A natural resource assessment of Chapungu Ranch, Save Valley Conservancy, Zimbabwe

by

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Submitted in partial fulfillment of the requirements for the degree

MAGISTER SCIENTIAE
(WILDLIFE MANAGEMENT)

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ABSTRACT

An assessment of the natural resources on Chapungu Ranch, Zimbabwe, was undertaken for the purpose of incorporating this ranch into the larger Sango Ranch. The geological description was based on literature, whilst the soils were classified using the soil taxonomic system described for Zimbabwe. The seven soils types on Chapungu Ranch were from the Amorphic, Calcimorphic and Natric orders and varied considerably in terms of depth, texture and chemical composition. Most soils were fertile and supported a herbaceous layer generally referred to as sweetveld.

A phytosociological classification and structural analysis of the vegetation identified nine plant communities and 15 subcommunities on Chapungu Ranch. Separation of plant communities was mostly influenced by the geological formations and soils. Each community was described in terms of its species composition and structure. The dry mass of the herbaceous layer was quantified using the disc pasture meter and the composition of the herbaceous layer using the step-point method. The veld condition ranged from moderate (30.1%) to very good (60.4%) and the biomass production ranged from very low to high. The browsing capacity was determined using the BECVOL method. On Chapungu only 15.4% of the total browse was available to browsers, 5.0% of the browse was available for herbivores up to 2 m and 10.4% of the browse was available to browsers feeding between >2 – 5 m in height. Grazing capacity of different plant communities ranged from 7 GU/100 ha to 38 GU/100 ha with a mean of 25 GU/100 ha. The browsing capacity ranged from as low as 0.3 BU/100 ha to 13 BU/100 ha with a mean of 9 BU/100 ha. In 2003, Chapungu Ranch had the capacity to carry 3 331 GU and 1 169 BU whereas the stocking density was 2 199 GU and 3 029 BU.

After the integration of Chapungu Ranch into Sango Ranch seven management units were identified. Animal populations were described in terms of population size and their spatial and temporal trends for the entire Sango Ranch. The populations of bushbuck, bushpig, Livingston's eland, hippopotamus, impala, greater kudu, warthog, leopard, cheetah, baboon and vervet monkey were already at ecological capacity when monitoring commenced, however, populations of black rhinoceros, common duiker, African elephant, klipspringer, sable antelope, Sharpe's grysbuck, waterbuck, blue wildebeest, Burchell's zebra, black-backed jackal and wilddog reached ecological capacity within the past 14 years. The populations for African buffalo, giraffe, nyala, white rhinoceros, lion and spotted hyena had still not reached ecological capacity.

Evaluation of the long-term monitoring program indicated that the stocking density for the grazer units (GU) exceeded the grazing capacity during the 2006/2007 season whilst the browsing capacity has been exceeded since the inception of the monitoring program in 2000.

Recommendations are made towards improving artificial water provision, erosion control and road management. Additionally, recommendations are presented on fire management, alien plant control, stocking density, elephant impact, vegetation harvesting, waste management and wildlife utilization. Finally, four research priorities were identified which included studies on sable antelope, lion, spotted hyena and brown hyena and small mammals on Sango Ranch.

CONTENTS

CHAPTER 9

CHAPTER 1

INTRODUCTION

Bothma (2002) defines an inventory as a statement of the physical assets of a business, which includes the monetary value of these assets. In wildlife ranching enterprises the list of physical assets may include land, all fixed improvements such as buildings, pipelines, dams, boreholes, fences, roads and many other immovable assets. An inventory list also includes the human resources, financial resources, natural resources and the marketable products of such an enterprise. Walker *et al.* (1978) suggested that a description of an ecosystem (natural system) should begin with a simple word description of its location and its components followed by a structural description of the geological, vegetation and animal components and their relationships.

When a management strategy for a wildlife enterprise is developed, the structure, dynamics and relations of the animal populations, habitats and people are identified as the three fundamental and mutually dependent characteristics to consider (Giles, 1978). However, Walker *et al.* (1978) also state that there is a conflict between resource conservation and increased productivity, which creates serious environmental problems. Management decisions are based and determined by the goals, the management strategies available and existing perceptions (Walker *et al.*, 1978) and any cost effective management of indigenous flora and fauna requires an understanding of their inherent properties (Child, 1995). A natural resource inventory for Chapungu Ranch is therefore the first step towards developing a management strategy for the property.

Joubert (1999) states that Sango Ranch is committed to sound land management practices, economic viability and the social upliftment of its human resources. In 2000, Hin compiled "A natural resource inventory of Sango Ranch, Save Valley Conservancy, Zimbabwe". In July 2002, Chapungu Ranch was purchased by the owner of Sango Ranch, Mr Wilfred Pabst, and included into Sango Ranch. By implication the objectives and goals for Chapungu Ranch are thus similar to the objectives and goals set for Sango Ranch. The title of the current study closely follows the title used by Hin (2000). The reason for this close resemblance of study titles is that a basic natural resource assessment for Chapungu has not yet been compiled and that ultimately the findings of the two studies have to be integrated.

The objectives of the study were therefore:

- To provide an overview and update of the Save Valley Conservancy, its formation, description and previous land-use practices.
- To describe the climate, geology, soils and vegetation on Chapungu Ranch.

- To compare the vegetation of Chapungu Ranch with the rest of Sango Ranch and to produce an integrated vegetation map.
- To describe spatial and temporal trends in animal population sizes at the entire Sango Ranch scale, once the vegetation and soils of Chapungu Ranch were aligned with those of Sango Ranch.
- Finally, to update management recommendations for Sango Ranch and to evaluate, and where necessary adjust, the current monitoring programme.

CHAPTER 2

STUDY AREA

2.1 Physiography, Locality and Size

The Sabi-Limpopo depression occupies the southeastern corner of Zimbabwe and extends towards the highveld regions in the north and northwest (Michie & Hawkridge, 1961). The basin was formed by an initial sinking of the land between the southern and eastern Zimbabwean Highlands and the Soutpansberg in the Transvaal (now Limpopo province, South Africa). The subsequent erosion that followed gave rise to the major drainage channels, namely Save, Rundi, Odzi and Limpopo rivers and their tributaries. Erosion was most rapid towards the north and northwest due to the relatively softer granite, whilst the extension of the depression eastwards was prevented by the harder rocks of the Meltsetter Plateau (Michie & Hawkridge, 1961).

Michie and Hawkridge (1961) defined all areas lying below 610 m (2000 feet), which includes the Sabi-Limpopo basin, as “Lowveld”. The Save Valley Conservancy (SVC) therefore lies within the southeastern Lowveld of Zimbabwe (Du Toit & Price Waterhouse, 1994).

The conservancy is situated between southern latitudes 19.95°and 20.95° and eastern longitudes 31.79° and 32.37° and comprises 24 management units that together cover an area of 350 196 hectares. The Masvingo to Birchenough Bridge road and the Devure River form the northern boundary of the SVC. The Mkwasine River and Mkwasine Sugar Estate mark the southern boundary. The Save River and the Gudo Communal Lands form the eastern boundary and the Devure Resettlement Area and the Matsai Communal Lands mark the boundary to the west (Figure 2.1).

The properties, Musawezi, Chanurwe, Chapungu and Sabi Ranches constitute Sango Ranch. However, Chapungu Ranch was incorporated into Sango Ranch only in 2002, whilst Musawezi, Chanurwe and Sabi ranches were part of the original founder properties acquired in 1993 (Figure 2.1). In Chapters 1 – 7 Sango Ranch refers to the original three properties and excludes Chapungu Ranch. However, from Chapter 8 onwards (Chapter 8 – 9 and Appendices) Chapungu Ranch was integrated into the three original properties and Sango Ranch therefore refers to all four properties

Chapungu Ranch falls within the northern half of the SVC and covers an area of 12 971 ha. Chapungu Ranch is bordered by Msaize Ranch to the north, the Save River to the east and by Sango Ranch on the southern and western boundaries.

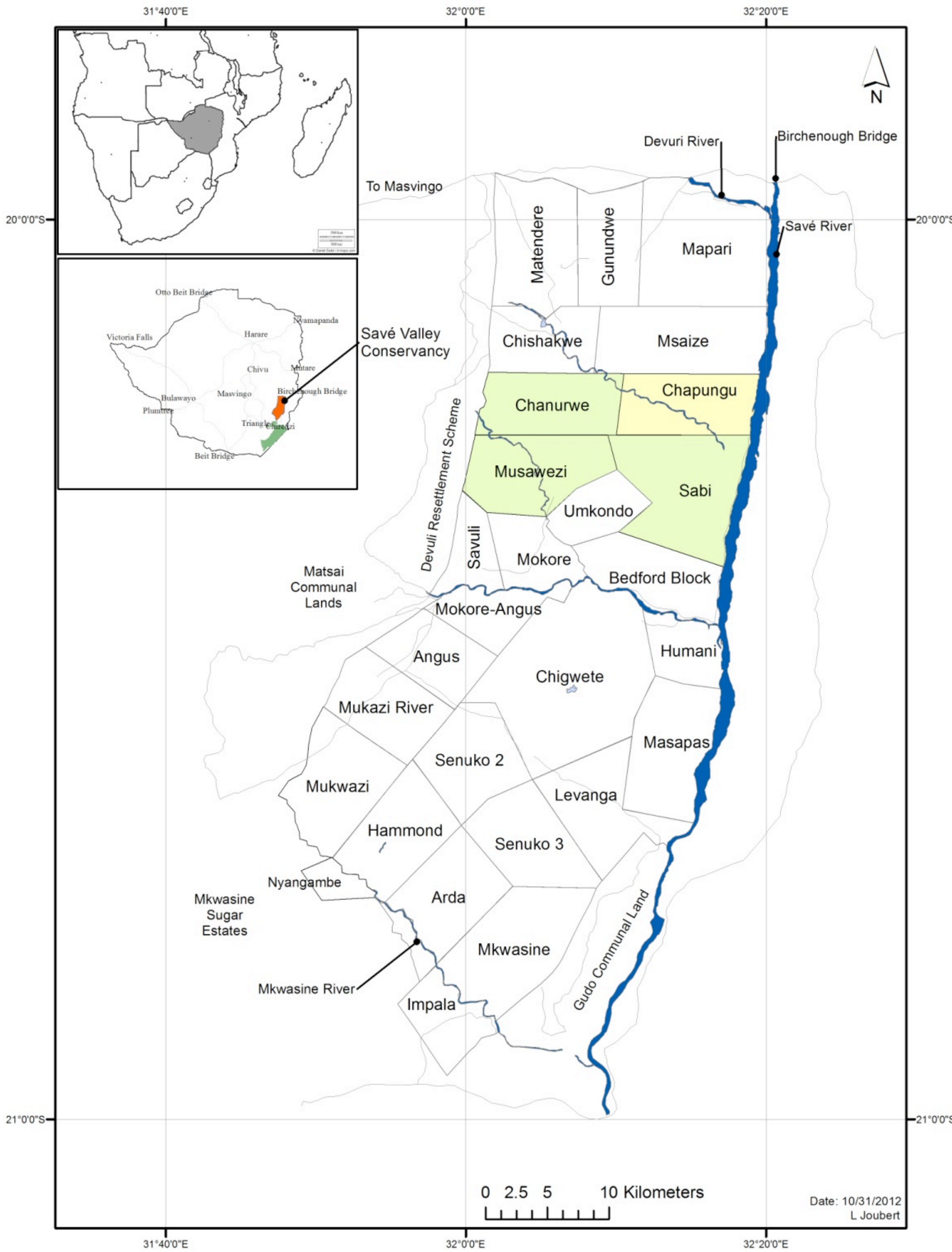


Figure 2.1: The location of the Save Valley Conservancy within Zimbabwe as well as Chapungu Ranch (yellow) and the rest of Sango Ranch (Green) within the conservancy.

Physiographically, Chapungu Ranch is a flat plain, which gently slopes in a southeasterly direction towards the Save River (Figure 2.2). The altitude, excluding the two hills, ranges from 547 m above sea level in the northwestern parts of the property to 448 m above sea level in the southeast where the Save River exits Chapungu. Chisangaurwe and Chawiwi hills are the only two kopjes on the property with highest altitudes of 619 m and 584 m above sea level respectively.

The Save, Msaize and Chenjera rivers are the major drainage channels flowing through Chapungu Ranch. The Save River has a catchment area that covers 84 550 km^2 and is the only perennial river. Along the banks of the Save River alluvial deposits have formed levees and as a consequence many tributaries such as the Msaize and Chenjera rivers are unable to reach the Save River directly resulting in large pan formations along the length of the Save River (Michie & Hawkridge, 1961; Broderick, 1997).

The Chenjera River and several smaller tributaries drain into the Chinga pans south of Chisangaurwe hill. The Chinga pans formed as a result of an extended raised levee of fine-grained overbank alluvial deposits (Broderick, 1997). During high rainfall years, excess water from the Chinga pans flows along a series of smaller pans into Masiauta Pan which is situated on Sango Ranch.

The Msaize River, which enters Chapungu Ranch on its northwestern boundary has a catchment area of 368 km^2 (Broderick, 1997) and flows in a southeasterly direction until it leaves the property in the southeast. The Msaize River channel narrows down and at approximately 2.5 km from the Save River splays into several streams that drain into the Masiauta, Mazewe and Chitoramazani pans. Excess water in the Masiauta, Mazewe and Chitoramazani pans spill into the Chi'honga River at approximately 1 km south of the end of the main Msaize River channel.

The Chi'honga River originates on Chapungu Ranch and initially flows in a southeasterly direction parallel to the Msaize River. At approximately 1 km from the Save River and just after the major pans drain into the Chi'honga River the river turns south and flows south further for approximately 6 km before it enters into the Save River (Broderick, 1997). The Chi'honga River is the only drainage channel, out of a potential eight drainage channels on Sango and Chapungu ranches that flows directly into the Save River from the west.

All along the length of the Save River, from the northern boundary with Msaize Ranch to the southern boundary with Sango Ranch, a raised levee series occurs, from 500 and 1000 m from the bank.

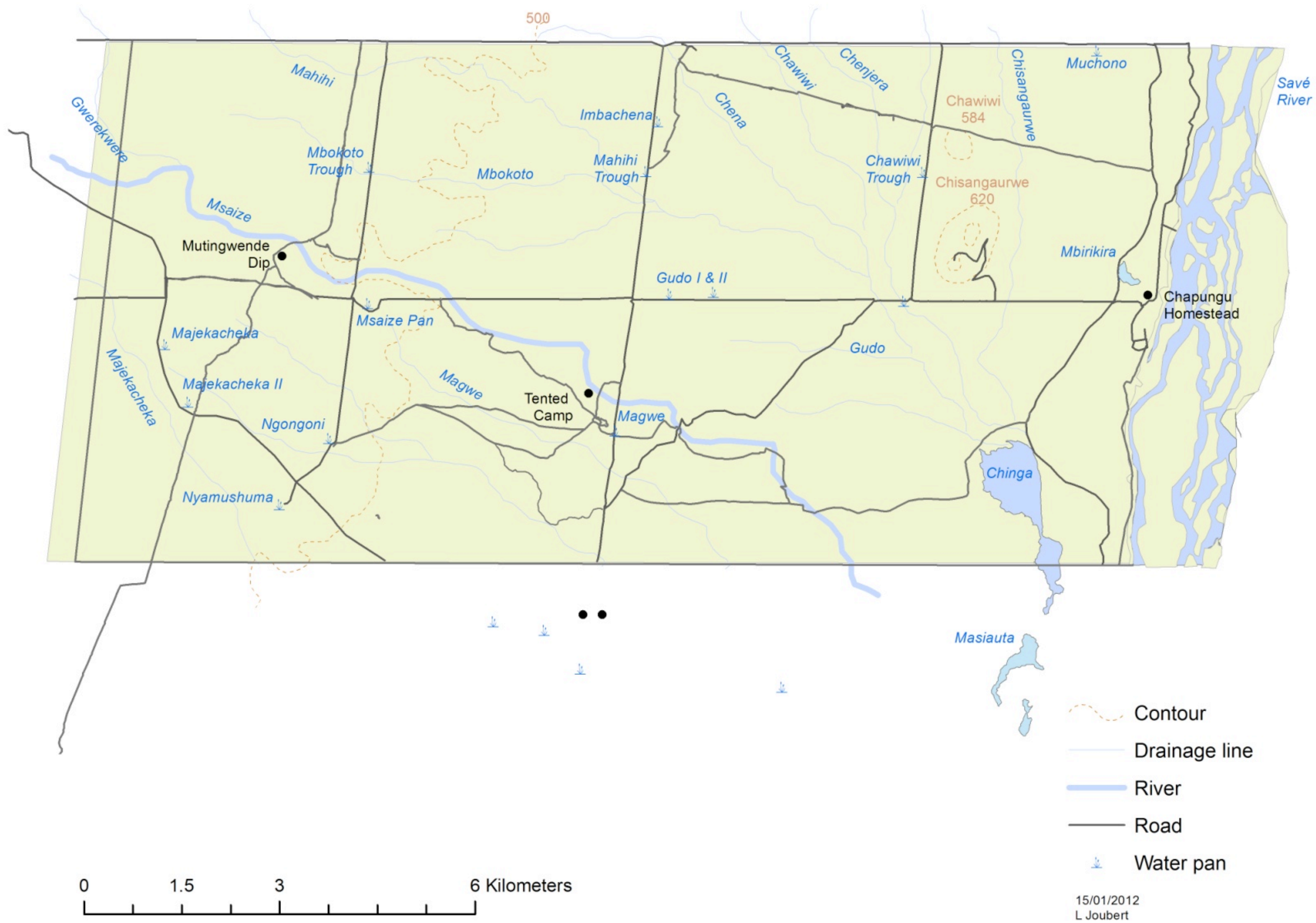


Figure 2.2: Topographical map of Chapungu Ranch, Save Valley Conservancy, Zimbabwe.

2.2 History

2.2.1 *Early settlement in the southeastern Lowveld of Zimbabwe (prior to 1920)*

The earliest evidence of human occupation in the southeastern Lowveld of Zimbabwe dates back 130 000 years and is from the Early Stone Age Bembesi (Sangoan) Industry found at the Mateke hills and the Save-Runde confluence (Cooke, 1960). Cooke (1960) also mentions surface scatters of unknown age that appear to be from the Middle Stone Age and an assemblage found at Sitanda Dam, west of the Mateke hills dating back to the Late Middle Stone Age (Cooke & Garlake, 1968).

Evidence of human occupation during the Late Stone Age suggests that hunter-gatherer occupation was sparse until approximately 2000 years ago (Walker, 1995). Walker (1995) proposed that hunter-gatherers dispersed from areas like the Matopos hills once early farming communities established about 2000 years ago. At the Malilangwe Trust, Later Stone Age materials were collected at Induna cave. On the basis of artifacts found at Gokomere Eastern Cave, Walker (1993) speculated that hunter-gatherer occupation continued until as recent as 200-300 years ago.

Dornan (1917), who was the first to report on hunter-gatherer peoples known as "Masarwas" in the southeastern Lowveld of Zimbabwe, mentions that few of these "Masarwas" or Bushman still inhabited the Sabi districts in the early 1900s (Figure 2.3). However, ceramic evidence and radiocarbon dating from excavations at Dombozanga and Mtanye suggest that hunter-gatherers survived as distinct groups amongst farming communities as recent as the fifteenth century (Throp, 2005).

Figure 2.3: Bushman paintings recently discovered on Sango Ranch.

Pottery dating back from the sixth and seventh centuries (Huffman, 1976) has been collected at Gokomere and is thought to represent the earliest settlement of farming communities in the region (Throp, 1995). Findings of pottery from the subsequent Coronation phase, which is thought to date between the seventh and ninth centuries (Huffman, 1976), suggest that human occupation of this phase could have stretched from Gokomere to as far down as the Malilangwe Trust (Throp, 2005). During this period, the southeastern Lowveld was occupied by the Kalundu Tradition, originating from Angola during the third century, and the Urewe Tradition, from East Africa at roughly the same time period (Throp, 2005).

Stone-walled settlements, currently attributed to the Zimbabwe Tradition, date back to the period between the thirteenth and fifteenth centuries. Three stone-walled sites of this nature were recorded by Burrett (unpublished) within the SVC (Throp, 2005).

Bannerman (1981) writes that Hlengwe people from Sol Do Save in Mozambique advanced into the southeastern Lowveld of Zimbabwe during the eighteenth century. They followed the river valleys of the Save, Runde, Chiredzi and Mutirikwi. The expansion of the Hlengwe northwards affected several Shona speaking groupings of which the Duma Confederacy of Shona people were most dramatic. The Duma Confederacy stretched from the middle Save River in the east beyond the Mutirikwi River in the west, and from the Devure River in the north to the Lowveld fringes in the south (Beach, 1994).

During the early nineteenth century, Nxaba with his followers known as the Gaza Nguni moved from KwaZulu-Natal into the southeastern Lowveld of Zimbabwe and in 1827 finally settled along the Save River amongst Ndau speaking people in Sanga (Beach, 1980). In 1836, Nxaba was expelled by the Gaza Nguni under Shoshangane. Although Shoshangane moved back to Bilene in 1938, Shoshangane's Gaza kingdom stretched from the Nkomati River in the south to the Zambezi River in the north and although most of his kingdom falls within Mozambique it is believed that the southeastern Lowveld of Zimbabwe fell under its sphere of influence until 1895. Mzila, son of Shoshangane, returned in 1862 to the highlands of Espungabera from southern Mozambique. Ngungunyane, the son of Mzila, stayed until 1889 when he returned with many of Tsovani's and Mahenye's Hlengwe speaking people to Bilene (Bannerman, 1981).

However, Throp (2005) states that the sequences of events are still not clearly established and he is currently preparing a more detailed description of events in the southeastern Lowveld of Zimbabwe especially since the ninth century AD.

Peters (1902 in Swift, 1962) mentions that the Shangaan people worked copper extensively to within 50 years of himself laying copper claims in the vicinity of Rupisi Hot Springs in 1900. He stated that the Shangaan people discontinued mining the metal as a result of Matabele raids into the area. The Umkondo mines were pegged in 1899 and can be viewed as the first European involvement in the area known as the SVC (Swift, 1962).

2.2.2 *Cattle ranching in the Save Valley (1920-1992)*

Despite early traders and hunters, human impact until the 1920s in the Save Valley remained virtually nonexistent with only the Umkondo mine and a few transport footpaths that tell a tale of the presence of modern man. In 1918, Lucas Bridges accompanied by Ally Hammond visited the Save Valley with the intention of buying a large piece of land from the British South African Company. The establishment of Devuli Ranch (Figure 2.4) in 1920 and Angus Ranch shortly afterwards marked an end to an era of complete wilderness and the start of considerable changes in the Save Valley (Somerville, 1976).

From the outset the objective of these landowners was primarily to farm with cattle. No time was wasted to develop this wild country and by the end of 1921, Devuli already had some 5 185 head of cattle in stock (Somerville, 1976). Roads were cut, fences erected and an everlasting "battle" ensued against the wildlife, especially against all predators. The first development phase ended in 1925 and by this time cattle numbers exceeded 23 000, section houses were in place, fences erected and roads cut. Wildlife was still plentiful and was regarded as a good source of meat and rations for the staff.

The eight years following 1925 marked an era of depression, droughts and outbreaks of foot and mouth disease. Cattle prices dipped to an all time low, whilst drought killed cattle and veterinary restrictions prevented any movement of cattle. Similar conditions were to be repeated almost four times before the turn of the century. All development on Devuli Ranch and the neighbouring Angus Ranch came to a grinding halt with management kept to a bare minimum. Despite these troubled times, cattle ranching remained the preferred land use option in the region and Humani Ranch was established in 1934. The remainder of land within the Save Valley was still state or crown land.

After the depression and the drought had eased their grip by the end of 1934 serious attempts were made to expand grazing areas for cattle. Several small dams were constructed and boreholes drilled. However, the toll of the depression and an outbreak of *Theileriosis* saw the demise of Angus Ranch in 1938 and it was sold to a cattle slaughter facility in Bulawayo. More fences were erected with the focus on development and the recovery of earlier developments that became neglected during the hard times. Then in 1939, World War II broke out with all ranches having to rely on skeleton staff once again. Italian prisoners of war were employed to assist in the daily running of the ranches. The war lasted from 1939 to 1945 and during the latter parts of the war Angus Ranch was sold to Devuli Ranching Company. After the war, the 1947 drought and disease amongst cattle once again resulted in severe stock losses (Somerville, 1976).

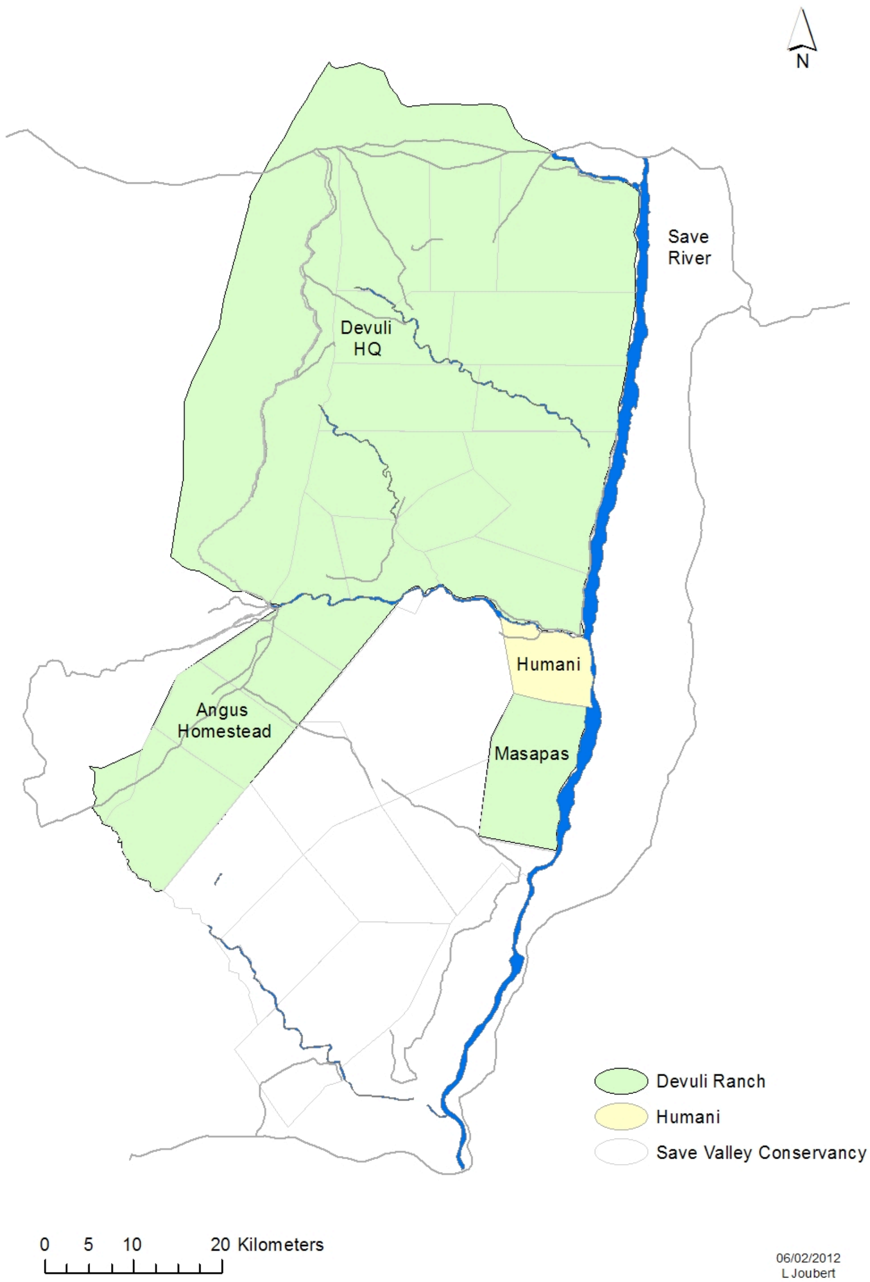


Figure 2.4: Map showing the early settlements in the area that comprises the Save Valley Conservancy.

Despite all these setbacks Devuli Ranch had recovered since the depression and the daily concerns were all cattle related. Cattle prices soared to new heights after the war from 1948 and continued to rise throughout the 1950s. Cattle ranching became more lucrative in the Save Valley and consequently more ranches were established in the Lowveld. The 1950s were regarded as the years of development and expansion. More cattle were purchased and the number of cattle on Devuli Ranch grew to above 28 000. Cattle numbers remained high for the next 21 years and were never lower than 23 000 head up until 1971. This high number of cattle soon impacted on the vegetation and, after threats to declare Devuli Ranch the worst managed ranch in Rhodesia, by 1968 Devuli Ranch entered into an agreement with the Natural Resources Board.

In June 1971, a Board of External Executive Directors was formed to carry the development of Devuli Ranch forward. One of the board's first objectives was to reduce the cattle numbers in order to restore areas that had been severely affected by overgrazing (61st Board meeting, Devuli Ranch). At the time the worst affected areas surrounded perennial watercourses and dams. To relieve pressure on previously overstocked areas the need arose to develop the ranch by:

a. opening alternative watering points to distribute grazing pressure more evenly across the ranch,
b. erecting more fences to control cattle movement and
c. reducing cattle numbers.

Cattle numbers were reduced to just under 20 000 by the end of 1972 with the reduction process fueled by the pending drought and frequent outbreaks of foot and mouth disease. Measures were put into place to reduce cattle grazing in the proximity of perennial water during the wet season. A section of Devuli Ranch had been paddock fenced by the end of 1971 and set aside to implement a rotational grazing scheme. This rotational grazing scheme yielded superior beef production and set the tone for the later development (61st Board meeting, Devuli Ranch). Angus and Masapas ranches were the first to be developed and were divided into approximately 5000-acre paddocks with each paddock supplied by an artificial waterpoint. The Turgwe and Save rivers supplied water through a series of pipelines to these artificial waterpoints. The new developments enabled Devuli Ranch once again to build up cattle numbers. Cattle numbers reached 24 000 head of cattle by the end of 1974.

By 1975 just as the development of Angus and Masapas ranches neared completion and plans instated for the development of the Devuli Ranch main block, the Rhodesian Bush War flared up. Cattle abductions were the order of the day, whilst security matters replaced every day cattle farming issues (68th Board meeting, Devuli Ranch). The effects of the war were disastrous for cattle ranching and by the end of 1979 Devuli Ranch was left with 5 280 head of cattle. Adding to the woes was the regular outbreak of foot and mouth disease with quarantine restrictions preventing any cattle movements and for a second time Devuli Ranch was faced with possible closure.

A newly elected government in 1981 brought about its own challenges but at the same time also some stability to the country. Devuli Ranch, now in financial trouble, seriously reviewed its future. Development plans, drawn up during the 1970s, had to be revised and adapted to suite the current state of affairs.

The lack of sufficient funds and the new government's land redistribution policy gave the board no option but to sell a large piece of Devuli Ranch land for resettlement in 1982. Development thereafter focused on the main Devuli block leaving the now devastated Angus and Masapas ranches from the development planning. Funds derived from the sale of land were poured into this new development scheme and by the end of 1983, the first phase was completed. However, the 1982/83 drought was taking its toll and Devuli was once again forced to send thousands of cattle to feedlots across the country. Phase II of the development scheme was completed at the end of 1984 and cattle ranching on Devuli Ranch was seemingly on track. However, the 1980s were characterized by low rainfall and by 1989 attention turned to wildlife. The 1992 drought was the final nail in the coffin for cattle ranching in the Save Valley and brought an end to 72 years of cattle ranching.

2.2.3 *The Save Valley Conservancy (1991-2011)*

Initial proposals for the formation of what is known today as the Save Valley Conservancy, date back as far as 1989 (du Toit, 1989). However, several individual ranches within the current SVC had already started experimenting with wildlife as an alternative and/or complementary source of income.

In 1989, proposals were drawn up to form what would have been known as the Save Valley Intensive Conservation Area. The initial focus of the proposal was to create a single large wildlife area especially for the re-establishment of endangered species and species that had been overexploited in the past. Cattle ranching would still remain the primary land use option with wildlife an additional source of income.

The formation of the Save Valley Conservancy came in June 1991 with the signing of the first constitution by the various members. However, the following 1991/1992 rainy season proved to be the driest season ever recorded. The drought proved to be a deciding factor for the landowners of the Save Valley Conservancy to determine the future land use. At a workshop held in November 1992 a decision was taken that wildlife would be the primary land use option and that all cattle still owned within the conservancy would be disposed of.

Members of the Save Valley Conservancy were then faced with new challenges and priorities. These included the translocation and release of wildlife into the Save Valley Conservancy, the removal of all internal fencing, the erection of a common perimeter fence and security.

Species that had already been released prior to June 1991 were black rhinoceros, Livingston's eland, African elephant, giraffe, nyala, sable antelope, waterbuck, blue wildebeest and Burchell's zebra. Animal species relocated into the SVC since signing the constitution in June 1991 include black rhinoceros, African buffalo, African elephant, Livingston's eland, giraffe, nyala, sable antelope, spotted hyena, tsessebe, lion, Lichtenstein's hartebeest, warthog, waterbuck, blue wildebeest and Burchell's zebra with African buffalo being the priority species.

With African buffalo earmarked as the priority species it became imperative that a standardized veterinary approved perimeter fence be erected. The perimeter fencing started in May 1992 and was finally completed in March 1995. At the same time all internal cattle fences were removed.

In the formative years security matters dealt largely with the protection of black rhinoceros with the SVC having a small, centralized anti-poaching unit. This soon expanded to general anti-poaching operations. Communication between members within the SVC became a necessity and in March 1993 the first radio repeater station was installed. Shotguns were issued to staff and all scouts either underwent police training or were registered with the police.

In conjunction with all of the above a feasibility study was undertaken by Price Waterhouse (Du Toit & Price Waterhouse, 1994) and completed by July 1994. The primary objective of the feasibility study was to compare different land use options and to investigate the possibility of new land use options within the southeastern Lowveld of Zimbabwe.

In 1995, the Angus Ranch land claim marked the end of what could be viewed as the conservancy's foundation years. By this time the Save Valley Conservancy concept had already created interest at both national and international level.

During the next five years, 1995 to 2000, a loan agreement was reached with the International Monetary Fund (IMF) primarily for re-stocking the SVC with wildlife. Table 2.1 provides detail of the number of animals brought into the SVC. In addition, partnership agreements with local communities and the implementation of the veterinary fence dictated everyday events. In 1997, the first community based joint partnership proposals were tabled by the SVC or individual members of the SVC to the Government of Zimbabwe. However, in 2000, the Save Valley Conservancy recorded the highest rainfall to date with extensive damage caused to the veterinary fence. All efforts were consequently directed to re-erect the fence and by March 2000 the fence neared completion.

However, March 2000 was also set aside for an election that would change the course of Zimbabwe from a progressive state to another failed African state. At the time, a referendum was called by the ruling party, Zanu-PF, to implement constitutional changes. The opposition party, MDC, who had gained 70% of the support against any constitutional changes, opposed these constitutional changes. This in turn sparked a nationwide land-grab campaign by the ruling Zanu-PF party in an attempt to reclaim power before the upcoming May 2000 presidential election. The land-grab campaign was executed under the banner of the "landless blacks".

Table 2.1: Species and the number of animals per species re-introduced into the Save Valley Conservancy, Zimbabwe

Animal Species	Number Of Animals Re-introduced			
	Prior to October 1993	November 1993 to December 1999	January 2000 to December 2002	January 2003 to present
African buffalo (*Syncerus caffer*)	91	88	253	40
African elephant (*Loxodonta africana*)	624	-	-	-
Black rhinoceros (*Diceros bicornis*)	-	31	-	-
Blue wildebeest (*Connochaetes taurinus*)	223	525	49	-
Burchell's zebra (*Equus burchellii*)	17	309	66	-
Giraffe (*Giraffa camelopardalis*)	36	101	44	-
Lichtenstein's hartebeest (*Alcelaphus lichtensteinii*)	-	-	-	28
Livingston's eland (*Tragelaphus oryx*)	215	263	102	-
Nyala (*Tragelaphus angasii*)	22	43	11	26
Lion (*Panthera leo*)	-	-	-	10
Spotted hyena (*Crocuta crocuta*)	-	-	-	3
Ostrich (*Struthio camelis*)	-	-	71	-
Sable antelope (*Hippotragus niger*)	49	203	122	-
Tsessebe (*Damaliscus lunatus*)	-	97	-	-
Warthog (*Phacochoerus aethiopicus*)	-	207	-	-
Waterbuck (*Kobus ellipsiprymnus*)	177	66	82	32
White rhinoceros (*Cerathotherium simum*)	-	-	-	20

The consequences of the "land-grab" action were devastating to wildlife on a national scale as well as for the SVC. The wildlife industry and ecotourism industry collapsed over-night. Sport hunting and trophy hunting became the only economically viable land use options and remained the only tangible source of income to the landowners of the SVC.

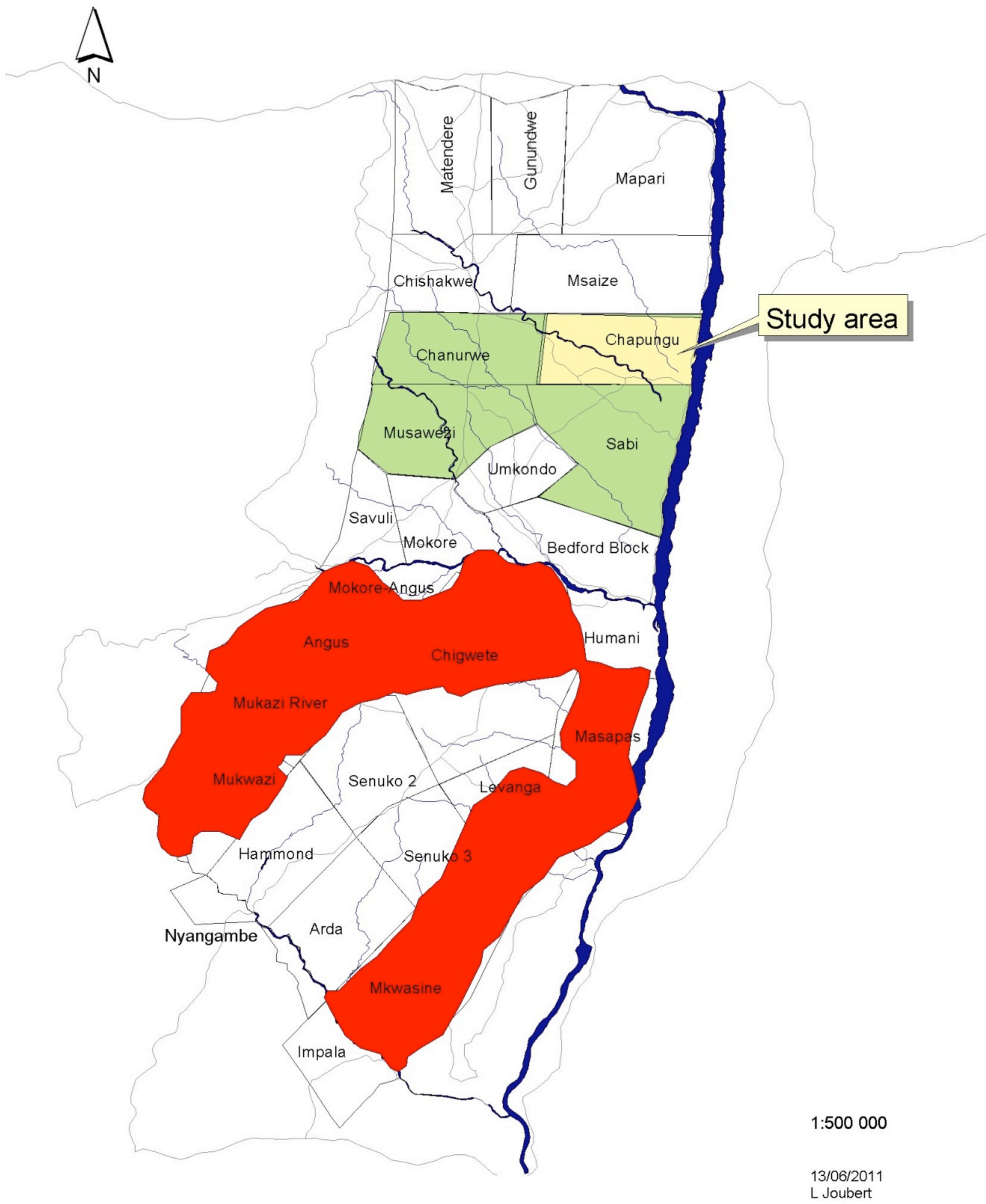


Figure 2.5: Location of the properties within the Save Valley Conservancy that remain invaded by illegal settlement since April 2000 (red), Sango Ranch (green) and Chapungu Ranch (yellow).

In April 2000, Angus, Bedford Block, Chigwete, Masapas, Mkwasine, Mokore-Angus, Mukazi, Mukwazi and Sango ranches were invaded by these illegal settlers. By July 2000 all illegal settlers were moved from Sango Ranch and Bedford Block Ranch. Angus, Chigwete, Masapas, Mkwasine, Mokore-Angus, Mukazi and Mukwazi ranches are currently still invaded. Figure 2.5 indicates the areas that remain invaded by illegal settlement in relation to the position of the study area. Few wild animals exist today in these areas, whilst large tracks of land have been cleared for subsistence farming.

The years following April 2000 to the present day were marked by insecurity, indiscriminate killing of wildlife and the destruction of the veterinary fences, high inflation rates that in turn caused serious personal losses to landowners and many job losses to the local people.

Nevertheless, despite all the negativity associated with the political upheaval, the properties north of the Turgwe River remained largely intact with wildlife populations still occurring in large numbers on these non-invaded properties.

2.3 Geology

Due to its copper and coal deposits, the Save Valley was extensively surveyed geologically (Broderick, 1997). Swift (1962) reported that Bradley's Copper was pegged in 1899 and resulted in several geological papers and maps being produced such as those by Mennell in 1920 and 1938, Thiele in 1924, Maufe in 1921, Phaup and Amm in 1935, the Victoria Prospecting Company in 1933, the Messina Transvaal Development Co. Limited in 1951. Hin (2000) further reported studies by Leitner in 1968, JCI Limited in 1971, Messina (Rhodesia) Development Company in 1973, Broderick in 1987 and Brandl in 1992. Hin (2000) adapted maps produced by Brandl in 1992 and Broderick (1997) to describe the geology of Sango Ranch.

Swift (1962) tabled the major geological formations that cover the Save Valley Conservancy as follows:

- the recent formations of calcareous tufa and alluvium,
- two ring-complexes consisting of igneous rocks,
- the Karoo System consisting mainly of sandstone, intrusive igneous rocks (dolerite) and, a second sandstone formation referred to as the Mapari Series,
- the Umkondo System that includes basic lava, shale, arkose and limestone and
- older Precambrian groups of paragneiss, gneiss, schist and granite.

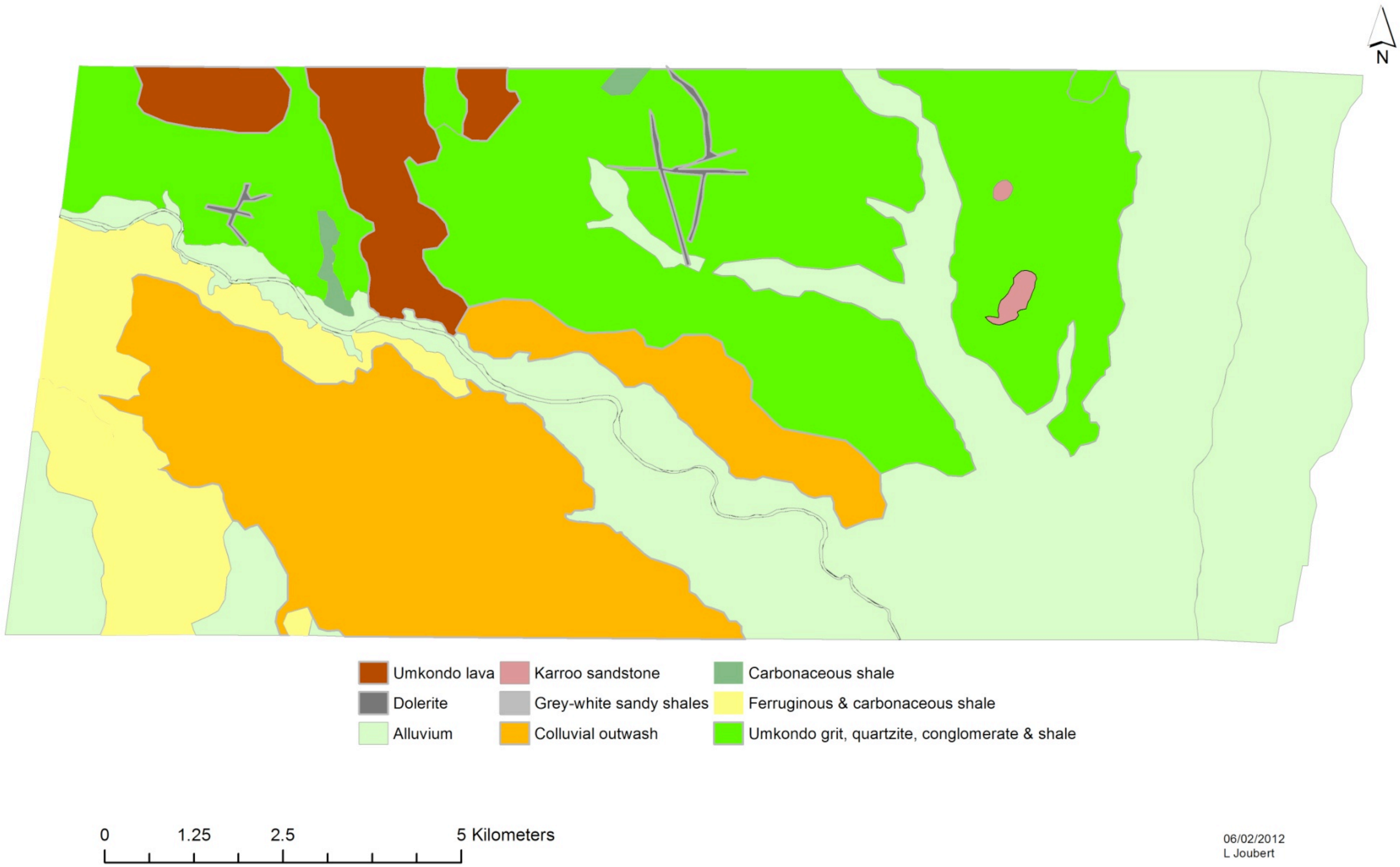


Figure 2.6: The geology of Chapungu Ranch, Save Valley Conservancy, Zimbabwe.

The geological features on Chapungu Ranch fall entirely within the Karoo Basin that includes the Karoo System, the Umkondo System, dolerite intrusions and recent alluvial deposits (Figure 2.6). The term "Karoo" was extrapolated from the main Karoo Basin of South Africa to describe all other basins with sedimentary fills of similar age across Gondwana (Catuneanu *et al.*, 2005). A lithographic sequence of the Save Karoo Basin is illustrated in Figure 2.7 and was adapted from Catuneanu *et al.* (2005).

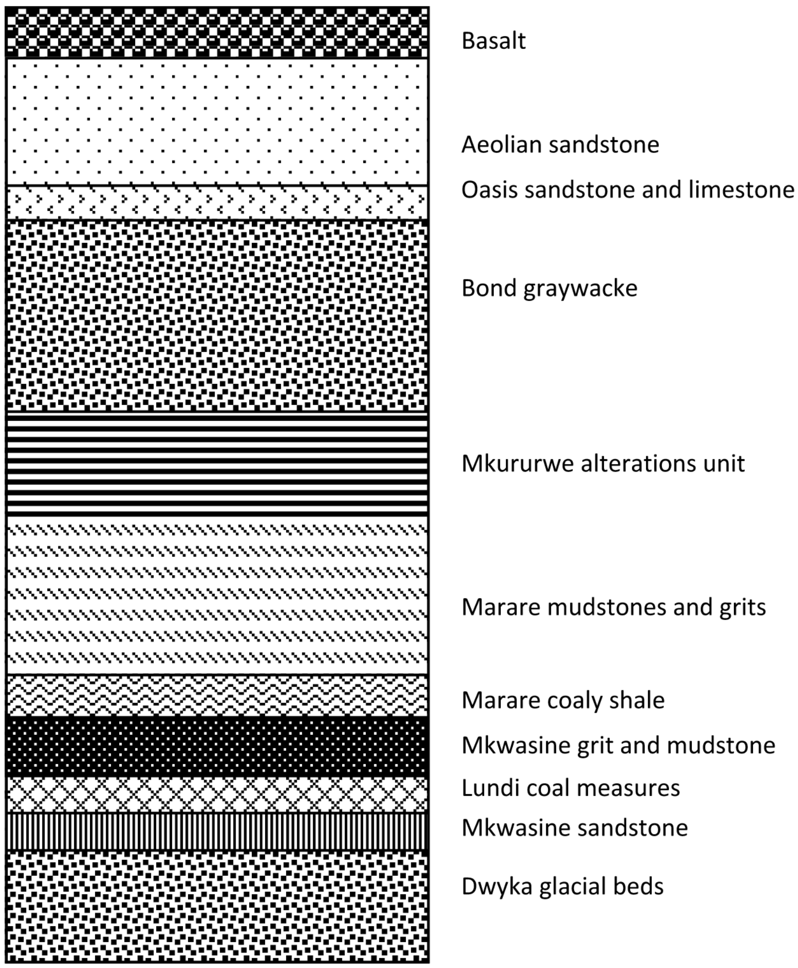


Figure 2.7: A simplified diagram of the lithostratigraphic sequence of the Save Karoo Basin Group (adapted from Catuneanu *et al.,* 2005).

The Umkondo System is the most complex geological feature on Chapungu Ranch and represents the oldest surface rocks on the map. Initially rocks of the basement complex were granitized and eroded to a very regular peneplain. The rocks of the Umkondo System were laid upon this regular peneplain after it was submerged under a shallow sea. The rocks of this system are all sedimentary with the exclusion of an overlaying layer of basic lavas. The Umkondo System can be described by three series:

- The Volcanic Series which is mostly basalt,
- Arenaceous Series including the sandstones, quartzites and shales, and
- The Calcareous Series with limestones, marl and arkose.

The arkose at the base of the Umkondo System is composed of sediments of local granite, pink feldspar, grey quartz and mica. The arkose bed is overlain by a layer of lower limestone and is separated from the upper limestone by the marl group. The marl group separating the lower and upper limestones consists of marls, thin limestone lenses and shales. Limestone often shows an oolitic texture and the arenaceous layer succeeding the limestones is frequently ripple-marked indicating shallow-water deposition throughout the Umkondo System. The arenaceous layer consists largely of feldspathic sandstones and quartzites but these are devoid of feldspars. Mudstones also occur in the sequence but are irregular in distribution. The basalt lavas are basic andesites and form the top layer of the Umkondo System. Intrusions of dolerite dykes into the Umkondo System are enormous and are mainly within the Calcareous Series (Swift, 1962).

The Karoo System overlies the Umkondo System and is recognized by the yellow, dune bedded sandstone on top of Chisangaurwe and Chawiwi hills (Swift, 1962).

Large parts of the property are covered with alluvial and colluvial deposits.

2.4 Climate

Zimbabwe is classified into two climate zones (a) a tropical climate zone that includes the low-lying areas bordering the Zambezi and the Limpopo valleys and (b) the sub-tropical zone that reigns over the uplands. The climate is continental as the nearest coastline is approximately 320 km from the eastern border of Zimbabwe (Vincent *et al*., 1958a & b).

The most frequently used climate classification for describing a climate zone is the Koppen-Geiger classification of Wladimir Köppen updated by Geiger in 1961 (Ketteck *et al.,* 2006). This method is based on precipitation and temperature. According to the Köppen-Geiger climate map the region of the Save Valley Conservancy falls within the hot, arid steppe climate zone (BSh) (Ketteck *et al.,* 2006) which implies that the climate of the SVC is a dry climate or desert where the annual evaporation is higher than the precipitation, the annual rainfall is between 380 and 760 mm and the annual mean temperature is above 18°C.

Swift (1962) describes the climate of the southeastern Lowveld as being arid and hot. Based on rainfall the climate of a single year is divided into a dry season and a wet season, but when temperature is also taken into account four seasons are distinguished (Vincent *et al*., 1958a). These four seasons are the hot season, the main rainy season, the post-rainy season and the cold season.

The hot season, which normally includes middle August, September, October and November, is characterized by high day temperatures. The onset of the hot season is marked by a rapid rise of day temperature and may start towards the middle of August with October usually being the hottest. At the beginning of the hot season humidity is low, but as the season progresses there is a steady increase of air moisture that may result in the occasional thunderstorm. The probability of thunderstorms increases towards the end of the season, in November, but high temperatures predominate. The hot season is also characterized by the wind regime which is rarely steady in direction and strength (Vincent *et al*., 1958a).

The main rainy season commences towards the end of November with no abrupt transition from the previous season. The season is characterized by increased cloudiness with more general rains. The rains are often convective and the distribution patchy. The day temperatures are lower than the day temperatures of the hot season but the night temperatures are as high and often higher due to the higher humidity associated with this season. Winds are normally light, but heavy squalls can occur during thunderstorms. Occasionally hail may accompany these thunderstorms. Generally, the main rainy season comes to an end towards the middle of March but like the onset of this season the cessation is unclear and highly variable from one year to the next (Vincent *et al*., 1958a).

The post-rainy season follows the main rainy season and usually lasts for a period of two months. The probability of rains during the post-rainy season decreases steadily and temperatures undergo a seasonal fall.

The cold season follows the post rainy season and usually sets in towards the middle of May and lasts until the middle of August. The temperatures are usually moderate with warm, sunny days and cold nights. Light drizzle and rain occurs occasionally, but rain is abnormal for this time of the year (Vincent *et al*., 1958a). Frost occurs sporadically in the southeastern Lowveld (Taylor, 1994).

2.4.1 *Temperature*

Vincent *et al*. (1958a) report that Lowveld temperatures commonly reach 43.3°C (110°F) in the summer months and fall below 4.4°C (40°F) in the winter months with occasional frost in the Sabi Valley (Farrel, 1968; Taylor, 1994). However, Hin (2000) mentions that the highest temperature recorded over a 26 year period for the Middle Sabi River weather station was 38.6°C and the lowest temperature 7.4°C. Farrel reports (1968) that the mean monthly maximum of the hottest month is below 35°C (95°F), with the absolute maximum 40.6°C (105°F). The mean monthly minimum temperature of the coldest month is 7.8°C (46°F) and the absolute minimum 3.6°C (37°F) (Farrel, 1968). According to Vincent *et al*. (1958a) the annual temperature ranges from 21.1°C (70°F) to 23.8°C (75°F).

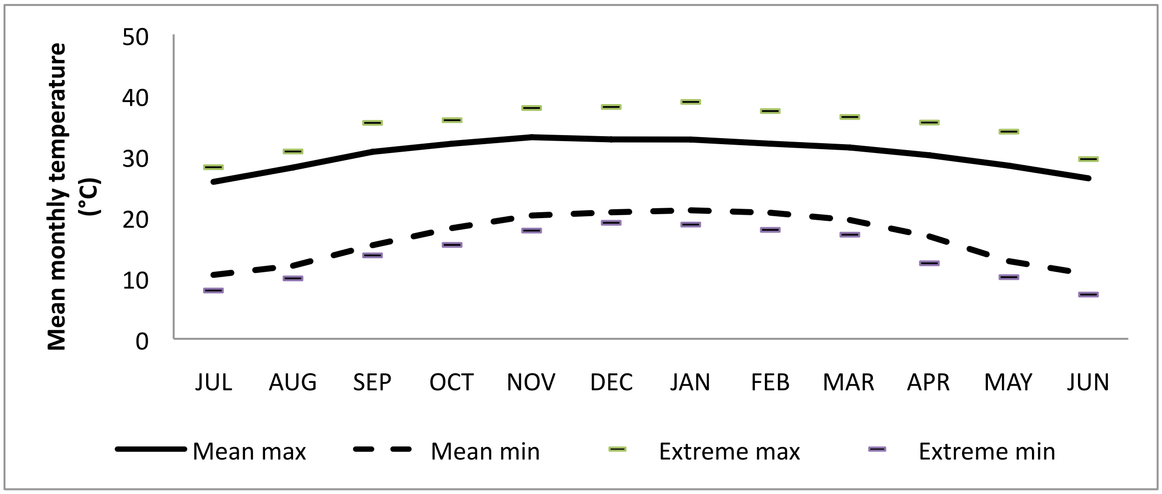


Figure 2.8: Mean monthly maximum and minimum temperatures and extreme maximum and minimum temperatures recorded at Mkwasine weather station for the past 29 years (1980-2009).

Temperatures recorded over the past 29 years at the Mkwasine weather station supports the findings of Hin (2000) with an absolute maximum temperature of 38.9°C and an absolute minimum of 7.3°C (Figures 2.8 & 2.9). The mean monthly maximum temperatures are highest towards the end of the hot, dry season in November (33.1°C) and lowest in the cold, dry month of July (25.8°C). The mean monthly minimum temperatures are highest during the hot wet season in January (21.1°C) and lowest during the cold dry season in July (10.5°C).

The monthly extreme maximum temperatures during the hot season range from 35.6°C to 38.9°C and from 28.2°C to 34.0°C during the cold season. The monthly extreme minimum temperatures during the hot season range from 12.4°C to 19.0°C and from 7.3°C to 10.1°C during the cold season.

2.4.2 *Rainfall*

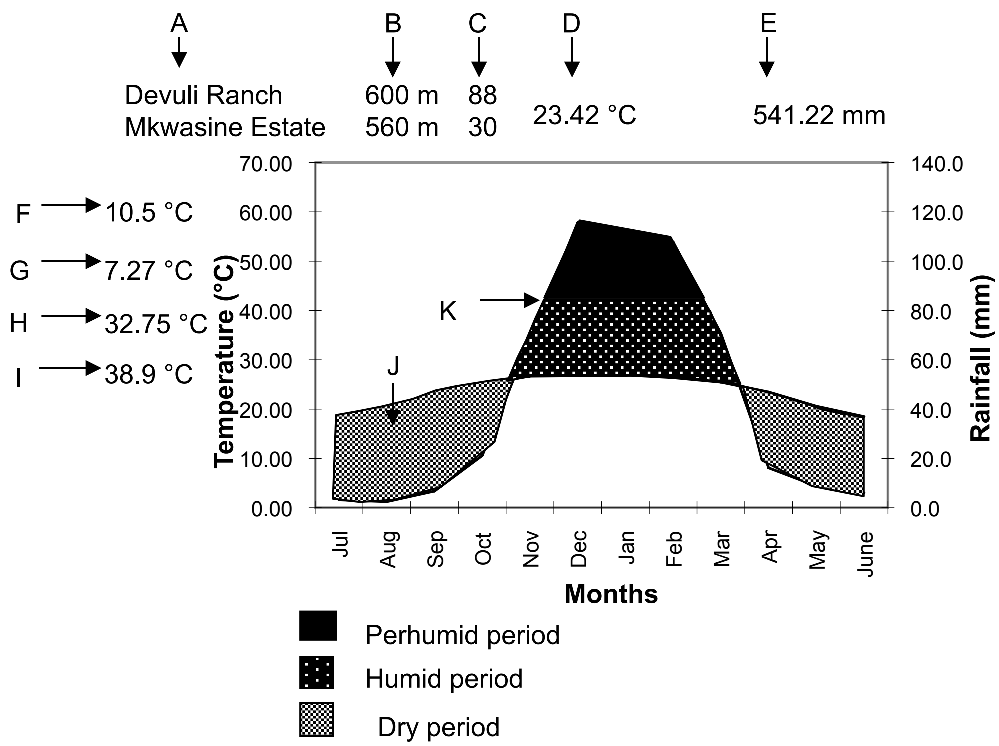
The rainfall of Zimbabwe is characterized by a unimodal rainfall distribution during the summer months (Farrel, 1968). On average, the rainfall received in the Sabi-Limpopo basin is below 500 mm (20 inches) per annum, but due to the high temperatures the effective rainfall drops to below 400 mm (16 inches) per annum (Vincent *et al*., 1958a). Wild (1955) describes the rainfall as being highly variable with annual totals ranging from 50% to 200% of the mean precipitation measured at the Sabi Valley Experimental Station. The wet season is from November to March with 90% to 95% of the annual rainfall received during this period. During the late dry season, cool moist air from the southeast gives rise to slight precipitation accompanied by a marked drop in temperatures.

Hin (2000) reported that the Middle Save River Valley has a mean rainfall of 526 mm per annum measured over a 77 year period. However, the mean rainfall for the Middle Save Valley is highly variable (cv = 30.2%). Lineham (1965) attributes the heavier and more general rainfall during the months November to March to the subtropical high-pressure belt that is situated in a more southerly position than usual. The intense heating of the interior of the continent during October to March periodically draws moist air masses into Zimbabwe. Cold moist air moves into the southeastern Lowveld of Zimbabwe through gaps in the plateau edge, mainly the Limpopo River Valley (Lineham, 1965).

The climate for the northern part of the Save Valley Conservancy is summarized below in the form of a climatogram (Figure 2.9). The mean rainfall for the period 1922 to 2009 was 541 mm per annum, but it is highly variable (cv = 31.7%). The majority of rainfall is received during the months of December to February, but the rainy season starts from the middle of November and lasts until the end of March.

The highest rainfall year, with a total of 998 mm, was recorded during the 1999/2000 rainy season. The highest monthly rainfall occurred during cyclone Eileen in February 2000 with a total precipitation of 473.8 mm. The lowest recorded rainfall season was during the 1991/1992 rainy season with a total of 156.5 mm.

Hin (2000) presented a rainfall oscillation model based on a polynomial regression and Figure 2.10 below is a continuation of the same model. The polynomial regression proved only useful as a broad indication (R^2 = 0.007, P = 0.538) of the rainfall cycles, whilst the 3-year moving average reflected the peak and trough periods of water availability to animals and plants.



A = weather station
B = altitude (m)
C = duration of observations in years for rainfall and temperatures 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 2.9: Climatogram for the northern parts of the Save Valley Conservancy, Zimbabwe. Rainfall data derived from the Devuli Ranch Headquaters rainfall station (Latitude S20°07’49.2”, Longitude E32°06’12.7”, Altitude 594 m) from 1922 to 2009. Temperature data obtained from the Mkwasine Estate weather station (Latitude S20°50’25.3”, Longitude E31°53’26.2”, Altitude 464 m) for the period 1980-2009.

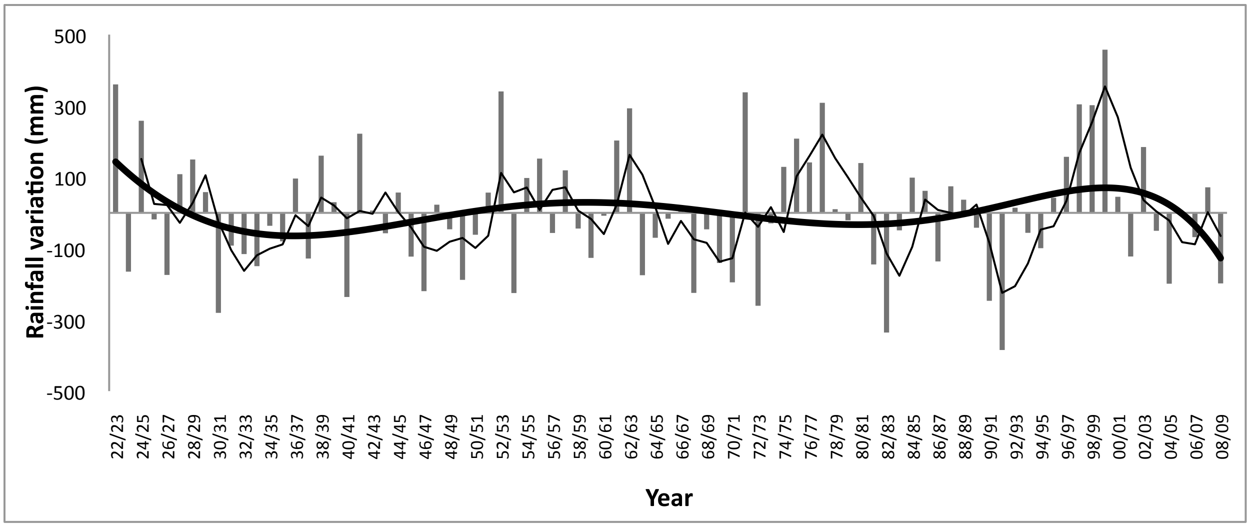


Figure 2.10: Rainfall oscillation cycles and 3-year moving average cycles for the period 1922 to 2009 (Devuli Headquaters rainfall station).

2.4.3 *Humidity and evaporation*

Humidity refers to the moisture in the air. It is particularly important as it also affects soil moisture content. When the soil moisture content is higher than the moisture content of the atmosphere there is a general tendency that the water will evaporate into the air (FAO Corporate Document undated).

The mean relative humidity ranges from a mean of 59.1% recorded in September, which is at the onset of the hot, dry season, to 75.4% recorded in March at the transition between the main rainy and post-rainy seasons (Figure 2.11).

Allen *et al.* (1998) define evaporation as the process through which liquid water is converted to water vapour and removed from the evaporating surface. The annual evaporation measured at the Mkwasine weather station is 1 677.3 mm and exceeds the annual precipitation of 541.2 mm by 1136.1 mm per annum. The daily evaporation rate is highest in the hot and dry months of October and November and lowest in the cold, dry months of May, June and July (Figure 2.12).

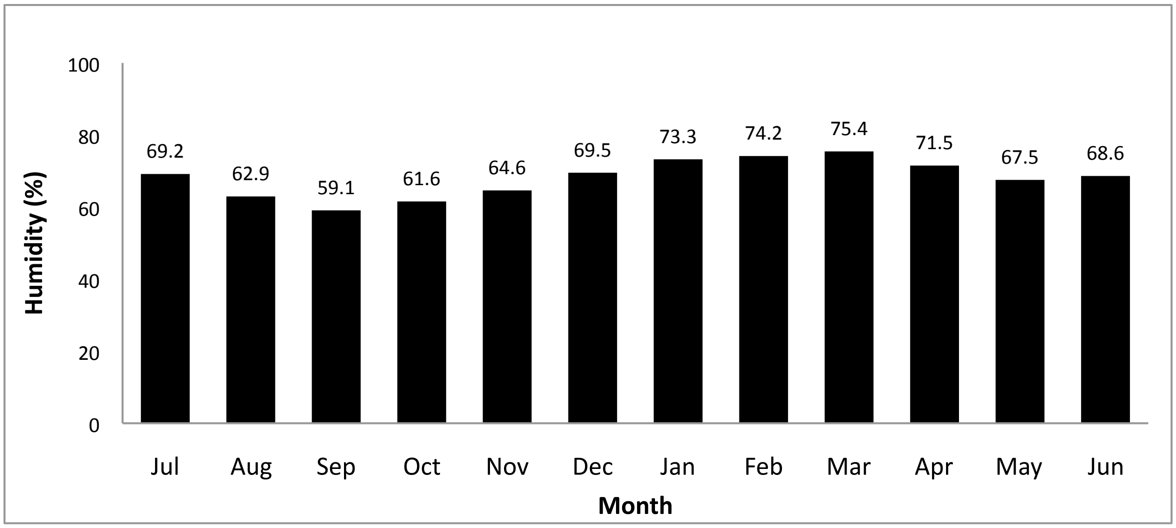


Figure 2.11: Mean relative humidity recorded for Mkwasine Weather Station from 1988 to 2009.

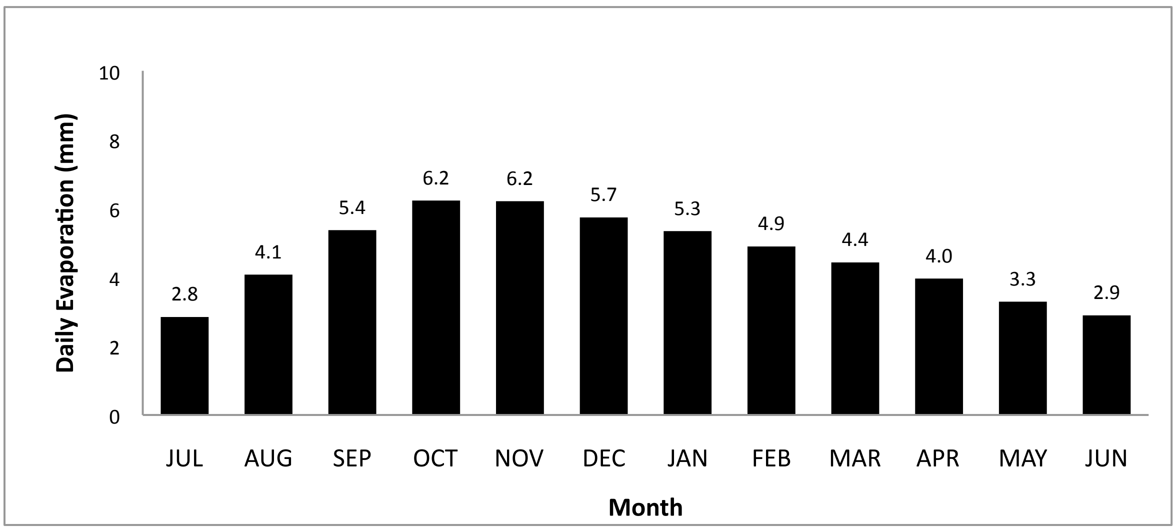


Figure 2.12: The mean daily evaporation rate recorded at Mkwasine weather station for the period 1988 to 2009.

2.5 Soils

Parent material, climate, topography, the catena and biotic components are the five interdependent factors that govern soil formation in Zimbabwe (Nyamapfene, 1991; Thompson, 1965).

The soils of the Save Valley Conservancy are strongly related to the underlying geology (Du Toit & Price Waterhouse, 1994). Soils derived from the paragneisses, gneisses and granites are mainly shallow, medium-grained siallitic loamy sands. Soils from the mafic paragneisses are more fertile and more heavily textured than the lighter sandier soils of the gneisses and granites. Deep siallitic soils occur on the extensive mid-Save alluvial deposits. The soils found on the Karoo and Umkondo Systems are similar to those on the granites, although usually these soils contain less weatherable minerals and are very shallow in places (Du Toit & Price Waterhouse, 1994). Thompson (1965) identified the soils of the Calcimorphic Order, Kaolinitic Order and Halomorphic Order as the three main soil orders covering the SVC, whilst Hin (2000) identified all four of the soil orders described in Nyamapfene (1991) for Sango Ranch, i.e. Amorphic Order, Calcimorphic Order, Kaolinitic Order and Natric Order.

The soils of the Calcimorphic Order are unleached with large reserves of weatherable minerals, a high base saturation and a clay fraction that is predominantly active (Nyamapfene, 1991). Hin (2000) found that all soils in the Calcimorphic Order fall within the Siallitic Group and are generally high in available phosphorous and relatively unleached with a high base status. These soils are mainly associated with the alluvial deposits found along the major drainage lines and the colluvial deposits from a shallow sea.

The soils of the Amorphic Order are characterized by a low degree of profile development and fall within the Lithosol Group. Soils of the Lithosol Group are mainly associated with the granite and paragneiss geological formations as well as the soils of the Umkondo System (Hin, 2000). These soils are characteristically shallow and have simply not had enough time to develop beyond their present depth.

The soils of the Kaolinitic Order are soils that are moderately to strongly leached. On Sango Ranch Hin (2000) classified all these within the Fersiallitic Group. These soils are also associated with the paragneiss and granite geological formations.

Small patches of soils from the Natric Order are found along the Save River on Sango Ranch (Hin, 2000) and are characterized by high levels of exchangeable sodium (Nyamapfene, 1991).

2.6 Vegetation

Early vegetation classifications of the region classified the low-altitude area into the *Colophospermum mopane* zone (Henkel, 1931; Keay, 1959; Rattray & Wild, 1961; Boughey, 1961; all cited in Farrel, 1968). Boughey (1961 as cited in Farrel, 1968) does, however, distinguish between *Colophospermum mopane* growing on granite, basalt and paragneiss (Farrel, 1968).

The first comprehensive woody vegetation survey and map of the lower Sabi-Lundi Basin was done by Farrel in 1968. The woody vegetation survey conducted by Farrel (1968) included the area that is now Chapungu Ranch. The map produced by Farrel (1968) identified four broad vegetation types for the proposed survey area. These include the *Acacia tortilis* savanna, the *Acacia tortilis – Philenoptera violacea*

(Lonchocarpus capassa) vegetation type, the stunted *Colophospermum mopane* vegetation type and the *Colophospermum mopane – Commiphora mollis* vegetation type.

Du Toit and Price Waterhouse (1994) described the following eight broad vegetation types for the Save Valley Conservancy.

- The mopane open woodland/bushveld/thicket/scrub vegetation occurs mainly in localities where the topsoil is very shallow and has reduced water availability. *Colophospermum mopane* is also found on the alluvial soils flanking drainage lines. The grass cover in this vegetation type is patchy and comprises mainly unproductive, hardy, annual grass species. *Colophospermum mopane* is also found as thickets on vertisols and on dry ridges and slopes of the Umkondo sediments and some granulites.
- The *Acacia – Combretum* open woodland/savanna/bushveld is recognized as an open woodland/savanna with species such as *Acacia nigrescens*, *Acacia tortilis*, *Combretum apiculatum*, *Combretum imberbe, Sclerocarya birrea* and *Albizia harveyi* being the distinctive tree species. The soils that support this vegetation type are often mafic soils overlying paragneisses and gneisses. This vegetation type also supports various palatable browse species such as *Grewia* spp., *Dalbergia melanoxylon*, *Ormocarpum trichocarpum* and *Dichrostachys cinerea*. The grass cover in this vegetation type is often dense with *Urochloa mosambicensis* dominating the grass layer.
- *Acacia tortilis* savanna and thicket are found on old alluvial soils along the major rivers within the Save Valley Conservancy. This vegetation type often comprises tall stands of *Acacia tortilis* within which species such as *Philenoptera violacea*, *Acacia nigrescens*, *Combretum imberbe* are conspicuous. The understory often includes species such as *Albizia anthelmintica*, *Capparis* spp., *Combretum microphyllum*, *Dalbergia arbutifolia* and *Ziziphus mucronata*. The understory varies from open parkland to impenetrable thickets. The vegetation type also includes areas previously disturbed by cultivation where *A. tortilis* forms dense thickets.
- Du Toit and Price Waterhouse (1994) further describe the rivulet vegetation as a distinct vegetation type occurring in narrow bands that extend along the rivulets throughout the Save Valley Conservancy. The rivulet vegetation type is distinguished from vegetation growing on the recent alluvial soils on the basis of species composition in both the top and bottom strata. The rivulet vegetation accommodates species such as *Spirostachys africana*, *Diospyros mespiliformis*, *Combretum imberbe*, *Philenoptera violacea*, *Hippocratea* spp., *Dalbergia arbutifolia*, *Strychnos potatorum*, *Euclea divinorum* and *Gymnosporia senegalensis*.
- The dense riparian forests on the recent alluvial soils are described by Du Toit and Price Waterhouse (1994) as the most diverse vegetation type occurring in the Save Valley Conservancy. *Hyphaene petersiana*, *Kigelia africana*, *Trichilia emetica*, *Combretum imberbe*, *Xanthocercis*

zambesiaca and *Philenoptera violacea* are some of the more common species within this vegetation type.

- The granite kopje vegetation occurs on the many granite hills that occur in the Save Valley Conservancy. A few species associated with this diverse kopje vegetation type include *Brachystegia glaucescens*, *Ficus abutilifolia*, *Ficus tettensis*, *Kirkia acuminata*, *Afzelia quanzensis*, *Entandrophragma caudatum* and *Combretum apiculatum*.
- The *Brachystegia glaucescens* groves are associated with nutrient poor sandy soils and occur towards the south of the study area. Species associated with the *B. glaucescens* groves vegetation type include *B. glaucescens*, *Catunaregam spinosa*, *Monodora junodii*, and *Gardenia resiniflua*.
- The Sandveld open woodland/savanna is also associated with nutrient poor sandy soils and occurs towards the south of the study area. Characteristic trees associated with the sandveld open woodland/savanna are *Terminalia sericea*, *Combretum apiculatum*, *Sclerocarya birrea*, *Strychnos* spp., *Pteleopsis myrtifolia*, *Flacourtia indica* and *Julbernardia globiflora*. Grass cover in this vegetation type is poor.

Although the description of the vegetation types of the Save Valley Conservancy by Du Toit and Price Waterhouse (1994) is at a superficial level, it nevertheless provides a good indication of the broad vegetation types within the study area. Both Farrel (1968) and Du Toit and Price Waterhouse (1994) described only the woody vegetation in the survey area.

Hin (2000) did a comprehensive study of both the woody and the herbaceous vegetation on Sango Ranch. He described nine different plant communities and 16 different subcommunities for Sango Ranch. Since Chapungu shares two boundaries with Sango Ranch, the findings of Hin (2000) are important for the current study not only to determine plant communities but also to achieve a common classification system for the two ranches combined. The nine communities distinguished on Sango Ranch by Hin (2000) were:

- The *Acacia tortilis* subsp. *heteracantha – Urochloa mosambicensis* Tall Closed Woodland is divided into four subcommunities and is found on the floodplain of the Msaize River. The diagnostic woody species is *Acacia tortilis* subsp. *heteracantha* with *Albizia anthelmintica* and *Cadaba termitaria* commonly found.

- The *Colophospermum mopane – Brachiaria deflexa* Short Thicket/ Short Closed Woodland is also divided further into four subcommunities. The diagnostic woody species is *Colophospermum mopane* and it dominates the woody layer in this community.

- The *Combretum apiculatum* subsp. *apiculatum – Colophospermum mopane* Short Closed Woodland is recognized by the presence of *Combretum apiculatum* subsp. *apiculatum,* *Colophospermum mopane, Acacia erubescens, Combretum imberbe, Afzelia quanzensis, Phyllanthus reticulatus, Acacia nigrescens* and *Kirkia acuminata*.

- The *Combretum apiculatum* subsp. *apiculatum – Digitaria milanjiana* Tall Closed Woodland is subdivided into three subcommunities. The woody layer is characterized by the diagnostic *Combretum apiculatum* subsp. *apiculatum* and the dominant *Diospyros quiloensis*.

- The *Millettia usamarensis* subsp. *australis – Brachiaria deflexa* Short Thicket Koppie plant community is associated with the many koppies scattered throughout the western side of Sango Ranch. *Millettia usumarensis* subsp. *australis* is the diagnostic woody species for this community with *Kirkia acuminata*, *Combretum apiculatum* subsp. *apiculatum*, *Grewia gracillima*, *Combretum mossambicense*, *Combretum microphyllum*, *Monodora junodii*, *Markhamia zanzibarica*, *Julbernardia* spp., *Artabotrys brachypetalus*, *Vitex isotjensis*, *Vitex buchananii*, *Diospyros lycioides* subsp. *sericea*, *Stadmannia oppositifolia*, *Mundulea sericea*, *Ficus tettensis*, *Ficus abutilifolia* and *Euphorbia confinalis* the dominant woody species.

- The *Acacia tortilis* subsp. *heteracantha – Panicum maximum* Tall Closed Woodland lies on the western bank of the Save River and is recognized by the diagnostic *Acacia tortilis* subsp. *heteracantha*. Species such as *Grewia inaequilatera*, *Grewia flavescens* var. *flavescens*, *Acacia galpinii*, *Acacia schweinfurthii* and *Dichrostachys cinerea* subsp. *africana* are the dominant woody components in this tall closed woodland.

- The *Dalbergia arbutifolia – Diospyros mespiliformis* High Riverine Forest is located on the banks of the major rivers such as the Save, Makore, Msaize and Saindota, and some smaller rivers and streams. This high riverine forest is subdivided into two subcommunities and is recognized by diagnostic woody species such as *Dalbergia arbutifolia*, *Artabotrys brachypetalus* and *Diospyros mespiliformis*.

- The *Phragmites mauritianus* Tall Closed Reedbeds are situated along the riverbanks and beds of the rivers of Sango Ranch and are dominated by the diagnostic *Phragmites mauritianus*.

- The *Echinochloa colona – Cyperus digitatus* subsp. *auricomus* Tall Open Wetland is divided into two subcommunities with the diagnostic species being *Echinochloa colona* and although there is no diagnostic woody species *Acacia xanthophloea* is common in this plant community (Hin, 2000).

2.7 Animals

Somerville (1976) mentions large concentrations of animals roaming the Save Valley. Species such as African buffalo, bushbuck, bushpig, African elephant, Livingston's eland, common duiker, impala, greater kudu, klipspringer, Lichtenstein's hartebeest, roan antelope, sable antelope, Sharpe's grysbuck, warthog, waterbuck and Burchell's zebra were commonly found throughout the Save Valley. However, during the cattle ranching era, wildlife was regarded as a menace. Not only was wildlife competing for water and forage resources but it was also a carrier of disease and therefore came into conflict with the objectives of the primary land use, namely cattle ranching. Wildlife was systematically eradicated until the late 1970s. In 1975 the Parks and Wildlife act was amended for wildlife occurring outside state protected land. This allowed landowners to utilize wildlife as a form of income (Bond & Cumming, 2006).

In the SVC, Humani Ranch was the first to experiment with wildlife, as an alternative to cattle ranching, as a source of income. In the early 1980s Humani Ranch introduced and re-introduced several wildlife species onto its properties. However, cattle ranching remained the land use of choice until the 1991/1992 drought when the Save Valley Conservancy was formed and wildlife ranching officially replaced cattle ranching.

Black rhinoceros, one of the catalyst species for the formation of the SVC, was also re-introduced. Increased herbivore numbers also meant that carnivores, almost totally eradicated during the cattle ranching era, could move into the SVC.

Today the SVC boasts a healthy population of both herbivore and carnivore populations. Table 2.2 provides the population estimates for the large herbivores in the SVC seen during the 2009 annual aerial survey (Joubert & Joubert, 2009). A population estimate is derived from estimated percentages given by Bothma (1996b) and Joubert (pers comm. 2004[1]). Population estimates for all other herbivores are currently not formally recorded. Population estimates of the large carnivores in the SVC were based on the spoor survey count method described by Stander (1998 cited in Groom, 2009). Table 2.3 provides the carnivore survey results for October 2009. Groom (2009) also reported a population estimate of four cheetah for the total SVC but states that the estimate is in all probability inaccurate because it is based on an insufficient sample size.

[1] Dr S.C.J. Joubert, Flaminklaan 214, Mookogophong, South Africa

Table 2.2: Population estimates for the large herbivore populations in the Save Valley Conservancy

Species	**Percentage of animal population seen %**		**Animals seen during 2009 survey**	**Population Estimate of animals in SVC**	
	Low	**High**	**Actual**	**Low**	**High**
African buffalo	75	95	2 788	2 935	3 717
African elephant	90	100	1 353	1 353	1 503
Black rhinoceros	45	55	40	72	89
Blue wildebeest	79	85	5 365	6 312	6 791
Burchell's zebra	85	124	4 018	3 240	4 727
Livingston's eland	85	100	1 183	1 183	1 392
Giraffe	90	106	703	663	781
Greater kudu	41	65	681	1 048	1 661
Impala	52	55	9 469	17 216	18 210
Sable antelope	80	90	114	127	143
Warthog	12	40	578	1 445	4 817
Waterbuck	85	124	456	368	536
White rhinoceros	90	100	28	28	31

Table 2.3: Population estimates for the large carnivore populations in the Save Valley Conservancy in 2009

Species	Population estimate
Lion	114
Leopard	252
Spotted hyaena	118
Wilddog	95

CHAPTER 3

SOILS

3.1 Introduction

The heterogeneity of the environment determines the distribution and composition of different communities and in terrestrial ecosystems soil and climate are considered the two most important environmental factors influencing the nature and distribution of its communities (Venter, 1990). Soil provides the substrate for sustaining all forms of biota (Joubert, 1992) and in many ways soil or the pedosphere can be described as the link between the components of ecosystems (Venter, 1990). Figure 3.1 was adapted from Venter (1990) and shows the relations between the pedosphere (soil body) and the litho-, hydro-, atmo- and biosphere.

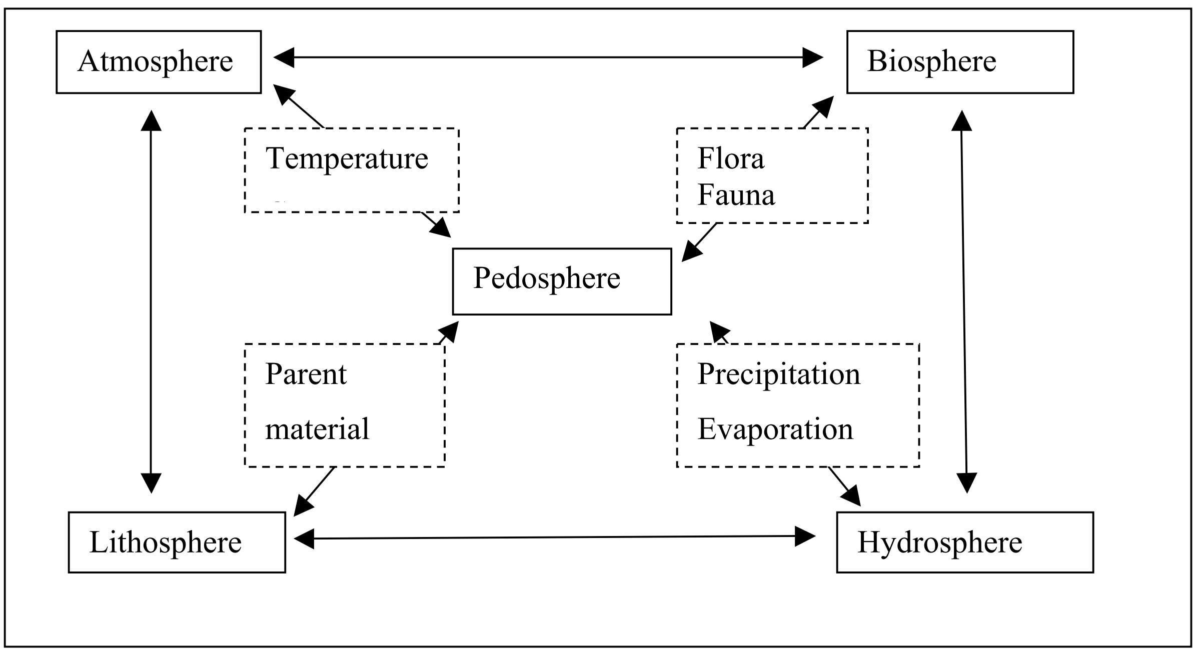


Figure 3.1: The relationship between the pedo-, litho-, atmo-, hydro- and biosphere (adapted from Venter 1990).

A strong correlation exists between the geology of an area and its soils and that relationship often also extends to the biotic communities or more specifically the type of plants occurring on it (Bredenkamp, 1982; Coetzee, 1983, 2005; Corfield, 1993; Du Toit and Price Waterhouse, 1994; Frazer *et al*., 1987; Gertenbach, 1987; Hin, 2000; Knight, 1965; Nyamapfene, 1991; Thompson, 1965; Van Rooyen & Theron, 1989; Venter, 1990; Vincent *et al*., 1958a). It is therefore not uncommon to see geological-, soil- and vegetation maps generally following the same patterns (Du Toit and Price Waterhouse, 1994; Gertenbach, 1987; Hin, 2000; Joubert, 1998; Purchase, 1994; Venter, 1990). Scholes (1990) stated that in dry savanna regions differences in soil fertility have profound effects on the species composition, physiognomy, structure and functioning of the savanna. Differences in soil fertility originate from geological, geomorphological, anthropogenic and/or biotic activity in an area (Scholes, 1990). Different soil types not only dictate the composition of the plant species within an area but also influence the palatability of the vegetation (Geogiardis & McNaughton, 1990). Furthermore, Högberg (1986) demonstrated the interaction between soil nutrient availability and root symbiosis and concluded that it strongly affects the composition of plant communities. Mapaure (1994) found that the silt fraction and total exchangeable bases significantly influenced the natural floristic heterogeneity.

In this study it was therefore important to identify the soils not only for their production and growth potential, but also to assist with the classification, description and mapping of the plant communities and ultimately of the management units. Knowledge of the soil properties is also useful in planning of infrastructure such as the location of pipelines, dams, waterpoints, roads and buildings.

The objectives of the soil survey were to:

- classify, map and describe the soil types of the study area,
- describe the physical and chemical properties of each soil type,
- identify areas with soils that are prone to erosion,
- determine the relationship between soils and vegetation types,
- integrate already existing soil maps from neighbouring areas with the study area.

3.2 Methods

For the sake of continuity the soil classification system used by Hin (2000) was used to describe the soils of Chapungu Ranch. The classification system is based on Thompson (1965, cited in Nyamapfene, 1991), which is commonly used to describe soils in Zimbabwe.

3.2.1 *Sampling procedures*

Sites were selected in a stratified random manner from sites used to describe the natural vegetation. At each selected site a soil profile pit was dug up to 1 200 mm deep or alternatively until the parent rock was reached. Samples of the topsoil and subsoil were taken at each pit and sent to a laboratory where the physical and chemical properties were determined. Samples of the topsoil were collected at depths varying between 0 - 100 mm and were identified to be similar to the diagnostic A-horizon described by Macvicar *et* *al*. (1991). The subsoil was collected at varying depths ranging from 150 – 400 mm and compared with the diagnostic B, C, G or E horizons typically described for the South African soil taxonomic system.

3.2.2 *Classification of soils*

Four taxonomic levels were used to describe the soils in the Zimbabwe system, namely the Order, the Group, the Family and the Series. The four orders namely Amorphic, Calcimorphic, Kaolinitic and Natric are separated on the basis of the degree of development, the degree of leaching and the presence of exchangeable sodium. At group level soils are classified into eight groups on the basis of a detailed analysis of morphological, chemical and mineralogical properties of the soil. The soil family is designated by a numerical symbol that refers to the soil group and an alphabetical symbol indicates the broad nature of the parent material. The series level of the taxonomic classification refers to a place name that is well known and for which climatic data can readily be obtained. A numerical number is also attached to describe the place of the soil on the catena (Nyamapfene 1991). In the current study the soils were only classified up to the family level.

3.2.3 *Physical and chemical analysis*

The following physical properties of the soil were determined in the field,

- geological origin,
- rock sizes,
- soil depth and root depth (Bloem, 1988).

Chemical analyses were done from a mixture of the topsoil and subsoil from each soil profile pit. Where clearly defined boundaries were identified the top and subsoils were analyzed separately. Physical properties determined in the laboratory included soil colour and texture (FSSA, 1974). The laboratory analyses included determining the clay, silt, sand and organic matter fractions, the pH, conductivity, nitrogen, phosphorus and the extractable cations namely potassium, calcium, magnesium and sodium. The cation exchange capacity and percentage exchangeable sodium (ESP) was also determined.

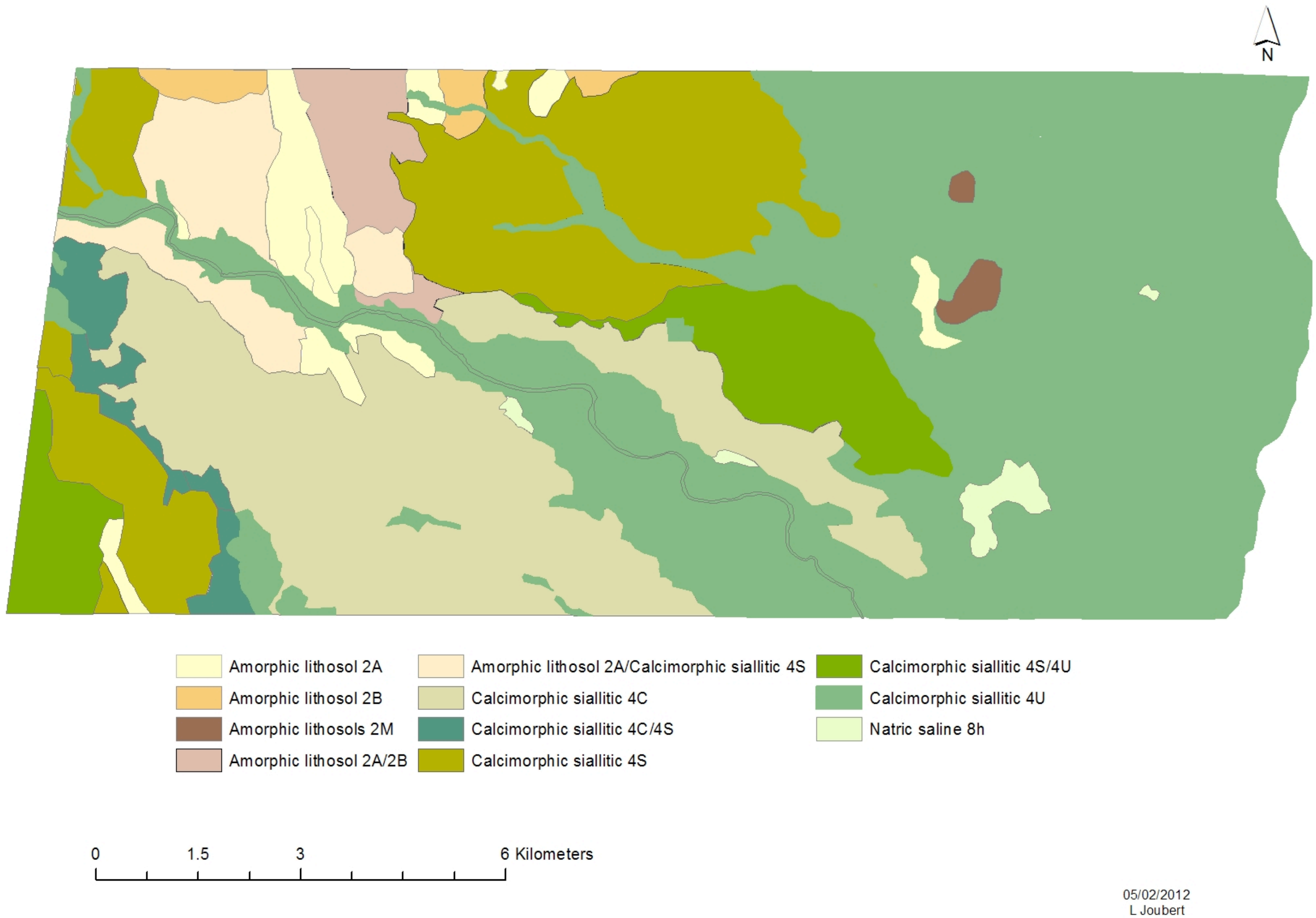


Figure 3.2: Map of the soils on Chapungu Ranch, Save Valley Conservancy.

Table 3.1: The physical and chemical properties of the soils on Chapungu Ranch, Save Valley Conservancy

SOIL ORDER	SOIL GROUP	SOIL FAMILY	MEAN SOIL DEPTH A HORISON	MEAN SOIL DEPTH B HORISON	MEAN SOIL DEPTH PROFILE	ROOT DEPTH	SOIL COLOUR	SOIL TEXTURE
Amorphic	Lithosol	2A	11.5	21.7	112.0	32.0	Brown	Sandy loam to Sandy clay loam
Amorphic	Lithosol	2B	43.0	-	45.0	-	Reddish brown	Sandy clay loam
Amorphic	Lithosol	2M	12.7	-	50.0	-	Yellowish brown	Sandy loam to Sandy clay loam
Calcimorphic	Siallitic	4C	30.6	79.3	150.0	53.3	Light brown - Brown	Loamy sand
Calcimorphic	Siallitic	4S	15.7	76.2	145.0	82.5	Reddish brown	Loamy sand to Sandy clay loam
Calcimorphic	Siallitic	4U	25.5	83.2	147.4	62.9	Light brown - Dark grey	Loamy sand to Sandy clay
Natric	Natric-saline	8h	63.4	93.8	137.1	17.3	Light grey	Loamy sand to Sandy clay

SOIL ORDER	SOIL GROUP	SOIL FAMILY	CLAY FRACTION (%)	SILT FRACTION (%)	SAND FRACTION (%)	Organic Material (%)	pH (1.5 suspension Soil:$CaCl_2$)	MINERAL NITROGEN: INITIAL	MINERAL NITROGEN: AFTER INCUBATION	AVAIL. P205 (ppm Resin Extract)
Amorphic	Lithosol	2A	14.1	10.4	75.5	1.4	6.5	10.8	19.4	55.6
Amorphic	Lithosol	2B	25.0	15.0	60.0	0.9	5.3	10.0	21.5	12.0
Amorphic	Lithosol	2M	17.6	11.2	71.2	1.0	5.0	-	-	103.6
Calcimorphic	Siallitic	4C	16.8	6.8	76.5	0.5	5.5	10.3	19.8	41.0
Calcimorphic	Siallitic	4S	21.7	12.3	66.0	1.3	6.5	10.0	20.6	17.3
Calcimorphic	Siallitic	4U	17.2	9.2	73.7	0.9	6.1	10.8	19.4	71.7
Natric	Natric-saline	8h	23.6	11.3	65.1	0.8	5.7	10.8	19.1	86.9

SOIL ORDER	SOIL GROUP	SOIL FAMILY	EXTRACTABLE CATIONS (m.e.%) K	Ca	Mg	Na	S-VALUE	ESP-VALUE	S/C VALUE	CONDUCTIVITY (microS/cm)
Amorphic	Lithosol	2A	1.0	10.6	2.9	0.3	14.8	2.7	140.5	76.9
Amorphic	Lithosol	2B	0.7	6.0	5.6	0.5	12.7	4.2	51.1	17.0
Amorphic	Lithosol	2M	0.6	1.3	0.6	0.0	2.5	1.8	13.9	68.8
Calcimorphic	Siallitic	4C	0.9	3.8	2.3	0.3	7.3	4.4	98.2	38.5
Calcimorphic	Siallitic	4S	1.1	10.5	3.2	0.3	15.1	2.6	106.5	67.3
Calcimorphic	Siallitic	4U	1.2	6.6	3.3	0.4	11.5	3.7	119.7	70.3
Natric	Natric-saline	8h	0.8	5.5	3.4	1.8	11.5	14.7	69.2	305.2

3.3 Results and Discussion

The soils of Chapungu Ranch comprised three Orders, namely the Amorphic, Calcimorphic and Natric orders. The siallitic soils of the Calcimophic Order dominated the soil on Chapungu Ranch followed by the lithosols from the Amorphic Order with the saline-sodic soils occurring only in small patches throughout the study site. Figure 3.2 illustrates the distribution of soil types on Chapungu Ranch whilst the physical and chemical properties are presented in Table 3.1. A brief description of the soils is provided below whilst Table 3.2 gives a breakdown of the soils found per vegetation community.

3.3.1 *Soils of the Amorphic Order*

All the soils of the Amorphic order displayed poorly developed horizons and were identified as belonging to the lithosol group. Three lithosol family groups were identified which belonged to the 2A, 2B & 2M family groups (Nyamapfene, 1991).

3.3.1.1 Amorphic lithosols 2A

The lithosol of the 2A family group were encountered on the weathered sandstone of the Umkondo System. The soil depth was shallow with a mean depth of 32.2 cm. Weathered rocks were encountered within the first 40 cm of the profile pit but were mostly loose arrangements allowing for good aeration and root penetration. The soil colour was brown.

The soil texture varied from sandy loam to sandy clay loam with a mean ratio of 14.1% clay: 10.4% silt: 75.5% sand. The soils tested slightly acidic (Marx *et al*., 1999) with a pH value of 6.5. The available nitrogen levels for plants (8.6 ppm) were low (<10 ppm) whilst phosphorus quantities were high (40 – 100 ppm). The potassium content was high at 1.4% m.e, high for calcium at 10.6% m.e, high for magnesium at 1.5% m.e and low in sodium at 0.3% m.e. The low salinity of the soil was confirmed with a low exchangeable sodium percentage (ESP = 2.7 %). Electrical conductivity was very low at 0.08 mS/cm^{-1}.

The *Seddera suffruticosa* – *Colophospermum mopane* Closed Woodland and the *Kirkia acuminata* – *Colophospermum mopane* Short Closed Woodland vegetation communities were identified as containing lithosols of the 2A family group.

3.3.1.2 Amorphic lithosols 2B

The lithosols of the 2B family group were associated only with the basalts of the Umkondo System. The soil depth was shallow with a mean depth of 43.0 cm often with hard impenetrable rock present. The soil colour was reddish brown.

The texture of the soil was a sandy clay loam with a mean ratio of 25% clay: 15% silt: 60% sand. The soils were moderately acidic at a pH value of 5.3. The available nitrogen levels (11.5 ppm) for plants were medium (10 – 20 ppm) whilst the phosphorus quantities (12 ppm) were low (<20 ppm). The potassium content was high at 0.7% m.e, medium for calcium at 6.0% m.e, high for magnesium at 5.6% m.e and low for sodium at 0.5% m.e. The ESP value for sodium was also low at 4.2%. The electrical conductivity was very low at 0.02 mS/cm^{-1}.

The plant community associated with the lithosols of the 2B family group was the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland.

3.3.1.3 Amorphic lithosols 2M

The lithosols of the 2M family group were associated only with the sandstone formations from aeolian decent belonging to the Umkondo System. The soil depth was shallow with a mean depth of 12.7 cm often with hard impenetrable rock present. The soil colour was yellowish brown.

The texture of the soil ranged from a sandy loam to a sandy clay loam with a mean ratio of 17.6% clay: 11.2% silt: 71.2% sand. The soils were strongly acidic at a pH value of 5.0. The phosphorus content of the soils (103.6 ppm) were excessively high (>100 ppm). The potassium content was high at 0.6% m.e, low for calcium at 1.3% m.e and low for magnesium at 0.6% m.e. The ESP value for sodium was low at 1.8 %. The electrical conductivity was very low at 0.07 mS/cm^{-1}.

The vegetation community identified on the lithosols of the 2M family group was the *Hibiscus ovalifolius-Albizia brevifolia* Closed Woodland Community.

3.3.2 *Soils of the Calcimorphic Order*

The soils of the Calcimorphic Order on Chapungu Ranch were derived from alluvial deposits that formed asynchyncronously. Ferring (1992) stated that sedimentation only takes place near the stream and is connected to the meandering belt of the stream. As a result of the active accumulation of alluvial deposits within this belt the surface of the floodplain and the stream rises. This is then followed by the breaking of levees and terraces and the development of a new streambed (Alexandrovskiy *et al.,* 2004). Based on the development and the topographical position of the alluvial soils within the Chapungu landscape the soils of the Calcimorphic order were classed into three broad age categories. The alluvial soils which formed as

- colluvial deposits under a shallow sea being the oldest alluvial deposit,
- followed by alluvial deposits of the old meandering belt with no active sedimentation taking place and well developed horizons, referred to as old alluvium and
- alluvial soils within the meandering belt of the streams and rivers on Chapungu Ranch with active sedimentation taking place, referred to as recent alluvium.

On Chapungu Ranch the soils of the Calcimorphic Order comprised soils that were relatively unleached with reserves of weatherable minerals. All the soils from the Calcimorphic Order belonged to the siallitic group and were separated at family level into the 4C, 4S and 4U family groups (Nyamapfene, 1991).

3.3.2.1 Calcimorphic siallitic 4C

The soils of the siallitic group belonging to the 4Cfamily group were associated with the colluvial outwash deposited by a shallow sea. The mean soil depth was 109.9 cm deep but soils often extended deeper than 1.5 m. The soil colour varied from light brown to brown.

The soil texture was a loamy sand with a mean ratio of 16.8% clay: 6.8% silt: 76.5% sand. The soils were moderately acidic with a pH value of 5.5. The available nitrogen (9.5 ppm) was low (<10 ppm) with a high (40 – 100 ppm) phosphorus content (41.0 ppm). The potassium content was high at 0.9% m.e, low for calcium at 3.8% m.e and high for magnesium at 2.3% m.e. The ESP value for sodium was low at 4.4%. The electrical conductivity was very low at 0.04 mS/cm^{-1}.

The *Albizia anthelmintica – Acacia tortilis* Open Woodland was associated with the siallitic soils of the 4C family group. The siallitic soils of the 4C family were often enriched by several nitrogen fixing legumes of the *Crotalaria*, *Indigofera* and *Tephrosia* genera (Nezomba *et al.,* 2008).

3.3.2.2 Calcimorphic siallitic 4S

The soils of the siallitic group belonging to the 4S family group were formed as recent alluvial deposits along the streams originating within the Umkondo System. The mean soil depth was 91.8 cm deep and the soil colour was reddish brown.

The soil texture ranged from a loamy sand to a sandy clay loam with a mean ratio of 21.7% clay: 12.3% silt: 66.0% sand. The soils were slightly acidic with a pH value of 6.5. The available nitrogen (10.6 ppm) was medium (10 – 20 ppm) with a low (<20 ppm) phosphorus content (17.3 ppm). The potassium content was high at 1.1% m.e, high for calcium at 10.5% m.e and high for magnesium at 3.2% m.e. The ESP value for sodium was low at 2.6%. The electrical conductivity was low at 0.07 mS/cm^{-1}.

The *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland associated with the siallitic soils of the 4S family group.

3.3.2.3 Calcimorphic siallitic 4U

The soils of the siallitic group belonging to the 4U family group were associated with alluvial soils on Chapungu Ranch. The soils of the 4U family group were further divided into recent and old alluvial deposits. Recent alluvium of the 4U family fell within the meandering belt of the stream, had a stratified weakly developed structure with active sedimentation still taking place. Old alluvial deposits had a moderate to well developed structure with no active sedimentation and fell beyond the meandering belt of the stream. The mean soil depth was 108.7 cm and the soil colour ranged from light brown to dark grey.

The soil texture ranged from a loamy sand to a sandy clay with a mean ratio of 17.2% clay: 9.2% silt: 73.7% sand. The soils were slightly acidic with a pH value of 6.1. The available nitrogen (8.6 ppm) was low (<10 ppm) with a high (40 – 100 ppm) phosphorus content (71.7 ppm). The potassium content was high at 1.2% m.e, medium for calcium at 6.6% m.e and high for magnesium at 3.3% m.e. The ESP value for sodium was low at 3.7%. The electrical conductivity was low at 0.07 mS/cm^{-1}.

The old alluvial deposits of the siallitic 4U family supported the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland, the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland, the *Albizia anthelmintica – Acacia tortilis* Open Woodland and the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland. Recent alluvial soils of the siallitic 4U family supported the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest and the *Echinochloa colona – Cyperus digitatus* Open Wetland.

3.3.3 *Soils of the Natric Order*

The soils belonging to the Natric Order were identified on alluvial sites where significant amounts of exchangeable sodium were present. All sodic soils on Chapungu Ranch were identified into the saline-sodic soils belonging to the 8h family group (Nyamapfene, 1991).

3.3.3.1 Saline-sodic soils

The soils of the saline-sodic group belonging to the 8h family were associated with alluvial habitats on Chapungu Ranch. The mean soil depth was 157.2 cm deep and the soil colour ranged from light grey to dark grey.

The soil texture ranged from a sandy clay loam to a clay with a mean ratio of 23.6% clay: 11.3% silt: 65.1% sand. The soils were slightly acidic with a pH value of 5.7. The available nitrogen (8.3 ppm) was low (<10 ppm) with a high (40 – 100 ppm) phosphorus content (86.9 ppm). The potassium content was high at 1.2% m.e, medium for calcium at 5.5% m.e and high for magnesium at 3.4% m.e. The ESP value for sodium was high at 14.7%. The electrical conductivity was 0.31 mS/cm^{-1}.

The soils of the saline-sodic 8h family were found in the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland and the *Echinochloa colona – Cyperus digitatus* Open Wetland.

Table 3.2 : The physical and chemical properties of the soils of the different plant communities on Chapungu Ranch, Save Valley Conservancy

PLANT COMMUNITY	SOIL ORDER	SOIL GROUP	SOIL FAMILY	SOIL LAYER	SOIL Colour	SOIL Texture	SOIL Depth
Hibiscus ovalifolius – Albizia brevifolia Closed Woodland	Amorphic	Lithosol	2M	Topsoil	Yellowish brown	Sandy loam to Sandy clay	12.7
				Sub-soil	Brown		
Seddera suffruticosa – Colophospermum mopane Closed Woodland	Amorphic	Lithosol	2A	Topsoil	Brown	Sandy loam	14.0
				Sub-soil	Brown	Sandy loam to Sandy clay	17.5
	Calcimorphic	Siallitic	4U	Topsoil	Light - reddish brown	Sandy-loam, Loamy sand and Sandy clay	16.0
				Sub-soil	Light brown	Sandy clay to Clay	70.9
Kirkia acuminata – Colophospermum mopane Short Closed Woodland	Amorphic	Lithosol	2A/2B	Topsoil	Reddish brown - brown	Sandy loam	6.0
				Sub-soil	Brown	Loamy sand to Sandy loam	18.5
	Calcimorphic	Siallitic	4S/4U	Topsoil	Reddish brown - brown	Sandy loam to Sandy clay	20.3
				Sub-soil	Reddish brown - brown	Sandy loam to Sandy clay	60.3
Albizia anthelmintica – Acacia tortilis Open Woodland	Calcimorphic	Siallitic	4M	Topsoil	Light brown - brown	Sandy loam to Loamy sand	31.2
				Sub-soil	Light brown - brown	Sandy loam to Sandy clay	80.7
	Natric	Saline-sodic	8h	Topsoil	Light grey	Sandy loam, Sand and Sandy clay	48.2
				Sub-soil	Light grey	Loamy sand to Sandy loam	93.0
Xanthocercis zambesiaca –- *Acacia tortilis* Closed Woodland	Calcimorphic	Siallitic	4U	Topsoil	Brown	Sandy loam	24.4
				Sub-soil	Light brown - brown	sandy loam to Loamy sand	109
Dalbergia arbutifolia – Diospyros mespiliformis Tall Closed Riverine Forest	Calcimorphic	Siallitic	4U	Topsoil	Brown	Sandy loam	16.6
				Sub-soil	Brown	Sandy loam to Loamy sand	97.0
Hyperbolius bowkeri – Sporobolus nitens Open Grassland	Natric	Saline-sodic	8h	Topsoil	Light grey	Clay	120.0
Echinochloa colona – Cyperus digitatus Open Wetland	Calcimorphic	Siallitic	4U	Topsoil	Dark grey	Sandy clay	150.0
				Sub-soil	Very dark grey	Clay	
	Natric	Saline-sodic	8h	Topsoil	Light grey	Loamy sand to Sandy loam	4.0
				Sub-soil	Dark grey	Sandy loam to Sandy clay	86.0

Table 3.2 cont.. The physical and chemical properties of the soils on Chapungu Ranch per vegetation community

PLANT COMMUNITY	SOIL ORDER	SOIL GROUP	SOIL FAMILY	SOIL LAYER	% Clay	% Silt	% Sand	% Organic Material	pH 1.5 suspension Soil:$CaCl_2$
Hibiscus ovalifolius – Albizia brevifolia Closed Woodland	Amorphic	Lithosol	2M	Topsoil	17.6	11.2	71.2	1.0	5.0
				Sub-soil					
Seddera suffruticosa – Colophospermum mopane Closed Woodland	Amorphic	Lithosol	2A	Topsoil	16.0	12.0	72.0	1.6	6.6
				Sub-soil	21.0	12.0	67.0	1.3	7.0
	Calcimorphic	Siallitic	4U	Topsoil	13.5	9.6	76.9	0.9	6.1
				Sub-soil	26.5	10	63.5	0.5	6.2
Kirkia acuminata – Colophospermum mopane Short Closed Woodland	Amorphic	Lithosol	2A/2B	Topsoil	8.5	9.5	82.0	1.8	6.5
				Sub-soil	11.0	10.0	79.0	1.4	6.4
	Calcimorphic	Siallitic	4S/4U	Topsoil	18.3	12.3	69.3	1.4	6.1
				Sub-soil	22.9	11.3	65.8	1.0	6.6
Albizia anthelmintica – Acacia tortilis Open Woodland	Calcimorphic	Siallitic	4U	Topsoil	9.6	6.8	83.6	0.7	5.1
				Sub-soil	22.8	6.8	70.5	0.4	6.1
	Natric	Saline-sodic	8h	Topsoil	20.7	11.3	68.0	0.7	4.6
				Sub-soil	12.0	6.0	82.0	0.1	5.8
Xanthocercis zambesiaca –- Acacia tortilis Closed Woodland	Calcimorphic	Siallitic	4U	Topsoil	12.6	11.7	75.7	1.8	5.4
				Sub-soil	19.7	9.7	71.3	0.5	7.2
Dalbergia arbutifolia – Diospyros mespiliformis Tall Closed Riverine Forest	Calcimorphic	Siallitic	4U	Topsoil	8.0	8.6	83.4	2.9	5.9
				Sub-soil	13.3	10.0	76.7	0.8	6.7
Hyperbolius bowkeri – Sporobolus nitens Open Grassland	Natric	Saline-sodic	8h	Topsoil	58.0	20.0	22.0	1.3	6.4
Echinochloa colona – Cyperus digitatus Open Wetland	Calcimorphic	Siallitic	4U	Topsoil	32.0	22.0	46.0	0.8	6.9
				Sub-soil					
	Natric	Saline-sodic	8h	Topsoil	11.0	9.0	80.0	0.9	5.4
				Sub-soil	18.0	10.0	72.0	0.8	6.5

Table 3.2 cont... The physical and chemical properties of the soils on Chapungu Ranch per vegetation community

PLANT COMMUNITY	SOIL ORDER	SOIL GROUP	SOIL FAMILY	SOIL LAYER	Mineral Nitrogen : Initial	Mineral Nitrogen : After Incubation	Avail. P205 (ppm Resin Extract)	Extractable Cations (m.e.%) : K	Ca	Mg	Na
Hibiscus ovalifolius – Albizia brevifolia Closed Woodland	Amorphic	Lithosol	2M	Topsoil			103.6	0.6	1.3	0.6	0.03
				Sub-soil							
Seddera suffruticosa – Colophospermum mopane Closed Woodland	Amorphic	Lithosol	2A	Topsoil	12.5	18.5	140.0	1.2	9.6	3.3	0.3
				Sub-soil	11.5	20.0	26.0	1.6	12	3.4	0.3
	Calcimorphic	Siallitic	4U	Topsoil	10.4	19.8	74.7	1.1	5.6	2.8	0.3
				Sub-soil	10.8	19.2	12.2	1.8	7.4	5.1	0.6
Kirkia acuminata – Colophospermum mopane Short Closed Woodland	Amorphic	Lithosol	2A/2B	Topsoil	10.5	18.8	53.5	0.9	11.9	2.7	0.2
				Sub-soil	9.3	19.8	28.5	0.6	12.5	3	0.3
	Calcimorphic	Siallitic	4S/4U	Topsoil	10.3	20.8	44.0	1.2	8.4	3.5	0.4
				Sub-soil	10.6	19.8	11.1	0.8	10.7	3.1	0.3
Albizia anthelmintica – Acacia tortilis Open Woodland	Calcimorphic	Siallitic	4U	Topsoil	10.3	19.0	72.2	0.8	2.8	1.4	0.2
				Sub-soil	10.8	19.7	41.4	1.0	5.9	3.0	0.4
	Natric	Saline-sodic	8h	Topsoil	10.0	18.7	78.3	0.5	3.9	2.8	1.4
				Sub-soil	11.0	21.0	15.5	0.5	3.1	1.6	0.4
Xanthocercis zambesiaca –- Acacia tortilis Closed Woodland	Calcimorphic	Siallitic	4U	Topsoil	10.6	17.9	153.6	1.2	8	2.9	0.3
				Sub-soil	13.5	23.5	80.3	0.6	9.8	5.1	0.7
Dalbergia arbutifolia – Diospyros mespiliformis Tall Closed Riverine Forest	Calcimorphic	Siallitic	4U	Topsoil	10.1	18.4	158.1	1.3	8.1	2.8	0.2
				Sub-soil	11.0	20.3	98.2	0.8	9.3	2.7	0.3
Hyperbolius bowkeri – Sporobolus nitens Open Grassland	Natric	Saline-sodic	8h	Topsoil	11.0	17.0	199.5	1.4	14.4	8.9	3.2
Echinochloa colona – Cyperus digitatus Open Wetland	Calcimorphic	Siallitic	4U	Topsoil	10.0	19.0	71.0	0.3	13.9	5.8	1.5
				Sub-soil							
	Natric	Saline-sodic	8h	Topsoil	11.0	19.0	57.5	0.6	3.4	1.9	0.7
				Sub-soil	11.5	20.0	88.0	1.1	3.8	2.1	3.4

Table 3.2 cont... The physical and chemical properties of the soils on Chapungu Ranch per vegetation community

PLANT COMMUNITY	SOIL ORDER	SOIL GROUP	SOIL FAMILY	SOIL LAYER	Cation Exchange Capacity Cations CMOL+/KG	Exchangeable Sodium Percentage	E/C Value (C.E.C/100 g clay fraction)	Conductivity (microS/cm)
Hibiscus ovalifolius – Albizia brevifolia Closed Woodland	Amorphic	Lithosol	2M	Topsoil	2.5	1.8	13.9	68.8
				Sub-soil				
Seddera suffruticosa – Colophospermum mopane Closed Woodland	Amorphic	Lithosol	2A	Topsoil	14.4	2.1	94.6	76.5
				Sub-soil	17.2	1.5	143.3	118.0
	Calcimorphic	Siallitic	4U	Topsoil	9.7	3.1	73.3	46.6
				Sub-soil	15.0	4.7	154.8	68.1
Kirkia acuminata – Colophospermum mopane Short Closed Woodland	Amorphic	Lithosol	2A/2B	Topsoil	15.6	1.5	193.0	85.5
				Sub-soil	16.4	4.2	149.0	71.0
	Calcimorphic	Siallitic	4S/4U	Topsoil	13.4	3.0	82.0	55.3
				Sub-soil	13.5	2.7	135.8	69.3
Albizia anthelmintica – Acacia tortilis Open Woodland	Calcimorphic	Siallitic	4U	Topsoil	5.2	4.8	57.4	34.4
				Sub-soil	10.2	3.8	161.1	61.4
	Natric	Saline-sodic	8h	Topsoil	8.6	12.8	45.6	369.7
				Sub-soil	5.5	6.8	88.6	21.5
Xanthocercis zambesiaca –- Acacia tortilis Closed Woodland	Calcimorphic	Siallitic	4U	Topsoil	12.3	2.5	97.2	72.7
				Sub-soil	16.3	3.8	169.5	173.8
Dalbergia arbutifolia – Diospyros mespiliformis Tall Closed Riverine Forest	Calcimorphic	Siallitic	4U	Topsoil	12.3	1.7	163.1	109.7
				Sub-soil	13.0	2.8	132.4	88.5
Hyperbolius bowkeri – Sporobolus nitens Open Grassland	Natric	Saline-sodic	8h	Topsoil	27.8	11.5	48.2	254.5
Echinochloa colona – Cyperus digitatus Open Wetland	Calcimorphic	Siallitic	4U	Topsoil	21.5	7.2	67.2	151.0
				Sub-soil				
	Natric	Saline-sodic	8h	Topsoil	6.5	10.5	65.8	82.0
				Sub-soil	10.4	10.4	109.5	766

3.4 Conclusions

The soils of Chapungu Ranch showed considerable variation in depth, texture and chemical composition. However most soils were fertile and supported a herbaceous layer generally referred to as sweetveld.

The fertility of soils is measured by depth, the ability to retain moisture, drainage, aeration, the range of acidity, mineral composition, organic matter content, micro organism activity and contamination (IFOAM, 2004).

Soil depths were generally shallow for the Amorphic lithosol soil family groups which restricted root penetration, however these soils were well aerated allowing for healthy root development. The soil depths recorded for the Calcimorphic siallitic soils were sufficient to allow for healthy plant establishments. On the soils of the Calcimorphic order soil moisture retention appeared to be the major limiting factor for plant growth and plant production. The soils on Chapungu Ranch were largely of a sandy nature allowing for good aeration and water infiltration but with poor water retention capabilities that were particularly evident for the Calcimorphic siallitic 4C and 4U soils in the *Albizia anthelmintica- Acacia tortilis* Open Woodland management unit.

In agricultural practices, crop production is best achieved with soil pH levels from 6.0 to 7.1 (Marx *et al*., 1999). On Chapungu Ranch, the soils of the Amorphic lithosols 2A, and the Calcimorphic siallitic 4S and 4U families ranged from pH 6.0 – 7.1 which is ideal for phosphorous uptake by plants and *Rhizobium* bacteria activity for nitrogen fixation. However, strongly acidic soils were encountered on the Amorphic lithosols 2M soils where soil phosphorous availability to plants and *Rhizobium* bacteria activity are expected to be compromised.

Based on the cation exchange capacity the soil retention and mineral availability for plants were mostly moderate despite the high percentage sand fraction in the soils. Cation exchange values were low for the Amorphic lithosol 2M and the Natric saline-sodic 8h soils. Nitrogen, which forms part of all living cells and the metabolic processes involved with synthesis and energy transfer, occurred mainly in low to moderate concentrations in the soils on Chapungu Ranch. However, soil nitrogen levels depend on biological activity and therefore the levels of nitrogen in the soil are influenced by the temperature and moisture regimes which fluctuate considerably (Marx *et al*., 1999) often resulting in misleading results. Sharma *et al*. (2009) found a positive correlation between the levels of nitrogen in the soil, the tree density and the total basal cover of forests growing on an altitudinal gradient in the Himalayas. The phosphorous content of the soils on Chapungu Ranch was generally high with only the Amorphic lithosols 2B and the Calcimorphic siallitic 4S soils recording low levels of phosphorous. Phosphorous is thus not considered a limiting factor to plant development and growth on Chapungu Ranch. Potassium is absorbed in large quantities by plants and affects photosynthesis, fruit quality, protein synthesis and disease control. However large intakes of potassium by animals through foraging may influence animal health. Although potassium levels were found to be high within all soils on Chapungu Ranch it was unlikely to influence animal health. Calcium forms an important component in the cell wall structure of plants. Eni *et al.* (2012) found a direct correlation between the calcium concentrations in soils and the structure and density of vegetation. Limiting amounts of calcium were recorded only on the strongly acidic Amorphic lithosol 2B soils and the moderately acidic Calcimorphic siallitic 4C soils. Magnesium is essential in the photosynthesis process of plants and was found to be in sufficient quantities in all soil types on Chapungu Ranch.

As a result of the high palatability and nutritional value of the herbaceous layer Chapungu Ranch is able to carry large numbers of wildlife when forage is available (see Chapter 8). This large number of animals often led to the ground being laid bare by overgrazing and trampling which in turn resulted in increased water run-off and reduced water infiltration.

With the exception of the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland, the terrain on Chapungu Ranch was generally flat and the soils not prone to gully erosion. The gentle slope did pose a problem when roads were constructed in this community (see Chapter 9). However, gully erosion did occur along the Magwe drainage line as a result of a road through a saline-sodic soil patch and measures should be taken to avoid further erosion (see Chapter 9). Gully erosion was also visible on the road leading up Chisangaurwe hill with rock falls blocking the road from time to time. In the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland with low herbaceous cover sheet erosion is a natural phenomenon.

CHAPTER 4

VEGETATION CLASSIFICATION

4.1 Introduction

The transition from historical to modern times in vegetation classification occurred between 1969 and 1974 (Mucina, 1997). Mucina (1997) argued that prior to 1956 no comprehensive account for table-sorting methods were available to phytosociologists despite table-sorting being the core of phytosociological classifications.

According to Mucina (1997) traditional handmade table-sorting techniques described by Mueller-Dombois & Ellenberg (1974) used simple statistical and numerical techniques to assist with the classification. However, the establishment of vegetation data banks and the rapid development of computers necessitated a more formalized classification system that could deal with large quantities of data. Today computer programs are used to formalize or to automate certain traditional hand sorting methods (Mucina, 1997).

The Zurich-Montpellier approach to vegetation classification is described fully by Werger (1974). This method for classifying vegetation is also known as the Braun-Blanquet or relevé method and is widely used as a means to describe plant communities (Bezuidenhout *et al.,* 1994, Bredenkamp, 1982; Bredenkamp & Deutschlander, 1995; Bredenkamp & Theron, 1976, 1990; Breebaart & Deutschlander, 1997; Brown & Bredenkamp, 1994; Brown *et al*., 1995, 1996; Cilliers & Bredenkamp, 1999; Coetzee & Werger, 1973; Götze et al. 2003; Hin, 2000; Kooij *et al*., 1990; Mostert *et al.,* 2009; Pauw, 1988; Schmidt, 1992; Siebert *et al.,* 2010; Stalmans & Peel, 2010; Visser *et al*., 1996; Werger, 1974). In the Zurich-Montpellier method all plant species within a relevé are recorded and a cover-abundance rating is assigned to each plant species. From the data vegetation units are extracted, interpreted and ranked into a hierarchy (Werger, 1974).

The hierarchical classification of floristically and environmentally related groups allows for the identification of plant communities (Hin 2000). Management of the vegetation can be applied at different levels in the hierarchical order depending on the type and the level of intensity of the management action required.

Werger (1974) highlighted the importance of vegetation structure as a parameter for determining homogeneous vegetation units. Smit and Rethman (1999) point out that there are both negative and positive interactions between the herbaceous layer and the woody layer. The net result of these negative and positive interactions on grass production depends on tree density (Stuart-Hill, 1987). Clearing of the woody plant layer had mixed results on the herbaceous layer and these differences could be attributed to differences in soil properties such as soil fertility (Dye & Spear, 1982) and rainfall (Dye & Spear, 1982; Fuhlendorf & Smeins, 1997). In the Molopo thornveld tree density affects grass production from 200 tree equivalents upwards (Moore and Odendaal, 1987), whereas in *Combretum* veld the removal of the woody layer induced only a slight increase in production of the grass layer (Donaldson, 1978). After evaluating many studies (e.g. those by Donaldson & Kelk, 1970; Dye & Spear, 1982; Harrington & Johns, 1990; Scanlan & Burrows, 1990; Richter, 1991) Tainton (1999) concluded that the total removal of the woody layer increased grass production substantially. However, woody plants can have a positive effect on the grass layer. For example, Smit and Swart (1994) pointed out that *Panicum maximum*, a highly palatable grass species, might develop as pure stands under woody plants.

On a wildlife ranch, the woody layer is important for two reasons (Peel, 1990): a) woody plants provide forage for browsing animals and provide shelter and b) the woody layer also influences the composition and production of the herbaceous layer. Knowledge of the woody vegetation structure of the plant communities on Chapungu is thus critically important to assess production potential, browse availability and habitat for animals.

4.2 Methods

The phytosociological classification of the vegetation on Chapungu was done using the Zurich-Montpellier method or Braun-Blanquet method (Werger, 1974). The structural assessment of the woody vegetation was achieved using the BECVOL method described by Smit (1989a and 1989b).

4.2.1 *Sampling procedures*

Prior to any site selection, a general reconnaissance survey was conducted during the dry season of 2002 to become familiar with the extent of the survey area, the geology, topography and vegetation.

Aerial photographs (1:50 000) were subsequently used to stratify the area into physiographic-physiognomic units on the basis of similar geological formations and the colour and texture of the vegetation on the photographs. These units were then verified by a reconnaissance survey conducted in December 2002 and sampling plots were selected within each of the initial physiographic-physionomic units delineated.

Representative sample sites were selected subjectively within each of the stratified units. Subjective selection of sampling plots was related to the representativeness, homogeneity and total number of plots to be sampled. Ellenberg (1956) points out that the subjective selection of sampling plots guarantees optimal sampling efficiency as obvious heterogeneous plots are avoided.

A total of 156 sampling plots were selected representing a sampling density of 1 plot every 85.3 ha. The number of sampling plots was determined by the scale of the survey, the variability of the vegetation and the degree of detail that needed to be achieved.

Barkman *et al*. (1986) and Westfall (1981) suggested a minimum of 10 sampling plots per vegetation type. Hin (2000) successfully used five sampling plots as the minimum number per vegetation type. In this study all vegetation communities were represented by more than five sample plots except for the small plant communities associated with the pans and saline areas.

The recommended plot size of 200 m^2 for savanna in southern Africa (Bredenkamp & Deutschlander, 1995; Coetzee, 1983; Pauw, 1988; Hin, 2000) was used for this study and for continuity followed Hin (2000).

The vegetation surveys were conducted during the growing season from January 2003 to April 2003. Floristic lists were compiled for each sample plot and a cover-abundance value assigned to each species at a site. The list of species compiled at each sample plot was done as thoroughly as possible. The cover-abundance scale allocated to each species was according to Werger (1974):

r - Very rare with negligible cover (usually a single individual).

+ - Present but not abundant and with small cover value (less than 1% of the plot area).

1 - Numerous but covering less than 1% of the plot area, or not so abundant but covering 1-5% of the plot area.

2a - Covering 6-12% of the of the plot area independent of abundance.

2b - Covering 13-25% of the plot area independent of abundance.

3 - Covering 26-50% of the of the plot area independent of abundance.

4 - Covering 51-75% of the of the plot area independent of abundance.

5 - Covering 76-100% of the of the plot area independent of abundance.

In addition to the floristic analysis, the following habitat characteristics were recorded at each sample plot. (Pauw, 1988, 1992; Schmidt 1992):

1. aspect,
2. altitude,
3. gradient,
4. geomorphology,
5. topography,
6. geology,

7. rock cover and size
8. erosion status,
9. degree of trampling,
10. percentage canopy cover by trees, shrubs, grasses and forbs, and
11. soil properties (see Chapter 3).

The BECVOL method was used to assess the structure of the woody vegetation and involved the measurement of all woody plants rooted within belt transects. The standard transect length and width were 100 m x 2 m. In areas with low woody plant densities the transect length was extended until a minimum of 30 woody plants were recorded. Tree height, tree height at maximum canopy diameter, tree height at minimum canopy diameter, maximum canopy diameter and minimum canopy diameter were measured according to the guidelines described by Smit (1989a & b).

Height classes used to describe the woody vegetation were based on Coetzee and Gertenbach (1977) and Hin (2000). On the basis of their maximum height, woody plants were grouped into the following eleven height classes: <0.75 m; 0.75 – <1.5 m; 1.6 – 2.5 m; 2.6 – 3.5 m; 3.6 – 5.5 m; 5.6 – 7.5 m; 7.6 – 9.5 m; 9.6 – 11.5 m; 11.6 – 13.5 m; 13.6 – 15.5 m and > 15.5 m. Cover values for all individuals per height class were summed per plot and means for the community/subcommunity calculated. Similarly, density per height class was calculated per plot and a mean for the community derived.

4.2.2 *Data analysis*

The TURBOVEG software was used to capture the floristic data (Hennekens & Schamineé, 2001). This produced a matrix with the relevés represented as columns and the species as rows. The cover-abundance values made up the entries in the matrix. The initial step in the floristic data analysis was to use the Two-Way Indicator Species Analysis (TWINSPAN) described by Hill (1979). A floristic data table converted into a Cornell Condensed Format was entered into WINTWINS version 2.3, a computer programme for Windows (Hill and Smilauer, 2005). TWINSPAN produced a dendogram which indicated the hierarchical classification of relevés on the grounds of similarities between relevés. The two-way table emphasized indicator species and presented a partially arranged matrix. The two-way table was further refined by using Braun-Blanquet procedures. Rearrangements and refinement of the matrix were done to enable an ecological interpretation of the table and identification of plant communities.

Plant communities were named according to the binomial system described by Barkman *et al*. (1986). Preferably the first name used to describe a community was a diagnostic species and the second name was the dominant plant species.

Edwards's (1983) structural classification system was used to add a descriptor of the vegetation structure to the community name. Edwards (1983) defines vegetation structure as the organization in space of individuals that form a stand (and by further extension a vegetation type). Growth form, height and cover are the primary elements of structure (Edwards, 1983).

Once the communities had been identified the sample plots were mapped onto the initial subjectively delineated units. Ground truthing was conducted to confirm or reject the grouping of relevés into plant communities.

The final phytosociological table was also used to identify management units.

4.3 Results and Discussion

4.3.1 Phytosociological classification

The phytosociological classification of the vegetation for Chapungu Ranch is provided in Appendix I and the spatial distribution of the vegetation communities on Chapungu Ranch is presented in Figure 4.1. The dendogram derived from the TWINSPAN table is presented in Figure 4.2. The dendogram is presented up to the fourth level of division, which was up to plant community level.

The first level of division grouped the plant communities found on the Umkondo System and the colluvial outwash together (Group A) and separated the communities found on alluvium into another group (Group B). The second division divided the plant communities of group A into those associated with the Umkondo and Karoo systems and those occurring on the colluvial outwash and natric soils. The communities of Group B were separated into those occurring on the alluviums and those on the clay soils associated with the pans.

The third level of division separated the koppie community growing on the sandstone from aeolian decent from the communities associated with basalt and sedimentary sandstone whilst on the other leg of Group A the community on the natric soils was separated from the community on the sandy colluvial deposits. In Group B the sandy reedbeds were separated from the other communities found on alluvium on the basis of their relative propotion of sand, silt and clay.

The fourth division of the TWINSPAN hierachical classification separated the remaining communities between those associated with basalt and those communities associated with sedimentary sandstone, arkose and limestone in Group A. The fourth division on Group B separated the communities on recent alluvial deposits from those on old alluvium deposits.

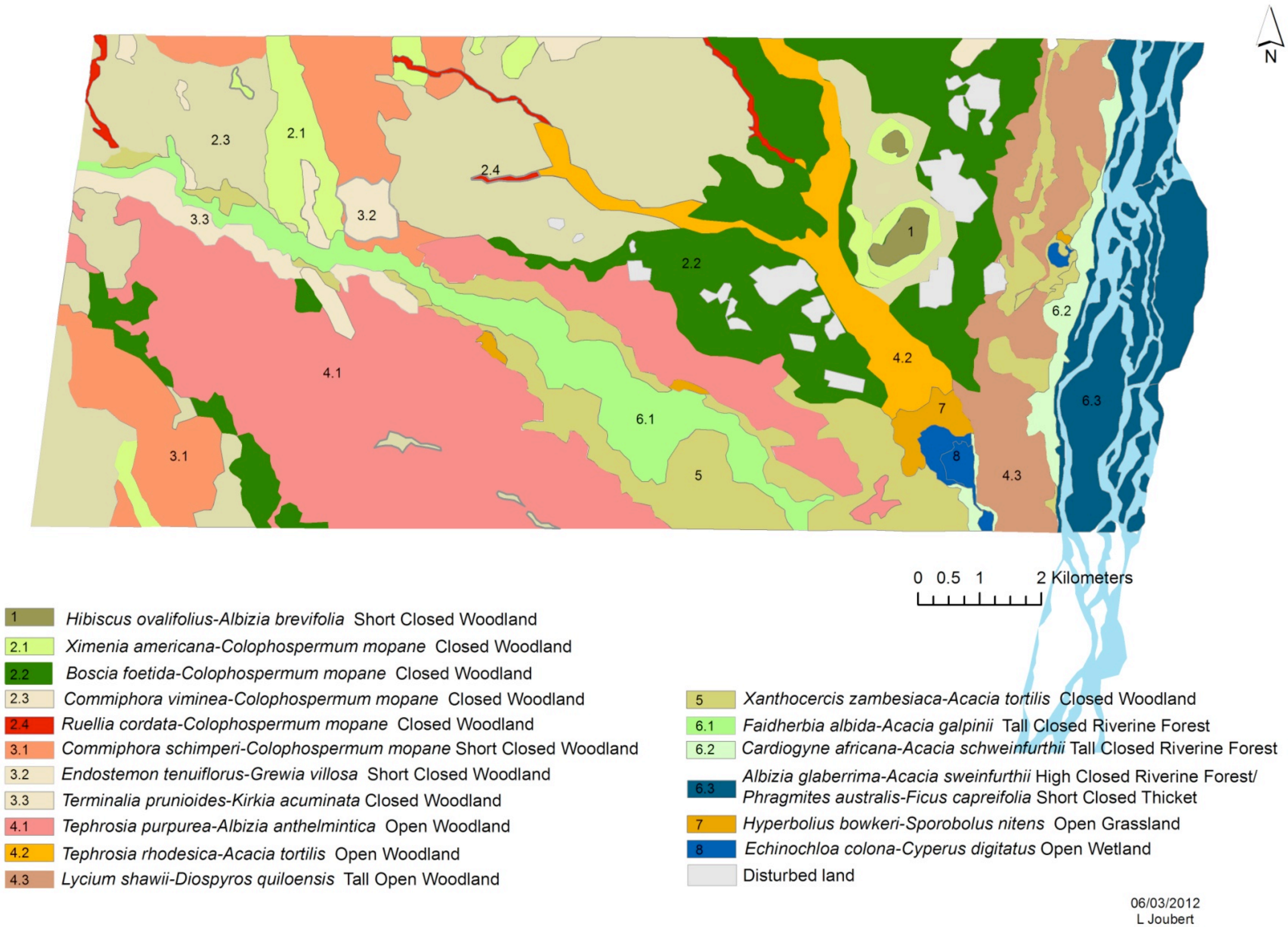


Figure 4.1: Plant communities of Chapungu Ranch, Save Valley Conservancy, Zimbabwe.

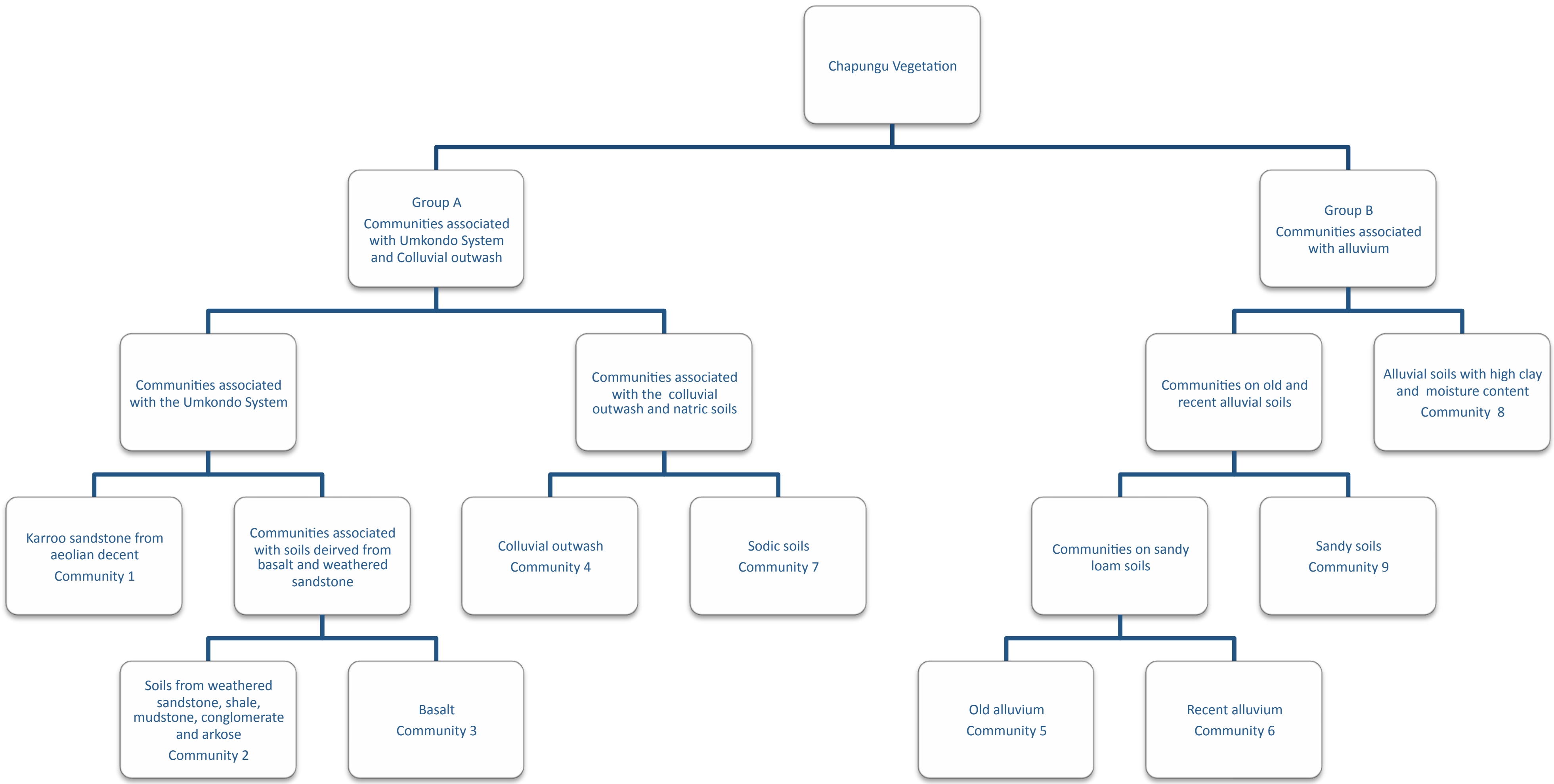


Figure 4.2: Dendogram presenting the TWINSPAN hierarchy of the plant communities on Chapungu Ranch.

The hierarchical classification of the vegetation on Chapungu Ranch identified nine vegetation communities and 15 subcommunities. The classification of the vegetation is summarised as follows:

1. *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland
   - 1.1 *Barleria meyeriana – Phyllanthus pinnatus* Short Closed Woodland
   - 1.2 *Strychnos decussata – Grewia gracillima* Short Closed Woodland

2. *Seddera suffruticosa – Colophospermum mopane* Closed Woodland
   - 2.1 *Ximenia americana – Colophospermum mopane* Closed Woodland
   - 2.2 *Boscia foetida – Colophospermum mopane* Closed Woodland
   - 2.3 *Commiphora viminea – Colophospermum mopane* Closed Woodland
   - 2.4 *Ruellia cordata – Colophospermum mopane* Closed Woodland

3. The *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland
   - 3.1 *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland
   - 3.2 *Endostemon tenuiflorus – Grewia villosa* Short Closed Woodland
   - 3.3 *Terminalia prunioides – Kirkia acuminata* Closed Woodland

4. *Albizia anthelmintica – Acacia tortilis* Open Woodland
   - 4.1 *Tephrosia purpurea – Albizia anthelmintica* Open Woodland
   - 4.2 *Tephrosia rhodesica – Acacia tortilis* Open Woodland
   - 4.3 *Lycium shawii – Diospyros quiloensis* Tall Open Woodland

5. *Xanthocercis zambesiaca* - *Acacia tortilis* Closed Woodland

6. *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest
   - 6.1 *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest
   - 6.2 *Cardiogyne africana – Acacia schweinfurthii* Tall Closed Riverine Forest
   - 6.3 *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest

7. *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland

8. *Echinochloa colona – Cyperus digitatus* Open Wetland

9. *Phragmites australis – Ficus capreifolia* Short Closed Thicket

4.3.2 Plant community descriptions

1. The *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland

This community was represented by seven relevés with a mean of 24 species per relevé (range 18-30; Appendix 1). It was situated on the only two koppies, mainly comprising sandstone, grit, conglomerate, limestone and mudstone and covered an area of 0.65 km^2. The soils were shallow amorphic lithosols of the 2M soil family. Altitude ranged from 515 m to 620 m above sea level and the topography varied from flat on the crests of the hills to steep midslopes at the boundary of the community. This community was also the only one on Chapungu where exposed rocks were prominent. The community was subdivided into two subcommunities, but these were not mapped separately as the physical boundary could not be delineated with certainty (Figure 4.1).

This community was recognized by the presence of *Albizia brevifolia*, *Canthium glaucum*, *Combretum apiculatum*, *Combretum padoides*, *Grewia gracillima*, *Gyrocarpus americanus*, *Hibiscus ovalifolius, Kirkia acuminata*, *Strychnos decussata* and *Tephrosia rhodesica*. The herbaceous layer was mostly sparse and was dominated by forb species such as *Barleria affinis*, *Barleria meyeriana*, *Sansevieria pearsonii*, *Tephrosia villosa* and grass species such as *Danthoniopsis pruinosa*, *Digitaria milanjiana* and *Digitaria deflexa*. The diagnostic species were *Albizia brevifolia* and *Hibiscus ovalifolius*. Other commonly found woody species included *Acacia erubescens*, *Phyllanthus pinnatus*, *Entandrophragma caudatum*, *Mundulea sericea* and *Thilachium africanum*.

Structure of the woody layer

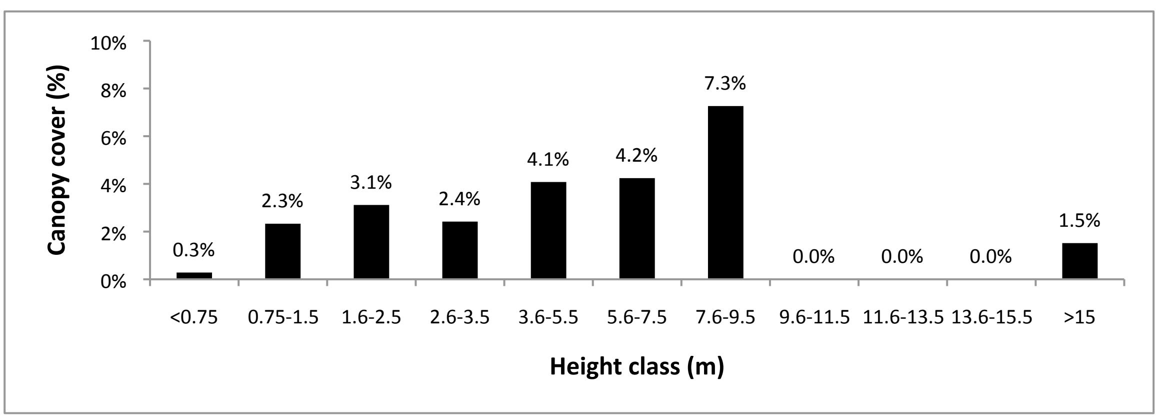


Figure 4.3: The mean percentage canopy cover for 11 height classes of the woody layer for the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

The total canopy cover for this community was 25% (Figure 4.3) and a mean density of 3 182 woody plants/ha was recorded. The community was closed (Edwards, 1983) with the dominant height class between 2 - 5 m. In terms of canopy cover the 7.6 – 9.5 m height class had the highest cover at 7.3%, followed by the 5.6 – 7.5 m and the 3.6 – 5.5 m height classes (Figure 4.3). The bar chart indicated a gap in the height classes 9.6 – 15 m. In terms of density the height class most represented was from 0.75 – 1.5 m with 37.4% of all individuals, followed by the <0.75 m (25.3%) height class and then by the 1.6 – 2.5 m (19.9%) height class (Figure 4.4).

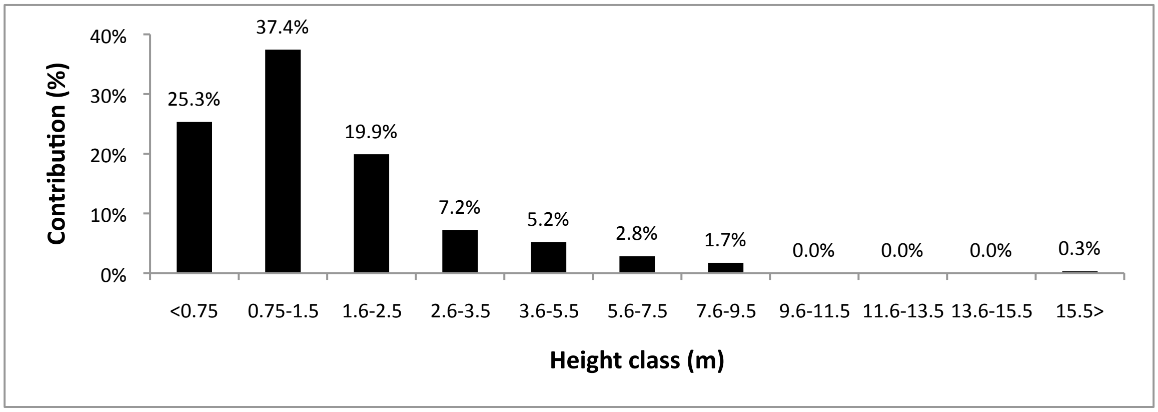


Figure 4.4: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

1.1 *Barleria meyeriana – Phyllanthus pinnatus* Short Closed Woodland

This subcommunity was associated with slightly deeper, but still shallow, soils found on the crests and terraces along the slopes of the hills. It was represented by three relevés with a mean number of 23 species. This subcommunity was separated from the *Strychnos decussata – Grewia gracillima* subcommunity on the basis of the occurrence of species such as *Mundulea sericea* and the absence of *Xerophyta retinervis, Strychnos decussata, Entandrophragma caudatum* and *Sansevieria pearsonii*. Species commonly found in this subcommunity were *Hibiscus ovalifolius, Phyllanthus pinnatus, Albizia brevifolia, Grewia gracillima, Diospyros quiloensis* and *Acacia erubescens.*

Structure of the woody layer

The total canopy cover for this subcommunity was 27% (Figure 4.5) and the density was 3 814 woody plants/ha. This community was classed as a short closed woodland (Edwards, 1983) based on the dominant height class being between 5 – 10 m. Canopy cover of the 7.6 – 9.5 m height class was the highest (9.9%), followed by the 3.6 – 5.5 m height class (Figure 4.5). In terms of the number of woody plants, the height classes most represented were 0.75 – 1.5 m at 33.6% of all individuals, <0.75 m (33.9%) and then 1.6 – 2.5 m (18.3%; Figure 4.6).

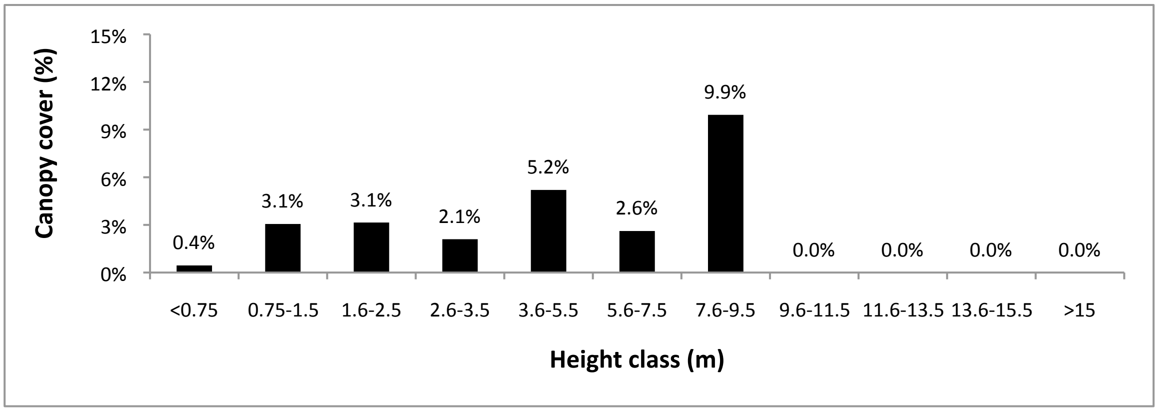


Figure 4.5: The mean percentage canopy cover for 11 height classes of the woody layer for the *Barleria meyeriana – Phyllanthus pinnatus* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

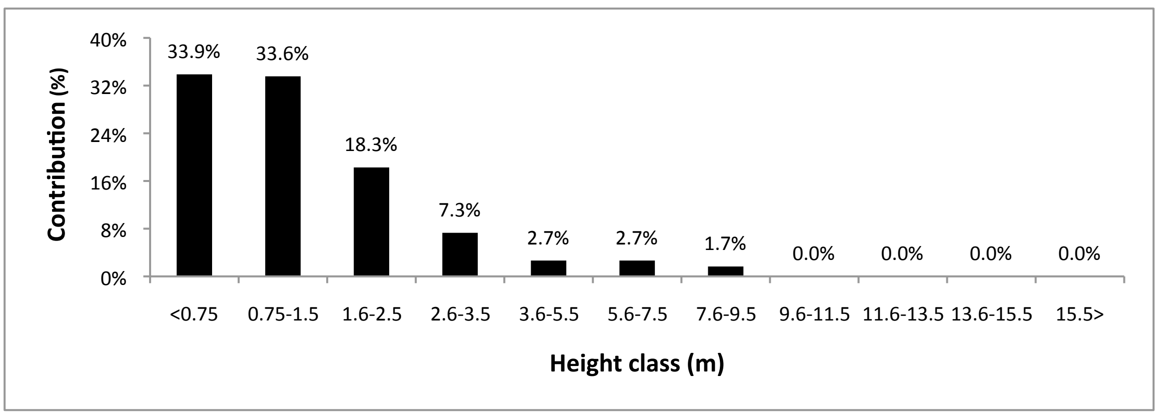


Figure 4.6: The mean percentage contribution of woody plants to 11 height classes in the *Barleria meyeriana – Phyllanthus pinnatus* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

1.2 The *Strychnos decussata – Grewia gracillima* Short Closed Woodland

This subcommunity was represented by four relevés and occurred on the slopes or between the exposed rocks and was associated with very shallow soils of the amorphic 2M order.

The *Strychnos decussata – Grewia gracillima* Short Closed Woodland is recognized by the presence of species such as *Xerophyta retinervis, Gyrocarpus americanus, Strophanthus kombe, Strychnos decussata, Entandrophragma caudatum* and *Sansevieria pearsonii*.

Structure of the woody layer

The total canopy cover for this subcommunity was 24% (Figure 4.7) with a density of 2 554 woody plants/ha. This subcommunity was classed as a short closed woodland (Edwards, 1983) based on the dominant height class being from 5 – 10 m. Canopy cover of the 5.6 – 7.5 m height class was highest at 5.9%, closely followed by the 7.6 – 9.5 m height class at 4.6%. In terms of the density of woody plants, the height class most represented was 0.75 – 1.5 m (41.3%), followed by the 1.6 – 2.5 m (21.6%) height class and then by the <0.75 m (16.8%) height class (Figure 4.8).

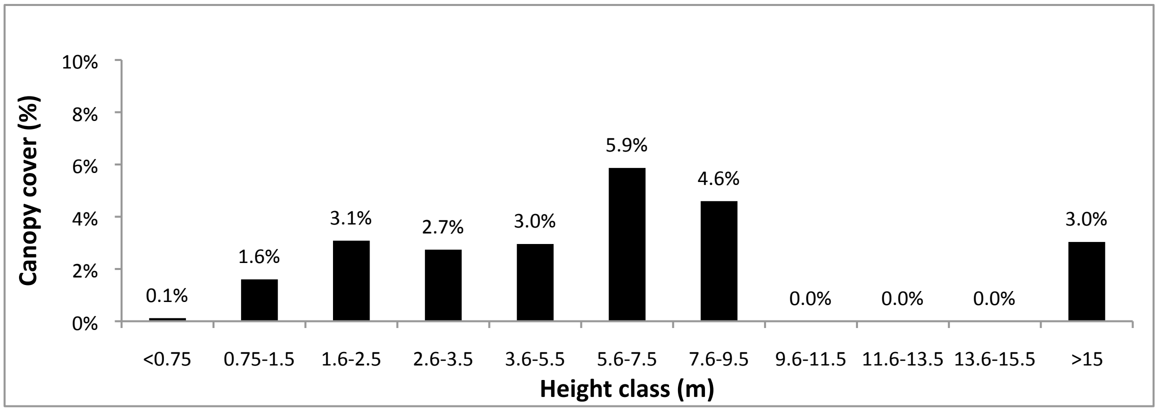


Figure 4.7: The mean percentage canopy cover for 11 height classes of the woody layer for the *Strychnos decussata – Grewia gracillima* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

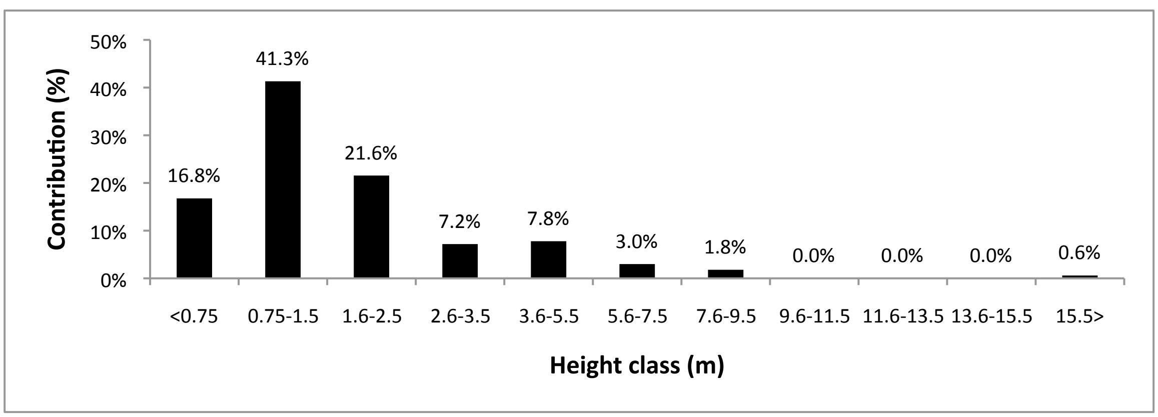


Figure 4.8: The mean percentage contribution of woody plants to 11 height classes in the *Strychnos decussata – Grewia gracillima* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

2. The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland

This community covered an area of 42.3 km^2 on Chapungu Ranch and was associated with siallitic alluvial soils of the Calcimorphic Order and the 4U family as well as the amorphic lithosols of the 2A family. It was represented by 31 relevés and was subdivided into three subcommunities. This community occurred between 460 – 520 m above sea level and the topography was generally flat, or sloping gently in a southeastern direction towards the Save River. A mean of 31 species were recorded per relevé but species richness ranged from 17 to 48 individuals per sampling plot.

The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland was dominated by *Colophospermum mopane*. Other woody plants occurring throughout its range were *Grewia bicolor, Grewia flavescens, Diospyros quiloensis, Zanthoxylum capense*, *Maerua parvifolia* and *Tricalysia junodii.* Species commonly found but restricted to some subcommunities were *Commiphora viminea, Ximenia americana, Salvadora australis*, *Boscia foetida* and *Stomatostemma monteiroae*.

The herbaceous layer was mostly sparse and was dominated by forb species such as *Pupalea lappacea, Hibiscus micranthus, Barleria prionitis, Ruellia patula, Ruellia cordata* and *Seddera suffruticosa.* The dominant grass species in this community were *Brachiaria deflexa*, *Brachiaria xantholeuca*, *Oropetium capense* and *Enteropogon macrostachyus.* Other forb species commonly found included *Kyllinga alba*, *Mariscus rehmannianus, Plectranthus tettensis, Abutilon fruticosum, Asparagus schroederi, Polygala sphenoptera, Ocimum filamentosum, Maerua decumbens, Blepharis diversispina* and *Evolvulus alsinoides.*

Structure of the woody layer

This community had a total canopy cover of 47% (Figure 4.9) and a density of 3 326 woody plants/ha. It was classed as a short closed woodland (Edwards, 1983) based on the dominant height class being 5 – 10 m. Canopy cover of the 5.6 – 7.5 m and the 9.6 – 11.5 m height classes were highest at 9.5%, followed by the 7.6 – 9.5 m height class at 8.1% (Figure 4.9). The <0.75 m height class contributed the most (48.7%) to the density of woody plants in this community followed by the 0.75 – 1.5 m height class (13.6%; Figure 4.10).

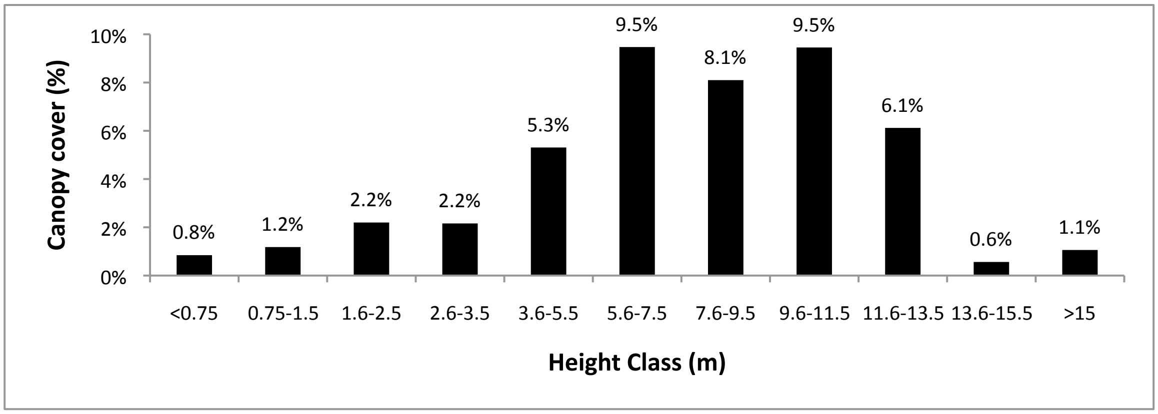


Figure 4.9: The mean percentage canopy cover for 11 height classes of the woody layer for the *Seddera suffruticosa – Colophospermum mopane* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

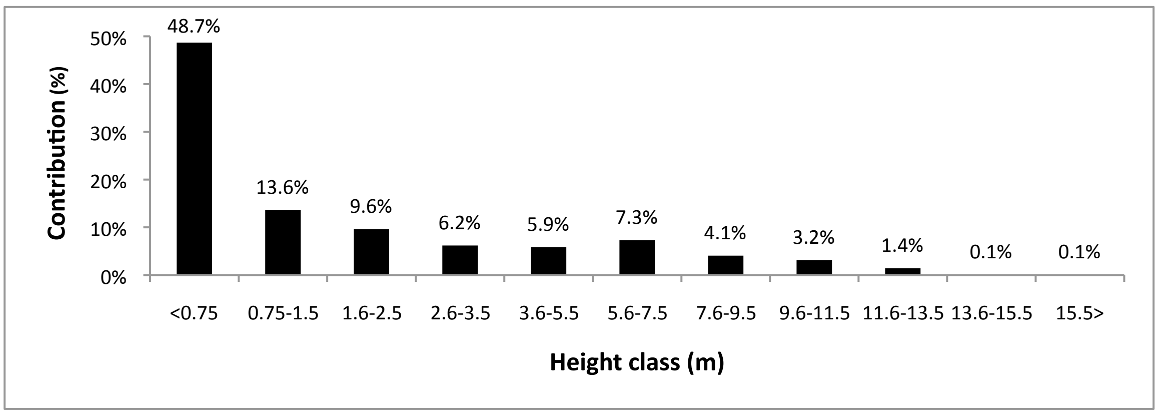


Figure 4.10: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Seddera suffruticosa – Colophospermum mopane* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

2.1 The *Ximenia americana – Colophospermum mopane* Closed Woodland

The *Ximenia americana – Colophospermum mopane* Closed Woodland subcommunity was found on shallow alluvial soils overlying weathered sandstone often displaying pebbles on the surface. It was represented by nine relevés and covered an area of 3.6 km^2. The only diagnostic species was *Ximenia americana*. The woody layer was dominated by *Colophospermum mopane* whilst *Commiphora viminea*, *Grewia bicolor* and *Diospyros quiloensis* commonly occurred.

The herbaceous layer included species such as *Pupalea lappacea, Hibiscus micranthus, Barleria prionitis, Monechma divaricatum, Ruellia patula, Ruellia cordata, Justicia flava, Seddera suffruticosa, Kyllinga* *alba*, *Asparagus schroederi,* and the dominant grass species in this community were *Aristida congesta*, *Oropetium capense* and *Enteropogon macrostachyus.*

Structure of the woody layer

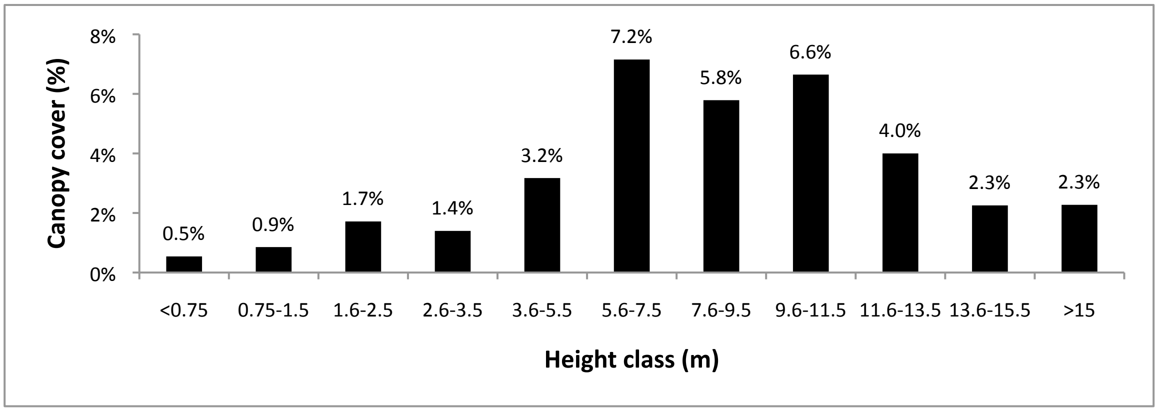


Figure 4.11: The mean percentage canopy cover for 11 height classes of the woody layer for the *Ximenia americana – Colophospermum mopane* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

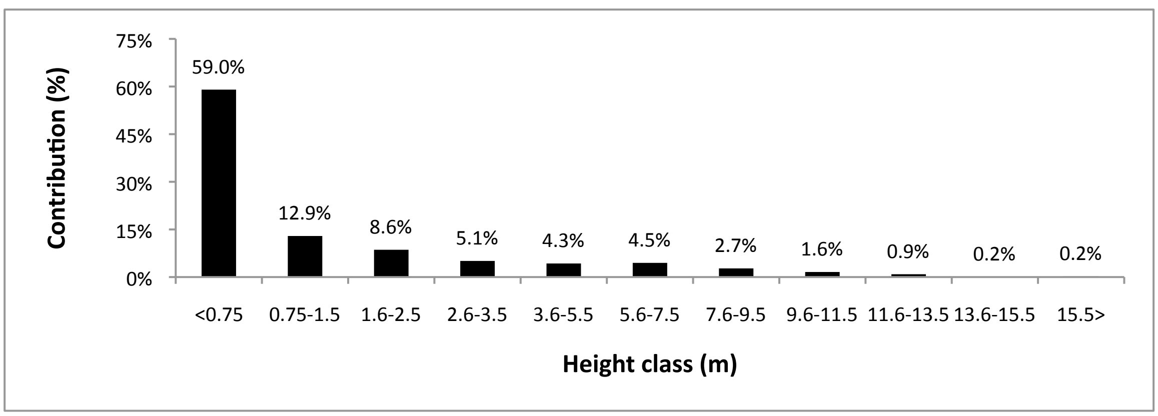


Figure 4.12: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Ximenia americana – Colophospermum mopane* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

The total canopy cover for this subcommunity was 36% (Figure 4.11) with a density of 3 672 woody plants/ha. It was classed as a medium-tall closed woodland (Edwards, 1983) based on the dominant height classes being 5 – 15 m. Canopy cover in the 5.6 – 7.5 m height class was highest at 7.2%, closely followed by the 9.6 – 11.5 m height class (6.7%) and then the 7.6 – 9.5 m height class (5.8%; Figure 4.11). The <0.75 m height class contributed the most (59.0%) to the total number of woody plants in this subcommunity followed by the 0.75 – 1.5 m height class (12.9%; Figure 4.12).

2.2 The *Boscia foetida – Colophospermum mopane* Closed Woodland

This subcommunity was found on the alluvial soils deposited over the Umkondo System. The *Boscia foetida – Colophospermum mopane* Closed Woodland covered an area of 15.6 km^2 and was represented by 10 relevés. The siallitic soils were all of Calcimorphic Order of the 4U family.

This subcommunity was recognized by the presence of *Boscia foetida, Commiphora viminea* and *Salvadora australis*. The dominant woody species was *Colophospermum mopane* whilst species such as *Grewia bicolor, Grewia flavescens, Diospyros quiloensis, Zanthoxylum capense* and *Maerua parvifolia* were common throughout this subcommunity.

The herbaceous layer was sparse and was dominated by forb species such as *Abutilon hirtus, Blepharis diversispina, Pupalea lappacea, Hibiscus micranthus, Barleria prionitis, Ruellia cordata* and *Seddera suffruticosa.* Other forb species commonly found included *Kyllinga alba*, *Mariscus rehmannianus, Plectranthus tettensis, Asparagus schroederi, Ocimum filamentosum, Maerua decumbens* and *Evolvulus alsinoides.* The dominant grass species in this community were *Brachiaria deflexa*, *Brachiaria xantholeuca*, *Oropetium capense* and *Enteropogon macrostachyus.*

Structure of the woody layer

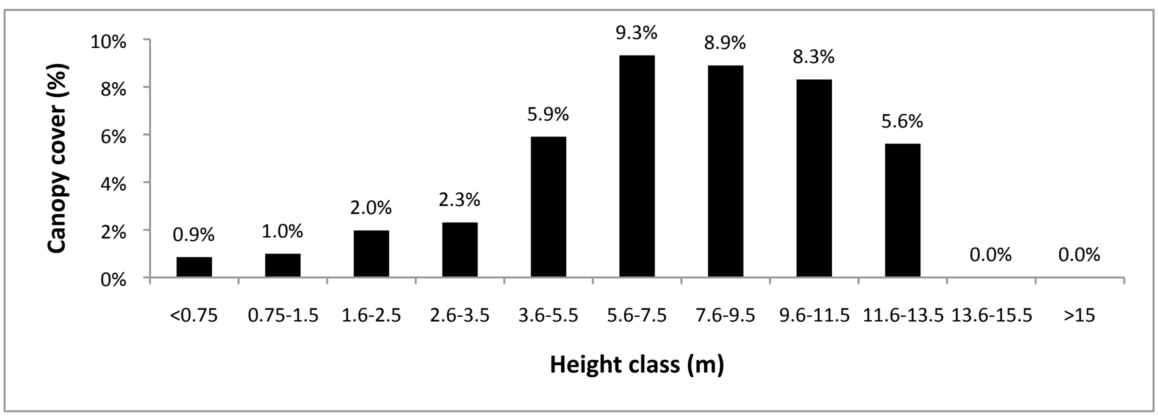


Figure 4.13: The mean percentage canopy cover for 11 height classes of the woody layer for the *Boscia foetida – Colophospermum mopane* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

The total canopy cover for this subcommunity was 42% (Figure 4.13) and the density of woody plants was 2 732 individuals/ha. It was classed as a short closed woodland (Edwards, 1983) based on the dominant height class being 5 – 10 m. Canopy cover in the 5.6 – 7.5 m height class was the highest at 9.3%, closely followed by the 11.6 – 13.5 m (8.9%) and 7.6 – 9.5 m (8.3%) height classes (Figure 4.13). The <0.75 m height class contributed the most (32.7%) to the density of woody plants in this subcommunity followed by the 0.75 – 1.5 m height class (17.1%; Figure 4.14).

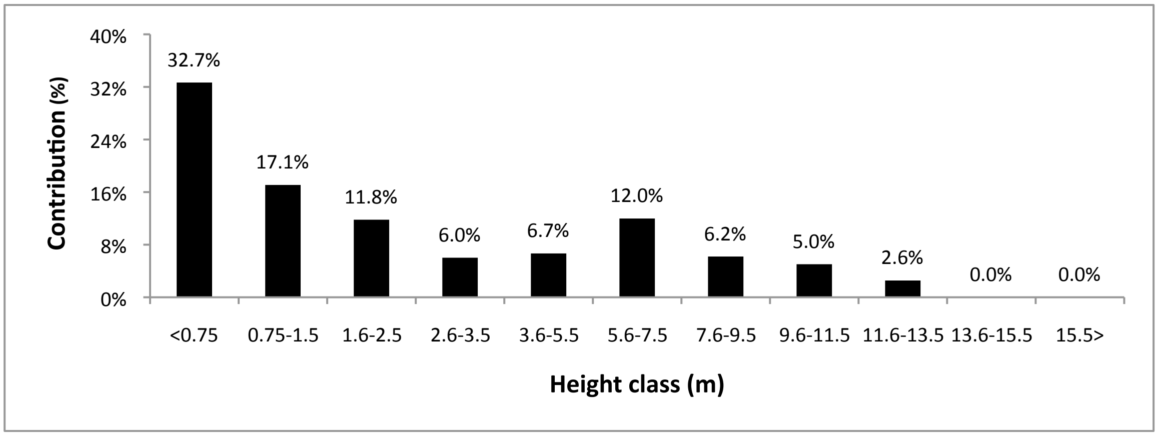


Figure 4.14: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Boscia foetida – Colophospermum mopane* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

2.3 The *Commiphora viminea – Colophospermum mopane* Closed Woodland

This subcommunity was found on the heavy soils associated with the Umkondo System. The soils were mostly lithosols of the 2A family belonging to the Amorphic Order, but also included siallitic soils of the Calcimorphic Order of the 4U and 4S families. The *Commiphora viminea – Colophospermum mopane* Closed Woodland covered an area of 21.5 km^2 and was represented by 10 relevés.

This subcommunity was recognized by the presence of *Commiphora viminea* but also the abscense of *Boscia foetida* and *Salvadora australis* that separated it from the *Boscia foetida – Colophospermum mopane* Closed Woodland. The dominant woody species was *Colophospermum mopane* whilst species such as *Grewia bicolor, Grewia flavescens, Diospyros quiloensis, Zanthoxylum capense*, *Maerua parvifolia* and *Tricalysia junodii* were common throughout this subcommunity.

The herbaceous layer was sparse and was dominated by forb species such as *Pupalea lappacea, Hibiscus micranthus, Ruellia cordata* and *Seddera suffruticosa.* Other forb species commonly found included *Kyllinga alba*, *Mariscus rehmannianus, Plectranthus tettensis, Asparagus schroederi, Ocimum filamentosum* and *Maerua decumbens.* The dominant grass species in this community were *Brachiaria deflexa*, *Oropetium capense* and *Enteropogon macrostachyus.*

Structure of the woody layer

The subcommunity had a total canopy cover of 54% (Figure 4.15) and a density of 4 599 woody plants/ha. It was classed as a short closed woodland (Edwards, 1983) based on the dominant height being 5 – 10 m. Canopy cover in the 9.6 – 11.5 m height class was the highest at 11.9%, closely followed by the 5.6 – 7.5 m (10.7%) and 7.6 – 9.5 m (9.0%) height classes (Figure 4.15). The <0.75 m height class contributed the most (54.4%) to the density of woody plants in this subcommunity followed by the 0.75 – 1.5 m height class (11.4%; Figure 4.16).

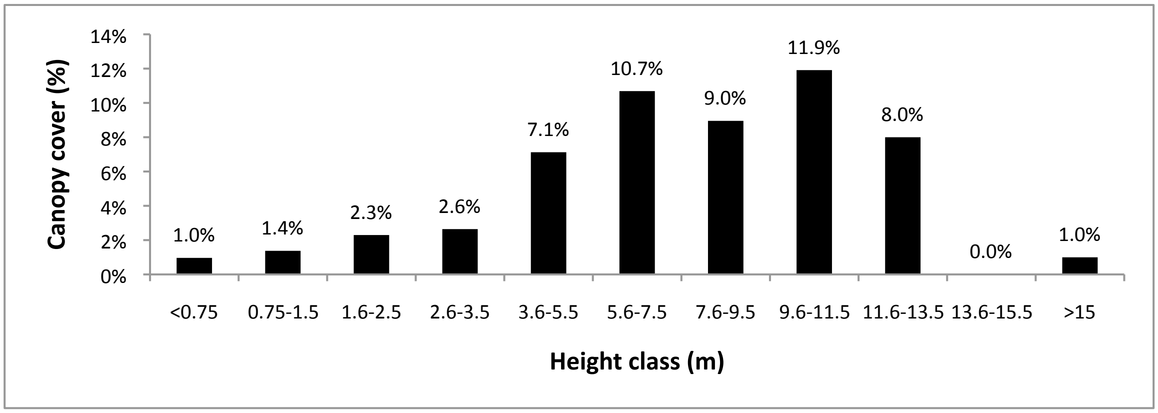


Figure 4.15: The mean percentage canopy cover for 11 height classes of the woody layer for the *Commiphora viminea – Colophospermum mopane* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

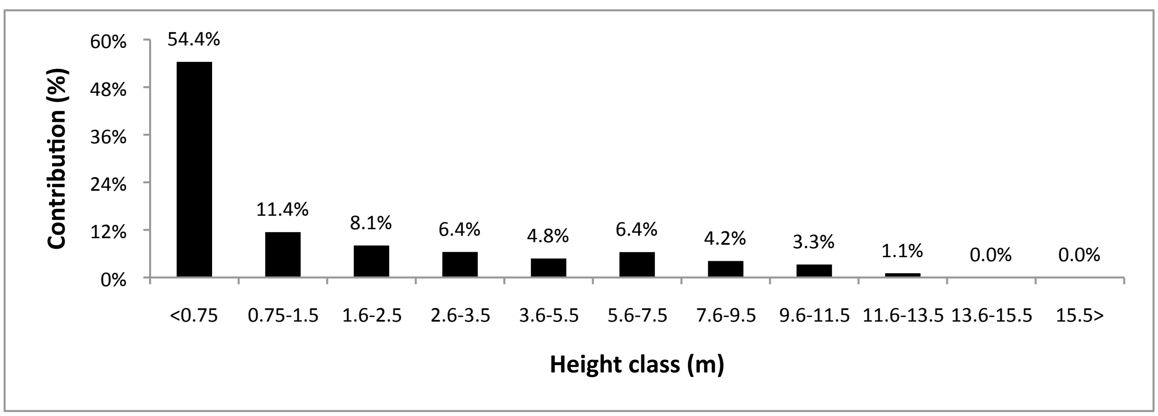


Figure 4.16: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Commiphora viminea – Colophospermum mopane* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

2.4 The *Ruellia cordata – Colophospermum mopane* Closed Woodland

The *Ruellia cordata – Colophospermum mopane* Closed Woodland occurred along the small streams and drainage lines often bordering on subcommunity 4.1 in the southwestern part of Chapungu. It covered an area of 1.7 km^2. The soils were siallitic alluvial deposits that belonged to the 4U family. The terrain was flat with no surface rocks present. The subcommunity was represented by seven relevés.

This tree layer was dominated by species such as *Boscia mossambicensis, Colophospermum mopane, Grewia bicolor* and *Grewia flavescens* whilst the herbaceous layer was dominated by *Justicia flava, Pupalea lappacea, Hibiscus micranthus, Phyllanthus angolensis, Ocimum filamentosum, Asparagus schroederi,* and the grass species *Enteropogon macrostachyus, Brachiaria deflexa* and *Urochloa mosambicensis*.

Structure of the woody layer

The total canopy cover for this subcommunity was 51% (Figure 4.17) and a woody plant density of 2 301 plants/ha. It was classed as a short closed woodland (Edwards, 1983) based on the dominant height being 5 – 10 m. Canopy cover was highest in the 9.6 – 11.5 m height class at 10.9 %, closely followed by the 5.6 – 7.5 m height class at 10.7% and then height class 7.6 – 9.5 m at 8.8% (Figure 4.17). The <0.75 m height class contributed the most (48.6%) to the total number of woody plants in this subcommunity followed by the 0.75 – 1.5 m with 12.9% (Figure 4.18).

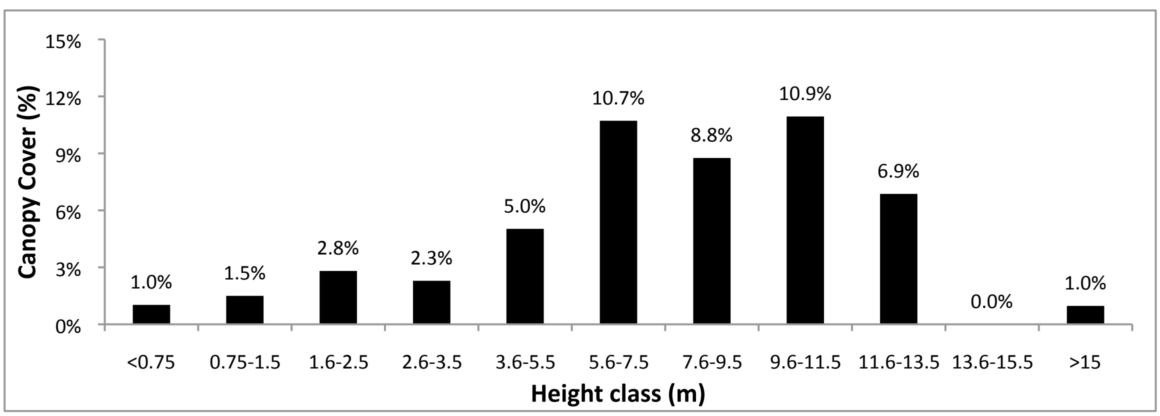


Figure 4.17: The mean percentage canopy cover for 11 height classes of the woody layer for the *Ruellia cordata – Colophospermum mopane* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

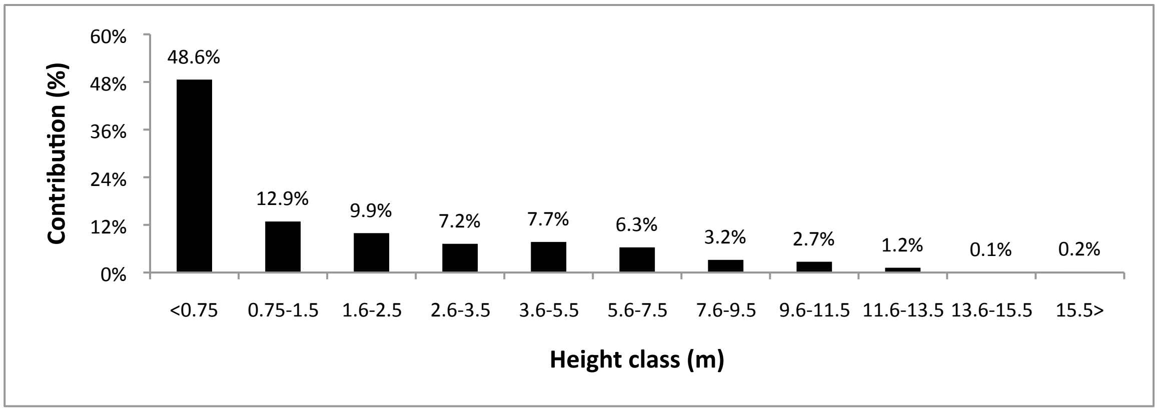


Figure 4.18: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Ruellia cordata – Colophospermum mopane* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

3. The *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland

This community was located on the Umkondo System and was represented by 29 relevés. A mean of 34 species (range 15 – 49) was recorded per relevé and the area covered by this community was 15.5 km^2. The topography was slightly undulating to flat with shallow soils belonging to the amorphic lithosols of the 2B family and calcimorphic siallitic soils of the 4S family. The altitude ranged from 500 m to 540 m above sea level and the landscape had a gentle slope in a southeasterly direction.

The *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland was dominated by *Colophospermum mopane* and could be recognized by the presence of woody species such as *Kirkia acuminata, Grewia villosa, Sterculia rogersii, Commiphora edulis, Commiphora mollis, Commiphora schimperi, Gardenia resiniflua* and *Terminalia prunioides*. Diagnostic herbaceous species for this community were *Barleria elegans, Enneapogon cenchroides*, *Cenchrus ciliaris, Stylosanthes fruticosa, Cyphostemma sulcatum, Melhania forbesii, Heteropogon contortus, Vigna unguiculata, Chloris roxburghiana, Crabbea velutina* and *Tetrapogon tenellus.* Other woody species commonly found in this community were *Grewia bicolor, Grewia flavescens, Cissus cornifolia, Lantana rugosa, Lannea schweinfurthii, Commiphora glandulosa* and *Diospyros quiloensis.* The common species on the herbaceous layer were *Brachiaria deflexa, Digitaria milanjiana, Chamaecrista absus, Triumfetta pentandra, Tephrosia purpurea, Hibiscus micranthus, Pavonia burchellii, Endostemon tereticaulis, Evolvulus alsinoides, Urochloa mosambicensis* and *Tephrosia villosa.*

Structure of the woody layer

The total canopy cover for this community was 22% (Figure 4.19) and the density was 2 372 woody plants/ha. This community was classed as a short closed woodland (Edwards, 1983) based on the 5 – 10 m height class dominating the canopy cover. The highest canopy cover was found in the 5.6 – 7.5 m height class (6.3%), followed by the 7.6 – 9.5 m height class (4.1%) and then height class 11.6 – 13.5 m (3.1%). The 0.75 – 1.5 m height class accounted for 24.9% of the total number of woody plants within this community, followed by the <0.75 m height class (23.2%) and then by 1.6 –2.5 m height class (20.1%; Figure 4.20).

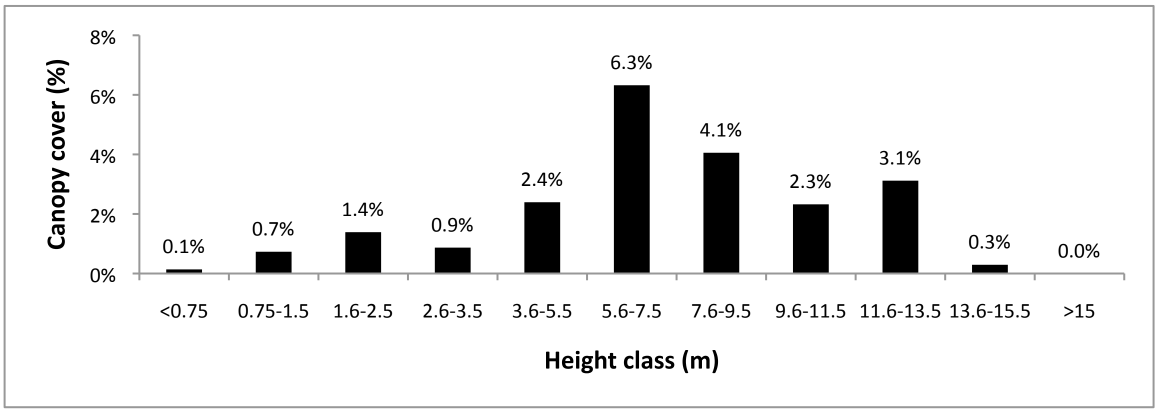


Figure 4.19: The mean percentage canopy cover for 11 height classes of the woody layer for the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

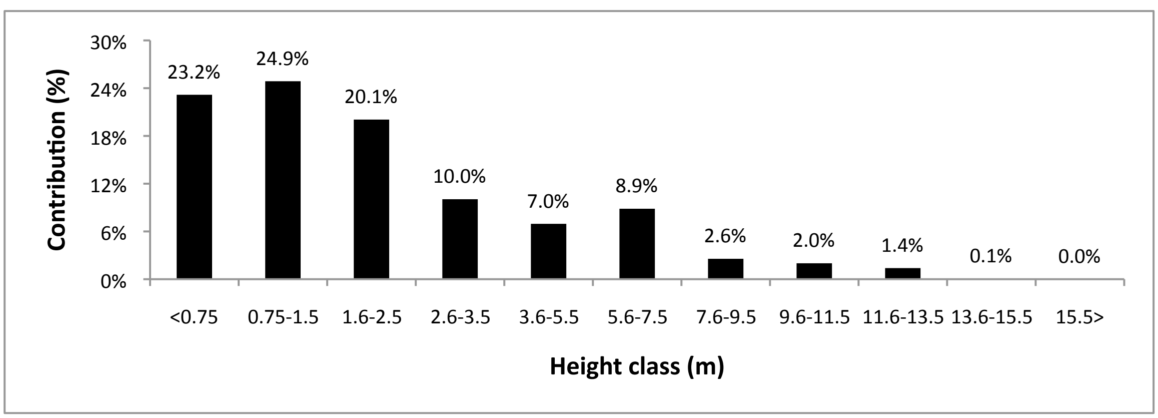


Figure 4.20: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

3.1 The *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland

This subcommunity is found towards the northern boundary with Msaize Ranch, the northwestern boundary with Sango and Msaize ranches and in the southeast of Chapungu. The soils, mainly derived from basalt, were shallow lithosols of the 2B family and siallitic soils of the 4S family. This subcommunity was represented by 15 relevés and was 10.4 km^2 in size.

Diagnostic species for the *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland were *Commiphora schimperi, Cissus cornifolia, Commiphora africana, Cenchrus ciliaris, Stylosanthes fruticosa* and *Cyphostemma sulcatum.* Species commonly found were *Kirkia acuminata, Colophospermum mopane*, *Grewia villosa, Sterculia rogersii, Commiphora edulis, Commiphora mollis, Gardenia resiniflua* and *Terminalia prunioides*. Herbaceous species commonly found were *Brachiaria deflexa, Digitaria milanjiana, Chamaecrista absus, Heteropogon contortus, Tephrosia purpurea, Hibiscus micranthus, Pavonia burchellii, Endostemon tereticaulis, Urochloa mosambicensis* and *Tephrosia villosa.*

Structure of the woody layer

The total canopy cover for this subcommunity was 24% (Figure 4.21) and the density was 2 073 woody plants/ha. It was classed as short closed woodland based on the dominant height being 5 – 10 m (Edwards, 1983). Canopy cover in the 5.6 – 7.5 m height class was highest at 6.5%, followed by height class 7.6 – 9.5 m at 4.8% and then height class 11.6 – 13.5 m at 4.4% (Figure 4.21). The <0.75 m height class accounted for 32.4% of the total number of woody plants within this community, followed by height class 0.75 – 1.5 m (19.6%) and then by height class 1.6 – 2.5 m (13.8%;Figure 4.22).

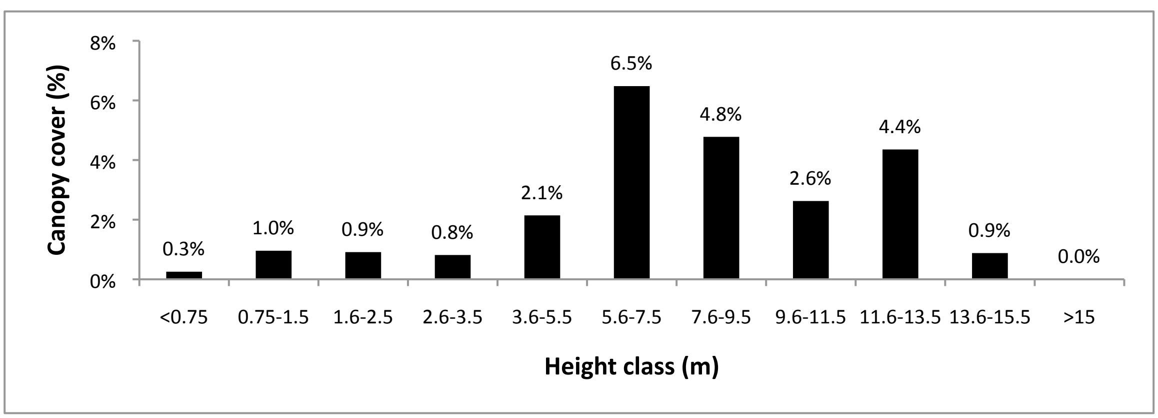


Figure 4.21: The mean percentage canopy cover for 11 height classes of the woody layer for the *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

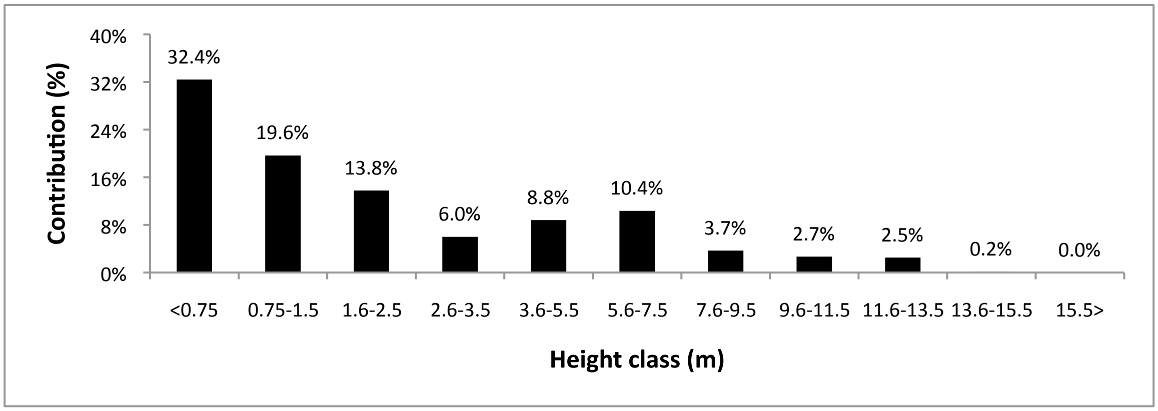


Figure 4.22: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

3.2 The *Endostemon tenuiflorus – Grewia villosa* Short Closed Woodland

This subcommunity was represented by four relevés and was situated along the banks of the Msaize River on weathered sandstone and conglomerates associated with the Umkondo geological system. The lithosol soils were shallow belonging to the 2B family and displayed weathered calcareous rock below the surface. The topography was flat but terraced towards the Msaize River. The size of this subcommunity was only 2.6 km^2.

The diagnostic species for this subcommunity was *Endostemon tenuiflorus,* but it was also recognized by the presence of woody species such as *Grewia villosa, Kirkia acuminata, Sterculia rogersii*, *Commiphora mollis, Commiphora edulis, Gardenia resiniflua, Terminalia prunioides* and herbaceous species such as *Bothriochloa radicans, Tetrapogon tenellus, Enneapogon cenchroides, Melhania forbesii* and *Phyllanthus maderaspatensis.* Other common species were *Grewia bicolor, Colophospermum mopane, Hibiscus micranthus, Tephrosia purpurea, Heteropogon contortus, Lantana rugosa* and *Digitaria milanjiana.*

Structure of the woody layer

The total canopy cover for this subcommunity was 22% (Figure 4.23) with a density of 2 842 woody plants/ha. This subcommunity was classed as short closed woodland (Edwards, 1983) with the dominant height class being 5 – 10 m high. The highest canopy cover of 7.2% was recorded in the 5.6 – 7.5 m height class followed by height class 11.6 – 13.5 m at 5.0% and then height class 7.6 – 9.5 m at 3.8% (Figure 4.23). The <0.75 m height class accounted for 25.5% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 23.6% and then by height class 1.6 – 2.5 m with 18.5% (Figure 4.24).

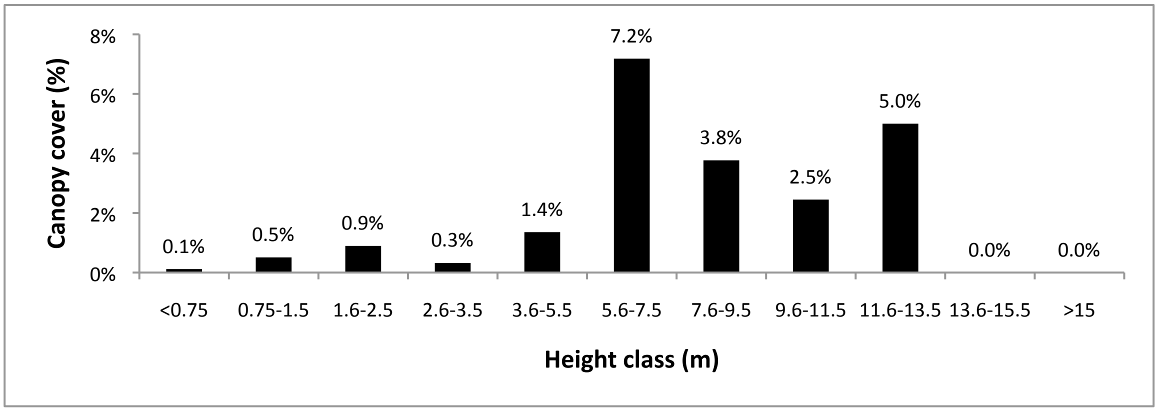


Figure 4.23: The mean percentage canopy cover for 11 height classes of the woody layer for the *Endostemon tenuiflorus – Grewia villosa* Short Woodland Community, Chapungu Ranch, Save Valley Conservancy.

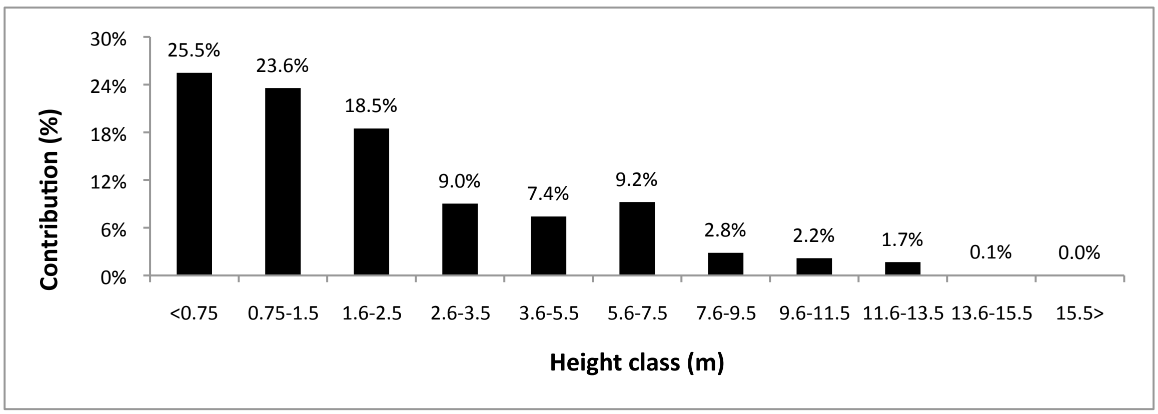


Figure 4.24: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Endostemon tenuiflorus – Grewia villosa* Short Woodland Community, Chapungu Ranch, Save Valley Conservancy.

3.3 The *Terminalia prunioides – Kirkia acuminata* Closed Woodland

The underlying geological formations in this subcommunity were sandstone, limestone and conglomerate and the soils ranged from amorphic lithosols of the 2B family to calcimorphic siallitic soils of the 4S family. The topography was mostly flat, forming terraces towards the Msaize River. This subcommunity occurred mainly to the south of the Msaize River and roughly followed the river from where it entered Chapungu in the west up to the center of the property. The subcommunity was sometimes found on the bank of the Msaize River on cliffs of exposed sandstone and conglomerate. A small section of this subcommunity was also found on the northern bank of the Msaize River. The subcommunity was represented by 10 relevés and covered 2.5 km^2.

This subcommunity was distinguised by the absence of diagnostic species but was recognized by the presence of *Grewia villosa, Kirkia acuminata, Commiphora edulis, Gardenia resiniflua, Terminalia prunioides* and herbaceous species such as *Tetrapogon tenellus, Crabbea velutina, Barleria elegans* and *Asparagus schroederi.* In parts of this subcommunity impressive stands of *Kirkia acuminata* were seen.

Structure of the woody layer

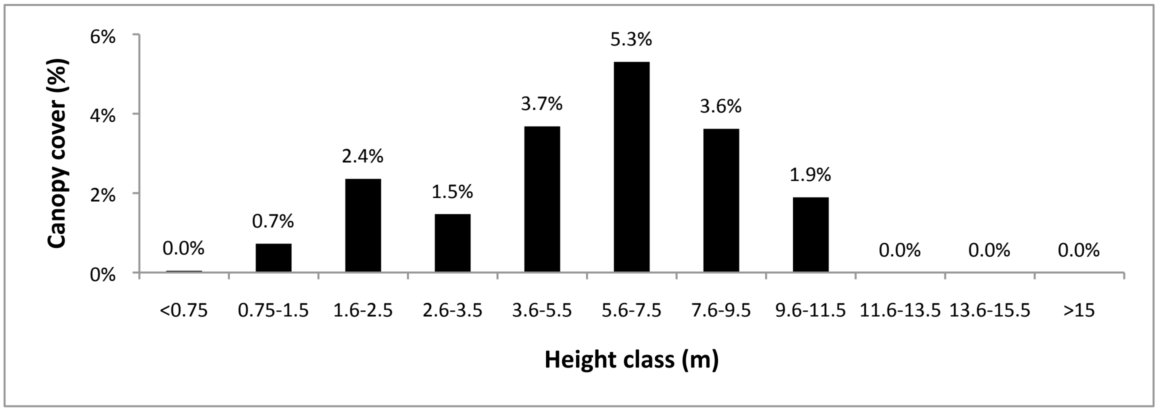


Figure 4.25: The mean percentage canopy cover for 11 height classes of the woody layer for the *Terminalia pruniodes – Kirkia acuminata* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

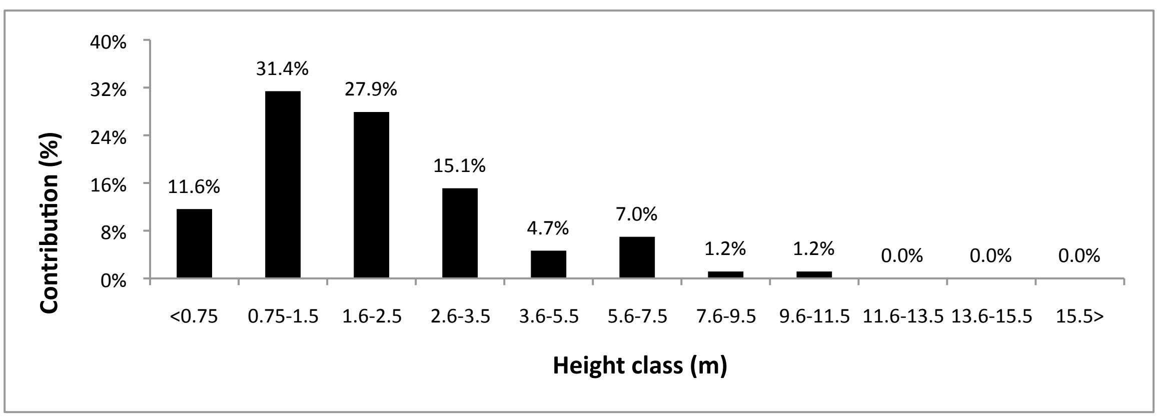


Figure 4.26: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Terminalia pruniodes – Kirkia acuminata* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

The total canopy cover for this community is 19% (Figure 4.25) and the density was 2 200 woody plants/ha. It was classed as a short closed woodland (Edwards, 1983) with the 5 – 10 m height class dominating total canopy cover. The highest canopy cover was found in the 5.6 – 7.5 m height class (5.3%) followed by the 3.6 – 5.5 m (3.7%) and 7.6 – 9.5 m (3.6%) height classes (Figure 4.25). The 0.75 – 1.5 m height class accounted for 31.4% of the total number of woody plants, followed by height class 1.6 – 2.5 m (27.9%) and then by height class 2.6 – 3.5 m (15.1%; Figure 4.26).

4. The *Albizia anthelmintica – Acacia tortilis* Open Woodland

This community was represented by 42 relevés with a mean of 29 species (range 14–41) per sampling plot. The community covered a total area of 39.7 km^2 and was associated with sandy colluvial and alluvial deposits of the 4U family. All the soils in this community were siallitic of the Calcimorphic Order. The topography was mostly flat, forming sandy terraces towards the Msaize River. Along the Save River a dune like levee also supported this community. The flat nature of the terrain and slow lateral movement of clays within the soil often resulted in the formation of natural pans within this community. Natural pans were also often encountered in the ecotonal areas between this community and other communities with higher soil clay contents. There were no surface rocks in this community.

The *Albizia anthelmintica – Acacia tortilis* Open Woodland was recognized by the presence of species such as *Albizia anthelmintica, Dichrostachys cinerea, Lycium shawii, Cleome monophylla, Cucumus anguria* and *Sida ovata.* Tree species commonly found in this community were *Acacia tortilis, Lannea schweinfurthii, Commiphora glandulosa, Diospyros quiloensis, Acacia nigrescens* and *Grewia bicolor.* The grass layer was dominated by *Urochloa mosambicensis* and *Digitaria milanjiana* whilst *Dactyloctenium giganteum* and *Panicum maximum* were also commonly found. Common forbs in this community were *Maerua juncea, Limeum fenestratum, Tephrosia purpurea, Indigofera praticola, Limeum sulcatum, Kyphocarpa angustifolia, Crotalaria distans, Crotalaria sphaerocarpa, Crotalaria distans, Celosia trigyna, Heliotropium steudneri, Triumfetta pentandra, Endostemon tereticaulis*, *Evolvulus alsinoides*, *Ipomoea sinensis, Justicia flava,* and *Commelina benghalensis.*

This community attracted large numbers of herbivores, especially during the wet summer months, and this could largely be attributed to the availability and palatability of the herbaceous layer (Chapter 8).

Structure of the woody layer

The total canopy cover for this community was 12% (Figure 4.27) and the density was 1 209 woody plants/ha. Despite the total canopy cover being 12% and slightly above the recommended criteria of <10% to qualify as an open woodland by Edwards (1983) this community was classed as a short open woodland based on height classes 5 – 10 m and 10 – 20 m having canopy cover values below 10%. The highest canopy cover was found in height class 9.6 – 11.5 m (2.8%) followed by the 3.6 – 5.5 m height class with 2.6% and 5.6 – 7.5 m height class with 2.0% (Figure 4.27). The <0.75 m height class accounted for 50.6%

of the total number of woody plants, followed by height class 0.75 – 1.5 m with 17.0% and then by height class 1.6 – 2.5 m with 10.0% (Figure 4.28).

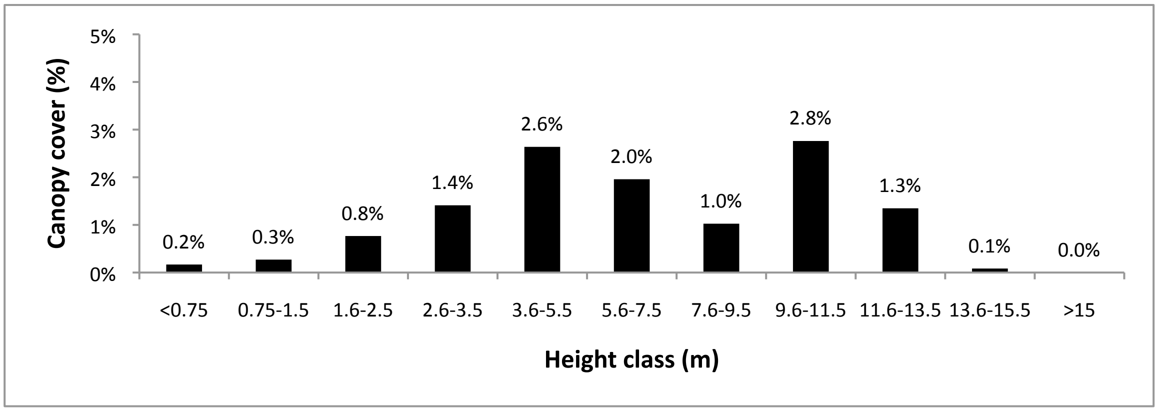


Figure 4.27: The mean percentage canopy cover for 11 height classes of the woody layer for the *Albizia anthelmintica – Acacia tortilis* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

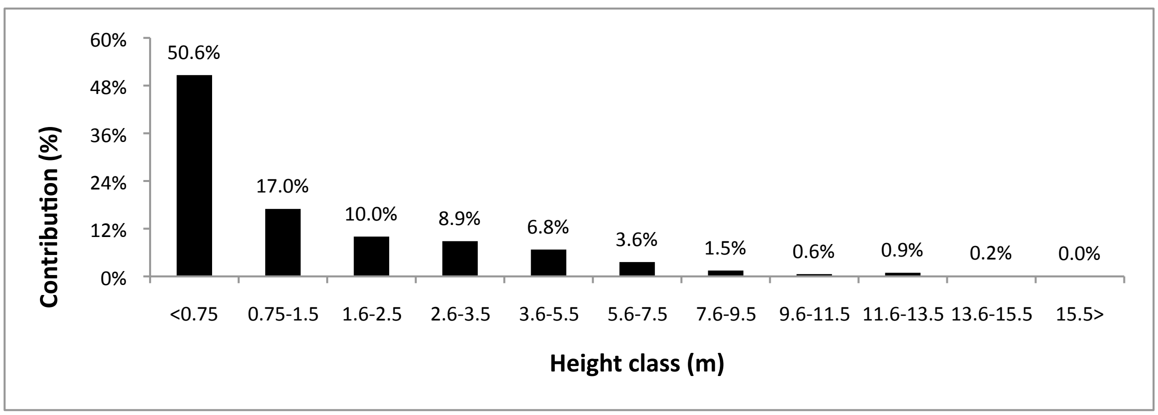


Figure 4.28: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Albizia anthelmintica – Acacia tortilis* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

4.1 The *Tephrosia purpurea – Albizia anthelmintica* Open Woodland

This subcommunity was 26.4 km^2 in size and occurred on the colluvial soils on both the northern and southern sides of the Msaize River. It was represented by 25 relevés and the topography was mostly flat, slightly sloping towards the southeast and often formed a terrace before the transition to the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland. The topsoils were mostly sandy to sandy loam whereas the subsoils were often sandy loams or sandy clay soils.

The *Tephrosia purpurea – Albizia anthelmintica* Open Woodland was recognized by the presence of species such as *Limeum fenestratum, Cadaba termitaria, Hermbstaedtia odorata, Crotalaria distans, Heliotropium ciliatum* and *Heliotropium strigosum*. The common woody species in this subcommunity were *Acacia tortilis, Lannea schweinfurthii, Commiphora glandulosa, Boscia mossambicensis, Albizia anthelmintica, Diospyros quiloensis, Grewia flavescens, Acacia nigrescens* and *Grewia bicolor.* The dominant grass species were *Digitaria milanjiana* and *Urochloa mosambicensis* whilst *Dactyloctenium giganteum, Panicum maximum* and *Tragus berteronianus* were some of the more common grass species. The herbaceous layer had a diverse and often large forb component of which *Maerua juncea, Limeum fenestratum, Tephrosia purpurea, Indigofera praticola, Limeum sulcatum, Kyphocarpa angustifolia, Hermannia glanduligera, Crotalaria distans, Cleome monophylla, Ipomoea pes-tigridis, Celosia trigyna, Heliotropium steudneri, Triumfetta pentandra, Endostemon tereticaulis*, *Evolvulus alsinoides, Hermbstaedtia odorata, Ipomoea sinensis, Justicia protracta, Justicia flava, Tribulus terrestris* and *Commelina benghalensis* were the most common species.

Structure of the woody layer

The total canopy cover for this subcommunity was 9% (Figure 4.29) with a density of 645 woody plants/ha. This subcommunity was classed as a short open woodland (Edwards, 1983) based on height class 5 – 10 m having the highest canopy cover. Canopy cover of all height class were low, with only height class 3.6 – 5.5 m having a canopy cover > 2.0. The <0.75 m height class accounted for 49% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 17.3% and then by height class 1.6 – 2.5m with 10.8% (Figure 4.30).

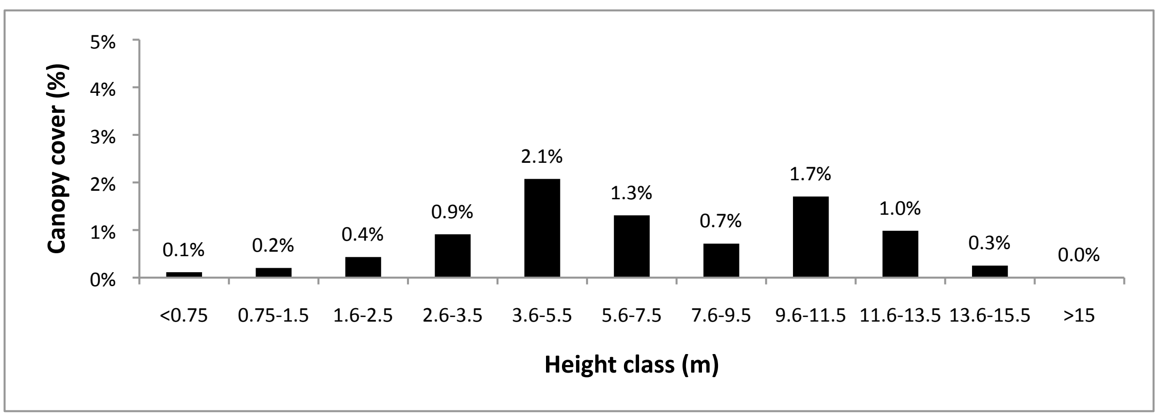


Figure 4.29: The mean percentage canopy cover for 11 height classes of the woody layer for the *Tephrosia purpurea – Albizia anthelmintica* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

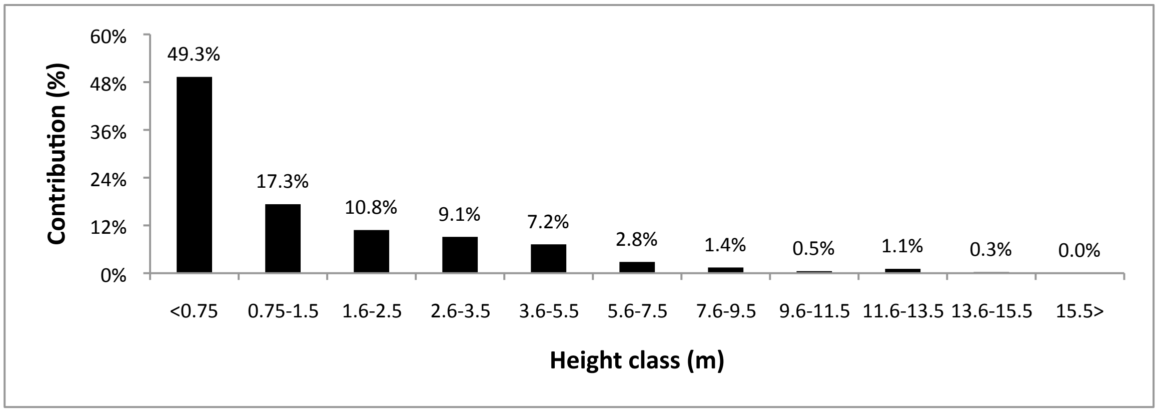


Figure 4.30: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Tephrosia purpurea – Albizia anthelmintica* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

4.2 The *Tephrosia rhodesica – Acacia tortilis* Open Woodland

This subcommunity was found along the bank of the Chenjera and Chisangaurwe rivers. It covered and area of 5.2 km^2 and was represented by four relevés. The calcimorphic siallitic soils were alluvial deposits that overlay the Umkondo System. These soils generally had a higher clay content than the colluvial and alluvial soils of the other two subcommunities. The topography was flat or gently sloping towards the southeast.

The *Tephrosia rhodesica – Acacia tortilis* Open Woodland was separated from the other two subcommunities by the presence of *Tephrosia rhodesica*. It shared many of the common woody species such as *Albizia anthelmintica, Boscia mossambicensis* and *Grewia bicolor*. The most prominent grass species were *Digitaria milanjiana* and *Urochloa mosambicensis* which were also common to all three subcommunities.

Structure of the woody layer

This subcommunity had a total canopy cover of 14% (Figure 4.31) and a density of 1 577 woody plants/ha. It was classed as a short open woodland (Edwards, 1983) based on height class 5 – 10 m having the highest canopy cover. Height class 3.6 – 5.5 m had a canopy cover of 3.1% followed by height class 5.6 – 7.5 m with 2.9% and height class 9.6 – 11.5 m with 2.5% (Figure 4.31). The <0.75 m height class accounted for 59.1% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 15.5% and then by height class 1.6 – 2.5 m with 8.2% (Figure 4.32).

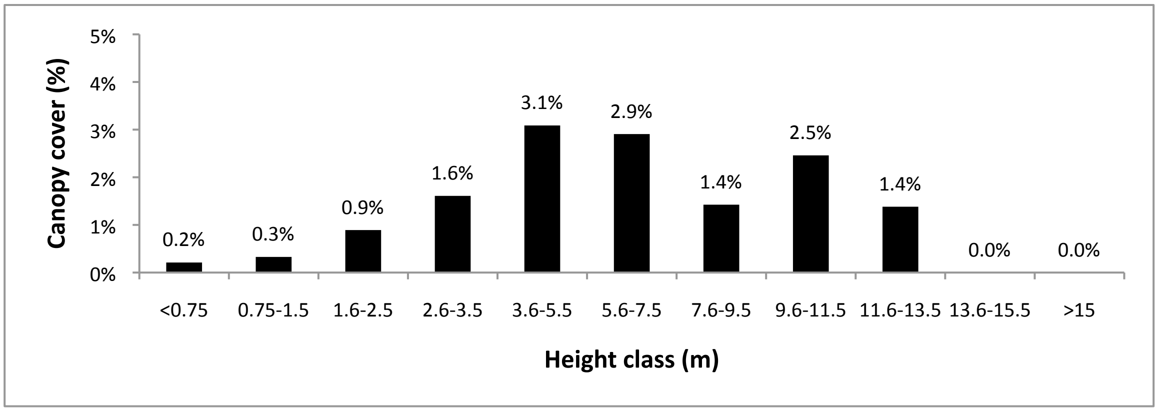


Figure 4.31: The percentage canopy cover for 11 height classes of the woody layer for the *Tephrosia rhodesica – Acacia tortilis* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

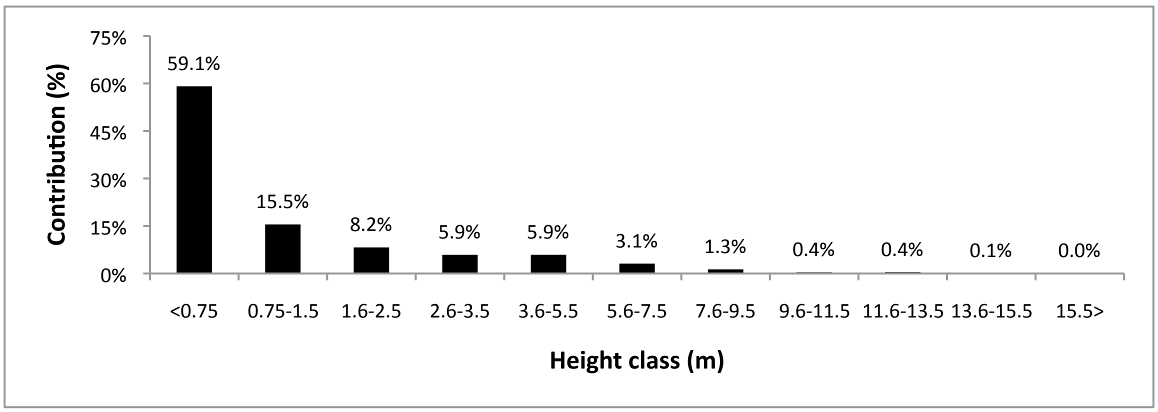


Figure 4.32: The percentage contribution of woody individuals to the density in 11 height classes in the *Tephrosia rhodesica – Acacia tortilis* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

4.3 The *Lycium shawii – Diospyros quiloensis* Tall Open Woodland

This subcommunity was 8.3 km^2 in size, represented by 13 relevés and occurred on a levee that stretched along the Save River from the northern boundary with Msaize Ranch to the southern boundary with Save River Ranch. The levee was essentially a sand bank or dune with deep, sandy siallitic soils belonging to the Calcimorphic Order.

The *Lycium shawii – Diospyros quiloensis* Open Woodland had no diagnostic species. The common woody species in this subcommunity were *Acacia tortilis, Commiphora glandulosa, Boscia mossambicensis, Albizia anthelmintica, Gymnosporia putterlickioides, Diospyros quiloensis, Grewia flavescens,* and *Grewia bicolor.* The dominant grass species were *Digitaria milanjiana* and *Urochloa mosambicensis* whilst *Panicum maximum* was the most common grass species. The herbaceous layer had a diverse and often large forb component of which *Maerua juncea, Tephrosia purpurea, Kyphocarpa angustifolia, Crotalaria sphaerocarpa, Cleome monophylla, Ipomoea pes-tigridis, Triumfetta pentandra, Endostemon tereticaulis*, *Evolvulus alsinoides, Ipomoea sinensis, Justicia flava, Sida cornifolia* and *Commelina benghalensis* were the most common species. A prominent feature in this subcommunity was the presence of a high density of baobabs, *Adansonia digitata*.

Structure of the woody layer

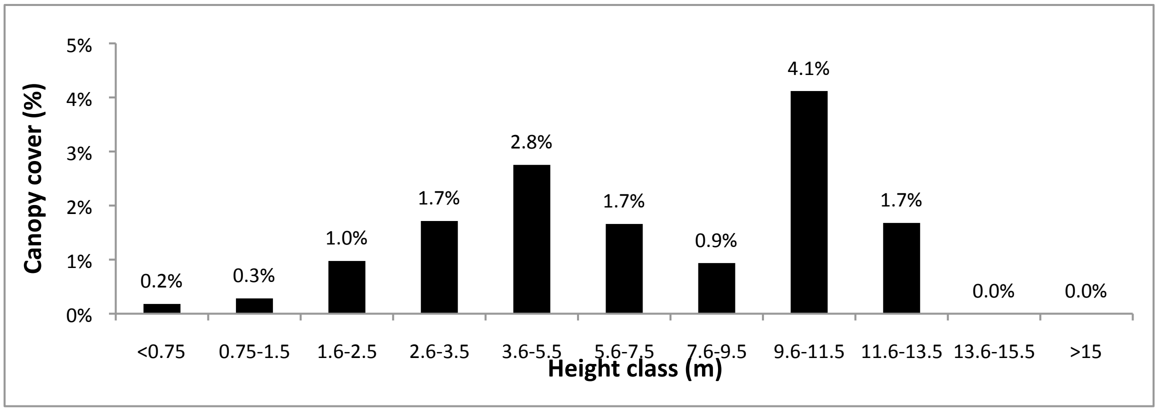


Figure 4.33: The mean percentage canopy cover for 11 height classes of the woody layer for the *Lycium shawii – Diospyros quiloensis* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

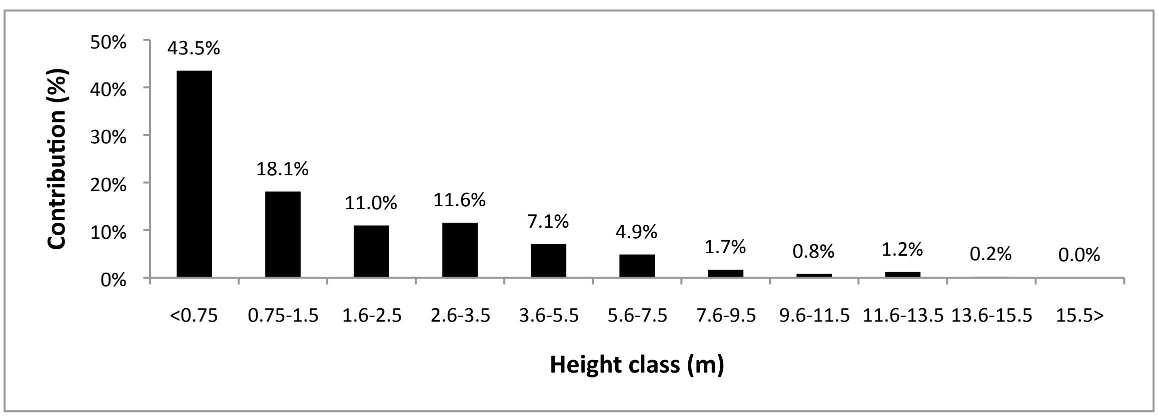


Figure 4.34: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Lycium shawii – Diospyros quiloensis* Open Woodland, Chapungu Ranch, Save Valley Conservancy.

This subcommunity had a total canopy cover of 14% (Figure 4.33) and a density of 1 675 woody plants/ha. It was classed as a tall open woodland (Edwards, 1983) based on height class 10 – 20 m having the highest canopy cover. Overall the canopy cover of the individual height classes was low, with the 9.6 – 11.5 m height class having the highest value at 4.1% (Figure 4.33). The <0.75 m height class accounted for 43.5% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 18.1% and then by height class 2.6 – 3.5 m with 11.6% (Figure 4.34).

5. The *Xanthocercis zambesiaca – Acacia tortilis* Tall Closed Woodland

This community was represented by six relevés and was associated with the older alluvial deposits along the major rivers on the property. It covered an area of 11.6 km^2 and had a mean of 27 species (range18–37) recorded per relevé. The siallitic soils were alluvial deposits and belonged to the 4U family. The topography was flat following the Msaize River with a gentle slope in a southeasterly direction. Along the Save River it sloped into an eastern direction. The *Xanthocercis zambesiaca – Acacia tortilis* Tall Closed Woodland essentially formed the transition between the *Albizia anthelmintica – Acacia tortilis* Open Woodland and the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest. In this region the soil regime changed from the sandy colluvial soils and the sandy soils associated with the levee to sandy loam alluvial soils that gave rise to a vegetation composition that included species from both communities.

This community was recognized by the presence of *Xanthocercis zambesiaca, Ehretia amoena, Cordia ovalis, Solanum panduriforme* and *Azima tetracantha. Acacia tortilis* dominated the woody layer, but species such as *Pavonia burchellii, Nelsia quadrangula, Anisotes formosissimus, Abutilon angulatum, Justicia protracta, Thilachium africanum, Lannea schweinfurthii* and *Strychnos potatorum* were common. The grass layer was dominated by *Panicum maximum*, *Dactyloctenium gigantium* and *Urochloa mosambicensis*.

Structure of the woody layer

This community was classed as a tall closed woodland (Edwards, 1983) based on the total canopy cover being 19%, with the dominant height class being from 10 – 20 m high. The density of woody individuals was 2 688 plants/ha (Figure 4.35). Height class 9.6 – 11.5 m had the highest canopy cover (7.1%) followed by height class 11.6 – 13.5 m (3.0%) and height class 13.5 – 15.5 m (2.7%; Figure 4.35). The <0.75 m height class accounted for 69.8% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 11.4% and then by height class 1.6 – 2.5 m with 4.9% (Figure 4.36).

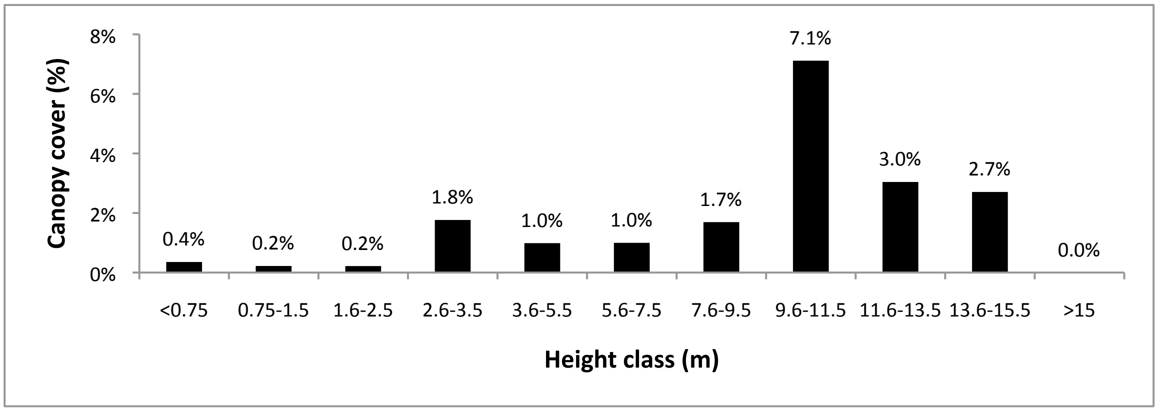


Figure 4.35: The mean percentage canopy cover for 11 height classes of the woody layer for the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

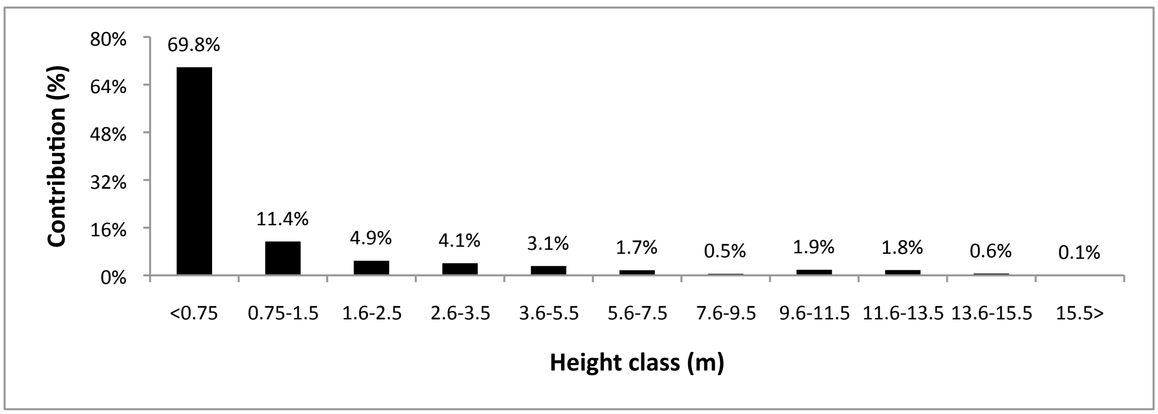


Figure 4.36: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland, Chapungu Ranch, Save Valley Conservancy.

6. The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest

This community was found along the banks and on the islands of the major rivers and drainage lines on Chapungu Ranch. It was represented by 21 relevés with a mean of 26 species (range 15–39) recorded per sampling plot. The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest covered 17.4 km^2 but this area also included the *Phragmites australis – Ficus capreifolia* Reedbed community. The altitude of the community ranged from 540 – 460 m above sea level and the soils were siallitic 4U alluvials from the Calcimorphic Order. The topography was flat.

The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest was recognized by the presence of *Dalbergia arbutifolia, Grewia sulcata, Ampelocissus obtusata* and *Teliacora funifera*.

Dominant woody species included *Diospyros mespiliformis*, *Acacia schweinfurthii* and *Grewia inaequilatera*. The herbaceous layer was dominated by *Panicum maximum.* Common woody species were *Philenoptera violacea, Kigelia africana, Cardiogyne africana, Ziziphus mucronata, Croton megalobotrys, Dombeya kirkii, Berchemia discolor, Hippocratea indica, Grewia flavescens, Boscia mossambicensis, Combretum paniculatum, Allophyllus alsinoides, Albizia versicolor, Cordyla africana, Bridelia cathartica, Trichilia emetica, Azima tetracantha, Ehretia amoena, Syzygium guineense, Artrabotrys brachypetalus* and *Combretum imberbe.* Common herbaceous species included *Solanum panduriforme, Commicarpus plumbagineus, Plumbago zeylanica, Thunbergia alata, Abutilon angulatum, Justicia protracta* subsp. *protracta, Brachiaria deflexa, Pavonia burchellii, Nelsia quadrangula, Pupalia lappacea, Leucas glabrata* and *Monechma divaricatum*.

Structure of the woody layer

This community was classed as a tall closed riverine forest (Edwards, 1983) based on the total canopy cover of 61%, and a dominant woody layer from 10 – 20 m high. Height class 11.6 – 13.5 m had a canopy cover of 13.3% followed by height class 13.6 – 15.5 m with 12.0% and height class 9.5 – 11.5 m with 9.1% (Figure 4.37). Total density was 4 333 woody plants/ha and the <0.75 m height class accounted for 70.3% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 11.4% and then by height class 1.5 – 2.5 m with 5.0% (Figure 4.38).

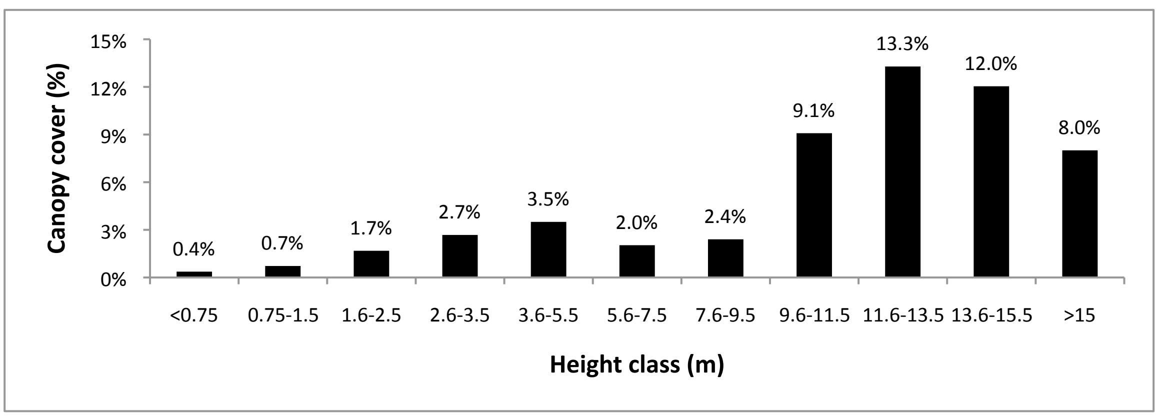


Figure 4.37: The mean percentage canopy cover for 11 height classes of the woody layer for the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest, Chapungu Ranch, Save Valley Conservancy.

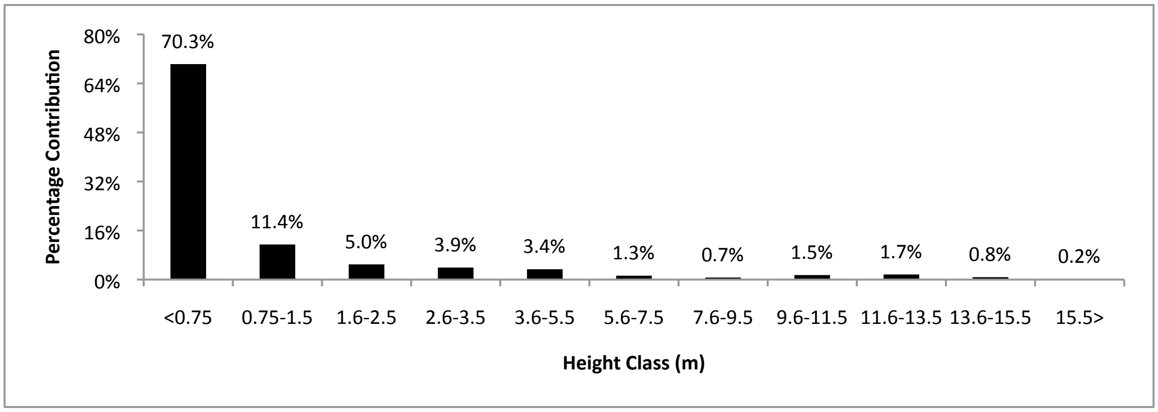


Figure 4.38: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest, Chapungu Ranch, Save Valley Conservancy.

6.1 The *Cardiogyne africana – Acacia schweinfurthii* Tall Closed Riverine Forest

This subcommunity was represented by 12 relevés and was found on recent, deep, stratified, alluvial deposits along the banks of the Msaize and Save rivers. On the Msaize River this subcommunity was wedged between the *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest and the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland. On the Save River it occurred between the *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest and the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland community. The topography was flat.

Species diagnostic to this subcommunity were *Diospyros mespiliformis, Berchemia discolor, Deinbolia xanthocarpa, Garcinia livingstonii, Hippocratea indica, Plumbago zeylanica, Thunbergia alata* and *Gymnosporia senegalensis.* Other common woody species included *Acacia schweinfurthii, Grewia inaequilatera*, *Philenoptera violacea, Kigelia africana, Cardiogyne africana, Ziziphus mucronata, Grewia flavescens, Boscia mossambicensis, Azima tetracantha, Strychnos potatorum, Ehretia amoena* and *Combretum imberbe.* The herbaceous layer was dominated by *Panicum maximum* whilst *Solanum panduriforme, Commicarpus plumbagineus, Abutilon angulatum, Justicia protracta* subsp. *protracta, Brachiaria deflexa, Pavonia burchellii, Pupalia lappacea, Leucas glabrata* and *Asystasia gangetica* were commonly found.

Structure of the woody layer

The total canopy cover for this subcommunity was 71% with a dominant layer from 10 – 20 m high. It was therefore classed as a high closed forest (Edwards, 1983). Height class 11.6 – 13.5 m had the highest canopy cover at 19.4%, followed by height class 13.6 – 15.5 m with 18.5 % and height class 9.6 – 11.5 m with 9.0% (Figure 4.39). Total density of woody plants was 5 718 plants/ha with the <0.75 m height class accounting for 69.8% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 11.4% and then by height class 1.6 – 2.5 m with 4.9% (Figure 4.40).

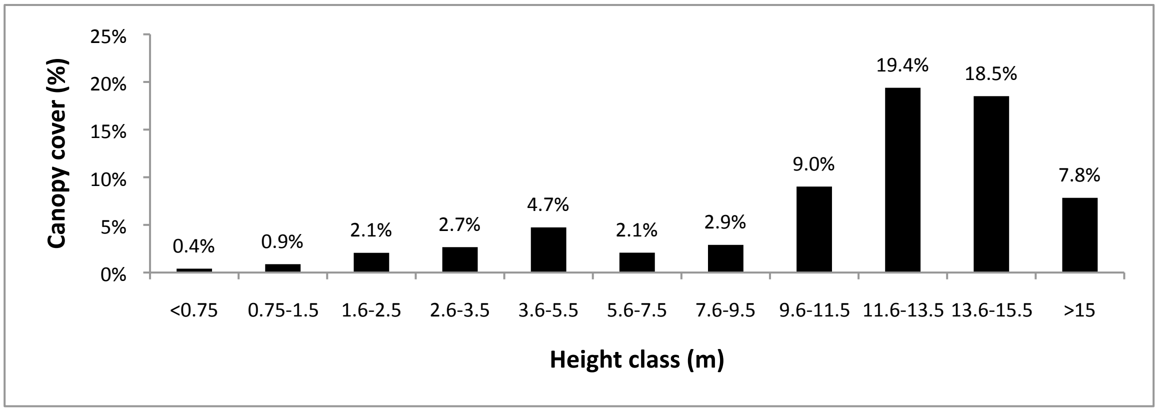


Figure 4.39: The mean percentage canopy cover for 11 height classes of the woody layer for the *Cardiogyne africana – Acacia schweinfurthii* Tall Closed Riverine Forest, Chapungu Ranch, Save Valley Conservancy.

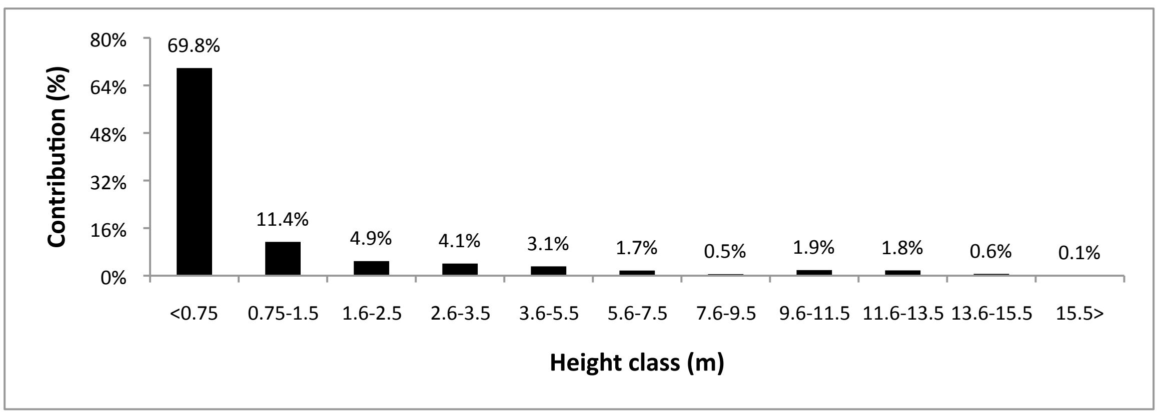


Figure 4.40: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Cardiogyne africana – Acacia schweinfurthii* Tall Closed Riverine Forest, Chapungu Ranch, Save Valley Conservancy.

6.2 The *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest

This subcommunity was largely confined to the sandy riverbeds of the Save River and Msaize River and occurred on alluvial soils overlain with river sand. It was represented by 3 relevés. In the Save River it was not uncommon for this subcommunity to occur together with the *Phragmites australis – Ficus capreifolia* Reedbeds although the latter often occurred on the outer fringes on almost pure river sand. The diagnostic species for this subcommunity were *Faidherbia albida, Acacia galpinii, Eragrostis rotifer, Cynodon* *dactylon* and *Ocimum gratissimum*. The common woody species occuring in this subcommunity were *Cardiogyne africana, Ziziphus mucronata, Croton megalobotrys* and *Dombeya kirkii*.

Structure of the woody layer

The total canopy cover recorded for this subcommunity was 41% and therefore it was classed as a tall closed woodland (Edwards, 1983) with a density of 3 132 woody plants/ha. Trees such as *Faidherbia albida* (five records) and *Acacia galpinii* (six records) were often estimated to grow taller than 20 m but did not dominate the dominant 10 – 20 m layer. Height class 9.6 – 11.5 m had the highest canopy cover (9.2%) followed by height class >15.5 m (8.2%; Figure 4.41). The <0.75 m height class accounted for 71.0% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 11.6% and then by height class 1.6 – 2.5 m with 4.9% (Figure 4.42).

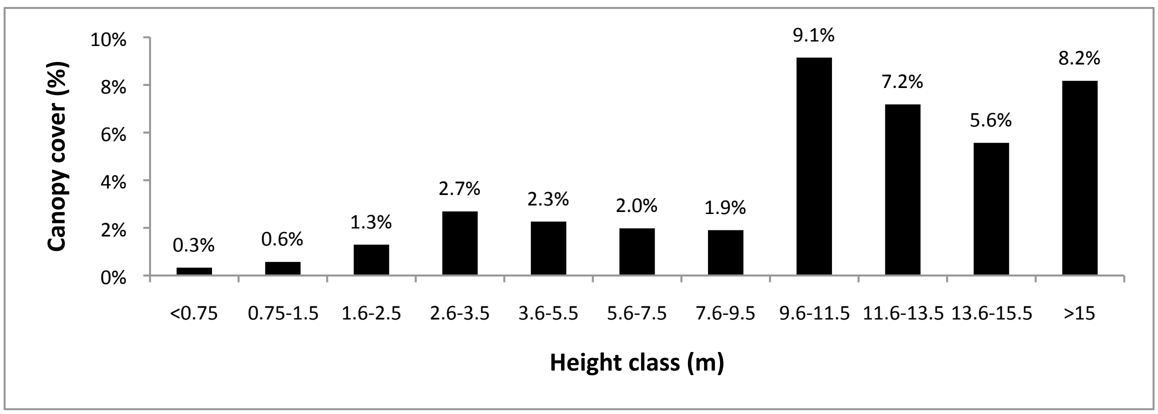


Figure 4.41: The mean percentage canopy cover for 11 height classes of the woody layer for the *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest, Chapungu Ranch, Save Valley Conservancy.

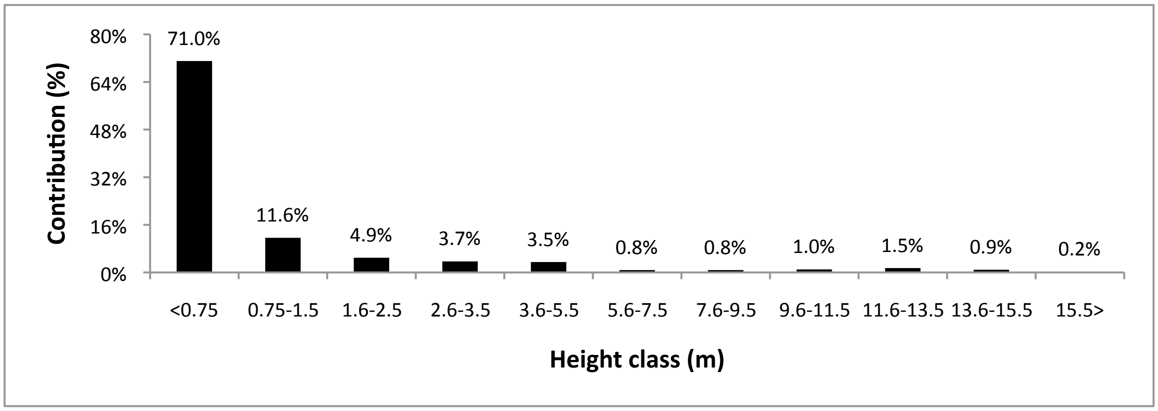


Figure 4.42: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest, Chapungu Ranch, Save Valley Conservancy.

6.3 *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest

This subcommunity was represented by 5 relevés and was situated along the lower banks and on the islands of the Save River. The siallitic soils were stratified alluvial deposits belonging to the 4U family. The topography was mostly flat.

Diagnostic species for the *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest were *Albizia glaberrima, Trichilia emetica, Bridelia cathartica, Allophyllus alsinoides, Syzygium guineense* and *Tabernaemontana elegans.* Common species were *Grewia inaequilatera, Combretum paniculatum, Albizia versicolor, Cordyla africana, Artrabotrys brachypetalus* and *Seersia guineense.* Common herbaceous plant species included *Justicia campylostemon, Justicia protracta* subsp*. protracta, Pupalia lappacea* and *Monechma debile*.

Structure of the woody layer

The total canopy cover for this subcommunity was 73% and it was therefore classified as a high closed forest (Edwards, 1983) with a density of 4 148 woody plants/ha. The 10 – 20 m stratum had the highest canopy cover, although the dominant tree species, *Albizia glaberrima*, often exceeded 20 m in height. The >15.5 m stratum had the highest canopy cover (20.5%) followed by the 11.6 – <13.5 m height class (13.2%) and 9.6 – 11.5 m height class (11.6%; Figure 4.43). The <0.75 m height class accounted for 71.8% of the total number of woody plants, followed by height class 0.75 – 1.5 m with 12.0% and then by height class 1.6 – 2.5 m with 4.8% (Figure 4.44).

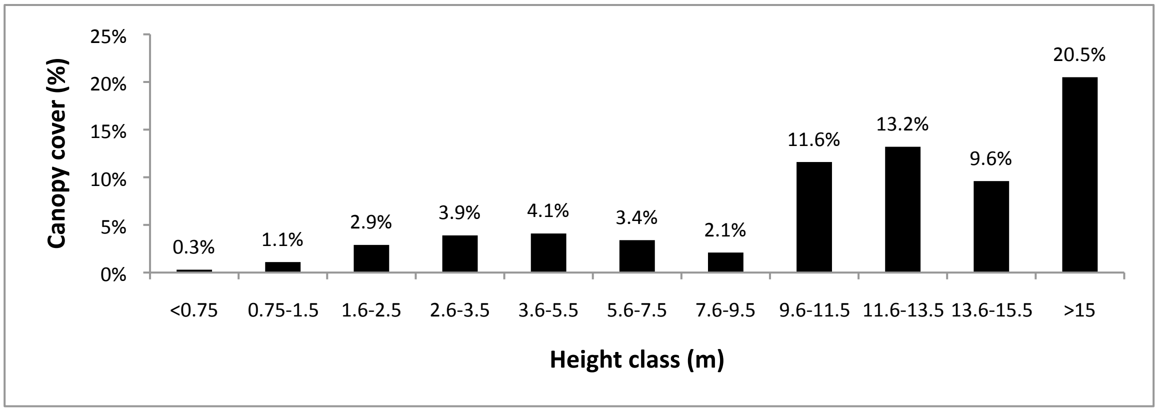


Figure 4.41: The mean percentage canopy cover for 11 height classes of the woody layer for the *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest, Chapungu Ranch, Save Valley Conservancy.

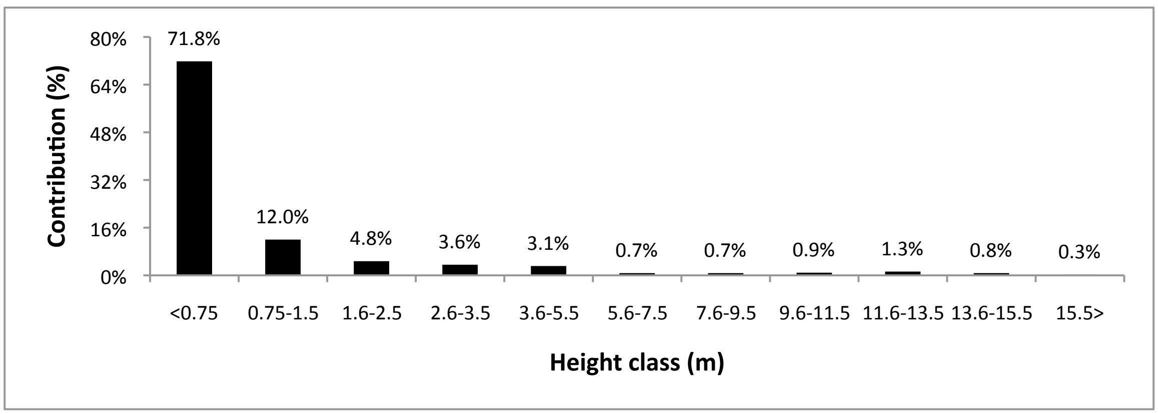


Figure 4.42: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest, Chapungu Ranch, Save Valley Conservancy.

7. The *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland

The *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland was represented by four relevés with a mean of 10 species (range 7 – 13) recorded per sampling plot. The community was associated with the inflow at the large pans and old drainage lines. The soils were saline-sodic from the 8h family and the surface area covered 1.6 km^2.

The diagnostic species were *Hyperbolius bowkeri, Sporobolus nitens, Ledebouria marginata, Dactyloctenium aegyptium, Dipcadi papillatum* and *Mollugo cerviana.* Other common species included *Tragus berteronianus, Portulaca kermesina, Sporobolus ioclados* and *Acacia tortilis.*

Structure of the woody layer

The woody vegetation in this community had a canopy cover of less than 0.1% and was therefore not measured. Woody species encountered in this community were *Acacia tortilis* and *Salvadora persica*.

8. The *Echinochloa colona – Cyperus digitatus* Open Wetland

This community was represented by three relevés and covered 0.85 km^2 on Chapungu. A mean of 10 species (range 9 – 10) was recorded per relevé. It was found in and along the large pans on Chapungu Ranch.

Diagnostic species for this community were *Acacia xanthophloea, Eriochloa meyeriana, Echinochloa colona, Paspalidium obtusifolium, Cyperus digitatus, Aeschynomene indica, Sesbania bispinosa, Chamaecrista mimosoides, Ammannia baccifera, Schoenoplectus senegalensis, Nymphaea nouchali* and *Schistostephium heptalobium.*

Structure of the woody layer

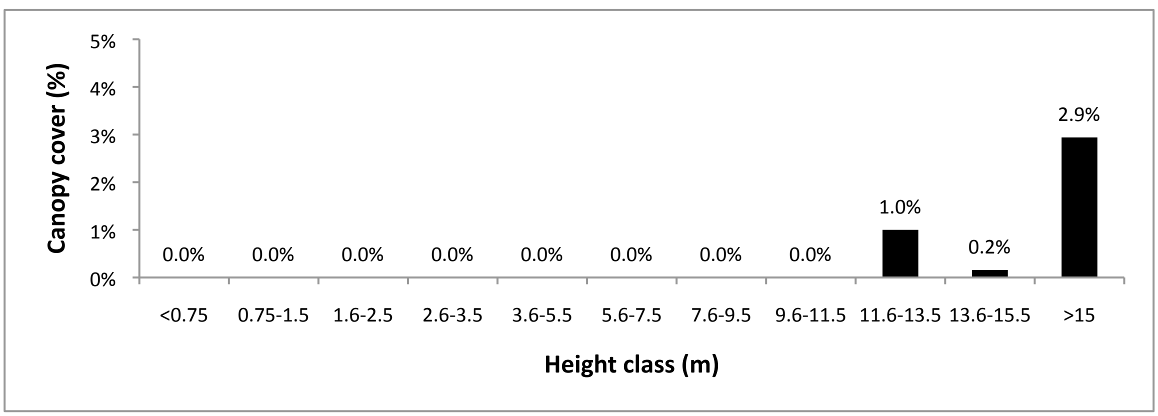


Figure 4.45: The mean percentage canopy cover for 11 height classes of the woody layer for the *Echinochloa colona – Cyperus digitatus* Open Wetland, Chapungu Ranch, Save Valley Conservancy.

The total canopy cover for this community was 4.1% suggesting an open woodland structure (Edwards, 1983) with a density of 310 woody plants/ha (Figure 4.45). This community could be further classed as a high open woodland based on the >15.5 m stratum being dominant with a canopy cover of 2.9%. Despite the <0.75 m height class contributing the highest number of woody plants (79.4%), the canopy cover contribution was negligible. The contribution of woody plants 1.6 – 11.5 m was also negligible (Figure

4.46). The absence of these height classes and the high proportion in the smallest height class may be indicative of a change occurring in the structure of this community.

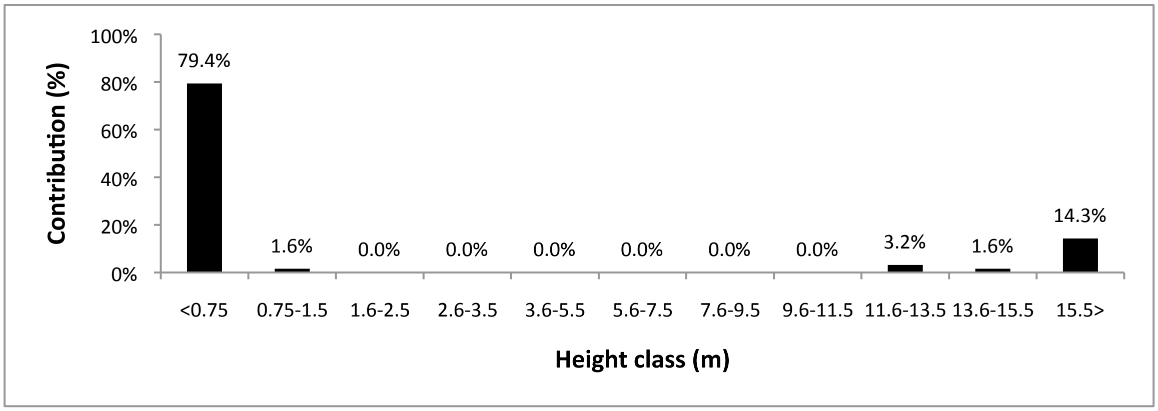


Figure 4.46: The mean percentage contribution of woody individuals to the density in 11 height classes in the *Echinochloa colona – Cyperus digitatus* Open Wetland, Chapungu Ranch, Save Valley Conservancy.

9. *Phragmites australis – Ficus capreifolia* Short Closed Thicket/Reedbed

This community was represented by three relevés and was found in and amongst the riverine community of the Save River. The soils were deep, sandy soils. The diagnostic and dominant species were *Phragmites australis* and *Ficus capreifolia.* Other species commonly found in this community were *Datura stramonium, Argemone ochroleuca, Achyranthus asper*a, *Cynodon dactylon* and *Ocimum gratissimum.*

Structure of the woody layer

The structure of the woody plants in this community was not measured due to its variability and difficulty in establishing the number of woody plants and their actual size. The dominant woody plant, *Ficus capreifoilia*, formed almost impenetrable thickets, along and often amongst the reedbeds. These thickets stabilize the newly formed reedbanks and provide cover for various animal species, most notably hippopotamus, *Hippopotamus amphibius*.

4.3.3 Regional comparisons

At landscape level, the plant communities on Chapungu compared well with the *Colophospermum mopane* forest landscape described by Gertenbach (1983). Gertenbach (1983) defined landscapes as areas with a specific geomorphology, macroclimate, vegetation patterns and associated fauna. Van Rooyen (1978) Van

Rooyen *et al.* (1981a, 1981b, 1981c) described this landscape in more detail and classed it as the *Colophospermum mopane – Euclea divinorum – Enteropogon macrostachyus* High Tree Savanna.

Similarities were identified between the *Colophospermum mopane* communities in the current study and the *Colophospermum mopane* vegetation described for the Punda – Milia – Wambiya area in the Kruger National Park (Van Rooyen, 1978) as the latter communities were also associated with the basalt and shale from the Karoo System. The *Colophospermum mopane – Acacia tortilis – Urochloa mosambicensis* tree savanna (Van Rooyen, 1978) resembled the *Ruellia cordata – Colophospermum mopane* Closed Woodland in terms of floristic composition and structure. Similarities were also found with the vegetation communities of the Honnet Nature Reserve in the Musina district of South Africa. For example, the *Colophospermum mopane – Terminalia prunioides* High Open Woodland (Visser *et al.,* 1996) resembled the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland community on Chapungu.

Du Plessis (2001) compared and classed the mopaneveld of southern Africa into major plant communities. The mopane veld of the South African Lowveld and the Zimbabwean mopane veld were separated at a third level TWINSPAN division. This indicates the close relationship between the South African and Zimbabwean mopane veld and can possibly be ascribed to similarities in the annual rainfall and the geology of the region.

Recent studies undertaken within the southeastern Lowveld of Zimbabwe, on the Hippo Valley Wildlife Reserve (Clegg & Clegg, 2001) and the Malilangwe Conservation Trust (Clegg & O'Connor, *in prep*) identified many similarities in the communities found on similar geological formations and soils. Clegg & O'Connor (*in prep*) classified Malilangwe into 38 vegetation units of which the *Colophospermum mopane – Heteropogon contortus* Open Woodland community closely resembled the *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland subcommunity identified on Chapungu. The *Colophospermum mopane – Endostemon tenuiflorus* Open Woodland also resembled the *Endostemon tenuiflorus – Grewia villosa* Short Closed Woodland subcommunity despite Clegg (*in prep*) not mentioning *Grewia villosa* within his description of this community. The three plant communities associated with alluvial soils on Malilangwe fell compare well with the *Xanthocercis zambesiaca* - *Acacia tortilis* Closed Woodland but there were also some resemblance to the *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest and the *Cardiogyne africana – Acacia schweinfurthii* Tall Closed Riverine Forest.

4.3.4 Integration of the vegetation classification of Chapungu Ranch with Sango Ranch

Hin (2000) described the plant communities of Sango Ranch and Table 4.1 compares the plant communities of the Sango Ranch with that of Chapungu Ranch. Many similarities were evident, although some differences were noted. The integration of Chapungu Ranch into Sango Ranch was done on a subjective basis following a separate assessment of the geology, soils and vegetation on Chapungu Ranch. The reason for the separation of the two assessment data sets was due to the herbaceous layer developing under different rainfall regimes as well as the changes recorded for animal numbers resulting in different utilisation regimes. Figure 4.47 illustrates the intergrated vegetation map for Chapungu Ranch and Sango Ranch. The map illustrates the final numbering and placement of communites as listed below.

The *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland (Community 1) was associated with the sandstone hills on Chapungu Ranch and because of its steep slopes and shallow soils this community was least disturbed by grazing animals and management influences. No community described by Hin (2000) compared with this plant community although many similar species occurred in the *Millettia usamarensis* subsp. *australis – Brachiaria deflexa* Short Koppie Thicket (Community 2). The difference is probably due to the geology as the *Millettia usamarensis* subsp. *australis – Brachiaria deflexa* Short Koppie Thicket (Community 2) occurs on granite whilst the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland is on sandstone (Community 1).

In the current study the *Colophospermum mopane* vegetation, typically described for the southeastern Lowveld of Zimbabwe (Farrell, 1968; Du Toit and Price Waterhouse, 1994; Hin, 2000), was separated into two communities. The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland (Community 5) was similar to the *Colophospermum mopane - Brachiaria deflexa* Short Thicket//Short Closed Woodland described by Hin (2000), whereas the *Kirkia acuminata – Colophospermum mopane* Closed Woodland (Community 4) resembled sections of the *Combretum apiculatum* subsp. *apiculatum – Colophospermum mopane* Short Closed Woodland (Hin, 2000), but was restricted to the Umkondo System. The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland (Community 5) was associated mainly with alluvium and the calcimorphic siallitic 4S soils derived from basalt, sandstone and shale. This community had a poor herbaceous layer and the woody layer was dominated by *Colophospermum mopane,* whereas the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland (Community 4) was associated mainly with soils derived from the Umkondo System. The herbaceous layer in the latter woodland was often diverse with a good grass cover and although *Colophospermum mopane* was still abundant, it did not necessarily dominate the woody layer.

The *Albizia anthelmintica – Acacia tortilis* Open Woodland (Community 6) was associated with the sandy, well-leached, colluvial soils and also the levees along the Save River. This community was similar to the *Acacia tortilis* subsp. *heteracantha – Urochloa mossambicensis* Tall Closed Woodland described by Hin (2000). During the wet season the grass and forb layers were well-developed and attracted large numbers of ungulates onto the area. A high percentage of the forbs comprised nitrogen-fixing legumes, such as *Indigofera* species and *Tephrosia* species, attracting Livingston's eland (*Tragelaphus oryx*) and greater kudu (*Tragelaphus strepsiceros*). The *Acacia tortilis* and *Albizia anthelmintica* trees also attracted large numbers of giraffe (*Giraffa camelopardalis*). In August/September, prior to the onset of the rains, *Albizia anthelmintica* comes into bloom and also attracts browsing animal species onto these plains.

The *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland (Community 7) was associated with the fertile alluvial soils of the 4U series and attracted large numbers of wildlife, especially during the dry months of the year. The *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland (Community 7) was similar to the *Acacia tortilis* subsp. *heteracantha – Panicum maximum* Tall Closed Woodland described by (Hin, 2000). In this community, many woody species are semideciduous with browse available during the dry season. Flowers and fruits of species, such as *Acacia tortilis*, *Balanites maughamii*, *Berchemia discolor*, *Ehretia amoena*, *Kigelia africana, Sclerocarya birrea* and *Xanthocercis zambesiaca* provided an additional forage source.

Hin (2000) identified two subcommunities within the *Echinochloa colona – Cyperus digitatus* Open Wetland (Community 10). On Chapungu these subcommunities were grouped together as the pans were filled with water during the sampling period. This community, despite being small, attracted large numbers of wildlife because of the availability of water and the green grass late into the dry season.

The *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland (Community 9) did not have an equivalent community in Hin's (2000) study. The community was associated with the pans and the diffuse drainage lines and conforms in terms of its species composition with the findings of Dye and Walker (1980). Dye and Walker (1980) attributed the poor production potential of the herbaceous layer in this community to the accumulation of sodium salts in poorly drained environments and the largely impenetrable B-horison. The grass layer in this community was sparse but highly palatable and also attracted large numbers of animals, mainly due to its proximity to the *Echinochloa colona – Cyperus digitatus* Open Wetland (Community 10).

The *Phragmites australis – Ficus capreifolia* Short Closed Thicket (Community 11), called the *Phragmites mauritianus* Tall Closed Reedbeds by Hin (2000), was associated with the riverine vegetation. The species occurring within this community were largely pioneer species stabilizing alluvial deposits for later successional species.

The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest (Community 8) was identical to the community with the same name described by Hin (2000). The community provided forage and shelter for many animal species. The herbaceous layer was highly palatable and the available browse combined with the proximity to water attracted large numbers of wildlife, especially in the dry seasons.

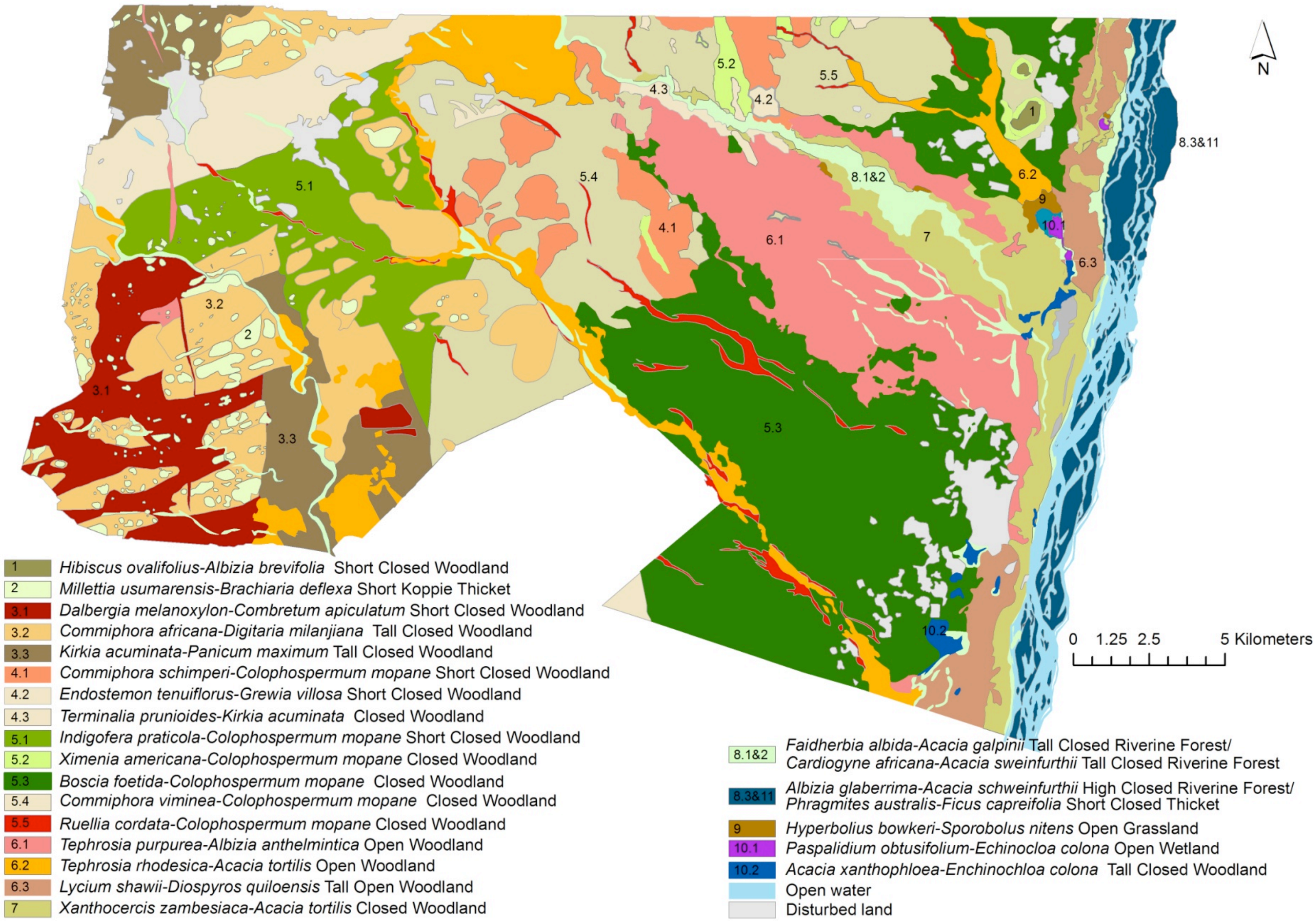


Figure 4.47: Map of the plant communities on the entire Sango Ranch, Save Valley Conservancy, Zimbabwe.

Table 4.1: A comparison between the plant communities identified on Chapungu Ranch and the plant communities described by Hin (2000)

Chapungu study Plant community and subcommunities identified (current study)	Sango study Plant community and subcommunities identified (Hin, 2000)	Comments
1. *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland (Community 1)	Not identified on Sango by Hin (2000)	The closest community resemblance was with the *Millettia usumarensis* subsp. *australis - Brachiaria deflexa* Short Koppie Thicket. These communities were separated due to the presence of *Albizia brevifolia* and the absence of *Millettia usumarensis* subsp. *australis* in the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland.
1.1 *Barleria meyeriana – Phyllanthus pinnatus* Short Closed Woodland (Sub-community 1.1)	Not identified on Sango by Hin (2000)	
1.2 *Strychnos decussata – Grewia gracillima* Short Closed Woodland (Sub-community 1.2)	Not identified on Sango by Hin (2000)	
2. *Seddera suffruticosa – Colophospermum mopane* Closed Woodland (Community 5)	2. *Colophospermum mopane – Brachiaria deflexa* Short Thicket//Short Closed Woodland	Similar plant community but excluded the *Indigofera praticola - Colophospermum mopane* Short Closed Woodland identified by Hin (2000).
2.1 *Ximenia americana – Colophospermum mopane* Closed Woodland Community (Subcommunity 5.2)	Not identified on Sango by Hin (2000)	Inserted onto the final Sango map as a separate community.
2.2 *Boscia foetida – Colophospermum mopane* Closed Woodland (Subcommunity 5.3)	Not identified on Sango by Hin (2000)	Resembles the *Thilachium africanum-Colophospermum mopane* Short Thicket.
2.3 *Commiphora viminea – Colophospermum mopane* Closed Woodland (Subcommunity 5.4)	2.4 *Ruellia patula – Colophospermum mopane* Tall Closed Woodland	Similar subcommunities.
2.4 *Ruellia cordata – Colophospermum mopane* Closed Woodland (Subcommunity 5.5)	2.1 *Commiphora edulis – Colophospermum mopane* Tall Closed Woodland	Similar subcommunities occurring along the drainage lines.
3. The *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland (Community 4)	3. *Combretum apiculatum* subsp. *apiculatum – Colophospermum mopane* Short Closed Woodland	Resembling parts of *Combretum apiculatum* subsp. *apiculatum - Colophospermum mopane* Short Closed Woodland (Hin, 2000), but restricted to the Umkondo geological formations. The community is further divided into three sub communities. Subcommunity 3.1 and subcommunity 3.3 also occurred on Sango.
3.1 *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland (Subcommunity 4.1)		
3.2 *Endostemon tenuiflorus – Grewia villosa* Short Closed Woodland (Subcommunity 4.2)	Not identified on Sango by Hin (2000)	

3.3 *Terminalia prunioides – Kirkia acuminata* Closed Woodland (Subcommunity 4.3)		
4. *Albizia anthelmintica – Acacia tortilis* Open Woodland (Community 6)	1. *Acacia tortilis* subsp. *heteracantha – Urochloa mosambicensis* Tall Closed Woodland	Similar plant communities, except for subcommunity 1.3 *Capparis tomentosa – Urochloa mosambicensis* Tall Closed Woodland which was included in the *Xanthocercis zambesiaca - Acacia tortilis* Closed Woodland
4.1 *Tephrosia purpurea – Albizia anthelmintica* Open Woodland (Subcommunity 6.1)	1.1 *Tephrosia purpurea* subsp. *leptostachya – Urochloa mosambicensis* Short Closed Woodland	
4.2 *Tephrosia rhodesica – Acacia tortilis* Open Woodland (Subcommunity 6.2)	1.4 *Sporobolus nitens – Urochloa mosambicensis* Short Closed Woodland	
4.3 *Lycium shawii – Diospyros quiloensis* Tall Open Woodland (Subcommunity 6.3)		Hin (2000) mapped this subcommunity into a mosaic with subcommunities 1.1 *Tephrosia purpurea* subsp. *leptostachya – Urochloa mosambicensis* Short Closed Woodland, 1.2 *Dichrostachys cinerea* subsp. *africana – Urochloa mosambicensis* Short Closed Woodland and 1.4 *Sporobolus nitens – Urochloa mosambicensis* Short Closed Woodland
5. *Xanthocercis zambesiaca - Acacia tortilis* Closed Woodland (Community 7)	6. *Acacia tortilis* subsp. *heteracantha – Panicum maximum* Tall Closed Woodland	Similar communities, except for subcommunity 1.3 *Capparis tomentosa – Urochloa mosambicensis* Tall Closed Woodland which was included into the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland
6. *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest (Community 8)	7. *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest	Similar communities
6.1 *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest (Subcommunity 8.1)	7.3 *Faidherbia albida – Eriochloa meyeriana* Tall Closed Woodland	Similar sub communities
6.2 *Cardiogyne africana – Acacia schweinfurthii* Tall Closed Riverine Forest (Subcommunity 8.2)	7.1 *Strychnos potatorum – Panicum maximum* High Closed Woodland//Short thicket	Similar sub communities
6.3 *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest (Subcommunity 8.3)	7.2 *Albizia glaberrima* var. *glabresens – Panicum maximum* High Forest	Similar sub communities
7. *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland (Community 9)		Hin (2000) mentioned this community under subcommunity 1.1 *Tephrosia purpurea* subsp. *leptostachya – Urochloa mosambicensis* Short Closed Woodland
8. *Echinochloa colona – Cyperus digitatus* Open Wetland (Community 10)	9. *Echinochloa colona – Cyperus digitatus* subsp. *auricomus* Tall Open Wetland	Similar at community level but differ at subcommunity level. Hin (2000) identified two subcommunities within this community.
9. *Phragmites australis – Ficus capreifolia* Short Closed Thicket (Community 11)	8. *Phragmites mauritianus* Tall Closed Reed beds	Similar communities

On Sango Ranch, Hin (2000) indentified the *Combretum apiculatum* subsp. *apiculatum – Digitaria milanjiana* Tall Closed Woodland (Community 3) and the *Millettia usamarensis* subsp. *australis – Brachiaria deflexa* Short Koppie Thicket (Community 2) which was not identified on Chapungu Ranch.

After the integration of the vegetation study on Chapungu Ranch the plant communities of Sango Ranch were the following:

1. *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland (current study – community 1)
   1.1 *Barleria meyeriana – Phyllanthus pinnatus* Short Closed Woodland (current study – subcommunity 1.1)
   1.2 *Strychnos decussata – Grewia gracillima* Short Closed Woodland (current study – subcommunity 1.2)

2. *Millettia usamarensis* subsp *australis – Brachiaria deflexa* Short Koppie Thicket (Hin, 2000)

3. *Combretum apiculatum – Digitaria milanjiana* Tall Closed Woodland (Hin, 2000)
   3.1 *Dalbergia melanoxylon – Combretum apiculatum* Closed Woodland (Hin, 2000)
   3.2 *Commiphora africana – Digitaria milanjiana* Tall Closed Woodland (Hin, 2000)
   3.3 *Kirkia acuminata – Panicum maximum* Tall Closed Woodland (Hin, 2000)

4. *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland (current study – community 3)
   4.1 *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland (current study – subcommunity 3.1 & Hin, 2000)
   4.2 *Endostemon tenuiflorus – Grewia villosa* Short Closed Woodland (current study – subcommunity 3.2)
   4.3 *Terminalia prunioides – Kirkia acuminata* Closed Woodland (current study – subcommunity 3.3 & Hin, 2000)

5. *Seddera suffruticosa – Colophospermum mopane* Closed Woodland (current study – community 2 & Hin, 2000)
   5.1 *Indigofera praticola – Colophospermum mopane* Closed Woodland (Hin, 2000)
   5.2 *Ximenia africana – Colophospermum mopane* Closed Woodland (current study – subcommunity 2.1)
   5.3 *Boscia foetida – Colophospermum mopane* Closed Woodland (current study – subcommunity 2.2)
   5.4 *Commiphora viminea – Colophospermum mopane* Closed Woodland (current study – subcommunity 2.3 & Hin, 2000)
   5.5 *Ruellia cordata – Colophospermum mopane* Closed Woodland (current study – subcommunity 2.4 & Hin, 2000)

6. *Albizia anthelmintica – Acacia tortilis* Open Woodland (current study – community 4 & Hin, 2000)
    6.1 *Tephrosia purpurea – Albizia anthelmintica* Open Woodland (current study – subcommunity 4.1 & Hin, 2000)
    6.2 *Tephrosia rhodesica – Acacia tortilis* Open Woodland (current study – subcommunity 4.2 & Hin, 2000)
    6.3 *Lycium shawii – Diospyros quiloensis* Tall Open Woodland (current study – subcommunity 4.3)

7. *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland (current study – community 5 & Hin, 2000)

8. *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest (current study – community 6 & Hin, 2000)
    8.1 *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest (current study – subcommunity 6.1 & Hin, 2000)
    8.2 *Cardiogyne africana – Acacia schweinfurthii* Tall Closed Riverine Forest (current study – subcommunity 6.2 & Hin, 2000)
    8.3 *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest (current study – subcommunity 6.3 & Hin, 2000)

9. *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland (current study – community 7)

10. *Echinochloa colona – Cyperus digitatus* Open Wetland (current study – community 8 & Hin, 2000)
    10.1 *Paspalidium obtusifolium – Echinochloa colona* Open Wetland (Hin, 2000)
    10.2 *Acacia xanthophloea – Echinochloa colona* Tall Closed Woodland (Hin, 2000)

11. *Phragmites australis – Ficus capreifolia* Short Closed Thicket (current study – community 9 & Hin, 2000)

4.3.5 Identification of Management Units

The integration of the vegetation maps for Sango Ranch and Chapungu Ranch enabled the identification of management units based on the relative uniformity of the topography, geology, soils and vegetation (Figure 4.48). Seven management units were identified and agree largely with those identified by Hin (2000).

1. *Combretum apiculatum* Woodland Management Unit
2. *Kirkia acuminata* Woodland Management Unit
3. *Colophospermum mopane* Closed Woodland Management Unit
4. *Acacia tortilis* Open Woodland Management Unit
5. *Xanthocercis zambesiaca* Closed Woodland Management Unit

6. *Diospyros mespiliformis* Riverine Management Unit
7. *Echinochloa colona* Wetland Management Unit

The *Combretum apiculatum* Woodland Management Unit comprised 28.7% of the total surface area on Sango Ranch. It includes three plant communities, *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland (Community 1), the *Millettia usamarensis* subsp. *australis – Brachiaria deflexa* Short Koppie Thicket (Community 2) and the *Combretum apiculatum – Digitaria milanjiana* Tall Closed Woodland (Community 3). The geology is predominately derived from granite and gneiss and the unit is recognized by the dominance of *Combretum* spp. and *Digitaria milanjiana* (Hin, 2000).

The *Colophospermum mopane* Woodland Management Unit described by Hin (2000) was subdivided into the *Kirkia acuminata* Woodland and the *Colophospermum mopane* Closed Woodland Management Units. The *Kirkia acuminata* Woodland Management Unit included the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland (Community 4) and covered 3.8% of the total surface area on Sango Ranch. The geology included basalt, sandstone, shale and limestone with shallow soils. It is recognized by the presence of *Kirkia acuminata*, *Commiphora edulis, Commiphora mollis*, *Terminalia prunioides, Combretum apiculatum* and *Colophospermum mopane* scattered throughout the area.

The *Colophospermum mopane* Closed Woodland Management Unit included the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland (Community 5) and covered 37.4% of the total surface area of Sango Ranch. *Colophospermum mopane* dominated this unit forming dense stands. The herbaceous layer was often poorly developed. The underlying geology comprised gneiss, shale, sandstone, limestone, alluvium and lava.

The *Acacia tortilis* Open Woodland Management Unit covered 20.4% of the total surface area on Sango Ranch and included the *Albizia anthelmintica – Acacia tortilis* Open Woodland (Community 6) and the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland (Community 9). It was recognized by the relatively open woodland with *Acacia tortilis* and *Albizia anthelmintica* dominating. The herbaceous layer was moderately developed with a well-developed forb component. The soils were from alluvial or colluvial descent.

The *Xanthocercis zambesiaca* Closed Woodland Management Unit covered 5.6% of the total surface area of Sango Ranch and could be recognized by the presence of tall trees such as *Xanthocercis zambesiaca, Acacia tortilis, Philenoptera violacea, Combretum imberbe* and shrubs such as *Annisotes formosissimus*, *Cordia ovalis* and *Grewia* spp. The soils of this management unit were from alluvial descent. This management unit was wedged between the *Acacia tortilis* Open Woodland Management Unit and the *Diospyros mespiliformis* Riverine Management Unit.

The *Diospyros mespiliformis* Riverine Management Unit included the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest (Community 8) and the *Phragmites australis – Ficus capreifolia* Short

Closed Thicket (Community 11). It comprised 6.3% of the total surface area of Sango Ranch and was recognized by a variety of tree and shrub species such as *Diospyros mespiliformis, Kigelia africana, Cordyla africana, Albizia versicolor, Albizia glaberrima, Strychnos potatotrum, Faidherbia albida, Acacia galpinii, Croton megalobotrys*, *Ficus* spp., *Acacia schweinfurthii* and *Bridelia cathartica*. It was situated on deep, moist alluvium soils along the banks and on the islands of the major rivers on Sango.

The *Echinochloa colona* Wetland Management Unit was associated with the pans on Sango Ranch and comprised 0.5% of the total surface area of Sango Ranch. The soils were dark with high clay contents. This management unit was recognized by the presence of *Echinochloa colona* and *Acacia xanthophloea.*

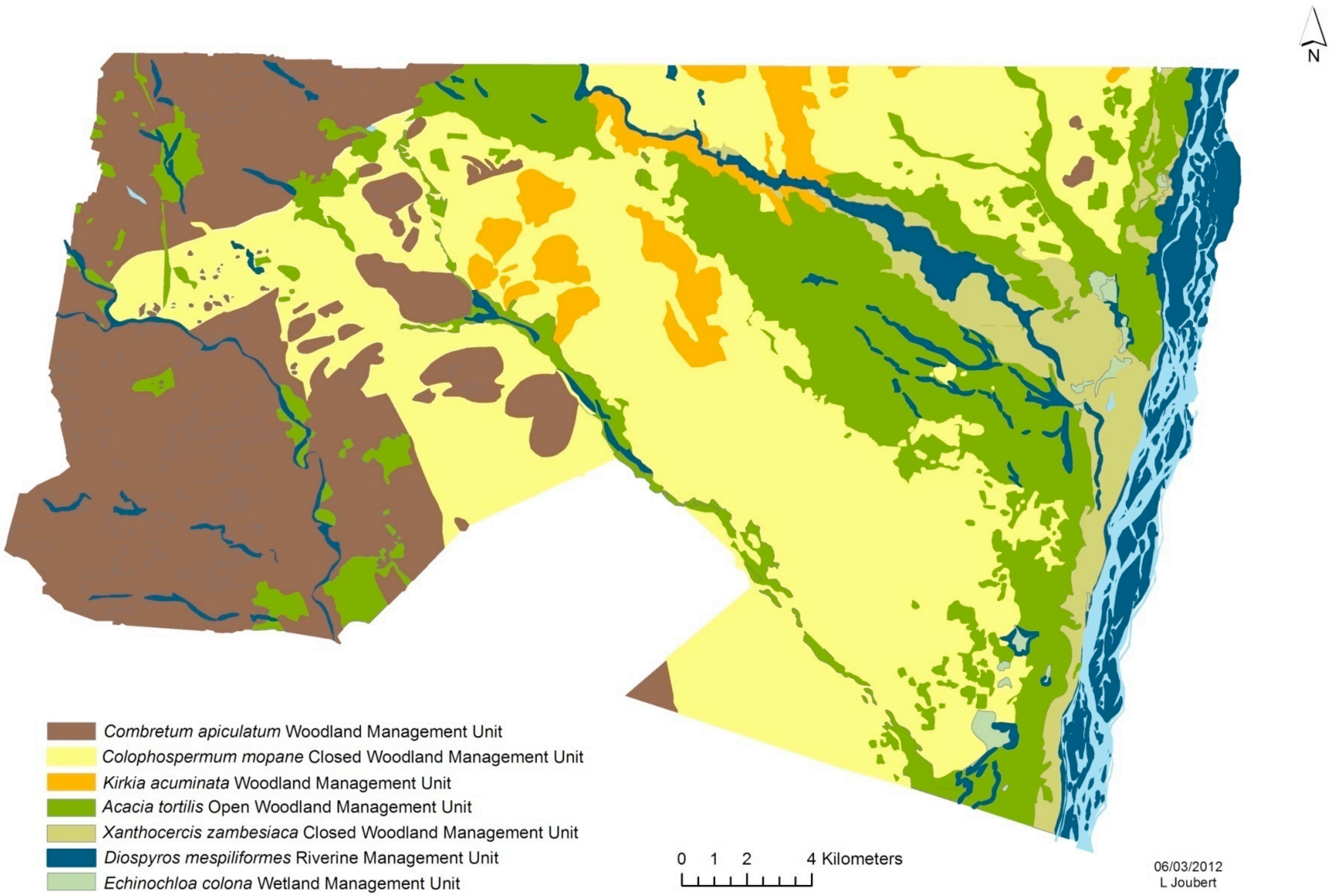


Figure 4.48: Management units identified for Sango Ranch, Save Valley Conservancy, Zimbabwe.

4.4 Conclusions

The phytosociological classification of Chapungu Ranch identified nine plant communities using 156 sampling plots. Two subcommunities were identified for the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland, three subcommunities for the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland, three subcommunities for the *Kirkia acuminata – Colophospermum mopane* Open Woodland, three subcommunities for the *Albizia anthelmintica – Acacia tortilis* Open Woodland and three subcommunities for the *Dalbergia arbutifolia-Diospyros mespiliformis* Tall Closed Riverine Forest. No subcommunities were identified for the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland, *Echinochloa colona – Cyperus digitatus* Open Wetland, *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland and the *Phragmites australis – Ficus capreifolia* Short Closed Thicket.

Species richness per plot varied considerably between the plant communities, but was generally high (mean 24-36 species per plot). Low species richness per plot was recorded for the *Echinochloa colona – Cyperus digitatus* Open Wetland, *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland and the *Phragmites australis – Ficus capreifolia* Short Closed Thicket.

Plant communities occurring on Chapungu were compared with those occurring on Sango Ranch and an integrated classification and vegetation map for the entire area compiled. This allowed the subsequent identification of seven management units, which are essential to develop a management plan and monitoring program for the entire Sango Ranch (Chapter 9). These management units will form the basis of the discussion of the animal populations (Chapter 8) of the integrated Sango Ranch.

CHAPTER 5

QUALITATIVE AND QUANTITATIVE ASSESSMENTS OF THE HERBACEOUS LAYER

5.1 Introduction

The condition of plant communities serves as a convenient measure to quantify and observe spatial and temporal changes within a particular plant community (Tainton, 1999). Veld condition is defined by Trollope (1990) as the state of health of the veld in terms of its ecological status, resistance to soil erosion and its potential for producing forage for sustained optimum livestock production. Veld condition of a particular plant community is thus only meaningful if it is related to a standard (Tainton, 1988). The determination of standards for veld assessments is based on either agronomic criteria or ecological criteria. Agronomic criteria focus on the ability of the veld to support livestock production, whilst the ecological approach focuses on the response to environmental impacts (Tainton, 1999). The ecological approach is thus the ideal as it focuses on long-term stability of plant communities and to minimize the loss of soil (Tainton, 1999).

Stuart-Hill (1989) gives three reasons for conducting veld condition assessments a) to determine the species composition, b) to establish a reference point for predicting grazing capacity and c) to monitor change of the veld.

Biomass is defined as the total amount of living material (plant and animal) present in a particular area at any given time and is expressed as kg/ha (Tainton, 1999). The herbaceous biomass refers to the proportion of the mass that is contributed by the herbaceous layer. Biomass of the herbaceous layer is of particular importance since it determines the amount of forage available to grazing herbivores and it enables the manager to determine stocking densities and grazing capacity (Bransby *et al*., 1977; Bransby & Tainton, 1977; Dankwerts & Trollope, 1980). In livestock production systems, it is generally accepted that the higher the daily forage intake of an animal the higher the opportunity for increased productivity (Macdonald *et al*., 1988). In extensive wildlife areas the measure of herbaceous biomass is concerned with the availability of forage rather than to increase voluntary intake. Nevertheless, the principle remains that the more forage available the higher the likelihood of increased production.

Herbaceous biomass also gives an indication of the fuel load available to carry a fire (Trollope, 1980, Trollope & Potgieter, 1986). Fire is an important management tool in veld management, especially to counter bush encroachment and to improve the vigour of the grass sward by removing moribund material

(Trollope, 1980, 1983, 1984; Tainton, 1999). Knowledge of grass fuel loads can also give an indication of the intensity of a fire (Trollope & Potgieter, 1986; Trollope *et al*., 1989)

The objectives of the assessment of the herbaceous layer were to:

- determine the composition of the herbaceous layer in each community, with special reference to the grass species,
- determine the veld condition of the herbaceous layer in each community,
- to determine the herbaceous biomass available to wildlife in each homogeneous vegetation unit, and
- to determine the herbaceous fuel load production for fire management.

5.2 Methods

5.2.1 Species composition and canopy cover of the herbaceous layer

A method based on the step-point method as described by Mentis (1981) was the basis for determining the composition of the herbaceous layer. Mentis (1981) compared the wheel-point method (Tidmarsh & Havenga, 1955) with the step-point method and concluded that the results from these two methods were not significantly different. Two advantages for using the step-point rather than the wheel-point method were the reduced time and the fact that no specialized apparatus was needed to conduct the survey.

Du Plessis (1992) argued that the step-point method can be improved by using a rod to demarcate a reference point instead of a mark on a shoe. This change in method has two fundamental advantages:

- the rod can reach areas inaccessible to walk in; and
- the rod is more unbiased than placing of a shoe (a person has to look down in certain areas before placement of the foot).

The current study consequently followed the rod method described by Du Plessis (1992). A further advantage of the rod method was that Hin (2000) also used it to determine the species composition of the herbaceous layer for Sango Ranch and therefore comparisons could be made between the two surveys.

A total of 200 points were recorded along a predetermined transect at each of the relevés. A rod was placed, approximately 2 m apart, along a transect line and the species closest to the point where the rod hit the ground was recorded. The transect line was kept straight to include herbaceous species occurring under shrubs and trees. A "miss" was recorded if no species occurred within 150 mm from the rod point. This cut-off distance was determined by Hin (2000) after an assessment of the nearest plant method (Snyman &

Grossman, 1990). Grasses were recorded to species level and all other non-grassy herbaceous plants were noted as forbs.

The herbaceous canopy cover was estimated separately for the grass and the forb component by subjectively estimating the canopy cover into an eight point rating scale. The eight canopy cover classes were: 1. <1%; 2. 1 – 5; 3. 6 – 10; 4. 11 – 20; 5. 21 – 40; 6. 41 – 60; 7. 61 – 80 and 8. 81 – 100. The mean value derived from 32 randomly measured sites along the step-point transect were used to derive a canopy cover score. The canopy cover for each vegetation community was calculated for grass and forbs by substituting the mean canopy cover score into the following equation.

$$Cc = 1.6947x^{0.3506}$$

where:

Cc = Canopy cover

x = Mean canopy score per vegetation community

5.2.2 Veld condition assessment

The "condition" of the veld was determined through the Ecological Index Method (EIM) (Vorster, 1982). Each grass species was classed into an ecological category based on its forage production potential and response to grazing pressure. This response to grazing pressure is an indication of palatability and preference by herbivores (Van Rooyen, 2010). The following ecological status categories were recognized:

- *Ecological Class 1*: Valuable and palatable tufted or stoloniferous perennial grass species with high productivity and palatability. Grazing value = 10.
- *Ecological Class 2*: Tufted perennial grass species with an intermediate productivity and moderate palatability. Grazing value = 7.
- *Ecological Class 3*: Tufted, tall, perennial grass species with a high productivity but a low palatability. Grazing value = 5.
- *Ecological Class 4*: Generally unpalatable and perennial, tufted and stoloniferous grass species with an intermediate productivity and a low palatability. Grazing value = 4.
- *Ecological Class 5*: Unpalatable, annual grass and forb species with low productivity and palatability. Weeds and other invader species are included. Grazing value = 1.
- *Ecological Class 6*: Bare soil. Grazing value = 0. Recorded as a "miss" in this study.

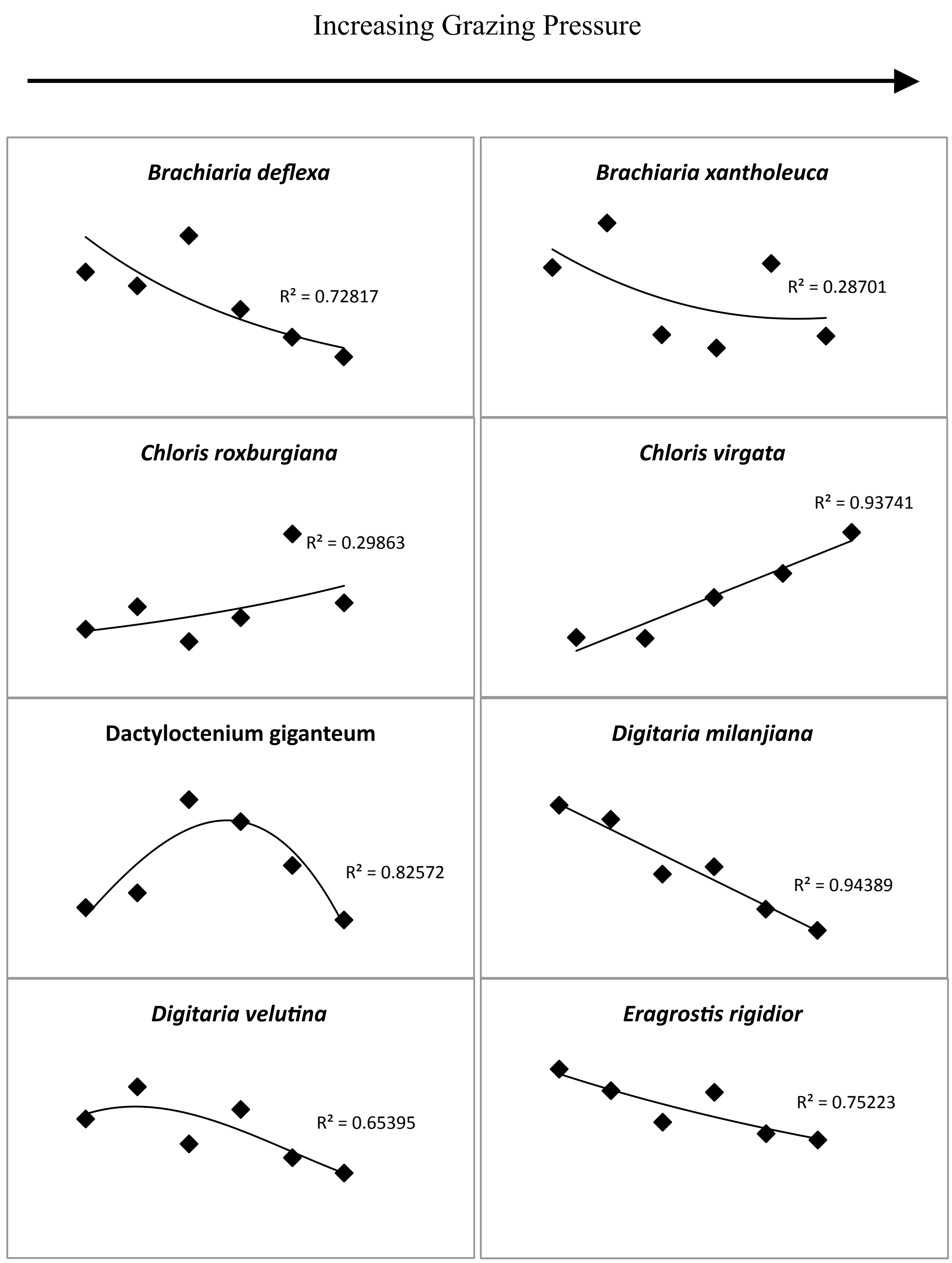
Table 5.1 lists the herbaceous species into ecological classes (Van Rooyen, 2010). Herbaceous species not classed by Van Rooyen (2010) were allocated an ecological class on the basis of their response to the grazing gradient (Figure 5.1). The allocation of grasses to a specific ecological class was determined using vegetation monitoring data sets collected since 1998. Species percentage presence for each grass was plotted on a graph against a six point grazing gradient rating scale. A 3rd order polynomial regression was used to establish a visual assessment along the grazing gradient which enabled a subjective placement of grass species into ecological classes.

A veld condition score for a vegetation community was derived by first grouping the herbaceous layer into ecological status classes. Each ecological status class was then expressed as a percentage towards the total herbaceous layer. The percentage contributions for each ecological status class were then multiplied with the predetermined grazing value. The values derived from these calculations were added to calculate the veld condition score. A veld condition score for each vegetation community can reach a maximum potential of a 1000 units. The veld condition index for each vegetation community was then calculated by dividing the veld condition score by 10. The veld condition index is thus an indication expressed as a percentage of the total potential.

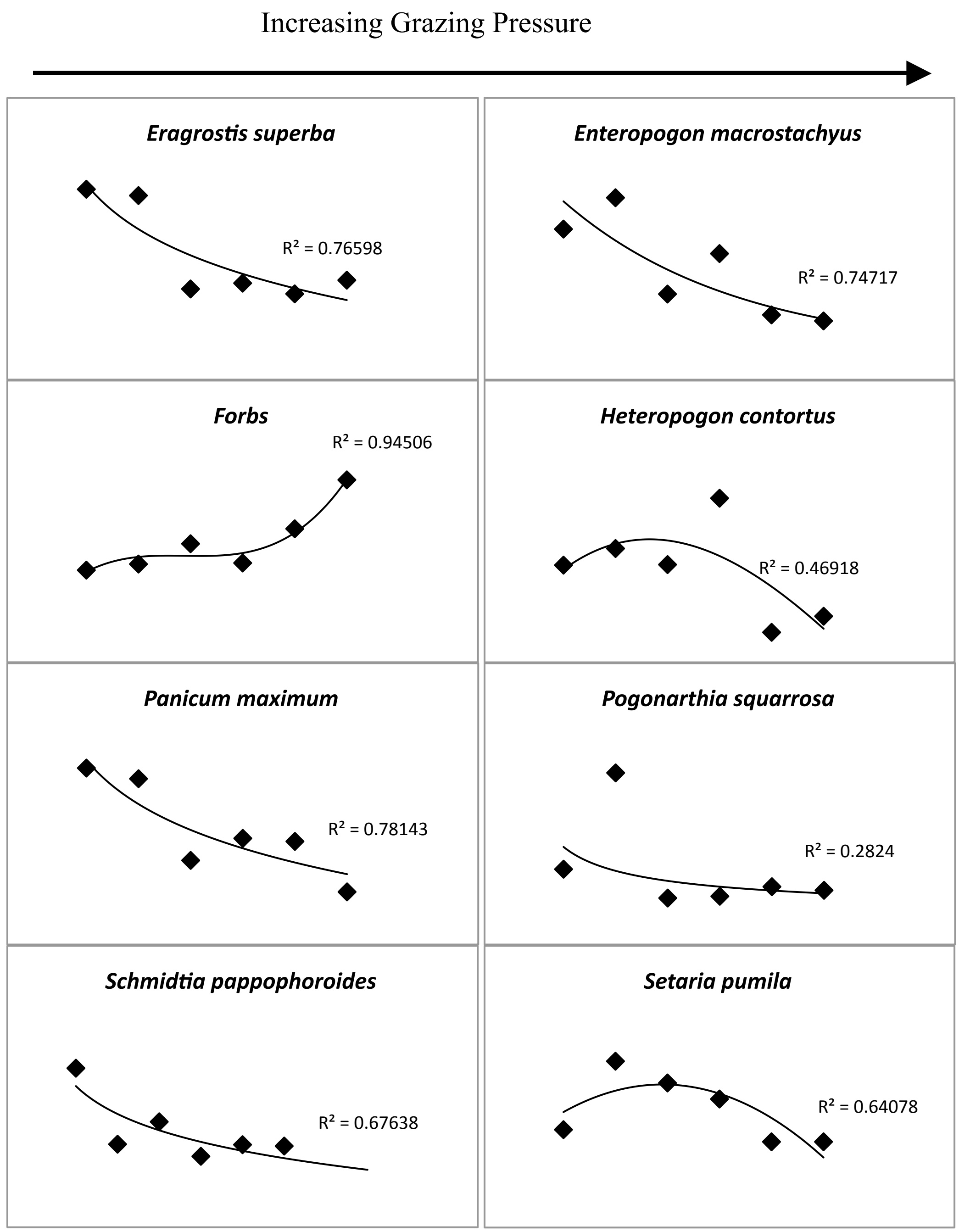
Table 5.1: The classification of the grass species found on Chapungu Ranch into ecological status classes (Van Rooyen, 2010)

Ecological Class				
Class 1 Grazing value: 10	Class 2 Grazing value: 7	Class 3 Grazing value: 5	Class 4 Grazing value: 4	Class 5 Grazing value: 1
Cenchrus ciliaris	*Brachiaria deflexa**	*Chloris roxburghiana**	*Arachne racemosa**	*Aristida adscensionis*
*Digitaria milanjiana**	*Dactyloctenium australe*	*Chloris virgata*	*Brachiaria xantholeuca**	*Aristida congesta*
*Eriochloa meyeriana**	*Echinochloa colona*	*Cynodon dactylon*	*Digitaria velutina*	*Aristida junciformis*
Panicum coloratum	*Echinochloa spp.**	*Dactyloctenium aegyptium*	*Eleusine coracana*	*Aristida rhiniochloa*
Panicum maximum	*Enteropogon macrostachyus**	*Dactyloctenium giganteum**	*Elionurus muticus*	*Bothriochloa insculpta*
Schmidtia pappophoroides	*Paspalidium obtusifolium**	*Danthoniopsis pruinosa**	*Enneapogon cenchroides*	*Bothriochloa radicans*
*Urochloa oligotricha**	*Setaria sphacelata*	*Eragrostis curvula*	*Eragrostis racemosa*	*Eragrostis aspera**
	*Sorghum versicolor**	*Heteropogon contortus*	*Eragrostis rigidior***	*Eragrostis cilianensis**
	Sporobolus fimbriatus	*Setaria sagittifolia**	*Eragrostis rotifer**	*Eragrostis cylindriflora**
	Sporobolus ioclados	*Stipagrostis uniplumis*	*Eragrostis superba*	*Forbs*
	Sporobolus nitens		*Eragrostis trichophora*	*Heteropogon melanocarpus**
	Urochloa mosambicensis		*Leptochloa uniflora*	*Melinis repens*
			Oropetium capense	*Perotis patens*
			*Panicum subalbidum**	*Pogonarthia squarrosa*
			*Tetrapogon tenellus**	*Setaria pallide-fusca*
			Tricholaena monachne	*Setaria ustilata*
				Setaria verticillata
				*Sporobolus festivus**
				*Sporobolus panicoides**
				Tragus berteronianus
				Tripogon minimus
				Urochloa panicoides
				Urochloa trichopus

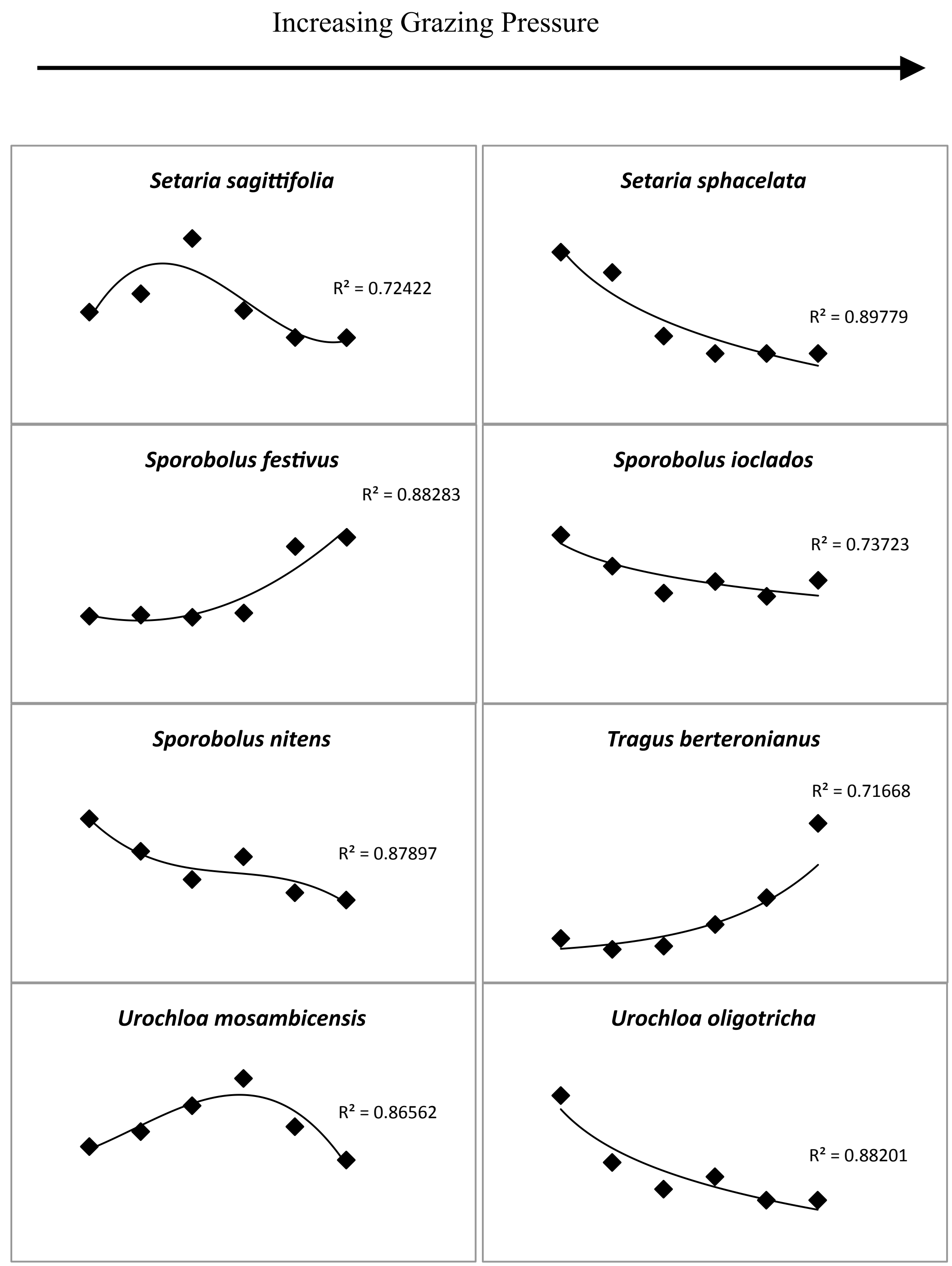
* Ecological status classes based on results obtained from the Sango Ranch monitoring program (Figure 5.1)



Figures 5.1: Changes in percentage frequency of the more common herbaceous species occurring on Chapungu Ranch along a gradient of increasing grazing pressure (left to right).



Figures 5.1 (continued): Changes in percentage frequency of the more common herbaceous species occurring on Chapungu Ranch along a gradient of increasing grazing pressure (left to right).



Figures 5.1 (continued): Changes in percentage frequency of the more common herbaceous species occurring on Chapungu Ranch along a gradient of increasing grazing pressure (left to right).

5.2.3 Biomass of the herbaceous layer

The quantitative measure of herbaceous production was determined by using the disc pasture meter as described by Bransby and Tainton (1977) and Bransby *et al.* (1977). The disc pasture meter consisted of three major parts:

- a central calibrated aluminium rod;
- an aluminium sleeve; and
- a strong aluminium base plate.

The disc pasture meter was used by holding the central rod perpendicular to the ground surface. The sleeve with the attached base plate was lifted to a standard height (600 mm) above ground level and dropped onto the grass sward. The settling height of the disc on the grass sward was then recorded to the nearest centimeter on the calibrated rod.

Prior to determining the herbaceous biomass, the disc pasture meter needed to be calibrated and this was done by using the method described by Trollope & Potgieter (1986). The calibration data for the disc pasture meter were further analysed using linear, exponential, polynomial and logarithmic regressions (Figure 5.2). The best fit was obtained with the following equation:

$$y = 466.61\sqrt{X} + 347.26 \ (R^2 = 0.912, p = 0.0414)$$

where

y = the estimated fuel load (kg/ha); and

X = the square root of the mean disc height (cm)

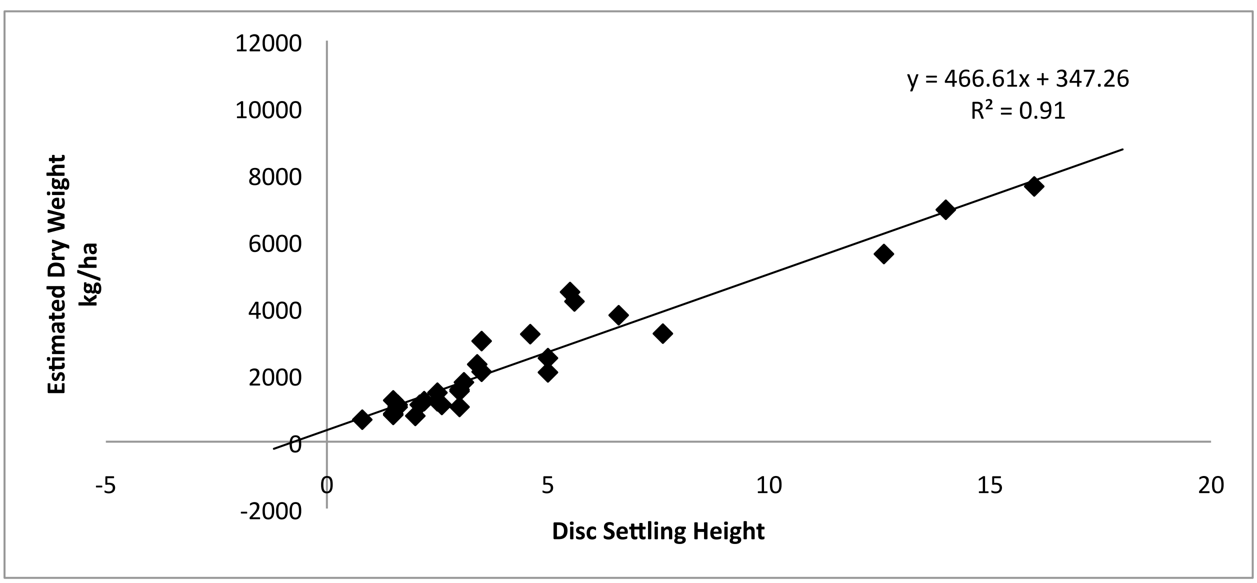


Figure 5.2: Regression for determining herbaceous biomass on Chapungu Ranch, Save Valley Conservancy, Zimbabwe.

Zambatis *et al*. (2006) re-evaluated the calibration of the disc pasture meter equation for the Kruger National Park and developed equations based on two disc-settling height criteria. These are mean disc-settling heights < 26 cm and disc settling heights > 26cm. Since the mean disc-settling height for all vegetation units measured < 26 cm the following equation was used.

$$y = (31.716 * (0.3218^{1/X}) * X^{0.2834})^2$$

where:

y = the estimated fuel load (kg/ha); and

x = the square root of the mean disc height (cm)

The herbaceous yield was estimated for each homogeneous vegetation unit by substituting the mean of the disc-settling height data into the calibrated regression equations. The equation developed by Trollope and Potgieter (1986) was maintained to enable direct comparisons between this study and the findings of Hin (2000). The final herbaceous biomass estimate used the equation of Zambatis *et al.* (2006).

5.3 Results and Discussion

5.3.1 Species composition and canopy cover of the herbaceous layer

Table 5.2 gives the mean percentage canopy cover estimated for the herbaceous layer on Chapungu Ranch for each vegetation community.

Tables 5.3 – 5.10 list the herbaceous species according to their relative percentage contribution to each major plant community. Only the species contributing more than 0.5% are listed. Also included into tables 5.3 – 5.10 are the relative percentage contribution for the more common grass species recorded by Hin (2000) which enabled comparisons between the composition of the herbaceous layer during periods of high rainfall as was experienced during 2000 and periods of low rainfall such as in 2003.

Table 5.2: Percentage canopy cover recorded for the herbaceous layer on Chapungu Ranch, Save Valley Conservancy.

Vegetation Community	Percentage Canopy Cover		
	Grass %	Forb %	Total %
Hibiscus ovalifolius – Albizia brevifolia Short Closed Woodland	13.8	0.1	13.9
Seddera suffruticosa-Colophospermum mopane Closed Woodland	5.2	6.9	12.1
Kirkia acuminata-Colophospermum mopane Open Woodland	26.0	11.1	37.1
Albizia anthelmintica-Acacia tortilis Open Woodland	13.8	11.4	25.2
Xanthocercis zambesiaca - *Acacia tortilis* Closed Woodland	12.4	23.7	36.1
Dalbergia arbutifolia-Diospyros mespiliformes Tall Closed Riverine Forest	18.9	27.5	46.4
Hyperbolius bowkeri-Sporobolus nitens Open Grassland	2.4	15.8	18.2
Echinochloa colona-Cyperus digitatus Open Wetland	4.3	23.7	28.1

The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest recorded the highest percentage total canopy cover (46.4%), whilst the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland recorded the lowest percentage total herbaceous canopy cover (12.1%). The canopy cover recorded for the *Kirkia acuminata-Colophospermum mopane* Open Woodland had the highest percentage grass cover at 26.0% whilst the *Hyperbolius bowkeri-Sporobolus nitens* Open Grassland recorded a grass canopy cover percentage of only 2.4%.

Grasses dominated the herbaceous canopy for the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland (13.8%), *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland (26.0%). The grass canopy and forb canopy for the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland (grass: 5.2%, forb: 6.9%) and the *Albizia anthelmintica – Acacia tortilis* Open Woodland (grass: 13.8%, forb: 11.4%) recorded near similar results. Forbs dominated the herbaceous canopy for the *Xanthocercis zambesiaca - Acacia tortilis* Closed Woodland (23.7%), *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest (27.5%), *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland (15.8%) and *Echinochloa colona – Cyperus digitatus* Open Wetland (23.7%; Table 5.2).

5.3.1.1 The *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland

Despite the low herbivore impact in this community, the forb component dominated the herbaceous layer (32.4%, Table 5.3) and was attributed to the shallow soils of this community. *Digitaria milanjiana* represented the dominant grass with a relative frequency of 18.7%, followed by *Brachiaria xantholeuca* (12.8%) and *Brachiaria deflexa* (7.9%). The total herbaceous canopy cover was estimated at 13.9% with the grass canopy cover contributing 13.8% to the total canopy, whilst the forb canopy cover only contributed 0.1%.

Table 5.3: Percentage contribution of species to the herbaceous layer in the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland

Species	Chapungu Study Relative percentage contribution (%)	Hin (2000)* Relative percentage contribution (%)
Forbs	32.4	-
Digitaria milanjiana	18.7	-
Brachiaria xantholeuca	12.8	-
Brachiaria deflexa	7.9	-
Miss	7.3	-
Enteropogon macrostachyus	5.2	-
Urochloa mosambicensis	4.9	-
Digitaria eriantha	4.4	-
Eragrostis rigidior	1.8	-
Aristida rhiniochloa	1.7	-
Panicum maximum	1.5	-
Dactyloctenium australe	1.0	-

*Hin (2000) found no equivalent community

5.3.1.2 The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland

The forb component was most frequently recorded and dominated the herbaceous layer with a frequency of 43.4%. *Oropetium capense* had the highest frequency (7.5%, Table 5.4) of all grass species, followed by *Urochloa mosambicensis* (6.1%) and *Digitaria milanjiana* (4.5%). Only 12.1% of the total surface area was covered by the herbaceous canopy and this was the lowest value of all communities on Chapungu Ranch. The grass component contributed 5.2% of the total canopy cover, whilst the forb component contributed 6.9%.

Table 5.4: Percentage contribution of species to the herbaceous layer in the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland

Species	Chapungu Study Relative percentage contribution (%)	Hin (2000) Relative percentage contribution (%)
Forbs	43.4	25.2
Miss	11.3	-
Oropetium capense	7.5	9.6
Urochloa mosambicensis	6.1	12.6
Digitaria milanjiana	4.5	8.2
Bothriochloa radicans	4.4	-
Aristida rhiniochloa	3.9	9.7
Brachiaria xantholeuca	3.2	-
Brachiaria deflexa	3.2	18.2
Tetrapogon tenellus	2.7	-
Enteropogon macrostachyus	1.7	0.6
Sporobolus ioclados	1.6	1.6
Tragus berteronianus	1.4	5.6
Sporobolus festivus	1.4	-
Eragrostis rigidior	1.4	-
Panicum maximum	0.9	1.4

5.3.1.3 The *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland

The forb component also dominated the herbaceous layer of this community (24.9%, Table 5.5), followed by grass species such as *Urochloa mosambicensis* (20.7%), *Brachiaria deflexa* (19.3%), *Digitaria milanjiana* (12.0%) and *Tetrapogon tenellus* (3.5%). The total canopy cover for the *Kirkia acuminata-Colophospermum mopane* Short Closed Woodland was 37.1% with the grass canopy component covering 26.0% and the forb canopy covering 11.1%.

Table 5.5: Percentage contribution of species to the herbaceous layer in the *Kirkia acuminata* – *Colophospermum mopane* Short Closed Woodland

Species	Chapungu Study Relative percentage contribution (%)	Hin (2000) Relative percentage contribution (%)
Forbs	24.9	-
Urochloa mosambicensis	20.7	-
Brachiaria deflexa	19.3	-
Digitaria milanjiana	12.0	-
Tetrapogon tenellus	3.5	-
Bothriochloa radicans	2.5	-
Enteropogon macrostachyus	2.0	-
Brachiaria xantholeuca	1.7	-
Aristida rhiniochloa	1.4	-
Tragus berteronianus	1.3	-
Chloris roxburghiana	1.3	-
Pogonarthia squarrosa	1.2	-
Setaria sagittifolia	1.1	-
Oropetium capense	1.0	-
Cenchrus ciliaris	0.8	-
Heteropogon contortus	0.8	-
Miss	0.8	-
Panicum maximum	0.6	-
Melinis repens	0.6	-
Eragrostis rigidior	0.5	-

*Hin (2000) found no equivalent community

5.3.1.4 The *Albizia anthelmintica – Acacia tortilis* Open Woodland

The forb component also dominated the herbaceous layer of the *Albizia anthelmintica – Acacia tortilis* Open Woodland (37.3%, Table 5.6) followed by grass species such as *Urochloa mosambicensis* (33.2%), *Digitaria milanjiana* (6.8%%) and *Tragus berteronianus* (5.7%). The total canopy cover recorded for the herbaceous layer was 25.2%. The grass layer had a canopy cover of 13.8% whilst the forb component covered 11.4%.

5.3.1.5 The *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland

The herbaceous layer in the *Xanthocercis zambesiaca* - *Acacia tortilis* Closed Woodland was dominated by forbs (61.4%, Table 5.7). The grass layer was dominated by *Urochloa mossambicensis* (11.1%), followed by *Setaria sagittifolia* (6.8%), *Sporobolus ioclados* (5.9%), *Brachiaria deflexa* (4.8%) and *Tragus berteronianus* at 4.0%. The herbaceous canopy cover for this community was 36.1%. The grass canopy cover was 12.4%, and the canopy cover for forbs was 23.7%.

Table 5.6: Percentage contribution of species to the herbaceous layer in the *Albizia anthelmintica – Acacia tortilis* Open Woodland

Species	Chapungu Study Relative percentage contribution (%)	Hin (2000) Relative percentage contribution (%)
Forbs	37.3	6.4
Urochloa mosambicensis	33.2	63.4
Digitaria milanjiana	6.8	16.1
Tragus berteronianus	5.7	0.6
Miss	3.1	-
Brachiaria deflexa	2.3	-
Panicum maximum	2.3	7.7
Dactyloctenium giganteum	2.3	0.8
Brachiaria xantholeuca	1.9	-
Sporobolus ioclados	1.3	1.9
Setaria sagittifolia	1.3	-
Eragrostis rigidior	0.9	0.6
Oropetium capense	0.5	-

Table 5.7: Percentage contribution of species to the herbaceous layer in the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland

Species	Chapungu Study Relative percentage contribution (%)	Hin (2000) Relative percentage contribution (%)
Forbs	61.4	37.4
Urochloa mosambicensis	11.1	9.3
Setaria sagittifolia	6.8	-
Sporobolus ioclados	5.9	-
Brachiaria deflexa	4.8	-
Tragus berteronianus	4.0	-
Dactyloctenium giganteum	1.8	2.4
Miss	1.1	-
Digitaria velutina	0.6	-
Leptochloa uniflora	0.6	-
Panicum maximum	0.6	49.3
Setaria verticillata	0.6	-
Chloris virgata	0.6	0.5

5.3.1.6 The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest

The forb component also dominated this community contributing 35.7% to the total herbaceous composition (Table 5.8). *Setaria sagittifolia* (19.2%) and *Panicum maximum* (18.4%) dominated the grass layer, whilst *Brachiaria deflexa* (11.1%) was also commonly recorded. The herbaceous canopy cover for this community was 46.4%. The grass canopy cover contributed 18.9% to the total herbaceous canopy cover, and the canopy cover for forbs contributed 27.5%.

Table 5.8: Percentage contribution of species to the herbaceous layer in the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest

Species	Chapungu Study Relative percentage contribution (%)	Hin (2000) Relative percentage contribution (%)
Forbs	35.7	29.2
Setaria sagittifolia	19.2	4.2
Panicum maximum	18.4	58.3
Brachiaria deflexa	11.1	-
Urochloa mosambicensis	4.7	-
Miss	4.7	-
Digitaria milanjiana	1.4	-
Digitaria velutina	1.1	-
Dactyloctenium giganteum	1.0	-
Tragus berteronianus	0.5	-
Leptochloa uniflora	0.5	-

5.3.1.7 The *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland

Forbs also dominated this plant community (53.1%, Table 5.9) followed by *Sporobolus nitens* (15.3%), *Echinochloa colona* (7.8%) and *Tragus berteronianus* (7.3%). Grass and forb species associated with saline soils were abundant in this community. The total canopy cover for the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland was 18.2% with the grass canopy component covering 2.8% and the forb canopy 15.8% to this total.

Table 5.9: Percentage contribution of species to the herbaceous layer in the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland

Species	Chapungu Study Relative percentage contribution (%)	Hin (2000) Relative percentage contribution (%)
Forbs	53.1	-
Sporobolus nitens	15.3	-
Echinochloa colona	7.8	-
Tragus berteronianus	7.3	-
Miss	7.3	-
Urochloa mosambicensis	4.8	-
Urochloa panicoides	2.0	-
Dactyloctenium australe	1.6	-
Sporobolus ioclados	0.8	-

5.3.1.8 The *Echinochloa colona – Cyperus digitatus* Open Wetland

The herbaceous layer of the *Echinochloa colona – Cyperus digitatus* Open Wetland was highly variable between seasons. Forbs made up 41.8% of the herbaceous layer, whilst *Echinochloa colona* contributed 40.9% (Table 5.10). Common grasses found were *Leptochloa uniflora* (7.1%), *Paspalidium obtusifolium* (2.9%) and *Eriochloa meyeriana* (2.9%). The herbaceous canopy cover for this community was 28.1%. The grass canopy covered 4.3% and the cover for forbs was 23.7%.

Table 5.10: Percentage contribution of species to the herbaceous layer in the *Echinochloa colona – Cyperus digitatus* Open Wetland

Species	Chapungu Study Relative percentage contribution (%)	Hin (2000) Relative percentage contribution (%)
Forbs	41.8	12.3
Echinochloa colona	40.9	3.1
Leptochloa uniflora	7.1	-
Paspalidium obtusifolium	2.9	79.8
Eriochloa meyeriana	2.9	-
Urochloa mosambicensis	1.5	-
Eragrostis spp.	1.4	-
Panicum maximum	1.4	-

5.3.2 Veld condition assessment of the herbaceous layer

Table 5.11 provides the veld condition scores for the plant communities found on Chapungu Ranch as well as the percentage contribution of the five ecological classes in each community.

The veld condition score recorded for the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland was poor despite low grazing pressure. This poor veld condition was mainly due to the high percentage rock cover and shallow soils in this community. The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland had the lowest veld condition score (Score = 301.45). Poor quality and quantity of grass production is well documented for mopane dominated vegetation communities throughout southern Africa (Dye & Spear, 1982; Richter *et al.,* 2001; Smit, 2005) and is mainly as a result of the high clay content in the B-horison of the soils and/or competition for water by the woody layer.

The *Kirkia acuminata – Colophospermum mopane* Open Woodland was also dominated by mopane but was situated on the basalts and sandstone of the Umkondo System. Soil structure and depth allow for water penetration and nutrient availability, resulting in the development of a good grass sward in high to moderate rainfall years. A moderate veld condition score (Score = 546.00) was recorded for this community during the below average rainfall year 2002/2003. The *Albizia anthelmintica – Acacia tortilis* Open Woodland had a moderate veld condition score of 501.25 and this was mainly due to grazing pressure and the poor rainfall season. The *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland was situated on the older alluvial soils which are highly productive in the high to moderate rainfall years. The 2002/2003 season produced a moderate veld condition score of 503.05.

The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest recorded the highest percentage frequency for ecological class 1 species at 38.83% but, nevertheless, resulted in a moderate veld condition score (543.34) due to the high presence of forbs. Despite heavy grazing pressure the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland had a moderate veld condition score of 441.06, whilst the *Echinochloa colona – Cyperus digitatus* open wetland had the highest veld condition score of 604.97.

Table 5.11: The veld condition score and the mean frequency (%) of the different ecological classes for the plant communities on Chapungu Ranch, Save Valley Conservancy, Zimbabwe

Plant community	Veld Condition Score	Frequency (%)					
		Ecological Class 1 Score = 10	Ecological Class 2 Score = 7	Ecological Class 3 Score = 5	Ecological Class 4 Score = 4	Ecological Class 5 Score = 1	Bare ground Score = 0 (Miss)
The *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland	395.61	14.60	24.05	0.00	16.27	16.20	28.88
The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland	301.45	4.67	23.22	0.80	13.73	33.36	24.23
The *Kirkia acuminata –Colophospermum mopane* Open Woodland	546.00	25.61	27.60	5.06	11.74	24.48	5.52
The *Albizia anthelmintica – Acacia tortilis* Open Woodland	501.25	23.64	29.59	1.33	3.27	38.01	4.17
The *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland	503.05	8.20	53.06	3.66	0.40	29.75	4.93
The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest	543.39	38.83	14.30	4.28	0.88	30.05	11.66
The *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland	441.06	0.88	57.23	0.30	0.20	29.35	12.04
The *Echinochloa colona – Cyperus digitatus* Open Wetland	604.97	34.05	32.18	0.00	3.97	23.36	6.44

5.3.3 Biomass yield of the herbaceous layer

Table 5.12 sets out the biomass production for the major plant communities found on Chapungu Ranch. The table compares the herbaceous biomass values derived from equations developed by Trollope and Potgieter (1986) and Zambatis *et al*. (2006) for the Kruger National Park with the regression developed during this study for Chapungu Ranch. The primary reason for the development of this equation was to measure trends in grass biomass production in predominantly sweetveld areas. The table furthermore, also compares the biomass production between the two below average rainfall seasons, the 2002/2003 rainfall season (341mm of rainfall) and the 2006/2007 rainfall season (272 mm of rainfall).

In the 2002/2003 season *Echinochloa colona – Cyperus digitatus* Open Wetland recorded the highest herbaceous biomass with 3 078.3 kg/ha (Table 5.12) whereas the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland recorded the lowest biomass production of 113.5 kg/ha followed by the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland with 188.1 kg/ha.

The Zambatis *et al*. (2006) herbaceous biomass equation recorded large decreases in herbaceous biomass production between the two below average rainfall seasons. Herbaceous biomass production decreased from the 2002/2003 rainfall season for the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland (99.4%), the *Kirkia acuminata – Colophospermum mopane* Open Woodland (87.6%), *Albizia anthelmintica – Acacia tortilis* Open Woodland (78.6%), *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland (29.7%), *Hyperbolius bowkeri – Sporobolus nitens* Open Woodland (91.8%) and the *Echinochloa colona – Cyperus digitatus* Open Wetland (63.7%) to the 2006/2007 rainfall season. Less substantial decreases were recorded for the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland (21.4%) between the two below average rainfall seasons. The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest was the only plant community recording an increase of 19.8% in herbaceous biomass production between the two dry rainfall seasons. It can be speculated that this decreased herbaceous biomass production was caused by a combination of an overall water regime change and increased grazing pressure between the two below average rainfall seasons.

5.3.4 Comparison of the herbaceous layer of Chapungu Ranch with Sango Ranch

The composition of the herbaceous layer on Chapungu Ranch differed markedly from the composition of similar communities measured on Sango Ranch (Hin, 2000). Perennial grass species which dominated the herbaceous layer on Sango Ranch (Hin, 2000) such as *Panicum maximum*, *Digitaria milanjiana* and *Urochloa mossambicensis* had largely been replaced with forbs. In the *Albizia anthelmintica – Acacia tortilis* Open Woodland the presence of *Urochloa mosambicensis* decreased from 63.4% in 1999 to 33.2% in 2003, *Digitaria milanjiana* decreased from 16.1% to 6.8%, whilst the contribution of forbs to the herbaceous layer increased from 6.4% to 37.3%. *Tragus berteronianus* also increased from a 0.6% contribution to a 5.7 % presence in the herbaceous layer. In the *Seddera* *suffruticosa – Colophospermum mopane* Closed Woodland, Hin (2000) reported that grasses contributed 78.8% to the herbaceous layer, whilst the grass component decreased to 45.2% in 2003. In the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland, the presence of *Panicum maximum* was reduced from 49.3% in 1999 to only 0.6% in 2003. Forbs increased from 37.4% in 2000 to 61.4% in 2003, whilst *Urochloa mosambicensis* remained relatively constant at contributing 9.3% and 11.1% between the two years. The herbaceous layer in the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest followed a similar trend to that recorded for the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland, with the dominant grass species, *Panicum maximum* decreasing from 58.3% in 1999 to 18.4% in 2003. The forb component remained high with a 29.2% contribution in 1999 and a 35.7% contribution to the herbaceous layer in 2003.

The veld condition index recorded for most of the plant communities compared favourably with the findings of Hin (2000) despite the compositional changes. The communities mostly affected by the dry conditions were the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland and the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland. The veld condition index for the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland decreased from 52.3% in 1999 to 30.1% in 2003. A similar trend was recorded for the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland measuring a veld condition index of 62.0% in 1999 that decreased to 50.3% in 2003.

The plant communities least affected were the *Albizia anthelmintica – Acacia tortilis* Open Woodland, the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest and the *Echinochloa colona – Cyperus digitatus* Open Wetland. The condition of the veld for the *Albizia anthelmintica – Acacia tortilis* Open Woodland remained fairly unchanged from 1999 to 2003 (50.0% in 2000 as opposed to 50.1% in 2003). Hin (2000) also recorded a veld condition index of 53.0% for the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest, whereas the 2003 study recorded a score of 54.3%. The veld condition index for the *Echinochloa colona – Cyperus digitatus* Open Wetland improved from an index of 43.0% in 2000 to 60.4% in 2003, however the veld condition for this community was highly variable as the water level of the pan influenced the grass layer (see Chapter 9).

The biomass estimates for Chapungu Ranch were lower than the estimates for similar vegetation communities on Sango Ranch (Hin, 2000). Biomass estimates for the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland in 1999 were 3 554 kg/ha compared to only 534 kg/ha in 2002. The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland measured a mean herbaceous biomass of 1 520 kg/ha in 1999, whereas the 2003 survey estimated the herbaceous biomass at 188 kg/ha. Biomass estimates for the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest in 1999 (3 100 kg/ha) were higher than the biomass estimates obtained in 2003 (1 228 kg/ha).

Table 5.12: The herbaceous biomass for the major plant communities on Chapungu Ranch, Save Valley Conservancy, Zimbabwe

Plant Community	Mean Disc Settling Height 2002	Mean Disc Settling Height 2007	Trollope & Potgieter (1986)			Zambatis *et al.* (2006)		Chapungu Equation	
			Hin* (2000) kg/ha	2002	2007	2002	2007	2002	2007
				$y=2260\sqrt{X} - 3019$ kg/ha		$y=(31.716 *(0.3218^{1/X})*X^{0.2834})^2$ kg/ha		$y=466.61\sqrt{X} + 347.26$ kg/ha	
Hibiscus ovalifolius – Albizia brevifolia Short Closed Woodland	1.15	1.05	-	-600.7	-708.4	149.9	117.9	846.6	824.3
Seddera suffruticosa-Colophospermum mopane Closed Woodland	1.26	0.37	1 520	-486.5	-1 649.6	188.1	1.2	870.1	629.9
Mixed *Kirkia acuminata-Colophospermum mopane* Open Woodland	4.55	1.23	-	1 800.5	-512.4	1 441.6	179.1	1 342.3	864.8
Albizia anthelmintica-Acacia tortilis Open Woodland	2.54	1.15	3 706	585.2	-599.9	700.0	150.1	1 091.4	846.7
Xanthocercis zambesiaca - *Acacia tortilis* Closed Woodland	2.13	1.74	3 554	282.6	-34.6	534.2	375.5	1 028.9	963.4
Dahlbergia aburtifolia-Diospyros mespiliformis Tall Closed Riverine Forest	3.93	4.63	3 100	1 462.4	1 845.7	1 227.8	1 470.4	1 272.5	1 351.7
Hyperbolius bowkeri-Sporobolus nitens open woodland	1.03	0.53	-	-724.1	-1 381.5	113.5	9.3	821.1	685.4
Echinochloa colona-Cyperus digitatus Open Wetland	10.52	3.63	3 769	4 312.2	1 287.6	3 078.3	1 118.9	1 860.9	1 236.4

*Values adopted from Hin (2000).

5.4 Conclusion

The composition of the herbaceous layer on Chapungu Ranch differed markedly from the composition of similar communities measured on Sango Ranch (Hin, 2000). Perennial grass species which dominated the herbaceous layer on Sango Ranch (Hin, 2000) such as *Panicum maximum*, *Digitaria milanjiana* and *Urochloa mossambicensis* had largely been replaced with forbs. The increases recorded for the forb component and for grass species in ecological class 4 and ecological class 5 implied increased pressures on the production of the herbaceous layer and were attributed to poor or infrequent rainfall and increased grazing pressure. Despite receiving 341 mm of rain, grass production in 2003 was poor due to infrequent rainfall and localised thunderstorms. Additionally, grazing and trampling increased exponentially during this time (see Chapter 8).

The veld condition index on Chapungu Ranch ranged from poor to good (30.2% to 60.5%). Despite compositional changes the veld condition index recorded for most of the plant communities compared favourably with the findings of Hin (2000).

Biomass estimates for Chapungu Ranch ranged from 113.5 kg/ha to 3 078.3 kg/ha in 2003 and 1.2 kg/ha to 1470.4 in 2007. Overall, the biomass estimates for Chapungu Ranch were lower than the estimates for similar vegetation communities on Sango Ranch (Hin, 2000).

CHAPTER 6

ASSESSMENT OF THE BROWSE AVAILABILITY OF THE WOODY VEGETATION

6.1 Introduction

The vegetation of an area can be divided into two broad components: a) the herbaceous layer which includes the grasses and the non-woody plants (generally referred to as forbs) and b) the woody layer which includes the larger plants classified as shrubs and trees. Herbivores are also classified in terms of their feeding behaviour into two main categories. Herbivores that select grass as their main diet are referred to as grazers and herbivores that predominantly consume leaves are called browsers. Many species of herbivores are mixed feeders and utilize both grass and browse.

Knowledge of the woody layer is thus of utmost importance to determine the browsing capacity of an area. It is also important to detect changes in the structure and composition of woody vegetation that might occur due to the impact of certain large herbivores on the vegetation, especially by the African elephant.

The objective for analyzing the woody vegetation was:

- to describe and determine the species composition and browse availability of the woody vegetation on Chapungu Ranch.

6.2 Methods

The Quantitative Description Index method described by Smit (1989a) was used to determine the composition and structure of the woody vegetation for Chapungu Ranch. The Quantitative Description Index method is based on the relationship between the spatial volume of a tree crown, its true leaf volume and its true leaf dry matter (Smit 1989a). It therefore takes into account the leaf density of different tree species.

Browsing capacity is determined by the condition of the woody vegetation in an area (Trollope, 1990) and the Quantitative Description Index method was used to provide estimates of the available browse for herbivores at two height levels, *viz.* 0 – 2 m and 0 – 5 m.

6.2.1 Sampling procedure

Sampling of the woody vegetation entailed the identifying and measuring of each woody plant in a 100 m by 2 m transect. In sparsely wooded areas, the transect length was extended until at least 30 individual plants was measured. A transect was surveyed at each sampling plot used for the Braun-Blanquet sampling method. A 2 m or 4 m rod, calibrated in 250 mm sections, was used to determine the dimensions of each woody plant. Five dimensional measurements were recorded for each woody plant encountered in a transect. These measurements consisted of the following:

- tree height (A);
- height of maximum canopy diameter (B);
- height of the first leaves or potential leaf bearing stems (C);
- maximum canopy diameter (D); and
- base diameter of the foliage at height C (E).

6.2.2 Data analysis

Data recorded for the woody vegetation were analyzed by the Biomass Estimate for Canopy Volume (BECVOL) computer programme (Smit, 1989a). The volumes of each tree were calculated from the five measurements obtained from the sampling data. The volume was then used to determine the following four quantitative values per tree:

- the Evapotranspiration Tree Equivalent (ETTE) defined as the leaf volume equivalent of a 1.5 m *Acacia karroo* tree;
- the Browse Tree Equivalent (BTE) defined as the leaf biomass equivalent of a 1.5 m *Acacia karroo* tree. Both ETTE and BTE depend upon the relationship between the spatial volume of the tree and its true leaf volume and true leaf mass respectively, and take into account the differences in leaf density;
- the Canopy Subhabitat Index (CSI), defined as the canopy spread of those trees in a transect, under which *Panicum maximum* is most likely to occur (Smit, 1989a); and
- total leaf dry matter up to heights of 1.5 m, 2.0 m and 5.0 m.

The total dry matter at heights of 0 – 1.5 m, 0 – 2.0 m and 0 – 5.0 m is of particular importance to determine the browsing capacity for the various browser populations in the study area. In this study the maximum browsing height was taken at 2.0 m for all the browsing species up to an adult eland and up to 5.0 m for giraffe and African elephant. The browsing capacity was based on the values obtained from calculating the available browse up to these two height levels. Mean values were calculated for each plant community.

6.3 Results and Discussion

Figures 6.1 to 6.7 give the relative contribution for species contributing 0.5% and above to the density in each plant community. The results from the BECVOL analysis are given in Tables 6.1 & 6.2. Results are discussed per plant community for the woody vegetation of Chapungu Ranch.

6.3.1 The *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland

A density of 3 182 woody plants/ha was recorded for the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland with a low canopy subhabitat index of 76 (Table 6.1). *Hibiscus ovalifolius* was the most abundant species (21.1%) closely followed by *Thilachium africanum* (20.5%) and *Phyllanthus pinnatus* with 14.7% (Figure 6.1). The available browse up to 2 m and 5 m were estimated at 747 kg dry leaf matter/ha and 1 755 kg dry leaf matter/ha respectively (Table 6.1). A total dry leaf mass of 5 711 kg/ha was recorded leaving only 13.1% of the dry leaf matter for browsers up to 2 m and 17.7% of the dry leaf matter for browsers feeding >2 – 5 m in height (Table 6.1 & 6.2).

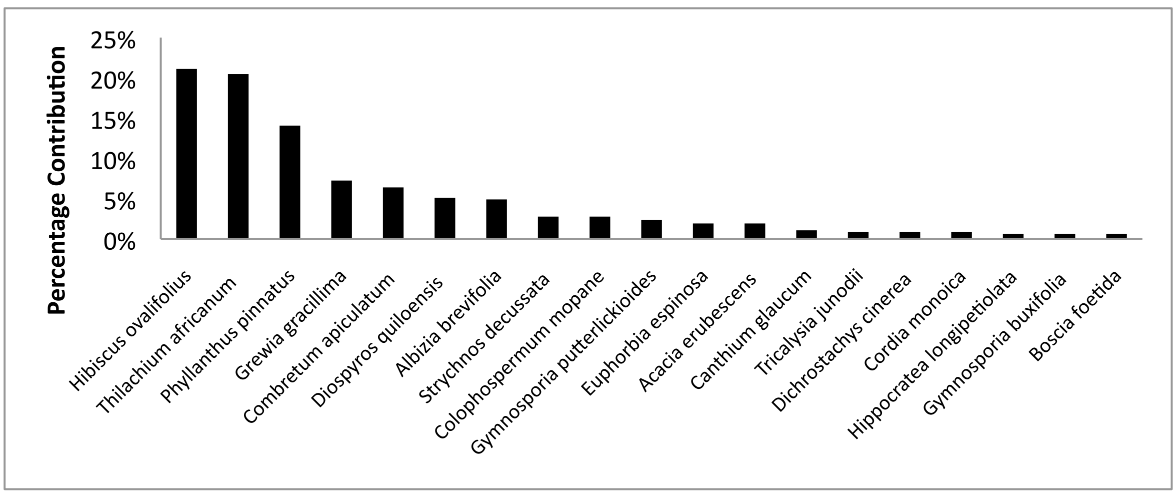


Figure 6.1: Woody species contributing 0.5% or more to the woody plant density in the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland.

Despite the high woody layer density, the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland contributed only 0.6% of the total available browse on Chapungu Ranch of which 0.2% was browse available for animals feeding up to 2 m and 0.4% of the available browse was in the >2 – 5 m height class (Table 6.2).

6.3.2 The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland

The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland had a density of 3 326 woody plants/ha, which is the second highest woody plant density per community recorded for Chapungu Ranch (Table 6.1). The woody layer was dominated by *Colophospermum mopane* contributing 54% to the total woody plants (Figure 6.2). A total leaf mass of 7 449 kg dry leaf matter/ha was estimated with 5.7% of the dry leaf matter for browsers up to 2 m and 17.5% of the dry leaf matter for browsers feeding >2 – 5 m in height (Table 6.1 & 6.2). The available browse up to 2 m was 423 kg dry leaf matter/ha and 1 727 kg dry leaf matter/ha from 0 – 5 m (Table 6.1).

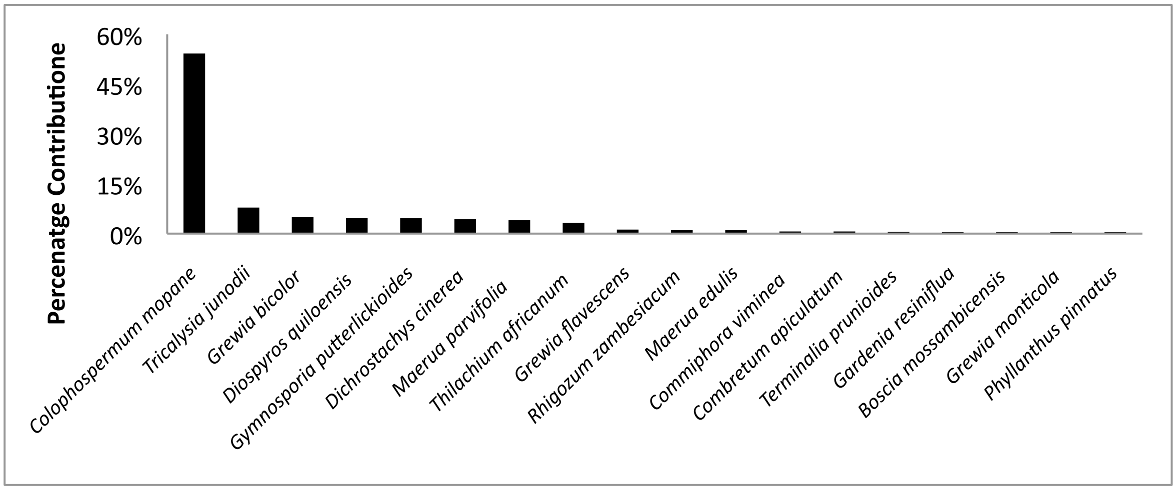


Figure 6.2: Woody species contributing 0.5% or more to the woody plant density in the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland.

The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland contributed 40.8% of the total available browse on Chapungu Ranch of which 10.0% was browse available for animals feeding up to 2 m and 30.8% of the available browse was in the >2 – 5 m height class (Table 6.2).

6.3.3 The *Kirkia acuminata – Colophospermum mopane* Open Woodland

A density of 1 912 woody plants/ha was recorded for the *Kirkia acuminata – Colophospermum mopane* Open Woodland (Table 6.1). *Colophospermum mopane* contributed the highest percentage (27.6% of all individuals) followed by *Grewia bicolor* (23.2%), *Maerua parvifolia* (7.0%) and *Grewia villosa* (6.6%; Figure 6.3). A striking feature of this community was the occurrence of *Kirkia acuminata* scattered throughout this community and in some cases forming clumps.

Despite a density almost half (43%) that of the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland, the total leaf mass contribution of 7 129 kg dry leaf matter/ha was almost the same (Table 6.1). The dry leaf matter for browsers up to 2 m accounted for 6.4% of the total leaf volume and the dry leaf matter for browsers feeding >2 – 5 m in height accounted for 11.2% (Table 6.2). The available browse up to 2 m was 457 kg dry leaf matter/ha and 1 257 kg dry leaf matter/ha from 0 – 5 m (Table 6.1).

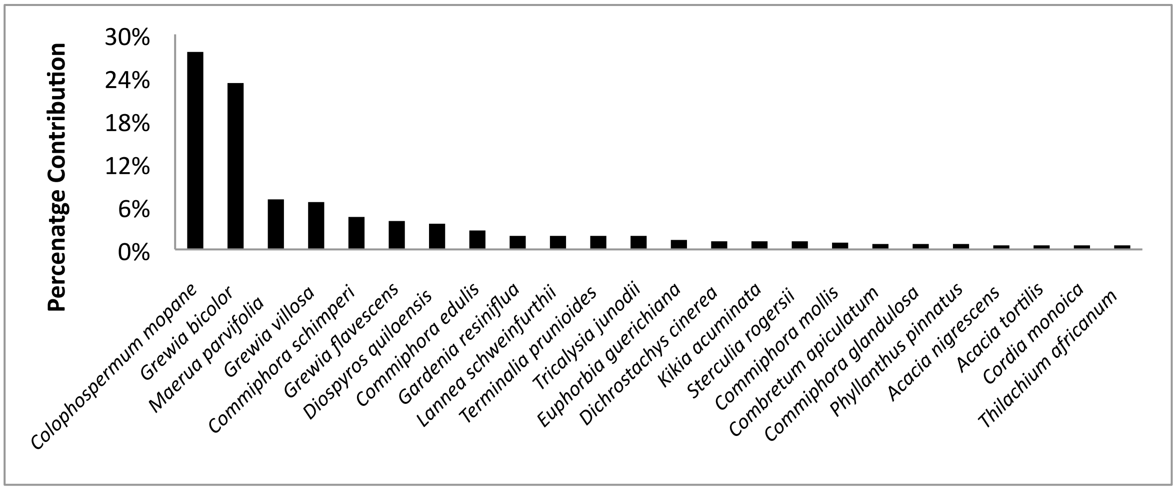


Figure 6.3: Woody species contributing 0.5% or more to the woody plant density in the *Kirkia acuminata – Colophospermum mopane* Closed Woodland.

The *Kirkia acuminata – Colophospermum mopane* Open Woodland contributed 10.9% of the total available browse on Chapungu Ranch of which 4.0% was browse available for animals feeding up to 2 m and 6.9% of the available browse was in the >2 – 5 m height class (Table 6.2).

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6.3.4 The *Albizia anthelmintica – Acacia tortilis* Open Woodland

The density recorded for the *Albizia anthelmintica – Acacia tortilis* Open Woodland was 1 278 woody plants/ha (Table 6.1). In terms of abundance the woody species contributing the most to the woody layer were *Grewia bicolor* (15.7%), *Grewia flavescens* (11.0%), *Dichrostachys cinerea* (10.1%) and *Acacia tortilis* 7.9% (Figure 6.4).

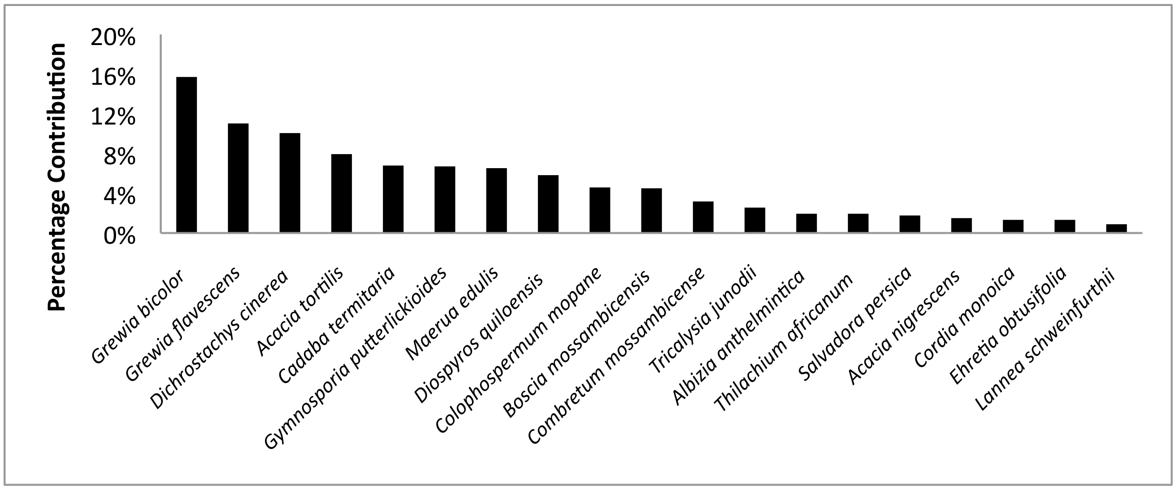


Figure 6.4: Woody species contributing 0.5% or more to the woody plant density in the *Albizia anthelmintica – Acacia tortilis* Open Woodland.

A total leaf mass of 3 975 kg dry leaf matter/ha was recorded with 6.9% of the dry leaf matter for browsers up to 2 m and 18.9% of the dry leaf matter for browsers feeding >2 – 5 m in height (Table 6.1 & 6.2). The available browse up to 2 m was 275 kg dry leaf matter/ha and 1 028 kg dry leaf matter/ha from 0 – 5 m (Table 6.1).

The *Albizia anthelmintica – Acacia tortilis* Open Woodland contributed 22.8% of the total available browse on Chapungu Ranch of which 6.1% was browse available for animals feeding up to 2 m and 16.7% of the available browse was in the >2 – 5 m height class (Table 6.2).

6.3.5 The *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland

The *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland had a density of 1 187 woody plants/ha (Table 6.1). The woody layer was dominated by *Acacia tortilis* contributing 38.6% to the total woody plants (Figure 6.5), followed by *Grewia flavescens* (18.1%), *Thilachium africanum* (8.4%), *Grewia bicolor* (7.2%), *Boscia mossambicensis* (4.8%) and *Ehretia amoena* (4.8%).

A total leaf mass of 6 131 kg dry leaf matter/ha was recorded with 4.7% of the dry leaf matter for browsers up to 2 m and 11.0% of the dry leaf matter for browsers feeding >2 – 5 m in height (Table 6.1 & 6.2). The available browse up to 2 m was 291 kg dry leaf matter/ha and 963 kg dry leaf matter/ha from 0 – 5 m (Table 6.1).

The *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland contributed 6.2% of the total available browse on Chapungu Ranch of which 1.9% was browse available for animals feeding up to 2 m and 4.3% of the available browse was in the >2 – 5 m height class (Table 6.2).

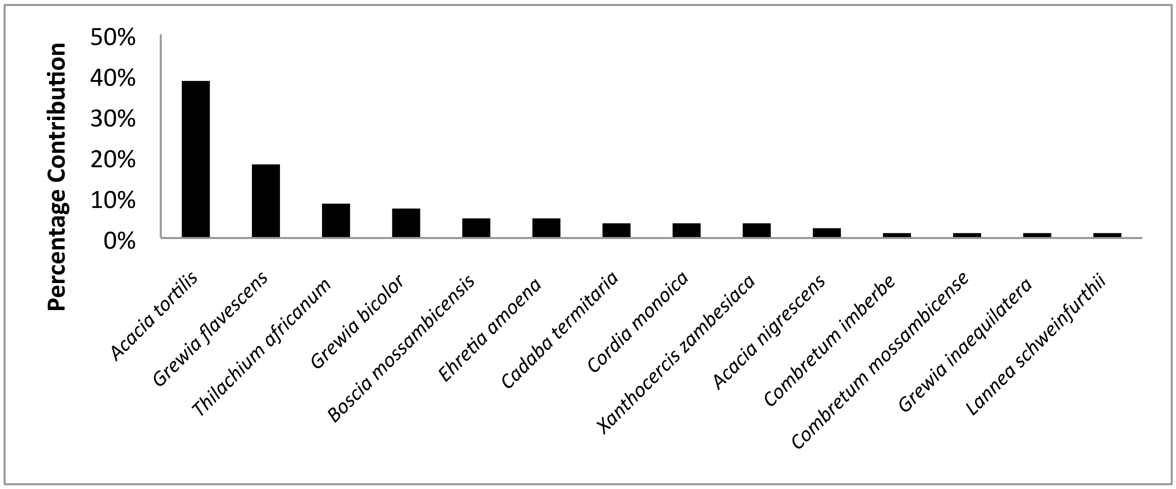


Figure 6.5: Woody species contributing 0.5% or more to the woody plant in the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland.

6.3.6 The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest

The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest recorded the highest density of woody plants in the study area at 5 718 woody plants/ha (Table 6.1). Figure 6.6 gives an indication of the woody plants most frequently found in the woody layer within this community. *Acacia schweinfurthii* was most commonly found (40.0%) followed by species such as *Azima tetracantha*, *Diospyros mespiliformis*, *Grewia inaequilatera* and *Bridelia cathartica*. The total leaf mass was as high as 21 869 kg dry leaf matter/ha with 2.9% of the dry leaf matter for browsers up to 2 m and 5.9% of the dry leaf matter for browsers feeding between >2 – 5 m high (Table 6.1 & 6.2). The available browse up to 2 m was 632 kg dry leaf matter/ha and 1 926 kg dry leaf matter/ha from 0 – 5 m (Table 6.1).

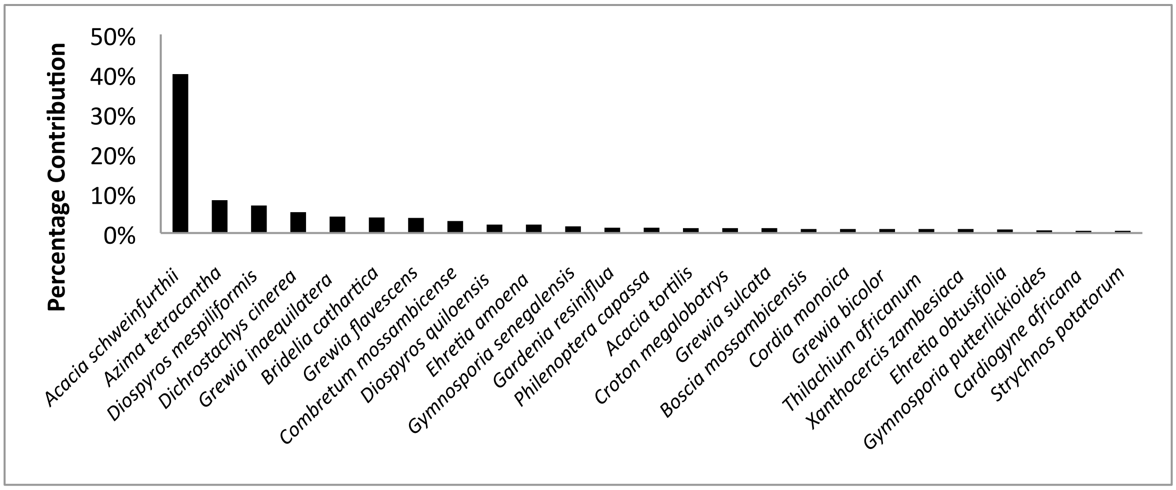


Figure 6.6: Woody species contributing 0.5% or more to the woody plant density in the *Dalbergia arbutifolia – Acacia schweinfurthii* Tall Closed Riverine Forest.

The *Dalbergia arbutifolia – Acacia schweinfurthii* Tall Closed Riverine Forest contributed 18.7% of the total available browse on Chapungu Ranch of which 6.1% was browse available for animals feeding up to 2 m and 12.6% of the available browse was in the >2 – 5 m height class (Table 6.2).

6.3.7 The *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland

No woody plants surveys were conducted within this community due to the small size and the low density of woody plants. Woody plants encountered within this plant community were *Acacia grandicornuta*, *Acacia tortilis*, *Salvadora australis* and *Hyphaene petersiana*. However the irregular occurrence of woody plants combined with the small sample size were insufficient to establish any reliable data on woody plant density and browse availability.

6.3.8 The *Echinochloa colona – Cyperus digitatus* Open Wetland

The woody layer of the *Echinochloa colona – Cyperus digitatus* Open Wetland has only 310 woody plants/ha (Table 6.1). The dominant and most striking woody plant species in this community was *Acacia xanthophloea* (83.3%) followed by *Searsia gueinzii* and *Acacia karroo* (Figure 6.7). The total leaf mass was 4 349 kg dry leaf matter/ha with negligible (0.01%) amounts of dry leaf matter up to 5 m in height (Table 6.1).

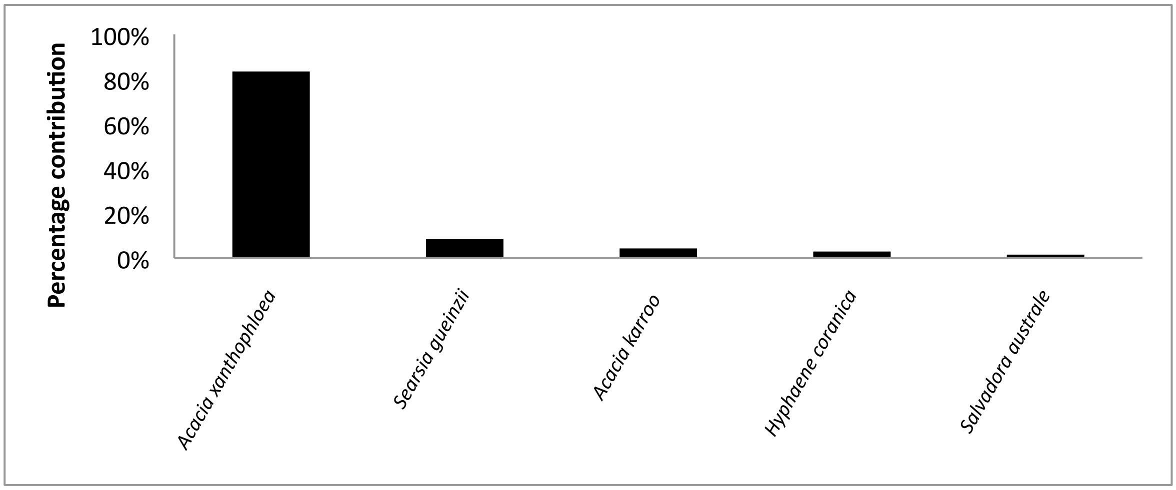


Figure 6.7: Woody species contributing 0.5% or more to the woody plant density in the *Echinochloa colona – Cyperus digitatus* Open Wetland.

The *Echinochloa colona – Cyperus digitatus* Open Wetland contributed 0.02% of the total available browse on Chapungu Ranch (Table 6.2).

6.3.9 *Phragmites australis – Ficus capreifolia* Short Closed Thicket

No quantitative assesments were done in terms of browse availability for the *Phragmites australis – Ficus capreifoilia* Short Closed Thicket due to inaccessibilty of the thicket and the impossible task of establishing a canopy for these plants. The percentage contributions of woody plants was established through transects and the results are given in Figure 6.8.

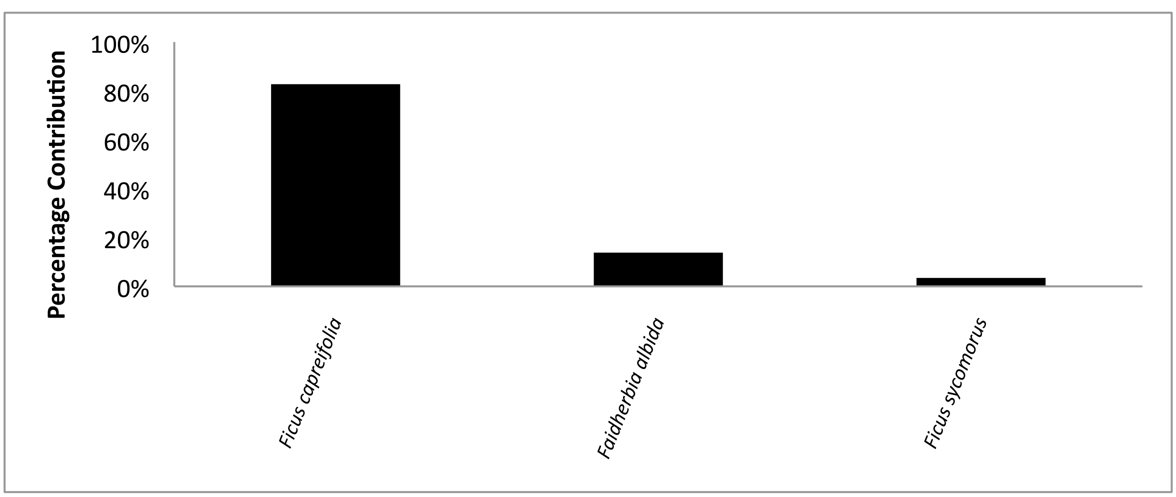


Figure 6.8: Woody species contributing 0.5% or more to the woody plant density in the *Phragmites australe – Ficus capreifoilia* Short Closed Thicket.

Table 6.1: The woody plant density, total leaf mass, evapotranspiration tree equivalent (ETTE), dry leaf mass for height class 0-2 m and 0-5 m, browse tree equivalent (BTE) and canopy subhabitat index (CSI) for Chapungu Ranch, Save Valley Conservancy

Plant community	Woody Plant Density Plants/ha	Total Dry Leaf Mass per hectare	Evapotranspiration Tree Equivalent	Dry Leaf Mass per Hectare 0 – 2 m	Dry Leaf Mass per Hectare 0 – 5 m	Browse Tree Equivalent	Canopy Subhabitat Index
Hibiscus ovalifolius – Albizia brevifolia Short Closed Woodland	3 182	5 711	11 422	747	1 755	11 039	76
Seddera suffruticosa – Colophospermum mopane Closed Woodland	3 938	7 449	14 897	423	1 727	15 252	108
Kirkia acuminata – Colophospermum mopane Open Woodland	1 912	7 129	14 259	457	1 257	13 780	111
Albizia anthelmintica – Acacia tortilis Open Woodland	1 278	3 975	7 950	275	1 028	7 611	67
Xanthocercis zambesiaca – Acacia tortilis Closed Woodland	1 187	6 131	12 261	291	963	11 366	103
Dalbergia arbutifolia – Diospyros mespiliformis Tall Closed Riverine Forest	5 718	21 869	43 736	632	1 926	40 211	378
Hyperbolius bowkeri – Sporobolus nitens Open Grassland	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured
Echinochloa colona – Cyperus digitatus Open Wetland	310	4 346	8 691	4	40	8 527	87
Phragmites australis – Ficus capreifolia Short Closed Thicket	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured	Not measured

Table 6.2: Available browse for Chapungu Ranch, Save Valley Conservancy

Vegetation community	Area size	Browse availability per hectare kg/ha		Total available browse kg/ha		
	Ha	Height Class 0 – 2 m	Height Class >2 – 5 m	Height Class 0 – 2 m	Height Class >2 – 5 m	Height Class 0 – 5 m
Hibiscus ovalifolius – Albizia brevifolia Short Closed Woodland	65	747	1 008	48 523	65 520	1 14 043
Seddera suffruticosa – Colophospermum mopane Closed Woodland	4 234	423	1 304	1 790 982	5 521 136	7 312 118
Kirkia acuminata – Colophospermum mopane Open Woodland	1 551	457	800	708 807	1 240 800	1 949 607
Albizia anthelmintica – Acacia tortilis Open Woodland	3 973	275	753	1 093 568	2 991 669	4 085 237
Xanthocercis zambesiaca - Acacia tortilis Closed Woodland	1 161	291	672	337 851	780 192	1 118 043
Dalbergia arbutifolia – Diospyros mespiliformis Tall Closed Riverine Forest	1 742	632	1 294	1 100 073	2 254 148	3 354 221
Hyperbolius bowkeri – Sporobolus nitens Open Grassland	160	Not measured	Not measured	Not measured	Not measured	Not measured
Echinochloa colona – Cyperus digitatus Open Wetland	85	4	36	340	3 060	3 400
Phragmites australis – Ficus capreifolia Short Closed Thicket	-	Not measured	Not measured	Not measured	Not measured	Not measured
Total	12 971	2 828	5 867	5 080 144	12 856 525	17 936 669

6.4 Conclusions

The structure and species composition of the woody plants varied considerably between the plant communities on Chapungu. Woody plant densities ranged from low densities (less than 1 woody plant/ha) for the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland to high densities (5 718 woody plants/ha) for the *Dalbergia arbutifolia – Acacia schweinfurthii* Tall Closed Riverine Forest. The composition of the woody layer was also diverse with a total of 136 different woody plant species recorded for Chapungu Ranch.

On Chapungu only 15.4% of the total browse was available to browsers, 5.0% of the browse was available for herbivores up to 2 m and 10.4% of the browse was available to browsers feeding >2 – 5 m in height. Hin (2000) recorded similar results with 16% of the browse available to browsers on Sango Ranch. Hin (2000) recorded 6% of the available browse for the height class up to 2 m height class and 13% of the available browse in the >2 – 5m height class.

The *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland had the highest leaf dry mass per hectare up to 2 m of all communities, whereas the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest had the highest leaf dry mass per hectare in the 0 – 5 m layer. However due to the large area covered by the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland it contributed the most to the overall leaf mass available to browsers.

The total amount of dry leaf matter available for browsers up to 2 m was 5 080 tons and 12 856 tons of dry leaf matter was recorded in the 2 – <5 m height class.

The diverse nature of the woody layer provides shelter, habitat and forage in the form of browse for a wide variety of animal species within Chapungu. The Quantitative Description method described by Smit (1989a & 1989b) enabled the calculation of the available browse for each plant community, the results of which can now can be used in combination with the results obtained from the herbaceous layer to determine overall ecological capacity of the study area (see Chapter 7).

CHAPTER 7

ECOLOGICAL GRAZING AND BROWSING CAPACITY AND STOCKING DENSITY

7.1 Introduction

Grazing capacity is described as the area of land required to maintain an animal unit in a good productive and reproductive condition without deteriorating the grazing or soils over time (Tainton *et al.*, 1978). Unfortunately, the relationship between productivity and stability is negative and striving towards greater productivity often leads to simplification of naturally complex ecosystems with subsequent disastrous consequences (Tainton, 1999). Meissner (1982) stated that the knowledge of grazing capacity is fundamental in developing and implementing sound management systems. Grazing capacity is affected by factors such as rainfall, the quantity and quality of forage available, condition of the veld, water availability and distribution, competition and the nutritional and behavioural requirements of the animals utilizing the land (Meissner, 1982). In wildlife production systems both the grazing and browsing capacity are used to determine the ecological capacity of an area. The ecological capacity is the maximum number of animals an area can support without deterioration of the habitat (Bothma, 1989a & b; Trollope, 1990).

According to Thompson (1992) the ecological capacity of the habitat for a specific animal population has been reached when all the ecological rules that apply to the occupation of a habitat by a particular population have been satisfied. The ecological rules referred to include the occupation of home ranges and territories, the establishment of hierarchies, the stabilization of the animal population's needs and its adjustment with other populations within the habitat it shares.

In wildlife management the stocking density of different species is primarily a function of the grazing and browsing capacity of the veld (Trollope, 1990; Bothma, 2002) but it is further complicated by the social behaviour of animals such as competition, territoriality and home range utilization (Bothma, 1996a).

The key objectives for this part of the study were:

- to determine the grazing capacity for each plant community;
- to determine the browsing capacity for each plant community; and
- to determine the ecological capacity for Chapungu Ranch.

7.2 Methods

Various methods have been developed to determine grazing and browsing capacity (Bigalke, 1972; Coe *et al.,* 1976; Mentis, 1983; Barnes *et al.,* 1984; Danckwerts, 1982a, 1982b; Meissner, 1982; Moore & Odendaal, 1987; Danckwerts, 1989a & b; Peel *et al.,* 1991; Peel & Stuart-Hill, 1993; Fritz & Duncan, 1994).

Coe *et al.* (1976) found a good correlation between the mean annual rainfall and the biomass production of a standing crop, energy expenditure and production by large mammalian herbivores. The method described by Coe *et al.* (1976) is useful mainly for first order predictions of ecological capacity but does not take into account local temporal and spatial variations within individual ecosystems. Peel (1990), Peel *et al.* (1991) and Peel & Stuart-Hill (1993) used palatability of the herbaceous layer and rainfall as the two major criteria determining grazing capacity for savanna areas in the eastern Transvaal Lowveld. The grazing capacity was expressed in terms of grazing units (GU) where one grazing unit equals $450^{0.75}$ / (Average body mass of species X) $^{0.75}$ x % graze in diet. Dankwerts (1989a, 1989b) used a combination of the annual rainfall and the condition of the veld (expressed as percentage) to determine the grazing capacity. Moore & Odendaal (1987) used herbaceous biomass production to calculate stocking densities for the Kalahari Thornveld. Herbaceous biomass production was measured by the disc pasture meter or through direct harvesting methods. Stocking densities are then determined by multiplying the herbaceous biomass with a predetermined utilization factor, an intake level and the number of days the veld will be utilized. Schmidt *et al.* (1995) compared the rainfall method of Coe *et al*. (1976), the combined rainfall/veld condition method of Dankwerts (1989a, 1989b) and the herbaceous phytomass method of Moore & Odendaal (1987) and concluded that all three methods were suitable for grazing capacity approximations. Fritz and Duncan (1994) investigated two environmental factors namely rainfall and soil nutrient levels and their effects on primary production. Results from their study confirm the dominant effect of rainfall on grazing capacity but also demonstrated the importance of soil nutrient levels. The level of biomass production on nutrient rich soils was found to be 20 times larger than soils with low nutrient availability. The study also found no significant difference in large ungulate biomass production on pastoral and natural ecosystems and there was no evidence to suggest that extensive pastoral management increases grazing capacity (Fritz & Duncan, 1994). Meissner (1982) used levels of energy requirements to determine the dietary requirement of well-studied livestock and derived substitution values for wild ungulates in terms of a biologically defined Large Animal Unit. A Large Animal Unit or Large Stock Unit is the equivalent of a 450 kg steer whose mass increases at 500 g per day on veld with a mean digestibility of 55% (Bothma, 2002). Grazing capacity is then expressed as Large Animal Units per hectare (LAU/ha) or as hectares per Large Animal Unit (ha/LAU).

Bothma *et al*. (2004) introduced the Grazing Unit method for calculating grazing capacity. Grazing capacity is determined by including factors such as percentage graze in the diet by a specific animal, the condition of the herbaceous layer, the herbaceous cover, the fire regime, the accessibility of the terrain to large herbivores and the rainfall.

In this study the method of Bothma *et al.* (2004) was used to calculate the grazing capacity for the study area. The browsing capacity was determined using the BECVOL method described by Smit (1989a, 1989b).

7.2.1 Grazing Capacity

The Grazing Unit Method expresses grazing capacity as grazer units that an area can sustain. A grazer unit is defined as the metabolic equivalent of a blue wildebeest with a body mass of 180 kg (Van Rooyen, 2010).

The grazing capacity for each of the plant communities on Chapungu was determined using the following equation (Bothma *et al.*, 2004):

$$GU/100\ ha = 0.547 \times \{[c + (r - 419) \times 0.23] \times a \times f\,(\log_{10}g - 1)^{0.4}\}$$

where:

GU/100 ha	=	Grazing capacity in Grazer Units per 100 ha
c	=	Veld condition index as a percentage
r	=	Mean rainfall of the preceding two rainfall seasons (mm)
419	=	Long-term mean rainfall for South African savanna areas (mm)
a	=	Topography index of accessibility (scaled 0.1 to1.0)
f	=	Fire index (scaled 0.8 to 1.0)
g	=	Percentage grass canopy cover

The topographical index of accessibility refers to the degree of access animals have to a particular plant community with 0.1 being totally inaccessible and 1.0 being fully accessible. The fire index is scaled between 0.8 and 1.0 with 0.8 indicating recent fire and 1.0 indicating the absence of recent fire.

The Grazing Unit method was the primary method used to describe the grazing capacity for the study area. However the results derived by means of the Grazing Unit method were compared with values derived by the methods proposed by Dankwerts (1989a, 1989b), Coe *et al*. (1976), Moore & Odendaal (1987) and Fritz & Duncan (1994).

The equation used for determining the grazing capacity expressed as LAU/ha according to Dankwerts (1989a & b) was:

$$GC = -0.03 + 0.00289X_1 + [(X_2 - 419.7) * 0.000633]$$

where:

GC = grazing capacity for cattle, expressed in LAU per hectares;

X_1 = percentage veld condition score;

X_2 = mean annual rainfall or total seasonal rainfall;

The grazing capacity derived from this equation is given as large stock units (LAU) per hectare (ha).

The rainfall method used the following equation (Coe *et al*., 1976):

$$\text{Stocking density} = \text{Log biomass (kg/km}^2\text{)} \times \text{Log mean rainfall (mm)} - 1.098.$$

The herbaceous phytomass method described by Moore & Odendal (1987) used the equation

$$SR = (\text{Biomass (kg/ha)} \times 0.35) / (10 \times 365)$$

where:

SR = stocking rate (LSU/ha/annum)

0.35 = utilization factor expressed as the percentage available

10 = 10 kg of feed per day to maintain one Large Stock Unit

365 = Number of days in the year.

The soil nutrient-rainfall method described by Fritz & Duncan (1994) used three equations depending on the soil type. These equations were as follows and were separated based on soil nutrient availability:

$\log Bt = 1.96 \times \log P - 2.04$ for soils with low nutrient availability,

$\log Bt = 1.78 \times \log P - 1.32$ for soils with a medium nutrient availability,

$\log Bt = 1.58 \times \log P - 0.67$ for soils with a high nutrient availability,

where:

Bt = large ungulate biomass (kg/km^2)

P = mean annual rainfall (mm/annum)

7.2.2 Browsing Capacity

Browsing capacity is expressed in terms of the number of browser units an area can sustain. A Browser Unit is defined as the metabolic equivalent of a greater kudu cow with a mass of 140 kg.

The BECVOL method described by Smit (1989a, 1989b) was used to determine the available browse and the potential browsing capacity of the study area. The browsing capacity was estimated after deducting leaf mass estimates for losses other than browse. Deductions were made for the physical unavailability of browse (browse out of the reach of the animals), for leaves utilized by other animals (invertebrates) and allowing for leaf re-growth. Von Holdt (1999) estimated that only 5% to 10% of the total available browse should be used to determine browsing capacity.

The browsing capacity was obtained by dividing the remaining leaf dry mass available by the leaf dry mass requirement of one Browser Unit per year.

The equation used to determine the browsing capacity was as follows:

BU/ha = (A x 0.1)/ 1533

where:

BU = Number of Browser Unit per ha

A = Available browse per ha

The equation assumes that only 10% of the available browse can be utilized by wildlife and that a Browser Unit, the equivalent of a 140 kg kudu cow, would need 1533 kg of dry leaf matter per annum to sustain itself in a good productive and reproductive condition.

7.2.3 Stocking density

The current stocking density for Chapungu Ranch was determined for the major large herbivores through various wildlife counting and census techniques. The techniques included total aerial surveys, road strip counts, line transect counts, grid square counts, spoor counts and known group counts.

All herbivores were then apportioned according to Bothma *et al.* (2004) and Van Rooyen (2010) into GU and BU equivalents. The first step was to consider the percentage grazing and browsing in the diet of each species. The percentage grass or browse in the diet of a species was based on values presented by Van Rooyen (2010) and based on findings by Grossman (1991), Gagnon & Chew (2000), Grubb (2005) and Skinner & Chimimba (2005). A conversion factor for each wildlife species into GU/animal and BU/animal was then determined using the relative metabolic mass for each type of animal (Meissner, 1982).

The equation used to determine the GU equivalent was

$$Species\ X = \frac{(\bar{x}\ mass\ of\ species\ X)^{0.75}}{(\bar{x}\ mass\ of\ 1\ GU)^{0.75}}$$

The equation used to determine BU equivalent was

$$Species\ X = \frac{(\bar{x}\ mass\ of\ species\ X)^{0.75}}{(\bar{x}\ mass\ of\ 1\ BU)^{0.75}}$$

Once each animal species had been assigned a GU and BU equivalent each species was classed into one of four main feeding classes according to Bothma *et al.* (2004).

7.3 Results and Discussion

The grazing and browsing capacity for each vegetation unit are presented in Table 7.1 and Table 7.2 respectively. Table 7.3 gives the stocking densities for Chapungu Ranch in 2003.

According to the grazer unit method, Chapungu Ranch was able to support 3 331 Grazer Units in total which may be different for each plant community (Table 7.1) during the 2003/2004 rainfall season. This value provides an indication of the ecological capacity of the ranch to support grazers. However, the ecological capacity of a ranch represents the level whereby the wildlife population densities are regulated through the availability of forage, water and shelter. At this level wildlife population densities cease to increase exponentially and density-dependent factors such as competition for resources result in lower fecundity and higher mortality rates. Wildlife populations will thus tend to oscillate around the level of ecological capacity. The upper level that represents the ecological capacity is not stable but fluctuates depending on rainfall, interspecific competitions, predator-prey relations and the fire regime of an area.

The economic capacity of an area is at a level below the ecological capacity and for this study it was proposed that animal populations be managed at 70% of the ecological capacity. The economic capacity aims at maintaining positive wildlife population growth, avoiding large-scale die-offs due to droughts and maintaining biodiversity.

The proposed economic grazing capacity for the 2003/2004 rainfall season on Chapungu Ranch was therefore estimated at 2 435 Grazer Units (equals approximately 1 218 LAU), whilst the actual stocking density was 2 199 Grazer Units. The grazing capacity was thus within the limits proposed for the long-term annual rainfall of the region.

The browsing capacity in 2003 was 1 169 Browser Units and the actual stocking density of 3 029 Browser Units exceeded the estimated browsing capacity by 141%.

Table 7.1: The ecological class composition of the herbaceous layer, veld condition and grazing capacity for the plant communities occurring on Chapungu Ranch, Save Valley Conservancy

Plant Community	Size (ha)	Tree cover (%)	Shrub cover (%)	Contribution of ecological classes	Class 1	Class 2	Class 3	Class 4	Class 5	Bare Ground	Veld Condition Score (Max. 1000)	Veld Condition Index (%)	Herbaceous Cover (%)	Long-term Mean Rainfall (mm/year)	Topographical Index of accessibility[b]	Fire factor[c]	**Ecological grazing capacity**	GU/100 ha	Total GU	Mean ecological grazing capacity (GU/100 ha)
Hibiscus ovalifolius – Albizia brevifolia Short Closed Woodland	65	17.1	8.2		14.6	24.1	0.0	16.3	16.2	28.9	395.6	39.6	13.9	538	0.4	1.0		7	4	
Seddera suffruticosa – Colophospermum mopane Closed Woodland	4 234	37.5	6.1		4.7	23.2	0.8	13.7	33.4	24.2	301.5	30.2	12.1	538	1.0	1.0		12	492	
Kirkia acuminata – Colophospermum mopane Open Woodland	1 551	18.5	3.1		25.6	27.6	5.1	11.7	24.5	5.5	546.0	54.6	37.1	538	1.0	1.0		36	555	
Albizia anthelmintica – Acacia tortilis Open Woodland	3 973	9.8	2.6		23.6	29.6	1.3	3.3	38.0	4.2	501.3	50.1	25.2	538	1.0	1.0		29	1 170	
Xanthocercis zambesiaca – Acacia tortilis Closed Woodland	1 161	30.5	4.4		8.2	53.1	3.7	0.4	29.8	4.9	503.1	50.3	36.1	538	1.0	1.0		34	390	
Dalbergia arbutifolia – Diospyros mespiliformis Tall Closed Riverine Forest	1 742	66.1	6.0		38.8	14.3	4.3	0.9	30.1	11.7	543.4	54.3	46.4	538	1.0	1.0		38	662	
Hyperbolius bowkeri – Sporobolus nitens Open Grassland	160	0.0	0.7		0.9	57.2	0.3	0.2	29.4	12.0	441.1	44.1	18.2	538	1.0	1.0		23	36	
Echinochloa colona – Cyperus digitatus Open Wetland	85	3.4	0.7		34.1	32.2	0.0	4.0	23.4	6.4	605.0	60.5	28.1	538	0.7	1.0		24	21	
Total	12 971																3 331			25.30

Table 7.2: The browsing capacity for two height classes and the total browsing capacity for each vegetation type on Chapungu Ranch, Save Valley Conservancy

Plant Community	**Available browse per ha**	Height class (0 – 2 m)	Height class (0 – 5 m)	Available browse (Height class 0 – 2 m)	Available browse (Height class 0 – 5 m)	**Ecological browsing capacity**	BU/100 ha (Height Class 0 – 2 m)	BU/100ha (Height Class 0 – 5 m)	Total BU (0 – 2 m)	Total BU (0 – 5 m)	**Ecological Carrying Capacity**	Total GU	Total BU
Hibiscus ovalifolius – Albizia brevifolia Short Closed Woodland		747	1 755	48 555	114 075		4.9	11.4	3.2	7.4		4	7
Seddera suffruticosa – Colophospermum mopane Closed Woodland		423	1 725	1 790 982	7 303 650		2.8	11.3	116.8	476.4		492	476
Kirkia acuminata – Colophospermum mopane Open Woodland		457	1 257	708 807	1 949 607		3.0	8.2	46.2	127.2		555	127
Albizia anthelmintica – Acacia tortilis Open Woodland		275	1 028	1 092 575	4 084 244		1.8	6.7	71.3	266.4		1 170	266
Xanthocercis zambesiaca – Acacia tortilis Closed Woodland		291	963	337 851	1 118 043		1.9	6.3	22.0	72.9		390	73
Dalbergia arbutifolia – Diospyros mespiliformis Tall Closed Riverine Forest		632	1 926	1 100 944	3 355 092		4.1	12.6	71.8	218.9		662	219
Hyperbolius bowkeri – Sporobolus nitens Open Grassland		n/m	n/m	n/m	n/m		n/m	n/m	n/m	n/m		36	0
Echinochloa colona – Cyperus digitatus Open Wetland		4	40	340	3 400		0.0	0.3	0.0	0.2		21	0
Total							2.6	8.1	331.4	11 69.5		3 331	1 169

Table 7.3: The Grazing and Browsing Unit equivalents for the major herbivore species occurring on Chapungu Ranch, Save Valley Conservancy during the 2002 (Joubert & Joubert, 2003)

Species	Population estimate	Mean mass	GU equivalent	BU Equivalent	Diet		Number of Grazing Units	Number of Browsing Units
					Percentage Graze	Percentage browse		
Low-selective grazers								
African buffalo	0	520	2.21	2.68	78	22	0	0
Burchell's zebra	356	260	1.32	1.60	93	7	437	40
Bushpig	170*	55	0.41	0.50	80	20	56	17
Hippopotamus	15**	1321	4.46	5.38	99	1	66	1
White rhinoceros	0	1727	5.45	6.58	100	0	0	0
High-selective grazers								
Blue wildebeest	447	180	1.00	1.21	87	13	389	70
Sable antelope	0	220	1.16	1.40	85	15	0	0
Waterbuck	26	205	0.91	0.75	84	16	20	3
Mixed feeders								
Livingston's eland	376	323	2.02	2.44	50	50	380	459
African elephant	158	3750	9.75	11.77	28	72	431	1 339
Impala	2 096	41	0.33	0.40	45	55	311	461
Nyala	0**	73	0.51	0.61	20	80	0	0
Warthog	343	30	0.26	0.31	70	30	62	32
Browsers								
Black rhinoceros	1	818	3.11	3.76	4	96	0	4
Bushbuck	120*	30	0.26	0.31	10	90	3	33
Giraffe	77	830	3.15	3.80	1	99	2	290
Greater kudu	326	140	0.83	1.00	15	85	41	277
Common duiker	15***	19	0.19	0.22	12	88	0	3
Klipspringer	2***	13	0.14	0.17	20	80	0	0
Sharpe's grysbok	4***	8	0.10	0.17	30	70	0	0
Total	4 532						2 199	3 029

*population estimated by line transect counts, ** population estimated by known groups, ***population estimated from grid square method

Grazing capacity in the different plant communities ranged from 7 GU/100 ha to 38 GU/100 ha with a mean of 25.3 GU/100 ha. The browsing capacity ranged from as low as 0.3 BU/100 ha to 12.6 BU/100 ha with a mean of 8.1 BU/100 ha for the height class 0 – 5 m.

These results were compared to other methods for establishing ecological capacities, despite those methods being designed for livestock production systems or describing ungulate stocking densities on a large land scale. The rainfall/large herbivore biomass method described by Coe *et al.* (1976) estimated the carrying capacity at 10 LAU/100 ha. This would allow 1 314 LAU for Chapungu and underestimates the grazing capacity calculated for Chapungu by the method of Bothma *et al.* (2004). The soil nutrient/rainfall method described by Fritz & Duncan (1994) estimated a total of 1 145 LAU for the study site or 8 LAU/100 ha, which is also lower than the Grazer Unit method. The combined rainfall/veld condition method (Dankwerts, 1989a, 1989b) estimated a grazing capacity of 18 LAU/100 ha or a total of 2 396 LAU for the study area and the herbaceous phytomass method (Moore & Odendaal, 1987) estimated a carrying capacity of 15 LAU/100 ha or 2 064 LAU for Chapungu Ranch. Both the latter values were higher than the Grazer Unit method.

Table 7.4: A comparison between the various methods for establishing ecological capacity for Chapungu Ranch, Save Valley Conservancy

Method	Grazing Capacity (LAU)	Grazing Capacity (ha/LAU)	Browsing Capacity (LAU)	Total Ecological Capacity (LAU)
BECVOL (Smit, 1989)			387	
Veld condition – Rainfall method (Dankwerts, 1989a)	2396	5.7		
Herbaceous phytomass (Moore & Odendaal, 1987)	2064	6.6		
Grazer Unit (Bothma *et al.*, 2004)	1740	7.9		2127
Rainfall – large herbivore biomass (Coe *et al.*, 1976)	1314	10.4		
Soil-nutrient-rainfall (Frits & Duncan, 1994)	1145	12.0		

The *Hibiscus ovalifolius – Albizia brevifolia* short closed woodland yielded the lowest grazing capacity at 7 GU/100 ha as a result of the shallow, nutrient deficient soils with low water holding capacity and high percentage surface rock within this community. Conversely the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest recorded the highest grazing capacity (38 GU/100 ha) due to its deep, nutrient and water-rich alluvial soils. The *Seddera suffruticosa – Colophospermum mopane* Closed Woodland community, despite nutrient rich soils, recorded a grazing capacity of only 12 GU/100 ha.

In contrast, the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland that was also dominated by *Colophospermum mopane* recorded the second highest grazing capacity (36 GU/100 ha).

The soils of this community were well aerated and rich in nutrients due to the layer of basalt within the predominately sandstone deposits of the Umkondo geological formation. The colluvial soils of the *Albizia anthelmintica – Acacia tortilis* Open Woodland (29 GU/100 ha) community and the alluvial soils of the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland community (34 GU/100 ha) also compared well with the grazing capacities recorded for other woodland communities, whilst the *Echinochloa colona – Cyperus digitatus* Open Wetland and *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland recorded low grazing capacities that were mainly restricted by the structure and salinity of the soils.

The browsing capacity for the plant communities on Chapungu Ranch varied from negligible for communities such as the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland with a low woody plant density to 12.6 BU/100 ha for the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest. The mean browsing capacity of 8.1 BU/100 ha recorded for Chapungu Ranch was considerably higher than the 4.9 BU/100 ha recorded by Hin (2000). The difference between the two studies could be because the vegetation in the western part of Sango Ranch has a lower browsing capacity than that of the eastern section in which Chapungu falls. It could also possibly be ascribed to increased bush encroachment on the colluvial plains. Additionally, elephant impact on the woody vegetation increased as elephant numbers increased and potentially lowering the available browse to wildlife through structural changes in the woody layer.

Low-selective grazers contributed 12%, high-selective grazers, 9%, mixed feeders 67% and browsers 13% of the total feeding class ratios on Chapungu Ranch (Table 7.3).

7.4 Conclusion

The ecological and economic capacity for Chapungu was estimated using the Grazer Unit/Browser Unit method described by Bothma *et al.* (2004). The BECVOL method described by Smit (1989a & b) was used to estimate the browsing component. The economic capacity in 2003 was 2 435 Grazer Units and 1 169 Browser Units. In 2003, the stocking density (2 199 Grazer Units) was therefore marginally lower than the grazing capacity of Chapungu, however, the number of browsing units (3 029 Browser Units) far exceeded the estimated browsing capacity.

However, stocking density recommendations can only be meaningfully discussed once the entire Sango Ranch is viewed as a unit. This is because of the free movement of animals between properties, especially in an east to west and west to east direction (Chapter 8 & 9).

CHAPTER 8

SURVEY OF THE FAUNA

8.1 Introduction

Managing a wildlife ranch effectively requires a basic knowledge of the dynamics and functioning of the wildlife population (Bothma & Du Toit, 2010). The viability of animal populations in an area is influenced by the age structure, sex ratios, social behaviour and growth potential of the population.

An animal population's growth measured over time generally follows an S-shaped curve although the shape may vary considerably between species and from one area to the next. In a newly established animal population births barely exceed deaths and the population size increases slowly. This initial slow growth phase steadily progresses into the next rapid growth phase until environmental resources become limited. Environmental limitations gradually start to influence the reproduction and survival capacity of a population resulting in slower growth until equilibrium is reached. In reality equilibrium is rarely reached, and if so only for a very brief period. Animal populations generally fluctuate between the environmental limits and are therefore never truly stable. This level of equilibrium is known as the ecological capacity of an area (Bothma & Du Toit, 2010).

The knowledge of the age structure and sex ratios in a given animal population is of particular importance as these may influence reproductive performance. Reproductive success is sensitive to environmental pressures and it reflects the health status and the potential growth of the population (Bothma & Du Toit, 2010).

The objectives of the animal survey on Sango Ranch were:

- to establish an inventory of the animal species occurring on Sango Ranch;
- to gain information on the population status of the large mammals by measuring population size, movement patterns, age structure, sex ratios, birth rates and survival rates.

8.2 Methods

The animal survey was conducted on the entire Sango Ranch, i.e. the four properties (Chapungu, Sabi, Musawezi and Chanurwe ranches) constituting Sango Ranch combined.

Wildlife census and counting techniques can broadly be divided into sampling and non-sampling methods (Collinson, 1985). On Sango both sampling and non-sampling methods were used to determine animal population sizes and spatial distribution patterns.

8.2.1 Aerial surveys

Aerial surveys were used to determine trends in population size, spatial distribution patterns and social organization of large herbivore populations within Sango (Joubert, 1983). This method has been in practice since the mid 1970s and has been successfully applied in extensive conservation areas throughout southern Africa.

A Cessna 206 aircraft was used to conduct the aerial survey. The survey team consisted of a pilot, a scribe and four observers. The observers were divided into teams of two. One team observed on the left-hand side of the aircraft while the other team observed on the right-hand side. The seating arrangement for team members took into account the mass distribution in the aircraft. The experience of the observers was also taken into account with the most experienced observer being assisted by the least experienced observer.

During the survey the observers were in constant communication with each other. The strip width was predetermined at 375 m on each side of the aircraft. To aid defining the boundary of the strip a streamer was fixed to the strut of the aircraft. The streamer was calibrated to markers on the ground when flying at a height of 300 feet above ground level. As the height of the aircraft continually changed the line was used as guidance rather than restricting observers from counting animals outside the line. Once a group of animals was seen, the first observer would call the species followed by the number seen i.e. "zebra 6". The second observer continued to search the area. If the second observer by chance also counted the same herd and counted a higher number of animals he would simply add the animals missed by the first observer. In areas where multiple species were seen specific species were allocated to specific observers who counted those species only.

The entire survey area was divided into predetermined flight paths. The flight paths were all directed in an east-west direction across the width of the survey area with the exception being the parts of the Save River. The Save River flight paths followed a north to south direction following the banks of the Save River. Each flight path was spaced at 750 meter intervals using Map Source© software and the flight paths were then loaded onto a Garmin GPS MAP496. The GPS (Global Positioning system) was connected to a laptop computer with CartaLinx© software and was used to collect real-time data during the ecological aerial survey (Viljoen & Retief, 1994). All animals seen during the flight were recorded and plotted into CartaLinx©. At the end of each survey flight, the data collected were exported to Microsoft Excel for analysis. The actual flight path, ground speed and height above sea level were recorded every 100 m by the GPS.

Environmental conditions such as temperature, cloud cover, haziness, wind strength and direction were recorded prior to and after each survey flight. The start and finish time for each survey flight was also recorded. Temperature was measured by means of a temperature gauge in the aircraft at ground level. Wind direction and strength were estimated from a standard windsock at the landing strip. A subjective estimate was made for cloud cover and haziness prior to and after each survey flight.

During survey flights observers were required to inform the scribe of the following sightings:

- all animals (wild and domestic) seen with the number of individuals in each group;
- eagle and vulture nests;
- ground hornbill and secretary birds;
- carcasses;
- surface water excluding flowing rivers and reservoirs; and
- fires and/or burnt areas.

To improve the accuracy for the African buffalo population, all large African buffalo herds were photographed with an Olympus C740 digital camera and counted (Figure 8.1). The photographs were imported into Photohouse©software, and the African buffalo counted by marking each individual buffalo with a white dot. All large herds of African elephant and Livingston's eland were circled and recounted to ensure better accuracy of the estimates.

Figure 8.1: Photograph showing an African buffalo herd and the counting method (insert).

All carcasses seen during the survey were classified into the following categories:

a) fresh carcasses (estimated to be less than two days old),
b) week old/open carcasses (estimated to be three to fourteen days old),
c) old carcasses (estimated to be more than fourteen days old).

A distinction was made between African elephant, giraffe and 'other' carcasses. The latter included all species larger than and including an adult kudu.

8.2.2 Road strip counts

The road strip count method was similar to that described by Bothma and Du Toit (2010) and Mason (1990). Five fixed routes were used that included all major plant communities within Sango Ranch. The travelling speed was maintained between 10 to 20 km/h. The surveys took 10 days to complete with each route surveyed three times. Once a route has been selected the route is driven once in the morning and then again in the afternoon following the same direction. The next morning the route is driven in the reverse direction during the morning only. A team of four people, consisting of a driver, a recorder and two observers, were used. An infrared range finder was used at 500 m intervals to determine the visibility within each plant community.

All animals as well as ground hornbill and game birds seen along the routes were recorded. Based on the mean visibility in a habitat type a fixed strip width was established for each habitat type. An infrared range finder was used to determine the strip width during the survey.

The following equation was used to estimate population size (Bothma & Du Toit, 2010):

$$N = \frac{nH}{h}$$

Where:

N = population estimate

H = total surface area of the study site (ha)

n = total number of animals counted

h = total sampling surface area (ha).

8.2.3 Grid square method

The grid square method was developed and introduced on Sango Ranch in 2000 and was designed for determining animal distribution over the medium to long-term but also to determine animal population trends (Joubert, 2001). The grid square method is based on a grid net of 1 km^2 overlain onto the Sango topographical map with each square or "grid block" given a grid code (Appendix IIIa). Game scouts were issued with patrol data sheets that were filled in during each anti-poaching patrol (Appendix IIIb).

All animal species seen by the game scouts were recorded by number and per grid square, for example "impala 15 in grid S31". Patrol sheets were collected on a monthly basis and captured into an Access©

database for analysis. The results were exported to ESRI ® ArcMap ™ 10 (License ArcView) to create the distribution maps.

Distribution maps were created for each species by plotting the relative density value for each grid on the Sango map. The relative density values were calculated over a period of 10 years. The relative density for each grid square was calculated as:

$$Rd = \sum \frac{x}{e}$$

Where:

Rd	= relative density per species per grid
x	= sum total of animals seen per species per grid
e	= total patrol effort per grid.

Total effort per grid refers to the sum total of patrols entering a grid during the entire survey period.

Annual population trend data were determined using sighting frequency and the mean relative population density per species. Sighting frequency was calculated as:

$$Sf = \sum \frac{N}{Te}$$

Where:

Sf	= sighting frequency
N	= total number of sightings per species
Te	= total patrol effort.

The total patrol effort (*Te*) refers to the sum total of grids patrolled per annum.

The mean relative population density was determined by:

$$Rpd = \sum \frac{X}{Te}$$

Where:

Rpd	= relative population density
X	= total of animals seen per species
Te	= total patrol effort

8.2.4 Known group counts

Nyala, hippopotamus and wild dog were also counted using the known group count method (Collinson, 1985). The nyala and hippopotamus groups were identified and were known by the number of groups and individuals in each group. Wild dog population estimates were determined using individual photographs to identify each individual within the group.

8.2.5 Line transect

Line transect counts (Collinson, 1985) were conducted in 2004 and 2005 to determine population estimates for bushbuck and bushpig. The line transects were set in the preferred habitat types for bushbuck and included the plant communities associated with the major rivers on Sango Ranch. Four scouts were spaced at 50 m intervals and moved along a predetermined line transect along the rivers. Three transects that varied in distance were used to complete the survey. The total length of the three line transects was 32.6 km long and the strip width maintained at 250 m. Each transect was repeated three times which covered a total surface area of 24.5 km^2. All bushbuck and bushpig seen within the strip were counted. A density was calculated using the following equation:

$$N = \frac{nH}{h}$$

Where:

N = population estimate
H = total surface area of the study site (ha)
n = total number of animals counted
h = total sampling area (ha)

The line transects were all within in the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest and the *Xanthocercis zambesiaca – Acacia tortilis* Closed Woodland plant communities and the total population size was determined by multiplying the animal density with the size of these two vegetation types.

8.2.6 Spoor counts

Large carnivores were counted using the spoor survey method described by Stander (1998). The spoor survey method is based on the strong correlation between spoor density and true population density

(Stander, 1998). The technique is considered to produce reliable estimates for lions, spotted hyaena, wild dogs and leopards (Davidson & Romanach, 2007).

Spoor surveys were conducted in October during the hot, dry season of each year. The survey team consisted of three people that included a driver and scribe and two trackers. A tracker was placed on the front bumper towards the left side of the vehicle whilst a second tracker scanned for spoor on the side of the driver. Travelling speed was maintained below 20 km/h. Once spoor was detected of a large carnivore the type of species, the number of individuals, the location, the direction of the spoor and the road surface conditions were recorded. The sex and age was recorded for lion and leopard.

The total transect distance was predetermined with the penetration value of 5.2. The penetration value was determined by dividing the total surface area of the ranch by the sum of the transect lengths. The total distance travelled was 194.5 km for each year.

The data were then used to determine total population sizes for the large carnivores on Sango.

The equation used to estimate population size for lion, hyena and wild dog was:

$$Pe = 0.69x$$

and for leopard:

$$Pe = 0.5263x$$

Where:

Pe = Population estimate

x = number of spoor seen per 100 km

8.2.7 Midden assessment

Activity-abundance and distribution data for hyaena and civet were gathered using faecal counts at middens along the roads on Sango Ranch. An activity-abundance scale was calculated according to the freshness and the number of faeces at each midden.

Middens were classed according to size and scored along the following criteria:

- Score 1: Single dropping
- Score 2: Small, i.e. 2 to 5 droppings
- Score 3: Medium, i.e. 6 to 10 droppings for hyaena and 0.5 to 1 m wide for civet
- Score 4: Large, i.e. 11 to 15 droppings for hyaena and a diameter of 1 to 2 m for civet
- Score 5: Very large, i.e. >15 droppings for hyaena and a diameter > 2 m for civet.

The freshness was classed and scored according to the most recent faeces in the midden. Faeces freshness was subjectively scored using the following criteria:

- Score 1: Very old, i.e. faeces older than two weeks (>14 days).
- Score 2: Old, i.e. faeces >7 to 14 days old
- Score 3: Recent, i.e. faeces >4 to 7 days old
- Score 4: Fresh, i.e. faeces 12 to 48 hours old
- Score 5: Very fresh, i.e. faeces < 12 hours old.

8.2.8 Random encounters

Animal species infrequently or randomly seen on Sango were also recorded. Data records for these species were not sufficient or encounters were too irregular to estimate population size or establish reliable trends and distributions.

8.2.9 Herd structure assessments

The sex ratios and age structure of the more abundant herbivore populations were determined during the lambing/calving season by recording all animals seen on predetermined days for the period December to April of each year. Records were kept on the group size, sex and the age of the individuals. Four age categories were recognised: (a) adult male, (b) adult female, (c) subadult which included only yearlings, and (d) juveniles which included the off-spring only for that particular season. Although all species seen were counted and classed into their respective categories only species encountered 30 times or more were analysed.

8.2.10 Animal population trends

Logistic regressions were used to establish the stage of an animal population on the sigmoidal population growth curve. Additionally, a third order polynomial regression was fitted to each data set. Polynomial regressions were used to support the findings of the logistic regression, but also to achieve a better understanding of the trend pathway for each of the animal populations. All curve-fitting was performed in GraphPad Prism (GraphPad Prism 6.1, GraphPad Software Inc.).

The status of an animal population in terms of its ecological capacity was then grouped into three main categories, namely

- animal populations at ecological equilibrium prior to the implementation of the monitoring program i.e. before 1998 (Category 1),
- animal populations that reached ecological equilibrium after the implementation of the monitoring program i.e. 1998 to 2011 (Category 2), and
- animal populations that have not yet reached ecological equilibrium (Category 3).

Logistic regressions were fitted to the animal data sets obtained from aerial surveys and the grid square method. A correlation coefficient was determined for each logistic regression and tested for significance at a 95% confidence interval. A third order polynomial regression was also fitted to the data sets and its correlation coefficient recorded. Animal populations were classed into the above three categories based on the following criteria.

- Category 1: A logistic regression could not be fitted to the data or when fitted the correlation coefficient was insignificant. A subjective visual assessment of the logistic regression and the 3rd order polynomial regression did not indicate a sigmoidal shaped growth curve;
- Category 2: A logistic regression fitted to the data set indicated a sigmoidal population growth curve and the correlation coefficient tested significant at a 95% confidence interval. A subjective visual assessment resulting in an sigmoidal curve whereby the growth rate reached a plateau after a rapid growth phase and the correlation coefficient was accepted by a two-tail hypothesis test;
- Category 3: A logistic regression fitted to the data sets indicated an upward curve associated with rapidly growing animal populations and the correlation coefficient tested significantly at a 95% confidence interval. A subjective visual assessment of the logistic regression and the 3rd order polynomial regression confirmed the upward trend and a correlation coefficient that tested significant at a 95% confidence interval.

8.3.11 Mapping animal distribution

All maps were created in ESRI ® ArcMap ™ 10 (License ArcView) software. Animal distribution maps were produced for the larger herbivores using real time aerial survey data recorded for Sango Ranch since 2002. Real time data was created in CartaLinx 1.2 (© ClarkLabs) by connecting a Garmin GPS to a laptop computer. CartaLinx data files were then imported into ArcMap to create the maps. Group size categories were created for each species prior to the 2002 aerial survey. Aerial surveys were conducted in September of each year.

The grid square method provided distribution maps over a ten-year monitoring period. All animal data were collected and entered into a Microsoft Access data base program. Animal data sets were exported from Access into Idrisi Taiga 16.05 (© ClarkLabs) for data management. Files were exported to ArcMap for basic spatial analysis, where sighting frequency and relative density estimates were calculated for each grid. The files were returned to Idrisi Taiga for raster development, with final presentation in ArcMap. The grid square method indicated animal population distributions throughout the year as opposed to aerial surveys which only provided distribution data for the dry season.

Additionally the spatial analysis of animal distributions in ArcMap also allowed for the temporal analysis of habitat selection by each species. A habitat selection table was created using the relative density estimates per species for each 1 km^2 grid covering Sango Ranch. These grids were then superimposed onto each of the seven vegetation units to calculated animal presence within each vegetation unit.

8.3.12 Estimating the habitat characteristics

The habitat characteristics used the medium term mean calculated for each habitat characteristic over an 11 year monitoring period. Since 2000 the vegetation monitoring was conducted at fixed locations during the dry and wet season of each year, mainly to describe the herbaceous layer. The characteristics for the woody layer were described using the mean value derived by the BECVOL method conducted at each of the fixed vegetation plots in 1998, 2003 and 2008.

The geology and soil information was derived from the studies conducted by Hin (2000) and the current assessment of Chapungu Ranch. The veld condition index was calculated using the results obtained from the step-point method whilst the disc pasture meter method was used to calculate the herbaceous biomass (Chapter 5). For descriptive purposes the values of the veld condition index were grouped into the following six point rating scale: very poor < 15%, poor 15 – 30%; moderate > 30 – 45%; good > 45 – 60%; very good > 60 – 80%; excellent > 80.0%. Herbaceous biomass was classified as: very low < 200 kg/ha; low 200 – 400 kg/ha; moderate > 400 – 700 kg/ha, moderately high > 700 – 1000 kg/ha, high > 1000 – 1500 kg/ha; abundant >1500 kg/ha. Herbaceous cover, grass length, graze pressure index and browse pressure index were calculated from predetermined rating scales or classes that were subjectively assessed at each fixed vegetation plot over a 10 year monitoring period.

Herbaceous cover was described by tossing a 1 m^2 grid randomly 15 times at each fixed vegetation monitoring plot. A subjective assessment then classed the herbaceous cover into the following cover classes: no cover < 1%; very sparse cover 1 – 5%; sparse cover 6 – 10%; moderately sparse cover 11 – 20%; moderate 21 – 40%; moderately good cover 41 – 60%; good cover 61 -80% and abundant cover> 81%

Grass length was classified using the following height classes: very short < 5 cm; medium short 6 – 10 cm; short 11 – 25 cm; short medium 25 – 40 cm; medium 40 – 60 cm; medium long 60 – 80 cm; tall 80 – 100cm; medium tall 100 – 150 cm; very tall > 150 cm.

Grazing pressure was classed into a six point rating scale: slight < 5%; low 5 – 25%; moderate > 25% - 40%; heavy > 40 – 60%; severe > 60 – 75%; extremely severe > 75.0%. A grazing pressure gradient was calculated plotting the mean value for each management unit derived from the rating scale using standard regression analysis and converting it into a percentage. The browsing pressure index was calculated on the same basis as the grazing pressure index using a five point rating scale as follows: no browse < 10%; slight 10 – 25%; moderate > 25 – 40%; conspicuous > 40% - 60%; severe > 60%.

8.3 Results and Discussion

An inventory list of all mammal species recorded on Sango Ranch since 1998 is presented in Appendix IV. The results from the various survey techniques used to establish population size and distribution are presented in section 8.3 for each species. The results were obtained from 14 aerial surveys covering the entire Sango Ranch, 246 718 scout data entries with a patrol effort covering 211 440 km^2, two line transect counts covering 24.5 km^2, three road strip counts, four spoor survey counts with a penetration value of 5.2, one faecal depository count and 12 herd structure assessments conducted over the past 14 years.

The results are presented in three broad categories. The first category deals with the results obtained for all the herbivore species on Sango Ranch. The second section provides the population size estimates and distribution for all carnivores and the third section presents the results for the primate species and some other potential indicator species such as ground hornbill and game birds such as guinea fowl.

Since there is a positive relationship between the annual rainfall and vegetation biomass production (O'Connor, 1993; O'Connor, 1994; Weber *et al.,* 1998; Shoshany *et al.*, 2000; Wei-Quang Li *et al.*, 2008) animal distribution patterns could also be affected by rainfall patterns. Figure 8.2 illustrates the 3-year moving average for rainfall received from 2000 to 2011. The figure clearly demonstrates the decrease in rainfall since the inception of the monitoring program in 1998. This decreased rainfall should be taken into consideration when interpreting animal movements in relation to forage availability.

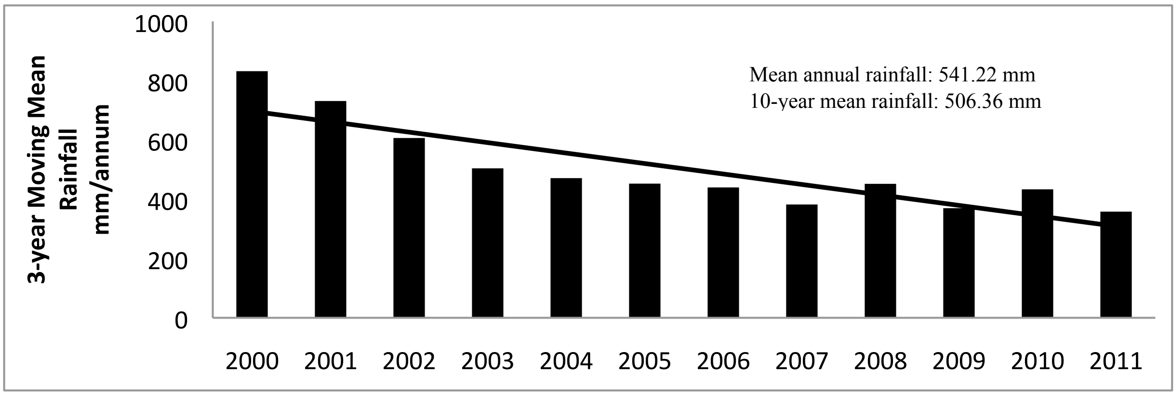


Figure 8.2: The 3-year moving average rainfall received since the first aerial survey in 1998, the mean rainfall for the past 87 years and the mean rainfall since 1998.

Table 8.1: Annual rainfall recorded for Sango Ranch since 1998 indicating the wet (green), moderate (orange) and dry rainfall years (red)

	Annual Rainfall on Sango Ranch (mean rainfall: 541mm)													
Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Rainfall	845	715	936	543	341	629	444	285	590	272	494	344	462	269

Figure 8.2 and Table 8.1 were used to interpret the distribution of animals within Sango Ranch. Three colour schemes were used to separate rainfall seasons into wet years (green), moderate rainfall years (orange) and dry years (red). The criteria used to group each year into a rainfall season were:

- wet years - annual rainfall received > 690 mm
- moderate rainfall years - annual rainfall received ranged from 390 mm to 690 mm
- dry years - annual rainfall received < 390 mm.

Table 8.2 gives a summary of the characteristics of the seven management units identified on Sango Ranch. The table gives an indication of the major geological formations, the soils, the quality and quantity of the herbaceous layer, the woody plant cover, density and browse availability and the grazing and browsing pressures measured over a ten year vegetation monitoring period.

8.3.1 Herbivores

Aerial survey results from 1998 to 2011 are presented for the large herbivore species counted on Sango Ranch and exclude all the "cryptic" herbivore species (Table 8.3). "Cryptic" herbivore species are animal species that are not easily seen from the air due to their colouration, size or habits. The results of the aerial surveys were used to establish population growth curves and to map distribution patterns since 2002.

Population trend information based on sighting frequency and relative density were calculated from the grid square method and presented for all herbivores. Additionally, line-transect counts for bushbuck in 2004 and 2005 and the road strip counts in 2011 are presented for the large herbivore species in Table 8.4. Table 8.5 provides an indication of habitat selection for each animal species, except for the large carnivores.

Table 8.2: Characteristics of the management units on Sango Ranch, Save Valley Conservancy

Management Unit		*Combretum apiculatum* Woodland Management Unit	*Kirkia acuminata* Woodland Management Unit	*Colophospermum mopane* Closed Woodland Management Unit	*Acacia tortilis* Open Woodland Management Unit	*Xanthocercis zambesiaca* Closed Woodland Management Unit	*Diospyros mespiliformes* Riverine Management Unit	*Echinochloa colona* Wetland Management Unit
Geological feature		Granite & Gneiss	Basalt & Sandstone	Alluvium & Sandstone	Colluvium & Alluvium	Alluvium	Alluvium	Alluvium
Soil	Order	Amorphic/ Kaolinitic/ Calcimorphic	Amorphic/ Calcimorphic	Calcimorphic	Calcimorphic	Calcimorphic	Calcimorphic	Calcimorphic
	Group	Lithosol/ Fersiallitic/Siallitic	Lithosol/ Siallitic	Siallitic	Siallitic	Siallitic	Siallitic	Siallitic
	Family	2G/4PE/5G	2B/4S/4U	4S/4U	4M	4U	4U	4U
	Texture	Sandy loam	Sandy loam to sandy clay	Sandy loan to sandy clay	Sandy loan to loamy sand	Sandy loam	Sandy loam	Sandy clay
Veld Condition Index		Very good	Good	Moderate	Good	Good	Good	Good
Graze pressure index (%) (y=17.679x - 30)	Dry Season	Moderate	Heavy	Heavy	Heavy	Heavy	Moderate	Severe
	Wet season	Low	Moderate	Low	Heavy	Moderate	Slight	Heavy
Herbaceous canopy cover (%)	Dry Season	Moderate	Moderate	Moderately sparse	Moderately sparse	Moderately sparse	Moderately sparse	Moderate
	Wet season	Moderately good	Moderate	Moderate	Moderate	Moderate	Moderately good	Moderate
Grass length (cm)	Dry Season	Short medium	Short	Short	Short	Short	Short medium	Short medium
	Wet season	Medium long	Medium	Medium	Medium	Medium	Medium long	Medium long
Herbaceous Biomass (kg/ha)	Dry season	Moderately high	Low	Low	Low	Moderate	Moderate	Moderate
	Wet season	Abundant	High	Moderate	Moderately high	Moderately high	High	High
Woody plant canopy cover (%)	Total cover	Closed woodland	Mixed open & closed woodland	Closed woodland	Open woodland	Closed woodland	Forest	Grassland
	Tree cover	17.7	28.7	34.0	6.0	34.0	54.3	5.3
	Shrub cover	15.1	19.2	24.0	7.0	19.2	48.9	0.5
Woody plant density (plants/ha)		2 541	1 912	3 280	882	1 101	3 659	310
Available Browse (kg/ha)	Height Class 0 - < 2m	361	423	457	275	291	632	4
	Height Class 0 - <5m	1 025	1 257	1 725	1 028	963	1 926	40
Browse pressure index (%)	Dry Season	Slight	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
	Wet season	No browse	No browse	No browse	Moderate	Moderate	No browse	No browse

Table 8.3: Aerial survey results for 14 consecutive counts of the large herbivores on Sango Ranch (1998-2011), Save Valley Conservancy

Species	Year													
	1998*	1999*	2000*	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
African buffalo	0	0	0	201	348	135	325	107	193	356	225	770	781	948
African elephant	119	101	74	52	164	235	327	392	392	192	573	654	462	525
Baboon troops	0	10	8	11	11	9	26	37	32	26	21	36	33	34
Black rhinoceros	0	4	0	0	5	9	11	10	14	17	15	9	14	15
Blue wildebeest	294	360	518	695	901	1447	2429	1451	2260	2343	2581	2462	2450	2377
Burchell’s zebra	433	659	610	582	659	1323	2214	1077	1908	1938	1315	1351	828	896
Livingston’s eland	226	468	659	495	392	1045	1191	1004	698	673	756	624	481	835
Giraffe	68	128	75	103	141	149	258	258	287	238	233	311	365	422
Greater kudu	404	443	470	536	868	980	1026	596	365	395	311	197	194	312
Impala	1483	1221	1774	1890	2029	5633	5945	4604	4741	3236	3366	2720	3802	4705
Sable antelope	0	27	28	40	32	34	60	70	101	77	121	28	48	42
Warthog	77	128	280	369	581	1034	2009	824	647	680	442	199	285	289
Waterbuck	2	35	37	106	77	260	372	278	285	218	245	120	89	261
White rhinoceros	0	1	1	0	0	0	0	3	26	11	14	21	11	12

* Values adapted to include Chapungu Ranch and exclude Umkondo Ranch

Table 8.4: Results for the 2011 road strip count on Sango Ranch, Save Valley Conservancy

Species	Population Estimates			Mean Population Estimate	STD*	Confidence Limit	
	Repetition I	Repetition II	Repetition III			Lower	Upper
African buffalo	2561	3537	1585	2561	976.10	1457	3666
African elephant	352	546	146	348	200.16	121	574
Baboon	2358	2287	2861	2502	312.97	2147	2856
Banded mongoose	481	718	0	400	365.81	0	814
Black rhinoceros	16	9	23	16	7.07	8	24
Blue wildebeest	3837	5644	4216	4565	952.91	3487	5644
Burchell's zebra	3130	4167	2626	3308	785.53	2419	4197
Bushbuck	32	0	0	11	18.34	0	31
Bushpig	76	0	64	47	40.85	0	93
Common duiker	14	29	0	14	14.38	0	31
Crested francolin	217	107	352	225	122.81	86	364
Dwarf mongoose	194	373	14	194	179.63	0	397
Livingston's eland	545	3347	781	1558	1553.95	0	3316
Giraffe	1523	2200	1952	1892	342.39	1504	2279
Greater kudu	506	738	338	527	200.66	300	754
Ground hornbill	196	173	195	188	13.25	173	203
Guinea fowl	6564	10078	6952	7865	1926.28	5685	10045
Hyrax	2223	2433	2013	2223	210.05	1986	2461
Impala	21450	22354	23533	22446	1044.42	21264	23628
Jackal	43	141	72	85	50.54	28	142
Klipspringer	64	128	0	64	64.11	0	137
Leopard	14	54	0	23	28.06	0	55
Natal francolin	269	27	55	117	132.81	0	267
Nyala	14	28	0	14	14.14	0	30
Red-crested Korhaan	9	22	9	13	7.34	5	21
Sable antelope	14	29	0	14	14.38	0	31
Sharpe's grysbok	21	29	14	21	7.31	13	30
Slender mongoose	30	50	22	34	14.84	17	51
Vervet monkey	178	76	0	85	89.25	0	186
Warthog	1473	2341	1088	1634	641.40	908	2360
Waterbuck	0	0	0	0	0.00		

*Standard deviation

Table 8.5: Animal habitat selection within Sango Ranch, Save Valley Conservancy, expressed as a percentage of the relative mean density

Species	Season	Habitat selection (%)						
		Combretum apiculatum Woodland Management Unit	*Kirkia acuminata* Woodland Management Unit	*Colophospermum mopane* Closed Woodland Management Unit	*Acacia tortilis* Open Woodland Management Unit	*Xanthocercis zambesiaca* Closed Woodland Management Unit	*Diospyros mespiliformes* Riverine Management Unit	*Echinochloa colona* Wetland Management Unit
Baboon	Dry	8.2	6.8	10.1	8.9	14.2	35.9	16.0
	Wet	10.8	7.7	11.2	10.7	15.9	29.8	14.0
Black rhinoceros	Dry	41.1	7.7	12.2	13.0	6.9	13.0	6.1
	Wet	35.0	7.5	8.9	11.1	7.5	11.8	18.2
Buffalo, African	Dry	40.2	0.7	6.6	11.9	6.4	17.3	16.9
	Wet	22.2	2.6	12.9	16.3	13.6	17.0	15.3
Bushbuck	Dry	12.4	0.4	6.6	5.5	10.1	50.8	14.3
	Wet	12.0	0.7	9.1	7.5	14.4	45.1	11.2
Bushpig	Dry	3.4	0.6	2.8	2.3	4.6	80.7	5.7
	Wet	12.2	2.6	10.0	8.9	14.6	32.5	19.2
Duiker, Common	Dry	28.3	12.0	12.8	12.8	8.6	16.7	8.8
	Wet	19.4	14.5	19.8	14.9	9.3	10.1	12.1
Eland, Livingston’s	Dry	13.7	8.2	11.3	14.1	13.0	15.3	24.4
	Wet	18.2	8.9	14.8	15.5	16.0	16.0	10.6
Elephant, African	Dry	5.8	4.4	11.6	9.1	11.9	39.6	17.7
	Wet	8.5	1.6	12.4	11.6	17.8	24.7	23.4
Giraffe	Dry	12.8	14.2	11.8	14.5	19.7	13.9	13.0
	Wet	11.7	16.7	14.8	16.2	18.6	12.7	9.4
Hippopotamus	Dry	0.0	0.0	12.4	2.9	4.9	74.2	5.6
	Wet	0.9	0.0	15.9	5.0	9.5	61.8	6.8
Impala	Dry	9.4	6.3	9.5	10.6	17.1	24.1	23.1
	Wet	10.9	8.9	10.9	13.2	17.6	19.4	19.2
Klipspringer	Dry	83.3	0.0	2.5	3.5	0.0	10.7	0.0
	Wet	59.7	0.0	4.8	4.8	3.8	11.3	15.6
Greater kudu	Dry	13.5	3.6	7.8	8.4	13.6	34.3	18.7
	Wet	16.5	6.1	11.4	11.6	15.2	23.7	15.6
Vervet monkey	Dry	3.2	1.8	10.3	6.8	12.7	51.1	14.0
	Wet	4.3	2.2	11.0	7.7	17.5	44.5	12.7
Nyala	Dry	54.7	0.0	6.5	8.6	2.9	25.2	2.2
	Wet	53.1	0.0	6.3	10.9	1.6	21.9	6.3
Sable antelope	Dry	72.6	0.3	2.4	9.6	0.0	15.1	0.0
	Wet	74.8	0.0	2.3	8.5	0.0	14.4	0.0
Sharpe's grysbok	Dry	68.0	1.0	3.1	9.3	3.1	15.5	0.0
	Wet	50.7	3.0	6.0	6.0	7.5	11.9	14.9
Warthog	Dry	10.2	7.9	10.1	10.5	14.0	26.8	20.5
	Wet	13.2	8.0	10.9	11.3	15.5	22.2	18.8
Waterbuck	Dry	9.2	0.3	4.9	5.4	11.5	48.0	20.6
	Wet	11.5	0.6	6.0	7.9	14.0	38.0	22.0
White rhinoceros	Dry	43.5	10.9	7.5	11.6	8.2	12.9	5.4
	Wet	25.9	6.1	11.7	14.2	15.2	14.2	12.7
Wildebeest, Blue	Dry	15.9	9.1	11.0	13.4	13.0	17.2	20.4
	Wet	11.0	12.4	13.5	15.1	17.4	14.9	15.5
Zebra, Burchell's	Dry	17.6	8.3	10.7	13.0	15.2	15.4	19.9
	Wet	13.5	9.1	14.2	16.4	17.0	14.8	14.9

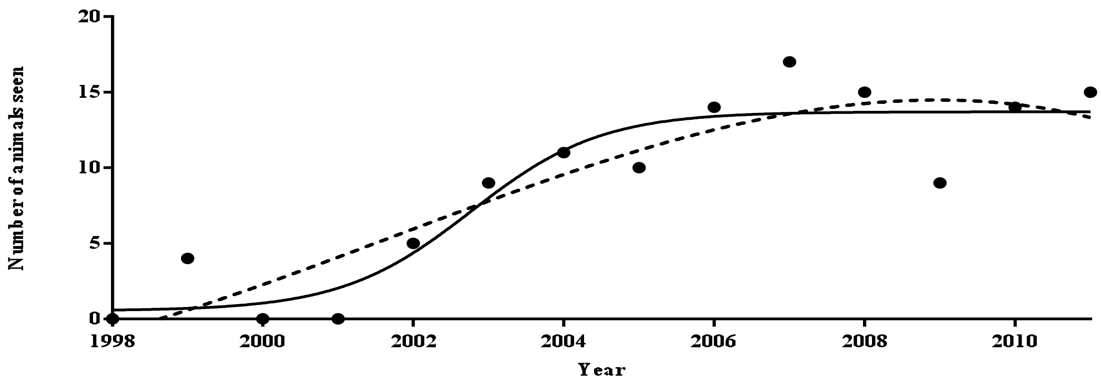
8.3.1.1 Black rhinoceros (*Diceros bicornis*)

Table 8.3 gives the aerial survey results for black rhinoceros. No black rhinoceroses were seen during the 1998 aerial survey, whilst 15 animals were seen during the 2011 aerial survey. The highest number of black rhinoceros was counted during the 2007 aerial survey when 17 animals were seen. The road strip count results for 1998 also failed to record any black rhinoceros (Hin, 2000), whilst a mean population estimate of 16 animals was recorded during the 2011 road strip count (Table 8.4). The logistic regression for the aerial survey suggested that the black rhinoceros numbers increased consistently since 1998 up until 2006 when the population growth curve levelled off (Figure 8.3a). The logistic regression for black rhinoceros followed the typical S-curve (Figure 8.3a) associated with growing animal populations (Bothma & Du Toit, 2010).

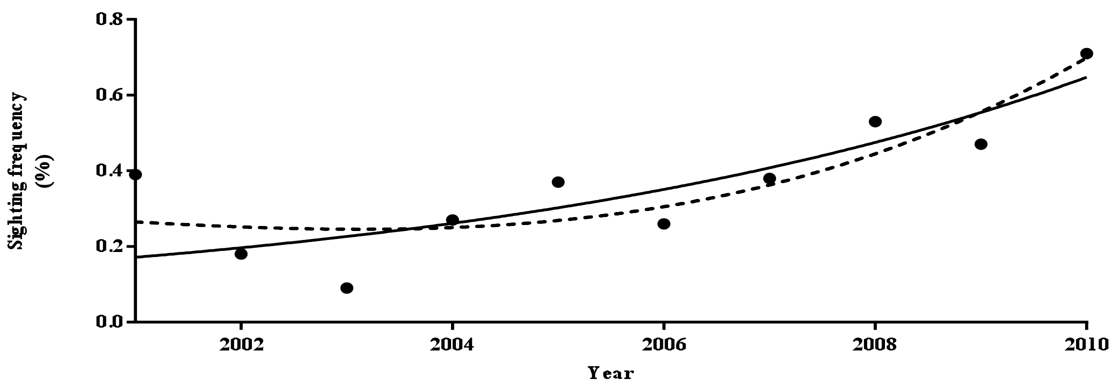
However the logistic regressions calculated using the sighting frequency data (Figure 8.3b) and the relative density data (Figure 8.3c) from the grid square method indicated that the black rhinoceros population on Sango Ranch was still increasing. A subjective assessment of all three graphs suggests that the black rhinoceros population has not yet reached ecological capacity on Sango Ranch, and that the levelling-off seen in the aerial survey data was possibly due to movement onto neighbouring properties during the late dry season.

The highest black rhinoceros density was recorded in the *Combretum apiculatum* Woodland Management Unit towards the west of Sango, but sightings of black rhinoceros were also regularly recorded in the *Kirkia acuminata* Woodland during the dry season and the *Colophospermum mopane* Woodland Management Unit on Chapungu Ranch and the *Colophospermum mopane* Woodland Management Unit towards the southern and southeastern boundary of Sango Ranch. Black rhinoceros were also regularly seen in the *Diospyros mespiliformis* Riverine, the *Acacia tortilis* Closed Woodland and in the vicinity of the *Echinochloa colona* Wetland Management Units (Figures 8.3d & 8.3e).

a.



b.



c.

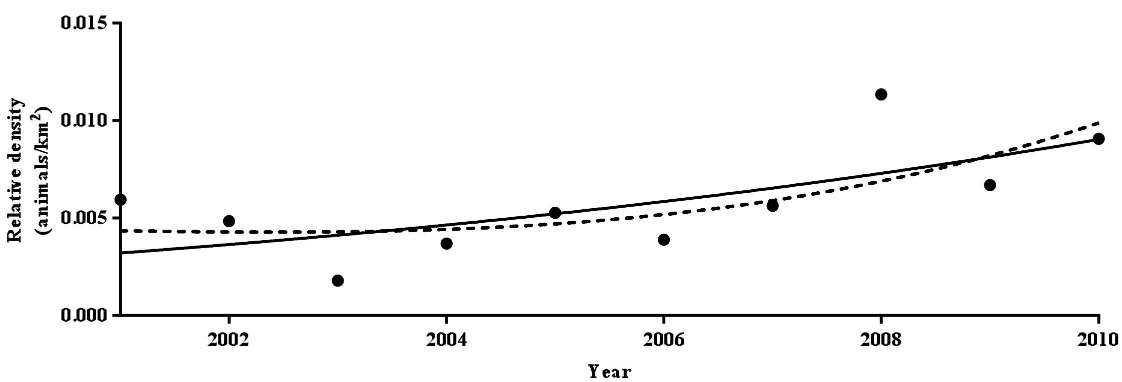


Figure 8.3a-c: Population trends for black rhinoceros on Sango Ranch, Save Valley Conservancy. (a) Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0002; - - - p = 0.0001; (b) —— p = 0.0171; - - - p = 0.0028; (c) —— p = 0.0825; - - - p = 0.0102.

Figure 8.3d: Distribution of black rhinoceros on Sango Ranch from aerial surveys conducted since 2002.

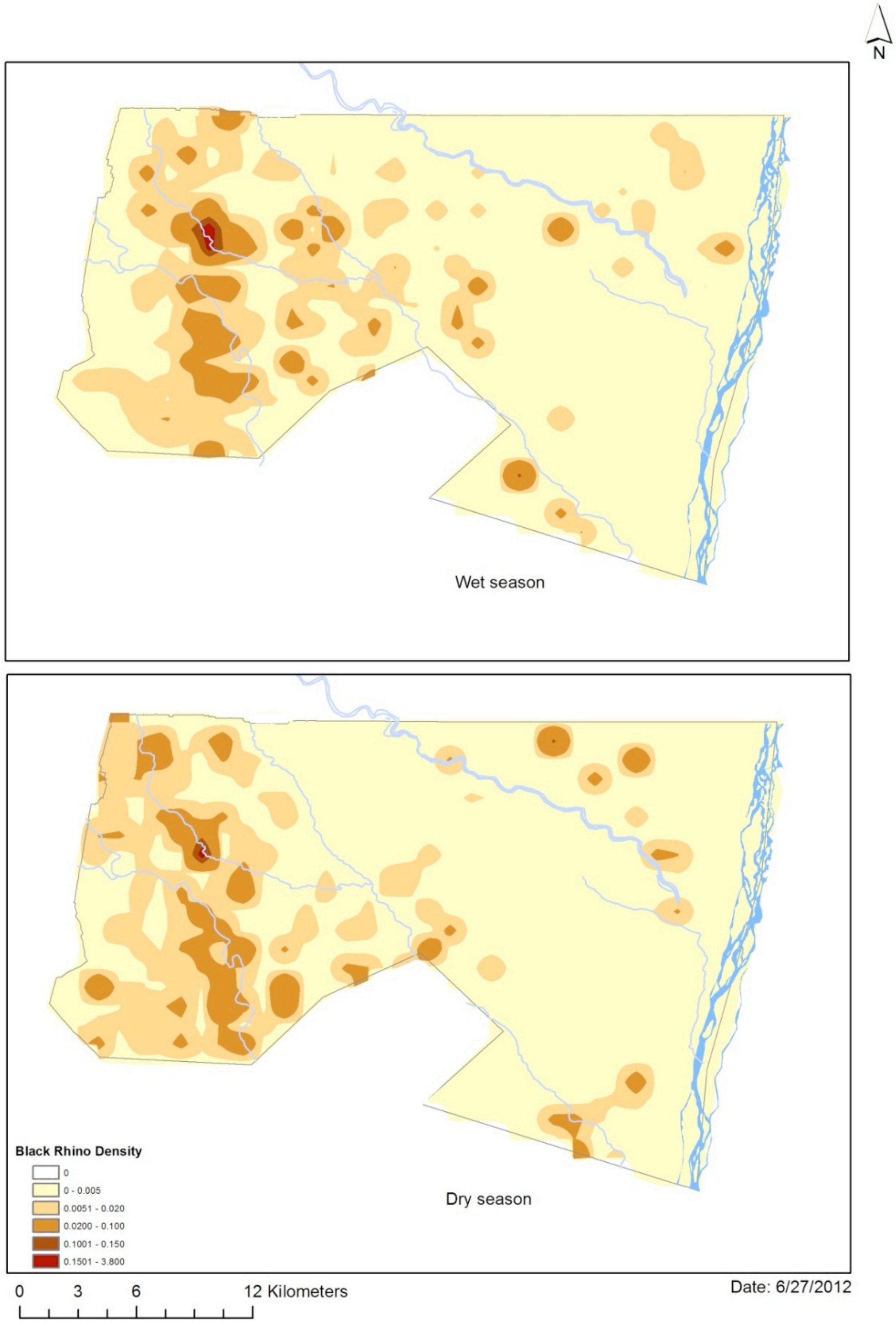


Figure 8.3e: Relative density (animals/km^2) distribution of black rhinoceros on Sango Ranch derived from the grid square method (2001 – 2010).

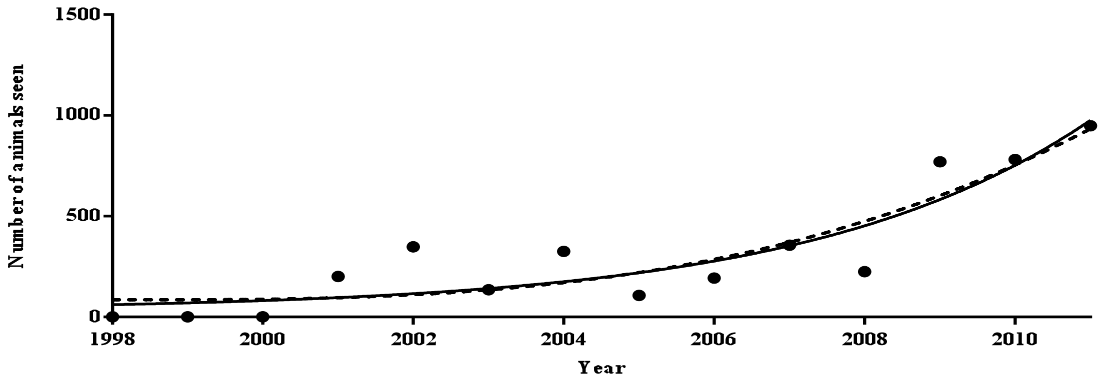
8.3.1.2 African buffalo (*Syncerus caffer*)

No African buffalo were seen during the first three aerial surveys, whilst the highest number of 948 African buffalo was counted during the 2011 aerial survey (Table 8.3). Considerable fluctuations between years were evident, but the general trend indicated that the population was still increasing (Figure 8.4a). The 1998 road strip count (Hin, 2000) also did not record any African buffalo whilst the 2011 road strip count estimated the African buffalo population at 2 561 animals (Table 8.4). The latter population estimate, although likely to be an overestimate, also supported an increase in the population size.

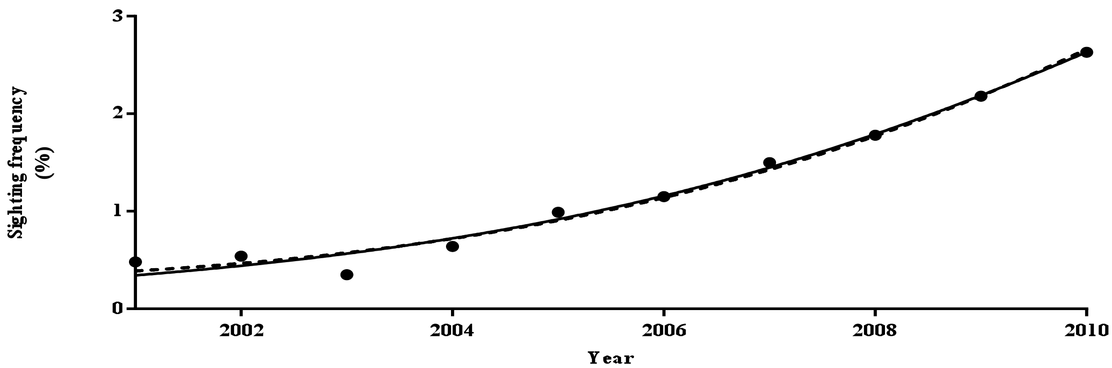
African buffalo population trend data based on the aerial survey results (Figure 8.4a), the sighting frequency (Figure 8.4b) and the relative density estimates (Figure 8.4c) suggest that the African buffalo population was still increasing and has not reached the ecological capacity on Sango Ranch.

The highest density of African buffalo was recorded in the *Combretum apiculatum* Woodland Management Unit (Figure 8.4d & 8.4e, Table 8.5). However, during the wet seasons African buffalo herds were also regularly present in the *Kirkia acuminata* Woodland Management Unit. The 2011 aerial survey also recorded African buffalo herds in the Save River in the *Diospyros mespiliformis* Riverine Management Unit. African buffalo also regularly utilised the *Acacia tortilis* Open Woodland Management Unit especially during the wet season. The grid square method recorded high African buffalo presence in and around the *Echinochloa colona* Wetland Management Unit during the dry season especially in the vicinity of Suni pan (Figure 8.4e).

a.



b.



c.

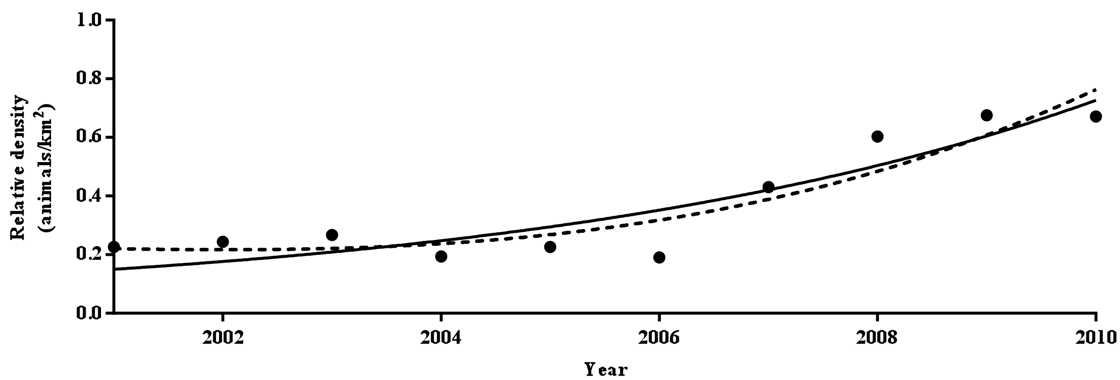


Figure 8.4a-c: Population trends for African buffalo on Sango Ranch, Save Valley Conservancy. (a) Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p = 0.0003$; - - - $p = 0.0013$; (b) —— $p < 0.0001$; - - - $p < 0.0001$; (c) —— $p = 0.0026$; - - - $p = 0.0005$.

Figure 8.4d: Distribution of African buffalo on Sango Ranch from aerial surveys conducted since 2002.

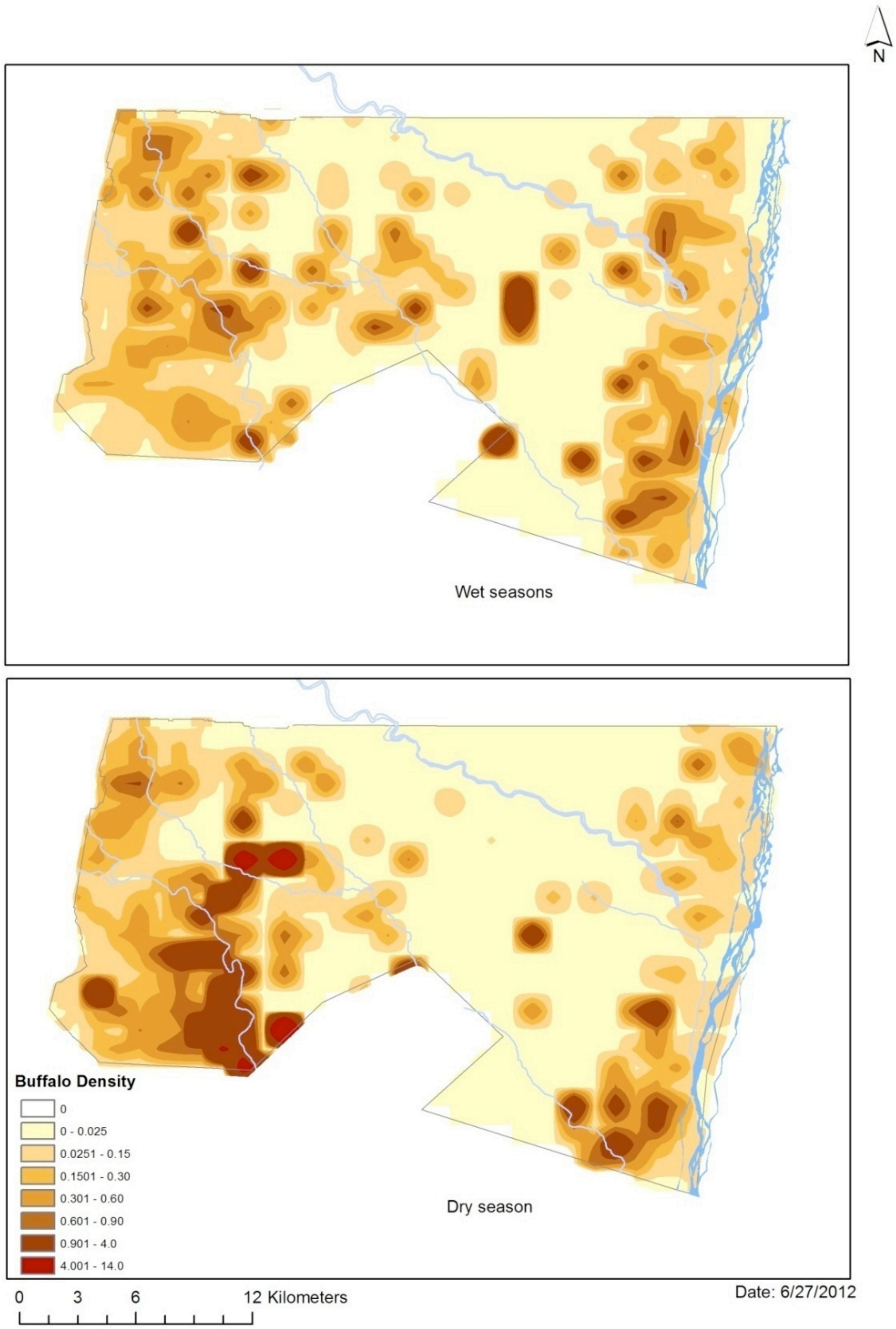


Figure 8.4e: Relative density (animals/km^2) distribution of African buffalo on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.3 Bushbuck (*Tragelaphus scriptus*)

Bushbuck are difficult to count from the air and therefore it was decided to conduct a road strip count for bushbuck as well as line-transect counts for bushbuck and bushpig. The road strip count in 2005 estimated the bushbuck population to be between 61 and 149 animals with a mean estimate of 105 animals (Table 8.6). The line transect count also done in 2005 estimated the bushbuck population at 486 animals with the lower estimate at 362 animals and the higher estimate at 610 animals.

Table 8.6: Comparison between the road strip and the line transect counts in 2005 for bushbuck on Sango Ranch

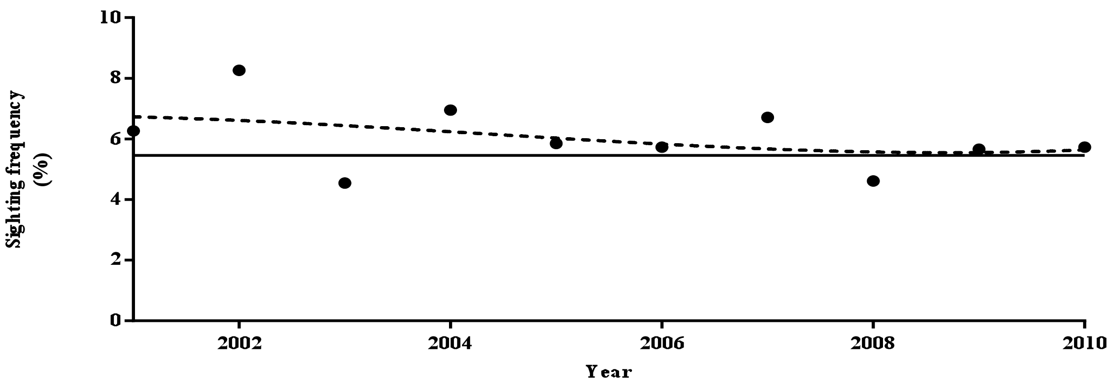
Bushbuck	Population Estimate	Confidence limit		Mean Population Density/km^2	STD	Variance	*n*
		Lower	Higher				
Road strip count	105	61	149	0.31	0.149	0.022	35
Line transect count	486	362	610	1.44	0.375	0.367	64

The population estimate for bushbuck in 1998 was 2 478, 105 for the 2005 road strip count and for the 2011 road strip count the populations size was estimated at 11 animals. These estimates indicated a sharp decline after 1998.

The logistic regression fitted to the bushbuck population data sets indicated a flat trajectory and subjective assessment suggested that the bushbuck population were already at ecological capacity in 2001. This is supported by the 3rd order polynomial regression. The sighting frequency chart (Figure 8.5a) suggests that the bushbuck population decreased up until 2008 where after there was a marginal recovery. The relative density estimates for the bushbuck population (Figure 8.5b) indicated that the bushbuck population was stable with a marginal decrease since 2008. Overall it appeared that the bushbuck population had already been at ecological capacity when the first surveys were conducted in 1998 and that the population was responding to environmental fluctuations. Recent decreases in the population size could also be attributed to poaching activities in the Save River.

The highest density of bushbuck was recorded in the *Diospyros mespiliformis* Riverine Management Unit along the Save and Mokore Rivers followed by the *Echinochloa colona* Wetland Management Unit and the *Combretum apiculatum* Woodland Management Unit (Figure 8.5c). Bushbuck also regularly used the 1*Xanthocercis zambesiaca* Closed Woodland Management Unit.

a.



b.

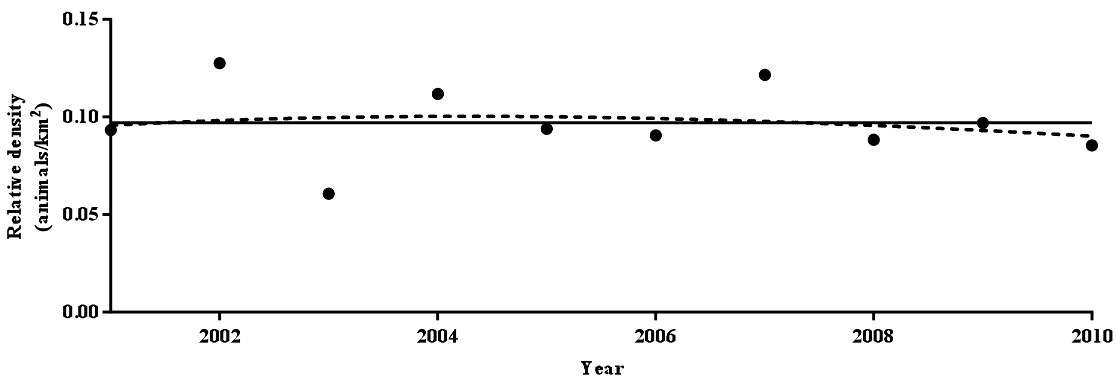


Figure 8.5a-b: Population trends for bushbuck on Sango Ranch, Save Valley Conservancy. (a) Sighting frequency from 2001 to 2010; and (b) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0462; - - - p = 0.0108; (b) —— p = 0.0292; - - - p = 0.0193.

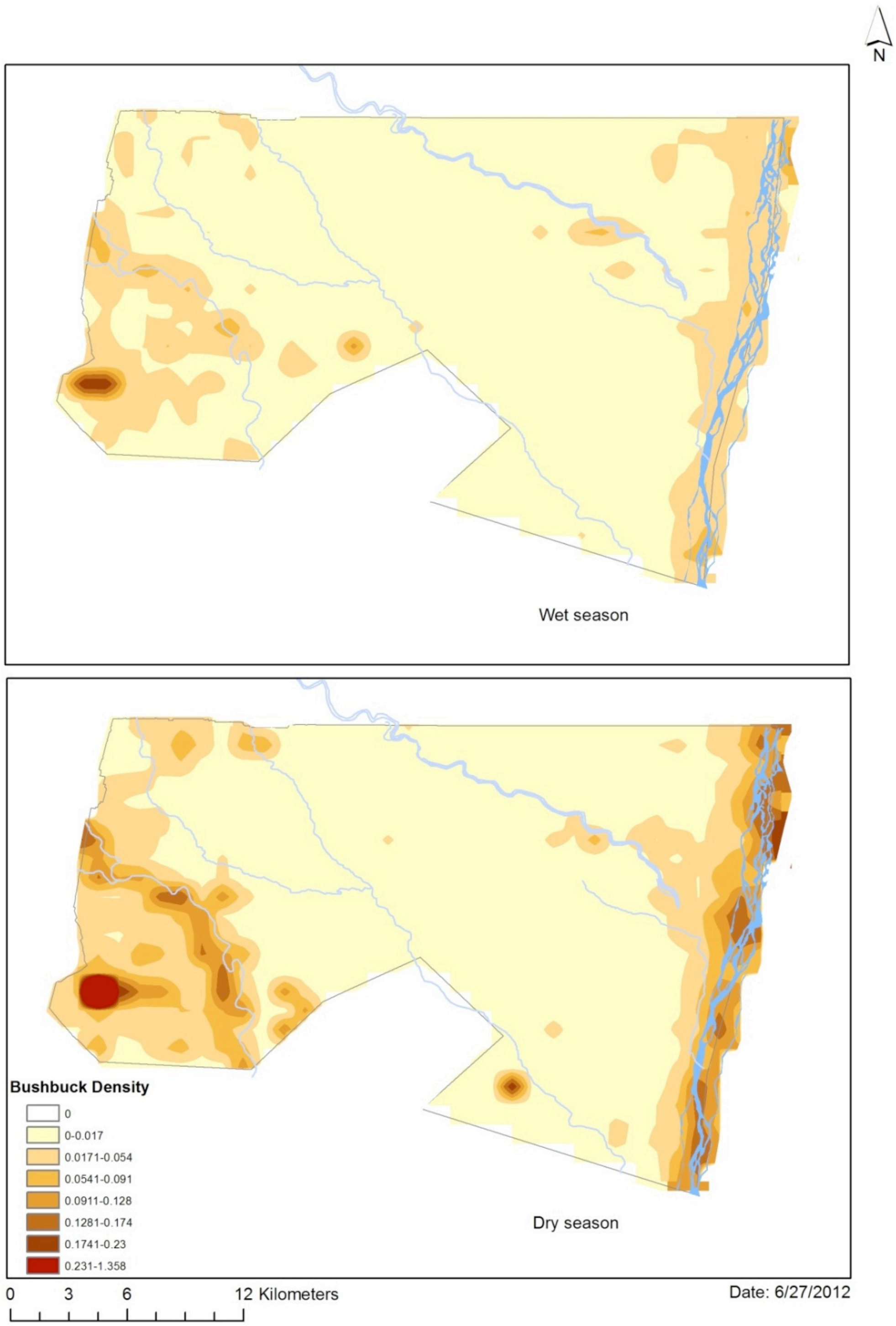
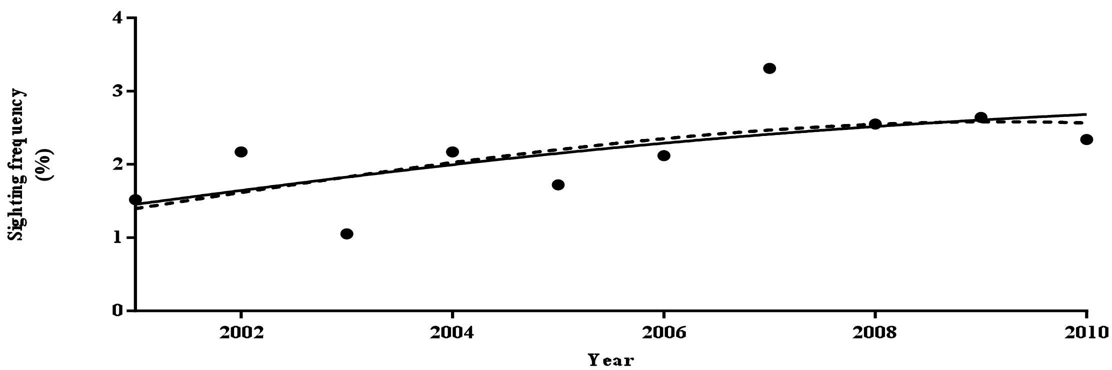


Figure 8.5c: Relative density (animals/km^2) distribution of bushbuck on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.4 Bushpig (*Potamochoerus larvatus*)

The 2004 line transect count estimated the bushpig population at 935 animals. The sighting frequency (Figure 8.6a) and relative density graphs (Figure 8.6b) indicated that the bushpig population was still on the increase whilst a subjective assessment of the slope of the logistic regression and the 3rd order polynomial regression indicated that the bushpig population was already at ecological capacity or nearing ecological capacity on Sango Ranch. High densities of bushpig were recorded in the *Diospyros mespiliformis* Riverine Management Unit, especially during the dry season. During the wet season bushpig also regularly utilised the *Combretum apiculatum* Woodland Management Unit, the *Kirkia acuminata* Woodland Management Unit, the *Xanthocercis zambesiaca* Closed Woodland Management Unit and the *Echinochloa colona* Wetland Management Unit (Figure 8.6c, Table 8.5).

a.



b.

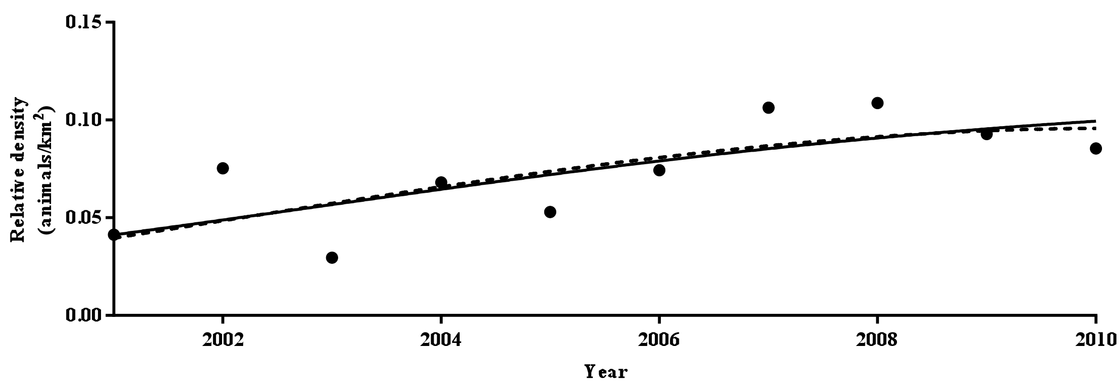


Figure 8.6a-b: Population trends for bushpig on Sango Ranch, Save Valley Conservancy. (a) Sighting frequency from 2001 to 2010; and (b) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0235; - - - p = 0.0212; (b) —— p = 0.0202; - - - p = 0.0193.

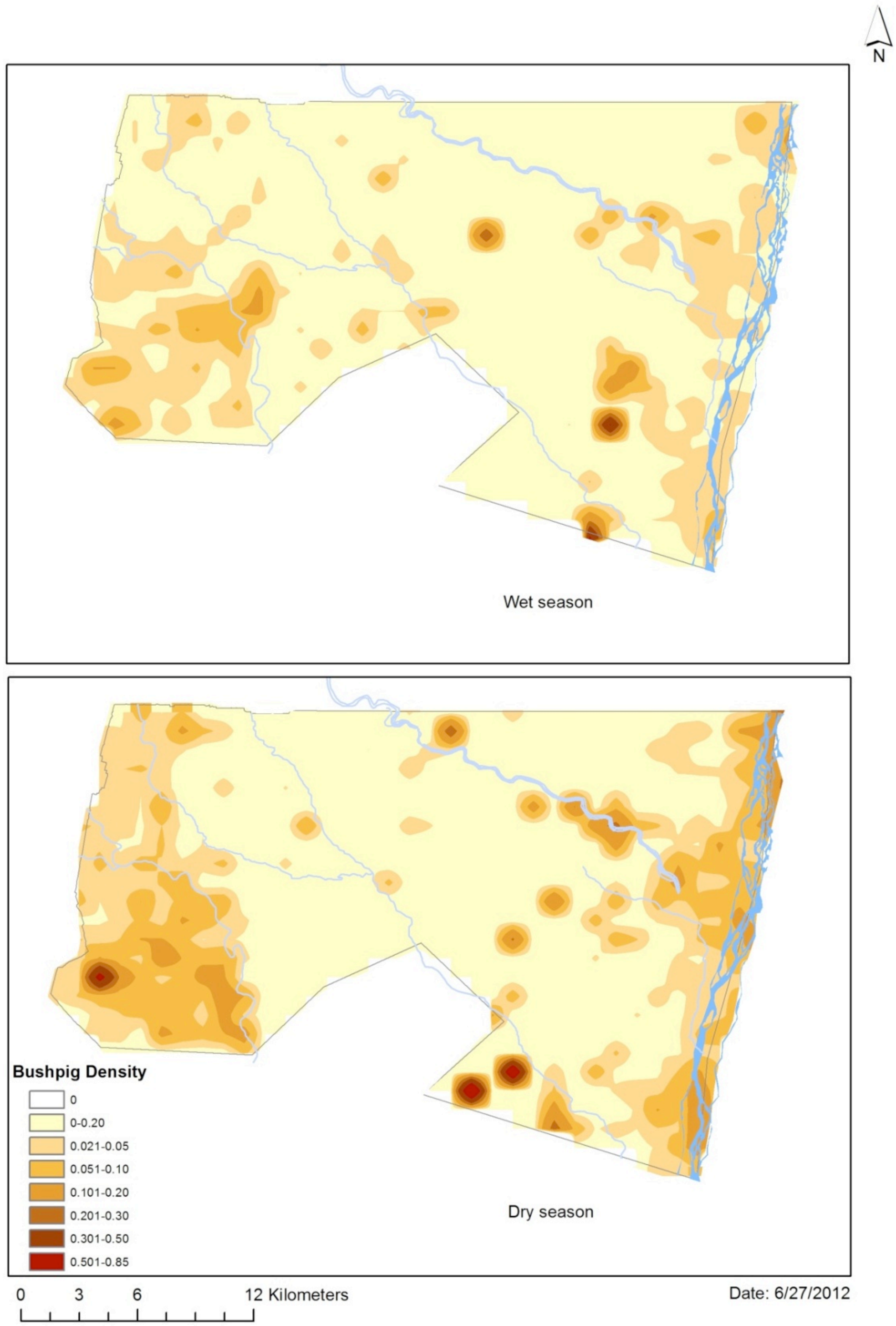
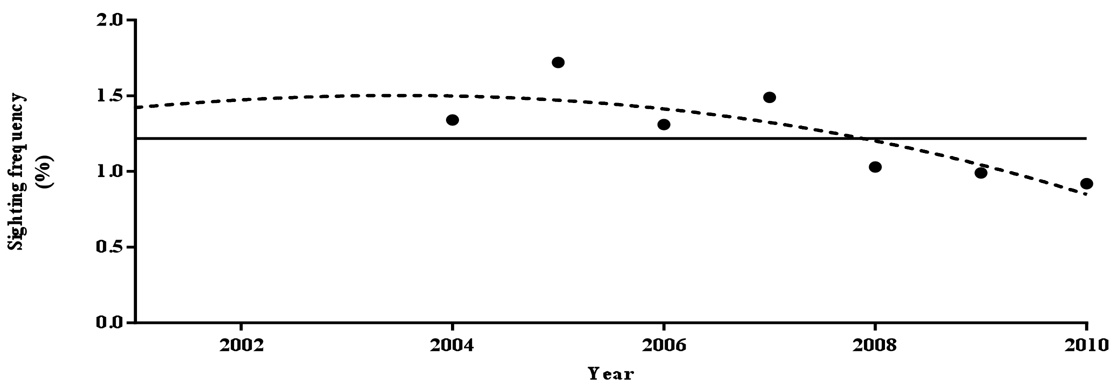


Figure 8.6c: Relative density (animals/km^2) distribution of bushpig on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.5 Common duiker (*Sylvicapra grimmia*)

Population trend data for the common duiker was only measured using the grid square method. Trend data from the sighting frequency indicated a common duiker population already at ecological capacity since being added to the monitoring program in 2004 (Figure 8.7a). Trend data based on the relative density estimates indicated a similar trend and it is concluded that the common duiker population was already at ecological capacity by 2004 (Figure 8.7b).

a.



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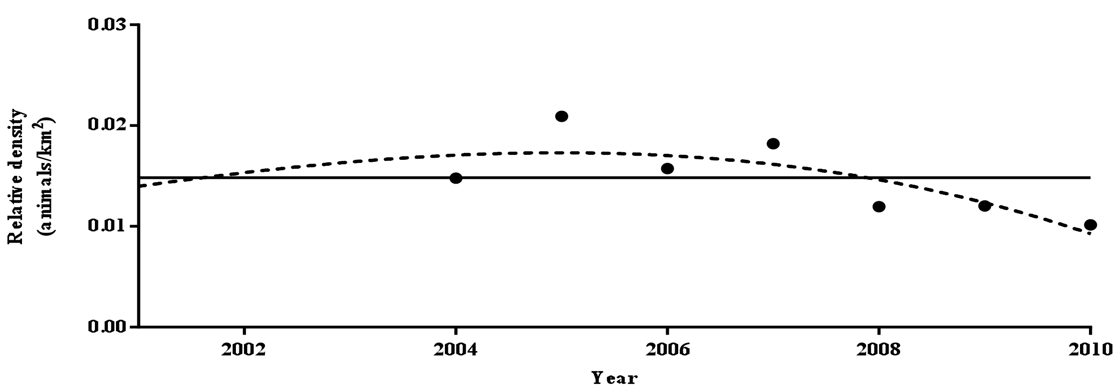


Figure 8.7a-b: Population trends for common duiker on Sango Ranch, Save Valley Conservancy. (a) Sighting frequency from 2001 to 2010; and (b) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0189; - - - p = 0.0107; (b) —— p = 0.1308; - - - p = 0.1045.

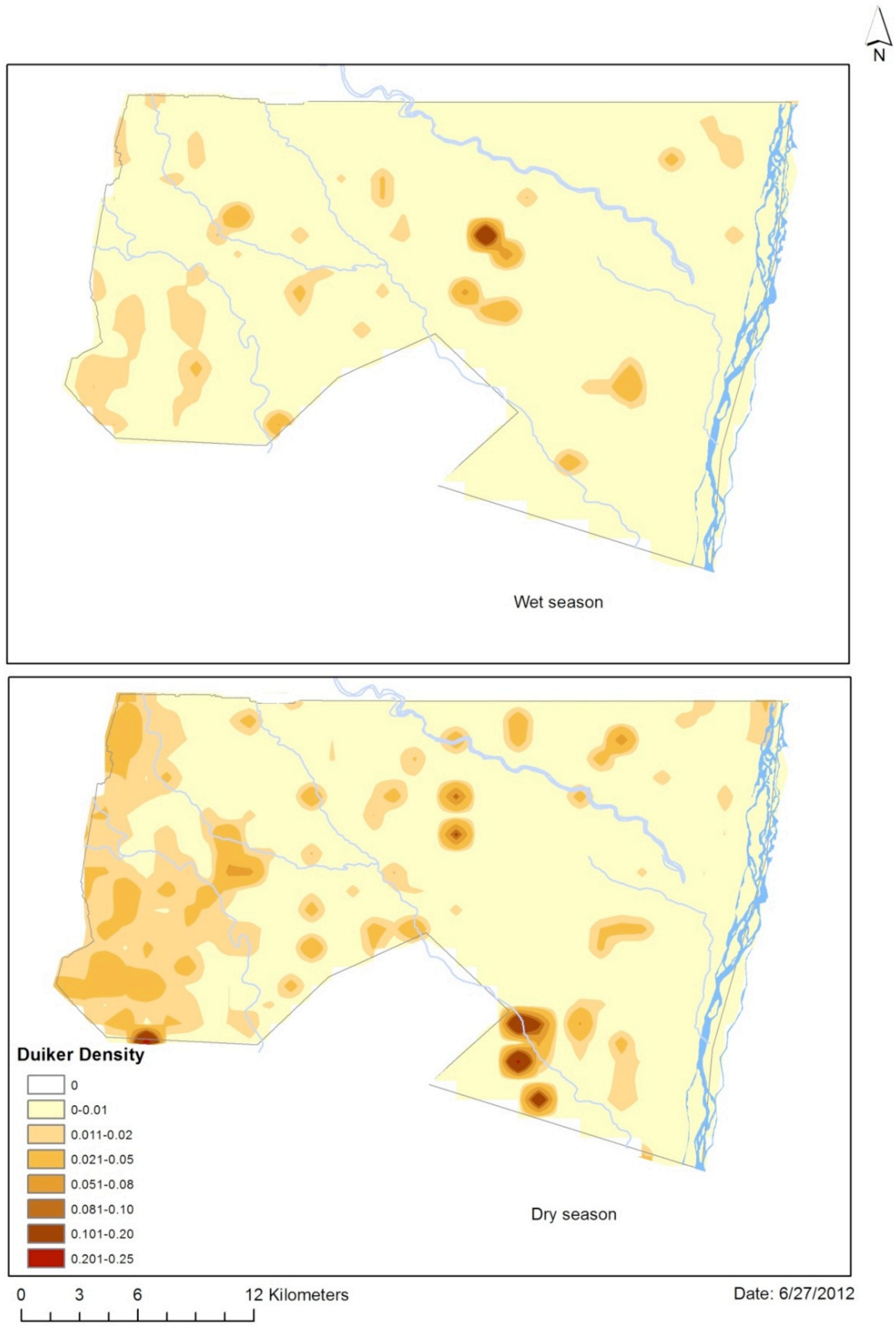


Figure 8.7c: Relative density (animals/km^2) distribution of common duiker on Sango Ranch derived from the grid square method (2001 – 2010).

Common duiker seemed to occur within most habitat types with high densities recorded in the *Combretum apiculatum* Woodland Management Unit. Common duiker also regularly utilised the *Kirkia acuminata* Woodland Management Unit, the *Colophospermum mopane* Closed Woodland Management Unit, the *Acacia tortilis* Open Woodland Management Unit and the *Diospyros mespiliformis* Riverine Management Unit (Figure 8.7c).

8.3.1.6 Livingston's eland (*Tragelaphus oryx*)

The highest number of Livingston's eland was recorded in 2004 when 1 191 animals were seen from the air, whilst the lowest count of Livingston's eland was in 1998 with only 226 animals counted (Table 8.3).

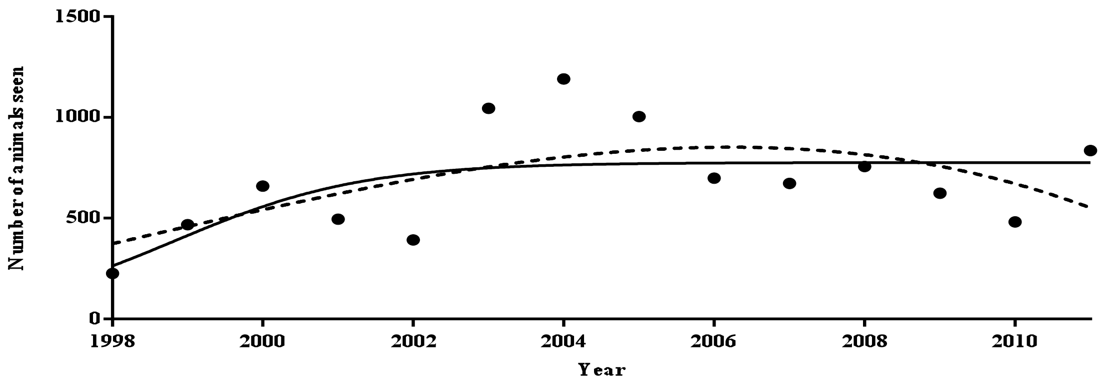
Aerial survey results suggested that the Livingston's eland population reached ecological capacity around 2002/2003 after which the population remained stable (Figure 8.8a). However, results from the sighting frequency trend data suggested that the Livingston's eland population was still on the increase and the relative density data suggested that the Livingston's eland population neared ecological capacity during 2008 (Figure 8.8b & 8c). The contrasting results between the findings of the aerial survey and the grid square methods were most likely as a result of Livingston's eland movement between properties.

Similar to the African buffalo, Livingston's eland is a highly mobile species and is able to move large distances in relatively short periods of time. Additionally, Livingston's eland herds aggregate during the calving season, which varies from one year to the next, but generally is from July to September. After the calving season the nursery herds remain on Sango Ranch while many animals disperse onto neighbouring properties. The dispersal of Livingston's eland depends on the time of the calving season and explains the variability in the Livingston's eland numbers from the aerial survey. It can thus be argued that Livingston's eland has not yet reached ecological capacity within Sango Ranch.

Livingston's eland selected a wide range habitat types within Sango Ranch. They regularly frequented the *Combretum apiculatum* Woodland management unit, the *Colophospermum mopane* Closed Woodland, the *Acacia tortilis* Open Woodland Management Unit, the *Xanthocercis zambesiaca* Closed Woodland Management Unit, the *Diospyros mespiliformis* Riverine Management Unit and the *Echinochloa colona* Wetland Management Unit (Figure 8.8d & 8.8e, Table 8.5).

The mean calving rate for Livingston's eland over a 12-year period was 26.2% but varied considerably between years (range 16.8 to 38.2%). The mean survival rate for Livingston's eland calves up to one year of age was only 15.4%.

a.



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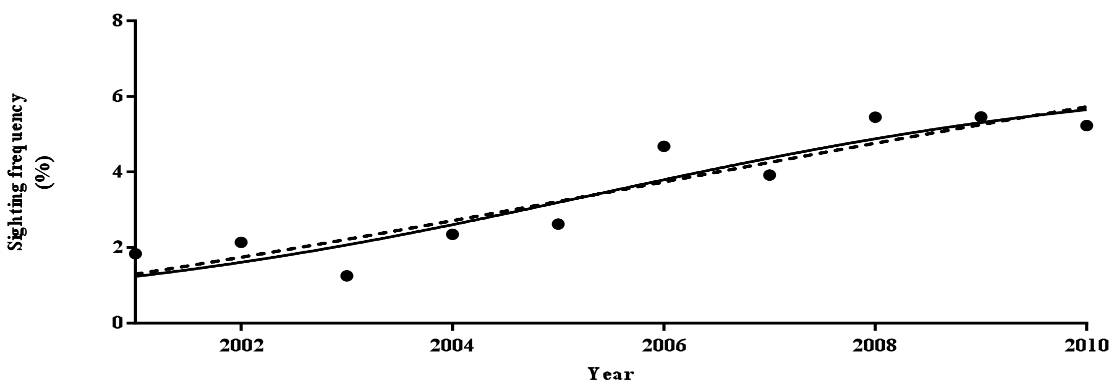

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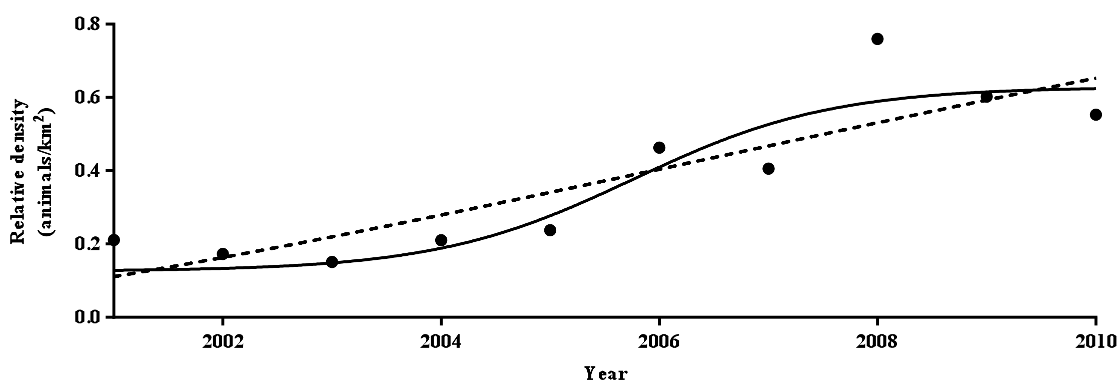


Figure 8.8a-c: Population trends for Livingston's eland on Sango Ranch, Save Valley Conservancy. (a). Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0459; - - - p = 0.0437; (b) —— p = 0.0007; - - - p = 0.0011; (c) —— p = 0.0034; - - - p = 0.0078.

Figure 8.8d: Distribution of Livingston's eland on Sango Ranch from aerial surveys conducted since 2002.

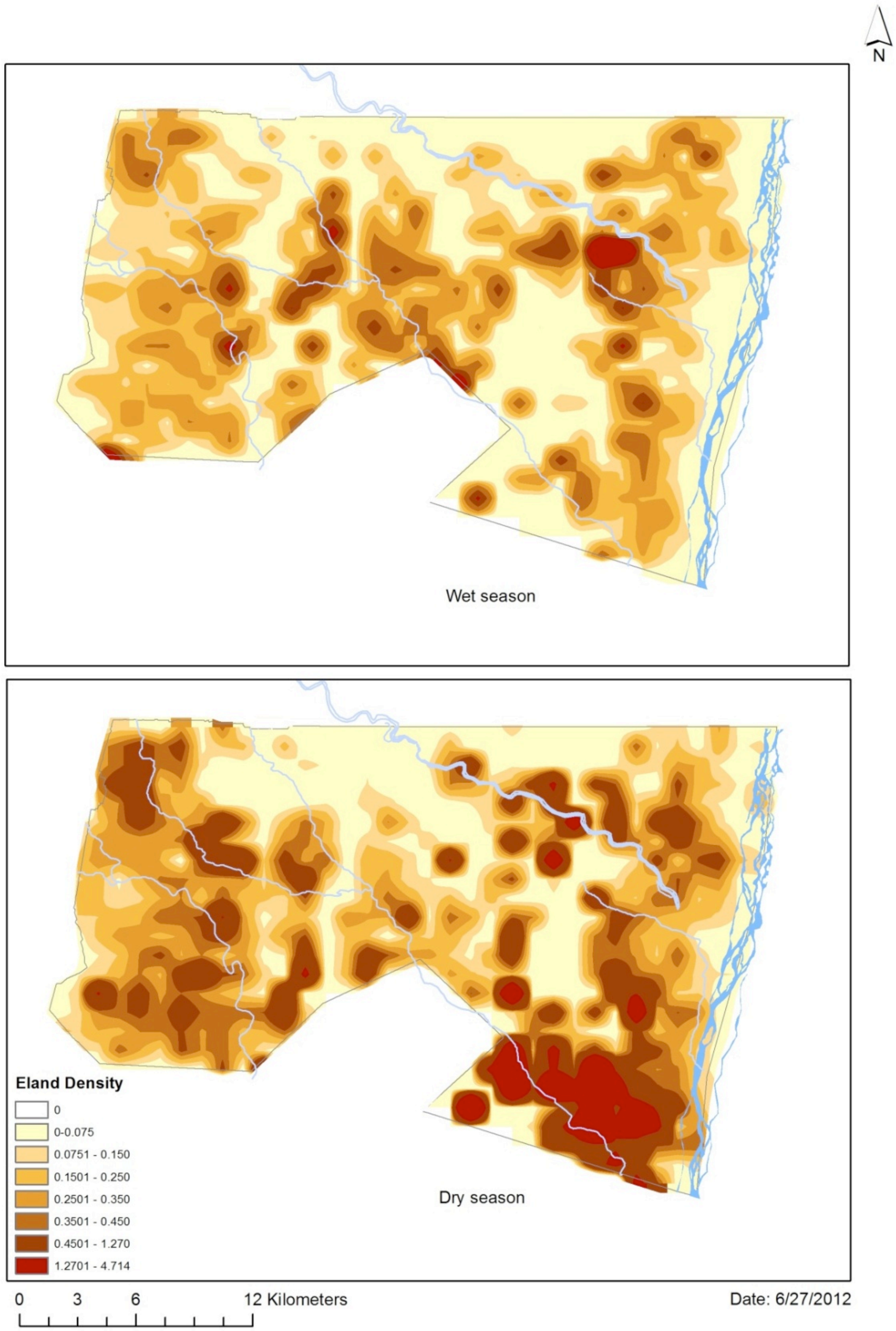


Figure 8.8e: Relative density (animals/km^2) distribution of Livingston's eland on Sango Ranch derived from the grid square method (2001 – 2010).

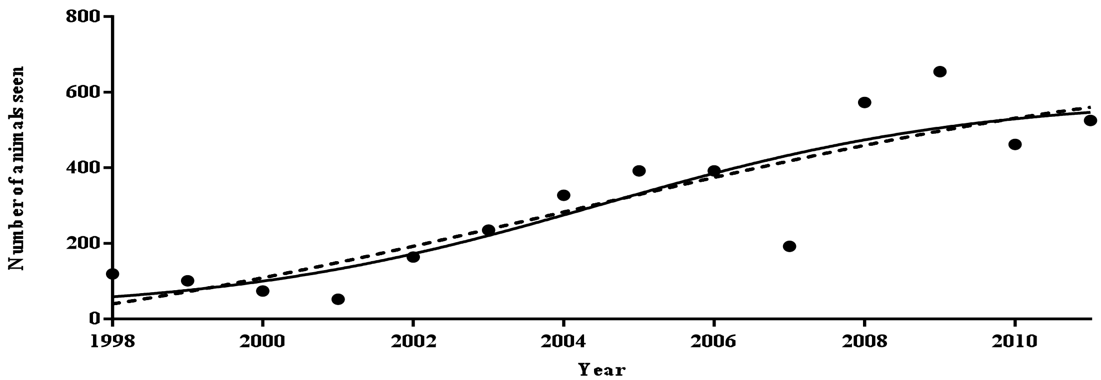
8.3.1.7 African elephant (*Loxodonta africana*)

A highest total of 654 African elephant was counted in 2009 and the lowest count was in 2001 with only 52 African elephant seen from the air (Table 8.3). The 1998 road strip count (Hin, 2000) estimated the population at 106 African elephant whilst the 2011 road strip count estimated the African elephant population at 348 animals.

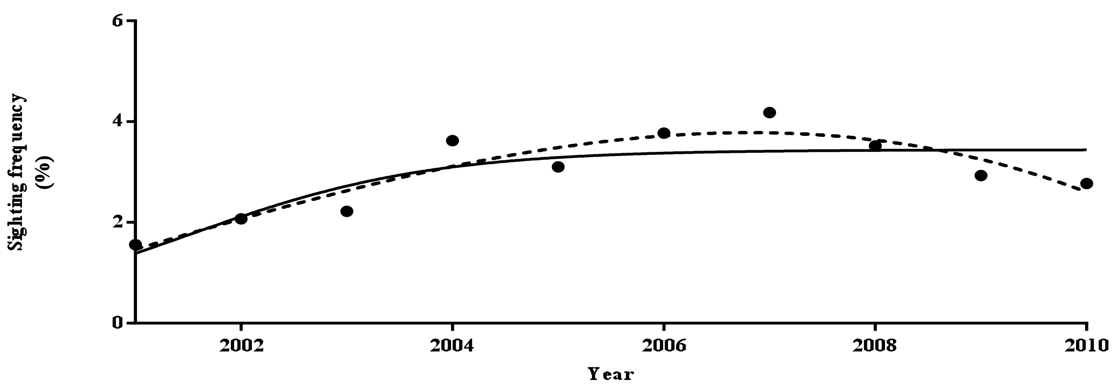
The trend information from the aerial surveys indicated an increasing African elephant population (Figure 8.9a). However, the growth in the African elephant population for both the sighting frequency and relative density curves seemed to have reached a plateau (Figure 8.9b & 8.9c).. This slower population growth recorded by means of aerial survey data for the African elephant population was most likely due to movement of African elephant between ranches but also as a result of the culling of African elephant on Sango Ranch. Since the implementation of the culling program in the SVC in 2009, a total of 66 African elephant were culled on Sango Ranch.

No clear distribution pattern for African elephant could be determined from aerial survey results (Figure 8.9d). However, the grid square method indicated high densities of African elephant in the *Diospyros mespiliformis* Riverine Management Unit. African elephant also regularly selected the *Colophospermum mopane* Closed Woodland Management Unit, the *Xanthocercis zambesiaca* Closed Woodland Management Unit and the *Echinochloa colona* Wetland Management Unit (Figure 8.9e).

a.



b.



c.

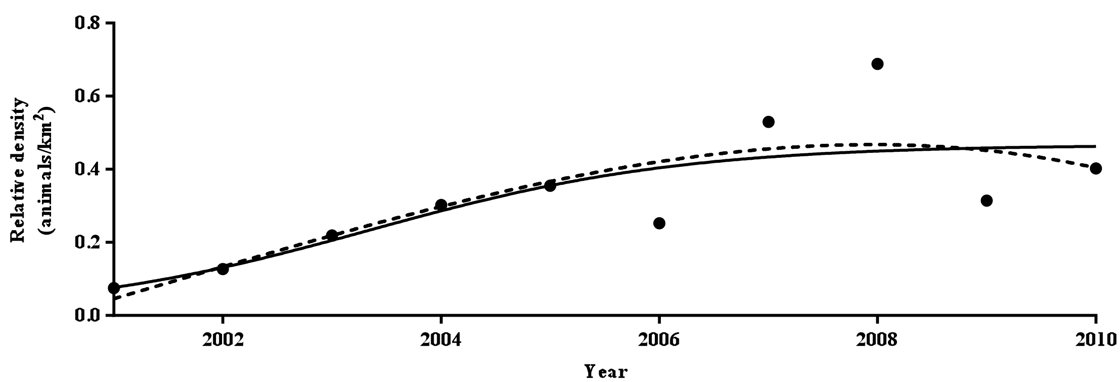


Figure 8.9a-c: Population trends for African elephant on Sango Ranch, Save Valley Conservancy. (a). Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0008; - - - p = 0.0010; (b) —— p = 0.0032; - - - p = 0.0002; (c) —— p = 0.0313; - - - p = 0.0223.

Figure 8.9d: Distribution of African elephant on Sango Ranch from aerial surveys conducted since 2002.

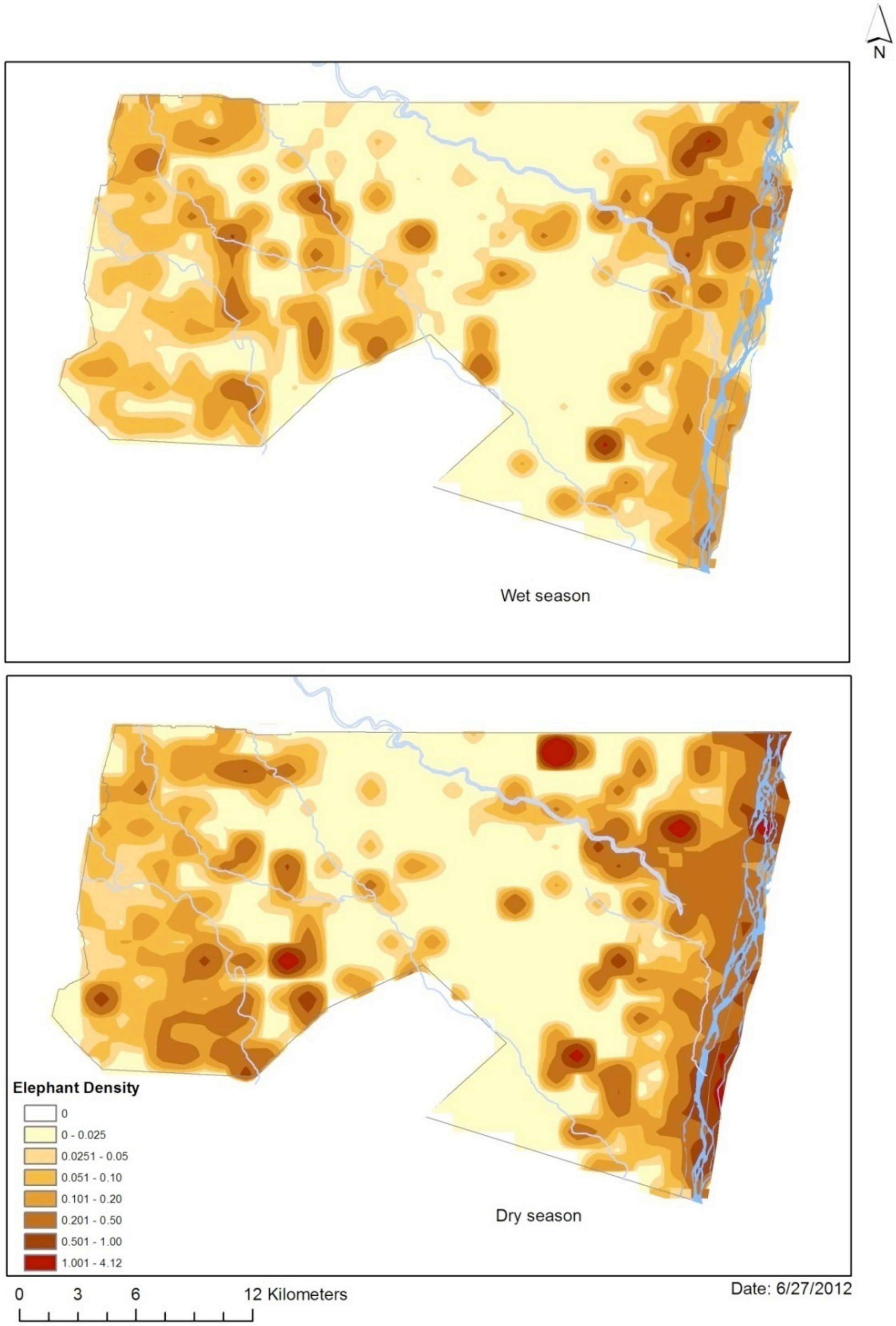


Figure 8.9e: Relative density (animals/km^2) distribution of African elephant on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.8 Giraffe (*Giraffa camelopardalis*)

The giraffe population increased from only 68 animals seen during the 1998 aerial survey to 422 giraffe counted in 2011 (Table 8.3). Road strip counts conducted in 1998 and 2011 confirmed an increasing giraffe population. The 1998 road strip count conducted by Hin (2000) estimated the giraffe population at 148 individual animals, whereas the 2011 road strip count estimated the population at 1 892 giraffe.

Trend line information gathered from the aerial surveys and the grid square suggested that the giraffe population has not yet reached ecological capacity on Sango Ranch and is currently in the rapid growth phase of the sigmoidal population growth curve (Figures 8.10a, 8.10b & 8.10c).

Giraffe were mainly associated with the *Xanthocercis zambesiaca* Closed Woodland Management Unit. However, giraffe utilised a wide range of habitats within Sango Ranch. Giraffe regularly occurred in the *Acacia tortilis* Open Woodland Management Unit (Figure 8.8d), the *Kirkia acuminata* Woodland Management Unit, the *Combretum apiculatum* Management Unit, the *Colophospermum mopane* Closed Woodland Management Unit and the *Diospyros mespiliformis* Riverine Management Units (Figure 8.8e). Giraffe densities were low in the *Echinochloa colona* Wetland Management Unit.

The mean calving and survival rates into the first year were 17% over a 12-year monitoring period.

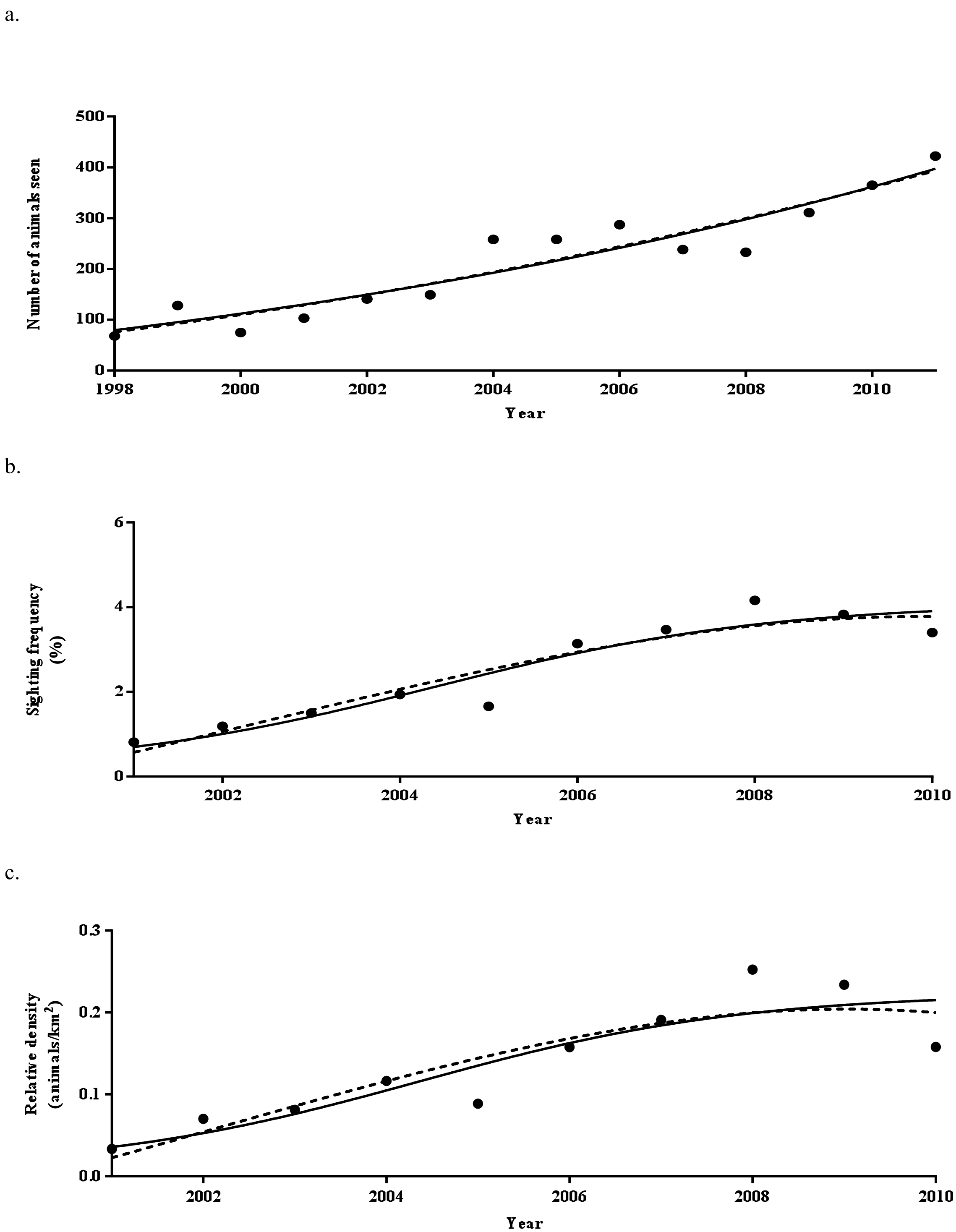


Figure 8.10a-c: Population trends for giraffe on Sango Ranch, Save Valley Conservancy. (a). Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p = 0.0001$; - - - $p < 0.0001$; (b) —— $p = 0.0003$; - - - $p = 0.0004$; (c) —— $p = 0.0034$; - - - $p = 0.0029$.

Figure 8.10d: Distribution of giraffe on Sango Ranch from aerial surveys conducted since 2002.

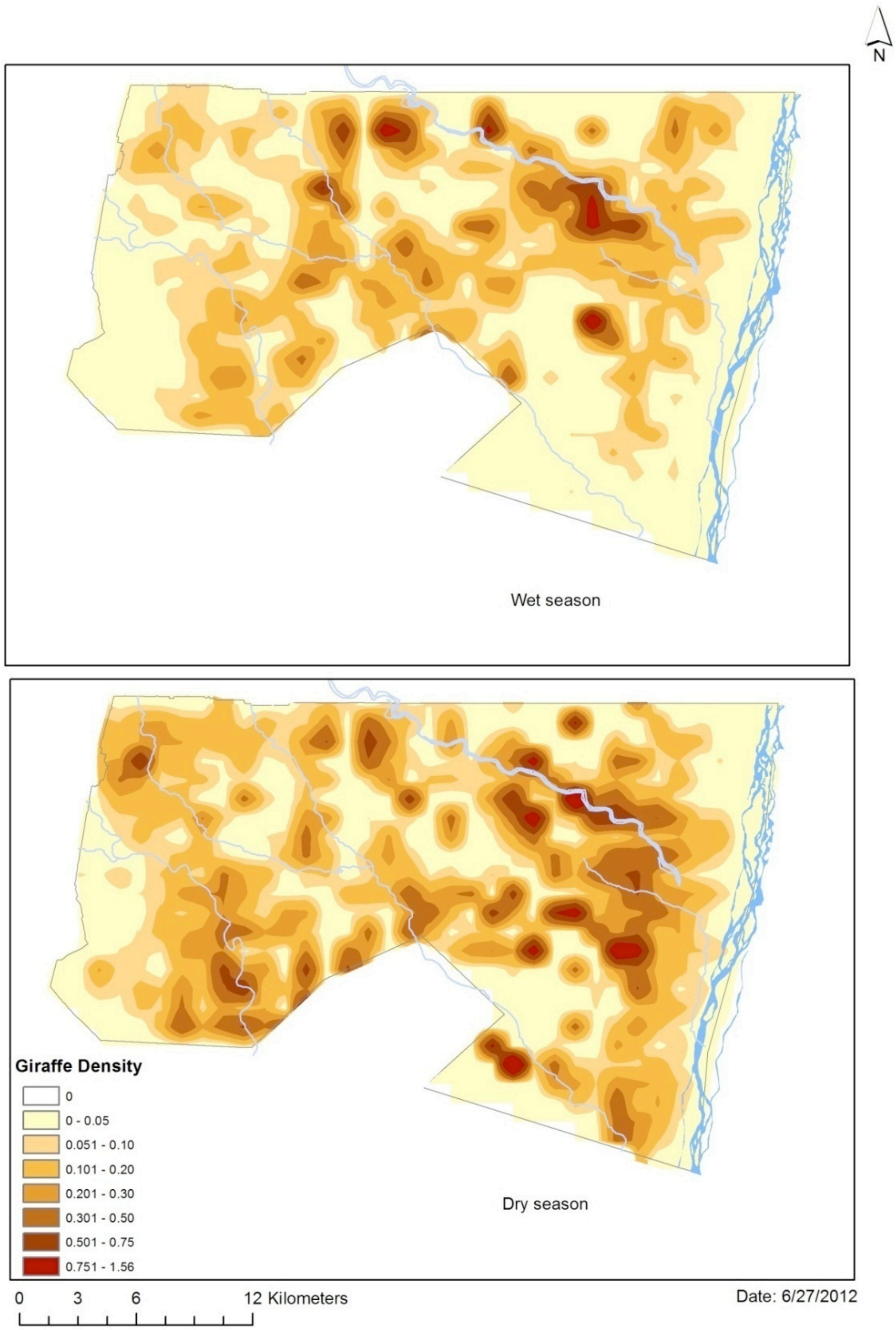
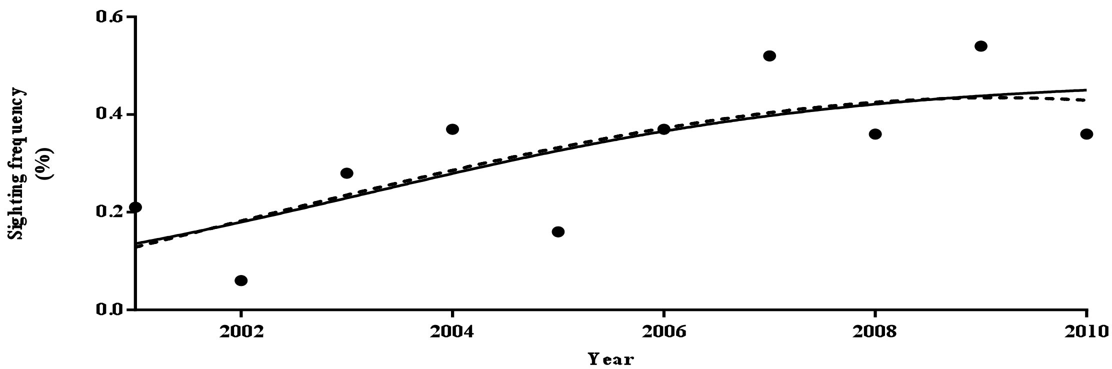


Figure 8.10e: Relative density (animals/km^2) distribution of giraffe on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.9 Hippopotamus (*Hippopotamus amphibius*)

Hippopotamus population size was determined using the known group count after a systematic search was conducted in the Save River to locate all the hippopotamus pods in the river. The population was estimated to contain between 25 and 30 individuals. Population trends were determined using the grid square method and whilst the sighting frequency data suggested that the hippopotamus population was still increasing (Figure 8.11a), the relative density trend data indicated that the hippopotamus population could already have reached ecological capacity (Figure 8.11b).

a.



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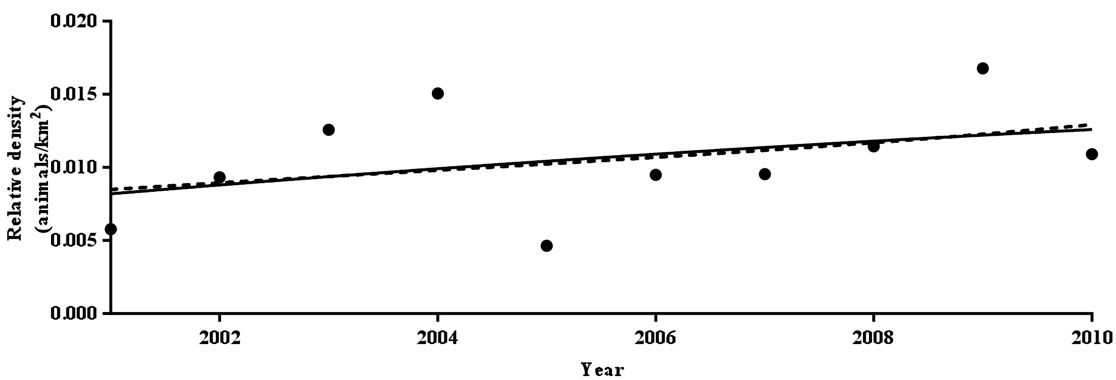


Figure 8.11a-b: Population trends for hippopotamus on Sango Ranch, Save Valley Conservancy. (a) Sighting frequency from 2001 to 2010; and (b) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0440; - - - p = 0.0419; (b) —— p = 0.1377; - - - p = 0.1364.

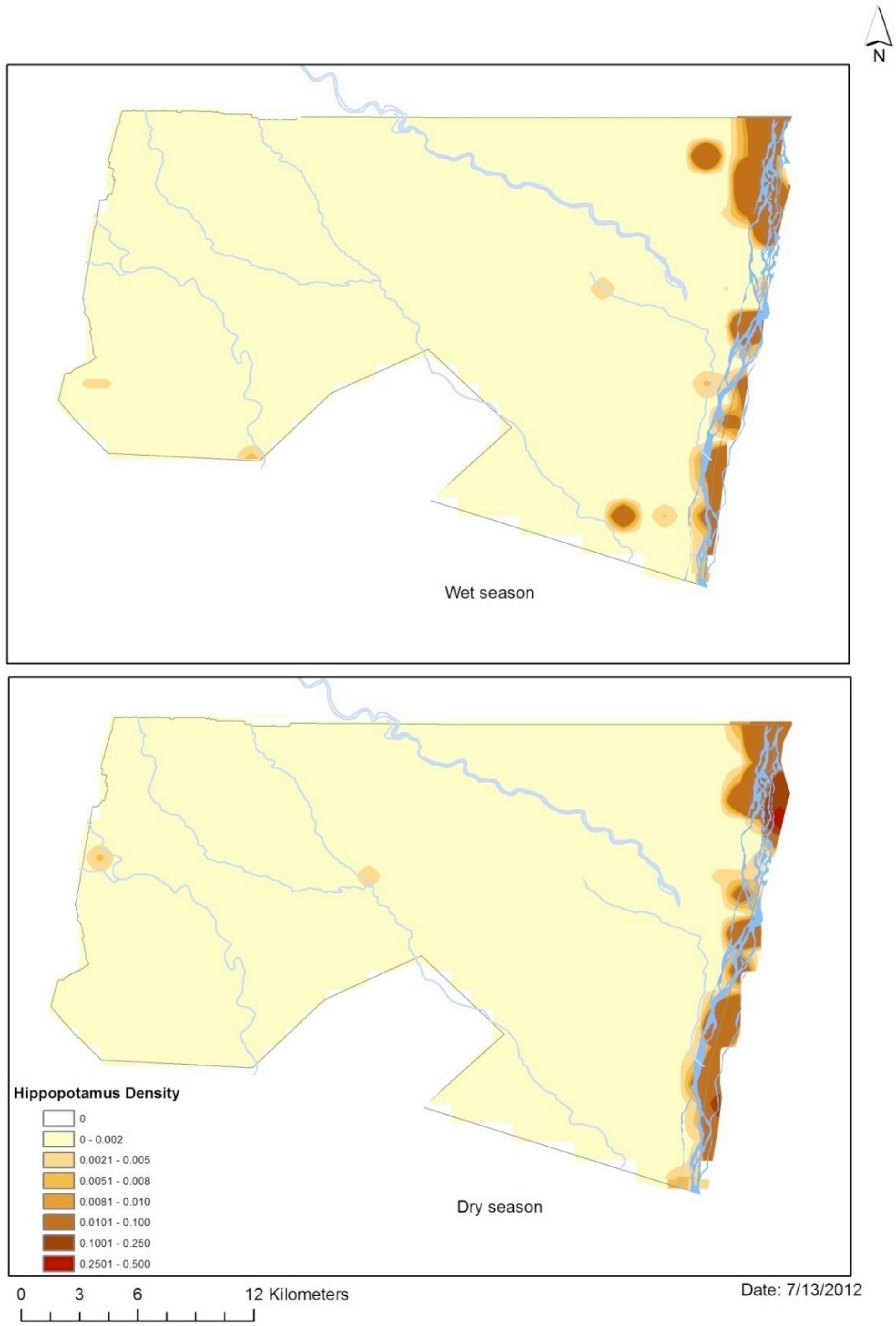


Figure 8.11c: Relative density (animals/km^2) distribution of hippopotamus on Sango Ranch derived from the grid square method (2001 – 2010).

Despite a few records of hippopotamus in the Mokore River, hippopotamus only occurred in the Save River in the *Diospyros mespiliformis* Riverine Management Unit (Figure 8.9c).

In the late 1990s and early 2000s the hippopotamus population in the Save River consisted of a few individuals and a pod of hippopotamus at the Chapungu homestead (W. Hofmeyer[2] pers comm.). Most of the hippopotamus in the area lived in dams, which were created by commercial farmers on the eastern banks of the Save River outside the SVC. Due to persecution and harassment by the new settlers after the land resettlement schemes in 2000, the hippopotamus population dispersed. A portion of the population resettled in the Save River.

8.3.1.10 Impala (*Aepyceros melampus*)

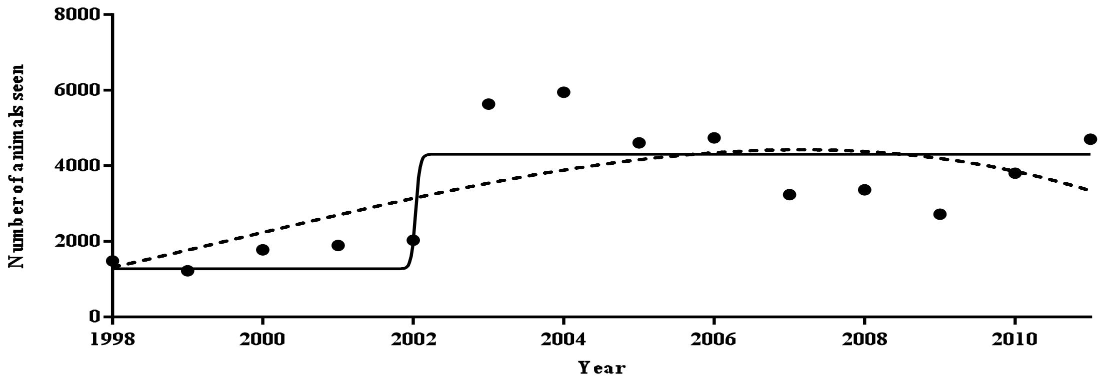
Impala were present within the SVC throughout the cattle ranching era and already occurred in large numbers at the formation of the SVC in 1991. It was therefore assumed that the impala population had reached ecological capacity by the time the first aerial survey was conducted in 1998 and that the population trend would follow the conditions dictated by the environment. The results from the aerial surveys for the past 14 years suggested that the impala population increased after 1998, peaked in 2004 after which it remained fairly stable (Figure 8.12a). The sighting frequency data indicated a stable impala population (Figure 8.12b), whilst the relative density graph followed a trend similar to that of the sighting frequency data (Figure 8.12c).

The impala population selected the *Diospyros mespiliformes* Riverine management unit, the *Xanthocercis zambesiaca* Closed Woodland Management Unit and the *Echinochloa colona* Wetland Management Unit whilst impala also regularly occurred in the *Acacia tortilis* Open Woodland Management Unit, *Colophospermum mopane* Closed Woodland Management Unit and the *Combretum apiculatum* Woodland Management Unit (Figure 8.12d & Figure 8.12e). Low densities of impala were recorded in the *Kirkia acuminata* Woodland Management Unit.

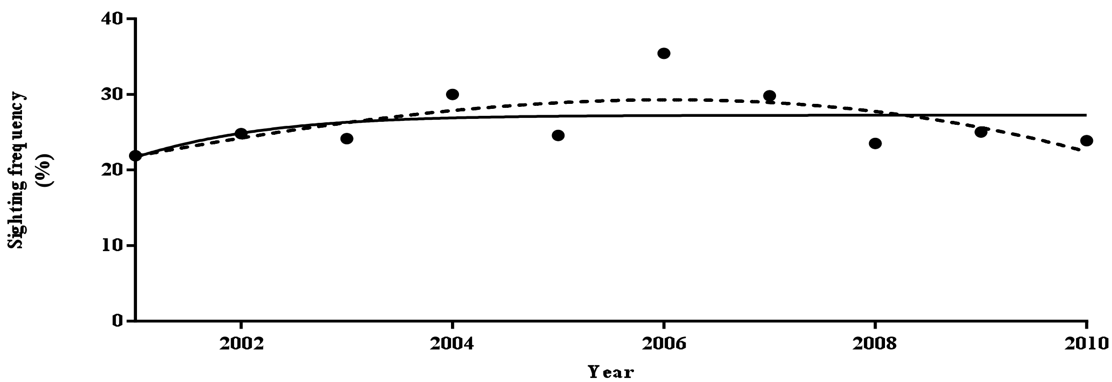
The mean birth rate for impala was 20.4% (range 16.9% to 26.8%) with a mean survival rate into the first year of 18.2% (range 14.2% to 22.6%).

[2]Hofmeyer, W. General Manager 1991-2002, Chapungu Ranch, Save Valley Conservancy.

a.



b.



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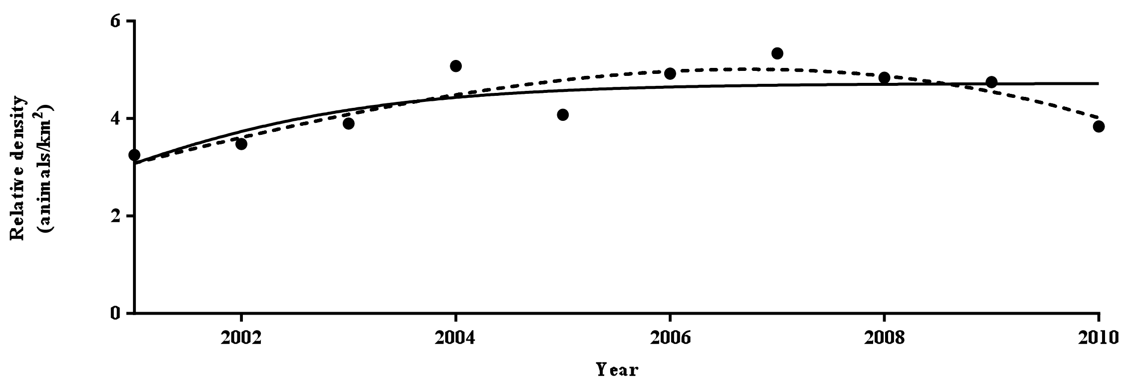


Figure 8.12a-c: Population trends for impala on Sango Ranch, Save Valley Conservancy. (a) Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p = 0.0055$; - - - $p = 0.0367$; (b) —— $p = 0.0047$; - - - $p = 0.0014$; (c) —— $p = 0.0009$; - - - $p < 0.0001$.

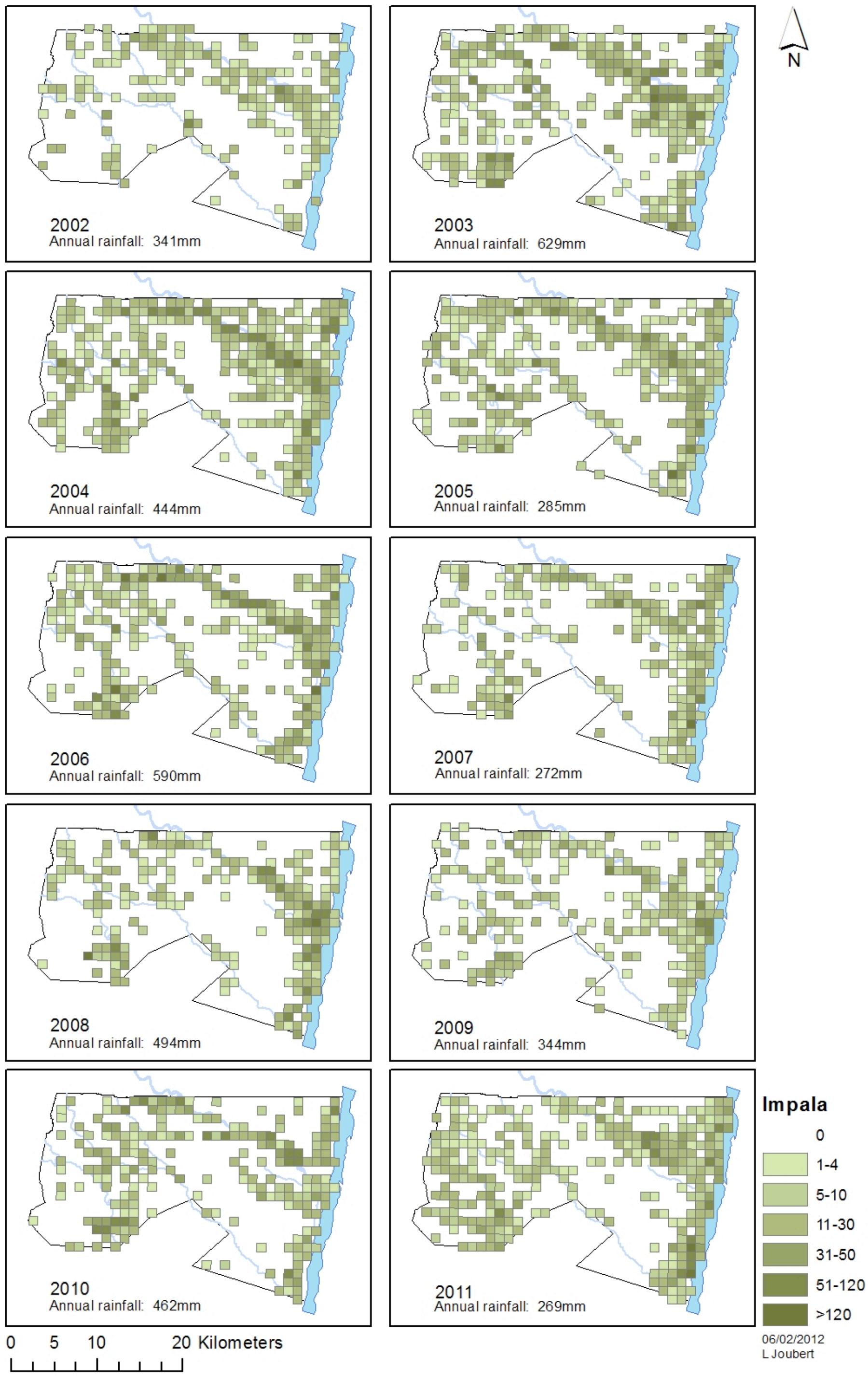


Figure 8.10d: Distribution of impala on Sango Ranch from aerial surveys conducted since 2002.

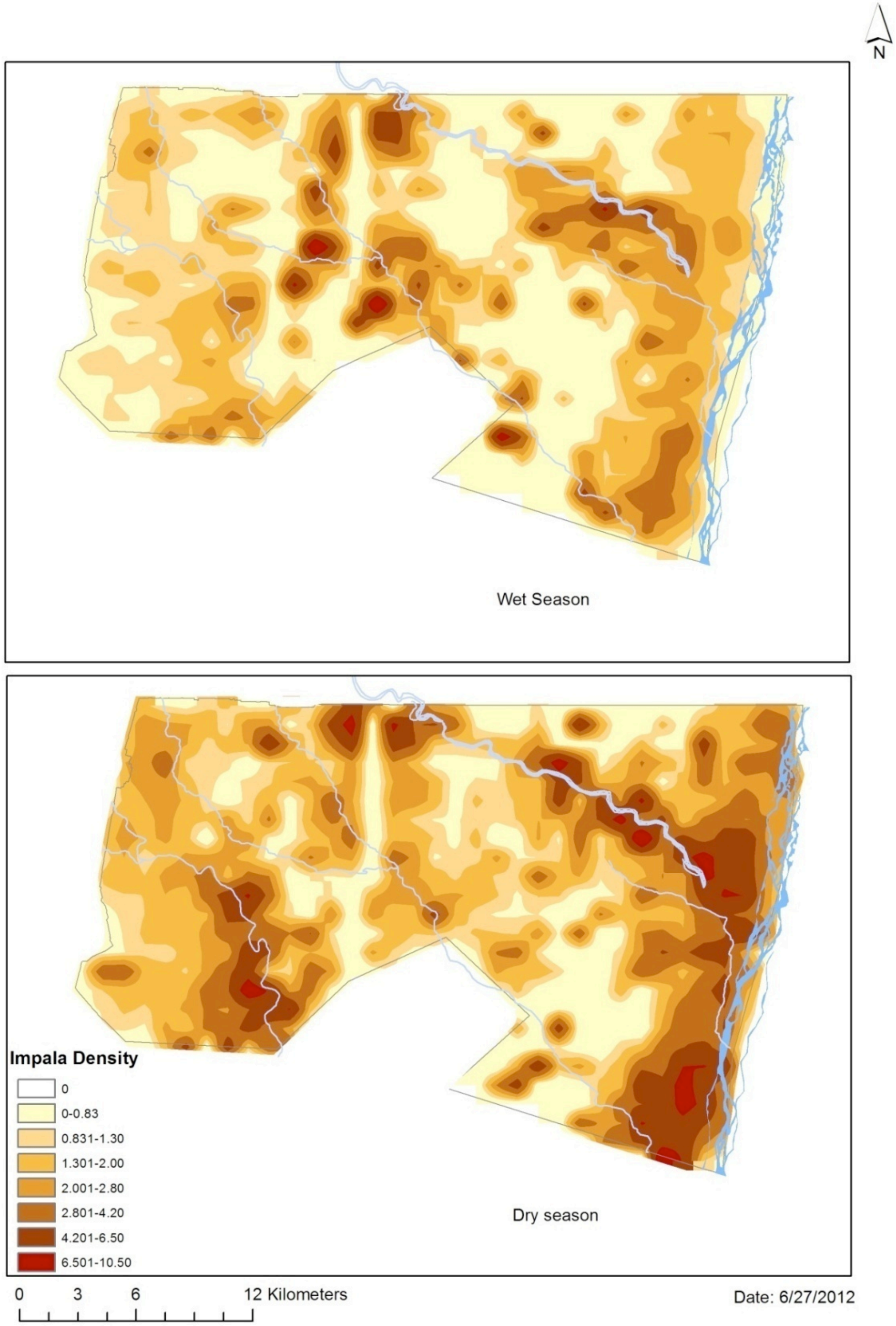
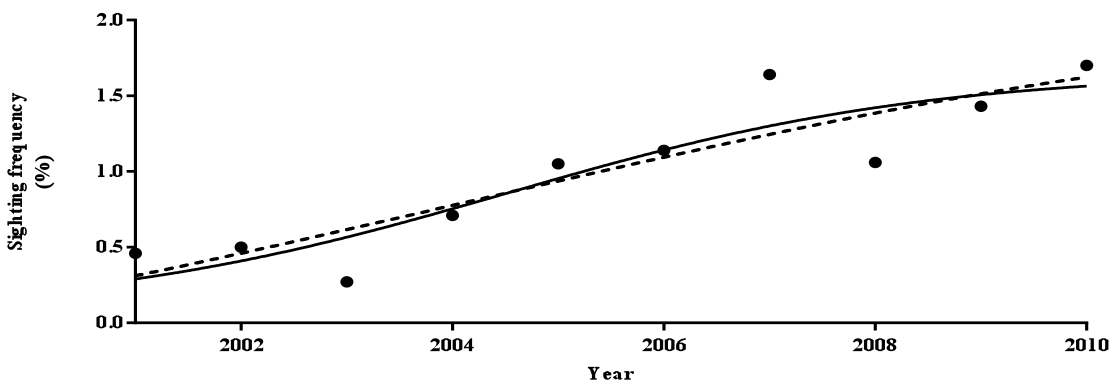


Figure 8.10e: Relative density (animals/km^2) distribution of impala on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.11 Klipspringer (*Oreotragus oreotragus*)

The 2011 road strip count estimated a klipspringer population of 64 individuals on Sango Ranch (Table 8.4). The sighting frequency trends (Figure 8.13a) and the relative density estimates (Figure 8.13b) indicated that the klipspringer population was still on the increase. Klipspringer was almost exclusively recorded in the *Combretum apiculatum* Woodland Management Unit but on occasion also recorded in the *Diospyros mespiliformis* Riverine Management Unit along the Mokore River (Figure 8.13c).

a.



b.

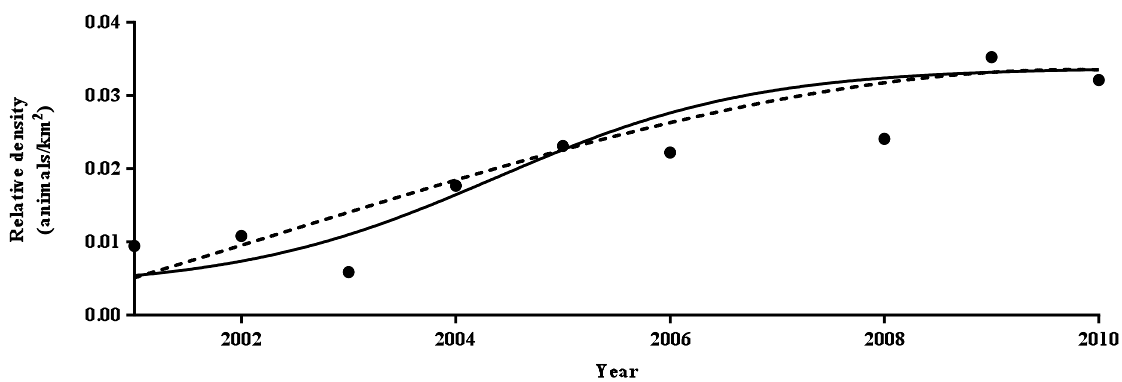


Figure 8.13a-b: Population trends for klipspringer on Sango Ranch, Save Valley Conservancy. (a) Sighting frequency from 2001 to 2010; and (b) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0022; - - - p = 0.0028; (b) —— p = 0.0082; - - - p = 0.0110.

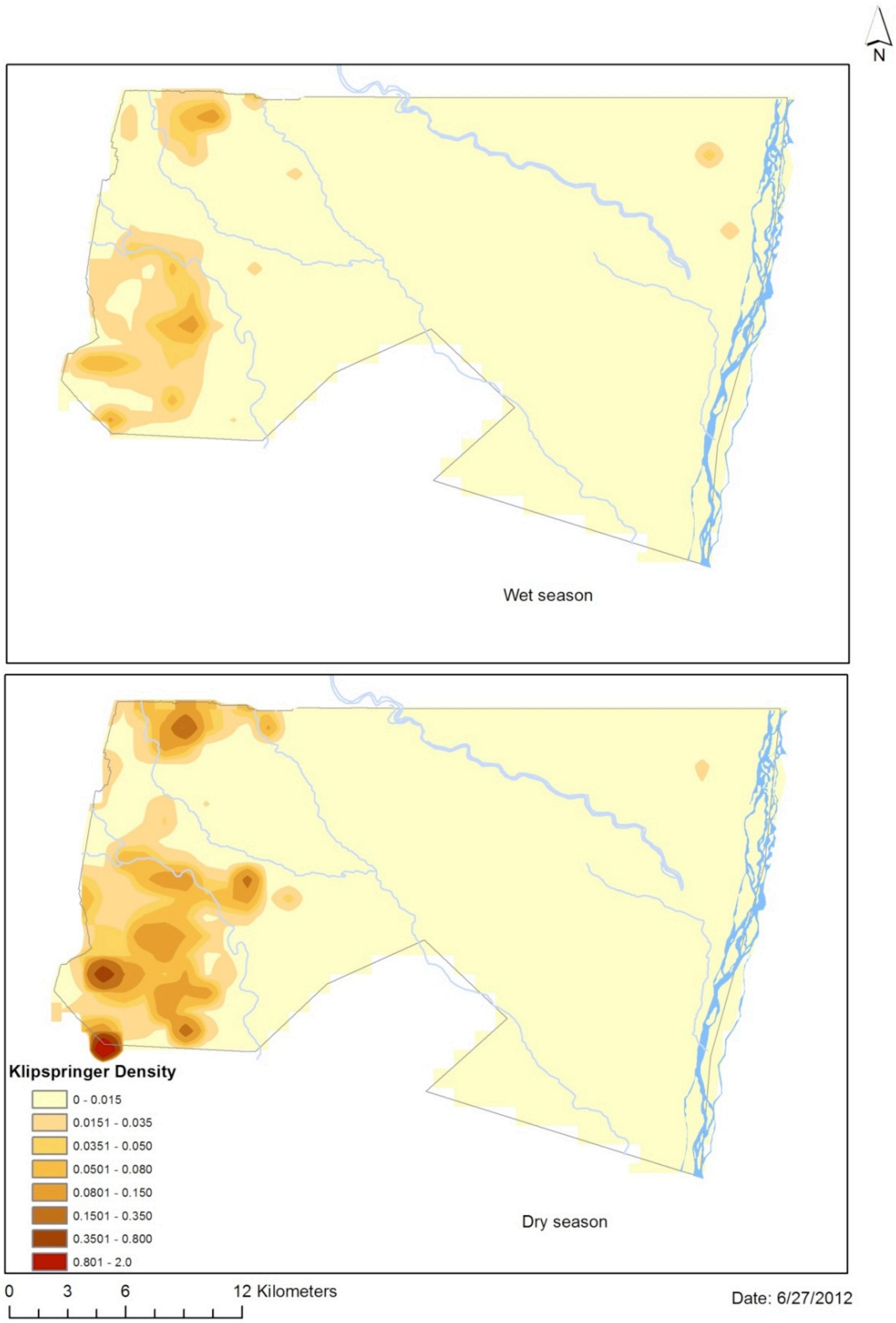


Figure 8.13c: Relative density (animals/km^2) distribution of klipspringer on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.12 Greater kudu (*Tragelaphus strepsiceros*)

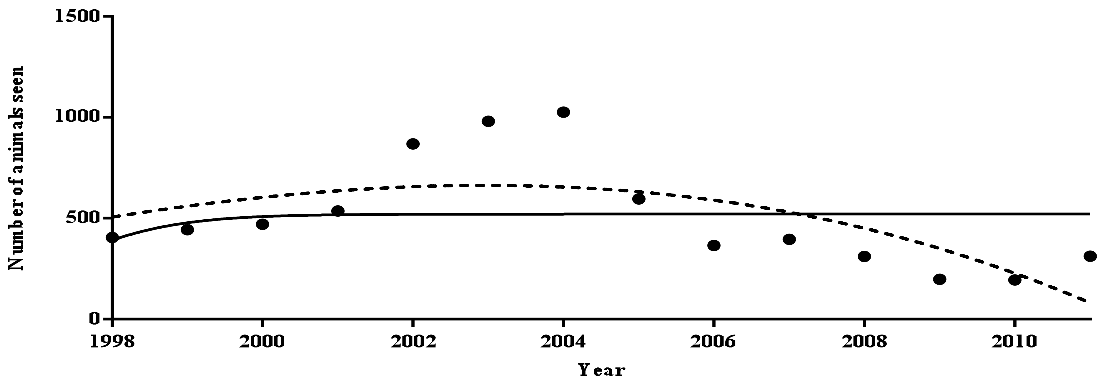
The greater kudu population increased up until 2004, when 1 026 greater kudu were recorded in the aerial survey. The 2010 aerial survey recorded the lowest count at 194 greater kudu seen (Table 8.3).

The aerial survey trend for the greater kudu population indicated an initial increase of the population up until 2004 after which the population decreased steadily until 2010 (Figure 8.14a). Trend line data for the sighting frequency for greater kudu indicated a consistent decline in the greater kudu population (Figure 8.14b). The relative density data indicated that the greater kudu population decreased since early 2000, but was recovering at a slow rate (Figure 8.14c). The greater kudu population suffered large die-offs during the 1999/2000 wet season due to poisoning by *Crotalaria* spp. and in 2004 with the outbreak of anthrax during the hot dry season. Additionally, the recovery of the greater kudu population was hampered by the introduction of lion on Sango Ranch in 2005. During the initial stages after re-introduction of lion, the greater kudu were regularly hunted and killed by lion (Joubert pers. obs).

High densities of greater kudu were recorded in and along the Save in the *Diospyros mespiliformis* Riverine Management Unit and the *Echinochloa colona* Wetland Management Unit (Table 8.5). Greater kudu regularly occurred in the *Xanthocercis zambesiaca* Closed Woodland Management Unit and the *Combretum apiculatum* Woodland Management Unit. During the wet season greater kudu also regularly selected the *Acacia tortilis* Open Woodland Management Unit and the *Colophospermum mopane Closed Woodland* Management Unit (Figure 8.14d & Figure 8.14e). The *Kirkia acuminata* Woodland Management Unit recoded low densities of greater kudu for both the dry season and wet season.

The mean birth rate for greater kudu was 14.2% (range 8.8% to 21.9%) with a mean survival rate into the first year of 12.4% (range 6.5% to 14.8%).

a.



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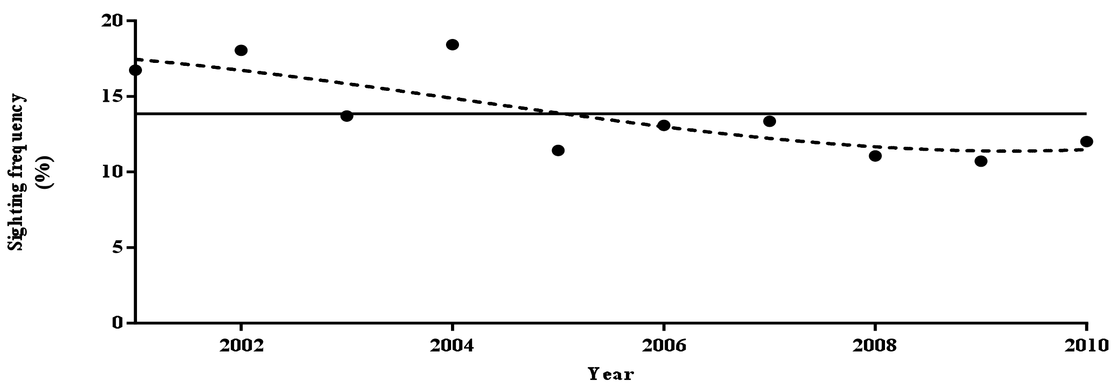

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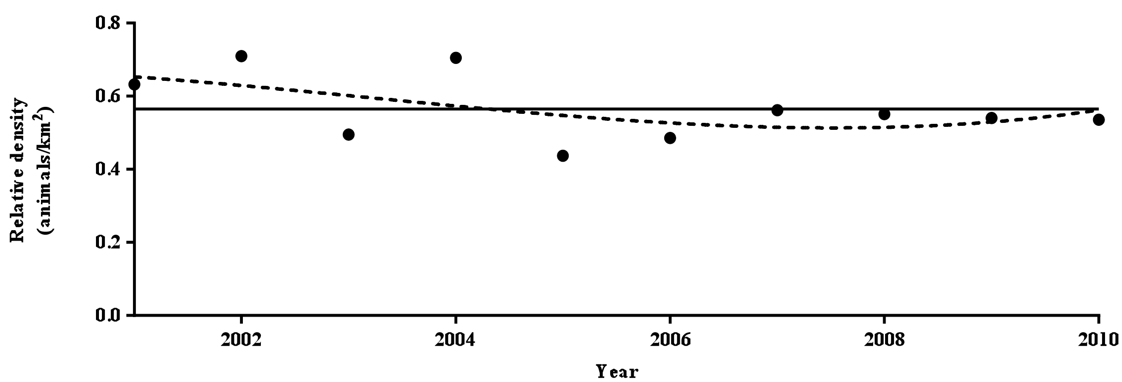


Figure 8.14a-c: Population trends for greater kudu on Sango Ranch, Save Valley Conservancy. (a) Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p = 0.4816$; - - - $p = 0.0388$; (b) —— $p = 0.0352$; - - - $p = 0.0014$; (c) —— $p = 0.0103$; - - - $p = 0.0035$.

Figure 8.14d: Distribution of greater kudu on Sango Ranch from aerial surveys conducted since 2002.

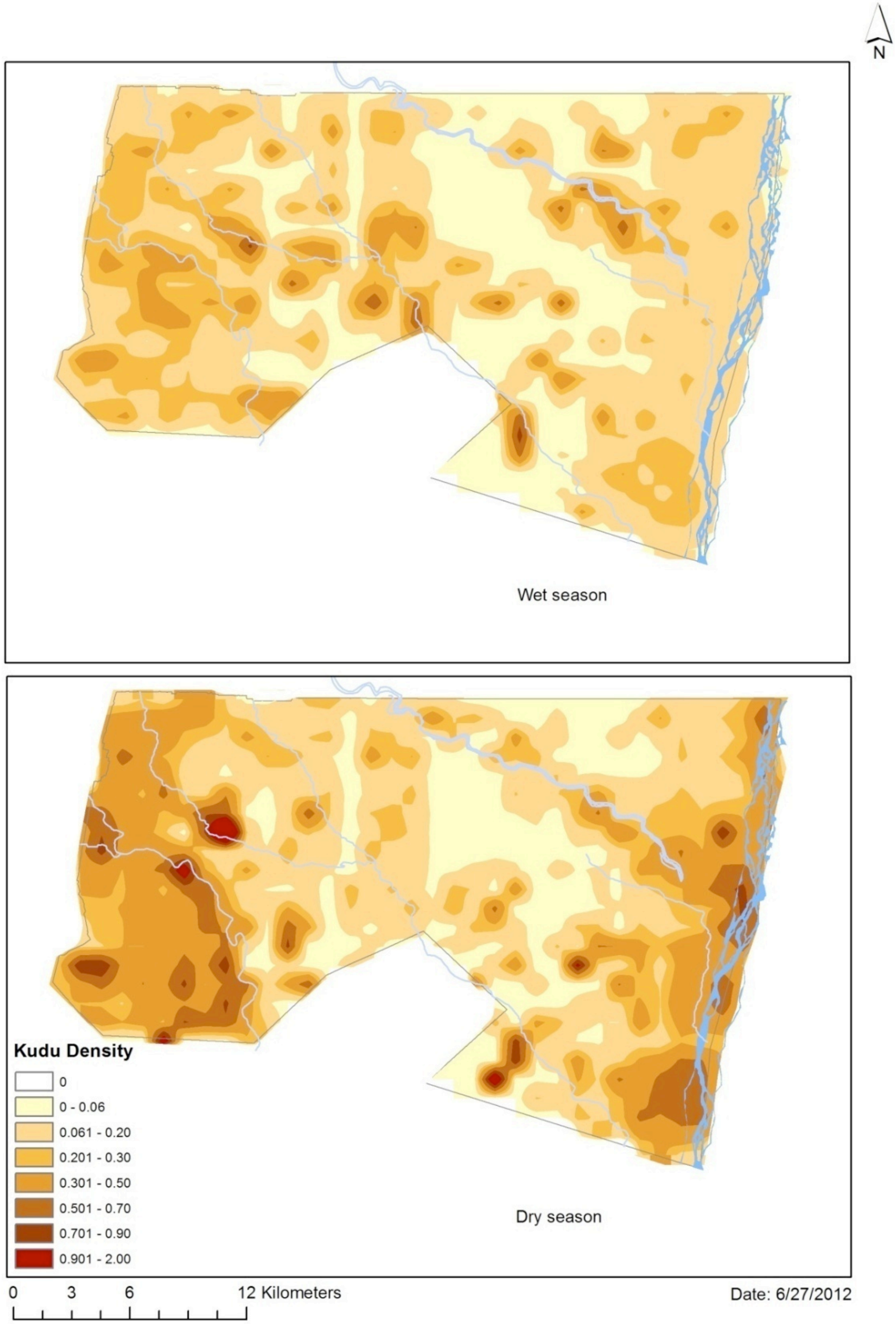
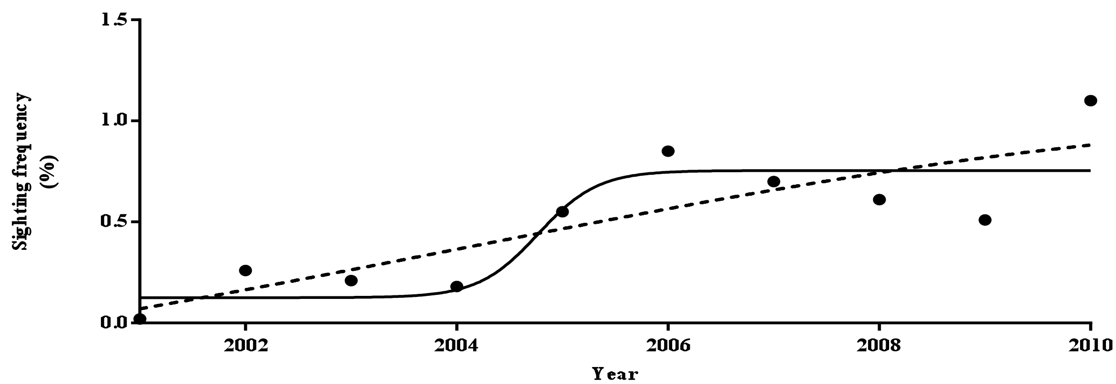


Figure 8.14e: Relative density (animals/km^2) distribution of greater kudu on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.13 Nyala (*Tragelaphus angasii*)

The nyala population was estimated using the known group method. Overall, the population has remained small with a maximum number of 41 nyala counted during 2011 on Sango Ranch. In 1998 and 1999 three nyala bulls were recorded along the Save River but soon after disappeared. Since the release of 26 nyala in 2002 the number of nyala remained approximately between 15 and 40 individuals. Despite a high birth rate (33%) the population remained small, which was attributed mainly to predation.

a.



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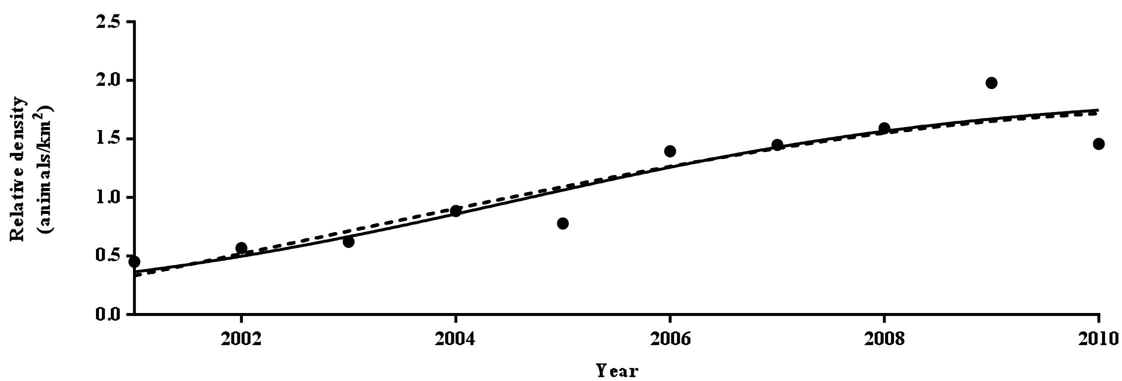


Figure 8.15a-b: Population trends for nyala on Sango Ranch, Save Valley Conservancy. (a). Sighting frequency from 2001 to 2010; and (b) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0122; - - - p = 0.0178; (b) —— p = 0.0082; - - - p = 0.0190.

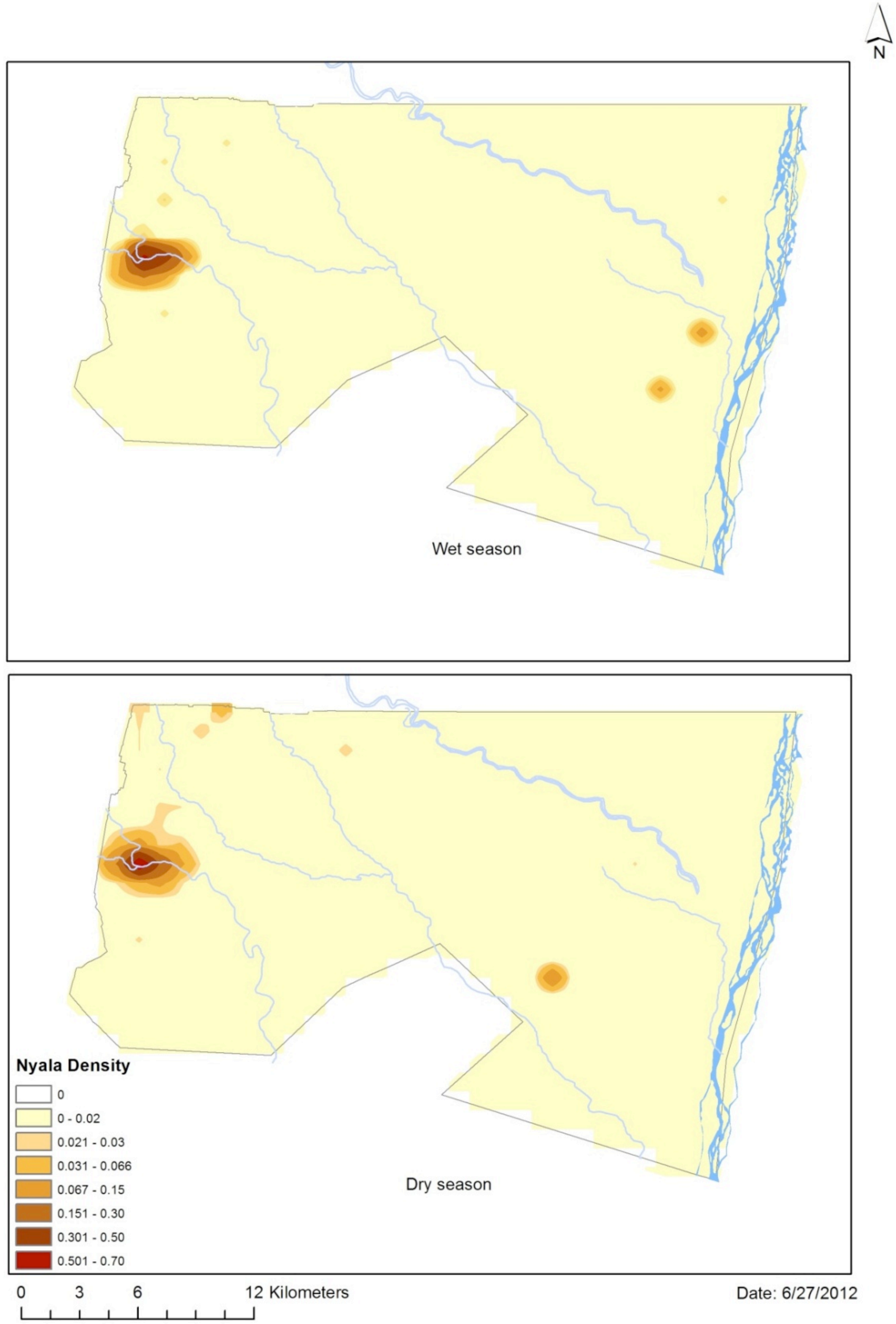


Figure 8.15c: Relative density (animals/km^2) distribution of nyala on Sango Ranch derived from the grid square method (2001 – 2010).

In September 2009 a decision was taken to breed nyala in an attempt to increase the breeding potential of this population. The breeding program started with one nyala bull and four ewes and has since increased to 22 animals of which eight individuals have been successfully released along the Save River.

Trend information based on the 3rd order polynomial regression for both the sighting frequency and relative density estimates indicated an increasing nyala population. However, the logistic regression for sighting frequency levelled off since 2005 (Figure 8.15a) and 2006 (Figure 8.15b) and was largely as a result of predation on a small population rather than a reflection of a population regulated through ecological constraints.

Since the introduction of nyala, the highest density has remained in the vicinity of the release site close to Sango Lodge in the *Combretum apiculatum* Woodland Management Unit. Recently, small groups of nyala were also recorded along the Save River in the *Acacia tortilis* Closed Woodland and the *Diospyros mespiliformis* Riverine Management Units (Figure 8.15c). During the wet season nyala regularly selected the *Acacia tortilis* Open Woodland Management Unit whilst nyala only utilized it occasionally during the dry season (Table 8.5).

8.3.1.14 Sable antelope (*Hippotragus niger*)

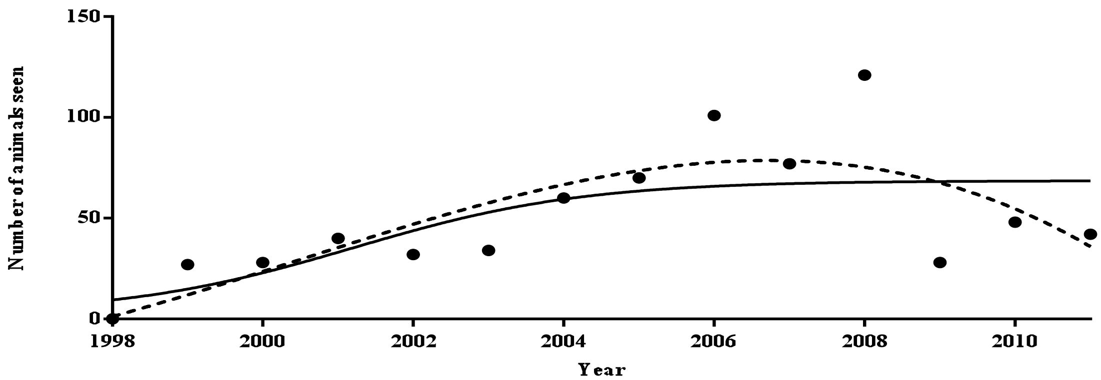
The sable antelope population increased from none seen in 1998 to 121 counted during the 2008 aerial survey. Sable antelope was re-introduced onto Sango Ranch in 2001 when 31 animals were released at Nyamutondo along the Mokore River.

The trend information from annual aerial surveys suggested that the sable population on Sango Ranch had reached ecological capacity from approximately 2005 to 2006. Since 2008 the number of sable antelope has sharply decreased on Sango Ranch (Figure 8.16a). The sable antelope population trend based on the sighting frequency suggested that the population was still increasing (Figure 8.16b) whilst the population trend based on relative density estimates (Figure 8.16c) followed the typical sigmoidal growth curve associated with growing animal populations and suggested that the sable population had reached ecological capacity during the 2007/2008 season.

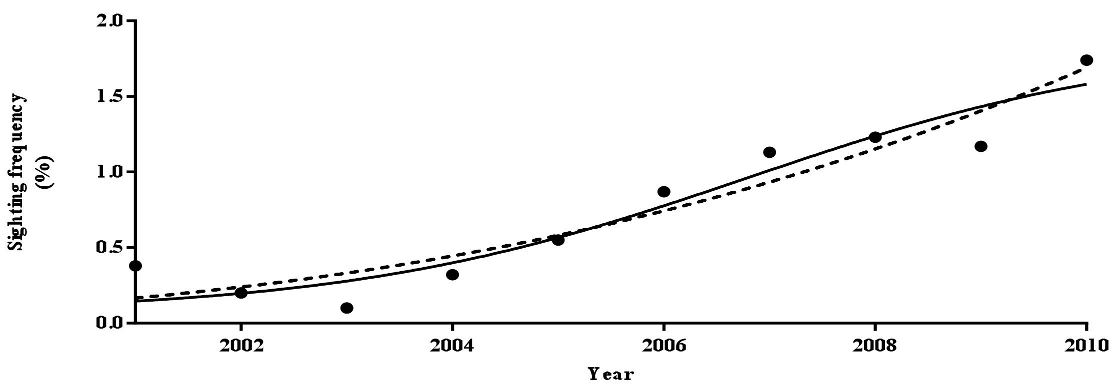
The two highest relative densities were recorded during 2007 and 2008, whilst the relative density estimates for the sable antelope population declined during 2009 and 2010. This declining population suggested that the sable antelope population was decreasing but also that movement occurred between properties.

Sable antelope occurred almost exclusively in the *Combretum apiculatum* Woodland Management Unit, although they also occurred in the *Diospyros mespiliformis* Riverine Management Unit along the Mokore River (Table 8.5, Figure 8.16d & Figure 8.16e). Despite a mean calving rate for sable antelope of 25% and a survival rate into the first year of 19% the sable antelope numbers decreased.

a.



b.



c.

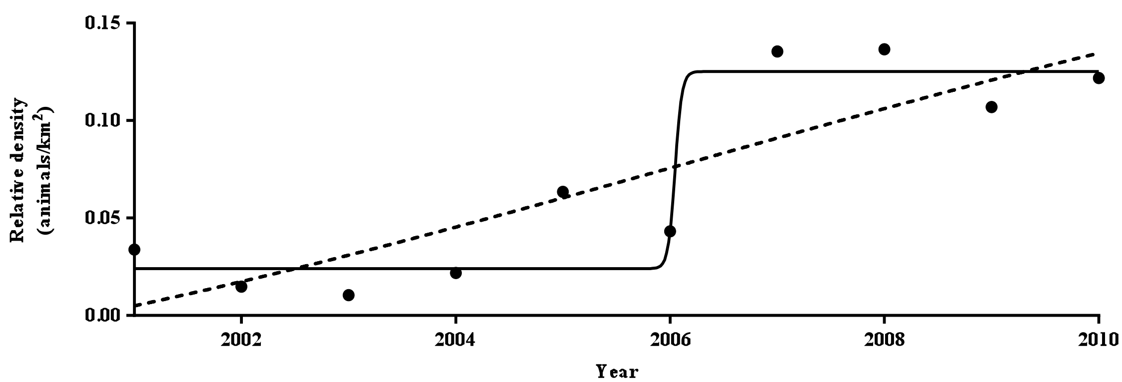


Figure 8.16a-c: Population trends for sable antelope on Sango Ranch, Save Valley Conservancy. (a). Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0713; - - - p = 0.0135; (b) —— p = 0.0003; - - - p = 0.0003; (c) —— p = 0.0013; - - - p = 0.0129.

Figure 8.16d: Distribution of sable antelope on Sango Ranch from aerial surveys conducted since 2002.

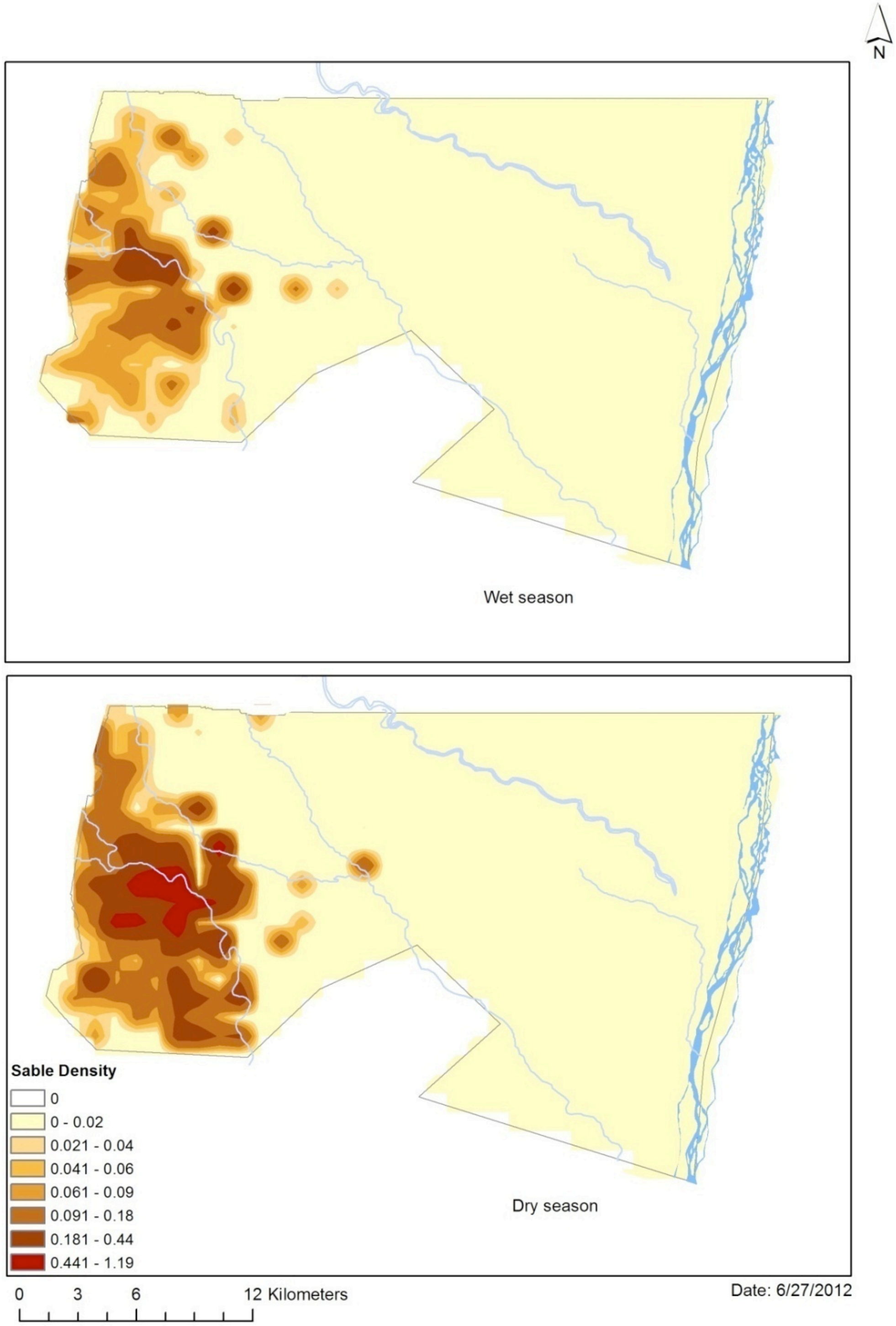
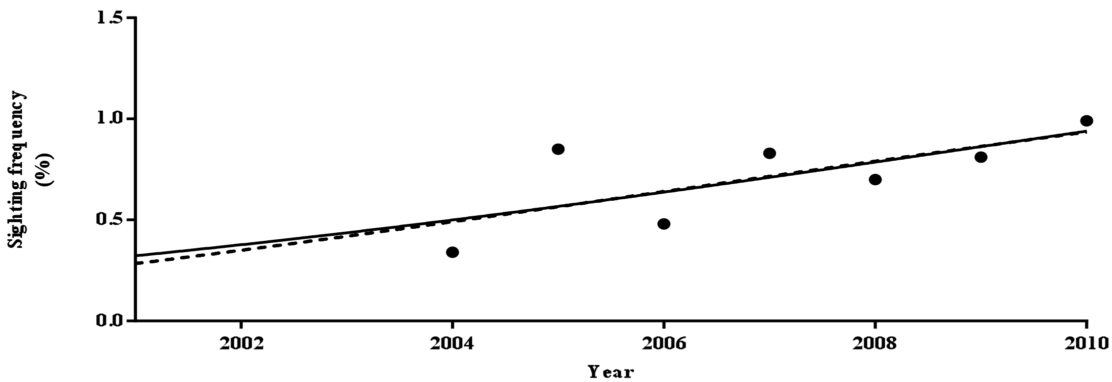


Figure 8.16e: Relative density (animals/km^2) distribution of sable antelope on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.15 Sharpe's grysbuck (*Rhaphicerus sharpei*)

Population trend information was gathered for Sharpe's grysbuck using the grid square method. The sighting frequency and relative density estimates both suggested that the Sharpe's grysbuck population are still on the increase however a subjective assessment of the rate of increase suggested that the population was nearing ecological capacity (Figure 8.17a & 8.17b). Sharpe's grysbuck was recorded in the *Combretum apiculatum* Woodland as well as in the vicinity of the *Echinochloa colona* Wetland Management Units (Figure 8.17c).

a.



b.

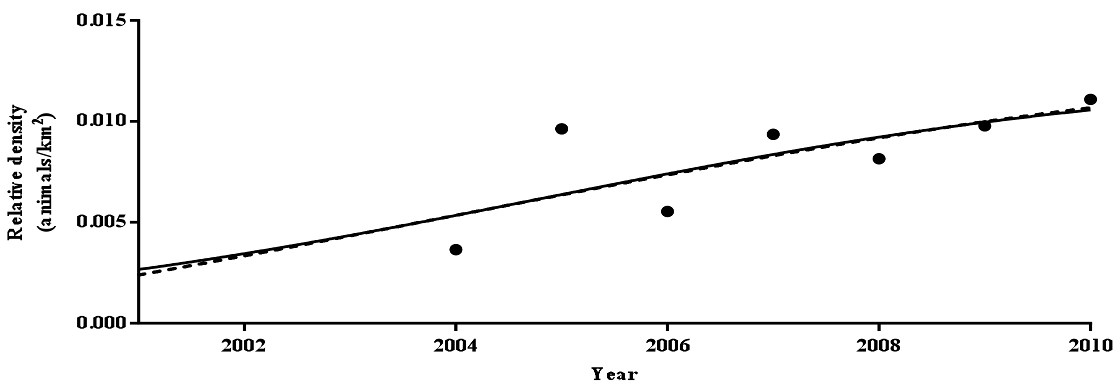


Figure 8.17a-b: Population trends for Sharpe's grysbuck on Sango Ranch, Save Valley Conservancy. (a). Sighting frequency from 2001 to 2010; and (b) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0017; - - - p = 0.0039; (b) —— p = 0.0291; - - - p = 0.0025.

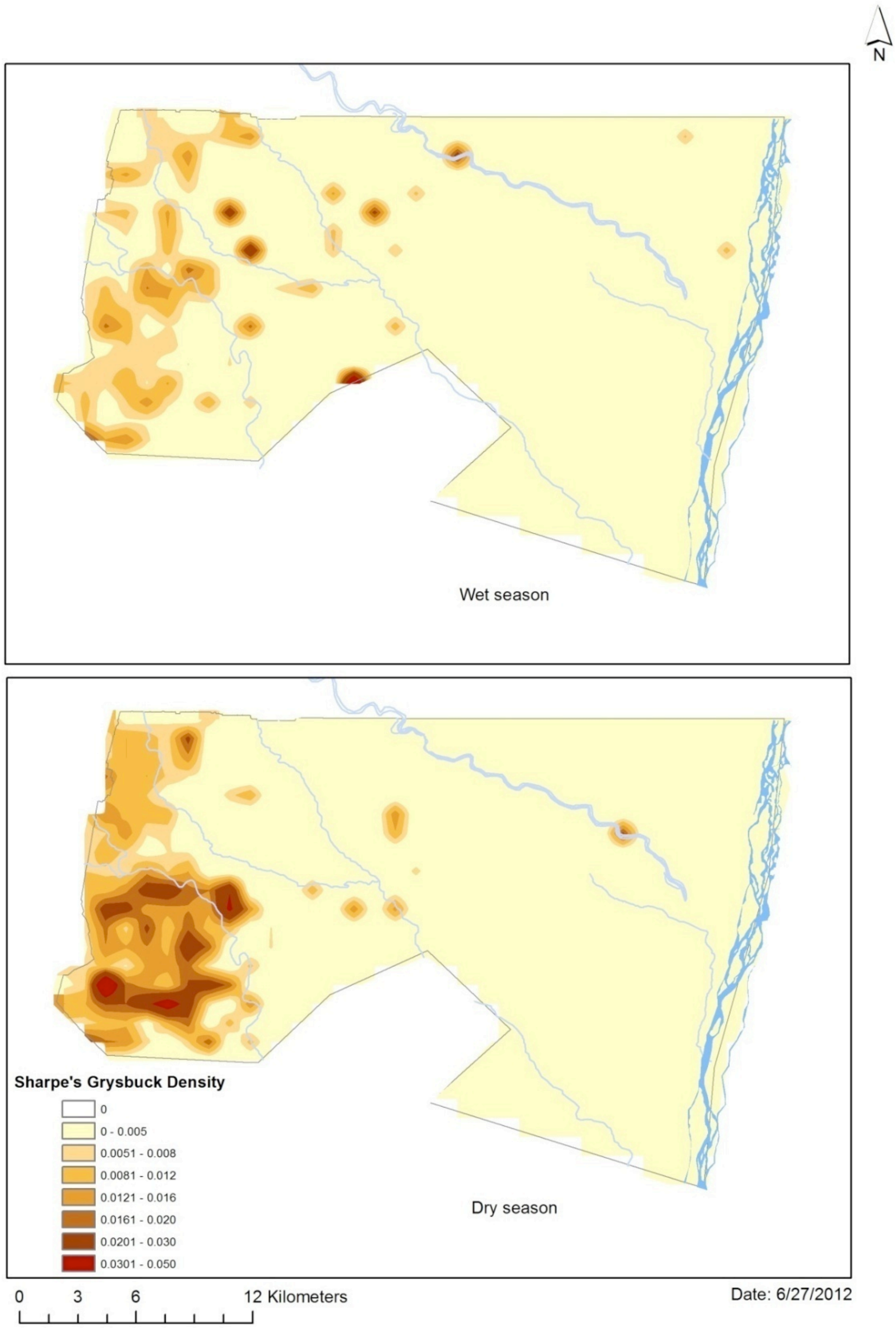


Figure 8.17c: Relative density (animals/km^2) distribution of Sharpe's grysbuck on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.16 Warthog (*Phacochoerus africanus*)

The warthog population peaked in 2004 with a total of 2 009 animals seen during the aerial survey, whilst the 1998 count was the lowest with only 77 warthog recorded (Table 8.3). Road strip counts conducted in 1998 by Hin (2000) estimated the warthog population at 312 individual animals whilst the 2011 road strip count estimated a total of 1 634 warthog for Sango Ranch. Road strip counts thus suggested a general increase in the size of the warthog population although the population could have fluctuated between years.

Trend data obtained from aerial surveys suggested that the warthog population increased from 1998 until 2004 whereafter it decreased. The sighting frequency (Figure 8.18b) and relative density graphs (Figure 8.18c) indicated similar trends for the warthog population as the aerial survey (Figure 8.18a). Overall, warthog population trends suggested that warthog had reached ecological capacity during the 2002/2003 seasons and were fluctuating at ecological equilibrium.

Warthog occurred throughout all management units with lower densities recorded for the *Colophospermum mopane* Woodland and *Kirkia acuminata* Woodland Management Units (Figure 8.18d & Figure 8.18e).

The mean birth rate for warthog was 42.2% (range 22.8% to 56%) with a mean survival rate into the first year of 23.3% (range 9.9% to 38.1%).

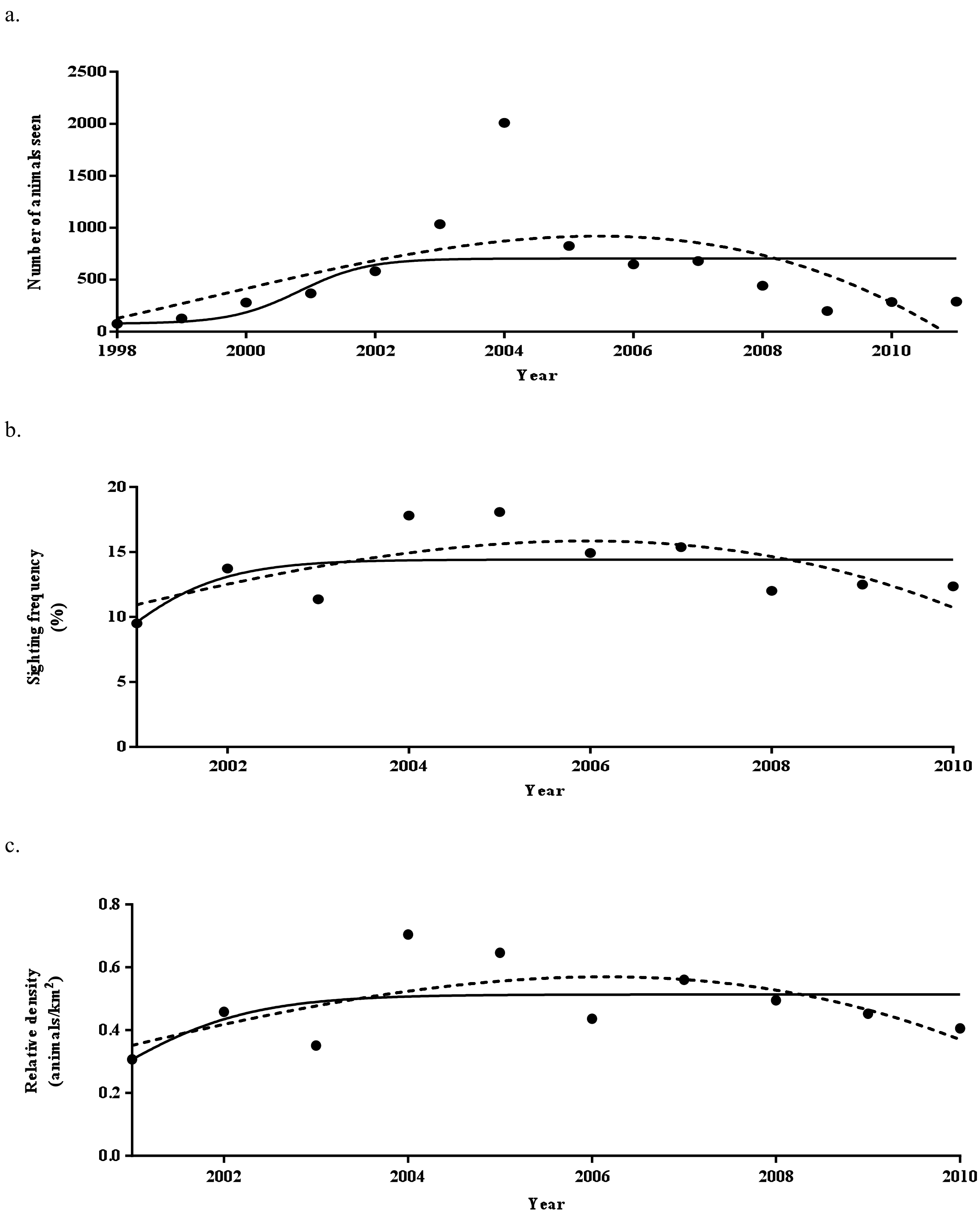


Figure 8.18a-c: Population trends for warthog on Sango Ranch, Save Valley Conservancy. (a). Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.3493; - - - p = 0.1080; (b) —— p = 0.0096; - - - p = 0.0033; (c) —— p = 0.0312; - - - p = 0.0151.

Figure 8.18d: Distribution of warthog on Sango Ranch from aerial surveys conducted since 2002.

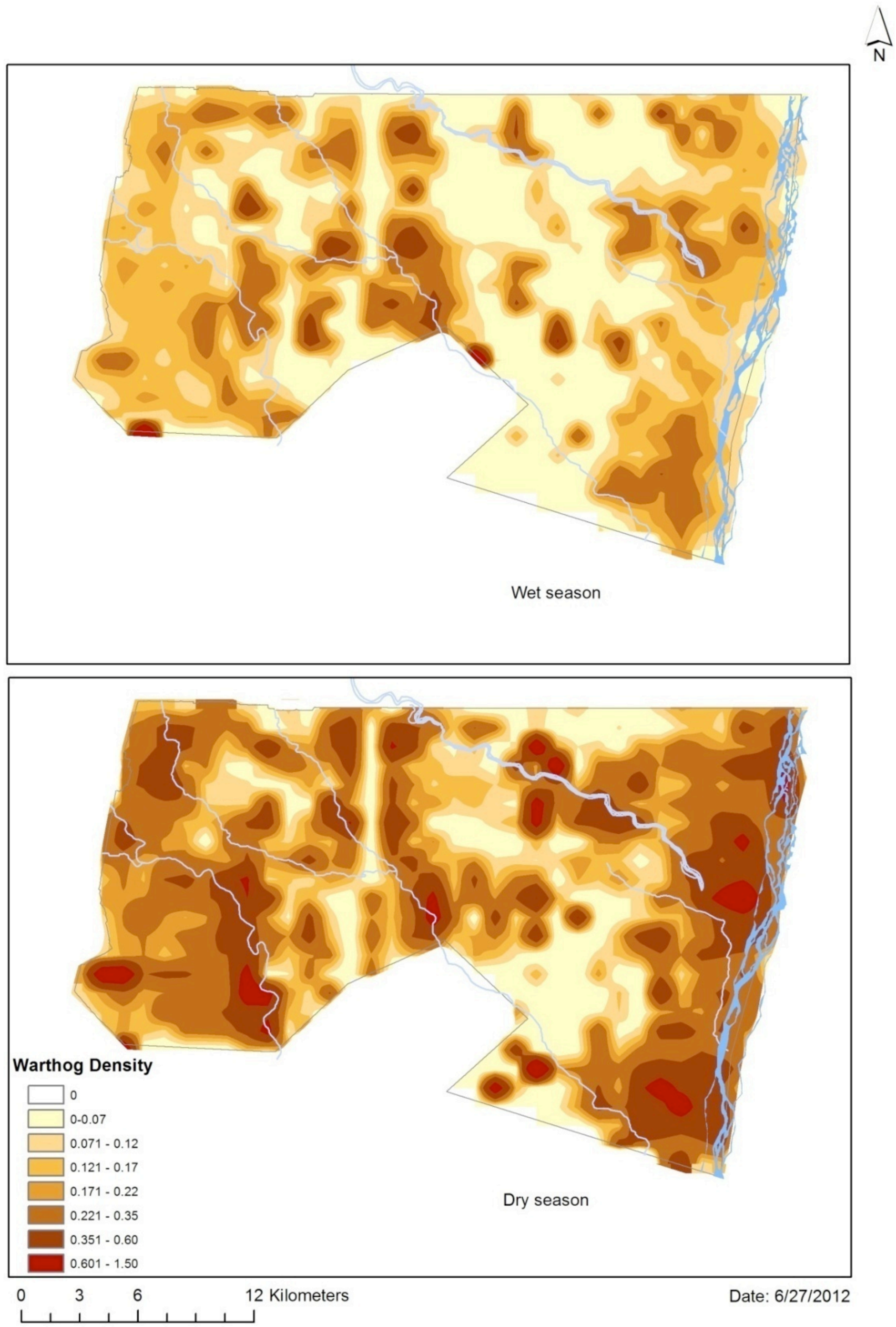


Figure 8.18e: Relative density (animals/km^2) distribution of warthog on Sango Ranch derived from the grid square method (2001 – 2010).

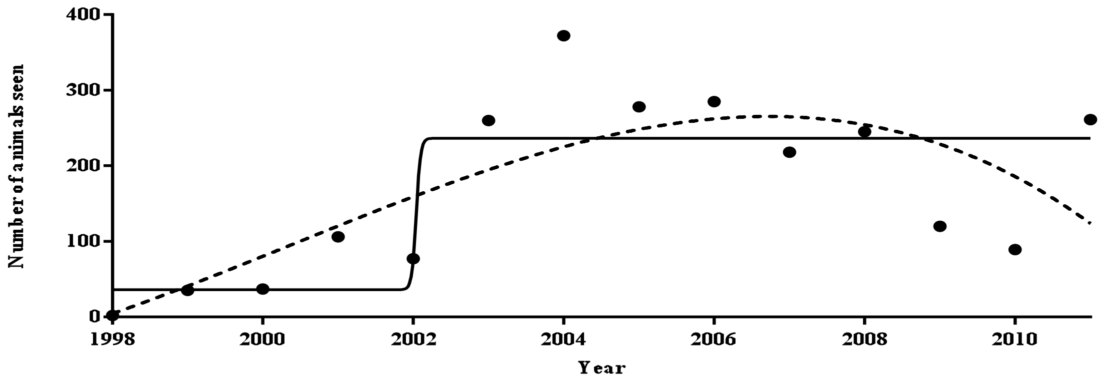
8.3.1.17 Waterbuck (*Kobus ellipsiprymnus*)

The waterbuck population increased from only 2 animals seen during the 1998 aerial survey to 372 waterbuck recorded in 2004 (Table 8.3). In 2002, the waterbuck population was supplemented with 29 animals that were released at the Mokore River Bridge west of the Sango Lodge.

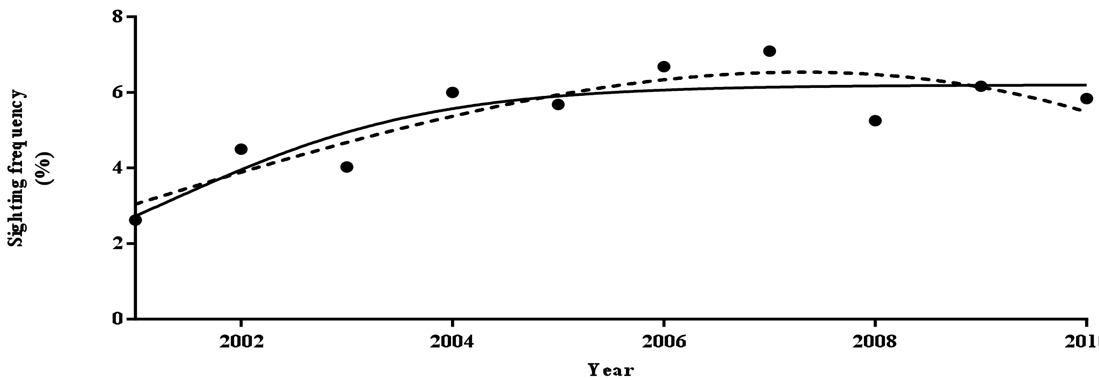
The population trend obtained from aerial surveys indicated that the waterbuck population increased rapidly until 2004, maintained population numbers until 2008, decreased during 2009 and 2010 and in 2011 recovered to 261 animals counted (Figure 8.19a). The sighting frequency (Figure 8.19b) and the relative density data (Figure 8.19c) both indicated a similar trend to the aerial survey data. It thus appeared that the waterbuck reached ecological capacity during the 2003/2004 season.

Waterbuck densities were highest in the *Diospyros mespiliformis* Riverine Management Unit followed by the *Echinochloa colona* Wetland Management Unit, the *Xanthocercis zambesiaca* Closed Woodland Management Unit and the *Combretum apiculatum* Woodland Management Unit (Figure 8.19d & Figure 8.19e). Waterbuck densities were especially high in the environs of the Save River and Dokwe dam as well as between the Musambe River and the Mokore River west of Sango Lodge.

a.



b.



c.

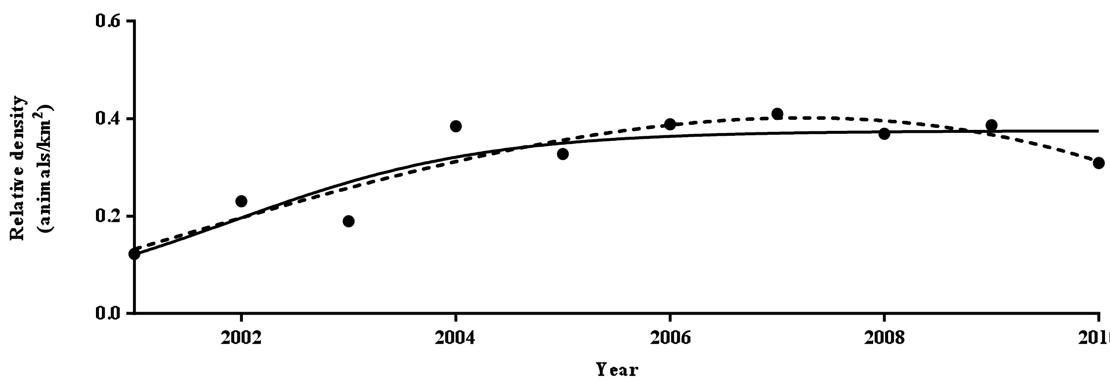


Figure 8.19a-c: Population trends for waterbuck on Sango Ranch, Save Valley Conservancy. (a) Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p = 0.0119$; - - - $p = 0.0257$; (b) —— $p = 0.0006$; - - - $p = 0.0005$; (c) —— $p = 0.0012$; - - - $p = 0.0004$.

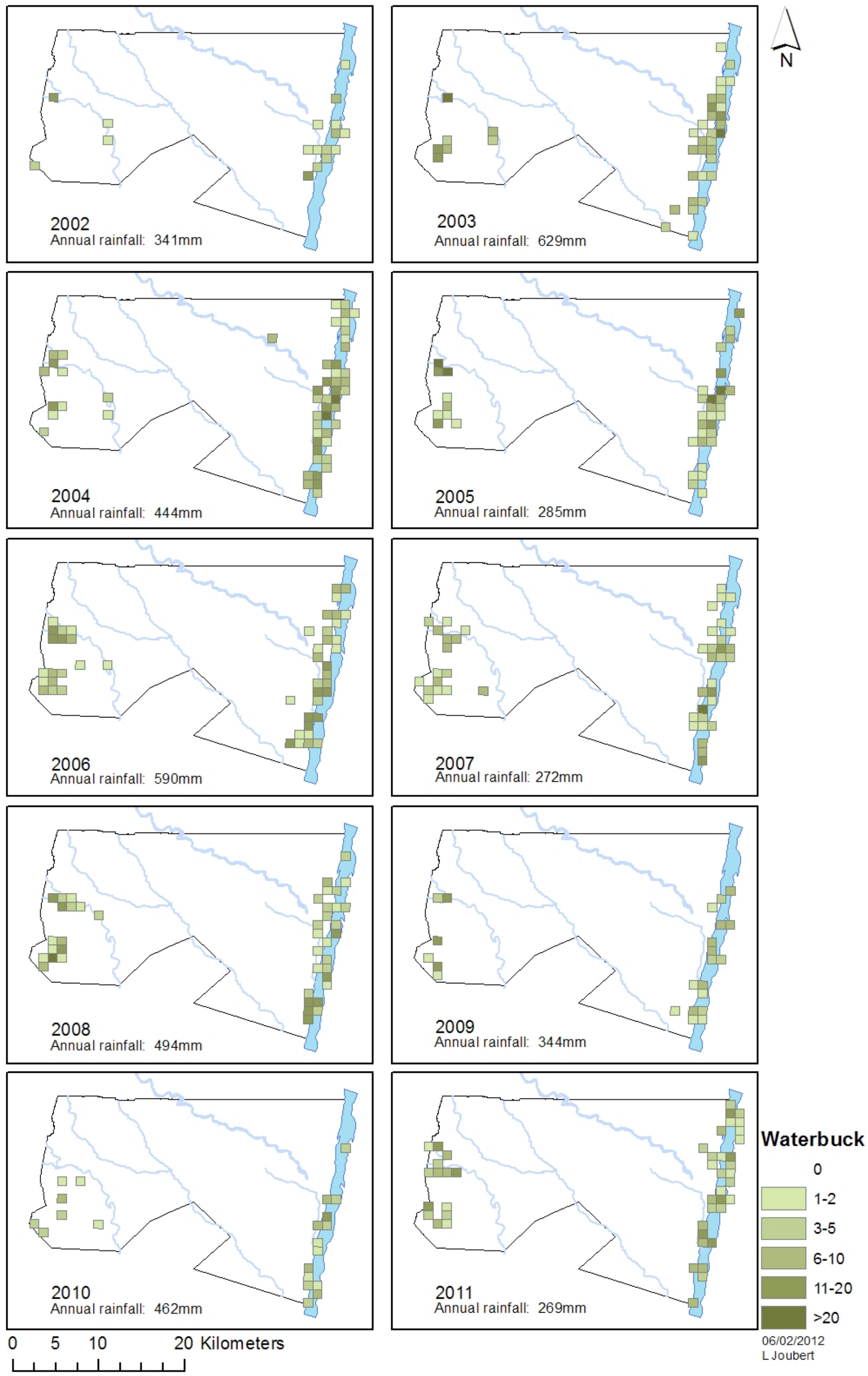


Figure 8.19d: Distribution of waterbuck on Sango Ranch from aerial surveys conducted since 2002.

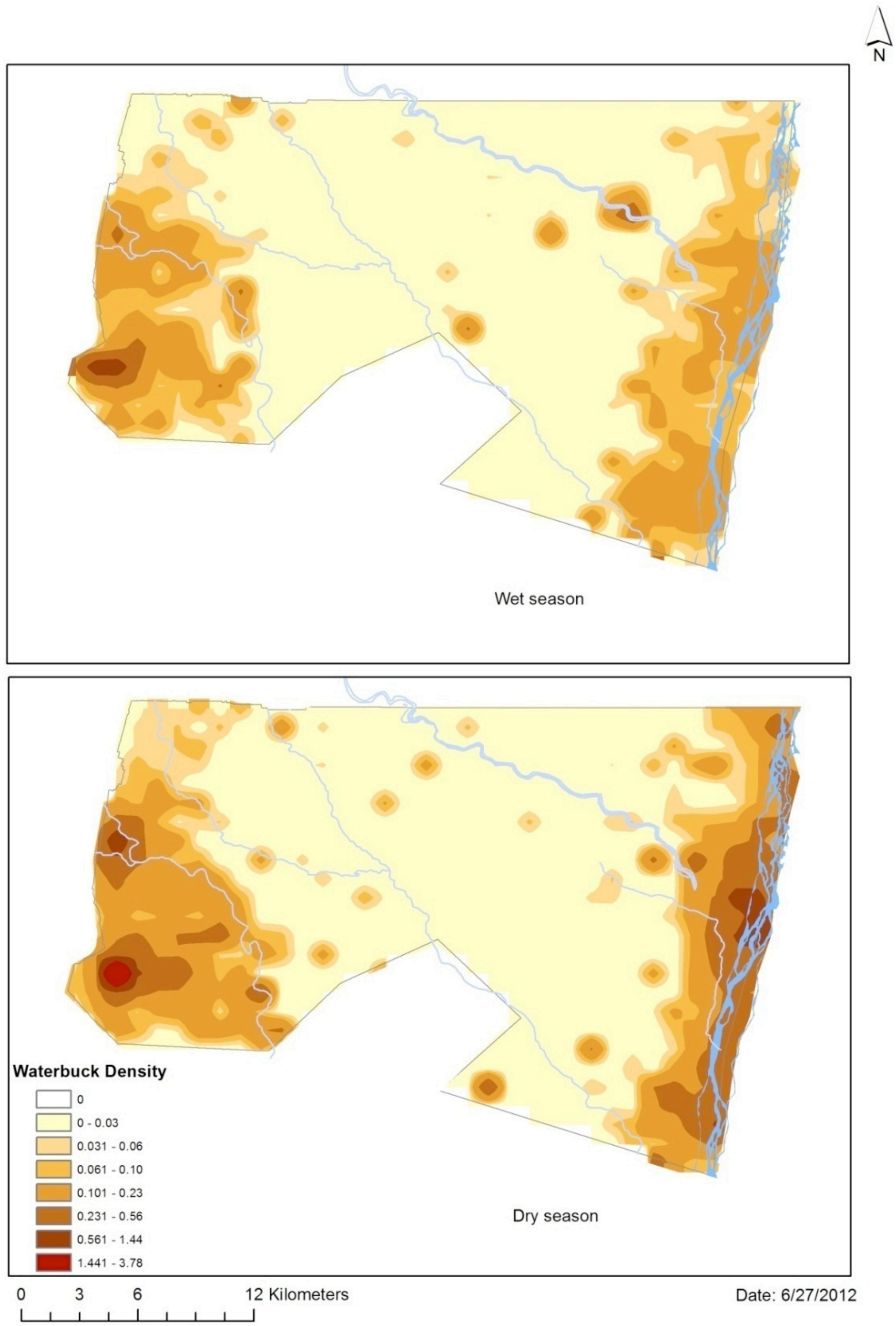


Figure 8.19e: Relative density (animals/km^2) distribution of waterbuck on Sango Ranch derived from the grid square method (2001 – 2010).

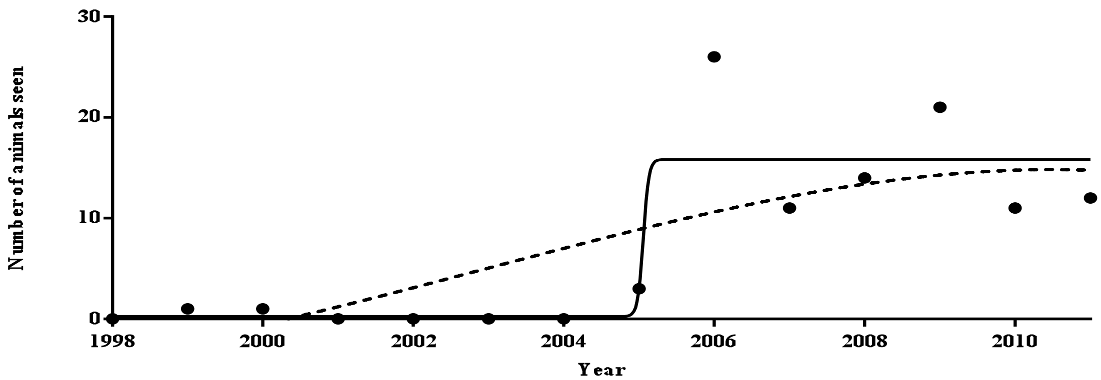
8.3.1.18 White rhinoceros (*Ceratotherium simum*)

Only one white rhinoceros was known to occur on Sango Ranch prior to 2005. The supplementation of 20 white rhinoceros to the population in 2005 explained the notable increase in 2006.

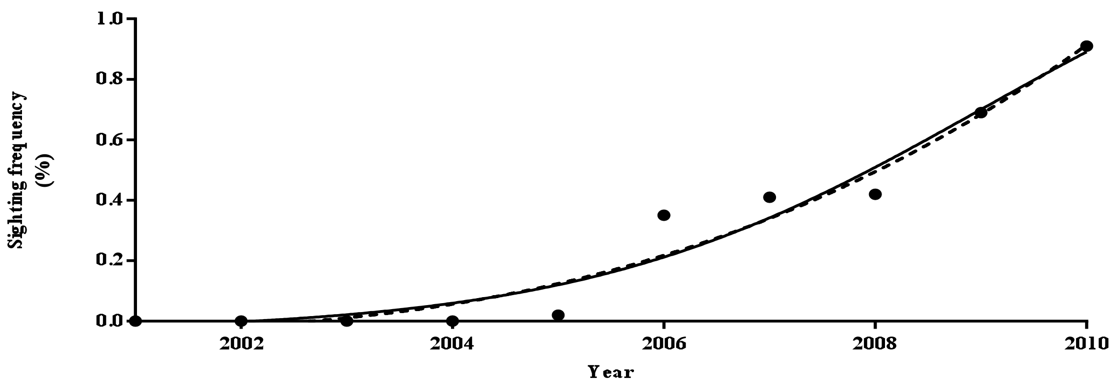
According to the aerial survey population trend it appeared that the white rhinoceros population on Sango Ranch had already reached ecological capacity (Figure 8.20a). However, the grid square data contradicted the findings of the aerial survey and suggested that the white rhinoceros population was still increasing. Sighting frequency data indicated a white rhinoceros population that was steadily increasing, whereas the relative density estimates indicated a similar rate of increase (Figure 8.20b & 8.20c). White rhinoceros have the ability to travel considerable distances and the fluctuating numbers of white rhinoceros seen during the aerial surveys were due mainly to movement onto neighbouring properties.

White rhinoceros frequently selected the *Combretum apiculatum* Woodland Management Unit (Table 8.5) whilst the *Acacia tortilis* Open Woodland Management Unit was also regularly occupied. During the dry months the *Colophospermum mopane* Closed Woodland Management Unit, the *Xanthocercis zambesiaca* Closed Woodland Management Unit and the *Echinochloa colona* Wetland Management Unit where regularly selected whilst the *Kirkia acuminata* Woodland Management Unit were also favoured during the wet season (Figure 8.20d & Figure 8.20e).

a.



b.



c.

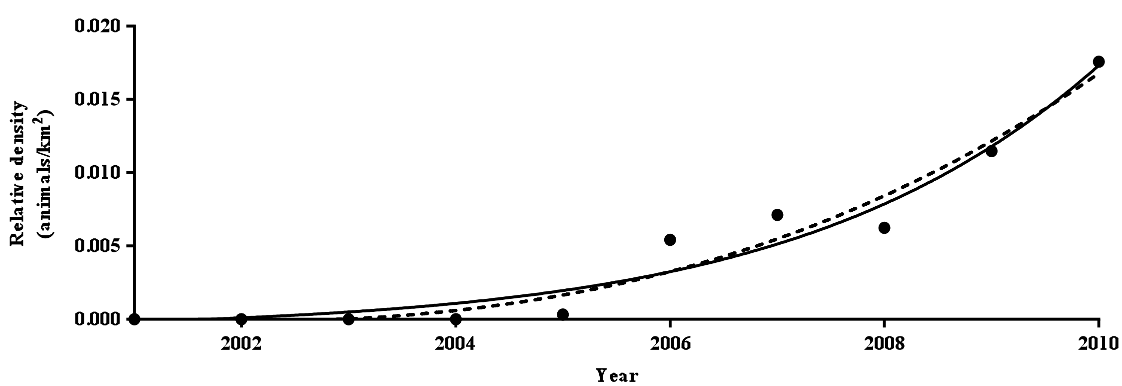


Figure 8.20a-c: Population trends for white rhinoceros on Sango Ranch, Save Valley Conservancy. (a) Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p = 0.0008$; - - - $p = 0.0425$; (b) —— $p = 0.0001$; - - - $p < 0.0001$; (c) —— $p = 0.0176$; - - - $p = 0.0002$.

Figure 8.20d: Distribution of white rhinoceros on Sango Ranch from aerial surveys conducted since 2002.

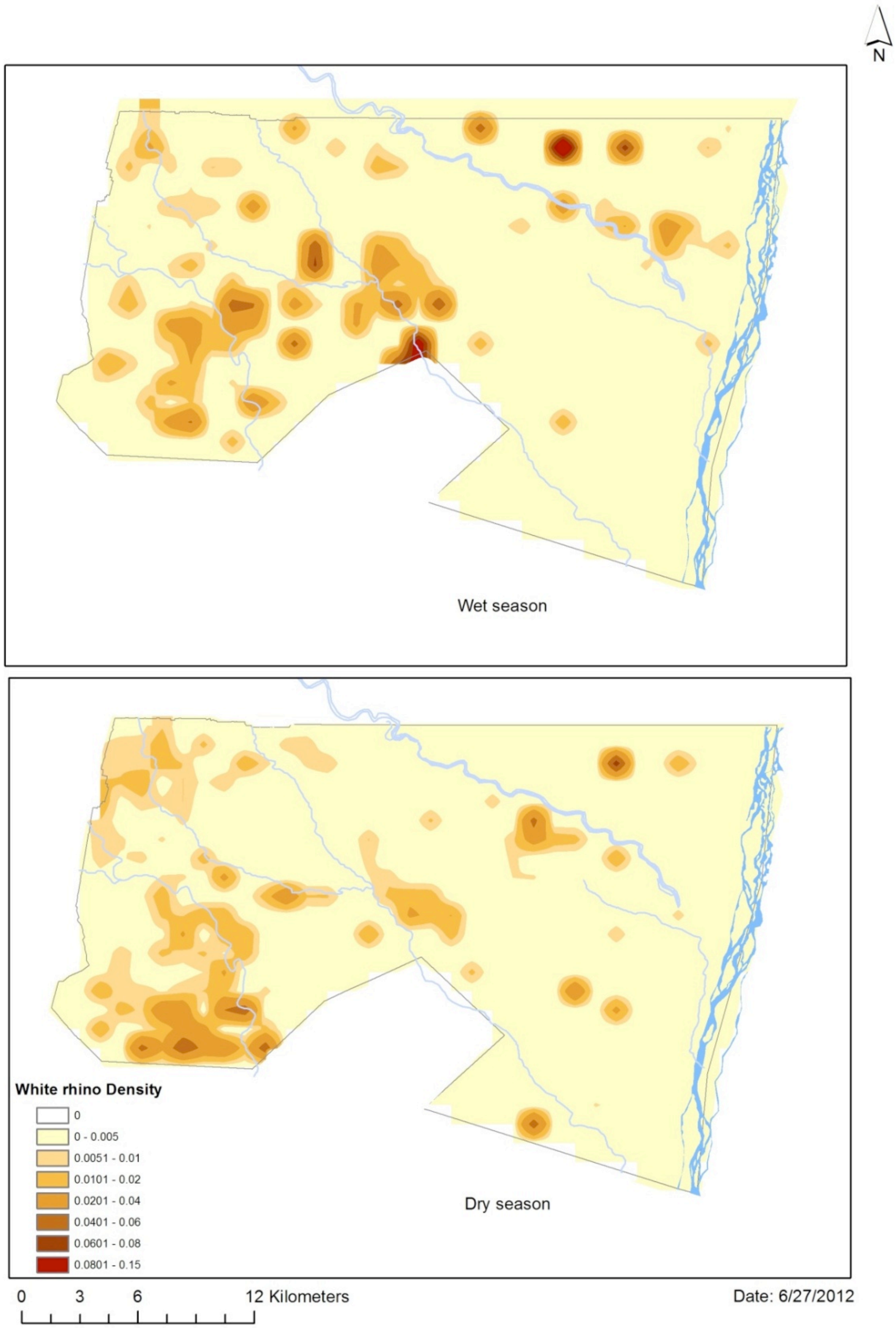


Figure 8.20e: Relative density (animals/km^2) distribution of white rhinoceros on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.19 Blue wildebeest (*Connochaetes taurinus*)

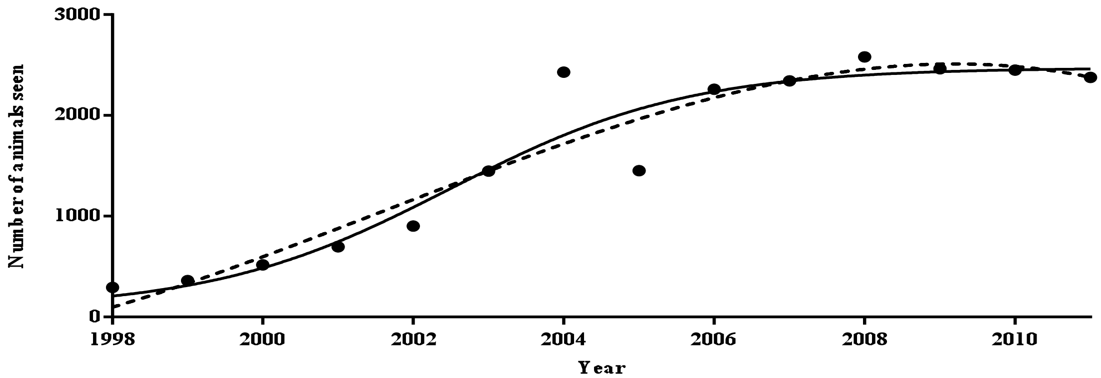
The blue wildebeest population increased from 294 animals seen in 1998 to 2 581 blue wildebeest counted during the 2008 aerial survey. Road strip counts conducted in 1998 (Hin, 2000) and in 2011 also indicted increases from 213 blue wildebeest in 1998 to 4 565 individuals in 2011.

Based on aerial survey results the population trend followed the sigmoidal growth curve (Figure 8.21a) and suggested that the blue wildebeest population had reached ecological capacity. The grid square population growth curves for the blue wildebeest suggested that the population was nearing ecological capacity (Figure 8.21b & Figure 8.21c).

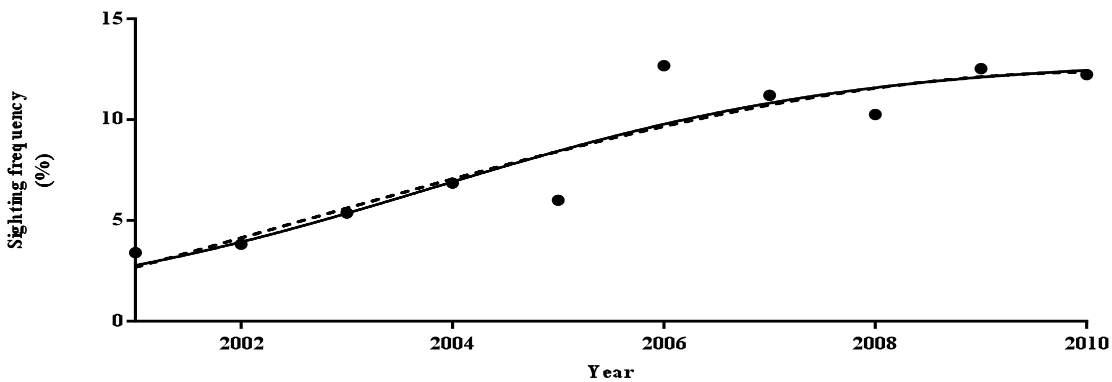
The aerials survey maps (Figure 8.21d) illustrate the movement of blue wildebeest from east to west as the environmental conditions got drier. Blue wildebeest selected a wide range of habitats with the highest densities recorded for the *Echinochloa colona* Wetland Management Unit whilst the *Combretum apiculatum* Woodland Management Unit, the *Xanthocercis zambesiaca* Closed Woodland Management Unit, the *Acacia tortilis* Open Woodland Management Unit, the Colophospermum mopane Closed Woodland Management Unit were regularly selected. The *Kirkia acuminata* Woodland Management Unit was also selected on a regular basis during the dry season (Figure 8.21d & Figure 8.21e). The *Diospyros mespiliformis* Riverine management unit recorded the lowest density of blue wildebeest.

The mean birth rate for blue wildebeest was 23.6% (range 15.9% to 28.6%) with a mean survival rate into the first year of 19.5% (range 13.4% to 24.2%).

a.



b.



c.

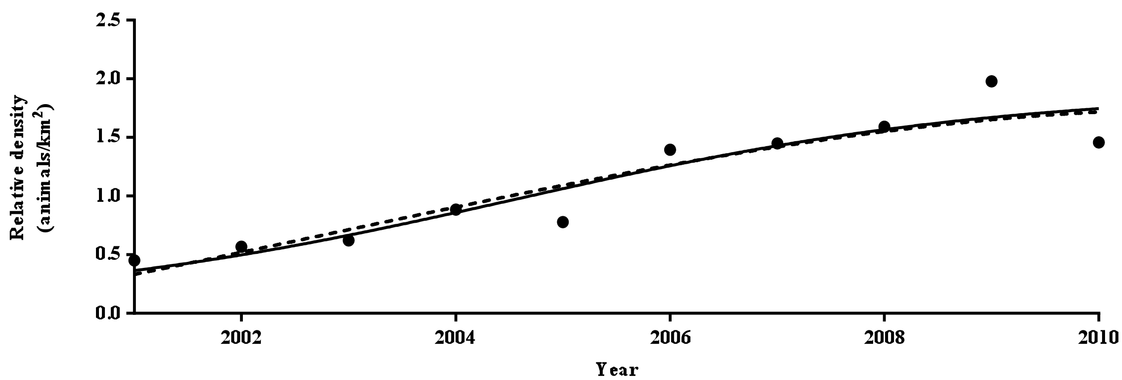


Figure 8.21a-c: Population trends for blue wildebeest on Sango Ranch, Save Valley Conservancy. (a) Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p < 0.0001$; - - - $p < 0.0001$; (b) —— $p = 0.0007$; - - - $p = 0.0008$; (c) —— $p = 0.0005$; - - - $p = 0.0006$.

Figure 8.21d: Distribution of blue wildebeest on Sango Ranch from aerial surveys conducted since 2002.

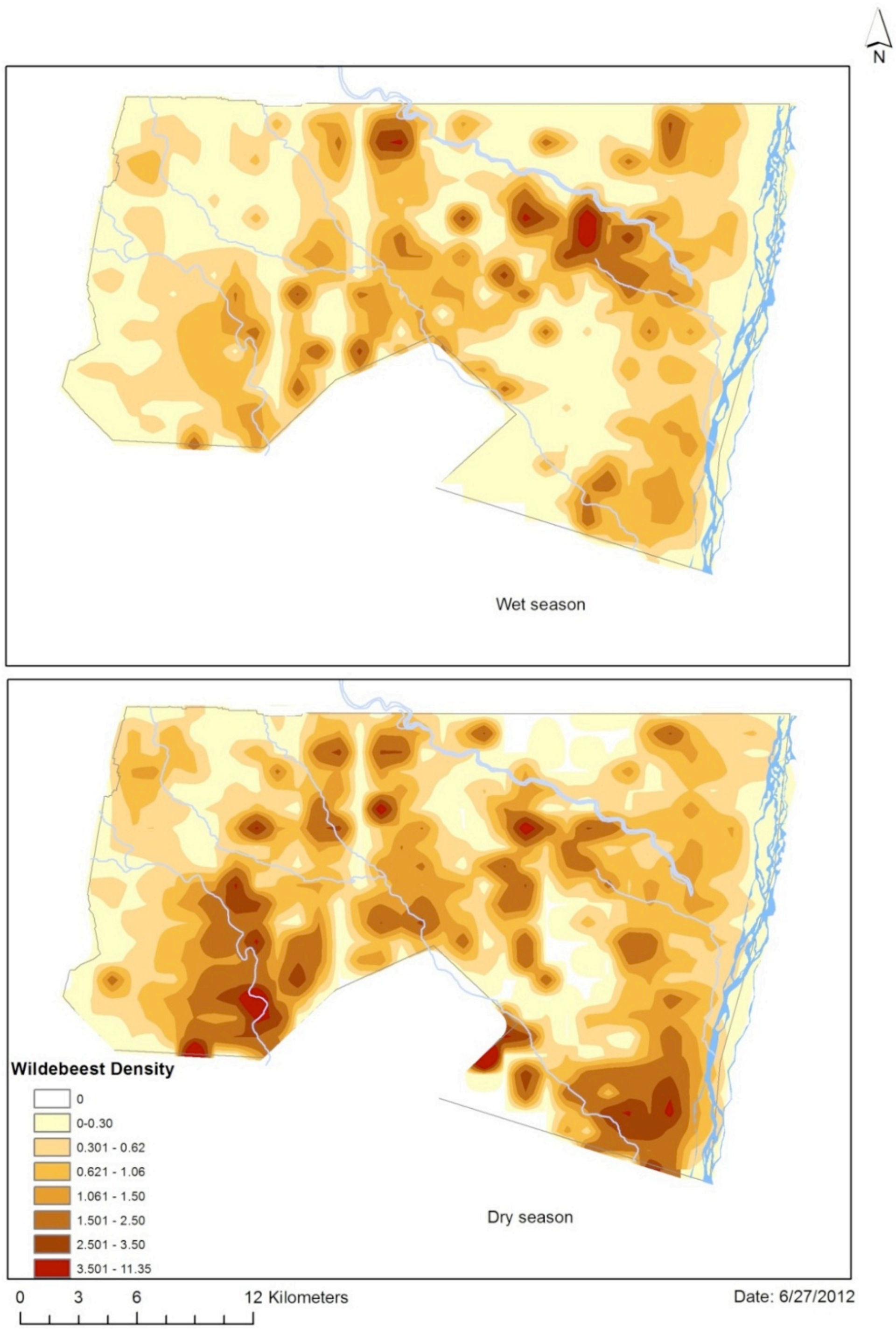


Figure 8.21e: Relative density (animals/km^2) distribution of blue wildebeest on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.1.20 Burchell's zebra (*Equus burchellii*)

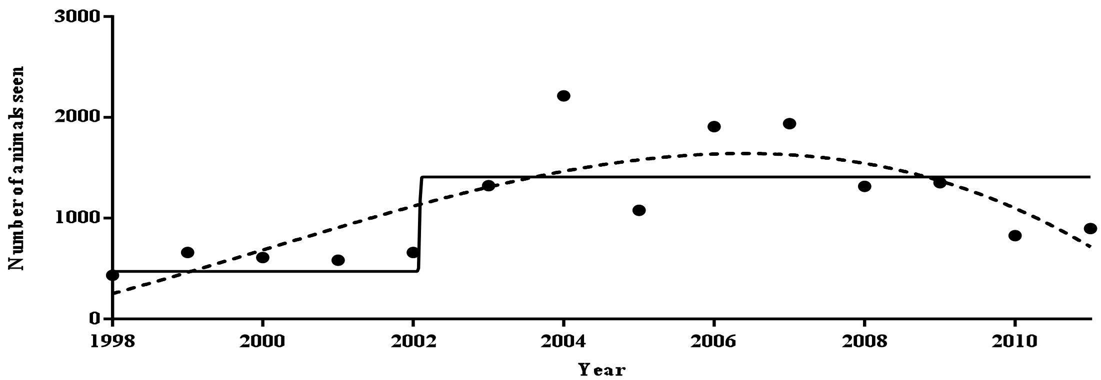
The Burchell's zebra population increased from 433 animals counted in 1998 to 2 214 Burchell's zebra seen during the 2004 aerial survey (Table 8.3). Road strip counts conducted in 1998 (Hin, 2000) and 2011 estimated the Burchell's zebra population at 538 and 3 308 animals respectively.

Aerial survey trend data indicated that the Burchell's zebra population had reached ecological capacity around 2005/2006 (Figure 8.22a). The grid square methods indicated that the Burchell's zebra population had not reached ecological capacity on Sango Ranch and was still increasing (Figure 8.22b & 8.22c).

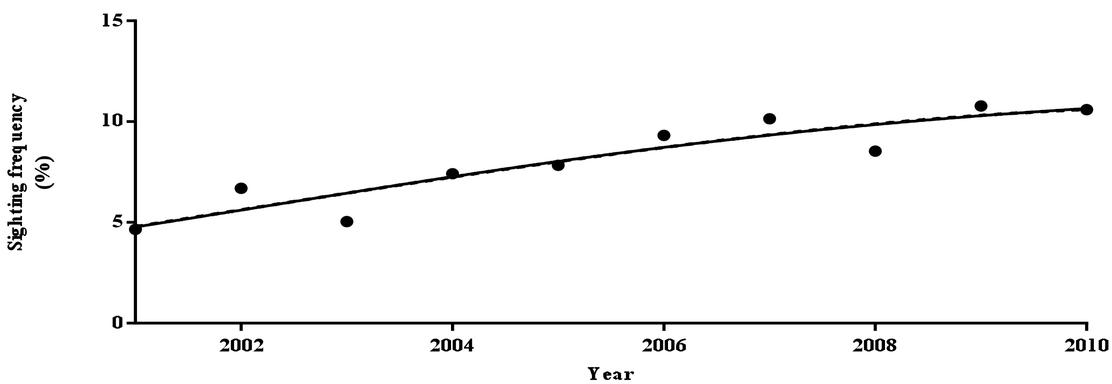
Burchell's zebra densities were high for the *Acacia tortilis* Open Woodland, the *Kirkia acuminata* Woodland, the *Combretum apiculatum* Woodland and the *Echinochloa colona* Wetland Management Units, whilst the density of Burchell's zebra was the lowest for the *Diospyros mespiliformis* Riverine Management Unit (Figure 8.22d & 8.22e). The aerial survey maps also demonstrated the movement of Burchell's zebra from east to west as the environmental conditions got drier in the latter years (Figure 8.22d).

The mean birth rate for Burchell's zebra was 15% (range 11.7% to 20.1%) with a mean survival rate into the first year at 11.6% (range 8.5% to 13.6%).

a.



b.



c.

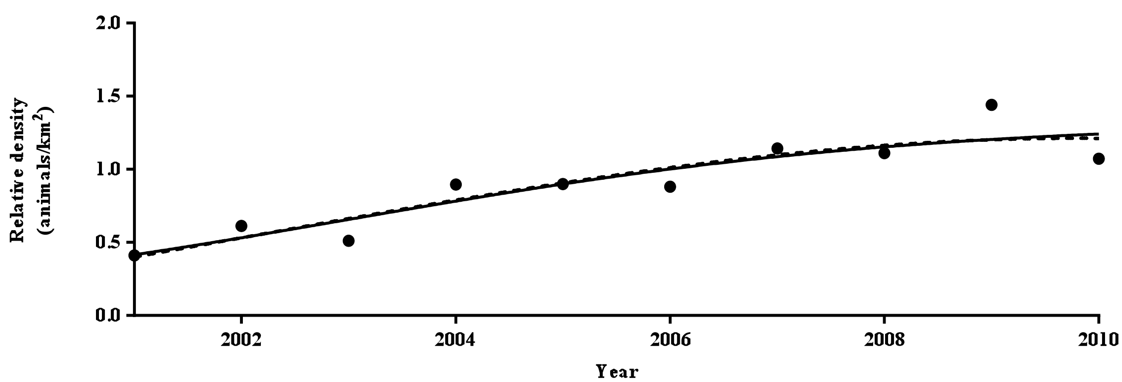


Figure 8.22a-c: Population trends for Burchell's zebra on Sango Ranch, Save Valley Conservancy. (a) Aerial survey from 1998 to 2011; (b) sighting frequency from 2001 to 2010; and (c) relative density estimates from 2001 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p = 0.0354$; - - - $p = 0.0060$; (b) —— $p = 0.0002$; - - - $p = 0.0002$; (c) —— $p = 0.0006$; - - - $p = 0.0006$.

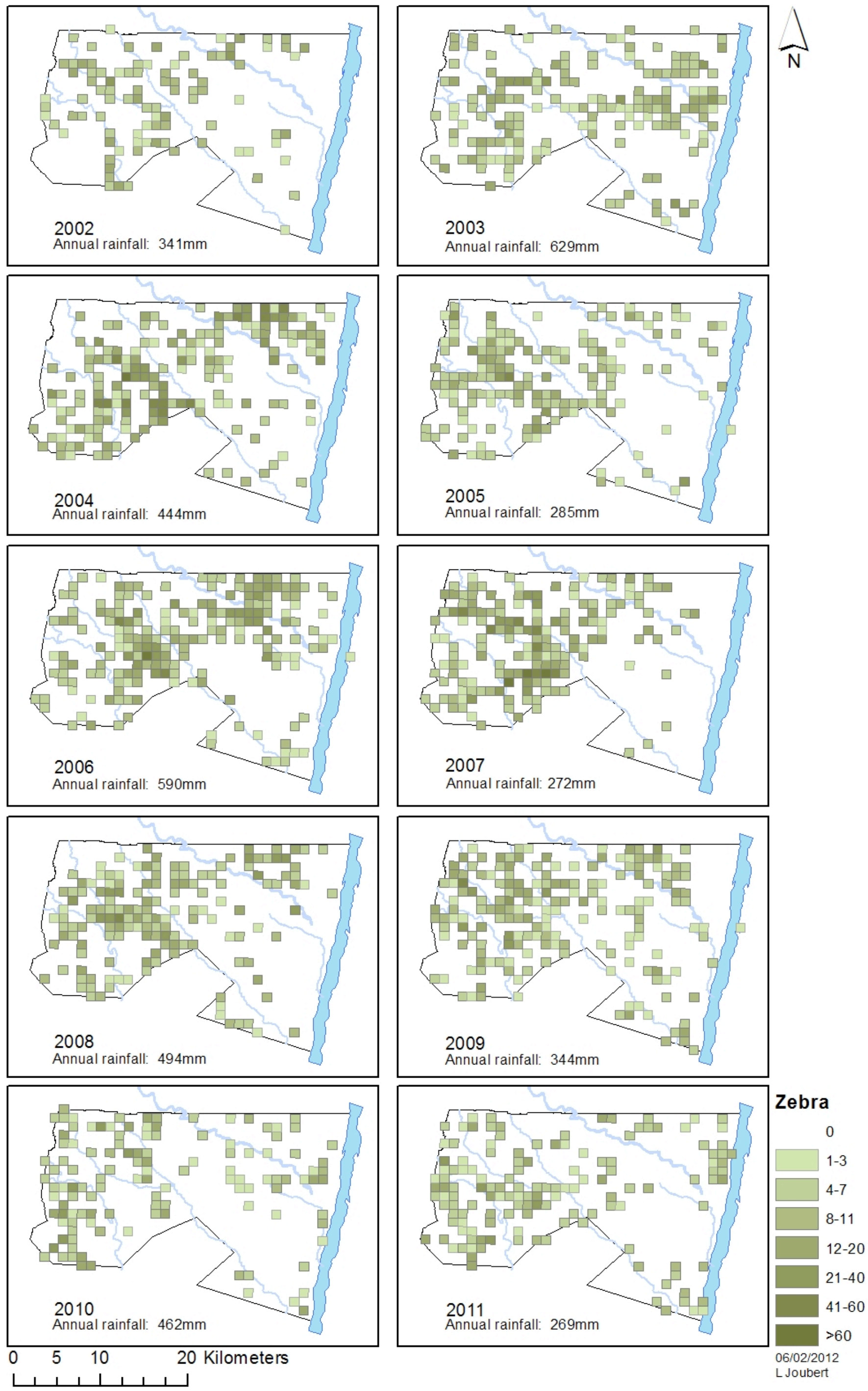


Figure 8.22d: Distribution of Burchell's zebra on Sango Ranch from aerial surveys conducted since 2002.

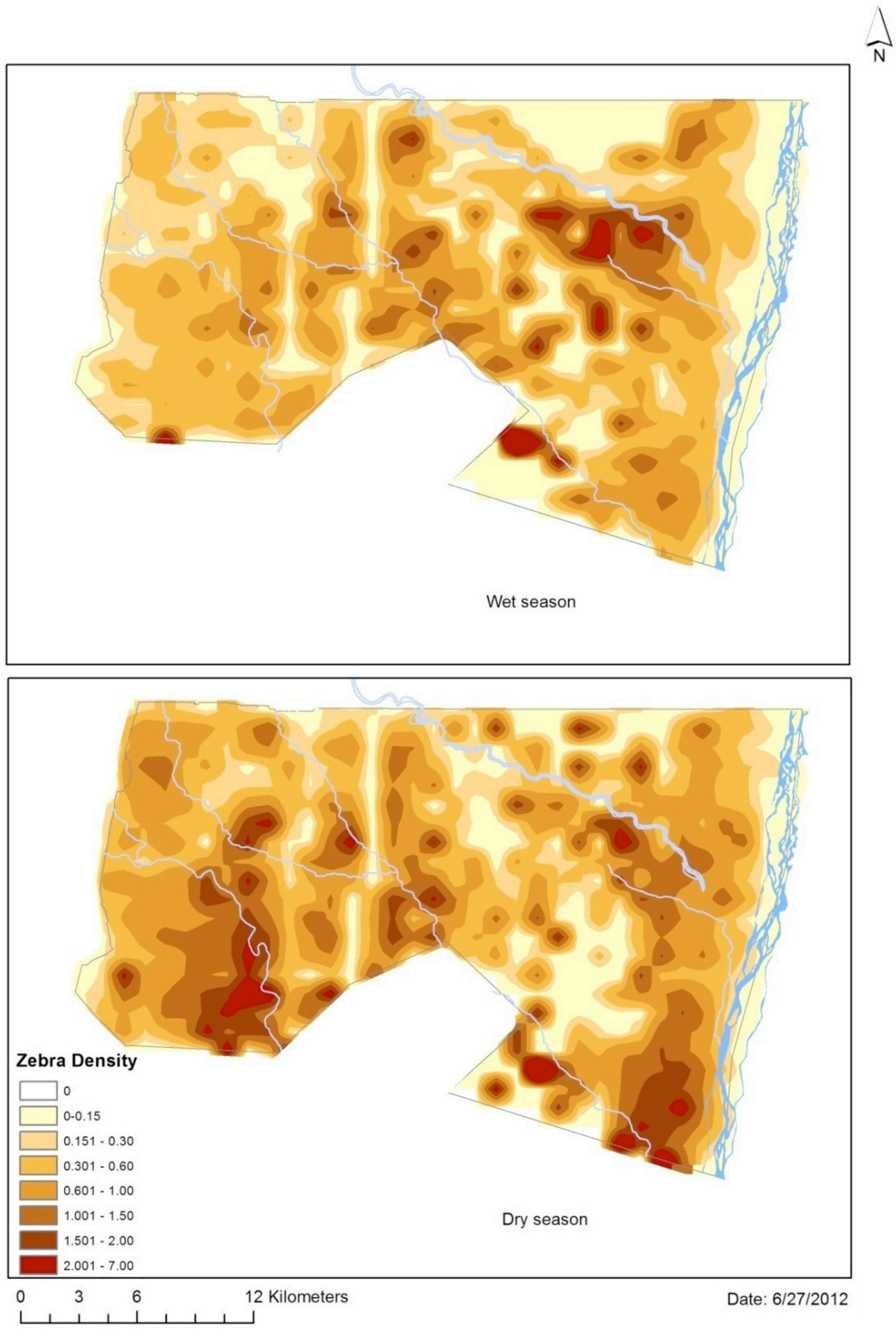


Figure 8.22e: Relative density (animals/km^2) distribution of Burchell's zebra on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.2 Carnivores

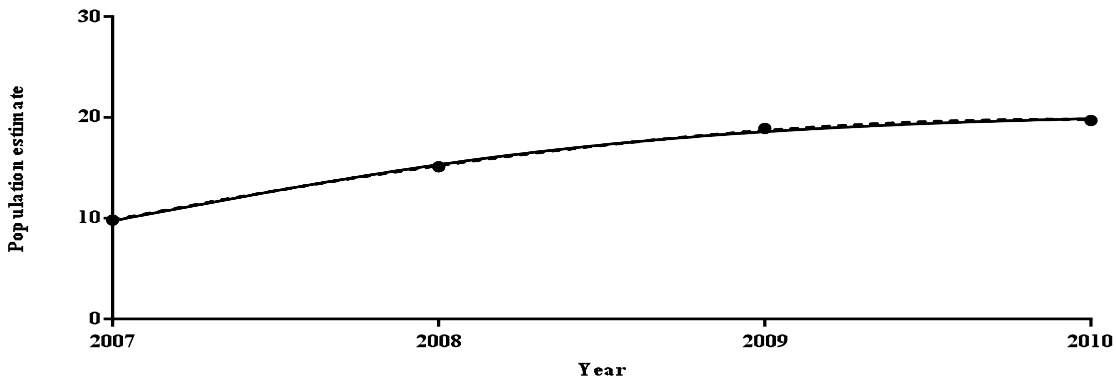
The large carnivore populations on Sango Ranch were estimated using the spoor index method (Stander, 1998) and known group counts. Spoor transects gave information on the carnivore population on Sango Ranch for a specific time period, whereas the known group estimates were determined over an entire year. Known group information was only available for lion and wild dog. Additionally, sighting frequencies were used to determine population trends for cheetah, lion and wild dog. Distribution maps for lion, leopard, cheetah and black-backed jackal were created using the relative density estimates from the grid square method. The distribution map for spotted hyena was created using the midden count data whilst the wild dog distribution map was created using the mean wild dog density for each pack size per den site.

8.3.2.1 Lion (*Panthera leo*)

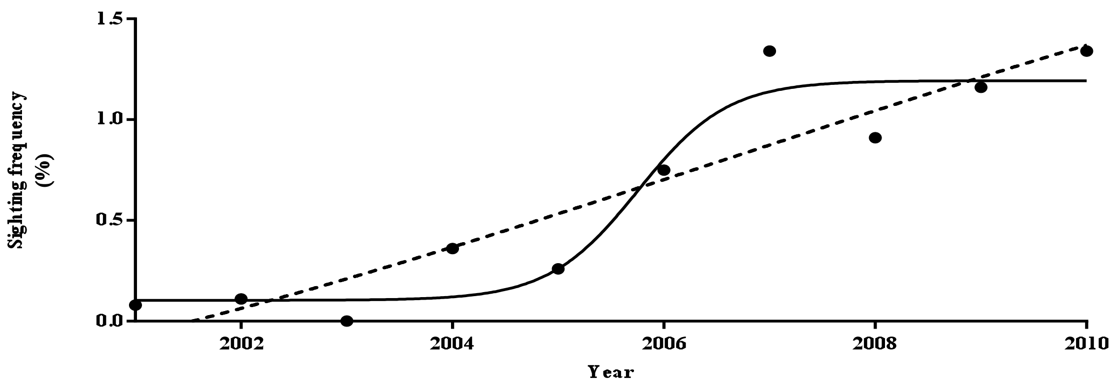
The lion population for the 2010 spoor transect survey was estimated at 20 animals, whilst the known group estimate for the lion population was 27 individual animals. The lion population trend based on the spoor transect count, indicated that the lion population levelled off in 2010 (Figure 8.23a).

The trend information based on sighting frequency supported the spoor transect count, indicating that the lion population levelled off in 2007 after a rapid growth phase of the sigmoid growth curve (Figure 8.23b). The trend information based on the relative density estimated from the number of lion tracks recorded by the game scouts, indicated that the lion population was still rapidly increasing on Sango Ranch (Figure 8.23c). It was concluded that the lion population on Sango Ranch was still increasing but is nearing ecological capacity.

a.



b.



c.

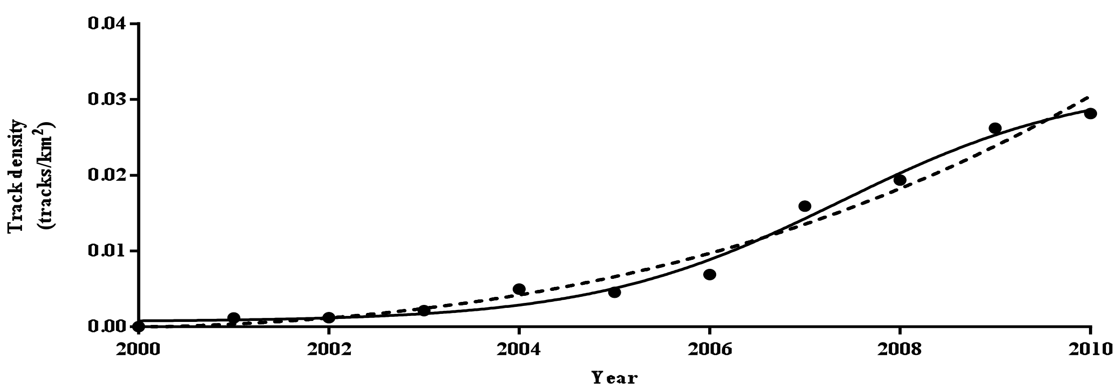


Figure 8.23a-c: Population trends for lion on Sango Ranch, Save Valley Conservancy. (a). Spoor survey from 2007 to 2010; (b) sighting frequency from 2000 to 2010; and (c) relative density estimates from 2000 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— $p = 0.0754$- - - p = not calculated; (b) —— $p = 0.004$; - - - $p = 0.0024$; (c) —— $p < 0.0001$; - - - $p < 0.\ 0001$.

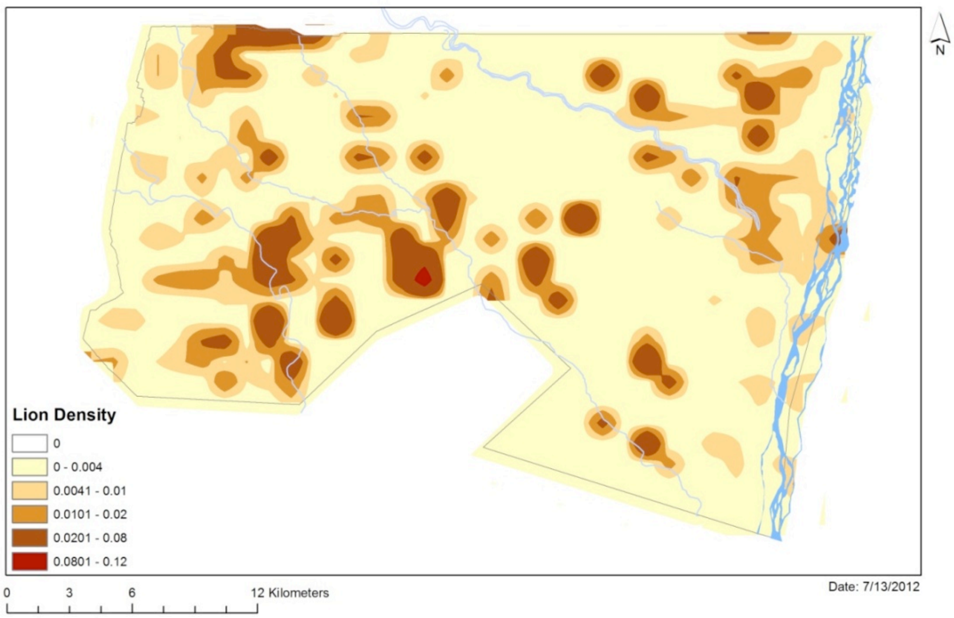


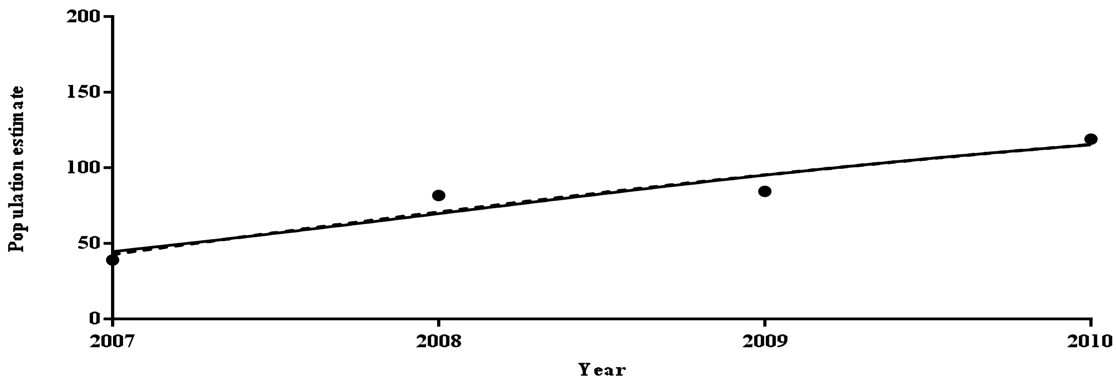
Figure 8.23c: Relative density (animals/km^2) distribution of lion on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.2.2 Leopard (*Panthera pardus*)

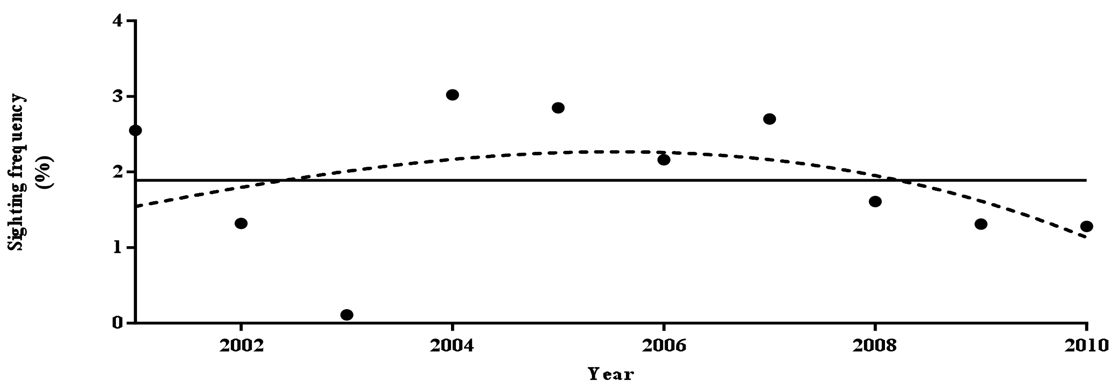
The leopard population was estimated at 115 animals during the 2010 spoor transect survey (Figure 8.24a). The population trend from spoor surveys indicated an increase in the leopard population since 2007. The sighting frequency data (Figure 8.24b & 8.24c) indicated that the leopard was already at ecological capacity prior to 2001. The differences in the findings between the spoor transect survey and the sighting frequency method highlighted the difficulty in establishing accurate population estimates for leopard. A camera trapping method developed in 2008 (Joubert in prep.) detected fluctuations between 90 and 100 individual leopards over a four-year period.

Leopard densities were highest for the *Diospyros mespiliformis* Riverine Management Unit and for the *Combretum apiculatum* Woodland Management Unit (Figure 8.24d).

a.



b.



c.

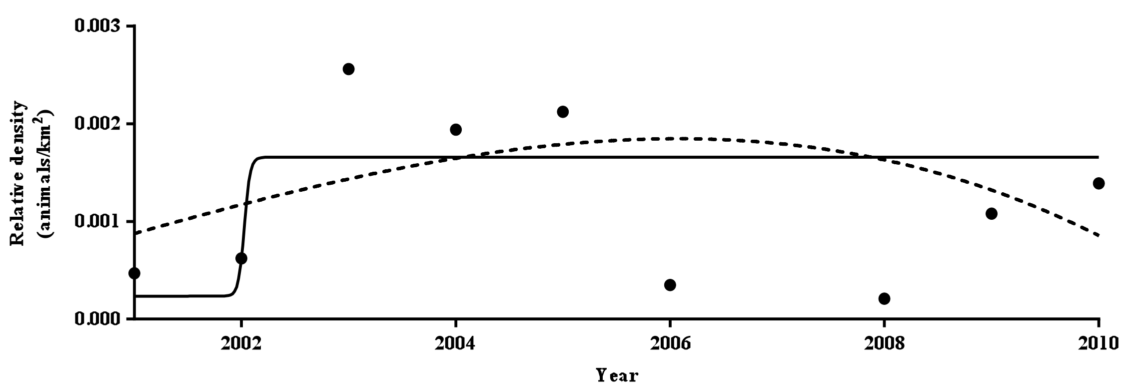


Figure 8.24a-c: Population trends for leopard on Sango Ranch, Save Valley Conservancy. (a) Spoor survey from 2007 to 2010; and (b) sighting frequency from 2000 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.1713; - - - p = 0.1600; (b) —— p = 0.4354; - - - p = 0.5339; (c) —— p = 0.4502; - - - p =0. 5516.

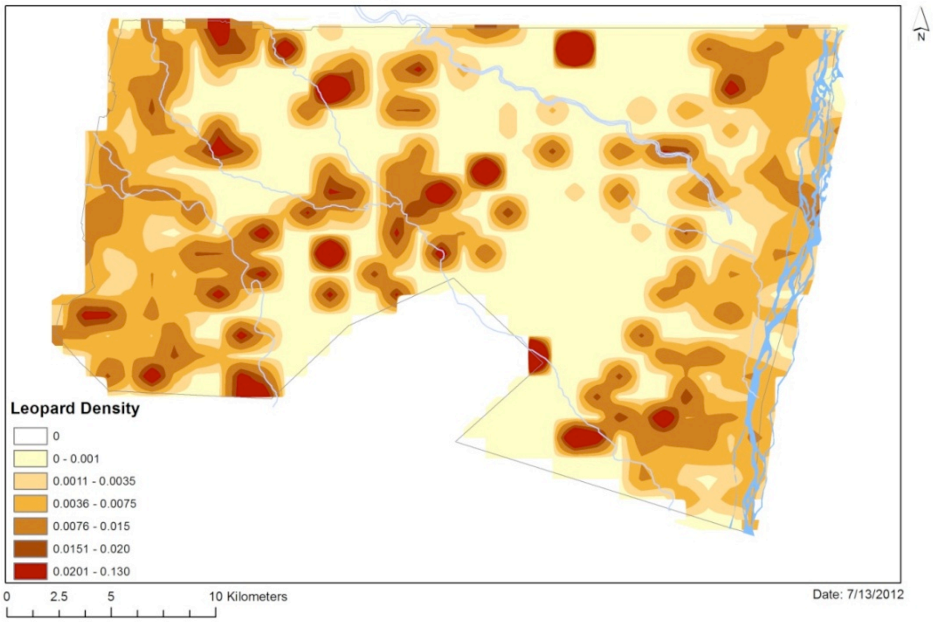


Figure 8.24d: Relative density (animals/km^2) distribution of leopard on Sango Ranch derived from the grid square method (2001 – 2010).

8.3.2.3 Spotted hyena (*Crocuta crocuta*)

The spotted hyena population increased rapidly after the re-introduction of three spotted hyena on Sango Ranch in 2003. The spoor transect count estimated the spotted hyena population at 44 animals in 2010. The population trend also indicated a rapid increase in population growth since 2007 (Figure 8.25a) and appeared to have reached ecological capacity based on the sighting frequency graph. The highest number of sightings for spotted hyena was recorded in 2004 and 2007, whilst the highest density recorded in 2007 and 2008 (Figure 8.25b & 8.25c).

The distribution of spotted hyena was determined using hyena depositories as indicators of presence in the area (Figure 8.25d).

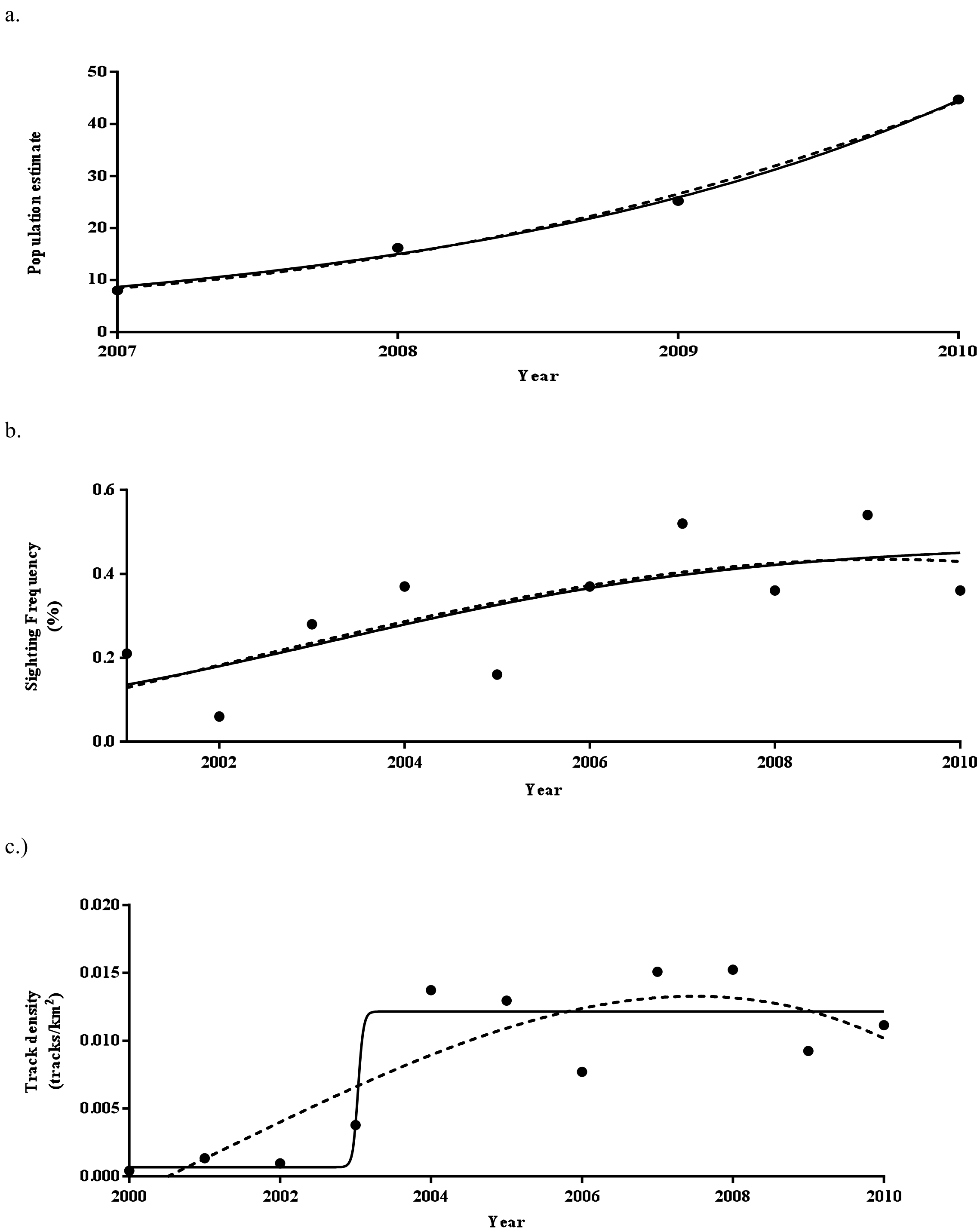


Figure 8.25a-c: Population trends for spotted hyena on Sango Ranch, Save Valley Conservancy. (a) Spoor survey from 2007 to 2010; (b) sighting frequency from 2000 to 2010; and (c) track density estimates from 2000 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p= 0.0403; - - - p = 0.0525 (b) —— p = 0.0010; - - - p = 0.0123; (c) —— p = 0.7032; - - - p = 0.0358.

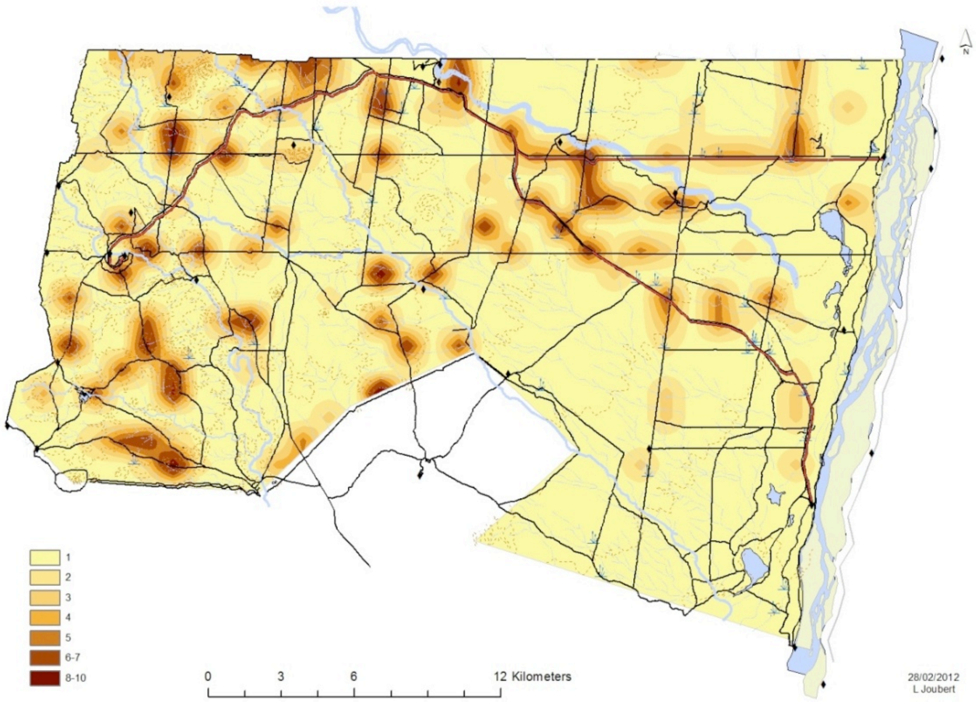
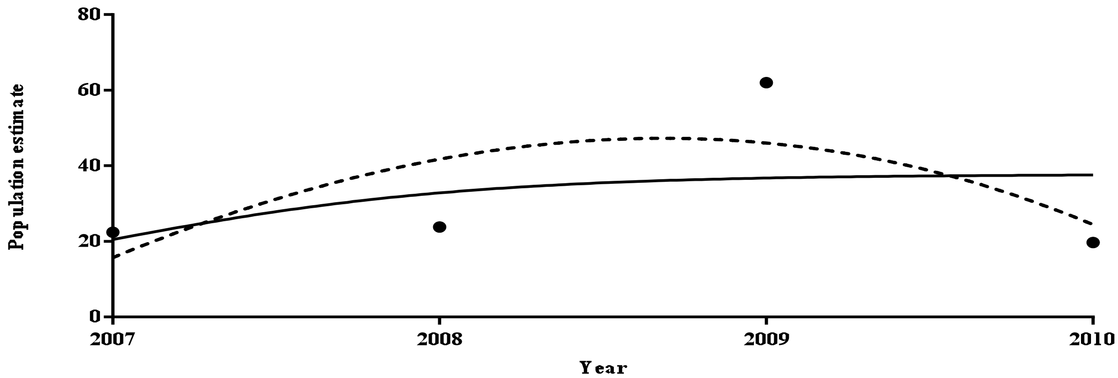


Figure 8.25d: Distribution of spotted hyena depositories during 2006 on Sango Ranch, Save Valley Conservancy, Zimbabwe.

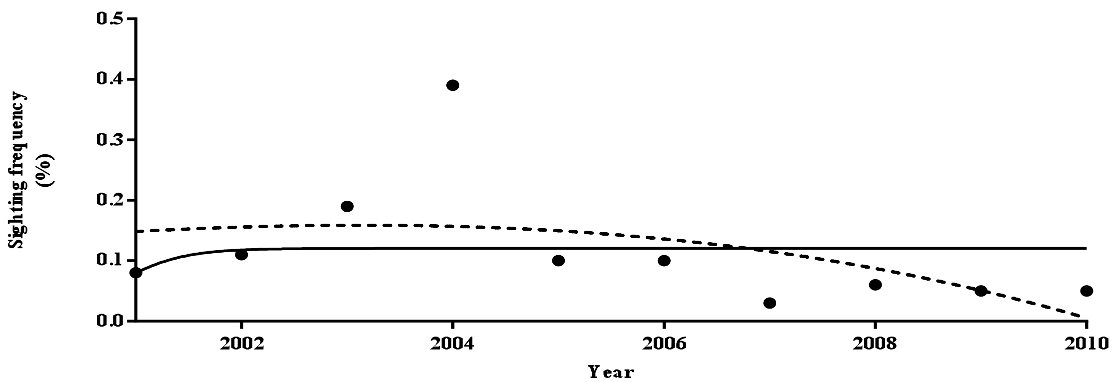
8.3.2.4 African wild dog (*Lycaon pictus*)

The African wild dog population peaked at a total of 69 wild dogs during the 2003/2004 season. After the introduction of 10 lion onto Sango in 2005 the wild dog population decreased notably. The distribution of wild dog den sites is presented in (Figure 8.26d) with the number of individuals within each pack recording the density. The population trends based on all three graphs indicated that the wilddog population has reached ecological capacity within Sango Ranch (Figure 8.26a - c). The wild dog population increased up until 2004, decreased until 2008 after which a slight increase was noted (Figure 8.26c).

a.



b.



c.

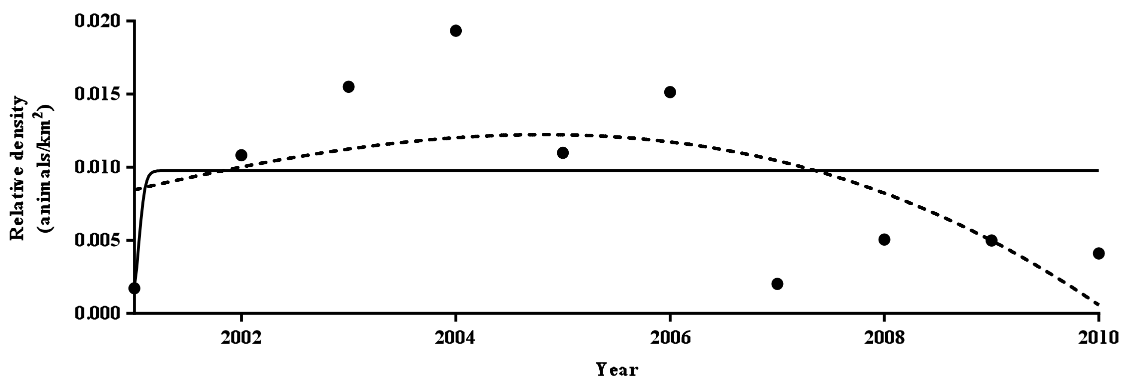


Figure 8.26a-c: Population trends for wild dog on Sango Ranch, Save Valley Conservancy. (a) Spoor survey from 2007 to 2010; (b) sighting frequency from 2000 to 2010; and (c) relative density estimates from 2000 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p= 0.676; - - - p = 0.5219; (b) —— p = 0.7579; - - - p = 0.3800; (c) —— p = 0.4174; - - - p = 0.2001.

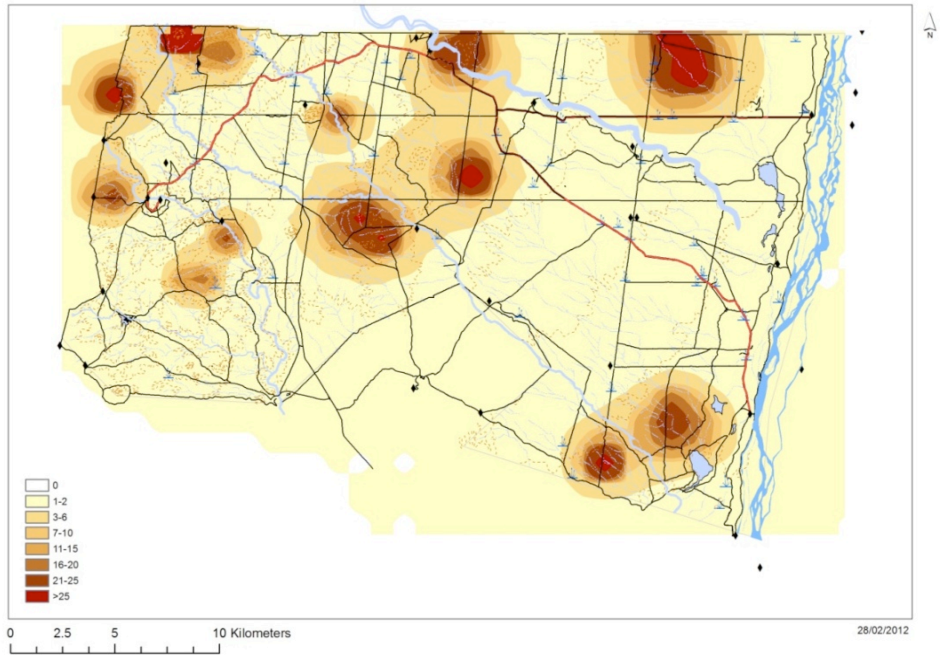
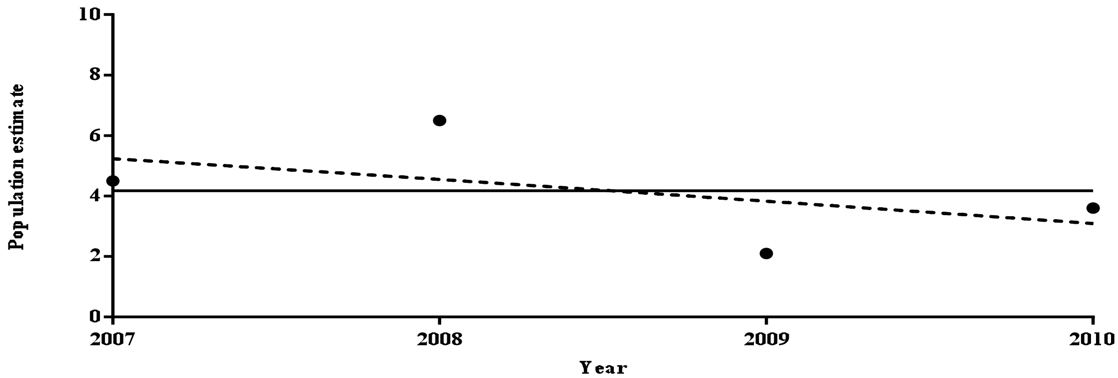


Figure 8.26d: Relative density (animals per den site/km^2) distribution of wilddog using den sites over a six year period on Sango Ranch, Save Valley Conservancy, Zimbabwe.

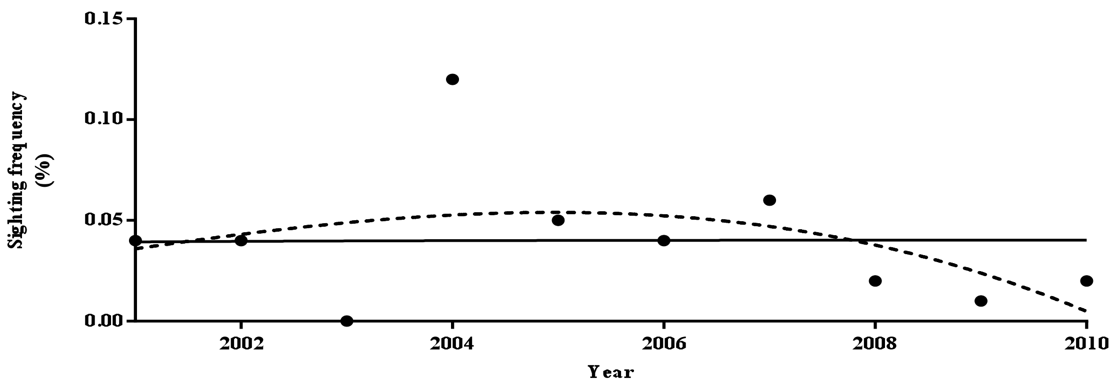
8.3.2.5 Cheetah (*Acinonyx jubatus*)

The cheetah population was estimated from spoor transect surveys and ranged from 2 to 4 individuals (Figure 8.27a). The spoor transect data suggested that the cheetah population fluctuated at ecological capacity despite being very low. The sighting frequencies of cheetah varied between 0.05% and 0.34% of the total effort with the highest number of sightings recorded in 2004 and 2007. The cheetah population trend data based on sighting frequencies (Figure 8.27b) and on relative density estimates from the total number of cheetah seen per annum suggested that the cheetah population had decreased substantially since 2003 (Figure 8.27c) and were at ecological capacity prior to 2001.

a.



b.



c.

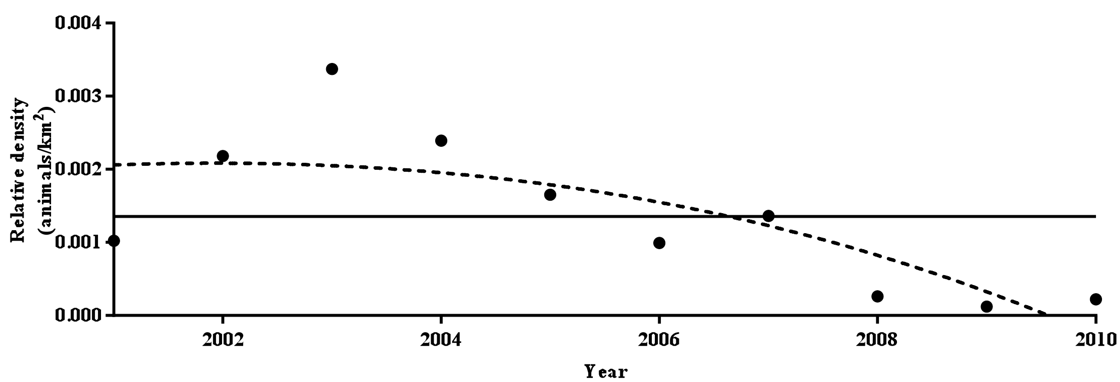


Figure 8.27a-c: Population trends for cheetah on Sango Ranch, Save Valley Conservancy. (a) Spoor survey from 2007 to 2010; (b) sighting frequency from 2000 to 2010; and (c) relative density estimates from 2000 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p= 0.6070; - - - p = 0.5199; (b) —— p = 0. 7518; - - - p = 0.3692; (c) —— p =0.4137; - - - p = 0.2001.

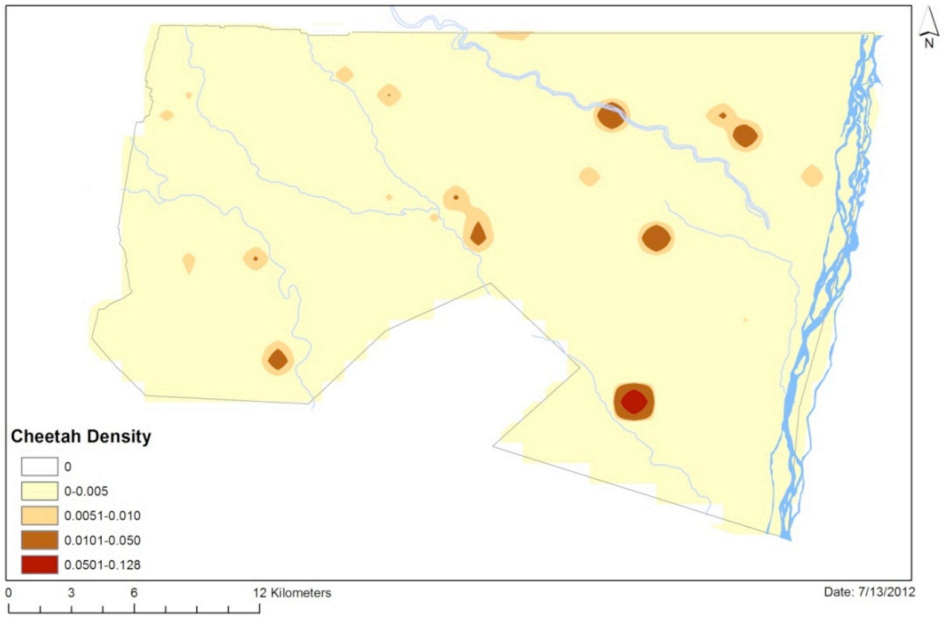


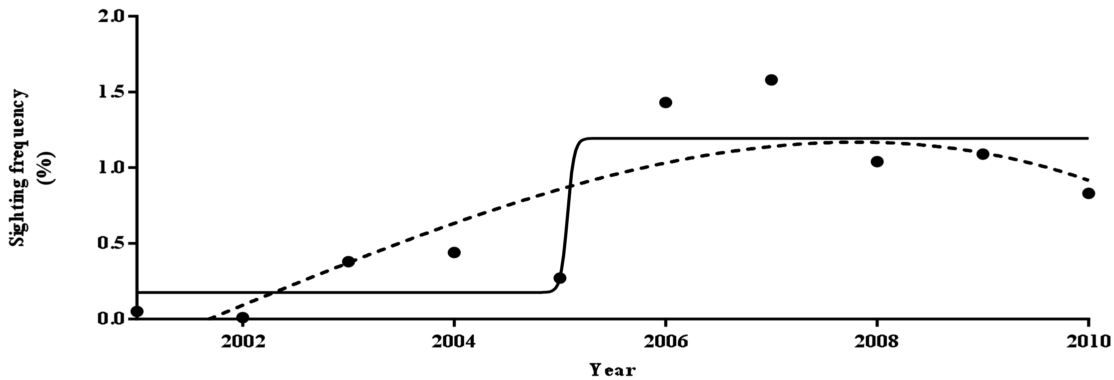
Figure 8.27d: Relative density (animals/km^2) distribution of cheetah on Sango Ranch derived from the grid square method (2001-2010).

Cheetahs were mostly recorded in the *Acacia tortilis* Open Woodland, *Kirkia acuminata* Woodland and the *Combretum apiculatum* Woodland Management Units (Figure 8.27d). The cheetah population remained small and population numbers are critically low on Sango Ranch.

8.3.2.6 Black-backed jackal (*Canis mesomelas*)

Similar population trends were recorded for both the sighting frequency (Figure 8.28a) and relative density estimates (Figure 8.28b). The sighting frequency and the relative density estimate graphs followed the typical sigmoid pattern associated with a growing animal population and suggested that the jackal population levelled off around 2006.

a.



b.

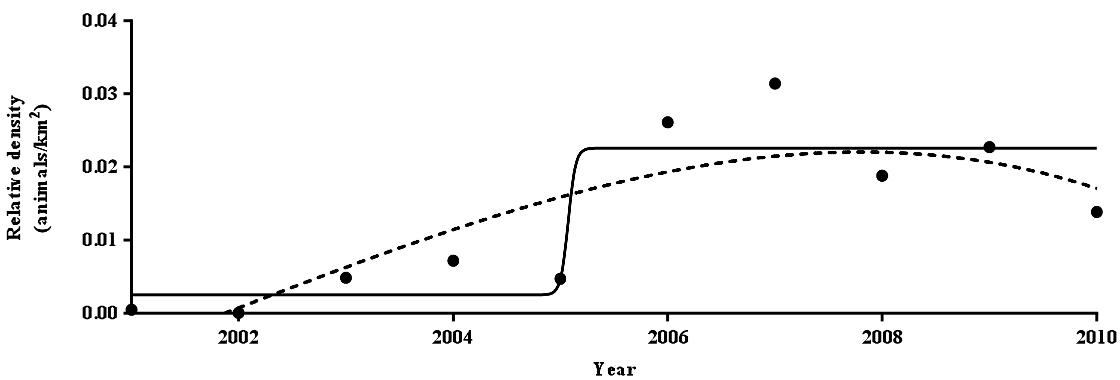


Figure 8.28a-b: Population trends for black-backed jackal on Sango Ranch, Save Valley Conservancy. (a) Sighting frequency from 2000 to 2010; and (b) relative density estimates from 2000 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0055.; - - - p = 0.0205; (b) —— p = 0.0124; - - - p = 0.0246.

The black-backed jackal was mainly associated with the *Acacia tortilis* Open Woodland and the *Kirkia acuminata* Woodland Management Unit (Figure 8.28c).

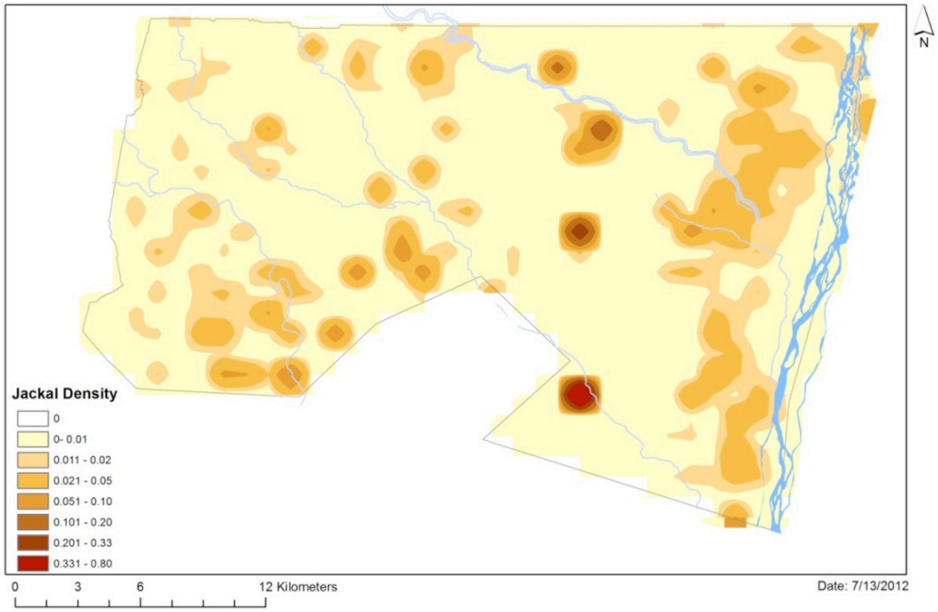


Figure 8.28c: Relative density (animals/km^2) distribution of black-backed jackal on Sango Ranch derived from the grid square method (2001 – 2010).

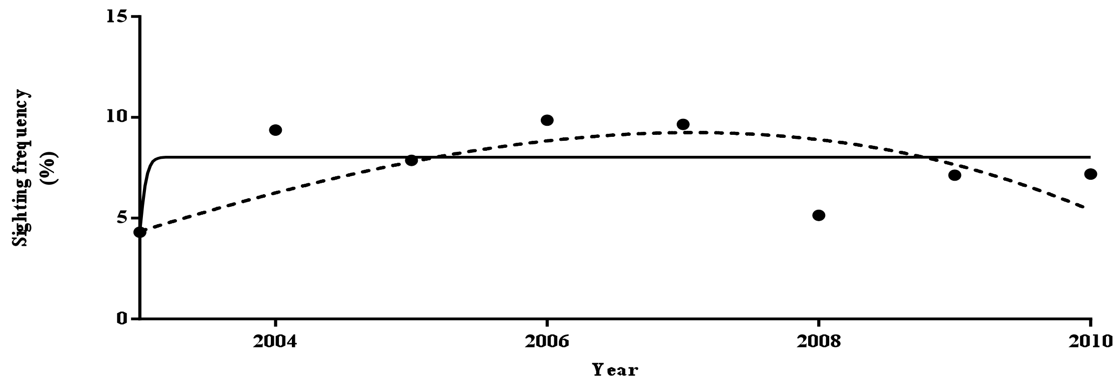
8.3.3 Primates

Population records were established for only two of the four primate species that occur on Sango Ranch. Baboons (*Papio ursinus*) and vervet monkeys (*Cercopithecus aethiops*) were recorded since 2003 and were recorded as troops rather than individual animals. There are thus only sighting frequency data available for these species. Baboon troop were also recorded during aerial surveys.

Aerial survey results indicated that the number of baboon troops initially increased on Sango Ranch but reached ecological capacity in 2009 (Figure 8.29a). The results from the sighting of baboon troops suggested that the baboon population had already reached ecological capacity at the time when the baboon monitoring started in 2003 (Figure 8.29b).

Baboons were mostly associated with the *Diospyros mespiliformis* Riverine Management Unit and the *Acacia tortilis* Closed Woodland Management Unit (Figure 8.29c).

a.



b.

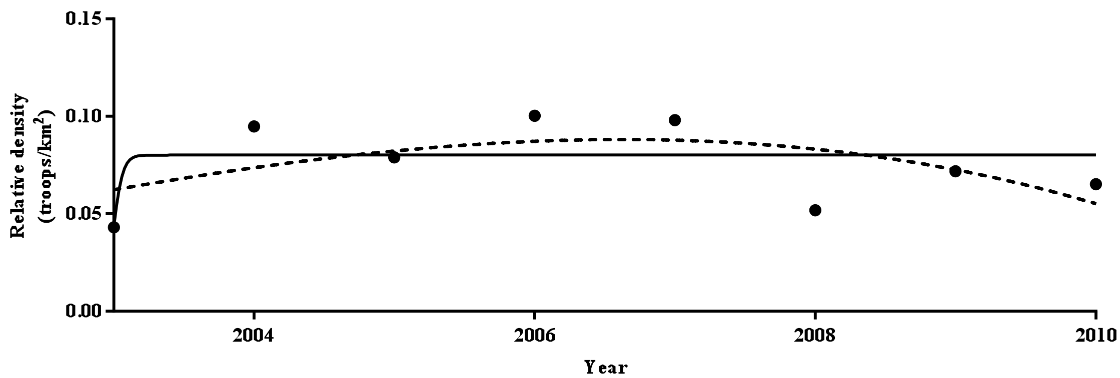


Figure 8.29a-b: Population trends for baboons/baboon troops on Sango Ranch, Save Valley Conservancy. (a) Spoor survey from 2007 to 2010; and (b) sighting frequency from 2000 to 2010. —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0381; - - - p = 0.0123; (b) —— p = 0.0501; - - - p = 0.0238.

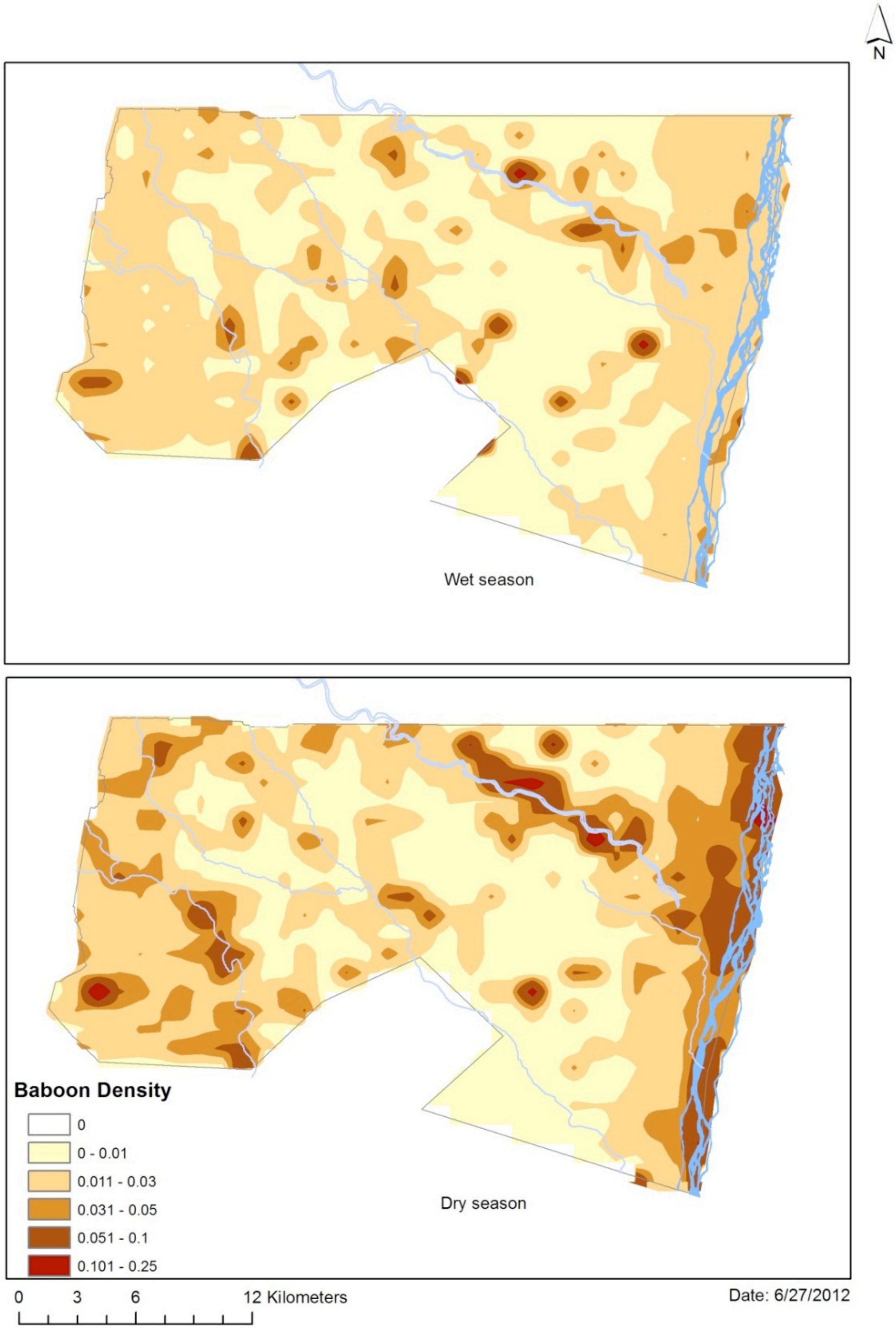
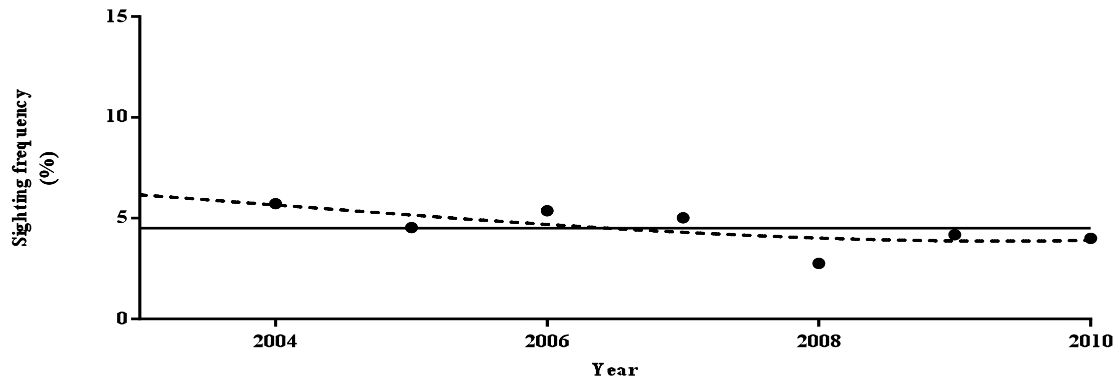


Figure 8.29c: Relative density (animals/km^2) distribution of baboon on Sango Ranch from the grid square method (2001 – 2011).

The vervet monkey population followed a similar trend to that of the baboon population and also appeared to have reached ecological capacity when monitoring of these species started in 2003. Vervet monkeys were mostly associated with the *Diospyros mespiliformis* Riverine Management Unit, the *Acacia tortilis* Closed Woodland Management Unit and the *Acacia tortilis* Open Woodland Management Unit (Figure 8.29d).

a.



b.

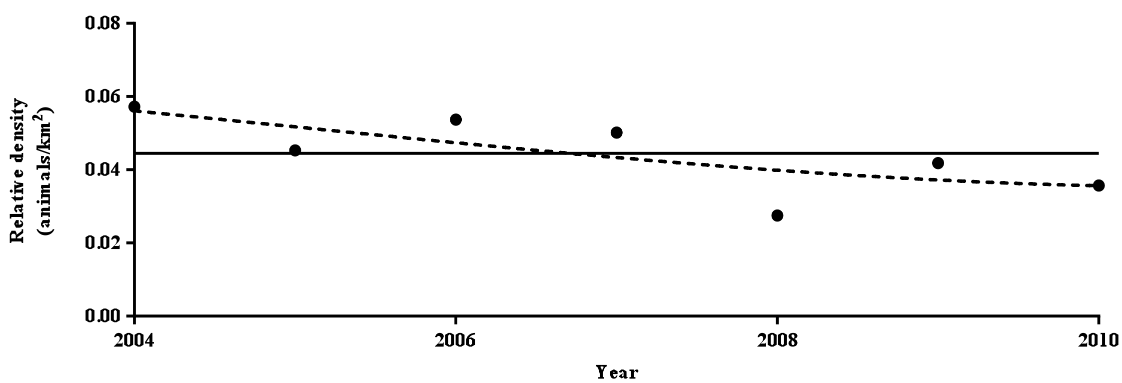


Figure 8.29d: Vervet monkey population trend based on sighting frequency (2003-2010). —— logistic curve; - - - third order polynomial: P-values: (a) —— p = 0.0434; - - - p = 0.0216; (b) —— p = 0.0232; - - - p = 0.0336.

8.3.4 *Summary of ecological status of the large mammals*

Animal populations were classed into three main categories,

- populations that were already at ecological capacity when monitoring commenced and were fluctuating around ecological equilibrium,
- populations that were still growing when monitoring commenced and had since reached ecological capacity and
- populations that were still growing in 2010.

Most of the animal species appeared to have reached ecological capacity in 2010 (Table 8.7). Herbivore species that showed some capacity for further increases in their numbers were African buffalo, giraffe, nyala and white rhinoceros. Amongst the carnivores lion and spotted hyaena had not yet reached ecological capacity.

Table 8.7: Ecological capacity status of the animal populations on Sango Ranch at the end of 2010

Population Ecological Capacity (EC) Status		
At EC prior to monitoring (before 1998)	Reached EC during monitoring (1998 to 2010)	Not at EC level (1998 to 2010)
	Herbivores	
Bushbuck	Black rhinoceros	African buffalo
Bushpig	Common duiker	Giraffe
Livingston's eland	African elephant	Nyala
Hippopotamus	Klipspringer	White rhinoceros
Impala	Sable antelope	
Greater kudu	Sharpe's grysbok	
Warthog	Waterbuck	
	Blue wildebeest	
	Burchell's zebra	
	Carnivores	
Leopard	Black-backed jackal	Lion
Cheetah	Wild dog	Spotted hyena
	Primates	
Baboon		
Vervet monkey		

8.4 Conclusions

Various methods have been developed to count wildlife (Collinson, 1985). Therefore, the current study relied on various counting techniques to establish either animal population size, distribution or population trends. This study also introduced the grid square method to provide data for a broad description of animal population trends and animal distribution patterns over an extended period. The grid square method was a practical way of establishing population trends and distribution patterns for animal species not easily measured by conventional methods. Additionally, the grid square method produced a long-term population distribution pattern that gave insight into habitat selection.

Total aerial surveys were found to be the most practical, reliable and repeatable method for determining population size and trends for the major large herbivore types on Sango Ranch. Animal species for which trend information was obtained by aerial surveys included black rhinoceros, African buffalo, Livingston's eland, African elephant, giraffe, impala, greater kudu, sable antelope, warthog, waterbuck, white rhinoceros, blue wildebeest and Burchell's zebra. Population estimates for these species were found to be sufficiently reliable for effective population management decisions to be taken over the past 12 years.

The grid square method was initially introduced to determine population estimates for all herbivore species including the "cryptic" ones. "Cryptic" herbivore species for which population trend data were established using only the grid square method included bushbuck, bushpig, common duiker, hippopotamus, klipspringer, Sharpe's grysbok and nyala. Although, the grid square method still lacked the ability to establish accurate population estimates, the sighting frequency and relative density estimates gave insight into animal population trends.

The differences noted between the aerial survey results and the relative density results are mostly associated with the more mobile species such as Livingston's eland, African elephant and Burchell's zebra whilst the less mobile species recorded similar population trends. Aerial surveys were conducted once a year during the dry season when visibility was best for counting animals from the air whilst the grid square method was a continual process. Aerial surveys covered the entire area in a short time period whilst the data recorded for the grid square method covered the survey area over an extended period of time. The differences noted between the sighting frequency and the relative density estimates were often as a result of the different animal group sizes recorded between years.

Additionally, road strip counts and line transect counts were conducted to estimate population size for smaller cryptic herbivores such as bushbuck and bushpig. These data were compared with data from previous road strip counts conducted on Sango Ranch during 1998.

The size of the large carnivore populations was estimated using the spoor-transect count, whilst the spoor-transect count and grid square method gave insight into carnivore population trends. Spoor transects, sighting and track frequencies and relative density estimates were used to determine trends for cheetah, lion, leopard, spotted hyena and wild dog. Black-backed jackal population trend data were collected from the grid square method for both the sighting frequency and relative density estimates.

The animal populations for which trend data were collected were grouped into four main categories based on the position of the population on the S-shaped sigmoid curve for growing animal populations.

The aerials survey maps indicated animal population distributions for the dry season of each year. Overall, these maps indicated a general east to west movement of animals as environmental conditions became drier. Species such as white rhinoceros, blue wildebeest and Burchell's zebra responded quickly to the drying conditions by moving from the eastern plains towards the west, whereas species such as impala and giraffe only responded over a prolonged period.

African buffalo and sable antelope populations responded by either moving south or north onto neighbouring properties or in the case of African buffalo into the Save River in the east. The distribution of species such as black rhinoceros, African elephant, Livingston's eland, greater kudu and waterbuck appeared to be unaffected by the drier conditions over the past 14 years although distributions varied considerably within seasons and between years.

CHAPTER 9

SYTHESIS AND MANAGEMENT RECOMMENDATIONS

9.1 Introduction

Wildlife ranching is doomed to failure unless it takes place within the ecological limits of the area and therefore wildlife management plans should be built around ecological principles (Bothma & Du Toit, 2010). Wildlife management plans should incorporate and account for the size and shape of an area, the energy flow within the area, the ecological capacity, the ecosystem concepts and animal population dynamics (Bothma & du Toit, 2010).

Sango Ranch (including Chapungu) is approximately 60 000 ha in extent, but forms part of the larger Save Valley Conservancy, which is approximately 350 000 ha and can thus be regarded as semi-extensive. The mere size of the area implies that Sango can strive towards maintaining natural conditions. However, the Save Valley Conservancy, as a whole, is mostly fenced or animal migrations are obstructed by human settlements. Additionally, the supplementation of waterpoints for wildlife, largely adopted from the cattle ranching days, is imposed onto the ecosystems within Save Valley Conservancy. Other major human-induced influences that affect the ecosystems and biodiversity within the Save Valley Conservancy include the road network, waste production from tourism and management, consumptive use, both legal and illegal, the fire regime and alien invasive plants.

This chapter is devoted to the management and monitoring of Sango Ranch in order to minimize the influences that negatively affect the natural ecosystems without neglecting the economic and socio-political environments.

9.2 Synthesis

Sango Ranch being 600 km^2 in size contributes 17.2% of the total landmass of the Save Valley Conservancy. This study assessed the natural resources on Chapungu Ranch, integrated the information with natural resource assessments conducted for Sango Ranch (Hin, 2000) and described the spatial and temporal trends for the animal population for the entire Sango Ranch that now also includes Chapungu Ranch.

9.2.1 Natural resource assessment of Chapungu Ranch

Assessment of the natural resources for Chapungu Ranch demonstrated the strong relationship that exists between the geology, soils and vegetation of an area. Plant communities were separated based on the underlying geological and soils regimes. Nine plant communities were identified on Chapungu Ranch with the first division of communities between those communities associated with the Umkondo System and the colluvial soils (Group A) separated from the communities associated with alluvium (Group B). Within Group A the second division separated the communities of the Umkondo System from those associated with the colluvial outwash. The third division separated the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland vegetation community on aeolian sandstone derived from the Karroo system from communities on the sandstone and basalt associated with the Umkondo system. A further division separated the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland growing on the sandstone, arkose, conglomerate, limestone and shales of the Umkondo System from the *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland found on basalt. This division also separated the *Albizia anthelmintica – Acacia tortilis* Open Woodland community found on the colluvial outwash from the *Hyperbolius bowkeri – Sporobolus nitens* Open Grassland community found mainly as an ecotonal community on sodic soils.

Separation of communities of the alluviums (Group B) was based on soil characteristics. Firstly the *Echinochloa colona – Cyperus digitatus* Open Wetland was separated from the rest of the communities of the alluvial soils based on the clay content, moisture content and texture of the soils. The next division separated the alluvium based communities on the soil texture and profile development. The sandy texture and high moisture content of the soils in the *Phragmites australis – Ficus capreifolia* Short Closed Thicket separated this community from the alluvial soils supporting the *Xanthocercis zambesiaca - Acacia tortilis* Closed Woodland and the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest. Finally the *Xanthocercis zambesiaca - Acacia tortilis* Closed Woodland and the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest were separated based on the age and moisture content of the alluvial soils. The final division between the *Xanthocercis zambesiaca - Acacia tortilis* Closed Woodland and the *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest was based on the development of the soil profile.

The floristic separation of the subcommunities of the *Hibiscus ovalifolius – Albizia brevifolia* Short Closed Woodland was supported by differences in soil depth and position on the landscape. The *Barleria meyeriana – Phyllanthus pinnatus* Short Closed Woodland was found mainly on shallow soils and steep slopes whilst the *Strychnos decussata – Grewia gracillima* Short Closed Woodland was recorded on deeper soils on the crests and terraces.

The subcommunities of the *Seddera suffruticosa – Colophospermum mopane* Closed Woodland were separated on the basis of geology and the soil types. The *Ximenia americana – Colophospermum mopane* Closed Woodland and the *Commiphora viminea – Colophospermum mopane* Closed Woodland were found on the calcimorphic siallitic 4S soils derived from Umkondo sandstone, limestone, shale and conglomerate whilst the *Boscia foetida – Colophospermum mopane* Closed Woodland and *Ruellia cordata – Colophospermum mopane* Closed Woodland were associated with the alluvial soils. The *Ximenia americana – Colophospermum mopane* Closed Woodland was found on soils with poorly developed profiles derived from sandstone and conglomerate, often displaying pebble stones on the surface whilst the soils of the *Commiphora viminea – Colophospermum mopane* Closed Woodland displayed moderate to well developed soil profiles derived from Umkondo grit, quartsite, lava and shale.

The *Kirkia acuminata – Colophospermum mopane* Short Closed Woodland vegetation subcommunities were separated on the basis of geological features. The *Commiphora schimperi – Colophospermum mopane* Short Closed Woodland was found on the shallow soils derived from basalt whilst the *Endostemon tenuiflorus – Grewia villosa* Short Closed Woodland was recorded on carbonaceous shales and the *Terminalia prunioides – Kirkia acuminata* Closed Woodland was redorded on mixtures of ferrogeneous and carbonaceous shales.

The *Albizia anthelmintica – Acacia tortilis* Open Woodland was separated into three subcommunities: the *Tephrosia purpurea – Albizia anthelmintica* Open Woodland was found exclusively on the colluvial deposits; the *Tephrosia rhodesica – Acacia tortilis* Open Woodland was recorded on the alluvium deposits along the small streams; and the *Lycium shawii – Diospyros quiloensis* Tall Open Woodland was restricted to the deep sandy soils associated with levées derived from alluvium.

The *Dalbergia arbutifolia – Diospyros mespiliformis* Tall Closed Riverine Forest was separated into three sub-communities: the *Faidherbia albida – Acacia galpinii* Tall Closed Riverine Forest was found on sandy, recent alluvial deposits with a weak soil profile development; the *Cardiogyne africana – Acacia schweinfurthii* Tall Closed Riverine Forest was found on sub-mesic, moderately develop soil profiles; and the *Albizia glaberrima – Acacia schweinfurthii* High Closed Riverine Forest occurrred on recent mesic, stratified alluvial deposits.

9.2.2 Integration of the vegetation classification of Chapungu Ranch with Sango Ranch

The identification and mapping of the geology, soils and vegetation on Chapungu Ranch allowed for Chapungu Ranch to be intergated into Sango Ranch. A vegetation map was created for Sango Ranch that included the vegetation communities identified on Chapungu Ranch. A total of 11 plant communities and 19 subcommunities were identified. The seven management units identified from the vegetation map were the *Combretum apiculatum* Woodland Management Unit, the *Kirkia acuminata* Woodland Management Unit, the *Colophospermum mopane* Closed Woodland Management Unit, the *Acacia tortilis* Open Woodland Management Unit, the *Xanthocercis zambesiaca* Closed Woodland Management Unit, the *Diospyros mespiliformes* Riverine Management Unit and the *Echinochloa colona* Wetland Management Unit. These management units were delineated based on the relative uniformity of the topography, geology, soils and vegetation.

9.2.3 The temporal and spatial trends for the animal populations within Sango Ranch

The identification of management units based on similarities regarding the topography, geology, soils and vegetation allowed for the identification of habitat preference of animal populations within Sango Ranch. Table 8.3

summarised the main ecological features of the seven management units and described habitat conditions for the animal populations on Sango Ranch using a simplified rating scale (Chapter 8, Table 8.4).

The undulating landscape of the *Combretum apiculatum* Closed Woodland Management Unit was favoured by animal species such as black rhinoceros, African buffalo, klipspringer, nyala, sable antelope, Sharpe's grysbuck and white rhinoceros. Other species that frequently utilized this management unit included species such as bushbuck, bushpig, common duiker, Livingston's eland, African elephant, giraffe, impala, greater kudu, warthog, waterbuck, blue wildebeest and Burchell's zebra. The underlying geological formations were predominantly derived from granite and gneiss, whilst the soils from the Amorphic, Calcimorphic and Kaolinitic orders were mostly sandy loams. The quality of the herbaceous layer was very good with abundant herbaceous biomass production during the wet season. The herbaceous canopy cover varied between a moderately good cover during the wet season to moderate cover during the dry season. The grass length varied between a tall-medium during the wet season to a short-medium during the dry season. The woody layer was dense with a dense shrub layer contributing 15.1% of the canopy cover and high available browse up to 2 m. The grazing pressure varied from low during the wet season to moderate during the dry season whilst the browsing pressure varied from almost no browse to a slight browsing pressure.

The landscape of the *Kirkia acuminata* Woodland Management Unit ranged from undulating to flat and was not favoured by any animal species. It was however, utilised by species such as baboon, black rhinoceros, common duiker, Livingston's eland, African elephant, giraffe, impala, kudu, warthog, white rhinoceros, blue wildebeest and Burchell's zebra. The geological formation was predominantly basalt, whilst the soils were predominantly from the Amorphic and Calcimorphic orders which ranged from sandy loams to sandy clay. The quality of the herbaceous layer was good with a high herbaceous biomass production during the wet season. The herbaceous canopy cover was moderate for both the wet season and the dry season. The grass length varied between a medium length during the wet season to a short length during the dry season. The woody layer ranged from an open woodland to a closed woodland with a dense shrub layer contributing 19.2% of the canopy cover and the highest available browse up to 2 m. The grazing pressure varied from moderately utilised during the wet season to heavily unutilised during the dry season whilst the browsing pressure varied from almost no browse to a moderate browsing pressure.

The mostly flat landscape of the *Colophospermum mopane* Closed Woodland Management Unit was not favoured by any species but was regularly utilized by species such as baboon, black rhinoceros, common duiker, Livingston's eland, giraffe, impala, kudu, warthog, blue wildebeest and Burchell's zebra. The geological formation was predominantly sandstone and alluvium, whilst the soils were predominantly from the Calcimorphic Order. The soil texture ranged from sandy loams to sandy clay. The quality of the herbaceous layer was moderate with a moderate to low herbaceous biomass production during the wet season. The herbaceous canopy cover was moderate during the wet season and moderate to sparse during the dry season. The grass length varied from a medium length during the wet season to a short length during the dry season. The woody layer was a closed woodland with a dense shrub layer contributing 24.0% of the canopy cover with a high browse availability up to 2 m. The grazing pressure varied from low utilization during the wet season to moderately unutilised during the dry season whilst the browsing pressure varied from almost no browse to a moderate browsing pressure.

The landscape of the *Acacia tortilis* Open Woodland Management Unit was flat and not favoured by any species but was regularly utilized by species such as baboon, black rhinoceros, African buffalo, common duiker, Livingston's eland, African elephant, giraffe, impala, greater kudu, warthog, white rhinoceros, blue wildebeest and Burchell's zebra. The geology was colluvial outwash and alluvium, whilst the soils were predominantly from the Calcimorphic Order. The soil texture varied between sandy loams and loamy sand. The quality of the herbaceous layer was good with a moderate to high herbaceous biomass production during the wet season. The herbaceous canopy cover was moderate during the wet season and moderate to sparse during the dry season. The grass length varied from a medium length during the wet season to a short length during the dry season. The woody layer was a open woodland with a sparse shrub layer contributing 7.0% of the canopy cover. The available browse up to 2 m was low. The grazing pressure was heavy during both the wet season and the dry season. A moderate browsing pressure was recorded for both the wet season and the dry season.

The landscape of the *Xanthocercis zambesiaca* Closed Woodland Management Unit was flat. This management unit was highly selected by species such as baboon, African buffalo, common duiker, Livingston's eland, African elephant, giraffe, impala, greater kudu, vervet monkey, warthog, waterbuck, blue wildebeest and Burchell's zebra. The geology was alluvium, whilst the soils were predominantly from the Calcimorphic Order. The soil texture was a sandy loam. The quality of the herbaceous layer was good with a moderate to high herbaceous biomass production during the wet season. The herbaceous canopy cover varied between moderate during the wet season to moderately sparse during the dry season. The grass length varied from a medium length during the wet season to a short length during the dry season. The woody layer was a closed woodland with a dense shrub layer contributing 19.2% of the canopy cover. The available browse up to 2 m was high. The grazing pressure varied from a moderate pressure during the wet season to being heavily utilized during the dry season. A moderate browse pressure was recorded for both the wet season and the dry season.

The landscape of the *Diospyros mespiliformis* Closed Woodland Management Unit was flat. This management unit was highly selected by species such as baboon, bushbuck, bushpig, African elephant, hippopotamus, greater kudu, vervet monkey and waterbuck whilst species such as black rhinoceros, African buffalo, common duiker, Livingston's eland, giraffe, impala, nyala, Sharpe's grysbuck, sable antelope, warthog, white rhinoceros, blue wildebeest and Burchell's zebra regularly utilized this management unit. The geology was alluvium, whilst the soils were predominantly from the Calcimorphic Order. The soil texture was a sandy loam. The quality of the herbaceous layer was good with a moderate to high herbaceous biomass production during the wet season. The herbaceous canopy cover varied from moderate to good during the wet season whilst the canopy cover during the dry season varied from sparse to moderate. The grass length varied from being a tall-medium length during the wet season to a short-medium length during the dry season. The woody layer constituted a forest woodland with a dense shrub layer contributing 48.9% of the canopy cover. The available browse below 2 m was very high. The grazing pressure varied from a slight pressure during the wet season to being moderately utilized during the dry season. Browse pressure varied from no browse to a moderate pressure during the dry season.

9.3 Monitoring and managing the abiotic components

Abiotic components include the climate, water, geology and soil within Sango Ranch. Monitoring programs are already in place for climate, artificial water distribution and water quality on Sango Ranch.

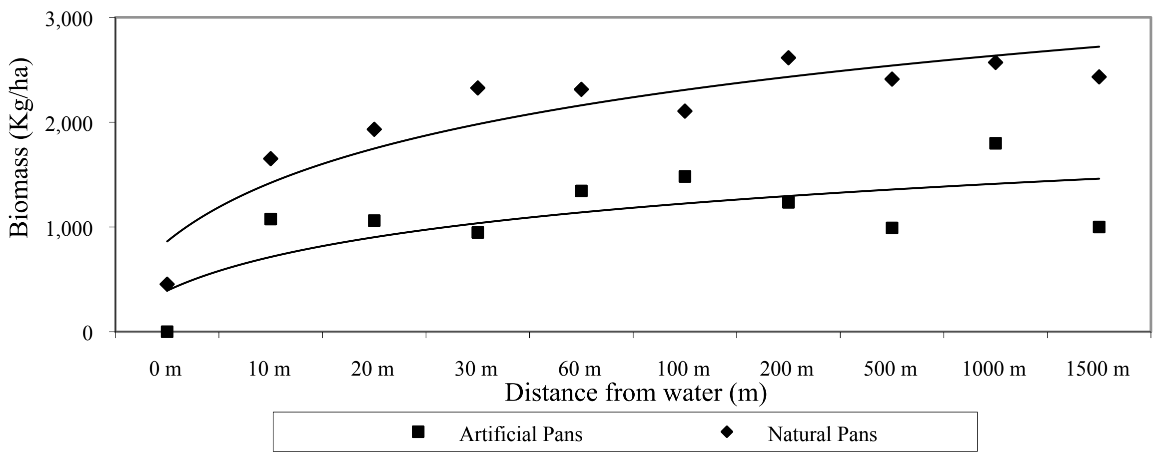
Temperature, rainfall, air humidity, wind strength, wind direction and cloud cover is monitored on a daily basis. Since 2008, temperature, air humidity, wind direction and strength are recorded electronically every 30 minutes. Rainfall is measured in quantity and distribution at 13 different rainfall stations whilst cloud cover is subjectively assessed on a daily basis at four intervals during the day.

9.3.1 Water provision

The artificial provision of water to wildlife has implications within ecosystems (Clegg, 1999; Trash, 1993). Artificial water provision for wildlife is monitored in terms of the pump hours and distribution of water within Sango Ranch. Artificial water provision aims at providing water for wildlife, especially the more water-dependent species and to promote more effective utilization of the available grazing. However, the provision of artificial water often leads to an increase in grazing pressure in areas that would under natural circumstances not have water with subsequent higher trampling of the area. Increased survival of water-dependent species often leads to a high stocking density that potentially changes the structure and composition of the vegetation. Furthermore, high density animal species often replace the more sensitive low density animal species which could lead to loss of diversity in animal species.

On Sango Ranch, a survey was undertaken to establish the detrimental effects of artificial water provision on the herbaceous layer. In January 2008, six natural pans were selected, three of which were artificially provided with water whilst the other three were filled only with naturally rain water. All six pans were within the *Albizia anthelmintica – Acacia tortilis* Open Woodland. Veld condition and herbaceous biomass production were determined at 5 m, 10 m, 20 m, 30 m, 60 m, 100 m, 200 m, 500 m, 1000 m and 1 500 m intervals in all four major wind directions surrounding the pan. The results of the survey indicated that herbaceous biomass production surrounding the artificially pumped pans was lower than the herbaceous biomass production surrounding the natural pans whilst there was only a slight difference between the veld condition scores between the pans (Figure 9.1a & b).

a.



b.

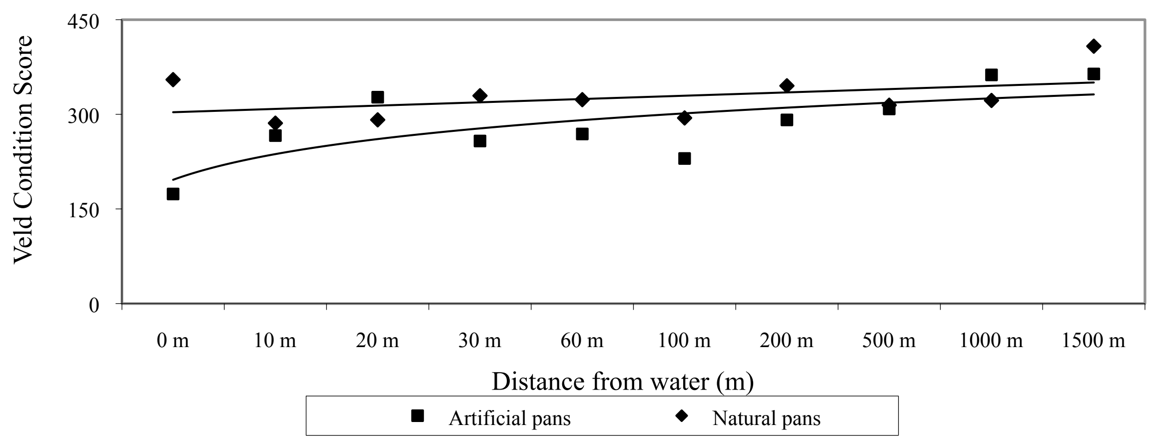
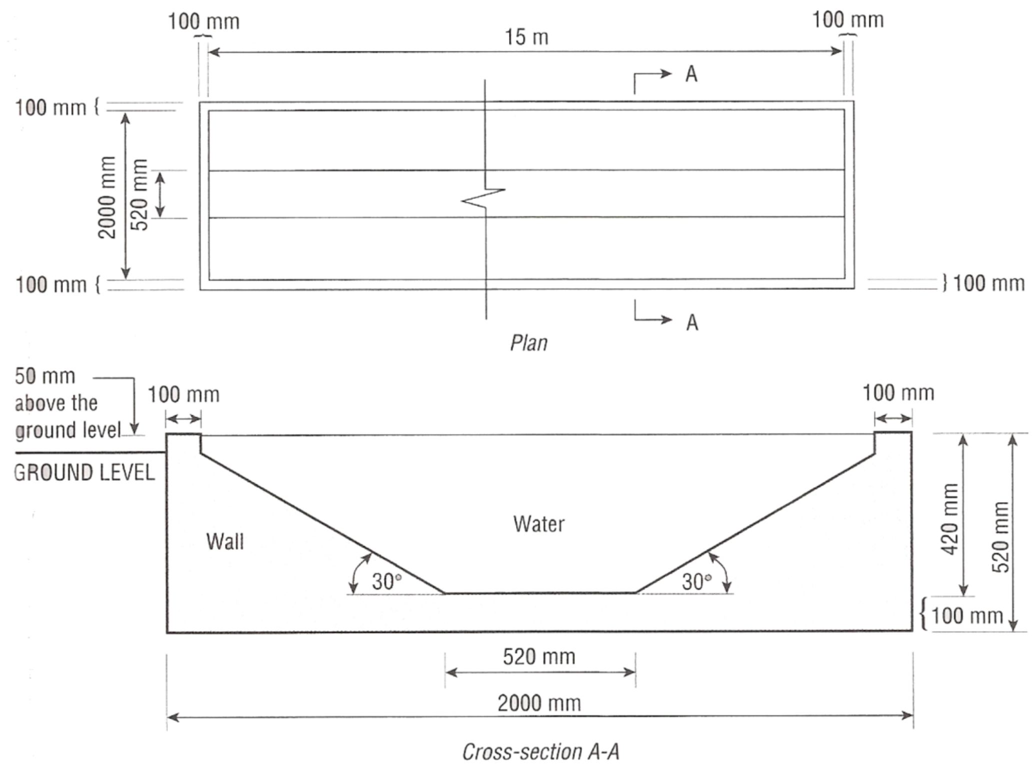


Figure 9.1a & b: A comparison between the herbaceous biomass production and veld condition of artificially pumped pans and natural pans.

An artificial water provision policy was developed and implemented for Sango Ranch in 2002. The policy, which was adopted, is a compromise between objectives set for tourism and the maintenance of the ecological integrity of the ranch. Thus, the policy strives, as far as possible, to maintain the balance between forage, water and habitat and the objectives set for a viable tourism operation. The policy recognized and accepted the existence of long-term environmental changes and it recognized that these environmental changes will ultimately dictate changes within the current ecosystems.

The artificial water provision policy developed for Sango Ranch should also be implemented on Chapungu Ranch. The policy aims at satisfying both the ecological interest and the tourism objectives for Sango Ranch. However, some structural changes not addressed by the artificial water provision policy are proposed to minimize water and energy wastage. It is proposed that all pan troughs be replaced with deep rectangular troughs (Figure 9.2) with a ball valve system.

a.



b.

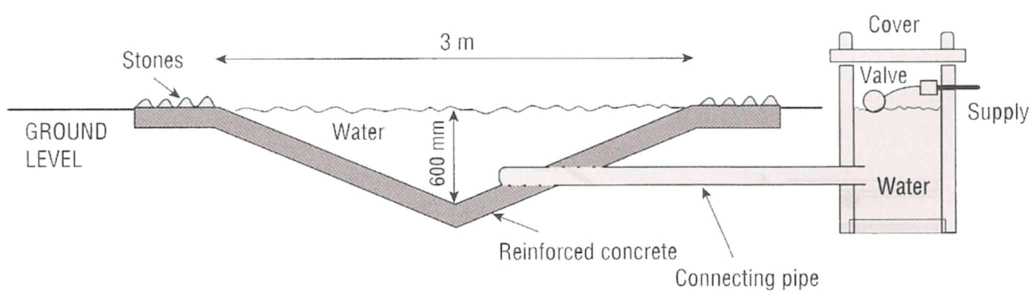


Figure 9.2: Illustrations and dimensions of the proposed artificial watering troughs to replace the current pan troughs.

Table 9.1 gives the status and site-specific recommendations for all artificial water troughs on Sango Ranch. It is further proposed that an assessment be done for each of the current watering points to establish its effectiveness and the potential risks to the objectives of Sango Ranch.

Table 9.1: Status and site specific recommendations for the artificial water points on Sango Ranch, Save Valley Conservancy

Artificial water point	Structure	Vegetation Management Unit	Watering regime	Recommendations
A3-trough	Trough	*Combretum apiculatum* Woodland Management Unit	Dry months	Rectangular, ball valve trough
Dirk's pan	Natural pan	*Combretum apiculatum* Woodland Management Unit	Dry months	Remains as per artificial water policy
A4-trough	Trough	*Combretum apiculatum* Woodland Management Unit	Infrequent, dry months	Rectangular, ball valve trough
B3-trough	Trough	*Combretum apiculatum* Woodland Management Unit	Dry months	Closed for repositioning to new site
B4-trough	Trough	*Combretum apiculatum* Woodland Management Unit	Dry months	Rectangular, ball valve trough
Hide	Natural pan	*Acacia tortilis* Open Woodland Management Unit	Dry months	Remains as per artificial water policy
Marogwe	Natural pan	*Acacia tortilis* Open Woodland Management Unit	Dry months	Remains as per artificial water policy
C4-trough	Trough	*Kirkia acuminata* Woodland Management Unit	Dry months	Closed for repositioning to new site
D3-trough	Trough	*Xanthocercis zambesiaca* Closed Woodland Management Unit	Dry months	Closed for repositioning to new site
Harkwapvuka	Natural pan	*Colophospermum mopane* Woodland Management Unit	Dry months	Remains as per artificial water policy
Mbokoti	Trough	*Colophospermum mopane* Woodland Management Unit	Dry months	Rectangular, ball valve trough
Msaize	Natural pan	*Xanthocercis zambesiaca* Closed Woodland Management Unit	Whole year	Remains as per artificial water policy
Ngongoni	Natural pan	*Acacia tortilis* Open Woodland Management Unit	Wet months - not in use	Remains as per artificial water policy
Magwe	Natural pan	*Xanthocercis zambesiaca* Closed Woodland Management Unit	Whole year	Remains as per artificial water policy
Mahwe I	Trough	*Acacia tortilis* Open Woodland Management Unit	Not in use	Permanent closure
Mahwe II	Natural pan	*Colophospermum mopane* Woodland Management Unit	Wet months - not in use	Remains as per artificial water policy
Mahwe III	Natural pan	*Colophospermum mopane* Woodland Management Unit	Wet months - not in use	Remains as per artificial water policy
Chawiwi	Trough	*Colophospermum mopane* Woodland Management Unit	Dry months	Rectangular, ball valve trough
Chisangaurwe	Natural pan	*Acacia tortilis* Open Woodland Management Unit	Whole year	Remains as per artificial water policy

9.3.2 River health

The South African Scoring System (SASS-5) designed for the Lowveld region was used to assess the health status for the perennial rivers. The biological bands generated for the SASS-5 and the average score per taxon (ASPT) scores for the South African Lowveld were used to class the river health status according to Dallas *et al*. (2007). Table 9.2 gives the health status for the Save River and the Mokore River on Sango Ranch.

According to the Dallas *et al.* (2007) scoring system the Save River with a SASS-5 score of 71.7 and a ASPT- score of 4.8 was seriously modified with fewer families present than expected and the basic ecosystem functioning has changed. The 2006 results indicated that the Save River was seriously modified with a SASS-5 score of 59.0 and an ASPT score of 5.9. The 2008 survey also found that the Save River was seriously modified with a SASS-5 score of 79.0 and an ASPT score of 5.6. The Mokore River with a SASS-5 score of 114.3 and an ASPT score of 6.6 was found to be largely modified in 2002 and severely modified in 2006 with an SASS-5 score of 88 and an ASPT of 5.3. The 2008 score sheet indicated that the Mokore River was largely modified with a SASS-5 score of 103 and an ASPT score of 5.7 (Table 9.2).

Table 9.2: Health status for the perennial rivers on Sango Ranch, Save Valley Conservancy

	SASS-5 Scores		
	2002	2006	2008
Save River			
Sampling score	71.7	59.0	79.0
No. of families	14.7	10.0	14
ASPT	4.8	5.9	5.6
Air breathing Score	16.7	12.0	n/r
Air breathing Families	3.3	4.0	n/r
Condition	Seriously modified	Seriously modified	Seriously modified
Mokore River			
Sampling score	114.3	88.0	103.0
No. of families	17.3	16.3	18.0
ASPT	6.6	5.3	5.7
Air breathing Score	20.7	28.7	n/r
Air breathing Families	4.3	6.0	n/r
Condition	Largely modified	Severely modified	Largely modified

9.3.3 Soil

Soil is formed as a result of interactions that take place between the geological formations, the climate, biotic components, relief and time (Jenny, 1941). In the context of wildlife management soil forms the substrate for plant growth and subsequent animal production. A threat to the production potential of an area is the loss of soils due to erosion. Whilst soil erosion is an accepted natural process poor land use practices often increase the rate of soil loss from the environment (Coetzee, 2005).

On Sango Ranch management related drivers of soil erosion were identified as:

- the roads and fences;
- the stocking density;
- artificial water provision to wildlife; and
- fire.

9.3.4 Roads and road maintenance

The roads on Sango were classed into three categories:

- Main road: all weather road to accommodate large vehicles;
- Main access roads: roads leading to main facilities on the property; and
- Tracks: roads used only for management and tourism.

It is recommended that all roads on Sango be graded and maintained as illustrated in Figure 9.3.

The convex design ensures proper drainage of surface water from the road thus preventing water infiltration and the softening of the road surface. Drainage channels placed along the side should lead water back into natural drainage paths into the bush.

The grading frequency must be kept to the absolute minimum depending on the road type.

- Main road: Two gradings per annum and dragged once a month.
- Main access roads: One grading per annum and dragged twice per annum.
- Tracks: Graded every 5 years and slashed annually.

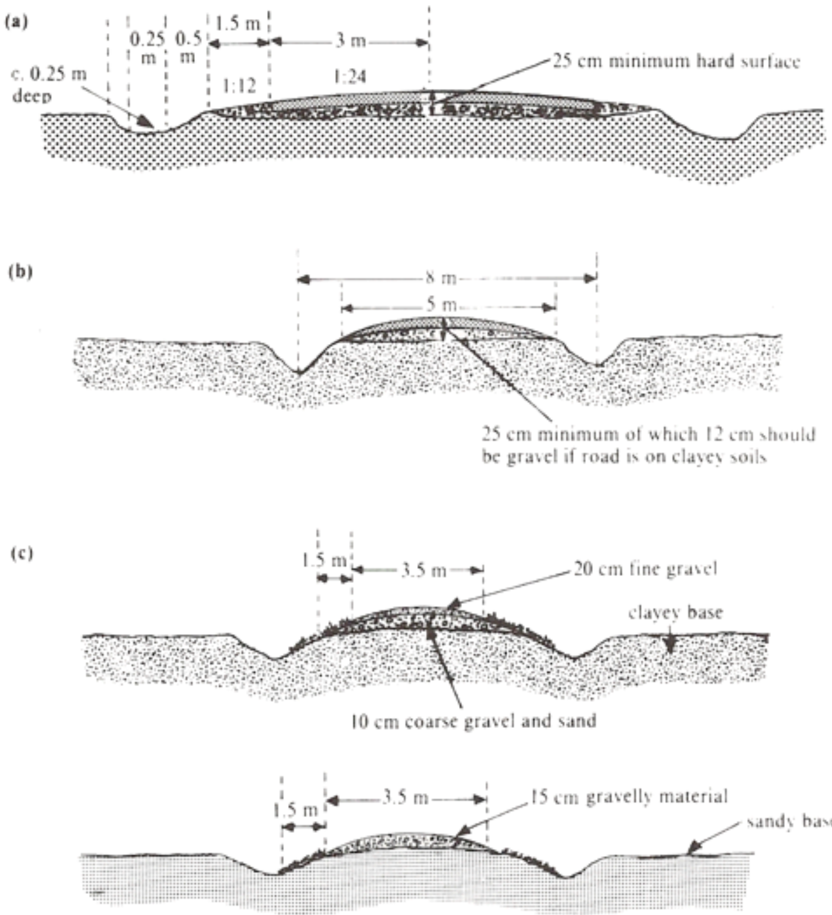


Figure 9.3: Dimensions for road maintenance a) main road: all weather road, and large enough to accommodate heavy vehicles; b) minor road; c) game viewing or hunting roads (Corfield, 1993).

On Sango Ranch the topography varies from undulating with occasional steep slopes in the *Combretum apiculatum* Woodland Management Unit. In this management unit, retaining walls must be built on the downstream end of the river crossing where the road crosses the stream. Retaining walls should be built on bedrock whilst large rocks are placed on the downstream end behind the retaining wall. Medium sized rocks should be placed on the upstream end of the retaining wall and covered with sand (Figure 9.4).

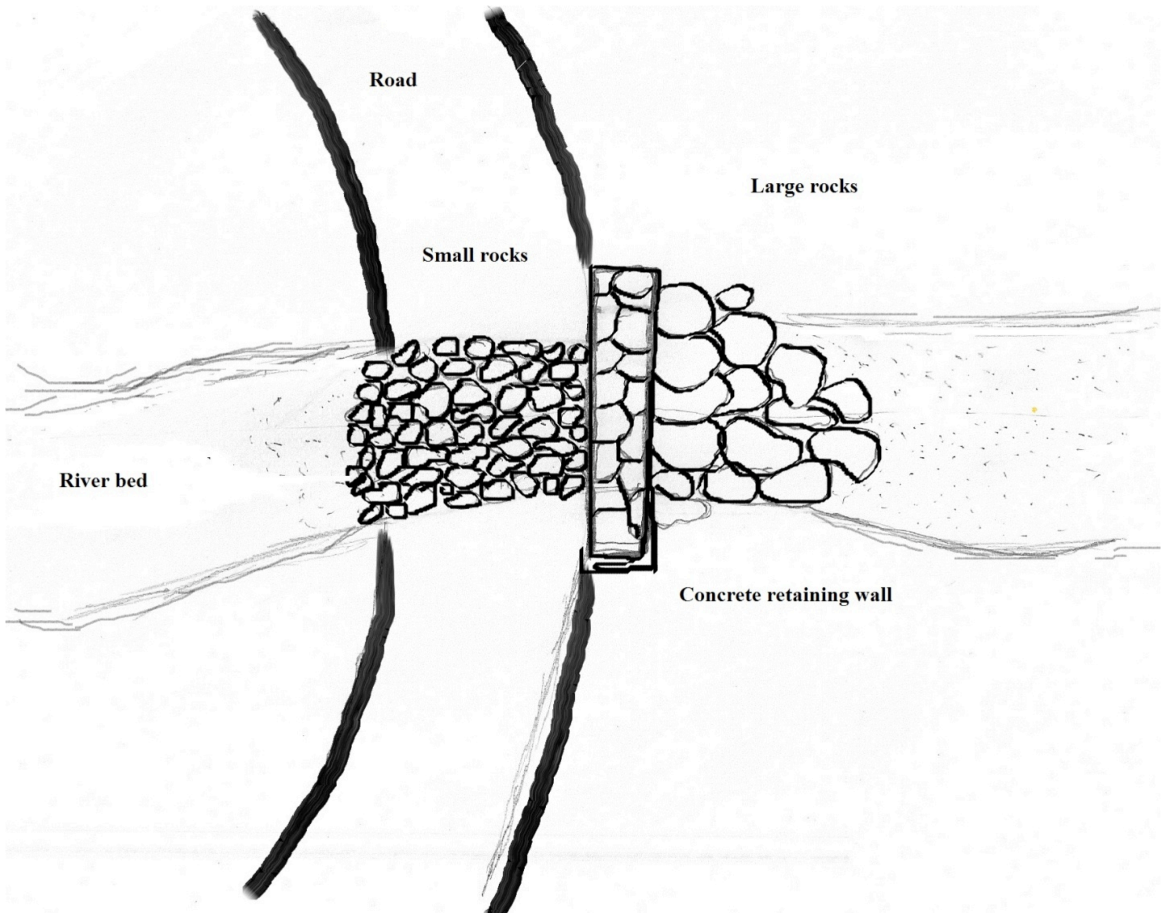


Figure 9.4: Illustration for the positioning of the retaining wall in small to medium sized drainage lines.

Erosion associated with roads was mostly found along the straight roads which followed an east-west direction, and when the road surface was graded or degraded below the surrounding soil surface. It is recommended that all these roads be graded with a crown to allow for run-off and to encourage grass growth on the crowns of these roads. Drainage channels and humps must be placed at regular intervals on the down sloping side of the road to lead water into the bush. The placement intervals of the drainage channels and humps depend on the slope of the road.

Roads crossing drainage lines on saline soils also tend to erode. These roads should be closed and redirected.

The boundary fences on Sango Ranch consist of a 1.2 m high buffalo fence and a 2.4 m high game fence. The buffalo fence and game fence are spaced approximately 7 m apart with a road between the two boundary fences. It is recommended that these roads be slashed rather than graded unless the road becomes unserviceable or there is a real threat of fires from neighbouring communities.

9.4 Managing the biotic components

On Sango Ranch stocking density, fire, elephant impact, alien invasive plants and vegetation harvesting are the main aspects affecting the vegetation.

9.4.1 Stocking density

Wildlife stocking density refers to the numbers of animals of various species that are present on a unit of land surface. Stocking densities are directly influenced by the ecological capacity of an area (Van Rooyen, 2010). Ecological capacity is reached when animal populations increase to the point where forage, water and habitat resources become limited to the extent that a zero growth rate is realised through competition for resources, lower fecundity and increased mortality. Animal population numbers from this point forward fluctuate around the ecological capacity. The ecological capacity itself varies due to factors such a rainfall variations, interspecific competition, predator-prey relationships or fires (Van Rooyen, 2010).

On Sango Ranch stocking densities were measured annually, mainly through annual aerial surveys. Herbivores were grouped into four main feeding classes, namely low-selective grazers, high-selective grazers, mixed feeders and browsers (Figure 9.5). The apportioning of wildlife into feeding classes followed the recommendations of Van Rooyen (2010) and differed slightly from the classification suggested by Hin (2000). The aerial survey results were then translated into grazing units and browsing units and compared to the ecological capacity for the ranch.

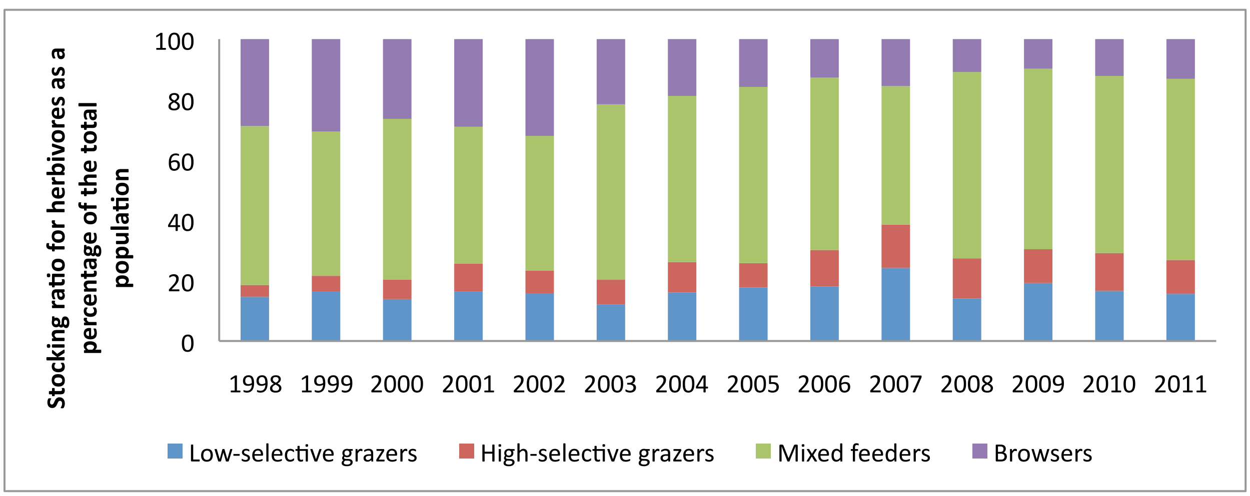


Figure 9.5: Percentage contributions of the four feeding classes of herbivores on Sango Ranch, Save Valley Conservancy, Zimbabwe.

Van Rooyen (2010) recommended a ratio of 4% low selective grazers, 13% high selective grazers, 50% mixed feeders and 33% browser for the mopane veld in the Limpopo province of South Africa. Hin (2000) based his recommendations on a ratio of 25% bulk grazers, 35% selective grazers, 20% mixed feeders and 20% browsers whilst Owen-Smith (1999) recommended a ratio of 2 bulk grazer: 1 selective grazer: 1 browser

On Sango Ranch the ratio between the different feeding catogories varied between years and animal movement patterns responded to the availability of natural resources, especially forage sources. Over a 10 year monitoring period with free movement of animals between ranches low-selective grazers contributed a mean of 16% (range from 12% to 24%), high-selective grazers contributed a mean of 10% (range from 4% and 14%), mixed feeders contributed a mean of 54% (range from 45% and 62%) and browsers contributed a mean of 20% (range from 10% and 32%).

Sango Ranch being an open system to the Save Valley Conservancy with animals able to move freely between properties makes recommendations based on feeding classes alone a futile exercise. However, subjective assessments of browsing pressure, scaled into five categories of severity, were used to measure the browse severity over 10 years and suggested that there was an increase in the browsing pressure since 2008. An increased browse pressure was recorded despite the browser component decreasing from 29% in 2000 to 13% in 2011. The percentage browse in the mixed feeder class thus possible increased, most probably due to the poor herbaceous production during the dry conditions. Mixed feeders found on Sango included African elephant, Livingston's eland, impala, nyala and warthog of which Livingston's eland and impala were the only two species occurring in sufficiently high numbers as to directly compete and impact on browse availibility for other mixed feeders and browsers. Population trend estimates for browsing species such as bushbuck and greater kudu indicated that bushbuck were declining and that greater kudu increased only marginally after the population "crash" due to anthrax in 2004. To facilitate recovery for these two species, especially for trophy hunting purposes, it is recommended that the Livingston's eland and impala populations be reduced by 15% and 20%, respectively.

Smit (2011) reported that ecological theories relating to feeding guild, water-dependence, allometric scaling, gut-morphology and predation vulnerability could explain most grazer distribution patterns observed in relation to surface-water, forage quality and quantity and the vegetation density. Arsenault & Owen-Smith (2002) stated that competition between herbivores is reduced primarily through body size and trophic adaptations. Large species can utilize low quality, high biomass forage, whilst small species need high forage quality but tolerate lower levels of forage biomass. Selective grazing of green leaf matter in taller grass swards by narrow-muzzled small species may deplete the quality forage component to the detriment of low selective feeders (Murray & Illius, 2000). Murray and Illius (2000) argued that vegetation modification is a critical component of resource competition between herbivores and suggested that herbivory by one species can modify the vegetation to the extent whereby the vegetation is "captured" by one species as a resource and then becomes less profitable for another. Arsenault and Owen-Smith (2002) reported that megaherbivores such as African elephant, hippopotamus and white rhinoceros may alter the vegetation to the extent whereby the habitat is altered to favour one species over the next. Arsenault and Owen-Smith (2002) explained this using the example of the Tsavo region in Kenya where increased African elephant numbers transformed the habitat from a dense shrubland to grasslands more suiteable for grazing animals. As a consequence grazing animals increased whilst browsers decreased. Increased grass growth and biomass in the Queen Elizabeth National Park followed the elimination of hippopotamus from the park with subsequent increases of African elephant, African buffalo and waterbuck. The recovery of the hippopotamus population once again led to decreases of these three species. Increased numbers of white rhinoceros in the Hluhluwe-Umfolozi Park, South Africa was associated with decreases in species dependent on tall grassland such as reedbuck and waterbuck, whilst species preferring short grassland increased in abundance. In all three examples one species facilitated the recovery of the population of another species or affected its ability to compete with another, thereby reducing its presence.

Kleynhans *et al.* (2011) found that resource partitioning by savanna herbivores was primarliy driven by body size during the dry season with the exception of megaherbivores such as white rhinoceros. During the non-growing season herbivores seggregate into distinct habitats or concentrate on different resource types (Jarman *et al.,* 1974). Hopcraft *et al.* (2012) found that forage and predation imposed greater constraints in the distribution of small grazers and that large grazers occurred on patches where forage was available, regardless of the predator risk. Ungulates of intermediate size balanced the risks associated with high biomass areas and forage quality.

Cain *et al.* (2011) found that sable antelope in the Kruger National Park moved further from water and drank less frequently in order to avoid high consentrations of other grazers. On Sango Ranch, it was found that the high density grazers generally moved eastwards into the *Acacia tortilis* Open Woodland Management Unit during the wet season. As conditions dried and forage become scarce, these high density grazers moved westwards into the *Combretum apiculatum* Woodland Management Unit which had a higher grass production. This movement, of especially blue wildebeest and Burchell's zebra into the extreme western sections of Sango Ranch could negatively affect the low density sable population. Both these high density grazing species were gradually moving into areas traditionally occupied by low density grazers such as sable antelope and by late 2011 resulted in a sable population shift southwards onto the neighbouring Savuli Ranch. After investigating the population decline for sable antelope in the Kruger National Park, Owen-Smit *et al.* (2012) warned that delays in responding to declining population numbers could jeopardize population recovery well before the actual population size dropped to a level threatening the viability of the population. To mitigate the competion pressure between high density grazers and low density grazers it is recommended that the blue wildebeest population be reduced by 30%. Recent aerial survey results for Sango Ranch indicated a drastic reduction in the Burchell's zebra population and any further off-take is therefore not recommended.

Figure 9.6 used two logarithmic regressions to illustrate trends between the actual stocking density and the grazing capacity on Sango Ranch. Bearing in mind that aerial survey population estimates are undercounts (Bothma & Du Toit, 2010) animal population numbers were adjusted according to a comparative survey estimate between a total aerial survey and a repeated helicopter survey using distance sampling to derive population estimates. Figure 9.6 illustrated that over the past decade the net grazing capacity was exceeded during the 2006/2007 season.

Consequently many animal species reached ecological equilibrium around that time (Chapter 8) with population growth rates leveling off.

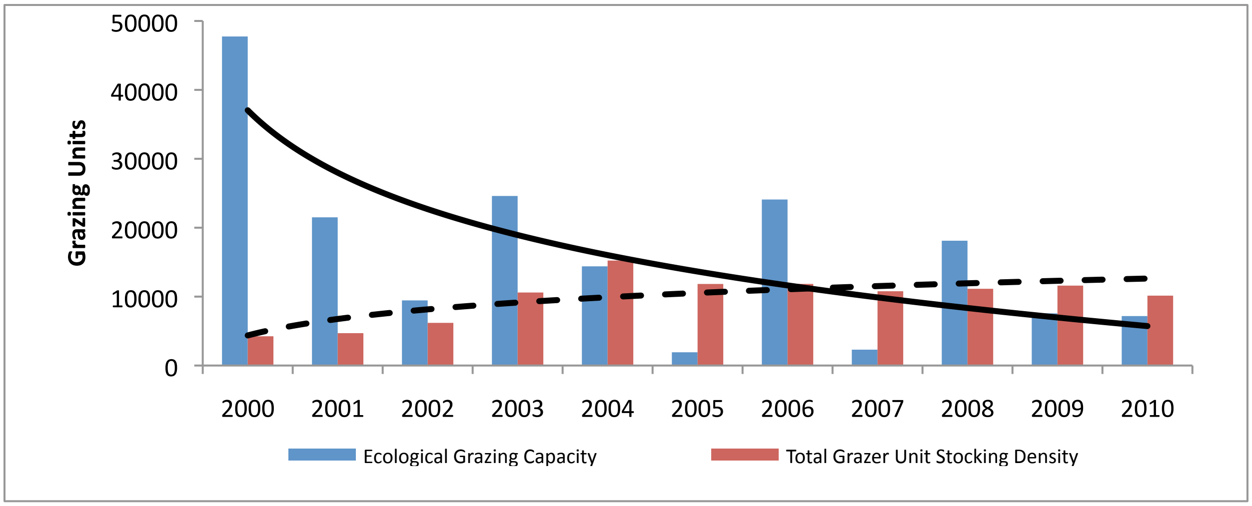


Figure 9.6: A comparison between the ecological grazing capacity with the grazer unit stocking density for each year (2000 – 2010).

Logarithmic regressions were also used to improve insight into the impact of the browsing regime on the ecological browsing capacity (Figure 9.7). Browsing capacity was exceeded for the entire 10 year monitoring period and explained the low growth rate measured amongst the populations of mixed feeders and browser (Chapter 8). It is therefore also recommended that the mixed feeder component be reduced to contribute only 40% to the herbivore feeding regime (see Figure 9.6).

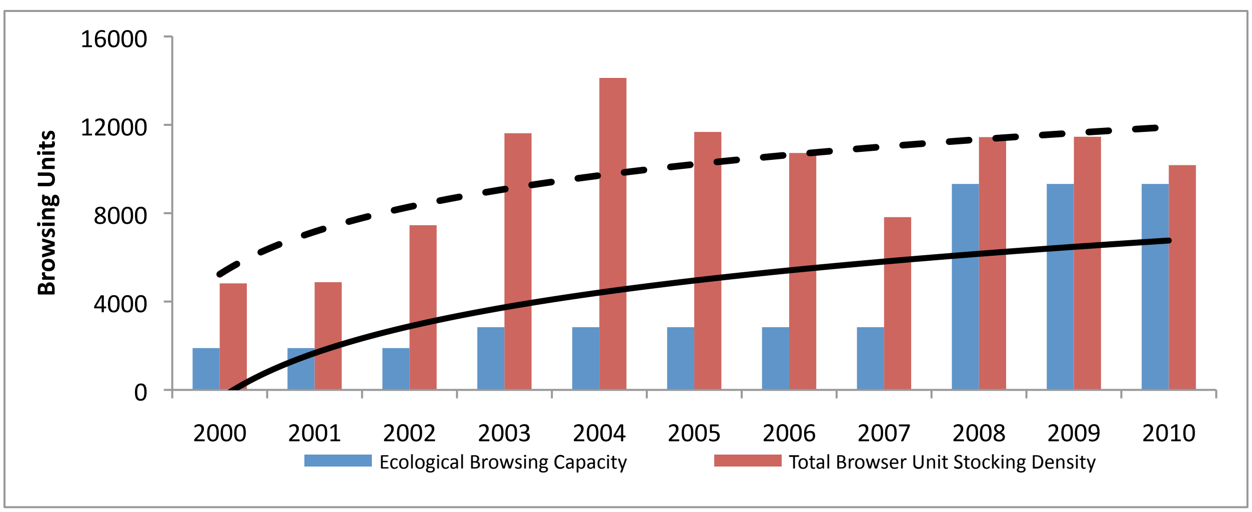


Figure 9.7: A comaprison between the ecological browsing capacity with the browser unit stocking density for each year (2000 – 2010).

9.4.2 Elephant impact management

The absence of fences between properties within the SVC allows for free movement of African elephant between properties. An African elephant management plan was adopted in 2006 which covered the entire SVC that included Sango Ranch. The African elephant management policy recognized the necessity to reduce African elephant numbers in order to protect biodiversity. The policy considered three options to reduce African elephant numbers, i.e. through translocation, contraception and culling. The SVC African elephant management policy adopted translocation as a first choice of African elephant population reduction followed by culling. Contraception of cows was rejected, however a new initiative has been tabled whereby African elephant bulls are sterilized and it is recommended that Sango Ranch as part of the Save Valley Conservancy investigate this possibility.

9.4.3 Fire management

African savanna ecosystems have been subjected to fire, natural or unnatural, since the beginning of time and it can be readily accepted that these fires contributed to the moulding of the present state of these ecosystems. However, where "natural" ecosystems are concerned fire functions as an integral part of these ecosystems as fire affects both the abiotic (non-living) and the biotic (living) attributes of ecosystems. Figure 9.8 indicates all accidental fires and management fires on Sango Ranch since 1980.

Sango Ranch adopted a fire management policy in 2002. The Sango fire management policy addressed issues relating to all unplanned fires, natural or unnatural, ecological considerations prior to management fires, pre-fire preparations, the fire and post-fire management. The policy relies on climatic predictions, especially rainfall predictions, amount of moribund material, and herbaceous biomass production to assess the likelihood of a "natural" fire occurring as well as the likelihood of recovery during the follow-up season. Once these criteria are satisfied the area to be burnt can be identified and measures taken to secure the fire. The area selected to burn should exceed 60 km^2 to allow for a mosaic burn pattern that simulates a "natural" fire. The policy further stipulates that fire breaks should be in place prior to igniting the fire and that the ignition point be placed on the upwind side of the prevailing wind (Joubert, 2002). Since the implementation of the fire management policy in 2002 the likelihood of "natural" fires occurring was too low to justify a management burn. The reasons for deciding not burn was mainly due to the generally poor rainfall received with subsequent lower grass production and low moribund accumulation. Animal numbers also increased resulting in reduced quantities of unutilised grass.

9.4.4 Vegetation harvesting

Currently, Sango Ranch does not harvest any plant material for commercial purposes, however, *Colophospermum mopane* was used for fence maintenance as well as providing building material for housing and schools at neighbouring communities. Over a 10 year period approximately 300 poles and 6 000 fence droppers were used for fence maintenance whilst 1000 poles went to local community development. Additionally *Phragmites australis* is harvested by local communities and used mainly for sleeping mats and roofing. Sango has allocated 60 days harvesting at 20 persons/day for local community development.

During the construction of Sango Lodge from 2000 to 2004, dead trees such as *Acacia nigrescens*, *Afzelia quanzensis* and *Combretum imberbe* were harvested. However, no harvesting of these species is currently taking place.

The impact of these harvesting practices is largely unknown. It is therefore recommended that the harvesting of *Colophospermum mopane* be monitored and the impact or recovery of the harvested areas be measured. Sustainable harvesting quotas should be scientifically determined for all relevant species.

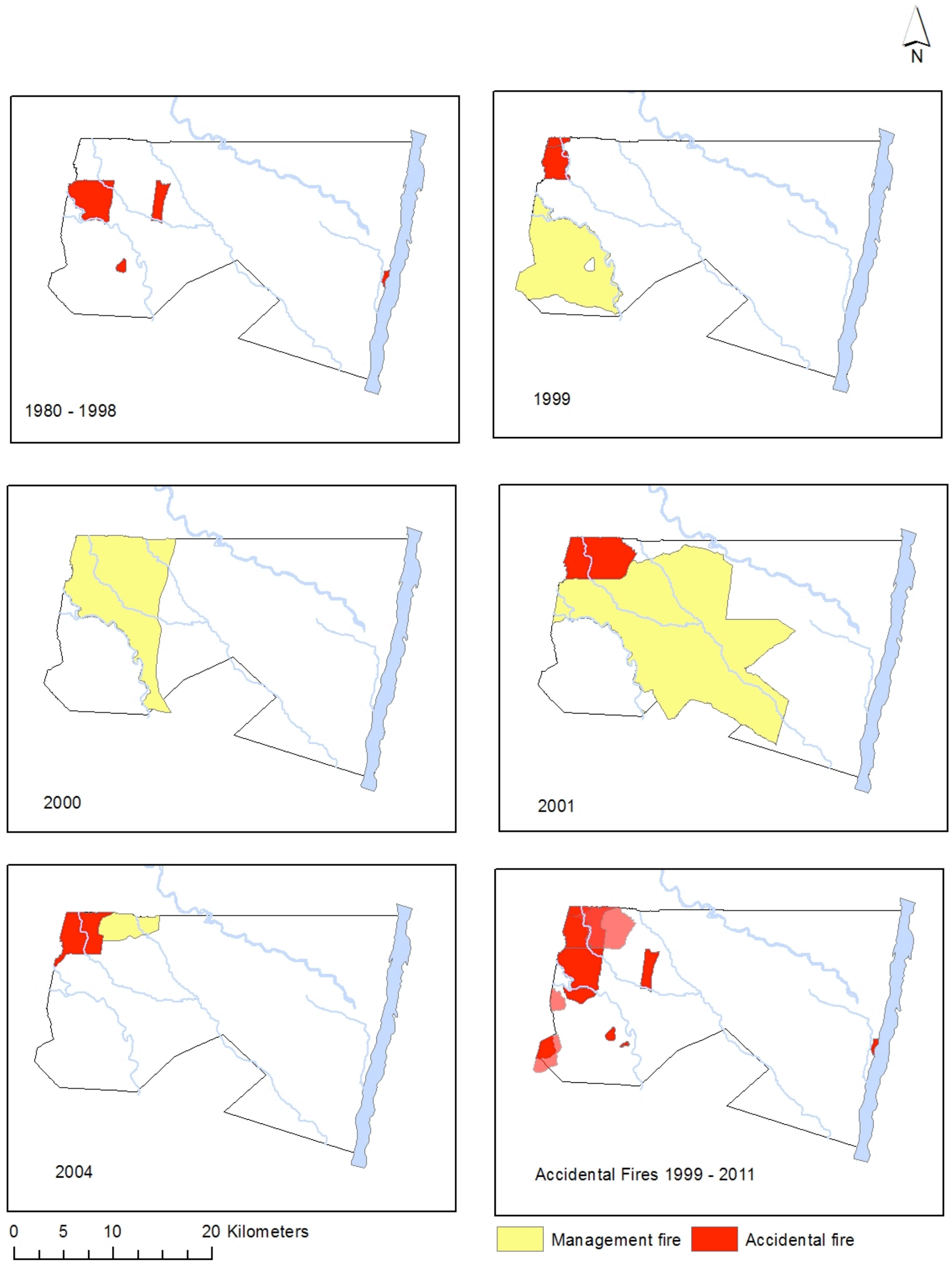


Figure 9.8: Accidental fires and management fires recorded for Sango Ranch, Save Valley Conservancy, Zimbabwe since 1980.

9.4.5 Waste management

Waste production on Sango Ranch is limited to the lodges and management headquarters. Solid waste production at these facilities is generally low, however a waste management program has been partially implemented.

Until recently all waste on Sango Ranch was disposed of using landfill pits. A waste management project was piloted at the Sango Ranch headquarters in 2011. The waste management program was based on the low volume of waste that is currently produced. Waste is separated into three main categories:

- Organic material;
- Burnable materials such as paper and plastic; and
- Non–burnable material such as metals and glass.

Waste management begins at household level with each household provided with three separation bins. All waste is collected twice weekly and taken to a central area for final separation and disposal. Organic material is disposed in compost heaps. Burnable material is burnt in an incinerator whilst non-burnable items are crushed and used as building material for various structures.

It is recommended that the waste management program be expanded to include the Sango Lodge, Sango tented camp and the Chapungu homestead.

9.4.6 Alien plant control

On Sango Ranch, three alien invasive plant species were identified, potentially threatening the ecological integrity of the area. Two species of *Opuntia* and *Lantana camara* were frequently recorded along the Save River whilst *Opuntia* spp. were also recorded in the *Colophospermum mopane* Closed Woodland Management Unit.

It is recommended that these species be removed through mechanical and biological control measures with limited use of chemical herbicides.

All plants prohibited from being planted on Sango Ranch are listed in Appendix VII. This is to avoid further spread of exotic species already occurring on Sango or the accidental introduction of new invasive species to the area.

9.4.7 Wildlife utilization

On Sango Ranch the management of animals can largely be divided into the consumptive and the non-consumptive use of wildlife. Consumptive use refers to management actions whereby animals are removed from the area such as hunting, harvesting and live animal sales. Non-consumptive use of the wildlife resources refers to the viewing of animals for recreational purposes without removing animals from the area.

9.4.7.1 Consumptive utilization of wildlife

The consumptive utilization of wildlife on Sango Ranch is divided into the hunting and harvesting of wildlife. Hunting can further be subdivided into trophy hunting and sport hunting (Joubert, 1996). Wildlife harvesting refers to utilization of a population through sustained production over a prolonged period (Bothma & Du Toit, 2010).

A. Hunting:

Trophy hunting can be defined as pleasure derived from the selective seeking of wildlife for a particular trait such as horn size, mass or length. The selective nature of trophy hunting and the reliance upon good trophy quality to maintain the sport necessitates careful consideration as to the species and the number of trophies of such species to be hunted. Trophy hunting is often critised on the basis of morality issues and cruelty towards animals for the sake of recreation.

Sango Ranch follows a strict code of hunting ethics when hunting is conducted and it is recommended that this code of hunting ethics be maintained. Nevertheless, establishing a sustainable trophy quality quota remains difficult and a subject of debate. Monitoring of trophy size and the age of the trophy animal has potential to give clear guidelines as to the sustainability of trophy hunting. It is thus recommended that all trophy animals shot be measured by trophy size for both the Rowland Ward measuring system and the Safari Club International trophy measuring system. Each trophy animal should, furthermore, be aged according to the tooth wear estimates found reported by Dunham (Dunham, 2000).

B. Harvesting

The harvesting of wildlife on Sango Ranch refers to the removal of animals either through culling or live sales of animals. It also includes the killing of animals for the sale of by-products and rations for the lodges and the staff. On Sango Ranch, aerial surveys were conducted annually and the animal off-take quota was based on a percentage of the actual number of animals seen from the air. A decision on the number and species for off-take is based on the total number of animals seen, the annual growth rate and the severity of the impact on the vegetation.

9.4.7.2 Non-consumptive utilization of wildlife

Non-consumptive use of animals refers to viewing animals for the purpose of recreation and is often referred to as photographic or ecotourism. Photographic tourism ventures thus rely on the diversity of species and the quality of viewing these species. Currently Sango Ranch hosts a diverse number of species for photographic tourism, but the quality of viewing wildlife varies considerably and is largely opportunistic. Whilst non-consumptive tourism and consumptive tourism generally tend to be conflicting, the size of Sango Ranch and its diverse nature lends itself to implementing both tourism options.

It is recommended that Sango Ranch follow a three-phased approach to improve the quality of wildlife viewing opportunities. These are

- Phase I: The identification of an area set aside exclusively for photographic tourism.
- Phase II: The habituation of general wildlife for quality photographic opportunities.
- Phase III: The habituation of the "big five" species such as African buffalo, African elephant, lion, leopard and black rhinoceros as well as other popular species associated with the photographic industry.

Figure 9.9 indicates the area set aside for photographic tourism. The photographic area includes most of the species occurring on Sango Ranch with the exception of sable antelope.

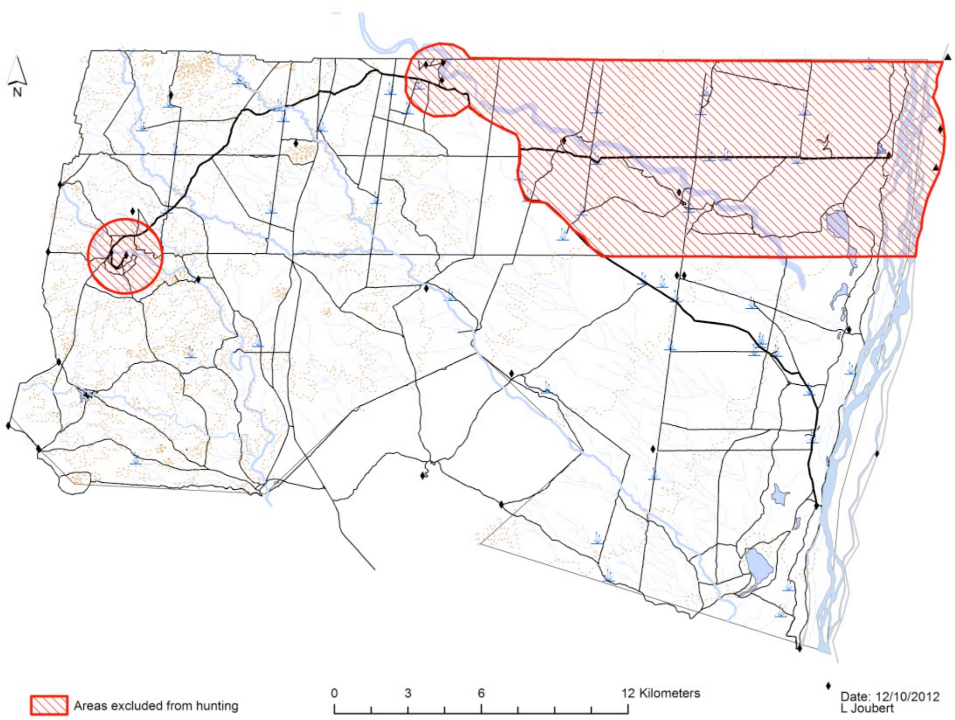


Figure 9.9: Areas demarcated for photographic tourism and no hunting zones on Sango Ranch.

9.5 Research priorities and monitoring program

9.5.1 Research objectives

With the completion of the natural resource assessment for Chapungu Ranch and its integration with Sango Ranch the baseline studies have been concluded. However, in terms of all natural resources the small mammal populations occurring on Sango Ranch and their contribution to the natural environment are still poorly understood. An inventory of the small mammals on Sango Ranch is therefore recommended as a first priority study.

Other research objectives are geared towards the maintenance of biodiversity and include:

- a study on the lion population, its dynamics and its threat to local communities,
- a study on brown hyena, a specially protected species in Zimbabwe, and its population viability with an increasing spotted hyena population and
- a study on the sable antelope population which is a low-density, highly valuable species, and often extirpated due to restricted movement and pressure from other ungulate species.

9.5.2 Monitoring program

Sinclair (1983) stated that nothing will be learnt of an area unless careful monitoring of the controls and the manipulations applied, are executed. A monitoring programme provides the information necessary for management decisions and the basis to evaluate the effects of management (Joubert, 1983). The fundamental basis for the design of a monitoring programme should be to establish trends.

Joubert (1983) identified the primary factors that are mutually important when management of large animal populations is the primary concern. It is essential to understand:

- factors affecting the vegetation composition and structure, the
- population dynamics of the mammal species in question and their associated species and
- the interactions between herbivore and the vegetation.

A comprehensive monitoring program is already implemented on Sango Ranch. The outcome of the data collected from this monitoring program has thus far been applied in the daily management of the property. The completion of the natural resource study for Chapungu Ranch will enable a more accurate assessment of the monitoring results.

The current monitoring program can largely be divided into the monitoring of the vegetation, the monitoring of the animals and other monitoring programs.

9.5.2.1 Monitoring of the vegetation

The vegetation monitoring program was designed to assess both the herbaceous and the woody components of the vegetation. A total of 45 vegetation monitoring plots were selected to include each management unit (Figure 9.10). However for easy access during the wet season plot placements were subjectively selected within each management unit.

The *Combretum apiculatum* Woodland Management Unit is represented by ten vegetation plots, the *Kirkia acuminata* Woodland Management Unit represented by four vegetation plots, the *Colophospermum mopane* Closed Woodland Management Unit by ten vegetation plots, the *Acacia tortilis* Open Woodland Management Unit by ten vegetation plots, the *Xanthocercis zambesiaca* Closed Woodland Management Unit by four vegetation plots, the *Diospyros mespiliformes* Riverine Management Unit by five vegetation plots and the *Echinochloa colona* Wetland Management Unit by two vegetation plots. The results of the vegetation monitoring program are primarily used to determine changes in the grazing and browsing capacity over time and to assess fuel loads for fire management.

Assessment of the herbaceous layer is done during the wet season and the dry season of each year. Fixed point photographs are taken at each vegetation plot. A qualitative assessment of the herbaceous layer is conducted at each vegetation plot during the wet season using a 100-point step-point, whilst a quantitative assessment recording 32 point disc-pasture heights is conducted. Grass height and the herbaceous canopy cover are subjectively assessed at 10 randomly selected sites within each plot. Subjective assessments are also conducted at each vegetation monitoring plot for trampling intensity, erosion, browsing pressure, grazing pressure, elephant impact, moribund material, termite activity and a greenness factor.

The woody vegetation is monitored every five years using the BECVOL technique (Smit, 1989a). It is recommended that the monitoring of the fixed vegetation plots be continued.

A shortcoming of the current vegetation monitoring program is that it does not measure the rate at which African elephant impact on the composition and structure and the woody vegetation. It is thus recommended that the monitoring technique described by Zambatis (2002) be implemented every second year.

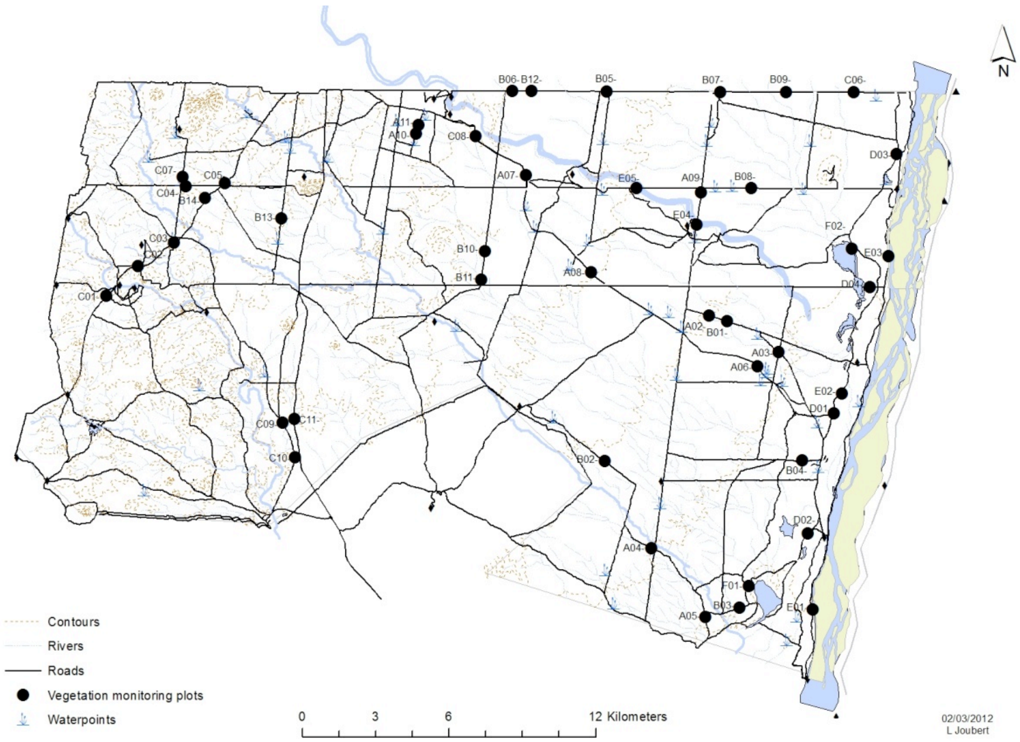


Figure 9.10: Distribution of fixed vegetation monitoring plots on Sango Ranch, Save Valley Conservancy, Zimbabwe.

9.5.2.2 Monitoring of the animals

Sango Ranch started its animal monitoring program in 1998 when the first annual aerial survey was conducted. Monitoring of the animals on Sango Ranch primarily focused on the presence and abundance of species on the property. Nevertheless, aerial surveys were only useful for establishing trend data of the larger herbivores and excluded the "cryptic" herbivores and carnivores that were not easily seen from the air. Several techniques were thus implemented to monitor and or assess animal presence and abundance on Sango Ranch (Chapter 8). The following recommendations pertain to the various techniques used to assess animal populations on Sango Ranch.

- Aerial survey: It is recommended that total aerial surveys be conducted on an annual basis to establish population trend for the larger herbivores on Sango Ranch.
- Grid square method: It is recommended that the grid square method be continued to monitor all herbivore and carnivore species on the property. It is further recommended that the method be refined to establish population size estimates.
- Road strip counts: It is recommended that road strip counts be conducted every second year for selected "cryptic" and small herbivores, game birds and small carnivores.

- Spoor transect counts: Annual spoor transect counts are to be conducted for carnivore species such as brown hyena, cheetah, leopard, lion, spotted hyena and wild dog.
- Depository survey: Depository surveys for civet, brown hyena and spotted hyena should be conducted every three years.
- Line transect survey: Annual line transect survey to be conducted in the *Xanthocercis zambesiaca* Closed Woodland Management Unit and the *Diospyros mespiliformis* Riverine Management Unit to establish population estimates for bushbuck and bushpig.

Other than population presence and abundance it is recommended that the population dynamics of the more abundant herbivore species and economically valuable species such as black rhinoceros, Livingston's eland, African elephant, giraffe, impala, greater kudu, sable antelope, warthog, waterbuck, white rhinoceros, blue wildebeest and Burchell's zebra be assessed in more detail.

Because Sango Ranch also relies heavily on trophy hunting as a source of income it is recommended that all animals hunted be measured for trophy size and age.

It is further recommended that once a small mammal inventory of Sango Ranch has been conducted and the primary drivers within the small mammal component have been identified that a monitoring technique be designed and implemented for these small mammals.

9.5.2.3 Other monitoring programs

All eagle and vulture nest sites were monitored annually up until 2005 but has since been discontinued. It is recommended that this monitoring process be re-instated as raptors often are indicators of the health status of ecosystems.

The monitoring of the aquatic environment has been discussed earlier in this chapter and it is recommended that the health status of the two perennial rivers be assessed every second year using the SASS-5 method.

ACKNOWLEDGEMENTS

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Finally I would like to thank my wife Lourette for her assistance with the maps, her valuable contributions in terms of interpretation and analising the vast number of data sets and for her patience and understanding at times when this study occupied much of my time.

Appendix I: Differential table of the floristic classification of the vegetation on Chapungu Ranch, Save Valley Conservancy, Zimbabwe

See back pocket of dissertation

Appendix IIa: List of tree and shrub species found on Sango Ranch, Save Valley Conservancy, Zimbabwe

Acacia abyssinica	Nyanga-flat top
Acacia erubescens	Blue thorn
Acacia galpinii	Monkey thorn
Acacia gerrardii	Red thorn
Acacia grandicornuta	Horned thorn
Acacia karroo	Sweet thorn
Acacia nigrescens	Knob thorn
Acacia nilotica	Scented thorn
Acacia schweinfurthii	River climbing thorn
Acacia tortilis	Umbrella thorn
Acacia xanthophloea	Fever tree
Adansonia digitata	Baobab
Adenium multiflorum	Impala lily
Afzelia quanzensis	Pod mahogany
Albizia amara	Bitter false-thorn
Albizia anthelmintica	Wormbark false-thorn
Albizia brevifolia	Rock false-thorn
Albizia forbesii	Broad-pod false-thorn
Albizia glaberrima	Lowveld false-thorn
Albizia harveyi	Common false-thorn
Albizia tanganyicensis	Paperbark false-thorn
Albizia versicolor	Large-leaved false-thorn
Allophyllus alnifolius	Lowveld false current
Anisotes formosissimus	
Annona senegalensis	Wild custard-apple
Antidesma venosum	Tassel-berry
Artabotrys brachypetalus	Purple hook-berry
Azanza garckeana	Snot apple
Azima tetracantha	Needle-bush
Balanites aegyptica	Simple-thorned torch-wood
Balanites maughamii	Green thorn
Bauhinia galpinii	Pride-of-de Kaap
Bauhinia tomentosa	Yellow bauhinia
Berchemia discolor	Brown ivory
Boscia angustifolia var. corymbosa	Rough-leaved shepherd's tree
Boscia foetida var. *rehmanniana*	Sandveld shepherd's tree
Boscia mossambicensis	Broad-leaved shepherd 's tree

Brachylaena rotundata	Mountain silver oak
Brachystegia spiciformis	Mountain acacia
Bridelia cathartica	Blue sweetberry
Bridelia mollis	Velvet sweetberry
Cadaba termitaria	Grey-leaved wormbush
Canthium glaucum subsp. *frangula*	Pink-fruited rock elder
Capparis tomentosa	Wooly caper-bush
Cardiogyne africana	African osage orange
Cassia abbreviata	Sjambok pod
Cissus cornifolia	Ivy-grape
Cissus rotundifolia	
Cleistochlamys kirkii	Purple cluster-pear
Clerodendrum glabrum	Tinderwood
Colophospermum mopane	Mopane
Combretum adenogonium	
Combretum apiculatum	Red bushwillow
Combretum hereroense	Russet bushwillow
Combretum imberbe	Leadwood
Combretum microphyllum	Flame climbing bushwillow
Combretum molle	Velvet bushwilllow
Combretum mossambicense	Knobbly climbing bushwillow
Combretum padoides	Thicket bushwillow
Combretum zeyheri	Large-fruit bushwillow
Commiphora africana	Poison-grub corkwood
Commiphora edulis	Rough-leaved corkwood
Commiphora glandulosa	Tall common corkwood
Commiphora marlothii	Paperbark corkwood
Commiphora mollis	Velvet corkwood
Commiphora mossambicensis	
Commiphora schimperi	Glossy-leaved corkwood
Commiphora viminea	Zebra-bark corkwood
Cordia grandicalyx	Large-fruit saucer-berry
Cordia monoica	Sandpaper saucer-berry
Cordia ovalis	Satin-bark saucer-berry
Cordia sinensis	Grey-leaved saucer-berry
Cordyla africana	Wild mango
Croton damarensis	
Croton megalobotrys	Feverberry
Dalbergia arbutifolia	River flat-bean
Dalbergia melanoxylon	Zebrawood

Deinbollia xanthocarpa	Northern soap-berry
Dichrostachys cinerea subsp. *africana*	Sickle bush
Diospyros lycioides	Bluebush
Diospyros mespiliformis	Jackal-berry
Diospyros quiloensis	Crocodile-bark jackal-berry
Dombeya kirkii	River dombeya
Drypetes mossambicensis	Lowveld ironplum
Ehretia amoena	
Ehretia obtusifolia	Hairy puzzle-bush
Ekebergia capensis	Cape-ash
Elephantorrhiza burkei	Broad-pod elephant-root
Entandrophragma caudatum	Wooden banana
Euclea divinorum	Magic guarri
Euphorbia confinalis	Lebombo euphorbia
Euphorbia espinosa	
Euphorbia guerichiana	
Euphorbia ingens	Naboom
Euphorbia tirucalli	Rubber-hedge euphorbia
Faidherbia albida	Ana-tree
Ficus abutilifolia	Large-leafed rock fig
Ficus capreifolia	Sandpaper fig
Ficus sanzibarica	Knobbly fig
Ficus sycomorus	Sycamore fig
Ficus tettensis	Small-leaved rock fig
Flacourtia indica	Governor's-plum
Flueggea virosa	White-berry bush
Friesodielsia obovata	Northern dwababerry
Garcinia livingstonei	African mangosteen
Gardenia resiniflua	Gummy gardenia
Gardenia volkensii	Bushveld gardenia
Grewia bicolor	White-leaved raisin
Grewia flavescens	Sandpaper raisin
Grewia gracillima/caffra	Silver square-stemmed raisin
Grewia inaequilatera	False silver raisin
Grewia monticola	Grey raisin
Grewia sulcata	Stellar raisin
Grewia villosa	Mallow raisin
Gymnosporia buxifolia	Common spikethorn
Gymnosporia putterlickioides	Large-flowered spikethorn
Gymnosporia senegalensis	Red spikethorn

Gyrocarpus americanus	Propeller tree
Hippocratea indica	Mopane-paddle-pod
Hymenocardia ulmoides	Small red-heart
Hyphaene petersiana	Northern lalapalm
Julbernardia globiflora	Munondo
Keetia venosa	Turkey-berry
Kigelia africana	Sausage tree
Kirkia acuminata	White seringa
Lannea schweinfurthii	False marula
Lantana camara	Christmas berry
Lantana rugosa	Bird's brandy
Lycium shawii	White honey-thorn
Maerua angolensis	Bean-bead tree
Maerua decumbens	Blue-leaved bush-cherry
Maerua juncea	Rough-skinned bush-cherry
Manilkara mochisia	Lowveld milkberry
Markhamia zanzibarica	Maroon bell-bean
Millettia usamarensis	Lowveld panga-panga
Monodora junodii	Green-apple
Mundulea sericea	Cork-bush
Ochna inermis	Stunted plane
Ormocarpum trichocarpum	Hairy caterpillar-pod
Pappea capensis	Jacket-plum
Peltophorum africanum	African-wattle
Philenoptera violacea	Apple-leaf
Phyllanthus pinnatus	Lebombo potato-bush
Phyllanthus reticulatus	Potato-bush
Rhigozum zambesiacum	Mopane rhigozum
Salvadora australis	Narrow-leaved mustard tree
Salvadora persica	Mustard tree
Spirostachys africana	Tamboti
Stadmannia oppositifolia	Silky-plum
Steganotaenia araliacea	Carrot-tree
Sterculia rogersii	Common star-chestnut
Strophanthus kombe	Large-leaved poison-rope
Strychnos decussata	Cape-teak
Strychnos madagascariensis	Black monkey-orange
Strychnos potatorum	Black bitterberry
Syzygium guineense	Bushveld waterberry
Tabernaemontana elegans	Toad tree

Teliacora funifera	
Terminalia prunioides	Lowveld cluster-leaf
Terminalia sericea	Silver cluster-leaf
Thilachium africanum	Cucumber-bush
Tinnea rhodesiana	Brown tinnea
Tricalysia junodii	Northern fluffy-flowered jackal coffee
Trichilia emetica	Natal mahogany
Vepris zambesiaca	Rare woodland vepris
Vitellariopsis ferruginea	Gourd bush milkwood
Vitex isotjensis	Golden vitex
Xanthocercis zambesiaca	Nyala berry
Xeroderris stuhlmannii	Wing-pod
Ximenia americana	Blue sourplum
Xylopia parviflora	Forest red-fingers
Zanthoxylum capense	Small knobwood
Ziziphus mucronata subsp. *mucronata*	Buffalo thorn

Appendix IIb: List of grass species found on Sango Ranch, Save Valley Conservancy, Zimbabwe

Aristida congesta
Aristida congesta subsp. *barbicollis*
Aristida junciformis
Aristida rhiniochloa
Bothriochloa insculpta
Bothriochloa radicans
Brachiaria deflexa
Brachiaria xantholeuca
Cenchrus ciliaris
Chloris roxburghiana
Chloris virgata
Dactyloctenium aegyptium
Dactyloctenium australe
Dactyloctenium giganteum
Danthoniopsis pruinosa
Digitaria milanjiana
Digitaria velutina
Echinochloa colona
Enneapogon cenchroides
Enteropogon macrostachyus
Eragrostis aspera
Eragrostis biflora
Eragrostis cilianensis
Eragrostis curvula
Eragrostis cylindriflora
Eragrostis heteromera
Eragrostis japonica
Eragrostis rigidior
Eragrostis rotifer
Eragrostis superba
Leptochloa uniflora
Melinis repens
Oropetium capense
Panicum coloratum
Panicum deustum
Panicum dregeanum
Panicum maximum
Panicum subalbidum
Paspalidium obtusifolium
Perotis patens
Phragmites australis
Pogonarthia squarrosa
Schmidtia pappophoroides
Setaria pumila
Setaria sagittifolia
Setaria sphacelata
Setaria verticillata
Sorghum versicolor
Sporobolus festivus
Sporobolus ioclados
Sporobolus nitens
Sporobolus panicoides
Tragus berteronianus
Tricholaena monachne
Tripogon minimus
Urochloa mosambicensis
Urochloa oligotricha
Urochloa panicoides
Urochloa trichopus

Appendix IIc: List of forb species found on Sango Ranch, Save Valley Conservancy, Zimbabwe

Abutilon angulatum	Elephant's ear
Abutilon fructicosum	Shrubby abutilon
Abutilon grandiflorum	
Abutilon hirtum	
Abutilon ramosum	Shade-loving abutilon
Abutilon rehmanni	
Acalypha fimbriata	
Acalypha indica	Indian girl
*Achyranthus aspera**	Chaff flower
Aeollanthus neglectus	Neglected spur bush
Aeschynomene indica	
Alectra orobanchoides	
Aloe aculeate	
Aloe littoralis	
Ammania baccifera	Waterbessiekruid
Amaranthus praetermissus	Misbredie
Ammocharis coranica	Sore eye lily
Ampelocissus africana	
Ampelocissus obtusata subsp. *kirkiana*	
Aneilema hockii	
Ansellia africana	Leopard orchid
Antidesma venosum	
Aponogeton stuhlmannii	Waterblaartjie
Aptosimum lineare	Carpet flower
*Argemone ochroleuca**	White mexican poppy
Asparagus africanus	
Asparagus aspergillus	
Asparagus cooperi	Haakdoring
Asparagus schroederi	
Asparagus suaveolens	Bushveld asparagus
Astripomoa lachnosperma	
Asystasia gangetica	
Barleria affinis	Downy barleria
Barleria albostellata	
Barleria dinteri	Leatherleaf barleria
Barleria heterotricha	
Barleria kirkii	
Barleria lugardii	White barleria
Barleria prionitis	
Barleria sinensis	Mozambique barleria
Barleria spinulosa	
Basilicum polystachyon	
Becium filamentosum	
Becium obovatum	
Bidens biternata	
Blainvillea gayana	
Blepharis acanthodioides	
Blepharis diversispina	
Blepharis subvolubilis	Eyelash flower
Blepharis transvaalensis	
Blumea viscose	
Boerhavia repens	Creeping spiderling
Bulbostylis densiflora	

Cardiospermum corindum	Bushveld balloon vine
Celosia trigyna	
Ceratotheca sesamoides	
Ceratotheca triloba	Wild foxglove
Chamaecrista mimosoides	Fishbone dwarf cassia
Chamaecrista absus	Hairy pod cassia
Chamaecrista sp.	
Cheilanthes involuta	
Chlorophytum blepharophyllum	
Chlorophytum macrosporum	
Chlorophytum sphacelatum	
Cissus cornifolia	Ivy-grape
Cissus rotundifolia	
Cissampelos mucronata	
Cissampelos pareira	
Cissus cactiformis	Cactus vine
Cissus integrifolia	
Cleome angustifolia	Yellow mouse whiskers
Cleome gynandra	African cabbage
Cleome hirta	Pretty lady
Cleome maculata	
Cleome monophylla	Single leaved cleome
Clerodendrum ternatum	Tinderwood
Coccinia adoensis	
Coccinia rehmannii	Wild cucumber
Cocculus hirsutus	Python climber
Commelina africana	Yellow commelina
Commelina benghalensis	Benghal blue wandering jew
Commelina subulata	
Commicarpus plumbagineus	
Corchorus kirkii	
Corchorus trilocularis	
Corallocarpus triangularis	Thicket coral-fruit creeper
Corchorus asplenifolius	Geel varingblaartjie
Corchorus longipedunculatus	Langsteel varingblaar
Corchorus tridens	
Crabbea velutina	
Crassula lanceolata	
Craterostigma plantagineum	Blue carpet
Crinum graminicola	
Crotalaria damarensis	Damaraland rattle pod
Crotalaria heidmannii	Narrow-leaved rattle pod
Crotalaria laburnifolia	Bushveld crotalaria
Crotalaria podocarpa	
Crotalaria sphaerocarpa	Mealie crotalaria
Crotalaria steudnerii	
Crotalaria virgulata	
Ctenolepis cerasiformis	
Cucumis anguria	Wild cucumber
Cucumis hirsutus	Hairy wild cucumber
Cucumis metuliferus	
Cummicarpus plumbagineus	Wit veld patats
Cyanotis lanata	
Cyathula lanceolata	Stekelbossie

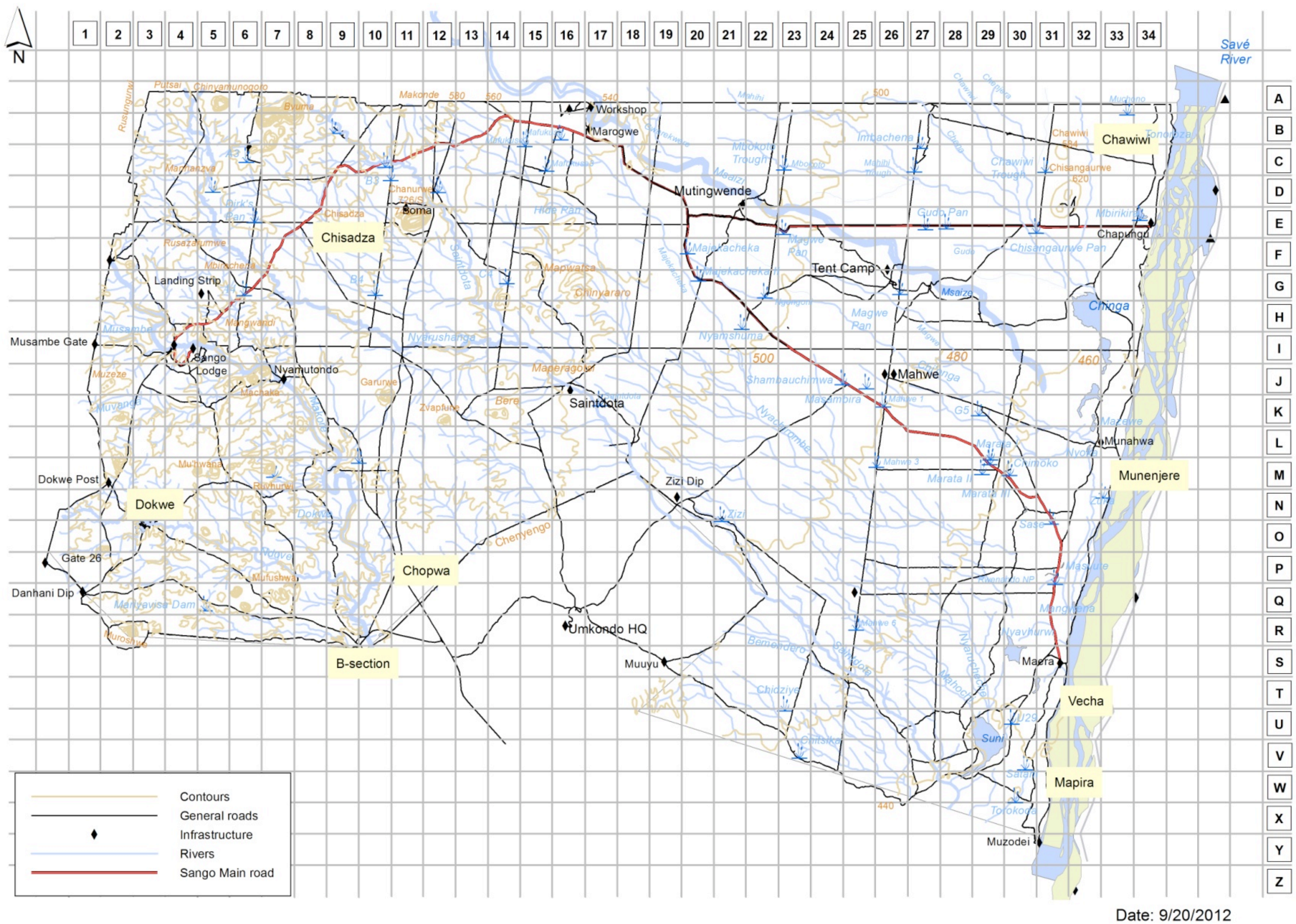
Cyathula orthacantha	
Cyperus digitatus subsp. *auricomis*	
Cyperus rupestris	Russet rock sedge
Cyperus schinzii	
Cyperus sexangularis	Matjiesgoed
Cyperus zollingeri	
Cyphostemma buchananii	
Cyphostemma sandersonii	Bobbejaandruif
Cyphostemma sp. 1	
Cyphostemma sp. 2	
Desmodium ospriostrebium	
Dicoma tomentosa	Hairy dicoma
Dipcadi pappillatum	Groenielie
Dipcadi platyphyllum	Crinkle-leaved dipcadi
Dipcadi vaginatum	Mopane veld dipcadi
Drimia indica	Secret lily
Dyschoriste matopensis	
Dyschoriste sp.	
Elytraria acaulis	
Endostemon tenuiflorus	Mopane veld keepsakes
Endostemon tereticaulis	Small purple keepsakes
Epaltes gariepina	
Eriospermum flagelliforme	Slender fluffy seed
Euphorbia benthamii	
Euphorbia hirta	Red milkweed
Euphorbia neupolycnemoides	Klein bont euphorbia
Eureiandra fasciculata	
Evolvulus alsinoides	Blue haze
Geigeria burkei	Knoppiesvermeerbossie
Gisekia africana	Rooi rankopslag
Gloriosa superba subsp. *superba*	
Gomphocarpus fructicosus subsp. *decipiens*	Cotton milkweed
*Gomphrena celosioides**	Bachelor's button
Helichrysum argyrosphaerum	Wild everlasting
Heliotropium ciliatum	Kalahari string of stars
Heliotropium ovalifolium	Riverbank heliotropium
Heliotropium steudneri	
Heliotropium strigosum	Single star heliotropium
Hermannia boraginiflora	Groot gombossie
Hermannia glanduligera	
Hermannia kirkii	
Hermbstaedtia odorata	
Hibiscus engleri	Wild hibiscus
Hibiscus mastersianus	
Hibiscus micranthus	Tiny white wild hibiscus
Hibiscus seineri	
Hibiscus sidiformis	
Hibiscus vitifolius subsp.*vulgaris*	De Klundert hibiscus
Hippocratea indica	
Hybanthus enneaspermus	Pink lady slipper
Hyperbolius bowkeriana	Wild fenugreek
Indigofera astragalina	Long leaved indigo
Indigofera lupatana	
Indigofera praticola	

Indigofera trictoria	
Indigofera trita subsp. *subulata*	
Indigofera varia	
Indigofera vicioides	
Ipomoea dischroa	Flannel morning glory
Ipomoea hochstetteri	
Ipomoea magnusiana	Small pink ipomoa
Ipomoea obscura	Wild petunia
Ipomoea pes-trigridis	
Ipomoea plebeia subsp. *africana*	
Ipomoea sinensis	Purple throated ipomoa
Ipomoea tenuipes	
Ipomoea tuberculata	
Jacquemontia tamnifolia	
Jasmimum fluminense	Wild jasmine
Jatropha erythropoda	Rooikambro
Jatropha spicata	Rocky jatropha
Justicia flava	Yellow justicia
Justicia glabra	
Justicia kirkiana	
Justicia matammensis	
Justicia protracta subsp. *protracta*	
Justicia protracta subsp. *rhodesica*	Veld justicia
Kalanchoe brachyloba	Short-lobed kalanchoe
Kalancoe lanceolata	
Kanahia laniflora	
Kedrostis leloja	Spindle-shaped cucumber
Keetia venosa	
Kyllinga alba	White sedge
Kyphocarpa angustifolia	Silky burweed
Lagenaria sphaerica	
Lantana rugosa	
Lapeirousia erythrantha	
Ledebouria cooperi	Cooper's squill
Ledebouria marginata	
Ledebouria sp.	
Leonotis nepetifolia	Annual wild dagga
Leucas glabrata	Dainty tumble weed
Limeum argute-carinatum	Koggelmandervoetkaroo
Limeum dinteri	
Limeum fenestratum	
Limeum sulcatum	Klosaarbossie
Limnophyton obtusifolium	
Lindernia monroi	Dogola snap dragon
Maerua decumbens	
Maerua juncea	Rough-skinned bush-cherry
Maerua parvifolia	Small-leaved spider bush
Marsinus rehmannianus	
Megalochlamys revoluta	
Melanthera albinervia	
Melhania acuminata	Bushy honeycub
Melhania forbesii	
Merremia kentrocaulos	Prickley stem merremia
Merremia pinnata	Feather-like merremia

*Mollugo cerviana**	Thread stemmed carpet weed
*Mollugo nudicaulis**	White star mollugo
Momordica boivinii	
Momordica kirkii	
Monechma debile	
Monechma divaricatum	
Nelsia quadrangula	Botswana burweed
Neorautanenia amboensis	Gemsbokboontjie
Neuracanthus africanus	Seningbossie
Nidorella microcephala	
Nymphaea nouchali	
Ocimum americanum	Wild basil
Ocimum filamentosum	Purple wild basil
Ocimum gratissimum	
Ornithoglossum vulgare	Brown tongue lily
Orthosiphon suffrutescens	
*Oxalis corniculata**	Creeping yellow sorrel
Oxygonum delagoense	Salt of the tortoise
Pancratium tenuifolium	Aandblommetjie
Pavonia burchellii	Dainty pavonia
Peponium pageanum	
Pergularia daemia	Trellis vine
Phyllanthus angolensis	Rooilitbessie
Phyllanthus maderaspatensis	Skildpadbossie
Phyllanthus parvula	
Physalis lagascae	
Plectranthus tettensis	
Plicosepalus kalahariensis	Fiery plicosepalus
Pluchea dioscoridis	
Plumbago zeylanica	Wild white plumbago
Polygala senesis	
Polygala sphenoptera	
Portulaca kermesina	Haaskos
Portulaca quadrifida	Wild purslane
Pouzolzia mixta	
Pseudoconyza viscosa	
Pterodiscus sp.	
Pupalea lappacea	
Raphionacme monteiroae	
Reissantia indica	
Rhoicissus revoilii	
Rhyncosia minima	Siesta carpet bean
Rothia hirsuta	
Ruellia cordata	Veld violet
Ruellia patula	White veld violet
Sansevieria sp. unidentified	
Sarcostemma viminale	Viney milkweed
Scadoxus puniceus	
Schoenoplectus senegalensis	Spring onion sedge
Seddera capensis	Small white seddera
Seddera suffruticosa	
Selaginella dregei	
Senna petersiana	
Sericorema remotiflora	Wolhaarbossie
Sesamum alatum	Wing-seeded sesame

Sesamum triphyllum	Wild sesame
Sesbania leptocarpa	
Sida alba	
Sida cordifolia	Heartleaf sida
Sida ovata	Mapungubwe sida
Solanum catombolense	Bitter apple
*Solanum nigrum**	Nightshade
Solanum panduriforme	
Solanum sp. 1	
Solanum sp. 2	
Spaeranthus angolensis	
Spermacoce senensis	Sena star
Stapelia kwebensis	Kwebe hills stapelia
Stomastemma monteiroae	Monteiro vine
Streptopetalum serratum	
Striga asiatica	
Striga gesnerioides	
Stylochiton puberulus	
Stylosanthes fructicosa	Wild lucerne
Syncolostemon bracteosus	White-tipped hemizygia
Syncolostemon canescens	Los-my-uit
Tarenna zygoon	
Tephrosia purpurea subsp. *leptostachya*	
Tephrosia reptans	
Tephrosia rhodesica	Pole Evans bush pea
Tephrosia villosa	
Tragia okanyua	
Tribulus terrestris	Devil's thorn
Tricliceras glanduliferum	Yellow lion's eye
Tridax procumbens	Tridax daisy
Triumfetta pentandra	
Vernonia cinerea	
Vernonia lundiensis	
Vignia unguiculata subsp. *dekindtiana*	
Waltheria indica	Meidebossie
Withania somnifera	
Xenostegia tridentata	Miniature morning glory
Xerophyta humilis	Reen metertjies
Xerophyta retinervis	Black-stick lily
Zaleya pentandra	
Zornia glochidiata	Caterpillar bean

Appendix IIIa: Grid square map used to determine animal densities and distributions for Sango Ranch, Save Valley Conservancy, Zimbabwe



Appendix IIIb: Patrol data sheet used for the grid square method, Sango Ranch, Save Valley Conservancy, Zimbabwe

Species	Grid	No seen	Grid	No seen	Grid	No seen	Grid	No seen	Grid	No seen	Grid	No seen	Grid	No seen	Grid	No seen	Grid	No seen	Grid	No seen
Mhara (Impala)	B4	15	C3	19	C3	1	X	X	J16	23	J16	2	L21	34	L22	6	X	X	J16	21
Nhoro (Kudu)	B4	4	B4	3	X	X	X	X	M14	8	X	X								
Dsoma (Bushbuck)	C4	1	B4	2	X	X	X	X	X	X										
Mhofu (Eland)	B4	1	C3	14	D3	2	X	X	K17	88	X	X	K12	8	K13	17	X	X		
Nyati (Buffalo)	C3	130	X	X	X	X	X	X												
Dhumukwa (Waterbuck)	X	X	X	X	X	X	X	X												
Ngongoni (Wildebeest)	C3	1	X	X	J16	25	K17	32	X	X	X	X								
Twisa (Giraffe)	X	X	K19	13	X	X	K17	8	X	X										
Njiri (Warthog)	X	X	K18	3	K19	1	K19	4	M19	1	X	X	M15	3	M17	2	X	X		
Mbizi (Zebra)	C3	7	D3	6	X	X	X	X	X	X										
Nguruve (Bushpig)	X	X	X	X	X	X														
Nhema (Black rhino))	B3	2	X	X	X	X	X	X												
Chipembere (White rhino)	X	X	X	X	X	X														
Nzou (Elephant)	X	X	X	X	X	X														
Ngwarati (Sable)	X	X	X	X	X	X														
Ngururu (Klipspringer)	A4	2	B4	2	X	X	X	X	X	X										
Deke/Himba (Sharpe's grysbuck)	B4	1	X	X	X	X					Hanga (Guinea fowl)			X	X	K19	35	X	X	X
Mhembwe (Duiker)	C4	1	X	X	J16	1	X	X			Mariti (Ground hornbill)			X	X	X	X	X	X	X
Gudo troop (Baboon troop)	X	X	K17	1	X	X	X	X												
Tsoko troop (Vervet monkey troop)	X	X	X	X	X	X	X	X	Dzere Spoor (Honey badger)					X	X	X	X	X	X	
Mvuu (Hippopotamus)	X	X	X	X	X	X	X	X	Ingwe spoor (Leopard)					X	X	J17	1	X	X	X
Ngwena (Crocodile)	X	X	X	X	X	X	X	X	Shumba Spoor (Lion)					X	X	X	X	X	X	X
Chi-haha (Black-backed jackal)	X	X	K18	1	X	X	X	X	Bere Spoor (Hyena)					X	X	K18	3	X	X	X
Nyala (Nyala)	X	X	X	X	X	X	X	X	Dindingwe Spoor (Cheetah)					X	X	X	X	X	X	X

* Species not on the list must be added in the open space or placed under the "off-interest" section

Waenda kupi nhasi? (Patrol route)

Date																				
15 October 2012	A4	B4	C3	D3	E3	D3	D4	C4	B4	A4										
16 October 2012	No animal data collected - anti-poaching ambush & transfer																			
17 October 2012	J16	J17	K17	K18	K19	L19	L20	L21	L22	M22	M21	N21	N20	N19	N18	M18	M17	M16	L16	K16
18 October 2012	J16	I16	I15	I14	I13	J13	K13	K12	K11	L10	L09	L10	K11	K12	K13	K14	K15	K16	J16	
19 October 2012	J16	K16	L16	M15	N15	N14	N13	M14	M15	M16	M17	L17	K17	J17	J16					
20 October 2012	No animal data collected – rain																			
21 October 2012	No patrol																			

Appendix IVa: List of large mammals found on Sango Ranch, Save Valley Conservancy, Zimbabwe

Aardwolf	*Proteles cristatus*	Mongoose, Banded	*Mungos mungo*
Aardvark	*Orycteropus afer*	Mongoose, Dwarf	*Helogale parvula*
Baboon, Chacma	*Papio ursinus*	Mongoose, Meller's	*Rhynchogale melleri*
Badger, Honey	*Mellivora capensis*	Mongoose, Selous	*Paracynictis selousi*
Buffalo, African	*Syncerus caffer*	Mongoose, Slender	*Galerella sanguine*
Bushbuck	*Tragelaphus scriptus*	Mongoose, White-tailed	*Ichneumia albicauda*
Bushpig	*Potamochoerus porcus*	Monkey, Vervet	*Cercopithecus aethiops*
Caracal	*Felis caracal*	Nyala	*Tragelaphus angasii*
Cheetah	*Acinonyx jubatus*	Otter, Cape Clawless	*Aonyx capensis*
Civet, African	*Civettictis civetta*	Pangolin, Grant's	*Manis temminckii*
Duiker, Common	*Sylvicapra grimmia*	Porcupine, South African	*Hystrix africaeaustralis*
Eland, Livingston's	*Tragelaphus oryx*	Rhinoceros, Black	*Diceros bicornis*
Elephant, African	*Loxodonta africana*	Rhinoceros, White	*Ceratotherium simum*
Galago, Lesser	*Galago moholi*	Sable Antelope	*Hippotragus niger*
Galago, Thick-tailed	*Otolemur crassicaudatus*	Serval	*Felis serval*
Genet, Large spotted	*Genetta tigrina*	Springhare	*Pedetes capensis*
Giraffe	*Giraffa camelopardalis*	Squirrel, Bush	*Paraxerus cepapi*
Grysbok, Sharpe's	*Raphicerus sharpei*	Waterbuck	*Kobus ellipsiprymnus*
Hare, Scrub	*Lepus saxatilis*	Warthog	*Phacochoerus aethiopicus*
Hippopotamus	*Hippopotamus amphibius*	Wild Cat, African	*Felis lybica*
Hyaena, Spotted	*Crocuta crocuta*	Wild Dog, African	*Lycaon pictus*
Hyaena, Brown	*Hyaena brunnea*	Wildebeest, Blue	*Connochaetes taurinus*
Impala	*Aepyceros melampus*	Zebra, Burchell's	*Equus burchelli*
Jackal, Side-striped	*Canis adustus*		
Jackal, Black-backed	*Canis mesomelas*		
Klipspringer	*Oreotragus oreotragus*		
Kudu, Greater	*Tragelaphus strepsiceros*		
Leopard	*Panthera pardus*		
Lion	*Panthera leo*		

Appendix IVb: List of reptiles found on Sango Ranch, Save Valley Conservancy, Zimbabwe

Bibron's burrowing asp	*Atractaspis bibronii*	Kirk's rock agama	*Agama kirkii*
Black file snake	*Mehelya nyassae*	Peter's ground agama	*Agama armata*
Black mamba	*Dendroaspis polylepis*	Southern tree agama	*Acanthocercus atricollis*
Boomslang	*Dispholidus typus*	Flap-neck chameleon	*Chamaeleo dilepis*
Boulenger's garter snake	*Elapsoidea boulengeri*	Nile crocodile	*Crocodylus niloticus*
Brown house snake	*Lamprophis fuliginosus*	Cape dwarf gecko	*Lygodactylus capensis*
Cape centipede eater	*Apparallactus capensis*	Flat headed tropical house gecko	*Hemidactylus platycephalus*
Cape file snake	*Mehelya capensis*	Moreau's tropical house gecko	*Hemidactylus mabouia*
Cape wolf snake	*Licophidion capense*	Speckled thick-toed gecko	*Pachydactylus punctatus*
Common brown water snake	*Lycodonomorphus rufulus*	Tasman's tropical house gecko	*Hemidactylus tasmani*
Common purple-glossed snake	*Amblyodipsas polylepis*	Tiger thick-toed gecko	*Pachydactylus tigrinus*
Common/Rhombic egg-eater	*Dasypeltis scabra*	Turners thick-toed gecko	*Pachydactylus turneri*
Delalande's beaked blind snake	*Rhinotyphlops lalandei*	Van Son's thick-toed gecko	*Pachydactylus vansonii*
Dwarf sand snake	*Psammophis angolensis*	Wahlberg's velvet gecko	*Homopholis wahlbergii*
East African shovel-snout snake	*Prosymna stuhlmannii*	Black-lined plated lizard	*Gerrhosaurus nigrolineatus*
Eastern Bark/Mopane snake	*Hemirhagerrhis nototaenia*	Bushveld lizard	*Heliobolus lugubris*
Eastern tiger snake	*Telescopus semiannulatus*	Cape rough-scaled lizard	*Ichnotropis capensis*
Green water snake	*Philothamnus hoplogaster*	Common flat lizard	*Platysaurus intermedius*
Gunther's garter snake	*Elapsoidea guentheri*	Common rough-scaled lizard	*Ichnotropis squamulosa*
Long-tailed thread snake	*Leptotyphlops longicaudus*	Giant plated lizard	*Gerrhosaurus validus*
Marbled cat-eyed tree snake	*Dipsadoboa aulica*	Holub's sandveld lizard	*Nucras holubi*
Mole snake	*Pseudaspis cana*	Kalahari round-headed worm lizard	*Zygaspis quadrifrons*
Mozambique spitting cobra	*Naja mossambica*	Large-scaled grass lizard	*Chamaesaura macrolepis*
Olive grass snake	*Psammophis mossambicus*	Ornate sandveld lizard	*Nucras ornata*
Olive marsh snake	*Natriciteres olivacea*	Nile/Water monitor lizard	*Varanus niloticus*
Peters' thread snake	*Leptotyphlops scutifrons*	Rock monitor lizard	*Varanus albigularis*
Puff adder	*Bitis arietans*	Rough-scaled plated lizard	*Gerrhosaurus major*
Red-lipped herald snake	*Crotaphopeltis hotamboeia*	Spotted sandveld lizard	*Nucras intertexta*
Reticulated centipede eater	*Apparallactus lunulatus*	Tropical girdled lizard	*Cordylus tropidosternum*
Rufous beaked snake	*Rhamphiophis rostratus*	Yellow-throated plated lizard	*Gerrhosaurus flavigularis*
Semiornate smooth snake	*Meizodon semiornatus*	Zimbabwe girdled lizard	*Cordylus rhodesianus*
Shield-nose snake	*Aspidelaps scutatus*	Bronze rock skink	*Mabuya lacertiformes*
Snouted cobra	*Naja annulifera*	Cape skink	*Mabuya capensis*
Snouted night adder	*Causus defilippii*	Five-lined/Rainbow skink	*Mabuya quinquetaeniata*
Southern African python	*Python natalensis*	Spotted-neck snake-eye skink	*Panaspis sp.*
Spotted bush snake	*Philothamnussemivariegatus*	Striped skink	*Mabuya striata*
Striped skaapsteker	*Psammophylax tritaeniatus*	Sundevall's writhing skink	*Lygosoma sundevallii*
Striped-bellied sand snake	*Psammophis subtaeniatus*	Variable skink	*Mabuya varia*
Sundevall's shovel-snout snake	*Prosymna sundevallii*	Wahlberg's snake-eye skink	*Panaspis wahlbergii*
Twig/Vine snake	*Thelotornis capensis*	Marsh/Helmeted terrapin	*Pelomedusa subrufa*
Two-striped shovel-snout snake	*Prosymna bivittata*	Pan hinged terrapin	*Pelusios subniger*
Western green snake	*Philothamnus angolensis*	Serrated hinged terrapin	*Pelusios sinuatus*
		Bell's hinged tortoise	*Kinixys belliana*
		Leopard tortoise	*Geochelone pardalis*
		Speke's hinged tortoise	*Kinixys spekii*

Appendix IVc: List of amphibians and scorpions found on Sango Ranch, Save Valley Conservancy, Zimbabwe

Frogs and Toads		**Scorpions**
Bull Frog, African	*Pyxicephalus edulis*	*Hottentotta trilineatus*
Caco, Common	*Cacosternum boettgeri*	*Lychas burdoi*
Frog, Banded Rubber	*Phrynomantis bifasciatus*	*Parabuthus mossambicensis*
Frog, Broad-banded Grass	*Ptychadena mossambica*	*Parabuthus transvaalicus*
Frog, Brown-backed Tree	*Leptopelis mossambicus*	*Uroplectes planimanus*
Frog, Bushveld Rain	*Breviceps adspersus*	*Uroplectes olivaceus*
Frog, Common River	*Rana angolensis*	*Uroplectes carinatus*
Frog, Dwarf Puddle	*Phrynobatrachus mababiensis*	*Uroplectes vittatus*
Frog, Foam Nest	*Chiromantis xerampelina*	*Uroplectes formosus*
Frog, Knocking Sand	*Tomopterna krugerensis*	*Opistacanthus asper*
Frog, Mottled Shovel-nosed	*Hemisus marmoratus*	*Cheloctonus jonesii*
Frog, Natal Sand	*Tomopterna natalensis*	*Hadogenes troglodytes*
Frog, Painted Reed	*Hyperolius marmoratus*	*Opistophthalmus glabrifrons*
Frog, Plain Grass	*Ptychadena anchietae*	
Frog, Russet-backed Sand	*Tomopterna marmorata*	
Frog, Sharpe-nosed Grass	*Ptychadena oxyrhynchus*	
Frog, Snoring Leaf-folding	*Afrixalus crotalus*	
Frog, Snoring Puddle	*Phrynobatrachus natalensis*	
Frog, Tremolo Sand	*Tomopterna crytotis*	
Frog, Water Lily	*Hyperolius pusillus*	
Kassina, Bubbling	*Kassina senegalensis*	
Kassina, Red-legged	*Kassina maculate*	
Platanna, Tropical	*Xenopis muelleri*	
Toad, Flat-backed	*Bufo maculates*	
Toad, Northern Pygmy	*Bufo fenoulheti*	
Toad, Olive	*Bufo garmani*	
Toad, Red	*Schismaderma carens*	

Appendix V. Species prohibited in gardens on Sango Ranch

All species of *Cactaceae*	eg. *Cerius, Harrisia, Opuntia*
All species of alien water weeds	eg. *Azolla, Eichhornia, Pistia, Salvinia*
All species of alien *Acacia*	eg. Wattle, Rooikrans, Blackwood, Port Jackson
All species of alien *Senna*	eg. Peanutbutter cassia
All species of *Ageratina*	eg. Crofton weed
All species of *Cestrum*	eg. Inkberry, Cestrum
All species of *Passiflora*	eg. Granadilla, passion flower, pepadilla

SPECIES	ENGLISH	AFRIKAANS
Antigonon leptopus	Coral creeper	Koraalklimop
Aristolochia elegans	Dutchmans pipe	Oupa se pyp
Arundo donax	Giant reed	Spaanse riet
Brugmansia condida	Moonflower	Maanblom
Callisia elegans	Small leafed wandering jew	
Cardiospermum grandiflorum	Balloon vine	Blaasklimop
Catharanthus roseus	Graveyard flower	Begrafnisblom
Chromolaena odorata	Triffid weed	Paraffienbos
Eriobotrya japonica	Loquat	Lukwart
Kalanchoe tubiflora	Fingers	
Lantana camara	Lantana	Lantana
Leucaena leucocephala	Leucaena	Wonderboom
Ligustrum sp.	Privet	Privet
Macfadyena unguiscati	Cats claw	Katklou
Melaleuca leucadendron	Mirte	Mirte
Morus alba	Mulberry	Moerbei
Nerium oleander	Oleander	Selonsroos
Psidium quajava	Guava	Koejawel
Syzygium cuminii	Water pear	Waterpeer
Solanum seaforthianum	Potato creeper	Aartappelklimop
Tecoma stans	Yellow bells	Geelklokkies
Thevetia peruviana	Yellow oleander	Geeloleander

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