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STRUCTURES OF TREE SPECIES IN YANKARI GAME RESERVE BAUCHI STATE, NIGERIA

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ABSTRACT

Forest resources provide multiple benefits and have direct and measurable impacts on people's livelihood but illicit human activities in forest reserves have been contributing to their degradation.This study therefore assessed the floral structure of tree species in Yankari Game reserve with aim of obtaining the floristic composition of the reserve towards its sustainable management. Five (5) line transects of 200m long were laid within the study area at 500m intervals. Two plots of 30m by 30m were established such that one is at 1m along the line transect and the second plot is at interval of 100m along the transect line. The data collected for this study included; complete enumeration of all individual trees in the selected plots, followed by taking DBH using a diameter tape in centimeters. This study quantitatively assessed tree species structure, basal area, relative frequency, dominance, and Importance Value Index (IVI) across 10 plots. *Prosopis africana* exhibited the highest basal area (380.13 cm²), while *Acacia senegal* dominated with the top IVI (124.51); diameter at breast height ranged 7-22cm and heights 9-22m, reflecting moderate structural heterogeneity amid savanna threats like grazing and logging. Findings establish baseline data for conservation, emphasizing *Acacia spp* and *Ziziphus mauritiana's* ecological roles in this Sudan Savanna hotspot.

Keywords: Yankari, Game Reserve, structure, basal area, Importance Value Index, relative.

Introduction

One of the greatest threats to the planet is ever increasing biodiversity loss and species extinction. Scientific researchers believe that the planet has entered the sixth mass extinction event, with human activity as a main driver (Maroun and Atkins, 2018). Quantitative assessment of the composition, diversity and structure of forest trees are essential, not only for understanding forest biodiversity and health but also for designing conservation strategies towards climate change (Juhan *et al*., 2019). Principal causes of deforestation in Nigeria include clearance for agriculture, road construction and plantation establishment, uncontrolled exploitation and poor organization and funding of the forestry subsector. Nevertheless the growing demand for food has led to significant encroachment of tropical rainforests, as they are being transformed into arable land for agriculture and other uses (Adekunle, 2006).

Africa is rich in forests and woodlands, as well as trees outside forests. According to African Forest Forum (AFF,2015) Africa has 624 million hectares under forests, which comprise 20.6 percent of the continent's land area and 15.6 percent of the World's Forest Cover. Africa's forest area has declined by about 2.8 million ha between 2010 and 2015, a much higher rate than in any other region of the world and this has been mainly due to deforestation and forest degradation (African Forest Forum, 2019).

Forests account for more than 80% of the world's terrestrial species, whose survival is threatened (Achard *et al*., 2009). The Convention on Biological Diversity (CBD, 2009) has estimated that an increase in deforestation over the last century has reduced the abundance of forest species by more than 30%. Species loss rates in forest areas are substantially faster than other ecosystems (Achard *et al*., 2009). Forests provide an essential resource to the livelihoods of an estimated 20% of the global Population (Juhan *et al*., 2019). The contribution of forest ecosystems and forest-based resources to poverty reduction is increasingly emphasized in international policy discourse and conservation and development investments. It's obvious that in Nigeria, forest resources provide multiple benefits and have direct and measurable impacts on people's lives. Forests, trees on farms and agro forestry systems play important roles in the livelihoods of rural people by providing employment, energy, nutritious foods and a wide range of goods and ecosystem services in most regions of the world (FAO, 2014).

It is evident that, despite the efforts made by the then administration to conserve biodiversity, in Yankari game reserve, it still faces a lot of challenges which include; livestock grazing, logging, illegal fishing, the reserve faces challenges including inadequate compensation for protection staff, limited financial resources, and a lack of effective communication with neighboring villages (Habu and Naziru, 2017). According to the information gathered from the protection staff who were tasked with safeguarding the reserve as well, the locals were in several occasions the main sources of threats to biodiversity conservation at Yankari Game Reserve.

It was projected that by 2050, more than 38% of Forest species will be lost in the World (United Nations Environmental Program 2008). Hence, Conservation of biodiversity including conservation of genetic resources and existing species, needs a proper understanding and evaluationof the status of the existing biodiversity and knowing the main succession pathways so as not to interfere with unintentional interference with the sequence pathway (Heydari *et al*., 2020).

Tree structure includes the physical arrangement, height, crown shape, and biomass distribution of tree species within an ecosystem. The structural complexity of forests significantly affects habitat availability for diverse animal species (Zhang *et al.,* 2024). For example, forests with a multi-layered canopy create microhabitats that support various ecological niches, thereby enhancing overall biodiversity.

In game reserves, a varied tree structure not only provides crucial shelter and nesting areas for wildlife but also supports essential ecological processes like water retention and soil health (Martinez-Merino *et al.,* 2023). Management strategies that promote diverse tree structures can improve habitat quality and enhance the ecosystem services provided by game reserves, including carbon storage, water regulation, and biodiversity Conservation.

Yankari Game Reserve is a critical biodiversity hotspot in Bauchi state, Nigeria, yet there is a paucity of comprehensive studies addressing the composition, diversity, and structure of plant species within this reserve. Yankari Game Reserve has witnessed severe degradation within the past thirty to forty years due to anthropogenic activities associated with the expansion and clearances of arable land for farming to meet the needs

of a rapidly growing human population around the reserve. The impacts are usually destructive, often resulting in permanent vegetation structure and composition changes in the game reserve.

Yankari Game Reserve (YGR) is a designated as a protected area. Such protected areas (PAs) play a vital role in promoting in-situ conservation of nature, preserving ecosystem resilience and providing essential ecosystem services, including water supply, public health and mitigating the effect of natural disasters, among other benefits. Yankari Game Reserve is among the oldest Protected Areas in the country that was first designated as a game reserve by the British colonialists in 1956 (Okochi *et al.,* 2016). The author further reported that, this reserve signaled the start of a systematic and coordinated effort to conserve wildlife in Nigeria, which was further reinforced by the introduction of national Resources conservation Strategy in 1985 and the enactment of decree No. 36 in 1991, changed Yankari Game Reserve to a National Park. The reserve was subsequently reverted back to its original designation as a Game reserve in the year 2006, at which point it was transferred to the jurisdiction of the Bauchi State Government, on request by the State government.

A number of studieshave been reported on Game Reserves of different zones of the World such as, Jonathan and Upham (2025), Bello *et al*., (2022), Bukar *et al*., (2021), Chenge *et al*., (2019) and Njoh *et al.*, (2013). However, there isinsufficient or outdated information available related to diversity of trees species on Yankari Game Reserve. The lack of an updated research in the reserve has potentials to hinder effective conservation efforts and management strategies, preventing a thorough understanding of the ecosystem and the potential threats it faces. Consequently, there is need to investigate and document the diversity of tree species within Yankari Game Reserve to provide crucial insights for conservation planning and ecological management.

It also raises awareness about the importance of conserving plant species and highlights the unique flora present in the study area. The results of the study provide baseline information on composition, diversity and structure of tree species for conservation purposes and policy making.

Materials and Methods

Study Area

The Yankari Game Reserve is one of the oldest game reserves in Nigeria. The Reserve was established as a Game Preservation Unit (GPU) of the then Northern Region of Nigeria in January 1956. It covers an area of about 2,244 km² and composes of savanna grassland with Well-developed patches of woodland. The game reserve is being managed by Bauchi State Government since 2006 as a game reserve (Umar *etal*., 2024).The Reserve lies in the southern part of the Sudan Savanna located in North-east Nigeria. It is also a region of rolling hills, mostly between 200m and 400m (656 and 1313ft).

Kariyo hill is the highest point at 640m (2100ft) above sea level. It located at approximately within latitudes 9°45'16N, and 10°30’37’’E. lying in the south-central area of Bauchi state (Umar *etal*., 2024).

Journal of Forestry Research and Management. Vol. 23 (1). 93-103; 2026, ISSN 0189-8418
www.jfrm.org.ng

The Mean Annual Rainfall in Yankari Game Reserve ranges between 900mm and 1000mm (NIMET, 2019). The rainy season is between May to September, while the dry season begins in early October and lasts until April (Richard, 2021). The mean annual temperatures of Yankari Game Reserves are relatively high with mean annual of 32ºC (Umar *et al.,* 2024). Temperature of the environment ranges from 18-36^{O}C in dry season and 20-31ºC in the rainy season (Umar *et.al*. 2024).

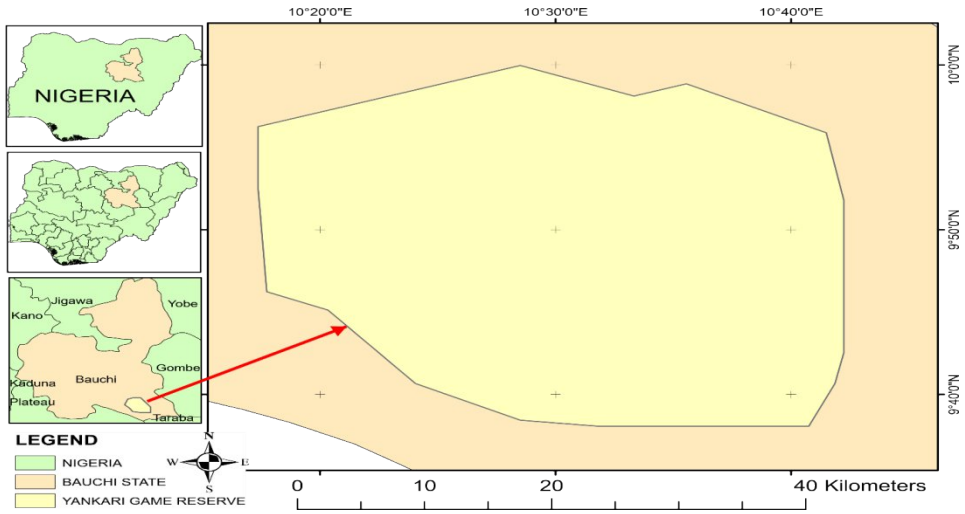


Figure 1. Map of Nigeria Showing Bauchi State and Yankari Game Reserve

Sampling Procedure

Five (5) line transects of 200m long were laid within the study area at 500m intervals. Two plots of 30m by 30m were established such that one is at 1m along the line transect and the second plot is at interval of 100m along the transect line. This give a total of ten (10) plots for the five lines transects. Trees within each plot were identified and data were collected for the determination of Basal area, relative frequency, density and relative dominance as adopted by (Akinwumi *et al.,* 2015).

Data Collection and Analysis

The data collected for this study include; taking diameter at breast height using a diameter tape in centimeters. The identified tree species were recorded with their total number of occurrences for further analysis. The relative frequency, relative density and relative dominance of the species were computed using percentages.

Basal Area = $(\pi D^2)/4$……..1

Where, BA = Basal area (m^2), D = Diameter at breast height (cm) and π = pie (3.142).

$$\text{Relative Frequency} = \frac{\text{Number of sampling points in which the specie occurred}}{\text{Total number of sampling points}} \; x\; 100 \ldots\ldots\ldots\ldots 2$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} X100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

$$\text{Relative Dominance} = \frac{\text{Total basal area of the species}}{\text{Total basal area of all species}} X100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

Journal of Forestry Research and Management. Vol. 23 (1). 93-103; 2026, ISSN 0189-8418
www.jfrm.org.ng

IVI= Relative Density + Relative Frequency + Relative Dominance……...5

Results and Discussion

Basal Area of the tree species

The basal area of tree species in Yankari Game Reserve provides critical insights into the structure, composition, and ecological significance of the forest ecosystem (Table 1). Basal area measures the cross-sectional area of tree trunks per unit area, which is a vital parameter for assessing forest density, dominance, and resource availability.

Prosopis africana had the highest basal area of 380.13cm^2 indicating its dominance in terms of trunk size and potential contribution to forest canopy and biomass. Other significant contributors include; *Ceiba pentandra* 283.53cm^2, *Balanite aegyptiaca* 254. 47cm^2 and *Ziziphus spino-christi* 201.06cm^2. These species likely play a crucial role in shaping the forest structure and supporting biodiversity.Less dominant Species with lower basal areas, such as *Borassusaethiopum* 38.49cm^2 and *Deuteriummacrocarpum* 63.62 cm^2, have smaller trunk sizes or fewer individuals. Though less dominant, they contribute to the diversity and functionality of the ecosystem.

The total basal area of 4468.13 cm^2 highlights the overall density and structural composition of tree species in the reserve. This value can be used to estimate biomass, carbon storage potential, and habitat complexity.

This finding is higher than that of Wakawa *et al.,* (2017) in his research carried out in Sahelian Ecosystem in North-East Nigeria where he reported that, the total basal area of tree species in the study area was 14.99 m^2. The total basal area of woody species in Amoro Forest was 18.5 m^2 and comparable to other Afro Mountane Forests in Ethiopia as reported by Birhanu *et al.* (2018). *Faidhabia albida* had the highest basal area of 30.3m^2 and followed by *Eucalyptus camaldulensis* with 27m^2 among other tree species in the University of Maiduguri as reported by (Bukar *et al*., 2021).

Relative Frequency of the Tree species

The results of woody plant species relative frequencies are shown in Table 1. The values ranged from 10.71% to 0.29% for the difference species in the study area. *Ziziphusmauritiana* had 10.71% relative frequency followed by *Acacia seyal* with 9.36 while *Ceiba pentandra* and *Magnifera indica* recorded the least tree species with relative frequencies of 0.29% each. *ZiziphusMauritiana* with highest value could be due to the species resistance to hot weather of the region and the rest of the species may be signs of reduced level of disturbance from human activities which could increase the vegetation growth and reproduction in the protected area.

The result is lower than that of Bello *et al.* (2022) who indicated that the findings on the relative frequencies of woody plant species showed the values that varied from 1% to 62.43% for different tree species in their Rabadi Forest reserve in Jigawa State. *Guiera senegalensis* had 62.43% followed by *Balanites aegyptiaca* with 60.29%, whereas *Adansonia digitata* and *Borassus aethiopum*recorded the least woody Species relative frequencies with 3.43% and 1% respectively. The high value of *Guierasenegalensis* could be explained by the fact that the species is not among the preferred trees for fuel wood due to low energy efficiency as reported by Salisu and Ahmad (2019).

This is in line with the report of FAO, (2010) that, the major cause of deforestation in Nigeria is unsustainable exploitation of wood fuels. The fact that fuel wood sellers do not prefer *Guiera senegalensis* but rather go for well grown trees that could provide large quantity and high-quality fuel wood to maximize their profit. While that of *Balanitesaegyptiaca* could be due to the prohibition of felling of fruit-bearing trees by the State government. The lowest frequency of *Borassus aethiopum*in the study area could not be unconnected with the high seed dormancy of the species, as well as the over exploitation of the seedling for food called "Muruci" in Hausa dialect.

Relative Dominance of the tree species

The result in Table 1.Presents the relative dominance values of various woody plant species in the Study area. *Borassus aethiopum* (7.64%), *Tamarindus indica* (7.29%), and *Ficus sycomoros* (6.95%) appeared to be the highest relative dominance followed by *Ximeniaamericana* (6.61%) and *Acaciasenegal* (6.28%). Other species with relatively high dominance values include *Acacia nilotica* and *Deutarium macrocarpum* (5.66%) each, *Ziziphus spino-christi* and *Acacia seyal* (each 5.35%), while*Vitex doniana* with (5.06%), indicating a more prominent presence in terms of size or biomass.Mid-range values were recorded for species of *Mangifera indica* (3.72%), *Ficus polita* (3.24%), and *Faidherbia albida* (3.01%), showing moderate dominance within the plant community.In contrast, species like *Hyphaenethebaica* (0.15%), *Combretumnigricans* (0.20%), and *Ceibapentandra* (0.20%) had the lowest relative dominance, suggesting that these are either smaller in size, less abundant, or both.

The findings are lower than the findings of Bello *et al*. (2022) carried on the relative dominance of woody plants in Rabadi Forest Reserves which found that, the relative dominance for different tree species ranged between (1%) and (21%).The findings showed that *Tamarindusindica* had the highest value of (21.30%), followed by *Adansonia digitata* with (16.34%), while *Combretumglutinosum* had the lowest value of (1.9%). The dominance by *T. indica* could be explained by the fact, the community are very conversant with wide range of benefits derive from the species such as fruits, medicines among others and thus became very conscious about their conservation.The result carried by Wakawa *et al*. (2017) in Gashua, Yobe State, revealed that, the relative dominance of tree species is higher than the values obtained in this study area. Their results showed that *Azadirachta indica* recorded the highest value of (24.2%) for relative dominance followed by *Tamarindusindica* with a value of (21.5%) while *Acaciasenegal* and *Ziziphus*spino-*christi* recorded the least value of (0.1%).

Importance Value index of the tree species

The results in Table 1 show that *Acaciasenegal* recorded the highest Important Value Index of 124.51, followed by *Acacia seyal* and *Zizpus mauritiana* with 20.07 and 19.71 respectively. The lowest IVI was recorded by *Diopyrosmespiliformis* 1.35, *Hyphaenethabeica* 1.07, and *Ceibapentandra* with 0.69. This is lower when compared with the findings of Zhigila*et al.,* (2015), who reported that, *Guiera senegalensis* recorded the highest 127.70 Important Value Index, in their research carried out in Tangaza Forest Reserve in Sokoto, Nigeria. They also reported that, the lowest IVI was recorded by *Combretum glutinosum,*

Detariummicrocarpum and *Lanneamicrocarpa* with 2.68 each. This is higher when compared with the reported from Bello *et al.,* (2022) results who obtained IVI that ranged between (1.41%) and (41.67%) in his work carried out in Rabadi Forest Reserve, Jigawa State Nigeria. The author reported that*Guiera senegalensis* and *Balanitesaegyptiaca* had the highest IVI values of (41.67%) and (38.27%), respectively.*Borassus aethiopum*recorded the least value of 1.41. Higher importance value index (IVI) of a species indicates its dominance and ecological success, its good power of regeneration and greater ecological amplitude and also those plants need monitoring, management, while, species which were grouped as low therefore need high conservation efforts as reported by Smith, (2020).

Diameter at Breast Height and Height of the Tree Species

The BDH Values ranges from 7.00m in (*Balanite aegyptiaca*) to highest number of 22.00m in *A. auriculiformis* with dominant canopy species whereas Height also varies significantly, from 9.00m in *Parkia biglobosa* as lowest values and 22.00m in *Hyphanaethebaica* appeared to be the highest range value. This diversity in height reflects the vertical stratification of forest, which support a range of ecological niches.

The dominant species (size and height) *(Mangiferaindica)* hadthehighest BDH (22.00cm), indicating that it is a key structural species in the area. However, its height was relatively low compared to taller species. *Hyphanae thebaica* which stand out as the tallest species (22.00m) playing a significant role in providing canopy cover and supporting bird and animal habitats. Species like *Anogeissus leocarpus (*DBH 10.00cm, Height: 21.10m) and *Guierasenegalensis*(DBH: 10.00cm, Height: 21.10m) demonstrate high height to DBH ratios, suggesting efficient vertical growth. Shorter species with relatively higher DBH, such as *Parkiabiglobosa*(DBH 13.00cm, height: 9.00m), may be or have lower canopy contributions. The total of 411.00cm and total height of 559.30m across all listed species underline the cumulative contribution of these species to forest biomass and structural complexity.

Our result is higher when compared with findings of Nath*et al.* (2016) who recorded that 90% of trees belonged to the 5-to-15m DBH class in the Chunati Wildlife Sanctuary, which is not similar to the present study. However, Hossain *et al.*, (2017) reported that the maximum number of species (169 species) was found to occur within the DBH range of 1 to 24.5m in the Dudhpukuria Dhopachori Wildlife Sanctuary, Chittagong, Bangladesh.

Arzai and Aliyu (2010) found a very sound linear relationship between DBH and height in *Parkia biglobosa*, *Khaya senegalensis,* and *Eucalyptus species,* as well as a strong relationship between DBH and canopy width for *Parkia biglobosa*, *Khaya senegalensis, Eucalyptus species, Adansonia digitata* and *Cassia siamea* species in the savanna zone of Nigeria. Kabir (2007) also found a good and significant relationship between volume and DBH where height was constant for *A. auriculiformis* plantation in Dhaka Forest Division of Bangladesh.

Journal of Forestry Research and Management. Vol. 23 (1). 93-103; 2026, ISSN 0189-8418
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Table 1: Structural Characteristics of Woody Plant Species in Yankari Game Reserve

Names of Species	BA(cm^2)	RF(%)	RDO(%)	IVI (%)	DBH(m)	HGT(m)
Acacia nilotica	78.54	27	5.66	13.92	14.00	16.00
Acacia Senegal	78.54	9	6.28	124.51	12.00	19.20
Acacia seyal	113.10	97	5.35	20.07	18.00	20.00
Adansonia digitata	153.94	12	1.82	4.51	11.00	20.00
Annona squamosa	226.98	7	0.81	2.30	17.00	20.00
Anogeissusleiocarpus	226.98	37	0.41	4.40	10.00	21.10
Azadirachta indica	95.03	9	1.49	3.85	10.00	21.00
Balanite aegyptiaca	254.47	14	2.19	9.10	7.00	16.00
Borassus aethiopum	38.49	5	7.64	15.76	11.00	20.00
Burkea africana	95.03	36	0.93	4.85	19.00	21.00
Ceiba pentandra	283.53	3	0.20	0.69	14.00	18.00
Combretum glutinosum	153.94	77	2.38	2.68	10.00	19.00
Combretum nigricans	78.54	35	0.20	3.78	17.00	11.00
Commiphora africana	153.94	28	0.26	3.23	9.00	18.00
Detarium macrocarpum	63.62	46	5.66	2.68	10.00	20.00
Diopyros mespiliformis	78.54	7	0.33	1.35	11.00	19.00
Fadherbia albida	95.03	88	3.01	14.52	10.00	12.00
Ficus polita	95.03	18	3.24	8.22	13.00	16.00
Ficus sycomoros	78.54	13	6.95	15.15	11.00	15.00
Gueira senegalensis	132.73	32	3.01	10.08	10.00	21.00
Hyphaene thebaica	78.54	8	0.15	1.07	12.00	22.00
Mangifera indica	113.10	3	3.72	7.73	22.00	12.00
Milicia excelsa	226.98	12	3.47	8.01	14.00	18.00
Parkia biglobosa	95.03	22	1.49	5.11	13.00	9.00
Phoenix dactylifera	63.62	12	0.81	2.78	11.00	13.00
Piliostigma reticulatum	95.03	89	0.50	9.59	11.00	17.00
Prosopis africana	380.13	24	0.41	3.14	9.00	15.00
Sclerocarya birrea	132.73	27	2.79	8.19	9.00	11.00
Tamarindus indica	63.62	9	7.29	15.45	15.00	17.00
Vitex doniana	176.72	12	5.06	11.28	14.00	11.00
Ximenia americana	153.94	9	6.61	14.09	12.00	19.00
Zizipus mauritiana	113.10	111	4.50	19.71	16.00	11.00
Zizipus spino-christi	201.06	62	5.35	16.69	9.00	21.00
Total	**4468.13**	**1036**	**100.00**	**300.00**	**411.00**	**559.30**

Source: Field Survey 2024

Conclusion Yankari Game Reserve hosts diverse woody

species with *Prosopis africana* leading basal area Dominance,*Acacia senegal* topping IVI, and varied DBH plus heights indicating multi-layered canopy potential despite anthropogenic pressures. Relative frequencies peaked at *Ziziphus mauritiana* (10.71%), while low IVI species like *Ceiba pentandra*(0.69) signal regeneration needs, aligning with prior Sahelian studies showing comparable densities. There is need of Initiate enrichment planting of dominant species (e.g., *Prosopis africana, Vitex doniana*) and monitor their DBH/height annually for regeneration also updating Bauchi State policies with IVI/basal area baselines, integrating local livelihoods to reduce encroachment.

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