A BIOLOGICAL SURVEY OF LANDS PROPOSED FOR RELEASE FOR AGRICULTURE IN THE MANJIMUP REGION

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Department of Conservation and Land Management
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INTRODUCTION

It has been proposed (Joint Working Group, 1984) that up to 2860 hectares of Crown land in the Manjimup Shire may be suitable for agricultural development. Some further investigation of the area in question has since been made (Kingdon and Stoneman, undated Department of Agriculture internal report). The aim of the present survey was to obtain information relevant to an assessment of the conservation value of the land proposed for release for agriculture.

AREAS UNDER STUDY

The six areas investigated are within the Warren Botanical District. All are within the Shire of Manjimup, and are within.36-105 km from Manjimup by road (Fig.1). Locations, approximate areas, and tenure are shown in Table 1.

Soil associations in the general area (except for the region of the JR105 block) have been mapped by McArthur and Clifton (1975). The soils are of lateritic origin, with some lateritic surfaces still present. Most soils in the area are podzols, podzolics or red earths, with sands in drainage lines. Further notes on the soils of each block are given by Kingdon and Stoneman (n.d.).

RATIONALE BEHIND APPROACH

A biological survey should include intensive sampling at replicated sites in each landform/vegetation unit in the study area, with sampling being repeated in different seasons. However, in the present survey, time was severely limiting. The following approach was therefore adopted:

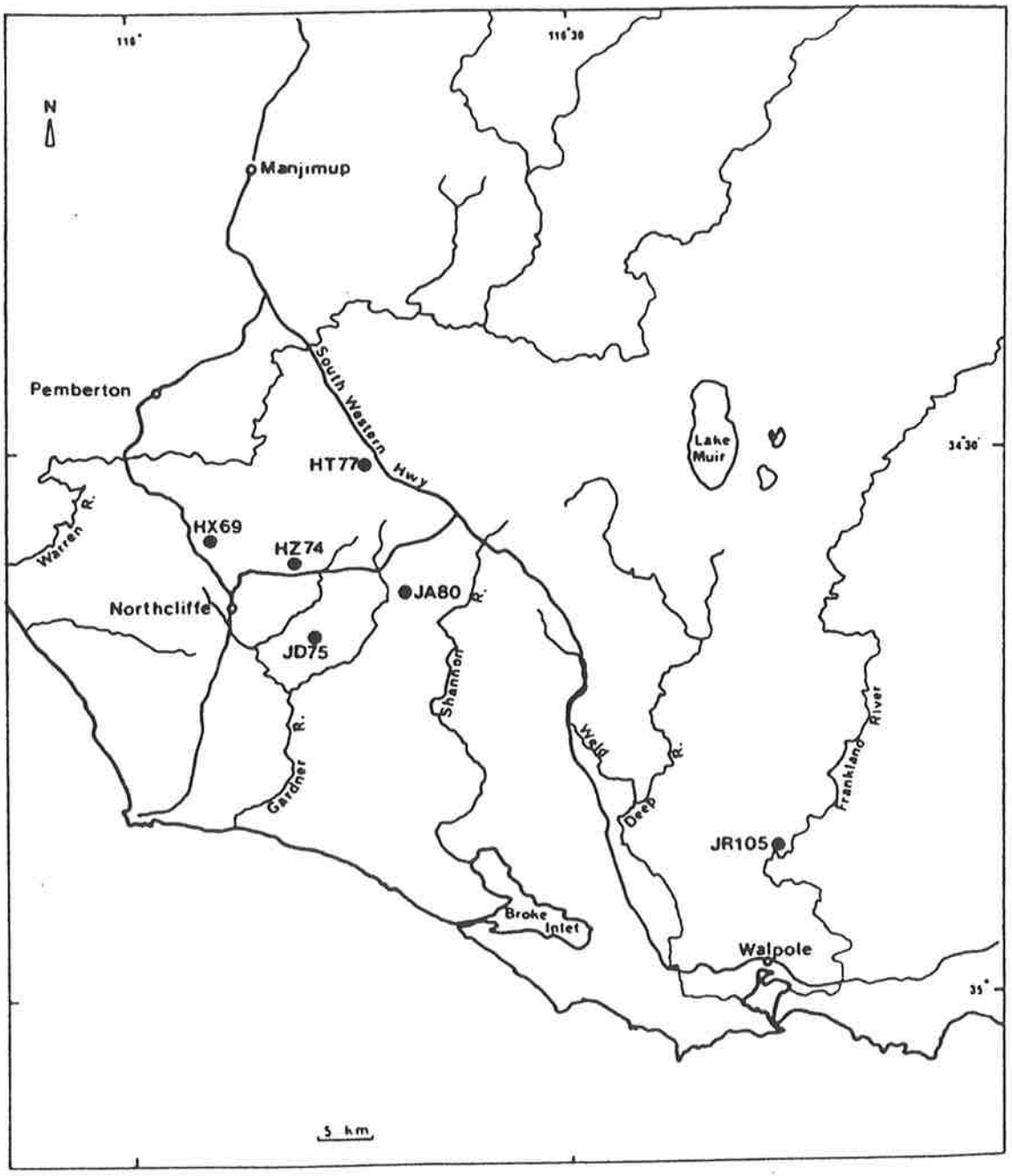

Figure 1 Locations of the six blocks surveyed, mapped in relation to nearby towns and major river systems.

Table 1: Location (grid reference on 1 : 50,000 forests maps), area and tenure of the six blocks investigated in the present survey. Data from Joint Study Group (1984).

Grid Reference	Area (ha)	Tenure
HT 77	900	SF
HX 69	200	SF
HZ 74	(350 (150	SF VCL
JD 75	710	VCL
JA 80	900	VCL/Prop. Nat. Pk.
JR 105	250	SF

rather than provide a superficial survey of as many organisms as possible in a very short time, it was decided to concentrate on one group - vascular plants - and gather opportunistic data on vertebrate groups.

Vascular plants were selected as an appropriate group on which to concentrate, as 1) it is easier and quicker to collect good assemblage data in a short time (hours per site rather than days per site for any vertebrate group), 2) sites are relatively species rich in plants compared with vertebrates, and therefore more amenable to numerical analysis, and 3) a sound knowledge of vegetation and floristics allows prediction of which vertebrate species would be expected to occur at a site, whereas the reverse generally is not possible.

A site-specific sampling method was considered essential to provide data which would allow meaningful comparisons between blocks within the study area, and with sites outside the study area.

METHODS

Maps

Each block is referred to by an alpha-numeric code corresponding to the location of the block in the grid system in 1:50,000 forests maps (Forests Dept., W.A.).

Vegetation

The report of Kingdon and Stoneman (undated), together with our observations made on a reconnaissance of all blocks, suggested that each block contained two major vegetation/landform units - forest on lateritic or loamy soils, and a sedgeland or shrubland community on sandy soils. In each block, one quadrat was placed in each of these units, except for block JR105 in which two quadrats were placed in the sandy areas low in the landscape.

All quadrats were described using Muir's (1977) system of vegetation classification. Brief notes were also made on areas outside the quadrats.

We used 25m x 25m quadrats to sample plant assemblage data. In order to determine minimum quadrat size for collection of this kind of data, four sets of nested quadrats were laid out. Two of these were in forest, and two in communities on sandy soils. Species accumulation curves are shown in Fig.2.

Analysis of the species accumulation curves using the intercept method (Mueller-Dombois and Ellenberg, 1974) showed that an area in excess of 20m x 20m would be required to include 95% of all the species found in the 25m x 25m area in each of the four nested quadrats except possibly quadrat 9. In each case, an area of 20m x 20m would be adequate to include over 90% of the species found in the 25m x 25m area. On this basis, a quadrat size of 25m x 25m is adequate to obtain reliable plant assemblage data in these communities.

In order to test this conclusion further, quadrat 1 (the most diverse floristically) was extended to 50m x 50m. An area greater than 25m x 25m would be required to sample 95% of the species in the 50m x 50m area, although 25m x 25m was adequate to sample 90% of species. Analysis of this species accumulation curve by an alternative method (Cain, 1938, cited in Mueller-Dombois and Ellenberg, 1974) showed that an area of 25m x 25m would be adequate at the 95% level.

In gathering assemblage data it is important not to sample too small an area. Provided that a single patch type is being sampled, using too large a quadrat would not affect analyses of the data. However, undersampling and representing only part of each assemblage could produce strong biases in the analyses. An area of 25m x 25m does, however, appear to be a suitable and practical size for

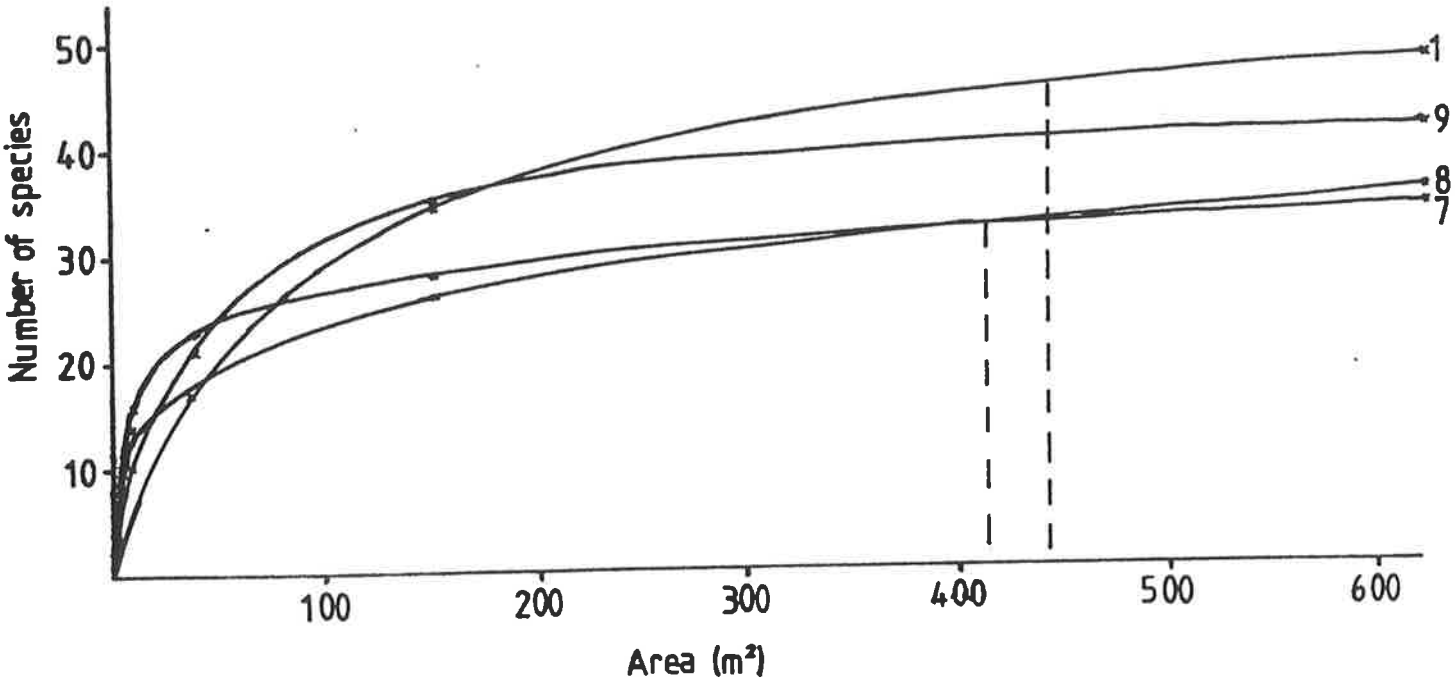

Figure 2 Species accumulation curves for four sets of nested quadrats. The dotted lines indicate the quadrat sizes required to include 95% of the species encountered in the 25m x 25m area for the least diverse and most diverse quadrat (quadrats 7 and 1 respectively).

collection of plant assemblage data in the community types sampled.

Some searching was done outside of quadrats in all vegetation formations in order to detect rare or patchily distributed species. Extra species found in this way are included in inventory lists, but did not form part of the numerical analysis.

Voucher specimens have been retained at the Western Australian Wildlife Research Centre.

Vertebrates

Vertebrates (frogs, reptiles, birds and mammals) were recorded opportunistically during the course of our reconnaissance trip and the floristic survey in September 1985. Observations were made on all blocks and mostly in the vicinity of our vegetation quadrats.

Both live sightings and observations of fresh tracks and signs (scats, diggings, burrows) were noted.

Some spotlighting from a vehicle was conducted on tracks on each block. Spotlighting effort per block is listed in Table 2, and totalled 9.3 hours. To some extent weather conditions dictated the time spent spotlighting.

A bat trap was set overnight on each of 4 blocks - HX69, JR105, JA80 and HZ74 - during the floristic survey. Representative specimens of frog, reptile and bat species were collected to verify field identifications. Frog and reptile specimens have been accessed by the Western Australian Museum. Mammal (bat) specimens have been identified at the museum and are to be accessed at a later date. Birds were sampled more thoroughly than other vertebrate groups since they are the most visible and audible group of vertebrates which are active during the day

Table 2: Spotlighting effort (hours) in each block. Spotlighting traverses from a vehicle were made on each block during either the reconnaissance trip or the floristic survey.

Block	HT77	HX69	HZ74	JA80	JD75	JR105
Spotlighting Effort (hours)	3.3	1.6	1.3	0.6	1.7	0.8

and therefore most easily inventoried during the course of vegetation sampling.

Our data on vertebrates are presented according to block or vegetation type/landform unit and therefore are not directly comparable with the plant quadrat data.

Floristic Analysis

Floristic data were analysed using the TAXON-P3 programs which were accessed via the CSIRONET system. Firstly, a matrix was generated using the Jaccard coefficient. (The Jaccard coefficient is an appropriate coefficient for binary (presence/absence) data.) Quadrats were treated as individuals, and species within them as attributes. A minimum spanning tree was then computed, and a dendrogram was produced using the output from a clustering program. The program used was SAHN, which is the Lance-Williams sequential agglomerative hierarchical non-overlapping clustering program, using a flexible sorting strategy with alpha = 0.6250 and beta = -0.2500. Following this, a principal coordinates analysis was done by means of the TAXON program PLOA. The program BACRIV was then used to calculate the correlation of each attribute (species) to the vectors provided by the principal coordinates analysis.

RESULTS

Vegetation

All blocks contained loamy or lateritic soils supporting forests and well-drained sandy soils supporting heaths, with most blocks (HZ74, JA80, JR105 and HT77) also having sedgelands on poorly-drained soils (Fig. 3). The vegetation maps lack detail, and should be regarded as preliminary only.

Locations of quadrats are shown in Figure 3, and detailed descriptions are presented in Appendix 1. Floristic lists

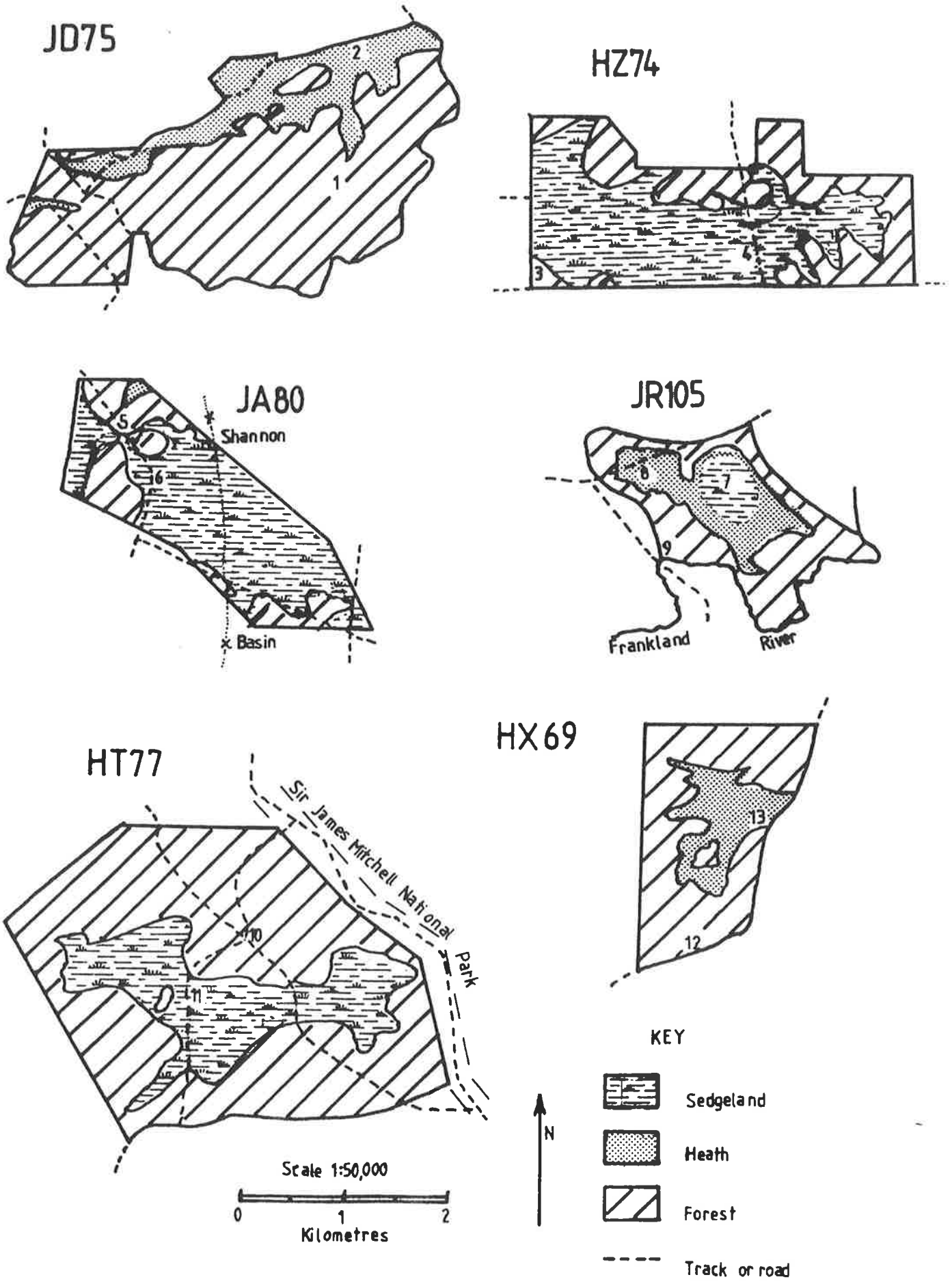

Figure 3 Preliminary vegetation maps for each of the six blocks surveyed.

for each quadrat and for each vegetation unit in each block are presented in Appendix 2.

The classification analysis (Fig.4) distinguished two clear-cut major groups of quadrats: forests on heavier soils and heaths and sedgelands on sandy soils. Each of these groups was further subdivided, providing four groups of quadrats in all.

The forest types were divided into jarrah forests on lateritic gravelly soils (quadrats 1 and 10) and forests containing karri and either jarrah or marri (or both) on more loamy soils (quadrats 3, 5, 9 and 12). Quadrats on sandy soils were divided into two groups. The first included heaths or thickets with scattered emergent stunted jarrah trees and with a poorly developed sedge layer on well drained sands (quadrats 2, 8 and 13). The second group included sedgelands, with various proportions of emergent heath, on poorly-drained sands (quadrats 4, 6, 7 and 11).

Results of the minimum spanning tree analysis (Fig.5) confirmed these groupings.

The four groups distinguished in the classification analysis also occur with the same quadrat composition in the ordination analysis (Fig.6). Eigenvalues for the first seven vectors, and the percentage variability accounted for by each are listed in Table 3. Only 23% of the variance is accounted for in the first vector. However, the two major groups of the classification analysis (forests on loamy or lateritic soils versus heaths and sedgelands on sandy soils) are clearly separated on this first vector (Fig.6a). Correlation coefficients between vectors and attributes (Table 4, Appendix 2) show that the species which contribute most to the separation on vector 1 are *Adenanthos obovatus*, *Dasypogon bromeliifolius* and *Leptocarpus* sp. 1 (which occur on all the sand quadrats but nowhere else) and *Pteridium esculentum* (which occurs on no sand quadrat but is present

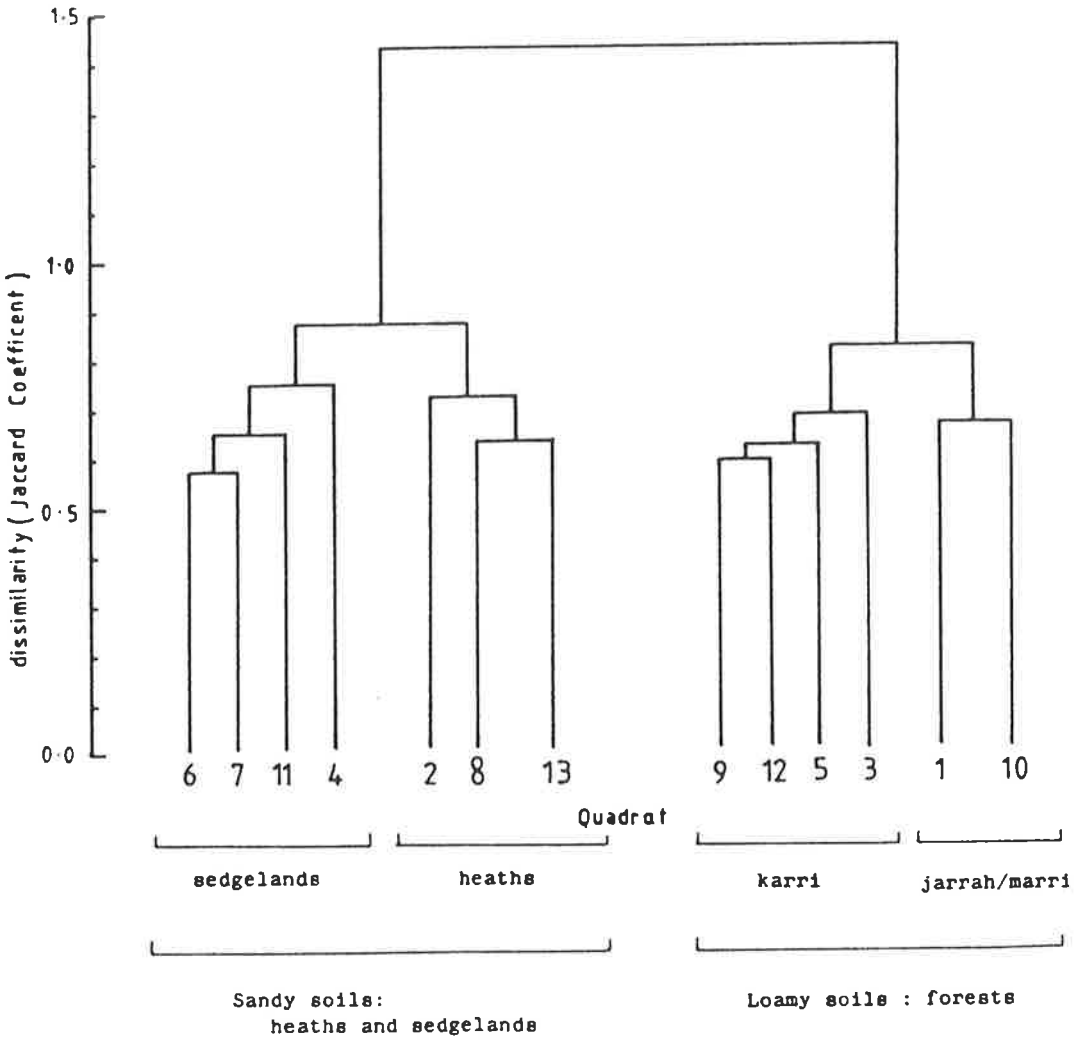

Figure 4 Grouping of floristic quadrats from the clustering analysis (see text for details of method).

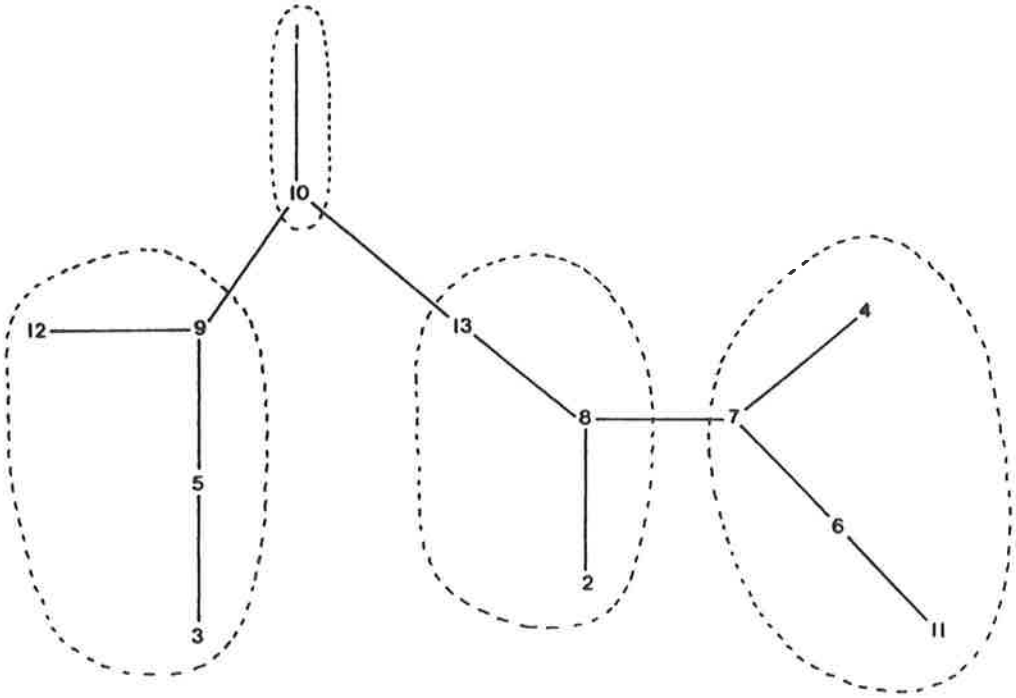

Figure 5 Minimum spanning tree for the 13 floristic quadrats. Group boundaries from the classification analysis have been superimposed on the tree.

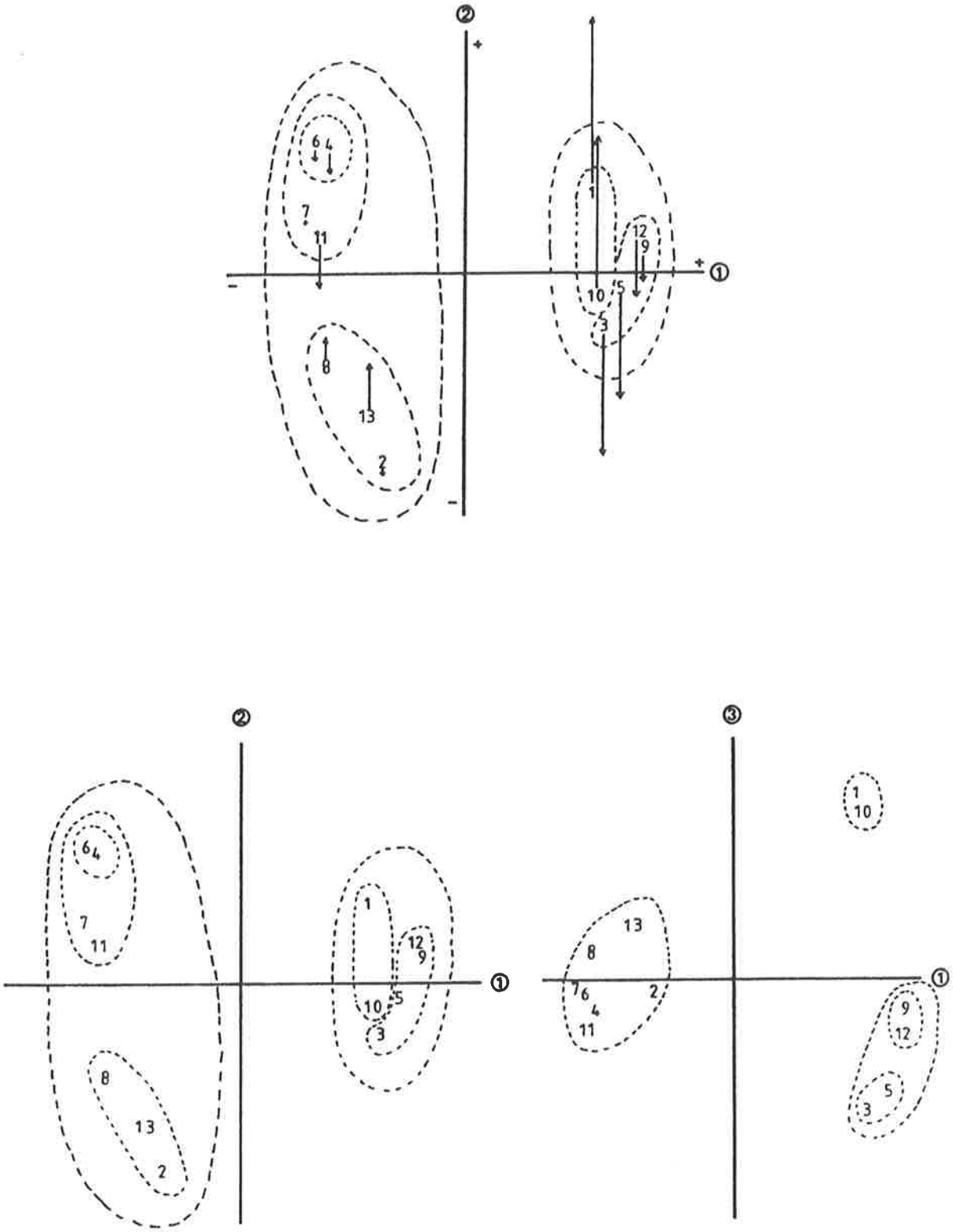

Figure 6 Plots for the 13 quadrats on the first three vectors from the principal coordinates analysis. Group boundaries from the classification analysis have been superimposed on the plots.

Table 3: Eigenvalues and percentage traces for the first seven vectors derived in the principal coordinates analysis.

Vector	1	2	3	4	5	6	7
Eigenvalue	1.157	.490	.440	.391	.370	.364	.345
% trace	23	9	8	7	7	7	6

in all other quadrats). A number of other species, including *Macrozamia riedlei* and *Podocarpos drouynianus*, show similar but less clear cut patterns of occurrence with respect to quadrat groups and hence soil types. Species of Cyperaceae and Restionaceae were more commonly encountered on the sand quadrats than in quadrats on laterites and loams. These latter quadrats were characterized by species from a number of families (Table 4a, Appendix 2).

The second vector separates the heathland group on well drained sands from the sedgeland group on poorly drained sands (Fig.6a,b), but contributes little to separation of the forest quadrats from one another. Species contributing most to separation on this axis are *Acacia extensa* and *Pultenaea ochreata* which occur on better drained sites, and *Anarthria gracilis* and *Sphaerolobium macranthum*, which occur on poorly drained sites (Table 4b, Appendix 2).

The jarrah forests on lateritic soils are clearly separated on the third vector from those forests containing karri on loamy soils (Fig.6a,c). Vector 3 shows strong correlations with *Crowea augustifolia* (which was found in jarrah but not karri forests), *Tremandra diffusa*, *Scaevola* sp. and *Acacia lateriticola* (mostly jarrah forests), and a "karri forest group" - *Allocasuarina decussata*, *Eucalyptus diversicolor*, *Lomandra pauciflora and Thomasia quercifolia* (Table 4c, Appendix 2).

Vertebrates

Table 5 is a list of frogs, reptiles and mammals that were recorded opportunistically on the six blocks under study. A total of 7 frog, 3 reptile and 5 mammal species were recorded.

Noting that only 1 night (a maximum of 3.3 hours) was spent spotlighting in each block, most blocks were found to support a rich frog fauna, with a maximum of 6 species on

Table 4: Correlations for attributes on vectors for the 20 attributes with the greatest absolute values of correlation for the first three vectors in the principal coordinates analysis.

(a) Correlations for vector 1

Attribute (Species)	Correlation	
	+ve	-ve
Adenanthos obovatus		.9858
Dasypogon bromeliifolius		.9858
Leptocarpus sp. 1		.9858
Pteridium esculentum	.9858	
Macrozamia riedlei	.8984	
Podocarpus drouynianus	.8984	
Acacia pentadenia	.8707	
Boronia gracilipes	.8644	
Hibbertia amplexicaulis	.8546	
Lomandra odora	.8546	
Opercularia sp. 1	.8546	
Persoonia longifolia	.8546	
Sphenotoma gracile		.8368
Tetrarrhena laevis	.8330	
Anarthria prolifera		.8302
Eriochilus dilatatus	.8173	
Xanthorrhoea preissii		.7642
Allocasuarina decussata	.7642	
Eucalyptus diversifolia	.7642	
Lomandra pauciflora	.7642	

Table 4:

(b) Correlations for vector 2

Attribute (Species)	Correlation	
	+ve	-ve
Acacia extensa		.6812
Pultenaea ochreata		.6806
Anarthria gracilis	.6408	
Sphaerolobium macranthum	.6408	
Bossiaea rufa		.6384
Schoenus brevisetis		.6384
Stylidium repens		.6384
Anarthria scabra		.6088
Andersonia caerulea		.5895
Boronia crenulata		.5734
Caladenia sp. 2		.5734
Choretrum glomeratum		.5734
Cryptostylis ovata		.5734
Drosera erythrorhiza		.5734
Hypocalymma strictum		.5734
Jacksonia horrida		.5734
Lepidosperma sp. 1		.5734
Leucopogon capitatum		.5734
Lyperanthus nigricans		.5734
Patersonia sp. 2		.5734

Table 4:

(c) Correlations for vector 3

Attribute (Species)	Correlation	
	+ve	-ve
Crowea angustifolia	.8647	
Tremandra diffusa	.6633	
Scaevola sp.(p)	.6577	
Acacia lateriticola	.6113	
Allocasuarina decussata		.6109
Eucalyptus diversicolor		.6109
Lomandra pauciflora		.6109
Thomasia quercifolia		.6109
Xanthorrhoea preissii	.6109	
Thomasia sp. 1		.6074
Anigozanthos manglesii	.6019	
Bossiaea linophylla	.6019	
Drosera sp. 1	.6019	
grass sp. 3	.6019	
Hakea amplexicaulis	.6019	
Hovea chorizemifolia	.6019	
Leptomeria pauciflora	.6019	
Loxocarya fasciculata	.6019	
Patersonia xanthina	.6019	
Restio sp. 3	.6019	

Table 5: Frogs, reptiles and mammals recorded on the six blocks.
+ indicates presence.
Museum accession numbers of voucher frog and reptile specimens are listed (e.g. R93743).
*Heard overhead

	Block Grid Reference					
	HT77	HX69	HZ74	JA80	JD75	JR105
Amphibians						
Crinia georgiana	+	+	+	+	+	R93746-48
Heleioporus eyrei	R93743					
Limnodynastes dorsalis	+	+	+	+	+	+
Litoria adelaidensis	R93760	+	+	+		+
L. moorei	R93758-9		+	+	R93749	+
Pseudophryne nichollsi					R93750	
Ranidella sp. ? glauerti	R93744		R93751 R93753	R93745		R93752
Number of species	6	3	5	5	4	5
Reptiles						
Hemiergis peronii					R93754-5	
Ctenotus labillardieri		R93757	R93756		+	
Tiliqua rugosa					+	
Number of species	-	1	1	-	3	-
Mammals						
Tarsipes rostratus			+			
Chalinolobus morio				+		+
Eptesicus regulus			+	+		+
*Tadarida australis**		+	+			
Macropus fuliginosus	+	+	+	+	+	+
Number of species	1	2	4	3	1	3

one block (HT 77) and 5 species being detected on three blocks: HZ74, JA80 and JR105.

With the exception of *Pseudophryne nichollsi* which was detected only in jarrah/marri forest on gravelly lateritic soils in JD75, all species were present in sedgelands on poorly drained sandy soils. Two species, *Crinia georgiana* (all blocks) and *Ranidella* sp (? *glauerti*) (HT77, HZ74, JA80, JR105) were detected only in poorly drained sedgeland or wet heaths. Both species were most abundant in areas of swampy sedgeland which had been inundated by winter rains e.g. on HZ74, JA80, JR105.

Four species, *Heleioporus eyrei*, *Limnodynastes dorsalis*, *Litoria adelaidensis* and *L. moorei* also occurred in wet forest (karri with marri or jarrah or both) on the blocks examined, although usually not far from sedgeland or wet heath.

With cool (and occasional wet) days persisting during our fieldwork in September, little reptile activity was observed. The three species recorded were detected during the course of vegetation sampling.

A single individual of *Tarsipes rostratus* (male, 8.5g) was captured while spotlighting on the southern boundary of HZ74. It appeared to be moving from a tall thicket of flowering *Agonis parviceps* (1.5 to 2 metres) with emergent stunted jarrah, to adjacent swampy sedgeland. *Adenanthos obovatus* and *Banksia quercifolia* were also present but were not common and were post-flowering.

Two bat species, *Eptesicus regulus* and *Chalinolobus morio* were detected in forest on 3 and 2 blocks respectively. *E. regulus* was captured in wet forest of karri and marri on HZ74 (see the description of quadrat 3, HZ74, Appendix 1), in open jarrah forest with a heath understorey on JA80, and on JR105 in jarrah/marri forest with a tree understorey of

Allocasuarina decussata and young jarrah/marri (to 15m) and a shrub understorey (to 2.5m).

C. morio was captured on JA80 and JR105 in the vegetation types which were described for *E. regulus*.

Macropus fuliginosus was detected on all blocks.

Table 6 lists bird species recorded on each of the 6 blocks according to presence on or near floristic quadrats or in similar vegetation types within each block. Species records are further summarized in terms of 4 main vegetation types recognized: forest or lateritic soils (jarrah, or jarrah and marri), forest on loamy soils (karri and jarrah or marri or both), wet heath on well drained sands and sedgeland (seasonably swampy) on poorly drained sands. In total, fifty-three species were recorded from the 6 blocks.

Four species were recorded only on sedgelands - Australian Shelduck, Pacific Black Duck, Maned Duck and Horsfield's Bronze Cuckoo. The first 3 species were mostly observed on bodies of water retained in ditches and pits and are unlikely to utilize the other vegetation types.

The Crested Shrike Tit, Australian Magpie and Grey Currawong were recorded only in wet forest. Three species, the Emu, Red-tailed Black Cockatoo and Varied Sittella, were recorded only in jarrah or jarrah/marri forest. However none of these species is likely to be confined to these forest types.

Highest bird species diversity was recorded in the 2 forest types: 34 in jarrah or jarrah/marri and 33 in karri (with jarrah or marri or both), although the structurally simpler sedgeland areas showed a surprisingly high level with 30 species.

Vegetation	Dry forest		Wet forest				Wet heath			Sedgeland			
Block	JD75	HT77	HZ74	JA80	JR105	HX69	JD75	JR105	HX69	HZ74	JA80	JR105	HT77
Species / Quadrat	1	10	3	5	9	12	2	8	13	4	6	7	11
Emu		+											
Australian Shelduck										+			
Pacific Black Duck										+			
Maned Duck										+			
Brown Goshawk			+				?			+			
Common Bronzewing						+							
Red-tailed Black-Cockatoo	+												
Baudin's Black-Cockatoo*		+		+	+	+				+			
Purple-crowned Lorikeet	+	+		+		+							
Red-capped Parrot		+								+			
Western Rosella	+	+		+		+				+	+		
Port Lincoln Ringneck	+	+				+				+			
Fan-tailed Cuckoo	+	+	+	+	+	+		+		+			
Pallid Cuckoo										+			
Horsfield's Bronze-Cuckoo											+		+
Shining Bronze-Cuckoo	+	+	+	+	+			+		+	+		+
Southern Boobook	+	+		+	+	+							
Tawny Frogmouth							+			+			
Australian Owlet-nightjar	+												
Laughing Kookaburra	+	+	+	+	+	+	+			+	+		
Tree Martin		+	+										
Fairy Martin		+								+		+	
Black-faced Cuckoo-shrike		+		+		+			+	+			
Scarlet Robin										+			+
White-breasted Robin	+			?									
Crested Shrike-tit				+		+							
Golden Whistler	+	+	+	+	+	+			+				
Rufous Whistler						+							
Grey Shrike-thrush	+	+		+	+	+							
Grey Fantail	+	+	+	+	+	+	+		+	+			
White-browed Babbler	+					+							
Little Grassbird										+			
Splendid Fairy-wren								+					
Red-winged Fairy-wren								+					
Fairy-wren species		+			+	+			+		+	+	+
White-browed Scrub-wren	+	+		+	+	+		+					
Western Gerygone	+	+	+	+	+	+			+				
Inland Thornbill	+	+		+	+			+		+			
Western Thornbill		+			+			+		+			
Varied Sittella	+	+											
Rufous Treecreeper							+						
Red Wattlebird		+	+	+	+	+				+			
Little Wattlebird		+									+		+
White-naped Honeyeater	+	+	+	+	+	+							
New Holland Honeyeater	+	+	+	+	+	+	+		+	+	+		+
Western Spinebill					+		+	+	+	+	+		+
Spotted Pardalote	+	+		+	+	+							+
Striated Pardalote	+	+	+	+		+							
Silvereye		+		+	+			+		+			+
Red-eared Firetail								+					
Dusky Woodswallow	+									+			
Australian Magpie				+									
Grey Currawong					+								
Australian Raven	+			+	+	+				+			
Number of species	35		33				18			30			

* White-tailed black cockatoos, probably all Baudin's.

Table 6: Birds recorded from the six blocks, tabulated according to presence on floristic quadrats or in similar vegetation types on the same block. Species records are further summarized in terms of the four main vegetation types recognized (see text for details). Names follow Blakers et al. (1984).

DISCUSSION

The Six Blocks

Taking the data set as a whole, there is considerable variation between quadrats, and consequently also between blocks. On the other hand, when considering individual blocks, all blocks are more or less equally different from each other. It is therefore difficult, on the basis of the numerical analysis, to single out blocks which are particularly unusual within this data set. Therefore, when these blocks are viewed in isolation from areas not covered in the present investigation, all blocks are of equal conservation value.

However, when the vegetation data are examined together with other observations, some further useful statements can be made.

Block JA80 partly overlaps the Shannon basin (Fig. 3), an area proposed for inclusion in a National Park (Shannon/D'Entrecasteaux Planning Group, 1984). This area includes two plant species of particular botanical interest (Table 7). The block is mainly flat and seasonally swampy, supporting a substantial tract of largely undisturbed sedgeland. Amongst the sedgeland quadrats, the quadrat in this area showed the highest species diversity. During the time of our field work, most of the area was inundated with water. It would be difficult (and therefore expensive) to drain (Joint Report, 1984; Kingdon and Stoneman, n.d.). Given the known biological and physical attributes of this block, and its geographic position relative to the proposed Shannon National Park, it should not be a candidate for release for agriculture.

Block HZ74 block (quadrats 3 and 4) is possibly the most distinct block on the basis of the numerical analysis, although the distinction is marginal. Quadrats 3 and 4 each separated out first within their respective groupings. This

Table 7: Plant records of particular interest.

SPECIES	FEATURE	REFERENCE	BLOCK
Aotus passerinoides	species of restricted occurrence (160km range, Pemberton-Albany)	Rye, 1982	JA80
Banksia quercifolia	farthest inland occurrence known	A. Taylor, pers. comm.	HT77
Lomandra brittanii	second record outside the Perth-Boddington region	T. McFarlane, pers. comm.	HT77
Meeboldina denmarkica	monotypic genus restricted to south-western Australia; known only from the Bunbury Walpole area	Rye, 1982	JA80

block also has a fairly extensive sedgeland area. Such areas, although present in the proposed Shannon National Park (A. Annels, pers. comm.), appear not to be well represented in the Manjimup region.

The HT77 block is surrounded by an extensive tract of forest which is dissected at present only by the South-Western Highway (Fig.3). Release of this block for agriculture would have at least two detrimental consequences: 1) increased pressure on the surrounding forest, heath and sedgeland communities from feral and semi-domestic animals and plants (weeds) in an area currently isolated to some extent from the sources of exotic species, and 2) an inevitable increase in the frequency of fires in the area (principally State Forest) immediately surrounding this block. Such events would be ecologically detrimental in these surrounding areas. This situation is particularly pertinent in the case of this block, which is completely surrounded by extensive areas of forest, unlike any other block. In addition, this block has one boundary of about three kilometres in common with the Sir James Mitchell National Park, a reserve already highly susceptible to environmental disturbances because of its linear shape. Furthermore, it includes two plant species occurrences of particular interest (Table 7).

The block at JR105 is located on the Frankland River, with the river forming the southern boundary. A major forest quarantine area, the Collis forest block, is situated on the opposite side of the Frankland. Given the serious threat posed by *Phytophthora cinnamomi* to native vegetation in the South-west, it may be unwise to release this land. If released and cleared for farmland, there would almost certainly be an increase in vehicular traffic via River (Loop) Road, which forms the western boundary of JR105, crosses the Frankland and immediately across the river forms the southern boundary of the quarantine block. This would lead to an inevitable increase in the spread of *Phytophthora*

into forested areas (and agricultural land) on either side of the Frankland. At the present time there is an effective buffer strip of apparently little used forest on the western side of the Frankland, including the JR105 block.

Records of three species encountered are of particular interest. Plant records of most interest are summarized in Table 7. None of the gazetted rare flora was found in any block, although searching was not systematic through the blocks. However, block JA80 contains one species of restricted occurrence (*Aotus passerinoides*) and a species of a monotypic genus (*Meeboldina denmarkica*) which is confined to the region, and HT77 contains two species (*Banksia quercifolia* and *Lomandra brittanii*) each at the limit of its range. Blocks HX69 and HT77 contain what appear to be the most north-westerly occurrences of *Banksia quercifolia*. The record from block HT77 is the farthest inland record in the Banksia Atlas (A. Taylor, pers. comm.).

Two bird species observed, the Crested Shrike-tit (*Falcunculus frontatus*) and the Red-eared Firetail (*Emblema oculata*), are listed in Schedule 2 of the Wildlife Conservation Act as being species which are "rare, or otherwise in need of special attention", although each is fairly widespread throughout the South-west. We found them in blocks JA80 and HX69 (the Shrike-tit) and block JR105 (the Firetail).

Release of these blocks for agriculture would result in a reduction of geographic range of several interesting plant species, a reduction in the amount of habitat available for the Shrike-tit and the Red-eared Firetail, and a reduction in the amount of genetic variability available in the gene pool of each of these species.

Regional Comparisons

Comparison of these blocks with other areas in the southern forests is difficult, due to an apparent lack of published

site-specific assemblage data for natural communities in this region. Without site-specific assemblage data from a range of vegetation types in the southern forests it is not possible to assess how well represented these communities are in conservation reserves. The report of Annels *et al.* (in press) does, however, provide some basis for comparison. The report covers 15 fauna surveys carried out between Busselton and just east of Denmark between 1972 and 1982. Most of these surveys cover vegetation communities unlike those encountered in the present survey, and none appear to be in communities which are strictly comparable. Nevertheless, two of these surveys ('Mitchell' and 'Karri') are in areas sufficiently close to the present survey area to allow some comparisons to be made. Allowing for the fact that the 'Mitchell' and 'Karri' survey areas were substantially larger than the present survey area, and also contained more vegetation types, the floristic diversity is roughly comparable in the three areas (Table 8). Our opportunistic bird sightings included an almost identical number of species as was reported from the 'Karri' survey, and 80% of the number recorded in the 'Mitchell' survey. The data of Annels *et al.* (in press) for these two survey areas suggest that, given the level of floristic and vegetation diversity found in the present survey, some 20 species of mammals would be expected to be found in this area. These data also suggest that some 15 reptile and 11 frog species would be expected to occur. These figures do not include species known to be rare in the region; any such species would further expand the list.

Given the opportunistic nature of our vertebrate observations, our lists are clearly incomplete, specially for frogs, reptiles and mammals. Comparison with data from the larger nearby 'Mitchell' and 'Karri' blocks is difficult due to differences in effort and sampling procedure. However, it can certainly be stated that the area which we examined would contain an extremely high proportion of the vascular plants and vertebrates known from the region.

Table 8: Some biological characteristics of three survey areas in the Manjimup-Walpole area. The "Mitchell" and "Karri" surveys concentrated on vertebrates; the present study concentrated on plants, with vertebrate observations being opportunistic (no trapping was done for mammals, reptiles or frogs). Data from "Mitchell" and "Karri" surveys from Annels *et al*. (in press).

Survey	No. of major vegetation types	No. of plant spp.	No. of frog spp.	No. of reptile spp.	No. of bird spp.	No. of mammal spp.
"Mitchell"	9	198	7	13	66	14
"Karri"	9?	314	9	10	52	11
Present Study	4	224	7	-	53	-

CONCLUSIONS

There are insufficient data to determine, in a regional context, the conservation status of the communities we examined. However, release of any of the blocks for agriculture would reduce the extent and diversity of the plant and animal communities contained within them. In view of the drastic reduction in area of these natural communities, and in particular the marked fragmentation which has already occurred in the southern forests region, further release must have detrimental biological consequences for the long term conservation of these community types.

Several points should be made, however, with respect to some of the blocks examined.

Release of blocks at JA80 and HT77 would cause significant management problems in adjacent land which is either National Park or proposed National Park. The JA80 block overlaps the proposed Shannon National Park, and therefore should not be considered for release. If the HT77 block was released, management problems in the adjacent section of the Sir James Mitchell National Park would become significant and in addition introduce a high level of ecological disturbance into surrounding State Forest. Release of either of these blocks would also result in the loss of several plant populations of some botanical interest.

Release of the JR105 block may cause problems with the spread of *Phytophthora* in adjacent areas.

Blocks at JR105, JA80 and HX69 include areas known to be utilized by species listed as being "rare, or otherwise in need of special attention" under the Wildlife Conservation Act. Although these two species are each fairly widely distributed in the south-west, release of these areas would reduce the amount of habitat available to them. Release of

block HX69 would also reduce the geographic range of *Banksia quercifolia* at the limit of its range.

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Appendix 1: Description of vegetation in each quadrat using Muir's (1977) system. Notes on vegetation out of quadrats are also included.

JD75

QUADRAT 1 Mc. SBd. Ji

Jarrah Forest, (25-30 m, 30-70% canopy cover) with some marri, over dense heath of Agonis parviceps and Acacia lateriticola, 1-1.5 m, greater than 70% cover, with Agonis flexuosa and Banksia grandis as occasional emergents. Below the Acacia layer is a number of species of varying heights, specially Crowea angustifolia and many herbs including Lomandra and Tehrarrhena. The soil is gravelly on a lateritic ridge with a gradual slope to the east.

Most of the forest in this block appears similar to the quadrat site. It has been cut over for timber for many years; this process is still occurring. In valleys where the soil is sandy, the forest vegetation is replaced by dense patches of floristically simple Agonis thickets. In valleys on heavier soils on the eastern side of the block, the jarrah forest merges into a karri dominated forest with Acacia pentadenia, Hibbertia cuneiformis, etc.

QUADRAT 2 Sc. SDd

Thickets of Agonis parviceps and Acacia extensa, just over 2 m, 30-70% canopy cover, over Dense Low Heath D (<0.5 m) of Podocarpus, various sedges including Anarthria spp., and mixed low shrubs. The soil is sandy, on a gentle slope, and well-drained. Scattered emergents of jarrah and Banksia ilicifolia outside of quadrat.

HZ74

Quadrat 3 Tc. Sd. Ji

Tall Forest (greater than 30 m) of karri and marri, with some jarrah; canopy cover 30-70%. Dense Thicket (>70% canopy cover) of 2.5 m Acacia pentadenia, with occasional emergents of Allocasuarina decussata. Sparse herbaceous layer (10-30% cover) with the tallest members being 0.5 m Pteridium, on loamy soil.

In other parts of the block, this merged into mid-dense forest of jarrah (30-70% canopy cover).

QUADRAT 4 VLd

Dense sedges (<0.5 m, >70% canopy cover) with Gahnia and Xanthorrhoea preissii common; on poorly drained sand.

Some otherwise similar areas outside the quadrat contained clumps of emergent myrtaceous species, particularly Beaufortia sparsa. Rare jarrah emergents also occurred. In the ecotone area on the boundary with the forest this community graded into dense thickets (>70% cover) of Agonis parviceps, up to 2 m and more.

JA80

QUADRAT 5 Md.SBd

Dense Forest of jarrah, (about 25 m, >70% canopy cover) with occasional karri, over Dense Heath B (1-1.5 m, 70-100% cover), mostly Agonis parviceps and Acacia spp. on loamy soil.

Outside the quadrat, marri was present nearby. In other parts of the block, karri was sometimes more frequent. In valleys where the soil was sandier, the vegetation

consisted of Dense Thickets of Agonis, grading through jarrah Woodland, over Dense Heath A to forest on the heavier soils.

QUADRAT 6 VTi. VLd

Sparse clumps of Gahnia (0.5-1.0 m, 10-30% cover) over dense mixed sedges (<0.5 m, 70-100% cover), with scattered emergents of Melaleuca rhaphiophylla (to 11 m) and clumps of Agonis parviceps (1-1.5 m). Outside of the quadrat were occasional clumps of sedges over 0.5 m, on sandy, poorly-drained soil.

JR105

QUADRAT 7 SBd. VT/VLd

Myrtaceous Dense Heath B (1-1.5 m, >70% cover) over dense monocots (mostly sedges) at various heights less than 1 m, on poorly drained sandy soil. Occasional Kingia emergents. Outside of the quadrat, scattered jarrah emergents to 20 m.

QUADRAT 8 SBc. VLc

Agonis parviceps Heath B (1-1.5 m, 30-70% cover) with Xanthorrhoea over sparse to mid-dense monocots, mostly sedges. Sandy soil, better drained than Quadrat 7. Out of quadrat there were patches of Agonis to 2 m or more, and scattered emergent jarrah.

QUADRAT 9 Mc. SAd. Jd

Mixed jarrah, karri and marri forest (25-30 m, 30-70% cover) over Dense Heath A (1.5 - 2 m, 70-100% cover) of Agonis parviceps and Acacia pentadenia over dense smaller shrubs and herbaceous species on loamy soil. In other parts of the block, particularly on the northern

edge, there are lateritic soils with jarrah and some marri but no karri. There is an ecotonal woodland area between the forest on the heavier soils and the heaths on the sandy soils.

HT77

QUADRAT 10 Tc. Sc.

Tall Forest (>30 m, 30-70% cover) of jarrah with scattered marri, over sparse to dense Thicket of Agonis parviceps and Acacia spp. on a lateritic ridge. Outside the quadrat there were some areas with karri in other parts of the block.

QUADRAT 11 SBi. VLd

Beaufortia shrubs 1-1.5 m, sparse (10-30% cover) over dense sedges (70-100% cover, <0.5 m), with rare emergents of Melaleuca rhaphiophylla (6 m) jarrah (E. marginata) (6 m) and Xanthorrhoea (to 1½ m)on poorly-drained sand.

Away from the quadrat, near the boundary of the sand, Melaleuca is more frequent occurring with Banksia littoralis and grades into jarrah Woodland and finally jarrah Forest of about 25 m in height.

HX69

QUADRAT 12 Tc. LAi. SBi.Ji

Tall forest (>30 m, 30-70% cover) of karri and marri over a low woodland (5-15 m) of sparse (10-30% cover) Allocasuarina decussata, Agonis spp and young eucalypts. Under this layer is a sparse shrub layer (10-30% cover, 1-1.5 m) of Agonis parviceps over sparse low shrubs and

herbs on a loamy soil. The area was burnt about two years ago in a control burn.

QUADRAT 13 SAc. Ji

Heath A (1.5-2 m, 30-70% cover) of Acacia spp. and Agonis parviceps over a sparse herbaceous layer, with scattered emergent jarrah (E. marginata), on well drained sandy soil with an easterly aspect of about 15°. The area was burnt about two years previously.

In some areas, jarrah was more frequent, to the extent that the vegetation here could be described as a woodland with a heath understorey. Eucalyptus patens was found on the ecotonal area between the heaths and the forests on the heavier soils.

Appendix 2: List of plant species found in quadrats (1) and out of quadrats in the same vegetation unit (0). Nomenclature is based on Green (1985). Most identifications have not yet been checked at the State Herbarium.

	Dry Forests		Wet Forests				Heaths			Sedgelands			
	JD75	HT77	HZ74	JA80	JR105	HX69	JD75	JR105	HX69	HZ74	JA80	JR105	HT77
Species	Quadrat												
	1	10	3	5	9	12	2	8	13	4	6	7	11
ADIANTACEAE													
Adiantum aethiopicum					0								
DENNSTAEDTIACEAE													
Pteridium esculentum	1	1	1	1	1	1							
LINDSAEACEAE													
Lindsaea linearis	1	1		1	1								
ZAMIACEAE													
Macrozamia riedlei	1	1	1	1	1	1	1						
PODOCARPACEAE													
Podocarpus drouynianus	1	1	1	1	1	1	1						
POACEAE													
grass sp.3	1												
Holcus lanatus										0			
Neurachne? sp.1	1	1	1	0		1		1					1
Neurachne? sp.2			1	0	1	1							
Poa annua										0			
Tetrarrhena laevis	1	1	1		1	1							
CYPERACEAE													
Evandra aristata												1	
Gahnia sp.1				0				1	0	1	1	1	
Lepidosperma effusum	0			1									
Lepidosperma gladiatum					1								
Lepidosperma sp.1							1						
Lepidosperma tenue		1	1			0							
Mesomelaena sp.1									1	0			
Schoenus brevisetis							1	1					
Schoenus sp.											1	1	1
sedge,flat leaf	1												
Tetraria octandra	1							1			1	1	
Tricostularia compressa											1		
ARACEAE													
Zantedeschia aethiopica										0			

Species	Quadrat												
	1	10	3	5	9	12	2	8	13	4	6	7	11
RESTIONACEAE													
Anarthria gracilis										1	1	1	1
Anarthria prolifera							1	1	1	1	1	1	
Anarthria scabra			1		0		1	1	1	0		1	1
Leptocarpus sp.							1	1	1	1	1	1	1
Loxocarya fasciculata	1												
Loxocarya sp.1					0								
Lyginia barbata							1	1		1	1		1
Meeboldina denmarkica											1		
Restio sp.1										1		1	1
Restio sp.2									1				
Restio sp.3	1												
XYRIDACEAE													
Xyris lacera													0
Xyris lanata												1	
JUNCACEAE													
Juncus pallidus						0				0	1		
LILIACEAE s.l.													
Chamaescilla corymbosa								1		1		0	
Dasypogon bromeliifolius							1	1	1	1	1	1	1
Johnsonia lupulina	0						1	1		1	1	1	
Kingia australis							0		0			0	
Lomandra brittanii		1											
Lomandra odora	1	1		1	1	1							
Lomandra pauciflora			1	1	1	1							
Lomandra sonderi								1					
Xanthorrhoea gracilis		1											
Xanthorrhoea preissii	1	1					1	1	1	1	1	1	1
HAEMODORACEAE													
Anigozanthos flavidus	1				1	0				0			
Anigozanthos ?manglesii	1										0		
Conostylis setigera		1			0								
Haemodorum spicatum											1		
Phlebocarya ciliata										1			
IRIDACEAE													
Patersonia sp.1						1							
Patersonia sp.2							1						
Patersonia umbrosa		1			1								
Patersonia xanthina	1				0								
Watsonia sp.1										0			

Species	Quadrat												
	1	10	3	5	9	12	2	8	13	4	6	7	11
ORCHIDACEAE													
Caladenia flava										1			
Caladenia latifolia			1										
Caladenia sericea	0				0				1				
Caladenia sp.1				1		1							
Caladenia sp.2							1						
Corybas dilatatus						1							
Corybas sp.1			1										
Cryptostylis ovata							1						
Diuris longifolia		1											
Eriochilus dilatatus	1	1	1	1	1								
Lyperanthus nigricans							1						
Prasophyllum sp.1			0										
Pterostylis vittata				1		0							
Thelymitra crinita			1										
Thelymitra aff. spiralis										1			
Thelymitra sp.1	1												
CASUARINACEAE													
Allocasuarina decussata	0		1	1	1	1							
PROTEACEAE													
Adenanthos obovatus							1	1	1	1	1	1	1
Banksia grandis	1	0		1					1				
Banksia ilicifolia							0						
Banksia littoralis									0				0
Banksia quercifolia								1	0	0	1	1	0
Banksia ?seminuda					0								
Grevillea aff. intricata					0								
Hakea amplexicaulis	1												
Hakea ceratophylla													1
Hakea lasianthoides					0								
Persoonia longifolia	1	1		1	1	1							
Petrophile diversifolia				1									
Petrophile longifolia								1			1		0
SANTALACEAE													
Choretrum ?glomeratum							1						
Leptomeria pauciflora	1												
Leptomeria scrobiculata							1	1					1
POLYGONACEAE													
Rumex? sp.						0							
RANUNCULACEAE													
Clematis pubescens	1		1		0	1							

Species	Quadrat												
	1	10	3	5	9	12	2	8	13	4	6	7	11
LAURACEAE													
Cassytha glabella							1	1				1	
Cassytha sp.1				1		1							
DROSERACEAE													
Drosera erythrorhiza							1						
Drosera macrantha		1	1	1		1	1	1	1	0	1	1	1
Drosera menziesii					0								
Drosera sp.1	1												
Drosera sp.2								1	1		0	1	
CRASSULACEAE													
Crassula pedicellosa										1			
PITTOSPORACEAE													
Billardiera candida						1							
Billardiera variifolia					1								
MIMOSACEAE													
Acacia aff. myrtifolia		1											
Acacia alata		1											
Acacia browniana				1	0								
Acacia divergens	0	1											
Acacia extensa	0	1					1		1	0			
Acacia hastulata								1	1	0			
Acacia lateriticola	1	1				1							
Acacia myrtifolia		0						0		0	0		
Acacia pentadenia		1	1	1	1	1							
Acacia pulchella													0
Acacia urophylla	0												
PAPILIONACEAE													
Aotus genistoides		0											
Aotus passerinoides											1		
Bossiaea laidlawiana	0												
Bossiaea linophylla	1				0								
Bossiaea ornata		0											
Bossiaea rufa							1	1					
Burtonia? conferta			1										
Chorizema glycinifolium					0								
Chorizema ilicifolium	1			1	1	1							
Chorizema rhombeum	1			1									
Daviesia sp.1										1			
Genista canariensis							0						
Gompholobium ovatum					0								
Gompholobium polymorphum		1											
Hardenbergia comptoniana	0												
Hovea chorizemifolia	1				0								
Hovea elliptica	1	1			1	1							

Species	Quadrat												
	1	10	3	5	9	12	2	8	13	4	6	7	11
Isotropis cuneifolia						0	0	1	0				
Jacksonia horrida							1						
Kennedia coccinea		1											
Latrobea tenella											0		
Oxylobium lanceolatum	0			0	1								
Pultenaea ochreata							1	1	1				1
Sphaerolobium macranthum										1	1	1	1
Sphaerolobium medium					0								
Sphaerolobium sp.		1											
RUTACEAE													
Boronia capitata			0				0		0				
Boronia crenulata							1						
Boronia gracilipes	1		1	1	1	1							
Boronia spathulata								1	1	1	1		1
Chorilaena quercifolia			1			0							
Crowea angustifolia	1	1			0	0							
TREMANDRACEAE													
Tetratheca aff. nuda							0						
Tremandra diffusa	1	1			1	0							
Tremandra stelligera	1		0	1	1	1				0			
POLYGALACEAE													
Comesperma confertum					0								0
EUPHORBIACEAE													
Amperea ericoides?				1									
Amperea micrantha											1	1	1
SAPINDACEAE													
Dodonaea viscosa					0								
STERCULIACEAE													
Thomasia quercifolia					1								
Thomasia aff. quercifolia			1	1		1							
Thomasia sp.1			1	1		1							
DILLENIACEAE													
Hibbertia amplexicaulis	1	1		1	1	1							
Hibbertia cuneiformis	0		0										
Hibbertia sp.1	1	1	1	1									
THYMELAEACEAE													
Pimelea hispida									0				
Pimelea sp.1	1						1		1	1	1		

Species	Quadrat												
	1	10	3	5	9	12	2	8	13	4	6	7	11
MYRTACEAE													
Agonis flexuosa	1				0	1							
Agonis ?hypericifolia					0								
Agonis linearifolia												1	
Agonis parviceps	1	1	1	1	1	1	1	1	1	0	1	1	
Astartea fascicularis											1		1
Beaufortia sparsa										0	1	1	1
Darwinia oederoides													0
Eucalyptus calophylla	1	1	1	0	1	0							
Eucalyptus diversicolor	0	0	1	1	1	1							
Eucalyptus marginata	1	1	1	1	0		0	1	1	0	0		0
Eucalyptus patens									0				
Homalospermum firmum										0	0	1	
Hypocalymma aff. ericifolium											1		
Hypocalymma strictum							1						
Kunzea recurva									0	0	0		
Melaleuca rhaphiophylla											1		1
Melaleuca sp.1											1		
Melaleuca? sp.2									0	1			
APIACEAE													
Actinotus omnifertilis		0						1	1			1	0
Pentapeltis silvatica					0								
Platysace compressa					1								
Platysace tenuissima		1											
Xanthosia hederifolia	1	1	1	1		0							
Xanthosia huegelii					0								
Xanthosia pusilla									1				
EPACRIDACEAE													
Andersonia aff. caerulea				1	0								
Andersonia caerulea		1			0		1	1	0	0	0		
Andersonia simplex												1	
Astroloma drummondii								1					
Leucopogon australis		1	1	1	1			1	1				1
Leucopogon capitellatus							1						
Leucopogon distans										1	0		
Leucopogon aff. nutans	1	1	1								1		
Leucopogon propinquus	0		1			1							
Leucopogon verticillatus	1	1			1	1							
Leucopogon sp.1	1										1		
Sphenotoma capitatum								1		1		1	
Sphenotoma gracile							1	1	1		1	1	1
Styphelia tenuiflora	1												
LOGANIACEAE													
Logania serpyllifolia			1	1		0	1						

Species	Quadrat												
	1	10	3	5	9	12	2	8	13	4	6	7	11
SOLANACEAE													
Solanum nigrum					1								
LENTIBULARIACEAE													
Polypompholyx tenella											0		
RUBIACEAE													
Opercularia volubilis					1								
Opercularia sp.1	1	1		1	1	1							
GOODENIACEAE													
Dampiera hederacea	0		1	1	1	0							
Dampiera linearis	1			1	1		1	1	1	1	1	1	1
Goodenia sp.1									1			1	
Scaevola striata				1		0	1						
Scaevola sp(p).	1	1				1			1				
Velleia trinervis						0							
STYLIDIACEAE													
Stylidium ?adnatum	1	1			1	1							
Stylidium ?amoenum	1										1	1	0
Stylidium aff. assimile									1		0		
Stylidium carnosum		1											
Stylidium piliferum								1				1	
Stylidium repens							1	1	0		0		0
Stylidium rhynchocarpum	0				0								
Stylidium scandens		1											
Stylidium spathulatum		1	1	1	1								
ASTERACEAE													
Arctotheca calendula										0			
Hypochaeris glabra			1			0							
Lagenifera huegelii	0	1	1		1		1						
Senecio sp.1						0							
Sonchus oleraceus										0			