BIOLOGICAL SURVEY OF KANGAROO HILLS AND CALOOLI TIMBER RESERVES, COOLGARDIE, WESTERN AUSTRALIA

M.J.Bamford
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CONTENTS

Abstract

The Kangaroo Hills and Calooli Reserves occupy 9721 hectares just south of Coolgardie between lat. 30° 58' 45" - 31° 05' 00" and long. 121° 01' 45" - 121° 10' 00". The area lies in the Coolgardie Botanical District and has rainfall of 256 mm/year with a slight winter maximum. Temperatures are hot in summer and relatively mild in winter, although minima down to -5°C may occur.

The landforms range from gilgaied clay flats and broad alluvial or erosional valleys to relatively rugged greenstone hills and small areas of rounded to flat granite outcrop. Sand sheets, sometimes in association with laterite occur in both reserves. The reserves have a diverse topography within a relatively small area.

The vegetation was systematically sampled at 19 sites and plants were collected throughout the reserves. Over 250 species and subspecies were identified. Several species of restricted occurrence were found and one species of Acacia (A. duriuscula) was collected for the first time since 1902. However there were no declared rare flora identified. *Stipa blackii* (a South Australian species) was recorded for the first time in Western Australia.

Nine vegetation units were recognised, three complex units for particular landforms and six woodland or open woodland associations dominated by eucalypts or acacias.

Floristically the area shows affinities with both the Eremaean and south west of Western Australia, but it is more closely related to the mesic south west than the drier inland.

Two amphibian, 32 reptile and 18 mammal (9 introduced) species were recorded in the reserves with pitfall trapping at 12 and Elliott trapping at six sites. The assemblage of reptile species in particular was transitional between the south-west and the Eremaean provinces. Of the landform units identified in the reserves, a few species were confined to and some were absent from the sandplain, but otherwise the local distribution of species was independent of landform. No rare or endangered species were found.

The avifauna of the Kangaroo Hills and Calooli Reserves was surveyed at nine sites in each of April, July and November. The species included representatives of south-western (Bassian) and arid (Eremaean) faunal provinces. Twelve species of passerines were amongst those described as confined to undisturbed native vegetation by Kitchener *et al.* (1982) during surveys of the Western Australian wheatbelt. The diversity of the vegetation enabled many species of locally nomadic birds to remain in the reserve throughout the year, although they used different parts of it at different seasons.

1. INTRODUCTION

Kangaroo Hills Forest Reserve and Calooli Sandalwood Reserve lie 3-18 km south of Coolgardie and have a combined area of 9,721 ha. Kangaroo Hills was gazetted in 1975 partly because of the presence of several eucalypt species with restricted distributions. Calooli was gazetted in 1926 for the conservation of Sandalwood (*Santalum spicatum*). This decision was presumably in response to comments by Hutchins (1916) that government control of Sandalwood stocks was necessary if the species was to survive and its economic potential be realised.

Sheep graze in both reserves but grazing is heaviest in the northern half of Kangaroo Hills. Exploration for mining also occurs in both reserves and is concentrated in the greenstone areas of Kangaroo Hills. Some 95% of Kangaroo Hills is under mining tenements (I. Keally pers. comm.) and the Nepean Mine on the eastern side of this reserve is active. Landuses in the surrounding region include pastoralism on Calooli pastoral lease and Vacant Crown Land to the south.

Early European explorers who passed through the area include: C.D. Hunt (1864-1866), W.P. Goddard (1890) and S.G. Hubbe (1986) (Jarvis 1979). As gold was discovered only a few kilometres north of the reserves in 1892, the area was undoubtedly regularly visited by Europeans from that time on and Londonderry Mine, just to the east of Kangaroo Hills, was active by 1898. Pastoralism had commenced in the general area by the turn of the century.

By 1900, there was a strong and increasing demand in the goldfields for timber for building materials and fuel. Before the completion of the Goldfields Water pipeline in 1902, the Coolgardie water condenser used 100 tons of wood per day (Jarvis 1979), while every mine required wood-fuel to drive engines. Writing in 1915, Hutchins (1916) bemoaned the uncontrolled destruction of forests in the vicinity of goldfields towns. Thus, harvesting for timber undoubtedly affected Kangaroo Hills and Calooli Reserves from the turn of the century. It is not known when logging ceased in this area, but it continued until the early 1950's south-east of Kalgoorlie (Hunter 1980).

Kangaroo Hills and Calooli Reserves lie in the north-east corner of the Boorabin-Southern Cross Study Area of the Biological Survey of the Eastern Goldfields. They are therefore close to the boundaries of four of the Eastern Goldfields Study Areas and are approximately mid-way between sampling sites in Boorabin-Southern Cross and Kurnalpi-Kalgoorlie. Unfortunately, the results of the work in these two Study Areas have yet to be published. Published reports, edited by the Biological Surveys Committee and produced as supplements to the Records of the WA Museum, are: Widgiemooltha-Zanthus (1984), Lake-Johnstone-Hyden (1988), Jackson-Kalgoorlie (1985) and Edjudina-Menzies (1988).

Access to and within the reserves is generally good, with two surfaced roads along the eastern and western boundaries of Kangaroo Hills and tracks through many areas of both reserves.

2. PHYSICAL ENVIRONMENT.

2.1. CLIMATE.

Typically for the southern interior of Western Australia, the study area experiences cool to cold winters and hot, dry summers. Rainfall is low and distributed throughout the year, coming from southern frontal systems in winter and troughs originating in the north in summer. Mean climatic data for Kalgoorlie are presented in Table 2.1. Incomplete meteorological records were kept during field-trips and are summarised below (temperatures in ^{o}C):

20-25 April.	Minima: 14.5, 14.0, 9.5, 9.5, 5.0, 8.5.
	Maxima: 29.0, 20.0, - 24.0,26.0, -
	Heavy rain on 21 April.
25-29 July.	Minima: -3.5, -5.0, -4.5, 3.0, -1.5.
	Maxima: - 13.0, 15.5, 18.0, 14.0.
	Showers on 25 July.
15-18 November.	Minima: 11.0, 11.0, 14.0, 8.0.
	Maxima: - 30.0, 31.0 -
	No significant rain.

In comparison with the long-term averages for Kalgoorlie, both the July and November trips were unseasonally cool, the minima especially being unseasonally low.

TABLE 2.1. Climatic data for Kalgoorlie (Bureau of Meteorology 1988). Temperatures in ^{o}C, rainfall in mm.

	Jan	Feb	Mar	Aprl	May	Jne	Jly	Aug	Sep	Oct	Nov	Dec
Mean max.	33.6	32.0	29.6	25.0	20.4	17.5	16.5	18.4	22.0	25.5	28.9	32.1
Mean min.	18.2	17.7	15.9	12.3	8.3	6.1	4.8	5.5	7.8	10.8	13.9	16.6
Mean rainfall	21	29	20	19	27	31	27	20	15	16	18	13

2.2 Landforms

The geology of Kangaroo Hills and Calooli Reserves has been extensively investigated, due to the presence of economic concentrations of gold and sub-economic concentrations of nickel in the well-exposed belt of greenstone hills that occupies a large part of the reserves (see, for example, Hunter 1989). The complex geological history of the area has created a very varied landscape and array of soil-types, from sandplain to rocky hills. Physiographic features of Kangaroo Hills-Calooli identified by Hunter (1989) include:

1. dissected Archaean greenstones around Comet Hill in Calooli and over much of the central third of Kangaroo Hills. In the Boorabin region studied by Hunter, these greenstones occur only in the north-eastern corner of the region.

2. dissected granitoid uplands with limited exposure.

3. undulating and eroding sandplain developed on granite. These are limited to the southern edge of Calooli and the northern end of Kangaroo Hills, but are extensive in the western half of the Boorabin region.
4. aeolian and fluvial sediments which have choked palaeo-drainage lines dating from a period of high precipitation which ended in the late Eocene to mid-Miocene.

The Department of Conservation and Land Management has produced a report recognising eight landform/vegetation units within this landscape (Kangaroo Hills and Calooli Vegetation, Anon., undated). Sampling during this flora and fauna study was based upon these units, which are described below.

Sandplain.

Sandy soils, ranging from very poor yellow sands to sandy loams, occur mainly at the northern end of Kangaroo Hills and along the southern boundary of Calooli. Vegetation typically includes hummock grasses and mallee-form eucalypts.

Alluvial woodland.

The low lying areas between the greenstone ridges are fairly varied depending on whether the substrate is truly alluvial or is derived from weathered basement rock. In a number of areas the valleys are cut into softer sections of the greenstone basement or are underlain by weathered granitic rock. To the north east of Comet Hill the plain is extensive with a very low slope towards the north.Close to the ridge on which Comet Hill occurs the basement of granite outcrops as very low domes, sometimes capped by lateritic material (Site 6). Further away fron the ridge the drainage lines are channelled between areas of clay which have a microtopography of giant gilgai. The depressions of the gilgai are arcuate with the tails of each arc pointing towards the ridge. It seems as if these areas are broad clay flows moving towards the north. In the southernmost part of Kangaroo Hills there are areas of similar gilgai landscape but the impression of flow direction is absent.

In the central area of Kangaroo Hills there is an extensive erosional basin. The basement is weathered granitic material, but to the north the erosioal divide is extending into sand sheets while in the south greenstone terrain forms the boundary. Sediment has built up in the lower parts of this basin because the only exit is through a narrow valley in the greenstone ridge on the eastern side of the reserve. The alluvial build-up in the basin is mainly of sands and loamy gravel concomitant with the acidic parent material.

The lowlands support woodlands and open woodlands, often with only sparse understorey. The mix of dominant eucalypts may be quite complex depending on the soil texture and underlying parent material.

Gravel.

There are several small areas with low relief and soils composed of loam and ironstone gravel. These gravel areas are usually closely associated with sand sheets and may intergrade with them. Vegetation consists of eucalypt woodland and shrubs of variable structure and density. In the north east of the Kangaroo Hills Reserve indurated ironstone outcrops at the edge of the sandplains. The vegetation is to a certain extent unique for the reserve but includes elements of the communities which surround the ironstone.

Blackbutt Hills.

Described in the CALM report as"either...a foothill to the main greenstone hills...or as low relief above generally flat [alluvial] woodlands". Soils typically were stoney or gravelly mixed with clay and the vegetation a low woodland with a sparse understorey of shrubs.

Comet Hills.

Steep greenstone hills dissected by ephemeral watercourses create a sharply undulating landform over much of the two reserves. Soils are generally very rocky, but vary with relief, as does the vegetation which ranges from dense scrub to open woodland with little understorey.

Headwaters and foothills.

This is a transitional unit between landforms that are high in the landscape, especially Blackbutt and Burbank Hills, and the more low-lying Alluvial Woodland. It cannot be clearly defined as it can range from Alluvial Woodland with tree species not usually associated with such areas, to low Blackbutt Hills.

Burbank Hills.

Greenstone hills similar to the Comet Hills landform but very rocky and generally with a lower tree cover.

Granite.

Although granite is indicated as fairly extensive in the northern parts of the reserves on the geological map the actual outcrop of relatively fresh rock is restricted to a small area north of Grossmont, an even smaller area near the centre of Kangaroo Hills and a few hectares at the northern corner of Calooli.The rock is generally lichen covered with the sandy aprons supporting herbfield, passing into sparse to dense scrub and woodland around the perimeter.

3. Methods

3.1 Sampling sites and programme of field-work

The aim of this biological survey was to conduct sampling in all the landform types identified in the two reserves (Section 2.2). Many parts of the reserves were visited by vehicle and on foot, but sampling was concentrated at a number of sites. The locations of these sites and the types of sampling carried out at them are given on Figure 3-1. Table 3-1 describes the environment at each sampling site and gives details of sampling effort. In this table, the sites are not listed in numerical order but are grouped into landform types, with similar landforms in juxtaposition.

Field-trips occurred in autumn, winter and spring 1990 and were preceded by a site-inspection trip in October 1989. Vegetation studies took place on 20-26 April, 3-7 August and 13-22 October. Field-trips for fauna sampling occurred in the periods 20-26 April, 25-30 July and 14-20 November.

3.2 Vegetation surveys

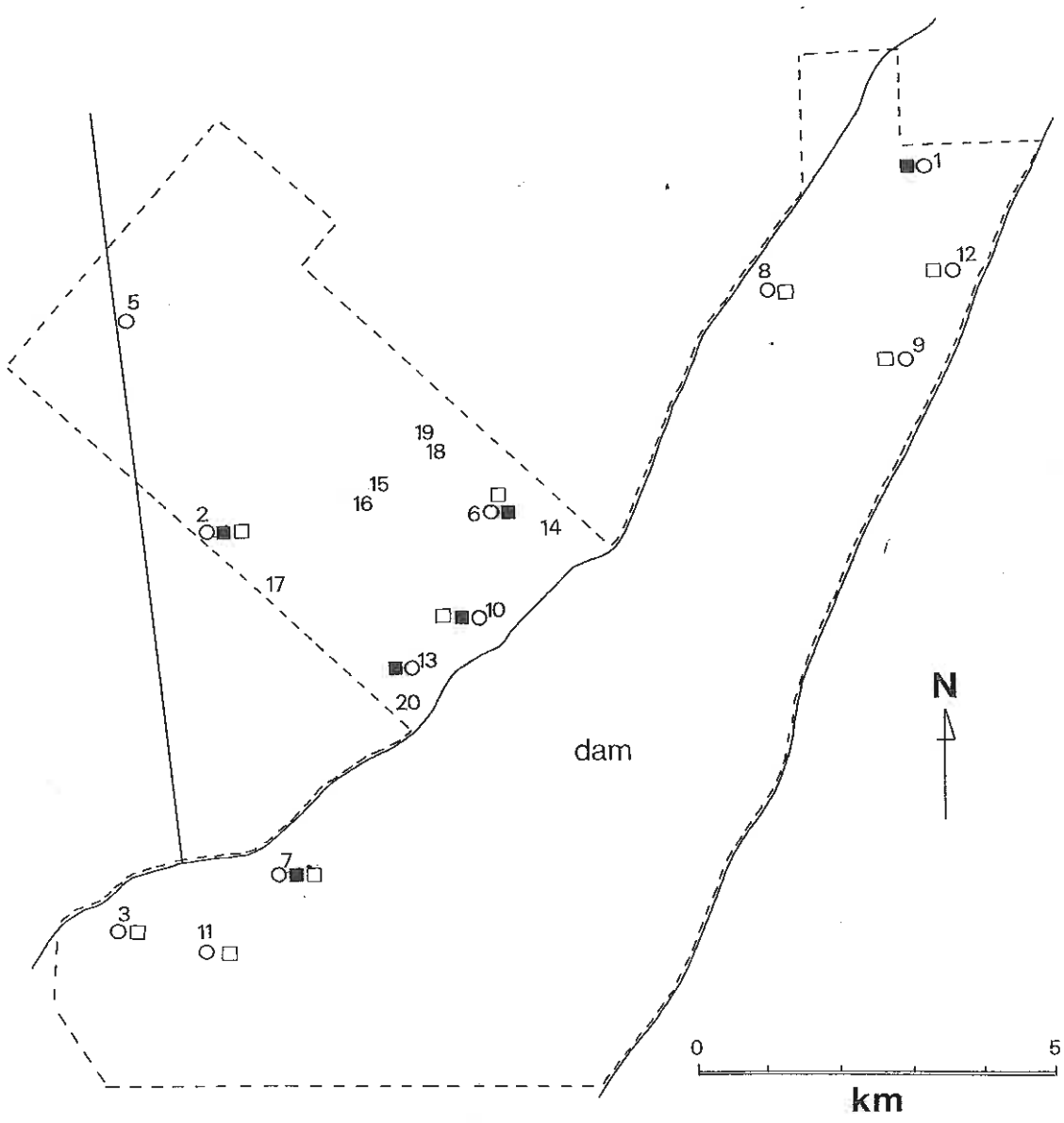
Vegetation samples were taken at the 19 sites marked on the vegetation map. These are numbered 1-20 but there was no site 4. All sites except 17, 18, 19 and 20 were visited three times, 17 and 20 were visited twice and 18 and 19 once. The sampled sites are described in Appendix 1. All vascular plants were recorded from a 20 X 20 m quadrat which extended 10 m either side and 20 m south of the steel star peg which marks sites 1-14. Sites 15-20 were treated in the same way but did not have pegs.

Plant species cover was recorded by modified Braun Blanquet cover values -

1 = <1% cover
2 = 1 - 5%
3 = 6 - 20%
4 = 21 - 50%

Tree density and basal area were measured at all sites except 17, in a 50 X 20 m quadrat which was a further 15 m extension E - W of the 20 X 20 m plot. The diameter of all stems of tree species which occurred within this 0.1 h were measured at 1.3 m above ground level.

Figure 3-1. Locations of vegetation (numbers 1-20) and fauna (numbers 1-13) sampling sites. Sampling at fauna sites included pitfall traps (open circles), Elliott traps (solid squares) and bird censusing (open squares).



3.3 Vertebrate sampling

3.3.1 Systematic sampling for vertebrates

a). Trapping

Two techniques for systematically trapping terrestrial vertebrates were employed: driftlines and Elliott traps. Driftlines consisted of six pitfalls, each 40 cm deep and 28 cm in diameter, spaced regularly along a 50 m fence. The fence was approximately 30 cm high. Elliott traps (9 cm x 9 cm x 32 cm) were used in lines of 20 with the traps at ca. 10 m intervals and were baited with universal bait (peanut paste and rolled oats).

There were 12 vertebrate trapping sites (see Fig.3-1). At least one site was placed in each of the eight landform types recognised in the two reserves, with replicates placed in the most distinctive landforms. One driftline was placed at each site and six of the sites (see Fig.3-1 and Table 3-1) also had a line of Elliott traps. The lines of Elliott traps were distributed to cover the widest range possible of landform types. Thus, there was one line in a rocky hills landform, one line at the granite site, one line at a gravel site, one line at an alluvial woodland site) and one line at each of the most widely separated sandplain sites.

In each of the three sampling periods (April, July and November), pitfall and Elliott traps were opened for five consecutive days and nights. Pitfalls were capped and Elliotts removed between sampling trips. In each sampling period, the sampling effort was 455 Elliott trap-nights and 360 pitfall trap-nights, giving total efforts of 1365 and 1080 Elliott and pitfall trap-nights respectively. Sampling efforts at each site are given in Table 3-1. The sampling effort with Elliott traps was slightly less than would have occurred with six lines of 20 Elliott traps because several traps were stolen by a picnic party. Some lines subsequently only had 19 traps, but capture rates were so low that the influence of this upon capture rates would have been negligible.

The majority of amphibians, reptiles and mammals handled were measured, weighed and individually marked before release. Weight (g) was taken with pesola spring balances accurate under field conditions to 0.1 g (0-10 g), 0.5 g (0-50 g) or 5 g (0-500 g). Measurements were: snout-to-vent length (SVL) (amphibians and reptiles); total length (reptiles) and crown length (mammals). All measurements were in mm and were taken with vernier calipers (SVL of amphibians and crown of mammals) or a clear plastic ruler (SVL and total of reptiles). Marking was by toe-clipping (amphibians and reptiles) and ear-punching (mammals).

b). Bird censussing

The method of bird censussing employed was that described by the Biological Surveys Committee (1984). This

TABLE 3.1. Vertebrate study sites: landform, environmental structure and 3.1 sampling effort. Locations of study sites are given on Figure and landforms are described in detail in Section 2.2.

Sandplain.

Site 1. Hummock grass, mallee and scrub on sand.
Pitfall traps: 30 pitfall-nights each sampling period.
Elliott traps: 100 trap-nights each sampling period.

Site 2. Scrub and mallee with a few clumps of hummock grass on sand.
Pitfall traps: 30 pitfall-nights each sampling period.
Elliott traps: 100 trap-nights each sampling period.

Site 12. Hummock grass and mallee on sand.
Pitfall traps: 30 pitfall-nights each sampling period.

Alluvial woodland.

Site 3. Eucalypt woodland with shrub understorey on loam.
Pitfall traps: 30 pitfall-nights each sampling period.

Site 13. Eucalypt woodland with sparse, shurb understorey on loam.
Pitfall traps: 30 pitfall-nights each sampling period.
Elliott Traps: 97 trap-nights each sampling period.

Gravel.

Site 5. Low woodland and scrub on gravel-loam.
Pitfall traps: 30 pitfall-nights each sampling period.

Site 6. Low woodland and scrub on gravel-loam.
Pitfall traps: 30 pitfall-nights each sampling period.
Elliott traps: 100 trap-nights each sampling period.

Blackbutt Hills.

Site 8. Low woodland on gravel-clay.
Pitfall traps: 30 pitfall-nights each sampling period.

Comet Hills.

Site 7. Low woodland and dense scrub on rocky soil.
Pitfall traps: 30 pitfall-nights each sampling period.
Elliott traps: 97 trap-nights each sampling period.

Headwaters and foothills

Site 11. Low woodland and scrub on rocky soil. Similar to site 7 (Comet Hills) in soil and vegetation structure.
Pitfall traps: 30 pitfall-nights each sampling period.

Burbank Hills.

Site 9. Low woodland with sparse scrub on very rocky soil.
Pitfall traps: 30 pitfall-nights each sampling period.

Granite.

Site 10. Dense scrub in loamy soils of the runoff zone of a granite outcrop.
Pitfall traps: 30 pitfall-nights each sampling period.
Elliott Traps: 97 trap-nights each sampling period.

is an area-search technique in which a quadrat with sides of 200 m is searched for half an hour on five consecutive days in each sampling period. Quadrats at eight sites were searched at this intensity and a quadrat at site 2 was surveyed once in each sampling trip (see Fig. 3-1). The sequence of censussing quadrats was varied to prevent bias due to time of day influencing the comparability of the results from different quadrats.

3.3.2 Opportunistic sampling for vertebrates.

Opportunistic sampling was carried out to supplement the results of the systematic sampling. Sight-observations of birds, reptiles and mammals were recorded at all times, spotlighting for nocturnal species was carried out on at least one night in April and November and active searching for reptiles took place in all sites. Mist-netting for bats was attempted at a dam on Kangaroo Hills Reserve (See Fig. 1) on one night in April and November, and over a claypan near site 5 on one night in November. Mist-netting for birds was carried out at granite (10) and Comet Hills (7) to confirm the identify of fairy-wren species at these sites.

4.1 FLORA

The flora of the Coolgardie region has historically been recognized as complex, being at the intersection of the Eremaean and Southwest vegetation provinces. In this survey over 239 species were recorded from 54 families. No species of declared rare flora has been recorded from the area. However during the field sampling the species *Acacia duriuscula* Fitzg. was collected for the first time since 1902, approximately 3 km. south of Coolgardie. In addition *Acacia websteri* Maiden & Blakely was collected from sand heath near the centre of the Kangaroo Hills reserve *A. prainii* Maiden var. *linearis* was recorded from a gravel site and *A. calcarata* Maiden and Blakely was found at site 8. *Eremophila veronica* (S. Moore) C.A. is listed by Briggs and Leigh (1988) with a 2K (limited distribution and poorly known) classification and *Thysanotus brachyantherus* Brittan is listed as a priority taxon at the Western Australian herbarium. Although not rare, these species do have fairly restricted distributions. *Stipa blackii* (a South Australian species) was recorded from granite and greenstone hills and does not seem to have been previously recorded from Western Australia.

The study area is relatively small in comparison with the areas of the recently completed Goldfields surveys. Despite this, some genera, notably *Eucalyptus* and *Eremophila* had quite a large number of species - 20 and 15 respectively. In contrast some taxa, such as the Proteaceae , which are well represented further to the south and west were not particularly species rich. The only Proteaceae taxa represented were *Grevillea, Hakea* and one species of *Persoonia*. The richness of Myrtaceae in the heaths was quite high; one site (site 2) had 10 species of shrub Myrtaceae out of 26 species in total recorded for the quadrat.

In general the heaths were more species rich than other areas. The overall species richness per site was 21 ± 5. However the richest sample was a *Eucalyptus griffithsii - E. yilgarnensis* woodland (site 17) with 33 species and the poorest was site 13 with only 9 species. The heaths were generally richer in woody shrubs than were other formations, while many of the outwash and clay plain sites had relatively high species richness because of the abundance of ephemeral therophytes. Rocky hillsides tended to be species poor, although the *Acacia quadrimarginea* site (site 15) had quite a number of ephemerals and 27 species in total.

The goldfield surveys of Widgiemooltha - Zanthus (Newby and Hnatiuk 1984) and Jackson - Kalgoorlie (Newby and Hnatiuk 1985) are both more intensive and extensive than this survey and no notable occurrences of species were identified at variance with these surveys. However the fact that over 240 species were recorded in the relatively small area of these two reserves compared favourably (in terms of species richness) with the total of 542 (Widgiemooltha -

Zanthus) and 780 (Jackson - Kalgoorlie) from very much larger areas.

4.2 VEGETATION

The species composition of the 19 formally sampled vegetation sites was analysed using computer classification (TWINSPAN) and ordination programs (CANOCO package). The clearest part of this analysis was that the sand heath sites (1,2,12) were a coherent group, very different from the other sites. Because they had so few species in common with the other vegetation communities they restricted the separation of the other sites when all sites were ordinated together. The sand sheet sites were removed and the remaining sites ordinated separately (Fig. 4.1). The new

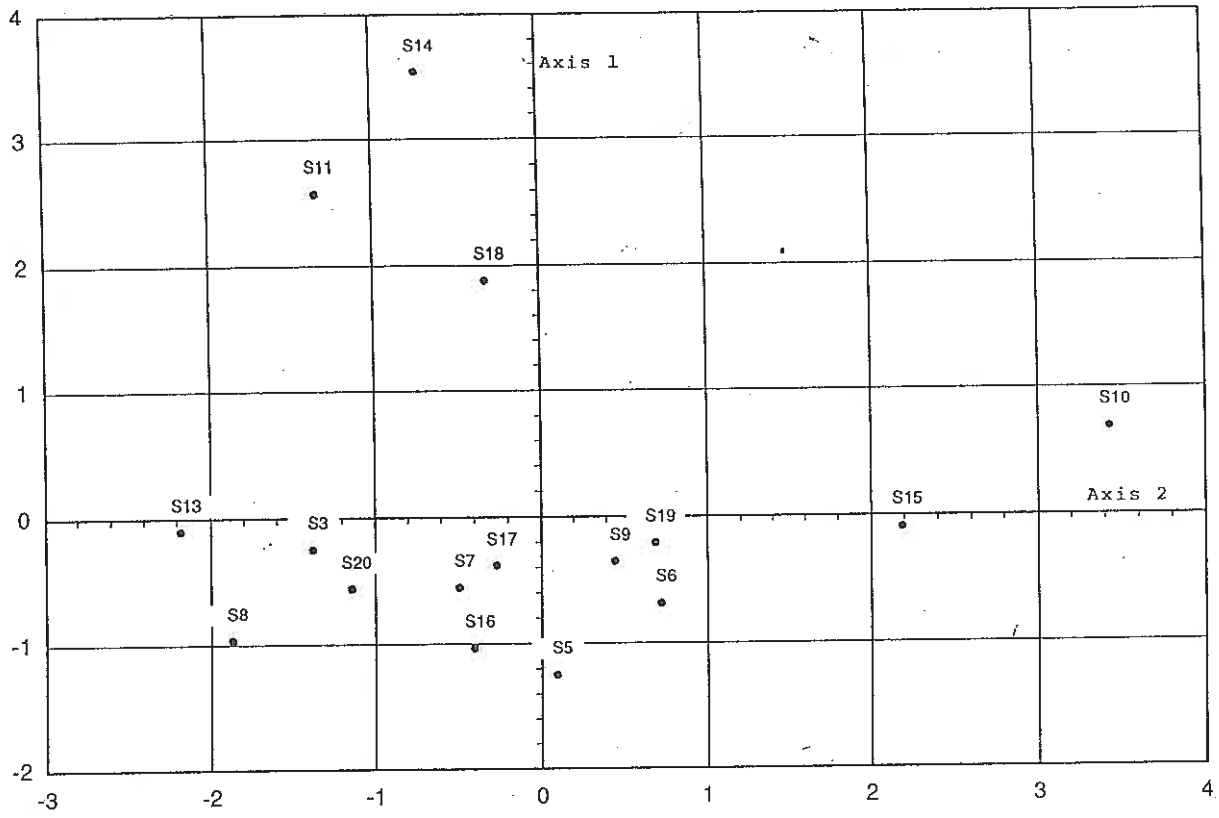


Figure 4.1. Canonical Analysis of the 16 non sand sheet sites from the Calooli/Kangaroo Hills Reserves.

ordination then showed separation of the sites on very clayey soils along the first axis with the rest of the sites arranged along the second axis. Granite sites are to the right and, in general, alluvial flats sites are to the left. The ordination results however, were not clear cut. There seemed to be no strong consistency between the location of the sites along the second axis and their position in the landscape (ie. aspect or geomorphic relationship), soil or rock type on which they occur.

Vegetation communities in this area form a complex mosaic. This will be considered in more detail in the discussion. However the need to recognise vegetation map units for the area meant that readily identifiable

vegetation associations needed to be recognised. This was not possible using the ordination results, so subjective units were chosen with some reference to the multivariate analysis, but also with regard to structural and floristic expression in the field.

The vegetation associations which were recognised are-

1. Sand sheet complex.
2. *Eucalyptus salubris* woodland.
3. *Eucalyptus salmonophloia* woodland.
4. *Acacia quadrimarginea* woodland.
5. *Eucalyptus griffithsii - E. oleosa* woodland.
6. *Eucalyptus clelandii - E. celastroides* woodland.
7. Granite complex.
8. Lateritic gravel complex.

1. SAND SHEET COMPLEX

This complex is very varied. The vegetation occupies high level sand sheets with sand of variable depth underlain by lateritic gravel. The areas within the reserve are disjunct, being separated by greenstone ridges and alluvial flats.

Vegetation may vary from woodland to low woodland through to scrub or heath. The taller communities are dominated by *Eucalyptus eremophila*, sometimes with *E. conncina* and *E. transcontinentalis*. the understorey is usually sparse and may be of one to several species of *Melaleuca uncinata, Acacia websteri, Casuarina acutivalvis, Westringia cephalantha, Bertya dimerostigma,* other *Acacia* and myrtaceous species and some eremophilas, eg. *Eremophila paisleyi*. Low woodlands may be dominated by *Melaleuca uncinata, Acacia websteri* and sometimes *Acacia acuminata. Eucalyptus leptopoda* and *Callitris preissii* may be present. Depending on the openness of the overstorey there is an understorey of heathy shrubs from the Myrtaceae and other families and *Plectrachne rigidissima,* when the overstorey is sparse. The heath tends to occur in patches within scrub or low open woodland. *Eucalyptus leptopoda* and *Callitris preissii* dominate the scrub while species such as *Grevillea eriostachya, G. juncifolia* and *Eucalyptus platycorys* may be emergent sparse small trees. The heath is mainly myrtaceous with *Thryptomene kockii, Malleostemon roseus, Baeckea maidenii, Wehlia thryptomenoides* and *Micromyrtus obovata* prominent. Shrubs from other groups such as the Rutaceae (*Drummondita hassellii, Phebalium filifolium, Eriostemon tomentellus*), *Westringia cephalantha, Bertya dimerostigma, Leucopogon hamulosus* and *Dampiera tenuicaulis* are common. *Casuarina acutivalvis* and/or *C. spinosissima* may also be present. *Plectrachne rigidissima* is particularly common in places, forming hummocks, rings or semicircles. *Amphipogon strictus* forms low hummocks and *Triodia scariosa* may be present but is much less common than *Plectrachne*. Tussock monocots such as *Lepidobolus preissianus, Chrysithrix distigmatosa* and *Lepidosperma angustatum* may be present in places. There are virtually no herbs in this community - *Stylidium piliferum*

was the only species recorded which might fit into this category. In addition this complex is virtually weed free, in contrast to most of the other vegetation units in these reserves.

2. *EUCALYPTUS SALUBRIS* WOODLAND TO OPEN WOODLAND.

This community occupies flat alluvial sites away from the greenstone ridges. In general the soils are very clayey and at some sites giant gilgai formations occur. At these sites the eucalypts occupy the top of the mounds, while the depressions are virtually devoid of plants. In the central area of the Kangaroo Hills reserve there are extensive stands of *E. salubris* on granitic soils in a lowlying situation.

Eucalyptus salubris is the dominant species and may be the only eucalypt present. At site 18 *E. celastroides* ssp *virella* also occurred and at other sites *E. salmonophloia* may be present. The community tends to grade into the *E. salmonophloia* community depending on the soil and topography. The trees tend to be fairly sparse and of woodland form, branching at about 0.5 - 1 m from the ground to form a rounded deep canopy.

The understorey tends to be sparse and low. There may be sparse shrubs of *Santalum acuminatum, Exocarpus aphyllus, Bossiaea leptacantha* and *Grevillea aculeolata*. However the most prominent species, because of its abundance is *Eremophila veronica,* which forms compact low mounds to 0.5m, particularly on clay plains with a buckshot scree. Low chenopods such as *Sclerolaena cuneata, S. diacantha* and *Maireana georgei* are also common.

On the strongly gilgaied sites shrubs are less common, but there is a large number of ephemeral herbs. Daisies such as *Helipterum rubellum, Cephalipterum drummondii, Brachycome ciliaris* and *Elachanthus pusillus* are frequent along with *Menkea lutea Haloragis trigonocarpa, ?Lawrencia glomeratus* and the weed *Carrichtera annua.*

3. *EUCALYPTUS SALMONOPHLOIA* OPEN WOODLAND

This community occupies the lowest parts of the landscape - the alluvial outwash areas and lowest wash through stream lines.

Eucalyptus salmonophloia is the dominant tree, although it may be very sparse. The trees are typical openform salmon gums - tall (to 20m) with widespread, upward directed branches, producing a dome-shaped open crown. Associated eucalypts are *E. transcontinentalis,* sometimes *E. griffithsii* near creek banks and occasional *E. celastroides.* The understorey shrubs are also very sparse. They include *Acacia tetragonophylla, A. hemiteles, Eremophila drummondii, Scaevola spinescens, Atriplex nummularia, A. holocarpa* and *Sclerolaena* spp. Herbs such as *Cephalipterum drummondii, Goodenia coronopifolia* and *Ptilotus chippendalei* occur sparsely, while weeds such as *Carrichtera annua, Centaurea melitensis* and *Pterigeron liatroides* may be quite common.

Much of the area occupied by this community is subject to grazing so that cover is extremely sparse and weeds are prevalent.

4. *ACACIA QUADRIMARGINEA* LOW WOODLAND

The community dominated by *Acacia quadrimarginea* occupies a band near the top of greenstone ridges and sometimes extends over the top of the ridge. The soils are very stoney and slopes relatively steep (to 15°) for this region. In places *A. quadrimarginea* is almost dense enough to form open forest. However on ridgetops the trees are sparse and tend to have *Eremophila angustifolia* as codominant. The trees are relatively short (to 4m tall) and on typical sites may attain a basal area of 3.6 sq m /h, and density of 370 trees/h. The species also occurs on other rocky sites such as the granite complex, but is usually less prominent than it is on greenstone ridges. *Eucalyptus websteriana* may be present as an understorey mallee in the community. *Acacia acuminata* is usually also present while shrubs such as *Prostanthera aspalanthoides*, and *Dodonaea stenozyga* are very common. Less common species which are fairly constantly present are *Acacia tetragonophylla, Scaevola spinescens, Cassia nemophila, Trymalium myrtillus* and *Ptilotus obovatus*. The herb and grass flora is not abundant but may be surprisingly rich with the grasses *Stipa elegantissima, S. blackii* and *Danthonia acerosa*, herbs *Erodium* spp., several daisy species, *Haloragis trigonocarpa, Zygophyllum ovatum, Calogyne berardiana, Stenopetalum filifolium, Crassula exerta, Thysanotus manglesianus* and *Pterostylis rufa* also present. Weeds such as *Carrichtera annua* may be present, especially where grazing occurs, such as at site 9.

5 *EUCALYPTUS GRIFFITHSII - E. OLEOSA* WOODLAND TO OPEN WOODLAND.

This community is the most widespread and varied in the two reserves. It occupies shaley greenstone slopes midway between the *Acacia quadrimarginea* woodland and the *Eucalyptus salmonophloia* open woodland, gravelly areas and some of the outwash plains areas, probably where rock is fairly close to the surface. Elements of this community intergrade into several of the other communities in the area. It grades into the *A. quadrimarginea* woodland upslope and into the plains communities downslope from the ridges. In the areas of less pronounced relief the community may form a mosaic with *E. salmonophloia* or *E. salubris* communities, or grade into sand sheet communities or granite complex, often through *Acacia acuminata* - dominated vegetation.

The main dominants are *E. griffithsii* and *E. oleosa*, both of which form open trees, usually multistemmed, branching low down. However *E. oleosa* on ridge slopes may be a tall, single stemmed tree. Almost all other eucalypts in the area may also be present. *Eucalyptus clelandii* may be a codominant, *E. torquata* occurs on ridges and rocky

greenstone sites, *E. celastroides* may be an understorey component, while *E. yilgarnensis* may be a codominant on clayey areas, but also on rocky sites (as at site 17).

The understorey is shrubby with few herbs, although in some places on clayey soils herbs may be quite frequent but never abundant. The shrubs may form several layers, generally sparse. Eremophilas are common, with most species occurring at some sites in the community. *Eremophila interstans, E. oppositifolia* and *E. scoparia* are common broom-type shrubs. *Eremophila angustifolia, E. alternifolia* and *E. granitica* are more rounded shrubs, which may be almost understorey thickets in places. Other common medium shrubs include: *Scaevola spinescens, Alyxia buxifolia, Acacia tetragonophylla, Exocarpus aphyllus, Halgania rigida* and *Pomaderris forrestiana,* while common low shrubs include *Atriplex nummularia, A. holocarpa, Olearia muelleri, Dodonaea stenozyga, D. lobulata* and *Cassia nemophila*. Herbs are not usually common but *Stipa trichophylla* is found at most sites, while *Ptilotus holosericeus, Carrichtera annua,* some other crucifer herbs, *Zygophyllum ovatum* and *Thysanotus manglesianus* are occasionally present.

On one west facing ridge slope near site 11 *Eucalyptus oleosa, E. torquata* and *E. campaspe* occurred as very sparse emergents over what was essentially a heath/scrub dominated by *Dodonaea lobulata, Acacia erinacea, Eremophila oppositifolia, Acacia hemiteles* and *Scaevola spinescens.* Other associated species were *Alyxia buxifolia, Halgania rigida, Westringia rigida, Acacia andrewsii, Santalum spicatum, Beyeria lechenaultii* and *Grevillea nematophylla.* This community occupies the zone of *A. quadrimarginea* and seems to contain elements of both this and the *E. griffithsii - E. oleosa* community.

6 *EUCALYPTUS CLELANDII - E. CELASTROIDES* WOODLAND TO OPEN WOODLAND.

This community is similar in structure to and intergrades with the previous one. It occupies gravelly loam soils, generally on areas of low to flat slope where rock may be close to the surface. It also merges with the *E. salubris* and *E. salmonophloia* communities on the flats.

The dominants are *E. clelandii* and *E. celastroides,* although usually there is sparse occurrence of other species such as *E. campaspe, E. loxophlebia, E. flocktoniae* and *E. oleosa*. Some of these may be codominant at some sites. The understorey is characterised by sparse shrubs and few herbs. *Eremophila interstans* and *E. scoparia* are common tall "broom" species, while *Santalum spicatum, Exocarpus aphyllus, Acacia erinacea, A. hemiteles, Atriplex nummularia, A. holocarpa, Scaevola spinescens, Eremophila glabra, Olearia muelleri* and *Cratystylis microphylla* are common lower shrubs. *Stipa elegantissima, Zygophyllum glaucescens* and several chenopods occupy the ground layer. This community tends to be characterised by more chenopods and fewer herbs than are found in the *E. griffithsii - E. oleosa* community.

7 GRANITE COMPLEX.

The granite complex is composed of a number of communities, the occurrence of which is related to the thickness of soil over the granite. The soil derived from granite tends to be a sandy clay with a more open structure than many of the other sandy clay soils of the area because of the coarse nature of the weathered granitic sand.

The vegetation may pass from low open woodland through scrub to herbfield on an idealised transect towards the granite outcrop. *Eucalyptus loxophlebia* is a common component of the community on deeper soil away from an outcrop. However the most distinctive community is dominated by low *Acacia acuminata*, which may form anything from an open woodland to a closed scrub. Associated with the *A. acuminata* are *A. quadrimarginea*, *Eucalyptus websteriana* and *Casuarina campestris*. Low shrubs include *Dodonaea stenozyga*, *Solanum lasiophyllum* and *Mirbelia depressa*. *Thryptomene tuberculata* forms thickets at the northwest corner of Calooli. The granite complex is rich in therophyte and geophyte herbs. The grasses *Stipa elegantissima*, *Stipa blackii* and *Eriachne ovata* occur with many species of daisy and goodeniaceous herbs. Other common herbs include *Isotoma petraea*, *Bulbine ciliata*, *Arthropodium curvipes*, *Haloragis nodulosus*, *Pterostylis rufa*, *Ophioglossum lusitanicum* and a number of weeds such as *Anagallis arvensis* and *Carrichtera annua*. The ferns *Pleurosorus rutifolius* and *Cheilanthes sieberi* occur in rock crevices. The herbfields on pockets of soil or in moss mats are composed of the same herb species as occur in the gaps of the tree dominated areas.

8 LATERITIC GRAVEL COMPLEX

Although sites were selected to cover the gravel areas (5 and 6) they proved to be better included in the *Eucalyptus griffithsii - E. oleosa* community.

The gravel complex is best represented near the corner of Comet Hill Road and Queen Victoria Rocks Road. Here *Casuarina campestris*, *C. acutivalvis* and *Acacia acuminata* dominate a scrub of varied density. Associated species include *Phebalium filifolium*, *Kerandrenia integrifolia*, *Melaleuca uncinata*, *Mirbelia depressa*, *Dampiera tenuicaulis* and *Acacia* spp. *Eucalyptus gracilis* and *E. oleosa* may also occur. Herb are virtually absent.

The gravel complex grades into several other communities depending on the physiography. Sand sheets tend to overlie the gravel deposits, although in some places they may occur down slope. In other places the gravel grades into granite complex communities or *E. griffithsii - E. oleosa* vegetation.

Ironstone ridges occur in the southeast corner of the Kangaroo Hills reserve. On these ridges *Casuarina cristata*, *C. acutivalvis* and *Melaleuca pauperiflora* may be prominent. *Eucalyptus eremophila*, *E. salmonophloia* and *E. griffithsii* may also be present on the outcrops, but where the land is

less 'lateritic' *E. clelandii* and *E. celastroides* become the dominants.

DISCUSSION

The Kangaroo Hills/Calooli area is vegetationally very complex. The communities which are recognised as map units are merely nodes in a vegetational continuum which depends heavily on the soil type, physiography and position in the landscape.

The southern part of the area has been mapped by Beard (1976) at a very broad scale (1:250 000). The study area is on the edge of Beard's Coolgardie Vegetation System, which is more extensive further east. Four vegetation associations are recognised -

Eucalyptus salmonophloia woodland,
Goldfields blackbutt woodland,
Mixed woodland,
Broombush thicket.

These are broad vegetation associations within which it is possible to include the finer subdivisions from this study. However some units overlap two of Beard's units.

Beard's Unit	This Study
Eucalyptus salmonophloia woodland	*E. salmonophloia* open woodland
Mixed woodland	*E. salubris* woodland *E. eremophila* sandsheet complex *E. griffithsii - E. oleosa* woodland
Goldfields blackbutt woodland	*E. griffithsii - E. oleosa* woodland *E. clelandii - E. celastroides* woodland
Broombush thicket	Sand sheet complex Lateritic gravel complex Granite complex

In the biological surveys of the goldfields which have been completed to date the vegetation was described in terms of the landform unit which it occupied. While this approach could have been used (and to a certain extent has already been used, Anon (undated) it was felt that some vegetation communities, although complex, extended over a wide range of landform units. Recognition of vegetation communities (despite their wide ambit) seemed a more effective method for this study.

The Kangaroo Hills/Calooli area has not yet been included in a published Goldfields survey, although it is encompassed in the completed, but unpublished Boorabin - Southern Cross volume. Having briefly seen a draft of this

report, it is clear that the Kangaroo Hills/Calooli area is not typical of the general area covered by the Boorabin - Southern Cross report. As identified by Beard (1976) the area is more usefully associated with the region further north and east. Of the Goldfield surveys so far released the most relevant for comparison are the Jackson - Kalgoorlie and the Widgiemooltha - Zanthus volumes.

The granite complex described for the eastern Widgiemooltha - Zanthus area (Newby and Hnatiuk 1984) is most similar to the Reserves' granite complex in the prevalence of broombush *Acacia acuminata* and *Casuarina campestris*. In the Kalgoorlie - Jackson area *C. huegeliana* and *Kunzea ericifolia* are important granite outcrop species, but these are absent from the study area. The ubiquitous therophytes and geophytes of granite outcrops seem to occur widely from the western edge of the wheat belt to far inland and the species recorded in this study were not particularly remarkable.

Casuarina cristata, which seems to be present on granite to the north and is extensive further east to Kalgoorlie was not present on granite in the study area, but did occur on laterite. The presence of smooth-barked *E. loxophlebia* is an indication of a more westerly influence as this species is common near granite to the west.

Sand plains are extensive to the west but the Coolgardie area seems to be near the eastern extremity of the sand sheets until the Great Victoria Desert. The communities show affinities with both east and west. The presence of 'spinifex' tends to give more of the feel of a desert community than kwongan. However there are few truly eremaean species. The sand plains as described for the Jackson - Kalgoorlie area show many similar species to the sandplains of the study area. The lack of typical kwongan Proteaceae such as *Petrophile, Isopogon, Banksia* and *Conospermum* highlights the difference of the Kangaroo Hills/Calooli sandplain flora from that further west. The wealth of myrtaceous shrubs found in the study area has not been reported from sand sheets in other areas.

The Broad Valley land form category of the Jackson - Kalgoorlie area includes the *E. salmonophloia* open woodlands, the *E. salubris* woodlands and some elements of the *E. griffithsii - E. oleosa* and the *E. clelandii - E. celastroides* woodlands in the study area. However the latter two communities are also found on other land forms. The Broad Valley vegetation dominated by *E. salubris* from the Jackson - Kalgoorlie area is very similar to the *E. salubris* woodlands of the Reserves.

Beard (1990) summarised the vegetational attributes of the Southwest Interzone and described changes in vegetation from ridge tops to valley floors as changes along soil catenas. This is clearly the situation over much of the Reserves. The accompanying two diagrams illustrate two catena progressions at two sites in the Reserves

Figure 4.2 illustrates a fairly typical transition for

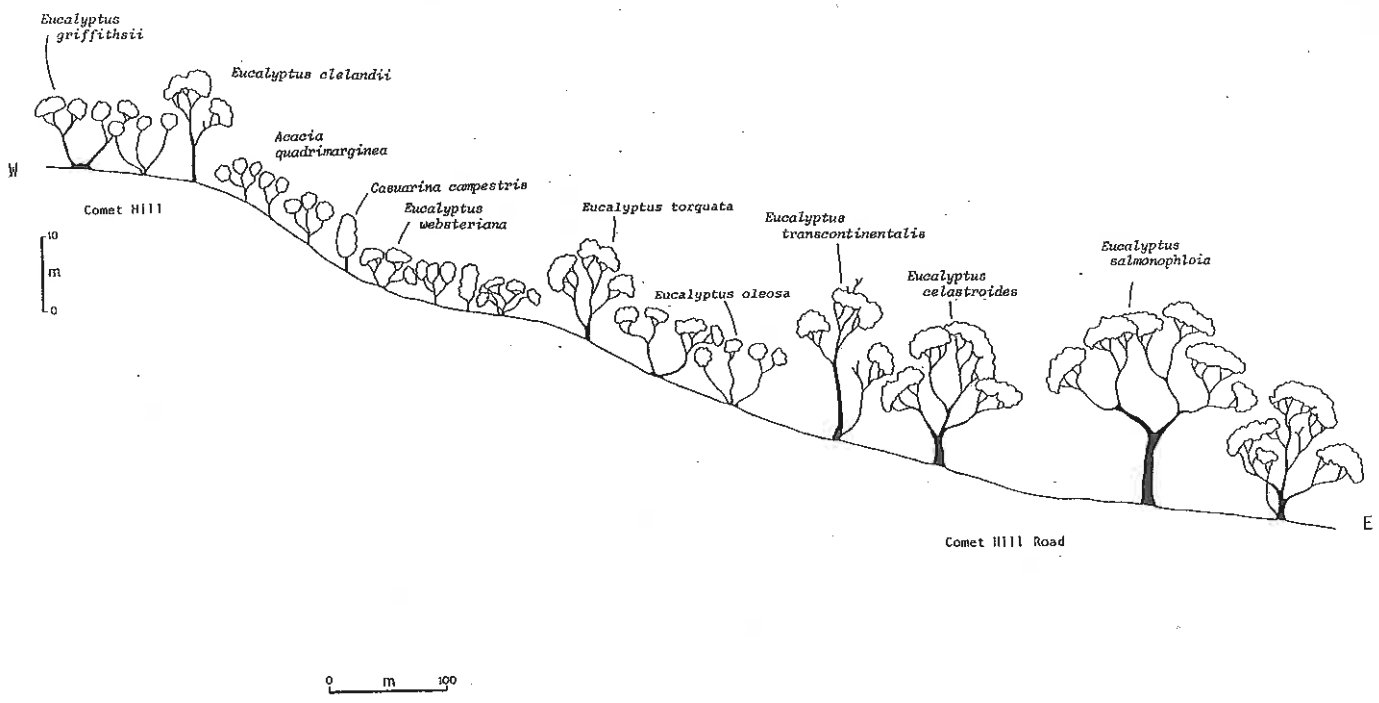


Figure 4.2. Diagrammatic representation of the changes in dominant species from Comet Hill to the alluvial plain.

a northerly facing slope down a greenstone ridge to the outwash plain. On the top of the ridge a number of eucalypt species may occur, in this case *E. oleosa, E. griffithsii, E. torquata, E. clelandii* and *E. celastoides* were present. At one site in the Kangaroo Hills *E. salmonophloia* occupied the ridgetop, which is rather at variance with its normal alluvial plains location. The next community downslope is fairly distinctive in the field, being dominated by *Acacia quadrimarginea*. This commonly occupies a broad band along the ridge slope just below the ridge crest. The community is also widespread on ironstone ridges in areas such as the Koolyanobbing Range (Beard 1990). Below this the slope flattens out, *A. quadrimarginea* becomes less dense and eventually disapears while *E. websteriana, Casuarina campestris* and *E. torquata* become important. *Eucalyptus griffithsii* and *E. oleosa* occur as the slope further flattens, but the soil is still fairly rocky. As the ridge merges into the plain *E.. transcontinentalis* and *E. celastroides* become dominant. On the flat plain itself these latter two species give way to *E. samonophloia* or *E. salubris* depending on the soil being less or more clayey (*E. salubris*). In terms of understorey the ridgetops are fairly poor in species with the richest zone being the mid slope region of *E. griffithsii - E. oleosa.*

In the central area of the Kangaroo Hills reserve another type of catena occurs where laterite and sand are also present, providing more diversity (Fig. 4.3).Lateritic

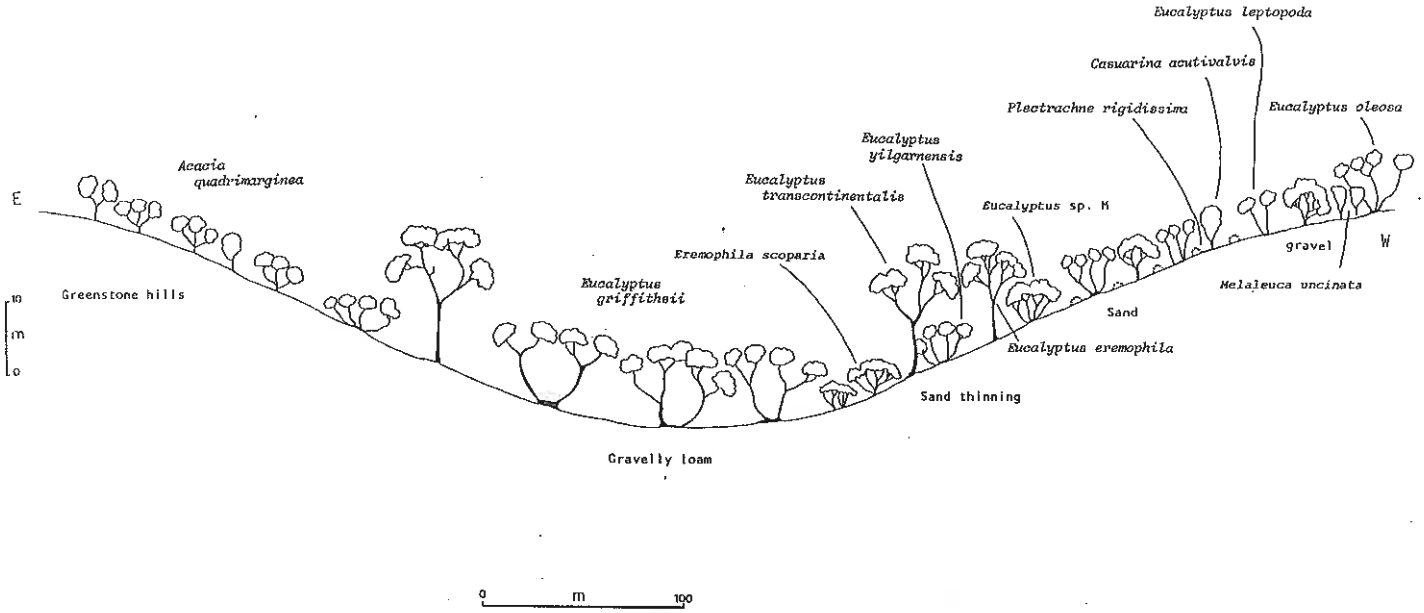


Figure 4.3. Diagrammatic representation of the changes in dominant species across a valley in the central area of Kangaroo Hills.

gravel and ironstone occupy the western ridgetop and support *Casuarina acutivalvis, Acacia acuminata* and *Melaleuca uncinata,* plus sparse *E. oleosa* and *E. gracilis.* Downslope sand has been blown over the ridge and formed a sloping sand sheet facing east. *Eucalyptus leptopoda, Casuarina acutivalvis* and *Acacia websteri* occur near the contact of the sand and gravel, while *E. eremophila* and *Eucalyptus* species M occur over *Plectrachne rigidissima.* Below this, as the sand sheet thins out, the *Plectrachne* fails and *E. yilgarnensis, E. eremophila* and *E. transcontinentalis* are dominant. *Eucalyptus griffithsii* occurs in the valley, as this section is above the outwash plains. On the eastern side of the valley the greenstone ridge influence is apparent. Firstly *E. clelandii* and *E. transcontinentalis* are dominants until *A. quadrimarginea* replaces them towards the top of the ridge. On the very top of this ridge there were sparse *Eremophila alternifolia* and *A. quadrimarginea* with very occasional *E. torquata.* This is fairly typical of the greenstone ridgetops on the eastern side of the Kangaroo Hills reserve.

These profiles illustrate that where environmental gradients are steep the plant species show quite specific topographic (?soil) correlations. However throughout most of the two Reserves this is not the case. Soil and elevation change gradually . The influence of different basement rocks is blurred by suface soil movement and the complex nature of the greenstone basement stratigraphy. This leads to gradual environmental gradients which are

paralleled by broad boundaries between plant communities. From a plant's point of view mineralogically very different substrates may be environmentally very similar. Thus *Acacia acuminata* is found on gravel, around granite outcrops, on greenstone slopes and in some places on sand sheets. *Eucalyptus salmonophloia* most commonly occurs on alluvial flats, but is also found in the Kangaroo Hills, at some sites, on the ridgetops. This, in turn, makes accurate mapping of the area (except where rock or soil changes are abrupt) very difficult.

This difficulty is demonstrated by the general classification of the Kangaroo Hills/Calooli vegetation (Anon undated), which was shown to us at the beginning of this survey. The classification is based on landforms rather than vegetation, as such, and there is clear overlap between a number of the units which have been recognised. In particular the vegetational distinction in the field between Comet Hills, Blackbutt Hills and Headwaters and Foothills is extremely difficult. The more definite soil/landform coincidences, however do generally lead to more easily recognised vegetation units. Thus the Sand Sheets are clearly differentiated from the rest of the vegetation in the Reserves in the present and the Anon treatments.

The Anon document noted that in the Sand Sheets there is a gradient from poorer soils to slightly better sandy loams, which is accompanied by a change in the vegetation. Certainly there is a variety of communities in the sand complex which may be related to a number of soil factors. However these factors could not be determined in this study. It was noted in the Anon document that *Eucalyptus diversifolia* was present in the sandy areas. However this is likely to have been a misidentification of *E. leptopoda*. Similarly *E. gracilis* was claimed to be widespread in the area, but in this study it was found to be restricted to lateritic areas. The closely related *E. yilgarnensis* is probably what was identified as *E. gracilis* and that species is widespread in the lower foothills and in the zone between *E. salubris* woodland and communities on less clayey soils. *Eucalyptus foecunda* was identified as occurring in the Headwaters and Foothills unit (Anon undated). However with recent taxonomic changes this species now only occurs on the coast near Perth, but it is not known what species it could be, because no individuals of this type were found.

5.1 AMPHIBIANS, REPTILES and MAMMALS

This section presents all information collected on amphibians (2 species), reptiles (32 species) and mammals (9 native and 9 introduced species) during the study. Table 5.1 is a summary of seasonal variation in captures in pitfall and Elliott traps, Table 5.2 presents the numbers of pitfall and Elliott trap captures of each species on each site and the annotated species list contains detailed information for each species. The annotated list includes all species recorded during the study, not just those sampled during the trapping programme. For each species, data in the annotated list include: capture rate, seasonal variation in captures, comments on variation in captures between sites, observations on biology (including breeding) and morphometrics.

Season had a great impact on the numbers of captures (Table 5.1). Captures of amphibians were restricted to April, captures of reptiles were highest in November and pitfall captures of mammals were similar in April and November but low in July. November was clearly the most effective field-trip for the purposes of the fauna survey, although one amphibian, three reptile and one mammal species were not trapped in this period. *Mus musculus* was trapped in April and July, while *Neobatrachus ?kunapalari*, *Diplodactylus pulcher*, *Rhynchoedura ornata* and *Ctenotus uber* were caught only in April. No species were recorded in July only, although the bitterly cold weather experienced during this field-trip almost certainly had an adverse affect on captures.

Captures of mammals in Elliott traps showed no seasonal variation. The difference between pitfall and Elliott captures of mammals could have been due to the different species sampled by the two trapping methods, particularly as *Notomys mitchelli* dominated Elliott captures but was rarely caught in pitfalls. Alternatively, Elliott traps attract animals with bait and this may override seasonal variations in activity which may be more truly reflected in captures by pitfalls, which are a passive, interception trap. The only other mammal caught in both pitfall and Elliott traps, *Mus musculus*, was caught in similar numbers in both types of traps in April and July but was not recorded in November.

The numbers of captures of most species were so low that few comments can be made on the local distribution of species in relation to landform (Table 5.2). The only possible associations between captures of a species and landform included: a few commonly-caught species recorded mainly on the sandplain, such as *N.mitchelli* and possibly *Diplodactylus assimilis*; species which were generally widespread but absent from the sandplain, such as *Diplodactylus pulcher* and *Underwoodisaurus milii*; and species that were restricted to stoney landforms, like *Diplodactylus granariensis* and *Pseudomys hermansbergensis*. These cases are discussed in the annotated list.

In terms of numbers of species and numbers of captures of all species (Table 5.2), the sites showed a great deal of variation both with pitfall and Elliott traps. With

respect to Elliott traps, these caught more individual mammals at sandplain (1 and 2) because *N.mitchelli* was so abundant at these sites. With the exception of this species at these sites, Elliott traps were remarkably ineffective. With pitfall traps, the number of vertebrate species ranged from five at gravel (5) to eleven at Comet Hills (7) and granite (10). The second gravel site (site 6) had nine species, however, while the headwaters and foothills sites (site 11), which was similar in vegetation and soil to Comet Hills (7), had only six species. The numbers of captures were similarly variable across the study sites with no clear pattern between numbers of captures and landform. The three study sites with high numbers of species and captures - sandplain (1), Comet Hills (7) and granite (10) - were all positioned close to an ephemeral watercourse. High species-richness for reptiles has been associated with hummock grassland environments (Dell and How 1984) such as occurred on the sandplain sites (especially sites 1 and 12). This was not clearly supported by the present study for while sandplain (1) had a high number of reptile species and the highest number of reptile captures, sandplain (12) was similar in these parameters to other sites. Possibly, the small areas of these hummock grasslands have led to the local extinction of species of reptiles associated with this environment.

The species of amphibians, reptiles and native mammals recorded during the study are those expected from the biogeography of the study area. With reptiles, there were species typical of the south-west (eg. *Hemiergis initialis, Tiliqua rugosa*), species more typical of the inland (eg. *Gehyra purpurascens, Tympanocryptis cephala, Lerista muelleri*), a large set of species typical of the southern interior (eg. *Diplodactylus assimilis, Ctenophorus cristatus, Lerista picturata*) and several very widespread species (eg. *Gehyra variegata, Lialis burtonis, Menetia greyii*). A number of species were at either the southern limit (eg. *Gehyra purpurascens, Rhynchoedura ornata, Varanus tristes, Tympanocryptis cephala*) or northern limit (eg. *Delma australis, Pygopus lepidopodus*) of their recognised range.

The number of reptile and mammal species recorded in the present study was fewer than found by Dell and How (1984, 1985 and 1988) and How *et al.* (1988) in the Widgiemooltha-Zanthus, Jackson-Kalgoorlie, Edjudina-Menzies and Hyden-Lake Johnstone areas respectively (see Table 5.3.). Part of the reason for the larger numbers of species in these goldfields surveys than in the present study was that the goldfields surveys occurred over large areas with widely seprated sampling sites. Additional species would have been recorded in the present study if the area of the study had been greater. For example, reptile species including *Pogona minor, Ctenophorus isolepis citrinus* and *Ctenophorus ornatus* were recorded near Victoria Rocks but were not recorded on Kangaroo Hills or Calooli Reserves.

In general, the differences in reptile and mammal species between the four goldfields surveys of the

Biological Surveys Committee and the present survey reflected known trends in biogeography. South-western species were well-represented in the Hyden-Lake Johnstone area but less so in the other survey areas while inland or northern species were best-represented in the Edjudina-Menzies area to the north. These patterns are summarized in Table 5.3 which also identifies species with records across the five study areas that are not consistent with the general biogeographic trends. These biogeographic patterns contributed to the higher numbers of species recorded in the goldfields surveys than at Kangaroo Hills-Calooli. The more northerly goldfields study areas had many eremaean species while the most southerly study area had many south-western species, with both of these faunas overlapping with southern interior species. In Kangaroo Hills-Calooli, however, there were fewer south-western species than in the Lake Johnstone-Hyden study area to the south, and fewer Eremaean species than in the study areas to the north and east.

Another factor is that sampling may not have been complete, as reptile species not recorded at Kangaroo Hills-Calooli but expected on the basis of their presence in nearby study areas included some that are very cryptic (eg. burrowing elapid snakes of the genera *Vermicella* and *Rhinopocephalus*) and some that occur at low population densities (eg. skinks of the genus *Egernia*). The presence and absence of some other species, however, may be due to variations in local environments that over-ride patterns of biogeography. *Diplodactylus assimilis* and *Gehyra purpurascens*, for example, were found on the sandplain in Kangaroo Hills-Calooli and *G.purpurascens* was also found at Edjudina-Menzies. Both species would have been expected in Jackson-Kalgoorlie, Widgiemooltha-Zanthus and Edjudina-Menzies on the basis of their generally recognized patterns of distribution (Storr *et al.*, 1990).

Among mammals, species with inconsistent records included *Cercartetus concinnus* and *Notomys mitchelli* (absent from Widgiemooltha-Zanthus), and *Pseudomys bolamai* and *Sminthopsis crassicaudata*. (absent from Kangaroo Hills-Calooli). The absence of *N.mitchelli* may be linked to its common association with deep, sandy soils in which it constructs burrows. The sandy soils in Widgiemooltha-Zanthus were shallow and lay over deep calcareous soils (Newby 1984). The absence of *C.concinnus* from Widgiemooltha-Zanthus is more difficult to explain, as is the absence of *P.bolamai* from Kangaroo Hills-Calooli, especially as the latter species has also been recorded at Victoria Rocks (A.Chapman pers. comm.). Captures of *S.crassicaudata* were on calcareous soils or associated with saltpan areas, both with low vegetation. Such landforms and vegetation types were absent from Kangaroo Hills-Calooli.

As usual for the south-west, few mammal species in the critical size range identified by Burbidge and Mckenzie (1989) were recorded at Kangaroo Hills-Calooli. Species such as the Numbat *Myrmecobius fasciatus* and the Chuditch *Dasyurus geoffroyi* probably occured in the area prior to the arrival of Foxes and major disturbances such as the

harvesting of timber. There have been occasional reports of Chuditch in the general region (but not specifically in these reserves) over the past decade (A.Chapman pers. comm.). The three species of bats recorded almost certainly do not account for all species present. Further bats would probably have been caught if mist-metting could have been carried out over water during hot weather or if more suitable netting sites were present in the area.

Table 5.1. Summary of the seasonal distribution of captures of amphibians, reptiles and small mammals in pitfall (pits) and Elliott (Ells) traps. In each sampling period, data are pooled from all sites. The numbers of captures include recaptures. The number of species in each taxon in each field-trip (N spp.) is followed by the number of species in each taxon recorded only in that field-trip in square brackets.

	April			July			November		
	pits	Ells	N spp.	pits	Ells	N spp.	pits	Ells	N spp.
Amphibians	12	-	1[1]	-	-	-	-	-	-
Reptiles	19	1	8[3]	-	-	-	52	4	19[15]
Mammals	22	31	5[0]	8	28	5[0]	26	26	5 [1]
Totals:									
Captures	53	32		8	28		78	30	
		85			36			108	
N spp.		14 [4]			5 [0]			24 [16]	

Table 5.2 Numbers of captures of amphibians, reptiles and small mammals at each site, pooled from April, July and November. Numbers of pitfall captures are presented in standard type, Elliott trap captures in italics and the numbers of individuals handled (underlined) are presented where the numbers of captures included some recaptures. An asterisk indicates a sight record only while "Cp" indicates a record at camp only. The sites are not presented in numerical order as they are grouped according to similarities in landform. Full scientific names are given on the annotated species list.

Species	Site number													
	1	2	12	3	13	5	6	8	7	11	9	10	T
Amphibia													
Leptodactylidae													
N.kunapalari	8	1				*	1				1	1	12
Reptilia													
Pygopodidae													
D.australis	1	*											1
L.burtonis		1											1
P.lepidopodus												*	
Gekkonidae													
C.ocellatus													Cp
D.assimilis	5												5
D.granariensis				3	1		1	1		1			7
D.maini								2					2
D.pulcher						2	1			2	2	1	8
G.purpurascens			1										1
G.variegata	1	1				1						2	5
												1	4
H.binoei											*		
R.ornata	1												1
U.milii				1	2		2		2	1	2	1	11
Agamidae													
C.cristatus	*		*	*					*			*	
C.reticulatus											1		1
M.horridus	*		1										1
T.cephala									*				
Varanidae													
V.tristes									3				3
									1				1
V.gouldii		2						*	*				2

Species	1	2	12	3	13	5	6	8	7	11	9	10	T
Scincidae													
C.plagiocephal						1					1	1	3
Ct.atlas	1												1
	1												*1*
Ct.uber				1				1					2
H.initialis													Cp
L.muelleri			1	1	1	1	1				*		5
L.picturata				1					1				2
M.greyi		3	*	1	1			1	2				8
T.occipitalis	2												*2*
T.rugosa									*		*		
Typhlopidae													
R.australis								1				1	2
Elapidae													
D.psammophis												1	1
P.australis									*				
Mammalia													
Muridae													
M.musculus					1		1						2
					8		*3*					*4*	*15*
N.mitchelli	1	1	2										4
	41	*28*										*1*	*70*
	19	20											42
P.hermansberg						1		1	7	2			11
									6				10
Dasyuridae													
S.dolichura	1	3					1	1	8	1		7	22
		1							7			6	18
N.ridei			1										1
Burramyidae													
C.concinnus		2	2	1	3	1			4	1	1	1	16
									3				15

TABLE 5.2. (cont). Summary of *numbers of species* and numbers of captures.

Taxon	1	2	12	3	13	5	6	8	7	11	9	10
pitfalls only												
Amphibia	*1* 8	*1* 1					*1* 1				*1* 1	*1* 1
Reptilia	*6* 18	*4* 7	*3* 3	*6* 8	*5* 6	*3* 4	*6* 7	*3* 4	*4* 8	*3* 4	*4* 6	*6* 7
Mammalia	*2* 2	*3* 6	*3* 4	*1* 1	*2* 3	*2* 2	*2* 2	*3* 3	*3* 19	*3* 4	*1* 1	*2* 9
Total	*9* 29	*8* 14	*6* 7	*7* 9	*7* 17	*5* 6	*9* 10	*6* 7	*11* 23	*6* 8	*6* 8	*11* 17
Elliott traps												
Reptilia	*1* 1	*1* 2			-		-		-			-
Mammalia	*1* 41	*1* 28			*1* 8		*1* 3		-			*2* 5

TABLE 5.3.. Presence/absence of frogs, reptiles and small mammals (excluding bats) in Kangaroo Hills-Calooli (K-C) and in four goldfields surveys: Hyden-Lake Johnstone (H-J) (How, Dell & Muir 1988), Widgiemooltha-Zanthus (W-Z) (Dell & How 1984), Jackson-Kalgoorlie (J-K) (Dell & How 1985) and Edjudina-Menzies (E-M) (Dell & How 1988). Frogs, reptiles and mammals are treated separately, the reptiles being further divided into families, and the species within each group are sorted into biogeographic classes on the basis of their generally recognized distributions (Storr *et al.* 1981, 1983,1986 and 1990, Tyler *et al.* 1984). These biogeographic classes are necessarily subjective and simple and are only intended as an aid to organising the species recorded in the five study areas. The study areas are presented in the order from most to least mesic. The presence of a species is indicated (+). A question mark is placed where a species is absent from a site at which it might be expected on the basis of its presence at other sites or its general distribution from references.

Species and biogeographic classes	Study area H-J	K-C	W-Z	J-K	E-M
Frogs -Leptodactylidae					
(south-west)					
Heleioporus eyrei	+				
Limnodynastes dorsalis	+				
Myobatrachus gouldii	+				
Pseudophryne guentheri	+				
Neobatrachus pelobatoides	+				
(southern interior)					
Neobatrachus wilsmorei					+
Neobatrachus spp.	+	+	+	+	+
Pseudophryne occidentalis	+	+	+	+	+
(inland)					
Limnodynastes spenceri					+

Species and biogeographic classes		H-I	K-C	W-Z	J-K	E-M
Reptiles -Gekkonidae						
(south-west)						
Phyllodactlus marmoratus		+				
Diplodactylus spinigerues		+				
(southern interior)						
Oedura reticulata		+	?	+	+	
Diplodactylus granariensis		+	+	+	+	+
Diplodactylus pulcher		+	+	+	+	+
Diplodactylus maini		+	+	+	+	+
Diplodactylus intermedius		+	?	+	+	+
Diplodactylus assimilis	?	+	?	?		
Underwoodisaurus milii		+	+	+	+	+
(inland)						
Diplodactylus conspicillatus						+
Diplodactylus squarrosus						+
Diplodactylus stenodactylus					+	
Diplodactylus strophurus						+
Gehyra purpurascens			+	?	?	+
Nephrurus laevissimus						+
Nephrurus stellatus					+	?
Nephrurus vertebralis					+	+
(widespread)						
Crenadactylus ocellatus		+	+	?	+	?
Gehyra variegata		+	+	+	+	+
Heteronotia binoei		+	+	+	+	+
Pygopodidae						
(south-west)						
Delma frazeri		+	?	+		
Pygopus lepidopodus		+	+	+		
(southern interior)						
Delma australis		+	+	+		
(inland)						
Delma nasuta				+	+	+
Pygopus nigriceps					+	+
(widespread)						
Lialis burtonis		+	+	+	+	+

Species and biogeographic classes	H-J	K-C	W-Z	J-K	E M
Agamidae					
(south-west)					
Tympanocryptis adelaidensis		+	?	+	
Ctenophorus ornatus	+				
(southern interior)					
Ctenophorus cristatus	+	+	+	+	+
Ctenophorus isolepis citrinus	+	?	?	+	
Ctenophorus maculatus	+	+			
Ctenophorus salinarum	+	?	+	?	+
(inland)					
Ctenophorus caudicinctus					+
Ctenophorus fordi				+	+
Ctenophorus inermis					+
Ctenophorus isolepis gularis			+	?	
Ctenophorus reticulatus		+	+	+	+
Ctenophorus scutulatus			+	+	+
Diporiphora reginae			+	?	
Tympanocryptis cephala		+	?	+	+
(widespread)					
Moloch horridus	+	+	+	+	+
Pogona minor	+	?	+	+	+
Varanidae					
(south-west)					
Varanus rosenbergi	+				
(inland)					
Varanus caudolineatus					+
Varanus giganteus				+	+
Varanus panoptes					+
Varanus tristes		+	?	+	+
(widespread)					
Varanus gouldii	+	+	+	+	+

Species and biogeographic classes		H-J	K-C	W-Z	J-K	E-M
Scincidae						
(south-west)						
Ctenotus impar		+				
Hemiergis initialis		+	+	+	+	
Hemiergis peroni		+				
Lerista distinguenda		+				
Morethia obscura		+				
Tiliqua rugosa		+	+	+		
(southern interior)						
Ctenotus atlas		+	+	+	+	+
Ctenotus leonhardi		+	?	+	+	+
Egernia depressa					+	+
Egernia inornata		+	?	+	+	+
Egernia multiscutata		+	?	+	+	
Egernia richardi		+				
Lerista terdigitata				+		
Lerista gerrardi					+	
Lerista macropisthopis					+	+
Lerista picturata	+	+	+	+	+	
Morethia butleri		+	?	+	+	+
Omelepida branchialis		+	?	+	+	+
Tiliqua occipitalis		+	+	?	+	+
(inland)						
Cryptoblepharus carnabyi					+	+
Ctenotus brooksi					+	
Ctenotus calurus					+	
Ctenotus greeri						+
Ctenotus helenae						+
Ctenotus pantherinus				+	+	+
Ctenotus uber			+	?	+	+
Ctenotus xenopleura					+	
Hemiergis millewae				+		
Lerista muelleri		+	+	+	+	+
(widespread)						
Cryptoblepharus plagiocephalus		+	+	+	+	+
Menetia greyii		+	+	+	+	+

Species and biogeographic classes	H-J	K-C	W-Z	J-K	E-M	
Typhlopidae						
(southern)						
Ramphotyphlops australis	+	+	?	+		
(inland)						
Ramphotyphlops bituberculata			+			
Ramphotyphlops hamatus				+		
Ramphotyphlops waitii					+	
Boidae						
(southern)						
Morelia spilotes	+					
(inland)						
Liasis stimsoni				+		
Elapidae						
(south-west)						
Notechis curtus	+					
Pseudonaja affinis	+					
Rhinopocephalus gouldi	?	?	+			
Vermicella bertholdi	+	?	+	+	+	
(southern interior)						
Denisonia atriceps	+					
Rhinopocephalus monachus			+	+	+	
(inland)						
Denisonia fasciata				+	+	
Demansia psammophis			+	+	+	+
Pseudechis australis		+	+	+	?	
Pseudonaja modesta			+	?	+	
Pseudonaja nuchalis					+	
Vermicella fasciolata					+	

Species and biogeographic classes	H-J	K-C	W-Z	J-K	E-M
Mammals					
(south-west)					
Cercartetus concinnus	+	+	?	+	
Sminthopsis granulipes	+				
Sminthopsis gilberti	+				
Pseudomys albocinereus		+	?	?	+
(southern interior)					
Notomys mitchelli	+	+	?	+	+
Pseudomys bolami	+	?	+	+	+
Sminthopsis crassicaudata	+	?	+	+	+
Sminthopsis dolichura	+	+	+		
(inland)					
Ningaui ridei		+	+	+	+
Ningaui yvonnae				+	+
Notomys alexis				+	+
Sminthopsis hirtipes				+	
(widespread)					
Mus musculus	+	+	+	+	+

Annotated species list of amphibians, reptiles and mammals

This list contains all species of amphibians, reptiles and mammals recorded during the study. Capture rates are over the entire study and include recaptures. Where specific reference is made to a trapped specimen, the site number is given in parenthesis following the landform name. Measurements (weight in gms, lengths in mms) are for adults unless otherwise indicated. Weight and total length are only given for reptiles with entire (ie. not broken and subsequently regenerated) tails. Where specimens were collected and lodged with the WA Museum, the specimen number, if known, is given. Numbers of captures on specific study sites are given in Table 5-2.

Anura
Leptodactylidae
Neobatrachus ?kunapalari (R103642).
[12 in pitfall traps. Capture rate: 11.1/1000 pit-nights].
All captures in April. Frogs probably of this species were heard calling at Camp and at the Dam in April. A recently-metamorphosed individual in a claypan near site 5 in November. Accurate identification of this *Neobatrachus* to species is not possible without detailed analysis of the call.
Wt (n=9). mean = 9.3. SD = 2.0.
SVL (n=11). mean = 38.4. SD = 2.17.

Pseudophryne occidentalis
Adults concentrated and calling around Dam in April. Not recorded elsewhere in the reserves, but several immature specimens found in a rockhole at Victoria Rocks in October 1989.
Wt (n=3). mean = 1.9. SD = 0.37.
SVL (n-3). mean = 27.3. SD = 0.97.

Reptilia
Gekkonidae
Crenadactylus ocellatus
A single specimen caught at Camp while active on the surface at night (November).

Diplodactylus assimilis
[5 in pitfall traps. 3M, 1F, 1 unsexed. Capture rate: 4.6/1000 pit-nights].
Only recorded on sandplain (1) and only caught in November.
Wt (n=3). mean = 5.7. SD = 0.87.
SVL (n=5). mean = 60.6. SD = 4.3.
Total (n=4). mean = 107. SD = 5.1.

Diplodactylus granariensis (R103646)
[7 in pitfall traps; 2M, 5 unsexed. Capture rate: 6.5/1000 pit-nights].

Recorded at 5 sites (Table). Six of the 7 specimens were caught in November.
Wt (n=3). mean = 5.1. SD = 1.2.
SVL (n=5). mean = 57. SD = 2.1.
Total (n=3). mean = 98.3. SD = 1.2.

Diplodactylus mainii (R105959)
[2 in pitfall traps; 1M, 1 unsexed. Capture rate: 1.9/1000 pit-nights].

Only at Blackbutt Hills (8) with two specimens pitfalled in November and one active on the surface at night in April.
SVL (n=1). 47 mm

Diplodactylus pulcher (R103643)
[8 in pitfall traps; 3M, 5 unsexed. Capture rate: 7.4/1000 pit-nights].

Recorded at 5 sites (Table 5-1). Sites where this species was recorded were all rocky or gravelly, while sites where it was absent were free of rocks and gravel. All specimens trapped in April and one specimen found under a granite slab near the granites (10) also caught in April.
Wt (n=4). mean = 3.6. SD = 0.73.
SVL (n=7). mean = 52.4. SD = 2.44.
Total (n=7). mean = 78.7. SD = 6.63.

Gehyra variegata
[4 in pitfall traps; 1F, 3 unsexed. Capture rate: 4.6/1000 pit-nights].

All pitfalled specimens were caught in November and one additional specimen was found under a granite slab in July. A female (site 5, 15 November) had two oviducal eggs. All four specimens had regrown tails.
SVL (n=4). mean = 46. SD = 1.9.

Gehyra purpurascens (R105958)
[1 in pitfall traps; 1F. Capture rate: 0.93/1000 pit-nights].

A single specimen, a gravid female with two oviducal eggs, collected on sandplain (12) in November.
SVL = 56. Total = 103.

Heteronotia binoei

Several specimens under building rubble near site 9 (Burbank Hills) in October 1989. One under a rock at camp in April.

Rhynchoedura ornata (R103640)
[1 in pitfall traps; unsexed). Capture rate: 0.93/1000 pit-nights].

A single specimen collected on sandplain (1) in April.
Wt = 2.0. SVL = 43. Total = 63.

Underwoodisaurus milii (R103645, R105957)
[11 in pitfall traps; 4M, 1F, 6 unsexed. Capture rate: 10.2/1000 pit-nights].

The most frequently captured reptile but absent from the sandplain sites (1,2,12). The specimens caught could be grouped into three size-classes, probably corresponding to age classes year 1, year 2 and year 3+.

Year 1. (n=2). Wt. #1 = 3.7. #2 = 2.1
SVL. #1 = 50. #2 = 44.
Total. #1 = 88. #2 = 73.

Year 2. (n=1). Wt = 8.5. SVL = 78. Total = 120

Year 3+. Wt (n=4). mean = 16.4. SD = 3.03.
SVL (n=8). mean = 86.8. SD = 4.52.
Total (n=5). mean = 136.8. SD = 11.48.

Pygopodidae
Delma australis (R106037)
[1 in pitfall traps. Capture rate: 0.93/1000 pit-nights].

Pitfalled specimen in sandplain (1) in November and two found under very dense litter in sandplain (2) in July.

One specimen. Wt = 3.5. SVL = 67. Total = 273.

Lialis burtonis
[1 in pitfall traps. Capture rate: 0.93/1000 pit-nights].

Pitfalled specimen, a gravid female, in sandplain (2) in November. Also, one specimen active on the surface during the day in sandplain (12) in April.

Gravid female, November, (site 2):
Wt = 21.0 SVL = 210 Total = 370

Unsexed, April, (site 12):
Wt = 8.5 SVL = 155 Total 235 (regenerated)

Pygopus lepidopodus

One found active on the surface during the day at the granites (10) in April.
Wt = 17.0 SVL = 150 Total = 430

Agamidae
Ctenophorus cristatus

No specimens trapped but seen regularly in October 1989 and in November at several sites (Table). A female with oviducal eggs dead on the road in sandplain (12) in November.

Ctenophorus reticulatus
[1 in pitfall traps. Capture rate: 0.93/1000 pit-nights].

One specimen trapped (November) and several seen in April and November in Burbank Hills (9).
Wt (n=3). mean = 19.5. SD = 2.27.
SVL (n=3). mean = 80. SD = 1.4.
Total (n=3). mean = 178.3. SD = 10.37.

Ctenophorus maculatus

Reported in Kangaroo Hills Reserve by A.Chapman (pers.comm.) but not recorded during the present survey.

Tympanocryptis cephala

A single specimen seen at Comet Hills (7) in each of April and November. The specimen seen in November was a gravid female.

Moloch horridus

[1 in pitfall traps. Capture rate: 0.93/1000 pit-nights].

Two specimens recorded in sandplain in November: one pitfall trapped at site 12 and one active at site 1.

One specimen. Wt = 46.0. SVL = 100. Total = 170.

Varanidae

Varanus gouldii

[2 in Elliott traps. Capture rate: 1.5/1000 Elliott-nights].

The two trapped specimens were both in sandplain (2) in November and both were immature. Three active specimens observed in November, one in each of sandplain (1), Comet Hills (7) and Blackbutt Hills (8). A pair in copula observed in foothills (not near a sampling site) in October 1989. The spcimen at site 8 was observed to excavate a wolf-spider (Lycosidae) burrow and to catch the spider.

One specimen (immature). SVL = 230. Total = 610.

Varanus tristes

[1 in pitfall traps. Capture rate: 2.8/1000 pit-nights].

A single specimen caught three times at Comet Hills (7) in November. As this species is primarily arboreal, it is probably present at all sites where hollow-forming trees occur.

One specimen. Wt = 32.0. SVL = 140. Total = 380.

Scincidae

Cryptoblepharus plagiocephalus

[3 in pitfall traps. Capture rate: 2.8/1000 pit-nights].

Single specimens trapped at three sites (Table) and one active on the trunk of a dead tree at camp in November.

Wt (n=3). mean = 0.87. SD = 0.17.

SVL (n=4). mean = 37.5. SD = 2.69.

Total (n=3). mean = 85.3. SD = 3.4.

Ctenotus atlas (R105956)

[1 in pitfall traps and one in Elliott traps. Capture rates: 0.93/1000 pit-nights and 0.73/1000 Elliott-nights].

Both specimens trapped were on sandplain (1) in November.

Specimen #1. Wt = 5.5. SVL = 65. Total = 190.

Specimen #2. Wt = 3.5. SVL = 62. Total = 195.

Ctenotus uber. (R103641)

[2 in pitfall traps. Capture rate: 1.9/1000 pit-nights].

Both specimens, an immature and an adult, were trapped in April in alluvial woodland (3) and gravel (6).

Immature specimen. Wt = 2.9. SVL = 50. Total = 155.

Adult specimen. Wt = - SVL = 79. Total = 245.

Hemiergis initialis

Two specimens found in July at camp under dense leaf-litter.

Specimen #1. Wt = 0.8. SVL = 44. Total = 94.
Specimen #2. Wt = 0.6. SVL = 36. Total = 80.

Lerista muelleri (R106038)

[5 in pitfall traps. Capture rate: 4.6/1000 pit-nights].

The five specimens caught in pitfalls were all recorded in November and were captured on five sites. A single specimen was found in July under a rotten log at Burbank Hills (9).

Wt (n=3). mean = 0.6. SD = 0.16.
SVL (n=5). mean = 38.6. SD = 1.74.
Total (n=4). mean = 79.2. SD = 6.6.

Lerista picturata

[2 in pitfall traps. Capture rate: 1.9/1000 pit-nights].

One found in July under leaf-litter at Comet Hills (7) with the two pitfalled specimens caught in November at Comet Hills (7) and alluvial woodland (3).

Specimen # 1. Wt = 5.0. SVL = 83. Total = 167.
Specimen # 2. Wt = 5.6. SVL = 90. Total = 142*.
Specimen # 3. Wt = 5.4. SVL = 90. Total = 140*.
(* specimens 2 and 3 with regrown tails).

Menetia greyii

[8 in pitfall traps. Capture rate: 7.4/1000 pit-nights].

All eight pitfalled specimens were caught in November but specimens seen active during the day in April and November at camp and sandplain (12).

Wt (n=2). #1 = 0.2. #2 = 0.4.
SVL (n=6). mean = 29.5. SD = 4.65.
Total (n=2). #1 = 53. #2 = 76.

Tiliqua occipitalis

[2 in Elliott traps. Capture rate: 1.5/1000 Elliott-nights].

Both trapped specimens were at sandplain (1), one in April and one in November, while one was found in July sheltering under leaf-litter at gravel (6). Tracks were found at sandplain (2) in November, but this was probably due as much to the soft sand at this site making tracks visible as to the species being abundant at this site.

Immature specimen. Wt = 44. SVL = 153. Total = 218.
Adult specimen. Wt = 275. SVL = 275. Total = 400.

Tiliqua rugosa

Specimens found active in April and November at Burbank Hills (9) and in November at Comet Hills (7). Probably more widespread in the reserves than indicated by these records.

Immature specimen. Wt = 120. SVL = 168. Total = 217.
Adult specimen. Wt = 350. SVL = 255. Total = 330.

Typhlopidae
Ramphotyphlops australis (R103644)
[2 in pitfall traps. Capture rate: 1.85/1000 pit-nights].
The two pitfalled specimens were both caught in April, at gravel (6) and granite (10).
Specimen # 1. Wt = 3.6. SVL = 195. Total = 205.
Specimen # 2. Wt = 7.1. SVL = 272. Total = 277.

Elapidae
Demansia psammophis
[1 in pitfall traps. Capture rate: 0.93/1000 pit-nights].
The single specimen was caught in November at granite (10).

Pseudechis australis
Three specimens were seen: one in alluvial woodland near site 6 in April; one on Victoria Rocks Road close to the north-eastern corner of Calooli in November and one at Comet Hills (7) also in November. This last specimen was ca. 1.4 m in length and was seen removing a *Sminthopsis dolichura* from a pitfall traps.

Mammalia
Tachyglossidae
Tachyglossus aculeatus
Evidence of Echidnas, in the form of diggings and tracks, were evident at sandplain (1 and 2) in November but the species was probably more widespread.

Muridae
Mus musculus
[2 in pitfall traps and 14 in Elliott traps. Capture rates: 1.9/1000 pit- nights and 11.0/1000 Elliott-nights].
Recorded at three sites only: gravel (6), granite (10) and alluvial woodland(13). The majority of captures were in Elliott traps, 59% of all captures were made in April and no captures were made in November. The high number of captures at alluvial woodland(13) (see Table) was probably associated with a nearby building providing shelter and food. No recaptues were made between field-trips but one individual was caught twice at granite (10) in April. The only evidence of breeding was a sexually active female caught in April at alluvial woodland (13).
Wt (n=11). mean = 12.8. SD = 2.47.
Crown (n=9). mean = 22.8. SD = 0.54.

Notomys mitchelli (M34118, M34120)
[3 in pitfall traps and 29 in Elliott traps. Immature: 3; Adult male: 7; adult female: 12; adult unsexed: 10. Capture rates: 2.2/1000 pit-nights and 51.3/1000 Elliott-nights].
Recorded at four sites with all but one of the 41 animals handled and all but one of the 74 captures made being at sandplain (1, 2 and 12) (Table 5-1.). The strong bias towards captures in Elliott traps was at least partly due to adults leaping out of pitfall

traps. Numbers of captures were similar in all field-trips, with 33%, 30% and 37% of total captures in April, July and November respectively. Sexually active females were recorded in July (one of five adult females) and November (all of seven adult females). Two juveniles were caught in November and one in April, suggesting that breeding occurs throughout spring and into late summer or early autumn. Recaptures were very frequently made with 30 recaptures within the same trip and 14 recaptures between trips. Of eight individuals marked at sandplain (1) in April, 3 were recaptured in July only and two were recaptured in July and November. At sandplain (2), 4 individuals were marked in April, one of these was subsequently recaptured in July only, one in November only and one in both July and November. These rates of recapture indicate strongly sedentary populations in the sandplain areas with a minimum survival from April to November of 33%. The capture of a sexually active female at granite (10) in November is at odds with the general picture of a sedentary species restricted to sandplain.

Immature specimens.

#1. Female. November. Wt = 26.0. Crown = 32.8.
#2. Female. November. Wt = 13.5. Crown = 29.0.
#3. Female. April. Wt = 22.0. Crown = 30.9.

Adult specimens.

Males. Wt (n=6). mean = 37.3. SD = 3.3.
Crown (n=3). mean = 35.3. SD = 0.37.
Females. Wt (n=8). mean = 42.1. SD = 5.5.
Crown (n=10). mean = 34.9. SD = 0.80.

Pseudomys hermansbergensis (M34117, M43505, M34506)
[11 in pitfall traps. Capture rate: 10.2/1000 pit-nights].

Recorded at four sites with the highest number of captures at Comet Hills (7). The absence of captures in Elliott traps is curious, as a line of Elliott traps was present at site 7 and other rodents were caught more often in Elliott than in pitfall traps. Captures occurred in all field-trips with the highest number of captures (45% of total) in November. One individual was caught twice in the same field-trip but no recaptures were made between field-trips. The only evidence of breeding was a male with scrotal testes in November.

Wt (n=9). mean = 10.8. SD = 2.0.
Crown (n=9). mean = 24.3. SD = 1.09.

Dasyuridae
Sminthopsis dolichura
[18 in pitfall traps. Immature male: 2; immature female: 2; adult male: 11; adult female: 2, adult unsexed:1. Capture rate: 16.7/1000 pit-nights].

Recorded in all landform types except alluvial woodland (3 and 13) and Burbank Hills (9), but numbers of captures low except at Comet Hills (7) and granite (10). High captures at these two sites

probably stochastic events, as four adults were caught in one night (18 November) at site 7, while three of the captures at site 10 were juveniles caught over two days in November. These juveniles were possibly siblings raised very close to the pitfall traps, as a post- breeding female was caught in the same period and had been previously caught in April. The numbers of captures were highest in November (59% of total captures) and lowest in July (4.5 % of total captures). Adult males were caught significantly more often than adult females ($X^2 = 6.23$, $P < 0.05$). Of five individuals marked in April, three were recaptured in November, suggesting that individuals were largely sendetary over this period. Breeding occurred in spring as both adult females caught in November had post-breeding pouches and four immature specimens were caught over the same period.

Immature specimens. (n=4). Wt. mean = 6.1. SD = 0.96.
Crown. mean = 23.6. SD = 0.27.
Adult males. Wt (n=9). mean = 14.0. SD = 2.9.
Crown (n=8). mean = 28.4. SD = 1.42.
Adult females. (n=2). Wt. #1 = 14.5. #2 = 15.0.
Crown. #1 = 27.8. #2 = 26.2.

Ningaui ridei (M ??)

[1 in pitfall traps. Capture rate: 0.93/1000 pit-nights].

A single, adult male caught at sandplain (12) in November.

Wt = 7.5.

Burramyidae

Cercartetus concinnus (M ?)

[15 in pitfall traps. Immature male: 2; adult male: 10; adult female: 3. Capture rate: 14.8/1000 pit-nights].

The most widely-caught mammal, being absent from only three sites (Table 5.2). No recaptures were made between field-trips but an adult female was caught twice in November at Comet Hills (7). The only evidence for breeding were two immature males caught in November and single females with pouch young in April and November. The brood of the female caught in November consisted of a single young with a crown to rump length of 13 mm.

Immature males. #1. Wt = 4.0. Crown = 17.4.
#2. Wt = 6.9. Crown = 19.4.
Adult males (n=8). Wt. mean = 11.3. SD = 0.97.
Crown. mean = 22.2 SD = 0.87.
Adult females (n=3). Wt. mean = 14.0. SD = 2.27.
Crown. mean = 21.9. SD = 0.50.

Macropodidae

Macropus fuliginosus, M.robustus and *M.rufa.*

Of 28 sight-records of kangaroos in April, July and November, 21 were of *M.fuliginosus* and the remainder were of *M.rubustus*. *Macropus rufa* was only seen in October 1989, when a group of *ca.* three animals was seen near the stock dam on Kangaroo Hills. Sight-

records were concentrated around the south- western boundary of Calooli and southern Kangaroo Hills (see Fig. 5.1). This distribution reflects the location of sampling sites to some extent but also corresponds to areas where livestock are not grazed. The small number of records in the northern end of Kangaroos Hills could also be due to disturbance from the nearby town.

Vespertilionidae
Chalinolobus gouldii

Three mist-netted over a claypan near gravel (5) in November.

Specimen #1. Female. Wt = - . Forearm = 43.9.
Specimen #2. Male. Wt = 13.0. Forearm = 42.5.
Specimen #3. Male. Wt = 12.0. Forearm = 41.6.

Eptesicus pumilus

Two mist-netted over the stock dam on Kangaroo Hills, one in April and one in November.

Specimen #1. Male. Wt = 5.5. Forearm = 35.9.
Specimen #2. unsexed. Wt = 5.5. Forearm = 30.3.

Molossidae
Tadarida australis

Several individuals heard every night over camp in the evening in April and November; also heard at the stock dam in April and November and near site 5 in November when netting was carried out at these locations. One was heard over camp in July, on an evening when the temperature at ground level was 0°C.

Leporidae
Oryctolagus cuniculus

Present throughout both reserves. A large warren is located beside the stock dam on Kangaroo Hills.

Felidae
Felis catus

One seen on Victoria Rock Road, near Grosmont, in April. Probably occurs throughout the reserves.

Canidae
Vulpes vulpes

Tracks seen regularly at several sites.

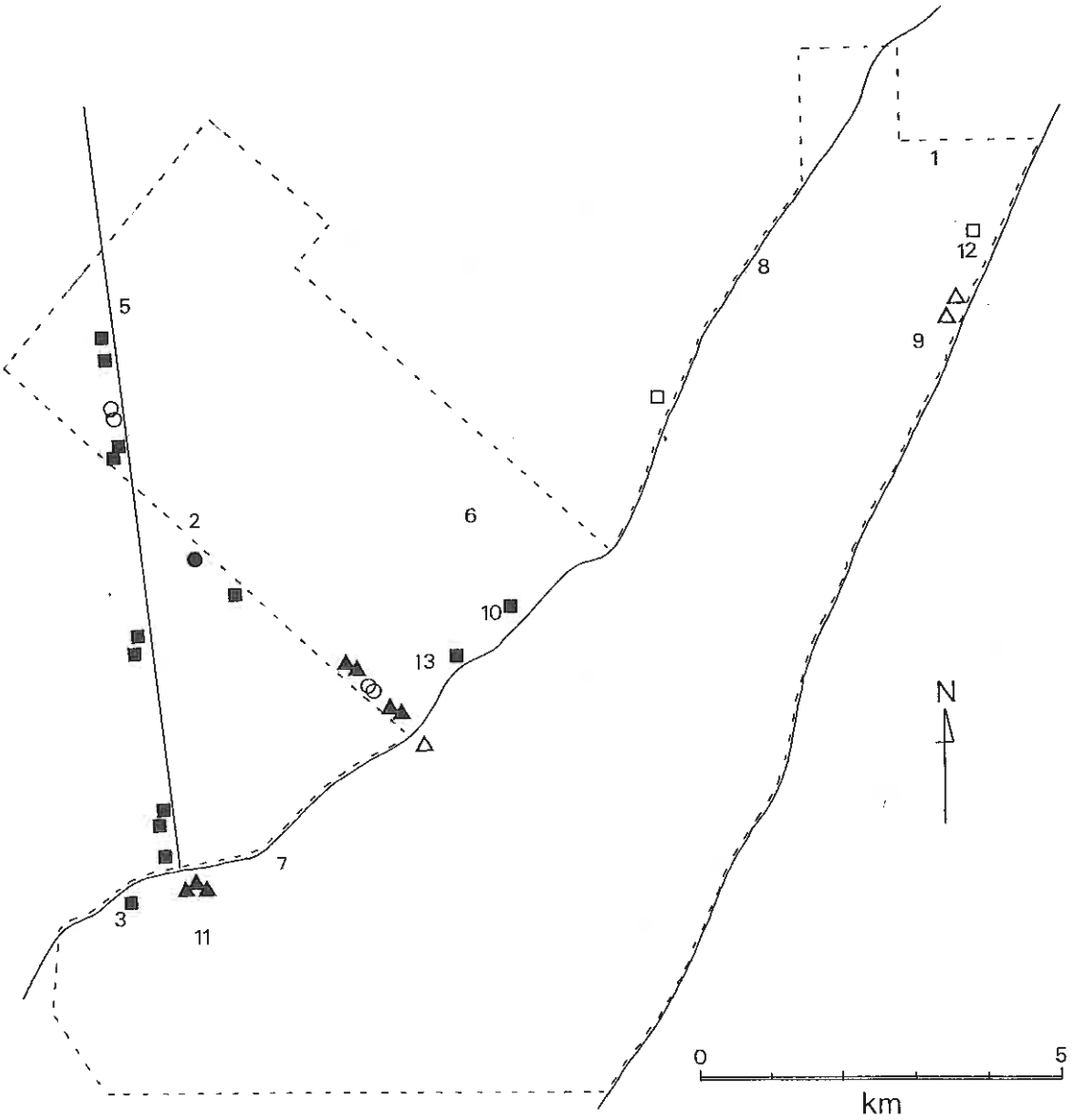
Equidae
Equus caballus

Several unshod but tame horses were seen on each field-trip in the region of site 13.

Bovidae
Capra hircus

Evidence of goats, in the form of droppings, was found in small caves of a breakaway on Kangaroo Hills, but none seen.

Figure 5-1. The distribution of kangaroo sightings in April (triangles), July (squares), and November (circles). Solid symbols represent Grey Kangaroos, open symbols represent Euros. Solid lines are roads and broken lines are reserve boundaries. Numbers 1-13 are the vertebrate sampling sites.



5.2 BIRDS

A total of 70 species of birds was recorded during the surveys of Kangaroo Hills and Calooli Timber Reserves. These comprised 23 non-passerines and 47 passerines. Tables 5.4, 5.5. and 5.6 list these species and indicate the number of sightings and total number of individuals in each landform during each survey (April, July and November). Breeding data are included in the Annotated List below.

All species were within their known range, although some, for example the Southern Whiteface, were close to the limit of their ranges. As was the case with the herpetofauna, there was a mixture of south-western (Bassian) and arid (Eremaean) species. Characteristic southwestern species included the Regent Parrot, Western Yellow Robin, Golden Whistler, Blue-breasted Fairy-wren, Rufous Treecreeper, White-eared Honeyeater, Yellow-plumed Honeyeater, Brown-headed Honeyeater, Red Wattlebird and Dusky Woodswallow. Notable arid zone species were Ground Cuckoo-shrike and Southern Whiteface. Other species whose range extends well into the arid zone but which are less universal in southwestern areas were Crested Pigeon, Galah, Black-eared Cuckoo, White-backed Swallow, Gilbert's Whistler, Crested Bellbird, Chestnut Quail-thrush, White-browed Babbler, Redthroat, White-fronted Honeyeater and Masked Woodswallow.

The passerine assemblage was considerably richer than the non-passerine. 174 individual non-passerines of 23 species were seen on the quadrat counts compared with 1378 individual passerines of 47 species. Among the non-passerines 63 were Purple-crowned Lorikeets and 55 Port Lincoln Ringnecks. In the passerines the most abundant species were Yellow-plumed Honeyeater (278 records), Chestnut-rumped Thornbill (215 records), Weebill (209 records) and White-fronted Honeyeater (132 records).

Some species were probably seasonal visitors to the reserves: the Regent Parrot in autumn and winter; the Rainbow Bee-eater and White-winged Triller in summer, the Golden Whistler and Western Gerygone in winter. Other species moved seasonally to different parts of the reserves to exploit abundances of food. Port Lincoln Ringnecks were generally distributed in April and July, but concentrated on Comet Hills (7) in November where they were feeding on *Acacia* pods. Purple-crowned Lorikeets were most abundant at all seasons in the Alluvial Woodland (3) but in April visited Comet Hills (7) and the Foothills (11), and in July the Gravel site (6) to feed on eucalypts flowering there at those times. Red Wattlebirds were thinly spread throughout the reserves in April, concentrated on the Granite (10) where eucalypts were flowering in July and Comet Hills (7) and the Sandplain (12) in November in response to the flowering of eucalypts and *Calothamnus* (sandplain). Yellow-plumed Honeyeaters were most abundant in the Alluvial Woodland (3) and Blackbutt Hills (8) on all visits, but in April visited flowering eucalypts in Comet Hills (7) and the Foothills (11). White-fronted Honeyeaters showed the most defined pattern. In April most

were at the Granite (10) where *Prostanthera* was flowering, in July in the Foothills (11) where eucalypts were flowering and in November in the Alluvial Woodland (3) and Sandplain (12) where eucalypts and in the case of the sandplains, *Calothamnus*, were flowering. The diversity of the reserves and their consequent ability to support a diverse avifauna throughout the year is well demonstrated by these movements.

The bird numbers were about equal in the quadrats on the autumn and spring visits, but slightly lower on the winter visit: April 73 non-passerines and 477 passerines (total 550), July 47 non-passerines and 416 passerines (463), November 52 non-passerines and 485 passerines (537). The avifaunal diversity on landforms varied. The Sandplains held 35 species, Gravel 33, Granite 31, Alluvial Woodland 30, Comet Hills 28, Burbank Hills 24, Foothills 24 and Blackbutt Hills 22. Thus the stoney landforms were slightly less diverse than the sandplains and woodlands. The Granite had many small thickets and much understorey where water accumulated after rain, supporting a diverse avifauna, despite its stoney nature.

Bird densities ranged from 0.05 birds/ha for species seen only occassionally to 2.15 birds/ha for the Yellow-plumed Honeyeater in the Blackbutt Hills (8) in July. The Yellow-plumed Honeyeater had densities of 1.35 birds/ha in April and 1.85 birds/ha in November at the same site. White-fronted Honeyeaters were at densities of 1.15 birds/ha at the Granite (10) in April, 1.05 birds/ha at the Foothills (11) in July, 1.71 birds/ha on the Sandplain (12) in November and 1.05 birds/ha in the Alluvial Woodland (3) in November, reflecting concentrations on flowering shrubs. Amongst the resident species Chestnut-rumped Thornbills were dense on the Gravel site (6) (0.85 birds/ha in April, 0.60 birds/ha in July and 1.55 birds/ha in November after breeding). The Weebill was also at high densities on the Gravel site (6) (0.65 birds/ha in April and 0.65 birds/ha in July).

A few species were notable for their absence. The Purple-gaped Honeyeater is known from Queen Victoria Rocks, thirty kilometres to the south, but was not seen on the reserves. Silvereyes occur regularly at Kalgoorlie but were not seen on the reserves. This Kalgoorlie population is shown as an isolated one in Blakers *et al* (1984) and the species may only reach the reserves ocassionally. The Southern Scrub-robin has been recorded both east and west of the reserves but was not seen on them. An Australian Hobby was seen about ten kilometres south of the reserves and probably hunts over them at times. It is surprising that few raptor species were seen, although rabbits were abundant on the reserves. No wetlands occur on the reserves so that waterbird species were absent, despite heavy rain in April during the survey visit. Direct comparison with the Biological Survey of the Eastern Goldfields is difficult because the reserves lie close to the boundaries of four survey regions. Nevertheless Table 5.7 compares the results from Kangaroo Hills and Calooli Timber Reserves with those from the Lake Johnston-Hyden, Jackson-Kalgoorlie, Widgiemooltha-Zanthus and Ejudina-Menzies

surveys. The diversity and transitional nature of the avifauna at Kangaroo Hills and Calooli are apparent from this comparison.

Annotated List

Emu *Dromaius novaehollandiae* Foothills (11): 1 in July. Many droppings and tracks on other sites including records near Gravel (6) in July and November, Granite (10) in July and Alluvial Woodland (13) in April, July, and November. Broods were seen on each visit as follows:
April 2 (adults) + 7 (chicks); 1 + 8
July 1 + 8; 1 + 6; 1 + 3 (near Site 1)
November 1 + 7; 1 + 8; 2 + 8 (near Site 5)
Many droppings contained *Santalum spicatum* or *S. acuminatum* seeds and also *Scaevola spinescens* seeds. A substantial breeding population of Emus is on the reserves at present.

Square-tailed Kite *Lophoictinia isura* Granite (10): 1 On two days in July. 1 cruising near Alluvial Woodland (3) and Foothills (11) one day in November.

Brown Goshawk *Accipiter fasciatus* Gravel (6): 1 nearby in November.

Wedge-tailed Eagle *Aquila audax* Alluvial Woodland (3): 1 nearby in November.

Brown Falcon *Falco berigora* Alluvial Woodland (3): 1 in November. Gravel (6): 1 nearby in November. Blackbutt Hills (8): 1 in April. Camp: 1 nearby in July. Resident at low density.

Malleefowl *Leipoa ocellata* Sandplain (2): 1 nearby in April. Tracks regularly seen on southern egde of Calooli Timber Reserve and probably breeds in the sandplain there.

Banded Lapwing *Vanellus tricolor* Sandplain (12): 2 on oval nearby in November. Camp: nearby in July.

Common Bronzewing *Phaps chalcoptera* Gravel (6): 2/ in April. Granite (10): 1 in April; 2 in July ; 2 in November. Sandplain (12): 1 in April; 1 in November. Sparsely distributed resident.

Brush Bronzewing *Phaps elegans* Comet Hiils (7): 1 in July. A small dark pigeon with grey under the wings was flushed late in the day; although Kangaroo Hills is beyond the accepted range of the Brush Bronzewing this sighting did not fit the characters of the Common.

Crested Pigeon *Ocyphaps lophotes* Sandplain (12): nearby on the town side in April and November. Apparently not in reserves but on disturbed edges.

Galah *Cacatua roseicapilla* 5 by roadside near southern boundary of Kangaroo Hills Timber Reserve in July.

Purple-crowned Lorikeet *Glossopsitta porphyrocephala* Sandplain (2): nearby in November; Alluvial Woodland (3): 12 in April; 12 in July; 7 in November. Gravel (6): 2 in April; 7 in July; nearby in November. Comet Hills (7): 9 in

April; 7 in July; 3 in November. Local nomad exploiting flowering eucalypts and probably breeding at Comet Hills in November.

Regent Parrot *Polytelis anthopepus* Sandplain (2): nearby in April. (12): 8 in July. Winter visitor

Port Lincoln Ringneck *Barnardius zonarius* Alluvial Woodland 5 in April; nearby in November. Gravel (6): 5 in April; nearby in November. Comet Hills (7): 2 in April; nearby in July; 28 in November. Blackbutt Hills (8): nearby in April, July and November. Burbank Hills (9): 4 in April; 1 in July; nearby in November. Granite (10): 1 in April; 1 in July. Foothills (11): 1 in April; 1 in July; nearby in November. Sandplain (12): 5 in April; nearby in July; 1 in November. Widespread and common resident. Only concentration was at Comet hills in November where pairs were feeding on fruiting shrubs.

Mulga Parrot *Psephotus chrysopterygius* Gravel (6): 4 in July; nearby in November. Camp: 12 in April; nearby in July.

Pallid Cuckoo *Cuculus pallidus* Alluvial Woodland (3): 2 in April. Burbank Hills (9): nearby in July; 1 in November. Sandplain (12): 1 (immature) in April. Uncommon but regular and perhaps even resident.

Black-eared Cuckoo *Chrysococcyx osculans* Alluvial Woodland (3): 2 in July. Gravel (6): nearby in April; 1 in July. Comet Hills (7): nearby in July and November. Blackbutt Hills (8): nearby in July. Foothills (11): nearby in July. Camp: nearby in July. Widespread and calling frequently in July; probably resident.

Horsfield's Bronze-Cuckoo *Chrysococcyx basalis* Single bird seen and heard near Camp in July.

Southern Boobook *Ninox novaeseelandiae* Sandplain (2): seen on nearby track in April. Camp: heard at night April and November.

Tawny Frogmouth *Podargus strigoides* Sandplain (12): 2 in July. Seen on road east of Grosmont Mine in April.

Australian Owlet-nightjar *Aegotheles cristatus* Camp: heard nearby on each visit. Calls heard most often in April, least often in July.

Spotted Nightjar *Caprimulgus guttatus* One flushed in sandplain just south of southern boundary of Calooli Timber Reserve in July.

Rainbow Bee-eater *Merops ornatus* Blackbutt Hills (8): 1 in November. Burbank Hills (9): 1 in November. Granite (10): nearby in November. Sandplain (12): nesting in quadrat, 6 sightings recorded November. Summer visitor.

White-backed Swallow *Cheramoecca leucosternum* Sandplain (12): 1 in November. The nearby sand-quarry provides nesting sites.

Welcome Swallow *Hirundo neoxena* Comet Hills (7): nearby in April and July. Welcome Swallows will use mine shafts as nest sites.

Black-faced Cuckoo-shrike *Coracina novaehollandiae* Alluvial Woodland (3): 1 in July; 5 in November. Gravel (6): nearby in November. Comet Hills (7): 2 in April. Blackbutt Hills (8): 4 in April; 1 in July; 2 in November. Granite (10): 3 in April. Foothills (11): 1 in July; nearby in November. Widespread; probably bred in Alluvial Woodland (3).

Ground Cuckoo-shrike *Coracina maxima* Burbank Hills (9): nearby in November.

White-winged Triller *Lalage sueurii* Sandplain (12): a male in November.

Red-capped Robin *Petroica goodenovii* Comet Hills (7): 1 in July. Burbank Hills (9): 2 in April; 1 in July; 5 in November. Granite (10): 4 in April; 4 in July; 8 and 1 immature mist-net contact in November. Common in three landforms; resident.

Western Yellow Robin *Eopsaltria australis* Granite (10): 1 in April; 1 mist-net contact in July. Confined to Granite but probably resident there.

Jacky Winter *Microeca leucophaea* Sandplain (12): 2 in April; nesting in quadrat, 9 sightings recorded November. Camp: nearby in July; uncommon resident.

Gilbert's Whistler *Pachycephala inornata* Alluvial Woodland (3): 1 female in April. Gravel (6): 1 male in November. Rare and local resident, using thickets along watercourses at edge of Alluvial Woodland.

Golden Whistler *Pachycephala pectoralis* Sandplain (2): nearby in July. Burbank Hills (9): 1 in July. Uncommon winter visitor.

Rufous Whistler *Pachycephala rufiventris* Burbank Hills (9): nearby in April. Granite (10): 2 in November. Uncommon resident.

Grey Shrike-thrush *Colluricincla harmonica* Sandplain (2): 1 in November. Comet Hills (7): nearby in July. Blackbutt Hills (8): 1 in April; 1 in July; nearby in November. Burbank Hills (9): 1 in November. Granite (10): 1 in April; 2 in November. Foothills (11): 1 in July. Sandplain (12): 1 in April. Ubiquitous, common resident.

Crested Bellbird *Oreoica guttularis* Sandplain (2): nearby in July and November; (12): nearby in April and July.

Alluvial Woodland (3): 2 in April; 2 in July; 1 in November. Gravel (6): 4 in April; nearby in July; 1 in November. Comet Hills (7): nearby in April and July. Blackbutt Hills (8): 1 in April; 1 in July; 2 in November. Burbank Hills (9): nearby in July and November. Granite (10): 1 in April; nearby in November. Foothills (11): nearby in April and November. Ubiquitous, common resident.

Willie Wagtail *Rhipidura leucophrys* Alluvial Woodland (3): 2 in April; nearby in July; 1 in Novemebr. Granite (10): 1 in November. Uncommon, in alluvial woodland and nearby areas.

Chestnut Quail-thrush *Cinclosoma castanotum* Gravel (6): 2 in April; 1 in July; 1 in November. Blackbutt Hills (8): 1 in April. Granite (10): 1 in April; nearby in November. Sandplain (12): 1 in April. Camp: nearby in April. Uncommon resident.

White-browed Babbler *Pomatostomus superciliosus* Sandplain (2): 6 in November. Gravel (6): 6 in April; 4 in July; 5 in November. Local resident on gravel and sandplain.

Splendid Fairy-wren *Malurus splendens* Granite (6): 5 and one mist-net contact in July. Rare, local resident around granite.

Blue-breasted Fairy-wren *Malurus pulcherrimus* Comet Hills (7): 2 in April; 3 and 4 mist-net contacts in November. Granite (10): 1 mist-net contact in July; nearby and 2 mist-net contacts in November. Local resident in thickets near watercourses.

Shy Hylacola *Sericornis cautus* Sandplain (1): 2 seen in rodent run display at close quarters in April. Granite (10): 2 in April. Rare local resident.

Redthroat *Sericornis brunneus* Alluvial Woodland (3): 2 in April. Gravel (6): 6 in April; 1 in July; 4 in November. Comet Hills (7): 2 in July; 3 and 1 mist-net contact in November. Burbank Hills (9): 1 in April; 1 in July; 4 in November. Granite (10): 1 in April; 2 and 1 mist-net contact in July; nesting in quadrat and 6 sightings in November. Foothills (11): 1 in April; 5 in November. Absent from sandplain but otherwise common resident.

Weebill *Smicrornis brevirostris* Sandplain (2): 1 in April; (12): 4 in April; 9 in July; 10 in November. Alluvial Woodland (3): 8 in April; 13 in July. Gravel (6): 13 in April; 13 in July; 4 in November. Comet Hills (7): 7 in April; 18 in July; 15 in Novemebr. Burbank Hills (9): 10 in April; 9 in July; 5 in November. Granite (10): 8 in April; 9 and 1 mist-net contact in July; 2 and 1 mist-net contact in November. Foothills(11): 20 in April; 20 in July; 17 in November. Called less in November than April and July. Unexpectedly absent from Blackbutt Hills despite abundant eucalypts. Otherwise widespread and abundant resident.

Western Gerygone *Gerygone fusca* Gravel (6): 1 in July. Uncommon winter visitor.

Inland Thornbill *Acanthiza apicalis* Alluvial Woodland (3): 3 in April. Gravel (6): 2 in July. Comet Hills (7): 1 in April; 1 in July; 4 in November. Burbank Hills (9): 2 in November. Granite (10): 2 in April; 2 and 5 mist-net contacts in July. Foothills (11): 2 in April; 1 in July; 2 in November. Camp: nearby in July. Resident, common in some landforms.

Chestnut-rumped Thornbill *Acanthiza uropygialis* Alluvial Woodland (3): 7 in April. Gravel (6): 17 in April; 4 in July; 31 in November. Comet Hills (7): 16 in April; 8 in July; 11 and 1 mist-net contact in November. Burbank Hills (9): 21 in April; 9 and nesting in quadrat in July; 22 in November. Granite (10): 15 in April; 17 and 3 mist-net contacts in July; 24 and 2 mist-net contacts in November. Foothills (11): 5 in November. Sandplain (12): nearby in November. Camp: nearby in July. Abundant resident; not recorded in Blackbutt Hills and least common in alluvial woodland, foothills and sandplain.

Yellow-rumped Thornbill *Acanthiza chrysorrhoa* Gravel (6): 5 in April. Burbank Hills (9): 2 in April. Granite (10): 5 in November. Resident, widely dispersed in small flocks.

Southern Whiteface *Aphelocephala leucopsis* Gravel (6): 2 in July. Rare but probably resident.

Varied Sitella *Daphoenositta chrysoptera* Comet Hills (7): 6 in July; nearby in November. Camp: nearby in November. Uncommon.

Rufous Treecreeper *Climacteris rufa* Alluvial Woodland (3): 4 in April; 11 in July; 11 in November. Blackbutt Hills (8): 2 in April; 2 in November. Resident, confined to alluvial woodland and Blackbutt Hills.

Red Wattlebird *Anthochaera carunculata* Alluvial Woodland (3): 1 in April; nearby in July; 1 in November. Gravel (6): nearby in April; 1 in July; 1 in November. Comet Hills (7) 1 in April; 3 in July; 10 in November. Blackbutt Hills (8): nearby in July and November. Burbank Hills (9): 4 in July. Granite (6): 1 in April. Foothills (11): 1 in April; 9 in July; nearby in November. Sandplain (12): 1 in April; nearby in July; 6 in November. Camp: nearby in July. Widely dispersed, possibly resident but concentrating on local flowerings of eucalypts.

Spiny-cheeked Honeyeater *Acanthagenys rufogularis* Sandplain (2): 1 in November; (12): 2 in April; nearby in July; 2 in November. Alluvial Woodland (3): 4 in April; nearby in July and November. Gravel (6): 1 in April; 1 in July; nearby in November. Comet Hills (7): 1 in July; 1 in November. Burbank Hills (9): 3 in July. Granite (10): 5 in April; 1 in July; nearby in November. Foothills (11): 3 in July; nearby in November. Sandplain (12): 2 in April;

nearby in July; 2 in November. Camp: nearby in April. Widely dispersed resident.

Yellow-throated Miner *Manorina flavigula* Alluvial woodland (3): nearby in April and November. Comet Hills (7): nearby in April; 3 in July; 4 in November. Blackbutt Hills (8): 4 in April; nearby in July; 1 in November. Burbank Hills (9): nearby in April; 6 in July; 1 in November. Sandplain (12): 2 in April; nearby in July; 8 in November. Resident groups encountered in five landforms.

White-eared Honeyeater *Lichenostomus leucotis* Sandplain (2): 2 in April; 2 in July; 2 in November; (12): 3 in April; 1 in July; 12 including immatures, in November. Alluvial Woodland (3): 1 in April; 1 in November. Gravel (6): 5 in July. Comet Hills (7): nearby in April; 3 in July. Burbank Hills (9): 3 in April; 1 in July. Granite (10): 3 in April; nearby in July. Foothills (11): 5 in April; 5 in July; 4 in November. Camp: nearby in April and July. Common resident.

Yellow-plumed Honeyeater *Lichenostomus ornatus* Sandplain (2): nearby in July; (12): 5 in April; 2 in July; 1 in November. Alluvial Woodland (3): 12 in April; 32 in July; 20 in November. Gravel (6): 11 in April; 14 in July; 9 in November. Comet Hills (7): 19 in April; 2 in July. Blackbutt Hills (8): 27 in April; 43 in July; 37 in November. Burbank Hills (9): nearby in April; 18 in July; nearby in November. Granite (10): 1 in April; nearby in July. Foothills (11): 19 in April; 5 in July; 1 in November. Camp: nearby in July. Resident, evidence of local movements to keep in touch with flowering eucalypts.

Brown-headed Honeyeater *Melithreptus brevirostris* Alluvial Woodland (3): 5 in April. Gravel (6): 3 in July. Comet Hills (7): 11 in April; 7 in July. Blackbutt Hills (8): nearby in April. Granite (10): 1 in April; 4 in July. Foothills (11): 16 in April; 16 in July. Sandplain (12): 4 in November. Camp: nearby in July. Possibly resident in reserves, but extensive local movements to keep in touch with flowering eucalypts.

Brown Honeyeater *Lichmera indistincta* Comet Hills (7): 1 in November. Burbank Hills (9): 2 in July. Granite (10): 1 in July. Foothills (11): 1 in April; nearby in July; 3 in November. Uncommon, known to move extensively and erratically; could be in considerable numbers in some years.

White-fronted Honeyeater *Phylidonyris albifrons* Sandplain (2): nearby in July; 17 in November; (12): 28 in November. Alluvial Woodland (3): 21 in November. Gravel (6): 4 in April; 1 in July; 1 in November. Comet Hills (7): 7 in April; 5 and 2 mist-net contacts in November. Burbank Hills (9): 5 in July. Granite (10): 23 in April; 2 in July. Foothills (11): 1 in April; 21 in July; 6 in November. Locally nomadic in 1990. The population concentrated on the granite in April, the foothills in July and the sandplains

and alluvial woodland in November. The species can be absent from a locality for several years before reappearing.

Mistletoebird *Dicaeum hirundinaceum* Sandplain (12): nearby in November.

Striated Pardalote *Pardalotus striatus* Alluvial Woodland (3): 1 in November. Gravel (6): 5 in November. Comet Hills (7): nearby in April; 8 in November. Blackbutt Hills (8): nearby in November. Burbank Hills (9): nearby in November. Granite (10): nearby in November. Foothills (1); 1 in July. Sandplain (12): nearby in April; 1 in November. Resident; conspicuous when calling frequently in November.

Masked Woodswallow *Artamus personatus* Camp: nearby in November; several flocks seen in district in November.

Black-faced Woodswallow *Artamus cinereus* Sandplain (2): 2 in April; (12): 2 in April. Scarce, possibly resident.

Dusky Woodswallow *Artamus cyanopterus* Gravel (6): 2 in April. Blackbutt Hills (8): 4 in April; 2 in July. Scarce resident.

Grey Butcherbird *Cracticus torquatus* Alluvial Woodland (3): 1 in April; 3 in November. Gravel (6): 3 in April. Comet Hills (7): nearby in April; 1 in July.; 1 in November. Blackbutt Hills (8): nearby in April; 1 in November. Granite (10): 1 in April. Foothills (11): 1 in July. Sandplain (12): 1 in April; 1 in July. Camp: nearby in April and July. Resident.

Pied Butcherbird *Cracticus nigrogularis* Alluvial Woodland (3): 3 in April. Blackbutt Hills (8): 1 in April. Burbank Hills (9): nearby in November. Foothills (11): nearby in November. Resident.

Australian Magpie *Gymnorhina tibicen* Alluvial Woodland (3): 2 in April; (13) nearby in April. Blackbutt Hills (8): nearby in April. Foothills (11): nearby in April. Sandplain (12): nearby in November. Scarce resident.

Grey Currawong *Strepera versicolor* Sandplain (2): 1 in November; (12): nearby in April and July. Alluvial Woodland (3): 1 in April; nearby in July. Gravel (6): 2 in April; nearby in July and November. Comet Hills (7): 3 in November. Blackbutt Hills (8): 1 in April; 2 in November. Burbank Hills (9): nearby in April and November. Granite (10): 2 in April; nearby in July; 1 in November. Foothills (11): 4 in April; nearby in November. Camp: nearby in April. Common resident.

Australian Raven *Corvus coronoides* Alluvial Woodland (3): nearby in July. Gravel (6): nearby in April; 2 in July; 1 in November. Comet Hills (7): nearby in April. Blackbutt Hills (8): 2 in April; 5 in July; 1 in November. Burbank Hills (9): 4 in April; nearby in November. granite (10):

nearby in April; 2 in July. Foothills (11): nearby in April and November. Sandplain (12): nearby in April and July. Camp: nearby in April and July. Common resident.

Little Crow *Corvus bennetti* Sandplain (2): nearby in April. Alluvial Woodland (3): 2 in July; 1 in November. Gravel (6): 1 in November. Blackbutt Hills (8): nearby in July. Camp: nearby in April and July . Uncommon but possibly resident.

TABLE 5.4 Record of birds seen at the various study sites in Kangaroo Hills and Calooli Timber Reserves during surveys in April, 1990. Each site is defined by a number from 2 to 12. Within the column the top figure in each record is the number of individuals seen and the bottom number is the number of records made. The number of quadrat days on which each site was searched is also shown. X means that the bird was seen near the quadrat site or on it outside the survey period.

Sites	2	12	3	6	8	7	11	9	10	Cp
Emu									X	
Square-tailed Kite										
Wedge-tailed Eagle										
Brown Falcon					1 1					
Malleefowl	X									
Banded Plover										
Common Bronzewing		1 1		2 1					1 1	
Brush Bronzewing										
Crested Pigeon		X								
Galah										
Purple-crowned Lorikeet			12 4	2 1	2 2	9 2	6 1			
Regent Parrot	2 1									
Port Lincoln Parrot			5 3	5 3	X	2 1	1 1	4 3	1 1	X
Mulga Parrot										12 1
Pallid Cuckoo		1 1	1 1							
Black-eared Cuckoo				X						
Horsfield's Bronze-Cuckoo										

Sites	2	12	3	6	8	7	11	9	10	Cp
Southern Boobook	X									X
Tawny Frogmouth						X				
Australian Owlet Nightjar										X
Spotted Nightjar										
Rainbow Bee-eater										
White-backed Swallow										
Welcome Swallow						X				
Black-faced Cuckoo-shrike					4 2	2 1			3 1	X
Ground Cuckoo-shrike										
White-winged Triller										
Red-capped Robin								2 2	4 2	
Western Yellow Robin									1 1	
Jacky Winter		2 1								
Gilbert's Whistler			1 1							
Golden Whistler										
Rufous Whistler								X		
Grey Shrike-thrush	2 1	1 1			1 1				1 1	
Crested Bellbird		X	2 2	4 4	1 1	X	X		1 1	
Willie Wagtail			2 2							
Chestnut Quail-thrush		1 1		2 2	1 1				1 1	X
White-browed Babbler				6 2						
Splendid Fairy-wren										

Sites	2	12	3	6	8	7	11	9	10	Cp
Blue-breasted						2				
Fairy-wren						1				
Shy Hylacola									2	
									1	
Redthroat			1	6			1	1	1	
			1	5			1	1	1	
Weebill	1	4	8	13		7	20	10	8	X
	1	3	6	9		5	9	5	5	
Western Gerygone										
Inland Thornbill			3			1	2		2	
			2			1	2		1	
Chestnut-rumped			7	17		16	11	21	15	
Thornbill			1	6		4	3	4	4	
Yellow-rumped				5				2		
Thornbill				2				1		
Southern Whiteface										
Varied Sitella										
Rufous Treecreeper			4		2					
			2		2					
Red Wattlebird		1	1	X		1	1		1	
		1	1			1	1		1	
Spiny-cheeked		2	4	1					5	
Honeyeater		2	4	1					4	
Yellow-throated		2	X		4	X		X		X
Miner										
		1			1					
White-eared	2	3	1		3	X	5	3	3	X
Honeyeater										
	2	2	1		3		4	3	3	
Yellow-plumed		5	12	11	27	19	19	X	1	
Honeyeater		3	9	7	14	12	10		1	
Brown-headed			5		X	11	16		1	
Honeyeater			1			1	1		1	
Brown Honeyeater							1			
							1			
White-fronted				4		7	1		23	X
Honeyeater				2		4	1		3	
Mistletoebird										

Sites	2	12	3	6	8	7	11	9	10	Cp
Striated Pardalote		X				X				
Masked Woodswallow										
Black-faced	2	2								
Woodswallow	1	1								
Dusky Woodswallow				2	4					
				1	1					
Grey Butcherbird		1	1	3	X	X			1	X
		1	1	3					1	
Pied Butcherbird			3		1		X			
			3		1					
Australian Magpie			2		X		X			
			1							
Grey Currawong			1	2	1		4	X	2	X
			1	1	1		1		1	
Australian Raven				X	2	X	X	4	X	X
					1			3		
Little Crow	X									X

TABLE 5.5 Record of birds seen at the various study sites in Kangaroo Hills and Calooli Timber Reserves during surveys in July, 1990. Each site is defined by a number from 2 to 12. Within the column the top figure in each record is the number of individuals seen and the bottom number is the number of records made. The number of quadrat days on which each site was searched is also shown. X means that the bird was seen near the quadrat site or on it outside the survey period.

Sites	2	12	3	6	8	7	11	9	10	Cp
Emu				X			1 1		X	X
Square-tailed Kite									2 2	
Wedge-tailed Eagle										
Brown Falcon										X
Malleefowl										
Banded Plover										X
Common Bronzewing									2 1	
Brush Bronzewing						2 1				
Crested Pigeon		X								
Galah			X							
Purple-crowned Lorikeet			12 7	7 2	2 1	1 1				
Regent Parrot					8 3					
Port Lincoln Parrot		X			X	X	1 1	1 1	1 1	X
Mulga Parrot				4 1						X
Pallid Cuckoo								X		
Black-eared Cuckoo			2 2	1 1	X	X	X	X		X

Sites	2	12	3	6	8	7	11	9	10	Cp
Horsfield's Bronze-Cuckoo										X
Southern Boobook										
Tawny Frogmouth		2 1								
Australian Owlet Nightjar										X
Spotted Nightjar	X									
Rainbow Bee-eater										
White-backed Swallow										
Welcome Swallow						X				
Black-faced Cuckoo-shrike			1 1		1 1		1 1			X
Ground Cuckoo-shrike										
White-winged Triller										
Red-capped Robin						1 1		1 1	4 3	
Western Yellow Robin									X	
Jacky Winter										X
Gilbert's Whistler										
Golden Whistler	X							1 1		
Rufous Whistler										
Grey Shrike-thrush				1 1	1 1	X	1 1			
Crested Bellbird	X	X	2 2	X	1 1	X		X		
Willie Wagtail			X							
Chestnut Quail-thrush				1 1						

Sites	2	12	3	6	8	7	11	9	10	Cp
White-browed Babbler				4						
				1						
Splendid Fairy-wren									5	
									2	
Blue-breasted									X	
Fairy-wren										
Shy Hylacola										
Redthroat				1		2		1	2	
				1		1		1	1	
Weebill		9		13		18	20	9	9	X
		5		5		9	11	7	5	
Western Gerygone				1						
				1						
Inland Thornbill				2		1	1		2	X
				1		1	1		2	
Chestnut-rumped				4		8		9	17	X
Thornbill				1		2		6	7	
Yellow-rumped										
Thornbill										
Southern Whiteface				2						
				1						
Varied Sitella						6				
						1				
Rufous Treecreeper			11							
			5							
Red Wattlebird		X	X	1	X	3	9	4		X
				1		1	7	2		
Spiny-cheeked		X	X	1		1	3	3	1	X
Honeyeater				1		1	3	2	1	
Yellow-throated		X			X	3		6		X
Miner										
						2		2		
White-eared	2	1		3			5	1	X	X
Honeyeater	2	1		3			4	1		
Yellow-plumed	X	2	32	14	43	2	5	18	X	X
Honeyeater		2	18	8	16	2	4	5		
Brown-headed				3		7	16		4	X
Honeyeater				1		4	3		1	
Brown Honeyeater							X	2	1	
								2	1	

Sites	2	12	3	6	8	7	11	9	10	Cp
White-fronted	X			1			21	5	2	
Honeyeater				1			9	2	2	
Mistletoebird										
Striated Pardalote							1			
							1			
Masked Woodswallow										
Black-faced Woodswallow										
Dusky Woodswallow					2					
					1					
Grey Butcherbird		1				1				X
		1				1				
Pied Butcherbird										
Australian Magpie		X								
Grey Currawong		X	X	X					X	X
Australian Raven		X	X	2	5			X	2	X
				1	2				2	
Little Crow			2		X					X
			1							

TABLE 5.6 Record of birds seen at the various study sites in Kangaroo Hills and Calooli Timber Reserves during surveys in November, 1990. Each site is defined by a number from 2 to 12. Within the column the top figure in each record is the number of individuals seen and the bottom number is the number of records made. The number of quadrat days on which each site was searched is also shown. X means that the bird was seen near the quadrat site or on it outside the survey period.

Sites	2	12	3	6	8	7	11	9	10	Cp
Emu				X						
Square-tailed Kite			X				X			
Wedge-tailed Eagle						X				
Brown Falcon			1	X						
			1							
Malleefowl										
Banded Plover		X								
Common Bronzewing		1								2
		1								2
Brush Bronzewing										
Crested Pigeon										
Galah										
Purple-crowned Lorikeet	X		7	X		3				
			4			3				
Regent Parrot										
Port Lincoln Parrot		1	X	X	X	28	X	X		
		1				15				
Mulga Parrot				X						
Pallid Cuckoo								1		
								1		
Black-eared Cuckoo										
						X				

Sites	2	12	3	6	8	7	11	9	10	Cp
Horsfield's Bronze-Cuckoo										
Southern Boobook										X
Tawny Frogmouth										
Australian Owlet Nightjar										X
Spotted Nightjar										
Rainbow Bee-eater		6			1			1	X	
		3			1			1		
White-backed Swallow		1								
		1								
Welcome Swallow										
Black-faced Cuckoo-shrike			5	X	2		X			
			5		2					
Ground Cuckoo-shrike								X		
White-winged Triller		1								
		1								
Red-capped Robin								5	8	
								4	7	
Western Yellow Robin										
Jacky Winter		9								
		7								
Gilbert's Whistler				1						
				1						
Golden Whistler										
Rufous Whistler									2	
									2	
Grey Shrike-thrush	1		1	X	X			1	2	
	1		1					1	2	
Crested Bellbird	X		1	1	2		X	X	X	
			1	1	2					
Willie Wagtail			1	1						
			1	1						
Chestnut Quail-thrush				1					X	
				1						

Sites	2	12	3	6	8	7	11	9	10	Cp
White-browed Babbler	6			5						
Splendid Fairy-wren										
Blue-breasted						3			X	
Fairy-wren						2				
Shy Hylacola										
Redthroat				4		3	5	4	6	
				4		3	3	3	5	
Weebill		10		4		15	17	5	2	
		7		4		11	10	5	1	
Western Gerygone										
Inland Thornbill						4	2	2		
						3	1	1		
Chestnut-rumped										
Thornbill		X		31		11	5	22	24	
				8		5	1	8	9	
Yellow-rumped									5	
Thornbill										
									1	
Southern Whiteface										
Varied Sitella						X				X
Rufous Treecreeper			11		2					
			8		1					
Red Wattlebird		6	1	1	X	10				
		2	1	1		9				
Spiny-cheeked	1	2	X	X		1	X		X	
Honeyeater	1	2				1				
Yellow-throated		8	X		1	4		1		
Miner										
		4			1	2		1		
White-eared	2	12	1				4			
Honeyeater										
	1	5	1				3			
Yellow-plumed		1	20	9	37		1	X		
Honeyeater		1	11	7	21		1			
Brown-headed		4								
Honeyeater		1								

Sites	2	12	3	6	8	7	11	9	10	Cp
Brown Honeyeater						1	3			
						1	2			
White-fronted	7	28	21	1		5	6			
Honeyeater	4	11	12	1		3	4			
Mistletoebird		1								
		1								
Striated Pardalote		1	1	5	X	8		X	X	
		1	1	5		5				
Masked Woodswallow										X
Black-faced Woodswallow										
Dusky Woodswallow										
Grey Butcherbird			3		1	1	X			
			3		1	1				
Pied Butcherbird								X		
Australian Magpie		X								
Grey Currawong	1			X	2	3	X	X	1	
	1				1	1			1	
Australian Raven				1	1		X			
				1	1					
Little Crow			1	1						
			1	1						

TABLE 5.7 Comparison of avian species seen at Lake Johnston - Hyden (JH), Kangaroo Hills - Calooli (KC), Widgiemooltha - Zanthus (WZ), Jackson - Kalgoorlie (JK) and Edjudina - Menzies (EM). Data from this study and the Reports of the Biological Surveys of the Eastern Goldfields of Western Australia. A cross X indicates that the species was present

SPECIES	JH	KC	WZ	JK	EM
CASUARIIDAE					
Dromaius novaehollandiae Emu	X	X	X	X	X
ACCIPITIDAE					
Lophoicintia isura Square-tailed Kite	X	X	X	X	
Aquila audax Wedge-tailed Eagle	X	X	X	X	X
Accipiter fasciatus Brown Goshawk	X	X			X
FALCONIDAE					
Falco berigora Brown Falcon	X	X	X	X	X
MEGAPODIIDAE					
Leipoa ocellata Malleefowl	X	X		X	X
CHARADRIIDAE					
Vanellus tricolor Banded Lapwing		X	X		X
COLUMBIDAE					
Phaps chalcoptera Common Bronzewing	X	X	X	X	X
Phaps elegans Brush Bronzewing	X	X			
Ocyphaps lophotes Crested Pigeon	X	X			X

Species	JH	KC	WZ	JK	EM
CACATUIDAE					
Cacatua roseicapilla Galah	X	X	X	X	X
LORIIDAE					
Glossopsitta porphyrocephala Purple-crowned Lorikeet	X	X	X	X	
POLYTELITIDAE					
Polytelis anthopeplus Regent Parrot	X	X	X	X	
PLATYCERCIDAE					
Barnardius zonarius Port Lincoln Ringneck	X	X	X	X	X
Psephotus varius Mulga Parrot	X	X	X		X
CUCULIDAE					
Cuculus pallidus Pallid Cuckoo	X	X	X		X
Chrysococcyx osculans Black-eared Cuckoo	X	X	X	X	X
Chrysococcyx basalis Horsfield's Bronze-Cuckoo	X	X	X		X
STRIGIDAE					
Ninox novaeseelandiae Southern Boobook	X	X	X	X	X
PODARGIDAE					
Podargus strigoides Tawny Frogmouth	X	X	X	X	X
AEGOTHELIDAE					
Aegotheles cristatus Australian Owlet-nightjar	X	X	X	X	X

Species	JH	KC	WZ	JK	EM
CAPRIMULGIDAE					
Caprimulgus guttatus Spotted Nightjar	X	X	X	X	X
MEROPIDAE					
Merops ornatus Rainbow Bee-eater	X	X	X	X	X
HIRUNDINIDAE					
Cheramoeca leucosternum White-backed Swallow		X			X
Hirundo neonexa Welcome Swallow		X			X
CAMPEPHAGIDAE					
Coricina novaehollandiae Black-faced Cuckoo-shrike	X	X	X	X	X
Coracina maxima Ground Cuckoo-shrike		X			X
Lalage sueurii White-winged Triller	X	X	X	X	X
MUSCICAPIDAE					
Petroica goodenovii Red-capped Robin	X	X	X	X	X
Eopsaltria griseogularis Western Yellow Robin	X	X	X	X	
Microeca leucophaea Jacky Winter	X	X	X	X	X
Pachycephala inornata Gilbert's Whistler		X	X	X	
Pachycephala pectoralis Golden Whistler	X	X	X	X	
Pachycephala rufiventris Rufous Whistler	X	X	X	X	X

Species	JH	KC	WZ	JK	EM
Colluricincla harmonica Grey Shrike-thrush	X	X	X	X	X
Oreoica gutturalis Crested Bellbird	X	X	X	X	X
Rhipidura leucophrys Willie Wagtail	X	X	X	X	X
ORTHONYCHIDAE					
Cinclosoma castanotum Chestnut Quail-thrush	X	X	X	X	X
TIMALIIDAE					
Pomatostomus superciliosus White-browed Babbler	X	X	X	X	X
MALURIDAE					
Malurus splendens Splendid Fairy-wren		X		X	X
Malurus pulcherrimus Blue-breasted Fairy-wren	X	X	X	X	X
ACANTHIZIDAE					
~~Sericornis~~ cautus (Hylacola cauta) Shy ~~Hylacola~~ Heath Wren.	X	X		X	
Sericornis brunneus Redthroat	X	X	X	X	X
Smicrornis brevirostris Weebill	X	X	X	X	X
Gerygone fusca Western Gerygone	X	X		X	
Acanthiza apicalis Inland Thornbill	X	X	X	X	X
Acanthiza uropygialis Chestnut-rumped Thornbill	X	X	X	X	X

Species	JH	KC	WZ	JK	EM
Acanthiza chrysorrhoa Yellow-rumped Thornbill	X	X	X	X	X
Aphelocephala leucopsis Southern Whiteface	X	X	X	X	X
NEOSITTIDAE					
Daphoenositta chrysoptera Varied Sittella	X	X	X	X	X
CLIMACTERIDAE					
Climacteris rufa Rufous Treecreeper	X	X	X	X	
MELIPHAGIDAE					
Anthochaera carunculata Red Wattlebird	X	X	X	X	X
Acanthagenys rufogularis Spiny-cheeked Honeyeater	X	X	X	X	X
Manorina flavigula Yellow-throated Miner	X	X	X	X	X
Lichenostomus leucotis White-eared Honeyeater	X	X	X	X	X
Lichenostomus ornatus Yellow-plumed Honeyeater	X	X	X	X	X
Melithreptus brevirostris Brown-headed Honeyeater	X	X	X	X	X
Lichmera indistincta Brown Honeyeater	X	X	X	X	X
Phylidonyris albifrons White-fronted Honeyeater	X	X	X	X	X
DICAEIDAE					
Dicaeum hirundinaceum Mistletoebird	X	X	X	X	X

Species	JH	KC	WZ	JK	EM
PARDALOTIDAE					
Pardalotus striatus Striated Pardalote	X	X	X	X	X
ARTAMIDAE					
Artamus personatus Masked Woodswallow	X	X	X		X
Artamus cinereus Black-faced Woodswallow	X	X	X	X	X
Artamus cyanopterus Dusky Woodswallow	X	X	X	X	
CRACTICIDAE					
Cracticus torquatus Grey Butcherbird	X	X	X	X	X
Cracticus nigrogularis Pied Butcherbird	X	X	X	X	X
Gymnorhina tibicen Australian Magpie	X	X	X	X	X
Strepera versicolor Grey Currawong	X	X	X	X	X
CORVIDAE					
Corvus coronoides Australian Raven	X	X	X	X	
Corvus bennetti Little Crow	X	X	X	X	X

6. GENERAL DISCUSSION

The Kangaroo Hills and Calooli Reserves are dominated by greenstone hills but the landscape ranges from rocky hills and breakaways through extensive areas of alluvial soils to sandplain. The complex geology of the reserves exists because they overlie the transition from the sandplains that extend to the south-west and the dissected greenstone hills that exist to the north and east (Hunter 1989).

Land uses in the area include pastoralism and mining which date from the late nineteenth century. Sandlewood collection and logging for mine-timbers were also carried out in the past. The reserves were probably cut over for timber as recently as the 1950's (Hunter 1980).

The diversity of landforms and the complexity of soil patterns in the reserves has led to a high diversity of vegetation and a relatively high plant species richness. The vegetation ranges from herbfields around granite outcrops through heaths, hummock grasslands and scrub on sandplain and gravel to open woodland and woodland on the rocky ridges and in the alluvial or erosional valleys. All the woodland and open woodland associations except one are dominated by eucalypts. The exception is the community dominated by *Acacia quadrimarginea* which occurs towards the tops of ridges throughout this area and to the north. Communities dominated by *Casuarina cristata* are extensive to the north and east but are virtually absent from the study area.

The flora is more aligned with that of south western Australia than with the Eremaean. Although the sand sheet communities are lacking in many typical kwongan species (Proteaceae in particular) and show affinities with more desert areas (the hummock grasses) there are few truly Eremaean species. In contrast there is quite a high richness in the shrubby heath species (particularly the Myrtaceae and to a lesser extent the Rutaceae). The woodland species are typical of the Coolgardie interzone. Most of the eucalypts occur widely throughout the Goldfields and, while acacias are abundant,they do not attain the importance that they have further east and north into the Eremaean. The acacias which are present do include several of restricted occurrence, but none is rare.

Although the vegetation communities and most of the species do occur widely, the value of these reserves is in the structural and specific richness in a relatively small area. The plant species richness in relation to reserve size is very high in comparison with the species complements of the Goldfields surveys which covered very much larger areas.

The amphibian and reptile fauna includes 34 species, which is a smaller total than obtained by the Biological Surveys Committee in any of the published goldfields surveys. This was partly due to small numbers of cryptic and uncommon species in the present survey; such species may have been missed during the field work. The transitional position of the study area, being neither south-west nor Eremaean, may also have contributed to the

slightly lower numbers of amphibian and reptile species when compared with the goldfields surveys. Numbers of species in the more southerly goldfields study areas were bolstered by south-west fauna, while more northerly and easterly study areas were bolstered by Eremaean species.

There was a mixture of southern and Eremaean amphibian and reptile species as would be expected from the location of the reserves. Species that can be classed as southern interior were particularly well-represented. A number of species were close to their northern or southern limits of distribution. No new or rare and endangered species were recorded, but the known ranges of several species were extended.

The mammal fauna contained 18 species of which nine were introduced. This fauna lacked some south-western and Eremaean species which contributed to higher numbers of mammal species in the goldfields surveys to the south and north respectively. The fauna also lacked mammals in the critical size range identified by Burbidge and McKenzie (1989), and bats were poorly represented due to the shortage of suitable trapping sites. No new or rare and endangered species were recorded.

The Kangaroo Hills and Calooli Timber Reserves contain an interesting diversity of birds. Of the 20 species of resident passerines reported by Kitchener *et al.* (1982) to be confined to undisturbed native vegetation in the Western Australian wheatbelt, 12 were sighted in these reserves. During the Eastern Goldfields Biological Survey 14 were seen at the Lake Cronin Study Site, 200 km south-west of the reserves, but only 11 at McDermid Rock, 120 km SSE, 10 at Frank Hann 220 km SSE and 9 at Peak Charles 200 km south. The Kangaroo Hills and Calooli reserves thus contain an excellent representation of the most vulnerable passerines of the transitional zone between the Eremaean and Bassian faunal provinces. In addition the diversity of the landforms and vegetation in the reserves appears to make them attractive to locally nomadic species - such as the White-fronted Honeyeater - throughout the year. Direct comparison with the Biological Survey of the Eastern Goldfields is difficult because the reserves lie close to the boundaries of four survey regions but the diversity of species, as well as the presence of so many vulnerable ones, makes these reserves important to the preservation of the avifauna of the region.

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Appendix I

Flora List

Species recorded during the survey are listed alphabetically by family, genus and species. Nomenclature generally follows Green (1981). However for taxa which have been dealt with in the Flora of Australia (except *Casuarina*) nomenclature follows that contained in the Flora. Voucher specimens are lodged with the Department of CALM. Species are listed by the vegetation communities and complexes recognised for the study area and used as map units. An asterisk indicates an introduced species.

Map Units

SS = Sand Sheet Complex
ES = *Eucalyptus salubris* Woodland - Open woodland
EL = *Eucalyptus salmonophloia* Open woodland
AQ = *Acacia quadrimarginea* Woodland
EG = *Eucalyptus griffithsii - E. oleosa* Woodland
EC = *Eucalyptus clelandii - E. celastroides* Woodland
G = Granite Complex
L = Lateritic Gravel Complex

Cover/ occurrence in vegetation units

\+ - Recorded from the vegetation unit but not quantitatively assessed
1 - Recorded from a quadrat, cover < 1%
2 - " " " " " 1 - 5%
3 - " " " " " 6 - 20%
4 - " " " " " 21 - 50%

SPECIES	SS	Sa	Sl	Aq	Eg	Ec	Gc	Lg
ADIANTIACEAE								
Cheilanthes sieberi Kunze							1	
AMARANTHACEAE								
Ptilotus chippendalei Benl		1			1			
Ptilotus exaltatus Nees					+			
Ptilotus gaudichaudii (Steudel) J. Black			+					
Ptilotus holosericeus (Moq.) F. Muell.		1						
Ptilotus obovatus (Gaud.) F. Muell.			+	+	+	+		
APIACEAE								
Hydrocotyle rugulosa Turcz.							1	
Trachymene ornata (Endl.)Druce							+	
APOCYNACEAE								
Alyxia buxifolia R.Br.	2				3			
ASCLEPIADACEAE								
Rhyncharrhena linearis (Decne)Wilson					1			
ASTERACEAE								
Actinobole uliginosum (A. Gray) Hj. Eichler							1	
Angianthus pusillus (Benth.) Benth.					+			
Angianthus tomentosus Wendl.					+			
Asteridea athrixioides (Sond. et F. Muell.) Kroner				1	1			
Blennospora drummondii A. Gray							1	
Brachycome ciliaris Labill. Less.		1		1				
Brachycome lineariloba (DC.) Druce							+	
Brachycome perpusilla (Steetz) Black var *tenella*							1	
Calotis hispidula (F.Muell.) F.Muell.				1				
**Centaurea melitensis* L.			+					
Cephalipterum drummondii A.Gray		1			1			
Cratystylis microphylla (F.Meull. et Tate)S. Moore						3		
Elachanthus pusillus F. Muell.		1	+	1	1			
Gnephosis pygmaea (A. Gray) Benth.							+	
Gnephosis skirrophora (Sonder & F.Muell. ex Sonder) Benth.			+					
Helichrysum bracteatum (Vent.) Andr.					1			
Helichrysum filifolium (Turcz.) F. Muell.					+			
Helipterum adpressum W. Fitzg.							+	
Helipterum battii F. Muell.							+	
Helipterum fitzgibbonii F. Muell.							+	
Helipterum hyalospermum F. Muell ex Benth.					1		1	
Helipterum laeve (A.Gray)Benth.							+	
Helipterum oppositifolium S. Moore				1	1		1	
Helipterum roseum (Hook.) Benth.		1						
Helipterum rubellum (A. Gray) Benth.		1		1	1			
Helipterum strictum (Lindl.) Benth.					+			
Helipterum tenellum Turcz.			+					
Helipterum zacchareus S. Moore		1			1		1	
Isoetopsis graminifolia Turcz.			+	1	1			
Ixiolaena viscosa Benth.							+	
Millotia myosotidifolia (Benth.)Steetz							1	
Olearia muelleri (Sonder) Benth.		2			2	1		
Olearia pimelioides (DC.) Benth.	+				1			
**Osteospermum clandestinum* (Less.) Norl.							+	

SPECIES	SS	Sa	Sl	Aq	Eg	Ec	Gc	Lg
Podolepis canescens Cunn. ex DC.				+				
Podolepis capillaris (Steetz) Diels			+				+	
Podolepis lessonii (Cass.) Benth.					1		1	
**Pterigeron cylindriceps* Black			+					
Rutidosis multiflora (Nees) B.L.Robinson							+	
Senecio glossanthus (Sonder)Belcher		1		1	1			
Toxanthes perpusillus Turcz.							+	
Waitzia acuminata Steetz				1	1		1	
Waitzia citrina Steetz in Lehm.				+			+	
BORAGINACEAE								
Halgania rigida S.Moore	2	1			2			
BRASSICACEAE								
**Carrichtera annua* (L.) DC.		1		1	1			
Lepidium merrallii F. Muell.					1			
Lepidium oxytrichum Sprague					1			
Menkea lutea E. Shaw		1						
?*Phlegmatospermum cochlearinum* (F. Muell.) O. Schulz					1			
Stephanopetalum filifolium Benth.				1				
Stephanopetalum lineare R.Br. ex DC.					1			
CAESALPINIACEAE								
Cassia cardiospermum F. Muell.					+			
Cassia nemophila A. Cunn. ex Vogel		2		2	1			
Cassia pleurocarpa F. Muell.	+							
CARYOPHYLLACEAE								
Stellaria filiformis (Benth.) Mattf.		1			1			
CASUARINACEAE								
*Casuarina acutivalvis*F.Muell.	3				1			
Casuarina campestris Diels							+	+
Casuarina spinosissima C.Gardner	3							
CHENOPODIACEAE								
Atriplex holocarpa F.Muell.		3			3			
Atriplex nummularia Lindl.		2			3	3		
Chenopodium gaudichaudianum (Moq.) P.G. Wilson			+					
Disocarpus paradoxus (R.Br.) Ulbr			+					
Enchyleana lanata P.G. Wilson			+					
Maireana georgei (Diels) P.G. Wilson		1			1	1		
Maireana tomentosa Moq.		1						
Rhagodia drummondii Moq.					1	+		
Sclerolaena cuneata P.G. Wilson		1			1			
Sclerolaena diacantha (Nees)Benth.		1			1	1		
CONVOLVULACEAE								
Wilsonia humilis R. Br.		1						
CRASSULACEAE								
Crassula colorata (Nees) Ostenf.							+	
Crassula exerta (Reader) Ostenf.		1		1	1		1	
CUPRESSACEAE								
Callitris preissii Miq. ssp. *verrucosa* (A. Cunn. ex Vogel) J. Garden	3							
CYPERACEAE								
Chrysitrix distigmatosa C.B. Clarke	+							
Isolepis stellata (C.B. Clark) K.L. Wilson							+	
Lepidosperma ?tuberculatum Nees				+				
Lepidosperma angustatum R. Br.	+							
Schoenus globifer Nees	2							

SPECIES	SS	Sa	Sl	Aq	Eg	Ec	Gc	Lg
DENNSTAEDTIACEAE								
Pleurosorus rutifolius (R. Br.) Fee							+	
DROSERACEAE								
Drosera macrantha Endl.							+	
EPACRIDACEAE								
Leucopogon hamulosus Pritzel	2							
EUPHORBIACEAE								
Bertya dimerostigma F. Muell.	2				1			
Beyeria lechenaultii (DC.) Baillon				+				
Monotaxia luteiflora F. Muell.								+
Poranthera microphylla Brongn.							+	
FRANKENIACEAE								
Frankenia desertorum Summerh.		1			+			
GERANIACEAE								
Erodium cygnorum Nees ssp. *cygnorum* Carolin		1		1	1		1	
**Erodium cicutarium* (L.) L'Her. ex Ait.			+	1				
GOODENIACEAE			+				+	
Dampiera tenuicaulis E. Pritzel var *curvula*	1							
Goodenia berardiana (Gaud.) Carolin				1	1			
Goodenia coronopifolia R. Br.			+					
Goodenia laevis Benth.	+							
Scaevola spinescens R. Br.		3	+	2	2			
Symphiobasis alsinoides S. Moore					1		1	
Velleia cycnopotamica F. Muell.					1		1	
HALORAGACEAE								
Gonocarpus nodulosus Nees							1	
Haloagis trigonocarpa F. Muell.		1		1	1			
LAMIACEAE								
Prostanthera aspalanthoides A. Cunn. ex Benth.				3				
Prostanthera baxteri A. Cunn. ex Benth.	+							
Prostanthera grylloana F. Muell.	+				2			
Westringia cephalantha F. Muell.	3							
Westringia rigida R.Br.					1			
LILIACEAE								
Arthropodium curvipes S. Moore							1	
Bulbine alata Baijnath							1	
Chamaexeros fimbriata (F. Muell.) Benth.	+							
Hypoxis occidentalis Benth.							+	
Lomandra effusa (Lindl.) Ewart					+			
Thysanotus brachyantherus Brittan		1						
Thysanotus manglesianus Kunth	1			1	1		1	
LOBELIACEAE								
Isotoma petraea F. Muell.							+	
LORANTHACEAE								
Amyema gibberulum (Tate) Danser							+	
Lysiana casuarinae (Miq.) Tieghem		1			+			
MALVACEAE								
?Lawrencia glomerata Hook.		1			1			
MIMOSACEAE								
Acacia acuminata Benth.				3	3		3	
Acacia andrewsii W. Fitzg.					+			
Acacia assimilis S. Moore ssp. *assimilis*	2							
Acacia calcarata Maiden and Blakely						1		

SPECIES	SS	Sa	Sl	Aq	Eg	Ec	Gc	Lg
Acacia duriuscula Fitzg.					+			
Acacia enervia Maiden ssp. *obstrangula* Cowan & Maslin (ms. name)					+	+		
Acacia erinacea Benth.					2			
Acacia gibbosa Cowan & Maslin (ms. name)								?+
Acacia hemiteles Benth.		3				1		
Acacia websteri Maiden et Blakely	+							
Acacia lasiocalyx C. Andrews	+							
Acacia leptopetala Benth.						+		
Acacia longispinea Morrison	+							
Acacia merrallii F. Muell.			+					
Acacia prainii Maiden var *linearis*								+
Acacia rendlei Maiden	+							
Acacia resinomarginea W. Fitzg.	2							
Acacia resinostipulea W. Fitzg.			+					
Acacia quadrimarginea F. Muell.				3			3	
Acacia tetragonophylla Maslin				2	1			
Acacia websteri	3							
MYOPORACEAE								
Eremophila alternifolia R. Br.					1			
Eremophila angustifolia (S. Moore) Ostenf.					3			
Eremophila caerulea (S. Moore) Diels			+					
Eremophila dempsteri F. Muell.								
Eremophila drummondii F. Muell.					3			
Eremophila glabra (R. Br.) Ostenf.					2	1		
Eremophila granitica S. Moore		3			3			
Eremophila interstans (S. Moore) Diels					2	3		
Eremophila ionantha Diels		3						
Eremophila oppositifolia R. Br.					3			
Eremophila paisleyi F. Muell.	+							
Eremophila parvifolia Black					2			
Eremophila saligna (S. Moore) C. Gardner					2			
Eremophila scoparia (R. Br.) F. Muell.		3			2	3		
Eremophila veronica (S. Moore) C.A. Gardiner		3						
MYRTACEAE								
Baeckea maidenii Ewart and J. White	3							
Baeckea sp.	1							
Calothamnus gilesii F. Muell.	3							
Calytrix birdii (F. Muell.) B.D. Jackson	2							
Eucalyptus campaspe S. Moore					3	3		
Eucalyptus celastroides Turcz. ssp *celastroides*					3	3		
Eucalyptus celastroides Turcz. ssp *virella* Brooker		+						
Eucalyptus clelandii (Maiden) Maiden					3	3		
Eucalyptus conncina Maiden and Blakely	+							
Eucalyptus eremophila (Diels) Maiden	3							
Eucalyptus flocktoniae (Maiden) Maiden						3		
Eucalyptus griffithsii Maiden					3			
Eucalyptus leptopoda Benth.	+							
Eucalyptus loxophlebia Benth.					2			
Eucalyptus oleosa F. Muell. ex Miq.					3	3		
Eucalyptus platycorys Maiden and Blakely	3							

SPECIES	SS	Sa	Sl	Aq	Eg	Ec	Gc	Lg
PRIMULACEAE								
**Anagallis arvensis* L.		1					1	
PROTEACEAE								
Grevillea acacioides C.A. Gardiner ex McGillivray	+							
Grevillea aculeolata S. Moore		1						
Grevillea apiciloba F. Muell.	3							
Grevillea eriostachya Lindl.	1							
Grevillea huegelii S. Moore								
Grevillea integrifolia (Endl.) Meisn.	2							
Grevillea juncifolia Hooker	+							
Grevillea nematophylla F. Muell.			+			+		
Grevillea pritzellii Diels ex Diels et Pritzel	3							
Hakea coriacea Machonochie	+							
Hakea francisiana F. Muell.	2							
Hakea multilineata Meisn.	+							
Persoonia diadena F. Muell.	+							
RESTIONACEAE								
Lepidobolus preissianus Nees	3							
RHAMNACEAE								
Cryptandra nutans Steudel	3							
Pomaderris forrestiana F. Muell.					1			
*Trymalium myrtillus*S. Moore				1	1			
RUTACEAE								
Eriostemon brucei F. Muell.								+
Eriostemon tomentellus Diels	+							
Phebalium filifolium Turcz.	2							
Drummondita hassellii (F. Muell.) P.G. Wilson var *hassellii*	3							
SANTALACEAE								
Exocarpos aphyllus R. Br.		2			2	+		
Santalum acuminatum (R Br.) A. DC.		2			2			
Santalum spicatum (R. Br.) A. DC.					3	+		
SAPINDACEAE								
Dodonaea lobulata F. Muell.					3			
Dodonaea stenozyga F. Muell.				3	3		4	
Dodonaea amblyophylla Diels	2							
SOLONACEAE								
Lycium australe F. Muell.					+			
Solanum nummularium S. Moore						+		
Solanum lasiophyllum Dunal ex Poir.					1		1	
STACKHOUSIACEAE								
Stackhousia monogyna Labill. (yellow form)				+				
STERCULIACEAE								
Keraudrenia integrifolia Steud.	1							+
STYLIDIACEAE								
Stylidium induratum R. Br.							+	
Stylidium piliferum R. Br.	1							
THYMELAEACEAE								
Pimelea microcephala R. Br. ssp. *microcephala*	+							
URTICACEAE								
Parietaria debilis Forst. f.							+	

SPECIES	SS	Sa	Sl	Aq	Eg	Ec	Gc	Lg
Eucalyptus rigidula Cambage and Blakely	3							
Eucalyptus salmonophloia F. Muell.			+					
Eucalyptus salubris F. Muell.		3						
Eucalyptus sp. M	3							
Eucalyptus torquata Luehm.					+			
Eucalyptus transcontinentalis Maiden	2		+					
Eucalyptus websteriana Maiden				3			3	
Eucalyptus yilgarnensis (Maiden) Brooker					3			
Leptospermum erubescens Schauer	1							
Malleostemon roseus (Pritzel) J.W. Green	1							
Melaleuca eleutherostachya F. Muell.	+							
Melaleuca leiocarpa F. Muell.								+
Melaleuca sp.			+					
Melaleuca pauperiflora F. Muell							+	
Melaleuca uncinata R. Br.	3						+	
Micromyrtus obovata (Turcz.) J. W. Green	3							
Thryptomene kockii E. Pritzel	3							
Thryptomene tuberculata							+	
Verticordia picta Endl.	1							
Wehlia thryptomenoides F. Muell.	1							
OPHIOGLOSSACEAE								
Ophioglossum lusitanicum L.							+	
ORCHIDACEAE								
Pterostylis rufa R. Br.				1			1	
PAPILIONACEAE								
Bossiaea leptacantha E. Pritzel.		+	+					
Daviesia chordophylla Meissn.			+					
Dillwynia glaberrima Sm.					1			
**Medicago minima*							+	
Mirbelia depressa E. Pritzel.							+	
PITTOSPORACEAE								
Billardiera bicolor (Putterl.) E.M. Bennett	1							
Pittosporum phylliraeoides DC.			+					
PLANTAGINACEAE								
Plantago varia R. Br.		1			1		+	
POACEAE								
**Aira caryophyllea* L.							+	
Amphipogon strictus	+							
Aristida contorta F. Muell.					1			
Danthonia acerosa J. Vickery					1			
Danthonia setacea R. Br.				1	1	1		
Eriachne ovata Nees							+	
**Pentaschistus airoides* (Nees) Stapf.		1			1			
Plectrachne rigidissima (Pilger) C.E. Hubbard	3							
**Schismus barbatus* (L.) Thell.					1	1		
Stipa elegantissima Labill.	+	1		1	1	1	1	
Stipa blackii C.E. Hubbard				1			1	
Stipa hemipogon Benth.		1			+		1	
Stipa pycnostachya Benth.	+							
Stipa trichophylla Benth.					1	1		
Triodia scariosa N. Burbidge	+							
PORTULACACEAE								
Calandrinia calyptrata J.D. Hooker					1			
Calandrinia eremaea Ewart					1		+	

SPECIES	SS	Sa	Sl	Aq	Eg	Ec	Gc	Lg
VIOLACEAE								
Hybanthus floribundus (Lindley) F. Muell.	+							
ZYGOPHYLLACEAE								
Zygophyllum fruticulosum DC.		+						
Zygophyllum glaucum F. Muell.						1		
Zygophyllum ovatum Ewart and White		1		1	1			

Appendix II

Description of Vegetation Sites

The following descriptions are of the 19 sample sites, 15 of which were visited three times, sites 18 and 19, only once and 17 and 20 only twice, to give a complete as possible enumeration of the species present in winter, early spring and late spring.

In all cases plant species were recorded in 20 X 20 m square quadrats and recorded by cover values (1 - < 1%, 2 - 1 - 5%, 2 - 6 - 20%, 4 - 21 - 50%).

Vegetation types are separated by structure and lifeform on the same basis as is done in the Goldfields surveys. The diameter at breast height (DBH) was measured for all trees (at 1.3 m above the ground, over bark) in 20 X 50 m quadrats based on extensions of the 20 X 20 m quadrats, at most sites. The results of this (ie. density and basal areas) are given on a per hectare basis in the sample descriptions.

Sample 1: *Eucalyptus* sp. M, *Callitris preissii* ssp. *verrucosa*, tall shrubland.

Location: 3 km SSW of Coolgardie (lat. 30° 58' 30", long.121° 09' 00").

Fauna sample: Yes.

Vegetation
Stratum 1: Mallee to 3 m, *Eucalyptus* species M (110 trees/h, 0.97 m^2/h), *E. leptopoda* (10 trees/h, 0.21 m^2/h), *Callitris preissii* ssp. *verrucosa* (20 trees/h, 0.90 m^2/h).

Stratum 2: Shrubs 1-2 m, *Grevillea acutiloba* (3), *Thryptomene kockii* (3), *Baeckea maidenii* (3), *Cryptandra nutans* (3), *Westringia cephalantha* (3).

Stratum 3: Hummock grass 0.5 m, *Plectrachne rigidissima* (3), *Schoenus globifer* (2).

Number of Taxa in Quadrat: 20.

Landform: Undulating plain.

Bedrock: Unknown.

Soil Description: Deep, red sand with small (0.5 cm) buckshot gravel and a little clay. No profile development until at 110 cm, ironstone gravel with some sand.

Comments: Northern part of an extensive sandplain which appears to be located above lateritic ironstone layers to the east. To the west passes into clay plains and to the south granitic soil country.

Sample 2: *Eucalyptus rigidula, E. eremophila,* tall shrubland to woodland.

Location: 4 km along the southern edge of Calooli Reserve from the Queen Victoria Rocks Road (lat.31° 01' 25", long.121° 02' 32").

Fauna sample: Yes.

Vegetation
Stratum 1: Trees or mallees 4-6 m tall, sparse, *Eucalyptus eremophila* (50 trees/h, 0.25 m^2/h), *E. transcontinentalis* (20 trees/h, 0.38 m^2/h).

Stratum 2: Mallees or small trees to 3 m; *Eucalyptus rigidula* (100 mallees/h), *Callitris preisii* ssp. *verrucosa* (40 trees/h).

Stratum 3: Shrubs to 2 m, *Melaleuca uncinata* (3), *Malleostemon roseus* (3), *Thryptomene kockii* (3), *Micromyrtus obovata* (3), *Acacia resinomarginea* (3), *Calothamnus gilesii* (3), *Drummondita hassellii* (3).

Stratum 4: Shrubs to 1 m, *Baeckea maidenii* (3), *Dampiera tenuicaulis* var *curvula* (2).

Stratum 5: Hummock grass, *Plectrachne rigidissima* (2).

Number of Taxa in Quadrat: 26.

Landform: Flat to undulating plain.

Bedrock: Unknown.

Soil Description: Deep red sand with a very small amount of clay. No profile development, sandy iron buckshot encountered at 25 cm depth - extends to 60 cm and probably beyond.

Comments: A high level sand sheet which passes into clay flats to the north-west and to the south-east slopes gradually to a shallow drainage line which is cut along the edge of granitic bedrock.

Sample 3: *Eucalyptus salubris* woodland.

Location: Approx. 200 m south-east of the Queen Victoria Rocks Road approx. 18 km from Coolgardie (lat. 31° 02' 30", long. 121° 02' 30").

Fauna Sample: Yes.

Vegetation

Stratum 1: Trees to 10 m, bushy (woodland form) branching low from the base, *Eucalyptus salubris* (50 trees/h, 3.8 m^2/h).

Stratum 2: Medium shrubs to 2 m, *Eremophila scoparia* (3), *E. ionantha* (3).

Stratum 3: Low shrubs, 0.5 to 1.5 m, *Scaevola spinescens* (3), *Acacia hemiteles* (3), *Cassia nemophila* (2), *Santalum acuminatum* (2).

Stratum 4: Very sparse herbs and grasses, *Stipa trichophylla* (1).

Number of Taxa in Quadrat: 14.

Landform: Flat plain with some indication of broad-scale gilgai.

Bedrock: Unknown - alluvial-colluvial.

Soil Description: Red, gravelly, silty loam. No horizons evident, gravel of quartz and iron buckshot.

Comments: Alluvial plain with some shallow washaway areas (not deep enough to be called creeks). In parts there are very broad-scale (over several metres) mounds delimited by relatively narrow (0.5 m) crevices.

Sample 5: *Eucalyptus salubris-E. griffithsii* woodland.

Location: Approx. 2 km due south of the Great Eastern Highway on the track leading into the western edge of Calooli Reserve, 20 m west of track (lat. 30° 59' 30", long. 121° 02' 32").

Fauna Sample: Yes.

Vegetation

Stratum 1: Trees usually of woodland form (to 12 m) branching low down and multi-stemmed above a short (0.5-1 m) trunk. *Eucalyptus salubris* (not in 20 x 20 quad, 40 trees/h, 1.9 m^2/h), *E. griffithsii* (30 trees/h, 0.8 m^2/h) *E. oleosa* (20 trees/h, 1.2 m^2/h), *E. loxophlebia* (10 trees/h, 0.1 m^2/h).

Stratum 2: Medium shrubs to 2 m tall, *Acacia acuminata* (3), *Eremophila saligna* (2), *E. graniticola* (2), *E. oppositifolia* (3), *Casuarina acutivalvis* (1).

Stratum 3: Low shrubs to 1 m, *Prostanthera grylloana* (2), *Cassia nemophila* (1), *Santalum spicatum* (3), *Scaevola spinescens* (2), *Acacia erinacea* (2).

Stratum 4: Sparse herbs and grasses, *Stipa elegantissima* (1), *Danthonia acerosa* (1), *Waitzia acuminata* (1).

Number of Taxa in Quadrat: 23.

Landform: Flat plain.

Bedrock: Unknown, but seems to be a pale weathered acidic rock..

Soil Description: Surface of ground covered with buckshot gravel. Top 25 cm is a red gravelly clay loam - further augering was impossible. Nearby there is a gravel pit with at least 1 m of buckshot gravel exposed as a face of the pit.

Comments: This rise seems to be on a gravelly clay loam plain. The weathered bedrock is probably a variable depth below the surface so that the gravel forms pockets. Further west from this rise the soil becomes less gravelly and more clayey and *E. salubris* is more common than at the quadrat site.

Sample 6: *Eucalyptus griffithsii-E. loxophlebia* sparse woodland.

Location: Approx. 2 km along Comet Hill Road from Queen Victoria Rocks Road, 300-400 m north of the track near experimental sandlewood exclosures (lat. 31° 01' 35", long. 121° 05' 30").

Fauna Sample: Yes.

Vegetation:

Stratum 1: Sparse trees from 5 to 8 m tall, usually multi-stemmed and of crooked form, *Eucalyptus griffithsii* (10 trees/h, 0.2 m^2/h), *E. loxophlebia* (not in 20 x 20 quadrat, 20 trees/h, 0.4 m^2/h).

Stratum 2: Tall shrubs to 3 m, *Eremophila augustifolia* (30 shrubs/h, 0.4 m^2/h).

Stratum 3: Medium shrubs to 1-2 m, *Santalum spicatum* (3), *Pomaderris forrestiana* (3), *Scaevola spinescens* (3), *Acacia acuminata* (3),

Stratum 4: Low shrubs to 1 m, *Dodonaea lobulata* (3), *Prostanthera grylloana* (1).

Stratum 5: Sparse herbs and grasses, *Stipa trichophylla* (1), *Haloragis trigonocarpa* (1), *Ptilotus* spp. (1), *Asteridea athrixiodes* (1), *Erodium cicutarium* (1).

Number of
Taxa in Quadrat: 21.

Landform: Low, rocky rise in a flat plain.

Bedrock: Probably granite, now weathered.

Soil Description: Red clayey gravel over rock at 25 cm. Gravel is shiny buckshot with dull ironstone.

Comments: The soil seems to be a lateritic mantle over weathered granite. The laterite is fairly crumbly ironstone grading into pale weathered bedrock. Throughout this area low rises of weathered rock (granite?) stand above a colluvial/alluvial plain.

Sample 7: *Eucalyptus griffithsii-E. oleosa* woodland.

Location: Approx. 500 m along a track south-east of the Queen Victoria Rocks Road, approx. 15 km from Coolgardie (lat. 31° 03' 40", long. 121° 03' 40").

Fauna Sample: Yes.

Vegetation
Stratum 1: Relatively sparse trees to 15 m tall, many multi-stemmed from about 1 m from the ground, *Eucalyptus griffithsii* (70 trees/h, 2.7 m^2/h) and *E. oleosa* (30 trees/h), 2.1 m^2/h). The actual identity of the *E. oleosa* is not clear. The buds are very similar to *Eucalyptus* sp. M but many of the trees are of the *E. longicornis* form, one being measured at a stem diameter (DBH) of 45 cm. *E. torquata* (10 trees/h, 0.4 m^2/h).

Stratum 2: Relatively sparse, tall (to 3 m) shrubs, *Eremophila interstans* (2), *E. scoparia* (2).

Stratum 3: Low to medium shrubs (0.5-1.5 m), *Alyxia buxifolia* (3), *Atriplex nummularia* (3), *A. holocarpa* (3), *Cassia eremophila* (3), *Dodonaea stenozyga* (3), *Scaevola spinescens* (2).

Stratum 4: Sparse herbs and grasses, **Carrichtera annua* (1), *Zygophyllum ovatum* (1), *Ptilotus holosericeum* (1).

Number of
Taxa in Quadrat: 23.

Landform: Rocky hillside, slope 5-10°, north aspect.

Bedrock: Komatite (according to Geological map).

Soil Description: Soil a sandy loamy gravel, impossible to auger. No horizon development and from pits dug in places there is crumbly white silcrete-like underlying material. Gravel is greenstone and quartz.

Comments: Soil appears to be skeletal colluvial wash over weathered bedrock - virtually no groundcover of herbaceous plants.

Sample 8: *Eucalyptus clelandii-E. celastroides* woodland.

Location: Approx. 100 m east of the Queen Victoria Rocks Road about 6.5 km from Coolgardie (lat. 31° 00' 00", long. 121° 07' 30").

Fauna Sample: Yes.

Vegetation

Stratum 1: Trees 4-8 m tall, most of woodland form, branching from a butt of about 1 m tall, single stemmed when in dense stands, *Eucalyptus clelandii* (150 trees/h, 0.26 m^2/h), *E. oleosa* (10 trees/h, 2.75 m^2/h), *E. flocktoniae* (40 trees/h, 0.59 m^2/h).

Stratum 2: Medium shrubs (1-2.5 m), fairly sparse, *Eremophila scoparia* (3), *E. interstans* (3).

Stratum 3: Low shrubs to 1 m tall, *Atriplex nummularia* (3), *Eremophila glabra, Cratystylis microphylla* (3), *Scaevola spinescens* (2), *Sclerolaena diacantha* (1), *Acacia hemiteles* (1).

Stratum 4: Grasses and herbs - very sparse, *Stipa elegantissima* (1).

Number of Taxa in Quadrat: 17.

Landform: Flat to gentle slope, moderate erosion, aspect SE.

Bedrock: Granite.

Soil Description: Gravelly, silty, clayey sand with rock close to the surface. Erosion is fairly obvious in this area. Grazed at present. This rise is on the NW edge of an erosional basin.

The erosional extension is towards the north and west.

Sample 9: *Eucalyptus griffithsii-Acacia quadrimarginea* open woodland.

Location: Approximately 700 m west of the road delineating the eastern edge of the Kangaroo Hills Reserve, 3.5 km from Coolgardie (lat. 30° 59' 45", long. 121° 09' 30").

Fauna Sample: Yes.

Vegetation

Stratum 1: Sparse eucalypts and somewhat more dense acacias from 3 to 6 m high. *Eucalyptus griffithsii* (10 trees/h, 0.8 m^2/h), *Acacia quadrimarginea* (340 trees/h).

Stratum 2: Tall to medium shrubs (1-2.5 m), *Eremophila alternifolia* (3).

Stratum 3: Low shrubs (to 1 m), *Dodonaea lobulata* (3), *Trymalium myrtillus* (1), *Atriplex nummularia* (2), *Cassia nemophila* (2), *Scaevola spinescens* (2).

Stratum 4: Herbs and grasses, *Danthonia setacea* (1), *Calandrinia eremaea* (1), *Isoetopsis graminifolia* (1), **Carrichtera annua* (1), *Senecio glossanthus* (1).

Number of Taxa in Quadrat: 22.

Landform: Hillside with slope 3-7°, aspect NE.

Bedrock: ?Basalt - according to a geological map of the area.

Soil Description: Red-brown, gravelly, silty loam, skeletal soil. Gravel is greenstone basement rock - no horizon development, most of the soil is colluvial in origin.

Comments: Heavily grazed area, the acacias are mostly single-stemmed, but the *E. griffithsii* are crooked and multi-stemmed.

Sample 10: *Acacia acuminata-Eucalyptus websteriana*, low woodland.

Location: Approx. 200 m NW of the Queen Victoria Rocks Road, 11 km from Coolgardie (lat. 31° 02' 00", long. 121° 05' 25").

Fauna Sample: Yes.

Vegetation
Stratum 1: Low trees to 2-4 m, dense in clumps, but sparse in other places, many multi-stemmed *Acacia acuminata* (140 trees/h, 1.9 m^2/h, *Eucalyptus websteriana* (60 mallees/h), *A. quadrimarginea* (20 trees/h, 0.29 m^2/h).

Stratum 2: Low shrubs to 1 m, *Dodonaea stenozyga* (4).

Stratum 3: Diverse assemblage of herbs and grasses, *Stipa blackii* (2), *S. elegantissima* (1), *Cheilanthes sieberi* (1), Goodeniaceae (2 species), daisies (9 species), lilies (2 species).

Number of
Taxa in Quadrat: 29.

Landform: Fairly flat area within granite outcrop.

Bedrock: Granite.

Soil Description: Light brown shallow, coarsely sandy loam collected in pockets of the granite outcrop.

Comments: Area of fairly fresh granite outcrop. *Acacia* in the deeper soil pockets and herb fields on the shallow soil aprons out from the outcrops. Many ephemeral daisy, lily and goodeniaceous herbs on the shallow soils and in crevices in the granite. *Isotoma petraea* quite conspicuous in crevices.

Sample 11: *Eucalyptus campaspe* woodland

Location: Approximately 1.5-2 km along a track southeast of the Queen Victoria Rocks Road, about 17 km from Coolgardie. 300 m up slope from the track. (lat. 31° 04' 35", long. 121° 03' 00").

Fauna sample: Yes

Vegetation
Stratum 1: Trees to 10 m tall with some to 15 m, *Eucalyptus campaspe*, woodland form tree branching about 1 m above the ground (220 trees/h, 2.14 m^2/h) with some *E.oleosa* in the area but not at the sample site.

Stratum 2: Shrubs to 2m, *Eremophila drummondii* (3), *Exocarpos aphyllus* (1).

Stratum 3: Low shrubs to 1 m, *Atriplex nummularia* (2), *A.holocarpa* (2), *Sclerolaena diacantha* (1), *S.cuneata* (1).

Stratum 4: Grass and herbs - very sparse. **Carrichtera annua* (1), other crucifers (2 species) **Schismus barbatus* (1), daisies (2 species).

Number of Taxa in Quadrat: 22

Landform: Low spur extending from main range, fairly flat but low slope to the south ($1-2^0$).

Bedrock: Basalt (from geological map).

Soil Description: Stoney red brown clay loam, fairly "fluffy" and cracked when dried after rain. Gravel and flat rocks of greenstone (basalt) country rock. Augering impossible due to rocks.

Comments: Soil is very rocky but also very clayey, very sticky after rain but "fluffy" when it dries out.

Sample 12: *Eucalyptus* species M - *E.platycorys* tall open shrubland.

Location: Approximately 3.5 km south of Coolgardie about 500 m west of the Nepean Road which delimits the eastern edge of the Kangaroo Hills Reserve. (lat. 30° 59' 00", long. 121° 09' 35").

Fauna sample: Yes

Vegetation

Stratum 1: Mallees to 3 or 4 m tall quite sparse and crooked, *Eucalyptus* sp. M. (40 trees/h, 0.97 m^2/h) and *E.platycorys* (30 trees/h, 0.54 m^2/h), *Grevillea eriostachya* (10 trees/h, 0.05 m^2/h).

Stratum 2: Low to medium shrubs 0.5 - 1.5 m, fairly open, *Casuarina spinosissima* (3), *Grevillea pritzelii* (3), *Westringia cephalantha* (3), *Halgania rigida* (2), *Acacia assimilis* ssp. *assimilis* (2) *Bertya dimerostigma* (2).

Stratum 3: Spinifex forming rings, hummocks and semicircles, *Plectrachne rigidissima* (4).

Number of
Taxa in Quadrat: 18

Landform: Flat sand plain.

Bedrock: Not known.

Soil Description: Red sand - not augered but probably similar to site 1, without the buckshot.

Comments: At this site there seemed to be no indication of the buckshot found at other sand sites. A sand pit near the site showed a deep sand profile, although from cores near the site there is evidently buckshot at depth.

Sample 13: *Eucalyptus clelandii - E.celastroides.* Open forest - woodland.

Location: Approximately 400 m northwest of the Queen Victoria Rocks Road, 12 km from Coolgardie.(lat. 31° 02' 30", long. 121° 05' 00").

Fauna Sample: Yes (not birds)

Vegetation
Stratum 1: Eucalypts to 10 m. Some, such as *Eucalyptus celastroides* only whipstick mallees to 3m. *E. clelandii* (100 trees/h, 4.7 m^2/h), *E.celastroides* (40 trees/h, 0.8 m^2/h), *E.campaspe* (20 trees/L, 0.3 m^2/h), *E.flocktoniae* (10 trees/h, 0.2 m^2/h).

Stratum 2: Very sparse shrubs from 2-4 m tall, *Eremophila scoparia* (10 plants/h).

Stratum 3: Sparse shrubs below 1 m, *Atriplex nummularia* (3), *Olearia muelleri* (1), *Sclerolaena diacantha* (1).

Stratum 4: Very sparse grasses, *Stipa* sp. (1).

Number of
Taxa in Quadrat: 9

Landform: Lower outwash slope from ridge - colluvial/alluvial material, slope $1-2^0$ to south.

Bedrock: Possibly basalt but covered by surficial material.

Soil Description: Red gravelly silty loam, no horizon development, no special features, gravel of greenstone and iron buckshot.

Comments: Relatively thick canopy cover and heavy litter layer under the trees. Extremely depauperate ground layer. Downslope the trees become very sparse with *E.salmonophloia* dominating.

Sample 14: *Eucalyptus salubris* woodland.

Location: 1 km along Comet Hill Road from the Queen Victoria Rocks Road. (150 m to the northeast of the track).(lat. 31° 01' 40", long. 121° 05' 45").

Fauna sample: No.

Vegetation

Stratum 1: Trees to 12 m, most of woodland form branching at about 0.5 to 1 m from the ground, *Eucalyptus salubris* (140 trees/h, 5.9 m^2/h).

Stratum 2: Very sparse medium shrub layer although these species were not located in the quadrat, *Santalum accuminatum, Exocarpos aphyllus*.

Stratum 3: Low shrubs to 0.5 m, *Eremophila veronica* (3), *Atriplex holocarpa* (2), *Sclerolaena diacantha* (1), *Wilsonia humilis* (1), *Maireana georgei* (1).

Stratum 4: Very sparse ground layer of grasses and a few herbs, *Stellaria filiformis* (1), *Helipterum zacchareus* (1), *Crassula exerta* (1), *Thysanotus brachyanthera*(1), *Stipa hemipogon* (1).

Number of Taxa in Quadrat: 17

Landform: Clay flats with some broad gilgai development giving a patterning to the area. Plants tend not to grow in the lower parts of the gilgai.

Bedrock: Granite ?

Soil Description: Red gravelly clay loam, some weakly developed macro-gilgai effects. Floaters of acidic country rock and quartz, but buckshot uncommon.

Sample 15: *Acacia quadrimarginea* low woodland - low open forest.

Location: Eastern slope of the spur running north from Comet Hill about 700 m from the summit and 100 m to the east of the road.(lat. 31° 01' 35", long. 121° 04' 00")

Fauna Sample: No.

Vegetation

Stratum 1: *Acacia quadrimarginea* (370 trees/h), 3.6 m^2/h) forms an open forest to woodland. Some trees multi trunked from about 0.5 m but most single-stemmed, approximately 4 m tall.

Stratum 2: Mallee eucalypts and shrubs to 2.5 m, *E.websteriana* (10 trees/h, 0.1 m^2/h) and *Acacia acuminata* (3), *A.tetragonophylla* (2) *Trymalium myrtillus* (3).

Stratum 3: Low shrubs (0.5 - 1 m) moderately dense in places, *Prostanthera aspalathoides* (3), *Dodonaea stenozyga* (3), *Scaevola spinescens* (2), *Cassia nemophila* (2).

Stratum 4: Herbs and grasses (fairly sparse) *Isoetopsis graminifolia* (1), *Helipterum oppositifol ium* (1), other daisies (3 sp.), *Zygophyllum ovatum* (1), *Danthonia setacea* (1), *Stipa blackii* (1), *Erodium* spp.(1).

Number of Taxa in Quadrat: 27

Landform: Eastern slope of greenstone ridge (10-15^0 slope).

Bedrock: Komatite (according to geological map).

Soil Description: Sandy clay loam gravel. Gravel of greenstone rocks.

Comments: The site is within the *A.quadrimarginea* band which occurs at the upper slopes of many of the ridges in the area.

Sample 16: *Eucalyptus clelandii - E.griffithsii* woodland.

Location: Northern slope of the spur running south from Comet Hill about 700 m from the summit and 70 m

to the west of the road.(lat. 31° 01' 25", long. 121° 04' 00")

Fauna Sample: No.

Vegetation

Stratum 1: Trees to 12 m tall many multi-stemmed from about 1 m up, *Eucalyptus clelandii* (3), *E.griffithsii* (3).

Stratum 2: Shrubs to 3 m tall, *Eremophila angustifolia* (3), *E.scoparia* (3), *E.oppositifolia* (2).

Stratum 3: Medium shrubs (0.5 to 2 m) *Santalum spicatum* (2), *Scaevola spinescens* (3), *Pomaderris forrestiana* (1), *Trymalium myrtillus* (1).

Stratum 4: Low shrubs to 0.5 m, *Acacia erinacea* (3), *Olearia muelleri* (2), *Eremophila parvifolia* (2), *E.glabra* (1), *Dodonaea lobulata* (2), *Ptilotus obovatus* (1), *Atriplex holocarpa* (1).

Stratum 5: Very sparse grasses, *Stipa* sp. (1).

Number of Taxa in Quadrat: 23

Landform: Low northerly slope (5-7^0) on side of ridge.

Bedrock: Basalt/Komatite (according to geology map).

Soil: Sandy loam gravel (impossible to auger). Gravel of greenstone.

Comments: Opposite side of ridge from sample 15, very different in terms of structure and soil is less clayey and slope more shallow. No tree measurements done.

Sample 17: *Eucalyptus griffithsii-E. yilgarnensis* woodland.

Location: 2.5 km along southern edge of Calooli Reserve, from Queen Victoria Rocks Road, about 160 m north of track.(lat. 31° 02' 00", long. 121° 03' 45").

Fauna sample: No.

Vegetation

Stratum 1: Trees to 10 m usually branching from a lignotuber-like structure just above ground

level, *Eucalyptus griffithsii* (3), *E. yilgarnensis* (3), *E. celastroides* (2).

Stratum 2: Shrubs to 3 m, *Eremophila angustifolia* (3), *E. scoparia* (3), *Scaevola spinescens* (1), *Santalum acuminatum* (2).

Stratum 3: Low shrubs from 0.5 to 1 m tall, *Dodonaea lobulata* (3), *Atriplex holocarpa* (3), *A. nummularia* (1), *Olearia muelleri* (2), *Cassia nemophila* (1), *Acacia erinacea* (2), *Maireana georgei* (1), *Sclerolaena diacantha* (1).

Stratum 4: Herbs and grasses, very sparse, *Stipa elegantissima* (1), *Danthonia setacea* (1), daisies (7 species), *Erodium cygnorum* (1).

Number of Taxa in Quadrat: 33.

Landform: Flat, rocky area.

Bedrock: Granite and acidic dykes.

Soil: Gravelly, sandy loam, no horizons and augering impossible, gravel of greenstone and quartz.

Comments: No tree measurements done at this site.

Sample 18: *Eucalyptus salubris-E. celastroides* ssp. *virella*, open woodland.

Location: Approx. 1.5 km NE of Comet Hill - see map. (lat. 31° 00' 45", long. 121° 04' 40").

Fauna sample: No.

Vegetation:

Stratum 1: Trees of woodland form, fairly sparse, branching low to the ground, *Eucalyptus salubris* (30 trees/h, 2.3 m^2/h), *E. celastroides* ssp. *virella* (not in 20 x 20 quad., 20 trees/h; 2.0 m^2/h).

Stratum 2: Medium shrubs to 2.5 m, *Eremophila granitica* (3).

Stratum 3: Low shrubs to 0.5 m, *Atriplex holocarpa* (3), *Frankenia desertorum* (2), *Maireana georgei* (1).

Stratum 4: Sparse herbs and grasses, daisies (6 species), *Erodium cygnorum* (1), *Menkea lutea* (1), *Haloragis trigonocarpa* (1), **Carrichtera annua* (1), *Stipa* sp. (1).

Number of
Taxa in Quadrat: 24.

Landform: Alluvial outwash gilgai plain.

Bedrock: ?

Soil: Red, gravelly clay. The area is a mosaic of hummocks about 2-3 m across separated by relatively sharp to broad depressions. The tops of the hummocks have gravelly sand approx. 2.5 cm deep over dense red clay, gravel is shiny buckshot to 1 cm diameter.

Comment: A very unusual gilgai area. The hummocks are arcuate with depressions to the SW (towards the hills). Most annual plants occur on the tops of the hummocks.

Sample 19: *Eucalyptus griffithsii-E. oleosa* woodland.

Location: Approx. 1.5 km NE of Comet Hill - see map. (lat. 31° 00' 45", long. 121° 04' 40")

Fauna sample: No.

Vegetation:

Stratum 1: Sparse trees to 8-10 m, most multistemmed from thick lignotubers at ground level or up to 0.5 m above ground. *Eucalyptus griffithsii* (30 trees/h, 2.1 m^2/h), *E. oleosa* (10 trees/h, 1.3 m^2/h).

Stratum 2: Tall shrubs to 3 m, may be relatively dense, *Acacia acuminata* (3), *Acacia tetragonophylla* (1), *Eremophila granitica* (3).

Stratum 3: Medium shrubs to 2 m, *Santalum spicatum* (2), *Rhagodia drummondii* (1).

Stratum 4: Low shrubs to 0.5 m, *Dodonaea lobulata* (2), *Cassia nemophila* (1), *Dillwynia glaberrima* (1), *Maireana georgei* (1), *Atriplex holocarpa* (1).

Stratum 5: Sparse grasses and herbs, daisies (7 species), *Erodium cygnorum* (1), *Velleia cycnopotamica* (1).

Number of
Taxa in Quadrat: 23.

Landform: Outwash flats between the clayey gilgai areas. From the air photos it seems to be a broad drainage line but no channels are evident on the ground.

Bedrock: ?

Soil: Red, sandy silt with a lot of quartz and ironstone gravel on the surface. Below 5 cm becomes a fine, sandy clay.

Comments: This area is a contrast from 18. The soil surface is sandier and level without the gravel pavement of site 18.

Sample 20: *Eucalyptus oleosa-E. celastroides* woodland.

Location: 1-5 km along the southern side of Calooli Reserve from Queen Victoria Rocks Road, about 50 m NE of track.(lat. 31° 03' 00", long. 121° 04' 25").

Fauna sample: No.

Vegetation:

Stratum 1: Trees to 15 m, most multistemmed from short trunks or lignotubers, *Eucalyptus oleosa* (30 trees/h, 2.8 m^2/h), *E. celastroides* (80 trees/h, 3.0 m^2/h), *E. torquata* (not in 20 x 20 quad., 20 trees/h, 0.6 m^2/h).

Stratum 2: Tall shrubs to 3 m, *Eremophila scoparia* (2), *E. interstans* (2).

Stratum 3: Low shrubs to 1 m, *Scaevola spinescens* (3), *Olearia muelleri* (2), *Atriplex nummularia* (3), *A. holocarpa* (3), *Dodonaea lobulata* (1), *Cassia nemophila* (1).

Stratum 4: Grasses and herbs, *Stipa* sp. (1), **Carrichtera annua* (1).

Number of Taxa in Quadrat: 16.

Landform: Small ridge with the site being on a shallow (1-2°) slope to the east.

Bedrock: Basalt (greenstone).

Soil: Sandy gravel - basically greenstone rock and impossible to auger.

Comments: Most of the trees in the sample are resprouts from stumps. The trees were presumably cut over at one time for mine timbers.

Appendix III

Notes on Particular Plant Species Found During the Survey.

Baeckea sp. - This specimen from sand heath on the southern boundary of Calooli Reserve (Site 2) did not match any of the species in the WA herbarium, nor any descriptions of WA or South Australian species. The flowers are relatively large (to 4mm across the top of the torus); the leaves are the most distinctive feature, being small (1 - 2mm), terete and markedly tuberculate due to raised glands.

Malleostemon roseus (Pritzel) J.W. Green - The specimens of this from sand heath on the southern boundary of Calooli Reserve (Site 2) agree well with the species except that there are 10 stamens rather than the 5 mentioned in the key in Blackall and Grieve.

Dillwynia glaberrima Sm. - This species is supposedly endemic in Victoria. However the specimen (from near site 6, other plants found near site 17) shows a great deal of similarity to the Victorian specimens in the WA herbarium and in addition there is a specimen collected from near Lake King to which it is also similar. The species seems to occur in WA.

Lepidium merralii - The determination is based on one very small specimen from Site 11 of the Survey.The species is listed in the Flora of Australia (Vol. 8) as being a very rare species endemic to the Southern Cross - Coolgardie region. The specimen accords quite well with the description in the flora, but it was not possible to compare it with any specimens, as there seem to be none in the WA herbarium.

Menkea lutea - The specimens collected during this Survey from gilgaied clay plains (Site 17) are very small, but were abundant at the site. There are few specimens of *M. lutea* in the WA herbarium, and the Calooli specimens do not accord entirely with these, particularly with respect to the septum of the fruit. In the Calooli specimens the septum is present while in the description (in the Flora) and the herbarium specimens it is lacking. However the petals are a brilliant chrome yellow and the Calooli specimens seem most closely matched with *M. lutea*.

Stipa blackii - This grass is quite widespread on the rocky hills of the Reserves. The awn on each spikelet is much shorter (only 2cm) than is given in Black (Flora of South Australia) and is closer to, but still shorter than, *S. aristiglumis*. However *S. aristiglumis* does not have the long hairs which occur at the top of the lemma in the Survey specimens and in *S. blackii*. *Stipa bigeniculata* is also close to *S. blackii* but does not have the long hairs at the top of the lemma. At present *Stipa blackii* seems to be the best determination for the Kangaroo Hills - Calooli specimens.

Eremophila spp. - There were two specimens of this genus which could not be determined to species level.