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Abstract

In the Kalahari, Botswana, as in many other parts of the world, wildlife is experiencing an increased pressure from a growing human population and intensified land use with domestic livestock. The intensified pressure on the vegetation cover induced by livestock limits the abundance of resources and creates a fragmented landscape for wild animals. The transformation of the landscape makes it difficult for some wildlife species to co-exist with human activities. Mammal population densities in the Kalahari vary due to natural causes as well. When resource availability is lowered, during the dry season, many species migrate to adjacent and more productive areas, creating temporal variance in regional mammal density. This project aims at investigating the spatial and temporal variation in density of mammals and ostrich (*Struthio camelus*) in Botswana, and to study how this variation relates to human land use. The results have been compared with previous studies conducted during different season and in different regions in Botswana. All domestic and wild terrestrial mammals with a size of tree squirrel (*Paraxerus cepapi*) or larger, and ostrich were counted along 10 predetermined transects located in four different land use areas; Communal Grazing Areas, Fenced Ranches, Wildlife Management Areas and National Parks. Large and medium sized herbivores and carnivores are most affected by human activities and smaller mammals least. The seasonal and regional differences in the environment did not prove to affect the wildlife as much as human land use. This study shows that human land use has a great impact on wildlife and has the potential to determine its distribution. Different types of wildlife respond differently to environmental changes and my study shows the need to maintain protected areas for the existence of many species.

Keywords: Land use, Mammal densities, Red listed species, Mammal communities, Savanna ecology

Introduction

The world's biological diversity is a source of genetic variation, biological relationships and ecological services, crucial for the development and existence of life on earth. It is also a resource that human communities, nations and future generations depend upon for survival. It provides food, medicine, housing and many other commodities. The diversity of organisms and processes is therefore important to preserve, or alternatively, exploit sustainably (Secretariat of the Convention of Biological Diversity 2000). However, today biodiversity is lost at a rate, which threatens human survival. Since the loss of biodiversity is irreversible it is important that we aim for a co-existence of humans and nature (Earth in focus et al. 2010). Hence, the United Nations (UN) has declared that "*The achievement of sustainable development requires the integration of its economic, environmental and social components at all levels*" (Division for Sustainable Development 2011). However, it is frequently observed that human transformation of the environment may lead to enormous negative impact on for example the success of wildlife conservation (Moleele & Mainah 2003). A common impact from land management in many countries is overly fragmented landscapes (Verlinden 1997; Hobbs et al. 2008) and habitat loss, which are one of the main threats to wildlife today (IUCN 2011).

Human activities may cause various impacts with regards to wildlife, either directly or indirectly. Direct impact is best exemplified by harvest, either through legal or illegal hunt. An example is the killing of large predators to protect livestock (Romañach et al. 2007). Indirect impact includes changes of vegetation cover and composition by livestock grazing, and competition for resources such as space and water (Wallgren et al. 2009). For example, 90% of the biomass of large herbivores on the African savannas is domestic livestock, leaving 10% for the wild herbivores (du Toit 1995). Due to such anthropogenic changes in the environment many wild species have declined to critical population levels (IUCN 2011). However, there are many reasons why some wildlife species are more threatened by human impact than others. In order to protect and draw attention to these species and the threat to the biodiversity, the International Union for Conservation of Nature, IUCN, generated the "IUCN red list of threatened species". The red list is a global system, which describes and evaluates the conservation status of most known species on earth today, with the main focus on those threatened with extinction (IUCN 2011).

If we are to understand how human transformation of the environment influences wild animals, it is important to first look at how animal species interact and what their traits are with regards to food and habitat choice etc. (Wallgren et al. 2008). Mammal communities in general are complex systems and the characteristics (e.g. composition and function) of a community often change seasonally as the environment changes (Wallgren et al. 2008). In this respect, the savanna ecosystem is no exception as it includes a large number of interacting species, a majority of which are herbivores but also including for example omnivores and predators (e.g. du Toit & Cumming 1999). The abundance of herbivores is mainly determined by the availability and nutritive quality of vegetation, which is governed by soil nutrient content, rainfall, fire incidents, as well as grazing or browsing pressure (du Toit 1995; Skarpe 1990). Water accessibility is also important. For the smaller mammal species the access to shelter can also be important (Blaum et al. 2007). The abundance of predators is, in turn, directly linked to the abundance of prey (often herbivores; du Toit 1995). Consequently the community structure may change if the balance between the different functional groups is disturbed. For example, if the predator density increases rapidly when herbivore food is scarce there may be pronounced effects on herbivore abundance. On the contrary, if herbivore numbers boom due to lower predation there can be severe negative effects on the vegetation (Begon et al. 1996).

In the Kalahari, Botswana, as in many other parts of the world, wildlife is experiencing an increased pressure from a growing human population and intensified land use (Romañach et al. 2007; Bergström & Skarpe 1999). For one thing, human activities are important factors controlling seasonal mammal distribution in the Kalahari (Wallgren et al. 2009). On a larger and regional scale, migration of mammals is affected by veterinary cordon fences and other fences that divide the country in different regions. The fences have been constructed in order to control the foot- and mouth disease carried by the wild buffalo (*Syncerus caffer*). The veterinary cordon fences restrict wildlife migrations, and with increasing occurrences of droughts in southern Kalahari, this has caused large declines in many herbivore species (Spinage 1992; Pearce 1993). Hence, it is important to seek solutions and develop conservation plans for each region to ensure future existence of the wildlife (Crowe 1994). The small-scale movements among herbivores in Botswana are also restricted by local cattle fences that have created patches where the wildlife can exist (Fjeldså et al. 2004; Perkins 2004). This applies primly to the northern and eastern parts of the country, whereas the southwestern part is less affected by human activities. Moreover, the cattle farming also transforms the vegetation towards increased dominance of woody vegetation as opposed to herbaceous vegetation, a phenomenon called bush encroachment. These changes in the vegetation cover can be detected in the southern Kalahari many decades after livestock grazing has ceased in an area (Skarpe 1986). Since the system is poorly investigated it is difficult to determine what impact such changes have on wildlife (Verlinden 1997).

In order to conserve wildlife and separate livestock production from wild animals, state lands in Botswana have been divided into different land use zones, protected areas and unprotected areas. The National Parks and the Wildlife Management Areas were formed to give wild animals protection. The National Parks give wildlife full protection, i.e. hunting is prohibited, whereas Wildlife Management Areas provide living space, i.e. most livestock is prohibited, although limited hunting is allowed (Twyman 2001; Central Statistics Office, 2005). The Communal Grazing Areas and Fenced Ranches are land use areas without any type of wildlife protection from human land use activities. These areas were created to enhance livestock production in Botswana and are often grazed all year round. The intense year round grazing has caused changes in the environment which has had a significant effect on the savanna ecosystem (Bergström et al. 1999). This is especially true in the Fenced Ranches, which are relatively small (often about 8 km x 8 km) enclosed areas for livestock (Wallgren et al. 2009). In Communal Grazing Areas, livestock can move freely close to the villages, within about 20km (Moleele & Mainah 2003; Verlinden 1997).

The transformation of the land cover in the unprotected areas makes it difficult for some wildlife species to co-exist with human activities (Moleele & Mainah 2003). For example, studies have shown that large wild herbivores are uncommon in areas where there are humans and livestock in permanently large numbers (Wallgren et al. 2008). It is suggested that the domestic herbivores outcompete some wild herbivores for resources. The intensified pressure on the vegetation cover induced by livestock limits the abundance of resources for wild herbivores (du Toit & Cumming 1999) and creates a fragmented landscape (Fjedså et al. 2004). Hunting may also be a reason why not only large wild herbivores (Wallgren et al. 2008), but also large carnivores are uncommon in areas with human activities (Romañach et al. 2007). Large carnivores are particularly difficult to conserve in areas where humans have settled, since these species conflict directly with human interest and may be killed by humans (Woodroffe 2000). Large carnivores have higher prey densities (livestock) in domesticated areas, but studies have shown that the carnivore densities tend to go down in areas where human densities are high (Woodroffe 2000).

There are also other causes of variation in mammal population densities in Kalahari. For example, when resource availability is lowered, during the dry season, many herbivores migrate to adjacent and more productive areas, creating temporal variance in regional mammal density (Andrews & O'Brien 2000; Smithers 2000). In southern Kalahari, which is the driest region in Botswana (Department of Meteorological Services Botswana, 2003), these density fluctuations are more pronounced compared to the situation in the wetter northern part of the country, where droughts are less common (Andrews & O'Brien 2000). Particularly water dependent herbivore species are largely restricted to the north (Scholes et al. 2002), since the fluctuations in water availability and temperature are more pronounced in the drier south (Andrews & O'Brien 2000). These variations create environmental gradients for the wildlife (Olff et al. 2002) and suggest a greater range of resource access in the northern Kalahari region, this is followed by a higher species diversity in the north than in the drier south (Andrews & O'Brien 2000). For example in open savanna landscapes there are plenty of resources for different species and the total animal density is high. This may explain the distribution of mammals with different functional traits, since the resource requirements vary for each species (Olff et al. 2002). Mammals with different functional traits are expected to respond differently to the environmental gradients (Andrews & O'Brien 2000). This is important to take into account when making conservation plans and, further, it is a way to analyse the anthropogenic effect in a region.

Objectives

This project aims at investigating the spatial and temporal variation in density of mammals and ostrich in Botswana, and to study how this variation relates to human land use. My first two questions relates to northern Botswana only, since the corresponding questions for southern Botswana have been published elsewhere (Jakobsson 2006). The third question deals with a comparison between two seasons and two regions. My questions were:

1. a) Do population densities of different mammal species and ostrich differ between areas with different types of land use?
   b) Are there differences between seasons of population densities of different mammal species and ostrich in areas with different types of land use?
2. Do red listed species show other population density patterns in relation to land use compared to more common species?
3. Does composition of mammal communities, with regards to functional traits, differ between types of land use depending on season and region?

I predict that there will be a negative impact on wild mammal and ostrich densities from livestock-related activities. I therefore hypothesize that the density of wild mammals is higher in protected than non-protected areas (hypothesis 1). It is believed that human-related activities have strongest negative impact on the red listed species. Hence, I hypothesize that these species will be more sensitive to differences in land use than common species (hypothesis 2). It is also believed that mammal densities are higher in northern compared to southern Kalahari, independent of season. I hypothesize that during periods when and in regions where vegetation productivity is high, effects from competition induced by livestock are smaller compared to periods when and regions where productivity is low (hypothesis 3).

Study area

Kalahari ecology

The Kalahari is a semi-arid savanna in Southern Africa, with diverse vegetation and irregular distribution of water resources (Bergström & Skarpe 1999). Geologically it is a ca 2.5 million ha basin covered with sand (Thomas & Shaw 1993, Scholes et al. 2002; Thomas et al. 2002) at an altitude of about 1000 m above sea level (Skarpe 1990). The wet season lasts from October/November to April (Scholes et al. 2002) with daily mean temperatures ranging between 20 – 35°C in Maun in the north and 12 – 34°C in Tshabong in the south (Botswana environment statistics 2008). The precipitation ranges from 250 mm/year in the south to 600 mm/year in the north (Department of Meteorological Services Botswana, 2003). Dry season temperatures vary between 8 – 33°C in Maun and 0.7 – 20°C in Tshabong (Botswana environments statistics 2008). During the dry season, occasional rainfall has been recorded and night frost is common (Scholes et al. 2002). The seasonal differences in temperature are greatest in the southern Kalahari where also fires are more frequent (Scholes et al. 2002).

The Kalahari soils are generally nutrient poor (Skarpe 1990) and permanent surface water is scarce (Verlinden et al. 1998). The vegetation is dominated by shrubs in the southern drier part and woodlands dominate in the northern wetter part.

The study areas

In order to investigate the variation of mammal and ostrich densities in the Kalahari, Botswana, the study was made in areas with four different types of land use: National Parks (NP), Wildlife Management Areas (WMA), Communal Grazing Areas (CGA) and Fenced

Ranches (FR). In the 1970s the government of Botswana changed the policy of land use, and the three latter land use types were formed (WMA, CGA and FR) (Moleele & Mainah 2003; Verlinden 1997). In the CGA, FR and to some extent the WMA boreholes have been established (in areas where there were not yet established) to make water available for year-round grazing livestock (Perkins1996). This was done mainly in the CGA and the FR which often lie beside each another. In CGA there are normally some sedentary human settlements, with free-ranging livestock within a range of about 30 km from the villages. The FR are formed in square blocks that are 16 km^2 or larger, with land usually leased from the government (Moleele & Mainah 2003; Verlinden 1997). These two types of area are without any form of wildlife protection, except the general legislation. In the WMA human settlements with agriculture are allowed, but restricted and regulated hunting is allowed during certain periods of the year. The WMAs are to some extent placed adjacent to the NPs and function in that case as buffer zones, or corridors for moving animals (Twyman 2001; Central Statistics Office, 2005). The NP was formed in the 1960s to create an area void of human disturbance (Twyman 2001).

The present study was based in Maun in Botswana (19°59'S, 23°25'E). Mammals were counted along road transects in areas with the four types of land use described above. Transects in the CGA were located around Nxaraga village and Shorobe village. Several ranches between Maun and Makalamabedi represented FR. The WMA studied here are managed by a trust called Sankuyo Tshwaragano Management Trustland and called NG33 and NG34 (in which the village Sankuyo lies). The WMA is adjacent to Moremi game reserve and close to Shorobe village. The investigation was also conducted in Savuti within the Chobe National Park (18˚34'S, 24˚03'E). Our study areas include all four of the different types of land use (see Fig. 1).

Studies conducted in the southern Botswana were situated around the Matsheng villages (24˚04'S, 21˚40'E) in the northern part of the Kgalagadi district and Kgalagadi Transfrontier Park (e.g. Viio 2003; Jakobsson 2006). CGA and FR were found in the vicinity of the Matsheng villages, including Hukuntsi, Lokgwabe, Lehututu and Tshane, as well as close to Ncojane. The rest of the southern study area was WMA and NP, the latter in the far south-west, the driest region in Botswana (Chanda et al. 2003). For a more detailed description of the areas see Wallgren (2001), Viio (2003), Carlsson (2005) and Jakobsson (2006).

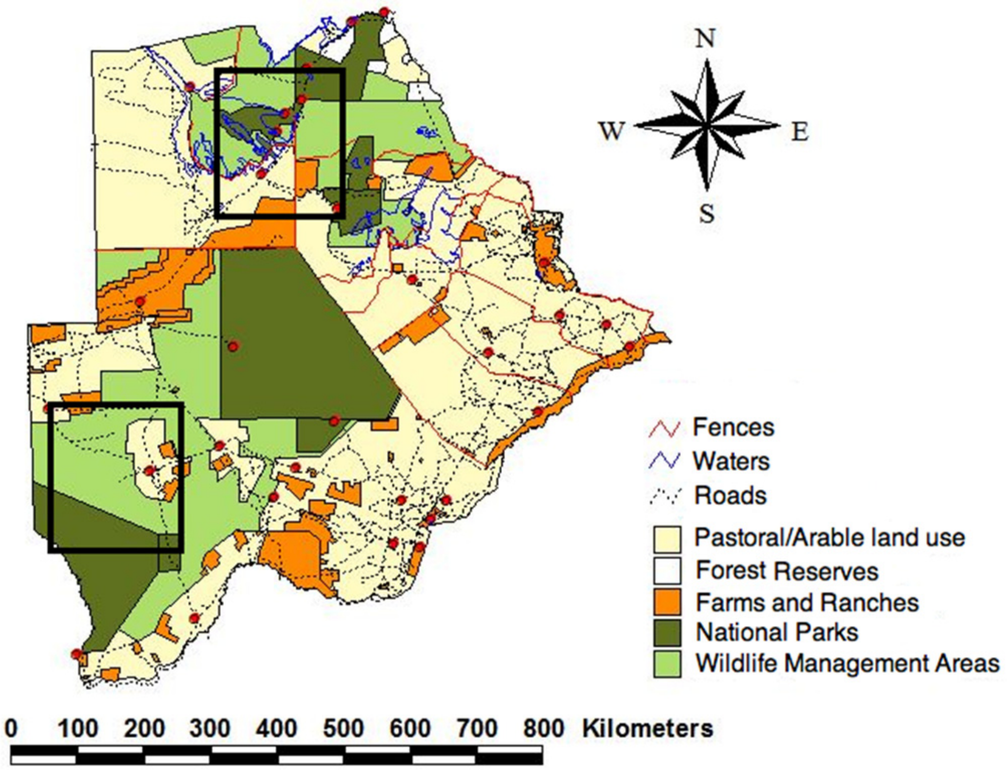

Figure 1. Map of Botswana, with land use types shown. The study areas are marked with black squares. The study was performed within the northern square. Source: Märtha Wallgren 2013.

Method

As a part of the SIDA-financed PhD-project "Mammal community structure in a world of gradients, effects of resource availability and disturbance across scales and biomes" (Märtha Wallgren at the Swedish University of Agricultural Sciences) the present study was conducted as a SIDA-financed research project (SWE-2006-136). Two of the previous studies of animal densities were conducted in the southern Kalahari during the dry and the wet season in 2002 and 2004 (Jakobsson 2006; Viio 2003). The third study was conducted in the northern Kalahari during the dry season in 2007, and performed in the same study area as the present investigation (Persson (in prep.)). The present study is the fourth part and the final survey of animal densities in Kalahari in this project.

Field method

My study was performed in the northern part of Botswana from the end of January until the beginning of April 2008, i.e. during the second half of the wet season (Fig. 1). Domestic and wild terrestrial mammals with a size of tree squirrel (*Paraxerus cepapi*) or larger, and ostrich were counted along 10 predetermined transects (Table 1) located in the four different land use areas - CGA, FR, WMA and a NP (see above for definitions). Transects were monitored by three persons using a Toyota Hilux 4x4. The vehicle was driven at an average speed of approximately 25 km/h to make sure that most animals were spotted. One person was driving and also spotting animals on the road. The other two stood at the back of the vehicle observing each side in an angle of 90° from the side to the front of the car. The observers rotated place (e.g. from driving the vehicle to standing on the back of the vehicle on the right side), each time a transect was driven. Observations were recorded using Distance method (Buckland et al. 1993). When an animal or a group of animals were detected the vehicle was stopped. At every observation, distance and direction to the animal observed were measured with a rangefinder and the group size was recorded. With these values, perpendicular distance from the driven line to each observation could be calculated. If an animal was observed further away than an estimated 30 m from another animal of the same species they were noted as separate observations. The direction of the road was also recorded at each observation. Species identification followed Smithers (2000).

To compare seasonal differences, most of the transects were the same as those used in previous studies by Persson (in prep.) in the dry season 2007. Heavy rainfall and biotic effects (such as high grass, fallen trees) had made many tracks and transects impossible to use. Therefore a number of the transects from 2007 had to be replaced with new transects of similar type. The transects, which remained unchanged from 2007 were mainly transects in the CGA. The other transects were placed as near as possible to those used in 2007. Transects followed tracks and small roads to prevent possible disturbance from traffic. Further, driving on tracks instead of off road made both day and night drives easier and quicker. The length of the transects varied from 7.0 km in the FR to 48.2 km in the NP (Table 1). All transects were driven several times. Short transects were repeated so that a comparable number of km were driven in each transect. It was assumed that the rainfalls were more frequent during the beginning of the field period than at the end. Since water availability and vegetation cover changed with the frequencies of rainfall, the replicates of each transect were divided as equally as possible during this period.

The sampling was made both during day (08 – 17h) and night (20 – 05h), making it possible to group animals observed during the day from those observed during the night. Spotlights were used to scan the area at night. The night observations and the day observations were not combined in the statistical analyses, since the detection function (Buckland et al. 2000) differs.

Distance sampling and analyses

Statistical analyses were performed using a program (DISTANCE 5.0) for handling data from the distance sampling method. This method is commonly used to estimate population densities (Fewster et al. 2009), i.e. the number of individuals per unit area (Buckland et al 1993). In this case the unit area was km^2. We observed mammals and ostriches by using line transect, and therefore I will focus on that technique.

When practising distance sampling, the observer moves along a line transect, observing both sides of the line. When making an observation, the perpendicular distance between the animal and the line transect is measured. However, since it is more difficult for the observer to spot an animal far away than one close by, the probability of making an observation will differ with the perpendicular distances from the road. This is taken into account in the statistical calculations when using distance analysis technique. The method assumes that all animals on the line transect is observed (Sutherland 2006), while the chance of failing to observe animals increases with the distance away from the line. The function that determines the probability of detecting an animal at different distances from the line transect, is called the detection function (Buckland et al. 2000) and is a central component in analysing distance sampling data (Thomas et al. 2002).

Using the perpendicular distance the detection function can be calculated by estimating the number of missed observations (Buckland et al. 2000). This is possible only if you assume that the density of an observed animal is constant in an area, i.e. the observations made on the transect line reflect the average number of observations. By repeating the sampling at the line transect, different observations will be made at different distances. The method then uses the variation from these observations to estimate the detection function and hence the density of the observed animals in an area (Thomas et al. 2002; Sutherland 2006). At least 60 observations of each species are recommended to make the density estimate reasonably accurate and the more observations the more precise estimates (Buckland et al.1993). However, we have chosen to estimate densities of species with at least 30 observations in total for all types of land use areas, so that results will be available for a large number of species. The small number of observations will be taken into consideration when discussing the results. To minimize statistical bias it is important that transects are representative of the area as a whole, e.g. far away from main roads or other infrastructure, since many animals tend to avoid artificial sound, light and people (Sutherland 2006).

To compare species occurrences and densities between the four different types of land use (CGA, FR, WMA, and NP) data were statistically analysed. Statistically significant differences between the land use types were determined with 95% confidence intervals in DISTANCE 5.0. Diurnal and nocturnal observations were separated since the detection functions may be different depending on the time of day.

The seasonal and regional differences were analysed using additional data published in previous studies by Viio (2003), Jakobsson (2006) and Persson (in prep.) (Table 1). In these studies the same sampling method was used as described above. This made it possible to look at differences in densities (using 95% confidence intervals) between both seasons and land use types.

The species, which were tested with DISTANCE 5.0 in northern and southern Botswana, were divided into different groups according to their functional trait. The traits that I am focusing on in this report are food preference, body mass and domesticated or wild animals, e.g. wild small herbivores (Appendix 2). Species with similar functional traits have formed functional groups by summing the densities in each type of land use in each region and season. The density of each functional group in every type of land use, season and region, has been compared to other functional groups in the same type of land use, season and region. From this the proportion of each functional group has been established in comparison to other functional groups.

Table 1. Kilometres driven per land use type for each season (2002, 2004, 2007 and 2008) and region (Northern and Southern Botswana) and the corresponding number of observations (No. obs.), as well as the total distance driven and number of observations per land use type.

Southern Botswana						
	Dry season 2002		Wet season 2004			
Land use type	Km	No. of obs.	Km	No. of obs.	Total km	Total obs.
CGA	1,015	777	1,165	638	2,180	1,415
FR	397	472	1,093	1,155	1,490	1,627
WMA	1,463	607	1,528	568	2,991	1,175
NP	761	336	1,490	536	2,251	872
Sum	3,636	2,192	5,276	2,897	8,912	**5,089**
Northern Botswana						
	Dry season 2007		Wet season 2008			
Land use type	Km.	No. of obs.	Km	No. of obs.	Total km	Total obs.
CGA	770	491	732	600	1,501.9	1,091
FR	796	458	671	1034	1,466.5	1,492
WMA	814	621	796	467	1,609.6	1,088
NP	794	980	761	983	1,554.5	1,963
Sum	3,174	2,550	2,960	3,084	6,134	**5,634**

Results

In my study, observations were made along 135 transects encompassing over 2,959 km of driving (Table 1). Totally I obtained 3,084 observations including 22,844 animals of 44 species in the four different types of land use (Table 2). Approximately 82% of the number of wild mammals and ostriches were observed in protected areas (WMA and NP).

Table 2. Species observed and number of observations per species in each type of land use. Species marked with * were analysed with DISTANCE 5.0. Names according to Smithers 2000.

Species	Scientific name	Abbr.	CGA	FR	WMA	NP
Wild species						
African elephant*	*Loxodonta africana*	ELE	2	0	17	195
African wildcat*	*Felis lybica*	AWC	3	1	16	11
Banded mongoose	*Mungos mungo*	BMG	0	0	0	1
Bat-eared fox	*Otocyon megalotis*	BFX	1	0	0	4
Black-backed jackal	*Canis mesomelas*	BBJ	3	13	0	2
Blue wildebeest*	*Connochaetes taurinus*	WIL	0	0	0	65
Cape fox	*Vulpes chama*	CFX	0	0	1	1
Cape/Scrub hare*	*Lepus capensis/saxatilis*	HAR	13	11	4	26
Common duiker	*Sylvicapra grimmia*	CDU	3	1	2	2
Dwarf mongoose	*Helogale parvula*	DMG	0	0	1	0
Giraffe*	*Giraffa camelopardalis*	GIR	0	0	29	64
Greater kudu	*Tragelaphus strepsiceros*	KUD	0	5	9	8
Ground squirrel	*Xerus inauris*	GSQ	0	3	0	0
Hippopotamus	*Hippopotamus amphibius*	HIP	1	0	0	0
Honey badger	*Mellivora capensis*	HBG	1	0	0	0
Impala*	*Aepyceros melampus*	IMP	0	0	251	307
Large spotted genet	*Genetta tigrina*	LSG	1	1	10	7
Leopard	*Panthera pardus*	LEO	0	0	1	2
Lesser bushbaby*	*Galago moholi*	BUB	34	5	21	19
Lion	*Panthera leo*	LIO	0	0	1	2
Ostrich	*Struthio camelus*	OST	3	4	0	16
Porcupine	*Hystrix africaeaustralis*	POR	2	2	2	0
Roan	*Hippotragus equinus*	ROA	0	0	0	1
Sable	*Hippotragus niger*	SAB	0	0	0	1
Side-striped jackal	*Canis adustus*	SSJ	1	0	0	0
Slender mongoose	*Galerella ssp.*	SMG	0	1	3	1
Small spotted genet	*Genetta genetta*	SGN	3	3	4	4
Spotted hyena	*Crocuta crocuta*	SHY	0	0	1	7
Springhare*	*Pedetes capensis*	SPH	20	24	42	131
Steenbok*	*Raphicerus campestris*	STE	5	10	26	12
Striped polecat	*Ictonyx striatus*	SPC	1	1	0	0
Tree squirrel	*Paraxerus cepapi*	TSQ	2	17	7	0
Tsessebe (Topi)	*Damaliscus lunatus*	TSE	0	0	2	5
Warthog	*Phacochoerus aethiopicus*	WAR	0	0	3	21
Wild dog	*Lycaon pictus*	WDG	0	0	0	1
Yellow mongoose	*Cynictis penicillata*	YMG	2	1	0	0

Zebra*	*Equus burchelli*	ZEB	0	0	14	67
Total wild			**101**	**103**	**467**	**983**
Domestic species						
Cattle*	*Bos taurus*	CAT	273	571	0	0
Domestic cat	*Felis catus*	DOC	2	0	0	0
Domestic dog*	*Canis familiaris*	DOG	33	46	0	0
Donkey*	*Equus asinus*	DON	100	180	0	0
Goat*	*Capra hircus*	GOA	67	74	0	0
Horse*	*Equus caballus*	HOR	21	56	0	0
Sheep	*Ovis aries*	SHE	3	4	0	0
Total domestic			**499**	**931**	**0**	**0**

Mammal densities depending on land use type in northern Botswana

The wild mammal densities differed greatly between land use types and mainly between the NP and the other areas (Table 3). The highest densities were encountered in the NP and the lowest in the FR.

Large herbivores were almost exclusively observed in the protected areas, and zebra (*Equus burchelli*) had a significantly higher density in the NP than in WMA. The same result was noted for springhare (*Pedetes capensis*) and african elephant (*Loxodonta africana*) (Table 3). Wild mammals encountered in the unprotected areas were african wildcat (*Felis lybica*), lesser bushbaby (*Galago moholi*), cape/scrub hare, springhare and steenbok (*Raphicerus campestris*). All were observed during the night. A significant difference was determined for african wildcat density between CGA and NP (Table 3), and NP had the highest density.

The highest densities found in this study were of domestic animals, mainly cattle in the FR. Domestic mammals were found only in the unprotected areas in the northern Botswana (Table 3).

Seasonal differences in northern Botswana

Data from northern Botswana could be compared by using my data and data from Persson (in prep.). There was an indication of higher densities of wild animals during the wet season compared with dry season in all four types of land use in northern Botswana (Table 3). At the species level this difference between seasons was significant in NP for impala and hare. Further, elephant also showed a significantly higher density in the WMA in the wet season, a result, which confirmed the hypothesis: when vegetation productivity is high, mammal densities are higher compared to periods when productivity is low.

However, contrary to the prediction, zebra and springhare showed higher densities during the dry season in the WMA. For springhare a significantly higher density in the NP during the dry season was also determined (Table 3).

Analyses of domestic animal densities did not significantly prove a difference between seasons, however all domestic animals were only observed in the unprotected areas (Table 3).

Table 3. Species densities over seasons in northern Botswana. LD = Low density (less than 0.01 animal species/km^2; U CL = upper confidential limits; L CL = lower confidential limits (Data from the dry season has been analyzed by Persson in prep.)

		Wet season				Dry season			
Wild animals		**CGA**	**FR**	**WMA**	**NP**	**CGA**	**FR**	**WMA**	**NP**
	U CL	0.4	2.1	8.9	0.8	0.2	0.2	0.8	1.2
AWC	**D**	**0.2**	**0.1**	**1.1**	**0.6**	**LD**	**0.1**	**0.4**	**0.7**
	L CL	0.1	LD	0.1	0.5	LD	LD	0.2	0.4
	U CL	0.5	3.7	0.1	0.0	0.0	0.4	0.3	0.9
BBJ	**D**	**0.2**	**0.7**	**0.1**	**0.0**	**0.0**	**0.1**	**0.1**	**0.4**
	L CL	0.1	0.1	0.1	0.0	0.0	LD	LD	0.2
	U CL	0.0	0.0	0.0	0.0	0.2	0.4	0.5	1.0
BFX	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.1**	**0.1**	**0.5**
	L CL	0.0	0.0	0.0	0.0	0.0	LD	LD	0.2
	U CL	3.2	4.1	3.0	0.5	1.6	0.2	2.6	1.9
BUB	**D**	**0.9**	**0.2**	**0.7**	**0.4**	**0.8**	**LD**	**1.5**	**0.4**
	L CL	0.3	LD	0.1	0.3	0.4	LD	0.9	0.1
	U CL	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0
CFX	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**LD**	**0.0**	**LD**	**0.0**
	L CL	0.0	0.0	0.0	0.0	LD	0.0	LD	0.0
	U CL	0.0	0.0	0.0	0.0	0.6	0.6	0.2	0.2
CDU	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**0.3**	**0.3**	**0.1**	**LD**
	L CL	0.0	0.0	0.0	0.0	0.2	0.1	LD	LD
	U CL	0.0	0.0	1.1	2.7	0.1	0.0	0.1	2.5
ELE	**D**	**0.0**	**0.0**	**0.3**	**1.8**	**LD**	**0.0**	**LD**	**1.6**
	L CL	0.0	0.0	0.1	1.2	LD	0.0	LD	1.0
	U CL	0.0	0.0	1.0	1.3	0.0	0.0	2.2	2.5
GIR	**D**	**0.0**	**0.0**	**0.5**	**0.8**	**0.0**	**0.0**	**0.9**	**1.4**
	L CL	0.0	0.0	0.3	0.5	0.0	0.0	0.4	0.8
	U CL	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0
GSQ	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**
	L CL	0.0	0.0	0.0	0.0	0.0	LD	0.0	0.0
	U CL	19.2	56.3	37.9	31.8	8.1	4.0	6.5	9.3
HAR	**D**	**9.2**	**6.4**	**3.0**	**18.6**	**5.3**	**0.5**	**3.5**	**5.2**
	L CL	4.4	0.7	0.2	10.9	3.5	0.1	1.9	2.9
	U CL	0.0	0.0	22.0	33.7	0.0	0.0	12.7	17.6
IMP	**D**	**0.0**	**0.0**	**11.5**	**25.2**	**0.0**	**0.0**	**6.3**	**10.7**
	L CL	0.0	0.0	6.0	18.8	0.0	0.0	3.2	6.6
	U CL	0.0	0.0	2.6	0.7	0.0	0.3	0.9	2.4
KUD	**D**	**0.0**	**0.0**	**0.3**	**0.4**	**0.0**	**0.1**	**0.2**	**1.1**
	L CL	0.0	0.0	LD	0.2	0.0	LD	0.1	0.5
	U CL	0.0	0.0	0.0	0.0	0.5	0.2	1.2	0.7
LGN	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**LD**	**0.6**	**0.3**
	L CL	0.0	0.0	0.0	0.0	0.1	LD	0.3	0.1
	U CL	0.4	0.6	0.0	0.9	0.3	0.7	0.1	0.9
OST	**D**	**LD**	**LD**	**0.0**	**0.5**	**0.1**	**0.3**	**LD**	**0.3**
	L CL	LD	LD	0.0	0.3	LD	0.1	LD	0.1
	U CL	0.0	0.0	0.0	0.0	0.6	0.6	1.1	0.3
SGN	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.3**	**0.7**	**0.1**

	L CL	0.0	0.0	0.0	0.0	0.1	0.1	0.4	LD
	U CL	0.0	0.0	0.0	0.0	0.6	1.3	0.7	1.9
SMG	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.4**	**0.2**	**0.5**
	L CL	0.0	0.0	0.0	0.0	LD	0.1	0.1	0.2
	U CL	3.4	3.3	1.3	4.4	1,0	1.4	7.7	33.8
SPH	**D**	**0.5**	**0.7**	**1.0**	**3.5**	**0.6**	**0.2**	**5.0**	**23.7**
	L CL	0.1	0.1	0.8	2.8	0.3	0.0	3.3	16.6
	U CL	1.4	5.1	1.4	0.8	0.4	2.6	1.1	1.7
STE	**D**	**0.2**	**0.5**	**0.9**	**0.6**	**0.2**	**1.7**	**0.8**	**1,0**
	L CL	LD	0.1	0.6	0.4	0.1	1.1	0.6	0.6
	U CL	38.6	0.0	43.4	30.8	8.4	0.0	7.1	6.9
TSQ	**D**	**5.9**	**0.0**	**13.2**	**18.6**	**3.7**	**0.0**	**4.4**	**2.6**
	L CL	0.9	0.0	4,0	11.3	1.6	0.0	2.7	1,0
	U CL	0.0	0.0	1.2	3.4	0.0	0.1	0.7	1.4
WAR	**D**	**0.0**	**0.0**	**0.1**	**1.8**	**0.0**	**LD**	**0.3**	**0.6**
	L CL	0.0	0.0	LD	1,0	0.0	LD	0.1	0.3
	U CL	0.0	0.0	0.0	3.1	0.0	0.0	0.0	1.3
WIL	**D**	**0.0**	**0.0**	**0.0**	**1.9**	**0.0**	**0.0**	**0.0**	**0.7**
	L CL	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.3
	U CL	0.0	0.0	0.0	0.0	0.6	0.7	0.7	1.8
YMG	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.2**	**0.1**	**0.8**
	L CL	0.0	0.0	0.0	0.0	LD	0.1	LD	0.3
	U CL	0.0	0.0	1.8	25.6	0.0	0.0	13.8	0.0
ZEB	**D**	**0.0**	**0.0**	**0.4**	**11.0**	**0.0**	**0.0**	**6.8**	**0.0**
	L CL	0.0	0.0	0.1	4.8	0.0	0.0	3.3	0.0

Domestic mammals		**Wet season**				**Dry season**			
		CGA	**FR**	**WMA**	**NP**	**CGA**	**FR**	**WMA**	**NP**
	U CL	7.2	35.2	0.0	0.0	10.7	7.0	0.0	0.0
CAT	**D**	**29.1**	**74.5**	**0.0**	**0.0**	**19.6**	**18.1**	**0.0**	**0.0**
	L CL	118.1	157.6	0.0	0.0	36.0	47.0	0.0	0.0
	U CL	0.5	0.2	0.0	0.0	0.7	0.0	0.0	0.0
DOG	**D**	**0.9**	**1.4**	**0.0**	**0.0**	**1.6**	**0.1**	**0.0**	**0.0**
	L CL	1.7	8.5	0.0	0.0	3.8	0.4	0.0	0.0
	U CL	0.8	2.6	0.0	0.0	0.8	0.3	0.0	0.0
DON	**D**	**2.7**	**8.5**	**0.0**	**0.0**	**1.4**	**1.4**	**0.0**	**0.0**
	L CL	9.3	27.4	0.0	0.0	2.7	6.6	0.0	0.0

	U CL	1.9	5.2	0.0	0.0	4.3	1.0	0.0	0.0
GOA	**D**	**7.1**	**17.7**	**0.0**	**0.0**	**8.3**	**6.2**	**0.0**	**0.0**
	L CL	25.9	60.6	0.0	0.0	16.2	38.1	0.0	0.0
	U CL	0.1	0.4	0.0	0.0	0.0	0.1	0.0	0.0
HOR	**D**	**0.4**	**1.6**	**0.0**	**0.0**	**0.1**	**0.3**	**0.0**	**0.0**
	L CL	1.9	5.4	0.0	0.0	0.4	1.0	0.0	0.0
	U CL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SHE	**D**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**
	L CL	0.0	0.0	0.0	0.0	0.1	0.5	0.0	0.0

Red listed species

The data for the red listed species in northern Botswana wet season were compared with data from Persson (in prep.). There were three predators and two large herbivores (see Table 4). Lion (*Panthera leo*), leopard (*Panthera pardus)* and wild dog (*Lycaon pictus)* were recorded only a few times and hippopotamus (*Hippopotamus amphibius*) once during wet season. As hypothesized, most of the observations of the red listed species were made in the WMA and the NP, where the red listed carnivores were exclusively observed independent of season. At three occasions red listed species were observed in CGA but never in the FR (Table 4.).

Table 4. Recorded red listed species in northern Botswana, with the number of observations in each land use type over seasons. The total number of observations of each species is also shown.

		Wet season				Dry season				
Species	**Latin name**	**CGA**	**FR**	**WMA**	**NP**	**CGA**	**FR**	**WMA**	**NP**	**Sum**
African elephant	*Loxodonta africana*	2	0	17	195	0	0	1	181	**396**
Hippopotamus	*Hippopotamus amphibius*	1	0	0	0	0	0	0	0	**1**
Leopard	*Panthera pardus*	0	0	1	2	0	0	1	4	**8**
Lion	*Panthera leo*	0	0	1	2	0	0	2	2	**7**
Wild dog	*Lycaon pictus*	0	0	0	1	0	0	0	1	**2**

Northern Kalahari in comparison to southern Kalahari

The total dataset from northern and southern Botswana during four study periods includes 5,656 observations of wild animals and 4,844 observations of domestic animals. A total of 82,505 mammals and ostriches were encountered. Many species observed in the north have not been observed in the south and the other way around. However, the composition of animals with different functional traits of the whole community was relatively similar in both regions (Appendix 2). Overall, 82% of the wild animals were observed in protected areas. Regional differences in densities of wild animals indicated higher densities in northern compared to southern Kalahari (current results compared with Jakobsson 2006) (Appendices 1 and 2).

The highest proportions of all herbivore densities were encountered in the unprotected areas independent of season and region. The domestic herbivores dominated, mostly in the FR, with the exception of southern Botswana dry season, where the highest proportions were recorded for CGA. In southern Botswana, domestic herbivores were also encountered in the WMA, although they constituted a small proportion of the total animal density of this functional group (Fig. 2 and 3).

The wild small herbivores varied across all of the different land use types. In southern Botswana the highest proportions where found in the protected areas with the peak in the NP, independent of season. In the north the proportion of the densities varied less between the seasons. During the wet season the WMA had higher proportion of the density than the NP, in contrary to the dry season in northern Botswana (Fig. 2 and 3).

The large wild herbivores compromised their highest proportion of the densities in the protected areas independent of season and region. In southern Botswana they were found in both unprotected and protected land use areas with the highest proportion of the densities in the NP. In the wet season a low proportion could be seen in the CGA and during the dry season in the FR. In the northern region during the wet season the NP had the highest proportions, but this functional group was also found in the WMA. In northern Botswana dry season large wild herbivores were encountered in all four types of land use, the highest estimated density proportions were found in the WMA followed by the NP. The CGA and the FR had very low proportions of the densities (Fig. 2 and 3).

The proportions of wild carnivore densities were highest in the protected areas independent of season and region, but encountered in both unprotected and protected areas. In northern Botswana wet season the estimated proportions density of the wild carnivore were found in all four types of land use with the peak in the WMA. During the dry season in northern Botswana this functional group were encountered in the FR, WMA and the NP, with the highest proportion in the protected areas. In southern Kalahari, during the wet season the proportion of the wild carnivores densities were only encountered in the protected areas (the highest proportion of the densities in the NP). During the dry season in southern Botswana wild carnivores were found in the unprotected areas as well, but with very low proportions of densities (Fig. 2 and 3).

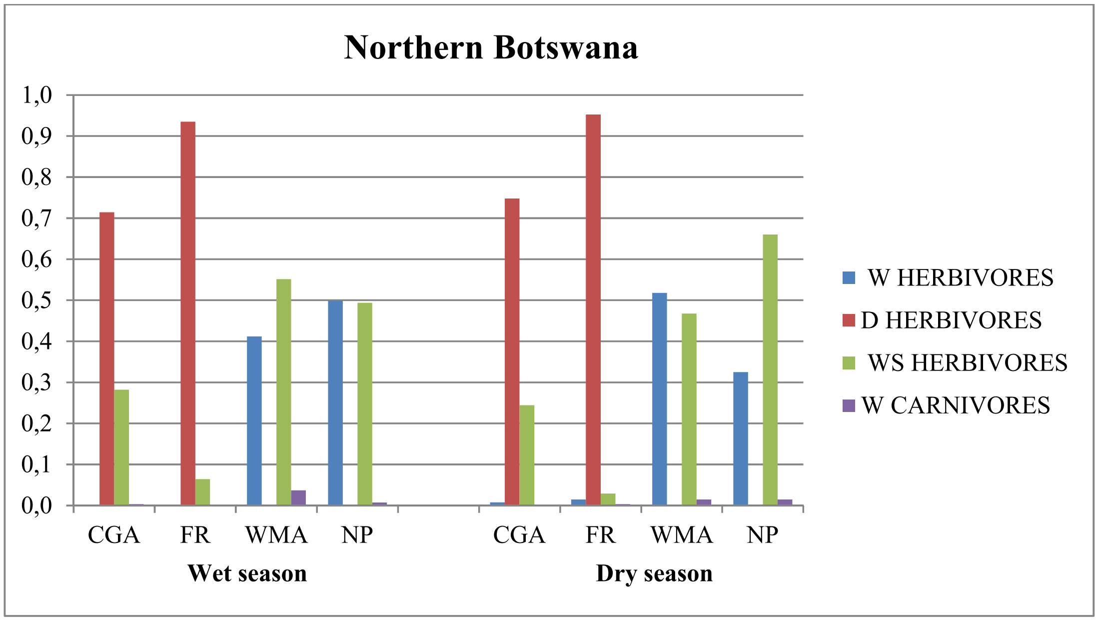

Figure 2. The proportions of wild carnivore, wild small herbivore, wild herbivore and domestic herbivore densities in relation to land use types in Northern Botswana. W Carnivores = Wild Carnivores, W = Wild Herbivores, D = Domestic Herbivores, WS = Wild Small Herbivores

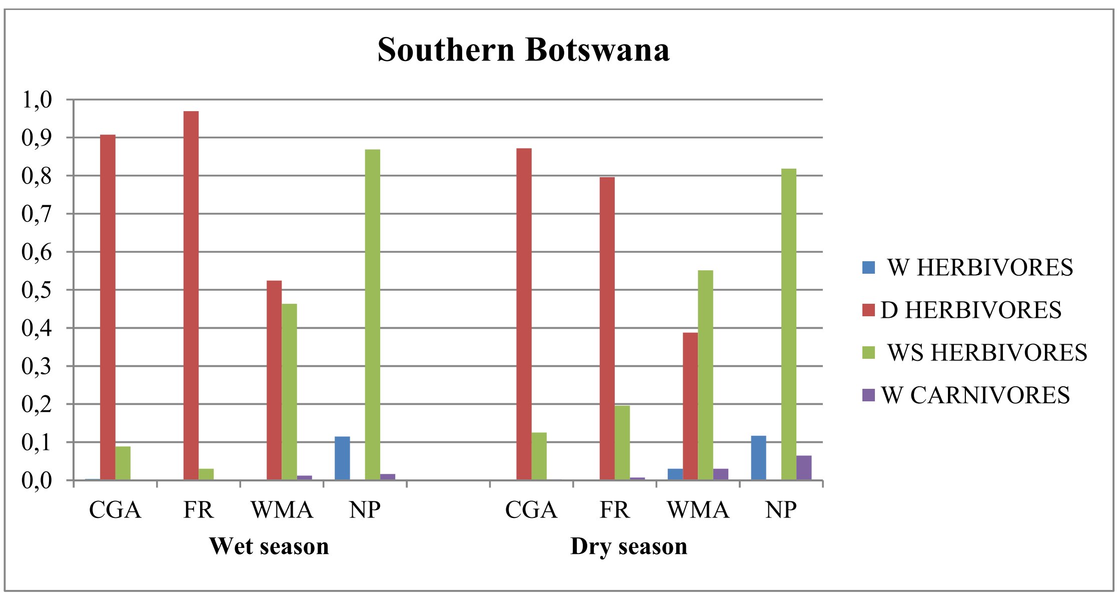

Figure 3. The proportions of wild carnivore, wild small herbivore, wild herbivore and domestic herbivore densities in relation to land use types in Southern Botswana. W Carnivores = Wild Carnivores, W = Wild Herbivores, D = Domestic Herbivores, WS = Wild Small Herbivores

Omnivore densities show a similar pattern over seasons and regions. This functional group were observed in all four types of land use and during the dry season, independent of region, the highest proportion of the densities was found in the protected areas. Domestic carnivores had the highest proportion in the unprotected areas independent of season and region.

However, in northern Botswana dry season domestic carnivores had the highest proportion of the density in the CGA (Fig. 4 and 5).

The insectivores were only analysed with DISTANCE 5.0 in northern Botswana The highest proportion of the functional group was in the FR during the dry season (Fig. 4 and 5).

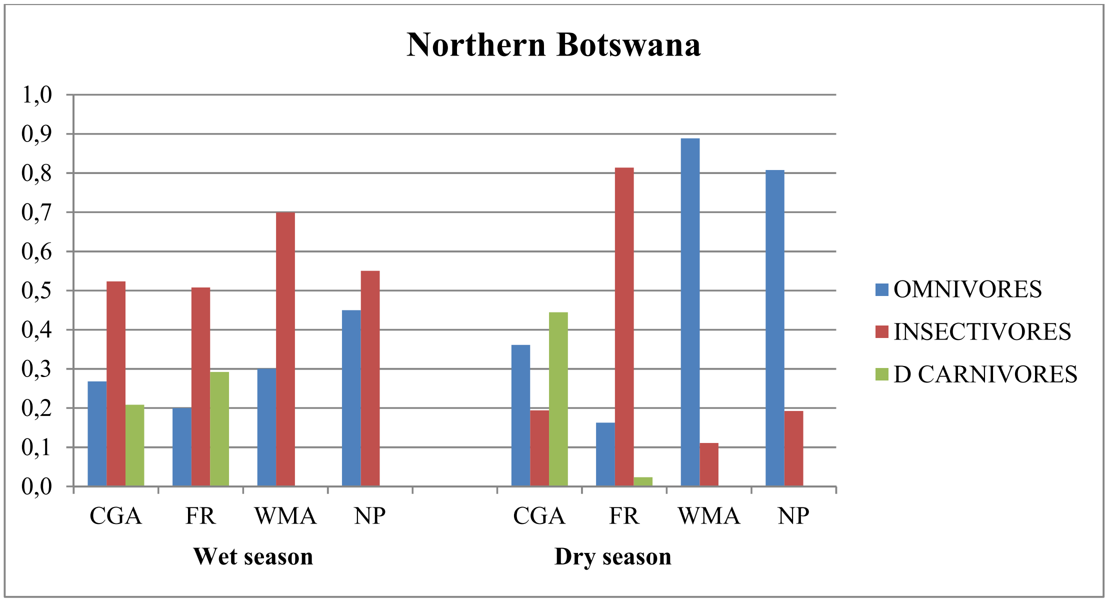

Figure 4. The proportions of domestic carnivores, insectivores and omnivore densities relation to land use types in Northern Botswana. D carnivores = Domestic carnivores

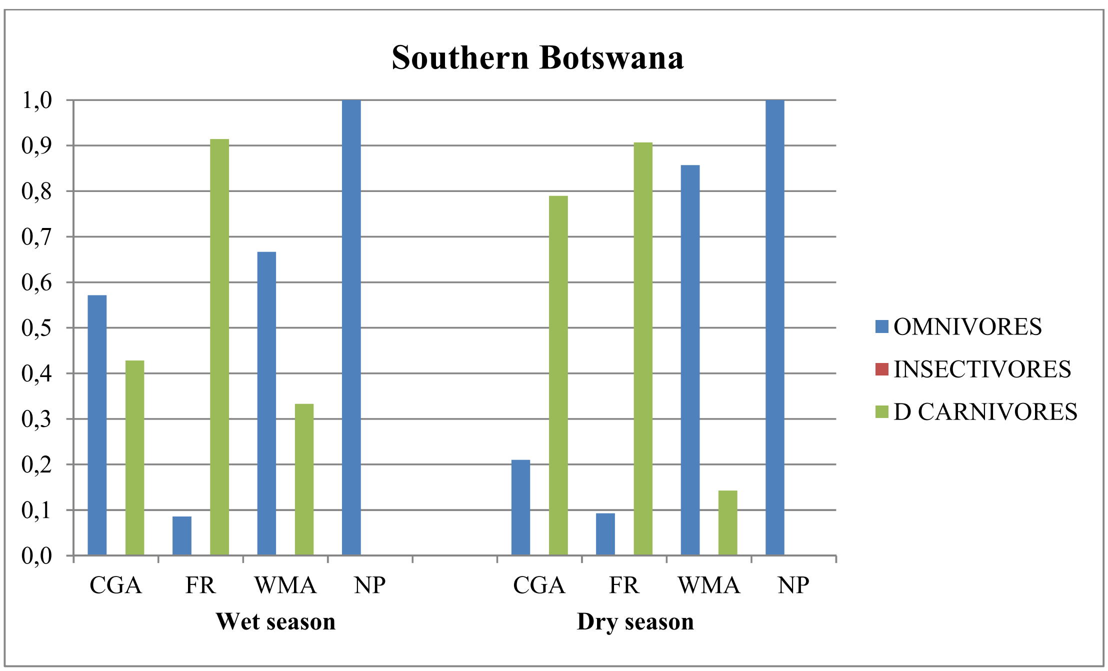

Figure 5. The proportions of domestic carnivores, insectivores and omnivore densities in relation to land use types in Southern Botswana. D carnivores = Domestic carnivores

Discussion

Impact of land use types on mammal densities, northern Kalahari

This study suggests that human related activities have a negative influence on wildlife in the Kalahari. Similar results were shown by previous studies (e.g. Moleele & Mainah 2003; Wallgren et al. 2009; Bergström & Skarpe 1999). The majority of the wild animal species had low densities or were not encountered at all in the unprotected areas, while the highest densities were encountered in the protected areas, specifically in the NP. This result is also emphasized by the fact that the highest densities found in this study were of domestic animals, mainly cattle, in the FR. Since the domestic animals are held in high densities in relatively small areas, hardly without any large movement pattern (Moleele & Mainah 2003; Verlinden 1997), the transformation of the landscape and competition for resources may cause an avoidance among many wild animals, as it reduces their fitness (Hobbs et al. 2008). Elephant and zebra confirmed the preference of protected areas over unprotected and no wild animal showed a preference for the unprotected areas. Hence the first hypothesis can be confirmed.

In northern Kalahari the wet season densities were higher than the dry season densities for most wild and domestic animals. The suggested more abundant vegetation during the wet season (Andrews & O'Brien 2000) and a subsequent better food situation will benefit the animals. An assumption could be that the higher animal densities observed during the wet season probably came from the same population. The population may have increased in number (giving birth e. g. impala) due to the higher resource availability during the wet season (Smithers 2000). Also, wild migratory animals tend to move away from areas with permanent water and better food quality, during the wet season (Bergström & Skarpe 1999). However, most of the wildlife was still found in the protected areas which suggest that the higher resource availability during the wet season in unprotected areas is of less significance. Human land use activities are more important than seasonal variations for the distribution of wildlife.

It is difficult to understand underlying factors to these types of differences. The seasonal variations of animal densities were mainly observed in the protected areas. It is easier for animals to move in the protected areas where there are no fences or other boundaries (roads, villages etc.; Fjeldså et al. 2004). However, since small-scale movements in unprotected areas are limited in Botswana (Perkins 1996) it may be an explanation for why the differences in seasonal variations were restricted to the protected areas. My results show that wild animals have a preference for the protected areas. The result indicates that human activities are a determining factor for the wildlife. As hypothesized, there is still a preference for the protected areas among the wild animals independent of season, which still confirms the first hypothesis.

Anthropogenic influence on red listed species

Most of the observations of red listed species were made in the protected areas independent of season, a result which confirms hypothesis number 2. Since these species already are more sensitive to human impact (direct/indirect conflict with human interest, resource competition etc.) than others, it is especially important to maintain and conserve the protected areas. The red listed carnivores were exclusively observed in the protected areas since it may be difficult for them to exist in areas with human activities. Large carnivores are particularly sensitive and their populations are expected to decrease even further, as the human population grows (Woodroffe 2000). These species require large areas to find enough resources and as top predators they play an important part in the ecosystem (Begon et al. 1996; Woodroffe 2000). As described previously in this report wild large carnivores conflict directly and indirectly with human activities and as my results show, they have difficulties to survive outside protected areas.

Most elephants were also observed in the protected areas, a few also in the unprotected areas. However, the largest population of elephants (approximately 100,000 animals) in the world is presently seen in northern Botswana and adjacent parts of Namibia, Zambia and Zimbabwe (Skarpe et al. 2004). The protected areas seem to be too small for the current population density and behaviour, hence, they probably have no choice but to move out to the unprotected areas.

Northern Kalahari in comparison to southern Kalahari

On regional scale the northern part of Botswana had higher densities of wild mammals and ostriches due to the overall higher productivity of vegetation and water availability (Andrews & O'Brien 2000). Also, most of the wildlife preferred the protected areas over other areas on a regional scale, which proves that wildlife avoid areas with human activities. This was true for all of the functional group, independent of season and region. Hypothesis 3 was thereby confirmed.

Among the studied functional groups, the gradients in the environment, caused by human land use activities, were responded differently for mammals with different functional traits. The wild herbivores dominated the protected areas and the domestic herbivores the unprotected. Today the domestic herbivores dominate the savannas in the Kalahari (Moleele & Mainah 2003) and the changes in the landscape they cause, has both direct and indirect effects on the wildlife. It seems like domestic herbivores outcompete large herbivores for resources. Livestock areas are many times overgrazed (Perkins 1996) and the savannas of the Kalahari support a higher herbivore density than it ever has done (du Toit & Cumming 1999). Wild animals tend to keep a distance to villages in a range of approximately 20 km (Bergström & Skarpe 1999) which suggest that the environment has changed close to areas with human activities. Wild animal densities have declined the past decades (Verlinden 1997) which may be since livestock areas are expanding in Botswana (Moleele & Mainah 2003; Wallgren et al. 2008). The increasing livestock production fragments the landscape and restricts the wildlife to other areas (Fjeldså et al. 2004). Hence, it is crucial to preserve the protected areas and find ways to make wild animals co-exist with human activities.

Wild animals encountered in the unprotected areas were mainly omnivores, insectivores and to some extent small herbivores. As mention earlier in this report the changes in the landscape in livestock areas, causes bush encroachment (Skarpe 1986). Bush encroachment may give some of these animals protection from predators, but on the other hand, many of the species have less food availability (beetles, grasshoppers etc.) in these areas. This is especially true where the bush encroachment is severe (Blaum et al. 2007). However, the highest proportions of the densities of these functional groups were still found in the protected areas which confirm hypothesis number 3.

Many similar studies have been made (Wallgren 2008; Persson in prep.; Träff in prep.; Jakobsson 2006; Carlsson 2006; Viio 2003) given similar result as in my study, showing that human land use strongly affects the wild animals. Both climatic and anthropogenic effects on the environment the past 30 years have caused large declines in many wildlife species (Spinage 1992). Even though, almost a one fourth of the country is set aside as protected areas in Botswana (Twyman 2001). Indicator species may be an option to measure the ecological impact human land use activities have outside the protected areas. Carnivores may be a good example to use, due to their vulnerability (Blaum et al. 2007). Also, the WMA is a good example for involving local livelihoods. They may benefit and in the same way preserve wild animals. Wildlife is proven to be able to occur in high densities in areas with a low human influence. This is a fact that may benefit both local communities and the future existence of wild animals in the African savannas (du Toit 2002).

Conclusion

This study is a comparative study of wildlife densities over environmental gradients, seasons and regions. Conclusively, the research shows that human land use have an influence on wild mammals as well as ostriches in Botswana. Large and medium sized herbivores and carnivores are most affected by human activities and smaller mammals least. Wild animals did not exist, or existed in low densities in the same areas as the domestic animals did. The seasonal and regional differences in the environment did not prove to affect the wildlife as much as human activity, which also was confirmed by Wallgren et al. (2009).

This study shows that human land use has a great impact on wildlife and has the potential to determine its distribution. Different types of wildlife will respond differently to environmental changes and my study shows the need to maintain protected areas for the existence of many species. It is important to focus on the influence that human-related activities cause, but also on the benefit we can make by conservation plans and preservation of wildlife. In general terms, little attention has been given to the fact that biodiversity has an economic value, and by sustainably develop and conserve natural ecosystems human wellbeing may improve.

However, a wider understanding and more research is needed both on local and global level on this matter (IUCN 2011).

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Appendix 1

Densities of wild and domestic mammals and ostriches in different types of land use (CGA, FR, WMA, NP) over different regions and seasons in Botswana. LD = Low density (less than 0.01 animal animals/km^2; U CL = upper confidential limits; L CL = lower confidential as well as statistical significant (S = significant, NS = no statistical significant) NB = Northern Botswana; SB = Southern Botswana. For species abbreviation see table 2.

		NB wet season				NB dry season				SB wet season				SB dry season				
Wild animals		CGA	FR	WMA	NP	CGA	FR	WMA	NP	CGA	FR	WMA	NP	CGA	FR	WMA	NP	**Sign.**
	U CL	0.4	2.1	8.9	0.8	0.2	0.2	0.8	1.2	0.1	0.1	0.1	0.1	0.3	0.8	0.2	0.7	
AWC	D	0.2	0.1	1.2	**0.6**	LD	0.1	**0.4**	**0.7**	LD	LD	LD	LD	0.1	0.3	0.1	0.3	S
	L CL	0.1	LD	0.1	0.5	LD	LD	0.2	0.4	LD	LD	LD	LD	LD	0.1	0.1	0.1	
	U CL	0.5	3.7	0.1			0.4	0.3	0.9	0.2	0.7	0.2	0.4	0.4	0.8	0.2	0.6	
BBJ	D	0.2	0.7	0.1	-	-	0.1	0.1	0.4	0.1	0.3	0.1	0.3	0.2	0.2	0.1	0.3	NS
	L CL	0.1	0.1	0.1			LD	LD	0.2	LD	0.1	0.1	0.2	0.1	LD	0.1	0.1	
	U CL					0.2	0.4	0.5	1.0		0.5	0.9	0.9	0.6	0.7	0.5	0.9	
BFX	D	-	-	-	-	0.1	0.1	0.1	0.5	-	0.1	0.4	0.5	0.2	0.2	0.2	0.5	NS
	L CL					0.0	LD	LD	0.2		LD	0.2	0.3	0.1	LD	0.1	0.2	
	U CL	3.2	4.1	3.0	0.5	1.6	0.2	2.6	1.9									
BUB	D	0.9	0.2	0.7	0.4	0.8	LD	1.5	0.4	-	-	-	-	-	-	-	-	NS
	L CL	0.3	LD	0.1	0.3	0.4	LD	0.9	0.1									
	U CL					0.1		0.2		0.1	0.1	0.2	0.3	0.1	0.8	0.4	0.3	
CFX	D	-	-	-	-	LD	-	LD	-	LD	LD	0.1	0.1	LD	0.3	0.2	0.2	NS
	L CL					LD		LD		LD	LD	LD	0.1	LD	0.1	0.1	0.1	
	U CL					0.6	0.6	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.8	0.2		
CDU	D	-	-	-	-	**0.3**	0.3	0.1	LD	0.1	LD	LD	LD	LD	0.1	0.1	-	S
	L CL					0.2	0.1	LD	LD	LD	LD	LD	LD	LD	LD	LD		

	U CL			1.1	2.7	0.1		0.1	2.5									
ELE	D	-	-	0.3	**1.8**	LD	-	LD	1.6	-	-	-	-	-	-	-	-	S
	L CL			0.1	1.2	LD		LD	1.0									
	U CL										0.2	0.1	1.2		0.2	0.1	1.2	
GEM	D	-	-	-	-	-	-	-	-	-	LD	LD	0.7	-	LD	0.1	0.6	NS
	L CL										LD	LD	0.4		LD	LD	0.3	
	U CL			1.0	1.3			2.2	2.5									
GIR	D	-	-	0.5	0.8	-	-	0.9	1.4	-	-	-	-	-	-	-	-	NS
	L CL			0.3	0.5			0.4	0.8									
	U CL						1.2			1.3	1.0	1.3	0.7	1.7	33.7	1.0	2.2	
GSQ	D	-	-	-	-	-	0.1	-	-	0.5	0.2	0.5	0.3	0.7	**9.8**	0.4	0.4	S
	L CL						LD			0.2	0.1	0.2	0.2	0.3	2.8	0.2	0.1	
	U CL	19.2	56.3	37.9	31.8	8.1	4.0	6.5	9.3	1.8	4.2	1.5	1.9	3.9	11.4	3.2	5.0	
HAR	D	**9.2**	6.4	3.0	18.6	5.3	0.5	**3.5**	5.2	0.9	1.9	0.8	1.1	2.2	4.9	2.0	2.7	S
	L CL	4.4	0.7	0.2	10.9	3.5	0.1	1.9	2.9	0.5	0.8	0.4	0.7	1.3	2.1	1.3	1.5	
	U CL			22.0	33.7			12.7	17.6									
IMP	D	-	-	11.5	**25.2**	-	-	6.3	10.7	-	-	-	-	-	-	-	-	S
	L CL			6.0	18.8			3.2	6.6									
	U CL						0.3	0.9	2.4							0.4	0.4	
KUD	D	-	-	-	-	-	0.1	0.2	**1.1**	-	-	-	-	-	-	0.1	0.1	S
	L CL						LD	0.1	0.5							LD	LD	
	U CL					0.5	0.2	1.2	0.7									
LGN	D	-	-	-	-	0.2	LD	0.6	0.3	-	-	-	-	-	-	-	-	NS
	L CL					0.1	LD	0.3	0.1									
	U CL					0.3	0.7	0.1	0.9	1.5	0.1	0.2	0.3	0.8		0.3	0.2	
OST	D	-	-	-	-	0.1	0.3	LD	0.3	0.3	LD	0.1	0.1	0.2	-	**0.2**	0.1	S
	L CL					LD	0.1	LD	0.1	0.1	LD	LD	LD	0.1		0.1	LD	
	U CL									0.2		0.7	0.2	0.2	0.2	0.3	1.0	
RHB	D	-	-	-	-	-	-	-	-	LD	-	0.4	0.1	LD	LD	0.1	0.2	NS
	L CL									LD		0.2	LD	LD	LD	LD	0.1	

	U CL					0.6	0.6	1.1	0.3		0.1	0.1	0.1	0.1	0.8	0.5	0.3	
SGN	D	-	-	-	-	0.2	0.3	**0.7**	0.1	-	LD	LD	LD	LD	0.2	0.3	0.1	S
	L CL					0.1	0.1	0.4	LD		LD	LD	LD	LD	LD	0.1	LD	
	U CL					0.6	1.3	0.7	1.9	0.4	0.4	0.2	0.3	0.4	2.5	0.7	1.1	
SMG	D	-	-	-	-	0.2	0.4	0.2	0.5	0.1	0.1	LD	0.1	0.1	0.3	0.3	0.3	NS
	L CL					LD	0.1	0.1	0.2	LD	LD	LD	LD	LD	LD	0.1	0.1	
	U CL	3.4	3.3	1.3	4.4	1.0	1.4	7.7	33.8	1.8	0.8	3.2	1.9	1.6	5.2	3.8	5.5	
SPH	D	0.5	0.7	1.0	**3.5**	0.6	0.2	**5.0**	**23.7**	1.2	0.3	**2.5**	**3.9**	**2.4**	**2.3**	**3.0**	3.2	S
	L CL	0.1	0.1	0.8	2.8	0.3	0.0	3.3	16.6	0.8	0.1	2.0	3.1	3.4	1.1	2.4	1.9	
	U CL									0.7	0.3	3.9	1.7	1.0	0.3	1.8	2.1	
SPR	D	-	-	-	-	-	-	-	-	0.2	0.1	1.1	1.0	0.3	LD	0.7	0.5	NS
	L CL									0.1	LD	0.3	0.6	0.1	LD	0.3	0.1	
	U CL	1.4	5.1	1.4	0.8	0.4	2.6	1.1	1.7	0.5	0.9	1.6	2.5	0.7	2.4	2.1	3.4	
STE	D	0.2	0.5	0.9	0.6	0.2	**1.7**	0.8	1.0	0.3	0.4	1.2	**2.0**	0.5	1.2	**1.6**	**2.2**	S
	L CL	LD	0.1	0.6	0.4	0.1	1.1	0.6	0.6	0.2	0.2	0.9	1.6	0.3	0.5	1.3	1.4	
	U CL					8.4		7.1	6.9									
TSQ	D	-	-	-	-	3.7	-	4.4	2.6	-	-	-	-	-	-	-	-	NS
	L CL					1.6		2.7	1.0									
	U CL						0.1	0.7	1.4	0.1						0.1		
WAR	D	-	-	-	-	-	LD	0.3	**0.6**	LD	-	-	-	-	-	LD	-	S
	L CL						LD	0.1	0.3	LD						LD		
	U CL				3.1				1.3			0.2	LD			0.2	1.1	
WIL	D	-	-	-	**1.9**	-	-	-	**0.7**	-	-	LD	LD	-	-	LD	0.2	S
	L CL				1.1				0.3			LD	LD			LD	LD	
	U CL					0.6	0.7	0.7	1.8	0.8	1.3	0.7	0.4	1.2	5.3	1.6	0.6	
YMG	D	-	-	-	-	0.1	0.2	0.1	0.8	0.4	0.3	0.3	0.1	0.5	2.5	0.7	0.1	NS
	L CL					LD	0.1	LD	0.3	0.2	0.1	0.1	LD	0.2	1.1	0.3	LD	
	U CL			1.8	25.6			13.8										
ZEB	D	-	-	0.4	**11.1**	-	-	**6.8**	-	-	-	-	-	-	-	-	-	S
	L CL			0.1	4.8			3.3										

Domestic animals		NB wet season				NB dry season				SB wet season				SB dry season				
		CGA	FR	WMA	NP	CGA	FR	WMA	NP	CGA	FR	WMA	NP	CGA	FR	WMA	NP	Sign.
	U CL	118.1	157.6			36.0	47.0			20.3	89.7	6.7		26.2	88.7	1.3		
CAT	D	29.1	74.5	-	-	19.6	18.1	-	-	**11.2**	**54.0**	2.9	-	**16.2**	**51.4**	0.4	-	S
	L CL	7.2	35.2			10.7	7.0			6.2	32.5	1.2		10.0	29.8	0.1		
	U CL	1.7	8.5			3.8	0.4			0.8	7.8	0.4		4.0	12.9	0.4		
DOG	D	0.9	1.4	-	-	1.6	0.1	-	-	0.3	**3.2**	0.1	-	1.5	**3.9**	0.1	-	S
	L CL	0.5	0.2			0.7	0.0			0.1	1.3	0.0		0.6	1.2	0.0		
	U CL	9.3	27.4			2.7	6.6			4.5	9.8	0.7		5.9	14.8	1.8		
DON	D	2.7	8.5	-	-	1.4	1.4	-	-	2.4	4.4	0.3	-	3.2	4.4	0.7	-	NS
	L CL	0.8	2.6			0.8	0.3			1.3	1.9	0.1		1.7	1.3	0.3		
	U CL	25.9	60.6			16.2	38.1			22.4	25.0	2.7		26.9	30.9	7.3		
GOA	D	7.1	17.7	-	-	8.3	6.2	-	-	**12.2**	**12.4**	1.0	-	**15.9**	7.5	2.3	-	S
	L CL	1.9	5.2			4.3	1.0			6.6	6.2	0.3		9.3	1.8	0.8		
	U CL	1.9	5.4			0.4	1.0			0.9	3.9	0.3		0.9	3.4	0.4		
HOR	D	0.4	1.6	-	-	0.1	0.3	-	-	0.3	**2.0**	0.1	-	0.5	**1.4**	0.2	-	S
	L CL	0.1	0.4			0.0	0.1			0.1	1.0	0.0		0.3	0.6	0.1		
	U CL					0.1	0.5			2.7	8.6			2.8	14.4	1.0		
SHE	D	-	-	-	-	0.0	0.1	-	-	0.5	**3.3**	-	-	1.0	**4.4**	0.2	-	S
	L CL					0.0	0.0			0.1	1.3			0.4	1.4	0.1		

Appendix 2

Functional groups of animals analyzed with DISTANCE 5.0 during the wet and dry seasons, in northern and southern Botswana.				
Wild animals				
Species	**Scientific name**	**Abbr.**	**Functional group**	**Body mass (kg)**
Bat-eared fox	*Otocyon megalotis*	BFX	Insectivores	3.0 - 5.4
Slender mongoose	*Galerella ssp.*	SMG	Insectivores	0.4 - 0.8
Yellow mongoose	*Cynictis penicillata*	YMG	Insectivores	0.6 - 0.8
Black-backed jackal	*Canis mesomelas*	BBJ	Omnivores	5.0 - 12.0
Large spotted genet	*Genetta tigrina*	LSG	Omnivores	1.4 - 2.5
Lesser bushbaby	*Galago moholi*	BUB	Omnivores	0.1 - 0.2
Ostrich	*Struthio camelus*	OST	Omnivores	90.0 - 100.0
Small spotted genet	*Genetta genetta*	SGN	Omnivores	1.5 - 2.6
Warthog	*Phacochoerus aethiopicus*	WAR	Omnivores	44.0 - 104.0
Cape/Scrub hare	*Lepus capensis/saxatilis*	HAR	Small herbivores	1.4 - 2.5
Ground squirrel	*Xerus inauris*	GSQ	Small herbivores	0.5 - 1.0
Springhare	*Pedetes capensis*	SPH	Small herbivores	2.9 - 3.9
Tree squirrel	*Paraxerus cepapi*	TSQ	Small herbivores	0.8 - 0.3
African wildcat	*Felis lybica*	AWC	Wild carnivore	2.4 - 6.4
Cape fox	*Vulpes chama*	CFX	Wild carnivore	2.3 - 4.2
African elephant	*Loxodonta africana*	ELE	Wild large and medium sized herbivore	2,500.0 - 6,000.0
Blue wildebeest	*Connochaetes taurinus*	WIL	Wild large and medium sized herbivore	180.0 - 250.0
Common duiker	*Sylvicapra grimmia*	CDU	Wild large and medium sized herbivore	15.3 - 25.4
Giraffe	*Giraffa camelopardalis*	GIR	Wild large and medium sized herbivore	700.0 - 1,400.0
Greater kudu	*Tragelaphus strepsiceros*	KUD	Wild large and medium sized herbivore	120.0 - 305.0

Impala	*Aepyceros melampus*	IMP	Wild large and medium sized herbivore	32.0 - 66.0
Gemsbok	*Oryx gazella*	GEM	Wild large and medium sized herbivore	210.0 - 260.0
Springbok	*Antidorcas marsupialis*	SPR	Wild large and medium sized herbivore	30.4 - 48.0
Steenbok	*Raphicerus campestris*	STE	Wild large and medium sized herbivore	3.9 - 13.2
Zebra	*Equus burchelli*	ZEB	Wild large and medium sized herbivore	260.0 - 340.0
Domestic animals				
Cattle	*Bos taurus*	CAT	Domestic large and medium sized herbivores	300.0 - 400.0
Donkey	*Equus asinus*	DON	Domestic large and medium sized herbivores	140.0
Goat	*Capra hircus*	GOA	Domestic large and medium sized herbivores	30.0
Horse	*Equus caballus*	HOR	Domestic large and medium sized herbivores	250.0
Sheep	*Ovis aries*	SHE	Domestic large and medium sized herbivores	30.0
Domestic dog	*Canis familiaris*	DOG	Domestic carnivore	15.0 - 25.0

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2013:6	The influence of forestry stands treatments on brown bears (*Ursus arctos*) habitat selection in Sweden – an option for Alberta forestry? Författare: Anna Maria Petré
2013:7	The effects of Gotland pony grazing on forest composition and structure in Lojsta hed, south eastern Sweden. Författare: Emma Andersson
2013:8	Social and economic consequences of wolf (Canis lupus) establishments in Sweden. Författare: Emma Kvastegård
2013:9	Manipulations of feed ration and rearing density: effects on river migration performance of Atlantic salmon smolt. Författare: Mansour Royan
2013:10	Winter feeding site choice of ungulates in relation to food quality. Författare: Philipp Otto
2013:11	Tidningen Dagens Nyheters uppfattning om vildsvinen (Sus scrofa)? – En innehålls-analys av en rikstäckande nyhetstidning. Författare: Mariellé Månsson
2013:12	Effects of African elephant (*Loxodonta africana*) on forage opportunities for local ungulates through pushing over trees. Författare: Janson Wong
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2013:14	Effekt av habitat på täthetsdynamik mellan stensimpa och ung öring I svenska vattendrag. Författare: Olof Tellström
2013:15	Effects of brown bear (*Ursus arctos*) odour on the patch choice and behaviour of different ungulate species. Författare: Sonja Noell
2013:16	Determinants of winter kill rates of wolves in Scandinavia. Författare: Mattia Colombo
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