BEHAVIOURAL-ECOLOGY OF THE WHITE RHINOCEROS (CERATOTHERIUM SIMUM) IN THE WILLEM PRETORIUS GAME RESERVE

by

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Summary

The main aim of this study was to classify and describe the plant communities in the home range of white rhinoceros in order to understand the animal seasonal foraging ecology. To provide a detailed habitat description, forty sample plots were stratified randomly. A TWINSPAN classification, refined by Braun-Blanquet procedures, was carried out on the Viewpoint section of the reserve. Ten plant communities, grouped into five major community types, were identified. The veld condition and ecological carrying capacity in these communities were measured, stating an abundance of food on long grass while the short grass equal the number of short grass feeders. A number of behavioural aspects such as activity data, home range utilization and dietary usage were examined. Statistical methods such as the Spearman rank-order correlation, Wilcoxon sign test and Student T-test were used on rhino data. The difference in usage of the home range during wet and dry seasons was insignificant.

KEY WORDS: Willem Pretorius Game Reserve (WPGR), White Rhinos, Braun-Blanquet, TWINSPAN, Ecological Carrying Capacity, Feeding Ecology, Vegetation Classification, Habitat Utilization, White Rhino Behaviour, Total Home Range.

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CHAPTER 1
INTRODUCTION

1.1. Historical background

Rhinoceros belong to the mammalian order Perissodoctyla, a group of odd-toed ungulates that has its origins in the Eocene Period some fifty million years ago. The only surviving members of this order comprise the tapirs, the horse family and five rhinoceros species (Prothero, 1991). Fossil records suggest that as many as 170 rhinoceros species may have become extinct over the past fifty million years (Balfour & Balfour, 1991). Skinner and Chimimba (2005) name four genera of fossil rhinoceros, namely *Brachypotherium, Acerathherium, Dicerorhinus and Chilotherium.* The *Baluchitherium* is an extinct member of the rhinoceros family and the fact that it stood at 5.5 metre high makes it the largest land mammal that ever lived (Mills & Hes, 1997). Dakes (1961) refers to the period when these now extinct rhinoceros roamed the world as the Pre-Adamite-World, the Dateless Past or the Ante-Chaotic age.

Today, three of the remaining five species in existence are found on the Asian continent (Figure 1.1) and two in Africa (Figure 1.2). The Indian rhinoceros or greater one-horned rhinoceros (*Rhinoceros unicornis)* occurs in southern Asia on the northern margin of the Indian sub-continent and adjacent to the southern slope of the Himalayas. The Javan rhinoceros or lesser one-horned rhinoceros (*Rhinoceros sondaicus)* occurs in western Indonesia, eastern Indochina and Java. The Sumatran rhinoceros or lesser two-horned rhinoceros (also called hairy rhinoceros) (*Rhinoceros sumatrensis)* occurs in the Peninsular of Malaysia, Sumatra and northern Borneo. On the African continent, two species of rhinoceros occur, the white rhinoceros (*Ceratotherium simum)* and black rhinoceros (*Diceros bicornis).* Both species occur in eastern, central, western and southern Africa.

There are currently more than 11 000 white rhinos, 3 500 black rhinos, about 2 575 India rhinos, less than 300 Sumatran rhinos and less than 60 Javan rhinos in existence (IUCN, 2009)

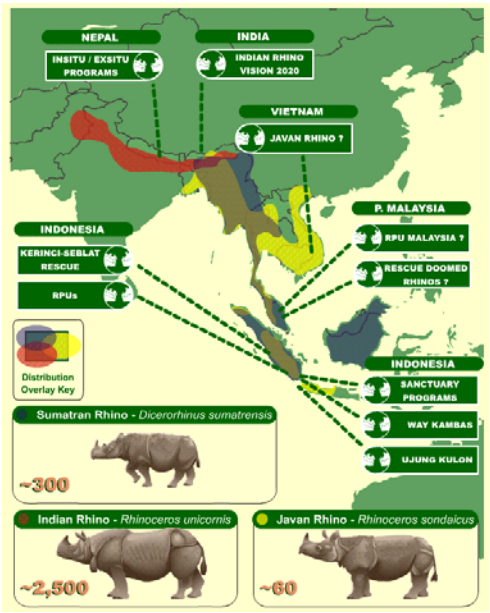

Figure 1.1: The distribution of the three Asian rhinoceros species with their total numbers for 2008 (From: http://www.rhinoceros-irf.org/asia. Accessed 30 August 2008).

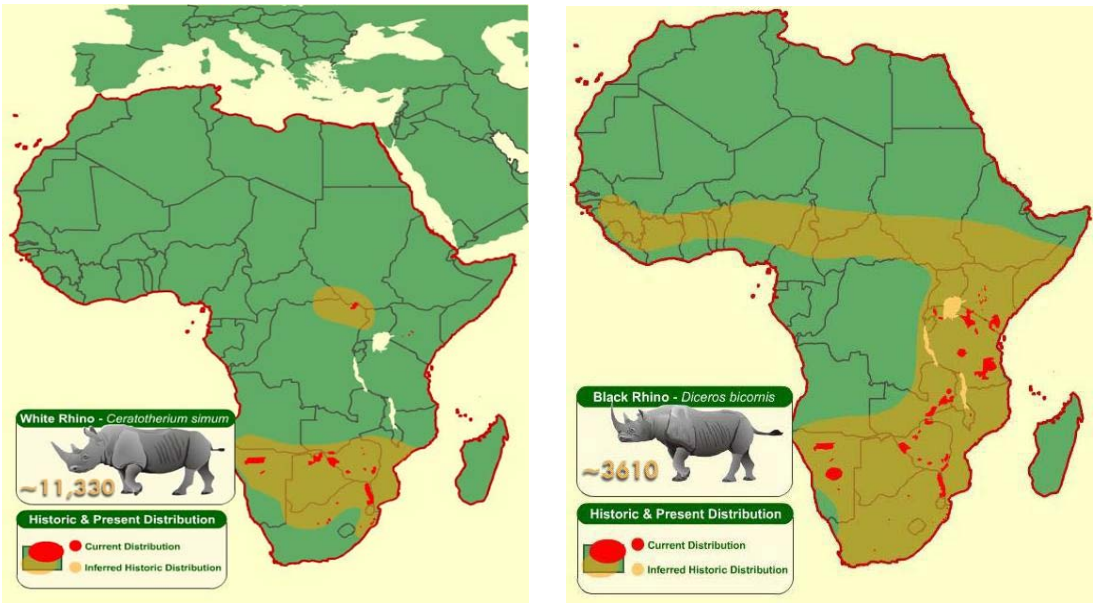

Figure 1.2: The distribution of the two African rhinoceros species throughout Africa with their total number for 2008 (From: http://www.rhinoceros-irf.org/asia. Accessed 30 August 2008).

The International Union for the Conservation of Nature and Natural Resources (IUCN, 2009) regard the northern white rhinoceros (*Ceratotherium simum cottoni)* as Critically Endangered with less than four individuals left.

While rhinoceros numbers are decreasing, an exponential growth in the world population of more than 6.5 billion people since 1830 has taken place (Campbell & Lasley, 1985). Since 2003, the Earth's carrying capacity or "Ecological Footprint" has been exceeding its natural resources by 25 % annually (Bonthuys, 2006). Thus a new expected onslaught on animal species and their habitat is inevitable.

President Paul Kruger proclaimed Africa's first game reserve, the Pongola Game Reserve, on 13 June 1894 to preserve wild game species (Pringle, 1982). Zululand reserves of Umfolozi and Hluhluwe were proclaimed by the Natal Government in 1897 in order to save the black and particularly the white rhinoceros (Balfour & Balfour, 1991). By 1904 only ten white rhinos remained throughout the world (Furstenburg, 2004).

Hundreds of game laws and nature reserves have been proclaimed throughout Africa to manage and protect animal species. The first conservative, yet effective, concepts of protecting wildlife were successful and in South Africa the southern white rhinoceros (*Ceratotherium simum simum*) multiplied from ten in 1904 to 7 913 in 1999 (Buijs, 1999). Stokes (1944) gives the official numbers of the northern white rhinoceros during 1940 in the Belgium Congo as 300, in Uganda as 220 and in Sudan there were between 500 and 600. Unfortunately, the northern white rhinoceros (*Ceratotherium simum cottoni*) declined from several thousand to "maybe two" due to political instability and smuggling ([1]Greeff, pers.comm. 2008).

In South Africa conservation-minded pioneer game farmers played an important role in conserving animal species. The Terblance and du Plessis families rescued the black wildebeest

[1] GREEF, J. 2008. Anti-poaching. Lapalala Wilderness Safaris, Vrede. (Controlled the anti-poaching unit in the Garamba National Park, DRC, to protect the last 27 northern white rhinoceros).

(*Connochaetes gnou*), the Van der Byls, Van Bredas and Albertyns rescued the bontebok (*Damaliscus pygargus pygargus)* and Hans Lombaard saved the Cape mountain zebra (*Equus zebra zebra),* (Young, 1984). These initial efforts grew progressively into commercial production of wildlife, for example: the sustainable utilization of ostrich (*Struthio camelus)* and crocodiles (*Crocodylus niloticus)* for the fashion industry (Bothma & Van Rooyen, 2005). Since the 1990's the private sector in southern Africa has invested a great deal in endangered wildlife species as an alternative to marginal game species. The white rhinoceros was targeted as a safe, high value and good investment species and this helped to increase their numbers in South Africa. Unfortunately, the uncertain political situation in South Africa forced landowners to invest in rare species such as white rhinos without purchasing more land ([2]Crous, pers. comm. 2006).

With the ever-increasing human population, political instability and demand for land in South Africa the white rhinoceros is forced to survive in restricted areas. With the latter in mind, a need exists to set guidelines for landowners to keep white rhinos on small game farms. Thus, as a first step in developing guidelines to manage these animals in smaller areas, it is necessary to have a good understanding of their utilization of natural habitats and their resource utilization as this will assist in making decisions on the implementation of management programmes (Marais, 2005).

1.2. Distribution of white rhinos

Several records indicate that historically white rhinos occurred in the southern African sub-region: President Paul Kruger (1902) described a personal encounter with a white rhinoceros in the vicinity of Rustenburg not far from Elephant's Pass. Player and Feely (1960) describe the northern limits for the distribution of white rhinos as ranging from southern Angola, via northern Namibia, Botswana and Zimbabwe to include Mozambique. Selous (1969) refers to the "extraordinary number of rhinos of both black and white species" that Captain Cornwallis Harris

[2] CROUS. R. 2006. Commercial game farmer. Kroonstad.

hunted between 1836 and 1837 in the interior of South Africa. Pringle (1982) mentions two paintings from the William Fehr Collection where a white rhinoceros was hunted by C. D. Bell in 1835 on the banks of the Crocodile River. These authors describe the southern limits as comprising the northern Bushveld parts of South Africa, the Northern Cape Province and Zululand. Balfour & Balfour (1991) wrote about a hunting party whose members shot six white rhinos near the confluence of the Black and White Umfolozi Rivers in 1895. Historically white rhinos appeared to have avoided the Transvaal Highveld and moist grasslands of Natal (Pienaar, 1994). According to Mills & Hes (1997), white rhinos were formerly widely distributed throughout the Bushveld area of South Africa as well as in Zimbabwe, Botswana and Namibia.

The last white rhinoceros in Zimbabwe was shot in 1895, while Selous shot one in 1874 in Botswana near the Zimbabwe border and Sir Hugh Beadle shot another in Mozambique in 1935 (Skinner & Chimimba, 2005). In the Cape Province the last rhinoceros was shot near Port Elizabeth in 1853 (Stokes, 1944). Both the last black and white rhinoceros in the Transvaal were killed between 1872 and 1890 (Balfour & Balfour, 1991).

In several articles and books, mention is made of place names with direct reference to the presence of rhinos in the Free State Province. Gilliomee (1989) mentions “Renosterkop” outside Kroonstad as the place where the last rhinoceros was shot in 1842, while Van der Merwe (1921) mentions “Renosterspruit” in the vicinity of Mazelspoort, near Bloemfontein, from where the father of President M.T. Steyn occasionally paid his sons a visit to ensure that all the farm affairs were in good order. There is also a Renosterspruit close to the Renosterkop outside Kroonstad, with the farms Renosterhoek and Renosterpoort in the Vredefort district. Various other records indicate that white rhinos did occur in certain areas of the Free State (Butzer *et al.* 1974; Cooke, 1974; Lynch, 1991).

By the 1960s there were no records of white rhinos occurring in the Free State and on 14 March 1962, the first white rhinoceros, named Ondini was relocated back to the Free State Province by the Natal Parks Board into the Willem Pretorius Game Reserve (WPGR) (Figure 1.3).

Figure 1.3: "Ondini" in the boma before being released into the Willem Pretorius Game Reserve (WPGR) on 14 March 1962.

A survey conducted by Terblanche (1988) found that during 1988 the province provided a home for fifteen white rhinos on private land and by 1989 a further 22 government-owned white rhinos existed in the Free State. A follow-up survey was done in 2009 by myself and a total of 214 white rhinos occurred in the Free State, of which 153 occurred on private land and 61 on state land. During 1990 no black rhinoceros (*Diceros bicornis)* were found on either state or private land in the Free State (Jordaan, 1990), but currently four male black rhinoses occur on state land while three males occur on private land.

1.3. White rhinoceros biology

The social organisation of white rhinos consists mostly of pairs (cow-calf, cow-cow), or small groups (adolescents, adult male, cow and offspring) which may number up to six individuals (Owen-Smith, 1971a). Adult males are often found alone. The well-ordered social system, low predation and year-round reproduction favours a territorial organisation which has the following

features: i) mutually exclusive ranges of 1 – 2 km², ii) a dominant assertiveness in interactions within the territory, iii) specialized scent marking techniques and iv) exclusive participation in reproduction (Owen-Smith, 1972).

White rhinos prefer a savanna habitat with an adequate supply of water. Shade and shelter were important during calving periods (Player & Feely, 1960). Pienaar *et al.* (1992) conducted a long- and short term study on the landscape preference of the white rhinoceros in the southern Kruger National Park. They found that the white rhinoceros preferred moderately undulating granitoid plains with *Combretum zeyheri* woodland while avoiding low granitoid mountains with *Combretum apiculatum* bushveld and granitoid lowlands with *Acacia grandicornuta* tree-savanna. They are suggested to have a feeding preference for short grass (Smithers, 1986).

White rhinos have been found to show peaks of activity in the early mornings and late afternoons and to lie down during the middle of the day, with more or less the same activity patterns at night (Owen–Smith, 1988). The reproduction of the white rhinos is not seasonally restricted and births occur throughout the year. The gestation period is sixteen months and calves are hidden for the first three to four weeks before the cow reappears in her usual grazing area (Owen-Smith, 1971).

Pitlagano (2007) investigated white rhinoceros movement patterns, home ranges and mortalities of reintroduced white rhinos in the Moremi Game Reserve of Botswana. She found a significant difference in distance moved from release site between animals in different batches. Home range sizes decreased with years after release. The number of rhinos present at the time of release influenced the movement pattern and home range size of the re-introduced white rhinos.

The main objectives of this study were to investigate the behavioural-ecology or relationship between the white rhinos and its habitat in the Willem Pretorius Game Reserve (WPGR) of the Free State.

The key research questions were:

1. What vegetation types occur in the study area of the WPGR?

2. What was the current veld condition and grazing capacity for the study area?

3. What was the population structure of the white rhinoceros?

4. What were the seasonal ranges of the white rhinoceros within the study area?

5. What habitat types were utilized?

6. Were there seasonal differences in food selection?

7. Were there seasonal differences in activity budgets?

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CHAPTER 2
STUDY AREA

2.1. Location and size

The Willem Pretorius Game Reserve is situated in the Winburg district at 28° 16' and 28° 21' south and 27° 07' and 27° 23' west. The reserve is approximately 12 091 ha, of which the Allemanskraal Dam covers 2 648 ha at full capacity. The reserve (Figure 2.1) was proclaimed as an Orange Free State Provincial Nature Reserve on 18 December 1970 (Ord.8/1969: Administrateurskennisgewing No 227, 1969). It was named after a Member of the Executive Council (MEC) Mr. Willem Pretorius, who started negotiations with the Central Government in 1950, to exchange the then existing "Free State Game Reserve" on the farm Summerville in the Bultfontein district for vacant state land surrounding Allemanskraal Dam. The transaction was approved by the Minister of Lands in 1954 (Kietzman, 1998).

Since Summerville was situated in a highly productive agricultural area, the provincial government decided to exchange it for state land adjacent to the Allemanskraal Dam which had low productive agricultural potential and was considered to be more suitable for game. Summerville was then privatized and became agricultural land (Van Zyl, 2008). The Free State Game Reserve was proclaimed in 1929 to protect the almost extinct black wildebeest (*Connochaetes gnou*).

These lands adjacent to Allemanskraal Dam also possessed significant cultural value. There are ruins on the reserve which date back to the Iron Age, 600 AD to 1823 AD. Indigenous tribes migrated from the north and travelled south where they lived a primitive life in the central part of the Free State. According to White et al.. (1975) these small, primitive people who lived in igloo-like stone houses were all killed by the Zulus and Matebele in the early nineteenth century. They were called Ghoya-people or Taung people. When the first "Voortrekkers" (European pioneers) came to this area they heard sounds like the roaring of lions. When they investigated, it was found that the Taung people lived on the grassy hills and roared like lions to chase off their enemies ([3]Coetzee, pers. comm., 1989).

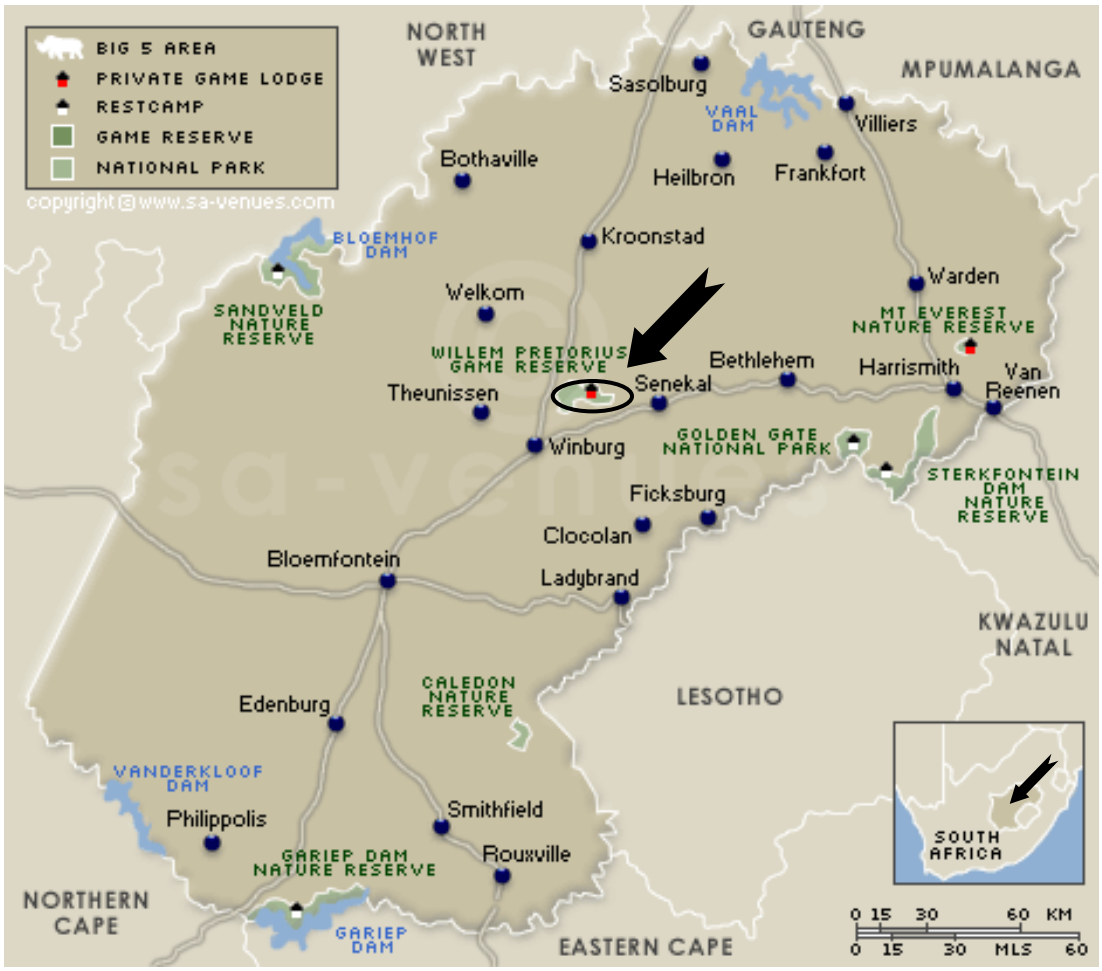

Figure 2.1: Location of the Willem Pretorius Game Reserve (WPGR).
(From: http://www.sa-venues.com/maps/freestate_reserves.htm. Accessed on 15 November 2008).

The WPGR has high plant diversity and hosts numerous indigenous and protected plants. The general physiognomic features are represented by grassy plains, kopjes and hillocks covered with shady bushes (Kok, 1975). The water surface of the Allemanskraal Dam makes the reserve an important tourist attraction for visitors and between 1988 and 1990 a resort was built on the reserve, close to the Allemanskraal Dam wall, to serve as a separate resort for black people. This initiative of the late state president, Mr. P.W. Botha, was sanctioned by Mr. F.W. De Klerk in 1990. Subsequently the director of the Department of Nature Conservation and Environmental

Affairs, Dr. G. Barkhuizen, decided to use the resort as a centre for environmental education ([3]Coetzee, pers. comm. 1989).

The area of the reserve in which this study took place stretches from Doringberg in the North towards the edge of Allemanskraal Dam in the South and from the West Gate towards the Witvlei in the East, an area of approximately 1103 ha (9% of the whole reserve) (Figure 2.2.). The area is ideal for viewing game, especially white rhinos as the habitat suits the white rhinos and they spend most of their time in this region, making observations much easier.

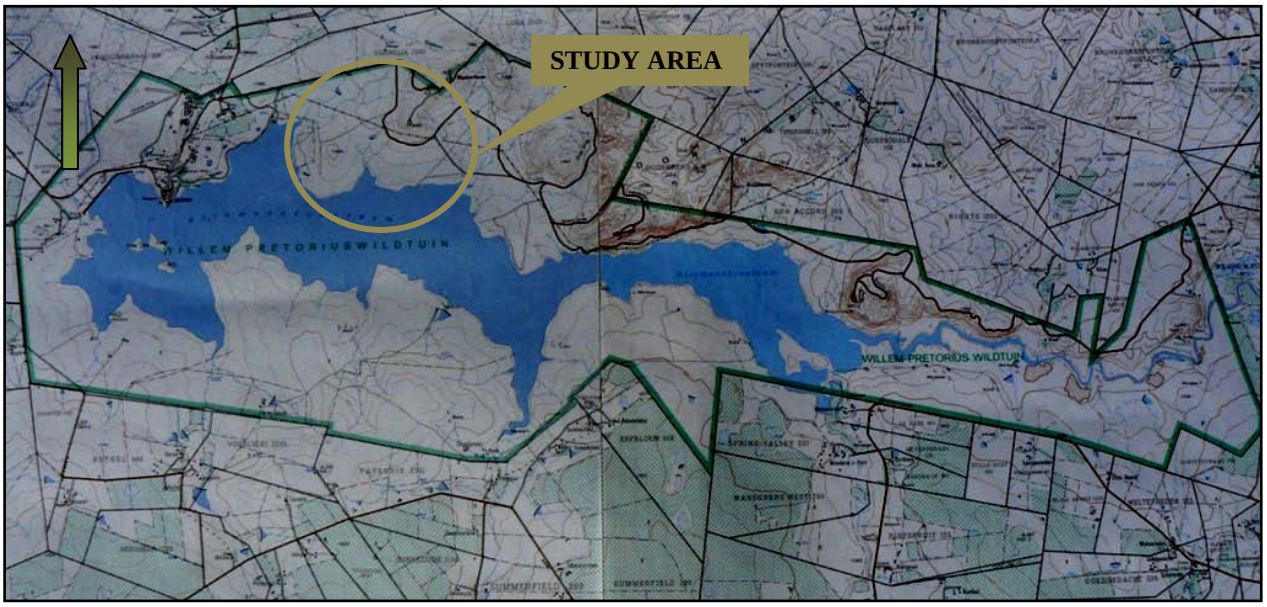

Figure 2.2: A 1:50 000 Topographical Map of Willem Pretorius Game Reserve (WPGR) and the location of the study area.

2.2. Topographic relief

The Allemanskraal Dam and Sand River divide the game reserve into two veld management areas, namely a northern and a southern part. The landscape slopes from north and south to the

[3] COETZEE, D.P. 1989. Former Chief Nature Conservator, WPGR.

valley encompassing the Sand River. This river flows through the reserve from east to west and adjoins the Vet River before it flows into the Vaal River. On the southern part, the gently sloping landscape contains sandstones and mud stones of the Beaufort series. The difference in height from the lowest to the highest point is approximately 60 meters (Muller, 1986). The northern part consists of a series of resistant dolerite intrusions and sandstone ridges that extend from east to west along the Sand River and Allemanskraal Dam, causing a rugged landscape which varies between 1 375 meters and 1 525 meters. The height difference results in steeper slopes of more than 40° (Muller, 1986).

2.3. Allemanskraal Dam

Construction on the Allemanskraal Dam occurred between 1955 and 1960. The catchment area of the Allemanskraal Dam is 3 626 km², and the dam wall is 213.36 meters long. The total shoreline comprises 64 km and the average evaporation rate comprises five millimetres per day. The dam forms part of the Sand-Vet Irrigation Scheme and thus provides water for the farmers downstream via a canal. The water surface of the dam has a bearing on the amount of space and grazing available for the animals in the reserve and should be managed accordingly (Kietzman, 1998).

2.4. Climate

2.4.1. Precipitation

The WPGR is situated in the summer rainfall area of South Africa. More than seventy percent of the annual precipitation is confined to the summer which occurs from October to March (Earle & Grobler, 1987). Rainfall figures have been recorded on the game reserve since 1976, and indicate an average of 578 mm per year (Figure 2.3a). Temperature ranges from below zero (0 ºC) during the winter months to above 30 ºC during the summer months (Figure 2.3b). Frost ranges from severe to light throughout the winter (Lynch, 1983). The climate diagram (Figure 2.3c) provides more detail on the climate of the study area.

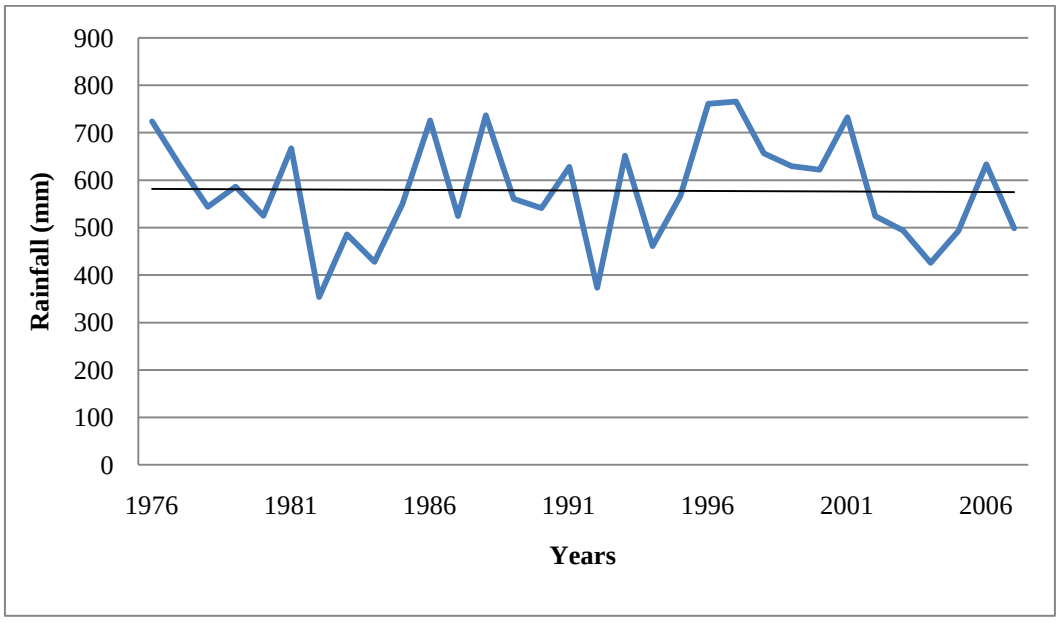

Figure 2.3a: The average annual rainfall at Willem Pretorius Game Reserve (WPGR) over 32 years (1976 – 2008).

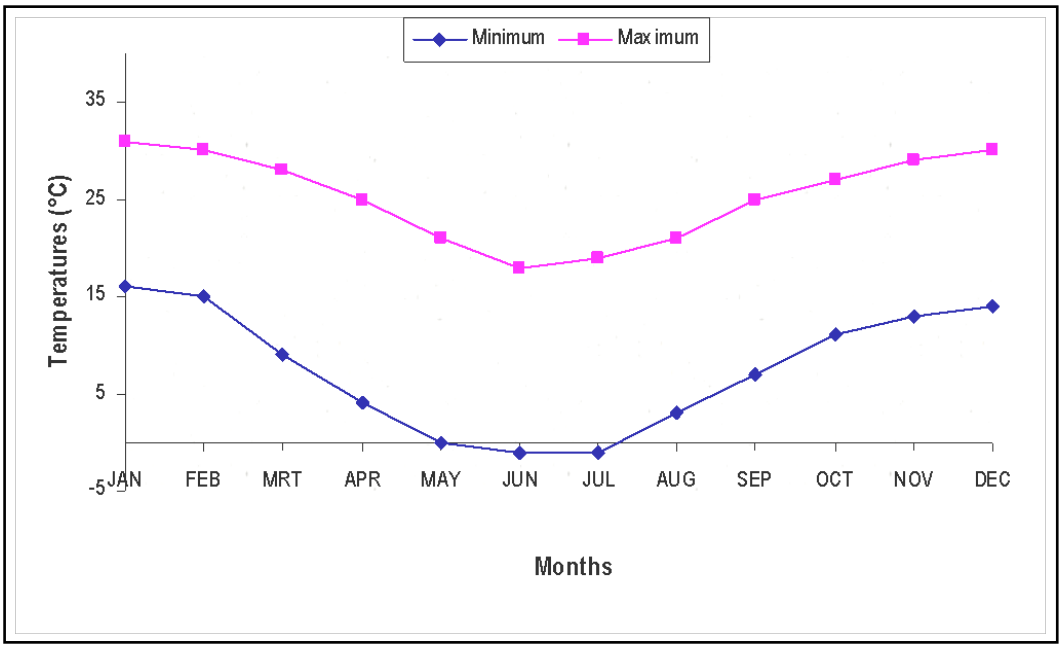

Figure 2.3b: Average monthly minimum and maximum temperatures on Willem Pretorius Game Reserve (WPGR) (Kietzman, 1998).

CLIMATE DIAGRAM OF THE WPGR

a.	b.	c.	d.	e.
W.P.G.R	1525m	32 years	16, 8°C	581, 4 mm
f.	**g.**	**h.**	**i.**	**j.**
17.8°C	-8,7°C	30,1°C	37,8°C	7 months

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a = Name of station

b = Maximum height

c = Rainfall period

d = Mean annual temperature

e = Mean annual rainfall

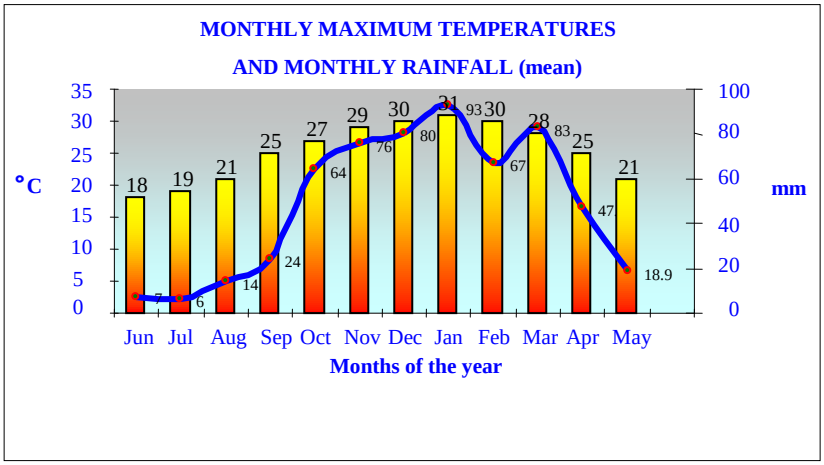
f = Mean daily minimum temperature of coldest month

g = Absolute minimum temperature

h = Mean daily maximum temperature of hottest month

i = Absolute maximum temperature

j = Frost-free months



JAS - ONDJFM - ONDJFM - MJJA

Dry period - Wet period - Months above 60 mm - Months below 0°C

Figure 2.3c: Climate diagram providing an overview of the climate on Willem Pretorius Game Reserve (WPGR) (Kietzman, 1998).

2.5. Winds

During the study period (August 2007 – July 2008), records (n = 116) were kept of wind directions, average wind speed, maximum wind speed and wind-chill (Figure. 2.4). Measurements were taken firstly from the Viewpoint on top of Doringberg West and secondly from any other place on the reserve where white rhinos were observed.

The average wind speed was a light breeze of between six and eleven kilometres per hour (or no 2 on the Beaufort scale). At the Viewpoint the average breeze measured 9.97 km/h, while 7.13 km/h was measured at a lower point approximately 100 metres downhill where rhinos were found.

A total of thirteen wind-still days were recorded. The maximum wind speed, which measured 100,3 km/h, was taken on 11 March 2008, indicating a violent storm (no 11 of 12 on the Beaufort scale).

Almost half (47 %) of the wind directions came from the north, blowing on an either north-western, northern or north-eastern course. It appears that the two strongest wind directions are north-easterly and south-westerly (Figure 2.4). These findings correspond with those of Muller (1986) who found that the dominant winds were those which possessed a northerly component.

Winds from the south-western sector are considered to be the strongest although they are not common. These strong south-westerly winds are normally of brief duration and tend to be associated with thunderstorms.

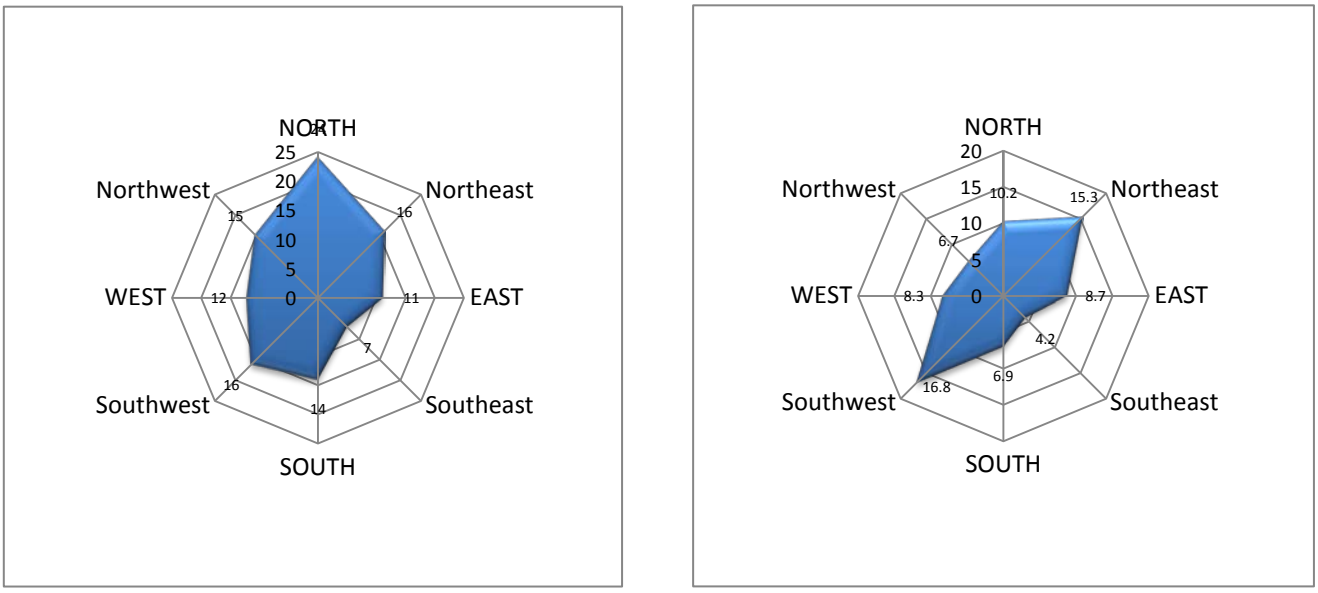


Figure 2.4: Wind directions and wind speeds on Willem Pretorius Game Reserve (WPGR) during the study period (August 2007 – July 2008). In the diagram on the left, the distribution of wind directions on the reserve is indicated with the prevailing wind being to the north, while in the diagram on the right, the average wind speed of each wind direction during the study period has been provided.

2.6. Wetlands

Wyatt (1993) defined seven different wetland types in South Africa:

1. Seepage Slope Wetland: the stream source spring and seepage slope in steeper younger valleys just below the watershed.
2. Basin Wetland: the typical pan, dam or open water of lakes.
3. Plains Wetland (un-channelled): occurs in all but the highest positions in the landscape.
4. Plains Wetland (channelled): which mostly assumes an ox-bow shape, likewise tends to occur on the highest positions in the landscape.
5. Stream Bank Wetland: comprises the channelled walls of river streams and dongas and flow is channelled within the site.
6. River Mouth Wetland: consists of the water body, floor and peripheral wetlands of estuaries and lagoons.

7. Marine Wetland: comprises the inter-tidal zone, the sub-tidal zone and coastal bays.

Five of these seven types of wetlands occur on the reserve. They have been assessed and identified (Figure 2.5) during the course of this study as: seepages (*n* = 71), basin (*n* = 28), plains channelled, (*n* = 19), plains un-channelled, (*n* = 25) and river wetlands (*n* = 6). The overall assessment is that they are in a good condition. Some dongas have already existed on the banks of the Sand River for several decades without further deterioration and are stable.

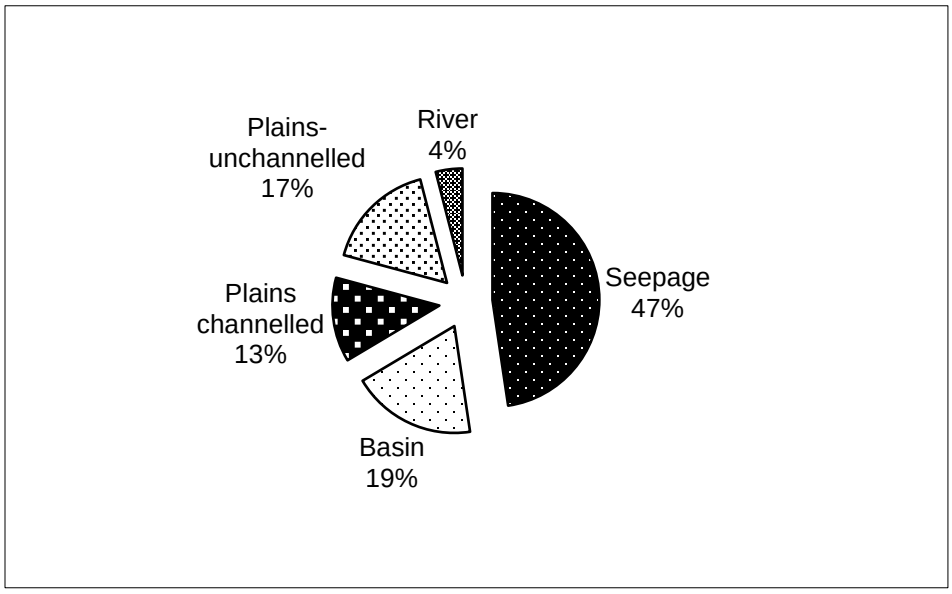


Figure 2.5: Different wetland types occurring on Willem Pretorius Game Reserve (WPGR).

2.7. Geology

The WPGR is situated in the Beaufort series of the Karroo Super group. Rocks of the Karroo Sequence underlie about half the total area of South Africa. Karroo rocks are sometimes the host rocks to the intrusive rocks and older rocks are less penetrated. These dolerites are regarded as the feeders of the Drakensberg lavas (Lurie, 1977).

The Karroo Rock succession is divided into the (1) Dwyka Series, (2) Ecca Series, (3) Beaufort Series and the (4) Stormberg Series. The Beaufort Series covers a large area of South Africa

with a thickness of 3 000 meters and is best known for its fossil reptiles (Mountain, 1968). The Karroo dolerite is an intrusive rock which is associated with Drakensberg lavas at the end of the Karroo period. Extensive dolerite sills form the ridges, plateaus and slopes of kopjes and cover alternating layers of mudstone and sandstone (Mucina & Rutherford, 2006).

2.8. Soil

Earle & Grobler (1987) describe the soils of central areas in the Free State as solonetzic soils with montmorillonitic (swelling) black and reddish clays which are poorly drained and generally unsupportive of trees. This explains the existence of seemingly endless grassy plains, broken only by riverine bush and by kopjes along the slopes of which the lithosol is well drained to support trees and shrubs.

Muller (1986) identified three different landtypes on WPGR. They are Ea, Dc and Ca. The Ea land-type (soils with one or more diagnostic horizons that are vertic, melanic or red structure) is found on the dolerite ridges or on higher lying areas. The Ca land-type (plinthic catena of high lying duplex or margalitic soils) is found mainly on the southern side of the reserve and is derived from the subterreanean sandstone. The Dc land-type (soils with prismacutanic or pedocutanic horizons that occur with vertic melanic or red structured horizons) occurs in the low lying areas on both sides of the reserve. Erosion occurs on the reserve in the Dc landtype with its prismacutanic soils underlying the topsoil which is well structured and makes it difficult for any root penetration and water movement. This soil type, which has a sealing effect, allows no water penetration (Kietzman, 1998).

2.9. Hydrology

The Sand River has its origin in the Wittenbergen, east of Paul Roux, and constitutes the main source of water for the Allemanskraal Dam and is assisted by the Sandspruit, De Beerspruit, Klipspruit, Rietspruit and Du Plooyspruit.

According to Kietzman (1998), the water quality of the Allemanskraal Dam has not shown any significant deviation since 1970. The pH varies between 6.3 and 9.5. No significant effluent

discharge upstream is experienced. Unfortunately, a great deal of effluent discharge occurs downstream in the Goldfields region ([4]Hardy, pers. comm., 2009).

2.10. Biota

Approximately three-quarters of the Free State is covered by grassveld (Lynch, 1983). Mucina & Rutherford (2006) classify most of the Free State as Dry Highveld Grassland and the area around the WPGR is categorized as Gh 7 Winburg Grassy Shrubland.

Typical taxa of the Gh 7 that occurs on the reserve are prominent grasses such as *Eragrostis curvula, Digitaria eriantha, Themeda triandra, Panicum coloratum, Cynodon dactylon, Aristida congesta* and *Cymbopogon pospischili*. Prominent small trees include, *Acacia karroo, Ziziphus mucronata, Grewia occidentalis, Olea europea africana, Celtis africana, Euclea crispa, Searsia pyroides, Searsia lancea* and *Lycium echinatum.* Herbs recorded include *Berkheya onopordifolia, Hermannia coccocarpa* and *Mohria caffrorum.* Geophytic herb *Oxalis corniculata* and succulent herb *Crassula lanceolata* also occur in this category. To date 427 plant species have been identified on the WPGR (Kietzman, 1998).

2.11. Alien Plants

The WPGR is situated within an agricultural zone with crop farming to the south and cattle farming to the north. These farming zones do not control alien and invasive plants intensively. This represents one of the reserve's on-going challenges. The main plant invaders occur mainly in the wetland and hilly areas and have their origin in the catchment's area (Kietzman, 1998). Some alien and invasive plants include: *Cirsium vulgare, Berkheya pinnatifiola, Bidens pilosa, Conyza bonariensis, Verbena officinalis, Verbena bonariensis, Tagetes minuta* and *Zinnia peruviana.* These species constantly invade the reserve, threatening its biodiverstiy, and thus form part of the main plant exterminating programme of the reserve. *Asparagus* species have invaded the reserve and represent a major problem for the foreseeable future.

[4] HARDY, J. 2009. Environmental Awareness Officer (DETEA). Welkom.

2.12. Fauna

The following nineteen game species occur on the reserve and have all been introduced from other reserves: buffalo (*Syncerus caffer)*, white rhinoceros (*Ceratotherium simum simum)*, Burchell's zebra (*Equus burchelli)*, black wildebeest (*Connochaetes gnou)*, blesbuck (*Damaliscus pygargus phillipsi)*, red hartebeest (*Alcelaphus buselaphus)*, sable antelope (*Hippotragus niger)*, eland (*Tragelaphus oryx)*, impala (*Aepyceros melampus melampus)*, giraffe (*Giraffa camelopardalis)*, kudu (*Tragelaphus strepsiceros)*, steenbuck (*Raphicerus campestris)*, mountain reedbuck (*Redunca fulvorufula)*, southern reedbuck (*Redunca arundinum)*, grey duiker (*Sylvicapra grimmia)*, bushbuck (*Tragelaphus scriptus)*, klipspringer (*Oreotragus oreotragus)*, warthog (*Phacochoerus aethiopicus)* and springbuck (*Antidorcas marsupialis)*. A total of 56 mammal species, 16 amphibian species, 10 fish species, 43 reptile species, 131 families of insects and 256 bird species have been identified on the WPGR (Kietzman, 1998).

2.13. Old Disturbances

The major source of old disturbances in the WPGR is related to past agricultural activities. These disturbances include old farm houses in the north and sheds at Vredespruit, Rietspruit, Gouda, and Stoompomp in the South. The old croplands which occur in the Driehoek on the southern side make driving in this area difficult. The latter area has not reached a climax stage, although the reserve has been under conservation for more than fifty years. The Allemanskraal Dam can also be regarded as an old disturbance due to the inconsistency of the water surface.

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CHAPTER 3

MATERIALS AND METHODS

3.1. Vegetation ecology

3.1.1. Vegetation types of the study area

One of the main objectives of this study is to identify, classify and describe the major plant communities within the study area.

Two 1:10 000 ortho photos were obtained to stratify the study area into physiographic-physiognomic vegetation units. Certain geological formations, such as steep slopes, dongas, wetlands and hills, together with areas of similar vegetation textures, were identified and delineated on the ortho photo. In order to ensure that all variations in the vegetation of the study area were sampled, a total of forty sample plots were placed on a randomly stratified basis within the various identified units. The number of sample plots per unit was based on a *pro rata* basis, depending on the size of the unit delineated on the ortho photo. More plots were placed in the larger units. A GPS (GARMIN *E*trex Legend) was used to note the co-ordinates of each plot. Plots have been marked on the 1:10 000 ortho photo. Bredenkamp (1982) found a suitable plot size, 200 m² (10 m x 20 m) for the Bushveld. The plot sizes in this study area comprise 400 m² (20 m x 20 m) to correspond with the size used by the Free State Department of Economic Development, Tourism and Environmental Affairs (DETEA) in their vegetation surveys (Kietzman, 1998).

The Braun-Blanquet Cover Abundance Scale (Mueller-Dombois & Ellenberg, 1974) was used to describe an ecological classification of the vegetation in the study area (Table 3.1). In each plot all trees, shrubs and herbaceous species were measured, according to their percentage cover. The soil texture, degree of erosion, geology and slope were also recorded. The sample plots of 400 m² were sampled between 18 February 2008 and 21 April 2008.

Table 3.1: Braun-Blanquet cover abundance scale used in this study (Mueller Dombois & Ellenberg 1974).

Scale	Description
R	One or few individuals with less than one percent cover of the total sample plot area.
+	Occasional and less than one percent cover of the total sample plot area.
1	Abundant, but with low cover; or less abundant but with a greater cover, but less than five percent of the total surface of the sample plot area.
2a **2b**	Abundant with cover of the total sample plot area, irrespective of the number of individuals. 5 - 12.5 % cover. 12.5 – 25 % cover.
3	25 – 50 % cover of the total sample plot area, irrespective of the number of individuals.
4	50 – 75 % cover of the total sample plot area, irrespective of the number of individuals.
5	75 % cover of the total sample plot area, irrespective of the number of individuals.

3.1.2. Ecological grazing capacity

The stocking rate as prescribed by department of Agriculture gives a broad guideline for domestic stock but this is not always effective for game (Bothma, 1986). Brown (1997) regarded the ecological grazing to be more suitable. The most practical model which incorporates most of these ecological factors is a model developed by Kruger (1983 a/b). Although the latter was developed mainly for grassveld it was modified for this study to include browsing and is based on a visual evaluation using certain applicable criteria.

The study area was divided into two separate grazing areas, namely grassveld and bushveld. The grassveld was divided into short, medium and long grass areas for grazing. For browsing the

bushveld was divided into dense bush, savanna and grassveld with scattered trees. Each of these areas was evaluated in order to establish the ecological carrying capacity. The different grass and bush areas were measured separately with a GPS. Evaluation sheets were used to evaluate the different grazing areas.

3.1.3. Data processing on vegetation

The floristic data were analyzed according to Braun-Blanquet procedures with the assistance of TURBOVEG (Hennekens, 1996a), which includes the two-way indicator species analysis (TWINSPAN) (Hill, 1979) multivariate classification technique for deriving an initial approximation of the main plant communities. The visual editor of MEGATAB (Hennekens, 1996b) was used to generate a phytosociological table. By means of the phytosociological table and the habitat information collected during sampling in the field, different plant communities were identified, described and ecologically interpreted. Plant communities were recognized by means of diagnostic species (as defined by Westhoff & Van der Maarel, 1978, as being those that are relatively restricted to a community). The different plant communities were described according to their dominant species.

The veld condition (V) was determined by the following formula given by Kruger (1983a) and the result was expressed in percentage value (%). Values were given for each of the five factors and the following symbols were used in the formula; (a) Coverage, (b) Botanical Composition, (c) Vitality, (d) Soil Condition, (e) Insect and Rodent damages. See evaluation sheets (Appendix B) that was used to determine the different values.

$$V = (a \times 0.3) + (b \times 0.3) + (a \times b \times 0.002) + (c \times 0.05) + (d \times 0.1) + (e \times 0.05)$$

In order to determine the grazing capacity (“W”) for the study area, the following formula, also by Kruger (1983b), was applied while the answer was expressed in ha/LSU:

$$W = \frac{657\,000}{V(3939 \ln(R) - 22450)}$$

Where: “V” is the current veld condition and “R” the rainfall for the study area.

3.2. Rhinoceros behaviour

3.2.1. Population structure

The Free State Department of Economic Development, Tourism and Environmental Affairs (DETEA) have a policy that stipulates all rhinos must be micro-chipped and ear notched for identification purposes ([5]Nel, pers. comm., 2007). Rhinos are physically marked on their ears with notches that indicate a number. The left ear notches are numbered 1, 3 and 5. The right ear notch is marked 10, 30 and 50. The numbers 1 (left) and 10 (right) are notched at the bottom of the ear. The numbers 5 (left) and 50 (right) are on the tip of the ear. Numbers 3 (left) and 30 (right) are indicated at the side of the ear. In practice this means that cow number 25 has one notch on the tip of its left ear (5) and two at the bottom (10, 10) of the right ear (Figure 3.1).

[5] NEL. P. 2007. State veterinarian. Department of Economic Development Tourism and Environmental Affairs. Bloemfontein.

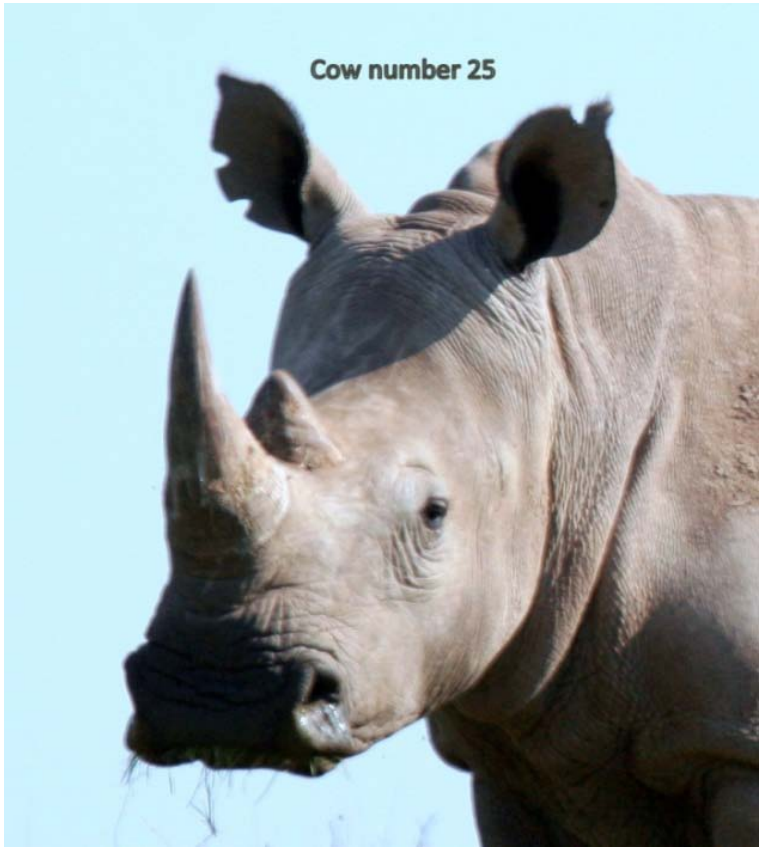

Figure 3.1: White rhinos in the study area have been ear-notched for easy identification. This adult cow was numbered 25. Note the ear notches (Photo: Courtesy, O. Van Nieuwholtz).

In a previous study (Jordaan, 1990), an age diagram (Figure 3.2) was used to determine the approximate ages of white rhinos using shoulder heights. Based on data collected from white rhinos (n = 93) on various Free State Nature Reserves, the same diagram was used together with other various characteristics such as horn length and sex to determine the age of individuals in this study (Table 3.2).

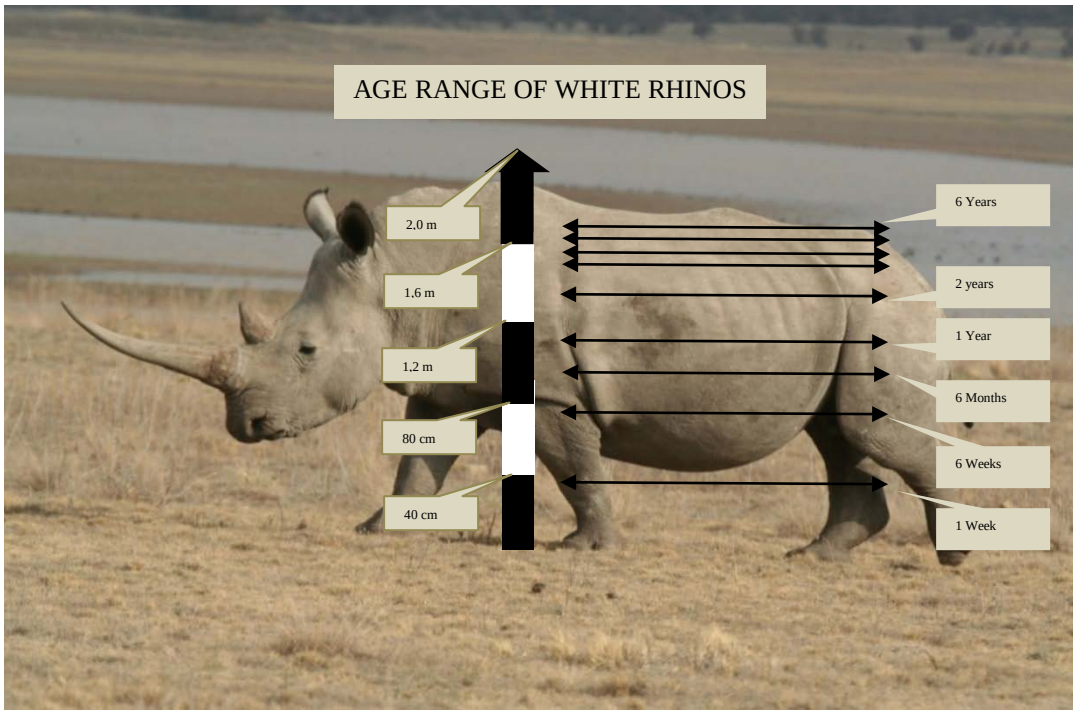

Figure 3.2: An estimate age diagram for white rhinos using shoulder heights (Photo: Courtesy, O.Van Nieuwholtz).

Table 3.2: Characteristics used to identify sex and age of the white rhinos at Willem Pretorius Game Reserve (WPGR) (Jordaan, 1990).

Sex & Age	Description
Adult bull	Bull older than 8 years. Front horn length > 62.5cm/25 inches. Shoulder height 1.6 m – 2,0 m.
Adult cow	Female older than 7 years. Front horn length > 62.5/25 inches. Shoulder height 1.6 m – 2,0 m.
Sub Adult cow	Female of 5 – 6 years old. Front horn 37.5 – 62.5 cm/15 – 25 inches. Shoulder height 1.4 m – 1.6 m.
Sub Adult bull	Male of 5 – 6 years old. Front horn 37.5 – 62.5 cm/15 – 25 inches. Shoulder height 1.4 m – 1.6 m.
Adolescent	Age of 3 – 4 years old. Front horn 15 – 37.5 cm/ 6 inches – 15 inches. Shoulder height 1.2 m – 1.4 m.
Calf	Suckling from mother and age 1 day – 2 years old. Front horn 0 – 15cm/ 0 – 6 inches. Shoulder height is 35 cm – 1.2 m.

For the purpose of this thesis, data (unless otherwise stated) were collected between July 2007 and June 2008. The rhinos were followed on a monthly basis for 96 hours at a time. In an attempt to observe their nocturnal behaviour, they were also observed at night.

The aim was to locate them at first light, with the aid of binoculars, at their sleeping site and to follow their movements during the day time. Their well-developed sense of smell and hearing complicated the process of following them on foot, and it was therefore decided to observe them from the "Viewpoint" or from another point from where they would not be disturbed. Previous experience (Jordaan, 1990) has shown that they run away for long distances when disturbed.

3.2.2. Total home range

In order to determine the total home range sizes of white rhinos in WPGR, the adult white rhinoceros bull (no.10) and one adult white rhinoceros cow (no.7) were selected. Both were chosen for their ability to travel extensively on the game reserve. The cow is well over 20 years old while the bull is 15 years old. Observations (n = 249) of the two individuals were collected over a period of 5 years (2004 – 2008) by myself and two rhinoceros guards who monitored the rhinos on a weekly basis.

3.2.2.1 Ranging patterns within the study area

The ranging patterns of nine (8 cows and 1 bull) rhinos within the study area were monitored during the period of this study. Between August and October 2007 (dry season) all the white rhinos moved from the western side (study area), of the game reserve to the eastern side and utilized a potential extra 1 000 ha (10km²) in search of food after a harsh winter with food being scarce during a severe drought. After high rainfall (149.5mm) in October 2007 they moved back to the study area during November 2007. Therefore, for this component of the study, GPS positions of the rhinos were recorded on a weekly basis from November 2007 to June 2008.

The GPS coordinates of the white rhinos were mapped on a 1:50 000 topographical map in order to calculate range patterns within the study area. These polygons were digitised as minimum areas and the areas calculated with the use of Arcview. Points were combined to estimate the seasonal ranging patterns within the study area.

3.2.3. Habitat utilization

According to Muller (1986) six habitat types occur on the reserve: River Community (252 ha), Thornveld (749 ha), Wetlands (649 ha), Grassveld (5 152 ha), Savanna (978 ha) and Trees & Shrubs (864 ha). All six of these habitat types occur within the study area and were used to determine the rhinos's habitat preferences. Observations were recorded on a daily basis during the field work.

For the purpose of this study, another area of approximately 1 854 ha (70 % of a potential maximum 2 648 ha water surface when the dam is full), nicknamed “Damkom”, was included as it was utilized by the white rhinos. The “Damkom” area is the part of the Allemanskraal Dam that is not covered by water but by grasses, sedges and forbs (see Keywords under Summary). During the study period the water surface of the Allemanskraal Dam covered approximately 30 % of the land surface and leaving 70 % of “Damkom” to be utilized by the white rhinos. The latter was regarded as grassland with mainly *Cynodon* spp. and forbs. Approximately 195 ha of plant community 1 (Damkom) was cover the study area.

3.2.4. Diet Selection

Whilst the rhinos were feeding, data on which plant species they were eating were collected. A specific bush, rock or open patch was marked closest to the specific area of one square metre where a single white rhinoceros was grazing. Once the individual or group left the area, these visually marked patches with associated one square metre areas were examined to identify the grass species utilized. If more than one grass species was utilized within the specific one square metre then the most abundant grass species was recorded as being grazed. For this study the bites per minute were also counted and used to compare with other studies.

3.2.5. Activity data

Data on activity patterns were collected by intermittant sampling at fifteen-minute intervals. Seven exclusive states were identified: *walking, sleeping, standing, standing alert, feeding, drinking* and *other* (Table 3.3). These scans were used to determine the relative allocation of time by rhinos to various activities.

Table 3.3: Activity data was collected on the white rhinos at fifteen-minute intervals, making use of seven main categories.

Activity	Definition
Walking	When a rhinoceros moved slowly from one point to another.
Sleeping	When an individual slept horizontally on its side or on its legs.
Standing	May be defined as static without moving at all, before engaging in another activity.
Standing Alert	When an animal stood facing in a specific direction with ears pointed towards a potential threat.
Feeding	Actively grazing on vegetation.
Drinking	Individual drinking water or a calf suckling from its mother.
Other	Included all social activities such as fighting, running, wallowing, etc.

3.2.6. Data analysis on behaviour

Data were recorded and analysed on Microsoft Excel spreadsheets. A normality test was done to test if data was normally distributed. The Shapiro-Wilk test was used to calculate the normality of the data and to determine whether there were any significant deviations from the normal distribution.

Differences in the size of area utilisation within the study area between the wet and dry season were analysed using the Wilcoxon signed rank test.

The activity budgets of the rhinos were calculated as follows:

$$\frac{\Sigma(records\_for\_activity\_i)}{\Sigma(records\_for\_activities)\ b} \times 100$$

Where statistical analysis was not appropriate, descriptive results were presented.

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CHAPTER 4

A VEGETATION DESCRIPTION OF THE STUDY AREA IN THE WPGR

4.1. Introduction

The Free State Province of South Africa contains a wide diversity of plant species with an estimated 3 000 plant taxa documented in the Herbarium of the National Museum at Bloemfontein (Zietsman, 2001).

The Willem Pretorius Game Reserve is located in the grassland biome of South Africa that covers most of the Free State, half of Gauteng, all of Lesotho, half of the Eastern Cape, North West, Mpumalanga and a substantial part of KwaZulu-Natal (Mucina & Rutherford, 2006). This centrally located grassland biome of South Africa occupies 349 174 km² and adjoins all other biomes except the desert, fynbos and succulent karroo biomes (O'Connor & Breedenkamp, 1997). Grasslands host high species diversity and levels of endemism (Nel, 2004). The Grassland Biome in the Free State Province has been irreversibly transformed with 60 % of it vanished through development, leaving only 3.4 % of the Province under formally conservation (DETEA, 2009). With such a small percentage conserved it is important that the different plant communities and their past and present conditions are studied before implementing grazing and management policies in an area.

The WPGR is the oldest proclaimed provincial nature reserve in the Free State Province and therefore its vegetation characteristics and veld conditions have been extensively studied by various ecologists. Their comments on the veld condition vary from "overgrazed areas", "heavily overgrazed", "very poor" to "under-utilization" and "moribund" (Muller, 1972; Bourquin, 1973; Vrahimis *et al.*, 1989; Kietzman, 1998; Avenant, 1999). Avenant (1999) also state: "The WPGR has for a long time been overgrazed". That is in contrast with Kietzman (1998) who described the vegetation status as "relatively good grazing conditions prevail in the reserve".

Climate and soil may control the structure and composition of vegetation while interferences such as fire and grazing/browsing could influence the dynamics of plant communities.

Plant communities represent eco-systems. Unless their different potentials are known, these cannot be managed successfully (Brown & Brand, 2004). Game species occupy and utilize diverse plant communities for different activities such as sleeping, feeding and reproduction. According to Brown (2003), plant communities of the home range of an animal must be studied as the basis of ecology, social interaction and dietary requirement. In this study white rhinos were monitored to establish their presence and utilization of the different plant communities within their home range.

The white rhinos occurred initially in the Zululand Thornveld and Lowveld types of Acocks (1988). According to Player and Feely (1968), the square-lipped rhinoceros (*Ceratotherium simum simum*) inhabits a wider range of bushveld types and their habitat determinants are water, cover and topography. White rhinos exhibit a definite preference for, and avoidance of, certain landscapes in the southern Kruger National Park (Pienaar *et al.*, 1992). An early report by Jordaan (1990) demonstrates that the white rhinos of WPGR spend 60 % of their time in tree and shrubveld communities on the hillsides and on the plains.

The main aim of this chapter was to describe and map the plant communities of the home range of certain white rhinos in the WPGR in order to determine their seasonal foraging ecology. Vegetation assessments are prerequisites to any ecological or habitat related research, forming a basis to any further studies. The following is a classification and description of the plant communities present within the home range of the study group of white rhinos in WPGR.

4.2. RESULTS

4.2.1. Classification

The largest part of the study area comprises savanna with related vegetation found predominantly at low altitudes, while the remainder consists of grassland vegetation. A small portion of the study area comprises of dense bush. The grasses *Themeda triandra, Digitaria*

eriantha, Sporobolus fimbriatus, Cymbopogon pospischili and *Enneapogon scoparius* are evenly distributed throughout the study area with *Triraphis andropogonoides* mainly on the hillsides and *Setaria verticilata* concentrated along the dam section underneath *Acacia karroo* trees. Certain herbs such as *Schkuhria pinnata, Conyza bonariensis* and *Bidens pilosa* were observed as invaders especially after some good rains following the drought, while *Verbena bonariensis* and *Verbena officinalis* invade the wetland areas. The sweet thorn tree *Acacia karroo* is spread throughout the study area as the most dominant tree specie.

Due to the heterogeneous topography in the study area, a great variation exists in the habitat which has resulted in the recognition of ten plant communities, which can be grouped into five major plant community types (Figure 4.1). See Appendix A for the complete list of plant species identified in the study area. All species groups are indicated in Table 4.1. The following plant communities were identified:

1. *Cynodon hirsutus* dam edge Grassland
2. *Themeda triandra-Setaria incrassata* moist Grassland

2.1 *Panicum coloratum-Eragrostis obtusa* moist Grassland

2.2 *Sporobolus-fimbriatus-Verbena bonariensis* vlei Grassland

3. *Cymbopogon excavatus* Grassland
4. *Eragrostis curvula-Acacia karroo* Woodland

4.1 *Acacia karroo-Setaria verticillata* dense Woodland

4.2 *Acacia karroo-Cynodon dactylon* savanna Woodland

4.3 *Acacia karroo-Enneapogon scoparius* rocky hill Woodland

4.4 *Acacia karroo-Grewia occidentalis* midslope Woodland

5. *Triraphis andropogonoides-Aristida diffusa* plateau Grassland

5.1 *Aristida diffusa-Cymbopogon pospischili* plateau Grassland

5.2 *Aristida diffusa-Hyparrhenia hirta* plateau Grassland

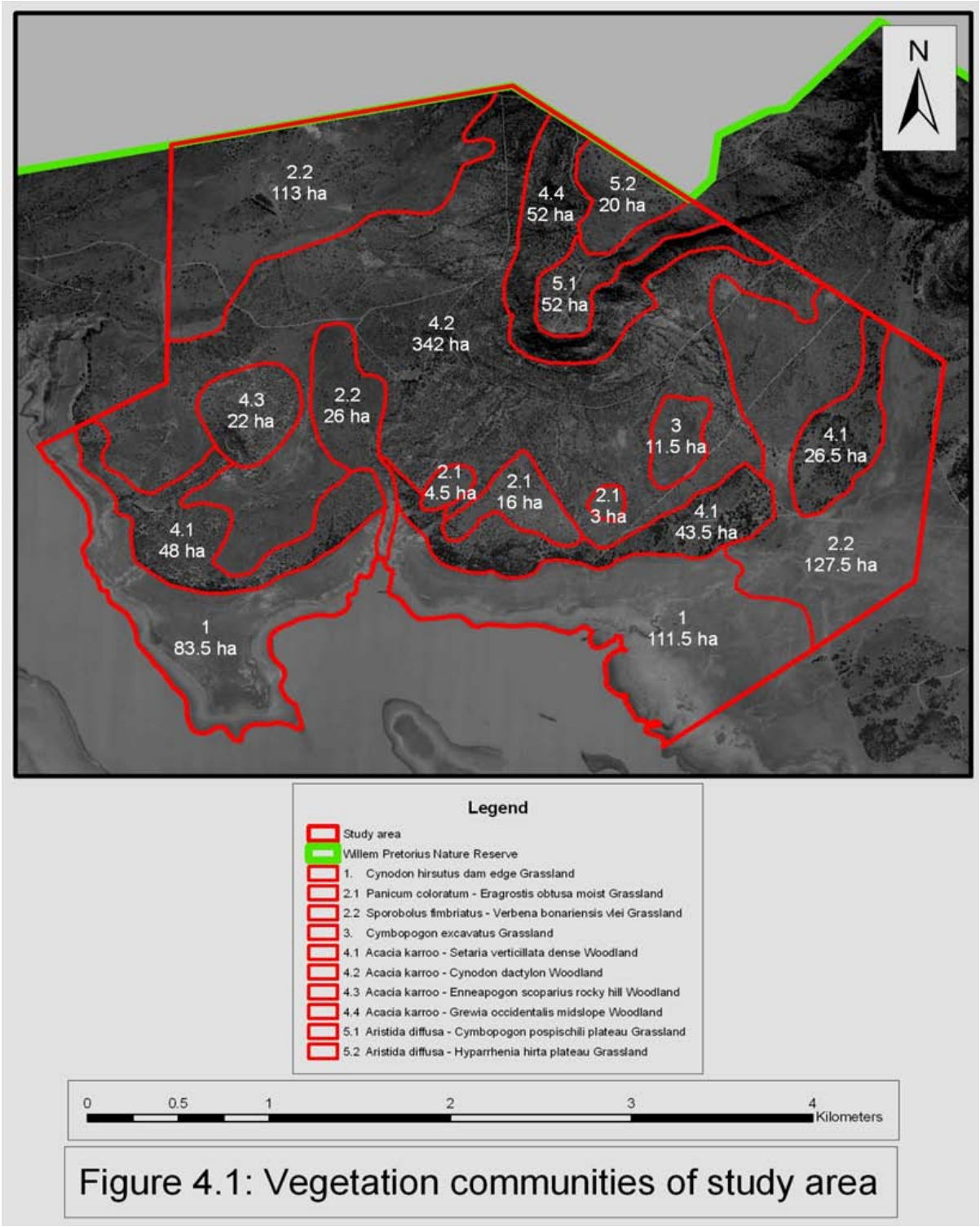

Figure 4.1: The different plant communities of the study area as well as the surface area of each plant community.

4.2.2. Description of the plant communities

1. *Cynodon hirsutus* dam edge Grassland

This community (195 ha) occurs on the lowest lying areas of the study area along the edge of the Allemanskraal Dam. The total area is under water when the Allemanskraal Dam is at full capacity. The area is flat and the altitude varies from 1 365 – 1 370 m above sea level with a slope < 2°. The dam was last full in 1997 and during the study period the water volume decreased to 25 % of its potential maximum. The soil is clayey and no surface rocks occur in this area. Shrub cover is less than 2 % with the grass cover 90 % and the forbs cover 3 %.

The *Cynodon hirsutus* dam edge Grassland community is characterized by the presence of species from Species group A. These are the grasses *Cynodon hirsutus, Aristida bipartita* and the forb *Delosperma cooperi*.

The vegetation is dominated by the grass *Cynodon hirsutus* (species group A). The grasses *Aristida bipartita* (species group A), *Eragrostis curvula* (species group R), *Aristida adscensionis* (species group N), and the forbs *Schkuhria pinnata* and *Conyza bonariensis* (species group R) are also present and sometimes locally prominent.

This community was utilized by the white rhinos during afternoons (Figure 4.2). Other grass species present are *Aristida congesta* (species group K). Woodland species such as *Acacia karroo* (species group F) is also present as invaders with low heights of < 50 cm.

This community has a species richness of 11 spp. per 400 m².

Figure 4.2: White rhinos searching for green patches of *Cynodon hirsutus* at the edge of the Allemanskraal Dam.

2. *Setaria incrassata-Themeda triandra* Grassland

This community occurs throughout the study area on gentle slopes and lower-lying areas all associated with drainage lines and seasonal moist conditions. Altitude ranges between 1 371 and 1 411 metres above sea level. The soil is clayey and no rocks occur in this area. Trees and shrub cover is less than 1 % with a grass cover of 95 % and the forbs cover 3 %.

This community is characterized by the presence of species from species group B. These are the grass *Setaria incrassata* and the forb *Berkheya pinnatifrola.*

The vegetation is dominated by the grasses *Themeda triandra* (species group L) and *Setaria incrassata* (species group B). The grasses *Eragrostis curvula* and *Digitaria eriantha* (species group R) are prominent throughout this community. Other species present within this community include the grasses *Cymbopogon pospischili* (species group R), *Panicum coloratum* (species group L), and the forb *Schkuhria pinnata* (species group R).

This community has a species richness of 19spp./400 m² and can be divided into two sub-communities:

2.1. *Themeda triandra-Cymbopogon pospischili* Grassland

The *Cymbopogon pospischili-Themeda triandra* Grassland (Figure 4.3) lies between 1 370 – 1 375 m above sea level and occur on flat areas with gentle slopes (2 – 3°) with a south-eastern aspect. This community comprises 23.5 ha and occurs as open patches within *Acacia* savanna. This grassveld community is of a climax stand and is based on clay soil and no surface rocks are present. The shrub layer covers < 1 %, the grass layer 97 % while the forbs layer cover approximately
2 %.

This sub-community is characterized by the presence of the grass *Eragrostis obtusa* and the forb *Crabbea hirsuta* (species group C). The vegetation is dominated by various climax grasses namely *Setaria incrassata* (species group B), *Themeda triandra* (species group L), *Cymbopogon pospischili* and *Digitaria eriantha* (species group R). Other species prominent include *Panicum coloratum* (species group L), *Eragrostis curvula*, *Sporobolus fimbriatus* and *Cymbopogon pospischili* (species group R).

Other species present include the forb *Monsonia angustifolia*, *Penzia viridus* (species group N), *Berkheyea pinnatifrola* (species group B) and *Crabbea hirsuta* (species group C).

Figure 4.3: The *Cymbopogon pospischili-Themeda triandra* Grassland lies also isolated in savanna vegetation in the southern section of the study area.

2.2. *Themeda triandra-Sporobolus fimbriatus* Grassland

This sub-community (266.5 ha) occurs in the lower grassland areas to the west and east of the Viewpoint areas (Figure 4.4). The altitude is 1 371 – 1 411 m above sea level, with a 2 – 4° south-western slope. The soil is clay with no rocks. The tree and shrub layer is less than 1 %, the grass cover is 97 % and the forbs cover 2 %.

This community is characterized by the presence of species from species group D and include the grasses *Eragrostis rotifer, Eragrostis plana* and the forbs *Verbena bonariensis, Galium capense, Anthephora pubescens, Conyza podocephala* and the exotic invader *Oenothera rosea.*

The vegetation is dominated by the grass *Sporobolus fimbriatus* (species group R) which characteristically grows in moist places. The grasses *Setaria incrassata* (species group B), *Themeda triandra* (species group L) and *Anthephora pubescens* (species group D) are prominent while the grass *Eragrostis curvula* and the forb *Verbena bonariensis* (species group D) are present throughout this community.

The moist clayey conditions are also emphasised by the local prominence of the grasses *Eragrostis rotifer* and *Eragrostis plana* (species group D).

The tree *Acacia karroo* (species group F) occurs mostly in smaller patches as seedlings throughout this sub-community and it slowly encroaching into these areas with a density of 42 woody individuals per hectare. Most of the mud-pools utilized by white rhinos were in this community.

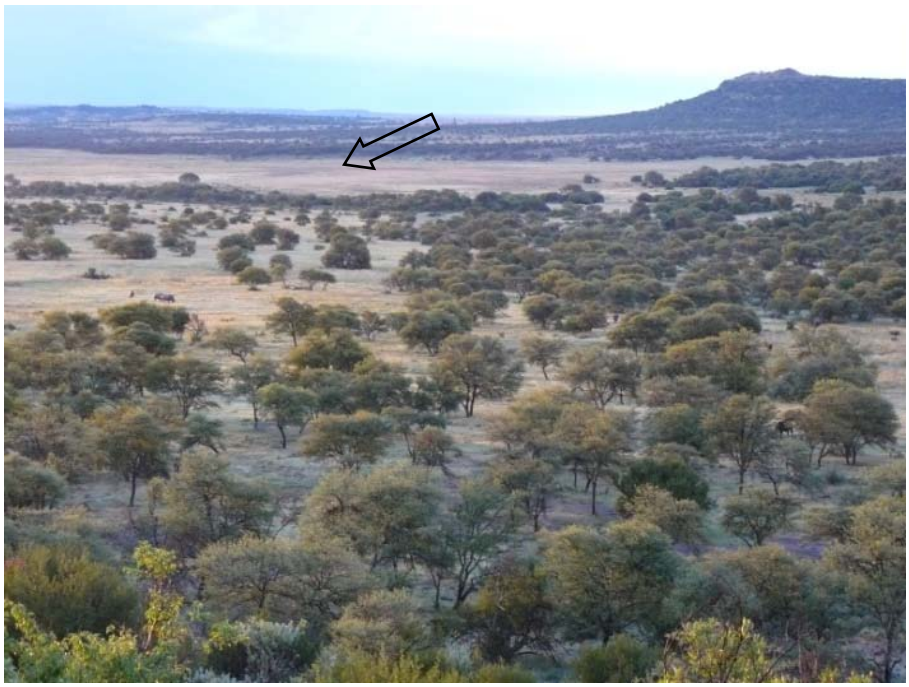

Figure 4.4: A section of *Sporobolus fimbriatus-Themeda triandra* Grassland on the eastern
` section of the study area.

3. *Cymbopogon excavatus* Grassland

This plant community (Figure 4.5) is the smallest community (11.5 ha) and be isolated in the *Cynodon dactylon-Acacia karroo* savanna Woodland (4.2). Altitude ranges between heights 1 376 and 1 377 m above sea level with a slope of 1 - 2°. The soil is clayish with no stones or rocks. The shrub layer is 3 %, the grass cover 85 % and the forbs cover 5 % of the area.

This community is characterized by the presence of species from group E and include the grasses *Cymbopogon excavatus*, *Aristida stipitata* and the forbs *Verbena brasiliensis*, *Walafrida teniufolia*, *Berkheya* species, *Plectranthus* species, *Evolvulus alsinoides*, *Geigeria burkei*, *Hermania species* and *Justicia anagalloides.*

The vegetation is dominated by the grasses *Cymbopogon excavatus* (species group E) and *Themeda triandra* (species group L). Other species present include the forbs *Penzia viridus* and *Monsonia angustifolia* (species group N).

This community has a species richness of 24spp./400 m².

Figure 4.5: The isolated *Cymbopogon-excavatus* grassland in *Cynodon dactylon-Acacia karroo* savanna woodland in the south-eastern section of the study area.

4. *Eragrostis curvula-Acacia karroo* Woodland

This community is located throughout the study area on gentle and steep slopes, lower-lying and high-lying areas all associated with drainage lines and seasonal moist conditions (Figure 4.6). Altitude ranges between 1 371 and 1 486 metres above sea level. The soil is clayey and 5 % surface rocks occur in this area. Trees and shrubs cover is more than 70 %, grass cover 45 % and the forbs cover is 5 %.

This community is characterized by the presence of species from species group F. These are the tree *Acacia karroo,* the shrub *Diospyros lycioides* and the grass *Cynodon dactylon.*

The vegetation is totally dominated by the tree *Acacia karroo* (species group F) while the grasses *Sporobolus fimbriatus, Eragrostis curvula* and the forbs *Conyza bonariensis, Tagetes minuta* and *Bidens pilosa* (species group R) are present throughout the community

This community has a species richness of 30 species per 400 m² and is divided into four sub-communities:

Figure 4.6: An overview of typical *Acacia* savanna Woodland on the northern section of the game reserve which served as the core ranging area of white rhinos during the study period.

4.1. *Acacia karroo-Setaria verticillata* dense Woodland

This community (118 ha) occurs on the second lowest lying areas of the study area (Figure 4.7). Topography is flat, with little variation in altitude (1 375 to 1 376). It occurs parallel to plant community 1 (*Cynodon hirsutus* dam edge Grassland), along the dam edge of the Allemanskraal Dam.

The soil is clayey and no surface rocks occur in this area. The tree layer has 95 – 100 % canopy coverage while the shrub layer has 70 % coverage under the tree layer. The woody density is 1 300 individuals per hectare. The grass layer has a cover of 50 % and the forbs cover more than 25 % of the area.

Species characteristic for this community are the grass *Setaria verticillata* and the forb *Verbena bonariensis* (species group G). While the woody layer is dominated by the tree *Acacia karroo* (species group F), the field layer is dominated by the grass *Setaria verticillata* (species group G). The shrub *Diospyros lycioides* (species group F), dwarf shrub *Asparagus laricinus* (species group L) and the forbs *Verbena officinalis* (species group G) and *Bidens pilosa* (species group R) are prominent throughout this sub-community.

This community is dominated by pioneer plants (*Setaria verticillata, Bidens pilosa* and *Tagetes minuta*) under the canopy of the *Acacia karroo* trees. The forb *Bidens pilosa* was grazed by cape eland (*Tragelaphus oryx oryx).* Tracks of various antelope were also observed on the ground at the time when white rhinos utilized this community.

Figure 4.7: The dense *Setaria verticillata-Acacia karroo* Woodland occuring next to the Allemanskraal Dam at the time of full capacity.

4.2. *Acacia karroo- Cynodon dactylon* savanna Woodland

This community is the largest of all the communities (342 ha) and lies around the foothills of the Doringberg Mountain in the study area. It is also known as the savanna area. Altitude varies between 1 391 – 1 423 m and the aspect varies greatly. The slope ranges between 2 – 15°. Soil texture is clay-loamy to gravel. Small to medium rocks covers between 30 and 80 % of the clayey soil surface. The tree layer has a 40 – 70 % and the shrub layer 5 – 40 % coverage compared to the 70 % coverage of the grass and 20 % forbs layers respectively.

The presence of the grass *Tragus berteronianus* and the forbs *Hibiscus trionum* and *Achyranthes aspera* (Species group H) is characteristic. The vegetation is dominated by the tree *Acacia karroo* and the grass *Cynodon dactylon* (species group F) while the grass *Panicum coloratum* (species group L) is dominant locally.

Various species such as the grass *Eragrostis curvula* (species group R), *Fingerhuthia africana* (species group I), and the pioneer forbs *Chenopodium album, Tribulus terrestris* (species group

K), *Schkuhria pinnata*, *Conyza bonariensis* and *Tagetes minuta* (species group R) are prominent throughout this community.

Tracks of cape eland (*Tragelaphus oryx oryx)* and droppings of common grey duiker (*Sylvicapra grimmia grimmia)* were observed in this community. White rhinos spend most of their time in this community for feeding especially on *Cynodon dactylon* and sleeping under specific trees (Figure 4.8).

Figure 4.8: White rhinos feeding on short grass patches in *Cynodon dactylon-Acacia karroo* Woodland plant community of the study area (Photo: Courtesy; O. Van Nieuwholtz).

4.3. *Acacia karroo-Enneapogon scoparius* rocky hill Woodland

The *Enneapogon scoparius-Acacia karroo* rocky hill Woodland is located in the west of the study area (Figure 4.9). It comprises a rocky hill of 22 ha in size. Altitude varies between 1 391 – 1 417 m. The slope ranges between 5 – 30°. Soil texture is clayey to loamy to gravelly. Small to medium rocks are present and cover between 40 to 80 % of the soil surface. The tree layer has a 50 – 70 % and the shrub layer 10 – 30 % coverage compared to the 65 – 80 % and 5 – 15 % coverage of the grass and forbs layers respectively.

This sub-community is characterized by the presence of the grasses *Fingerhuthia africana, Andropogon shirensis* and the forbs *Lycium cinereum, Dianthus basuticus* and *Solanum* species (species group I). The vegetation is dominated by the *Acacia karroo* trees (species group F) and the grasses *Enneapogon scoparius* (species group K) and *Panicum coloratum* (species group L). Various other species are present throughout this sub-community (and in some cases prominent) and include the woody *Searsia undulata* (species group M), the grasses *Fingerhuthia africana* (species group I), *Eragrostis curvula, Cymbopogon pospischili* and the forb *Conyza bonariensis* (species group R).

Figure 4.9: A view on the *Enneapogon scoparius-Acacia-karroo* rocky hill Woodland to the south-west of the study area.

4.4. *Acacia karroo-Grewia occidentalis* mid-slope Woodland

The *Grewia occidentalis-Acacia karroo* mid-slope Woodland (52 ha) is situated central to north in the study area (Figure 4.10).

This sub-community occurs along steep slopes (45 – 65°) on the mid-slopes of the Doringberg Mountain and is situated in the second highest lying areas of the study area. Altitude varies between 1 445 – 1 486 m above sea level and the shallow soils are mostly covered with boulders, covering up to 80 % of the area. The vegetation consists mainly of trees taller than 2 metres that cover between 55 – 95 % of the area. This community have the highest woody density of 2450 individuals per hectare. The shrub layer has a 45 – 70 % cover while the grass layer is not well developed and covers only 5 – 15 % and the forbs cover approximately 5 % of this community.

Species from species group J are characteristic for this sub-community and include the trees and shrubs *Gymnosporia buxifolia, Ehretia rigida, Grewia occidentalis, Euclea crispa, Searsia leptodictya, Searsia burchelli, Celtis africana, Searsia lancea*, the grasses, *Eragrostis superba, Panicum maximum* and the forb *Zinnia peruviana*.

The vegetation is dominated by the trees *Grewia occidentalis* (species group J), *Acacia karroo* (species group F) and the grass *Panicum maximum* (species group J). The pioneer forb *Bidens pilosa* (species group R) is prominent throughout this community. The woody layer comprises a mixture of species with the trees *Gymnosporia buxifolia, Ehretia rigida* (species group J), Searsia *undulata* and *Ziziphus mucronata* (species group M) all locally dominant. Prominent grasses include *Enneapogon scoparius* (species group K), *Panicum coloratum* (species group L) and *Eragrostis curvula* (species group R). Other forbs species present include *Zinnia peruviana* (species group J) and *Schkuhria pinnata* (species group R).

The white rhinoceros cows found shelter in these communities when calving. They also utilize the *Panicum maximum* during cold winter months by moving deep into the thickets to graze on this grass species under the trees and shrubs. There were also observations on cape eland (*Tragelaphus oryx oryx)* feeding on *Bidens pilosa* in this sub-community.

The absence of seedlings of the woody component in the western part of this plant community is of great concern and may be to the result of soil erosion due to overgrazing more than sixty years ago.

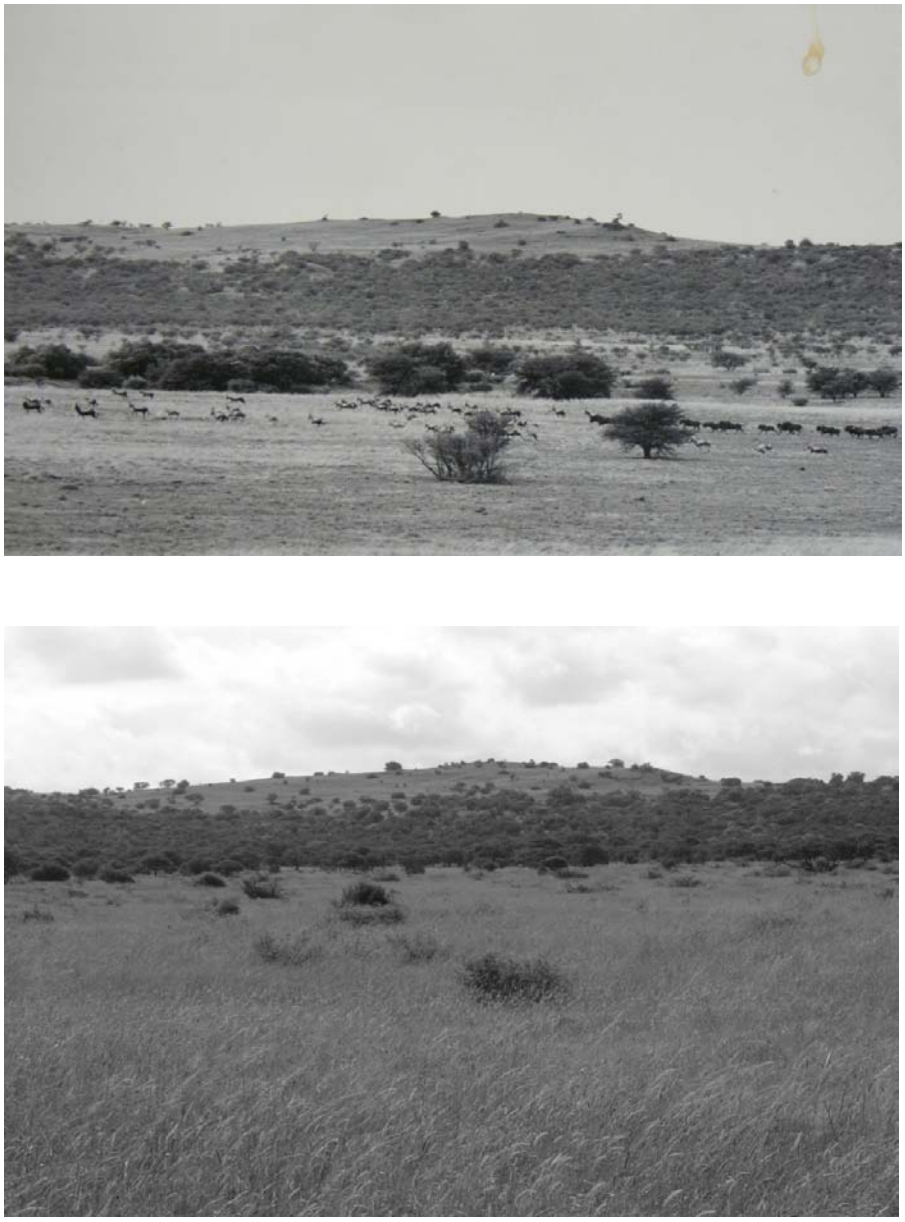

Figure 4.10: The *Grewia occidentalis-Acacia karroo* midslope Woodland prominent against the western slope of Doringberg West. The top black-and-white photo was taken in the early 1970's and the bottom photo in 2010. Large numbers of plains game utilize community 2.2 (wetland) on the black-and-white photo while almost no game utilize the same community in 2010.

5. *Triraphis andropogonoides-Aristida diffusa* plateau Grassland

This community comprises 72 ha and lies mostly on top of the Doringberg Mountain to the north of the study area. The altitude varies between 1 475 – 1 505 metres above sea level. The mountain slopes ranging moderately from 15 – 45° mainly to the east and west on top of the mountain. The soil is shallow and consists mainly of gravel with patches of clay. Rock cover is 15 – 90 % with loose lying stones. Loose stones from early settlements are the outcome of wars by the Matebeles on the Taung people who basically demolished the settlements (White *et al.*, 1975). Trees and shrubs cover 35 %, grasses cover 75 % and forbs cover 25 % of the total area.

This community is characterized by the presence of species from species group O and include the grass *Aristida diffusa,* the forbs *Cheilanthes eckloniana, Arctotis venusta* and *Blepharis squarrosa.*

The vegetation is dominated by a mixture of species including the grasses *Triraphis andropogonoides* (species group M), *Aristida diffusa* (species group O), *Digitaria eriantha, Cymbopogon pospischili* (species group R), and the forbs *Cheilanthes eckloniana* and *Blepharis squarrosa* (species group O).

This community have the highest species richness of 35 species per 400 m² and is divided into two sub-communities:

5.1. *Aristida diffusa-Cymbopogon pospischili* plateau Grassland

This sub-community is 52 ha in size and located next to the viewpoint on an altitude which varies between 1 480 – 1 494 m above sea level (Figure 4.11). Soil is gravelly and rockiness range from 30 – 50 %. The tree and shrub layer is 10 - 45 % while the grass cover is 60 % and the forbs cover approximately 5 - 40 %.

This sub-community is characterized by the presence of the forbs *Bulbostylis burchellii, Teucrium trifidum, Sutera palustris* and *Ursinia nana* (species group P). The vegetation is dominated by the grasses *Triraphis andropogonoides* (species group M), *Digitaria eriantha,*

Cymbopogon pospischili (species group R), and the forb *Bulbostylis burchellii* (species group P). Other species locally prominent include the trees *Celtis africana, Searsia lancea* (species group J), the grasses *Aristida diffusa* (species group O), *Eragrostis curvula*, (species group R) with forbs *Cheilanthus eckloniana* (species group O) and *Sutera palustris* (species group P).

White rhinos seldom visited this sub-community. They only travel through this community to move away from cold eastern winds to the western section of Doringberg for shelter.

Figure 4.11: A typical *Cymbopogon pospischili-Aristida diffusa* plateau Grassland on top of Doringberg West next to the Viewpoint.

5.2. *Aristida diffusa-Hyparrhenia hirta* plateau Grassland

This *Hyparrhenia hirta-Aristida diffusa* plateau grassland lies between 1 487 – 1 500 m above sea level and occur on slopes (10 – 45°) with a northern aspect (Figure 4.12). The mild to steep slopes (15 – 40°) are northerly faced. The soil is gravelly and rockiness varies from 10 – 70 %. The tree and shrub layer has 15 – 20 % coverage while the grass has 40 – 60 % and the forbs layers 30 – 40 % cover.

Species from species group Q are characteristic and include the grasses *Hyparrhenia hirta*, *Chloris virgata*, and the forbs *Helichrysum* species, *Hermannia tranvaalensis* and *Cleome rubella.* There is no dominant species and vegetation comprises various locally dominant species such as the grasses *Triraphis andropogonoides* (species group M), *Digitaria eriantha, Eragrostis curvula, Sporobolus fimbriatus, Cymbopogon pospischili* (species group R) and the forbs *Helichrysum* species, *Cleome rubella* (species group Q), *Schkuhria pinnata* and *Bidens pilosa* (species group R).

White rhinos were never recorded within this sub-community.

Figure 4.12: The *Hyparrhenia hirta-Aristida diffusa* plateau Grassland with its typical low shrubs of ≤ 2.5 m.

4.3. Discussion

A total of 215 plant species (Appendix A) were identified in the study area, representing 134 genera and 51 families. Of the 51 plant families, three families of pteridophytes, nine families of monocotyledoneaes and 39 families of dicotyledons were recorded in the Viewpoint area of the WPGR. Poaceae (25 % of the total flora) with 53 species and Asteraceae (17 %) were the first and second most dominant families. This is in accordance with the most important families found in the Vredefort Dome (Reimhold & Gibson, 2005) who listed the major families (with numbers of taxa for the latter in brackets) as: Asteraceae (42), Poaceae (24), Cyperaceae (22), Convolvulaceae (10), Euphorbiaceae (8), Rubiaceae (8), Scrophulariaceae (8), Solanaceae (8), Malvaceae (7) and Acanthaceae (6). The ratio of 3:1 dicotyledons to monocotyledons species observed compares well with the Cape Floristic region with also a 3:1 ratio (Goldblatt & Manning, 2000).

A total of 21 exotic plant species (mostly invaders) occurred in the study area and cause problems in unutilized vegetation and needs to be managed. The average species richness of the five main plant communities was 24 species per 400 m² (range; 11 – 35; n = 40). The *Cynodon hirsutus* dam edge Grassland (community 1) had the lowest species richness of 11 species per 400 m². The homogeneous nature of this community with its pioneer species can most probably be ascribed to the unpredictable water mark of the Allemanskraal Dam. The highest species richness was from the *Triraphis andropogonoides-Aristida diffusa* plateau Grassland (community 5) with a species richness of 35 species per 400 m².

The study area was measured as 1 103 ha and it was classified into the mentioned five major plant communities. Mostert (1958) described a valley *Acacia* Bush Community which is related to the *Acacia karroo-Cynodon dactylon* savanna Woodland (community 4.2). The vegetation also corresponds with the *Themeda triandra–Acacia karroo* microphyllous woodland as described by Breedenkamp & Brown (2003). *Acacia karroo*-dominated woodland is a temperate microphyllous bushveld that occurs widespread throughout the grassland biome. According to Mucina & Rutherford (2006) the vegetation of the study area is classified as Winburg Grassy Shrubland (Gh 7) and as Central Free State Grassland (Gh 6). This vegetation type occurs over a

wide range of geology, land types, soils and terrain types with low rock cover, but is mostly associated with moderately deep and often clayey, high nutrient, alluvial soils derived from andesite shale, karroo sediments or dolomite. The areas in which it occurs are in many cases overgrazed, due to the presence of palatable grass species. Overgrazed or poorly managed sites in the grassland are often invaded by *Acacia karroo* and associated species, resulting in bush encroachment and degradation of the herbaceous layer (Breedenkamp & Bezuidenhout, 1990).

The *Eragrostis curvula-Acacia karroo* Woodland ranges between open to quite dense and is characterized by the presence of the diagnostic trees *Acacia karroo* and *Ziziphus mucronata* which dominating the woody layer. The diagnostic multi-stemmed shrubs *Asparagus suaveolens* and *Asparagus laricinus* and the forb *Teucrium trifidum* are almost always associated with this vegetation type (Breedenkamp & Brown, 2003). For the *Eragrostis curvula-Acacia karroo* Woodland (community 4) the tree *Acacia karroo* and the shrub *Asparagus laricinus* are also present throughout the community while the tree *Ziziphus mucronata* is also present throughout this community except in sub-community 4.1. It seems as though the woody *Acacia karroo* is encroaching into most of the grassland areas with various seedlings and shrubs scattered in clumps throughout these areas. This is of great concern and will need to be addressed by management.

The most important food items utilized by the white rhinos were the grasses *Cynodon dactylon, Aristida congesta* and *Enneapogon scoparius*. Thus taking these into account, communities 1, 2, 3 and 4, are expected to be the most preferred communities by the white rhinos and to a lesser extent community 5.

4.4. Conclusion

By using the Braun-Blanquet procedures a total of ten distinguishable plant communities were identified, described and mapped within the Viewpoint section of the game reserve.

Most of the plant communities (except community 5.2) identified and described in this study are all situated within the home range of the white rhinos and therefore provides detailed data on the different plant species as well as habitats that exist within their home range.

Of the various plant communities described, only the *Acacia karroo* Woodland community shows affinity to an association of plants in the Vredefort Dome (Snyman, 2007) and to the Bloemfontein-Brandfort district (Mostert, 1958). The southern slopes of Doringberg provide more resistance against cold and wind and show affinity with warmer vegetation such as trees and shrubs.

The species *Maytenus heterophylla, Ehretia rigida, Ziziphus mucronata, Searsia undulata, Diospyros lycioides, Celtis africana, Searsia lancea, Searsia burchellii* and *Euclea crispa* are well presented in the *Acacia karroo-Grewia occidentalis* midslope Woodland but this implies that special management consideration should be given to this woodland to ensure the continued existence of this species within this community. Signs of soil erosion may be the cause of the absence of seedlings in this sub-community.

Without the classification and delineation of the various plant communities, the food availabilities and use within the various plant communities by the white rhinos could not be determined. It is especially important that the dietary requirements of the animals are taken into account when deciding on a burning programme for the area. An incorrect burning programme would not only alter the suitable habitat, but would also cause a reduction in food availability. The vegetation data discussed in this chapter will also be used in the following chapters to determine plant community preferences and use by the white rhinos throughout the year.

Special attention should be paid to the invasion of the tree *Acacia karroo* and the shrubby *Asparagus* species in the study area as well as in other parts of the reserve where they tend to invade valuable areas such as wetlands, riverine areas and open grasslands. Chemical application with the assistance of a burning programme and correct stocking rate must form part of a veld management programme in order to rectify the incorrect practices which have already caused severe veld deterioration. Moreover, there are also too many exotic plant species on the reserve. Some of them such as *Achyranthes aspersa* and *Bidens pilosa* have already become problematic and need to be destroyed.

No species of endemism related to the Drakensberg Alpine Centre have been found in the east, Griqualand West Centre in the west or to Sekhukhuneland Centre to the north. The reserve seems to be in the transitional region between the Albany Centre and the Drakensberg Alpine Centre (Van Wyk & Smith, 2001).

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CHAPTER 5

THE ECOLOGICAL GRAZING CAPACITY OF THE STUDY AREA

5.1. Introduction

Objectives for assessing veld condition are to detremine the potential of each ecological zone, to monitor veld condition over time and to classify the different vegetation types in that area (Tainton, 1999). The grazing capacity on the available 8 500 ha of the WPGR is based on agricultural guidelines for the region which is 7 ha/LSU (Large Stock Unit). The policy of the scientific services of the Free State Department of Economic Development, Tourism and Environmental Affairs (DETEA) is to utilize 70% of the potential carrying capacity which is 802.1 LSU for the reserve (Kietzman, 1998). The rotational grazing systems applied with domestic livestock today better simulate of the past grazing patterns of wildlife, where herds of game migrated from the High- to the Lowveld in winter, than the confined continuous grazing systems used by present game managers (Mentis & Huntley, 1982).

Grazing capacity (GC) is the potential of an area to maintain a certain number of animals without any degradation on the current veld condition (Jordaan, 1996). It is expressed as the total hectares needed for a Large Stock Unit (LSU) for a one year period (LSU/ha). A LSU is expressed as cattle weiging 450 kg each who increase 500 gram per day, the equivalent of 75 mega joule (MJ) per day (Meissner, 1982). According to Liversidge & Van Eck (1992) these agricultural stocking rates are purely based on the physiological energy requirements of cattle.

To determine the stocking rate for game is a complicated issue, especially with the uncontrolled movement of game on nature reserves. Although measures exist to attract animals to less preferred areas by means of controllable water points, licks and veld burning it still remains a difficult matter (Brown, 1997). A fixed carrying capacity with associated LSU for a specific region is also a controversial issue. Liversidge & Van Eck (1992) states further that “carrying capacity” is a meaningless concept in arid zones. Different vegetation units are unique due to veld condition and vegetation composition. To manage game a more accurate carrying capacity is needed according to the potential of each farm (Bothma, 1986). The term “veld condition”

describes vegetation in relation to its long-term potential for livestock production (Tainton, 1999).

There are currently literally tens of formulas to determine veld condition and carrying capacity. Danckwerts (1981) wrote his dissertation on a technique to assess the grazing capacity of sweetveld. Stuart-Hill *et al.* (1986) developed a method of assessing the veld condition of the Valley bushveld region. Swart (1988) describes five different methods of determining carrying capacities for different veld types. Stuart-Hill & Swart (1990) did experiments on carrying capacity in the Kirkwood district. Van Rooyen (1991) describes an easy method to determine carrying capacity while Jordaan (1996) developed a formula to determine the carrying capacity of browsing game for the North-West Bushveld of Transvaal. Smit (1996) developed the BECVOL method for determining browsing capacity for browsing animals.

In reality, virtually no habitat is indefinitely stable (Bredenkamp & Brown, 2006). Normal successional changes takes place over many years and climax communities tend to be in equilibrium with the environment unless disturbed when changes might occur (Bredenkamp & Brown, 2006). Seasonal variations occur but are mostly restricted to the herbaceous layer. Grazing practices and especially incorrect stocking rates could influence the herbaceous vegetation drastically and could lead to the rapid deterioration of the veld (Brown 1997). Therefore the rate at which an area is stocked is the most important factor in grazing management that affects animal production (Tainton, 1988), plant species structure and composition (Brown 1997).

The feeding relationship between the different game species is equally important. A well balanced ratio of animals for different veldtypes must be maintained to prevent over-and-under-utilization. According to Jordaan (1996) giraffes (*Giraffa camelopardalis*) browse 90 % of their time above the browsing height of greater kudu (*Tragelaphus strepsiceros*), impala (*Aepyceros melampus*) and steenbuck (*Raphicerus campestris*). Greater kudu spend only 33 % of their browsing time at a height of between 1.2 m and 1.7 m and 50 % of their time beneath 1.2 m. These ratios are important when managing wildlife under fairly natural circumstances.

The model developed by Kruger (1983a) was used to determine GC. Although it was developed mainly for grassveld it was adapted in this study to include browsing (Appendix B).

The GC for the study area (1103 ha) was determined in the following order:

- Two broad veldtypes were identified, namely grassveld and bushveld. Each veldtype was further sub-divided using the plant communities identified in this study. Grassveld was divided into short grass (plant community 1), medium grass (plant community 4) and tall grass (plant community 2).
  Bushveld was divided into dense bush (plant community 4.4), savannah (plant community 4.1) and grassveld (plant community 4.2) with scattered shrubs and trees.
- The area sizes were determined for each sub-division.
- Kruger's (1983a) formula of veld condition was applied in each veldtype.
- All factors were combined to determine the ecological grazing capacity (chapter 3).

5.2. RESULTS

5.2.1. Measuring the grassveld

According to Enslin in Celliers (1995) the surface area of different plant communities must be measured to determine the different stocking rates per community. In this study; short, medium and long grass were regarded as types of grassveld and measured accordingly. The different short grass patches (i.e *Cynodon* spp.) found isolated in plant communities 2, 4.1, 4.2, 4.3 & 5 of the study area were measured with a GPS (Garmin *E*trex Legend) to determine the total available food for the short grass feeders. The remaining areas were divided into medium grass (plant communities 2, 4.2, 4.3, i.e. *Eragrostis* veld) and long grass (vegetation type 2.1, 2.2, 3, 4.3, 4.4 & 5.2, i.e. *Themeda* veld) with only the medium grass measured.

The short grass areas (*Cynodon* spp.) measured 109 ha in the study area. The medium grassveld (i.e. *Eragrostis* spp.) was 245 ha, leaving the long grassveld (i.e. *Themeda* sp.) with the

remaining 554 ha of the total 1 103 ha. The 195 ha of "Damkom" was excluded from the calculation, due to the fluctuation of the water surface on a weekly basis.

5.2.2. Measuring the bushveld

The surface area of bushveld was also measured with a GPS and divided into three categories namely: savanna, dense bush and grassveld with scattered trees. The dense bush (plant communities 4.2, 4.4 & 5.1) measured 122 ha, the savanna veld (plant communities 4.1, 4.2, 4.3) 314 ha and the grassveld with scattered trees & shrubs made up the remaining 667 ha from plant communities 2, 3, 4 & 5.

5.2.3. Large Stock Units present on study area

A total of 12 game censuses were held during the mentioned period in the study area. The total number of "ANIMALS in STUDY AREA" was divided by the LSU equivalent (Meissner, 1982) to determine the acceptable number of animals in the study area. Feeding spectrum for game is according to Bothma (2006). The results are presented in Table 5.1.

Table 5.1: The ecological capacity examined.

Game Specie	LSU – Equivalent (Meissner, 1982)	Total animals in study area (Ave.)	Short Grass Feeder (LSU)	Medium Grass Feeder (LSU)	Long Grass Feeder (LSU)	Browser (LSU)
Eland	1.1	13		12		
Giraffe	0.6	5				8
Grey duiker	11.6	6				0.5
Impala	6.1	43		7		
Kudu	2.3	11				5
Mountain Reedbuck	8.0	5			1	
Ostrich	3.5	14		4		
Rhinoceros	0.5	6	12			
Sable	2.0	22			11	
Steenbuck	15.7	4	0.3			
Springbuck	8.1	15	1.9			
Warthog	5,3	5	1			
Zebra Burchell	1.7	12			7	
TOTAL		**161** (Head of game)	**15.2 LSU** (14 LSU available for short grass)	**23 LSU** (35 LSU available for medium grass)	**19 LSU** (97 LSU available for long grass)	**13.5 LSU** (12.2 LSU available for browsers)

5.2.4. Formula on veld condition

The assessment of veld condition is one of the most important factors when calculating the GC of an area (Brown, 1997). As previously stated (Chapter 3) the veld condition (V) and grazing capacity were determined by the formulas given by Kruger (1983b): The game reserve had 527 mm rainfall for the 12 months (2007-2008) study period. The total study area, is 1 103 ha. The veld condition of the grassveld (Table 5.2) and bushveld (Table 5.3) were calculated for the 908 ha above the full water mark of the dam. According to Enslin in Celliers (1995) adjustment must be made for veld condition. For an example the 23 LSU's for short grassveld (109/4.7 = 23 LSU) must be adjusted because the area is 62 % of its potential 100 %. Therefore 23 LSU x 62 % = 14 LSU's.

Table 5.2: The three identified grassveld areas were assessed and had the following results:

Grassveld Areas	Surface (Ha)	Veld Condition (%)	Hectare/ Large Stock Unit (Ha/LSU)	LSU X Veld Condition of grazing area	Results in LSU
Short grassveld	109 ha	62 %	4.7	23 LSU x 62 %	14 LSU
Medium grassveld	245 ha	65 %	4.5	54 LSU x 65 %	35 LSU
Long grassveld	554 ha	72 %	4.1	135 LSU x 72 %	97 LSU
Total	*908 ha	66.3 % (mean)	4.4 (mean)	212 LSU	**146 LSU**

*The 908 ha exclude the 195 ha of plant community 1.

The same formula as described by Kruger (1983b) for evaluating grassveld was used to determine the ecological GC for the bushveld. For the purpose of the study, special attention and adaptations were made to the criteria for evaluating the bushveld (which include dense bush, savanna and grassveld with scattered trees and shrubs) in the study area (appendix B). For an example the 16.7 LSU's (122/7.3 = 16.7 LSU) on the dense bush must be adjusted because the area is 40 % of its potential 100 %. Therefore 16.7 x 40 % = 6.7 LSU's.

Table 5.3: The bushveld area was assessed and had the following results:

Bushveld areas	Surface (ha)	Veld Condition (%)	Hectare/ Large Stock Unit (ha/LSU)	LSU x Veld Condition of browsing area	Results in LSU
Dense bush	122 ha	40 %	7.3	16.7 x 40 %	6.7
Savannah	314 ha	21 %	13.9	22.5 x 21 %	4.7
Grassveld with scattered bush	472 ha	7 %	41.9	11.3 x 7 %	0.8
Total	*908 ha	22 % (mean)	21.0 (mean)	49.1 (LSU)	**12.2 LSU**

*The 908 ha exclude the 195 ha of plant community 1.

5.2.5. Results on grazing capacity

The results indicate that the grassveld may carry 146 LSU's while the bushveld has food available for 12.2 LSU's. Consequently, food is available for 158.2 LSU's on the 908 ha while only 70.7 LSU's are currently utilizing the vegetation on the mentioned area. Thus, less than 50 % of the potential grassveld is presently utilized. The short grassveld currently carry 15.2 LSU's while 14 LSU's is available, while the medium grassveld carry 23 LSU's instead of 35 LSU's. The long grass carry 19 LSU's with food available for 97 LSU's. The browsers carry 13.5 LSU's whereas only 12.2 LSU's is available.

5.3. Discussion

However, the stocking rate is already low resulting in the underutilized areas. It is therefore recommended that the stocking rate is kept, but that management actions are taken to lure the animals to the underutilized areas. Thus would provide some rest for the slightly overgrazed areas. It is evident that the vegetation of the study area is underutilized especially with regards

to the medium and tall grass patches which are in certain areas moribund. The short grass vegetation patches with trees and shrubs of the browsing area seems to be slightly overgrazed.

The concern mentioned by Furstenburg & Van Hoven (1992), about the tannin as anti-defoliate agent especially in fenced off areas where overstocking occur, is not applicable in the study area. No heavy over grazing occur in the study area. The additional 1.3 LSU on the browsing animals should not have a negative effect on the veld since they will only trample it slightly. The additional 1.2 LSU on the short grass (plant communities 2, 4.1, 4.2, 4.3 & 5) is also of no concern as there is still 195 ha of mainly *Cynodon hirsutus* dam edge Grassland (community 1) available in the Damkom area. The latter should be kept as a buffer against unforeseen drought.

Management recommendations would be to keep the number of white rhinos in the WPGR at 20. The prescribed official policy and management plan stated that their numbers should be kept at 19. The 109 ha short grass in their home range prove to be enough to maintain them year round. Records on the reserve showed that the white rhinos seemed to flourish between a total of 16 – 26 animals, given that the correct sex ratio was implemented. A sex ratio of 1:9 productive adults is adequate allowing cow-calf, sub-adult-adolescence groups to keep the population structure productively.

Certain areas (plant community 2.1, 2.2) that are moribund need a burning or mowing programme in order to force the white rhinos to utilize the vegetation effectively. At one occasion it was observed that they spend more than two weeks grazing on *Themeda* veld in a fire break. Mowing or burning un-utilized grass should enable the white rhinos and other ungulates to utilize moribund grass more effectively. It will also give some relief to the short grass patches and allow re-growth.

The number of other ungulates utilizing medium and long grass should rather be increased to utilize the excessive grass available for the animals.

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CHAPTER 6

RESULTS AND DISCUSSION OF WHITE RHINOCEROS BEHAVIOUR

6.1. Introduction

Pienaar *et al.* (1992) determined the landscape preferences of the white rhinoceros in the southern Kruger National Park (KNP) to be landscape 3 "moderately undulating granitoid plains with *Combretum zeyheri* woodland". Roche (2000) conducted a similar project on the seasonal landscape preferences of white rhinos in the Timbavati Private Nature Reserve (TPNR) and found that the white rhinoceros densities in the TPNR are significantly higher in both dry and wet seasons than those on the same landscapes in the adjacent KNP. Shrader *et al.* (2006) studied the food and nutrient intake rates of white rhinos in the Hluhluwe-Umfolozi Park and suggest that white rhinos mobilize fat reserves to meet their nutritional needs during the dry season.

The ranging area of white rhinos varies depending on the availability of resources and generally increases during the dry seasons. White rhinos are said to have four basic habitat requirements: 1) short grass up to 25 cm, 2) sufficient drinking water and mud holes, 3) adequate bush cover and 4) a relatively flat terrain. These requirements are all met in wooded grasslands (Furstenburg, 2004). Generally, they will avoid steep slopes, but will traverse them when moving between feeding grounds and water (Skinner & Chimimba, 2005). White rhinoceros diets and habitat utilization will therefore reflect local circumstances and differ from area to area depending on the availability of particular resources.

A management plan (Kietzman, 1998) and a study of the habitat utilization, feeding preferences, home ranges and population structure of the white rhinos (Jordaan, 1990) at WPGR was previously conducted. However, no recent work has been published on the ecology of the white rhinos in the Free State grassland systems.

6.2. Population structure

Two bulls and two cows were relocated into WPGR in 1962. Their number increased to 18 in 1971. Since then, their numbers have seldom exceeded 26. The current departmental policy is to carry nineteen white rhinos on the reserve (Kietzman, 1998). According to reserve records, a total of four white rhinos died naturally, two disappeared (it is suspected by drowning in the Allemanskraal Dam), seventeen were sold live, 28 were transferred to other reserves and parks in Botswana, Namibia and other Free State Provincial nature reserves and five were hunted. Thus, a total of 56 rhinos were born, died or removed between 1976 and 2008.

In 1989, I counted 16 animals: one bull, nine adult females, two calves and four sub-adults (Jordaan, 1990). At the beginning of this study in July 2007, the white rhinoceros population consisted of 17 animals and due to two births they increased to 19 (Figure 6.1) by the end of the study period in August 2008.

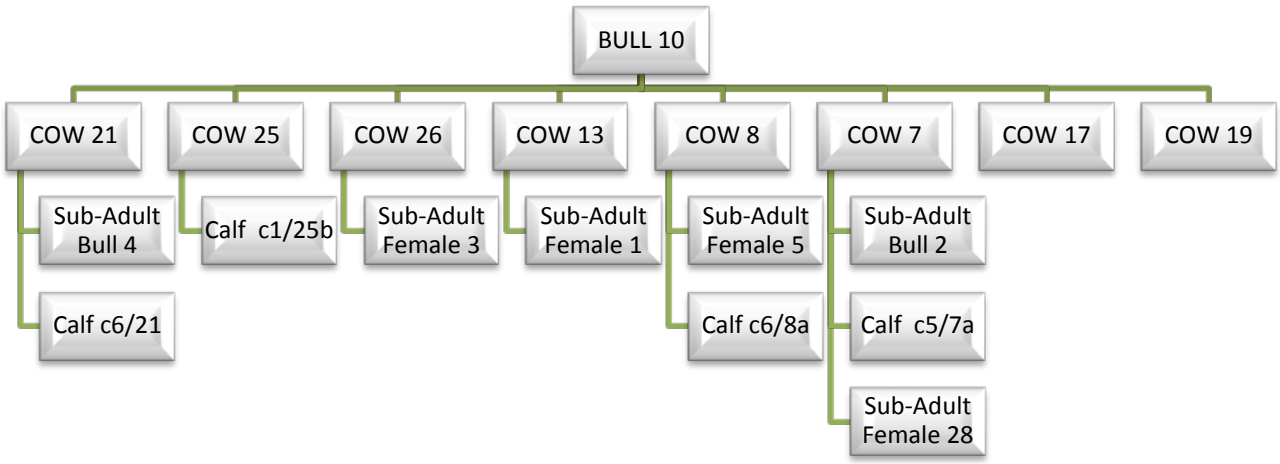

Figure 6.1: The composition of the white rhinoceros population at the end of the study period.

The dominant bull was born in 1995 and introduced from the Hluhluwe-Umfolozi Park, KwaZulu-Natal in 2003. At the age of 16, he is responsible for the conception of all the sub-

adults and calves on the reserve during the study period. The removal of the bull has subsequently been recommended by reserve management to prevent in-breeding.

6.3. Total home range

The home range of the adult bull (no. 10) averaged 12.38 km² while the home range of an adult cow (no. 7) was found to comprise 17.68 km² across the entire game reserve (n = 249).

6.3.1 Range use within study area

The mean range size for nine of the white rhinos during the study period within the study area was 5.05 km² (n = 274) while that for the wet season was 4.64 km² (n = 233). The smallest range size measured for the dry season was 2.7 km² for cow number 8 and the largest was 7.3 km² for the dominant bull. The smallest range measured during the wet season was 3.4 km² also in respect of cow number 8 and the largest was 8.2 km², for bull number 10. Wilcoxon signed rank tests showed no significant differences between the size of area utilised during the wet and dry seasons (p = 0.286, n = 9). The bull utilised 83 % of the study area during the wet- and 75 % during the dry season. The cows (n = 8) utilized 38 % of the study area in the wet- and 44 % during the dry season.

All white rhinos utilised similar vegetation types: plant community 1, plant community 2, plant community 4 and plant community 5 of the study area. The seasonal ranges and frequency within vegetation types of the adult bull and the white rhinoceros cows within the study area are presented in figure 6.2 and 6.3.

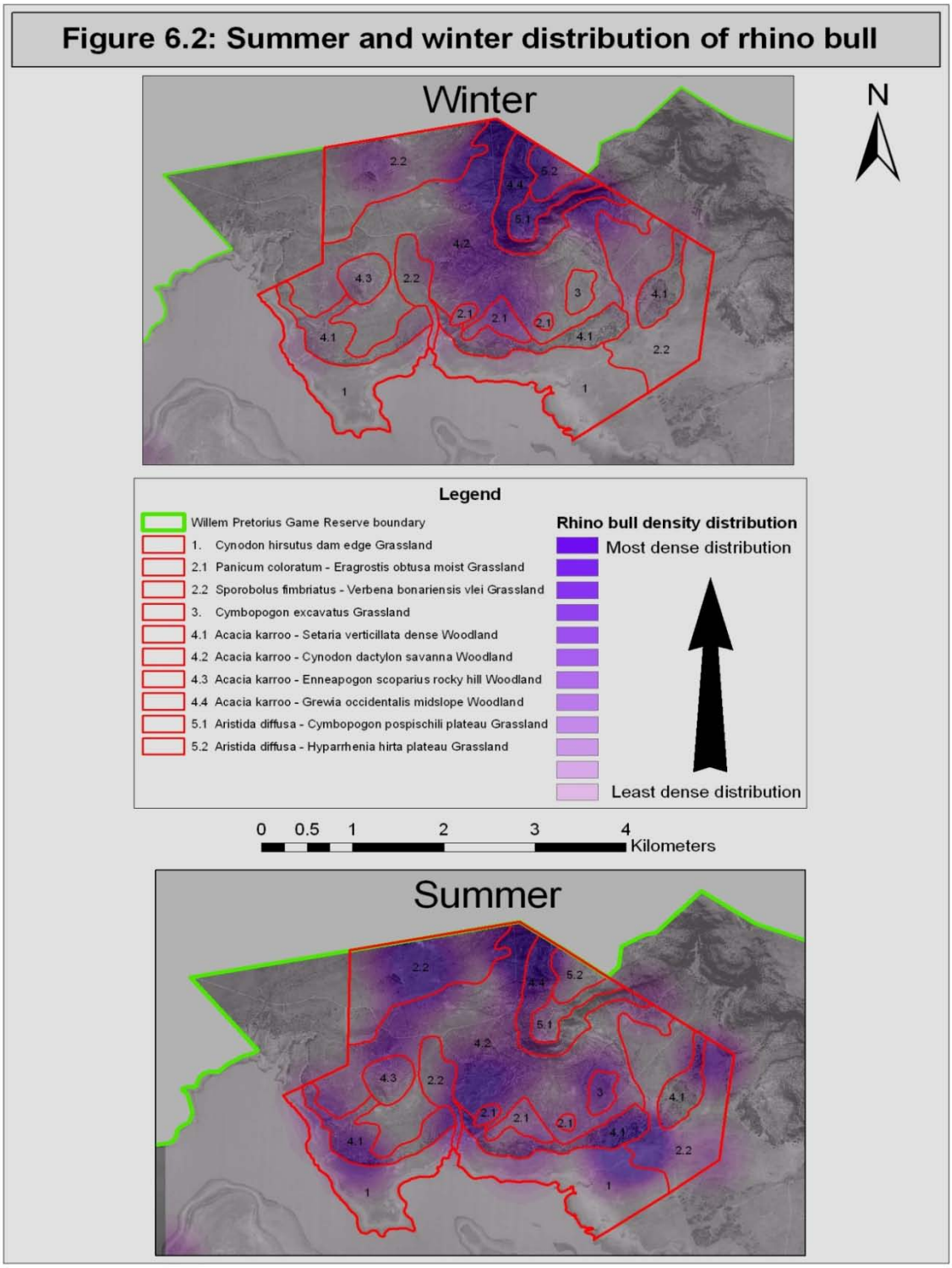

Figure 6.2: Winter and summer distribution of the white rhinoceros bull. Plant sub-community 2.1, 4.2, 4.4 and 5.1 were utilized north-south in the dry season while all plant communities were equally utilized in the wet season.

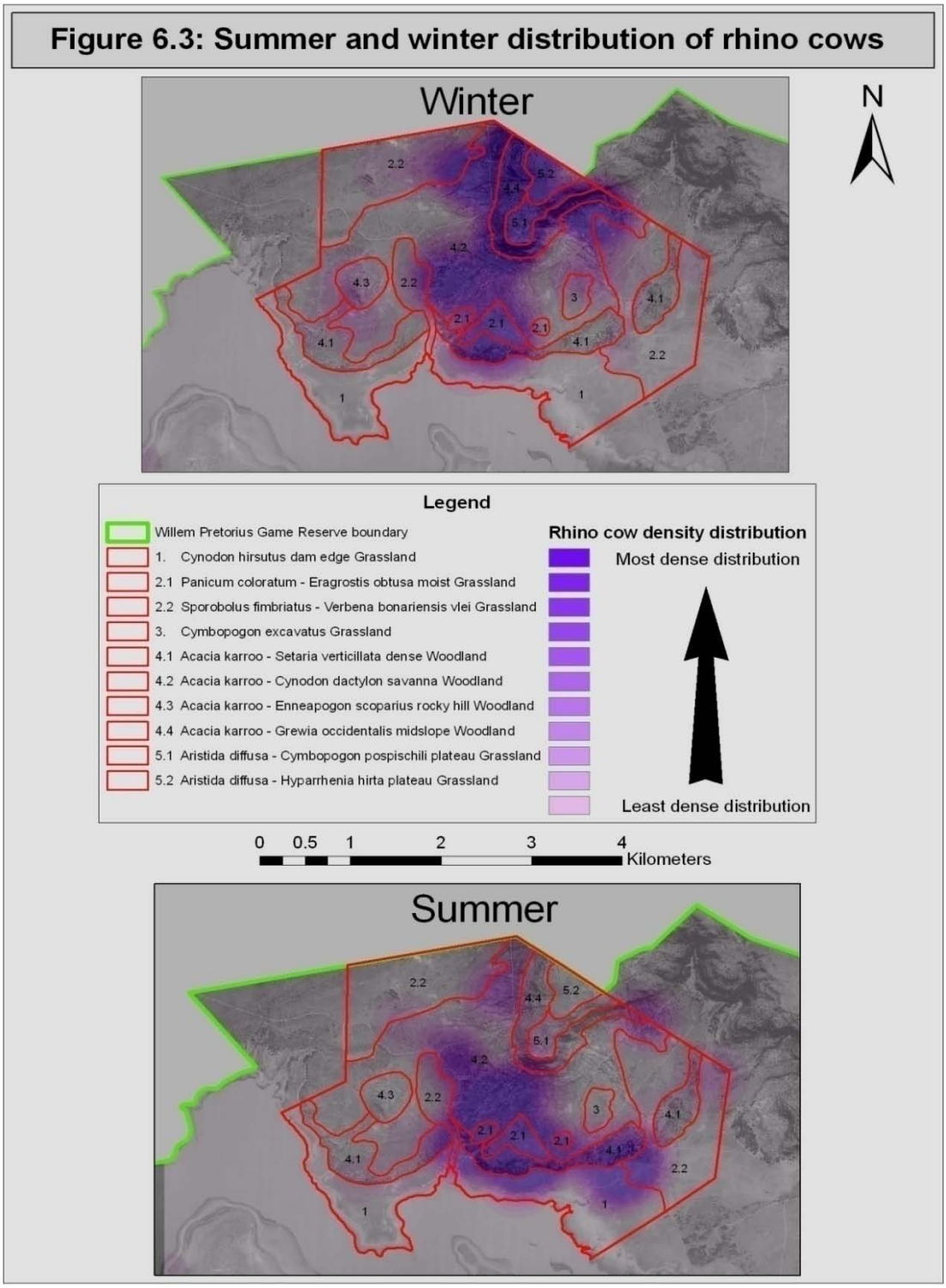

Figure 6.3: Summer and winter distributions of white rhinoceros cows. Plant sub-community 2.1, 4.2, 4.4 and 5.1 were also utilized north-south in the dry season while plant sub-community 1, 2.1, 4.1 and 4.2 were utilized in the wet season.

6.4. Habitat utilization by white rhinos

The plant communities identified in this study could not be directly compared with those of Muller (1986) which was on a larger scale. In order to be able to compare the habitat utilization of white rhinos as found by Muller (1986) with this study the plant communities were grouped into Muller's broad habitat types (Savanna, River Community, Wetlands, Grassveld, Thornveld and Trees & Shrubveld).

The white rhinos frequented different habitat types unequally (Figure 6.4): Treeveld and Shrubveld (29 %, *n* = 660) were utilized the most, with Savanna (19 %, *n* = 438), the Thornveld (18 %, *n* = 414) and River Community (15 %, *n* = 338) used frequently. Grassveld (5 %, *n* = 123), Wetlands (5 %, *n* = 124) and Damkom (9 %, *n* = 218) were the least frequently utilized habitat types.

During the study period the white rhinos spent 80% of their time (*n* = 1 850) in a habitat with cover and 20 % (*n* = 465) in grassland areas such as wetlands, "damkom" and grassveld.

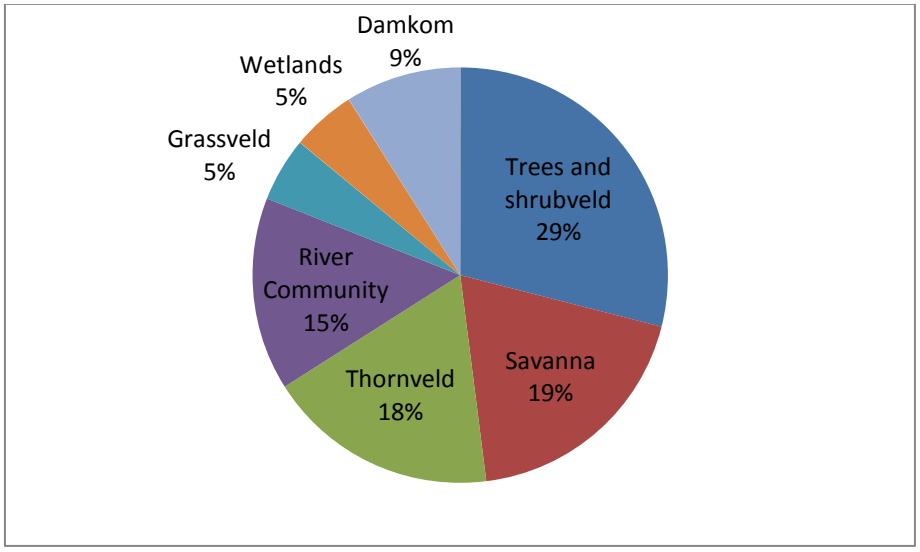

Figure 6.4: Percentage of observations (*n* = 2 315) of white rhinos within different habitat types.

A further difference in use of habitat types were observed when data was separated seasonly (Figure 6.5). The main difference in seasonal use of the different habitat types was that the percentage of observations in the 'trees & shrubs' habitat type (plant sub-community 4.4 & 5.1) was greater during the dry season than during the wet season. The 'Thornveld, River Community and Damkom' habitat types (plant sub-communities 1, 4.1 & 4.2) were utilized slightly more frequently during the wet than dry season.

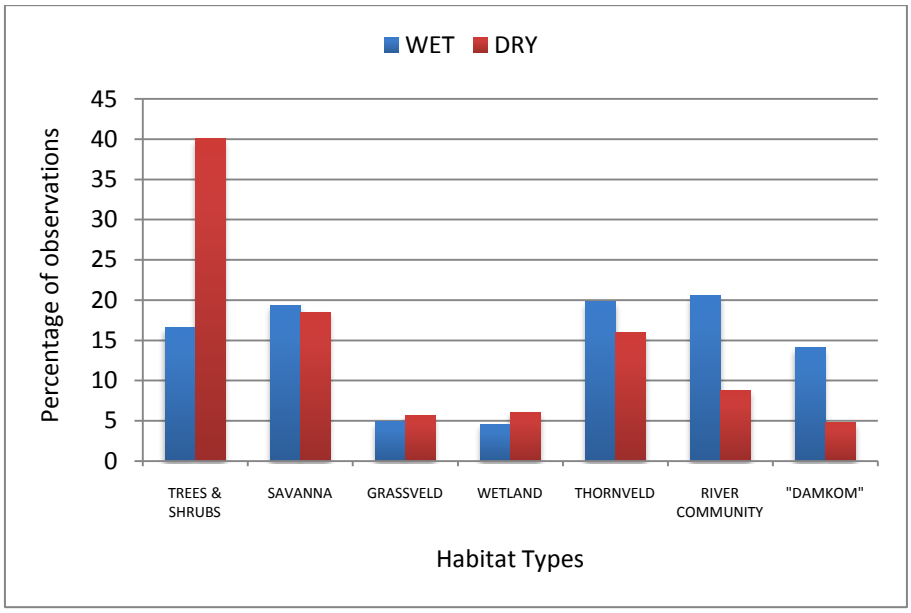

Figure 6.5: Seasonal differences in habitat preferences of white rhinos (*n* = 2 315).

6.5. Diet selection of white rhinos

A total of 1198 feeding bouts were recorded. Thirty five plant species were observed to be eaten by the white rhinoceros during this study. These included 28 grass species, 1 shrub species and 6 forb species (Table 6.1). No browsing was observed. Five observations suggest that forbs were accidentally ingested along with grass, with the exception of *Atriplex semibaccata* (Australian saltbush) which was utilized during winter time (*n* = 17).

Table 6.1: A list of all the plant species foraged on by the white rhinos throughout the study period.

Plant Species	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
	Grass Species											
Anthephora pubescens										x	x	
Aristida adsensionis						x	x					
Aristida congesta	x	x	x	x	x	x	x	x	x	x	x	x
Aristida diffusa burkei						x	x					
Brachiaria eruciformis			x	x								
Chloris virgata	x										x	x
Cymbopogon plurinodes							x	x	x	x		
***Cynodon* species.**	x	x	x	x	x	x	x	x	x	x	x	x
Digitaria eriantha					x						x	
Enneapogon scoparius		x	x	x	x	x	x	x	x	x	x	
Eragrostis chloromelas	x	x	x	x	x	x	x	x	x	x	x	x
Eragrostis curvula	x	x	x	x	x	x	x	x	x	x	x	x
Eragrostis lehmanniana									x	x	x	
Eragrostis obtuse			x	x								
Eragrostis rotifer									x	x	x	
Fingerhuthia africana											x	x
Hemarthria altissima		x			x		x	x	x	x		
Heteropogon contortus									x	x	x	
Koeleria cristata						x		x				
Melica decumbens											x	
Panicum maximum				x	x	x	x	x				
Panicum coloratum				x		x	x					
Setaria sphacelata										x	x	
Sporobolus fimbriatus					x	x		x				
Themeda triandra		x	x		x		x	x	x	x	x	
Tragus racemosus				x	x							
Urochloa panicoides		x										
	Forbs											
Pentzia viridus						x	x					
Lepidium africanum					x							
Atriplex semibaccata					x	x	x					
Walafrida densiflora				x								
Schkuhbia pinnata					x	x						
***Senecio* species**							x					
	Shrub											
***Asparagus* species**						x						

A seasonal difference in the diet selection of the white rhinos was also found (Figure 6.6). Although *Cynodon* spp. (*n* = 302) were utilized throughout the year they demonstrated a higher utilization for it during the wet season (46 % of their diet) compared to that of the dry season (28%). The grass *Enneapogon scoparius* was the third most frequently utilised species during the dry season at 12 %. At the end of the dry season towards spring time most of the white rhinos migrate to the eastern section of the reserve where they foraged on the hygrophilous grass *Hemarthia altissima* which occurs on the banks of the Sand River. This grass has long, robust, prostrate stems rooting at the nodes to form dense mats. After the drought of 2006/7, good follow-up rains caused population outbursts of certain weeds such as *Schkurhia pinnata*, *Conyza bonariensis*, *Cenecio* spp. *Cirsium vulgare* and *Verbena* spp. The latter, which are tall weeds, were not utilized. However, the *Schkurhia pinnata* was utilized, probably because it is short and amongst other short grass such as *Aristida* spp. and *Enneapogon scoparius.* In the late dry season it was observed that the white rhinos occasionally foraged on some young *Protasparagus laricinus* (*n* = 3).

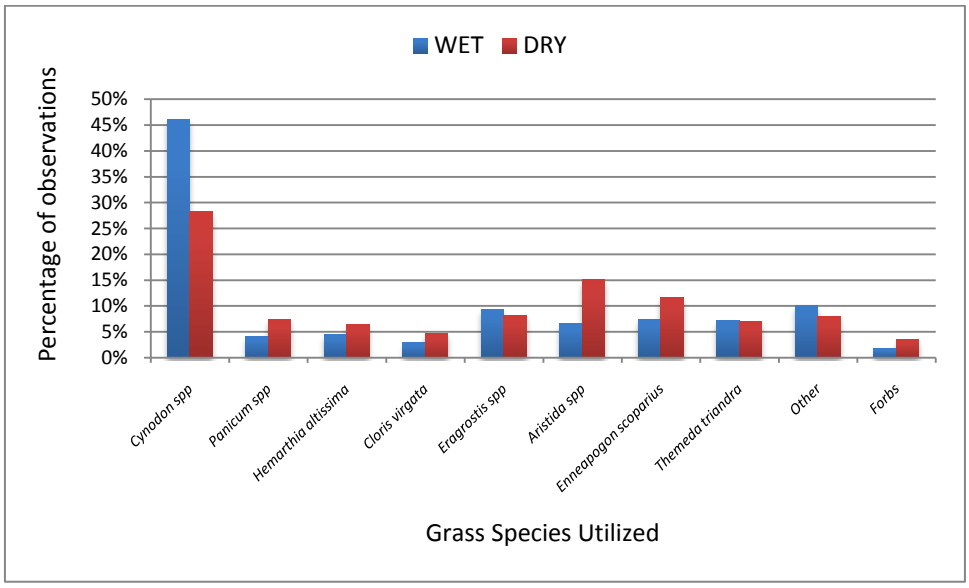

Figure 6.6: Grass species utilized by the white rhinos during different seasons. Grasses that made up less than 1 % of those eaten were grouped together under "other".

The average bites per minute numbered 49 (Range; 16 – 78, SE; 2.29, *n* = 66). On *Cynodon* spp (plant sub-community 1, 4.2 & 4.4) an average of 66 bites per minute (Range; 45 – 78) were recorded. The scattered grass such as *Enneapogon scoparius* were utilized with an average of 36 bites per minute due to the distance between the grass tuft. The total minutes of sampling comprised 66 minutes.

6.6. Activity budgets for white rhinos

Based on 14 903 samples, the white rhinos at WPGR spent on average 46 % of their time resting, 40 % feeding and 14 % on other activities such as walking, standing, standing alert, drinking, mating, rubbing, wallowing, running, playing and fighting (Figure 6.7). Over a 24 hour period they slept on average eleven hours, fed for ten hours and engaged in other activities for approximately three hours.

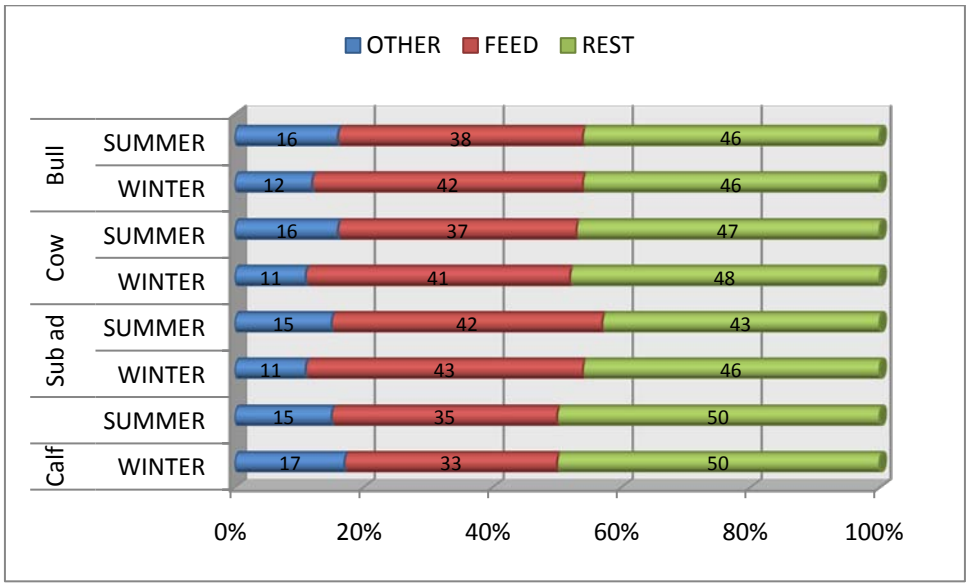

Figure 6.7: Activity budgets of white rhinos separated into age groups. Time budgets are shown as a percentage (%) of the total observations (*n* = 14 903).

White rhinos slept more than nine hours during extreme cold winter nights, and also nine hours during the daytime, particularly on extreme hot mid-summer days. In the dry season they will sleep until 07:00 – 08:00 in the morning and then start feeding for short periods of up to two

hours before going down to sleep from 10:00 – 15:00 for five hours. After awakening they feed for six hours until 21:00 before sleeping until 07:00 the following morning at the same locality.

During the wet season they will sleep from early morning (08:00) until late afternoon (16:00), feeding for six hours and then resting at one place from 22:00 – 00:30, feeding until 03:00 and resting at another place until 05:30 before grazing again until 08:30 (Figure 6.8).

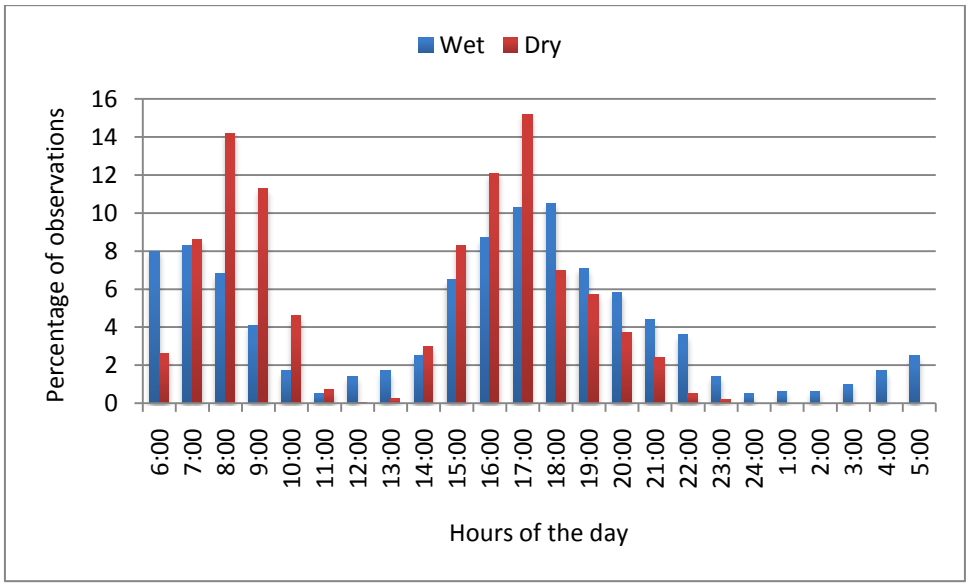

Figure 6.8: Feeding time during wet and dry seasons (Dry season; *n* = 4 174, Wet season; *n* = 3 345).

6.7. Discussion

6.7.1. Population structure

A comparison with data from other white rhinoceros studies (Owen-Smith, 1972; Pienaar *et al.*, 1992; Pitlagano, 2007, Galebotswe, 2008) indicates both similarities and differences. This study was conducted in an area with very cold winters with an absolute minimum of -7°C to very hot and dry summers with an absolute maximum of 35°C. The mean daily maximum temperature is 30.1ºC for the mid-summer (January) and 17.7ºC for mid-winter (July). The corresponding mean daily minima for the study area are 15.6ºC and -1.1ºC. A study conducted by Owen-Smith (1972), records in the Umfolozi-Hluhluwe complex a mean daily maximum temperature of 32.6ºC in January (mid-summer) and 25.3ºC in July (mid-winter), and a minimum of 21.8ºC and 13.2ºC. It appears that the Free State is a harsher environment for the white rhinos to survive in.

Owen-Smith (1988) states that the maximum sustained rates of population growth for white rhinos are 9 %, while mortality rates vary between 2 – 5 % per annum. According to Kietzman (1998) the annual natality rate from 1976 to 1997 was 9.98 % for the WPGR, while the mortality rate (excluding removals) for the same period was 1.98 %. The natality rate is high for the period under review, considering that there were no calves born from 1986 until 1990. The dominant bull was mistakenly hunted (World record trophy) as an adult cow, and the sub-dominant bull was not yet sexually productive at the time with an age of five years. He only became sexually productive at the age of eight years and the first calf was born in late 1990 (Jordaan, 1990). The natality rate for the study period from July 2007 until August 2008 was 15.8 % and may be regarded as satisfactory for an animal whose historical occurrence in this area is questionable.

The population structure at the WPGR presently consists of one bull, eight adult cows, four sub-adult cows, two sub-adult bulls and four calves, forming a total of 19 white rhinos on the reserve; thus producing a sex ratio of 1 male: 8 females.

6.7.2 Total home range and movements within habitat types

6.7.2.1 Total home range

Other studies on white rhino home ranges were conducted in the Moremi Game Reserve (4 871 km²), Botswana (Pitlagano, 2007; Galebotswe, 2008), Kruger National Park (19 485 km²), Mpumalanga, South Africa (Pienaar *et al..*, 1992) and the Hluhluwe-Umfolozi Game Reserve (950 km²), Kwa-Zulu Natal (Owen-Smith, 1972). WPGR is only 120 km², and is small compared to these other game reserves. Although huge surface areas are described, the actual home range of the white rhinos in these spacious reserves are simular. The total home ranges for cows described by Owen-Smith (1988) were 10 – 15 km² and that by White *et al.*. (2007) to be 20 km² and in core areas 5 km². These compares with cow no 7 on WPGR who had a total home range of 17.68 km².

Pitlagano (2007) described two wandering white rhinos in the Moremi Game Reserve as having a core home range of between 22 – 24 km². Other bulls have been recorded to have home ranges of 5 – 11.3 km² (Skinner & Chimimba 2005). Owen-Smith (1972) describes the home range of the adolescents' from 4 – 10 km² and territorial bulls' ranges from 1 – 2 km². Bull no. 10 on WPGR had a home range of 12.38 km² which falls within the findings of previous studies on both WPGR (Kietzman 1998) and white rhinos in other reserves.

Pienaar *et al.* (1992) recorded home ranges of 5.5 km² – 45.2 km² for reintroduced animals in Kruger National Park. Pitlagano (2007) describes home ranges for two white rhinos in the Moremi National Park, Botswana which varied extensively from 17 km² – 6706 km², while the other nineteen had a core area of 5 km² – 40 km². These two wanderers had a core area of 22 km² and 24 km² respectively, after settling down.

It must be noted that the home ranges with big variability as described by Pienaar *et al.*. (1992) for the Kruger National Park (5.5 – 45.2 km²) and Van Gysenham (1984) in Murchison Falls National Park (7 – 97 km²) could be attributed to disturbances such as elephants and humans. On several occasions during my study encounters were monitored between tourists and white rhinos on the game reserve. In one such incident, some tourists were disturbing the rhinos at

West Dam late afternoon (18:00) before leaving the reserve. This incident resulted in the disappearance of the rhinos that night. They were found under the Viewpoint at 20:00 but disappeared again. They moved throughout the entire night for approximately 12 km and were found at 12:00 am at Doringberg east. A similar incident was reported at Umfolozi Game Reserve, where some tourists had been boasting about a competition they had held to see who could place the best shot with a paint ball on a white rhinoceros. Such incidents will force individuals out of their range for three to four days before they will return to their territory.

6.7.2.2 Range use within study area

The mean range size within the study area for the study period was 5.27 km² for the dry season and 4.81 km² for the wet season (Range: 2.7 km² - 7.3 km²). Rhinos wandering through the study area during the dry season in search for their ideal dry season food such as *Panicum maximum* and *Enneapogon scoparius.* They also found shelter mainly in plant sub-communities 4.2 and 4.4, which is situated in the Doringberg Mountain. In the wet season they travel freely along the edge of the Allemanskraal Dam where it is cool and abundance of food such as *Cynodon hirsutus* and *Cynodon dactylon* is available. They utilized mainly plant community 1, plant sub-community 2.1, 4.1 and 4.2 of the study area. A small portion of approximately 20 km² (approximately 17 % of the total reserve) of the northern section of the game reserve consists of savanna and mountains with associated trees and shrubs vegetation which make it ideal habitat for white rhinos. The rest of the reserve is mainly open grassveld and were mostly avoided by the white rhinos.

6.7.3. Habitat utilization

The habitat utilization differs somewhat from a similar project done in 1990, where the habitat preference for white rhinos was found to be Savanna (31 %), Trees & Shrubveld (29 %), Wetlands (11 %), Grassveld (10 %), Thornveld (9 %) and Riverine Vegetation (8 %). With the exception of Trees and Shrub habitat (29 %, 1990; 29.3 %, 2010) all the other habitats were utilized differently. This could be related to the water level of the Allemanskraal Dam with it having been at full capacity (100 %) in 1990 and nearly empty (only 23 % full) for the duration of this study.

In this study the white rhinos showed a preference for plant community 4.4 (Trees & Shrubs) in the dry season and plant community 4.1 (River community) during the wet season. During the dry season the lactating cows moved deep into the thickets of steep cliffs and gullies (plant community 4.4) to feed on green grasses such as *Panicum maximum* which survived the frost by being situated under trees and shrubs such as *Ehretia rigida, Searsia undulata* and *Grewia occidentalis.*

The white rhinos preferred an average altitude of 1 416 m during the dry season and 1 406 m during the wet season, confirming that they prefer the mountainous areas for shelter against the cold during the dry season and the lower habitats next to the Allemanskraal Dam during the wet season to cool off against the hot summer days. Furthermore, the Thornveld, River community and Damkom run alongside the Allemanskraal Dam which provides cool shelter in the summer, while a preferred food, C*ynodon* grass, is found growing in the near vicinity. Wetlands provide a few green grasses due to the seepage effect and simultaneously receive heat from the sun during the winter months.

The results recorded in chapter 4 indicate that white rhinos did not use all plant communities within their home range equally. The complete avoidance of some communities suggests that the white rhinos either obtain their food from another source or that the topography of the areas wherein these communities occur is unsuitable.

6.7.4. Diet Selection

This study confirms previous findings that white rhinos are predominantly short grass feeders (Player & Feely, 1968; Owen-Smith, 1988; Shrader *et al.*, 2006) with the exceptional utilization of medium and tall grass (Mills and Hes (1997). Although, some forbs were accidentally ingested along with grass, these animals did show some dietary adjustment to the dry season, namely the inclusion of the exotic plant *Atriplex semibaccata*. According to Mostert (1958) *Atriplex* spp. are evergreen, good soil protectors and readily eaten by animals especially in the winter and drought.

Diet selection varied seasonally, with 19 grass species being utilized in the wet season and 27 during the dry season. Surprisingly, *Enneapogon scoparius* was utilized as the third most popular grass species during the dry season. As mentioned previously, during the course of this study, all the white rhinos moved from the western side (study area), to the eastern side in search for food after a harsh winter. They found suitable green grasses such as *Hemarthia altissima* on the inside banks of the Sand River and mainly utilized those during this period. Mostert (1958) states that the hygrophilous grass *Hemarthia altissima* is a stoloniferous, palatable grass with a low fibre content which is of high grazing value, especially during drought and in winter.

The bites per minute on short grass was not as those recorded in the findings of Owen-Smith (1988) who counted on average 72 bites per minute whereas 49 bites per minute were counted during this study. Grass species such as *Aristida* and *Enneapogon* spp. naturally occur on poor soil types with much filtration, such as along tourist roads and on slopes beneath the Viewpoint (plant sub-community 4.2 and 4.3). These scattered grasses were utilized with an average 36 bites per minute due to the distance between the grass poles.

A typical feeding spell involves aggressive grazing for approximately three hours on one specific *Cynodon* spp. site and then foraging over a wider area occurs before moving to a resting place. It was noticed that during the first spell of grazing they are not easily disturbed but in later spells they become more alert to their surroundings. Sometimes they feed so intensively on short grass among trees and shrubs that they lose contact with the rest of the group only to find themselves alone and isolated. Viewing from the top of Doringberg Mountain, it was observed how an individual would track the location of the disappeared group by walking on the group's exact trail until it found the rest of the group. Similar behaviour was noted by Moss (1976) in the Ngorongoro Crater and Tsavo National Park. Moss (1976) noted that black rhinos all had characteristically strong smelling feet and he suggested that they used these scent trails in order to orientate themselves within their home range.

6.7.5. Activity budgets

This study revealed that the white rhinos on WPGR allocate most of their daily activity budgets to feeding and resting. White rhinos generally moved from one core area of resource to the next available core area, sleeping at suitable sites. It was observed that the rhinos would walk through apparently suitable sheltered areas to a specific resting place to spend some hours resting. During the dry season they would sleep all through the night until between 07:00 and 08:00, feed for short periods of up to two hours and then sleep again for five hours. During the afternoon they would feed for up to six hours until about 21:00 and then sleep again until the next morning. On the other hand, during the wet season they would typically sleep from early morning until late afternoon, feed for six hours and then rest at one place for about two hours before feeding again for another two hours. They would then rest again before grazing starts early morning.

The white rhinos slept for more than nine hours during extreme cold winter nights and during. extreme hot summer days. A preference for the cool shadows of savanna *Acacia* trees in the wet season and the thicket evergreen *Searsia* shrubs in the ravines in the dry season was observed. A small percentage of time is dedicated to other activities such as playing, rubbing, wallowing and fighting. Half of these “other” activities are normally associated with high energy consumption such as fighting and mating whilst wallowing and standing are associated with low energy consumption.

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CHAPTER 7

SLEEPING PATTERNS, EYESIGHT ASSESSMENT AND OTHER ANECDOTAL OBSERVATIONS OF WHITE RHINOS

7.1. Introduction

During the course of this study a number of interesting behavioural activities were noticed. Consequently, it was decided to collect data on these activities. In most cases, the data sets are small but reveal interesting patterns which lend towards suggestions for further research.

While observing the white rhinos it became obvious that they slept in certain formations. No reference regarding their sleeping behaviour has been published and data was collected to determine if these patterns were influenced by the number of individuals present.

Various secular books, magazines and articles refer traditionally to the eyesight of white rhinos (*Ceratotherium simum*) as poor, bad, weak to relatively poor, short-sighted or near-sighted, terribly poor, and extremely poor (Burton & Burton, 1969; Hopf, 1972; Moss, 1976; Ellis, 1999). Some speculate that the distance that rhinos can see as only 5 m, while others consider it to be less than 30 m (Dorst & Dandelot, 1970; Harlow & Parsons, 1974). White rhinos have responded more readily to moving objects which they detect from between 10 and 40 metres (Smithers, 1983; Skinner and Chimimba, 2005). Owen-Smith (1988) suggested that white rhinos were unable to identify human intruders at ranges exceeding 20 – 30 m provided they remain immobile. The aim of the experiment conducted during this study was to investigate the efficiency of white rhinoceros eyesight.

During observations, the white rhinos often disappear into thick vegetation. Although it was expected to relocate them a few hours later 3 – 5 km away, they were often found only 50 – 200 m further from their previous position. This led to the investigation of their travelling distance per grazing period.

Owen-Smith (1988) studied the drinking behaviour of white rhinos and found that they have a drinking frequency of every 2 - 3 days. The drinking behaviour of the white rhinos on WPGR was investigated to compare with Owen-Smith's findings.

The hearing ability of rhinos has been described as being very good (Milne and Milne, 1963), with studies recording distances of up to 800 metres (Harlow & Parsons, 1974; Owen-Smith, 1988). There is however, no real indication as to what frequency of sound they do hear.

A previous study conducted on the WPGR (Jordaan, 1990) indicated that white rhinos spent most of their time alone rather than in association with other species. Data was collected during this study to use as a comparison to the earlier study.

7.2. Materials and methods

7.2.1. Sleeping formations

The sleeping formations (patterns in which the rhinos lay down) and the number of individuals making up the formations were recorded whenever they were observed lying down for a sleep/rest. The location where they slept as well as if it was under some type of vegetation cover or out in the open was also noted.

White rhinos have a tendency to sleep close to each other. When an individual was sleeping further than seven metres away from the group it was regarded as a separate formation. They tend to stand up regularly during resting times and shift their positions as the day progresses, shadows shifting and temperature changes. The recordings were those of sleeping formations observed during the first morning sleep. Sketches were made of their sleeping formations in relation to nearby trees and then categorised into the different groups.

7.2.2. Eyesight assessment of white rhinos

The testing of the white rhinoceros's eyesight was conducted on WPGR during the period April 2006 – August 2009. Initially, I tried to use myself as the stimulus and recorded the distance between myself and the rhinos together with their initial reaction. This however, proved to be too dangerous and it was decided to use mannequins instead. Two mannequins were used and initially placed randomly beneath the Viewpoint to simulate humans so that the behaviour of the rhinos could be observed without any disturbance. The initial anticipation of the rhinoceros's direction was usually incorrect and they did not pass the mannequins. The second attempt was to get close to the rhinos, anticipate their direction and put the mannequins approximately 100 m in front of them and run away. This however, caught the attention of the rhinos and it was thought that the human scent on the mannequin's clothes would cause the rhinos to react to the smell without necessarily seeing the mannequin. The third attempt was to place the mannequins together along the route to the drinking hole. Although they wore different clothes it could not be determined which one they actually saw. Finally, it was decided to place the two mannequins (one dressed in camouflage and one dressed in white clothes) upright at different strategic drinking points of the white rhinos next to the Allemanskraal Dam.

The two mannequins were dressed in clothes that did not vibrate in the wind and were positioned in the early morning (06h00) at specific spots beside the water surface from where the white rhinos would be able to notice them (Figure 7.1). All smell disappeared through the day time and no apparent human scent was present when the white rhinos came to drink water. Experiments were conducted once a month. To prevent habituation to the mannequins, they were removed from the site between experiments. No attempts were made to place them out at night-time or to monitor their sight at night.

Figure 7.1. Mannequins (one white and one camouflaged clothing) were placed at the water's edge of the Allemanskraal Dam from where the white rhinos had an equal chance of seeing them.

When white rhinos approached the drinking point, they were classified as either calf, sub-adult or adult. Data collected included the initial reaction of the rhinoceros/s to the mannequins and the distance from the mannequin at which this initial reaction took place. Distances were recorded in increments of 10 metres i.e. 100 m to 90 m; 91 m – 80 m; etc. Data for this component of the study was only conducted during the day. Additional information was also noted; the time of day, ambient temperature and wind speed (Beaufort scale). For the purpose of this chapter, eyesight is defined as the direct line of sight from the white rhinoceros's eye straight towards the mannequin.

7.2.3. Walking distance per grazing period

Being able to speculate the distance white rhinos are likely to move is useful during monitoring operations if they disappear in vegetation. The walking distances per grazing period was determined by recording when a white rhinoceros arose from a place of rest and started feeding, until it stopped feeding and walked to a suitable resting place, lay down and slept. The distance was measured initially with a measuring wheel, vehicle and a GPS, but it was found

that each gave the same results and thereafter only the GPS and vehicle were used to measure the distances. In most cases, distances were rounded of to the nearest 100 meters due to some difficult terrain. Data was collected for both the wet and dry seasons. Data from white rhinos that moved further than 5 000 m were not included as those long distances were usually caused by some disturbance such as tourists that caused the animals to leave the area for at least three to four days before returning back to its former grazing grounds.

7.2.4. Drinking patterns

Whenever the rhinos were observed to drink water the following data was recorded: the time of day, the number of drinking bouts during a drinking session, the duration of drinking bouts and the sex of each animal.

7.2.5. Hearing assessment of white rhinos

An experiment to assess the potential hearing ability of the white rhinos was conducted using a FM 1-BAND Radio. The radio was tuned to a music station, to produce an unfamiliar sound. A TFA Wind metre was used to measure the temperature and wind speed. An Auto Ranging TOP TRONIC (T8209) Multimeter was used to measure the Decibels (dB). The Multimeter was placed 1 metre in front of the FM 1-Band Radio and the volume was adjusted until it reached between 85 – 90 dB. The distance from the radio at which the rhinoceros first reacted was recorded. This experiment was only conducted on absolute windstil days or with a wind speed of less than 5 km/h. Furthermore, the experiment was only conducted in areas of open terrain without any barriers such as trees or rocks.

7.2.6. Association with other species

During morning and afternoon feeding spells, all animals observed within a 50 metre radius from the white rhinos were recorded. Data recorded included numbers of individuals of each species, date, time of the day and any reactions to or by the white rhinos.

7.3. Results and discussion

7.3.1. Sleeping formations and locations

A total of 245 observations were made on the sleeping formations. The following ten sleeping formations of white rhinos were recorded: Oval, Star, Irregular, Circle, T-Shape, L-Shape, V-Shape, One-Way, Two-Way and Alone (Figure 7.2).

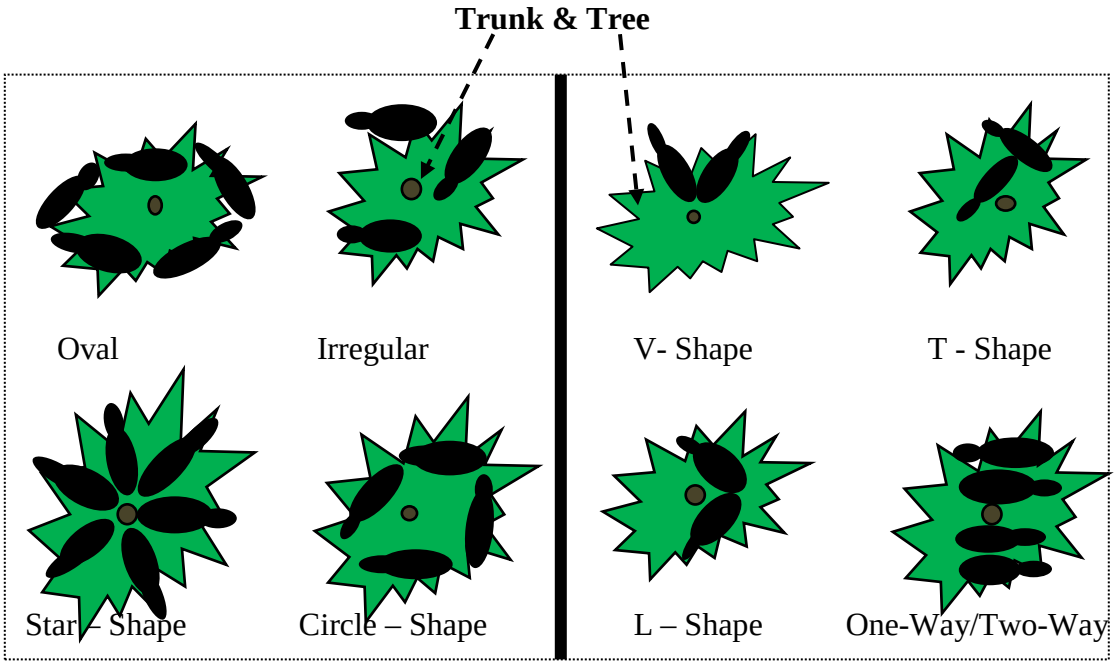


Figure 7.2: Observed sleeping formations of white rhinos during the wet season. Two or fewer are illustrated on the right of the black vertical line while more than two individuals are left of the thick black line.

The Star, Oval and Circle formations consist of individuals of more than four individuals, while the irregularly shaped formations consists mostly of unequal numbers such as three and five. The T-Shape, V-Shape, L-Shape, Two-Way and One-Way formations was mostly utilized by two individuals while Alone was only used by only one animal (Table 7.1). The Oval formation (33 %) was the most frequently formed formation during the dry season, while the Star formation (19%) (Figure 7.3) was the most frequently formed during the wet season.

Table 7.1: Number of individuals observed making up the different sleeping formations of white rhinos.

Formation	**Number of individuals making up formation**
Oval	Range: 4 – 8 (*n* = 52)
Star	Range: 5 – 13 (*n* = 50)
Circle	Range: 4 – 5 (*n* = 19)
Irregular	Range: 3 – 7 (*n* = 43)
1-way	Range: only 2 (*n* = 10)
2-way	Range: only 2 (*n* = 20)
T-shape	Range: 2 – 3 (*n* = 13)
L-shape	2 (*n* = 14)
V-shape	2 (*n* = 18)
Alone	1 (*n* = 16)

Figure 7.3: A typical Star-Shape sleeping formation. (Photo: Courtesy; O. Van Nieuwholtz).

During the wet season 77.4 % of sleeping observations were under trees and 22.6 % in the open grassveld (plant sub-community 2.1 & 2.2), while in the dry season 17 % of sleeping observations were under the trees in the shade and 83 % in the open grassveld (Figure 7.4).

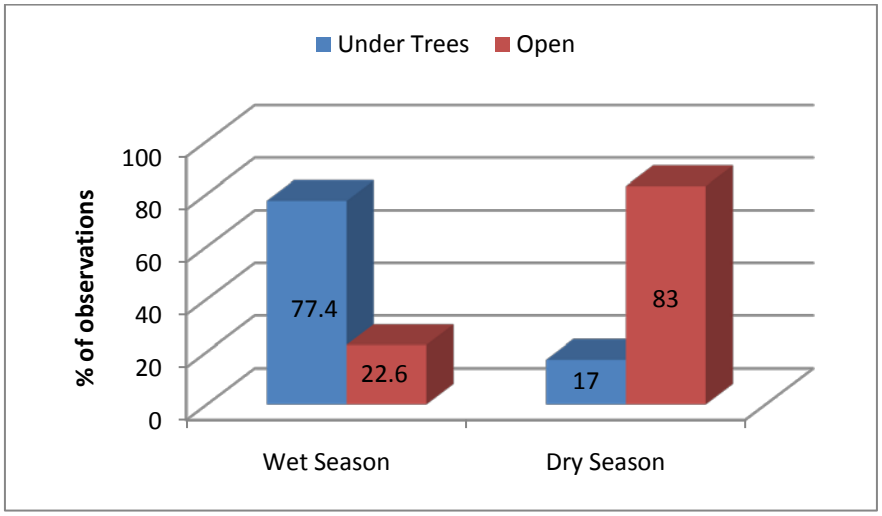


Figure 7.4: Seasonal comparison of rhinos sleeping under trees versus in the open (n = 284).

A total of 301 observations were made on the locations of the rhinos sleeping sites (Figure 7.5). On very cold days rhinos slept on northern fronted slopes in valleys (kloof) while bathing in the sun. They always sought big trees with sufficient shadows in the wet season.

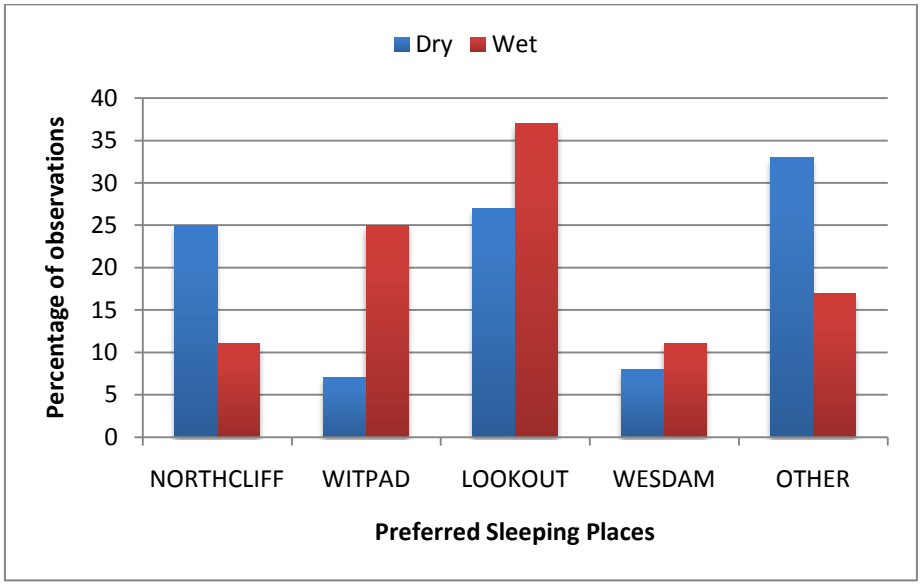


Figure 7.5: A comparison between sleeping sites utilized in wet and those utilized in dry seasons.

7.3.2. Eyesight assessment of white rhinos

Part of the initial experiment was to investigate the initial reaction of the rhinos immediately after spotting the mannequin. Five different initial reactions were observed and are described in Table 7.2. When a group of white rhinos were alerted to the presence of an intruder they appeared confused and uncertain how to react, shuffling around agitatedly, ready to run off, but then standing their ground again in a defensive rump-against-rump formation facing outwards in different directions (Figure 7.6). If the entire group saw the intruder or mannequin they stood in an alert position, touching each other shoulder-against-shoulder and facing the intruder or mannequin. Sometimes one member of the group would make a mock charge and then retreat again to its former position.

Figure 7.6: A typical reaction activity of white rhinos – "standing alert" in a defensive rump-against-rump formation facing all directions. (Photo: Courtesy; O. Van Nieuwholtz).

Table 7.2: Descriptions of the initial reactions of white rhinos to mannequins. (Photos: Courtesy; O. Van Nieuwholtz).

Reaction	Activity
Stand Alert 	Rhinoceros faces mannequin with ears pointed forward.
Mock Charge 	Rhinoceros rushes towards the mannequin for a short distance and then retreats to its previous position.
Ignore 	Rhinoceros looks up; takes notice of the mannequin and continues its previous activity.
Runaway 	Rhinoceros sees the mannequin, gets a fright and runs away.
Investigate 	Rhinoceros sees the mannequin, approaches slowly, and confronts the mannequin shoulder-to-shoulder with head held high.

The initial reaction of the rhinos to the mannequins was usually to "stand alert" (33% of observations, n = 28) and then walk towards the mannequin (Figure 7.7). If the rhinos saw the mannequins and then 'ignored' them (29%), it was because the mannequins were usually far enough not to be of any concern or threat to the rhinos. Once the mannequin was spotted an individual would be alerted and run away (5 %). If they approached the mannequin as a group, an individual would sometimes make a mock charge (17 %). Sometimes the rhinos would walk closer to the mannequins to investigate.

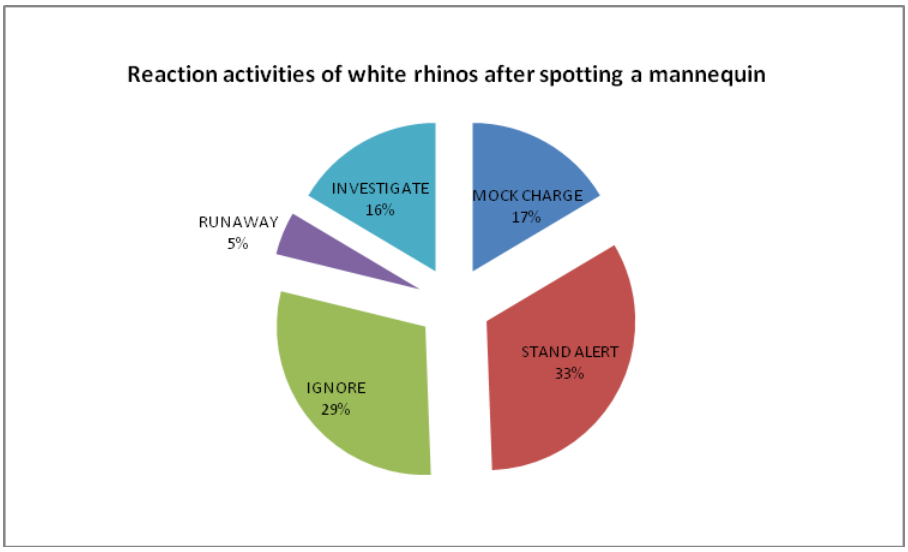


Figure 7.7: Reaction activity patterns for white rhinos after spotting a mannequin.

In almost half of the observations (46 %) the mannequins were spotted first by non adults (calves, adolescents and sub adults) (Figure 7.8). Adults saw the mannequins first for 31 % of the observations, whilst 23 % of the observations were when individuals from all age groups saw the mannequin/s simultaneously.

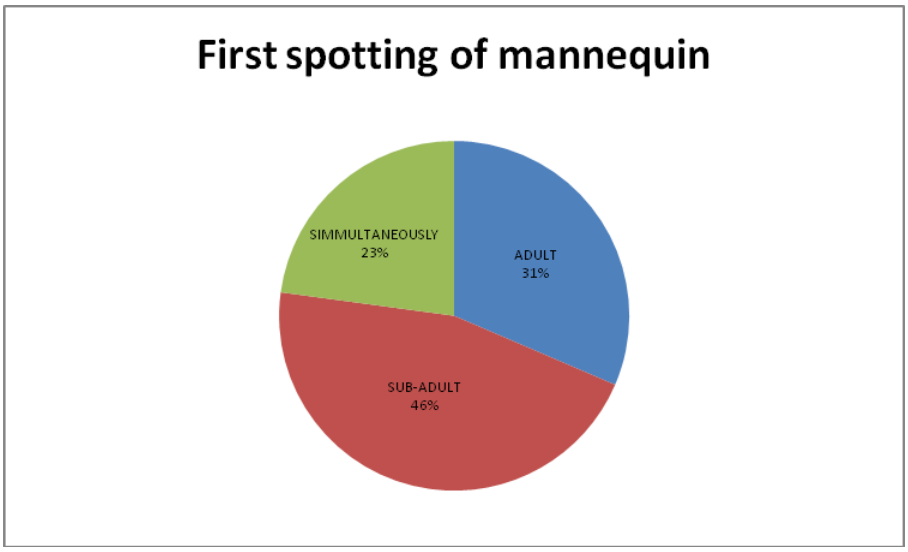
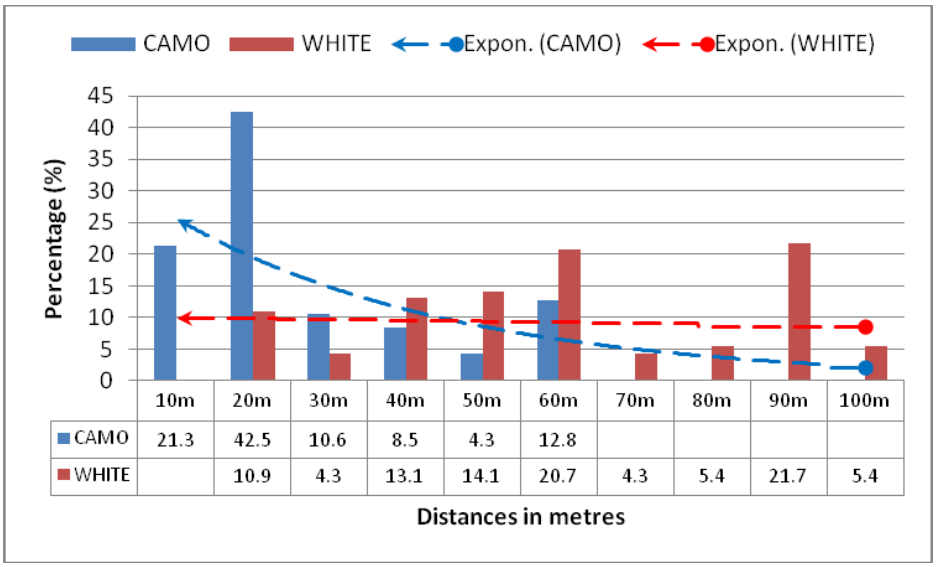


Figure 7.8: Representation of the age class which noticed the mannequins first.

Most of the camouflage mannequins observations came from within the 20 m category (27.5 %) followed by the 10 m (22.5 %) and thirdly from the 60 metre category (17.5 %). For the white mannequins most of the observations came from the 90 metre category (25.6 %) while the second-most came from the 50 metre category (16.7 %) and the third came from the 40 metre zone (15 %) (Figure 7.9).



	10m	20m	30m	40m	50m	60m	70m	80m	90m	100m
CAMO	21.3	42.5	10.6	8.5	4.3	12.8				
WHITE		10.9	4.3	13.1	14.1	20.7	4.3	5.4	21.7	5.4

Figure 7.9: The distance that white rhinos first noticed the mannequins.

The mean distance that the adult white rhinoceros saw the camouflaged mannequin was 29 metre (n = 19, SE = 2.139) and the white mannequin, 63 metre (n = 44, SE = 2.811). Both adults and sub-adults did however notice the mannequin dressed in white significantly sooner than the mannequin in camouflaged clothing (Adults: p = 0.000, n = 63; sub-adult: p = 0.000, n = 65). The sub-adult white rhinoceros saw the camoflage mannequin at 35 metre (n = 32, SE = 3.295) and the white mannequin at 61 metre (n = 33, SE 4.532) (Figure 7.10). There were no significant differences in the distance at which adults or sub-adults first noticed the mannequins.

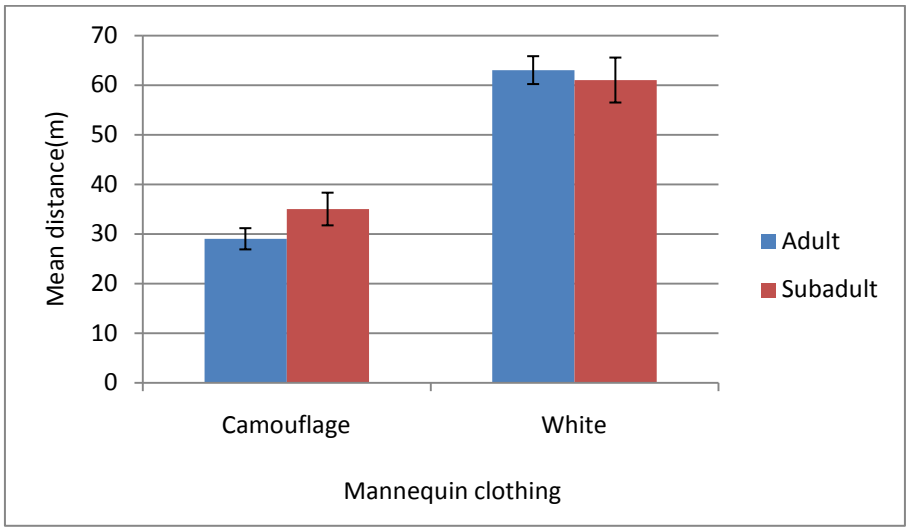


Figure 7.10: Comparison between sightings of the camo- and the white mannequin.

7.3.3. Walking distance per grazing period

The mean grazing period of the white rhinos was found to be 4.2 hours during the wet season and 4.0 hours during the dry season. The rhinos were observed as moving a mean distance of 1.433 km per grazing period (or 332.58 m/hour) during the wet season and 1.398 km per grazing period (or 358.2 m/hour) during the dry season. Comparisons between distances travelled per grazing period during the wet and dry seasons did not show significant differences (T = -0.09, P = 0.931, F = 1.13, df = 30).

7.3.4. Drinking patterns

The drinking period peaked mainly in the evening between 15:00 and 18:00 (Figure 7.11). Most of the observations (*n* = 192) took place during the day time and no night time drinking was observed between 21:00 and 06:00. Only a few observations (*n* = 14) were recorded of white rhinos drinking between the hours of 07:00 and 10:00 in the morning while the rest of the observations (*n* = 178) were noted between the hours 13:00 – 21:00 with a peak between 16:00 and 18:00. A maximum of nine drinking bouts by a single individual occurred during a single drinking session and ranged on average from 97.80 seconds during the first bout to 22.30 seconds during the ninth bout.

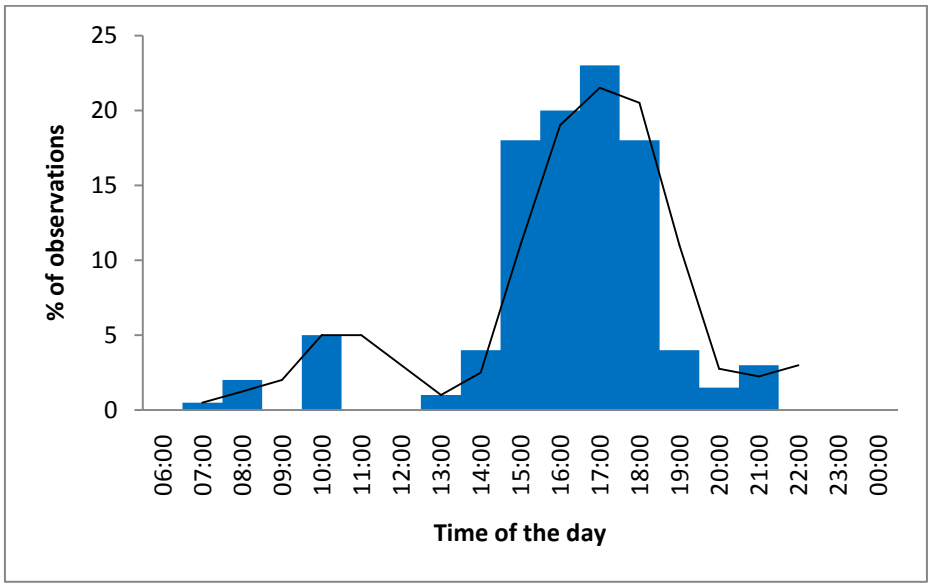


Figure 7.11: Percentage of observations of drinking behaviour at different times of the day during the study period (*n* = 192).

7.3.5. Hearing assessment of white rhinos

The experiment resulted in 117 recordings. The mean reaction time was 6.01 seconds (SE = 0.81), with mean wind speed of 2.10 km/h (SE= 0.38) and a mean of 85.06 decibels. The mean distance at which white rhinos first heard the recordings was 455. 04 m (SE = 32.4, Range = 217 - 710 m).

Spearman rank correlation on hearing indicated that a non-significantally negative correlation (R = -0.1299; p = 0.212) exists between decibels of music and distance at which rhinos initially react to the stimulus (Figure 7.12).

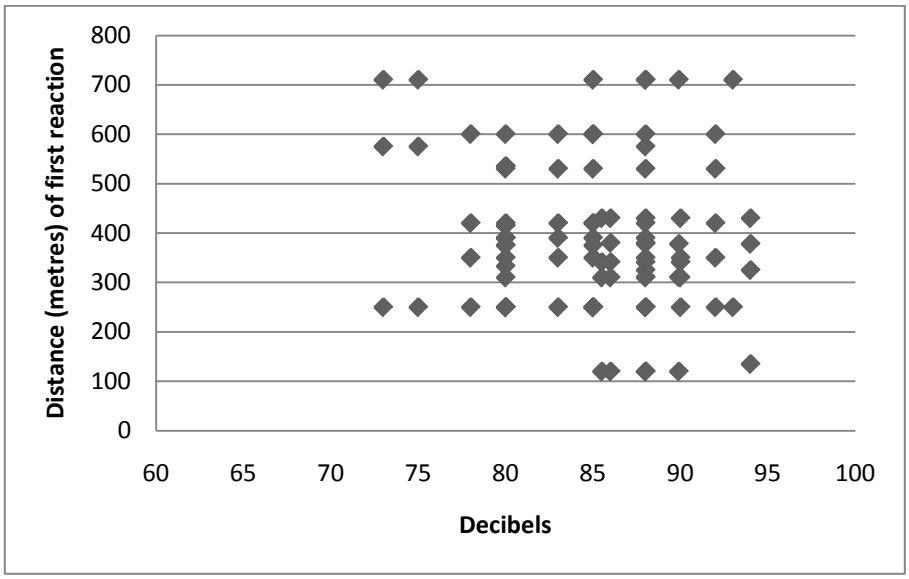


Figure 7.12: Distance at which rhinos first react to different decibels of music (*n* = 117).

7.3.6. White rhinoceros association with other species

During this study 62.5 % of observations recorded found that white rhinos did not associate with any other species except with cattle egrets (*Bubulcus ibis*) 17.3 % (Figure 7.13).

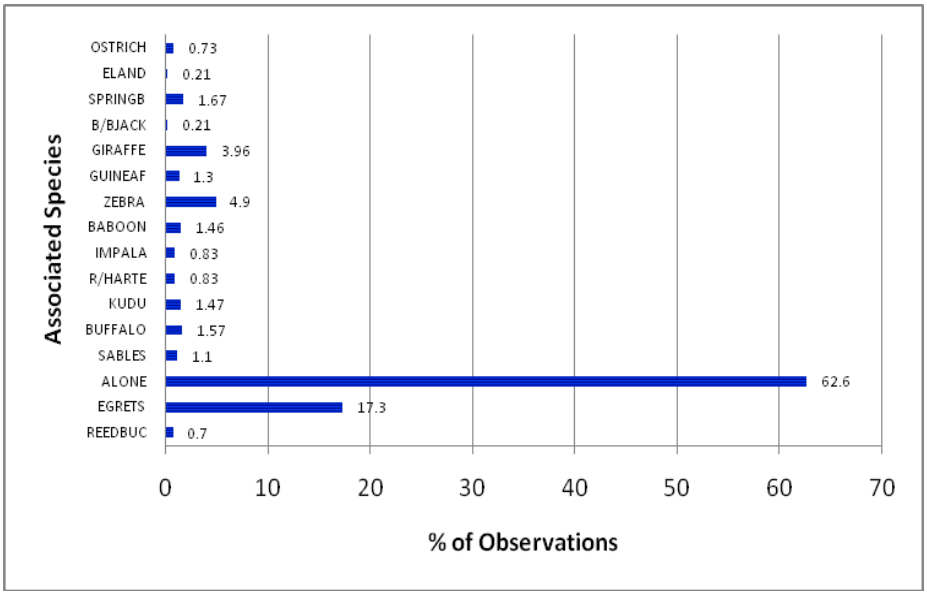


Figure 7.13: Association of white rhinos with other species (*n* = 961).

7.4. Discussion

7.4.1. Sleeping formations and locations

The sleeping of the four larger groups under certain trees in the study area had an influence on the ecology. By over-utilizing the soil and vegetation by means of rolling and lying they disturb the vegetation to a lesser extent. The small groups only have an influence under the trees which they slept.

7.4.2. Eyesight assessment of white rhinos

The initial reaction activities of the white rhinos suggest that they will not automatically attack an intruder but will rather try to chase it off with intimidation in the form of a mock charge. If the intruder remains they will stand alert until they feel it is safe for them to continue with their previous activity or they will circle into a defensive mode with their rump-against-rump formation until they sense where the intruder is and will then confront the agressor with a shoulder-against-shoulder position in a conventional battle line formation, moving slowly forward until they are right in front of the intruder.

It appears that white rhinos can see flat coloured materials (white) better than camouflage materials, given that the latter blend in with natural surroundings of the bush. Although no statistical significant differences were found between distances that adults or youngsters first spotted the mannequins, the youngsters did appear to see the camouflaged mannequin before the adults. Further research into this topic will be needed to verify if there really is a significant difference. If a real distance is found it could potentially suggest that one of the reasons that young white rhinoceros calves run in front of the cows is that they see better and will notice a threat sooner.

It must also be noted that most of the game spotted the mannequins from much greater distances than the rhinos. Two Cape Buffalo (*Cynceros caffer)* spotted the mannequin from 200 metre. They walked towards it with heads held high up to 50 metre from the mannequin, stopped, starring continuously at the mannequin, moved 5 metres stopped, stared, walked closer, until

they were 1 metre in front of it. They were staring at the mannequin until after dark without moving. The following morning the mannequin was still there untouched.

7.4.3. Walking distance per grazing period

Knowing the distances that white rhinos walk per grazing period will be of great assistance during management operations. Rangers will be able to locate animals quicker for management purposes. It is of great help to know that white rhinos seldomly move further than 2,5 km per grazing period. It is usefull to know that they move approximately 350 m/hour and that they are more alert to surroundings at the end of a feeding spell.

7.4.4. Drinking patterns

The drinking patterns reveal that white rhinos prefer late afternoon drinking. At WPGR it was noticed that the white rhinos came out daily to feed on *Cynodon hirsutus* (plant community 1) and drink water simmultaneasly. Player & Feely (1960) also observed rhinos drinking daily. This study did however, differ from the study done by Owen-Smith (1988) who mentioned a drinking frequency of 2 - 3 days. The white rhinos during this study had a mean of nine drinking bouts per drinking session which lasted for approximately 10 – 15 minutes. The drinking patterns reveal that white rhinos prefer late afternoon drinking. The dry, harsh environments often found in the Free State, force the animals to drink water daily. It is therfore important for the management of white rhinos to have sufficient drinking water available on a daily basis.

7.4.5. Hearing assessment of white rhinos

White rhinos hear well and react to various sounds ranging from the starting of a vehicle to that of a Whitewinged Tern (*Chlidonias leucopterus*). In other parts of southern Africa rhinos (black and white) rely on commensal birds such as oxpeckers (*Buphagus*) spp., glossy starlings (*Lamprotornis nitens)* and cattle egrets (*Bubulcus ibis*) to warn them of potential danger (Player & Feely, 1968; Moss, 1976; Owen-Smith, 1988). No oxpeckers occur on WPGR and white rhinos rely on alarm calls of helmeted guineafowls (*Numida meleagris*), blacksmith plovers *(Vanellus armatus*) and running antelope such as springbuck *(Antidorcas marsupialis*). I noticed

that if the rhinos are sleeping and a calf is disturbed by a sound, it will stand up and rub its front legs against each other, which alerts the cow who would then stand up and investigate.

7.4.6. White rhinoceros association with other species

In an earlier study I found that the white rhinos at WPGR spent most of their time alone (53.8 %) while cattle egrets (*Bubulcus ibis)* (18.7 %) were closely related during summer times (Jordaan, 1990). A total of 793 observations were made in 1990 and 961 observations in 2008. Similar results were achieved during this study. For the period of this study 62.5 % of observations recorded were alone and 17.3 % with cattle egrets (*Bubulcus ibis*). The cattle egrets seem to live in symbioses with the rhinos in the wet season, making the most of the insects being disturbed as the white rhinos feed.

7.5. References

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CHAPTER 8

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Due to the controversy as to whether or not white rhinos historically occurred in the Free State an investigation of their behaviour and ecology in a 'harsh' environment - the Highveld region of southern Africa was made.

8.1 Vegetation description of the study area in the WPGR.

The plant communities of the Viewpoint section of the WPGR were successfully identified, described, classified and ecologically interpreted. A vegetation map was produced. From these descriptions it became clear that the Viewpoint section is to a lesser extent heterogeneous in terms of floristic and plant community composition. The greatest floristic diversity is found on the rocky hills of Doringberg where the flora of grassveld and savanna meet and is therefore of high conservation value. On average, 35 species/400 m² were counted in plant community 5 on the Doringberg Mountain.

The various plant communities in the Viewpoint section of the game reserve were a good representation of the broader vegetation types in the reserve and can be used in the biological management plan of the game reserve. Some of these plant communities show an association with the Vredefort dome vegetation, Bloemfontein-Brandfort vegetation and to a lesser extent the Bankenveld and Drakensberg vegetation areas.

The Braun-Blanquet method proved to be an accurate way of identifying, describing and classifying delineated plant communities. A number of new indigenous plant species were recorded within these plant communities and were added to the inventories of the WPGR. No species of endemism were recorded.

Special management consideration should be given to the western section of the *Grewia occidentalis-Panicum maximum* woodland (Vegetation type 4.4) to ensure the continued existence of species within this community. A lack of seedlings within this community is of

great concern. Special attention should be paid to rehabilitating the prevailing soil erosion. Game, particularly white rhinos tend to over utilize certain areas in this community for shelter. The eroded areas should be rehabilitated and fenced off to allow progression of plant succession.

The high occurrence of exotic plant species within both the study area and the reserve also need attention and should be managed. Another dilemma in the study area is the thickening of indigenous species such as *Acacia karroo* and *Asparagus laricinus*. They too should be managed in areas, such as plant sub-community 4.1, 4.2, and 4.4, where they cause serious problems that could lead to veld degradation.

8.2 The ecological carrying capacity of the study area.

The ecological carrying capacity of the study area indicates veld condition from moribund to over-utilization in certain areas. Results from this study suggest that there is sufficient food available for the current number of game present on WPGR. The game numbers of the medium and long grass feeders should be allowed to increase in order to utilize the large quantity of food. Until such a period plant sub-community 2.1, 2.2 and plant community 3 should be mowed or burnt to force the animals to start utilizing these areas. It must be noted that certain areas that are being over-utilized by the white rhinos, such as their favourite sleeping places, should not be seen as a negative influence but rather as a refuge during runaway veld fires.

8.3. Population structure

The individual white rhinoceross were successfully identified, monitored and counted using the methods previously described. The current departmental policy to carry nineteen white rhinos on the reserve could be increased to twenty, with a recommended sex ratio of 1:9

This study was conducted in an area with very cold winters and hot, dry summers. Although the Free State is a potentially harsh environment for the white rhinoss to survive in, they do well given that their basic living requirements are met, such as water, enough shelter and short grass.

8.4. Total home range

The total home range of the adult bull (no. 10) and adult cow (no. 7), as representatives of all the other white rhinos, are adequate. The home ranges for these individuals were comparable to other studies done in Africa, despite WPGR being relatively small compared to the other game reserves. The reserve therefore provides enough space for the population to survive in.

8.4.1 Ranging patterns within the study area

There were no significant seasonal differences in ranging sizes between the wet and the dry season within the study area. All white rhinos utilized the isolated short grass patches within plant community 1, plant community 2, plant community 3, plant community 4 and plant community 5 of the study area. Habitat heterogeneity, possibly in conjunction with permanent water, made it possible for the white rhinos to restrict their home range.

8.5. Habitat utilization by white rhinos

The white rhinos frequented different habitat types unequally. They prefered the Trees and Shrubveld, Savanna, Thornveld and the River Community. The less frequently utilized habitat types were Grassveld, Wetlands and Damkom. During the twelve month study period the white rhinos spent 80% of their time in a habitat with cover and 20 % in grassland. The cold and harsh winters forced the animals into a trees and shrubs habitat (plant community 4.4) for shelter and grassland and wetlands (plant community 2.1 & 2.2) for food. With the exception of Trees and Shrub habitat, the habitat utilization differs somewhat from a similar project done some twenty years before this study period on the same reserve. This could be due to the influence of the Allemanskraal Dam with its full capacity (100 %) in the first study period and the almost empty (23 %) dam during the last study of 2007 – 2008.

During this study white rhinos preferred mainly plant community 4.4 (Trees & Shrubs) in the dry season and plant community 4.1 (River community) during wet season. During the dry season (March – July, in this case) the lactating cows moved deep into the thickets of steep cliffs and gullies (plant community 4.4) to feed on green grasses such as *Panicum maximum* which survived the frost by finding shelter under trees and shrubs such as *Ehretia rigida,*

Searsia undulata, Grewia occidentalis, etc. The female and new born calf remain in these thickets for the first few days before entering the open veld and savanna areas to graze on their normal diet.

8.6. Diet selection of white rhinos

Thirty five plant species were observed to be eaten and included 28 grass species, 1 shrub species and 6 forb species. No browsing was observed. They preferred *Atriplex semibaccata* during the dry season. Short grasses comprised the most important food resource. The results recorded in chapter 4 indicate that white rhinos did not use all plant communities within their home range to an equal extent. The complete avoidance of some communities suggests that the white rhinos either obtain their food from another source or that the topography of the areas in which these communities occur is unsuitable.

During the dry season the diet selection changed to a variety of grass species and even forbs. A total of 19 grass species were utilized in the wet season and 27 during the dry season. They found green grass such as *Hemarthia altissima* palatable during the dry season.

8.7. Activity budgets for white rhinos

The data reveals that, the white rhinos allocates its time mainly to feeding and resting rather than to any other activity. White rhinos move literally from one core area of resource to the next available core area. The same behaviour applies when the rhinos are resting. They move from one suitable sleeping or resting place to another between grazing periods. Rhinos will walk through suitable shelter to the ideal resting place to spend some hours resting. White rhinos allocates a small percentage of its time to other activities such as playing, rubbing, wallowing and fighting.

8.8. Sleeping patterns, eyesight assessment and other anecdotal observations of white rhinos

The collecting of the anecdotal data throughout the study period has some management implications:

The camping of the four larger groups under certain trees especially in plant sub-community 4.2 and 4.4 in the study area had an influence on the ecology. It is not a serious threat and could be remained as such.

The reaction activities of the white rhinos showed that they will not easily attack an intruder but will rather try to chase it off with a mock charge. Animals can now be stalked or avoided with more safety by dressing appropriately and remaining out of range of the animals sight.

Knowing the distances that white rhinos walk per grazing period would be of great assistance during management operations. During monitoring activities rangers will be able to locate animals that disappear into thick vegetation relativley quickly by being able to predict the distances which they move.

The drinking patterns reveal that white rhinos prefer late afternoon drinking. The harsh climate conditions found in the Free State, force the animals to drink water daily. It is therfore important for the management of white rhinos to have sufficient drinking water available on a daily basis.

The hearing of the white rhinos is well developed but due to their poor eyesight, the use of alarm calls from other species as indicators of potential threats is important to their survival. Management needs to be aware of which species rhinos rely on for this information and take this into consideration when stocking reserves.

White rhinos do not appear to intentionally associate with game species, although cattle egrets were associated with rhinos during the wet season. This however, is more likely the cattle

egrets associating with the rhinos for the benefit of insects being disturbed by the rhinos on which the egrets rely on for food.

8.9. Suggestions for further research

The information obtained from this study will be of great value to breeders of white rhinos in intensive breeding programmes. A need exists to compile management plans which will aid these breeding programmes to farm with white rhinos under intensive camp systems effectively and sustainable.

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Appendix A: A complete list of all the plant species collected on the Viewpoint Section of the WPGR during the study period. Naturalised or exotic taxa are marked with an asterisk (*) before the name. The list is according to Germishuizen & Meyer, 2003.

PTERIDOPHYTA

n	**FAMILIES** **GENERA – SPECIES – TAXA**
	ANEMIACEAE
1.	*Mohria caffrorum* Sw.
	PTERIDACEAE
1.	*Cheilanthus eckloniana* (Kunze) Mett.
2.	*Cheilanthus hirta* Sw.
3.	*Pellaea calomelanos* Sw.
	SELAGINELLACEAE
1.	*Selaginella dregei* (C.Presl) Hieron.

MONOCOTYLEDONS

n	**FAMILIES** **GENERA – SPECIES – TAXA**
	AMARYLLIDACEAE
1.	*Ammocharis coronica* (Ker Gawl.) Herb.
2.	*Crinum bulbispermum* (Burm.f) Milne-Redh. & Schweick.
3.	*Boophone disticha* (L.f.) Herb.
	ANTHERICACEAE
1.	*Anthericum fasciculatum* Baker = *Chlorophytum fasciculatum*
	ASPARAGACEAE
1.	*Protasparagus cooperi* Baker
2.	*Asparagus densiflorus* (Kunth) Jessop
3.	*Asparagus laricinus* Burch.
4.	*Protasparagus setaceus* (Kunth) Jessop
5.	*Protasparagus suaveolens* Burch.
	ASPHODELACEAE
1.	*Bulbine capitata* Poelln.
2.	*Trachyandra asperata* Kunth var. *basutoensis* (Poelln.) Oberm.
3.	*Trachyandra asperata* Kunth var. *nataglencoensis* (Kunth) Oberm.
	COMMELINACEAE
1.	*Commelina africana* L. var. *africana*
	CYPERACEAE
1.	*Bulbostylus burchellii* (Ficalho & Hiern) C.B. Clarke
2.	*Cyperus esculentus* L. var. *esculentus*
3.	*Cyperus obtusiflorus* Vahl var. *flavissimus*
4.	*Cyperus* spp. L.
5.	*Mariscus congestus* (Vahl) C.B. Clark
	HYACINTHACEAE

1.	*Urginea depressa* Baker = *Drimia depressa*
2.	*Urginea* sp.
	IRIDACEAE
1.	*Morea thomsonii* Baker
	POACEAE
1.	*Andropogon schirensis* A. Rich.
2.	*Anthephora pubescens* Nees
3.	*Aristida adscensionis* L.
4.	*Aristida bipartita* (Nees) Trin. & Rupr.
5.	*Aristida congesta* Roem. & Scholt. subsp. *barbicollis* (Trin. & Rupr.)
6.	*Aristida congesta* Roem. & Scholt. subsp. *congesta*
7.	*Aristida diffusa* Trin. subsp. *burkei* (Stapf) Melderis
8.	*Aristida stipitata* Hack. subsp. *graciliflora* (Pilg.) Melderis
9.	*Brachiaria marlothii* (Hack.) Stent
10.	*Brachiaria serrata* (Thunb.) Stapf
11.	**Bromus catharticus* Vahl
12.	*Chloris virgata* Sw.
13.	*Cymbopogon excavatus* (Hochst) Stapf ex Burt Davy
14.	*Cymbopogon plurinodis* (K.Schum.) C.E. Hubb. = *C. pospischilii*
15.	*Cynodon dactylon* (L.) Pers.
16.	*Cynodon hirsutus* Stent
17.	*Digitaria argyrograpta* (Nees) Stapf
18.	*Digitaria eriantha* Steud.
19.	*Diheteropogon filifolius* (Nees) Clayton
20.	*Elionurus muticus* (Spreng.) Kuntze
21.	*Enneapogon cenchroides* (Roem. & Schult.) C.E. Hubb.
22.	*Enneapogon scoparius* Stapf
23.	*Eragrostis curvula* (Schrad.) Nees
24.	*Eragrostis echinochloidea* Stapf

25.	*Eragrostis gummiflua* Nees
26.	*Eragrostis lehmanniana* Nees var. *lehmanniana*
27.	*Eragrostis obtusa* Munro ex Ficalho & Hiern
28.	*Eragrostis plana* Nees
29.	*Eragrostis racemosa* (Thunb.) Steud.
30.	*Eragrostis rotifer* Rendle
31.	*Eragrostis superba* Peyr.
32.	*Eustachys paspaloides* (Vahl) Lanza & Mattei
33.	*Fingerhuthia africana* Lehm.
34.	*Helictotrichon turgidulum* (Stapf) Schweick.
35.	*Hemarthria altissima* (Poir.) Stapf & C.E. Hubb.
36.	*Hyparrhenia hirta* (L.) Stapf
37.	**Lolium perenne* L.
38.	*Panicum coloratum* L. var. *coloratum*
39.	*Panicum maximum* Jacq.
40.	*Phragmites mauritianus* (Cav.) Steud.
41.	*Setaria incrassate* (Hochst.) Hack.
42.	*Setaria sphacelata var. sphacelata* (Schumach.) Moss var. *sphacelata*
43.	*Setaria verticillata* (L.) P. Beauv.
44.	*Sporobolus africanus* (Poir.) Robyns & Tournay
45.	*Sporobolus fimbriatus* (Trin.) Nees
46.	*Tetrachne dregei* Nees
47.	*Themeda triandra* Forsk.
48.	*Tragus berteronianus* Schult.
49.	*Tragus racemosus* (L.) All.
50.	*Trichoneura grandiglumis* (Nees) Ekman
51.	*Triraphis andropogonoides* (Steud.) E. Philips
52.	*Urochloa mosambicensis* (Hack.) Dandy
53.	*Urochloa panicoides* P. Beauv.

DICOTYLEDONS

n	**FAMILIES** **GENERA – SPECIES – TAXA**
	ACANTHACEAE
1.	*Barleria macrostegia* Nees
2.	*Barleria marlothii* Engl. = *B. damarensis*
3.	*Barleria obtusa* Nees (4)
4.	*Blepharis squarrosa* (Nees) T. Anderson
5.	*Crabbea acaulus* N.E.Br.
6.	*Crabbea agustifolia* Nees
7.	*Crabbea hirsute* Harv.
8.	*Justicia anagalloides* (Nees) T. Anderson
	AMARANTHACEAE
1.	**Achyranthus aspersa* L. var. *aspersa*
2.	**Alternanthera pungens* Kunth
	ANACARDIACEAE
1.	*Searsia lancea* L.f.
2.	*Searsia leptodictya* Diels
3.	*Searsia pyroides* Burch. var. *pyroides*
4.	*Searsia undulate* Jacq.
	APIACEAE
1.	**Ciclospermum leptophyllum* (Pers.) Sprague
	APOCYNACEAE
1.	*Cynanchum ellipticum* (Harv.) R.A. Dyer
2.	*Brachystelma oianthum* Schltr.
	ASTERACEAE
1.	*Arctotis venusta* Norl.
2.	*Berkheya* spp.

3.	*Berkheya pinnatifida* (Thunb.) Thell. subsp. *pinnatifida*
4.	**Bidens pilosa* L.
5.	*Cineraria lyrata* DC (15) = *C. lyratiformis* Cron
6.	**Cirsium vulgare* (Savi) Ten.
7.	**Conyza bonariensis* (L.) Cronquist
8.	*Conyza floribunda* Kunth = *C. albida*
9.	*Conyza podocephala* DC
10.	*Conyza* sp.
11.	*Cotula anthemoides* L.
12.	*Dicoma anomala* Sond.subsp. *cirsioides* (Harv.) Wild (9)
13.	*Gazania krebsiana* Less. subsp. *serrulata* (DC) Roessler
14.	*Geigeria burkei* Harv. Subsp. *burkei* var. *burkei*
15.	*Haplocarpha lyrata* Harv.
16.	*Helichrysum acutatum* DC
17.	*Helichrysum* spp.
18.	*Lactuca capensis* Thunb. = *L. inermis*
19.	**Lactuca serriola* L.
20.	*Nidorella resedifolia* DC subsp. *resedifolia*
21.	*Pentzia viridis* Kies
22.	**Schkuhria pinnata* (Lam.) Cabrera
23.	*Senecio burchelii* DC.
24.	*Senecio coronatus* (Thunb.) Harv.
25.	*Senecio hastatus* L.
26.	*Senecio inauquidens* DC.
27.	*Senecio* sp.
28.	*Senecio* sp.
29.	*Senecio* sp.
30.	*Senecio* sp.
31.	*Senecio* sp.

32.	*Senecio* sp.
33.	**Tagetes minuta* L.
34.	*Tarchonanthus camphorates* L.
35.	*Ursina nana* DC subsp. *nana*
36.	**Zinnia peruviana* (L.)L.
	BORAGINACEAE
1.	*Ehretia rigida* (Thunb.) Druce subsp. *rigida*
	BRASSICACEAE
1.	*Lepidium africanum* (Burm.f.) DC. subsp. *africanum*
2.	**Lepidium bonariense* L.
	CAMPANULACEAE
1.	*Wahlenbergia undulate* (L.f) A.DC.
	CAPPARACEAE
1.	*Cleome gynandra* L.
2.	*Cleome rubella* Burch.
	CARYOPHYLLACEAE
1.	*Dianthus basuticus* Burt Davy subsp. *basuticus* var. *basuticus*
	CELASTRACEAE
1.	*Maytenus heterophylla* (Eckl. & Zeyh.) = *Gymnosporia heterophylla*
	CELTIDACEAE
1.	*Celtis africana* Burm.
	CHENOPODIACEAE
1.	*Atriplex semibaccata* R.Br.
2.	**Chenopodium album* L.
3.	**Chenopodium murale* L. var. *murale*
4.	*Salsola etoshensis* Botsch.
	CONVOLVULACEAE
1.	*Cuscota* sp. L.
2.	*Cuscuta africana* Willd.

3.	*Evolvulus alsinoides* (L.) L.
	CRASSULACEAE
1.	*Kalanchoe paniculata* Harv.
2.	*Kalanchoe rotundifolia* (Haw.) Haw.
	EBENACEAE
1.	*Diospyros lycoides* Desf. subsp. *lycioides*
2.	*Euclea crispa* (Thunb.) Gürke subsp. *crispa*
	EUPHORBIACEAE
1.	*Acalypha angustata* Sond.
2.	*Chamaecyce inaquilatera* (Sond) Sojak = *Euphorbia inaequilatera*
3.	*Chamaesyce* sp.
4.	*Clutia pulchella* L. var. *pulchella*
	FABACEAE
1.	*Acacia karoo* Hayne
2.	*Argyrolobium pauciflorum* Eckl. & Zeyh. var. *pauciflorum*
3.	*Indigofera alternans* DC. var. *alternans*
4.	*Indigofera filipes* Benth. Ex Harv.
5.	*Melolobium colycinum* Benth.
6.	*Rhynchosia minima* (L.) DC. var. *prostrata* (Harv.) Meikle
7.	*Rhynchosia totta* (Thunb.) DC. var. *totta*
8.	*Tephrosia capensis* (Jacq.) Pers. var. *capensis*
	FLACOURTIACEAE
1.	*Scolopia zeyheri* (Nees) Harv.
	GERANIACEAE
1.	*Monsonia angustifolia* E.Mey. ex A. Rich.
	LAMIACEAE
1.	*Actrome hispida* Benth.
2.	*Plectranthus hereoensis* Engl.
3.	*Plectranthus* spp.

4.	*Salvia* spp.
5.	*Salvia runcinata* L.f.
6.	*Stachys aethopica* L.
7.	*Stachys hyssopoides* Burch. ex Benth.
8.	*Teucrium trifidum* Retz.
	MALVACEAE
1.	*Hibiscus microcarpus* Garcke
2.	*Hibiscus pusillus* Thunb.
3.	*Hibiscus trionum* L.
4.	*Hibiscus* sp.
5.	*Pavonia burchellii* (DC.) R.A. Dyer
6.	*Sida* sp.
	MESEMBRYANTHEMACEAE
1.	*Delosperma cooperi* (Hook.f.) L. Bolus
2.	*Delosperma herbeum* (N.E.Br.) N.E.Br.
3.	*Delosperma* sp.
4.	*Sphalmanthus congestus* (L. Bolus) = *Phyllobolus congestus*
	NYCTAGINACEAE
1.	*Commicarpus pentandruss* (Burch.) Heimerl
	OLEACEAE
1.	*Olea europaea* L. subsp. *africana* (Mill.) P.S. Green
	ONAGRACEAE
1.	**Oenothera rosea* L'Hér. Ex Aiton
2.	**Oenothera stricta* Ledeb. Ex Link subsp. *stricta*
	OXALIDACEAE
1.	*Oxalis depressa* Eckl. & Zeyh.
	PORTULACACEAE
1.	*Talinum caffrum* (Thunb.) Eckl. & Zyeh.
	RANUNCULACEAE

1.	*Clematis brachiata* Thunb.
	RHAMNACEAE
1.	*Ziziphus mucronata* Willd. Subsp. *mucronata*
	RUBIACEAE
1.	*Kohautia lasiocarpa* Klotzsch = *K. caespitosa subsp. brachyloba*
2.	*Kohautia* spp.
	SCROPHULARIACEAE
1.	*Sutera caerulea* (L.f.) Hiern (Hiern in part)
2.	*Sutera palustris* Hiern = *Sutera levis*
3.	*Sutera* spp.
4.	*Walafrida densiflora* (Rolfe) = *Selago densiflora*
5.	*Walafrida tenuifolia* Rolfe = *Selago tenuifolia*
	SOLANACEAE
1.	*Lycium afrum* L.
2.	**Solanum elaeagnifolium* Cav.
3.	*Solanum incanum = S. lichtensteinii*
4.	*Solanum penduriforme* E. Mey.
5.	**Solanum sisymbriifolium* Lam.
	STERCULIACEAE
1.	*Hermannia resedifolia* (Burch.) R.A.Dyer = *H. erodioides*
2.	*Hermannia transvaalensis* Schinz
3.	*Hermannia* spp.
	TILIACEAE
1.	*Corchorus asplenifolius* Burch.
2.	*Grewia occidentalis* L. var. *occidentalis*
	VERBENACEAE
1.	*Chascanum pinnatifidum* (L.f.) E.Mey. var. *pinnatifidum*
2.	*Lippia scaberrima* Sond.
3.	**Verbena bonariensis* L.

4.	**Verbena officinalis* L.
	VITACEAE
1.	*Rhoicissus tridentata* (L.f.) Wild & R.B. Drumm. subsp. *cuneifolia*
	ZYGOPHYLLACEAE
1.	*Tribulus terrestris* L.

Appendix B: Evaluation sheet used to determine veld condition of grassland (Kruger, 1983).

NAME OF LOCALITY:			**TOTAL SCORE:**				
	a)	**PLANT COVERAGE**					
CRITERIA	Density of vegetation	Infiltration vs drainage intensity	Look for exposed areas	Perennial vegetation	Stability		**SCORE**
VALUE	Very poor 0-35	Poor 35-45	Satisfactory 45-55	Good 55-65	Very Good 65-75	Exceptional 75+	
POINT out of 100							
	b)	**BOTANICAL COMPOSITION**					
CRITERIA	Relationship between: productive-unproductive, desired-inferior	Productivity in terms of tastefulness	Top soil production	Resistance against grazing	Drought resistance	Fire resistance	**SCORE**
VALUE	Exclusively undesired 0-35	Mostly undesired 35-45	Desired & undesired 45-55	Mostly desired 55-65	Exclusively desired 65+		
POINT out of 100							
	c)	**GROWTH POTENTIAL**					
CRITERIA	Look at growth rate	Look at leave color	Look at leave size	Tuff of grass sizes	New seedlings	Dead grass tuffs	**SCORE**
VALUE	Very poor 0-35	Poor 35-45	Satisfactory 45-55	Good 55-65	Very Good 65-75	Exceptional 75+	
POINT out of 100							
	d)	**CONDITION OF SOIL SURFACE**					
CRITERIA	Fertility of the soil	Stability of soil in terms of erosion	Quantity of organic material	The infiltration Capacity			**SCORE**
VALUE	Advanced Deterioration 0-35	High degree deterioration 35-45	Moderate deterioration 45-55	Low degree deterioration 55-65	Insignifica. deteriorat. 65-75	No deterioration 75+	
Point out of 100							
	e)	**INSECT DAMAGE**					
CRITERIA	Look at presence of ants	Presence of rodents	Presence of hares	Presence of termites			**SCORE**
VALUE	Very severe 0-35	Severe 35-45	Moderate 45-55	Little 55-65	Insignific. 65-75	None 75+	
Point out of 100							
EQUATION	$V = (a \times 0.3) + (b \times 0.3) + (a \times b \times 0.002) + (c \times 0.05) + (d \times 0.1) + (e \times 0.05)$ V = Veldcondition						

An evaluation sheet used to determine veld condition for bushveld (trees and shrubs).

NAME OF LOCALITY:			**TOTAL SCORE:**				
	a)	**TREE & SHRUB COVERAGE**					
CRITERIA	Density of trees and shrubs	Visibility through bush/forest	Open spaces as seen from top	Young versus old Trees	Stability		**SCORE**
VALUE	Very poor 0-35	Poor 35-45	Satisfactory 45-55	Good 55-65	Very Good 65-75	Exceptional 75+	
POINT out of 100							
	b)	**WOODY COMPOSITION**					
CRITERIA	Relationship between: productive-unproductive, desired-inferior	Productivity in terms of tastefulness	Number of leaves up to 2 metre	Deciduous versus non-deciduous	Drought resistance	Fire resistance	**SCORE**
VALUE	Exclusively undesired 0-35	Mostly undesired 35-45	Desired & undesired 45-55	Mostly desired 55-65	Exclusively desired 65+		
POINT out of 100							
	c)	**GROWTH POTENTIAL**					
CRITERIA	Look at growth rate	Gaze at leave color	Look at leave size	Tree size – large/small	New seedlings	Dead branches & trees	**SCORE**
VALUE	Very poor 0-35	Poor 35-45	Satisfactory 45-55	Good 55-65	Very Good 65-75	Exceptional 75+	
POINT out of 100							
	d)	**CONDITION OF SOIL SURFACE**					
CRITERIA	Fertility of the soil	Stability of soil in terms of erosion	Quantity of organic material	The infiltration capacity	Signs of fire	Presence of moss	**SCORE**
VALUE	Advanced Deterioration 0-35	High degree deterioration 35-45	Moderate deterioration 45-55	Low degree deterioration 55-65	Insignifica. deteriorat. 65-75	No deterioration 75+	
POINT out of 100							
	e)	**INSECT & RODENT DAMAGE**					
CRITERIA	Look at presence of ants/termites	Presence of rodents	Presence of hares	Presence of bugs/beetles	Presence of birds		**SCORE**
VALUE	Very severe 0-35	Severe 35-45	Moderate 45-55	Little 55-65	Insignifi-cant 65-75	None 75+	
POINT out of 100							
EQUATION	V = (a x 0.3) + (b x 0.3) + (a x b x 0.002) + (c x 0.05) + (d x 0.1) + (e x 0.05) V = Veldcondition						