A NATURAL RESOURCE INVENTORY OF SANGO RANCH, SAVE VALLEY CONSERVANCY, ZIMBABWE

by

CHARLES JAMES HIN

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Centre for Wildlife Management
Faculty of Natural, Agricultural and Information Sciences
University of Pretoria
Pretoria

Supervisor: Prof. Dr. J. du P. Bothma
Co-supervisor: Prof. Dr. N. van Rooyen

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ABSTRACT

Research was conducted to describe the natural resources of Sango Ranch, Zimbabwe, in terms of soils, vegetation and animal populations. A phytosociological and structural classification facilitated the identification of plant communities and management units. Veld condition and responses of the common grass species to grazing pressure were determined with a DECORANA ordination. The grasses were allocated to various ecological categories according to their responses along the grazing gradient so obtained. Herbaceous biomass for each management unit was determined with the disc pasture meter. The browsing capacity was determined by calculating the available leaf biomass of the woody vegetation. The grazing capacity was calculated using GRAZE. Ecological capacity was calculated as the sum of the grazing and browsing capacities. Phenological characteristics of 23 plant species were collected for 12 months. It followed a typical pattern. Recommendations are made on the ecological management of Sango Ranch and a monitoring programme is presented.

CONTENTS

CHAPTER 1

INTRODUCTION

An inventory is a statement listing the physical assets of a business or institution (Van Zyl, Von Bach and Bothma 1995) and the planning process for any business requires an analysis of the internal infrastructure and the available resources (Kroon 1996). For a game ranch the physical assets include infrastructure such as roads, pipelines, water sources, fences, vehicles, pumps and buildings. Further available resources include human resources, financial resources and the products being marketed, the natural resources in the form of geology, soils, wild animals and plants. The animals depend on their habitat for food, shelter and water and thus survival (Van Rooyen, Bredenkamp and Theron 1996). Therefore it follows that the habitat is an important resource that must be taken into consideration in the planning phases. Successful management of large natural areas thus depends a great deal on the composition of the vegetation, the extent to which it is being utilised, and the changes that take place in response to differential use by herbivores and fire (Walker 1976a). An inventory of the natural resources will deliver both qualitative and quantitative information on the geology, soils, vegetation and animals in an area. This then enables the wildlife manager to develop a multi-disciplinary and goal-orientated wildlife management plan.

Sango Ranch has committed itself to playing a constructive role in applying sound ecological principles in its land management practices, and to strive towards economic viability and social upliftment (Joubert 1999a). In this context, the objective of this study is to present an inventory of the natural ecosystems of Sango Ranch in order to develop a plan for the ecological management and utilisation of the natural resources of Sango Ranch in compliance with its vision, mission, aims and objectives. A general description of the physical environment, background and history of the Save Valley Conservancy and Sango Ranch is followed by an analysis and assessment of the soils as well as the plant and animal communities of Sango Ranch. This information is used in conjunction with published literature to make recommendations on the management of the vegetation and animal communities and on the sustainable utilisation of the various natural resources of Sango Ranch. It is recognised that the management guidelines presented here are speculative due to the complex nature of natural systems. Therefore they are only intended to be valid over a short period due to the dynamic properties of natural systems in southern Africa (Bothma 1995a). However, the management strategy recommended here utilises periodic data collection techniques in order to constantly update and improve management programmes and guidelines in accordance with new information or changes in aims and objectives.

CHAPTER 2

STUDY AREA

LOCATION

Sango Ranch is situated in the Save Valley Conservancy, Masvingo Province, in the southeastern Lowveld of Zimbabwe, 65 km northeast of the town of Chiredzi and 30 km north of Gona-re-zhou National Park (Figure 1). The Save Valley Conservancy consists of 23 individual properties and comprises an area of 345 067 ha (Figure 2). It stretches from southern latitudes 20° 00' and 21° 00' and eastern longitudes 31° 05' and 32° 25'. The Masvingo to Birchenough Bridge road and the Devure River marks the northern boundary of the Conservancy (Figure 1). The Save River forms the entire eastern boundary of the Conservancy (Figure 2). To the west lies the Devure Resettlement Scheme and the Matsai Communal Land, while the Mkwasine Sugar Estate marks the southern boundary. Sango Ranch lies in the centre of the Save Valley Conservancy north of the Turgwe River and consists of the properties Musawezi, Chanurwe and Sabi (Figure 2). Sango Ranch covers an area of 44 348 ha and lies between southern latitudes 20° 10' and 20° 23' and eastern longitudes 32° 00' and 32° 20'.

PHYSIOGRAPHY

The development of the landscape of the Save Valley Conservancy was caused by downward erosion within the Post-African erosion cycle (Lister 1987). The most prominent feature of the Save Valley Conservancy is the Save River that flows in a southerly direction in the conservancy. The Save River is the biggest river in Zimbabwe and the catchment area covers 84 550 km^2 (Natural Resources Bulletin 1998). The catchment area covers 4 200 000 ha in terms of resource base and forms the heart of the southeastern Zimbabwe Lowveld. According to the Natural Resources Bulletin (1998), the Save River is severely silted due to continuous degradation of the catchment area. Whitlow (1988), as quoted in the Natural Resources Bulletin (1998), estimated the extent of soil loss in the catchment to be 50 to 80 tons of soil per ha per year. Within the Save Valley Conservancy the Save River is at places 1.5 km wide (Broderick 1997).

The Save Valley Conservancy gradually slopes downward towards the southeast and is described as a flat plain with a few scattered koppies (Goodwin, Kent, Parker and Walpole 1997). The altitude of the Conservancy varies from around 400 m above sea-level in the south to around 800 m above sea-level in the northwest. Hills rise up to 250 m above the plains but are generally little more

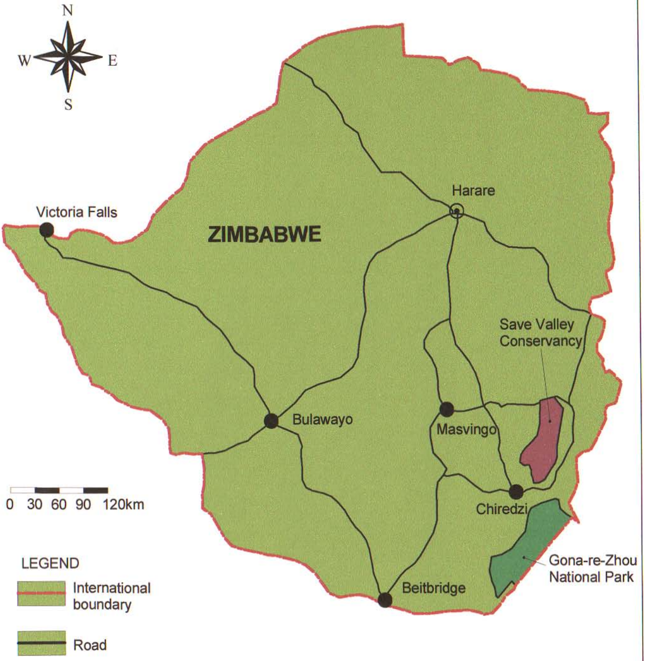
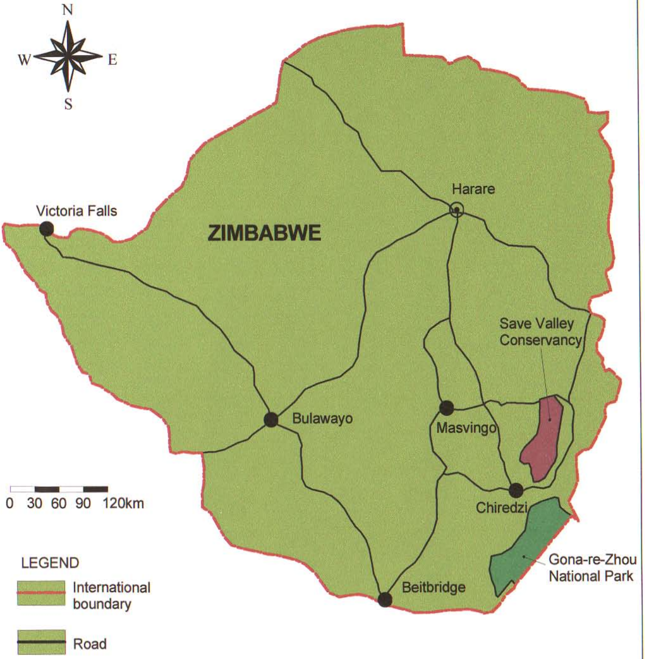


Figure 1: Location of the Save Valley Conservancy, Zimbabwe.



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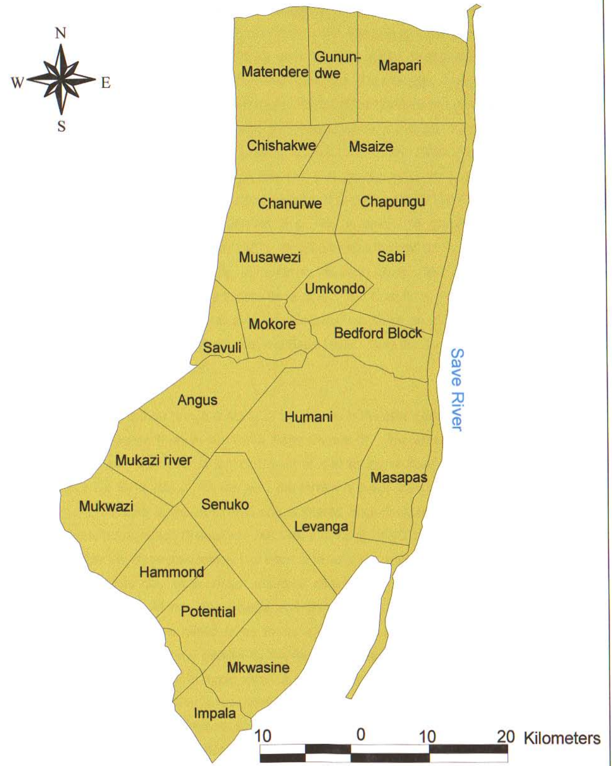


Figure 2: Map of Save Valley Conservancy, Zimbabwe, showing various properties.

than 100 m high. The Save Valley Conservancy is dissected by several seasonal rivers and streams, all flowing in a southeasterly direction, most notably the Msaizi, Makore, Turgwe and Mkwasine Rivers. An interesting feature is the extensive alluvium of the mid-Save River area, where deposits from the Save, Turgwe, Msaizi, Gunundwe Rivers and others have combined to form a plain 20 km wide, extending 60 km along the west bank of the Save River (Goodwin *et al.* 1997). It is speculated that this alluvium was deposited by a meandering Save River prior to its stabilisation in its present course (Swift 1962). The alluvium appears to be mostly derived from granite and has proven to be an excellent aquifer, with the Save River as a constant source of recharge (Swift 1962). The alluvium has been estimated to contain 215 775 ha-meters of groundwater (Hindson and Wurzel 1963, *In:* Lister 1987). In the alluvium the banks of the Save River are slightly higher than the surrounding country (Swift 1962) forming numerous seasonal pans on the adjacent flood plain. The Gunundwe and Msaizi Rivers and other smaller seasonal streams discharge via these pans and small drainage channels instead of directly into the Save River. Only the Turgwe River flows directly into the Save River.

Physiographically, Sango Ranch consists of a flat plain in the east, which dips in a southeasterly direction towards the Save River (Figure 3). The altitude ranges from 780 m above sea-level in the northwest to 430 m above sea-level in the southeast at the Save River. To the west the terrain is hillier than the east with large angular koppies in the northwest and scattered hogs-back koppies to the south of the latter, of which Chanurwe (748.1 m) and Vumba (780 m) are the most notable. Other physiographic features of interest include the alluvial plain with its numerous seasonal clay pans; major drainage channels such as the Makore, Saindota and Msaizi Rivers; and Chinga and Sune Pan. In the northeastern corner of Sango Ranch a raised levee forms a ridge east of Chinga Pan that stretches southwards, running parallel to the Save River (Broderick 1997). The sand bed of the Msaizi River ends about 2.5 km from the Save River at the western extremity of the Save River alluvium. According to Broderick (1997) the floodwaters of the Msaizi River splay out at this point and then coalesce in a southerly direction into the so-called Msaizi River extension. The splaying out of the water is probably caused by a slowing down effect resulting when the water course meets the Save River alluvium. The Msaizi River extension then flows parallel to the Save River for 6 km before flowing into it. Coincidentally, the end of the Msaizi River channel lies directly above the Musikavahu Fault but this does not contribute to the outward splaying of the floodwaters (Broderick 1997). The Chinga Pan, of which only the southern tip lies on Sango Ranch, takes its water recharge from the Gunundwe River and its tributaries. The series of pans of Sune

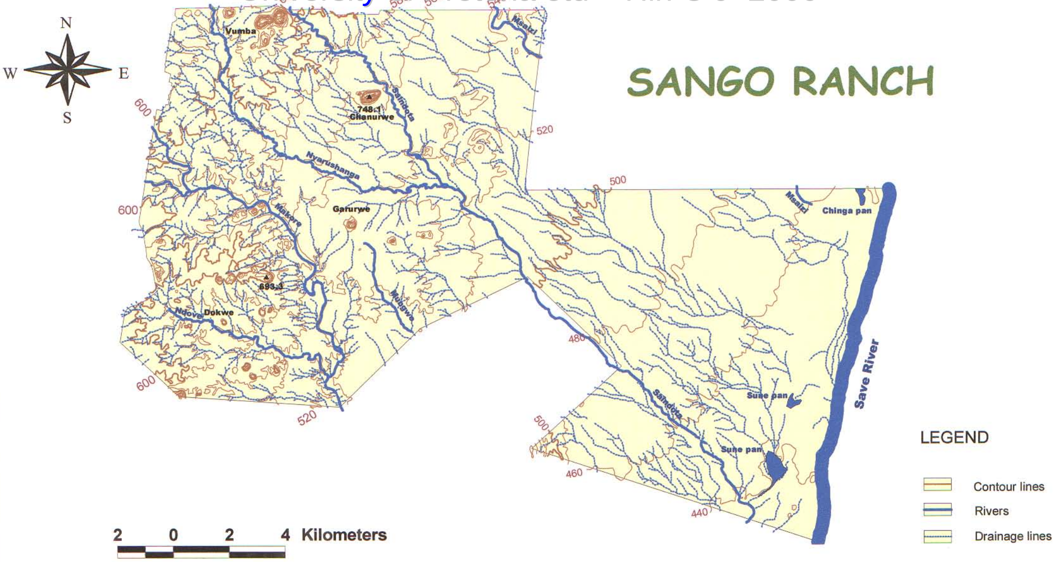


Figure 3: Topographical map of Sango Ranch, Save Valley Conservancy, Zimbabwe.

Pan are recharged from streams flowing towards the Save River alluvium north of the Saindota River and south of the Msaizi River. According to Broderick (1997) the series of pans of Sune Pan do not receive any water from the Msaizi River. All of the pans mentioned above are associated with deep vertisol muds that retain their water throughout most of the wet season. A broad alluvial belt supporting an open grassland is associated with the Saindota River and begins as a narrow ribbon to the north of Chanurwe Hill, becoming gradually wider towards the southeast. This alluvial belt then extends in a southerly direction just south of Sune Pan into the Bedford Block (Figure 2).

GEOLOGY

The first known account of the geology of the Save River Valley is by Thiele in 1914. This account was published in 1915 (Swift 1962). After Thiele, several geologists produced papers and maps on the geology of the area, including Mennell (1920, 1938), Maufe (1922), Teale (1924), The Victoria Prospecting Company (1932), Phaup (1937) and Swift, White, Wiles and Worts (1953). These authors are all quoted in Swift (1962). Recent geological observations were made by Brandl (1992) and Broderick (1997).

A graphic representation of the geological formations found on Sango Ranch appears in Figure 4 and is adapted from maps given by Brandl (1992) and Broderick (1997). The oldest rocks in the Save Valley Conservancy belong to the Basement Complex which was formed during the Precambrian period, 3 350 to 2 350 million years ago (Bond 1965). These rocks consist of the granites with schist intrusions, gneisses and granitic gneisses (Swift 1962). In the southern parts of the Save Valley Conservancy the granites and included portions of Basement schists falling within the Limpopo Mobile Belt have been converted to highly contorted granitic gneisses by being subjected to a later regional metamorphism in the form of tectonism. A narrow band of Basement Complex gneiss was not subjected to Limpopo Mobile Belt tectonism and lies between the Limpopo Mobile Belt and the unmetamorphosed granite in the north. The division between the granite in the north and the granitic gneisses and granulites in the south is a sharply defined east-north-east thrust-defined contact which lies just north of Chanurwe Hill at the boundary between the Sango and Chishakwe Ranches (Figure 4). These granites are the oldest rocks in the area and form a broken country characterised by koppies. The granitic gneisses include basic gneisses and granulites and form a flatter landscape than in the Basement Complex with fewer koppies, the koppies being of the hogs-back type. The granitic gneiss is wound into tight anticlines and synclines which clearly show an intricate system of

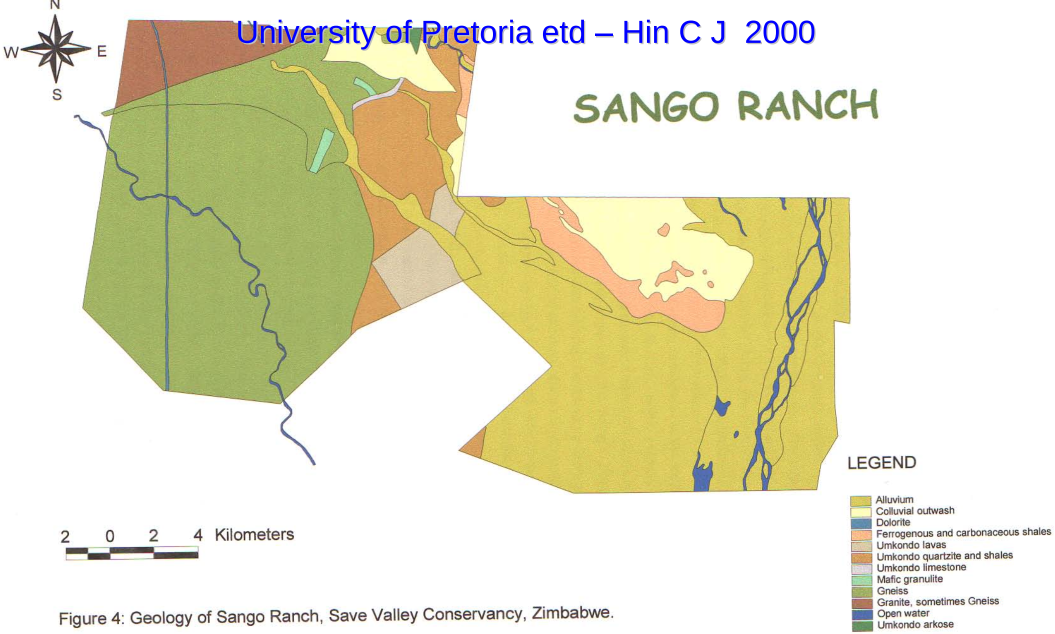


Figure 4: Geology of Sango Ranch, Save Valley Conservancy, Zimbabwe.

folding (Swift 1962) (Figure 4). The granite is intruded by north-north-west trending dolerite dykes that correlate with what is known as the Sebanga Poort Trend (Broderick 1997). One of these dykes is located in the west of Sango Ranch (Figure 4). Other rocks similar to dolerite are found throughout the southern area and are highly metamorphosed, but outcropping as dykes and sills intrusive into the granitic gneiss prior to metamorphism. After metamorphism of the granite and schists the area was reduced to a regular peneplain by a long period of erosion (Swift 1962). The rocks of the Umkondo System consist of quartzites, lavas, shales, arkoses, limestones and sandstones. The rocks of the Umkondo System were laid upon this peneplain after submergence beneath a shallow sea. The Umkondo System was formed during the Early Pre-Cambrian period, 1 600 to 1 900 million years ago (Bond 1965). The Umkondo System occurs in down-folded troughs and runs from the northeastern corner of the Save Valley Conservancy south of Birchenough Bridge, southwards to the south of the Turgwe River (Swift 1962). The Umkondo System, which consists of the Umkondo lavas and Umkondo quartzites and shales, crosses the centre of Sango Ranch southwards into the Umkondo Lease (Figure 4). According to Swift (1962) much of the Umkondo System in the Save Valley Conservancy is covered by alluvium. It is speculated that the extensive alluvium of the mid-Save River area was recently deposited during meandering of this river prior to its stabilisation in its present course (Swift 1962). The alluvium was deposited during the Quaternary period, 2 million years ago (Bond 1965). The alluvium appears to be mostly derived from granite (Swift 1962). Most of the eastern half of Sango Ranch consists of alluvium (Figure 4). The limestones show oölithic texture and the sandstones are frequently ripple-marked which provides evidence that a water body of some sort once existed there. The basic lavas overlie the limestones and sandstones and contain interbedded sandstones near the base. In a few areas the Umkondo lavas are overlain with red shales and sandstones. The Umkondo System has suffered extensive faulting and is mostly of post-Karoo age while some of it is probably pre-Karoo. The Mapari Series is found in the north of the Save Valley Conservancy and although it overlies the beds of the Umkondo System it is regarded as being separate from the Umkondo System. Swift (1962) regards the Umkondo System to be similar to the Transvaal System and the Mapari System to be similar to the Rooiberg Series, both found in South Africa. Much of the Umkondo System was removed by erosion, and the Karoo System was overlain on top of the Umkondo beds (Swift 1962). The Karoo System dates from 225 to 270 million years ago, during the Triassic to Permian periods (Bond 1965). Much of the Karoo System has been stripped by subsequent erosion and only patches of conglomerate, grit, sandstone and shale remain (Du Toit and Price Waterhouse 1994). Shale, grits and conglomerates of the Karoo Supergroup are seen to outcrop about 2 km downstream of the Sango Ranch Headquarters along the Msaizi River (Broderick 1997) (Figure 4). The rocks of this group weather as a surface deposit and occur in a feldspathic grit matrix of rounded quartz pebbles. The Save Valley appears to be a pre-Karoo feature, carved by erosion along the line of pre-Karoo faulting, and the Lower Karoo beds show unconformable overlap in a northerly direction (Swift 1962).

SOILS

The soils of Zimbabwe generally fall into two main categories. They are: lightly textured sandy soils, and medium to heavy textured loams and clays (Rattray 1957). Sandy soils with a low fertility are derived either from acidic rocks such as granite, or from sedimentary sandstones or paragneiss. The heavier loams and clays originate from basic igneous rocks such as dolerites or from various other sedimentary sediments. Black vlei soils are widespread, and possess a high fertility. The soils all bear a close relationship to the underlying rocks, and are classed as immature soils (Swift 1961). Mature soils are found only on flat ground. Ellis (1950) named the soils of the Save River Valley the Mopani soils. These soils are associated with the mopane *Colophospermum mopane*. According to Ellis (1950) the Mopani soils on the west bank of the Save River are of three types: alluvial soils derived from granite and the Umkondo System; or fine, clinging Permian soils derived from quartzites and sandstones; or black, heavy basalt soils. Mopani soils generally have a sandy eluviated A-horizon, which may vary from 25 mm to 150 mm or more in depth.

The soils of the Save Valley Conservancy are strongly related to the underlying geology (Du Toit and Price Waterhouse 1994). Thompson (1965) identified three main soil orders in the area of the Save Valley Conservancy. The soils of the Calcimorphic Order consist of unleached soils, with large reserves of weatherable materials. The Siallitic Group consists of calcimorphic soils that vary from shallow to moderately shallow soils formed on miscellaneous rock types, to deep siallitic soils on alluvium and colluvium. The clay fraction of the fersiallitic soils consists either of illite or poorly crystalline illite to montmorillonitic mixed with layer minerals, mainly in a 2:1 lattice (Thompson 1965). Base saturation is generally over 80 percent. An accumulation of illuvial calcium is sometimes found in the lower solum or underlying layer. The soils on paragneisses, gneisses, and granites are shallow, medium-grained, siallitic loamy sands with an inherent fertility (Du Toit and Price Waterhouse 1994). On the mafic paragneisses the soils are redder and more heavily textured than the paragneisses and on the granites the soils are lighter and sandier. Deep siallitic soils are found in the region of the

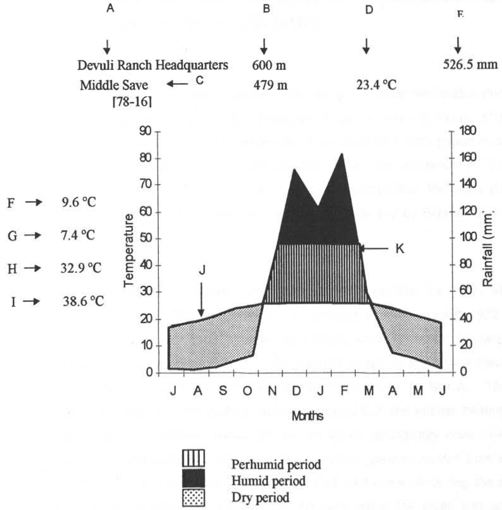
Save River alluvium and possess a particularly high phosphate status. This is probably due to several alkali ring complexes found upstream. The soils on Karoo and Umkondo sediments are similar to those on the granites and granulites but are shallower and usually possess a low infertility.

The soils of the Kaolinitic Order are moderately to strongly leached, with a clay fraction consisting mainly of kaolinite with appreciable amounts of free sesquioxides of iron and aluminium (Thompson 1965). The Fersiallitic Group are kaolinitic soils ranging from fersiallitic red granular clays formed on ultrabasic and basic rocks to fersiallitic, predominantly sandy soils formed on siliceous rocks. Fersiallitic soils tend to be formed on parent materials that give rise to sandy soils mainly in areas of low rainfall. Such soils possess appreciable amounts of weatherable mineral reserves and have a base saturation of more than 40 percent. The clay fractions contain some 2:1 lattice minerals.

The soils of the Halomorphic Order contain significant amounts of exchangeable sodium and/or water-soluble salts. The Sodic Group consists of halomorphic soils that morphologically resemble solonetz and solodized-solonetz. However, their genesis is different. Lateral water movement across the surface of the dense impermeable sodic horizon is thought to be responsible for the very abrupt change between surface and sub-surface soils. Soils vary from strongly sodic to weakly sodic to saline. Highly sodic soils with a low impenetrability are found in some areas of the alluvium with diffuse drainage (Du Toit and Price Waterhouse 1994). Sodic soils are found along drainage lines due to the low rainfall causing insufficient removal of sodium-rich bases and clays from the bottom of the soil catena (Thompson and Purves 1978, *In:* Du Toit and Price Waterhouse 1994).

CLIMATE

The southeast Lowveld of Zimbabwe falls in the BSh climatic zone when using the Köppen classification (Schulze and McGee 1978). This zone is arid and possesses a dry hot steppe climate with a mean annual temperature of above 18 °C. Invasions of cool moist air from the southeast occur during the late dry season, giving rise to slight precipitation and marked drops in day time temperatures. The Save River Valley is characteristically hot and arid (Swift 1962). A climatogram for the Middle Save River Valley appears in Figure 5. The rainfall figures are from the Devuli Headquarters rainfall station (Latitude 20° 08'



A = weather station
B = altitude (m)
C = duration of observations in years, for rainfall and temperature, respectively)
D = mean annual temperature (°C)
E = mean annual rainfall (mm)
F = mean daily minimum temperature of the coldest month (°C)
G = absolute minimum temperature (°C)
H = mean daily maximum temperature of the hottest month (°C)
I = absolute maximum temperature (°C)
J = mean monthly temperature (°C)
K = mean monthly rainfall (mm)

Figure 5. Climatogram for the Middle Save River Valley, Zimbabwe from 1922 to 1999 as derived from the Middle Save River weather station (Latitude 20° 13' S, Longitude 32° 23' E, altitude 479 m) and the Devuli Headquarters rainfall station for the period 1977 to1993 (Latitude 20° 08' S, Longitude 32° 06' E, altitude 600 m).

S, Longitude 32º 06' E, Altitude 600 m above sea level)[1] and were recorded from 1922 to 1999. The temperature figures were attained from the Middle Save River weather station (Latitude 20º 13' S, Longitude 32º 23' E, Altitude 479 m above sea level)[1] and were recorded from 1977 to 1993.

Rainfall

The rainfall of Zimbabwe is characterised by a unimodal distribution during the summer months (Farrell 1968). However, it can be seen in Figure 5 that two peaks in rainfall appear in December and February with a drier period in January. Southern Zimbabwe is more persistently under the influence of the drier southeasterlies and so receives a much lower rainfall than the north (Lineham 1965). The southeast Lowveld is classified as semi-arid by Schulze and McGee (1978).

Rainfall for the Middle Save River Valley is highly variable (cv = 30.2%) with a mean rainfall of 526.5 mm per annum received over the period 1922 to1999 (Figure 5).[1] Du Toit (1990b) reported a highly variable rainfall for Msaizi and Gunundwe Ranches (cv = 33%). The majority of rain in the Middle Save River Valley is received during the summer from November to March. The more southerly position of the subtropical high pressure belt and intense heating of the interior of the continent during October to March periodically draw moister air masses into Zimbabwe, giving heavier and more general rainfall than at other times (Lineham 1965). Periodic incursions of cold moist air during the summer months are induced by increasing air pressure along the south and southeast coasts of southern Africa and enter the southeast Lowveld of Zimbabwe by major gaps in the plateau edge, mainly the Limpopo River Valley (Lineham 1965). Orographic rain or drizzle then occurs on all the windward-facing slopes. This is locally known as 'guti'.

The Middle Save River Valley experiences periodic droughts. Somerville (1976) reported a series of droughts in the 1930's, and a disastrous drought in 1946/1947 when a total rainfall of only 321.6 mm was recorded. The most recent and the historically most severe drought occurred in the 1991 to 1992 rain season when a total of only 156.5 mm of rainfall was recorded at Devuli Ranch Headquarters. The highest recorded rainfall was 901.5 mm which fell in the season of 1922 to 1923. According to Schulze and McGee (1978), the southeast Lowveld of Zimbabwe experiences an annual rainfall surplus of less than 100 mm. According to Du Toit and Price Waterhouse (1994), the rainfall is higher in the hilly western

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[1] Zimbabwe Meterological Services, PO Box BE 150, Belvedere, Harare, Zimbabwe

areas of the Save Valley Conservancy than elsewhere, because these areas are less influenced by the rainshadow created by the Chipinge Highlands to the east.

A cyclical rainfall pattern occurs and Figure 6 shows the variation from the mean annual rainfall for Devuli Headquarters over a 78-year period. A polynomial regression revealed a quasi 20-year rainfall oscillation in which approximately 20 years of below average rainfall are followed by another 20 years of above average rainfall. Tyson (1978) demonstrated a quasi 20-year oscillation in rainfall that coincided with similar but inverse temperature oscillations for the summer rainfall areas of South Africa. From Figure 6 it is evident that a period of above average rainfall is currently being entered into. Significantly, the rainfall in March 1999 was reported as being above average for about 80 percent of Zimbabwe (Zimbabwe Meteorological Services 1999).

Provided that the rhythm and pattern of rainfall oscillations over the past 78 years continues to repeat itself, it can be expected that the wetter period currently being experienced will persist for the next two decades. However, some periods of below average rainfall and even drought may still occur within this period. The oscillatory nature demonstrated here will have important implications for the management program of Sango and this will be discussed in Chapter 11.

Temperature

Although relief influences the main temperature pattern, the relative accessibility to invasions of cold air is also of importance (Torrance 1965b). Such invasions of cool moist air from the southeast occur in most months of the year at one- to two-weekly intervals. Because of their associated cloudiness they affect the temperature conditions materially. Cloudy cool days are more common in the southeast Lowveld of Zimbabwe because the central watershed of Zimbabwe forms a natural weather boundary. The Middle Save River Valley lies between the 30 °C and 32.5 °C isotherms for summer and between the 7.5 °C and 10 °C isotherms for winter (Schulze and McGee 1978).

Maximum temperatures for the Middle Save Valley vary between 25.5 °C and 26.6 °C during June to July and between 32.4 °C and 32.9 °C during October to January, with an annual mean maximum of 30.5 °C (Figure 5).[1] Minimum temperatures range from 9.6° C to 10.7 °C during June to July and from 17.3 °C to 20.8 °C during October to January with an annual mean minimum of 16.3°C. The highest and lowest temperatures recorded for the Middle Save River area over the period 1977 to 1993 are 38.6 °C in January and 7.4 °C in July, respectively. Frost is rare in the Save River Valley (Farrell 1968).

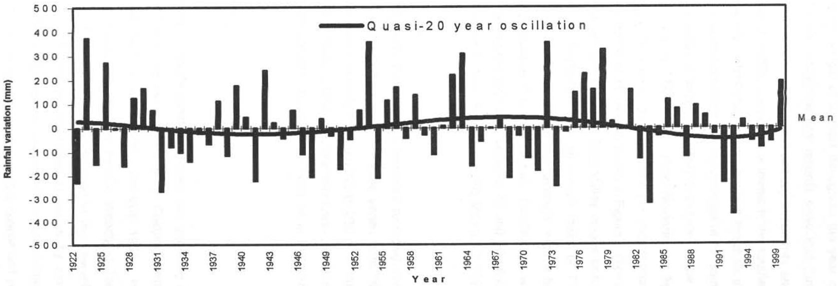

Figure 6. The actual variation from the mean annual rainfall for the Middle Save River Valley, in Zimbabwe as recorded at the Devuli Headquarters rainfall station (Latitude 20° 08' S, Longitude 32° 06' E, Altitude 600 m above sea level) from 1922 to 1999.

Sunshine and humidity

Variations in the length of daylight throughout the year are comparatively small (Torrance 1965a). Meteorological records show that Zimbabwe can expect an average of 8 to10 hours of sunshine per day in summer and about 6 hours per day in winter (Rattray 1957). Sunniness is lowest in the southeast of Zimbabwe due to the cloudy weather which results from periodic moist air invasions. However, the Save Valley experiences the greatest sunniness of the southeastern Lowveld. The total sunshine hours received from May to October in the southeast of Zimbabwe ranges from 1 500 to 1 600 hours. From November to April it ranges from 1 300 to 1 400 hours. The mean daily sunshine per month recorded in the Save River Valley over a period of 13 years is shown in Figure 7 (Torrance 1965a). The mean daily sunshine per month for the Save Valley ranges from 6.0 hours in December to 9.5 hours in September with an annual mean of 7.9 hours. The periodic invasions of moist air maintain a high average relative humidity of the air in the southeast of Zimbabwe (Torrance 1965a). The 24-hour relative humidity of the air for the southeast Lowveld varies between 65 and 70 percent during November to April and between 50 and 55 percent during May to October (Torrance 1965a).

Solar radiation

The incoming solar radiation flux densities recorded over a period of 10 years (1963 to 1973) in southeastern Zimbabwe varied from 160 to 170 x 10^5 Jm^2 per day for winter (June-August) and from 220 to 230 x 10^5 Jm^{-2} per day (Schulze and McGee 1978). These values are relatively lower than the rest of the country and are due to the periodic invasions of moist air in the southeast causing radiation attenuation.

VEGETATION

The vegetation of southeastern Zimbabwe can generally be classified as a sweet *Colophospermum mopane* savanna or a *Colophospermum mopane* woodland (Rattray 1957; Rattray 1961; Rattray and Wild 1968). Henkel (1931) called the vegetation the *Colophospermum mopane* Woodland Zone and reported almost pure stands of *Colophospermum mopane* in the Lowveld of the then Southern Rhodesia, now Zimbabwe, interrupted in places by low hills and ridges where *Colophospermum mopane* occurred mixed with other trees. Henkel (1931) noted that the understorey of grass was unusually sparse and poorly developed. White (1983) classified the greater part of the vegetation of southeastern Zimbabwe as a deciduous Zambesian mopane woodland and scrub woodland with an area of semi-deciduous Zambesian miombo woodland dominated by *Brachystegia* spp., either alone or with *Julbernardia* spp. to the north. The vegetation of the alluvial

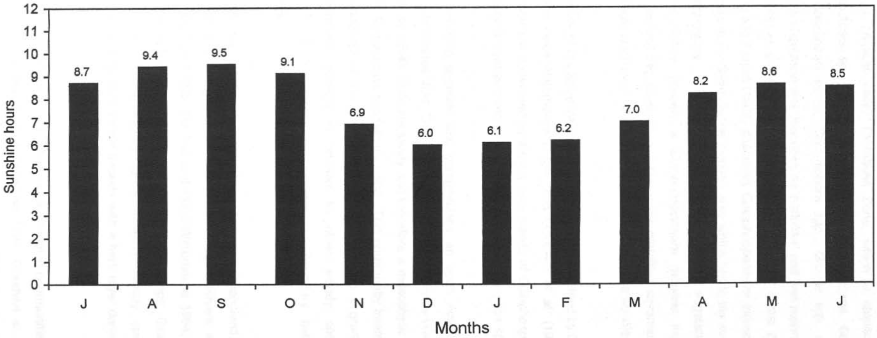

Figure 7. Mean daily sunshine hours per month recorded in the Save River Valley, Zimbabwe over a period of 13 years (Torrance 1965).

basin of the Save River Valley was broadly categorised by Rattray and Wild (1955) as a Tropical Valley Thornbush Zone, which is characterised by the presence of *Acacia* spp., *Dichrostachys cinerea* subsp. *africana*, *Colophospermum mopane*, *Sclerocarya birrea*, *Commiphora* spp., *Grewia* spp. and *Adansonia digitata*. The vegetation was described as 'park-like' and was reported by Wild and Rattray (1955) as showing remarkable similarities to that of the Zambezi Valley. Wild (1955) and Farrell (1968) described *Colophospermum mopane* as being the dominant tree in the Save-Runde junction area which lies to the south of the Save Valley Conservancy. Wild (1965) identified four general vegetation types in the Save River Valley, namely a *Colophospermum mopane* tree savanna, a *Terminalia sericea* tree savanna, a *Julbernardia globiflora* savanna woodland, and a *Brachystegia spiciformis* - *Julbernardia globiflora* savanna woodland.

The vegetation of the Save Valley Conservancy was described by Du Toit (1990b), Du Toit and Price-Waterhouse (1994) and Goodwin *et al.* (1997). An open mopane woodland dominated by almost pure stands of *Colophospermum mopane* with a poor herb layer is found on alkaline clays and shows a low species diversity.

On soils overlying gneisses and paragneisses an open *Acacia* - *Combretum* Woodland dominates (Du Toit 1990b; Du Toit and Price-Waterhouse 1994; Goodwin *et al.* 1994). Soils are sandy and therefore a mesophytic community has developed. Grass cover is relatively good. This community intermingles with the mopane woodland at the bottom of the slopes, where a gradual increase in *Colophospermum mopane* in relation to other woody species is seen. Consequently, it is difficult to demarcate a boundary between the two communities.

A tall almost closed *Acacia tortilis* subsp. *heteracantha* woodland is found on the heavy, deep alluvial soils of the Save and Turgwe Rivers and their major tributaries (Du Toit 1990b, Du Toit and Price-Waterhouse 1994; Goodwin *et al.* 1997). The understorey often forms thicket-like clumps. Grass species are palatable. On old abandoned lands invasive woody species such as *Dichrostachys cinerea* form dense thickets with a herb layer dominated by weedy forbs.

On shallower alluvial plains, considerably intermingled communities are found (Du Toit 1990b; Du Toit and Price-Waterhouse 1994; Goodwin *et al.* 1997). The dominant species include *Acacia xanthophloea* and *Salvadora persica*. Trees such as *Xanthocercis zambesiaca*, *Kigelia africana*, *Trichilia emetica*, *Combretum* *imberbe* and *Lonchocarpus capassa* are common in these communities and their abundance increases towards the major rivers.

A riverine fringe woodland occurs as a dense riparian community growing on consolidated alluvium along the banks of the larger rivers (Du Toit 1990b; Du Toit & Price-Waterhouse 1994; Goodwin *et al.* 1997). A number of large evergreen trees form a closed canopy under which a dense understorey and lianas are found.

A hilltop woodland and thicket is found on granite and granulite koppies with *Brachystegia glaucescens, Adansonia digitata, Kirkia acuminata, Afzelia quanzensis, Ficus abutilifolia, Ficus tettensis, Entandrophragma caudatum, Combretum apiculatum* subsp. *apiculatum, Sclerocarya birrea* and *Xeroderris stuhlmannii* as conspicuous species (Du Toit 1990b; Du Toit & Price-Waterhouse 1994; Goodwin *et al.* 1997). *Brachystegia glaucescens* also occurs in groves on interfluves on undulating granulitic terrain with pockets of sandy soil, as well as in areas of Umkondo and Karoo sediments.

On some interfluves with relatively deep, sandy soils, a mixed sandveld or open woodland occurs in place of *Brachystegia glaucescens* groves (Du Toit 1990b; Du Toit and Price-Waterhouse 1994; Goodwin *et al.* 1997). Dominant trees are *Terminalia sericea, Combretum apiculatum* subsp. *apiculatum, Sclerocarya birrea, Strychnos* spp., *Cissus cornifolia, Flacourtia indica* and with *Julbernardia globiflora* and *Pseudolachnostylis maprouneifolia* being less common. The grass cover is variable.

ANIMALS

The Save River Valley was once noted for its large animal concentrations (Somerville 1976). Somerville (1976) mentions large herds of elephant, eland, sable antelope, kudu, zebra and impala that occurred there in the 1920's. Near running water hippopotamuses and waterbuck existed and in thick forest buffalo herds roamed. Lichtenstein's hartebeest, roan antelope, reedbuck, klipspringer, bushbuck, duiker, Sharpe's grysbok, bushpig and warthog were also present. Rhinoceroses, black and white, were rare. Over the years the wildlife populations were eradicated as they were seen as a danger to livestock. Lichtenstein's hartebeest and roan antelope were the first to become rare. Leopards, lions and other large carnivores were common and a predator eradication policy was adopted from the outset. The predators, especially lions, leopards and wild dog, were shot, trapped and poisoned. In the second year of operations a lion problem still existed but Somerville (1976) noted that the lions did avoid certain areas. The lion, cheetah, spotted hyaena and wild dog populations were greatly reduced but a healthy leopard population survived. Elephants were little hunted in the early days because they did little damage. During the 1950's elephant populations increased drastically and the Game Department of the then Southern Rhodesia was asked to control these animals. Buffalo and hippopotamus numbers were also controlled during this period (Meadows 1996). During the 1970's cattle fencing was erected and a programme to eradicate both buffalo and elephant was implemented in response to the Department of Veterinary Services' request that all foot-and-mouth disease risks be reduced (Du Toit and Price Waterhouse 1994). All buffalo and all but five elephant were exterminated in the Middle Save River area. According to Somerville (1976) foot-and-mouth disease first appeared on Devuli Ranch in 1931. In 1976 lions and spotted hyaenas still existed in the area. Sensitive grazers such as sable antelope and roan antelope were unable to compete with the cattle, and sable antelope were only able to survive in the southeast of what is today the Save Valley Conservancy, while roan antelope became extinct in the area. Hunting was practised throughout the period as a means of reducing wildlife competition with cattle (Goodwin *et al.* 1997).

Prior to the formation of the Save Valley Conservancy, game restocking was limited to small numbers of animals. A small number of white rhinoceros were established on Humani Ranch during the mid-1970's through introductions and strays from other populations in Zimbabwe. These other rhinoceros populations had in turn been created through the importation of white rhinoceros from Kwazulu-Natal in South Africa (Du Toit and Price Waterhouse 1994). Prior to 1991 small numbers of giraffe, waterbuck, nyala and tsessebe were reintroduced to Humani Ranch and a small number of elephant calves came from culling operations in Gona-re-zhou National Park and joined the existing herd thus bringing their number to approximately 60. The drought in Gona-re-zhou and a consequent translocation increased the elephant numbers to approximately 700 at the end of 1996 (Goodwin *et al.* 1997). The changes that had been brought about in the vegetation by cattle ranching created habitat suitable for the black rhinoceros and 20 black rhinoceroses were translocated from the Zambezi Valley to Humani Ranch in 1986, 1987 and 1988, on loan from the Department of National Parks and Wildlife Management. The danger of poaching created the need for a co-ordinated programme for the protection and monitoring of these animals and this was a major catalyst in the formation of the Save Valley Conservancy (Du Toit and Price Waterhouse 1994). During 1993 further black rhinoceroses were brought into the Save Valley Conservancy and the population has since increased by natural recruitment to the latest figure of approximately 60. Since 1991 some 1 600 animals have been brought into the Save Valley

Conservancy. Waterbuck, sable antelope, giraffe, Burchell's zebra, blue wildebeest and buffalo were reintroduced into the Save Valley Conservancy in 1993 (Goodwin *et al.* 1997). Buffalo were to play an important role in the transformation of the Save Valley Conservancy from cattle ranching to full-scale wildlife ranching. Buffalo were only released into the Save Valley Conservancy in January 1996 due to veterinary restrictions relating to foot-and-mouth disease.

Today many of the larger ungulates are present in healthy numbers (Table 1). However, warthog and bushpig numbers were severely reduced by the drought of 1991 and 1992, and Burchell's zebra and hippopotamus numbers were also affected (Goodwin *et al.* 1997). Rare antelope present include the nyala, sable antelope, tsessebe and Sharpe's grysbok. Healthy numbers of predators exist in the Save Valley Conservancy. Besides a large leopard population, lion, cheetah and spotted hyaena have all returned and wild dogs have appeared. According to Pole (pers. comm.)[2], three wild dog packs have returned to the Save Valley Conservancy. Both spotted hyaena and lion numbers are low, however, with a single lion pride residing on Senuko Ranch.

The Save Valley Conservancy plans to restock rare animals such as Lichtenstein's hartebeest and roan antelope in the near future (Goodwin *et al.* 1997). Each property in the Save Valley Conservancy is restocking animals on an on-going basis as they become available, although a planned stocking rate does exist for the area.

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[2] Mr. A. Pole, Doctoral Student, Save Valley Conservancy, PO Box 170, Chiredzi, Zimbabwe

Table 1. Large mammal population estimates for the Save Valley Conservancy, Zimbabwe (Goodwin *et al.* 1997).

ANIMALS	*ESTIMATED POPULATION SIZE*	
	1992	*1996*
Buffalo	38	350
Cheetah	12	50
Crocodile	-	200
Eland	1500	2200
Elephant	50	700
Giraffe	30	300
Hippopotamus	15-20	30
Impala	40 000	60 000
Klipspringer	300	400-500
Kudu	12 000	15 000
Leopard	200	250
Lion	-	4
Nyala	120	200
Ostrich	3	-
Rhinoceros, Black	-	60
Rhinoceros, White	4	6
Sable antelope	20	150
Tsessebe	25	100
Waterbuck	200	300
Wild dog	40	80-100
Wildebeest, Blue	100	200
Zebra, Burchell's	1500	2000

CHAPTER 3
BACKGROUND AND HISTORY

THE SOUTHEAST LOWVELD

In general, the pattern of utilisation by humans of the natural resource base has followed rather similar lines throughout the low altitude, savanna ecosystems of the summer rainfall areas of southern Africa in the last 100 to 150 years (Joubert 1999a). Initially this involved extensive livestock production and, in many cases, also some form of rotational grazing by moving stock to alternative areas at different seasons of the year. This form of ranching, together with seasonal grazing alternatives, offered some form of protection from the impacts of the severe periodic droughts, which naturally ravage these areas in a cyclic manner. From the earliest of times the harsh climatic conditions also precluded virtually any form of dryland crop production on an economically viable scale.

The area that today forms the Save Valley Conservancy was first occupied by British colonists in 1920 (Somerville 1976). Prior to this the Save River Valley was sparsely populated by indigenous cattle herders and limited cultivation was practised (Du Toit and Price Waterhouse 1994). The Devuli and Humani Ranches were created when British pioneers first moved into the area in 1920 and settled the land (Somerville 1976). Devuli Ranch was square in shape and was bound by the Devuli River in the north, the Turgwe River in the south, the Sabi River to the east and the Bikita Native Reserve to the west. The total area was over 200 000 ha. Humani Ranch lay to the south of the Turgwe River and was considerably smaller. Cattle, oxen, horses and donkeys from Europe were brought into Devuli Ranch in 1920 and by 1921 there were 5 185 head of cattle on Devuli Ranch. The Senuko, Hammond and Levanga Ranches were created in the 1970's (Goodwin *et al.* 1997).

Copper was discovered at what is today the Umkondo Copper Mine between 1850 and 1890 (Somerville 1976) and was first pegged in 1899 (Swift 1962). From that date onwards various claims have been registered or re-registered. However, ancient workings were found in the mine which indicated that this area was inhabited previously. When Somerville (1976) first entered the Save River Valley in 1920, he passed by the Umkondo Mine and found it to be in operation by Europeans. Somerville (1976) saw the ancient workings that were dug into the side of a hill. However, a few months after Somerville's visit the mine closed down. Later, the mine was re-opened and flourished during World War I because of a high copper price. The mine is currently deserted and studies have shown that no viable copper reserves remain (Goosen pers. comm.)[3].

The infrastructure for cattle management on Devuli Ranch was created in the form of roads, water supplies and fences (Somerville 1976). Water development took place from 1966 to 1971. Apart from cattle ranching, crops such as maize and cotton were cultivated on the alluvium adjacent to the Save River. Several irrigation farms were also created on the ranch. Hunting was also an important source of income to supplement revenue from cattle when the revenue form cattle was surpressed by poor rainfall and disease. Huge mahogany trees (*Afzelia quanzensis*) were felled in the forests for houses and several areas of vegetation were cleared for various reasons (Somerville 1976). The land-use to which the Save Valley Conservancy was exposed to in the past altered the area and today few undisturbed areas exist.

THE SAVE VALLEY CONSERVANCY

By the late 1980's the landowners in the Save River Valley had realised that cattle production was losing its viability, the incidence of drought was escalating and the importance of the wildlife industry was increasing (Goodwin *et al.* 1997). The productivity of the land was declining and the soils were being eroded. By the early 1990's cattle ranching had ceased to become profitable to the landowners of Devuli Ranch and they consequently began selling their assets. The 1991 to1992 drought resulted in an almost complete destocking of cattle. It was during this time that extensive discussions were being conducted between the landowners of the area and the Department of National Parks and Wildlife Management of Zimbabwe about the potential of developing a financially viable wildlife enterprise.

The Save Valley Conservancy was formed in June 1991 when the constitution was signed by its various members (Du Toit and Price Waterhouse 1994). The original reason for the formation of the Save Valley Conservancy was the creation of an area large enough to facilitate the breeding and conservation of the black rhinoceros. The formation of the Save Valley Conservancy was a collaborative endeavour between the Department of National Parks and Wildlife Management, the World-Wide Fund for Nature and the Beit Trust (Goodwin *et al.* 1997). It was envisaged that the black rhinoceros would become a valuable asset as part of a profitable wildlife venture, together with plains game and cattle. The re-introduction of black rhinoceros into Humani Ranch and the subsequent re-

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[3] Mr D. Goosen, General Manager, Sango Ranch, PO Box 24, Birchenough Bridge, Zimbabwe.

introductions served as a catalyst for the formation of the Save Valley Conservancy.

In November 1992 a planning workshop was held by the Save Valley Conservancy members to discuss the future of the Save Valley Conservancy (Goodwin *et al.* 1997). At this workshop the members attempted to identify their strengths and weaknesses and the following Mission Statement of the Save Valley Conservancy was decided upon[4]:

To create a land-use model based on economically and ecologically sustainable utilisation[5] of wildlife. The land-use model will lead to maximum wealth creation for stakeholders[6] through the establishment and management of internationally renowned tourism[7] operations. These operations will lead to a healthy and viable environment in the Conservancy and will contribute to the conservation of endangered species, especially the black rhinoceros. In undertaking these operations the Conservancy intends to take maximum advantage of the synergy potential of group effort, while at the same time ensuring that the identity of individual properties is maintained.

A report by Price Waterhouse (1994) concluded that wildlife production was particularly suitable as a land-use option in the Save River Valley because the financial returns were significantly higher than cattle ranching, employment opportunities were significantly increased, foreign exchange was promoted, the economy of the area would be enhanced and environmental degradation would be reversed. The Save Valley Conservancy was seen as possessing an enormous ecotourism and conservation appeal due to its large size. At a meeting of the Save Valley Conservancy members in 1994[8] an agreement was reached that the major objective of all the members would be the development of multi-use wildlife production systems based on high quality tourism (Goodwin *et al.* 1997). Simultaneously, the members agreed that such operations would necessitate the presence of substantial wildlife populations including the "Big Five" (Du Toit and Price Waterhouse 1994). This would entail the reintroduction of a wide range of antelope as well as the elephant, lion and buffalo. Buffalo became one of the most sought after animals due to the fact that these animals greatly enhance the

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[4] Save Valley Conservancy Strategic Planning Workshop Summary, 16 to 17 November 1992.

[5] Original footnote: "Consumptive or non-consumptive".

[6] Original footnote: "Primarily consisting of landowners and investors in the Conservacy, and the local communities".

[7] Original footnote: "Definition of tourism includes hunting".

[8] Save Valley Conservancy Project Outline, July 1994.

viability of ranch-based hunting operations (Child 1988, In: Price Waterhouse 1994). These factors were significant in the formation of the Save Valley Conservancy in that lion reintroductions would threaten the cattle populations present, that elephant reintroductions would result in fence and crop damage and that buffalo reintroductions would only be approved by the Department of Veterinary Services when all the cattle were removed. The Save River Valley is situated in a "red zone" with regards to foot-and-mouth disease and this places severe restrictions on the marketing of various animal products (Du Toit and Price Waterhouse 1994). The members agreed that their objective would be to re-introduce all necessary species as quickly as possible and to dispose of any cattle that they still owned. The Save Valley Conservancy members decided to target high-quality tourism and to ensure that all the developments were of a sufficiently high standard so as to create and sustain a reputation as a game reserve of international standing (Goodwin *et al.* 1997). A policy of low tourist densities, with minimum disturbance to neighbouring properties, was adopted by the Save Valley Conservancy and it was agreed that the Save Valley Conservancy would be a leading example of a sustainable wildlife-based land-use option. There are at the time of writing 23 members in the Save Valley Conservancy (Table 2).

THE VISION, MISSION AND OBJECTIVES OF SANGO RANCH

Essentially, the vision for Sango Ranch is:

To establish a wildlife conservation area in which the natural assets are maintained in their pristine, natural state, as far as this may be possible and for the sake of posterity, and to utilise its natural resources on a sustainable basis for the socio-economic benefit of the region (Joubert 1999a).

The mission for Sango Ranch is:

To maintain the natural biodiversity of the area through the application of sound ecological management practices and to gain maximum economic viability and social upliftment through the sustainable utilisation of its resources on a consumptive and non-consumptive basis (Joubert 1999a).

The major objective of the owners of Sango Ranch is for Sango to make a meaningful contribution towards the Save Valley Conservancy. However, this can only be entertained so long as the Save Valley Conservancy subscribes to the same ideals as Sango Ranch (Joubert 1999a).

Table 2. Membership of the Save Valley Conservancy in Zimbabwe.

RANCH	*OWNER*	*AREA IN HA*
Matendere	Pioneer Capital Partners/ARDA	13 123
Gunundwe	B. J. Gouws	11 374
Mapari	H. J. Vorster	23 153
Chishakwe	Rovambira (Pvt) Ltd	9 977
Msaize	Powerlock (Pvt) Ltd	16 340
Chapungu	Zimbabwe Sun Ltd	12 976
Umkondo Mine	Bikita Rural Council	6 627
Savuli	Savuli Property Investments (Pvt) Ltd	5 529
Mokore	Mokore Ranch (Pvt) Ltd	7 451
Bedford Block	Dunmow (Pvt) Ltd	12 215
Humani	Humani Estates (Pvt) Ltd	41 158
Angus	Sabi Star Enterprises (Pvt) Ltd	15 792
Mukazi River	Mukazi River Ranch (Pvt) Ltd	11 457
Mukwazi	Wenhope (Pvt) Ltd	12 549
Senuko	Senuko Ranching (Pvt) Ltd and Save Lodges (Pvt) Ltd	24 120
Masapas	Bataleurs Peak Farm Holdings (Pvt) Ltd	15 437
Levanga	Kingsbrook (Pvt) Ltd	13 040
Mkwasine	Mkwasine Ranching Co. (Pvt) Ltd	12 547
Impala	Fair Range Estates (Pvt) Ltd	13 040
Potential	ARDA	12 146
Sango	Pabst Holdings (Pvt) Ltd	44 348
Mkwasine Estate	Mkwasine (Pvt) Ltd	3 502
Hammond	Mid-West Ranching Ltd, Nyerzi Safari s	12 109
Total		345 067

A further objective of the owners of Sango Ranch is to consolidate their interests in such a way that they can give effect to their objectives, either as part of the Save Valley Conservancy, or independently when the Save Valley Conservancy disagrees with their objectives (Joubert 1999a). To achieve such independence, Sango Ranch must be managed as a self-sufficient ecological unit and it must also be in a position to enter into co-operative partnerships with its immediate neighbours. Sango Ranch could at present, with some constraints, be managed as an ecological unit, but the addition of neighbouring properties would greatly enhance the ecological integrity of the area, and also provide additional opportunities in terms of socio-economic objectives. The Umkondo Lease is a property situated approximately midway along the southern boundary of Sango Ranch and comprises 6 627 ha (Figure 2). Umkondo is an arid area with no natural surface water resources and is not ecologically self-sustaining. However, its addition can make a major contribution towards the ecological integrity of Sango Ranch and also ease management practices by straightening its southern boundary.

A number of wards of the Devuri Resettlement Scheme adjoin the western boundary of the Save Valley Conservancy. Sango Ranch shares a common boundary of 16 km with this Scheme and it is envisaged that an area, approximately 5 km wide, on the eastern half of these wards could be incorporated into the Save Valley Conservancy or Sango Ranch (Joubert 1999a). Throughout these eastern areas local residents are sparsely distributed and are, with the exception of a single village, confined to scattered homesteads. The local community utilises this land for stock ranching with cattle and goats and for dryland agriculture. However, because of the recurrence of frequent droughts both forms of land use have largely failed, or are at best unreliable. Any neighbouring properties within the Save Valley Conservancy that may become available for acquisition will also be considered for consolidation into Sango Ranch. The achievement of these objectives will rely heavily on the reintroduction and/or augmentation of key animal populations of which the numbers have been depleted by past land uses (Joubert 1999a). Animals enjoying the highest priority in this regard are buffalo, sable antelope, roan antelope and tsessebe.

Sango Ranch has committed itself to play a constructive role in applying sound ecological principles in its land management practices, and to strive towards economic viability and social upliftment (Joubert 1999a). These ideals would preferably be met within the framework of the Save Valley Conservancy, on condition that the same ultimate goals, as set out in the vision and mission statements of the Sango Ranch, are accepted and implemented by its members.

CHAPTER 4

SOILS

INTRODUCTION

Soil forms an important part of the ecology of natural ecosystems in semi-arid regions (Venter 1990). Soil plays a role in the supply of nutrients to plants; the development and distribution of roots; and the movement of nutrients, water, and air to the root surfaces for absorption (Foth 1990). Soil properties such as depth, texture and structure determine the quantity and availability of soil water, and together with soil nutrients, are reflected in the vegetation of the area. The physical and chemical properties of soil can also influence the species composition and structure of the vegetation (Kruckeberg 1969, In: Fraser, Van Rooyen and Verster 1987). In semi-arid areas there is usually a good correlation between geological formations, soil forms and plant communities (Bredenkamp 1982; Coetzee 1983; Gertenbach 1987; Van Rooyen and Theron 1989; Venter 1990). The soils thus often determine the type of plant community growing on them. The close relationship existing between soil and vegetation is a useful aid in the mapping of vegetation types (Fraser *et al.* 1987). Soil chemistry and physics also affect the productivity and palatability of the vegetation (Van Rooyen and Theron 1995). The potential grass composition and grazing capacity of an area can also be derived from the soil properties (Coetzee 1983). Soil type therefore has an important influence on the grazing and browsing capacity of an area.

Soil type can also have a great influence on man-made structures. Therefore it must be taken into account during the planning and placing of buildings, dams, sewage pipes, water pipes and roads (Du Toit and Van Rooyen 1995; Van Rooyen *et al.* 1996). The main objectives of soil surveys in studies of the type carried out here are to gain a basic knowledge of the physical and chemical properties of the soils so as to enable an interpretation of the results derived from the vegetation studies carried out, and to classify the soils to help define management units and a management strategy for these units (Schmidt 1992). For these reasons it was therefore necessary to conduct a superficial soil survey on Sango Ranch.

The objectives of the soil survey were to:

- Describe the general soil types occurring in the study area.
- Classify the soils according to a recognised system.
- Describe the physical and chemical properties of these soils.
- Identify sensitive areas.

- Use the soil data to assist in the interpretation of data from the vegetation surveys.
- To explain the distribution of plant communities.

METHODS

The soils of the study area were surveyed according to the methods used by Bredenkamp (1982), Coetzee (1983), Bloem (1988), Pauw (1988), Sievers (1991), Schmidt (1992), Smith (1992) and Coetsee (1993).

Selection of sample sites

Sample sites were chosen in such a way that the dominant soil forms in each management unit were surveyed. The management units are discussed in Chapter 5. Sites were selected in a stratified random manner from sites used during the Braun-Blanquet survey (Chapter 5). Enough sites were selected to include at least two profile pits in each soil colour and texture variation and in each vegetation unit. In this way 98 soil profiles were dug to represent each geological, vegetation and terrain unit. Profiles were dug 1.2 m deep or until rock was reached.

Classification of soils

Each profile pit was classified according to the Zimbabwe Soil Classification System of Thompson (1965). The Zimbabwean classification system was used to allow for comparisons with other local soils studies. Because of the scale of the survey and a lack in detail of the classification system, profiles were classified only to family level. Where possible, equivalents in the United States Department of Agriculture (USDA) Soil Classification System (Soil Survey Staff 1994) are given. The horizons were tested with 10 % HCl for the presence of carbonates. Samples and photographs were also taken of each horizon.

Physical and chemical analysis

The physical information that was recorded in the field at each soil profile included:

1. Soil colour (Munsell Soil Color Chart 1954).
2. Geological type.
3. Percentage clay (FSSA 1974).
4. Soil depth (Bloem 1988).
5. Root depth (Bloem 1988).
6. Water depth (Bloem 1988).
7. Degree of moistness (Coetsee 1993).

8. Rock or stone size.

Soil samples were also taken from the topsoil and sub-soil at each profile pit. The topsoil is defined as the upper 50 mm of the soil. Soil samples considered to be most representative of each type were then analysed physically and chemically at a soil analytical laboratory.[9] Soil texture and the chemical properties phosphate concentration(P_2O_5), exchangeable cations, anions ($S0_4^2$ and NO^3), electrical conductivity, pH ($CaCl_2$), mineral nitrogen (N), and copper (Cu) were analysed. Soil texture was determined with the soil hydrometer method.[9] In some cases texture was determined using the sausage method (National Working Group for Vegetation Ecology 1986). Mineral nitrogen was extracted using 1M KCl Nitrate reduced to ammonia with Devarda's alloy. All ammonia was displaced by MgO and steam distilled over.[9] Titration was done with 0.0025M H_2SO_4.[9] Exchangeable cations were extracted using 1.0M ammonia acetate pH 7.0 and determined by I.C.P.[9] Nitrate and sulphate are water soluble and were extracted using 0.01M KH_2PO_4.[9] The nitrate and sulphate concentrations were then determined by ion micrograph.[9]

RESULTS AND DISCUSSION

The soil map for Sango Ranch appears in Figure 8. The classification and chemical analytical data for the soils of Sango Ranch appear in Tables 3 and 4, and the physical analytical data in Table 5. Data are given for each of the six management units as identified and described in Chapter 5.

The *Acacia tortilis* Open Woodland Management Unit

The soils of this unit are all a mosaic of siallitic soils of the Calcimorphic Order and saline-sodic soils of the Natric Order and are found on the footslopes of the floodplains of the Msaizi, Makore, Saindota and smaller rivers (Figure 8). The 4U family of siallitic soils is derived from alluvium (Nyamapfene 1991). Siallitic soils correspond to the Inceptosols, some Entisols and vertic sub-groups of Aridosols and Alfisols of the USDA Soil Classification System (Nyamapfene 1991). The P_2O_5 value in the topsoil is fairly high in comparison with the results for the other management units (Table 3). According to Brady (1974) phosphorous availability is highest between pH values 5.0 and 7.0 and the results for the *Acacia tortilis* Open Woodland Management Unit indicate a high phosphorous availability. The soils of the Siallitic Group are relatively unleached and possess a high base status. Total exchangeable bases (TEB)/100 g clay values are not less than 31

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[9] Aglab, PO Box 2472, Harare, Zimbabwe.

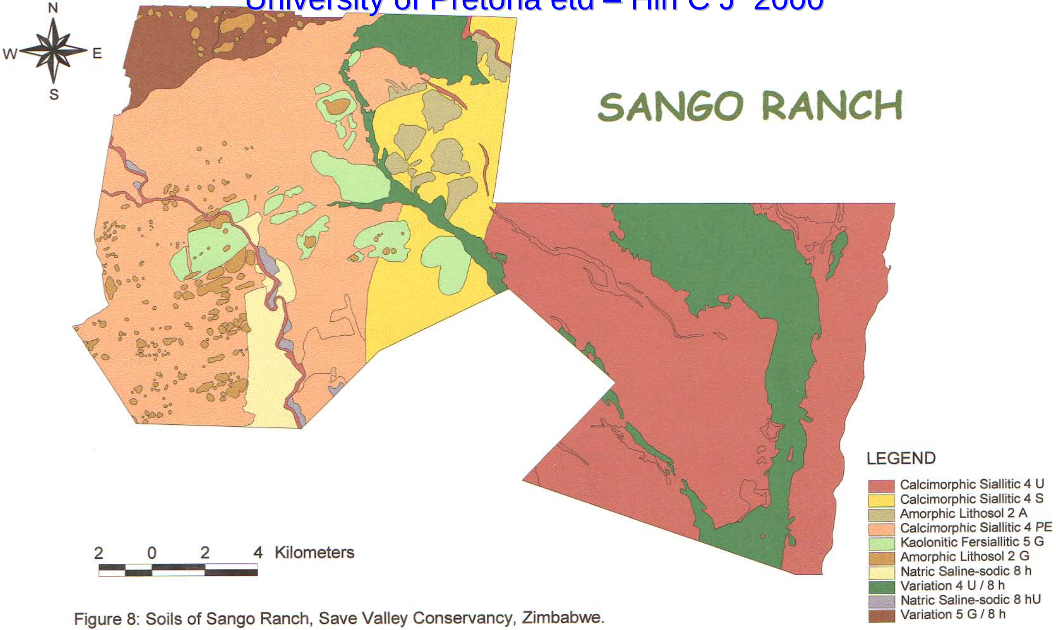

Figure 8: Soils of Sango Ranch, Save Valley Conservancy, Zimbabwe.

Table 3. Chemical analytical data of the most common soils of the six management units of Sango Ranch, Save Valley Conservancy, Zimbabwe. Dash indicates no results obtained.

MANAGEMENT UNIT	SOIL ORDER	SOIL GROUP	SOIL FAMILY	SOIL LAYER	PH AS $CaCl_2$	CONDUCTIVITY IN MICROS/CM	NITROGEN IN PPM	P_2O_5 IN PPM
Acacia tortilis Open Woodland	Calcimorphic	Siallitic	4U	topsoil	6.6	50	4	111
				subsoil	5.5	30	5	9
	Natric	Saline-sodic	8h	topsoil	6.6	60	9	141
				subsoil	6.9	290	2	16
Colophospermum mopane Woodland	Calcimorphic	Siallitic	4S/4U/4PE	topsoil	5.1	60	9	9.1
				subsoil	5.9	50	7	13
	Amorphic	Lithosol	2A	topsoil	7.5	10	-	-
				subsoil	8.1	20	-	-
Combretum apiculatum Woodand	Calcimorphic	Siallitic	4PE	topsoil	4.9	70	248	8
				subsoil	4.6	40	9	2
	Kaolinitic	Fersiallitic	5G	topsoil	5.7	30	4	47
				subsoil	4.2	20	4	6
	Natric	Saline-sodic	8h	topsoil	7.0	180	12	25
				subsoil	7.0	120	2	20
	Amorphic	Lithosol	2G	topsoil	5.8	90	27	42
				subsoil	-	-	-	-
Acacia tortilis Closed Woodland	Calcimorphic	Siallitic	4U	topsoil	6.0	60	-	-
				subsoil	6.7	80	-	-
Diospyros mespiliformes Riverine	Calcimorphic	Siallitic	4U	topsoil	5.1	40	8	34
				subsoil	6.4	40	1	18
Echinochloa colona Wetland	Calcimorphic	Siallitic	4U	topsoil	6.1	90	5	42
				subsoil	-	-	-	-

Table 4. Further chemical analytical data of the most common soils of the six management units of Sango Ranch, Save Valley Conservancy, Zimbabwe. Dash indicates no results obtained.

MANAGEMENT UNIT	SOIL ORDER	SOIL GROUP	SOIL FAMILY	CATIONS CMOL+/KG					TOTAL BASES CMOL+/100G CLAY	ANIONS ppm		FREE CARBON
				Ca^{2+}	K^+	Mg^{2+}	Na^+	S-VALUE		SO_4^2	NO^3-N	
Acacia tortilis Open Woodland	Calcimorphic	Siallitic	4U	2.2	0.62	2.37	0.15	5.35	104.9	3	1	None
				1.9	0.30	0.86	0.04	3.11	124.4	3	1	None
	Natric	Saline-sodic	8h	6.7	0.50	2.03	0.07	9.25	149.2	5	9	Present
				62.3	1.72	5.78	4.97	74.75	1052.8	29	1	Present
Colophospermum mopane Woodland	Calcimorphic	Siallitic	4S/4U/4PE	2.8	0.30	1.16	0.02	4.33	96.2	3	8	None
				5.5	1.15	2.79	0.13	9.60	147.7	5	6	Present
	Amorphic	Lithosol	2A	-	-	-	-	-	-	-	-	None
				-	-	-	-	-	-	-	-	Present
Combretum apiculatum Woodland	Calcimorphic	Siallitic	4PE	0.8	0.14	0.4	0.03	1.37	26.9	18	24	None
				0.4	0.09	0.40	0.06	0.94	22.4	5	8	None
	Kaolinitic	Fersiallitic	5G	1.0	0.14	0.50	0.02	1.64	29.8	3	<1	None
				0.4	0.12	0.62	0.11	1.23	153.8	3	1	None
	Natric	Saline-sodic	8h	73.4	0.72	5.26	0.27	79.68	538.4	8	18	Present
				37.2	1.39	10.99	1.65	51.27	242.99	6	1	Present
	Amorphic	Lithosol	2G	15.2	0.40	3.61	0.03	-	19.28	5	15	None
				-	-	-	-	-	-	-	-	None
Acacia tortilis Closed Woodland	Calcimorphic	Siallitic	4U	-	-	-	-	-	-	-	-	Present
				-	-	-	-	-	-	-	-	Present
Diospyros mespiliformes Riverine	Calcimorphic	Siallitic	4U	2.1	0.46	1.22	0.06	3.79	74.3	3	6	None
				6.6	0.29	2.43	0.20	9.55	212.0	4	<1	None
Echinochloa colona Wetland	Calcimorphic	Siallitic	4U	10.0	0.68	5.08	0.51	16.28	178.9	15	1	None
				-	-	-	-		-	-	-	None

Table 5. Physical analytical data of the most common soils of the six management units of Sango Ranch, Save Valley Conservancy, Zimbabwe. Dash indicates no results obtained. Asterisk indicates sausage method[a] used.

MANAGEMENT UNIT	SOIL ORDER	SOIL GROUP	SOIL FAMILY	SOIL LAYER	% SAND	% SILT	% CLAY	TEXTURE	SOIL COLOUR	SOIL DEPTH (m)
Acacia tortilis Open Woodland	Calcimorphic	Siallitic	4U	topsoil	85.34	5.10	9.58	Sandy loam	Very dark grey	>1.2
				sub-soil	85.64	2.50	11.86	Sandy loam	Dark reddish brown	-
	Natric	Saline-sodic	8h	topsoil	81.94	6.20	11.86	Sandy loam	Dark brown	>1.2
				sub-soil	74.74	7.10	18.16	Sandy loam	Light grey	-
Colophospermum mopane Woodland	Calcimorphic	Siallitic	4S/4U/4PE	topsoil	83.04	4.50	12.46	Sandy loam	Dark brown	>1.2
				sub-soil	67.04	6.50	25.46	Sandy loam	Dark brown	-
	Amorphic	Lithosol	2A	topsoil	-	-	-	Sandy clay*	Dark reddish brown	0.2
				sub-soil	-	-	-	Rock	-	-
Combretum apiculatum Wodland	Calcimorphic	Siallitic	4PE	topsoil	86.44	5.1	8.46	Sandy loam	Strong brown	>1.2
				sub-soil	87.64	4.2	8.16	Sandy loam	Strong brown	-
	Kaolinitic	Fersiallitic	5G	topsoil	87.66	5.5	8.16	Sandy loam	Very dark brown	0.6
				sub-soil	87.34	0.8	11.86	Sandy loam	Yellowish red	-
	Natric	Saline-sodic	8h	topsoil	61.04	14.8	24.16	Clay loam	Strong brown	-
				sub-soil	55.04	21.1	23.88	Sandy clay loam	Strong brown	<1.2
	Amorphic	Lithosol	2G	topsoil	80.74	11.10	8.16	Sandy loam	Black	0.25
				sub-soil	-	-	-	Rock	-	-
Acacia tortilis Closed Woodland	Calcimorphic	Siallitic	4U	topsoil	-	-	-	Sandy loam*	Very dark grey	>1.2
				sub-soil	-	-	-	Sandy loam*	Very dark grey	-
Diospyros mespiliformes Riverine	Calcimorphic	Siallitic	4U	topsoil	-	-	-	Sandy loam*	Dark yellowish brown	>1.2
				sub-soil	85.34	4.5	10.16	Sandy loam	Dark brown	-
Echinochloa colona Wetland	Calcimorphic	Siallitic	4U	topsoil	60.74	9.1	30.16	Clay loam	Very dark grey	>1.2
				sub-soil	-	-	-	-	-	-

[a] – According to National Working Group for Vegetation Ecology (1986).

and cation exchange capacity (CEC)/100 g clay values are not less than 35 (Nyamapfene 1991). The upper limit is undefined and is relatively open (Nyamapfene 1991). The E/C value (TEB per 100 g clay) for this management unit lies beyond this limit at 104.9 (Table 4) which indicates a high base status which in turn indicates a high level of productivity (Nyamapfene 1991). Free carbonates were detected in some profiles (Table 4). The siallitic soils contain relatively high amounts of both kandites and 2:1 clay minerals (Nyamapfene 1991). The composition and proportions vary according to parent material and topographic position. According to Nyamapfene (1991), soils derived from siliceous parent materials have low amounts of smectite. However, siallitic soils found around vleis tend to have high amounts of smectite and vermiculite and may therefore have vertic properties. Most siallitic soils also contain considerable reserves of feldspar and other weatherable materials.

The clay content is also usually moderate to high. However, the content for the soils of the *Acacia tortilis* Open Woodland Management Unit is low because Siallitic soils of relatively low clay content may develop from siliceous parent material in low lying areas where bases can accumulate (Nyamapfene 1991). The soils are deep, extending below 1.2 m of the surface (Table 5). The soils are sandy; being classified as sandy loam (Table 5). In sandy soils the moisture is immediately available for the rapid germination of seeds and the regrowth of perennial grasses following light rains (Pauw 1988). The grasses growing on these soils are generally highly palatable and are classified as sweetveld (Nyamapfene 1991). Sandy soils, however, possess a poor water holding capacity and thus dry out very quickly. The high temperatures experienced in the Save River Valley contribute to this phenomenon. The soils in this management unit become hard when dry.

Because of the low rainfall, weathering intensity is low in the siallitic soils and there is generally insufficient moisture for extensive leaching to occur (Nyamapfene 1991). However, the soils are susceptible to sheet erosion by the considerable runoff which results from high rainfall.

Weakly saline-sodic soils are found adjacent to the Save River and on the floodplain of the Msaizi and other smaller rivers (Figure 8). These soils belong to the Sodic Group of Thompson (1965) and correspond to the Alfisols and Inceptisols of the USDA classification system (Nyamapfene 1991). Nyamapfene (1991) also reports on the occurrence of saline-sodic soils in the Save Valley. These soils have a limited and patchy distribution on Sango Ranch, occurring in pan depressions and along diffuse drainage lines. The soils of this group belong to the 8h family and are derived from alluvium. The restricted drainage and possible presence of parent material rich in sodium-releasing feldspars are the reasons Nyamapfene (1991) gives for the sodic properties of this soil. Saline-sodic soils are also found in the *Colophospermum mopane* Woodland Management Unit especially along drainage lines and in depressions on alluvium. The sodium cation, calcium cation, electrical conductivity, phosphorous content, E/C value and sulphur content are high in comparison to other soils of Sango Ranch (Tables 3 and 4). The high sodium and electrical conductivity suggest a saline-sodic nature (Foth 1990). Important properties of this soil are the high erodability, compacted and hard subsoil horizons and surface capping. The two latter properties result in bare patches on which few plants are able to grow. The soil pH is neutral and this property makes the soil more favourable for plant growth than strongly sodic soils (Nyamapfene 1991). Woody species such as *Salvadora australis* and *S. persica* and herbaceous species such as *Sporobolus nitens* and shallow rooted forbs are commonly found on sodic soils (Chapter 5). The surface soil is lightly textured and provides the rooting medium for plants while the impermeable subsoil creates conditions which allow appreciable amounts of water to remain within the zone in which roots can reach it (Nyamapfene 1991).

The *Colophospermum mopane* Woodland Management Unit

The soils of the *Colophospermum mopane* Woodland Management Unit fall into two groups: Siallitic Group and Lithosol Group. The siallitic soils of the *Colophospermum mopane* Woodland Management Unit are very similar to those of the *Acacia tortilis* Open Woodland Management Unit and are found on the mid-slope position (Figure 8). The soils in this area belong to the 4S, 4U and 4PE families. The 4S soils are derived from quartzites, shales, lavas and limestone while the 4U soils are alluvial and the 4PE soils are of gneissic origin (Nyamapfene 1991). The soils of the *Colophospermum mopane* Woodland Management Unit, however show a lower phosphorous content, a slightly higher nitrogen value (Table 3), and a higher E/C value and clay content in the subsoil horizon than in the topsoil horizon (Tables 4 and 5). The high clay content is associated with a high soil nutrient availability and therefore a high fertility. According to Nyamapfene (1991) the leaves of *Colophospermum mopane* occurring on siallitic soils have a high protein content and nutritive value. The bare soils in the *Colophospermum mopane* Woodland Management Unit are particularly vulnerable to high water runoff and sheet erosion.

Lithosols of the Amorphic Order are found on the uplands and koppies (Figure 8). These soils are shallow having a depth of less than or equal to 250 mm and overlie hard or partially weathered rock (Thompson and Purves 1978). The Lithosols of the *Colophospermum mopane* Woodland Management Unit belong to the 2A family. The soils vary widely in soil reaction, clay content and morphology according to the parent material from which they are derived. In this case the soils are derived from quartzite, shales, and lavas of the Umkondo System and grits and conglomerates of the Karoo Group. The Lithosols correspond to the Entisols and Inceptisols of the USDA classification system (Nyamapfene 1991). The electrical conductivity is low, the pH is slightly alkaline and the texture is sandy clay (Tables 3, 4 and 5). No other chemical and physical data are available for the Lithosols of this management unit. The shallowness of these soils and the steep slopes on which they are generally found results in a high potential for erosion. These soils also possess a poor water holding capacity and are extremely susceptible to desiccation. Several trees on Lithosols died during the 1992 drought and this is probably because of the shallowness of the soils.

The *Combretum apiculatum* Woodland Management Unit

The soils of the *Combretum apiculatum* Woodland Management Unit fall into four groups: Siallitic, Fersiallitic, Lithosol and Saline-sodic. Siallitic soils of the *Combretum apiculatum* Woodland Management Unit are found on the midslopes and footslopes of the granite and gneiss formations in the western half of Sango Ranch (Figure 8). These soils belong to the 4PE soil family and are derived from gneiss. These siallitic soils tend to be rockier than in the *Acacia tortilis* Open Woodland and *Colophospermum mopane* Woodland Management Units and the electrical conductivity, nitrogen content, TEB, and clay content are higher in the topsoil horizon (Tables 3, 4 and 5). The clay content is lower in the subsoil horizon than in the topsoil (Table 5). The soils are slightly acidic indicating slight leaching caused by a sandy nature in the B horizon (Table 3, Table 5). However, these soils are fertile and the vegetation growing on them possesses a high nutritional status and nutritive quality (Nyamapfene 1991). Plants such as *Combretum apiculatum* subsp. *apiculatum* and *Digitaria milanjiana* are found here and are highly nutritious (Van Oudtshoorn 1992; Venter and Venter 1996; Chapter 5).

Soils of the Fersiallitic Group are found on upland areas on granite and mafic granulite and belong to the 5G soil family (Figure 8). These soils correspond to the Alfisols of the USDA classification system (Nyamapfene 1991). These soils are moderately leached with low TEB values. The rainfall in the west of Sango Ranch is slightly higher than the east and accounts for the leached soils (Chapter 2). This is evident from Tables 3 and 4. The soils are slightly acidic and possess a low electrical conductivity and TEB value, especially in the topsoil. The phosphorous content is low in the subsoil horizon. However, phosphorous availability is not a problem (Nyamapfene 1991). The TEB value, however, is high in the sub-soil horizon. Some reserves of weatherable minerals are present in

Fersiallitic soils (Thompson and Purves 1978). The clay content is higher in the subsoil horizon than the topsoil and Nyamapfene (1991) also reports this (Table 5). The dominant clay mineral in most fersiallitic soils is kaolonite, with small amounts of mica and sometimes smectite or vermiculite. These soils are mostly moderately shallow (Table 5). In the lower rainfall conditions of the Save River Valley the parent material is not as highly weathered, as is the case in most other areas in southern Africa with high rainfall (Nyamapfene 1991). The granitic saprolite resulting is relatively impenetrable, which results in conditions leading to temporary periods of water saturation, even in the uplands. This situation, according to Purves (1976 *In:* Nyamapfene 1991), is responsible for the sandy nature of these soils. The fersiallitic soils are generally low in fertility and possess a low water holding capacity.

The Lithosols of the *Combretum apiculatum* Woodland Management Unit are similar to those of the *Colophospermum mopane* Woodland Management Unit, although the Lithosols are derived from granite and gneiss and belong to the 2G soil family (Nyamapfene 1991). The Lithosols of the *Combretum apiculatum* Woodland Management Unit are found on rocky outcrops and koppies in the broken country to the west of Sango Ranch (Figure 8). These soils tend to be extremely shallow and overlie hard unweathered rock. The pH, TEB value, electrical conductivity and phosphorous content are low (Tables 3 and 4). The soils are therefore acidic, leached and the fertility is low. The soils are very sandy with a low clay content and are black in colour because of a high organic content (Table 5).

Weakly saline-sodic soils of the 8h soil family are found adjacent to the Makore River (Figure 8). These soils are derived from gneiss (Nyamapfene 1991). The E/C values, electrical conductivity, nitrogen and clay content are high (Tables 3, 4 and 5). The high erodability of this soil has resulted in the dongas found to the west of the Makore River (Figure 8), where past overgrazing by cattle has exposed the soil. The rolling topography found in this area is caused by erosion along drainage lines. This area is sensitive and management must be applied to remedy the present erosion and prevent future erosion.

The *Acacia tortilis* Closed Woodland Management Unit

The soils of the *Acacia tortilis* Closed Woodland Management Unit are classified as siallitic and are found on the deep alluvium on the banks of the Save River and the floodplain of the Msaizi River near to the point where the Msiazi River ends (Figure 8). These soils belong to the 4U soil family. Free carbonates are present in both the top- and subsoil horizons (Table 4). The texture is a sandy loam and the TEB value is probably high although no data are available (Table 5). The water table in this management unit is high due to the Save River aquifer on which it lies (Chapter 2). The deep moist fertile soils of this management unit support a closed and dense woodland dominated by *Acacia tortilis* subsp. *heteracantha* and a rank herbaceous layer consisting almost exclusively of the highly nutritious and productive shade-loving grass *Panicum maximum* (Chapter 5).

The *Diospyros mespiliformes* Riverine Management Unit

The soils of the *Diospyros mespiliformes* Riverine Management Unit also belong to the Siallitic Group and are found along the banks of the larger rivers, particularly along the Save River (Figure 8). The soils are fertile with a high water holding capacity and belong to the 4U family. The high moisture content supports a very dense and closed riverine forest dominated by large trees and impenetrable thickets. Severe siltation of the Save River has resulted in the deposition of silt that eventually forms islands. The soils of these islands are deep and sandy and are initially highly unstable. They are stabilised by pioneer plants such as *Phragmites mauritianus* and *Ficus capreifolia* and later by *Faidherbia albida*. The islands eventually become permanent with the development of the sub- to climax community dominated by extremely large specimens of *Albizia glaberrima* var. *glabrescens* (Chapter 5). Colour mottles are sometimes visible because of a fluctuating water table.

The *Echinochloa colona* Wetland Management Unit

The soils of the *Echinochloa colona* Wetland Management Unit also fall in the Siallitic Group and are found in and around the Sune, Masiyauta, Chinga and other smaller pans (Figure 8). These soils are classified into the 4U soil family. In some cases the soils are vertic with large visible surface cracks. This is particularly evident around Sune Pan. The soils possess a high fertility due to the high clay content (Tables 3 and 4). The soils are also slightly saline-sodic but do not qualify as Saline-Sodic as defined by Thompson (1965). The soils possess a high water retention and are saturated for most of the year. In some cases colour mottles are evident due to the fluctuating water table. The grazing in these pans is nutritious because of the highly fertile soils.

CONCLUSION

The soils of Sango Ranch are highly variable ranging from deep, fertile, unleached, alkaline soils to shallow and infertile acidic soils. The fertile alkaline siallitic soils support a sweeter veld than the shallower more leached acidic soils of the Fersiallitic and Lithosol Groups. Most of the soils are vulnerable to erosion, especially where the vegetation is removed on steep slopes. Care should be taken when constructing gravel roads in the upland areas of the *Colophospermum mopane* Woodland and *Combretum apiculatum* Woodland Management Units. The midslope and footslope soils of the *Colophospermum mopane* Woodland Management Unit are also susceptible to erosion especially in areas with a low ground cover and also in the saline-sodic areas. An area of high concern with regards to erosion is the B6 area where considerable erosion has already taken place. The soils have a blocky structure and with the undulating terrain contribute to the high degree of erodability. The road passing through this area should be closed and re-routed in order to allow the area an opportunity to recover. No permanent waterholes or dams should be constructed in this area. Veld burning should not be applied in this area. A fire will remove the ground cover, resulting in exposure of the soil which could further aggravate the erosion problem. It is recommended that rehabilitation measures be taken in this area.

CHAPTER 5

VEGETATION

INTRODUCTION

PHYTOSOCIOLOGY

A plant community is a combination of plants that are dependent on their environment as well as on each other (Mueller-Dombois and Ellenberg 1974). Plant communities with similar interrelationships and environmental parameters often reflect similar floristic compositions (Westhoff and Van der Maarel 1982). Vegetation cover can therefore be divided into subunits of plant communities. The description and classification of such uniform or homogeneous units form the basis for phytosociological studies. The method of phytosociology used here is known as the Braun-Blanquet, the relevé or Zurich-Montpellier method, and is regarded as the standard method of vegetation survey and classification in most countries (Werger 1974). The method has been widely used in South Africa (Werger 1974; Bredenkamp and Theron 1976; Bredenkamp 1982; Behr and Bredenkamp 1988; Pauw 1988; Bredenkamp, Joubert and Bezuidenhout 1989; Kooij, Bredenkamp, and Theron 1990; Matthews 1991; Schmidt 1992; Van Heerden 1992; Schulze, Theron and Van Hoven 1994; Bezuidenhout 1994; Bezuidenhout 1995; Brown, Bredenkamp and Van Rooyen 1995; Orban 1995; Swart 1995; Brown, Bredenkamp and Van Rooyen 1996; Visser, Van Hoven and Theron 1996; Cilliers and Bredenkamp 1999). Scheepers (1983) suggested that the method be standardised for all phytosociological studies in South Africa. The Braun-Blanquet method may be used in all vegetation types south of the equator (Werger 1974). Myre (1960, 1962, 1964) applied the method in southern Mozambique and Volk and Leippert (1971) applied it in the Windhoek area, Namibia (Werger 1974). Werger, Wild and Drummond (1978) used the Braun-Blanquet approach in northern Zimbabwe, Cauldwell, Zieger, Bingham and Bredenkamp (1998) used the method in Central Province, Zambia and Botha (1999) used it in Central Kenya. Bredenkamp and Theron (1978) point out that the Braun-Blanquet method is advantageous for the management of natural plant communities. The method allows a hierarchical classification of vegetation into floristically and environmentally related groups. Numerous small vegetation communities, showing certain ecological similarities are grouped successively into larger, more practical units known as management units. A management programme can then be adapted and applied at different levels in the hierarchy of communities.

WOODY VEGETATION STRUCTURE

Peel (1990) considers the woody layer to be important to the ecology of an area for two reasons. Firstly, it provides an important food source and habitat for animals, especially browsers. Secondly, the woody plants exert an important influence on the species composition of the herbaceous layer. Similarly, Smit (1989a, 1989b, 1994, 1996) considers woody vegetation to be important due to competition with herbaceous vegetation for moisture; food for browsers; and the creation of subhabitats suitable for certain grasses.

Tainton (1981) states that in savanna communities the tree component of the vegetation should be analysed together with the herbaceous layer. A structural survey of the woody layer will allow the identification of bush encroachment, will indicate the success of an encroachment controlling programme, will give an indication of the available browse, and will indicate the condition of the woody layer in general.

The identification of vegetation communities and homogeneous units is invaluable in drawing up a management plan for an area (Bredenkamp and Theron 1978). Each homogeneous unit can be managed according to its specific environmental conditions and similar units can be grouped to form management units. A survey of the woody layer is essential to gain an understanding of the ecology of an area. Such a survey will allow the manager to determine the condition, species composition and structure of the woody layer in each homogeneous unit and this will then allow him to make certain decisions regarding the clearing of encroaching bush and also the suitability of each habitat for ungulates.

The objectives of phytosociological and structural assessments are to:

- Identify, describe, classify and map the homogeneous plant communities of the area.
- Compile a plant species list.
- Identify protected or endangered plant species.
- Identify ecologically sensitive areas.
- Identify problem plant species.
- Identify environmental parameters important in influencing the vegetation.
- Delineate management units for use in the future management of the study area.
- Describe the composition and structure (percentage canopy cover, density, leaf biomass) of the various layers within the woody vegetation layer in each of the homogeneous plant communities of the area.

METHODS

PHYTOSOCIOLOGICAL ASSESSMENT

The non-statistical Braun-Blanquet method, as described by Mueller-Dombois and Ellenberg (1974), Werger (1974) and Westhoff and Van der Maarel (1982), was used to classify the vegetation of Sango Ranch into homogeneous physiognomic-physiographic units. Phytosociological studies can be divided into an analytical and a synthetic phase (Werger 1974; Westhoff and Van der Maarel 1982). In the analytical phase the environmental, floristic and structural data are collected in the field. The data are then classified in the synthetic phase, to deliver the delineation of plant communities on the basis of their floristic and structural differences (Schmidt 1992).

Analytical Phase

The analytical phase was done over two growing seasons in 1998 and 1999, from mid-February to mid-May. An initial reconnaissance survey was done in January and February 1998 to become familiar with the topography and vegetation of the area. Voucher specimens of conspicuous plants were collected throughout the study period and were identified by the staff of the Harare National Herbarium in Harare, Zimbabwe.[10]

The study area was stratified into relatively homogeneous physiographic-physiognomic units by recognising and mapping possible uniform vegetation units from stereo aerial photographs (1:25 000) by means of a stereoscope (Walker 1976a). The physiographic-physiognomic units were drawn on a transparency and were then overlaid at the correct scale on a 1:50 000 topocadastral map. A geological map was also used to further assist in the identification of physiographic-physiognomic units. The stratification was reinforced by referring to all possible published environmental information and vegetation data relevant to the study area (Matthews 1991). The detailed vegetation descriptions of Wild (1955), Rattray (1957), Rattray (1961) and Farrell (1968) were used in this respect. All possible topographical, geological and soil types should be represented (Potgieter 1982). This enabled a sound stratification of the study area for efficient sampling of the representative vegetation types.

An attempt was made to place the plots in such a way that the habitat within the sample plots was as uniform as possible within each vegetation stand (Mueller-Dombois and Ellenberg 1974). Because homogeneity is extremely difficult to test

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[10] National Herbarium, PO Box CY550, Causeway, Harare, Zimbabwe.

for statistically it was assessed visually (Werger 1974). Care was taken that no plots were placed in ecotonal or degraded areas.

Subjective stratified random sampling was used to allocate sample plots *pro rata* to the size of the physiographic-physiognomic units. The number of plots thus allocated to a physiographic-physiognomic unit depended on the size of that unit. This ensured that areas were not over- or undersampled. The sample plots were then placed randomly within each homogeneous vegetation unit. Stratified random sampling allows sampling over the whole vegetation unit, while still ensuring that statistical errors are kept to a minimum (Mueller-Dombois and Ellenberg 1974).

The number and size of plots depended entirely upon the scale of the survey, the variation in the vegetation and the detail required (Werger 1974; Bredenkamp 1982). The time available and cost involved were also important determinants. The number and size of plots were chosen to reflect the total variety within the study area as adequately as possible (Werger 1974). Westfall (1981) suggested using a minimum of 10 plots per community. Barkman, Moravec and Rauschert (1976) stated that 10 relevés are the minimum required for an original diagnosis of an association or sub-association. Van Rooyen (pers. comm.)[11] suggested a minimum of five quadrats per homogeneous vegetation unit, and this was used. A total of 230 plots equating to one plot per 193 ha was therefore used.

Plot size was fixed at 200 m^2 (20 x 10 m) for savanna areas, because this size has been widely used in studies in the bushveld areas of South Africa (Coetzee 1983; Pauw 1988; Schmidt 1992; Van Heerden 1992; Schulze *et al.* 1994; Orban 1995). As far as possible the plots were rectangular, but in certain cases the plots were shaped as to conditions to ensure homogeneity (Kooij 1990; Matthews 1991). The plots were placed in a north-south direction or along a specific gradient. The physiographic-physiognomic units and plots were confirmed in the field and were sometimes adapted as required. Where the pre-determined position of the sample plots did not meet the requirements mentioned above, or fell on roads and other structures (Matthews 1991), the plots were moved to more suitable areas in compliance with the Braun-Blanquet methods (Werger 1974).

In the Braun-Blanquet method a complete species list of vascular plants is normally compiled for each stand to derive a comprehensive floristic description (Werger 1974). However, this requirement cannot always be met in arid and semi-

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[11] Prof. N. van Rooyen, Department of Botany, University of Pretoria, Pretoria, 0002, South Africa.

arid areas (Werger 1974). The time available and the extent of the study area prevented multiple visits to each plot site. Therefore an attempt was made to compile as complete a species list as was possible in the time available.

Taxa were identified as far as possible in the study area by using the relevant field guides and keys and with the aid of species lists compiled by Wild (1955), Rattray (1957, 1961) and Farrell (1968). These were confirmed by Drummond[12] at the Harare National Herbarium. Voucher specimens were collected and pressed in triplicate according to the specifications of Fish (1997). The specimens are housed at Sango Ranch with another set at the National Herbarium in Harare. Taxa are named according to Arnold and De Wet (1993). A list of plant species with author names appears in Appendix A.

A Global Positioning System (GPS) reading in longitude and latitude and a terrain description were taken at each sample plot to facilitate future location of the specific stand. At each stand, species cover was estimated with the following cover-abundance scale given by Werger (1974):

5: any number with cover >75%
4: any number with cover >50-75%
3: any number with cover >25-50%
2b: any number with cover >12-25%
2a: any number with cover 5-12%
1: numerous, less than 5% cover or -+scattered
+: few, with small cover
r : solitary, with small cover

The following habitat factors (Pauw 1988; Schmidt 1992) were also recorded and placed into the relevant categories at each sample site:

1. Aspect.
2. Altitude in metres above sea level.
3. Exposure.
4. Gradient: 0-3° (flat), 4-8° (gradual), 9-16° (average), 17-26° (steep) and 27-45° (very steep).
5. Geomorphology: flat, concave or convex.
6. Topography: mountain, ridge, tallus, kloof, valley, plain, vlei, pan, floodplain, riverbed and riverbank.
7. Geology.

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[12] Mr R.B. Drummond, 5 Chatsworth Road, Mt. Pleasant, Harare, Zimbabwe.

8. Percentage rock cover.
9. Rock/stone size: ≥10 mm (gravel), 11-50 mm (small stones), 51-200 mm (stones), ≥200 mm (rocks).
10. Degree of erosion: none, slight, moderate, severe.
11. Type of erosion (Anon. 1988): none, sheet, groove, donga, wind.
12. Intensity of burn (Joubert 1983): none, light, moderate, heavy.
13. Degree of trampling: none, slight, moderate, severe;
14. Degree of utilisation of the herbaceous layer (Coetsee 1993): none, slight, moderate, severe.
15. Biotic influences such as fire, termites and overgrazing.
16. Soil factors as determined from the soil survey.

The vegetation structure at each relevé was described according to a system of structural classification (Edwards 1983). The total canopy cover of the tree and shrub layers were recorded using the line intercept method (Mueller-Dombois and Ellenberg 1974) in a north-south directed line-transect starting at each quadrat. Cover values for grasses and herbs were derived from the Braun-Blanquet cover-abundance classes assigned to these layers.

Synthetic Phase

To classify the field data the floristic data in each relevé was consolidated and entered into the computer program TURBOVEG (Hennekens 1996a). The data were then analysed with the program MEGATAB (Hennekens 1996b). Two-Way Indicator Species Analysis (TWINSPAN) (Hill 1979b) is incorporated in the MEGATAB program and was applied to the data set.

Floristic data were also subjected to a Detrended Correspondence Analysis (DECORANA) (Hill 1979a) to determine vegetation gradients and to illustrate gradients common to the vegetation and the environmental factors. The results are depicted in a scatter diagram that may be compiled on any standard spreadsheet program.

Plant communities were named binomially according to the recommendations and guidelines of Barkman, Moravec and Rauschert (1986). The first name is the species name of a diagnostic plant species within the specific community. The second name is that of a dominant species. Diagnostic and dominant species are defined as follows (Schmidt 1992):

- A diagnostic species is one that predominates in one vegetation unit and has a constancy of occurrence of > 75 %, but is not restricted to it.

- A dominant species is one with > 30 % constancy of occurrence in a vegetation unit, with > 20 % cover-abundance values greater than 2b and a minimum of two cover-abundance values of > 2b.

An applicable physiognomic term according to the structural classification of Edwards (1983) is then added to the species names (Pauw 1988; Swart 1995).

Management units were identified on the basis of discontinuity and floristic affinity (Schulze *et al.* 1994). The management units were recognised on a TWINSPAN (Hill 1979b) dendogram showing the hierarchical classification of the major plant communities that was delivered by MEGATAB (Fuls *et al.* 1993). Plant communities showing similar floristic and environmental affinities were grouped into management units.

STRUCTURAL ASSESSMENT OF THE WOODY VEGETATION

Sampling technique

The survey was carried out at the same points as were used for the phytosociological survey. All the woody plants above 0.5 m height (Dörgeloh 1998) rooted within a belt transect (placed north-south) were recorded in compliance with Smit (1989a), Peel (1990), Smit (1994), Orban (1995), and Swart (1995). Since transect size depends on tree spacing (Mueller-Dombois and Ellenberg 1974) a transect of 50 x 2 m was used in the more closed mopane woodlands and one of 100 x 2 m in the more open areas. Because of the difficult terrain a transect of 50 x 2 m was used for surveys on koppies. The dimension meter of Smit (1989c, 1994) was used to measure maximum tree height, minimum tree height, maximum canopy diamater and minimum canopy diameter (Chapter 8). Smit (1989c, 1994) found the dimension meter to be accurate and rapid. The only problem, however, is obstruction by other trees in dense situations and tall grass covering stem bases (Smit 1989c, 1994).

Structural analysis

For classing the trees according to height, the following class levels were used: <0.75 m; 0.75 m-<1.5 m; 1.5 m-<2.5 m; 2.5 m-<3.5 m; 3.5 m-5.5 m; and >5.5 m (Coetzee and Gertenbach 1977). However, since most tall trees fell above these categories, the following categories were added: 5.5-<7.5 m; 7.5-<9.5 m; 9.5-<11.5 m; 11.5-<13.5 m; 13.5-15.5 m; and >15.5 m.

RESULTS AND DISCUSSION

Phytosociological classification

The phytosociological classification of the vegetation of Sango Ranch appears in Tables 6 to 9. The boundaries of the vegetation communities are depicted on a vegetation map (Figure 9). The Braun-Blanquet and TWINSPAN analyses aided in identifying nine plant communities and 16 sub-communities. The TWINSPAN dendogram is presented in Figure 10. The following hierarchical classification of the vegetation of Sango Ranch was made:

1. The *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland
    - 1.1 The *Tephrosia purpurea* subsp. *leptostachya–Urochloa mosambicensis* Short Closed Woodland
    - 1.2 The *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Closed Woodland
    - 1.3 The *Capparis tomentosa–Urochloa mosambicensis* Tall Closed Woodland
    - 1.4 The *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland
2. The *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland
    - 2.1 The *Commiphora edulis–Colophospermum mopane* Short Thicket
    - 2.2 The *Indigofera praticola–Colophospermum mopane* Short Closed Woodland
    - 2.3 The *Thilachium africanum–Colophospermum mopane.* Short Thicket
    - 2.4 The *Ruellia patula–Colophospermum mopane* Tall Closed Woodland
3. The *Combretum apiculatum* subsp. *apiculatum–Colophospermum mopane* Short Closed Woodland
4. The *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland
    - 4.1 The *Dalbergia melanoxylon–Combretum apiculatum* subsp. *apiculatum* Short Closed Woodland
    - 4.2 The *Commiphora africana–Digitaria milanjiana* Tall Closed Woodland
    - 4.3 The *Kirkia acuminata–Panicum maximum* Tall Closed Woodland

Table 6. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 1.

Percentage rock cover	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Herb layer utilisation	2	3	2	5	3	3	3	2	3	3	3	2	2	2	2	2	3	2	3	2	3	2	2	3	3	3	4	3	3	3	3	3	3	2	1	1	3	3	1	2	3	3	3	2	5	1	2	2	2	3	2	2	3	3	2	2	3	2	2	2	2	2	2	2	2
Woody layer utilisation	2	3	2	2	2	3	3	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	2	2	2	3	3	3	4	3	2	2	2	3	2	2	3	3	3	2	5	2	2	2	2	3	2	2	2	2	3	3	2	2	2	2	2	2	2	2	3
Degree of trampling	2	3	2	2	2	2	3	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	3	2	3	3	2	3	2	2	2	2	3	2	3	3	3	3	2	3	1	2	2	3	3	2	2	2	2	2	2	1	1	2	2	2	2	2	2	3
Degree of erosion	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	1	2	1	1	2
Topography	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	PI	FP	FP	FP	PI	FP	PI	PI	FP	FP	FP	FP	PI	PI	FP	Va	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP	FP
Gradient	1	1	1	2	1	2	2	2	2	1	1	2	2	2	2	2	1	2	2	2	2	2	2	1	1	1	1	1	2	1	1	2	1	1	1	1	2	2	2	1	2	2	2	1	1	1	1	2	1	2	1	1	2	1	1	2	1	2	2	2	1	1	1	2	1
Aspect	SE	SE	SE	E	SE	E	E	E	SE	SE	SE	SE	S	SE	E	N	SE	S	SE	SE	S	E	S	E	S	S	S	W	S	W	E	E	SE	E	S	SE	E	N	S	N	SE	SE	SE	SE	SE	W	S	SE	E	SE	SE	SE	N	S	S	E	SE	SE	SE	S	SE	SE	SE	SE	S
Terrain unit	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	3	3	1	2	2	2	2	2	2	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Geology	Sao	Sao	Sao	Sao	All	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	Sao	All	All	All	All	Sao	All	All	Sao	Gne	All	Gne	All	All	All	Gne	Gne	All	All	All	All	Gne	Gne	All	All	All	All	All	All	Sao	All	All	Sao	All	Sao	Sao	Sao	Sao	Sao	Sao	Sao	All
Altitude above sea-level	470	470	470	460	450	460	460	460	480	480	480	470	480	480	540	560	540	540	540	550	550	470	550	450	450	450	450	440	470	450	450	470	560	450	520	470	450	510	520	540	450	420	450	510	570	600	510	550	450	440	470	460	490	440	445	470	450	470	480	560	470	470	480	470	430
Relevé number	10	12	14	30	78	31	29	32	15	7	8	11	27	28	24	6	4	1	2	3	23	35	25	74	84	94	77	91	34	83	82	33	59	75	190	71	101	157	127	209	88	106	93	158	21	147	159	5	76	112	171	201	26	81	80	20	79	17	16	22	19	13	9	18	90
Number of species per relevé	11	10	12	10	6	9	7	9	15	15	07	10	9	9	17	7	9	13	8	9	14	13	12	13	14	12	12	10	8	11	17	12	10	15	30	14	18	18	29	30	18	13	16	12	13	14	12	9	9	10	12	7	13	10	6	10	9	11	7	11	9	8	9	8	7
COMMUNITY	1																																																																
SUB-COMMUNITY	1.1														1.2										1.3										1.4																														
SPECIES GROUP A																																																																	
Hibiscus micranthus	1	+	+	r	+	+																r								1				1																															
SPECIES GROUP B																																																																	
Cissus rotundifolia									+	+	+	+		+								+																	+		+																								
Maerua juncea									+				r																																																				
SPECIES GROUP C																																																																	
Tephrosia purpurea ssp. leptostachya	+		+	1			+	+	+	+	+	+	r	+																	+	1			+		+	1	+							1												1			+		+	+	
SPECIES GROUP D																																																																	
Dichrostachys cinerea ssp. africana															a	a	1	+	+	+	+	r	+	+		+		+		1									+	+						+	+	+			+														
SPECIES GROUP E																																																																	
Capparis tomentosa																									3	1				+		+		+															+						+										
Thilachium africanum																									+	r	1		r				r																																
Maerua decumbens																												+			+																		r																
Salvadora persica																									+	+	a														b																								
Anisotes formosissimus																									+	1		1																																					
SPECIES GROUP F																																																																	
Grewia monticola	a		+						+	+		+	+		+						+	+									+		+	a	+			+	+																						+				
Grewia flavescens			+				+		+							+	+				+		+	+			+				+		1	+																															
Eragrostis cylindriflora								1		+							1	+	+										+																																				
SPECIES GROUP G																																																																	
Ipomoea sinensis																																			+	+		+	+	1													r												
Hermannia glanduligera																				r															+		+			+																									
Cyathula orthacantha																																			+	+			+																										
Aristida congesta										+																					+					+	1																												
Heliotropum strigosum																																			+			+																											
Dactylocteni australe																																					+	+			+																								
SPECIES GROUP H																																																																	
Dactylocteni aegyptium																																						+				+		+	+																				
Ipomoea dichroa																																									+		+				+																		
Lonchocarpus capassa																																														r		+																	
Vernonia lundiensis																																									+	+																							
SPECIES GROUP I																																																																	
Corchorus trilocularis																																				+			+	+	1	+																							
Abutilon grandiflorum																									+									+		+			+	+	+		+						+																
Brachiaria deflexa																																							+	b							1																		
Hermbstaedtia odorata																	r							+														+		+						+																			
Setaria pumila																																				+									+																				
Echinochloa sp.																																				+								r																					
Aeschynomene indica																																				+								r																					
Cucumis metuliferus																																							1				+																						
Acyranthus aspera																																							1		1																								
Eragrostis cilianensis																																								+						+																			
Kyllinga alba																																			+												+							+											
SPECIES GROUP J																																																																	
Pupalea lappacea		+	+	+					+						+						r	+		+						+	+		+	+			+		+			+																							
Justicia flava	+	1									1														+					+	+									+													+												
SPECIES GROUP K																																																																	
Chloris virgata																													+						+		1	+	1	3	1	+	1	1	+	+		+				3	+		a										
Indigofera praticola																																			+	+	+	1	+	+		1	1	1			+			a	3	a													
Commelina benghalensis						r																	+												+			+	+	+		+	+				+			+	+		+							+					
Tragus berteronianus										+					+							+													+		+	+		+				+	+	+	+					+	+	+											
Celosia trigyna																																			+				+	+			+								+														
Heliotropium steudnerii													+									r													+		+									+				+															
SPECIES GROUP L																																																																	
Dactyloctenium giganteum															r							+		+					+	+	1	+		+		+	r	1	+		1		b	+	4					1	+						+	+	+						
Kalanchoe lanceolata															+	+					+							r					+	r														+												+					
Cordia monoica																								+	1									+	+				+				+													+									
Pavonia burchelii																							+																	1																+									

Table 6. Phytosociological table of the plant commuties of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 1.

COMMUNITY	1																																																																
SUB-COMMUNITY	1.1														1.2										1.3										1.4																														
SPECIES GROUP M																																																																
Sericorema remotiflora									+	1					+		+	+	+	+	r														+											+						+				r			+					
SPECIES GROUP N																																																																
Eragrostis rigidior		+				+			+		+			+	1			+		1			+				+			b		+	+		1		+																			+	a	+					
SPECIES GROUP O																																																																
Sporobolus nitens		+																							1					1					+	+	1	+	1			1		a	+		1	+	a	+	+	b	+	3	3		1	+	1		+				
Cucumis anguria	+											+		+																	+	+			+	+			+	+		+		+	+	+	1			+	1	+				+					+	+	r	+	
SPECIES GROUP P																																																																
Acacia tortilis ssp heteracantha		3				1		+		1					b		b	+	+	+			+	b	1	+	+	4	a	a	3	+					a	+	a	3	b	a	a			+		b	a		1		a	1	+		+	a	+	a				+	b
Sida ovata	+			+	+	1	a	+	+		+		+	1	+			1	+		+	+	+	+			a		+	1	1	+		1	+		+		+	+			+	+						+		+	+		1	+	1	1				+	+	
Albizia anthelmintica			+	a		+		1	a	1	1				3						a				a	a		+		1																	1		a			r		a	3	a			b		+			
SPECIES GROUP Q																																																																
Urochloa mosambicensis	b	b	3	3	a	3	3	3	b	b	b	3	4	3	b	3	a	3	b	b	b	4	3	a	3	b	3		3	a	1	4	3	1	5	5	3	4	4	a	1	4	3	4	+	4	5	3	3	4	4	4	3	1	a	3	b	a	a	3	3	3	a	b	3
Digitaria milanjiana	b	1	1	+	3		+		+	1	1	1	+	+	+		1	+	+	1	+	1	+	a			a	1	+	3	3	+	a	3	+		+		+	+												+	1		+	1	b	b	+	+	+	b	b	1
Panicum maximum	+	+	+		+			+	+	+		+			1	a					+	+	+	3	a	3		3		+	b			1					1		1		1		1		+	+	1							+						1			b
Cadaba termitaria	+	1	+		1	1	+	+				+	+	+										+			+		+	+		+					a														+			+				+	+			+	+		+	
Endostemon tereticaulus				+		a	+	+						+			+	+	+	+	1							1			1							+			+														1		+					+	1				+
Boscia mossambicensis	+		+						+	+	a	+											1	+							1																+	+								1					a		1		1	+	b	+		
Diospyros quiloensis															a																	+				+																+																+	+	
Hin 116		+											+				r		+																																										
Kyphocarpa angustifolia																			+			r														+																				+									+
Colophospermum mopane										a					+																						+																												
SPECIES GROUP R																																																																
Lannea schweinfurthii																									1											a	+											b																		
Acacia nigrescens																a																										a																											
Plectranthus caninus																	r																																																		
Asparagus schroederi																r																																																			
Blepharis transvaalensis										r																																																								
Epaltes gariepina											r																																																							
Plectranthus tetensis				+																																																						+					
Evolvulus alsinoides																															+																															r		
Waltheria indica																																																															r		
Limeum fenestratum																		r																																																
Hibiscus vitifolius ssp. vulgaris												+																																																				
Hin 136									+																																																							
Sclerocarya birrea ssp caffra																					a																																											
Seddera suffruticosa														r																																																		
Hin 167																																r																																
Hin 241																								+																																								
Tricholaena monachne																																		+																														
Oropetium capense																																																						1										
Dalbergia melanoxylon																														+																																		
Azima tetracantha																									1																																							
Tricalysia junodii																									+																																							
Gardenia volkensii																																																																	+
Artabotrys brachypetal																										+																																						
Gymnosporia buxifolia																										+																																						
Solanum panduriforme																										+																																						
Ipomoea plebeia ssp. africana				+																																			1																								
Combretum apiculatum ssp apiculatum																																	+						r																								
Commiphora africana																																	+									+																						
Zaleya pentandra																																													+																			
Eragrostis cilianensis																																													r																			
Sida alba																																				+																												
Vigna unguiculata ssp. dekindtiana																																																							+									
Zanthoxylum capense																															+																														+			
Albizia amara ssp. *Sericocephala*																																									1																							
Blumea viscosa																																									+																							
Basilicum polystachyon																																									+																							
Echinochloa sp.																																									a																							
Ipomoea pes-trigridis																																									3																							
Commiphora mollis																																											+																					
Indigofera varia																																											1																					
Grewia inaequilatera																																										+																						
Crotalaria virgulata																																																		1														
Acalypha fimbriata																																							+																									
Indigofera trita ssp. subulata																													r			r																										+						
Tephrosia purpurea																																							+																									
Chamaecrista sp.																																														+																		
Acacia nilotica ssp. kaussiana																																														1																		
Combretum imberbe																																						b																										
Spermacoce senensis																																						+																										
Stylochaeton puberulus																																						r																										
Crotalaria steudneri																																															1																	
Melhania forbesii																																																			+													
Hin 473																																			+																													
Portulaca kermesina																																			+																													
Gisekia africana																																			+																													
Ruellia patula																																			+																													
Digitaria velutina																																								+																								
Chamaecrista absus																																								+																								
Cyathula orthacantha																																								+																								
Asystasia schimperi																																								+																								
Boerhavia coccinea																																								+																								
Rhigozum zambesiacum																																								+																								
Tribulus terrestris																																								+																								
Setaria verticillata																																													b																			
Berchemia zeyheri																																			a																													

Table 7. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 2.

Percentage rock cover	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	2	2	2	3	2	3	2	2	7
Herb layer utilisation	1	2	3	2	2	3	2	2	1	2	1	1	5	2	1	1	1	2	1	1	2	1	2	1	1	1	2	2	1	1	1	1	1	1	2	1	2	2	2	2	1	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	4	2	3	2	1	2	2	1
Woody layer utilisation	2	2	3	2	3	3	3	2	2	3	2	2	5	2	2	2	2	3	2	2	3	2	2	2	2	1	2	2	3	2	2	3	2	2	2	3	3	3	4	4	3	2	3	2	5	2	3	2	5	3	2	2	3	2	2	2	2	2	2	2	3	2	3	4	2	2
Degree of trampling	1	2	3	2	2	3	3	3	1	2	2	2	4	1	2	1	2	2	1	1	2	1	2	2	1	1	2	2	1	2	1	3	1	2	2	1	2	2	2	2	1	3	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	1	3	2	2	2	2	2	2	1
Degree of Erosion	2	3	2	2	3	2	2	2	2	2	2	2	3	3	2	2	2	2	2	2	2	2	2	3	3	2	2	2	3	2	3	3	2	2	2	3	2	2	2	2	3	2	3	2	2	2	2	2	2	2	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	1
Topography	R	R	R	P	P	R	P	P	P	P	P	P	P	P	F	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	V	P	R	P	P	P	P	V	V
	B	B	B	I	I	H	I	I	I	I	I	I	I	I	P	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	a	I	I	I	I	I	I	a	a
Gradient	2	2	1	1	1	2	2	2	1	1	1	2	1	1	2	1	1	2	3	1	1	1	2	2	1	2	2	1	1	1	2	2	1	3	1	1	1	1	1	1	1	2	2	1	1	1	1	2	1	2	1	1	2	1	1	2	1	1	2	2	2	2	1	2	1	2
Aspect	N	S	S	S	S	S	N	S	S	E	E	S	S	S	N	E	S	S	E	S	S	S	S	S	S	S	S	S	S	E	N	S	S	S	S	S	S	S	S	S	S	S	E	S	S	S	S	S	E	E	S	S	S	S	S	S	S	S	N	N	S	S	S	S	S	S
			E	E	E	E			E			E	E	E			E	E		E	E	E	E	E	E		E	E	E		E	E	E	E	E	E	E		E		E	E	E			E	E	E						E	E	E	E	E		E	E	E	E	E	E	E
Terrain unit	1	1	1	3	3	3	1	3	3	3	3	3	2	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	4	5	3	3	3	3	2	2
Geology	G	G	A	G	G	G	A	A	S	G	S	S	S	G	S	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	L	S	S	L	S	L	G	G	G	G	G	C	C
	N	N	L	N	N	N	L	L	H	N	H	H	H	N	H	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	A	H	H	A	H	I	N	N	R	N	N	O	O
	E	E	L	E	E	E	L	L	A	E	A	A	A	E	A	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	V	A	A	V	A	M	E	E	A	E	E	N	N
Altitude	5	5	4	5	5	5	5	5	5	5	5	5	4	5	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	5	4	4	4	5	5	5	5	4	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	6	6	6	5	5
	7	5	6	7	6	3	0	0	1	6	3	2	7	6	2	7	5	7	6	7	7	5	7	5	5	5	7	8	7	7	8	6	1	5	6	9	3	2	4	2	9	4	7	4	3	3	4	4	4	4	6	4	4	2	2	4	2	4	4	8	8	0	0	0	4	4
	0	0	0	5	5	0	0	0	5	0	0	0	0	5	0	0	0	0	0	5	0	0	0	0	0	0	0	5	0	0	5	0	0	5	5	0	0	5	0	5	0	0	0	5	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	5	5
Relevé number	2	1	1	1	1	1	1		1	1	2	1	1	1	2	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1					1		1												1											
	2	7	1	8	2	9	5	9	7	6	2	6	9	8	1	1	2	3	2	6	3	1	4	0	1	0	3	4	4	3	2	2	5	0	3	4	3	4	3	4	5	4	8	5	4	3	3	4	4	5	5	4	5	5	6	4	5	5	4	6	6	6	6	6	5	5
	6	8	8	0	4	2	3	2	6	2	1	0	4	4	9	2	1	7	5	3	8	5	3	4	4	9	6	8	5	1	4	9	2	0	0	9	8	1	7	0	0	4	5	0	2	9	6	5	6	2	3	7	1	4	1	8	5	8	9	8	3	0	1	4	7	6
Number of species	3	2	1	2	2	3	2	2	3	2	1	3	2	1	1	4	3	3	3	3	3	2	1	2	3	2	2	2	2	3	3	2	2	2	1	3	2	1	2	2	2	2	2	2	2	1	1	2	2	1	2	2	1	2	1	2	1	1	1	1	1	1	1	2	1	2
per relevé	9	6	6	7	5	6	6	7	2	9	8	0	4	6	5	4	4	7	2	1	0	5	6	4	0	3	9	6	4	1	2	1	8	9	8	1	0	6	5	4	7	4	3	5	1	7	7	4	5	8	3	2	7	0	3	2	5	7	4	7	5	6	4	0	8	8
COMMUNITY	2																																																										3							
SUBCOMMUNITY	2.1			2.2												2.3																				2.4																														
SPECIES GROUP A																																																																		
Commiphora edulis	1		1																																																															
Gardenia resiniflua	1		+																																																									+						+
Setaria pumila	1	+								+																																																								
Ctenolepis cerasiformis	+	+																																																																
Ipomoea dichroa	+	+		+																					+																																									
SPECIES GROUP B																																																																		
Indigofera praticola						+	a	a		1	1	+	+																																																					
Ipomoea sinensis				1	+				1	+	+		+								+																																													
Triumfetta pentandra	+					+	+			1		1						+													+																																			
Tephrosia purpurea	1						a	1	1																																																										
Rhyncosia minima				+		+																																																													
Acacia nilotica ssp. kraussiana				1	+																																																													
Justicia protracta	+				+	+																																																												
Commiphora glandulosa	r	r										1																								r																														
SPECIES GROUP C																																																																		
Eragrostis aspera																+	+	+																																																
Pavonia burchellii																	1			+						+																																								
Bothriochloa radicens																+			+																																															
Enneapogon cenchroides																+					+																																													
Lantana rugosa																	+	+																														r																		
SPECIES GROUP D																																																																		
Thilachium africanum																+	+	+	+	+	+	+		+	+	+					+		+	+														+	+	+															+	+
Plectranthus tetensis								1			+					b	1		1	1		+	+			+			+	1				+		+																														
Melhania forbesii																	+		+	+	+		+	+			+	+	+	a																								+						1				+		r
Hin 554																	1		b	1		a	+	+	a	1																																								
Barleria prionitis																	+		+	+		+			+	+																																								
Ruellia patula			+																+			+	1				+																																							
Rhigozum zambesiacum						1				+						a									1	1																																								
Corchorus trilocularis	+					+												+										+		+																																				
Balanites maughamii		r														+													+			1													r																					
Crotalaria virgulata									+									+			+													+																																
Sida ovata						+										+											+																												+												
Melinis repens																+								+																																										
SPECIES GROUP E																																																																		
Ipomoea plebeia ssp africana						1	+					+					+				+									+																																					
Dactyloctenium australe						+			r															+					+												+																									
Acyranthus aspera			1			a																					+				+																																			
SPECIES GROUP F																																																																		
Sporobolus festivus																												+		+	+	+	+		+					+																									
Urochloa panicoides																															+		+																																	
Coccinea adoensis														+																		+																																		
SPECIES GROUP G																																																																		
Dactyloctenium giganteum						b			+		1		+		+			+						1						+		+		+									+																						
Celosia trigyna						+							+				+								+		+				+				+																															
SPECIES GROUP H																																																																		
Plectranthus caninus																+		1			1									+			+			1		a	1	1	1			+	a							+							1							
Pavonia burchellii									1																											+	+	1	1	+			+												+											
Boscia mossambicensis								+																												+	+		+		+		+	+																						
Hin 188																																					+	1		+		+		+												+									
Crassula lanceolata																+			+			+			+				+							1	+					+																								
Dactyloctenium aegyptium													+											+																	+		+																							
SPECIES GROUP I																																																																		
Oropetium capense					1		+	+				+	1	1		1	+		1	1	+	1	a	1	1	+	1	1	+	+	1	a	+	1	+	+	1	1		+	+	+	+	+				+	+						+					+				+	
Abutilon angulatum					1		+	+	+	+	+	+	+		+		+	+	+		+	+	+	+			+	1	+	+	+		+			+	+	1	+	+	+			+	+					+											+					
Kylinga alba					+	+		+				+	+			+		+				+			+			+	+		+	1	+	+	+	+					+		+																						
Tephrosia purpurea				+	1	+	a	a		+		1					+		+											1	+								+						+	+	+																			+
Zanthoxylum capense												+	+	+		+	+		+		+						r		+				+					r		+			+	r												+										
Portulaca kermesina									+	+								1												+		r	+		+	+			+		+																									
Evolvulus alsinoides							+											+			+						+			+		+													+	+													+							
SPECIES GROUP J																																																																		
Tragus berteronianus	+	1		+	1	+	1	+	+	+	+	+	1	1	+	+	+	+	+	1		1	1	+	1	+	+	1	1	+	1	1	+	a	+	+			+		1	+	+		+			+										+									
Commelina benghalensis	+		+	+	+	1	+	1	1	+	+	+			1	+	+	+	+		+	+	1		+	+	+	+		+	+		+		1	1	+		+	+	1	+	a		+		+	+	+			+														
Grewia bicolor	1	+	1	+		+		+		+		1				+	+	1	+	+	1	+	+	1		+	+	+	+	1			+	+	+	+	+				+			+			1		+																	
Tricalysia junodii	+								+	+	+					+	+	+		+	+	+				+	+		1	+				+		+				+			+			1		+																+	r	+
Hin 54		+		+	+	1	+	+		b			a		1	+	+					+	1		+		1							+					+			+					+	+	+																	+
Chloris virgata	1					3		+	+				a		+	+									+	+			1			1	+			+			+		+		+																							
Indigofera varia	1						a	1	1			a				+		1	+		1							+	+	1			+			+					+																									
Chloris roxburghiana		+	1		+					+		+					+	+		+							+	+														+						+	1																	
Bulbostylis densiflora	+	1							+		+							1			1			+																	+																									
Cucumis metuliferus		+	+		+	+									+					+																							+																						

Table 7. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 2.

COMMUNITY	2																																																										3							
SUBCOMMUNITY	2.1			2.2												2.3																				2.4																														
SPECIES GROUP K																																																																		
Lannea schweinfurthii																																																	+	+				1	+				+					a		
Crabbea velutina																																															+		+			+										+				
Gymnosporia putterlickoides																																				+															1					+									+	
Boscia angustifolia																																																	r	+																
Cissus cornifolia									+																																								+			+														
Commiphora mossambicensis																																																		+			1													
Eragrostis superba																																																			+						+								
SPECIES GROUP L																																																																		
Justicia flava				+			1		+			+	a	+		1	+	+	+	1	+	1	a	+	+	+	+	1	1	1	1		+	+	1	a	a	1	a	1	1	+	b	1	1		a				b	+	a	+		b									
Cissus rotundifolia			+				+					1			+	+		+	+	+		+	+	+	+	+		+	+		+	+	+	+		+			+	+	+		+						+			+		+				+								
Stylochiton puberulus					r		+						r			+			r	+								r												r		r							+		+					r										
Commiphora merkeri									+										1																									+	a			1	+			1													
Commiphora africana										+						+									r																							+			1														
Vigna unguiculata ssp dekindtiana				+														+																																		+						+								
Sericorema remotiflora				+																							+	+																												+										
SPECIES GROUP M																																																																		
Cucumis anguria	+		+	+		1	+	+	+	+	+		+		+	+	+		+	+	+					+	+	+		+			+	+	+						+	r			+									1			1									
Dichrostachys cinerea ssp africana		+		+			+					r				+	+			r																	+			+	+			+			r									r		+						+		
Kyphocarpa angustifolia	+																+		+		+						+											r	+			+						+						+		+										
Elytraria acaulis	+													+						+		+																		+																r										
SPECIES GROUP N																																																																		
Acacia erubescens						b																																																					1		+	+				
Combretum imberbe																																					r						r																	1			+			
SPECIES GROUP O																																																																		
Cadaba termitaria													+				+	+	+	r		+			+			+		+		a		+	+				+				1	+	+	1		+	+	+	+		+				r				+	+	+			
Abutilon hirtum				+		+						+	+	+		+		+		+	+		1		+		+					+		+								+	+						r	1	+		+		+			+	+			+				
SPECIES GROUP P																																																																		
Ruellia patula	+	+			1	+	+	+	+	+	+	1	1	+		+	+	+	+	+						+	+	+	+	+	+		+	+	+	+	+	1	+	1		1	a	1	a	+	1	3	1	1	1	1	a	+	+	1	+		1	+			+			
Digitaria milanjiana	+			1	+	a	+	+	+	+		+						+																r			+		+					1			+		a	+		a	1	4		+	a	+		b	a	a	a	a		
Endostemon tereticaulus	+	+				+		+		+		+				+		+	+	+				+			+		+	+			+						+					+		+				+		+		+			1	+		1	+					
Asparagus schroederi	+				+									+		+	+					+		+										+		+		r		+		+	+	+	+	r		+		+	+	+				+					+	+		+		
Grewia flavescens	+			+														+																	+	+									+	+					+		+			+		+		b	1	1	a	+		
SPECIES GROUP Q																																																																		
Afzelia quanzensis																																																																	+	+
Garcinia livingstonei																																																																		+
Canthium glaucum ssp frangula																																																																	+	
Strychnos potatorum																																																																	+	
Hin 49																																																																	+	
SPECIES GROUP R																																																																		
Combretum apiculatum ssp apiculatum																																																	r										a	a	a	a	1	1	a	+
Barleria kirkii												+														1							+																										+			+	+	+		b
Phyllanthus reticulatus														r														+																																	+				r	r
Acacia nigrescens		+																																																								+		a				+		b
Kirkia acuminata																																																						3					3							
SPECIES GROUP S																																																																		
Hibiscus micranthus									+		+	+			+	+		+	+	+	+	+		+	+	+	+	+	+	+		+		+	+	+	1	1	1	1	+	+	+	+	3	+	1	a	+	+	1	1	a	+	+	+	+	1	1	1	+	+	1	+	1	1
SPECIES GROUP T																																																																		
Colophospermum mopane	b	b	4	+	3	a	b	3	3	b	+	3	3	3	4	b	4	4	4	4	4	4	5	4	b	4	4	4	3	4	b	b	3	3	4	4	3	3	3	3	b	a	4	3	4	4	4	3	a	+	b	b	b		+	b	1	3			b		+	a		+
Pupalea lappacea			a	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+	+	+	3	1	1	1	1	+	a	1	3	1		1	a	a	+	a	1	a		+	1	a	1	+	a	a	+	b	1	1		1
Aristida junciformis	1	1			+			+			1	1	+			3	4	b	3	a	1	b	b	4	+	3	+	+		3	+	1		b	+		+		+	+		+		+		+		+	+				+	+		1	1	+		+		+				+
Enteropogon macrostachys	+	+	+		+								+							+	+	+		+	+	+					+	+	+			+		+		+	+		1	+		+		+		+	+	+	+	+						+		+		+		+
SPECIES GROUP U																																																																		
Brachiaria deflexa	3	3	3	+	b		1	1	3	3	+	3	1	b	1	b	3	3	1	3	4		3	+	+	b	b	4	3	4	3		3	+	3	a				+	a	+	+	+	+	+	+	+	+		+	+	+	+	1	+						+		+		1
Urochloa mosambicensis	+			4		1	4	4	1	3	4	1	+		4													+		+	1	+	+						+			+		a	+		3	+	+	1	+		a	1	4	+	+	+	1	a			1	b	+	
Eragrostis rigidior	a				+		1	1	+		1	+				+								+						+				+			1		+			+		b		1	a	+	b	+	1	1	1	a		+	b	a			1				a	
Diospyros quiloensis	1	+						+	+	+		r				+	+	+			+						+	+	+	r	+		+	+		+				+		+		+	+			+	+	+	+	1	+					+				+	+	+	+	a
Grewia monticola	+					+			+	r							+	+				+					+						+			+		+	+	1					+			+			1	1	+	+	+	+		+	b	+	1	1		+	+	
Panicum maximum	+	+	b			+	+							+			+	+				+			+					+		+					+									+	+				+	+	b	+			+	1		+				+	+	1
SPECIES GROUP V																																																																		
Maerua juncea																																								r																										
Ipomoea pes-tigridis																																													1																					
Waltheria indica																																										+																							
Crotalaria podocarpa																																									+																								
Heliotropium steudneri																		+																					+																											
Desmodium ospriostreblum																																		+																																
Maerua decumbens																									+																																									
Sida cordifolia																																			+																															
Stylosanthes fruticosa																														1																																				
Adansonia digitata																					+																																													
Diospyros lycioides ssp sericea																					+																																													
Alectra orobanchoides																					+																																													
Boscia foetida																				r																																														
Reissantia indica																								+									r																																	
Euclea divinorum														a		+																																																		
Allophylus alnifolius																				+																																														
Crotalaria podocarpa																+																																																		
Stomastemma monteiroae																+																																																		
Hibiscus sidiformis																+																																																		
Indigofera trita																+																																																		
Tribulus terrestris																															+																																			
Ximenia caffra																			+																																															
Perotis patens																																															+																			
Neuracanthus africanus			+																																																															
Combretum molle					+																																																													
Dalbergia melanoxylon					+																																																													
Raphionacme monteiroae					+																																																													

Table 7. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 2.

COMMUNITY	2							3	
SUBCOMMUNITY	2.1	2.2	2.3			2.4			
Blainvillea gegana		+				+			
Neorautanenia amboensis		r							
Ormocarpum trichocarpum		+							
Heteropogon contortus	+								
Tephrosia purpurea	+								
Abutilon ramosum		+							
Acacia gerrardii		+							
Azanza garckeana		+							
Eragrostis cilianensis		+							
Ipomoea hochstetteri		+							
Lonchocarpus capassa		+							
Albizia anthelmintica		+							
Capparis tomentosa		+							
Chamaecrista absus		+							
Acalypha fimbriata		1							
Hermannia glanduligera	+								
Aristida rhiniochloa	+								
Pogonarthria squarrosa						+			+
Sporobolus panicoides	a						+		
Commiphora mollis	1								+
Enneapogon cenchroides	+						+		
Cordia monoica								+	
Albizia glaberrima								b	
Erichloa meyeriana								+	
Millettia usumarensis								+	
Tricholaena monachne								+	
Grewia gracillima								+	
Adansonia digitata							b		
Sterculia rogersii							r		
Combretum hereroense								+	
Eragrostis curvula		+	+						
Vernonia lundiensis		+		+					
Striga asiatica		+		+					
Hermbstaedtia odorata		+		+					r
Setaria sagittifolia	+	+				r	+		
Enneapogon cenchroides	+				r		+		
Terminalia prunioides	+		+						+
Grewia villosa		+				+	+ +		
Kalanchoe lanceolata		+		+					
Eragrostis cylindriflora				+	+				
Selaginella dregei				1					
Salvadora australis				1					

Table 8. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 3.

Percentage rock cover	1	1	2	3	2	2	3	3	1	2	2	2	1	3	1	1	1	1	1	1	3	1	2	2	3	1	2	1	3	2	1	3	2	2	2	2	1	1	1	2	6	1	3	3	3	3	1	1	6	2	3	1	3	1	1	4	6	6	4	6	6	7	6	7	4	6	7	4
Herb layer utilisation	1	1	1	1	2	1	1	1	1	1	2	1	2	1	3	2	1	2	1	1	1	1	2	1	1	2	1	1	1	2	2	1	1	1	1	1	3	1	1	1	1	2	1	1	1	2	2	1	2	2	3	1	1	1	3	3	3	1	2	2	1	1	1	1	1	1	1	1
Woody layer utilisation	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2	2	3	4	2	2	2	2	3	2	2	2	3	2	3	3	3	3	2	2	3	3	3	1	2	2	2	2	3	2	2	2	2	2	2
Degree of tramping	1	2	1	1	2	1	1	1	2	1	3	2	2	1	3	2	2	3	2	2	2	1	2	1	2	2	1	2	1	2	3	1	2	1	1	2	3	1	2	1	2	3	1	1	2	3	2	2	2	2	3	2	1	2	3	3	2	1	3	2	1	2	2	2	1	2	2	2
Degree of erosion	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	3	2	2	2	1	2	2	2	2	2	2	2	1	2	2	2	2	2	2	1	1	2
Topography	R	R	R	R	R	R	R	R	R	R	R	B	R	R	P	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	K	R	R	B	B	R	R	R	K	R	B	R	R	B	R	R	K	K	K	K	K	K	K	K	K	K	K	K
	H	H	H	H	H	H	H	H	H	H	H	H	H	i	i	i	H	i	i	H	i	H	i	H	H	H	H	H	H	H	i	H	H	H	H	H	H	H	i	H	O	H	H	H	H	H	H	H	O	H	H	H	H	H	H	O	O	O	O	O	O	O	O	O	O	O	O	O
Gradient	3	1	3	3	2	2	3	3	2	1	2	2	2	1	1	2	1	1	1	2	2	1	2	1	2	1	1	1	2	2	2	2	2	2	2	1	1	2	2	2	5	2	1	2	2	2	2	2	5	2	3	2	2	2	1	2	2	2	5	5	5	5	5	5	4	4	5	5
Aspect	S	S	S	S	N	S	S	E	S	S	N	S	N	S	N	S	N	N	N	S	W	E	N	S	S	S	N	S	N	S	S	N	N	S	S	N	S	S	W	N	S	S	S	N	N	S	S	W	N	E	S	S	S	N	E	W	N	W	E	N	E	N	N	S	S	N	S	N
	E			E	W	E	E			E	E	E	E		W	E		E		E			W			E								E	E		E	W						E		E						E	E				E							W		E	E	
Terrain Unit	4	1	4	2	3	3	5	2	3	3	3	3	3	5	3	5	5	5	2	3	5	5	3	5	3	4	5	5	3	3	5	4	4	3	4	5	3	2	5	3	4	2	3	3	4	3	3	3	4	3	4	2	3	4	3	4	5	5	4	4	4	5	4	4	4	4	4	4
Geology	G	D	G	G	G	G	G	G	G	G	G	G	G	G	L	G	G	L	G	G	S	G	S	G	G	G	G	G	D	G	G	G	G	G	G	G	G	G	A	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
	N	O	N	N	N	N	N	N	N	N	N	R	N	N	A	N	N	A	N	N	H	N	H	N	N	N	N	N	O	N	N	N	N	N	N	N	N	N	L	N	N	N	N	R	R	N	N	N	N	N	R	N	N	R	N	R	R	N	N	N	N	R	N	R	N	N	N	N
	E	L	E	E	E	E	E	E	E	E	E	A	E	L	V	L	E	V	L	E	A	E	A	E	E	E	E	E	L	E	L	E	E	E	E	E	E	E	L	E	E	E	E	A	A	E	E	E	E	E	A	E	E	A	E	A	A	E	E	E	E	A	E	A	E	E	E	E
Altitude above sea- level	6	5	5	5	5	5	5	5	5	6	5	6	5	5	5	5	5	5	5	5	5	6	5	5	5	5	6	5	5	6	5	6	5	6	6	5	5	5	4	6	6	5	5	6	6	5	5	5	6	5	6	5	6	6	5	6	6	6	6	6	6	6	6	6	5	5	6	6
	0	6	6	8	8	8	8	6	8	0	9	0	9	6	5	5	4	1	4	5	4	0	6	9	8	6	0	3	8	0	4	0	7	1	0	6	4	6	6	1	0	8	8	5	3	4	2	6	0	4	2	2	0	1	4	2	4	5	0	0	2	2	0	4	8	8	1	2
	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	0	5	0	0	0	0	5	0	0	5	0	0	5	5	0	0	0	0	0	0	5	0	5	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Relevé number			2				1	1	2	2				2	1	2	1	1	1	1	1	1	1	2	1	1	2	1	2	2	1	1	1	1		1	1			1	1		1	1	1	1	2	2	2	2	1	1	1	1	1	1	2	2	1	1	1	2	2	2	2	2	1	2
	7	9	0	6	7	6	3	9	0	0	6	6	6	1	6	1	9	0	7	8	7	4	7	0	8	8	0	0	1	0	7	9	9	2	7	8	8	9	8	2	5	9	5	5	9	3	0	0	2	2	1	7	4	7	6	9	1	1	7	6	6	1	2	2	2	3	5	1
	3	5	3	9	0	6	4	9	4	0	7	2	5	3	5	4	6	2	2	8	7	4	5	2	6	1	8	5	7	6	3	7	8	5	2	7	9	7	6	0	4	9	5	6	3	3	5	7	8	0	1	0	2	9	9	5	5	8	4	4	8	0	2	3	9	0	1	1
Number of species	2	2	2	2	1	1	3	2	2	2	1	1	1	2	2	3	3	3	3	3	2	2	2	2	2	2	3	2	3	2	2	2	2	2	4	2	2	2	2	3	2	3	2	3	3	3	1	3	2	1	2	2	2	1	2	2	1	2	2	1	2	1	1	2	3	2	2	2
per relevé	6	1	0	9	7	2	2	8	3	5	8	3	2	5	2	3	4	1	4	2	1	4	0	7	8	3	3	9	1	7	6	4	8	2	0	2	1	8	5	3	8	8	8	6	0	6	8	0	6	9	6	3	8	3	3	3	5	7	7	8	6	0	8	5	2	2	0	4
COMMUNITY	4																																																							5												
SUBCOMMUNITY	4.1													4.2																											4.3																											
SPECIES GROUP A																																																																				
Enchloa meyenana	+	1			+					+										+				1																																												
Gymnospna buxifolia				+	+					+																																																										
Euclea divinorum	+		+																																									+									+															
Ormocarpum trichocarpum		r	+														+																																																			
Cucumis hirsitus		+	r																																																																	
Garcinia livingstonei	+			+																																																																
Strychnos madagascariensis	+			+																																					+																											
SPECIES GROUP B																																																																				
Gardenia resiniflua							+	+	+	+	+																																					+			+	+																
Hybanthus enneaspermus							1	+																																					+																							
Sericorema remotiflora							r		+																				+																																							
SPECIES GROUP C																																																																				
Dalbergia melanoxylon	+	+	+	+	r	1	+			+												r							r						+						+																											
Eragrostis superba		1	1		+			+	+																								+																																			
Acacia gerrardii					+			+																																																												
Barleria kirkii				+								1																																														+										
SPECIES GROUP D																																																																				
Cissus cornifolia														+	+			+		+		+																																														
Chloris virgata															+		+	+	b											1																																						
Indigofera varia																		1	1	a			1																							+																		1			+	
Strptopetalum serratum														1		1			+						+						+																																					
Kyphocarpa angustifolia												+		+		+	+											+																																								
Sorghum versicolor															+				+	+																																																
Crotalaria podocarpa														1		1					b					+																																										
Heliotropium steudneri																1	+							+																																												
Sida ovata															+			+																								+																										
SPECIES GROUP E																																																																				
Lannea schweinfurthii		b									+	a	+		a	+					+																																															
Endostemon tereticaulus								+	+	+							+						+								+																																					
Lonchocarpus capassa				+				+	+								+																	+																				+														
Sporobolus panicoides							+												+	+																																																
SPECIES GROUP F																																																																				
Enneapogon cenchroides																								+		+	+		1			+	+																																			
Cleome monophylla																	+							+	+			+		+			+																																			
Ceratotheca sesamoides																			+					+				+			+					+						+																									+	
Stylochaeton puberulus																									r	r								r	+					r																r									+			
Kylinga alba																+									+		+							+																																		
Combretum imberbe			r																							1			+									1																														
Sporobolus festivus																								+			1					+																											+									
Tragus berteronianus																													1	+																																						
Ampelocissus africana																												+									+																															
Pogonarthria squarrosa																					1										+																																					
Corchorus trilocularis																																		r					+																													
SPECIES GROUP G																																																																				
Commiphora africana				+											+			+	r			r		r								+			+																																	
Tephrosia purpurea																1		+		a											b			1																																		
Heliotropum strigosum														1			+								+				1	+														+																								
Hin 10									+					+			+													a					a						+																											
Euphorbia benthamii														+													+																																									
SPECIES GROUP H																																																																				
Heteropogon contortus		1	+	a	1		1	1		1								+						+									+		+			+		+		+																			+							
Grewia bicolor	+											1			+			1		+					1	+		+	+								+																															
Lapeirousia erythrantha			+				+		+															+			+		+																																							
Asparagus schroederi		r									+																							+	r				+														+															
Combretum hereroense										+	+														+		+																																									
SPECIES GROUP I																																																																				
Tricalysia junodii				+																														1							+	+	+		+																							
Cordia grandicalyx																																									+			+							+																	
Strychnos potatorum																																									1		+					1										+										
Achyrathus aspera																																									+											+																a
Albizia anthelmintica																																			+								1	+																								
Acacia tortilis ssp heteracantha																																										+								+																		
Dactyloctenium aegyptium																																										+				+																						
Polygala sphenoptera																																												+			+																					
Brachystegia spiciformis																																													a																							
Indigofera praticola																												+																			+		+	1																		
Albizia tanganyicensis																																																	b									a										

Table 8. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 3.

COMMUNITY	4						5
SUBCOMMUNITY	4.1		4.2		4.3		
SPECIES GROUP J							
Bulbostylis densiflora			1 1 + +	+ +	+ + +		
Ipomoea plebeia			+ a 1 + 1		+ 1		
Dactyloctenium giganteum			+	+ +	+ + +		
Pavonia burchellii	+		+ +	+ +	+ +		
SPECIES GROUP K							
Eragrostis rigidior	1 1 1 1	+ +	+ b + + 4	b + b 1 a + + 1	+ + + +		
Ruellia patula	1 +	a + + + +	+ + + 1 +	+ + + + + 1	+ 1 1		
Dichrostachys cinerea ssp africana	+ + +	+	+ + +	+ + + + a	+ + + + +	+	
Acacia nigrescens	1 + +	+ r +	+ +	1 a +	a a + + a r		
Melhania forbesii	+ 1 1	1 + 1 + +	+	+ + + +	+		+
Tricholaena monachne	1	1 +	+	1 3 3	a 1		
Commiphora glandulosa	+	1	+	r + 1 +	+ 1		
Solanum panduriforme	+	1		1 +	+ + +		
Acacia erubescens		1	+	+ +	+	1	
Hibiscus sidiformis		+ +		+ +	+		
SPECIES GROUP L							
Urochloa mosambicensis	a 1 4 1 3 3	1 a 3 4 b 1	b + a a + + a a a	a 1 b a + a a b a 1 a a 1	1 + 1 + + 3	+ +	
Chamaecrista absus	+ + +	1 +	a 1 1 + 1 a 1 + 1 +	1 1 3 a 1 1 a a 1 1 1 b 1 1 1	+ 1 + 1 + 1	1 + a	+
Pupalia lappacea	+ +	+ + + a a 1	+ +	+ + + 1 + + + 1 + 1 +	+ + 1 a + + + + + +	1 1 +	+
Grewia flavescens	1 + +	+ 1 a +	+ + + +	+ + + + + + + + 1	+ + + +	+	
Justicia kirkiana		+ + +	1 +	+ + + + +	+ +	+	+
Colophospermum mopane	+ +		+ 1 a 3	r 3 a a		1 1	
SPECIES GROUP M							
Millettia usumarensis							+ + a a + + + a
Enteropogon macrostachys			+ +				+ a + 3 + +
Grewia gracillima	+			+ +	+		+ b + + +
Combretum mossambicens				+			+ + + + +
Monodora junodii		+			+		+ a + +
Markhamia zanzibarica		+			1		+ + +
Combretum microphyllum					1		+ + a
Cheilanthes involuta							+ + +
Abutilon hirtum	1 +				+		+ + + +
Melinis repens		+		+ +	+		+ + +
Brachystegia spiciformis							5 b
Artabotrys brachypetalus							1 1
Vitex isotjensis							+ 1 1
Vitex buchananii							1 +
Bidens biternata					+		+ +
Peponium pageanum							+ +
Aeplianthis neglectus							1 +
Ampelocissus obtusa		+					+ +
Diospyros lycioides ssp sericea							+ +
Corchorus kirkii				+			+ +
Stadmannia oppositifolia							+ +
Eragrostis acraea							+ +
Hin 241							a
Combretum padoides					a		a
Justicia glabra							1
Canthium glaucum ssp frangula		+					+
Leptochloa uniflora							+
Combretum adenogonium	+			+			+
Mundulea sericea							b
Solanum sp.							a
Cypeus zollingeri							a
Plectranthus caninus							1
Withania somnifera							+
Ficus tettensis							a
Euphorbia confinalis							1
Ficus abutilifolia							1
Commiphora mariothii							a
Cassia abbreviata					1		+
Hin 529							+
Danthoniopsis pruinosa							a
Sterculia rogersii			+				b
SPECIES GROUP N							
Celosia trigyna			+		+ + + + + + +	+	+ + + a + 1 + 1 + + 1 +
Digitaria velutina			+	+	+ 1 +		+ b 1 + +
SPECIES GROUP O							
Cucumis metuliferus				+ + + + +	+ + 1 + + + + + +	1	+ + + 1 +
SPECIES GROUP P							
Cucumis anguria			+ 1 + + + + +	+ + + + + + + + + +	+ 1 1 + + + + 1 + +	+ 1	+ + +
Vigna unguiculata ssp dekindtiana		1	+ + + + + 1 + +	+ 1 1 1 + + 1 + 1	1 1 + + 1	+	+ + + + + 1 + +
Justicia protracta	+		1 1 + + + 1	+ + 1 + + 1 1 1 +	+ + a + + 1	1	+ + 1 +
Ipomoea sinensis		+	+ + 1 1	+ + + 1 + + 1	+ +	1 +	+
Ctenolepis cerasiformis			+ + + +	+ + + + 1	+ + +	+	+ +
Ipomoea dichroa		r		+ r + +	+ + + + 1	1	+ + +
Kirkia acuminata			+ 4	b	b 3 5 3	b 3	b 3
Crotalaria virgulata			+ + +	+ +	+ +		+ + +
Spermacoce senensis			1 1 +	+ 1	1 +	+	+
Commiphora edulis				+ r 1 a		+ +	a a 1
Ipomoea pes-tigridis		+	1 1 + 1 +	+ 1 + + 1 + + 1 + 1 1 1	1 + 1 1 + 1 +	+ 1	+ + + 1 + +
Setaria sagittifolia		+	1 1	+ + + 1	+ 1 + 1	+ + +	+ + + + +
Rhyncosia minima	+		1 1 + + 1	+ + 1 + a	1 3 1		1 + +
Vernonia fundiensis		1	1 1 + + 1	+ + + + 1 +	+ + 1 + + 1 +	+	+ 1 + + + + +
Triumfetta pentandra	+	+ +	a + 1 + 1 1 1 1 +	+ 1 + + 1 1 1 + + 1 + + 1 +	+ + + 3 a a 1 + + +	1 1	+ + 1 a a 1 1 1 a a
Acalypha fimbriata	+	+ +	+ + + +	+ + + 1 1 + a 1 a	1 + + a + + + + +	1 1	1 1 + 1 + + + 1 + 1
Commelina benghalensis	+	+	+ + + 1 + +	1 + + + + + + + 1 + 1 + 1	1 + 1 1 a + + 1 + + +	+ 1 +	1 + + 1 + + 1 1 1 a a
Blainvillea gayana	+	1 +	+	+ + + 1 1 1 + + 1 1	a + + 1 1	1 +	+ a + 1 a a +

Table 8. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 3.

COMMUNITY	4																																																						5												
SUBCOMMUNITY	4.1													4.2																												4.3																											
SPECIES GROUP Q																																																																				
Combretum apiculatum ssp apiculatum	b	1	1	a	1	a	b	+	a	b	a	3	3	a		1			+	1				1	a	1	+		+	a	a	a	3	1	+	b	+	b		b	1	+	+	3	a	+			1	b	b	+	+	a				1	1		3				a			
Cordia monoica								+			+																					+							+													+							+									
Setaria pumila	+							+		+				1					3	b				+		a	+	+	1	1	1			+	+	a	+	1		1	+	+		+	1			+	a		+		1		1									1	+			
Phyllanthus reticulatus				+		+	+					+																	+		+			a	1					+	+		+		+						+	+							+		1			+		+		+
Commelina africana	+						1										+			+		+		r			+					+		+						1				1	a								+					+									+	
Tragia okanyua	+						+			+																	+					+												+									+												+			+
Commiphora mollis			r				1	+								+						+													+					1																					1							
Ziziphus mucronata ssp mucronata			+	+						+																									+					+	+		+																+									
SPECIES GROUP R																																																																				
Brachiaria deflexa	+	+		+			a	+	+	+			+	a	3	+	+		3	a		b		1	b	1	1	+	3	3		+		a	3	3		1	1	1	4	+	+	a	a	b		+	4			+	1		3		+	1	b	a	3	+	a	b	b	1	1	+
Panicum maximum	4	3		+		1		3	+	1	+		+	+	1	+		+			+	1	+	+	1		+	1	+	a			1	+	+	1	b	+		1	+	1	b	+	b	+	4	+	1	b	4	4		5	a	3			1	+				+	1	a		1
Digitaria milanjiana	1	3	a	b	b	a	b	a	a	3	a	b	b	a	4	1	1	b	+	1	+	a	+	4	a	1	3	4	3	1	b	3	a	1	1	1	3	3	a	+		1	+	a	a	1	a	3		a	1		b		1			+					+				+	
Grewia monticola	+		+	+	1			+		1	1		+				+	+		+			+	+		+		+		+	+	+	+		+		+	+	b	+	+	+	+	+		+	+	1		+		+	1		+		+		1							+		
Diospyros quiloensis		r	+		+						+	+	r	+		+	+		+	+		+	+	r		+	+				r		+			+				+	+	+	+	+		+			a	+		+						+										+
Aristida junciformis				1														+	+	+				+															1			+				1														+	+	+	1				a	b
SPECIES GROUP S																																																																				
Terminalia prunioides											3																																																									
Commiphora mossambicensis											1																																																									r
Albizia harveyi						+											+																																																			
Cadaba termitaria											+																																																									
Justicia flava													r																	+																																						
Crotalaria virgulata					r																																																															
Gymnosporia putterlickoides		+																																																		+																
Rhoicissus revoilii		+																																							+																											
Cissampelos pareira								+																																														+														
Clerodendrum ternatum										+																																																										
Flacourtia indica										r																																																										
Aeschynomene indica									+																																																											
Lantana rugosa									+																																																											
Cypeus schinzii																																			+																																	
Stomastemma monteiroae																																			+																																	
Orthosiphon suffrutescens																																			r																																	
Kalanchoe lanceolata																																																																				
Aptosimum lineare																																							+																													
Momordica boivinii																																							+																													
Flueggea virosa										+																									+																																	
Tephrosia reptans								1																																																												
Evolvulus alsinoides																																							+																													
Cenchrus ciliaris																		+																																																		
Sclerocarya birrea ssp caffra					+																												1										3																									
Xeroderris stuhlmannii			+																						+																							1																				
Eragrostis cilianensis																		+																																																		
Phyllanthus maderaspa																		+																																																		
Keetia venosa																												+																																								
Leonotis nepetifolia																					+																														+																	
Corchorus longipedunculatus																																		r																																		
Dactyloctenium australe																																														+				+																		
Astripomoea lachnosperma																																														+																						
Cissus integrifolia																																														+																						
Blepharis acanthodioides																																																					+															
Ipomoea hochstetteri																						+																																													
Hermbstaedtia odorata														+																													+																									
Combretum molle																																												+																								
Hin 585																																												+																								
Friesodielsia obovata																																												+																								
Crotalaria steudneri															+																																																					
Indigofera astragalina																																				b																				+												
Bothriochloa radicans															+																																																					
Grewia villosa															+																																																					
Perotis patens																															1																																					
Zornia glochidiata																															1																																					
Merremia pinnata																															1																																					
Cleome hirta																					1																																															
Stylosanthes fruticosa																					a																																															
Sida cordifolia																					+																																															
Waltheria indica																					a																																															
Barleria albostellata																																+																						+														
Tricliceras hirsutum																									r																																											
Chamaecrista sp.																																				1																																
Chloris roxburghiana																				+																																																
Pouzolzia mixta																																													+																							
Dyschoriste matopensis																																													+																							
Striga asiatica																																													+																							
Rothia hirsuta																	+																																																			
Hibiscus sidiformis																								r																																												
Indigofera trita																														+																																						
Gardenia volkensii																																																+																				
Adansonia digitata																											+																																									
Sesamum alatum																													+																																						
Strophanthus kombe																																																	+																			
Dalbergia arbutifolia																																																	+																			
Pappea capensis																																																													+							
Bridelia mollis																																																											+									
Barleria heterotricha																																																											+									
Indigofera lupatana																																																										+										
Aneilema hockii																																																										+										
Desmodium ospriostreblum																																																																1				
Cardiogyne africana																																																																	+			
Combretum adenogonium																																																																	+			
Cyanotis lanata																																																																		+		
Hibiscus vitifolius				+																																																																
Hibiscus micranthus				1																																			+																													

*New to Zimbabwe

Table 9. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 4.

Percentage rock cover	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Herb layer utilisation	3	2	2	3	1	2	3	2	2	1	1	3	1	2	2	3	2	2	3	2	2	2	2	2	1	1	3	3
Woody layer utilisation	3	2	2	2	2	3	3	3	3	3	2	3	3	3	2	2	2	2	3	2	2	1	1	1	1	1	3	3
Degree of trampling	3	2	2	3	1	2	3	2	2	2	2	3	3	2	2	3	2	2	3	2	2	2	1	2	1	1	3	3
Degree of erosion	2	1	1	1	2	1	2	1	1	2	2	2	3	1	2	2	3	2	3	2	1	3	3	3	1	1	2	3
Topography	V	V	V	V	R	V	V	R	V	R	R	R	R	R	R	S	S	S	S	S	R	I	I	I	P	P	P	P
	A	A	A	A	B	A	A	B	A	B	B	B	B	B	B	I	I	I	I	I	B	S	S	S	A	A	A	A
Gradient	1	1	1	1	3	2	1	1	1	1	1	1	5	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Aspect	S	E	E	E	N	E	S	E	E	E	E	E	E	S	S	S	S	S	S	S	E	S	S	S	S	S	S	S
	E				E		E								E													
Terrain unit	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2
Geology	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Altitude	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	4	5	5	5	4	5	5	3	3	4	5	5	5	3	6	5	3	3	3	3	3	4	5	4	4	4	3	3
	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	5	0	0	0	5	0	5	0	0	0	0	0	0
Relevé number		1	1	1	1	1		1		1		1	1	2	1	1	1	1	1	1	1	1	1	2	1	1	1	1
	8	3	3	6	6	8	8	8	9	0	9	4	2	2	0	2	1	0	3	1	1	2	4	1	4	2	1	1
	7	2	9	6	7	3	9	2	6	7	8	1	2	7	3	3	3	8	5	9	0	6	6	6	0	8	6	7
Number of species	2	1	1	1	2	1	1	0	1	1	1	1	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0
per relevé	1	7	6	5	4	5	1	9	3	8	4	7	9	7	5	9	1	2	9	3	5	1	1	1	5	3	6	4
COMMUNITY	6									7												8			9			
SUBCOMMUNITY												7.1				7.2				7.3					9.1		9.2	
SPECIES GROUP A																												
Acacia tortilis ssp heteracantha	a	3	3	4		5	a		5					+														
Ipomoea dichroa	a	1	1		b	+		1							1													
Commelina benghalensis	1	+		+	+	+			+																			
Abutilon hirtum	+	+	+	+			1								+													
Grewia flavescens	+		+		+		+		+		+																	
Lonchocarpus capassa		+		1	+		3																					
Anisotes formosissimus		a	+					b																				
Capparis tomentosa		a		+			1					r																
Abutilon grandiflorum		+				+		1				+																
Abutilon ramosum			+	+	+																							
Ctenolepis cerasiformis	1				+	+																						
Corchorus trilocularis	1		+																								+	+
Ipomoea pes-tigridis	a				+																						+	
Cyathula orthacantha			+	1																								
Ipomoea tenuipes		a						1																				
Setaria sagittifolia		1			a										a													
Urochloa mosambicensis	a			a																								
Cadaba termitaria	+						+																					
Cucumis anguria	1					+									+													
Lagenaria sphaerica		+						a				+																
Acacia galpinii			b																									
Celosia trigyna	b																											
Gymnosporia putterlickoides			a																									
Dactyloctenium giganteum	1																											
Chloris virgata	1																											
SPECIES GROUP B																												
Cardiogyne africana	+				b					1	a					r												
Friesodielsia obovata										1	+																	
Hin 585										+	+																	
Sclerocarya birrea ssp caffra										a																		
Justicia glabra										a																		
Asystasia gangetica											b		+															

Table 9. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 4.

COMMUNITY	6									7												8			9			
SUBCOMMUNITY										7.1						7.2				7.3					9.2		9.2	
SPECIES GROUP C																												
Trichilia emetica													b	b														
Gymnosporia buxifolia												+		+				+										
Ziziphus mucronata ssp mucronata			a							+		r		+														
Croton megalobotrys															4													
Kigelia africana												4																
Triumfetta pentandra															a													
Hyphaene coriacea														1														
Tabernaemontana elegans														1														
SPECIES GROUP D																												
Lannea schweinfurthii					b					a	3		3															
Strychnos potatorum					+					b		a	1															
SPECIES GROUP E																												
Acacia schweinfurthii		a			1	+	+	+	+	+	+	1		1	1	+												
Cucumis metuliferus	b	1	+	+	+	+			1	+	+	+																
Dichrostachys cinerea ssp africana		a	+	+		+	+		1						+	+												
Acalypha fimbriata					1	+		1	a	+		1			1													
SPECIES GROUP F																												
Albizia glaberrima																4	+	5	4									
Grewia sulcata														+		+	+		1		+							
Phyllanthus reticulatus																+		+	+									
Syzigium guineense																	3		1									
Bridelia cathartica																		a										
SPECIES GROUP G																												
Dalbergia arbutifolia					+					+	1	a	1	+			+	+										
Artabotrys brachypetalus					+					+	b					+	+	+										
Diospyros mespiliformis										a	+	3	4					+	+									
Blumea voscosa								+			+	+					a	1		+								
Rhus guenzii															+				+		+							
SPECIES GROUP H																												
Grewia inaequilatera					+	+	+		1			1			+	+		b	1									
Achyranthus aspera		a		+					b	1					3		1		a									
Pupalia lappacea				+					+			+			+													
Albizia harveyi			1									+																
Asparagus schroederi					+									+													+	
SPECIES GROUP I																												
Faidherbia albida																				b	5							
Erichloa meyeriana																b	b			4	4							
SPECIES GROUP J																												
Panicum maximum	+	3	3	4	+	5	4	4	3	+	+	a		a	a		3	a			a							

Table 9. Phytosociological table of the plant communities of Sango Ranch, Save Valley Conservancy, Zimbabwe. Part 4.

COMMUNITY	6									7												8			9			
SUBCOMMUNITY										7.1						7.2				7.3					9.1		9.2	
SPECIES GROUP K																												
Phragmites mauritianus																			3			5	5	5				
SPECIES GROUP L																												
Nymphaea nouchali																									a	1		
Eragrostis curvula																									+	1		
Paspalidium obtusifolium																									5			
SPECIES GROUP M																												
Acacia xanthophloea																											b	a
SPECIES GROUP N																												
Echinochloa colona																									3	5	4	3
Cyperus digitatus ssp auricomis																	+								+		+	1
SPECIES GROUP O																												
Grewia monticola						+																						
Combretum mossambicens						+																						
Berchemia discolor						+																						
Stylochaeton puberulus					+																							
Blainvillea gagana					+																							
Gardenia resiniflua					+																							
Hin 476					+																							
Digitaria velutina					+																							
Maerua decumbens				+																								
Commiphora edulis				+																								
Barleria kirkii			+																									
Cordia monoica		+																										
Gymnosporia senegalensis		0																										
Berchemia zeyheri															+													
Pergularia daemia									+																			
Ocimum gratissimum									+																			
Tricalysia junodii							+																					
Vernonia lundiensis	+																											
Urochloa panicoides	+																											
Indigofera varia	+																											
Commicarpus plumbagineus	+																											
Solanum panduriforme													+															
Piliostigma thonningii													+															
Grewia bicolor												+																
Hin 592												+																
Azima tetracantha												+																
Mariscus rehmannianus																	+											
Lantana camara													1					+										
Ficus capreifolia																		+										
Allolyphus alnifolius										+																		
Strychnos madagascarie										+																		
Reissantia indica											+																	

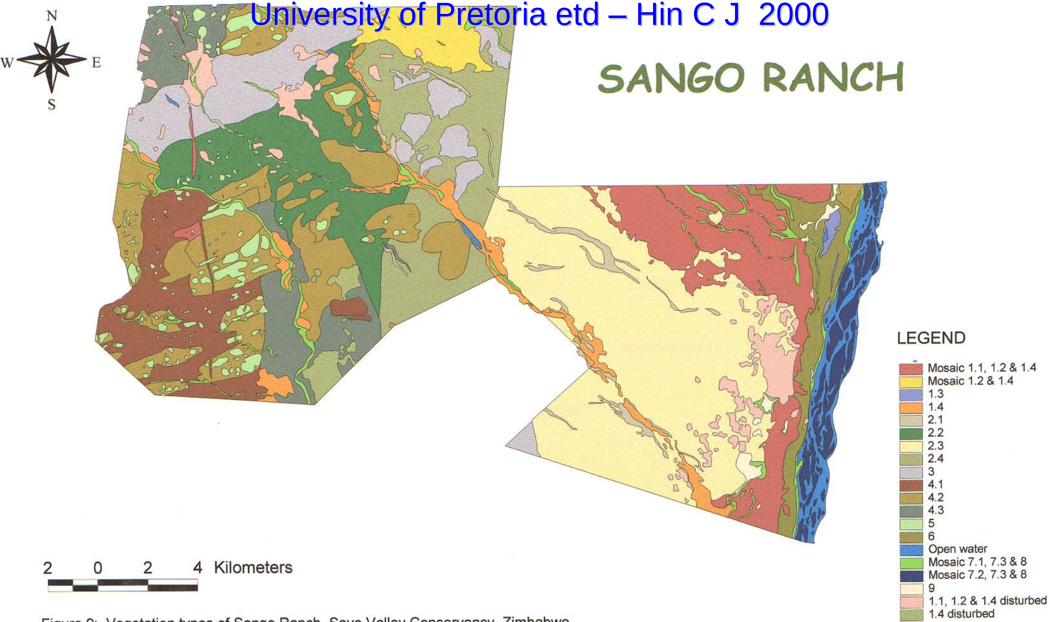


Figure 9: Vegetation types of Sango Ranch, Save Valley Conservancy, Zimbabwe.

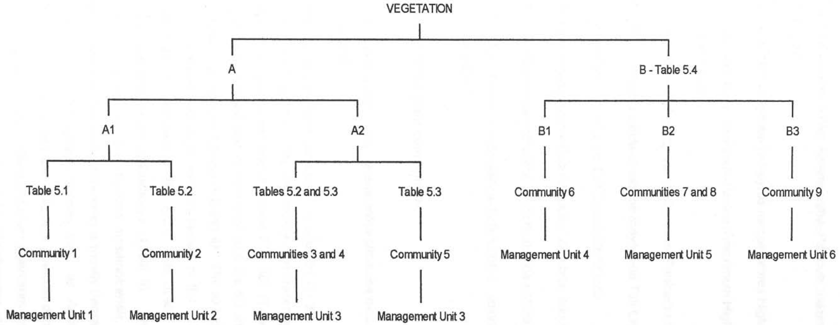


Figure 10. TWINSPAN dendogram of the vegetation communities identified on Sango Ranch, Save Valley Conservancy, Zimbabwe.

5. The *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket
6. The *Acacia tortilis* subsp. *heteracantha–Panicum maximum* Tall Closed Woodland
7. The *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest
    - 7.1 The *Strychnos potatorum–Panicum maximum* High Closed Woodland // Short Thicket
    - 7.2 The *Albizia glaberrima* var. *glabresens–Panicum maximum* High Forest
    - 7.3 The *Faidherbia albida–Eriochloa meyeriana* Tall Closed Woodland
8. The *Phragmites mauritianus* Tall Closed Reedbeds
9. The *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland
    - 9.1 The *Paspalidium obtusifolium–Echinochloa colona* Tall Closed Grassland
    - 9.2 The *Acacia xanthophloea–Echinochloa colona colona* Tall Closed Woodland

Description of the plant communities

1. The *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland

This tall closed woodland community is situated on the floodplain of the Msaizi River (Figures 9 and 11). The community is represented by 65 relevés with an average of 12 species per relevé (range 7 to 30) (Table 6). This community is found on sandy outwash and is associated with the 4U and 8h soil families, which are derived from alluvium (Chapters 2 and 4). The altitude varies between 440 m and 560 m above sea level and the terrain is flat. This community can be recognised by the presence of the herbs *Sida ovata, Hibiscus micrantha* and *Tephrosia purpurea* subsp. *leptostachya* (Table 6). The dominant herbaceous species in this community are *Urochloa mosambicensis, Panicum maximum* and *Digitaria milanjiana.* The herbaceous layer is mostly dense but in overutilised areas the soil is bare and pioneer species such as *Aristida junciformis*, *Tragus berteronianus, Chloris virgata* and *Indigofera praticola* dominate. At the beginning of the 1999 growing season, *Dactyloctenium giganteum* was a prominent feature of the herbaceous layer. According to Van Oudtshoorn (1992), this species forms dense stands after seasons of good rainfall, which was the case during 1999. The diagnostic woody species is *Acacia tortilis* subsp. *heteracantha. Albizia*

Figure 11. The *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland Community on Sango Ranch, Save Valley Conservancy, Zimbabwe.

anthelminthica is also common. Another common woody species is *Cadaba termitaria*.

Structure of the woody layer

Histogrammatic representations of the percentage canopy cover and the density of the woody species in the *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland appear in Figures 12 and 13, respectively. The contribution of woody species contributing >1% to the total woody species composition appears in Table 7. The highest canopy cover and tree density are evident in height classes 0.75-<1.5 m and 1.5-<2.5 m (Figures 12 and 13). *Cadaba termitaria* is a frequent woody shrub in these layers but *Acacia tortilis* subsp. *heteracantha*, *Dichrostachys cinerea* subsp. *africana*, *Grewia monticola*, *Salvadora persica* and *Thilachium africanum* contribute highly (Table 7). This community is closed with a total canopy cover of 13 % and a total density of 336 individuals/ha (Figures 12 and 13). The highest tree class that qualifies as the dominant layer according to Edwards (1983) consists of *Acacia tortilis* subsp. *heteracantha* and it has a height of between 11.5 m and 13.5 m (Figure 12, Table 7). The community is therefore classified as a tall closed woodland and contains a low thicket component (Edwards 1983).

The *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland is sub-divided into four sub-communities:

1.1 The *Tephrosia purpurea* subsp. *leptostachya* –*Urochloa mosambicensis* Short Closed Woodland

This short closed woodland is found on the floodplain of the southeastern section of the Msaizi River and forms a mosaic with the *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Open Woodland and the *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland (Figures 9 and 14). The sub-community is represented by 14 relevés with a mean of 9 species per relevé (range 6-15) (Table 6). The vegetation of the *Tephrosia purpurea* subsp. *leptostachya–Urochloa mosambicensis* Short Closed Woodland is recognised by the presence of the diagnostic species *Tephrosia purpurea* subsp. *leptostachya* var. *pubescens* (Table 6). The woody layer is dominated by by *Albizia anthelminthica*.

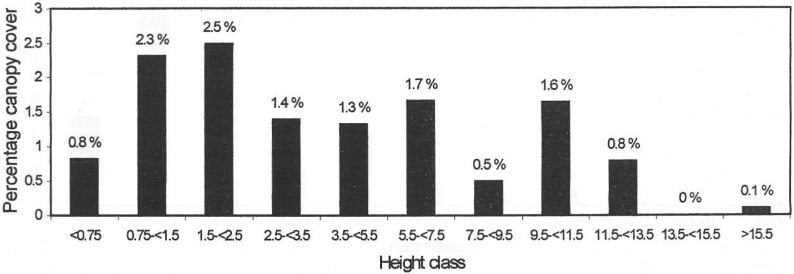


Figure 12. The percentage canopy cover in 11 height classes (m) of the woody species of the *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 13.0 %

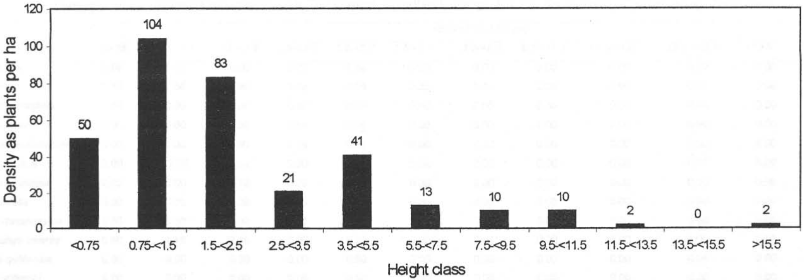


Figure 13. The density of the woody species in 11 height classes (m) of the *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 336.

Table 10. The percentage contribution of 17 woody species in 11 height classes to the total woody species composition of the *Acacia tortilis* subsp. *heteracantha* – *Urochloa mosambicensis* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*Total*
Acacia nilotica	0.00	0.60	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	1.20
Acacia tortilis	1.19	2.68	0.90	1.49	6.54	2.38	1.49	2.08	0.60	0.00	0.00	19.35
Albizia anthelminthica	1.19	0.30	0.00	0.00	0.60	0.60	0.60	0.30	0.00	0.00	0.00	3.59
Azima tetracantha	0.30	0.60	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20
Boscia mossambicensis	0.00	0.30	0.60	1.19	0.90	0.00	0.00	0.00	0.00	0.00	0.00	2.99
Cadaba termitaria	0.00	12.20	6.54	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.04
Capparis tomentosa	0.60	0.90	1.19	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	2.99
Cordia monoica	0.30	0.30	0.30	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40
Dalbergia melanoxylon	0.30	0.30	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.90
Dichrostachys cinerea	0.90	1.19	2.38	0.90	0.90	0.30	0.00	0.00	0.00	0.00	0.00	6.57
Diospyros quiloensis	0.30	0.00	0.30	0.00	0.60	0.00	0.30	0.00	0.00	0.00	0.00	1.50
Gardenia volkensi	0.00	0.00	0.00	0.00	0.90	0.30	0.00	0.00	0.00	0.00	0.00	1.20
Grewia flavescens	0.00	1.19	1.49	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.98
Grewia monticola	0.30	0.30	2.08	1.19	0.60	0.00	0.00	0.00	0.00	0.00	0.00	4.47
Maerua decumbens	0.90	0.30	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50
Salvadora persica	0.90	4.17	2.98	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	8.35
Thilachium africanum	2.08	3.27	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.25

Figure 14. The *Tephrosia purpurea* subsp. *leptostachya–Urochloa mosambicensis* Short Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

Structure of the woody layer

A histogrammatic representation of the percentage canopy cover and the density of the woody species in the *Tephrosia purpurea* subsp. *leptostachya–Urochloa mosambicensis* Short Open Woodland Sub-community appears in Figures 15 and 16, respectively. The contribution of eight woody species contributing >1% to the total woody species composition is presented in Table 10. The highest canopy cover and tree density are evident in height classes 0.75-<1.5 m and 1.5-<2.5 m (Figures 15 and 16). This is due to the shrub *Cadaba termitaria,* which is frequent in this height layer (Table 8). This community is closed with a total canopy cover of 12.0 % and a total density of 247 individuals/ha (Figures 15 and 16). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Albizia anthelminthica* and its height is 7.5-<9.5 m; the sub-community is thus classified as a short closed woodland with a low thicket component (Figure 15, Table 10, Edwards 1983).

1.2 The *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Open Woodland

This short open woodland is found on the floodplain to the south of the Msaizi River and south of Msaize Ranch and forms a mosaic with the *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland (Figures 9 and 17). The sub-community is represented by 10 relevés consisting of a mean of 12 species per relevé (range 7-17) (Table 6). This sub-community is associated with the same soil types as the *Tephrosia purpurea* subsp. *leptostachya –Urochloa mosambicensis* Short Open Woodland (Table 6). Habitat conditions are similar to the *Tephrosia purpurea* subsp. *leptostachya–Urochloa mosambicensis* Short Open Woodland in all but the altitude, which varies between 540 m and 570 m, and the presence of a north-facing relevé (Table 6). The herbaceous layer of the *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Closed Woodland is dominated by *Sericorema remotiflora* (Table 6). The diagnostic woody species is *Dichrostachys cinerea* subsp. *africana.*

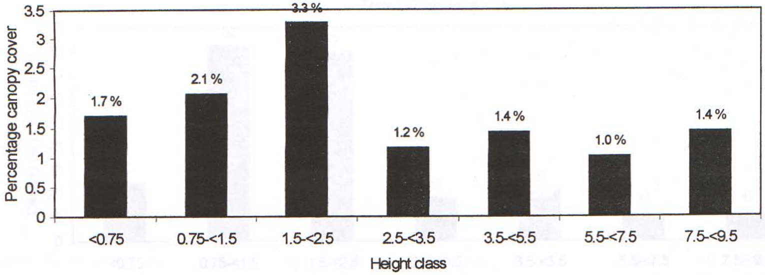


Figure 15. The percentage canopy cover in seven height classes (m) of the woody species of the *Tephrosia purpurea* subsp. *leptostachya–Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 12.1 %.

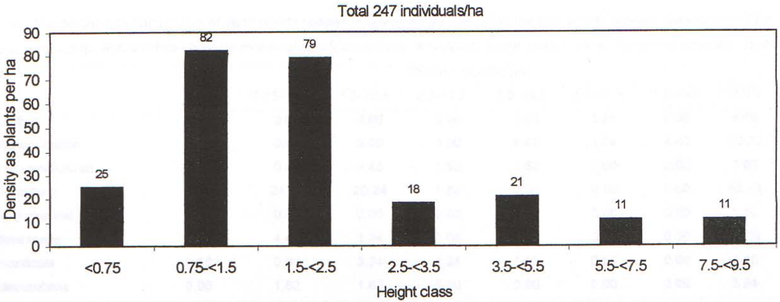


Figure 16. The density of the woody species in seven height classes (m) of the *Tephrosia purpurea* subsp. *leptostachya Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 247.

Table 10. The percentage contribution of eight woody species in seven height classes to the total woody species composition of the *Tephrosia purpurea* subsp. *leptostachya-Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*							
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*TOTAL*
Acacia tortilis	1.62	0.00	0.00	0.00	0.00	3.24	0.00	4.86
Albizia anthelminthica	0.00	0.00	0.00	0.00	4.45	1.62	4.45	10.52
Boscia mossambicensis	0.00	0.00	4.45	1.62	1.62	0.00	0.00	7.69
Cadaba termitaria	5.67	24.70	20.24	1.62	0.00	0.00	0.00	52.23
Diospyros quiloensis	0.00	0.00	0.00	0.00	1.62	0.00	0.00	1.62
Grewia flavescens	2.83	4.45	3.24	0.00	0.00	0.00	0.00	10.52
Grewia monticola	0.00	0.00	3.24	3.24	1.62	0.00	0.00	8.10
Maerua decumbens	0.00	1.62	1.62	0.00	0.00	0.00	0.00	3.24

Figure 17. The *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Open Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

Structure of the woody layer

A histogrammatic representation of the percentage canopy cover and the density of the woody species in the *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Open Woodland is depicted in Figures 18 and 19, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is presented in Table 11. The highest canopy cover is evident in height class 9.5-<11.5 m and the highest density is seen in height class 0.75-<1.5 m (Figures 18 and 19). The reason for this is the broad canopy of large *Acacia tortilis* subsp. *heteracantha* specimens; a few individuals will then deliver a large canopy cover. *A. tortilis* subsp. *heteracantha, Dichrostachys cinerea* subsp. *africana, Grewia flavescens* var. *flavescens* and *G. monticola* contribute most to the density in the 0.75-<1.5 m height class (Table 11). This community is slightly closed with a total canopy cover of 14.6 % and a total density of 405 individuals/ha (Figures 18 and 19). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Acacia tortilis* subsp. *heteracantha* and lies in the 9.5-<11.5 m class (Figure 18, Table 11). The sub-community is thus classified as a short closed woodland and contains a low thicket component (Edwards 1983).

1.3 The *Capparis tomentosa–Urochloa mosambicensis* Short Open Woodland

This short open woodland is found south of Masiyauta Pan adjacent to the Save River (Figures 9 and 20). It is represented by 10 relevés with an average of 12 species per relevé (range 8-17) (Table 6). This sub-community is also associated with the soil families 4U and 8h that are derived from alluvium (Chapter 4; Table 6). Altitude varies mostly between 440 m and 470 m. Several pans are found throughout this sub-community (Figure 9). *Acacia tortilis* subsp. *heteracantha, Capparis tomentosa, Thilachium africanum, Salvadora persica* and *Anisotes formosissimus* are characteristic species of the *Capparis tomentosa–Urochloa mosambicensis* Tall Closed Woodland (Table 6).

Structure of the woody layer

A histogrammatic representation of the percentage canopy cover and the density of the woody species in the *Capparis tomentosa–Urochloa mosambicensis* Short Open Woodland is depicted in Figures 21 and 22, respectively. The percentage

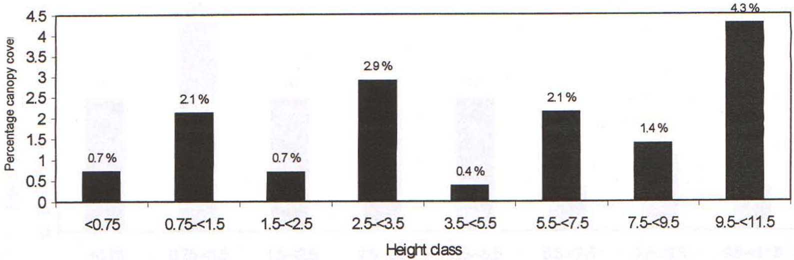


Figure 18. The percentage canopy cover in eight height classes (m) of the woody species of the *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. Total canopy cover is 14.6 %.

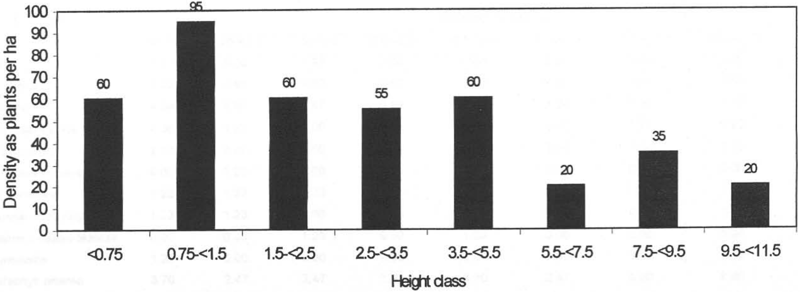


Figure 19. The density of the woody species in eight height classes (m) of the *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total number of plants per ha is 405.

Table 11. The percentage contribution of 17 woody species in eight height classes to the total woody species composition in the *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*								
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*TOTAL*
Hin 242	0.00	0.00	1.23	0.00	0.00	0.00	0.00	0.00	1.23
Acacia nilotica	0.00	0.00	0.00	0.00	1.23	0.00	0.00	0.00	1.23
Acacia tortilis	4.94	8.64	2.47	9.88	3.70	1.23	4.94	3.70	39.5
Albizia anthelminthica	0.00	1.23	0.00	0.00	0.00	0.00	1.23	0.00	2.46
Azima tetracantha	2.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.47
Boscia mossambicensis	0.00	1.23	0.00	1.23	1.23	0.00	0.00	0.00	3.69
Cadaba termitaria	1.23	1.23	1.23	0.00	0.00	0.00	0.00	0.00	3.69
Colophospermum mopane	1.23	1.23	0.00	0.00	0.00	0.00	0.00	0.00	2.46
Combretum mossambicense	0.00	0.00	1.23	0.00	1.23	0.00	0.00	0.00	2.46
Cordia monoica	1.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.23
Dichrostachys cinerea	3.70	2.47	2.47	1.23	3.70	2.47	0.00	0.00	16.04
Diospyros quiloensis	0.00	0.00	0.00	0.00	1.23	0.00	0.00	0.00	1.23
Grewia flavescens	0.00	2.47	6.17	1.23	0.00	0.00	0.00	0.00	9.87
Grewia monticola	0.00	3.70	0.00	0.00	2.47	0.00	0.00	0.00	6.17
Lonchocarpus capassa	0.00	0.00	0.00	0.00	0.00	1.23	0.00	0.00	1.23
Markhamia zanzibarica	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.00	1.23
Sclerocarya birrea	0.00	0.00	0.00	0..00	0.00	0.00	1.23	0.00	1.23

Figure 20. The *Capparis tomentosa–Urochloa mosambicensis* Short Open Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

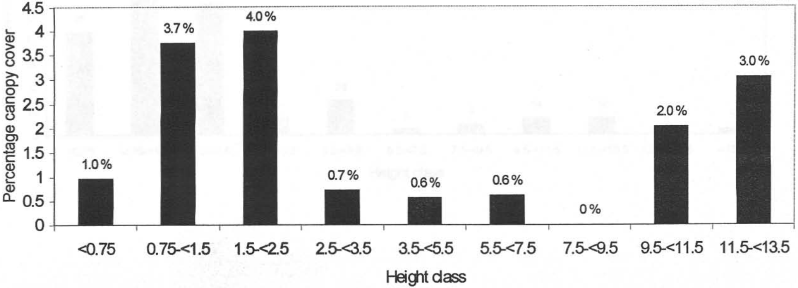


Figure 21. The percentage canopy cover in nine height classes (m) of the woody species of the *Capparis tomentosa–Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 15.6 %.

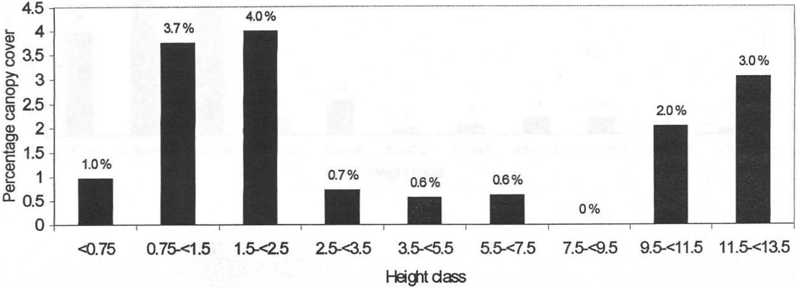


Figure 21. The percentage canopy cover in nine height classes (m) of the woody species of the *Capparis tomentosa–Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 15.6 %.

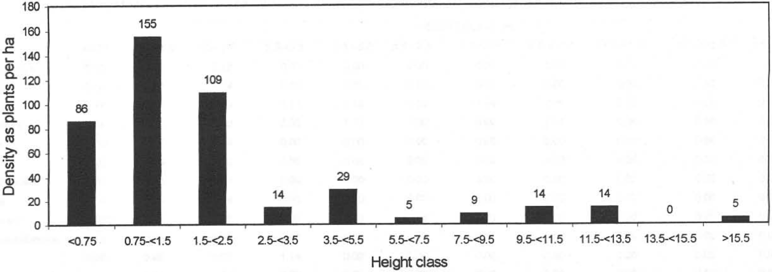


Figure 22. The density of the woody species in 11 height classes (m) of the *Capparis tomentosa–Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total number of plants per ha is 440.

Table 12. The percentage contribution of 21 woody species in 11 height classes to the total woody species composition in the *Capparis tomentosa–Urochloa mosambicensis* Short Open Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*										
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Anisotes formosissimus	0.00	4.10	3.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.28
Lycium shawii	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Acacia tortilis	1.14	3.18	0.00	1.14	3.18	0.00	1.14	2.05	3.18	0.00	0.00	15.01
Albizia anthelminthica	1.14	0.00	0.00	0.00	1.14	0.00	0.00	1.14	0.00	0.00	0.00	3.42
Azima tetracantha	0.00	3.18	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.32
Boscia foetida	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Boscia mossambicensis	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Cadaba termitaria	1.14	6.14	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.42
Capparis tomentosa	2.05	4.09	7.27	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	14.55
Combretum mossambicense	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Cordia monoica	0.00	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Dalbergia melanoxylon	1.14	1.14	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.42
Dichrostachys cinerea	0.00	0.00	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Diospyros quiloensis	0.00	0.00	1.14	0.00	1.14	0.00	1.14	0.00	0.00	0.00	0.00	3.42
Grewia bicolor	0.00	0.00	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.05
Grewia flavescens	0.00	2.05	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.10
Grewia monticola	0.00	1.14	3.18	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.46
Lannea schweinfurthii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14	1.14
Salvadora persica	5.23	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.28
Thilachium africanum	2.05	6.14	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.33
Ziziphus mucronata	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14

contribution of woody species contributing >1% to the total woody species composition is presented in Table 12. The highest canopy cover and density is evident in the 0.75-<1.5 m and 1.5-<2.5 m height classes (Figures 21 and 22). *Capparis tomentosa, Anisotes formosissimus, Grewia flavescens* var. *flavescens, Cadaba termitaria, Thilachium africanum* and *Azima tetracantha* contribute mostly to the canopy cover and density (Table 12). This community is slightly closed with a total canopy cover of 15.6 % and a total density of 440 individuals/ha (Figures 21 and 22). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Acacia tortilis* subsp. *heteracantha* and lies in the 11.5-<13.5 m class (Figure 21, Table 12). The sub-community is thus classified as a tall closed woodland with a low thicket component (Edwards 1983).

1.4 The *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland

This short closed woodland sometimes forms a mosaic with the *Tephrosia purpurea* subsp. *leptostachya–Urochloa mosambicensis* Short Open Woodland and the *Dichrostachys cinerea* subsp. *africana–Urochloa mosambicensis* Short Open Woodland and is sometimes found mixed with these two communities, especially along drainage lines (Figures 9 and 23). The sub-community is also found on the floodplains of the Saindota and Makore Rivers (Figure 9). This community is represented by 31 relevés with an average of 13 species per relevé (range 7-30) (Table 6). The soils in this community belong to the saline-sodic 8h soil family derived from alluvium and gneiss (Chapter 4; Table 6). Altitude varies between 440 m and 560 m and the terrain is a mostly flat valley but along the Makore River it becomes steeper (Figure 3). Percentage rock cover is low but along the Makore River stone and rock cover is higher (Table 6). The herb layer of this sub-community is recognised by *Sporobolus nitens* (Table 6). No diagnostic or dominant woody species are evident from Table 6.

Structure of the woody layer

A histogrammatic representation of the percentage canopy cover and the density of the woody species in the *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland is depicted in Figures 24 and 25, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is presented in Table 13. The highest canopy cover is evident in the 3.5-<5.5 m and 5.5-<7.5 m height classes (Figure 24) and the highest density is seen in the 0.75-<1.5 m and 1.5-<2.5 m classes (Figure 25). *Acacia tortilis* subsp. *heteracantha* is once again responsible for this (Table 13). *Salvadora persica* is the dominant species in the 0.75-<1.5 m and 1.5-<2.5 m

Figure 23. The *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

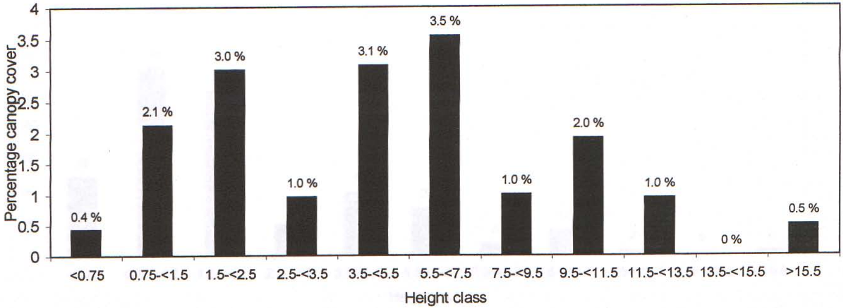


Figure 24. The Percentage canopy cover in 11 height classes (m) of the woody species of the *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 17.5 %.

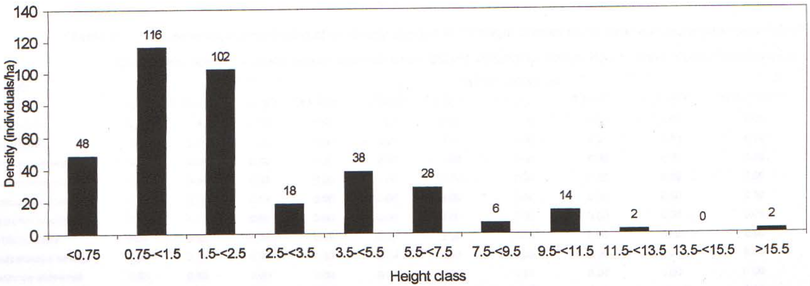


Figure 25. The density of the woody species in 11 height classes (m) of the *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 374.

Table 13. The percentage contribution of 17 woody species in 11 height classes to the total woody species composition in the *Sporobolus nitens–Urochloa mosambicensis* Short Closed Woodland, Sango Ranch, Save Valley Conservancy.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia nilotica	0.00	1.60	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	2.67
Acacia tortilis	0.53	2.14	1.60	0.00	3.21	4.81	1.60	3.21	0.53	0.00	0.00	17.63
Albizia anthelminthica	0.00	0.00	0.00	0.00	0.53	1.60	0.00	0.00	0.00	0.00	0.00	2.13
Boscia mossambicensis	0.00	0.00	0.53	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	2.13
Cadaba termitaria	2.67	3.21	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.41
Capparis tomentosa	0.53	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60
Cordia monoica	0.00	0.53	0.53	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06
Dichrostachys cinerea	1.07	2.14	5.35	1.60	2.14	0.53	0.00	0.00	0.00	0.00	0.00	12.83
Diospyros quiloensis	0.53	0.53	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	1.59
Grewia bicolor	0.53	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06
Grewia flavescens	0.53	0.53	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.59
Grewia inaequilatera	0.00	0.53	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06
Grewia monticola	0.53	0.00	3.21	2.14	0.53	0.00	0.00	0.00	0.00	0.00	0.00	6.41
Maerua decumbens	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53
Phyllanthus reticulatus	0.53	0.00	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.06
Salvadora persica	0.00	10.16	8.02	0.00	0.53	0.00	0.00	0.00	0.00	0.00	0.00	18.71
Thilachium africanum	4.81	6.42	2.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.37

height classes, but *Acacia tortilis* subsp. *heteracantha, Dichrostachys cinerea* subsp. *africana* , *Cadaba termitaria* and *Thilachium africanum* also contribute to the density (Table 13). This community is slightly closed with a total canopy cover of 17.5 % and a total density of 374 individuals/ha (Figures 24 and 25). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Acacia tortilis* subsp. *heteracantha* and lies in the 9.5-<11.5 m class (Figure 24, Table 13). The sub-community is thus classified as a short closed woodland with a low thicket component (Edwards 1983).

2. The *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland

This community lies over the centre of Sango Ranch (Figures 9 and 26). The community is represented by 66 relevés with an average of 25 species per relevé (13-44) (Table 7). This community is associated with slightly more clayey midslope soils of the 4S, 4U, 4PE and 4S soil families (Chapter 4; Table 7). The soils are derived from gneiss, lava, shale, quartzite, limestone, grits and alluvium (Chapter 2; Table 7). Altitude varies between 460 m and 600 m. The terrain varies from rolling hills to flat plains and valleys. Rock cover is low except on the hills where large rocks and stones lie scattered on the surface. The herbaceous layer is mostly sparse but along drainage lines a dense herb layer is found. The herb layer is recognised by the diagnostic *Pupalia lappacea* var. *velutina* (Table 7). *Aristida junciformis* and *Enteropogon macrostachys* are also present. Dominant grasses are *Brachiaria deflexa, Urochloa mosambicensis, Panicum maximum* and *Eragrostis rigidior*. The pioneers *Pupalia lappacea* var. *velutina, Aristida junciformis, Plectranthus tetensis, P. caninus, Oropetium capense, Kylinga alba, Tragus berteronianus, Chloris virgata* and *Justicia flava* dominate on the 4U soils on alluvium, while *Sporobolus nitens* dominates on 8h soils. The diagnostic woody species is *Colophospermum mopane* and it dominates the woody layer in this community (Table 7).

Structure of the woody layer

Figures 27 and 28 depict a histogrammatic representation of the percentage canopy cover and the density of the woody species in the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is presented in Table 14. The highest canopy cover is

Figure 26. The *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

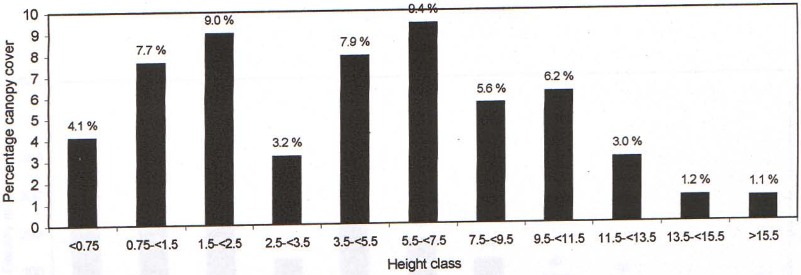


Figure 27. The percentage canopy cover in 11 height classes (m) of the woody species of the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 58.4 %.

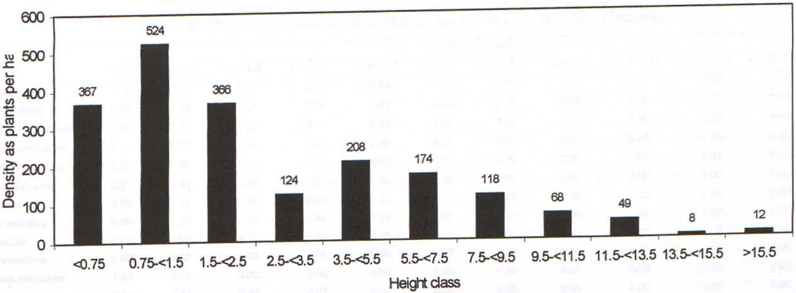


Figure 28. The density of the woody species in 11 height classes (m) of the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 2 018.

Table 14. The percentage contribution of 13 woody species in 11 height classes to the total woody species composition in the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia erubescens	0.00	0.28	0.21	0.00	0.64	0.21	0.00	0.00	0.00	0.00	0.00	1.34
Cadaba termitaria	0.60	1.84	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.65
Colophospermum mopane	6.45	7.72	6.60	2.41	5.52	5.81	3.90	2.30	1.80	0.28	0.42	43.21
Combretum apiculatum	1.13	1.20	1.13	1.63	2.20	0.50	0.00	0.00	0.00	0.00	0.00	7.79
Dichrostachys cinerea	0.35	1.35	0.21	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.12
Diospyros quiloensis	0.21	0.35	1.36	0.50	1.20	1.20	0.07	0.00	0.00	0.00	0.00	4.89
Euclea divinorum	0.00	0.21	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01
Gardenia resiniflua	0.00	0.28	0.50	0.64	0.28	0.00	0.00	0.00	0.00	0.00	0.00	1.70
Grewia bicolor	0.00	4.82	4.12	0.42	0.65	0.00	0.00	0.00	0.00	0.00	0.00	10.01
Grewia flavescens	0.92	0.00	1.63	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.26
Phyllanthus reticulatus	1.84	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.55
Thilachium africanum	0.71	1.77	0.35	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.90
Tricalysia junodii	2.76	2.30	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.77

evident in the 0.75-<1.5 m, 1.5-<2.5 m and 3.5-<5.5 m height classes (Figures 27) and the highest density is seen in the <0.75, 0.75-<1.5 m class (Figure 28). A shrub-like form of *Colophospermum mopane* is responsible for these figures (Table 14). This community is fairly closed with a total canopy cover of 58.4% (Figure 27) and total density of 2 018 individuals/ha (Figure 28). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Colophospermum mopane* and lies in the 9.5-<11.5 m class (Figure 27, Table 14). The high number of shrubs in some areas results in a mosaic of short closed woodland and thicket (Edwards 1983).

The *Colophospermum mopane– Brachiaria deflexa* Short Thicket // Short Closed Woodland can be sub-divided into four sub-communities:

2.1 The *Commiphora edulis–Colophospermum mopane* Short Thicket

The *Commiphora edulis–Colophospermum mopane* Short Thicket is situated along small drainage lines in the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland (Figures 9 and 29). The sub-community is represented by three relevés with an average of 27 species per relevé (Table 7). This sub-community lies on the alluvial 4U and 8h soil families that are found along the drainage lines of the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland (Chapter 4; Figure 9; Table 7). Altitude varies from 460 m to 570 m. The terrain is flat and surface rocks are absent (Table 7). The vegetation of drainage lines is moderately utilised and trampled, while no severe erosion is evident. The herb layer contains no diagnostic species but is dominated by the characteristic *Setaria pumila*, *Ctenolepis cerasiformis* and *Ipomoea dichroa* (Table 7). Dominant woody species in this sub-community include *Commiphora edulis* and *Gardenia resiniflua*.

Structure of the woody layer

Histograms of percentage canopy cover and density for this sub-community appear in Figures 30 and 31, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is presented in Table 15. The highest canopy cover is evident in the 0.75-<1.5 m, 1.5-<2.5 m, 3.5-<5.5 m and 7.5-<9.5 m height classes (Figures 30) and the highest density is seen in the 0.75-<1.5 m and 1.5-<2.5 m classes (Figure 31). Shrub-like forms of *Colophospermum mopane, Grewia* sp., *Grewia bicolor* and *G. monticola* are

Figure 29. The *Commiphora edulis–Colophospermum mopane* Short Thicket on Sango Ranch, Save Valley Conservancy, Zimbabwe.

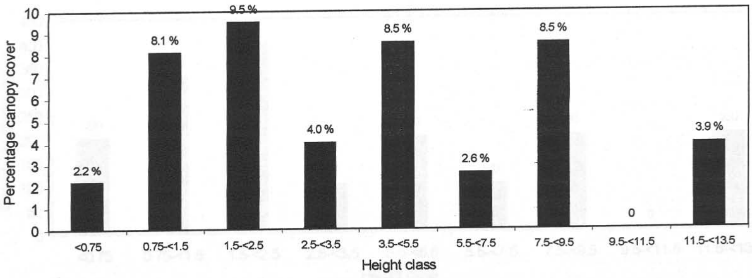


Figure 30. The percentage canopy cover in nine height classes (m) of the woody species of the *Commiphora edulus*–*Colophospermum mopane* Short Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 47.4 %.

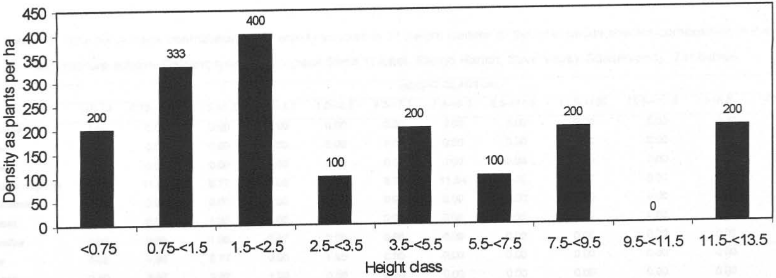


Figure 31. The density of the woody species in nine height classes (m) of the *Commiphora edulus– Colophospermum mopane* Short Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 1 733.

Table 15. The percentage contribution of 11 woody species in 11 height classes to the total woody species composition in the *Commiphora edulus–Colophospermum mopane* Short Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*										
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia nigrescens	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90
Celosia trigyma	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90
Cissus cornifolia	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90
Colophospermum mopane	5.77	11.54	5.77	0.00	5.77	5.77	11.54	0.00	3.87	0.00	0.00	50.03
Diospyros quiloensis	0.00	0.00	0.00	0.00	1.90	0.00	0.00	0.00	0.00	0.00	0.00	1.90
Euclea divinorum.	0.00	0.00	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90
Gardenia resiniflua	0.00	0.00	1.90	3.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.77
Grewia bicolor	0.00	1.90	5.77	0.00	1.90	0.00	0.00	0.00	0.00	0.00	0.00	9.57
Grewia monticola	0.00	3.87	3.87	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.64
Grewia sp.	0.00	0.00	3.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.87
Grewia villosa	0.00	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90

responsible for the cover figures in the lower height classes, while *C. mopane, G. bicolor* and *G. monticola* contribute to the high density (Table 15). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Colophospermum mopane* and lies in the 7.5-<9.5 m class (Figure 32, Table 15). The high total canopy cover (47.4%; Figure 30), high total density (1 733 individuals/ha; Figure 31), the dominance of a short height class and a high shrub cover forms a short thicket structure (Edwards 1983).

2.2 The *Indigofera praticola–Colophospermum mopane* Short Closed Woodland

This short closed woodland lies more or less in the centre of Sango Ranch (Figures 9 and 32). It is represented by 12 relevés with an average of 25 species per relevé (range 15-36) (Table 7). The soils of this sub-community belong to the more heavily textured soils of the 4PE soil family on midslopes and are derived from gneiss, alluvium and shale (Chapter 4; Table 7). Altitude varies from 450 m to 575 m (Table 7). The herbaceous layer here is dominated mainly by *Tephrosia purpurea* subsp. *leptostachya* var. *pubescens* and *Ipomoea sinensis* subsp. *blepharosephala* (Table 7). *Acacia nilotica* subsp. *kraussiana* and *Commiphora glandulosa* are dominant woody species.

Structure of the woody layer

Histograms of percentage canopy cover and density for this sub-community are shown in Figures 33 and 34, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is depicted in Table 16. The highest canopy cover is evident in the 5.5-<7.5 m height class (Figure 33) and the highest density is seen in the 0.75-<1.5 m class (Figure 34). *Colophospermum mopane* is responsible for these cover and density figures (Table 16). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Colophospermum mopane* and lies in the 5.5-<7.5 m class (Figure 33, Table 16). The high total canopy cover (56.34 %; Figure 34), high total density (1 917 individuals/ha; Figure 33) and the dominance of a short height class results in the classification into a short closed woodland structure with a low thicket component (Edwards 1983).

Figure 32. The *Indigofera praticola–Colophospermum mopane* Short Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

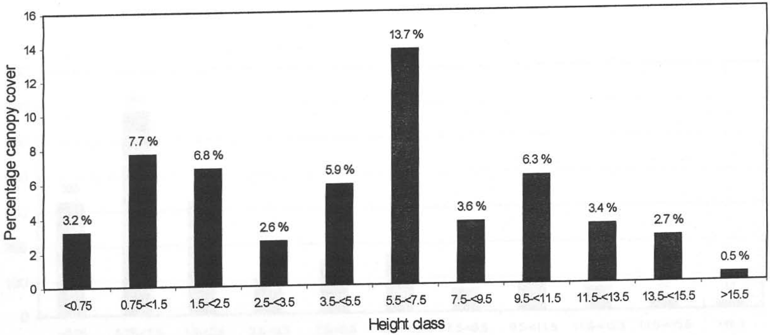


Figure 33. The percentage canopy cover in 11 height classes (m) of the woody species of the *Indigofera praticola–Colophospermum mopane* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 56.3 %.

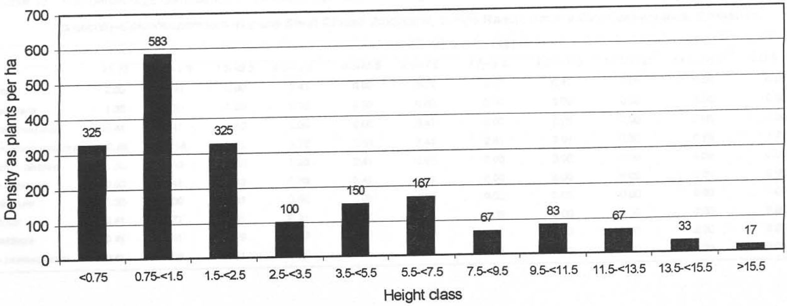


Figure 34. The density of the woody species in nine height classes (m) of the *Indigofera praticola–Colphospermum mopane* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. Total plants per ha is 1 917.

Table 16. The percentage contribution of 10 woody species in 11 height classes to the total woody species composition in the *Indigofera praticola–Colophospermum mopane* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	HEIGHT CLASS (m)											TOTAL
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	
Acacia tortilis	0.00	0.00	0.00	0.41	0.00	0.00	0.41	0.41	0.00	0.00	0.00	1.23
Cadaba termitaria	1.30	4.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.1
Combretum apiculatum	0.41	0.41	0.00	0.00	0.00	0.41	0.00	0.00	0.00	0.00	0.00	1.23
Colophospermum mopane	10.85	19.14	9.13	1.72	5.63	7.41	2.61	3.91	3.50	0.89	1.72	66.51
Dichrostachys cinerea	1.30	0.89	0.89	1.30	0.41	0.00	0.00	0.00	0.00	0.00	0.00	4.79
Diospyros quiloensis	0.00	0.41	0.83	0.89	0.41	0.89	0.00	0.00	0.00	0.00	0.00	3.43
Euclea divinorum	0.00	0.00	2.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.61
Grewia bicolor	0.41	1.72	0.41	0.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.95
Grewia monticola	0.41	0.41	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.71
Rhigozum zambesiacum	0.41	0.89	0.41	0.00	0.41	0.00	0.00	0.00	0.00	0.00	0.00	2.12

2.3 The *Thilachium africanum–Colophospermum mopane* Short Thicket

This short thicket is situated on the eastern half of Sango Ranch (Figures 9 and 35). The sub-community is represented by 20 relevés with an average of 26 species per relevé (range 16-44) (Table 7). The soils of this sub-community belong to the sandy 4U soil family, which lies on alluvium (Chapter 4; Table 7). Altitude varies between 450 m and 510 m and the terrain is a flat midslope with no surface stones or rocks (Table 7). No diagnostic herbaceous species are present in this sub-community (Table 7). Diagnostic woody species in this sub-community include *Thilachium africanum*, *Rhigozum zambesiacum* and *Balanites aegyptiaca*.

Structure of the woody layer

Histograms representing the percentage canopy cover and density for this sub-community are shown in Figures 36 and 37, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is depicted in Table 17. The highest canopy cover is evident in the 1.5-<2.5 m, 3.5-<5.5 m and 9.5-<11.5 m height classes (Figure 36) and the highest density is seen in the 0.75-<1.5 m class (Figure 37). A shrub-like *Colophospermum mopane* is responsible for the high cover values in these classes (Table 17). *Thilachium africanum* possesses the greatest density in the 0.75-<1.5 m height class (Table 17). Other species contributing to the high density in this height class include *C. mopane, Grewia bicolor, Cadaba termitaria* and *Tricalysia unodiii* var. *kirkii* (Table 17). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Colophospermum mopane* and lies in the 9.5-<11.5 m class (Figure 36, Table 17). The very high total canopy cover (71.5 %; Figure 36), total density (2 595 individuals/ha; Figure 37) and the high shrub cover results in the classification into a short thicket structure (Edwards 1983).

2.4 The *Ruellia patula–Colophospermum mopane* Tall Closed Woodland

This tall closed woodland runs in a north-south strip in the centre of Sango Ranch and crosses over into the Umkondo Lease (Figures 9 and 38). It is is represented by 23 relevés with an average of 21 species per relevé (range 13-31) (Table 7). The dominant soils in this sub-community are classified into the heavily textured 4S soil family that is derived from the Umkondo Shales and Lavas (Chapter 4; Table 7). Altitude varies between 470 m and 560 m and the

Figure 35. The *Thilachium africanum–Colophospermum mopane* Short Thicket on Sango Ranch, Save Valley Conservancy, Zimbabwe.

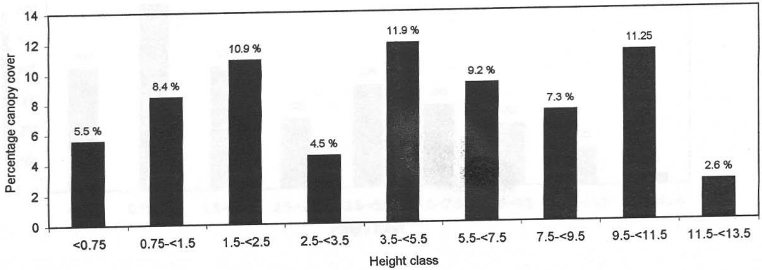


Figure 36. The percentage canopy cover in nine height classes (m) of the woody species of the *Thilachium africanum–Colophospermum mopane* Short Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 71.5 %.

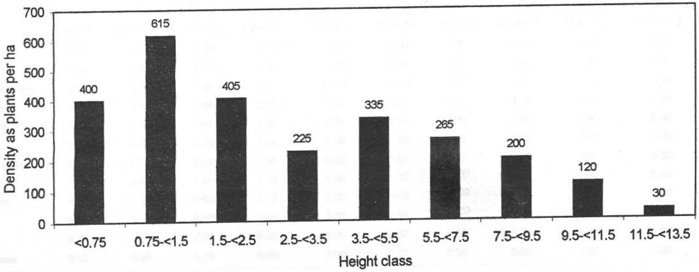


Figure 37. The density of the woody species in nine height classes of the *Thilachium africanum–Colophospermum mopane* Short Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 2 595.

Table 17. The percentage contribution of 12 woody species in 11 height classes to the total woody species composition in the *Thilachium africanum–Colophospermum mopane* Short Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Balanites aegyptiaca	0.39	0.58	0.39	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.55
Cadaba termitaria	1.16	3.47	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.40
Colophospermum mopane	4.05	4.62	8.86	7.51	11.18	10.02	7.32	4.43	1.16	0.00	0.00	59.15
Commiphora merkeri	0.00	0.19	0.00	0.00	0.58	0.00	0.00	0.19	0.00	0.00	0.00	0.96
Diospyros quiloensis	0.19	0.58	0.96	0.39	0.58	0.19	0.00	0.00	0.00	0.00	0.00	2.89
Grewia bicolor	0.77	3.28	0.39	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.63
Rhigozum zambesiacum	0.00	0.19	0.58	0.00	0.39	0.00	0.00	0.00	0.00	0.00	0.00	1.16
Salvadora australis	0.00	0.00	1.93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.93
Thilachium africanum	1.35	5.59	0.96	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.09
Tricalysia junodii	4.24	3.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.71
Ximenia caffra	0.77	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.96
Zanthoxylum capense	0.19	0.96	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34

Figure 38. The *Ruellia patula–Colophospermum mopane* Tall Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

terrain is a mostly flat midslope (Table 7). Surface rocks are almost absent with a few areas having large rocks lying on the soil surface. The herbaceous layer here is recognised the diagnostic *Ruellia patula* and by the non-diagnostic *Plectranthus caninus*, *Pavonia burchelii* and *Sporobolus festivus* (Table 7). The woody layer contains no diagnostic species.

Structure of the woody layer

Histograms showing the percentage canopy cover and density for this sub-community are presented in Figures 39 and 40, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is depicted in Table 18. The highest canopy cover is evident in the 5.5-<7.5 m height class (Figure 39) and the highest density is seen in the 0.75-<1.5 m class (Figure 40). *Colophospermum mopane* is responsible for the high cover values in the 5.5-<7.5 m class (Table 18). *Grewia bicolor* and *Colophospermum mopane* possess the greatest density in the 0.75-<1.5 m height class (Table 18). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Colophospermum mopane* and lies in the >15.5 m class (Figure 39, Table 18). The high total canopy cover (47.9%; Figure 39), high total density of plants (1 849 individuals/ha; Figure 40) and the dominance of a tall layer thus results in the classification into a tall closed woodland structure with a low thicket component (Edwards 1983).

3. The *Combretum apiculatum* subsp. *apiculatum–Colophospermum mopane* Short Closed Woodland

This short closed woodland consists of low hills scattered within the *Ruellia patula–Colophospermum mopane* Short Thicket Sub-community and also lies in a narrow band in the north-west of Sango Ranch (Figures 9 and 41). The community is represented by eight relevés with an average of 18 species per relevé (range 14-23) (Table 7). The soils of this community belong to the 4S and 4PE soil families (Chapter 4; Table 7). The geology of the low hills and outcrops on which the community lies varies from gneiss and granite to conglomerate and limestone (Table 7). The altitude of these low hills varies between 540 m and 600 m. Large stones and rocks are found on the soil surface. The vegetation here is sometimes severely overutilised and trampling and erosion are slight to moderate. The dominant general species evident are *Hibiscus micrantha* and *Pupalia lappacea* var. *velutina* (Table 7). This community may be recognised by the presence of a combination of the diagnostic *Combretum apiculatum* subsp. *apiculatum* and the general *Colophospermum mopane*. Other important diagnostic

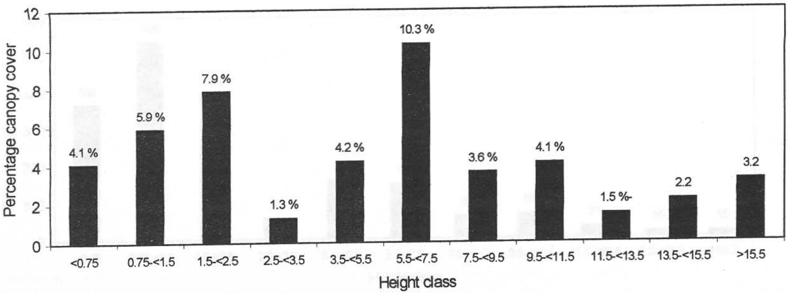


Figure 39. The percentage canopy cover in 11 height classes (m) of the woody species of the *Ruellia patula–Colophospermum mopane* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 47.9 %.

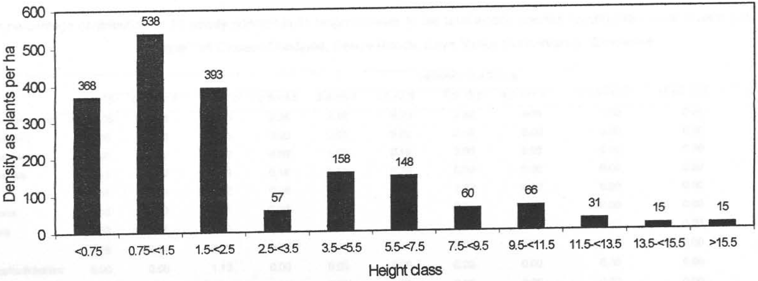


Figure 40. Density of the woody species in 11 height classes (m) of the *Ruellia patula–Colophospermum mopane* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha 1849.

Table 18. The percentage contribution of 11 woody species in 11 height classes to the total woody species composition in the *Ruellia patula–Colophospermum mopane* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Colophospermum mopane	10.05	8.16	8.35	2.25	7.15	5.76	2.52	3.31	1.50	0.91	0.91	50.84
Commiphora africana	0.38	0.75	0.16	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	1.44
Commiphora merkeri	1.07	0.00	0.38	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	1.60
Diospyros quiloensis	0.16	0.47	1.56	0.16	1.71	0.38	0.00	0.00	0.00	0.00	0.00	4.42
Grewia bicolor	2.31	6.04	4.22	0.38	0.16	0.00	0.00	0.00	0.00	0.00	0.00	13.09
Grewia flavescens	0.16	0.69	0.91	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.14
Grewia monticola	0.00	0.75	3.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.95
Grewia villosa	0.38	3.04	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.79
Gymnosporia putterlickoides	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13
Thilachium africanum	0.47	1.12	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50
Tricalysia junodii	1.93	5.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.05

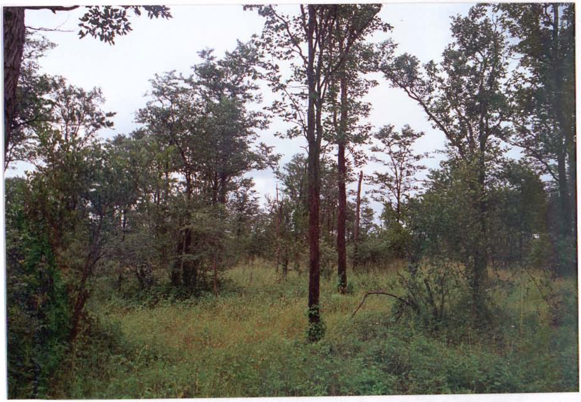


Figure 41. The *Combretum apiculatum* subsp. *apiculatum–Colophospermum mopane* Short Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

woody species are *Acacia erubescens*, *Combretum imberbe*, *Afzelia quanzensis*, *Phyllanthus reticulatus*, *Acacia nigrescens* and *Kirkia acuminata*. The community appears to be ecotonal area between community 2 and community 4.

Structure of the woody layer

Histograms showing the percentage canopy cover and density for this sub-community are presented in Figures 42 and 43, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is depicted in Table 19. The highest canopy cover is evident in the 1.5-<2.5 m height class (Figure 42) and the highest density is seen in the 0.75-<1.5 m and 1.5-<2.5 m classes (Figure 43). *Combretum apiculatum* subsp. *apiculatum*, *Grewia bicolor, G. flavescens* var. *flavescens* and *Phyllanthus reticulatus* contribute to the cover and density values in these classes (Table 19). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Combretum apiculatum* subsp. *apiculatum* and *Commiphora mollis* and lies in the 7.5-<9.5 m class (Figure 42, Table 19). The total canopy cover, total density (32.8 %, Figure 42; 926 individuals/ha, Figure 43, respectively) and the dominance of short tree layer results in a short closed woodland structure with a low thicket component .

4. The *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland

The *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Short Closed Woodland lies on the western side of Sango Ranch (Figures 9 and 44). The community is represented by 56 relevés with an average of 24 species per relevé (range 12-38) (Table 8). The soils of this plant community vary from acidic shallow light soils to neutral and alkaline deeper heavy textured soils that belong to the 5G and 4PE soil families, respectively (Chapter 4; Table 8). These soils are derived from granite and gneiss (Chapter 4; Table 8). This community lies at 460 m and 650 m (Table 8). The terrain is mostly broken and rocky with scattered castle koppies and inselbergs of the *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket Community. The vegetation is locally overutilised and trampled, and severe erosion occurs in one area. No diagnostic herbaceous species are found in this community (Table 8). The dominant species include *Urochloa mosambicensis*, *Chamaecrista absus*, *Panicum maximum*, *Brachiaria deflexa* and *Digitaria milanjiana*. The woody layer is characterised by the diagnostic

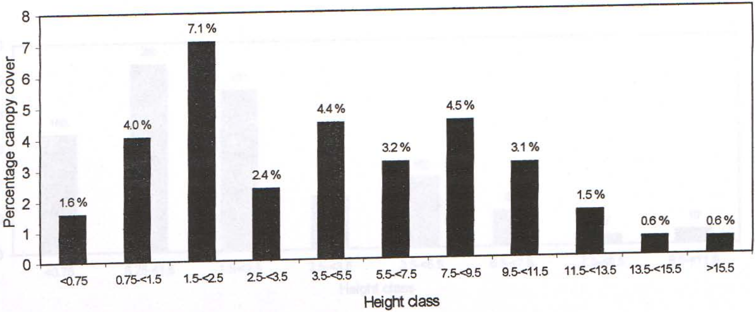


Figure 42. The percentage canopy cover in 11 height classes (m) of the woody species of the *Combretum apiculatum* subsp. *apiculatum–Colphospermum mopane* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 32.8 %.

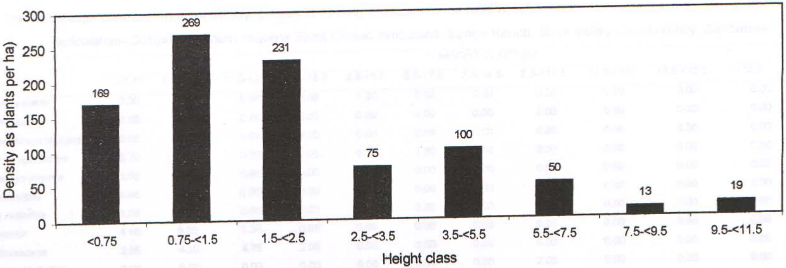


Figure 43. The densities of the woody species in nine height classes (m) of the *Combretum apiculatum* subsp. *apiculatum*–*Colphospermum mopane* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 926.

Table 19. The percentage contribution of 14 woody species in 11 height classes to the total woody species composition in the *Combretum apiculatum* subsp. *apiculatum–Colophospermum mopane* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia erubescens	0.00	0.66	0.66	0.00	1.30	0.66	0.00	0.00	0.00	0.00	0.00	3.28
Canthium glaucum	0.00	0.66	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Colophospermum mopane	2.05	0.66	1.94	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	5.31
Combretum apiculatum	2.70	3.50	3.50	4.90	6.70	1.30	0.66	0.00	0.00	0.00	0.00	23.26
Dichrostachys cinerea	0.00	3.50	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.16
Ehretia obtusifolia	0.66	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Gardenia resiniflua	0.00	0.66	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Grewia bicolor	4.10	8.00	7.34	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.10
Grewia flavescens	2.05	4.10	4.75	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.95
Lannea schweinfurthii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.05	0.00	0.00	0.00	2.05
Phyllanthus reticulatus	5.40	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.45
Strychnos madagascariensis	0.66	0.00	0.00	0.00	0.66	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Thilachium africanum	0.66	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.32
Tricalysia junodii	0.00	1.30	2.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.35

Figure 44. The *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

species *Combretum apiculatum* subsp. *apiculatum*. The dominant woody species is *Diospyros quiloensis*.

Structure of the woody layer

The canopy cover and density for the woody layer of this community are depicted as histograms in Figures 45 and 46, respectively. The contribution of woody species contributing >1% to the total woody species composition in the various height classes is presented in Table 20. It is clear from Figure 45 that the highest canopy cover is found in the 1.5-<2.5 m height class. The highest density is observed in the 0.75-<1.5 m and 1.5-<2.5 m classes (Figure 46). The woody species contributing mostly to the canopy cover and density in these height classes are *Combretum apiculatum* subsp. *apiculatum, Grewia monticola* and *Phyllanthus reticulatus* (Table 20). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Acacia nigrescens* and lies in the >15.5 m class (Figure 45., Table 20). Total canopy cover and density are fairly high (34.8 %, Figure 45 and 1 032 individuals/ha, Figure 46) and this community is thus classified as a tall closed woodland with a low thicket component (Edwards 1983).

The *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland can be sub-divided into three sub-communities:

4.1 The *Dalbergia melanoxylon–Combretum apiculatum* subsp. *apiculatum* Short Closed Woodland

This short closed woodland lies on the western side of Sango Ranch (Figures 9 and 47) and is represented by 13 relevés with an average of 21 species per relevé (range 12-32) (Table 8). The soils of this sub-community belong to the 4PE soil family, are light to heavy textured and are sometimes acidic (Chapter 4; Table 8). The soils are derived from gneiss, granite and dolerite (Table 8). This sub-community lies on an undulating and sometimes rocky and broken upland terrain at 560 m to 605 m (Table 8). This sub-community is characterised by the diagnostic species *Gardenia resiniflua*, *Dalbergia melanoxylon* and *Acacia gerrardii* (Table 8).

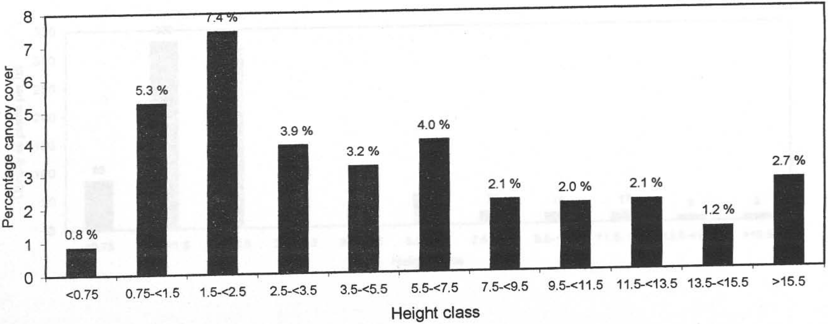


Figure 45. The percentage canopy cover in 11 height classes (m) of the woody species of the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 34.8 %.

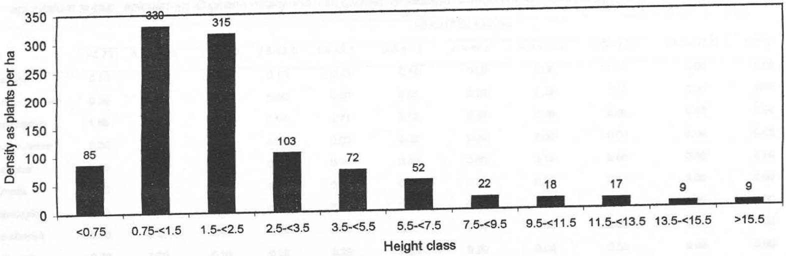


Figure 46. The density of the woody species in nine height classes (m) of the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 1032.

Table 20. The percentage contribution of 25 woody species in 11 height classes to the total woody species composition in the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*										
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia erubescens	0.10	0.10	0.00	0.10	0.49	0.10	0.00	0.00	0.10	0.00	0.00	0.99
Colophospermum mopane	0.30	0.40	0.39	0.00	0.00	0.00	0.20	0.20	0.70	0.20	010	2.49
Combretum apiculatum	1.65	4.10	5.04	1.94	2.71	2.13	0.39	0.29	0.00	0.10	0.00	18.35
Combretum paniculatum	0.00	1.45	1.74	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.58
Commiphora edulus	0.20	0.48	0.20	0.00	0.20	0.39	0.00	0.10	0.00	0.00	0.00	1.57
Commiphora mollis	0.10	0.10	0.00	0.00	0.00	0.48	0.20	0.29	0.00	0.00	0.00	1.17
Dalbergia melanoxylon	0.40	0.58	0.48	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00	1.76
Dichrostachys cinerea	0.70	2.33	0.80	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.22
Diospyros quiloensis	0.30	1.00	0.10	0.29	0.29	0.29	0.20	0.00	0.00	0.00	0.00	2.47
Grewia bicolor	0.00	0.29	0.48	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.87
Grewia gracillima	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48
Grewia flavescens	0.10	1.40	2.33	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	4.03
Grewia monticola	0.30	4.36	3.50	0.58	0.39	0.00	0.00	0.00	0.00	0.00	0.00	9.13

Table 20 continued. The percentage contribution of 25 woody species in 11 height classes to the total woody species composition in the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

Species	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Gymnosporia buxifolia	0.00	0.40	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Gymnosporia putterlickoides	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Kirkia acuminata	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.10	0.39	0.10
Lannea schweinfurthii	0.10	0.10	0.10	0.10	0.10	0.10	0.00	0.10	0.58	0.00	0.00	1.28
Markhamia zanzibarica	1.00	1.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.29
Millettia usumarensis	0.00	0.87	2.23	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.30
Monodora junodii	0.00	0.48	1.00	0.58	0.39	0.00	0.00	0.00	0.00	0.00	0.00	2.45
Mundulea sericea	0.80	0.20	0.20	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.36
Phyllanthus reticulatus	0.58	3.39	4.36	0.29	0.10	0.00	0.00	0.00	0.00	0.00	0.00	8.72
Strychnos madagascariensis	0.10	0.39	0.58	0.20	0.10	0.00	0.00	0.00	0.00	0.00	0.00	1.37
Tricalysia junodii	0.20	0.70	0.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29
Ziziphus mucronata	0.10	0.29	0.29	0.10	0.00	0.10	0.20	0.00	0.00	0.00	0.00	1.37

Figure 47. The *Dalbergia melanoxylon–Combretum apiculatum* subsp. *apiculatum* Short Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

Structure of the woody layer

The canopy cover and density in the various height classes are depicted in Figures 48 and 49, respectively. Table 21 shows the percentage contribution of woody species contributing >1% to the total woody species composition in the various height classes. Figure 48 shows that the greatest canopy cover is found in the 1.5-<2.5 m height class, while Figure 49 shows that the greatest density occurs in the 0.75-<1.5 m and 1.5-<2.5 m classes. The community is thus fairly closed with a tall tree component (9.5-<11.5m) consisting mainly of *Combretum apiculatum* subsp. *apiculatum* and *Commiphora mollis* (Table 21). *Combretum apiculatum* subsp. *apiculatum* and *Grewia monticola* are responsible for the greatest canopy cover and density figures (Table 21). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Combretum apiculatum* subsp. *apiculatum, Colophospermum mopane, Commiphora mollis* and *Lannea schweinfurthii* and lies in the 9.5-<11.5 m class (Figure 48, Table 21). The total canopy cover (38.2 %, Figure 48) and total density (1 173 individuals/ha, Figure 49) result in the classification of this sub-community as a short closed woodland with a low thicket component (Edwards 1983).

4.2 The *Commiphora africana–Digitaria milanjiana* Tall Closed Woodland

This tall closed woodland is scattered throughout the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland and the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland and possesses a patchy distribution (Figures 9 and 50). This sub-community is represented by 27 relevés with an average of 26 species per relevé (range 21-33) (Table 8). The terrain is a broken upland that is sometimes rocky (Table 8). The soils are mainly derived from gneiss, dolerite, granulite and lava and belong to the 5G and 4PE soil families (Chapter 4, Table 8). The soils vary from shallow light coarse-grained soils on gneiss, granulite and lava to deeper light textured fine to medium soils on gneiss (Chapter 4). The altitude varies between 515 m and 615 m. The herbaceous layer is characterised by the diagnostic *Tephrosia purpurea* subsp. *leptostachya* var. *pubescens*, *Heliotropum strigosum*, *Sporobolus nitens* as well as *Ipomoea sinensis* subsp. *blepharosephala* (Table 8). No diagnostic woody species are present.

Structure of the woody layer

The canopy cover and density for the various height classes are depicted in Figures 51 and 52. The contribution of woody species contributing >1% to the total

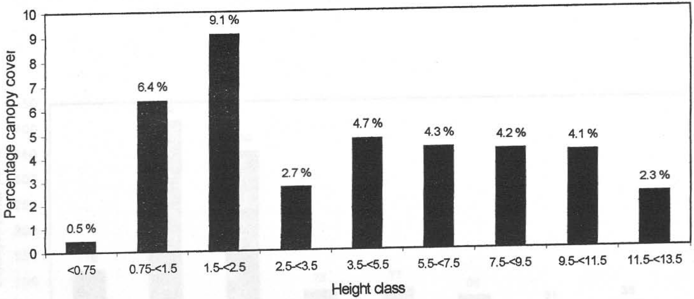


Figure 48. The percentage canopy cover in nine height classes (m) of the woody species of the *Dalbergia melanoxylon–Combretum apiculatum* subsp. *apiculatum* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 38.2 %.

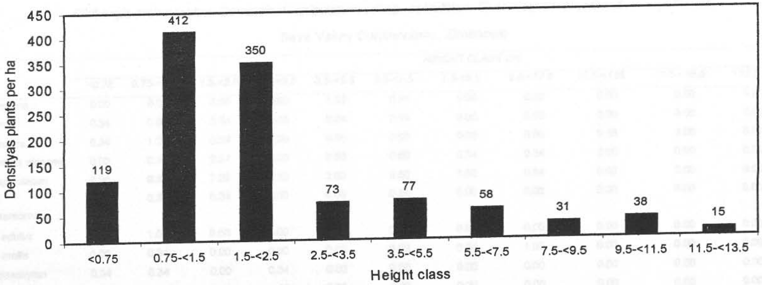


Figure 49. The density of the woody species in nine height classes (m) of the *Dalbergia melanoxylon–Combretum apiculatum* subsp. *apiculatum* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 1 173.

Table 21. The percentage contribution of 23 woody species in 11 height classes to the total woody species composition in the *Dalbergia melanoxylon–Combretum apiculatum* subsp. *apiculatum* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											*TOTAL*
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	
Acacia erubescens	0.00	0.00	0.00	0.00	1.02	0.34	0.00	0.00	0.00	0.00	0.00	1.36
Acacia gerrardii	0.34	0.00	0.34	0.00	0.34	0.34	0.00	0.00	0.00	0.00	0.00	1.60
Acacia nigrescens	0.34	1.28	0.34	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	2.64
Colophospermum mopane	0.00	0.34	0.34	0.00	0.00	0.00	0.34	0.34	0.00	0.00	0.00	1.36
Combretum apiculatum	4.26	6.91	7.25	3.32	3.60	3.60	1.02	0.34	0.00	0.00	0.00	30.30
	0.00	0.34	0.34	0.00	0.00	0.34	0.00	0.00	0.00	0.00	0.00	1.02
Combretum hereorense												
Commiphora edulus	0.34	1.02	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36
Commiphora mollis	0.00	0.34	0.00	0.00	0.00	0.00	0.34	1.02	0.00	0.00	0.00	1.70
Dalbergia melanoxylon	0.34	0.34	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
Dichrostachys cinerea	1.62	0.00	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.64
Diospyros quiloensis	0.34	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36

Table 21 continued. The percentage contribution of 23 woody species in 11 height classes to the total woody species composition in the *Dalbergia melanoxylon–Combretum apiculatum* subsp. *apiculatum* Short Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Grewia bicolor	0.00	0.68	1.02	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	2.04
Grewia flavescens	0.00	2.98	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.41
Grewia monticola	0.68	5.29	3.24	0.68	0.68	0.00	0.00	0.00	0.00	0.00	0.00	10.57
Gymnosporia buxifolia	0.00	1.30	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.64
Lannea schweinfurthii	0.00	0.34	0.00	0.34	0.34	0.00	0.00	0.34	0.68	0.00	0.00	2.04
Markhamia zanzibarica	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
Millettia usumarensis	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34
Monodora junodii	0.00	1.02	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.04
Ormocarpum trichocarpum	0.34	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.02
Strychnos madagascariensis	0.34	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.36
Xeroderris stuhlmani	0.34	0.34	0.00	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	1.02
Ziziphus mucronata	0.00	0.68	0.00	0.00	0.00	0.34	0.68	0.00	0.00	0.00	0.00	1.74

Figure 50. The *Commiphora africana–Digitaria milanjiana* Tall Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

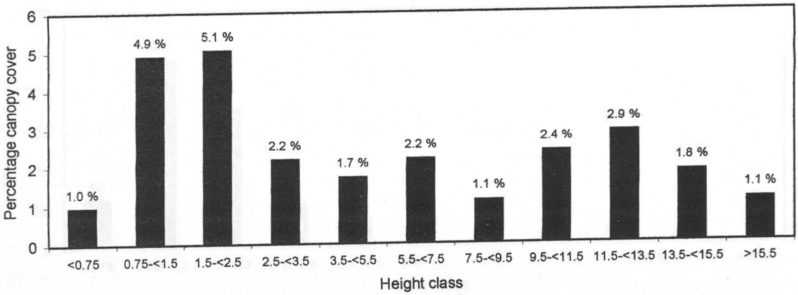


Figure 51. The percentage canopy cover in 11 height classes (m) of the woody species of the *Ipomoea sinensis* subsp. *blepharosephala –Digitaria milanjiana* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 26.2 %.

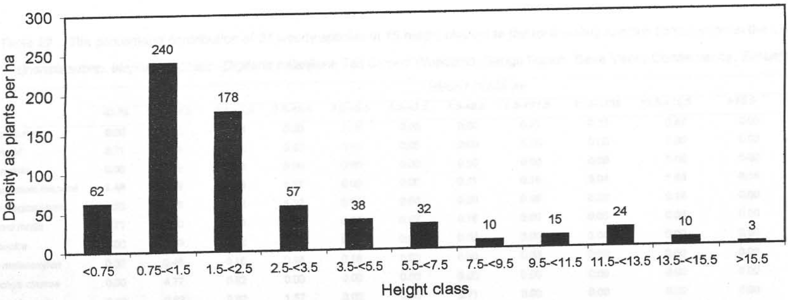


Figure 52. The density of the woody species in 11 height classes (m) of the *Ipomoea sinensis* subsp. *blepharosephala* –*Digitaria milanjiana* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 669.

Table 22. The percentage contribution of 23 woody species in 15 height classes to the total woody species composition in the *Ipomoea sinensis* subsp. *blepharosephala –Digitaria milanjiana* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*										
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia nigrescens	0.00	0.00	0.16	0.00	0.16	0.00	0.00	0.71	0.77	0.87	0.00	2.67
Albizia harveyi	0.71	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41
Cissus cornifolia	0.00	2.82	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.98
Colophospermum mopane	1.48	4.22	0.46	1.17	0.00	0.00	0.71	0.16	3.04	1.63	0.16	12.07
Combretum apiculatum	1.50	3.66	7.32	4.32	5.30	2.66	0.00	0.46	0.00	0.16	0.00	25.37
Commiphora mollis	0.71	0.00	0.00	0.00	0.00	0.87	0.16	0.00	0.00	0.00	0.00	1.74
Cordia monoica	0.00	0.00	0.62	0.16	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.93
Dalbergia melanoxylon	0.32	0.46	0.16	0.16	0.16	0.00	0.00	0.00	0.00	0.00	0.00	1.08
Dichrostachys cinerea	0.00	4.77	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.39
Diospyros quiloensis	0.62	0.62	0.62	1.57	0.00	0.00	0.71	0.00	0.00	0.00	0.00	4.27
Grewia flavescens	0.00	1.48	3.05	0.32	0.16	0.00	0.00	0.00	0.00	0.00	0.00	5.01
Grewia monticola	0.32	9.61	7.86	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.41
Phyllanthus reticulatus	1.63	2.21	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Tricalysia junodii	0.16	1.64	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	195
Ziziphus mucronata	1.41	0.00	0.16	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.73

woody species composition is shown in Table 22. The highest canopy cover and density are evident in the 0.75-<1.5 m and 1.5-<2.5 m height classes (Figure 51 and 52). *Colophospermum mopane, Combretum apiculatum* subsp. *africanum, Dichrostachys cinerea* subsp. *africana* and *Grewia monticola* contribute to these height classes (Table 22). The highest tree layer that qualifies as the dominant layer according to Edwards (1983) consists of *Colophospermum mopane* and lies in the 11.5-<13.5 m class (Figure 51, Table 22). The total canopy cover (26.2 %, Figure 51), the total density (669 individuals/ha, Figure 52) and the tall tree layer result in the classification into a tall closed woodland with a short thicket component (Edwards 1983).

4.3 The *Kirkia acuminata–Panicum maximum* Tall Closed Woodland

This sub-community lies on the floodplain of the Makore River and also in the extreme north-west of Sango Ranch (Figures 9 and 53). The sub-community is represented by 15 relevés with an average of 26 species per relevé and a range of 13-38 (Table 8). The terrain in this sub-community consists of a rolling and sometimes broken and rocky valley (Table 8). The drainage lines are very deeply incised and dongas are evident, especially in west of the Makore River (Figure 3; Table 8). The herbaceous layer is overutilised in some areas with bare soil patches being evident. The soils are clayey, weakly saline-sodic, belong to the 8h soil family and are derived from gneiss and granite (Chapter 4, Table 8). The altitude of this sub-community varies between 520 m and 650 m. This sub-community is recognised by the diagnostic woody species *Tricalysia junodii* var. *kirkii* and *Kirkia acuminata* (Table 8).

Structure of the woody layer

Figures 54 and 55 show the canopy cover and density of this sub-community on the various height classes, respectively. Table 23 shows the percentage contribution of woody species contributing >1% to the total woody species composition in the various height classes. The highest canopy cover is found in the 1.5-<2.5 m and >15.5 m height classes (Figure 54), while the greatest density is observed in the 0.75-<1.5 m height class (Figure 55). *Combretum apiculatum* subsp. *apiculatum, C. mossambicense, C. paniculatum, Dichrostachys cinerea* subsp. *africana* and *Grewia monticola* contribute most towards these figures (Table 23). The highest tree layer qualifying as dominant (Edwards 1983) consists of *Kirkia acuminata* and lies in the <15.5 m class (Figure 54, Table 23). The total

Figure 53. The *Kirkia acuminata–Panicum maximum* Tall Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

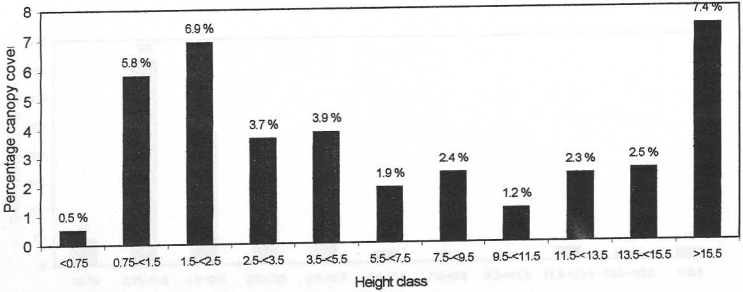


Figure 54. The percentage canopy cover in 11 height classes (m) of the woody species of the *Kirkia acuminata–Panicum maximum* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 38.4 %.

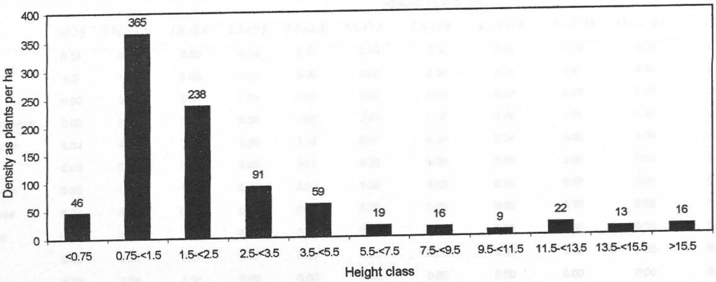


Figure 55. The density of the woody species in 11 height classes (m) of the *Kirkia acuminata–Panicum maximum* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 894.

Table 23. The percentage contribution of 19 woody species in 11 height classes to the total woody species composition in the *Kirkia acuminata–Panicum maximum* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia erubescens	0.34	0.34	0.00	0.34	0.67	0.00	0.00	0.00	0.34	0.00	0.00	2.03
Acacia nigrescens	0.0	1.02	0.00	0.00	0.00	0.00	0.34	0.34	0.67	0.34	0.34	3.05
Canthium glaucum	0.00	0.00	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.50
Colophospermum mopane	0.00	0.67	0.67	0.34	0.00	0.34	0.00	0.00	1.01	0.34	0.34	3.71
Combretum apiculatum	0.34	4.42	7.40	2.50	3.13	0.67	0.34	0.34	0.00	0.00	0.00	19.14
Cordia grandicalyx	0.00	0.34	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01
Dalbergia melanoxylon	0.68	1.70	1.80	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	4.52
Dichrostachys cinerea	0.34	3.02	0.00	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70
Diospyros quiloensis	0.00	1.70	1.01	0.67	0.34	0.00	0.34	0.00	0.00	0.00	0.00	4.06
Grewia bicolor	0.00	0.34	0.67	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.68
Grewia flavescens	0.00	1.34	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.35

Table 23 continued. The percentage contribution of 19 woody species in 11 height classes to the total woody species composition in the *Kirkia acuminata–Panicum maximum* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*										
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Grewia monticola	0.34	5.25	5.30	0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.23
Kirkia acuminata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.34	1.01	1.35
Lonchocarpus capassa	0.00	0.34	0.34	0.00	0.00	0.00	0.34	0.00	0.00	0.00	0.00	1.02
Monodora junodii	0.00	0.34	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01
Phyllanthus reticulatus	1.34	0.00	0.67	1.50	0.34	0.00	0.00	0.00	0.00	0.00	0.00	3.85
Strychnos madagascariensis	0.00	0.34	0.67	0.67	0.34	0.00	0.00	0.00	0.00	0.00	0.00	2.02
Tricalysia junodii	0.34	0.34	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.18
Ziziphus mucronata	0.00	0.34	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35

canopy cover (38.4%, Figure 54), the total density (894 individuals/ha, Figure 55) and the tall tree layer result in the classification into a tall closed woodland structure with a short thicket component (Edwards 1983).

5. The *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket

The *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket is found scattered throughout the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland (Figures 9 and 56). An average of 22 species per relevé was recorded in 13 relevés (range 10-32) (Table 8). This community lies on the koppies that are scattered throughout the western side of Sango Ranch (Figure 9). The steep-sided koppies are extremely rocky and vary in altitude from 580 m and 650 m (Table 8). The soils are very shallow and coarse-grained and are grouped into the 5G soil family, derived from granite and gneiss (Chapter 4, Table 8). These soils are leached and therefore acidic and infertile (Chapter 4). This community can be recognised by the diagnostic species *Millettia usumarensis* subsp. *australis* (Table 8). *Brachiaria deflexa* dominates the herbaceous layer, while *Kirkia acuminata* and *Combretum apiculatum* subsp. *apiculatum* also dominate. Other dominant species in this community include *Grewia gracillima, Combretum mossambicense, C. microphyllum, Monodora junodii, Markhamia zanzibarica, Julbernardia* sp., *Artabotrys brachypetalus, Vitex isotjensis, Vitex buchananii, Diospyros lycioides* subsp. *sericea, Stadmannia oppositifolia, Mundulea sericea, Ficus tettensis, F. abutilifolia* and *Euphorbia confinalis.*

Structure of the woody layer

Canopy cover and density are depicted as histograms in Figures 57 and 58, respectively. The contribution of woody species with value >1% to the total woody species composition is shown in Table 24. The highest canopy cover is evident in the 1.5-<2.5 m height class (Figure 57). *Millettia usumarensis* subsp. *australis* reaches its highest density and canopy cover in the 1.5-<2.5 m class (Figures 57 and 58; Table 24). The dominant height class is 5.5-<7.5 m (Edwards 1983) and consists of *Combretum apiculatum* subsp. *apiculatum* and *Commiphora mollis* (Table 24). The community is classified as a short thicket due to the high shrub cover in the 1.5-<2.5 m class and the short tree layer (Edwards 1983).

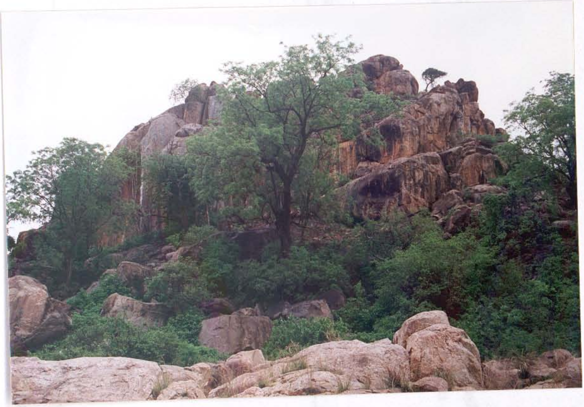


Figure 56. The *Millettia usumarensis* subsp. *australis*–*Brachiaria deflexa* Short Koppie Thicket on Sango Ranch, Save Valley Conservancy, Zimbabwe.

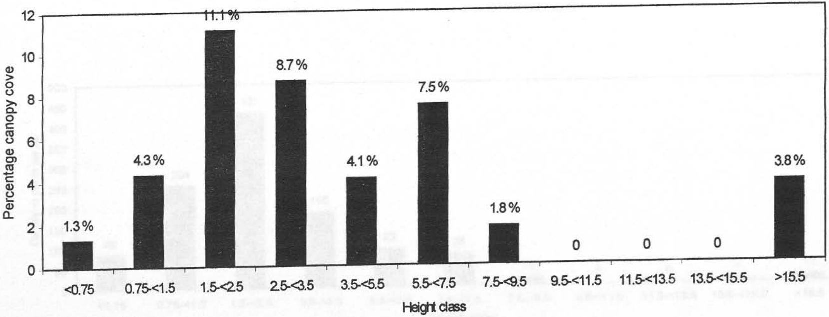


Figure 57. The percentage canopy cover in 11 height classes (m) of the woody species of the *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 42.7 %

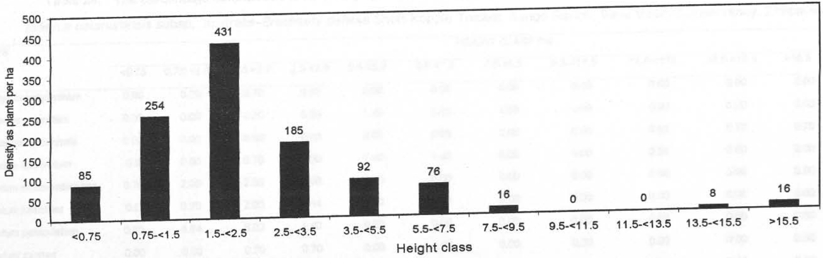


Figure 58. The density of the woody species in 11 height classes (m) of the *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 1 163.

Table 24. The percentage contribution of 21 woody species in 11 height classes to the total woody species composition in the *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*										
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Artabotrys brachypetalus	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40
Brachylaena rotundata	0.00	0.00	0.70	0.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	2.10
Brachystegia spiciformis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.70	1.40
Combretum apiculatum	0.0	0.00	0.70	0.00	1.40	1.40	0.00	0.00	0.00	0.00	0.00	3.50
Combretum mossambicense	0.70	2.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.30
Combretum padoides	0.0	0.70	2.00	3.44	1.40	0.00	0.00	0.00	0.00	0.00	0.00	7.54
Combretum paniculatum	0.00	6.64	6.02	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.06
Combretum zeyheri	0.00	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40
Commiphora mollis	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	1.40
Diospyros lycioides	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00
Diospyros quiloensis	0.00	0.00	0.00	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.00	1.40

Table 24 continued. The percentage contribution of 21 woody species in 11 height classes to the total woody species composition in the *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Ficus abutilifolia	0.00	0.00	0.00	0.00	0.70	0.70	0.00	0.00	0.00	0.00	0.00	1.40
Grewia gracillima	0.00	0.70	2.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.10
Grewia monticola	0.00	0.00	0.70	0.70	0.70	0.00	0.00	0.00	0.00	0.00	0.00	2.10
Milletia usumarensis	0.00	2.00	7.91	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.61
Monodora junodii	0.00	0.70	2.00	2.00	1.40	0.00	0.00	0.00	0.00	0.00	0.00	6.10
Mundulea sericea	2.70	0.70	0.70	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.10
Phyllanthus reticulatus	0.00	2.00	9.30	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.30
Vitellariopsis ferruginea	0.00	0.70	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40

6. The *Acacia tortilis* subsp. *heteracantha–Panicum maximum* Tall Closed Woodland

This tall closed woodland lies to the west of the Save River and runs along the length of the river (Figures 9 and 59). An average of 16 species was recorded in nine relevés (range 11-24) (Table 9). This community is situated on the flat alluvium that lies adjacent to the Save River (Figure 9). The alluvium contains an extensive aquifer that is fed by the Save River (Chapter 2). The soils are sandy and deep, being moist at 1.2 m depth (Chapter 4). The soils belong to the 4U soil family (Table 9). Altitude varies between 430 m and 540 m. This community can be recognised by the diagnostic *Acacia tortilis* subsp. *heteracantha* which forms an almost closed canopy (Table 9). *Grewia flavescens* var. *flavescens*, *Acacia galpinii*, *Acacia schweinfurthii*, *Dichrostachys cinerea* subsp. *africana* and *Grewia inaequilatera* are dominant species. No diagnostic herbaceous species exist in this community. *Panicum maximum* is the dominant herbaceous species (Table 9).

Structure of the woody layer

The canopy cover and density are represented in Figures 60 and 61, respectively. The percentage contribution of the woody species with value >1% in the various height classes to the total woody species composition is depicted in Table 25. The greatest canopy cover is found in the 1.5-<2.5 m height class (Figure 60), and the highest density is seen in the 0.75-<1.5 m and 1.5-<2.5 m classes (Figure 61). *Anisotes formosissimus*, *Acacia schweinfurthii*, *Grewia flavescens* var. *flavescens* and *G. inaequilatera* are responsible for the high canopy cover and density in these height classes (Table 25). The >15.5 m height class qualifies as the dominant layer (Edwards 1983) and consists of *Acacia tortilis* subsp. *heteracantha* (Figure 60, Table 25). The high canopy cover (53.2%, Figure 60), density (778 individuals/ha, Figure 63) and high dominant tree layer result in the classification as a tall closed woodland with a low thicket component (Edwards 1983).

7. The *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest

This high riverine forest is located on the banks of the major rivers such as the Save, Makore, Msaizi and Saindota, and some of the smaller rivers and streams (Figures 9 and 62). It is represented by 12 relevés with an average of 10 species per relevé (range 3-18) (Table 9). The alluvium of this community is mostly flat, but in some areas the banks have been washed away forming steep slopes (Table 9). Within the bed of the Save River, sand deposition has formed a

Figure 59. The *Acacia tortilis* subsp. *heteracantha–Panicum maximum* Tall Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

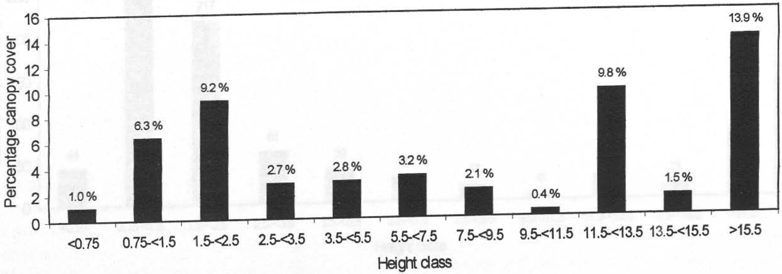


Figure 60. The percentage canopy cover in 11 height classes (m) of the woody species of the *Acacia tortilis* subsp. *heteracantha–Panicum maximum* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 53.2 %.

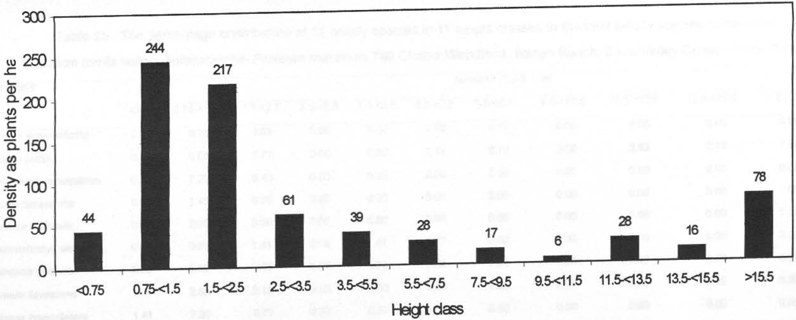


Figure 61. The density of the woody species in 11 height classes (m) of the *Acacia tortilis* subsp. *heteracantha–Panicum maximum* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 778.

Table 25. The percentage contribution of 12 woody species in 11 height classes to the total woody species composition in the *Acacia tortilis* subsp. *heteracantha–Panicum maximum* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia schweinfurthii	2.83	9.25	8.61	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00	21.46
Acacia tortilis	0.00	0.00	0.77	0.00	0.00	1.41	0.77	0.00	2.83	2.10	7.84	15.72
Anisotes formosissimus	0.00	7.20	6.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.63
Azima tetracantha	0.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41
Cadaba termitaria	0.00	2.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20
Dichrostachys cinerea	0.00	0.00	1.41	2.19	1.41	0.77	0.00	0.00	0.00	0.00	0.00	5.78
Gardenia volkensi	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.77
Grewia flavescens	1.41	2.83	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.43
Grewia inaequilatera	1.41	7.20	0.77	0.77	0.77	0.00	0.00	0.00	0.00	0.00	0.00	10.92
Gymnosporia buxifolia	0.00	0.00	3.60	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.20
Strychnos potatorum	0.00	0.00	0.00	0.00	0.77	0.77	0.00	0.00	0.00	0.00	0.00	1.54
Tricalysia junodii	0.00	0.77	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.54

Figure 62. The *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest on Sango Ranch, Save Valley Conservancy, Zimbabwe.

series of islands (Figure 9). The 4U soils are very sandy and in the Save Riverbed a series of layers are evident in the profile (Table 9). This community lies at 430 m and 460 m. Due to the closed tree canopy of this community, few herbaceous species occur (Table 9). *Panicum maximum* dominates in open areas. This community can be recognised by the presence of the woody diagnostic species *Dalbergia arbutifolia*, *Artabotrys brachypetalus* and *Diospyros mespiliformes*. No woody species dominates but common species include *Cardiogyne africana*, *Friesodielsia obovata*, *Sclerocarya birrea* subsp. *caffra*, *Trichilia emetica*, *Croton megalobotrys*, *Kigelia africana*, *Hyphaene coriacea*, *Tabernaemontana elegans*, *Lannea schweinfurthii*, *Strychnos potatorum*, *Acacia schweinfurthii*, *Albizia glaberrima* var. *glabrescens*, *Grewia inaequilatera* and *Faidherbia albida*.

Structure of the woody layer

The canopy cover and density for this community are depicted as histograms in Figures 63 and 64, respectively. The percentage contribution of the woody species with a value >1% to the total woodyspecies composition is given in Table 26. The greatest canopy cover and density are evident in the 0.75-<1.5 m height class (Figure 63 and 64). *Friesodielsia obovata*, *Grewia inaequilatera* and *Grewia sulcata* contribute mainly to the cover and density in this height class (Table 26). The dominant height class is the >15.5 m class and consists of *Diospyros mespiliformes*, *Albizia glaberrima* var. *glabrescens* and *Faidherbia albida* (Figure 63,Table 26) (Edwards 1983). This community forms a very dense and closed high canopy (total canopy cover=103.2 %, Figure 63; total density 732 individuals/ha, Figure 64). The community is thus classified as a high forest with a significant low thicket component (Edwards 1983).

The *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest can be sub-divided into three sub-communities:

7.1 The *Strychnos potatorum–Panicum maximum* High Closed Woodland

This high closed woodland lies on the banks of the major and minor rivers of Sango Ranch and is forms a mosaic with the *Faidherbia albida–Panicum maximum* High Closed Woodland Sub-community and the *Phragmites mauritianus* Tall Closed Reedbeds (Figures 9 and 65). It is represented by six relevés with an average of

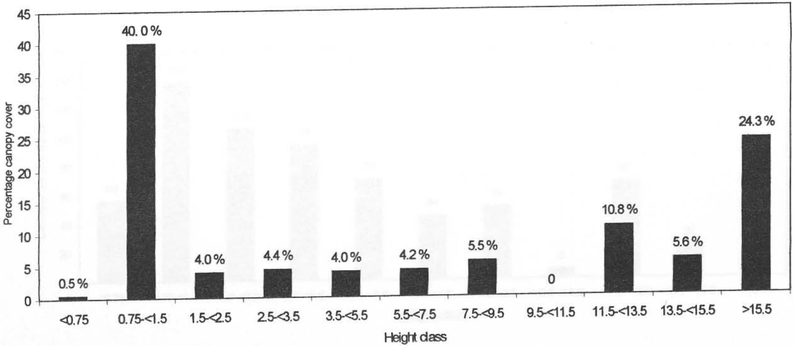


Figure 63. The percentage canopy cover in 11 height classes (m) of the woody species of the *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 103.2 %.

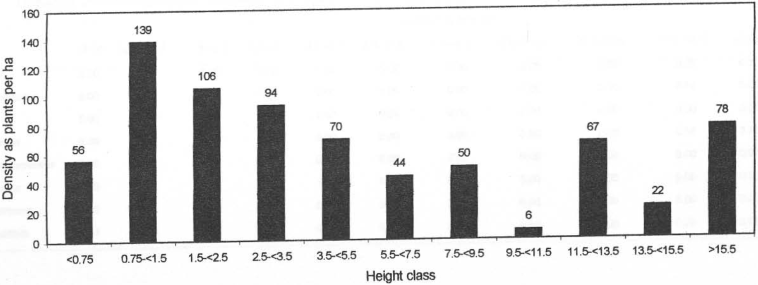


Figure 64. The density of the woody species in 11 height classes (m) of the *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 732.

Table 26. The percentage contribution of 20 woody species in 11 height classes to the total woody species composition in the *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia galpinii	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.00	1.00
Acacia schweinfurthii	0.00	1.05	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.49
Acacia tortilis	0.00	0.00	0.00	0.00	1.87	0.00	0.00	0.00	0.00	0.00	0.00	1.87
Albizia glaberrima	0.00	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	5.57
Artabotrys brachypetalus	0.00	0.00	0.00	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87
Bridelia cathartica	0.00	0.00	0.00	0.00	0.0	1.05	0.44	0.00	0.00	0.00	0.00	1.49
Cardiogyne africana	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Dalbergia arbutifolia	0.54	0.44	0.00	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.85

Table 26 continued. Thepercentage contribution of 20 woody species in 11 height classes to the total woody species composition in the *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	HEIGHT CLASS (m)											
	<0.75	0.75-<1.5	1.5-<2.5	2.5-<3.5	3.5-<5.5	5.5-<7.5	7.5-<9.5	9.5-<11.5	11.5-<135	13.5-<15.5	>15.5	TOTAL
Diospyros mespiliformes	0.00	0.44	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.00	1.05	1.93
Faidherbia albida	0.00	0.00	0.00	6.67	0.00	6.67	0.00	0.00	0.00	6.67	13.33	33.3
Friesodielsia obovata	0.00	1.60	0.00	1.05	0.44	0.00	0.00	0.00	0.00	0.00	0.00	3.09
Grewia inaequilatera	2.13	3.47	9.02	0.00	2.33	0.00	0.00	0.00	0.00	0.00	0.00	19.02
Grewia sulcata	0.00	1.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.88
Gymnosporia buxifolia	0.00	0.50	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Lannea schweinfurthii	0.00	0.00	0.00	0.00	0.00	0.44	1.60	0.44	0.00	0.00	0.00	2.49
Lantana camara	0.00	1.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.87
Monodora junodii	0.54	0.54	0.44	0.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.97
Strychnos potatorum	0.00	0.00	0.00	0.44	0.44	0.44	0.00	0.00	0.00	0.00	0.00	1.33
Syzigium guineense	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.57	0.00	0.00	5.57
Trichilia emetica	0.00	0.00	0.00	0.00	0.44	0.44	1.05	0.00	0.00	0.00	0.00	1.93

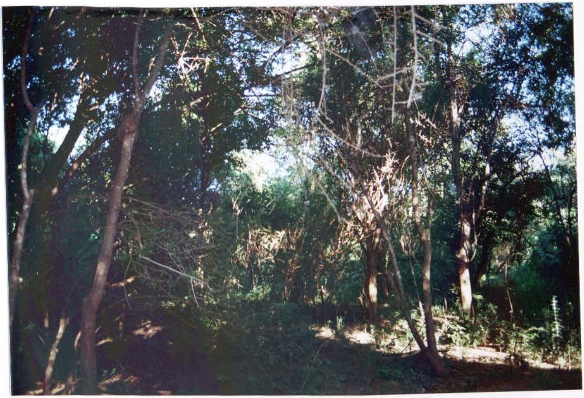


Figure 65. The *Strychnos potatorum–Panicum maximum* High Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

15 species per relevé (range 14-18) (Table 9). The riverbanks are flat to steep, and in some places are vertical where they have been washed away (Table 9). The soils are a fertile sandy loam of the 4U soil family. Altitude varies between 430 m and 460 m. This closed sub-community may be recognised by the presence of the diagnostic species *Lannea schweinfurthii, Strychnos potatorum* and *Diospyros mespiliformes* (Table 9).

Structure of the woody layer

The canopy cover and density are shown in Figures 66 and 67, respectively. The 7percentage contribution of woody species contributing >1% to the total woody species composition is depicted in Table 27. The highest canopy cover is seen in the 7.5-<9.5 m height class (Figure 66) and the greatest density is evident in the 0.75-<1.5 m class (Figure 67). *Bridelia cathartica*, *Lannea schweinfurthii* and *Trichilia emetica* contributes to the high canopy cover, while *Acacia schweinfurthii, Friesodielsia obovata* and *Grewia inaequilatera* are responsible for the high density (Table 27). The dominant height layer is >15.5 m (Edwards 1983) and consists of *Diospyros mespiliformes* (Table 27, Figure 66). The high canopy cover (62.9 %, Figure 66), total density (1 051 individuals/ha, Figure 67) and high tree layer result in the classification as high closed woodland with a low thicket component (Edwards 1983).

7.2 The *Albizia glaberrima* var. *glabresens–Panicum maximum* High Forest

This high forest lies on the islands within the Save Riverbed and is mixed with the *Faidherbia albida–Panicum maximum* High Closed Woodland and the *Phragmites mauritianus* Tall Closed Reedbeds (Figures 9 and 68). It is represented by four relevés with an average of 10 species per relevé (range 9-12) (Table 9). The terrain consists of a series of small to large islands that lie in the bed of the Save River (Figure 9). These islands are all the result of silt deposition. The soils are sandy and belong to the 4U soil family (Table 9). Altitude varies between 430 m and 455 m. The woody layer is very thick and is recognised by the diagnostic *Albizia glaberrima* var. *glabresens* (Table 9).

Structure of the woody layer

Canopy cover and density are depicted in Figures 69 and 70, respectively. The percentage contribution of the woody species with a value of >1% to the total

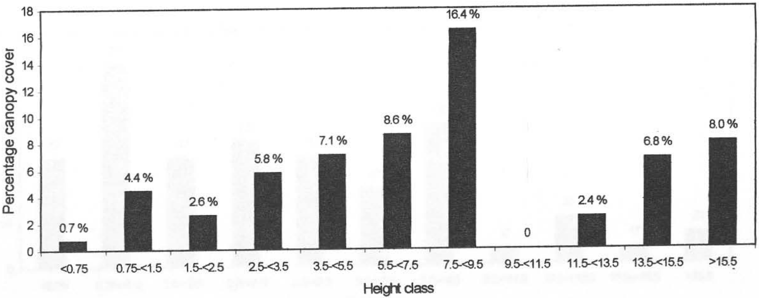


Figure 66. The percentage canopy cover in 11 height classes (m) of the woody species of the *Strychnos potatorum-Panicum maximum* High Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 62.9 %.

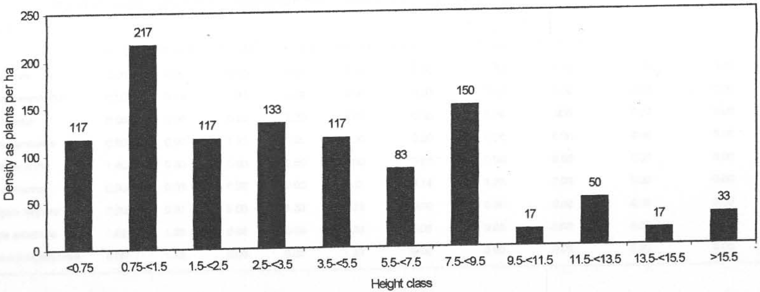


Figure 67. The density of the woody species in 11 height classes (m) of the *Strychnos potatorum–Panicum maximum* High Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is1 051.

Table 27. The percentage contribution of 23 woody species in 11 height classes to the total woody species composition in the *Strychnos potatorum–Panicum maximum* High Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<135*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia galpinii	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	1.33	0.00	0.00	2.66
Acacia schweinfurthii	0.00	3.14	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.47
Albizia harveyi	0.00	0.00	0.00	1.33	0.00	0.00	0.00	000	0.00	0.00	0.00	1.33
Allophylus alnifolius	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33
Azima tetracantha	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.62
Bridelia cathartica	0.00	0.00	0.00	0.00	0.0	3.14	1.33	0.00	0.00	0.00	0.00	4.47
Cardiogyne africana	0.00	0.00	0.00	1.33	1.33	0.00	0.00	0.00	0.00	0.00	0.00	2.66
Dalbergia arbutifolia	1.62	1.33	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	4.28
Diospyros mespiliformes	0.00	1.33	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	3.14	5.80

Table 27 continued. The percentage contribution of 23 woody species in 11 height classes to the total woody species composition in the *Strychnos potatorum–Panicum maximum* High Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	HEIGHT CLASS (m)											
	<0.75	0.75-<1.5	1.5-<2.5	2.5-<3.5	3.5-<5.5	5.5-<7.5	7.5-<9.5	9.5-<11.5	11.5-<135	13.5-<15.5	>15.5	TOTAL
Diospyros quiloensis	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33
Friesodielsia obovata	0.00	4.80	0.00	3.14	1.33	0.00	0.00	0.00	0.00	0.00	0.00	9.27
Grewia inaequilatera	6.40	4.80	1.33	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	13.86
Gymnosporia buxifolia	0.00	1.33	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	2.66
Hyphaene coriacea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	0.00	1.33
Lannea schweinfurthii	0.00	0.00	0.00	0.00	0.00	1.33	4.80	1.33	0.00	0.00	0.00	7.46
Lonchocarpus capassa	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33
Monodora junodii	1.62	1.62	1.33	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.90
Reissantria indica	0.00	1.62	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.95
Sclerocarya birrea	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	1.33
Strychnos madagascariensis	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33
Strychnos potatorum	0.00	0.00	0.00	1.33	1.33	1.33	0.00	0.00	0.00	0.00	0.00	3.99
Trichilla emetica	0.00	0.00	0.00	0.00	1.33	1.33	3.14	0.00	0.00	0.00	0.00	5.80
Ziziphus mucronata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.33	0.00	0.00	1.33

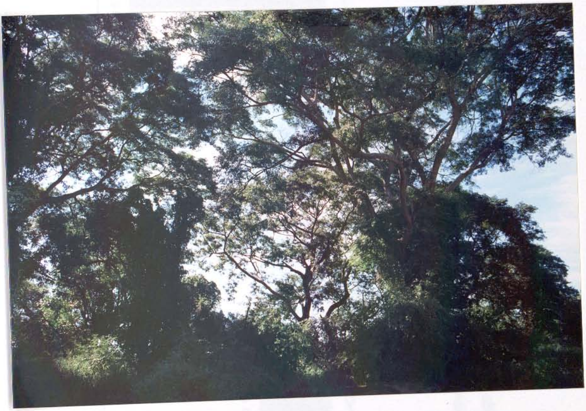


Figure 68. The *Albizia glaberrima* var. *glabresens–Panicum maximum* High Forest on Sango Ranch, Save Valley Conservancy, Zimbabwe.

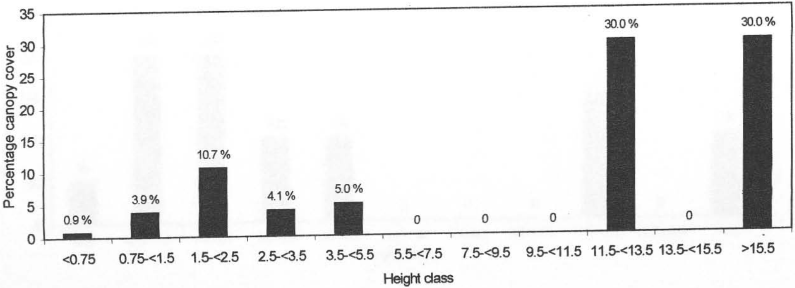


Figure 69. The percentage canopy cover in 11 height classes (m) of the woody species of the *Albizia glaberrima* var. *glabresens*–*Panicum maximum* High Forest, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 84.4 %.

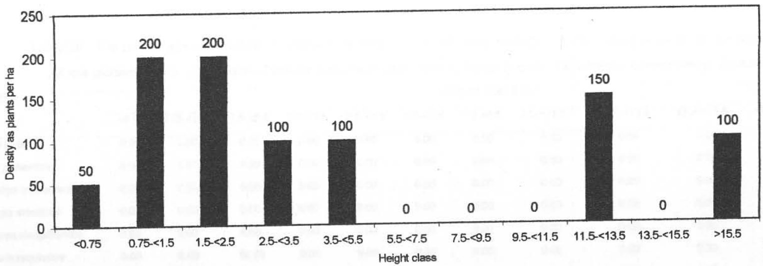


Figure 70. The density of the woody species in 11 height classes (m) of the *Albizia glaberrima* var. *glabresens–Panicum maximum* High Forest, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 900.

Table 28. The percentage contribution of nine woody species in 11 height classes to the total woody species composition in the *Albizia glaberrima* var. *glabresens*–*Panicum maximum* High Forest, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	HEIGHT CLASS (m)											
	<0.75	0.75-<1.5	1.5-<2.5	2.5-<3.5	3.5-<5.5	5.5-<7.5	7.5-<9.5	9.5-<11.5	11.5-<13.5	13.5-<15.5	>15.5	TOTAL
Acacia tortilis	0.00	0.00	0.00	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	5.60
Albizia glaberrima	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.10	16.70
Artabotrys brachypetalus	0.00	0.00	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.60
Dalbergia arbutifolia	0.00	0.00	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.60
Diospyros mespiliformes	5.60	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.20
Grewia inaequilatera	0.00	5.60	16.70	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	27.90
Grewia sulcata	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.60
Lantana camara	0.00	5.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.60
Syzigium guineense	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.70	0.00	0.00	16.70

composition is shown in Table 28. The greatest canopy cover is seen in the 11.5-<13.5 m height class (Figure 69) and the highest density is observed in the 0.75-<1.5 m and 1.5-<2.5 m height classes (Figure 70). *Syzigium guineense* and *Albizia glaberrima* var. *glabresens* are responsible for the canopy cover in this high layer, while *Grewia inaequilatera* contributes to the density in the lower layers (Table 28). The dominant height class is <15.5 m (Edwards 1983) and consists of *Albizia glaberrima* var. *glabresens* (Figure 69, Table 28). The canopy is closed (84.4 %, Figure 69) and the sub-community is thus classified as a high forest and contains a thicket-like low shrub component (Edwards 1983).

7.3 The *Faidherbia albida–Eriochloa meyeriana* High Closed Woodland

This high closed woodland forms a mosaic with both the *Diospyros mespiliformes–Panicum maximum* High Closed Woodland and the *Albizia glaberrima* var. *glabresens–Panicum maximum* High Forest (Figures 9 and 71). The sub-community is represented by two relevés with an average of 4 species per relevé (range 3 to 5) (Table 9). The habitat here is similar to that of the *Strychnos potatorum–Panicum maximum* High Closed Woodland and the *Albizia glaberrima* var. *glabrescens–Panicum maximum* High Forest (Table 9). The soils are fairly recently deposited and altitude varies between 430 m and 435m. This sub-community is characterised by the diagnostic herbaceous species *Eriochloa meyeriana* (Table 9). *Faidherbia albida* is diagnostic for this sub-community.

Structure of the woody layer

The canopy cover and density for this sub-community are depicted in Figures 72 and 73, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is shown in Table 29. The greatest canopy cover is found in the >15.5 m height class (Figure 72). The highest density is observed in the 2.5-<3.5 m and 5.5-<7.5 m height classes (Figure 73). *Faidherbia albida* is responsible for these cover and density values (Table 29). The >15.5 m height class dominates and, together with the total cover (52%, Figure 74) and density (250 plants per ha, Figure 73) results in a high closed woodland structural classification (Edwards 1983)

Figure 72. The *Faidherbia albida–Eriochloa meyeriana* High Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

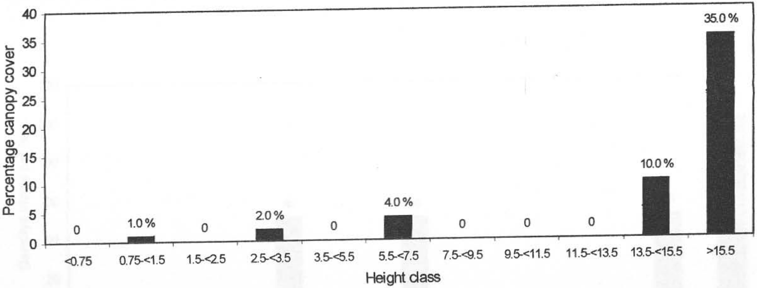


Figure 73. The percentage canopy cover in 11 height classes (m) of the woody species of the *Faidherbia albida–Eriochloa meyeriana* High Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 52 %.

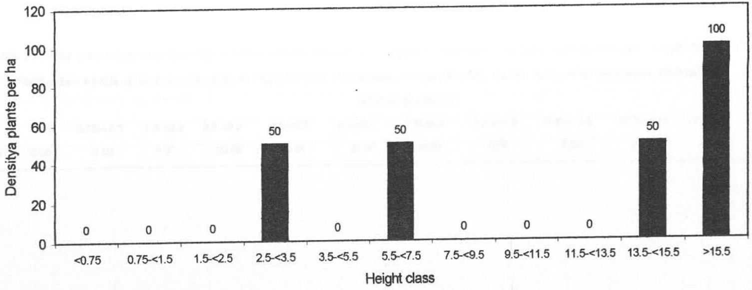


Figure 74. The density of the woody species in 11 height classes (m) of the *Faidherbia albida–Eriochloa meyeriana* High Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 250.

Table 29. The percentage contribution of one woody species in 11 height classes to the total woody species composition in the *Faidherbia albida–Eriochloa meyeriana* High Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<13.5*	*13.5-<15.5*	*>15.5*	*TOTAL*
Faidherbia albida	0.00	0.00	0.00	20.00	0.00	20.00	0.00	0.00	0.00	20.00	40.00	100.00

8. The *Phragmites mauritianus* Tall Closed Reedbeds

The tall closed reedbeds are found along the riverbanks and beds of the rivers of Sango Ranch and is found in a mosaic with the *Strychnos potatorum–Panicum maximum* High Closed Woodland, the *Albizia glaberrima* var. *glabresens–Panicum maximum* High Forest and the *Faidherbia albida–Eriochloa meyeriana* High Closed Woodland (Figures 9 and 74). It is represented by three relevés with an average of 1 species per relevé (Table 9). The habitat is similar to that of the *Strychnos potatorum–Panicum maximum* High Closed Woodland, the *Albizia glaberrima* var. *glabresens–Panicum maximum* High Forest and the *Faidherbia albida–Eriochloa meyeriana* High Closed Woodland (Table 9). However, the soils are fairly recently deposited (Table 9). The herbaceous layer is dominated by the diagnostic *Phragmites mauritianus* (Table 9). No other herbaceous or woody species are found here.

No woody species are found in this community (Table 9).

9. The *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland

These wetlands are found scattered along the western bank of the Save River (Figures 9 and 75). It is represented by four relevés with an average of 5 species per relevé (range 3-6) (Table 9). This community lies on the alluvial plains and consists of a series of pans, the largest of which is Sune (Figure 9, Table 9). The 4U soils are extremely clayey and are in some cases vertic (Chapter 4). Aspect is south and altitude of the pans varies between 430 m and 440 m (Table 9). The herbaceous layer is recognised by the dominant and diagnostic *Echinochloa colona* and *Cyperus digitatus* subsp. *auricomus* (Table 9). No dominant species occur here and therefore the community name consists of the two diagnostic species. Other common species include *Nymphaea nouchali, Eragrostis curvula* and *Paspalidium obtusifolium*. No diagnostic woody species occur here. This community can, however be recognised by the presence of the common *Acacia xanthophloea*.

Structure of the woody layer

Canopy cover and density are presented as histograms in Figures 76 and 77, respectively. The percentage contribution of woody species contributing >1% to the total woody species composition is depicted in Table 31. The greatest canopy cover is found in the 11.5-<13.5 m height class (Figure 76), while the highest density appears in the 13.5-<15.5 m class (Figure 77). *Acacia xanthophloea*

Figure 74. The *Phragmites mauritianus* Tall Closed Reedbeds on Sango Ranch, Save Valley Conservancy, Zimbabwe.

Figure 75. The *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland, Save Valley Conservancy, Zimbabwe.

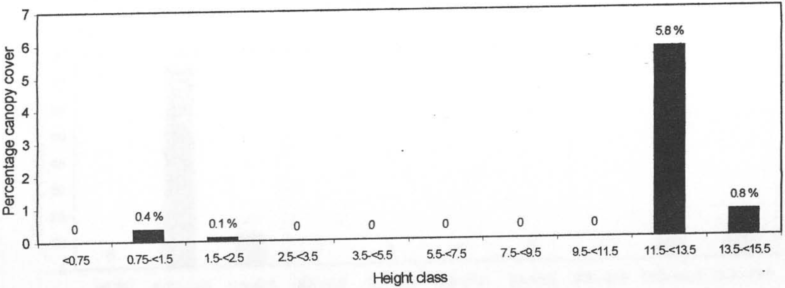


Figure 76. The percentage canopy cover in 10 height classes (m) of the woody species of the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover 7.1 %.

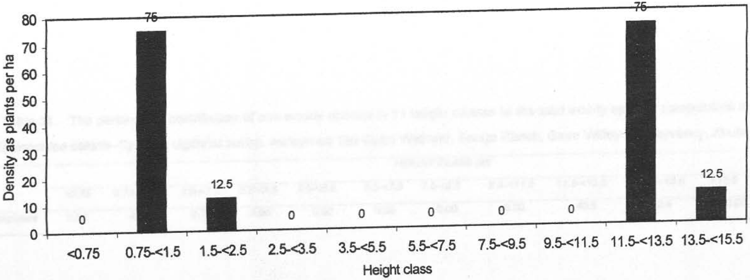


Figure 77. The density of the woody species in 10 height classes (m) of the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 175.

Table 31. The percentage contribution of one woody species in 11 height classes to the total woody species composition in the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

SPECIES	*HEIGHT CLASS (m)*											
	<0.75	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<13.5*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia xanthophloea	0.00	49.5	0.70	0.00	0.00	0.00	0.00	0.00	49.5	0.4	0.00	100.00

contributes completely to these values (Table 31). The dominant tree layer is in the 11.5-<13.5 m class and together with the low canopy cover (7.1 %, Figure 76) and the low density (175 individuals/ha, Figure 77) forms a tall open woodland (Edwards 1983).

The *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland is sub-divided into two sub-communities:

9.1 The *Paspalidium obtusifolium–Echinochloa colona* Tall Closed Grassland

This seasonally wet tall closed grassland lies within the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland and forms a mosaic with the *Acacia xanthophloea–Echinochloa colona* Tall Closed Woodland (Figures 9 and 78). It is represented by two relevés with an average of 4 species per relevé (range 3 to 5). The habitat is the same as the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland (Table 9). This sub-community can be recognised by the presence of the diagnostic species *Nymphaea nouchali, Eragrostis curvula* and *Paspalidium obtusifolium* (Table 9). No woody species are found in this sub-community (Table 9).

9.2 The *Acacia xanthophloea–Echinochloa colona* Tall Closed Woodland

This tall closed woodland appears in the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland and forms a mosaic with the *Paspalidium obtusifolium–Echinochloa colona* Tall Closed Grassland (Figures 9 and 79). It is represented by two relevés with an average of 5 species per relevé (range 4 to 6) (Table 9). The habitat is the same as the *Paspalidium obtusifolium– Echinochloa colona* Tall Closed Grassland Wetland, except that the vegetation is more utilised and more sheet erosion is present (Table 9). The sub-community is recognised by the diagnostic *Acacia xanthophloea*. No other woody species are common (Table 9).

Structure of the woody layer

The canopy cover and density are given in Figures 80 and 81, respectively. The percentage woody species composition contribution to the total woody species composition is presented in Table 32. The highest canopy cover is found in the 11.5-<13.5 m height class (Figure 80) and the greatest density is evident in the

Figure 78. The *Paspalidium obtusifolium–Echinochloa colona* Tall Closed Grassland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

Figure 79. The *Acacia xanthophloea–Echinochloa colona* Tall Closed Woodland on Sango Ranch, Save Valley Conservancy, Zimbabwe.

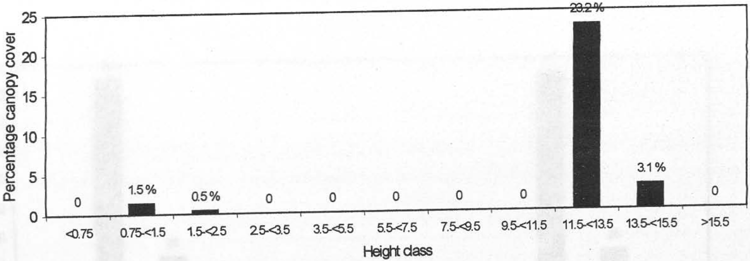


Figure 80. The percentage canopy cover in 11 height classes (m) of the woody species of the *Acacia xanthophloea–Echinochloa colona* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total canopy cover is 28.2 %.

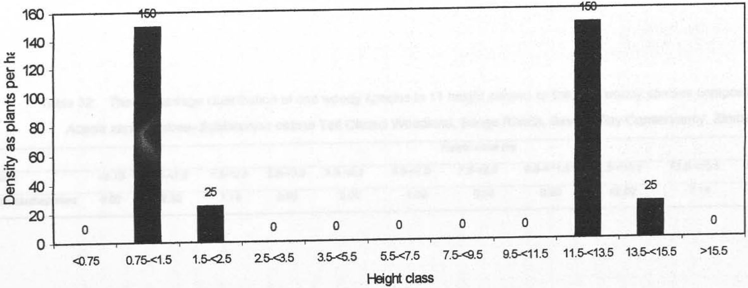


Figure 81. The density of the woody species in 11 height classes (m) of the *Acacia xanthophloea–Echinochloa colona* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe. The total plants per ha is 350.

Table 32. The percentage contribution of one woody species in 11 height classes to the total woody species composition *in the Acacia xanthophloea–Echinochloa colona* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe.

	Height class (m)											
Species	*<0.75*	*0.75-<1.5*	*1.5-<2.5*	*2.5-<3.5*	*3.5-<5.5*	*5.5-<7.5*	*7.5-<9.5*	*9.5-<11.5*	*11.5-<13.5*	*13.5-<15.5*	*>15.5*	*TOTAL*
Acacia xanthophloea	0.00	42.80	7.14	0.00	0.00	0.00	0.00	0.00	42.80	7.14	0.00	100.00

0.75-<1.5 m and 11.5-<13.5 m classes (Figure 81). *Acacia xanthophloea* is responsible for these figures (Table 32). The 11.5-<13.5 m height class is dominant and together with the total cover (28.2 %, Figure 80) and the total density (350 individuals/ha, Figure 81) form a tall closed woodland (Edwards 1983).

Ordination

The results of the DECORANA ordination are depicted as scatter diagrams in Figures 82 to 85. In the *Acacia tortilis-Urochloa mosambicensis* Tall Closed Woodland a gradient of sodic and non-sodic soils is seen on axis 2 (Figure 82). No gradient is evident on axis 1. In the *Combretum apiculatum* subsp. *apiculatum–Colophospermum mopane* Short Thicket and the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland a gradient is seen on axis 1, indicating deep sandy soils on the left and shallow rocky soils to the right (Figures 83 and 84). From Table 7 it is observed that subcommunities 2.1 and 2.3 lie on deep soils on alluvium and gneiss, while subcommunities 2.2 and 2.4, and community 3 lie on rocky shale, gneiss, lava and granite. No gradient is evident on axis 2. In the sourveld communities, a gradient ranging from flat to steep slope is evident on axis 2 in Figure 84. The *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland lies to the left with gentle slopes and relatively few rocks while the *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket lies to the right with steep slopes and rocky soils. No other gradients are evident. In the riverine communities a gradient in soil clay content is evident on axis 1, with sandy soils on the left and clay soils on the right (Figure 85). The *Acacia tortilis–Panicum maximum* Tall Closed Woodland, the *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest and the *Phragmites mauritianus* Tall Closed Reedbeds lie on relatively sandy recently deposited alluvial soils, while the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland lies on the soils of the pans that are high in clay (axis 1). On axis 2, a decrease in soil water content is observed. The soil water content is higher in the riverine and floodplain vegetation of community 9 and sub-communities 7.1, 7.2 and 7.3 and decreases toward community 6. Although community 6 has a lower soil water content than the floodplain and riverine communities, the soil water content is higher overall there than in all the other plant communities on Sango Ranch.

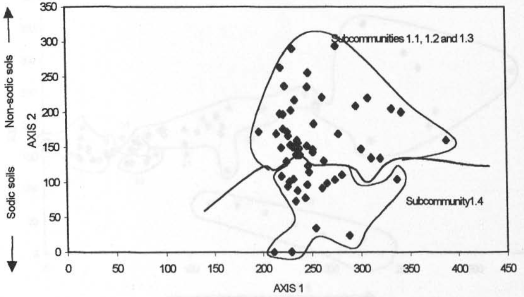


Figure 82. The DECORANA scatter diagram for the *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland, Sango Ranch, Save Valley Conservancy, Zimbabwe (see Table 6).

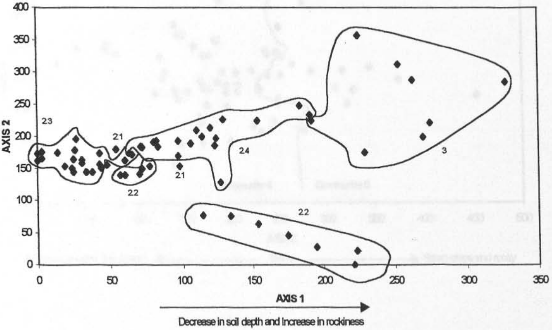


Figure 83. The DECORANA scatter diagram for the *Colophospermum mopane-Brachiaria deflexa* Short Thicket // Short Closed Woodland (2.1 to 2.4) and the *Combretum apiculatum* subsp. *apiculatum–Colophospermum mopane* Short Closed Woodland (3), Sango Ranch, Save Valley Conservancy, Zimbabwe (see Table 7).

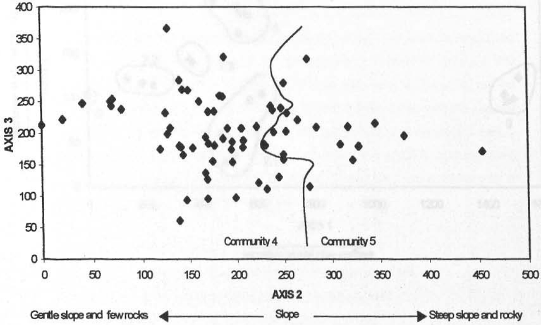


Figure 84. The DECORANA scatter diagram for the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland (Community 4) and the *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket Short Closed Woodland (Community 5), Sango Ranch, Save Valley Conservancy, Zimbabwe (see Table 8).

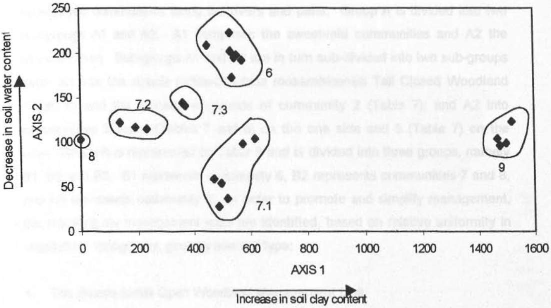


Figure 85. The DECORANA scatter diagram for the *Acacia tortilis* subsp. *heteracantha–Panicum maximum* Tall Closed Woodland (6), the *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest (71.1, 7.2 and 7.3), the *Phragmites mauritianus* Tall Closed Reedbeds (8) and the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Wetland (9), Sango Ranch, Save Valley Conservancy, Zimbabwe (see Table 9).

Identification of management units

The dendogram of the original TWINSPAN classification (Figure 10) shows that the vegetation of Sango Ranch can be divided into two main groups. Group A contains the xerophytic and mesophytic communities and Group B the hydrophytic communities along the rivers and pans. Group A is divided into two sub-groups A1 and A2. A1 comprises the sweetveld communities and A2 the sourveld ones. Sub-groups A1 and A2 are in turn sub-divided into two sub-groups each: A1 into the *Acacia tortilis-Urochloa mosambicensis* Tall Closed Woodland (Table 6) and the mopane woodlands of community 2 (Table 7); and A2 into communities 3 and 4 (Tables 7 and 8) on the one side and 5 (Table 7) on the other. Group B is represented by Table 9 and is divided into three groups, namely B1, B2 and B3. B1 represents community 6, B2 represents communities 7 and 8, and B3 represents community 9. In order to promote and simplify management, the following six management units are identified, based on relative uniformity in vegetation, topography, geology and soil type:

1. The *Acacia tortilis* Open Woodland Management Unit
2. The *Colophospermum mopane* Woodland Management Unit
3. The *Combretum apiculatum* Woodland Management Unit
4. The *Acacia tortilis* Closed Woodland Management Unit
5. The *Diospyros mespiliformes* Riverine Management Unit
6. The *Echinochloa colona* Wetland Management Unit

Related plant communities are grouped where possible but practical considerations necessitated the inclusion of smaller units (Brown 1997). The boundaries of the management units are shown in Figure 86.

Description of the management units of Sango Ranch

1. *Acacia tortilis* Open Woodland Management Unit

Management Unit 1 consists of the *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland and comprises 16.5 % of the total surface area of Sango Ranch. It is easily recognised by the presence of *Acacia tortilis* subsp. *heteracantha, Albizia anthelminthica* and *Urochloa mosambicensis* which has a short, open, woodland structure. This management unit is situated on a sandy outwash on floodplains (Chapter 2) and the soils are fairly sandy and fertile (Chapter 4). The grass cover is high (Chapter 6).

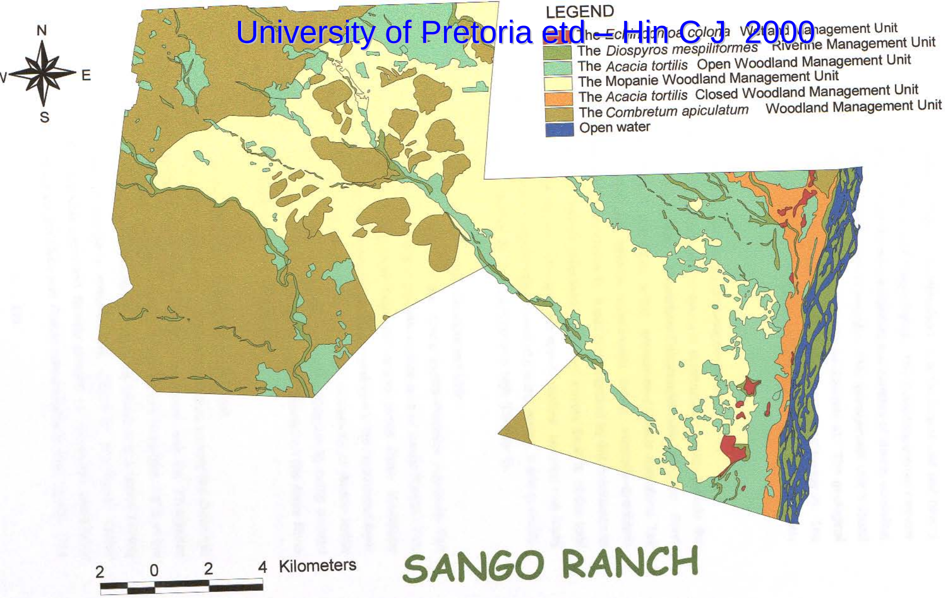


Figure 86: Management units of Sango Ranch, Save Valley Conservancy, Zimbabwe.

2. The *Colophospermum mopane* Woodland Management Unit

This management unit consists of the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland. It is the largest unit and covers 50.5 % of the total surface area of Sango Ranch. The *Colophospermum mopane* Woodland Management Unit is easily recognised and consists of stands consisting almost exclusively of *Colophospermum mopane.* This management unit is found on the lower slopes, and the soils are fairly clayey (Chapter 4). The geological types vary between alluvium, gneiss, shale, lava and sandstone (Chapter 2). The grass cover varies from low under closed canopies to high in open areas (Chapter 6).

3. The *Combretum apiculatum* Woodland Management Unit

This management unit consists of the sourveld communities, which include the *Combretum apiculatum* subsp. *apiculatum–Colophospermum mopane* Short Thicket, the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland and the *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket (Table 7). It can be recognised by the dominance of *Combretum* spp. and *Digitaria milanjiana.* This unit covers 24.9 % of the total surface area of Sango Ranch. The soils are mostly shallow, leached and rocky (Chapter 4). The major geological types consist of granite, gneiss, mafic granulite, shale and limestone (Chapter 2). The grass cover is high (Chapter 6).

4. The *Acacia tortilis* Closed Woodland Management Unit

This management unit consists of the *Acacia tortilis–Panicum maximum* Tall Closed Woodland and covers 3 % of the total surface area of Sango Ranch. This management unit is distinguished from the *Acacia tortilis* Open Woodland Management Unit by the dominance of *Panicum maximum* in the herbaceous layer and a tall and closed tree canopy consisting almost exclusively of *Acacia tortilis* subsp. *heteracantha*. The soils are deep and fertile (Chapter 4) being derived from alluvium (Chapter 2). This management unit is situated on the Save River aquifer and soil moisture content is therefore high.

5. The *Diospyros mespiliformes* Riverine Management Unit

This management unit consists of the riverine communities, namely the *Dalbergia arbutifolia–Diospyros mespiliformes* High Riverine Forest and the *Phragmites mauritianus* Tall Closed Reedbeds. This management unit comprises 4.6 % of the surface area of Sango Ranch. It is recognised by the presence of a closed canopy forest consisting of *Diospyros mespiliformes, Strychnos potatorum, Croton megalobotrys, Faidherbia albida* and *Trichilia emetica.* A thicket-like shrub layer consisting of *Dalbergia arbutifolia* and *Acacia schweinfurthii* is also typical. The soils are deep and fertile with a high water table (Chapter 4) and are derived from alluvium. The grass cover is low due to the closed canopy of the vegetation (Chapter 6).

6. The *Echinochloa colona* Wetland Management Unit

This management unit consists of the wetland community, the *Echinochloa colona–Cyperus digitatus* subsp. *auricomus* Tall Open Woodland and covers 0.5 % of the study area. It is recognised by the presence of *Echinochloa colona, Cyperus* sp. and *Acacia xanthophloea*. The pans forming these wetlands are found scattered throughout the plains of Sango Ranch (Figure 86). The soils have a high clay content and sometimes have a vertic nature (Chapter 4). The grass cover is high due to the openness of this vegetation type(Chapter 6).

CONCLUSION

Although different methods were used, the results obtained in this study are similar to those obtained by Wild (1955), Wild and Rattray (1955), Wild (1965), Farrell (1968), Du Toit (1990b), Du Toit and Price-Waterhouse (1994) and Goodwin *et al.* (1997). Nine major vegetation types related to certain environmental factors have been identified using 220 sample plots.

From Tables 6 to 9 it is evident that apart from the *Phragmites mauritianus* Tall Closed Reedbeds and the *Echinochloa colona–Cyperus digitatus* Tall Open Wetland, species richness is fairly high in all vegetation communities. Frequent species found on Sango Ranch belong to Species Groups P and Q (Table 6), T and U (Table 7), and Q and R (Table 8). Many of the species in Tables 6 to 9 indicate that certain floristic affinities exist between the different vegetation communities.

The *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland contains several pioneer species (Table 6). From the aerial photographs of the study area and historical records it is evident that several vegetation disturbances have occurred on Sango Ranch in the past. These areas are indicated on the vegetation map in Figure 9. Secondary succession by *Acacia tortilis* subsp. *heteracantha* is usually associated with recovery after ploughing, overgrazing and other forms of disturbance (Milton 1983). *Acacia tortilis* subsp. *heteracantha* and other associated pioneer woody species such as *Dichrostachys cinerea* subsp. *africana* and unpalatable pioneer grasses such as *Tragus berterorianus, Aristida junciformis* and *Chloris roxburghiana* therefore dominate the areas of disturbed vegetation on Sango Ranch. In cases of severe disturbance these species encroach severely and become densely wooded with a poor herbaceous layer. The undisturbed form of the *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland is more open and has a well-developed herbaceous layer containing palatable perennial grass species. The *Acacia tortilis* subsp. *heteracantha–Panicum maximum* Tall Closed Woodland seems to be closely associated with the *Acacia tortilis* subsp. *heteracantha-Urochloa mosambicensis* Tall Closed Woodland but the presence of the aquifer along the Save River separates the two (Figure 9).

The *Colophospermum mopane–Brachiaria deflexa* Short Thicket// Short Closed Woodland is typical of the southeastern Lowveld of Zimbabwe (Wild 1955; Wild and Rattray 1955; Wild 1965; Farrell 1968; Du Toit 1990b; Du Toit and Price-Waterhouse 1994 and Goodwin *et al.* 1997). This plant community is associated with the lower parts of the soil catena on clay-rich depositional soils (Timberlake 1995). The poor grass layer is typical (Henkel 1931; Timberlake 1995). On the lighter textured and shallow soils the woody layer is more open and the grass layer is well developed. Species richness in the woody layer is low, being dominated by almost pure stands of *C. mopane.* These homogeneous and almost exclusive stands of mopane are known as "cathedral mopane" (Timberlake 1995). The herbaceous layer, although mostly poorly developed is sometimes quite diverse. The *Combretum apiculatum* subsp. *apiculatum–Colophospermum mopane* Short Closed Woodland is an ecotonal community. It lies at the junction between the *Colophospermum mopane–Brachiaria deflexa* Short Thicket // Short Closed Woodland and the *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland. It therefore possesses elements of both vegetation types.

The *Combretum apiculatum* subsp. *apiculatum–Digitaria milanjiana* Tall Closed Woodland is typical of the Lowveld areas of southern Africa (Van Rooyen 1978; Coetzee 1983). It has the greatest species richness in both the woody and herbaceous layers and appears to be a sub-climax or climax vegetation type. The herbaceous layer is extremely well developed and this is important in fire management. The presence of *Julbernardia globiflora* and *Brachystegia spiciformis* shows an affinity with the Miombo woodlands further north. The *Millettia usumarensis* subsp. *australis–Brachiaria deflexa* Short Koppie Thicket is typical of koppies in the area (Du Toit and Price-Waterhouse 1994; Goodwin *et al.* 1997). The riverine and pan communities are also typical for the Lowveld areas of southern Africa.

The management units identified above are easily recognisable in the field and are based on environmental differences in the various vegetation types. Within each management unit, the herbaceous biomass, veld condition, and grazing and browsing capacity can be determined. This makes it possible to develop an ecological management plan for Sango Ranch. The management units can also be used to monitor the herbaceous biomass, veld condition, vegetation change and grazing/browsing capacity changes. The management practices can then be applied to each management unit according to its specific requirements.

CHAPTER 6

HERBACEOUS SPECIES COMPOSITION AND VELD CONDITION ASSESSMENT

INTRODUCTION

Possible methods for use in determining the species composition of the herbaceous layer are the Levy bridge method (Levy and Madden 1933, *In*: Walker 1970), the line intercept method (Canfield 1941, *In*: Floyd and Anderson 1987), the loop method (Parker 1951, *In*: Johnston 1957), the wheel-point method (Tidmarsh and Havenga 1955), the variable plot method (Hyder and Sneva 1960, *In*: Walker 1970), the descending point method (Roux 1963, *In*: Vorster 1982), the dry-weight rank method ('t Mannetjie and Haydock 1963), the belt transect method (Mueller-Dombois and Ellenberg 1974), the comparative yield method (Haydock and Shaw 1975), the step-point method (Mentis 1981); the metric belt transect method (Everson and Clarke 1987), the line transect method (Snyman 1989), a combination of the dry-weight rank method and the comparative method (Snyman, Grossman and Rethman 1990; Schmidt 1992), and near infrared reflectance spectroscopy (García-Criado, García-Criado and Perez-Corona 1991). However, estimates of species composition are most commonly determined with the wheel-point apparatus (Tidmarsh and Havenga 1955) or modifications thereof (Mentis 1981). The step-point method (Mentis 1981) has also been used extensively in savanna vegetation (Du Plessis 1992; Orban 1995; Swart 1995). A sample size of 200 points is commonly used (Hardy and Walker 1991). The step-point and wheel-point methods are commonly used in conjunction with the nearest-plant method (Mentis, Collinson and Wright 1980; Everson and Clarke 1987; Everson, Clarke and Everson 1990; Snyman *et al.* 1990; Hardy and Walker 1991). However, criticism has been levelled at the nearest-plant method (Snyman *et al.* 1990). Moreover, Snyman *et al.* (1990) regard the technique as unsuitable for use in arid areas where annual species dominate and the ecological status of grass species varies from year to year.

The various techniques used for determining species composition have been evaluated by various authors (Johnston 1957; Walker 1970; Becker and Crockett 1973; Mentis 1981; Barnes, Odendaal and Beukes 1982; Gillen and Smith 1986; Everson and Clarke 1987; Floyd and Anderson 1987; Friedel and Shaw 1987; Novellie and Strydom 1987; Everson *et al.* 1990; García-Criado *et al.* 1991) and the general consensus is that not one technique alone is completely accurate. Each author recommends a different technique and this is of course dependent on the conditions that prevailed when the methods were tested. It seems as if their suggestions are best followed to obtain an idea of the best method for the conditions under which the survey will be carried out. Considerations include the type of grass, the cover, the terrain, the researcher's objectives, expertise and enthusiasm and the finances available.

Veld condition is defined by Trollope, Trollope, and Bosch (1990) as the condition of the vegetation in relation to some or other functional characteristic, usually maximum forage production and resistance to soil erosion. The veld is thus described in terms of its state of health (Tainton 1981). Stuart-Hill (1989b) gives three reasons for conducting veld condition assessments. The first is to determine the species composition of the veld. The second is to establish a reference point for predictions of grazing capacity or runoff from a particular piece of veld. The third is to monitor vegetation change to determine the effect of management practices on the veld. Once the species composition and condition of a piece of veld is known then objectives can be defined on the basis of its potential for forage production and resistance to soil erosion. The wildlife manager then has a scientific basis upon which to base his management decisions. By monitoring the veld condition over a certain period the researcher or manager can obtain information on the effect of rainfall, fire and grazing on that particular veld (Tainton 1981). Trends observed will then indicate to the manager whether his past and current management practices have had any success or whether modifications should be brought about.

The objectives of the veld condition assessment are to:

- Determine the proportional species composition of the herbaceous layer.
- Determine a grazing gradient.
- Attempt an objective allocation of grass species to ecological categories.
- Assess the condition of the veld using two different methods.
- Compare the results of the two methods and select the simplest yet most reliable method to be used during monitoring.
- Attempt an explanation of the ecological factors contributing to the current veld condition.
- Use these data to determine the grazing capacity of an area.

METHODS

SPECIES COMPOSITION OF THE HERBACEOUS LAYER

An adaptation of the wheel-point method (Tidmarsh and Havenga 1955) and the step-point method (Mentis 1981) was used to determine the species composition of the herbaceous layer. The adaptation consisted of a thin rod and the technique is therefore called the rod method (Du Plessis 1992). Du Plessis (1992) tentatively suggested that the rod method might give more accurate results than either the step-point or wheel-point method. The rod method was used in a survey consisting of line transects placed in a north-south direction commencing from each point used for the Braun-Blanquet survey. Because of the difficult terrain no herbaceous surveys were conducted on koppies. At each site 200 point observations were made at 2 m intervals that were stepped out in four parallel line transects of 100 m in length. The plots were placed in such a way that sub-habitats both under and in-between trees were included (Snyman 1989). The nearest plant to the point was recorded according to the nearest plant method (Snyman *et al.* 1990). The maximum radius to the nearest plant was determined during a survey of 2 000 point observations placed in a stratified manner in each of the homogeneous plant communities (Snyman *et al.* 1990). A maximum radius of 150 mm was used and was taken as the distance in which plant species were present in 90 percent of the observations. Only plants rooted within this maximum radius were recorded. Grass plants were identified to species level and all other herbaceous plants were recorded as forbs. The grass canopy cover was estimated visually by using the Braun-Blanqet cover-abundance scale (Chapter 5).

VELD CONDITION

The condition of the herbaceous component of the vegetation was assessed using the method of Vorster (1982). However, because this original method has been criticised for its subjective allocation of grasses to ecological status groups, a more objective method of determining ecological status was applied. Van Rooyen, Bredenkamp and Theron (1991) and Cauldwell, Zieger, Bredenkamp and Bothma (1999) have both used this latter method.

Identification of a degradation gradient

The methods of Bosch and Janse Van Rensburg (1987), Bosch, Janse Van Rensburg and Truter (1987), Bosch (1989), Janse Van Rensburg and Bosch (1990), Bosch and Gauch (1991), Van Rooyen *et al.* (1991), Bosch and Kellner (1991), and Cauldwell *et al.* (1999) were used to identify a grazing gradient. Only the Braun-Blanquet data (Chapter 5) for the grass species were used for the identification of the degradation gradient (Cauldwell *et al.* 1999). A separate survey was conducted in areas that represented varying degrees of degradation, for example near water points, protected areas and grazing areas. The data were subjected to a DECORANA ordination (Hill 1975a). The axis representing a grazing gradient was identified after refinement by the ordinated positions of the stands that were surveyed at increasing distances from watering points, next to fenced areas, at points of animal concentration and at protected areas.

Classification of plant species into ecological categories

Species frequency curves were fitted to the degradation gradient by means of a polynomial regression technique to identify decreaser and increaser species (Van Rooyen *et al.* 1991; Cauldwell *et al.* 1999). These were then compared with the theoretical curves from Figure 87 for each of the ecological status groups (Van Rooyen *et al.* 1991). The herbaceous species were categorised into one of the following categories according to their response to grazing intensity (Vorster 1982):

- Decreasers : Species decreasing when the veld is over-utilised but that dominate in good veld.
- Increasers 1 : Species rare in good veld but increasing when the veld is underutilised.
- Increasers 2 a : Grass species rare in good veld but increasing when the veld is moderately overutilised.
- Increasers 2 b : Species rare in good veld but increasing when the veld is heavily overutilised.
- Increasers 2 c : Species rare in good veld but increasing when the veld is excessively overutilised.

Veld condition assessment

Relative index values are assigned to each ecological status category, to reflect various stages of degradation, and the value of an ecological class as a grazing resource (Barnes, Rethman and Kotze 1984). The following relative index values are widely used in southern Africa (Van Rooyen *et al.* 1996), and were used here too: Decreasers: 10; Increasers 1: 7; Increasers 2a: 5; Increasers 2b: 4; Increasers 2c: 1.

The mean percentage frequency of grass species of each ecological class were calculated for each management unit, and were then multiplied by the appropriate relative index values. The total score then represents the veld condition index (Foran, Tainton and Booysen 1978; Vorster 1982). The veld condition possesses a maximum theoretical value of 1000 and a minimum theoretical value of 100. The veld condition index score obtained is then divided by 10 to render a veld condition score on a scale from 10 to 100.

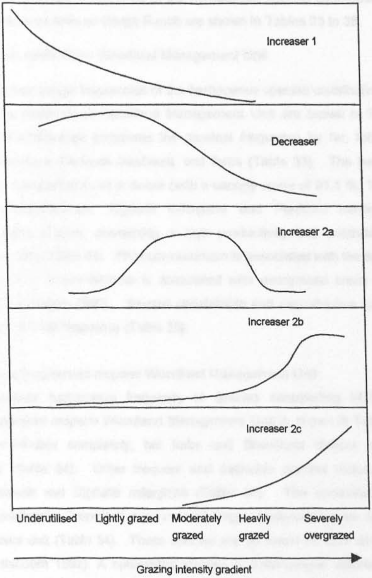


Figure 87. Schematic representation of the five general ecological status classes as defined along a grazing intensity gradient (Van Rooyen *et al.* 1991).

RESULTS AND DISCUSSION

GRASS SPECIES COMPOSITION

The relative percentage frequencies of the herbaceous species contributing >0.5% to the management units on Sango Ranch are shown in Tables 33 to 38.

1. The *Acacia tortilis* Open Woodland Management Unit

The relative percentage frequencies of the herbaceous species contributing >0.5% to the *Acacia tortilis* Open Woodland Management Unit are shown in Table 33. *Urochloa mosambicensis* possesses the greatest frequency by far, followed by *Digitaria milanjiana, Panicum maximum,* and forbs (Table 33). The herbaceous layer in this management unit is dense (with a canopy cover of 91.1 %, Table 33). *Urochloa mosambicensis, Digitaria milanjiana* and *Panicum maximum* are desirable grass species, possessing a high productivity and palatability (Van Oudtshoorn 1992, Table 39). *Panicum maximum* is associated with the subcanopy habitat, while *U. mosambicensis* is associated with overgrazed areas on fertile soils (Van Oudtshoorn 1992). Several unpalatable and unproductive species are present, but at a low frequency (Table 33).

2. The *Colophospermum mopane* Woodland Management Unit

The percentage herbaceous frequency of species contributing >0.5% to the *Colophospermum mopane* Woodland Management Unit is shown in Table 34. No species dominates completely, but forbs and *Brachiaria deflexa* occur most frequently (Table 34). Other frequent and desirable species include *Urochloa mosambicensis* and *Digitaria milanjiana* (Table 34). The undesirable annuals *Aristida junciformis, Oropetium capense* and *Tragus berterorianus* are found in this management unit (Table 34). These species are all found on bare denuded soils (Van Oudtshoorn 1992). A noteworthy species is *Enteropogon macrostachys.* It grows on sandy soils in the shade of trees (Van Oudtshoorn 1992). *Sporobolus nitens* indicates the presence of saline-sodic soils where it occurs (Van Oudtshoorn 1992). The canopy cover is high at 93.8 % (Table 34).

3. *Combretum apiculatum* Woodland Management Unit

The percentage frequencies of the herbaceous species of the *Combretum apiculatum* Woodland Management unit are shown in Table 35. Forbs are most frequent in this management unit, followed by *Urochloa mosambicensis, Digitaria milanjiana,*

Table 33. The species composition of the herbaceous layer as a relative percentage frequency in the *Acacia tortilis* Open Woodland Management Unit. Canopy cover 91.1 %.

SPECIES	*RELATIVE PERCENTAGE FREQUENCY*
Urochloa mosambicensis	63.4
Digitaria milanjiana	16.1
Panicum maximum	7.7
Forbs	6.4
Sporobolus nitens	1.9
Eragrostis rigidior	1.6
Chloris virgata	0.9
Dactyloctenium giganteum	0.8
Eragrostis curvula	0.6
Tragus berterorianus	0.6

Table 34. The species composition of the herbaceous layer as a relative percentage frequency in the *Colophospermum mopane* Woodland Management Unit. Canopy cover is 92.1 %.

SPECIES	*RELATIVE PERCENTAGE FREQUENCY*
Forbs	25.2
Brachiaria deflexa	18.2
Urochloa mosambicensis	12.6
Aristida junciformis	9.7
Oropetium capense	9.6
Digitaria milanjiana	8.2
Tragus berterorianus	5.6
Eragrostis rigidior	3.8
Sporobolus nitens	1.6
Panicum maximum	1.4
Chloris virgata	1.2
Panicum coloratum	0.7
Enteropogon macrostachys	0.6

Brachiaria deflexa and *Panicum maximum*. Several other palatable and productive species occur here, namely *Setaria pumila* and *S. sagittifolia* (Van Oudtshoorn 1992). On the other hand, several unproductive species are also present, namely *Eragrostis rigidior, Heteropogon contortus, Aristida junciformis, Pogonarthria squarrosa, Oropetium capense, Tricholaena monachne* and *Tragus berterorianus.* Many of these unproductive species have a preference for sandy or stony soils (Van Oudtshoorn 1992). The grass layer is dense, with a canopy cover of 95.6 %.

4. *Acacia tortilis* Closed Woodland Management Unit

The percentage frequencies of the herbaceous species of the *Acacia tortilis* Closed Woodland Management Unit are presented in Table 36. The very productive and palatable *Panicum maximum* is most frequent in this community. Forbs are also very frequent, followed by *Urochloa mosambicensis* and *Dactyloctenium giganteum.* Very few unproductive grass species are found in this very rank herbaceous layer (the canopy cover is 96.8 %).

5. The *Diospyros mespiliformes* Riverine Management Unit

Table 37 shows the percentage frequencies of the herbaceous species of the *Diospyros mespiliformes* Riverine Management Unit. *Panicum maximum* is most frequent in this closed canopy management unit. *Eriochloa meyeriana* and forbs are also frequent, with the productive species *Setaria sagittifolia* growing in the shade. Because of the closed woody layer canopy (Chapter 5), the herbaceous canopy cover is a low 68 %.

7. The *Echinochloa colona* Wetland Management Unit

Table 38 shows the percentage frequencies of the herbaceous species of the *Echinochloa colona* Wetland Management Unit. The tall herbaceous layer is dominated by *Echinochloa colona,* with a canopy cover of 80.5 %. Apart from the few forbs present, the grasses are all palatable and productive (Van Oudtshoorn 1992).

DEGRADATION GRADIENT

A scatter diagram showing a general degradation gradient for Sango Ranch based on the DECORANA ordination is shown in Figure 88. A degradation gradient is evident on the first axis. The gradient was divided into four equal sections, which roughly correspond to the utilisation levels found on Sango Ranch. It is clear that

Table 35. The species composition of the herbaceous layer as a relative percentage frequency in the *Combretum apiculatum* Woodland Management Unit. Canopy cover is 95.6 %.

SPECIES	*RELATIVE PERCENTAGE FREQUENCY*
Forbs	28.1
Digitaria milanjiana	17.9
Urochloa mosambicensis	16.3
Brachiaria deflexa	14.8
Panicum maximum	10.3
Setaria pumila	2.9
Eragrostis cylindriflora	1.1
Eragrostis rigidior	1.1
Tricholaena monachne	0.8
Aristida junciformis	0.7
Setaria sagittifolia	0.7
Heteropogon contortus	0.6
Oropetium capense	0.1

Table 36. The species composition of the herbaceous layer as a relative percentage frequency in the *Acacia tortilis* Closed Woodland Management Unit. Canopy cover is 96.8 %.

SPECIES	*RELATIVE PERCENTAGE FREQUENCY*
Panicum maximum	49.3
Forbs	37.4
Urochloa mosambicensis	9.3
Dactyloctenium giganteum	2.4
Eragrostis rigidior	1.1
Chloris virgata	0.5

Table 37. The species composition of the herbaceous layer as a relative percentage frequency in the *Diospyros mespiliformes* Riverine Management Unit. Canopy cover is 68 %.

SPECIES	*RELATIVE PERCENTAGE FREQUENCY*
Panicum maximum	58.3
Forbs	29.2
Eriochloa meyeriana	*20.8*
Setaria sagittifolia	4.2

Table 38. The species composition of the herbaceous layer as a relative percentage frequency in the *Echinochloa colona* Wetland Management Unit. Canopy cover 80 percent.

SPECIES	*RELATIVE PERCENTAGE FREQUENCY*
Paspalidium obtusifolium	79.8
Forbs	12.3
Eragrostis curvula	4.9
Echinochloa colona	3.1

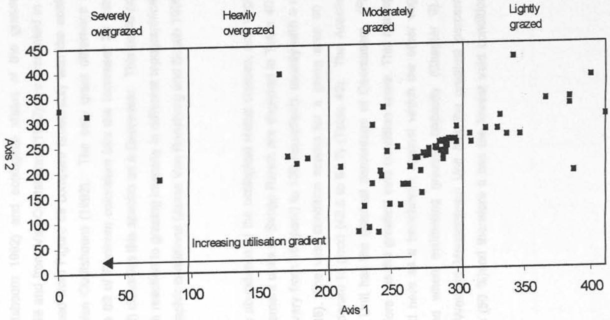


Figure 88. Scatter diagram to show the degradation gradient present in the DECORANA ordination (Hill 1979a) of the herbaceous species on Sango Ranch, Save Valley Conservancy, Zimbabwe.

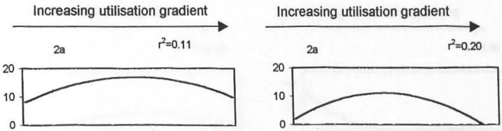
the majority of sites are moderately grazed and only three sites are severely overgrazed.

ECOLOGICAL STATUS CATEGORIES

The changes in percentage frequency of the common grass species along the degradation gradient are depicted in Figure 89. No Increaser 1 category could be found for Sango Ranch, possibly indicating that no areas are underutilised. The palatability (Van Oudtshoorn 1992) and ecological status of the grasses as determined in Figure 89 and from Van Oudtshoorn (1992) are presented in Table 39. The results obtained from Figure 89 compare favourably with the ecological status categories of Van Oudtshoorn (1992). The only great difference is the classification in Figure 89 of *Panicum coloratum* into the Increaser 2a category. Van Oudtshoorn (1992) classifies this species as a Decreaser. This could possibly be due to a variation in reaction to grazing intensity in different topographical units and under different edaphic conditions (Janse Van Rensburg and Bosch 1990).

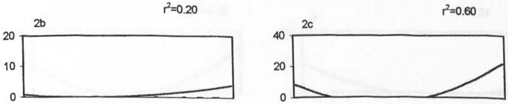
VELD CONDITION

The mean percentage abundance of the ecological status classes, and vegetation scores for the management units of Sango Ranch are depicted in Table 40. Veld condition scores can vary from 10 (poor) to 100 (excellent), usually with a median of 55 (Cauldwell 1998). The veld condition scores for a given area on Sango Ranch vary from moderate to good (42.5 to 61.7) (Table 40). The *Acacia tortilis* Closed Management Unit has the greatest percentage of Decreasers *(Panicum maximum)* and therefore has the greatest veld condition score. This management unit is therefore used here as a benchmark against which the other vegetation units were compared when estimating grazing capacity (Chapter 9). The *Echinochloa colona* Wetland Management Unit has the greatest percentage of Increaser 2c species (50 %)and therefore it has the lowest veld condition score (42.5).



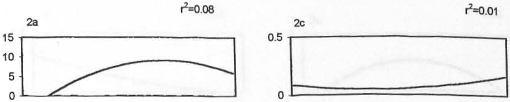
a) Forbs

f) *Digitaria milanjiana*



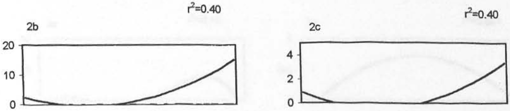
b) *Aristida junciformis*

g) *Echinochloa colona*



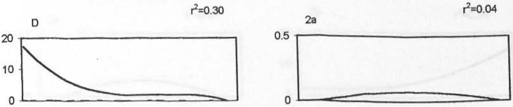
c) *Brachiaria deflexa*

h) *Enteropogon macrostachys*



d) *Chloris virgata*

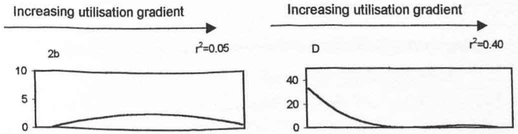
i) *Eragrostis curvula*



e) *Dactyloctenium giganteum*

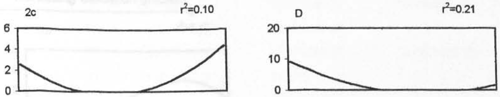
j) *Eragrostis cylindriflora*

Figure 89. Changes in percentage frequency of 22 common grass species along a grazing gradient on Sango Ranch, Save Valley Conservancy, Zimbabwe.



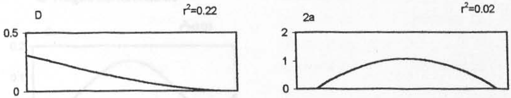
k) *Eragrostis rigidior*

p) *Panicum maximum*



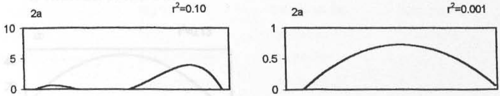
l) *Eriochloa meyeriana*

q) *Paspalidium obtusifolium*



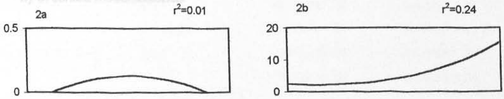
m) *Heteropogon contortus*

r) *Setaria pumila*



n) *Oropetium capense*

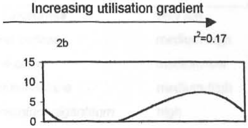
s) *Setaria sagitifolia*



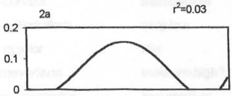
o) *Panicum coloratum*

t) *Sporobolus nitens*

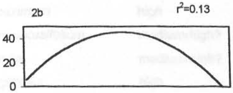
Figure 89. Changes in percentage frequency of 22 common grass species along a grazing gradient on Sango Ranch, Save Valley Conservancy, Zimbabwe.



u) *Tragus berteronianus*



v) *Tricholaena monachne*



w) *Urochloa mosambicensis*

Figure 89. Changes in percentage frequency of 22 common grass species along a grazing gradient on Sango Ranch, Save Valley Conservancy, Zimbabwe.

Table 39. The palatability and ecological status of 23 grass species in Sango Ranch, Save Valley Conservancy, Zimbabwe as determined from Figure 89.

SPECIES	*PALATABILITY**	*ECOLOGICAL STATUS*	
		Figure 6.3	*Van Oudsthoorn (1992)*
Aristida junciformis	very low	Increaser 2b	Increaser 2c
Brachiaria deflexa	medium-high	Increaser 2a	-
Chloris virgata	medium-low	Increaser 2b	Increaser 2c
Echinochloa colona	medium-high	Increaser 2c	-
Dactyloctenium giganteum	high	Decreaser	-
Digitaria milanjiana	high	Increaser 2a	-
Enteropogon macrostachys	medium?	Increaser 2b	-
Eragrostis curvula	medium-low	Increaser 2c	Increaser 2b
Eragrostis cylindriflora	very low	Increaser 2a	-
Eragrostis rigidior	low	Increaser 2b	Increaser 2b
Eriochloa meyeriana	medium-high?	Increaser 2c	-
Heteropogon contortus	low-medium	Decreaser	Variable
Oropetium capense	low	Increaser 2a	-
Panicum coloratum	high	Increaser 2a	Decreaser
Panicum maximum	high	Decreaser	Decreaser
Paspalidium obtusifolium	medium-high?	Decreaser	-
Setaria pumila	medium-high?	Increaser 2a	-
Setaria sagittifolia	high	Increaser 2a	-
Sporobolus nitens	medium	Increaser 2b	Increaser 2c
Tragus berterorianus	low	Increaser 2b	Increaser 2c
Tricholaena monachne	medium	Increaser 2a	Increaser 2b/2c
Urochloa mosambicensis	high	Increaser 2b	Increaser 2c
Forbs	-	Increaser 2a	Increaser 2a

* Source: Van Oudtshoorn (1992)

Table 40. The mean percentage abundance of the ecological status classes, and veld condition scores for the management units of Sango Ranch, Save Valley Conservancy, Zimbabwe.

MANAGEMENT UNIT	*PERCENTAGE FREQUENCY*				*VELD CONDITION SCORE*	*VELD CONDITION CLASS*
	Decreasers	*Increasers 2a*	*Increasers 2b*	*Increasers 2c*		
1	20	20	50	10	51.0	Moderate
2	15	31	54	0	52.3	Moderate
3	15	62	23	0	55.4	Moderate
4	33	17	50	0	61.7	Good
5	25	50	0	25	52.5	Moderate
6	25	25	0	50	42.5	Moderate
Mean	22.2	34.2	29.5	14.2	52.6	Moderate

1. The *Acacia tortilis* Open Woodland Management Unit
2. The *Colophospermum mopane* Woodland Management Unit.
3. The *Combretum apiculatum* Woodland Management Unit
4. The *Acacia tortilis* Closed Woodland Management Unit
5. The *Diospyros mespiliformes* Riverine Management Unit
6. The *Echinochloa colona* Wetland Management Unit

CHAPTER 7

HERBACEOUS BIOMASS ASSESSMENT

INTRODUCTION

Biomass is defined by Trollope *et al.* (1990) as the total amount of living material present in a specific area at any given time. It is usually expressed in kg per ha. The biomass production of the herbaceous layer is invaluable in monitoring the amount of herbage available to herbivores. It can be related to animal performance (Alder and Richards 1962) and can serve as an indication of the grazing capacity and stocking rate of an area (Castle 1976; Bransby, Matches and Krause 1977; Bransby and Tainton 1977). Biomass production can also be used to estimate the fuel loads of the grass layer (Trollope 1980). Fire is an important tool in veld management, especially for the removal of excess dead plant material and the control of encroachers (Trollope 1980; Van Wilgen and Willis 1988). Information on the available fuel loads makes accurate predictions possible on the regularity of expected veld fires (Van Wilgen and Willis 1988). It also gives an indication of the ability of an area to carry a fire at a given time (Trollope, Potgieter and Zambatis 1989).

Considerable research has been devoted to methods to estimate herbage yield. Consequently a multitude of techniques have been developed. Herbage yield has been estimated with various instruments, including a power-driven sheep-shearing head (Alder and Richards 1962), various electronic instruments (Campbell, Phillips and O'Reilly 1962; Back 1968), a radio frequency bridge (Nichols 1973), disc instruments (Castle 1976; Bransby *et al.* 1977; Bransby and Tainton 1977; Trollope and Potgieter 1986), and a spectral reflectance instrument (Boutton and Tieszen 1983). Other widely used methods are the dry-weight-rank method ('t Mannetjie and Haydock 1963), the comparative yield method (Haydock and Shaw 1975), and the key grass species method for assessing veld condition. The latter also gives an estimate of the fuel potential for burning (Trollope *et al.* 1989; Trollope 1990).

The disc-pasture meter (Castle 1977; Bransby and Tainton 1977; Bransby *et al.* 1977; Trollope and Potgieter 1986) provides an objective, accurate, inexpensive and rapid estimate of herbage yield (Bransby and Tainton 1977; Bransby *et al.* 1977; Danckwerts and Trollope 1980; Hardy and Mentis 1985; Trollope and Potgieter 1986). The disc-pasture meter is used to determine mean settling heights for each management unit that then provides estimates of herbage yield. Various linear regression equations have been developed to determine dry matter yield from total biomass estimates derived with a disc pasture meter. Trollope and

Potgieter (1986) developed a regression equation for the southern regions and the mopane shrubveld in the central and northern regions of the Kruger National Park. In areas where no regression equations have been developed, prior calibration of the disc pasture meter is essential (Trollope and Potgieter 1986). Trollope and Potgieter (1986) describe calibration of the disc pasture meter for the bushveld areas of southern Africa. Danckwerts and Trollope (1980) and Hardy and Mentis (1985) evaluated the efficiency of disc meter sampling and found it to be efficient for measuring herbaceous biomass. Hardy and Mentis (1985) recommend the use of the disc pasture meter for biomass production estimation because it is a non-destructive procedure.

In the formulation of resource inventories for natural areas, estimates of herbage yield are therefore extremely useful in terms of pasture, game and fire management. The aims of the herbaceous biomass assessment are to:

- Obtain an estimate of the available herbaceous biomass in each homogeneous management unit.
- Determine the ability of the veld to carry a fire.
- Aid in the determination of the need for a burn.

METHODS

Herbage yield was estimated in the present study with the disc pasture meter because it is a rapid, non-destructive method and is fairly efficient for measuring herbaceous biomass (Bransby and Tainton 1977; Bransby *et al.* 1977; Danckwerts and Trollope 1980; Hardy and Mentis 1985; Trollope and Potgieter 1986). Moreover, it has already been calibrated for the mopane veld (Trollope and Potgieter 1986). The technique was applied as described and used by Castle (1976), Bransby and Tainton (1977), Bransby *et al.* (1977), Danckwerts and Trollope (1980), Danckwerts (1982a), Downing and Marshall (1983), Hardy and Mentis (1985), Trollope and Potgieter (1986), Wentzel, Bothma and Van Rooyen (1991) and Van Heerden (1992).

Selection of sample sites

Sample sites were placed in exactly the same position as for the herbaceous assessment (Chapter 6). The plots were placed in a north-south direction and 100 readings were taken in two parallel line transects, each 100 m long. The settling height of the disc was recorded at 2 m intervals.

Measurement of settling height

The central rod of the pasture meter was held perpendicular to the ground surface and the sleeve with the attached disc was released onto the grass sward from a standard height of 0.6 m above the ground level (Bransby and Tainton 1977). The settling height of the disc was read off the rod from a position corresponding with the upper end of the sleeve. In grass swards more sensitive to compression the sleeve with the attached disc was placed gently on the sward surface and allowed to settle until a constant height was reached or for a maximum settling time of 15 seconds. Care was taken on uneven ground that the lower end of the rod was not placed in a hole or on top of a mound or tuft of grass.

Calculation of herbage yield

The mean settling height of the disc was determined for each management unit. This was substituted into the regression equation calculated by Trollope and Potgieter (1986). Since the disc pasture meter was calibrated for the mopane shrubveld of the northern Kruger National Park, the regression equation of Trollope and Potgieter (1986) was used in the study area.

RESULTS AND DISCUSSION

The dry mean herbaceous biomass of the six management units (Chapter 5) of Sango Ranch is presented as a histogram in Figure 90. The mean estimated herbaceous biomass of Sango Ranch is high at 3 457 kg per ha. The highest recorded biomass of 8 551 kg per ha was recorded in management unit 3 and the lowest of 1 520 kg per ha in management unit 2. The highest mean estimated biomass of 5 092 kg per ha was recorded in the *Combretum apiculatum* Woodland Management Unit. The lowest average estimated biomass of 1 502 kg per ha was recorded in the *Colophospermum mopane* Woodland Management Unit. Herbaceous biomass does, however, vary considerably in these two management units. Some areas in the *Colophospermum mopane* Woodland Management Unit have a high herbaceous biomass of 2 000 to 4 000 kg per ha. Of interest are the low estimates recorded in the *Colophospermum mopane* Woodland Management Unit. Several authors have commented on the poor grass cover in the mopane woodland areas of southern Africa (Timberlake 1995).

In southeastern Zimbabwe, Kelly (1973, *In:* Walker 1976b), obtained a dry mean herbaceous biomass estimate of 1 690 kg per ha. In the Nylsvley Nature Reserve of the Northern Province of South Africa, Grunow and Bosch (1978) obtained herbaceous biomass estimates of 623 to 1 033 kg per ha. Pieterse and Grunow (1985) recorded a herbaceous biomass of 1 600 to 2 500 kg per ha at the Mara

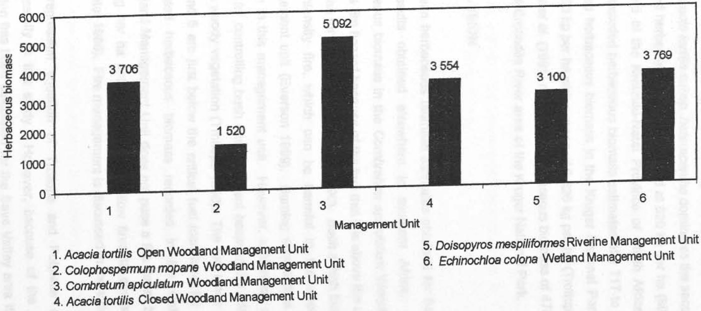


Figure 90. The average herbaceous biomass (kg per ha) of the management units of Sango Ranch, Save Valley Conservancy, Zimbabwe. The mean herbaceous biomass is 3 457 kg per ha.

Research Station in the Northern Province of South Africa. Van Heerden (1992) obtained herbaceous biomass figures of 256 to 1 287 kg per ha for the Lissataba Game Ranch of the Northern Province of South Africa. Herbaceous biomass estimates for the Doornpoort Experimental Game Ranch in the Gauteng Province of South Africa, varied from 1 960 to 4 600 kg per ha (Smith 1992). Estimated herbaceous biomass figures in the Eastern Cape and Kwazulu-Natal Provinces of South Africa varied from 2 000 to 3 500 kg per ha (Danckwerts and Trollope 1980; Hardy and Mentis 1985). In the Tugela Dry Valley Bushveld, Kwazulu-Natal, where *Acacia tortilis* subsp. *heteracantha* dominates the secondary succession, the estimated herbaceous biomass peaked at 830 kg per ha (Milton 1983). In the Tall Grassveld of the Kwazulu-Natal Province of South Africa, Morris and Tainton (1996) recorded herbaceous biomass estimates of 1 717 to 6 591 kg per ha. The estimated herbaceous biomass in the Kruger National Park varied between 187 and 8 600 kg per ha with a mean of 3 826 kg per ha (Trollope and Potgieter 1986). Wentzel *et al.* (1991) recorded a herbaceous biomass of 470 to 2 357 kg per ha in the Sabi-Crocodile River area of the Kruger National Park.

CONCLUSION

The mean herbaceous biomass estimates obtained for Sango Ranch are in line with results obtained elsewhere in southern Africa. The high estimated herbaceous biomass in the *Combretum apiculatum* Woodland Management Unit poses a fire hazard because of the fact that it is above the critical fuel load of 4000 kg per ha for intense fires (Trollope 1990). Such a high biomass will easily carry a high intensity fire, which can be harmful to the woody component of this management unit (Everson 1999). Burning should thus be done with extreme caution in this management unit. However, a biomass of >4 000 kg per ha is useful for controlling bush encroachment because the hot fire which it generates will kill woody vegetation (Trollope 1990). The fuel loads in management units 1, 4, 5 and 6 are just below the critical fuel load level for intense fires. The low estimated herbaceous biomass recorded in the *Colophospermum mopane* Woodland Management Unit does not pose a fire threat because a fuel load of 1 500 kg per ha and less does not allow fires to spread readily (Trollope and Potgieter 1986). Fire management is discussed in more detail in Chapter 11.

The regression equation of Trollope and Potgieter (1986) has been used successfully in this study. However, because of the fact that no regression equation has been calculated for the Save Valley area it is recommended that a calibration be carried out by using the method of Trollope *et al.* (1989) . This calibration will then more accurately describe the variations in herbaceous biomass in the area.

CHAPTER 8

AVAILABLE BROWSE

INTRODUCTION

Browsing capacity and browse availability can be influenced by the density of woody plants, the amount of leaf material within reach of an animal, the palatability and digestibility of the woody species and the growth potential of the woody species (Pauw 1988). Schmidt (1992) adds the concentration of condensed tannins in the leaves of the woody plants as a factor. According to Rutherford, the terms browse and available browse must not be confused (Rutherford 1979). Von Holdt (1999) defines browse as the sum total of plant material on woody plants that is potentially edible to a specified set of browsing animals, and which is regarded as the current season's growth of leaves and twigs. Available browse refers to a more restricted quantity than the term browse and is determined on the basis of the maximum height above the ground to which an animal can potentially utilise the browse. The figures given here will refer to the available browse as defined by Von Holdt (1999).

Several techniques have been developed and used for estimating the available browse (Rutherford 1979, 1982a, 1982b; Pellew 1983; Pauw 1988; Smit 1989a, 1989b; Peel 1990; Sievers 1991; Schmidt 1992; Smith 1992; Van Heerden 1992; Smit 1994; Orban 1995; Swart 1995; Smit 1996). The Quantitative Descriptive Index and the BECVOL (Browse Estimates from Canopy Volume) method of Smit (1989a, 1989b, 1994, 1996) are used here. Orban (1995) used the Quantitative Descriptive Index (Smit 1989a, 1989b) and the BECVOL method and program (Smit 1996) to survey the woody vegetation of the Lionspruit Game Reserve, of the then Eastern Transvaal. The species composition, size and vertical distribution of live woody plant canopy were surveyed to determine the tree density, percentage cover of woody vegetation at different height levels and the potential productivity of the available browse material. The height levels of Coetzee and Gertenbach (1977) were used to class plants according to their height. The BECVOL program was then used to determine the Evapotranspiration Tree Equivalent, Browse Tree Equivalents and Canopy Sub-habitat Index. Swart (1995) also used the Quantitative Descriptive Index (Smit 1989a, 1989b) and the BECVOL method and program (Smit 1996) to produce a quantitative description of the woody vegetation in the Letaba Ranch, Northern Province, South Africa. Swart (1995) compared the BECVOL method to the Variable Quadrat Method (Coetzee and Gertenbach 1977) and suggested that the two methods are comparable although this has not been verified statistically.

The aim of this study was to:

- Determine the amount of available browse on Sango Ranch which will be used to determine browsing capacity.

METHODS

The dimension meter of Smit (1989c, 1994) was used to measure the following tree dimensions: maximum canopy height (m), minimum canopy height (m), maximum canopy diameter (m) and minimum canopy diameter (m) (Smit 1994, 1996). Observations were made for all woody plants >0.5 m tall and rooted in the belt transects used in the assessment of the structure of the woody vegetation (Chapter 5). The data were then entered into the BECVOL computer program in order to determine the potential available browse material in the form of leaf dry mass production per ha for each management unit. Because a feeding-height stratification exists at various levels the leaf dry mass per ha was calculated at two lower maximum browse heights of 1.5 m and 2 m, the former being the maximum level at which most smaller animals such as duiker utilise leaves, while the latter is the maximum level at which impala, kudu and eland utilise leaves (Dayton 1978; Du Toit 1990a), and at a third maximum browse height of 5 m at which giraffe and elephant are able to browse (Dayton 1978; Pellew 1983; Du Toit 1990a). However, only bull giraffe utilise browse at heights above 5 m (Pellew 1983). Two maximum browse heights, one of 2 m and one of 5 m were used as the maximum heights at which a kudu and a giraffe can browse, respectively.

A certain percentage of the total browse material in any area is inaccessible to browsers (Von Holdt 1999). This is because of the degree of deciduousness,inaccessibility, spinescence, growth form and secondary compound content of plants. A high percentage of browse material is also utilised by other animals such as insects (Brewer 1994). The total browse must then be reduced by a certain percentage to obtain a realistic estimate of the browse available to browsing ungulates. Von Holdt (1999) discussed the percentage of browse available to browsers. Following Von Holdt (1999) the following percentages of the total available browse will be used here: 5 %, 10 % and 13 %.

Palatability of woody species is difficult to quantify and measure directly (Schmidt 1992). Instead, published literature was used to as far as possible describe these two factors in the herbaceous and woody species of Sango Ranch. The following literature was used to describe the palatability and digestibility of the woody species: Leuthold and Leuthold (1972); Hall-Martin (1974b); Hall-Martin and Basson (1975); Guy (1976); Grunow (1980); Leuthold (1980); Kok and Opperman

(1980); Frost (1981); Pauw (1988); Peel (1990); Macleod, Kerley and Gaylard (1996).

RESULTS AND DISCUSSION

The total estimated leaf dry mass and the available leaf dry mass at different height levels for the management units of Sango Ranch are presented in Table 41. The leaf dry mass is presented cumulatively for each height class. The total browse and available browse present in two height levels available on Sango Ranch as depicted in Table 42 were calculated from Table 41. Total browse includes palatable and unpalatable browse while available browse includes only palatable browse < 5m above the ground. The total estimated leaf dry mass and leaf dry mass for the woody species of each management unit contributing >1 per cent to the total leaf dry mass are shown in Tables 43 to 48. The acceptability of these browse species to browsing animals is depicted in Table 48 based on information from Leuthold and Leuthold (1972); Hall-Martin (1974b); Hall-Martin and Basson (1975); Guy (1976); Grunow (1980); Leuthold (1980); Kok and Opperman (1980); Frost (1981); Pauw (1988); Peel (1990); Macleod *et al.* (1996).

The greatest amount of total and palatable browse material in all six management units lies in the >5 m height class which is not available to browsers (total browse = 83 %, palatable browse = 85 %) (Table 41), (Dayton 1978; Pellew 1983; Du Toit 1990a). The greatest amount of total and palatable browse in all six management units lies in the >2-5 m height class (total browse =11 %, palatable browse = 11 %; Table 41), and is only available to the giraffe and elephant (Dayton 1978; Pellew 1983; Du Toit 1990a). Of the total palatable and unpalatable browse on Sango Ranch 16 % is therefore available to browsers. Only 15 % of palatable browse material on Sango Ranch is available to browsers. The *Diospyros mespiliformes* Riverine Management Unit has the greatest amount of leaf dry mass, although it does not have the highest tree density. This is because of the large number of tall trees in this management unit. The *Acacia tortilis* Open Woodland Management Unit has the lowest leaf dry mass and this is because of the low number of woody plants in this management unit. The *Colophospermum mopane* Woodland Management Unit has the greatest leaf dry mass in the 0 to 2 m and >2 to 5 m height categories.

Table 41. The estimated total and palatable leaf dry mass estimates (kg per ha) in four height strata of the management units of Sango Ranch, Save Valley Conservancy, Zimbabwe.

MANAGEMENT UNIT	ESTIMATED LEAF DRY MASS									
	All 0-1.5 m	*Palatable 0-1.5 m*	*All >1.5-2 m*	*Palatable >1.5-2 m*	*All >2-5 m*	*Palatable >2-5 m*	*Total 0-5 m*	*Total Palatable 0-5 m*	*Total All >5 m*	*Total Palatable >5 m*
1	104	90	77	72	347	301	528	463	467	455
2	198	153	164	139	848	721	1 210	1 013	4 223	4 161
3	104	76	157	145	224	201	485	422	1 105	1 091
4	127	127	64	64	185	185	376	376	3 341	3 341
5	120	12	73	73	762	752	955	837	7 923	7 839
6	29	29	33	33	351	351	413	413	2 877	2 877
Total	682	487	568	526	2 717	2 511	3 967	3 524	19 936	19 764
Average	113.7	81.2	94.7	87.7	452.8	418.5	661.2	587.3	3 322.7	3 294

Table 42. The estimated total browse and available browse in kg in two height classes present in the management units of Sango Ranch, Save Valley Conservancy, Zimbabwe.

MANAGEMENT UNIT	AREA IN HA	TOTAL BROWSE	AVAILABLE BROWSE	
			0-2 m	>2-5 m
1	7 096.7	7 061 216.5	1 149 966.4	2 136 106.7
2	21 769.8	118 275 320.0	6 356 781.6	15 696 602.6
3	1 0731.6	17 062 290.0	2 371 683.6	2 157 051.6
4	1 307.2	4 858 862.4	249 675.2	241 832.0
5	1 975.7	17 540 265.0	167 934.5	1 485 726.4
6	224.8	739 592.0	13 937.6	78 904.8
Total	43 105.8	165 492 550.0	10 309 675.9	21 795 644.5

Table 43. The estimated leaf dry mass in kg per ha of the 13 dominant woody species in the *Acacia tortilis* Open Woodland Management Unit on Sango Ranch, Save Valley Conservancy, Zimbabwe.

WOODY SPECIES	*ESTIMATED LEAF DRY MASS*				
	0-1.5 m	*>1.5-2 m*	*>2-5 m*	*>5 m*	*Total*
Acacia tortilis subsp. *heteracantha*	30	30	128	242	430
Albizia anthelminthica	0.8	2.2	43	46	105
Boscia mosambicensis	6	5	12	0	23
Cadaba termitaria	15	3	4	0	22
Capparis tomentosa	5	1	25	4	35
Combretum imberbe	0	0	0.4	21.6	22
Dichrostachys cinerea subsp. *africana*	3	10	39	2	54
Diospyros quiloensis	0.2	0.2	11.6	8	20
Gardenia volkensi	2	2	14	3	21
Grewia flavescens var. *flavescens*	8	2	1	0	11
Grewia monticola	9	4	9	0	22
Lannea schweinfurthii	0	0	0	0	51
Sclerocarya birrea subsp. *caffra*	0	0	1	24	25

Table 44. The estimated leaf dry mass in kg per ha of the four major woody species in the *Colophospermum mopane* Woodland Management Unit on Sango Ranch, Save Valley Conservancy, Zimbabwe.

WOODY SPECIES	*ESTIMATED LEAF DRY MASS*				
	0-1.5 m	*>1.5-2 m*	*>2-5 m*	*>5 m*	*Total*
Acacia tortilis subsp. *heteracantha*	0.2	0.1	64	412	476
Colophospermum mopane	127	49	780	4437	5393
Diospyros quiloensis	5	4	75	42	126
Grewia bicolor	40	21	52	20	133

Table 45. The estimated leaf dry mass in kg.ha of the 11 major woody species in the *Combretum apiculatum* Management Unit on Sango Ranch, Save Valley Conservancy, Zimbabwe.

WOODY SPECIES	ESTIMATED LEAF DRY MASS				
	0-1.5 m	*>1.5-2 m*	*>2-5 m*	*>5 m*	*Total*
Acacia erubescens	4	2	19	22	47
Acacia nigrescens	1.2	0.5	13.3	141	156
Acacia tortilis subsp. *heteracantha*	0.2	0	1	16.8	18
Adansonia digitata	0	0	0	66	66
Albizia tanganyicensis	0	0	6	12	18
Brachystegia spiciformis	0	0	1	54	55
Colophospermum mopane	2	2	9	119	132
Combretum apiculatum subsp. *apiculatum*	11	12	89	45	157
Commiphora mollis	0	0.5	40.5	54	95
Diospyros quiloensis	1	1	9	8	19
Ficus abutilifolia	1	0	11	6	18
Grewia flavescens var. *flavescens*	14	6	2	0	22
Grewia monticola	14	7	2	0	23
Kirkia acuminata	0	1	1	254	256
Lannea schweinfurthii	0.3	0.4	5.3	357	363
Phyllanthus reticulatus	12	4	1	0	17

Table 46. The estimated leaf dry mass in kg per ha of the 11 major woody species in the *Acacia tortilis* Closed Woodland Management Unit on Sango Ranch, Save Valley Conservancy, Zimbabwe.

WOODY SPECIES	*ESTIMATED LEAF DRY MASS*				
	0-1.5 m	*>1.5-2 m*	*>2-5 m*	*>5 m*	*Total*
Acacia galpinii	0	0	0	475	475
Acacia schweinfurthii	30	15	5	31	81
Acacia tortilis subsp. *heteracantha*	2	1	19	1256	1278
Albizia harveyi	0	0	0	426	426
Anisotes formosissimus	42	3	0	0	45
Dichrostachys cinerea subsp. *africana*	7	13	41	3	64
Gymnosporia putterlickoides	0	0	10	27	37
Lannea schweinfurthii	0	0	0	1060	1060
Gymnosporia buxifolia	11	11	15	0	37
Strychnos potatorum	2	3	35	10	50
Ziziphus mucronata ssp. *mucronata*	0	2	17	29	48

Table 47. The estimated leaf dry mass in kg per ha of the 14 major woody species in the *Diospyros mespiliformes* Riverine Management Unit on Sango Ranch, Save Valley Conservancy, Zimbabwe.

WOODY SPECIES	*ESTIMATED LEAF DRY MASS* 0-1.5 m	>1.5-2 m	>2-5 m	>5 m	Total
Acacia galpinii	0	0	19	51	70
Acacia tortilis subsp. *heteracantha*	0	0	32	0	32
Albizia glaberrima var. *glabresens*	0	0	0	1896	1896
Dalbergia arbutifolia	8	5	21	0	34
Diospyros mespiliformes	4	1	21	459	485
Faidherbia albida	0	16	268	3844	4128
Grewia inaequilatera	47	19	38	2	106
Hyphaene coriacea	0	0	10	84	94
Lannea schweinfurthii	0	0	29	124	153
Sclerocarya birrea ssp. *caffra*	0	0	0	109	109
Strychnos potatorum	2	2	0	83	87
Syzigium guineense	0	0	181	1112	1293
Trichilia emetica	0	0	70	102	172
Ziziphus mucronata ssp. *mucronata*	0	0	0	78	78

Table 48. The available browse per woody species in kg per ha in the *Echinochloa colona* Wetland Management Unit on Sango Ranch, Save Valley Conservancy, Zimbabwe.

WOODY SPECIES	*ESTIMATED LEAF DRY MASS* 0-1.5 m	>1.5-2 m	>2-5 m	>5 m	Total
Acacia xanthophloea	10	11	117	1947	2085

Table 49. The acceptability of 42 woody species of Sango Ranch, Save Valley Conservancy, Zimbabwe to browsing ungulates (see text for references).

WOODY SPECIES	*ACCEPTABILITY CLASS*
Acacia galpinii	A
Acacia erubescens	A
Acacia nigrescens	A
Acacia schweinfurthii	A
Acacia tortilis subsp. *heteracantha*	A
Acacia xanthophloea	A
Adansonia digitata	A
Albizia anthelminthica	A
Albizia harveyi	A
Albizia glaberrima var. *glabresens*	A
Albizia tanganyicensis	?
Anisotes formosissimus	?
Boscia mosambicensis	A
Brachystegia spiciformis	L
Capparis tomentosa	L
Colophospermum mopane	A
Combretum apiculatum subsp. *apiculatum*	A
Combretum imberbe	A
Commiphora mollis	L
Dalbergia arbutifolia	A
Dichrostachys cinerea subsp. *africana*	A
Diospyros mespiliformes	A
Diospyros quiloensis	L
Faidherbia albida	A
Ficus abutilifolia	L
Gardenia volkensi	A
Grewia bicolor	L
Grewia flavescens var. *flavescens*	A
Grewia inaequilatera	A
Grewia monticola	L
Gymnosporia putterlickoides	A
Hyphaene coriacea	L
Kirkia acuminata	A
Lannea schweinfurthii	A
Cadaba termitaria	A
Gymnosporia buxifolia	A
Phyllanthus reticulatus	L
Sclerocarya birrea subsp. *caffra*	A
Strychnos potatorum	A
Syzigium guineense	A
Trichilia emetica	A
Ziziphus mucronata subsp. *mucronata*	A

A = Acceptable

B = Limited acceptability

Of the available browse on Sango Ranch there is 10 309 675.9 kg of browse in the 0 to 2 m height level which is available to the kudu and smaller animals (Table 42). This is 6.2 % of the total browse. The browse available in the >2 to 5 m height class is 21 795 644.5 kg and is only available to the giraffe and elephant. This is 13.2 % of the total browse. *Acacia tortilis* subsp. *heteracantha* is an important browse species nutritionally in the *Acacia tortilis* Open Woodland Management Unit, the *Colophospermum mopane* Woodland Management Unit and the *Acacia tortilis* Closed Woodland Management Unit (Tables 43, 44 and 46). The leaves of *Acacia tortilis* subsp. *heteracantha* are palatable and nutritious and are utilised by the elephant, giraffe, eland, waterbuck, kudu, nyala, bushbuck, impala and grey duiker (Venter and Venter 1996). Because of its semi-deciduous nature, *Acacia tortilis* subsp. *heteracantha* is an important browse species during the dry season when browse is at a minimum (Kok and Opperman 1980). However, the greatest amount of browse in this species lies in the >2 to 5 m and >5 m height classes and therefore it is only available to the giraffe and elephant. *Colophospermum mopane* is the dominant browse species in the *Colophospermum mopane* Woodland Management Unit (Table 44). It is a palatable and nutritious browse species and is important food source for many wildlife species in the dry season, being semi-deciduous (Timberlake 1995; Venter and Venter 1996). The mature leaves are mostly eaten during summer and autumn (Venter and Venter 1996). Elephant utilise *Colophospermum mopane* to a great degree as a source of food (Skinner and Smithers 1990; Timberlake 1995). The greatest amount of available *Colophospermum mopane* browse on Sango Ranch is beyond the reach of game species of Sango Ranch (82%; Table 44). In the lower height classes, 2 % of the browse is found in the 0 to 1.5 m class and 15% is found in the >2 to 5 m class (Table 44). The browse of *Colophospermum mopane* is thus fairly limited in the lowest height classes.

Lannea schweinfurthii is important as a browse species and food source in the *Combretum apiculatum* Management Unit and the *Acacia tortilis* Open Woodland Management Unit (Tables 45 and 46). However, the greatest proportion of this browse material is unavailable to the game species of Sango Ranch. The leaves are palatable and are utilised by the giraffe, kudu, nyala, bushbuck and grey duiker (Venter and Venter 1996). *Lannea schweinfurthii* is not important during the dry season, being deciduous and bare in winter (Venter and Venter 1996). No browse species dominates in the *Combretum apiculatum* Woodland Management Unit (Table 45). However, *Acacia nigrescens, Combretum apiculatum* subsp. *apiculatum,* and *Kirkia acuminata* contribute the most to the total browse of this management unit. *Acacia nigrescens* is an important wet season browse species for elephant, giraffe, kudu, impala and duiker (Venter and Venter 1996). However, most of the browse is present in the >2-5 m and >5m height classes (Table 45). *Combretum apiculatum* subsp. *apiculatum* is an excellent fodder tree and the leaves are utilised by many herbivore species (Venter and Venter 1996). Because of its semi-deciduous nature, it is an important dry season source of browse (Venter and Venter 1996). The greatest amount of the browse material is, however, only available to giraffe and elephant, but some browse material is available to the other herbivores in the lower height classes (Table 45). *Acacia galpinii, Albizia harveyi* and *A. versicolor* contribute greatly to the browse material in the *Acacia tortilis* subsp. *heteracantha-Panicum maximum* and the *Diospyros mespiliformes* Riverine Management Unit. However, this is unavailable at >5 m (Tables 46 and 47). *Diospyros mespiliformes* and *Faidherbia albida* are very important browse species in the *Diospyros mespiliformes* Riverine Management Unit while *Acacia xanthophloea* is completely dominant in the *Diospyros mespiliformes* Riverine Management Unit (Tables 47 and 48). *Diospyros mespiliformes, Faidherbia albida* and *Acacia xanthophloea* have very nutritious and palatable leaves (Venter and Venter 1996). Most of the browse in these trees is unavailable to the game species of Sango Ranch but some of it is available in the >2 to 5 m height class (Tables 47 and 48). *Diospyros mespiliformes* is semi-deciduous to deciduous and is therefore an important dry season browse species (Venter and Venter 1996).

CONCLUSION

Data on browse from the savanna areas of southern Africa are generally similar to those obtained for Sango Ranch (Kelly and Walker 1976; Dayton 1978; Scholes 1987; Pauw 1988; Smith 1992; Van Heerden 1992; Swart 1995; Brown 1997; Cauldwell 1998). Sango Ranch has a large amount of palatable browse material, but most of it is out of reach of its browsing herbivores. Only 6.2 % of all the palatable browse material is available to browsers. However, by pushing over and breaking trees the elephant places some of this browse material within the reach of the smaller animals (Skinner and Smithers 1990). Elephants are therefore important in the ecology of Sango Ranch, provided their numbers do not exceed the ecological capacity of the ranch.

CHAPTER 9

ECOLOGICAL CAPACITY

INTRODUCTION

The term carrying capacity has been used in many different ways with different meanings in the past (Dhondt 1988). Little consensus exists in the literature on the definition of carrying capacity (Schmidt, Theron and Van Hoven 1995). Trollope *et al.* (1990) define carrying capacity as the potential of an area to support livestock through grazing and/or browsing and/or fodder production over an extended number of years without deterioration to the overall system. Dhondt (1988) suggests dropping the term altogether and rather using the term ecological capacity. Dhondt (1988) points out that if this term were to be used, then it must be defined as the animal density that can be sustained over a long period of time without damaging the ecosystem.

Since carrying capacity was the accepted term in the past, this term will be used only in the following description - thereafter, and in subsequent chapters, the term ecological capacity, as defined by Dhondt (1988), will be used. In terms of herbivores, the terms grazing capacity and browsing capacity will be used. Combined, the grazing capacity and browsing capacity are the ecological capacity of an area to support herbivores. Carrying capacity estimates have been in the past expressed in terms of biomass (Bigalke 1972; Coe, Cummings and Phillipson 1976) or in relation to the energy requirements of a well-studied animal through the common denominator of metabolic mass (Meissner 1982). Such animals were usually livestock. Various methods have been presented for the calculation of carrying capacity (Bigalke 1972; Coe *et al.* 1976; Mentis and Duke 1976; Mentis 1977; Danckwerts 1982a, 1982b; Meissner 1982; Moore and Odendaal 1987; Danckwerts 1989; Peel, Cummings and Phillipson undated). Carrying capacity was expressed in terms of large stock units (LSU). A large stock unit is defined as a steer of 450 kg gaining mass at a rate of 500 g on grass with a mean digestibility of 55 % and to maintain this 75 mJ of metabolic energy per day is required.

Various methods that were originally developed for the determination of the livestock carrying capacity of an area have been used for the estimation of the ecological capacity of wild ungulates (Coe *et al.* 1976; Mentis and Duke 1976; Mentis 1977; Danckwerts 1982a, 1982b; Meissner 1982; Moore and Odendaal 1987; Danckwerts 1989). Since these methods were developed mostly for grazing livestock they only gave an indication of the grazing capacity. Therefore the agricultural carrying capacity is of limited use in wildlife situations. Since rotational grazing is difficult to implement on game ranches, the overall game ranch ecological capacity will be lower than the agricultural carrying capacity (Sievers 1991). Different habitat and feeding preferences also exist between wild ungulates and domestic stock (Sievers 1991).

According to Peel *et al.* (undated) the methods given above take into account only the grass component of the veld. These techniques were also developed for commercial livestock and are not suitable for game. Peel *et al.* (undated) indicated that the woody component of the vegetation has been omitted from these techniques. Since these two forage sources are utilised separately by grazers and browsers with some overlap between the two, Peel *et al.* (undated) suggest describing the two separately. The ecological capacity of an area should therefore be calculated as the sum of the grazing capacity and the browsing capacity. Grazing capacity describes the grazable portion of the veld and is the number of animal units per unit area of land which will achieve maximum animal production per unit input, without resulting in soil erosion or vegetation composition changes that would reduce the potential of the vegetation to produce animal products (Danckwerts 1982, In: Peel *et al.* undated). Since the woody component reacts differently to utilisation, the browsing capacity is defined as the number of browser units that may achieve stable animal production (Peel *et al.* undated). The method proposed by Peel *et al.* (undated) also takes into account the different feeding strategies among wild ungulates, namely grazers (bulk feeders and selective grazers), browsers and mixed feeders (grazers and browsers). Because of these differences in feeding patterns Peel *et al.* (undated) regarded the large stock unit method as inefficient for calculating ecological capacity. Peel *et al.* (undated) suggested calculating the ecological capacity of an area by adding the browsing and grazing capacity to derive stocking rates expressed as grazer units and browser units. A grazer unit is defined as an animal of 450 kg that grazes exclusively. A browse unit is defined as an animal of 140 kg that browses exclusively. A basal metabolic rate of $W^{0.75}$ is used.

Knowledge of the ecological capacity of the veld is essential for the development of sound management systems and the planning of reserves (Meissner 1982). Ecological capacity is affected by factors such as rainfall, veld condition, availability of palatable and nutritious plant material, water availability and distribution of water-points, competition, energy and nutritional requirements and behaviour of the animals (Meissner 1982). All of these factors must be taken into account when calculating the ecological capacity of an area. The present study will attempt to take these factors into account as far as is possible since little information in this regard exists for wild African ungulates (Meissner 1982).

The aim of this part of the study is therefore to:

- Determine the palatability and digestibility of the herbaceous and woody species.
- Determine a first approximation of the ecological capacity of Sango Ranch.

METHODS

Grazing capacity

Grazing capacity was determined using the computer program GRAZE (Bredenkamp pers. comm)[13]. Mean annual rainfall, veld condition scores, size in ha, the percentage canopy cover of trees and shrubs, grass canopy cover and information on accessibility and fire for each of the six management units of Sango Ranch were entered into the program to give the grazing capacity in ha per large stock unit.

Browsing capacity

Browsing capacity was determined from the available browse as calculated in Chapter 8 using the BECVOL method (Smit 1996). Following Von Holdt (1999) 5 % and 10 % of total available browse is used to calculate the browsing capacity. The number of browse units are derived from the assumed consumption rate for a browse unit (1 533 kg per year) (Owen-Smith 1985). Browser units are converted to large stock units by dividing dry material by 4 928 which is the dry mass feeding requirements for 1 large stock unit per year (Botha 1999). This enables the calculation of ecological capacity in a single unit.

RESULTS AND DISCUSSION

Grazing capacity

The grazing capacity estimates in ha per large stock unit and the total large stock units for average rainfall and below average rainfall periods using GRAZE (Bredenkamp pers. comm.)[13] are presented in Table 50. Wild ungulates cannot be stocked at the same rate as domestic cattle, because differences exist in their feeding behaviour and the movement of game animals cannot be controlled (Mentis 1977). Therefore wild ungulates should be stocked at a lower rate than cattle (Mentis and Duke 1976). The grazing capacity for game is usually calculated at 70 % of that for cattle (Cauldwell 1998). The *Acacia tortilis* Closed Woodland Management Unit has the highest grazing capacity of the management units of

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[13] Prof. G.J. Bredenkamp, Dept. Botany, University of Pretoria, Pretoria, 0002.

Table 50. Veld condition scores, benchmark comparisons and grazing capacities of the management units of Sango Ranch, Save Valley Conservancy, Zimbabwe using GRAZE (Bredenkamp pers. comm)[13].

MANAGEMENT UNIT	*AREA IN HA*	*VELD CONDITION SCORE*	*GRAZING CAPACITY (HA PER LSU)*				*TOTAL LSU FOR GAME AVERAGE RAINFALL YEARS*	*TOTAL LSU FOR GAME BELOW AVERAGE RAINFALL YEARS*
			Average rainfall		*Below average*			
			Cattle	*Game*	*Cattle*	*Game*		
1	7 096.7	51.0	4.7	7.9	9.0	15.0	902.7	471.9
2	21 769.8	52.3	4.3	5.9	8.2	11.2	3 686.7	1 943.0
3	10 731.6	55.4	4.0	5.8	7.4	10.8	1851.0	993.3
4	13 07.2	61.7	3.7	5.2	6.8	9.5	249.7	138.2
5	19 75.7	52.5	4.5	5.8	8.5	11.0	342.2	179.2
6	224.8	42.5	5.6	9.5	11.1	19.4	23.6	11.6
Total	43 105.8	-	-	-	-	-	7 056.0	3 737.2
Average	-	52.6	3.35	5.01	6.38	9.61	1 175.98	622.9

Sango Ranch (Table 50). The *Echinochloa colona* Wetland Management unit, with the poorest veld condition score also has the lowest grazing capacity (Chapter 6, Table 50),. The grazing capacity estimates obtained are similar to those obtained from other areas in southern Africa and are considered realistic for the Lowveld savanna areas of southern Africa (Van Rooyen pers. comm.)[11]. If 90 % of the ecological capacity estimate were considered to be in the form of grazing and 10 % browsing (Botha 1999), then the grazing and browsing estimates for Sango Ranch would be 6 350.4 LSU and 635.0 LSU, respectively for average rainfall years. During below average rainfall years the grazing and browsing capacities will be 3 363.5 LSU and 373.7 LSU, respectively.

Browsing capacity

The browsing capacity in browser units per ha which are present at two height levels on Sango Ranch are depicted in Table 51 and were calculated from Table 42. The available browse figures were taken from Table 42. The total available browse below 2 m is 10 309 675.9 kg, 5 % of this equates to 515 483.8 kg and 10 % to 1 030 967.6 kg. The total available browse from a height of 2 and 5 m above the ground is 21 795 644.5 kg, 5 % of this is 1 089 782.3 kg and 10 % of this is 2 179 564.5 kg. These figures are divided by the assumed consumption rate of 1 533 kg per year for a browse unit. Using 5 % of total available browse, the available browse below 2 m should be able to sustain 336.3 browse units or 104.6 large stock units. The available browse between 2 and 5 m should be able sustain 710.9 browse units or 221.1 large stock units. The total browsing capacity is then 0.0243 browse units per ha or 0.008 large stock units per ha or 1047.2 browse units or 325.7 large stock units. Using 10 % of total available browse, the available browse below 2 m should sustain 672.5 browse units or 209.2 large stock units, and the available browse between 2 and 5 m should be able to sustain 1 421.7 browse units or 442.2 large stock units. The total browsing capacity is then 0.0486 browse units per ha or 0.02 large stock units per ha or 2 094.2 browse units or 651.4 large stock units. The figures given in Table 51 are also calculated per management unit.

The *Colophospermum mopane* Woodland Management Unit has the highest browsing capacity (0.0360 browse units per ha), while the lowest browsing capacity is found in the *Acacia tortilis* Closed Woodland Management Unit (0.0122 browse units per ha). The low browsing capacity in the *Acacia tortilis* Closed Woodland Management Unit is due to the high canopy of the woody vegetation, which is mostly unavailable to browsers.

Table 51. Browsing capacities in browsing units per ha in two height levels of the management units of Sango Ranch, Save Valley Conservancy, Zimbabwe.

MANAGEMENT UNIT	*Area (ha)*	*NUMBER OF BROWSE UNITS*				*BROWSING CAPACITY*			
		5 %		*10 %*		*5 %*		*10 %*	
		0-2 m	*>2-5 m*	*0-2 m*	*>2-5 m*	*0-2 m*	*>2-5 m*	*0-2 m*	*>2-5 m*
1	7 096.7	37.5 (11.7 LSU)	69.7 (21.7 LSU)	75.0 (23.3 LSU)	139.3 (43.4 LSU)	0.0053	0.0098	0.0105	0.0196
2	21 769.8	207.3 (64.5 LSU)	512.0 (159.3 LSU)	414.7 (130.0 LSU)	1 023.9 (318.6 LSU)	0.0095	0.0235	0.0190	0.0470
3	10 731.6	77.3 (24.1 LSU)	70.4 (21.9 LSU)	154.7 (48.1 LSU)	140.7 (43.8 LSU)	0.0072	0.0066	0.0144	0.0131
4	1 307.2	8.1 (22.8 LSU)	7.9 (2.5 LSU)	16.3 (5.1 LSU)	15.8 (5.0 LSU)	0.0062	0.0060	0.0125	0.0121
5	1 975.7	5.5 (1.7 LSU)	48.5 (15.1 LSU)	11.0 (3.4 LSU)	96.9 (30.2 LSU)	0.0028	0.0246	0.0056	0.0490
6	224.8	0.5 (0.1 LSU)	2.6 (0.8 LSU)	0.9 (0.3 LSU)	5.1 (1.6 LSU)	0.0022	0.0116	0.0040	0.0227
Total	43 105.8	336.3 (104.6 LSU)	710.9 (221.1 LSU)	672.5 (209.2 LSU)	1 421.8 (442.2 LSU)	0.0078	0.0165	0.0156	0.0330

1. The *Acacia tortilis* Open Woodland Management Unit
2. The *Colophospermum mopane* Woodland Management Unit.
3. The *Combretum apiculatum* Woodland Management Unit
4. The *Acacia tortilis* Closed Woodland Management Unit
5. The *Diospyros mespiliformes* Riverine Management Unit
6. The *Echinochloa colona* Wetland Management Unit

The GRAZE method (Bredenkamp pers.comm.)[13] gave a browsing capacity of 635.0 large stock units or 0.01 large stock units per ha for average rainfall years and 373.7 large stock units or 0.008 large stock units per ha for below average rainfall years. Van Rooyen (pers. comm.) recommends a browsing capacity of 0.03 browse units per ha for the dense bushveld savanna areas of South Africa. The results obtained for Sango Ranch are almost identical to the 5 % and 10 % figures obtained by Von Holdt (1999) for an open bushveld savanna in Kenya. The browsing capacity of Sango Ranch is thus taken as 0.0486 browse units per ha or 0.02 large stock units per ha or 2 094.2 browse units or 651.4 large stock units for average rainfall years. For below average rainfall years the browsing capacity is taken as 0.0243 browse units per ha or 0.008 large stock units per ha or 1047.2 browse units or 325.7 large stock units for below average rainfall years. The stocking rates currently present on Sango Ranch are discussed in Chapter 11. The suggested ecological capacity for Sango Ranch is therefore 7 056.0 large stock units for average rainfall years and 3 727.2 large stock units for below average rainfall years, with a browsing capacity of 651.4 large stock units for all years.

CHAPTER 10

PHENOLOGY

INTRODUCTION

Phenology involves the study of the life cycle phases or activities of plants and animals and their temporal appearance throughout the year (Leith 1970). Van Rooyen *et al.* (1986) define phenology as the visible responses of organisms to a seasonally changing environment. Phenological events by definition usually coincide with the seasons. The seasonal availability of leaves, flowers and fruits is often an important factor affecting the distribution, diet and nutrition of animals (Hall-Martin 1974a, 1974b; Hall-Martin and Basson 1975).

Most survey methods of phenology consist of selecting a representative sample of a plant population and then observing the phenophases of these plants (Hall-Martin and Fuller 1975; Monasterio and Sarmiento 1976; Guy, Mahlangu and Charidza 1979; Borchart 1980; Reich and Borchart 1984; Van Rooyen, Theron and Grobbelaar 1986; Childes 1989). The various phenophases can then be placed into quantitative classes of abundance (0-25 %, 26-50 %, 51-75 %, 76-100 %) (Hall-Martin and Fuller 1975). Various difficulties have been encountered with such measures of abundance and Guy *et al.* (1979) and Childes (1989) used the abundance classes of Frankie *et al.* (1974, *In*: Guy *et al.* 1979) which only defined nil, few and many individuals. Borchart (1980) developed a scale for rating developmental stages in *Erythrina* spp. Van Rooyen *et al.* (1986) used a six-point scale to record rate, number and stage of each phenophase. The information can be displayed as a phenogram that gives the phenophases for each species over the same period of observation. In this way Van Rooyen *et al.* (1986) were able to describe the phenology of the most important plant species of the Roodeplaat Dam Nature Reserve. Various harvesting techniques have also been used in phenological studies (Opperman and Roberts 1978; Milton and Moll 1982; Prins 1988).

Phenology may therefore provide meaningful information to explain the seasonal aspects of ecological phenomena. The aims of the current phenological study were:

- To determine the seasonal availability of the leaves, flowers and fruits of the most important and conspicuous trees, shrubs, forbs and grasses in each of the homogeneous plant communities.
- To use these data to gain a greater insight into the extent to which the availability of plant species determines the habitat and plant food selection by herbivores.
- To use these data to assist in the assessment of the suitability of a habitat for a specific animal species.

METHODS

A total of 23 conspicuous plant species were marked with tags to collect the phenological data (Hall-Martin and Fuller 1985; Guy *et al.* 1979; Van Rooyen *et al.* 1986). Conspicuous plants are those with high cover-abundance values in Tables 6 to 9 and with a high constancy. The following qualitative and quantitative phenological variables were monitored for 10 individuals of each plant species for a period of 12 months (Van Rooyen *et al.* 1986):

1. Number of immature and mature leaves.
2. Leaf fall stage.
3. Leaf senescence stage.
4. Number of flower buds.
5. Number of open flowers.
6. Number of withered flowers and unripe fruit.
7. Fruit maturation stage.
8. Fruit discoloration stage.
9. Number of ripe fruit.
10. Dissemination rate of fruit and/or seeds.
11. Stage of dissemination.

Monthly observations were made from May 1998 to April 1999. The phenophases were recorded on a six-point scale (0, 1, 2, 3, 4, 5, 6) as given by Van Rooyen *et al.* (1986). A large number of a specific variable is awarded a high value, here a six and vice versa, where a zero or one is awarded. A high degree of a certain *stage* was also awarded a high value and vice versa. The first recording of a specific phenophase was regarded as the starting point of that phenophase (Van

Rooyen *et al.* 1986). For each observation date the mean of the data of individuals of each specific species was used to indicate the average stage of development for each species. The results are displayed in phenograms. The climatogram as presented in Figure 5 was used to interpret the influence of climate on the phenology of the plants of Sango Ranch.

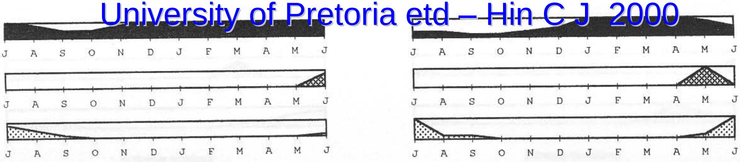
RESULTS AND DISCUSSION

Phenograms for the 23 plant species examined are presented in Figure 91. Climatological data for the study area are given in Figure 5 in Chapter 2.

Leaf phase

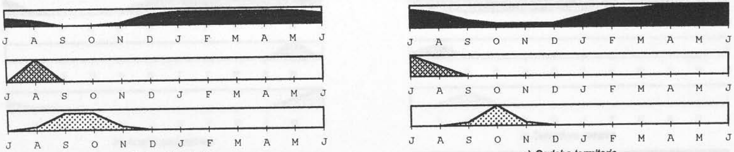
Only *Salvadora persica* was evergreen. Hall-Martin and Fuller (1975) also found this species to be evergreen in Malawi. Of the 11 tree and shrub species, *Acacia tortilis* subsp. *heteracantha, Colophospermum mopane* and *Cadaba termitaria* were semi-deciduous. These plants all started losing their leaves from July to August in the middle of the dry period. The lowest number of leaves was recorded from September to December at the end of the dry period. All the other species were deciduous, beginning to lose their leaves from July to August. In Malawi *Grewia flavescens* var. *flavescens* is also deciduous (Hall-Martin and Fuller 1975). All woody species, except *Acacia nigrescens* which was leafless from October to November, were leafless from September to October, at the end of the dry season and before the onset of the perhumid period from October to November (Figure 5). In Malawi, *Acacia nigrescens* bore leaves during the dry season (Hall-Martin and Fuller 1975). Leaf senescence and abscission are the result of water stress caused by water shortage at the onset of the dry season when water loss by transpiration exceeds water absorption through the roots (Reich and Borchart 1982). However, *Boscia mosambicensis* began dropping its leaves in December and was leafless in February during the peak rain season. This is normal because Hall-Martin and Fuller (1975) and Van Rooyen *et al.* (1986) believe that growth activities in woody savanna plants appear to be initiated by temperature or day-length changes, rather than rainfall.

Leaf emergence in the deciduous and semi-deciduous species is gradual and commenced from October to November just before the onset of the perhumid period. In the Sengwa Wildlife Research Area, Zimbabwe, leaf buds in nearly all



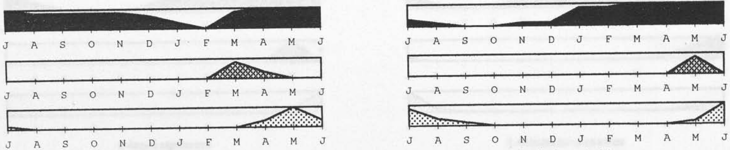
a) *Acacia tortilis*

d) *Colophospermum mopane*



b) *Albizia anthelminthica*

e) *Cadaba termitaria*

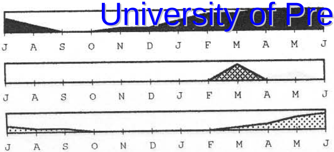


c) *Boscia mossambicensis*

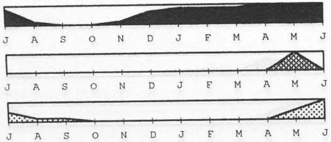
f) *Combretum apiculatum*

■ Leaf phase
▩ Flower phase
▒ Fruit phase

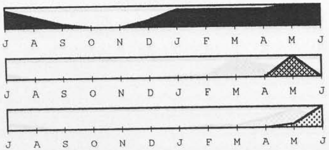
Figure. 91. Phenograms for the 23 species of plants on Sango Ranch, Save Valley Conservancy, Zimbabwe.



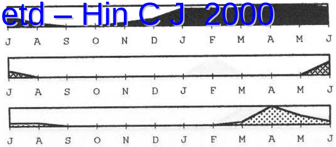
g) *Grewia monticola*



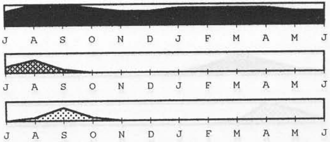
h) *Acacia erubescens*



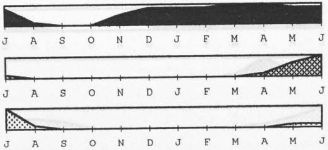
i) *Acacia nigrescens*



j) *Grewia flavescens*



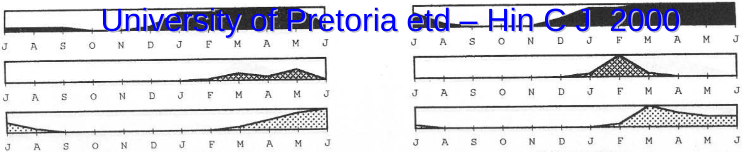
k) *Salvadora persica*



l) *Anisotes formosissimus*

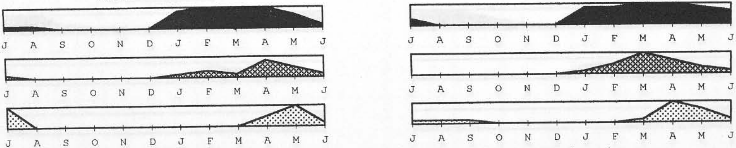
■ Leaf phase
▩ Flower phase
░ Fruit phase

Figure. 91. Phenograms for the 23 species of plants on Sango Ranch, Save Valley Conservancy, Zimbabwe.



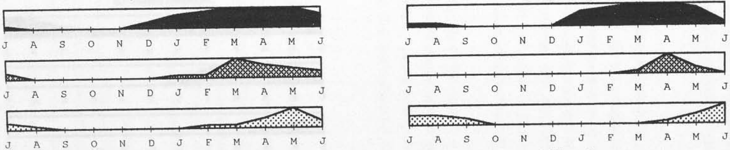
m) *Endostemon tereticaulis*

p) *Ruellia patula*



n) *Justicia flava*

q) *Plectranthus caninus*

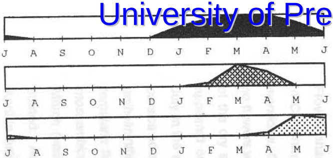


o) *Pupalia lappacea*

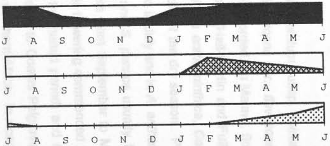
r) *Sida ovata*

■ Leaf phase
▩ Flower phase
▦ Fruit phase

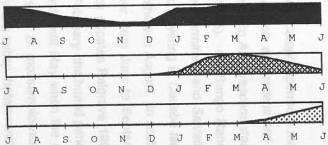
Figure. 91. Phenograms for the 23 species of plants on Sango Ranch, Save Valley Conservancy, Zimbabwe.



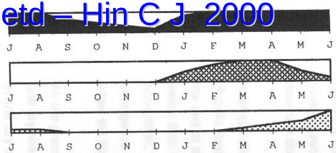
s) *Hibiscus micranthus*



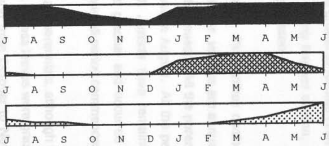
t) *Panicum maximum*



u) *Urochloa mosambicensis*



v) *Digitaria milanjiana*



w) *Eragrostis rigidior*

■ Leaf phase
▩ Flower phase
░ Fruit phase

Figure. 91. Phenograms for the 23 species of plants on Sango Ranch, Save Valley Conservancy, Zimbabwe.

the woody species were observed between August and December with a peak in October (Guy *et al.* 1979). On Sango Ranch, leaf emergence in *Boscia mosambicensis* began from February to March, towards the end of the rainy season. An increase in the water potential within the plant above a certain threshold causes growth to resume (Van Rooyen *et al.* 1986). Browse is therefore most abundant during the wet season, although the evergreen species do carry leaves in the dry season.

Amongst the herbs, *Plectranthus caninus*, *Sida ovata, Hibiscus micranthus* and *Pupalia lappacea* var. *velutina* are annuals, that died from August to September at the end of the dry season. All the perennial herbs are deciduous and they started losing their leaves in August. All the perennials were leafless from September to November, with *Justicia flava* remaining leafless well into December. Leaf emergence was gradual and occurred from November to December, a period when the high rainfall period commences (humid period in Figure 5).

All the grasses are perennials, although they enter into a dormant phase during the late dry season. Grass leaves were grazed to the ground in most cases by the end of the dry season from October to November. Leaf emergence only started in December during the humid period when the first substantial rain is received (Figure 5).

Flower phase

In *Combretum apiculatum* subsp. *apiculatum, Colophospermum mopane*, *Grewia monticola*, *G. flavescens* var. *flavescens*, *Acacia erubescens* and *A. nigrescens* no flowers were recorded. In Malawi, flowering in *A. nigrescens* started at the end of the dry season (Hall-Martin and Fuller 1975). On Sango Ranch, flowerbuds appeared on *Albizia anthelminthica*, *Cadaba termitaria* and *Salvadora persica* in July in the middle of the dry season. Peak flowering in *Cadaba termitaria* and *S. persica* occurred in July and in *A. anthelminthica* in August. In southern Africa, *A. anthelminthica* and *S. persica* usually flower from June to September, while *C. termitaria* flowers from September to March (Coates Palgrave 1995). In *Boscia mossambicensis* flowering commenced in February (the humid period), peaked in March (end of the humid period) and lasted until May when the dry period had started. According to Coates Palgrave (1995) *B. mossambicensis* flowers from April to June in southern Africa. In *Acacia tortilis* subsp. *heteracantha* flowers were recorded in only two of the 10 individuals in the dry season from May to June. In the Northern Province, South Africa, *Acacia tortilis* subsp. *heteracantha* flowered from January to March (Milton 1987), while Coates Palgrave (1995) states that flowering is from November to January. According to Milton (1987) the phenology of *A. tortilis* subsp. *heteracantha* is constant throughout southern Africa. According to Van Rooyen *et al.* (1986), *C. apiculatum* subsp. *apiculatum* tends to flower at the same time each year regardless of the variation in climatic conditions from year to year. The stimulus for flowering is probably some constant external variable such as photoperiod (Alvim and Alvim 1978, In: Van Rooyen *et al.* 1986). In the Sengwa Wildlife Research Area, Zimbabwe, flower buds were seen on most species at about the same time that the leaf buds emerged (Guy *et al.* 1979). In Sengwa, the formation of flower buds of *Colophospermum mopane* was delayed until after the leaf flush.

With the exception of *Anisotes formosissimus*, flowering in the herbs commenced from December to February during the humid period. *Anisotes formosissimus* began flowering in March at the end of the perhumid period. Peak flowering for all herbs occurred from March to May at the end of the perhumid period and the onset of the dry period. Flowering ended in all species, except for *Ruellia patula*, which ended in April, from July to August in the middle of the dry period.

In the grasses flowering started fom December to January at the peak of the humid period and peaked from February to March at the end of the humid period. In all the grasses the flowers lasted until June. Flowering in grasses is initiated by a certain daylength or a certain sequence of daylengths as well as favourable growing conditions (Wolfson and Tainton 1999). *Urochloa mosambicensis, Eragrostis rigidior* and *Panicum maximum* usually flower from October to July (Van Oudtshoorn 1992), while *Digitaria milanjiana* flowers from January to February (Gibbs Russell, Watson, Koekemoer, Smook, Barker, Anderson and Dallwitz 1991).

Fruit phase

Fruiting in all the woody species, except *Cadaba termitaria*, commenced towards the end of the perhumid period and the onset of the dry period from February to May. Fruit in these species ripened during the middle of the dry season from May to July and disseminated at the end of the dry season from August to October.

This corresponds with information from elsewhere in southern Africa (Coates Palgrave 1995) Fruit first appeared on *Cadaba termitaria* in the middle of the dry period in August. Ripening occurred in the late dry season in October and dissemination took place from November to December during the humid period. In most cases fruiting followed directly after flowering. In all the other species fruiting occurred during the wet season. Fruit is therefore available throughout the year, but it is more abundant during the late wet season.

The fruit phase in the herbs started from the middle of and towards the end of the humid period from January to March. Fruit ripened in the dry period from April to June and disseminated in the middle to late dry period from August to October.

The grasses followed a similar pattern to the forbs, except that seeds in all four species examined here ripened simultaneously in July.

CONCLUSION

The phenological patterns in the plant species monitored here follow the phenological patterns of these species elsewhere in southern Africa. From the results it is clear that savanna plants show an annual alteration between a period of minimal activity and one of maximum development (Monasterio and Sarmiento 1976). During the dry season these plants enter into a phase of semi- to full dormancy, while in the wet season a period of intense assimilation and vegetative and reproductive growth occurs. However, some plants are active physiologically in the dry season and this ensures a constant supply of food in the form of leaves, flowers and fruit throughout the year. Plant species in different habitats also have different phenologies which also contributes to this phenomenon of providing a constant supply of food throughout the year (Hall-Martin and Fuller 1975, Guy *et al.* 1979). Quantities of food on offer to animals therefore shift between different species groups and, hence, also between habitats.

CHAPTER 11

WILDLIFE MANAGEMENT RECOMMENDATIONS

INTRODUCTION

Giles (1969) defines wildlife management as the science and art of changing the characteristics and interactions of habitats, wild animal populations, and men in order to achieve specific human goals by means of the wildlife resources. These goals are often for recreational activities such as hunting, game-viewing, hiking or for ecological and economic reasons. Wildlife management should begin when a natural area is enclosed by a fence (Bothma 1995b). Once such artificial situations have been created it becomes necessary to manage the impact of the continuous presence of animals on the veld. When the natural migration routes of the animals are cut off it is necessary to supply the animals with adequate sources of water and food.

According to Bell (1983) the following aspects contribute to the wildlife management plan of any game reserve:

- The collection and supply of comprehensive data on the specific ecosystems.
- Practical limitations regarding finances, manpower and expertise.
- Patterns of land-use in neighbouring areas.
- Definition of limitations within which permissible changes in the biological and environmental components may take place.
- Estimates of future trends and needs, both of the area and its users.
- The compilation of a time plan for the management plan.
- Description of each realistic option that may exist in order to attain the management objectives.
- Choice of preferred options and description of the management plan based thereupon.
- Constant re-evaluation of the management plan and goals.

The information gathered during the resource inventory allow the following recommendations to be made:

- Veld management.
- Fire management.

- Grazing management.
- The harvesting of selected natural resources.
- Animal management
- Monitoring programme
- Research recommendations

These aspects are dealt with briefly below:

ADAPTIVE MANAGEMENT

Clear-cut plans for the ecological management of game ranches are lacking (Grossman, Holden and .F.H. Collinson 1999). Many components and variables make up the management of multi-species systems and a flexible management approach is therefore required. The concept of adaptive management is extremely important in the management of natural areas. Adaptive management is the term used for the system of making management decisions based on the lessons learnt from one's mistakes (Stuart-Hill 1989a). It entails the *a priori* construction of a set of management-related hypotheses, the implementation of the relevant management actions, the monitoring of the outcome of such actions, and the evaluation of the results obtained against the expectations (Grossman *et al.* 1999). Should the results agree with the predictions, the knowledge base is deemed reliable and management procedures may be continued. When not, further research and hypothesis generation or a change in management action is required. The system is practised by monitoring the following key parameters: rainfall, temperature, stocking rate, animal performance, vegetation and habitat use, veld condition, fires, bush encroachment, predator-prey relationships, alien plants, diseases, soil erosion and the effects of tourism (Stuart-Hill 1989a; Trollope 1990). By keeping reliable and complete records of these parameters the manager will be able to identify certain trends and adapt or maintain his or her management techniques as dictated by such trends.

VELD MANAGEMENT

Veld management on a game ranch is determined by the objectives for the ranch (Grossman *et al.* 1999). The type of veld management practices followed are determined by the objectives of the game ranching enterprise and it is therefore important that a clear statement of objectives be made. The following recommendations are made in light of the objectives of the management of Sango Ranch:

FIRE MANAGEMENT

Fire is regarded as a natural factor in the environment of southern Africa (Tainton 1999a) and plays an important ecological role in plant communities (Tainton and Mentis 1984). The grassland and savanna areas of southern Africa are prone to fire and support many plant and animal species that have evolved adaptations in response to fire (Mentis and Bigalke 1979, *In:* Tainton 1999a). In southern African ecosystems fire has several important advantages (Van Heerden 1992; Tainton 1999a; Van Rooyen pers. comm.). The moribund, unproductive material is removed allowing new palatable growth to become established; the height of browse material can be lowered, fire can be used to promote rotational grazing, and bush encroachment and parasites can be controlled. The objectives of using fire in wildlife management programmes must be taken into account when considering veld burning. The most common objectives of veld burning in southern African ecosystems are (Tainton 1999a; Van Rooyen pers. comm.):

- To burn the unpalatable growth from the previous seasons which, when not removed would smother the new season's growth.
- To control the encroachment of undesirable plants.
- To lower the height of browse.
- To promote rotational grazing.
- To contribute to fire control by reducing fuel loads.
- To maintain or develop grass cover for soil and water conservation.

For the ecological management of Sango Ranch all of these objectives must be taken into account. In Chapter 7 it was shown that some areas of Sango Ranch have large amounts of moribund grass material which pose a fire hazard. Fire would then be used in these areas to remove this moribund grass and promote the growth of green grass. Van Wilgen and Willis (1988) report that accurate predictions of veld fires depend on correct information on the available combustible material. It is therefore imperative that fuel loads be monitored to enable predictions on fire behaviour. The disc pasture meter as applied in Chapter 7 can be used for such purposes. Readings must be taken at the end of the growing season just before burning is considered. To ensure accurate fuel load estimates it is important that the disc pasture meter be calibrated for the specific conditions on Sango Ranch. The following recommendations of Trollope (1990) can be used in the decision-making model (Van Heerden 1992) to decide whether veld burning is required in a certain area on Sango Ranch:

1. Does bush encroachment pose a problem?
   Yes.............2
   No...............5
2. Is the grass fuel load >4 000 kg per ha
   Yes...............3
   No................4
3. Burn the veld under the following conditions:
   Air temperature >25 ºC
   Relative humidity of the air < 30%
4. Wait until >4 000 kg per ha of grass material has accumulated before burning.
5. Is moribund grass material present and is it smothering fresh green growth?
   Yes..............6
   No...............9
6. Is the grass fuel load between 2 000 and 4 000 kg per ha?
   Yes.............7
   No...............8
7. Burn the veld under the following conditions:
   Air temperature < 20ºC
   Relative humidity of the air> 50%
8. Wait until grass material has accumulated to at least 2 000 kg per ha.
9. Burning is not necessary.

In sweetveld areas the herbaceous layer is mostly maintained by climate , and fire is less important there (Hatch 1999). In sweetveld areas fire is only used as a management tool to control bush encroachment, to remove moribund grass material and to promote rotational grazing. On Sango Ranch moribund material is currently only found in the *Combretum apiculatum* Woodland Management Unit. The other areas are well utilised and fuel loads from August to September are too low to require burning. Monitoring of fuel loads and the decision-making model above will determine when each management unit requires burning. An important point is that the veld must only be burned under specific fuel loads and atmospheric conditions depending on whether bush encroachment is to be controlled or whether moribund grass material is to be removed. Hot fires are required for bush encroachment control while cool fires are required to remove moribund material. Hot fires kill off young woody plants but are detrimental to the herbaceous layer (Trollope 1990). However, hot fires in certain cases will not kill larger trees. It is then necessary to apply mechanical or chemical control. Fire can be used to lower the height of browsing material (Van Rooyen pers. comm.). Atmospheric conditions in all cases must be stable because unstable conditions can result in fires running out of control. Because grazing ungulates concentrate on freshly burned areas it is important that a large enough area be burned to prevent trampling and overgrazing (Trollope 1999). The type of fire must also be considered. Backfires significantly depress grass regrowth compared to head fires (Trollope 1978). On the other hand, head fires cause a greater topkill of the stems and branches of trees and shrubs than do backfires because of the fire's greater intensity and because more of the heat is carried up into the tree and shrub canopies (Trollope and Tainton 1986).

The season of burning is important because out of season burning can reduce grass vigour, reduce the basal and canopy cover of grass, increase the runoff of rainwater and causes increased soil erosion (Van Rooyen *et al.* 1996). The best time to burn to remove moribund material is in the late winter and early spring and immediately after the first rains when the plants are dormant (August to September) (Everson 1999). Late winter and early spring burning has a disastrous effect on the already actively growing grass plants (Everson 1999). To control bush encroachment, burning of the grass in late winter (August to September) before the spring rains is recommended (Brown 1997). The dry and dormant grass causes a high intensity fire (Van Oudtshoorn 1992). Burning to achieve an out of season green flush is not advised and should be avoided at all costs (Van Rooyen *et al.* 1996). Frequent veld burning can result in either increased or decreased tree density (Trollope 1999). When burning to remove moribund material, the required frequency of burning will depend on the rate at which grass material accumulates (Trollope 1989). As a guide, such accumulation should not exceed 4 000 kg per ha. Burning frequency will then depend on rainfall and grazing intensity (Trollope 1999). Grass fuel loads of >4 000 kg per ha pose a fire hazard and such areas must be burnt with great caution and under cool moist conditions, when the objective is to remove moribund grass material.

The practice of block burning that is currently practised in some wildlife areas may be problematic on Sango Ranch because refinements are often required to accommodate erratic and unpredictable rainfall and unplanned fires (Grossman *et al.* 1999). Homogeneous fire regimes could also reduce spatial heterogeneity and ecosystem resilience (Scholes and Walker 1993). It is therefore important to vary the fire parameters such as frequency, seasonality, intensity and type of fire spatially and temporally across the landscape (Van Wilgen and Scholes 1997). Patch-burning may provide a mosaic of newly burned, recently burned and unburned areas on large game ranches (Grossman *et al.* 1999). Grossman *et al.* (1999) made the following recommendations: fires should be point-ignited under diverse weather and fuel conditions and should be allowed to follow their own course. This will depend on the fuel load and veld condition, wind direction, existence of barriers such as rivers, rocky, bare or sparsely-grassed areas and roads, rather than the conventional firebreaks used in block burning. Naturally ignited fires should also be allowed to follow their own course. Following such a veld burning approach poses severe dangers. The danger of out of control fires is present and this must be taken into consideration. It is therefore important to be able to apply the approach of Grossman *et al.* (1999) in a safe manner. The decision-making model given above should be used when deciding on when and where to burn. The relationship between rainfall and grass fuel load will ensure that the frequency of veld burning will be varied. In this way no burning will take place in low rainfall periods and vice versa. The time of burning can also be varied but burning must always occur when the grass plants are dormant. It is recommended that firebreaks be established aside from rivers, bare areas and roads to enable the containment of fires when required. A further safety factor is the necessity for sufficient manpower and water to control fires during controlled burns.

Different vegetation types react differently to burning (Tainton 1999a). In general, grassland and savanna areas are well adapted to fire. Fire is also important in wetlands (Tainton 1999a). Forest areas are sensitive to fire and when exposed to frequent hot fires are reduced to grasslands (Tainton 1999b). It is recommended that only cool fires be applied in the *Diospyros mespiliformes* Management Unit of Sango Ranch.

GRAZING AND BROWSING MANAGEMENT

The common approach to grazing management in South Africa has been one of facilitating periods of rest during which the grass plant is not defoliated (Grossman *et al.* 1999). The rotational grazing system has been used to achieve this rest period. However, this system is difficult to practice in a free-ranging game situation such as is found on Sango Ranch. Controlled burning, licks and the opening and closing of water points have all been used to facilitate a form of rotational grazing on game ranches (Van Oudtshoorn 1992). It is, however, difficult to enforce rotational grazing on a game ranch, because animals show specific habitat preferences. For example, impala and blue wildebeest are attracted to the nutrient-rich areas while sable antelope and roan antelope prefer nutrient-poor areas to minimise competition (Grossman *et al.* 1999). It would then be difficult to attract impala and blue wildebeest out of the well-utilised areas into the nutrient-poor areas of a ranch. This situation exists on Sango Ranch. High density animals such as the blue wildebeest, impala and warthog are attracted to the nutrient-rich habitats of the *Acacia tortilis* Open Woodland, *A. tortilis* Closed Woodland and *Diospyros mespiliformes* Riverine Management Units while the *Colophospermum mopane* Woodland and *Combretum apiculatum* Woodland Management Units contain the low density species such as sable antelope. The veld condition scores shown in Chapter 6 reflect this situation. The *Acacia tortilis* Open Woodland Management Unit is currently being overutilised by impala and blue wildebeest. In cases of sweetveld overutilisation it is recommended that the stocking rates of the high density animals be reduced. In the sourish areas stocking with long to medium grass grazers such as white rhinoceros, hippopotamus, buffalo, zebra, roan antelope, sable antelope and waterbuck is recommmended (Grossman *et al.* 1999). The preferred habitats of the high-density species will be underutilised and at lower stocking rates these species can be attracted from overutilised areas to underutilised areas. The high-density species mentioned above are all water-dependent and are never found more than 5 to 6 km away from permanent water (Grossman *et al.* 1999). To ensure that certain sweetveld areas remain under-utilised, waterholes in these areas can be closed. During the wet season this is impossible because natural pans are filled by rainfall. It is therefore recommended that long to medium grass grazers such as white rhinoceros, hippopotamus, buffalo, roan antelope, sable antelope and waterbuck be introduced to the *Combretum apiculatum* Management Unit which is currently only utilised lightly. Water points should be established in the *Combretum apiculatum* Woodland Management Unit to supply water to the water-dependent species. The placement of water points in this management unit must be done with great care to avoid veld degradation and erosion. The stocking rate of the high-density selective grazers such as impala and blue wildebeest within the *Acacia tortilis* Open Woodland Management Unit should be reduced in order to allow the veld condition to improve.

Browsing management is difficult to apply because browsers are mostly water-independent. Where browse overutilisation is evident, the stocking rate of browsers should be reduced. The ratio of grazers to browsers is also important and is discussed under stocking rate. See Table 53 for the recommended stocking rates for impala and blue wildebeest

STOCKING RATE

The stocking rate of different animal species is dependent on the condition and type of the different available habitats and on the objectives of the area (Bothma, Van Rooyen and Du Toit 1995). The stocking rate of the different herbivores will primarily be a function of the grazing and browsing capacity of the area (Trollope 1990). The grazing and browsing capacity of the study area is discussed in Chapter 9. The main aim of the study area is to manage for optimal game-viewing, maximum species diversity and trophy quality. Trollope (1990) suggests that for these purposes the stocking rate should be close to the ecological carrying capacity of the study area. However, Bothma (1995a) recommends that animals be stocked at the same rate as during drought conditions. The current consensus is that a conservative stocking rate should be adopted on game ranches (Grossman *et al.* 1999).

The feeding behaviour of different animal species must be considered when making stocking rate recommendations (Orban 1995). Mentis (1981) classified ruminant and non-ruminant ungulates according to their feeding behaviour into bulk grazers, concentrate grazers and browsers. As most of the tree species in the area are deciduous and many animals graze and browse, Mentis and Duke (1976) suggested a ratio of approximately 2 bulk grazers to 2 concentrate grazers to 1 browser. In sweetveld areas Trollope (1990) recommends a ratio of 2 bulk grazers to 1 selective grazer. This then allows for the grass being eaten by browsers to be included in the calculation of stocking rate (Danckwerts 1989). Also, the bulk grazers feed mostly on tall, coarse grass and this then opens up the veld for the concentrate grazers that prefer short grass (Odum 1983). The sex ratio of the animals should also be correct so as to ensure a healthy reproductive population (Bothma *et al.* 1995). The grazing and browsing capacity should also be assigned in the ratio 2 bulk grazers: 1 selective grazer: 1 browser (Owen-Smith 1999).

Aerial count estimates of the animals (Joubert 1998, 1999b) on Sango Ranch and the total number of browsers and grazers for 1999 are presented in Table 52. The aerial counts were conducted during 1999 and 2000 by the staff of Sango Ranch and the Save Valley Conservancy. Aerial counts substantially underestimate the true population and the degree of undercounting also varies between animals and regions (Bothma 1995d). The aerial count estimates for Sango Ranch are probably an underestimate, especially for animals such as the kudu, bushbuck, nyala and bushpig. No buffalo appear on the list in Table 52 because these animals moved onto Bedford Block to the south of Sango Ranch (Figure 2) during the dry period when the aerial count was conducted (Goosen pers. comm.)[3]. The ecological capacity for Sango Ranch for average rainfall periods was estimated at 7 056 large stock units while that for below average rainfall years was estimated at 3 737.2 large stock units (Chapter 9). The current number of large stock units present on Sango Ranch is 46.1 % of the estimated ecological capacity. However, the current number of browsing LSU's exceeds the browsing capacity for average rainfall years by 66 % and the below average rainfall browsing capacity by 73 % (Table 52). A browse line can already be seen in the *Colophospermum mopane* Woodland Management Unit and this is probably due to the high number of browsers.

The ratio of bulk grazers: selective grazers:mixed feeders:browsers is currently approximately 19:8:39:34 (Table 52). The recommended ratio is 25:35:20:20 (Van Rooyen pers. comm.).[11] This indicates that, proportionately, too many browsing animals and too few bulk and selective grazers are present on Sango Ranch. The recommended animal numbers for average rainfall years for Sango Ranch is given in Table 53. The animals are stocked at 59.4 % of the total capacity. As

Table 52. The current number of browsing and grazing game on Sango Ranch, Save Valley Conservancy, Zimbabwe.

FEEDING CATEGORY*	ANIMAL	NO. OF ANIMALS.***	LSU CONVERSION*	% GRASS IN DIET**	% BROWSE IN DIET **	LSU EQUIVALENT*	GRAZING LSU'S	BROWSING LSU'S
Non-selective grazers	Hippo	16	0.45	100	0	35.8	35.8	0.0
	White rhino	1	0.36	80	20	2.8	2.2	0.6
	Zebra	587	1.51	100	0	388.7	388.7	0.0
Sub-total		604	-	-	-	427.3	426.7	0.6
Selective grazers	Sable	24	1.70	100	0	14.1	14.1	0.0
	Wildebeest	321	2.00	100	0	160.5	160.5	0.0
	Waterbuck	2	2.00	100	0	1.0	1.0	0.0
Sub-total		347	-	-	-	175.6	175.6	0.0
Mixed feeders	Eland	417	0.92	30	70	453.3	125.1	317.3
	Impala	1088	5.20	50	50	209.2	104.6	104.6
	Nyala	1	4.40	20	80	0.2	0.0	0.2
	Warthog	114	4.04	100	0	28.2	28.2	0.0
Sub-total		1620	-	-	-	690.9	257.9	422.1
Browsers	Black rhino	4	0.64	0	100	6.3	0.0	6.3
	Bushbuck	1	7.62	0	100	0.1	0.0	0.1
	Elephant	90	0.25	30	70	360.0	108.0	252.0
	Giraffe	114	0.63	0	100	181.0	0.0	181.0
	Kudu	395	1.84	0	100	214.7	0.0	214.7
Sub-total		514	-	-	-	762.1	108.0	654.1
Total		3085	-	-	-	2055.9	968.2	1076.8

* Van Rooyen, Bredenkamp and Theron (1995), **Snyman (1989), *** Joubert (1998, 1999b)

Table 53. Recommended numbers for browsing and grazing game during average rainfall years on Sango Ranch, Save Valley Conservancy, Zimbabwe.

*FEEDING CATEGORY**	*ANIMAL*	*LSU CONVERSION**	*LSU EQUIVALENT**	*NO. OF ANIMALS.*	*% GRASS IN DIET***	*% BROWSE IN DIET ***	*NO. GRAZING LSU'S*	*NO. BROWSING LSU'S*
Non-selective grazers	Buffalo	0.93	374.5	350	100	0	374.5	0.0
	Bushpig	4.50	66.0	300	100	0	66.0	0.0
	Hippo	0.45	87.4	39	100	0	87.4	0.0
	White rhino	0.36	22.0	8	80	20	17.6	4.4
	Zebra	1.51	990.0	1500	100	0	990.0	0.0
Sub-total		-	1539.9	2197	-	-	1535.5	4.4
Selective grazers	Tsessebe	2.60	88.9	234	100	0	88.9	0.0
	Reedbuck	7.62	9.5	50	40	60	3.8	5.7
	Roan	1.55	25.6	40	90	10	23.0	2.6
	Sable	1.70	154.0	275	100	0	154.0	0.0
	Wildebeest	2.00	1000.0	2000	100	0	1000.0	0.0
	Waterbuck	2.00	383.0	766	100	0	383.0	0.0
Sub-total		-	1661.2	3365	-	-	1652.7	8.3
Mixed feeders	Eland	0.92	216.0	200	30	70	64.8	151.2
	Impala	5.20	190.0	1000	50	50	95.0	95.0
	Nyala	4.40	9.2	40	20	80	1.8	7.4
	Warthog	4.04	150.0	600	100	0	150.0	0.0
Sub-total		-	565.2	1840	-	-	311.6	253.6
Browsers	Black rhino	0.64	14.9	9	0	100	0.0	14.9
	Bushbuck	7.62	19.5	150	0	100	0.0	19.5
	Elephant	0.25	159.6	40	30	70	47.9	111.7
	Duiker, common	10.74	3.0	100	0	100	0	3.0
	Giraffe	0.63	63.2	40	0	100	0.0	63.2
	Klipspringer	14.27	14.0	200	10	90	2.1	14.0
	Kudu	1.84	135.0	250	0	100	0.0	135.0
	Sharpe's Grysbok	20.54	7.5	150	20	80	1.5	6.0
	Steenbok	16.18	9.0	150	10	90	0.9	8.1
Sub-total		-	425.7	989	-	-	52.4	375.4
Total		-	4192.0	8391	-	-	3552.2	643.7

Van Rooyen *et al.* (1995)

** Snyman (1989)

Table 54. Recommended numbers for browsing and grazing game during below average rainfall years on Sango Ranch, Save Valley Conservancy, Zimbabwe (* Van Rooyen *et al.* (1995) ** Snyman (1989)).

FEEDING CATEGORY*	ANIMALS	LSU CONVERSION*	LSU EQUIVALENT*	NO. OF ANIMALS.	% GRASS IN DIET**	% BROWSE IN DIET **	NO. GRAZING LSU'S	NO. BROWSING LSU'S
Non-selective grazers	Buffalo	0.93	171.2	160	100	0	171.2	0.0
	Bushpig	4.50	26.4	120	100	0	26.4	0.0
	Hippo	0.45	42.6	19	100	0	42.6	0.0
	White rhino	0.36	22.0	8	80	20	17.6	4.4
	Zebra	1.51	462.0	700	100	0	462.0	0.0
Sub-total		-	724.2	1007	-	-	677.2	4.4
Selective grazers	Tsessebe	2.60	38.0	100	100	0	38.0	0.0
	Reedbuck	7.62	4.8	25	40	60	1.9	2.9
	Roan	1.55	25.6	40	90	10	23.0	2.6
	Sable	1.70	67.2	120	100	0	67.2	0.0
	Wildebeest	2.00	500.0	1000	100	0	500.0	0.0
	Waterbuck	2.00	175.0	350	100	0	175.0	0.0
Sub-total		-	810.6	1635	-	-	805.1	5.5
Mixed feeders	Eland	0.92	108.0	100	30	70	32.4	75.6
	Impala	5.20	95.0	500	50	50	47.5	47.5
	Nyala	4.40	9.2	40	20	80	1.8	7.4
	Warthog	4.04	50.0	200	100	0	50.0	0.0
Sub-total		-	262.2	840	-	-	131.7	130.5
Browsers	Black rhino	0.64	14.9	9	0	100	0.0	14.9
	Bushbuck	7.62	9.1	70	0	100	0.0	9.1
	Duiker, common	10.74	1.5	50	0	100	0	0
	Elephant	0.25	119.7	30	30	70	35.9	83.8
	Giraffe	0.63	31.6	20	0	100	0.0	31.6
	Klipspringer	7.0	14.0	100	10	90	0.7	6.3
	Kudu	1.84	64.8	150	0	100	0.0	64.8
	Sharpe's Grysbok	20.54	4.0	80	20	80	0.8	3.2
	Steenbok	16.18	4.8	80	10	90	0.5	4.3
Sub-total		-	262.9	539	-	-	37.9	219.5
Total		-	2061.4	4071	-	-	1651.9	359.9

mentioned previously, the sweetveld areas of the ranch are being overutilised while the sourveld areas are being utilised lightly. Buffalo will utilise the *Combretum apiculatum* Woodland Management Unit and it is recommended that buffalo be reintroduced in this management unit. The number of selective grazers, especially sable antelope and roan antelope should be increased in this management unit. The recommended stocking rate for below average rainfall periods for Sango Ranch is presented in Table 54.

The recommended number of LSU's is 55 % of the ecological capacity for below average rainfall periods. It is recommended that the stocking rates be adapted according to the rainfall cycle being entered into. Rainfall cycles on Sango Ranch are discussed in Chapter 2.

The recommended sex ratios are presented in Table 55. These sex ratios are based on Bredenkamp (pers comm)[13]. The recommendations on the stocking rate of herbivores are a broad guideline and a first approximation. Veld condition, animal condition, grazing and browsing capacity and herbaceous biomass should all be monitored annually to allow for an adaptation of the stocking rates as required. The adaptive management approach as given in Figure 92 should be followed. When determining stocking rates, the current number of animals per management unit should be determined in order to derive the stocking rate per management unit. As already mentioned, overutilisation of the sweetveld areas will take place when the stocking rate is based on the area as a whole and not on the individual management units.

PLACING AND CONTROL OF WATER POINTS

Water points are often areas of severe herbivore utilisation intensity (Thrash 1993) where overgrazing may occur during the dry season (Thrash, Nel, Theron and Bothma 1991a). Thrash *et al.* (1991a, 1991b) concluded that the provision of a permanent but artificial supply of drinking water for animals in the Kruger National Park has had a negative impact on both the woody and herbaceous vegetation in the vicinity of the dams. The herbaceous vegetation also seemed more sensitive to disturbance by animals. Ayeni (1975) found that vegetation degradation at small waterholes in the Tsavo National Park was only slight, while at large

Table 55. The recommended sex ratio and herd size for animals on Sango Ranch, Save Valley Conservancy, Zimbabwe (Bredenkamp pers. comm.)[13].

ANIMAL	*SEX RATIO**	*MINIMUM HERD SIZE*
Black rhinoceros	2:3	5
Buffalo	1:3	5
Bushbuck	1:3	8
Bushpig	2:3	5
Duiker	1:1	4
Eland	1:3	12
Elephant	0	10
Giraffe	3:5	8
Grysbok, Sharpe's	1:1	4
Hippopotamus	2:3	5
Impala	1:4	25
Klipspringer	1:1	4
Kudu	1:3	12
Nyala	3:7	10
Reedbuck, common	3:7	10
Roan antelope	3:5	8
Sable antelope	3:5	8
Steenbok	1:1	6
Tsessebe	3:5	8
Warthog	2:3	10
Waterbuck	3:5	8
White rhino	1:2	6
Wildebeest, blue	1:4	15
Zebra, Burchell's	3:7	10

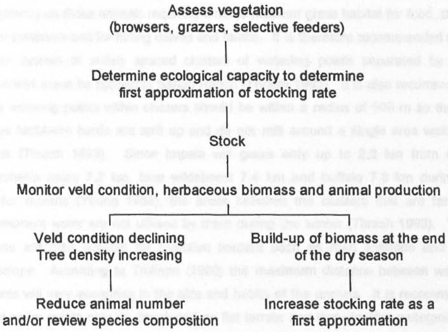


Figure 92. Flow chart showing the adaptive management approach that can be applied in grazing and browsing management and stocking rate determination on game ranches in southern African savannas (Grossman *et al.* 1999).

permanent waterholes a fair amount of vegetation destruction was observed during the dry season. Factors to be considered when developing water points are the topography, type of soil, type of veld, distance from other watering points and the movements of animals (Du Toit 1995). Numerous and closely distributed water points result in an overlap in areas of high use and will result in a decline in habitat diversity (Grossman *et al.* 1999). A series of overlapping zones of high use, where thicket and a herbaceous layer dominated by annuals predominate, will impact negatively on those animals requiring a tall to medium grass habitat for food, shelter from predators and for hiding calves and lambs. It is therefore recommended that a water system of widely spaced clusters of watering points separated by large waterless areas be applied in Sango Ranch (Thrash 1993). It is also recommended that watering points within clusters should be within a radius of 500 m so that the large herbivore herds are split up and do not mill around a single area waiting to drink (Thrash 1993). Since impala will graze only up to 2.2 km from water, Burchell's zebra 7.2 km, blue wildebeest 7.4 km and buffalo 7.8 km during the winter months (Young 1989), the areas between the clusters that are far from permanent water are not utilised by them during the winter (Thrash 1993). These areas are then suitable for selective feeders such as roan antelope and sable antelope. According to Trollope (1990) the maximum distance between watering points will vary according to the size and habits of the anmals. It is recommended that water points only be developed on flat terrain and that closable waterpoints be used because of the ease of manipulation for the purposes of rotational resting (Trollope 1990). Trollope (1990) also suggests that very few water points should be placed in sensitive sweetveld due to its susceptibility to overgrazing. The system of adaptive management (Stuart-Hill 1989a; Grossman *et al.* 1999) should be applied to determine the effects of the animals on the vegetation at the water points and further management actions can then be applied as the situation requires.

THE HARVESTING OF SELECTED PLANT SPECIES

Several indigenous southern African plants are harvested and used for personal and commercial purposes (for example Palgrave 1956; Watt and Breyer-Brandwijk 1962; Goldsmith and Carter 1981; Cunningham 1987; Cunningham 1988, 1990a, 1990b; Shackleton 1990; Brophy, Boland and Van Der Lingen 1992; Venter and Venter 1996; Geldenhuys 1997). On Sango Ranch, *Colophospermum mopane* shows the greatest potential for such harvesting. *Phragmites mauritianus* is also suitable for harvesting and is used for mats, furniture and in hut and fence construction (Van Der Walt 1999). This plant is abundant along the rivers on Sango Ranch. Its rapid growth rate makes it ideal for harvesting. However, it is important in the stabilisation of sandbanks and should therefore not be overharvested (Van der Walt 1999). *Hyphaene coriacea* is used for the making of palm wine (Cunningham 1990) and the leaves are used for the weaving of mats (Cunningham 1988). This plant does not occur in sufficient densities on Sango Ranch to allow commercial its harvesting. *C. mopane* is used for its timber which is hard and durable (Venter and Venter 1996). It is mainly used as fencing posts, hut poles, mine-props, railway sleepers and sometimes parquet flooring (Timberlake 1995). A survey of mopane in the Zambezi Valley of Zimbabwe, showed that there were few trees suitable for railway sleepers because most trees with a butt diameter of over 0.3 m had a timber height less than 3 m (Carter and Thompson, *In*: Timberlake 1995). Trees suitable for sleepers do however exist on Sango Ranch (Chapter 5). Most large trees have poor form, contain large knots and are often hollow because of heartwood rot (Palgrave 1956; Fanashawe 1962; Palmer and Pitman 1972; Wyk 1972; Pearce 1986; quoted in Timberlake 1995). *C. mopane* provides a good firewood and is a preferred species in areas where it occurs (Palmer and Pitman 1972, In: Timberlake 1995). The wood burns slowly and produces much heat and makes good charcoal. *C. mopane* is not used widely for medicine, but a bark extract is used to treat syphilis and sore eyes (Watt and Breyer-Brandwijk 1962). The seeds yield a hard resin termed gum copal, Angolan copal or basalm on extraction (Timberlake 1995). The yields are, however, low. Fifty different essential oils have been detected along with other compounds (Brophy *et al.* 1992). Other uses of *C. mopane* include soil stabilisation (Kumar and Shankarnarayan 1986, In: Timberlake 1995), making of twine and string and wood ash fertiliser (Palmer and Pitman 1972, In: Timberlake 1995). *C. mopane* occurs in sufficient densities to allow the harvesting of timber poles (Chapter 5).

Little information is available on the growth rates of natural stands of *C. mopane* (Timberlake 1995). In Botswana, Tietama (1989, *In:* Timberlake (1995), reported growth rates of 10 tonnes per ha per year. Scholes (1990) reported a basal area increment of 0.4 m^2 per ha per year for coppice growth in the Northern Province, South Africa. This area had been cleared of *C. mopane* shrub and thicket and had returned to a pre-clearing state within 14 years.

Smit (1994) investigated the influence of intensity of tree thinning on mopaneveld. Plots were thinned to 10 %, 20 %, 35 %, 50 % and 75 % of the standing density and were monitored over three seasons. Aspects investigated were population dynamics, structure, available biomass, grass cover, soil nutrients and soil water. Thinning of *C. mopane* reduced inter-tree competition that resulted in marked increases in the flowering and fruiting of remaining trees (Smit 1994; Smit and Rethman 1998). However, no evidence of faster seedling establishment on low-density plots was found. On a structural basis the trees showed increases in canopy cover rather than increases in tree height (Smit 1994). The available browse at peak biomass was reduced by tree thinning, but trees from the low density plots displayed a much better distribution of browse, having leaves in comparatively younger phenological states over an extended period. By cutting mopane trees and then allowing them to coppice, the amount of browsable leaves at low strata can be increased. However, this is undesirable when the manager aims to control bush encroachment and additional measures that kill the trees will have to be applied. Drastic colonisation of bare soil by herbaceous plants resulted with increasing intensity of tree thinning of *Colophospermum mopane*. Annual grasses were the main colonisers of bare soil in these areas with perennials only constituting a small percentage of the grass species composition. The successional order of establishing grasses was *Tragus berteronianus*, *Brachiaria deflexa* and *Aristida* spp. At high tree densities the *C. mopane* trees completely surpressed the grass layer with a resultant low grazing capacity. With an increase in tree thinning an increase in grass cover with an increase grazing capacity was noted. Of the soil variables investigated, few changed significantly as the result of tree thinning. An increase in potassium and a decline in electrical resistance were observed. In relation to increasing *C. mopane* densities, soil water penetration occurred to a shallower depth. Increased infiltration was associated with the establishment of a higher grass cover.

It is clear that severe *C. mopane* thinning can result in drastic changes in structure of the woody layer, and the cover and composition of the herbaceous layer. However, *C. mopane* stands are able to recover quickly after severe thinning (Scholes 1990). Because the management of Sango Ranch aims at maintaining the vegetation in its natural state, harvesting of *C. mopane* will have to be conducted at low intensities. Natural *C. mopane* stands can be thinned by 10 % without adversely affecting the population or resulting in vegetation change (Smit 1994). The

Thilachium africanum–Colophospermum mopane Short Thicket has the greatest *C. mopane* density and should be utilised for harvesting (Chapter 5). It is recommended that the size class required be thinned at not more than 10 % of the entire *C. mopane* population. To calculate the number of trees that can be harvested, take the 10 % of the density of the size class required for harvesting and multiply this density by 9 740 which is the size of the *Thilachium africanum–Colophospermum mopane* Short Thicket in ha. Permanent long-term monitoring plots in both harvested and unharvested areas should be established and species composition, structure, available browse, stem diameter distribution, reproduction dynamics, soil variables and soil water should be recorded. Rainfall should also be measured, since *C. mopane* recovery is affected by the amount of rain received (Scholes 1990). Smit (1994) did not investigated the effect of elephants on the tree layer. This should be investigated on Sango Ranch. Furthermore, harvesting should not be concentrated in a single area but be distributed over a large area so that thinning will not be evident to casual observation. Tree stumps should be allowed to coppice and these coppicing plants will begin to produce browse material, flowers and seeds at a browsable level for most browsers. Trials with coppicing in southern Zimbabwe have shown that 20 to 80 % of all the stumps have coppice shoots 3 months after cutting, and that trees coppiced at 1 m height produced more and taller coppice shoots than those cut at 100 mm height (Mushove and Makoni 1993, In: Timberlake 1995). The added advantage is that browse material will be brought into a lower level. It has also been found that production of poles from seedlings takes twice as long as production from coppice (Tietema *et al.* 1988, In: Timberlake 1995).

An important consideration in the harvesting of resources in natural systems is that harvesting be carried out in such a way as to ensure that rate of harvesting not exceed the rate of recruitment of new individuals (Geldenhuys 1997). The use of such resources for food and shelter by wild animals must also be considered.

MONITORING PROGRAMME

In extensive natural areas the outcome of a particular land-use or management strategy cannot be predicted with any degree of certainty because of the dynamic nature of ecosystems. Therefore, management must be applied and adjusted according to the current situation. Monitoring is essential to determine the extent to which specific management goals are realised (Joubert 1983). The techniques suggested for use are in compliance with the financial and human resources available on Sango Ranch.

Biotic factors

Vegetation

It is recommended that a total of 30 permanent plots should be established at representative sites within each of the management units identified during the phytosociological study. The plots are placed *pro rata* on the basis of the size of the management units. Plots are also placed at artificial waterpoints. The suggested co-ordinates of these plots appear in Table 56. The following dynamic components must be monitored at each of these plots:

1. Short, medium and long-term vegetation change

Fixed-point photography should be applied to identify short and medium term vegetation changes in the vegetation (Joubert 1983). At each point four colour photographs should be taken in the four directions of the compass around the fixed point. Photographs should be taken at each point every second year from August to September. Vertical aerial photographs should be used to complement the data derived from fixed-point photography. Large-scale colour vertical aerial photographs have been used successfully in the Kruger National Park (Joubert 1983). The method may deliver information on basal cover for the field layer and canopy cover regime for the woody plants; and help with the identification and subsequent monitoring of large samples of specific tree and shrub species.

2. Veld condition trend

Veld condition trends and grass species composition changes should be recorded by means of the method described in Chapter 6 for grass species composition and veld condition. Surveys should be carried out annually.

3. Changes in woody vegetation structure

Woody vegetation structure (density, cover, height) should be monitored annually as described in Chapter 5 using belt transects.

4. Seasonal and annual variations in herbaceous biomass

Table 56. The suggested co-ordinates for the permanent monitoring plots of the vegetation of Sango Ranch, Save Valley Conservancy, Zimbabwe.

MANAGEMENT UNIT	*POINT*	*CO-ORDINATES*
Management Unit 1	1	20° 18.895' S 32° 05.661' E
	2	20°16.862' S 32° 15.148' E
	3	20° 15.020' S 32° 15.469' E
	4	20° 11.769'S 32° 02.622' E
	5	20° 19.225' S 32° 17.194' E
Management Unit 2	6	20° 12.065' S 32° 06.181' E
	7	20° 18.995' S 32° 16.461' E
	8	20° 14.910' S 32° 12.526' E
	9	20° 12.617' S 32° 08.130' E
	10	20°10.376' S 32° 09.954' E
	11	20° 14.677' S 23° 06.028' E
	12	20°21.303' S 32° 13.465' E
	13	20°15.562' S 32° 08.120' E
	14	20°18.910' S 32° 14.245' E
	15	20° 12.625' S 32° 07.585' E
	16	20° 18.125' S 32° 04.671' E
	17	20° 12.076' S 32° 07.795' E
	18	20° 15.407' S 32° 00.379' E
	19	20° 13.231' S 32° 04.763' E
	20	20° 17.567' S 32° 11.722' E
Management Unit 3	21	20° 10.564' S 32° 06.136' E
	22	20° 14.598' S 32° 04.728' E
	23	20° 11.064' S 32° 03.165' E
	24	20° 17.208' S 32° 02.378' E
	25	20° 15.446' S 32° 07.291' E
	26	20° 10.447' S 32° 01.816' E
	27	20° 17.930' S 32° 00.426' E
Management Unit 4	28	20° 17.023' S 32° 17.880' E
	29	20° 19.738' S 32° 17.540' E
Management Unit 5	30	20° 16.733' S 32° 18.500' E
	31	20° 14.999' S 32° 19.004' E
Management Unit 6	32 Masiyauta Pan	20° 15.467' S 32° 10.143' E
	33 Sune Pan	20° 21.620' S 32° 16.006' E

Herbaceous biomass should be measured annually just before the commencement of the growing season. By also measuring herbaceous biomass at the beginning of the growing season one can determine grass production. Herbaceous biomass should be monitored by means of the disc-pasture meter as described in Chapter 7. Exclosures should be used to determine grazing pressure by herbivores.

5. Available browse and ecological capacity

Because the ecological capacity varies with climate, it should be monitored annually using the techniques described in Chapters 8 and 9.

Large herbivores

Annual aerial surveys should be conducted during the dry season when most of the large water-dependent herbivores are found near water and when the vegetation structure is open. These surveys will yield information on trends in density, spatial distribution and social organisation. Additional information on age and sex structure and animal condition can be obtained by means of road strip counts as given by Mason (1990). Hunting provides a convenient method of monitoring animal condition. Hunted animals can be checked for condition using the techniques described by Ebedes (1995).

Predator-prey relations

The presence of large predators in the area poses several problems. Predators may have severe effects on the rarer prey species such as sable antelope (Mills 1991). The larger predators often have a negative influence on the smaller rarer predators such as the cheetah *Acinonyx jubatus*, black-backed jackal *Canis mesomelas*, leopard *Panthera pardus* and wild dog *Lycaon pictus*. Predators also often come into conflict with man (Anderson 1981; Stander 1990; Mills 1991; Scheepers and Venzke 1995). Lions and spotted hyaenas have the greatest impact because of their high density (Smuts 1982). On Sango Ranch, where no lions occur and hyaenas are at a low density, the impact from these predators should be minimal. Where possible, predator numbers and prey use should be monitored to determine predator-prey relations.

Abiotic factors

Daily, seasonal and annual variations in the climate should be monitored. Several recording stations are recommended at key points to record at least rthe ainfall and minimum and maximum temperatures. These points should be representative of variations in altitude within Sango Ranch. Stations should be established at headquarters, at the Save River house and at Ingwe Lodge as shown in Figure 3.

General factors

Various abiotic and biotic environmental variables should also be recorded at each permanent plot together with the veld condition, herbaceous biomass and fixed-point photographs, namely:

1. Degree of erosion.
2. Type of erosion.
3. Degree of trampling.
4. Degree of utilisation of the herbaceous layer.
5. Intensity of a burn separately for the herbaceous and woody layers.
6. Height of herbaceous layer.
7. Canopy cover separately for woody and herbaceous layers.
8. Phenology separately for woody and herbaceous layers.
9. Proportion of green material as a percentage of all the plant material available.
10. Amount of litter.

The degree and type of erosion should be monitored throughout Sango Ranch, and not only at the monitoring plots.

A NATURAL RESOURCE INVENTORY OF SANGO RANCH, SAVE VALLEY CONSERVANCY, ZIMBABWE

by

CHARLES JAMES HIN

Supervisor: Prof. Dr. J. du P. Bothma

Co-supervisor: Prof. Dr. N. van Rooyen

Centre for Wildlife Management
Faculty of Natural, Agricultural and Information Sciences
University of Pretoria

Pretoria

Magister Scientiae (Wildlife Management)

SUMMARY

Ecological data were collected from January 1998 to September 2000 on Sango Ranch, Save Valley Conservancy, southeastern Zimbabwe.

A background is given on the physiography, geology, climate, soils, vegetation, animals and history of the Save Valley Conservancy. The mission statement and objectives for the Save Valley Conservancy and Sango Ranch are described. Rainfall and temperature data were analysed and a climatogram for Sango Ranch is presented.

A superficial soil survey was conducted and the soils are classified into soil groups. The soils of Sango Ranch vary from deep fertile alkaline soils to shallow rocky acidic soils.

The Braun-Blanquet method was used to identify, classify and describe the vegetation on Sango Ranch. Nine plant communities and 16 subcommunities are described. The belt transect method was used to describe the vegetation structure. The vegetation types of Sango Ranch vary from forest to open woodland. A DECORANA ordination was applied and environmental gradients were identified and discussed. Six management units were identified and described, using a TWINSPAN classification.

The step-point method was used to determine the herbaceous species composition. A DECORANA ordination was applied to the grass data from the Braun-Blanquet survey to determine a degradation gradient. A gradient ranging from severely overutilised to slightly utilised was identified. Twenty grass species were allocated to ecological categories according to their responses to grazing pressure. Veld condition for each management unit was determined using the Ecological Index Method. Veld condition varies from moderate to good.

Herbaceous biomass data were collected by means of the disc-pasture meter. Herbaceous biomass for the management units varies from 1 520 to 5 092 kg per ha. It is recommended that the disc-pasture meter be calibrated for the area to allow for more accurate estimates.

The BECVOL method and computer program were used to determine the available browse on Sango Ranch. Only 6.2 % of palatable browse is available to browsing animals. The GRAZE program (Bredenkamp pers. comm.)[13] yielded an ecological capacity of 7 056 LSU during average rainfall periods and 3 727.2 LSU during below average rainfall periods. The browsing capacity was calculated at 651.4 LSU for average rainfall periods and 325.7 LSU during below average rainfall periods and at.

Phenological characteristics of 23 conspicuous plant species over a period of 12 months are described and discussed. The patterns observed are typical for southern Africa.

Recommendations are given for the ecological management of Sango Ranch. A stocking rate for the animals of Sango Ranch is suggested. Recommendations are given on veld management and the harvesting of selected plant species. The

adaptive management method is recommended for the ecological management of Sango Ranch. A monitoring program is suggested. It is recognised that the management guidelines presented are speculative due to the complex nature of natural systems and are only intended to be valid over a short period due to the dynamic properties of natural systems in southern Africa.

'N INVENTARIS VAN DIE NATUURLIKE HULPBRONNE VAN SANGO RANCH, SAVE VALLEY CONSERVANCY , ZIMBABWE

DEUR

CHARLES JAMES HIN

Leier: Prof. Dr . J. du P. Bothma
Mede-leier: Prof. Dr. N. van Rooyen

Sentrum vir Natuurlewebestuur
Fakulteit Natuur-, Landbou- en Inligtingwetenskappe
Universiteit van Pretoria
Pretoria

Magister Scientiae (Natuurlewebestuur)

OPSOMMING

Verskeie ekologiese data is vanaf Januarie 1998 tot September 2000 op Sango Ranch, geleë in die Save Valley Conservancy in die laeveld van suidoos Zimbabwe, versamel.

Die fisiografie, geologie, klimaat, grondtipes, plantegroei, diere en geskiedenis van die Save Valley Conservancy is bespreek as agtergrond. Die missie en doelstellings van die Save Valley Conservancy en Sango Ranch is bespreek. Reënval en temperatuur data is geanaliseer en 'n klimatogram vir Sango Ranch is opgestel. 'n quasi 20-jaar reënval siklus is geïdentifiseer.

Na 'n oppervlakkige grondopname is die gronde in groepe geklassifiseer. Die gronde van Sango Ranch wissel van taamlik diep alkaliese vrugbare gronde tot vlak rotsagtige suurgronde.

Die Braun-Blanquet metode is gebruik om die plantegroei van Sango Ranch te identifiseer, klassifiseer en te beskryf. Nege plantgemeenskappe en 16 subgemeenskappe is beskryf. Die strookperseelmetode is gebruik om die plantegroeistruktuur te beskryf. Die plantegroei van Sango Ranch wissel van digte bos tot oop woud. 'n DECORANA ordening is toegepas en omgewingsgradiente is geïdentifiseer en beskryf. Ses bestuurseenhede is met die TWINSPAN klassifikasie afgelei en beskryf.

Die stappuntmetode is toegepas om die grasspesiesamestelling van Sango Ranch te verkry. Na 'n DECORANA ordening op die kruiddata uit die Braun-Blanquet opname, is 'n degradasie-gradient geïdentifiseer. Die gradient wissel vanaf erg oorbenut tot bykans onbenut. Twintig grasspesies is volgens hulle reaksie op weidingsdruk in ekologiese kategorieë geplaas. Die veldtoestand vir elke bestuurseenheid is bepaal met die Ekologiese Indeksmetode. Veldtoestand wissel van middelmatig tot goed.

Die biomassa van die kruidlaag is met behulp van die weiveldskyfmeter bepaal. Die biomassa van die kruidlaag van die bestuurseenhede wissel van 1 520 tot 5 092 kg per ha. Dit word aanbeveel dat die weiveldskyfmeter vir die gebied gekalibreer word. Dit sal toelaat dat meer akkurate opnames moontlik is.

Die BECVOL metode en rekenaarprogram is gebruik om die beskikbare blaarmateriaal te bepaal. Net 6.2 % van smaaklike blaarmateriaal is beskikbaar vir blaarvreters. Ekologiese kapasiteit is bepaal as die som van weikapasiteit en blaarvreetkapasiteit. Die GRAZE program (Bredenkamp pers. komm.)[13] lewer 'n ekologiese kapasiteit van 7 056 GVE tydens gemiddelde reënvalperiodes en 3 737.2 GVE tydens ondergemiddelde reënvalperiodes. Blaarvreetkapasiteit word op 651.4 GVE tydens gemmidelde reënval periodes beraam en word op 325.7 GVE tydens ondergemiddelde reënval periodes beraam.

Die fenologiese eienskappe van 23 kenmerkende plantspesies is oor 'n tydperk van 12 maande weergegee en beskryf. Die patrone is tipies vir suider Afrika.

Aanbevelings met betrekking tot die ekologiese bestuur van Sango Ranch is gebaseer op die data verkry tydens die studie en vanaf gepubliseerde literatuur. Aanbevelings vir veldbestuur en die oes van uitgesoekte plantspesies is voorgestel.

'n Wildlading is ook vir Sango Ranch voorgestel. Die aanpassingbestuurmetode en 'n moniteringsprogram word voorgestel. Dit word beklemtoon dat die bestuursriglyne wat hier voorgestel word, danksy die dinamiese eienskappe van die natuurlike sisteme van suider-Afrika, spekulatief is en slegs beskou moet word as korttermyn voorstelle.

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APPENDIX A: PLANT SPECIES LIST FOR SANGO RANCH, SAVE VALLEY CONSERVANCY, ZIMBABWE

The following is a list of plant species encountered on the study area between January 1998 to September 1999. The plant families are not listed in any particular order. Exotic species are marked with an asterisk. The nomenclature and format of the species list follow that of Arnold and De Wet (1993). The term not threatened refers to the category as defined by Hilton-Taylor (1996). No other red data species were encountered. *Peponium pageanum* is a new record for Zimbabwe.

PTERIDOPHYTA

ADIANTACEAE
***CHEILANTHES* Sw.**
- *involuta* (Sw.) Schelpe ex N.C. Anthony var. *obscura* (N.C. Anthony) N.C. Anthony

SELAGINELLACEAE
***SELAGINELLA* Beauv.**
- *dregei* (c. Presl) Hieron

MONOCOTYLEDONAE

AMARYLLIDACEAE
***CRINUM* L.**
- *graminicola* I. Verd.

***SCADOXUS* Raf.**
- *puniceus* (L.) Friis and Nordal

CYPERACEAE
***BULBOSTYLIS* Kunth**
- *densiflora* (Lye) Goetgh.

***CYPERUS* L.**
- *digitatus* Roxb. subsp. *auricomus* (Spreng.) Kük.
- *schinzii* Boeck.
- *zollingeri* Steud.

***KYLLINGA* Rottb.**
- *alba* Nees

***MARISCUS* Gaertn.**
- *rehmannianus* C.B. Cl.

ARACEAE
***STYLOCHITON* Lepr.**
- *puberulus* N.E. Br.

COMMELINACEAE
***ANEILEMA* R. Br.**
- *hockii* De Wild

***COMMELINA* L.**
- *africana* L.
- *benghalensis* L.
- *subulata* Roth.

***CYANOTIS* D. Don.**
- *lanata* Benth.

COLCHICACEAE
***GLORIOSA* L.**
- *superba* L. subsp. *superba*

POACEAE
***ARISTIDA* L.**
- *adscensionis* L.
- *congesta* Roem. x Schult.
- *junciformis* Trim. and Ruper.
- *rhiniochloa* Hochst.

***BOTHRIOCHLOA* Kuntze**
- *radicens* (Lehm.) A. Camus

***BRACHIARIA* (Trin.) Griseb**
- *deflexa* (Schumach.) Robyns

***CENCHRUS* L.**
- *ciliarus* L.

***CHLORIS* O. Swartz**
- *roxburghiana* Schult.
- *virgata* Sw.

***DACTYLOCTENIUM* Willd.**
- *aegyptium* (L.) Willd.
- *australe* Steud.
- *giganteum* Fisher and Schweick.

***DANTHONIOPSIS* Stapf**
- *pruinosa* C.E. Hubb. not threatened

***DIGITARIA* Haller**
- *milanjiana* (Rendle) Stapf
- *velutina* (Forssk.) P. Beauv.

***ECHINOCHLOA* Beauv.**
- *colona* (L.) Link

***ENNEAPOGON* Beauv.**
- *cenchroides* (Licht.) C.E. Hubb.

***ENTEROPOGON* Nees**
- *macrostachys* (A. Rich.) Benth.

***ERAGROSTIS* Wolf.**
- *aspera* (Jacq.) Nees
- *cilianensis* (All.) Janch.
- *curvula* (Schrad.) Nees
- *cylindriflora* Hochst.
- *japonica* (Thunb.) Trin.
- *rigidior* Pilg.
- *rotifer* Rendle
- *superba* Peyr

***ERIOCHLOA* Kunth**
- *meyeriana* (Nees) Pilg.

***HETEROPOGON* Pers.**
- *contortus* (L.) Roem. and Schult.
- *melanocarpus* (Ell.) Benth

***LEPTOCHLOA* R. Br.**
- *uniflora* A. Rich. not threatened

***MELINIS* Beauv.**
- *repens* (Willd.) Zizka subsp. *repens*

***OROPETIUM* Trin.**

- *capense* Stapf

***PANICUM* L.**
- *coloratum* L.
- *deustum* Thunb.
- *dregeanum* Nees
- *maximum* Jacq.
- *subalbidum* Kunth

***PASPALIDIUM* Stapf**

obtusifolium (Delile) N.D. Simpson

***PEROTIS* Aiton**
- *patens* Gand.

***PHRAGMITES* Adans**
- *mauritianus* Kunth

***POGONARTHIA* Stapf**
- *squarrosa* (Roem. and Schult.) Pilg.

***SETARIA* Beauv.**
- *pumila* (Poir.) Roem. and Schult.
- *sagittifolia* (A. Rich.) Walp.
- *verticillata* (L.) P. Beauv.

***SCHMIDTIA* Steud.**
- *pappophoroides* Steud.

***SORGHUM* Moench**
- *versicolor* Anderss.

***SPOROBOLUS* R. Br.**
- *festivus* A. Rich
- *nitens* Stent
- *panicoides* A. Rich.

***TRICHOLAENA* Schrad.**
- *monachne* (Trin.) Stapf x C.E. Hubb

***TRAGUS* Haller**
- *berteronianus* Schult.

***TRIPOGON* Roem. and Schult.**
- *minimus* (A. Rich.) Steud.

***UROCHLOA* Beauv.**
- *mosambicensis* (Hack.) Dandy
- *oligotricha* (Fig. and De Not.) Henrard
- *panicoides* Beauv.
- *trichopus* (Hochst) Stapf

ASPHODELACEAE

***ALOE* L.**
- *aculeata* Pole Evans
- *littoralis* Bak.

ASPARAGACEAE

***ASPARAGUS* Oberm.**
- *africanus* Lam.
- *aspergillus* Jessop
- *schroederi* Engl.

IRIDACEAE

***LAPEIROUSIA* Pourret**
- *erythrantha* (Klatt) Baker

DICOTYLEDONAE

ARECACEAE

***HYPHAENE* Gaertn.**

coriacea Gaertn.
MORACEAE
***CARDIOGYNE* Bur.**
africana Bur.
***FICUS* L.**
abutilifolia (Miq.) Miq.
capreifolia Delile
sansibarica Warb.
sycomorus L.
tettensis Hutch.
OLACACEAE
***XIMENIA* L.**
caffra Sond. var. *caffra*
POLYGALACEAE
***POLYGALA* L.**
senensis Klotzsch
sphenoptera Fresen.
AMARANTHACEAE
***ACHYRANTHES* L.**
aspera L. var. *pubescens* (Moq.) C.C. Townsend*
aspera L. var. *sicula* L.*
***CELOSIA* L.**
trigyma L.
***CYATHULA* Blume**
orthacantha (Asch.) Schinz
***GOMPHRENA* L.**
celosoides Mart.*
***HERMBSTAEDTIA* Reichb.**
odorata (Burch.) T. Cooke
***KYPHOCARPA* (Fenzl) Lopr.**
angustifolia (Moq.) Lopr.
***PUPALIA* Juss.**
lappacea (L.) A. Juss. var. *velutina* (Moq.) Hook. f.
***SERICOREMA* (Hook f.) Lapr.**
remotiflora (Moq.) Lopr.
CAPPARACEAE
***BOSCIA* Lam.**
angustifolia A. Rich. var. *corymbosa* (Gilg) DeWolf
foetida Schinz var. *rehmanniana* (Pestal.) Toelken
mossambicensis Klotzsch
***CADABA* Forssk.**
termitaria N.E. Br.
***CAPPARIS* L.**
tomentosa Lam.
***CLEOME* L.**
hirta (Klotzsch) Oliv.
monophylla L.
***MAERUA* Forssk.**
angolensis DC.
decumbens (Brongn.) De Wolf
juncea Pax
***THILACHIUM* Lour.**
africanum Lour.

CRASSULACEAE
***KALANCHOE* Adans**
lanceolata (Forssk.) Pers.
FABACEAE
***AESCHYNOMENE* L.**
indica L.
***ACACIA* Mill.**
erubescens Welw. ex Oliver
galpinii Burtt Davy
gerrardiii Benth.
grandicornuta Gerstner
nigrescens Oliv.
nilotica (L.) De Lile subsp. *kraussiana* (Benth.) Brenan
schweinfurthii Brenan and Exell
tortilis (Forssk.) Hayne subsp. *heteracantha* (Burch.) Brenan
xanthophloea Benth.
***AFZELIA* Smith**
quanzensis Welw.
***ALBIZIA* Durazz.**
anthelmintica (A. Rich.) Brongn.
amara (Roxb.) Boiv. subsp. *sericocephala* (Benth.)
glaberrima (Schumach. and Thonn.) Benth. var. *glabrescens* Brenan
harveyi Fourn.
tanganyicensis Baker f.
***BLAINVILLEA* Cass.**
gayana Cass.
***BRACHYSTEGIA* Benth.**
spiciformis Benth.
***CASSIA* L.**
abbreviata Oliver
***CHAMAECRISTA* Moench**
absus (L.) Irwin and Barneby
sp. unidentified
***COLOPHOSPERMUM* Kirk ex Benth.**
mopane (Kirk ex Benth.) Kirk ex L. Léonard
***CORDYLA* Lour.**
africana Lour.
***CROTALARIA* L.**
laburnifolia L. subps. *laburnifolia*
podocarpa DC.
steudneri Schweinf.
virgulata Klotzsch
***DALBERGIA* L. f.**
arbutifolia Baker
melanoxylon Guill. x Perr.
***DESMODIUM* Desv.**
ospriostreblum Choiv.
***DICHROSTACHYS* (A. DC.) Wight and Arn.**
cinerea (L.) Wight and Arn. subsp. *africana* Brenan and Brummitt
***FAIDHERBIA* A. Chev.**
albida (Del) A. Chev.
***INDIGOFERA* L.**

astragalina DC.
lupatana Baker f.
praticola Baker f.
tinctoria L. var. *arcuata* J.B. Gillett
trita L. f. var. *subulata* (Poir.) Ali
varia E. Mey.
***JULBERNARDIA* Pellegr.**
globiflora (Benth.) Troupin
***LONCHOCARPUS* Kunth**
capassa Rolfe
***MILLETTIA* Wight and Arn.**
usumarensis Taub. subsp. *australis* J.B. Gillett
***MUNDULEA* Benth.**
sericea (Willd.) Chev.
***NEORAUTANENIA* Schinz**
amboensis Schinz
***ORMOCARPUM* Beauv.**
trichocarpum (Taub.) Engl.
***PELTOPHORUM* (Vogel) Benth.**
africanum Sond.
***PILIOSTIGMA* Hochst**
thonningii (Schumach) Milne-Redh.
***ROTHIA* Pers.**
hirsuta (Guill. and Perr.) Baker
***RHYNCHOSIA* Lour.**
minima (L.) DC. var. *minima*
***SENNA* Mill.**
petersiana (Bolle) Lock
***SESBANIA* Scop.**
leptocarpa DC. var. *leptocarpa*
***STYLOSANTHES* Sw.**
fruticosa (Retz.) Alston
***TEPHROSIA* Pers.**
purpurea (L.) Pers. subsp. *leptostachya* (DC.) Brummitt var. *pubescens* Brummitt
reptans Baker var. *reptans*
rhodesica Baker f. var. *polystachyoides* (Baker f.) Brummitt
villosa (L.) Pers. subsp. *ehrenbergiana* (Schweinf.) Brummitt var. *ehrenbergiana*
***VIGNA* Savi**
unguiculata (L.) Walp. subsp. *dekindtiana* (Harms) Verde.
***XANTHOCERCIS* Baillon**
zambesiaca (Baker) Dumaz-le Grand
***XERODERRIS* Roberty**
stuhlmannii (Taub.) Mendonça and E.P. Sousa
***ZORNIA* J.F. Gmel.**
glochidiata DC.
BALANITACEAE
***BALANITES* Del.**
aegyptiaca (L.) Delile
EUPHORBIACEAE
***ACALYPHA* L.**
fimbriata Schumach. and Thonn.

***ANTIDESMA* L.**
  venosum Tul.
***BRIDELIA* Willd.**
  cathartica G. Bertol. (not threatened)
  mollis Hutch.
***CROTON* L.**
  damarensis Engl.
  megalobotrys Müll. Arg.
***EUPHORBIA* L.**
  benthamii Hiem
  confinalis R.A. Dyer
  ingens E. Meyer ex Boiss.
  tirucalli L.
***FLUGGEA* Willd.**
  virosa (Rox. ex Willd.) Pax and K. Hoffm.
***PHYLLANTHUS* L.**
  maderaspatensis L.
  reticulatus Poir.
***PSEUDOLACHNOSTYLIS* Pax**
  maprouneifolia Pax
***SPIROSTACHYS* Sond.**
  africana Sond.
***TRAGIA* L.**
  okanyua Pax
MENISPERMACEAE
***ANISOCYCLA* Baill.**
  blepharosepala Diels
ANACARDIACEAE
***LANNEA* A. Rich**
  schweinfurthii (Engl.) Engl.
***RHUS* L.**
  guienzii Sond.
***SCLEROCARYA* Hochst.**
  birrea (A. Rich.) Hochst. subsp. *caffra* (Sond.) Kokwara
CELASTRACEAE
***GYMNOSPORIA* (Wight and Arn.) Hook f.**
  buxifolia (L.) Szyszyl.
  putterlickoides Loes.
  senegalensis (Lam.) Loes.
***HIPPOCRATEA* L.**
  indica (Willd.) N. Hallé var. *orientalis* N. Hallé ex B. Mathew
SAPINDACEAE
***ALLOPHYLUS* L.**
  alnifolius (Baker) Radlk.
***PAPPEA* Eckl. and Zeyh.**
  capensis Ecklon and Zeyher
***STADMANNIA* Lam.**
  oppositifolia Poiret
RHAMNACEAE
***BERCHEMIA* Neek ex DC.**
  discolor (Klotzsch) Helmsley)
***ZIZIPHUS* Mill.**
  mucronata Willd. subsp. *mucronata*

VITACEAE
***AMPELOCISSUS* Planch.**
- *africana* (Lour.) Merr.
- *obtusata* (Baker) Planch. subsp. *kirkiana* (Planch.) Wild and R.B. Drumm.

***CISSUS* L.**
- *cornifolia* (Baker) Planch.
- *integrifolia* (Baker) Planch.
- *rotundifolia* (Forssk.) Vahl

***CYPHOSTEMMA* (Planch.) Alston**
- *buchananii* (Planch.) Wild and R.B. Drumm.
- *Cyphostemma sp.* Hin 473
- *Cyphostemma sp.* Hin 529

***RHOICISSUS* Planch.**
- *revoilii* Planchon

TILIACEAE
***CORCHORUS* L.**
- *kirkii* N.E. Br.
- *longipedunculatus* Mast.
- *tridens* L.
- *trilocularis* L.

***GREWIA* L.**
- *bicolor* Juss.
- *flavescens* Juss. var. *flavescens*
- *gracillima* Wild
- *inaequilatera* Garcke
- *monticola* Sond.
- *sulcata* Mast.
- *villosa* Willd.

***TRIUMFETTA* L.**
- *pentandra* A. Rich.

MALVACEAE
***ABUTILON* Mill.**
- *angulatum* (Guill. and Perr.) Mast.
- *grandiflorum* D. Don
- *hirtum* (Lam.) Sweet
- *ramosum* (Cav.) Guill. and Perr.

***AZANZA* Alef.**
- *garckeana* (F. Hoffm.) Exell and Hillcoat

***HIBISCUS* L.**
- *mastersianus* Hiern
- *micranthus* L.f.
- *seineri* Engl.
- *sidiformis* Baill.
- *vitifolius* L. subsp. *vulgaris* Brenan and Exell

***PAVONIA* Cav.**
- *burchelii* (DC.) R.A. Dyer

***SIDA* L.**
- *alba* L.
- *cordifolia* L.
- *ovata* Forssk.

STERCULIACEAE
***HERMANNIA* L.**

- *glanduligera* K. Schum.
- *kirkii* Mast.

***MELHANIA* Forssk.**

- *acuminata* Mast.
- *forbesii* Plach. ex Mast.

***STERCULIA* L.**

- *rogersii* N. E. Br.

***WALTHERIA* L.**

- *indica* L.

CLUSIACEAE

***GARCINIA* L.**

- *livingstonei* T. Anders.

FLACOURTIACEAE

***FLACOURTIA* Comm. ex L'Herit.**

- *indica* (Burm. f.) Merr.

ALISMATACEAE

***LIMNOPHYTON* Miq.**

- *obtusifolium* (L.) Miq.

COMBRETACEAE

***COMBRETUM* Loefl.**

- *adenogonium* A. Rich
- *apiculatum* Sonder subsp. *apiculatum*
- *hereroense* Schinz
- *imberbe* Wawra
- *microphyllum* Klotzsch.
- *molle R.* Br. ex G. Don
- *mossambicense* (Klotzsch) Engl.
- *padoides* Engl. and Diels
- *zeyheri* Sond.

***PTELEOPSIS* Engl.**

- *myrtifolia* (M.A. Lawson) Engl. and Diels

***TERMINALIA* L.**

- *sericea* Burch. ex DC.
- *prunioides* C. Lawson

SAPOTACEAE

***VITELLARIOPSIS* (Baillon) Dubard**

- *ferruginea* Kupicha

EBENACEAE

***DIOSPYROS* L.**

- *lycioides* Desf. subsp. *sericea* (Bernh.) De Winter
- *mespiliformis* Hochst. ex A. DC.
- *quiloensis* (Hiern) F. White

***EUCLEA* Murray**

- *divinorum* Hiern

APOCYANACEAE

***STROPHANTHUS* DC.**

- *kombe* Oliv.

***TABERNAEMONTANA* L.**

- *elegans* Stapf

CONVOLVULACEAE

***ASTRIPOMOEA* A. Meeuse**

- *lachnosperma* (Choisy) A. Meeuse

***EVOLVULUS* L.**

  alsinoides (L.) L.

***IPOMOEA* L.**
  dichroa Choisy
  hochstetteri House
  pes-tigridis L.
  plebia R. Br.subsp. *africana* A. Meeuse
  sinensis (Desr.) Choisy subsp. *blepharosepala* (A. Rich.) A. Meeuse
  tenuipes Verde.
  tuberculata Ker-Gawl. var. *tuberculata*

***JACQUEMONTIA* Choisy**
  tamnifolia (L.) Griseb.

***MERREMIA* Dennst.**
  kentrocaulos (C.B. Clarke) Rendle var. *pinnatifida* N.E. Br.
  pinnata (Choisy) Hall f.

***SEDDERA* Hochst.**
  suffruticosa (Schinz) Hall f.

BORAGINACEAE

***CORDIA* L.**
  grandicalyx Oberm.
  monoica Roxb.

***EHRETIA* P. Br.**
  obtusifolia DC.

***HELIOTROPIUM* L.**
  ciliatum Kaplan
  ovalifolium Forssk.
  steudneri Vatke
  strigosum Willd.

VERBENACEAE

***CLERODENDRUM* L.**
  ternatum Schinz

***LANTANA* L.**
  camara L.*
  rugosa Thunb.

***VITEX* L.**
  buchananii Gürke
  isotjensis Gibbs

LAMIACEAE

***AEOLLANTHUS* Mart. ex K. Spreng**
  neglectus (Dinter) Launert

***BASILICUM* Moench.**
  polystachyon (L.) Miq.

***BECIUM* Lindl.**
  filamentosum (Forssk.) Chiov.
  obovatum (Benth.) N.E. Br.

***ENDOSTEMON* N.E. Br.**
  tereticaulis (Poir.) Ashby

***HEMIZYGIA* (Benth.) Briq.**
  bracteosa (Benth.) Briq.

***LEONOTIS* (Pers.) R. Br.**
  nepetifolia (L.) W.T. Aiton

***OCIMUM* L.**
  americanum L.

gratissimum L.
ORTHOSIPHON **Benth.**
suffrutescens (Thonn.) J.K. Morton
PLECTRANTHUS **L'Herit.**
caninus Roth
tetensis (Bak.) Agnew
SOLANACEAE
LYCIUM **L.**
shawii Roem. and Schult.
PHYSALIS **L.**
lagascae Roem. and Schult.
SOLANUM **L.**
panduriforme E. Mey.
Solanum sp. Hin 534
Solanum sp. Hin 548
WITHANIA **Pauquy**
somnifera (L.) Dunal
SCROPHULARIACEAE
ALECTRA **Thunb.**
orobanchoides Engl.
APTOSIMUM **Burch.**
lineare Marloth and Engl.
CRATEROSTIGMA **Hochst.**
plantagineum Hochst.
STRIGA **Lour.**
asiatica (L.) Kuntze
DRACAENACEAE
SANSEVIERIA **Thunb.**
sp. unidentified
BOMBACACEAE
ADANSONIA L.
digitata L.
ACANTHACEAE
ANISOTES **Nees**
formosissimus (Klotzsch) Milne-Redh.
ASYSTASIA **Blume**
gangetica (L.) T. Anderson
schimperi T. Anderson
BARLERIA **L.**
albostellata C.B. Clarke
heterotricha Lindau
kirkii T. Anderson
prionitis L. subsp. *ameliae* (A. Meeuse) Brummitt and J.R.I. Wood
spinulosa Klotzsch
BLEPHARIS **Juss.**
acanthodoides Klotzsch
diversispina (Nees) C.B. Clarke
transvaalensis Schinz
CRABBEA **Harv.**
velutina S. Moore
DYSCHORISTE **Nees**
sp. unidentified
ELYTRARIA **Mitch.**

- *acaulis* (L. f) Lindau

***JUSTICA* L.**

- *flava* (Vahl) Vahl
- *glabra* Roxb.
- *kirkiana* T. Anderson
- *protracta* (Nees) T. Anderson subsp. *protracta*

***MEGALOCHLAMYS* Lindau**

- *revoluta* (Lindau) Volleson subsp. *cognata* (N.E. Br.) Volleson

***MONECHMA* Hochst**

- *divaricatum* (Nees) C.B. Clarke

***NEURACANTHUS* Nees**

- *africanus* S. Moore var. *africanus*

***RUELLIA* L.**

- *patula* Jacq.

RUBIACEAE

***CANTHIUM* Lam.**

- *glaucum* Hiern subsp. *frangula* (S. Moore) Bridson

***GARDENIA* Ellis**

- *resiniflua* Hiern
- *volkensii* K. Schum.

***KEETIA* Phill.**

- *venosa* (Oliv.) Bridson

***SPERMACOCE* Gaertn.**

- *senensis* (Klotzsch) Hiern

***TARENNA* Gaertn.**

- *zygoon* Bridson (not threatened)

***TRICALYSIA* A. Rich. ex DC.**

- *junodii* (Schinz) Brenan var. *kirkii* (Hook f.) Robbr.

CUCURBITACEAE

***COCCINIA* Wight and Arn.**

- *adoensis* (A. Rich.) Cogn.
- *rehmannii* Cogn.

***CTENOLEPIS* Hook f.**

- *cerasiformis* (Stocks) Hook f.

***CUCUMIS* L.**

- *anguria* L.
- *hirsitus* Sond.
- *metuliferus* Naudin

***EUREIANDRA* Hook f.**

- *fasciculata* (Sond.) C. Jeffrey

***LAGENARIA* Ser.**

- *sphaerica* (Sond.) Naudin

***MOMORDICA* L.**

- *boivinii* Baill.

***PEPONIUM* Engl.**

- *pageanum* C. Jeffrey

ASTERACEAE

***BIDENS* L.**

- *biternata* (Lour.) Merr. and Sherff*

***BLUMEA* DC.**

- *viscosa* (Mill.) Badillo

***BRACHYLAENA* R. Br.**

- *rotundata* S. Moore

EPALTES **Cass.**
- *gariepina* (DC.) Steetz

MELANTHERA **Rohr**
- *albinervia* O. Hoffm. subsp. *albinervia*

NIDORELLA **Cass.**
- *microcephala* Steetz

PLUCHEA **Cass.**
- *dioscoridis* (L.) DC.

SPHAERANTHUS **L.**
- *angolensis* O. Hoffm.

VERNONIA **Schreb.**
- *cinerea* (L.) Less. var. *cinerea*
- *lundiensis* (Wild) Pope

ANNONACEAE

ANNONA **L.**
- *senegalensis* Pers.

ARTABOTRYS **R. Br.**
- *brachypetalus* Benth.

FRIESODIELSIA **Van Steenis**
- *obovata* (Benth.) Verdc.

MONODORA **Dunal**
- *junodii* Engl. and Diels

SALVADORACEAE

AZIMA **Lam.**
- *tetracantha* Lam.

SALVADORA **Garcin ex L.**
- *australis* Schweick.
- *persica* L.

BURSERACEAE

COMMIPHORA Jacq.
- *africana* (A. Rich.) Engl.
- *edulis* (Klotzsch) Engl.
- *glandulosa* Schinz
- *marlothii* Engl.
- *merkeri* Engl.
- *mollis* (Oliv.) Engl.
- *mossambicensis* (Oliver) Engl.

BIGNONIACEAE

KIGELIA **DC.**
- *africana* (Lam.) Benth.

MARKHAMIA **Seem ex Baillon**
- *zanzibarica* (Bojer ex DC.) K. Schum.

RHIGOZUM **Burch.**
- *zambesiacum* Baker

SIMAROUBACEAE

KIRKIA **Oliver**
- *acuminata* Oliver

URTICACEAE

POUZOLZIA **Gaudich**
- *mixta* Solms

LOGANIACEAE

STRYCHNOS **L.**
- *madagascariensis* Poiret

potatorum L. f.
MELIACEAE
***ENTANDROPHRAGMA* C. DC.**
caudatum (Sprague) Sprague
***TRICHILIA* P. Browne**
emetica Vahl
MYRTACEAE
***SYZYGIUM* gaertn.**
guineense (Willd.) DC.
RUTACEAE
***VEPRIS* Commerson ex Adr. Juss.**
zambesiaca S. Moore
***ZANTHOXYLUM* L.**
capense (Thunb.) Harv.
APIACEAE
***STEGANOTAENIA* Hochst.**
araliaceae Hochst.
NYCTAGINACEAE
***BOERHAVIA* L.**
coccinea Mill.
***COMMICARPUS* Standley**
plumbagineus (Cav.) Standl.
PEDALIACEAE
***CERATOTHECA* Endl.**
sesamoides Endl.
***SESAMUM* L.**
alatum Thonn.
triphyllum Welw. ex Aschers
ANTHERICACEAE
***CHLOROPHYTUM* Ker-Gawl**
blepharophyllum Baker
macrosporum Baker
sphacelatum (Baker) Kativu subsp. *milanjianum* (Rendle) Kativu
MENISPERMACEAE
***CISSAMPELOS* L.**
pareira L. var. *orbiculata* (DC.) Miq.
CRASSULACEAE
***CRASSULA* L.**
lanceolata (Eckl. and Zeyh.) Walp. subsp. *transvaalensis* (Kuntze) Toelken
VIOLACEAE
***HYBANTHUS* Jacq.**
enneaspermus (L.) F. Müll.
NYMPHAEACEAE
***NYMPHAEA* L.**
nouchali Burm. f.
ASCLEPIADACEAE
***KANAHIA* R. Br.**
laniflora (Forssk.) N.E. Br.
***PERGULARIA* L.**
daemia (Forssk.) Choiv.
PORTULACACEAE
***PORTULACA* L.**

kermesina

PERIPLOCACEAE

***RAPHIONACME* Harv.**

monteiroae (Oliv.) N.E. Br.

***STOMASTEMMA* N.E. Br.**

monteiroae (Oliv.) N.E. Br.

ZYGOPHYLLACEAE

***TRIBULUS* L.**

terrestris L.

TURNERACEAE

***STREPTOPETALUM* Hochst.**

serratum Hochst.

***TRICLICERAS* Thonn. ex DC.**

hirsitum (A. and R. Fern) R. Fern

AIZOACEAE

***GISEKIA* L.**

africana (Lour.) Kuntze

***LIMEUM* L.**

fenestratum (Fenzl) Heimerl

***ZALEYA* Burm. f.**

pentandra (L.) Jeffrey

APPENDIX B: LIST OF MAMMALS OF SANGO RANCH, SAVE VALLEY CONSERVANCY, ZIMBABWE

An alphabetical list of the larger mammal species observed on Sango Ranch is given below. The nomenclature is according to Estes (1995). Note the species list differs from that given in Table 1 due to different species distributions within the Save valley Conservancy.

African wild dog	*Lycaon pictus* Temminck 1820
African wild cat	*Felis lybica* Forster 1780
Black-backed jackal	*Canis mesomelas* Schreber 1778
Black rhinoceros	*Diceros bicornis* Linnaeus 1758
Blue wildebeest	*Connochaetes taurinus* Burchell 1823
Buffalo	*Syncerus caffer* Sparmann 1779
Bushbuck	***Tragelaphus scriptus*** Pallas 1766
Bushpig	***Potamochoerus porcus*** Linnaeus 1854
Burchell's Zebra	***Equus burchellii*** Gray 1824
Caracal	***Felis caracal*** Schreber 1776
Cheetah	***Acinonyx jubatus*** Schreber 1775
Common duiker	***Sylvicapra grimmia*** Linnaeus 1758
Eland	***Taurotragus oryx*** Pallas 1766
Elephant	***Loxodonta africana*** Blumenbach 1797
Giraffe	***Giraffa camelopardalis*** Linnaeus 1758
Hippopotamus	***Hippopotamus amphibius*** Linnaeus 1758
Honey badger	***Mellivora capensis*** Schreber 1776
Impala	***Aepyceros melampus*** Lichtenstein 1812
Klipspringer	***Oreotragus oreotragus*** Zimmermann 1783
Kudu	***Tragelaphus strepsiceros*** Pallas 1766
Leopard	***Panthera pardus*** Linnaeus 1758
Nyala	***Tragelaphus angasii*** Gray 1849
Sable Antelope	***Hippotragus niger*** Harris 1838
Serval	***Felis serval*** Schreber 1776
Sharpe's grysbok	***Raphicerus sharpei*** Thomas 1897
Steenbok	***Raphicerus campestris*** Thunberg 1811
Warthog	***Phacochoerus aethiopicus*** Pallas 1766
Waterbuck	***Kobus ellipsiprymnus*** Ogilby 1833
White rhinoceros	***Ceratotherium simum*** Burchell 1868

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