THE PREDICTION OF WOODY PRODUCTIVITY IN THE SAVANNA BIOME, SOUTH AFRICA

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ABSTRACT

This thesis reports upon the findings of a four year study into the nature and management of woody plant productivity in the savanna biome, South Africa. The key components were to (1) quantify the range of woody productivity from a variety of sites throughout the biome, (2) seek relationships between the measured productivity and site and environmental variables, and (3) elucidate the impact of selected management actions on woody productivity. Each of these was pursued through a combination of field surveys and empirical experimentation. The basic tenet of the study was to highlight the range of variability and to sample across it, rather than the pursuit of central tendencies and mean responses.

Absolute woody plant productivity, as indexed through mean annual increment in stand basal area at 51 sites over four years, was spatially and temporally variable, ranging from 0.2 m^2/ha/yr to 0.65 m^2/ha/yr (corrected for death). Significant correlates were rainfall and soil texture. Mean relative woody plant productivity ranged from 2.0 % to 6.4 %. The primary correlate was stand basal area, but a significant relationship was also evident with mean annual rainfall. Whilst most sites indicated an increase in woody basal area from year to year, high mortality rates resulted in 34 % of sites having a net decrease in basal area over the four year period. Stem mortality averaged 4.4 % per year on a density basis. In comparison, seedling recruitment was not prevalent across all sites, but where it was recorded, the number of recruits was considerably higher than required to compensate for mortality. Inter-site recruitment was positively related to rainfall. Densitometry analysis from stem cross sections failed as a means to determine past growth rates. The addition of fertiliser and water increased basal area increment and shoot length. Conflicting results were evident with respect to the role of competition. Nearest-neighbour analysis from a number of sites suggested that competition was not important at most, but not all, sites. Yet, the strong negative relationship between relative growth rate and stand basal area, and growth enhancement from a thinning study, indicated that competition is a significant factor affecting individual tree and stand productivity.

Most of annual production is allocated to leaves, other than in large trees, where the increase in the wood component is the largest contributor to total production. Production of deadwood was consistent from year to year, at approximately 1.7 % of standing biomass. Most litterfall occurs during the first months of winter (April - June), and occurs during a shorter period in toplands than bottomlands. Annual litterfall ranged from 90 - 360 g/m^2 and was strongly related to stand basal area and biomass. Over 80 % of litterfall was leaves. Fruit production varied between years, both in the amount per tree, and the proportion of trees bearing fruits. In more arid situations and years, only the larger trees bear

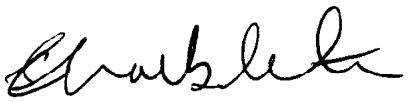
fruit. Trees start to bear fruit, given adequate rainfall, at approximately 20 % of their maximum potential size, and all individuals of a given species fruit once larger than two-thirds of their maximum potential size. At 1.5 - 2.0 % of stand biomass, extrapolated fruit production was higher than has been recorded in other studies.

Wood harvesting has a marked impact on woody community structure and biomass and hence productivity. Relative growth rates are increased because of the dominance by smaller, faster growing stems. Absolute yields are reduced because of the lowered basal area and biomass. All species examined demonstrated strong coppicing ability. Within a species, the number of coppice shoots was positively related to cutting height. Between species, the density of coppice shoots per stump was negatively related to the maximum potential height of the species. Pruning of regrowth of *Terminalia sericea* significantly accelerated regrowth of the remaining coppice shoots, although this was interactive with mean shoot number. Turn around times to the next harvest ranged from 3 - 9 years depending on original stem size.

Fire had complex impacts on woody community structure and biomass , and hence productivity. The impact of fire at the scale of an individual tree was dependent upon tree size and fuel load. The smaller the stem and the higher the fuel load, the greater was the proportion of stems killed during a fire. Over 50 % of stems less than 5 cm in circumference were killed during burning. Overall, approximately 6.5 % of stems were killed, and approximately 23 % were unaffected by fire. The rest experienced some degree of damage and resprouted either from the roots, from aerial portions, or both. Overall community structure is significantly altered by fire, and a predictable pattern is evident in relation to fire frequency. The mean biomass, height and circumference decreases with increasing fire frequency, whilst stem density increases. The change to a site dominated by smaller stems with less biomass per unit area results in a higher relative basal area increment, but a lower absolute basal area increment. The effects of fire on germination of woody plant seeds appears to be species specific, with some being stimulated and some being inhibited by fire. Consequently, fire may also facilitate a change in community species composition.

DECLARATION

I declare that this thesis is my own unaided work, except where acknowledged. No part of this thesis has previously been submitted for any degree or examination to any other University.



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GENERAL INTRODUCTION

1.1 PRIMARY PRODUCTION IN ECOSYSTEM STUDIES

Productivity has been a unifying theme across theoretical and applied research for several decades. To the theorist, understanding productivity provides insights into carbon and energy flows and ecological efficiencies in the food chain (Pomeroy & Service 1986). It represents an integration of several biological and ecological processes. To the applied researcher and manager, productivity symbolises the end product of one's labours and interventions; something that can be manipulated and improved towards a higher economic gain. As such, it is one of the few areas of ecological research than can be truly interdisciplinary with disciplines within and outside the biological realm.

In the last two decades or so, productivity of natural and man-made systems has attained an even greater significance in the face of an increasing world population and the accumulation of greenhouse gases in the atmosphere. The first demands greater productivity to meet human demands. This may be through intensification of man-made systems, but also increased harvesting from and management of extensive natural systems. There is little room for economically unproductive tracts of land in a food- and job-hungry world. The second means that carbon dynamics and storage are of major interest and concern. More precise estimates of natural primary productivity are required to provide the detailed regional budgets of carbon gains and losses, as well as mechanisms to improve primary productivity and thereby immobilise some of the build up of carbon dioxide in the atmosphere (Eamus & Jarvis 1989, Solbrig *et al.* 1991, Myneni & Los 1995, Scholes & Hall 1996). Slowing of the rates of deforestation is regarded as a major element in a suite of strategies to combat global warming (O'Brien 1996).

1.2 WOODY PRODUCTIVITY & SUSTAINABLE RURAL LIVELIHOODS

It is implicit in the search for reliable determinations of woody productivity that these values will be used in appropriate management and policy fora, i.e. the knowledge will be used to make more informed and hence improved decisions. At an applied level, the value of woody productivity is particularly pertinent in

southern Africa in the realm of rural community development and natural resource management systems. Both have explicit links to nature conservation and cattle ranching.

Rural communities use a variety of products harvested from lands around their homestead or settlement. Trees are a major contributor, having multiple uses, including fuelwood, construction timber, carving timber, medicines, fruits, browse and dyes. Trees may also provide the necessary habitat or food for other harvested resources, such as woodroses and mopane worms. The direct multiple use value of trees is not equalled by any other life form. The indirect benefits are of equal importance.

In South Africa many rural communities face a shortage of these resources because of high human population densities in the rural areas, largely a result of translocations during the apartheid era (Grossman & Gandar 1989). This has frequently broken traditional management systems and traditions that governed the harvesting of resources and maintenance of the resource base. Hence a recent focus emerging during the last few years on the value of trees and appropriate management systems to maintain tree biomass and maximise potential benefits from trees. Several conservation agencies also base their neighbour relations programmes with adjacent rural communities on the supply of resources, such as wood and fruits (e.g. Hughes 1994). All these users are interested in the value of products from woody plants, and sustainable harvesting levels and mechanisms. Entrepreneurial opportunities from sustainable harvesting of such products commercially are viewed as one means of providing much needed income opportunities (Shackleton 1996), scaling up the already prevalent trade in woody resources (Gandar 1994a, Dzerefos *et al.* 1995). Despite this interest in products from woody plants, the predictive knowledge-base required for the long-term management and enhancement of woody resources is lacking.

1.3 PRODUCTIVITY OF TERRESTRIAL ECOSYSTEMS

There is a wide range in primary productivity from one ecosystem to the next (Table 1.1), as well as within ecosystems. The open oceans contribute a considerable proportion of total global production by virtue of covering 70 % of the globe. However, on a per unit area basis, they are surpassed by terrestrial ecosystems that include a woody component. Tropical forests are widely regarded as the most productive ecosystems, followed by temperate forests and then savannas.

Table 1.1. Summary estimates of net primary production per major world ecosystem.

ECOSYSTEM	ANNUAL NET PRIMARY PRODUCTION ($g/m^2/yr$)			
	Whittaker (1975)	McNaughton & Wolf (1979)	Ajtay *et al.* (1979)	Melillo *et al.* (1993)[1]
Forests - tropical	2 000	2 000	2 200	2 270
Forests - temperate	1 250	1 300	1 250	1 430
Savannas	900	700	900	850
Grasslands	600	300	600	630
Desert	40	70	90	120
Tundra	140	200	140	260
Fresh water	250	200	400	
Marine - pelagic	125	125	125	
Marine - coastal	360	350	360	
Marine - estuarine	1 800	2 000	1 500	

[1]Converted from g C to g Organic mass = x 2.3

1.4 PRODUCTIVITY IN SAVANNAS

Savannas are one of the world's major terrestrial ecosystems, comprising between 10 % and 15 % of the world's land surface, depending upon definition. Distributed across nearly all the continents, they occur in broad bands between the equatorial forests and mid-latitude deserts. Approximately 50 % of the African continent, and one third of South Africa are savannas. They are home to over 30 % of the world's population (Solbrig *et al.* 1991). The majority of the world's savannas, including South Africa, are managed as extensive ranching areas (Grossman & Gandar 1989).

Savannas are an unusual vegetation formation because of the codominance of herbaceous and woody components. Whilst each component has both positive and negative feedbacks on the other, it can be hypothesised that the presence of two well developed components could result in a higher combined

productivity per unit area for the system as a whole relative to other ecosystems. This does not appear to be the case (Whittaker 1975, McNaugthon & Wolf 1979), and is a reflection of the particular suite of determinants that characterise savanna structure and function, and hence productivity. Nevertheless, it is now appreciated that savannas are considerably more productive than once believed (Scholes & Hall 1996).

1.4.1 Determinants of savannas

It is generally argued that savanna structure and function is broadly determined by the interplay of four major determinants: soil moisture, soil nutrients, fire and herbivory (Frost *et al.* 1986, Skarpe 1992, Teague & Smit 1992, Scholes & Walker 1993). The first two are frequently termed the primary determinants since they affect the potential structure and function in the absence of the other two, usually referred to as secondary determinants. Humans are also being recognised as an equally important secondary determinant. Recently Jeltsch *et al.* (1996) concluded that these determinants alone were insufficient to explain the coexistence of a woody and herbaceous component and hence savanna structure and function of an modelled arid savanna. Several other minor determinants are recognised for specific localities but are not considered important at the biome scale, for example temperature (Teague & Walker 1988). The effects of the determinants are interactive.

1.4.1.1 Soil moisture

The key aspects of climate are temperature and the seasonality of precipitation. Together they are the overriding determinants of plant available soil moisture, along with the smaller scale determinants of soil texture and aspect.

The higher the duration of adequate soil moisture the greater will be the biomass of vegetation, woody and herbaceous, except in waterlogged soils. Generally arid savannas occur in areas where the mean annual rainfall averages from 250 mm to ± 800 mm, intergrading into moist savannas which occur between ± 700 mm and 1 800 mm.

Soil texture modifies the availability of precipitation received. Infiltration and hydraulic conductivity are

higher in sandy soils than clay soils. Clay soils have a higher water holding capacity but at lower conductivities. Consequently, in low to medium rainfall areas, sandy soils offer greater plant available water, and are thus characterised by a higher plant biomass than on clay soils under similar rainfall. At higher rainfall, the opposite occurs because the saturation of clays negates the effects of the low conductivity. Additionally, at high rainfalls, sands are prone to greater leaching than clays. The effects of soil texture are interactive with the effects of soil nutrients because of the higher nutrient status of clays. Scholes (1990a) has argued that available moisture determines the duration of the growing period, but soil nutrients control the growth rate.

Slope aspect affects soil moisture through its effect on incoming radiation flux and hence evaporation, as well as the gravitational effects on the movement of soil moisture and soluble nutrients.

1.4.1.2 Soil nutrients

Higher soil nutrient status generally leads to higher plant productivity, and this holds true for savannas. In savannas this simple relationship is modified by the effects of rainfall and plant available moisture. High rainfall promotes leaching, which in turn is slowed by the soil exchange capacity depending upon soil texture and clay type. Low rainfall results in low leaching, but also low plant available moisture. Because plants take up nutrients in solution, if plant available moisture is low even highly eutrophic soils will have a low productivity. This is particularly pertinent with respect to the availability of soil nitrogen.

1.4.1.3 Fire

Fire's major effect on savanna structure and productivity is through its impact on plant recruitment and mortality (especially the smaller size classes). The effect of fire interacts with the primary determinants in that there has to be sufficient fuel load for fire to occur. Thus, arid savannas only experience high intensity fires relatively infrequently because of the time required to accumulate sufficient burnable material. In areas conducive to regular fires, savanna biomass and stature is lowered by frequent burning because woody plant recruitment is constrained. This may promote productivity on a individual plant basis because of reduced competition and the higher productivity of smaller stems, but overall area-based productivity

diminishes. This may be compensated for by increased belowground biomass and productivity but requires further study. The role of changes in soil nutrient status under frequent fires, and how that affects woody production also requires further study.

1.4.1.4 Herbivory

Herbivory effects the absolute amounts of plant material, as well as the tree to grass ratio. It is usually spatially and temporally variable, enhancing patchiness in the environment. Rapid increases in woody density have been attributed to excessive grazing of the herbaceous layer. Heavy browsing does not appear to stimulate a similar reaction in the herbaceous layer. Browsing affects the recruitment of woody plants, and hence community density and structure. Herbivores favour eutrophic savannas or eutrophic patches within dystrophic savannas, despite higher productivities. This may result in a lower plant biomass in eutrophic savannas relative to dystrophic ones under the same rainfall. There is some suggestion that concentrations of herbivore activity may sustain such eutrophic patches (Blackmore, *et al.* 1990). Herbivory accelerates nutrient cycling. The timing of herbivory relative to other environmental stress, such as drought or post-fire period may have long-term effects on community composition, structure and productivity.

1.4.1.5 Humans

Humans have impacted on savanna structure and hence potential productivity for millennia. Impacts vary in scale, frequency, intensity, duration and persistence. The degree of persistence is particularly pertinent as in many instances the effects of human activities alter the local abiotic environment so that savanna structure and function are permanently altered, even after the end to direct human activities in the area. For example, the conversion of broadleaved dystrophic savannas to self-sustaining eutrophic microphyllous savanna on sites of Iron Age occupation (Blackmore, *et al.* 1990, Scholes & Walker 1993), or the enhanced recruitment of *Acacia tortilis* at abandoned kraal sites of Turkana pastoralists (Reid & Ellis 1995). The long historical role of humans in modifying vegetation structure and productivity is not confined to savannas (e.g. Denevan 1992). In modern times humans have had an accelerated impact on savanna structure over large tracts through clearance, selective thinning, and harvesting of a range of products, as well as manipulation of the fire regime and levels of herbivory (Grossman & Gandar 1989).

The interaction of these determinants, coupled with the inevitable local exceptions, results in a wide variety of different savanna types, ranging from open grasslands with few trees, through to dense, tall woodlands with a continuous canopy, but still with an established herbaceous layer. Woody basal area in savannas ranges from less than 0.5 m^2/ha to 32 m^2/ha (Shackleton 1994a); a 60 fold difference. Savannas transitional to forest may have basal areas of up to 33 m^2/ha (Chidumayo 1993).

1.4.2 Savanna productivity

Because of the wide range in savanna types and ratios of woody to herbaceous standing crop and the interplay of each component on the other, it is hardly surprising to find a considerable range in savanna productivity. Annual herbaceous productivity alone ranges from less than 100 kg/ha to over 2 500 kg/ha (Rutherford 1978). Regression equations derived by Scholes and Hall (1996) provide a range in total annual production of less 200 g/m^2 to over 3 000 g/m^2 with most falling within the range of 1 200 - 1 400 g/m^2. However, the number of empirical studies relative to the global expanse of savannas is inadequate to capture the true range of total productivity.

1.5 DEFINITION OF TERMS

a. *Savanna* refers to a neotropical vegetation type in which fire-adapted, co-dominant herbaceous and tree strata experience markedly seasonal growth patterns in relation to the seasonal delivery of precipitation. In Africa, several classifications exist subdividing the biome on the basis of water availability (Huntley 1982, Rutherford & Westfall 1986), soil nutrient status (Huntley 1982, Scholes 1990a), structure (Cole 1986) and floristics (e.g. White 1980, Acocks 1988).

b. *Primary production* is the mass of living plant material produced per unit time (Dajoz 1977) as a result of the conversion of radiant energy into chemical energy through the process of photosynthesis. In this project only aboveground production is considered.

c. *Woody plant* is a collective term to include both trees and shrubs. It is synonymous with phanerophyte according to Raunkier's (1934) terminology.

1.6 WOODY PRODUCTIVITY

Total above ground woody productivity is still a relatively unknown value in southern African and world savannas. Some components, such as stem increment or browse production, have been measured, but not all components from the same stand at the same time. The best available estimate from Scholes & Walker (1993) of 2.8 t/ha/yr was derived from a series of disparate studies in the same area. The range in woody productivity across contrasting rainfall regimes and soil types is unknown. Even at the level of individual trees a recent review commented that there is only limited information regarding the growth rate of savanna trees (Smit *et al.* 1996).

1.6.1 Woody versus herbaceous productivity in savannas

Parallelling the range in savanna types is the probable range in productivity, and its division between the herbaceous and woody components. Scholes & Walker (1993) found a relatively equitable division of total productivity between the herbaceous and woody components. Woody plants accounted for ± 64 % of the total aboveground productivity (best estimates). Menaut & Cesar (1982) studying four savanna facies along a continuum of increasing woody density (up to 1 500 trees/ha) in Ivory Coast, reported that woody productivity contributed only 1,7 % to 20,1 % of the total productivity, corresponding to 3,6 % to 30,3 % of total aboveground productivity. Ovington (1963) found that 64 % of total aboveground production in a temperate oak savanna was from woody plants. Kelly & Walker (1976) found that browse production alone was greater than herbaceous production at five sites in Zimbabwe. At four other sites browse constituted between 25 % and 44 % of aboveground productivity where only herbaceous and browse production were measured. Thus, it is apparent that although there is a wide range in the ratio of woody to herbaceous productivity, that woody plants can contribute up to two-thirds of aboveground production in savannas, through to almost 100 % grading into woodlands and forests.

1.6.2 Components of woody productivity

Woody productivity can be divided into a series of components corresponding to the productivity of the different organs of a woody plant. A major division is between aboveground plant parts and belowground

parts, namely the roots. Few studies have quantified both aboveground and belowground woody productivity from the same site during the same season. Belowground productivity has been estimated using the ratio of aboveground to belowground standing crop and assuming the same ratio for above- to belowground productivity. Yet, it is readily accepted that production rates of the different aboveground components (wood, bark, shoots, leaves, fruits) are not equal, therefore it is erroneous to assume that productivity rates applicable for the total above ground biomass are the same for the total belowground biomass. Estimates from the Nylsvley savanna indicates that approximately 40 % of total woody productivity is below ground (Scholes & Walker 1993). Slightly lower values were measured in several temperate forest sites (Nadelhoffer *et al.* 1985), although values up to 65 - 70 % has been suggested (Raich & Nadelhoffer 1989, Scholes & Hall 1996). Substantial progress is required before sufficient, accurate measurements are available, from which summary conclusions and generalities can be made.

Of the aboveground organs, total productivity is the sum of the productivity of wood, twigs, leaves, flowers and fruits. Leaves and twigs are frequently considered together as browse. Production of flowers and fruits are rarely measured.

Given the applied nature of this study I find it useful to categorise woody productivity according to utilisable components rather than plant organs, although there is overlap. Consequently, the major components (generalist use) are livewood, deadwood, browse and fruits. Minor components (specialist use) are bark, roots and sap (especially for dyes). This study concentrated on the major utilisable components.

1.6.3 Determinants of woody productivity

On a continental and landscape level the distribution, structure and function of savannas have been correlated with climatic and soil characteristics (see Sect. 1.4). It is therefore implicit that these two factors also determine the gross productivity of savannas, modified by fire, herbivory and man.

At the level of an individual plant, woody productivity is determined by the balance between photosynthesis and respiration. The external variables determining the rate of one or both of these two processes include radiant flux density light intensity, concentration of atmospheric carbon dioxide, air temperature and water availability (Lambers & Poorter 1992).

Between these two scales is woody community or stand level productivity, and its determinants. Extrapolation from plant level studies is problematic because of the influences neighbouring plants have upon one another through shading and competition, thereby altering the values of the controlling variables, and subsequent rates of net photosynthesis. Interpolation from the landscape level is not possible, as productivity *per se* has not been widely measured at that level, simply the distribution and structure of savannas. With notable exceptions, estimates derived from satellite-based techniques frequently suffer from inadequate ground-truthing (Kgathi *et al.* 1994).

At the stand level, estimates of woody productivity have been made for several savannas (e.g. Kelly & Walker 1976, Rutherford 1978, Scholes & Walker 1993). These have provided a range of productivity estimates mirroring the diversity of savanna types. Very few studies provide estimates from more than two sites over more than one or two growing seasons, and as such can provide only limited insight into why productivity rates differ from one place to another. Few efforts have been made to integrate and compare these findings with one another to generate hypothesis regarding woody productivity. Individual studies have found correlation between woody productivity, or a specific component of woody productivity (such a browse) and current seasons rainfall (Kelly & Walker 1976, Scholes 1990b), previous seasons rainfall (Rutherford & Panagos 1982) and soil nutrient status (Prins & van der Jeugd 1992). These need to be tested in a rigorous fashion, along with structural attributes of the woody community under investigation, such as density, basal area, and size class profile.

1.6.4 Issues and uncertainties

The above overview of savanna woody productivity has highlighted some of the major issues and uncertainties in woody productivity research. These are summarised as key questions below.

a. What is the range in woody productivity across a range of environments?
b. What are the key biotic and abiotic determinants of woody productivity at a community level?
c. What are the respective roles of current seasons and previous seasons rainfall in current season woody productivity?
d. What is the relationship between stand structure and woody productivity?
e. What is the range in productivity across the different woody plant components?

f. What is the impact of management actions on total woody plant productivity and the productivity of utilisable components?
g. What is the range in belowground woody plant productivity, and its relationship to aboveground woody productivity and site variables?

1.7 OBJECTIVES OF THIS STUDY

1.7.1 Objective

The objective of this study was to gain a predictive knowledge-base of aboveground woody production within the South Africa savanna biome.

1.7.2 Goals

1. To determine aboveground woody plant productivity across a range of environments within the South African savanna biome.
2. To seek relationships between woody productivity and structural and site characteristics.
3. To determine the productivity of the different components of aboveground woody biomass.
4. To explore the effects of management practices on woody plant productivity.

Specific goals are presented in each chapter (Sect. 1.9).

1.8 APPROACH TO THIS STUDY

With the current lack of productivity estimates, gross estimates across the range of savanna types were considered more important than more precise estimates from a few sites. Therefore, the approach was to seek out the inherent variation of savanna structure, rather than select 'representative' sites. This approach facilitates comparison between different savanna types, across the entire range, thereby allowing synthesis

of the data into meaningful relationships to enhance predictive capacity. It also allows model testing and definition of new avenues for investigation.

Predictive capacity can be established at a variety of scales, through employment of different tools, and reporting of a certain suite of statistics. Reflecting my personal preference and strengths, the approach in this study was largely empirical at the level of a woody community. This is also the scale at which management actions are formulated and implemented. Predictive capacity was founded on the derivation of statistical relationships across a range of savanna communities. Scope exists for this to be integrated at a higher level into basic mechanistic models, but was not pursued here.

Although one of the primary goals was to identify the determinants of woody productivity through comparison of production from a range of habitats, it was implicit throughout the design of the study, on the strength of previous work, that water availability was a major factor. Consequently, most components of the study were replicated across a rainfall gradient.

1.9 STRUCTURE OF THE THESIS

This thesis has been divided into six sections (A - F). Each section groups a few chapters around a common theme:

SECTION A: Introduction

Chap. 1. General introduction

Chap. 2. Intensive study sites: vegetation description

SECTION B: The range in woody plant productivity

Chap. 3. Woody plant growth and death across a range of sites

Chap. 4. Extending the time frame using densitometry

Chap. 5. The influence of water and fertiliser

Chap. 6. The prevalence and role of competition

Chap. 7. The role of community phenology

Chap. 8. Seedling recruitment and survival

SECTION C: Production of harvestable components

Chap. 9. Biomass relationships and growth ratios of selected species

Chap. 10. Deadwood

Chap. 11. Litter

Chap. 12. Fruit

SECTION D: Impacts of wood harvesting on woody plant productivity

Chap. 13. Community level impacts: a review

Chap. 14. Plant level impacts: the influence of stump dimensions and post-harvest pruning on regrowth

Chap. 15. Plant level impacts: effects on growth rate of the neighbouring tree

SECTION E: Impacts of fire on woody plant productivity

Chap. 16. Community level impacts: influence on woody community structure

Chap. 17. Plant level impacts: tree and seed mortality and survival

SECTION F: Summing up

Chap. 18. Summary and synthesis

Chap. 19. References

Section A sets the scene for the reader, and provides the necessary background information. Section B is orientated at addressing the first goal (Sect. 1.7.2), but also contributes to Goal 2. The third goal is largely addressed by Section C, although part of Section B is relevant. The last goal is covered by Sections D and E that deal with wood harvesting, and fire, respectively. Each chapter within sections is presented in a stand-alone format, with a brief introduction of the issue, and more detailed key questions and hypotheses than presented in this Introductory chapter, followed by results and discussion. Chapters are cross-referenced as necessary with Chapter 18 summarising and integrating all components of the study.

INTENSIVE STUDY SITES: VEGETATION DESCRIPTION

2.1 INTRODUCTION

The first two goals of this study (Sect. 1.7.2) necessitated the selection of a series of sites across a range of environments throughout the savanna biome, and the measurement of some component of woody productivity by which to compare the sites. Achievement of the second two goals required more detailed approaches with more frequent measurements. This was only possible at a smaller number of localities. This chapter provides the reader with a description of these more intensive localities. A varying number of plots or transects were sampled at each of the localities according to the requirements for the different sections of the project.

Given that the availability of water for plant growth processes is regarded as the primary determinant of savanna structure and function (Frost *et al.* 1986, Scholes & Walker 1993), it was deemed necessary to replicate all experimental aspects of this project (as far as possible) within contrasting rainfall zones. Consequently three localities were selected along a rainfall gradient for a variety of experimental procedures. For convenience the three localities are referred to as arid (Hoedspruit Nature Reserve), semi-arid (Wits Rural Facility) and mesic (Bushbuckridge Nature Reserve) reflecting their relative positions along the rainfall gradient.

2.2 OBJECTIVE

The objective of this part of the study was to characterise the species composition and structure of the woody vegetation at each of the three intensive monitoring localities.

2.3 STUDY AREAS

2.3.1 Location

All three localities were located in the central lowveld straddling the boundary between Mpumalanga and Northern Province (Fig 2.1). The north-south distance between the localities is approximately