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Plant surrogacy: An evaluation of its use and application in the effort to conserve ground dwelling invertebrates

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PLANT SURROGACY: AN EVALUATION OF ITS USE AND APPLICATION IN THE EFFORT TO CONSERVE GROUND DWELLING INVERTEBRATES

BY

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ABSTRACT

A study conducted in the Ridges State Forest, Yanchep was designed to investigate the relationship between plant species richness, vegetation association and ground dwelling invertebrate species richness. Four plant communities were sampled at two scales of measurement. Two treatments were located in woodland and two in heath. Within each vegetation association, plant communities that were representative of both high and low species richness were selected. Three invertebrate orders, Araneae, Coleoptera and Araneae were sorted to morphospecies level. Ordinal richness was also investigated.

Two-way ANOVAs indicated that there was no relationship between plant species richness, vegetation association or the interaction between these factors for ordinal richness, Araneae or Coleoptera species richness. However, a significant relationship between Hemiptera and plant species richness was found to exist when analysed at a fine scale of $1m^2$. Spearman's rank order correlations also demonstrated that there was an association between Hemiptera richness and plant species richness.

Treatments were also surveyed for life form species richness. The study revealed that shrub richness was a better indicator of overall plant species richness then herbs and grasses.

The study also investigated the role that a number of environmental attributes play in determining ground dwelling invertebrate species richness. Spearman's rank order correlations indicated highly significant results for soil and litter moisture. Temperature was also a major determining factor. Ground dwelling invertebrate species richness does not appear to be related to litter cover and depth.

The project has, however, demonstrated that although there is no direct association between ground dwelling invertebrate species richness and certain other environmental parameters measured during the study there are a number of parameters that are cross correlated with each. There is obviously a complex interaction and on close inspection some of these results suggest that ground dwelling invertebrate species richness may be associated with vegetation structure. It is recommended that future studies investigate this association in more detail with particular attention being paid to the relation that exists between Hemiptera and plant species richness.

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Dated: 10.09.2004

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

1.1 Overview

Historically, reserve selection criteria in Australia has been opportunistic and ad hoc resulting in a selection process that is generally biased towards vascular plants and vertebrates, yet they contribute only a small fraction of biodiversity. Despite invertebrate fauna constituting a major component of biodiversity (Stork, 1999; Wilson, 1987), their conservation has been largely incidental with their fate frequently tied to vegetation (Hill & Michaelis, 1988). The assumption that invertebrate species richness is linked to plant species richness has rarely been tested. Unless we can gain a better understanding of the relationship that exists between the two then we run the risk of selecting conservation reserves that will only provide suboptimal protection for invertebrates. Failure to protect all aspects of biodiversity, and in particular invertebrates, that play a major role in ecosystem functioning, could destabilise these processes with unforeseen consequences in the long term (Margules & Pressey, 2000).

In recent years a more systematic approach to reserve selection has replaced the ad hoc procedures adopted in the past. The catalyst for this change in approach stems from the release of the 1987 report of the World Commission on Environment and Development *Our Common Future* (the Brundtland Report). The Brundtland Report highlighted the unprecedented loss of biodiversity and called for a global and unified effort to curb this trend. The report resulted in a number of international treaties and conventions that were signed at the United Nations Conference on Environment and Development (UNCED) held in Brazil in June 1992 (Ecologically Sustainable Development Steering Committee, 1992). Australia endorsed these conventions and treaties and as a signatory demonstrates its commitment to the

preservation of biodiversity. The Australian government fulfils its obligations, under these agreements, through numerous mechanisms. In December 1992 the Council of Australian Governments endorsed the National Strategy for Ecologically Sustainable Development. It is this strategy that forms the corner stone that drives Australia's bid to conserve biodiversity.

In June 1993, Australia ratified the Convention on Biological Diversity that requires that member nations implement national strategies, plans or programs to preserve biodiversity within their capabilities and in accordance with their particular circumstances (Department of the Environment Sport and Territories, 1996).

Australia's response to its obligations under this convention was to develop a National Strategy for the Conservation of Biological Diversity that provides guidelines for biological diversity conservation within Australia and lists nine objectives. At the heart of these objectives is the commitment to establishment a comprehensive, adequate and representative reserve system across Australia. This paved the way to setting aside areas that better serve invertebrates and their conservation, however, our lack of knowledge of terrestrial invertebrates remains a major impediment to their conservation. In the absence of alternative measures, there is a strong reliance on surrogates to guide management decisions concerning their conservation. The government does, however, recognise the limitations of surrogacy and has called for improvement (Resource Assessment Commission, 1993).

1.2 Terrestrial Invertebrates: The Roles They Play

Invertebrates are a major component of biodiversity both in the number of species and biomass. It has been estimated that they constitute over ninety-seven per cent of the known species of fauna in the world (Marks, 1969). By 1987, 1.4 million invertebrate species had been described and up to 20 000 new species are still being identified every year. Estimates of the total number of insects range from 1.84 million to 50 million, but just under 10 million is probably more realistic (Samways, 1994). In comparison there are approximately 50 000 species of vertebrates in the world (Committee of Ministers, 1987; Yen & Butcher, 1997). In Australia alone there are over 300 000 species of non-marine invertebrates. The majority of them are endemic and have not yet been formally described (Clarke & Spier-Ashcroft, 2004).

Knowing exactly how many invertebrate species there are is not particularly important from an ecological point of view, it is the understanding that they are numerous and play a major role in maintaining life support systems (Samways, 1994). Invertebrates are involved in all ecological functions including decomposition, pollination, nutrient cycling and maintenance of soil fertility. Not only are they the principle food source for many vertebrates, they play direct and indirect roles in food production. Many invertebrate species act as natural regulators of populations of other species through predation and parasitism. Their roles in scientific research, monitoring and education are only just being recognised. Many are potential sources of important compounds used in medicine. Their cultural and aesthetic values are rarely considered and for ethical reasons alone should enjoy the same level of protection that is afforded to the more charismatic animals. Despite all their virtues they have received little recognition and their conservation has been largely overlooked in the past, however attitudes are slowly changing (Taylor & Doran, 2001; Yen & Butcher, 1997).

1.3 Historical Background to Invertebrate Conservation in Australia

In 1983 when the IUCN Invertebrate Red Data Book was published it listed 22 invertebrate taxa as threatened with extinction (Wells, Pyle, & Collins, 1983). By 2000 this number had risen to 374. Many of those listed are molluscs, together with 34 insect species. There are over 70 invertebrate species (excluding crustacea and butterflies) currently listed as threatened under Commonwealth and State legislation with Western Australia accounting for at least a third of these species. These numbers are almost certainly an underestimation (Clarke & Spier-Ashcroft, 2004) and it is likely that we will never know just how many species have become extinct in Australia over the past 200 years. Mawdsley & Stork (1995) estimated that globally anywhere between 100 000 and 500 000 species may become extinct during the next 300 years. This is virtually instantaneous when viewed over geographical time-scales.

It is not uncommon for invertebrates to undergo population surges and busts which has probably lead us into a false sense of security that they will take care of themselves. However many of these busts, and now extinctions are now mainly

human-induced (Samways, 1996). Yen and Butcher (1997) listed five main categories of threatening processes responsible for the decline in invertebrate species:

- habitat destruction,
- habitat alteration,
- the introduction of exotic species,
- direct over exploitation,
- long term environmental change.

They identified a further eight primary and secondary processes that act either separately or concurrently with each of these five categories that include agriculture, forestry, urbanisation, transport, recreation, industrial development, mining, energy production and tourism.

There is general agreement among scientists that habitat destruction and alteration is the most serious and current threat to invertebrates (Doherty et al., 2000; New, 1993; Samways, 1989). However, there has been very little research done that documents the primary and secondary impacts caused by the loss of habitat and the long term problems that this poses (Clarke & Spier-Ashcroft, 2004). Since European settlement approximately 13% of Australia has been cleared. Approximately 32% of native vegetation in the agricultural and urban areas has either been cleared or highly modified. The areas most severely affected are the higher rainfall zones in the south-east and far south-west of the continent (National Land and Water Resources Audit, 2001). Continued land clearance in the high rainfall zones of southern Australia could have serious implications in the long term for invertebrate conservation. These areas may be the only remaining refuges for some invertebrates that are unable to tolerate extremes of drought and rely heavily on regular rainfall for their survival. Even species with wide ranges may still be vulnerable (Hughes, 2003).

There has been a significant decline in rainfall in south-western Australia. Since the early 1960s, the region has become 25% drier during winter with fewer rainy days (Hennessy, Suppiah, & Page, 1999). Although this trend has slowed since the mid 1970s annual rainfall is still well below pre-1960 levels. However trends differ between regions and in many areas rainfall has increased by up to 15% whilst others have experienced no change (Hughes, 2003: Penn, Page, & Howden, 2002). This is equally detrimental to invertebrates that are disadvantaged by extreme wet

conditions. Blair, Todd & Callaham (2000) have demonstrated that soil invertebrate responses to changes in water availability are highly complex and they urge the need for caution before making any assumptions about the long term consequences of climate change based on short-term manipulative studies.

Although it is difficult to assign trends in the booms and busts of particular invertebrate species directly to climate change, research has shown that there have been changes in phenology, distribution and the abundance of invertebrates that demonstrates some consistency with climate change. Long-term changes in the distribution of certain butterfly species have been identified in the northern hemisphere (Harrington, Fleming, & Woiwod, 2001; Parmesan, 1996). Studies in Australia that have utilised BIOCLIM, a bioclimatic analysis and prediction system, that investigates the potential changes that might occur under different climatic scenarios have demonstrated that butterfly species that currently have wide climatic ranges may still be vulnerable to climate change (Beaumont & Hughes, 2002; Hughes, 2003). The prognosis for the Giant Gippsland Earthworm (*Megascolides australis*) is far worse. The worm's bioclimate covers an area of 2500 km^2 of which only 1% is conserved. If the temperature rises by 1° C their bioclimate virtually disappears. Any further increase in temperature and the giant worm would become extinct (Bennett et al., 1991). Although these results are predictive, the evidence would suggest that range changes are already occurring. Rusek (2000) found that certain alpine collembolan communities changed substantially during the 1977-1990 period in response to global warming.

Despite the important roles that invertebrates play in ecosystem functioning such as decomposition, pollination, seed dispersal and their potential use in scientific research and monitoring (Yen & Butcher, 1997), they have been largely viewed as pests. Until recently they have been largely overlooked in reserve and conservation planning. If Australia is to fulfil its objective to establish and manage a comprehensive, adequate and representative system for the protection of biodiversity then it must give equal consideration to vertebrate and plant species, but also include our invertebrate fauna. In the past, Australia has lagged behind the United States and Britain in invertebrate conservation (Yen & Butcher, 1997).

The earliest reference to invertebrate conservation in Australia was in the mid 1960s when Day (1965) stressed the important ecological roles insects play,

particularly in agriculture and forestry, and called for their recognition in wildlife conservation planning. The issue wasn't raised again until Marks (1969) outlined three requirements that would improve the prospects for invertebrate conservation. She recommended that we overcome our defeatist attitude towards invertebrate conservation, establish a central clearing house for invertebrate data and educate the public. Her recommendations are as valid today as they were over thirty years ago (Yen & Butcher, 1997). Following Marks' paper, there was little mention of or concern directed towards invertebrate conservation until the early 1980s.

During the early 1980s, proposals were put forward for the legal protection of ten insect species in New South Wales. However, legislation designed to protect single invertebrate species was strongly opposed by some entomologists. They believed that single species conservation was unnecessary and counterproductive. Not only would it hinder entomological research and recreational collecting but the legislation would not address the threatening processes that were causing the decline of certain species. Although 'protective legislation' is well intentioned, habitat conservation is considered to be a more effective invertebrate conservation technique and has a proven track record in Britain and in the United States of America (Hill & Michaelis, 1988; New, 1992).

Since the early 1980s, invertebrate conservation has received more attention but has only gained momentum in recent years (New, 1991; Samways, 1994). However, it is fraught with political, taxonomic and ecological impediments (Horwitz, Recher, & Majer, 1999). Their sheer diversity impedes species-orientated conservation programmes. The only viable course of action is to preserve particular habitat types without prior evaluation of the component species that utilise these habitats (New, 1991). Consequently, invertebrate conservation has centred mainly around the selection of relatively undisturbed areas that are rich in plant species and are representative of a particular vegetation community (Greenslade & New, 1991). This approach to inverterbate and biodiversity conservation in general is referred to as surrogacy.

1.4 Surrogates: Their Use in Invertebrate Conservation Planning

Environmental surrogates are frequently used in the reserve selection process to identify important areas for biodiversity conservation. As basic inventory data for most invertebrate taxa is lacking, the use of surrogates overcomes this problem quickly and cheaply (Raven & Wilson, 1992; Roberts, 1988). However, there is debate over the effectiveness of surrogates (Brooks, da Fonseca, & Rodrigues, 2004; Landres, Verner, & Thomas, 1988; Williams & Gaston, 1994).

The Resource Assessment Commission (1993) defines a surrogate as:

"...a quantity or combination of quantities used to obtain information about the target in lieu of measuring the target more directly".

Surrogates range from general environmental data to specific habitat attributes for particular species. Assumptions are made that a correlation exists between the surrogate and actual species' distributions, and variations within a surrogate will also represent individual species (Ferrier & Watson, 1997; Flather, Wilson, Dean, & McComb, 1997; Resource Assessment Commission, 1993).

Although surrogates are used extensively for biodiversity conservation, there is conflicting evidence about their effectiveness. Different species occupy and interact with the landscape and other organisms at different temporal and spatial scales (Hoekstra, Allen, & Flather, 1991). As a consequence extrapolations from one species, guild or population to another is empirically and conceptually flawed (Landres et al., 1988). Biodiversity conservation investigations span all levels of scale ranging from local up to global therefore assumptions based on a local perspective may be inappropriate at a regional or continental scale (Humphries, Williams, & Vane-Wright, 1995)

Over broad scales, Currie (1991) found that for many well studied organisms species richness patterns are not monotonic for a number of environmental variables. Many of the relationships that have been detected are non-linear, with high species richness corresponding to both high and low levels of the same environmental variable (Williams & Gaston, 1994). A number of studies have provided similar evidence that a 'hot spot' for one taxon is not necessarily predictive for other taxa (Araujo et al., 2001; Dobson, Rodriguez, Roberts, & Wilcove, 1997; Flather et al.,

1997; Prendergast, Quinn, Lawton, Eversham, & Gibbons, 1993; van Jaarsveld et al., 1998). Although there is some support for the use of surrogates, at continental scales, the support is often accompanied by caveats that usually recommend that more than one surrogate is used and that there is a congruence between the surrogate and a number of different taxa (Faith, 2003; Howard et al., 1998; Pearson & Cassola, 1992; Su, Debinski, Jakubauskas, & Kindscher, 2004).

There is also conflicting evidence regarding the effectiveness of surrogates at both local and regional scales. Promising results came from studies of butterflies, moths and leafhoppers in tallgrass prairie ecosystems which supported, to a certain extent, the use of a vegetative approach to invertebrate conservation (Panzer & Schwartz, 1998). Montane insect communities have also demonstrated an affinity to plant habitat type (Hughes, Daily, & Ehrlich, 2000). However, the majority of studies have found little support for a vegetative approach to invertebrate conservation (Cranston & Trueman, 1997; Kremen, 1992; Oliver, Beattie, & York, 1998; Webb & Hopkins, 1984; Wilcox, Murphy, Ehrlich, & Austin, 1986).

In Australia, an evaluation of broad environmental surrogates using vegetation mapping, environmental classification, environmental ordination, raw environmental distance, canonical ordination and species distribution modelling revealed clear differences between different types of surrogates and between different biological groups. With the exception of species distribution modelling, forest type mapping outperformed the other surrogates investigated for vertebrate fauna and vascular plants. However, all surrogates performed poorly for ground dwelling invertebrates (Ferrier & Watson, 1997). Although these authors acknowledged that the use of surrogates was based on assumptions that were rarely tested, it would appear that they failed to heed their own advice. They made assumptions without first demonstrating that a relationship existed between the surrogate and the organism/s that the surrogate purported to represent. Doherty et al. (2000) point out that Ferrier & Watson (1997) did not attempt to establish that a correlation existed between ground dwelling invertebrates and the broad surrogates that were used. They believe that if phytophagous (plant feeding) insect taxa had been chosen for the study then the results may have had a different outcome.

Without adequate research, and given the complexity of natural systems, it is difficult if not impossible to judge the efficacy of a surrogate to act as an indicator of

habitat quality for a suite of organisms (Landres et al., 1988). Before any assumptions are made, the relationship between the indicator and the target species must be validated (Noss, 1990; Williams & Gaston, 1994). Without validation, incorrect assumptions that other species are benefiting from the protection of the indicator/surrogate can result in the inadvertent loss of species (Landres et al., 1988). Unfortunately, a review of the literature doesn't clarify or provide any clear insight into the complexity that surrounds the relationships that exist between plant species richness and invertebrate richness, however, research to date is underpinned by one common belief. Theoretically, a more diverse resource base should support a more diverse array of consumers (MacArthur, 1972; Rosenzweig, 1995; Whittaker, 1975). This appears to apply under certain circumstances but it is not universal (Hooper et al., 2000).

1.5 Plant Species Richness Acting as a Surrogate of Invertebrate Species Richness

The major assumption that forms the basis of adopting surrogates for the purpose of invertebrate conservation is that a relationship exists between plant species richness and invertebrate species richness. Despite the failure of a number of researchers to demonstrate the efficiency of vegetation to act as a surrogate for invertebrate richness a relationship has been found to exist between certain invertebrate groups and plant species richness. Most of these studies have focused on phytophagous invertebrates and as Doherty et al. (2000) predicted the relationship between this group and plant species richness appears to be stronger than for others. However it does not hold for all the species within a particular order or from other orders from this trophic group. Butterflies for instance have demonstrated everything from close associations for a particular species (Launer & Murphy, 1994) to no association at all for the order as a whole (Kremen, 1992 but see Panzer & Schwartz, 1998). Gall-insects were found to track plant species richness in the Cape Floristic Region in South Africa (Wright & Samways, 1998). Homoptera richness was found to be correlated with plants, but Murdoch, Evans and Peterson (1972) were unable to determine whether this relationship was due to plant species richness or to plant structure. The inter-correlation between these two variables is well documented in

the literature (Greenslade & Majer, 1993; MacArthur & MacArthur, 1961; Naveh & Whittaker, 1979).

A review of the literature tends to support the proposal that plant structure is a more important determinate of invertebrate species richness than plant species richness alone. Strong, Lawton and Southwood (1984) reviewed twelve studies that compared phytophagous insect species richness with plant structure (architecture) and found that only one study failed to detect significant architectural effects on insect diversity. A study conducted in south-western Australia demonstrated that both variables influenced invertebrate species richness, however, the results differed between vegetation types and only weak correlations were found between invertebrates species richness and plant species richness (Abensperg-Traun et al., 1997). Abbot (1976) demonstrated that there was a relationship between structural diversity and invertebrate species richness but did not find plant species richness as a major influence. Two other studies that investigated structural diversity supported his findings (Haysom & Coulson, 1998; Moran, 1980). The Cape Floristic Region on the south-western tip of Africa is characterised by its exceptionally high plant species richness and yet in comparison is not particularly rich in phytophagous invertebrate fauna (Giliomee, 2003).

There is convincing evidence to suggest that increased structural diversity and/or plant species richness is favoured by certain phytophagous invertebrate groups. Whether plant species richness translates into more favourable conditions for ground dwelling invertebrates and consequently more diverse communities is less well studied. In a heterogeneous litter environment, species diversity would be expected to be higher than in a homogenous one due to increased resources and a wider range of microhabitats (Sulkava & Huhta, 1998). However, soil and litter fauna studies have often returned contradictory, weak or idiosyncratic results (Wardle, Yeates, Williamson, & Bonner, 2003).

Chapman, Whittaker and Heal (1988) found that, while Norway spruce and Scots pine had higher than expected litter fauna populations than pure stands, the mixed litter input from spruce/alder and spruce/oak did not. Blair, Parmelee and Beare (1990) also found that the abundance of certain soil biota groups changed in response to single and mixed litter combinations, however, the changes varied between different decomposer organisms. Wardle and Lavelle (1997) suggest that

these conflicting results indicate that plant litter quality can strongly influence the complex competitive and mutualistic relationships that exist between different soil biota but it does so in unpredictable ways.

There is evidence to suggest that the species richness of certain families of Acarina is positively correlated with litter species richness. Hansen (2000) found that several characteristics of monotypic-litter habitats appear to erode oribatid mite assemblages, while mixed-species litter tends to enhance oribatid mite and other soil microarthropod species richness (Hansen & Coleman, 1998; Kaneko & Salamanca, 1999).

Successional studies have provided evidence that Collembolan species richness is related to plant species richness, vegetation structural diversity (Greenslade & Majer, 1993), and plant community composition (Rusek, 2000). The effects of vegetation structure on Araneae species richness has also been investigated. Of the two studies reviewed, vegetation height was the major influencing factor (Webb & Hopkins, 1984) whilst prey availability was not found to be a significant predictor of web spider species diversity (Greenstone, 1984). De Bruyn, Thys, Scheirs, & Verhagen (2001) found that two soil dwelling, saprophagous, fly families were directly affected by soil humidity and soil organic matter but there was no relationship between plant species richness and the fly diversity indices.

Coleoptera have demonstrated a range of responses to plant species richness. Although their species richness showed a positive trend towards native plant species richness in a study conducted in New Zealand, they were almost as species rich in modified habitats. Quantitative measurements of the vegetation structure were not made during the study. It would appear from the results that the increase in Coleoptera species richness on some treatments may have been due to increased structural diversity rather than plant species richness (Crisp, Dickinson, & Gibbs, 1998). Other studies have demonstrated an association with vegetation types (Yen, 1987) vegetation cover (Webb & Hopkins, 1984) and vegetation structure (Southwood, Brown, & Reader, 1979) but there is no evidence to suggest that this is related to plant species richness.

Although ground dwelling invertebrates exhibit responses to different litter mixes they do so in unpredictable ways which would suggest that there are other

ecological processes at work that influence the species richness of this group. For over a century ecologists have grappled with the question of why there are so many kinds of animals (Brown, 1981; Hutchinson, 1959) and have sought to understand what causes variations in species richness. Patterns of species richness exist and many of these patterns can be predicably related to environmental gradients (MacArthur, 1965; May, 1975). After a 'cursory overview of the literature' Palmer (1994) identified 120 hypotheses which have been proposed to explain variations in species richness. Although it appears to be a bewildering number however many of them are synonyms or near-synonyms. Currie (1991) simplifies it down to eight hypotheses including climate, climate variability, habitat heterogeneity, history, energy, competition, predation and disturbance.

There is no doubt from the literature that climate and seasonal variability strongly influence terrestrial invertebrate populations in composition and in abundance (Curry, 1987; Koch & Majer, 1980; Majer & Koch, 1982). Therefore any study that investigates the relationship between plant species richness and invertebrate richness must isolate seasonal noise by sampling throughout the year, or over a number of years, to reduce this confounding factor. As an honours project, constrained by time limitations, that was not possible but it opened the way to future research.

1.6 Scale

Another issue that has and continues to receive much attention in the literature is scale. There are claims that studies may not be detecting the important processes and resource regulation mechanisms that maintain invertebrate communities because sampling programmes are not conducted at the appropriate scale (Cale & Hobbs, 1994; Levin, 1992; Schneider, 2001). Scale has also been identified as an important factor that must be considered when selecting and evaluating surrogates for the conservation of biodiversity (Humphries et al., 1995). Insect distributions operate on a finer scale than plants and they appear to be influenced by more subtle ecological effects. Consequently a vegetative approach that utilises plant species richness as a surrogate to guide invertebrate conservation, without scale considerations, has its limitations.

1.7 Summary

By the late 1980s, a vegetation approach to invertebrate conservation was being questioned and researchers began to appreciate the limitations of surrogacy (Greenslade & New, 1991). However, it is generally accepted that the practice will continue in the foreseeable future given the lack of funds, baseline data and the shortage of expertise and time to adopt another approach.

To date generalised linear models have provided limited predictive capacity. Although models are continually being refined, they are only as good as the information that forms their base. The only way to improve their efficiency is to gather sufficient data from experimental or inventory studies so that a link between the surrogate and the target can be validated through rigorous statistical testing (Resource Assessment Commission, 1993).

1.8 Aims and Objectives

This study aims to determine if a relationship exists between plant species richness and the richness of ground dwelling invertebrates and therefore provides an insight into the adequacy of surrogacy as a conservation tool. A number of other possible influencing factors on species richness will also be investigated.

The Yanchep National Park and surrounding areas were chosen for the study on the basis that there are still large tracks of relatively undisturbed vegetation in the region. Many of the vegetation communities that are characteristic of the Swan Coastal Plain are represented. There have been a number of floristic surveys conducted in the area that have demonstrated a small range in plant species richness but unfortunately the range was not sufficient to provide a gradient of plant species rich sites. Therefore sites were selected on the basis of being either rich or poor in plant species. Although the flora is relatively well studied very little known about the ground dwelling invertebrate fauna of the region.

The objectives of the study are to:

1 establish if a relationship exists between plant species richness and ground dwelling invertebrate richness that would support the use of plant surrogacy in invertebrate conservation;

2 investigate the role that vegetation structure plays in ordinal and invertebrate morphospecies richness;

3 examine the correlates that exist between invertebrate species richness and aspects of their environment; and

4 investigate the influence that the scale of measurement has on the outcome of the sampling results.

The thesis is structured in the following way as the study required that two independent studies were carried out in conjunction with each other. Initially a plant survey was undertaken. The plant survey was followed shortly by an invertebrate study. Each phase of the project was designed to complement the other. Each study is reported in its own right and the outcome of both studies were combined to answer the hypothesis. Does plant species richness influence ground dwelling invertebrate richness?

Chapter 2 (Methods) defines, in detail, the area that was investigated during the project and supports the reasons why this area was chosen for the study. This chapter provides the rationale behind the study and directs the reader through the approaches that were taken to ensure that the best possible precautions were taken to ensure that the project was successful. Given the restriction of time, the results are reported in good faith and critique is welcome.

Chapter 3 (Results) works through the results and again reports the two surveys independently. Section 3.5 attempts to mesh the two studies together providing the reader with an understanding of the outcome of each study and when combined, what these results implicate for invertebrate conservation.

Chapter 4 (Discussion) pulls together the results from this study and compares them with similar studies in this field of research. I conclude with Chapter 5 that, although demonstrates that the project was limited in its scope opens up numerous questions that beg to be answered.

CHAPTER TWO

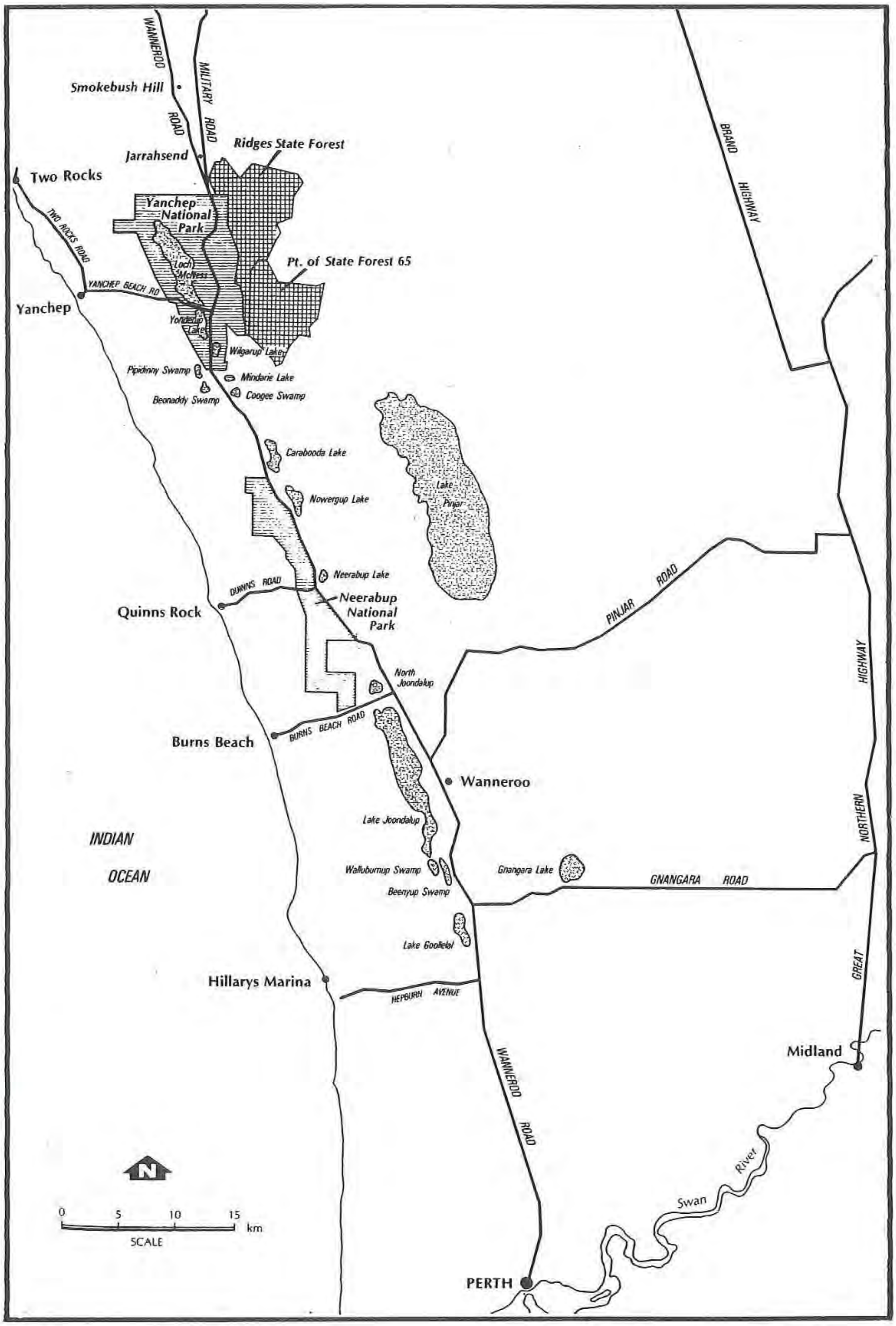
METHODS

2.1 Study Area

2.1.1 History

The Yanchep National Park is located 48 km north of Perth. It covers an area of 2799 ha making it one of the last substantial tracts of native bushland remaining on the Swan Coastal Plain. As a consequence the park is highly valued for conservation and recreation. Its recreational value was first recognised in the 1930s with the establishment of a major tourist resort. The area was managed primarily for recreation up until 1969 when it was declared a National Park (CALM, 1989). The Wanneroo Road segregates the park into two main sections. The impact of tourism is clearly visible in the west whilst the area to the east remains relatively undisturbed apart from some small, disused limestone quarries, an apiary site that is used exclusively for breeding and a network of walking and 4wd tracks.

In 1983 the Environmental Protection Authority recommended that the Ridges Management Priority Area (MPA) which abuts the eastern boundary of the park be incorporated into its boundaries (CALM, 1983). In 1987 and again in 1989 the Department of Conservation and Land Management (CALM) proposed the inclusion of two adjacent areas of State Forest 65 to the south of the MPA. These additions would increase the area of the park to approximately 5900 ha (CALM, 1987). A map showing the Yanchep National Park and proposed extension is provided in Figure 2.1.The area is noted for its high conservation and recreation values and its massive limestone ridges harbour critically threatened plant communities (Weston & Gibson, 1997).To date these proposals have not been implemented. These areas are not formally integrated into the park and are referred to as the Ridges extension.



(Source) (CALM, 1989)

Figure 2.1 Map showing the location of the Yanchep National Park and the Ridges State Forest Block which forms the proposed extension to the park

2.1.2 Vegetation

The Ridges extension lies entirely within the Cottesloe soil unit overlying the Spearwood Dune System (Churchward & McArthur, 1980) and is dominated by heath and woodland. Floristic surveys in the region have demonstrated that the heath and woodland vegetation types are both represented by species rich and poor communities (Gibson, Keighery, Keighery, Burbidge, & Lyons, 1994). Therefore the area provided the opportunity to investigate if a relationship exists between plant and invertebrate species richness. Additionally, the hypothesis could be tested in two different vegetation types and across two levels of plant species richness.

2.1.3 Fire History

Fire history was another important consideration when selecting sites. It has been demonstrated that the species richness of ground-dwelling invertebrates decreases following a reduction in litter quantity as a result of fire (Bornemissza, 1969; Koch & Majer, 1980; Springett, 1976). During a visit to CALM's Wanneroo office, Mike Cantelo and Brian Ingelis, who are familiar with the burning regime in the area, provided maps and satellite imagery that demonstrated the fire history of the area. Whilst large tracts of the park had been burnt within recent years, the Ridges extension had not been burnt for over eight years prior to this study.

2.1.4 Invertebrate Fauna

Terrestrial invertebrates have not been comprehensively studied in the area. Only two studies have been carried out and they have been within the park boundaries. During 1992 a study compared the effects of disturbance on the structure and composition of ant communities (Burbidge, Leicester, McDavitt, & Majer, 1992). A later study in the winter of 1995 investigated the foraging preferences of the introduced honeybee and the implications they posed for conservation management (Judd, 1995). It is assumed that invertebrates are relatively abundant given the diversity of flora and other fauna. A major management objective for the park is to maintain viable populations of all indigenous fauna (CALM, 1989). Consequently research on the terrestrial invertebrates of the region would aid decisions on their conservation and management.

2.2 Experimental Design

2.2.1 Rationale

Most ecological models predict that a more diverse resource base should support a more diverse array of consumers (Rosenzweig, 1995; Evan Siemann, 1998; Tilman, 1986). To investigate this hypothesis, floristic communities with both low and high plant species richness were sampled. To determine if similar patterns existed within and between vegetation associations, two vegetation types were included in the study.

Scale is another issue that has important implications for invertebrate conservation (Ferrier, Gray, Cassis, & Wilkie, 1999; Gill, Woinarski, & York, 1999). The importance of scale has received much attention in the literature. There is growing concern that scales of study are not always appropriate for the research aims and do not reflect the patterns and processes at the scale most important from the organisms point of view (Caldow & Racey, 2000; Cale & Hobbs, 1994). Consequently the project was designed so that the issue of scale could be addressed. Two scales were investigated including $100m^2$ and $1m^2$.

2.2.2 Treatment Selection

Treatments were located in both heath and woodland vegetation types and were selected on the basis of their plant species richness, the structure of the understorey, fire history and aspect. An earlier floristic study in the area conducted by Gibson, Keighery, Keighery, Burbidge and Lyons (1994) and consultation with David Pike, a local plant expert, provided sufficient information to identify vegetation associations of varying species richness. Visual inspection guided by the presence and/or absence of certain dominant canopy and/or understorey species facilitated identification of distinct communities within these associations. Communities dominated by *Melaleuca systena/M. huegelii* and *Melaleuca systena/Acacia lasiocarpa/Baeckea robusta* were selected for the low and high species treatments in heath. These communities are referred to as Heath Poor (HP) and Heath Rich (HR) respectively. A *Banksia attenuata/B. menziesii* and depending on location, scattered *Eucalyptus todtiana* or *E. marginata* community represented

the high species treatment and *Banksia attenuata/B. ilicifolia/Melaleuca preissiana* the low species treatment in woodland. These communities are referred to Woodland Rich (WR) and Woodland Poor (WP) respectively.

To increase statistical power five 100m^2 replicates were identified within each community type. All of the replicates for each treatment were located within a 5km radius of the Yeal Swamp and Pigeon Road intersection. One was located outside the Ridges extension but within the boundary of the Yanchep National Park. Figure 2.2 shows the location of the replicates.

2.2.3 Replicate Selection

Replicates were located using a random walk procedure (Kent & Coker, 1992). Random numbers were generated between 1 and 360 to give a compass bearing for direction. Another set of numbers were drawn to indicate distance. A peg was placed at the point indicated by the direction and distance of these numbers. The location of a second peg was determined using a random number to generate direction only as distance was already determined by the size of the quadrat ie. 10m. The remainder of the replicate was marked out using a system designed by Ted Griffin for setting up 100m^2 study sites (Keighery, 1993). Although a random walk procedure is not strictly random (Kent & Coker, 1992) it was the only practical way to site each replicate in the small heath communities. Replicates were located on south-easterly aspects. Aspects were confirmed using a compass. Slope was determined using a clinometer. Topographical details for each replicate and soil type are provided in Table 2.1. The geographical coordinates of the replicates were established using a Magellan 315/320 GPS unit and for consistency were determined at the south-east corner of each replicate.

To ensure independence and thereby avoiding one type of pseudoreplication (Hurlbert, 1984) replicates were segregated by access ways where possible. Others were isolated in a matrix of different floristic communities. In cases were total segregation was impossible, replicates were spatially separated by distance.

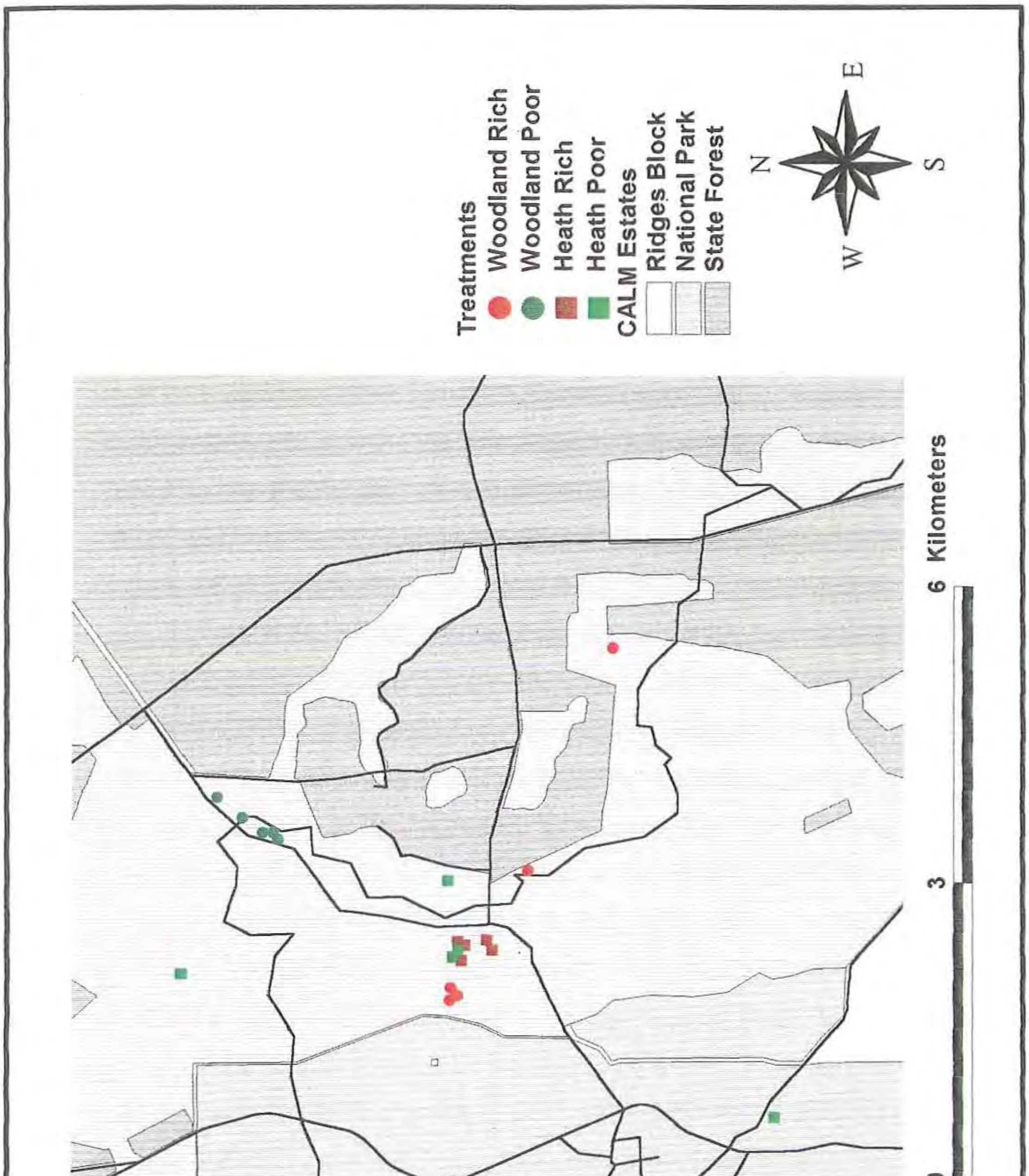


Figure 2.2 Map showing the locations of Woodland Rich, Woodland Poor, Heath Rich and Heath Poor replicates sampled for plant and ground dwelling invertebrate richness in the Yanchep region

Table 2.1 Summary of landscape attributes including a detailed description of soil characteristics

TREATMENT REPLICATE	ALTITUDE (m)	ASPECT	SLOPE	TOPOGRAPHIC DESCRIPTION	SOIL TEXTURE	MUNSELL SOIL (dry) COLOUR	MUNSELL SOIL COLOUR CODE
WOODLAND RICH							
WR1	54	SE	8	Gently inclined waning mid-slope	Sand	grayish brown	2.5Y 5/2
WR2	51	SE	4	Gently inclined waning lower slope	Sand	grayish brown	2.5Y 5/2
WR3	57	SE	7	Gently inclined waning mid-slope	Sand	grayish brown	2.5Y 5/2
WR4	56	SE	7	Gently inclined waning mid-slope	Sand	grayish brown	2.5Y 5/2
WR5	65	SE	9	Gently inclined waning mid-slope	Sand	light olive brown	2.5Y 5/3
WOODLAND POOR							
WP1	35	SE	6	Gently inclined waning lower slope	Sand	dark gray	2.5Y 4/1
WP2	38	SE	10	Gently inclined waning lower slope	Sand	dark gray	2.5Y 4/1
WP3	36	SE	8	Gently inclined waning lower slope	Sand	dark gray	2.5Y 4/1
WP4	36	SE	8	Gently inclined waning lower slope	Sand	dark gray	2.5Y 4/1
WP5	33	SE	2	Very gently inclined waning lower slope	Sand	dark gray	2.5Y 4/1
HEATH RICH							
HR1	85	SE	9	Gently inclined waning upper slope	Light sandy clay loam	dark yellowish brown	10YR 4/4
HR2	75	SE	8	Gently inclined waning upper slope	Light sandy clay loam	dark yellowish brown	10YR 4/4
HR3	70	SE	6	Gently inclined waning mid-slope	Light sandy clay loam	brown	10YR 4/3
HR4	65	SE	10	Gently inclined waning mid-slope	Light sandy clay loam	brown	10YR 4/3
HR5	73	SE	6	Gently inclined waning mid-slope	Light sandy clay loam	dark yellowish brown	10YR 4/4
HEATH POOR							
HP1	70	SE	5	Gently inclined waning upper slope	Loamy sand	very dark grayish brown	10YR 3/2
HP2	78	SE	8	Gently inclined waning upper slope	Loamy sand	very dark grayish brown	10YR 3/2
HP3	14	SE	5	Gently inclined waning lower slope	Loamy sand	brown	10YR 4/3
HP4	82	SE	15	Moderately inclined waning upper slope	Loamy sand	very dark brown	10YR 2/2
HP5	61	SE	8	Gently inclined waning mid-slope	Loamy sand	brown	10YR 4/3

2.2.4 Replicate Layout

Each 10 x 10m plant quadrat, from now on referred to as 'the replicate', was subdivided as follows. Five $1m^2$ plots were located within each replicate. The sampling intensity was chosen to ensure that a more representative sample was obtained. The patchy distribution of invertebrates is widely reported in the literature (Edwards, 1991; Greenslade & Greenslade, 1983; Hughes, 1962). Four invertebrate sampling plots 'the plots' were restricted to a 6 x 6m stratified quadrat, 'the quadrat', that was nested centrally within the replicate. A diagram of the layout is provided in Figure 2.3. The quadrat was divided into four equal areas to ensure consistent sampling intensity. A fifth plot was located directly in the centre of the quadrat. The layout created a buffer zone between the quadrat and the outer perimeter of the replicate. A disturbance effect on animal behaviour, as a consequence of walking on site, has been demonstrated (Joosse & Kapteijn, 1968). The buffer was designed to reduce this disturbance by facilitating a preliminary floristic survey without the need to enter the quadrat and disturb the plots prior to invertebrate sampling. The buffer also served to reduce edge effects in the smaller plant communities and provided added insurance that the plots were well within the targeted community. In order to reduce 'noise' only one microhabitat, the litter layer, was sampled. Areas that contained bare ground or logs were avoided. Consequently it was impossible to strictly adhere to random sampling. Random sampling is appropriate in circumstances where there are no alternatives or in cases where biases are otherwise difficult to avoid (Underwood, 1997).

2.2.5 Species Richness Survey Techniques and Scale Determination

2.2.5.1 Floristic Survey

Transects were considered but were not suited to the high beta diversity characteristic of the heath communities. Plant species cumulation curves prepared from data obtained during a pilot study (refer to Appendix 1) supported the use of 10 x 10m plant quadrats. This is the standard size used for floristic studies undertaken in the region (Griffin, Hopkins, & Hnatiuk, 1983; Griffin & Keighery, 1989). All of the plant species present within the $100m^2$ quadrat were collected with only the occasional new species being found at the completion of each survey.

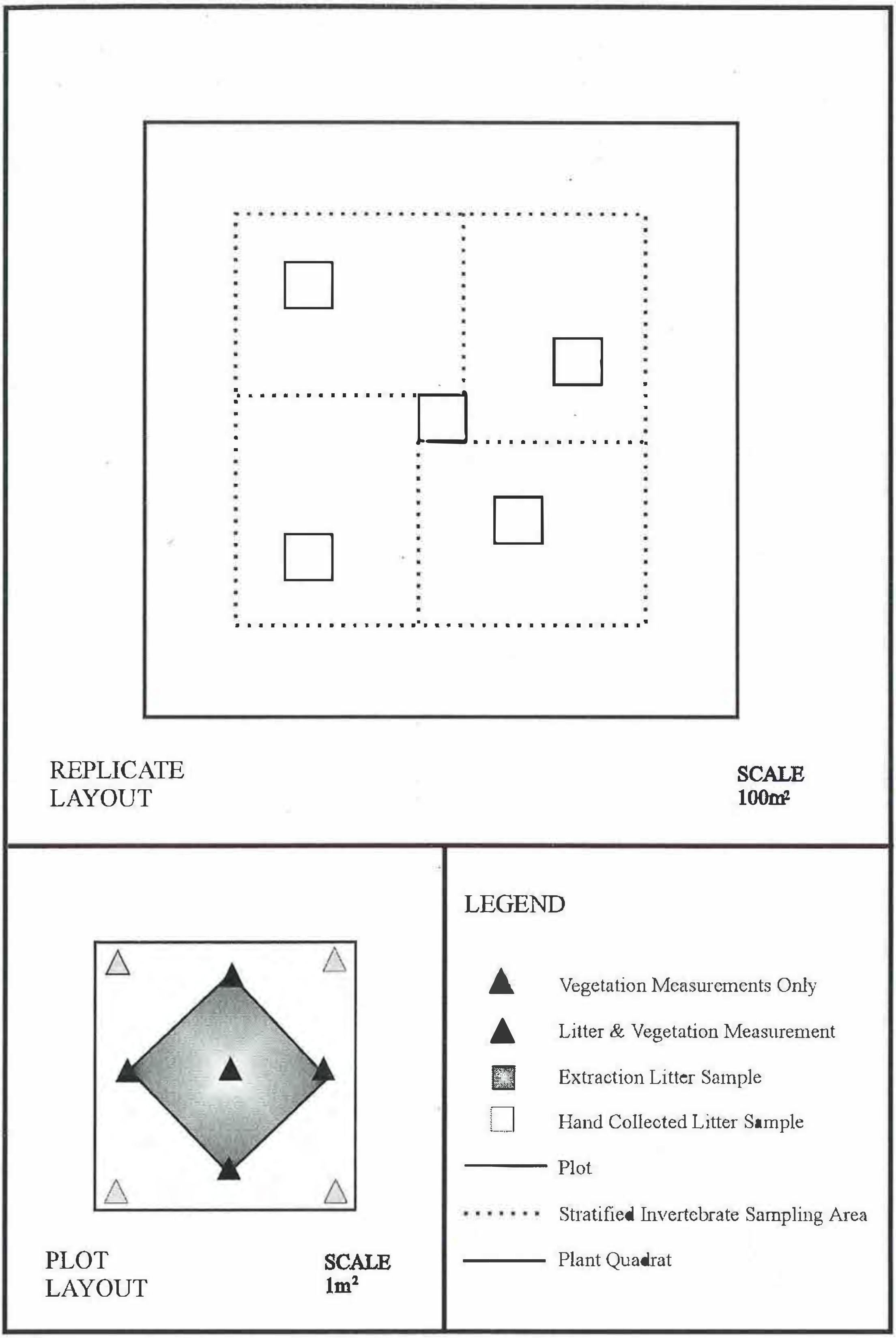


Figure 2.3 Diagrammatic layout of the treatment replicates and within replicate plot layout used during the study to investigate if a relationship exists between plant species richness and ground dwelling invertebrate richness

2.2.5.2 Invertebrate Survey

It is generally accepted in the literature that to obtain a quantitative comparison of soil and litter invertebrates, at least two sampling techniques should be employed during any one sampling programme (Macfadyen, 1962; Standen, 2000). Given the high percentage of mesofauna in the woodland litter, a decision was made to use a dry funnel extraction method.

The Kempson extraction method is an efficient technique used to separate invertebrate fauna from litter. It is particularly efficient (90-100%) for Acarina and Collembola (Kempson, Lloyd, & Ghelardi, 1963; Macfadyen, 1962; New, 1998; Southwood & Henderson, 2000). Modified versions of Kempson extractors were available for the project and a decision was made to use those for the project.

Hand sorting was considered to be more appropriate than pitfall trapping. This method was chosen as opposed to pitfall trapping for one important reason. Although both techniques have their inherent biases, pitfall traps are not recommended when quantitative comparisons of soil and litter fauna are being made between two or more habitats or in different vegetation types. Some ground covers are more restrictive to movement than others and capture rates can be biased (Greenslade, 1964). Heath and woodland litters are distinctively different therefore pitfall trapping and hence sampling over time was not suited to the project. The disadvantage of spot sampling, which only provides a "snapshot' in time, was offset by overcoming the biases that pitfall traps are widely reported to have (Adis, 1979; Greenslade, 1964; Luff, 1975; Topping & Sunderland, 1992).

Three sizes of invertebrate plots (50 x 50cm, 100 x 100cm and 200 x 200cm) were trialed during the pilot study. A report detailing the outcome of this study is provided in Apendix 1. The study reaffirmed the species – area theory in that the larger plots sampled more species (Arrhenius, 1921). However, the study also identified some problems associated with sampling plots larger than 50 x 50cm. The larger plots were not practical for this project given the time restraints and the availability of equipment.

2.2.6 Species Counts

Due to the time constraints imposed on the study it was not possible to include abundance data, consequently only the number of morphospecies identified were counted. Presence-absence data collected from a relatively large number of sampling-units can prove more informative in community studies than abundance data (Macfadyen, 1962). Species counts also avoid the problems that are associated with abundance data on the basis that the relationship between catch size and density of each species is irrelevant (Rushton, Luff, & Eyre, 1989).

2.2.7 Environmental Parameters

In addition to the plant and invertebrate surveys, a number of environmental parameters were assessed to evaluate their possible influence on species richness.

2.3 Sampling Regime

Sampling commenced on the 14th October and was completed by the end of Spring on the 30th November 2003. Plant and invertebrate species richness was sampled at each replicate over the course of two consecutive days with numerous follow up visits to measure certain environmental parameters. To reduce the effect of changing weather patterns treatments were sampled in a consecutive order (ie one replicate from each treatment over the course of an eight day period). However due to difficulties in securing volunteers strict compliance to this order was not always possible. Sampling dates, geographical coordinates and weather conditions prevailing during the sampling programme are summarised in Table 2.2.

Replicates were initially sampled either in the morning or in the afternoon, however unseasonal weather patterns (mid day temperatures rising to 40^{o}C) prompted a change to morning sampling only. To keep sampling consistent each treatment was sampled once in the afternoon. Invertebrate sampling was staggered to ensure that there was always a constant feed to the extraction funnels while keeping storage time down to a minimum of 48 hours. A number of environmental parameters were also measured to determine what influence they might have on invertebrate richness.

Table 2.2 Summary of invertebrate sampling details including weather conditions prevailing at the time of sampling and 24 hour climate data for the region

TREATMENT	REPLICATE	COORDINATES SE CORNER		SAMPLING DATE	SAMPLING TIME	PREVAILING WEATHER CONDITIONS	WIND CONDITIONS	24 HOUR TEMPERATURE Perth Max.	24 HOUR TEMPERATURE Perth Min.	RAINFALL Pearce RAAF (mm)	SAMPLED BY
WOODLAND RICH	WR1	31 31' 58"S	115 42' 13"E	14.10.03	9.30 am	Fine, partially cloudy	Calm	19	8	4.6 mm	K. Ironside
	WR2	31 31' 59"S	115 42' 17"E	26.10.03	2.00 pm	Fine, clear sky	Calm	23	15	0 mm	K. Ironside & D. Fewings
	WR3	31 31' 57"S	115 42' 14"E	14.11.03	9.00 am	Fine, partially cloudy	Calm	27	15	0 mm	K. Ironside
	WR4	31 32' 07"S	115 43' 10"E	20.11.03	8.45 am	Fine, clear sky	Calm	24	13	2.4 mm	K. Ironside
	WR5	31 32' 41"S	115 44' 40"E	30.11.03	10.00 am	Fine, clear sky	Calm	26	15	0 mm	K. Ironside & D. Fewings
WOODLAND POOR	WP1	31 30' 38"S	115 43' 31"E	19.10.03	2.30 pm	Fine, partially cloudy	Calm	20	8	0 mm	K. Ironside
	WP2	31 30' 37"S	115 43' 32"E	05.11.03	10.00 am	Fine, clear sky	Calm	25	13	0 mm	K. Ironside
	WP3	31 30' 40"S	115 43' 32"E	10.11.03	10.00 am	Fine, clear sky	Calm	34	15	0 mm	K. Ironside
	WP4	31 30' 35"S	115 43' 36"E	18.11.03	10.00 am	Overcast, occassional rain	Calm	19	11	11 mm	K. Ironside
	WP5	31 30' 27"S	115 43' 43"E	26.11.03	8.45 am	Fine, clear sky	Calm	24	13	0 mm	K. Ironside
HEATH RICH	HR1	31 31' 47"S	115 42' 31"E	26.10.03	9.30 am	Fine, clear sky	Calm	23	15	0 mm	K. Ironside & D. Fewings
	HR2	31 31' 47"S	115 42' 28"E	02.11.03	9.00 am	Fine, clear sky	Calm	30	14	0 mm	K. Ironside & D. Fewings
	HR3	31 31' 43"S	115 42' 42"E	09.11.03	9.00 am	Fine, clear sky	Calm	31	14	0 mm	K. Ironside & D. Fewings
	HR4	31 31' 45"S	115 42' 40"E	23.11.03	8.30 am	Fine, partially cloudy	Windy	25	21	0 mm	K. Ironside & D. Fewings
	HR5	31 31' 43"S	115 42' 38"E	30.11.03	2.00 pm	Fine, clear sky	Calm	26	15	0 mm	K. Ironside & D. Fewings
HEATH POOR	HP1	31 31' 42"S	115 42' 40"E	02.11.03	2.00 pm	Fine, clear sky	Calm	30	14	0 mm	K. Ironside & D. Fewings
	HP2	31 31' 43"S	115 42' 41"E	06.11.03	9.30 am	Fine, clear sky	Calm	27	12	0 mm	K. Ironside
	HP3	31 33' 35"S	115 41' 42"E	16.11.03	8.20 am	Fine, partially cloudy	Calm	30	17	0 mm	K. Ironside & D. Fewings
	HP4	31 30' 14"S	115 42' 20"E	24.11.03	10.00 am	Overcast, occassional rain	Windy	21	17	3.6 mm	K. Ironside
	HP5	31 31' 39"S	115 43' 09"E	27.11.03	10.00 am	Fine, clear sky	Calm	25	14	0 mm	K. Ironside

The following section describes the procedure and methods employed during the project. Each phase of the project is dealt with separately. Techniques employed in the field are described followed by the laboratory methods, species identification and lastly data analysis.

2.4 Field Methods – Species Richness Surveys

2.4.1 Floristic Survey

A floristic survey was conducted at each replicate. A preliminary but intensive survey was restricted to the 2m buffer zone to ensure that the plots were left undisturbed prior to litter removal. A quick check of the plots was made to ensure that small plant species were not being removed unnoticed during litter removal. An intensive survey of the remaining area was completed after the litter was removed.

Two specimens of each new plant species encountered were collected, allocated a number and returned to the laboratory for pressing and identification. Specimens were stored in sealed plastic bags at a constant temperature of 25°C for subsequent identification. A set of specimens were pressed and retained for offer to the WA Herbarium. In the event that the specimens are not required by the herbarium they will be placed in Edith Cowan University's herbarium. Another set of specimens was pressed and used as a field reference thereby reducing the amount of duplication and unnecessary destructive sampling.

Independent species counts were also carried out on each plot. Only the species that formed the understorey and were rooted in the plot were counted. A visual estimation of the cover using a modified Braun-Blanquet scale (Braun-Blanquet, 1932), that allowed for a more refined estimation of the herb cover, was used to allocate a relative importance value to each species (Naveh & Whittaker, 1979). Table 2.3 shows the original Braun-Blanquet scale and how it compares to the modified version used during the study. The allocation of importance values provided the means to eliminate species if their value was low and their contribution to the litter layer minimal. Detailed species lists and cover estimations for each replicate are provided in Appendix 3.

Table 2.3 Modified Braun-Blanquet scale used to determine importance values for individual plant species

ORIGINAL SCALE		MODIFIED SCALE	
1	<1%	1	<1%
2	1 – 5%	2	1 – 5%
3	6 – 25%	3	6 – 10%
4	26 – 50%	4	11 – 25%
5	51 – 75%	5	26 – 50%
6	76 – 100%	6	51 – 75%
		7	76 – 100%

2.4.2 Invertebrate Survey

Two litter samples were collected from each plot. The sampling area was standardised using two metal quadrats. A 50 x 50cm quadrat was placed centrally but diagonally within the $1m^2$ quadrat. This particular configuration was instrumental in measuring certain environmental parameters and is discussed in more detail in later sections. Litter lying within the 50 x 50cm quadrat was removed for extraction (refer to Section 2.6.2) whilst the remainder was collected for hand sorting ex situ (refer to Section 2.6.1). Attention was paid to the order in which the litter was removed. The litter lying outside the $50cm^2$ frame was collected first, effectively herding other invertebrates into the centre of the plot. Litter samples were placed in pre-weighed, sealed plastic bags to prevent desiccation and stored at a constant temperature of 25°C awaiting either extraction or hand sorting.

2.5 Field Methods – Environmental Parameters

2.5.1 Overview

Sampling techniques were tailored to match the scale of sampling. A combination of qualitative and quantitative measurements were used. Small scale

measurements were not always representative of the larger scale. A decision was made to independently measure five parameters at both replicate and plot scale. A summary of the parameters measured and the scale at which they were measured is provided in Table 2.4. Procedures for each scale are described in the following sections.

The understorey and canopy were measured separately. Vegetation below two meters in height was considered understorey and vegetation above two meters as canopy. Dead vegetation was excluded. Litter is defined as 'a mixture of relatively high quality resources such as fresh leaf-litter, flowers, fruits, seeds, dead micro-organisms and animals and structures of lower quality, mainly woody materials' (Lavelle & Spain, 2001, p. 388). For the purposes of this study, mosses constituted a portion of the litter. Mosses do not form part of the litter layer whilst they are living (Keighery, 1993). All of the heath sites had a high percentage of dried out moss that was removed with the litter. Litter cover and depth were measured at both scales as was the percentage cover of exposed limestone that frequently occurred on the heath sites but was absent in the woodland.

2.5.2 Parameters Measured at the Plot Scale

A simplified version of a point intercept method developed by Levy and Madden (1933) was used for certain plot measurements. The corners of two metal quadrats (50 x 50cm and 1m^2) that were used to delineate invertebrate sampling units were also used to define sampling units and points for measuring vegetation height and litter depth. Measurements for these parameters were also taken at the centre of each plot.

2.5.2.1 Understorey

Understorey cover was visually estimated at each plot. Point intercepts tend to overestimate percentage cover. Optical or light measurements can be used as a surrogate for percentage cover and are recommended when percentage cover is the only structural attribute being measured (Goodall, 1952). It was decided that visual estimates supported by light measurements would provide an adequate measure of cover for the purposes of the study. Light measurements are discussed under the heading Insolation in Section 2.5.2.6.

Table 2.4 Summary of the biotic and abiotic parameters sampled showing the scale at which each parameter was measured to determine if any relationships existed that might influence the species richness of the invertebrate groups investigated during the study

VARIABLE	VEGETATION ASSOCIATION n = 2	TREATMENT Actual n = 4	REPLICATE 100m2 Actual n = 20	REPLICATE 100m2 Average n = 20	PLOT 1m2 n = 100
Woodland	*	*	----	*	*
Heath	*	*	----	*	*
Plant Species Richness		*	----	*	*
Life Form		*	----	*	*
Shrub		*	----	*	*
Herb		*	----	*	*
Grass & Sedges		*	----	*	*
Importance Value		----	----	*	*
Understorey Cover		*	*	*	*
Understorey Height		*	*	*	*
Canopy Cover		----	----	----	*
Canopy Height		----	----	----	*
Litter Cover		*	*	*	*
Litter Depth		*	*	*	*
Litter Moisture		----	----	*	*
Litter Patchiness		*	*	----	*
Litter t/ha		*	----	----	---
Litter Fine			----	*	*
Litter Medium			----	*	*
Litter Coarse			----	*	*
Fruit and Flowers			----	*	*
Twigs			----	*	*
Woody Debris			----	*	*
Miscellaneous			----	*	*
Coarse Rock			----	*	*
Soil Moisture			----	*	*
Soil Organic Matter			----	*	*
Limestone			----	----	*
Temperature			----	*	*
Insolation			----	*	*
Average Insolation			----	*	*

* Indicates the parameters measured and at what scale; ---- Indicates that these parameters were not measured

Vegetation height was measured using point intercepts. A sampling anomaly, whereby centrally located sampling points were only measuring the morphology of individual shrubs if they were dominant on the plot, was overcome by measuring five points within each plot and four on the outer perimeter. A 10 cm thick Levy rod (Levy & Madden, 1933; Sneeuwjagt, 1971) marked at 1 cm intervals up to a length of 2 m was placed vertically on the soil litter interface. The highest point at which foliage was intercepted was recorded at nine points. Average height was calculated using only the points that intercepted foliage.

2.5.2.2 Canopy

Canopy cover immediately above the plot was visually estimated. Cover and density was also measured indirectly using a light metre. Tree height was measured using a clinometer and the following formula:

$$\text{Height} = h1 + h2$$

Where $h1 = \tan\theta \times d$, d = distance from the base of the tree and h2 = the height (m) at which the clinometer was held above the ground (Lund & Hindmarsh, 1997).

2.5.2.3 Litter

Three physical characteristics of litter were measured in situ, litter cover, depth and patchiness. Litter sampling units and points were determined by the placement of metal quadrats. In this manner, the plot was effectively partitioned into five sections. A diagram of the plot layout is provided in Figure 2.3.

Percentage litter cover was evaluated for each of the five partitions. The percentage cover estimates were summed to arrive at a plot average. The five cover estimates were then used to rate patchiness of each plot. The degree of patchiness was rated on a scaled of 1 – 3 using the criteria described in Table 2.5.

Litter depth was determined by lowering the Levy rod down through the litter until it rested on the soil litter interface. Measurements were rounded to the nearest 5 cm. Measurements less than 2.5 cm were recorded as zero and were not used to calculate the plot average.

Table 2.5 Plot Patchiness Scale

No. of Partitions With Partial Cover	Category	
> 3	1	Very Patchy
= 3	2	Patchy
< 3	3	Evenly Distributed

Woody debris with a diameter >10mm and <25mm as defined by McKenzie, Ryan, Fogarty, & Wood (2000) was collected prior to litter removal and weighed on return to the laboratory.

2.5.2.4 Soil Parameters

Soil samples were removed from the centre of each plot immediately after the litter had been removed. Samples were later analysed for soil moisture and organic matter content in the laboratory. Soils were sampled to a depth of 3 cm and sample size standardised using an 8.5 cm diameter corer. Samples were stored in sealed plastic bags to prevent moisture loss.

2.5.2.5 Exposed Limestone

Limestone outcrops were characteristic of the heath sites but did not occur in the woodland areas. Plots were selected which had minimal limestone outcropping. Where possible plots were situated in areas that contained no limestone. Percentage limestone cover was visually estimated.

2.5.2.6 Insolation

Certain terrestrial invertebrates have been shown to be sensitive to levels of insolation (Gill et al., 1999). Light measurements were taken by placing a MC-88 light meter at the centre of each plot. Lux readings were multiplied by a correction factor of 0.95 to adjust for daylight conditions. Measurements were taken during invertebrate sampling. Two additional readings were made at, or as close as possible

to either 10.30 am, 12.30 pm and 2.30 pm depending on the time of the first reading. Cloud cover and wind conditions were taken into account at each reading. On all but two occasions, readings were taken in clear calm conditions. The meter was placed on the ground directly in the centre of each plot and ten measurements systematically recorded. These measurements were subsequently averaged and expressed as a percentage of the available light as measured in an open area in close proximity to the site. Single measurements are expressed as percentage insolation. The combined averages from the three readings are expressed as average percentage insolation.

2.5.2.7 Temperature

A thermometer was suspended slightly above the litter layer at the centre of each plot. After several minutes temperature was recorded. Site average litter surface temperature was calculated from the sum of five plot measurements.

2.5.3 Parameters Measured at the Replicate Scale

Seven environmental parameters were measured at two scales. Three 10m transects were set up across each site. They ran in a north – south direction, two along the east and west boundaries of the invertebrate quadrat, the third directly through the centre of the site.

2.5.3.1 Understorey

Cover estimates for the understorey and the canopy were obtained using a rapid field method described in Walker and Hopkins (1998). The amount of foliage intercepted per meter along an axial tape running the length of each transect was estimated and tallied for each transect. Results from each transect were combined and expressed as percentage cover over a distance of 30 m.

Understorey height measurements were taken every 1m along each transect. A Levy rod was passed down through the vegetation until it rested on the soil litter interface and the highest point at which foliage intercepted the rod recorded. Average height was calculated using only the points that intercepted foliage.

2.5.3.2 Canopy

Average canopy height was estimated by summing the heights of every tree present on site. A clinometer was used to measure height. The procedure used is described in an earlier section.

2.5.3.3 Litter

Litter cover was estimated by measuring the distance of cover intercepted along each 10 m transect. The lengths recorded from each transect were tallied and used to calculate a percentage cover value for each replicate. Litter depth was measured to the nearest 5 cm at 1m intervals along each transect. Average litter depth was calculated using only the points that intercepted litter.

The degree of litter patchiness for each replicate was determined by counting the number of bare ground intercepts along each transect and rating each replicate on a scale of 1 - 3 according to the number of bare ground intercepts encountered. The maximum number of intercepts recorded at any one site was nine. The criteria used to determine each category is described in Table 2.6.

Table 2.6 Replicate Patchiness Scale

No. of Bare Ground Intercepts	Category	
> 5	1	Very Patchy
= 5	2	Patchy
< 5	3	Evenly Distributed

2.6 Laboratory Methods – Invertebrates

2.6.1 Hand Sorting

Litter samples were hand sorted within one week of collection. Prior to sorting they were stored at 15°C to reduce mortality. Each sample was emptied into a white tray and searched intensively for approximately one hour or until no further

animals were found. Animals were collected from the samples using a pooter and placed directly into a solution of 70% ethanol and stored for later identification.

2.6.2 Dry Funnel Extraction

Eight modified Kempson extraction units, discussed earlier in Section 2.2.5.2, each containing four litter receptacles, were used during the project. The Kempson method is described as a behavioural method of extraction as, unlike mechanical methods that physically separate the animals from the litter substrate, the invertebrates are stimulated to leave. Heat is applied and a temperature gradient is formed (Kempson et al., 1963; Macfadyen, 1962; Southwood & Henderson, 2000). Litter was weighed prior to extraction as a precursor to determining the moisture content of each sample. Optimal extraction times and temperatures were established during the pilot study and after some consultation with Adrianne Kinnear, the owner of the equipment. Ten days proved to be the optimal length of time for extractions, however, due to time constraints extractions were limited to eight days. The extraction units were pre heated to 25°C. During the first two days, the temperature in the units was increased by 5°C every 24 hours. The temperature was kept constant at 35°C for the third and fourth days. At the end of the fourth day the temperature was increased to 45°C and raised by 10°C every 48 hours until the end of eight days when the litter was removed. The total temperature gradient from the top of the litter to the collection bowls was approximately 30° (45 – 15) at the end of the extraction period. Four extraction units were operated out of synchrony with the others. While the litter from two sites was undergoing extraction, litter from two other sites was being loaded into the units. This ensured that the litter was always processed within 48 hours from the time of removal from the field.

Invertebrates were collected in ethylene glycol rather than picric acid, a recommended collection media for the Kempson extraction method (Kempson et al., 1963). Trials with the ethylene glycol showed no evidence that glycol was giving off any noxious fumes that might have repelled the animals or causing any other adverse affects and was substituted for picric acid which is highly explosive under certain conditions and also toxic. At the end of each extraction, the glycol was strained through a 0.5mm mesh sieve to remove the invertebrates. After the animals had been removed, the glycol was strained through filter paper using a vacuum flask. Medical

gauze is normally placed at the base of each litter receptacle to reduce the amount of debris falling into the collection media. During this project, an alternative method was used to ensure that the larger macroinvertebrates were not unduly impeded by this barrier. Before each extraction, litter baskets were firmly shaken into a white tray to dislodge any loose litter. This tended to settle the litter sufficiently enough to get relatively clean samples. Any litter that was dislodged was reintroduced into the top of the basket prior to extraction. This technique also helped identify potential escapees that were collected and placed directly into prepared vials containing diluted ethanol to be eventually incorporated into the invertebrate collection. Invertebrates were preserved in diluted ethanol prior to sorting and identification to order and morphospecies (Oliver & Beattie, 1993). After the litter was removed from the extraction units it was placed back into sealed plastic bags ready for oven drying. The procedures adopted for litter analysis is described in following sections.

2.7 Laboratory Methods – Environmental Parameters

2.7.1 Litter Moisture

Litter and woody debris samples that had been pre-weighed, as discussed in the previous section and Section 2.5.2.3, respectively, in their wet state were transferred into weighed paper bags and re-weighed. Each sample was dried to a constant weight in an air forced oven set at 75°C. Heating the samples to a maximum of 75°C left the option open to analyse the chemical properties of the litter if time permitted. Heating litter above 80°C can result in partial pyrolysis causing decomposition of certain organic compounds, volatilisation of some vegetative oils, and the risk of combustion (Reuter, Robinson, Peverill & Lambert, 1997). Moisture content was calculated and expressed as a percentage after allowing for the weight of the paper bag using the following formula:

$$\text{Litter Moisture \%} = \frac{\text{wet weight} - \text{oven dried weight}}{\text{wet weight}} \times 100$$

2.7.2 Litter Structure

Litter was sieved to remove all particles <2mm. It was re-sieved to remove all particles >2mm and <5mm. The remaining litter was sorted into six components: >5mm litter, fruit and flowers, twigs <10mm, woody debris, rock fragments and miscellaneous decomposing matter (charcoal, animal feces etc.). Each component was weighed and expressed as a percentage of the total weight of the litter sample.

2.7.3 Litter Tonnage

The average dry weight of litter removed from five 50 x 50 cm sampling units minus the weight of the <2mm fraction (soil and organic matter particles) and rock fragments was used to calculate t/ha^{-1} of litter at each site.

2.7.4 Soil Moisture

Wet soil samples were assessed for colour and texture. Soil colour was assessed using Munsell Colour Charts (1998). Texture was determined using the adapted Northcote system described in McDonald & Isbell (1990).

Wet soil samples were transferred from sealed plastic bags into pre-weighed paper bags and dried in an air forced oven to a constant weight. The following formula was used to calculate percentage soil moisture after the paper bag weight was taken into account:

$$\text{Soil Moisture \%} = \frac{\text{wet weight} - \text{oven dried weight}}{\text{wet weight}} \times 100$$

2.7.5 Loss on Ignition

Oven-dried soil samples were passed through a 2 mm sieve and the <2mm fraction placed into pre-weighed 100ml crucibles. The crucibles were re-weighed and placed into a laboratory furnace preheated to 500°C. Samples were removed from the furnace after 24 hours and weighed. Loss on ignition (the mass loss of organic matter after ignition) was calculated using the following formula (Froend, 1999):

$$\text{Loss on Ignition} = \frac{\text{mass of oven-dried soil} - \text{mass of ignited soil}}{\text{mass of oven-dried soil}} \times 100$$

2.8 Species Identification

2.8.1 Flora

All attempts were made to identify specimens to species level but in the event that attempts failed the unidentified species were allocated a number. Specimens were also identified into functional groups according to their life form. Species were classified as either shrubs, herbs, grasses, sedges or trees. A number of resources were used to aid classification including Bennett (1988), Wheeler, Marchant & Lewington (2002) and Marchant, Wheeler, Rye, Bennett, Lander & Macfarlane (1987). Specimens were also checked against a Yanchep National Park Plant List (Keighery, 1993), Flora Base, and with voucher specimens held at Edith Cowan University's herbarium. As the survey was carried out during spring, many of the species were in flower aiding identification. Those that were not found in flower during the sampling period and evaded identification by all other means were referred to David Pike, a local plant expert and long term CALM volunteer, who regularly conducts nature walks at Yanchep National Park. Verification was also sought for some species that were difficult to identify. The remaining species in the collection will require verification from the staff at the WA Herbarium at a later date.

2.8.2 Invertebrates

Invertebrates were sorted to ordinal and morphospecies level using a dissecting microscope. Orders were identified with the aid of Harvey and Yen (1989), CSIRO (1991), Zborowski and Storey (1998) and Chu (1949) and presence and absence status recorded.

Not all orders of invertebrates were investigated in this study. Three orders were selected according to the following criteria:

1. the sampling techniques used during the study were suited to the taxa, ensuring that a representative sample of the species richness had been collected,
2. that taxa were collected on at least four replicates of each treatment,

3. taxa had easily distinguishable morphological characteristics, and
4. taxa had shown responses, positive or negative, to plant species richness or vegetation structure in previous studies.

Coleoptera, Hempitera and Araneae satisfied these criteria. The Kempson dry funnel extractor is reported to have relatively high efficiency rates in separating these orders from a range of soils and vegetation types (Edwards, 1991). Its main drawback is its bias towards the smaller, slower moving animals (Southwood & Henderson, 2000), however, the larger more mobile fauna were readily captured by hand sorting. These groups were well represented throughout the study and fulfilled all of the criteria set for the selection of orders.

Each order selected for the study was sorted to 'morphospecies' and each morphospecies identified was treated as one species for the purposes of invertebrate species richness counts. The protocols for this system of classification are described in Oliver and Beattie (1993). This method provides the means for a rapid assessment of biodiversity where taxa are sorted by morphological characteristics rather than by taxonomic differences. The method is advantageous because it does not require specialist taxonomists. A study demonstrated that estimates of species richness made by biodiversity technicians using this method were sufficiently close to formal taxonomic estimates of species richness and is advocated as a useful approach to rapid biodiversity assessments (Oliver & Beattie, 1993).

2.9 Data Analysis

Statistical analysis was performed using SPSS v10 and PRIMER v5 for all data that fulfilled the assumption of independence. Both methods were adopted because only the between treatment, (species richness) and across treatment (vegetation type) data normalised using a Log (x + 1) transformation. The normalised data was analysed using SPSS parametric 2-way ANOVA statistical tests. PRIMER (ANOSIM permutations 10 000) was used to analysis data that failed to normalise and therefore violated one of the major assumptions of ANOVA. Data measured

from the five 1m^2 plots located within each replicate was averaged prior to data analysis.

As many of the environmental parameters failed to normalised after transformation, non-parametric Kruskal-Wallis (SPSS) tests were performed on the coarse scale data.

At the fine scale or (100m^2) the plots were not independent consequently invertebrate species richness and the biotic and abiotic parameters measured at this scale were analysed using SPSS Spearman's rank order correlations. Cross correlations, between these parameters, were also investigated using Spearman's rank order correlations. These results are provided in Appendix 8 which demonstrate the complexity and the inter relationships that exist between invertebrates and their environment.

Table 2.4 provides a summary of the parameters and the scales at which each parameter was measured during the study.

CHAPTER THREE

RESULTS

3.1 Overview

During the study four floristic communities referred to as the 'treatments' were surveyed. Two treatments were located in woodland and two in heath. The woodland treatments comprised a floristically rich Low Woodland A (Muir, 1977) dominated by *Banksia attenuata, B. menziesii* and depending on the location of the replicate either scattered *Eucalyptus todtiana* or *E. marginata*. This treatment compares with a relatively restricted *Banksia attenuata* with scattered *B. ilicifolia* and *Melaleuca preissiana* Low Woodland A that supported fewer plant species. These communities are referred to as Woodland Rich (WR) and Woodland Poor (WP).

The heath treatments, distinguished by their dominant shrubs, were highly restricted in their distribution. A community dominated by *Melaleuca systena, Acacia lasiocarpa* and *Baeckea robusta* and characteristic of Dense Low Heath D (Muir, 1977) supported higher plant species richness than a community dominated by *Melaleuca systena* and *M. huegelii*. This community was characteristic of a Dense Low Heath C by virtue of the height of the shrub stratum (Muir, 1977). These communities will be referred to as Heath Rich (HR) and Heath Poor (HP). The plant species richness for each treatment is presented in Table 3.1 along with a summary of the vegetation communities sampled. Photos that demonstrate the differences between these communities are provided in Plate 3.1. The dominant understorey species of these vegetation communities are described for individual replicates in Appendix 2 and full species lists are provided in Appendix 3.

Four approaches were adopted to investigate the influence of plant species richness on invertebrate richness. Initially the effect of overall plant species richness

Table 3.1 Summary of the vegetation communities sampled in the Ridges extension of the Yanchep National Park and the corresponding plant species richness of each replicate

Treatment	Replicate Number	Plant Species Richness Replicate	Average Plant Species Richness Plot	Vegetation Type	Dominant Plant Species
Woodland Rich	WR1	55	10.8	Low Woodland A	*Banksia attenuata, B. menziesii & Eucalyptus todtiana*
	WR2	53	11.8	" " "	*Banksia attenuata, B. menziesii & Eucalyptus todtiana*
	WR3	52	11.8	" " "	*Banksia attenuata, B. menziesii & Eucalyptus todtiana*
	WR4	53	16	" " "	*Banksia attenuata, B. menziesii & Eucalyptus marginata*
	WR5	49	12	" " "	*Banksia attenuata, B. menziesii & Eucalyptus marginata*
Woodland Poor	WP1	44	8	Low Woodland A	*Banksia attenuata, B. ilicifolia & Melaleuca preissiana*
	WP2	37	11.4	" " "	" " " " " " "
	WP3	35	7.6	" " "	" " " " " " "
	WP4	40	12	" " "	" " " " " " "
	WP5	36	10.6	" " "	" " " " " " "
Heath Rich	HR1	52	18.2	Dense Low Heath D	*Melaleuca systena, Acacia lasiocarpa & Baeckea robusta*
	HR2	45	14.6	" " " "	" " " " " " "
	HR3	48	13	" " " "	" " " " " " "
	HR4	50	18.2	" " " "	" " " " " " "
	HR5	53	16.2	" " " "	" " " " " " "
Heath Poor	HP1	36	14.2	Dense Low Heath C	*Melaleuca systena & M. huegelii*
	HP2	37	13.4	" " " "	" " " " "
	HP3	39	13.2	" " " "	" " " " "
	HP4	30	13.2	" " " "	" " " " "
	HP5	29	15	" " " "	" " " " "

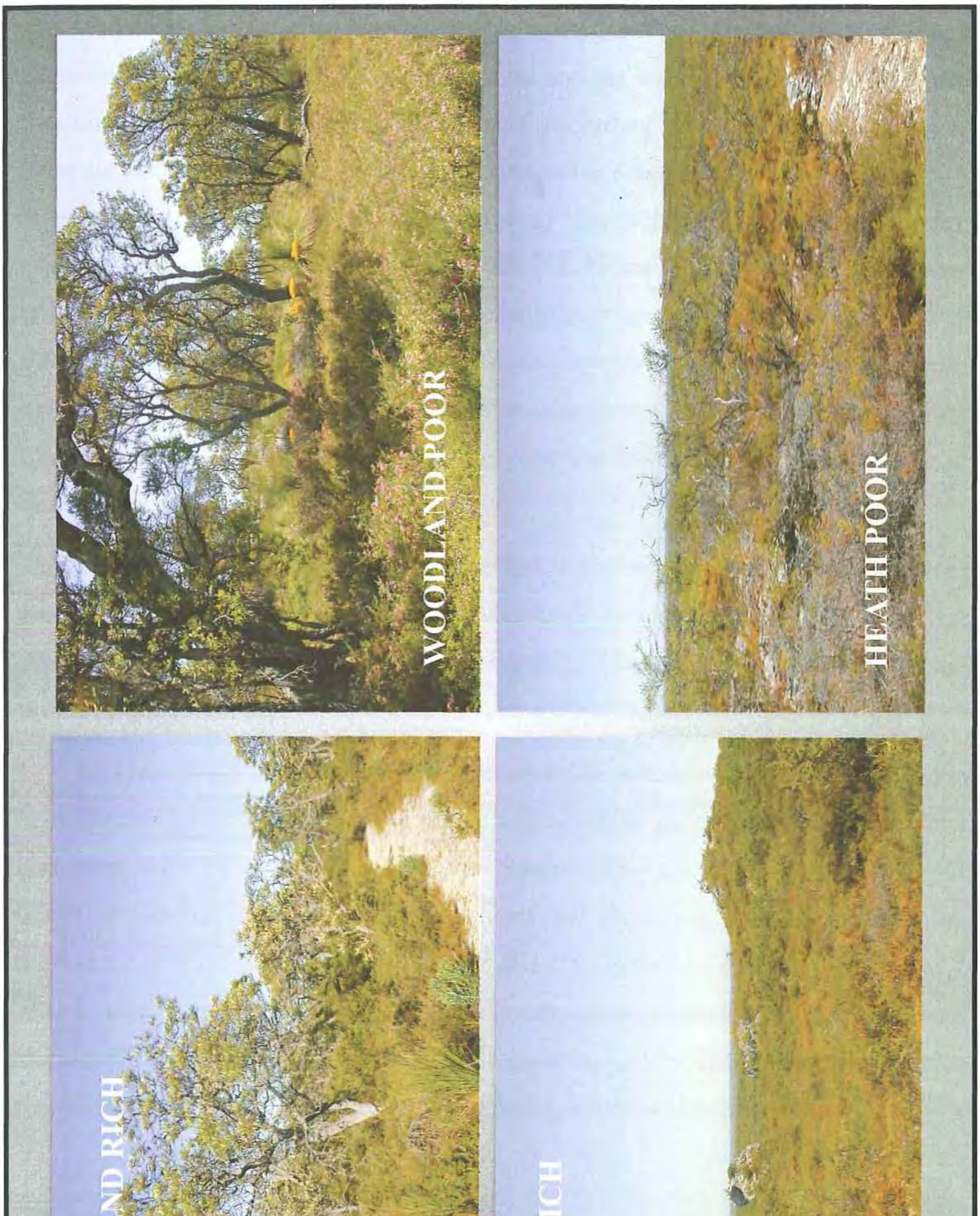


Plate 3.1 Photos showing the rich and poor woodland and heath plant species rich treatments that were studied in the Ridges State Forest Block

was investigated. Statistical tests were also carried out using plant life forms as a possible influencing factor. In addition, plant species were allocated an importance (dominance) value on a scale from 1 to 7 according to either species rarity or percentage cover and hence their contribution to the litter layer. Finally the effect of scale was investigated. This aspect of the study was facilitated by the nested design of the experiment that is explained in Section 2.2. Hence the 10 x 10 m replicates are referred to as the 'coarse scale' of measurement. A reference to coarse scale indicates that the values are either actual counts or measurements or are averages derived from the 1 m^2 plots that are located within individual replicates. Fine scale refers to values from individual 1 m^2 invertebrate sampling plots that have not been averaged prior to statistical analysis.

Two-way ANOVAs that were used to test if a relationship exists between plant species richness and ground dwelling invertebrate species richness failed to detect any significant differences between treatments. The results for these tests are provided in Section 3.3.

At a fine scale, Spearman's rank order correlation tests were used to investigate invertebrate relationships with certain environmental parameters that were then compared with the coarse scale results. Spearman's rank order correlation tests demonstrated that scale is an important factor that can strongly influence results. A number of relationships that were evident at a fine scale could not be detected at a coarse scale. It would appear that scale is an important consideration in invertebrate studies. Consequently the scale of measurement should be clearly stated otherwise results maybe misleading resulting in poor management decisions.

3.2 Floristic Survey

During the study 167 plant specimens were collected. All but three specimens were identified to species level. A species list of all plants, excluding mosses, collected during the survey is provided in Appendix 5. The information gained from the survey produced data sufficient to test if there is any relationship between plant species richness and invertebrate richness. The differences between the rich and poor treatments are demonstrated in Figure 3.1.

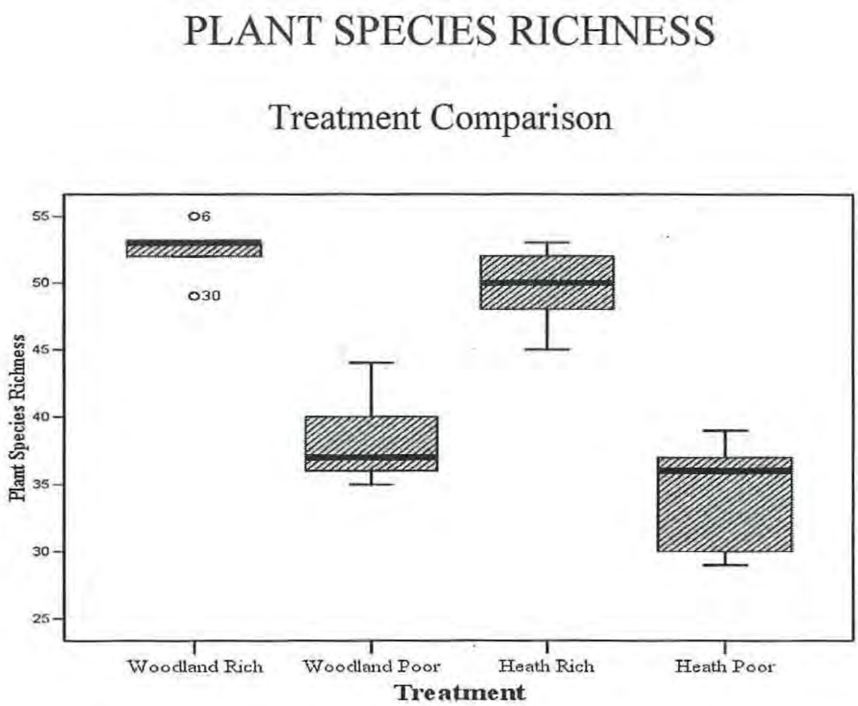


Figure 3.1 Boxplot showing the median, 25th and 75th percentiles that demonstrate the range of plant species richness sampled on four replicated treatments. The boxplot shows that there was a significant difference between the treatments that supported high plant species richness and those that supported a lower level of plant species richness

3.2.1 Plant Species Richness at the Coarse Scale

At this scale, woodland rich (WR) replicates supported more plant species than the other treatments. Species counts ranged between 49 and 55 with an average of 52 species. The maximum number of species recorded for any one replicate during the study was 55. Heath rich (HR) replicates were marginally lower. They ranged between 45 and 53 with an average of 50 species. There was a marked difference in species richness for the heath species poor treatment. Average plant species richness for this treatment was 34 with replicates ranging from 29 up to 39. Species richness for this treatment not only ranged more widely than the other treatments but one of the replicates had the lowest species count recorded during the study. Woodland poor (WP) replicates supported slightly more species than HP that averaged 38 species across the treatment with replicates ranging between 35 and 44 species.

3.2.2 Plant Species Richness at the Fine Scale

The average plant species richness of the 1 m^2 plots is summarised in Table 3.1 and described in detail in Appendix 2 which provides the details of each replicate sampled during the study. Overall, plots showed only slight variations in species richness. Woodland poor plots varied more widely than the plots located in the other treatments with mean species richness ranging between 7.6 and 12 species per 1 m^2 plot. Overall, woodland treatments were more variable than heath. The plant species richness of the HP plots varied only slightly across the treatment with mean species richness ranging between 13.2 and 15 species per 1 m^2 plot.

A Spearman's rank order correlation indicated that there was no relationship between mean plant species richness of plots and the richness of the replicate in which they were located. Figure 3.2 demonstrates that there is no association between the two scales of measurement (r_s = 0.177, d.f. 19, P = 0.454). Spearman's rank order correlations that support this outcome are provided in Table 3.1.

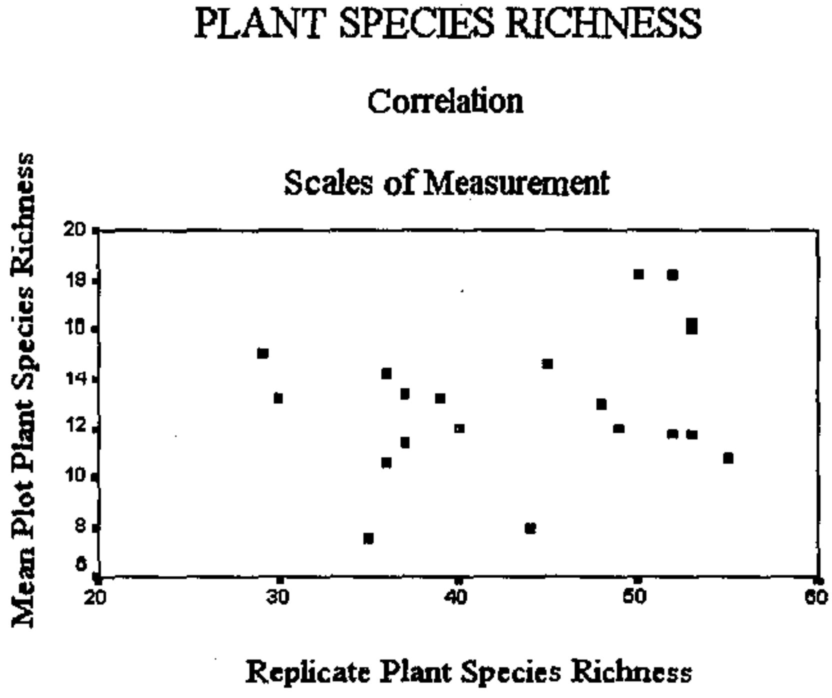


Figure 3.2 Scatterplot demonstrating that there is no relationship between the plant species richness of individual invertebrate sampling plots and the replicates in which they are nested.

Table 3.2 Spearman's rank order correlations that demonstrate the relationship between plant species richness, various plant life forms and species importance values (based on percentage cover) and the invertebrate groups studied

PLANT SPECIES RICHNESS	INVERTEBRATE GROUP									
	Orders	Coleoptera	Hemiptera	Araneae	Total Species	Orders	Coleoptera	Hemiptera	Araneae	Total Species
Plant Species Richness										
Plot Scale (n =100)	-0.62	0.06	**0.281***	-0.036	0.124					
Replicate Scale (n = 20)	0.329	0.223	0.152	0.306	0.26	-0.244	-0.077	0.222	-0.293	-0.085
Life Form Richness										
Plot Scale (n = 100)										
Shrubs	**0.225***	**0.243***	0.164	0.169	**0.227***					
Herbs	**-0.257***	-0.119	**0.196***	**-0.210***	-0.058					
Grasses & Sedges	-0.051	0.013	0.167	-0.044	0.069					
Replicate Scale (n = 20)										
Shrubs	0.384	0.21	0.065	0.254	0.23	**0.456***	0.339	0.218	0.189	0.345
Herbs	0.222	0.161	0.219	0.142	0.184	-0.351	-0.22	-0.005	-0.344	-0.24
Grasses & Sedges	-0.145	-0.206	-0.091	-0.1	-0.18	-0.276	-0.116	0.216	-0.348	-0.145
Importance/Cover Values										
> 1%	0.093	0.155	0.189	0.092	0.179	0.246	0.077	0.163	0.051	0.138
> 5%	0.016	0.161	0.154	0.034	0.152	-0.091	0.06	0.254	-0.182	0.081
> 10%	0.068	0.172	0.127	-0.119	0.067	-0.019	0.066	0.287	-0.441	0.017
> 25%	0.181	0.143	0.155	0.121	0.172	-0.043	0.08	**0.487***	-0.439	0.027
> 50%	0.015	0.004	**- 0.208***	0.102	-0.05	-0.118	0.052	-0.046	0.196	0.101
> 75%	0.053	-0.083	**- 0.209***	0.045	-0.094	-0.388	-0.216	-0.327	0.013	-0.199

***P < 0.05; **P < 0.01**

The plant species richness of individual plots varied not only between treatments but within treatments. The average plant species richness of the WP plots (9.92) was considerably lower than the HP plots (13.8). This compares with an average of 12.48 species for the WR and 16.04 for the HR plots. For a summary of these results refer to Table 3.1

3.2.3 Life Form

All plant specimens collected during the study were classified into their functional groups according to their life form. Five categories were recognised including trees, shrubs, herbs, grasses and sedges. The contribution each category made to overall plant species richness was investigated at both scales of measurement. Refer to Appendices 2 and 3. These appendices provide species counts and a species inventory that indicates the various life forms of each species present on the replicates. The proportional contribution that the different life form categories contributed to each replicate is demonstrated in Figure 3.3. The pie charts represent average plot species counts. It should be noted that none of the plots sampled supported mature trees. Although some tree species were present they were saplings less than 2 m in height and have been included in the shrub count. Due to the low numbers of grasses and sedges encountered during the study they have been grouped together for the purposes of statistical analysis.

3.2.4 Life Form Species Richness at the Coarse Scale

Trees were present in all of the replicates surveyed in the woodland treatments, with the exception of one that was located in the WP treatment. These treatments were located in Low Woodland A where canopy cover characteristically ranged between 10 – 30% (Muir, 1977). Two replicates, one in WR and the other in WP exceeded this range (refer to Appendix 2). Woodland rich replicates averaged 22% and WP 14% canopy cover. A one-way analysis of similarity (ANOSIM) indicated that the treatments varied significantly in the number of shrub species they supported ($R = 0.651$, $p < .001$). Herbs and grasses were also significantly different between treatments. A one-way ANOSIM indicated that grasses ($R = 0.173$, $p < .05$) were slightly more variable than herbs ($R = 0.161$, $p < .05$). Pairwise R statistic comparisons are provided in Table 3.3.

Table 3.3 ANOSIM analysis results showing all significant global R statistics and pairwise comparisons for plant species richness, life form and importance values that were compared between plots and replicates

PLANT SPECIES RICHNESS	SCALE PLOT (1M2)					SCALE REPLICATE (100M2)				
	GLOBAL R	GLOBAL p %	REP. No.	PAIRWISE* R	PAIRWISE* Level %	GLOBAL R	GLOBAL p %	REP. No.	PAIRWISE* R	PAIRWISE* Level %
Life Form										
Shrubs	0.279	0.5				0.651	0			
			1, 4	0.776	0.8			1, 2	0.784	0.8
			3, 4	0.77	0.8			1, 4	1	0.8
								2, 4	0.932	0.8
								3, 4	0.988	0.8
Herbs	0.451	0				0.161	7.2			
			1, 3	0.768	1.6			2, 3	0.548	3.2
			1, 4	1	0.8					
			2, 3	0.326	4.8					
			2, 4	0.64	0.8					
Grass/Sedges	0.491	0				0.173	2.1			
			1, 2	0.414	4			1, 2	0.356	2.4
			1, 3	0.466	2.4			2, 3	0.462	1.6
			1, 4	0.452	0.8					
			2, 3	0.86	0.8					
			2, 4	0.844	0.8					
Importance Values										
< 1%	0.223	1.3								
			1, 4	0.34	3.2					
			2, 3	0.308	4					
			3, 4	0.668	0.8					
< 5%	ns	ns								
< 10%	ns	ns								
< 25%	ns	ns								
< 50%	ns	ns								

* R Significance levels above 5% not shown

REF. NO. = 1 - Woodland Rich; 2 - Woodland Poor; 3 - Heath Rich; 4 - Heath Poor

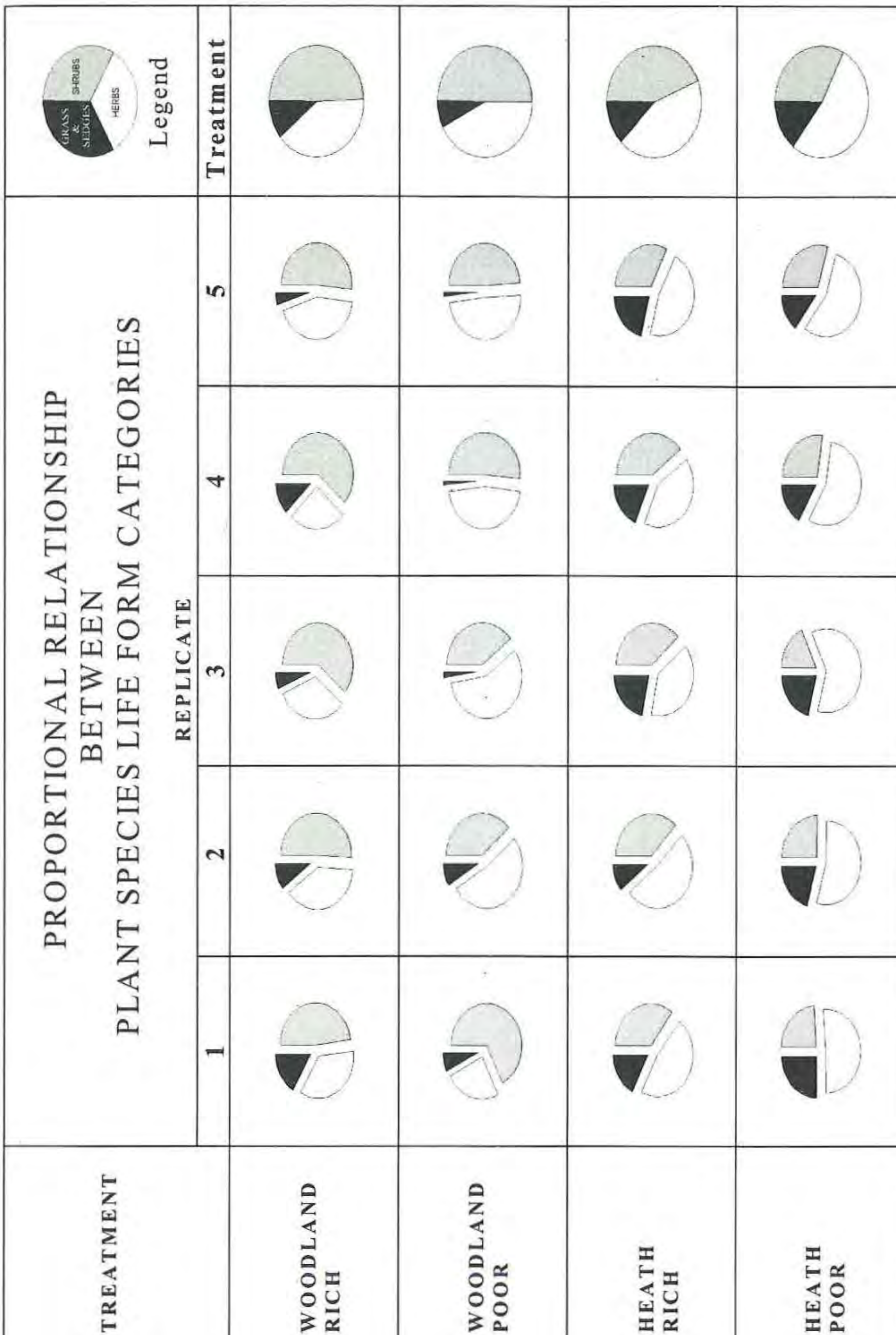


Figure 3.3 Proportional relationship between various plant species life forms derived from mean species counts of each life form category on $1m^2$ invertebrate sampling plots located within replicates

Spearman's rank tests demonstrated that there is a positive relationship between the species richness of shrubs and the plant species richness of the replicates (r_s = 0.867, d.f. 19, P<0.001), and herbs (r_s = 0.714, d.f. 19, P <0.001), and to a slightly lesser extent grasses/sedges (r_s = 0.624, d.f. 19, P <0.05).

3.2.5 Life Form Species Richness at the Fine Scale

The contribution each life form made to plant species richness on individual plots differed from that of the replicates consequently the scale of sampling can produce conflicting results. This is a confounding factor that may have significant implications in invertebrate studies.

There was a significant difference between the plot life form composition across all treatments. Life form species richness did not necessarily track the overall plant species richness of the replicates as demonstrated in Figure 3.3. Although shrubs reflect the species richness of the replicate (ANOSIM, R = 0.279, p <.05), species rich treatments do not necessarily support more herbs or grasses. Heath plots have an extremely rich herb layer in comparison to woodland plots. Woodland rich plots had fewer herb species than plots on the other treatments. Appendix 3 provides the full details of the life form composition for each replicate. Highly significant results were obtained from one-way analysis of similarity (ANOSIM) that demonstrated that grass species richness (R = 0.491, p <.001) or herb (R = 0.451, p <0.001) species richness is representative of the plant species richness status of the treatment. Grasses and sedges were also poorly represented in the woodland especially in WP. A summary of the pairwise R statistics comparisons is provided in Table 3.3. These findings were confirmed by Spearman rank order correlations. They indicated that shrub species richness was highly correlated with treatment plant species richness (r_s = 0.684, d.f. 19, P <0.001) but there were no associations evident for herbs and grasses.

3.2.6 Importance Value

Importance values ranging between 1 – 7 were allocated to all plant species that were present on the 1 m^2 plots (refer to Section 2.4.1). Values were allocated according to percentage cover in an attempt to isolate out species that contributed little to the litter layer. These values provided the means to manipulate plant species

richness to determine if there was a threshold whereby plant species richness ceased to play a role in invertebrate richness, however, no meaningful results were obtained using this approach. Full details of the species present and their relative importance values are provided in Appendix 3.

A one-way analysis of similarity (ANOSIM) indicated that, despite the exclusion of all species that contributed less that 1%, the plant species richness of the plots remained significantly different for at least half of the treatments ($R = 0.223$, $p < .05$). When plant species contributing between 1 and 5% cover were also excluded, plots on the various treatments shared similar plant species richness levels. Pairwise R statistic results for these tests are provided in Table 3.3.

Consistent patterns across treatments were also evident. Approximately 2/3rds of the plant species present in the $1m^2$ plots contributed less than 5% of the total cover. Approximately 50% of all the species present contributed less than 1% of total cover. This pattern was observed in all but one treatment, WR, where the number of species in the 1-5% category was significantly higher than those present in the other treatments. Few species contributed more than 50% to the overall cover. Less than 2% plant species fell within the 51-75% and 76-100% categories. The exception was WP where, on average, almost 4% of the species contributed between 51-75% cover. When categories 3, 4 and 5 that relate to cover values ranging between 6 – 50% are summed, average values tended to reflect the treatment richness, however, the differences between treatments were not significant. The only treatment that exhibited strong correlations between replicate plant species richness and importance value was the WP treatment. A positive correlation between importance values and replicate species richness was demonstrated in the 6-10% category but negatively correlated for the 51-75% cover range. A full summary of the percentage breakdown and average species counts for each category is provided in Appendix 4.

3.3 Invertebrate Survey

The relationship between plant species richness and invertebrate richness was investigated at the ordinal level and three orders were sorted to morphospecies for in depth investigation. The orders selected for the study were Araneae, Coleoptera and

Hemiptera. The number of species collected from each of these orders, were summed to give a 'total species' count prior to analysis. The five groups were analysed using 2-way ANOVAs (SPSS) at both the coarse ($100m^2$) and fine ($1m^2$) scales. No significant relationship could be detected at either scale for any of the groups with the exception of Hemiptera that demonstrated a significant relationship with plant species richness at a fine scale of measurement. The results are summarised in Table 3.4 and discussed in detail in the following sections.

3.3.1 Ordinal Richness

Twenty-seven orders of invertebrates were collected during the study. This included a rich fauna of Insecta, Arachnida, Collembola and to a lesser extent, Diplopoda, Chilopoda, Malacostraca and Diplura. Twenty orders were represented on every treatment except WR where 23 orders were collected. The cumulative curve shown in Figure 3.4 indicates that most of the orders present on all the treatments, except WR, were collected during the study.

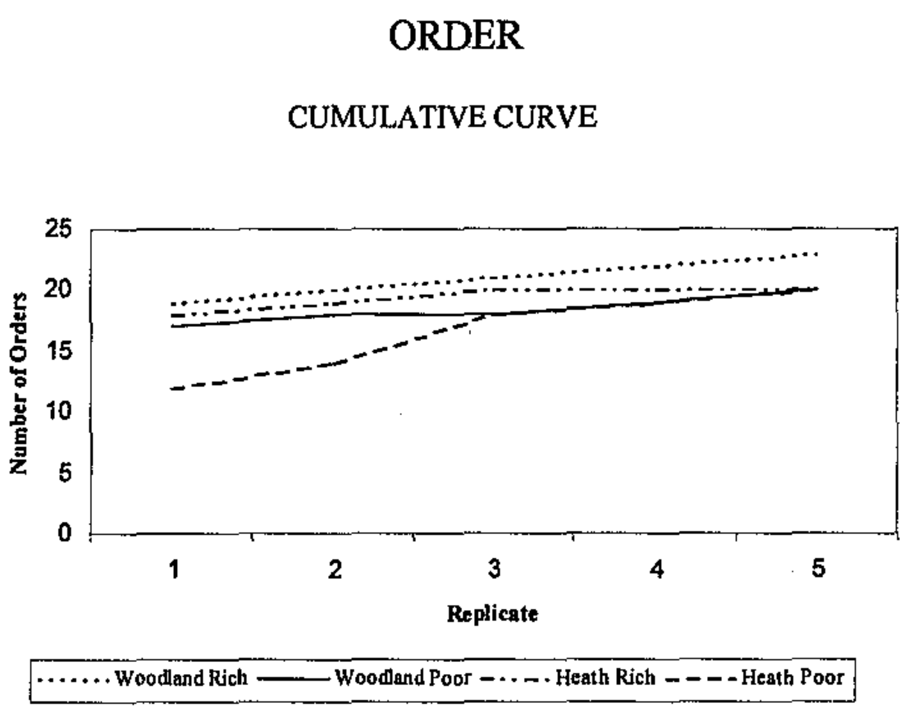


Figure 3.4 Cumulative graph representing the number of Orders collected from five successive replicates of each treatment sampled in the vicinity of the Yanchep National Park

Table 3.4 Summary of 2-way ANOVAs showing the relationship that exists between plant species richness, vegetation association, the interaction between factors and ground dwelling invertebrate richness at two scales of measurement

INVERTEBRATE GROUP		SCALE PLOT (1m2)					SCALE REPLICATE (100m2)				
	Factor	d.f.	SS	MS	*F*-ratio	*P*-value	d.f.	SS	MS	*F*-ratio	*P*-value
Order	Plant Species Richness	1	0.03	0.03	0.207	0.651	1	0.013	0.013	0.318	0.581
	Vegetation Association	1	0.226	0.226	1.569	0.213	1	0.159	0.159	3.895	0.066
	Interaction	1	0.003	0.003	0.018	0.894	1	0	0	0.004	0.954
	Error	96	13.802	0.144			16	0.653	0.041		
Araneae	Plant Species Richness	1	1.137	1.137	3.276	0.073	1	0.032	0.032	0.193	0.666
	Vegetation Association	1	0.835	0.835	2.406	0.124	1	0.285	0.285	1.739	0.206
	Interaction	1	0.607	0.607	1.75	0.189	1	0.289	0.289	1.764	0.203
	Error	96	33.305	0.347			16	2.621	0.164		
Coleoptera	Plant Species Richness	1	0.056	0.056	0.101	0.751	1	0.029	0.029	0.035	0.853
	Vegetation Association	1	0.206	0.206	0.375	0.542	1	0.072	0.072	0.088	0.771
	Interaction	1	0.272	0.272	0.493	0.484	1	0.238	0.238	0.289	0.598
	Error	96	52.866	0.551			16	13.136	0.821		
Hemiptera	Plant Species Richness	1	1.755	1.755	5.773	0.018*	1	0.092	0.092	0.513	0.484
	Vegetation Association	1	0.874	0.874	2.876	0.093	1	0.031	0.031	0.17	0.685
	Interaction	1	0.969	0.969	3.187	0.077	1	0.023	0.023	0.131	0.723
	Error	96	29.178	0.304			16	2.876	0.18		
Total Species	Plant Species Richness	1	1.41	1.41	3.165	0.078	1	0.018	0.018	0.068	0.798
	Vegetation Association	1	0.02	0.02	0.045	0.833	1	0.076	0.076	0.289	0.598
	Interaction	1	0.035	0.035	0.078	0.78	1	0.21	0.21	0.804	0.383
	Error	96	42.757	0.445			16	4.174	0.261		

*P < 0.05; **P < 0.001

No relationship was found between ordinal richness, plant species richness, vegetation association and the interaction between the two factors, however, a relationship was found for certain life forms and ordinal invertebrate richness at the 1 m^2 scale and at this scale of measurement when averaged across replicates. Spearman's rank correlations (as demonstrated in Table 3.2) indicate that there is an association between ordinal richness and the number of shrubs (r_s = 0.225, d.f. 99, P <0.05), (r_s = 0.456, d.f. 99, P <0.05) and herbs (r_s = -0.257, d.f. 99, P <0.05). This association was not evident at the coarse scale (n = 20). Table 3.5 summarises the ordinal richness presence-absence data and detailed information for each replicate is presented in Appendix 6.

One-way analysis of similarity (ANOSIM) indicated that there were significant differences in ordinal richness within treatments at the replicate scale. There is evidence to suggest that weather patterns might have been responsible for the result. The literature documents that invertebrates are extremely sensitive to climate (Curry, 1987; Koch & Majer, 1980; Majer & Koch. 1982). The WP treatment demonstrated the highest degree of variation between replicates returning a global test statistic of (R = 0.346, p <0.001). Pairwise R statistic comparisons also revealed significant values > .7 between certain replicates sampled within the other treatments. The ANOSIM results are provided in Table 3.6.

3.3.2 Morphospecies Richness

A total of 187 invertebrate morphospecies, referred to as 'species' were identified during the study. Only three orders satisfied the criteria set for the selection of orders to be investigated during the project in detail (see Section 2.8.2). The responses of each order, to the treatments applied, are investigated and discussed in the following sections. There was, however, no direct response from any of these groups to plant species richness between treatments. The study has shown, however, that certain invertebrate groups may be indirectly associated with plant species richness.

Table 3.5 Summary of ordinal richness presence-absence data for four treatments representing different levels of plant species richness

CLASS	ORDER	WOODLAND RICH	WOODLAND POOR	HEATH RICH	HEATH POOR
Arachnida	Araneae	1	1	1	1
	Pseudoscorpionida	1	1	1	1
	Acarina	1	1	1	1
	Opilionida	0	0	0	1
Malacostraca	Isopoda	1	1	1	0
Chilopoda	Scolopendrida	1	0	1	0
	Geophilida	1	1	0	1
Diplopoda	Polyxenida	1	1	1	1
	Julida	1	0	0	0
Collembola	Collembola	1	1	1	1
Diplura	Diplura	1	1	1	1
Insecta	Thysanura	1	1	1	1
	Blattodea	1	1	1	1
	Isoptera	1	1	0	0
	Mantodea	0	0	1	0
	Dermaptera	1	1	0	1
	Orthoptera	1	1	1	0
	Phasmatodea	1	1	1	1
	Psocoptera	1	1	1	1
	Hemiptera	1	1	1	1
	Thysanoptera	1	1	1	1
	Neuroptera	1	0	0	1
	Coleoptera	1	1	1	1
	Mecoptera	0	0	0	1
	Diptera	1	1	1	1
	Lepidoptera	0	0	1	0
	Hymenoptera	1	1	1	1
TOTAL ORDERS		23	20	20	20

3.3.2.1 Araneae

A total of 55 Araneae (spider) species were collected during the study. A 2-way ANOVA (SPSS) demonstrated no significant relationship exists between plant species richness, vegetation association or the interaction between these two factors and Araneae irrespective of the scale of measurement. The results are shown in Table 3.4. Presence absence data for Araneae are summarised in Table 3.7 with supporting data provided in Appendix 7A.

Although Araneae species richness does not appear to be related to plant species richness there were significant differences in species richness within treatments and Spearman's rank order correlations suggest that this order demonstrates a preference for vegetation type.

Almost half of the species were collected in the woodland treatments with equal numbers identified on both high plant species richness and low plant species rich treatments. Twenty-one species of Araneae were identified in HR. Heath species poor replicates returned the lowest number of species with only 12 species identified. The species cumulative curves shown in Figure 3.5 suggest that most of the species present were collected on all but the WP treatment. Whilst cumulative curves for the other treatments demonstrate some levelling out there is a steep rise evident for the WP treatment. However, there was clear evidence that weather patterns strongly influenced the numbers of invertebrates collected from replicates. Had the other treatments been sampled during cooler conditions or shortly after rain they might also display a similar trend as the WP treatment.

Spearman's rank order correlation indicates that there is a significant negative association between Araneae and herb species richness ($r_s = -0.210$, d.f. 99, $P < 0.05$). Although evident at a fine scale it could not be demonstrated at the coarse scale or when plot life form species numbers were averaged for each replicate. A summary of the correlation results is provided in Table 3.2.

Table 3.6 ANOSIM analysis results showing all significant global R statistics and pairwise comparisons for invertebrate richness and four replicated treatments that supported either high or low plant species richness

INVERTEBRATE GROUP	WOODLAND RICH					WOODLAND POOR					HEATH RICH					HEATH POOR				
	GLOBAL		REP. PAIRWISE*			GLOBAL		REP. PAIRWISE*			GLOBAL		REP. PAIRWISE*			GLOBAL		REP. PAIRWISE*		
	R	p %	No.	R	Level %	R	p %	No.	R	Level %	R	p %	No.	R	Level %	R	p %	No.	R	Level %
Orders	0.207	0.7				0.346	0				0.274	0.6				0.259	0.6			
			1, 5	0.692	0.8			1, 2	0.42	2.4			1, 2	0.656	2.4			1, 4	0.58	0.8
			3, 4	0.446	2.4			1, 3	0.36	4.8			1, 5	0.748	0.8			2, 4	0.66	0.8
			4, 5	0.76	0.8			2, 3	0.324	4.8			2, 3	0.528	3.2			3, 4	0.819	0.8
								2, 4	0.444	2.4			3, 5	0.384	4			4, 5	0.468	2.4
								2, 5	0.492	1.6										
								3, 4	0.776	0.8										
								3, 5	0.612	2.4										
Total Species	0.634	0				0.275	0.6				ns	ns				0.177	2.4			
			1, 2	0.912	0.8			1, 3	0.608	1.6								1, 4	0.713	0.8
			1, 3	0.972	0.8			3, 4	0.7	1.6								2, 4	0.702	1.6
			1, 5	0.984	0.8			3, 5	0.612	1.6										
			2, 4	0.664	0.8															
			2, 5	0.8	0.8															
			3, 4	0.864	0.8															
			3, 5	0.572	2.4															
			4, 5	0.964	0.8															

* R Significance levels above 5% not shown

Table 3.6 Cont... ANOSIM analysis results showing all significant global R statistics and pairwise comparisons for invertebrate richness and four replicated treatments that support either high or low plant species richness

INVERTEBRATE GROUP	WOODLAND RICH					WOODLAND POOR					HEATH RICH					HEATH POOR				
	GLOBAL R	GLOBAL p %	REP. No.	PAIRWISE* R	PAIRWISE* Level %	GLOBAL R	GLOBAL p %	REP. No.	PAIRWISE* R	PAIRWISE* Level %	GLOBAL R	GLOBAL p %	REP. No.	PAIRWISE* R	PAIRWISE* Level %	GLOBAL R	GLOBAL p %	REP. No.	PAIRWISE* R	PAIRWISE* Level %
Araneae	ns	ns				ns	ns				ns	ns				ns	ns			
Coleoptera	0.367	0.6				ns	ns				ns	ns				0.387	0.4			
			2, 4	0.644	0.8													2, 3	0.775	1.6
			3, 4	0.891	4.8													3, 4	0.591	4.8
Hemiptera	0.323	0.6				ns	ns				0.186	3								
			1, 2	0.76	0.8								1, 2	0.374	4					
			1, 3	0.92	0.8								1, 5	0.542	4.8					
			1, 5	0.897	1.8								2, 5	0.268	4.8					

* R Significance levels above 5% not shown

Table 3.7 Summary of the total number of morphospecies collected from the invertebrate orders Araneae, Coleoptera and Hemiptera from four treatments that supported either high or low levels of plant species richness

ORDER	TREATMENT	REPLICATE 1					REPLICATE 2					REPLICATE 3					REPLICATE 4					REPLICATE 5					TOTAL
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	SPECIES
Araneae	Woodland Rich	7	4	3	2	8	4	3	5	2	3	3	3	1	3	3	8	1	6	3	6	1	1	0	2	0	32
	Woodland Poor	0	3	5	1	3	1	0	9	4	1	2	3	1	2	2	6	5	5	1	3	7	5	9	0	3	31
	Heath Rich	2	1	1	3	4	0	5	7	3	3	2	4	3	5	4	1	3	5	4	1	2	3	1	5	2	21
	Heath Poor	1	0	2	1	2	1	1	1	2	2	5	1	3	3	0	2	3	2	2	6	0	5	0	0	2	12
Total Morphospecies																											55
Coleoptera	Woodland Rich	10	6	2	4	6	2	3	0	1	2	2	0	0	1	0	8	5	4	4	4	0	0	0	0	1	30
	Woodland Poor	2	4	4	3	6	0	0	8	0	0	0	0	0	0	0	7	3	5	2	4	5	4	9	2	3	34
	Heath Rich	8	2	4	2	6	0	1	1	3	1	1	6	4	2	2	1	7	3	2	1	0	0	0	2	0	27
	Heath Poor	1	0	0	0	0	3	2	3	3	3	1	1	0	2	1	4	4	2	2	4	0	2	0	2	3	25
Total Morphospecies																											73
Hemiptera	Woodland Rich	5	7	6	7	5	2	1	3	3	1	2	1	3	2	2	5	3	1	7	5	1	0	1	0	3	30
	Woodland Poor	2	3	3	1	2	0	0	3	1	0	0	0	3	0	0	2	0	4	1	2	3	2	3	2	1	22
	Heath Rich	4	3	3	3	5	2	2	1	2	3	2	5	2	1	3	3	6	3	4	1	5	1	1	1	1	21
	Heath Poor	3	0	0	0	3	1	2	2	1	3	4	1	4	3	1	2	6	5	6	3	2	5	3	4	2	20
Total Morphospecies																											59

3.3.2.2 Coleoptera

A total of 73 Coleoptera (beetle) species were collected during the study. A 2-way ANOVA demonstrated that there was no significant relationship between plant species richness, vegetation association or the interaction between these factors and Coleoptera species richness irrespective of the scale of measurement. The results are summarised in Table 3.4.

Significant within treatment differences, between species numbers, was indicated by one-way ANOSIM tests. There were large variations between the replicates in WR ($R = 0.367$, $p < 0.05$) and HP ($R = 0.387$, $p < 0.05$). Pairwise R statistic comparisons revealed differences with significance values exceeding 7.5 for two WR replicates. No significant results were obtained from the other treatments. A summary of the pairwise R statistics is provided in Table 3.6. The woodland poor replicates supported 34 species that was slightly more than the number collected from the WR replicates. Heath treatments had fewer species with HR supporting 27 species and HP supporting 25 species.

Spearman's rank order correlations failed to demonstrate any relationship between overall plant species richness and Coleoptera richness. There was, however, an indication that there was a positive association between the number of Coleoptera collected and the number of shrub species present ($r_s = 0.243$, d.f. 99, $P < 0.05$). This result was not repeated at the coarse scale and was not evident when plot shrub species numbers were averaged for each replicate (refer to Table 3.2).

The cumulative curve shown in Figure 3.5 suggests that the study did not adequately sample the plant species poor treatments. Coleoptera species presence absence data is summarised in Table 3.7 with supporting data provided in Appendix 7B.

3.3.2.3 Hemiptera

A total of 59 Hemiptera (bugs) species were collected during the study. The Sternorrhyncha group were not included in the count as there are few distinguishing morphological characterstics displayed by some members of this group and identification to morphospecies level was less conclusive.

A 2-way ANOVA (SPSS) demonstrated that there is no significant difference in the numbers of Hemiptera species collected on the various treatments at the coarse

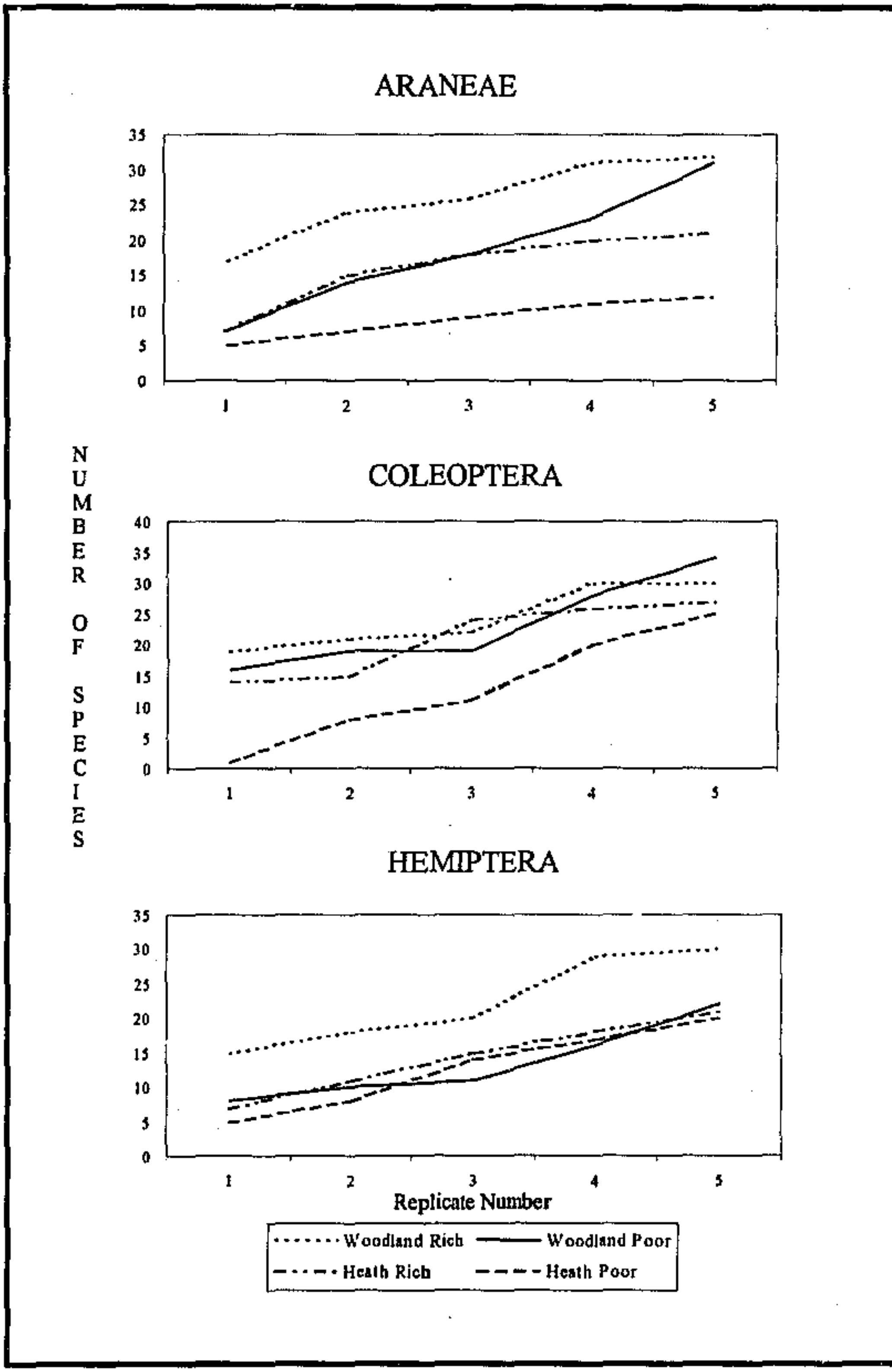


Figure 3.5 Cumulative curves representing the number species collected from treatments sampled in the vicinity of the Yanchep National Park

scale. However, at the fine scale a 2-way ANOVA (SPSS) returned a significant value of ($F_{1,96}$ = 5.773, P = 0.018). The results are aummarised in Table 3.4.

A Spearman's rank order correlation test also demonstrated that Hemiptera were associated with plant species richness (r_s = -0.281, d.f. 99, P <0.05) at the fine scale. A weak relationship between herb richness and Hemiptera species numbers was also indicated by a Spearman's rank order correlation test (r_s = -0.196, d.f. 99, P <0.05). A summary of these results is provided in Table 3.2.

A significant difference in the numbers of Hemiptera species collected between replicates was demonstrated for the WR treatment (ANOSIM - R = 0.323, p <.05). This treatment returned one pairwise R significance value that was in excess of 0.9 that suggests that the replicates beared no similarity at all in the numbers of species they each supported. Significant results were also obtained for HR however the differences between replicates were less (R = .186, p <.05). A summary of these pairwise R statistics is provided in Table 3.6. The WR treatment provided half of the species identified. Approximately 20 species were collected in each of the other treatments. Hemiptera presence absence data for each replicate is summarised in Table 3.7 with supporting data provided in Appendix 7C. A species cumulative curve shown in Figure 3.5 demonstrates that the none of the treatment curves level off suggesting that further sampling is required before any assumptions might be made as to the number of species these treatments actually support.

In addition, this order responded to manipulated levels of plant species richness. Through the allocation of importance values certain species were excluded from the plant species richness count on the basis of their limited contribution to the litter layer. Although Spearman's rank order correlations indicated that relationships exist, the associations were restricted to the more dominant species that attracted high importance values by virtue of their biomass. A breakdown of the relevant data is provided in Table 3.2. The result suggests that Hemiptera may be responding to vegetation structure but not plant species richness itself.

3.3.3 Total Species Richness

Overall the average number of species collected from the Araneae, Coleoptera and Hemiptera orders, from any one replicate, was approximately 25. The HP treatment was the exception where on average only 18 species were collected.

Figure 3.6 demonstrates the relative contribution that each of the above orders made to the invertebrate communities of each treatment. Despite the difference between HP and the other treatments, 2-way ANOVAs indicated that this difference was not significant either at the fine scale or at the coarse scale. These results are summarised in Table 3.4.

Spearman's rank order correlations indicated that there was a weak positive relationship between species richness, ordinal richness and shrub richness (r_s = 0.227, d.f. 99, P <0.05), however, the response was only demonstrated at the fine scale (refer to Table 3.2).

Within treatment variations were significantly different in all but the HR replicates. The woodland rich treatment varied more widely in invertebrate species richness than the other treatments returning a highly significant global R result (ANOSIM - R = 0.634, P <0.001). The pairwise comparisons between replicates are provided in Table 3.6. The number of species collected from WR replicates ranged between 6 and 50. Fifty were collected from one replicate during mid October. By the end of November, after lengthy periods of hot weather only six species were collected from another replicate that was characteristic of this treatment. The average number of species, however, was very similar to that collected in the WP and HR treatments. Within treatment variation, although of significance, was much lower in WP (ANOSIM - R = 0.275, p <.05) and substantially less in HP (R = 0.177, p <.05) despite two replicates returning pairwise R values slightly above 0.7. A summary of these results is provided in Table 3.6.

3.4 Environmental Parameters

3.4.1 Vegetation Structure

The structure of the understorey differed significantly between treatments with cover demonstrating high median variation (Kruskal-Wallis H = 12.397, d.f. = 3, P < 0.05) followed by height (Kruskal-Wallis H = 8.280, d.f. = 3, P < 0.05). Most of the differences could be attributed to the HP replicates that had an average cover

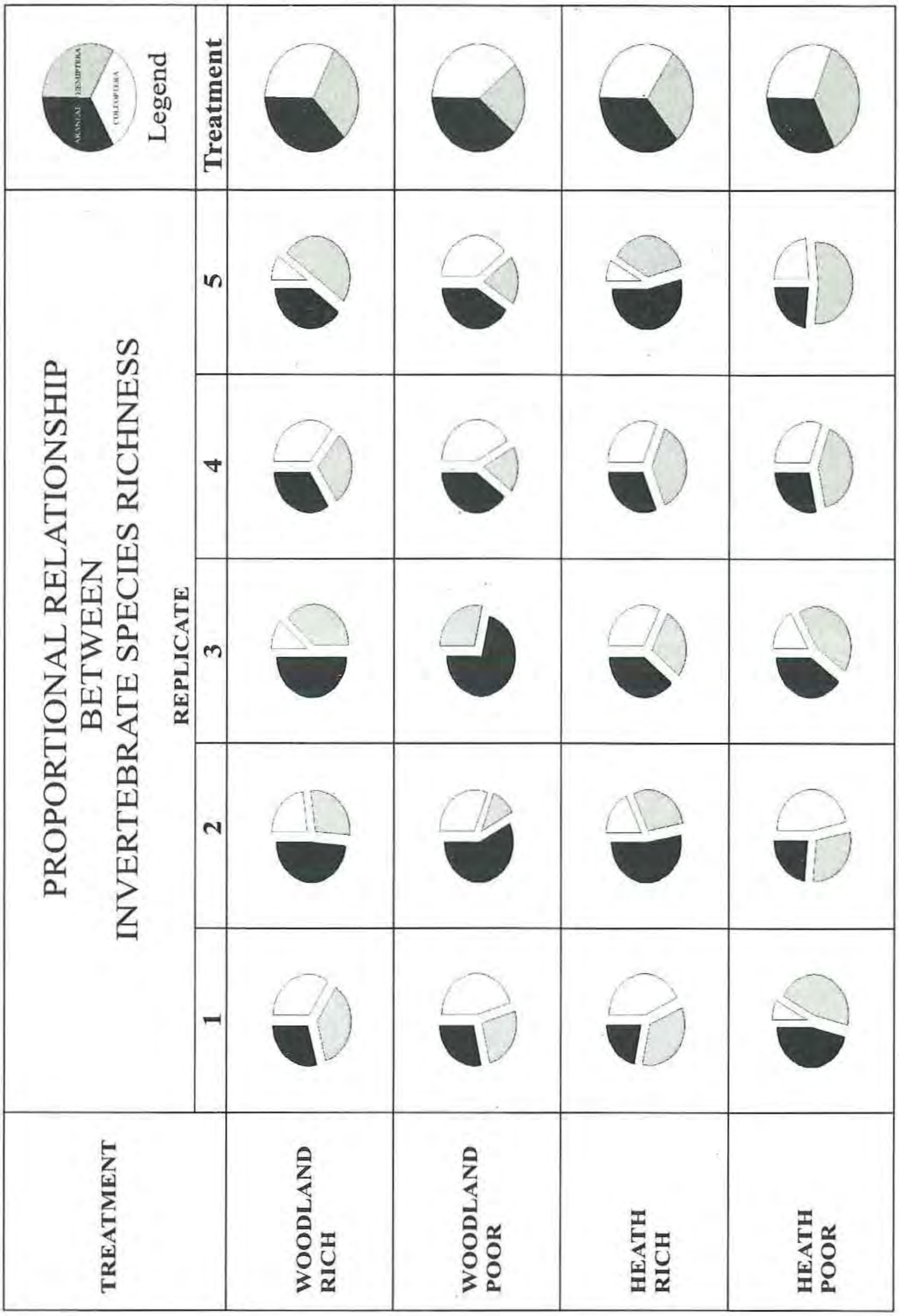


Figure 3.6 Proportional relationship between the average number of Araneae, Coleoptera and Hemiptera morphospecies collected from four replicated treatments located in the vicinity of the Yanchep National Park.

of 73% compared to a maximum of 86% on the WR treatment. With the exception of the WR treatment the understorey height in the HP replicates was also different from the other treatments. The average height was 69 cm. This was well above the average height of 56 cm that was characteristic of the other treatments.

In comparison to the coarse scale, average plot understorey cover and height were relatively similar across all treatments. A Kruskal-Wallis (SPSS) test failed to detect any significant differences between treatments.

Spearman's rank order correlations indicated that there was a relationship between the overstorey and Araneae species richness. A positive association was detected at both scales of measurement but was stronger at the coarse scale. Weak associations were also demonstrated between the understorey cover, Coleoptera, Araneae and total species however the relationship could not be demonstrated at the coarse scale. These results are summarised in Table 3.8.

3.4.2 Litter Parameters

Kruskal-Wallis (SPSS) tests indicated that there were no significant differences between the median cover, depth or patchiness of litter on the plots however there was a significant difference in the litter cover (Kruskal-Wallis H = 8.059, d.f. = 3, $P < 0.05$) between the treatments. Litter cover on the HL replicates was lower at 81% than the WR replicates that had the highest average cover of 91%. No significant differences in litter depth or patchiness were detected at the treatment level.

The remaining litter parameters were only analysed at the fine scale. Kruskal-Wallis (SPSS) tests failed to detect any significant differences for either litter moisture or the volume of litter expressed as tonnes per hectare at this scale.

The litter was sorted into its various structural components. Eight categories were recognised. These categories and their average contribution to the litter layer of each treatment are illustrated in Figure 3.7. Only three of these categories were statistically analysed. These were the fine (<2 mm), medium (>2 mm <5 mm) and the coarse (>5 mm) litter structural components. Only the medium (Kruskal-Wallis H = 11.491, d.f. = 3, $P < 0.05$) and coarse (Kruskal-Wallis H = 8.664, d.f. = 3, $P < 0.05$) components were found to be significantly different between treatments.

Table 3.8 Spearman's rank order correlations that demonstrate the relationship between selected invertebrate groups investigated during the study and selected environmental parameters

ENVIRONMENTAL PARAMETER	INVERTEBRATE GROUP					PLOT AVERAGE (n = 20)				
	Orders	Coleoptera	Hemiptera	Araneae	Total Species	Orders	Coleoptera	Hemiptera	Araneae	Total Species
Vegetation Structure										
Plot Scale (n = 100)										
Understorey Cover	0.165	**0.290***	0.165	**0.198***	**0.274***					
Understorey Height	0.036	-0.011	0.086	-0.003	0.018					
Canopy Cover	0.143	0.154	0.097	**0.229***	0.171					
Canopy Height	0.135	0.154	0.1	**0.231***	0.175					
Replicate Scale (n = 20)										
Understorey Cover	0.235	0.168	-0.024	0.116	0.131	-0.042	0.211	0.375	-0.171	0.193
Understorey Height	0.072	-0.033	0.211	-0.231	-0.027	-0.043	-0.241	0.125	-0.312	-0.197
Canopy Cover	0.43	0.17	-0.153	**0.465***	0.21					
Canopy Height	0.296	0.134	-0.231	**0.540***	0.193					
Soil Parameters (n = 100)										
Soil Moisture	**0.506****	**0.564****	**0.527****	**0.262***	**0.572****	0.379	**0.541***	**0.682***	0.064	**0.514***
Organic Matter (LOI)	-0.037	0.077	0.161	-0.126	0.061	-0.169	0.002	0.209	**-0.594***	-0.13
Abotic Parameters (n = 100)										
Exposed Limestone	-0.104	-0.056	**0.209***	-0.179	-0.028	-0.226	-0.119	0.234	-0.409	-0.144
Temperature	**- 0.617****	**-0.612****	**-0.347****	**-0.379****	**-0.576****	**-0.687***	**-0.840****	**-0.627****	-0.403	**- 0.800****
Insolation	-0.106	**-0.217***	0.015	-0.078	-0.117	0.018	-0.142	-0.215	0.276	-0.075
Average Insolation	-0.126	**-0.208***	-0.092	-0.145	-0.192	-0.036	-0.138	-0.103	0.308	-0.031

***P < 0.05; **P < 0.001**

The differences were found to exist between the woodland treatments and the heath. The major component of woodland litter was microphyll (broadleaf) while heath litter was comprised mainly of nanophyll or smaller leaves that were often needle like (Raunkiaer, 1934).

The relationships between the different invertebrate orders and litter type vary considerably and are scale dependent. Spearman's rank order correlations were carried out using the data obtained from the individual plots and also after this data was averaged for each replicate. Highly significant positive associations were found, irrespective of the scale of measurement, between litter moisture for all of the invertebrate groups investigated with the exception of Araneae. The results from each invertebrate group investigated during the study are shown in Table 3.9. Araneae indicated a weak association with soil moisture but were not correlated to litter moisture.

Hemiptera were found to be positively associated with litter cover however the relation was weak and could only be demonstrated prior to the data being averaged. Coleoptera's association with litter cover is quite the opposite. Both of the relationships are scale dependent.

A number of other associations were evident between certain invertebrate groups and different litter parameters, but it is questionable as to the true nature of these relationships. Certain litter characteristics were treatment specific. It is possible that the correlations are reflecting the vegetation type and not the parameter itself. A summary of these results is provided in Table 3.9.

3.4.3 Abiotic Parameters

Kruskal-Wallis (SPSS) tests demonstrated that there were no significant differences between treatments for soil and litter moisture, surface temperature and levels of insolation at the coarse scale. Despite this outcome Spearman's rank order correlations demonstrate highly significant associations with litter moisture, soil moisture and litter surface temperature. These parameters had marked effects on the invertebrate groups studied with each order responding slightly differently. Whilst most orders demonstrate a positive correlation with soil moisture they are negatively associated with temperature. However as Tables 3.8 and 3.9 demonstrate, these

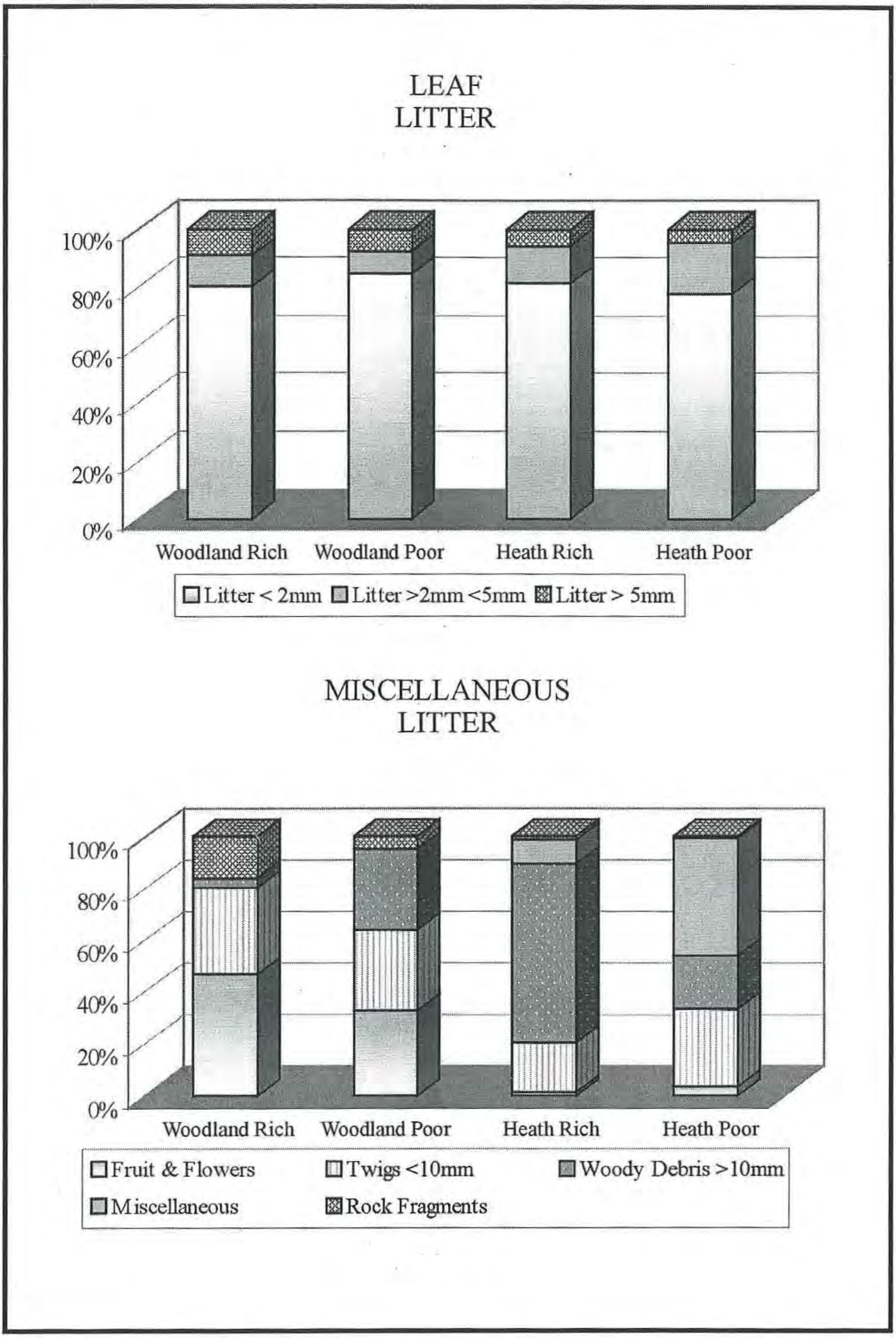


Figure 3.7 Stacked graphs demonstrating the various components of litter that were removed from plots located within the five replicates of each treatment studied. The graphs show averages only for each of the treatments investigated.

Table 3.9 Spearman's rank order correlations that demonstrate the relationship between the richness of selected invertebrate groups investigated during the study and certain litter characteristics

ENVIRONMENTAL PARAMETER	INVERTEBRATE GROUP					PLOT AVERAGE (n = 20)				
	Orders	Coleoptera	Hemiptera	Araneae	Total Species	Orders	Coleoptera	Hemiptera	Araneae	Total Species
Litter Parameters										
Plot (n = 100)										
Litter Cover	0.124	0.078	0.235*	0.128	0.148					
Litter Depth	0.216*	0.165	0.127	0.215*	0.211*					
Replicate (n = 20)										
Litter Cover	-0.119	-0.089	-0.071	0.161	-0.031	-0.283	-0.459*	-0.012	-0.281	-0.383
Litter Depth	-0.097	-0.114	-0.218	0.057	-0.096	-0.246	-0.023	0.044	0.097	-0.002
Litter Moisture	0.677*	0.829**	0.759**	0.349	0.806**	0.741**	0.741**	0.499**	0.450**	0.727**
Patchiness	-0.04	-0.037	0.179	-0.42	-0.105	0.145	0.07	0.144	0.074	0.113
Litter tonnes/ha	-0.09	-0.166	0.004	-0.465*	-0.211	0.221*	0.188	0.112	0.084	0.174
Litter Structure (n = 100)										
Litter Fine <2 mm	0.075	0.162	-0.007	0.406	0.19	-0.153	-0.111	-0.146	-0.042	-0.142
Litter Medium >2mm<5mm	-0.2	-0.133	0.186	-0.431	-0.171	0.1	0.165	0.184	0.048	0.186
Litter Coarse >5mm	0.239	-0.015	-0.076	0.311	0.09	0.189	0.02	0.019	0.211*	0.096
Fruits & Flowers	0.456*	0.002	-0.187	0.02	-0.031	0.205*	0.169	0.117	0.143	0.161
Twigs <10mm	-0.255	-0.151	0.041	-0.441	-0.231	-0.082	-0.025	0.117	-0.086	-0.005
Woody Debris >10mm	-0.238	0.106	0.275	-0.269	0.061	-0.156	-0.006	0.051	-0.147	-0.025
Miscellaneous	0.077	-0.137	-0.433	0.117	-0.134	-0.11	-0.166	-0.106	0.122	-0.057
Rock fragments	-0.136	0.007	0.284	-0.449*	-0.069	-0.031	-0.016	0.203*	-0.171	-0.002

***P < 0.05; **P < 0.001**

parameters are cross correlated. While Araneae appear to be more tolerant of lower soil moisture content and litter surface temperature, Coleoptera demonstrate a negative response to insolation levels as shown by Table 3.8.

Spearman's rank order correlations suggests that Araneae respond negatively to increased levels of soil organic matter as demonstrated in Table 3.8. Soil organic matter concentrations were significantly different (Kruskal-Wallis $H = 10.977$, d.f. = 3, $P < 0.05$) between treatments. The heath treatments had higher concentrations of soil organic matter than the woodland treatments. The HP replicates were particularly rich in organic matter (17%) compared to an average concentration of 10.5% across all treatments. Soil characteristics for each replicate are described in Table 3.8. Tables 3.8 and 3.9 demonstrate that many of the associations detected by Spearman's rank order correlations are scale dependent.

Across treatments these parameters were not significantly different. However there were major differences within treatment comparisons. Weather patterns strongly influenced the number of species collected from certain replicates. The heath treatments were sampled under more similar (drier) weather conditions than some of the woodland treatments. The WR replicates that were sampled in October, during cooler conditions or replicates that were sampled after rain showed a marked difference in the number of invertebrates collected. The effect that moisture had on the number of species collected is demonstrated in Figure 3.8 which shows that the peaks in litter and soil moisture are generally accompanied with peaks in ground dwelling invertebrate richness.

3.5 Summary

The study failed to demonstrate that there was any relationship between plant species richness, vegetation association or the interaction between these two factors and ground dwelling invertebrate richness at a coarse scale. However, there was evidence to suggest that there is a significant relationship between plant species richness and Hemiptera species richness at a fine scale ($F_{1,96} = 5.773$, $P = 0.018$).

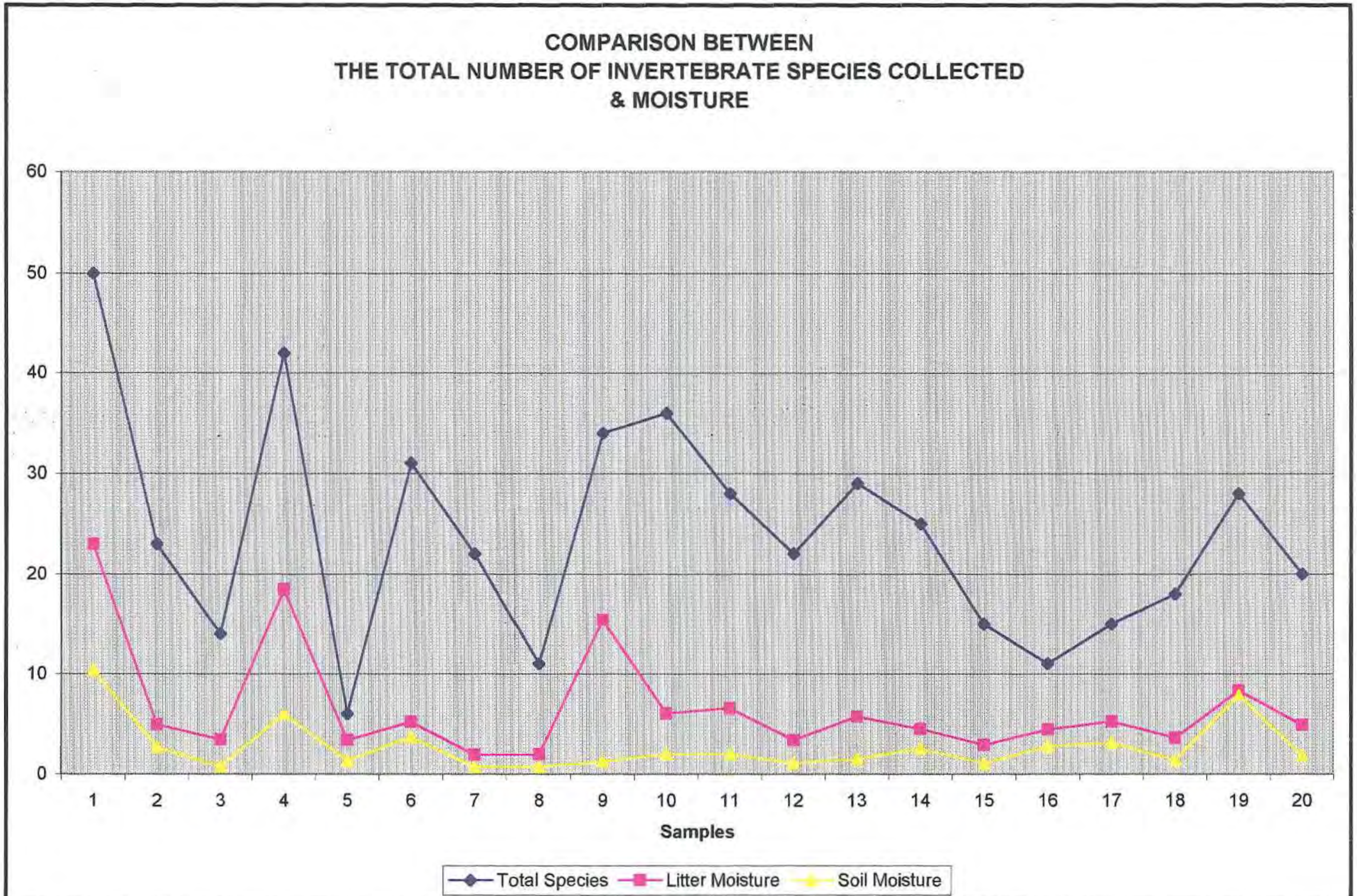


Figure 3.8 Line graph that shows a comparison between ground dwelling invertebrate richness and the moisture content of the litter and soil

Two-way ANOVAs (SPSS) demonstrated that there were no differences in ordinal invertebrate richness between treatments irrespective of scale. However, Spearman's rank order correlations demonstrated that there was a positive association between ordinal richness and the number of shrubs (r_s = 0.225, d.f. 99, P <0.05), (r_s = 0.456, d.f. 19, P <0.05) and a negative association with herbs (r_s = -0.257, d.f. 99, P <0.05). Spearman's rank order correlations also indicated that there was a weak positive relationship between Coleoptera richness and shrub richness (r_s = 0.243, d.f. 99, P <0.05). Hemiptera was the only order that provided evidence that their richness was linked to plant species richness by demonstrating an association with plant species richness (r_s = 0.281, d.f. 99, P <0.05) and herb richness (r_s = 0.196, d.f. 99, P <0.05). However, none of these associations could be demonstrated at the coarse scale (n = 20). During the study, the woodland rich treatment varied more widely in invertebrate species richness than the other treatments, however, this appears to be related to the weather conditions prevailing at the time of sampling.

Although treatments were significantly different in plant species richness at the coarse scale, at a fine scale plant species richness was similar across all treatments. However a one-way analysis of similarity (ANOSIM) indicated that the treatments varied significantly in the number of shrub species they supported (R = 0.651, p <.001) and did reflect the plant species richness of the treatment suggesting that shrubs are a relatively good indicator of plant species richness.

Herbs and grasses were significantly different between treatments. Both Heath treatments had an extremely rich herb layer in comparison to woodland plots. Woodland rich plots had fewer herb species than plots on the other treatments therefore these plant life forms are not indicative of overall plant species richness.

Spearman's rank order correlations suggested that Araneae respond negatively to increased levels of soil organic matter. This was apparent from the high soil organic matter concentrations in the HP treatment (r_s = -0.594, d.f. 19, P <0.05) Araneae richness also appears to be linked to vegetation structure, however, they demonstrated this indirectly by showing positive associations to environmental parameters that were specific to woodland, ie. canopy. They had a negative association with rock fragments and herbs that are characteristic of heath.

The richness of all of the invertebrate groups studied were strongly associated with litter and soil moisture and temperature. These parameters are cross correlated

consequently it was difficult to isolate out the parameter that is more important but the relationships, as demonstrated by Spearman's rank order correlations, were generally stronger for litter moisture.

There was little evidence to support that litter cover is an important influence on invertebrate species richness although litter depth plays an important role for some groups. Although the association was weak it was still significant for ordinal richness, Araneae and morphospecies richness when the orders studied were viewed as a whole.

Theoretical manipulations of plant species richness failed to produce any meaningful results however they did reveal certain plant community patterns that were consistent across all of the vegetation types studied.

CHAPTER FOUR

DISCUSSION

4.1 Overview

This study focused primarily on the relationship between plant species richness and groud dwelling invertebrate richness, but also investigated a number of environmental parameters, including vegetation structure, litter and soil attributes that might influence invertebrate richness. Analysis of variance (ANOVA) provided evidence that would suggest that invertebrate richness, at least for Araneae and Coleoptera is not related to plant species richness. Hemiptera, however, have demonstrated some evidence that their species richness is related to plant species richness. The possibility remains that this association is a response to vegetation structural complexity afforded by the diversity plant species richness itself provides. Previous studies have raised the same issue. Murdoch, Evans and Peterson (1972) left the issue unresolved, unable to determine which of the two variables were more important. Araneae also indicate an association with vegetation but the relationship appears to be linked to vegetation type rather than plant species richness. Araneae have, indirectly, demonstrated a preference for woodland as opposed to heath. Coleoptera display a preference for shrubs, and fail to show a relationship with other plant life forms.

Results from this study and others that have investigated the relationship between plant species richness and soil organisms are generally idiosyncratic and weak (Chapman et al., 1988; Korthals, Smilauer, Van Dijk, & Van Der Putten, 2001; Spehn, Joshi, Schmid, Alphei, & Korner, 2000; Wardle et al., 1999; Wardle et al., 2003). Studies that have investigated above-ground consumers, have provided evidence to suggest that there is a weak relationship between plant species richness or plant functional groups and certain invertebrate groups, and in particular herbivores (Giliomee, 2003; Haddad, Tilman, Haarstad, Ritchie, & Knops, 2001; Siemann, Tilman, Haarstad, & Ritchie, 1998; Symstad, Siemann, & Haarstad, 2000).

However, there is little evidence from this project, and from similar studies, to support that this also applies to the ground dwelling invertebrate community.

Most of the relationships detected during the study were scale dependent. The importance of scale is not only evident for invertebrate groups but also for the plant community. The outcome of the study raises major questions about scale. The study supports the scaling issues that are now well acknowledged in the literature. What scale is the most appropriate to use if we are to detect the important patterns and processes that act on the daily lives of invertebrates? We may need to move away from an anthropological point of view and take into consideration "the organism's point of view" when designing field studies (Cale & Hobbs, 1994).

During the study certain environmental parameters were shown to have an important influence on invertebrate richness. The parameters found to be most influential are seasonally based and suggest that invertebrate richness is strongly reliant on litter and soil moisture.

These issues are raised again in the following sections that discuss in depth, the responses that individual invertebrate orders demonstrated to the various parameters investigated during the study.

4.2 Plant Species richness

The average plant species richness for this study was 52 in the species rich treatments and 34 in the species poor treatments. Although the difference was not particularly large from a biological point of view, these levels of plant species richness are fairly typical of the region and fulfilled the requirements of the study. There are, however, vegetation associations on the Swan Coastal Plain that support, on average, approximately 70 species and others that support as few as 13. Most of these communities are either located in the Jarrah forests south of Perth, border wetlands in the region or were located in urban remnant bushlands that were likely to be highly modified (Gibson et al., 1994).

Although plant species richness was a major consideration there were other important criteria that needed to be fulfilled before a vegetation type was considered

to be suited to the study. The open canopy of the Banksia woodland was considered to be a better match to the heath than forested areas with closed canopies. The understorey in Banksia was structurally similar to that of the heath and because of their close proximity to each other, both vegetation types shared the same climatic conditions. Selecting for plant species richness alone could have introduced a number of confounding factors that may have compromised the study.

By the end of the survey it became apparent that, although the replicates for each treatment supported different levels of plant species richness, this was not the case for the 1 m^2 invertebrate sampling plots. Irrespective of treatment, at this scale, the plots supported similar levels of plant species richness. There was no correlation between the species richness of the replicates and the plots located within them. This raises the issue of scale. What is the most appropriate scale to use when determining the plant species richness of an area for the purposes of invertebrate conservation?

It also appears that shrub richness provides a more consistent and reliable measure of plant species richness. Shrubs tended to track the species richness of each treatment and as the majority of them are perennials they are not subjected to the same temporal variation as many of the herb species. This may have important implications when identifying areas for invertebrate conservation especially if the areas are selected on the basis of plant species richness. Plant species richness is commonly used by government agencies to identify areas of high conservation value. For example a large proportion of the data used to identify priority areas during the Regional Forest Agreement process in Western Australia consisted of herbarium records (Gioia & Pigott, 2000). An underlying assumption of this rapid inventory technique is that the selection of areas with a large proportion of native vegetation or those that are particularly plant species rich will preserve the maximum number of other native species, including invertebrates (Doherty et al., 2000).

Unlike shrubs, herbs were found to be poor indicators of plant species richness. A rich herb stratum does not necessarily reflect overall plant species richness. Although at certain times of the year they contribute a large percentage of the biomass, their inclusion into plant species richness counts may be misleading.

The allocation of importance values to various species according to their level of cover (or dominance) demonstrated that at least 50% of the species present on any

1 m^2 plot contributed less than 5% to overall cover. This would account for most of the herbs on the plots. However no relationship could be found between the theoretical manipulation of plant species richness and invertebrate richness for species whose cover was less than 25%.

During the sampling period plant species richness within treatments became evident. Many of the annuals that were present during the early stages of the survey were absent during the latter stages of the survey. Consequently plant species richness counts may have been misleading however most of the treatments would have been biased to some degree as a consequence of seasonal variation and it is doubtful that the study was compromised as a result. However it may be an important consideration in surveys that extend over longer time periods. Tremblay & Larocque (2001) found considerable differences between sites in plant species richness and biomass during the growing season with peaks, for different plant species, occurring at different times of the year.

The project has demonstrated that plant species richness is difficult to quantify. Not only are species counts affected by scale, and seasonal variation but there is the added complication of succession. A plant community might be extremely species rich in an early successional stage, for example following fire, but it may be quite species poor after it reaches a state of equilibrium (Mouquet, Munguia, Kneitel, & Miller, 2003). These changes have profound effects on invertebrate species richness. The relationship between plant and insect diversities in succession was studied by Southwood, Brown and Reader (1979) who found that up until a successional age of 16 months, the taxonomic diversities of plants and insects rose. At later stages of succession plant species richness declined far more than insect diversity. This has implications for a vegetative approach to invertebrate conservation.

Any reliance on plant species richness as an indicator of invertebrate richness should be treated with the utmost caution. This project has raised a number of questions that require further investigation before a vegetative approach can be justified as a useful tool in invertebrate conservation.

4.3 Invertebrate Richness

4.3.1 Ordinal Richness

During the study, 27 invertebrate orders were collected, with all treatments supporting 20 orders except for the woodland rich (WR) treatment that supported 23. Out of these orders, only 15 were common to all treatments, most of them collected on at least two out of five 1 m^2 plots, with the exception of Phasmatodea and Diplura. The other 12 orders were relatively rare. Five were only found within one treatment. Three orders were restricted to two treatments and four were found in only three treatments.

Twenty-seven orders were collected during the pilot study. This study was conducted during winter and invertebrates were only collected from seven plots (3 x 50 x 50cm, 3 x 100 x 100cm and 1 x 200 x 200cm). All of the plots were located in Banksia woodland within a 10 x 10m quadrat that was previously sampled for plant species richness earlier in the study.

Although the same number of orders were collected during both studies there was a marked difference in the abundance and community structure. While some orders were well represented in the pilot study they were only collected in small numbers during the main study. The difference was particularly evident for the Chilopoda and Diplopoda classes. These classes appear to favour damp conditions whilst the reverse was true for insects. More insects were collected during the main study when conditions were drier. This demonstrates the difficulties in making generalisations relating to invertebrate conservation.

The difference between the two studies supports the claims in the literature that invertebrates are highly seasonal (Curry, 1987; Moeed & Meads, 1985). However, over the short term of this study (the six weeks commencing mid October and ending at the end of November) there was little evidence to suggest that ordinal diversity was strongly influenced by the weather conditions prevailing at the time.

During the sampling programme, the weather pattern was highly variable. Temperatures ranged between 18 and 40°C (although invertebrates were not sampled on days when the temperature exceeded 34°C) and during two weeks of the study,

there were short periods of rain (refer to Table 2.2). There was a significant increase in the number of species collected during the wet periods.

Decomposer abundance was found to be higher in the wetter months on sites surveyed in Perth and Dwellingup in south-western Australia, however, abundance levels were more closely associated with the warmer months at Manjimup. As Manjimup is much further south than the other sites, cooler temperatures in the winter months was cited as one of the possible reasons for the difference in decomposer abundance between localities (Koch & Majer, 1980). Variation in seasonal invertebrate activity was also demonstrated for a number of hexapods during a related study. Herbivore diversity was higher in spring, summer and autumn at Perth, but fluctuated less with season at Dwellingup (Majer & Koch, 1982). The results from this study tend to support the outcomes from the previous studies.

Although a two-way ANOVA failed to demonstrate that a relationship exists between invertebrate ordinal richness, plant species richness or vegetation association, Spearman's rank order correlation tests suggest that certain orders may have a preference for vegetation types and/or vegetation structure. However the results are idiosyncratic and scale dependent and are discussed in detail in the following sections.

4.3.2 Morphospecies Richness

Although 15 orders were well represented across all treatments, they were not always well represented at the species level. In addition, a review of the literature revealed that the sampling techniques used during the study were more suited to certain orders and may not have returned a representative sample of species richness for others. For example, data for ants and a number of other important orders, were not analysed. Although these orders were relatively abundant, different species have distinctly different foraging times (Greenslade & Greenslade, 1977) and consequently the sampling methods used during the study was not appropriate for their inclusion in the study.

Weather conditions prevailing at the time of sampling also influenced the number of Collembola collected. Collembolan assemblages are positively correlated with soil moisture (Rodgers, 1997). The pilot study and this study provided evidence

to support this notion. Collembola were abundant in wet weather and for short periods after rain but their abundance quickly dropped under drier conditions. Due to the highly variable weather patterns that persisted during the study, there were extreme variations in their abundance within and between treatments. The biases were quite evident and a fair assessment of species richness for certain treatments would not have been possible. As a result Collembola were omitted from the study. Nevertheless, Rodgers (1997) found no evidence that a relationship existed between the structure of Collembolan assemblages and understorey plant species on a Eucalypt woodland site, although the study was limited to four plant species.

Although there were a number of orders collected during the sampling programme that would have been more suited to this study, especially decomposers, Araneae, Coleoptera and Hemiptera were the only orders that fulfilled the requirements of the study. The criteria set for the selection of orders are outlined in Section 2.8.2. These orders are discussed in detail in the following sections.

4.3.2.1 Araneae

The conservation value of spiders and the growing recognition of their functional role in ecosystems made Araneae an ideal group to investigate. Spiders as a dominant predator strongly influence the structure of invertebrate communities and are well recognised for their potential as indicators of environmental change (Churchill, 1997; Curry, Humphreys, Koch, & Main, 1985; Main, 1987).

Although a two-way ANOVA failed to detect any significant differences between Araneae species richness and the various plant species rich treatments they appear to be linked to certain vegetation types. Araneae were negatively associated with herbs, rock fragments and soil organic matter and positively associated with woodland replicates that supported mature trees. Rock (limestone) fragments and high concentrations of soil organic matter (dried moss) are characteristic of heath but not woodland. Herbs were more abundant in heath. This would suggest that Araneae are indirectly demonstrating a preference for woodland. Churchill (1997) found that Araneae favour structurally complex plant communities, particular those with a high percentage of foliage cover.

Not only do Araneae demonstrate a correlation with certain environmental parameters that are different to Coleoptera and Hemiptera they also share common

relationships with the other orders studied. However the associations are generally weaker. Araneae species richness is related to litter and soil moisture and temperature similar to the other orders studied but their responses are complex and are highly scale dependent. While other orders tend to demonstrate a relationship to litter and soil moisture and temperature irrespective of the scale of measurement Araneae failed to respond to soil moisture when an average was taken for the plots and did not respond to litter moisture at the coarse scale. They appear to tolerate temperature better than Coleoptera sharing this trait with Hemiptera but while these orders are influenced by temperature at all scales Araneae are not. Over larger temperature ranges this may not be the case.

Apart from orders in general, Araneae is the only order that tend to favour deep litter but the composition of the litter itself bears no relationship to this association except for a weak alliance with coarse litter that again is characteristic of the woodland treatments.

The results of the study appear to support Churchill's (1997) findings in that Araneae demonstrated an indirect relationship with more structurally complex plant communities through their positive association with woodland sites. However there is no evidence to suggest that this association is directly related to plant species richness in itself.

4.3.2.2 Coleoptera

In comparison to the other orders collected during the study, Coleoptera was well represented. A total of 73 morphospecies were identified, which was substantially more than the numbers identified for Araneae and Hemiptera. This group is reported to be highly sensitive to sampling techniques. Pitfall trapping, at least for Carabid fauna, cannot be relied upon to obtain a quantitative assessment of species richness in any habitat. Greenslade (1964) also suggested that seasonal changes within different vegetation communities may affect trapping efficiency.

The biases that certain sampling techniques can introduce into studies that focus on Coleoptera were well illustrated during a study that manipulated the plant diversity of grasslands in Switzerland and Sweden. During a pitfall trapping sampling programme carabid beetle abundance, along with spiders, was found to decrease linearly with plant species and functional group richness. Koricheva,

Mulder, Schmid, Joshi & Huss-Danell (2000) also found that during their study, sweep netting and suction samples returned different results. Using these sampling techniques the same groups were unaffected by plant diversity.

Coleoptera not only fulfilled the criteria for the study but they are particularly good candidates for the study given their ecological importance. They are the largest order of insects, constituting approximately 40% of known insect species, and interact with the ground habitat in a variety of ways (Greenslade, 1964; Yen, 1987). They are active in the litter layer with herbivores, predators and scavengers all represented in the adult stage whilst the larval forms feed almost exclusively on plant litter and fungi (Gill et al., 1999).

Coleoptera are relatively well studied and have demonstrated a range of responses to varying levels of plant species richness and vegetation structural diversity. The literature tends to support the notion that there is a relationship and this study lends some support to previous findings that there is an association at least for plant community structural diversity. Numerous studies have found this relationship. A weak positive relationship was also found between shrub species richness but there was no evidence that a relationship exists between Coleoptera species richness and plant species richness per se. However, this relationship deserves further investigation over a number of seasons before any generalisations can be made.

A study in Western Australia found that vegetation structural diversity and plant species richness was an efficient indicator of beetle richness in Gimlet woodlands. Abensperg-Traun, Arnold, Steven, Smith, Atkins, Viveen and Gutter (1996) caution that this may not apply to other vegetation types. They emphasise the need for further study before any assumptions are made on the effectiveness of these parameters to act as indicators of invertebrate species richness in plant communities other than Gimlet woodlands.

There have been similar findings in New Zealand. Crisp, Dickinson and Gibbs (1998) found that sites supporting more plant species, either native or introduced, also supported more Coleoptera species. The order does not appear to discriminate between native or introduced plant species. They also found that disturbed sites were almost as diverse in beetle richness as natural habitats and suggested that modified areas should also be considered for the conservation of

Coleoptera. Rich assemblages of selected, ground dwelling invertebrates were also found in urban bushland remnants in Perth, Western Australia (Harvey, Waldock, How, Dell, & Kostas, 1997) and especially the larger remnants. This supports Crisp, Dickinson and Gibbs (1998) findings that modified habitats are important refuges for invertebrates.

However coffee plantations that were structurally simplified by the removal of shade trees supported fewer scarabaeid beetle species than the plantations that maintained relatively high levels of plant species richness and retained their shade trees (Nestel, Dickschen, & Altieri, 1993). Their results concur with those of this study, where Coleoptera are negatively associated with insolation. The relationship is significant but weak and Coleoptera are unique in their response to insolation (light levels) at least for the orders investigated during this study.

Although this study has provided some evidence that Coleoptera richness is linked the richness of the shrub stratum, plant species richness itself does not appear to be an influencing factor. The heath rich treatment supported a similar level of plant species richness yet Coleoptera appeared to favour a combination of plant species richness and plant structural diversity. Woodland rich treatments offered both whilst heath rich communities, although plant species rich, were structurally simple. In addition the relationships that are apparent are relatively weak and can only be demonstrated at a fine 1 m^2 scale of measurement ie.(n = 100).

What was particularly evident from the study was Coleoptera's highly significant relationship with soil and litter moisture and hence a seasonal effect. However the association is not connected to litter cover, depth or litter structure. Coleoptera also demonstrate a highly significant negative response to high litter surface temperatures. These relationships are evident irrespective of the scale of measurement.

As Coleoptera are the only order to demonstrate a negative response to insolation (daily levels of sunlight) and taking into consideration previous studies it is likely that Coleoptera are demonstrating a preference to shaded areas. Spearman's rank order correlations indicate that their preference for shade extends throughout the day. However shade is correlated with the structure of the understorey at a fine scale ($100m^2$) which in turn is correlated with plant species richness. There is no correlation between shade and the understorey at the replicate scale of measurement.

4.3.2.3 Hemiptera

A one-way ANOVA failed to find any difference between Hemiptera species richness and the treatments. However, Hemiptera was the only order that demonstrated a relationship with plant species richness. The association was weak and scale dependent ($100m^2$) and could only be detected using Spearman's rank order correlations.

Previous studies have demonstrated a relationship between herbivores and plant species richness. Root (1973), during a controlled experiment that investigated the plant-arthropod association in simple and diverse collard (*Brassica Oleracea)* stands, found that there was a relationship. Herbivore abundance in the pure stands was consistently higher. However, in the diverse stands both the number of herbivore species and the diversity of the herbivore load were greater.

Murdoch, Evans and Peterson (1972) found that plant species richness was positively correlated with Homoptera. Within treatments the correlation was generally weak but when the samples were bulked between treatments the relationship was stronger. However, they were not able to determine whether the association was related to plant species richness itself or whether it was plant structure that was more important. In subsequent studies, vegetation structure appears to be more important. As suggested by Lawton (1978), Lawton & Schroder (1977) and Strong & Levin (1979) 'there are presumably more ways of making a living on a bush than there are on a bluebell'. More complex plants provide more niches and consequently support more insects.

Another study demonstrated that only the most sessile and specialised groups (leafhoppers and wingless aphids) were influenced by plant diversity. The study also demonstrated the sensitivity of certain Hemipteran groups to sampling technique (Koricheva, Mulder, Schmid, Joshi, & Huss-Danell, 2000).

As this study focused on litter dwelling invertebrates and the sampling techniques employed during the study were selected specifically for this group Hemipteran's that feed exclusively above-ground would have been rarely captured. However they were collected in sufficient numbers to warrant statistical analysis and fulfilled other criteria set for the selection of orders. Nevertheless if sampling techniques, such as sweep netting, that are more suited to this order were used the

outcome of the study may have been different. The results from this study that relate to plant species richness and Hemiptera richness should be viewed with caution.

Unlike Coleoptera that demonstrated a response to shrub richness, Hemiptera responded positively to herb richness. The association is weak and scale dependent and may be a sampling anomaly that is indicating a preference for vegetation type. Herbs were relatively abundant on the heath treatments but were not as well represented in the woodland treatments. Nevertheless the relationship between herbs and Hemiptera richness warrants further investigation. As discussed earlier herb richness was not a good indicator of overall plant richness for any of the treatments studied.

Hemiptera along with the other orders studied have demonstrated a highly significant positive relationship with soil and litter moisture. The relationship is apparent irrespective of scale. The order also demonstrates a negative association with temperature. However Hemiptera appear to be more tolerant to temperature than the other groups studied with the exception of Araneae. Hemiptera's association with temperature was relatively weak in comparison to Coleoptera. Hemiptera and Araneae appear to have similar tolerance levels to temperature and demonstrate no adversity to light levels.

There is no evidence that Hemiptera are influenced by vegetation structure although there is a weak positive relationship between this order and litter cover. However Hemiptera's relationship with litter cover, like many other correlations that exist oetween certain invertebrate groups and environmental parameters is confounded by scale. Murdoch, Evans and Peterson (1972) left open the question as to whether Homoptera were influenced by plant structure or plant species diversity. This study would tend to support that Hemiptera species richness is linked to plant species richness rather than the structural attributes of the vegetation but the results should be viewed with caution without the benefit of studies that investigate these responses over at least a year if not more.

4.4 Summary

Apart from Hemiptera's response to plant species richness the study failed to provide evidence that there was a direct relationship between plant species richness

and invertebrate richness, at least for the groups studied. There was, however, evidence that indirect relationships do exist between some invertebrate groups and vegetation types.

Araneae and Coleoptera appear to prefer more structurally diverse vegetation. Although Coleoptera demonstrated a relationship with shrub species richness it is more likely that shrubs provide a more diverse understorey which provides them with more shelter and cooler conditions.

Araneae consistently, but indirectly, demonstrated their preference for woodland as opposed to heath. However they are more tolerant of temperature and as predators are probably responding to food source rather than cooler conditions.

Spearman's rank order correlations ($100m^2$) demonstrate that numerous relationships exist between certain invertebrate groups and certain environmental parameters. Many of the environmental parameters investigated were highly scale dependent and cross correlated with a number of other parameters.

What is clear is the positive influence that soil and litter moisture had on the invertebrate groups studied. Temperature was equally influential. However these three parameters are cross correlated with each other. These relationships were evident irrespective of scale with few exceptions.

The study has provided correlative evidence that vegetation structure and not plant species richness is more important than plant species richness although the two parameters are often associated with each other. Moisture and seasonal conditions appear to play a more important role in invertebrate species richness.

CHAPTER FIVE

CONCLUSIONS

5.1 Influences on Ground Dwelling Invertebrate Species Richness

The results from the study support a growing body of evidence that suggests that the species richness of ground-dwelling invertebrates is not linked to plant species richness (Wardle et al., 2003). Consequently conservation areas that have been selected on the basis of plant species richness alone may not necessarily support a rich fauna of invertebrates.

However the study has demonstrated that vegetation structure, particularly cover, and the presence of a rich shrub stratum is likely to play an important role either directly or indirectly for certain ground dwelling invertebrate orders. Therefore it would appear that a vegetative approach to invertebrate conservation does have some merits especially in circumstances where there is limited data and few resources. In situations where the use of surrogates is called for, then two or more indicators should be selected.

This study suggests that some of the existing reserves may not be representative of the invertebrate fauna of the region. Plant species richness and structural diversity are often interrelated but this is not always the case. For instance some of the plant communities in the semi arid zone of south-western Australia are extremely species rich but they are structurally very simple (Hopper, 1979). These communities are similar in structure and in species richness to those (fynbos) found in the Cape Floristic Region (CFR) of South Africa (Naveh & Whittaker, 1979). Despite having high plant diversity, Johnson (1992) warns that 'anyone expecting to find fynbos teeming with insect life is bound to be disappointed'. Giliomee's (2003) study of the region supports this claim and suggests that this is due, amongst other things, to the structural simplicity of these plant communities (Linder, Meadows, & Cowling, 1992) and low annual litter production rates (Mitchell, Coley, Webb, & Allsopp, 1986).

Reserves located in areas that support these plant community types might be quite deceptive and not representative of invertebrate diversity. The Fitzgerald National Park is a prime example of this. This park protects vast tracks of extremely rich but structurally simple plant communities. Large areas of comparatively species poor but structurally complex plant communities lie outside the park's boundaries which would appear to leave vulnerable much of the regions invertebrate diversity. It is areas such as these that require further investigation.

Although this study only demonstrated a weak relationship between certain ground dwelling invertebrates and litter cover (Hemiptera) and depth (ordinal and Araneae) this outcome is slightly deceptive. The major factors influencing invertebrate richness were found to be temperature, soil and litter moisture. However, during this study, soil moisture was interrelated with litter cover and depth whilst litter moisture is dependent on soil moisture and vegetation structure. Consequently, any reduction in the litter layer as a result of fire or from land clearing would reduce soil moisture levels that would remove, not only food resources, but habitat for ground-dwelling invertebrate species richness that could have major ramifications on ecosystem functioning.

A loss of invertebrate species richness as a result of prescribed burning has already been demonstrated in previous studies in south-western Australia. Springett (1976) found that a reduction in litter quantity, following fire, decreased both invertebrate species diversity and population densities with the effects still evident at the end of a prescribed burning rotation despite the quantity of litter returning to pre burn levels. A more recent study has shown that frequent burning has an impact on the quantity, structure and spatial distribution of litter. Fire also changes the structure and spatial heterogeneity of components of understorey vegetation and reduces moisture levels in the top-soil (Gill et al., 1999). This study has demonstrated that these parameters are the important determinants of invertebrate species richness, suggesting that prescribed burning should be carried out with the utmost of caution.

Not only does the study highlight the potential effects of prescribed burning but it also demonstrates that climate change could also have some devastating effects on ground-dwelling invertebrates. As moisture is clearly an important influence on ground dwelling invertebrate species richness it would follow that seasonal

conditions should be taken into consideration when areas are being selected for the purposes of invertebrate conservation.

Whilst there has been no observable trends in annual rainfall for south-western Australia since 1975 there has been no return to pre 1960 levels following the significant decline in annual rainfall during the 1960s and early 1970s (Hennessy et al., 1999). Invertebrates appear to rely heavily on weather conditions and hence, we should heed warnings of future long-term climate change predictions and adapt our management practices around the possibility of these changes.

Bushland remnants appear to offer the most potential for invertebrate conservation especially for those that have good powers of dispersal. Farmers should be encouraged to fence off their remnant vegetation. As vegetation structure is one of the important determinants of invertebrate species richness then remnants that are open to grazing will be of little value. These areas should be returned to their natural state. This is where education plays an important role. Farmers should see this as a gain rather than a loss.

Although the mechanisms underpinning the observed responses to losses of biodiversity are not well understood, there is some evidence to suggest that changes in biodiversity can have significant impacts on ecosystem processes (Lawton, 1994; Naeem, Thompson, Lawler, Lawton, & Woodfin, 1994). It has been demonstrated that strong positive relationships between plants and ecosystem processes can be modified in the presence of insects (Mulder, Koricheva, Huss-Danell, Hogberg, & Joshi, 1999).

This study has also shown that the scale at which certain environmental parameters are measured can strongly influence results, although many of these responses are possibly related to climate. Many of the relationships that were found to exist were only demonstrated at a fine scale of measurement. This would suggest that studies conducted at larger scales may fail to detect some of the important processes that maintain invertebrate community composition. It also raises questions as to the appropriate scale at which management techniques should apply. This may mean that, for the purposes of invertebrate conservation, many small reserves are required to complement the existing reserve system. This, however, is outside the scope of the project but warrants further investigation.

5.2 Future Studies

Spatial variation and community composition were not investigated during this study due to time constraints however an understanding of these issues is critical to the development of a reserve system that not only caters for plants and vertebrate species but also invertebrates. Species richness counts alone tells us nothing about the changes that might be occurring within a community.

In addition, the high seasonality of invertebrates require that studies are conducted over at least one year preferably more in order to establish clear patterns of invertebrate species richness. Spot sampling only gives a snap shot in time. To gain a better appreciation of species richness it is necessary to sample at different times of the day. Although pitfall traps are known to be biased towards certain species this can be overcome, to a certain extent, by using a number of different size pit traps. A combination of pitfall trapping, hand collecting and heat extraction would return a much more representative sample.

Although a relationship between plant species richness and ground dwelling invertebrate richness was not demonstrated in this study there is some evidence that plant functional groups do play a role in invertebrate species richness. This is an avenue of research that also warrants further investigation. The study might have been better served if the invertebrates had also been sorted into their respective trophic groups. However, these issues are projects within themselves and are better investigated over longer periods of time.

What is certain is that, in the absence of alternative methods, we can not afford to dismiss the use of surrogates in invertebrate conservation. They have their place and if chosen carefully will provide some level of protection to certain invertebrate groups. However, we need to continue to improve our understanding of the relationships that exist between the surrogate and the target. We can no longer afford to make assumptions without validating that these relationships do actually exist. This can only be achieved through continued experimental or observational studies. If we do not carry out the basic ground work then we stand to loose a major component of biodiversity and place at risk the integrity of our life support systems.

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APPENDIX 1: Plot Study Report

APPENDIX 1: PILOT STUDY REPORT

INTRODUCTION

A pilot study was conducted in the Ridges Extension to the Yanchep National Park during July, August and September 2003. The principle aim of the study was to determine optimal scales for sampling plant and invertebrate communities. In addition the study aimed to identify potential invertebrate orders for the honours project, and provided an opportunity to experiment with the modified Kempson heat extraction units located on campus. The Ridges Extension is approximately 30 km north of Perth and was chosen for the study due to its close proximity to the city. The area is dominated by heath and open woodland. The sites were located approximately 1 km north of Yeal Swamp Road on the border of Yanchep National Park and the proposed extension to the park. Two 10 x 10m quadrats were marked out. They encompassed a representative sample of both heath and banksia woodland.

METHODS

Floristic Survey

The floristic survey was conducted using 10 nested quadrats commencing from a $1m^2$ quadrat increasing each subsequent quadrat in size up to a total sampling area of $100m^2$. All plant species occurring within the first quadrat were collected and allocated a number. During each survey only new species found in the larger quadrats were collected. Species were numbered and labelled according to the quadrat in which they were found and returned to the university for identification. Following identification species accumulation curves were produced. Nine ECU students assisted during the survey under the supervision of Dr. K. Lemson and myself. The fieldwork formed part of their assessment for Plant Diversity Unit SCB2423. Sampling took place on the 31^{st} August 2003.

Invertebrate Survey

An alternative method to nested quadrats was used during the invertebrate survey. The survey was designed to determine the most appropriate scale at which to sample invertebrates. Three plot sizes were trialed. The 50 x 50 cm (Trial A) and the 10 x 10 cm (Trial B) plots were replicated three times. The 200 x 200 cm plot (Trial C) was not replicated due to time constraints. Plots were randomly located within each 100 m^2 plant quadrat. Litter was removed from each plot and returned to the laboratory to undergo heat extraction using modified Kempson extraction units. Litter samples were stored in cold storage at a consent temperature of 15° prior to extraction. A limited amount of hand searching was also undertaken on site. Only invertebrates remaining on the soil surface after the litter was removed were collected.

The pilot study provided the opportunity to experiment with the Kempson extractors. Four variables were investigated during this phase of the study. They included extraction time, temperature, sample contamination and invertebrate escapees. Different treatments were applied to each batch of litter. Table 1 summarises the treatments applied.

Table 1: Summary of Litter Extraction Treatments

Trial No.	Temp. Day 1	Temp. Day 2	Temp. Day 4	Temp. Day 6	Temp. Day 8	Temp. Day 10	Total Days	Contaminate Control Technique	Litter Covered
A	25	35	45	-	-	-	6	Nil	Yes
B	25	35	45	-	-	-	6	Medical Gauze	No
C	30	35	45	55	65	-	10	Shaken	No

The base of each litter basket was fitted with a 1cm^2 mesh to allow the macroinvertebrate fauna to move freely in to the collection bowls. A small quantity of water was placed in each bowl. At the end of each extraction the water was strained through a 0.5 mm mesh sieve and the invertebrates preserved in 70% ethanol. All of the invertebrates collected were sorted to order.

RESULTS

The plant survey confirmed that a 10 x 10m quadrat adequately sampled the vegetation types under consideration. The number of new plant species collected from the first six nested quadrats varied considerably. However during both surveys the numbers of new species collected from the larger quadrats dropped significantly. Only one new species was found on the largest quadrat on the woodland site and no new species were collected from the equivalent size quadrat in the heath. Figure 1 shows the species accumulation curves obtained from each site. Although not all species could be identified forty-one different plant specimens, listed in Table 2, were collected from the woodland site and thirty-seven, listed in Table 3, from the heath site.

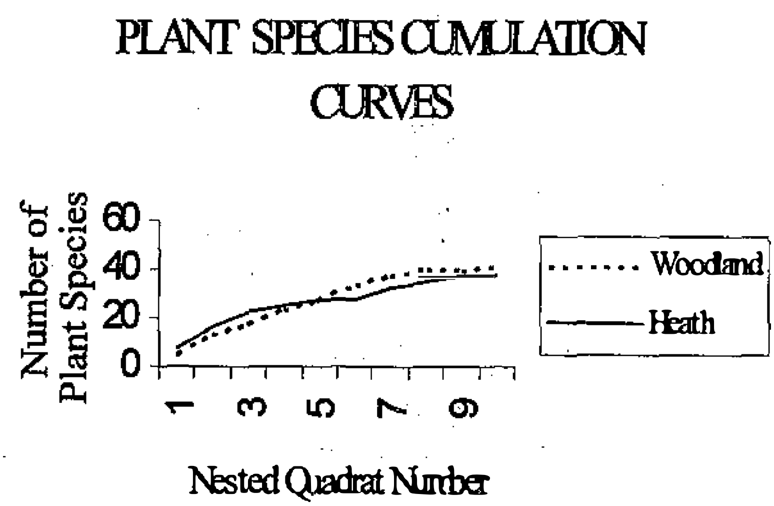

Figure 1 Plant species cumulative curves produced for the purpose of determining the scale of sampling for a floristic survey during a forthcoming honours project

Table 2: List of plant species collected from a Banksia woodland plot for the purposes of producing species cumulative curves to determine appropriate sampling scales for floristic surveys during forthcoming honours project

Quadrat No.	Species No.	Species Name	Total No. of Species
1	2	*Hypochaeris glabra*	
	10	*Astartea fascicularis*	
	6	*Hibbertia hypericoides*	
	4	*Drosera erythrorhiza*	
	5	Unidentified Species 1	5
2	12	*Ursinia anthemoides*	
	14	*Gladiolus caryophyllaceus*	
	15	*Conostylis aculeata*	
	17	*Gomopholobium tomentosum*	
	11	Unidentified Species 2	
	13	*Asteridia pulverulenta*	
	3	*Burchardia umbellata*	
	7	*Caladenia flava*	
	1	*Polycarpon tetraphyllum*	9
3	19	*Banksia attenuata*	
	8	*Mesomelaena Stygia*	
	22	*Hibbertia huegelii*	3
4	9	*Conostylis Setigera*	
	25	*Drosera pallida*	
	20	*Loxocarya cinerea*	
	23	*Jacksonia ??*	
	26	Unidentified Species 3	
	16	*Elythranthera brunonis*	
	24	*Wandering Jew*	7
5	35	*Dryandra nivea*	
	33	*Macrozamia riedlei*	
	36	*Conostephium preissii*	
	27	Unidentified Species 4	4
6	38	Unidentified Species 5	
	41	*Clematis microphylla*	
	21	*Stylidium brunonianum*	
	30	*Calothamnus quadrifidus*	
	32	*Synaphea spinulosa*	
	18	Unidentified Species 6	6
7	29	*Anigozanthos humilis*	
	40	*Xanthorrhoea preissii*	
	39	*Andersonia lehmanniana*	3
8	31	*Bossiaea Eriocarpa*	
	34	*Cassytha racemosa*	
	28	Unidentified Species 7	3
9			0
10	37	*Cryptandra arbutiflora*	1
TOTAL SPECIES			41

Table 3: List of plant species collected from a heath plot located 31 32 06 S 115 42 07 E for the purposes of producing species accumulation curves to determine appropriate sampling scale for floristic survey to be conducted during forthcoming honours project

Quadrat No.	Species No.	Species Name	Total No. of Species
1	1	*Calothamnus quadrifidus*	
	2	*Astartea fascicularis*	
	3	*Hibbertia hypericoides*	
	4	*Petrophile macrostachya*	
	5	*Astroloma macrocalyx*	
	6	Unidentified Species 1	
	7	Unidentified Species 2	7
2	8	*Gladiolus caryophyllaceus*	
	9	*Mesomelaena Stygia*	
	10	*Dryandra nivea*	
	11	*Macrozamia riedlei*	
	12	*Loxocarya cinerea*	
	13	*Jacksonia??*	
	14	*Hypochaeris glabra*	
	15	*Bossiaea eriocarpa*	
	16	Unidentified Species 3	9
3	17	*Dryandra sessilis*	
	18	*Drosera pallida*	
	19	*Conostylis setigera*	
	20	*Conostylis hybrid*	
	21	*Gomopholobium tomentosum*	
	22	*Hakea trifurcata*	6
4	23	*Acacia pulchella*	
	24	*Haemodorum laxum*	
	25	*Anagallis arvensis*	3
5	26	Unidentified Species 4	
	27	Unidentified Species 5	2
6	28	*Clematis Microphylla*	1
7	29	*Xanthorrhoea preissii*	
	30	*Drosera erythrorhiza*	
	31	Unidentified Species 6	
	32	Unidentified Species 7	4
8	33	*Adenanthos cygnorum*	
	34	*Leucopogen propinquus*	
	35	*Actinostrobus pyramidalis*	3
9	36	*Allocasuarina humilis*	
	37	*Ursinia anthemoides*	2
10			0
TOTAL SPECIES			37

During the study representatives from 27 invertebrate orders were collected. Table 4 provides a summary of the orders identified. Due to the high abundance of invertebrate fauna collected and time constraints none of the orders were sorted to morphospecies level. However it was possible to roughly estimate the number of species collected (refer to Table 4) while the invertebrates were sorted into orders. The most abundant and species rich orders were Collembola and Acarina. Isopods were rare, only three animals of the same species were collected during the study. Julida and were abundant but they appeared to be the same species. Two species of Polyxendia were collected but they were extremely rare. Hymenoptera, Araneae, Coleoptera and Pseudoscorpions were abundant and appeared to be relatively species rich. Geophilida were abundant but were not particularly species rich. Most of the other orders collected were rare usually only represented by one species. It must be stressed however that these are very conservative estimates and there is no doubt that many species would have been overlooked. Larvae were extremely abundant but no attempt was made to sort them into orders.

It was evident from Trial C that extended over 10 days that the majority of invertebrates were collected on Day 6 and 8. Some of the litter samples that were removed from the extraction units after Day 6 were still damp suggesting that 6 day extractions were too short and consequently may not have retrieved all of the invertebrates present. As trials A and B were only conducted over 6 days and the temperature did not exceed 45^{o} it is unlikely that a representative sample was obtained. However after Day 8 there was a significant reduction in invertebrates retrieved especially for Collembola. Acarina constituted the bulk of the invertebrates collected on Day 10 with only a small number of representatives from the other orders present.

Medical gauze placed over the plastic mesh covering the base of each litter basket was more effective in reducing the accumulation of litter debris in the samples than the other techniques used. However a major concern was that the gauze might have impeded the movement of the larger invertebrates into the collection receptacles.

Table 4: Summary of the invertebrate orders collected, their relative abundance and an estimation of each orders species richness

CLASS	ORDER	ABUNDANCE	ESTIMATED SPECIES RICHNESS
Arachnida	Scorpionida	Rare	1
	Araneae	Common	>5
	Pseudoscorpionida	Common	3 - 5
	Opilionida	Rare	1
	Acarina	Abundant	>10
Malacostraca	Isopoda	Rare	1
Chilopoda	Scolopendrida	Rare	1
	Geophilida	Common	<3
	Lithobiida	Rare	1
Diplopoda	Polyxenida	Rare	<3
	Spirobolida	Rare	1
	Julida	Common	1
	Spirostreptida	Rare	1
Collembola	Collembola	Abundant	>10
Diplura	Diplura	Rare	1
Insecta	Thysanura	Rare	<3
	Blattodea	Common	3-5
	Isoptera	Rare	1
	Orthoptera	Rare	1
	Embioptera	Rare	1
	Hemiptera	Common	3-5
	Thysanoptera	Rare	<3
	Neuroptera	Rare	<3
	Coleoptera	Common	>5
	Diptera	Rare	3-5
	Lepidoptera	Rare	1
	Hymenoptera	Common	>5

The litter baskets that were firmly shaken, prior to heat extraction, until most of the loose litter and sand had been dislodged proved to be an effective way of keeping the samples relatively free from debris while still ensuring that the macroinvertebrates could move freely into the collection bowls. Baskets that weren't prepared in this manner returned samples that were so contaminated with debris that it was extremely time consuming and difficult to separate out the invertebrates.

The plastic covers used to reduce the number of escapees collected condensation preventing the litter from drying out.

Water was not an acceptable collection media. Samples were often contaminated by algae making sorting difficult and the quality of the specimens poor.

Generally a $50cm^2$ plot yielded sufficient litter to fill two litter baskets. A $1m^2$ often filled as many as six baskets whilst the $2m^2$ utilised all of the available units and some times more. Therefore the capacity of the extraction units, given the time constraints of the study, was the major factor that determined the size of the invertebrate sampling plots.

DISCUSSION

Unfortunately one of the main aims of the pilot study was not realised. The optimal scale for sampling invertebrates was not determined. Trial C was the only trial that would have produced a representative sample given that Trials A and B were conducted over such a short time period and the temperature was not high enough to ensure that all of the invertebrates would have moved down into the collection bowls. Another problem that was encountered was the delay in treating the litter. The capacity of the extraction units was overestimated and large quantities of litter remained in cold storage for lengthy periods. Consequently most of the invertebrates collected would not have survived.

The pilot study did however produce some valuable information about the litter fauna that inhabit Banksia woodland. It also provided an excellent opportunity to

experiment with the extraction units so they could be operated effectively during the main study. Although a 200 x 200m plot returned the most invertebrate taxa the study proved that the volume of litter removed from such a large area was not practical. The study demonstrated that a $1m^2$ plot was a reasonable compromise to gain a representative sample of invertebrate species richness but the extraction units were not capable of processing the volume of litter that would have been collected from plots of this size given the time frame of the study. Therefore the pilot study resulted in a decision to sample a number of 50 x 50cm plots for the purpose of heat extraction and compliment this sampling technique with hand collection.

It was found that 8 day extractions were adequate providing that the temperature in the cabinets were raised gradually to at least 65^o. Due to the large numbers of Acarina collected during the study and the time required to sort this order to morphospecies it was considered impractical to include them in the main study. It was evident that not all orders could be sorted to morphospecies given the time constraints of the study. However Collembola were identified as an important order for the purposes of the study. They were abundant, species rich and responded to heat extraction earlier than the equally abundant and species rich Acarina. Consideration should also be given to some predator groups.

The amount of litter debris that accumulates in the collection bowls during the extraction process is a major concern and could potentially add weeks to this phase if relatively clean samples cannot be obtained. However it is equally important that the macroinvertebrates can move freely into the collection bowls. It is therefore recommended that the litter is well shaken to dislodge most of the loose litter prior to extraction. Water is not recommended for use in the extraction units. Ethylene glycol holds promise and is currently under investigation. It is possible that the extraction process could be improved if escapees were controlled however the numbers that escape appear to be relatively low.

Nested quadrats rather than independent quadrats, to produce species accumulation curves, are recommended for future studies. The latter method

proved extremely larbour intensive requiring large volumes of litter to be processed that by the end of the study failed to produce any clear evidence as to the most appropriate scale at which to sample invertebrates.

CONCLUSION

The pilot study has demonstrated that 10 x 10m quadrats are adequate to sample Banksia woodland and heath vegetation communities. Practicality rather than scale determined the size of the invertebrate sampling plots. Although scale is an important issue equipment availability and time constraints were the major determinants for this aspect of the study. It would appear that a good compromise for the invertebrate survey would be to sample a number of $1m^2$ plots located within each replicate using two complimentary sampling techniques. Litter will be removed from an area of 50 x 50cm within each plot for heat extraction purposes. The remaining litter within each plot will be hand sorted.

The Kempson heat extraction units provide representative samples of species richness for most invertebrate taxa provided that each extraction extends over a period of at least eight days and the temperature is carefully monitored whilst it is gradually increased to a maximum temperature of 65^{o}. Litter should not be stored in cold storage for any longer than 48 hours.

Before orders are selected for sorting into morphospecies they should meet a set of pre-selected criteria. Although saprophagous invertebrates were the preferred taxa for the project it may be necessary to include other invertebrate groups.

K.L. Ironside
30.10.2003

APPENDIX 2: Summary of individual replicate characteristics for each treatment

TREATMENT: Woodland Rich

Site No: WR1

The site was located in the Ridges State Forest approximately 0.75km north of Yeal Swamp Road and 0.5km east of the Yanchep National Park. It was situated at an altitude of 54m, facing in a south-easterly direction on a gently inclined (8°) waning mid-slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a mid-dense (39%) canopy of *Banksia attenuata* and scattered *Eucalyptus todtiana* averaging 5.5m in height. The percent canopy cover on site exceeded the treatment average of 22% but otherwise this vegetation is characteristic of Low Woodland A (Muir, 1977). A dense (85%) understorey was dominated by *Xanthorrhoea preissii*, *Hibbertia hypericoides* and *Leucopogon polymorphus*. The shrub stratum averaged 46cm in height and supported a rich herb layer. A total of 55 plant species comprising 24 shrubs, 25 herbs, 5 grass and sedges and one tree species were identified.

Patchy predominantly broad leaf litter covered 87% of the site. Litter depth ranged between 0 – 20mm and averaged 9.8mm. Dry weight of litter on site was estimated to be approximately 4.9 t/ha^{-1}. Litter and soil moisture content was high averaging 23% and 10.4% respectively and soil organic matter 4%. A summary of the parameters that were also measured at each 1m^2 plot is provided in Table1.1. Measurements are expressed as a mean (s.e. ±) for the five plots surveyed on site.

TABLE 1.1 Summary of Average Plot Parameters

PLOT Characteristics	Mean	S.E.
Plant Species Richness	10.8	±0.20
Understorey Cover	66%	±4.85
Understorey Height	33.2cm	±2.55
Litter Cover	84.4%	±9.60
Litter Depth	14 mm	±2.53
Exposed Limestone	Absent	

TREATMENT: Woodland Rich

Site No: WR2

The site was located in the Ridges State Forest approximately 0.75km north of Yeal Swamp Road and 0.5km east of the Yanchep National Park. It was situated at an altitude of 51m, facing in a south-easterly direction on a gently inclined (4^{o}) waning lower-slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a sparse (22%) canopy of *Banksia attenuata* and scattered *Eucalyptus todtiana* averaging 5.8m in height. This vegetation structure is characteristic of Low Woodland A (Muir, 1977). A dense (86%) understorey was dominated by *Xanthorrhoea preissii*, *Hibbertia hypericoides* and *Leucopogon polymorphus*. The shrub stratum averaged 61.3cm in height and supported a rich herb layer. A total of 53 plant species comprising 24 shrubs, 21 herbs, 7 grass and sedges and one tree species were identified.

Very patchy predominantly broad leaf litter covered 90% of the site. Litter depth ranged between 0 – 25mm and averaged 11.2mm. Dry weight of litter on site was estimated to be approximately 6 t/ha^{-1}. Litter and soil moisture content averaged 4.9% and 2.6% respectively. These results represent a marked reduction in moisture content for the site compared to the treatment average of 10.6% and 4.2%. Soil organic matter averaged 2.6%. A summary of the parameters that were also measured at each $1m^2$ plot is provided in Table1.2. Measurements are expressed as a mean (s.e. $\pm$) for the five plots surveyed on site.

TABLE 1.2 Summary of Average Plot Parameters

PLOT Characteristics	Mean	S.E.
Plant Species Richness	11.8	$\pm$0.73
Understorey Cover	71%	$\pm$7.31
Understorey Height	56.2cm	$\pm$9.55
Litter Cover	75.6%	$\pm$8.54
Litter Depth	11.1mm	$\pm$2.27
Exposed Limestone	Absent	

TREATMENT: Woodland Rich

Site No: WR3

The site was located in the Ridges State Forest approximately 0.75km north of Yeal Swamp Road and 0.7km east of the Yanchep National Park. It was situated at an altitude of 57m, facing in a south-easterly direction on a gently inclined (7^o) waning mid-slope (Speight, 1990). The area had not been burnt within the 8 years of the survey.

The vegetation comprised a sparse (15%) canopy of *Banksia attenuata* and scattered *Eucalyptus todtiana* averaging 5.2m in height. This vegetation structure is characteristic of Low Woodland A (Muir, 1977). A dense (89%) understorey was dominated by *Xanthorrhoea preissii*, *Hibbertia hypericoides* and *Leucopogon polymorphus*. The shrub stratum averaged 58.9cm in height and supported a rich herb layer. A total of 52 plant species comprising 22 shrubs, 23 herbs, 6 grass and sedges and one tree species were identified.

Very patchy predominantly broad leaf litter covered 87.3% of the site. Litter depth ranged between 0 – 15mm and averaged 8.4mm. Dry weight of litter on site was estimated to be approximately 8.6 t/ha^{-1}. Litter and soil moisture content averaged 3.4% and 0.8% respectively. These results represent a marked reduction in moisture content for the site compared to the treatment average of 10.6% and 4.2%. Soil organic matter averaged 2.5%. A summary of the parameters that were also measured at each $1m^2$ plot is provided in Table1.3. Measurements are expressed as a mean (s.e. $\pm$) for the five plots surveyed on site.

TABLE 1.3 Summary of Average Plot Parameters

PLOT Characteristics	Mean	S.E.
Plant Species Richness	11.8	$\pm$1.16
Understorey Cover	62%	$\pm$3.74
Understorey Height	44.2cm	$\pm$4.43
Litter Cover	91.6%	$\pm$2.79
Litter Depth	9.6mm	$\pm$1.51
Exposed Limestone	Absent	

TREATMENT: Woodland Rich

Site No: WR4

The site was located in the State Forest 65 approximately 0.5km south of the Pigeon and Hawk Road intersection. It was situated at an altitude of 56m, facing in a south-easterly direction on a gently inclined (7^{o}) waning mid-slope (Speight, 1990). The area had not been burnt within 8 years of the survey and bordered a cleared portion of the Pinjar pine plantation.

The vegetation comprised a very sparse (7%) canopy of *Banksia attenuata* and scattered *B. Menziesii* averaging 5.5m in height. The percent canopy cover on site was below the treatment average of 22% but otherwise this vegetation type is characteristic of Low Woodland A (Muir, 1977). A dense (84%) understorey was dominated by *Xanthorrhoea preissii*, *Hibbertia hypericoides* and *Leucopogon polymorphus*. The rich shrub stratum averaged 81.1cm in height and supported a relatively poor herb layer. A total of 53 plant species comprising 27 shrubs, 19 herbs, 6 grass and sedges and one tree species were identified.

Evenly distributed predominantly broad leaf litter covered 97% of the site. Litter depth ranged between 0 – 25mm and averaged 11mm. Dry weight of litter on site was estimated to be approximately 4.7 t/ha^{-1}. Litter and soil moisture content averaged 18.4% and 6% respectively. These results are a marked increase on the treatment average of 10.6% and 4.2%. Soil organic matter averaged 3.1%. A summary of the parameters that were also measured at each 1m^{2} plot is provided in Table1.4. Measurements are expressed as a mean (s.e. $\pm$) for the five plots surveyed.

TABLE 1.4 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	16	$\pm$ 1.10
Understorey Cover	68%	$\pm$ 5.83
Understorey Height	64cm	$\pm$13.85
Litter Cover	94.8%	$\pm$ 1.74
Litter Depth	8.4mm	$\pm$ 1.21
Exposed Limestone	Absent	

TREATMENT: Woodland Rich

Site No: WR5

The site was located in the State Forest 65 immediately south of the Haddrill and Mardo Road intersection. It was situated at an altitude of 65m, facing in a south-easterly direction on a gently inclined (9^{o}) waning mid-slope (Speight, 1990). The area had not been burnt within 8 years of the survey and bordered the Pinjar pine plantation.

The vegetation comprised a very sparse (26%) canopy of *Banksia attenuata* and scattered *Eucalyptus marginata* averaging 5.3m in height. This vegetation structure is characteristic of Low Woodland A (Muir, 1977). A dense (86%) understorey was dominated by *Xanthorrhoea preissii*, *Hibbertia hypericoides* and *Leucopogon polymorphus*. *Scholtzia involucrata*, a small to medium size shrub was also abundant on site. The rich shrub stratum averaged 58.1cm in height and supported a relatively poor herb layer. A total of 49 plant species comprising 27 shrubs, 15 herbs, 5 grass and sedges and two tree species were identified.

Evenly distributed predominantly broad leaf litter covered 94.3% of the site. Litter depth ranged between 0 – 25mm and averaged 13.3mm. Dry weight of litter on site was estimated to be approximately 8.5 t/ha^{-1}. Litter and soil moisture content averaged 3.4% and 1.3% respectively. These results are a marked decrease on the treatment average of 10.6% and 4.2%. Soil organic matter averaged 5%. A summary of the parameters that were also measured at each $1m^2$ plot is provided in Table1.5. Measurements are expressed as a mean (s.e. ±) for the five plots surveyed on site.

TABLE 1.5 Summary of Average Plot Parameters

PLOT Characteristics	Mean	S.E.
Plant Species Richness	12	±0.84
Understorey Cover	60%	±8.22
Understorey Height	54.6cm	±5.45
Litter Cover	85.6%	±5.78
Litter Depth	9 mm	±2.05
Exposed Limestone	Absent	

TREATMENT: Woodland Poor

Site No: WP1

The site was located in the Ridges State Forest on Yeal Swamp Road approximately 2km north of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 35m, facing in a south-easterly direction on a gently inclined (6^o) waning lower slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation in the area was comprised of a sparse (10-30%) canopy of *Banksia attenuata*, scattered *B. ilicifolia* and *Melaleuca preissiana* with an estimated height of 7m. This vegetation structure is characteristic of Low Woodland A (Muir, 1977). The dense (78%) understorey was dominated by *Beaufortia elegans*, *Eremaea pauciflora* and *Scholtzia involucrata*. The shrub stratum averaged 60cm in height and supported a relatively rich herb layer. A total of 44 plant species comprising 21 shrubs, 21 herbs, 2 grass and sedges were identified. Trees were absent.

Very patchy predominantly broad leaf litter covered 76% of the site. Litter depth ranged between 0 – 20mm and averaged 8.3mm. Dry weight of litter on site was estimated to be approximately 8.1 t/ha^{-1}. Litter and soil moisture content averaged 4.8% and 2.7% respectively which is slightly below the treatment average of 6% and 1.5%. Soil organic matter was recorded as 4.25%. A summary of the parameters that were also measured at each $1m^2$ plot is provided in Table 2.1. Measurements are expressed as a mean (s.e. $\pm$) for the five plots surveyed on site.

TABLE 2.1 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	8	$\pm$ 0.89
Understorey Cover	70%	$\pm$ 5.48
Understorey Height	48.8cm	$\pm$ 3.45
Litter Cover	62.4%	$\pm$10.05
Litter Depth	10.8mm	$\pm$ 1.91
Exposed Limestone	Absent	

TREATMENT: Woodland Poor

Site No: WP2

The site was located in the Ridges State Forest on Yeal Swamp Road approximately 2km north of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 38m, facing in a south-easterly direction on a gently inclined (10^o) waning lower slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a sparse (16%) canopy of *Banksia attenuata* averaging 6.9m in height. Scattered *B. ilicifolia* and *Melaleuca preissiana* were common in the area. This vegetation structure is characteristic of Low Woodland A (Muir, 1977). The dense (74%) understorey was dominated by *Beaufortia elegans*, *Eremaea pauciflora* and *Scholtzia involucrata*. The shrub stratum averaged 41.6cm in height and supported a relatively poor herb layer. A total of 37 plant species comprising 19 shrubs, 14 herbs, 3 grass and sedges and one tree species were identified.

Very patchy predominantly broad leaf litter covered 82.3% of the site. Litter depth ranged between 0 – 25mm and averaged 11.3mm. Dry weight of litter on site was estimated to be approximately 5.2 t/ha^{-1}. Litter and soil moisture content averaged 1.9% and 0.7% respectively which is significantly lower than the treatment average of 6% and 1.5%. Soil organic matter was recorded as 3.2%. A summary of the parameters that were also measured at each $1m^2$ plot is provided in Table 2.2. Measurements are expressed as a mean (s.e. $\pm$) for the five plots surveyed on site.

TABLE 2.2 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	11.4	$\pm$ 1.03
Understorey Cover	54%	$\pm$ 6.78
Understorey Height	35.3cm	$\pm$ 4.25
Litter Cover	73%	$\pm$10.55
Litter Depth	10.4mm	$\pm$ 1.56
Exposed Limestone	Absent	

TREATMENT: Woodland Poor

Site No: WP3

The site was located in the Ridges State Forest on Yeal Swamp Road approximately 2km north of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 36m, facing in a south-easterly direction on a gently inclined (8^{o}) waning lower slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a very sparse (7%) canopy of *Banksia attenuata* averaging 6.9m in height. Scattered *B. ilicifolia* and *Melaleuca preissiana* were common in the area. The canopy cover on site was not representative of the sparse canopy (10 – 30%) that was characteristic of the Low Woodland A (Muir, 1977) in the surrounding area. The dense (73%) understorey was dominated by *Beaufortia elegans*, *Eremaea pauciflora* and *Scholtzia involucrata*. The shrub stratum averaged 53.7cm in height. A total of 35 plant species comprising 15 shrubs, 14 herbs, 5 grass and sedges and one tree species were identified.

Evenly distributed predominantly broad leaf litter covered 94.3% of the site. Litter depth ranged between 0 – 25mm and averaged 12.1mm. Dry weight of litter on site was estimated to be approximately 6.8 t/ha^{-1}. Litter and soil moisture content averaged 2% and 0.7% respectively which is significantly lower than the treatment average of 6% and 1.5%. Soil organic matter was recorded as 2.6%. A summary of the parameters that were also measured at each $1m^2$ plot is provided in Table 2.3. Measurements are expressed as a mean (s.e. ±) for the five plots surveyed on site.

TABLE 2.3 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	7.6	±1.50
Understorey Cover	58%	±4.90
Understorey Height	57.6cm	±6.32
Litter Cover	98.8%	±0.80
Litter Depth	13.6mm	±0.93
Exposed Limestone	Absent	

TREATMENT: Woodland Poor

Site No: WP4

The site was located in the Ridges State Forest on Yeal Swamp Road approximately 2.5km north of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 36m, facing in a south-easterly direction on a gently inclined (8^o) waning lower slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a mid-dense (31%) canopy of *Banksia attenuata* and *B. ilicifolia* averaging 7.9m in height. *Melaleuca preissiana* was also common in the area. The canopy cover on site was not representative of the sparse canopy (10 – 30%) that was characteristic of the Low Woodland A (Muir, 1977) in the surrounding area. A dense (86%) understorey was dominated by *Beaufortia elegans*, *Eremaea pauciflora* and *Scholtzia involucrata*. The shrub stratum averaged 44cm in height. A total of 40 plant species comprising 18 shrubs, 16 herbs, 4 grasses and two tree species were identified.

Evenly distributed predominantly broad leaf litter covered 95% of the site. Litter depth ranged between 0 – 30mm and averaged 13.2mm. Dry weight of litter on site was estimated to be approximately 7.9 t/ha^{-1}. Litter and soil moisture content averaged 15.4% and 1.3% respectively. Litter moisture content was significantly higher than the treatment average of 6%. Soil organic matter was recorded as 2.5%. A summary of the parameters that were also measured at each $1m^2$ plot is provided in Table 2.4. Measurements are expressed as a mean (s.e. $\pm$) for the five plots surveyed.

TABLE 2.4 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	12	±0.77
Understorey Cover	57	±4.36
Understorey Height	31.1cm	± 3.58
Litter Cover	72.6%	±7.55
Litter Depth	7.7mm	±0.95
Exposed Limestone	Absent	

TREATMENT: Woodland Poor

Site No: WP5

The site was located in the Ridges State Forest on Yeal Swamp Road approximately 3.5km north of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 33m, facing in a south-easterly direction on a very gently inclined (2^o) waning lower slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a sparse (16%) canopy of *Banksia attenuata* averaging 5.8m in height. Scattered *B. ilicifolia* and *Melaleuca preissiana* were common in the area. This vegetation structure is characteristic of Low Woodland A (Muir, 1977). The mid-dense to dense (70%) understorey was dominated by *Beaufortia elegans*, *Eremaea pauciflora* and *Scholtzia involucrata*. The shrub stratum averaged 48.1cm in height. A total of 36 plant species comprising 18 shrubs, 16 herbs, one grass and one tree species were identified.

Patchy predominantly broad leaf litter covered 79% of the site. Litter depth ranged between 0 – 20mm and averaged 9.2mm. Dry weight of litter on site was estimated to be approximately 8.5 t/ha^{-1}. Litter and soil moisture content averaged 6% and 2% respectively which compares well with the treatment average of 6% and 1.5%. Soil organic matter was recorded as 3.3%. A summary of the parameters that were also measured at each $1m^2$ plot is provided in Table 2.5. Measurements are expressed as a mean (s.e. $\pm$) for the five plots surveyed on site.

TABLE 2.5 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	10.6	$\pm$0.93
Understorey Cover	59%	$\pm$2.45
Understorey Height	41.2cm	$\pm$2.52
Litter Cover	90.4%	$\pm$3.66
Litter Depth	8.6mm	$\pm$0.68
Exposed Limestone	Absent	

TREATMENT: Heath Rich

Site No: HR1

The site was located in the Ridges State Forest east of the Ridge's lookout point approximately 0.5km north west of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 85m, facing in a south-easterly direction on a gently inclined (9^{o}) waning upper slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena, Acacia lasiocarpa* and *Baeckea robusta*. The average percentage cover and height of the shrub stratum was 83% and 40cm respectively. This vegetation structure is characteristic of Dense Low Heath D (Muir, 1977). The community type was rare being restricted to the limestone ridges in the area. The shrub stratum supported an equally rich layer of herbs. A total of 52 plant species comprising 23 shrubs, 22 herbs and 7 grasses were identified. The mosses were not included in the species count as they were dried out and therefore formed part of the litter layer (Keighery, 1993).

A dense, evenly distributed, layer of dried annual herbs and mosses covered 79.7% of the site. Litter depth ranged between 0 – 20mm averaging 10.7mm. Dry weight of litter on site was estimated to be approximately 13.1 t/ha^{-1}. Litter and soil moisture content averaged 6.6% and 1.9% respectively and soil organic matter 5.4%. Limestone outcrops featured on site with an average percentage cover of 13%. A summary of the parameters that were also measured at each 1m^2 is provided in Table 3.1. Measurements are expressed as a mean (s.e. ±) for the five plots.

TABLE 3.1 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	18.2	±1.53
Understorey Cover	71%	±2.92
Understorey Height	45.5cm	±6.21
Litter Cover	92.4%	±4.75
Litter Depth	12.8mm	±1.77
Exposed Limestone	4%	±1.00

TREATMENT: Heath Rich

Site No: HR2

The site was located in the Ridges State Forest west of the Ridge's lookout point approximately 0.5km north west of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 75m, facing in a south-easterly direction on a gently inclined (8^o) waning upper slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena, Acacia lasiocarpa* and *Baeckea robusta*. The average percentage cover and height of the shrub stratum was 81% and 36.3cm respectively. This vegetation structure is characteristic of Dense Low Heath D (Muir, 1977). The community type was rare being restricted to the limestone ridges in the area. The shrub stratum supported an equally rich layer of herbs. A total of 45 plant species comprising 20 shrubs, 20 herbs and 5 grasses were identified. The mosses were not included in the species count as they were dried out and therefore formed part of the litter layer (Keighery, 1993).

A dense but very patchy layer of dried annual herbs and mosses covered 87.3% of the site. Litter depth ranged between 0 – 25mm averaging 10.9mm. Dry weight of litter on site was estimated to be approximately 6.2 t/ha^{-1}. Litter and soil moisture content averaged 3.4% and 1.1% respectively and soil organic matter 3.9%. Limestone outcrops rarely featured on site with an average percentage cover of 3%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 3.2. Measurements are expressed as a mean (s.e. ±) for the five plots.

TABLE 3.2 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	14.6	±0.51
Understorey Cover	67%	±7.35
Understorey Height	30.5cm	±4.22
Litter Cover	73.6%	±4.87
Litter Depth	10.9mm	±3.32
Exposed Limestone	1%	±1.00

TREATMENT: Heath Rich

Site No: HR3

The site was located in the Ridges State Forest south of a disused limestone quarry approximately 0.7km north west of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 70m, facing in a south-easterly direction on a gently inclined (6^o) waning mid-slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena, Acacia lasiocarpa* and *Baeckea robusta*. The average percentage cover and height of the shrub stratum was 85% and 66.4cm respectively. This vegetation structure is characteristic of Dense Low Heath D (Muir, 1977). The community type was rare being restricted to the limestone ridges in the area. The shrub stratum supported an equally rich layer of herbs. A total of 48 plant species comprising 19 shrubs, 22 herbs and 7 grasses were identified. The mosses were not included in the species count as they were dried out and therefore formed part of the litter layer (Keighery, 1993).

A dense, evenly distributed, layer of dried annual herbs and mosses covered 87.3% of the site. Litter depth ranged between 0 – 25mm averaging 11.4mm. Dry weight of litter on site was estimated to be approximately 10.7 t/ha^{-1}. Litter and soil moisture content averaged 5.7% and 1.5% respectively and soil organic matter 5.2%. Limestone outcrops featured on site with an average percentage cover of 11%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 3.3. Measurements are expressed as a mean (s.e. $\pm$) for the five plots.

TABLE 3.3 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	13	$\pm$1.10
Understorey Cover	75%	$\pm$3.87
Understorey Height	51.3cm	$\pm$5.73
Litter Cover	87.2%	$\pm$7.86
Litter Depth	10.6mm	$\pm$1.54
Exposed Limestone	11%	$\pm$9.80

TREATMENT: Heath Rich

Site No: HR4

The site was located in the Ridges State Forest south of a disused limestone quarry approximately 0.7km north west of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 65m, facing in a south-easterly direction on a gently inclined (10^o) waning mid-slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena, Acacia lasiocarpa* and *Baeckea robusta.* The average percentage cover and height of the shrub stratum was 84% and 49.4cm respectively. This vegetation structure is characteristic of Dense Low Heath D (Muir, 1977). The community type was rare being restricted to the limestone ridges in the area. The shrub stratum supported a relatively rich layer of herbs. A total of 50 plant species comprising 25 shrubs, 19 herbs and 6 grasses were identified. Mosses were not included in the species count as they were dried out and therefore formed part of the litter layer (Keighery, 1993).

A dense, evenly distributed, layer of dried annual herbs and mosses covered 86.7% of the site. Litter depth ranged between 0 – 25mm averaging 12.4mm. Dry weight of litter on site was estimated to be approximately 8.3 t/ha^{-1}. Litter and soil moisture content averaged 4.5% and 2.5% respectively and soil organic matter 4.5%. Limestone outcrops featured on site with an average percentage cover of 10%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 3.4. Measurements are expressed as a mean (s.e. ±) for the five plots.

TABLE 3.4 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	18.2	±0.97
Understorey Cover	74%	±2.45
Understorey Height	51.7cm	±6.79
Litter Cover	93.6%	±3.66
Litter Depth	12.3mm	±2.34
Exposed Limestone	15%	±6.32

TREATMENT: Heath Rich

Site No: HR5

The site was located in the Ridges State Forest south-west of a disused limestone quarry approximately 0.7km north west of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 73m, facing in a south-easterly direction on a gently inclined (6^o) waning mid-slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena, Acacia lasiocarpa* and *Baeckea robusta*. The average percentage cover and height of the shrub stratum was 79% and 34.5cm respectively. This vegetation structure is characteristic of Dense Low Heath D (Muir, 1977). The community type was rare being restricted to the limestone ridges in the area. The shrub stratum supported an equally rich layer of herbs. A total of 53 plant species comprising 22 shrubs, 24 herbs and 7 grass and sedges were identified. Mosses were not included in the species count as they were dried out and formed part of the litter layer (Keighery, 1993).

A dense but patchy layer of dried annual herbs and mosses covered 86.3% of the site. Litter depth ranged between 0 – 20mm averaging 9.8mm. Dry weight of litter on site was estimated to be approximately 9.4 t/ha^{-1}. Litter and soil moisture content averaged 2.9% and 1.1% respectively and soil organic matter 4.3%. Limestone outcrops rarely featured on site with an average percentage cover of 6%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 3.5. Measurements are expressed as a mean (s.e. $\pm$) for the five plots.

TABLE 3.5 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	16.2	$\pm$0.58
Understorey Cover	62%	$\pm$5.61
Understorey Height	32.2cm	$\pm$2.88
Litter Cover	97.6%	$\pm$1.17
Litter Depth	11.6mm	$\pm$0.81
Exposed Limestone	3%	$\pm$3.00

TREATMENT: Heath Poor

Site No: HP1

The site was located in the Ridges State Forest south of a disused limestone quarry approximately 0.7km north west of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 70m, facing in a south-easterly direction on a gently inclined (5^o) waning upper slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena* and *M. huegelii.* The average percentage cover and height of the shrub stratum was 72% and 74.6cm respectively. This vegetation structure is characteristic of Dense Low Heath C (Muir, 1977). The community type 26a (Gibson, Keighery, Keighery, Burbidge, & Lyons, 1994) is recognised as critically threatened (Weston & Gibson, 1997). A total of 36 plant species comprising 10 shrubs, 21 herbs and 5 grasses were identified. Mosses were not included in the species count as they were dried out and formed part of the litter layer (Keighery, 1993).

A dense, evenly distributed, layer of dried annual herbs and mosses covered 86% of the site. Litter depth ranged between 0 – 15mm averaging 8.3mm. Dry weight of litter on site was estimated to be approximately 9.4 t/ha^{-1}. Litter and soil moisture content averaged 4.4% and 2.7% respectively and soil organic matter 11.4%. Limestone outcrops featured on site with an estimated cover of 11%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 4.1. Measurements are expressed as a mean (s.e. $\pm$) for the five plots.

TABLE 4.1 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	14.2	$\pm$0.58
Understorey Cover	70%	$\pm$3.16
Understorey Height	59.2cm	$\pm$7.51
Litter Cover	97.2%	$\pm$2.80
Litter Depth	9.1mm	$\pm$0.98
Exposed Limestone	4%	$\pm$1.87

TREATMENT: Heath Poor

Site No: HP2

The site was located in the Ridges State Forest south-west of a disused limestone quarry approximately 0.7km north west of the Yeal Swamp and Pigeon Road intersection. It was situated at an altitude of 78m, facing in a south-easterly direction on a gently inclined (8^o) waning upper slope (Speight, 1990). The area had not been burnt within 8 years of the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena* and *M. huegelii.* The average percentage cover and height of the shrub stratum was 78% and 59.6cm respectively. This vegetation structure is characteristic of Dense Low Heath C (Muir, 1977). The community type 26a (Gibson et al., 1994) is recognised as critically threatened (Weston & Gibson, 1997). A total of 37 plant species comprising 12 shrubs, 19 herbs and 6 grasses were identified. Mosses were not included in the species count as they were dried out and formed part of the litter layer (Keighery, 1993).

A dense, evenly distributed, layer of dried annual herbs and mosses covered 86.3% of the site. Litter depth ranged between 0 – 20mm averaging 10.4mm. Dry weight of litter on site was estimated to be approximately 6.6 t/ha^{-1}. Litter and soil moisture content averaged 5.2% and 3.1% respectively and soil organic matter 10.1%. Limestone outcrops rarely featured on site with an estimated cover of 6%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 4.2. Measurements are expressed as a mean (s.e. ±) for the five plots.

TABLE 4.2 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	13.4	±0.51
Understorey Cover	69%	±4.58
Understorey Height	42.9cm	±6.34
Litter Cover	88.4%	±6.40
Litter Depth	10mm	±2.00
Exposed Limestone	4%	±2.45

TREATMENT: Heath Poor

Site No: HP3

The site was located in the Yanchep National Park south of the Old Yanchep Road and 1.5km east of the Wanneroo Road. It was situated at an altitude of 14m, facing in a south-easterly direction on a gently inclined (5^{o}) waning lower slope (Speight, 1990). The area had not been burnt for approximately 12 years.

The vegetation comprised a mid-dense to dense heath dominated by *Melaleuca huegelii* and *M.* systena. The average percentage cover and height of the shrub stratum was 66%, slightly lower than the treatment average, and 73.5cm respectively. This vegetation structure is characteristic of Dense Low Heath C (Muir, 1977). The community type 26a (Gibson et al., 1994) is recognised as critically threatened (Weston & Gibson, 1997). A total of 39 plant species comprising 14 shrubs, 19 herbs and 6 grasses were identified. Mosses were not included in the species count as they were dried out forming part of the litter layer (Keighery, 1993).

A dense, evenly distributed, layer of dried annual herbs and mosses covered 72.7% of the site. Litter depth ranged between 0 – 20mm averaging 11.8mm. Dry weight of litter on site was estimated to be approximately 5.3 t/ha^{-1}. Litter and soil moisture content averaged 3.6% and 1.4% respectively and soil organic matter 5.3%. Limestone outcrops featured prominently on site with an estimated cover of 20%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 4.3. Measurements are expressed as a mean (s.e. $\pm$) for the five plots.

TABLE 4.3 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	13.2	±0.73
Understorey Cover	54%	±4.00
Understorey Height	59cm	±6.29
Litter Cover	90.8%	±7.36
Litter Depth	8.6mm	±0.75
Exposed Limestone	19%	±5.10

TREATMENT: Heath Poor

Site No: HP4

The site was located in the Ridges State Forest approximately 1.25km east of the Wanneroo Road and west of a disused limestone quarry on Parrot Ridge. It was situated at an altitude of 82m, facing in a south-easterly direction on a moderately inclined (15^o) waning upper slope (Speight, 1990). The area had not been burnt for approximately 17 years prior to the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena* and *M. huegelii.* The average percentage cover and height of the shrub stratum was 72% and 81.6cm respectively. This vegetation structure is characteristic of Dense Low Heath C (Muir, 1977). The community type 26a (Gibson et al., 1994) is recognised as critically threatened (Weston & Gibson, 1997). A total of 30 plant species comprising 10 shrubs, 16 herbs and 4 grasses were identified. Mosses were not included in the species count as they were dried out and formed part of the litter layer (Keighery, 1993).

A dense, evenly distributed, layer of dried annual herbs and mosses covered 76% of the site. Litter depth ranged between 0 – 20mm averaging 9.6mm. Dry weight of litter on site was estimated to be approximately 9 t/ha^{-1}. Litter and soil moisture content averaged 8.3% and 7.9% respectively and soil organic matter 20.6%. Limestone outcrops featured prominently on site with an estimated cover of 24%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 4.4. Measurements are expressed as a mean (s.e. $\pm$) for the five plots.

TABLE 4.4 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	13.2	$\pm$ 0.66
Understorey Cover	64%	$\pm$ 6.20
Understorey Height	67.8cm	$\pm$11.02
Litter Cover	90.2%	$\pm$ 4.76
Litter Depth	10.2mm	$\pm$ 0.49
Exposed Limestone	20%	$\pm$ 2.24

TREATMENT: Heath Poor

Site No: HP5

The site was located in the Ridges State Forest approximately 1km north of the Pigeon and Hawk Road intersection and east of a disused limestone quarry. It was situated at an altitude of 61m, facing in a south-easterly direction on a gently inclined (8^{o}) waning mid-slope (Speight, 1990). The area had not been burnt for approximately 8 years prior to the survey.

The vegetation comprised a dense heath dominated by *Melaleuca systena* and *M. huegelii.* The average percentage cover and height of the shrub stratum was 75% and 56.6cm respectively. This vegetation structure is characteristic of Dense Low Heath C (Muir, 1977). The community type 26a (Gibson et al., 1994) is recognised as critically threatened (Weston & Gibson, 1997). A total of 29 plant species comprising 10 shrubs, 15 herbs and 4 grasses were identified. Mosses were not included in the species count as they were dried out and formed part of the litter layer (Keighery, 1993).

A dense, evenly distributed, layer of dried annual herbs and mosses covered 94.7% of the site. Litter depth ranged between 0 – 15mm averaging 9.3mm. Dry weight of litter on site was estimated to be approximately 10.2 t/ha^{-1}. Litter and soil moisture content averaged 4.9% and 1.8% respectively and soil organic matter 5.4%. Limestone outcrops featured on site with an estimated cover of 10%. A summary of the parameters that were also measured at each $1m^2$ is provided in Table 4.5. Measurements are expressed as a mean (s.e. $\pm$) for the five plots.

TABLE 4.5 Summary of Average Plot Measurements

PLOT Characteristics	Mean	S.E.
Plant Species Richness	15	$\pm$1.14
Understorey Cover	70%	$\pm$6.89
Understorey Height	51.7cm	$\pm$2.39
Litter Cover	94.8%	$\pm$3.77
Litter Depth	10.6mm	$\pm$1.36
Exposed Limestone	5%	$\pm$1.58

APPENDIX 3: Plant species inventory for each replicate showing plant species richness counts for individual plots and the importance value assigned to individual plant species according to their importance value (cover/dominance) and hence their contribution to the litter layer

TREATMENT: WOODLAND RICH			PLOT NUMBER				
REPLICATE NO: 1							
UNDERSTOREY PLANT SPECIES RICHNESS			1	2	3	4	5
SHRUB			6	4	5	4	7
HERB			3	5	2	6	3
GRASSES			1	1	1	0	0
SEDGES			1	1	2	1	1
TOTAL NUMBER OF SPECIES	REPLICATE:	55PLOTS:	11	11	10	11	11

SPECIES PERCENTAGE COVER

COVER CODE:

BRAUN-BLANQUET

1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
TREES	Myrtaceae	*Eucalyptus*	*todtiana*					
SHRUBS	Dilleniaceae	*Hibbertia*	*huegelii*	2				
		Hibbertia	*hypericoides*	5	6	5	5	5
	Epacridaceae	*Conostephium*	*preissii*					
		Croninia	*kingiana*					
		Leucopogon	*nutans*					
		Leucopogon	*polymorphus*	3	4	3	3	2
		Lysinema	*ciliatum*					
	Mimosaceae	*Acacia*	*pulchella*					
	Myrtaceae	*Calothamnus*	*quadrifidus*	5			4	4
		Calytrix	*flavescens*					
		Leptospermum	*spinescens*					
	Papilionaceae	*Bossiaea*	*eriocarpa*					2
		Gompholobium	*tomentosum*	2	1	2		1
		Hovea	*trisperma*					
		Oxylobium	*capitatum*					2
	Proteaceae	*Dryandra*	*nivea*					
		Hakea	*ruscifolia*					
		Petrophile	*linearis*		1	1	1	1
		Petrophile	*macrostachya*					
		Petrophile	*serruriae*					
		Stirlingia	*latifolia*					
		Synaphea	*spinulosa*					
	Rubiaceae	*Opercularia*	*vaginata*					
	Xanthorrhoeacea	*Xanthorrhoea*	*preissii*	2		2		
HERBS	Anthericaceae	*Thysanotus*	*arenarius*					
	Apiaceae	*Trachymene*	*pilosa*				1	1
	Asteraceae	*Brachyscome*	*iberidifolia*					
		Hypochaeris	*glabra*					
		Ursinia	*anthemoides*					1
	Colchicaceae	*Burchardia*	*umbellata*					
	Dasypogonaceae	*Lomandra*	*preissii*	1	2			
	Droseraceae	*Drosera*	*erythrorhiza*					
		Drosera	*pallida*					
	Haemodoraceae	*Conostylis*	*aculeata*					
		Conostylis	*hybrid*					
		Conostylis	*setigera*	1		1		
		Haemodorum	*laxum*					
	Iridaceae	*Gladiolus*	*caryophyllaceus*					
	Loganiaceae	*Mitrasacme*	*paradoxa*					
	Orchidaceae	*Caladenia*	*flava*					
		Elythranthera	*brunonis*					
	Ranunculaceae	*Clematis*	*microphylla*	2	2	2	2	
	Restionaceae	*Desmocladus*	*asper*		1		1	1
		Hypolaena	*exsulca*					
	Stylidiaceae	*Levenhookia*	*pusilla*					
		Stylidium	*brunonianum*				1	
		Stylidium	*crossocephalum*		1		1	
		Stylidium	*repens*		1		1	
		Stylidium	*schoenoides*					
GRASSES	Poaceae	*Aira*	*cupaniana*					
		Pentaschistis	*airoides*	1	1	1		
		Vulpia	*myuros*					
SEDGES	Cyperaceae	*Lepidosperma*	*angustatum*	1	1	1	1	1
		Mesomelaena	*pseudostygia*			2		
TOTAL NUMBER OF SPECIES				11	11	10	11	11

TREATMENT: WOODLAND RICH				**PLOT**				
REPLICATE NO: 2				**NUMBER**				
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				7	6	5	5	7
HERB				3	5	6	4	5
GRASSES				1	1	1	0	0
SEDGES				1	1	1	0	0
TOTAL NUMBER OF SPECIES		REPLICATE:	53 PLOTS:	12	13	13	9	12

SPECIES PERCENTAGE COVER

COVER CODE:

BRAUN-BLANQUET

1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
TREES	Proteaceae	*Banksia*	*attenuata*	2				
SHRUBS	Dilleniaceae	*Hibbertia*	*huegelii*					
		Hibbertia	*hypericoides*	4	5		5	4
	Epacridaceae	*Conostephium*	*preissii*	3				
		Croninia	*kingiana*		3			5
		Leucopogon	*nutans*					
		Leucopogon	*polymorphus*	2	3	3	4	4
	Mimosaceae	*Acacia*	*pulchella*			2		
	Myrtaceae	*Calothamnus*	*quadrifidus*			2		2
		Calytrix	*angulata*					
	Papilionaceae	*Bossiaea*	*eriocarpa*		2		2	
		Gompholobium	*tomentosum*		2		1	1
		Hovea	*trisperma*					
		Jacksonia	*sternbergiana*	7				
		Oxylobium	*capitatum*					
	Proteaceae	*Dryandra*	*nivea*					
		Dryandra	*sessilis*					3
		Hakea	*ruscifolia*					
		Petrophile	*linearis*	2			2	
		Petrophile	*macrostachya*			4		
		Petrophile	*serruriae*		2			
		Stirlingia	*latifolia*					
		Synaphea	*spinulosa*	5		3		4
	Rubiaceae	*Opercularia*	*vaginata*					
	Xanthorrhoeacea	*Xanthorrhoea*	*preissii*					
HERBS	Asteraceae	*Brachyscome*	*iberidifolia*					
		Hypochaeris	*glabra*			1	1	
		Ursinia	*anthemoides*					
		Waitzia	*suaveolens*				1	
	Colchicaceae	*Burchardia*	*umbellata*					
	Dasypogonaceae	*Lomandra*	*preissii*	1				
	Droseraceae	*Drosera*	*pallida*					
	Haemodoraceae	*Anigozanthos*	*humilis*					
		Conostylis	*aculeata*					
		Conostylis	*hybrid*		2			
		Conostylis	*setigera*	1	1	2	2	
		Haemodorum	*laxum*					
	Loganiaceae	*Mitrasacme*	*paradoxa*					
	Orchidaceae	*Elythranthera*	*brunonis*					
	Pittosporaceae	*Pronaya*	*fraseri*					
	Ranunculaceae	*Clematis*	*microphylla*	2	4	3	2	2
	Restionaceae	*Desmocladus*	*asper*					2
		Hypolaena	*exsulca*		1	1		1
	Stylidiaceae	*Levenhookia*	*pusilla*					
		Stylidium	*brunonianum*		1	1		1
		Stylidium	*crossocephalum*			1		1
		Stylidium	*repens*					
GRASSES	Poaceae	*Amphipogon*	*turbinatus*					
		Pentaschistis	*airoides*	1	1	1		
		Stipa	*flavescens*					
		Vulpia	*myuros*					
SEDGES	Cyperaceae	*Lepidosperma*	*angustatum*					
		Mesomelaena	*pseudostygia*	1	2	3		
		Schoenus	*curvifolius*					
TOTAL NUMBER OF SPECIES				12	13	13	9	12

TREATMENT: WOODLAND RICH				PLOT NUMBER				
REPLICATE NO: 3								
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				6	8	7	9	6
HERB				3	4	4	5	3
GRASSES				0	2	0	0	0
SEDGES				1	0	0	1	0
TOTAL NUMBER OF SPECIES		REPLICATE:	52 PLOTS:	10	14	11	15	9

SPECIES PERCENTAGE COVER

COVER CODE:

BRAUN-BLANQUET

1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
TREES	Proteaceae	*Banksia*	*attenuata*					
SHRUBS	Casuarinaceae	*Allocasuarina*	*humilis*					
	Dilleniaceae	*Hibbertia*	*huegelii*				2	
		Hibbertia	*hypericoides*	4	2	4		5
	Epacridaceae	*Conostephium*	*preissii*					
		Croninia	*kingiana*					
		Leucopogon	*polymorphus*	2	2	4	2	3
		Lysinema	*ciliatum*	2	2	3	2	
	Mimosaceae	*Acacia*	*pulchella*		4	2		
	Myrtaceae	*Calothamnus*	*quadrifidus*	3	3	5	2	2
		Leptospermum	*spinescens*					
	Papilionaceae	*Bossiaea*	*eriocarpa*		2		2	2
		Gompholobium	*tomentosum*	2		2	2	2
		Jacksonia	*sternbergiana*					
		Oxylobium	*capitatum*		1	2		
	Proteaceae	*Hakea*	*ruscifolia*					
		Petrophile	*linearis*					
		Petrophile	*macrostachya*					
		Petrophile	*serruriae*					2
		Stirlingia	*latifolia*	4			5	
		Synaphea	*spinulosa*		6		2	
	Thymelaeaceae	*Pimelea*	*argentea*					
	Xanthorrhoeacea	*Xanthorrhoea*	*preissii*				2	
HERBS	Apiaceae	*Trachymene*	*pilosa*					
	Asteraceae	*Brachyscome*	*iberidifolia*					
		Hypochaeris	*glabra*					1
		Siloxerus	*humifusus*					
		Ursinia	*anthemoides*		1			
	Colchicaceae	*Burchardia*	*umbellata*					
	Dasypogonaceae	*Lomandra*	*preissii*		1	1	2	
	Droseraceae	*Drosera*	*pallida*					
	Haemodoraceae	*Conostylis*	*aculeata*					
		Conostylis	*setigera*				1	
		Haemodorum	*laxum*					
	Iridaceae	*Gladiolus*	*caryophyllaceus*					
		Patersonia	*occidentalis*					
	Loganiaceae	*Mitrasacme*	*paradoxa*					
	Lyginiaceae	*Lyginia*	*barbata*					
	Pittosporaceae	*Pronaya*	*fraseri*					
	Ranunculaceae	*Clematis*	*microphylla*	2	2	2	2	1
	Restionaceae	*Desmocladus*	*asper*	1			1	
		Desmocladus	*fasciculata*					
		Hypolaena	*exsulca*	1	1	1		1
	Stylidiaceae	*Stylidium*	*brunonianum*					
		Stylidium	*crossocephalum*			1	1	
		Stylidium	*repens*					
GRASSES	Poaceae	*Pentaschistis*	*airoides*		1			
		Poa	*drummondiana*					
		Avellinia	*michelii*		1			
SEDGES	Cyperaceae	*Mesomelaena*	*pseudostygia*	4			2	
		Lepidosperma	*angustatum*					
		Lepidosperma	*scabrum*					

TOTAL NUMBER OF SPECIES	10	14	11	15	9

TREATMENT: WOODLAND RICH				PLOT NUMBER				
REPLICATE NO: 4								
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				11	9	8	12	9
HERB				5	4	3	4	5
GRASSES				1	1	2	2	1
SEDGES				1	1	0	1	0
TOTAL NUMBER OF SPECIES		REPLICATE:	53 PLOTS:	18	15	13	19	15

SPECIES PERCENTAGE COVER

COVER CODE:

BRAUN-BLANQUET

1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
TREES	Proteaceae	*Banksia*	*attenuata*					
SHRUBS	Dilleniaceae	*Hibbertia*	*huegelii*					
		Hibbertia	*hypericoides*	4	4	5	4	4
	Epacridaceae	*Conostephium*	*preissii*		3		3	
		Leucopogon	*polymorphus*	3	4	4	3	3
		Croninia	*kingiana*	2		3	4	
		Lysinema	*ciliatum*	2			2	
		Andersonia	*lehmanniana*		3	3	2	3
	Mimosaceae	*Acacia*	*pulchella*	3			4	4
	Myrtaceae	*Calothamnus*	*quadrifidus*	3	5	3		2
		Eremaea	*pauciflora*	5			5	4
		Eremaea	*asterocarpa*				3	
		Leptospermum	*spinescens*					
	Papilionaceae	*Gompholobium*	*tomentosum*	3	3	2	2	2
		Oxylobium	*capitatum*		2			2
		Hovea	*trisperma*					
		Bossiaea	*eriocarpa*	2	3		3	
		Jacksonia	*sternbergiana*	6				
	Proteaceae	*Dryandra*	*nivea*					
		Synaphea	*spinulosa*					
		Petrophile	*linearis*	2			2	
		Stirlingia	*latifolia*		4	2		2
		Petrophile	*serruriae*					
		Dryandra	*sessilis*					
		Petrophile	*macrostachya*					
		Hakea	*ruscifolia*					
	Thymelaeaceae	*Pimelea*	*argentea*					
	Xanthorrhoeacea	*Xanthorrhoea*	*preissii*			3		
HERBS	Apiaceae	*Trachymene*	*pilosa*					
	Asteraceae	*Ursinia*	*anthemoides*					
		Brachyscome	*iberidifolia*					
		Hypochaeris	*glabra*	1			1	
		Sonchus	*oleraceus*					
	Droseraceae	*Drosera*	*pallida*		1			
	Haemodoraceae	*Haemodorum*	*laxum*				2	
		Conostylis	*aculeata*					
		Conostylis	*setigera*	2	2		2	2
	Iridaceae	*Patersonia*	*occidentalis*	2		2		2
	Lauraceae	*Cassytha*	*flava*					
	Loganiaceae	*Mitrasacme*	*paradoxa*					
	Lyginiaceae	*Lyginia*	*barbata*					
	Ranunculaceae	*Clematis*	*microphylla*	2	2	2	2	2
	Restionaceae	*Desmocladus*	*asper*					2
	Stylidiaceae	*Stylidium*	*crossocephalum*	1	1			
		Stylidium	*brunonianum*					
		Stylidium	*schoenoides*					
		Stylidium	*repens*			1		2
GRASSES	Poaceae	*Pentaschistis*	*airoides*	1	1	1	1	1
		Aira	*cupaniana*					
		Poa	*drummondiana*					
		Avellinia	*michelii*			1	1	
SEDGES	Cyperaceae	*Mesomelaena*	*pseudostygia*	2	2		1	
		Lepidosperma	*angustatum*					
TOTAL NUMBER OF SPECIES				18	15	13	19	15

TREATMENT: WOODLAND RICH			PLOT NUMBER				
REPLICATE NO: 5							
UNDERSTOREY PLANT SPECIES RICHNESS			**1**	**2**	**3**	**4**	**5**
SHRUB			4	5	6	10	6
HERB			8	3	5	3	7
GRASSES			0	1	1	1	0
SEDGES			0	0	0	0	0
TOTAL NUMBER OF SPECIES	REPLICATE:	49 PLOTS:	12	9	12	14	13

SPECIES PERCENTAGE COVER

COVER CODE:

BRAUN-BLANQUET

1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
TREES	Myrtaceae	*Eucalyptus*	*marginata*					
	Proteaceae	*Banksia*	*attenuata*					
SHRUBS	Dilleniaceae	*Hibbertia*	*huegelii*					3
		Hibbertia	*hypericoides*	4	4	5	4	
	Epacridaceae	*Andersonia*	*lehmanniana*		2			
		Conostephium	*preissii*			2		
		Leucopogon	*conostephioides*					
		Leucopogon	*polymorphus*	3	3	4	4	4
	Mimosaceae	*Acacia*	*pulchella*					
	Myrtaceae	*Calothamnus*	*quadrifidus*		4		5	
		Calytrix	*flavescens*					
		Eremaea	*pauciflora*					4
		Leptospermum	*spinescens*					
		Scholtzia	*involucrata*		3	4	6	
	Papilionaceae	*Bossiaea*	*eriocarpa*	3			2	2
		Daviesia	*decurrens*					
		Gompholobium	*tomentosum*			2	3	
		Isotropis	*cuneifolia*					1
		Jacksonia	*floribunda*					
		Jacksonia	*furcellata*					
		Jacksonia	*sternbergiana*					
		Oxylobium	*capitatum*					
	Proteaceae	*Dryandra*	*nivea*				2	
		Hakea	*ruscifolia*			4		
		Petrophile	*linearis*	2			2	
		Petrophile	*macrostachya*					
		Stirlingia	*latifolia*				4	5
	Rutaceae	*Eriostemon*	*spicatis*					
	Xanthorrhoeacea	*Xanthorrhoea*	*preissii*				5	
HERBS	Apiaceae	*Trachymene*	*pilosa*	1				
	Asteraceae	*Hypochaeris*	*glabra*	1				
	Colchicaceae	*Burchardia*	*umbellata*					
	Haemodoraceae	*Conostylis*	*aculeata*					2
		Conostylis	*setigera*	2	2	2	1	2
		Haemodorum	*laxum*					
	Iridaceae	*Patersonia*	*occidentalis*					
	Loganiaceae	*Mitrasecme*	*paradoxa*					
	Ranunculaceae	*Clematis*	*microphylla*	3	2	3	3	3
	Restionaceae	*Desmocladus*	*asper*					
		Hypolaena	*exsulca*			2	2	2
		Loxocarya	*cinerea*	2				2
	Stylidiaceae	*Stylidium*	*brunonianum*	1		1		1
		Stylidium	*crossocephalum*	2				
		Stylidium	*repens*	2	2	2		2
GRASSES	Poaceae	*Avellinia*	*michelii*			1		
		Pentaschistis	*airoides*		1		1	
		Stipa	*flavescens*					
SEDGES	Cyperaceae	*Lepidosperma*	*angustatum*					
		Mesomelaena	*pseudostygia*					
TOTAL NUMBER OF SPECIES				12	9	12	14	13

TREATMENT: WOODLAND POOR				PLOT				
REPLICATE NO: 1				NUMBER				
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				7	4	3	7	6
HERB				1	2	2	2	3
GRASSES				1	1	0	1	0
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 44	PLOTS:	9	7	5	10	9

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Anthericaceae	*Corynotheca*	*micrantha*					
	Asteraceae	*Olearia*	*axillaris*	1				
	Dilleniaceae	*Hibbertia*	*racemosa*				3	5
	Epacridaceae	*Conostephium*	*preissii*	2			2	
		Leucopogon	*conostephioides*		3		4	
		Lysinema	*ciliatum*					
	Goodeniaceae	*Dampiera*	*linearis*					
		Lechenaultia	*biloba*	1	1		3	3
	Mimosaceae	*Acacia*	*pulchella*					4
	Myrtaceae	*Beaufortia*	*elegans*	5	5	4	6	
		Calytrix	*flavescens*					
		Eremaea	*asterocarpa*					
		Eremaea	*pauciflora*	4	6	5		5
		Scholtzia	*involucrata*	1		5	4	1
	Papilionaceae	*Bossiaea*	*eriocarpa*					
		Daviesia	*podophylla*				4	
		Gompholobium	*tomentosum*					
		Oxylobium	*capitatum*					2
	Proteaceae	*Dryandra*	*nivea*					
		Petrophile	*linearis*	1				
	Xanthorrhoeacea	*Xanthorrhoea*	*preissii*					
HERBS	Apiaceae	*Trachymene*	*pilosa*	1				1
	Asteraceae	*Hypochaeris*	*glabra*					
		Ursinia	*anthemoides*					
	Dasypogonaceae	*Lomandra*	*caespitosa*					
	Droseraceae	*Drosera*	*pallida*					
	Haemodoraceae	*Anigozanthos*	*humilis*					
		Conostylis	*aculeata*					
		Conostylis	*hybrid*					
		Conostylis	*setigera*					
	Haloragaceae	*Gonocarpus*	*pithyoides*		1	1		1
	Iridaceae	*Gladiolus*	*caryophyllaceus*					
	Lobeliaceae	*Lobelia*	*gibbosa*					
	Loganiaceae	*Mitrasacme*	*paradoxa*					
	Lyginiaceae	*Lyginia*	*barbata*				1	1
	Restionaceae	*Desmocladus*	*fasciculata*		1	1		
		Hypolaena	*exsulca*					
		Loxocarya	*cinerea*					
	Stylidiaceae	*Levenhookia*	*pusilla*					
		Stylidium	*brunonianum*					
		Stylidium	*macrocarpum*					
		Stylidium	*repens*				1	
GRASSES	Poaceae	*Vulpia*	*myuros*	1	1		1	
SEDGES	Cyperaceae	*Mesomelaena*	*pseudostygia*					
TOTAL NUMBER OF SPECIES				9	7	5	10	9

TREATMENT: WOODLAND POOR				PLOT				
REPLICATE NO: 2				NUMBER				
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				3	5	6	3	5
HERB				4	5	6	7	8
GRASSES				1	1	1	1	1
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 37	PLOTS:	8	11	13	11	14

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
TREES	Proteaceae	*Banksia*	*attenuata*					
SHRUBS	Anthericaceae	*Corynotheca*	*micrantha*					
	Dilleniaceae	*Hibbertia*	*huegelii*					2
		Hibbertia	*racemosa*	4	1		4	
	Epacridaceae	*Conostephium*	*preissii*			4		3
	Goodeniaceae	*Lechenaultia*	*biloba*		2		1	
	Mimosaceae	*Acacia*	*pulchella*			3		
		Acacia	*stenoptera*					
	Myrtaceae	*Beaufortia*	*elegans*	2	6	4	6	4
		Calytrix	*flavescens*					
		Eremaea	*asterocarpa*					
		Scholtzia	*involucrata*	4	2	2		4
	Papilionaceae	*Bossiaea*	*eriocarpa*					
		Gompholobium	*confertum*			2		2
		Gompholobium	*tomentosum*					
		Oxylobium	*capitatum*					
	Polygalaceae	*Comesperma*	*calymega*					
	Proteaceae	*Petrophile*	*linearis*		3	2		
		Petrophile	*macrostachya*					
	Xanthorrhoeacea	*Xanthorrhoea*	*preissii*					
HERBS	Anthericaceae	*Agrostocrinum*	*scabrum*					
	Apiaceae	*Trachymene*	*pilosa*	1	1	1	1	1
	Asteraceae	*Hypochaeris*	*glabra*			1	1	1
		Ursinia	*anthemoides*					1
	Dasypogonaceae	*Lomandra*	*caespitosa*				3	
	Gentianaceae	*Centaurium*	*erythraea*					
	Haemodoraceae	*Conostylis*	*hybrid*					
		Conostylis	*setigera*	1	1	1	1	
	Haloragaceae	*Gonocarpus*	*pithyoides*		1			1
	Lyginiaceae	*Lyginia*	*barbata*	1		4	3	2
	Restionaceae	*Loxocarya*	*cinerea*		1		1	1
	Stylidiaceae	*Stylidium*	*brunonianum*					1
		Stylidium	*piliferum*			1		
		Stylidium	*repens*	1	1	1	1	1
GRASSES	Poaceae	*Avellinia*	*michelii*		1	1	1	1
		Stipa	*flavescens*	1				
SEDGES	Cyperaceae	*Lepidosperma*	*angustatum*					
TOTAL NUMBER OF SPECIES				8	11	13	11	14

TREATMENT: WOODLAND POOR				PLOT				
REPLICATE NO: 3				NUMBER				
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				2	2	6	2	3
HERB				5	6	7	1	3
GRASSES				0	0	0	1	0
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 35	PLOTS:	7	8	13	4	6
SPECIES PERCENTAGE COVER								
COVER CODE:								
BRAUN-BLANQUET								
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%								
Life Form	**Family**	**Genus**	**Species**	**1**	**2**	**3**	**4**	**5**
TREES	Proteaceae	*Banksia*	*attenuata*					
SHRUBS	Anthericaceae	*Corynotheca*	*micrantha*		1			
	Dilleniaceae	*Hibbertia*	*huegelii*					2
		Hibbertia	*racemosa*			2		2
	Epacridaceae	*Conostephium*	*preissii*					
	Goodeniaceae	*Lechenaultia*	*biloba*				2	
	Mimosaceae	*Acacia*	*pulchella*	2				
	Myrtaceae	*Beaufortia*	*elegans*	6	6	6	7	7
		Calytrix	*flavescens*					
		Scholtzia	*involucrata*			3		
	Papilionaceae	*Bossiaea*	*eriocarpa*			2		
		Gompholobium	*tomentosum*			2		
		Jacksonia	*furcellata*					
	Proteaceae	*Dryandra*	*nivea*					
		Petrophile	*linearis*			2		
	Rubiaceae	*Opercularia*	*vaginata*					
HERBS	Apiaceae	*Trachymene*	*pilosa*	1	1	1		
	Asteraceae	*Hypochaeris*	*glabra*			1		
		Siloxerus	*humifusus*	1				
		Ursinia	*anthemoides*					
	Dasypogonaceae	*Lomandra*	*caespitosa*		1			2
	Haemodoraceae	*Conostylis*	*hybrid*	1	1			
	Haloragaceae	*Gonocarpus*	*pithyoides*			1		
	Loganiaceae	*Mitrasacme*	*paradoxa*		1	1		
	Lyginiaceae	*Lyginia*	*barbata*					
	Restionaceae	*Hypolaena*	*exsulca*	1	1	1		1
	Stylidiaceae	*Levenhookia*	*pusilla*					
		Stylidium	*brunonianum*			1		
		Stylidium	*macrocarpum*					
		Stylidium	*repens*	1	1	1	1	1
GRASSES	Poaceae	*Avellinia*	*michelii*				1	
		Pentaschistis	*airoides*					
		Stipa	*flavescens*					
SEDGES	Cyperaceae	*Lepidosperma*	*angustatum*					
		Mesomelaena	*pseudostygia*					
TOTAL NUMBER OF SPECIES				7	8	13	4	6

TREATMENT: WOODLAND POOR				PLOT				
REPLICATE NO: 4				NUMBER				
UNDERSTOREY PLANT SPECIES RICHNESS				**1**	**2**	**3**	**4**	**5**
SHRUB				6	6	6	6	7
HERB				6	3	7	6	6
GRASSES				1	0	0	0	0
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 40	PLOTS:	13	9	13	12	13

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
TREES	Proteaceae	*Banksia*	*attenuata*					
		Banksia	*ilicifolia*					
SHRUBS	Dilleniaceae	*Hibbertia*	*racemosa*			2	2	3
	Epacridaceae	*Conostephium*	*preissii*	5	4			4
		Lechenaultia	*biloba*	1	2		2	3
	Goodeniaceae	*Leucopogon*	*propinquus*					
	Mimosaceae	*Acacia*	*pulchella*	1	2			2
	Myrtaceae	*Beaufortia*	*elegans*	3	4	5	3	3
		Calytrix	*flavescens*					
		Eremaea	*asterocarpa*			3	3	
		Eremaea	*pauciflora*					
		Scholtzia	*involucrata*					
	Papilionaceae	*Bossiaea*	*eriocarpa*	3	4	3	4	2
		Gompholobium	*tomentosum*	3	3	2	3	2
		Jacksonia	*furcellata*					
		Oxylobium	*capitatum*					
	Proteaceae	*Dryandra*	*nivea*					
		Persoonia	*saccata*					
		Petrophile	*linearis*					
	Rubiaceae	*Opercularia*	*vaginata*			2		
HERBS	Anthericaceae	*Agrostocrinum*	*scabrum*					
	Asteraceae	*Hypochaeris*	*glabra*	1				1
	Dasypogonaceae	*Lomandra*	*caespitosa*					
	Gentianaceae	*Centaurium*	*erythraea*					
	Haemodoraceae	*Conostylis*	*hybrid*		2	2	2	2
		Conostylis	*setigera*	1				
	Haloragaceae	*Gonocarpus*	*pithyoides*	2		2	2	1
	Loganiaceae	*Mitrasacme*	*paradoxa*					
	Lyginiaceae	*Lyginia*	*barbata*					
	Ranunculaceae	*Clematis*	*microphylla*			2	2	
	Restionaceae	*Desmocladus*	*fasciculata*			3		
		Hypolaena	*exsulca*	1	1	1	1	1
		Loxocarya	*cinerea*	2	1	1	1	2
	Stylidiaceae	*Stylidium*	*macrocarpum*					
		Stylidium	*piliferum*					
		Stylidium	*repens*	1		2	1	1
GRASSES	Poaceae	*Amphipogon*	*turbinatus*					
		Avellinia	*michelii*					
		Pentaschistis	*airoides*	1				
		Stipa	*flavescens*					
TOTAL NUMBER OF SPECIES				13	9	13	12	13

TREATMENT: WOODLAND POOR				PLOT				
REPLICATE NO: 5				NUMBER				
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				7	3	5	7	4
HERB				6	4	6	5	5
GRASSES				0	1	0	0	0
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE:	31 PLOTS:	13	8	11	12	9

SPECIES PERCENTAGE COVER

COVER CODE:

BRAUN-BLANQUET

1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
TREES	Proteaceae	*Banksia*	*attenuata*				4	
SHRUBS	Asteraceae	*Olearia*	*axillaris*					
	Dilleniaceae	*Hibbertia*	*huegelii*	3	3	2	4	3
		Hibbertia	*racemosa*	2			1	
	Epacridaceae	*Conostephium*	*preissii*					
	Myrtaceae	*Beaufortia*	*elegans*	6	6	4	4	5
		Eremaea	*asterocarpa*	3				
		Eremaea	*pauciflora*					
		Scholtzia	*involucrata*	4	2	5	5	4
	Papilionaceae	*Bossiaea*	*eriocarpa*	2			2	4
		Gompholobium	*confertum*					
		Gompholobium	*tomentosum*			3		
		Jacksonia	*floribunda*					
	Polygalaceae	*Comesperma*	*calymega*					
	Proteaceae	*Adenanthos*	*cygnorum*					
		Conospermum	*incurvum*					
		Dryandra	*nivea*					
		Petrophile	*linearis*	2			1	
	Rubiaceae	*Opercularia*	*vaginata*			2		
HERBS	Apiaceae	*Trachymene*	*pilosa*				1	
	Asteraceae	*Hypochaeris*	*glabra*					
	Haemodoraceae	*Anigozanthos*	*humilis*					
		Conostylis	*setigera*	2	2		2	2
	Haloragaceae	*Gonocarpus*	*pithyoides*	2				
	Iridaceae	*Patersonia*	*occidentalis*					2
	Lobeliaceae	*Lobelia*	*tenuior*					
	Loganiaceae	*Mitrasacme*	*paradoxa*			1	1	
	Lyginiaceae	*Lyginia*	*barbata*					1
	Ranunculaceae	*Clematis*	*microphylla*	2	2	2		2
	Restionaceae	*Desmocladus*	*fasciculata*					
		Hypolaena	*exsulca*	1	1	1	2	
		Loxocarya	*cinerea*					
	Stylidiaceae	*Stylidium*	*brunonianum*	1		1		
		Stylidium	*piliferum*			1		
		Stylidium	*repens*	1	1	1	1	1
GRASSES	Poaceae	*Pentaschistis*	*airoides*		1			
TOTAL NUMBER OF SPECIES				13	8	11	12	9

TREATMENT: HEATH RICH				PLOT				
REPLICATE NO: 1				**NUMBER**				
UNDERSTOREY PLANT SPECIES RICHNESS				**1**	**2**	**3**	**4**	**5**
SHRUB				4	6	9	7	6
HERB				10	10	8	11	4
GRASSES				3	4	2	4	3
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 62	PLOTS:	17	20	19	22	13

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Aizoaceae	*Carpobrotus*	*edulis*					
	Euphorbiaceae	*Beyeria*	*cinerea*		3	4	4	4
		Phyllanthus	*calycinus*	2	3	2	3	
	Mimosaceae	*Acacia*	*lasiocarpa*	2	4	5	6	6
	Myoporaceae	*Eremophila*	*glabra*					
	Myrtaceae	*Baeckea*	*robusta*					
		Calothamnus	*quadrifidus*		4	4	4	4
		Melaleuca	*huegelii*			4	4	4
		Melaleuca	*systena*	4	5	3	2	3
	Papilionaceae	*Gompholobium*	*tomentosum*		2	3		
		Hovea	*pungens*					
		Jacksonia	*stricta*					
		Templetonia	*retusa*				3	
	Proteaceae	*Dryandra*	*nivea*			4		
		Dryandra	*sessilis*					1
		Grevillea	*preissii*	5		3		
		Hakea	*trifurcata*					
	Rhamnaceae	*Trymalium*	*albicans*					
	Rubiaceae	*Opercularia*	*vaginata*					
	Rutaceae	*Diplolaena*	*angustifolia*					
	Sapindaceae	*Diplopeltis*	*huegelii*					
	Sterculiaceae	*Thomasia*	*triphylla*					
	Unidentified	*Sp. 1*						
HERBS	Anthericaceae	*Thysanotus*	*manglesianus*				1	
	Apiaceae	*Trachymene*	*pilosa*					
	Asteraceae	*Brachyscome*	*iberidifolia*	1			2	1
		Hypochaeris	*glabra*	1	1	1	1	
		Millotia	*tenuifolia*	1	2	2	2	2
		Sonchus	*oleraceus*	1		1	1	
		Waitzia	*suaveolens*					
	Brassicaceae	*Brassica*	*oxyrrhina*	1	1	1	1	
		Heliophila	*pusilla*	1	1		1	1
	Colchicaceae	*Burchardia*	*umbellata*					
	Crassulaceae	*Crassula*	*colorata*				1	
	Geraniaceae	*Geranium*	*molle*		2			
	Haemodoraceae	*Conostylis*	*candicans*			2		
	Lauraceae	*Cassytha*	*flava*	2	3		1	
	Orchidaceae	*Caladenia*	*flava*					
		Microtis	*media*		1			
	Portulacaceae	*Calandrinia*	*corrigioloides*					
	Primulaceae	*Anagallis*	*arvensis*	1	1	1	2	1
	Restionaceae	*Desmocladus*	*asper*	2	2	2		
	Stylidiaceae	*Stylidium*	*bulbiferum*	2	2	2	2	
		Stylidium	*schoenoides*					
	Unidentified	*Sp. 3*						
GRASSES	Poaceae	*Aira*	*cupaniana*	1	1		1	1
		Avellinia	*michelii*					
		Pentaschistis	*airoides*					
		Poa	*annua*	2	2	2	2	2
		Poa	*drummondiana*		1			
		Stipa	*flavescens*				1	
		Vulpia	*myuros*	2	2	2	1	1
TOTAL NUMBER OF SPECIES				17	20	19	22	13

TREATMENT: HEATH RICH				PLOT				
REPLICATE NO: 2				NUMBER				
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				5	6	6	3	7
HERB				7	7	7	9	8
GRASSES				1	1	2	3	1
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 45	PLOTS:	13	14	15	15	16
SPECIES PERCENTAGE COVER								
COVER CODE:								
BRAUN-BLANQUET								
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%								
Life Form	**Family**	**Genus**	**Species**	**1**	**2**	**3**	**4**	**5**
SHRUBS	Epacridaceae	*Astroloma*	*macrocalyx*					
	Euphorbiaceae	*Beyeria*	*cinerea*		3			3
		Phyllanthus	*calycinus*		3			3
	Mimosaceae	*Acacia*	*lasiocarpa*		5	5		3
	Myoporaceae	*Eremophila*	*glabra*					
	Myrtaceae	*Baeckea*	*robusta*	2	2	4		4
		Calothamnus	*quadrifidus*	2	2	3	2	
		Melaleuca	*huegelii*			3		
		Melaleuca	*systena*	4		4	6	4
	Olacaceae	*Olax*	*benthamiana*					
	Papilionaceae	*Gompholobium*	*tomentosum*					
		Templetonia	*retusa*					
	Proteaceae	*Dryandra*	*nivea*	3			4	3
		Dryandra	*sessilis*					
		Grevillea	*preissii*	2	4	2		3
	Rhamnaceae	*Trymalium*	*albicans*					
	Rubiaceae	*Opercularia*	*vaginata*					
	Rutaceae	*Diplolaena*	*angustifolia*					
	Sapindaceae	*Diplopeltis*	*huegelii*					
	Unidentified	*Sp. 1*						
HERBS	Anthericaceae	*Thysanotus*	*manglesianus*					1
	Apiaceae	*Trachymene*	*pilosa*	1				1
	Asteraceae	*Brachyscome*	*iberidifolia*	1	1			1
		Hypochaeris	*glabra*				1	
		Millotia	*tenuifolia*	2	2	2	2	2
		Sonchus	*oleraceus*		1		1	1
		Waitzia	*suaveolens*		1			
	Brassicaceae	*Brassica*	*oxyrrhina*	1		1		
		Heliophila	*pusilla*	1	1	1	1	1
	Caryophyllaceae	*Petrorhagia*	*velutina*					
	Haemodoraceae	*Conostylis*	*candicans*			2	2	
	Lauraceae	*Cassytha*	*flava*		2	1	3	2
	Orchidaceae	*Microtis*	*media*					
	Papilionaceae	*Trifolium*	*arvense*					
	Portulacaceae	*Calandrinia*	*corrigioloides*					
	Primulaceae	*Anagallis*	*arvensis*	1			1	
	Restionaceae	*Desmocladus*	*asper*	2	3	3	2	2
	Stylidiaceae	*Stylidium*	*bulbiferum*			2	2	
		Stylidium	*schoenoides*					
	Unidentified	*Sp. 3*						
GRASSES	Poaceae	*Avellinia*	*michelii*				1	
		Pentaschistis	*airoides*					
		Poa	*annua*			1	1	
		Stipa	*flavescens*					
		Vulpia	*myuros*	1	1	1	1	1
TOTAL NUMBER OF SPECIES				13	14	15	15	16

TREATMENT: HEATH RICH				PLOT NUMBER				
REPLICATE NO: 3								
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				5	5	6	3	6
HERB				7	8	3	4	4
GRASSES				3	3	3	3	2
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 48	PLOTS:	15	16	12	10	12

SPECIES PERCENTAGE COVER

COVER CODE:

BRAUN-BLANQUET

1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Aizoaceae	*Carpobrotus*	*edulis*					
	Dilleniaceae	*Hibbertia*	*hypericoides*			2		4
	Epacridaceae	*Astroloma*	*macrocalyx*	4	4	4		2
	Euphorbiaceae	*Beyeria*	*cinerea*	4				
		Phyllanthus	*calycinus*					
	Mimosaceae	*Acacia*	*lasiocarpa*	5	4	6	7	5
	Myoporaceae	*Eremophila*	*glabra*					
	Myrtaceae	*Baeckea*	*robusta*			4	2	
		Calothamnus	*quadrifidus*	2	3			
		Melaleuca	*huegolii*					
		Melaleuca	*systena*	4	6	3	2	
	Olacaceae	*Olax*	*benthamiana*					
	Papilionaceae	*Templetonia*	*retusa*					
	Proteaceae	*Dryandra*	*nivea*		4			3
		Dryandra	*sessilis*					2
		Grevillea	*preissii*			4		5
	Rhamnaceae	*Trymalium*	*albicans*					
	Rutaceae	*Diplolaena*	*angustifolia*					
	Sterculiaceae	*Thomasia*	*triphylla*					
HERBS	Anthericaceae	*Thysanotus*	*manglesianus*	1				
	Apiaceae	*Trachymene*	*pilosa*		1		1	
	Asteraceae	*Hypochaeris*	*glabra*					
		Millotia	*tenuifolia*	3	3	2		
		Senecio	*lautus subsp?*					
		Sonchus	*oleraceus*					
	Brassicaceae	*Brassica*	*oxyrrhina*					
		Heliophila	*pusilla*	1	1	1	1	1
	Crassulaceae	*Crassula*	*colorata*					
	Haemodoraceae	*Conostylis*	*candicans*	2	2	2	2	2
	Iridaceae	*Gladiolus*	*caryophyllaceus*					
	Lauraceae	*Cassytha*	*flava*	1	3			
	Lobeliaceae	*Lobelia*	*tenuior*		1			1
	Orchidaceae	*Microtis*	*media*					
	Papilionaceae	*Trifolium*	*arvense*					
	Pittosporaceae	*Pronaya*	*fraseri*					
	Primulaceae	*Anagallis*	*arvensis*	1	1			
	Restionaceae	*Desmocladus*	*asper*		4		2	1
	Stylidiaceae	*Stylidium*	*bulbiferum*					
		Stylidium	*schoenoides*					
	Unidentified	*Sp. 2*		2				
	Unidentified	*Sp. 3*						
GRASSES	Poaceae	*Aira*	*cupaniana*					
		Avellinia	*michelii*		1		1	
		Pentaschistis	*airoides*	1	1	1		
		Poa	*annua*	2	1	2	2	1
		Poa	*drummondiana*			1		
		Stipa	*flavescens*					1
		Vulpia	*myuros*	2			1	
TOTAL NUMBER OF SPECIES				15	16	12	10	12

TREATMENT: HEATH RICH				PLOT NUMBER				
REPLICATE NO: 4								
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				7	9	7	6	7
HERB				8	10	6	7	7
GRASSES				2	3	5	4	3
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 50	PLOTS:	17	22	18	17	17

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Dilleniaceae	*Hibbertia*	*hypericoides*					
	Epacridaceae	*Astroloma*	*macrocalyx*	3	4	2	3	4
		Leucopogon	*nutans*					
		Leucopogon	*polymorphus*					
	Euphorbiaceae	*Beyeria*	*cinerea*		2		3	
		Phyllanthus	*calycinus*	4	3	3	3	
	Goodeniaceae	*Scaevola*	*thesioides*					
	Mimosaceae	*Acacia*	*lasiocarpa*	5	5	4	5	5
	Myrtaceae	*Baeckea*	*robusta*					3
		Calothamnus	*quadrifidus*	2	4	5		
		Melaleuca	*huegelii*					2
		Melaleuca	*systena*	4	4	5	5	4
	Olacaceae	*Olax*	*benthamiana*	3				
	Papilionaceae	*Gompholobium*	*tomentosum*					
		Jacksonia	*stricta*					
		Mirbelia	*trichocalyx*		1			
		Templetonia	*retusa*					
	Proteaceae	*Dryandra*	*nivea*	4		5		5
		Dryandra	*sessilis*					2
		Grevillea	*preissii*			4	4	
		Hakea	*lissocarpa*		4			
	Rhamnaceae	*Trymalium*	*albicans*					
	Rubiaceae	*Opercularia*	*vaginata*					
	Rutaceae	*Diplolaena*	*angustifolia*		3			
	Thymelaeaceae	*Pimelea*	*rosea*					
HERBS	Anthericaceae	*Thysanotus*	*manglesianus*					
		Tricoryne	*elatior*		2			
	Apiaceae	*Trachymene*	*pilosa*		1	1	1	1
	Asteraceae	*Brachyscome*	*iberidifolia*		1		1	1
		Hypochaeris	*glabra*	1	1	1	1	1
		Millotia	*tenuifolia*	2	2	1	2	2
		Senecio	*lautus subsp?*	1				
		Sonchus	*oleraceus*					
	Brassicaceae	*Brassica*	*oxyrrhina*					
		Heliophila	*pusilla*	1	1	1		1
	Caryophyllaceae	*Petrorhagia*	*velutina*		1			
	Haemodoraceae	*Conostylis*	*candicans*	3				2
	Lauraceae	*Cassytha*	*flava*	4	2	3	4	
	Lobeliaceae	*Lobelia*	*tenuior*		1		1	
	Orchidaceae	*Microtis*	*media*					
	Primulaceae	*Anagallis*	*arvensis*	1		1	1	
	Ranunculaceae	*Clematis*	*microphylla*					
	Restionaceae	*Desmocladus*	*asper*	2	2			
	Stylidiaceae	*Stylidium*	*bulbiferum*					2
GRASSES	Poaceae	*Avellinia*	*michelii*			1		1
		Pentaschistis	*airoides*		1	1	1	1
		Poa	*annua*	1	1	1	1	1
		Poa	*drummondiana*					
		Stipa	*flavescens*			1	1	
		Vulpia	*myuros*	1	1	1	1	
TOTAL NUMBER OF SPECIES				17	22	18	17	17

TREATMENT: HEATH RICH
REPLICATE NO: 5

UNDERSTOREY PLANT SPECIES RICHNESS				**1**	**2**	**3**	**4**	**5**
SHRUB				5	7	4	4	6
HERB				9	8	8	7	6
GRASSES				3	3	3	4	4
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: **53**	PLOTS:	17	18	15	15	16

(PLOT NUMBER)

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Aizoaceae	*Carpobrotus*	*edulis*					
	Epacridaceae	*Astroloma*	*macrocalyx*					
	Euphorbiaceae	*Beyeria*	*cinerea*					
		Phyllanthus	*calycinus*		5		3	
	Lamiaceae	*Hemiandra*	*pungens*					
	Mimosaceae	*Acacia*	*lasiocarpa*	5	5	2		4
	Myoporaceae	*Eremophila*	*glabra*					
	Myrtaceae	*Baeckea*	*robusta*					
		Calothamnus	*quadrifidus*	2	2			2
		Melaleuca	*huegelii*					
		Melaleuca	*systena*	4	4	4	5	4
	Papilionaceae	*Gompholobium*	*tomentosum*					
		Jacksonia	*stricta*					
		Mirbelia	*trichocalyx*					
	Polygalaceae	*Comesperma*	*confertum*		1	1		1
	Proteaceae	*Dryandra*	*nivea*	3	4		3	5
		Dryandra	*sessilis*			3		
		Grevillea	*preissii*	4	3		3	3
		Hakea	*trifurcata*					
		Petrophile	*serruriae*					
	Rubiaceae	*Opercularia*	*vaginata*					
	Sapindaceae	*Diplopeltis*	*huegelii*					
HERBS	Amaranthaceae	*Ptilotus*	*drummondii*					2
	Anthericaceae	*Tricoryne*	*elatior*					
	Apiaceae	*Trachymene*	*pilosa*	1				
	Asteraceae	*Brachyscome*	*iberidifolia*	1		1	1	1
		Hypochaeris	*glabra*	1				1
		Millotia	*tenuifolia*	2	2	1	2	2
		Senecio	*lautus subsp?*		1		1	1
		Sonchus	*oleraceus*			1		
		Waitzia	*citrina*					
	Brassicaceae	*Brassica*	*oxyrrhina*				1	
		Heliophila	*pusilla*	1	1	1		
	Colchicaceae	*Burchardia*	*umbellata*					
	Crassulaceae	*Crassula*	*colorata*					
	Haemodoraceae	*Conostylis*	*candicans*	2				
	Lauraceae	*Cassytha*	*flava*	4	3	2	4	
	Lobeliaceae	*Lobelia*	*tenuior*		1			
	Orchidaceae	*Microtis*	*media*			1	1	
	Orobanchaceae	*Orobanche*	*minor*					
	Papilionaceae	*Trifolium*	*arvense*					
	Primulaceae	*Anagallis*	*arvensis*	1	2	1	1	
	Restionaceae	*Desmocladus*	*asper*		2			3
	Stylidiaceae	*Stylidium*	*bulbiferum*					
		Stylidium	*schoenoides*					
	Unidentified	*Sp. 3*		1	1	1		
GRASSES	Poaceae	*Avellinia*	*michelii*					
		Pentaschistis	*airoides*	1	1	1	1	1
		Poa	*drummondiana*					
		Poa	*annua*	1	1	1	1	1
		Stipa	*flavescens*				1	1
		Vulpia	*myuros*	1	1	1	1	1
SEDGES	Cyperaceae	*Isolepis*	*cernua*					
TOTAL NUMBER OF SPECIES				17	18	15	15	16

TREATMENT: HEATH POOR			PLOT NUMBER				
REPLICATE NO: 1							
UNDERSTOREY PLANT SPECIES RICHNESS			1	2	3	4	5
SHRUB			3	2	4	5	3
HERB			8	8	7	7	6
GRASSES			4	4	4	3	3
SEDGES			0	0	0	0	0
TOTAL NUMBER OF SPECIES	REPLICATE:	36 PLOTS:	15	14	15	15	12

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Epacridaceae	*Astroloma*	*macrocalyx*				1	
	Euphorbiaceae	*Beyeria*	*cinerea*	4	5	3	4	5
	Goodeniaceae	*Scaevola*	*thesioides*					
	Mimosaceae	*Acacia*	*lasiocarpa*				6	
	Myoporaceae	*Eremophila*	*glabra*					
	Myrtaceae	*Melaleuca*	*huegelii*	5	6	6	4	6
		Melaleuca	*systena*	3		3	4	
	Proteaceae	*Dryandra*	*nivea*					
		Grevillea	*preissii*			3		5
	Rhamnaceae	*Trymalium*	*albicans*					
HERBS	Anthericaceae	*Thysanotus*	*manglesianus*					
	Apiaceae	*Trachymene*	*pilosa*	1		1	1	1
	Asteraceae	*Brachyscome*	*iberidifolia*	1	1	1	1	
		Hypochaeris	*glabra*	1	1		1	1
		Millotia	*tenuifolia*	2	2	1	1	1
		Sonchus	*oleraceus*		1			
		Waitzia	*citrina*					
	Brassicaceae	*Brassica*	*oxyrrhina*					
		Heliophila	*pusilla*	1	1		1	1
	Colchicaceae	*Burchardia*	*umbellata*					
	Crassulaceae	*Crassula*	*colorata*					
	Euphorbiaceae	*Poranthera*	*microphylla*					
	Geraniaceae	*Geranium*	*molle*					
	Lauraceae	*Cassytha*	*flava*	3	4	4	3	
	Lobeliaceae	*Lobelia*	*tenuior*		1	1		1
	Orchidaceae	*Microtis*	*media*	1	1		1	
	Portulacaceae	*Calandrinia*	*corrigioloides*					
	Primulaceae	*Anagallis*	*arvensis*	1				
	Restionaceae	*Desmocladus*	*asper*					3
	Stylidiaceae	*Stylidium*	*bulbiferum*			2		
	Unidentified	*Sp. 3*				1		
GRASSES	Poaceae	*Pentaschistis*	*airoides*	1	1	1	1	1
		Poa	*drummondiana*					
		Poa	*annua*	2	2	2	2	2
		Stipa	*flavescens*	1	1	1		
		Vulpia	*myuros*	1	2	1	1	1
TOTAL NUMBER OF SPECIES				15	14	15	15	12

TREATMENT: HEATH POOR				PLOT NUMBER				
REPLICATE NO: 2								
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				4	3	3	3	4
HERB				6	8	7	7	8
GRASSES				3	3	2	3	3
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES	REPLICATE:	37	PLOTS:	13	14	12	13	15

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Epacridaceae	*Astroloma*	*macrocalyx*					
	Euphorbiaceae	*Beyeria*	*cinerea*					
		Phyllanthus	*calycinus*		3	4	4	2
	Mimosaceae	*Acacia*	*lasiocarpa*				7	5
	Myrtaceae	*Melaleuca*	*huegelii*	5				
		Melaleuca	*systena*	4	4	5	4	3
	Papilionaceae	*Templetonia*	*retusa*					
	Proteaceae	*Dryandra*	*nivea*					
		Dryandra	*sessilis*					
		Grevillea	*preissii*	5	5	4		4
	Rhamnaceae	*Trymalium*	*albicans*					
	Rubiaceae	*Opercularia*	*vaginata*	2				
HERBS	Anthericaceae	*Thysanotus*	*manglesianus*			1		
	Apiaceae	*Trachymene*	*pilosa*	1	1	1	1	1
	Asteraceae	*Brachyscome*	*iberidifolia*					
		Hypochaeris	*glabra*	1	1	1	1	
		Millotia	*tenuifolia*	3	3	2	2	2
		Senecio	*lautus subsp?*		1			
		Sonchus	*oleraceus*	1			1	1
	Brassicaceae	*Brassica*	*oxyrrhina*					
		Heliophila	*pusilla*	1	1	1	1	1
	Crassulaceae	*Crassula*	*colorata*					1
	Geraniaceae	*Geranium*	*molle*					
	Haemodoraceae	*Conostylis*	*candicans*					
	Lauraceae	*Cassytha*	*flava*			1		3
	Lobeliaceae	*Lobelia*	*tenuior*		1			1
	Papilionaceae	*Trifolium*	*arvense*					
	Primulaceae	*Anagallis*	*arvensis*	1	1	1	1	1
	Restionaceae	*Desmocladus*	*asper*					
	Stylidiaceae	*Stylidium*	*bulbiferum*					
	Unidentified	*Sp. 3*			1		1	
GRASSES	Poaceae	*Avellinia*	*michelii*				1	
		Pentaschistis	*airoides*	1	1	1	1	1
		Poa	*annua*	2	2	2	2	2
		Poa	*drummondiana*					
		Stipa	*flavescens*					
		Vulpia	*myuros*	1	1			1
TOTAL NUMBER OF SPECIES				13	14	12	13	15

TREATMENT: HEATH POOR
REPLICATE NO: 3

UNDERSTOREY PLANT SPECIES RICHNESS		PLOT NUMBER 1	2	3	4	5
SHRUB		3	2	1	4	2
HERB		8	10	8	7	7
GRASSES		3	3	2	3	3
SEDGES		0	0	0	0	0
TOTAL NUMBER OF SPECIES	REPLICATE: 39 PLOTS:	14	15	11	14	12

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Aizoaceae	*Carpobrotus*	*edulis*					
	Epacridaceae	*Astroloma*	*macrocalyx*					
	Euphorbiaceae	*Phyllanthus*	*calycinus*					
	Mimosaceae	*Acacia*	*lasiocarpa*				5	
	Myrtaceae	*Baeckea*	*robusta*					
		Melaleuca	*huegelii*	5	4	5	4	5
		Melaleuca	*systena*	2	5		4	4
	Papilionaceae	*Hardenbergia*	*comptoniana*					
	Polygalaceae	*Comesperma*	*confertum*				2	
	Proteaceae	*Dryandra*	*nivea*					
		Grevillea	*preissii*					
	Rhamnaceae	*Cryptandra*	*mutila*	5				
		Trymalium	*albicans*					
	Rubiaceae	*Opercularia*	*vaginata*					
HERBS	Anthericaceae	*Thysanotus*	*manglesianus*					
	Apiaceae	*Trachymene*	*pilosa*	1	1	1	1	1
	Asteraceae	*Brachyscome*	*iberidifolia*		1			
		Hypochaeris	*glabra*		1	2		
		Millotia	*tenuifolia*	1	2	2	2	2
		Senecio	*lautus subsp?*			1	1	
	Brassicaceae	*Brassica*	*oxyrrhina*	1				1
		Heliophila	*pusilla*		1			
	Crassulaceae	*Crassula*	*colorata*					1
	Geraniaceae	*Geranium*	*molle*					
	Haemodoraceae	*Conostylis*	*candicans*					
	Lobeliaceae	*Lobelia*	*tenuior*	1	1		1	1
	Orobanchaceae	*Orobanche*	*minor*			1		
	Papilionaceae	*Trifolium*	*arvense*					
	Phormiaceae	*Dianella*	*divaricata*					
	Primulaceae	*Anagallis*	*arvensis*	1	1		1	
	Restionaceae	*Desmocladus*	*asper*	2	2	3	2	4
	Stylidiaceae	*Stylidium*	*bulbiferum*	2	2	3		3
	Unidentified	*Sp. 3*		1	1	1	2	
GRASSES	Poaceae	*Avellinia*	*michelii*					
		Bromus	*diandrus*	1	1		1	1
		Pentaschistis	*airoides*					
		Poa	*annua*	2	2	1	2	2
		Poa	*drummondiana*					
		Vulpia	*myuros*	2	2	1	1	2
TOTAL NUMBER OF SPECIES				14	16	11	14	12

TREATMENT: HEATH POOR				PLOT				
REPLICATE NO: 4				NUMBER				
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				4	4	3	3	4
HERB				6	8	9	8	6
GRASSES				3	3	2	2	1
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 30	PLOTS:	13	15	14	13	11

SPECIES PERCENTAGE COVER

COVER CODE:

BRAUN-BLANQUET

1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Epacridaceae	*Astroloma*	*macrocalyx*		3			3
		Leucopogon	*parviflorus*					
	Euphorbiaceae	*Beyeria*	*cinerea*			4	5	
	Mimosaceae	*Acacia*	*lasiocarpa*	5	3			2
	Myrtaceae	*Melaleuca*	*huegelii*	5	5			6
		Melaleuca	*systena*	4	3	4	5	
	Papilionaceae	*Gompholobium*	*tomentosum*					
	Proteaceae	*Grevillea*	*preissii*			3	3	
	Rhamnaceae	*Cryptandra*	*mutila*	4				5
		Trymalium	*albicans*					
HERBS	Apiaceae	*Trachymene*	*pilosa*		1	1	1	1
	Asteraceae	*Brachyscome*	*iberidifolia*			1		
		Hypochaeris	*glabra*		1	1	1	
		Millotia	*tenuifolia*	2	2	2	2	2
		Sonchus	*oleraceus*		1			1
		Waitzia	*citrina*					
	Brassicaceae	*Heliophila*	*pusilla*	1	1			
	Crassulaceae	*Crassula*	*colorata*	1	1	1		
	Euphorbiaceae	*Poranthera*	*microphylla*					
	Geraniaceae	*Geranium*	*molle*					
	Juncaginaceae	*Triglochin*	*centrcarpa*					
	Lauraceae	*Cassytha*	*flava*	3	3		3	2
	Lobeliaceae	*Lobelia*	*tenuior*	1	1	1	1	1
	Primulaceae	*Anagallis*	*arvensis*	1		1	1	1
	Restionaceae	*Desmocladus*	*asper*			2	2	
	Unidentified	*Sp. 3*				1	1	
GRASSES	Poaceae	*Pentaschistis*	*airoides*	1	1			
		Poa	*annua*	2	2	2	2	2
		Stipa	*flavescens*					
		Vulpia	*myuros*	1	1	1	2	

TOTAL NUMBER OF SPECIES	13	15	14	13	11

TREATMENT: HEATH POOR				PLOT				
REPLICATE NO: 5				NUMBER				
UNDERSTOREY PLANT SPECIES RICHNESS				1	2	3	4	5
SHRUB				4	4	5	5	4
HERB				5	11	8	9	9
GRASSES				2	3	2	2	2
SEDGES				0	0	0	0	0
TOTAL NUMBER OF SPECIES		REPLICATE: 29	PLOTS:	11	18	15	16	15

SPECIES PERCENTAGE COVER
COVER CODE:
BRAUN-BLANQUET
1=<1%; 2=1-5%; 3=6-10%; 4=11-25%; 5=26-50%; 6=51-75%; 7=76-100%

Life Form	Family	Genus	Species	1	2	3	4	5
SHRUBS	Euphorbiaceae	*Beyeria*	*cinerea*	3	3	4	4	4
		Phyllanthus	*calycinus*			2	3	
	Mimosaceae	*Acacia*	*lasiocarpa*	5	4	4	5	
	Myrtaceae	*Baeckea*	*robusta*					3
		Melaleuca	*huegelii*					
		Melaleuca	*systena*	3	5	4	4	5
	Proteaceae	*Dryandra*	*nivea*					
		Grevillea	*preissii*	5	5	4	5	6
	Rhamnaceae	*Trymalium*	*albicans*					
	Sapindaceae	*Diplopeltis*	*huegelii*					
HERBS	Anthericaceae	*Thysanotus*	*manglesianus*					
	Apiaceae	*Trachymene*	*pilosa*		1	1	1	1
	Asteraceae	*Brachyscome*	*iberidifolia*		1	1	1	1
		Hypochaeris	*glabra*		1		1	1
		Millotia	*tenuifolia*	2	2	2	2	
		Waitzia	*citrina*		1		1	1
	Brassicaceae	*Heliophila*	*pusilla*	1	1	1	1	1
	Crassulaceae	*Crassula*	*colorata*		1		1	
	Lauraceae	*Cassytha*	*flava*	2		4	2	4
	Lobeliaceae	*Lobelia*	*tenuior*	1	1	1		1
	Orchidaceae	*Microtis*	*media*	1	1	1	1	1
	Papilionaceae	*Trifolium*	*arvense*					
	Primulaceae	*Anagallis*	*arvensis*		1			
	Restionaceae	*Desmocladus*	*asper*					
	Unidentified	*Sp. 3*			1	1		1
GRASSES	Poaceae	*Pentaschistis*	*airoides*		1	1		
		Poa	*annua*	1	1		1	1
		Stipa	*flavescens*					
		Vulpia	*myuros*	1	1	1	1	1

TOTAL NUMBER OF SPECIES	11	18	15	16	15

APPENDIX 4: Table summarising the percentage breakdown and average plant species counts for importance category values, which, as allocated, represented the estimated cover (dominance) that individual plant species contributed to the litter layer of each replicate.

Appendix 4

Table summarising the percentage breakdown and average species counts for importance (dominance) categories which represented the estimated cover that individual plant species contributed to 1m2 invertebrate sampling plots

CATEGORY NUMBER	MODIFIED BRAUN-BLANQUET SCALE %	WOODLAND RICH REPLICATE % 1	2	3	4	5	Av.	WOODLAND POOR REPLICATE % 1	2	3	4	5	Av.	HEATH RICH REPLICATE % 1	2	3	4	5	Av.	HEATH POOR REPLICATE % 1	2	3	4	5	Av.
PERCENTAGE OF TOTAL PLANT SPECIES																									
1	< 1	52	34	29	18	17	30	48	58	60	30	34	46	38	40	37	46	56	43	58	58	48	47	60	54
2	1 - 5	26	32	47	40	40	37	8	16	24	37	34	24	32	29	28	16	16	24	13	15	30	23	9	18
3	6 - 10	6	14	7	22	17	13	10	9	3	22	9	11	10	18	9	12	11	12	10	7	5	14	7	9
4	11 - 25	5	11	10	14	18	12	13	13	0	8	13	9	15	9	16	16	11	13	8	12	8	5	14	9
5	26 - 50	9	7	7	5	8	7	18	0	0	3	6	5	3	3	5	10	6	5	7	7	9	9	9	8
6	51 - 75	2	0	0	1	0	1	3	4	8	0	4	4	2	1	3	0	0	1	4	0	0	2	1	1
7	76 - 100	0	2	0	0	0	0	0	0	5	0	0	1	0	0	2	0	0	0	0	1	0	0	0	0
AVERAGE SPECIES COUNT																									
1	< 1	5.6	4.0	3.4	2.8	2.0		3.8	6.6	4.6	3.6	3.6		7.0	5.8	4.8	8.4	9.0		8.2	7.8	6.4	6.2	9.0	
2	1 - 5	2.8	3.8	5.6	6.4	4.8		0.6	1.8	1.8	4.4	3.6		5.8	4.2	3.6	3.0	2.6		1.8	2.0	4.0	3.0	1.4	
3	6 - 10	0.6	1.6	0.8	3.6	2.0		0.8	1.0	0.2	2.6	1.0		1.8	2.6	1.2	2.2	1.8		1.4	1.0	0.6	1.8	1.0	
4	11 - 25	0.6	1.4	1.2	2.2	2.2		1.2	1.6	0.0	1.0	1.4		2.6	1.4	2.2	2.8	1.8		1.2	1.4	1.0	0.8	2.0	
5	26 - 50	1.0	0.8	0.8	0.8	1.0		1.4	0.0	0.0	0.4	0.6		0.6	0.4	0.6	1.8	1.0		1.0	1.0	1.2	1.2	1.4	
6	51 - 75	0.2	0.0	0.0	0.2	0.0		0.2	0.4	0.6	0.0	0.4		0.4	0.2	0.4	0.0	0.0		0.6	0.0	0.0	0.2	0.2	
7	76 - 100	0.0	0.2	0.0	0.0	0.0		0.0	0.0	0.4	0.0	0.0		0.0	0.0	0.2	0.0	0.0		0.0	0.2	0.0	0.0	0.0	

APPENDIX 5: An inventory of plant species collected during the project

APPENDIX 5: An inventory of plant species collected during the project

AIZOACEAE
Carpobrotus edulis (L.) N.E .Br.

AMARANTHACEAE
Ptilotus drummondii (Moq.) F. Muell.

ANTHERICACEAE
Agrostocrinum scabrum (R. Br.) Baill.
Corynotheca micrantha Druce
Thysanotus arenarius Brittan
Thysanotus manglesianus Kunth
Tricoryne elatior R. Br.

APIACEAE
Trachymene pilosa Sm.

ASTERACEAE
Brachyscome iberidifolia Benth.
Hypochaeris glabra L.
Millotia tenuifolia Cass.
Olearia axillari (DC.) Benth.
Senecio lautus Willd.
Siloxerus humifusus Labill.
Sonchus oleraceus L .
Ursinia anthemoides (L.) Poir.
Waitzia citrina (Benth.) Steetz
Waitzia suaveolens (Benth.) Druce

BRASSICACEAE
Heliophila pusilla L.f.
Raphanus raphanistrum (L.)

CARYOPHYLLACEAE
Petrorhagia velutina (Guss.) P.W. Ball & Heywood

CASUARINACEAE
Allocasuarina humilis (Otto & F. Dietr.) L.A.S.Johnson

COLCHICACEAE
Burchardia umbellata R. Br.

CRASSULACEAE
Crassula colorata (Nees) Ostenf.

CYPERACEAE
Isolepis cernua (Vahl) Roem. & Schult.
Lepidosperma angustatum R. Br.
Lepidosperma scabrum Nees
Mesomelaena pseudostygia (Kuek.) K.L. Wilson
Schoenus curvifolius (R. Br.) Roem. & Schult.

DASYPOGONACEAE
Lomandra caespitosa (Benth.) Ewart
Lomandra preissii (Endl.) Ewart

DILLENIACEAE
Hibbertia huegelii (Endl.) F. Muell.
Hibbertia hypericoides (DC.) Benth.
Hibbertia racemosa (Endl.) Gilg

DROSERACEAE
Drosera erythrorhiza Lindl.
Drosera pallida Lindl.

EPACRIDACEAE
Andersonia lehmanniana Sond.
Astroloma macrocalyx Sond.
Conostephium preissii Sond.
Croninia kingiana (F. Muell.) J.M. Powell
Leucopogon conostephioides DC.
Leucopogon nutans E. Pritz.
Leucopogon parviflorus (Andrews) Lindl.
Leucopogon polymorphus Sond.
Leucopogon propinquus R. Br.
Lysinema ciliatum R. Br.

EUPHORBIACEAE
Beyeria cinerea (Muell. Arg.) Baill.
Phyllanthus calycinus Labill.
Poranthera microphylla Brongn.

GENTIANACEAE
Centaurium erythraea Rafn

GERANIACEAE
Geranium molle L.

GOODENIACEAE
Dampiera linearis R. Br.
Lechenaultia biloba Lindl.
Scaevola thesioides Benth.

HAEMODORACEAE
Anigozanthos humilis Lindl.
Conostylis aculeata R. Br.
Conostylis candicans Endl.
Conostylis hybrid
Conostylis setigera R. Br.
Haemodorum laxum R. Br.

HALORAGACEAE
Gonocarpus pithyoides Nees

IRIDACEAE
Gladiolus caryophyllaceus (Burm. f.) Poir
Patersonia occidentalis R. Br.

JUNCAGINACEAE
Triglochin centrocarpa Hook.

LAMIACEAE
Hemiandra pungens R. Br.

LAURACEAE
Cassytha flava Nees

LOGANIACEAE
Mitrasacme paradoxa R. Br.

LOBELIACEAE
Lobelia gibbosa Labill.
Lobelia tenuior R. Br.

LYGINIACEAE
Lyginia barbata R. Br.

MIMOSACEAE
Acacia lasiocarpa Benth.
Acacia pulchella R. Br.
Acacia stenoptera Benth.

MYOPORACEAE
Eremophila glabra (R. Br.) Ostenf.

MYRTACEAE
Beaufortia elegans Schauer
Baeckea robusta F. Muell.
Calothamnus quadrifidus R. Br.
Calytrix angulata Lindl.
Calytrix flavescens A. Cunn.
Eremaea asterocarpa Hnatiuk
Eremaea pauciflora (Endl.) Druce
Eucalyptus marginata Sm.
Eucalyptus todtiana F. Muell.
Leptospermum spinescens Endl.
Melaleuca huegelii Endl.
Melaleuca systena Craven
Scholtzia involucrata (Endl.) Druce

OLACACEAE
Olax benthamiana Miq.

ORCHIDACEAE
Microtis media R. Br.
Caladenia flava R. Br.
Elythranthera brunonis (Endl.) A.S. George

OROBANCHACEAE
Orobanche minor Sm.

PAPILIONACEAE
Bossiaea eriocarpa Benth.
Daviesia decurrens Meisn.
Daviesia podophylla Crisp
Gompholobium confertum (DC.) Crisp
Gompholobium tomentosum L abill.
Hardenbergia comptoniana (Andrews) Benth.
Hovea pungens Benth.
Hovea trisperma Benth.
Isotropis cuneifolia (Sm.) Heynh.

PAPILIONACEAE Cont..
Jacksonia floribunda Endl.
Jacksonia furcellata (Bonpl.) DC.
Jacksonia sternbergiana Huegel
Jacksonia stricta Meisn.
Mirbelia trichocalyx Domin
Oxylobium capitatum Benth.
Templetonia retusa (Vent.) R. Br.
Trifolium arvense L.

PHORMIACEAE
Dianella divaricata R. Br.

PITTOSPORACEAE
Pronaya fraseri (Hook.) E.M. Benn.

POACEAE
Aira cupaniana Guss.
Amphipogon turbinatus R. Br.
Avellinia michelli (Savi) Parl.
Bromus diandrus Roth
Pentaschistis airoides (Nees) Stapf
Poa annua L.
Poa drummondiana Nees
Stipa flavescens Labill.
Vulpia myuros (L.) C.C. Gmel.

POLYGALACEAE
Comesperma calymega Labill.
Comesperma confertum Labill.

PORTULACACEAE
Calandrinia corrigioloides Benth.

PRIMULACEAE
Anagallis arvensis L.

PROTEACEAE
Adenanthos cygnorum Diels
Banksia attenuata R. Br.
Banksia ilicifolia R. Br.
Conospermum incurvum Lindl.
Dryandra nivea (Labill.) R. Br.
Dryandra sessilis (Knight) Domin
Grevillea preissii Meisn.
Hakea lissocarpha R. Br.
Hakea ruscifolia Labill.
Hakea trifurcata (Sm.) R. Br.
Persoonia saccata R. Br.
Petrophile linearis R. Br.
Petrophile macrostachya R. Br.
Petrophile serruriae R. Br.
Stirlingia latifolia (R. Br.) Steud.
Synaphea spinulosa (Burm.f.) Merr.

RANUNCULACEAE
Clematis microphylla DC.

RESTIONACEAE
Desmocladus asper (Nees) B.G. Briggs & L.A.S. Johnson
Desmocladus fasciculatus (R. Br.) B.G. Briggs & L.A.S. Johnson
Hypolaena exsulca R. Br.
Loxocarya cinerea R. Br.

RHAMNACEAE
Cryptandra mutila Reissek
Trymalium albicans (Steud.) Reissek

RUBIACEAE
Opercularia vaginata Juss.

RUTACEAE
Diplolaena angustifolia Hook.
Eriostemon spicatus A. Rich.

SAPINDACEAE
Diplopeltis huegelii Endl.

STERCULIACEAE
Thomasia triphylla (Labill.) Gay

STYLIDIACEAE
Levenhookia pusilla R. Br.
Stylidium brunonianum Benth.
Stylidium bulbiferum Benth.
Stylidium crossocephalum F. Muell.
Stylidium macrocarpum (Benth.) F.L. Erickson & J.H. Willis
Stylidium piliferum R. Br.
Stylidium repens R. Br.
Stylidium schoenoides DC.

THYMELAEACEAE
Pimelea argentea R. Br.
Pimelea rosea R. Br

XANTHORRHOEACEAE
Xanthorrhoea preissii Endl.

APPENDIX 6: Project invertebrate orders presence absence data

Appendix 6A Presence absence data for invertebrate orders collected from Woodland Rich replicates

Appendix 6B Presence absence data for invertebrate orders collected from Woodland Poor replicates

Appendix 6C Presence absence data for invertebrate orders collected from Heath Rich replicates

Appendix 6D Presence absence data for invertebrate orders collected from Heath Rich replicates

APPENDIX 6: Invertebrate Orders Presence Absence Data

CLASS	ORDER	WOODLAND RICH Replicate						WOODLAND POOR Replicate						HEATH RICH Replicate						HEATH POOR Replicate					
		1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total
Arachnida	Araneae	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Pseudoscorpionida	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Acarina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Opilionida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Malacostraca	Isopoda	1	0	0	1	0	1	0	0	0	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0
Chilopoda	Scolopendrida	0	0	0	0	1	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	Geophilida	1	0	0	1	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	1	1
Diplopoda	Polyxenida	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0	1
	Julida	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Collembola	Collembola	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1
Diplura	Diplura	1	1	1	0	0	1	0	1	0	0	0	1	1	0	0	0	0	1	1	0	1	0	0	1
Insecta	Thysanura	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1
	Blattodea	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1	0	1	1	0	0	1	0	1
	Isoptera	1	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	Mantodea	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	Dermaptera	0	0	0	1	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	1	1	0	1
	Orthoptera	1	0	0	1	0	1	1	1	0	1	1	1	1	0	0	0	0	1	0	0	0	0	0	0
	Phasmatodea	1	0	0	1	0	1	1	0	0	0	1	1	1	0	0	0	0	1	1	0	0	0	0	1
	Psocoptera	0	1	0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Hemiptera	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Thysanoptera	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	0	1	1	1
	Neuroptera	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Coleoptera	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Mecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Diptera	1	1	1	0	1	1	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	0	0	1
	Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
	Hymenoptera	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TOTAL ORDERS		19	14	15	17	14	23	17	11	10	17	19	20	18	10	14	14	10	20	12	10	15	14	11	20

APPENDIX 6A: Presence absence data for invertebrate orders collected from Woodland Rich replicates

CLASS	ORDER	REPLICATE I PLOT						REPLICATE 2 PLOT						REPLICATE 3 PLOT						REPLICATE 4 PLOT						REPLICATE 5 PLOT					
		1.1	1.2	1.3	1.4	1.5	Total	2.1	2.2	2.3	2.4	2.5	Total	3.1	3.2	3.3	3.4	3.5	Total	4.1	4.2	4.3	4.4	4.5	Total	5.1	5.2	5.3	5.4	5.5	Total
Arachnida	Araneae	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1
	Pseudoscorpionida	1	0	1	0	0	1	1	1	0	1	0	1	1	1	1	0	0	1	1	1	1	1	1	1	0	0	0	1	0	1
	Acarina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Opilionida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malacostraca	Isopoda	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0	0
Chilopoda	Scolopendrida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
	Geophilida	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0
Diplopoda	Polyxenida	1	0	1	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1	1	0	0	1	0	1	0	0	1	0	0	1
	Julida	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Collembola	Collembola	1	1	0	1	1	1	1	1	0	0	0	1	1	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	1	1
Diplura	Diplura	0	1	0	0	0	1	0	1	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Insecta	Thysanura	1	1	1	0	0	1	1	1	0	1	1	1	0	1	1	1	1	1	1	0	1	0	1	1	0	1	1	0	1	1
	Blattodea	1	0	1	1	1	1	0	1	0	0	0	1	1	0	0	0	0	1	1	1	1	1	0	1	1	0	0	0	1	1
	Isoptera	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Mantodea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dermaptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0
	Orthoptera	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0
	Phasmatodea	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
	Psocoptera	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	0	1	1
	Hemiptera	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1
	Thysanoptera	1	1	0	1	0	1	1	1	0	1	1	1	1	1	0	1	1	1	1	0	0	1	0	1	0	0	0	0	1	1
	Neuroptera	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Coleoptera	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	0	0	0	0	1	1
	Mecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Diptera	0	1	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1
	Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hymenoptera	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	0	0	1	1	0	1
TOTAL ORDERS WOODLAND RICH		13	11	13	10	9	19	11	13	3	10	8	14	11	9	6	8	7	15	14	10	12	14	11	17	4	3	6	6	8	14

APPENDIX 6B: Presence absence data for invertebrate orders collected from Woodland Poor replicates

CLASS	ORDER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total
Arachnida	Araneae	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
	Pseudoscorpionida	1	1	1	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1
	Acarina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Opilionida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malacostraca	Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	1	0	0	1
Chilopoda	Scolopendrida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Geophilida	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	1	0	0	0	1
Diplopoda	Polyxenida	0	1	1	0	1	1	1	0	1	0	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1	1	1	1	0	1
	Julida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Collembola	Collembola	1	1	1	0	1	1	0	0	1	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
Diplura	Diplura	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Insecta	Thysanura	1	0	1	1	1	1	0	0	0	0	0	0	1	0	0	0	0	1	1	1	0	0	0	1	1	1	1	1	1	1
	Blattodea	0	1	1	0	1	1	1	0	0	0	0	1	0	1	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	1
	Isoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Mantodea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dermaptera	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	1
	Orthoptera	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	0	1
	Phasmatodea	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
	Psocoptera	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	1	0	1
	Hemiptera	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Thysanoptera	1	0	0	0	1	1	0	0	1	0	0	1	1	0	0	0	1	1	1	1	0	0	0	1	1	1	1	1	0	1
	Neuroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Coleoptera	1	1	1	1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
	Mecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Diptera	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	1	0	1	0	0	0	1	0	1	0	0	0	1
	Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hymenoptera	1	1	1	1	1	1	0	0	1	0	0	1	1	0	0	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1
TOTAL ORDERS WOODLAND POOR		8	11	12	8	12	17	4	1	10	4	4	12	8	7	5	7	8	10	12	15	10	12	10	18	13	15	15	12	8	19

APPENDIX 6C: Presence absence data for invertebrate orders collected from Heath Rich replicates

CLASS	ORDER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total
Arachnida	Araneae	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Pseudoscorpionida	1	1	1	1	1	1	0	1	1	1	0	1	1	0	1	1	1	1	1	1	1	0	1	1	1	0	1	1	1	1
	Acarina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Opilionida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malacostraca	Isopoda	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
Chilopoda	Scolopendrida	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Geophilida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diplopoda	Polyxenida	1	0	0	1	0	1	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	1	0	1	0	1	1	0	0	1
	Julida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Collembola	Collembola	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0	0	0	1
Diplura	Diplura	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insecta	Thysanura	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0	0	1
	Blattodea	1	0	0	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0	1	0	0	0	0	0	0
	Isoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mantodea	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dermaptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Orthoptera	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Phasmatodea	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Psocoptera	0	0	1	1	0	1	0	0	0	1	0	1	1	1	0	1	0	1	0	1	1	1	0	1	0	1	1	1	0	1
	Hemiptera	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Thysanoptera	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	1	0	1	0	0	1	1	0	1	0	0	0	0	0	0
	Neuroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Coleoptera	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	0	1
	Mecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Diptera	0	0	0	0	1	1	1	0	0	0	0	1	0	0	1	0	1	1	0	1	0	1	0	1	0	0	0	0	0	0
	Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Hymenoptera	1	1	1	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1
TOTAL ORDERS HEATH RICH		11	9	12	10	9	18	5	5	5	9	4	10	7	8	10	13	10	14	7	11	13	10	6	14	5	8	6	7	5	10

APPENDIX 6D: Presence absence data for invertebrate orders collected from Heath Poor replicates

CLASS	ORDER	REPLICATE 1						REPLICATE 2						REPLICATE 3						REPLICATE 4						REPLICATE 5					
		PLOT						PLOT						PLOT						PLOT						PLOT					
		1.1	1.2	1.3	1.4	1.5	Total	2.1	2.2	2.3	2.4	2.5	Total	3.1	3.2	3.3	3.4	3.5	Total	4.1	4.2	4.3	4.4	4.5	Total	5.1	5.2	5.3	5.4	5.5	Total
Arachnida	Araneae	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1	0	0	1	1
	Pseudoscorpionida	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1
	Acarina	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Opilionida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
Malacostraca	Isopoda	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chilopoda	Scolopendrida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Geophilida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Diplopoda	Polyxenida	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0
	Julida	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Collembola	Collembola	0	0	0	0	0	0	1	1	1	1	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1	0	0	1	1
Diplura	Diplura	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Insecta	Thysanura	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	1	1	0	1	0	0	1	1
	Blattodea	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0
	Isoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Mantodea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Dermaptera	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0
	Orthoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Phasmatodea	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Psocoptera	1	0	0	0	0	1	1	1	1	1	0	1	1	1	0	1	0	1	1	1	1	0	1	1	0	1	1	1	1	1
	Hemiptera	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Thysanoptera	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	1	0	0	1	1
	Neuroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Coleoptera	1	0	0	0	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1
	Mecoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	Diptera	0	0	0	0	1	1	1	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	Lepidoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Hymenoptera	1	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TOTAL ORDERS HEATH POOR		8	3	3	9	6	12	9	9	9	8	6	10	7	9	6	5	7	15	11	11	12	10	12	14	5	10	5	6	10	11

APPENDIX 7A: Presence absence data for Araneae

APPENDIX 7A1: Presence absence data for Araneae morphospecies collected from Woodland Rich replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT						REPLICATE 2 PLOT						REPLICATE 3 PLOT						REPLICATE 4 PLOT						REPLICATE 5 PLOT						TOTAL SPECIES
		1.1	1.2	1.3	1.4	1.5	Total	2.1	2.2	2.3	2.4	2.5	Total	3.1	3.2	3.3	3.4	3.5	Total	4.1	4.2	4.3	4.4	4.5	Total	5.1	5.2	5.3	5.4	5.5	Total	
ARANEAE	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	3	1	1	0	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	1	0	1	0	1	1	0	0	0	0	0	0	1
	4	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
	5	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	6	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
	7	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	8	0	1	0	0	1	1	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	0	1
	9	0	1	0	0	0	1	1	0	0	0	0	1	0	1	0	0	0	1	1	0	1	0	1	1	0	0	0	0	0	0	1
	12	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	13	0	0	1	1	1	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	14	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	16	0	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	17	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	18	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
	19	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	20	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	23	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	25	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	26	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	27	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	28	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	29	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	1	0	1	1	0	0	0	0	0	0	1
	30	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1
	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	1	0	1	0	1	1
	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	36	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
	38	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	44	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	1
TOTAL WOODLAND RICH		7	4	3	2	8	16	4	3	5	2	3	12	3	3	1	3	3	7	8	1	6	3	6	13	1	1	0	2	0	2	32

APPENDIX 7A2: Presence absence data for Araneae morphospecies collected from Woodland Poor replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total	TOTAL SPECIES
ARANEAE	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
	3	0	1	0	1	1	1	0	0	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	1	1
	4	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	5	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	9	0	1	1	0	1	1	0	0	1	1	0	1	0	0	0	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	1
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	1	1
	11	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	13	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	1	0	0	1	0	0	0	0	0	0	1
	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	18	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1
	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	1	1
	34	0	1	1	0	0	1	0	0	1	1	0	1	0	1	1	0	0	1	0	1	1	1	0	1	0	0	1	0	1	1	1
	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1
	38	0	0	1	0	0	1	1	0	1	1	0	1	0	0	0	0	0	0	1	1	1	0	0	1	1	1	1	0	0	1	1
	39	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	41	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	42	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	43	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	44	0	0	1	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	1	1	1	0	1	1	1	1	1	0	1	1	1
	46	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	55	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
TOTAL WOODLAND POOR		0	3	5	1	3	7	1	0	9	4	1	11	2	3	1	2	2	8	6	5	5	1	3	11	7	5	9	0	3	15	31

APPENDIX 7A3: Presence absence data for Araneae morphospecies collected from Heath Rich replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT						REPLICATE 2 PLOT						REPLICATE 3 PLOT						REPLICATE 4 PLOT						REPLICATE 5 PLOT						TOTAL SPECIES
		1.1	1.2	1.3	1.4	1.5	Total	2.1	2.2	2.3	2.4	2.5	Total	3.1	3.2	3.3	3.4	3.5	Total	4.1	4.2	4.3	4.4	4.5	Total	5.1	5.2	5.3	5.4	5.5	Total	
ARANEAE	3	1	0	0	0	0	1	0	1	0	0	0	1	1	1	1	1	1	1	0	1	1	1	0	1	0	1	0	0	0	1	1
	7	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	8	0	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	9	0	0	0	0	0	0	0	1	1	0	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1
	21	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	22	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	24	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	29	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	31	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	1	0	0	0	1	0	1	1
	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
	34	0	1	1	1	1	1	0	0	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1
	39	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	41	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	42	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1	0	0	1	0	0	1	1	0	0	1	0	1	1
	44	0	0	0	0	1	1	0	1	1	0	0	1	0	1	0	0	0	1	0	1	0	1	0	1	0	0	0	1	1	1	1
	45	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	51	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	52	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL HEATH RICH		2	1	1	3	4	16	0	5	7	3	3	12	2	4	3	5	4	9	1	3	5	4	1	7	2	3	1	5	2	8	21

APPENDIX 7A4: Presence absence data for Araneae morphospecies collected from Heath Poor replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT						REPLICATE 2 PLOT						REPLICATE 3 PLOT						REPLICATE 4 PLOT						REPLICATE 5 PLOT						TOTAL SPECIES
		1.1	1.2	1.3	1.4	1.5	Total	2.1	2.2	2.3	2.4	2.5	Total	3.1	3.2	3.3	3.4	3.5	Total	4.1	4.2	4.3	4.4	4.5	Total	5.1	5.2	5.3	5.4	5.5	Total	
ARANEAE	3	0	0	0	0	1	1	1	0	1	1	1	1	1	0	0	0	0	1	0	0	1	1	0	1	0	1	0	0	0	1	1
	8	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	1	0	0	0	1	1
	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	29	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	30	0	0	1	0	0	1	0	0	0	1	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
	34	0	0	1	1	0	1	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	1	1	0	1	0	0	0	1	1
	41	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	1
	42	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	1	1	0	0	1	1	1	0	1	0	0	0	1	1
	44	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	0	0	1	1	0	1	0	0	1	1	1
	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	1
	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
TOTAL HEATH POOR		1	0	2	1	2	5	1	1	1	2	2	3	5	1	3	3	0	7	2	3	2	2	6	8	0	5	0	0	2	6	12

APPENDIX 7B: Presence absence data for Coleoptera

Appendix 7B1 Presence absence data for Coleoptera morphospecies collected from Woodland Rich replicates

Appendix 7B2 Presence absence data for Coleoptera morphospecies collected from Woodland Poor replicates

Appendix 7B3 Presence absence data for Coleoptera morphospecies collected from Heath Rich replicates

Appendix 7B4 Presence absence data for Coleoptera morphospecies collected from Heath Poor replicates

APPENDIX 7B1: Presence absence data for Coleoptera morphospecies collected from Woodland Rich replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total	TOTAL SPECIES
COLEOPTERA	1	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	2	1	1	1	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	3	1	1	0	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	4	1	1	0	0	0		0	1	0	0	0		0	0	0	0	0		1	1	1	1	1		0	0	0	0	0		1
	6	1	0	0	1	0		0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		1
	7	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	8	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	9	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	10	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	11	0	1	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	14	0	0	1	0	0		0	0	0	0	0		0	0	0	1	0		0	0	0	0	0		0	0	0	0	1		1
	15	0	0	0	1	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	16	0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	17	0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	18	0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	19	0	0	0	0	1		1	0	0	0	0		1	0	0	0	0		1	0	0	1	1		0	0	0	0	0		1
	20	0	1	0	0	1		0	1	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	21	0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		0	1	1	0	1		0	0	0	0	0		1
	22	0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	23	1	1	0	0	0		1	0	0	1	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	24	0	0	0	0	0		0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	26	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	27	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	28	0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	29	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	30	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	31	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	32	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	1	1	0		0	0	0	0	0		1
	33	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	1	0		0	0	0	0	0		1
	34	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	1		0	0	0	0	0		1
TOTAL WOODLAND RICH		10	6	2	4	6		2	3	0	1	2		2	0	0	1	0		8	5	4	4	4		0	0	0	0	1		30

APPENDIX 7B2: Presence absence data for Coleoptera morphospecies collected from Woodland Poor replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total	TOTAL SPECIES
COLEOPTERA	2	0	1	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	3	0	0	0	0	1		0	0	1	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	4	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	1	1		0	0	0	0	0		1
	9	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	11	0	1	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	14	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		1
	16	0	0	0	1	1		0	0	0	0	0		0	0	0	0	0		0	0	0	1	0		0	0	0	0	0		1
	19	0	0	0	0	1		0	0	1	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	20	0	1	1	0	0		0	0	1	0	0		0	0	0	0	0		1	1	0	0	0		1	0	1	0	0		1
	21	0	0	1	1	0		0	0	1	0	0		0	0	0	0	0		1	0	1	0	1		1	0	1	1	0		1
	22	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	23	0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	27	0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	29	0	0	0	0	1		0	0	1	0	0		0	0	0	0	0		0	0	1	0	0		0	0	1	0	0		1
	30	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	1		1
	31	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		1	0	0	0	0		1
	32	0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	1	0	0		1
	33	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	35	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	1		1
	38	0	0	1	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	39	0	0	1	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	41	0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	42	0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	44	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		1
	45	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		1
	46	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	1	0	1		0	0	0	0	0		1
	48	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	1		0	0	0	0	0		1
	49	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		1
	50	0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	51	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	1	1	1	1		1
	52	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	1	0	0	0		1
	53	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	1	0	0		1
	54	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	66	0	1	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		1
TOTAL WOODLAND POOR		2	4	4	3	6		0	0	8	0	0		0	0	0	0	0		7	3	5	2	4		5	4	9	2	3		34

APPENDIX 7B3: Presence absence data for Coleoptera morphospecies collected from Heath Rich replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total	TOTAL SPECIES
COLEOPTERA	2	1	0	1	0	0		0	0	0	0	0		0	1	1	0	0		0	1	0	1	0		0	0	0	0	0		1
	9	0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	14	0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	19	1	0	1	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	23	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	30	1	0	0	0	0		0	0	1	1	0		0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		1
	33	0	1	0	0	1		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	36	0	0	1	0	1		0	1	0	1	0		0	1	0	1	1		0	1	1	1	1		0	0	0	0	0		1
	42	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	47	0	0	0	0	0		0	0	0	0	0		0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		1
	50	0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		0	1	1	0	0		0	0	0	0	0		1
	55	1	1	0	0	0		0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	56	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	57	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	58	1	0	0	1	1		0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		0	0	0	1	0		1
	59	0	0	0	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	60	0	0	1	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	61	0	0	0	0	0		0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	62	0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	63	0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	64	0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	65	0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	66	0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	67	0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		0	0	0	0	0		1
	68	0	0	0	0	0		0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		0	0	0	0	0		1
	69	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	70	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	1	0		1
TOTAL HEATH RICH		8	2	4	2	6		0	1	1	3	1		1	6	4	2	2		1	7	3	2	1		0	0	0	2	0	0	27

APPENDIX 7B4: Presence absence data for Coleoptera morphospecies collected from Heath Poor replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT						REPLICATE 2 PLOT						REPLICATE 3 PLOT						REPLICATE 4 PLOT						REPLICATE 5 PLOT						TOTAL SPECIES
		1.1	1.2	1.3	1.4	1.5	Total	2.1	2.2	2.3	2.4	2.5	Total	3.1	3.2	3.3	3.4	3.5	Total	4.1	4.2	4.3	4.4	4.5	Total	5.1	5.2	5.3	5.4	5.5	Total	
COLEOPTERA	5	1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	12	0	0	0	0	0		0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	13	0	0	0	0	0		0	0	0	0	0		0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		1
	19	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	1		0	0	0	0	0		1
	25	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	1	0		1
	27	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	1		1
	30	0	0	0	0	0		0	0	1	0	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	31	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	1		1
	32	0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	33	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	1	0		1
	34	0	0	0	0	0		0	1	0	1	1		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	36	0	0	0	0	0		1	1	1	1	1		0	1	0	0	1		0	0	0	1	0		0	0	0	0	0		1
	37	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		1
	40	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	43	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	1		0	0	0	0	0		1
	52	0	0	0	0	0		0	0	1	0	0		0	0	0	0	0		0	0	0	1	1		0	0	0	0	0		1
	54	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
	64	0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	1		1
	66	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	1		0	0	0	0	0		1
	68	0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1
	69	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	0	0	0		0	0	0	0	0		1
	70	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		0	1	1	0	0		0	0	0	0	0		1
	71	0	0	0	0	0		0	0	0	0	0		0	0	0	1	0		0	0	0	0	0		0	0	0	0	0		1
	72	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	1	1	0	0		0	0	0	0	0		1
	73	0	0	0	0	0		0	0	0	0	0		0	0	0	0	0		1	0	0	0	0		0	0	0	0	0		1
TOTAL HEATH POOR		1	0	0	0	0		3	2	3	3	3		1	1	0	2	1		4	4	2	2	4		0	2	0	2	3		25

APPENDIX 7C: Presence absence data for Hemiptera

Appendix 7C1 Presence absence data for Hemiptera morphospecies collected from Woodland Rich replicates

Appendix 7C2 Presence absence data for Hemiptera morphospecies collected from Woodland Poor replicates

Appendix 7C3 Presence absence data for Hemiptera morphospecies collected from Heath Rich replicates

Appendix 7C4 Presence absence data for Hemiptera morphospecies collected from Heath Poor replicates

APPENDIX 7C1: Presence absence data for Hemiptera morphospecies collected from Woodland Rich replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total	TOTAL SPECIES
HEMIPTERA	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	2	1	1	1	1	1	1	0	0	1	1	0	1	1	0	1	0	1	1	1	1	0	0	1	1	0	0	0	0	0	0	1
	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1
	5	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	8	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	9	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	11	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	12	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	15	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	16	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	17	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	18	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	19	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	20	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	21	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
	23	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
	26	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	27	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	0	1	0	0	0	0	0	0	1
	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	1	1	1
	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
TOTAL WOODLAND RICH		5	7	6	7	5	15	2	1	3	3	1	5	2	1	3	2	2	4	5	3	1	7	5	14	1	0	1	0	3	3	30

APPENDIX 7C2: Presence absence data for Hemiptera morphospecies collected from Woodland Poor replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT						REPLICATE 2 PLOT						REPLICATE 3 PLOT						REPLICATE 4 PLOT						REPLICATE 5 PLOT						TOTAL SPECIES
		1.1	1.2	1.3	1.4	1.5	Total	2.1	2.2	2.3	2.4	2.5	Total	3.1	3.2	3.3	3.4	3.5	Total	4.1	4.2	4.3	4.4	4.5	Total	5.1	5.2	5.3	5.4	5.5	Total	
HEMIPTERA	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	3	0	1	1	1	1	1	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	1	1	0	1	1	1	1	1	1
	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
	17	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	0	1	1
	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	32	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1
	34	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
	36	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	37	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
	46	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	47	1	0	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	49	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	51	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	55	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1
	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	1
TOTAL WOODLAND POOR		2	3	3	1	2	8	0	0	3	0	0	3	0	0	3	1	0	3	2	0	4	1	2	7	3	2	3	2	1	8	22

APPENDIX 7C3: Presence absence data for Hemiptera morphospecies collected from Heath Rich replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total	TOTAL SPECIES
HEMIPTERA	2	1	1	1	1	1	1	0	0	1	1	1	1	0	1	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	0	1
	3	1	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	0	1	1	0	1	1	1	1	1
	4	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	0	0	0	0	1
	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
	22	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	23	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	32	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	1	1
	34	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1
	36	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	39	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
	44	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1
	45	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	1	0	1	0	1	0	0	0	0	0	0	1
	47	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	1
	48	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	52	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	53	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	56	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL HEATH RICH		4	3	3	3	5	7	2	2	1	2	3	6	2	5	2	1	3	8	3	6	3	4	1	9	5	1	1	1	1	5	21

APPENDIX 7C4: Presence absence data for Hemiptera morphospecies collected from Heath Poor replicates

ORDER	MORPHOSPECIES NUMBER	REPLICATE 1 PLOT 1.1	1.2	1.3	1.4	1.5	Total	REPLICATE 2 PLOT 2.1	2.2	2.3	2.4	2.5	Total	REPLICATE 3 PLOT 3.1	3.2	3.3	3.4	3.5	Total	REPLICATE 4 PLOT 4.1	4.2	4.3	4.4	4.5	Total	REPLICATE 5 PLOT 5.1	5.2	5.3	5.4	5.5	Total	TOTAL SPECIES
HEMIPTERA	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	1	0	0	1	1	0	1	1
	3	1	0	0	0	1	1	0	1	1	0	0	1	1	1	1	1	1	1	0	1	1	0	1	1	0	1	0	1	0	1	1
	6	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
	13	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	1	0	1	0	1	1
	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1
	28	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	32	0	0	0	0	0	0	1	1	1	1	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	1	1	1	1
	33	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1
	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	1	1
	35	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	37	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1
	41	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	1	1	1	1	0	0	0	0	0	0	1
	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
	47	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	50	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	1
	53	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
TOTAL HEATH POOR		3	0	0	0	3	5	1	2	2	1	3	4	4	1	4	3	1	7	2	6	5	6	3	9	2	5	3	4	2	8	20

APPENDIX 8: Spearman's rank order cross correlations

Appendix 8A Spearman's rank order correlations showing the significance values of cross correlations between plant species richness, plant life form and environmental parameters

Appendix 8B Spearman's rank order correlations showing the significance values of environmental parameters that are related at the replicate scale

Appendix 8C Spearman's rank order correlations showing the significance values of environmental parameters that are related at the plot scale

APPENDIX 8A: Spearman's rank order correlations showing the significance values of cross correlations between plant species richness, plant life forms and environmental paramters

ENVIRONMENTAL PARAMETER	N = 20				PLANT & LIFE FORM SPECIES RICHNESS N = 100				Average N = 20			
	Plant	Shrub	Herb	Grasses	Plant	Shrub	Herb	Grasses	Plant	Shrub	Herb	Grasses
Understorey Cover	**0	**0	ns	ns	*0.008	ns	ns	*0.003	ns	ns	*0.039	ns
Understorey Height	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Canopy Cover	ns	*0.029	ns	ns	ns	*0.013	*-0.015	*-0.002				
Canopy Height	ns	ns	ns	ns	ns	*0.013	*-0.021	*-0.001				
Litter Cover	ns	ns	ns	ns	0.01	ns	0.013	*0.014	ns	ns	ns	ns
Litter Depth	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Litter Moisture	ns	ns	ns	ns	ns	*0.021	ns	ns				
Patchiness	ns	ns	ns	ns	ns	ns	ns	*0.011				
Tonnes	ns	ns	ns	ns	ns	ns	ns	*0.035				
Litter Fine	ns	ns	ns	ns	ns	ns	ns	*-0.017				
Litter Medium	ns	ns	ns	ns	*0.002	ns	*0.001	**0				
Litter Coarse	ns	*0.017	ns	ns	*-0.028	*0.031	*-0.005	**0				
Fruit & Flowers	ns	ns	ns	ns	*-0.009	*0.047	**0	*-0.005				
Twigs	ns	ns	ns	ns	ns	*-0.001	ns	*0.007				
Woody Debris	ns	ns	ns	ns	*0.002	ns	*0.002	**0				
Miscellaneous	ns	*0.023	ns	ns	ns	ns	*-0.018	*-0.02				
Coarse Rock	ns	*-0.007	ns	ns	*0.014	*-0.001	**0	**0				
Soil Moisture	ns	ns	ns	ns	ns	ns	*0.035	*0.015				
Soil Organic Matter	ns	*-0.037	ns	ns	*0.028	*-0.006	**0	**0				
Limestone	ns	*-0.018	ns	ns	*0.001	*-0.009	**0	**0				
Temperature	ns	ns	ns	ns	ns	*-0.001	*0.027	ns				
Insolation	ns	ns	ns	ns	ns	ns	ns	*-0.039				
Average Insolation	ns	ns	ns	ns	ns	ns	ns	ns				

*P < 0.05; **P < 0.001

APPENDIX 8B: Spearman's rank order correlations showing the significance values of environmental parameters that are related at the replicate scale

ENVIRONMENTAL PARAMETERS

CROSS CORRELATIONS

REPLICATE SCALE (N = 20)

	UC	UH	CC	CH	LT	LD	LM	P	TH	LF	LE	LC	FF	T	WD	M	RF	SM	OM	L	TP	I	AI
U/Cover																							
U/Height	ns																						
C/Cover	*0.043	ns																					
C/Height	ns	ns	**0																				
L/Cover	*0.004	ns	*0.046	ns																			
L/Depth	ns	ns	ns	ns	ns																		
L/Moisture	ns	ns	ns	ns	ns	ns																	
Patchiness	ns	ns	ns	ns	ns	ns	ns																
Tonnes	ns	ns	*0.042	*0.028	ns	ns	ns	ns															
L/Fine	ns	ns	ns	ns	ns	ns	ns	ns	**0														
L/Medium	ns	ns	ns	*0.004	ns	ns	ns	*0.031	*0.006	*0.003													
L/Coarse	ns	ns	*0.004	*0.004	*0.017	ns	ns	ns	ns	ns	ns												
F/Flowers	ns	ns	*0.001	*0.002	ns	ns	ns	ns	ns	ns	*0.33	*0.47											
Twigs	ns	ns	*0.046	*0.016	ns	*0.014	ns	ns	ns	*0.002	*0.006	ns	ns										
W/Debris	ns	ns	**0	**0	ns	ns	ns	ns	*0.046	ns	ns	*0.007	*0.005	ns									
Miscell.	*0.036	ns	ns	ns	ns	ns	ns	ns	ns	ns	*0.03	ns	ns	ns	ns								
C/Rock	ns	ns	*0.001	*0.001	ns	ns	ns	*0.004	ns	ns	*0.005	*0.017	*0.01	ns	*0.026	*0.015							
S/Moistue	ns	*0.02	ns	ns	ns	ns	**0	ns	ns	ns	ns	ns	ns	*0.028	ns	ns	ns						
O/Matter	*0.033	ns	**0	**0	*0.009	ns	ns	ns	*0.049	*0.012	*0.001	*0.004	ns	**0	*0.001	*0.028	**0	*0.031					
Limestone	ns	ns	**0	**0	*0.042	ns	ns	*0.018	*0.019	ns	*0.001	*0.005	*0.001	ns	*0.001	*0.018	**0	ns	**0				
Temperature	ns	ns	ns	ns	ns	ns	**0	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*0.011	ns	ns			
Insolation	ns	ns	*0.026	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns		
Av. Insolation	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**0	

UC - Understorey Cover; UH - Understorey Height; CC - Canopy Cover; CH - Canopy Height; LT - Litter Cover; LM - Litter Moisture; P - Patchiness;
TH - Litter T/ha; LF - Litter Fine; LE - Litter Medium; LC - Litter Coarse; FF - Fruit & Flowers; T - Twigs; WD - Woody Debris; M - Miscellaneous
RF - Rock Fragments; SM - Soil Moisture; OM - Organic Matter; L - Limestone; TP - Temperature; I - Insolation; AI - Average Insolati *P < 0.05; **P < 0.001

APPENDIX 8C: Spearman's rank order correlations showing the signficance values of environmental parameters that are related at the plot scale

ENVIRONMENTAL PARAMETERS

CROSS CORRELATIONS

PLOT SCALE (N = 100)

	UC	UH	CC	CH	LT	LD	LM	P	TH	LF	LE	LC	FF	T	WD	M	RF	SM	OM	L	TP	I	AI
U/Cover																							
U/Height	*0.001																						
C/Cover	ns	ns																					
C/Height	ns	ns	**0																				
L/Cover	ns	*0.053	*0.23	*0.025																			
L/Depth	ns	ns	ns	ns	**0																		
L/Moisture	*0.009	ns	ns	ns	ns	ns																	
Patchiness	*0.044	*0.018	ns	ns	**0	**0	ns																
Tonnes	ns	ns	ns	ns	*0.002	**0	ns	**0															
L/Fine	*0.008	*0.002	ns	ns	*0.022	*0.008	*0.002	*0.005	**0														
L/Medium	*0.014	*0.034	ns	ns	**0	*0.028	**0	**0	**0	**0													
L/Coarse	ns	ns	**0	**0	ns	*0.006	ns	ns	ns	ns	ns												
F/Flowers	ns	ns	**0	**0	ns	ns	*0.012	ns	ns	ns	ns	ns											
Twigs	ns	*0.042	ns	ns	ns	*0.049	ns	*0.005	*0.02	**0	**0	ns	ns										
W/Debris	*0.012	ns	**0	**0	ns	ns	ns	ns	**0	*0.005	ns	**0	**0	ns									
Miscell.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**0	*0.014	ns	ns	ns								
C/Rock	ns	*0.011	*0.012	*0.12	ns	ns	ns	ns	ns	*0.007	*0.002	*0.002	ns	*0.039	*0.029	**0							
S/Moistue	*0.002	*0.024	ns	ns	*0.036	*0.025	**0	*0.012	ns	*0.001	**0	ns	ns	*0.007	ns	*0.022	*0.006						
O/Matter	*0.006	*0.011	ns	ns	*0.019	ns	ns	*0.008	**0	**0	**0	*0.001	ns	**0	**0	*0.032	**0	**0					
Limestone	ns	ns	*0.007	*0.007	ns	ns	ns	ns	ns	*0.019	*0.015	**0	*0.032	*0.008	*0.006	*0.013	**0	ns	**0				
Temperature	ns	ns	ns	ns	*0.05	ns	**0	ns	ns	ns	ns	ns	*0.01	ns	ns	ns	ns	**0	ns	ns			
Insolation	**0	**0	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*0.032	*0.046	ns	ns		
Av. Insolation	**0	*0.019	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*0.01	ns	ns	**0	

UC - Understorey Cover; UH - Understorey Height; CC - Canopy Cover; CH - Canopy Height; LT - Litter Cover; LM - Litter Moisture; P - Patchiness;
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RF - Rock Fragments; SM - Soil Moisture; OM - Organic Matter; L - Limestone; TP - Temperature; I - Insolation; AI - Average Insolation *P < 0.05: **P < 0.001