POSSIBLE PREDICTORS OF SABLE ANTELOPE (*Hippotragus niger*) DECLINE IN KGASWANE MOUNTAIN RESERVE.

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DECLARATION

I declare that this thesis is my own, unaided work. It is being submitted for the degree of Masters in Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

Phenya Tshenkeng (Student Number: 693786)

Date: 05/09/2017

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ABSTRACT

Sable antelope numbers have been declining in protected areas of South Africa and they are listed as Vulnerable in the National Red List Assessment. In Kruger National Park, since 1986, the abundance of sable antelope has declined from 2240 to just under 400 individuals in 2014, making them at risk of local extirpation.

The aim of the study was to explore some of the possible explanations, not explored before, for sable antelope (*Hippotragus niger*) perceived decline in the Kgaswane Mountain Reserve (KMR), in the North-West Province of South Africa. I therefore looked at assessing sable antelope use of space in relation to 'high risk' areas as determined by distances to fences, campsites and roads; determining the seasonal variations in the nutritional status of sable antelope; estimating calves recruitment, survival and population sex ratio. To achieve these objectives two sable antelope heifers were collared in the reserve, one from the 'vlei' herd and one from the 'woodland' herd.

Both herds avoided 'high risk' areas, especially areas close to camping huts. The herds made little use of areas where there was lots of human movement. I expected the herds to utilise areas close to fences, especially after security burns along the perimeter of the park, but that was not the case as these areas were little utilised. Both herds preferred the tall grassland type of vegetation. As expected both herds utilised burnt areas and the woodland herd used these areas more than the vlei herd.

Faecal crude protein and faecal phosphorus values during the dry season were higher compared to a previous study in KMR, which seems to suggest that currently the sable population in KMR is doing better compared to 2002-2003. Since 2011 until 2014, there were a total of 34 calves born with 15 missing after the study but only one mortality recorded. Therefore the reasons for the missing calves are still unclear. The best way to monitor survival of populations for long term studies would be to mark individuals in a population but unfortunately this was impossible for this study. I expected more females to be born as compared to males and this was not the case as there were more males (20) born than females (14), further indicating that potentially currently the population is doing better than in the past.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1: GENERAL INTRODUCTION

CHAPTER 2: METHODOLOGY

CHAPTER 3: RESULTS

LIST OF TABLES

CHAPTER 1: GENERAL INTRODUCTION

CHAPTER 3: RESULTS

LIST OF ABBREVIATIONS AND ACRONYMS

AF - Adult Female

AM - Adult Male

AU - Adult Unknown

CP - Faecal Crude Protein

CV - Coefficient of Variance

CW - Closed Woodland

ED - Early Dry Season

et al.- *et alia* and others

FN - Faecal Nitrogen

FP - Faecal Phosphorus

GPS - Global Positioning System

IUCN - International Union for Conservation of Nature

JF - Juvenile Female

JM - Juvenile Male

JU - Juvenile Unknown

KMR - Kgaswane Mountain Reserve

KNP - Kruger National Park

LD - Late Dry Season

MG - Moist Grassland

MOU - Memorandum of Understanding

NWPB - North West Parks Board

OS - Open Shrubland

P - Phosphorus

pers.obs - Personal Observation

P_f - Faecal phosphorus

PNP - Pilanesberg National Park

READ - Rural, Environment and Agricultural Department

RF - Rainbow Farms

SD - Standard Deviation

SF - Sub-Adult Female

SM - Sub-Adult Male

SPSS - Statistical Package for the Social Science

SSC - Species Survival Commission

SU - Sub-Adult Unknown

TG - Tall Grassland

Tr – Transition Season

UHF - Ultra High Frequency

UNESCO - The United National Education, Scientific and Cultural Organisation

VH –Vlei Herd

VHF - Very High Frequency

WH - Woodland Herd

CHAPTER 1: GENERAL INTRODUCTION

1.1 AIM

The aim of the project is to explore some of the possible explanations, not explored before, for sable antelope (*Hippotragus niger*) perceived decline in the Kgaswane Mountain Reserve, in the North-West Province, South Africa.

1.2 MOTIVATION FOR THE STUDY

According to the International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Antelope Specialist Group (2008), the global conservation status of sable antelope is categorised as least concern. However their numbers have been declining in protected areas of South Africa and they are listed as Vulnerable in the National Red List Assessment (Parrini *et al.,* 2016). For example, since 1986, the abundance of sable antelope in Kruger National Park has declined from 2240 to just under 400 individuals in 2014 (Parrini *et al.*, 2016), making them at risk of local extirpation (Owen-Smith *et al.*, 2011).

Kgaswane Mountain Reserve (KMR) in the North West province, a provincial park in the Magaliesberg mountain range not far from where the first sable sighting was recorded (Harris 1852), was deemed to provide suitable habitat for sable antelope. About 12 sable antelope were initially introduced in 1967 when the reserve was proclaimed (Wilson, 1975). Since then, sable antelope numbers have been increasing, and in more recent years numbers have been fluctuating (Table 1.1). Based on game counts from 1999 until 2014, average sable count was 58 with maximum count of 79 (2003) and minimum count of 37 (2010) (Nel *et al.*, 2014).

There are other large herbivores in the reserve that despite being managed might potentially compete with sable antelope, like zebra (*Equus quagga burchellii*), red hartebeest (*Alcelaphus busephalus*) and waterbuck (*Kobus ellipsiprymnus*) (Table 1.1). In addition, KMR has experienced low survival rate of sable juveniles in the past years (pers.obs). This is not new since, based on the study by Wilson (1975) in the same reserve, the proportions of sable juveniles which were seen annually were higher than that of yearlings suggesting a high mortality rate in the first year of life. This should be a serious concern because other herbivores' juveniles survive in the same environment.

Table 1.1: Animal population estimates in Kgaswane Mountain Reserve from aerial census data for the period 1999-2014 (Source-Tshenkeng, 2015).

Species	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Blesbok							3			5	6	7	10	14	18	24
Common Reedbuck	16	18	8	14	11	4	6			12	4	4	5	13	12	14
Eland	67	92	73	57	43	43	50	49	83	51	46	57	85	74	71	50
Giraffe	1		2	2	1	1	1									
Red Hartebeest			105	84	72	61	75	73	71	96	97	80	98	103	77	86
Impala	59	67	100	120	108	84	122	139	155	104	117	84	81	83	97	95
Klipspringer				5	16	12	10			4			6		3	2
Kudu		55	23	10	14	22	20	47	45	19	42	4	15	19	12	17
Mountain Reedbuck	265	204	152	193	130	133	148	123	109	49	46	17	41	33	38	21
Oribi				6	4	7	3	9			4	2	6	10	2	3
Roan	4	5	3	4	3	1	1	4		2	3		3	3	1	2
Sable	**69**	**77**	**72**	**71**	**79**	**62**	**39**	**58**	**73**	**50**	**43**	**37**	**45**	**52**	**49**	**51**
Springbok	56	43	28	20	31	24	30	26	23	11	9	5	7	10	12	12
Waterbuck	67	85	42	32	58	49	35	75	72	67	107	81	68	84	78	57
Zebra	238	317	181	97	65	62	74	81	83	87	100	81	90	84	92	80

In 2004 about 20 sable antelopes were removed from the reserve (Tshenkeng, 2015), following which the population increased initially but then dropped in 2008 with no clear explanation, since only three mortalities were recorded and no removal was done. Since 2000, only seven juvenile mortalities have been recorded, the latest being in 2013. Calves were born and vanishing without leaving a trace in the reserve. This has been a serious concern in the reserve because there is no information on the cause of disappearance. Based on monitoring data by Field Rangers, we know that it is during winter time when most of the calves disappear.

A previous study done on the sable antelope population in the reserve in 2002 and 2003 suggests that, at the time, sable were doing nutritionally well in the woodland/open grassland mosaic characterising their home ranges (Parrini & Owen-Smith, 2010). This past study had looked at the foraging behaviour of sable antelope and how it was influenced by changing forage quantity and quality through the years. Behaviourally, sable antelope demonstrated a good ability to adapt their foraging to changing conditions, from feeding on tall stemmy brown grasses when green grass availability was low, to feeding on short green regrowth in burned areas, in order to meet their nutritional requirements (Parrini & Owen-Smith, 2010). The study therefore suggested that causes of sable antelope decline needed to be explored outside of their feeding ecology. The study also suggested that sable antelopes were not competing with other grazers in situations where vlei areas and high abundance of preferred grass species were available, but no specific data was collected on that. The study did not look at other aspects that could have a negative impact on sable antelope numbers.

As the game counts seem to suggest (Table 1.1), the poor performance of the sable antelope population only started after this previous study had been concluded. It could be due to changed vegetation conditions or different burning regime, sable antelopes are now nutritionally deficient and might suffer because they are out-competed by other grazers, especially bulk grazers like zebra and waterbuck, and especially during the dry season, even if that was not the case before 2004. Alternatively or additionally, the dwindling sable antelope numbers could potentially be due to a decrease in natality: 11 calves were born in 2011, ten calves in 2012, seven in 2013 and six in 2014. There is a steady decrease annually in natalities in the reserve. What is interesting is that during 2009 and 2010, calves have been born but could not be seen after the dry season with no records of mortalities, escapes, hunting, removals or culling (pers.obs).

Even though at the time this study was set up there were no records of poaching in the reserve, it is possible that poaching might be one of the contributing factors in the population decline. Some evidence supporting this option comes from a chance finding in 2014 when one adult sable was found dead due to snaring. The snare was just inside the fence in a corner of the reserve far from any road or path and would not have been found if it was not that the sable caught in it had a GPS collar. Therefore one of the aspects of this study is to look at the space use by sable in relation to 'high risk' areas in terms of areas potentially at risk of poaching like close to not well patrolled roads and close to not well maintained fences.

Based on monitoring data, leopard (*Panthera pardus*) is seen seldom and since no other predators are present, susceptibility to predation is highly unlikely. There was one leopard introduced in 2014 in the reserve from nearby farms. Also in 2015 one leopard was released in the park, but that is irrelevant for this study that focuses on years before 2015. There are no records of mortalities due to suspected diseases in KMR. It is unclear therefore whether the decline in sable antelope and low survival rate of juveniles is due to predation and poaching or extreme weather conditions during the dry season affecting forage availability, potential competition for resources with other species and ultimately sable nutritional status. Lack of enough green regrowth on burnt areas may also have an impact on the decline of the sable population. Usually early burns are implemented from May and in the past three years the area has been experiencing very late rains.

As an employee of the North West Parks Board (NWPB), it's our objective to ensure the establishment, development and efficient management of a network of formally protected areas in order to conserve indigenous biodiversity, representative samples of natural ecosystems and habitats of critically important threatened species. This research project will therefore be beneficial to the reserve management as this will assist in the management of the sable antelope population which is one of the key attractions for the KMR.

1.3 OBJECTIVES

The objectives of the research include:

1. To assess sable antelope use of space in relation to 'high risk' areas as determined by distances to fences, campsites and roads for the period 2012-2014.
2. To determine the seasonal changes in nutritional status of sable antelope in 2013-2014.
3. To estimate calves recruitment, survival and calves and population sex ratio for 2013-2014.

1.4 LITERATURE REVIEW

1.4.1 Resource Use

The distribution of large herbivores is influenced by aspects of animal behaviour ranging from an individual's choice of dietary items to predator avoidance strategies that affect use of space across many levels of ecological resolution (Senft *et al*., 1987; O'Reagain & Schwartz, 1995). In southern Africa, the resource limiting season is the dry season, when herbivores are forced to decrease their forage due to lack of forage (Scoones, 1995). During the dry season, as resources become progressively more limiting, herbivores move to areas that allow them to mitigate the effects of these poor quality resources (Scoones, 1995). For example in the Serengeti, during the dry season, as larger grazers progressively become unable to maintain themselves on the increasingly short and brown grass, they move down the catena to areas with higher biomass, which they open up allowing the smaller grazers to select the lower levels of the grass layer that are more nutritious (Bell, 1971). These areas that sustain herbivores during the dry season are often referred to as key resource areas (Scoones, 1995).

Research done in African savannas show that some herbivore species prefer to forage on burnt areas compared to non-burnt areas (Wilsey 1996; Tomor & Owen-Smith, 2002). The green grass regrowth on burnt areas are used by a number of herbivores such as blue wildebeest (*Connochaetes taurinus*) and zebra during the dry season (van de Vijver *et. al*, 1999). Also studies done in Serengeti ecosystem confirm that large herbivores such as wildebeests, zebras, Thomson's gazelles (*Gazella thomsoni*), buffalo (*Syncerus caffer*) and topi (*Damaliscus lunatum*) move between burnt and unburnt vegetation (Hassan *et al*., 2007) to find the right balance between grazing quality and quantity (Belovsky, 1984). The use of freshly burnt areas by large herbivores is often related to the observation that burnt areas support vegetation with boosted nutritional quality compared to unburnt areas, but low biomass limits intake levels (Allred *et al*., 2011). Sable antelope have been observed to make extensive use of burnt areas in Pilanesberg National Park (PNP) and Loskop Dam Nature Reserve (Magome, 1991; Wilson & Hirst, 1977). In a Lowveld Game Ranch, Gureja & Owen- Smith (2002) did not observe sable antelope utilising burnt areas. However, the extent to which sable antelope can rely on burnt areas to bridge the dry season depends on how much green regrowth the areas provide and how fast the new grass regrows (Parrini & Owen-Smith, 2010).This was evident in the study by Parrini & Owen-Smith (2010) where sable made extensive use of burnt areas during one of the dry seasons but not during the other dry season when there was little green regrowth.

Some herbivores use low lying areas where grasses retain greenness for longer as key resource areas during the dry season. Roan antelope (*Hippotragus equinus*) preferred using bottomlands and vlei in the basaltic regions of Kruger National Park (KNP) where high soil moisture enabled green grass to be preserved longer during the dry season (Knoop & Owen-Smith, 2006). The degree of grazing by roan in the uplands only exceeded that in the bottomlands during particularly dry years when grass in the vlei became depleted (Knoop & Owen-Smith, 2006). Beardall *et al.* (1984) found out that impala (*Aepyceros melampus*) prefer lower lying areas along drainage lines, with short grass and generally more flattened and disturbed, under open woodland in KNP. A part from the use of burnt areas, sable antelope also move to bottomlands during the dry season. The avoidance of slopes and selection for valley habitats by sable antelope in the dry season was ascribed to green leaf still available in valleys (Sekulic, 1981). Similarly, in PNP, sable used slopes in the wet season and bottomlands during the dry season (Magome, 1991). In KMR sable antelope increased the use of the vlei and low lying valleys during the dry season, especially when no burnt areas were available (Parrini, 2006).

Other herbivores switch to different resources when the preferred resources become limiting. The mixed feeder impala are considered to be mostly grazers while the nutritional value and palatability of grasses are still at acceptable levels (Estes, 1991) but during the dry season they can switch to browsing (Dunham, 1981). Similarly Ojwang (2000) classified eland (*Tragelaphus oryx*) as mixed feeders, that feed on grass only when it is young, but switch to browsing when the nutritional quality of the grass decreases in the winter season (Melton & Snyman, 1989). Some grazers might even switch to browsing as a copying strategy, as observed with sable antelope in Botswana (Hensman, 2012). No browsing by sable antelope has been reported from previous studies on their foraging ecology in KMR (Wilson & Hirst, 1977; Parrini, 2006).

Sable antelope are considered an open woodland species, favouring habitats with sparse trees over open areas. Sable antelope herds in Kenya selected habitats on edges of forests with medium-tall grass and sparse tree canopy cover, often located on mid-slopes (Sekulic, 1981). Here, sable antelope herds did not use thick woodland areas. Sable avoided open savannas and secondary grasslands in PNP (Magome, 1991). At the same time, those habitats avoided were selected by blue wildebeest, white rhino (*Ceratotherium simum*), red hartebeest, and zebra. Hence, the explanation was that this separation partially reduced competition between sable antelope and these other ungulates. In most cases in KMR, zebra, waterbuck and eland use similar areas to sable antelope (pers.obs). The fact that herds made extensive use of burnt areas when available despite the higher number of other grazers (zebra, waterbuck, eland) present in these areas as compared to unburnt ones during the study by Parrini (2006), seems to suggest that competition was not a problem, at least then.

In South Africa, fences are considered as a way of protecting wildlife, therefore there are areas fenced and designated for wildlife habitat (Woodroffe *et al.*, 2014). Even though fences are useful in avoiding human and wildlife conflicts, the disadvantages and advantages must be considered first before they are set up (Hayward & Kerley, 2009). If not well maintained it could be easy to access a reserve from neighbouring areas, placing the wildlife inside the protected area at risk of possible poaching (Hayward & Kerley, 2009).

Roads have a negative impact on wildlife as they create boundaries in their habitat, restricting movement and behaviour and this might also lead to road kills (Seiler, 2001). To minimize these impacts, a number of mitigation measures have been considered and these include for example underpasses, putting warning signs and having fences (Malo *et al.*, 2004). Roads may transform the activities of animals either positively or negatively through five mechanisms and these include home range shifts, altered movement patterns, altered reproductive success, altered escape response and altered physiological state (Trombulak & Frissell, 2000)

Sometimes humans and wildlife can be uncomfortable neighbours and that is why it is important to separate the two by putting a fence and this can be mutually beneficiary (Woodroffe *et al.*, 2014). Wildlife can destroy crops; some attack humans whereas humans can poach wildlife for trade or meat. In the past, geographical features like rivers and well-known landmarks have been used as a boundary to demarcate usage and land ownership and this includes land use for conservation and land used for commercial farming (Beck, 2008). Currently there are fences that are used as boundaries for all protected areas in Southern Africa. From preliminary observation it is noted that sable antelope occur often close to fences possibly to take advantage of the green regrowth after fire breaks are done along the fences (pers. obs.) and are often seen not far from the roads.

1.4.2 Nutritional Status and Faecal Analysis

For the animal to survive, grow or reproduce, they need to obtain sufficient energy and nutrients from the environment (Owen-Smith, 2002). Mortality losses of herbivores due to malnutrition, even if ultimately caused by predation, generally increase in the dry season when there is limited food and more energy is used as herbivores range wide in search of food (Owen-Smith, 2002). Therefore nutritional status is a determinant of animal performance and a sign of well-being of herbivore populations (Meyers & Dove, 2000).

There are few studies that looked at nutrient requirement in herbivores (Grant & Scholes, 2006) but the dietary crude protein requirement to sustain wild animals ranges between 5-8% of dry matter (Robbins, 1993; Prins, 1996). Herbivores sometimes have a challenge of diet insufficiencies during the year (Owen-Smith, 1982; Dörgeloh, 1999). During the wet season macro-mineral and nitrogen content of grasses is higher in the savanna biome than during the dry season, with the fibre content being low at the commencement of the wet season (Heitkönig, 1993; Dörgeloh, 1999).

Large herbivores graze on a mix of different plants species and this makes it difficult to estimate the nutritional values of the diets that they ingest. Several methods are available for obtaining diet samples from ruminants such as diet observation, consumption techniques, fistula sampling (Holechek *et al.,* 1982), but nutrient contents from animal faeces have been widely used as indices for nutritional value of the diet of wild and domestic herbivores (Leslie *et al*., 2008). Faecal analysis has several advantages since it is a non-invasive method for investigating diet quality, it allows repeated sampling, and it does not interfere with normal animal behaviour (Holechek *et al.,* 1982; Meyes & Dove, 2000).

Faecal nutritional studies focus in particular on faecal crude protein as a measure of nutritional status (Holechek *et al.,* 1982; Henley, 2005; Codron *et al., 2007*; Magome *et al.,* 2008). Crude protein, soluble carbohydrates, mineral elements and the digestible energy content of the plant determine its nutritional value (Owen-Smith, 2002). Faecal crude protein (CP) is usually at its highest during the growing season and at its lowest in the cold dry season (Owen-Smith, 1982).

The late dry season is crucial period for grazing ungulates because the nutritional worth of the remaining brown grass is lowest then and levels of crude protein and digestible organic matter in grass may fall below levels essential for maintenance in animals (Owen-Smith, 1982). In fact most of the studies reported seasonal dissimilarities in crude protein levels where the wet season levels are much higher than dry season levels (Henley, 2005; Codron *et al.,* 2007; Magome *et al.,* 2008).

In Robbins (1993), suggested that for ruminants, the forage crude protein level needed for maintenance for a medium size ruminant such as a sable antelope would be is 6-8%. Sinclair (1977) regarded crude protein as the maximum limiting forage value parameter for buffalo. African buffalo needs at least 5% of protein concentration of dry matter in the forage that they consume in order to sustain their nutritional balance (Sinclair, 1977).

Crude protein levels below maintenance levels were confirmed for sable antelope in Kruger National Park during the dry season (5.4 % vs. 7.5% during the wet season; Codron *et al.,* 2007). As mentioned in the resource use section, sable are predominantly grazers but in the Kwedi region of Botswana (in the north east of the Okavango Delta) they have been observed browsing during the dry season when the nutritional value of the grass was low and managed to maintain crude protein levels above maintenance levels (Hensman, 2012). In PNP the crude protein levels were below/close to maintenance levels at the beginning of the dry season but increased in August immediately after utilising burnt areas (Magome, 1991). Sable faecal crude protein dropped to just above 7% at the end of the dry season when no burnt areas were available to them (Parrini & Owen-Smith, 2010). Instead, when burned areas were available during the dry season, sable antelope, by foraging in these areas, managed to maintain their crude faecal proteins to levels similar to those in the wet season at around 10.6% (Parrini & Owen-Smith, 2010).

Phosphorus (P) is also considered one of the key minerals in animal's nutrition (Wrench *et al*., 1997). In animal's body, P is considered to be the second most abundant element after calcium (Ca) (Du Toit *et al.,* 1940b). About 80% of P is found in bones and teeth, whereas the remaining 20% is distributed in soft tissues and body fluids (Ryan *et al*., 2004). With little supply of P, it is possible for an animal to suffer from P deficiency and this will affect physical well-being and reproduction in large mammals (Wrench *et al*., 1997). It was also confirmed by Wrench *et al*. (1997) that to determine dietary P, concentration of Faecal Phosphorus can be used.

1.4.3 Recruitment, Survival and Sex Ratio

In population dynamics, juvenile existence is considered as one of the important factors because off-springs will determine future population structure (Ibáñez *et al*., 2014). Charnov (1982) stated that females may increase their fitness by adjusting progeny sex ratio according to their value, because the sex of the progeny with a higher likelihood of achieving high reproductive accomplishment may vary with the mothers' quality. In polygynous mammals, high-value females may enhance their fitness by calving a high proportion of males (Côté & Festa-Bianchet, 2001).

Birth date has important implications for various life history characteristics such as growth rate and survival rate (Côté & Festa-Bianchet, 2001). In ungulates, late-born juveniles generally have higher death rate than those born earlier (Birgersson & Ekvall, 1997; Keech *et al*., 2000). In many ungulates, the mother's availability during the first dry season, however, seemed to increase the probability of calf survival (Côté & Festa-Bianchet, 2001). In mountain goats (*Oreamnos americanus*), survival to one year was the same in both sexes and appeared uncorrelated with maternal phenotypic quality (Côté & Festa-Bianchet, 2001).

In KMR, based on monitoring data, there are few mortalities recorded and no sign of predation and there is also no evidence of lack of recruitment. It is suspected that poaching of calves might be the cause of their disappearance. Sable antelope calves are very tame, they can stand next to a car without moving especially if there are no movements in the car (pers. obs.). In KMR, there are more males calves born compared to females. In 2010 there were three males and one female born. The following year (2011) 11 calves were born, eight males and three females. In 2012, about ten calves (six males and four females) were born.

1.4.4 Ecology of Sable Antelope

The first written records of sable antelope occurrence are by Harris, who encountered and collected the original type specimen west of Pretoria and described it in 1838 (Skinner & Chimimba, 2005). Sable antelope are medium-sized grazing ruminants, with adult females weighing about 220 kg and males about 235 kg (Estes, 1991). Sable antelope adult bulls have a very shiny black skin while cows and young bulls look reddish both with white under parts. Newly born are light tan in colour (Skinner & Chimimba, 2005). Their face marking is black and white. Both males and females have horns, with the horns of males thicker and longer than those of females.

Sable antelope is considered a savanna woodland species and their distribution is restricted to the south–eastern portion of the African continent (Skinner & Chimimba, 2005). Sable antelopes in countries such as Kenya, Angola and Botswana but in Angola it is an isolated population which is believed to be a different subspecies, the so called Giant sable (Stuart & Stuart, 2007). Sable antelope in South Africa prefer areas with low tree density and tall grass (Skinner & Chimimba, 2005). In South Africa, KNP remains the area with the largest population of sable antelope (Skinner & Chimimba, 2005). More populations occur on private and state owned reserves in Mpumalanga, Limpopo, and North West Province. In the North West province, free ranging populations occur, besides in KMR, in Borakalalo National Park (48) and PNP (4) (Nel *et al.*, 2014). In PNP they had a total of 34 sable antelope in 2001, but the numbers have been decreasing annually due to predation.

In KMR, sable antelope are usually seen in the vlei area and in kloofs where there is permanent water. They are water-dependent species and it is suggested that they remain within 1-3 km from water (Grobler, 1981; Martin, 1983). Sable antelope mostly avoid competition with other species (Wilson 1975), like zebra and waterbuck (pers.obs). They have territorial bulls, breeding herds and bachelor herds (Skinner & Chimimba, 2005), with the breeding herds size between 10 and 20. The breeding herd consists of territorial bulls, adult females and juveniles. In KMR, sub-adult males are sometimes seen within the breeding herds with two to three adult males. Even though mature males are considered to be territorial, based on monitoring observations, males sometimes move between two main herds in the reserve, and this was also evident in the research done by Parrini (2006).

Females become sexually active at two years of age, usually having their first calf at the age of three years and continue to calve up to the age of ten and more. Males become sexually active between 16 – 19 months (Skinner & Chimimba, 2005). Gestation period can be up to 270 days (Stuart & Stuart, 2007). Calving in KMR occurs between February and April (pers. obs).

In KMR there are two breeding herds, called the 'vlei herd' and the 'woodland herd', which sometimes split into four during calving but later join to make two groups again. Based on the reserve monitoring data, the biggest herd (vlei herd) currently has just over 20 animals and the smallest herd (woodland herd) has just over 10 animals. There are more than seven territorial bulls. As mentioned above, the bachelor herd of about seven or eight sable antelope is seldom seen in the reserve.

1.5 HYPOTHESES

Objective 1: To assess sable antelope use of space in relation to 'high risk' areas as determined by distances to fences, campsites and roads for the period 2012-2014.

Hypothesis

It is expected that sable antelope will be seen in 'high risk' areas in the reserve. These areas include non-tourist's routes and near the fence. Due to limited monitoring in the reserve, fence monitoring is not done effectively and the fence of the reserve is not up to the required standard of the provincial department of protected areas. The recently added rainbow section of more than 600 ha as part of the reserve is also considered as 'high risk' due to insufficient access and I expect sable antelope to utilize that area at times during the year because of minimum competition with other herbivores. Also it is expected that sable antelope will use burnt areas especially around November/December that is the period when first rainfall is expected after burning.

Objective 2: To determine the seasonal changes in nutritional status of sable antelope for 2013-2014.

Hypothesis

It is expected that nutritional status of sable antelope will decrease during the dry season compared to the wet season. However, if sable antelope are found to use the burnt areas immediately after burns, I expect the nutritional status of sable antelope not to decline through the dry season. Also it is expected that faecal phosphorus will reduce during the dry season.

Objective 3: To estimate calves recruitment, survival and calves and population sex ratio for 2013-2014.

Hypothesis

Since 2010 there has been good recruitment of sable antelope calves in the reserve. In 2010 about four calves were born but were not seen after the dry season. For 2011 and 2012, 11 and 10 calves were born respectively and some survived the dry season; hence I expect calves born in 2013 to survive the dry season.

During the sex and age survey for all animals in the reserve which is done twice (May and October) annually, the results give us an idea of the sex ratio of males to female. Based on the results of May 2012 there were at least 10 adult and three sub adult males and 15 adults and four sub adults' females which suggests that the sex ratio is skewed towards females. Based on that I either expect more females than males to be born or the mortality to be higher among males than among females.

1.6 STUDY AREA

1.6.1 Location

Kgaswane Mountain Reserve (KMR) - 25 43' S, 27 11' E, it is situated at the outskirts of Rustenburg in the North West Province of South Africa (Figure 1.1). It is 5388 ha in extent and lies on the summit and against the northern slopes of the Magaliesberg at an altitude of 1200-1750 m above sea level. In the past the area was used for cattle and game grazing by local tribes and eventually by white settlers in the last century (Nel, 2000). It was proclaimed as Rustenburg Nature Reserve in 1967 (Nel, 2000) and after the amalgamation of Bophuthatswana Parks and Transvaal Parks Association it was known as Kgaswane Mountain Reserve. The reserve is within the boundaries of the Magaliesberg Protected Environment, proclaimed as a Biosphere Reserve by The United National Education, Scientific and Cultural Organisation (UNESCO) in 2015.

The reserve also encloses a catchment of 172 km^2 which is a source of water to Waterkloofspruit (Nel, 2000). There are other streams which flow within the reserve. Kgaswane Mountain Reserve is presently enclosed by a standard 2.3 m high game perimeter fence. The fence was approved following the last inspection that was conducted by the Rural, Environment and Agricultural Department (READ) across the North West Province for permit exemptions. Currently the fence condition is deteriorating, and there are holes in certain sections (pers. obs.), but there are developments underway to upgrade it with the assistance of the Department of Environmental Affairs.

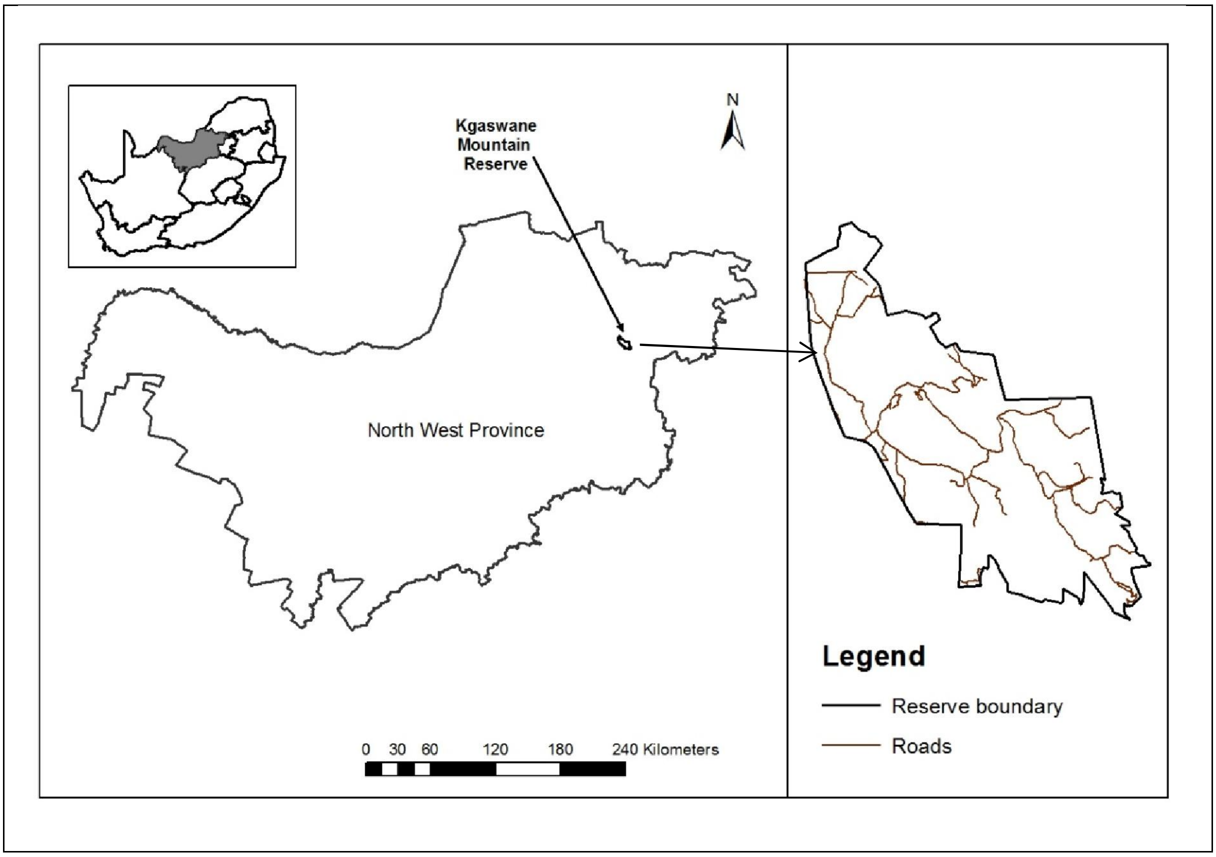

Figure 1.1: Kgaswane Mountain Reserve, located adjacent to the town of Rustenburg, North West Province of South Africa.

1.6.2 Vegetation and Geology

The Magaliesberg Mountains form a boundary between two biomes, savanna and grassland (Mucina & Rutherford, 2006). Vegetation structure is primarily determined by both temperature and climatic water balance (Box, 1981). The main vegetation type of the area according to Mucina & Rutherford (2006) is the Gold Reef Mountain Bushveld with small portions of Moot Plains Bushveld and Northern Afrotemperate Forest (Figure 1.2).

Figure 1.2: Vegetation types found in Kgaswane Mountain Reserve (Mucina & Rutherford, 2006).

Nel (2000) created a more detailed vegetation classification specifically for the reserve, aiming at improving vegetation management, which is an essential activity as it forms the basis for decision making around management interventions, i.e. fire management, game removal quotas and game introductions. According to this classification, it is possible to distinguish four main vegetation classes (Figure 1.3):

I. *Selaginella dregei - Oldenlandia herbacea* Open Shrubland,
II. *Becium obovatum - Elionurus muticus* Tall Grassland,
III. *Ziziphus mucronata - Rhus leptodictya* Closed Woodland,
IV. *Pteridium aquilinum - Miscanthus junceus* Moist Grassland.

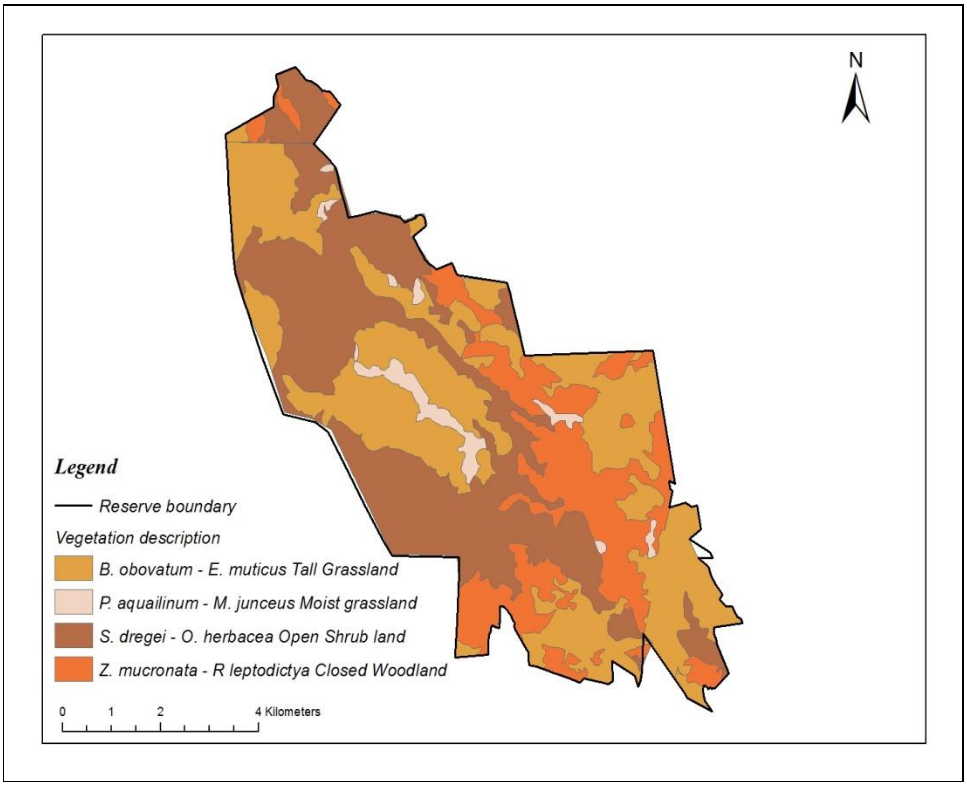

Figure 1.3: Detailed vegetation types for Kgaswane Mountain Reserve (Nel, 2000).

The reserve covers two geological formations, the re-crystallized quartzite from the Transvaal System and the norite intrusions of the Bushveld Igneous Complex (Nel, 2000). The Transvaal System consists of all the sedimentary and volcanic rocks which are dropped in an east-west basin in the south-central part of Transvaal (Walraven, 1981). The Transvaal Sequence is represented by three series which are the Black Reef, Dolomite and Pretoria series in the North West Province (Nel, 2000). According to Walraven (1981), Magaliesberg quartzite and Silverton Shale formations are found in KMR. It includes an ultra–basic to basic unit, about 9 km thick, known as the Rustenburg Layered Suite which crops out as eastern, western and northern lobes, associated with acid rocks named the Lebowa Granite and Rashoop Granophyre Suites (Walraven, 1981). The Rustenburg Layered Suite has all the basic layered rocks of the Complex in the reserve (Nel, 2000).

1.6.3 Rainfall

In African savannas, seasons are largely governed by variability in rainfall that affects the availability and value of forage resources encountered by herbivores through commanding cycles of grass growth (Illius & O'Connor, 2000).

The mean long term (1980-2014) annual rainfall for the reserve is 600 mm (CV = 40%), with maximum rainfall of 1152 mm experienced in 2011 and minimum of 148 mm in 1992 (Figure 1.4). Frost is common in winter especially in the south but less common on ridges and hills.

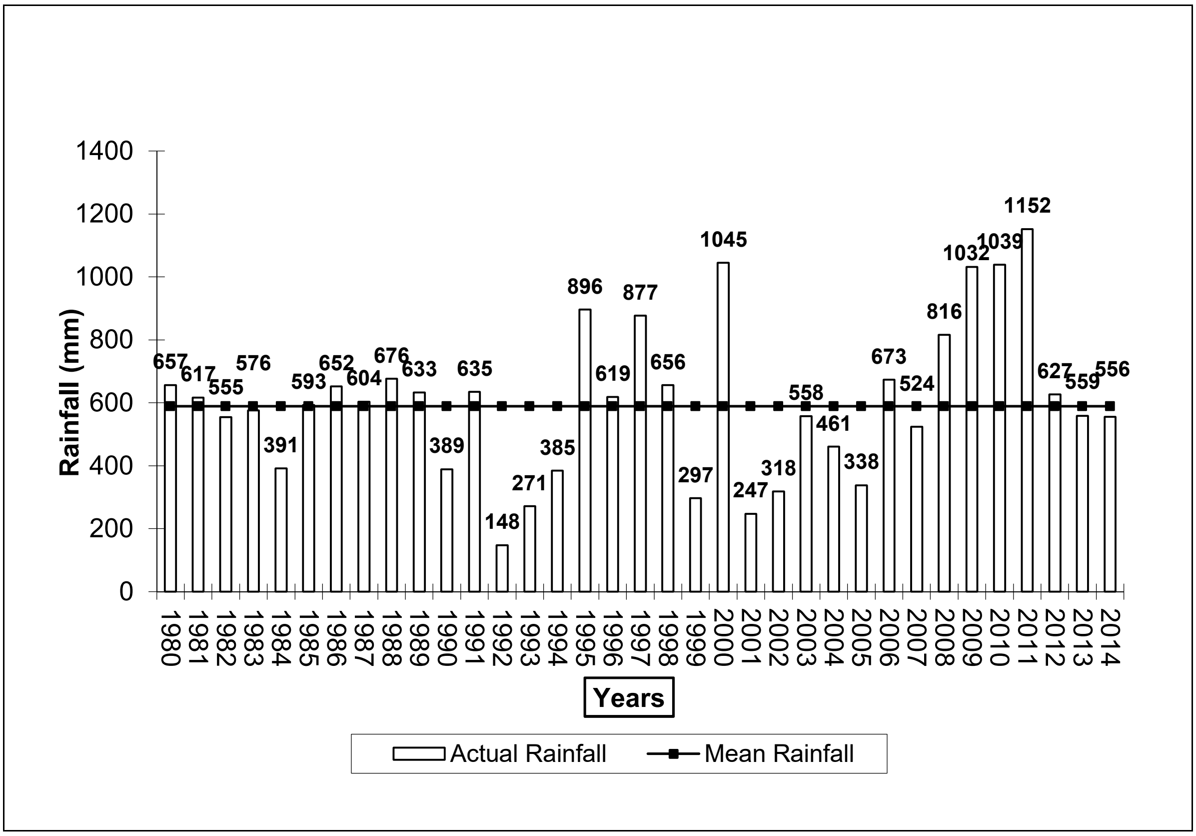

Figure 1.4: Rainfall and mean rainfall (1980-2014) in Kgaswane Mountain Reserve (Source-Tshenkeng, 2015).

In 2004 and 2005 the rainfall was below average (461 and 338 mm respectively, Figure 1.4) it was during these years when the sable antelope population started to destabilize. Subsequently sable antelope number decreased substantially from 2007 to 2008 when rainfall was again below average (Figure 1.4). A similar declining trend during below average rainfall years was observed for other ungulate species, like eland and mountain reedbuck (*Redunca fulvorufula*) with no removals or moralities recorded (Table 1.1).

Since 2008, the rainfall has been above average and could potentially be linked to better foraging conditions that are allowing the sable population to be stable again. Hence possibly the decline observed was a delayed effect of poor rainfall condition; if that is the case the next few counts until 2012 should reflect an increase in sable antelope number following good rainfall seasons. During the time of the study, however rainfall was again below average for 2013 (559 mm) and 2014 (556 mm). The regional climate where Kgaswane Mountain Reserve lies is a warm – temperate with summer rainfall and dry winters (Mucina & Rutherford, 2006).

1.6.4 Fire

Fire is a natural determinant of plant species diversity and is included as part of ecological management in KMR (Tshenkeng, 2015). It is mainly used to remove moribund plant material from past seasons and improve forage quality and quantity to maintain animal production (Bond, 1997). Fire is also used to secure park infrastructures e.g. campsite, staff houses from accidental and uncontrolled dry season fires.

From 1972 until 2014, an average area of 857.5 ha equalling to 16% of the reserve has been burnt each year (Figure 1.5). Both wildfires and other fires contribute to the total size of the area burnt, therefore affecting timing, intensity and spatial location of fires. For example in 2011 an area of 648.6 ha was burnt (Figure 1.5) and it included wildfires. The highest percentage (63%) of the reserve was burnt in 2003 due to an uncontrolled accidental fire. The lowest percentage (1%) was burnt in 1996.

During the period investigated in my study, the total area burnt in the reserve is estimated at 731.45 ha in 2012 and 813.80 ha in 2013 – this excludes fire breaks. Wildfires and accidental burns contributed towards fires in 2012 and 2013. In 2014, there was a run-away fire which burnt 771 ha. Unfortunately the fire team underestimated the wind speed and direction. It took the team 6 hours to extinguish the fire.

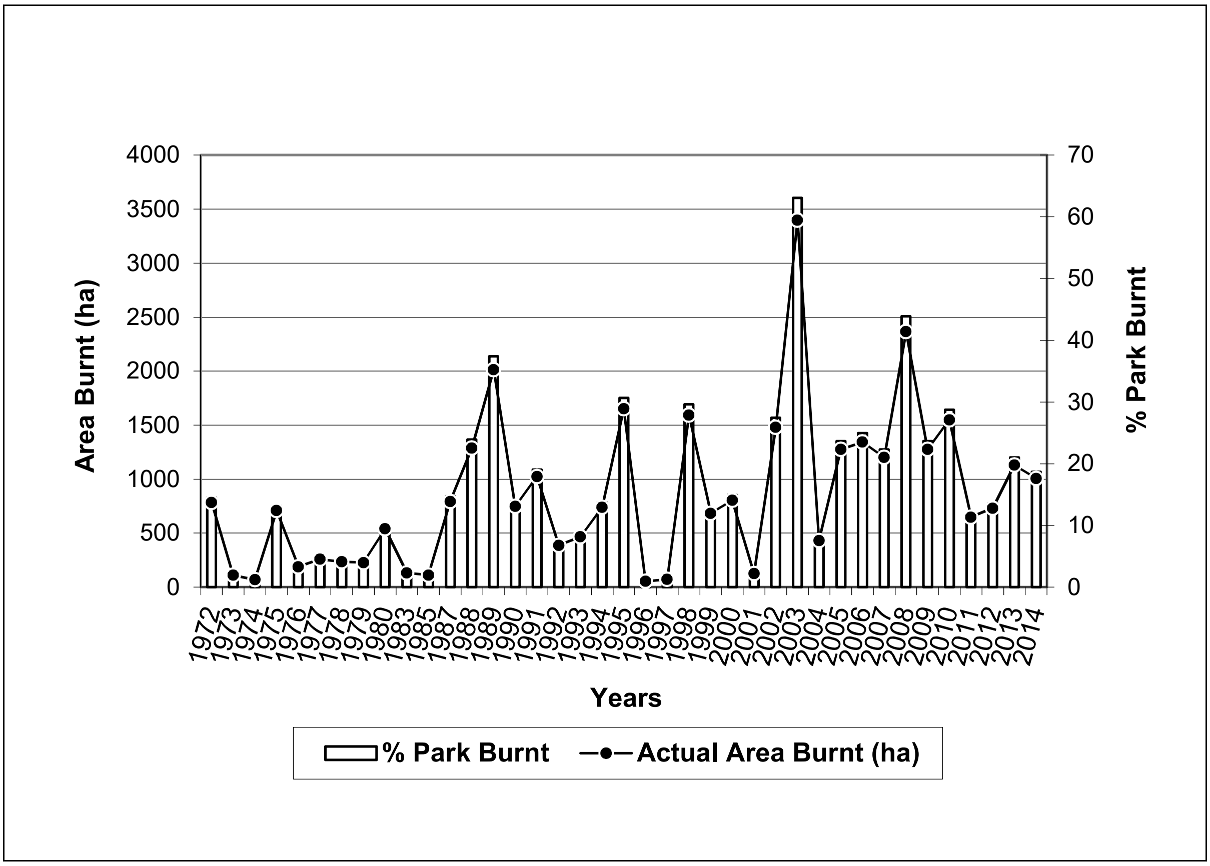

Figure 1.5: Fire history for Kgaswane Mountain Reserve indicating the size and percentage of reserve burnt (1972-2014) (Source-Tshenkeng, 2015).

CHAPTER 2: METHODOLOGY

2.1 STUDY DESIGN

Based on the objectives, the study was divided in three sections:

1. An assessment of sable antelope use of space in relation to ‘high risk’ areas as determined by distances to fences, campsites and roads for the period 2012-2014. (Objective 1).
2. An estimate of the seasonal variation in the nutritional status of the two herds for 2013-2014 (Objective 2).
3. A description of calves recruitment, survival and calves and population sex ratio in the sable antelope population in KMR for 2013-2014. (Objective 3).

Two sable antelope heifers were collared with a tracking device that had a Global Positioning System (GPS) unit with an Ultra High Frequency (UHF) and Very High Frequency (VHF) transmitter, on May 28, 2012 (Figure 2.1).

Figure 2.1: The two sable antelope heifers collared with GPS collars on the 28th of May 2012, in Kgaswane Mountain Reserve.

One female from each of the two herds in the reserve was immobilized from the helicopter. The collars were manufactured by Africa Wildlife Tracking (www.awt.co.za) and recorded latitude and longitude coordinates, date, time, altitude and temperature at hourly intervals. All the data were downloaded from the manufacturer's website. These collars were replaced on July 12, 2013, and lasted until 31 August 2014 (University of the Witwatersrand Animal Ethics certificate: 2013/14/04).

Based on the rainfall in the reserve during the study period (Figure 2.2), I divided each year into four seasons: Early Dry Season (ED) - April to July; Late Dry (LD) - August to October; Transition (Tr) – November; Wet (Wet) – December to March. Therefore the data spanned three early dry seasons (ED 12, ED 13, ED 14); two late dry seasons (LD 12, LD 13); two transition seasons (Tr 12, Tr 13) and two wet seasons (Wet 12/13, Wet 13/14).

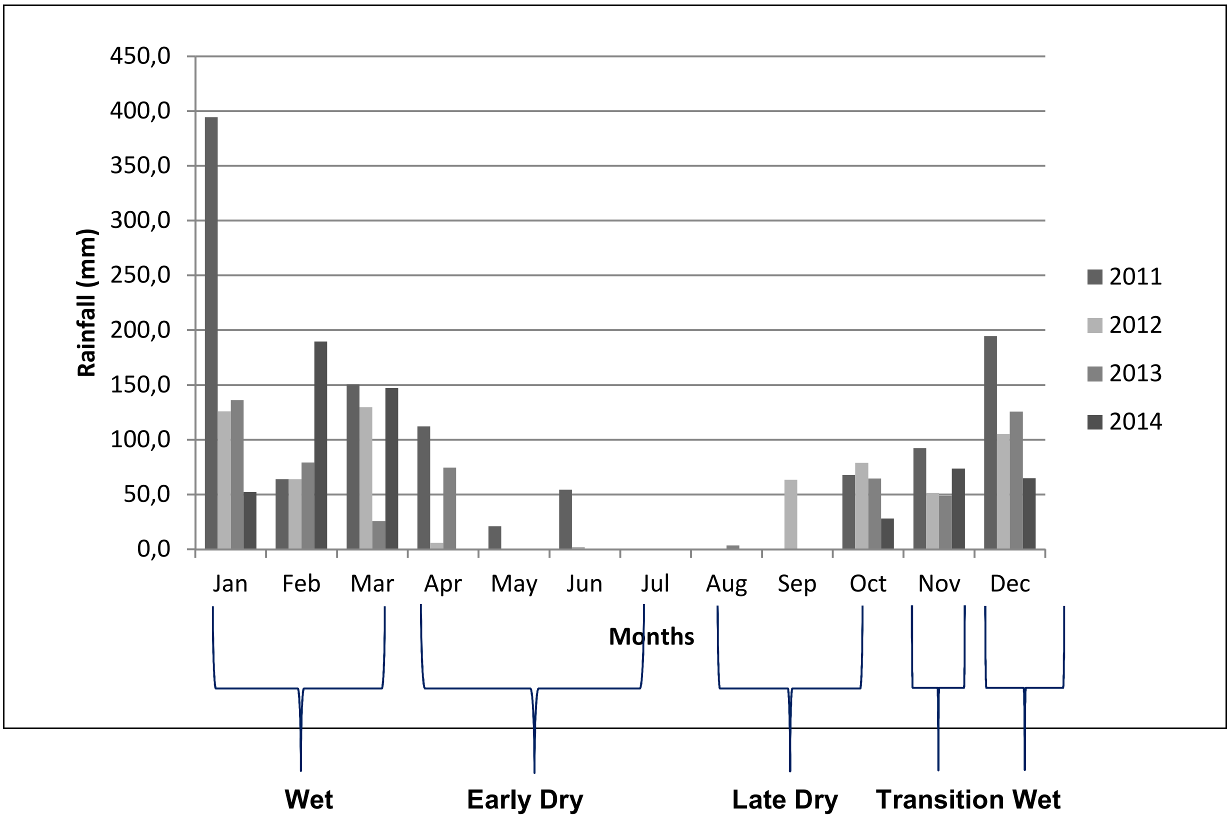

Figure 2.2: Rainfall for Kgaswane Mountain Reserve from January 2011 to June 2014.

For the first objective, I used GPS collars data downloaded from May 2012 until March 2014. In ArcGIS 10.0 (ESRI, 2010) I superimposed the sable antelope GPS positions on vector layers representing vegetation types, burnt areas, and the distance from roads, camping sites and boundaries, in order to asses space use in relation to risky areas (fences, roads and camp sites), taking into account the possible effect of use of burnt areas and specific vegetation types on use of space.

For the second objective, dung pellets were collected between April 4, 2013 and March 28, 2014. During this period the two sable antelope herds were visited at least once a week, when possible, using a car or during foot patrols/monitoring. Location of sable antelope herds was facilitated by using the most recent GPS coordinates. The reserve is a mountainous area and sometimes it was practically impossible to reach the area were sable where according to the GPS coordinates and hence, with the assistance of the Field Rangers, dung pellets were collected every week. When monitoring the sable antelope herds, a distance of at least 50 m from the animals was always kept, as to not disturb the individuals during foraging or other activities. Only after the herd had left the area, either myself or the Field Ranger would walk to the area where sable antelopes had been observed and collect fresh dung samples.

For the third objective, during monitoring of the two breeding herds, sex and age information for all individuals in the herd were recorded. As a side note, any animal that appeared to be in poor conditions or injured was noted.

2.2 <u>DATA COLLECTION</u>

<u>Objective 1 – Sable antelope use of space in relation to 'high risk' areas as determined by distances to fences, campsites and roads for the period 2012-2014.</u>

Defining 'high risk' areas

High risks areas in the reserve include the boundary, roads and camp sites (Figure 2.3). For roads, camps and boundaries, existing shapefiles provided by NWPB were used. In order to asses if fences were according to READ standards, fence patrols were conducted in the dry season (the season when most calves disappear) and in the wet season. In the dry season, fence patrol started on the 18^{th}

of August 2012 and it took 2 weeks to survey the whole reserve perimeter of 95.2 km.

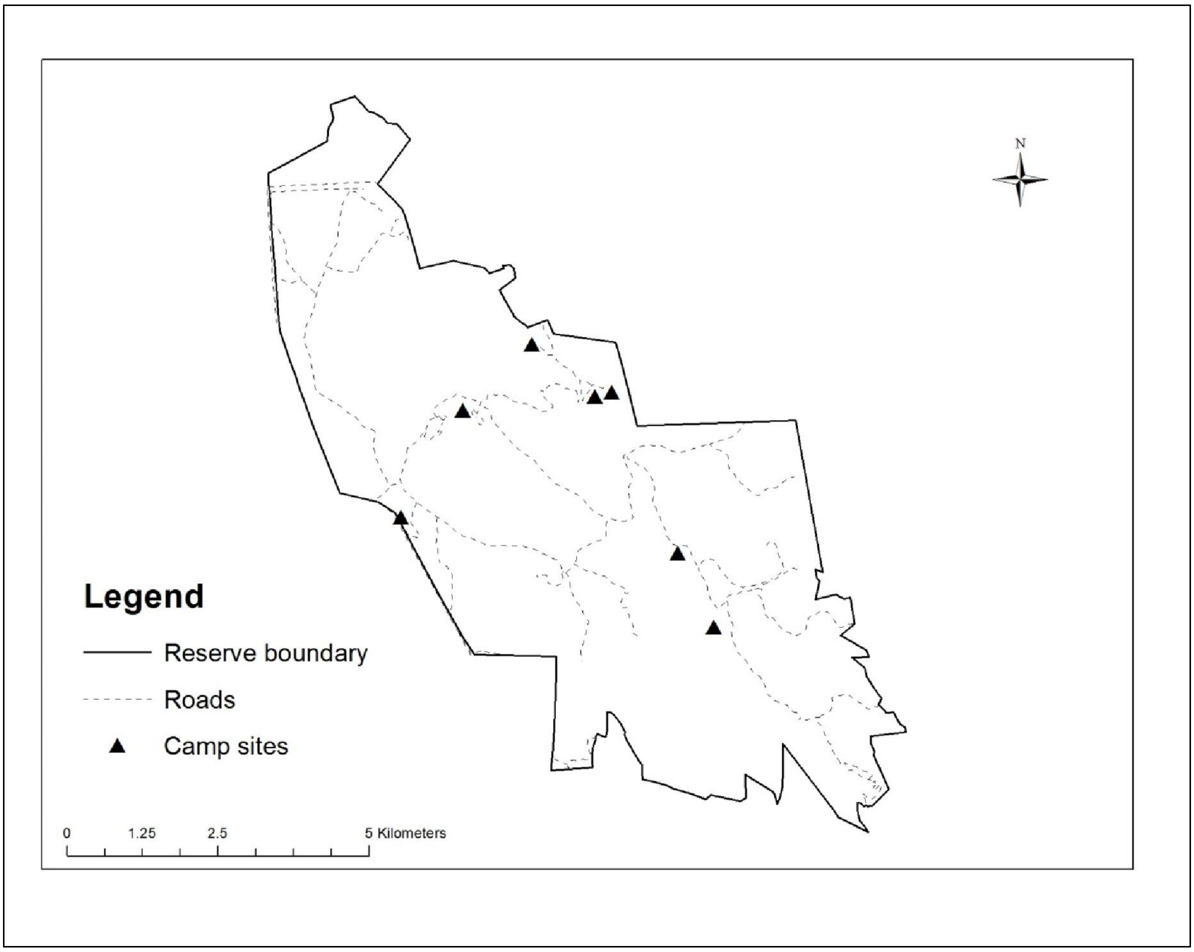

Figure 2.3: Map of Kgaswane Mountain Reserve showing camping huts, roads and boundary

I made buffers of different distances from roads and fence; distance classes were 0-100 m, 101-200 m, 201-500 m, 501-1000 m, and > 1001 m. For the camping huts I used distance classes 0-500 m, 501-1000 m and > 1001 m.

Vegetation types and burned areas

For this study, I considered the fires from 2011-2013 (Figure 2.4) since I was interested in the use of firebreaks that might keep sable close to fences or camps, and because sable antelope have been shown to select for recently burned areas or areas burned the previous year (Parrini & Owen-Smith, 2010). I had GPS locations from May 2012 as mentioned earlier; therefore I wanted to see how burnt/unburnt locations were utilised for the 2011 fires.

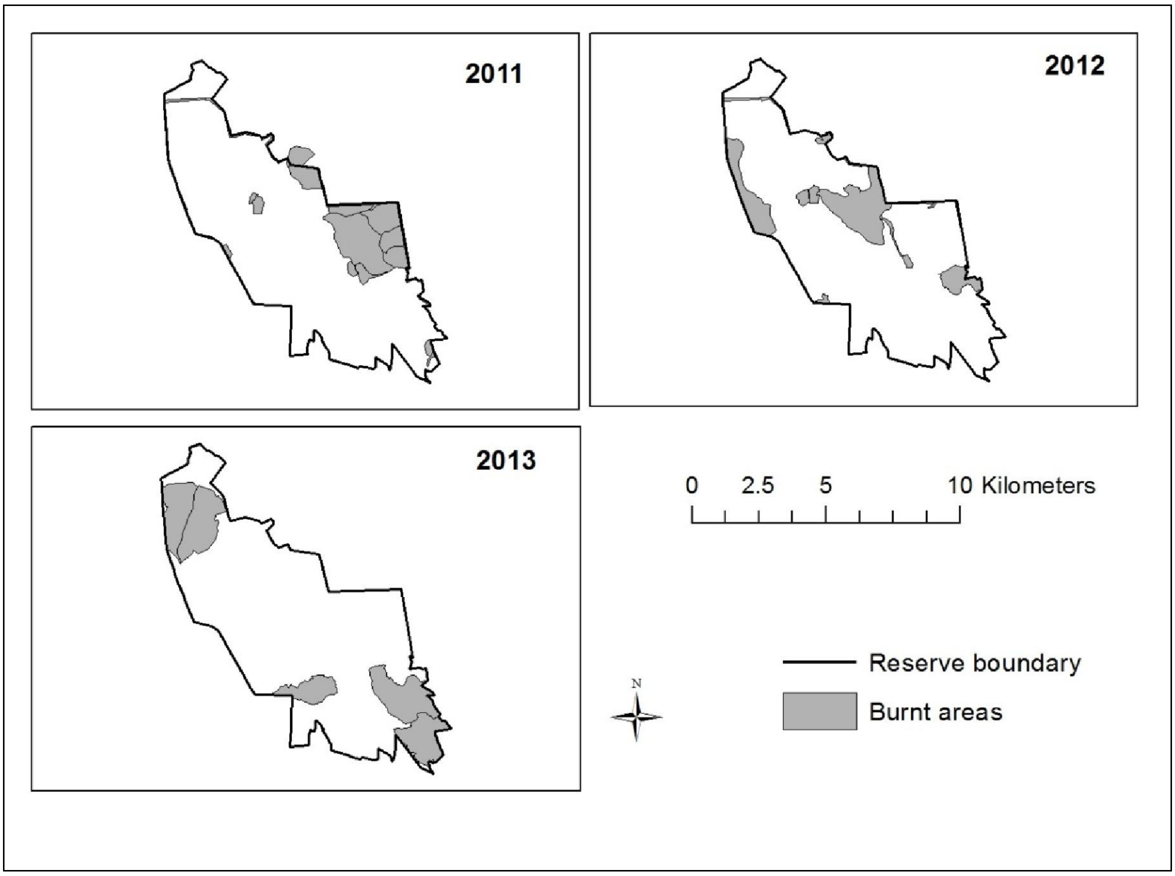

Figure 2.4: Areas burnt during 2011-2013 in Kgaswane Mountain Reserve.

Each year, the field rangers mark the GPS coordinates of the boundaries of burnt areas, and hence burnt areas layers were available to assess usage of burnt and not burnt areas. I looked at how the two herds utilized burn/unburnt areas, each year classifying as burnt areas the ones that were more recently burned and as non-burned all the rest.

Vegetation layers of the reserve were available as a pre-existing shapefile with 51 vegetation categories that were reduced to four categories meant to assist the management of the reserve in terms of classification of vegetation (Nel, 2000). The four vegetation management categories, which I used in this study to be comparable with Parrini (2006), include tall grassland, moist grassland, open shrubland and closed woodland (Nel, 2000).

Objective 2 – Seasonal variation in the nutritional status of the two herds for 2013-2014

I started most of the monitoring sessions in the morning after downloading the latest GPS locations of the two herds. The sable antelope herds where then located either by car or foot and fresh faecal samples were collected once the herd had moved off, either by me or the field rangers that would be doing the monitoring on the day. We avoided contamination by the soil or grass by collecting fresh samples and only collecting from the top of the dung pile. Collection of fresh samples as soon as the herd has moved off an area also avoids taking pellets of other animals. Samples from more than one animal were collected and then pooled together into a cumulative sample for that herd on that day.

Sampling covered all seasons during the study, in an attempt to have one sample per herd per week (see study design section). A total of 104 samples were collected (52 samples for the vlei herd and 52 samples for the woodland herd) for 52 weeks. Data was collected from the 4th of April 2013 until the 28th of March 2014. The samples were placed in brown paper bags and marked the day they were collected. The samples were then stored to dry at room temperature to prevent fungal growth and then later placed in a refrigerator.

The samples were then taken to the University of Free State – Department of Animal, Wildlife and Grassland Science's laboratory for faecal phosphorus (FP) and faecal nitrogen (FN) analysis. FN was determined using the Leco Nitrogen Analyzer (Leco 2001). Phosphorus (P) was determined according to the procedure described by De Waal (1979).

Objective 3 – Calves recruitment, survival and population sex ratio in the sable antelope population in KMR.

Sex and age was recorded in the patrol data sheets every time one of the herds was located either by using the GPS coordinates to find them or during routine reserve activities by the Wildlife Monitoring Officer and the Field Rangers. We always maintained a distance of at least 50 m from the observed herd, to be as close as possible to be able to classify the animals, without scaring them away. Binoculars were used to get a clear picture of the sex and age structure of the herds. Bachelor herds and lone bulls were also recorded when encountered.

I also included the data from the sex and age surveys, which is done in April/May and October/November annually in the reserve. Sex and age surveys are important in our nature reserve as this assist us to get an idea of our sable antelope population structure. These surveys are conducted in order to complement the aerial surveys and ad-hoc monitoring with the supply of comprehensive sex and age data. These surveys are done on foot, along three pre-determined routes to cover all areas of the reserve. Usually there are three monitoring groups and each group is assigned one of three routes worked out before the survey by the Wildlife Monitoring Officer and the Regional Ecologist. Observers use binoculars and spotting scopes to record age and sex of each sable individual seen along the route.

Sex and age structures of the two herds and also bachelors groups are recorded in patrol sheets and then captured in excel spreadsheets. Classification of animals includes:

- adults male (AM) - older than 2 years,
- adult female (AF) - older than 2 years,
- adult unknown (AU) - older than 2 years with sex unknown,
- sub-adult male (SM) - between 1-2 years,
- sub-adult female (SF) - between 1-2 years,
- sub-adult unknown (SU) - between 1-2 years with sex unknown,
- juvenile male (JM) - less than 1 year,
- juvenile female (JF) - less than 1 year,
- juvenile unknown (JU) - less than 1 year with sex unknown.

Since 2010, we have been monitoring natalities of sable antelope in the reserve. All natalities have been recorded and these were visibly seen between February and April. Monitoring of the growth of the calves was done every time we were collecting faecal samples.

In this study I included sex and age data from the surveys done in 2013 and in 2014. This was because I wanted to check if there was any difference between data collected during the surveys and during the field work for my study.

2.3 <u>DATA ANALYSIS</u>

<u>Objective 1 – Sable antelope use of space in relation to 'high risk' areas as determined by distances to fences, campsites and roads for the period 2012-2014.</u>

'High risk' areas

GPS locations of the woodland and the vlei herd were overlaid on the distance to features layers (distance to roads, distance to fences, and distance to camps) in ArcGIS 10.0. GPS locations were hourly, which could create issues of temporal and spatial autocorrelation when doing this type of spatial analysis. Therefore for each herd and for each season I used 10% of the total GPS locations for the data analysis. I determined the appropriate ratio to use, by comparing proportion of locations in different distance zones when using all locations, when using 50% of the total locations, and when using 10% of the total locations for each season to ensure that the subset of data used was representative of the whole. Also a same number of points as the used locations were randomly generated in each season to represent 'availability'.

For the vlei herd and the woodland herd, for each season, I calculated proportion of location in the different distance buffers (see data collection section for the distance classes) and compared to the distance distribution of the random generated points. Chi – square test was used to compare the two distributions for each herd and for each season, to analyse how sable utilized high risk areas across the nine seasons. Areas which were considered most risky were areas which were close to the fence, roads, and camp sites, and areas which were considered less risky were away from the boundary, roads and camp sites.

Vegetation types and burnt areas

The same locations used for the above analyses, were overlaid on the vegetation shapefile to extract the vegetation type used by sable antelope of each herd in each season. I also overlaid the same data to the fire shapefiles of 2011, 2012 and 2013. For this analysis I classified the locations, for each herd and each season, in two categories namely 'burnt' and 'unburnt' when discussing the results. A location was classified as burnt when it fell within an area burnt that year or the previous year. I wanted to observe if the herds uses burnt area immediately after burn which is during the dry season, during the transition period or during the wet season. Burnt areas included security burns, prescribed burns, accidental burns and wildfires.

Objective 2 – Seasonal variation in the nutritional status of the two herds for 2013-2014.

Once I received the faecal N and faecal P results from the laboratory where the samples were sent for analysis, I used a factor of 6.25 to convert the N content to faecal Crude Protein (FCP) content (De Waal, 1979). A 2-way ANOVA was used to compare the FCP and FP from the two herds and four seasons. Analysis was performed with SPSS (Statistical Package for the Social Science). Values were also compared with the values from the previous study done on sable antelope in KMR (Parrini & Owen-Smith, 2010).

Objective 3 – Calves recruitment, survival and population sex ratio in the sable antelope population in KMR.

I calculated the total number of males and females per age class. I then calculated the cumulative number of males and females where the 1st sighting was considered as a first sample, the second sample was 1st sighting+2nd sighting and the third sample was the 1st sighting+2nd sighting+3rd sighting until the last sighting. I then calculated the sex ratio by dividing the cumulative number of females by cumulative number of males. The last sample ratio was considered as a sex ratio of the samples. The Standard Deviation (SD) and the Coefficient of Variance (CV) between the samples were calculated from both weekly and annual surveys.

CHAPTER 3: RESULTS

Distance to fences

During the Early Dry Season 12 (ED 12) the vlei herd locations in the various distance classes to fences were not significantly different from what would have been expected from a random use of space, with most locations away from the fence (Table 3.1, Fig. 3.1 a). In all other seasons there was instead significant difference between actual and expected use of various distance classes (Table 3.1).

Table 3.1: Chi-squared statistics of used vs. random locations at different distances from fences for the vlei herd in different seasons, that is Early Dry Season (ED), Late Dry Season (LD), Transition Season (Tr) and Wet Season (Wet).

Distance (m)	Chi-square test (X^2)	P-value	Degrees of Freedom
ED 12 (N=141)	5,53	>0.05	4
ED 13 (N=219)	34,81	p<0.001	4
ED 14 (N=132)	110,23	p<0.001	4
LD 12 (N=222)	39,16	p<0.001	4
LD 13 (N=221)	29,71	p<0.001	4
Tr 12 (N=72)	19,06	p<0.001	4
Tr 13 (N=72)	187,13	p<0.001	4
Wet 12 (N=217)	18,68	p<0.001	4
Wet 13 (N=290)	252,81	p<0.001	4

While in the ED 12 there was no clear selection for any distance (Figure 3.1 a), in the ED 13 areas closer than 100 m were used more than expected and areas further than 1000 m less than expected (Figure 3.1 b). This pattern was even more extreme in the ED 14 when most locations where less than 1000 m from the fence, with the majority between 500 and 1000 m (Figure 3.1 c). In the LD 12 there was positive selection for areas between 100 and 500 m from the fence, while areas between 500 and 1000 m were underutilised (Figure 3.2 a). The following year (LD 13) areas close to fences were avoided and areas further than 1000 m used more than expected (Figure 3.2 b). In both transition periods sable selected for areas within 100 m from the fence (Figure 3.3 a) and in the Tr 13 they were never seen at distances further than 1000 m from the fence (Figure 3.3 b). In both wet seasons sable antelope used areas within 100 m from fences more than expected, with a clear avoidance of areas further than 1000 m in Wet 13/14 (Figure 3.4).

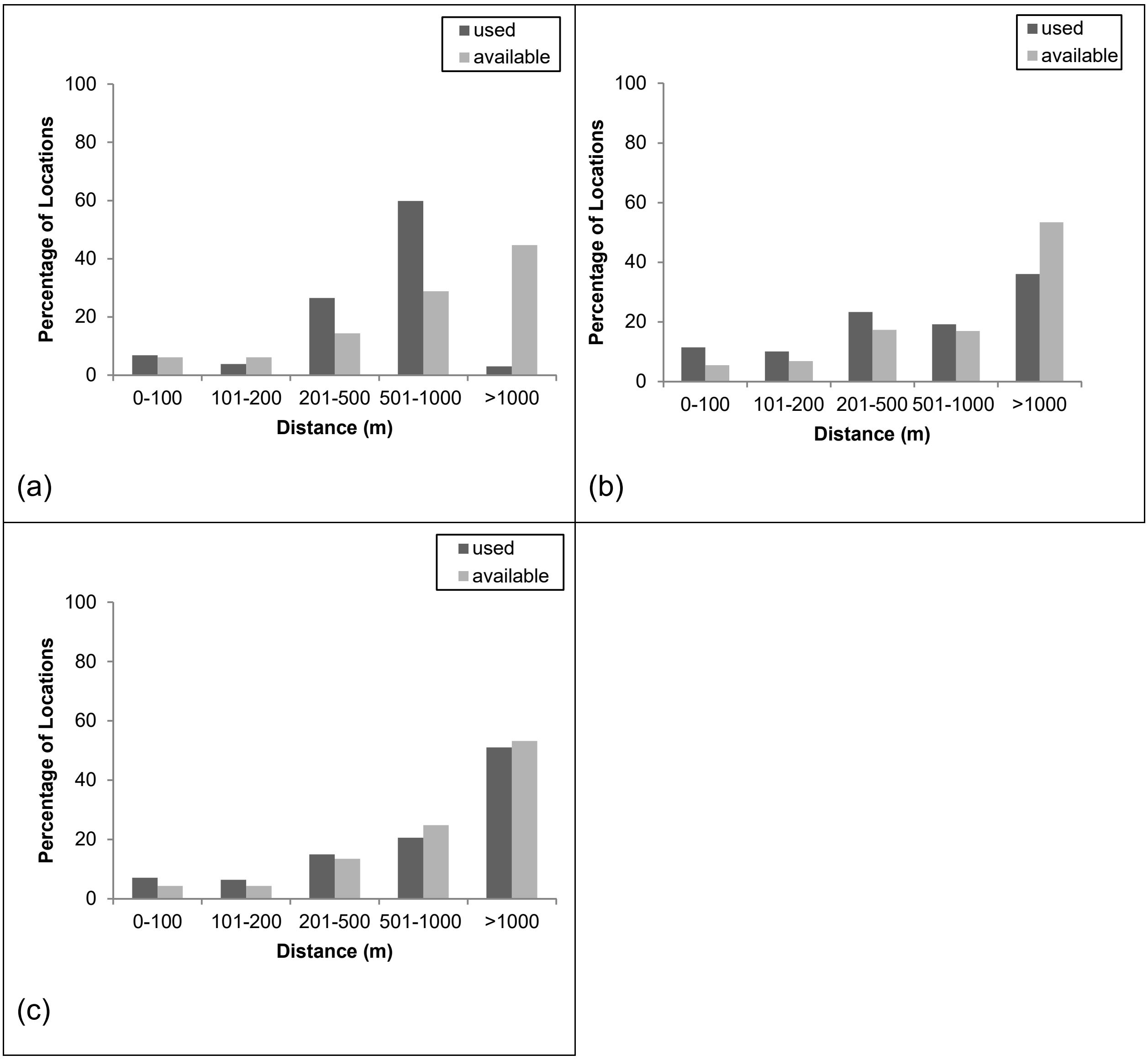

Figure 3.1: Percentage of sable antelope locations and random created points in the different distance classes from fences in the (a) early dry season 12, (b) early dry season 13 and (c) early dry season 14 for the vlei herd.

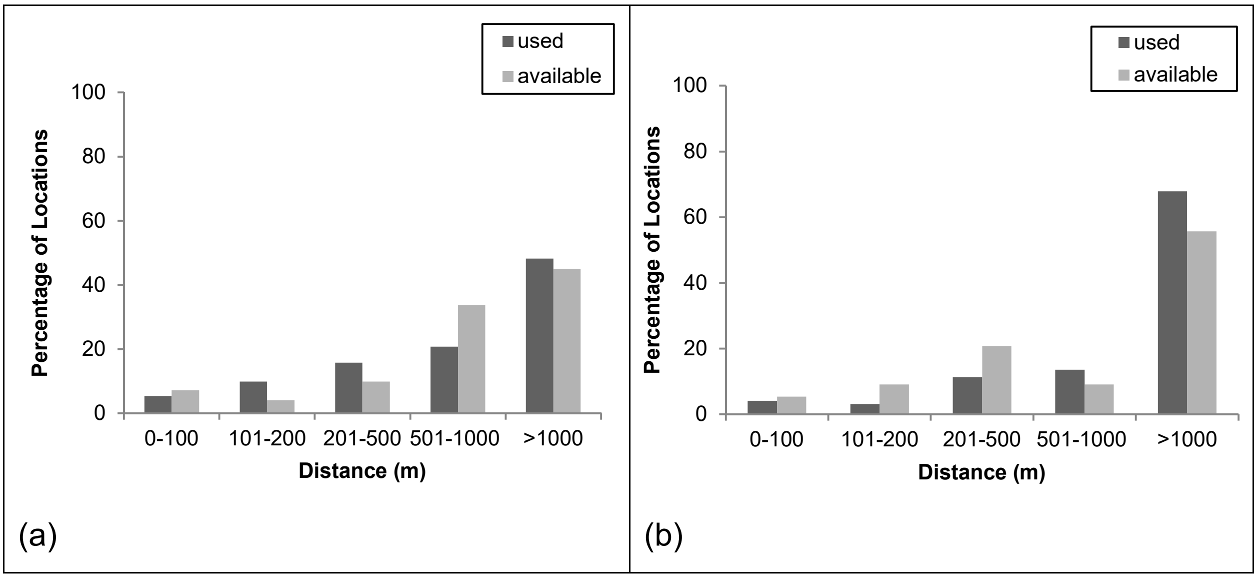

Figure 3.2: Percentage of sable antelope locations and random created points in the different distance classes from fences in the (a) late dry season 12, (b) late dry season 13 for the vlei herd.

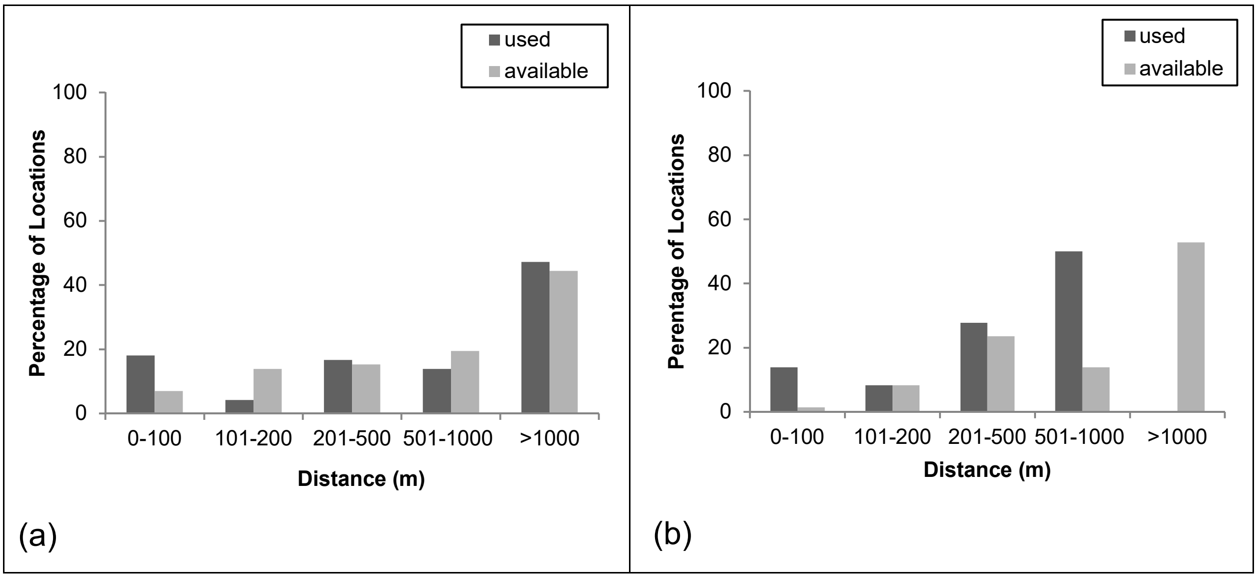

Figure 3.3: Percentage of sable antelope locations and random created points in the different distance classes from fences in the (a) transition 12, (b) transition 13 for the vlei herd.

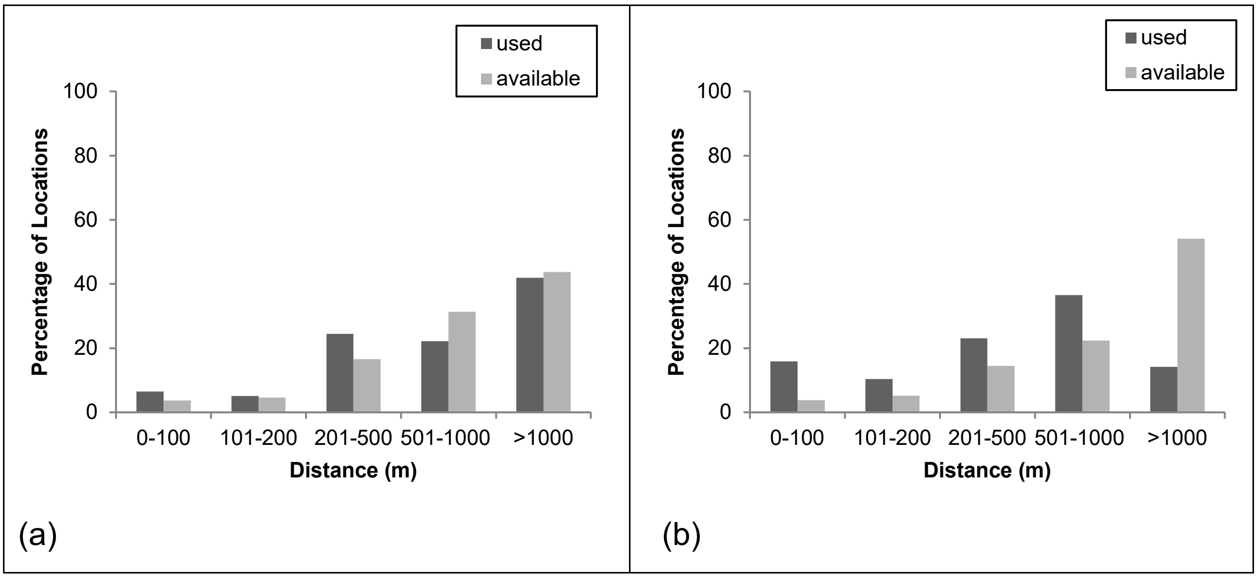

Figure 3.4: Percentage of sable antelope locations and random created points in the different distance classes from fences in the (a) wet season 12/13, (b) wet season 13/14 for the vlei herd.

The woodland herd showed a significant difference between available and used locations at various distances from the fence in all seasons (Table 3.2). In the ED 12 and ED 13 the woodland herd used locations closer than 500 m more than expected, and avoided areas > 1000 m away from the fence (Figures 3.5 a, b). In the ED 12 the herd never used areas further than 1000 m from the fence (Figure 3.5 a). The opposite trend was observed in the ED 14 when areas closer than 500 m were avoided (Figure 3.5 c). During the LD 12, LD 13, Tr 12 and Tr 13 the woodland herd utilised areas in distance classes 0-500 m more compared to what was expected (Figures 3.6, 3.7). In both wet seasons instead areas very close to fences (<100 m) were avoided and intermediate distances selected (Figure 3.8).

Table 3.2: Chi-squared statistics of used vs. random locations at different distances from fences for the woodland herd in different seasons.

Distance (m)	Chi-square test (X^2)	P-value	Degrees of Freedom
ED 12 (N=141)	281,91	$p<0.001$	4
ED 13 (N=221)	183,62	$p<0.001$	4
ED 14 (N=132)	79,11	$p<0.001$	4
LD 12 (N=102)	90,30	$p<0.001$	4
LD 13 (N=222)	296,03	$p<0.001$	4
Tr 12 (N=18)	11,37	$p<0.05$	4
Tr 13 (N=72)	102,95	$p<0.001$	4
Wet 12 (N=212)	70,59	$p<0.001$	4
Wet 13 (N=290)	28,28	$p<0.001$	4

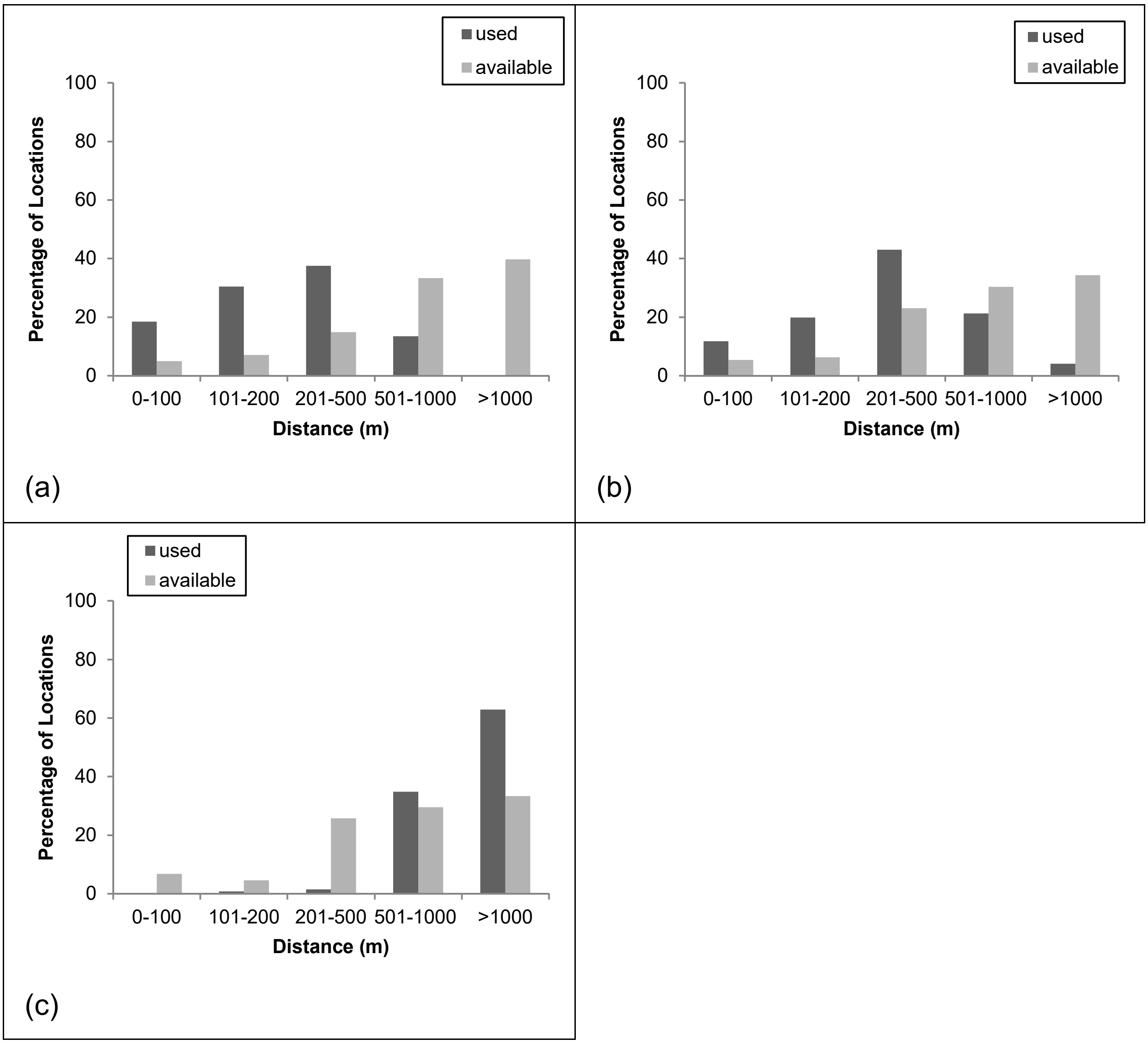

Figure 3.5: Percentage of sable antelope locations and random created points in the different distance classes from fences in the (a) early dry season 12, (b) early dry season 13 and (c) early dry season 14 for the woodland herd.

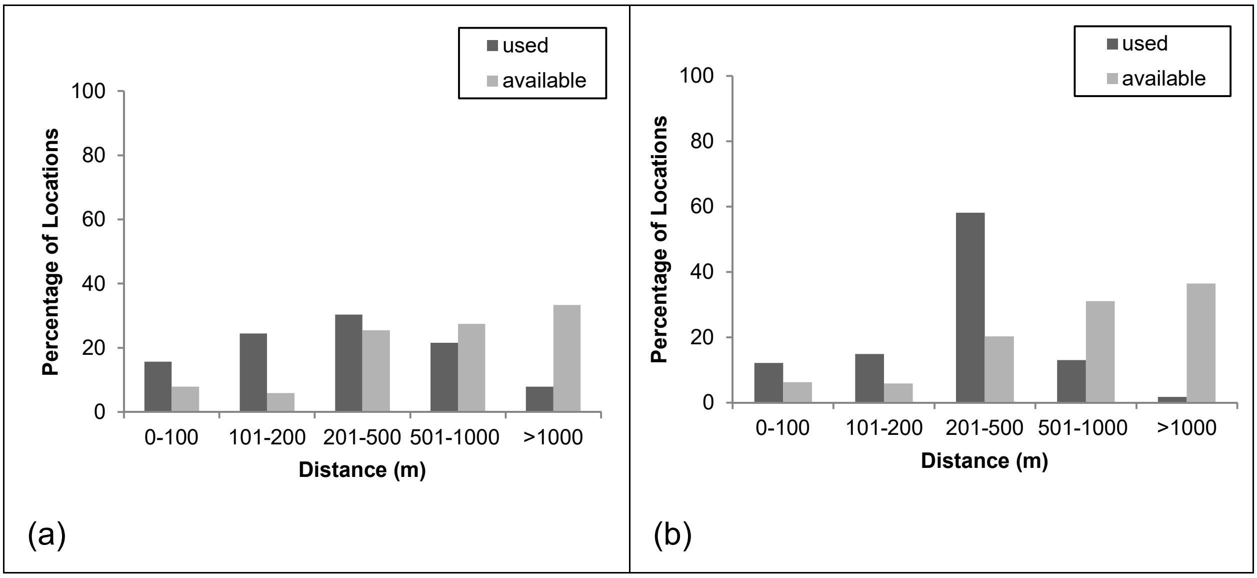

Figure 3.6: Percentage of sable antelope locations and random created points in the different distance classes from fences in the (a) late dry season 12, (b) late dry season 13 for the woodland herd.

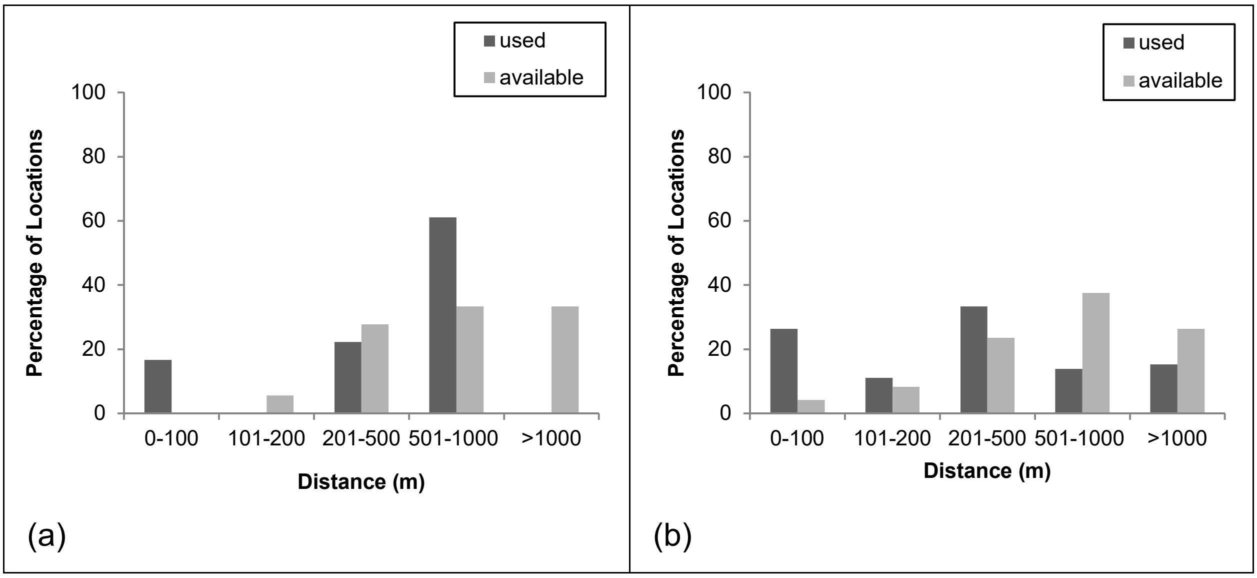

Figure 3.7: Percentage of sable antelope locations and random created points in the different distance classes from fences in the (a) transition 12, (b) transition 13 for the woodland herd.

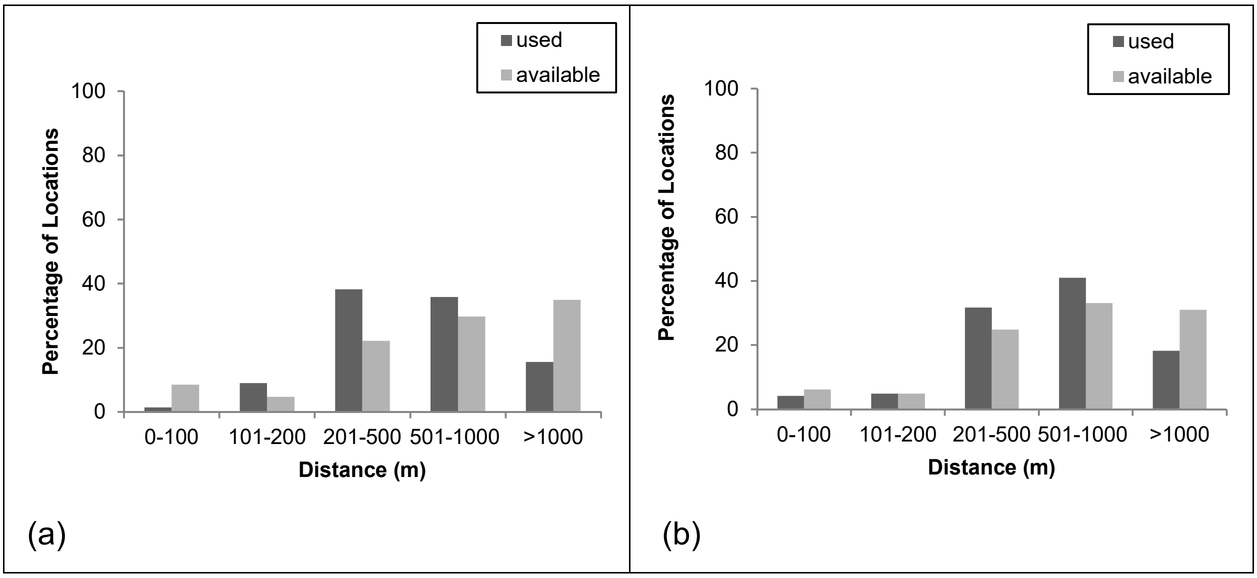

Figure 3.8: Percentage of sable antelope locations and random created points in the different distance classes from fences in (a) wet season 12/13, (b) wet season 13/14 for the woodland herd.

Roads

The vlei herd showed a significant difference between expected and used locations in various distance classes away from the roads in all seasons (Table 3.3). In the ED 12 the vlei herd used areas closer than 1000 m from roads less than expected (Figure 3.9 a), while in the ED 13 and ED 14 they were never further than 1000 m from roads and used more locations compared to what was expected in distance classes 0-500 m (Figure 3.9 b, c). Overall in all seasons, except the ED 12, the vlei herd utilised areas < 200 m away from the roads more than expected (Figures 3.9, 3.10, 3.11, 3.12).

Table 3.3: Chi-squared statistics of used vs. random locations at different distances from roads for the vlei herd in different seasons.

Distance (m)	Chi-square test (X^2)	P-value	Degrees of Freedom
ED 12 (N=141)	279,57	<0.001	4
ED 13 (N=219)	72,71	p<0.001	4
ED 14 (N=132)	34,15	p<0.001	4
LD 12 (N=222)	85,72	p<0.001	4
LD 13 (N=221)	106,68	p<0.001	4
Tr 12 (N=72)	19,50	p<0.001	4
Tr 13 (N=72)	11,50	<0.05	4
Wet 12 (N=217)	89,99	p<0.001	4
Wet 13 (N=290)	60,12	p<0.001	4

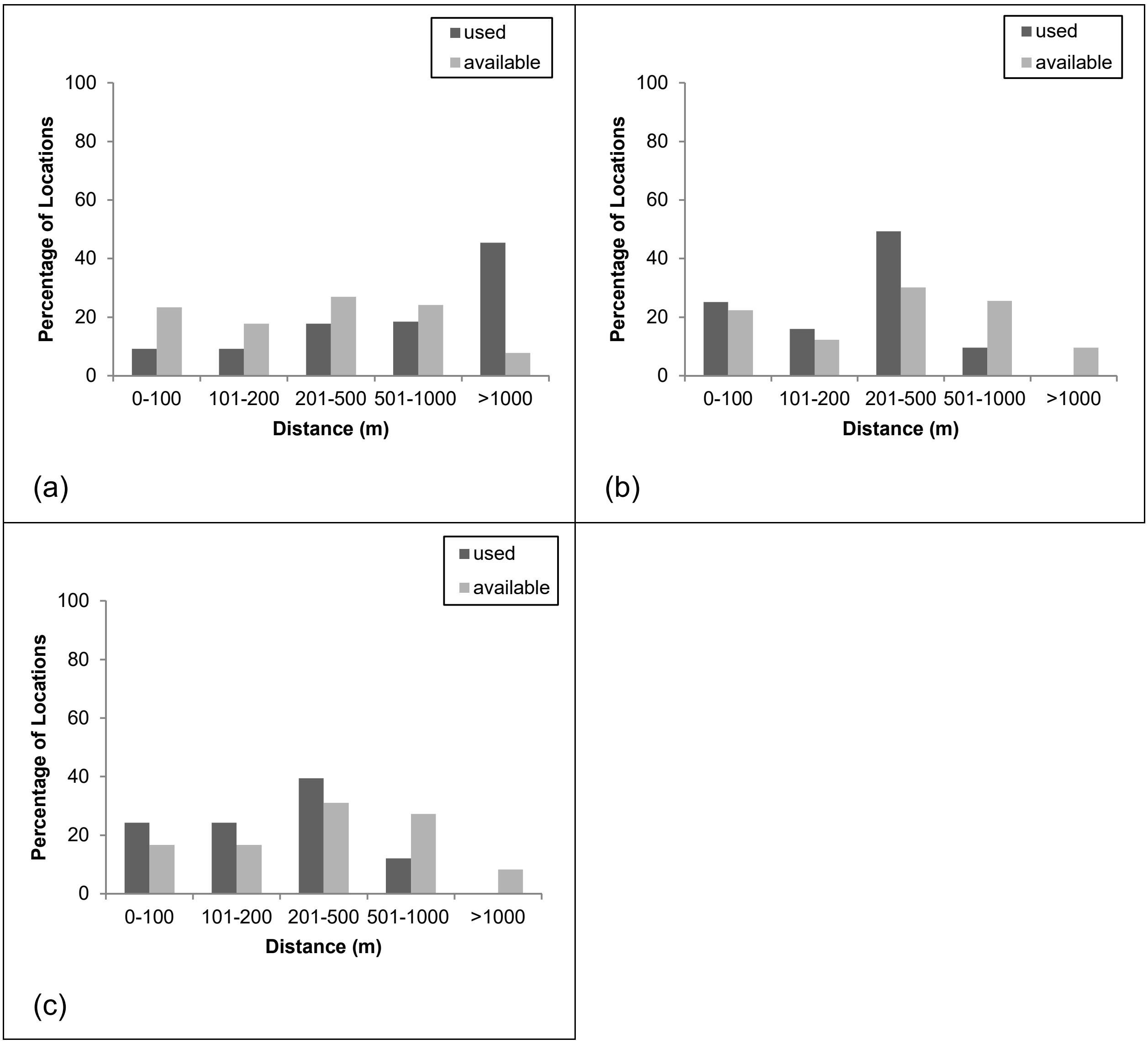

Figure 3.9: Percentage of sable antelope locations and random created points in the different distance classes from roads in the (a) early dry season 12, (b) early dry season 13 and (c) early dry season 14 for the vlei herd.

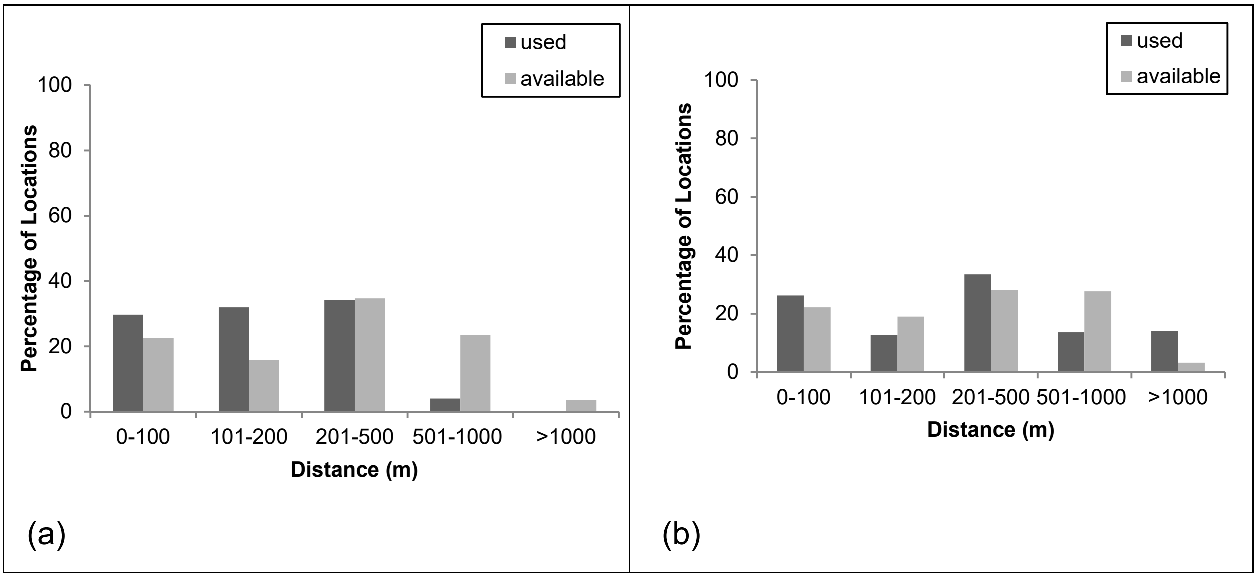

Figure 3.10: Percentage of sable antelope locations and random created points in the different distance classes from roads in the (a) late dry season 12, (b) late dry season 13 for the vlei herd.

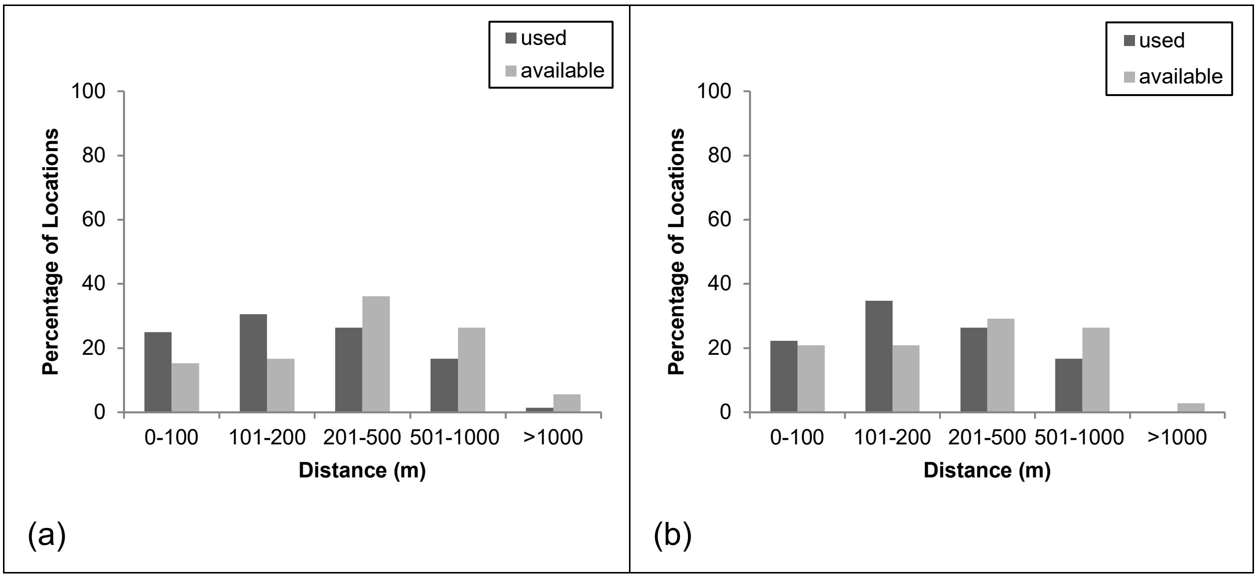

Figure 3.11: Percentage of sable antelope locations and random created points in the different distance classes from roads in the (a) transition 12, (b) transition 13 for the vlei herd.

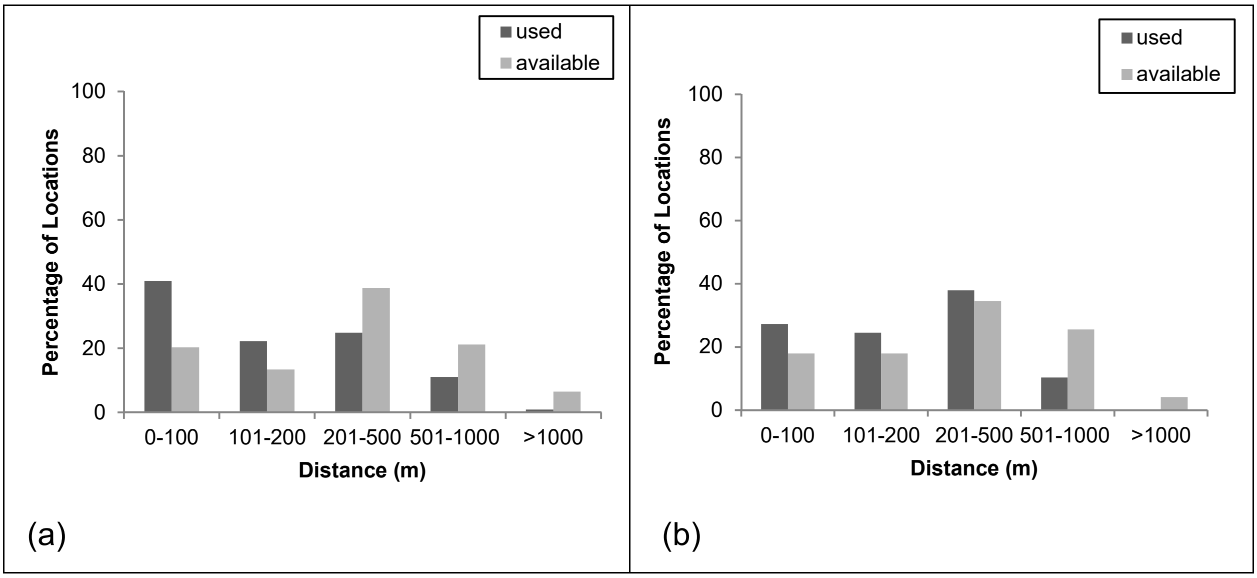

Figure 3.12: Percentage of sable antelope locations and random created points in the different distance classes from roads in the (a) wet season 12/13, (b) wet season 13/14 for the vlei herd.

During the ED 12, ED 13 (Figure 3.13 a, b) and Tr 13 (Figure 3.15 b) the woodland herd locations in the various distance classes to roads were not significantly different from what would be expected from a random use of space, being mostly seen at distances less than 500 m from roads and very little further than 500 m from a road (Table 3.4). Areas further than 500 m from roads were avoided by the woodland herd in all seasons, while areas closer than 200 m were always used more than expected (Figures 3.13 c, 3.14, 3.15, 3.16).

Table 3.4: Chi-squared statistics of used vs. random locations at different distances from roads for the woodland herd in different seasons.

Distance (m)	Chi-square test (X^2)	P-value	Degrees of Freedom
ED 12 (N=141)	1,08	>0.05	3
ED 13 (N=221)	4,81	>0.05	3
ED 14 (N=132)	20,55	p<0.001	3
LD 12 (N=102)	13,97	p<0.01	3
LD 13 (N=222)	22,26	p<0.001	3
Tr 12 (N=18)	15,50	p<0.01	3
Tr 13 (N=72)	3,69	>0.05	3
Wet 12 (N=212)	22,24	p<0.001	4
Wet 13 (N=290)	22,02	p<0.001	4

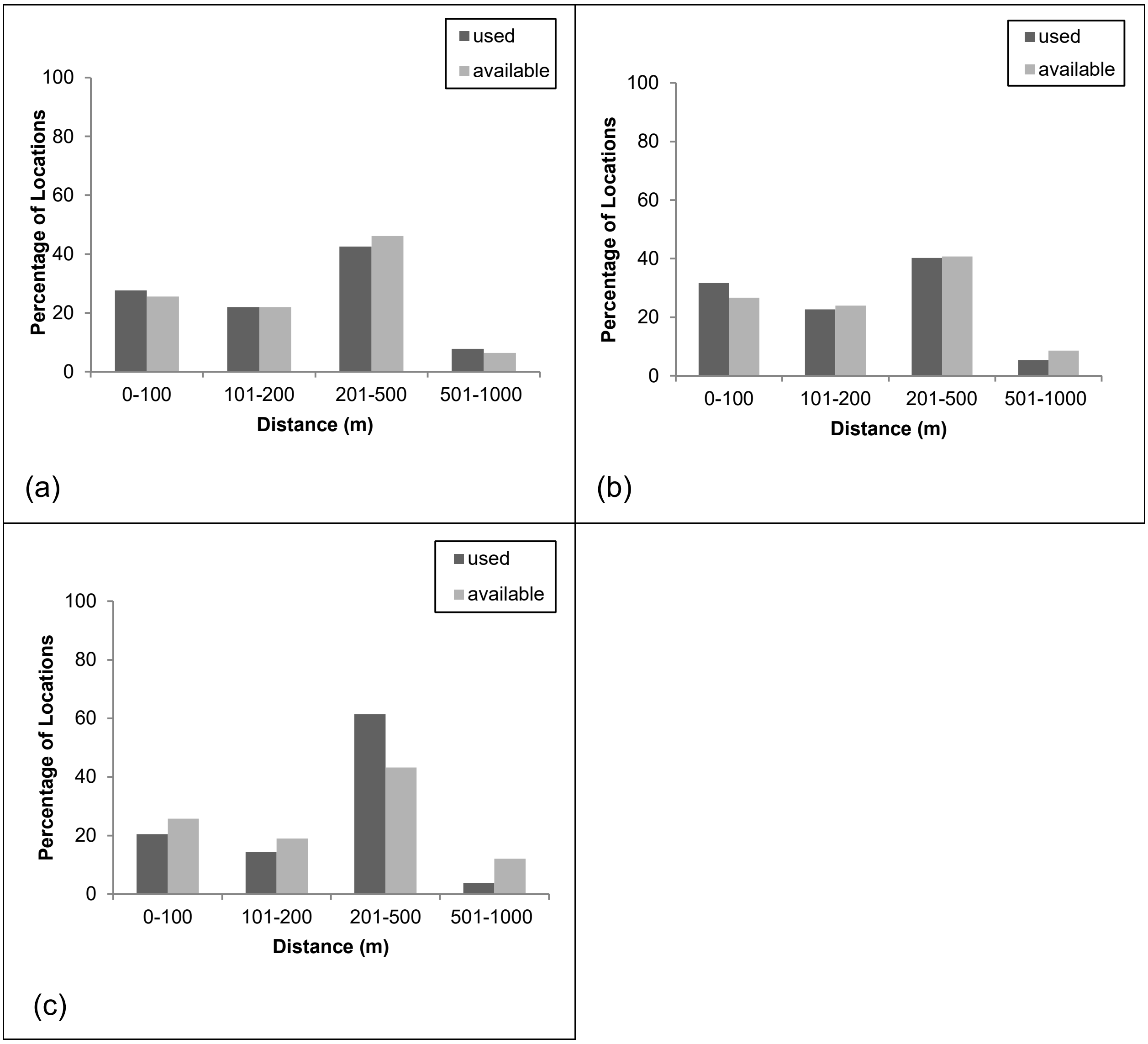

Figure 3.13: Percentage of sable antelope locations and random created points in the different distance classes from roads in the (a) early dry season 12, (b) early dry season 13 and (c) early dry season 14 for the woodland herd.

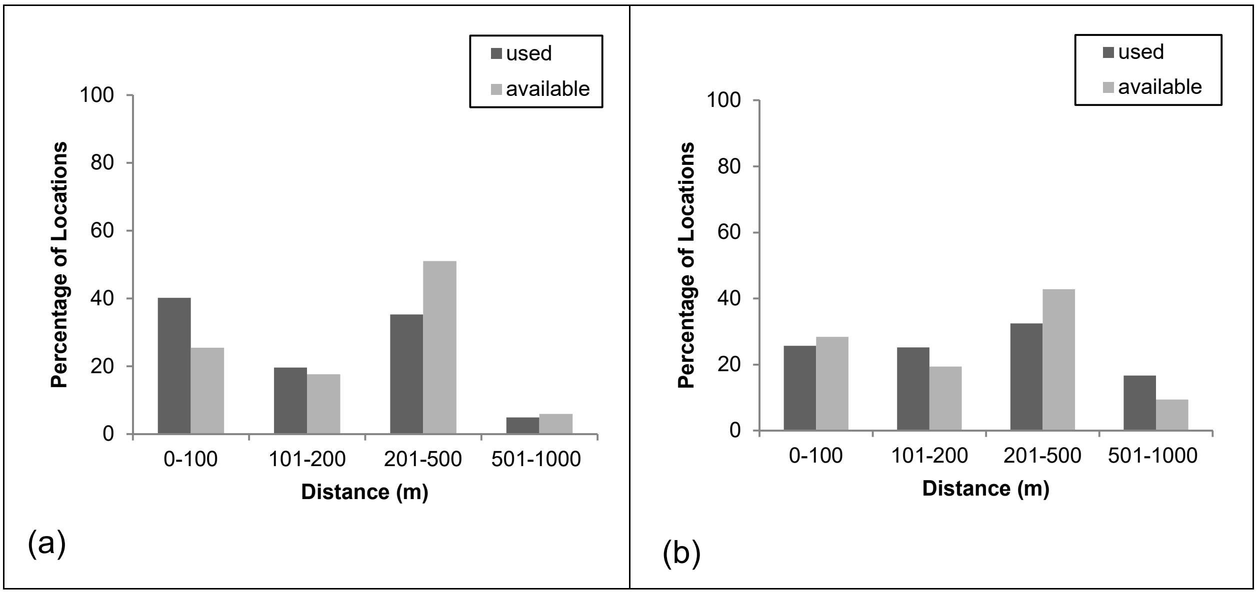

Figure 3.14: Percentage of sable antelope locations and random created points in the different distance classes from roads in the (a) late dry season 12, (b) late dry season 13 for the woodland herd.

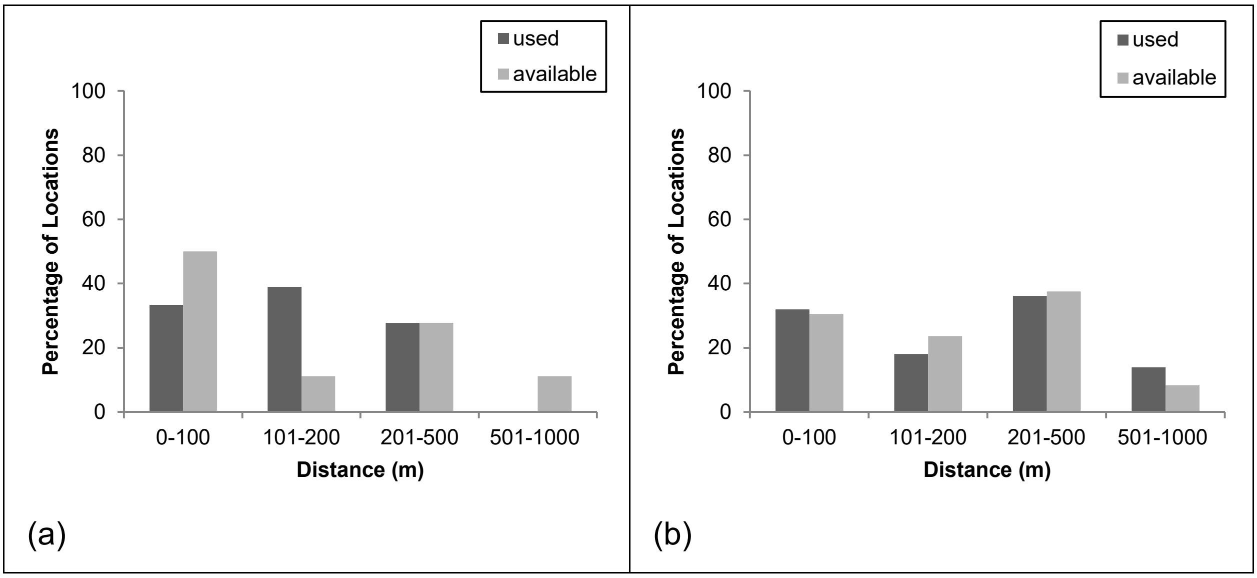

Figure 3.15: Percentage of sable antelope locations and random created points in the different distance classes from roads in the (a) transition 12, (b) transition 13 for the woodland herd.

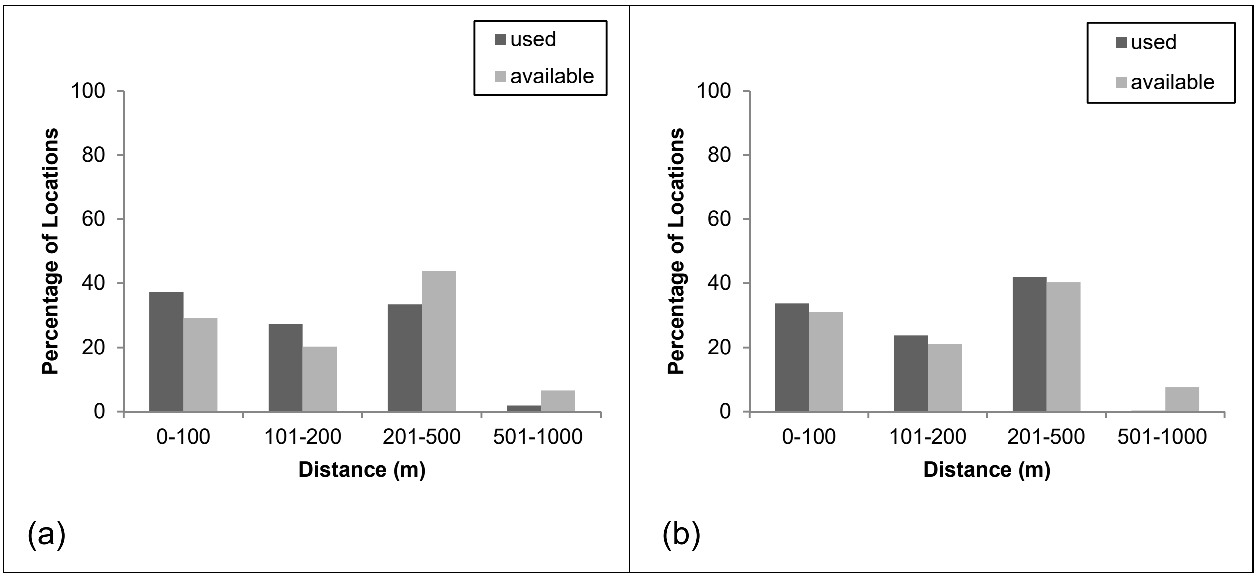

Figure 3.16: Percentage of sable antelope locations and random created points in the different distance classes from roads in the (a) wet season 12/13, (b) wet season 13/14 for the woodland herd.

Camping Huts

The vlei herd showed a significant difference between available and used locations at various distances from the camping huts in all seasons (Table 3.5). Although in most seasons the areas which were mostly used by the vlei herd were further than 1000 m from the campsites, in the ED 12 there were more locations than expected between 500-1000 m and no locations within 500 m from camping sites (Figure 3.17 a); in the ED 13 they used areas <1000 more than expected (Figure 3.17 b) and in the ED 14 areas closer than 500 m more than expected (Table 3.5), Figure 3.17 c). In the LD 12 areas within 1000 m from camping huts were used more than expected and areas further than 1000 m less than expected (Figure 3.18 a), while the following year in LD 13 the vlei herd almost never used areas closer than 1000 m from campsites (Figure 3.18 b). During the Tr 12, Tr 13 and Wet 12 the vlei herd locations in the various distance classes to camping huts were not significantly different from what would be expected from a random use of space (Table 3.5). During these seasons, the vlei herd utilised little of the areas in distance classes 0-500 m and 501-100 m as expected based on availability and most locations were further than 1000 m as expected (Figures 3.19, 3.20 a). This was not very different from the Wet 13 period when however the areas further than 1000 m where used even more than expected (Figure 3.20 b).

Table 3.5: Chi-squared statistics of used vs. random locations at different distances from camping huts for the vlei herd in different seasons.

Distance (m)	Chi-square test (X^2)	P-value	Degrees of Freedom
ED 12 (N=141)	9,37	<0.01	2
ED 13 (N=219)	126,45	p<0.001	2
ED 14 (N=132)	9,53	p<0.01	2
LD 12 (N=222)	19,95	p<0.001	2
LD 13 (N=221)	43,47	p<0.001	2
Tr 12 (N=72)	0,58	>0.05	2
Tr 13 (N=72)	5,65	>0.05	2
Wet 12 (N=217)	2,32	>0.05	2
Wet 13 (N=290)	19,00	p<0.001	2

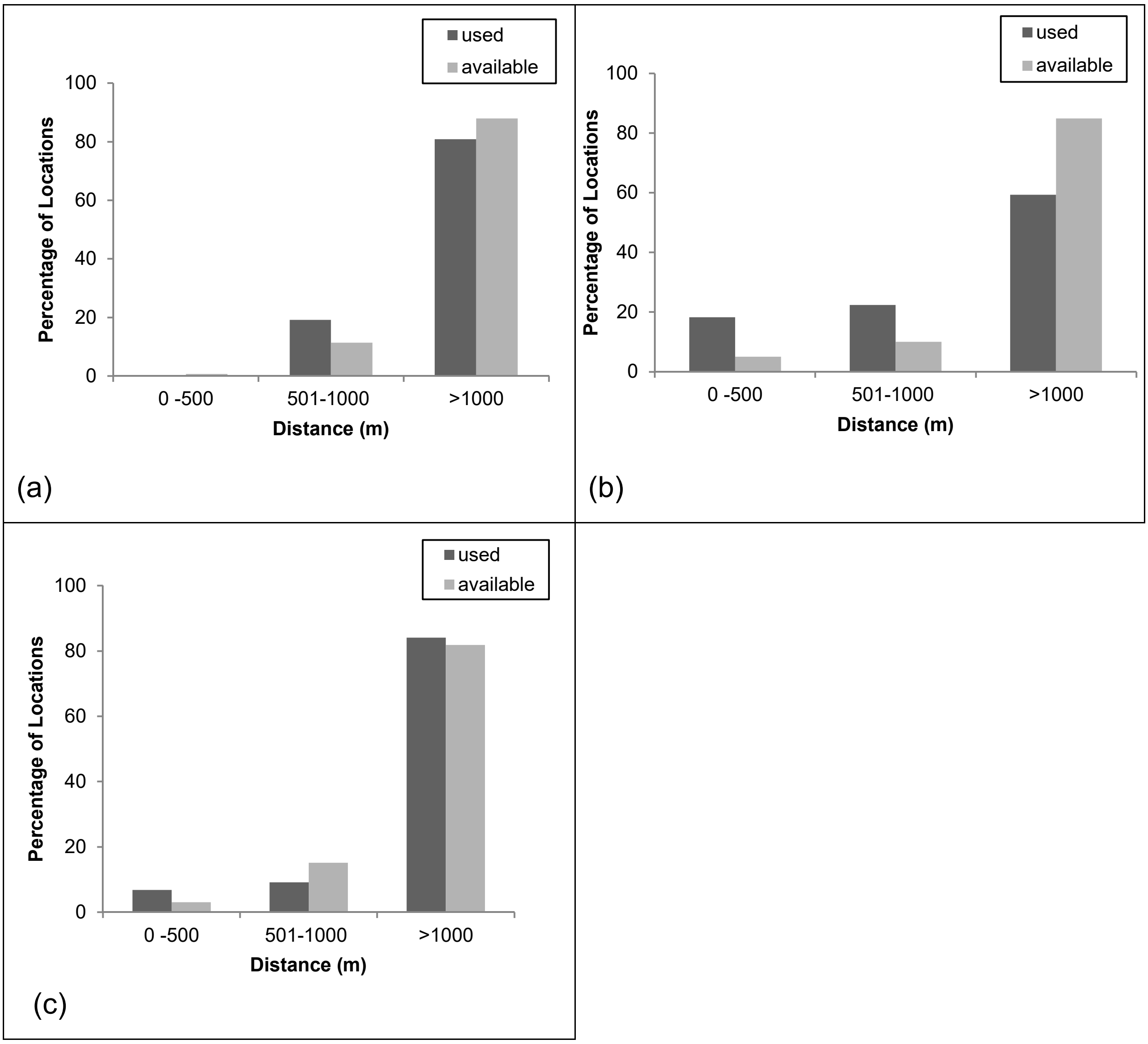

Figure 3.17: Percentage of sable antelope locations and random created points in the different distance classes from camping huts in the (a) early dry season 12, (b) early dry season 13 and (c) early dry season 14 for the vlei herd.

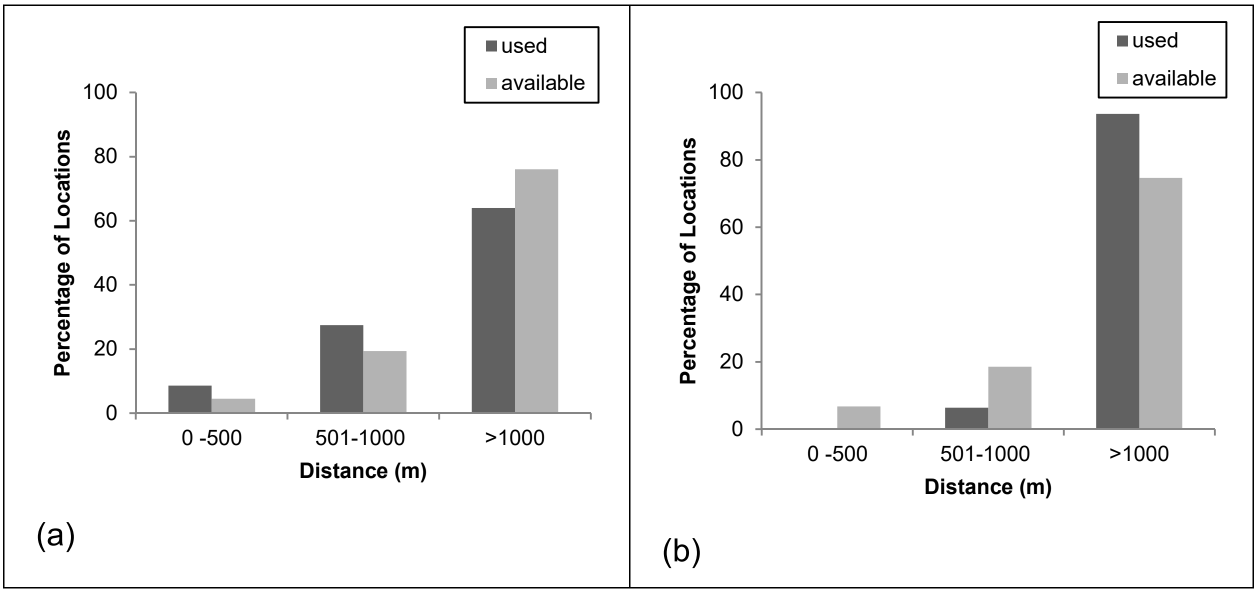

Figure 3.18: Percentage of sable antelope locations and random created points in the different distance classes from camping huts in the (a) late dry season 12, (b) late dry season 13for the vlei herd.

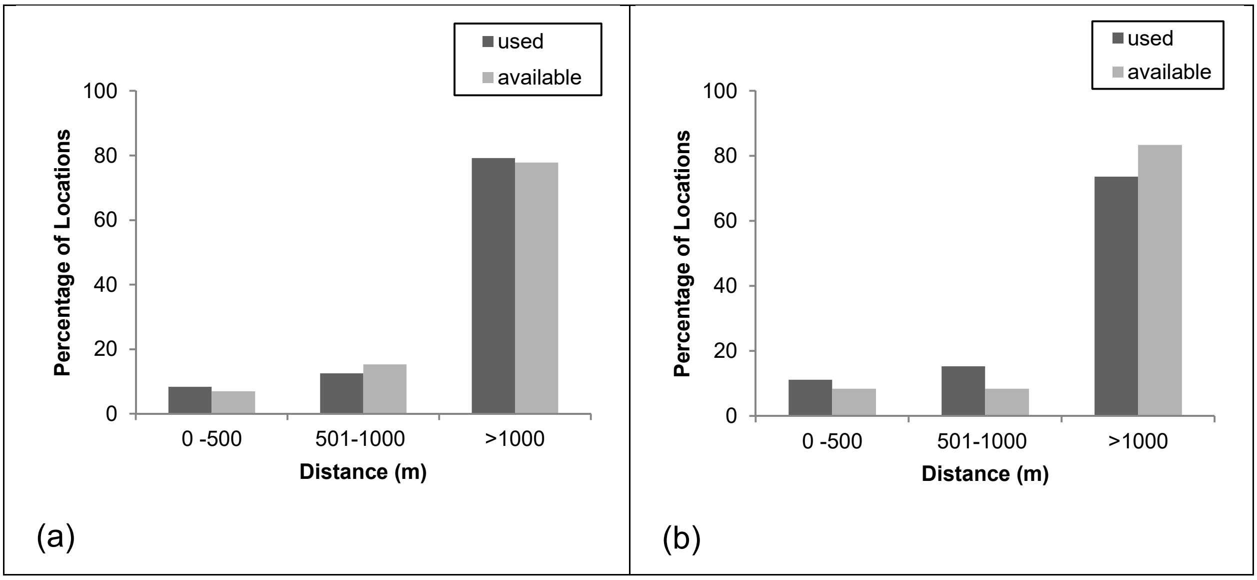

Figure 3.19: Percentage of sable antelope locations and random created points in the different distance classes from camping huts in the (a) transition 12, (b) transition 13 for the vlei herd.

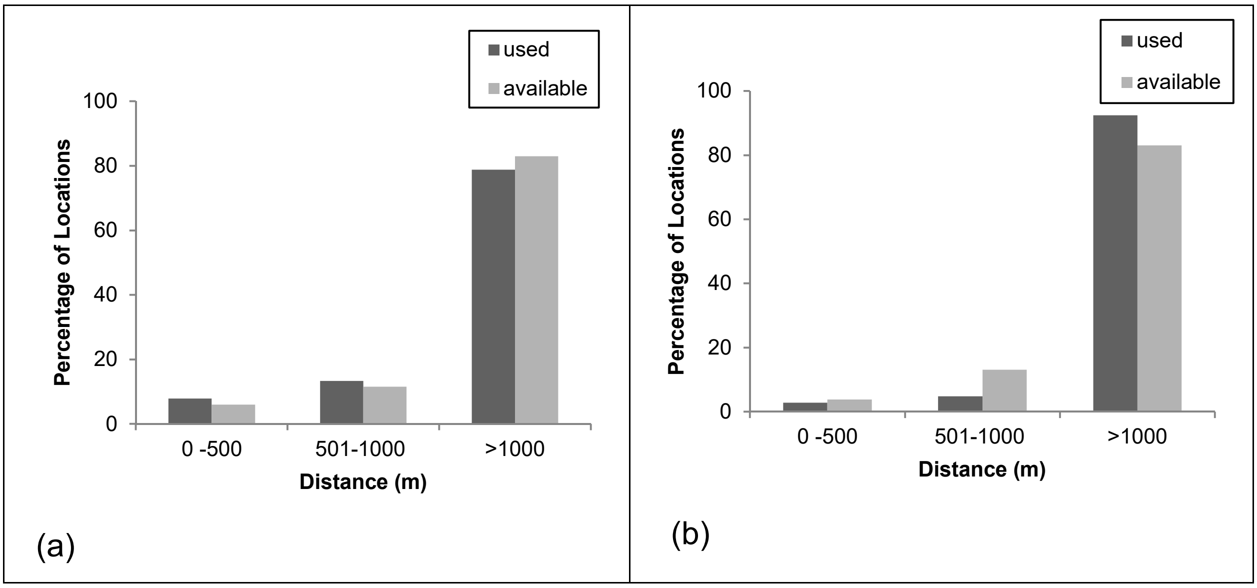

Figure 3.20: Percentage of sable antelope locations and random created points in the different distance classes from camping huts in the (a) wet season 12/13, (b) wet season 13/14 for the vlei herd.

There was no significant difference from what would have been expected from random use of space by the woodland herd during the ED 12 and LD 12 (Table 3.6), which means most locations were found further than 1000 m from camp sites (Figure 3.21a, 3.22 a). In other seasons there was a significant difference between available and used sable locations in various classes away from the camping huts (Table 3.6), but the majority of locations was still away (>1000 m) from campsites. In the ED 13 and ED 14 areas further than 1000 m were used more than expected (Figure 3.21 b, c) and in ED 14 areas closer than 500 m were totally avoided (Figure 3.21 c). In LD 13, Tr 12, Tr 13, Wet 13 and Wet 14 areas further than 1000 m were used more than expected and areas closer than 1000 m were avoided (Figures 3.22 b, 3.23, 3.24). During the LD 13 and Tr 12 the herd totally avoided areas in distance classes 0-500 m and 501-1000 m (Figures 3.22 b, 3.23 a).

Table 3.6: Chi-squared statistics of used vs. random locations at different distances from camping huts for the woodland herd in different seasons.

Distance (m)	Chi-square test (X^2)	P-value	Degrees of Freedom
ED 12 (N=141)	1,77	>0.05	2
ED 13 (N=221)	7,69	<0.05	2
ED 14 (N=132)	21,17	p<0.001	2
LD 12 (N=102)	2,33	>0.05	2
LD 13 (N=222)	119,57	p<0.001	2
Tr 12 (N=18)	9,00	<0.02	2
Tr 13 (N=72)	11,22	<0.01	2
Wet 12 (N=212)	81,56	p<0.001	2
Wet 13 (N=290)	71,68	p<0.001	2

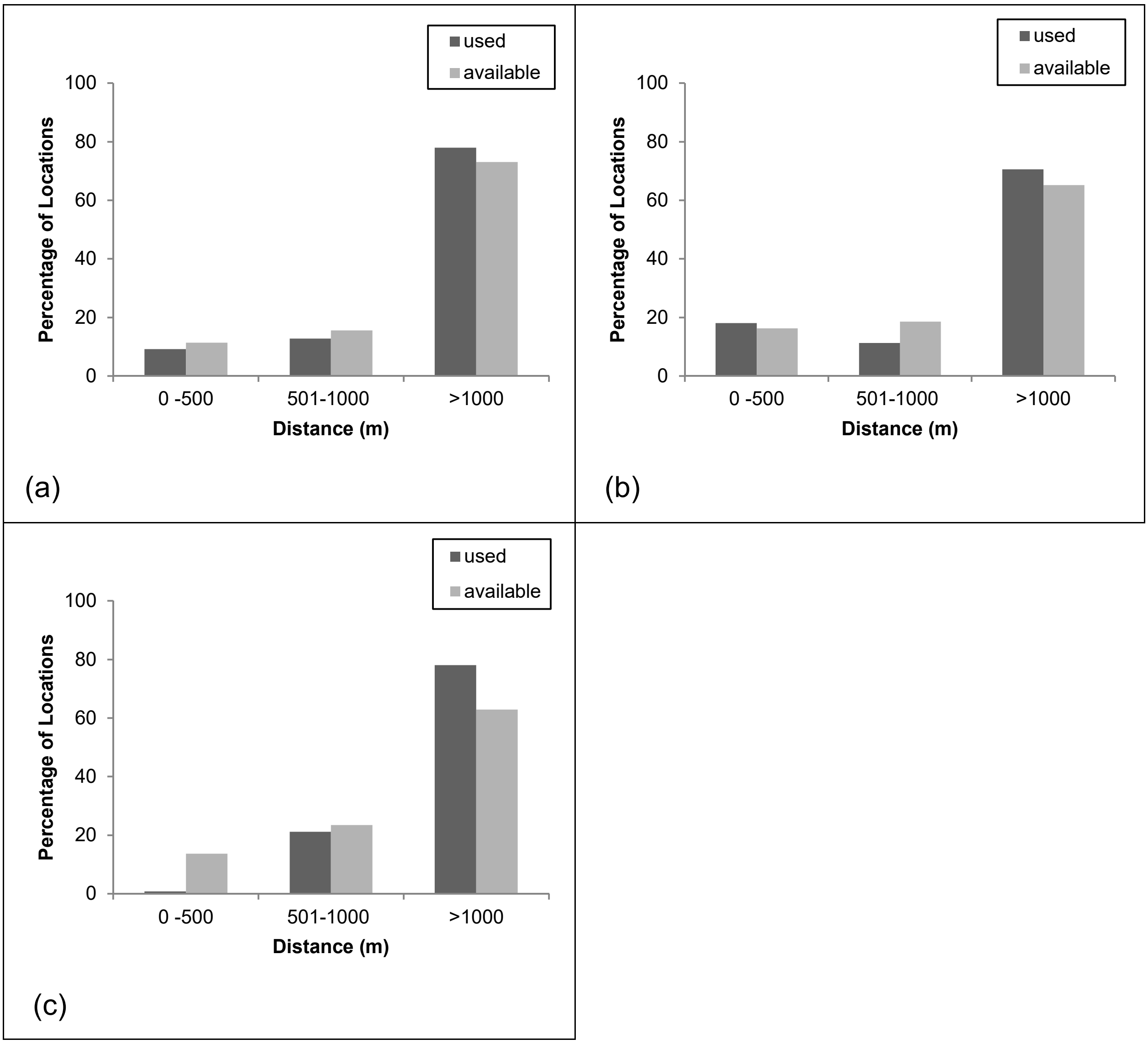

Figure 3.21: Percentage of sable antelope locations and random created points in the different distance classes from camping huts in the (a) early dry season 12, (b) early dry season 13 and (c) early dry season 14 for the woodland herd.

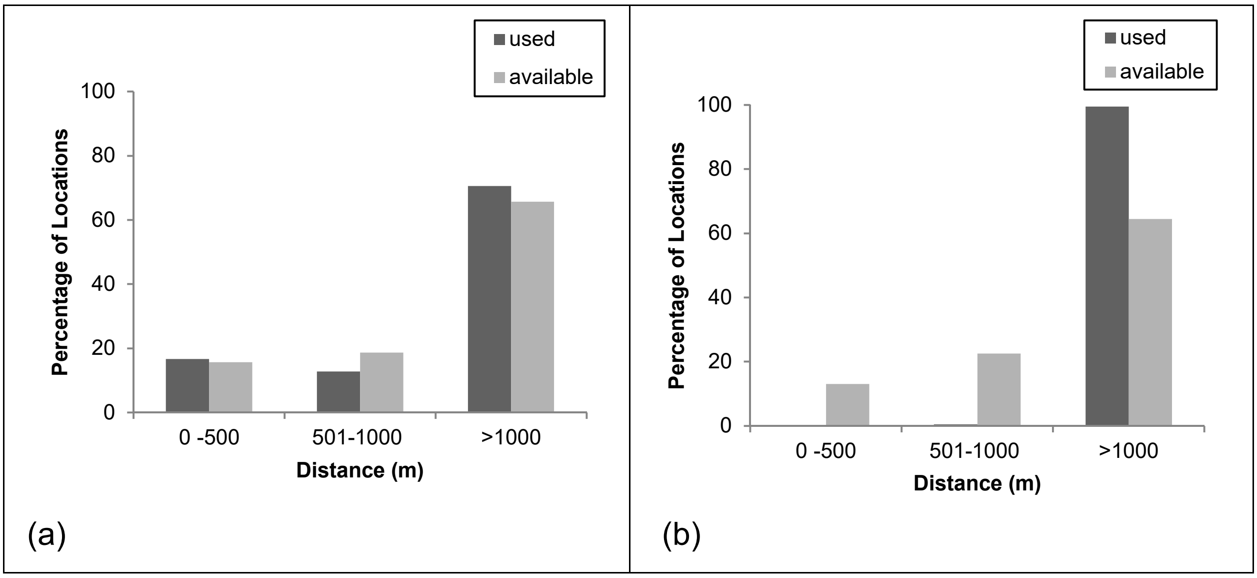

Figure 3.22: Percentage of sable antelope locations and random created points in the different distance classes from camping huts in the (a) late dry season 12, (b) late dry season 13 for the woodland herd.

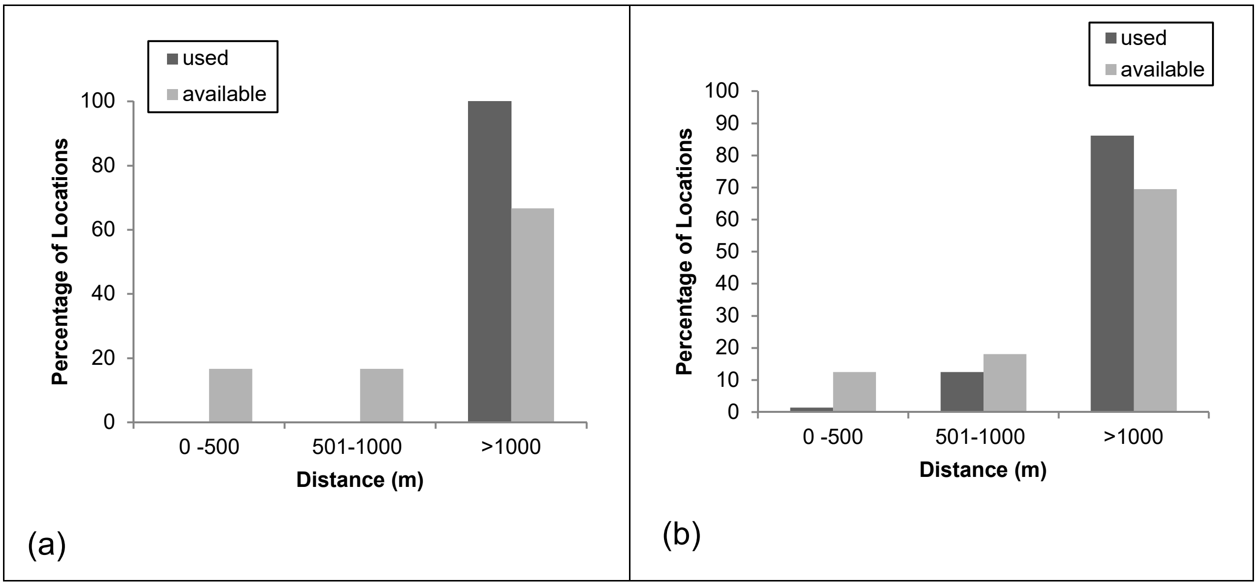

Figure 3.23: Percentage of sable antelope locations and random created points in the different distance classes from camping huts in the (a) transition 12, (b) transition 13 for the woodland herd.

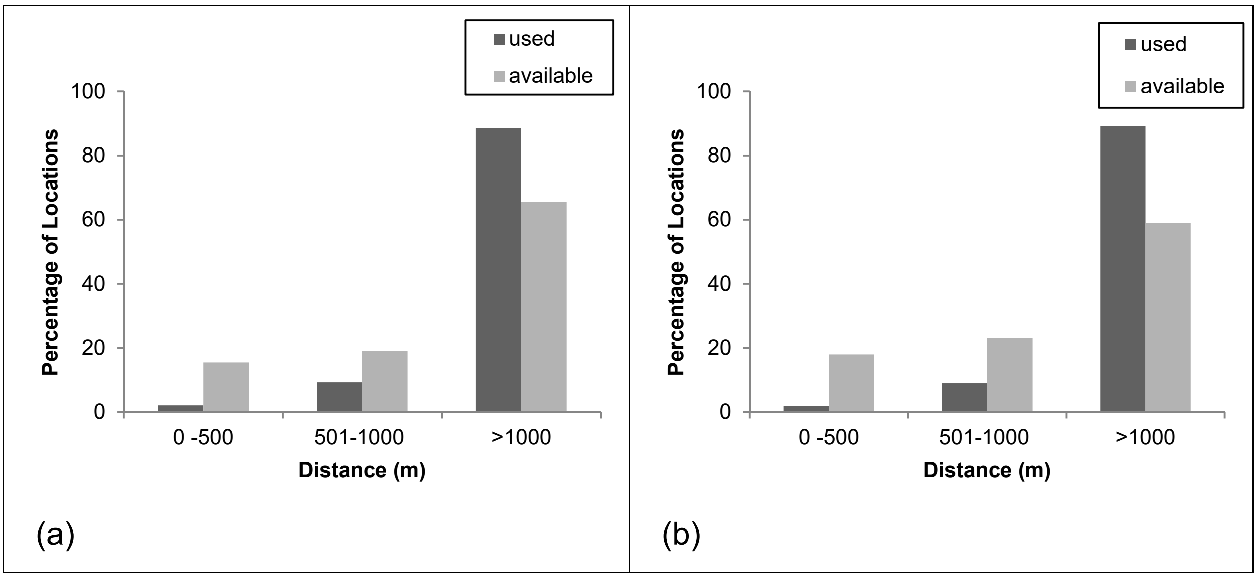

Figure 3.24: Percentage of sable antelope locations and random created points in the different distance classes from camping huts in the (a) wet season 12/13, (b) wet season 13/14 for the woodland herd.

Vegetation types and burnt areas

Both sable herds spent most of their time in the tall grassland vegetation type (54,1% of GPS location for the vlei herd; 61,8% of GPS locations for the woodland herd). The vlei herd utilised the tall grassland (TG) mostly during the Wet 12/13 and Wet 13/14 with 63,4% and 68,5% locations respectively (Figure 3.25). The second mostly used vegetation by the vlei herd was the open shrubland (OS) recording 41,3% of GPS locations. The season with the majority of locations within this vegetation type was the ED 13 with 53,9% of GPS locations. Moist grassland (MG) was rarely used vegetation by the vlei herd with 3,9% of GPS locations and 14,3% of GPS locations being the highest during the LD 13 (Fig. 3.25). The closed woodland (CW) was the least used vegetation type by the vlei herd with an average of 0,7% of GPS locations recorded. The most GPS locations for this type of vegetation recorded was 2,6% in the ED 13 (Fig. 3.25).

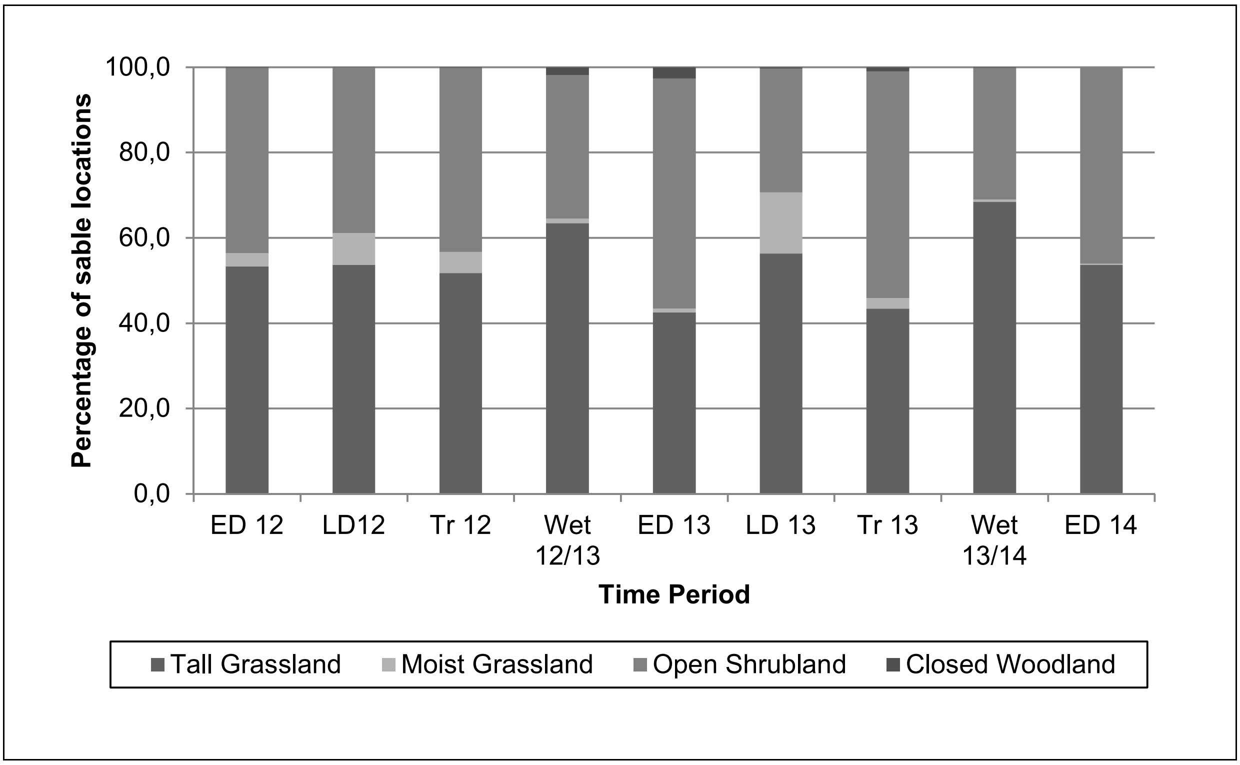

Figure 3.25: Seasonal variation in proportion of sable antelope sightings in different vegetation types for the vlei herd in Kgaswane Mountain Reserve.

The woodland herd utilised TG mostly during the LD 13 recording 89,9% of GPS locations (Figure 3.26). The second mostly used vegetation by the woodland herd was the CW recording and average of 25,0% of GPS locations for all seasons. The OS was rarely a used vegetation type by the woodland herd with an average of 11,6% of GPS locations and 23,9% of GPS locations being the highest during the Wet 12/13 and Wet 13/14 (Figure 3.26). During the ED 14 there were no records of GPS locations in the OS vegetation type. The MG was the least used vegetation type by the woodland herd with an average of 1,6% of GPS locations recorded. The most GPS locations for this type of vegetation recorded was 4,4% recorded in Tr 12.

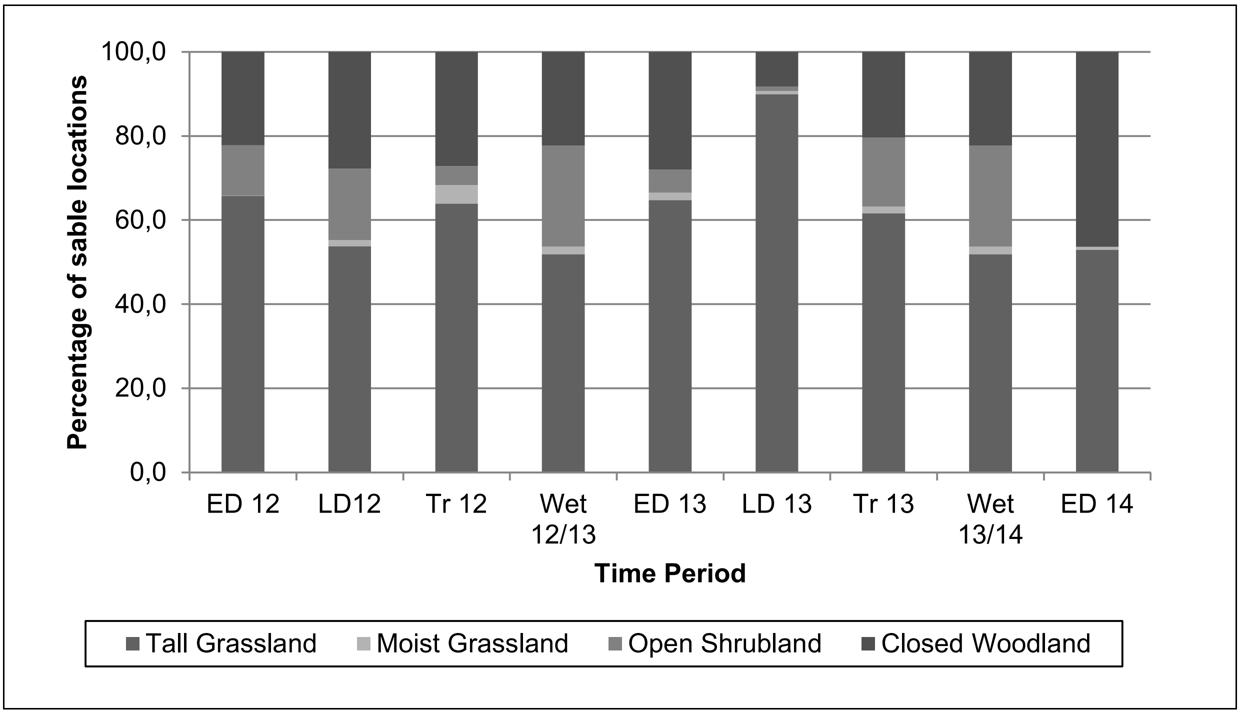

Figure 3.26: Seasonal variation in proportion of sable antelope sightings in different vegetation types for the woodland herd in Kgaswane Mountain Reserve

Looking at the spatial distribution of GPS locations recorded from May 2012 to April 2014, the two herds used burnt/unburnt areas quite differently. The vlei herd recorded an average of 25.3% of GPS locations in bunt areas and 74.7% of GPS positions in unburnt area for the duration of the study, while the woodland herd had 55.8% of GPS locations records on burnt areas compared to 44.2% of GPS locations recorded in unburnt areas. The vlei herd only used burnt areas more than unburnt areas in the ED 12 (94.6% of GPS locations) and in the Wet 13/14 (62.9%) (Figure 3.27). ED 11 was when the burnt areas were least used with 2.8% of GPS locations recorded (Figure 3.27). The woodland herd used burnt area more than the unburnt areas during most of the seasons, except for the Tr 11, LD 12, Wet 12/13, ED 13 (Figure 3.28). In the ED 12, the herd spends almost the whole season only in the burnt area (99.9%) (Figure 3.28).

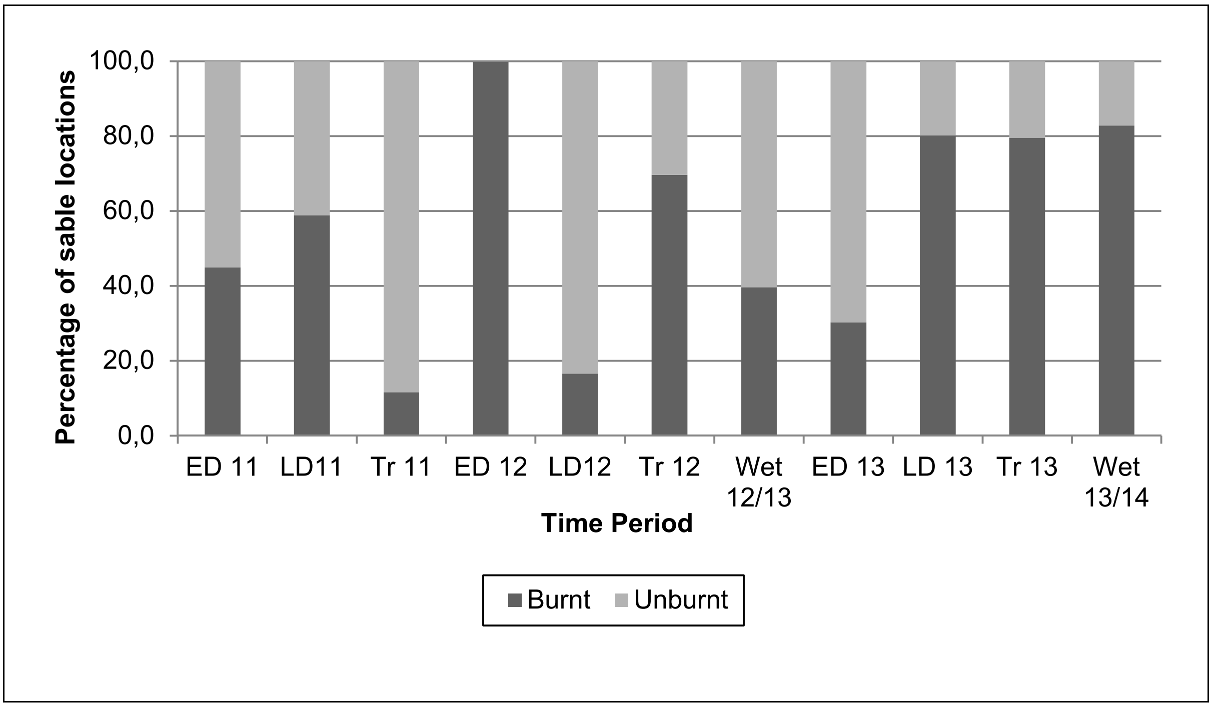

Figure 3.27: Seasonal variation in the use of burnt/unburnt areas by the vlei herd in Kgaswane Mountain Reserve.

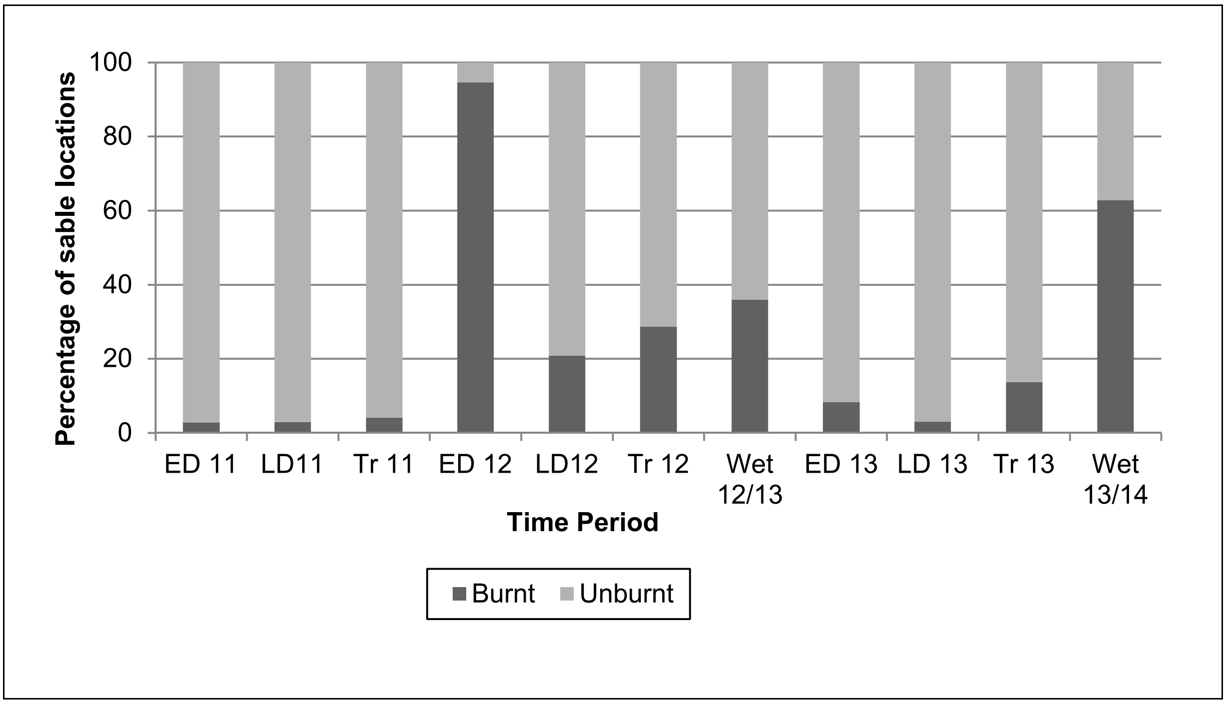

Figure 3.28: Seasonal variation in the use of burnt/unburnt areas by the woodland herd in Kgaswane Mountain Reserve.

Nutritional status

A total of 104 faecal samples were analysed for both nitrogen and phosphorus. As expected, Crude Protein (CP) concentrations differed between seasons for both herds (vlei: ANOVA, $F_{1.6}$= 0.75, p<0.05; woodland: ANOVA, $F_{1.6}$= 0.22, p<0.05). Both herds had highest values of CP concentrations in the Tr 13 (vlei herd: 14.66%; woodland herd: 13.40%) and Wet 13/14 (vlei herd: 14.87%; woodland herd: 13.57%) and the lowest values in ED 13 and LD 13 year as expected. For the vlei herd, CP concentrations during ED 13 were 9.69 % and 10.30 % during LD 13, while the CP concentration of the woodland herd during the ED 13 and LD 13 was 10.26 % and 10.13 % respectively (Figure 3.29).

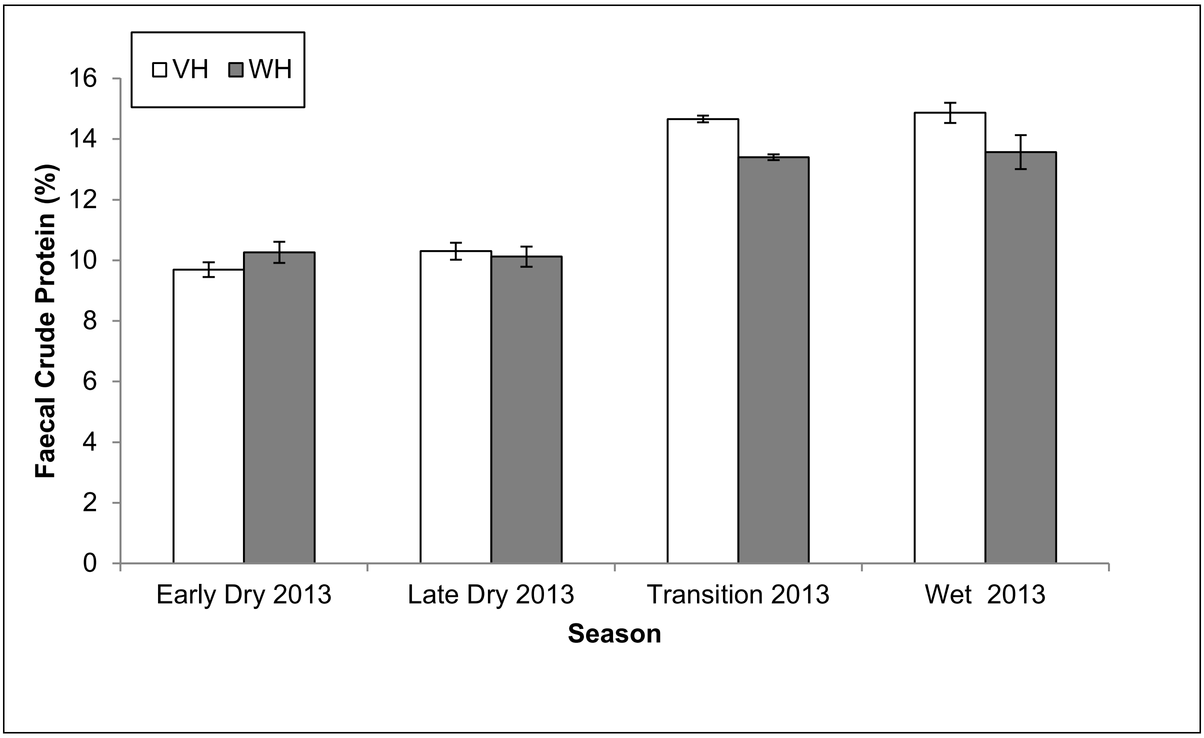

Figure 3.29: Faecal Crude Protein concentrations of sable antelope over a period of four seasons for the Vlei Herd and the Woodland Herd in Kgaswane Mountain Reserve.

As expected, P_f concentrations were different in different seasons (vlei: ANOVA, $F_{1.6}$= 0.94, p<0.05; woodland: ANOVA, $F_{1.6}$= 0.13, p<0.05). For both herds, P_f concentration was at its lowest during the ED 13 and LD 13 (0.29 % and 0.27 %

respectively for the vlei herd; 0.29 % and 0.31 % for the woodland herd), and at its highest during the Tr 13 (vlei: 0.46%; woodland: 0.48%) (Figure 3.30).

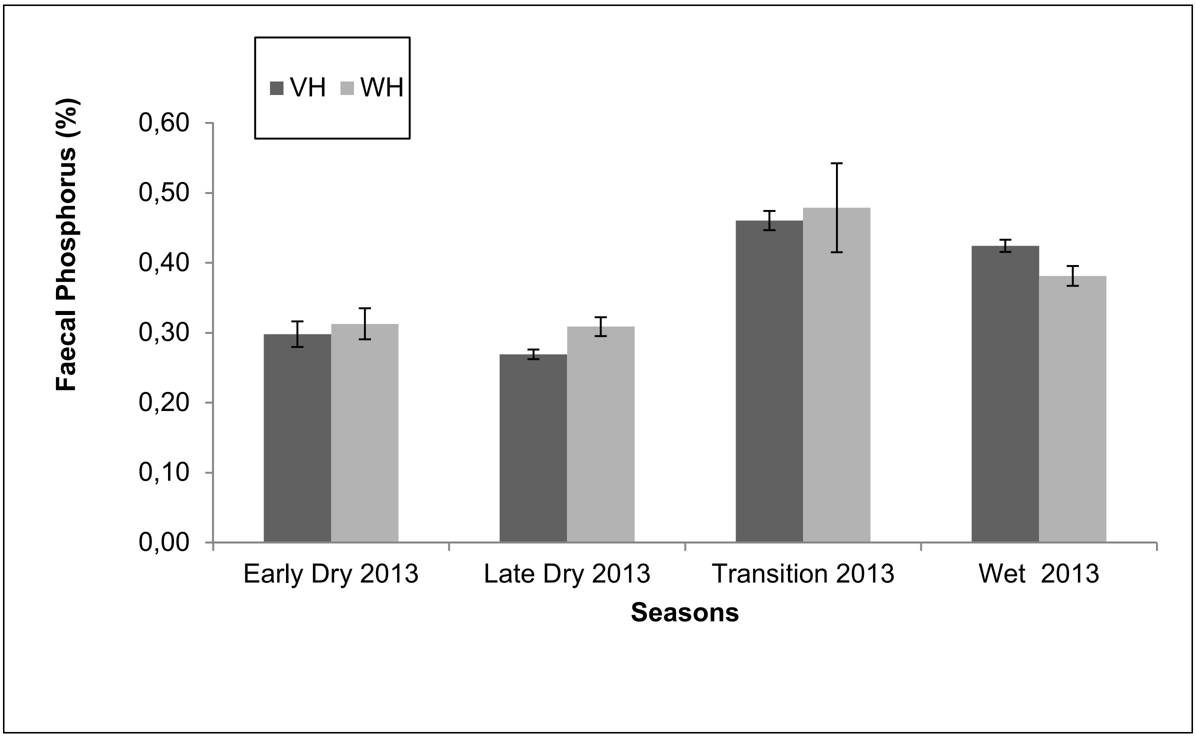

Figure 3.30: Faecal Phosphorus concentrations of sable over a period of four seasons for the Vlei Herd and the Woodland Herd in Kgaswane Mountain Reserve.

Calves recruitment, survival and sex ratio

The vlei herd had 19 calves (11 males and 8 females) whereas the woodland herd had 15 calves (9 males and 6 females) between 2011 and 2014. From 2011 until 2014, a total of 34 sable antelope calves were recruited in the reserve. Births of calves were between February and April. Calves are usually seen between February-April for the vlei herd and between March-April for the woodland herd. From 2011 to 2014, natalities of sable antelope has been decreasing in the reserve with 11(2011), ten (2012), seven (2013) and six (2014) calves born in years mentioned above. For 2011 and 2012 natalities, I relied on data collected during monitoring done by me and Field Rangers during weekly patrols and from April 2013 to March 2014 I relied on data which was collected weekly when collecting dung pallets. Data for 2011 until 2012 included breeding herds and lone bulls whereas data from April 2013 to March 2014 was for the breeding herds only. As mentioned in the methodology (Chapter 2), monitoring was done weekly on both herds and population size was recorded.

In 2011, from the 11 calves born in that year six calves were seen in the next year with four calves surviving from the ten born in 2012. One calf from the woodland herd was seen during the 2012 game counts running alone and not being part of the herd. During the study I followed seven calves born in 2013 weekly. There were four born in the vlei herd and three in the woodland herd. On the 29th of July 2013, calf mortality was observed during patrols in the kloofs near Group Camp area and the cause of death was unknown. The vlei herd was missing one calf in August 2013. On the 4th of October 2013, the woodland herd split into two groups and we only managed to see a group of 11 which had the collared sable antelope within. It was observed that during the split, only two calves were seen with the remaining herd. There were six calves born in 2014 with four males and two females from both herds (vlei herd: three males and one female; woodland herd: one male and one female). On the 23rd of June 2014, there were three calves seen in the vlei herd with one calf limping. By the end of 2014 only two calves survived in the vlei herd. From the woodland herd both calves survived 2014. A total of 15 sable antelope calves went missing between 2011 and 2014 with one mortality recorded.

In 2013, the park had two surveys, one in April and one in November. In the April 2013 survey, there were six sightings of sable antelope and in the November survey there were 11 sightings of sable antelope (Table 3.7, 3.8). The following year in the April 2014 survey (Table 3.7, 3.8 and Figure 3.32 c), there were six sightings of sable antelope and the sex ratio was 1 male: 2.50 females. There were five sightings of sable antelope during the survey done in November 2014 and the sex ratio was 1 male: 2.00 females (Table 3.7 and Figure 3.32 d). During my study from April 2013-March 2014, I had 166 sightings of sable antelope with an average of five juveniles (Table 3.8). The sex ratio for sable antelope was 1 male: 1.47 females (Table 3.7 and Figure 3.31 e). Looking at the sex ratio during the study and during annual surveys the sex ratio was skewed towards males with values 1 male: 1.60 females (April 2013), 1 male: 1.50 females (November 2013), 1 male: 2.50 females (April 2014),1 male: 2.00 females (November 2014) and during the study sex ratio was 1 male: 1.47 females (Figures 3.31 a-e).

Table 3.7: Sex ratios of the sable antelope population in Kgaswane Mountain Reserve as recorded during the annual park surveys.

Period	Sex ratio	SD	CV (%)
April 2013	1M: 1.60F	0.89	0.56
November 2013	1M: 1.50F	0.16	0.11
April 2014	1M: 2.50F	1.40	0.56
November 2014	1M: 2.00F	0.70	0.37
April 2013 – March 2014	1M: 1.47F	0.11	0.07

Table 3.8: Number of sable antelope sightings and age classification during the surveys and the study.

Period	Number of sightings	Classified adults	Unclassified adults	Classified sub-adults	Unclassified sub adults	All juveniles
April 2013	6	39	5	0	9	7
November 2013	11	42	16	13	0	5
April 2014	6	35	0	4	20	14
November 2014	5	25	0	5	0	0
April 2013 – March 2014	166	416	13	163	21	105

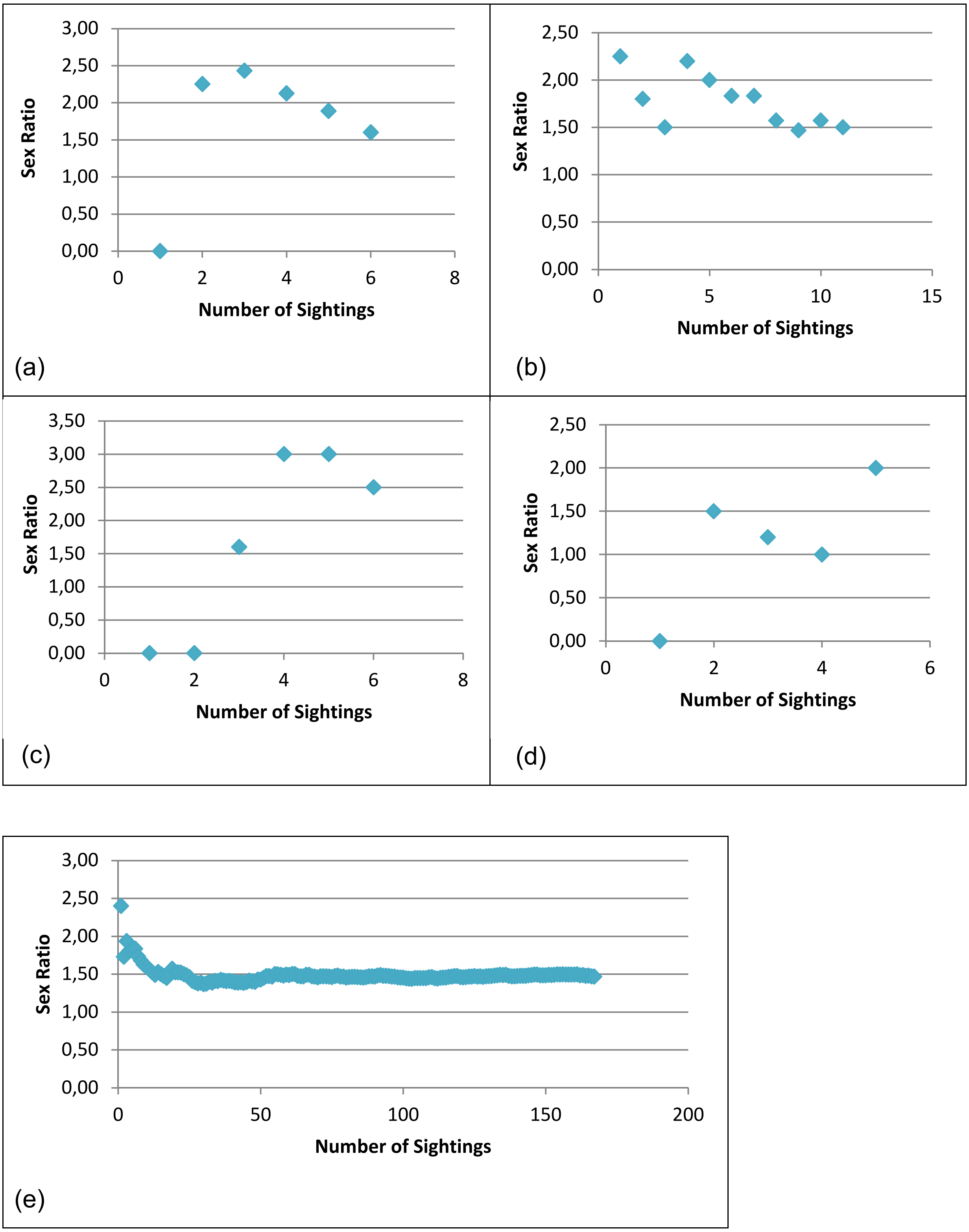

Figure 3.31: Graphical representation of the sex ratios of the sable antelope as the number of sightings increases. (a) April 2013, (b) November 2013, (c) April 2014, (d) November 2014 and (e) April 2013 to March 2014.

CHAPTER 4: DISCUSSION

Sable use of space in relation to 'high risk' areas

In this study I used distance to fences, campsites and roads as a proxy for poaching risk for the two sable antelope herds in KMR. Despite a relative small proportion (never larger than 26%) of the total locations being within 200 m from the fence at most times of the year, in some of the seasons it was a higher proportion that would have been expected from just a random use of the area. In addition this pattern of use was variable from season to season and also from year to year. In most seasons the 0-100 m distance from 'high risk' areas was used more than expected based on random use of space, the only exceptions being both late dry seasons for the vlei herd, and ED 14 and both wet seasons for the woodland herd. Despite that, the proportion of total locations falling in the 0-100 m distance layer were never larger than 20% for the vlei herd, with the highest utilisation found in the transition periods. Proportion of locations for the woodland herd falling within the 0-100 m distance layer were never lager than 20% except for Tr 13 (26%).

Areas close to the fence did not offer enough forage as they are burned (security burns) due to the short grass between April and September (Parrini & Owen-Smith, 2010). Sable will use burned areas if there is enough green flush even in the dry season (Parrini & Owen-Smith, 2010). However, later in the transition period, following rains in late October and November these areas might provide green flush which could explain the increased use of those fence-line areas in the transition periods. Parrini & Owen-Smith (2010) reported how even burnt areas that did not provide sable with green regrowth during the dry season. Burnt areas provided green flush in the transition period as soon as the rain started and sable would move into these areas when regrowth was available (Parrini & Owen-Smith, 2010).

As much as fences do not provide a comprehensive defence against human beings, they act as a security line for wildlife in protected areas (Foster & Humphrey, 1995). Having a boundary between humans and animals can be beneficial to both (Woodroffe *et al*., 2014). However fencing materials sometimes are used to create snares which will then be used to poach animals which might be the case in KMR as the fence has been cut in the past (pers. obs).

Studies on elephant (*Loxodonta africana*) show how they are lot of human movement (Eltingham, 1990; Hoare & Du Touit, 1999), and in KMR part of the fence-line borders areas with high human density. It was evident in this study that sable preferred areas far from human activities. The vlei herd was mostly occupying the north-eastern part of the reserve with few hiking trails and few patrols by field rangers. The woodland herd occupied the southern part of the reserve also where little patrol is done by the field rangers and with minimal hiking trails.

The other area considered to be risky in the study was distance from roads. It is a great concern for scientists around the world on how roads negatively affect wildlife populations in protected areas (Reed *et al*., 1996; Mumme *et al*., 1998; Wielgus & Vernier 2003). There is enough evidence that has showed how roads affect home range of animals and alter usage, and impacts behaviour of wild animals (Lyon, 1984). KMR has roads which are used by the public and also those only used by management, therefore a road does not necessarily mean high human density. However sometimes in those management roads, guests seen utilising them and while some drive there by mistake, some guests know that those roads are prohibited to the public (pers. obs.). The vlei herd was mostly seen within 500 m from roads except for the ED 12, and the proportion of locations in the 0-100 m distance category was as high as 40% in the Wet 12/13. It must be noted that most areas available to the vlei herd were within 1000 m from roads. This is even more extreme for the woodland herd, whose available area is for the majority within 500 m from a road, with also up to 40% of locations within 100 m from roads during the LD 12.

Roads constructed in protected areas impact wildlife in different ways, that is mortalities due to building of new roads, animals colliding with cars, modification in vegetation and regular human activities in the area (Trombulak & Frissell, 2000). Even though there are no reported vehicle collisions with sable antelope in KMR, there have been reported cases of road kills in the reserve which include impala, common duiker (*Sylvicapra grimmia*), steenbok (*Raphicerus campestris*) and snakes. Based on personal observation, for both herds, even though there were recorded locations of them close to the roads, mostly it was due to crossing rather than spending most of their time close to the roads.

Research has confirmed that black bears (*Ursus americanus*) in North Carolina in North America preferred to use areas far from busy roads (Brody & Pelton, 1989); and both elk (*Cervus elaphus*) and mule deer (*Odocoileus hemionus*) choose areas more than 200 m away from the roads in winter (Rost and Bailey, 1979). In this study most of the sable locations were seen relatively close to the roads for both herds as most of the areas >1000 m away from the roads were areas outside the reserve and the herds did not have access to them.

From the three potentially risky features considered in this study, distance from the camping huts was the least important, due to few or no locations in the distance layer 0-500 m from the camping huts, with most locations > 1000 m away for both the herds. Sable completely avoided areas within 0-100 m from the camping huts confirming again the avoidance of areas with potential high human density.

There are about seven camping sites in the reserve which include four camping huts, one group camp, one cottage and one tent/caravan camping site. Annually security burns are done around all these camping sites and sometimes there is a ‘green flush’ which are used by the impala (pers.obs). Animals will always move to an area when it provides shelter, security and where there is forage (Burt, 1943). These areas close to the camping sites offer little in the aspects mentioned above, apart from potentially providing a green flush. Usually these areas are disturbed with little or no food and also there are many human activities around these areas. Social factors and relations with other animals must also be pondered when looking at animal’s use of space (Borger *et al*., 2006). Animals like red hartebeest, zebra and waterbuck also avoid areas close to camping huts just like sable antelope. Impala and warthog (*Phacochoerus africanus*) are always seen in areas close to the camping sites.

In KMR no conflicts of sable antelope with humans have been reported, which means there is little interaction between humans and sable. In this study it was evident that sable antelope avoided areas where there are human movements (camping sites) but not vehicles (roads). Immediately when a human being moves out of the car, they start to run away (pers.obs). Sable antelope in the reserve are used to vehicles and can allow a vehicle to come close to them without running, just like in the study done in Okavango Delta by Hensman (2012) were he observed sable allowing vehicle to come close to them within a few meters.

Vegetation types and burnt areas

Choosing preferred vegetation can be influenced by the size of the area or the quality of vegetation (Miller, 2013). Sable antelope herds utilised almost the same areas as per the study done by Parrini (2006). The vlei herd was seen foraging in the north western part of the reserve mainly characterised by open vegetation types, while the woodland herd foraged mostly in the south eastern part of the reserve.

From a detailed vegetation map of the reserve by Nel (2000), I used the reduced vegetation classes of four for this study. These include *Selaginella dregei - Oldenlandia herbacea* (open shrubland), *Becium obovatum - Elionurus muticus* (tall grassland), *Ziziphus mucronata - Rhus leptodictya* (closed woodland) and *Pteridium aquilinum - Miscanthus junceus* (moist grassland). Both herds utilised all four vegetation types even though some were used more than the others. In KMR the widespread grass is *Themeda triandra* in the grassland and open woodland habitats, whereas *Panicum maximum* is widespread in the woodland habitats (Parrini, 2006). Previous studies by Grobler (1974) in Zimbabwe, Hans Merensky Nature Reserve and Pilanesberg National Park in South Africa (Wilson & Hirst, 1977; Magome, 1991) also confirmed sable utilised *T. triandra.*

The vlei herd foraged mostly the tall grassland, followed by open shrubland in all seasons except the ED 13 and Tr 13 when open shrubland was the most used vegetation type. The *Becium obovatum - Elionurus muticus* Tall Grassland is dominated by *T. triandra, Diheteropogon amplectens* and *Brachiaria serrata* grass species (Nel, 2000). The vlei herd also used the *Selaginella dregei - Oldenlandia herbacea* (open shrubland) type of vegetation. Dominant grasses in this vegetation type include *Schizachyrium sanguineum, Melinis nerviglumis, T. triandra* and *D. amplectens* (Nel, 2000). The vlei herd shared their grazing range with red hartebeest, zebra, blesbok (*Damaliscus pygargus phillipsi*) and waterbuck (pers.obs). *Pteridium aquilinum - Miscanthus junceus* (moist grassland) was mostly used during the late dry season 2013 and the closed woodland was the least used vegetation type by this herd. Studies by Estes & Estes (1974) in Angola and Grobler (1981) in Zimbabwe also have confirmed the use of open vlei grassland by sable antelope.

The woodland herd similarly used tall grassland the most, followed by the *Ziziphus mucronata - Rhus leptodictya* (closed woodland) as the second most used vegetation type, particularly in the dry seasons. This is the vegetation type that has the woodland and forest communities of the reserve (Nel, 2000). Sekulic (1981) also confirmed preference of sable for woodlands. In the study by Parrini (2006) in KMR, the woodland herd also foraged in this type of vegetation. The late dry season is considered a vital time for herbivores due to the low levels of nutritional value in the available grass to maintain nutritional requirements (Owen-Smith, 1982) and woodland areas are characterised by grass species like *Panicum maximum* that retain greenness for longer into the dry season (Parrini, 2006).

The moist grassland was least used by the woodland herd, which was expected since the vlei area, which makes up most of the moist grassland vegetation type in the reserve, is found in a part of the reserve that is not visited by the woodland herd (Parrini, 2006). This was expected because even during the study by Parrini (2006), the woodland herd never utilises the vlei ares.

The two herds utilised burnt and unburnt areas differently. Overall the woodland herd utilised burnt areas more compared to the vlei herd even though both their ranges experienced fires. The vlei herd less utilised the burnt areas in all seasons of 2011 while the woodland herd utilised burnt areas in the ED 11 and LD 11. This was because from the total of 648 ha burnt in 2011, only 76 ha were in the area of the vlei herd. This changed in 2012; both herds were seen often in the burnt areas in the ED 12, with the woodland herd almost spending the whole season in the recently burnt area. The use of burnt areas dropped in the LD 12 season for both herds due to the little rainfall experienced in the reserve. There was little increase in utilisation of the burnt areas by the vlei herd during the Tr 12 while the woodland herd increased its burned area use compared to the end of the dry season. During the following dry season (2013) the use of burnt areas was much lower than compared to 2012. Without field observation on the state of the ‘green up’ on these burnt areas it is impossible to say for sure that the little use of burnt areas in 2013 compared to 2012 was due to the lack of grass regrowth following the fires, but that could be the case based on previous studies (Parrini, 2006). In a previous study that included field assessment of the vegetation regrowth following fires both sable herds utilised burnt areas in one dry season when green regrowth was available, despite the higher grazing pressure from other grazers on burnt as compared to unburnt regions (Parrini & Owen-Smith, 2010). The following dry season, the herds didn’t utilise the burnt areas because there was no green flush to graze on (Parrini &

Owen-Smith, 2010). In 2013, the reserve experienced little rainfall which might have had an impact on poor grass regrowth on burnt areas (Henley, 2005). Both herds also used burnt areas during the wet seasons, with the woodland herd having 82% of locations in burnt areas compared to 63% of locations in burnt areas of the vlei herd during the Wet 13/14 season.

Generally both sable antelope herds appeared to have used different selection criteria towards burned areas. The fact that the vlei herd made less use of burnt areas compared to the woodland herd, could be due to the availability of palatable grasses on the vlei area which is not available to the woodland herd. The vlei was considered an important resource area that helped the vlei herd to survive the dry season while the woodland herd relied more often on the burnt areas in a previous study in the same area (Parrini, 2006). In other areas during the dry season sable also depend on green grass normally found in vlei area or areas burnt prior to the dry season (Magome *et al*., 2008). The study confirmed that sable antelope uses burnt areas immediately after burns. Also it is evident that after rainfall the sable antelope will also forage burnt areas, therefore burning of grass to get green flush is good for sable antelope.

<u>Seasonal variation in the nutritional status of sable antelope</u>

Faecal Crude Protein (CP) of sable antelope differed seasonally with highest values as expected in the transition and wet season and the lowest values in the dry season for both herds. A previous study (Parrini & Owen-Smith, 2010) reported a similar pattern for the sable population in KMR: lowest CP levels in the dry season when sable could not make use of burnt areas because of lack of a “green flush”. However in that study, undertaken in the years 2002-2003, the CP was 7.5% during the early dry season with no burns (compared to 9.5% in this study), hence it seems that currently the sable population in KMR is performing above those levels.

Faecal CP during the early dry season in my study was also higher compared to other studies in other regions of South Africa. In the study done by Macandza (2009) in the north of KNP, CP was 8.1% while another study in KNP reported alues of as low as 5.4% (Henley, 2005). In PNP, CP levels were reported to be above 6.6% (Magome *et al*., 2008). This shows that in this study sable antelope was doing better nutritionally as compared to previous studies mentioned above. In dry season studies on other herbivores species of similar body size to sable, CP of 7.5% was recorded in Mkhunzi Game Reserve (Edwards, 1991) and also in KNP (Grant *et al.*, 2000) for wildebeest. Also CP of 8% for buffalo and 7.5% for zebra was recorded by Codron *et al*. (2007) in KNP, and between 5.1% and 6.3% for roan antelope (*Hippotragus equinus*) also in KNP (Knoop & Owen-Smith, 2006).

In this study, a CP value of 10.1% was recorded for the woodland herd in LD 13 when they made extensive use of burnt areas. During the study by Parrini (2006) in KMR, CP of 10.1% was recorded when sable antelope were using burnt areas. Instead there was a significant difference in CP when sable used unburnt areas during the dry season, since in the current study the vlei herd recorded 10.3% of CP and in the study by Parrini (2006) the value recorded was 7.4%. In the current study, even though the vlei herd made little use of the area burnt in the LD 2013, the area they were frequent seen in was the area burnt in 2012. In the PNP, sable antelope CP levels were 12-14% when they used burnt areas during the dry season (Magome, 1991). In KNP, CP of 7.5% was recorded for sable antelope during the dry season when not using burnt areas (Macandza *et al*., 2012).

Following early rains in the late dry season season, the CP of both herds improved during the transition season as compared to the late dry season. This might be due to the grass becoming green and there is abundance of food and less competition with other grazers. During the transition and wet seasons the CP for the vlei herd increased to values above 13%. The reserve had a total rainfall of 515.2 mm during the Wet 13/14. Due to the abundance of food both herds utilised the tall grassland type of vegetation which is dominated by *T. triadra* grass species. In addition the previously burnt areas were used more than unburnt areas by the two herds during the wet season. Comparing to the study by Parrini (2006) where CP of 10.6%-11.6% was recorded during the transition and wet seasons, both herds performed better in the current study. CP recorded in this study was almost the same as the one recorded in the study done in PNP where CP of 14% was recorded in the wet season (Magome, 1991) but much higher than the 7.5% recorded during the wet season in KNP (Henley, 2005; Codron *et al*., 2007).

Faecal phosphorus (P_f) was the lowest during LD 13 (0.27%) and the highest during Tr 13 (0.46%) for the vlei herd and was the lowest in the ED 13 (0.31%) and highest during the Tr 13 (0.48%) season for the woodland herd. Minerals like phosphorus (P) and sodium (Na) are considered to be very important for nutrition of herbivores (Robbins, 1993). An increase in P_f was observed during the transition season when the reserve started to receive some rainfall. It was observed that P_f was the highest when sable foraged in areas which were recently burned or burnt the previous year like the transition season. Concentrations of P in the grass were considered higher in areas regularly grazed than in areas grazed sometimes (McNaughton, 1988). P_f in the dry season was almost the same as it was like during the study by Parrini (2006), but instead of an increase in the transition and wet seasons as in this study, Parrini (2006) found little seasonal variation in P_f content. Faecal phosphorus can be used as an indicatior to determine how healthy the veld is (Wrench *et al*., 1997). De Waal (1979) claimed P to be scarce across South Africa except in the scrub bushveld region and sometimes its scarcity can affect the growth and fertility in herbivores (Wrench *et al*., 1997). Based on my results, and the comparison with the previous study, P_f values seem to confirm that currently the sable population in KMR is doing better compared to 2002-2003.

<u>Recruitment, survival and sex ratio</u>

In this study, more males were born compared to females. From 2011 until 2014, a total of 34 sable antelope calves were born in the reserve. Separation of the vlei herd and woodland herd did not affect birth dates of calves as females in both herds gave birth around the same period mentioned above. From May to September it is when calves start to disappear from the herds, with about an average of three per year lost (out of an average total per year of 8-9 calves been born).

This means that about one third of the calves born each year will not make it to reproductive age. During the study, from a total of 34 calves born, 15 calves went missing and only one mortality was recorded. The calves disappear from the herds mainly during the late dry season and transition to wet season period. The two breeding herds sometimes break up into smaller groups during the late dry season but at a later stage combine again. There are possibilities of potentially losing the young ones during these break-ups. The loss of the calves could also be a consequence of the limiting resources in the dry season.

Côté & Festa-Bianchet (2001) suggested that birth date always has consequences on both development rate and survival rate. One of the most important advantages of calves born earlier in the year is accessibility to high-quality vegetation by the lactating females (Bunnell, 1982; Linnell & Andersen, 1998). This is because newly born calves spend more time in this vegetation compared to late born calves (Guinness *et al*., 1978b; Festa-Bianchet, 1988a). In pronghorn antelope (*Antilocapra americana),* birthweight decreased during late dry season (Fairbanks, 1993) and calves born earlier survived better compared to those bone later (Birgersson and Ekvall, 1997; Keech *et a*l., 2000).This could be the case in KMR where lactating females of calves born in April only have a short period of good quality forage before the limiting dry season.

It would be interesting to see if it is the late born calves that do not make it through the dry season, but that would require individual identification to monitor individual fate. From previous studies it is clear that the best way to monitor survival of populations for long term studies is to mark individuals in a population (Gaillard *et al*., 1998). However marking of calves is not an option in KMR because of the conservation status of the population and because marking would require capturing and darting of calves and this is expensive. A few studies have also proved that in hoofed animals females in poor physique have the tendency to give birth late as compared to those in better physique (Mitchell & Lincoln, 1973; Clutton-Brock *et al*., 1986; Byers, 1997) and this might also affect sable in KMR. It was also observed that in studies of red deer (*Cervus elaphus*) and domestic goats (*Capra domestic*) young male calves are allowed to suckle more than the females calves (Clutton-Brock *et al*.,1981; Pickering 1983) and in red deer mothers who successfully managed to bring up their sons until they are a year old fail to breed the following year as compared to females that gave birth to female calves (Clutton- Brock *et al*., 1981). Looking at the current population in KMR, birth rate has been decreasing annually which might be to males sucking too long and this affecting birth rate. Also looking at the crude protein results of the two herd, it suggest that nutritionally the the vlei herd is doing better than the woodland herd.

Predators like leopard *(Panthera pardus)* and spotted hyena (*Crocuta crocuta)* ignored sable antelope as their main prey (Hayward, 2006) but if an opportunity comes they can prey on calves of the sable antelope (Hayward *et al*., 2006; Grobler, 1981). Since 2012, about two leopards have been introduced in the reserve from farms outside. In KMR, there have been a few reports on predation on other animals (pers. obs.) and not for sable antelope, but it cannot be excluded that survival of calves might be due to predation even though there is no evidence regarding this. Usually sable antelope calves hide using vegetation cover for camouflage for the first two to four weeks after their birth (Estes, 1991). Also due to malnutrition adults move around a lot looking for food in habitats with high risk of predation, animals end up being killed before they die due to starvation (Sinclair & Arcese, 1995). Besides, starving animals are the easiest to catch compared to those not starving (Owen-Smith & Ogutu, 2003).

Since the sable in this study were doing well nutritionally, it seems to confirm Trivers & Willard (1973)'s study which stated that more males will be produced by healthy females. This is because in polygamous species, that increases the probability of more genes being passed on to the future generation (Lande, 1981). After an assessment of the reproductive performance of herd of elk (*Cervus canadensis*) kept in a feedlot, it was observed that younger females gave birth to male and older females gave birth to females (Hudson *et al*., 1991).

It also looks like more male calves survive the "calve stage" to yearlings compared to females. In other hooved animals, survival to yearlings was independent of sex (bighorn sheep (*Ovis canadensis)*: Bérubé, 1997; pronghorn antelope: Fairbanks, 1993; roe deer (*Capreolus capreolus)*: Wauters, *et al*., 1995). In my study, it looks like more males survive juvenile stage as more males are born compared to females. Population increase is dependent on calves born and surviving. It is believed that juvenile survival has an impact on population instability (Owen-Smith & Mason, 2005).

An important factor that was an oversight in this study was the increase of lone bulls, and the bachelor herd seen lately in the reserve. In this study I focused more on the two breeding herds and not individual males or the bachelor herd. Looking at game count data, number of lone bulls has increased and since 2013 there has been a bachelor herd of about six males which increased to eight in 2014. It was also recorded that a few sable antelope bulls have been seen in the Rainbow Farms section of the reserve. One bull was seen in 2012 outside the reserve, in the Rainbow Farms section. As mentioned earlier, the study focused a lot on the two breeding herds neglecting lone bulls and the bachelor herd and this could give 'false' results of the sex and age structure of the population. It was important to look at all sable antelope in the reserve to give the correct sex and age structure of the population in the reserve.

<u>Limitations of the study</u>

The study focused on possible causes of decline of sable antelope in KMR for the past years. One of the limitations of the study was fence monitoring. It was a challenge because it was approved by the READ, but the fence always had holes in it. In some areas of the reserve, field rangers did patch work on the fence every time they did fence patrols. Even though fencing can be beneficial to conservation areas, sometimes it is expensive (Woodroffe *et al*., 2014). Due to North West Parks Board (NWPB) being a government parastatal, it is given a specific budget for fence maintenance and when the money is finished they survive with fence materials from other reserves. Sometimes these fencing structures can provide materials that can be used to make snares by poachers (Woodroffe *et al*., 2014). The other challenge for me to analyze the fence was lack of data from field rangers regarding patch work done on the fence. They did not have proper records of fence maintenance done through the study. On several occasions people are found in the reserve that did not access the reserve from the gate, with a number of snaring reports from the Resource Security of the NWPB existing.

The other challenge was access to Rainbow Farms (RF), from which we were prohibited. Even though, based on the collared sable locations, there were no records of the collared sable antelopes in the RF; it might not necessarily mean that some individuals did not cross over to RF. This is because the herds sometimes split, especially the woodland herd during the birth season. Also six sable antelope bulls were found in the RF.

After burns, grazers run into high value forage even though the grass is short limiting the quantity of intake, but usually grazers increase the bite rate to make up for the small bites (Wallis de Vries & Daleboudt, 1994). According to my hypothesis, I expected sable antelope to be seen in the high risk areas immediately after burns and that is in areas close to the fence and buildings. Instead sable less utilised areas close to the fence from the GPS locations. As I have already mentioned above, there is a possibility of other sable antelope within the herd that might have utilised areas close to the fence more than the collared ones.

Both herds showed that they were able to uphold higher faecal N and P levels than required for maintenance even during the dry season, as opposed to the study done in KMR in 2002-2003 indicating that currently the sable population is doing better than in the past. This seems to be confirmed by the higher number of males being born compared to females, in a population that still has an adult sex ration skewed towards females.

Monitoring of calves in both herds was a challenge due to splitting of herds and hiding of calves. The collared sable would be within the herd and but the calves would be with other females. This has been evident especially within the woodland herd, as is the herd that usually splits. It is also important to monitor the period when yearling males move away from the herd.

Even though there are few records of poaching in the reserve, it might be one of the reasons for decline of sable antelope in the reserve. Only one report of a collared sable was found with a snare just near Group Camp Gate. There have been a few poaching activities reported in the reserve where snares where found.

The management of the reserve will have to make a few sacrifices to assist in monitoring sable in the reserve. Firstly, some part of the fence must be replaced in order to have an improved security in the reserve. There are portions of fence which has been replaced, but all of the boundary fence of the reserve must be in good condition. Also random searching of cars must be done. Vehicles are never searched and sable calves seldom run away from cars (pers.obs).

Management recommendations

I recommend that in future studies at least three to four female heifers are collared per herd to give better results regarding fission-fusion dynamics and spatial distribution. Also individual sable antelope bulls and bachelor herds should also be considered. Even though our collars were sending locations of collared sable antelopes at hourly intervals for two years, I still believe that more data are required for better results. More funds must be sourced as collaring can also be expensive.

Currently sable antelope is the most expensive antelope in the reserve, intensive monitoring must be done on the species. Sable herds and lone bulls monitoring should be done twice a week for the two main herds and once for the bachelor herd or lone bulls. This will assist the reserve management in monitoring the number of sable antelope and respond to changes. Immediately when the herds split, monitoring officers will be able to know how many have left the herd. Also this will give the reserve management a better idea of which areas sable forage on during different times of the year.

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