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Mammal communities in the southern Kalahari: differences between land use types and seasons



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Abstract

Tourism is the fastest growing economic sector in Botswana, and is in all essential wildlife based. Thus, an increased knowledge of how wild mammal communities are affected by other land use practises is highly important. Sustainable use of wild resources, may improve the economy and livelihood for local human communities, and presumably also help maintaining biodiversity and the unique composition of African savanna ecosystems. This study investigates the effect that different land uses have on mammal communities in the southern Kalahari in the wet season. Mammals from the size of mongooses and larger as well as ostriches and livestock were counted along 25 predetermined transects in four land use types, i.e. Fenced Ranches, Communal Grazing Areas, Wildlife Management Areas and National Park. Recent studies show a rapid decline in densities of large mammals in the dry savannas of Kalahari. The effect of land use on wildlife may be most pronounced in the dry season, when food is scarce and of poor quality. By complementing the data collected in the dry season of 2002 with data from the wet season, an overall picture of the wildlife situation could be examined. I found that land uses have an obvious effect on wildlife, from species richness to composition of mammal communities, in livestock areas, i.e. Fenced Ranches and Communal Grazing Areas. No obvious difference between seasons could be found.

Foreword

This master thesis is based on data collected during a Minor Field Study, financed mainly by the Swedish International Development Cooperation Agency (SIDA) through the Committee of Tropical Ecology (ATE) at Uppsala University. This study is part of an EU-project: Management and policy options for the sustainable development of communal rangelands and their communities in southern Africa, MAPOSDA, INCO Project No. ACA4-CT-2001-10050.

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Front page photo: Lion in the Kgalagadi Transfrontier Park, Mabuasehube (Tobias Jakobsson).

1. INTRODUCTION

1.1 Mammal communities in African savannas

The African savanna biome supports a higher diversity of ungulate species than any other biome or continent (du Toit 1995). Larger herbivore species tolerate lower plant nutrient content but require greater plant abundance than smaller species, which need high nutrient concentration but require little biomass. Generally, there is an inverse relationship between rainfall, promoting large plant biomass production, and soil nutrients, promoting high concentration of nutrients in plant tissue (Olf et al. 2002). The highest herbivore diversity should therefore occur in locations with intermediate moisture and high nutrient content (Olf et al. 2002). The composition of large herbivore communities varies considerably across southern Africa (du Toit 1995). The primary ecological determinants of community composition in a “natural” community of indigenous large herbivores have been suggested to be soil nutrients, rainfall and vegetation characteristics of the particular region in which the community occurs (du Toit 1995, Fritz et al. 2002). Competition is also likely to play a key role in shaping these communities, as well as predation and diseases (Sinclair 1985). However, it is probably impossible to find any natural ecosystems undisturbed by modern man. Indigenous large herbivores now constitute less than 10% of the large herbivore biomass in African savannas, with the remaining 90% being made up of domestic livestock (du Toit 1995).

Large carnivores are able to adapt to a variety of habitat and prey types and are widely distributed across the subcontinent. However, large carnivores are among the first species to disappear from formerly remote regions when human and livestock populations begin to increase (du Toit 1995).

A number of hypotheses have been put forward to explain the relationship between plant productivity and species richness of plants and animals. The energy limitation hypothesis states that energy limits the number of individuals that can be sustained in a habitat (Currie 1991). When plant productivity increases, the amount of energy available for consumers increases and thus more individuals will be able to inhabit the area. More individuals will result in more species (Aava-Olsson 2001). The environmental heterogeneity hypothesis (Abrams 1988) says that when productivity is low the landscape will be uniformly barren and the existing resources homogenous. Under these conditions few species can exist. As plant productivity rises, plant diversity will increase and make resources more heterogeneous for animals, which allows for greater species richness. At some point plant diversity may decline as a result of increasing dominance by a few species, and resources become less heterogeneous again and animal diversity drops (Aava-Olsson 2001). With more specialisation the hypothesis argues that productivity increases the abundance of rare resources or conditions that specialist species are dependent upon, enabling them to exist (Abrams 1988).

The structure and function of the African savanna ecosystems are strongly influenced by the ungulate communities, e.g. species body size classes and feeding guilds and (du Toit & Cumming 1999). Savanna ecosystems are also regulated by a multitude of feedback loops between large herbivores and plants (du Toit & Cumming 1999). The balance between grass and woody biomass can depend on the densities of elephants impacting on the mature canopy and opening woodlands for invasion of fire (Dublin et al. in du Toit & Cumming 1999). Further, giraffes may, prevent medium-sized trees from growing out of fire-susceptible size classes (Pellew 1983 in du Toit & Cumming 1999), and small ruminants like impala and steenbok may constrain tree recruitment through browsing on seedlings and saplings (du Toit 1990).

1.2 Land use in the Kalahari

1.2.1 Land use policies

In 1975 a new livestock development policy in Botswana was established, the Tribal Grazing Lands Policy (TGLP) (Thomas et al 1999). The aim of the TGLP was to move livestock owners with large herds off communal lands to nearby fenced ranches to reduce the environmental pressure on communal land, and at the same time allow a better development for smaller livestock owners (White 1993). The TGLP has been widely criticized for being founded on inappropriate assumptions about the Kalahari environment and its human use. Soon after the establishment, TGLP ranches were already being seen as a source of environmental degradation in a system regarded as fragile (Thomas et al. 1999).

1.2.2 Impact of grazing

Most savannas are today used as grazing land for livestock, and millions of humans depend on these pastoral systems for their survival (Skarpe 1991). There have been reports of bush encroachment; i.e. increases in the cover of woody vegetation, in many arid and semi-arid grasslands and savannas in the world. Such bush encroachment has been suggested to be the result of indirect human disturbance, in many cases heavy grazing by livestock. Other suggestions include the decrease of the fire frequency and of browsing, as well as changes in the climate (Skarpe 1990). The generally accepted theory on bush encroachment was formulated by Walter (1954) and further developed by Noy-Meir (1982). It states that grasses out-compete woody species for water in the upper soil, leaving limited amounts to penetrate to deeper layers, where it is exclusively available to trees and shrubs. When the grasses are damaged, more water becomes available for woody growth (Skarpe 1990).

The most important difference between natural grazing by indigenous herbivores and heavy livestock grazing is the scale of selectivity. Domestic animals are more or less restricted in their movements, which makes large-scale selectivity impossible. The large indigenous herbivores, on the other hand, will respond to spatial and temporal differences in the vegetation, and will adjust selectivity on all scales (Skarpe 1991).

1.2.3 Decline of the wildlife

No other country in Africa has set aside such a large proportion of its land area for animal wildlife conservation as the Republic of Botswana. However, the wildlife of Botswana is vanishing, as the national fauna is diminishing in both absolute numbers and species diversity (Mordi 1989). Over the past 40 years or more, fences have been erected in the part of Kalahari that lies in Botswana. Fences in Kalahari include those along international boundaries and main roads, as well as veterinary cordon fences that were installed to control foot-and-mouth disease in the North and central Kalahari. These fences are now blocking or severely disrupting wildlife movements both in and out of the region. Species that are unable to cope with abnormal arid conditions have to move out of the Kalahari during times of droughts in search of perennial water sources (Williamson & Williamson 1984). Drought-related mass mortalities of large herbivores have been recorded in the Kalahari since the 1930s. The die-offs that occurred in the southern Kalahari during the 1980s, where possibly as many as 80,000 wildebeest died, are suggested to be a result of several preceding years of below average rainfall, when fences hindered the migration routes (Knight 1995, Spinage 1992). Poaching, both by traditional hunters and by those engaging in illicit hunting on a commercial basis, has been increasing in Botswana (Wildlife conservation policy 1986). According to Mordi (1989), poaching plays a significant role in the decline of wildlife populations. Inexpensive hunting licenses for citizens have developed a "black market", where inexpensively purchased licenses are being sold to foreigners for exorbitant amounts.

1.3 Objectives

The over-all objective of the study was to confirm (or disconfirm) that land use practises influence the rapid decline in densities of large mammals in the dry savannas of Kalahari reported by Crowe 1995 and Wallgren 2001. There are indications of differences in species richness between areas with different land use, during the dry season, May-October (Viio 2003).

In this study, my aim is to assess:

- if different land uses influence mammal species richness, diversity and abundance during the wet season and if there are differences between wet and dry season.
- if land use and environmental variables affect the distribution of species differently in the wet season and the dry season.
- if there is a difference in mammal community composition between different land use types during wet season and if there are differences between the wet and dry seasons.
- if differences in land use affect mammal community composition in terms of functional types during the wet season, and if there are differences between the wet and dry seasons.

2. STUDY AREA

2.1 The Kalahari environment

The Kalahari is often misnamed a desert although it has vast resources of vegetation and large wildlife populations (Cooke 1985). It forms an almost flat, sand-covered plateau about 1000 metres above sea level. It encompasses most part of Botswana as well as adjacent areas of Namibia and South Africa (Skarpe 1990).

Kalahari is a semi-arid to arid savanna with hot summers and cooler winters. Mean daily temperature ranges from ca 26°C (January) to 12°C (July). The temperature occasionally drops below 0°C during winter nights and ground frosts are common (Botswana Weather Bureau, unpublished). Rainfall occurs during the summer months (October-April) and the annual average increases from ca. 200mm in the SW to ca. 500mm in the NE (Thomas, Shaw 1991 according to Thomas et. al. 1999).

The vegetation of the Kalahari is mostly scrub savanna, ranging from woodland savanna in the north to a more open scrub savanna with scattered trees in the drier south-west. The field layer mainly consists of tufted perennial grasses (Skarpe 1986).

The soils of the Kalahari are in general poorly structured and infertile and can be divided into red, pink and white sand. The red sand occurs on plains, undulating flats and dunes and is by far the most common. Pink sand occurs mainly in dune slacks and in the vicinity of pans. The least common sand type, the white, is mainly found in pans and along the edges of some riverbeds (Skarpe 1986).

A pan is a depression in the sandy savanna, normally with a flat bottom, either bare or grass-covered, which may temporarily be filled with rainwater (Parris 1970). Pans of the western Kalahari are often shallow with a diameter of between 200 and 2000 metres and have soils with relatively high silt and clay content. Compared with the surrounding savannas, pans have different vegetation (Bergström & Skarpe 1999). Pans in uninhabited areas are extensively used by wildlife. The pans may provide wild animals with water that is collected there after rains, and also with “salt licks” i.e. mineral rich soil eaten by antelopes (Parris & Child 1973). Pans also provide a suitable habitat for small burrowing animals such as ground squirrels, which prefer to have their burrows in hard soil. Pans also constitute a suitable environment for predators like lions, cheetahs and hyenas, because of the aggregation of prey (Parris 1970).

2.2 The Matsheng area

The study was conducted in the Matsheng area, located in the south-western part of Kalahari in Botswana (21°80'E, 24°00'S)(fig. 2.1). The Matsheng villages, Hukuntsi, Tshane, Lehututu and Lokgwabe, are situated in the northern part of the Kgalagadi district and have ca 6000 inhabitants. The area is remote, approximately 550 km west of the capital Gaborone (Chanda 2003). The villages are surrounded by communally managed rangelands, and in the vicinity are many more small settlements in Wildlife Management Areas. It is important to emphasize that there is a difference between villages and settlements. Villages have 500 or more inhabitants and have an infrastructure with schools, clinics, etc. Settlements are less formal arrangements, lacks regular water supply and are inhabited by people with nomadic background (Chanda 2003). The villages are situated near large pans, which once had permanent surface water, enabling cattle keeping. At some of the pans permanent water is still

available in hand-dug wells, but today the supply is heavily supplemented with water from deep drilled boreholes (Chanda 2003).

2.2.1 Land use types

The wildlife communities of four land use types were studied. Communal grazing areas around villages (CGA) are not homogeneously used, but show a strong gradient of decreasing grazing impact with increasing distance from the villages. Cattle graze largely uncontrolled up to 20-25 km from the villages, and they come back to drink – every day to every third day (Brundin & Karlsson 1999, Skarpe 2000).

Fenced ranches (FR) have more homogenous grazing pressure than the CGAs. The explicit aim of commercial ranches is to even out grazing effects by distributing the animals more equitably over the ranch by the use of paddocks and rotation of the herds. Although such paddocks are then rested, the level of disturbance reached has been far higher than that endured over most of the grazing area close to water points in CGAs (Perkins 1996). The result of the high grazing pressure can be seen through the creation of barren vegetation areas around boreholes and through bush encroachment elsewhere on ranches (Thomas et al 2000).

Wildlife management areas (WMA) are areas where different forms of sustainable wildlife utilisation are the prioritised land use. Small settlements with some livestock and cultivation also exist in these areas. This makes WMAs fairly heterogeneous with regard to human and livestock impact. Some Wildlife Management Areas serve as a buffer zone to adjacent National Parks and Game Reserves in order to prevent conflict between the wildlife and areas of more intensive human use, while others provide protection to migrating wildlife by safeguarding migratory corridors (Wildlife conservation policy 1986).

The National park (NP) studied was the northern part of The Kgalagadi Transfrontier Park (KTP), which is a trans-border National Park on the border of South Africa and Botswana (Wildlife conservation policy 1986). It is an area with very low human impact, although there was a large livestock post at Mabuasehube until 1948 (Parris & Child 1973). Total preservation of the wildlife resources is now practised (Wildlife conservation policy 1986).

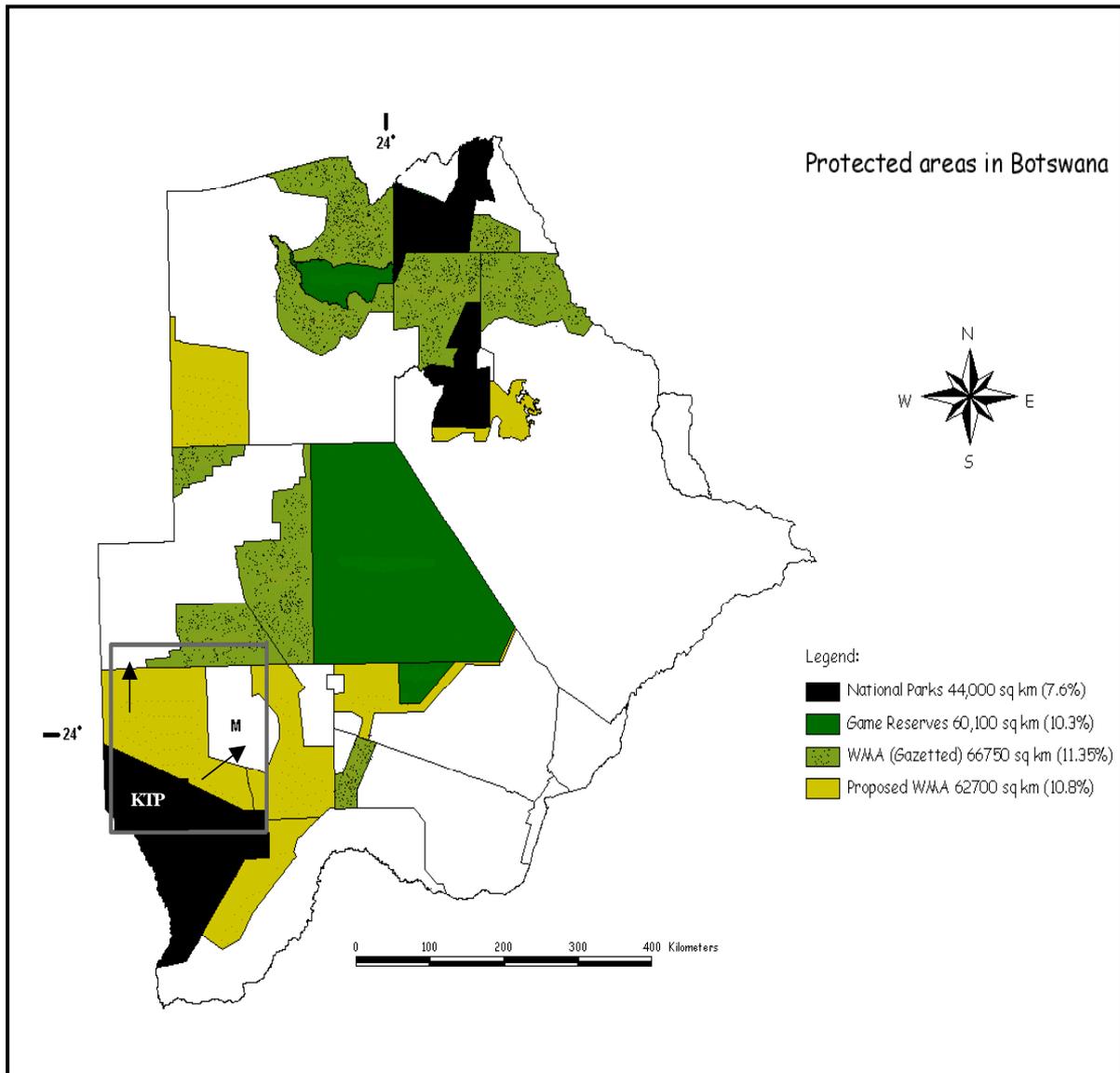


Figure 2.1. Map over protected areas in Botswana. The square shows the study area in the southwestern Kalahari and the arrows point towards where the studied ranches are situated. The letter M shows the Matsheng area and KTP, The Kalahari Transfrontier Park (after map by Broekhuis 1997 in Viio 2003).

3. METHODS

3.1 Field methods

The study was conducted during the wet season, from January 10th to March 27th of 2004. Animals were counted along transects within the study area which consisted of the four land use types described above. Road-side counts along the transects were conducted both during day and night, using a 4 wheel drive vehicle. All wild and domestic mammals from the size of mongooses and larger, as well as ostriches, were included in the study. The transects followed bush roads from the size of two-lane gravel roads to nearly non-existing wheel tracks in the sand.

3.1.1 Road counts

A total of 211 road-side counts were performed, 106 during day and 105 during night (appendix 1). Day-transects were driven between 08.00 and 17.00, and night-transects between 20.00 and 05.00. These limits were to avoid twilight, when both nocturnal and diurnal animals may be active. Due to circumstances like car trouble, there were a few exceptions from the time limits.

The transects were driven in both directions and every transect was driven an equal number of times day and night, with one exception. Transects were divided so that approximately the same number of kilometres were driven in each of the four land use areas. The same transects were driven as done by Wallgren (2001) and Viio (2003) with a few exceptions. Four of the transects followed the same route as Bergström and Skarpe (1999) surveyed in 1975-83. One extra ranch (ranch 4) was added in the area of Ncojane ranches as well as one in the Matsheng area (Casino farm). This was done to make the work more efficient, i.e. to get more data, since the drives on ranches are shorter in comparison with those in other land use types. Some changes were also made in the Kalahari Transfrontier Park. Additional transects were added in the Kaa entrance area and the previous transects in the area of the Mabuasehube entrance were extended, and put together into one longer transect.

3.1.2 Road count observations

Three persons performed the study, one driving and two standing on the back of the car. The vehicle was driven in an average speed of 25 km/h. The driver looked for animals on the road and the other two looked for animals on each side of the track. When an animal was spotted the car was stopped. Species and number of individuals and time of observation were recorded. Date, weather and period of the day (day or night) were recorded for each road-side count. For species identification *Field Guide to Southern African Mammals* (Stuart & Stuart 2001) was used as reference literature.

A rangefinder, a binocular that shows distance and compass degrees to the object, was being used to record the exact position of the animal in relation to the vehicle. Angle to animal, angle to road and distance to animal were recorded with the rangefinder. A GPS (Geographic Positioning System) was used to get the coordinates of the car for each observation and the distance driven of the transect. This was noted by the driver.

Animals were spotted by the naked eye approximately up to 300 metres during daytime. There was less visibility along tracks with thick vegetation and more visibility around pans. Spotlights were used during nights. This was done by sweeping the spotlight back and forth repeatedly, in an angle of 90-degrees starting in the direction of the car. The spotlights were connected to a car battery. Three car batteries were used, one in the car engine, one for the spotlights and one charged reserve standing in the car.

When spotting an animal at the start of a transect, the animal had to be within the area of 90 degrees on each side of the vehicle, starting in front of the vehicle. Occasionally situations came up where an animal was spotted in front of the car while the road was turning. In this situation the angle of the road was measured exactly in between the road and the animal. When two or several animals were spotted at the same time, fairly close to each other, <30 metres, they were counted as one observation, otherwise as two or more.

3.1.3 Vegetation study

A vegetation study was performed along the transects. The study was done once for each of the transects. The stops for vegetation sampling were made at predetermined distances, every second to every fifth kilometre, depending on the length of the transect. The study was performed parallel with the animal observations by the two persons standing on the back of the car. The odometer function of the GPS was used to determine when to stop. Date, coordinates and distance from the starting point were recorded for all the stops. Thereafter, the following was examined:

- Cover of green grass (%)
- Height of green grass (cm)
- Cover of wilted grass (%)
- Height of wilted grass (cm)
- Cover of forbs & woody plants < 0.5 m (%)
- Cover of woody plants > 0.5 m and < 3.0 m (%)
- Cover of woody plants > 3.0 m (%)
- Cover of *Acacia mellifera* (%)

3.2 Statistical methods

3.2.1 Statistics in community ecology

Community ecology is the study of many species simultaneously in relation to their environment. Data used in community ecology are often multivariate, which means that each statistical sampling unit is characterized by many attributes. By using multivariate methods, one can make such data much easier to handle (Jongman, ter Braak & van Tongeren 1995). This makes it also possible to describe relationships between species composition patterns and the underlying environmental gradients, which influence these patterns (Leps & Smilauer 2003).

3.2.2 Types of analysis

Multivariate analysis methods in ecology can be divided into *direct gradient analysis* and *indirect gradient analysis*. In direct gradient analysis only the variation that can be explained by the recorded environmental variables will be shown in the ordination, and these variables will be considered to be the only relevant factors. Thus, it will not reveal if there are any other, more important factors that have been left out in the study. Indirect gradient analysis shows all the variation in the data, i.e., if an important environmental factor has been overlooked, this will be visualized in the ordination diagram, since none of the given environmental variables will well explain the main variation in the species data (Jongman, ter Braak & van Tongeren 1995). By using Monte Carlo permutation test, the significance of the environmental variables can be tested. This is done in CCA by choosing forward selection (Leps & Smilauer 2003).

3.2.3 Ordination techniques and response models

Ordination is the collective term for multivariate techniques, where sites and species are arranged along axes that represent theoretical variables in such a way that these arrangements optimally summarize the species data. The indirect ordination techniques that are most popular with community ecologists, are principal components analysis (PCA), and correspondence analysis (CA). Both PCA and CA are suitable to detect different types of underlying data structure. PCA relates to a linear response model, in which abundance of any species either increases or decreases with the value of each of the latent environmental variables. By contrast, CA is related to a unimodal response model, in which any species occurs in a limited range of values of each of the latent variables (Jongman, ter Braak & van Tongeren 1995). When deciding whether to use an ordination method based on a model of linear species response or of unimodal species response, one could examine the lengths of gradient in DCA (for indirect gradient analysis) or DCCA (for direct gradient analysis). The gradient length measures the beta diversity in community composition along the individual independent gradients (ordination axes). If the longest gradient exceeds 4.0 S.D one should use unimodal methods (DCA, CA, or CCA), if shorter than 3.0 S.D, the linear method is probably better. In the range between 3.0 and 4.0 S.D, both types of ordination methods work reasonably well (Leps & Smilauer 2003).

3.2.5 Data treatment

Transects were divided into 5 kilometre segments, from here on called sites. Each site summarizes the number of individuals for all animal species that were observed in this particular site. It also corresponds to measured vegetation variables. In cases of more than one vegetation sample per 5 km, a mean of the two samples was used. Variables “distance to pan” and “distance to villages” were also calculated per site, and it should be mentioned that these distances are not the exact ones, due to the length of the sites. In addition to the data collected in the wet season, data from the dry season of 2002 (Viio 2003) were used to investigate the difference between the two seasons.

3.2.6 Species diversity

The simplest measure of diversity is the number of species in the community, also referred to as species richness (Krebs 2001). Another way of measuring diversity is to combine species richness and equitability, which is done e.g., in the Shannon-Wiener function (Krebs 2001).

$$H = - \sum_{i=1}^s p_i \ln p_i$$

where p_i is the proportion of individuals found in the i th species and ‘ln’ denotes the natural logarithm.

Night and day data were separated in the analyses to reveal possible differences between nocturnal and diurnal species richness, as many species are mainly active either during day or during night, and some animals may move on a daily basis between areas with different land use. To get an overall picture of the difference in number of individuals of wild and domestic species between land use types, the mean number of individuals per 5 km was calculated.

3.2.7 Community structure

Data were analysed using multivariate statistics from the program package CANOCO 4.5 (Leps & Smilauer 2003). Indirect gradient analysis was used in which the total variation in the data is taken into account, and relations with environmental variables are calculated afterwards. Correspondence Analysis (CA) assuming a unimodal response fitted my data best, since the longest gradient had a value over 4.0. Both biplots of species and environmental variables and biplots of sites and environmental variables were constructed. Only significant environmental variables were included in the ordinations. Log transformation of data and down weighting of rare species was selected.

3.2.8 Functional types

The recorded animal observations were classified into functional types based on food preference and body size. Animals with a body mass >30 kg were classified as large, and < 30 kg as small (tab. 4.6). Body mass and food preference was taken from Stuart & Stuart (2001). Some types were only based on food preference, to avoid types that only included one or two species. Large browsers (eland and kudu) were left out in the analysis due to few observations, the same was the case with small grazer (sheep). Functional type ‘small browser’ includes only two species, but were included due to the high abundance of these species. Species ordination diagrams were created in CA with unimodal response, to visualize animal communities based on functional types. Significant environmental variables were included in the ordination. Log transformation of data and down weighting of rare species were selected.

4. RESULTS

4.1 Species diversity

A total of 39 mammal species from the size of mongooses and larger, as well as ostriches, were recorded during the study. Eight of these were domestic species. The corresponding number for the dry season was 38 and 8, respectively (Viio 2003). A total of 29,243 individuals were observed, of which 84% were domestic mammals and 16 % wild mammals (tab 4.1).

Table 4.1. Species and number of individuals observed in the different land use areas.

| Species | FR | | CGA | | WMA | | NP | | All | | Total |
|-------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|--------------|--------------|--------------|
| | Day | Night | Day | Night | Day | Night | Day | Night | Day | Night | |
| Wildlife | | | | | | | | | | | |
| Aardvark | | | | 1 | | | | 1 | | 2 | 2 |
| Aardwolf | | | | | | 1 | | | | 1 | 1 |
| African Wild Cat | | 1 | | 2 | | 3 | | 3 | | 9 | 9 |
| Black-backed Jackal | 3 | 24 | 2 | 5 | | 13 | 2 | 25 | 7 | 67 | 74 |
| Bat-eared fox | | 6 | | | | 34 | | 48 | | 88 | 88 |
| Brown Hyena | | | | | | 2 | | 3 | | 5 | 5 |
| Caracal | | | | 1 | | 1 | | | | 2 | 2 |
| Cape Fox | | 1 | | 2 | | 9 | | 14 | | 26 | 26 |
| Cheetah | | | | | | | | 1 | | 1 | 1 |
| Duiker | | 2 | | 3 | 1 | 1 | 5 | 1 | 6 | 7 | 13 |
| Eland | | | | | 3 | | | | 3 | | 3 |
| Gemsbok | 3 | 4 | | | 12 | 15 | 205 | 39 | 220 | 58 | 278 |
| Ground Squirrel | 7 | | 23 | | 23 | | 15 | | 68 | | 68 |
| Hare | 4 | 19 | 2 | 10 | 1 | 9 | 2 | 14 | 9 | 52 | 61 |
| Honeybadger | | | | 1 | | | | 1 | | 2 | 2 |
| Leopard | | | | | | | | 1 | | 1 | 1 |
| Lion | | | | | | 4 | 4 | 4 | 4 | 8 | 12 |
| Ostrich | 15 | | 50 | | 69 | 3 | 32 | | 166 | 3 | 169 |
| Porcupine | | 1 | | 1 | | 4 | | | | 6 | 6 |
| Red Hartebeest | 1 | | 1 | 6 | 110 | 55 | 46 | 10 | 158 | 71 | 229 |
| Spotted Hyena | | | | | | 13 | | 2 | | 15 | 15 |
| Slender Mongoose | 2 | | 2 | | 1 | | 2 | | 7 | | 7 |
| Springhare | | 67 | | 139 | | 337 | | 703 | | 1246 | 1246 |
| Springbok | 17 | 14 | 34 | 38 | 589 | 361 | 543 | 216 | 1183 | 629 | 1812 |
| Small-spotted Genet | | 1 | | | | 1 | | 2 | | 4 | 4 |
| Side-striped Jackal | | | | | | | 1 | | 1 | | 1 |
| Steenbok | 25 | 28 | 12 | 28 | 121 | 100 | 171 | 110 | 329 | 266 | 595 |
| Suricat | 4 | | | | 13 | | 9 | | 26 | | 26 |
| Warthog | | | 2 | | | | | | 2 | | 2 |
| Wilderbeest | | | | | 32 | 8 | 2 | | 34 | 8 | 42 |
| Yellow Mongoose | 7 | | 7 | | 5 | | 2 | | 21 | | 21 |
| Total | 88 | 168 | 135 | 237 | 980 | 974 | 1041 | 1198 | 2244 | 2577 | 4821 |
| Domestic animals | | | | | | | | | | | |
| Camel | | 3 | | | | | | | | 3 | 3 |
| Cattle | 6014 | 4995 | 1708 | 1575 | 572 | 573 | | | 8294 | 7143 | 15437 |
| Dog | 113 | 59 | 10 | 3 | 9 | 17 | | | 132 | 79 | 211 |
| Domestic Cat | | 5 | | | | | | | | 5 | 5 |
| Donkey | 420 | 85 | 268 | 73 | 71 | 6 | | | 759 | 164 | 923 |
| Goat | 1799 | 2219 | 1807 | 401 | 432 | | | | 4038 | 2620 | 6658 |
| Horse | 269 | 38 | 78 | 27 | 26 | 23 | | | 373 | 88 | 461 |
| Sheep | 439 | 184 | 56 | 35 | 7 | 3 | | | 502 | 222 | 724 |
| Total | 9054 | 7588 | 3927 | 2114 | 1117 | 622 | 0 | 0 | 14098 | 10324 | 24422 |
| All total | 9142 | 7756 | 4062 | 2351 | 2097 | 1596 | 1041 | 1198 | 16342 | 12901 | 29243 |

The Shannon-Wiener index (tab. 4.2) shows that the diversity is lower in unprotected areas (FR, CGA) than in protected areas (WMA, NP) in both seasons. The highest diversity exists in WMA.

More wild animals were recorded in protected areas than in unprotected areas, and more livestock were recorded in unprotected areas than in protected areas. The same trends may be seen when comparing wet season with dry season (Viio 2003) (fig. 4.2). How land use differences affect densities of mammals are further investigated by Jakobsson (2005). Total number of wild species seems to be larger in protected areas than unprotected areas both during wet and dry season (fig. 4.3). More wild species were observed during night than day in the four land use types (fig. 4.4).

Table 4.2 The Shannon-Wiener diversity index displays the diversity in the four land use areas during wet and dry season.

| Land use | Diversity index | |
|----------|-----------------|------------|
| | Wet season | Dry season |
| FR | 1,1 | 1,2 |
| CGA | 1,2 | 1,5 |
| WMA | 2,0 | 2,6 |
| NP | 1,9 | 2,2 |

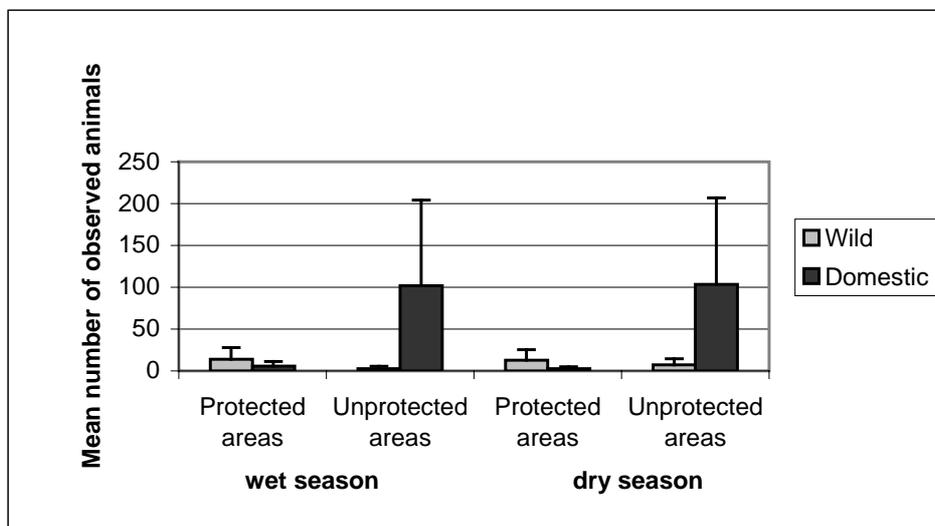


Figure 4.2. Mean number (\pm SE) of wild and domestic individuals observed per 5 kilometre in protected and unprotected areas during wet and dry season.

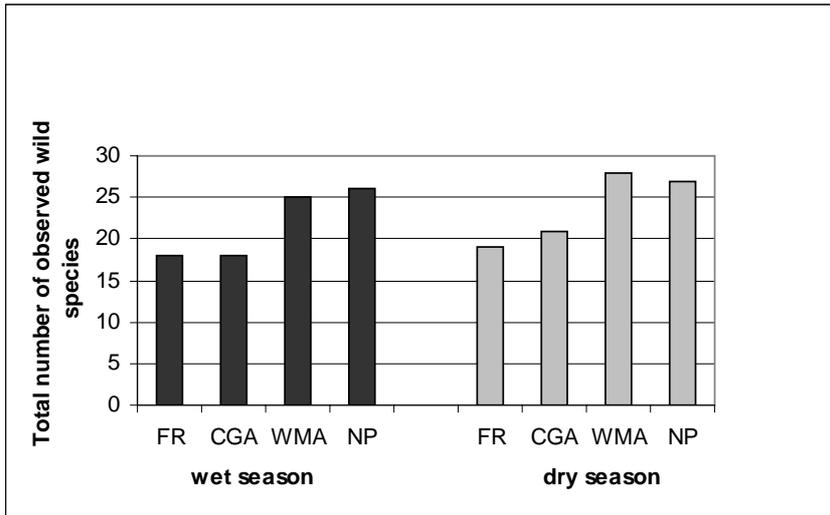


Figure 4.3. Total number of wild species observed in the four land use areas during the wet and dry season.

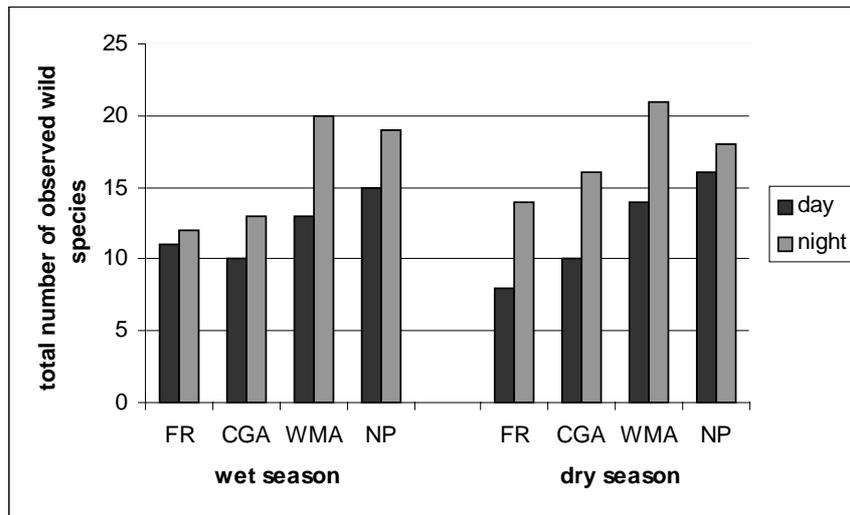


Figure 4.4. Total number of wild species observed in the four land use areas during day and night in the wet and dry season.

4.2 Relations between species distribution and environmental variables

All environmental variables were significant when tested. As much as 83 % of the variance in the data set from the wet season was explained by the measured variables (tab.4.3).

Corresponding number for the dry season are shown in table 4.4. Some of the variables in the wet season were closely correlated, i.e. Cover of forbs & woody plants < 0.5 m, Cover of woody plants > 0.5 m and < 3.0 m, Cover of woody plants > 3.0 m, and therefor were merged into one variable, FW. Further, cover of wilted grass and height of wilted grass represents variable WG. Codename for all animal species are shown in table 4.5.

Table 4.3. Data variance explained by environmental variables in the wet season.

| Environmental variables | Code name | P-value | F value | Variance explained |
|---|-----------|---------|---------|--------------------|
| National Park | NP | 0.002 | 17.47 | 0.30 |
| Wildlife Management Area | WMA | 0.002 | 6.94 | 0.25 |
| distance to pan | d pan | 0.002 | 3.28 | 0.08 |
| cover of green grass | CG | 0.02 | 2.27 | 0.04 |
| distance to village | d village | 0.002 | 17.2 | 0.03 |
| Communal Grazing Area | CGA | 0.002 | 14.2 | 0.03 |
| height of wilted grass | WG | 0.002 | 10.48 | 0.02 |
| cover of forbs and woody plants <0.5 m | FW | 0.016 | 3.04 | 0.02 |
| cover of forbs and woody plants 0.5-3.0 m | FW | 0.036 | 2.42 | 0.01 |
| height of green grass | HG | 0.04 | 1.77 | 0.02 |
| cover of woody plants >3.0 | FW | 0.002 | 5.54 | 0.01 |
| cover of <i>Acacia mellifera</i> | AM | 0.01 | 4.89 | 0.01 |
| cover of wilted grass | WG | 0.022 | 4.89 | 0.01 |

Table 4.4. Data variance explained by environmental variables in the dry season.

| Environmental variables | P-value | F-value | Variance explained |
|-------------------------|---------|---------|--------------------|
| CGA | 0.002 | 11.17 | 0.24 |
| FR | 0.006 | 2.45 | 0.14 |
| d village | 0.002 | 9.71 | 0.07 |
| d pan | 0.002 | 3.53 | 0.04 |
| WMA | 0.002 | 9.81 | 0.04 |

The CA diagram (fig. 4.5) shows that cover of forbs and woody plants, as well as cover of *Acacia mellifera* are positively correlated with FR and CGA and negatively correlated with NP, WMA and distance to village. Wilted grass shows the opposite pattern. Cover of green grass seems to be positively correlated with livestock. Height of green grass shows to be positively correlated to smaller ungulate species as well as to foxes. The distribution of species seems to be similar during wet and dry season (fig. 4.5 & fig. 4.6). The majority of wild species are positively correlated with distance to village and the opposite can be seen for domestic species. The species ordination diagram clearly separates the species according to land use types in two areas, with WMA and NP placed on the positive side of axis 1, and FR and CGA on the negative side. Evidently, land use is an important factor that influences species distribution both during wet and dry season. Axis 2 represents a pan gradient in both wet and dry season. Distance to pan shows strong negative correlation with domestic species as well as a weak negative correlation with some wild species that prefer this habitat. In the wet season these are springbok, wildebeest, red hartebeest, ground squirrel, ostrich, leopard and suricate, and in the dry season: springbok, wildebeest, ground squirrel.

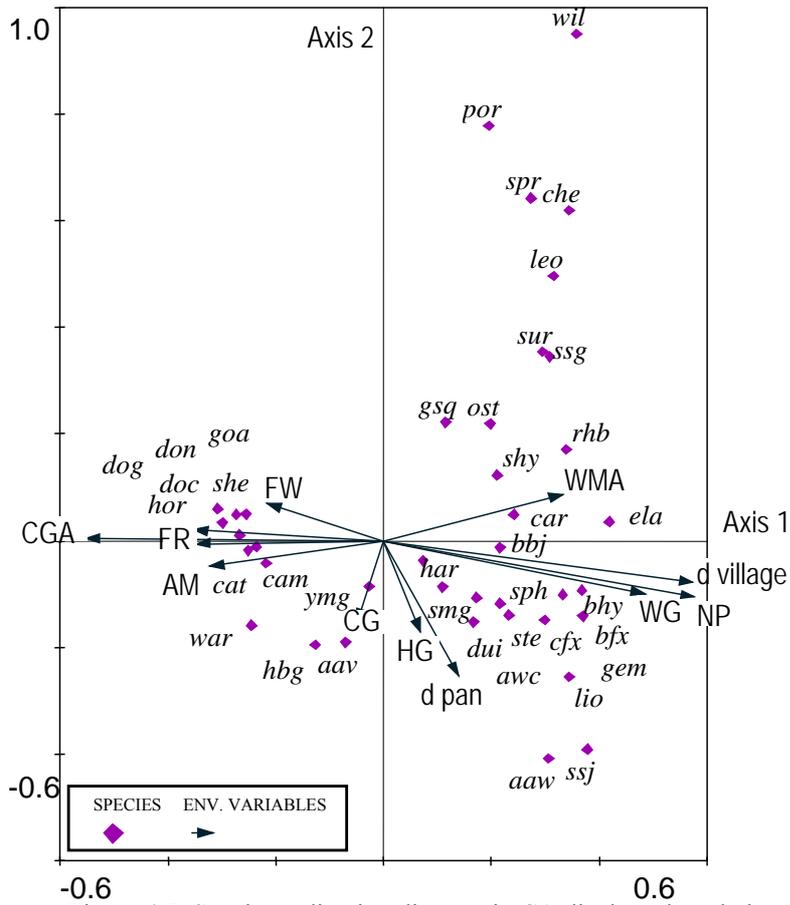


Figure 4.5. Species ordination diagram in CA displays the relationship between species and measured environmental variables during the wet season. Codename for species are shown in Table 4.5.

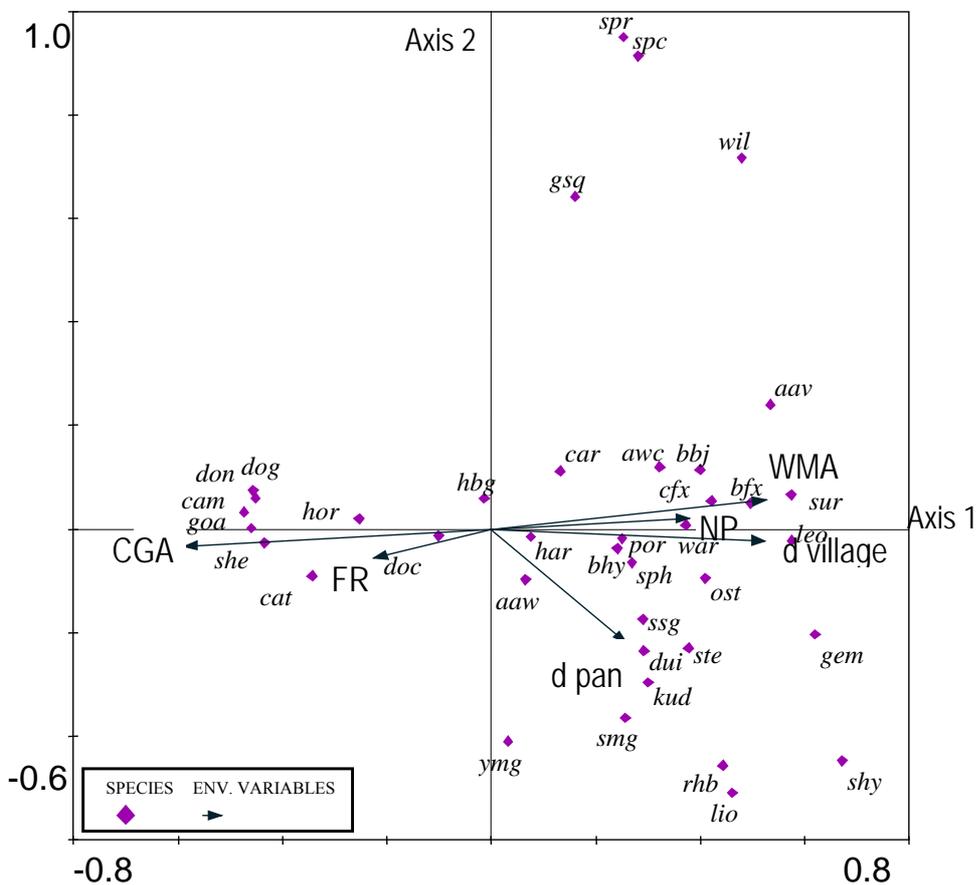


Figure 4.6. Species ordination diagram in CA displays the relationship between species observed and between species and measured environmental variables during the dry season. Codename for species are shown in Table 4.5.

Table 4.5. Common species, scientific and codename of all species recorded in the study. Species marked with * were only observed during the dry season. Scientific names were received from Stuart & Stuart (2001).

| Group | Common species name | Scientific name | Code name | |
|--------------|---------------------|---------------------------------|----------------------------|-----|
| Wild animals | Aardvark | <i>Orycteropus afer</i> | aav | |
| | Aardwolf | <i>Proteles cristatus</i> | aaw | |
| | African wildcat | <i>Felis silvestris lybica</i> | awc | |
| | Bat-eared fox | <i>Octocyon megalotis</i> | bfx | |
| | Black-backed jackal | <i>Canis mesomelas</i> | bbj | |
| | Blue wildebeest | <i>Connochaetes taurinus</i> | wil | |
| | Brown hyena | <i>Hyaena brunnea</i> | bhy | |
| | Cape fox | <i>Vulpes chama</i> | cfx | |
| | Caracal | <i>Felis caracal</i> | car | |
| | Cheetah | <i>Acinonyx jubatus</i> | che | |
| | Common duiker | <i>Sylvicapra grimmia</i> | dui | |
| | Gemsbok | <i>Oryx gazella</i> | gem | |
| | Ground squirrel | <i>Xerus inauris</i> | gsq | |
| | Hare Cape/Scrub | <i>Lepus capensis/saxatilis</i> | har | |
| | Honey badger | <i>Mellivora capensis</i> | hbg | |
| | Kudu* | <i>Tragelaphus strepsiceros</i> | kud | |
| | Leopard | <i>Panthera pardus</i> | leo | |
| | Lion | <i>Panthera leo</i> | lio | |
| | ostrich | <i>Struthio camelus</i> | ost | |
| | Porcupine | <i>Hystrix africaeaustralis</i> | por | |
| | Red hartebeest | <i>Alcelaphus buselaphus</i> | rhb | |
| | Side-striped jackal | <i>Canis adustus</i> | ssj | |
| | Slender mongoose | <i>Galerella sanguinea</i> | smg | |
| | Small spotted genet | <i>Genetta genetta</i> | ssg | |
| | Spotted hyena | <i>Crocuta crocuta</i> | shy | |
| | Spring hare | <i>Pedetes capensis</i> | sph | |
| | Springbok | <i>Antidorcas marsupialis</i> | spr | |
| | Steenbok | <i>Raphicerus campestris</i> | ste | |
| | Striped pole-cat* | <i>Ictonyx striatus</i> | spc | |
| | Suricate | <i>Suricata suricatta</i> | sur | |
| | Yellow mongoose | <i>Cynictis penicillata</i> | ymb | |
| | Domestic animals | Camel | <i>Camelus dromedarius</i> | cam |
| | | Cattle | <i>Bos taurus</i> | cat |
| Dog | | <i>Canis familiaris</i> | dog | |
| Domestic cat | | <i>Felis silvestris catus</i> | doc | |
| Donkey | | <i>Equus asinus</i> | don | |
| Goat | | <i>Capra hirculus</i> | goa | |
| Horse | | <i>Equus caballus</i> | hor | |
| Sheep | | <i>Ovis aries</i> | she | |

4.3 Community structure and land use

A CA biplot of sites was created for the wet and dry season, which shows all the sites and to which land use type they belong. Sites that are placed close to each other in the diagrams have a similar composition of species and clusters of sites can be seen as a community. Axis 1 represents land use in both diagrams, with NP and WMA on the positive and FR and CGA on the negative side of axis 1. From the wet season site diagram (fig. 4.7) I can distinguish three clusters:

Cluster 1: Mainly sites situated in FR and CGA, hosting 14 wild and 8 domestic species, characterised by species like cattle, donkey, goat, sheep.

Cluster 2: Mainly sites situated in CGA, hosting 18 wild and 4 domestic species, characterised by species like cattle, donkey, horse. As for the wild species, springhare, springbok and steenbok were among the most frequent.

Cluster 3: Mainly sites situated in WMA and NP, hosting 28 wild and 1 domestic species, characterised by species like gemsbok, red hartebeest, bat eared fox, wildebeest, lion, brown hyena and spotted hyena. Springbok, steenbok and springhare were the most frequent in this cluster.

Several species occur in all three ‘communities’, e.g. springbok, steenbok, ostrich, duiker, ground squirrel, black-backed jackal, cape fox and red hartebeest. The species tend to increase in numbers from cluster 1 to cluster 3. Clusters one and two seem to be communities with similar species composition, although cluster 2 hosts fewer domestic species than cluster 1. They also differ in correlation to the pan gradient, cluster 2 shows a negative correlation. There are some species that can only be found in cluster three; brown hyena, eland, lion, spotted hyena and wildebeest.

From the dry season site diagram (fig. 4.8) I can distinguish two clusters:

Cluster 1: Mainly sites situated in FR and CGA, hosting 23 wild and 8 domestic species, characterised by species like cattle, horse, donkey, goat as well as wild species like slender mongoose, springbok and duiker.

Cluster 2: Mainly sites situated in WMA and NP, hosting 28 wild and 2 domestic species, characterised by species like gemsbok, red hartebeest, spotted hyena, lion, leopard, kudu. Cluster 1 is negatively correlated to the pan gradient. In resemblance to the wet season communities, the two distinguished communities in dry season also have several species that occur in both communities. In addition to the species above, kudu, red hartebeest and bat eared fox could be mentioned. Species that can only be found in cluster two are lion, spotted hyena and leopard. For a complete list of species found in respective cluster see Appendix 2.

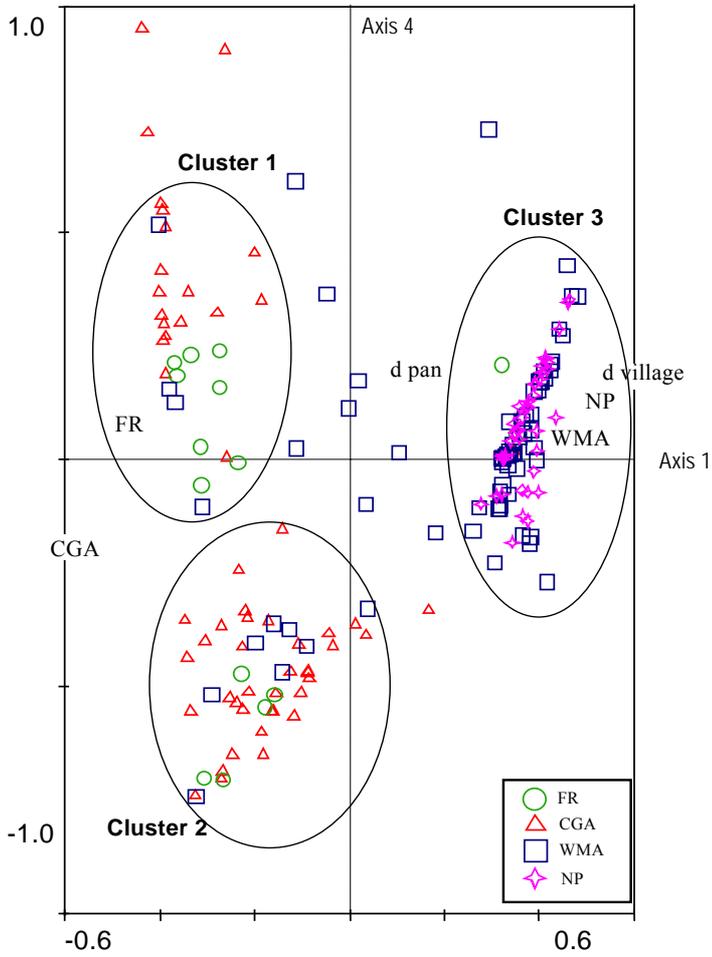


Figure 4.7. CA biplot of sites displays the relation between sites and environmental variables in the wet season.

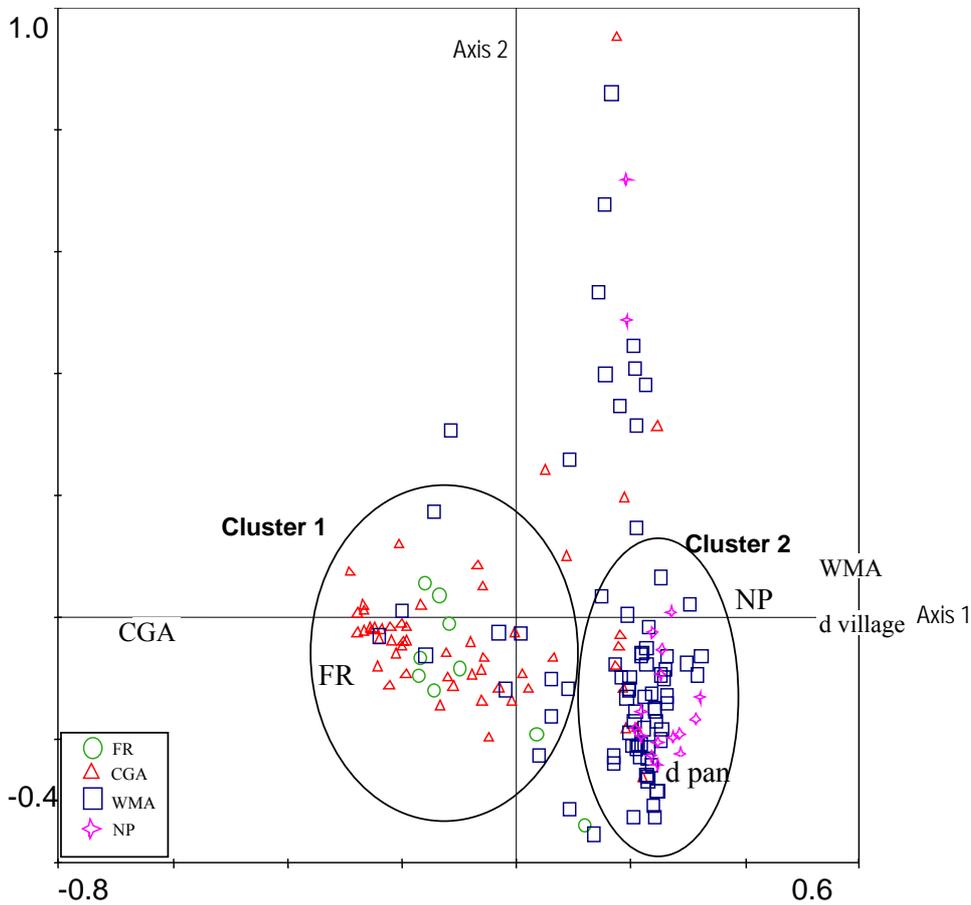


Figure 4.8. CA biplot of sites displays the relation between sites and environmental variables in the dry season.

4.4 Functional types

The CA biplot of sites shows the sites and which land use type they belong to (fig.4.9 & 4.10). Sites that are placed close to each other in the diagrams have a similar composition of functional types. Species and functional types are shown in table 4.6. Selected environmental variables explain 20 % and 16 % of the variation in wet respectively dry season data, which suggests that there would be at least one more important, non measured environmental variable.

There seems to be a clear separation between sites situated in WMA, NP and FR and CGA. Large grazers and small mixed herbivores (tab.4.7) dominate sites on the negative side along axis 1 in the wet season diagram. These functional types also dominate the positive side, although with a markedly smaller frequency. Large differences were found between the negative and the positive side along axis 1. Apparently, large carnivores, insectivores, omnivores and small browsers are less frequent in sites situated on the negative side than on the positive side. Similar trends in the distribution of functional types are revealed in dry season sites (tab.4.7).

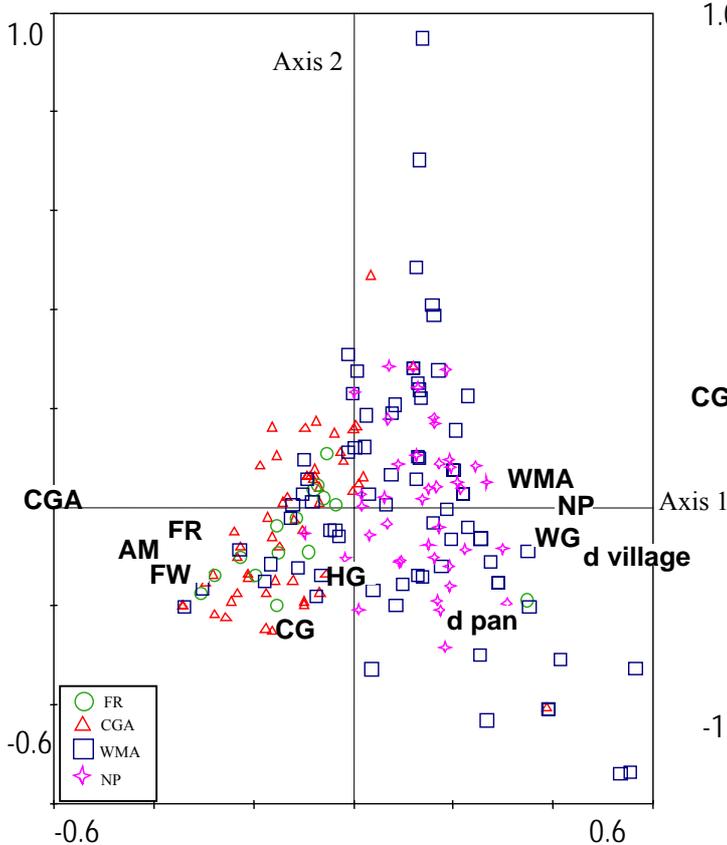


Fig. 4.9. CA biplot of sites displays the relation between sites and environmental variables in the wet season.

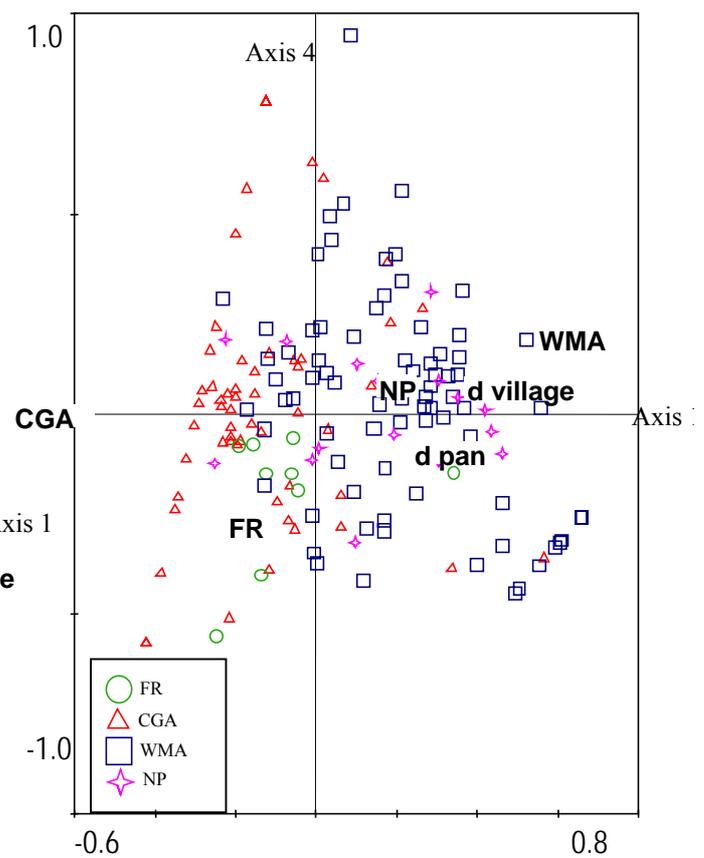


Fig. 4.10. CA biplot of sites displays the relation between sites and environmental variables in the dry season.

Table 4.6. Functional types based on size and food preference. Species marked with * were only observed during dry season. Information about mass and food preference was received from Stuart & Stuart (2001) and Viio (2003).

| Wild animals | Mass (kg) | Size | Food preference | Codename |
|-------------------------|------------------|-------------|------------------------|-----------------|
| Aardvark | 40.0-70.0 | Large | Insectivore | I |
| Aardwolf | 6-11 | Small | Insectivore | I |
| African Wild Cat | 2.5-6 | Small | Carnivore | SC |
| Black-backed Jackal | 6-10 | Small | Carnivore | SC |
| Bat-eared fox | 3-5 | Small | Insectivore | I |
| Brown Hyena | 42-47 | Large | Carnivore | LC |
| Caracal | 7-19 | Small | Carnivore | SC |
| Cape Fox | 2.5-4 | Small | Carnivore | SC |
| Cheetah | 40-60 | Large | Carnivore | LC |
| Duiker | 18-21 | Small | Browser | SB |
| Eland | 450-900 | Large | Browser | LB |
| Gemsbok | 210-240 | Large | Grazer | LG |
| Ground Squirrel | 0.5-1.0 | Small | Mixed herbivore | O |
| Hare | 1.4-4.5 | Small | Mixed herbivore | SM |
| Honeybadger | 8-14 | Small | Omnivore | O |
| Kudu* | 180-250 | Large | Browser | LB |
| Leopard | 17-90 | Large | Carnivore | LC |
| Lion | 110-225 | Large | Carnivore | LC |
| Ostrich | 90-110 | Large | Omnivore | O |
| Porcupine | 10-24 | Small | Omnivore | O |
| Red Hartebeest | 120-150 | Large | Grazer | LG |
| Spotted Hyena | 60-80 | Large | Carnivore | LC |
| Slender Mongoose | 0.37-0.8 | Small | Carnivore | SC |
| Springhare | 2.5-3.8 | Small | Mixed herbivore | SM |
| Springbok | 37-41 | Small | Mixed herbivore | SM |
| Small-spotted Genet | 1.5-2.6 | Small | Carnivore | SC |
| Side-striped Jackal | 7.5-12 | Small | Omnivore | O |
| Steenbok | 11.0 | Small | Browser | SB |
| Striped pole-cat* | 0.1-1.4 | Small | Carnivore | SC |
| Suricat | 0.62-0.96 | Small | Insectivore | I |
| Warthog | 45-105 | Large | Grazer | LG |
| Wilderbeest | 180-250 | Large | Grazer | LG |
| Yellow Mongoose | 0.45-0.9 | Small | Carnivore | SC |
| Domestic animals | | | | |
| Camel | 450-650 | Large | Grazer | LG |
| Cattle | 450 | Large | Grazer | LG |
| Dog | 12-75 | Small | Carnivore | SC |
| Domestic Cat | 3-6 | Small | Carnivore | SC |
| Donkey | 275 | Large | Grazer | LG |
| Goat | 26-42 | Small | Mixed herbivore | SM |
| Horse | 350-700 | Large | Grazer | LG |
| Sheep | 25-36 | Small | Grazer | SG |

Table 4.7. List over functional types and number of animals found in respective type in the wet and the dry season.

| Functional types | Wet season | | Dry season | |
|-------------------------|-------------------|---------------|-------------------|---------------|
| | Negative side | Positive side | Negative side | Positive side |
| I | 0,5 | 36,5 | 2,6 | 18,5 |
| LC | 5,0 | 8,1 | 1,6 | 7,1 |
| SC | 40,9 | 49,5 | 83,1 | 158,8 |
| LG | 3791,6 | 195,0 | 2805,5 | 108,8 |
| O | 25,2 | 83,0 | 44,7 | 60,4 |
| SM | 1870,1 | 812,1 | 1874,9 | 332,6 |
| SB | 44,2 | 165,7 | 41,8 | 164 |

5. DISCUSSION

5.1 Species diversity

The results show that the species diversity is higher in WMA and NP than in FR and CGA, both during the wet and the dry season (Table 4.2). A factor that might be highly important for this discussion is the lack of rain in the beginning of the wet season during the field work (pers.obs). Heavy rains occurred first in February, which means that the dry season went on for longer than normal. This might have resulted in more species moving out of the area. In the Kalahari, many, but not all species of herbivores undertake long-distance movements in response to water and food availability (Crowe 1995 in Bergström & Skarpe 1999). WMA is the land use that seems to have the highest diversity regardless of season, not NP that one might expect. This is simply because the diversity index includes both wild and domestic species. Both WMA and NP are rich in wild species, while domestic species only occur in WMA.

The majority of observed domestic animals were made in FR and CGA, and the observed wild animals in these areas were fewer than in WMA and NP. The difference in observed wildlife between protected and unprotected areas is smaller in the dry season than in the wet season, whereas the number of livestock seems to be similar between seasons. It might indicate that wildlife prefers protected areas, but that they to a larger extent move away to unprotected areas during the dry season. A possible reason for this movement might be the search for food and water.

There are slightly more wild species recorded in all four land use types during the dry season than in the wet season. This might be just a coincidence. Species like kudu and striped polecat that were observed during the dry season were seen in the wet season as well, but never observed during transect drives. Some species that were seen only in the dry season were observed on very few occasions, which helps explain the difference of species observed in the wet and the dry season. The indirect human disturbance through livestock keeping in FR and CGA is the most likely reason for the low species richness of wild animals in these areas.

The species richness is higher during night-time than day-time in the four land use areas for both seasons, although the difference is markedly larger in FR and CGA during the dry season when comparing both seasons. Viio (2003) suggested that human disturbance in FR and CGA is probably much less during night- than daytime and that nocturnal animals are less active during the day and may hide so that they are recorded to a lesser extent during day-time. Black-backed Jackal and honeybadger are two species that are mainly nocturnal when in conflict with man, but when undisturbed are active during daytime (Stuart & Stuart 2001). Another possibility is that wild mammals that are active during night may stay in WMA and NP during day and move to CGA and FR during night when some livestock are kraaled and the villagers are asleep (Viio 2003). All these suggestions sound reasonable, and it may also be that the competition for food between wild and domestic animals is less pronounced during the wet season. This allows species to stay in these areas regardless on time of the day. Another explanation could be that a few wild species, species that are usually never found in ranches and communal grazing areas, were observed during daytime on one or few occasions. A few observations had a large influence and thus, the result might be a bit misleading.

5.2 Relations between species distribution and environmental variables

The results imply that land use has an influence on species distribution, both in wet and dry season. There is no obvious difference in species distribution with regards to season. Livestock and wildlife are clearly separated, with livestock close to village and wildlife increasing with distance to village. This also coincides with land use types since FR and CGA lie closer to villages than WMA and NP. Earlier studies have shown that distance from villages and pans is important in affecting species distributions (Bergström & Skarpe 1999, Wallgren 2001). In their study, Bergström & Skarpe (1999) generally found a gap of ca 10 km between the livestock observations furthest away from villages and the wildlife observations closest to the village.

Unsettled pans are important for wildlife in southern Africa and especially in the Kalahari (Parris & Child 1973). The presence of large permanent villages, on the other hand, seriously reduces the number of wild animals using the pan, which is caused by disturbance such as hunting, competition from domestic stock and general noise from the village (Parris & Child 1973). In this study the pan habitats seemed to be particularly important for springbok, wildebeest, red hartebeest, ground squirrel, ostrich, suricate, as well as large carnivores like leopard and cheetah. Bergström & Skarpe (1999) found that springbok, gemsbok and ostrich utilized pans more in the rainy season than in the dry, independent of whether pans held water or not. Springbok generally prefers the short vegetation at pans and preferentially feeds on short grass in the wet season and browses primarily from dwarf shrubs surrounding the pans in the dry season (Bigalke in Bergström & Skarpe 1999). Gemsbok and red hartebeest graze the closely cropped grass around pans as well as in the surrounding savanna (DHV in Skarpe & Bergström 1999). The grazeable biomass around the pans during most of the year is very low, but quality is high (Knight 1995). Smaller-bodied ungulate species have narrower dietary tolerances than larger species and tend to specialize on habitats, e.g. pans, that provide high quality forage throughout the year (du Toit & Smith 1989). Large-bodied grazers, occurring in big groups, are more dependent on quantity of biomass, and are not always able to find enough grazing in the vicinity of the pans (Bergström, Skarpe 1999). This could explain why gemsbok was excluded from the group of species I found negatively correlated with distance to pan in the wet season, as well as for both species in the dry season.

Pans are suitable for large carnivores with the game concentrations and the open terrain (Parris 1970). Because of few observations of leopards, I find it inadequate to base a discussion on them.

The vegetation study performed during the wet season explains some of the variation in the data. The positive correlation between forbs and woody plants as well as *Acacia mellifera* and livestock areas, i.e. FR and CGA, agree with previous vegetation studies in Kalahari. Skarpe (1990) showed that *Acacia mellifera* is strongly dominant in the heavily grazed vegetation, and Verlinden (1997) that tree cover is positively correlated to livestock in the wet season. Increases in cover of woody species on the expense of grass cover have probably had negative effects on grazing wild animals. Both wilted grass and height of green grass showed a positive correlation to wildlife, which is probably an effect of less grazing pressure in areas further away from villages.

The majorities of larger herbivorous mammals prefer green areas but also try to avoid areas characterised by livestock (Verlinden 1997). The result from this study indicates a possible conflict over resources between wildlife, more specifically large herbivores and livestock in the wet season. Another interpretation is that livestock are more dependent on green areas than wildlife, but also that people probably have selected green areas for their livestock (Verlinden 1997). It is important to mention that the vegetation study was performed in the

beginning of the wet season. Rainfall in the Kalahari is unpredictable in both space and time and some wildlife need to move to areas where rainfall has occurred in a particular year. If livestock keep wildlife away from the greener areas, they are confined to areas where there is an increased probability that sufficient rain will not have fallen (Thouless 1998).

Vegetation data are missing from the dry season study in 2002 (Viio 2003), so for further discussions about difference in vegetation between wet and dry season, and how it affects wildlife distribution, other sources are being used. Cover of green grass in the dry seasons is a variable that might be able to provide more knowledge on how species are distributed over seasons, especially when it comes to large mammals which are known to prefer green areas (Verlinden 1997). One probability is that less green areas are available during the dry season and that the competition between wildlife and livestock would therefore be more pronounced than during the wet season. Vegetation data from the dry season in 1991 confirm a reduction in grass cover as a result of livestock grazing in the immediate surroundings of the water point, and further, that the effect of grazing on grass cover in the dry season apparently extends further than found in other areas during the wet season (Perkins & Thomas 1993 according to Verlinden et al. 1998). Exactly how much the difference in grass greenness between seasons actually affects the distribution of wildlife is difficult to say. When approaching villages, the activity of humans increases considerably. If wildlife avoids livestock areas, the greenness of the grass would not be the major problem, but the livestock itself. It has also been suggested that selective wildlife utilization, e.g. hunting and poaching is a more important factor in the current distribution of common game species than avoidance of areas changed by livestock in the southern Kalahari (Verlinden et al. 1998).

5.3 Community structure and land use

It is fairly obvious that land use affects the wildlife communities in the Kalahari. Sites in protected areas (WMA, NP) are clearly different from sites in unprotected areas (FR, CGA) both during wet and dry season. Wildlife and livestock communities were distinguished in the dry season (Fig. 4.8). Three communities were found in the wet season, of which one is clearly a wildlife community, which exists further away from villages than the other two. Cluster 2 holds as many wild species as cluster 1, but has less domestic species, which could be explained by its stronger correlation to CGA than FR (Fig. 4.7). The absence of goat and sheep also indicates that this community exists further away from villages than cluster 1, since these species mainly forage close to villages (Jansson 2001). FR might act as a deterrent barrier or even as an impossible passage for some species. Some ranches, especially in the Ncojane ranchblock also suffer from extensive bush encroachment (Thomas et al. 1999). CGA are in that respect less affected by humans. Cluster 2 showed to be a pan community. Cattle were most frequent in this cluster, which indicate that livestock depend on and to large extent utilize pans in wet season, especially the once placed closed to villages.

There are species that benefit from the heavy stocking of livestock in human areas. By trampling the grass, livestock make it more accessible to the termites on which the Aardvark feeds (Stuart & Stuart 2001). Common duiker, springbok, steenbok and ostrich have previously been suggested, as species not negatively affected by livestock in overgrazed areas (Verlinden 1997). The three browsing ruminants (springbok is a mixed feeder), will probably be less affected by the dominance of woody plants in heavily grazed areas, compared with grazing species. The advantage of mixed herbivore communities, with complementary use of various vegetation components, was recognized long time ago, and the role of wild browsers is central, given their ability to feed on various heights in the woody vegetation (Fritz et al. 1996). With exceptions from aardvark these species were found in all communities in both wet and dry season. Although, they seem to be more frequent further away from villages,

except for common duiker in the dry season. This suggests a preference for areas with less human disturbance, but it might also be a result of hunting in areas close to villages. It could be argued that large carnivores could benefit from these areas as well, since their nocturnal activity patterns would allow them to move in these areas during nights and feed on livestock and carcasses when disturbance from villages are less. Although some large carnivores/scavengers (brown hyena) were observed in unprotected areas in dry season, this was not confirmed by this study.

Some species that were only to be found in the wildlife communities during both seasons were spotted hyena, leopard and lion. The present distribution of intact large carnivore communities in southern Africa is largely an artefact reflecting the distribution of protected wildlife areas (du Toit 1995). Large carnivores are especially sensitive to human activity, because their requirements often conflict with those of local people (Woodroffe 2000). This study shows that large carnivore communities, are more restricted with regards to land use, and are mainly seen in protected areas, while herbivore communities to a larger extent can reside with livestock communities in unprotected areas. This pattern also agrees with data from the dry season.

5.4 Functional types

Species are the most common units for community studies, but there is an increasing interest in the generalisation from species to functional types (Skarpe 2000). This has been used to understand plant adaptations to different environmental constraints (Landsberg et. al. 1999) and could also be applied for studying mammal communities.

There are many ways of combining the functional types used in this study, depending on the number of food preference classes used, as well as the limits for classifying species as small or large. Other possibilities are to use types based on activity patterns, whether species are gregarious, solitary, if they live in pairs or in family groups. One obvious weakness with the functional types used in this study is that some types are well represented by several species, while others include only a few. Some species are also more abundant than others are. By using fewer types, a more equal distribution of species within each type would have been achieved. On the other hand, this would increase the risk for species with less similar food preference etc. to end up in the same type.

The results indicate that land use is an important factor that plays a significant role in the composition of mammal communities. The majority of large grazers were found on the negative side along axis 1 in the wet season diagram, as well as small mixed herbivores. Since most wild large herbivores are encountered 10 km further away from villages compared to cattle (Bergström & Skarpe 1999), it could be stated that these mostly constitutes of domestic species like cattle, donkey and horse. Large carnivores, insectivores, omnivores, small browsers and small carnivores were all more frequent in sites placed further away from villages. No clusters were found, which indicates that the effect of land use on mammal communities is more on a species level. There is no difference, in the distribution of functional types between the wet and the dry season. The result seems to agree with previous analysis performed in this thesis.

5.5 Conclusions

This study is one of the first in this area to compare the influence of land use types on mammal communities between wet and dry season. It did not confirm that the effect of land use on wildlife is more pronounced in the dry season than in the wet season. I have shown that species richness differs between the four land use types, with more species in NP and WMA than in FR and CGA in both wet and dry seasons. The diversity was higher in NP and WMA than in CGA and FR in both seasons. Overall, diversity tended to be higher in the dry season than in the wet season. The results from the vegetation study agree with previous surveys regarding bush encroachment in livestock areas. It also implies that there is possibly a competition over resources between domestic animals and wild herbivores in the wet season. Distance to pan is another important variable that affects species distribution. The mammal community study showed that wild and domestic species can reside in the same areas to some extent, but that wildlife increases with distance to village. Lion, spotted hyena and leopard are species that were only encountered in WMA and NP, and can be considered to exclusively exist in these areas. This thesis also shows that there is no difference between mammal communities in wet and dry season.

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APPENDIX

Appendix 1. Transects and total driven kilometres in the four land use types.

| Transect | Abbreviation | Land use type | Def. Length | Day | Night | Km Day | Km Night |
|---------------------------------------|--------------|-------------------------|-------------|------------|------------|---------------|---------------|
| Casino Ranch | fcas | fr | 10,7 | 4 | 4 | 42,8 | 42,8 |
| Lokgwabe Ranch BB74 | flor | fr | 11,4 | 10 | 10 | 114 | 114 |
| Lokgwabe Ranch Zolcon | flor | fr | 4 | 10 | 10 | 40 | 40 |
| Ncojane Ranch 4 | fncr | fr | 16,4 | 9 | 9 | 147,6 | 147,6 |
| Njocane Ranch 10 | fncr | fr | 8,1 | 10 | 10 | 81 | 81 |
| Njocane Ranch 17 | fncr | fr | 8,2 | 10 | 10 | 82 | 82 |
| Njocane Ranch 23 | fncr | fr | 3,9 | 10 | 10 | 39 | 39 |
| Hukunsi NW | chnw | cga | 41,6 | 2 | 2 | 83,2 | 83,2 |
| Hukunsi SW | chsw | cga | 42,7 | 1 | 1 | 42,7 | 42,7 |
| Lehututu / Huhukwe | cleh | cga | 80,9 | 2 | 2 | 161,8 | 161,8 |
| Lokgwabe N | clon | cga | 31 | 3 | 3 | 93 | 93 |
| Njocane E | cnce | cga | 20,6 | 2 | 2 | 41,2 | 41,2 |
| Ncojane S | cncs | cga | 23,7 | 2 | 2 | 47,4 | 47,4 |
| Tshane | ctsh | cga | 28,3 | 4 | 4 | 113,2 | 113,2 |
| Lokgwabe S | wlos | wma | 56,4 | 3 | 3 | 169,2 | 169,2 |
| Maitlo-a-Phuduhudu | wmap | wma | 73,6 | 2 | 2 | 147,2 | 147,2 |
| Mosieding | wmos | wma | 22,3 | 2 | 2 | 44,6 | 44,6 |
| Ngwatle | wngw | wma | 56,1 | 2 | 2 | 112,2 | 112,2 |
| Tshutswa E | wtse | wma | 16,8 | 1 | 1 | 16,8 | 16,8 |
| Tshutswa W | wtsw | wma | 72,2 | 2 | 1 | 144,4 | 72,2 |
| Uhkwe | wukw | wma | 82,9 | 2 | 2 | 165,8 | 165,8 |
| Gnus Gnus | npgn | np | 54,2 | 2 | 2 | 108,4 | 108,4 |
| Kaa | npka | np | 30,1 | 2 | 2 | 60,2 | 60,2 |
| Mabuasehube | npma | np | 69,4 | 7 | 7 | 485,8 | 485,8 |
| Swart Pan | npsp | np | 45,4 | 2 | 2 | 90,8 | 90,8 |
| All transects in land use | | fr | | 63 | 63 | 546,4 | 546,4 |
| All transects in land use | | cga | | 16 | 16 | 582,5 | 582,5 |
| All transects in land use | | wma | | 14 | 13 | 800,2 | 728 |
| All transects in land use | | np | | 13 | 13 | 745,2 | 745,2 |
| All transects in all land uses | | fr, cga, wma, np | | 106 | 105 | 2674,3 | 2602,1 |

Appendix 2. List over species and number of individuals found in respective cluster.

| Dry season | Cluster 1 | No. of ind. | Cluster 2 | No. of ind. | Wet season | Cluster 1 | No. of ind. | Cluster 2 | No. of ind. | Cluster 3 | No. of ind. |
|-------------------|------------------|--------------------|------------------|--------------------|-------------------|------------------|--------------------|------------------|--------------------|------------------|--------------------|
| | aaw | 0,5 | aav | 1,2 | | awc | 0,3 | aav | 0,5 | aav | 0,1 |
| | awc | 4,0 | aaw | 0,5 | | bbj | 1,1 | awc | 0,5 | awc | 1,7 |
| | bbj | 5,8 | awc | 5,5 | | cam | 0,8 | bbj | 1,8 | bbj | 13,0 |
| | bfx | 5,7 | bbj | 12,8 | | cat | 1861,7 | cat | 1520,8 | bfx | 31,3 |
| | bhy | 1,2 | bfx | 12,4 | | cfx | 0,1 | cfx | 0,8 | bhy | 1,1 |
| | cam | 1,5 | bhy | 1,9 | | doc | 0,5 | dog | 0,7 | car | 0,3 |
| | car | 0,7 | car | 0,2 | | dog | 30,2 | don | 56,8 | cfx | 7,2 |
| | cat | 2051,6 | cfx | 3,4 | | don | 182,4 | dui | 1,1 | dui | 1,8 |
| | cfx | 1,4 | doc | 7,7 | | dui | 0,1 | gem | 0,4 | ela | 1,5 |
| | doc | 2,7 | dui | 0,5 | | goa | 1515,2 | gsq | 10,6 | gem | 72,4 |
| | dog | 1,5 | gem | 35,6 | | gsq | 1,1 | har | 4,8 | gsq | 12,4 |
| | don | 51,0 | gsq | 3,0 | | har | 1,9 | hbg | 1,0 | har | 8,6 |
| | dui | 288,2 | har | 8,3 | | hor | 65,5 | hor | 51,9 | hbg | 0,1 |
| | gem | 0,2 | hbg | 0,2 | | ost | 1,2 | ost | 6,5 | hor | 1,1 |
| | goa | 1182,8 | hor | 2,0 | | rhb | 0,3 | por | 0,6 | leo | 0,1 |
| | gsq | 25,2 | kud | 4,0 | | she | 118,3 | rhb | 2,0 | lio | 2,3 |
| | har | 19,3 | leo | 1,6 | | sph | 15,0 | smg | 0,7 | ost | 33,6 |
| | hbg | 0,5 | lio | 1,9 | | spr | 16,1 | sph | 47,4 | por | 0,8 |
| | hor | 73,5 | ost | 13,3 | | ssg | 0,1 | spr | 23,0 | rhb | 90,0 |
| | kud | 2,0 | por | 2,0 | | ste | 6,8 | ste | 24,1 | shy | 5,3 |
| | ost | 2,0 | rhb | 43,9 | | sur | 0,4 | war | 1,0 | smg | 0,8 |
| | por | 1,1 | shy | 4,8 | | ymg | 2,6 | ymg | 0,6 | sph | 271,1 |
| | rhb | 3,5 | smg | 1,2 | | | | | | spr | 580,7 |
| | she | 2,5 | sph | 2,8 | | | | | | ssg | 2,0 |
| | smg | 106,5 | spr | 158,3 | | | | | | ssj | 0,5 |
| | sph | 1,9 | ssg | 1,9 | | | | | | ste | 137,8 |
| | spr | 145,7 | ste | 125,4 | | | | | | sur | 9,4 |
| | ssg | 37,2 | sur | 54,4 | | | | | | wil | 20,8 |
| | ste | 41,5 | war | 1,0 | | | | | | ymg | 2,6 |
| | sur | 4,8 | ymg | 1,7 | | | | | | | |
| | ymg | 11,9 | | | | | | | | | |