species which, in the long term, must result in continued degradation of the vegetation and decline in their conservation value. Research on this aspect is urgently needed from both plant ecological and practical management viewpoints.

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APPENDIX 1

Site Floristic Description

Site 1 Average roadside verge width 24.0 m.
Open mallee (*Eucalyptus* spp.) woodland with occasional wandoo (*E. wandoo*). Understorey consisted of scattered *Allocasuarina campestris* shrubs (to 2 m high) and occasional *Hakea scoparia* shrubs (to 1.5 m high). Ground cover was dominated by leaf litter and variable amounts of annual herbs, annual and perennial grasses.

Site 2 Average roadside verge width 25.5 m.
Mixed open wandoo and gimlet (*Eucalyptus salubris*) woodland. No understorey shrubs were present. The ground cover was dominated by annual herbs, annual and perennial grasses and variable presence of a succulent species.

Site 3 Average roadside verge width 38.9 m.
An open woodland dominated by wandoo and occasional gimlet. No understorey shrub species were present. The ground cover was dominated by leaf litter, annual herbs and a succulent species, while annual and perennial grasses were present in small amounts.

Site 4 Average roadside verge width 11.9 m.
Open gimlet woodland. Understorey consisted of occasional *Acacia* spp., *Grevillea* spp. and *Santalum acuminatum*. Ground cover variably dominated by annual herbs, grasses and leaf litter.

Site 5 Average roadside verge width 4.6 m.
Mallee, mixed heathland site. A number of heath shrubs were present (up to 2 m high) including *Acacia*

multispicata, A. fragilis, A. acuminata, Melaleuca spp., *Grevillea paniculata, Leptospermum erubescens, Santalum acuminatum.* The sedge species *Borya* sp., *Loxocarya* spp. and *Lepidosperma gracile* were present in variable amounts. Annual herbs, annual and perennial grasses variably dominated the ground cover.

Site 6 Average roadside verge width 4.0 m.
Closed heathland site dominated by *Allocasuarina corniculata* and *A. campestris.* Other understorey shrubs present included various *Acacia* spp., *Santalum acuminatum, Baeckea muricata, Melaleuca conothamnoides, Hakea scoparia* and *Hibbertia uncinata.* Leaf litter tended to dominate ground cover; annual herbs, annual and perennial grasses were present but not abundant.

Site 7 Average roadside verge width 4.5 m.
Open mallee woodland with occasional gimlet. Understorey consisted of occasional *Acacia* spp., *Melaleuca uncinata, Olearia axillaris* and *Allocasuarina acutivalvis* shrubs. Ground cover tended to be dominated by leaf litter. Annual herbs, annual and perennial grasses were present but not abundant.

Site 8 Average roadside verge width 4.0 m.
Open gimlet woodland with occasional mallee. Understorey similar to that described for Site 7. Ground cover dominated by annual herbs and grasses.

Site 9 Average roadside verge width 23.0 m.
Open wandoo woodland. Understorey consisted of a few scattered *Acacia* spp. shrubs. Ground cover was dominated by leaf litter with variable annual herb, annual and perennial grass cover.

Site 10 Average roadside verge width 23.6 m.
Gimlet woodland with understorey, consisting of *Melaleuca lateriflora*, *Acacia colletioides*, and *A. ixiophylla*. Ground cover consisted of annual herbs, annual and perennial grasses and leaf litter.

Site 11 Average roadside verge width 30.6 m.
Mixed heathland, comprising a variety of shrub species including *Allocasuarina campestris*, *Grevillea eriostachya*, *G. pritzellii*, *G. paradoxa*, *Melaleuca leptospermoides*, and *Acacia coolgardiensis*. Annual herbs, annual and perennial grasses were present but not abundant.

Site 12. Average roadside verge width 32.7 m.
Heathland site dominated by *Allocasuarina campestris*. Other shrub species present included *Melaleuca uncinata*, *Acacia fragilis*, and *Hakea subsulcata*. Sedges, *Boyra* sp. and to a lesser extent *Ecdeiocolea monostachya* dominated ground cover. Annual herbs and perennial grasses were not abundant.

Site 13 Average roadside verge width 4.8 m.
Closed heathland site comprising a variety of shrub species including *Acacia mackeyana*, *A. multispicata*, *A. coolgardiensis*, *Melaleuca conothamnoides*, *M. uncinata*, *Allocasuarina campestris*, *Santalum acuminatum*, *Hakea scoparia* and *Calothamnus quadrifidus*. Ground cover was dominated by leaf litter and annual herbs.

Site 14 Average roadside verge width 2.9 m.
Closed mallee heathland site, with a variety of shrub species present including *Acacia fragilis*, *A. signata*, *Leptospermum erubescens*, *Hakea scoparia*, and *Allocasuarina campestris*. Ground cover was variably dominated by annual herbs and grasses.

Site 15 Average roadside verge width 7.6 m.
Closed heathland site. Shrub species present included *Acacia mackeyana, A. nigripilosa, A. signata* and *Hakea recurva*. Ground cover was variably dominated by annual herbs and grasses.

Site 16 Average roadside verge width 25.3 m.
Heathland dominated by *Allocasuarina campestris* (to 2 m high) with occasional mallee. Other shrubs present included several *Melaleuca* spp., *Acacia assimilis, Santalum acuminatum, Hakea scoparia* and *Grevillea paniculata*. The sedges *Ecdeiocolea monostachya* and *Lepidosperma gracile* were present in variable amounts. Ground cover was dominated by leaf litter with variable amounts of annual herbs, annual and perennial grasses.

Site 17 Average roadside verge width 23.0 m.
Site dominated by *Allocasuarina campestris* and *A. acutivalvis* (to 5 m high). Leaf litter dominated the ground cover. Annual herbs were present but not abundant.

Site 18 Average roadside verge width 45.0 m (Durokoppin/Kodj Kodjin corridor).
Closed mallee heathland. Understorey shrubs dominated by various *Melaleuca* spp. (up to 2 m high). The sedge component of vegetation was dominated by *Borya* sp., *Loxocarya* spp., *Lomandra effusa; Chamaescilla corymbosa* and *Lepidosperma gracile*were also present. Ground cover was dominated by leaf litter; annual herbs, annual and perennial grasses were sparse.

Site 19 Average roadside verge width 46.2 m. (Durokoppin/Kodj Kodjin corridor).
Similar to Site 7.

Site 20 Average roadside verge width 6.4 m.
Mallee, heathland site. Understorey shrub species included *Allocasuarina acutivalvis, Grevillea eriostachya, Santalum acuminatum* and *Acacia* spp. Leaf litter, annual herbs and grasses variably dominated ground cover.

Site 21 Average roadside verge width 4.8 m.
Similar to Site 20 except more open and a greater presence of mallee.

Site 22 Average roadside verge width 3.8 m.
Open woodland site containing mallee and gimlet. Understorey consisted of occasional *Acacia acuminata* and *Santalum acuminatum*. Ground cover dominated by annual herbs and grasses. Perennial grasses were also present in variable amounts.

APPENDIX 2

Description and locations of sites on Durokoppin Nature Reserve

Seven sites representing the range of vegetation associations were selected as study areas. Brief descriptions of these vegetation associations are given below.

Site 1 Wandoo woodland with occasional *Acacia acuminata*. Understorey predominantly *Loxocarya* spp., with patches of mixed Poaceae and Asteraceae herbs.

Site 2 Granite outcrop - the tree stratum dominated by *Allocasuarina huegeliana* and occasional *Acacia acuminata*. The understorey was dominated by sedge species: *Lepidosperma gracile*, *Dianella revoluta* and *Stypandra imbricata*. Ground cover consisted of *Stipa hemipogon* and abundant *Borya* sp.

Site 3 An open sedge heathland. Sedges predominantly *Ecdeiocolea monostachya*, *Mesomelaena stygia* and *Lepidosperma angustatum*. Shrub layer included *Allocasuarina campestris*, *Hakea incrassata*, *Conospermum stoechadis* and *Grevillea eriostachya*, with occasional *Xylomelum angustifolium* to 4 m high.

Site 4. Low heathland dominated by *Melaleuca conothamnoides*, *M.* species, *Grevillea pritzelii*, *Astroloma serratifolium*, *Leucopogon hamulosus* and the sedge *Ecdeiocolea monostachya*, with scattered *Allocasuarina acutivalvis* to 5 m tall.

Site 5 Open *Eucalyptus loxophleba/Acacia acuminata* woodland with occasional *E. wandoo* trees. Understorey consisted of sparse *Acacia acuaria* shrubs (approximately 1 m high) with a ground cover of mixed Poaceae and Asteraceae herbs.

Site 6 *Allocasuarina campestris* shrubs to 2 m high with very sparse *Hakea scoparia* over *Melaleuca platycalyx*, *M. conothamnoides* and *Ecdeiocolea monostachya* sedge.

Site 7 Mixed heathland of *Xylomelum angustifolium* and *Grevillea eriostachya*.

APPENDIX 3

Species List

Native species

Reptiles:	*Menetia greyii*
	Tiliqua rugosa
	T. occipitalis
	Diplodactylis maini
	Rhinoplocephalus gouldii
Frogs:	*Helioporus albopunctatus*
	Neobatrachus kunapalari
	N. pelobatoides
	Pseudophryne guentheri
	Limnodynastes dorsalis
Marsupials:	*Macropus fuliginosus* (western grey kangaroo)
	M. robustus (euro)
	Sminthopsis dolichura (common dunnart)
Placentals:	*Pseudomys albocinereus* (ash-grey mouse)
Monotreme:	*Tachyglossus aculeatus* (echidna)

Introduced species

Oryctolagus cuniculus (rabbit)
Mus musculus (house mouse)
Vulpes vulpes (fox)
Felis catus (cat)

APPENDIX 4

Sites at which each bird species was seen

Black-tailed Native Hen	1,11
Crested Pigeon	1,2,4,5,6,8,10,11,12,15,16,21
Common Bronzewing	3,5,6,7,10,12,16,18
Galah	1,2,3,5,8,9,11,19,22
Port Lincoln Ringneck	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15, 16,17,18,19,20,21,22
Mulga Parrot	6,10,17
Pallid Cuckoo	3,5,10,16,18
White-backed Swallow	10,17,20
Richard's Pipit	4,13
Black-faced Cuckoo-shrike	5,12,16
Black-faced Woodswallow	19
Crested Bellbird	12
Rufous Whistler	16,17,18
Red-capped Robin	1,2,3,10,11,12,14,16,17,18,19,21,22
Grey Fantail	1,5,10,11,12,16,17,18,19
Willie Wagtail	1,4,5,6,10,11,12,13,14,15,16,17,19,20, 21,22
White-browed Babbler	1,11,12,17
Rufous Songlark	13
Restless Flycatcher	17
Grey Shrike-Thrush	11,16,17
Blue-breasted Fairy-wren	11
Inland Thornbill	1,5,11,12,16,17,18,19,21,22
Yellow-rumped Thornbill	1,5,6,7,11,12,16,17,18,19,21
Chestnut-rumped Thornbill	1,18,19
Shy Hylacola	7
Weebill	1,5,10,14,16,19
White-eared Honeyeater	5,11,12,14,18,19
Singing Honeyeater	1,4,5,6,10,11,12,13,14,15,16,17,18,19, 20,21,22
Brown Honeyeater	11,18,21

Yellow-throated Miner	1,2,3,4,5,7,8,9,10,11,12,13,14,20
Brown-headed Honeyeater	10
White-fronted Honeyeater	14,16,18
Tawny-crowned Honeyeater	17
White-fronted Chat	5,7,8,10,11,14,18,20
Striated Pardalote	1,4,18,20
Zebra Finch	4
Australian Magpie Lark	1,3,4,5,8,9,11,20
Dusky Woodswallow	19
Grey Butcherbird	1,2,3,7,8,9
Pied Butcherbird	9
Australian Magpie	1,2,3,4,8,9,10,19,20,21
Australian Raven	2,3,4,5,8,9,19,22