A SURVEY OF COLEOPTERA (BEETLES) AT WHITEMAN PARK, WESTERN AUSTRALIA 2000

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THIS REPORT IS AN OPTIONAL COMPONENT OF THE BACHELOR OF SCIENCE (ENVIRONMENTAL BIOLOGY) DEGREE AT CURTIN UNIVERSITY OF TECHNOLOGY, IT REPRESENTS 12.5% OF THE FORMAL COURSE REQUIREMENTS OF THE FINAL YEAR.

ABSTRACT

A survey of Coleoptera (beetles) was undertaken at Whiteman Park, Whiteman, Western Australia from December 1999 to September 2000. Three habitat types were surveyed: Banksia woodland, Pasture and Wetlands. During the course of the study 341 individuals were collected, representing 13 families and 74 species. The families collected were Anthicidae, Carabidae, Curculionidae, Dysticidae, Elateridae, Heteroceridae, Hydrophilidae, Leiodidae, Nitidulidae, Scarabaeidae, Scirtidae, Tenebrionidae, and Trogidae. The three habitat types did not differ significantly in their family composition.

Keywords: Banksia woodland, Pasture, Wetlands, Coleoptera

ACKNOWLEDGEMENTS

I wish to thank Harry Gratte, Assistant Manager-Whiteman Park, and all the Park's staff for their help and advice. My thanks also to Brian Heterick for help in identifiying the beetles I caught, and to Michelle Drew for allowing me to use the vertebrate pitfall traps she dug at Whiteman Park. Finally, thanks to Professor Stephen Davies for his advice on the preparation of this report.

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INTRODUCTION

Ecosystems are the basic functional units of ecology, through which energy flows and is transformed. (Knox et al, 1994). In this system the amount of energy in equals the amount of energy out. Figure 1 illustrates this concept, and it is to be noted that energy is neither lost nor created, but may be transformed into heat.

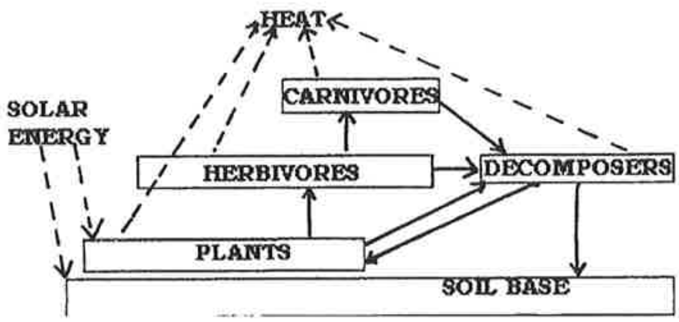

Figure 1: Energetics of an ecosystem, depicting energy flow and heat loss. (modified after Brafield & Llewellyn, 1984)

Forest ecosystems rely on organic and inorganic nutrients becoming available again for uptake by plants. The process by which this occurs, the **nutrient cycle**, is dependent on the accrual, concentration and decomposition of plant litter in combination with energy in the form of photosynthetically-fixed carbon. (Attiwill and Adams, 1993; O'Connell, 1989). Nutrients are made available through **decomposition** or the oxidation of carbon, and **mineralisation** or the transformation of organically-bound nutrients to simple ionic forms or inorganic nutrients. (Attiwill and Adams, 1993).

Australian terrestrial flora is dominated by sclerophylls, in contrast to other continents and islands of the world. (Knox et al, 1994). Special environmental conditions are responsible for this dominance. Australian soils are ancient, deeply weathered and leached of nutrients; the climate is largely arid; and low levels of phosphorous are limiting factor that tend to favour sclerophylls over other vegetation. (Springett, 1978; Knox et al, 1994). Recurrent fire is also a special feature.

The sclerophyll forest and woodlands, which cover more than 70% of Australia (Knox et al, 1994), are complex patch-works of understorey and overstorey vegetative associations. (Morrow, 1977). The main components of these ecosystems are *Acacia,* eucalypts, *Banksia,* casuarinas, grass trees, heaths, native peas and hummock grasses. (Knox et al, 1994). More than 90% of Australian woodlands and forests are dominated by *Eucalyptus* and *Acacias*, each of have more than 600 described species. (Morrow, 1977). These species all possess features that allow them to overcome the problems of low soil nutrients, lack of water and fire. (Morrow, 1977).

The nutrient cycle and decomposition

The availability of organic and inorganic nutrients for plant uptake in the forest ecosystem is determined by the nutrient cycle. This process is reliant on:

- Inputs to the forest through sunshine, rainfall, dust, biological fixation and weathering of rocks.
- Outputs from the ecosystem through stream water, denitrification and gaseous release from fire.
- The uptake and return of nutrients to the soil by leaching, litter and root decomposition and mineralisation, and the death of individuals.
- Redistribution of nitrogen, phosphorous and other nutrients.

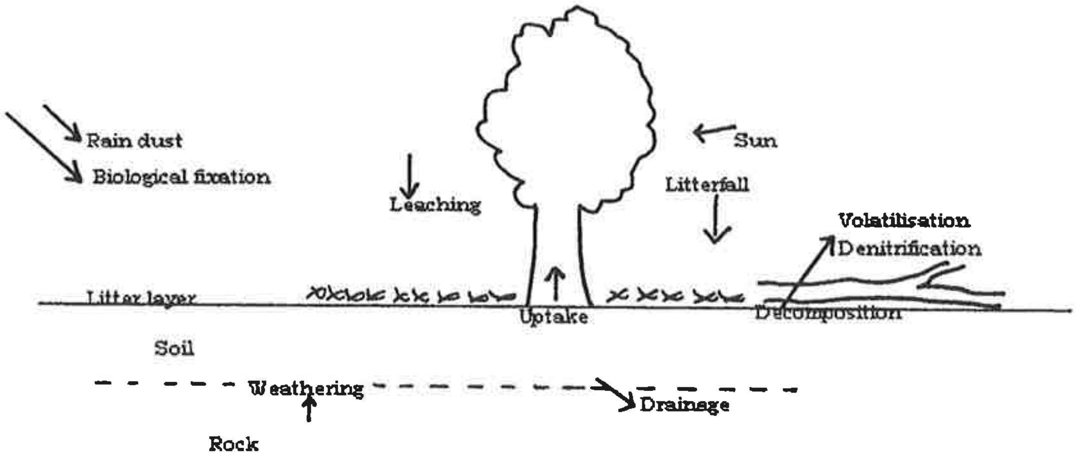

Figure 2: The nutrient cycle of a forest. (from Attiwill and Adams, 1993).

Three related sub-systems, illustrated in Figure 3, allow the ecosystem to function efficiently and nutrient cycling to take place. (O'Connell, 1988; Hutson, 1989). These are:

- The plant sub-system; where net primary production or biological fixation enters the decomposition sub-system through annual litter fall.
- The herbivore sub-system; where released CO_2 enters the plant sub-system and detritus enters the decomposer sub-system.

- The decomposer sub-system; where forest floor litter is broken down through the actions of microflora and microfauna to release inorganic nutrients for use by the plant sub-system.

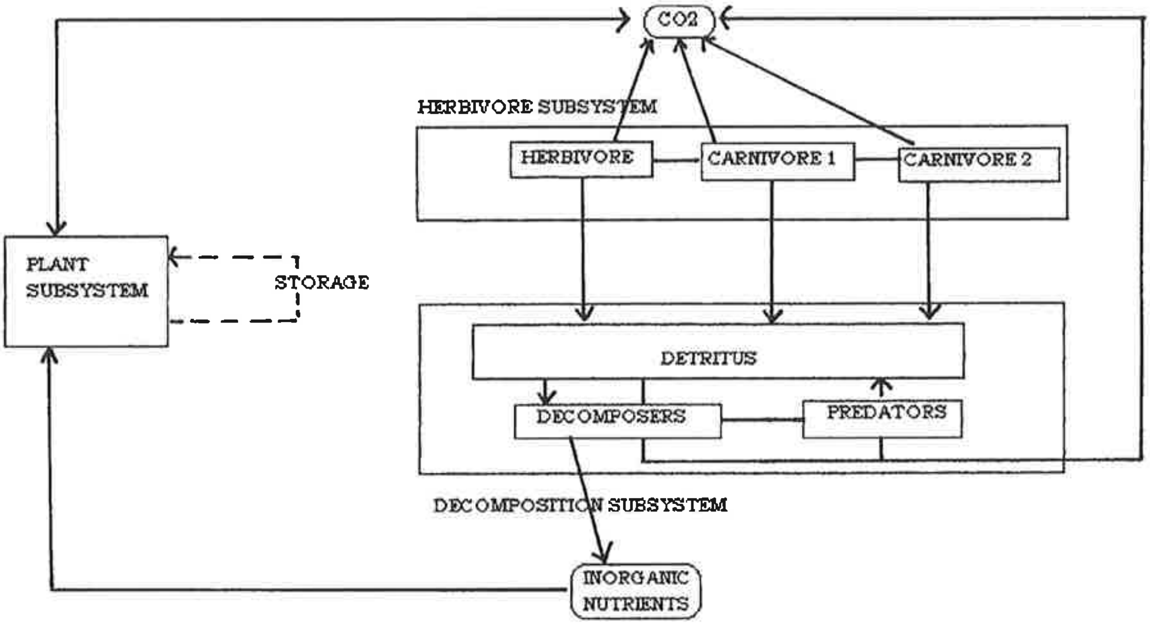

Figure 3: Ecosystem structure and major pathways of matter transfer. (from Hutson,1989)

Through decomposition, dead roots, plant litter, root exudates and dead root cells are returned to the soil as a natural supply of organic matter. (Hutson, 1989).

The rate of nutrient cycling through the decomposition sub-system regulates ecosystem activity and ultimately the mineralisation of nutrients. (Springett, 1976a; Hutson, 1989). This rate is determined by:

- The nature and quality of the litter accumulated.
- The climate.
- The biological composition and activity of the soil.
- The organisms present.

In her study comparing the litter decomposition rates and soil microarthropod densities between *Pinus pinaster* stands, and a mixed *Eucalyptus, Banksia* & *Hakea* woodland, Springett (1976a) found that:

- Litter decomposition was faster in soil than in the litter layer.
- Litter decomposition was faster in the litter layer than the litter surface.
- Decomposition was rapid in the cool wet seasons, and slower in hot, dry seasons.

- Soil biota were able to decompose native litter fall, cellulose fibres and pine needles faster under native vegetation than soil biota under pine plantation.
- Arthropod diversity was greater under native vegetation than under pine plantation.

Springett (1976b) and Grove & Stork (1999) found that invertebrate communities were invaluable as indicators of ecosystem health, and useful in the assessment and monitoring of ecological change for several reasons:

- Insects can be surveyed rapidly and economically.
- They can indicate degrees of change within an ecosystem.
- Some groups are especially sensitive to change and serve as an alerting device to more subtle changes.

Role of beetles in Australian woodlands

Coleoptera (beetles) have some 20,000 described species in Australia, and it is known that they occupy a range of ecological niches in forests. This wide range of habitats and feeding behaviours contribute to nutrient cycling in woodlands. (Lawrence & Britton, 1994; Neumann et al, 1995). Figure 4 depicts the general feeding behaviours of beetles and their food types. In this paper I will only consider herbivores, predators and scavengers (or decomposers). It is to be noted that many feeding behaviours overlap, and that the larva and adults of some species may have completely different food sources. Coleoptera are considered one of the most dominant groups in the decomposition of carrion and dung.

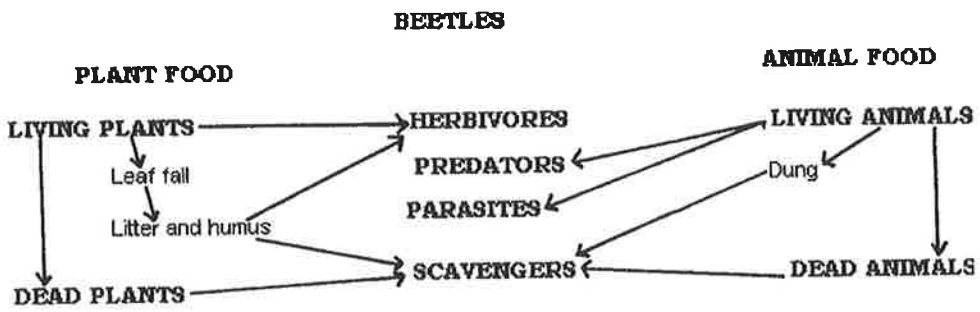

Figure 4: Schematic diagram of interrelationships between beetles and their food sources. (from Evans, 1975).

Herbivores
Herbivores feed mainly on living plant or vegetative materials. These can include foliage, flowers, stems, bark, roots, seeds, nuts, fruit and timber. They may also feed on leaf litter.

Some major families include the Scarabaeidae; Scirtidae; Chrysomelidae; Buprestidae; Nitidulidae; Boganiidae; Elateridae; Cantharidae; Bostrichidae; Anobiidae; Cerambycidae; Curculionidae; and Colydiidae.

Herbivory regulates the flow of energy and nutrients to decomposers and can ensure consistent and optimal output of plant production. (Springett, 1978). Bark beetles prepare the way for ecological succession in forests by selectively cropping certain age classes of hosts. (Coulson & Witter, 1984).

Herbivores can be pests, and examples of this include wood borers consisting mainly of larvae, such as Buprestidae, although some Bostrichidae, Anoibiidae and Curculionidae adults tunnel through wood in order to lay their eggs. (Lawrence & Britton, 1994). This damage can reduce the value of commercial trees, and many beetles are pests of cereal and root crops. (Evans, 1975). Some larval species of beetles feed on roots and rhizomes, and as such can be pests of food crops. (Couslon & Witter, 1994),Bark beetles may cause significant economic damage in forests as they colonise a living tree host, and either kill the host or portions of it. (Coulson & Witter, 1984). Regrowth stands and plantations are especially vunerable to Cerambycidae (longicorn) damage. (Matthews, 1997).

Scavengers
Scavengers feed upon dead and decaying plant and animal materials. These can include carrion, dung, dead plants, logs, leaf litter and humus. Both adults and larvae are well represented in this group. (Barbosa & Wagner, 1989).

Some major families include the Bostrichidae; Anobiidae; Curculionidae; Cupedidae; Lucanidae; Passalidae: Leiodidae; Silphidae; Trogidae; Dermestidae; adult Hydrophilidae; Geotrupidae; Anthicidae; Tenebrionidae, and Heteroceridae.

By consuming and breaking up decaying matter, scavengers help return organic substances more rapidly to the soil for reuse by plants. (Evans, 1975). The decomposition of carrion modifies soil structure in its immediate vicinity, as decomposition products pass directly into the soil during the putrefaction and fermentation stages. (Barbosa & Wagner, 1989). Wood boring beetles and bark beetles allow the introduction of fungi into dead, dying and newly cut trees via their feeding and tunnelling activities which assist in the decomposition process. (Barbosa & Wagner, 1989), Larval Troaidae and Geotrupidae are humus and soil feeders that perform the same role as earthworms in nutrient extraction and soil aeration. (Lawrence & Britton, 1994).

Some bark beetles can cause serious loss in fruit trees. (Evans, 1975).

Predators

Predators obtain their food by killing and eating other animals (Evans, 1975). Barbosa & Wagner (1989) state that Coleoptera are important consumers of all types of invertebrate animal life on the forest floor and make up the greatest proportion of predators in the forest. They consume soil insects, caterpillars, pupae and some phytophagous Coleoptera. Hammond (1990), however, does not consider predatory beetles to be significant consumers of non-predatory beetles. Rather, he believes Coleoptera to be of more significance in the consumption of Diptera, Homoptera, Collembola, Acari and Nematoda.

Some major families include the Carabidae; Elateridae; Coccinellidae; Histeridae; larval Hydrophilidae; Cleridae; Staphylinidae; Cucujidae; and Dytiscidae.

Predatory beetles effectively control other insects, particularly bark beetles. (Barbosa & Wagner, 1989). Chequered beetles (Cleridae), rove beetles (Staphlinidae) and click beetles (Elateridae) prey on various life stages of bark beetles. (Barbosa & Wagner, 1989).

Predators are generally seen as beneficial to man by regulating destructive herbivores of tree and food crops. The Coccinellidae are significant predators of both aphids and scale insects. (Barbosa & Wagner, 1989).

Fire

Many studies have been conducted to gauge the effects that prescribed fires have on invertebrate fauna diversity and densities, soil properties and nutrient cycling. Studies by Abbott (1984) and Christensen and Abbott (1989) of eucalypt forests in south-western Australian suggest that soil properties are not permanently affected by low intensity burns. Yet Abbott et al (1984) found that a long-term unburnt jarrah stand (47 years) had significantly different soil properties to a jarrah stand that was periodically burnt. Both studies, however, found that soil and litter fauna, such as Coleoptera were not significantly changed after fire. Initially, it was found that insect diversity and density were reduced, but after some years there was a recovery in species density. This recovery of species density was also noted in Majer's (1984) study. A study by Holliday (1992) of carabid populations in Canadian boreal forests also indicated post-fire regeneration. Major findings of Neumann & Tolhurst (1991) and Neumann et al (1995) studies in west-central Victorian forests after low intensity fires were similar. Neumann & Tolhurst's (1991) study was based on Coleopteran data at an ordinal level, while Neumann et al (1995) was based on data at a family level.

Purpose of study
The purpose of this study is to collect and identify beetles, if possible, to family level, from banksia woodland, pasture and wetland habitats within Whiteman Park, Western Australia.; and to prepare a representative collection of beetles for the Park.

It is hypothesized that habitat type and season affects Coleopteran diversity, and, in particular, that the collections from the pasture will include a number of exotic species.

Climate

Perth has a typically Mediterranean climate with hot dry summers and mild wet winters. Figures 5 and 6 illustrate average monthly rainfall and temperature for Perth.

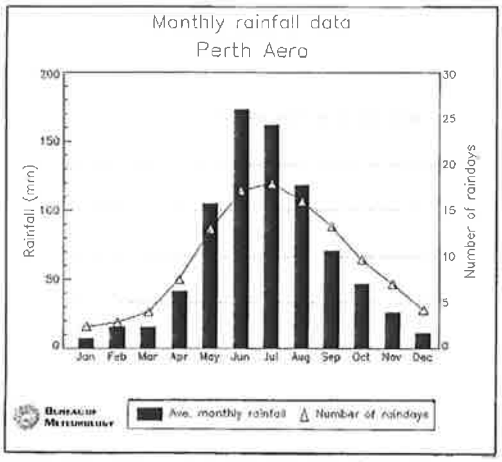

Figure 5: Average monthly rainfall for Perth (after Commonwealth Bureau of Meteorology).

Average maximum temperatures range from 32°C in February to 18°C in July. Rainfall is highest in winter, with a June average of 167mm, and is lowest in January with an average of 4mm.

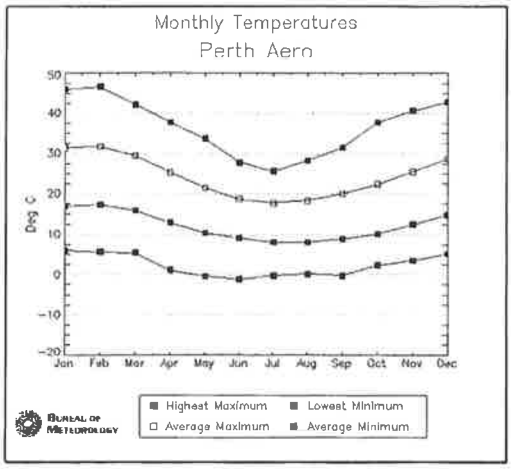

Figure 6: Average monthly temperature for Perth. (after Commonwealth Bureau of Meteorology).

Study Area

Whiteman Park, Whiteman, (31°41'S, 115°56'E), in Western Australia is an area of natural bush and farmland originally covering approximately 2600 hectares, some 18 km northeast from Perth's central business district. It is bounded by Gnangara Rd to the north, Beechboro Rd to the west, Lord St to the east, and Marshall and Harrow Rds. to the south. Bushland covers about 1416 ha (Environmental Protection Authority, 1998) and of this 700 ha has been set aside as a Conservation Zone. Over the course of the study, a further 1300 ha has been added to the Park (31/3/00), to the west of Beechboro Rd, and a corridor along Bennett Brook leading to the Swan River to the south. These additional areas are not included in the study. A map in Appendix 1 shows the general layout of the Park.

The country is generally flat and is typical of the Bassendean sand formation, and is interspersed by the Pinjarra Plain formation (McArthur & Bettenay, 1974). These formations are depicted Appendix 2. Three sand ridges pass through the Park from the south-west to the north-east. The southern ridge is broken by the line of Bennett Brook and surrounding swamplands. (Maunsell & Partners, 1979). Bassendean Dune is characterised by low, vegetated hills of quartz sand with numerous interdunal swamps and lakes, due to the poor draining qualities of the soils, which are podzols. Pinjarra Plain is an alluvial tract, consisting mainly of unconsolidated riverine material. (Beard, 1981). The dune system originated along a calcareous sand coastline, but is now highly leached and deficient in both carbonate & iron (McArthur & Bettenay, 1974; Western Australian Planning Commission, 1997). Bennett Brook and adjacent swamplands consists of peat and organic silty clays up to 1 1/2 m thick and of narrow width (Maunsell & Partners. 1979).

The Park is situated over part of the Gnangara Mound; a shallow unconfined aquifer. (Maunsell & Partners, 1979). This is an important supply of metropolitan water to Perth, with 14 groundwater abstraction bores located within the Park (Western Australian Planning Commission, 1997). Bushland plays an important role in maintaining water quality (Maunsell & Partners, 1979). Underground water movement is to the south-east. Mussel Pool is part of the Bennett Brook catchment, and underground waters stored in Gnangara Mound rise to the surface over the winter months and move to and via Bennett Brook to the Swan River at Guildford. (Maunsell & Partners, 1979). Winter water moves through Mussel Pool in a south-easterly direction. (Gratte, per.com.).

In the summer months, due to evaporation, a volume in the region of 78,000 cubic litres of water is pumped from irrigation bores to maintain the water level in the Pool. (Gratte, per. com.). During the winter months, winter water overflow runs through an artificial channel into wetland areas to the south-east of the Pool.

METHOD

Study Area

In consultation with Stephen Davies and Harry Gratte, three habitat types were identified within the Park:

- Banksia woodland - a typical mixture of an open woodland of *Eucalyptus marginata, E. calophylla* and *Banksia ilicifolia*. Three sites were chosen within this habitat type, two along the pitfall transect line and one in an open area of *Banksia ilicifolia*, *Verticordia* spp. and *Hibbertia* spp. The fire weed *Stirlingia* sp. is present at many sites.
- Pasture - the unimproved pasture area is severely degraded, and is still used for cattle. Little native vegetation remains, and many exotic weeds are present. Dung is an obvious feature of the area. A mixture of feed grasses such as ryegrass (*Lolium* spp.) and clover (*Trifolium* spp.) cover the ground. Only two sites within this area could be utilized for collection, because cattle were often present, and some tree cover was necessary for the protection of the equipment. The aerial photograph in Appendix 3 illustrates this area, together with Mussel Pool and parts of the Bennett Brook wetlands area.
- Wetlands - a site at Mussel Pool, and three sites within the Bennett Brook wetlands stream zone were chosen. Mattiske & Associates (1989) found that the wetlands are dominated by species of the Myrtaceae family. Prominent species are *Melaleuca preissiana* (Modong) and *Melaleuca rhaphiophylla* (Swamp paperbark), as well as *Regelia* spp., *Pericalymma* spp., *Verticordia*

spp. and *Agonis linearifolia* (Swamp peppermint). Also present is *Eucalyptus rudis* (flooded gum). The site at Mussel Pool is severely degraded, but is the only permanent substantial water body in the Park.

The map in Appendix 1 shows the locations chosen for trapping within these habitat types. Appendix 4 is a complete list of plant species identified within the Park during the 1989 ecological survey by Mattiske & Associates. The photographs in Appendix 5 illustrate several typical sites.

Collection

The main method of collection within the Park was by light traps (E700 12V 8W DC, Australian Entomological Supplies, Bangalow, NSW) attached to 12 volt batteries. The three light traps did not arrive from the supplier until March (ordered before Christmas), and these did not function well. On several occasions the condenser unit burnt out and one or more traps were unavailable for several weeks at a time, over the course of several months. This meant that rather than the intended two visits per month, three or more visits were necessary to have the same number of trapping hours per month. Pitfall trapping, hand collection and the use of a handheld ultra violet black-light was utilized during the period January to March. Two to three times a month, one to three light traps were set in late afternoon or early evening and emptied the following day (representing six traps per month for a total of eighty-four trapping hours). Two traps were set per habitat type per month. In addition, twenty-six existing pitfall traps were utilized, in the Banksia woodland habitat. Twenty- three traps were in a 575m line with 25m between traps, on one side of a limestone track, and three more were in a 75m line with 25m between traps on the other side of the limestone track. These were opened twice a month (coinciding with the setting of the light traps), giving a monthly total of fifty-two traps and 728 trapping hours. Standard 25cm plastic pitfall buckets and lids were utilized. Some hand collection was also attempted in the three habitat types. Each visit comprised three hours in the afternoon/evening and three hours the following day (a total of twelve to eighteen hours per month). Photographs in Appendix 5 illustrate the type of light trap and pitfall traps used. Fauna was collected under Licence No. SF003075.

Laboratory

Specimens were collected in jars, and labeled with date and location. They were then placed in freezer to kill the beetles humanely. Thawed specimens were sorted into petri dishes with date and location, with one species per dish per date per location, and identified in the laboratory using Davis & Christidis (1997), Lawrence & Britton (1994), Matthews (7 vols. 1980, 1982, 1984, 1985, 1987, 1992, & 1997) and Tyndale-Biscoe (1990), and a stereomicroscope.

A representative collection of beetles collected in the Park, was retained at Whiteman Park.

Statistical Analysis

Data collected was analyzed by habitat using the Shannon-Wiener Index of Diversity and Sorenson's Similarity Index . It is anticipated that the data will not be normally distributed, and therefore a non-parametric test, such as Friedman's, is indicated. (Siegel, 1956, Zar, 1999). Seasonality and method of trapping could not be statistically analyzed due to the problems experienced with the light traps.

RESULTS

A comparison of the effectiveness of each method of collection; light trap, pitfall trap and hand collection is shown in Table 1. Only figures for the banksia habitat could be compared, as this was the only area in which all three trapping methods were used. Of the 14 individuals hand collected, 13 *Colpochila* sp. were collected at one location in December in a matter of minutes. Only one further specimen (*Prochelyna* sp.) was collected during a further 11 hours of hand collection.

Table 1: Comparison of methods of trapping beetles (Coleoptera) in Banksia woodland.

Trap type	Hours of trapping	No. of individual Coleoptera caught	No. of individual Coleoptera caught per hour
Light trap	224	82	0.366
Pitfall trap	6552	13	0.002
Hand collection	12	14	1.167
Total	6788	109	0.016

The light traps were an effective method of collection, with an average of 0.366 individuals caught per hour of operation, compared with an average of 0.002 individuals caught per hour of operation of the pitfall traps. The pitfall traps were not originally intended to catch invertebrates and lacked drift net fencing, which may have made them more effective in catching beetles.

Of the 341 individuals collected during the survey, the families Scarabaeidae, Hydrophilidae and Heteroceridae were the most highly represented (with 145, 55 and 46 individuals respectively). The families least represented were the Anthicidae, Colydiidae, Curculionidae, Trogidae, Elateridae and Scirtidae with 1, 1, 2, 2, 3 and 4 individuals respectivley. Appendix 6 has a total list of species identified and in which habitat type, while Appendix 7 lists the species and dates of collection.

A comparison of families by habitat type (illustrated in Figure 7), shows the Scarabaeidae to be the most highly represented across all habitat types, with 47 individuals found in Banksia, 47 individuals found in Pasture and 51 individuals found in Wetlands. The Hydrophilidae with 31 individuals found in Pasture, and the Heteroceridae with 24 individuals found in Banksia and 18 individuals found in Pasture were the next most numerous. The Dytiscidae, Curculionidae and the Trogidae had only 1 individual each found in Banksia. In Pasture, the Anthicidae, Colydiidae, Curculionidae, Elateridae and Tenebrionidae had only 1 individual each, as did the Trogidae in the Wetlands (see Appendix 8 for a complete listing of the number of individuals found per family in each of the habitat types). The Pasture habitat had the highest number of individuals caught at 126, followed by the Banksia habitat with 109 individuals caught, and the Wetlands habitat with 106 individuals caught.

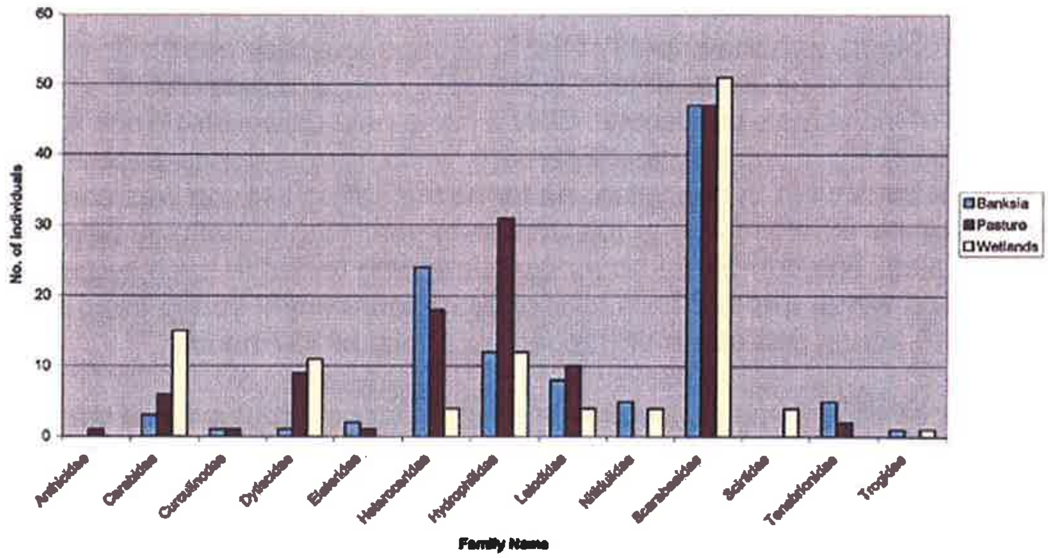

Figure 7: Number of Coleopteran individuals found per family in each habitat type.

The calculation of the Shannon-Wiener Index of Diversity and the J scale of evenness showed that all the habitat types had similar moderately even distributions of number of families. The Wetlands habitat had the most evenly distributed number of families at 0.7506, followed by the Pasture habitat at 0.7162 and Banksia at 0.7150.Table 2 shows these results.

TABLE 2: Results of calculation of Diversity Indexes for each of the three habitat types.

Habitat type	Shannon-Wiener Index of Diversity	J evenness
Banksia	0.7446	0.7150
Pasture	0.7458	0.7162
Wetlands	0.7162	0.7506

Sorenson's Index of Similarity indicates that the Banksia and Pasture sites were the most similar with a rating of 81.82% for family composition, as shown with 9 out of 13 families in common. A comparison of the Banksia and Wetlands sites, with a rating of 80% was also high, with 8 out of 12 families in common. The Pasture and Wetlands sites were the least similar with a rating of 60% in family composition. This was quite clear with only 6 out of 14 families in common. No habitat contained all 14 families. The Banksia and Pasture habitats were each represented by 11 families, while the Wetlands habitat had only 9 families.

Friedman's two-way analysis of variance by ranks accepted H_o: number of individuals per families represented in each habitat type is the same. The calculated value was $Xr^2_{0.05,3,14}$= 0.464, and the critical value was $Xr^2_{0.05,3,14}$= 6.143 (±). Therefore, family composition did not differ significantly in the three habitat types. Appendix 9 ranks the families by habitat type.

Due to problems with the supply of the light traps and their habit of breaking down, it proved to be impossible to statistically compare seasonality and numbers of individuals per family. Only a hand-held ultra violet black light was used for trapping in January and February, while from March to September, the three light traps were in operation. As far as the spring season was concerned the constraints imposed due to the University year meant that only September was sampled. The number of hours spent trapping varied in each season, with autumn and winter trapped for a total of 2439 hours each, spring trapped for a total of 815 hours, and summer trapped for a total of 737 hours.

However, bearing these constraints in mind, it appears that autumn was the time of most activity with 185 individuals caught, followed by spring with 66 individuals caught, then summer with 49 individuals and winter with 41 individuals (illustrated in Figure 8). A comparison of the average number of beetles caught per trapping hour shows that the highest number caught were in spring with 0.081 individuals indicating that spring was actually the time of most activity, followed by autumn with 0.076 individuals, then summer with 0.066 individuals. Lowest of all was winter with 0.017 individuals caught per hour of trapping. These results are illustrated in Appendix 10, which has a complete listing of individuals caught per family per season.

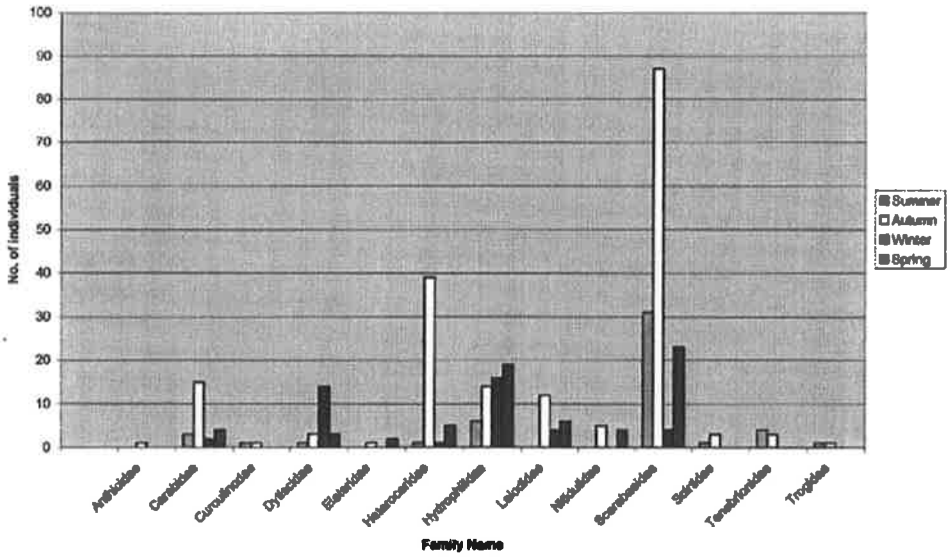

Figure 8: Number of Coleopteran individuals found per family in each season.

Appendix 11 shows the number of individuals caught per family in each habitat type per season, again no statistical comparisons could be made due to the constraints enumerated above. Autumn appeared to be the time of peak activity, with high number of individuals caught in all three habitat types (73 individuals in Pasture, 69 individuals in Banksia and 43 individuals in the Wetlands). Spring was also a time of high activity with large number of individuals caught in the Pasture habitat (39 individuals). Figure 9 illustrates the numbers found in each habitat per season. One anomaly was that no individuals were caught in the Pasture habitat during the summer, while the Banksia habitat and the Wetlands habitat had 23 and 26 individuals collected respectively. Winter numbers were low in all three habitat types (9 individuals in Banksia, 14 in Pasture and 18 in the Wetlands).

Four exotic or potentially exotic species were identified (*Aphodius* sp. 1, *Aphodius* sp. 2, *Heteronychus arator* and *Onitis alexis*). Three of these species are dung beetles (both *Aphodius* spp. and *Onitis alexis)*. A native dung beetle was also caught, *Onthophagus mniszechi.* Three species each were found in both the Banksia habitat and the Pasture habitat, while only 2 species were found in the Wetlands habitat. The only native dung beetle species, *Onthophagus mniszechi*, was found in the Pasture habitat. *Aphodius* sp. 1 and

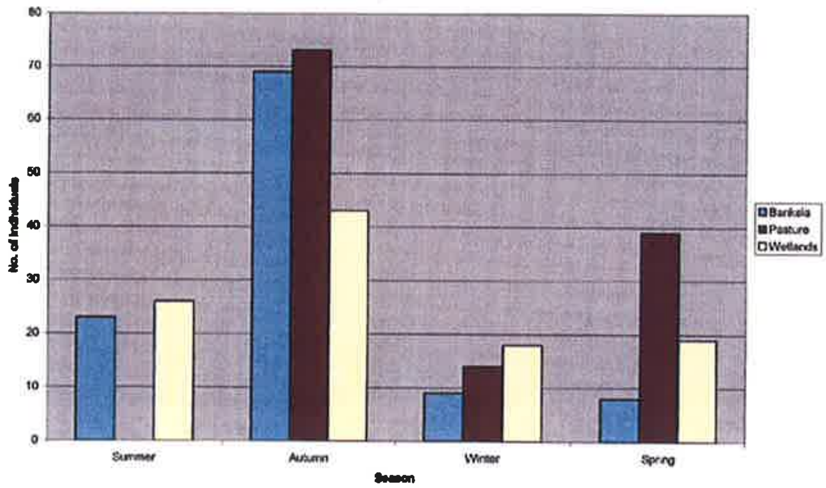

Figure 9: Number of Colepteran individuals found in each habitat type per season.

Aphodius sp. 2 were found in all habitat types, and *Onitis alexis* was only found in the Banksia habitat. Table 3 illustrates these dung beetles and specifies in which habitat they were found.

Table 3: Dung beetle species caught in each habitat type.

Species of dung beetle	Banksia	Pasture	Wetlands
Aphodius sp. 1*	Yes	Yes	Yes
Aphodius sp. 2*	Yes	Yes	Yes
Onthophagus mnisczechi	No	Yes	No
*Onitis alexis**	Yes	No	No

* exotic species

A comparison of the number of species per family collected within Whiteman Park to the number of species per family within Australia is shown in Table 4. The family best represented within the Park is the Heteroceridae with 20% of the Australian species composition. All other families have less than 3% of overall Australian species composition.

Herbivores are well represented within the Park with 164 individuals from 6 families collected, as were the scavengers with 132 individuals from 6 families. Of the predatory species 45 individuals from 2 families were collected. This represents a ratio of prey to predator ratio of 6:1.

Table 4: Comparison of the number of Coleopteran species in Australia per family with number of species per family collected at Whiteman Park.

Family	No. of known species in Australia	No. of species in Whiteman Park	% of species
Anthicidae	200	1	0.5
Carabidae	2500	16	0.64
Colydiidae	120	1	0.83
Curculionidae	6000	2	0.033
Dytiscidae	185	5	2.7
Elateridae	800	3	0.375
Heteroceridae	15	3	20
Hydrophilidae	175	8	4.57
Leiodidae	135	1	0.74
Nitidulidae	300	2	0.066
Scarabaeidae	3000	27	0.9
Scirtidae	70	1	1.43
Tenebrionidae	1500	3	0.2
Trogidae	50	1	2

DISCUSSION

It is clear that all three habitat types; Banksia, Pasture and the Wetlands, were much the same in family composition and number of individuals collected. Autumn and spring were important in terms of beetle activity, while winter displayed extremely low activity.

The distribution of families was similar in Banksia and Pasture with the Scarabaeidae, Hydrophilidae and Heteroceridae being the most numerous. In contrast, the Scarabaeidae, Carabidae, Hydrophilidae and the Dytiscidae were the most numerous in the Wetlands.

The season also appeared to have a marked affect on family distribution. The Scarbaeidae were most numerous in summer, the Scarabaeidae and the Heteroceridae the most numerous in autumn, the Hydrophilidae and Dytiscidae most numerous in winter, and the Hydrophilidae and Scarabaeidae most numerous in spring. It is hardly surprising that the two water beetle families (Hydrophilidae and Dytiscidae) would be the most prominent in winter and spring, a time of relatively high rainfall and large volumes of water moving through the Bennett Brook stream zone.

The diversity of the dung beetles was surprisingly low in all three habitat types, but particularly in the Pasture habitat given the presence of cattle. This may be due to the degraded and unimproved condition of the pasture. So, while the Pasture did include a number of exotic species, the other two habitat types also did.

The most numerous species collected during the survey were *Heterocerus* sp. 2 , *Limininxenos* sp. , *Aphodius* sp. 1 and *Heteronyx* sp. 2. These species represent the families Heteroceridae, Hydrophilidae and the Scarabaeidae respectively. This reflects the high numbers of individuals collected overall for each of the families.

The most individuals collected were on 18 March 2000, 25 March 2000, 8 April 2000 and 23 September 2000, reflecting the high overall numbers collected in autumn and spring. A comparison with weather conditions and phases of the moon may have been useful.

Data collected showed that high numbers of water beetles (such as the Hydrophilidae) were collected in the Pasture habitat. This would seem to indicate that they are not constrained by the presence or absence of water, but rather range some distance from standing water. This would seem to imply that the beetles collected in this survey are not likely to suffer much due to the 12 year controlled burning rotation currently in operation in the Park.

More work needs to be done in regard to those families collected in very small numbers (Anthicidae, Colydiidae, Curculionidae and the Trogidae) to determine their level of abundance within the Park, and the level of post-fire recolonization by these families.

While the Coleopteran species composition of Whiteman Park may appear to be unrepresentative when compared to the distribution of families in the Australian fauna (refer to Table 4) it must be remembered that only three habitat types were surveyed, and only 2-3 sites per habitat were used.

It is clear that the problems associated with the light traps and the shortness of the University year hindered the collection of data in this survey. It did not allow statistical comparison between the seasons or allow a statistical comparison between season and habitat. The use of pitfall traps intended for vertebrate capture is not recommended. Future surveys will need to address these problems when planning and executing invertebrate collection, particularly the collection of Coleoptera. Other forms of collection, such as bark trapping and more intensive hand collection should be tried.

Areas of potential study could include a comparison of beetle activity with weather and phases of the moon, and the comparison of beetle diversity between a recently burnt area with a long-term unburnt area in the three different habitat types in order to gauge post-fire recolonization potential.

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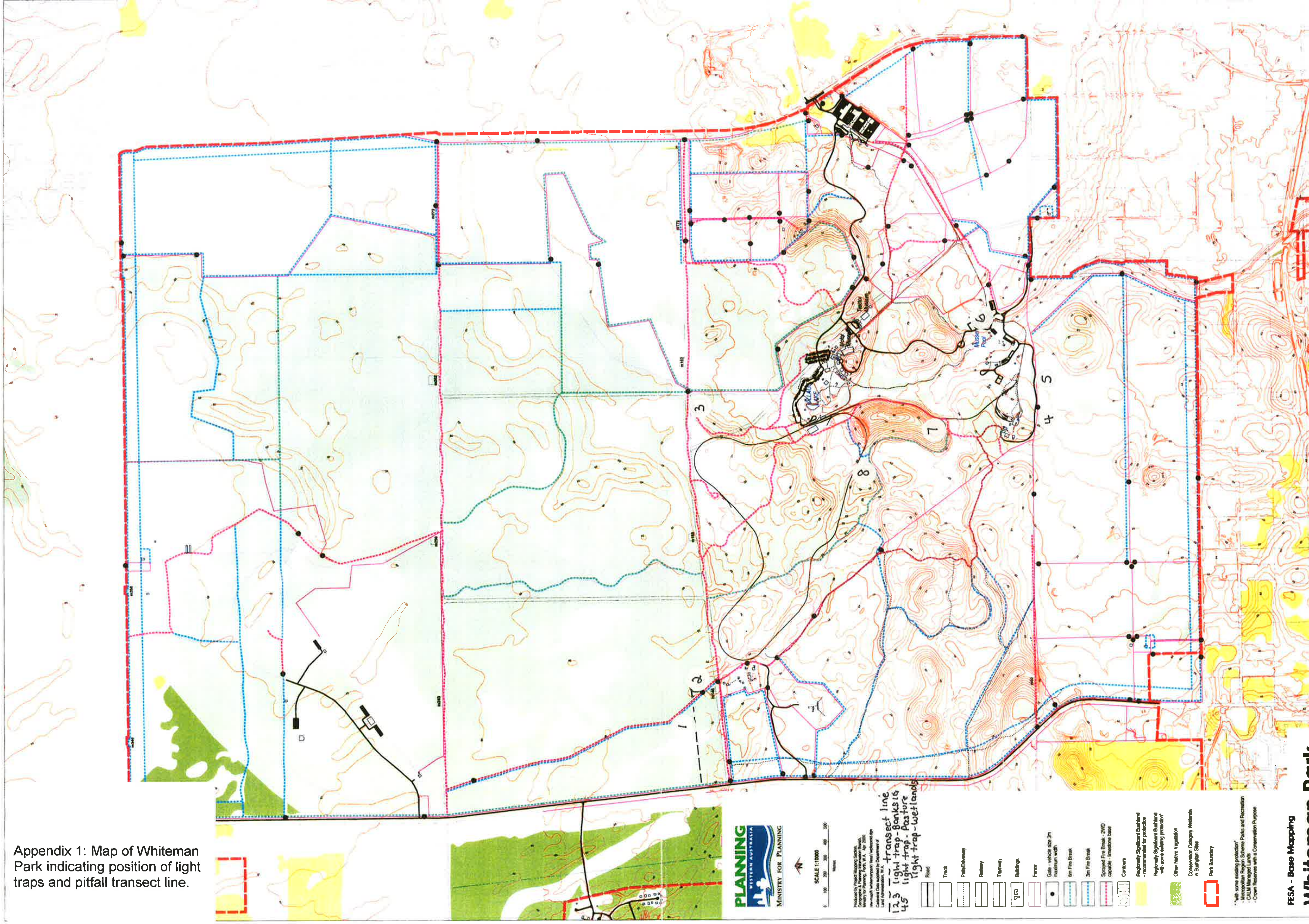
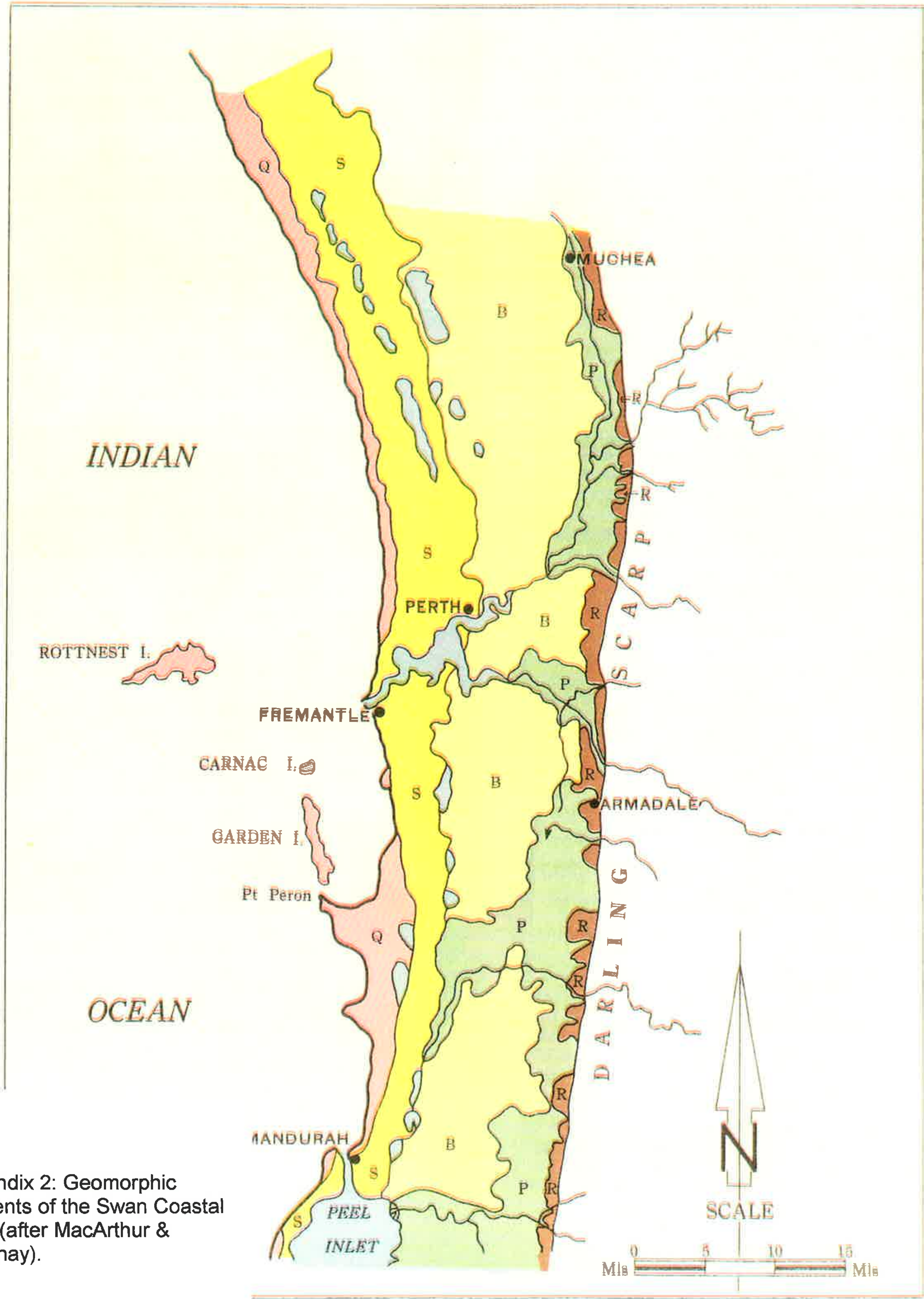
LIST OF APPENDICES

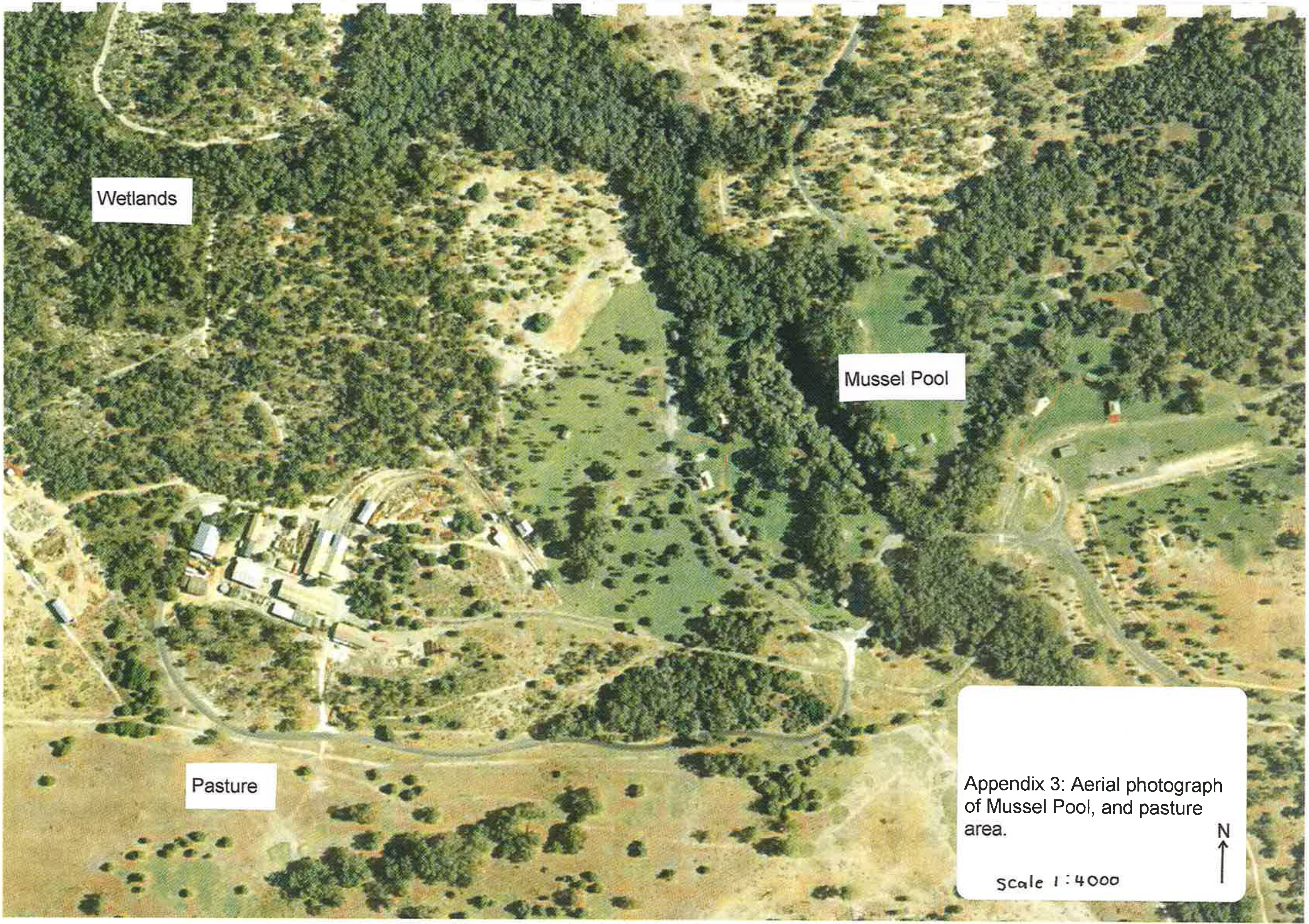


Appendix 1: Map of Whiteman Park indicating position of light traps and pitfall transect line.



Appendix 2: Geomorphic elements of the Swan Coastal Plain (after MacArthur & Bettenay).

Fig. 2 (a).—Geomorphic elements of the Swan Coastal Plain. Ridge Hill Shelf (R), Pinjarra Plain (P), Bassendean Dunes (B), Spearwood Dunes (S), Quindalup Dunes (Q).



Appendix 3: Aerial photograph of Mussel Pool, and pasture area.

Scale 1:4000

Appendix 4: List of plant species found during 1989 ecological survey by E.M. Mattiske & Associates.

VASCULAR SPECIES LIST FOR WHITEMAN PARK SURVEY AREA

FAMILY	GENERA	SPECIES
DENNSTAEDTIACEAE	Pteridium	esculentum
ZAMIACEAE	Macrozamia	riedlei
PINACEAE	*Pinus	pinaster
TYPHACEAE	*Typha	orientalis
JUNCAGINACEAE	Triglochin	procera
POACEAE	*Aira	caryophyllea
	Amphipogon	turbinatus
	*Briza	maxima
	*Briza	minor
	Danthonia	setacea
	*Ehrharta	calycina
	*Ehrharta	longiflora
	*Holcus	lanatus
	*Hordeum	?leporinum
	*Lagurus	ovatus
	*Lolium	perenne
	Neurachne	alopecuroidea
	Paspalidium	sp.
	*Paspalum	dilatatum
	*Phalaris	sp.
	*Polypogon	monspeliensis
	Stipa	campylachne
	Stipa	compressa
	*Vulpia	myuros
CYPERACEAE	Baumea	arthrophylla
	Baumea	articulata
	Baumea	juncea
	Baumea	preissii
	Cyathochaeta	avenacea
	*Cyperus	brevifolius
	*Cyperus	congestus
	Cyperus	rotundus
	Gahnia	decomposita

APPENDIX

VASCULAR SPECIES LIST FOR WHITEMAN PARK SURVEY AREA

FAMILY	GENERA	SPECIES
CYPERACEAE (Cont)	Lepidosperma	angustatum
	Lepidosperma	gladiatum
	Lepidosperma	longitudinale
	Lepidosperma	scabrum
	Lepidosperma	tenue
	Lepidosperma	tetraquetrum
	Mesomelaena	pseudostygia
	Mesomelaena	stygia
	Mesomelaena	tetragona
	Schoenoplectus	?validus
	Schoenus	bifidus
	Schoenus	curvifolius
	Schoenus	rodwayanus
ARACEAE	*Zantedeschia	aethiopica
RESTIONACEAE	Alexgeorgea	arenicola
	Hypolaena	exsulca
	Leptocarpus	scariosus
	Leptocarpus	sp. B.
	Lepyrodia	glauca
	Loxocarya	fasciculata
	Loxocarya	flexuosa
	Lyginia	barbata
	Restio	leptocarpoides
	Restio	stenostachyus
JUNCACEAE	*Juncus	acutus
	Juncus	pallidus
DASYPOGONACEAE	Calectasia	cyanea
	Dasypogon	bromeliifolius
	Lomandra	hermaphrodita
	Lomandra	purpurea
	Lomandra	suaveolens
XANTHORRHOEACEAE	Xanthorrhoea	preissii
PHORMIACEAE	Dianella	revoluta

APPENDIX

VASCULAR SPECIES LIST FOR WHITEMAN PARK SURVEY AREA

FAMILY	GENERA	SPECIES
ANTHERICACEAE	Arnocrinum	preissii
	Hensmania	turbinata
	Laxmannia	ramosa
	Laxmannia	squarrosa
	Thysanotus	arenarius
	Thysanotus	dichotomus
	Thysanotus	multiflorus
	Thysanotus	sparteus
	Tricoryne	elatior
COLCHICACEAE	Burchardia	umbellata
HAEMODORACEAE	Anigozanthos	humilis
	Conostylis	aculeata ssp. aculeata
	Conostylis	aculeata ssp. bromeliodes
	Conostylis	juncea
	Conostylis	setigera
	Haemodorum	laxum
	Haemodorum	spicatum
	Phlebocarya	ciliata
IRIDACEAE	*Gladiolus	caryophyllaceus
	*Homeria	flaccida
	Patersonia	occidentalis
	*Romulea	rosea
ORCHIDACEAE	Epiblema	grandiflorum
	Lyperanthus	nigricans
	Microtis	unifolia
CASUARINACEAE	Allocasuarina	fraseriana
	Allocasuarina	humilis
PROTEACEAE	Adenanthos	cygnorum
	Adenanthos	obovatus
	Banksia	attenuata
	Banksia	grandis
	Banksia	ilicifolia
	Banksia	littoralis
	Banksia	menziesii
	Conospermum	stoechadis
	Dryandra	nivea

APPENDIX

VASCULAR SPECIES LIST FOR WHITEMAN PARK SURVEY AREA

FAMILY	GENERA	SPECIES
PROTEACEAE (Cont)	Hakea	varia
	Isopogon	drummondii
	Persoonia	saccata
	Petrophile	linearis
	Stirlingia	latifolia
	Synaphea	spinulosa
SANTALACEAE	Leptomeria	cunninghamii
	Leptomeria	preissiana
LORANTHACEAE	Nuytsia	floribunda
POLYGONACEAE	*Rumex	acetosella
	*Rumex	crispus
AMARANTHACEAE	Alternanthera	nodiflora
AIZOACEAE	*Carpobrotus	edulis
MOLLUGINACEAE	Macarthuria	australis
LAURACEAE	Cassytha	racemosa
	Cassytha	sp.
DROSERACEAE	Drosera	erythrorhiza
	Drosera	gigantea
	Drosera	paleacea
PITTOSPORACEAE	Billardiera	coeruleo-punctata
	Sollya	heterophylla
ROSACEAE	*Acaena	echinata
MIMOSACEAE	Acacia	huegelii
	Acacia	pulchella var. pulchella
	Acacia	saligna
	Acacia	sessilis
	Acacia	spathulifolia
	Acacia	stenoptera

APPENDIX

VASCULAR SPECIES LIST FOR WHITEMAN PARK SURVEY AREA

FAMILY	GENERA	SPECIES
PAPILIONACEAE	Aotus	cordifolia
	Aotus	gracillima
	Bossiaea	eriocarpa
	Burtonia	conferta
	Burtonia	scabra
	Daviesia	divaricata
	Daviesia	physodes
	Daviesia	triflora
	Euchilopsis	linearis
	Eutaxia	virgata
	Gompholobium	tomentosum
	Hardenbergia	comptoniana
	Hovea	pungens
	Hovea	trisperma
	Jacksonia	densiflora
	Jacksonia	furcellata
	Jacksonia	sternbergiana
	Kennedia	prostrata
	*Lotus	suaveolens
	*Lupinus	cosentinii
	*Medicago	sp.
	Oxylobium	capitatum
	Oxylobium	lanceolatum
	Oxylobium	lineare
	Pultenaea	reticulata
	*Trifolium	glomeratum
	*Trifolium	sp.
	Viminaria	juncea
GERANIACEAE	*Erodium	sp.
RUTACEAE	Boronia	crenulata var. gracilis
	Boronia	purdieana
	Eriostemon	spicatus
POLYGALACEAE	Comesperma	calymega
	Comesperma	flavum
	Comesperma	virgatum
EUPHORBIACEAE	Phyllanthus	calycinus

APPENDIX

VASCULAR SPECIES LIST FOR WHITEMAN PARK SURVEY AREA

FAMILY	GENERA	SPECIES
STACKHOUSIACEAE	Tripterococcus	brunonis
DILLENIACEAE	Hibbertia	acerosa
	Hibbertia	helianthemoides
	Hibbertia	huegelii
	Hibbertia	hypericoides
	Hibbertia	pachyrrhiza
	Hibbertia	racemosa
	Hibbertia	stellaris
	Hibbertia	subvaginata
	Hibbertia	vaginata
VIOLACEAE	Hybanthus	floribundus
THYMELAEACEAE	Pimelea	sulphurea
MYRTACEAE	Agonis	linearifolia
	Astartea	fascicularis
	Beaufortia	elegans
	Calothamnus	lateralis
	Calothamnus	sp.
	Calytrix	angulata
	Calytrix	flavescens
	Calytrix	fraseri
	Eremaea	fimbriata
	Eremaea	pauciflora
	Eremaea	sp. A
	Eucalyptus	calophylla
	Eucalyptus	marginata
	Eucalyptus	rudis
	Eucalyptus	todtiana
	Hypocalymma	angustifolium
	Hypocalymma	robustum
	Kunzea	ericifolia
	Kunzea	recurva
	Melaleuca	lateritia
	Melaleuca	preissiana
	Melaleuca	rhaphiophylla
	Melaleuca	scabra
	Melaleuca	seriata
	Melaleuca	viminea

APPENDIX

VASCULAR SPECIES LIST FOR WHITEMAN PARK SURVEY AREA

FAMILY	GENERA	SPECIES
MYRTACEAE (Cont)	Pericalymma	ellipticum
	Regelia	ciliata
	Scholtzia	involucrata
	Verticordia	densiflora
	Verticordia	drummondii
	Verticordia	nitens
HALORAGACEAE	Glischrocaryon	flavescens
	Gonocarpus	cordiger
	Gonocarpus	pithyoides
	Gonocarpus	sp.
APIACEAE	Actinotus	glomeratus
	Platysace	compressa
	Xanthosia	atkinsoniana
	Xanthosia	huegelii
EPACRIDACEAE	Astroloma	pallidum
	Astroloma	xerophyllum
	Conostephium	minus
	Conostephium	pendulum
	Leucopogon	australis
	Leucopogon	conostephioides
	Leucopogon	polymorphus
	Leucopogon	propinquus
	Leucopogon	sprengelioides
	Lysinema	ciliatum
PRIMULACEAE	*Anagallis	arvensis
MENYANTHACEAE	Villarsia	albiflora
LAMIACEAE	Hemiandra	pungens
	*Mentha	pulegium
SOLANACEAE	*Solanum	nigrum
	*Solanum	sodomaeum
SCROPHULARIACEAE	Gratiola	peruviana
OROBANCHACEAE	*Orobanche	minor

APPENDIX

VASCULAR SPECIES LIST FOR WHITEMAN PARK SURVEY AREA

FAMILY	GENERA	SPECIES
CUCURBITACEAE	*Cucumis	myriocarpus
LOBELIACEAE	Lobelia	alata
	Lobelia	tenuior
	Lobelia	sp.
GOODENIACEAE	Dampiera	linearis
	Lechenaultia	floribunda
	Scaevola	paludosa
STYLIDIACEAE	Stylidium	amoenum
	Stylidium	brunonianum
	Stylidium	calcaratum
	Stylidium	piliferum
	Stylidium	repens
ASTERACEAE	*Arctotheca	calendula
	*Centaurea	melitensis
	*Conyza	bonariensis
	*Dittrichia	graveolens
	*Hypochaeris	glabra
	Olearia	paucidentata
	Podolepis	gracilis
	Podotheca	gnaphalioides
	*Sonchus	oleraceus
	*Ursinia	anthemoides
	*Vellereophyton	dealbatum
	Waitzia	paniculata
	Waitzia	podolepis
	Waitzia	suaveolens

* exotic species

Appendix 5: Photographs

Light trap in Banksia woodland

Pitfall trap in Banksia Woodland

Banksia woodland

Pasture

Wetlands

	Banksia	Pasture	Wetlands
Heteronychus arator(24)*		x	
Heteronychus sp. 1			x
Heteronyx sp. 1 (4)		x	x
Heteronyx sp. 2 (36)	x	x	x
Heteronyx sp. 3 (33)			x
Heteronyx sp. 4 (12)	x	x	x
Heteronyx sp. 5 (27)			x
Heteronyx sp. 6 (85)	x	x	
Neodon sp. (19)	x	x	
Neophyllotocus sp. (73)	x		
Onthophagus mniszechi (54)?		x	
Onitis alexis (5)*?	x		
Prochelyna sp. (84)	x		
Scarabid sp. 1 (10)			x
Scarabid sp. 2 (26)			x
Scarabid sp. 3 (27)	x		
Scarabid sp. 4 (28)			x
Scarabid sp. 5 (30)			x
Scarabid sp. 6 (35)			x
Scarabid sp. 7 (40)		x	
Scarabid sp. 8 (52)	x	x	
Scarabid sp. 9 (53)	x		
Scarabid sp. 10 (76)			x
Scarabid sp. 11 (77)			x
Family: Scirtidae			
c.f. Cyphon sp. (9)			x
Family: Trogidae			
Trox sp.1 (21)	x		x
Superfamily: Staphylinoidea			
Family: Leiodidae			
Dietta sp. (40)	x	x	x
Superfamily: Tenebrionoidea			
Family: Anthicidae			
Anthicid sp. 1		x	

	Banksia	Pasture	Wetlands
Family: Colydiidae			
Ablabus sp. (65)		x	
Family: Tenebrionidae			
Cheirodes caulobiiodes (66)		x	
Helea sp.(43)	x		
Tenebrionid sp. 1 (61)	x		

* exotic species
# may be exotic species
? dung beetle

Species	12.99	16.1.00	1.2.00	17.2.00	23.2.00	24.2.00	18.3.00	25.3.00	8.4.00	14.4.00	14.5.00	19.5.00	4.6.00	29.6.00	21.7.00	25.7.00	27.7.00	3.8.00	11.8.00	9.9.00	23.9.00	TOTAL
Ablabus sp.									1													1
Aeolus sp.											1											1
Agonocheila sp. 1										3												3
Agonocheila sp. 2								1		1												2
Agonocheila sp. 3										1												1
Allodessus sp.														3							1	4
Anomatarus sp.																					1	1
Anthicid sp. 1								1														1
Aphodius sp. 1		14	1				5	2		2										3	9	36
Aphodius sp. 2									6							1	1					8
c.f. *Cyphon* sp.		1					3															4
c.f. *Idaethina* sp.																				4		4
Carabid sp. 1							1															1
Carabid sp. 2							1															1
Carabid sp. 3							1	1						1								3
Carabid sp. 4														1								1
Carabid sp. 5								1			1											2
Carabid sp. 6								3														3
Carabid sp. 7																				1		1
Catasaurus sp.				1																		1
Cenogmus sp.								1												1		1
Cheirodes caulobiiodes								1														1
Colpochila sp.	13																					13
Curculinid sp. 1									1													1
Dietta sp.									11			1				3			1	5	1	22
Dytiscid sp. 1													1									1
Egadroma sp.		2																				2
Elaterid sp. 1																				1		1
Elaterid sp. 2																					1	1
Euryscaphus sp.						1																1
Euthenaris sp.		1						1														2
Helea sp.				4																		4
Heterocerus sp. 1		1						1						1								3
Heterocerus sp. 2							38														4	42
Heterocerus sp. 3																				1		1
Heteronychus arator																					1	1
Heteronychus sp. 1								4														4
Heteronyx sp. 1							2	1														3
Heteronyx sp. 2								5	21	2				1						4		33

Appendix 7: List of Coleopteran species and number of individuals collected for each trapping session.

Species	12.99	16.1.00	1.2.00	17.2.00	23.2.00	24.2.00	18.3.00	25.3.00	8.4.00	14.4.00	14.5.00	19.5.00	4.6.00	29.6.00	21.7.00	25.7.00	27.7.00	3.8.00	11.8.00	9.9.00	23.9.00	TOTAL
Heteronyx sp. 3								4														4
Heteronyx sp. 4		1						2														3
Heteronyx sp. 5								2														2
Heteronyx sp. 6																						1
Hydrochus sp.														1								1
Hydrophilid sp. 1																2						2
Hydrophilid sp. 2																						1
Hydrophilid sp. 3		3														1					2	6
Hydrophilid sp. 4		1								2												3
Hydrous sp.															1							1
Lancetes lanceolatus											1			6		2						9
Limninxenos sp.		2						2		2	5			8	3						17	39
Neodon sp.											1					1						2
Neophyllotocus sp.																				1		1
Onitis alexis							2															2
Onthophagus mniszechi									1													1
Paracymus sp.								2														2
Platynectes sp.														2								2
Prochelyna sp.																					1	1
Rhantus sp.		1			2																2	5
Sarothrocrepis sp.														1							1	2
Scarabid sp. 1		1																				1
Scarabid sp. 2								2												2		4
Scarabid sp. 3						1																1
Scarabid sp. 4								1														1
Scarabid sp. 5								1														1
Scarabid sp. 6								4													1	5
Scarabid sp. 7			1																			1
Scarabid sp. 8								1		4												5
Scarabid sp. 9										6												6
Scarabid sp. 10					1																	1
Scarabid sp. 11																					1	1
Tenebrionid sp. 1										1												1
Thalycrodes sp.							2		2	2												6
Trox sp.			1					1														2
TOTAL	13	28	3	5	3	1	55	45	42	26	9	1	1	25	4	11	2		1	23	44	341

Appendix 8: Number of Coleopteran individuals found per family by habitat type.

	HABITAT			
FAMILY	**Banksia**	**Pasture**	**Wetlands**	**Total**
Adephaga				
Carabidae	3	6	15	24
Dytiscidae	1	9	11	21
Polyphaga				
Anthicidae		1		1
Colydiidae		1		1
Curculionidae	1	1		2
Elateridae	2	1		3
Heteroceridae	24	18	4	46
Hydrophilidae	12	31	12	55
Leiodidae	8	10	4	22
Nitidulidae	5		4	9
Scarabaeidae	47	47	51	145
Scirtidae			4	4
Tenebrionidae	5	1		6
Trogidae	1		1	2
Total	109	126	106	341

Appendix 9: Ranks of fourteen Coleopteran families by habitat type

	HABITAT		
FAMILY	**Banksia**	**Pasture**	**Wetlands**
Adephaga			
Carabidae	1	2	3
Dytiscidae	1	2	3
Polyphaga			
Anthicidae	1.5	3	1.5
Colydiidae	1.5	3	1.5
Curculionidae	2.5	2.5	1
Elateridae	3	2	1
Heteroceridae	3	2	1
Hydrophilidae	1.5	3	1.5
Leiodidae	2	3	1
Nitidulidae	3	1	2
Scarabaeidae	1.5	1.5	3
Scirtidae	1.5	1.5	3
Tenebrionidae	3	2	1
Trogidae	2.5	1	2.5
Total	28.5	29.5	26

Appendix 10: Number of Coleopteran individuals found per family by season

	SEASON				
FAMILY	**Summer Dec-Jan-Feb**	**Autumn Mar-Apr-May**	**Winter Jun-Jul-Aug**	**Spring Sept**	**Total**
No. of hours trapping	737	2439	2439	815	6430
<u>Adephaga</u>					
Carabidae	3	15	2	4	24
Dytiscidae	1	3	14	3	21
<u>Polyphaga</u>					
Anthicidae		1			1
Colydiidae		1			1
Curculionidae	1	1			2
Elateridae		1		2	3
Heteroceridae	1	39	1	5	46
Hydrophilidae	6	14	16	19	55
Leiodidae		12	4	6	22
Nitidulidae		5		4	9
Scarabaeidae	31	87	4	23	145
Scirtidae	1	3			4
Tenebrionidae	4	2			6
Trogidae	1	1			2
Total	49	185	41	66	341
Beetles trapped per hour	0.066	0.076	0.017	0.081	0.053

Appendix 11: Number of Coleopteran individuals found in each habitat type by season

	HABITAT			
SEASON	**Banksia**	**Pasture**	**Wetlands**	**Total**
Summer Dec-Jan-Feb	23		26	49
Autumn Mar-Apr-May	69	73	43	185
Winter Jun-Jul-Aug	9	14	18	41
Spring Sept	8	39	19	66
Total	109	126	106	341