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Fire and its implication on trees and tree species utilize by birds for nesting in the savanna woodlands of Yankari Game Reserve, Nigeria.

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Summary of activities

- Fire and its implication on trees and tree species utilized by birds for nesting in Yankari Game Reserve were investigated.
- 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 employed. Vegetation variables (habitat variables) were measured along a 1000 m transects.
- A total of 90 transects were established and visited in the savanna woodlands.

Summary of key findings

- Fire generally had negative effects on woody plants in the Yankari Game Reserve. More woody plants were affected during the late burning regime than the early regime.
- The results also showed that higher density of death and stunted trees were recorded in a burnt area compared with an unburnt area of the reserve.
- Breeding birds have well learnt to adapt to the fire regime practiced in the reserve. There was more bird nest in the burnt area of the reserve than the unburnt area.
- The *Combretum glutinosum* was adversely affected by fire compared with other woody plants. Similarly, more bird-nests were recorded in the *Combretum glutinosum* compared with other woody plants.

Acknowledgement

This project was generously funded by the Rufford Small Grant Foundation; I appreciate your laudable contribution to the conservation of nature and indeed a suitable planet for us all. With gratitude, I appreciate Mr Samson Da'an for being a formidable team member particularly during the field work of this project. I also appreciate my colleagues at the APLORI Yankari Game Reserve station, notably; Onoja Joseph, Yankasta and Talatu Tende. It is great experience working with you. I also appreciate the A.P. Leventis Ornithological Research Institute (APLORI) for providing logistic support during the field work, and Yankari Game Reserve Management and staff for availing me the 'biodiversity lab' to carry out this research. Thank you Dr. Will Cresswell, Dr. Ulf Ottosson and Prof. Jan-Ake Nilsson and Dr. Manu Shiiwua for the support and confidence you repose in me. I acknowledge with gratitude the moral support of my wife Julcit Turshak, Dr. Georgina Mwansat and Dr. Adams Chaskda.

1.0 Introduction

Background information

Determining the extent to which ecological systems are experiencing anthropogenic disturbance and change in structure and function is critical for the long-term conservation of biological diversity (Canterbury *et al.* 2000, Eriksen 2007).

The phenomenon of fire and vegetation has evolved a long time ago. Due to man, fire has assumed an important dimension compared with other climatic variables in shaping the composition, biomass, structure and distribution of plant communities, including animal populations dependent on them (Eriksen 2007), particularly in the savanna system (NCF and WWF 1987). Fire occurs mainly in the dry season at different times of the year in different parts of the world. It can occur at the beginning, middle or end of the dry season with markedly different ecological effects. The ecological effects of fire vary enormously according to the time of year, the quantity, condition and distribution of the fuel, the prevailing climatic conditions, the severity and intensity of the fire, the slope aspect and elevation, the vegetation and soil type (Kimmins 1997).

Early dry season fires are rarely hot, and quantities of unburned grass stubble are left standing. This will not support another fire in the same dry season. Early season fires are not a danger to the woody plants, however, they are detrimental to perennial grasses (Rose Innes, 1971, NCF and WWF 1987). When they are still partially green, they have not completed transferring their food reserves from leave to storage in the roots. Burning these perennial grasses will results to lose of their food reserves. If there is enough, moisture in the soil to induce them to sprout again, it is at the expense of partially replenished root reserves and further stress is put on the grasses if they are grazed. Continual treatment of this sort year after year will results in eventual death of the perennial grasses (Rose Innes, 1971, NCF and WWF 1987).

Late season fires are not harmful to the perennial grasses because they do not sprout until after the rains have begun. But woody plants often sprout long before the first rains. The newly sprouted shoots are susceptible to burning at this season. Late season burns are extremely hot,

damaging tree trunks and branches and the soil is exposed to isolation and erosion (Rose Innes 1971, NCF and WWF 1987).

Fire selection exerts an influence on the distribution of savanna trees. Some species possess protective coverings of thick bark or reproduce vegetative by suckers from shallow root systems (NCF and WWF 1987).

Fire can be used as management tool in the Sudan and Guinea savanna zones. Annual fires set early in the growing season after the first rains, with trees sprouting but grass still dormant, will result in more open grassland after a few years, as woody plants are killed off. This may be good for grazing species, but harmful to perennial grasses if done on a yearly basis (NCF and WWF 1987).

Project Justification

This project evolved as a result of observation during a study of mammals and primates of the Yankari Game Reserve where the whole reserve is burnt. The fire regime seems to be carried out haphazardly. The fires are set between November and February of every year. A good number of the tree species in the reserve were observed to be death or having scars from the adverse effect of the fire. These trees were visibly wounded or stunted in their growths. Few bird nests have been recorded in the reserve that stimulates an interest of whether or not the fire interferes with their breeding activities through damage to their nests. No study has considered the impact of the fire regimes to the tree species and its impact on bird nest.

The aim of this project is to investigate the effects of fire on trees and tree species utilise by birds for nesting, and to present the findings of the research to the managers of the reserve with the view to re-assessing the fire regime currently being employed.

Objectives

1. To assess the impact of fire on tree species (woody plants) in the reserve
2. To assess the impact of fire on bird nests in the reserve
3. To assess the impact of fire on some floristic components of the reserve

2.0 Methods

Study site

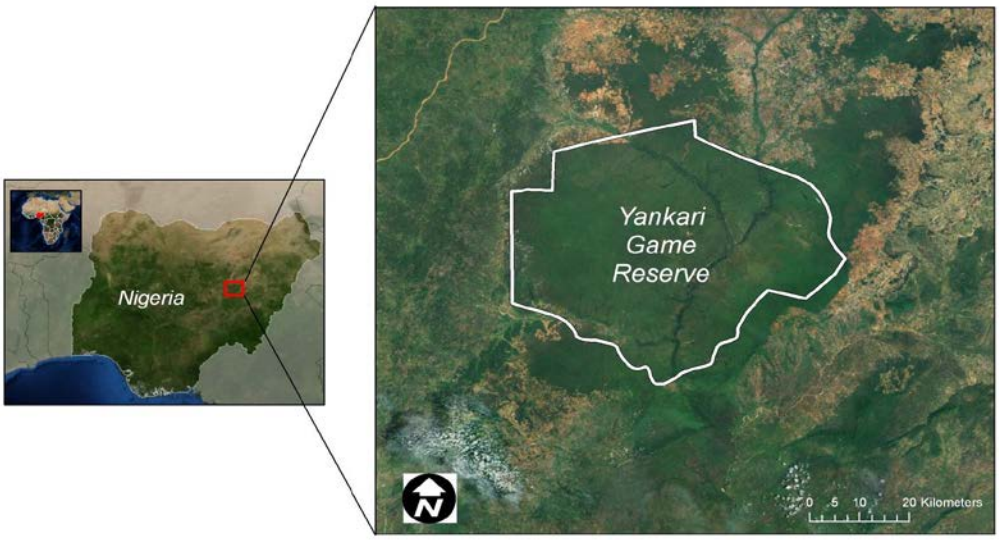

Figure 1. Map of Nigeria showing the Yankari Game Reserve

This work was carried out in Yankari Game Reserve (9°45'N 10°30'E), 100 km south east of Bauchi town in Bauchi state, Nigeria. The reserve covers a total area of 2,244 km², in the east-central part of Nigeria. The reserve records an average annual rainfall of about 900 to 1000 mm, which occurs between April and October (Crick and Marshall 1981). The peak of the rain fall generally occurs in August. Prevailing winds are from the south west and temperatures are moderate (18°C to 33°C) during the wet season (NCF and WWF 1987).

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). Yankari was designated and opened as Nigeria's biggest National Park in 1991 (but is now a game reserve). Yankari Game Reserve is the most popular destination for tourists in Nigeria and therefore plays a crucial role

in the development and promotion of ecotourism in Nigeria (Odunlami 2000). The Reserve is bisected by the River Gaji (see Figure 1). Some common woodland tree species include *Afzelia africana, Burkea africana, Pterocarpus erinaceus, Isoberlina doka, Monotes kestingii, Combretum glutinosum, Detarium microcarpum* and *Anogeissus leiocarpus. Gardenia aqualla* and *Dischrostachis glomerata* (see Geerling 1773 and Ezealor 2002 for details).

About 337 species of birds have been recorded (Ezealor 2002). Of these, 130 are resident, 50 are pale arctic 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) See Ezealor 2002 for further details on the status of birds and other animals in Yankari Game Reserve.

Data Collection

Line transect as described by Bibby *et al.* 2000 was used to record densities of vegetation and bird nest variables. Ninety transects of 1000 m long was selected by random stratification in the Savanna woodlands. The following variables were recorded at each 100 m section along the transect line:

1. density of wounded trees (caused by fire), trees with visible scars due to fire,
2. density of stunted trees (caused by fire), trees whose growth are affected by fire,
3. density of death trees (caused by fire),
4. density of wildlings or saplings (young growing woody plants of equal to or less than one meter in height),
5. density of trees (woody plants greater than one meter and above),
6. density of old (non active) and new (active) bird nest.

Tree species and bird nests were identified and recorded along each transect. Density estimate of these variables were carried out at each 100 m section along the transect line. All the variables were measured within a 20 x 20 m plot. A tree is considered when the circumference at breast height (CBH) is 50 cm; below that height is a wildling (sapling). A wildling or sapling in this study was measured one meter and below in height (modification from Kent and Cooker 1996 and Bibby

et al. 2000). All variable were counted within a 100 m width strip to allow for density estimate. Field work for data collection lasted for a period of four months before and after the fire. When a nest was found, its location was marked using the Global Positioning System (GPS) and the nest was given an identification number (ID) and the following variables recorded: date, location (tree species), nest height in trees, height of tree in which nest is located**.** Woody plants were identified using Arbonnier 2002. Findings from this project were presented to the Managers of the Yankari Game Reserve for consideration.

Results

Objective 1: Impact of fire on tree species in the reserve

Fire had a significant effect on the different species of woody plants recorded in the reserve (student t-test; t=36.5, df=179, p<0.001). The most affected of the plant species are shown in Figure 2. The tree species affected are mainly the genus *Combretum, Balanites, Ziromthes, Anogeissus, Crosopteryx* and *Acacia* in decreasing order. Late fire regime had a significant effects on the density of death trees (paired-sample t-test; t=-8.886, df=74, p<0.001), density of stunted trees (paired-sample t-test; t=-2.985, df=74, p<0.001) (figure 3 and 4 respectively). However, no fire regimes had a significant effect on the density of wounded trees in the reserve (paired-sample t-test; t=1.191 df=74, p=0.237; Figure 5).

Except for wounded trees, the fire category indicates that there was a significantly high density of death and stunted trees in the burnt than in the unburnt part of the reserve (Table: 1 Fig. 6, 7 and 8).

Table1: Paired sample t-test of measured variables in unburnt and burnt areas of the Yankari Game Reserve

	Pair variable	T	df	P
Pair 1	Density of death trees	-10.068	89	<0.001
Pair 2	Density of stunted trees	-4.062	89	<0.001
Pair 3	Density of wounded trees	1.416	89	0.160
Pair 4	Density of life trees	0.681	89	<0.001
Pair 5	Density of wildlings	-3.807	89	0.497
Pair 6	Mean number of nest	-3.814	89	<0.001
Pair 7	Density of shrubs	3.823	89	<0.001
Pair 8	Density of bush	6.667	89	<0.001
Pair 9	Percentage grass cover	-10.708	89	<0.001
Pair 10	Percentage bear ground	14.893	89	<0.001

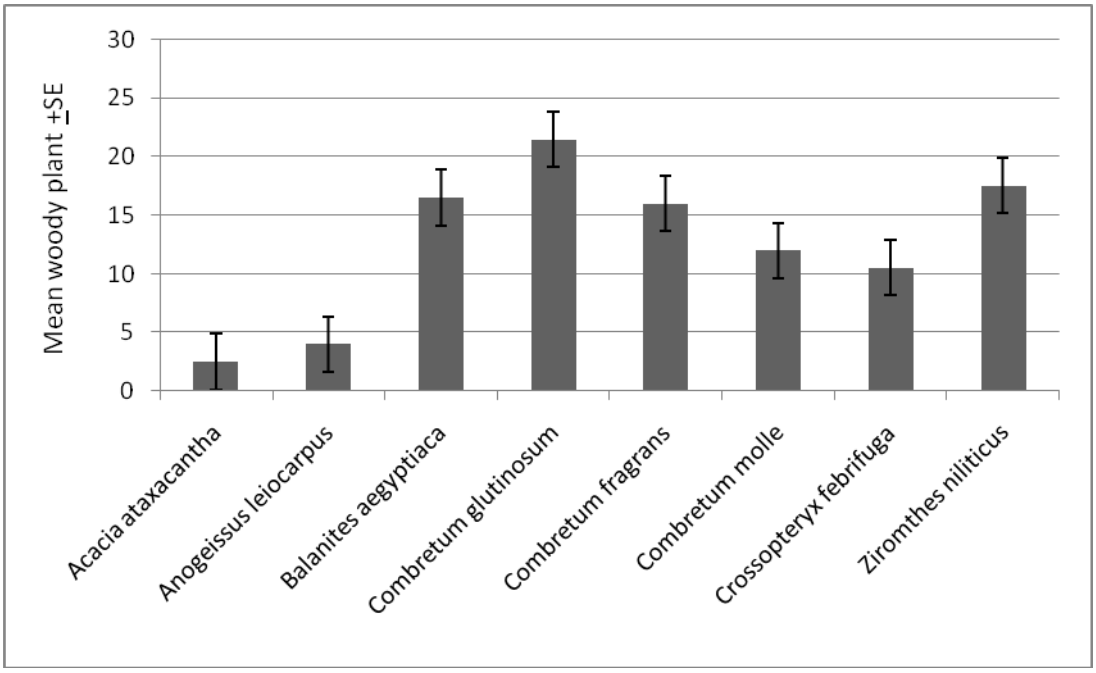

Figure 2: Mean death woody plant species caused by fire

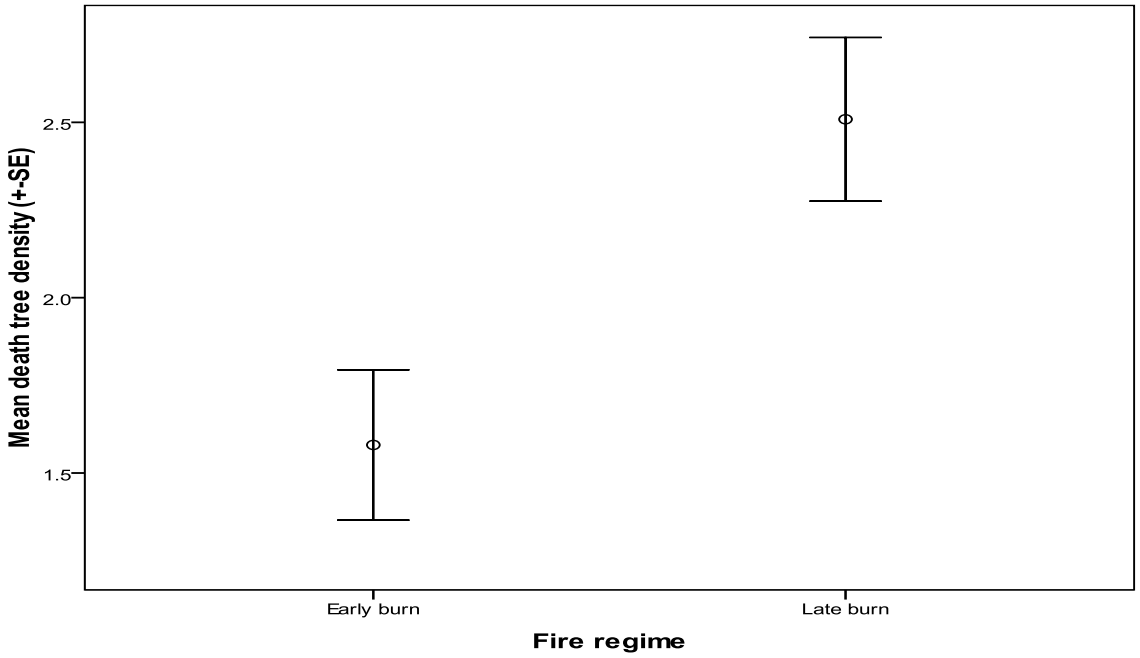

Figure 3: Mean death tree density in early and late burn fire regimes.

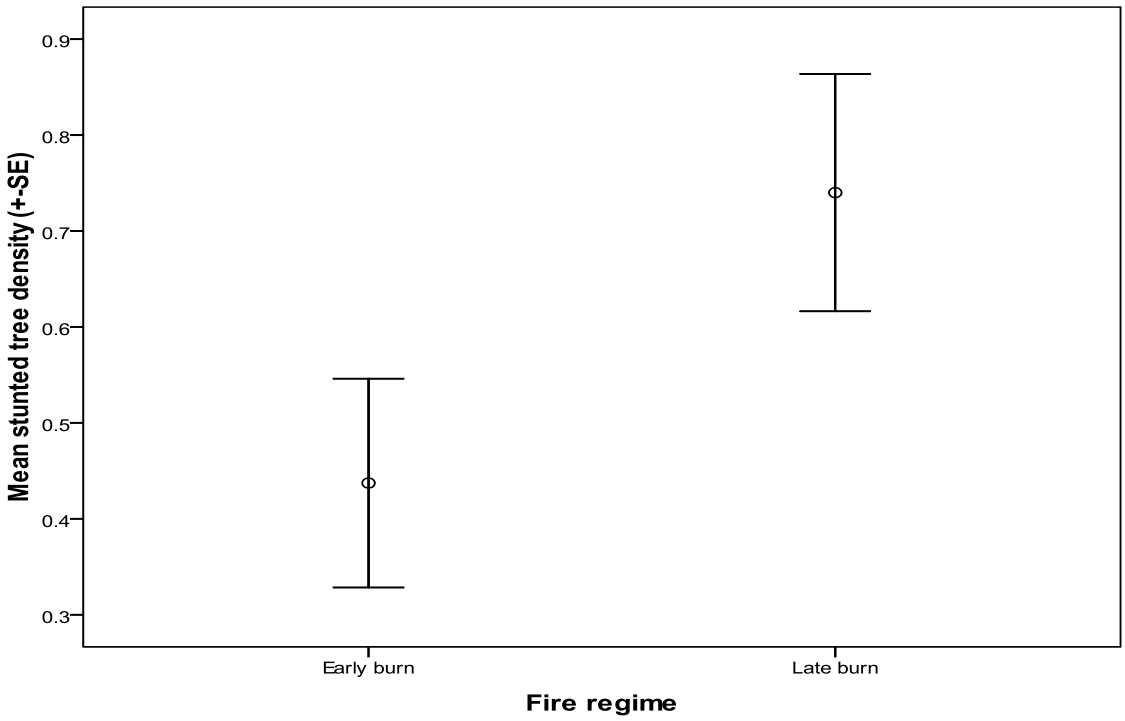

Figure 4: Mean stunted tree density in early and late burn fire regimes.

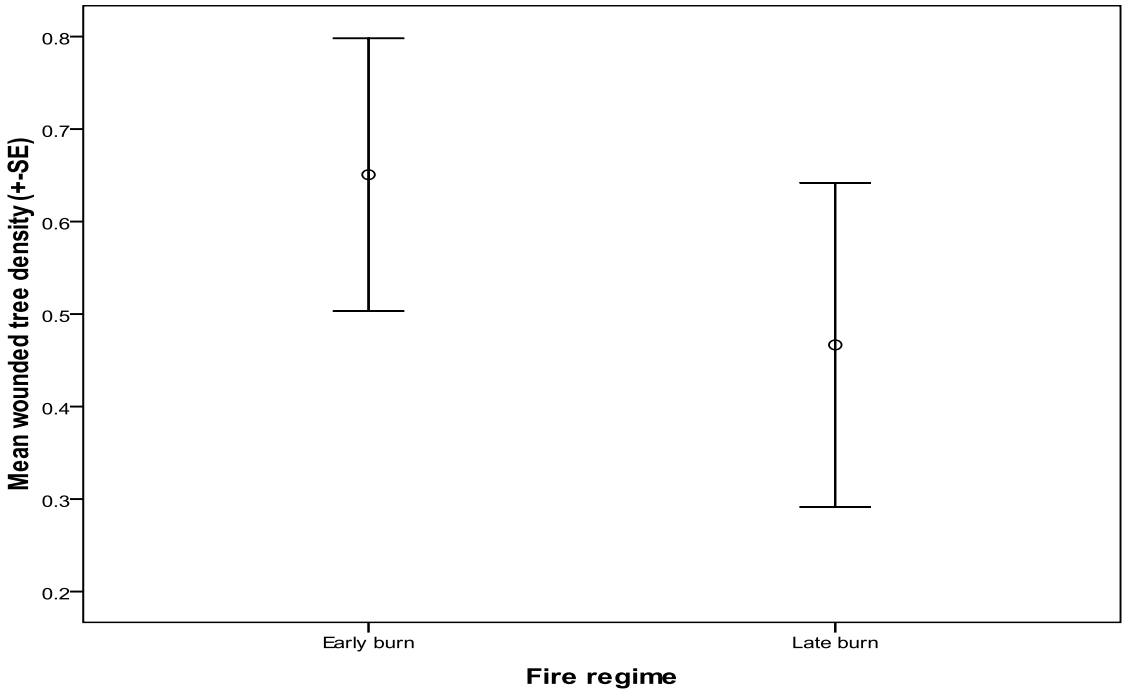

Figure 5: Mean wounded tree density in early and late burn fire regimes.

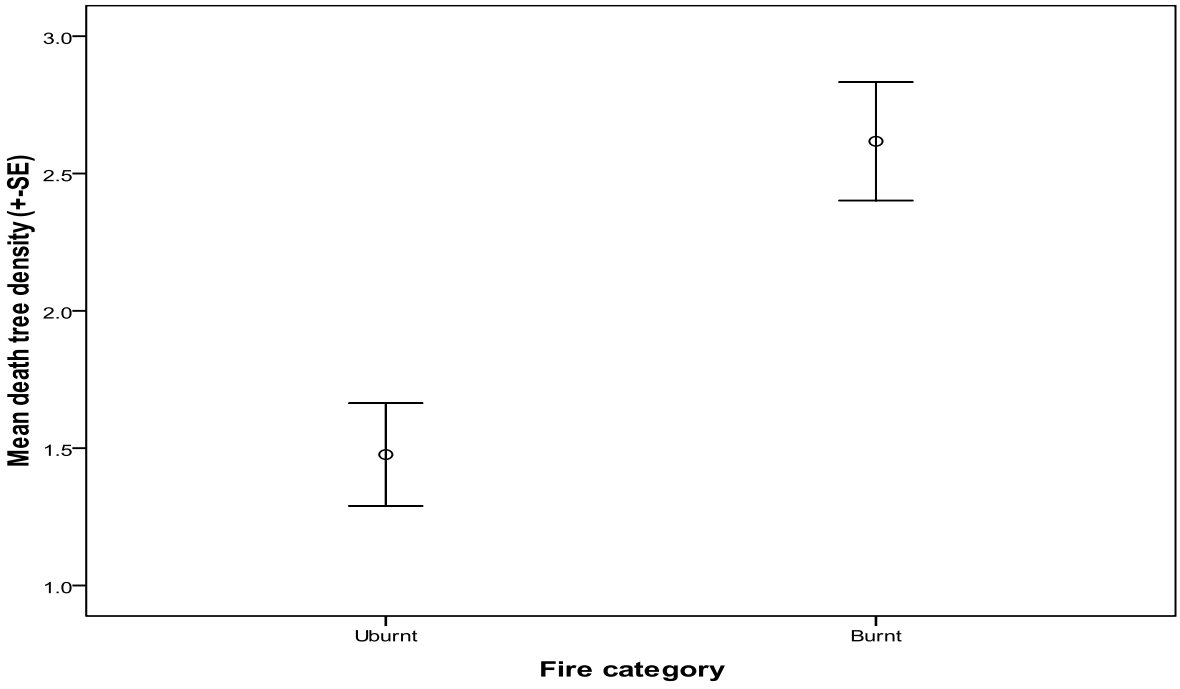

Figure 6: Mean death tree density in between unburnt and burnt fire category.

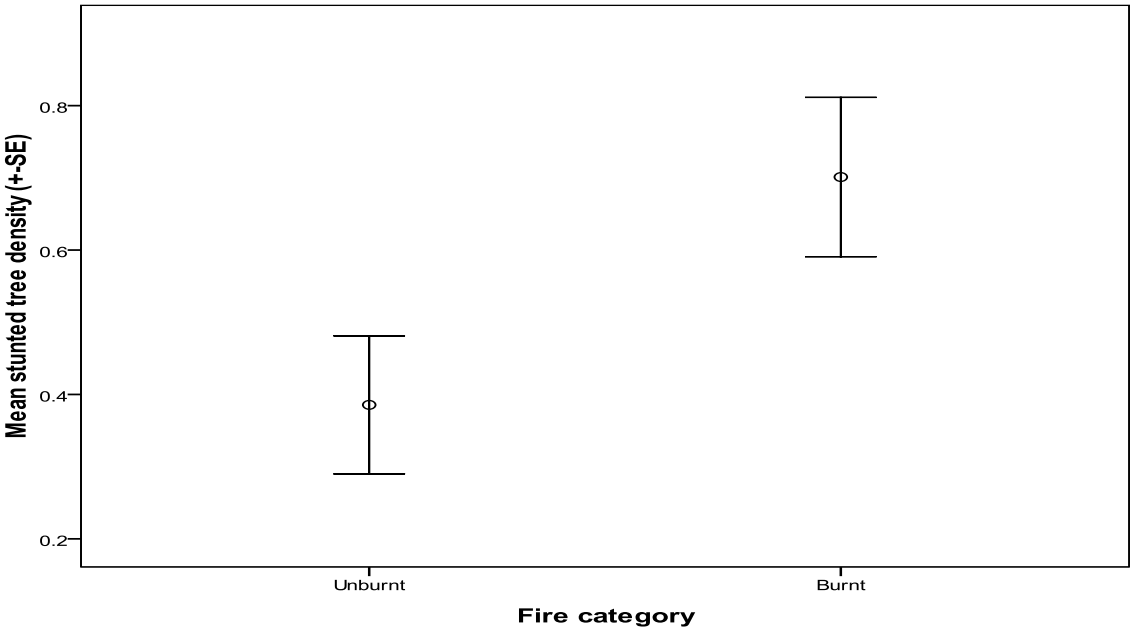

Figure 7: Mean stunted tree density between unburnt and burnt fire category.

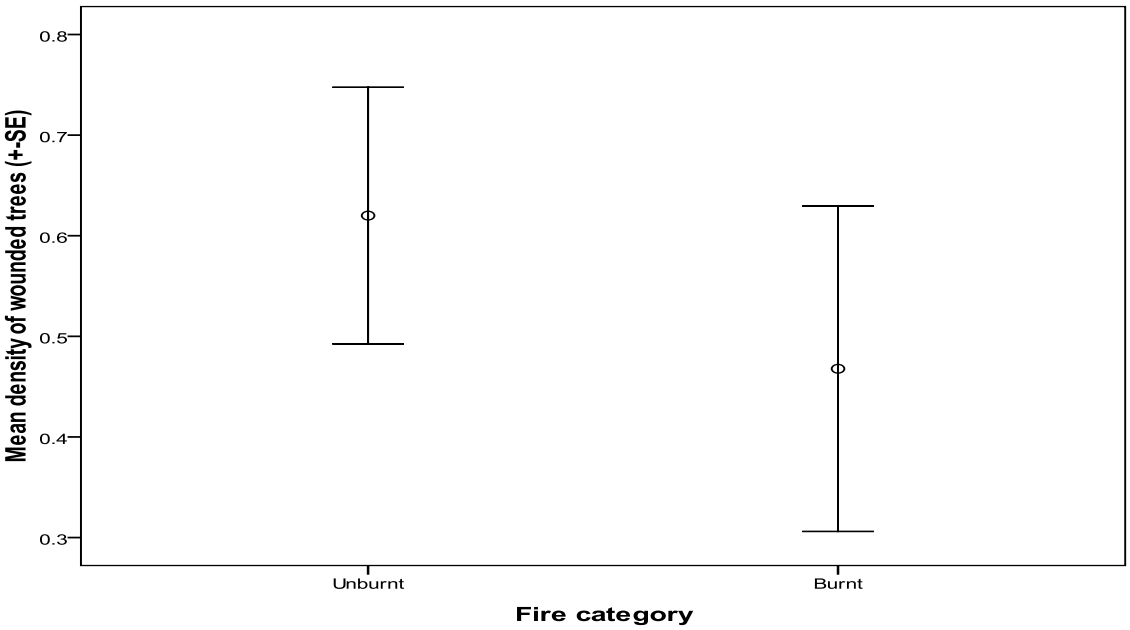

Figure 8: Mean wounded tree density between unburnt and burnt fire category.

Objective 2: Impact of fire on bird nests in the reserve

There was a significant difference in the mean density of bird nest between burnt and unburnt areas of the reserve (paired-sample t-test; t=-3.814, df=89, p<0.001; Figure 9). There ware more nest recorded in the burnt area compared with the unburnt.

There was also a significant difference in the choice of height by which birds establish their nest in trees (One-sample t-test; t=31.783, df=153, p<0.001), and the height of trees that birds choose to build their nest (One sample t-test; t=30.332, df=153, p<0.001). Majority of birds established their nest on the following plant species, *Combretum glutinosum, Combretum fragrans, Ziromthes noliticus, Balanites aegyptica,*

Combretum molle, Crosopteryx fabrifuga, Anogeissus leiocarpus and Acacia ataxacantha in a decreasing order (Figure 10).

A comparison of old and new bird-nest number indicates that there was no significant difference ($F_{152, 142}$=0.802, t=-0.74, p=0.941; Figure 11). This means that old and new nests are equally distributed in the reserve. However, most birds established their nest high up in trees, as the average height in which nests are built is 5.4 m with an average tree height of 6.6 m.

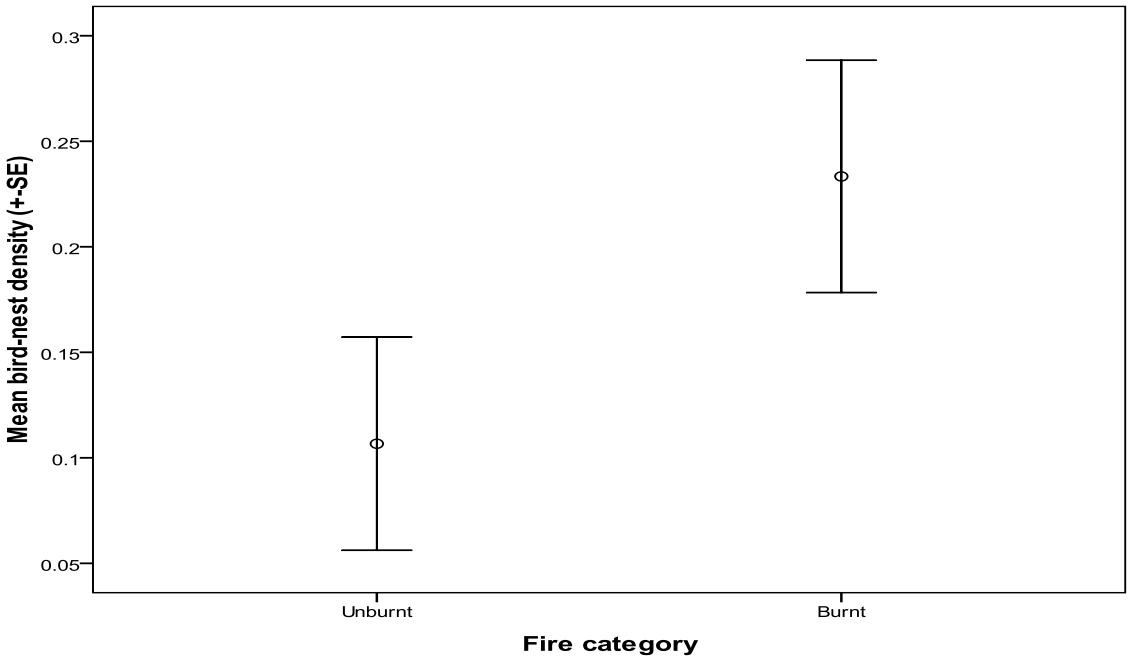

Figure 9: Mean bird-nest density.

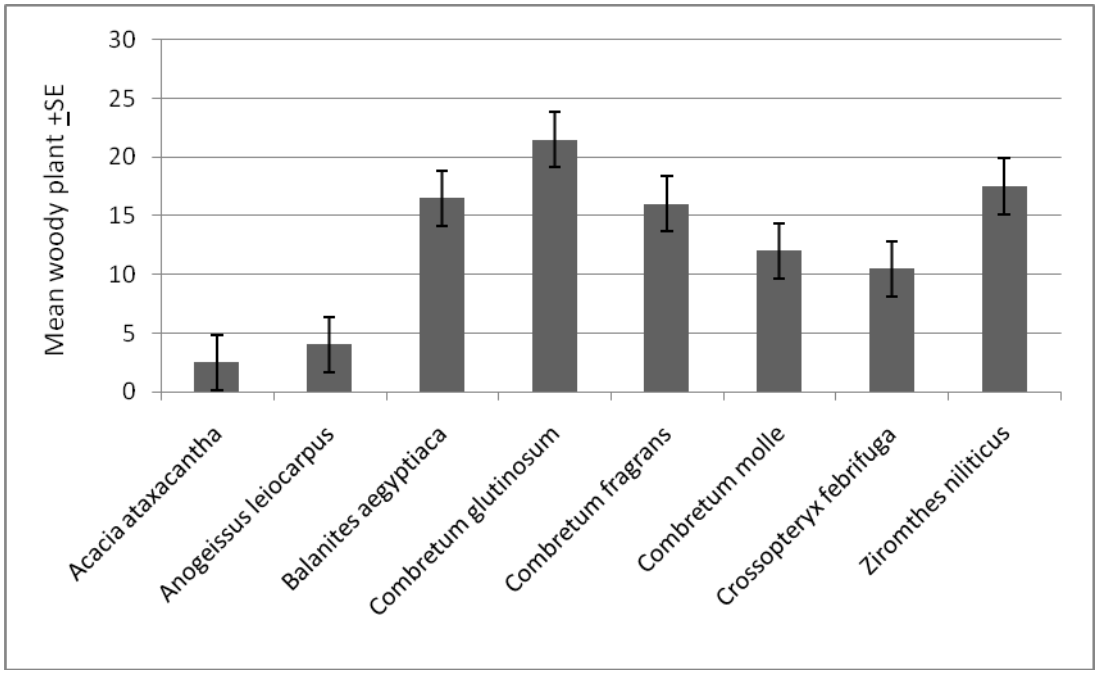

Figure 10: Mean woody plants preferentially utilized by birds for nesting

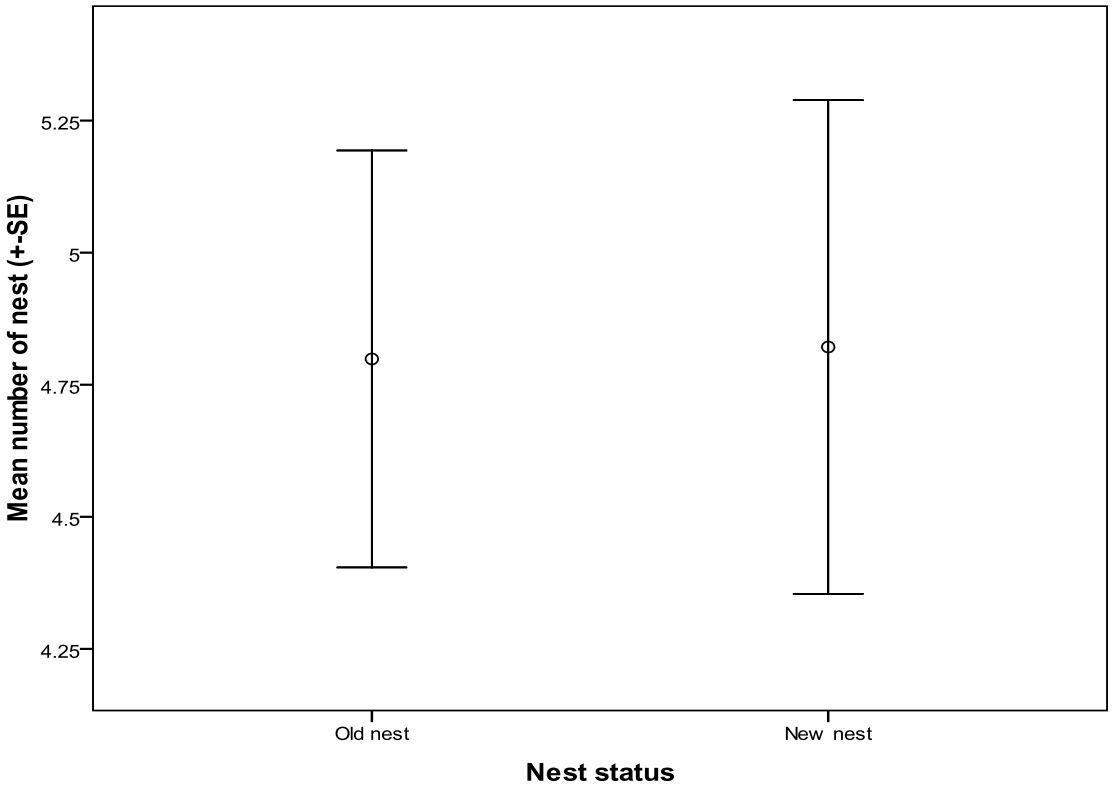

Figure 11: Mean number of old and new bird nest

Objective 3: Impact of the fire on some floristic components in the reserve

A comparison of some floristic components (habitat variables) between burnt and unburnt area showed a highly significant difference. More floristic components were affected by fires in the burnt area compared with the unburnt, except for wildling (see Table 1).

3.0 Discussion and Conclusion

Impact of fire on tree species and some floristic components in the reserve

Fire has been shown to cause direct decline in the cover of woody vegetation by killing trees or reducing them to smaller sized classes (Andy 1993). Fire had a significant effect on the different species of woody plants recorded in the reserve. This implies that there were significantly more tree species killed or damage by fire in the burnt area of the reserve compared with the unburnt area. The most affected of the plant species by fire are shown in Figure 3, the tree species affected are mainly of the genus *Combretum, Balanites, Ziromthes, Anogeissus, Crossopteryx, Acacia, and Afzelia.* The Yankari Game Reserve is said to be dominated by the Combrataceous woody plants. This perhaps explains why it tops the list of woody plants from the reserve most vulnerable to fire. These results concur with that of Miller & Silander 1999, where fire also had a significant effect on the vegetation composition and diversity of two species of *Puya* in Paramo, Northern Ecuador, preventing the habitat from attaining its true climax of a forest. The negative effects of fire on woody plants over time could eventually change the vegetation of the reserve, with possible replacement of the present woodlands with alien species.

Furthermore, there were significantly higher death and stunted trees in late burn compared with early burnt (Figure 7 & 8), this was also true for density of death and stunted trees between burnt and unburnt area, where a significantly higher number of death trees in burnt area of the reserve were recorded compared with the unburnt area (Figure 4 & 5). However, fire did not impact significantly on wounded trees either between late and early burn, nor between burnt and unburnt (Figure 6 and 9). This suggests that the fire intensity caused direct death and stuntedness to most woody plants. Many studies have shown that late fire regimes are hotter and detrimental to woody plants (NCF & WWF 1987, Baxter; P.W. J & Getz 2005). This is important, since the woodlands of Yankari Game Reserve has suffered drought between 1983 and 1986 (NCF & WWF 1987). Perhaps early burn regime should be adopted in the reserve, and the burn should be carried out once every three or four years. The establishment of fire breaks in the early dry season is very crucial; this could help in curbing illegal fire set up by poachers and pastoralists.

There was a significant effects of fire on other floristic components of the reserve (Table 1.), except for density of wildlings. Higher tree density, shrub density, bush density, percentage grass cover, percentage bear ground in the burnt area compared with the unburnt area. These results are expected especially that the late burns are carried out when the grasses are dried (Baxter and Getz 2005) Wildlings are shorter plants compared with trees; one would expect the hottest situation slightly above the wildling height compared with trees which are taller.

Impact of fire on bird nest

There are a lot of factors that interferes with the breeding activities of birds, one of which is fire, particularly in the guinea savanna region (Stutchbury and Morton 2001). Fire had a significant impact on bird nest in the reserve. There ware significantly more bird nest recorded in the burnt area of the reserve compared with the unburnt area which perhaps suggests that breeding birds have learned to avoid fire from burning their nest by establishing nests after the fire regimes. It means that breeding birds have become adapted to the fire regimes; they do this by maximizing their fitness in breeding after the fire regimes. The genus *Combretum* are mostly use for nesting, unfortunately, they are the woody plant species mostly affected by fire (Figure 11, Table 2). The preferred woody plants use for nesting activity in decreasing order include *Combretum glutinosum, Combretum fragrans, Ziromthes noliticus, Balanites aegyptica, Combretum molle, Crosopteryx fabrifuga, Anogeissus leiocarpus and Acacia ataxacantha*.

There was no significant difference in the mean number of old (non-active) and new (active) nests. Most of the non-active nests were used in the last breeding season, some of which are refurbished for a new breeding season. The nests were established almost to the top of the tree where fire in some cases during the dry season is unable to reach. This could be a strategy to avoid uncontrolled fire occurrence, by this; birds are able to renew the nests in the next season easily, thereby minimizing energy usage in building a new nest.

Recommendation and conservation action plan

Based on the findings of this study, the following conservation action plans are recommended to the Management of the Yankari Game Reserve in order to address conservation issues relating to fire. The recommendations that follow are feasible to pursue namely.

I. Burning regime should be reviewed. It is recommended that the early fire regime be practiced. In this study, early fire regimes does not impact adversely on woody plant density compared with late fire regime. Early fire regime could be set up between late October and Early January, beyond which may adversely affect woody plants. It will be best to burn the reserve in three or four year interval to maintain natural status quo of the savanna woodland system. Alternatively, early fire could be employed to burn parts of the reserve in one season, leaving other parts for another season, this is only necessary for annual burns. The early fire regime system has the advantage of avoiding incidental fire set up by poachers and herdsmen, particularly during the late dry season when fire has a devastating effects on woody plants.

II. The importance of fire breaks throughout the reserve cannot be overempahsised. Creating fire breaks will help to prevent fires set by poachers, hunters and herdsmen that intrude the reserve illegally.

III. 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. A close monitoring of the patrolling activities should be carried out to encourage effectiveness.

IV. 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 indescriminate setting of fires. Setting up a site support group in the adjoining communiteis 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.

V. A more detailed research could be carried out by incorporating models of fire, herbivory, and the woodlands to predict the fate of the woody plants of the reserve, and how this will affect particularly the large hervivores.

Implementing these recommendations and conservation action plan as management strategies in the Yankari Game Reserve will ensure that the impact of fire on trees and tree species, bird nest and indeed other biological resources are drastically minimise thus allowing perpetuation of viable populations over time.

Further study

1. Study the effects of fire on plants that are utilized by the large herbivores for food and shelter to predict possible changes that may occur in the future will also give a more insight into the fire problem in Yankari Game Reserve (also refer to recommendation 5 above).
2. Comparing the effects of fire and elephant trampling on woody plants should also be considered in future studies. These are studies that have not been done in the Yankari Game Reserve.

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