

POLYTECHNIC OF NAMIBIA



Department of Agriculture & Natural Resource Management



Title: Impacts of fire on grazers and browsers movements at Waterberg plateau park, central Namibia

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PREFACE

The main aim of the study was to determine the impacts of fire on grazers and browsers activities (movements) of different mammal species at Waterberg Plateau Park, Central Namibia using dung counts as a method to determine abundance of animals in recently burnt areas in comparison with areas burnt before.

The study was carried out as Work Integrated learning project, for 5 months from February to June 2014. The study project was fully funded by SASSCAL task 148, that is being coordinated by Dr David Joubert of the Polytechnic of Namibia where I am pursuing my bachelor degree in Natural resource management.

SASSCAL (Southern Africa Science Service Centre for Climate Change and Adaptive Land-use) is a joint initiative of Angola, Botswana, Namibia, South Africa, Zambia, and Germany, responding to the challenges of global change.

SASSCAL mission is to “conduct problem-oriented research in the area of adaptation to climate change and sustainable land management and provide advice for all decision-makers and stakeholders to improve the livelihoods of people in the region and to contribute to the creation of an African knowledge-based society” (www.sasscal.org)

SASSCAL is funded by the German Federal Ministry of Education and Research (BMBF) and scientifically coordinated by the University of Hamburg and implemented in a collaborative effort by Southern African and German partners.

ABSTRACT

Fire is one of the major ecological factors that determines structure and function of grassland and savanna ecosystems through its effects on vegetation composition and primary production, and foraging behaviour and distribution of populations of wildlife species, therefore, some wildlife protected areas in Namibia like Waterberg Plateau Park have a fire management scheme to cater for a variety of purposes such as, to prevent bush encroachment into grassland, to increase production of quality forage, to control wild fires from outside the protected areas and their spread, and to keep animals in tourist areas for visitors' enjoyment.

The responses to fire of ecosystem processes can be quantified but the outcomes are generally complex depending on the nature of the fire regime, primarily the frequency and timing of the fire events. Burning has been a management tool in protected areas and a common practice of range management by pastoralists. Herdsmen use fire to improve the pasture quality for cattle. Removal of old or dead grass material by fire enhances sprouting of plants, which improves, at least for a short-term, the quality of the sward. In Waterberg Plateau six fire blocks have been burnt to date with the recent fire by lightning strike in October 2013.

The perceived importance of fire to the management and conservation of Waterberg ecosystem has driven this research to focus on the effects of fire on herbivores movements and their forage resources in the Waterberg Plateau Park. To accomplish that, the research aimed at determining 1) the movements of different mammal species utilizing different habitats in relation to fire history at Waterberg Plateau Park using dung counts as a method 2) determining utilisation of different grasses, shrubs and weeds by different mammal species in relation to fire history at Waterberg Plateau Park and 3) determining decomposition/ decay rate of dung heaps of different mammals species at Waterberg Plateau Park.

Results from the area burnt 10 months ago shows high species diversity, distribution, composition and abundance of herbivore species compared to other blocks burnt years ago. Findings show that herbivores switch between burnt and non-burnt areas maybe for shade, resting and ruminating in areas burnt long ago. More plant utilization was identified in the recent burnt area and it appears to be governed by enhanced concentrations of macronutrients, increased digestibility and reduced concentration of acid detergent fibers.

Selection for non-burnt or burnt areas or against areas burnt by some species of ungulates is also indicative that quality and/or quantity of forage in the respective patch underlay patch choice. The reason there is nearly much utilization in areas burnt years back is because

grasses are more palatable only at the beginning of the season; and if not utilized, the palatability of the new growth deteriorates through the growing season because palatability of the new growth will approach that of the new growth of grasses that were not burnt at the end of the first growing season.

For decomposition, the study has found that moisture is often singled out as the main factor that influences persistence of mammalian fecal pellets, with higher moisture levels resulting in faster decay rates and shorter persistence times.

Lastly, this research shows that fire is important in influencing mammal's utilization of available resources, and inclusion of the fire-herbivore interaction into ecological studies and conservation practices of fire systems will aid in better understanding and managing.

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1. INTRODUCTION

1.1 Fire as a management tool

Fire is recognised as a key factor that has been shaping woodland savannas for millennia (Oktay *et al.*, 2009). Historically, lightning was a primary source of fire which burned in woodlands and it benefited the ecosystems by increasing soil nutrients (Snyder, 1986), regulating ecosystem productivity and diversity (DeBano *et al.*, 1998).

Fire is an ecological factor and a tool for veld management. It is essential for maintaining vigorous veld and for ensuring long-term animal production from the veld. However, its misuse can have detrimental consequences. An understanding of the principles relating to burning is essential for its effective employment (Tainton, 1999). Our ancestors probably used bush fires to help with hunting and herding wild animals. Fire might have been used to keep animals migration routes open and to attract animals to graze on new grass which would have made hunting easier.

Fire comes in 3 types, surface, crown and ground fire. In Namibia, the vast majority occurs as surface fires that spread in the grass and shrub layer. Crown fires and ground fires occur over only limited geographical areas. The major natural cause of wildfire ignitions are lightning; Lightning fire is the most significant natural cause, but accounts for a small percentage of all fires. The majority of fires are ignited by people, either deliberately or accidentally.

Fire behaviour is influenced by fuel load, fuel size, fuel distribution, fuel compaction, fuel moisture, temperature, humidity, wind and slope. Fire is a useful and indispensable aid to veld management and must form an integral part of the veld management strategy practiced on any rangeland.

According to (Tainton, 1999) Fire prescribed by management results in:

- Burning off unpalatable growth left over from previous seasons
- Controlling the encroachment of undesirable plants in the veld;
- Protecting the veld (and farm) from wildfires and accidental fires
- Stimulating growth during those months of the year when there is little young forage available, and thus
- Providing green feed when it does not occur naturally; and
- Destroying parasites

Fire can also be used to manage alien and undesirable woody or herbaceous plants and/or weeds that reduce stocking rate and the last one is in the making of firebreaks and block burning to stimulate and increases stocking rate and to stimulate grazing pressure. Another importance of fire is to manipulate the movement of animals in Wildlife parks and game ranches, describing the movement of animals to burned areas as due to high-quality, easily digestible components such as new shoots and leaves, flowers, fruits and storage organs (e.g. tubers), are frequently only seasonally available and rare.

In addition, fire reduces the chances of woody establishment events by drastically increasing the mortality of seedlings and saplings, and maintains woody species at a browsable level (Joubert *et al.*, 2008). Fire promotes a temporary improvement in grass quality in recently burnt areas where new shoots were found to have crude protein content of around 20 %, as opposed to dry grass which had crude protein content or around 3 to 4 % Erb (1993).

As cited by Lunt, (2011) "Removal of litter creates gaps that can be filled by pioneer plant species or by resprouts of established fire-resistant perennials (Eriksson *et al.*, 2003; Hanley *et al.*, 2001; Pellew, 1983; Yu *et al.*, 2009); these processes promote vegetation heterogeneity".

According to (Curtis and Manheimer, 2009, P.viii) frequent fires compromise seed germination, seedling establishment, and continuous growth of trees such as *Burkea africana* and *Ochna pulchra*. Fire considered as a tool for veld management, one should burn depending on the production rate of grasses, rainfall and utilization of veld.

1.2 Fire history at Waterberg Plateau Park

As in the fire management plan, Waterberg Plateau Park is divided into 6 fire zones. The zones are divided into blocks and each zone has two to three blocks (approximately equal in size 2000 ha each except zone 6 and based on the current road system) (fig 1) with road-width as fire breaks (approximately 5 m). In total, 14 blocks have been burnt to date.

The six fire zones (Fig. 2) are divided into different fire blocks of different fire intervals, with the highest interval being 18.2 and the lowest being 4.6 years.

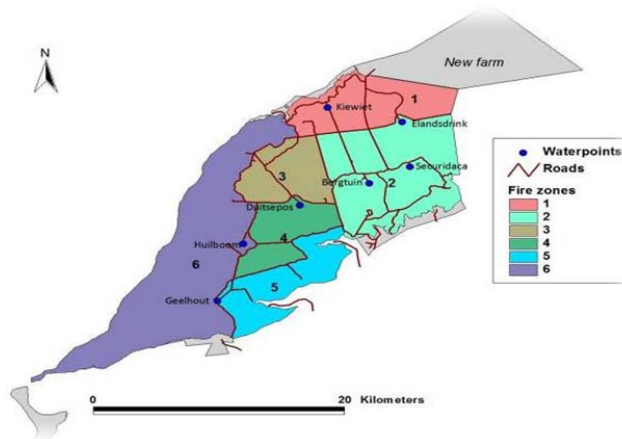


Figure 1 Map of the Park showing the six current fire zones, and proposed blocks within the zones. The artificial water points in the park are included. (Eco Impact Consultants. 2011).

A maximum of approximately 50 % of the Park has to be burnt, as an approach to ensure sufficient grazing in the event of poor rains which may cause an unresponsive grass sward after burning. 50 % maximum burn only occurs if all the rules are met, including average rainfall for the Park. The closure of water points close to burnt areas is also included, in an attempt to rest grass, after the initial grazing in the first season after the burn.

Table 1 A preliminary fire history for each zone and block sampled. (David Joubert, unpublished data).

Zone	Block	Fire interval	Time since last burn	Rank interval	Rank time since last burn
1	A	9.3	1	5	2
1	B	18.5	24	10	11
2	A	6.2	0	2	1
2	B	9.3	14	5	6

1.3 Introduction to dung counts

No Literature research has shown dung count methods been practiced in Namibia, but much has been done in Africa and worldwide. Some researchers have practiced it in Southern Ghana

and Kenya to estimate elephant densities, some have practiced it to estimate hare density in Florida and fox abundance in central Italy (Barnes RFW. 2001).

Fecal counting has been widely used to index or estimate the abundance of ungulates, and to monitor changes (Campbell; Swanson; and Sales 2004).

(Bailey and Putman 1981), described pellet counting a method that may prove to be a particularly useful tool to census endangered species because it requires less time than live trapping and can be conducted with no interaction with the endangered animals. They further described fecal counts to be more advanced and reliable compared to other methods. Ground surveys such as road or spotlight counts are unreliable because animals are difficult to detect in forested habitat, thus surveys often are limited to easily accessible roads. Live-capture and photographic mark-recapture methods usually are very expensive and limited.

The accuracy of dung counts is less dependent on the skill of the observer, and its measurement is easier to standardize between observers. If it is affected, less by viewing conditions and the act of observing does not influence what is observed (Barnes, (2001).

1.4. Study area

Waterberg Plateau Park (WPP) is located in central Namibia (between 20° 37'S, 17° 08'E and 20° 11'S, 17° 26'E), 280 km northeast of Windhoek and about 64 km east of Otjiwarongo (Fig. 1), at an elevation between 1550 m and 1850 m above sea level. Sandstone plateau rises up to 200 m above the surrounding plain, extending some 50 km in length and 16 km in width (Thalwitzer *et al.*, 2011). The WPP comprises about 45 000 ha. The park was proclaimed in 1972, originally as a sanctuary for rare and endangered species including Buffalo, Eland, Giraffe, Kudu, Red hartebeest, impala, Sable and Roan antelopes which were relocated from north east regions for breeding purposes (Schneider, 1993).

According to Schneider (1993) the park has an estimated 200 bird species. This includes birds of prey such as, cape vultures, lapped face vultures, white backed vultures, tony eagle, black eagle and pale chanting goshawk. Smaller birds include red billed francolin, Kalahari scrub robin, grey backed camaropteras, puff back shrike and monteiro's hornbill. (Schneider, 1993) further stated that 7 bird species namely Monteiro's hornbill, Carps black tit, Short toed rock thrush, bradfield's swift, Rueppels's parrot, Hartlaub's francolin and Rock runners are endemic to Namibia or southern Africa.

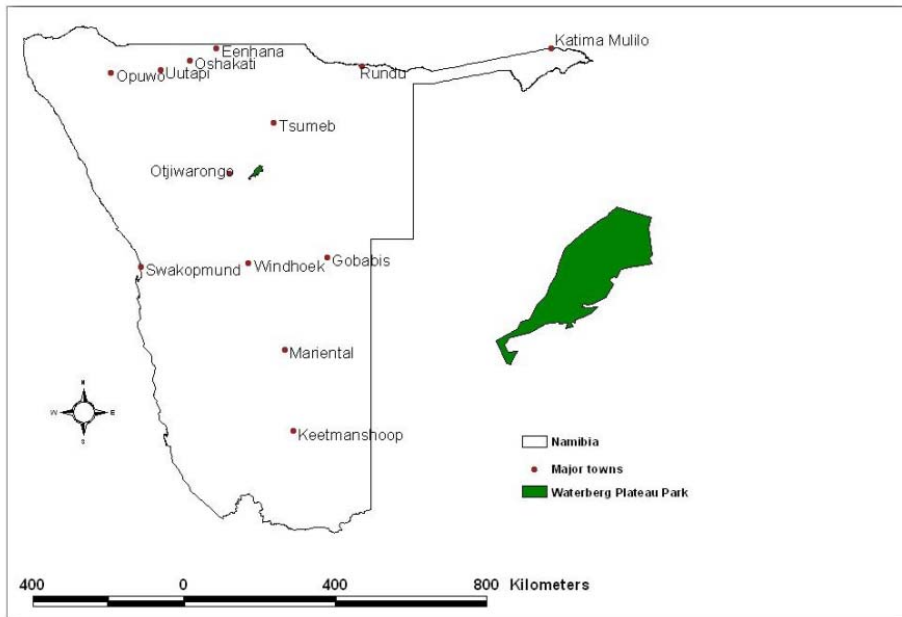


Figure 2 Location of Waterberg Plateau Park in Namibia (Mukaru, 2009)

1.4.1. Climate

The park is within the 500 - 600mm rainfall isohyet (Du Preez, 2001) which makes the area more habitable to some endangered animals such as Roan and sable which do not naturally occur in areas that experience less than an average of 400 mm rainfall per year and buffalos that cannot occur in an area that receive less than 250 mm rain per year (Apps, 2000). The mean annual rainfall measured at Onjoka was 424.5 mm with a standard deviation of 129 mm for the period 1981 until 2001 (Du Preez, 2001). This year, wpp received an of mm rainfall. WPP receives summer rainfall of which 90% falls between October – March, with February being the wettest month (Erb, 1993). The average daily minimum temperature for the coldest months is between 4 °C and 5 °C, where the temperatures during June can be as low as -5 °C (Mukaru, 2009). The average daily maximum temperature in the hottest months ranges between 31 °C and 32 °C and from October to January it can up to 39.4 °C (Mukaru, 2009).

The east winds are predominant throughout the year, being strong between June and December (Mukaru, 2009). The north winds become west winds in the late afternoons during April and October, and the south and southeast winds usually blow during September and October. As stated by, Erkie (2007) in Mukaru (2009), the wind patterns influence the rain which

usually occurs with the north, northeast and east winds, which brings humid air from those directions.

Dew and mist occur in summer and autumn (Mukaru, 2009). Frost occurs during winter on the plateau and this is associated with its topography, with a higher incidence of low temperatures occurring in the more low-lying areas (Mukaru, 2009).

1.4.2. Vegetation

Waterberg Plateau Park falls within the Tree Savanna and Kalahari Woodland vegetation types of Namibia and consists mainly of a variety of deciduous trees, shrubs, and grasses (Erckie, 2007). The most dominating shrub on the plateau is *Terminalia sericea* painting almost the entire landscape with its silvery greenish-grey touch (Schneider, 1993). Amongst them also grow *Burkea africana*, *Combretum spp*, *Acacia spp*, *Croton gratissimus*, *Bauhinia petersiana*, *Philenoptera nelsii*, *Peltophorum africanum*, *Dombeya rotundifolia*, *Grewia spp*, *Ximenia americana and caffra*, and *Ochna pulchra* (Schneider, 1993). Grass species include *Eragrostis pallens*, *Brachiaria nigropedata*, *Digitaria seriata*, *Panicum kalahariensis*, *Eragrostis stipitata*, *Eragrostis Jefrisii*, *Eragrostis riguidior*, and *Cenchrus ciliaris* (Schneider, 1993).

1.4.3. Geology

The top of the plateau is made up of lithified dunes, belonging to the Etjo formation, which forms part of the Karoo sequence (Erb, 1993). The soil is sandy with low clay content ($\leq 20\%$) (Erb, 1993.) Soil pH ranges between 3.6 and 6, with an average value of 4.4. Mixture of very sandy soils and the Etjo sandstone cause the Plateau to absorb any water that is sucked up into the soil until it reaches the impermeable stone from where it runs off underground to emerge as springs, where the plateau got its name (Schneider, 1993).

2. AIM AND OBJECTIVES

The project aim was to monitor animal movements (e.g. dung counts) on burnt areas and on unburnt areas in relation to fire histories at Waterberg Plateau Park.

1. To determine the movements of different mammal species utilizing different habitats in relation to fire history at Waterberg Plateau Park using dung counts as a method.
2. To determine utilisation of different grasses, and shrubs by different mammal species in relation to fire history at Waterberg Plateau Park.
3. To determine decomposition/ decay rate of dung heaps of different mammals species at Waterberg Plateau Park

2.1 Research questions

1. Is the amount of dung in the recently burnt area more compared to other fire blocks in response to fire history?
2. Is the amount of utilisation in the recently burnt area significantly related to other fire blocks in response to fire history?

3. MATERIALS AND METHODS

3.1. Materials

- 30 m measuring tape to measure distances
- GPS for coordinates and directions
- Sony Camera
- Scatolog, A quick identification guide to Southern African animal droppings.
- Data sheet 2, data for dung counts (appendix 1)
- Data sheet 3, for decay/ decomposition rate (appendix 2)
- Data sheet 1, data for utilization(appendix 3)
- Pen, clipboard and field notebook to record information
- Le Roux and Muller's field guide to trees and shrubs of Namibia,
- Muller's field guide to grasses of Namibia
- Smithers field guide to the signs of the wild
- Plastic zip lock bags to collect scats and unidentified shrubs, herbs, weeds and grasses

3.2. Methods

3 field trips (2 weeks long) were undertaken for sampling and data collection. 6 transects that are 200 m long were randomly laid out using the random number system in the four blocks.



Figure 3 Photo showing how dense the vegetation burnt 14 years ago and how open the vegetation burnt months ago.

The random number system determined the distance, direction and the road to use for that particular fire block. Calculations done determined the distance from the road to the beginning or to the end of transect. When transect was in close proximity with a water hole, the distance was randomly increased with a kilometre to avoid waterholes. GPS devices were used to determine the direction to move in and the coordinates for each transect

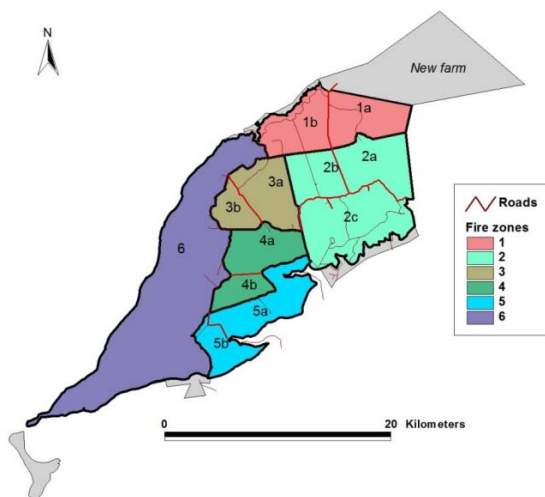


Figure 4 Map of WPP showing the six current fire zones, and proposed blocks within the zones. (Eco Impact Consultants. 2011).

3.2.1. To determine the movement of different mammal species in relation to fire history at Waterberg Plateau Park using dung counts as a method

Along each 200 m transect, dung counts were done at every 20 m within a 4 m x 8 m quadrat. See Appendix 1. A total of 60 points were sampled in each block, making a total of 240 points in the 4 blocks.

Pellet counting was standardized to ten pellets to be counted as an individual animal. For smaller mammals, E.g. Hare, 1 single distributed pellet represented 1 hare that just passed by and 1 pile of hare pellets represent 1 hare that have been sitting at that particular place. Very old, scoured dungs as in the picture below were not counted because they might have been lying there a long period of time (over a year) which is typical of ungulate's pellets and it might lead to density overestimates.



Figure 5 Picture showing an example of old dung that was not counted in the study.

3.2.2. To determine utilization of grasses, shrubs and weeds species by different mammal species in relation to fire history at Waterberg Plateau Park.

Within each 4 m x 8 m quadrant corner, each nearest shrub, weed and grass was identified, recorded and observed for grazing and browsing damage. See Appendix 2.

This was carried out to see if the animals are using different fire blocks for feeding compared to resting, hiding and ruminating. Physical observations ensured that grasses are really grazed (not damaged by insects or due to trampling) and weeds and shrubs/trees are really browsed. E.g. one missing twig is not browsing damage because an animal might have just broken it off or just tasted for palatability in such plant.

A total of 12 observations were made at each point, making a total of 120 points in transect, a total of 720 points in a block and a total of 2880 sampled points in the 4 blocks.

3.2.3. To determine decomposition rate of dung heaps of different mammals species utilizing the habitats

Practical identification of faeces of different mammal species at Waterberg Plateau Park was carried out using a Scatolog, A quick identification guide to Southern African animal droppings as well as contacting experts in the field. See appendix 3.

Fresh dung heaps for buffalo and rhino were collected from Huilboom waterhole and were located at the Huilboom camp for decomposition rate experiment. The experiment included also 20 fresh pellets from giraffe, oryx, roan/sable and eland, that were collected from various places around the park. The specimens were observed on a daily basis for the first week and then changed to a weekly basis monitoring due to transport problems. Weather condition and soil moisture readings were taken before the experiment. The experiment was carried out to test how fast the microbial activities of the soil are, and how fast and important the dung beetles are in the ecosystems.

4. ANALYSIS

Data collected is not normally distributed, the variances are not the same, data is discrete and the samples/observations were ranked, so a non-parametric analytical statistic Mann Whitney *U* test was recommended, but analysis was done using descriptive statistic in excel.

5. RESULT

5.1. Dung counts

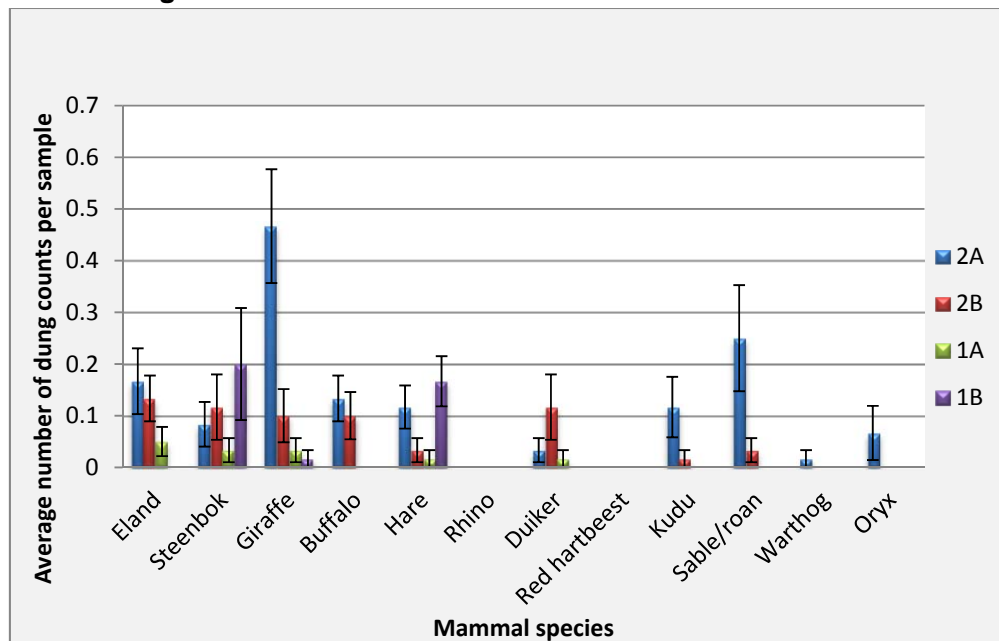


Figure 6 Mean abundance of different mammal species that has utilized the 4 fire blocks.

The study through dung counts shows that a total number of 12 species, 169 animals (97 individuals from 10 species in the recently burnt, 39 individuals from 8 species in the area burnt

14 years ago, 9 individuals from 5 species in the area burnt a year ago and 23 individuals from 3 species in the area burnt 24 years ago) has utilised the 4 blocks.

Five of the species that has utilized the fire blocks are classified as browsers, namely: Giraffe, Kudu, eland, duiker and steenbok four mainly grazers namely sable/roan, hare, warthog, oryx and buffalo

Abundance and richness were higher in the recently burned area compared to other blocks. Figure 6 shows that giraffe was most abundant in the recently burnt area with sable/roan while duiker and warthog were least abundant. Warthog and Oryx dung was only counted in the recently burnt area. Steenbok and hare dung was most abundant in(1B) the area burnt 24 years ago, and duiker dung was most abundant in the area burnt 14 years ago(2B), whilst rhino and red hartebeest dung was least abundant (none) in all 4 blocks.

There is more species distribution and composition in the recently burnt area compared to the area burnt a year ago and there is more species distribution and composition in the area burnt 14 years ago compared to the area burnt a year ago and 24 years ago.

5.2. Plants utilization

5.2.1. Grasses

Through visual observations for utilization of grasses, the study has shown 12 recorded grass species and grass utilization in 10 species.

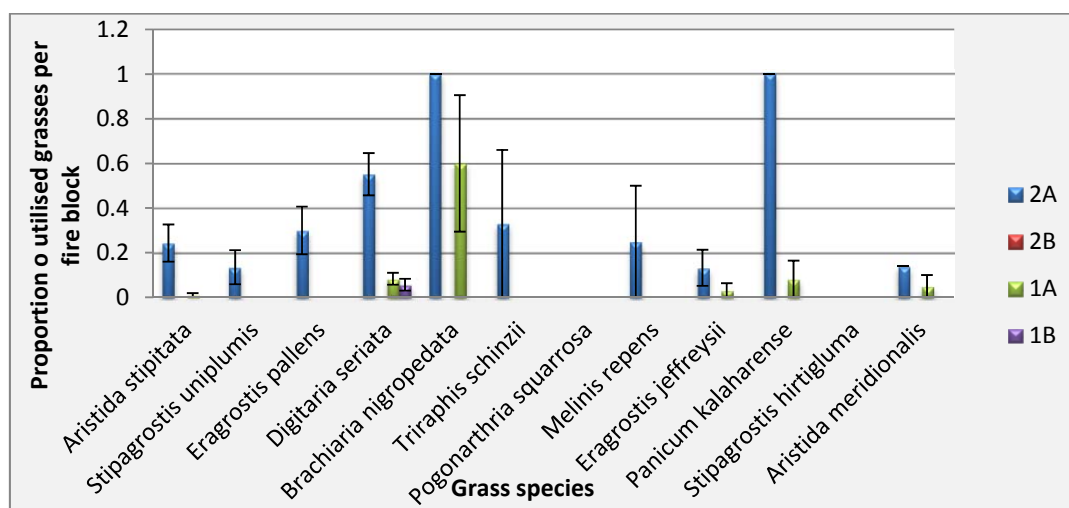


Figure 7 proportion numbers of utilized grasses in each fire block

Brachiaria nigropedata, and *Panicum kalaharens* shows total utilization and no variation in the recently burnt area. *Digitaria seriata* shows about 55% utilization in the recently burnt area compared to other fire blocks. There was no any grass utilization in block burnt 14 years ago. *Stipagrostis uniplumis*, *Eragrostis pallens*, *Triraphis schinzii* and *Melinis repens* were only utilized in the recently burnt area.

The area burnt a year ago was the second abundantly utilized with most utilization in *Brachiaria nigropedata* and least utilization in *Digitaria seriata*, *Eragrostis jeffreysii* *Aristida stipitata*, *Digitaria seriata*, *Panicum kalaharens* and *Aristida meridionalis*. In the area burnt 24 years ago, *Digitaria seriata* was the only utilized grass with about 4% utilization in the whole block. *Pogonarthria squarrosa* and *Stipagrostis hirtigluma* was never utilized in the four fire blocks.

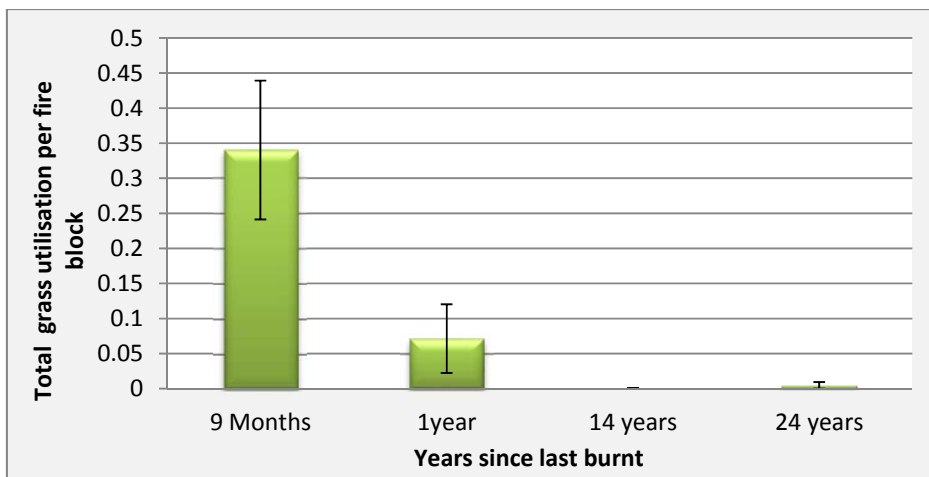


Figure 8 Total utilization of grass species in each fire block

Overall grass utilization in all blocks, the recently burnt area was more utilized than all other blocks. The area burnt a year ago shows low utilization but more species and it was more utilized compared to the area burnt 14 years ago and the area burnt 24 years ago. The area burnt 24 years ago was more utilized compared to the area burnt 14 years ago and least utilized compared to an area burnt recently and a year ago had no specie composition. It is quite surprising how quick utilization decrease in a year (area burnt a year ago) compared to area burnt 24 years ago.

5.2.2. Shrubs utilization

Through visual observations for utilization of shrubs, the study has shown 17 recorded shrub species and shrub utilization in 15 species.

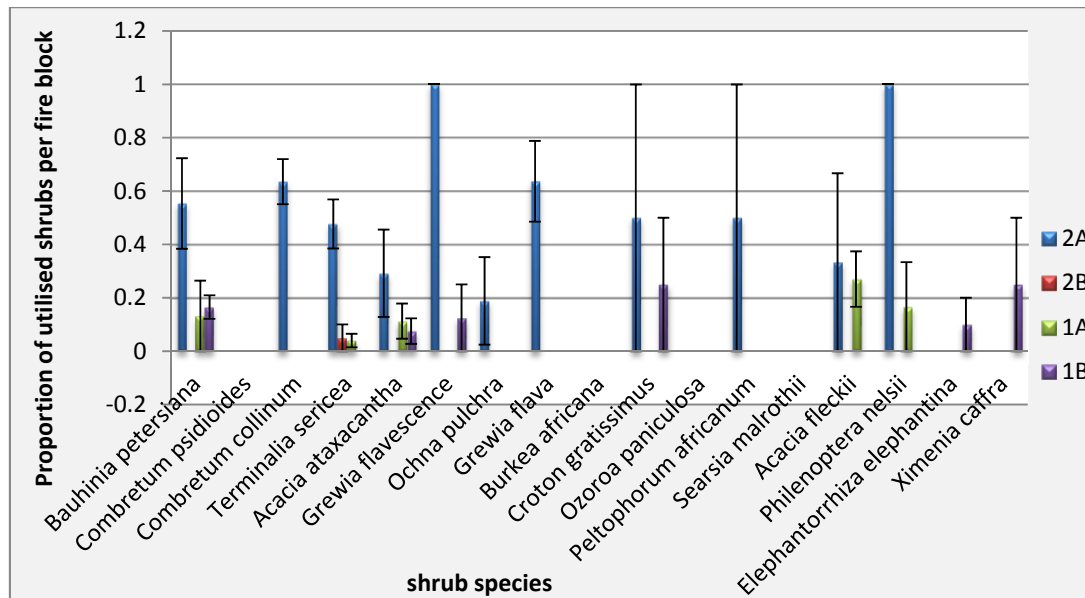


Figure 9 proportion number of shrubs utilized per fire block

Grewia flavescens and *Philenoptera nelsii* were abundantly utilized in 2A (recently burnt). *Combretum collinum*, *Ochna pulchra* and *Peltophorum africanum* were only utilized in 2A.

Block burnt 24 years ago was the second abundantly utilized with most utilization in *Bauhinia petersiana*, *Croton gratissimus* and *Ximenia caffra* and least utilization in *Elephantorrhiza elephantina* and *Acacia ataxacantha*.

The area burnt 24 years ago, *Terminalia sericea* was the only utilized grass in the whole block.

Searsia malrothii, *Burkea africana*, *Ozoroa paniculosa*, *Combretum psidioides* and *Peltophorum africanum* were never utilized.

Overall shrub utilization in all blocks, the recently burnt area was more utilized than all other blocks. The area burnt 24 years ago was more utilized compared to the area burnt a year ago and 14 years ago. There was more shrub utilization in area burnt 24 years ago compared to area burnt 14 years ago and less utilization compared to the area burnt recently and a year ago. Area burnt 14 years ago had least shrub utilization compared to all blocks and had no specie composition.

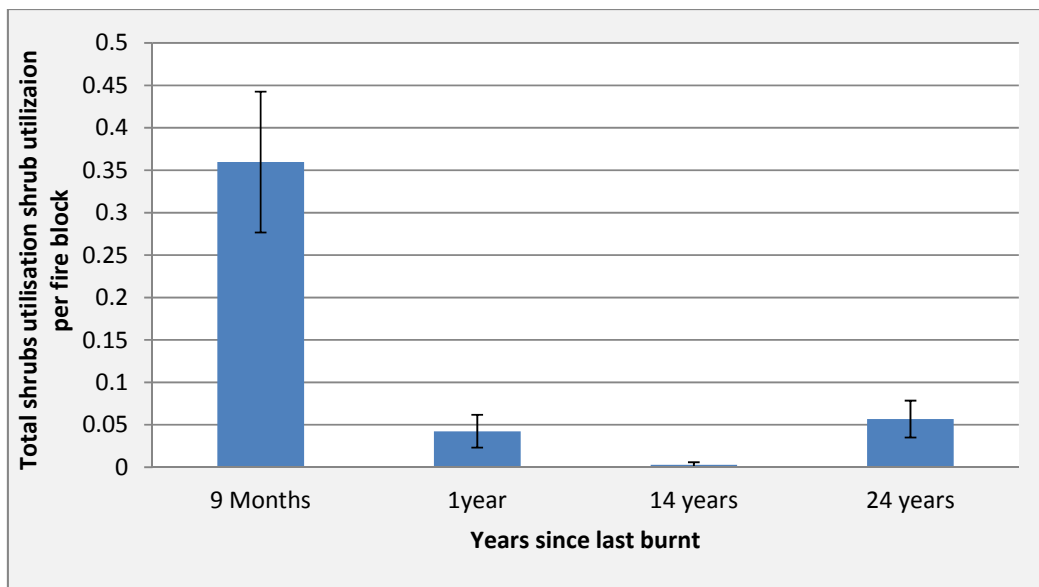


Figure10 Total shrub utilization per fire block

Fire stimulated growth and led to larger increments in green phytomass in the recently burnt area compared to the non-burnt areas. These findings agree with results from other studies in grasslands showing that fire stimulates regrowth (Norton-Griffiths, 1979; Briggs & Knapp, 2001)

5.2.3. Decomposition/disappearance rate

Table 2. Decomposition/disappearance rate of dungs over a period of 6 months.

Month		January	February	March	April	May	June
Specie	Eland	0	0	0	0	0	0
	Giraffe	0	0	0	0	0	0
	Buffalo	100%	100%	100%	100%	100%	100%
	Sable/Roan	0	0	0	0	0	0
	Oryx	0	0	0	0	0	0
	Rhino	0	50%	50%	50%	50%	50%

The table shows total decomposition/ disappearance in buffalo dung and it happened over a night under moist conditions, while in eland, Giraffe, sable/roan and Oryx dung there was no decomposition/disappearance for 6 months, despite moist conditions. There was 50% decomposition in rhino dung after a month, because of the fibrous waste that was left after the fresh dung has been utilized by beetles or soil microorganisms.

6. DISCUSSIONS

6.1.1 Dung counts

The high species diversity, distribution, composition and abundance of herbivore species in the recently burnt area compared to other blocks which are burnt years back is more driven by quality of forage preference by herbivores for some periods and in non-burnt areas due to high phytomass in other periods. The animal movement in these patches will increase soil fertility and promote germination of new grasses, and increase the patch mosaic effect.

Although there were no Eland counts in the area burnt 24 years ago, probably because of old moribund and unpalatable grasses, eland is mostly wide spread and can utilize most habitats (Apps, 2000). Steenbok, hare and giraffe have utilized all habitats. Steenbok prefers thick areas with cover (Apps, 2000) which in this case makes it to be the area burnt a year ago, 14 years ago and 24 years ago. Although the recently burnt area is not thick, steenbok could have been driven there by nutritious sprouts of shrub species like *Bauhinia petersiana*. Hare could have been utilizing the recently burnt area for food (short grass) and the areas burnt years ago for shelter.

Giraffe prefer open woodland to shrubby areas with different *Acacia* species (Apps, 2000). Giraffe could have been utilizing all the burnt areas for *Acacia ataxacantha* and *Acacia fleckii* to fulfill their diets. Buffalo prefers areas with sufficient edible grass and shade (Apps, 2000) and thus it should be a reason for utilizing the recently burnt area, for sufficient edible grass and the area burnt 14 years ago for sufficient shade.

Rhino and red hartebeest could have been using different latrines not close to areas when sampling was done. Overall findings show that herbivores switch between burnt and non-burnt this could be for shade, resting and ruminating in areas burnt long ago and for nutritious forage in the recently burnt area.

6.1.2. Grasses utilization

While fire and grazing affect ecosystem processes independently, the interaction between them may be more ecologically important than their independent effects. This interaction has been proposed as a single disturbance, pyric herbivory, defined as grazing driven by fire (Fulhendorf et al 2009 in Lunt 2011).

More grass utilization was identified in the recent burnt area and it appears to be governed by enhanced concentrations of macronutrients, increased digestibility and reduced concentration of acid detergent fibers. *Brachiaria nigropedata* decreases with the grazing and it was totally utilized (100% utilization) in the recently burnt area and more utilization in the area burnt a year ago compared to other two area burnt years ago. This can be because it is valuable, palatable

climax grass and favoured by game and livestock and it require fire to achieve its full potential (Muller, 2007).

100% total utilization of *Panicum kalaharese* in the recently burnt area can be because of *P. kalaharese* being a compact grass and only reasonably palatable in the young stages (Muller, 2007) which makes sense, because it have been utilized only in the recently burnt area and the area burnt a year ago and because that the tufts becomes woody with age, making it hard and unpalatable. Other valuable grass species utilized in the recently burnt area such as *Digitaria seriata*, *Triraphis schinzii*, *Stipagrostis uniplumis*, *Melinis repens* and *Aristida meridionalis* were also readily utilized and (Muller, 2007) indicates that they contributes mostly to good pastures in Namibia.

Unpalatable grass species with little forage and poorly utilization due to their hardness such as *Aristida stipitata*, *Eragrostis jeffreysii* and *Eragrostis pallens* were utilized and (Muller, 2007) indicates that they can be reasonably palatable in the young stages. This shows real value of fire in the recently burnt block and it shows that there is energy flow to the animals.

The reason there is nearly much utilization in areas burnt years back is because grasses are more palatable only at the beginning of the season; however, the palatability of the new growth will approach that of the new growth of grasses that were not burnt at the end of the first growing season, so then animals will feed anywhere. Palatability will deteriorate through the growing season hence allowing game to graze after the fire is important and impossible to stop in any case.

6.1.3 Shrubs utilization

Browsing, frictional pressures and fire are typical savanna disturbances that encourage heterogeneity at a variety of spatial and temporal scales, and promote species richness and diversity (Bakker and Olf, 2003; Cosyns *et al.*, 2006; Fuhlendorf and Engle, 2004; Hulme, 1996 in Lunt 2011).

There was more shrub utilization in the recently burnt area because of new growth after fire but other possibility is that the less utilized species, either in the recently burnt area or other areas burnt years ago less intensively due to the abundance of species that were relatively more palatable like *Grewia flavescens*, *Philenoptera nelsii*, *Combretum collinum*, *Grewia flava* and *Bauhinia petersiana* this may have been due to moderate levels of chemical and physical defence in plants.

Despite the fact that *Grewia spp* possess chemical defences, (Hooimeijer *et al.*, 2005; Maloiy and Clemens, 1999; Muya and Ogege, 2000 in Lunt 2011), *Grewia flavescens* and *Grewia flava* were well utilized.

Another reason that there is much utilization in the area burnt 24 years ago, compared to the area burnt 14 years and a year ago is that, the area burnt 24 years ago has rock outcrops. That means high nutrients in rocks are sometimes washed away or get lost through weathering process and then plants absorb them and make use of nutrients.

Since chemical defences were not quantified, the reasons for the selection cannot be clearly stated beyond assuming the presence of anti-feedants and toxins in species known to contain them (Watson and Dallwitz, 1992 onwards in Lunt 2011).

6.1.4. Decomposition/ disappearance rate

Buffalo dungs disappear directly with association of moist conditions. They get rolled by dung beetles as food sources in scarce times.



Figure 11 photos showing dung beetles rolling a dung balls

Dung beetles suck the moisture out of rhino dung heaps and leave a fibrous waste that stay for long, decompose into the soil and more important as a source of mulch or organic material.



Figure 12 photos showing dung beetles' sucking out moisture from fresh rhino dung and the fibrous waste left after moisture is sucked out.

Antelope pellets stays for longer and they don't decompose easily because of less moisture in it making it indigestible nor be washed away.



Figure 13 a photo showing typical antelope pellets

Moisture is often singled out as the main factor that influences persistence of mammalian fecal pellets, with higher moisture levels resulting in faster decay rates and shorter persistence times (Wigley and Johnson 1981, Harestad and Bunnell 1987, Prugh and Krebs 2004 in Lunt 2011).

7. CONCLUSIONS

This study has provided sufficient light on the interrelationship between fire, forage and herbivores' responses to the fire mediated resources at temporal and spatial levels in the landscape. The study has demonstrated fulfilment of the desire of fire management program under the Waterberg Plateau Park to supply nutritious forage to herbivores.

Parallel to that, the study has demonstrated presence of nutritious sprouts on burnt area thus why more dung counts and plants utilization compared to areas burnt years ago.

Both lessons are supposed to be motive and challenge, respectively, towards reaching a fire regime suitable to the ecosystem. Equally important, this study has shed new light on quantitative use of burnt and non-burnt grasslands and has shown the response of herbivores in the selection of areas differing in fire history.

On the whole, this study is summarized under four conclusions:

1. Fire changes the structure of grass, result which leads to support the expectation that herbivores could shift the preference between burnt and non-burnt patches along with the development of the grass.
2. Burning enhance plant sprouting, hence higher forage supply and quality on burnt than on non-burnt areas.

3. This research shows that fire is important in influencing mammal's utilisation of available resources, with a strong influence on site selection that drives the fire–herbivore interaction. This interaction is an ecosystem process that replaces fire and grazing as separate factors, shaping grassland landscapes. Inclusion of the fire–herbivore interaction into ecological studies and conservation practices of fire systems will aid in better understanding and managing.

4. Moisture is often singled out as the main factor that influences persistence of mammalian fecal pellets, with higher moisture levels resulting in faster decay rates and shorter persistence times. (Wigley and Johnson 1981, Harestad and Bunnell 1987, Prugh and Krebs 2004 in Lunt 2011).

8. RECOMMENDATIONS

1. I would recommend that the same study be repeated in another wet season to determine any differences in terms of species diversity, composition and distribution.

2. I would recommend that the same study be repeated in a dry season to determine any differences in terms of species diversity, composition and distribution.

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10. REFERENCES

1. Apps, P. (ed). 2000. *Smithers' Mammals of Southern Africa*. Struik Publishers (Pty) Ltd, Cape Town, South Africa.
2. Bailey, R. E. and Putman, R. J., (1981): Estimation of fallow deer (*Dama dama*) populations from fecal accumulation. *Journal of Applied Ecology*, 18:697-702.
3. Barnes, R.F.W. (2001). How reliable are dung counts for estimating elephant numbers. *African Journal of Ecology* 39:1-9.
4. Brinkman, J. T, Person, K. D., Chapin. F. S., Smith. W., Hundertmark, J. K., (2011): Estimating abundance of Sitka black- tailed deer using DNA from fecal pellets. *Journal of Wildlife Management*, 75(1):232-242.
5. Campbell, D., Swanson, G.M., Sales, J. (2004). Comparing the precision and cost effectiveness of fecal pellet group count methods. *Journal of Applied Ecology* 41: 11885-1196.
6. DeBano, L.F., Neary, D.G., & Folliott, P.F. (1998). *Fire's Effects on Ecosystems*. John Wiley and Sons, Inc. New York.
7. Du Preez, P. (ed). 2001. Management Plan for Waterberg Plateau Park. Final draft. Unpublished paper. Ministry of Environment and Tourism. Windhoek. Namibia.
8. Eco Impact Consultants. (2011). Waterberg Plateau Park Management and Tourism Development Plan. Ministry of Environment and Tourism, Windhoek, Namibia
9. Erb, K. P. (1993). The Roan Antelope (*Hippotragus equinus*, Desmarest 1804), its ecology in the Waterberg Plateau Park. MSc. Thesis, University of Stellenbosch, South Africa. Unpublished.
10. Erckie, J. B. (2007). Assessing the effects of grazing intensity by large herbivores on species diversity and abundance of small mammals at Waterberg Plateau Park, Namibia. MSc. Thesis, University of Namibia, Windhoek. Unpublished.
11. Joubert, D.F., Smit, G.N., & Hoffman, M.T. (2012). The role of fire in preventing transitions from a grass dominated state to a bush thickened state in arid savannahs. *Journal of Arid Environments*, 87: 1-7.
12. Lunt, N. (2011), The role of small antelope in ecosystem functioning in the Matombo Hills, Zimbabwe. PhD. Thesis, Rhodes University. South Africa. Unpublished.
13. Mannheimer, C.A., & Curtis, B.A. (Eds) 2009. *Le Roux and Muller's Field guide to the Trees and Shrubs of Namibia*. Windhoek: Macmillan Education Namibia.
14. Muller, M. A. N. (Eds) 2007. *Grasses of Namibia*. Windhoek, Namibia, Ministry of Agriculture, Water and Forestry.

15. Mukaru, W.C. (2009). Impacts of large herbivores on vegetation and soils around water points in Waterberg Plateau Park, central Namibia. MSc. Thesis, University of Namibia and Humboldt University in Berlin. Unpublished.
16. Oktay, Y., Derya, E., Murat, S & Bulent, T. (2009). Effects of forest fire on soil nutrients in Turkish pine (*Pinus brutia*, Ten) Ecosystems. *Journal of Environmental Biology*
17. Schneider, I. (1993). *Waterberg Plateau Park*. Shell Namibia.
18. Snyder, J.R. (1986). The impact of wet and dry season prescribed fire on Miami rock ridge Pineland. Report SFRC 86/06. Everglades national Park: South Florida Research Center.
19. Tainton, N. M., (Eds) 1999. *Veld Management in South Africa*. University Of Natal Press: Pietermaritzburg
20. Thalwitzer, S., Joubert, D., Johann, L., Alberts, M., & Förtsch, M. (2011). Waterberg Plateau Park Management and Tourism Development Plan. Unpublished paper. Ministry of Environment and Tourism. Windhoek. Namibia
21. Web references
www.sasscal.org Accessed on 15 July 2014.

Appendix 2 Utilization sheet

Transect Zone	Grass	Utilization	Shrub	Utilization	Weed	Utilization
	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
40 m	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
60 m	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
80 m	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
100 m	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
120 m	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
140 m	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
160 m	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
180 m	1.		1.		1.	
	2.		2.		2.	
	3.		3.		3.	
	4.		4.		4.	
200 m	1.		1.		1.	
	2.		2.		2.	

