STRUCTURE AND DYNAMICS OF GRAZED WOODLANDS IN NORTH-EASTERN AUSTRALIA

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Structure and Dynamics of Grazed Woodlands in North-eastern Australia

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Abstract

Data from 75 permanent belt transect sites were utilised for an analysis of the floristics and temporal dynamics of the woody vegetation of the grazed woodlands of Queensland, Australia. Woody species abundance, composition and structure were described based on over 42, 000 individual recorded plants and.Detrended Correspondence Analysis was used to divide the transects into seven community types based on floristic similarity. The time between first and last recording varied between sites, with 17 years between initial and final recording for the oldest site and three years or less for the 39 remaining sites were recorded. Between first and last recording events mortality was 2.6% of initial woody plant density per year while recruitment was 6.7%, resulting in an overall increase in woody plant numbers of 17% of initial density. The woodlands experienced a decrease in basal area of 0.7% of initial basal area per year despite the increase in density, reflecting that many the majority of recruits were small plants with minimal basal area.

Despite fluctuation in basal area and density, species composition remained largely unchanged over time. Size class distributions remained unchanged over time and followed a reverse-J pattern for most woodland types. Ordination analysis revealed that a range of environmental factors including temperature, geographic location, soil type and topography were important in influencing the distribution of community types. Linear models revealed that that dynamics patterns within the woodlands were poorly correlated with those environmental factors utilised.

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Declaration

I declare that the main text of this thesis is an original work. Some material has been published in similar format in journal articles. I have not submitted any of the content of this thesis previously for an academic degree.

Signed

Laurence James Tait

"The thing the ecologically illiterate don't realize about an ecosystem is that it's a system. A system maintains a certain fluid stability that can be destroyed by a misstep in just one niche. A system has order, a flowing from point to point. If something dams the flow, order collapses. The untrained miss the collapse until too late. That's why the highest function of ecology is the understanding of consequences."

Frank Herbert, in "**Dune**"

Chapter 1: Introduction and Literature Review

1.1 Introduction

The state of Queensland covers an area of 173 million ha, approximately 151 million ha (87%) of which is occupied by land devoted exclusively or partially to the grazing of sheep and cattle (Scanlan and Chilcott 2000). Of this grazing land over one third, 60 million hectares (Figure 1), has some type of tree cover (Burrows 1995). These grazed woodland areas of Queensland are the primary focus of this thesis.

It is now generally accepted that all the grazed woodlands of Queensland have been disturbed to a greater or lesser degree by human induced impacts such as grazing, fire, weed invasion, timber harvesting and climate change (Boulter 2000), and the changes induced by these disturbances are ongoing. Many changes have been undesirable, from either an economic or environmental viewpoint, and attempts to minimise or reverse these changes requires an understanding of what is occurring within the woodland ecosystems. Thus management of grazed woodlands for sustainable and efficient agricultural production, as well as for environmental purposes, will require a more comprehensive knowledge of both the current structure of these woodlands and the processes occurring within them.

This interest in understanding the functioning of the grazed woodlands of

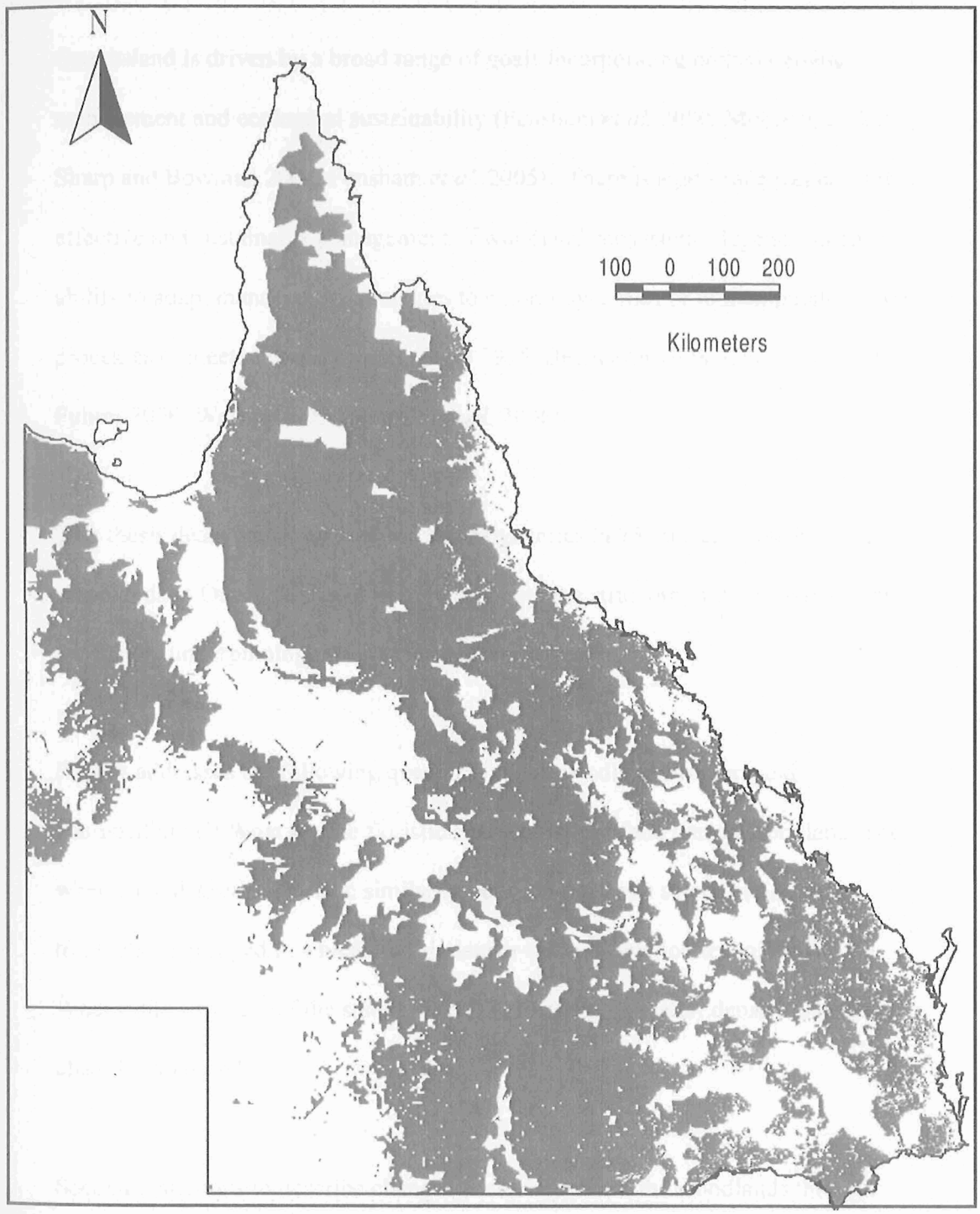

Figure 1.
Distribution of grazed woodlands in Queensland.

Queensland is driven by a broad range of goals incorporating both economic management and ecological sustainability (Fensham *et al.* 2000, Moore *et al.* 2001, Sharp and Bowman 2004, Fensham *et al.* 2005). There is a general acceptance that effective and sustainable management of woodland ecosystems depends on an ability to adapt management strategies to natural dynamics or to manipulate natural processes to meet necessary goals (Shiel 1995, Bengtsson 1998, Diaz *et al.* 2000, Fuhrer 2000, Werner 2005, Wiegand *et al.* 2006).

This thesis deals with structure and stand dynamics in 75 transect plots in grazed woodlands in Queensland and investigates both the structure of the woodlands and the factors underpinning the changes occurring therein.

First, it addresses the following questions about woodland structure and composition: (i) What are the floristic characteristics of the grazed woodlands and what is the degree of floristic similarity between disparate stands? (ii) Can the transects be grouped in a meaningful manner using ordination techniques? (iii) What is the structure of the stands in terms of height, diameter, density and size class distribution?

Second it attempts to describe changes occurring within the woodlands through measures of mortality, recruitment, growth, and population dynamics. Specifically the following three questions are addressed: (i) Are stand structural components

(number of individuals, number of stems and basal area) changing with time? (ii) Is species richness balanced by immigration and extinction? (iii) Does mortality match recruitment? (iv) How are changes in populations distributed across size classes?

Finally, the relationship between environment and species distribution and dynamics is considered: (i) Do species or communities correlate to environmental factors? (ii) Is it possible to determine which environmental factors influence dynamic processes such as plant mortality, seedling recruitment and plant growth rate?

1.2 Grazed Woodlands

The majority of forest and woodland communities in Queensland are grazed, the major exception being the closed forest types. Closed forests, primarily wet sclerophyll and rainforests on the east coast, are not grazed owing to the closed structure precluding grass growth, and hence offering little opportunity for grazing (Lodge and Whalley 1984, White 1986). In contrast the woodlands in Queensland typically form an open structure, with widely spaced trees and an open canopy, allowing the growth of a herbaceous layer essential for grazing by domestic livestock (Harrington *et al.* 1984c *et al.* 1984, Mott and Tothill 1984, Burrows *et al.* 1990). This type of woodland structure is defined by (Werner *et al.* 1991) as a

savanna: "tropical and subtropical ecosystems characterised by a continuous herbaceous cover of C4 grasses that show seasonality related to water, and in which woody species are significant but do not form a closed canopy or continuous cover".

1.3 Distribution and Climate

Grazed woodlands span the entire length and breadth of Queensland from 10°S to 29°S, and from 138° East to 153° West. Given this large geographical spread it is not surprising that the climate is equally diverse. Rainfall can range from as little as 150 mm per annum on average to in excess of 1000 mm (Harrington *et al.* 1984a, Mott and Tothill 1984, Pressland *et al.* 1990). A majority of rainfall occurs in summer throughout the state, however southern areas tend to experience somewhat more winter rainfall with northern, central and southern Queensland receiving approximately 90% 75% and 70% of annual rainfall in summer respectively (Weston 1988b). Total rainfall tends to decrease with distance from the coast and that part of Queensland which receives greater than 700 mm of rainfall annually is usually found within 180 km of the coast (Mott and Tothill 1984, Weston 1988b). Rainfall in Queensland, and Australia generally, is more variable than other areas of the world. This is due largely to the long-term influence of the El nino –southern oscillation (ENSO) pattern. ENSO is an irregular interchange of atmospheric pressure between the South Pacific and Indian Oceans with a period of around 2-10 years resulting in changes in ocean

temperatures off the East Coast of Australia that affects rainfall. The unreliability of rainfall increases as mean annual rainfall decreases, leading to the greatest relative fluctuations in the most arid regions (Harrington *et al.* 1984b). The majority of the state experiences mean daily maxima above 32°C in January, while only a small area in the central and southeast receive a mean daily minimum below 4.4°C in July (Weston 1988b). Temperature generally increases with distance form the coast and with decreasing latitude.

1.4 Community structure

Woodlands dominated by the eucalypts (Genera *Corymbia* and *Eucalyptus,* Family Myrtaceae) are by far the most common in Queensland and dominate the more humid eastern and northern parts of the state, above the 500 mm annual average rainfall isohyet (Mott and Tothill 1984). Eucalypt woodlands occupy a range of environments and the overstorey may be dominated by a range of species, including *E. populnea, E. crebra, E. melanophloia, E. tereticornis, E, coolibah, Corymbia citriodora and C. clarksoniana*. The size and structure of eucalypts tends to vary across their range, with plants of the eastern regions tending to be represented by taller species than in western and northern regions. Eucalypt sizes range from trees in excess of 25 m in eastern districts to trees rarely exceeding 15 m in the northern areas (Mott 1994, Florence 1996). In eastern and northern areas in swampy localities of low fertility another genus of the Myrtaceae, *Melaleuca*, can form woodlands, usually less than 15 m tall (Weston 1988a, Anderson 1993,

Gillison and Walker 1994). *Melaleuca* frequently forms mixed stands with *Corymbia* or *Eucalyptus* (Sharp and Bowman 2004). The leguminous wattles (*Acacia* species) form an important component of both melaleuca and eucalypt dominated woodlands, primarily as an understorey/sub-canopy genus (White 1986, Burrows *et al.* 1988).

Acacia species are also capable of forming the dominant overstorey component of woodlands in their own right, although all species frequently co-occur with eucalypts. Mulga (*Acacia aneura)* forms the dominant overstorey component over 19.1 m ha in the arid and semi-arid south-west of the state within the 250 mm to 500 mm annual average rainfall (Harrington *et al.* 1984b, Burrows *et al.* 1990, Sullivan *et al.* 1990). Mulga woodlands vary in structure, and may take the form of medium sized trees forming a continuous canopy, open forests of small to medium sized trees or sparse open shrublands. A number of *Acacia* species dominate communities on coarse textured and infertile soils across the state, commonly on sloping and hilly terrain or tablelands. *A. catenulata* and *A. petraea* are commonly found in the drier regions, between the 150 and 750 mm isohyets, while *A. shirleyii* is commonly found between 500 and 750 mm. *A. rhodoxylon* occurs in higher rainfall regions in the 600-800 mm isohyet (Johnson and Burrows 1994). Two *Acacia* species, brigalow (*A. harpophylla)* and gidgee (*A. cambagei)* form open woodlands on flat and gently undulating terrain on heavy and relatively fertile clay and clay-loam soils primarily in the 300-700 mm annual rainfall region.

These brigalow and gidgee woodlands extend from a northern extreme of 20° S into northern New South Wales. Brigalow and gidgee occur as mixed communities in some regions and are commonly associated with several other woody species, including overstorey species such as *Eucalyptus coolabah*, *E cambageana*, *Casuarina cristata*, and a range of understorey species (Scanlan 1988, Anderson and Back 1990). In the north-western regions Black gidgee (*A. argyrodendron*) replaces brigalow in many areas, while in Central-Western districts Boree (*A tephrina*) forms woodlands and shrublands, frequently on cracking clay soils, often in association with *A. cambagei*. Georgina gidgee (*A. georginae*) woodlands are found in more arid regions in the 200-250 mm rainfall belt (Johnson and Burrows 1994)

Another major species in Queensland's woodlands is the conifer white cypress pine (*Callitris glaucophylla*). *Callitris glaucophylla* forms stands on sandy soils throughout much of the state, although extensive woodland stands are found only in the south (Boland *et al.* 1984, Weston 1988a). The species usually grows to around 20 metres in height, though occasional plants may reach 30m and may be found in near pure stands, or in conjunction with hardwood species, including several *Eucalyptus* species, *Angophor*a species and *Allocasuarina leuhmanii* (Weston 1988a, Taylor 1990).

The woodlands of Queensland hold several key features in common despite their

wide geographic, environmental and botanical range. Rainfall is strongly seasonal, with a skew towards summer rainfall, and tends to be unreliable, particularly in the south-western areas, and is the primary limiting factor to plant growth and the distribution of vegetation (Harrington *et al.* 1984a, Mott and Tothill 1984, Flannery 1994, Wilson *et al.* 2000). It is this variability in rainfall that dominates the management of these woodlands (Harrington *et al.* 1984a, Wilson *et al.* 2000). Soils are commonly infertile or shallow and soil nutrition, particularly low phosphorus levels, is also a major limiting factor in plant growth, although there are exceptions in the brigalow soils (Harrington *et al.* 1984a, Mott and Tothill 1984, Burrows *et al.* 1990). Nutrient turnover within these woodlands is also typically low (White 1986, Flannery 1994). The grazed woodlands in Queensland also tend to adopt an open structure, with widely spaced trees and an open canopy, allowing the growth of an associated herbaceous layer essential for grazing (Harrington *et al.* 1984a, Mott and Tothill 1984). Grasses in these woodlands are mainly tall to mid-height tussock or bunch grasses, although within the *Acacia* and *Callitris* woodlands pasture is often sparse (Harrington *et al.* 1984b, Weston 1988a).

In common with the rest of Australia the woodlands of Queensland were adapted to an existence without large herbivores prior to European colonisation (Freeland 1991, Flannery 1994). A widespread feature of these woodlands is the tendency amongst the trees and shrubs towards scleromorphy, the evolution of leathery,

hard, spiny or reduced leaves with short internodes (Mott and Tothill 1984, White 1986, Burrows *et al.* 1990, Flannery 1994). Many woody plants also produce leaves unpalatable to herbivores by the inclusion of toxic and indigestible compounds in an attempt to maintain these long-lived leaves. These traits this make the majority of woody plants in these woodlands largely unpalatable to domestic livestock (Mott and Tothill 1984). It is therefore important from a grazing perspective that these woodlands support a more or less continuous layer of herbaceous ground cover dominated by grasses (Mott and Tothill 1984, Burrows *et al.* 1990).

All Queensland's grazed woodlands are liable to be burnt with varying frequencies and most of the woody plants of these woodlands have developed adaptations to survive and minimise the effects of fire (Harrington *et al.* 1984a). In general plants in the higher rainfall woodlands are well adapted to surviving frequent, low intensity fire by resprouting and tree mortality is normally very low as a result of fire (Mott and Tothill 1984, Dyer *et al.* 1997). Plants in the more arid regions, where fire is less frequent due to lower fuel loads, tend to have varying abilities to survive fire, and many rely on mechanisms that ensure recovery following fire by germination from a soil seed bank (Dyer *et al.* 1997) Species associated with the *A. harpohylla* communities also generally have a good capacity for re-sprouting following fire, and *A. harpohylla* itself sprouts freely from the butt or living stems in response to fire damage. A notable exception to the fire tolerance of *A.*

harpohylla communities occurs in what are referred to as softwood scrubs, which are dense communities of *A. harpohylla* and a range of particularly fire-sensitive species. Both *A. cambagei* and *A. argyrodendron*, in contrast, have a limited capacity to resprout following fire damage (Anderson and Back 1990, Johnson and Burrows 1994). Mulga woodlands are also not well adapted to regular fire and species in mulga communities vary in their ability to survive fires (Hodgkinson *et al.* 1984, Dyer *et al.* 1997). Cypress pine itself is fire sensitive, especially while small, and has limited capacity to regenerate after fire damage (Taylor 1990)

1.5 Ecological Changes

Grazed woodlands are very poorly represented in reserve systems in Queensland's (Sattler and Williams 1999) and as such management for conservation needs to be conducted in large part simultaneously with commercial grazing management. Utilisation of these woodlands for grazing of sheep and cattle has been implicated in producing substantial change and degradation of these woodlands (Pressland *et al.* 1988, Winter 1991), ranging from changes in species composition to woody weed encroachment and severe soil erosion. Grazing has been implicated in changes in woody vegetation structure in many woodlands throughout Queensland, including communities dominated by eucalypts and mulga (Pressland *et al.* 1988), *Melaleuca* (Crowley and Garnett 1998) and Cypress pine (Lunt *et al.* 2006). In all cases the changes associated with grazing have been attributed at least partially to a change in fire regime, and the effects of fire and grazing are often confounded

(Wilson *et al.* 2000). Large areas have also been cleared of woody vegetation. Over the period 2002-2003 the average annual state-wide clearing rate was 554000 ha/yr with 95 % of this being clearing to pasture (DNRM 2005). However recent legislation has resulted in a cessation of all broad scale land clearing in Queensland from the end of 2006 (Anon. 2004).

A number of exotic plants species have been introduced to the woodlands of Queensland. These introductions have the potential to significantly alter the structure and composition of woodlands across the state (Grice and Brown 1999, Butler and Fairfax 2003, Grice 2006), and have already done so in many areas through a numbers of processes including altering the fire regime, increasing grazing pressure, competing with native vegetation and occupying previously vacant ecological niches (Scanlan 1988, Tothill and Gillies 1992, Smith *et al.* 2000).

The woodlands are also expected to be effected by increases in atmospheric CO_2 and alteration of rainfall regimes woodlands in the near future, with unpredictable consequences (Hoffmann *et al.* 2002).

1.6 Long-term monitoring

Trees, and most woody species, are long lived, and forests and woodlands are long-lived systems in a state of continuous change and require long-term observation and monitoring to obtain insights into the causes of such change (Noss 1999). Many changes, including human induced changes and ecological phenomena such as succession, occur on a cycle of many decades and given that the some woody plants in the grazed woodlands have an potential lifespan of over a century (Florence 1996) it is evident that long term monitoring programs may be required to gain an understanding of the dynamics of the woodlands. Rare events, such as droughts or disease outbreaks, and subtle processes where the year to year variation may be larger than the long-term trend, can also be observed by long term monitoring in a way that monitoring within a short time frame does not allow. Long term monitoring also has the potential for providing baseline data for comparisons when other changes may occur. Many authors (e.g. Archer1991; Ayyappan 1999; Fensham and Holman 1999) have noted the need for such data to differentiate between anthropogenic and non-anthropogenic induced changes in woodland structure.

The monitoring of long term trends in woodlands can be achieved using repeated sampling at different points within the area of interest, however it is generally more useful to utilise permanent plots where measurements are made at the same specific

site. The primary advantage of permanent plots is that they comprise a time series with a well known stand history (Ranneby and Rovainen 1995) allowing for a determination of whether short term patterns are trends or fluctuations (Shiel 1995). The use of permanent plots also increases the possibility that woodland response to infrequent events can be studied (Burslem *et al.* 2000).

Two types of permanent plots are common in the study of forest and woodland dynamics: horizontal point sample plots and permanent sample plots. Horizontal point samples rely on angle-count sampling from a fixed point. Each tree is included based on the apparent diameter of the tree from the observation point, hence larger tress have a greater effective sampling area than small trees. Hradetzky (1995) discusses permanent horizontal point samples and notes the problem that, because trees are selected with a probability relative to their basal area, the composition of samples changes simply due to growth and therefore variance tends to be high.

Permanent sample plots rely on each tree being individually identified and permanently located and marked, either with an identifying numbered tag or by a grid reference. Shiel (1995) notes that despite the high cost and requirement for high levels of expertise, time, commitment and resources permanent sample plots can still be justified by the quality of information and level of understanding they are capable of generating. The greatest advantage of the permanent sample system

is that it allows individual plants to be followed throughout their life cycle. (Ehrlen) 2000 notes the importance of measuring individuals due to the effect of the individual's history on larger scale composition and population dynamics. Each tree is unique and its growth and survival are primarily affected by its immediate neighbourhood and this is likely to have consequences on the overall behaviour of the stand. Monitoring individual trees provides an opportunity for integrating diverse pieces of knowledge. Gourlet-Fleury and Houllier (2000) and Jones and Sharitz (1998) note the importance of tracking individual plants in understanding the establishment and early survival of woody species. These early life stages are among the least understood processes in woodland dynamics, yet may be of particular importance in understanding the effects of human induced change, particularly since it appears that it is during these stages that plants are most susceptible to grazing and fire-induced mortality (Florence 1996, Jones and Sharitz 1998).

Monitoring of woody plants using permanent plots has been undertaken in numerous tropical forests around the world (Condit 1995, Shiel 1995, Vanclay *et al.* 1995, Philippi *et al.* 1998, Ayyappan 1999, Soehartono and Newton 2000), however far fewer studies have focussed on the more open savanna and woodland communities. Archer (1991) notes that the ecosystem processes of savannas have not been well researched and that long-term ecological research could well provide basic ecological knowledge. Fensham *et al.* (2000) suggest that there is little data

available on the long term changes of regrowth savanna vegetation over time. Permanent plots have been utilised in Australian grazed woodlands to gauge the effect of fire regime on woody plants (Bowman and Panton 1995, Back 1998, Guinto *et al.* 1999), and to assess the impact of weed control techniques (Burrows *et al.* 1999, Lindsay *et al.* 1999).

1.7 Dynamics, Structure and Composition

Composition, Structure and Dynamics are the three basic characteristics of woodland ecosystems. *Composition* refers to the variety of ecosystem components and is commonly expressed in terms of species richness and abundance. *Structure* refers to the pattern and distribution of plants within the woodlands, both vertically and horizontally. *Dynamics* refers to how processes and changes occur within the system and the consequences of interaction between components of the system (Florence 1996, Fuhrer 2000, Peng 2000). Structural, dynamic and compositional attributes of a stand are often interdependent, so that attributes from one group may also be surrogates for attributes from another group (Phillips *et al.* 1994, Noss 1999).

1.7.1 Composition

Biodiversity, the variety of living organisms within a system, is an important concept in the management of grazing lands in Australia (Williams *et al.* 2001). The importance of biodiversity stems from the connection between biodiversity

and ecosystem services, conservation value and land-use sustainability (Smyth and James 2004). Floristic data are a basic tool for evaluating and monitoring biodiversity and, with few exceptions, diversity inventories in tropical savannas incorporate woody species as a principle element. Woody species are seen as an important aspect of overall woodland diversity (Smyth and James 2004), dictate resources and habitat structure for many other species (Sharp and Bowman 2004) have a major impact on the composition of the herbaceous layer (Scanlan and Chilcott 2000, Bortolussi *et al.* 2005) and affect human management and utilisation of the land (Harrington *et al.* 1984b, Harrington *et al.* 1984c *et al.* 1984, Lunt *et al.* 2006). Analysis of floristic data is also commonly combined with environmental and historical variables to provide information on the how those variables influence species distribution, dynamics, structure and composition. Woody species floristics have therefore received some attention in northern Australian savannas (Bowman 1992, Williams *et al.* 1997, O'Grady *et al.* 2000, Williams *et al.* 2003, Vigilante and Bowman 2004).

1.7.2 Structure

Structure may be defined by the size and species distributions of living and dead vegetation, usually with a focus on the tree component , including features such as spacing and density, height, diameter and shape (Spies 1998). Tree diameter is a ubiquitous measure of tree size in the literature concerning forest structure. It is

typically quantified in terms of diameter at breast height (dbh) and stand basal area. Stand basal area is an attribute directly related to mean dbh and stand biomass. Density (number of trees or basal area per unit area), reflects the arrangement of trees within the stand and the distribution of species in relation to one another (Ayyappan 1999, Catterall *et al.* 2001).

Mixed uneven-aged communities typically have diameter distributions in an approximately reversed-J shaped or negative expomnential curve (Rubin *et al.* 2005). However the shape of the diameter distribution is influenced by factors such as competition, regeneration patterns and differences in environment or climate. Structural analysis based on size structure has often been used to reconstruct the history of forest development and provide information on stability over time and predict successional trends (Arista 1995, Felfili 1997, Nascimento and Proctor 1997, Diaz *et al.* 2000, Sherman *et al.* 2000, Sharp and Bowman 2004, Rubin *et al.* 2005). Such analyses have been for the evaluation of management practices on long-term species survival (Teketay 1997, Pinard *et al.* 1999, McCarthy *et al.* 2001). It has also been utilised to define niche requirements for fauna, investigate regeneration and explain climatic variation (Zenner and Hibbs 2000).

1.7.3 Dynamics

The change in a woodland over time can be described in terms of tree mortality and recruitment, diameter growth and species turnover. These population parameters

are essential to the study and prediction of responses of vegetation to perturbation (Phillips *et al.* 1994, Condit *et al.* 1995, Poorter *et al.* 1996).

Savanna woodlands are inherently unstable ecosystems, with disturbance in the form of fire or variable rainfall allowing the co-existence of grasses and woody vegetation (Scholes and Archer 1997, Wiegand *et al.* 2006). Because of this instability, the grazed woodlands of Queensland are prone to both rapid and long-term change as a result of both anthropogenic and natural processes. However, the factors influencing change within the grazed woodlands of Northern Australia remain unclear despite evaluation using long-term monitoring plots (Burrows *et al.* 2002), aerial photography (Fensham and Fairfax 2003, Brook and Bowman 2006) and landscape scale experiments (Vigilante and Bowman 2004, Andersen *et al.* 2005).

It is apparent however that the grazed woodlands are highly dynamic, for example an increase in woody plant biomass, commonly referred to as thickening or woody plant encroachment has been recorded in grazed woodlands across northern Australia (Archer 1991, Flannery 1994, Florence 1996, Jones and Sharitz 1998, Smith *et al.* 2000, Gifford and Howden 2001, Lunt *et al.* 2006). This increase is usually attributed to some extent to grazing effects and the subsequent reduction in fire, however some authors have suggested that observed increases may be primarily a consequence of natural climatic variation (Fensham and Fairfax 2003,

Fensham *et al.* 2005, Wiegand *et al.* 2006), increases in atmospheric CO_2 concentrations (Brook and Bowman 2006) or changes in landscape morphology and catchment function (Pringle and Tinley 2003).

1.8 Classification and Ordination

A major challenge in managing and conserving the grazed woodlands of Queensland is their size and heterogeneity, containing as they do a wide variety of soil types, vegetation communities and topography (Harrington *et al.* 1984, Lodge and Whalley 1984, Boulter 2000). Resources do not exist to conserve every unique combination of environmental vegetation type at the finest scales, and management may be less effective if not carried out on a landscape scale (Vigilante and Bowman 2004). To overcome this problem plant communities are commonly partitioned into collections of similar sites. By utilizing such community subdivisions in management it is possible to target conservation and management strategies to broad and sustainable community types rather than attempting to represent numerous viable samples of tiny areas. Muller and Ellenberg (1984) state that there are three major categories of community classification: those based on the vegetation itself, those based on properties distinct from the vegetation and those that combine vegetation and environment.

Cluster analysis is the most common method for producing classifications based solely on vegetation. Cluster analysis is a family of analytic procedures designed to

produce natural groupings of sites, with strong associations between members of the same cluster and weak associations between members of different clusters (Kent and Coker 1992). Cluster analyses have been used to produce vegetation classifications in grazed woodlands in Northern Australia to assess conservation value (Fensham 1999) and to assess susceptibility to thickening (Sharp and Bowman 2004).

Combined vegetation-environmental classification has the advantage over strictly botanical classification in that it allows inferences about environmental factors from floristic data or alternatively explains floristic patterns through correlation with environmental variables (Kent and Coker 1992, Austin and Meyers 1996, Austin 1999). Classification based on a combination of environmental and vegetation data has been frequently applied to savanna woodlands (Zeilhofer and Schessl 1999, Catterall *et al.* 2001, Vigilante and Bowman 2004, Hejcmanova-Nezerkova and Hejcman 2006). The use of such combined vegetation-environmental subdivisions in managing woodlands, particularly for conservation purposes, has a basis in law in Queensland, with the Vegetation Management Act 1999 (Anon. 2004) being based on regional ecosystems defined by the dominant woody vegetation types and geology.

The vegetation in the grazed woodlands is known to differ as a function of precipitation (Bowman 1993, Fensham *et al.* 2005), temperature (Bowman 1993,

Bowman and Connors 1996), fire regime (Anderson *et al.* 1988, Anderson and Back 1997, Bastin *et al.* 2003, Andersen *et al.* 2005, Werner 2005), grazing pressure (Bastin *et al.* 2003, Werner 2005) and edaphic factors (Tracey 1969, Sharp and Bowman 2004). Nevertheless it is still not clear how the distribution of plant species and variation in community structure respond to environmental variability. Such uncertainty is reflected by the fact that research on plant community structure and plant species distribution and dynamics across environmental gradients continues to be a central focus in both temperate and tropical forest ecology (Gosz 1992, Bowman 1996, Ter Steege *et al.* 2003, Hunter 2005).

Chapter 2: Material and Methods

2.1 Site selection, construction and recording

This study utilised a series of seventy-five transect sites established by the Queensland Department of Primary Industries in grazed woodlands in Queensland south of 18°S and east 0f 143°E (Figure 2). Sites were established in between 1982 and 1998. Twenty-eight of the oldest sites were established by other Department of Primary Industries staff and the remainder established by the author. Sites were not randomly located, instead they were purposely located in target communities deemed to be representative of the major woodland types in different regions. A previous study, using a subset of these sites dominated by *Eucalyptus* and *Corymbia* species found that the sites incorporated the full range of both mean rainfall and temperature of the wettest quarter experienced by Eucalypt woodlands in Queensland (Burrows *et al.* 2002) . Thus we can be reasonably certain that the sites used in this study are representative of the climatic conditions of eucalypt dominated woodlands within the study area. While the sites utilised in this study were expected to be less representative of non-eucalypt communities due to the small number of sites that are not eucalypt dominated, they are expected to be broadly representative of the environment of the study area.

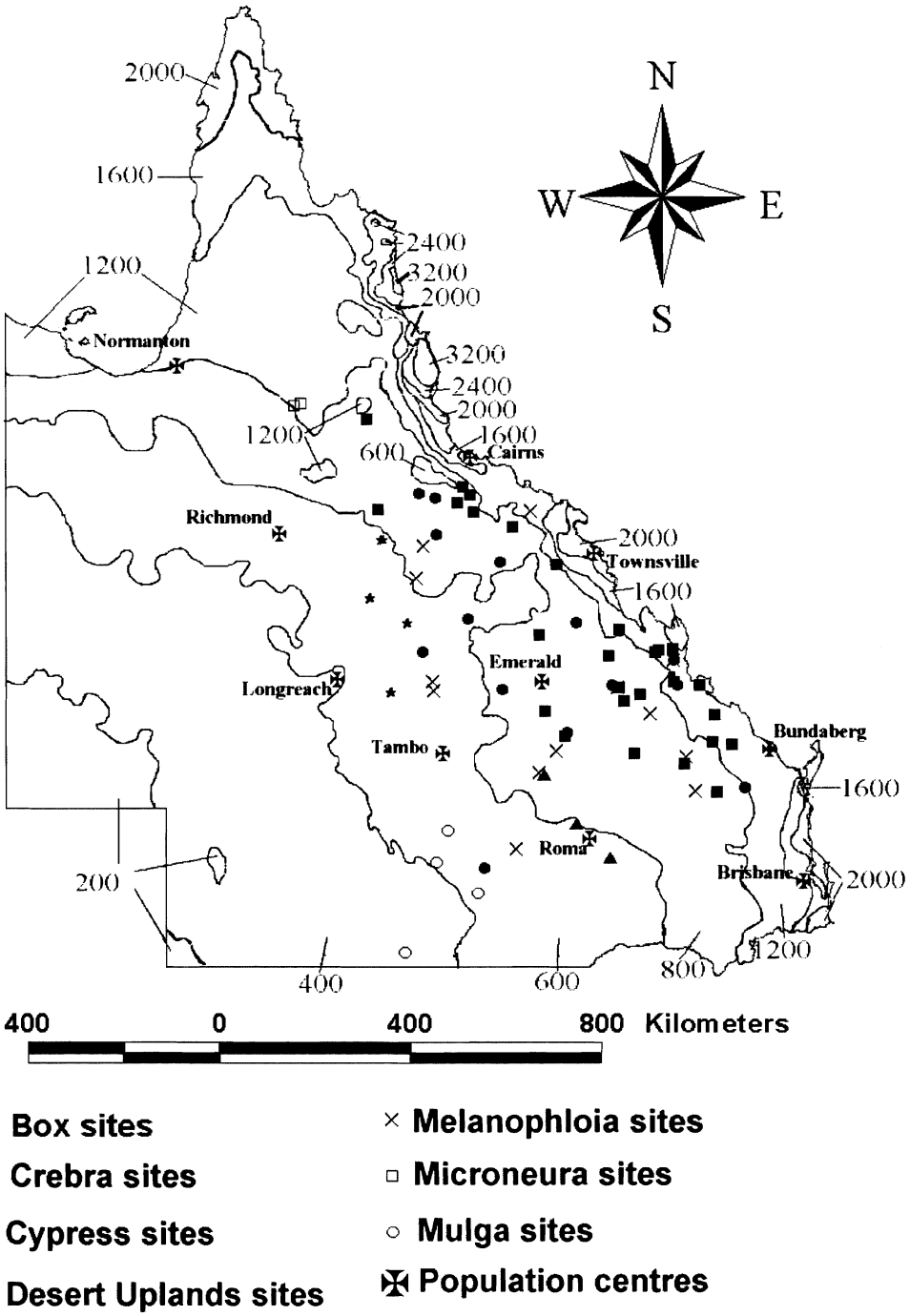

Figure 2.
Position of transect study sites in Queensland with reference to rainfall isohyets (mm).
Map constructed utilising Bureau of Meteorology 30 year climatology data 1961-1991.

Sites were located so as to have a minimum 100 m buffer of the same community and soil type extending on all sides beyond the transects. Sites were located at least 100 m from permanent water and artefacts such as fences and roads that may affect stock movement and hence influence vegetation dynamics. All sites were located in woodlands that were being commercially grazed by introduced livestock and established in co-operation with primary producers and local government stock-routes officers. Sites were purposely established in vegetation types representing the dominant communities within their region. The sites under consideration were established in what appeared to be undisturbed communities (i.e. on sites with no evidence of clearing), with the exception of those sites established in vegetation dominated by white cypress pine (*Callitris glaucophylla*). Sites in cypress communities are all known to have been established in stands subject to periodic commercial logging. This was made necessary by the unavailability of unlogged, grazed cypress pine stands. However, it is reasonable to assume that all sites have suffered some human induced disturbance in the past 50 years in the form of timber harvesting or tree thinning. Since exact knowledge of site histories is scarce, for the purposes of this thesis these sites are considered to be undisturbed woodlands except for the effect of introduced grazing animals.

Sites were constructed and recorded according to the TRAPS (Transect Recording and Processing System) method of Back *et al.* (1997). A standard site consisted of 5 parallel transects on a North-South orientation established 25 m apart and marked

using steel pickets. Each transect was 100 m in length and comprised two 50 metre segments. A fibreglass tape measure was laid out between the pickets and all woody plants within 2 m either side of the transect were recorded with their position along the transect line and position out from the line noted. Each plant was measured for height using a measuring stick for plants <3m in height and a clinometer for taller plants. Each plant was also measured for circumference or diameter at 30 cm above ground level using vernier callipers for plants <10 cm diameter and a flexible tape measure for larger plants. All plant were identified to species level wherever possible. Any individuals that could not be positively identified were and given a unique descriptor to identify them as distinct and unidentified species where this was not possible. When identification was not possible in the field a specimen was collected for later identification in the laboratory or by Queensland herbarium staff.

Soil texture was assessed in the vegetation plot using the bolus technique (Tongway and Hindley 1995) and assigned to one of four classes: silty to heavy clay (Class 4), sandy clay loam to sandy clay (Class 3), sandy loam to silty loam (Class 2) and sand to clayey sand (Class 1). Topography for each site was classified into five categories following a modification of Back *et al.* (1997) with high values indicating sites on steep slopes and low values indicating sites on flat terrain (Table 1).

Code	Topography	Av. Slope %	Max Slope(%)
1	Plains, Flat	0.5	1
2	Plains with low relief	<3	3
3	Plains, undulating with low rises	<9	12
4	Hills, low	<18	24
5	Hilly to mountainous	24	no limit

Table 1.
Topography categories used to describe transect sites.

Climate data was obtained for each site from the Queensland Department of Natural Resources DataDrill package, which generates climate figures for given co-ordinates on a daily timescale from an algorithm based on recorded data at nearby weather stations and known weather patterns (DNR, 2003).

The following deviations from the method of Back *et al.* (1997) were found to be necessary: In some open communities it was not possible to record sufficient mature trees using the standard 5 m x 100 m x 4 m belt transect and in these circumstances either the length of the transect or the width of the belt was increased until such time as sufficient mature trees (nominally 30 trees >25% mature height) were recorded. Increasing the length of the transect consisted of adding an additional 50 m to the northern ends of each of the initial 5 lines until

such time as sufficient plants were recorded. Increasing the width of the transects involved recording all plants within 4 m or 8 m of the transect line. Several sites were smaller in area than the standard 0.2 ha plot. Such sites consisted of either the standard layout, but with plants measured in a 2 m belt, or were comprised of 5 x 50 m lines, 4 x 100 m lines or 3 x 100 m lines. As a result of this variation in site layout transect size ranged from 0.1 to 0.8 ha, with an average size of 0.27 ha (Table 2). The combined area of all plots was 20.1 ha.

A total of 75 sites were considered for analysis in this study. The number of recordings and length of time between first and last recordings varied considerably between sites (Table 2). The sites were established from1982 as part of the woodland management project of the Queensland Department of Primary Industries (QDPI). Since were established opportunistically up to 1998. The longest period over which a site was recorded was 17 years, while the shortest period is slightly more than 12 months. Sites were established in a wide range of communities (Table 2) and vegetation characteristics show considerable variability (Table 3 and Figure 3).

2.2 Data analysis

Initial data analysis was carried out using Wintraps (Kennedy 1997) software designed specifically for analysis of TRAPS data. This application produced a

Table 2.
General site details.

Site Name	First recording	Last recording	Years between first and last recordings	Latitude (xx°.xx'.xx")	Longitude (xx°.xx'.xx")	Area (ha)	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean annual rainfall (mm)	Mean annual rainfall over recording period (mm)
Anchor	3-Jun-83	30-Oct-97	14	23.49.29	149.53.52	0.2	29	16	674.6	587
Aqua Downs	25-Jun-98	1-Mar-00	2	27.08.27	146.59.28	0.2	28	13	463	643
Archer	17-Jun-83	11-Nov-99	16	23.34.49	150.33.51	0.2	27	17	832	742
Balmoral	1-Jun-82	11-Mar-99	17	22.58.45	150.16.22	0.2	27	18	912	861
Bowie	14-Jul-97	16-Nov-99	2	21.40.36	145.56.40	0.2	31	17	502	596
Bungobine	9-Mar-98	2-Feb-00	2	21.17.09	146.34.10	0.3	30	16	574	486
Burtle	27-May-97	15-Nov-99	2	23.11.09	146.34.10	0.2	30	16	533	627
Canal Creek	10-Jul-97	13-May-99	2	22.57.12	150.32.25	0.2	26	18	1317	1134
Carfax Control	4-Feb-82	26-Oct-94	12	22.27.12	148.42.52	0.2	29	17	626	631
Carfax Stylo	5-Feb-82	27-Oct-94	12	22.26.15	148.43.03	0.2	29	17	626	631
Centauri	28-Nov-97	27-Oct-99	2	20.04.14	146.16.18	0.2	30	17	599	959
Clifton	28-Jun-98	16-Mar-00	2	27.35.58	146.50.40	0.2	28	14	406	532
Coalstoun Lakes	21-Feb-97	10-Feb-00	3	25.37.04	151.53.51	0.8	26	14	805	840
Cooper Downs	22-Sep-82	24-Feb-99	17	24.10.58	150.06.31	0.3	29	15	683	634
Croxdale	22-Apr-97	19-Jan-00	3	26.24.57	146.16.18	0.1	28	14	483	604
Dykehead	20-Feb-97	26-May-99	2	25.40.52	150.58.16	0.4	27	14	687	877
Eumina	21-Mar-97	2-Jun-99	2	26.16.59	148.43.09	0.3	27	13	565	699
Exevale	11-Feb-98	2-Feb-00	2	21.19.36	148.21.50	0.5	27	16	871	785
Forest Hills	2-Mar-83	5-Aug-92	9	24.57.16	149.48.39	0.2	33	20	721	613
Glenrock	30-Nov-97	27-Oct-99	2	25.41.45	151.21.53	0.2	28	14	716	816
Goldsborough	11-Dec-97	22-Apr-98	1	20.17.02	145.00.31	0.2	29	16	615	966
Granite Vale	15-Sep-83	21-Jan-00	17	22.34.15.	149.31.55	0.2	28	18	849	724
Hedlow Creek	10-Aug-83	10-Mar-99	16	23.10.26	150.33.35	0.4	26	17	1101	959
Heidelberg	12-Feb-98	2-Feb-00	2	20.36.20	147.31.16	0.8	30	17	660	548
Huntly	10-Apr-84	6-May-96	12	22.41.45	148.02.53	0.2	27	14	672	603
Hyde Park	14-Sep-84	8-Mar-99	15	23.34.54	146.00.57	0.2	30	16	506	462
Inveresk	3-Jun-97	7-Jul-99	2	21.57.22	144.50.58	0.2	30	17	456	551

Table 2 (cont). General site details

Site Name	First recording	Last recording	Years between first and last recordings	Latitude (xx°.xx'.xx")	Longitude (xx°.xx'.xx")	Area (ha)	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean annual rainfall (mm)	Mean annual rainfall over recording period (mm)
Julia Park	1-Dec-97	29-Oct-99	2	20.50.42	145.05.18	0.2	30	15	542	619
Kerry	23-Jun-98	29-Feb-00	2	26.45.36	147.34.59	0.3	27	13	487	551
Kiauroo	2-Oct-83	12-Oct-99	16	23.04.56	149.20.14	0.1	28	16	630	620
Kirk River Exclosure	1-Jan-86	10-Oct-98	12	20.00.24	146.43.48	0.1	29	17	678	619
Kirk River Grazed	1-Jan-86	11-Oct-98	12	20.00.24	146.43.49	0.1	29	17	678	532
Kooralbyn Eucre	1-Jan-86	11-Oct-98	12	23.56.07	149.36.28	0.4	29	15	731	595
Leyshon View Exclosu	1-Jan-88	11-Oct-98	10	20.09.01	146.28.27	0.4	30	17	616	595
Leyshon View Grazed	1-Jan-88	11-Oct-98	10	20.09.06	146.28.29	0.2	30	17	610	703
Longton	3-Dec-97	30-Oct-99	2	20.58.40	145.51.02	0.2	31	17	569	507
Lundsville	28-May-85	18-Apr-00	15	24.46.34	152.09.12	0.2	27	16	984	509
Magazine	31-May-83	28-Apr-99	16	23.38.47	150.37.53	0.2	28	17	833	811
Meadowvale exclosure	1-Jan-86	9-Oct-98	12	19.50.20	146.35.21	0.2	29	17	666	842
Meadowvale grazed	1-Jan-86	9-Oct-98	12	19.50.23	146.35.26	0.6	29	17	666	722
Medway	22-May-98	6-Mar-00	2	23.44.28	147.19.44	0.4	29	15	645	565
Mistletoe	13-Nov-96	29-Aug-98	2	18.15.19	143.32.49	0.2	33	19	790	565
Monavale	27-Oct-82	20-Oct-99	17	23.03.44	150.11.39	0.2	27	17	890	546
Mt. Panorama	29-Mar-85	16-Jan-92	7	24.23.37	148.33.33	0.4	29	14	646	734
Mt. Pleasant	28-Mar-85	9-Nov-99	14	24.36.57	148.36.01	0.3	29	14	667	847
Mt. Pleasant Bowen	14-Jan-98	31-Jan-00	2	20.18.34	147.53.07	0.2	28	17	869	595
Myrrlumbing	2-Dec-97	28-Oct-99	2	19.58.57	145.46.16	0.2	30	17	597	615
Namuel	11-Dec-96	22-Sep-98	2	18.17.39	143.24.51	0.2	33	19	715	806
Netherleigh	7-Jun-83	14-Oct-99	16	24.12.38	151.20.15	0.4	23	15	1129	885
New Gildale	23-Nov-96	23-Sep-98	2	18.33.59	144.47.32	0.2	29	16	668	728
Nyanda	19-Feb-97	27-Jan-00	3	25.41.54	151.21.53	0.2	27	12	808	1020
Old Rawbelle	4-Feb-97	24-May-99	2	24.54.32	148.20.52	0.2	28	13	665	766
Pajingo	26-Feb-97	17-Mar-99	2	25.44.35	151.16.46	0.2	31	17	598	812
Rosebank	20-Mar-97	1-Jun-99	2	25.01.30	150.47.43	0.3	25	13	860	673

Table 2 (cont).

Site Name	First recording	Last recording	Years between first and last recordings	Latitude (xx°.xx'.xx")	Longitude (xx°.xx'.xx")	Area (ha)	Mean maximum temperature (°C)	Mean minimum temperature (°C)	Mean annual rainfall (mm)	Mean annual rainfall over recording period (mm)
Rostock	6-Jun-83	8-Feb-99	16	26.55.25	149.22.08	0.1	28	13	563	696
Rundle	25-Feb-97	16-Mar-99	2	23.41.44	151.01.49	0.1	26	18	935	859
Scotston	30-Mar-98	24-Jan-00	2	25.18.51	150.45.50	0.4	27	13	689	753
Springsure Reserve	1-Jan-86	11-Oct-98	12	24.08.56	148.07.53	0.4	27	14	699	664
St. Pauls Exclosure	1-Jan-86	10-Nov-98	12	20.19.49	146.47.25	0.2	30	17	624	578
St. Pauls Grazed	2-Apr-84	14-Sep-99	15	20.19.43	146.47.30	0.2	30	17	624	578
Summerdel	13-May-97	14-Mar-00	3	23.45.32	146.02.03	0.2	29	15	517	481
Sunrise East	15-May-97	7-Mar-00	3	25.20.29	148.06.51	0.2	27	12	623	731
Sunrise West	2-Jun-97	16-Sep-99	2	25.19.47	148.01.09	0.2	27	12	632	750
Swanlea	30-May-97	15-Sep-99	2	22.25.54	145.31.57	0.6	30	16	465	581
Texas	20-May-98	5-Jul-99	1	23.00.25	145.50.08	0.8	30	16	488	548
The Patrick	26-Nov-97	30-Oct-99	2	23.46.10	145.14.01	0.2	30	17	472	459
Tinnenburra	18-Jun-98	11-Apr-00	2	28.44.17	145.27.52	0.2	28	14	330	655
Tryphinia Eucre	11-Nov-82	1-Nov-99	17	23.41.13	149.31.51	0.2	29	16	708	618
Tryphinia Eumel	12-Dec-82	8-Oct-98	16	23.40.46	149.30.50	0.2	29	16	700	631
Tryphinia Eumol	22-Feb-84	14-Jan-99	15	23.41.51	149.32.44	0.2	29	16	708	391
Walthum	10-Mar-87	18-Sep-96	9	22.22.48	146.41.43	0.4	30	16	515	567
Wandobah T6 R1	8-Apr-87	14-May-98	11	23.37.21	149.25.03	0.16	29	16	685	551
Wandobah T6 R2	19-Aug-87	8-May-98	11	23.36.40	149.25.22	0.16	29	16	682	542
Wandobah T6 R3	26-Mar-87	6-May-98	11	23.36.15	149.24.39	0.16	29	16	678	604
Yanna	23-Apr-97	19-Jan-00	3	27.00.54	146.03.02	0.2	28	14	483	469

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Table 3.
Species contributing 75% of basal area for each site.

Site Name	Primary Dominant Species	Basal Area Contribution (%)	Secondary Dominant Species	Basal area contribution (%)	Tertiary Dominant species	Basal area contribution (%)
Anchor	*Eucalyptus crebra*	66	*Eucalyptus melanophloia*	13		
Aqua Downs	*Eucalyptus populnea*	41	*Eremophila mitchellii*	41		
Archer	*Eucalyptus crebra*	98				
Balmoral	*Eucalyptus fibrosa*	100				
Bowie	*Eucalyptus melanophloia*	98				
Bungobine	*Eucalyptus brownii*	88				
Burtle	*Eucalyptus melanophloia*	88				
Canal Creek	*Melaleuca viridiflora*	56	*Eucalyptus exserta*	31		
Carfax Control	*Eualyptus populnea*	58	*Corymbia dallachyana*	21		
Carfax Stylo	*Eualyptus populnea*	84				
Centauri	*Acacia shirleyii*	91				
Clifton	*Acacia excelsa*	45	*Acacia aneura*	45		
Coalstoun Lakes	*Eucalyptus tereticornis*	97				
Cooper Downs	*Eucalyptus melanophloia*	96				
Croxdale	*Acacia aneura*	89				
Dykehead	*Eucalyptus melanophloia*	100				
Eumina	*Callitris glaucophylla*	90				
Exevale	*Eucalyptus crebra*	89				
Forest Hills	*Eucalyptus crebra*	20	*Corymbia tessellaris*	20	*Petalostigma pubescens*	13.6
Glenrock	*Corymbia citriodora*	20	*Eucalyptus crebra*	20		
Goldsborough	*Eucalyptus quadricostata*	97				
Granite Vale	*Eucalyptus crebra*	82				
Hedlow Creek	*Eucalyptus populnea*	89				
Heidelberg	*Eucalyptus platyphylla*	21	*Corymbia dallachyana*	21		
Huntly	*Eucalyptus orgadophila*	21	*Corymbia erythrophloia*	21		
Hyde Park	*Eucalyptus melanophloia*	94				

Table 3. (cont.)
Species contributing 75% of basal area for each site.

Site Name	Primary Dominant Species	Basal Area Contribution (%)	Secondary Dominant Species	Basal area contribution (%)	Tertiary Dominant Species	Basal area contribution (%)
Inveresk	*Eucalyptus whiteii*	94				
Julia Park	*Eucalyptus similis*	57	*Eucalyptus terminalis*	26		
Kerry	*Eucalyptus melanophloia*	85				
Kiauroo	*Eucalyptus crebra*	71				
Kirk River Exclosure	*Eucalyptus xanthoclada*	85				
Kirk River Grazed	*Corymbia erythrophloia*	80				
Kooralbyn Eucre	*Eucalyptus crebra*	92				
Leyshon View Exclosure	*Dolichandrone heterophyllum*	34	*Grevellia striata*	19	*Dolichandrone heterophyllum*	16
Leyshon View Grazed	*Eucalyptus crebra*	98				
Longton	*Eucalyptus melanophloia*	79				
Lundsville	*Eucalyptus crebra*	48	*Corymbia intermedia*	25	*Corymbia citriodora*	
Magazine	*Eucalyptus populnea*	80				
Meadowvale exclosure	*Corymbia erythrophloia*	83				
Meadowvale grazed	*Corymbia erythrophloia*	87				
Medway	*Eucalyptus tereticornis*	47	*Corymbia tessellaris*	30		
Mistletoe	*Eucalyptus microneura*	88				
Monavale	*Eucalyptus crebra*	76				
Mt. Panorama	*Eucalyptus coolabah*	83				
Mt. Pleasant	*Eucalyptus melanophloia*	84				
Mt. Pleasant Bowen	*Eucalyptus crebra*	77				
Myrrlumbing	*Eucalyptus brownii*	77				
Namuel	*Eucalyptus microneura*	78				
Netherleigh	*Corymbia citriodora*	52	*Eucalyptus crebra*	21	*Eucalyptus exserta*	13
New Gildale	*Eucalyptus crebra*	96				
Nyanda	*Eucalyptus melanophloia*	98				
Old Rawbelle	*Eucalyptus melanophloia*	100				

Table 3. (cont.)
Species contributing 75% of basal area for each site.

Site Name	Primary Dominant Species	Basal area contribution (%)	Secondary Dominant Species	Basal area contribution (%)	Tertiary Dominant Species	Basal area contribution (%)
Pajingo	*Acacia argyrodendron*	27.1	*Eucalyptus cambageana*	27.1		
Rosebank	*Corymbia citriodora*	25.4	*Eucalyptus crebra*	25.4		
Rosebank	*Corymbia citriodora*	25.4	*Eucalyptus crebra*	25.4		
Rostock	*Callitris glaucophylla*	41.2	*Eucalyptus populnea*	41.2		
Rundle	*Eucalyptus moluccana*					
Scotston	*Eucalyptus crebra*					
Springsure Reserve	*Eucalyptus orgadophila*	33.3	*Macrozamia moorei*	33.3		
St. Pauls Exclosure	*Corymbia erythrophloia*					
St. Pauls Grazed	*Corymbia erythrophloia*	17.7	*Eucalyptus crebra*	17.7		
Summerdel	*Eucalyptus melanophloia*	86.8				
Sunrise East	*Callitris glaucophylla*					
Sunrise West	*Eucalyptus melanophloia*					
Swanlea	*Eucalyptus similis*					
Texas	*Eucalyptus populnea*					
The Patrick	*Corymbia plena*	23.8	*Corymbia dallachyana*	23.8		
Tinnenburra	*Acacia aneura*					
Tryphinia Eucre	*Eucalyptus crebra*					
Tryphinia Eumel	*Eucalyptus melanophloia*					
Tryphinia Eumol	*Eucalyptus moluccana*	28.8	*Eucalyptus crebra*	28.8		
Walthum	*Eucalyptus brownii*					
Wandobah T6 R1	*Eucalyptus populnea*					
Wandobah T6 R2	*Eucalyptus populnea*					
Wandobah T6 R3	*Eucalyptus populnea*					
Yanna	*Acacia aneura*					

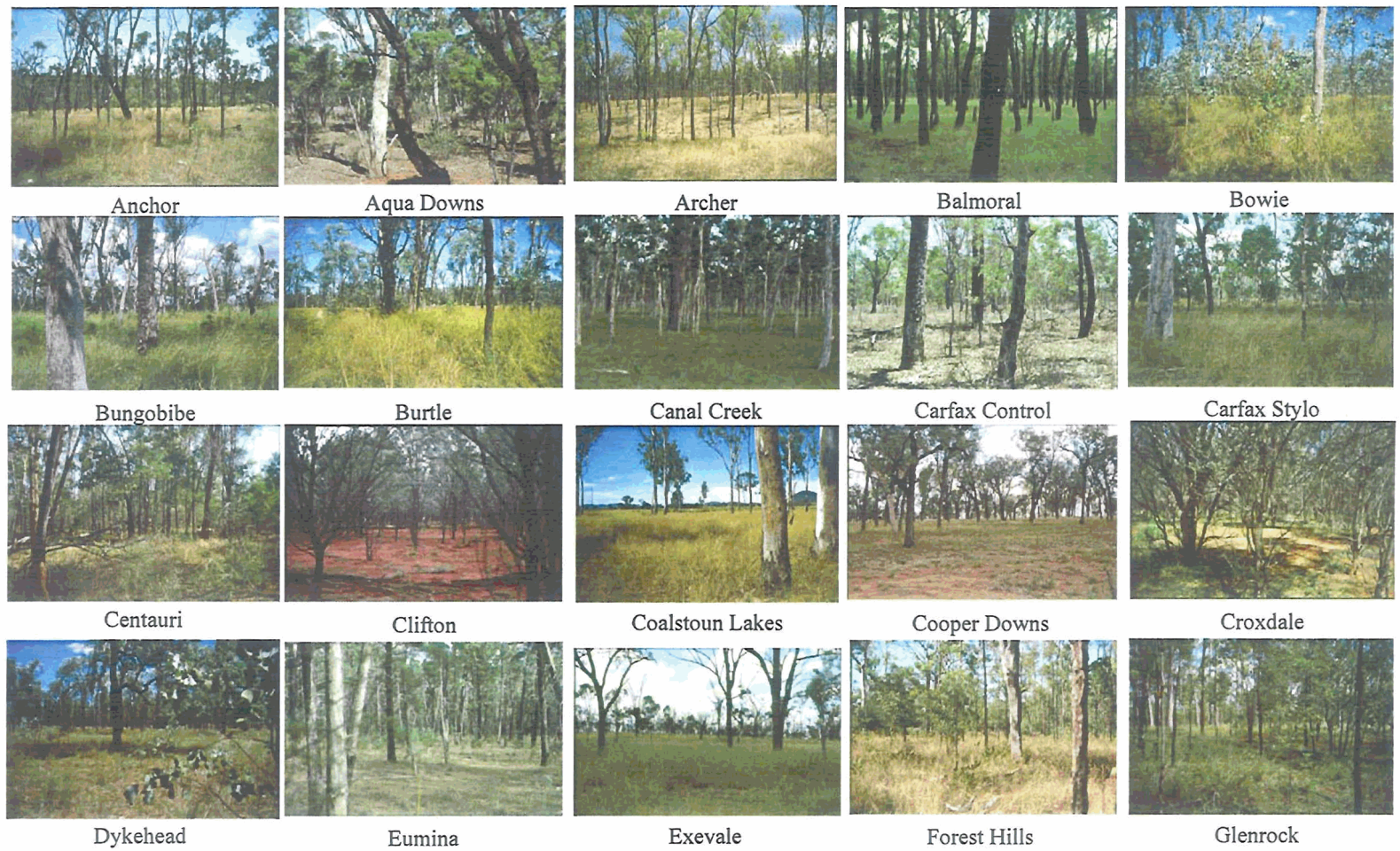


Figure 3.
Photographs of transect sites.

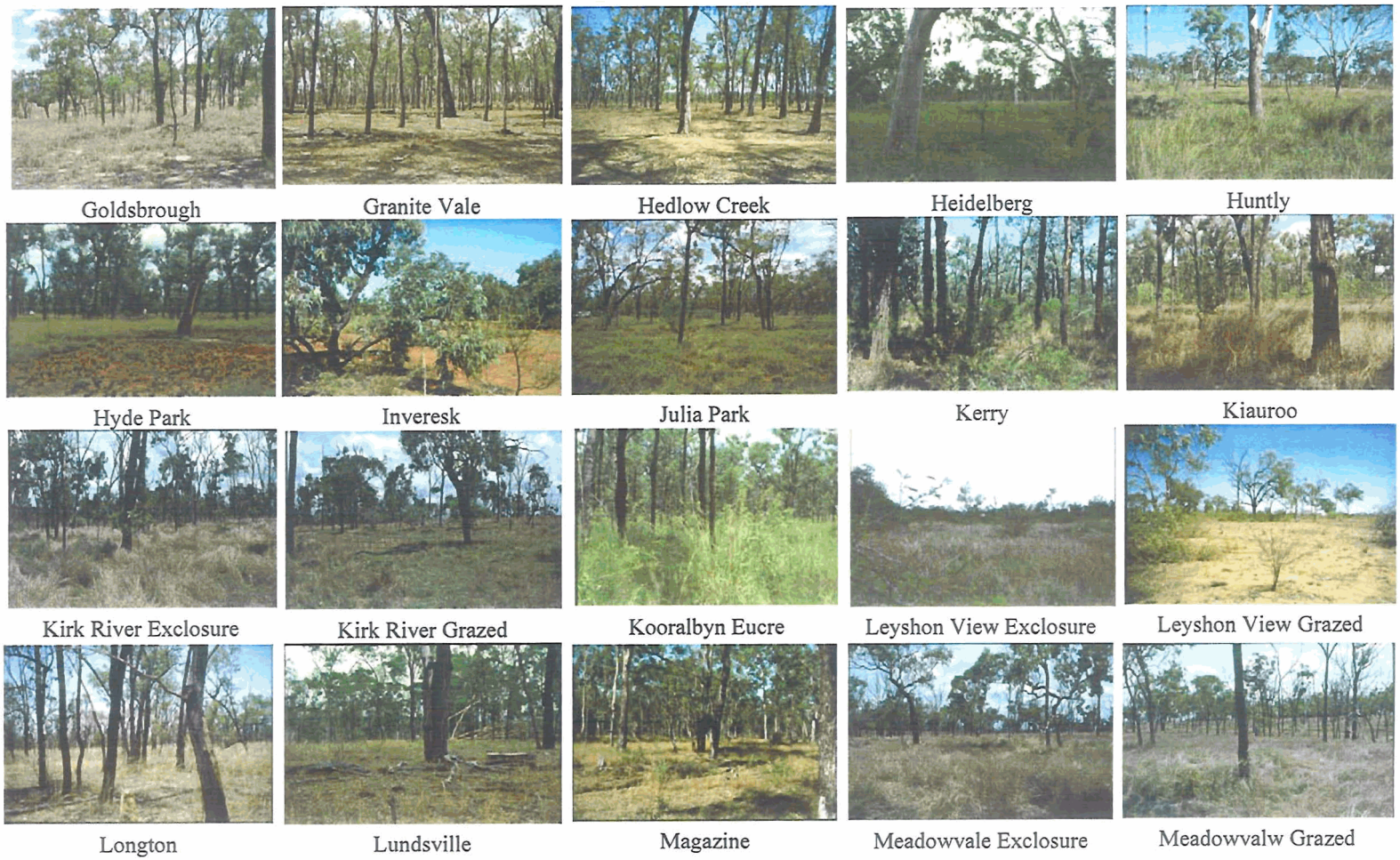


Figure 3 (cont).
Photographs of transect sites.

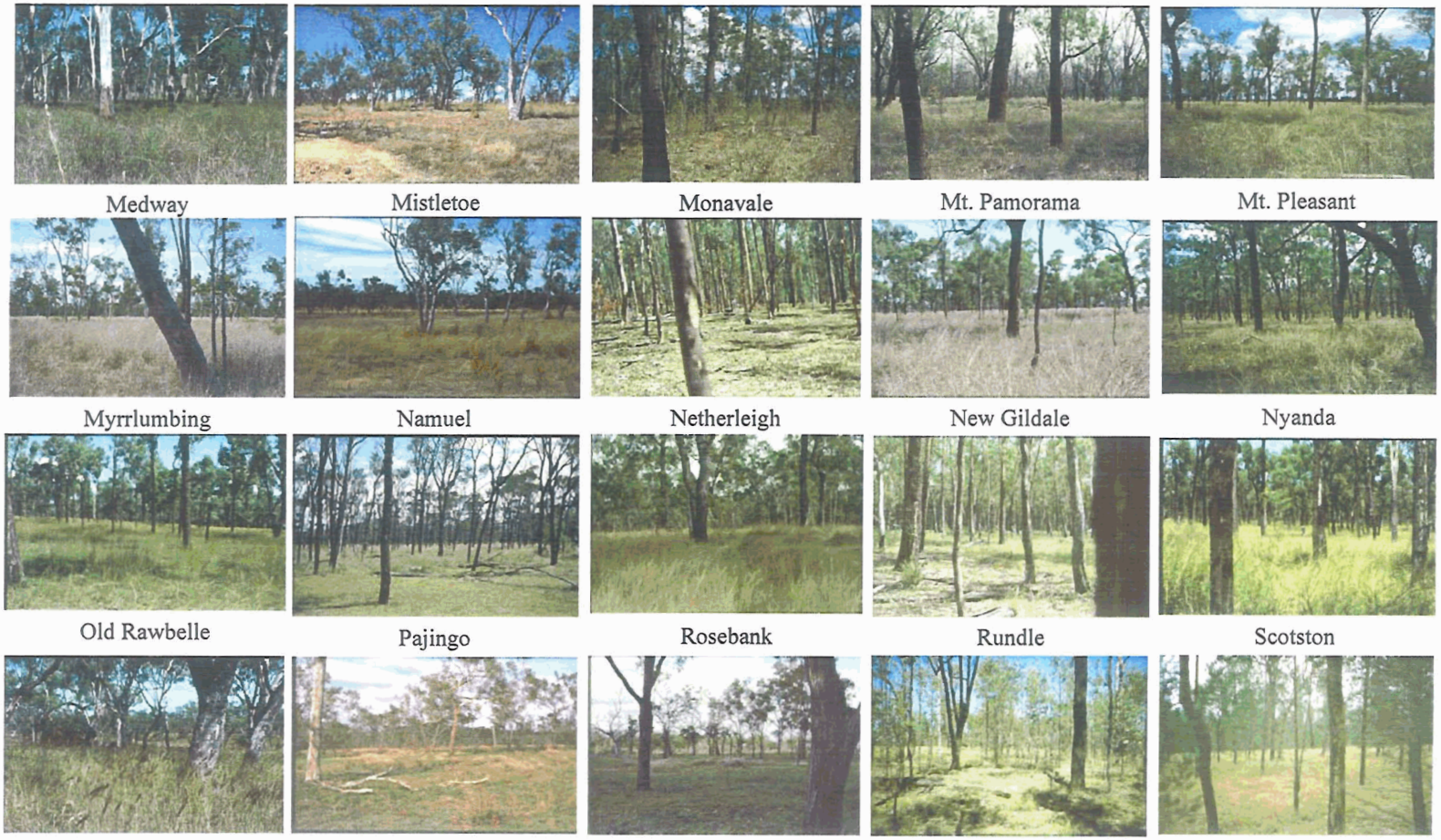


Figure 3 (cont).
Photographs of transect sites.

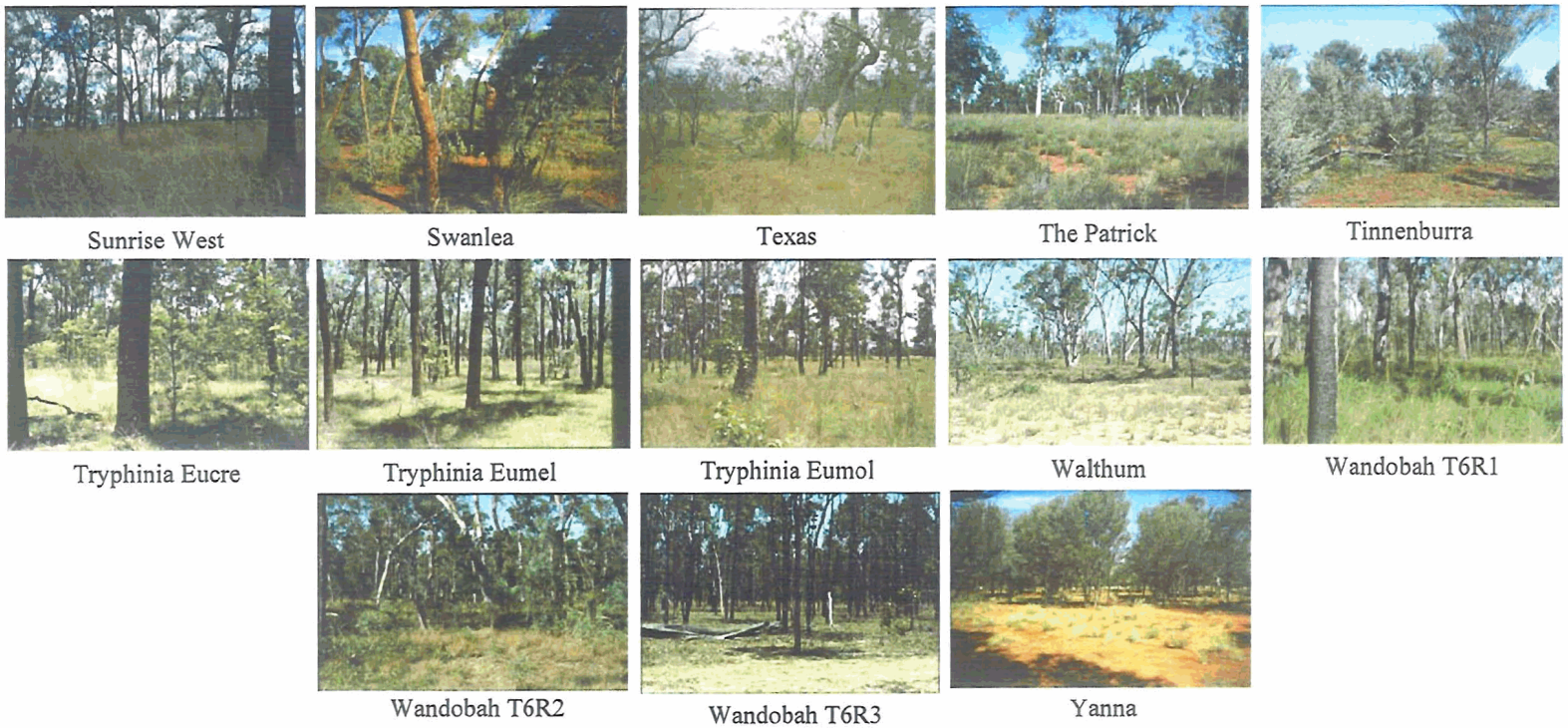


Figure 3 (cont).
Photographs of transect sites.

graphical representation of site structure and also provided basic information on density and basal area. This allowed a rapid preliminary examination of the data to be carried out, and was used primarily for identifying and correcting errors such as misidentification of species or gross changes in size between successive recordings. More detailed analysis was carried out using Microsoft Access databases.

All plants at each site were assigned a unique identification number, which allowed each plant to be readily followed through each successive recording and for the accurate identification of recruits. For multi-stemmed plants, which required multiple entries to accommodate all stems, the plant retained the same identification number for all stems. This permitted an analysis of absolute plant numbers rather than stems. Plants that were not identified to species level were removed from any analysis of species diversity or similarity, although retained for analyses of plant density and number. This was necessary due to the difficulty of correctly identifying some seedlings to species level, particularly within the genera *Eucalyptus* and *Corymbia.* An exception to this occurred where plants were able to be designated as an unidentified species, i.e. clearly not the same as any listed species, but could not be positively identified due to an absence of fertile material. In these cases the species was retained in the analysis.

2.2.1 Floristic analysis

Family importance values (FIV) and species importance values (SIV) were calculated for individual sites and for all sites combined. FIV and SIV were defined and calculated as follows according to the method of Nebel *et al.* (2001).

FIV= relative diversity + relative density + relative dominance

where

$$\text{Relative diversity} = \frac{\text{number of species of a family}}{\text{total number of species of the sample}} \times 100$$

$$\text{Relative density} = \frac{\text{number of individuals/ha of a family}}{\text{total number of individuals/ha of the sample}} \times 100$$

$$\text{Relative dominance} = \frac{\text{basal area/ha of a family}}{\text{total basal area/ha of the sample}} \times 100$$

SIV= relative frequency + relative density + relative dominance

where

$$\text{Relative frequency} = \frac{\text{number of sample units containing a species}}{\text{sample units for all species of the sample}} \times 100$$

$$\text{Relative density} = \frac{\text{number of individuals/ha of a species}}{\text{number of individuals/ha of the sample}} \times 100$$

$$\text{Relative dominance} = \frac{\text{basal area/ha of a species}}{\text{total basal area/ha of the sample}} \times 100$$

Values aside from species and family numbers were converted to a per hectare basis in order to equalise potential differences arising from different transect sizes. The number of sample units in which individuals of a species occur was used to calculate relative frequency. These sample units were the two sides of 50 m segments of transect lines, giving 20 sample units for a standard 500 m transect. These sample units were then corrected for area.

Species importance values were compiled into a species-by-site matrix for analysis using Detrended Correspondence Analysis (DCA) (Kent and Coker 1992) performed using the DECORANA computer program (Minchin 1997) in order to better compare the floristic makeup of the sites. Rare species were downweighted for this analysis using the option included within DECORANA. Forty-six species occurred at a single site only. Such unicates and taxa without determinations to specific level were excluded from the correspondence analysis since they provide no basis for comparison. Based on the results of this ordination the sites were divided into seven woodland types. Species importance values were calculated for each woodland type in order to describe the vegetation types they represented.

The similarity of species makeup between the woodland types was assessed using the Sorensen coefficient (*S*) (Kent and Coker 1992):

$$S = \frac{(2 \text{ x number of shared species})}{(\text{number of species of community 1} + \text{number of species of community 2})}$$

The Shannon-Wiener index of species diversity (*H*) was calculated for each woodland type following the method of Kent and Coker (1992):

$$H' = \Sigma\, p_i \log p_i$$

Where p_i = decimal fraction of individuals belonging to the i^{th} species

Evenness of distribution of species within woodland types was calculated from the Shannon-Wiener index following Kent and Coker (1992) as:

$$\text{Evenness} = H'/H_{max}$$

where H_{max} = ln (number of species).

Evenness provides information on the proportion of each species present in a

community, with high Evenness indicating that all species are equally abundant.

Species-area curves were generated for each woodland type and for each site. For species accumulation curves each transect was split into sub-plots to equalise differences in area between transects and to produce sufficient points for curve generation. For analysis of woodland types 200 m^2 plots were used, while 100 m^2 plots were utilised for individual sites. Exponential functions were fitted to the species area curves using Microcal Origin 6.1 (Microcal Software 1991) software and following the formula derived from Soberon and Llorente(1993):

$S = 1/z \ln (1 + zat)$

Where:

$z = 1 - \exp(-b)$

S = the number of species

t = the number of subplots

and

a and b are coefficients

Exponential functions are commonly thought to provide a reasonable reflection of fit for species area relationships for large sample areas (Soberon and Llorente1993).

The sampling effort required to obtain 90% of species based on the asymptote was calculated from the formula of Soberon and Llorente (1993):

$$\text{Effort} = 1/b \ln[(1/1-q)]$$

Where q is the proportion of asymptotic species richness desired.

Species losses and colonisations were compiled for the woodlands as a whole, woodland types and individual sites. Species composition change was quantified following Collins (2000) as:

$$\text{Composition change} = ((E+C)/N) * 100$$

where E = number of local extinctions, C = number of colonisations and N = the number of species present at initial recording. The change period was the interval between initial and last recording for each parameter examined.

In order to investigate the relationship between species change and density change, relative density of species at the first and last recording were regressed against one another for each site as well as for an amalgamation of all sites.

2.2.2 Analysis of Structure and Structural Change

Stem density and basal area per hectare were calculated for each site in order to quantify the abundance of woody plants. Annual rate of change in stem density and in basal area was calculated for each site and woodland type. Differences in density between first and last recordings were compared using a Kruskall-Wallis test to test whether changes in density or basal area varied between woodland types. Change in density and basal area between first and last recordings for diameter classes were tested with Wilcoxon's matched pairs test using individual sites as pairs. Similarly mean plant height and annual rate of change in mean height was calculated for each site and woodland type and changes in height between woodland types was tested using a Kruskall-Wallis test. Change in mean height between first and last recordings for diameter class increments were tested with Wilcoxon's matched pairs test using using individual sites as pairs.

In order to evaluate the adequacy of the sampling procedure, the variation in range of basal area values with increasing sampling effort was investigated. This was achieved by a method similar to that used for generation of species area curves. Each transect was split into 100 m^2 sub-plots to equalise differences in area between transects and to produce sufficient points for curve generation. Sub-plots were randomly ordered and the range of basal area (difference between maximum value and minimum value) encountered with each plot was calculated. In order to allow comparison between sites the basal area ranges were converted to percentage

of the maximum range. These percentages were then plotted against the number of sub-plots. Sigmoidal relationships were fitted to these plots using SPSS for Windows v10.1 (SPSS, 2000). A sigmoidal function was chosen because the location of the upper asymptote provides a convenient objective measure of the adequacy of sampling. Where the range of basal area values has ceased to increase significantly with range the asymptote will be close to 100% and the greater the difference from 100% the greater the variation in basal area range at the end of sampling.

The mortality rate for each site was extracted from the data sets according to the formula:

$m= N_O - St/t$

where N_O is the initial number of individuals measured at time 0, St is the number of original plants surviving at the last recording and t is time measured in years.

The recruitment rate was similarly calculated as:

$r= N_t - S_t/t$

where N_t is the number of individuals measured at the last recording and S_t is the

number of original plants surviving at the last recording and t is time measured in years. To allow comparison between transects of differing areas and different measurement periods all figures for mortality and recruitment were converted into a rate per hectare per year.

Difference in mortality and recruitment rates between woodland types and between circumference classes within woodland types were analysed using a Kruskall-Wallis test.

2.2.3 Diameter distributions

Size class distributions (graphs of the density of trees in 300 mm circumference classes) for both first and final recordings were generated for woodland types in order to understand the patterns of growth within the transect sites. Basal area class distributions for first and final recordings were compared using a Kolmogorov-Smirnov two-sample test to evaluate whether any significant changes in size distribution had occurred over time. Mature stands of trees are expected to have a diameter distribution pattern with numerous plants in the smallest size class with a constant decrease in density between subsequent size classes. Such a distribution pattern produces a steeply descending reverse-J shape with a negative exponential function (Rubin *et al.* 2005). To quantify how well the size distribution patterns of sites and woodland types fit the theoretical reverse-J shape typical of mature

communities a negative exponential function was fitted to diameter distributions using SPSS for Windows v10.1 (SPSS 2000).

The diameter distribution of multi-species stands may produce a reverse-J shape because of differences in mortality, growth rates and maximum size of different species, regardless of stand history (O'Hara 1986, Goodburn *et al.* 1999). To evaluate whether diameter distributions were affected by interspecific variation, 12 tree species were selected for size class analysis for the amalgamated site data. If the multi species diameter distributions were the result of the multiple species involved then it would be expected that the distributions of the individual species would produce a different distribution pattern. The following species were selected for individual diameter distribution anlysis: *Acacia aneura, Acacia shirleyii, Callitris glaucophylla, Corymbia citriodora, Corymbia erythrophloia, Eremophila mitchellii, Eucalyptus brownii, Eucalyptus crebra, Eucalyptus melanophloia, Eucalyptus populnea, Melalueca viridiflora* and *Petalostigma pubescens.* These species were selected because they were judged to be important structural components of the woodlands and represented a range of genera and growth habits. Each of the selected species met the following criteria:

- The species has a maximum potential height of greater than 8 metres, and is thus potentially able to reach the upper levels of the woodlands.

- The species is one of those that contributes to the first 75% of basal in at least one site, demonstrating that it is capable of being dominant.
- The species is represented by more than 100 stems with >300 mm circumference, totalled across all sites at either the initial or final recording.

2.2.4 Influence of Environmental Factors

A range of factors were considered in order to evaluate the effect of environment. These factors were mostly biotic or abiotic environmental factors considered likely to influence plant growth, establishment and survival (e.g.initial plant density, soil type, topography and rainfall), with Latitude and Longitude also included as potential surrogates for environmental factors such as solar radiation for which data was not available. The range of factors considered will be referred to throughout as "environmental factors" despite Latitude and Longitude not being strictly environmental factors.

All environmental factors were analysed by Pearson's correlation coefficient. This analysis was also used to enable the omission of tightly correlated variables from subsequent models and ordinations. Associations between stand structural characteristics at the time of final recording and environmental factors were also analysed by Pearson's correlation coefficient.

Forward stepwise linear models generated using SPSS for Windows 10.1 (SPSS 2000) were used to explore the influence of environmental factors on dynamics. Potential predictor variables selected were: Longterm mean annual rainfall, Longterm mean maximum daily temperature, Longterm mean minimum daily temperature, Mean annual rainfall over the recording period as a percentage of the longterm mean, Mean maximum daily temperature over the recording period as a percentage of the longterm mean, Mean minimum daily temperature over the recording period as a percentage of the longterm mean, Latitude, Longitude, Topography, Soil, Plant density, Density of plants with >300 mm circumference, α diversity, Basal area, Mean plant height and Mean height of plants with >300 mm circumference. Longterm mean annual rainfall, Longterm mean maximum temperature and Longterm mean minimum temperature were extracted from DataDrill (DNR 2003) and calculated as the annual means for the period 1889-2003.

The probability for predictor variables to enter into or be removed from linear models was 0.05. The following variables were selected as response variables: Recruitment as a percentage of initial density, Mortality as a percentage of initial density, Change in density as a % of initial density, Change in density of plants with >300 mm circumference as a % of initial density and Change in basal area as a % of initial basal area. Changes in basal area of plants with >300 mm circumference was not considered as a response variable due to basal area of plants

with >300 mm circumference being closely correlated with total basal area. A Kolmogorov-Smirnov One-Sample Test revealed that annual mean rainfall, annual mean rainfall over the recording period as a percentage of the longterm mean, topography, soil and density variables deviated significantly from normal distributions and these were subject to logarithmic transformations (ln [x + 1]) prior to model fitting.

Relationships of the environmental factors with the DCA derived plant associations were analysed by the Kruskall-Wallis test (Zar 1984).

The relationship between environmental factors and species importance at the time of final recording was analysed using Canonical Correspondence Analysis (CCA) ordination using the program MVSP v. 3.12 (Anon, 2001) in order to investigate the role played by environment in determining floristic pattern. CCA is a multivariate direct gradient analysis technique that allows the identification of floristic patterns directly related to the incorporated environmental variables (Ter Braak 1986). Canonical Correspondence Analysis also allows simultaneous plotting of species and site in an ordination diagram where the length of an arrow within the diagram indicates the importance of a variable while the direction indicates whether the correlation is positive or negative.

Chapter 3: Results

3.1 Ordination and Community Classification

An initial DECORANA analysis produced an ordination plot in which four sites dominated by mulga (*Acacia aneura*) formed an outlier group (Figure 4). It was decided that the four mulga sites formed a distinct vegetation type. These sites were therefore removed and the remaining data reanalysed to display the similarity between them more clearly. Based on field knowledge and visual inspection of the results of the second DECORANA analysis the sites were divided into 6 woodland types in addition to the MULGA woodland type subdivided at the initial analysis (Figure 5). The communities delineated were:

MULGA. Comprising 4 sites (5% of total). Total sample area 0.8 ha. Located in the south west of the state with an overstorey dominated by *A. aneura*.

CYPRESS. Comprising 3 sites (4% of total). Total sample area 0.7 ha. Located in Southern central Queensland. Overstorey dominated by white cypress pine (*Callitris glaucophylla*).

MICRONEURA. Two sites (3% of total). Total sample area 0.4 ha. Located in the northwest in the Georgetown area. Dominated by Gilbert River box

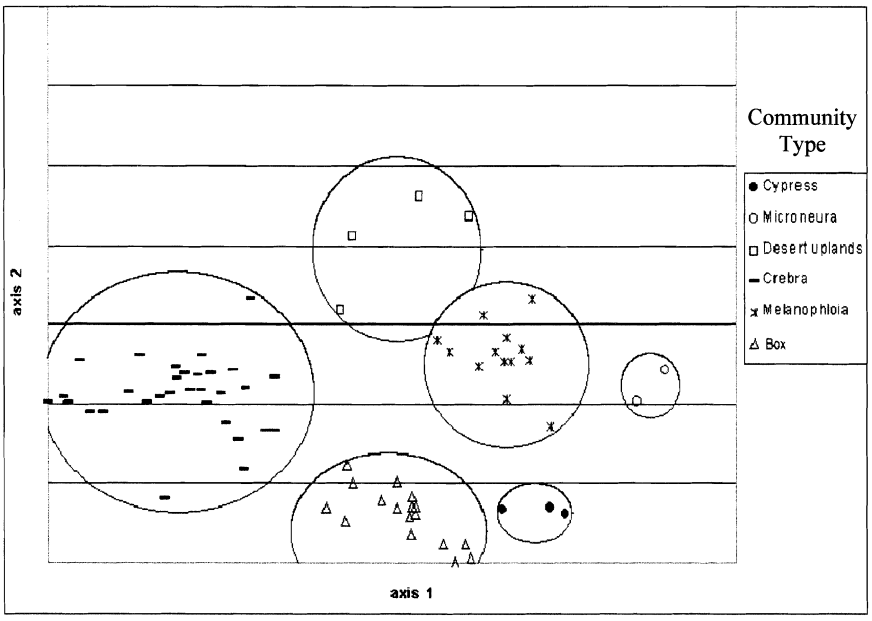


Figure 5
Ordination plot produced by detrended correspondence analysis ordination of sites with MULGA sites excluded. Sites within one of the six community types delimited on the basis of this ordination are bounded by ellipses.

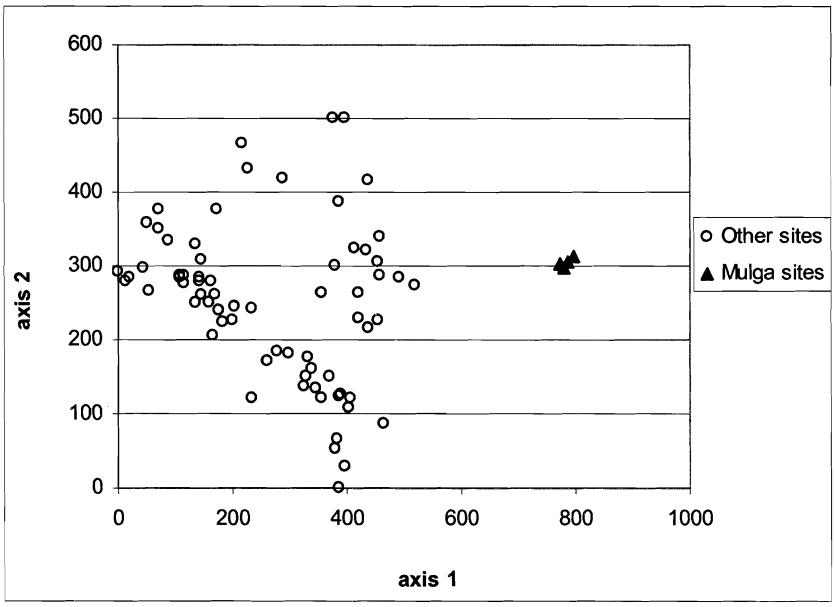


Figure 4
Ordination plot produced by detrended correspondence analysis of woodland site sites, with MULGA sites forming an outlier group.

(*Eucalyptus microneura*) and with an important contribution by dry season deciduous species such as *Terminalia aridicola* and *Gardenia vilhelmii.*

DESERT UPLANDS. Four Sites (5% of total). Total sample area 1.2 ha. Located in the central west of the state with dominant overstorey species *Eucalyptus similis, Eucalyptus whitei, Corymbia plena and Corymbia terminalis.*

BOX. Seventeen sites (23% of total). Total sample area 5.38 ha. Most sites are dominated by the *E. populnea/E. brownii* complex. Also included are sites dominated by forest blue gum (*E. tereticornis),*Coolibah *(E. coolabah)* and Blackwood (*Acacia cambagei)* growing on heavy soils. One site dominated by lancewood (*A. shirleyii)* is also included in this community.

MELANOPHLOIA. Thirteen sites (17% of total). Total sample area 3.02 ha. All dominated by silver leafed ironbark (*E. melanophloia).*

CREBRA. Thirty two sites (43% of total). Total sample area 8.9 ha. Largely dominated by various species of ironbarks (*Eucalyptus crebra, E. quadricostata, E. xanthoclada, E. fibrosa*) sometimes in association with lemon scented gum (*Corymbia citriodora*). Most sites are located on slopes and ranges. This community type also incorporates those sites dominated by

mountain coolibah (*Eucalyptus orgadophila)* and gum topped box (*Eucalyptus mollucana*) in addition to two seasonally waterlogged sites dominated by poplar gum (*Eucalyptus platyphylla*) and broad leafed tea tree (*Melaleuca viridiflora*).

3.2 Density

In total 1659 plants/ha were recorded at the final recording, which was 17% more than at the initial recording (Table 4). This corresponds to a mean annual net increase of 60 plants per hectare. The increase in density was significant (Wilcoxon's matched pairs, $p<0.01$). The positive balance was due to 34 dead or missing plants/ha/yr and 94 newly recruited plants/ha/yr, corresponding to a mortality and recruitment rate of 2.6% and 6.7% per year, respectively, yielding a net annual increase of 4.1%. The density of plants >300 mm circumference at 30 cm decreased from 218 plants/ha to 208 plants/ha (-0.17%), an average decline of –1.15 plants/ha/yr. Both the highest (6045 plants/ha) and lowest (168 plants/ha) individual site densities were recorded in CREBRA woodland sites (Appendix 1 Table 1).

There was considerable variation in changes in density between sites (Figure 6), with the majority of the change in all sites due to plants smaller than 10 cm diameter at 30 cm. The majority of sites (59 of the 75) experienced an increase in plant density between first and last recordings, with 13 sites experiencing a

Table 4.
Mean tree density (plants/ha) by circumference class and total in the woodland types under study. "Change" is the annual change in plant density. "Change %" is the change as a percentage of the initial density. "Sig" is the Wilcoxon's matched pairs significance for comparison of initial and final values.

	Box Woodland					Crebra Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	1489.2	1803.6	314.40	21.11	<0.01	1264.1	1562.0	297.86	23.56	<0.01
300-600	91.2	59.6	-31.62	-34.67	0.19	65.2	62.6	-2.64	-4.05	0.66
600-900	36.2	32.0	-4.14	-11.44	0.14	42.7	34.4	-8.25	-19.33	0.07
900-1200	24.5	20.9	-3.60	-14.71	0.40	24.2	23.0	-1.21	-5.00	0.52
1200-1500	11.3	10.8	-0.54	-4.76	0.81	10.6	12.2	1.65	15.63	0.43
1500-1800	4.9	6.1	1.26	25.93	0.04	6.1	5.4	-0.66	-10.91	0.50
1800-2100	4.1	3.8	-0.36	-8.70	0.29	2.8	4.2	1.43	52.00	0.24
2100-2400	2.3	2.9	0.54	23.08	1.00	0.3	0.2	-0.11	-33.33	0.79
2400-2700	1.1	1.1	0.00	0.00	1.00	0.4	0.3	-0.11	-25.00	0.79
2700-3000	0.9	0.7	-0.18	-20.00	0.32	_	0.2	0.20	100.00	0.18
3000-3300	0.2	0.4	0.18	100.00	0.32	_	_	_	_	_
<3300	0.9	0.7	-0.18	-20.00	0.32	_	_	_	_	_
Total	1666.2	1942.2	276.00	16.56	0.35	1415.6	1701.7	286.08	20.21	0.11

	Cypress Woodland					Desert Upland Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	1762.7	2142.6	379.89	21.55	0.11	1176.1	1180.3	4.18	0.36	0.07
300-600	224.2	229.3	5.14	2.29	0.29	91.3	90.5	-0.83	-0.91	0.65
600-900	129.9	121.4	-8.57	-6.59	0.65	53.1	47.3	-5.81	-10.94	0.27
900-1200	27.1	37.1	10.00	36.84	0.11	12.5	14.1	1.66	13.33	0.59
1200-1500	1.4	2.8	1.41	98.88	0.32	8.3	10.0	1.66	20.00	0.18
1500-1800	_	_	_	0.00	1.00	0.8	0.8	0	0	1.00
1800-2100	2.9	2.9	0.00	0.00	1.00	_	0.8	0.80	100.00	1.00
2100-2400	_	_	_	0.00	_	_	_	_	_	_
2400-2700	1.4	2.9	1.43	100.00	1.00	_	_	_	_	_
2700-3000	1.4	0	-1.42	100.00	1.00	_	_	_	_	_
3000-3300	_	_	_	_	_	_	_	_	_	_
<3300	_	_	_	_	_	_	_	_	_	_
Total	2151.1	2539.0	168.38	8.58	0.02	1355.3	1514.2	158.88	11.72	0.18

Table 4 (cont).
Mean plant density (plants/ha) by circumference class and total in the woodland types under study. "Change" is the annual change in plant density. "Change %" is the annual change as a percentage of the initial density. "Sig" is the Wilcoxon's matched pairs significance for comparison of initial and final values.

	Melanophloia Woodland					Microneura Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	947.2	1087.4	140.19	14.80	0.02	157.0	192.5	35.50	22.61	0.32
300-600	74.6	84.2	9.57	12.83	0.24	57.0	52.0	-5.00	-8.77	0.32
600-900	56.1	52.1	-3.96	-7.06	0.86	52.5	59.0	6.50	12.38	0.32
900-1200	34.7	36.0	1.32	3.81	0.96	33.0	35.0	2.00	6.06	0.32
1200-1500	11.6	14.2	2.64	22.86	0.24	9.0	9.0	0.00	0.00	1.00
1500-1800	5.9	7.6	1.65	27.78	0.30	5.0	6.0	1.00	20.00	0.32
1800-2100	2.0	1.3	-0.66	-33.33	0.32	7.5	7.5	0.00	0.00	1.00
2100-2400	0.7	0.7	0.00	0.00	1.00	–	–	–	–	–
2400-2700	0.3	0.3	0.00	0.00	1.00	–	–	–	–	–
2700-3000	–	–	–	–	–	–	–	–	–	–
3000-3300	–	–	–	–	–	–	–	–	–	–
<3300	–	–	–	–	–	–	–	–	–	–
Total	1116.92	1292.31	175.38	15.70	0.01	320.0	361.3	41.25	12.89	0.23

	Mulga Woodland					Total				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	1225.0	1238.8	13.75	1.12	0.72	1208.2	1411.3	-26.73	-2.21	<0.01
300-600	140.0	158.8	18.75	13.39	0.27	102.3	124.1	1.78	1.74	0.90
600-900	21.3	21.3	0.00	0.00	1.00	57.5	60.4	-0.61	-1.06	0.02
900-1200	6.3	8.8	2.50	40.00	0.65	28.6	34.1	0.21	0.72	0.87
1200-1500	6.3	7.5	1.25	20.00	0.32	11.5	15.6	0.33	2.88	0.20
1500-1800	2.5	1.3	-1.50	-60.00	0.32	5.1	6.8	0.16	3.17	0.22
1800-2100	–	–	–	–	–	2.7	3.7	-0.03	-1.20	0.96
2100-2400	–	–	–	–	–	0.7	0.8	0.00	0.56	0.89
2400-2700	–	–	–	–	–	0.6	0.8	0.02	3.86	0.59
2700-3000	–	–	–	–	–	0.3	0.2	-0.01	-3.09	0.58
3000-3300	–	–	–	–	–	0.0	0.1	<0.01	17.72	0.32
<3300	–	–	–	–	–	0.2	0.2	-0.01	-4.01	0.32
Total	1401.3	1436.3	35.00	2.50	0.39	1416.8	1658.8	242.00	17.08	<0.01

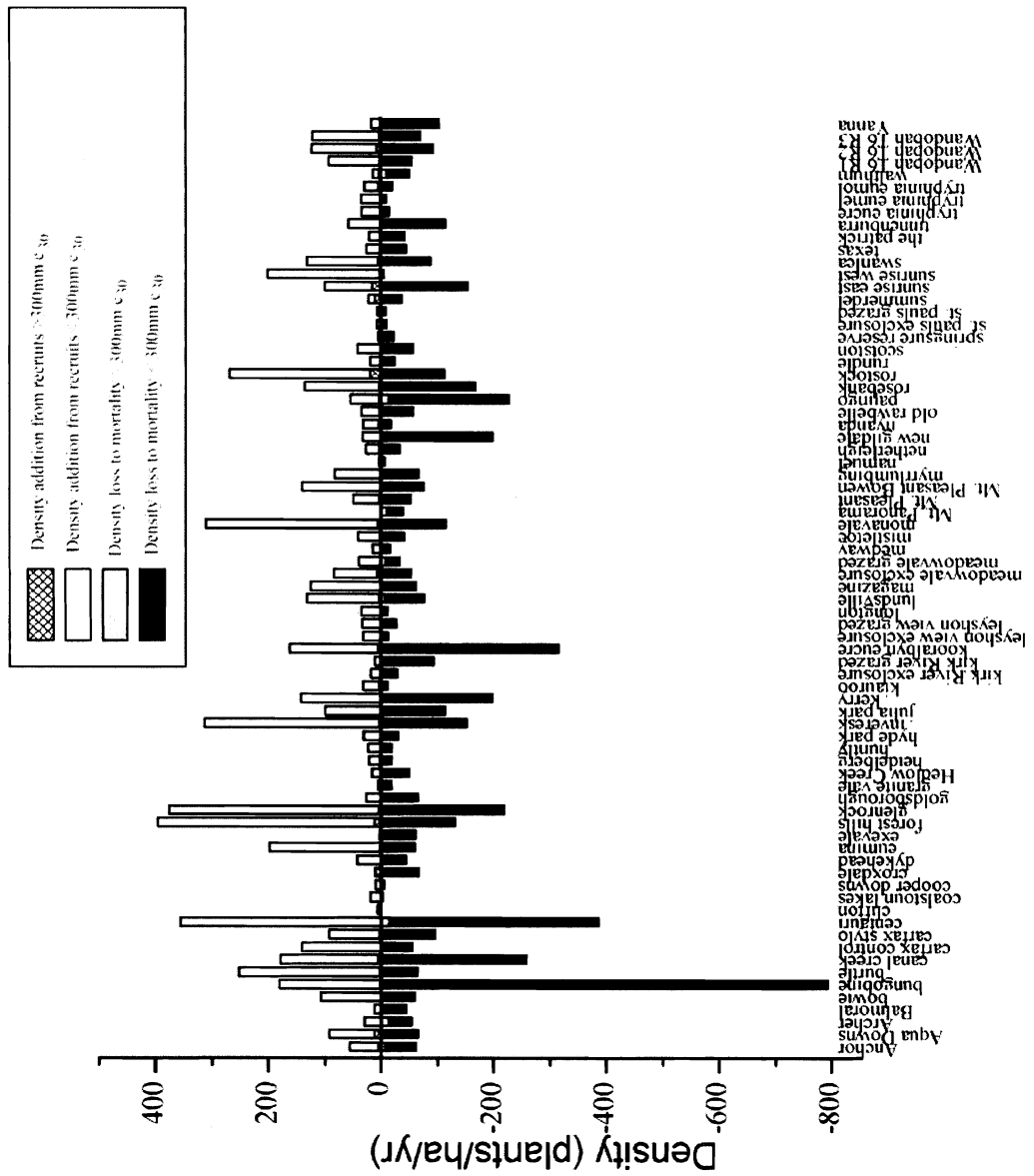


Figure 6.
Change in density by site illustrating the relative contributions of recruitment and mortality to

decrease and three remaining stable. The mean change for those sites experiencing an increase in density was 82.4 plants/ha/yr or 5.45% of the initial density/ha/yr. The mean change for those sites experiencing a decrease was –25.8 plants/ha/yr or a loss of 1.8% of the initial density/ha/yr. The greatest relative decrease was 5.2% of the initial population/ yr (75 plants/ha/yr) while the greatest absolute decrease was 134.5 plants/ha/yr (2.2%/yr). The greatest relative increase was 27.0%/yr (18.5 plants/ha/yr) while 373 plants/ha or 10.8% of the initial population accrued annually at the site with the greatest increase.

There was no significant difference in plant density between the different woodland types at either first or last recording (Kruskall-Wallis test, $p = 0.40$ and $p = 0.46$ for initial and final recordings respectively). . The density change rate (plants/ha/yr) did not differ significantly between woodland types (Kruskall-Wallis test, $p = 0.18$).

Within the recording period woody plant density increased significantly for woodlands overall. All woodland types experienced an increase in density, however the change was significant only for the CYPRESS and MELANOPHLOIA woodland types (Table 4). A significant change in density occurred within the 0-300 mm circumference class for the BOX, CREBRA and MELANOPHLOIA woodland types and a marginally significant difference was detected in the DESERT UPLANDS woodland type. There was a corresponding

significant change in the smallest size class for an amalgamation of all sites. These were the only significant changes within any size class although the CREBRA woodlands showed a marginally significant change in the 600-900 mm circumference class (p= 0.07).

3.3 Basal Area

At the final recording a basal area of 12.15 m^2/ha was recorded which was 0.14 m^2/ ha less than at initial recording. Taking into account differing transect sizes and periods of measurement this equates to an average decrease of 0.04 m^2/ha/year or 0.7% of the initial basal area annually (Table 5). This change in basal area was not significant (Wilcoxon's matched pairs test, p=0.67). CYPRESS woodlands recorded the highest mean basal area (23.1 m^2/ha) while the DESERT UPLANDS woodlands recorded the lowest basal area, with an average value of 6.8 m^2/ha. The highest site basal area of 35.8m^2/ha was recorded at a CYPRESS woodland site (Appendix 1, Table 2). The lowest basal area of 0.3m^2/ha was recorded in a site in the CREBRA woodland type that had experienced severe drought death.

Basal area variation was asymptotic for most sites (Figure 7). The use of the upper asymptote of a fitted sigmoidal function appeared to provide a good surrogate for the degree of stability at the end of sampling. Upper asymptote values between 90 and 105 indicate sites at which the sampled area appears to have captured most of the variation in basal area (Table 6, Figure 7), while values outside that range

Table 5.
Mean tree Basal area (m^2/ha) by circumference class and total in the woodland types under study. "Change" is the annual change in basal area. "Change %" is the annual change as a percentage of the initial density. "Sig" is the significance value measured using a Wilcoxon's matched pairs test.

	Box Woodland					Crebra Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	0.59	0.65	<0.01	0.23	0.05	0.38	0.42	<0.01	0.43	1.00
300-600	1.42	1.35	0.03	1.76	0.38	1.31	1.25	0.01	0.95	0.76
600-900	2.46	2.15	-0.06	-2.58	0.12	2.57	2.05	-0.04	-1.69	0.02
900-1200	2.64	2.29	-0.12	-4.51	0.18	2.64	2.49	0.01	0.43	0.49
1200-1500	2.14	2.04	-0.005	-0.23	0.88	1.87	2.18	0.03	1.71	0.57
1500-1800	0.99	1.52	0.13	13.59	0.07	1.36	1.25	-0.02	-1.57	0.57
1800-2100	1.13	0.91	-0.10	-8.40	0.40	0.86	1.30	0.06	6.46	0.22
2100-2400	0.68	0.73	0.07	9.71	1.00	0.15	0.12	-0.03	-20.76	0.72
2400-2700	0.43	0.42	-0.02	-3.47	0.47	0.29	0.24	-0.04	-14.67	0.72
2700-3000	0.57	0.37	-0.01	-2.08	0.59	0.00	0.14	0.08	100.00	0.18
3000-3300	0.07	0.30	0.01	18.85	0.32	–	–	–	–	–
<3300	1.06	0.79	-0.03	-309.81	0.65	–	–	–	–	–
Total	14.20	13.53	-0.21	-1.08	0.49	11.64	11.44	-0.018	-1.40	0.51

	Cypress Woodland					Desert Upland Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	1.65	1.45	-0.09	-5.11	0.29	0.42	0.47	0.02	4.54	0.14
300-600	6.17	6.53	0.15	2.43	0.11	1.82	1.86	0.02	1.16	0.07
600-900	6.55	6.35	-0.10	-1.51	1.00	2.53	2.21	-0.14	-5.44	0.27
900-1200	2.13	3.04	0.39	17.81	0.11	1.11	1.23	0.06	5.29	0.47
1200-1500	0.72	0.85	0.06	7.52	0.65	0.75	0.87	0.05	5.93	0.59
1500-1800	–	–	–	–	–	0.08	0.06	-0.02	-28.29	1.00
1800-2100	1.31	1.41	0.04	3.32	0.18	0.00	0.09	0.08	100.00	1.00
2100-2400	–	–	–	–	–	–	–	–	–	–
2400-2700	1.55	3.44	0.86	53.25	1.00	–	–	–	–	–
2700-3000	2.08	0.00	-0.95	-44.43	1.00	–	–	–	–	–
3000-3300	–	–	–	–	–	–	–	–	–	–
<3300	–	–	–	–	–	–	–	–	–	–
Total	22.48	23.06	0.24	1.30	0.11	6.97	6.79	-0.06	-0.49	0.29

Table 5. (cont)
Mean tree Basal area (m^2/ha) by circumference class and total in the woodland types under study. "Change" is the annual change in basal area. "Change %" is the annual change as a percentage of the initial density. "Sig" is the significance value measured using a Wilcoxon's matched pairs test.

	Melanophloia Woodland					Microneura Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	0.48	0.57	0.02	4.70	0.02	0.14	0.12	-0.01	-6.92	0.18
300-600	1.41	1.46	0.001	0.10	0.42	1.19	1.05	-0.02	-1.91	0.65
600-900	3.11	2.65	0.02	0.82	0.38	2.70	2.60	0.08	3.30	0.65
900-1200	3.39	3.43	0.02	0.50	0.97	3.02	3.26	0.14	4.49	0.65
1200-1500	1.88	2.25	0.08	4.46	0.07	1.16	1.12	-0.02	-2.03	0.18
1500-1800	1.35	1.88	0.11	8.10	0.24	1.18	1.42	0.13	11.38	0.65
1800-2100	0.66	0.44	-0.09	-12.98	0.35	1.04	1.15	0.06	5.83	1.00
2100-2400	0.28	0.31	0.003	1.05	0.65	–	–	–	–	–
2400-2700	0.19	0.19	<0.01	0.00	1.00	–	–	–	–	–
2700-3000	–	–	–	–	–	–	–	–	–	–
3000-3300	–	–	–	–	–	–	–	–	–	–
<3300	–	–	–	–	–	–	–	–	–	–
Total	12.75	13.16	0.03	0.14	0.15	10.39	10.72	0.19	1.75	0.81

	Mulga Woodland					Total				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	1.62	1.46	0.03	1.98	0.72	0.57	0.58	<0.01	0.69	0.17
300-600	2.53	2.54	0.15	5.89	0.07	1.64	1.60	0.03	1.63	0.28
600-900	0.98	1.16	0.03	3.11	0.59	2.69	2.31	-0.04	-1.39	0.15
900-1200	0.53	0.69	0.07	12.45	0.59	2.57	2.49	0.01	0.27	0.68
1200-1500	0.99	1.36	0.09	8.57	0.47	1.76	1.95	0.04	2.06	0.26
1500-1800	0.57	0.32	-0.09	-15.19	0.32	1.10	1.26	0.04	3.46	0.29
1800-2100	–	–	–	–	–	0.82	0.93	-0.01	-0.65	0.65
2100-2400	–	–	–	–	–	0.29	0.27	<0.01	0.71	0.92
2400-2700	–	–	–	–	–	0.32	0.37	0.01	4.02	0.95
2700-3000	–	–	–	–	–	0.21	0.14	-0.01	-3.81	0.75
3000-3300	–	–	–	–	–	0.03	0.07	<0.01	19.15	0.32
<3300	–	–	–	–	–	0.24	0.18	-0.01	-3.30	0.65
Total	7.20	7.61	0.15	2.04	0.28	12.29	12.15	-0.04	-0.74	0.67

Table 6
Upper asymptote values for sigmoidal functions fitted to basal area accumulation curves for individual sites.

Transect Name	Upper Asymptote
Anchor	95
Aqua Downs	100
Archer	1308
Balmoral	101
Bowie	101
Bungobine	99
Burtle	82
Canal creek	100
Carfax control	97
Carfax stylo	100
Centauri	98
Clifton	111
Coalstoun Lakes	100
Cooper Downs	739
Croxdale	202
Dykehead	101
Eumina	101
Exevale	100
Forest Hills	90
Glenrock	100
Goldsborough	101
Granitevale	1849
Hedlow Creek	103
Heidelberg	102
Huntly	100
Hyde Park	109
Inveresk	100
Julia park	81
Kerry	96
Kiauroo	100
Kirk River exclosure	100
Kirk River grazed	100
Kooralbyn eucre	100
Leyshon View exclosure	1581
Leyshon View grazed	100
Longton	97
Lundsville	100
Magazine	100
Meadowvale exclosure	100
Meadowvale grazed	100
Medway	100
Mistletoe	504

Transect Name	Upper Asymptote
Mistletoe	504
Monavale	100
Mt. Panorama	100
Mt. Pleasant	449
Mt. Pleasant Bowen	99
Myrrlumbing	95
Namuel	99
Netherleigh	99
New Gildale	102
Nyanda	100
Old Rawbelle	126
Pajingo	101
Rosebank	91
Rostock	698
Rundle	93
Scotston	100
Springsure reserve	86
St. Pauls exclosure	109
St. Pauls grazed	121
Summerdel	100
Sunrise east	92
Sunrise west	100
Swanlea	98
Texas	101
The Patrick	99
Tinnenburra	100
Tryphinia eucre	121
Tryphinia eumel	100
Tryphinia eumol	120
Walthum	1495
Wandobah T6 R1	97
Wandobah T6 R2	101
Wandobah T6 R3	143
Yanna	100

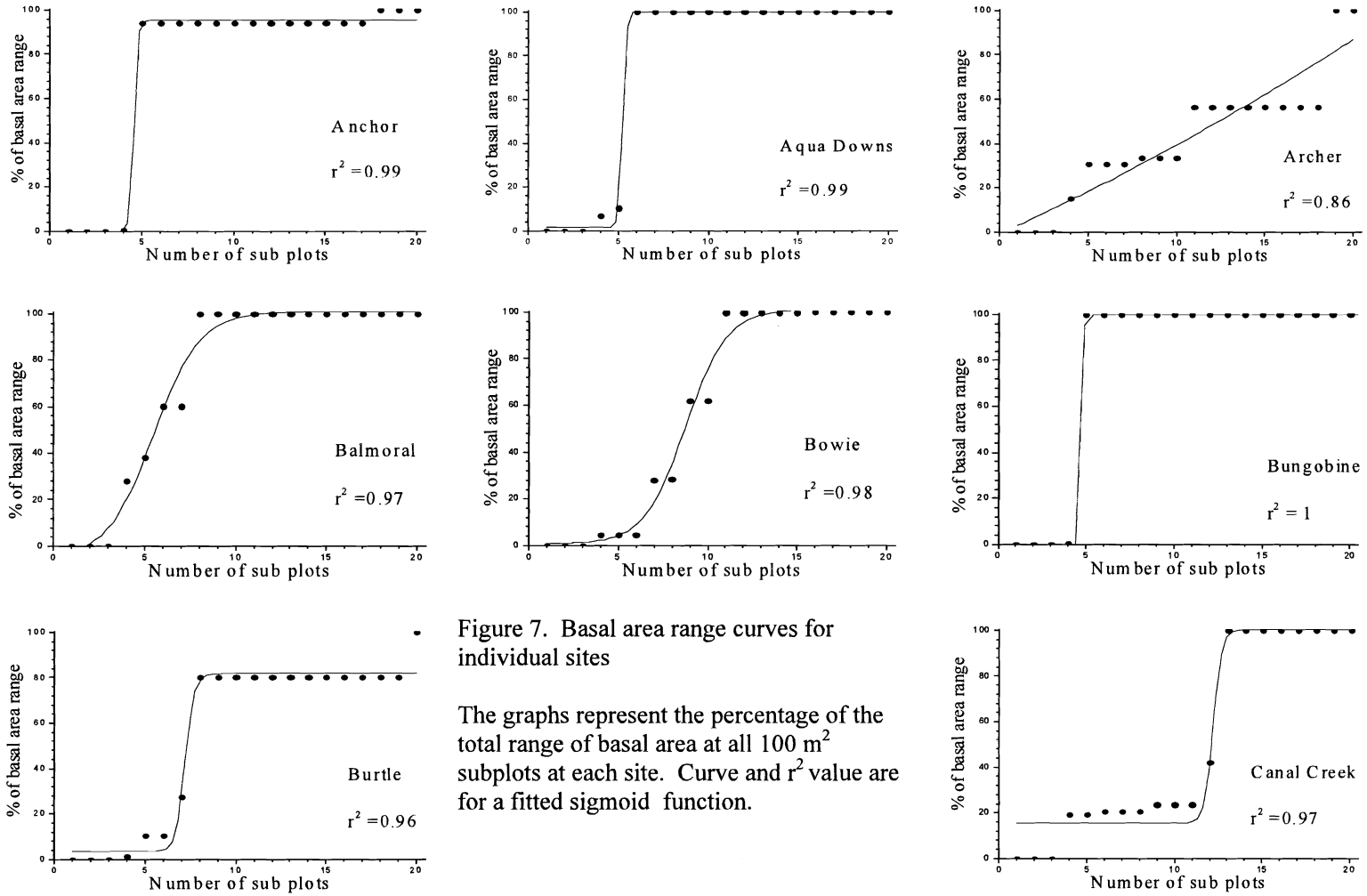


Figure 7. Basal area range curves for individual sites

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

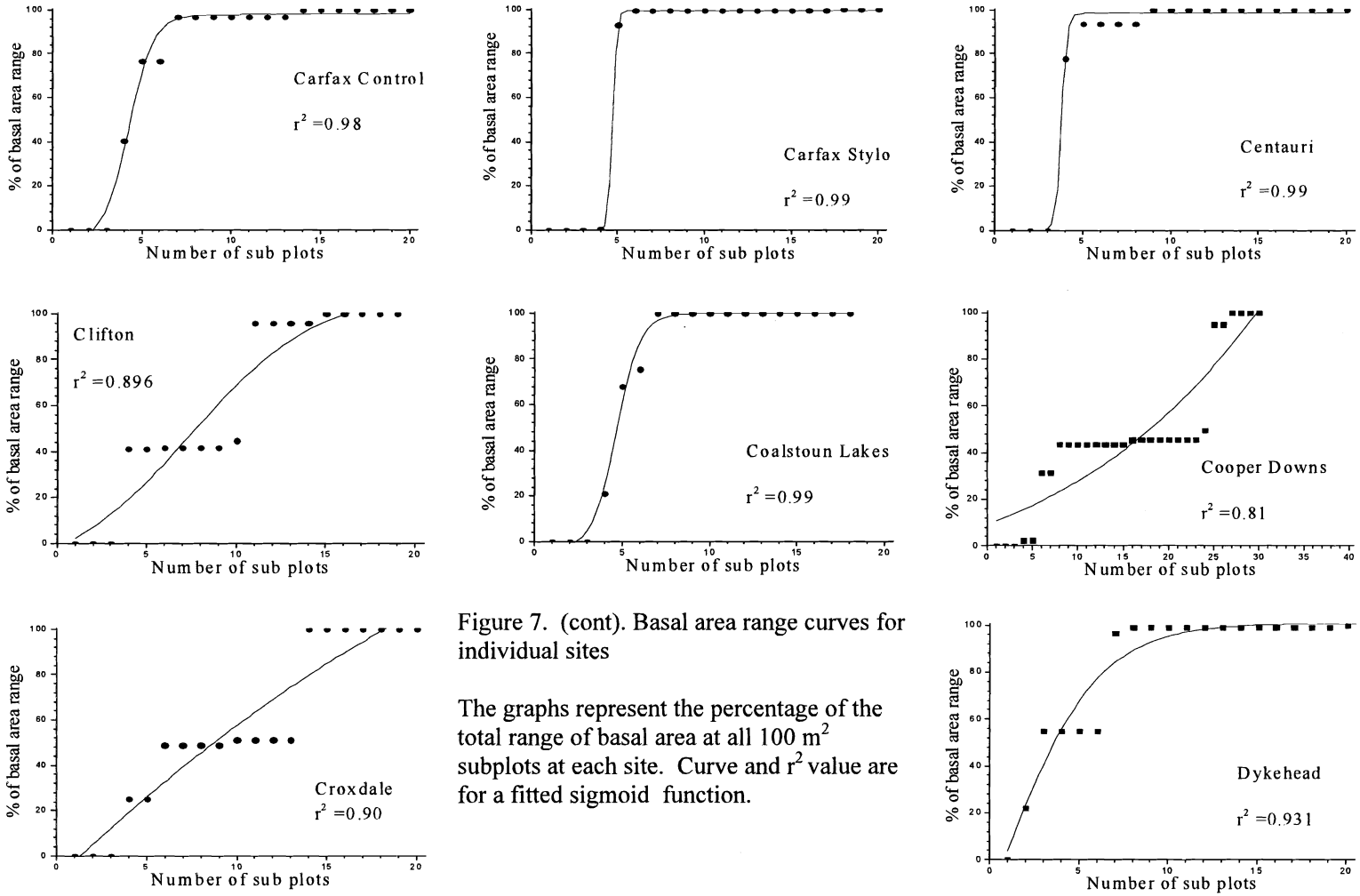


Figure 7. (cont). Basal area range curves for individual sites

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

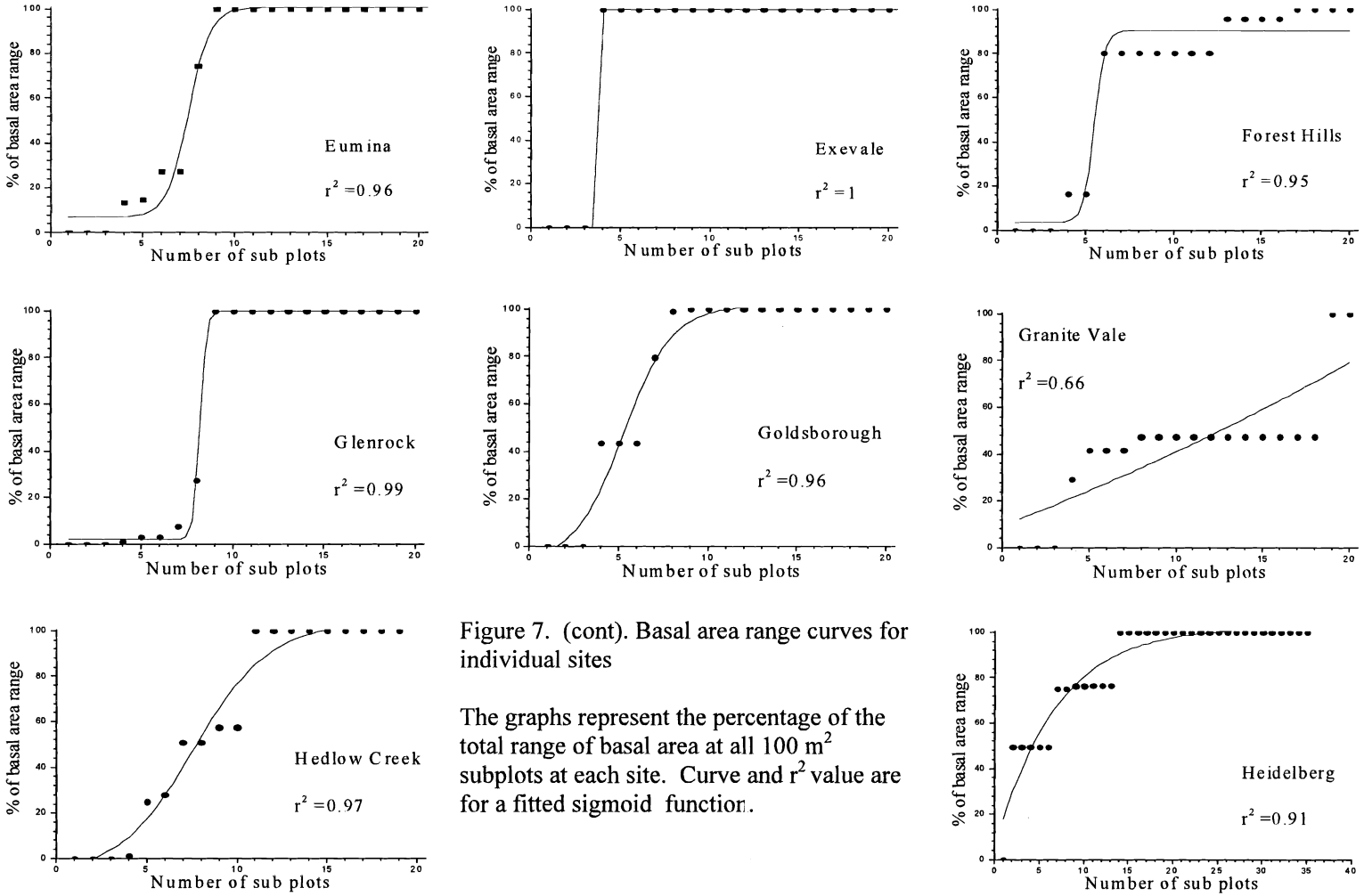


Figure 7. (cont). Basal area range curves for individual sites

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

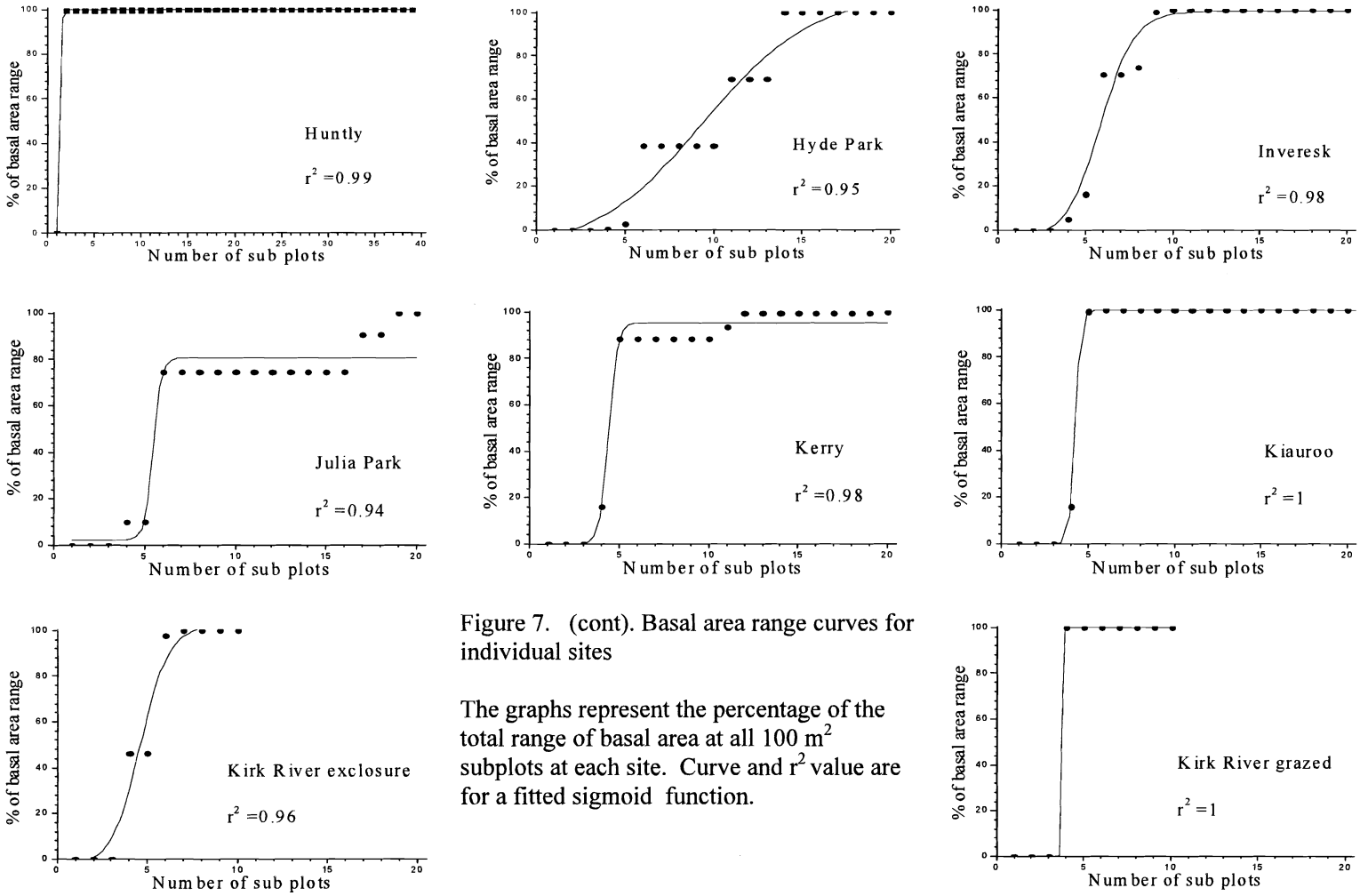


Figure 7. (cont). Basal area range curves for individual sites

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

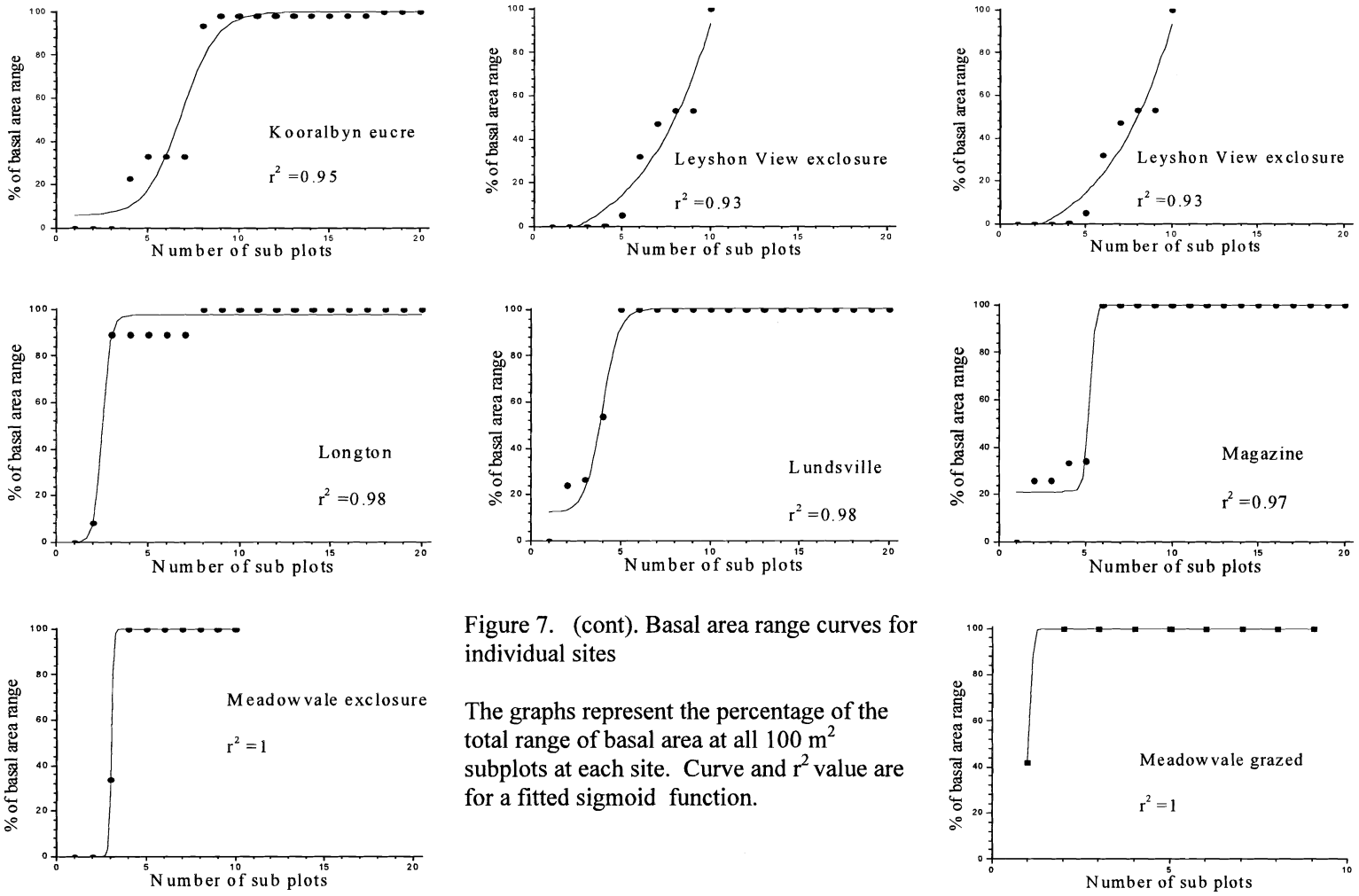


Figure 7. (cont). Basal area range curves for individual sites

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

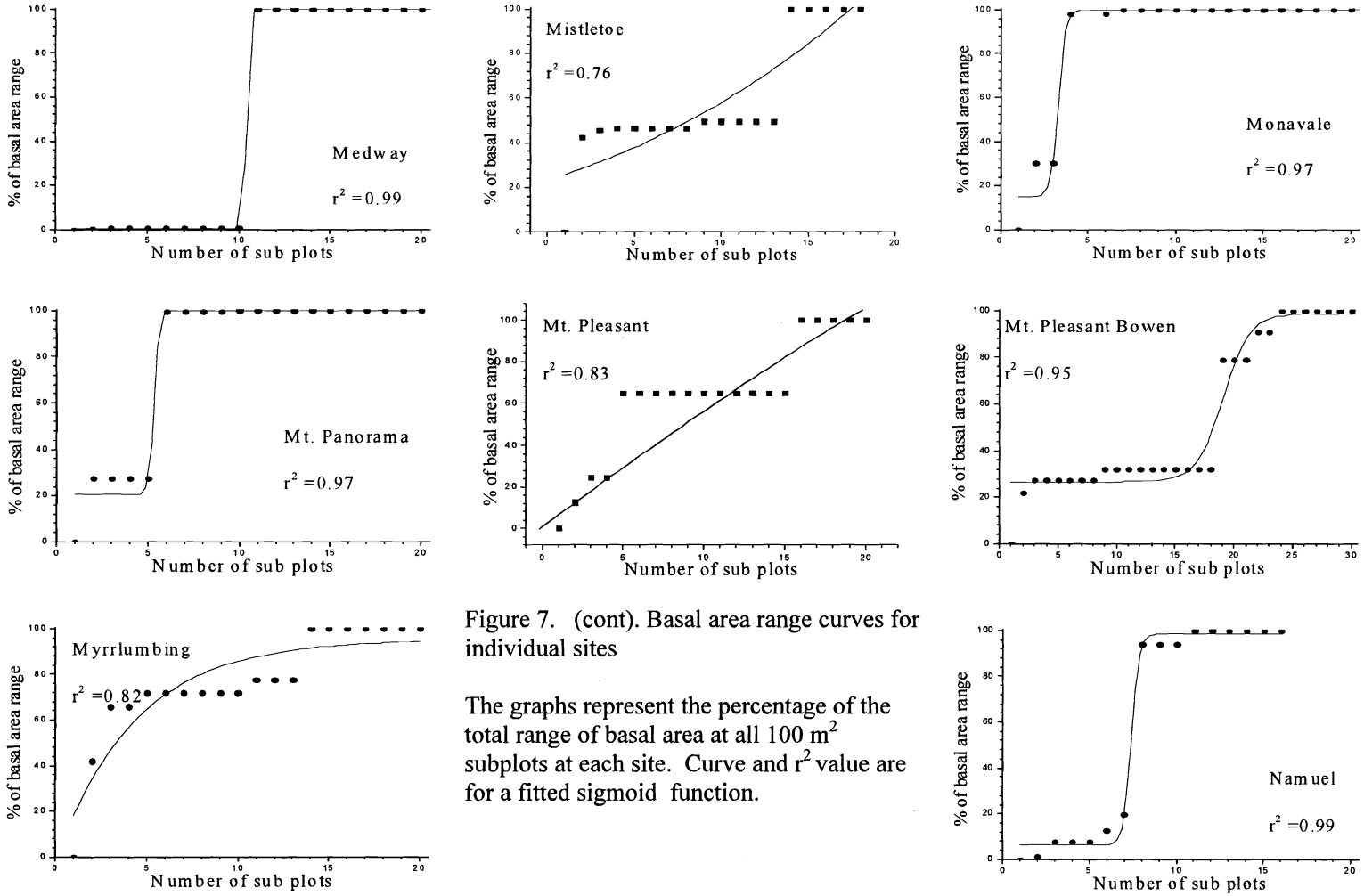


Figure 7. (cont). Basal area range curves for individual sites

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

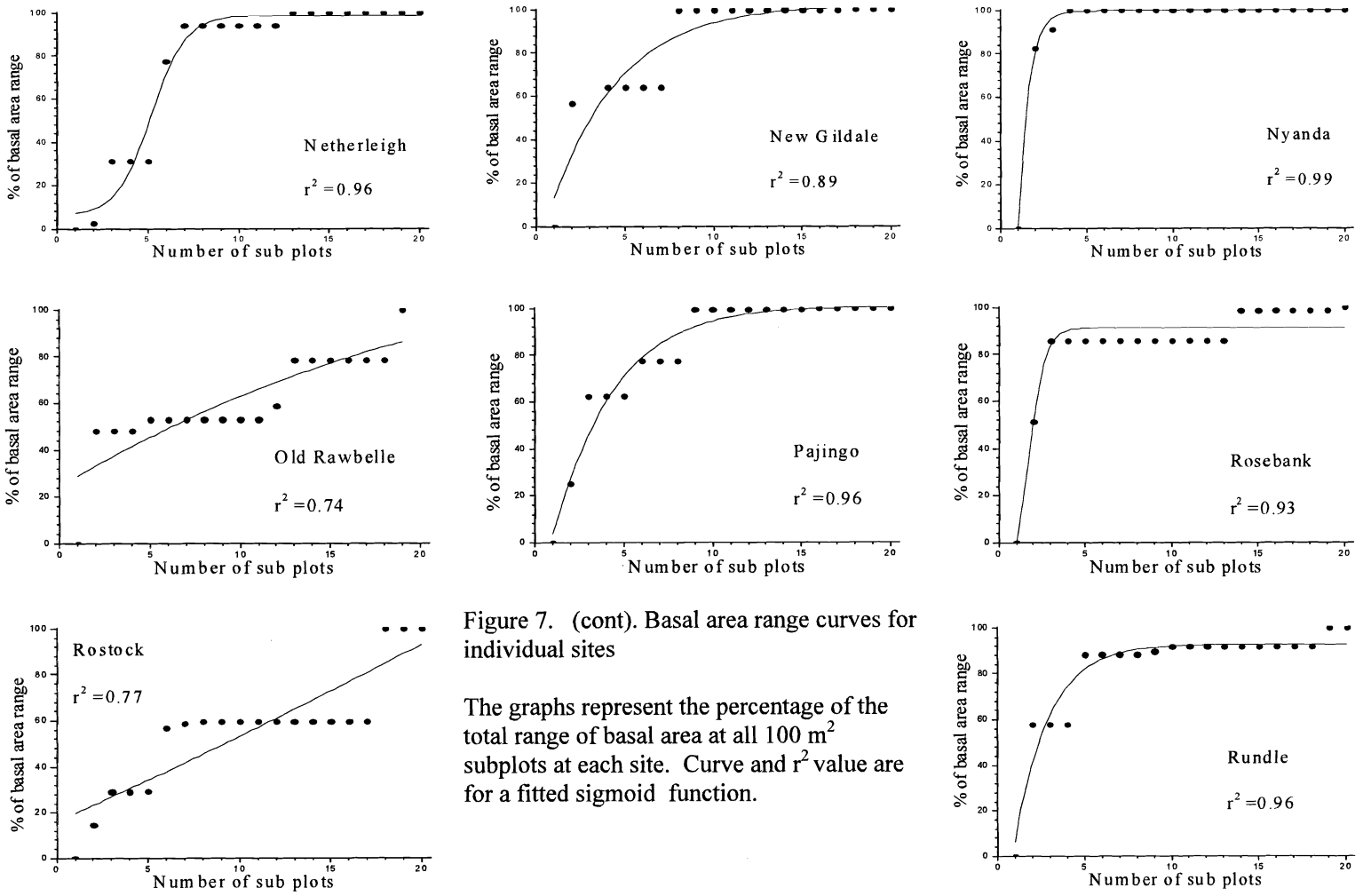
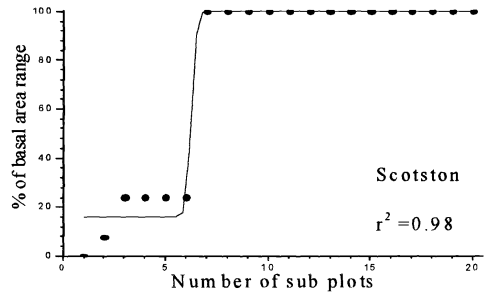
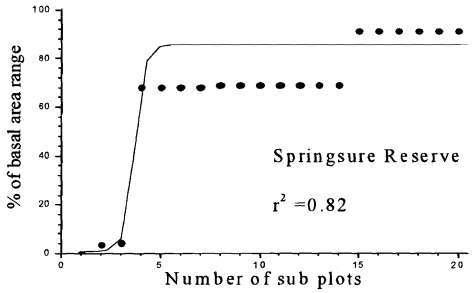
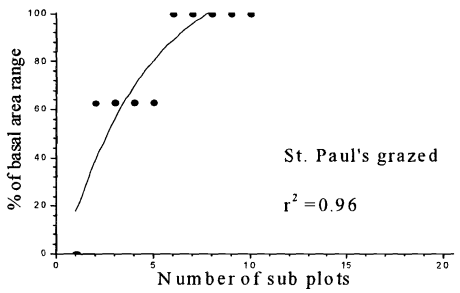


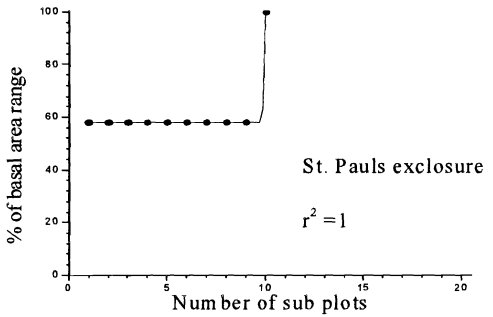
Figure 7. (cont). Basal area range curves for individual sites

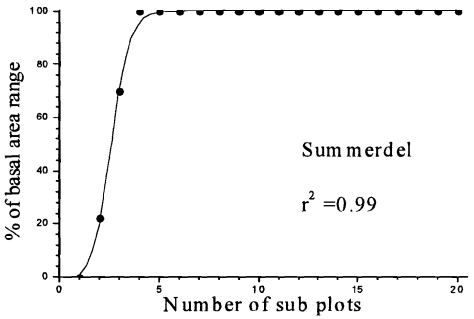
The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

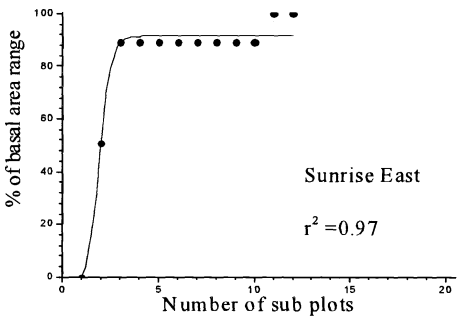












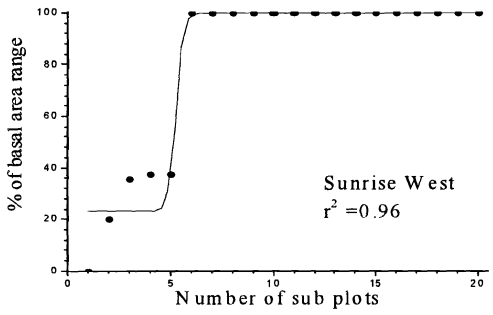
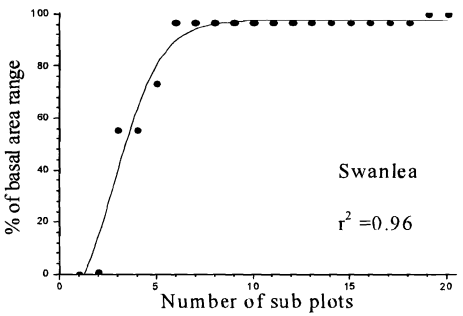
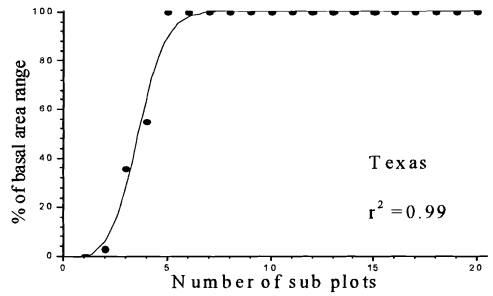
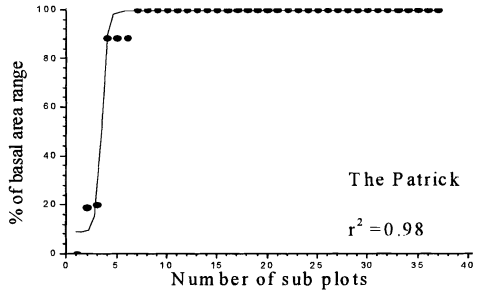


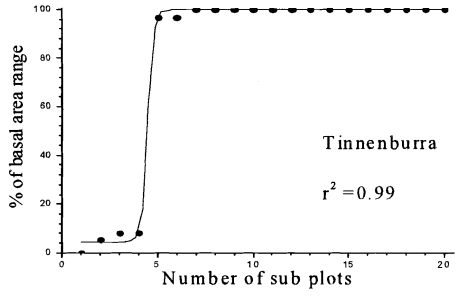
Figure 7. (cont). Basal area range curves for individual sites

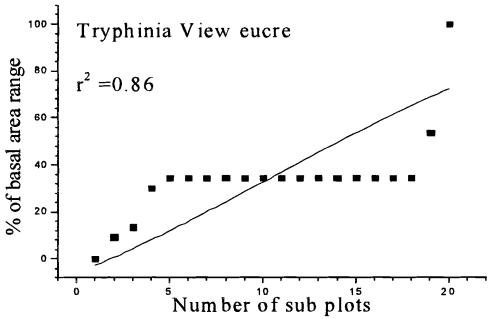
The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

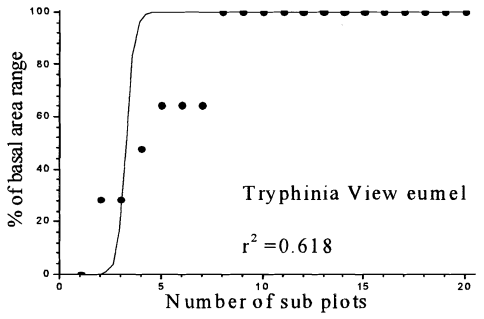


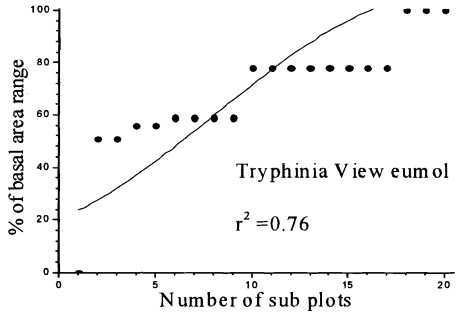












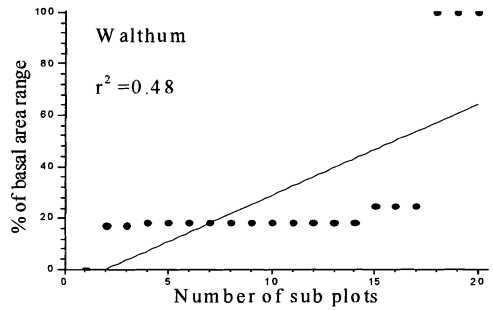
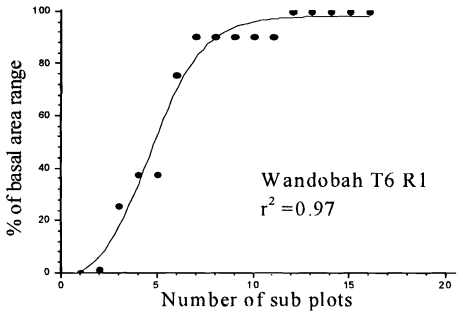


Figure 7. (cont). Basal area range curves for individual sites

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.



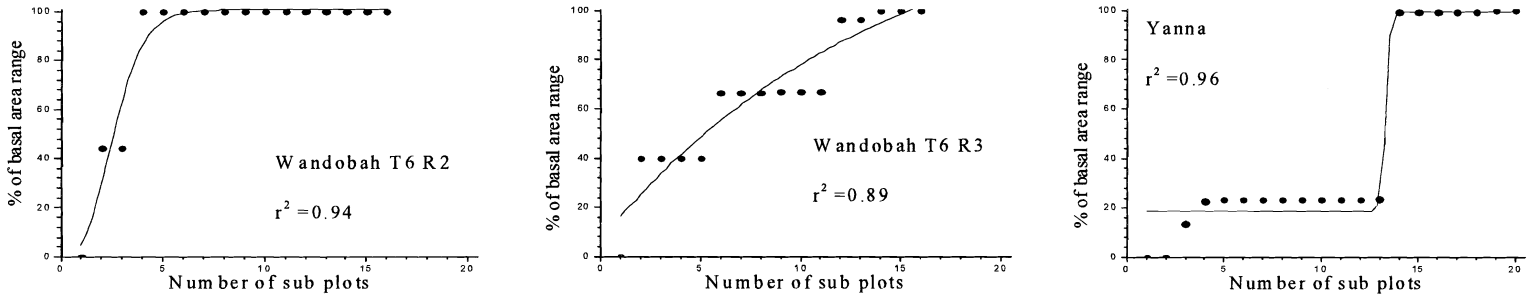


Figure 7. (cont). Basal area range curves for individual sites

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

indicate sites at which the curve is still rising at the end of sampling. Fifty-five of the 75 sites fell within this range, indicating that additional sampling is required to capture the full variation in basal area at the remaining sites.

Basal area variation was asymptotic and the upper asymptote within the 90-105 range for all woodland types excepting Desert Uplands (Figure 8, Table 7) indicating that sampling effort was sufficient for all save one woodland type. Within the desert uplands no asymptote as apparent, suggesting that a much greater sample area may be required to capture the full diversity of basal area variation.

Basal area changes were primarily due to plant death and changes within the initial plant population, with new plants making only minor contributions to basal area at all sites (Figure 9). As a consequence very similar basal area changes were seen for both large and small trees. Several sites experienced an overall decrease in the basal area of surviving plants due to the widespread death of original stems followed by re-shooting from roots or coppicing below the 30 cm level of measurement. The basal area of plants >300 mm circumference decreased by the same order of magnitude, declining from 11.7 to 11.5 m^2/ha, an average of 0.03 m^2/ ha/year (0.8%), (Appendix 1, Table 2).

The majority of sites (42 of the 75) experienced an increase in total basal area between first and last recordings with the remaining 33 sites experiencing a

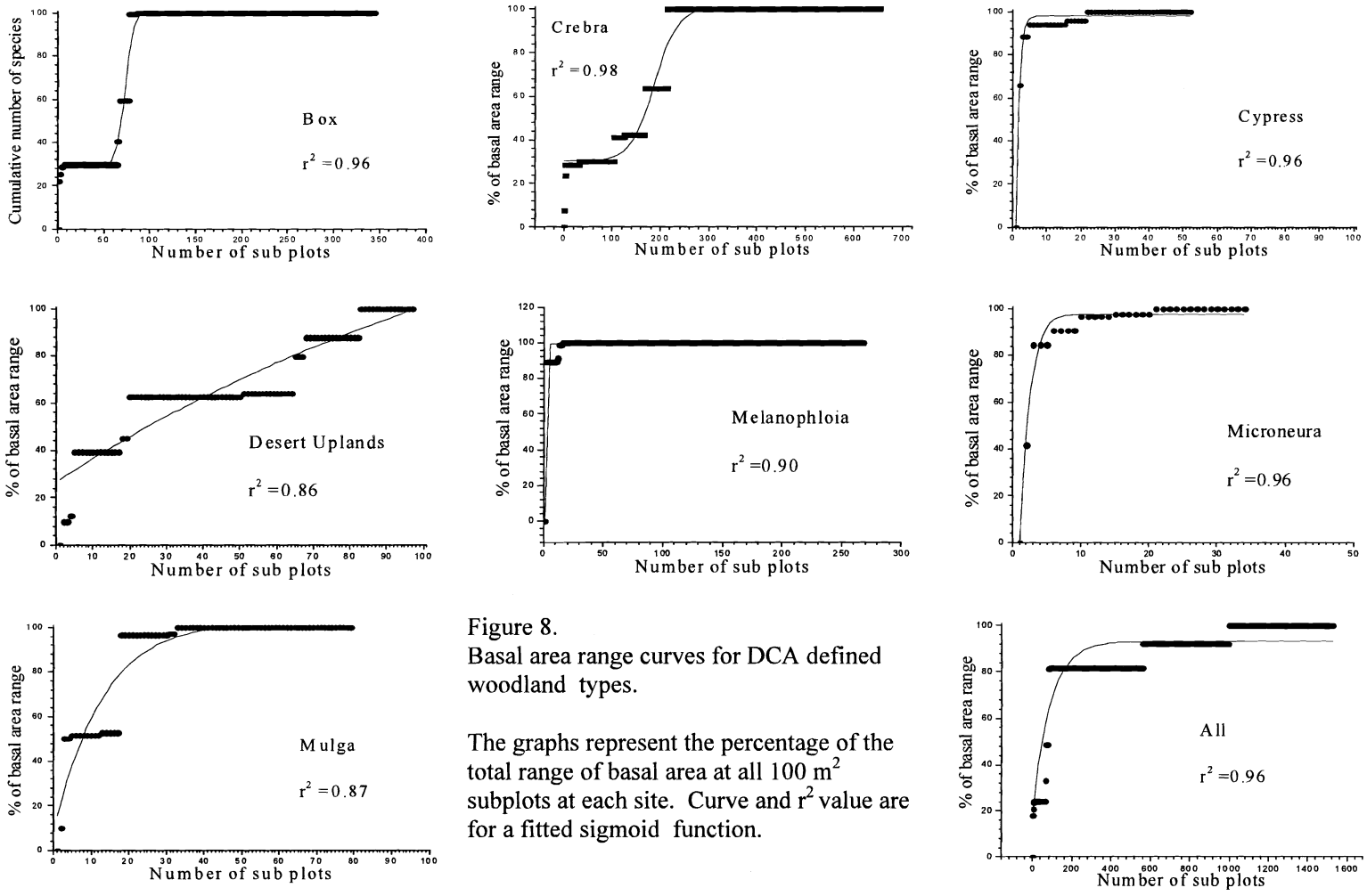


Figure 8.
Basal area range curves for DCA defined woodland types.

The graphs represent the percentage of the total range of basal area at all 100 m^2 subplots at each site. Curve and r^2 value are for a fitted sigmoid function.

Table 7.
Upper asymptote values for sigmoidal functions fitted to basal area accumulation curves for woodland types.

Woodland type	Upper Asymptote
Box	100
Crebra	101
Cypress	98
Desert Uplands	170
Melanophloia	100
Microneura	98
Mulga	102
All	93

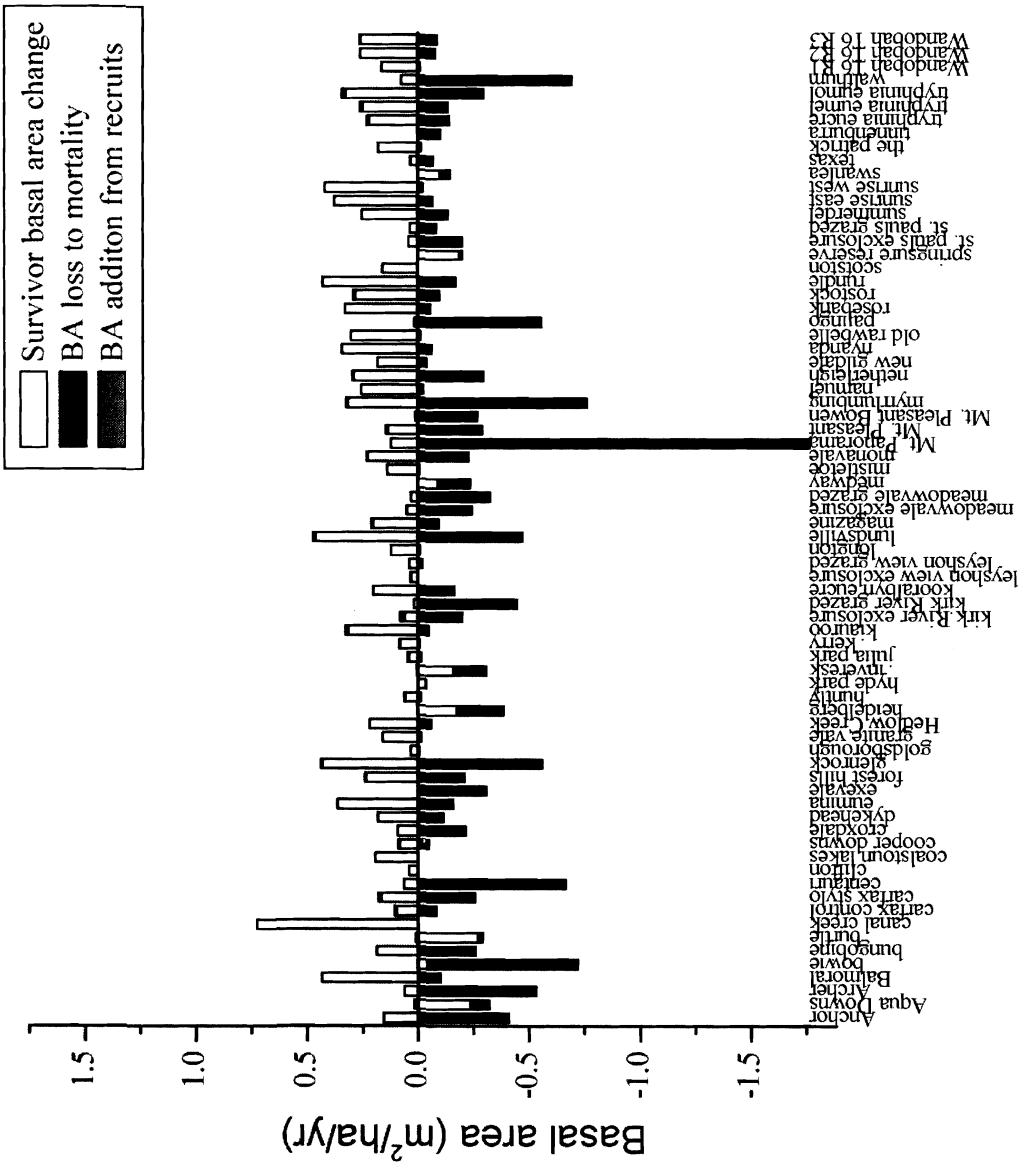


Figure 9.
Change in basal area by site illustrating the relative contributions of recruitment and mortality to basal area changes.

decrease. The mean change for those sites experiencing a decrease was -0.29 m^2/ ha/year or an annual decrease of 3.68% of the initial area. The mean change for those sites experiencing an increase was 0.16 m^2/ha/year or an annual increase of 1.57% of the initial density.

Within individual sites the largest absolute basal area decrease for all plants was 1.64m^2/ha/year or a loss of 3.68% of the initial basal area/year. The site with the largest absolute increase in basal area experienced a positive change of 0.72m^2/ha/ year or 3.29% of the initial basal area. The largest relative basal area increase was 10.97% of the initial basal area/year or 0.04m^2/ha/year. The site experiencing the largest relative basal area decrease for all plants showed a decrease of 33.84% of initial basal area annually, or 0.31m^2/ha/year.

BOX, CREBRA and DESERT UPLANDS woodlands experienced a decrease in total basal area, although the loss was minor and insignificant at 0.01m^2/ha/year (0.74% of the initial basal area/yr). CREBRA, DESERT UPLANDS and MELANOPHLOIA woodlands also showed an approximately stable basal area while the remaining woodlands demonstrated slight though still insignificant increases (Table 5).

There was a significant difference in basal area between the different woodland types at both first and last recording (Kruskall-Wallis test, significance 0.04 for

both initial and final recordings respectively). A post-hoc nonparametric equivalent of Tukey's Honestly Significant Difference test (Zar 1984) indicated that the difference lay primarily between CYPRESS and DESERT UPLANDS woodlands and between CYPRESS and MULGA woodlands for both initial and final recordings (Table 8). The basal area change rate (m^2/ha/yr) did not differ significantly between woodland types (Kruskall-Wallis test, $p = 0.23$).

No obvious pattern emerged from the relative annual basal area change across size classes within woodland types. The only significant changes in basal area within size classes occurred within the 0-300 mm circumference class for BOX and MELANOPHLOIA woodland types.

A plot of cumulative basal area with increasing species count revealed a much greater dominance by a few species than a similar plot of cumulative plant numbers for all woodland types (Figure 10, Figure 11). Species have been ordered based on their contribution to basal area in Figure 10 and their contribution of plant numbers in Figure 11, so that species with the highest number of individuals or basal area were counted first. The plot of the DESERT UPLANDS type woodland showed a slower rate of increase in the number of species with increasing plant numbers than the other woodland types, with the most abundant 10% of species comprising approximately 55% of individuals compared to 65 - 80% of individuals in other woodland types.

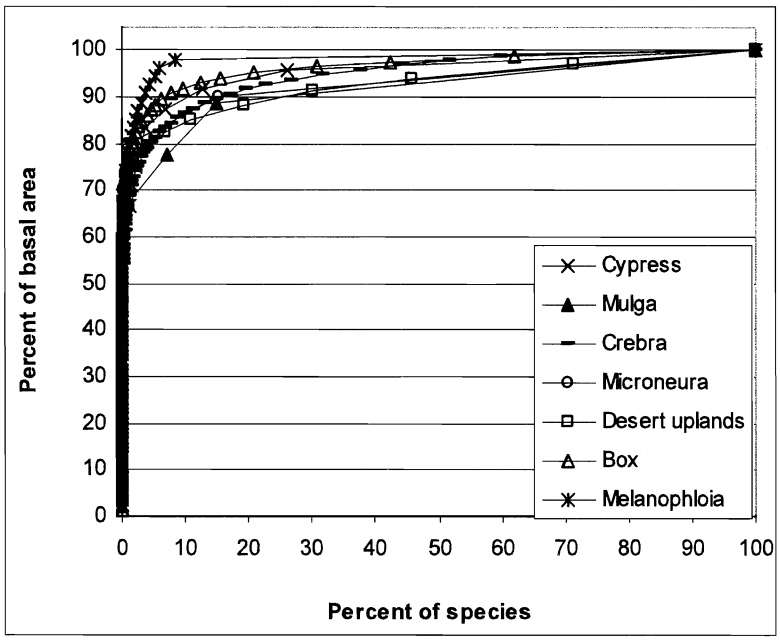


Figure 10.
Cumulative percentage of basal area as a function of the cumulative percentage of species for each of the woodland types. Data are ordered by basal area per species.

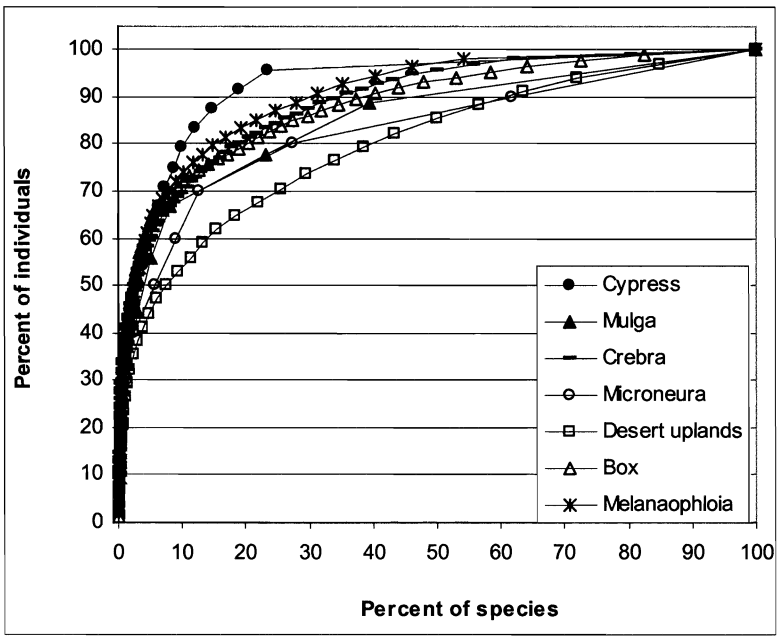


Figure 11.
Cumulative percentage of individuals as a function of the cumulative percentage of species for each of the woodland types. Data are ordered by number of individuals per species.

Table 8.
Tukey's honestly significant difference test results for a comparison of basal area between woodland types at initial and final recordings.

Initial Recording

Woodland type	Box	Crebra	Cypress	Desert uplands	Melanophloia	Microneura
Crebra	0.89					
Cypress	0.46	0.14				
Desert uplands	0.46	0.82	0.05			
Melanophloia	1.00	1.00	0.28	0.75		
Microneura	0.99	1.00	0.46	1.00	1.00	
Mulga	0.36	0.73	0.04	1.00	0.65	0.99

Final Recording

Woodland type	Box	Crebra	Cypress	Desert uplands	Melanophloia	Microneura
Crebra	0.95					
Cypress	0.30	0.09				
Desert uplands	0.62	0.89	0.05			
Melanophloia	1.00	0.99	0.29	0.70		
Microneura	1.00	1.00	0.51	0.99	1.00	
Mulga	0.55	0.83	0.04	1.00	0.63	0.99

3.4 Mortality

The annual mortality rate for an amalgamation of all sites for all plants was 80 plants/ha/yr, or 6% of the initial density per year (Table 9). For plants >300 mm circumference the annual mortality rate was 2.91 plants/ha/yr or a loss 1.60% of the initial density annually (Appendix 1, Table 3). Absolute mortality within sites ranged from 0 plants/ha/yr to 371 plants/ha/yr while relative mortality ranged from 0% to 34% of the initial plant density per year. Mortality for plants >300 mm circumference varied between 0 plants/ha/yr and 16 plants/ha/yr. Relative mortality for plants >300 mm circumference varied between 0% and 15% of the initial density annually. For individual woodland types absolute mortality varied from 123 plants/ha/yr to 19 plants/ha/yr for all plants, while relative mortality varied between 2% per year and 6% per year . One site, "Exevale", recorded very high levels of relative total mortality and relative mortality for plants >300 mm circumference. This was attributed to the site being affected by severe drought induced dieback prior to establishment. As a result woody plant densities were low and residual effects of the drought caused further mortalities in surviving but weakened plants.

There was no significant difference in percentage mortality between the different woodland types for pooled data or for size classes (Table 9). Differing size classes did vary significantly in percentage mortality within the BOX and CREBRA woodlands and for the pooled site data. There were insufficient cases of mortality

Table 9.
Mortality rates (plants/ha/yr) by circumference class and total in the woodland types under study. "Mort. %" is the annual mortality rate as a percentage of the initial site density.

Sig is significance calculated using Kruskall-Wallis test.
† = insufficient cases for anlysis.

	Box Woodland		Crebra Woodland		Cypress Woodland		Desert Upland Woodland		Melanophloia Woodland		Microneura Woodland		Mulga Woodland		Total	
Circumference Class (mm)	Mort/ ha/year	Mort (%)	Mort/ ha/year	Mort (%)	Mort/ ha/year	Mort (%)	Mort/ ha/year	Mort (%)	Mort/ ha/year	Mort (%)	Mort/ ha/year	Mort (%)	Mort/ ha/year	Mort (%)	Mort/ ha/year	Mort (%)
0-300	118.85	6.7	68.17	5.35	105.34	5.1	95.44	8.07	43.5	4.46	24.49	13.06	70.18	5.9	75.14	6.95
300-600	2.34	2.4	1.33	1.81	0.98	0.64	1.97	1.85	0.53	1.02	0	0	0	0	0.75	1.55
600-900	1.28	4.43	0.87	2.22	1.01	1.32	0.6	2.99	0.3	1.34	0	0	0.46	4.56	4.58	2.81
900-1200	0.99	6.6	0.39	2.32	0	0	0	0	0.21	1.58	0	0	0.46	12.17	0.51	5.67
1200-1500	0.1	5.57	0.29	3.35	0	0	0	0	0.05	1.3	0	0	0	0	0.15	3.41
1500-1800	0.06	3.33	0.07	6.34	_	_	0	0	0.05	4.56	0	0	_	_	0.06	4.74
1800-2100	0.18	30.25	0.12	8.53	0	0	0	0	0.16	42.74	0	0	0	0	0.15	27.17
2100-2400	0.02	10.5	0	0	_	_	_	_	0	0	0	0	_	_	0.02	10.5
2400-2700	0.04	14.71	0	0	0	0	_	_	_	_	0	0	0	0	0.04	14.71
2700-3000	0	0	0	0	0	0	_	_	_	_	0	0	0	0	0	0
3000-3300	0	0	_	_	_	_	_	_	_	_	_	_	_	_	_	_
<3300	0.04	4.9	_	_	_	_	_	_	_	_	_	_	_	_	0.04	4.9
Total	123.89	6.64	71.22	6.33	107.33	3.77	98.01	6.54	44.81	5.42	24.49	11.49	71.09	6.61	80.21	6.43

within individual size classes to conduct post hoc tests to investigate these differences for the individual woodlands, however for the amalgamated data a nonparametric Tukey's honestly significant difference test was conducted. This clearly indicated that the difference exists primarily between the smallest size class and all larger sizes (Table 10). Despite this, no clear pattern was evident in mortality linked to diameter classes and the variation was large among the four largest classes.

3.5 Recruitment

The annual recruitment rate for all sites for all species was 94 plants/ha/yr, or 7% of the initial density. Absolute recruitment within sites ranged from 0 plants/ha/yr to 464 plants/ha/yr while relative recruitment ranged from 0% to 25% of the initial plant density annually (Table 11). Within woodland types absolute recruitment ranged from 27 plants/ha/yr to 217 plants/ha/yr while relative recruitment ranged from 1% to 13% of the initial plant density (Table 11). The recruitment rate (plants/ha/yr) did not differ significantly between woodland types (Kruskall-Wallis test, significance 0.63). Three sites recorded recruitment rates >20%. In the case of one of these sites, "Inveresk" this was apparently due to a fire just prior to site establishment. Numerous smaller plants had been razed by the fire and had not re-sprouted by the time of the initial recording. The other two sites, "Mistletoe" and "Coalstoun Lakes" showed large relative density increases because total density

Table 10.
Tukey's honestly significant difference test results for a comparison of mortality rates between woodland types.

	0-300	300-600	600-900	900-1200	1200-1500	1500-1800	1800-2100	2100-2400	2400-2700	2700-3000
300-600	<0.01									
600-900	<0.01	1								
900-1200	<0.01	1	1							
1200-150(	<0.01	1	1	1						
1500-180(	0.03	1	1	1	1					
1800-210(	0.01	1	1	1	1	1				
2100-240(	0.04	1	1	1	1	1	1			
2400-270(	0.01	1	1	1	1	1	1	1		
2700-300(	<0.01	1	1	1	1	1	1	1	1	
3000-330(	_	_	_	_	_	_	_	_	_	
<3300	<0.01	1	1	1	1	1	1	1	1	1

Table 11.
Recruitment rates for individual sites grouped by DCA determined woodland types.

Woodland Type	Transect	Recruitment (plants/ha/yr)	Annual recruitment as % of initial density
Box	Aqua Downs	80.18	5.94
	Bungobine	180.43	4.77
	Carfax control	105.04	5.28
	Carfax stylo	67.97	3.29
	Centauri	355.83	8.20
	Coalstoun Lakes	18.53	26.96
	Hedlow Creek	15.40	1.31
	Magazine	124.14	6.88
	Medway	13.96	3.36
	Mt. Panorama	13.63	2.27
	Myrrlumbing	81.46	11.47
	Pajingo	132.78	11.60
	Texas	20.00	2.72
	Walthum	145.84	16.62
	Wandobah T6 R1	160.93	10.91
	Wandobah T6 R2	145.66	4.33
	Wandobah T6 R3	69.29	2.86
n		17	17
Mean		101.83	7.57
Std. Error of Mean		20.93	1.58
Cypress	Eumina	197.08	12.34
	Rostock	255.58	11.94
	Sunrise east	199.16	7.33
n		3.00	3.00
Mean		217.27	10.54
Std. Error of Mean		19.16	1.61
Desert uplands	Inveresk	463.73	24.67
	Julia Park	99.57	7.66
	Swanlea	144.75	8.25
	The Patrick	56.72	11.66
n		4	4
Mean		191.19	13.06
Std. Error of Mean		92.61	3.97

Table 11 (cont).
Recruitment rates for individual sites grouped by DCA determined woodland types.

Woodland Type	Transect	Recruitment (plants/ha/yr)	Annual recruitment as % of initial density
Melanophloia	Bowie	166.61	16.83
	Burtle	253.08	18.14
	Cooper Downs	8.83	2.29
	Dykehead	42.06	4.04
	Hyde Park	29.70	2.98
	Kerry	142.31	6.06
	Longton	34.11	3.50
	Mt. Pleasant	46.18	4.59
	Nyanda	31.70	4.59
	Old Rawbelle	51.96	9.12
	Summerdel	85.17	4.00
	Sunrise west	226.70	17.24
	Tryphinia eumel	26.52	3.90
n		13	13
Mean		88.07	7.48
Std. Error of Mean		22.69	1.64
Microneura	Mistletoe	79.58	22.74
	Namuel	5.62	1.94
n		2	2
Mean		42.60	12.34
Std. Error of Mean		36.98	10.40
Mulga	Clifton	0.00	0.00
	Croxdale	1.82	0.21
	Tinnenburra	92.36	2.74
	Yanna	12.77	1.60
n		4	4
Mean		26.74	1.14
Std. Error of Mean		22.06	0.64
Total			
n		75	75
Mean		93.97	6.70

Table 11 (cont).
Recruitment rates for individual sites grouped by DCA determined woodland types.

Woodland Type	Transect	Recruitment (plants/ha/yr)	Annual recruitment as % of initial density
Crebra	Anchor	51.70	3.26
	Archer	29.57	3.25
	Balmoral	11.92	0.85
	Canal Creek	173.93	5.13
	Exevale	2.03	1.21
	Forest Hills	386.04	8.98
	Glenrock	373.09	10.83
	Goldsborough	26.24	2.65
	Granitevale	5.20	0.56
	Heidelberg	19.02	7.25
	Huntly	21.95	5.05
	Kiauroo	29.12	3.57
	Kirk River exclosure	16.44	1.93
	Kirk River grazed	10.96	0.76
	Kooralbyn eucre	158.57	2.62
	Leyshon view exclosure	30.39	7.37
	Leyshon view grazed	32.48	5.99
	Lundsville	128.26	4.66
	Meadowvale exclosure	84.58	9.14
	Meadowvale grazed	39.55	6.88
	Monavale	304.77	8.20
	Mt. Pleasant Bowen	140.38	16.17
	Netherleigh	31.39	2.43
	New gildale	35.95	5.47
	Rosebank	250.17	11.53
	Rundle	41.45	4.43
	Scotston	48.28	6.57
	Springsure reserve	8.02	1.83
	St. pauls exclosure	8.36	3.93
	St. pauls grazed	12.62	6.16
	Tryphinia eucre	37.61	3.07
	Tryphinia eumol	12.86	1.93
N		32	32
Mean		80.09	5.11
Std. Error of Mean		18.93	0.63

was low. Absolute numbers of new plants at each site were no higher than for a majority of sites.

3.6 Height

The mean height of all plants for amalgamated site data decreased from 2.54 to 2.33 m between first and last recordings (Table 12). Taking into account differing transect sizes and periods of measurement this equates to a loss of 0.06 m/year or 2.4% of the initial mean height. The mean height of plants >300 mm circumference remained stable at 11.4 m (Appendix 1, Table 4). The majority of sites (45 of the 75) experienced a decrease in mean height between first and last recordings, with 30 sites experiencing an increase and two remaining stable. A total of was 0.5 m/ year was gained at the site with greatest increase in mean height, while 1.5 m was lost annually at the site with the greatest decrease.

There was no significant difference in mean tree height between the different woodland types at either first or last recording (Kruskall-Wallis test, significance 0.48 for both initial and final recordings). Within the recording period plant height decreased for woodlands overall and for BOX, CREBRA, CYPRESS, MELANOPHLOIA, and MICRONEURA woodland types, while the MULGA and DESERT UPLANDS woodlands experienced an increase in height. The height change rate (m/yr) did not differ significantly between woodland types (Kruskall-Wallis test, $p = 0.37$).

Table 12.
Mean tree height (m) by circumference class and total in the woodland types under study. "Change" is the annual change in plant height. "Change %" is the annual change as a percentage of the initial hieght. "Sig" is the Wilcoxon's matched pairs significance for comparison of initial and final values.

	Box Woodland					Crebra Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	0.97	1.04	0.01	0.90	0.36	0.77	0.83	0.01	0.82	0.18
300-600	8.73	8.67	-0.01	-0.09	0.87	8.74	8.18	-0.05	-0.62	0.49
600-900	12.01	12.10	0.01	0.09	0.92	12.28	11.78	-0.05	-0.40	0.21
900-1200	14.41	14.99	0.07	0.52	0.41	15.03	14.91	-0.01	-0.08	0.69
1200-1500	15.84	16.76	0.12	0.75	0.18	16.48	16.50	0.00	0.01	0.69
1500-1800	18.22	17.93	-0.04	-0.21	0.95	16.98	18.47	0.14	0.84	0.29
1800-2100	18.25	20.03	0.23	1.27	0.26	18.65	17.15	-0.14	-0.78	0.36
2100-2400	16.57	17.38	0.11	0.64	0.61	19.95	25.75	0.56	2.81	0.07
2400-2700	21.09	19.18	-0.25	-1.17	0.72	19.68	19.20	-0.05	-0.23	0.66
2700-3000	20.43	18.18	-0.29	-1.43	0.29	0.00	18.23	18.23	_	1.00
3000-3300	13.70	18.40	0.61	4.45	1.00	_	_	_	_	_
>3300	20.25	19.75	-0.06	-0.32	0.66	_	_	_	_	_
Total	2.27	2.23	-0.01	-0.25	0.33	2.45	2.05	-0.04	-1.61	0.87

	Cypress Woodland					Desert Upland Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	2.29	1.82	-0.19	-8.36	0.59	0.90	1.02	0.06	7.14	0.47
300-600	10.12	10.55	0.18	1.78	0.29	5.98	6.21	0.12	2.04	0.47
600-900	13.58	13.37	-0.09	-0.66	1.00	7.92	7.98	0.03	0.38	0.47
900-1200	14.58	15.00	0.17	1.19	1.00	9.00	9.64	0.35	3.83	0.47
1200-1500	22.00	16.08	-2.46	-11.17	1.00	12.25	10.29	-1.06	-8.65	0.18
1500-1800	_	_	_	_	_	15.60	12.70	-1.56	-10.03	0.73
1800-2100	11.20	11.00	-0.08	-0.74	0.66	0.00	15.90	15.90	100.00	1.00
2100-2400	_	_	_	_	_	_	_	_	_	_
2400-2700	30.00	24.70	-2.20	-7.32	0.45	_	_	_	_	_
2700-3000	19.50	0.00	-19.50	_	1.00	_	_	_	_	_
3000-3300	_	_	_	_	_	_	_	_	_	_
>3300	_	_	_	_	_	_	_	_	_	_
Total	4.46	3.98	-0.20	-4.44	0.44	1.82	1.87	0.03	1.46	0.90

Table 12 (cont).
Mean tree height (m) by circumference class and total in the woodland types under study. "Change" is the annual change in plant height. "Change %" is the annual change as a percentage of the initial height. "Sig" is the Wilcoxon's matched pairs significance for comparison of initial and final values.

	Melanophloia Woodland					Microneura Woodland				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	1.07	1.12	0.01	0.59	0.65	1.40	1.25	-0.08	-5.90	0.66
300-600	8.46	8.06	-0.05	-0.58	0.51	6.44	6.74	0.16	2.55	0.18
600-900	12.31	11.55	-0.09	-0.76	0.04	8.27	8.68	0.23	2.75	0.18
900-1200	13.48	13.69	0.03	0.19	0.75	8.24	9.42	0.66	8.02	0.18
1200-1500	14.12	14.24	0.01	0.10	0.88	9.37	10.64	0.71	7.59	0.18
1500-1800	15.87	16.24	0.05	0.29	0.59	5.15	7.32	1.21	23.57	0.18
1800-2100	15.93	16.97	0.13	0.80	0.80	10.33	8.27	-1.16	-11.20	0.45
2100-2400	12.10	10.10	-0.25	-2.03	0.35	_	_	_	_	_
2400-2700	17.90	17.90	>0.01	>0.01	1.00	_	_	_	_	_
2700-3000	_	_	_	_	_	_	_	_	_	_
3000-3300	_	_	_	_	_	_	_	_	_	_
>3300	_	_	_	_	_	_	_	_	_	_
Total	3.04	2.86	-0.02	-0.70	0.75	3.98	3.81	-0.10	-2.41	0.08

	Mulga Woodland					Total				
Circumference class (mm)	Initial	Final	Change	Change (%)	Sig	Initial	Final	Change	Change (%)	Sig
0-300	2.09	2.10	>0.01	0.06	0.72	1.02	1.06	>0.01	0.45	0.08
300-600	6.74	7.08	0.15	2.25	0.72	8.42	8.16	-0.03	-0.39	0.44
600-900	8.60	8.97	0.17	1.93	0.11	11.78	11.47	-0.04	-0.34	0.11
900-1200	8.18	8.40	0.10	1.23	0.66	13.83	14.05	0.03	0.20	0.59
1200-1500	10.28	11.09	0.36	3.55	0.27	15.20	15.40	0.03	0.17	0.35
1500-1800	11.15	9.50	-0.74	-6.61	0.66	16.19	16.89	0.09	0.54	0.43
1800-2100	_	_		_	_	17.27	17.18	-0.01	-0.07	0.88
2100-2400	_	_		_	_	17.32	19.56	0.28	1.63	0.14
2400-2700	_	_		_	_	21.45	19.72	-0.22	-1.02	0.40
2700-3000	_	_		_	_	20.20	18.18	-0.26	-1.26	0.29
3000-3300	_	_		_	_	13.70	18.40	0.59	4.32	1.00
>3300	_	_		_	_	20.25	19.75	-0.06	-0.31	0.66
Total	2.53	2.84	0.13	5.30	0.36	2.54	2.33	-0.06	-2.36	0.17

Mean height did not change significantly overall or within woodland types (Table 12). A marginally significant change (Wilcoxon's matched pairs, $p = 0.07$) in height did occur in the 2100-2400 mm circumference class for the CREBRA woodland type and the 600-900 mm circumference class for the MELANOPHLOIA woodland. The smaller size classes (<900 mm circumference) showed less fluctuation in mean height in absolute terms, though the relative changes were comparable to the larger size classes in many cases. This suggests that, although large changes in height aren't occurring within the smaller size classes, plant heights are still dynamic within that class.

3.9 Size Class Distributions

The frequency distributions of stem circumference classes did not differ significantly between first and last recordings for any site or woodland type or for any of the selected species for amalgamated site data (Tables 13 - 15).

The greatest density of plants occurred in the smallest circumference class at both initial and final recordings for all but one site (Figure 12). The exception was the "Namuel" site where there was a slightly lower density of trees in 0-300 mm circumference class than in the next largest.

Table 13.
Probabilities for Kolmogorov-Smirnov test comparing initial and final circumference class distributions for individual sites.
Sig. dom = Significance for species contributing the greatest amount of basal area at each site.
Sig total = Significance for all species.

Transect name	sig. dom	sig. total
Anchor	0.54	0.94
Aqua Downs	0.82	1.00
Archer	0.89	0.82
Balmoral	0.89	0.89
Bowie	1.00	1.00
Bungobine	1.00	1.00
Burtle	0.94	0.94
Canal Creek	1.00	1.00
Carfax Control	1.00	1.00
Carfax Stylo	0.99	1.00
Centauri	1.00	1.00
Clifton	0.96	1.00
Coalstoun Lakes	0.99	1.00
Cooper Downs	1.00	1.00
Croxdale	1.00	1.00
Dykehead	1.00	1.00
Eumina	1.00	1.00
Exevale	0.89	0.89
Forest Hills	1.00	1.00
Glenrock	1.00	1.00
Goldsborough	1.00	1.00
Granite Vale	1.00	1.00
Hedlow Creek	0.94	0.94
Heidelberg	0.94	1.00
Huntly	0.94	0.94
Hyde Park	0.96	1.00
Inveresk	1.00	1.00
Julia Park	1.00	1.00
Kerry	1.00	1.00
Kiauroo	1.00	0.94
Kirk River Exclosure	1.00	1.00
Kirk River Grazed	1.00	0.33
Kooralbyn Eucre	1.00	1.00
Leyshon View Exclosure	1.00	0.52
Leyshon View Grazed	0.94	1.00
Longton	1.00	1.00
Lundsville	0.94	0.94

Transect name	sig. dom	sig. total
Magazine	0.99	0.94
Meadowvale exclosure	1.00	1.00
Meadowvale grazed	1.00	0.82
Medway	1.00	0.89
Mistletoe	1.00	1.00
Monavale	1.00	1.00
Mt. Panorama	1.00	0.94
Mt. Pleasant	0.98	1.00
Mt. Pleasant Bowen	1.00	1.00
Myrrlumbing	1.00	1.00
Namuel	1.00	1.00
Netherleigh	0.89	1.00
New Gildale	1.00	1.00
Nyanda	0.96	1.00
Old Rawbelle	1.00	1.00
Pajingo	1.00	1.00
Rosebank	1.00	1.00
Rostock	1.00	0.89
Rundle	0.94	1.00
Scotston	1.00	1.00
Springsure Reserve	1.00	1.00
St. Pauls Exclosure	0.94	1.00
St. Pauls Grazed	0.94	0.94
Summerdel	0.89	1.00
Sunrise East	1.00	0.94
Sunrise West	1.00	1.00
Swanlea	1.00	1.00
Texas	1.00	1.00
The Patrick	1.00	1.00
Tinnenburra	1.00	0.94
Tryphinia Eucre	0.94	1.00
Tryphinia Eumel	1.00	0.33
Tryphinia Eumol	1.00	1.00
Walthum	0.98	0.52
Wandobah T6 R1	0.70	1.00
Wandobah T6 R2	0.89	1.00
Wandobah T6 R3	1.00	0.94
Yanna	0.89	1.00

Table 14.
Probabilities for Kolmogorov-Smirnov test comparing initial and final circumference class distributions for woodland types and an amalgamation of all sites.

Woodland type	sig.
Box	1.00
Crebra	1.00
Cypress	1.00
Desert uplands	1.00
Melanophloia	1.00
Microneura	1.00
Mulga	1.00
Total	1.00

Table 15.
Probabilities for Kolmogorov-Smirnov test comparing initial and final circumference class distributions for selected species.

Species	sig.
Acacia aneura	1.00
Acacia shirleyii	1.00
Callitris glaucophylla	1.00
Corymbia citriodora	1.00
Corymbia erythrophloia	0.89
Eremophila mitchellii	1.00
Eucalyptus brownii	0.98
Eucalyptus crebra	1.00
Eucalyptus melanophloia	1.00
Eucalyptus populnea	1.00
Melalueca viridiflora	1.00
Petalostigma pubescens	1.00

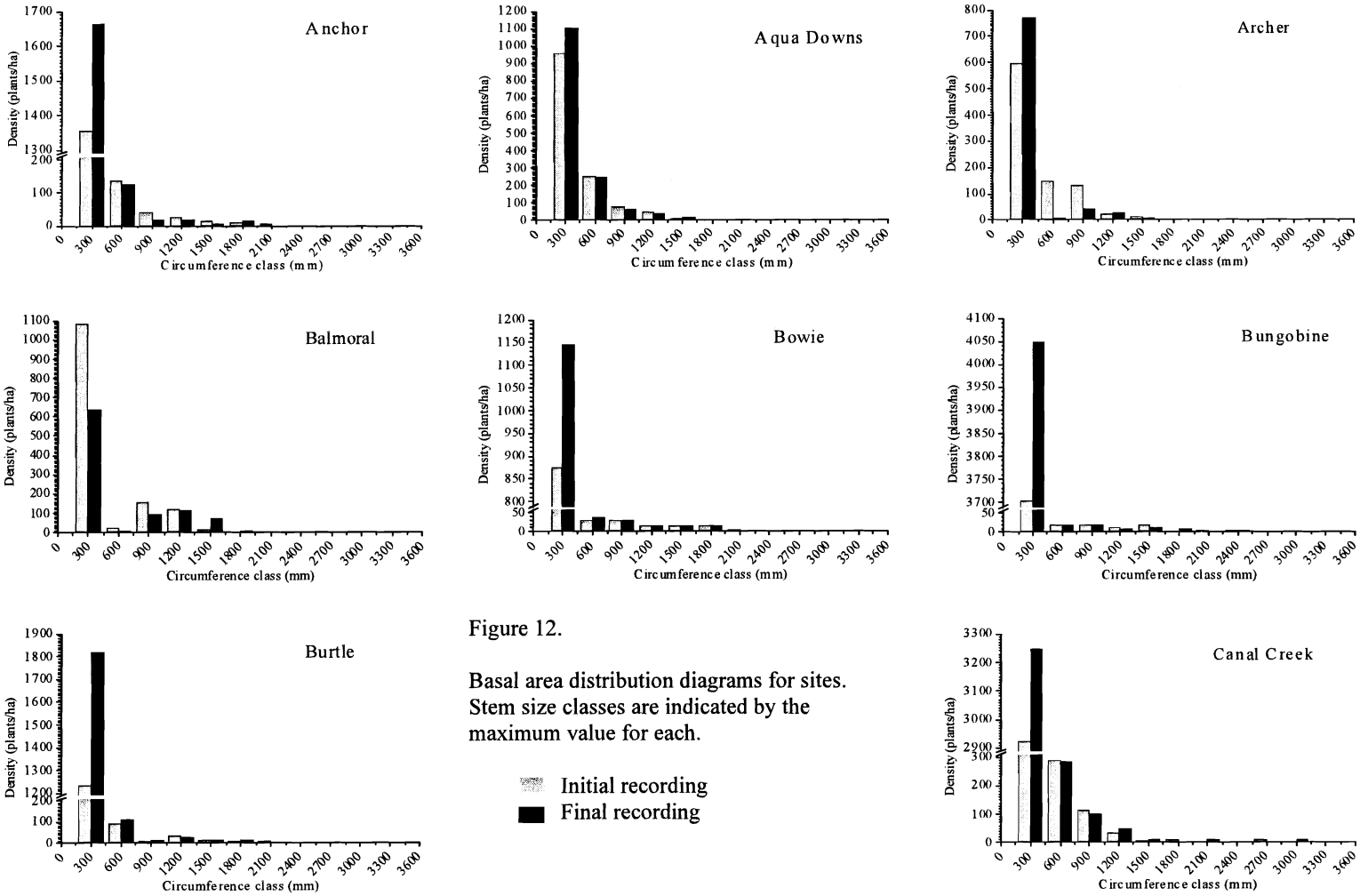


Figure 12.

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

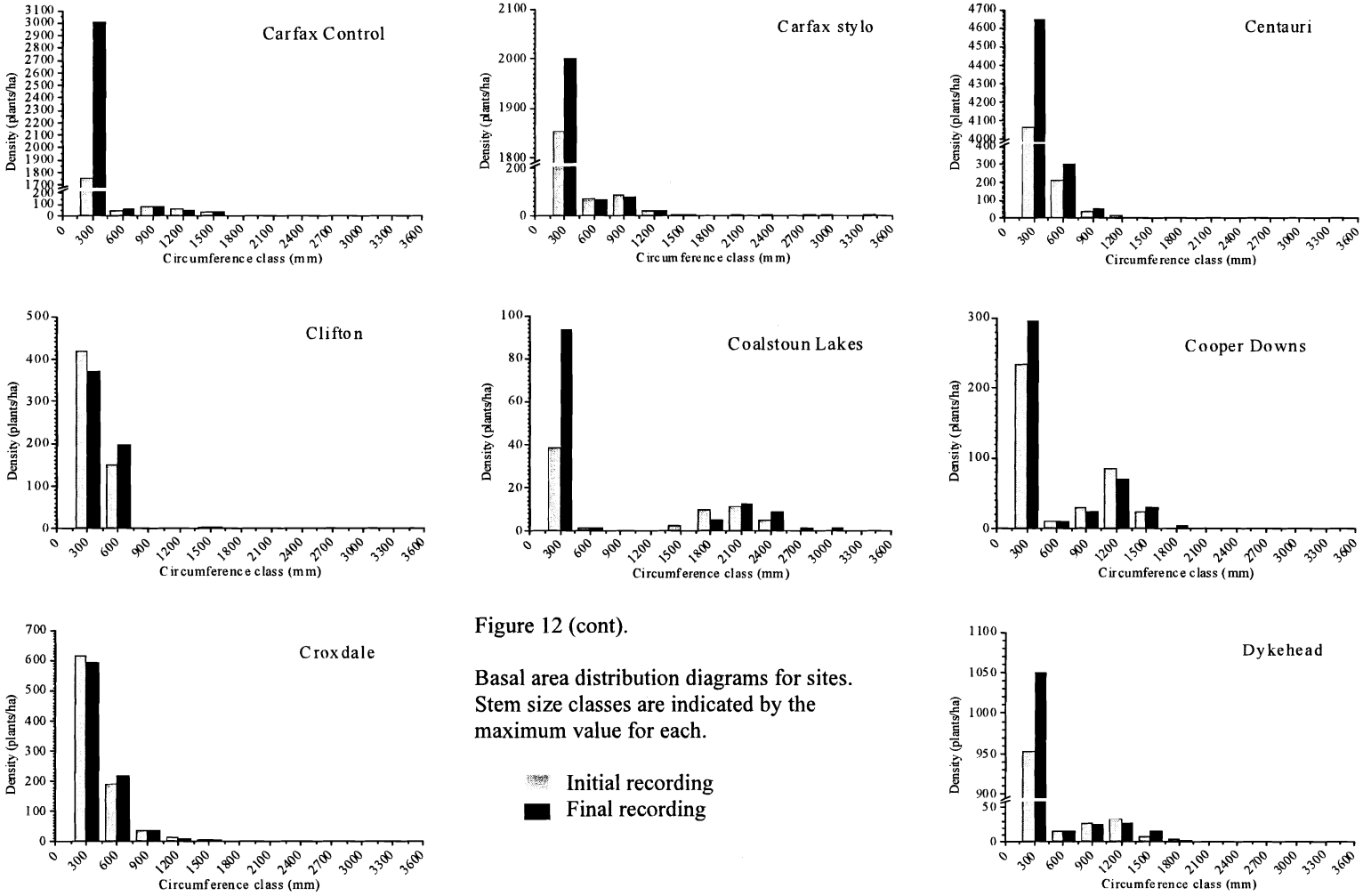


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

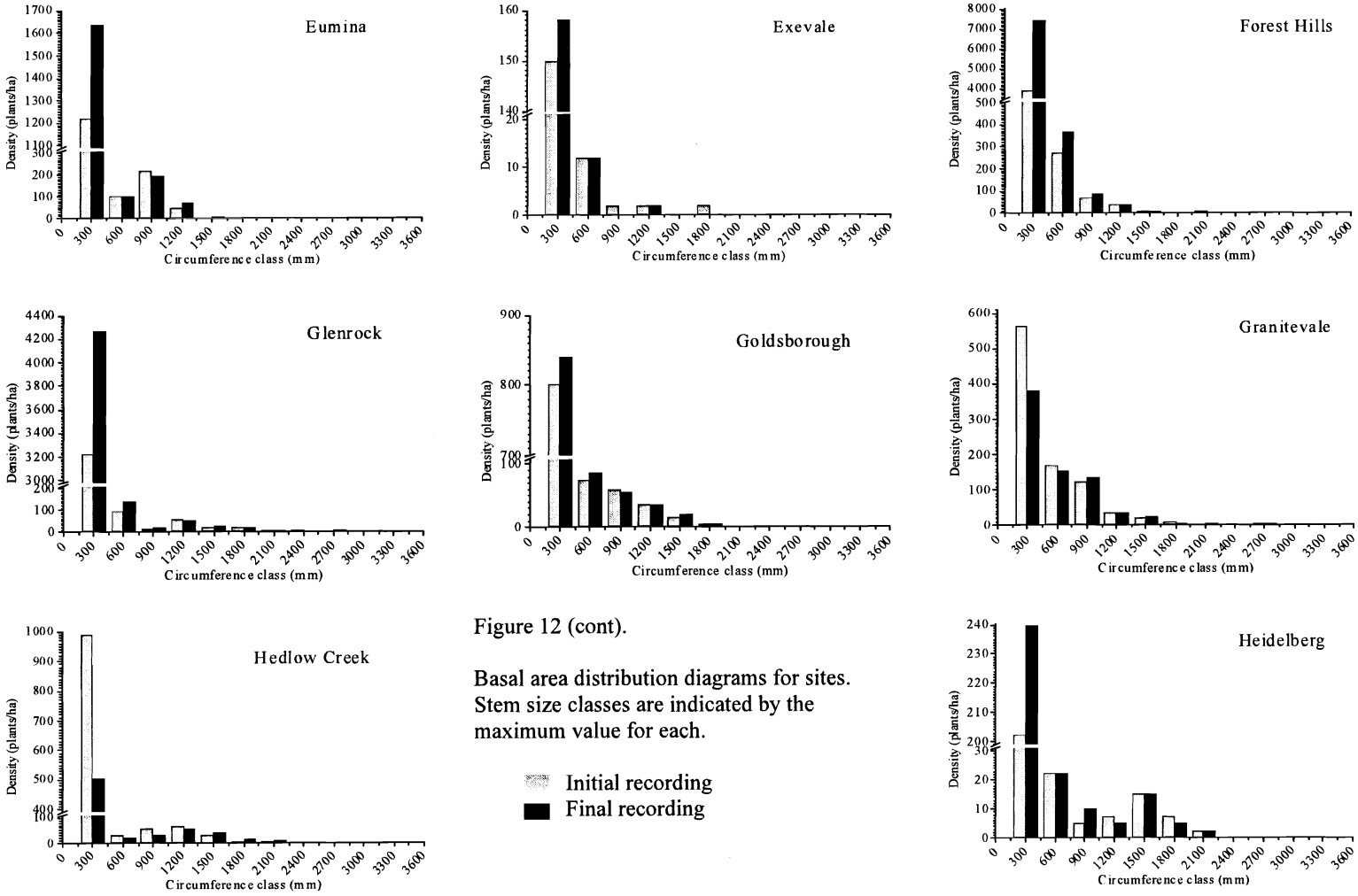


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

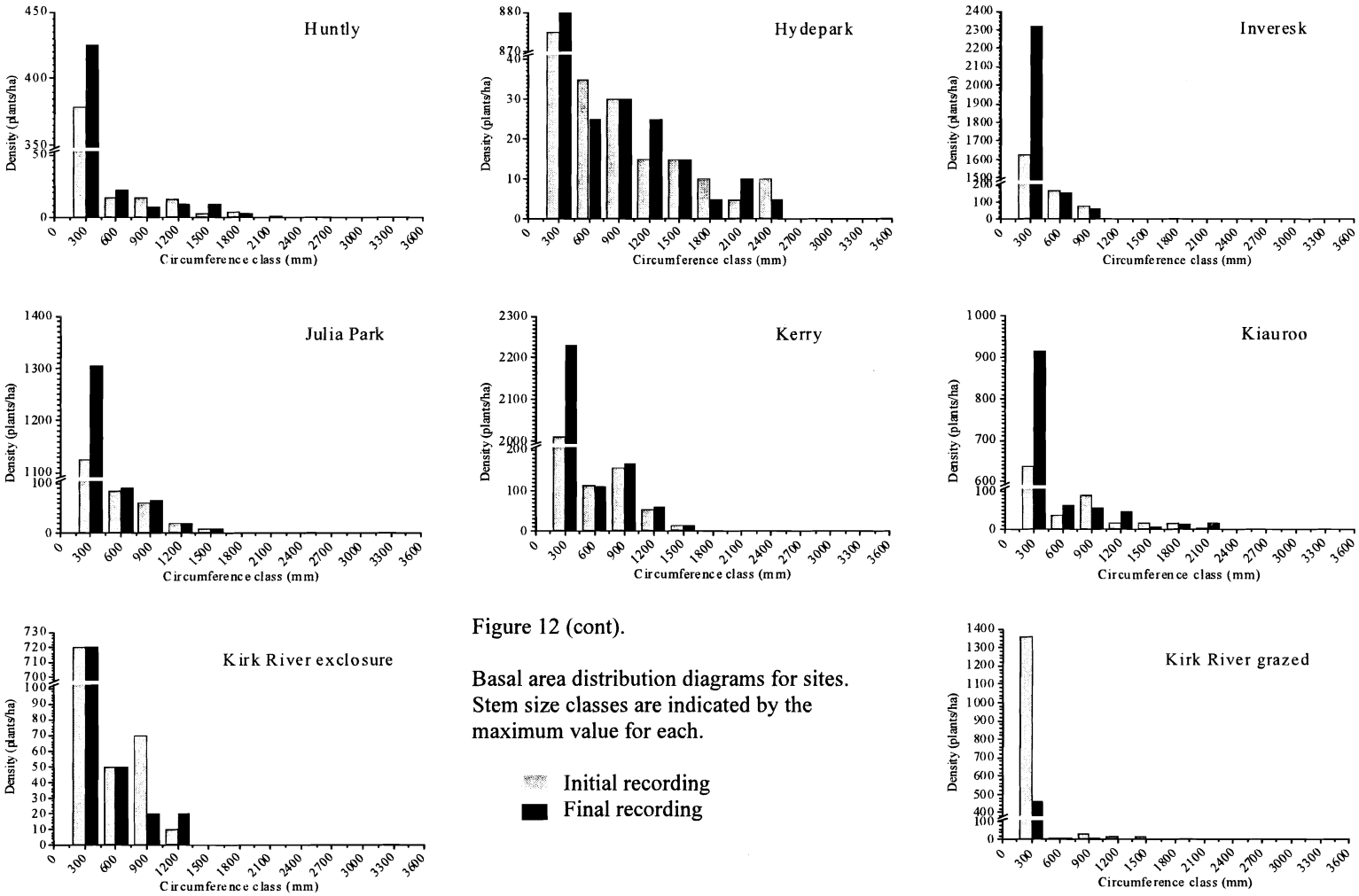


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

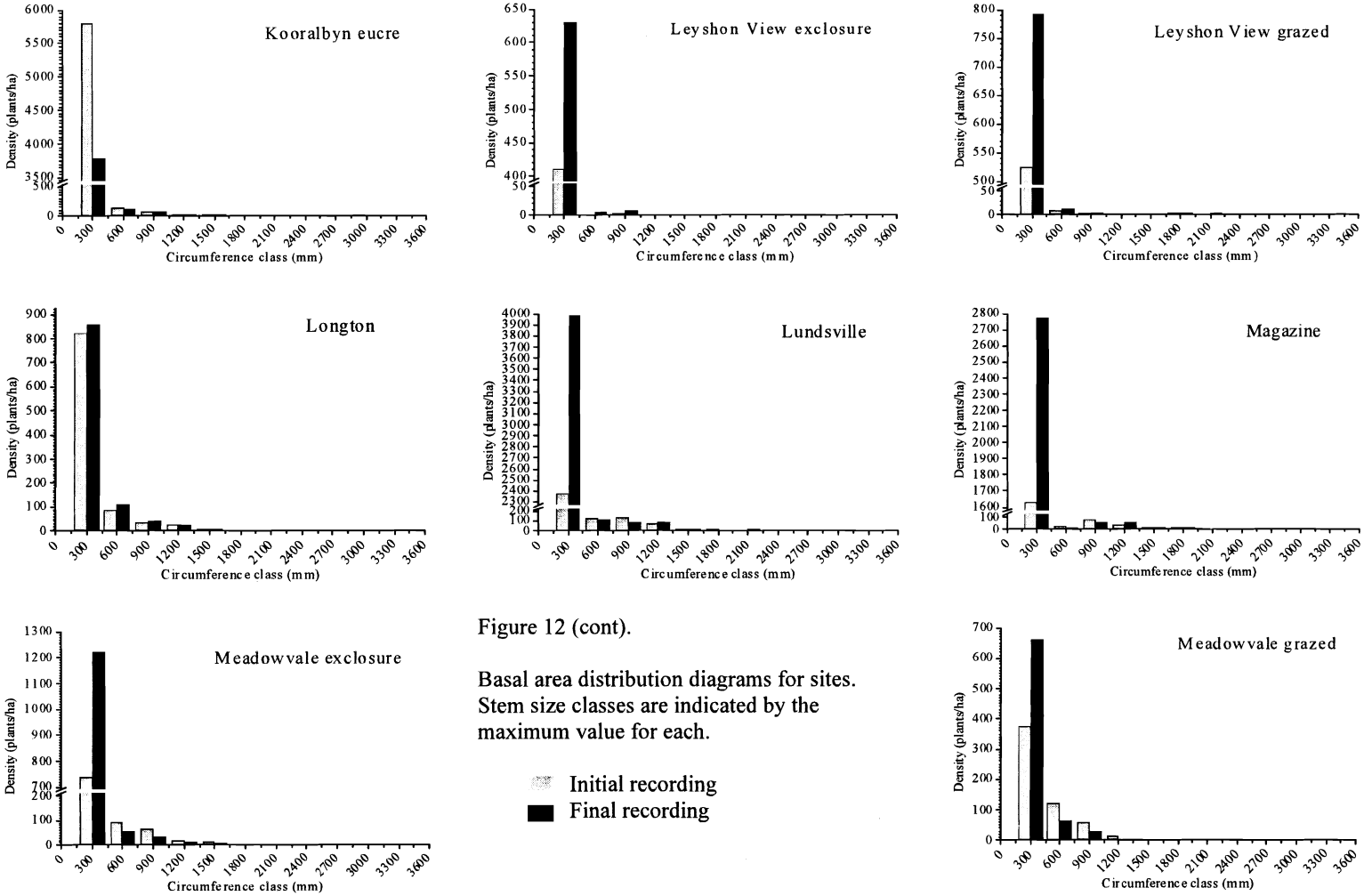


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

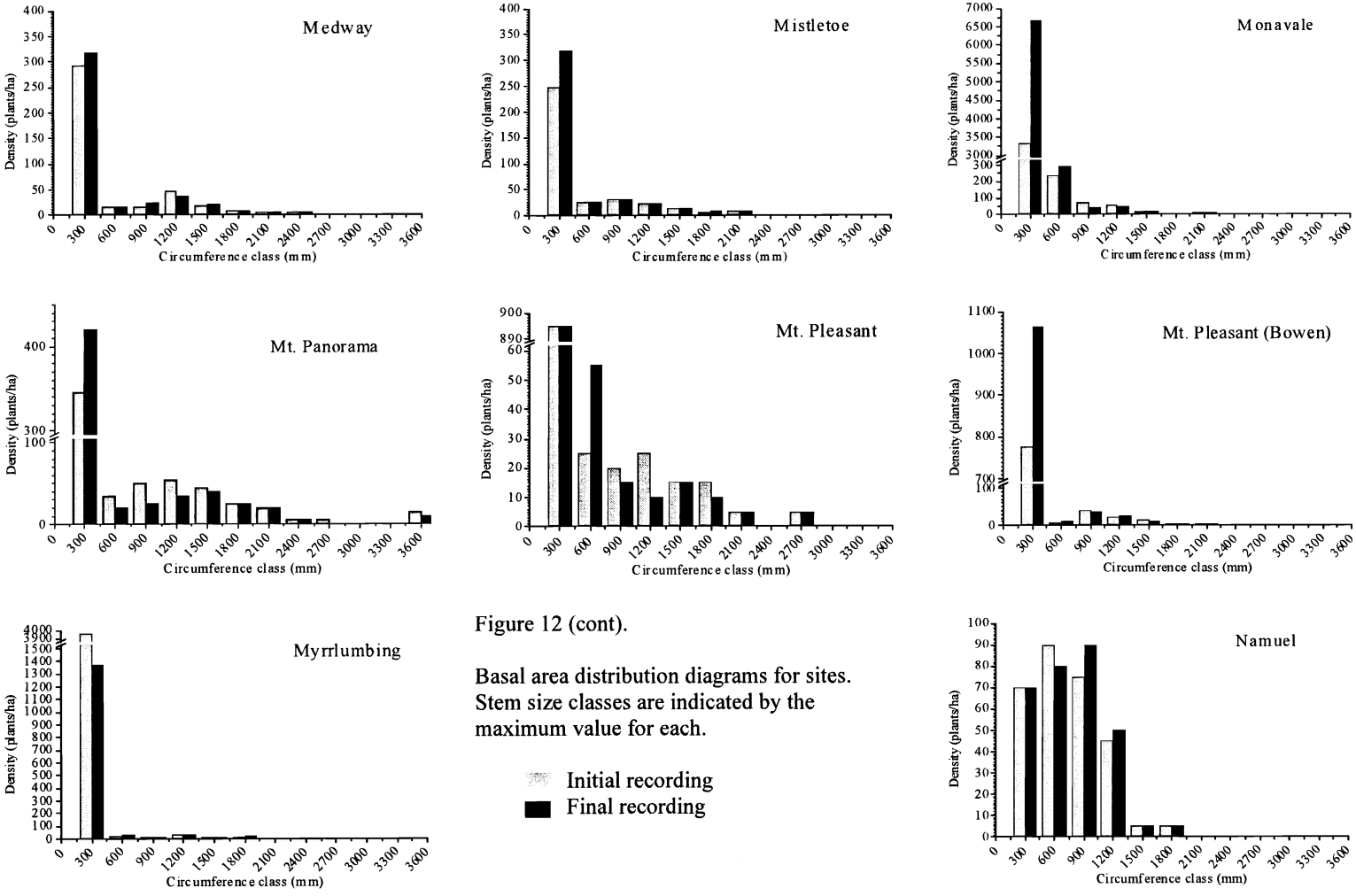


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

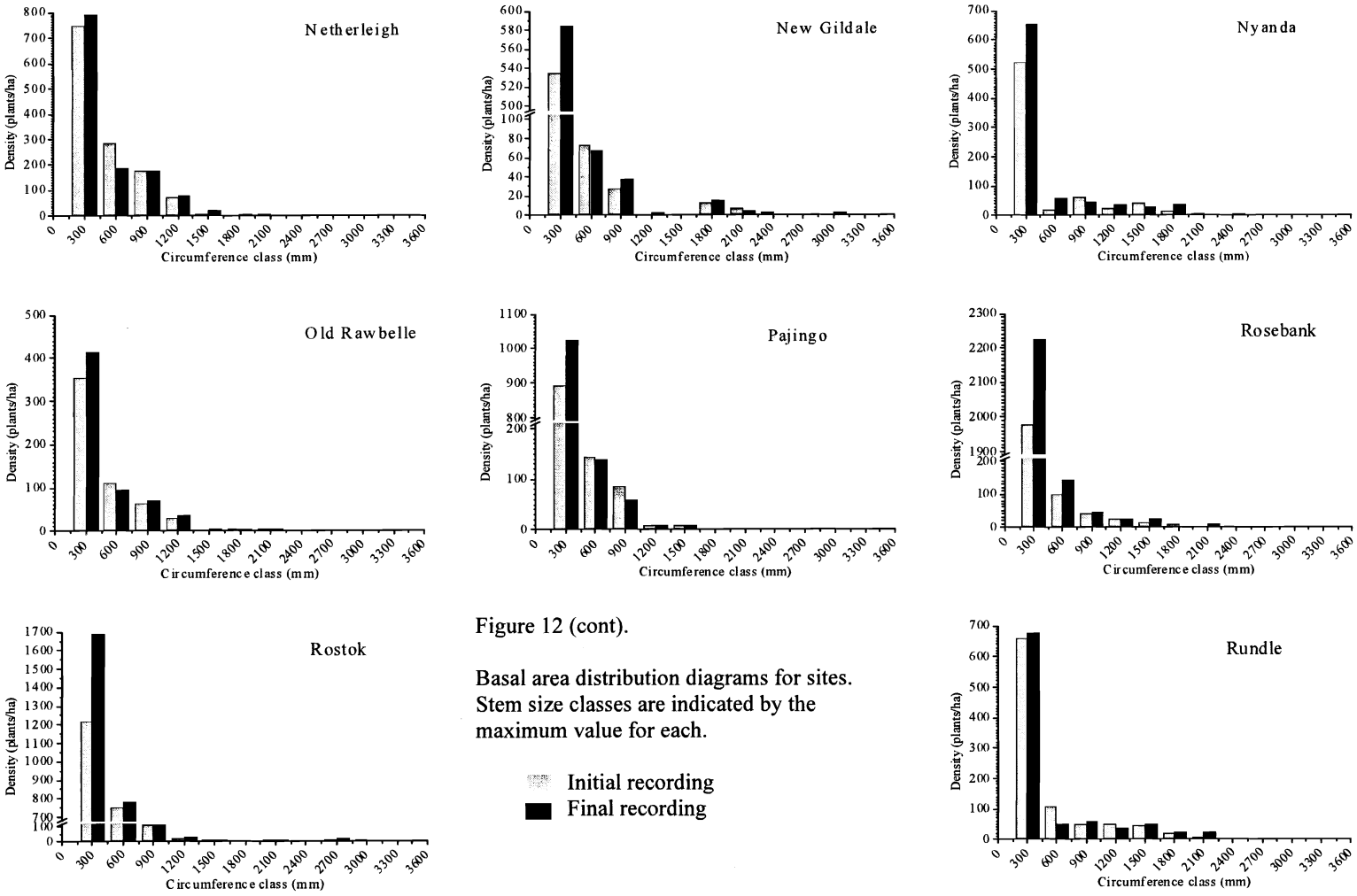


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

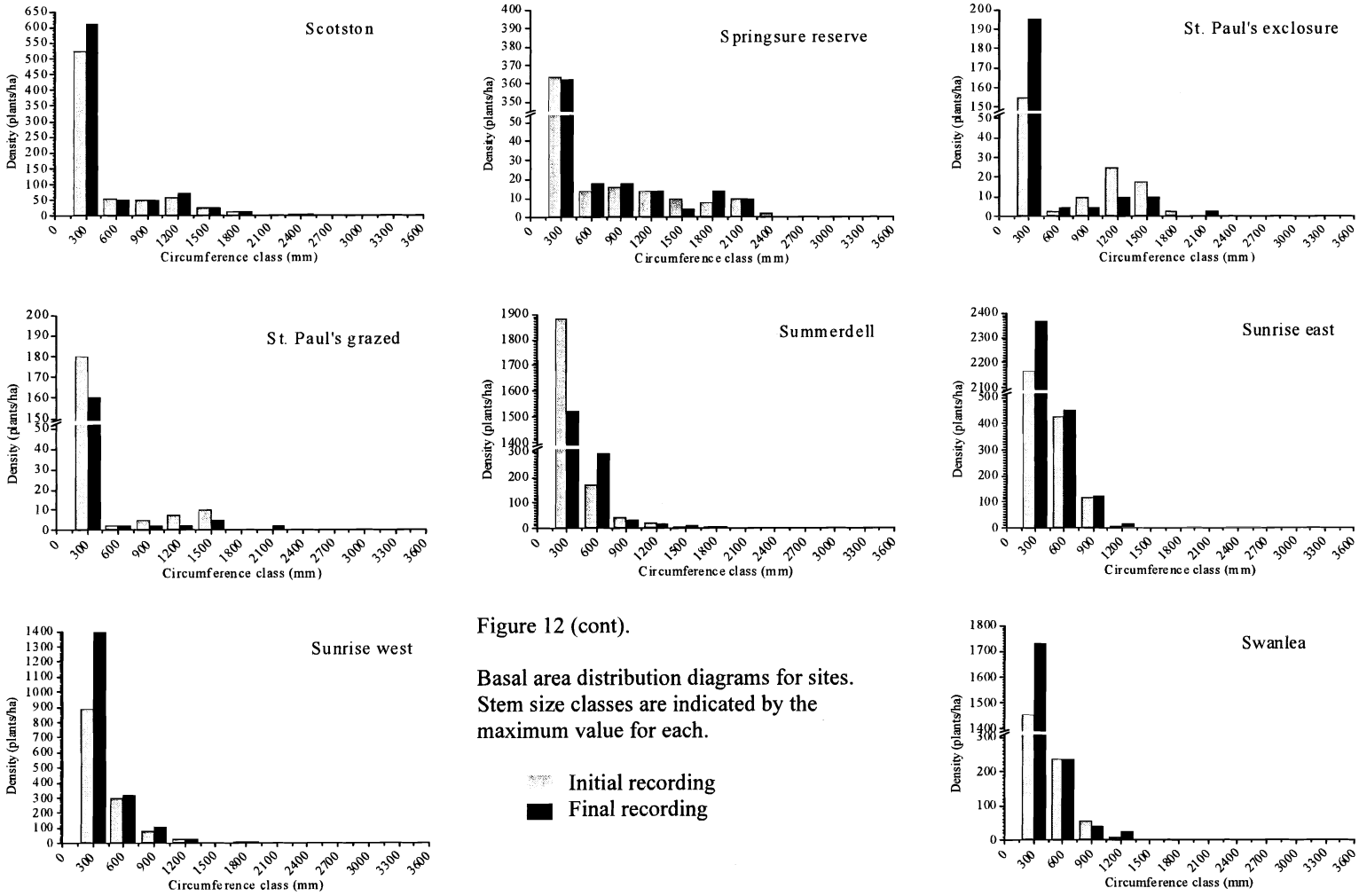


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

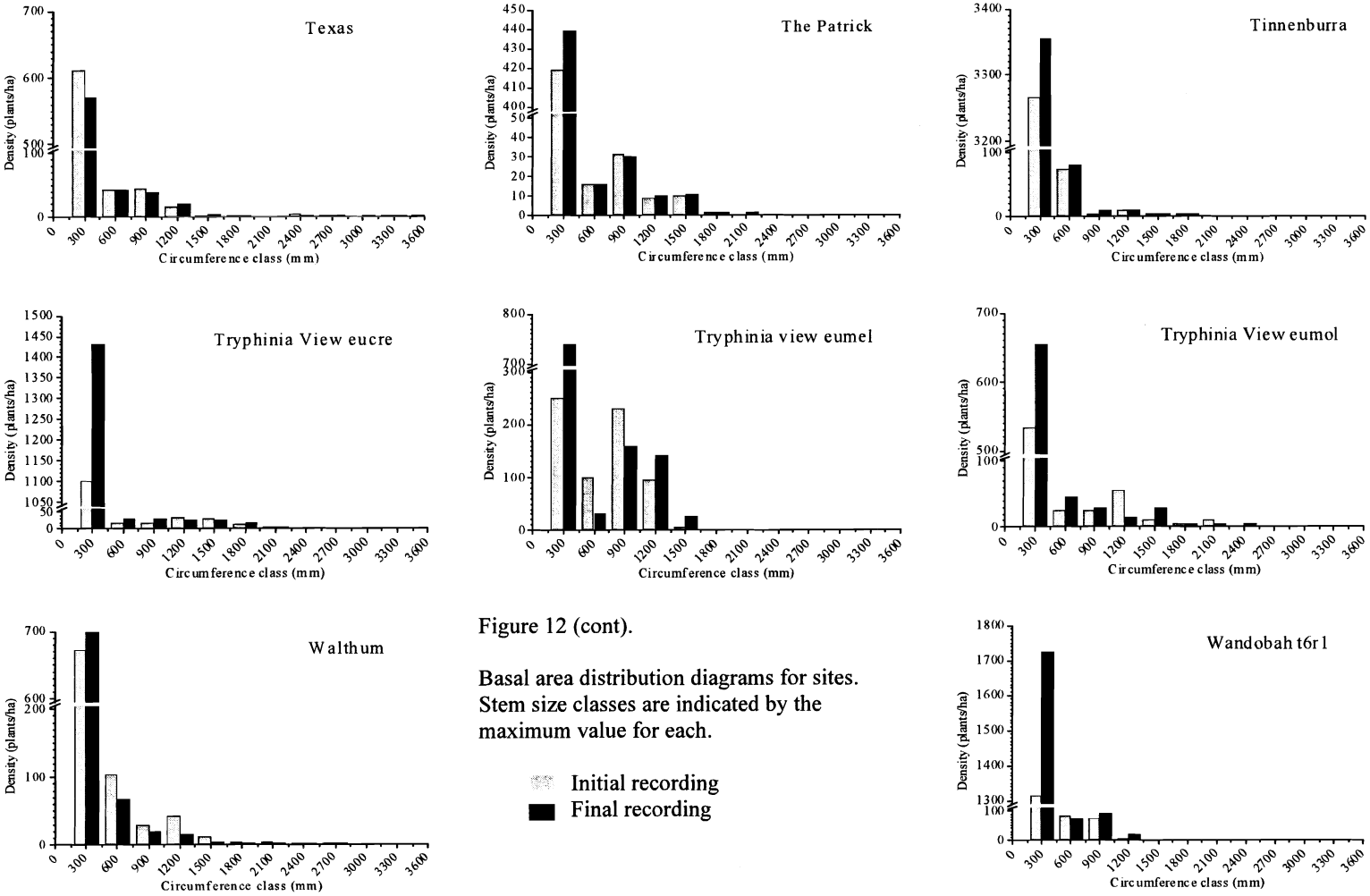


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

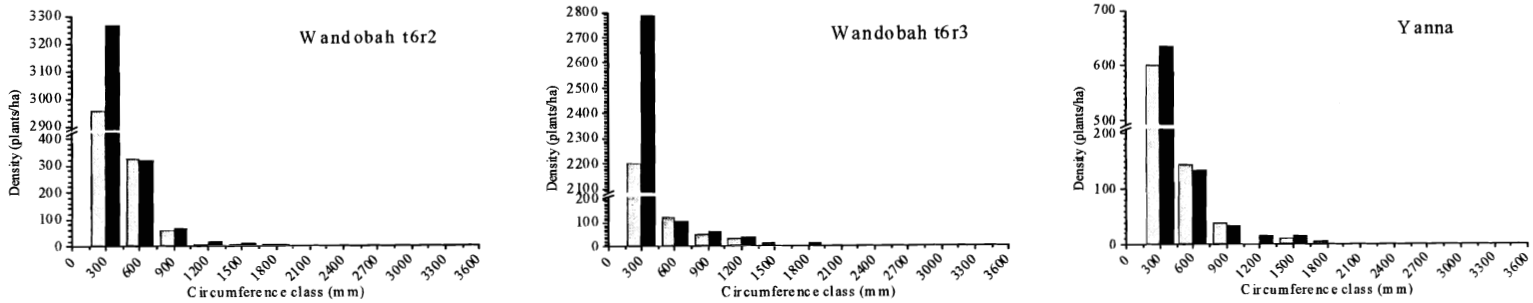


Figure 12 (cont).

Basal area distribution diagrams for sites. Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

The size distribution in many sites has an approximately constant decrease with increasing size class, producing a negative exponential curve. However some sites showed a bimodal distribution with a large decrease in density in the smallest size classes followed by a rise to a secondary peak in the mid size classes and a further decline in the largest trees. Negative exponential functions appear to accurately reflect the degree to which size distribution patterns meet the reverse-J shape. Approximately half (37 of 75) sites have clearly defined reverse-J/negative exponential size class distributions and these sites all have r^2 values >0.78 for the fitted function (Table 16). As r^2 values decrease the size class distributions become increasingly bimodal.

The size class distributions for all woodland types in the present study also approximated a reverse J-curve (Figure 13) and all have r^2 values >0.84 for the fitted negative exponential functions (Table 17). However the size class distribution patterns differed significantly between woodland types (Kolmogorov-Smirnov test, $p<0.02$). The size distributions for MICRONEURA and CYPRESS woodlands were less monotonously decreasing than the other woodland types. This was due to disjunct size distributions in the upper size classes for CYPRESS while for MICRONEURA woodlands the distribution pattern plateaus in both the upper an lower ranges producing a rotated sigmoid shape.

The basal area distribution for each species was a reverse J/negative exponential

Table 16.
r^2 values for negative exponential functions fitted to size class distributions from initial recordings for each site.

	Total	
Transect name	r^2	Sig.
Anchor	0.62	0.001
Aqua Downs	0.97	0.000
Archer	0.57	0.011
Balmoral	0.38	0.033
Bowie	0.52	0.004
Bungobine	0.40	0.009
Burtle	0.57	0.002
Canal creek	0.56	0.000
Carfax control	0.54	0.006
Carfax stylo	0.44	0.001
Centauri	0.94	0.000
Clifton	0.27	0.124
Coalstoun Lakes	0.00	0.800
Cooper Downs	0.33	0.049
Croxdale	0.99	0.000
Dykehead	0.65	0.002
Eumina	0.51	0.004
Exevale	0.49	0.011
Forest Hills	0.72	0.000
Glenrock	0.59	0.000
Goldsborough	0.91	0.000
Granitevale	0.53	0.001
Hedlow Creek	0.63	0.001
Heidelberg	0.65	0.000
Huntly	0.60	0.001
Hyde Park	0.68	0.000
Inveresk	0.64	0.006
Julia park	0.91	0.000
Kerry	0.85	0.000
Kiauroo	0.74	0.000
Kirk River exclosure	0.81	0.002
Kirk River grazed	0.45	0.034
Kooralbyn eucre	0.86	0.000
Leyshon View exclosure	0.20	0.380
Leyshon View grazed	0.32	0.035
Longton	0.94	0.000
Lundsville	0.47	0.007

	Total	
Transect name	r^2	Sig.
Meadowvale exclosure	0.89	0.000
Meadowvale grazed	0.53	0.041
Medway	0.78	0.000
Mistletoe	0.78	0.000
Monavale	0.53	0.003
Mt. Panorama	0.47	0.000
Mt. Pleasant	0.61	0.001
Mt. Pleasant Bowen	0.47	0.002
Myrrlumbing	0.51	0.004
Namuel	0.75	0.000
Netherleigh	0.62	0.001
New Gildale	0.36	0.005
Nyanda	0.50	0.002
Old Rawbelle	0.36	0.023
Pajingo	0.93	0.000
Rosebank	0.59	0.001
Rostock	0.41	0.002
Rundle	0.74	0.000
Scotston	0.45	0.004
Springsure reserve	0.47	0.003
St. Pauls exclosure	0.43	0.011
St. Pauls grazed	0.52	0.004
Summerdel	0.92	0.000
Sunrise east	0.98	0.000
Sunrise west	0.90	0.000
Swanlea	0.97	0.000
Texas	0.30	0.006
The Patrick	0.66	0.000
Tinnenburra	0.71	0.001
Tryphinia eucre	0.60	0.001
Tryphinia eumel	0.48	0.028
Tryphinia eumol	0.54	0.001
Walthum	0.84	0.000
Wandobah T6 R1	0.85	0.001
Wandobah T6 R2	0.89	0.000
Wandobah T6 R3	0.58	0.004
Yanna	0.44	0.019

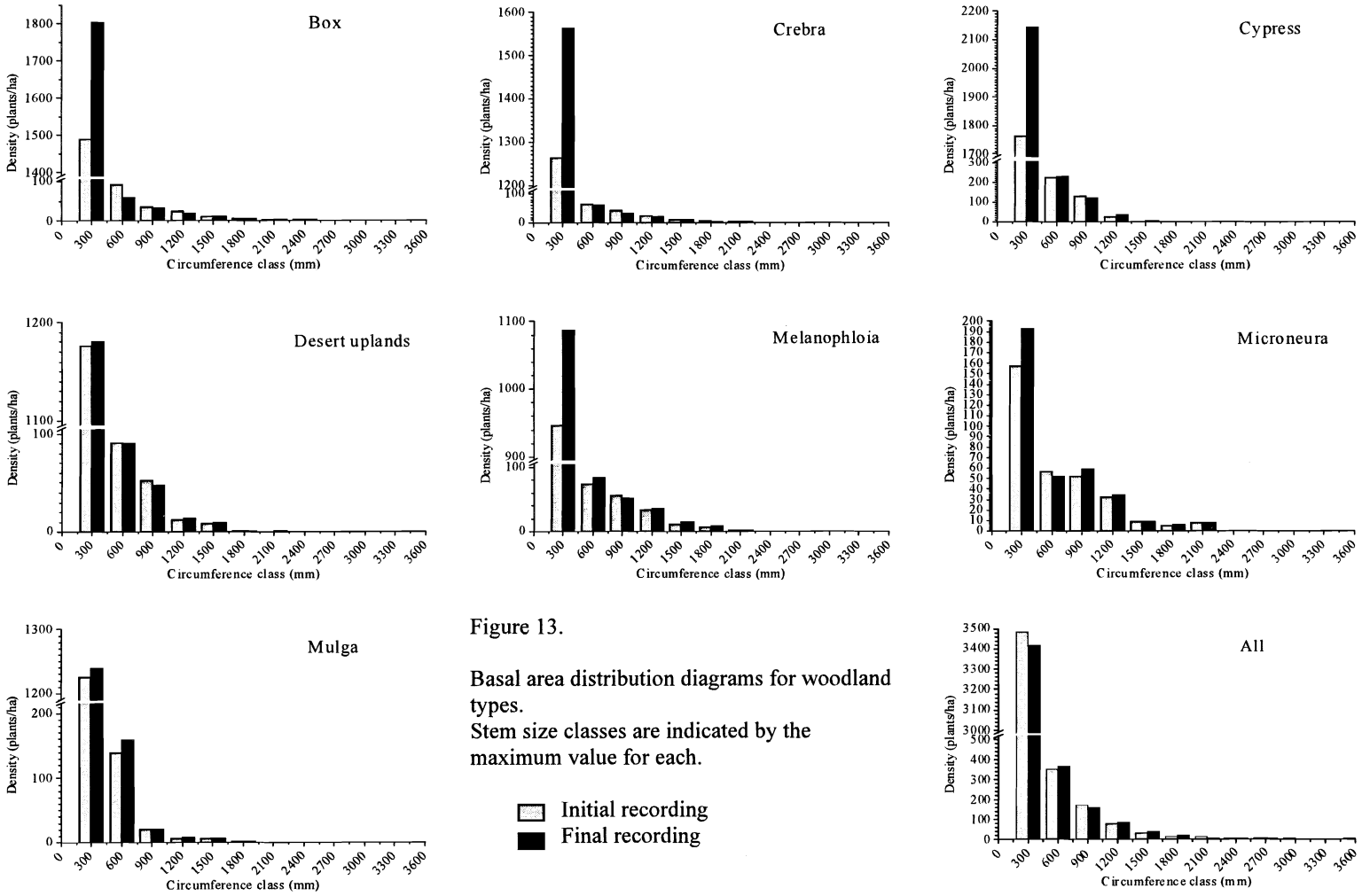


Figure 13.

Basal area distribution diagrams for woodland types.
Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

Table 17.
r^2 values for negative exponential functions fitted to size class distributions from initial recordings for each woodland type and for all sites amalgamated.

Woodland type	r^2
Box	0.93
Crebra	0.97
Cypress	0.89
Desert	0.92
Melanophloia	0.94
Microneura	0.84
Mulga	0.98
All	0.95

shape (Figure 14) and all have r^2 values >0.80 for the fitted negative exponential functions (Table 18). However the size class distribution patterns differed significantly between species (Kolmogorov-Smirnov test, $p<0.02$). The size distributions for *A. aneura, A. shirleyii, E. mitchellii, P. pubescens* and *M. viridiflora* showed a concentration of plants entirely within the smaller size classes, attributable to the smaller mature sizes of these species. Both *E. populnea* and *E. brownii* exhibited plateaux or a very weak bimodal tendency in the mid size ranges.

3.10 Floristic Composition

A total of 153 woody species belonging to 66 genera and 34 families were identified in the initial recordings of 20.1 ha covered by the 75 sites (Table 19). Species richness for each site ranged from 3 to 24 species/site with a mean of 11.2 (Table 20). Table 5 in Appendix 1 presents the raw data of species at each site at initial recording. The most species rich family was Myrtaceae with 35 species, followed by Mimosaceae with 27 species (Table 21). *Acacia* was the most speciose genus with 27 species (Table 22). The most abundant species over all sites were *Eucalyptus crebra* (91 plants/ha), *Eucalyptus melanophloia* (91plants/ha) and *Alphitonia excelsa* (83 plants/ha) (Table 20).

The MULGA woodlands exhibited the lowest species richness, with 9 species recorded, while the CREBRA woodlands were the most species rich with 91 species. Family richness at each site ranged from 2 to 17. Overall sites shared an

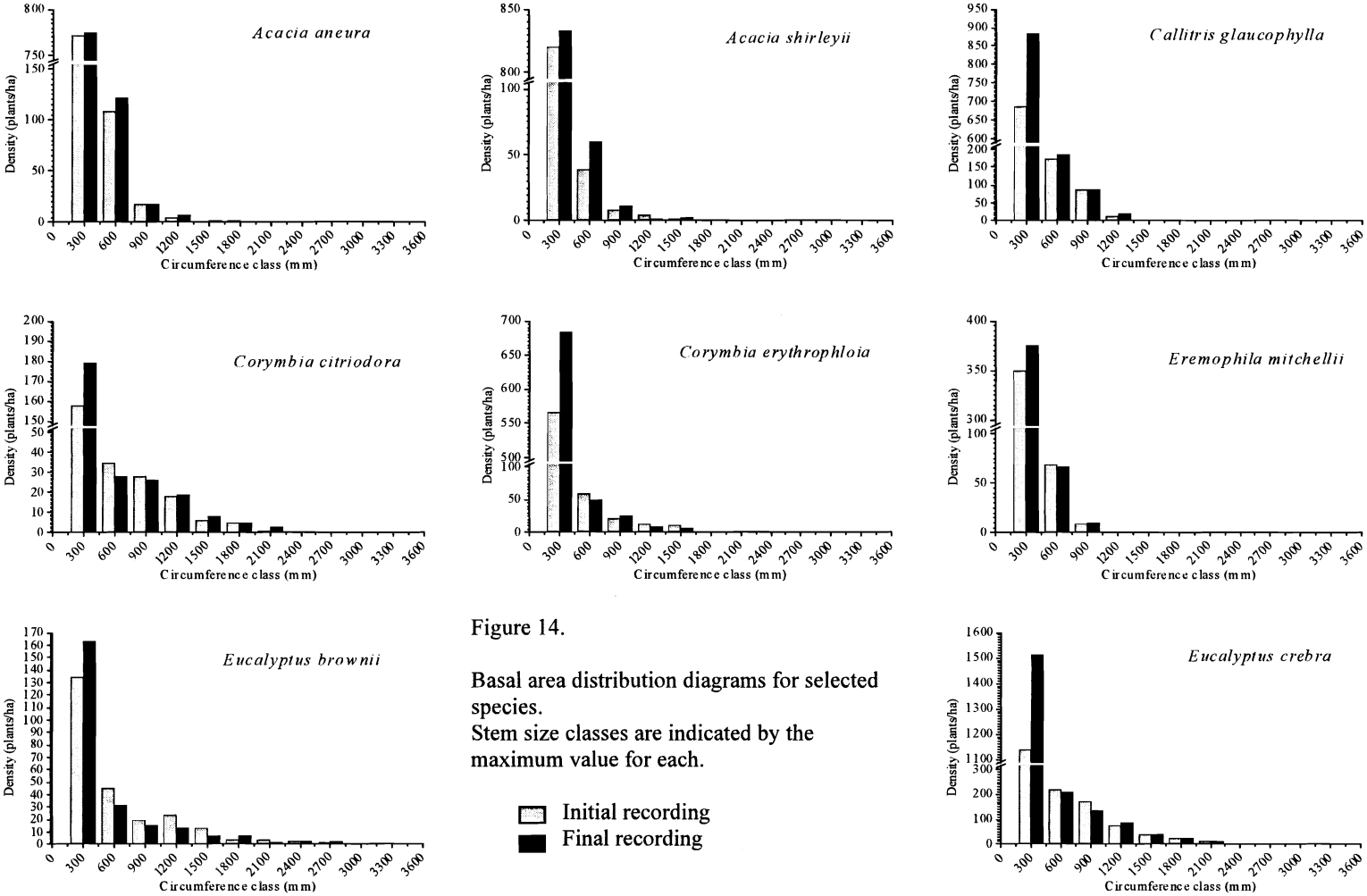


Figure 14.

Basal area distribution diagrams for selected species.
Stem size classes are indicated by the maximum value for each.

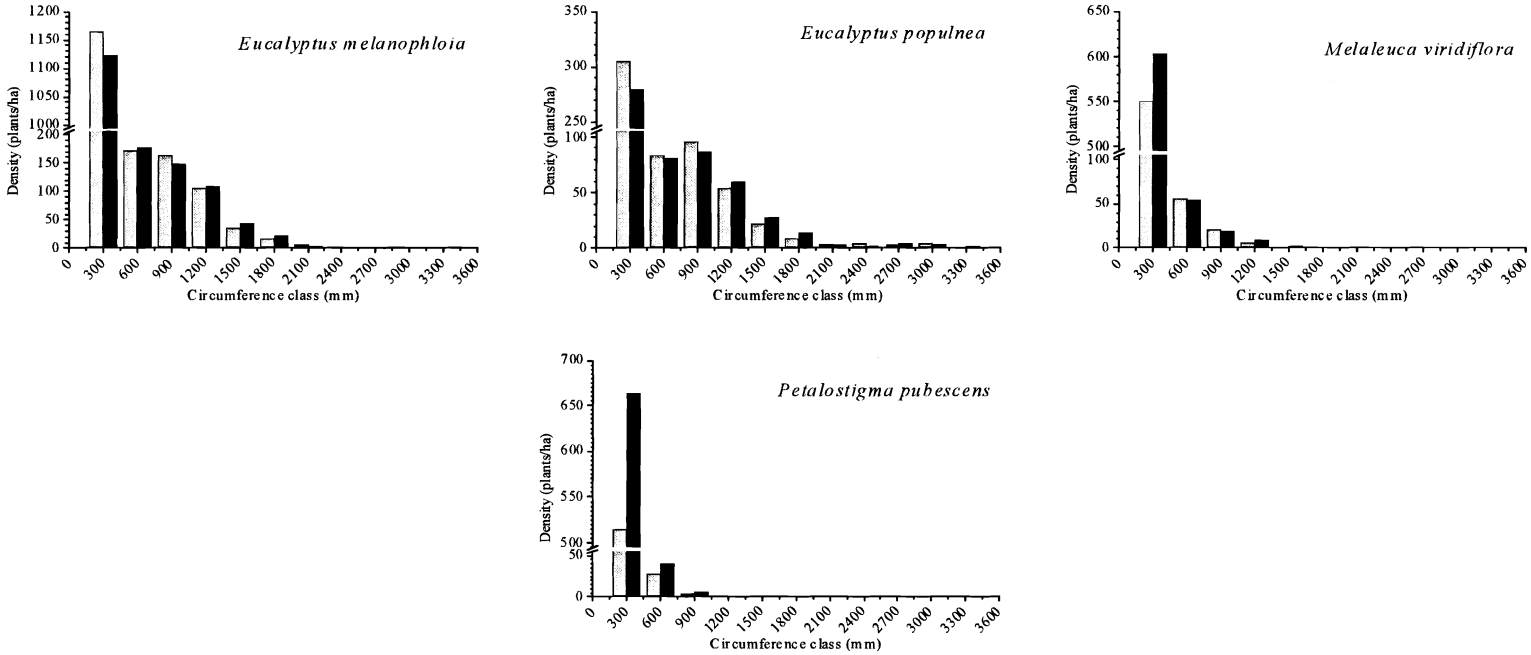


Figure 14 (cont).

Basal area distribution diagrams for selected species.
Stem size classes are indicated by the maximum value for each.

Initial recording
Final recording

Table 18.
r^2 values for negative exponential function fitted to size class distributions from initial recordings for selected species.

Species	r^2
Acacia aneura	0.91
Acacia shirleyii	0.93
Callitris glaucophylla	0.80
Eremophila mitchellii	1.00
Eucalyptus brownii	0.95
Corymbia citriodora	0.95
Eucalyptus crebra	0.98
Corymbia erythrophloia	0.92
Eucalyptus melanophloia	0.98
Eucalyptus populnea	0.93
Melalueca viridiflora	0.98
Petalostigma pubescens	0.99

Table 19.
List of species recorded in the study area at initial recording by family.

Family	Species	Density (plants/ha)
Apocynaceae	*Alstonia constricta*	0.05
	Carissa lanceolata	61
	Carissa ovata	23.73
	Parsonsia eucalyptophylla	0.45
	Parsonsia lanceolata	0.1
Asclepiadaceae	*Cryptostegia grandiflora*	1.24
	Sarcostemma viminale	0.15
Asteraceae	*Cassinia leavis*	2.99
Bignoniaceae	*Dolichandrone heterophyllum*	1.24
	Pandorea pandorana	0.1
Boraginaceae	*Ehretia membranifolia*	3.78
Cactaceae	*Eriocerius martinii*	0.3
	Opuntia stricta	2.09
	Opuntia tomentosa	6.22
Caesalpiniaceae	*Cassia brewsteri*	2.59
	Lysiphyllum carronii	0.3
	Lysiphyllum gilvum	0.9
	Lysiphyllum hookeri	0.05
	Senna artemisoides	9.65
	Senna coronilloides	4.38
Capparaceae	*Apophyllum anomalum*	2.69
	Capparis canescens	1.34
	Capparis lassiantha	2.09
	Capparis loranthifolia	0.1
	Capparis mitchellii	1.64
Casuarinaceae	*Allocasuarina luehmannii*	0.7
Celastraceae	*Denhamia umbellata*	1
	Maytenus cunninghamii	28.06
Combretaceae	*Terminalia aridicola*	7.26
	Terminalia oblongata	0.35
Cupressaceae	*Callitris glaucophylla*	62.09
Ebanaceae	*Diospyrus ferrea*	0.05
Epacridaceae	*Melichrus* sp.	0.35
Erythroxylaceae	*Erythroxylum australe*	6.22
Euphorbiaceae	*Breynia oblongifolia*	10.8
	Gardenia ochreata	0.4
	Petalostigma pubescens	27.31
Fabaceae	*Erythrina vespertilio*	0.9
	Jacksonia scoparia	3.03
Lecythidaceae	*Planchonia careya*	0.95
Meliaceae	*Melia azedarach*	0.15
	Owenia acidula	0.8
Verbenaceae	*Lantana camara*	0.85
	Lantana montevidensis	0.2
	Clerodendrum floribundum	7.21

Table 19 (cont).
List of species recorded in the study area at initial recording by family.

Family	Species	Density (plants/ha)	Family	Species	Density (plants/ha)
Mimosaceae	*Acacia aneura*	48.96	Myoporaceae	*Eremophila gilesii*	2.39
	Acacia argyrodendron	4.53		*Eremophila latrobei*	8.21
	Acacia aulacocarpa	11.69		*Eremophila longifolia*	9.55
	Acacia bidwillii	4.78		*Eremophila mitchellii*	24.83
	Acacia carolaea	0.25		*Myoporum acuminatum*	6.07
	Acacia coriaccaea	12.24		*Myoporum desertii*	5.92
	Acacia cowleana	4.43			
	Acacia crassa	1.39	Myrtaceae	*Angophora costata*	0.05
	Acacia decora	3.33		*Corymbia citriodora*	12.99
	Acacia excelsa	16.02		*Corymbia clarksoniana*	8.11
	Acacia farnesiana	9.00		*Corymbia dallachyana*	25.07
	Acacia fasciculifera	0.40		*Corymbia erythrophloia*	34.38
	Acacia grandifolia	1.69		*Corymbia intermedia*	7.76
	Acacia holosericea	0.05		*Corymbia plena*	1.49
	Acacia laccata	2.29		*Corymbia setosa*	0.05
	Acacia leiocalyx	26.67		*Corymbia terminalis*	2.14
	Acacia leptostachya	0.95		*Corymbia tessellaris*	7.81
	Acacia longispicata	0.20		*Eucalyptus brownii*	13.08
	Acacia macradenia	0.10		*Eucalyptus cambageana*	0.30
	Acacia melleodora	0.95		*Eucalyptus chloroclada*	0.55
	Acacia oligonphleba	0.05		*Eucalyptus coolabah*	3.13
	Acacia rhodoxylon	0.05		*Eucalyptus crebra*	91.19
	Acacia salicina	10.80		*Eucalyptus exserta*	6.72
	Acacia shirleyii	48.11		*Eucalyptus fibrosa*	14.23
	Acacia stipuligra	2.04		*Eucalyptus hybrid*	0.80
	Acacia tenuissima	8.66		*Eucalyptus melanophloia*	91.00
	Archidendropsis basaltica	0.10		*Eucalyptus microneura*	3.83
				Eucalyptus moluccana	11.00
Moraceae	*Ficus opposita*	0.05		*Eucalyptus orgadophila*	4.38
				Eucalyptus platyphylla	1.04
				Eucalyptus populnea	31.19
Xanthoroeaceae	*Xanthorrhoea johnsonii*	0.30		*Eucalyptus quadricostata*	5.12

Table 19 (cont).
List of species recorded in the study area at initial recording by family.

Family	Species	Density (plants/ha)
Myrtaceae (cont).	*Eucalyptus similis*	6.52
	Eucalyptus tereticornis	4.13
	Eucalyptus whiteii	5.67
	Eucalyptus xanthoclada	9.05
	Lophostomen confertus	2.34
	Lophostomon suaveolens	0.65
	Melaleuca bracteata	0.30
	Melaleuca nervosa	6.47
	Melalueca viridiflora	32.09
	Micromyrtus sp.	5.33
Pittosporaceae	*Bursaria incana*	0.50
	Bursaria spinosa	0.30
	Citriobatus lineare	0.05
	Citriobatus spinescens	0.20
	Pittosporum phylliraeoides	0.10
Proteaceae	*Grevillea parrallela*	4.78
	Grevillea prteridifolia	0.30
	Grevillea striata	2.84
	Hakea fraserii	0.35
	Hakea lorea	0.15
	Hakea species	0.60
	Persoonia falcata	0.10
Rhamnaceae	*Alphitonia excelsa*	82.84
	Ventilago viminalis	8.41
	Zizyphus mauritiana	3.83
Xanthoroeaceae	*Xanthorrhoea johnsonii*	0.30
Rubiaceae	*Caelospermum reticulatum*	5.22
	Canthium attenuatum	3.33
	Canthium buxifolium	0.10
	Canthium coprosmoides	1.94
	Canthium oleifolium	5.92
	Canthium vacciniifolium	5.17
	Gardenia vilhelmii	0.15
Rutaceae	*Flindersia dissosperma*	6.02
	Flindersia maculosa	0.35
	Geijera parviflora	0.85
	Geijera salicifolia	0.10
Santalaceae	*Santalum lanceolatum*	0.30
Sapindaceae	*Dodonaea* species	0.15
	Alectryon diversifolium	0.20
	Dodonaea physicarpus	0.05
	Cupaniopsis anacardioides	0.10
	Alectryon oleifolius	0.85
	Dodonaea viscosa	0.75
	Atalaya hemiglauca	54.58
Sterculiaceae	*Brachychiton australe*	0.05
	Brachychiton populneus	1.59
Zamiaceae	*Macrozamia moorei*	2.59

Table 20.
Species and family richness for sites and woodland types at initial recording.
"Trees" are those plants >300 mm circumference at 30 cm.

Woodland type	Site	Families	Species	
			Total	Trees
Cypress				
	Eumina	6	7	3
	Rostoc	11	17	9
	Sunrise East	8	11	3
	Total	14	23	14
Microneura				
	Mistletoe	7	8	3
	Namuel	5	5	3
	Total	8	10	5
Desert uplands				
	Inveresk	10	15	2
	Julia Park	7	11	5
	The Patrick	15	19	8
	Swanlea	10	15	2
	Total	17	34	17
Melanophloia		22	53	28
	Bowie	8	11	2
	Burtle	14	20	5
	Cooper Downs	6	7	3
	Dykehead	6	10	1
	Hyde Park	9	14	4
	Kerry	7	11	4
	Longton	7	9	5
	Mt. Pleasant	4	7	2
	Nyanda	9	11	2
	Old Rawbelle	3	4	1
	Summerdell	7	9	4
	Sunrise West	4	6	2
	Tryphinia Eumel	5	7	3
	Total	22	53	28
Mulga		4	9	4
	Clifton	2	3	2
	Croxdale	3	4	2
	Tinnenburra	3	3	1
	Yanna	4	6	3

Table 20 (cont).
Species and family richness for sites and woodland types at initial recording.
"Trees" are those plants >300 mm circumference at 30 cm.

Woodland type	Site	Families	Species	
			Total	Trees
Crebra				
	Anchor	10	16	5
	Archer	9	13	1
	Balmoral	6	7	1
	Canal Creek	3	6	3
	Exevale	5	7	3
	Forest hills	15	23	7
	New Gildale	4	6	3
	Glenrock	9	13	6
	Goldsborough	7	10	2
	Granitevale	3	8	2
	Heidelberg	6	9	5
	Huntly	8	10	5
	Kiauroo	11	15	4
	Kirk River exclosure	4	6	4
	Kirk River grazed	2	3	1
	Kooralbyn eucre	7	11	3
	Leyshon view exclosure	8	12	3
	Leyshon view grazed	11	15	5
	Lundsville	8	15	8
	Meadowvale exclosure	4	5	2
	Meadowvale grazed	2	3	2
	Monavale	9	16	5
	Mt Pleasant Bowen	8	11	4
	Netherleigh	7	15	8
	Rosebank	8	12	3
	Rundle	8	11	2
	Scotston	6	9	2
	Springsure	7	8	4
	St. Pauls exclosure	7	9	4
	St. Pauls grazed	6	9	3
	Tryphinia eucre	5	7	4
	Tryphinia eumol	10	16	6
	Total	25	91	63

Table 20 (cont).
Species and family richness for sites and woodland types at initial recording.
"Trees" are those plants >300 mm circumference at 30 cm.

Woodland type	Site	Families	Species	
			Total	Trees
Box				
	Aqua Downs	6	9	3
	Bungobine	15	21	4
	Carfax control	13	19	7
	Carfax stylo	13	19	5
	Centauri	11	16	3
	Coalstoun Lakes	6	10	2
	Hedlow Creek	7	11	4
	Magazine	8	12	2
	Medway	7	9	3
	Mt. Panorama	6	7	1
	Myrrlumbing	8	12	4
	Pajingo	7	7	2
	Texas	10	15	6
	Walthum	12	16	3
	Wandobah T6R1	14	19	6
	Wandobah T6R2	17	24	6
	Wandobah T6R3	16	24	4
	Total	25	83	49
All sites		34	153	107

Table 21.
Species number recorded in the study area at initial recording, by family.

Family	Number of species	Percentage of total species
Apocynaceae	5	3.25
Asclepiadaceae	2	1.3
Asteraceae	1	0.65
Bignoniaceae	2	1.3
Boraginaceae	1	0.65
Cactaceae	3	1.95
Caesalpiniaceae	6	3.9
Capparaceae	5	3.25
Casuarinaceae	2	1.3
Celastraceae	2	1.3
Combretaceae	2	1.3
Cupressaceae	1	0.65
Epacridaceae	1	0.65
Erythroxylaceae	1	0.65
Euphorbiaceae	3	1.95
Fabaceae	2	1.3
Lecythidaceae	1	0.65
Meliaceae	1	0.65
Mimosaceae	27	17.53
Moraceae	2	1.3
Myoporaceae	6	3.9
Myrtaceae	35	22.73
Pittosporaceae	5	3.25
Proteaceae	7	4.55
Rhamnaceae	3	1.95
Rubiaceae	7	4.55
Rutaceae	4	2.6
Santalaceae	1	0.65
Sapindaceae	7	5.19
Sterculiaceae	2	1.3
Verbeaceae	2	1.3
Verbenaceae	1	0.65
Xanthoroeaceae	1	0.65

Table 22.
Species number recorded in the study area at initial recording, by genus.

Genus	Number of species	Percentage of total species
Acacia	27	17.53
Alectryon	2	1.30
Allocasurina	1	0.65
Alphitonia	1	0.65
Alstonia	1	0.65
Angophora	1	0.65
Apophyllum	1	0.65
Archidendropsis	1	0.65
Atalaya	1	0.65
Brachychiton	2	1.30
Breynia	1	0.65
Bursaria	2	1.30
Caelospermum	1	0.65
Callitris	1	0.65
Canthium	5	3.25
Capparis	4	2.60
Carissa	2	1.30
Cassia	1	0.65
Cassinia	1	0.65
Casuarina	1	0.65
Citriobatus	2	1.30
Clerodendrum	1	0.65
Corymbia	9	5.84
Cryptostegia	1	0.65
Cupaniopsis	1	0.65
Denhamia	1	0.65
Dodonaea	3	1.95
Dolichandrone	1	0.65
Ehretia	1	0.65
Eremophila	4	2.60
Eriocerius	1	0.65
Erythrina	1	0.65
Erythroxylum	1	0.65

Genus	Number of species	Percentage of total species
Eucalyptus	18	11.69
Ficus	2	1.30
Flindersia	2	1.30
Gardenia	2	1.30
Geijera	2	1.30
Grevillea	3	1.95
Hakea	3	1.95
Jacksonia	1	0.65
Lantana	2	1.30
Lophostemon	2	1.30
Lysiphyllum	3	1.95
Macrozamia	2	1.30
Maytenus	1	0.65
Melaleuca	3	1.95
Melia	1	0.65
Melichrus	1	0.65
Micromyrtus	1	0.65
Myoporum	2	1.30
Opuntia	2	1.30
Owenia	1	0.65
Pandorea	1	0.65
Parsonsia	2	1.30
Persoonia	1	0.65
Petalostigma	1	0.65
Pittosporum	1	0.65
Planchonia	1	0.65
Santalum	1	0.65
Sarcostemma	1	0.65
Senna	2	1.30
Terminalia	2	1.30
Ventilago	1	0.65
Xanthorrhoea	1	0.65
Zizyphus	1	0.65

average of 32% of species and sites in the same community type shared only 43% of their species in common (Table 23).

Shannon-Wiener diversity indices varied between 1 in the MULGA woodlands and 3.3 in the BOX woodlands, with a value of 4 for an aggregate of all sites (Table 23). Species evenness was equally variable between woodland types, with a maximum evenness value of 0.8 for DESERT UPLANDS and a minimum of 0.5 for MULGA, CYPRESS and MELANOPHLOIA types. The Sorensen coefficient for the woodland types showed varying degrees of similarity between woodland types ranging from 0.52 for CREBRA/BOX to complete dissimilarity between MICRONEURA and MULGA communities (Table 24). Forty-three species were found at only one site and no species was common to all sites.

Total species richness (alpha-diversity) fluctuated slightly over time, with 153 and 156 species identified in the initial and final tree surveys, respectively. This constitutes an increase of 1.9%. Within woodland types diversity changes ranged from a 11.1% increase in MULGA type woodlands to a stable diversity in DESERT UPLANDS and MICRONEURA woodlands (Table 25). Two species were lost from the transect sites and 5 species colonised the sites over the study period (Table 26). Colonisations and losses were more variable for individual woodland types, with colonisations ranging from nine in CREBRA woodlands to zero in DESERT UPLANDS and MICRONEURA and species losses ranging

Table 23.
Species diversity and distribution by woodland type.

Woodland type	Mulga	Crebra	Cypress	Microneura	Desert uplands	Box	Melanophloia	All
Number of sites	4	32	3	2	4	17	13	75
Species richness	9	91	23	10	34	83	53	153
Mean species richness/site	4.8	9.4	11.3	7.5	15.0	14.4	8.7	10.5
Percentage of total species present in woodland type	5.7	57.6	14.6	6.3	21.5	52.5	33.5	96.8
Number of species unique to woodland type.	2	35	3	4	10	23	1	155
Percentage of total species represented by species unique to type	1.3	22.2	1.9	2.5	6.3	14.6	0.6	98.1
Percentage of species in type represented by species unique to type	22.2	38.5	13.0	40.0	29.4	27.7	1.9	101.3
Number of species shared by all sites within type.	1.0	0.0	4.0	3.0	3.0	0.0	1.0	2.0
% species shared by all sites within type.	11.1	0.0	17.4	30.0	8.8	0.0	1.9	0.0
% of species shared by 2 or more sites within type	75.3	23.5	52.0	55.6	50.0	27.0	31.5	31.8
Shannon-Weiner diversity index	1.0	3.2	1.7	1.3	2.8	3.3	2.0	4.0
Species evenness	0.5	0.7	0.5	0.6	0.8	0.7	0.5	0.8

Table 24.
Comparisons of species richness and evenness for the DCA determined woodland types.

Woodland type	Mulga & Crebra	Mulga & Cypress	Mulga & Microneura	Mulga & Desert uplands	Mulga & Box	Mulga & Melanophloia	Crebra & Cypress	Crebra & Microneura	Crebra & Desert uplands	Crebra & Box	Crebra & Melanophloia	Cypress & Microneura	Cypress & Desert uplands	Cypress & Box	Cypress & Melanophloia	Microneura & Desert uplands	Microneura & Box	Microneura & Melanophloia	Desert uplands & Box	Desert uplands & Melanophloia
Number of sites	36	7	6	8	21	17	35	34	36	49	45	35	5	20	16	6	19	15	21	17
Number of species recorded in combined woodland types	96	29	17	37	86	52	96	98	109	127	109	32	50	92	59	41	89	58	99	64
Percentage of total species present in combined woodland type	61	18	11	23	54	33	61	62	69	80	69	20	32	58	37	26	56	37	63	41
Number of species shared by both types	1	2	0	3	4	5	18	3	15	47	2	2	6	14	14	2	4	2	17	19
Number of species unique to woodland types	41	6	8	14	28	5	45	46	52	77	43	10	16	31	8	18	32	9	39	12
Total number of species	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158
Percentage of total species represented by species unique to type	26	4	5	9	18	3	29	29	33	49	27	6	10	20	5	11	20	6	25	8
Percentage of species in type represented by species unique to type	43	21	47	38	33	10	47	47	48	61	39	31	32	34	14	44	36	16	39	19
Sorensen coefficient	0	0.1	0	0.1	0.1	0.2	0.3	0.1	0.2	0.5	0	0.1	0.2	0.3	0.4	0.1	0.1	0.1	0.3	0.3
Number of species shared by all sites within type.	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
% species shared by all sites within type.	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0

Table 25.
Changes in total species richness and composition by woodland type.

Composition change = ((E+C)/N) * 100 where E = number of local extinctions, C = number of colonisations and N = the number of species present at initial recording.

Woodland type	A. Number of species present at initial recording	B. Number of species present at final recording	C. Diversity change	(C/A) * 100 Diversity change as a percentage of initial species richness.	Composition change
Box	83	88	5	6.02	13.58
Crebra	91	99	8	8.79	11.90
Cypress	23	24	1	4.35	4.55
Desert uplands	34	34	0	0.00	0
Melanophloia	53	56	3	5.66	10.20
Microneura	10	10	0	0.00	0
Mulga	9	10	1	11.11	12.50
Total	153	156	3	1.96	4.58

Table 26.
Species colonisations and losses by woodland type.

Total	
Colonisations	Losses
Acacia cretata	*Alyxia ruscifolia*
Casuarina cristata	*Diospyrus ferrea*
Denhamia oleaster	
Ficus obliqua	
Lysiphyllum carronii	

Box	
Colonisations	Losses
Acacia holosericea	*Acacia leiocalyx*
Brachychiton australe	*Diospyrus ferrea*
Brachychiton populneus	*Eremophila longifolia*
Denhamia oleaster	
Dodonaea viscosa	
Eriocerius martinii	
Hakea fraserii	
Macrozamia miquellii	

Cypress	
Colonisations	Losses
Alectryon oleifolius	

Crebra	
Colonisations	Losses
Acacia cretata	*Alyxia ruscifolia*
Acacia longispicata	
Alstonia constricta	
Casuarina cristata	
Ficus obliqua	
Flindersia dissosperma	
Lysiphyllum carronii	
Pandorea pandorana	
Parsonsia lanceolata	

Mulga	
Colonisations	Losses
Geijera parviflora	

Melanophloia	
Colonisations	Losses
Acacia stipuligra	*Acacia crassa*
Breynia oblongifolia	
Carissa ovata	
Pittosporum phylliraeoides	

from three in BOX woodlands to zero for CYPRESS, MULGA DESERT UPLANDS and MICRONEURA. The total change in species composition was determined to be 4.58% with an annual rate of 0.44% (Table 25). Annual composition change within the different woodland types ranged from 0% to 5.58%.

Species accumulation curves were uneven across all woodland types (Figure 15) and no asymptotic tendency was apparent for any of the communities. As a result estimates of sampling effort required to sample 90% of species diversity based on the fitted exponential curve was high for all woodlands types, ranging from 106 sub-plots for MICRONEURA woodlands to 9208 for MELANOPHLOIA woodlands (Table 27). Accumulation curves were more even for the majority of individual sites (Figure 16). Estimates of sampling effort required to sample 90% of species were also much closer to the actual sampling sizes (Table 28), with a majority of sites (38) exceeding the area required to sample 95% of species.

3.10.1 Importance Values

The Families Mimosaceae and Myrtaceae ranked first and second in importance in all woodland types except MULGA, where Myrtaceae was absent completely, and CYPRESS where Mimosaceae ranked fourth (Table 29). These two families accounted for 95% of basal area, 62% of woody plant density and 43% of all species recorded. Myrtaceae, with a FIV of 171 accounted for 25% of species diversity, 94% of the basal area and 51% of density. With 77% of the species, the

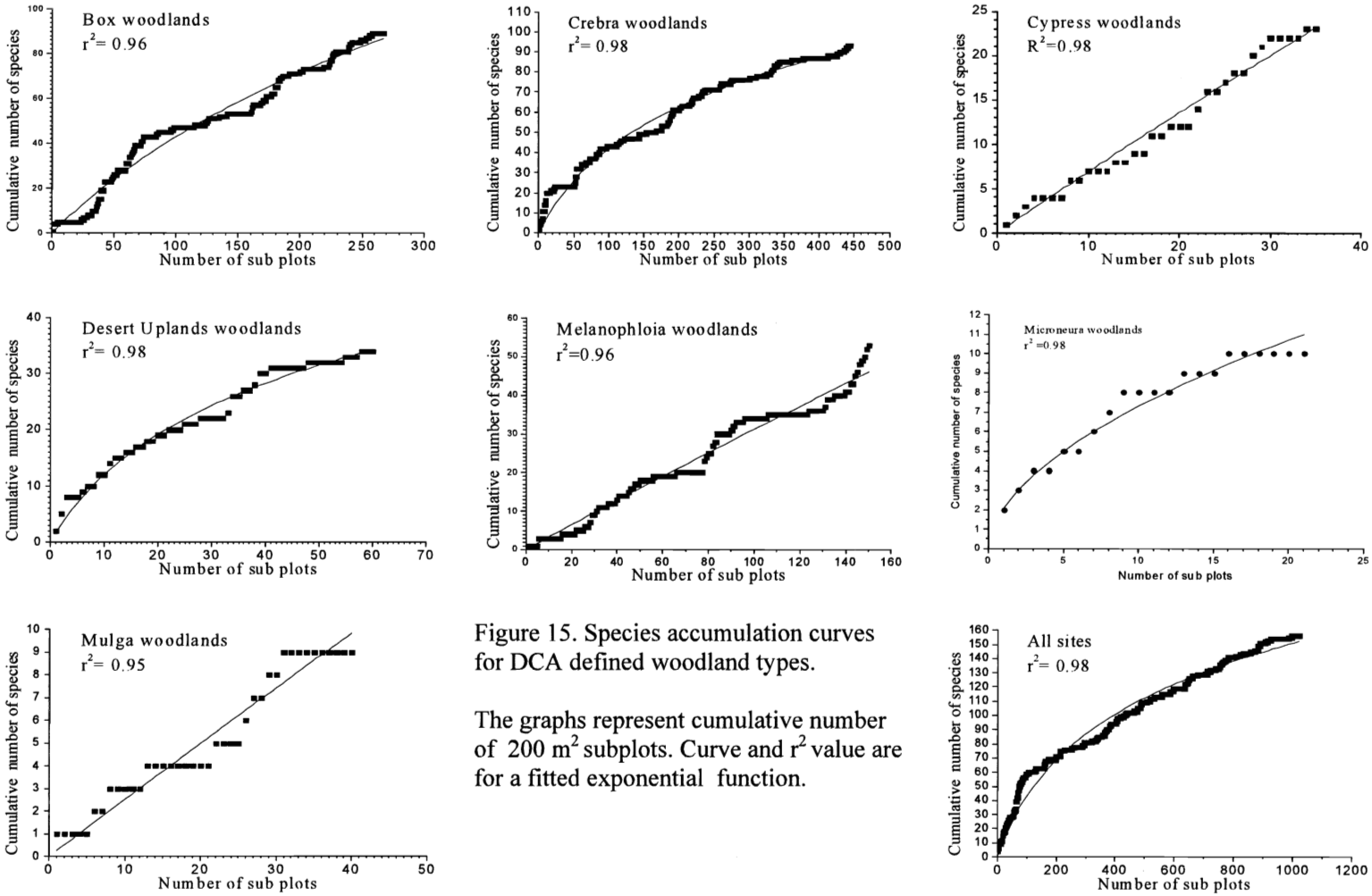


Figure 15. Species accumulation curves for DCA defined woodland types.

The graphs represent cumulative number of 200 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

Table 27.
Number of 200 m^2 subplots required to obtain 90% of species for each DCA defined woodland type using extrapolation of fitted negative exponential function.

"% of required subplots" is the number of subplots actually sampled as percentage of the number required for 90% species sampling.

Woodland type	Number of subplots required	% of required subplots sampled
Box woodlands	2019	13
Crebra woodlands	1006	44
Cypress woodlands	4604	1
Desert uplands woodlands	418	14
Melanophloia woodlands	9208	2
Microneura woodlands	106	19
Mulga woodlands	3836	1
All sites	1535	66

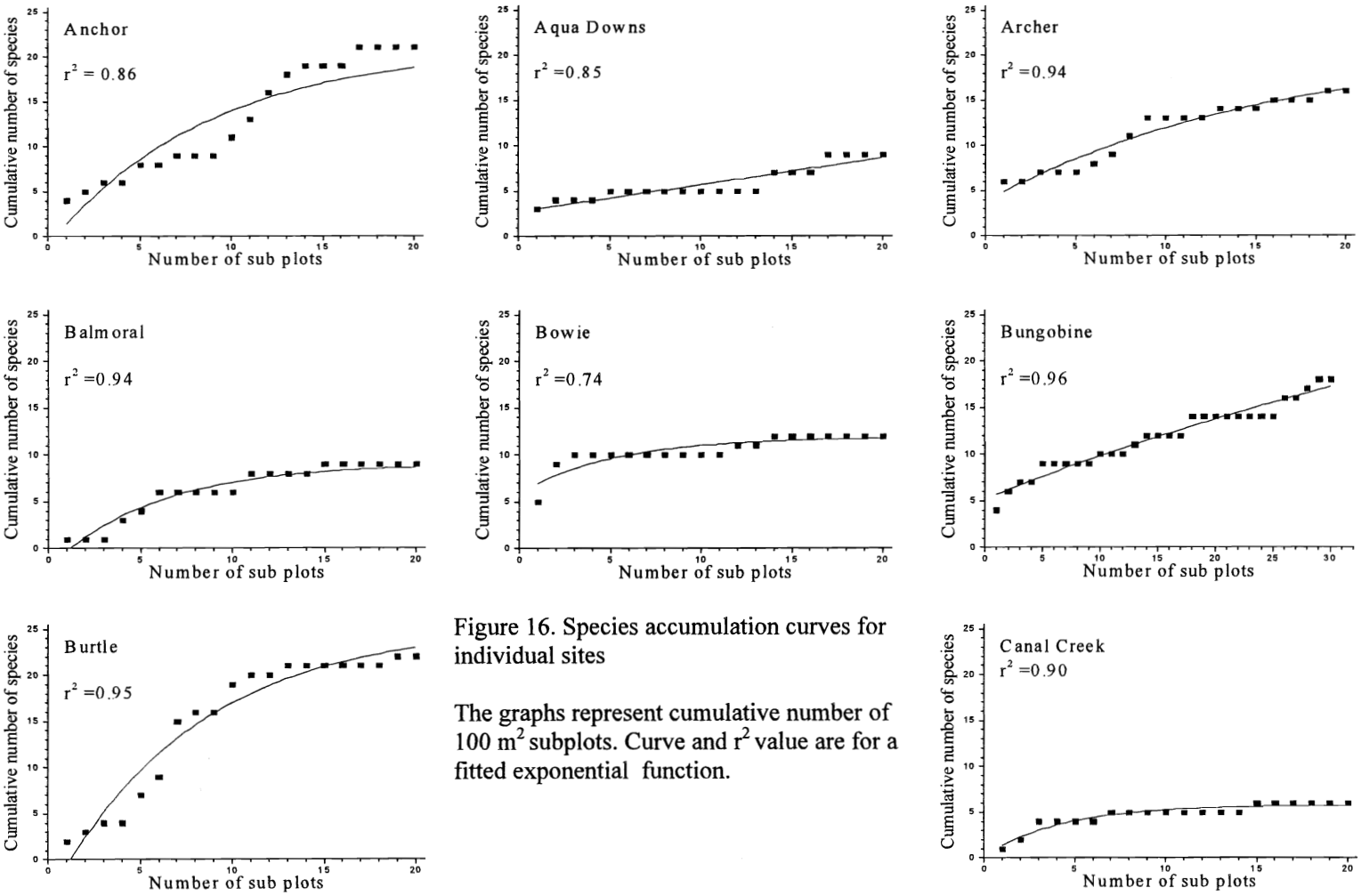


Figure 16. Species accumulation curves for individual sites

The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

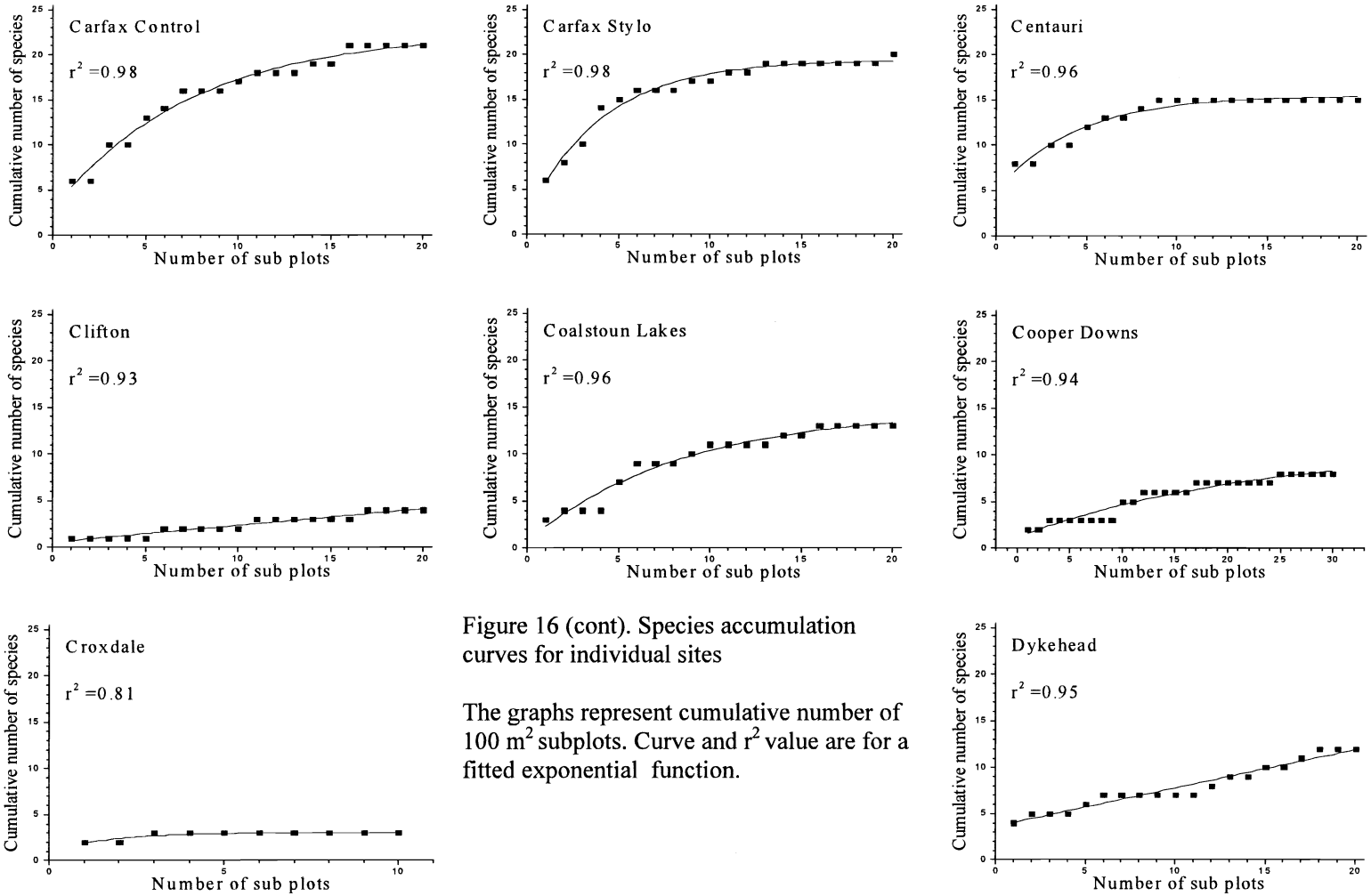


Figure 16 (cont). Species accumulation curves for individual sites

The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

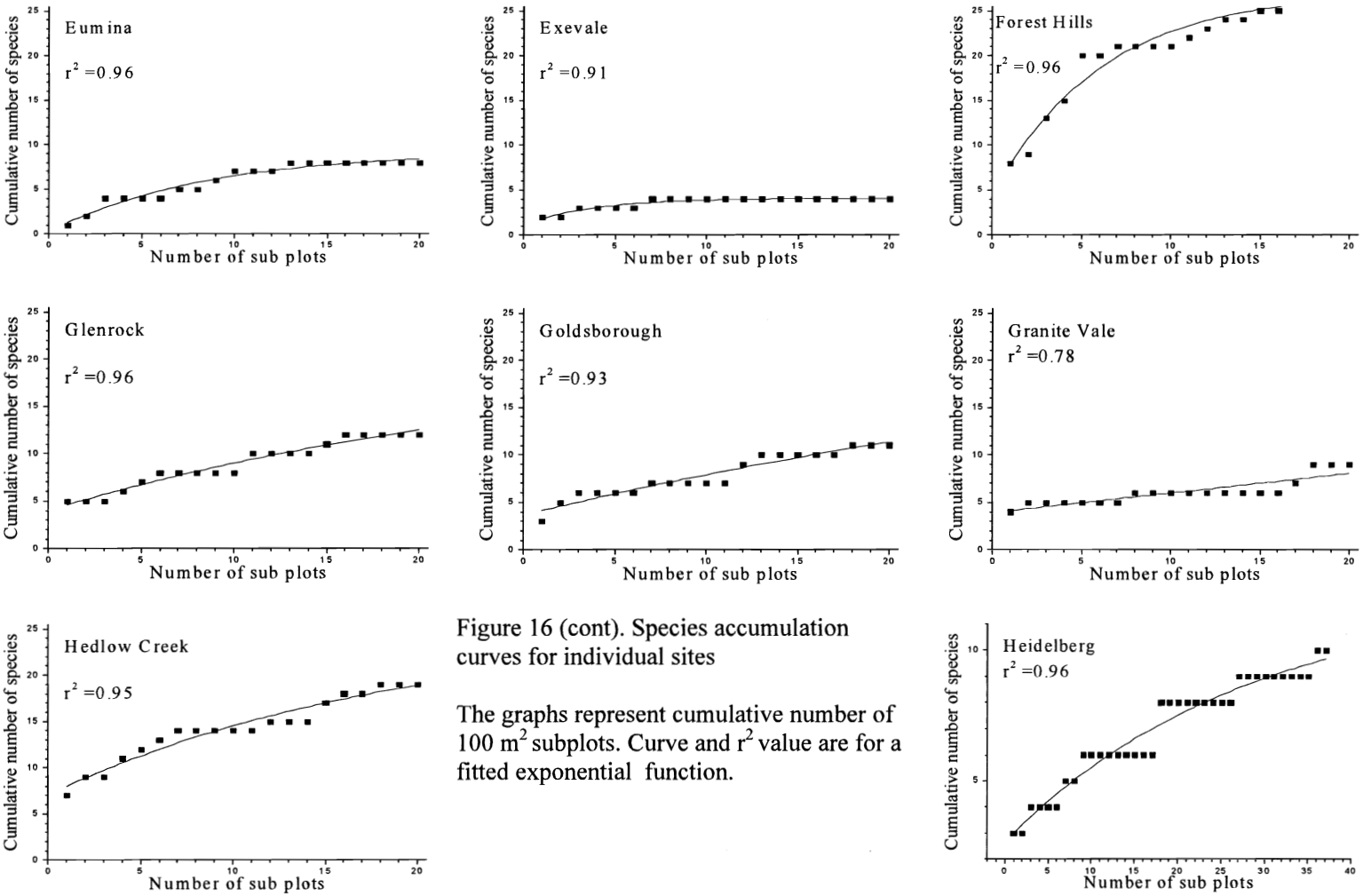


Figure 16 (cont). Species accumulation curves for individual sites

The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

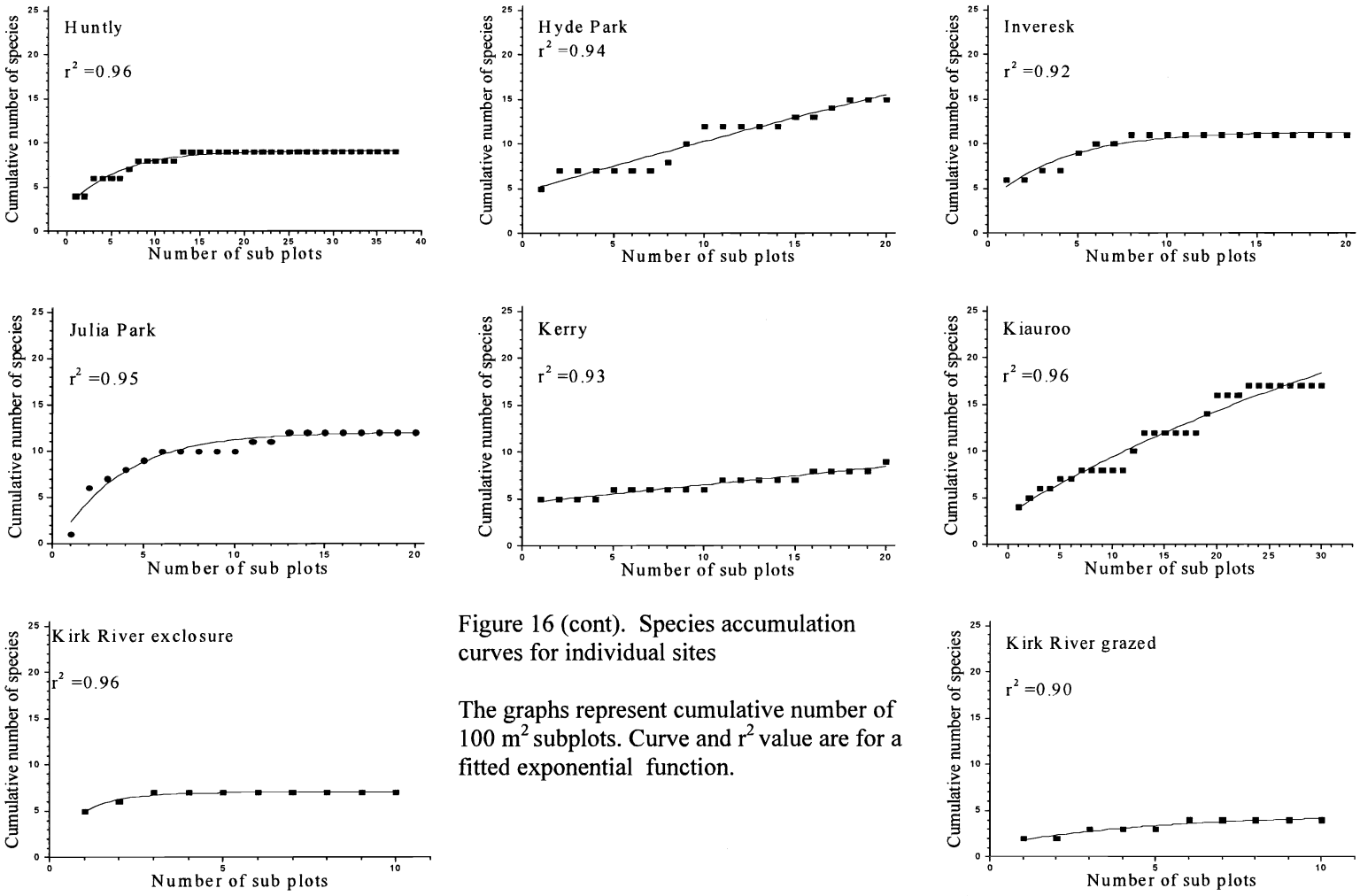


Figure 16 (cont). Species accumulation curves for individual sites

The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

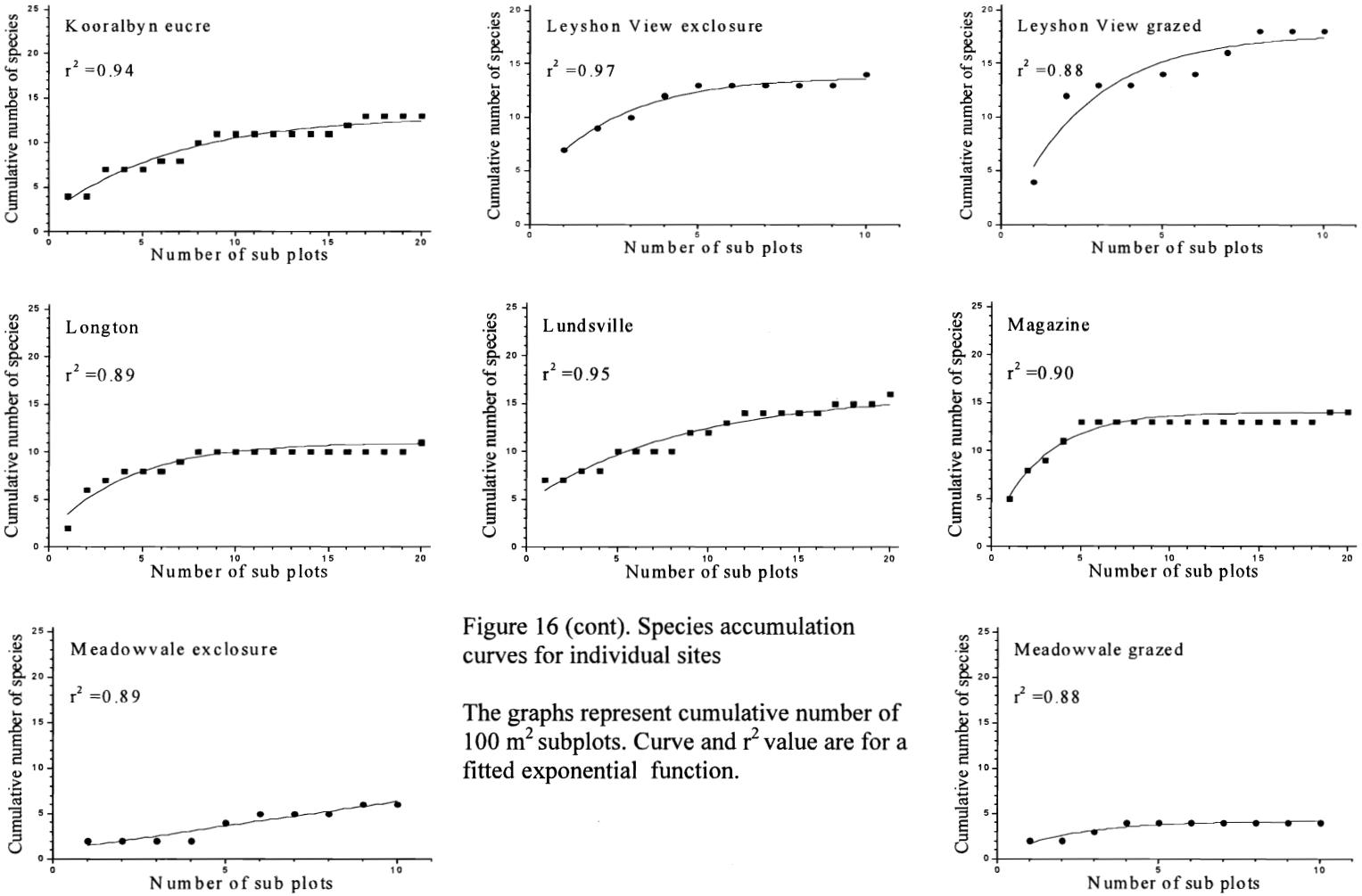
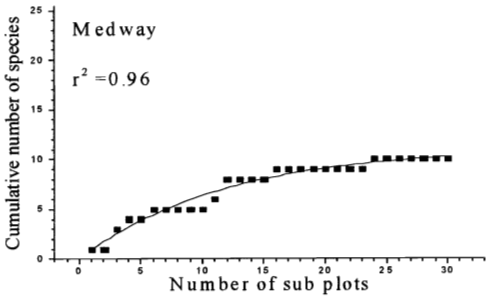
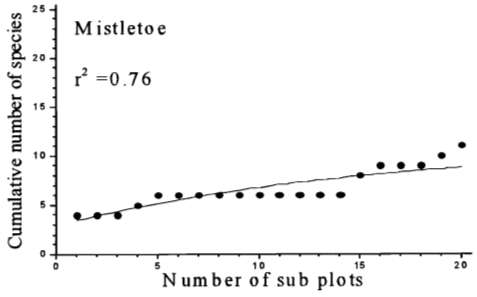
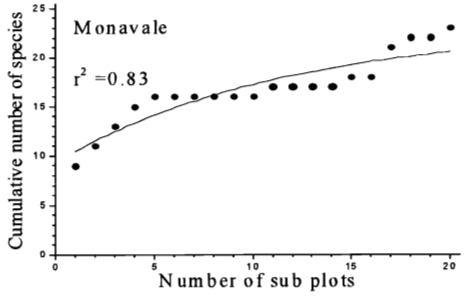


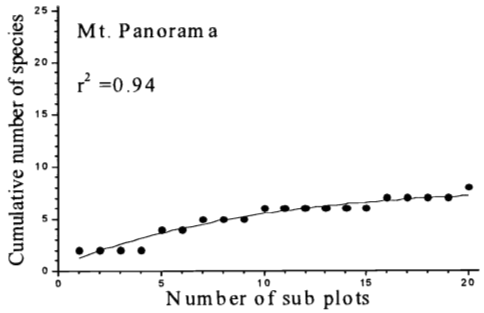
Figure 16 (cont). Species accumulation curves for individual sites

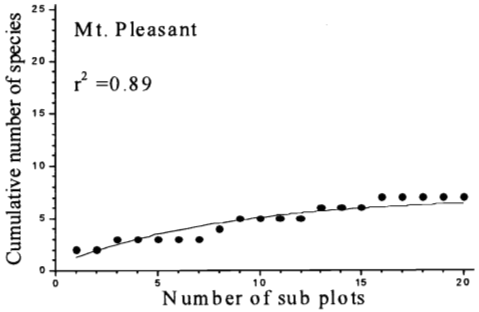
The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

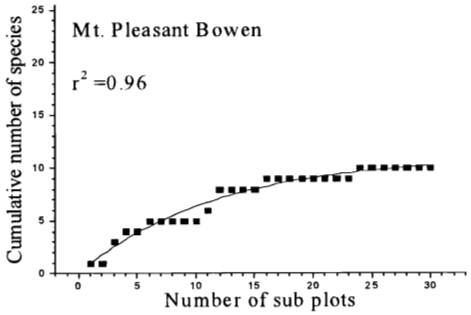












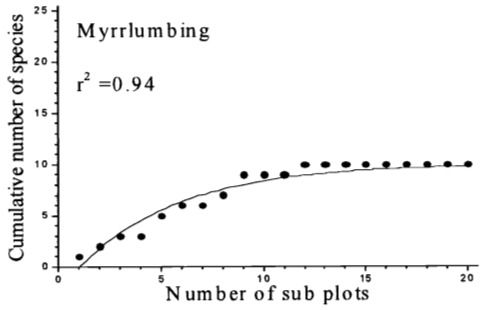
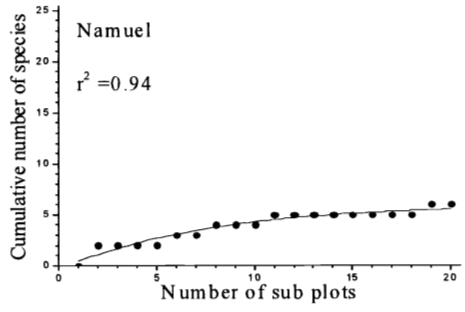


Figure 16 (cont). Species accumulation curves for individual sites

The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.



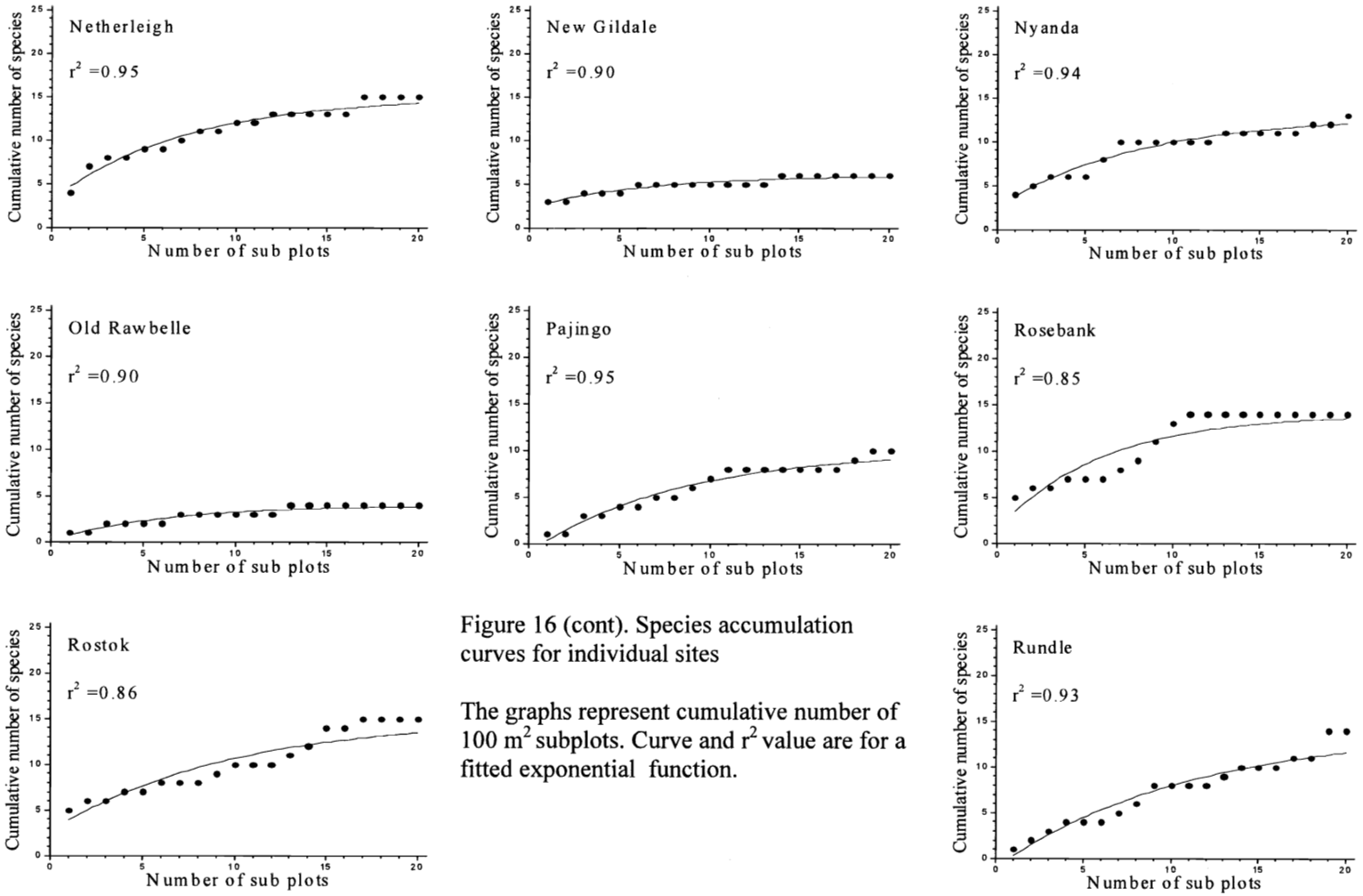


Figure 16 (cont). Species accumulation curves for individual sites

The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

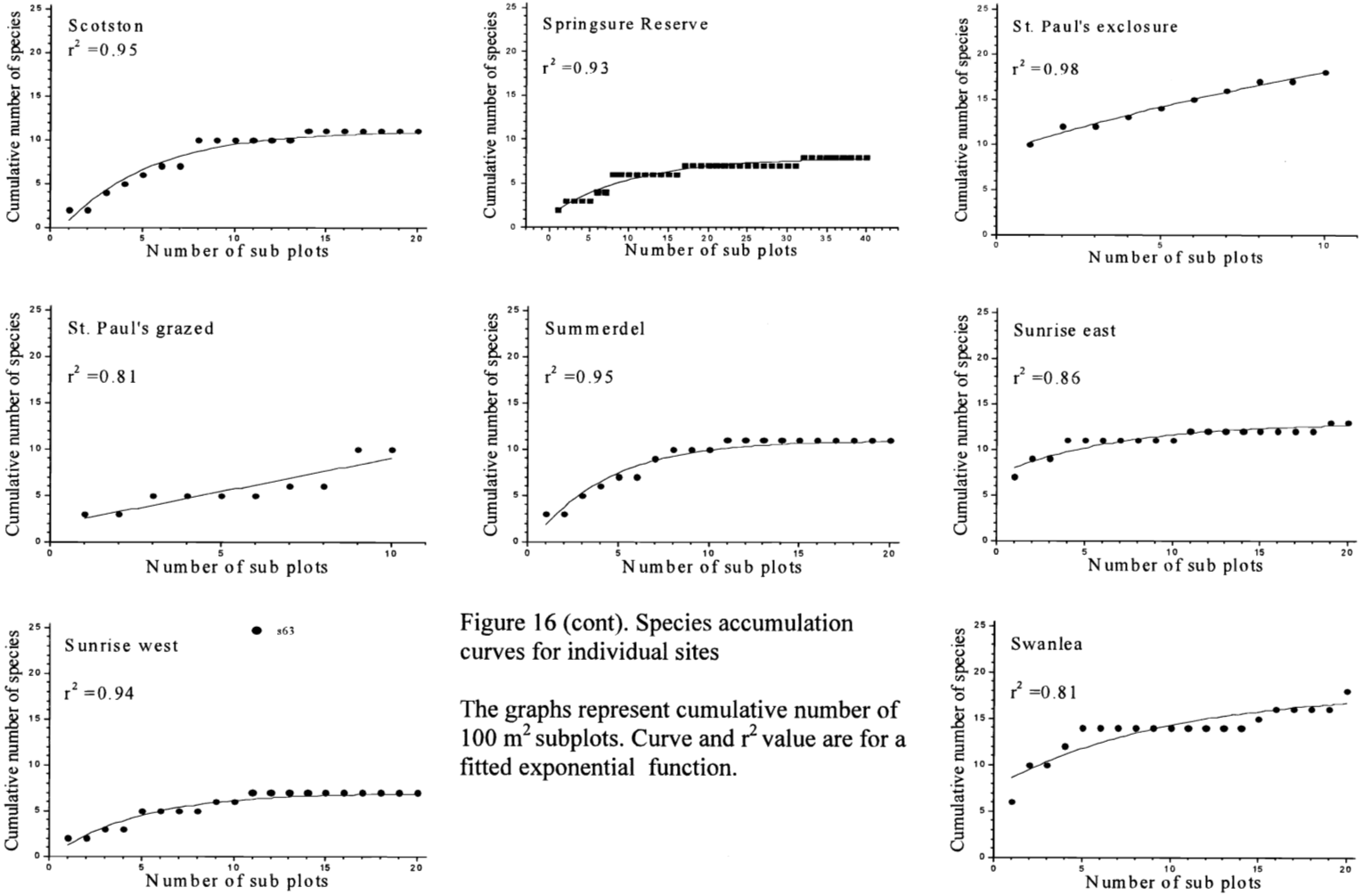
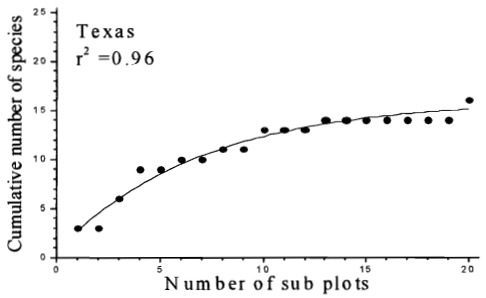
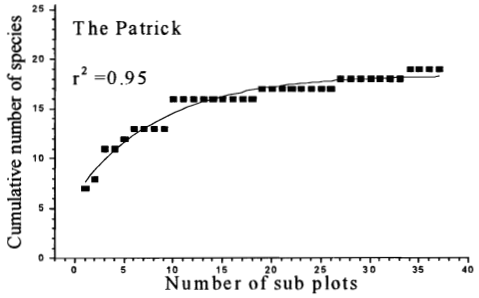
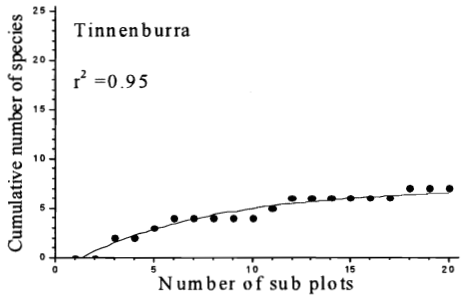


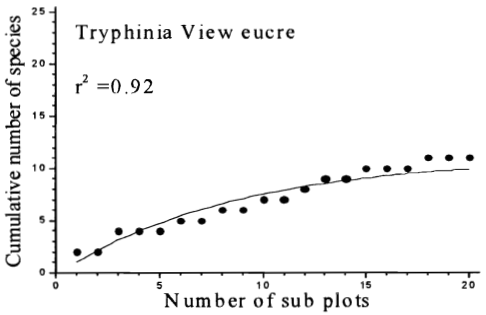
Figure 16 (cont). Species accumulation curves for individual sites

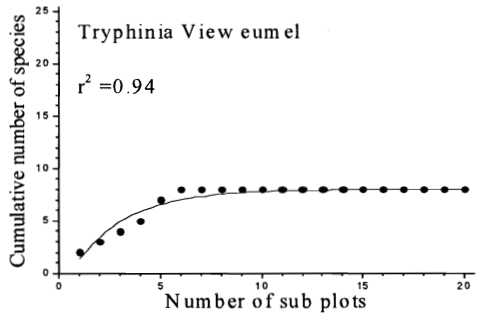
The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

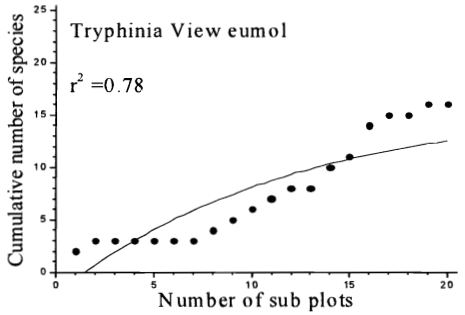












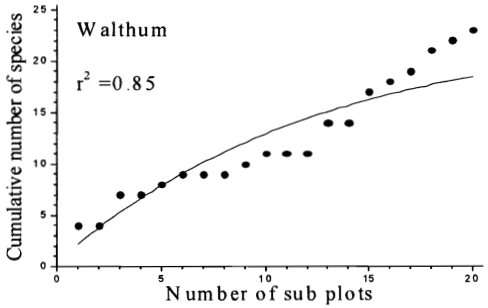
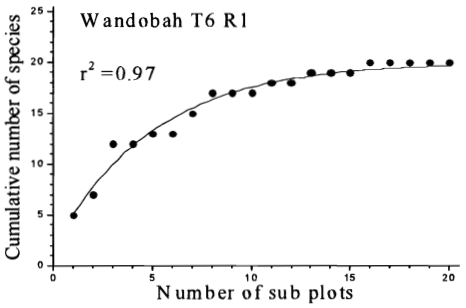


Figure 16 (cont). Species accumulation curves for individual sites

The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.



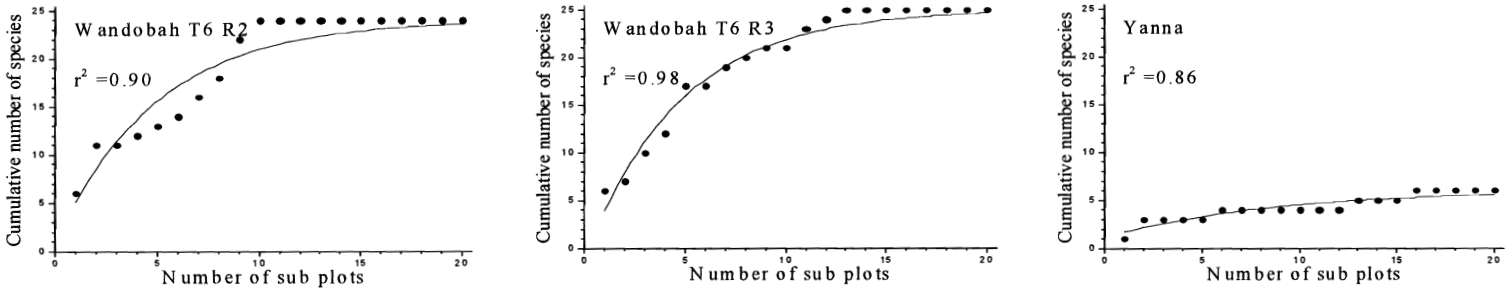


Figure 16 (cont). Species accumulation curves for individual sites

The graphs represent cumulative number of 100 m^2 subplots. Curve and r^2 value are for a fitted exponential function.

Table 28.
Number of 100 m^2 subplots required to obtain 90% of species for each site using extrapolation of fitted negative exponential function.

"% of required subplots" is the number of subplots actually sampled as percentage of the number required for 90% species sampling.

Transect name	Number of subplots required	% of required subplots sampled
Anchor	23	87
Aqua Downs	48	42
Archer	24	82
Balmoral	29	68
Bowie	15	130
Bungobine	99	30
Burtle	39	52
Canal creek	16	127
Carfax control	29	69
Carfax stylo	22	92
Centauri	14	141
Clifton	22	91
Coalstoun Lakes	36	224
Cooper Downs	31	98
Croxdale	3	400
Dykehead	37	108
Eumina	14	213
Exevale	19	257
Forest Hills	21	95
Glenrock	35	57
Goldsborough	34	59
Granitevale	65	31
Hedlow Creek	31	130
Heidelberg	49	163
Huntly	19	104
Hyde Park	34	58
Inveresk	19	106
Julia park	14	141
Kerry	87	35
Kiauroo	52	19
Kirk River exclosure	3	288
Kirk River grazed	18	56
Kooralbyn eucre	21	195
Leyshon View exclosure	17	240
Leyshon View grazed	20	98
Longton	19	106
Lundsville	36	55
Magazine	16	121

Transect name	Number of subplots required	% of required subplots sampled
Meadowvale exclosure	30	66
Meadowvale grazed	15	391
Medway	33	121
Mistletoe	42	48
Monavale	42	48
Mt. Panorama	16	249
Mt. Pleasant	24	127
Mt. Pleasant Bowen	28	72
Myrrlumbing	9	220
Namuel	19	106
Netherleigh	25	161
New Gildale	28	72
Nyanda	22	92
Old Rawbelle	18	110
Pajingo	21	95
Rosebank	25	121
Rostock	34	29
Rundle	32	32
Scotston	12	332
Springsure reserve	20	204
St. Pauls exclosure	37	54
St. Pauls grazed	18	109
Summerdel	16	126
Sunrise east	44	45
Sunrise west	18	114
Swanlea	31	192
Texas	15	542
The Patrick	31	65
Tinnenburra	13	158
Tryphinia eucre	17	115
Tryphinia eumel	16	128
Tryphinia eumol	25	78
Walthum	22	186
Wandobah T6 R1	19	83
Wandobah T6 R2	35	46
Wandobah T6 R3	22	72
Yanna	19	105

Table 29.
Relative density (rel. den.), relative diversity (rel. div), relative dominance (rel. dom.) and resulting family importance values (FIV) for families present in the study area by Detrended Correspondence Analysis determined woodland type.
See text for explanation of terms.

	BOC				MELANOPHLOIA				MULGA				All sites		
	rel. div.	rel. den.	rel. dom.	FIV	rel. div.	rel. den.	rel. dom.	FIV	rel. div.	rel. den.	rel. dom.	FIV	rel. div.	rel. den.	rel. dom.
Apocynaceae	4.88	11	0.02	15.9	6	2.7	0.03	8.73	–	–	–	–	3.27	3.77	0.01
Asclepiadaceae	2.44	0.21	0	2.65	–	–	–	–	–	–	–	–	1.31	0.09	0.01
Asteraceae	–	–	–	–	–	–	–	–	–	–	–	–	0.65	0.07	0
Bignoniaceae	–	–	–	–	2	0.03	0	2.03	–	–	–	–	1.31	0.09	0.02
Boraginaceae	1.22	0.7	0.03	1.96	2	0.15	0.04	2.19	–	–	–	–	0.65	0.22	0.02
Cactaceae	2.44	0.4	0	2.83	4	0.99	0	4.99	–	–	–	–	1.96	1.19	0
Caesalpiniaceae	3.66	1.23	1.17	6.06	4	5.73	0.01	9.74	14.29	1.3	0.01	15.6	3.92	1.38	0.31
Capparaceae	6.1	1.92	0.02	8.03	2	0.44	0	2.44	–	–	–	–	3.27	0.85	0.02
Casuarinaceae	1.22	0.15	0	1.37	–	–	–	–	–	–	–	–	1.31	0.1	0.15
Celastraceae	2.44	1.74	0.01	4.18	2	3.44	0.07	5.52	–	–	–	–	1.31	2.28	0.05
Combretaceae	2.44	0.26	0.22	2.91	2	1.59	0.32	3.91	–	–	–	–	1.31	0.53	0.49
Cupressaceae	–	–	–	–	2	8.85	2.49	13.34	–	–	–	–	0.65	5.78	5.39
Epacridaceae	–	–	–	–	–	–	–	–	–	–	–	–	0.65	0.05	0.02
Erythroxylaceae	1.22	1.47	0.26	2.95	2	0.07	0.01	2.07	–	–	–	–	0.65	0.41	0.07
Euphorbiaceae	3.66	1.93	0.47	6.05	4	0.49	0.06	4.55	–	–	–	–	1.96	3.32	0.6
Fabaceae	–	–	–	–	–	–	–	–	–	–	–	–	1.31	0.5	0.07
Lecythidaceae	–	–	–	–	–	–	–	–	–	–	–	–	0.65	0.07	0
Meliaceae	1.22	0.35	0.01	1.58	–	–	–	–	–	–	–	–	0.65	0.1	0
Mimosaceae	10.98	20.56	7.92	39.46	16	10.8	2.45	29.25	28.57	65.12	93.52	187.21	17.65	16.8	6.61
Moraceae	–	–	–	–	–	–	–	–	–	–	–	–	1.31	0.01	0
Myoporaceae	4.88	8.21	2.92	16.01	10	9.57	0.37	19.94	42.86	31.55	0.01	74.41	3.92	4.77	0.81
Myrtaceae	17.07	16.76	84.97	118.81	20	47.68	93.19	160.87	–	–	–	–	22.88	35.07	83.08
Pittosporaceae	2.44	0.02	0	2.46	2	0.07	0.04	2.11	–	–	–	–	3.27	0.11	0.03
Proteaceae	4.88	2.1	0.05	7.03	–	–	–	–	14.29	2.03	6.09	22.4	4.58	0.82	0.3
Rhamnaceae	2.44	5.75	0.23	8.42	4	4.64	0.15	8.8	–	–	–	–	1.96	11.87	0.76
Rubiaceae	3.66	3.5	0.07	7.22	2	1.75	0.01	3.76	–	–	–	–	4.58	2.37	0.15
Rutaceae	4.88	3.1	0.34	8.32	2	0.24	0.09	2.33	–	–	–	–	2.61	0.98	0.16
Santalaceae	1.22	0.01	0	1.23	2	0.03	0	2.03	–	–	–	–	0.65	0.02	0
Sapindaceae	7.32	16.59	0.56	24.46	6	0.41	0.01	6.42	–	–	–	–	4.58	5.28	0.17
Sterculiaceae	2.44	0.02	0	2.46	2	0.2	0.08	2.28	–	–	–	–	1.31	0.33	0.05
Verbenaceae	3.66	2.04	0	5.7	2	0.14	0	2.14	–	–	–	–	1.96	0.67	0
Xanthoroeaceae	–	–	–	–	–	–	–	–	–	–	–	–	0.65	0	0
Zamiaceae	1.22	0.02	0	1.24	–	–	–	–	–	–	–	–	1.31	0.09	0.37

Table 29 (cont).
Relative density (rel. den.), relative diversity (rel. div), relative dominance (rel. dom.) and resulting family importance values (FIV) for families present in the study area by Detrended Correspondence Analysis determined woodland type.
See text for explanation of terms.

	rel. div.	rel. den.	rel. dom.	FIV	rel. div.	rel. den.	rel. dom.	FIV	rel. div.	rel. den.	rel. dom.	FIV	rel. div.	rel. den.	rel. dom.	FIV
Apocynaceae	4.40	0.69	<.001	5.09	–	–	–	–	–	–	–	–	3.03	1.22	0.00	4.25
Asclepiadaceae	1.10	0.07	0.01	1.19	–	–	–	–	–	–	–	–	3.03	1.22	0.00	4.25
Asteraceae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Bignoniaceae	2.20	0.16	0.04	2.40	–	–	–	–	10.00	2.78	0.00	12.78	–	–	–	–
Boraginaceae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Cactaceae	2.20	0.61	<.001	2.81	12.50	10.25	<.001	22.75	–	–	–	–	6.06	2.65	0.00	8.72
Caesalpiniaceae	2.20	0.02	0.00	2.22	–	–	–	–	10.00	2.78	0.47	13.24	3.03	0.22	0.00	3.25
Capparaceae	3.30	0.59	0.03	3.91	–	–	–	–	–	–	–	–	–	–	–	–
Casuarinaceae	2.20	0.08	0.33	2.61	4.17	0.44	0.18	4.79	–	–	–	–	3.03	7.83	0.15	11.02
Celastraceae	1.10	1.78	0.08	2.96	4.17	1.90	0.01	6.08	–	–	–	–	–	–	–	–
Combretaceae	–	–	–	–	–	–	–	–	10.00	37.70	16.29	63.99	–	–	–	–
Cupressaceae	–	–	–	–	4.17	67.90	64.76	136.83	–	–	–	–	3.03	0.44	0.07	3.54
Epacridaceae	–	–	–	–	4.17	0.37	0.00	4.53	10.00	0.79	0.57	11.36	–	–	–	–
Erythroxylaceae	–	–	–	–	–	–	–	–	–	–	–	–	3.03	8.05	1.42	12.50
Euphorbiaceae	2.20	5.40	1.06	8.66	–	–	–	–	–	–	–	–	–	–	–	–
Fabaceae	2.20	0.22	0.06	2.48	4.17	6.22	0.54	10.93	–	–	–	–	3.03	0.04	0.00	3.07
Lecythidaceae	1.10	0.16	0.00	1.26	–	–	–	–	–	–	–	–	24.24	47.47	6.58	78.28
Meliaceae	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Mimosaceae	17.58	10.87	1.32	29.77	16.67	2.73	0.77	20.17	20.00	1.98	0.03	22.01	3.03	0.02	0.01	3.06
Moraceae	2.20	0.02	0.00	2.22	–	–	–	–	–	–	–	–	21.21	24.76	90.84	136.81
Myoporaceae	1.10	0.14	0.00	1.24	4.17	0.15	0.04	4.35	–	–	–	–	–	–	–	–
Myrtaceae	25.27	51.47	94.27	171.02	25.00	7.66	30.53	63.19	10.00	39.29	82.63	131.92	3.03	0.17	0.75	3.95
Pittosporaceae	4.40	0.23	0.05	4.67	–	–	–	–	–	–	–	–	6.06	4.29	0.01	10.36
Proteaceae	4.40	0.40	0.11	4.90	–	–	–	–	–	–	–	–	3.03	0.15	0.12	3.30
Rhamnaceae	3.30	22.19	1.45	26.94	4.17	0.15	1.10	5.41	–	–	–	–	–	–	–	–
Rubiaceae	4.40	2.59	0.06	7.04	4.17	0.59	1.32	6.07	10.00	2.78	0.01	12.78	3.03	0.28	0.04	3.36
Rutaceae	2.20	0.06	0.00	2.26	4.17	1.02	0.74	5.94	–	–	–	–	–	–	–	–
Santalaceae	–	–	–	–	–	–	–	–	–	–	–	–	6.06	0.28	0.00	6.34
Sapindaceae	3.30	1.32	0.06	4.67	4.17	0.15	0.00	4.31	20.00	11.90	0.01	31.91	–	–	–	–
Sterculiaceae	2.20	0.62	0.09	2.92	4.17	0.49	0.00	4.65	–	–	–	–	3.03	0.91	0.00	3.95
Verbenaceae	2.20	0.10	0.00	2.30	–	–	–	–	–	–	–	–	–	–	–	–
Xanthoroeaceae	1.10	0.01	0.00	1.11	–	–	–	–	–	–	–	–	–	–	–	–
Zamiaceae	2.20	0.19	0.91	3.30	–	–	–	–	–	–	–	–	–	–	–	–

eucalypts (genera *Eucalyptus* and *Corymbia*) accounted for the majority of plants within the Myrtaceae. *Eucalyptus* and *Corymbia* were the second and third most species rich genera, comprising 18 and 9 species respectively (Table 30). Combined, the eucalypts accounted for 81% of the basal area and 31% of the plant density over all the sites studied.

With individuals of the family Myrtaceae contributing only 8% of plant density in CYPRESS woodlands, the family's basal area contribution was disproportionate to the number of individuals. Within the woodland types MICRONEURA, DESERT UPLANDS, BOX and MELANOPHLOIA the family Myrtaceae accounted for 80-95% of the basal area. The relative density of Myrtaceae varied more than the basal area within these woodland types, with the family producing 47% of individuals in MELANOPHLOIA woodlands, 39% in MICRONEURA, 25% in DESERT UPLANDS and 17% in BOX. The low relative density of myrtaceous plants in the BOX woodland type was attributable in large part to the presence of two sites dominated by *Acacia* species, particularly the *Acacia shirleyii* dominated site "Centauri" which, at 5010 plants/ha at the final recording, represented the highest density of any site.

Mimosaceae accounted for 19% of the total number of species recorded and contributed 17% of plant density. However this family accounts for only 7% of the basal area, giving a FIV of 41 (Table 29). The contribution of Mimosaceae to

Table 30.
Species number recorded in the study area at initial recording, by genus.

Genus	Number of species	Percentage of total species
Acacia	27	17.53
Alectryon	2	1.3
Allocasurina	1	0.65
Alphitonia	1	0.65
Alstonia	1	0.65
Angophora	1	0.65
Apophyllum	1	0.65
Archidendropsis	1	0.65
Atalaya	1	0.65
Brachychiton	2	1.3
Breynia	1	0.65
Bursaria	2	1.3
Caelospermum	1	0.65
Callitris	1	0.65
Canthium	5	3.25
Capparis	4	2.6
Carissa	2	1.3
Cassia	1	0.65
Cassinia	1	0.65
Casuarina	1	0.65
Citriobatus	2	1.3
Clerodendrum	1	0.65
Corymbia	9	5.84
Cryptostegia	1	0.65
Cupaniopsis	1	0.65
Denhamia	1	0.65
Dodonaea	3	1.95
Dolichandrone	1	0.65
Ehretia	1	0.65
Eremophila	4	2.6
Eriocerius	1	0.65
Erythrina	1	0.65
Ficus	2	1.3
Flindersia	2	1.3
Gardenia	2	1.3
Geijera	2	1.3
Grevillea	3	1.95
Hakea	3	1.95
Jacksonia	1	0.65
Lantana	2	1.3
Lophostomen	2	1.3
Lysiphyllum	3	1.95
Macrozamia	2	1.3
Maytenus	1	0.65
Melalueca	3	1.95
Melia	1	0.65
Melichrus	1	0.65
Micromyrtus	1	0.65
Myoporum	2	1.3
Opuntia	2	1.3
Owenia	1	0.65
Pandorea	1	0.65
Parsonsia	2	1.3
Persoonia	1	0.65
Petalostigma	1	0.65
Pittosporum	1	0.65
Planchonia	1	0.65
Santalum	1	0.65
Sarcostemma	1	0.65
Senna	2	1.3
Terminalia	2	1.3
Ventilago	1	0.65
Xanthorrhoea	1	0.65
Zizyphus	1	0.65

diversity and density was disproportionate to the approximately 7% of sites that are *Acacia* dominated. In contrast to the Myrtaceae, Mimosaceae was only important in terms of basal area contribution in the MULGA woodlands and the two northern *Acacia* woodland sites where this family dominated the overstorey. In MULGA woodlands Mimosaceae contributed 95% of the basal area and 65% of the woody plant density and in the northern acacia woodlands contributed 83% of the basal area and 66% of plant density. The family Mimosaceae accounted for less than 10% of basal area in all woodland types other than MULGA. The importance of the family Mimosaceae in those woodlands not dominated by *Acacia* species was in its contribution to plant numbers and species diversity. Within the CREBRA and MELANOPHLOIA woodlands Mimosaceae contributed approximately 11% of the total woody plant density and 17% of the species. In the CYPRESS and MICRONEURA woodlands Mimosaceae contributed approximately 3% of the density and 20% of the species. In the BOX woodlands the family accounted for 21% of density and 11% of species, assisted by the two *Acacia* dominated sites. In the DESERT UPLANDS woodland type, Mimosaceae accounted for 47% of plant density and 24% of all species. Within the MULGA woodlands the Mimosaceae also made a large contribution to species diversity, accounting for 29% of the species. The genus *Acacia* accounted for 96% of the genera within the family Mimosaceae. The genus *Acacia* was also the most speciose genus in the study area, comprising 26 species, 15% of plant density and 7% of basal area.

Mimosaceae was the only family to rank in the top five most important families for all woodland types. Excluding MULGA woodlands all other types showed a further degree of similarity in terms of FIVs with Myrtaceae ranking first or second. Although no other families were found in the top 10 FIVs for all woodland types Rubiaceae, Rhamnaceae, Sapindaceae and Caesalpinaceae ranked highly in the majority of types.

Cupressaceae, the family to which white cypress pine *(Callitris glaucophylla)* belongs, ranked fourth in family importance with a FIV of 12 despite being represented by only one species at 4 sites. This reflects the high densities and basal areas recorded at those sites dominated by *C. glaucophylla*. The third and fifth ranked families were Rhamnaceae, with a FIV of 15, and Sapindaceae, with a value of 10. Both these families are represented almost exclusively by understorey individuals and have achieved a high FIV despite contributing less than 1% of the total basal area. Rhamnaceae gains its high FIV largely due to the exceptionally high density of *Alphitonia excelsa*. The high FIV of Sapindaceae was largely attributable to the density and wide distribution of *Atalaya hemiglauca*.

The three most important species for the amalgamated sites at initial recording were all eucalypts: *E. crebra, E. melanophloia* and *E. populnea* with SIVs of 30, 27 and 17 respectively (Table 31). These values were the result of high basal area, frequency and density of these species and largely reflect the number of sites

Table 31.
Species Importance values (SIV) at first and last recording for the 10 highest ranked species at first recording.

All woodland types				
Species	Initial SIV	Final SIV	SIV rank initial	SIV rank final
Eucalyptus crebra	30.20	31.36	1	1
Eucalyptus melanophloia	26.71	29.97	2	2
Eucalyptus populnea	17.51	15.06	3	4
Alphitonia excelsa	14.81	17.12	4	3
Callitris glaucophylla	12.35	12.08	5	5
Atalaya hemiglauca	7.47	10.88	6	6
Acacia aneura	6.42	8.99	7	7
Corymbia erythrophloia	5.87	6.03	8	11
Corymbia citriodora	5.63	7.71	9	8
Petalostigma pubescens	5.44	6.25	10	10

Box woodlands				
Species	Initial SIV	Final SIV	SIV rank initial	SIV rank final
Eucalyptus populnea	61.81	57.12	1	1
Atalaya hemiglauca	23.67	18.44	2	4
Acacia shirleyii	16.84	15.59	3	6
Eucalyptus coolabah	16.63	21.07	4	2
Eucalyptus brownii	16.53	18.56	5	3
Carissa ovata	12.85	9.25	6	10
Eucalyptus tereticornis	12.06	10.96	7	9
Corymbia dallachyana	11.41	13.54	8	7
Eremophila mitchellii	11.18	11.19	9	8
Acacia salicina	10.04	7.18	10	11

Crebra woodlands				
Species	Initial SIV	Final SIV	SIV rank initial	SIV rank final
Eucalyptus crebra	77.26	76.58	1	1
Alphitonia excelsa	31.82	25.53	2	2
Corymbia erythrophloia	16.63	17.51	3	3
Corymbia citriodora	14.43	13.54	4	4
Eucalyptus moluccana	12.85	12.87	5	5
Melalueca viridiflora	11.22	11.53	6	6
Eucalyptus fibrosa	10.01	9.91	7	8
Eucalyptus exserta	9.83	8.84	8	9
Petalostigma pubescens	8.56	6.76	9	12
Corymbia clarksoniana	7.07	8.21	10	10

Cypress woodlands				
Species	Initial SIV	Final SIV	SIV rank initial	SIV rank final
Callitris glaucophylla	169.96	174.27	1	1
Eucalyptus populnea	24.88	26.08	2	2
Opuntia tomentosa	22.14	17.62	3	3
Jacksonia scoparia	11.75	12.13	4	4
Eucalyptus chloroclada	11.73	12.03	5	5
Eucalyptus melanophloia	10.64	9.38	6	6
Angophora costata	9.34	8.25	7	7
Eriocerius martinii	7.88	2.48	8	14
Corymbia tessellaris	5.50	4.77	9	9
Maytenus cunninghamii	5.18	5.07	10	8

Desert Uplands woodlands				
Species	Initial SIV	Final SIV	SIV rank initial	SIV rank final
Eucalyptus similis	60.43	63.29	1	1
Eucalyptus whiteii	39.44	40.92	2	2
Acacia tenuissima	28.54	24.69	3	3
Petalostigma pubescens	21.35	20.66	4	4
Acacia coriaceae	18.03	16.26	5	6
Corymbia terminalis	15.71	16.60	6	5
Acacia cowleana	14.74	13.18	7	8
Corymbia plena	14.26	14.43	8	7
Maytenus cunninghamii	13.43	10.74	9	9
Acacia laccata	9.49	7.45	10	12

Melanophloia woodlands				
Species	Initial SIV	Final SIV	SIV rank initial	SIV rank final
Eucalyptus melanophloia	172.22	178.43	1	1
Acacia coriaceae	15.59	14.97	2	2
Callitris glaucophylla	12.94	10.08	3	3
Alphitonia excelsa	8.04	5.82	4	9
Carissa lanceolata	7.66	7.01	5	5
Maytenus cunninghamii	6.77	3.71	6	13
Myoporum desertii	6.63	6.89	7	6
Senna artemisoides	6.36	6.14	8	7
Canthium oleifolium	6.16	2.70	9	16
Eremophila longifolia	5.86	2.68	10	17

Table 31. (Cont)
Species Importance values at first and last recording for the 10 highest ranked species at first recording.

Microneura woodlands				
Species	Initial SIV	Final SIV	SIV rank initial	SIV rank final
Eucalyptus microneura	159.54	163.46	1	1
Terminalia aridicola	82.22	80.87	2	2
Atalaya hemiglauca	17.20	15.34	3	3
Denhamia umbellata	12.83	13.64	4	4
Dolichandrone heterophyllum	12.09	3.67	5	8
Gardenia vilhelmii	11.43	4.97	6	6
Lysiphyllum gilvum	7.96	8.09	7	5
Acacia bidwillii	3.96	4.05	8	7
Melichrus species	2.49	2.58	9	9
Acacia holosericea	1.63	1.66	10	11

Mulga woodlands				
Species	Initial SIV	Final SIV	SIV rank initial	SIV rank final
Acacia aneura	228.37	228.49	1	1
Acacia excelsa	27.43	27.31	2	2
Eremophila longifolia	12.05	12.11	3	3
Eremophila gilesii	10.97	10.12	4	4
Hakea species	10.27	9.77	5	5
Eucalyptus populnea	6.21	6.43	6	6
Senna artemisoides	5.90	5.00	7	7
Eremophila mitchellii	0.77	0.76	8	8
Geijera parviflora	0.76	0.00	9	9
Acacia holosericea	1.63	1.66	10	11

dominated by these species (Appendix 1, Table 2). These three species also form the dominant species in terms of basal area in the CREBRA, MELANOPHLOIA and BOX woodlands.

Alphitonia excelsa ranked fourth in SIV at the initial recording and third at the final. This species can grow into a small tree, but in these sites it was predominantly found as an understorey shrub with an average height of 1.2 m. This growth habit was reflected in the low relative dominance for this species. *Alphitonia excelsa* was one of the few species that occurs in five of the seven woodland types. *C. glaucophylla* ranked fifth in SIV due to the high basal area and density of this species in the sites where it dominates. Mulga (*A. aneura*) ranked seventh in SIV while *E. microneura,* the species that dominates the MICRONEURA woodlands, ranked twenty-eighth. *Eucalyptus similis*, the most important species in the DESERT UPLANDS woodland type, ranked thirty-third in importance across all sites.

None of the woodland types shared the same top ten species in terms of SIV, although *E. populnea* ranked in the top two for both CYPRESS and BOX woodland types while *C. glaucophylla* ranked in the top two for both CYPRESS and MELANOPHLOIA woodlands. The highest SIVs for each woodland type were produced by species that constituted the dominant overstorey of the majority of sites within that type: *Eucalyptus crebra* for the CREBRA woodlands, *E.*

microneura for MICRONEURA, *E. similis* for DESERT UPLANDS, *Acacia ane*ura for MULGA, *E. melanophloia* for MELANOPHLOIA, *E. populnea* for BOX and *C. glauophylla* for CYPRESS. The high density and ubiquity within type of *Alphitonia excelsa* and *Atalaya hemiglauca* resulted in these primarily understorey species rating second in SIV for CREBRA woodlands and BOX woodlands respectively despite a low basal area.

Seven of the recorded species were non-native; two lantana species (*Lantana montevidensis* and *L. camara),* Chinee apple *(Zizyphus mauritiana)*, Rubbervine (*Cryptostegia grandiflora*) and three cactus species comprising two prickly pears *(Opuntia tomentosa and O. stricta)* and the prostrate harrisia cactus *(Eriocerius martinii).* The contribution of introduced species was only significant in CYPRESS woodlands where the densities of *O. tomentosa* and *E. martinii* were sufficient for them to rank in the top 10 SIVs and make Cactaceae the third most important family.

There were no major changes in community composition over the recording period. Of the 10 most important species, in terms of SIV, in the initial recordings only one species had moved more than one ranking position at the final recording. That species, *Corymbia erythophloia,* had moved from number eight at the initial recording to number eleven at the final. The eleventh ranked species at the initial recordings had moved to ninth rank at the final. Only one species moved out of the

top ten SIV rankings within BOX, CREBRA, CYPRESS and DESERT UPLANDS woodlands, with those species moving into eleventh, twelfth, fourteenth and twelfth rankings for BOX, CREBRA, CYPRESS and DESERT UPLANDS woodlands respectively. Within MELANOPHLOIA woodlands three species dropped out of the top ten positions, though they remained within the top 20. MICRONEURA and MULGA woodlands experienced no change in the rankings of the top 10 species.

The number of plant families did not change over the monitoring period, with 34 families present at both initial and final recordings. (BOX 25/25, CREBRA 25/25, CYPRESS 14/14, DESERT UPLANDS 18/18, MELANOPHLOIA 22/22, MICRONEURA 9/9, MULGA 5/6) Additionally, the taxonomic rankings did not change. The most species-rich families in the initial recordings were Myrtaceae (66), Mimosaceae (48). Sapindaceae (16), Myoporaceae (16) and Apocynaceae (16). At the final recording, Myrtaceae (66). Mimosaceae (49). Sapindaceae (16). Myoporaceae (16) and Apocynaceae (16) were again the most species-rich. Furthermore, the functional form of the relationship between number of families and number of species per family remained similar between initial and final recordings for all woodland types (Figure 17).

A regression of species relative density at first and last recordings for an amalgamation of all sites produced a highly significant relationship between the ranked data sets (Figure 18). Regressions for specific woodland types produced

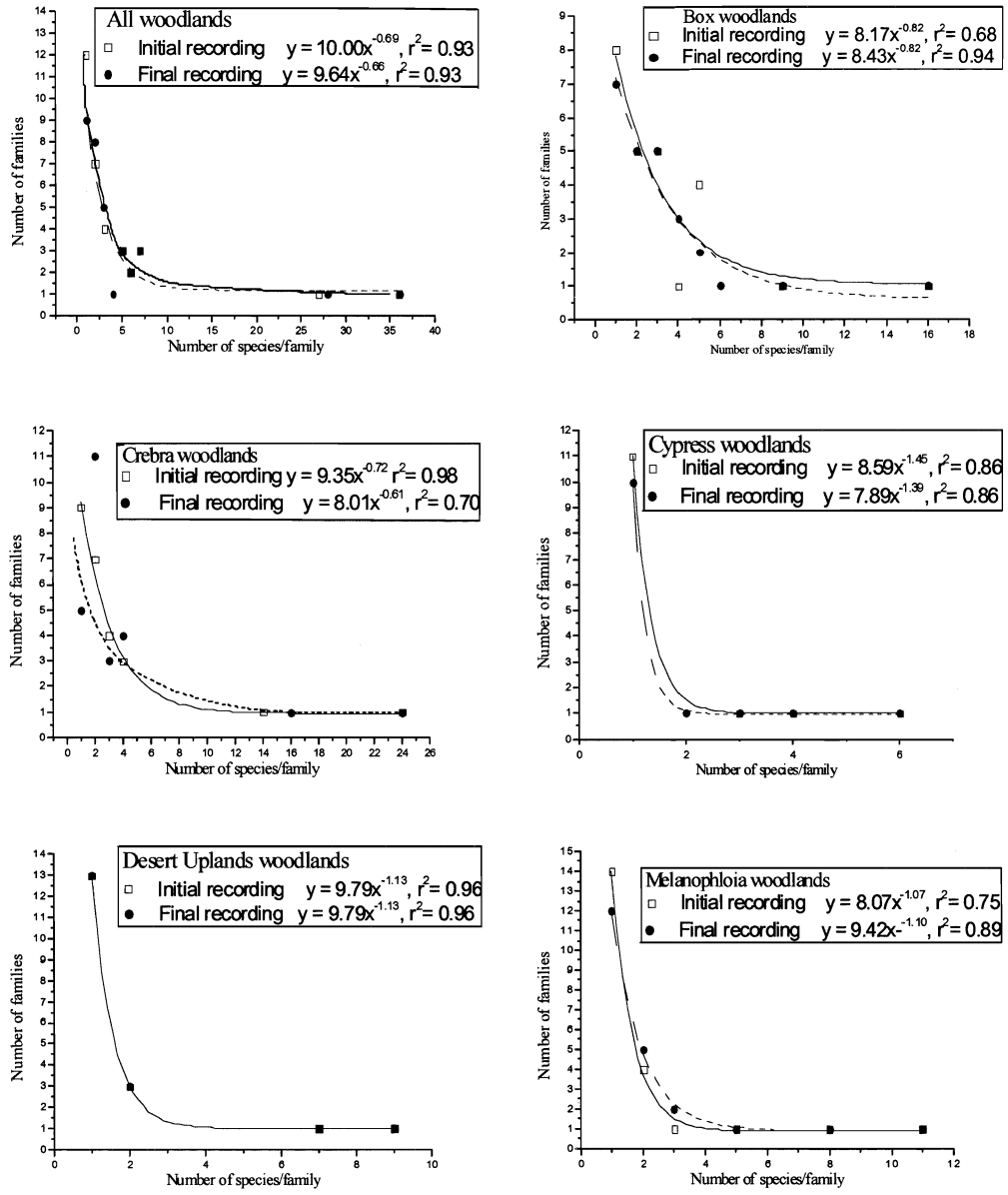


Figure 17.
Number of species per family, as a function of number of families, at initial and final recordings for each DCA defined woodland type.

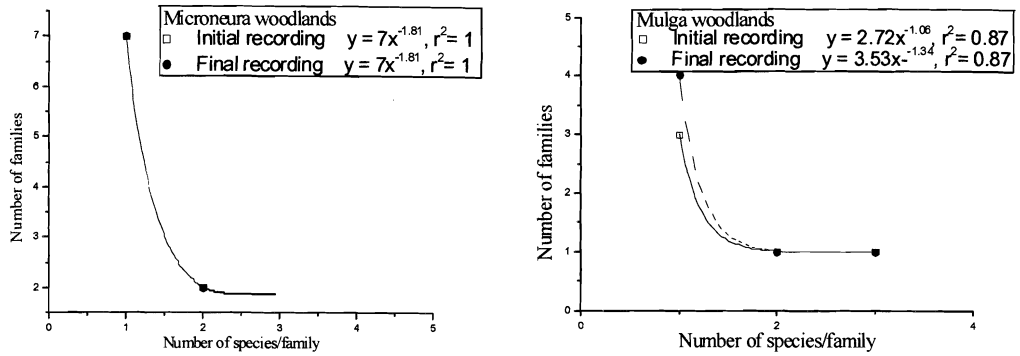


Figure 17 (continued)
Number of species per family, as a function of number of families, at initial and final recordings.

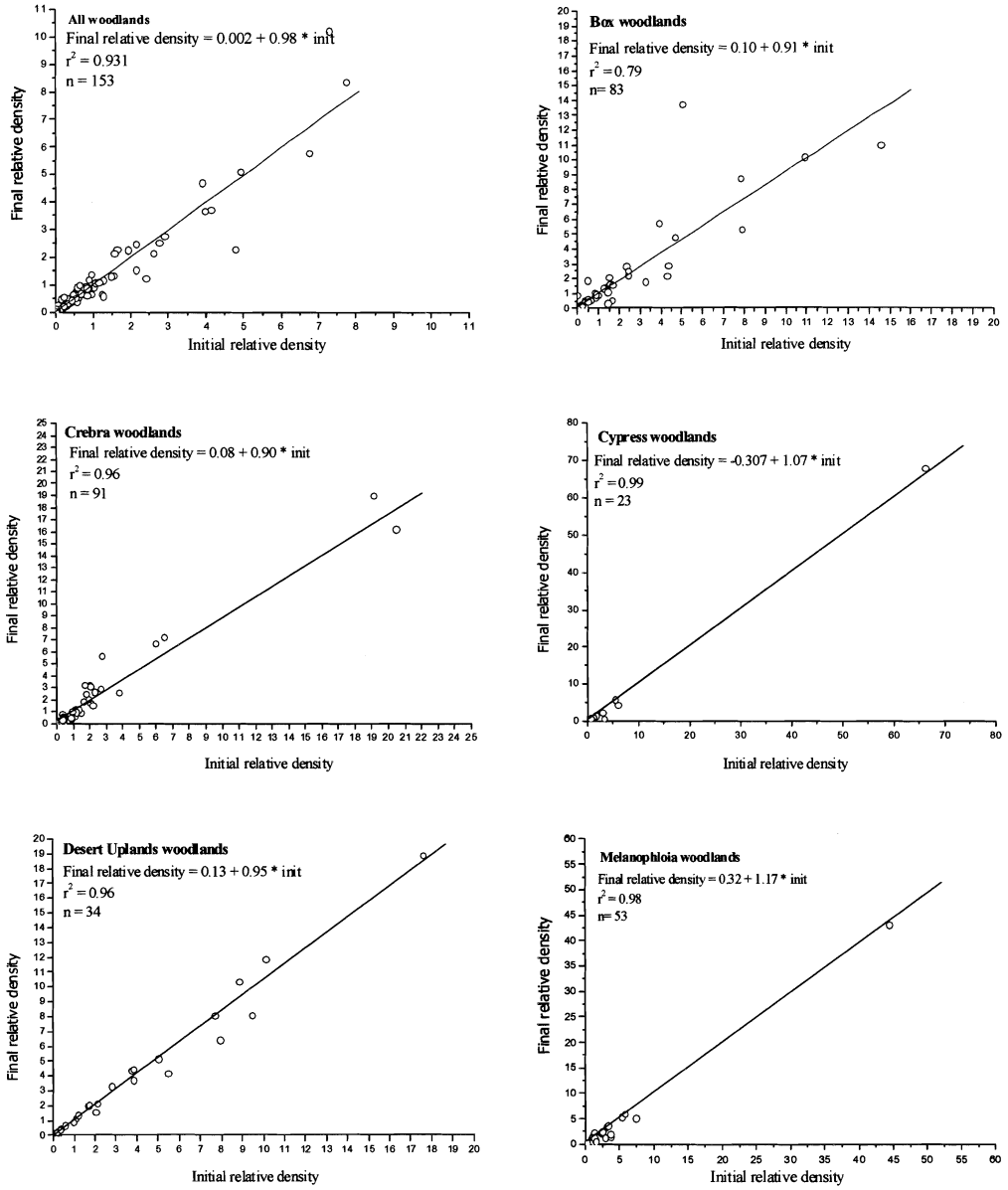


Figure 18
Regression of species relative density at first and last recordings.
See text for explanation of relative density.

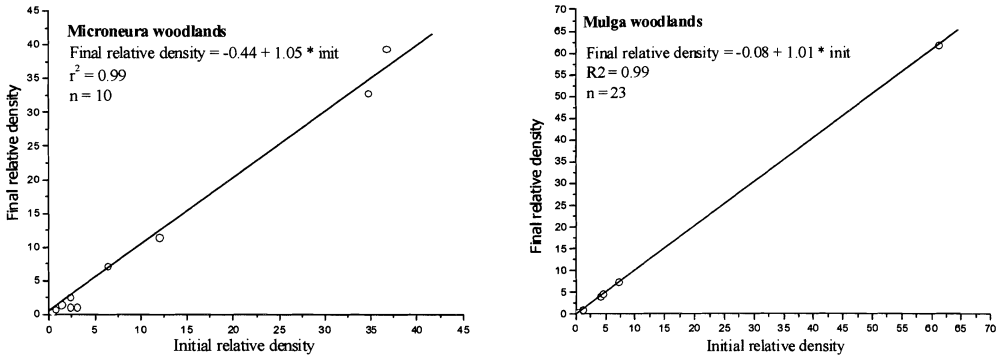


Figure 18 (cont)
Regression of species relative density at first and last recordings.
See text for explanation of relative density.

even stronger correlations, suggesting that variation in density for some species was relatively more important within differing woodland types. BOX woodlands initially showed a weaker correlation due to the presence of a large number of new *Carrissa ovata* shrubs formed by the fracturing of larger plants by fire, primarily located in one site. When plants of this species at this site were removed, the new regression produced an r^2 value of 0.95.

3.11 Relationships Between Environmental Factors

Structural and environmental variables in this section have been referred to in tables by abbreviations in order to simplify the layout of tables. Table 32 provides an explanation of abbreviations used.

There was considerable interrelationship between environmental variables with the exception of soil (Table 33). Generally the interrelationship between abiotic factors appeared to reflect a combination of the change from winter to summer dominated rainfall patterns with decreasing latitude and an increasingly warm and arid climate with distance from the east coast. Longitude was strongly positively correlated with annual rainfall and negatively correlated with maximum temperatures, reflecting the increasingly arid conditions encountered with distance from the coast. Similarly latitude was negatively correlated with summer rainfall and positively correlated with winter rainfall reflecting the increasingly monsoonal rainfall pattern in more tropical regions. Longterm rainfall (mean annual rainfall from 1936 to 2001) was

Table 32.
Structural/environmental and growth characteristics and their abbreviations.

		Environmental Variables
Rain	*	Annual mean rainfall, 1889-2001
Max	*	Mean daily maximum temperature , 1889-2001
Min	*	Mean daily minimum temperature , 1889-2001
Sum max		Mean daily maximum temperature for Dec-Feb , 1889-2001
Sum min		Mean daily minimum temperature for Dec-Feb , 1889-2001
Win max		Mean daily maximum temperature for Jun-Aug, 1889-2001
Win min		Mean daily minimum temperature for Jun-Aug, 1889-2001
Sum rain		Mean rainfall for Dec-Feb, 1889-2001
Sum rain %		Average annual summer rainfall over recording period as a percentage of sum rain
Win rain		Mean rainfall for Jun-Aug, 1889-2001
Win rain %		Average annual winter rainfall over recording period as a percentage of win rain
Rain rec		Rainfall recieved between initial and final recording.
Rainrec%		Rain/rec as a percentage of Rain
MaxRecPe		Max between initial and final recoridng
MaxRec%		MaxRecPe as a percentage of Max
MinRecPe		Min between initail and final recording
MinRec%		MinRecPe as a percentage of Min
Lat	*	Latitude
Lon	*	Longitude
Topo	*	Topography
Soil	*	Soil type.
		Structural variables
Diver		α diversity
Dens		Plant density
Dens >300		Plant density for plants >300 mm circumference
BA		Basal area
Ht		Mean plant height
Ht >300		Mean plant height >300mm circumference
SCD		r^2 value of power function fitted to size class distribution.
Rec %		Recruitment as a percentage of initial density
Mort %		Mortality as a percentage of initial density
Δ Dens %		Change in density as a percentage of initial density
Δ Dens >300		Change in density of plants >300mm circumference as a percentage of initial density

Table 33.
Spearman's coefficient of correlation among environmental characteristics. Abbreviations used are explained in Table 32.
* = p<0.05
** = p<0.01

	Rain	Max	Min	Sum max	Sum min	Win max	Win min	Sum rain	Win rain	Rain rec	Rainrec%	MaxRecPe	MaxRec%
Max	-0.47**												
Min	0.24*	0.58**											
Sum max	-0.82**	0.80**	0.09										
Sum min	-0.1	0.74**	0.88**	0.46**									
Win max	-0.04	0.86**	0.85**	0.39**	0.78**								
Win min	0.44**	0.39**	0.95**	-0.18	0.71**	0.76**							
Sum rain	0.86**	-0.04	0.62**	-0.57**	0.26*	0.41**	0.76**						
Win rain	0.68**	-0.86**	-0.38**	-0.77**	-0.53**	-0.66**	-0.22	0.23					
Rain rec	0.76**	-0.51**	-0.02	-0.69**	-0.29*	-0.22	0.17	0.63**	0.54**				
Rainrec%	-0.45**	-0.02	-0.39**	0.31**	-0.2	-0.30**	-0.44**	-0.45**	-0.23*	0.21			
MaxRecPe	-0.43**	0.97**	0.57**	0.75**	0.70**	.859**	.39**	-0.02	-0.82**	-0.48**	-0.05		
MaxRec%	0.33**	-0.44**	-0.24*	-0.46**	-0.38**	-0.29*	-0.12	0.127	0.44**	0.29*	-0.11	-0.2	
MinRecPe	0.23*	0.60**	0.98**	0.1	0.862**	0.85**	0.94**	0.61**	-0.40**	0.01	-0.33**	0.61**	-0.14
MinRec%	-0.09	0.01	-0.19	0.04	-0.19	-0.04	-0.16	-0.07	-0.1	0.14	0.30**	0.15	0.53**
Lat	-0.12	-0.54**	-0.74**	-0.04	-0.53**	-0.78**	-0.77**	-0.52**	0.51**	-0.022	0.24*	-0.52**	0.24*
Lon	0.63**	-0.67**	-0.25*	-0.71**	-0.41**	-0.41**	-0.08	0.27**	0.83**	0.43**	-0.36**	-0.58**	.054**
Topo	-0.09	0.01	-0.14	0.03	-0.18	-0.03	-0.09	-0.07	-0.13	0.11	0.27*	-0.02	-0.09
Soil	0.003	-0.11	-0.13	-0.03	-0.09	-0.13	-0.12	-0.02	0.06	0.09	0.13	-0.05	.23*

	MinRecPe	MinRec%	Lat	Lon	Topo
MinRec%	0.013				
Lat	-0.76††	-0.01			
Lon	-0.28††	-0.067	0.486††		
Topo	-0.15	-0.03	0.05	-0.07	
Soil	-0.09	0.20	0.12	0.05	-0.17

positively correlated with absolute rainfall during the recording period, yet negatively correlated with relative rainfall over the same period. This indicates that the moister regions were experiencing a drying influence that was not seen to the same degree in more arid regions. A similar pattern was seen with maximum temperature. Mean daily maximum temperature was strongly positively correlated with mean daily maximum during the recording period, yet significantly negatively correlated with relative daily maximum over the same period. This indicates that during the recording period warmer regions were experiencing abnormally cool conditions not experienced in cooler locales.

Stand structure was generally poorly correlated with environmental factors as indicated by the results from the results of Spearman correlations (Table 34). Mean height of plants >300 mm circumference showed the greatest correlation with individual environmental factors, with strong correlation with longitude ($r = 0.70$) and correlation with maximum summer temperature, winter rainfall and basal area ($r > 0.50$). Alpha diversity showed correlation with both density and density of plants >300 mm circumference($r > 0.50$). Other single environmental variables were less well correlated with density, but important variables included density of plants >300 mm circumference height and size class distributions ($r = 0.40$). Density of plants >300 mm circumference was best correlated with diversity, latitude ($r = 0.38$) and basal area ($r=-0.66$). Basal area was also significantly correlated with several other environmental factors, including longitude ($r=0.46$)

Table 34.
Spearman's coefficient of correlation for environmental characteristics and final stand structure. Abbreviations used are explained in Table 32.
* = $p<0.05$
** = $p<0.01$

	RAIN	MAX	MIN	SUMMAX	SUMMIN	WINMAX	WINMIN	SUMRAIN	WINRAIN	LAT	LON	TOPO
DIVER	0.02	0.04	0.05	0.02	0.06	0.05	0.02	-0.03	0.12	0.15	0.249*	-0.216
DENS	0.07	0	0.05	0.01	0.07	0.01	0.05	0.03	0.09	0.17	0.182	0.03
DEN300	0.19	-0.29*	-0.22	-0.18	-0.19	-0.30**	-0.2	0.02	0.34**	0.38**	0.33**	-0.06
BA	0.31**	-0.30**	-0.21	-0.24*	-0.22	-0.25*	-0.18	0.11	0.45**	0.38**	0.47**	-0.07
HT	0.16	-0.28*	-0.26*	-0.22	-0.31**	-0.25*	-0.2	0.02	0.29*	0.28*	0.30**	0.13
HT300	0.49**	-0.44**	-0.15	-0.53**	-0.33**	-0.23	-0.016	.254*	0.59**	0.25*	0.70**	0.05
SCD	-0.17	0.06	-0.09	0.18	0.01	-0.06	-0.15	-0.17	-0.08	0.15	-0.13	-0.12

	LON	TOPO	SOIL	DIVER	DENS	DEN10	BA	HT	HT10
DIVER	0.25*	-0.22	-0.10						
DENS	0.18	0.03	-0.09	0.51**					
DEN300	0.33**	-0.06	0.05	0.52**	0.40**				
BA	0.46**	-0.07	0.07	0.30*	0.22	0.66**			
HT	0.30**	0.13	0.16	-0.09	-0.34**	0.37**	.50**		
HT300	0.70**	0.05	0.04	0.13	0.02	0.13	.52**	.50**	
SCD	-0.13	-0.12	0.05	0.24*	0.30**	0.40**	0.05	-0.04	-0.26*

and mean height ($r = 0.49$). Size class distributions were poorly correlated with the measured environmental variables with diversity, density, density of plants >300 mm circumference and mean height of plants >300 mm circumference showing low correlation ($r < 0.40$) when analysed singly.

The woodland types defined by DCA differed significantly in several environmental and structural variables (Table 35), including basal area, mean height of plants >300 mm circumference, annual mean rainfall and mean maximum temperature and mean minimum temperature.

3.12 Relationship between woodland structure and dynamics and environment.

Changes in stand structure were poorly explained by environmental factors through linear model fitting (Table 36). The models best explained mortality (28% of variance explained), which was positively related to relative minimum temperature over the recording period and negatively correlated to latitude and relative rainfall over the recording period. Recruitment rate was explained by relative minimum temperature over the recording period (14% of total variance). Density change rate was positively associated with latitude and negatively associated with relative annual rainfall annual (19% of total variance). Basal area change rate was influenced by latitude and topography, with the model explaining 17% of total variance.

Table 35.
Mean values of environmental structural variables for DCA defined woodland types at final recording. Abbreviation for variables are explained in Table 32. Sig (KW) is significance of difference between types based on Kruskall- Wallis test.

		BOX (n = 17)		CREBRA (n = 32)		CYPRESS (n = 3)		DESERT UPLANDS (n = 4)		MELANOPHLOIA (n = 13)		MICRONEURA (n = 2)		MULGA (n = 4)	
Variable	Sig. (KW	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Diver	0.1	67.1	42.7	45.3	25.1	95	73.4	57.2	24.2	45.6	22.1	22.5	3.5	25	12.3
Dens	0.12	1861.3	1324.1	1415.1	1384.8	2155.1	553	1357.2	629.4	1118.5	573.8	323.8	40.7	1402.5	1314.3
Density >300	0.22	205.6	100.3	200.5	139	612.1	252.5	202.8	98.6	212.9	121.4	165	84.9	182.5	60.4
BA	0.03	14.2	8.5	11.6	6.9	22.5	11.3	7	1.6	12.8	4	10.4	1.5	6.5	1.7
Ht	0.13	3.2	2.5	2.8	1.6	4.9	1.9	1.9	0.3	3.4	1.6	4.6	2.1	3.2	1.4
Ht >300	0.01	13.1	3.8	11.7	3.5	11.9	1	7.7	2.3	11.2	1.9	8.4	0.6	7.6	1.5
SCD	0.39	0.7	0.3	0.6	0.3	0.8	0.1	0.8	0.2	0.7	0.2	0.8	0.1	0.9	0.2
Rain	>0.001	65.7	15	76.6	16.2	58.4	3.4	48.4	3.9	61.2	10	75.3	5.3	42.6	7.4
Max	0.004	29	1.4	28.3	1.8	27.4	0.3	30.6	0.4	28.7	1.5	32.8	0	28	0.2
Min	>0.001	16.1	1.2	16.3	1.5	12.8	0.4	16.5	0.2	14.6	1.6	18.8	0.1	14	0.2
Rainrec%	0.01	101	21.8	95.1	12.4	117.5	1.5	115.8	33.7	103	16.1	99.9	5.6	125.7	4.5
MaxRec%	0.004	100.5	1.6	101.1	1	101.8	2	98.7	2	100.8	1.9	98.8	0.3	98.9	1
MinRec%	0.45	102.6	2.3	102.6	2.3	105	3.1	102.9	2.5	102.7	2.3	102.1	1.1	100.4	2.1
Lat	>0.001	22.8	1.9	22.2	2	26	0.7	22	1.2	23.9	1.6	18.2	0	27.3	0.9
Lon	0.001	148	1.9	148.5	2	148.6	0.6	145	0.4	147.8	1.9	143.3	0.1	146	0.5
Topo	0.339	2	0.87	4.38	1.16	4.33	1.53	1.75	0.5	3.38	1.45	4.5	0.71	2.25	0.5
Soil	0.082	2.65	0.61	2.38	0.49	1.67	0.58	2.25	0.5	2.38	0.51	2	0	2	0

Table 36.
Linear models of relationship of dynamics factors to environmental variables selected by stepwise regression.
Abbreviations used are explained in Table 32.

Variable	Model				Variance explained (%)
Recruitment as a percentage of initial density	0.77 min/rec%			-73.53	14.43
p	*0.001*				
Mortality as a percentage of initial density	0.71 min/rec%	-0.79 Lat	22.8 ln(Rain/rec+1)	-94.37	27.98
p	*0.008*	*0.002*	*0.011*		
Change in density as a % of initial density	1.26 lat	-39 lnRain/rec		48.73	18.68
p	*0.002*	*0.003*			
Change in basal area as a % of initial basal area	0.43 lat	-6.3 ln(Rain/rec+1)		-21.76	17.28
p	*0.001*	*0.029*			

While the clustering of plots on the CCA ordination were not as definitive as in the DCA ordination, the two ordinations provide complimentary results (Figure 19). MULGA woodland sites formed a cluster in the lower right quadrant, clearly separated from the remaining sites due to their location in the southwest of the study area and the associated low winter temperatures. CYPRESS woodlands form a relatively isolated cluster in the upper left hand quadrant due to their location in dry southerly regions on steeply sloping terrain with sandy soils. MELANOPHLOIA woodlands formed a relatively isolated cluster defined by generally low rainfall and coarse textured soils on flat to moderately sloping terrain. CREBRA sites formed a relatively distinct cluster defined by high rainfall, steeply sloping topography and soils low in clay content.

The eigenvalues of 0.28 and 0.20 for axes 1 and 2 respectively indicated a moderate degree of separation along the measured gradients. The strength of correlations of environmental variables with the first two axes were similarly moderate. This result indicates that species are responding to the measured environmental factors but that these factors are by no means the sole contributors to species distributions. Species composition along axis 1 was correlated most strongly with mean minimum temperature (r=0.42), and topography (r=-0.40) and less strongly with mean annual rainfall (r=0.21), latitude (r = -0.18) and mean maximum temperature (r=0.18). Species patterns along axis 2 was correlated most strongly with latitude (r=-0.57), with approximately equal correlations with

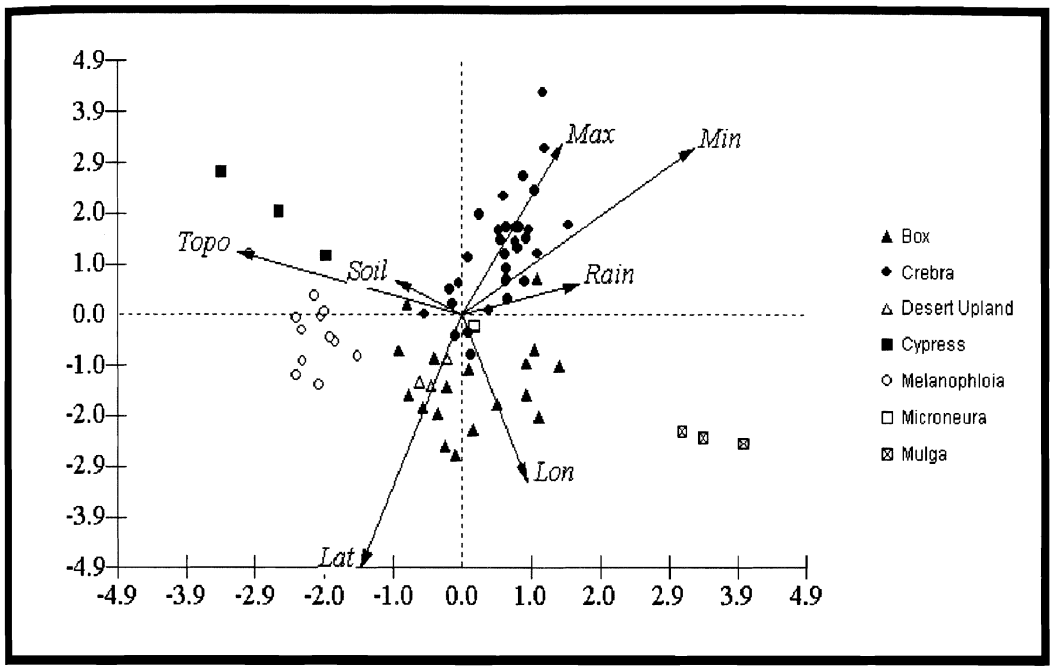


Figure 19.
Community ordination Canonical Correspondence Analysis of all sites and the selected environmental and structural factors by woodland type as defined by Detrended Correspondence Analysis analysis.

longitude, mean maximum temperature and mean minimum temperature (all r=0.38).

Chapter 4 : Discussion

4.1 Species Diversity and Community Similarity

Detrended Correspondence Analysis based on species composition suggested that the vegetation communities observed across the 75 sites could be classified into seven community types

- MULGA
- CYPRESS
- MICRONEURA
- DESERT UPLANDS
- BOX
- MELANOPHLOIA
- CREBRA

A majority of species (51%) were found in only one woodland type. A further 28% of species were restricted to two woodland types, while the remaining 21% of species could be found in three or more types (Table 23). However the woodland types were noted to share some common species. This result is expected as many of the species are recorded as being widely distributed in woodlands across Queensland (Anderson 1993, Milson 1994). Forty-three species were found at only

one site and no species was common to all sites. The fact that over half the species are restricted to a single woodland type suggests that the woodland types derived from the ordination results are realistic.

However the floristic delineation is far from perfect, and this seems to be related at least in part to geographic overlap. BOX and CREBRA woodlands overlapped considerably geographically (Figure 2) and were the least precisely defined woodland types floristically despite the large numbers of species unique to each community. DESERT UPLANDS and MELANOPHLOIA woodlands also overlap considerably and showed a high degree of floristic similarity, with a Sorenson coefficient of 0.31 and 19 shared species. CYPRESS/ CREBRA, CYPRESS/BOX, CYPRESS/MELANOPHLOIA and DESERT UPLANDS/BOX community pairs also showed a relatively high degree of similarity and exhibit some degree of geographic overlap. The more geographically distinct woodland types, MULGA and MICRONEURA, show much less overlap with other woodland types and form floristic extremes. Slik *et al.* (2003) note that many studies of tropical forests and woodlands show a close relationship between floristic similarity and geographic distance between sites and attribute this to the fact that environmental variables change with geographic distance. This suggests that climate, and possibly other environmental factors such as soil and management effects, play a significant role in defining community composition within Queensland's grazed woodlands, producing a continuum of species in woodlands across the state with distinct

community types only at extremes.

Sites established in the same woodland type shared on average less than 50% of their species with other sites in that type. The mean number of shared species between any two sites within the entire study, irrespective of woodland type, was over 30% , suggesting that species importance values are more useful in classifying these woodlands than the presence or absence of any potential indicator species.

The 156 woody plant species (6 genera, 34 families) recorded in this study reflect only a part of the overall tree diversity of the area, as demonstrated by the species area curves (Figure 15), which continue to increase at the end of sampling for all woodland types. There was also a high degree of variation between sites within the woodlands, with 43 of the 156 species occurring at only one site. This also indicates an increasing species count with area and produced species area curves with a very uneven increase in species number. A very similar pattern was found in a study of savannas in Brazil conducted by Ratter *et al.* (1996). In that study none of the 534 woody plant species recorded occurred at all sites and approximately one third of the species occurred at only one site. The lack of asymptotic tendency in the species accumulation curves combined with the high level of heterogeneity resulted in species richness being largely related to the size of the sample area. The MULGA woodlands were the only community type not to fit this trend, with a slightly lower richness than the MICRONEURA woodlands despite a larger area

sampled. The predicted sampling effort required to obtain 90% of species for the woodlands as a whole was considerably lower than that predicted for the MELANOPHLOIA, CYPRESS and MULGA woodland types (Table 27). This was due to an uneven increase and lack of asymptote of the curves for the MELANOPHLOIA, CYPRESS and MULGA woodland types woodland types producing essentially linear relationships, which in turn made any meaningful extrapolation beyond the fitted exponential curves difficult. All of these factors suggest that far greater sampling effort is required to produce a reliable picture of the floristic structure of these woodlands. Indeed the total sample area for all woodlands was only 66% of the predicted sampling effort required for 90% species inclusion. Any increased sampling effort should be focussed primarily on the MULGA, MELANOPHLOIA and CYPRESS woodland types which show limited curvature in the species area curve.

Species richness was related to sample area, with the BOX and CREBRA and MELANOPHLOIA woodlands containing the largest number of species (Table 20). However the relationship with area did not extend to measures of diversity and evenness, with the DESERT UPLANDS woodlands exhibited high diversity and high evenness despite a relatively small sample area and low species richness. This is indicative of multiple species with overlapping niches within this community type. In contrast MELANOPHLOIA woodlands exhibited a relatively low diversity and evenness despite a relatively high species richness due to a dominance by large

numbers of individuals of relatively few species. These results are confirmed by the plots of cumulative plant numbers (Figure 9). The fact that species richness does not follow the same trend as species diversity and evenness demonstrates that neither richness nor diversity alone are suitable for studying diversity within these woodlands.

A plot of cumulative plant numbers showed a much slower increase with increasing species count than a similar plot of cumulative basal area for all woodland types (Figures 8 and 9). This result indicates that there were relatively few overstorey species, with much of the diversity contributed by understorey species. In all woodland types a small number of species contributed a disproportionate amount of basal area. In MELANOPHLOIA woodlands, *E. melanophloia* accounted for a majority of basal area producing a situation where 5% of species accounted for approximately 95% of basal area. In other woodland types a similar though less pronounced trend was recorded with 5% of species accounting for approximately 80% of basal area.

Direct comparison of species richness with other studies reported in the literature is complicated by differences in methodology, particularly which species were recorded and differences in sample area. Nonetheless the 3-24 woody species per site recorded in this study appears in general agreement with the ~7.0 species/0.02 ha site recorded in savanna in Northern Australia by Bowman (1992) and 29

species at a 0.24 ha site recorded in a eucalypt savanna in Northern Australia by O'Grady *et al.* (2000). None of the sites in the present study approached the 49 species recorded at a single 2 ha site in northern Australia by Williams *et al.* (1997). O'Grady *et al.* (2000) attributed the high species richness reported by Williams *et al.* (1997) to the absence of fire, with the observations made in an area from which fire had been excluded for some 20 years.

4.2 Family Importance Values

The woodlands in this study were dominated by the families Myrtaceae and Mimosaceae. The Myrtaceae consisted mainly of upper canopy tree species with significant basal area contributions while the Mimosaceae largely consisted of understorey and low canopy tree species with three species forming a dominant part of the canopy and basal area contribution at six sites. This is a pattern typical for Australian woodlands (Gillison *et al.* 1994). The floristic composition of these woodlands shows some similarities with tropical African and South American savannas where Mimosaceae is also a significant component (Furley 1999; Scholes *et al.* 1999; Batalha *et al.* 2001; Hejcmanova-Nezerkova 2006;) with Myrtaceae also forming a significant component of the South American savanna flora (Furley 1999).

The dominance of Myrtaceae may be partially accounted for by the large number of sites established in eucalypt woodlands, although Myrtaceae also contributed

30% of the basal area in CYPRESS woodlands. The basal area contribution of the family Myrtaceae in CYPRESS woodlands was disproportionate to the number of individuals of that family (Table 29). This reflects the fact that the eucalypts within these woodlands consisted almost exclusively of large trees with few seedlings and saplings. This may indicate that the conditions necessary for recruitment of eucalypts in the CYPRESS woodlands are no longer being met, with few young trees being produced. Lunt *et al.* (2006) have previously presented evidence that cypress woodlands are changing both in species composition and tree density, from open eucalypt co-dominant woodlands to toward closed cypress dominated woodlands. This change was ascribed to a reduction in fire frequency and intensity.

In the MULGA woodlands the family Myrtaceae was not recorded at all, although eucalypts are considered to be common associates in MULGA woodlands (Harrington *et al.* 1984). This result suggests a need for additional sites targeting mixed mulga/eucalypt communities.

The Family Mimosaceae made a large contribution to both species diversity and plant numbers despite being overstorey dominants/codominants at only six sites. This situation reflects the status of *Acacia* species as understorey plants within open woodlands, with numerous wattle species that rarely, if ever, reach a size that contributes significantly to the basal area of the stand (Gillison *et al.* 1994; White 1986).

Floristically the woodlands remained essentially unchanged over the recording period with an approximately constant richness at the species and family levels and losses and colonisations confined to species represented by small numbers of individuals that appear only in single sites.

Species composition for the woodlands changed by less than 2% over the recording period, with more colonisations than losses (5 and 2 species respectively). This constancy may indicate that the woodlands have reached a plateau in terms of local richness or may be indicative of the short recording period for many sites. Those species which vanished locally were both represented by fewer than five individuals at the initial recording. Both species which vanished from the sites (*Alyxia ruscifolia* and *Diospyrus ferrea)* are species associated with "dry rainforest" thickets (Williams 1984) which suggests a sensitivity to fire and a possible reason for their loss. However one of the colonizing species (*Ficus obliqua*) is also a fire sensitive species, so one needs to be cautious about drawing conclusions about the role of fire in species turnover in the absence of data on fire frequency within these sites. Those species which colonised were all represented by a single individual at the final recording.

4.3 Density

Tree densities (where a tree is a plant >300 mm circumference) for the majority of

sites recorded in this study were comparable to other woodlands in Eastern Australia, which range from the 64-127 plants/ha recorded in semi-arid eucalypt woodlands in northern Queensland by McIvor (2001) to the mean of 1,474 trees/ha with variation from 256 to 7,433 trees/ha for cypress woodlands in Eastern Australia reported by Lunt *et al.* (2006). Eight sites recorded densities lower than the 64 plants/ha recorded by McIvor (2001) and of these five had experienced drought associated mortality prior to site establishment which reduced the tree density considerably. The remaining three low density sites were apparently undisturbed and represented naturally open communities.

Smaller plants make an important contribution to plant numbers in all of the woodland types. Approximately 90% of all plants in CREBRA, DESERT UPLANDS, BOX, MULGA and MELANOPHLOIA communities were less than 10 cm in diameter, while in CYPRESS and MICRONEURA communities such small plants contributed 75% and 54% of plant numbers respectively. An analysis of all sites also shows that on average 60% of plants are <1 m in height. The number of plants < 1m in height by community type ranges from 30% in MICRONEURA communities to 71% in CREBRA woodlands. This compares to the findings of Scanlan (1988) who presented figures suggesting 50% of individuals in eucalypt woodlands existing as suppressed seedlings. These suppressed plants establish from seed and are then kept in a stunted form through interactions of grazing and trampling, fire and competition with grasses (Andersen

et al. 2005; Clarke, 2002).

Annual density increase in the woodlands averaged 60 plants/ha/yr (4%/ha/yr) for all plants.. When only plants >300 mm circumference are analysed from this study these woodlands show a decline in plant density, averaging 1.15 plants/ha/yr (-0.17%/yr).

These relative rates of change for plants >300 mm circumference are comparable to figures reported for other savanna types, which generally showed a decrease. For example van de Vijver *et al.*(1999) reported annual density losses of 9 and 13 plants/ha (-1.4%/yr and -1.0%/yr respectively) for east African savannas, Bowman *et al.* (2004) reported annual density declines of 1.2% for a tropical savanna in Northern Australia and Fensham *et al.* (2003) reported an annual decline of 8.2 plants/ha/yr (-2.1%/yr) in Northern Australia

The influence of small plants on density dynamics is also seen in the distribution of density change across size classes where the greatest absolute change in density occurred primarily in the small size classes. Despite this large absolute change the higher density of plants in the smallest size class meant that the relative change was smaller than that seen in many of the larger size classes. No significant change in density was seen in any other size class.

It should be noted that individual plants in some instances regressed into smaller size classes due to several factors. All diameters were measured over bark and large sections of bark falling off occasionally produced situations where a tree regressed into a smaller size class. Where an irregularity such as a scar or gall occurred at the 30 cm height at which circumference was measured, operator variability could have contributed to errors in assessing stem circumferences. In addition, many trees were observed to regress into smaller size classes due to death of primary trunks followed by coppicing or re-sprouting. The effects of this are highly noticeable in the 2400-2700 mm circumference class for the CYPRESS woodland type (Table 4) where a single plant regressing from the 2700-3000 mm size class has doubled the population of that class. The effects may also be seen in Figure 9, with the surviving plants at several sites showing an overall decrease in basal area.

4.4 Basal Area

Basal area at the majority of sites falls within the range of published figures for savanna woodlands in northern Australia which range from ~5 m^2/ha (Fensham *et al.* 2003; McIvor 2001) to 26 m^2/ha (Williams *et al.* 2003). A small number of sites had markedly smaller basal area than those recorded in earlier studies. Visual assessment and communication with the landholders revealed that all of these had experienced drought associated mortality prior to transect establishment with a resultant decrease in basal area. The highest basal areas in this study (36 m^2/ha)

were recorded in communities that Gillison *et al.* (1994) classify as "tall woodland" or "woodlands of medium height" and the basal areas are more typical of communities described elsewhere as open eucalypt forest or cypress forest (McElhinny, 2005; Woldendorp *et al.* 2002).

Despite the overall increase in stem abundance over the monitoring period, the woodlands experienced a decrease in basal area. Once again this reflects the fact that much of the dynamics was occurring amongst the smallest plants that contributed little to basal area. Trees >300 mm circumference basal area contributed the majority basal at all sites, despite making relatively minor contributions to density at the majority of sites (Figure 20, Appendix 1 Table 1, Appendix 1, Table 2). As a result the loss in basal area due to death of large trees was not compensated by the growth of either surviving plants or new recruits in sufficient size or numbers. That relatively little basal area change resulted from the addition of new plants is not surprising given that new plants will be, almost by definition, individuals that were small enough to escape detection at the initial recording. Such newly recruited individuals may be either new seedlings, new stems from the roots of established plants or plants that had been razed by grazing, fire or other disturbance. Even in large numbers and with high growth rates it would be improbable for such small stems to make a significant contribution to an established woodland in the time periods for which these sites were recorded.

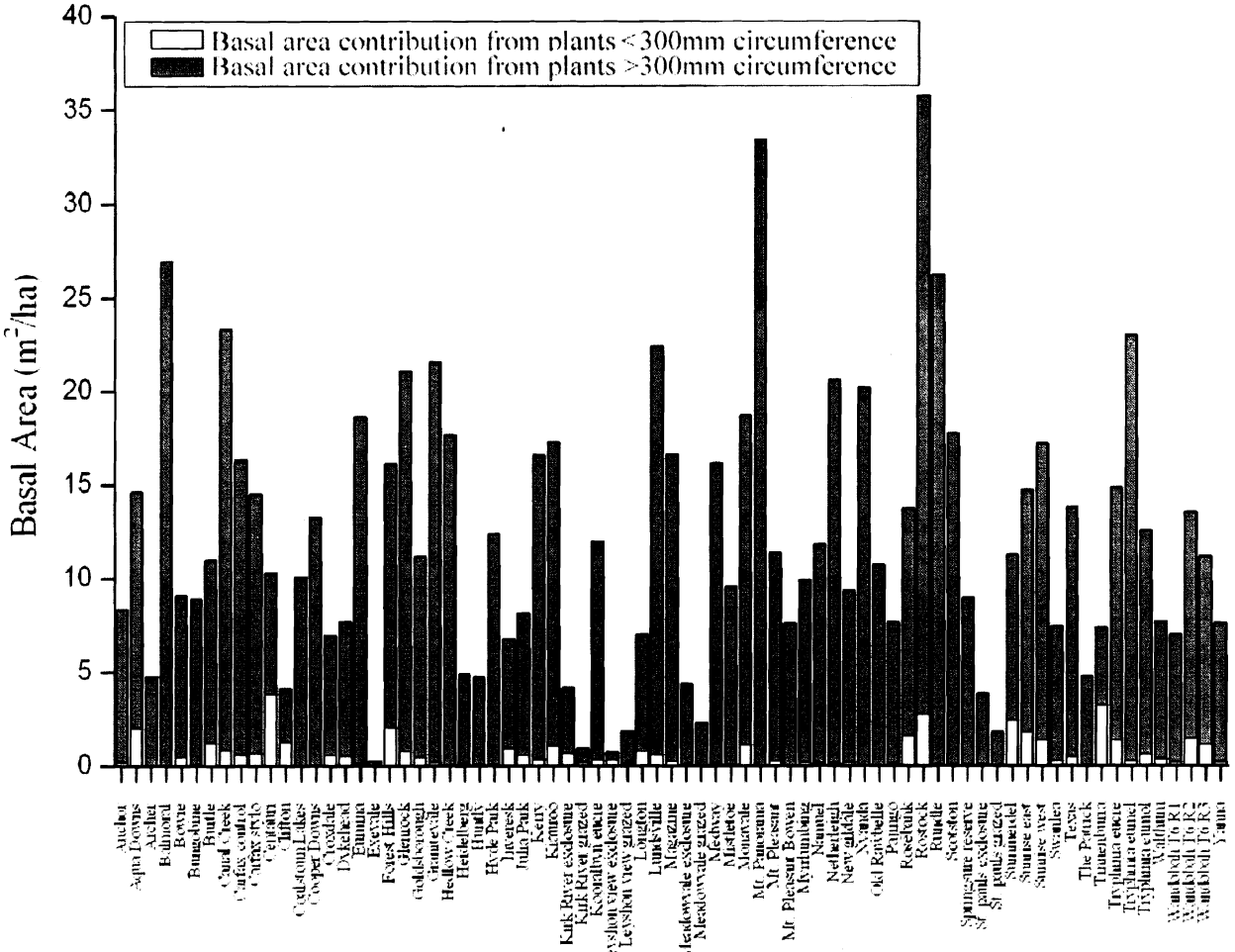


Figure 20.

Basal area contributions from large and small plants at final recording for all sites.

The magnitude of the average basal area change at those sites experiencing a decrease was approximately twice that of the average change at those sites experiencing an increase. As a result the woodlands experienced a slight decrease in basal area overall, despite a majority of sites experiencing an increase in basal area. The greater magnitude of basal area decline in those sites where decline did occur suggests that decreases may be the result of infrequent catastrophic events rather than smaller ongoing process. Large areas of Northern Queensland are known to have suffered from drought induced plant deaths during the study period (Fensham *et al.* 1999; Rice *et al.* 2004), and observation and personal communication with landholders revealed that drought attributable deaths had occurred at several sites during the study period or just prior to site establishment. These drought affected sites included the 17 of the 21 sites which exhibited the greatest relative decline in basal area (Table 37). Drought related dieback was not contingent solely on rainfall deficit and factors such as soil type, slope, tree species and initial stocking density also seem to have played a role in determining whether rainfall deficit resulted in tree deaths. As a result several sites which experienced significantly below average rainfall (e.g.Balmoral, Monavale) did not experience tree death (Table 38).

With known drought affected sites removed from the analysis the mean basal area change was an increase of 0.05 m^2/ha/yr (0.76%/yr). The figures for this study are very close to the figures of 0.07 m^2/ha/yr and 0.7%/yr reported by Williams *et al.*

Table 37.
The 21 transects with the greatest basal area decrease. Those transects marked with an asterisk were affected by drought induced dieback based upon observation and communication with landholders.

Transect		Annual change in basal area (m^2/ha/yr)	Annual change in basal area as % of initial basal area
Exevale	*	-0.31	-33.84
Heidelberg	*	-0.38	-6.80
Kirk River grazed	*	-0.43	-6.63
Bowie	*	-0.72	-6.62
Pajingo	*	-0.54	-6.23
Centauri	*	-0.60	-5.22
Meadowvale grazed	*	-0.30	-4.91
Walthum	*	-0.62	-4.55
Myrrlumbing	*	-0.44	-4.08
Inveresk	*	-0.30	-4.06
Archer		-0.47	-3.76
Mt. Panorama		-1.64	-3.68
Mt. Pleasant Bowen	*	-0.26	-3.16
Meadowvale exclosure	*	-0.19	-2.80
St. Pauls exclosure	*	-0.16	-2.69
Burtle	*	-0.28	-2.38
Springsure reserve		-0.20	-2.18
Anchor	*	-0.25	-2.10
Kirk River exclosure	*	-0.12	-2.10
Aqua Downs		-0.30	-1.98
St. Pauls grazed	*	-0.05	-1.90

Table 38.
Rainfall figures for sites highlighting the rainfall deficit or surplus experienced during 1991-2000 relative to the longterm mean from 1889-2003.

Site Name	Mean annual rainfall (mm)	Mean annual rainfall 1991-2000 (mm)	1991-2000 rainfall as a percentage of longterm mean
Anchor	675	603	89
Aqua Downs	463	467	101
Archer	832	672	81
Balmoral	912	689	76
Bowie	502	419	84
Bungobine	574	478	83
Burtle	533	476	89
Canal Creek	1317	1005	76
Carfax Control	626	521	83
Carfax Stylo	626	521	83
Centauri	599	483	81
Clifton	406	397	98
Coalstoun Lakes	805	745	93
Cooper Downs	683	590	86
Croxdale	483	469	97
Dykehead	687	580	84
Eumina	565	566	100
Exevale	871	703	81
Forest Hills	721	733	102
Glenrock	716	676	94
Goldsborough	615	581	94
Granite Vale	849	669	79
Hedlow Creek	1101	853	77
Heidelberg	660	552	84
Huntly	672	554	82
Hyde Park	506	474	94
Inveresk	456	388	85
Julia Park	542	492	91
Kerry	487	535	110
Kiauroo	630	441	70
Kirk River Exclosure	678	598	88
Kirk River Grazed	678	598	88
Kooralbyn Eucre	731	640	88
Leyshon View Exclosure	616	516	84
Leyshon View Grazed	610	514	84
Longton	569	482	85
Lundsville	984	774	79
Magazine	833	684	82
Meadowvale exclosure	666	595	89
Meadowvale grazed	666	595	89
Medway	645	547	85

Table 38 (cont)..
Rainfall figures for sites highlighting the rainfall deficit or surplus experienced during 1991-2000 relative to the longterm mean from 1889-2003.

Site Name	Mean annual rainfall (mm)	Mean annual rainfall 1991-2000 (mm)	1991-2000 rainfall as a percentage of longterm mean
Monavale	890	694	78
Mt. Panorama	646	572	89
Mt. Pleasant	667	596	89
Mt. Pleasant Bowen	869	703	81
Myrrlumbing	597	480	80
Namuel	715	660	92
Netherleigh	1129	953	84
New Gildale	668	654	98
Nyanda	808	764	95
Old Rawbelle	665	581	87
Pajingo	598	484	81
Rosebank	860	705	82
Rostock	563	554	98
Rundle	935	782	84
Scotston	689	595	86
Springsure Reserve	699	625	89
St. Pauls Exclosure	624	552	88
St. Pauls Grazed	624	552	88
Summerdel	517	492	95
Sunrise East	623	591	95
Sunrise West	632	596	94
Swanlea	465	383	82
Texas	488	416	85
The Patrick	472	453	96
Tinnenburra	330	362	110
Tryphinia Eucre	708	580	82
Tryphinia Eumel	700	574	82
Tryphinia Eumol	708	580	82
Walthum	515	400	78
Wandobah T6 R1	685	576	83
Wandobah T6 R2	682	556	81
Wandobah T6 R3	678	542	80
Yanna	483	469	97

(1999) for unburned eucalypt savanna in Northern Australia which strongly indicates that the basal area decline observed for these woodlands is primarily the result of drought effects. Bray *et al.* (2007) also attributed a loss of basal area in Queensland woodlands to the effects of prolonged drought. These figures also accord with an earlier analysis by Burrows *et al.* (2002) utilising a subset of these sites which found a basal area increase of 0.07 m^2/ha/year (0.63%/yr) for the longer established sites and an increase of 0.10 m^2/ha/year (0.95%/yr) for sites recorded for <3 years.

Frequency distributions of stem diameter remained statistically unchanged over time, reflecting the evenness of relative density changes across size classes resulted . The diameter distribution of woodland types and for individual sites were stable over time, with no statistically significant changes in size class distributions. This stability of size class distributions is indicative that the woodlands remained on the same trajectory over the recording period. The combination of increasing density of understorey plants along with increased basal area at a majority of sites is in agreement with the thickening reported in Queensland woodlands (Winter 1991, Burrows *et al.* 1998, Burrows *et al.* 1999, Fensham and Holman 1999). That total basal area has declined seems to be due to the superimposition of an unusual drought influence (Table 38).

4.5 Size Class Distributions

Age estimation is problematic for trees in the tropics due to variable rainfall and lack of a distinct annual temperature regime which inhibits the formation of unambiguous annual tree rings (Baker, 2003, Brookhouse, 2006, Martin *et al.* 1997). To overcome this problem tree size is routinely used as a surrogate for tree age (Goodburn *et al.* 1999, O'Grady *et al.* 2000, Sharp *et al.* 2004).

The use of size class as a surrogate for age is based on an assumption that trees grow at a constant or age-determined rate and hence the largest trees are also the oldest. It must be noted that within this study such an assumption may not be entirely warranted. A significant number of plants exist as suppressed seedlings and may be capable of existing in this form for decades (Scanlan 1988). As a consequence size may not be directly related to age although it may still relate to the time since a plant was released from a suppressed form. In addition many older plants were observed to regress into smaller size classes due to death of primary trunks followed by coppicing or re-sprouting (Figure 9). The utility of size class distributions is further complicated in mixed species stands of the type investigated in this study because different species have differing growth rates and differing maximum sizes.

However if the premise that size is, at least broadly, a surrogate for age is accepted, then diameter distributions can reveal past population processes such as

recruitment and indicate whether current population trends are sustainable. Many authors (Masaki *et al.* 1999, Nebel *et al.* 2001, Rubin *et al.* 2006) have stated that a natural, mature woodlands can be expected to have steeply descending 'reverse-J' or negative exponential distributions. Such distributions are indicative of the equivalent mortality and growth across size classes required of self-replacing populations. Deviations from the reverse J/negative exponential-shape distribution probably indicate major disturbance sometime in the past, with peaks indicating past episodes of recruitment and troughs past periods without recruitment or periods of high mortality (Goodburn *et al.* 1999).

The size class distributions for all except one woodland types in the present study approximated a reversed J-curve indicative of stable mature woodlands with continuous establishment, growth, and death (Figure 13). However MICRONEURA woodlands showed plateaux in both the mid (300-600 and 600-900 mm) and large (>1500 mm) size ranges, producing a rotated sigmoid distribution. This may reflect the limited number of samples, with only two sites for this woodland type, or it may indicate that the MICRONEURA woodlands have experienced a series of recruitment events in the past. This could reflect rainfall patterns favourable to seedling survival, which is known to influence recruitment in semi-arid woodlands (Moore *et al.* 2001, Brown *et al.* 2005) or periods of low or nil fire intensity which have allowed fire sensitive seedlings to survive (Williams *et al.* 1999, Sharp *et al.* 2003).

CYPRESS woodlands also showed a deviation from a regularly decreasing size distribution, with several gaps in distribution in the larger size classes (Figure 13, Table 4). Plants in size classes >1800 mm were all *Euclayptus* species. This further reinforces the hypothesis of Lunt *et al.* (2006) that the Cypress woodlands are in a state of transition from open Eucalypt co-dominant woodlands to Cypress dominated closed woodlands and forests.

It is worth noting that while the pooled size class distribution of all woodland types are reverse J/negative exponential curves, less than half the individual sites have clear reverse J-curve distributions (Figure 11, Table 16). This may indicate that the sampling area of individual sites is too small to produce negative exponential distributions. Given that the mean site area in this study was only 0.27 ha it should be expected that the reverse J distribution would be apparent for data pooled over a large area, yet not apparent in all sub-samples. If this is the case then the pooling of data for different sites should be viewed with some caution since maximum plant size will naturally vary depending on climatic and environmental conditions even within the same species.

A reverse J-curve for pooled data despite individual sites showing less uniform patterns may be indicative of the sporadic and patchy nature of disturbance in these woodlands. Weigand *et al.* (2006) suggest that the conditions of precipitation and

competition required for woody plant recruitment in savannas may occur in patches of just a few hectares. Fensham *et al.* (2005) suggest that rainfall deficit is the primary driver of mortality in savannas. Such deficits are unlikely to occur across the whole study area simultaneously and the magnitude of their effects are related to other factors such as soil type and topography (Tracey 1969, Adams 1996) that vary between sites. Consequently the conditions required for these mortality and recruitment events are not synchronised across the whole of the study area and it would thus be expected that many individual sites would show size distribution patterns indicative of past population fluctuations. Nonetheless the size distribution pattern for pooled sites would be expected to be a reverse J-curve provided the woodlands overall are in the process of returning to an approximately uniform state through recruitment and self thinning , with some sites in the 'climax' state and contributing the majority of large trees and others representing varying phases of the recovery/succession phase.

With a single exception the size class distributions for selected species (Table 18) fit the negative exponential distribution pattern as well as the distributions for woodland types (Table 17). This result largely mitigates the concern that the effect of multi-species stands may be producing reverse J-curves regardless of site history. The one exception to this was *C. glaucophylla* which, with an r^2 of 0.80, produced a poorer fit to the negative exponential distribution than any woodland

type. The poor fit of *C. glaucophylla* to the negative exponential function appears to be due to the utilisation of the single species removing the extremely large eucalypts that occupy the largest size classes in the *C. glaucophylla* dominated woodlands. This indicates that the discrepancy between the community wide size class distribution and the dominant species distribution for the *C. glaucophylla* stands is not due to differences in mortality, growth rates and maximum size of differing species as proposed by some authors (Goodburn *et al.* 1999, O'Hara 1986). Rather it is the result of a shift from eucalypt co-dominance to purely *Callitris* dominance within these woodlands.

4.6 Mortality and Recruitment

Caution should be used when interpreting mortality and recruitment figures from the present study. It may be that the transects were not recorded for long enough to capture what are relatively rare events. Recruitment events in Northern Australian savannas are often assumed to be related to favourable rainfall patterns (Crowley et al. 1998, Brown *et al.* 2005, Moore *et al.* 2001). Precipitation in these regions is highly variable, and successive favourable events which may be needed for successful recruitment can be extremely rare. Factors linked to tree mortality such as periods of below average rainfall, fire and changes in grazing regime (Brown and Wu 2005, Sharp and Bowman 2004, Sharp and Whittaker 2003, Hodgkinson 1991) can also be very rare events. Less dramatic ongoing mortality, particularly of larger plants decades old, must also be an inherently rare event to produce

appreciable numbers of such plants in populations with stable age structure. The study period, which ranged from 1 - 17 years for different sites, is therefore probably too short to give a meaningful recruitment or mortality estimate for any of the sites studied. These transects are designed as long term permanent plots and future recordings carried out at 10 year intervals for several decades should be undertaken to provide more meaningful information.

Data from the 75 woodland sites indicated that the woodlands as a whole and the different woodland types were relatively stable over the recording period. However the apparent large scale stability masks to an extent the high degree of variability both between sites and between different plant size classes. Changes that were observed were confined primarily to the smallest plants.

The relative rate of recruitment (6.7% of initial density/yr) was slightly higher than mortality (6.4% of initial density/yr), resulting in an increase in population overall. Annual mortality for the woodlands under study (6.4% of initial density/yr) was higher than the 1-3% community-wide mortality rates in tropical forest (Swaine *et al.* 1987, Condit *et al.* 1995) and higher then the 3% reported by Williams *et al.* (1999) for unburned savanna in Northern Australia. However the figure was lower than the 13-18% mortality reported by Williams *et al.* (1999) for burned savanna, suggesting that the woodlands in this study may have been experiencing some stress leading to increased mortality, but not to the extent that radical change in fire

regime can induce.

Comparison of annual mortality between size classes showed that the absolute mortality rate was highest in the smallest size class. Werner (2005) similarly found the highest mortality rate amongst the smallest size classes in unburned savanna in Northern Australia. In this study, the higher mortality rate for small plants reflected the large numbers of plants in the smaller size classes and the relative change (7% of initial density/yr) was smaller than that seen in many of the larger size classes. The annual mortality rates were irregular for the six largest diameter classes, and was probably due to the low numbers of plants in these classes. In the other diameter classes the mortality rate remained approximately stable across classes. In contrast Williams *et al.* (1999) and Werner (2005) reported that mortality rates were highest amongst the smallest and largest plants in Northern Australian savannas under changes in fire and grazing regimes. Williams *et al.* (1999) also reported that mortality decreased with size in unburned savanna, Moustakas *et al.* (2006) noted that mortality was highest in the mid size classes for an *Acacia* species in an undisturbed African savanna. Fensham *et al.* (1999) report that drought related mortality for multiple species was largely independent of stem size in savannas in North East Queensland. The fact that the mortality pattern in the current study is approximately independent of size indicates that drought may have been a more significant agent in population change within the woodlands than fire or grazing.

4.7 Height

Mean height declined for the woodlands and, as with density and basal area, changes in height were strongly influenced by the smallest plants. The total population had a much lower mean height than the population comprised solely of plants >300 mm circumference (~2.5 m vs. ~11.5 m). Yet despite a taller average stature plants >300 mm circumference decreased in mean height by just 0.2%/yr (0.02 m/yr) compared to an annual decrease of 2.4%/yr (0.06 m/yr) for the total population. Since mortality was not significantly higher for plants >300 mm circumference, the greater height decrease for the population incorporating these smaller plants can be attributed primarily to an increased abundance of small plants lowering the mean height of the woodlands.

4.8 Environmental Factors

The observed significant correlations of total species richness with total plant density, density of plants >300 mm circumference, basal area and size class distributions appear to simply reflect that diversity tends to be highest under conditions of low environmental stress and where conditions necessary for plant establishment are most frequent. Those same conditions that permit greater plant densities to establish and persist should also be expected to permit a greater number of species to persist simply because the number of potential ecological niches is higher and the ability of chance colonists to establish is higher. Denslow (1995)

expressed the same principle in generalised form as "habitats with greater total available energy will support larger populations and therefore more species than habitats with less total available energy". This correlation between diversity and woody plant density has been observed in tropical forests (Denslow 1995, Wright 1992), African savanna communities (Lwanga *et al.* 2000) and tropical Australian savannas (Bowman and Connors 1996).

Diversity was also positively correlated with longitude. Longitude is a distal variable with no direct potential to exert a physiological effect on woodland structure and the observed effects are necessarily dependent upon linked environmental factors. Hunter (2005) suggested that insular radiation may play a role in the interrelationship between diversity and longitude in Eastern Australia. Ter Steege *et al.* (2003) found that in tropical forests diversity is usually correlated with rainfall. Annual rainfall in Queensland generally decreases from east to west (Weston 1990) and rainfall was significantly correlated with longitude (Table 33). However diversity is not closely correlated to the rainfall variables themselves, which suggests that if rainfall is playing a role in the effect of longitude on diversity it is doing so via an interplay with numerous other factors such as edaphic factors or grazing management.

Total plant density appears to be correlated mostly to competition related factors, with other environmental factors considered in this study playing relatively little

role. Increasing mean plant height was associated with decreased plant density within the model. This appears to reflect an absolute constraint placed upon the density of large plants by competition. Smith and Goodman (1986) suggest that competition between plants in savannas will result in the stunting or death of one or more of the plants affected, primarily as a result of water stress, and that this results in the distance between any plant and its nearest neighbour being correlated with plant size. According to this principle a savanna can exist, at least in theory, entirely as widely spaced mature trees of maximum size with little or no competition between individuals. Such a savanna will have a large average height despite a low plant density. However competition between individuals means that there is an absolute limit to the number of individuals of maximum size that can exist within a given area. As a result any savanna with a large woody plant density must be comprised primarily of smaller individuals, whether stunted overstorey plants or understorey shrubs, resulting in a low average height. This appears to be the reason for the negative relationship between density and mean height seen in the model. When the relationship between density and relative proportion of large plants is plotted there appears to be a distinct upper bound (dashed line in Figure 21), suggesting the upper density allowable due to competition for prevailing environmental conditions. The same relationship would also explain the significant positive relationship between density and size class distribution.

Density also showed a significant positive relationship with density of plants >300

mm circumference. This is most likely attributable to the density of plants >300 mm circumference being a subset of total density. The correlation could be due to those sites with conditions able to support high total densities of plants being able to support high densities of larger plants as well. However such an explanation is unlikely since density of plants of plants >300 mm circumference was positively correlated with mean plant height, while overall density was negatively correlated. This indicates that many sites with numerous large trees do not have equivalent densities of smaller plants bringing the average height down.

Density of plants >300 mm circumference and basal area were significantly correlated. This result is unsurprising since high densities of plants with large basal area measurements in a site would be expected to increase the basal area of the site. Density of plants >300 mm circumference and basal area also showed similar correlations with other factors. Both showed significant negative correlation with maximum temperature and maximum winter temperature and a positive correlation with winter rainfall, latitude and longitude.

Basal area showed significant correlation with mean annual rainfall, maximum temperature, maximum summer and winter temperatures, winter rainfall, latitude and longitude. These environmental factors are difficult to isolate from one another, with considerable correlation between these factors. The general pattern would seem to indicate that the density of larger plants, and hence basal area,

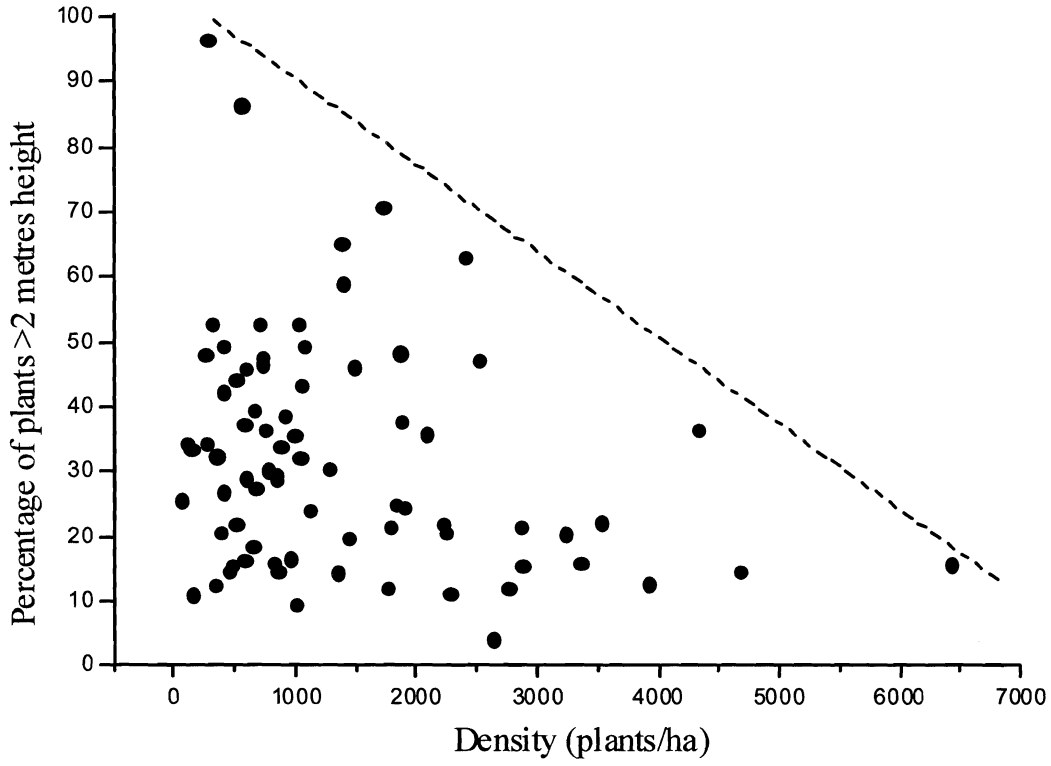


Figure 21.
Relationship between density and proportion of small plants.
Dashed line represents an apparent upper bound to density allowed by competition.

declines with increasing water stress. Such water stress results from lower rainfall in the drier winter months or from increased evaporative demand at elevated temperatures. A negative relationship between savanna plant density and available water has been noted in Africa by Smith and Goodman (1986) and Scholes *et al.* (1999) and decline in rainfall has been suggested as a mechanism for decline in density in Northern Australian savannas by Bowman and Connors (1996). The positive correlation of both density of plants >300 mm circumference and basal area with mean plant height most probably reflects the relationship between plant height and diameter. Burrows *et al.* (2000) found that plant height was relatively closely correlated to basal area for eucalypts in the woodlands of Eastern Australia.

Both mean height and mean height of plants >300 mm circumference appeared to be strongly determined by water availability Both factors showed significant positive correlations to winter rainfall and longitude and an equivalent negative correlation to maximum temperature. Scholes *et al.* (1999) previously noted a correlation between mean height of large trees and rainfall in African savannas.

4.9 Dynamics Models

No more than 28% of the changes within these woodlands was explained by the incorporated environmental variables, despite the variables included in this analysis being acknowledged as having strong influences on woody vegetation dynamics (Wright 1992, Denslow 1995, Bowman and Connors 1996, Lwanga *et al.* 2000,

Fensham *et al.* 2005). This result raises the question of why these factors are so unimportant in this study. A strong possibility is simply that the overriding effect of climatic factors linked to a prolonged and severe drought in the study area in the mid 1990s (Fensham and Holman 1999) masked many 'typical' though less dramatic interactions between these woodlands and environmental factors.

An additional reason why changes were not well predicted by any combination of measured environmental variables may be that the transects were not recorded for long enough to capture relatively rare events. Population dynamics of arid and semi -arid woody plants are generally slow (Cody 2000) with infrequent and relatively rapid periods of significant mortality (Allen *et al.* 1998. Fensham and Holman 1999. Williams et al. 1999) or recruitment (Brown and Wu 2005, Sharp and Bowman 2004, Sharp and Whittaker 2003, Hodgkinson 1991) in response to factors such as fire, rainfall, drought or grazing.

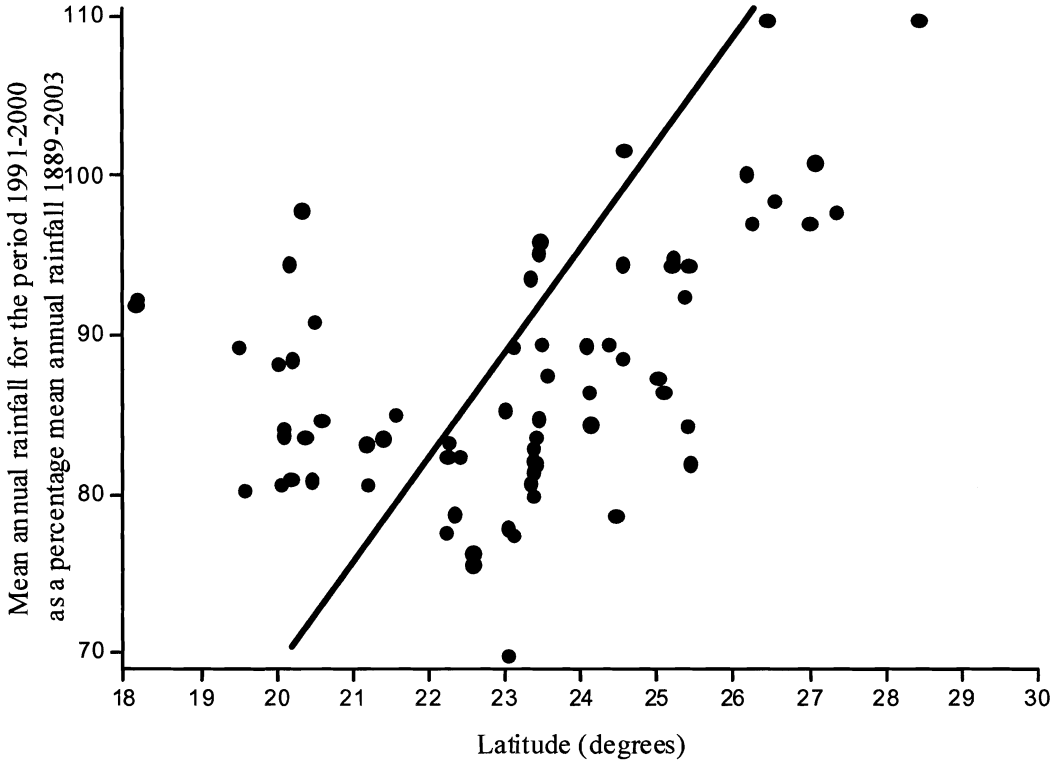
A third possibility for the low explanatory power is that other unmeasured environmental variables were more important. The literature suggests that, while rainfall is important in savanna dynamics, it exerts an effect through complex interaction with grass growth, grazing pressure and fire (Moore *et al.* 2001, Fensham *et al.* 2005). The three latter factors were not considered in this study. Margules *et al.* (1987) found that the growth of *Eucalyptus* species in south-eastern Australia was related to solar radiation while Tracey (1969) and Adams (1996)

both note the importance of edaphic factors in determining woodland dynamics in Eastern Australia. Additional research is required to evaluate the relative importance of these factors in explaining variation in the woodland structure.

Linear models were used in this analysis, however the relationship between environmental factors and dynamics may not be linear, and this may explain the poor fit produced by the models. There may also have been an interaction between some of the variables, and the models produced did not incorporate interactions. While strong interactions between environmental variables were screened for using a Pearson correlation analysis, this may not have removed weaker interactions. More importantly interactions between the biotic response variables were not considered at all.

Rainfall, latitude and minimum temperature over the recording period emerged as important explanatory variables in those models with more than 10% explanatory power. The responsiveness to these three factors could to be largely attributed to drought effects. Within the study area the 1990s drought became increasingly severe with latitude (Figure 22) and several transects in Northern and Central regions experienced significant drought related mortality during the recording period. As a result, mortality increased with decreasing latitude while plant density and basal area decreased. The models produced the opposite relationships for relative rainfall, with higher rainfall levels being positively related to mortality and

Figure 22.
Regression of relative annual rainfall and latitude for each site for the period 1991-2000 demonstrating the increasing influence of the drought with decreasing latitude.



negatively related to plant density and basal area. This appeared paradoxical given that the relationships between latitude and dynamics appear so closely tied to a rainfall deficit. However an examination of the data revealed that a number of transects established after the drought had abated to some degree had nonetheless experienced high mortality as a residual effect of the drought. As a result several of the transects with the highest mortality rates had experienced relatively normal rainfall over the period in which they were recorded, producing a positive relationship between mortality and relative rainfall.

Biotic factors such as initial plant density or initial basal area proved to have little or no correlation with changes in woodland structure. Such biotic factors commonly have been used as predictor variables in other studies (Fensham *et al.* 2005, Umeki 1999). A weak relationship was observed between change in density of plants >300 mm circumference and diversity. This relationship probably reflects the underlying relationship between diversity and density of plants >300 mm circumference, however the relationship is scarcely strong enough to draw any meaningful conclusions.

In summary, dynamic processes were not adequately predicted by any of the measured environmental variables and it is suggested that the relatively brief recording period of many sites has allowed only gross and dramatic influences such as that associated with an unusual dry period to be detected. Subtle dynamics at the

time scale of this study may be largely a function of alternative factors, such as fire, grazing or soil properties.

4.10 Canonical Correspondence Analysis

Canonical correspondence analysis based on Species Importance Values indicated that, while vegetation was responding to several environmental factors (geographic location, temperature, topography, soil and rainfall), the measured environmental factors were almost certainly not the only significant factors at play.

Acacia aneura dominated transects were the most distinct grouping produced by canonical correspondence analysis, isolated along both axes by their occurrence on flat terrain in the cool, dry southwest of the study area. This is consistent both with the suggestion of Johnson and Burrows (1994) that *A. aneura* communities occur in a zone receiving between 500 mm and 200 mm mean annual rainfall with some rainfall occuring in all seasons. This result is also consistent with the hypothesis of Bowman and Connors (1996) that *A. aneura* dominates colder regions in Northern Australia due to better adaptation to low minimum temperatures than eucalypts, rather than factors directly associated with water regimes. Within this study either or both factors could be playing a role, with the observed clarity of the grouping due in large part to the restriction of *A. aneura* transects to the southwestern region of the study area, which in turn corresponded with both low rainfall and low temperatures.

The relationship of *A. aneura* communities with flat terrain is consistent with mulga communities occurring most extensively on sand plains and similar flat terrain (Johnson and Burrows 1994).

Callitris glaucophylla dominated transects formed a distinct cluster defined primarily by rainfall, temperature, topography and soil. These results are in agreement with Johnston (1975) and Thompson and Eldridge (2005) who note that *C. glaucophylla* dominated communities are usually restricted to sandy soils and are highly drought tolerant and commonly found in regions experiencing minimum temperatures below 0°C.

The MELANOPHLOIA type transects formed a surprisingly well defined cluster despite the wide geographic distribution and the degree of overlap with other woodland type. Demarcation within the CCA ordination was due in large part to topography, rainfall and soil, and in general the MELANOPHLOIA type woodlands seem to correspond to situations of high water stress such as arid zones or, in more humid locales, sites with light soils with poor water holding capacity and sloping terrain with high drainage rates.

The remaining woodland types formed less clear groupings within the ordination. Most CREBRA type transects formed a relatively distinct grouping delineated

largely by topography, with a majority of sites located on hill slopes or uneven terrain. *Eucalyptus crebra* is usually found on ridges and higher slopes, especially in higher rainfall regions (Craze and Salmon 2004). Those CREBRA type transects that are found within the bottom half of the ordination diagram (Figure 19) are dominated by species other than *E. crebra* (e.g. *E. fibrosa, E. molucanna and Corymbia plena*) that are known to occur either on lower slopes or flat terrain (Brooker and Kleinig 1990, Gillison and Walker 1994, Craze and Salmon 2004). CYPRESS type woodlands are also defined in large part by topography and within the ordination CREBRA type transects are kept distinct from CYPRESS transects by the effect of latitude and the associated higher temperatures, with all except one CYPRESS transect located further south than any CREBRA transect. However, the clarity of this distinction should be viewed with some suspicion since *E. crebra* dominated woodlands have a latitudinal distribution extending well south of the study area (Brooker and Kleinig 1990). The apparent latitudinal demarcation between CREBRA and CYPRESS type woodlands may well be primarily the result of a failure to place any sites in CREBRA type communities in southern Queensland.

It is clear from the analysis that the measured variables did not explain all the variation in species composition. Some of the remaining variation in species composition may be due to a factors being more complex than the parameters used. For example, soil fertility and chemistry are known to have important effects on

plant community structure and composition (Compton *et al.* 1998) and both topography and soil type are likely exerting at least part of their influence through a relationship to the soils' nutrient and water availability (Tracey 1969, Adams 1996). Topography is also potentially exerting an effect via controlling fire (Adams 1996) or radiation (Margules *et al.* 1987, Hunter 2003, Hunter 2005). It is plausible that the variation is due to factors which were not incorporated in the study at all, especially management or chance events such as such as burning or grazing that are known to have important consequences for the structure and composition of savanna communities (Moore *et al.* 2001). Unfortunately adequate records of these factors were not available to enable examination their effects on woodland composition in the present case.

Chapter 5: Conclusions

The short recording period of many sites (three years or less for 39 of the 75 sites) must be borne in mind when interpreting findings relating to changes in woodland structure and composition. Taking this into account however the study showed an approximately stable woodland system with community distribution defined largely, though not entirely, by environment despite no obvious environmental effect on dynamics.

The study showed that the grazed woodlands of Queensland remained floristically largely unchanged over time. Approximately 150 species in 34 families were identified in the sites, but analysis of species-area curves suggests that more sampling is required to capture the true floristic diversity of the woodlands. The woodlands were dominated by the families Myrtaceae and Mimosaceae in terms of both basal area and woody plant numbers. A small number of species also dominated the woodlands, contributing the vast majority of basal area and plant numbers. A small number of species also dominated the woodlands, contributing the vast majority of basal area and plant numbers.

Despite the high level of diversity and a high degree of floristic heterogeneity between sites, the woodlands could be divided into sevan floristically distinct community types with a majority of species confined to just one woodland group. The mulga communities of the South-West of the study area were the most floristically distinct, with the other community types showing a greater degree of

floristic overlap. Significant differences were found to exist between the woodland types based on structural and environmental variables.

The woodlands experienced an increase in woody plant density over the study period, however because most of the increase was confined to the smallest plants this did not translate into an increase in basal area. Basal area declined for the woodlands, in contrast with a large body of published work suggesting that grazed woodlands both in Queensland and worldwide have been experiencing a prolonged increase in basal area (Archer 1991, Flannery 1994, Florence 1996, Jones and Sharitz 1998, Smith *et al.* 2000, Gifford and Howden 2001, Lunt *et al.* 2006). Evidence suggested that the basal area decrease observed in the current study was largely the result of period of rainfall deficit during the study period. When obviously drought affected sites were excluded basal area was found to have increased.

Size class distributions remained unchanged over time and followed the reverse J/ negative exponential pattern typical of natural, mature stands for most woodland types. However, most individual sites did not display a reverse J pattern. Further study is required to determine whether this indicates patchy disturbance across the woodlands, with different sites at different stages of recovery, or whether it is a reflection of the small sample areas of individual sites.

The study has revealed a number of patterns in the distribution of woodland communities, in environmental characteristics and between these ecological and physical systems. Woodland groups were created through cluster analysis that reflect differences in species composition between sites depending on environmental factors. This was seen in the similarity of site clustering between DCA analysis based solely on floristic composition and CCA analysis incorporating environmental characteristics. Ordination analysis revealed that a range of environmental factors including temperature, geographic location, soil type and topography were important in influencing the distribution of woodland associations. The results reveal the complexity of the study area, but highlight some trends and patterns that link environmental and vegetation systems. The study also revealed a need for the establishment of more sites to gain an accurate understanding of the influences of environment on the distribution of woodland associations.

Stand structure within the woodlands was found to have some correlation with environmental factors. The density and diversity of woody plants were found to be correlated to competition related factors, with environments that supported a greater density of woody plants also supporting a greater diversity. Basal area appeared to be highest in areas of highest water availability.

Linear models revealed that that dynamics patterns within the woodlands were poorly correlated with environmental factors. This lack of correlation may have been due to three factors. An overwhelming effect of a severe drought during the study period may have been masking more subtle correlations, the models may not have incorporated the environmental parameters that are truly influencing structure and dynamics or the recording period may have been too short to capture relatively rare recruitment or mortality events. Further research is required to determine which of these is correct or whether a combination of these factors is at play.

The information contained within this thesis could be of value in land management. Vegetation structure is currently monitored on a broad scale via remote sensing technologies providing information on canopy and projected foliage cover and a basal area estimate derived from that information (Kuhnell *et al.*1998). However this methodology does not provide accurate information on understorey structure or species diversity, which may vary widely within regions of similar foliage cover. Results obtained form the sites described in this study provide an effective starting point for a description of understorey structure for land management directed at habitat, biodiversity or landscape function. The results also form a basis for addressing questions and validating models requiring long term data, such as the impact of management practices on biodiversity and vegetation structure. This study provides information on the interaction between climate and growth parameters. Such information can assist in understanding the impacts of climate

change on these woodlands and potentially identify means of mitigating such impacts. By quantifying the changes in basal area, and hence biomass, the results may enable a quantification of the contribution of woodland thickening to carbon sequestration and hence mitigation of anthropogenic climate change.

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APPENDICES

Appendix 1 Table 1.

Woodland Type	Transect	Woody plant density at initial recording (plants/ha)	Woody plant density at final recording (plants/ha)	Annual change in woody plant density plant density (plants/ha/yr)	Annual change in woody plant density as % of initial density	Woody plant density at initial recording, plants >300 mm circumference (plants/ha)	Woody plant density at final recording, plants >300 mm circumference (plants/ha)	in woody plant density plant density, plants >300 mm circumference (plants/ha)	in woody plant density as % of initial density, plants >300 mm circumference (plants/ha)
Box	Aqua Downs	1350	1480	77.2	5.7	375	355	-11.9	-0.9
	Bungobine	3787	4130	180.4	4.8	83	80	-1.8	-0.1
	Carfax control	1990	3240	73.6	3.7	240	230	-0.8	0
	Carfax stylo	2065	2190	7.4	0.4	210	185	-2	-0.1
	Centauri	4340	5010	350.6	8.1	375	345	-15.7	-0.4
	Coalstoun Lakes	69	124	18.5	27	30	30	0	0
	Hedlow Creek	1180	675	-32.4	-2.8	190	170	-1.3	-0.1
	Magazine	1805	2935	71	3.9	180	160	-1.3	-0.1
	Medway	415	438	13	3.1	123	122	-0.9	-0.2
	Mt. Panorama	600	600	0	0	255	180	-11	-1.8
	Myrrlumbing	710	825	60.4	8.5	110	105	-2.6	-0.1
	Pajingo	1145	1245	52	4.5	255	220	-18.2	-1.6
	Texas	735	692	-18.8	-2.6	128	125	-1.5	-0.2
	Walthum	878	820	-6	-0.7	190	110	-8.4	-1
	Wandobah T6 R1	1475	1913	39.4	2.7	163	175	1.1	0.1
	Wandobah T6 R2	3363	3694	30.9	0.9	369	406	3.5	0.1
	Wandobah T6 R3	2419	3006	52.9	2.2	219	213	-0.6	0
N		17	17	17	17	17	17	17	17
Mean		1666	1942	57.1	4.1	206	189	-4.3	-1.8
Std. Error of Mean		295	358	21.9	1.6	24	24	1.5	0.5
Cypress	Eumina	1597	2010	187.99	11.77	397	387	-4.55	-0.28
	Rostock	2140	2650	231.98	10.84	890	930	18.19	0.85
	Sunrise east	2716	2957	85.17	3.14	550	583	11.75	0.43
N		3	3	3	3	3	3	3	3
Mean		2151	2539	168.38	8.58	612	633	8.46	1.01
Std. Error of Mean		323	279	43.5	2.73	146	159	6.77	1.08

Appendix 1 Table 1 (cont).
Changes in density for each transect. Sites are grouped by DCA determined woodland types.

Woodland Type	Transect	Woody plant density at initial recording (plants/ha)	Woody plant density at final recording (plants/ha)	Annual change in woody plant density plant density (plants/ha/yr)	Annual change in woody plant density as % of initial density	Woody plant density at initial recording, plants >300 mm circumference (plants/ha)	Woody plant density at final recording, plants >300 mm circumference (plants/ha)	Annual change in woody plant density plant density, plants >300 mm circumference (plants/ha)	Annual change in woody plant density as % of initial density, plants >300 mm circumference (plants/ha)
Desert uplands	Inveresk	1880	2028	310.8	16.8	250	235	-7.2	-0.4
	Julia Park	1300	1490	99.6	7.7	190	190	0.0	0.0
	Swanlea	1755	2030	120.2	6.9	300	300	0.0	0.0
	The Patrick	486	509	20.0	4.1	71	70	-1.1	-0.2
N		4	4	4.0	4.0	4	4	4.0	4.0
Mean		1355	1514	137.6	8.9	203	199	-2.1	-1.1
Std. Error of Mean		315	358	61.6	2.8	49	48	1.7	0.7
Microneura	Mistletoe	350	423	40.5	11.6	105	103	-1.4	-0.4
	Namuel	290	300	5.6	1.9	225	230	2.8	1.0
N		2	2	2.0	2.0	2	2	2.0	2.0
Mean		320	361	23.1	6.8	165	166	0.7	0.0
Std. Error of Mean		30	61	17.4	4.8	60	64	2.1	1.3
Mulga	Clifton	575	575	0.0	0.0	175	185	5.8	1.0
	Croxdale	865	870	1.8	0.2	250	265	5.5	0.6
	Tinnenburra	3365	3465	56.7	1.7	105	105	0.0	0.0
	Yanna	800	835	12.8	1.6	200	200	0.0	0.0
N		4	4	4.0	4.0	4	4	4.0	4.0
Mean		1401	1436	17.8	0.9	183	189	2.8	1.4
Median		833	853	7.3	0.9	188	193	2.7	1.1

Appendix 1 Table 1 (cont).

Woodland Type	Transect	Woody plant density at initial recording (plants/ha)	Woody plant density at final recording (plants/ha)	Annual change in woody plant density plant density (plants/ha/yr)	Annual change in woody plant density as % of initial density	Woody plant density at initial recording, plants >300 mm circumference (plants/ha)	Woody plant density at final recording, plants >300 mm circumference (plants/ha)	Annual change in woody plant density plant density, plants >300 mm circumference (plants/ha/yr)	Annual change in woody plant density as % of initial density,>300 mm circumference (plants/ha/yr)
Crebra	Anchor	1585	1850	18.39	1.16	220	180	-2.78	-0.17
	Archer	910	850	-3.66	-0.40	320	75	-14.94	-1.63
	Balmoral	1405	920	-28.91	-2.06	335	300	-2.09	-0.15
	Canal Creek	3390	3710	173.93	5.13	455	465	5.44	0.16
	Exevale	168	172	2.03	1.21	20	14	-3.04	-1.81
	Forest Hills	4300	7930	384.98	8.95	385	475	9.54	0.22
	Glenrock	3445	4540	373.09	10.83	260	255	-1.70	-0.05
	Goldsborough	990	1040	26.24	2.65	195	195	0.00	0.00
	Granitevale	930	745	-11.31	-1.22	365	360	-0.31	-0.03
	Heidelberg	263	300	19.02	7.25	60	58	-1.27	-0.48
	Huntly	435	484	4.04	0.93	56	60	0.31	0.07
	Kiauroo	817	1120	18.93	2.32	180	203	1.46	0.18
	Kirk River exclosure	850	810	-3.13	-0.37	140	90	-3.91	-0.46
	Kirk River grazed	1440	480	-75.15	-5.22	80	20	-4.70	-0.33
	Kooralbyn eucre	6045	4035	-134.48	-2.22	250	240	-0.67	-0.01
	Leyshon view exclosur	413	643	21.34	5.17	8	13	0.46	0.11
	Leyshon view grazed	543	813	25.06	4.62	20	20	0.00	0.00
	Lundsville	2755	4305	104.09	3.78	385	315	-4.70	-0.17
	Meadowvale exclosure	925	1325	31.33	3.39	185	110	-5.87	-0.63
	Meadowvale grazed	575	755	14.10	2.45	200	95	-8.22	-1.43
	Monavale	3715	7080	198.17	5.33	385	415	1.77	0.05
	Mt. Pleasant Bowen	868	1155	140.38	16.17	96	92	-1.61	-0.19
	Netherleigh	1290	1260	-1.83	-0.14	525	465	-3.67	-0.28
	New gildale	658	715	31.39	4.77	128	128	0.00	0.00
	Rosebank	2170	2475	132.78	6.12	250	250	0.00	0.00
	Rundle	935	920	-0.96	-0.10	270	250	-1.28	-0.14
	Scotston	735	825	43.89	5.97	215	215	0.00	0.00
	Springsure reserve	438	440	1.10	0.25	80	76	-2.20	-0.50
	St. pauls exclosure	213	228	1.17	0.55	58	35	-1.76	-0.83
	St. pauls grazed	205	175	-2.33	-1.14	25	15	-0.78	-0.38
	Tryphinia eucre	1225	1565	20.03	1.64	130	130	0.00	0.00
	Tryphinia eumol	665	790	8.39	1.26	135	140	0.34	0.05
N		32	32	32.00	32.00	32	32	32.00	32.00
Mean		1416	1702	47.88	2.78	200	180	-1.44	-0.28
Std. Error of Mean		245	343	19.15	0.75	25	25	0.71	0.09

Appendix 1 Table 1 (cont).
Changes in density for each transect. Sites are grouped by DCA determined woodland types.

Woodland Type	Transect	Woody plant density at initial recording (plants/ha)	Woody plant density at final recording (plants/ha)	Annual change in woody plant density plant density (plants/ha/yr)	Annual change in woody plant density as % of initial density	Woody plant density at initial recording, plants >300 mm circumference (plants/ha)	Woody plant density at final recording, plants >300 mm circumference (plants/ha)	Annual change in woody plant density plant density, plants >300 mm circumference (plants/ha/yr)	Annual change in woody plant density as % of initial density,>300 mm circumference (plants/ha/yr)
Melanophloia	Bowie	990	1255	113.21	11.43	115	110	-2.14	-0.22
	Burtle	1395	2005	247.01	17.71	180	185	2.02	0.14
	Cooper Downs	385	435	3.04	0.79	155	145	-0.61	-0.16
	Dykehead	1040	1135	42.06	4.04	88	85	-1.11	-0.11
	Hyde Park	995	995	0	0	120	120	0	0
	Kerry	2350	2580	136.38	5.8	350	345	-2.96	-0.13
	Longton	975	1040	34.11	3.5	155	155	0	0
	Mt. Pleasant	1005	1010	0.34	0.03	120	110	-0.68	-0.07
	Nyanda	690	865	12.97	1.88	170	210	2.96	0.43
	Old Rawbelle	570	630	29.26	5.13	210	215	2.44	0.43
	Summerdel	2130	1880	-16.18	-0.76	220	340	7.77	0.36
	Sunrise west	1315	1875	199.16	15.15	455	455	0	0
	Tryphinia eumel	680	1095	26.23	3.86	430	360	-4.42	-0.65
N		13	13	13	13	13	13	13	13
Mean		1117	1292	63.66	5.27	213	218	0.25	0.12
Std. Error of Mean		159	170	23.25	1.64	34	33	0.85	0.4
Total	N	75	75	75	75	75	75	75	75
	Mean	1417	1659	60.04	4.07	218	208	-1.15	-0.45
	Std. Error of Mean	134	176	11.33	0.62	17	18	0.62	0.19

Appendix 1 Table 2.
Changes in basal area for each site. Sites are grouped by DCA determined woodland types.

Woodland Type	Transect	Woody plant basal area at initial recording (m^2/ha)	Woody plant basal area at final recording (m^2/ha)	Annual change in basal area (m^2/ha/yr)	Annual change in basal area as % of initial basal area	Woody plant basal area at initial recording (m2/ha) plants >300 mm circumference	Woody plant basal area at final recording (m2/ha) plants >300 mm circumference	Annual change in basal area (m2/ha/yr) plants >300 mm circumference	Annual change in basal area as % of initial basal area plants >300 mm circumference
Box	Aqua Downs	15.18	14.68	-0.30	-1.98	13.06	12.66	-0.24	-1.85
	Bungobine	9.05	8.92	-0.07	-0.79	8.92	8.81	-0.06	-0.62
	Carfax control	16.01	16.35	0.03	0.16	15.75	15.73	0.00	-0.01
	Carfax stylo	15.54	14.55	-0.08	-0.50	15.21	13.85	-0.11	-0.70
	Centauri	11.48	10.33	-0.60	-5.22	7.46	6.55	-0.48	-6.43
	Coalstoun Lakes	9.52	10.09	0.19	2.04	9.52	10.09	0.19	2.04
	Hedlow Creek	15.22	17.70	0.16	1.05	15.21	17.67	0.16	1.04
	Magazine	14.85	16.67	0.11	0.77	14.80	16.39	0.10	0.68
	Medway	16.61	16.19	-0.24	-1.43	16.46	16.04	-0.23	-1.42
	Mt. Panorama	44.60	33.43	-1.64	-3.68	44.53	33.36	-1.64	-3.69
	Myrrlumbing	10.77	9.93	-0.44	-4.08	10.57	9.71	-0.45	-4.27
	Pajingo	8.71	7.67	-0.54	-6.23	8.59	7.51	-0.56	-6.50
	Texas	13.91	13.83	-0.04	-0.27	13.36	13.34	-0.01	-0.05
	Walthum	13.62	7.72	-0.62	-4.55	13.00	7.32	-0.60	-4.58
	Wandobah T6 R1	5.35	7.05	0.15	2.86	5.25	6.84	0.14	2.74
	Wandobah T6 R2	11.65	13.60	0.18	1.56	10.14	12.15	0.19	1.84
	Wandoban T6 R3	9.28	11.22	0.17	1.88	8.63	10.08	0.13	1.51
N		17.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
Mean		14.20	13.53	-0.21	-1.08	13.56	12.83	-0.20	-1.19
Std. Error of Mean		2.05	1.50	0.11	0.68	2.09	1.55	0.11	0.71
Cypress	Eumina	18.21	18.66	0.20	1.12	18.08	18.52	0.20	1.11
	Rostock	35.33	35.75	0.19	0.54	32.00	32.97	0.44	1.37
	Sunrise east	13.89	14.77	0.31	2.23	11.82	12.98	0.41	3.47

Appendix 1 Table 2 (cont).
Changes in basal area for each site. Sites are grouped by DCA determined woodland types.

Woodland Type	Transect	Woody plant basal area at initial recording (m^2/ha)	Woody plant basal area at final recording (m^2/ha)	Annual change in basal area (m^2/ha/yr)	Annual change in basal area as % of initial basal area	Woody plant basal area at initial recording (m2/ha) plants >300 mm circumference	Woody plant basal area at final recording (m2/ha) plants >300 mm circumference	Annual change in basal area (m2/ha/yr) plants >300 mm circumference	Annual change in basal area as % of initial basal area plants >300 mm circumference
Desert uplands	Inveresk	7.37	6.75	-0.30	-4.06	6.51	5.82	-0.33	-5.05
	Julia Park	8.10	8.16	0.03	0.40	7.53	7.61	0.05	0.60
	Swanlea	7.81	7.47	-0.15	-1.89	7.40	7.15	-0.11	-1.51
	The Patrick	4.58	4.77	0.16	3.60	4.54	4.73	0.17	3.69
N		4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Mean		6.97	6.79	-0.07	-0.49	6.50	6.33	-0.06	-0.57
Std. Error of Mean		0.81	0.73	0.10	1.64	0.69	0.65	0.11	1.84
Melanophloia	Bowie	10.82	9.14	-0.72	-6.62	10.35	8.68	-0.72	-6.91
	Burtle	11.69	11.00	-0.28	-2.38	10.32	9.77	-0.23	-2.19
	Cooper								
	Downs	12.63	13.31	0.04	0.33	12.63	13.23	0.04	0.29
	Dykehead	7.56	7.71	0.07	0.87	7.18	7.19	0.00	0.04
	Hyde Park	13.00	12.43	-0.04	-0.31	12.94	12.32	-0.04	-0.33
	Kerry	16.48	16.62	0.08	0.48	16.06	16.21	0.09	0.53
	Longton	6.83	7.05	0.12	1.69	6.07	6.31	0.13	2.08
	Mt.								
	Pleasant	13.51	11.39	-0.15	-1.07	13.46	11.13	-0.16	-1.19
	Nyanda	16.47	20.21	0.28	1.68	16.43	20.13	0.27	1.67
	Old								
	Rawbelle	10.16	10.74	0.29	2.82	10.05	10.70	0.32	3.20
	Summerdel	9.45	11.28	0.12	1.26	7.54	8.86	0.09	1.13
	Sunrise west	16.07	17.19	0.40	2.48	14.74	15.84	0.39	2.64
	Tryphinia								
	eumel	21.06	23.05	0.13	0.60	21.03	22.78	0.11	0.53
N		13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00
Mean		12.75	13.16	0.03	0.14	12.22	12.55	0.02	0.11
Std. Error of Mean		1.11	1.33	0.08	0.69	1.18	1.38	0.08	0.72
Microneura	Mistletoe	9.32	9.57	0.14	1.46	9.22	9.47	0.14	1.47
	Namuel	11.46	11.87	0.23	2.05	11.25	11.72	0.26	2.31
N		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Mean		10.39	10.72	0.19	1.76	10.24	10.60	0.20	1.89
Std. Error of Mean		30	61	17.44	4.82	60	64	2.11	1.29

Appendix 1 Table 2 (cont).
Changes in basal area for each site. Sites are grouped by DCA determined woodland types.

Woodland Type	Transect	Woody plant basal area at initial recording (m^2/ha)	Woody plant basal area at final recording (m^2/ha)	Annual change in basal area (m^2/ha/yr)	Annual change in basal area as % of initial basal area	Woody plant basal area at initial recording (m2/ha) plants >300 mm circumference	Woody plant basal area at final recording (m2/ha) plants >300 mm circumference	Annual change in basal area (m2/ha/yr) plants >300 mm circumference	Annual change in basal area as % of initial basal area plants >300 mm circumference
Crebra	Anchor	12.02	8.39	-0.25	-2.10	11.34	8.16	-0.22	-1.94
	Archer	12.45	4.77	-0.47	-3.76	12.27	4.77	-0.46	-3.73
	Balmoral	21.39	26.98	0.33	1.56	21.39	26.98	0.33	1.56
	Canal Creek	22.00	23.33	0.72	3.29	21.12	22.49	0.74	3.52
	Exevale	0.91	0.30	-0.31	-33.84	0.90	0.29	-0.31	-34.11
	Forest Hills	15.85	16.16	0.03	0.21	13.08	14.10	0.11	0.83
	Glenrock	21.49	21.13	-0.12	-0.57	20.60	20.35	-0.08	-0.41
	Goldsborough	11.16	11.22	0.03	0.28	10.78	10.80	0.01	0.11
	Granitevale	19.19	21.59	0.15	0.76	18.79	21.36	0.16	0.84
	Heidelberg	5.63	4.88	-0.38	-6.80	5.40	4.71	-0.35	-6.45
	Huntly	4.11	4.71	0.05	1.22	4.04	4.60	0.05	1.15
	Kiauroo	12.90	17.31	0.28	2.13	12.90	16.19	0.21	1.59
	Kirk River exclosure	5.74	4.21	-0.12	-2.10	5.60	3.51	-0.16	-2.92
	Kirk River grazed	6.47	0.99	-0.43	-6.63	6.02	0.76	-0.41	-6.84
	Kooralbyn eucre	11.43	12.02	0.04	0.34	10.79	11.66	0.06	0.54
	Leyshon view exclosure	0.34	0.75	0.04	10.97	0.33	0.39	0.01	1.94
	Leyshon view grazed	1.60	1.83	0.02	1.33	1.54	1.70	0.01	0.97
	Lundsville	22.42	22.42	0.00	0.00	22.00	21.83	-0.01	-0.05
	Meadowvale exclosure	6.84	4.39	-0.19	-2.80	6.78	4.29	-0.20	-2.88
	Meadowvale grazed	6.03	2.25	-0.30	-4.91	6.00	2.25	-0.29	-4.90
	Monavale	18.69	18.76	0.00	0.02	16.91	17.62	0.04	0.24
	Mt. Pleasant								
	Bowen	8.14	7.61	-0.26	-3.16	8.10	7.58	-0.25	-3.14
	Netherleigh	20.66	20.63	0.00	-0.01	20.17	20.43	0.02	0.08
	Newgildale	9.14	9.40	0.14	1.55	8.82	9.16	0.18	2.09
	Rosebank	13.19	13.80	0.27	2.04	11.52	12.22	0.31	2.66
	Rundle	22.25	26.27	0.26	1.15	21.99	26.15	0.27	1.21
	Scotston	17.47	17.80	0.16	0.93	17.37	17.69	0.16	0.90
	Springsure reserve	9.32	8.95	-0.20	-2.18	9.22	8.84	-0.21	-2.31
	St. pauls exclosure	5.88	3.86	-0.16	-2.69	5.88	3.75	-0.17	-2.83
	St. pauls grazed	2.42	1.83	-0.05	-1.90	2.41	1.76	-0.05	-2.10
	Tryphinia eucre	13.40	14.87	0.09	0.64	13.23	13.50	0.02	0.12
	Tryphinia eumol	11.94	12.58	0.04	0.36	11.85	11.97	0.01	0.07
N		32.00	32.00	32.00	32.00	32.00	32.00	32.00	32.00
Mean		11.64	11.44	-0.02	-1.40	11.22	11.00	-0.01	-1.69
Std. Error of Mean		1.22	1.46	0.04	1.19	1.18	1.43	0.04	1.14
Microneur	Mistletoe	9.32	9.57	0.14	1.46	9.22	9.47	0.14	1.47

Appendix 1 Table 2 (cont).
Changes in basal area for each site. Sites are grouped by DCA determined woodland types.

Woodland Type	Transect	Woody plant basal area at initial recording (m^2/ha)	Woody plant basal area at final recording (m^2/ha)	Annual change in basal area (m^2/ha/yr)	Annual change in basal area as % of initial basal area	Woody plant basal area at initial recording (m2/ha) plants >300 mm circumference	Woody plant basal area at final recording (m2/ha) plants >300 mm circumference	Annual change in basal area (m2/ha/yr) plants >300 mm circumference	Annual change in basal area as % of initial basal area plants >300 mm circumference
Mulga	Clifton	4.07	4.14	0.04	1.04	2.75	2.87	0.07	2.48
	Croxdale	7.32	6.98	-0.12	-1.70	6.54	6.41	-0.05	-0.73
	Tinnenburra	7.58	7.40	-0.10	-1.34	4.14	4.20	0.03	0.80
	Yanna	7.20	7.61	0.15	2.04	7.00	7.40	0.15	2.10
N		4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Mean		6.54	6.53	-0.01	0.01	5.11	5.22	0.05	1.16
Std. Error of Mean		0.83	0.81	0.06	0.91	1.01	1.03	0.04	0.73
Total									
N		75	75	75.00	75.00	75	75	75.00	75.00
Mean		12.29	12.15	-0.04	-0.74	11.70	11.53	-0.03	-0.81
Std. Error of Mean		0.82	0.84	0.04	0.55	0.81	0.83	0.04	0.54

Appendix 1 Table 3.
Mortality rates for individual sites

Woodland Type	Transect	Mort (plants/ha/yr)	Mort (plants/ha/yr) plants >300 mm circumference	Annual mortality as % of initial density	Annual mortality as % of initial densityplants >300 mm circumference
Box	Aqua Downs	59.52	5.94	4.41	1.58
	Bungobine	44.22	3.50	1.17	4.22
	Carfax control	54.64	1.57	2.75	0.65
	Carfax stylo	93.16	3.93	4.51	1.87
	Centauri	371.73	15.70	8.57	4.19
	Coalstoun Lakes	3.38	0.00	4.90	0.00
	Hedlow Creek	48.14	1.60	4.08	0.84
	Magazine	61.64	1.57	3.41	0.87
	Medway	0.93	0.93	0.22	0.76
	Mt. Panorama	13.63	11.03	2.27	4.32
	Myrrlumbing	21.02	2.63	2.96	2.39
	Pajingo	80.82	15.59	7.06	6.11
	Texas	38.81	2.17	5.28	1.70
	Walthum	151.88	11.02	17.31	5.80
	Wandobah T6 R1	121.52	0.56	8.24	0.35
	Wandobah T6 R2	114.76	3.50	3.41	0.95
	Wandobah T6 R3	16.42	2.81	0.68	1.29
N		17	17	17	17
Mean		123.90	4.94	7.22	1.51
Std. Error of Mean		46.77	1.24	1.78	0.39
Cypress	Eumina	54.79	3.03	3.43	0.76
	Rostock	23.60	0.00	1.10	0.00
	Sunrise east	114.00	2.94	4.20	0.53
N		3.00	3.00	3.00	3.00
Mean		107.33	1.99	3.77	5.43
Std. Error of Mean		28.57	1.00	1.07	4.88
Desert uplands	Inveresk	148.33	4.78	7.89	1.91
	Julia Park	115.79	0.00	8.91	0.00
	Swanlea	24.60	4.37	1.40	1.46
	The Patrick	36.72	1.11	7.55	1.56
N		4	4	4	4
Mean		98.01	2.57	6.54	0.43
Std. Error of Mean		22.54	1.19	1.55	0.43
Mulga	Clifton	0	0	0.00	0.00

Appendix 1 Table 3 (cont).
Mortality rates for individual sites.

Woodland Type	Transect	Mort (plants/ha/yr)	Mort (plants/ha/yr) plants >300 mm circumference	Annual mortality as % of initial density	Annual mortality as % of initial densityplants >300 mm circumference
Crebra	Anchor	53.47	7.29	3.37	3.31
	Archer	39.63	14.94	4.36	4.67
	Balmoral	43.23	2.09	3.08	0.62
	Canal Creek	259.56	0.00	7.66	0.00
	Exevale	57.87	3.04	34.45	15.20
	Forest Hills	129.51	2.12	3.01	0.55
	Glenrock	213.31	5.11	6.19	1.97
	Goldsborough	65.79	0.00	6.65	0.00
	Granitevale	17.74	0.61	1.91	0.17
	Heidelberg	16.50	2.54	6.27	4.23
	Huntly	19.06	0.41	4.38	0.74
	Kiauroo	12.48	0.62	1.53	0.35
	Kirk River exclosure	23.49	4.70	2.76	3.36
	Kirk River grazed	90.84	4.70	6.31	5.87
	Kooralbyn eucre	311.91	4.68	5.16	1.87
	Leyshon view exclosure	13.93	0.00	3.37	0.00
	Leyshon view grazed	27.39	0.46	5.04	2.32
	Lundsville	69.85	7.39	2.54	1.92
	Meadowvale exclosure	53.25	5.09	5.76	2.75
	Meadowvale grazed	25.45	8.61	4.43	4.31
	Monavale	106.60	3.53	2.87	0.92
	Mt. Pleasant Bowen	0.00	1.61	0.00	1.69
	Netherleigh	33.23	5.81	2.58	1.11
	New gildale	4.55	0.00	0.69	0.00
	Rosebank	117.39	2.18	5.41	0.87
	Rundle	42.41	1.91	4.54	0.71
	Scotston	4.39	0.00	0.60	0.00
	Springsure reserve	6.93	1.10	1.58	1.37
	St. pauls exclosure	7.19	1.96	3.38	3.40
	St. pauls grazed	14.95	0.78	7.30	3.11
	Tryphinia eucre	17.57	0.88	1.43	0.68
	Tryphinia eumol	4.46	3.02	0.67	2.24
N		32.00	32	32	32
Mean		59.50	3.04	1.61	1.61
Std. Error of Mean		13.30	0.57	0.30	0.30
Microneura	Mistletoe	9.32	9.57	0.14	1.46

Appendix 1 Table 3 (cont).
Mortality rates for individual sites.

Woodland Type	Transect	Mort (plants/ha/yr)	Mort (plants/ha/yr) plants >300 mm circumference	Annual mortality as % of initial density	Annual mortality as % of initial densityplants >300 mm circumference
Melanophloia	Bowie	53.42	2.14	5.40	1.86
	Burtle	67.07	0.00	4.81	0.00
	Cooper Downs	5.79	0.91	1.50	0.59
	Dykehead	44.44	1.11	4.27	1.26
	Hyde Park	29.72	0.35	2.99	0.29
	Kerry	196.43	0.00	8.36	0.00
	Longton	13.16	0.00	1.35	0.00
	Mt. Pleasant	45.84	2.74	4.56	2.28
	Nyanda	18.73	0.37	2.71	0.22
	Old Rawbelle	22.70	0.00	3.98	0.00
	Summerdel	101.35	2.91	4.76	1.32
	Sunrise west	27.54	1.78	2.09	0.39
	Tryphinia eumel	0.29	4.74	0.04	1.10
N		13	13	13	13
Mean		44.81	1.31	5.42	1.74
Std. Error of Mean		13.96	0.41	1.90	0.48
Microneura	Mistletoe	39.09	0.00	11.17	0.00
	Namuel	0.00	0.00	0.00	0.00
N		2	2	2.00	2.00
Mean		24.49	0.00	11.49	0.00
Std. Error of Mean		16.01	0.00	3.79	0.00
Mulga	Clifton	0.00	0.00	0.00	0.00
	Croxdale	63.87	3.65	7.38	1.46
	Tinnenburra	35.65	0.00	1.06	0.00
	Yanna	0.00	0.00	0.00	0.00
N		4	4	4.00	4.00
Mean		71.09	0.91	6.61	0.49
Std. Error of Mean		26.22	0.91	3.17	0.30
Total					
N		75	75	75.00	75.00
Mean		80.20	2.91	6.43	1.60

Appendix 1 Table 4.
Height change for each site.

Transect	Mean plant height at initial recording (m).	Mean plant height at final recording (m).	Annual change in mean height (m).	Annual change in mean height as % of initial mean height	Mean plant height (m) at initial recording plants >300 mm circumference	Mean plant height (m) at final recording plants >300 mm circumference	Annual change in mean height (m) plants >300 mm circumference	Annual change in mean height as % of initial mean height plants >300 mm circumference
Anchor	2.30	1.81	-0.03	-1.48	10.57	12.28	0.12	1.12
Aqua Downs	3.49	3.27	-0.13	-3.76	6.81	7.24	0.26	3.75
Archer	5.16	1.47	-0.23	-4.36	13.26	16.11	0.17	1.31
Balmoral	3.38	4.84	0.09	2.57	13.68	14.75	0.06	0.47
Bowie	1.94	1.73	-0.09	-4.65	10.62	10.28	-0.15	-1.37
Bungobine	1.05	0.55	-0.26	-24.87	11.29	11.03	-0.14	-1.24
Burtle	3.35	2.05	-0.53	-15.72	10.93	9.99	-0.38	-3.48
Canal Creek	1.65	1.60	-0.03	-1.76	8.52	8.58	0.03	0.35
Carfax Control	1.62	1.58	0.00	-0.16	10.26	15.43	0.30	2.97
Carfax Stylo	1.58	1.82	0.01	0.93	10.08	11.64	0.09	0.91
Centauri	2.88	2.98	0.05	1.82	10.10	10.18	0.04	0.44
Clifton	4.85	4.81	-0.02	-0.44	6.85	6.42	-0.25	-3.65
Coalstoun Lakes	10.36	6.04	-1.46	-14.04	22.81	23.00	0.07	0.29
Cooper Downs	4.36	3.84	-0.03	-0.72	10.39	10.03	-0.02	-0.21
Croxdale	3.85	4.21	0.13	3.41	8.53	9.23	0.26	3.01
Dykehead	1.93	2.31	0.17	8.80	14.24	14.44	0.09	0.63
Eumina	3.84	3.27	-0.26	-6.73	12.66	12.92	0.12	0.93
Exevale	1.20	0.88	-0.16	-13.37	7.08	8.11	0.53	7.42
Forest Hills	2.30	1.22	-0.11	-4.97	10.21	9.80	-0.04	-0.42
Glenrock	1.77	1.53	-0.09	-4.80	16.09	15.74	-0.12	-0.73
Goldsborough	2.71	2.70	-0.01	-0.23	9.77	9.68	-0.05	-0.47
Granite Vale	6.57	7.85	0.08	1.19	14.54	15.36	0.05	0.34
Hedlow Creek	2.99	4.55	0.10	3.35	17.07	16.77	-0.02	-0.11
Heidelberg	3.76	3.28	-0.25	-6.56	11.49	12.10	0.31	2.72
Huntly	1.62	1.71	0.01	0.44	8.88	9.46	0.05	0.54
Hyde Park	1.69	1.65	0.00	-0.17	11.31	10.32	-0.07	-0.61
Inveresk	1.39	1.68	0.13	9.68	4.97	5.46	0.23	4.66
Julia Park	2.18	1.98	-0.10	-4.74	9.02	9.02	0.00	0.02
Kerry	2.64	2.39	-0.15	-5.76	11.02	11.03	0.01	0.06
Kiauroo	3.65	4.40	0.05	1.27	15.00	14.44	-0.04	-0.23
Kirk River Exclosure	2.27	2.48	0.02	0.70	10.65	7.60	-0.24	-2.24
Kirk River Grazed	1.63	1.36	-0.02	-1.28	13.63	7.40	-0.49	-3.58
Kooralbyn Eucre	1.04	1.45	0.03	2.61	13.42	13.66	0.02	0.12
Leyshon View	0.64	1.22	0.05	8.40	6.00	4.76	-0.12	-1.92
Leyshon View Grazed	0.92	0.85	-0.01	-0.65	7.36	9.20	0.17	2.32

Appendix 1 Table 4 (cont).
Height change for each site.

Transect	Mean plant height at initial recording (m).	Mean plant height at final recording (m).	Annual change in mean height (m).	Annual change in mean height as % of initial mean height	Mean plant height (m) at initial recording plants >300 mm circumference	Mean plant height (m) at final recording plants >300 mm circumference	Annual change in mean height (m) plants >300 mm circumference	Annual change in mean height as % of initial mean height plants >300 mm circumference
Lundsville	2.48	1.54	-0.06	-2.56	14.05	14.64	0.04	0.28
Magazine	2.05	1.27	-0.05	-2.39	14.21	14.86	0.04	0.29
Meadowvale exclosure	2.23	1.01	-0.10	-4.27	9.50	7.70	-0.14	-1.48
Meadowvale grazed	3.49	1.32	-0.17	-4.87	9.83	7.58	-0.18	-1.79
Medway	5.98	5.76	-0.12	-2.08	17.04	16.62	-0.24	-1.38
Mistletoe	3.10	2.80	-0.17	-5.35	8.18	8.82	0.36	4.38
Monavale	2.16	1.33	-0.05	-2.26	10.79	12.00	0.07	0.66
Mt. Panorama	7.16	6.50	-0.10	-1.36	16.50	17.26	0.11	0.68
Mt. Pleasant	2.22	2.10	-0.01	-0.38	15.25	13.81	-0.10	-0.65
Mt. Pleasant Bowen	1.60	1.42	-0.09	-5.55	12.83	13.86	0.50	3.94
Myrrlumbing	0.90	1.79	0.47	51.56	12.28	12.28	0.00	0.02
Namuel	6.09	6.55	0.26	4.30	7.40	7.98	0.32	4.36
Netherleigh	6.33	6.35	0.00	0.02	15.88	16.44	0.03	0.21
New Gildale	2.73	2.47	-0.14	-5.24	10.54	10.99	0.25	2.33
Nyanda	4.20	3.68	-0.04	-0.92	14.76	13.60	-0.09	-0.59
Old Rawbelle	4.61	4.11	-0.24	-5.23	11.32	11.47	0.07	0.64
Pajingo	3.01	2.48	-0.28	-9.14	11.96	11.63	-0.17	-1.45
Rosebank	2.60	2.55	-0.02	-0.88	12.85	12.04	-0.35	-2.76
Rostock	7.11	5.82	-0.59	-8.29	11.65	11.74	0.04	0.36
Rundle	6.30	5.69	-0.04	-0.62	19.39	19.38	0.00	0.00
Scotston	5.12	4.59	-0.26	-5.09	16.04	15.34	-0.34	-2.11
Springsure Reserve	1.98	2.27	0.16	7.91	8.47	8.33	-0.08	-0.92
St. Pauls Exclosure	3.23	2.22	-0.08	-2.45	9.80	8.89	-0.07	-0.72
St. Pauls Grazed	1.59	1.36	-0.02	-1.12	10.82	9.68	-0.09	-0.82
Summerdel	2.76	3.69	0.06	2.18	9.43	9.38	0.00	-0.03
Sunrise East	3.68	3.83	0.05	1.48	10.29	11.04	0.26	2.55
Sunrise West	4.66	3.95	-0.25	-5.40	9.44	10.08	0.23	2.43
Swanlea	1.91	2.04	0.06	3.01	5.95	6.05	0.04	0.75
Texas	1.84	2.61	0.34	18.35	8.86	8.72	-0.06	-0.71
The Patrick	1.95	1.85	-0.09	-4.45	10.06	10.32	0.23	2.27
Tinnenburra	1.85	2.29	0.25	13.48	6.27	6.11	-0.09	-1.41
Tryphinia Eucre	2.15	3.33	0.07	3.23	15.27	15.80	0.03	0.20
Tryphinia Eumel	7.48	4.98	-0.16	-2.11	11.52	12.36	0.05	0.46
Tryphinia Eumol	4.21	3.60	-0.04	-0.98	18.24	13.51	-0.32	-1.74
Walthum	3.79	3.23	-0.06	-1.54	10.99	10.05	-0.10	-0.90
Wandobah T6 R1	1.56	1.57	0.00	0.07	11.46	11.36	-0.01	-0.08
Wandobah T6 R2	2.37	2.40	0.00	0.14	11.36	12.05	0.06	0.56
Wandobah T6 R3	1.96	2.05	0.01	0.39	11.77	13.27	0.14	1.15
Yanna	2.33	2.33	0.00	0.13	7.85	8.46	0.22	2.82
Total	2.54	2.33	-0.06	-2.36	11.44	11.43	0.02	0.17

Appendix 1 Table 5.
Species distribution by sites. A "1" indicates species presence.

SPECIES	Anchor	Aqua Downs	Archer	Balmoral	Bowie	Bungobine	Burtle	Canal Creek	Carfax Control	Carfax Stylo	Centauri	Clifton	Coalstoun Lakes	Cooper Downs	Croxdale	Dykehead	Eumina	Exevale	Forest Hills	New Gildale	Glenrock	Goldsborough	Granite Vale	Hedlow Creek	Heidelberg	Huntly	Hyde Park	Inveresk
Acacia aneura		1										1			1													
Acacia argyrodendron																												
Acacia aulacocarpa			1	1				1															1					
Acacia bidwillii									1										1						1			
Acacia carolaea																												
Acacia caroleae					1		1																				1	1
Acacia cowleana																												1
Acacia crassa											1																	
Acacia cretata																												
Acacia decora	1		1																							1		
Acacia excelsa		1				1	1					1			1												1	
Acacia farnesiana																												
Acacia fasciculifera																												
Acacia grandifolia																					1							
Acacia holosericea											1																	
Acacia laccata																												1
Acacia leiocalyx																			1		1		1					
Acacia leptostachya																												
Acacia longispicata																												
Acacia macradenia																	1											
Acacia melleodora					1																						1	1
Acacia olignophleba																												
Acacia rhodoxylon	1																											

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Anchor	Aqua Downs	Archer	Balmoral	Bowie	Bungobine	Burtle	Canal Creek	Carfax Control	Carfax Stylo	Centauri	Clifton	Coalstoun Lakes	Cooper Downs	Croxdale	Dykehead	Eumina	Exevale	Forest Hills	New Gildale	Glenrock	Goldsborough	Granite Vale	Hedlow Creek	Heidelberg	Huntly	Hyde Park	Inveresk
Acacia macradenia																	1											
Acacia melleodora					1																						1	1
Acacia olignophleba																												
Acacia rhodoxylon	1																											
Acacia salicina							1		1	1				1										1		1	1	
Acacia shirleyii											1																	
Acacia stipuligra					1																							
Acacia tenuissima																												1
Alstonia constricta						1													1									
Alphitonia excelsa	1		1	1		1	1	1			1					1			1		1			1				
Allocasuarina luehmannii																					1							
Alectryon oleifolius		1							1	1			1						1								1	
Angophora costata																												
Apophyllum anomalum																												
Archidendropsis basaltica	1					1	1		1	1									1									
Atalaya hemiglauca						1	1		1	1									1							1		
Brachychiton australe													1								1	1						
Breynia oblongifolia	1			1	1		1				1								1	1	1	1		1				
Brachychiton populneus													1						1									
Bursaria incana							1															1						

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Anchor	Aqua Downs	Archer	Balmoral	Bowie	Bungobine	Burtle	Canal Creek	Carfax Control	Carfax Stylo	Centauri	Clifton	Coalstoun Lakes	Cooper Downs	Croxdale	Dykehead	Eumina	Exevale	Forest Hills	New Gildale	Glenrock	Goldsborough	Granite Vale	Hedlow Creek	Heidelberg	Huntly	Hyde Park	Inveresk
Bursaria spinosa																		1										
Canthium attenuatum																												
Cassia brewsteri						1			1	1																		
Canthium buxifolium																												
Capparis canescens	1		1						1	1											1							
Canthium coprosmoides																												
Casuarina cristata																												
Callitris glaucophylla																	1											
Cassinia leavis																												
Carissa lanceolata					1		1				1																1	1
Capparis lassiantha	1					1	1		1	1																	1	
Capparis loranthifolia																												
Capparis mitchellii																		1	1			1				1		
Canthium oleifolium	1		1	1		1	1				1			1		1	1	1	1		1		1			1	1	1
Carissa ovata						1			1	1									1						1			
Canthium vacciniifolium											1																	
Citriobatus lineare													1															
Citriobatus spinescens																			1									
Clerodendrum floribundum					1				1	1																		1
Caelospermum reticulatum			1																				1					

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Anchor	Aqua Downs	Archer	Balmoral	Bowie	Bungobine	Burtle	Canal Creek	Carfax Control	Carfax Stylo	Centauri	Clifton	Coalstoun Lakes	Cooper Downs	Croxdale	Dykehead	Eumina	Exevale	Forest Hills	New Gildale	Glenrock	Goldsborough	Granite Vale	Hedlow Creek	Heidelberg	Huntly	Hyde Park	Inveresk
Cryptostegia grandiflora																												
Cupaniopsis anacardioides																								1	1			
Denhamia oleaster										1																		
Dodonaea species		1																										
Dolichandrone heterophyllum																												
Dodonaea physicarpus																												
Dodonaea viscosa																1												
Ehretia membranifolia						1								1														
Erythroxylum australe						1	1		1		1																	
Eremophila gilesii												1			1													
Eremophila latrobei		1																										
Eremophila longifolia					1		1																					
Eriocerius martinii																												
Eremophila mitchellii		1																	1								1	
Erythrina vespertilio																										1		
Eucalyptus brownii						1																						
Eucalyptus cambageana																												
Eucalyptus chloroclada																	1											
Corymbia citriodora																					1							
Corymbia clarksoniana			1						1	1									1		1				1			

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Anchor	Aqua Downs	Archer	Balmoral	Bowie	Bungobine	Burtle	Canal Creek	Carfax Control	Carfax Stylo	Centauri	Clifton	Coalstoun Lakes	Cooper Downs	Croxdale	Dykehead	Eumina	Exevale	Forest Hills	New Gildale	Glenrock	Goldsborough	Granite Vale	Hedlow Creek	Heidelberg	Huntly	Hyde Park	Inveresk
Eucalyptus coolabah																												
Eucalyptus crebra	1		1								1							1	1	1	1		1	1				
Corymbia erythrophloia																1		1		1			1			1		
Eucalyptus exserta			1					1															1					
Eucalyptus fibrosa				1																								
Corymbia intermedia								1																				
Eucalyptus melanophloia	1				1		1							1		1	1										1	
Eucalyptus microneura																												
Eucalyptus moluccana																												
Eucalyptus orgadophila																										1		
Corymbia dallachyana	1			1		1			1	1	1			1				1						1	1			
Eucalyptus platyphylla																								1	1			
Corymbia plena																												
Eucalyptus populnea		1					1		1	1						1			1					1				
Eucalyptus quadricostata																						1						
Corymbia setosa																												
Eucalyptus similis																												
Corymbia terminalis																						1						
Eucalyptus tereticornis													1			1												
Corymbia tessellaris													1			1			1					1				

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Anchor	Aqua Downs	Archer	Balmoral	Bowie	Bungobine	Burtle	Canal Creek	Carfax Control	Carfax Stylo	Centauri	Clifton	Coalstoun Lakes	Cooper Downs	Croxdale	Dykehead	Eumina	Exevale	Forest Hills	New Gildale	Glenrock	Goldsborough	Granite Vale	Hedlow Creek	Heidelberg	Huntly	Hyde Park	Inveresk
Eucalyptus whiteii																												
Eucalyptus xanthoclada																												
Ficus obliqua																												
Ficus opposita																												
Flindersia dissosperma										1																		
Flindersia maculosa																												
Gardenia ochreata											1																	
Gardenia vilhelmii																												
Geijera parviflora	1						1												1								1	
Geijera salicifolia											1																	
Grevillea parrallela									1	1										1								
Grevillea prteridifolia																												
Grevillea striata																												
Hakea fraserii										1									1			1						
Hakea lorea																												
Hakea species															1													
Alectryon diversifolium						1																						
Alectryon oleifolius																												
Jacksonia scoparia																												
Lantana camara											1																	

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Anchor	Aqua Downs	Archer	Balmoral	Bowie	Bungobine	Burtle	Canal Creek	Carfax Control	Carfax Stylo	Centauri	Clifton	Coalstoun Lakes	Cooper Downs	Croxdale	Dykehead	Eumina	Exevale	Forest Hills	New Gildale	Glenrock	Goldsborough	Granite Vale	Hedlow Creek	Heidelberg	Huntly	Hyde Park	Inveresk
Lantana montevidensis													1															
Lophostomen confertus																												
Lophostomon suaveolens								1																				
Lysiphyllum carronii	1																											
Lysiphyllum gilvum																												
Lysiphyllum hookeri						1																						
Maytenus cunninghamii	1		1		1	1	1				1						1	1	1	1		1				1	1	
Macrozamia miquellii																												
Macrozamia moorei																												
Melia azedarach													1															
Melaleuca bracteata																												
Melichrus species																												
Melaleuca nervosa					1																		1		1			
Melalueca viridiflora								1																				
Micromyrtus species																											1	
Myoporum acuminatum						1																		1			1	
Myoporum desertii										1																		
Opuntia stricta													1			1								1				
Opuntia tomentosa	1		1				1		1	1			1	1			1		1		1					1		
Owenia acidula						1			1																			

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Anchor	Aqua Downs	Archer	Balmoral	Bowie	Bungobine	Burtle	Canal Creek	Carfax Control	Carfax Stylo	Centauri	Clifton	Coalstoun Lakes	Cooper Downs	Croxdale	Dykehead	Eumina	Exevale	Forest Hills	New Gildale	Glenrock	Goldsborough	Granite Vale	Hedlow Creek	Heidelberg	Huntly	Hyde Park	Inveresk
Parsonsia eucalyptophylla		1																										
Parsonsia lanceolata																												
Pandorea pandorana																												
Persoonia falcata																						1						
Petalostigma pubescens						1	1		1							1			1	1	1	1			1			1
Pittosporum phylliraeoides			1																									
Planchonia careya			1	1																					1			
Santalum lanceolatum																												1
Sarcostemma viminale																												
Senna artemisoides		1												1														1
Senna coronilloides					1																							
Terminalia aridicola											1																	
Terminalia oblongata						1																						
Ventilago viminalis	1					1	1		1	1																		
Xanthorrhoea johnsonii																												

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Julia Park	Kerry	Kiauroo	Kirk River	Kirk River	Kooralbyn	Leyshon View	Leyshon View	Longton	Lundsville	Magazine	Meadowvale	Meadowvale	Medway	Mistletoe	Monavale	Mt. Panorama	Mt. Pleasant	Mt. Pleasant	Myrrlumbing	Namuel	Netherleigh	Nyanda	Pajingo	The Patrick	Old Rawbelle	Rosebank	Rostock
Acacia aneura		1																										
Acacia argyrodendron																								1				
Acacia aulacocarpa										1						1						1						
Acacia bidwillii							1	1											1		1							
Acacia carolaea																												
Acacia caroleae	1								1																1			1
Acacia cowleana	1																											1
Acacia crassa																												
Acacia cretata			1																									
Acacia decora																												
Acacia excelsa	1	1					1	1	1										1						1			
Acacia farnesiana							1	1																				
Acacia fasciculifera																												
Acacia grandifolia																												
Acacia holosericea															1													
Acacia laccata																												1
Acacia leiocalyx			1			1																1	1				1	
Acacia leptostachya																											1	
Acacia longispicata																												
Acacia macradenia																												
Acacia melleodora	1																											1

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Julia Park	Kerry	Kiauroo	Kirk River	Kirk River	Kooralbyn	Leyshon View	Leyshon View	Longton	Lundsville	Magazine	Meadowvale	Meadowvale	Medway	Mistletoe	Monavale	Mt. Panorama	Mt. Pleasant	Mt. Pleasant	Myrrlumbing	Namuel	Netherleigh	Nyanda	Pajingo	The Patrick	Old Rawbelle	Rosebank	Rostock
Acacia olignophleba																												
Acacia rhodoxylon																												
Acacia salicina											1			1			1	1		1								
Acacia shirleyii						1																						
Acacia stipuligra																												
Acacia tenuissima																												1
Alstonia constricta																												
Alphitonia excelsa	1		1			1				1						1							1				1	1
Allocasuarina luehmannii																			1									1
Alectryon oleifolius							1										1								1			1
Angophora costata										1												1						
Apophyllum anomalum											1																	
Archidendropsis basaltica																												
Atalaya hemiglauca			1				1	1			1	1			1		1	1	1	1			1	1				
Brachychiton australe																												
Breynia oblongifolia			1			1				1						1			1									
Brachychiton populneus						1																1				1	1	
Bursaria incana			1																									
Bursaria spinosa																												
Canthium attenuatum																												
Cassia brewsteri						1			1	1																		

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Julia Park	Kerry	Kiauroo	Kirk River	Kirk River	Kooralbyn	Leyshon View	Leyshon View	Longton	Lundsville	Magazine	Meadowvale	Meadowvale	Medway	Mistletoe	Monavale	Mt. Panorama	Mt. Pleasant	Mt. Pleasant	Myrrlumbing	Namuel	Netherleigh	Nyanda	Pajingo	The Patrick	Old Rawbelle	Rosebank	Rostock
Canthium buxifolium																												
Capparis canescens								1		1						1												
Canthium coprosmoides																												
Casuarina cristata																												
Callitris glaucophylla																												1
Cassinia leavis																									1			
Carissa lanceolata	1						1	1	1			1	1							1				1				
Capparis lassiantha											1													1				
Capparis loranthifolia																												
Capparis mitchellii	1		1													1									1		1	
Canthium oleifolium			1	1					1											1			1		1			1
Carissa ovata											1			1														
Canthium vacciniifolium																												
Citriobatus lineare																												
Citriobatus spinescens																												
Clerodendrum floribundum						1		1						1											1			
Caelospermum reticulatum																1						1						
Cryptostegia grandiflora								1			1	1							1									
Cupaniopsis anacardioides																												
Denhamia oleaster																												
Dodonaea species																												

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Julia Park	Kerry	Kiauroo	Kirk River	Kirk River	Kooralbyn	Leyshon View	Leyshon View	Longton	Lundsville	Magazine	Meadowvale	Meadowvale	Medway	Mistletoe	Monavale	Mt. Panorama	Mt. Pleasant	Mt. Pleasant	Myrrlumbing	Namuel	Netherleigh	Nyanda	Pajingo	The Patrick	Old Rawbelle	Rosebank	Rostock
Dolichandrone heterophyllum							1	1							1													
Dodonaea physicarpus															1													
Dodonaea viscosa																							1					
Ehretia membranifolia									1								1											
Erythroxylum australe																												
Eremophila gilesii																												
Eremophila latrobei		1																										
Eremophila longifolia																		1										
Eriocerius martinii																												1
Eremophila mitchellii		1																							1			1
Erythrina vespertilio										1																		
Eucalyptus brownii																				1								
Eucalyptus cambageana																								1				
Eucalyptus chloroclada																												1
Corymbia citriodora						1				1												1					1	
Corymbia clarksoniana			1			1												1										1
Eucalyptus coolabah																	1											
Eucalyptus crebra			1			1		1		1						1			1	1		1	1				1	
Corymbia erythrophloia				1	1		1	1				1	1			1				1		1					1	
Eucalyptus exserta																1						1						
Eucalyptus fibrosa																												

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Julia Park	Kerry	Kiauroo	Kirk River	Kirk River	Kooralbyn	Leyshon View	Leyshon View	Longton	Lundsville	Magazine	Meadowvale	Meadowvale	Medway	Mistletoe	Monavale	Mt. Panorama	Mt. Pleasant	Mt. Pleasant	Myrrlumbing	Namuel	Netherleigh	Nyanda	Pajingo	The Patrick	Old Rawbelle	Rosebank	Rostock
Corymbia intermedia										1																		
Eucalyptus melanophloia		1							1									1					1			1		
Eucalyptus microneura															1						1							
Eucalyptus moluccana																												
Eucalyptus orgadophila																												
Corymbia dallachyana			1	1			1	1								1			1	1					1			
Eucalyptus platyphylla																												
Corymbia plena																									1			
Eucalyptus populnea		1									1			1				1										1
Eucalyptus quadricostata																												
Corymbia setosa																												
Eucalyptus similis	1																											
Corymbia terminalis	1																								1			
Eucalyptus tereticornis										1	1			1								1						
Corymbia tessellaris										1				1				1								1		1
Eucalyptus whiteii																												
Eucalyptus xanthoclada				1	1							1	1															
Ficus obliqua																												
Ficus opposita										1																		
Flindersia dissosperma																								1				
Flindersia maculosa																												

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Julia Park	Kerry	Kiauroo	Kirk River	Kirk River	Kooralbyn	Leyshon View	Leyshon View	Longton	Lundsville	Magazine	Meadowvale	Meadowvale	Medway	Mistletoe	Monavale	Mt. Panorama	Mt. Pleasant	Mt. Pleasant	Myrrlumbing	Namuel	Netherleigh	Nyanda	Pajingo	The Patrick	Old Rawbelle	Rosebank	Rostock
Gardenia ochreata																												
Gardenia vilhelmii															1													
Geijera parviflora		1																					1					1
Geijera salicifolia																												
Grevillea parrallela			1																	1								
Grevillea prteridifolia																									1			
Grevillea striata							1	1											1									
Hakea fraserii																												
Hakea lorea																												
Hakea species																												
Alectryon diversifolium											1																	
Alectryon oleifolius																												
Jacksonia scoparia																										1		
Lantana camara										1						1										1		
Lantana montevidensis																												
Lophostomen confertus																					1					1		
Lophostomon suaveolens										1						1												
Lysiphyllum carronii																												
Lysiphyllum gilvum															1						1							
Lysiphyllum hookeri																	1											
Maytenus cunninghamii	1							1	1											1					1			1

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Julia Park	Kerry	Kiauroo	Kirk River	Kirk River	Kooralbyn	Leyshon View	Leyshon View	Longton	Lundsville	Magazine	Meadowvale	Meadowvale	Medway	Mistletoe	Monavale	Mt. Panorama	Mt. Pleasant	Mt. Pleasant	Myrrlumbing	Namuel	Netherleigh	Nyanda	Pajingo	The Patrick	Old Rawbelle	Rosebank	Rostock
Macrozamia miquellii																						1						
Macrozamia moorei																												
Melia azedarach																												
Melaleuca bracteata											1																	
Melichrus species																					1							
Melaleuca nervosa									1										1	1		1						
Melalueca viridiflora																												
Micromyrtus species																												
Myoporum acuminatum											1																	
Myoporum desertii		1																										
Opuntia stricta														1														1
Opuntia tomentosa			1			1	1				1					1							1			1		1
Owenia acidula																									1			
Parsonsia eucalyptophylla		1																										
Parsonsia eucalyptophylla		1																										
Parsonsia lanceolata																											1	
Pandorea pandorana																							1					
Persoonia falcata																												
Petalostigma pubescens	1		1	1		1				1				1		1							1		1			
Pittosporum phylliraeoides																	1											
Planchonia careya																1						1						

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Julia Park	Kerry	Kiauroo	Kirk River	Kirk River	Kooralbyn	Leyshon View	Leyshon View	Longton	Lundsville	Magazine	Meadowvale	Meadowvale	Medway	Mistletoe	Monavale	Mt. Panorama	Mt. Pleasant	Mt. Pleasant	Myrrlumbing	Namuel	Netherleigh	Nyanda	Pajingo	The Patrick	Old Rawbelle	Rosebank	Rostock
Santalum lanceolatum		1												1											1			
Sarcostemma viminale																				1								
Senna artemisoides		1																							1			
Senna coronilloides																									1			
Terminalia aridicola									1						1						1							
Terminalia oblongata																												
Ventilago viminalis																								1	1			
Xanthorrhoea johnsonii																						1						

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Rundle	Scotston	Springsure	St. Pauls	St. Pauls	Summerdel	Sunrise East	Sunrise West	Swanlea	Texas	Tinnenburra	Tryphinia	Tryphinia	Tryphinia	Walthum	Wandobah	Wandobah	Wandobah	Yanna
Acacia aneura											1								1
Acacia argyrodendron																			
Acacia aulacocarpa	1													1					
Acacia bidwillii					1												1	1	
Acacia carolaea									1										
Acacia caroleae						1			1										
Acacia cowleana																			
Acacia crassa												1							
Acacia cretata																			
Acacia decora			1																
Acacia excelsa						1		1									1	1	1
Acacia farnesiana					1														
Acacia fasciculifera	1																		
Acacia grandifolia																			
Acacia holosericea																			
Acacia laccata																			
Acacia leiocalyx								1					1	1					
Acacia leptostachya		1																	
Acacia longispicata	1						1												
Acacia macradenia																			
Acacia melleodora									1										
Acacia olignophleba																			
Acacia rhodoxylon																			
Acacia salicina															1	1			

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Rundle	Scotston	Springsure	St. Pauls	St. Pauls	Summerdel	Sunrise East	Sunrise West	Swanlea	Texas	Tinnenburra	Tryphinia	Tryphinia	Tryphinia	Walthum	Wandobah	Wandobah	Wandobah	Yanna
Acacia salicina															1	1			
Acacia shirleyii														1					
Acacia stipuligra									1										
Acacia tenuissima									1										
Alstonia constricta																			
Alphitonia excelsa	1	1							1			1	1	1		1		1	
Allocasuarina luehmannii																1			
Alectryon oleifolius																			
Angophora costata							1												
Apophyllum anomalum																			
Archidendropsis basaltica															1				
Atalaya hemiglauca					1				1	1					1	1	1	1	
Brachychiton australe																			
Breynia oblongifolia	1			1										1			1	1	
Brachychiton populneus			1			1	1												
Bursaria incana				1								1							
Bursaria spinosa																			
Canthium attenuatum																			
Cassia brewsteri						1			1	1									
Canthium buxifolium																			
Capparis canescens	1		1						1	1									
Canthium coprosmoides																			
Casuarina cristata																			
Callitris glaucophylla																	1		

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Rundle	Scotston	Springsure	St. Pauls	St. Pauls	Summerdel	Sunrise East	Sunrise West	Swanlea	Texas	Tinnenburra	Tryphinia	Tryphinia	Tryphinia	Walthum	Wandobah	Wandobah	Wandobah	Yanna
Callitris glaucophylla																	1		
Cassinia leavis																			
Carissa lanceolata					1		1				1								
Capparis lassiantha	1					1	1		1	1									
Capparis loranthifolia																			
Capparis mitchellii		1															1	1	
Canthium oleifolium				1		1				1			1	1	1	1	1	1	
Carissa ovata				1	1								1	1	1	1	1	1	
Canthium vacciniifolium																			
Citriobatus lineare																			
Citriobatus spinescens																			
Clerodendrum floribundum									1						1	1			
Caelospermum reticulatum	1																		
Cryptostegia grandiflora																			
Cupaniopsis anacardioides																			
Denhamia oleaster																			
Dodonaea species																			
Dolichandrone heterophyllum																			
Dodonaea physicarpus																			
Dodonaea viscosa																	1		
Ehretia membranifolia																	1		
Erythroxylum australe															1				
Eremophila gilesii											1								
Eremophila latrobei																			

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Rundle	Scotston	Springsure	St. Pauls	St. Pauls	Summerdel	Sunrise East	Sunrise West	Swanlea	Texas	Tinnenburra	Tryphinia	Tryphinia	Tryphinia	Walthum	Wandobah	Wandobah	Wandobah	Yanna
Eremophila latrobei																			1
Eremophila longifolia																			
Eriocerius martinii										1							1		1
Eremophila mitchellii																			
Erythrina vespertilio										1					1				
Eucalyptus brownii																			
Eucalyptus cambageana							1												
Eucalyptus chloroclada														1					
Corymbia citriodora		1				1		1				1		1		1	1	1	
Corymbia clarksoniana																			
Eucalyptus coolabah	1	1			1							1	1	1				1	
Eucalyptus crebra			1	1	1										1				
Corymbia erythrophloia																			
Eucalyptus exserta																			
Eucalyptus fibrosa																			
Corymbia intermedia						1	1	1					1						
Eucalyptus melanophloia																			
Eucalyptus microneura	1													1					
Eucalyptus moluccana			1																
Eucalyptus orgadophila				1	1							1				1	1	1	
Corymbia dallachyana																			
Eucalyptus platyphylla																			
Corymbia plena										1			1			1	1	1	
Eucalyptus populnea																			

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Rundle	Scotston	Springsure	St. Pauls	St. Pauls	Summerdel	Sunrise East	Sunrise West	Swanlea	Texas	Tinnenburra	Tryphinia	Tryphinia	Tryphinia	Walthum	Wandobah	Wandobah	Wandobah	Yanna
Eucalyptus populnea										1			1			1	1	1	
Eucalyptus quadricostata																			
Corymbia setosa									1										
Eucalyptus similis									1										
Corymbia terminalis																			
Eucalyptus tereticornis		1														1			
Corymbia tessellaris		1														1			
Eucalyptus whiteii																			
Eucalyptus xanthoclada				1															
Ficus obliqua	1																		
Ficus opposita																			
Flindersia dissosperma														1		1	1	1	
Flindersia maculosa										1									
Gardenia ochreata																			
Gardenia vilhelmii																			
Geijera parviflora										1					1				
Geijera salicifolia																			
Grevillea parrallela																			
Grevillea prteridifolia									1										
Grevillea striata										1					1	1		1	
Hakea fraserii																			
Hakea lorea															1		1		
Hakea species																			1
Alectryon diversifolium															1				

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Rundle	Scotston	Springsure	St. Pauls	St. Pauls	Summerdel	Sunrise East	Sunrise West	Swanlea	Texas	Tinnenburra	Tryphinia	Tryphinia	Tryphinia	Walthum	Wandobah	Wandobah	Wandobah	Yanna	
Alectryon diversifolium															1					
Alectryon oleifolius										1										
Jacksonia scoparia							1													
Lantana camara														1						
Lantana montevidensis																				
Lophostomen confertus																				
Lophostomon suaveolens																				
Lysiphyllum carronii																				
Lysiphyllum gilvum																				
Lysiphyllum hookeri																				
Maytenus cunninghamii				1	1		1		1	1					1	1	1	1		
Macrozamia miquellii																		1		
Macrozamia moorei			1																	
Melia azedarach																				
Melaleuca bracteata																				
Melichrus species							1													
Melaleuca nervosa																		1		
Melalueca viridiflora																				
Micromyrtus species																				
Myoporum acuminatum																	1	1		
Myoporum desertii										1								1		
Opuntia stricta	1						1										1			
Opuntia tomentosa		1	1				1	1						1		1		1		
Owenia acidula																1	1	1		
Parsonsia eucalyptophylla																				

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Rundle	Scotston	Springsure	St. Pauls	St. Pauls	Summerdel	Sunrise East	Sunrise West	Swanlea	Texas	Tinnenburra	Tryphinia	Tryphinia	Tryphinia	Walthum	Wandobah	Wandobah	Wandobah	Yanna
Owenia acidula																1	1	1	
Parsonsia eucalyptophylla																			
Parsonsia lanceolata																			
Pandorea pandorana		1																	
Persoonia falcata																			
Petalostigma pubescens			1			1			1			1		1	1	1	1		
Pittosporum phylliraeoides																			
Planchonia careya																			
Santalum lanceolatum									1										
Sarcostemma viminale																			
Senna artemisoides									1		1								1
Senna coronilloides																			
Terminalia aridicola																			
Terminalia oblongata																	1	1	
Ventilago viminalis						1				1						1	1	1	
Xanthorrhoea johnsonii																			

Appendix 1 Table 5(cont).
Species distribution by sites. A "1" indicates species presence.

SPECIES	Rundle	Scotston	Springsure	St. Pauls	St. Pauls	Summerdel	Sunrise East	Sunrise West	Swanlea	Texas	Tinnenburra	Tryphinia	Tryphinia	Tryphinia	Walthum	Wandobah	Wandobah	Wandobah	Yanna
Owenia acidula																1	1	1	
Parsonsia eucalyptophylla																			
Parsonsia lanceolata																			
Pandorea pandorana		1																	
Persoonia falcata																			
Petalostigma pubescens			1			1			1			1		1	1	1	1		
Pittosporum phylliraeoides																			
Planchonia careya																			
Santalum lanceolatum									1										
Sarcostemma viminale																			
Senna artemisoides									1		1								1
Senna coronilloides																			
Terminalia aridicola																			
Terminalia oblongata																	1	1	
Ventilago viminalis						1				1						1	1	1	
Xanthorrhoea johnsonii																			

Appendix 1 Table 7 (cont)
Relative density (rel. den.), relative frequency (rel. freq), relative dominance (rel. dom.) and resulting species importance values (SIV) for species present in the study area by woodland type.
See text for explanation of terms.

	Cypress				Microneura				Desert uplands				Mulga			
SPECIES	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.
Acacia bidwillii	0.38	0.15	0.23	0.00	2.95	1.59	1.33	0.03	–	–	–	–	–	–	–	–
Acacia carolaea	–	–	–	–	–	–	–	–	0.75	0.17	0.57	0.00	–	–	–	–
Acacia coriaceae	–	–	–	–	–	–	–	–	17.80	4.39	8.86	4.55	–	–	–	–
Acacia cowleana	–	–	–	–	–	–	–	–	14.37	8.18	6.00	0.20	–	–	–	–
Acacia excelsa	2.85	1.17	0.92	0.75	–	–	–	–	9.24	4.09	3.71	1.43	14.39	3.91	2.40	8.08
Acacia holosericea	–	–	–	–	1.06	0.40	0.67	0.00	–	–	–	–	–	–	–	–
Acacia laccata	–	–	–	–	–	–	–	–	10.22	5.57	4.57	0.08	–	–	–	–
Acacia longispicata	1.45	0.73	0.69	0.02	–	–	–	–	–	–	–	–	–	–	–	–
Acacia macradenia	1.61	0.68	0.92	0.00	–	–	–	–	–	–	–	–	–	–	–	–
Acacia melleodora	–	–	–	–	–	–	–	–	7.02	2.44	4.57	0.01	–	–	–	–
Acacia stipuligra	–	–	–	–	–	–	–	–	8.34	3.74	4.57	0.02	–	–	–	–
Acacia tenuissima	–	–	–	–	–	–	–	–	32.30	18.88	13.14	0.28	–	–	–	–
Alectryon oleifolius	0.38	0.15	0.23	0.00	–	–	–	–	0.31	0.02	0.29	0.00	–	–	–	–
Allocasuarina luehmannii	1.31	0.44	0.69	0.18	–	–	–	–	–	–	–	–	–	–	–	–
Alphitonia excelsa	1.47	0.15	0.23	1.10	–	–	–	–	8.85	4.26	4.57	0.01	–	–	–	–
Angophora costata	5.23	2.93	2.31	0.00	–	–	–	–	–	–	–	–	–	–	–	–
Atalaya hemiglauca	–	–	–	–	14.18	11.51	2.67	0.01	0.83	0.26	0.57	0.00	–	–	–	–
Brachychiton populneus	1.41	0.49	0.92	0.00	–	–	–	–	–	–	–	–	–	–	–	–
Callitris glaucophylla	146.05	67.90	13.39	64.76	–	–	–	–	–	–	–	–	–	–	–	–
Canthium oleifolium	3.06	0.59	1.15	1.32	–	–	–	–	1.13	0.15	0.86	0.12	–	–	–	–
Capparis mitchellii	–	–	–	–	–	–	–	–	1.07	0.22	0.86	0.00	–	–	–	–
Carissa lanceolata	–	–	–	–	–	–	–	–	3.79	1.22	2.57	0.00	–	–	–	–
Cassinia leavis	–	–	–	–	–	–	–	–	4.93	1.22	3.71	0.00	–	–	–	–
Clerodendrum floribundum	–	–	–	–	–	–	–	–	4.91	0.91	4.00	0.00	–	–	–	–
Corymbia clarksoniana	0.60	0.29	0.23	0.08	–	–	–	–	–	–	–	–	–	–	–	–

Appendix 1 Table 7 (cont)
Relative density (rel. den.), relative frequency (rel. freq), relative dominance (rel. dom.) and resulting species importance values (SIV) for species present in the study area by woodland type.
See text for explanation of terms.

	Cypress				Microneura				Desert uplands				Mulga			
SPECIES	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.
Owenia acidula	–	–	–	–	–	–	–	–	0.61	0.04	0.57	0.00	–	–	–	–
Petalostigma pubescens	–	–	–	–	–	–	–	–	24.32	8.05	14.86	1.42	–	–	–	–
Santalum lanceolatum	–	–	–	–	–	–	–	–	1.18	0.28	0.86	0.04	–	–	–	–
Senna artemisoides	–	–	–	–	–	–	–	–	3.35	1.07	2.29	0.00	2.72	1.30	1.40	0.01
Senna coronilloides	–	–	–	–	–	–	–	–	6.45	1.59	4.86	0.00	–	–	–	–
Terminalia aridicola	–	–	–	–	70.66	37.70	16.67	16.29	–	–	–	–	–	–	–	–

Appendix 1 Table 7 (cont)
Relative density (rel. den.), relative frequency (rel. freq), relative dominance (rel. dom.) and resulting species importance values (SIV) for species present in the study area by woodland type.
See text for explanation of terms.

	Crebra				Box				Melanophloia				All sites			
SPECIES	SIV	rel. den	freq.	dom.	SIV	den	freq.	dom.	SIV	den	freq.	dom.	SIV	den	freq.	dom.
Acacia aneura	–	–	–	–	0.38	0.11	0.27	0.00	0.40	0.03	0.08	0.29	6.42	2.09	1.19	3.14
Acacia argyrodendron	–	–	–	–	4.56	0.92	1.23	2.41	–	–	–	–	1.12	0.25	0.26	0.61
Acacia aulacocarpa	4.80	1.91	2.62	0.27	–	–	–	–	–	–	–	–	2.01	0.81	1.09	0.11
Acacia bidwillii	1.91	0.47	1.41	0.03	1.19	0.41	0.75	0.03	–	–	–	–	1.13	0.33	0.79	0.02
Acacia carolaea	–	–	–	–	–	–	–	–	–	–	–	–	0.04	0.01	0.03	0.00
Acacia coriaceae	–	–	–	–	–	–	–	–	12.86	6.55	5.33	0.98	2.86	1.19	1.36	0.31
Acacia cowleana	–	–	–	–	–	–	–	–	–	–	–	–	0.76	0.46	0.30	0.01
Acacia crassa	0.30	0.08	0.21	0.01	0.10	0.04	0.07	0.00	–	–	–	–	0.15	0.04	0.10	0.00
Acacia cretata	0.04	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Acacia decora	2.28	1.01	1.14	0.12	–	–	–	–	–	–	–	–	0.94	0.42	0.47	0.05
Acacia excelsa	0.32	0.07	0.24	0.00	5.90	2.62	2.13	1.16	4.29	1.52	2.08	0.68	3.53	1.41	1.32	0.81
Acacia farnesiana	1.99	1.17	0.79	0.03	–	–	–	–	–	–	–	–	0.83	0.49	0.33	0.01
Acacia fasciculifera	0.19	0.08	0.10	0.00	–	–	–	–	–	–	–	–	0.08	0.03	0.04	0.00
Acacia grandifolia	1.59	0.72	0.66	0.21	–	–	–	–	–	–	–	–	0.66	0.30	0.27	0.08
Acacia holosericea	–	–	–	–	0.48	0.14	0.34	0	–	–	–	–	0.13	0.04	0.09	0.00
Acacia laccata	–	–	–	–	–	–	–	–	–	–	–	–	0.54	0.31	0.23	0
Acacia leiocalyx	4.26	2.57	1.59	0.1	–	–	–	–	4.03	1.59	2.08	0.36	2.42	1.3	1.02	0
Acacia leptostachya	0.54	0.22	0.31	0.01	–	–	–	–	–	–	–	–	0.22	0.09	0.13	0.11
Acacia longispicata	0.22	0.08	0.14	0	–	–	–	–	–	–	–	–	0.18	0.08	0.1	0
Acacia macradenia	–	–	–	–	–	–	–	–	–	–	–	–	0.1	0.05	0.06	0
Acacia melleodora	–	–	–	–	–	–	–	–	0.5	0.17	0.33	0	0.45	0.16	0.29	0
Acacia olignophleba	–	–	–	–	–	–	–	–	–	–	–	–	0	0	0	0
Acacia rhodoxylon	0.4	0.04	0.1	0.27	–	–	–	–	–	–	–	–	0.16	0.01	0.04	0
Acacia salicina	0.04	0	0.03	0	9.1	3.94	5.01	0.15	1.99	0.57	1.42	0	2.51	1.17	1.3	0.11
Acacia shirleyii	1.79	0.91	0.62	0.26	16.84	10.98	1.71	4.15	–	–	–	–	5.18	3.4	0.62	0.04
Acacia stipuligra	–	–	–	–	–	–	–	–	0.12	0.03	0.08	0	0.46	0.21	0.24	1.16
Acacia tenuissima	–	–	–	–	–	–	–	–	–	–	–	–	1.72	1.06	0.66	0
Alectryon diversifolium	–	–	–	–	0.24	0.04	0.21	0	–	–	–	–	0.05	0.01	0.04	0.01

Appendix 1 Table 7 (cont)
Relative density (rel. den.), relative frequency (rel. freq), relative dominance (rel. dom.) and resulting species importance values (SIV) for species present in the study area by woodland type.
See text for explanation of terms.

	Crebra				Box				Melanophloia				All sites			
SPECIES	SIV	rel. den	freq.	dom.	SIV	den	freq.	dom.	SIV	den	freq.	dom.	SIV	den	freq.	dom.
Acacia aneura	–	–	–	–	0.38	0.11	0.27	0.00	0.40	0.03	0.08	0.29	6.42	2.09	1.19	3.14
Acacia argyrodendron	–	–	–	–	4.56	0.92	1.23	2.41	–	–	–	–	1.12	0.25	0.26	0.61
Acacia aulacocarpa	4.80	1.91	2.62	0.27	–	–	–	–	–	–	–	–	2.01	0.81	1.09	0.11
Acacia bidwillii	1.91	0.47	1.41	0.03	1.19	0.41	0.75	0.03	–	–	–	–	1.13	0.33	0.79	0.02
Acacia carolaea	–	–	–	–	–	–	–	–	–	–	–	–	0.04	0.01	0.03	0.00
Acacia coriaceae	–	–	–	–	–	–	–	–	12.86	6.55	5.33	0.98	2.86	1.19	1.36	0.31
Acacia cowleana	–	–	–	–	–	–	–	–	–	–	–	–	0.76	0.46	0.30	0.01
Acacia crassa	0.30	0.08	0.21	0.01	0.10	0.04	0.07	0.00	–	–	–	–	0.15	0.04	0.10	0.00
Acacia cretata	0.04	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Acacia decora	2.28	1.01	1.14	0.12	–	–	–	–	–	–	–	–	0.94	0.42	0.47	0.05
Acacia excelsa	0.32	0.07	0.24	0.00	5.90	2.62	2.13	1.16	4.29	1.52	2.08	0.68	3.53	1.41	1.32	0.81
Acacia farnesiana	1.99	1.17	0.79	0.03	–	–	–	–	–	–	–	–	0.83	0.49	0.33	0.01
Acacia fasciculifera	0.19	0.08	0.10	0.00	–	–	–	–	–	–	–	–	0.08	0.03	0.04	0.00
Acacia grandifolia	1.59	0.72	0.66	0.21	–	–	–	–	–	–	–	–	0.66	0.30	0.27	0.08
Acacia holosericea	–	–	–	–	0.48	0.14	0.34	0	–	–	–	–	0.13	0.04	0.09	0.00
Acacia laccata	–	–	–	–	–	–	–	–	–	–	–	–	0.54	0.31	0.23	0
Acacia leiocalyx	4.26	2.57	1.59	0.1	–	–	–	–	4.03	1.59	2.08	0.36	2.42	1.3	1.02	0
Acacia leptostachya	0.54	0.22	0.31	0.01	–	–	–	–	–	–	–	–	0.22	0.09	0.13	0.11
Acacia longispicata	0.22	0.08	0.14	0	–	–	–	–	–	–	–	–	0.18	0.08	0.1	0
Acacia macradenia	–	–	–	–	–	–	–	–	–	–	–	–	0.1	0.05	0.06	0
Acacia melleodora	–	–	–	–	–	–	–	–	0.5	0.17	0.33	0	0.45	0.16	0.29	0
Acacia oligophleba	–	–	–	–	–	–	–	–	–	–	–	–	0	0	0	0
Acacia rhodoxylon	0.4	0.04	0.1	0.27	–	–	–	–	–	–	–	–	0.16	0.01	0.04	0
Acacia salicina	0.04	0	0.03	0	9.1	3.94	5.01	0.15	1.99	0.57	1.42	0	2.51	1.17	1.3	0.11
Acacia shirleyii	1.79	0.91	0.62	0.26	16.84	10.98	1.71	4.15	–	–	–	–	5.18	3.4	0.62	0.04
Acacia stipuligra	–	–	–	–	–	–	–	–	0.12	0.03	0.08	0	0.46	0.21	0.24	1.16
Acacia tenuissima	–	–	–	–	–	–	–	–	–	–	–	–	1.72	1.06	0.66	0
Alectryon diversifolium	–	–	–	–	0.24	0.04	0.21	0	–	–	–	–	0.05	0.01	0.04	0.01

Appendix 1 Table 7 (cont)
Relative density (rel. den.), relative frequency (rel. freq), relative dominance (rel. dom.) and resulting species importance values (SIV) for species present in the study area by woodland type.
See text for explanation of terms.

	Crebra				Box				Melanophloia				All sites			
SPECIES	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	Rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.
Cassinia leavis	–	–	–	–	–	–	–	–	–	–	–	–	0.25	0.07	0.19	0.00
Casuarina cristata	0.05	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Citriobatus lineare	–	–	–	–	0.07	0.00	0.07	0.00	–	–	–	–	0.02	0.00	0.01	0.00
Citriobatus spinescens	0.18	0.05	0.14	0.00	–	–	–	–	–	–	–	–	0.08	0.02	0.06	0.00
Clerodendrum floribundum	0.09	0.02	0.07	0.00	2.93	1.70	1.23	0.00	0.22	0.14	0.08	0.00	1.05	0.55	0.50	0.00
Corymbia citriodora	13.79	2.83	2.14	8.83	–	–	–	–	–	–	–	–	5.63	1.18	0.89	3.56
Corymbia clarksoniana	4.51	1.00	1.93	1.58	2.15	0.37	0.96	0.82	2.22	0.42	1.08	0.71	2.78	0.60	1.20	0.98
Corymbia dallachyana	4.95	1.27	3.07	0.61	10.28	3.42	4.59	2.27	0.73	0.11	0.42	0.20	4.94	1.51	2.45	0.98
Corymbia erythrophloia	13.83	5.43	4.66	3.75	0.28	0.03	0.14	0.12	0.60	0.17	0.42	0.01	5.87	2.29	2.03	1.55
Corymbia intermedia	5.75	2.39	1.00	2.35	–	–	–	–	–	–	–	–	2.36	1.00	0.41	0.95
Corymbia plena	–	–	–	–	–	–	–	–	–	–	–	–	0.57	0.03	0.24	0.29
Corymbia setosa	–	–	–	–	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Corymbia terminalis	0.14	0.04	0.10	0.00	–	–	–	–	–	–	–	–	0.67	0.15	0.23	0.29
Corymbia tessellaris	2.86	1.07	0.90	0.89	4.74	0.66	1.65	2.43	1.06	0.15	0.42	0.49	2.75	0.75	0.87	1.13
Cryptostegia grandiflora	0.26	0.07	0.17	0.01	0.71	0.16	0.55	0.00	–	–	–	–	0.27	0.07	0.19	0.01
Cupaniopsis anacardioides	0.04	0.01	0.03	0.00	0.11	0.02	0.07	0.02	–	–	–	–	0.04	0.01	0.03	0.01
Denhamia oleaster	–	–	–	–	0.09	0.02	0.07	0.00	–	–	–	–	0.02	0.00	0.01	0.00
Dodonaea physicarpus	–	–	–	–	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Dodonaea species	–	–	–	–	0.09	0.02	0.07	0.00	–	–	–	–	0.02	0.00	0.01	0.00
Dodonaea viscosa	–	–	–	–	0.23	0.09	0.14	0.00	0.62	0.27	0.33	0.01	0.15	0.06	0.09	0.00
Dolichandrone heterophyllum	0.57	0.15	0.38	0.04	–	–	–	–	–	–	–	–	0.34	0.08	0.24	0.02
Ehretia membranifolia	–	–	–	–	2.11	0.70	1.37	0.03	0.52	0.15	0.33	0.04	0.57	0.22	0.34	0.02
Eremophila gilesii	–	–	–	–	–	–	–	–	–	–	–	–	0.93	0.64	0.29	0.00
Eremophila latrobei	–	–	–	–	2.36	1.04	1.30	0.02	3.91	2.57	1.33	0.01	1.16	0.66	0.50	0.01
Eremophila longifolia	–	–	–	–	–	–	–	–	3.48	2.14	1.33	0.00	0.99	0.72	0.27	0.00
Eremophila mitchellii	0.31	0.14	0.17	0.00	10.49	4.26	3.36	2.88	1.83	1.08	0.58	0.16	3.08	1.40	0.92	0.76
Eriocerius martinii	–	–	–	–	–	–	–	–	–	–	–	–	0.41	0.29	0.11	0.00

Appendix 1 Table 7 (cont)
Relative density (rel. den.), relative frequency (rel. freq), relative dominance (rel. dom.) and resulting species importance values (SIV) for species present in the study area by woodland type.
See text for explanation of terms.

	Crebra				Box				Melanophloia				All sites			
SPECIES	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	Rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.
Erythrina vespertilio	0.75	0.17	0.52	0.06	–	–	–	–	–	–	–	–	0.31	0.07	0.21	0.03
Erythroxylum australe	–	–	–	–	4.27	1.47	2.54	0.26	0.16	0.07	0.08	0.01	1.02	0.41	0.54	0.07
Eucalyptus brownii	–	–	–	–	15.80	2.15	3.22	10.43	–	–	–	–	3.90	0.59	0.67	2.64
Eucalyptus cambageana	–	–	–	–	1.24	0.07	0.27	0.90	–	–	–	–	0.30	0.02	0.06	0.23
Eucalyptus chloroclada	–	–	–	–	–	–	–	–	–	–	–	–	0.67	0.10	0.11	0.46
Eucalyptus coolabah	–	–	–	–	16.31	0.67	1.17	14.47	–	–	–	–	4.09	0.18	0.24	3.66
Eucalyptus crebra	72.49	19.91	11.62	40.96	2.04	0.17	0.62	1.25	0.38	0.10	0.25	0.03	30.20	8.36	4.99	16.85
Eucalyptus exserta	8.93	2.35	2.00	4.58	–	–	–	–	–	–	–	–	3.66	0.98	0.83	1.85
Eucalyptus fibrosa	9.91	1.80	0.76	7.35	–	–	–	–	–	–	–	–	4.03	0.75	0.31	2.97
Eucalyptus melanophloia	0.55	0.07	0.17	0.30	–	–	–	–	156.15	43.09	21.58	91.47	26.71	6.28	3.89	16.54
Eucalyptus microneura	–	–	–	–	–	–	–	–	–	–	–	–	2.56	0.24	0.41	1.91
Eucalyptus moluccana	12.24	1.58	1.21	9.45	–	–	–	–	–	–	–	–	4.97	0.66	0.50	3.82
Eucalyptus orgadophila	4.40	0.35	1.79	2.25	–	–	–	–	–	–	–	–	1.80	0.15	0.74	0.91
Eucalyptus platyphylla	1.37	0.09	0.48	0.79	0.13	0.02	0.07	0.04	–	–	–	–	0.59	0.04	0.21	0.33
Eucalyptus populnea	0.05	0.01	0.03	0.00	62.75	8.58	10.70	43.47	0.82	0.14	0.42	0.27	17.51	2.45	2.39	12.68
Eucalyptus quadricostata	4.77	1.13	0.66	2.98	–	–	–	–	–	–	–	–	1.95	0.47	0.27	1.20
Eucalyptus similis	–	–	–	–	–	–	–	–	–	–	–	–	2.41	0.59	0.50	1.32
Eucalyptus tereticornis	1.20	0.20	0.45	0.55	12.08	0.56	2.74	8.77	0.10	0.02	0.08	0.00	3.45	0.24	0.77	2.44
Eucalyptus whiteii	–	–	–	–	–	–	–	–	–	–	–	–	1.48	0.49	0.27	0.72
Eucalyptus xanthoclada	3.38	1.17	0.76	1.45	–	–	–	–	–	–	–	–	1.39	0.49	0.31	0.58
Ficus obliqua	0.05	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Ficus opposita	0.05	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Flindersia dissosperma	0.05	0.01	0.03	0.00	5.40	2.98	2.13	0.30	–	–	–	–	1.36	0.83	0.46	0.08
Flindersia maculosa	–	–	–	–	0.50	0.05	0.41	0.04	–	–	–	–	0.11	0.01	0.09	0.01
Gardenia ochreata	–	–	–	–	0.21	0.07	0.14	0.00	–	–	–	–	0.05	0.02	0.03	0.00
Gardenia vilhelmii	–	–	–	–	–	–	–	–	–	–	–	–	0.12	0.02	0.10	0.00
Geijera parviflora	0.19	0.05	0.14	0.00	0.39	0.04	0.34	0.01	0.83	0.24	0.50	0.09	0.49	0.13	0.29	0.08

Appendix 1 Table 7 (cont)
Relative density (rel. den.), relative frequency (rel. freq), relative dominance (rel. dom.) and resulting species importance values (SIV) for species present in the study area by woodland type.
See text for explanation of terms.

	Crebra				Box				Melanophloia				All sites			
SPECIES	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	Rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.
Geijera parviflora	0.19	0.05	0.14	0.00	0.39	0.04	0.34	0.01	0.83	0.24	0.50	0.09	0.49	0.13	0.29	0.08
Geijera salicifolia	–	–	–	–	0.17	0.04	0.14	0.00	–	–	–	–	0.04	0.01	0.03	0.00
Grevillea parrallela	0.53	0.13	0.38	0.02	0.73	0.18	0.55	0.00	–	–	–	–	0.38	0.10	0.27	0.01
Grevillea prteridifolia	–	–	–	–	–	–	–	–	–	–	–	–	0.10	0.01	0.07	0.02
Grevillea striata	0.72	0.17	0.48	0.07	3.21	1.87	1.30	0.04	–	–	–	–	1.10	0.58	0.47	0.04
Hakea fraserii	0.31	0.09	0.21	0.01	0.09	0.02	0.07	0.00	–	–	–	–	0.15	0.04	0.10	0.00
Hakea lorea	–	–	–	–	0.18	0.03	0.14	0.01	–	–	–	–	0.04	0.01	0.03	0.00
Hakea sp.	–	–	–	–	–	–	–	–	–	–	–	–	0.37	0.07	0.09	0.22
Jacksonia scoparia	0.12	0.05	0.07	0.00	–	–	–	–	–	–	–	–	0.65	0.43	0.17	0.04
Lantana camara	0.32	0.08	0.24	0.00	0.53	0.32	0.21	0.00	–	–	–	–	0.27	0.12	0.14	0.00
Lantana montevidensis	–	–	–	–	0.22	0.02	0.21	0.00	–	–	–	–	0.05	0.00	0.04	0.00
Lophostomen confertus	1.39	0.46	0.24	0.69	–	–	–	–	–	–	–	–	0.57	0.19	0.10	0.28
Lophostomon suaveolens	1.09	0.19	0.45	0.45	–	–	–	–	–	–	–	–	0.45	0.08	0.19	0.18
Lysiphyllum carronii	0.05	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Lysiphyllum gilvum	–	–	–	–	–	–	–	–	–	–	–	–	0.08	0.02	0.06	0.01
Lysiphyllum hookeri	–	–	–	–	1.13	0.24	0.75	0.13	–	–	–	–	0.26	0.07	0.16	0.03
Macrozamia miquellii	0.05	0.01	0.03	0.00	0.09	0.02	0.07	0.00	–	–	–	–	0.04	0.01	0.03	0.00
Macrozamia moorei	1.51	0.18	0.41	0.91	–	–	–	–	–	–	–	–	0.61	0.08	0.17	0.37
Maytenus cunninghamii	4.31	1.78	2.45	0.08	4.40	1.72	2.67	0.01	5.85	3.44	2.33	0.07	4.72	2.28	2.39	0.05
Melaleuca bracteata	–	–	–	–	0.09	0.02	0.07	0.00	–	–	–	–	0.02	0.00	0.01	0.00
Melaleuca nervosa	0.77	0.30	0.45	0.02	0.18	0.04	0.14	0.00	1.60	0.84	0.75	0.00	0.89	0.37	0.51	0.01
Melalueca viridiflora	11.48	7.05	0.79	3.64	–	–	–	–	–	–	–	–	4.73	2.94	0.33	1.47
Melia azedarach	–	–	–	–	0.22	0.01	0.21	0.00	–	–	–	–	0.05	0.00	0.04	0.00
Melichrus species	–	–	–	–	–	–	–	–	–	–	–	–	0.17	0.05	0.10	0.02
Micromyrtus species	–	–	–	–	–	–	–	–	4.30	2.63	1.67	0.00	0.67	0.38	0.29	0.00
Myoporum acuminatum	–	–	–	–	4.76	2.82	1.92	0.02	0.35	0.10	0.25	0.00	1.24	0.79	0.44	0.01
Myoporum desertii	–	–	–	–	0.44	0.09	0.34	0.00	5.72	3.68	1.83	0.20	0.98	0.56	0.39	0.04
Opuntia stricta	0.05	0.01	0.03	0.00	1.04	0.14	0.89	0.00	0.72	0.14	0.58	0.00	0.41	0.08	0.33	0.00
Opuntia tomentosa	2.18	0.60	1.59	0.00	1.35	0.25	1.10	0.00	2.44	0.86	1.58	0.00	2.30	0.81	1.49	0.00

Appendix 1 Table 7 (cont)
Relative density (rel. den.), relative frequency (rel. freq), relative dominance (rel. dom.) and resulting species importance values (SIV) for species present in the study area by woodland type.
See text for explanation of terms.

	Crebra				Box				Melanophloia				All sites			
SPECIES	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.	SIV	rel. den	Rel. freq.	rel. dom.	SIV	rel. den	rel. freq.	rel. dom.
Owenia acidula	–	–	–	–	0.98	0.35	0.62	0.01	–	–	–	–	0.26	0.10	0.16	0.00
Pandorea pandorana	0.05	0.01	0.03	0.00	–	–	–	–	0.12	0.03	0.08	0.00	0.04	0.01	0.03	0.00
Parsonsia eucalyptophylla	–	–	–	–	0.17	0.04	0.14	0.00	0.45	0.17	0.25	0.03	0.11	0.03	0.07	0.01
Parsonsia lanceolata	0.05	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Persoonia falcata	0.05	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Petalostigma pubescens	7.82	4.14	2.62	1.06	3.11	1.47	1.17	0.47	1.19	0.39	0.75	0.06	5.44	2.64	2.20	0.60
Pittosporum phylliraeoides	0.05	0.01	0.03	0.00	0.09	0.02	0.07	0.00	–	–	–	–	0.04	0.01	0.03	0.00
Planchonia careya	0.57	0.16	0.41	0.00	–	–	–	–	–	–	–	–	0.26	0.07	0.19	0.00
Santalum lanceolatum	–	–	–	–	0.08	0.01	0.07	0.00	0.12	0.03	0.08	0.00	0.10	0.02	0.07	0.00
Sarcostemma viminale	–	–	–	–	0.26	0.05	0.21	0.00	–	–	–	–	0.06	0.01	0.04	0.00
Senna artemisoides	–	–	–	–	0.19	0.05	0.14	0.00	6.22	5.63	0.58	0.01	1.27	0.93	0.34	0.00
Senna coronilloides	–	–	–	–	–	–	–	–	0.35	0.10	0.25	0.00	0.39	0.10	0.29	0.00
Terminalia aridicola	–	–	–	–	0.75	0.18	0.55	0.03	2.91	1.59	1.00	0.32	1.59	0.51	0.64	0.44
Terminalia oblongata	–	–	–	–	0.61	0.08	0.34	0.19	–	–	–	–	0.14	0.02	0.07	0.05
Ventilago viminalis	0.05	0.01	0.03	0.00	9.74	5.15	4.39	0.20	0.69	0.27	0.42	0.00	2.53	1.46	1.02	0.05
Xanthorrhoea johnsonii	0.05	0.01	0.03	0.00	–	–	–	–	–	–	–	–	0.02	0.00	0.01	0.00
Zizyphus mauritiana	1.66	0.48	1.00	0.18	–	–	–	–	–	–	–	–	0.69	0.20	0.41	0.07