

## A REPORT SUBMITTED TO RUFFORD SMALL GRANT 2016



### **FIRE AND HERBIVORY IMPACTS SAVANNA VEGETATION: UNDERSTANDING THE FIRE, HERBIVORE AND WOODLAND COMMUNITY INTERPLAY IN ONE OF NIGERIA'S FOREMOST GAME RESERVES**

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**August, 2016**

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## Summary of Activities

- A study was carried out to deepen our understanding of the effects of fire and elephant herbivory on the feeding ecology of other herbivores at the Yankari Game Reserve, Nigeria.
- Preference by large herbivores inhabiting the various woodlands of the reserve including dietary shift with seasons and fire regime was also studied
- Yankari Game Reserve is located in Bauchi State, North Eastern region (along geo-political zone) of Nigeria, West Africa.
- Line transect as described by Bibby *et al.* 2000 was used to record feeding herds of large herbivores to determine aspects of their tree food and food ecology.
- Ten transects of 1000 m in length were randomly located in a mapped woodland located with GPS by marking the start and end of transects. The transects were used in order to generate data on tree species browsed by herbivores.

## Summary of Key Findings

- Large herbivore fed almost exclusively on grasses than on trees or shrubs at the Yankari Game Reserve.
- Large herbivores fed on grasses in both dry and wet seasons. They however fed more on early fire regime areas compared with late.
- More animals were recorded in the combretum woodland compared with other woodland types. The study revealed that the combretum woodland is a critical woodland type for habitation and feeding ecology for most large herbivores.
- Effects of fire and browsing by elephant herbivory did not affect other large herbivore's food within the reserve.

## 1.0 Background

Ecosystems are shrinking at an alarming rate, wildlife is disappearing without significant mitigation measures, and man is the most culpable for it. There is a growing trend in the extent to which ecological systems are experiencing anthropogenic activities and change in function and structure, this phenomenon is critical to the long term sustainable conservation of biological diversity.

Ecosystems such as Savanna woodlands play considerable role in maintaining the integrity of biological diversity across the globe. Savannas are tropical ecosystems made up of grasslands with scattered trees, occupying 20% of the land surface on earth, 40% percent of Africa and 60% of sub-Saharan Africa (Canterbury *et al.*, 2000) with rich and fascinating wildlife. The savanna is also characterized by vegetation cover determined to a large degree by disturbances from fire and herbivory compared with rainfall and soil resources.

Fire acts to limit tree cover through demographic bottleneck, limiting the recruitment of tree seedlings to adulthood. Intense fires cause direct decline in the cover of woody vegetation by killing trees or reducing them to smaller sized classes, while herbivores reduce woody vegetation in which trees are either killed or reduced in size (Dublin *et al.*, 1990; Andy, 1993; Dublin, 1995 and van Langevelde *et al.*, 2003; Baxter and Getz, 2005). Many, particularly large herbivores are adversely affected by the reduction in cover and the quality of browse with elephants having most profound effects. Vegetation modification from woodland to grassland have most often been attributed to the joint action of elephants and fire (Napier and Sheldrick, 1963; Lawton and Gough, 1970; Barnes, 1983b; Pellew, 1983 and Leuthold, 1996). While elephants can impact large or small trees, fire normally acts to suppress re-establishment of the damaged plants to reproductive heights (Guy, 1981; Trollope *et al.*, 1998; Jacobs & Biggs, 2002a), often acting in conjunction with other browsers (Pellew, 1983; Ruess and Halter, 1990; Jacobs and Biggs, 2002a).

The Yankari Game Reserve is one of the richest in biodiversity and most popular destination for tourists in Nigeria, and as such, plays a crucial role in the development and promotion of ecotourism in Nigeria. Therefore, any effort aimed at boosting research with the view to

effective and sustainable management of the reserve cannot be overemphasized and should be supported by all and sundry. The reserve management gives priority to operational research. This study is cardinal to the sustainability of the biodiversity of the game reserve given that, it is geared towards investigating the fate of the ecosystem at the prevailing circumstances.

### **1.1 Justification**

This project emanates from curious observation on the population dynamics of mammals and primates of the Yankari Game Reserve where the trees supposedly utilized as food by the animals are set on fire indiscriminately. The fire regime seems to be carried out haphazardly, without any specific patterns. A good number of the tree species in the reserve were observed to be dead, wounded or retarded from the adverse effect of the fire. The first and the second Rufford Small Grant addressed part of this concern raised but left more to be desired. This thought provoking area of biodiversity conservation led to interest in studying the effects of fire and elephant herbivory on tree food and food ecology of large herbivores at the Yankari Game Reserve, Nigeria.

### **1.2 Aim**

The aim of this project is to determine the impact of fire and herbivory on woody plants (tree species) as food vis-à-vis the seasonal distribution and dietary shifts of herbivores in the savanna woodland system of the Yankari Game Reserve, Nigeria.

### **1.3 Objectives**

This research project set out to achieve the following objectives:

1. To determine food and dietary shifts of large herbivores that feed on tree species caused by seasonal changes, fire regimes and elephant herbivory. This will add to our understanding of the food resources that specific large herbivores fed on during the dry and wet seasons and before and after fire regimes.
2. To determine how large herbivores are distributed across various woodlands of the game reserve.

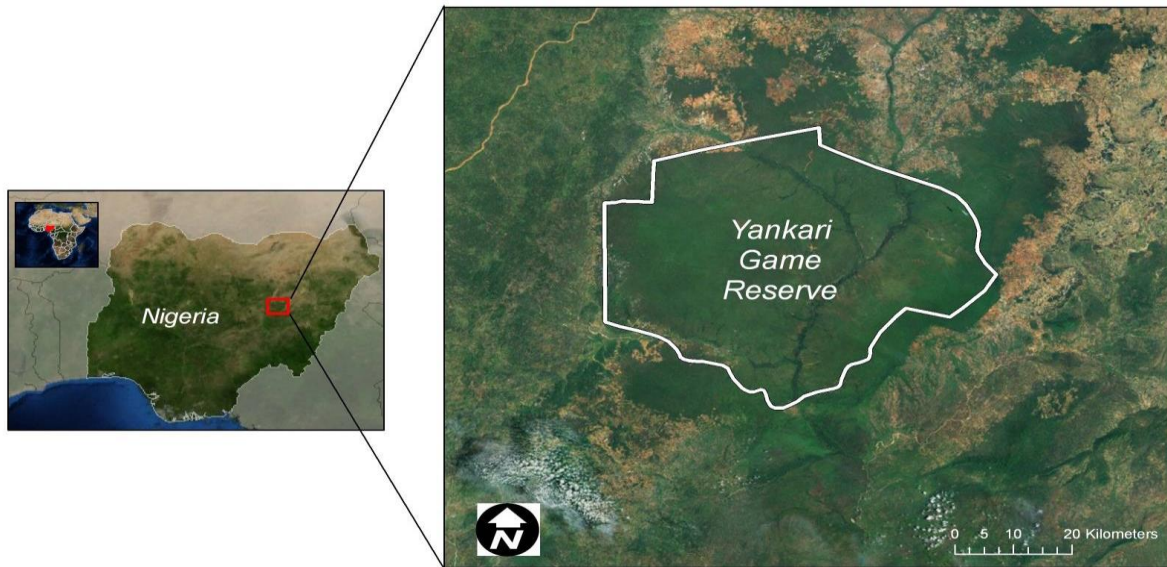
3. To determine the extent to how fire and elephant herbivory affects tree species that are food for specific large herbivores.
4. To persuade the management of the Yankari Game Reserve and other stakeholders to take a more pragmatic measure towards protecting the ecosystem.

## 2.0 METHODS

### 2.1 Study Area

This study was carried out at the Yankari Game Reserve (9°45'N 10°30'E), 100 km South east of Bauchi town in Bauchi state. The reserve covers a total area of 2,244 km<sup>2</sup>, in the east-central part of Nigeria. The reserve records an average rainfall of about 1000 mm per year, which occurs between April and October (Crick and Marshall, 1981). Yankari Game Reserve lies within the Sudan Savanna Zone (Geerling, 1973) of Nigeria with a vegetation made up of swampy flood plain bordered by patches of forest, gallery forest and riparian forest, woodland Savanna (Crick and Marshall, 1981). The Game Reserve was designated and opened as Nigeria's biggest National Park in 1991 (but is now a game reserve). It is the most popular destination for tourists in Nigeria and, as such, plays a crucial role in the development and promotion of ecotourism in Nigeria (Odunlami, 2000). The Reserve is bisected by the River Gaji. Common woodland tree species include *Afzelia africana*, *Burkea africana*, *Pterocarpus erinaceus*, *Isobertina doka*, *Monotes keatingii*, *Combretum glutinosum*, *Detarium microcarpum* and *Anogeissus leiocarpus*. *Gardenia aqualla* and *Dischrostachis glomerata* are frequent in the shrub layer, while *Hyparrhenia involucrate* and *H. bagirmica* are the dominant grasses. In riparian forest *Khaya senegalensis*, *Vitex doniana*, *Acacia sieberiana*, *Tamarindus indica*, *Borassus aethiopium* and *Daniella oliveri* are common. Characteristics of Yankari are large monodominant stands of *Pteleopsis habeensis*, which grow in some drier areas along riverbanks, the only place in the country where such stands occur. In the seasonally flooded fadamas, *Ficus* spp. and *Mitragyna* sp. are the dominant trees, while tangles of *Mimosa pigra* dominate the shrub stratum. About 337 species of birds have been recorded (Ezealor, 2002). Of these, 130 are resident, 50 are palearctic migrants and the rest are intra-African migrants that move locally within Nigeria and/or Africa. The birds in the reserve include the Saddle-billed Stork (*Ephippiorhynchus senegalensis*), Martial Eagle (*Polemaetus bellicosus*), Abyssinina Ground Hornbill (*Bucorvus abyssinicus*), Narina's Trogon (*Apaloderma narina*) among others (Olokesusi, 1990).

## Location of Yankari Game Reserve in Bauchi State, Eastern Nigeria



**Figure 1. Map of Yankari Game Reserve, Bauchi State, Nigeria.**

### 2.2 Game Reserve Mapping

The reserve was first mapped out to identify the various woodlands types. A Global Position System (GPS) device was used to map the locations of woodlands in the game reserve. Mapping of the game reserve was carried out to help in identification of the different woodland types as well as herbivore preferences.

### 2.3 Line Transects

Line transects was used to record large herbivores browsing as herds or as individuals. Ten transects of 1000 m in length was randomly located in a mapped woodland location using GPS by marking the start and end of transects. Transects were used in order to generate data on tree species browsed by herbivores. When foraging herds or individuals were located in a particular woodland type, the following variables were recorded: tree species, size classes of trees browsed base on height and DBH, season, and fire regime. Five herbivores including; Roan



Antelope *Hippotragus equinus*, Bushbuck *Tragelaphus sylvaticus*, Waterbuck *Kobus defassa*, Western Hartebeest *Alcelaphus buselaphus*, and African Buffalo *Syncerus caffer* were selected for this study. These large herbivores were selected because their relative rate of encounter is higher than other herbivores (Adeiza, 2008). While on transect visit, feeding individuals or herds of any of the herbivores were recorded in order to identify species of trees utilized by the herbivores. All transects were visited during the dry and wet seasons in 2015 and 2016. Data for the wet season field session run from May 2015 to October 2015 and that of the dry season run from November 2015 to April 2016.

#### **2.4 Data Analyses**

All data analysis was carried out using SPSS, R-statistics and Arch View. The software was used to produce figures and statistical analyses. Findings from this project has been incorporated with elements of the first and second RSGs and presented to the Management and Staff of the Yankari Game Reserve for implementation.

### 3.0 RESULTS

#### 3.1 Tree Species Browse by Large Herbivores at Different Seasons and Fire Regimes.

There was significantly more large herbivores that fed on grasses than on trees during the wet and dry season (Mann-Whitney U-test;  $Z=-4.72$ ,  $N=32$ ,  $P=0.001$ ). This study showed that large herbivore at the Yankari Game Reserve fed on grasses almost exclusively than on tree species (Figure 2). Herbivore fed more on grasses during the dry and wet season. It was observed however that some herbivore fed on some few tree species during the early wet season when new leaves are being produced. Herbivores fed on newly sprouted grasses during the dry season and do so even more during the wet season as many grass species have grown. The grass species fed by the herbivores were mainly *Andropogon* and *Pennisetum* species (Plate 1).

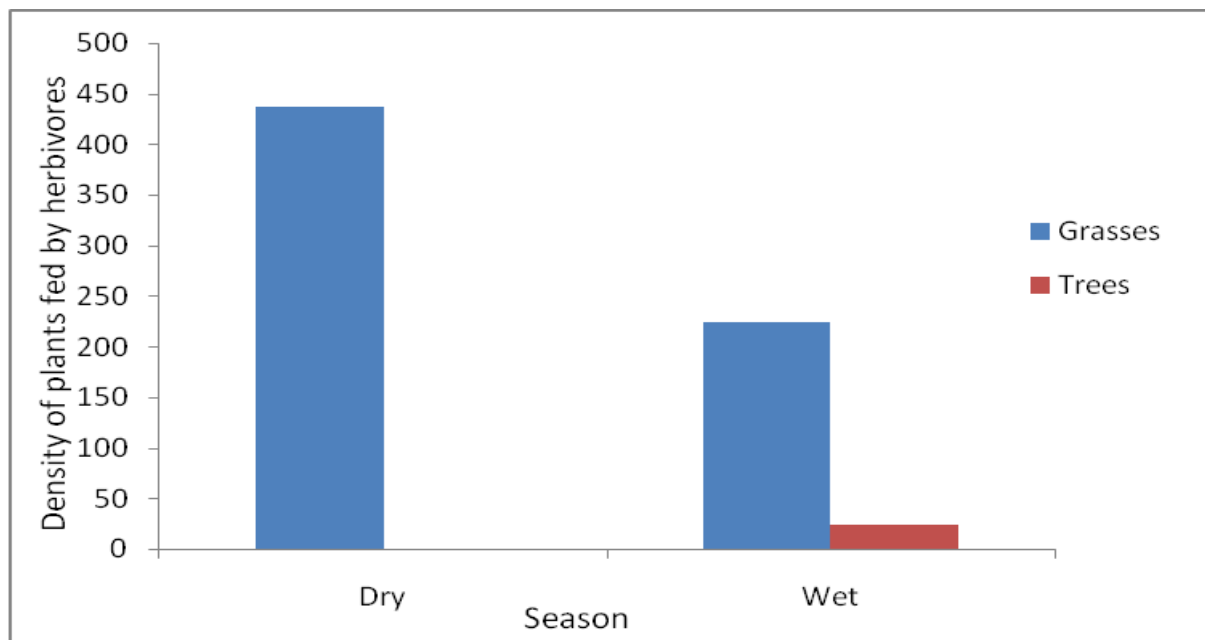
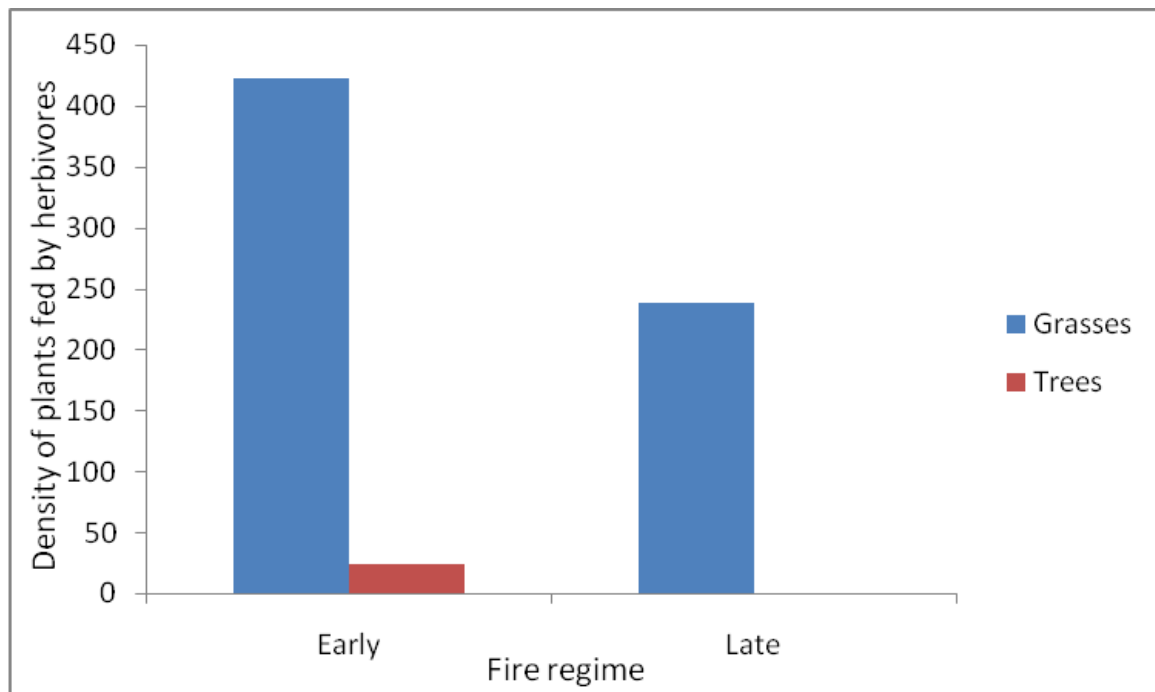


Figure 2. Density of plants fed by herbivores in relation to season



**Plate 1. *Andropogon* spp is a species of grass commonly fed by large herbivores at the Yankari Game Reserve.**

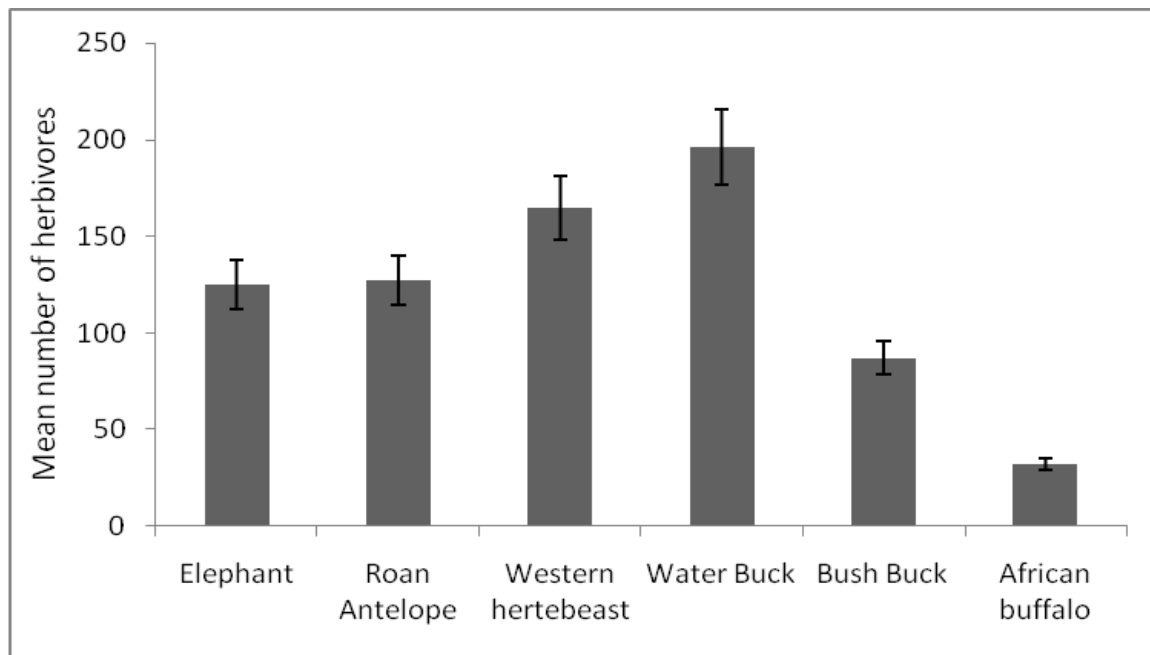
In respect to fire regime, although, there was no significant difference in herbivores' grazing between early and late fire regimes, (Mann-Whitney U-test;  $Z=-1.14$ ,  $N=94$ ,  $P=0.271$ ) data shows that more herbivores fed on grasses in areas with early burn compared with late burn. Few tree species were also browsed by herbivore in early burn areas with none recorded in late burn (Figure 3). It was generally observed that early burn areas in the reserve had more grasses sprouting compared with late burn fire regime.



**Figure 3. Density of plants fed by herbivores in relation to fire regime**

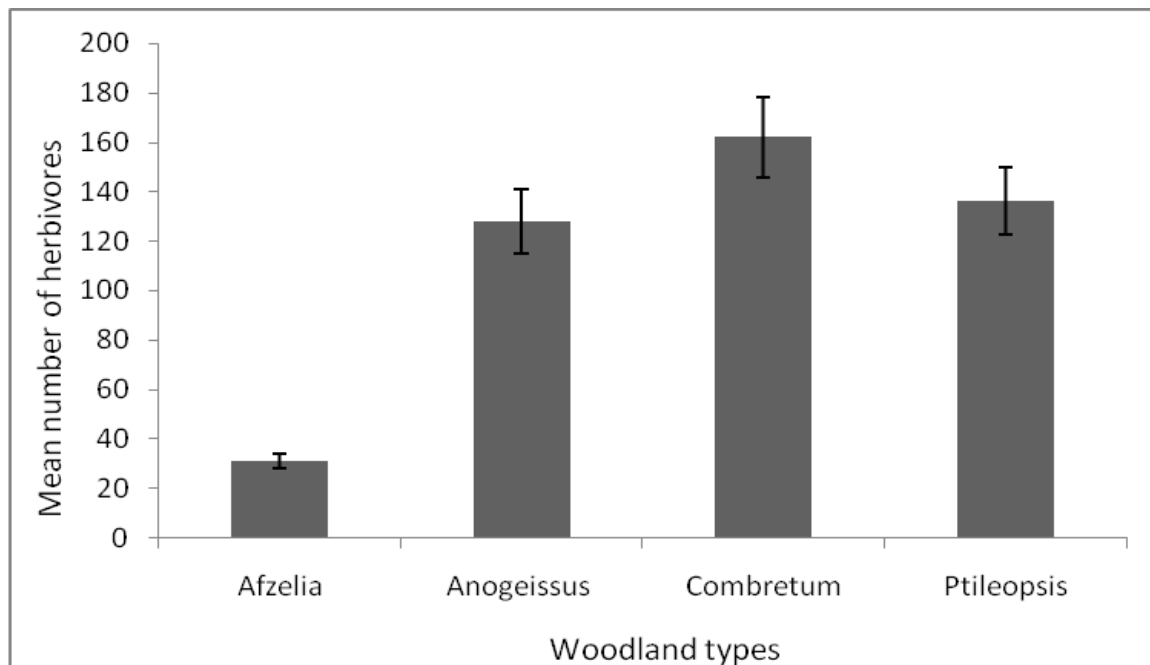
### **3.2 Distribution of Large Herbivores across Various Woodlands**

There was a significant difference in the mean number of herbivores recorded in the Yankari Game Reserve (Mann-Whitney U-test;  $Z=-3.14$ ,  $N=94$ ,  $P=0.002$ ). Generally, Water Buck, Western Hartebeest, and Roan Antelope constitute the highest number of large herbivores recorded during this study. The least of herbivores recorded include Elephants and African Buffaloes. It was observed that fewer elephants and elephant activities were noted in the game reserve compared with encounters during the first and second RSG research (Figure 4).



**Figure 4. Mean number of herbivores recorded.**

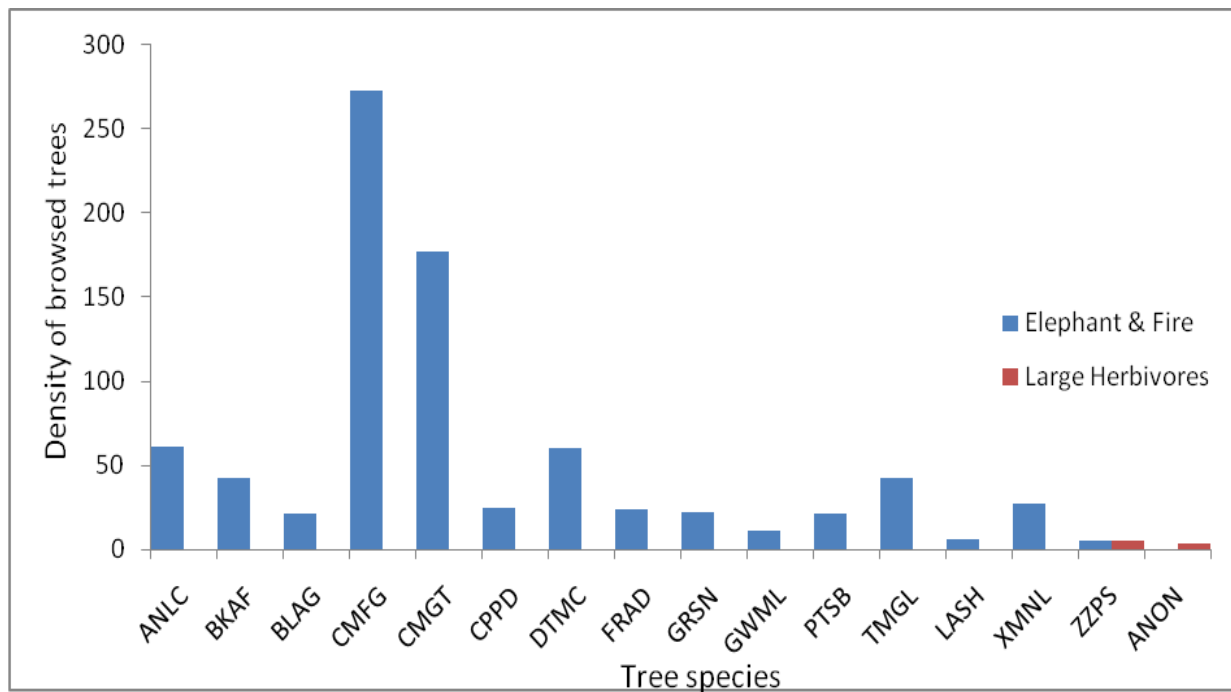
In terms of herbivores distribution according to woodland types. There were four major woodland types identified at the Yankari Game Reserves by which herbivores were recorded. These woodlands include Combretum, Pteleopsis, Anogiusus and Afzelia woodland types. There was a significant difference in the mean number of large herbivores recorded across the woodlands types in the game reserve (kruskal Wallis;  $t=7.65$ ,  $df=3$ ,  $P=0.54$ ). Higher number of herbivores were recorded in the combretum woodland types. From records, combretum woodland is widely distributed at the Yankari Game Reserves compared with other woodland types. Next to combretum woodland types is Pteleopsis and Anogiesus. The least woodland that recorded fewer herbivores was the Afzelia woodland type (Figure 5).



**Figure 5. Mean number of herbivores recorded in the different woodland types.**

### **3.3 How Fire and Elephant Herbivory Affects Tree Species that are Food for Large Herbivores.**

A comparison of tree species browsed by elephants which is also affected by fire regimes during the second RSG report with what other large herbivores browsed on in this study showed that only *Zizyphus* overlaps. This means that *Zizyphus* was browsed by elephants and affected by fire which is also fed by large herbivores. It is worth mentioning that only bush buck was sighted feeding on *Annona senegalensis*, this is an additional woody plant in the list of herbivores plant diet which was not earlier documented by the first and second RSG report (Figure 6) at the Yankari Game Reserve.



**Figure 6. Density of tree species frequently browsed by elephants and affected by fire (blue bars) vis a vis browsing by other large herbivores (red bars).** *Anogeissus leiocarpus* (ANLC), *Burkea africana* (BKAF), *Balanites aegyptiaca* (BLAG), *Combretum fragrans* (CMFG), *Combretum glutinosum* (CMGT) *Commiphora pendunculata* (CPPD), *Detarium microcarpum* (DTMC), *Feretia apodanthera* (FRAD), *Grewia erubescens* (GRSN), *Grewia mollis* (GWML), *Pteleopsis suberosa* (PTSB), *Taminalia glaucescens* (TMGL) and *Annona* (ANON).

## 4.0 DISCUSSION AND CONCLUSION

The savannas ecosystem, particularly the African savannas contain the world's largest diversity of wild ungulates, and also constitute a critical resource for the ever growing human population. This fragile and important ecosystem is at the risk of disturbance arisen from an uninformed and evidence based scientific research that may lead to a copious loss of the ecosystem, the services it provides and the rich biodiversity inherent (Cech, 2008). Fires and herbivory are synonymous and common features of most African savannas (Lawton and Gough 1970, Liedloff 2001, Gandiwa 2011) including Nigeria.

### 4.1 Tree Species Browse by Large Herbivores at Different Seasons and Fire Regimes.

This study in comparison to previous RSG reports (Turshak, 2010 and Turshak, 2013) shows that herbivores have dramatically shifted from browsing on different tree species to feeding almost exclusively on grasses. Observation in the game reserve revealed that fewer large herbivores were recorded compared with previous data. This revelation may have informed shift of herbivores from browsing trees to grazing for both seasons and fire regimes. This could be so as fewer animal species in a large area with such a diverse food resource will select whatever food they require at will (Geerling, 1973; Ezealor, 2002). Herbivores were observed feeding on grasses during both dry and wet seasons. In the dry season, they feed more on sprouting grasses in areas that was burnt earlier than later. This is expected as early fire regime could afford the grasses the opportunity to grow faster than late regime. Herbivores even when they browsed tree species, they do so on new tree shoot and leaves rather than the old. Some studies have shown that where there is available food resources, animals will choose the best food option and leave out the alternate this is also shown in the ideal despotic model (Begon *et al.*, 2003).



#### 4.2 Distribution of Large Herbivores across Various Woodlands

There was a significant difference in the mean population of the large herbivores in the game reserve, although a general decline in number of some herbivores were observed during the study. For example, it was observed in particular that fewer elephants and elephant activities were noted in the game reserve compared with encounters during the first and second RSG research. It is not clear as to why elephants population have suddenly been desimated but preliminary unfounded reports showed that a corridor exist where mass exodus of animals to a Cameronian reserve was speculated. Again, its was observed that few herdsmen were grazing cows in parts of the reserves, particularly at the fringes boadering commuties. This could scare herbivores to hiding in difficult terrains where accessibilty is difficult and so result in underreporting of actual herbivore numberpresent. Bush buck and Western Hertebeast were the frequently recorded ungulates within the reserve as seen in the result above, however, most sightings were noted in or near the camp where animals were probably safer.

Although many herbivore browsed fewer trees compared with grases, Combretum woodland recorded more herbivores than other woodland types. It is worth noting that in the second RSG report, fire affected the combretum woodland much more than other woodlands, this is an indication that the habitat of large herbivores may be threatened, since they spend more time grazing in this woodland type. The two most common tree species recorded as browsed by elephants and other herbivores are *Combretum fragrans* and *Combretum glutinosum* which happens to be the woody plants affected by fire. A nagative trend observed during field work showed that herdsmen intruding the reserved cut down branches and trunks of *Afzelia africana* for their livestock which are cows, sheep and donkeys in some cases. This tree species is rich in nutrient for cows and other livestock. In a particular occasion during field work, some donkeys were recorded straying inside the park although no in the most interior part of the reserve. This activity is unhealthy for the sustainability of the reserves as this may introduce diseases to the wildlife rich game reserve.

### **4.3 Effects of Fire and Elephant Herbivory on Tree Species that are Food for Large Herbivores**

Base on the finding that large herbivores fed almost exclusively on grasses, effects of fire and elephant herbivory is not significant to specific large herbivores. Only *Ziziphus* was shown to be affected by fire regime and elephant herbivory.

Large herbivores have probably adjusted their feeding habit to grazing due to change in the population and activities of elephants. In previous RSG supported studies (Turshak, 2010 and Turshak, 2013), elephant population was higher and therefore higher activities such as their movement from one place to the other have caused trampling effects on trees, shrubs and grasses. In this study however, these activities have drastically reduced which perhaps enabled large herbivores to freely feed on plant and vegetation materials of their choice. In addition to this, it is known that dramatic reduction in the population of elephants and other herbivores can lead to a corresponding increase in the amount of grasses (Dublin *et al.*, 1990; Dublin 1995; van Langevelde *et al.*, 2003), this is so because the absence of elephants could encourage intense fire, a phenomenon that can trigger the growth of grasses. Fire is known to break the dormancy of some plants to enable them germinate and grow given the right conditions (van Langevelde *et al.*, 2003; Bond & Keeley, 2005; Beerling & Osborne, 2006). It is important to states that the interactive effect of fire and herbivory have a significant impact on the woody and grass biomass in the ecosystems. These effects centre on the interface between fuel load (grass biomass) and fire intensity. Changes in the level of browsing and grazing may influence this positive feedback, in which a change in grass biomass leads to a change in fuel load. An increase in grass biomass leads to more intense fires and more damage to trees, consequently allowing grass biomass to increase (van Langevelde *et al.*, 2003). Late fire regime has been shown to cause intense fire on the woody plants particularly in the savanna woodland compared with the riparian and gallery forest.

### **4.4 Recommendations and Conservation Action Plan**

In view of the findings obtained from this study, the following conservation action plans are recommended for implementation:

- i. Since the Yankari Game Reserve is largely comprise of combretum woodland and because more herbivores were recorded in this woodland, it is important to ensure that the earlier recommendations on fire return interval of between three and four years in the second RSG report (Turshak 2013) be implemented to avoid severe effects of fire on this peculiar woodland type. It is worth noting that all the large herbivores were recorded in this woodland type inspite of the presence of riparian and gallery forests.
- ii. It is not clear why elephants populations have drastically reduced compared with numbers recorded during the first and second RSG report. It is therefore recorded that a population census be conducted to ascertain not only the population of elephants and other herbivore, it will be useful to study the immediate and remote causes of this decline. A serious attention must be given to patrolling the reserve. Intensifying efforts at patrol will help to ward off illegal activities including illegal fire in the reserve.
- iii. An educational awareness campaign should be organised for the adjoining communities of the game reserve. This is to inform them of the negative implication of indiscriminate setting of fires. Setting up a site support group in the adjoining communitéis may help to put a watchfull eye on illegal activities in the reserve. The importance of local community conservation support group can not be overemphasised.

#### **4.5 Further Study**

- i. A study to determine the population density of the large herbivores and the immediate and remote causes of general decline in some of the ungulates should be conducted to help in effective conservation of this important ecosystem
- ii. A study on the population and effects of fire and herbivory on woody plants that are utilized by primates for food and shelter.
- iii. A conservation education advocacy to the adjourning communities to the Yankari Game Reserve is critical to establishing a site support group for effective conservation of this important system cannot be over emphasised. Establishment of site support group will help to give a sense of responsibility and belonging to the adjourning communities considering the direct and indirect benefit of the reserve to their community members.

- iv. It may be interesting to study the different macro or micro woodlands within the reserve to determine their role in nutrient cycling as it affects the large herbivores and other animal taxa.

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## 6.0 APPENDICES

### Appendix 1. Checklist of tree species commonly utilize by large herbivores at the Yankari Game Reserve

S/N	Tree species	Tree Species Code	Average Height	DBH (cm)	Density per 20 x 20 m plot
1	<i>Afzelia Africana</i>	AFAF	6	70	8
2	<i>Anogeissus leiocarpus</i>	ANLC	6	33	112
3	<i>Burkea africana</i>	BKAF	5	31	84
4	<i>Balanites aegyptiaca</i>	BLAG	6	48	22
5	<i>Bombax costatum</i>	BMCS	8	60	7
6	<i>Boscia salicifolia</i>	BSSL	3	21	12
7	<i>Combretum fragrans</i>	CMFG	4	18	1070
8	<i>Combretum glutinosum</i>	CMGT	4	18	328
9	<i>combretum molle</i>	CMML	4	28	6
10	<i>Commiphora pendunculata</i>	CPPD	5	30	49
11	<i>Croton zambezicus</i>	CTZB	2	7	2
12	<i>Detarium microcarpum</i>	DTMC	3	19	131
13	<i>Feretia apodanthera</i>	FRAD	3	10	58
14	<i>Grewia erubescens</i>	GRSN	3	9	24
15	<i>Grewia mollis</i>	GWML	8	11	23
16	<i>Guira senegalensis</i>	HXMN	5	26	14
17	<i>Hymenocardia acida</i>	HYAC	5	11	10
18	<i>Lannea schimperi</i>	LASH	6	52	13
19	<i>Phyllanthus muellerianus</i>	PHML	3	15	3
20	<i>Pericopsis laxiflora</i>	PRLX	3	13	1
21	<i>Pterocarpus erinaceus</i>	PTER	5	33	14
22	<i>Pteleopsis suberosa</i>	PTSB	3	13	62
23	<i>Strychnos innocua</i>	STIN	4	24	2
24	<i>Strychnos spinosa</i>	STSP	2	11	1
25	<i>Sterculia satigera</i>	STST	4	23	6
26	<i>Swarzia madagascariensis</i>	SWMG	4	20	18
27	<i>Taminalia avicennoides</i>	TMAV	4	23	7



28	<i>Taminalia glaucescens</i>	TMGL	5	24	83
29	<i>Ximenia americana</i>	XMAM	3	20	8
30	<i>Xeromphuis nilotica</i>	XMNL	5	21	4

### **Acknowledgement**

I sincerely thank Rufford Small Grant Foundation for funding this project. I appreciate the management and staff of Yankari Game Reserve in collaboration with University of Jos, A P Leventis Ornithological Research Institute, Nigeria for their support at one point or the other. I also like to extend my special appreciation to Naziru Zakare for his valuable assistance during data collection and arrangement of logistics. I appreciate Mrs Julcit Turshak for her inputs to this report.

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