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Original Research Article

# Comparison of Effectiveness of Management Approaches of Gashaka-Gumti National Park and Yankari Game Reserves in Dry Region of North-East Nigeria on Conservation of Tree Species

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## Abstract

Both United Nations (UN) and Convention on Biological Diversity (CBD) recognized the importance of protected areas (PAs) as a key strategy for biodiversity conservation and sustainable development. This makes global protected areas an important contribution to achieving these commitments. However, PA coverage alone does not effectively measure the overall effectiveness of the protected areas performance or conservation success, thus the effectiveness of the curved or designated PAs needs to be monitored. This paper investigated the Effectiveness of National Parks and Game Reserves in Tree Species Conservation in Dry Region of North-East Nigeria by comparing Gashaka-Gumti national (GGNP) park and Yankari Game reserve (YGR). Wandering quarter method of vegetation analysis was employed as instrument for data generation where five sampling points (five vegetation zones in GGNP and four angles and centre in YGR) were established in each of the PA for data collection. Basal area, percentage frequency, relative density, relative dominance, importance value index were determined on each species encountered. Mean distance between tree stands, mean area as well as number of trees per hectare were also calculated. Results obtained indicated higher species diversity in GGNP over that of YGR (53 and 22 respectively). Basal area records indicated highest (34, 552.6cm) at GGNP on Uapaca togoensis against highest at YGR (25, 598.2 cm) on Khaya senegalensis. Same trend was observed on measures of Relative density, relative dominance and importance value indices (IVI). Going by the IVI, the vegetations of the PAs were described as Uapaca-Crossopteryx-Danielli complex and Kyaya-Combretum-Danielli type of vegetation in GGNP and YGR respectively. Values for mean distance ($d_m$) between Trees, mean area (MA) occupied by Tree and Density of Trees per hectare indicated 3.4m, 11.6m & 862 in GGNP respectively against 6.2m, 38.4m, & 260 in YGR respectively.
**Keywords**: Biodiversity; Protected Area; Sustainable development; Vegetation.

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## INTRODUCTION

The Convention on Biological Diversity (CBD) adopted the Strategic Plan for Biodiversity (2010-2020) and its 20 Aichi Biodiversity Targets in the year (2010) [1] and multilateral environmental agreements was endorsed by parties as a global framework for biodiversity conservation. In 2015, members of the United Nations adopted the 2030 Agenda for Sustainable Development and its Sustainable Development Goals. These constituted two of the most important environment and sustainable development commitments ever made by governments in the international fora; and both recognized the importance of protected areas as key strategy for biodiversity conservation and sustainable development in the targets they contain. This makes global protected areas an important contribution to achieving these commitments. The recently adopted Sustainable Development Goal to halt biodiversity loss by the United Nations Sustainable Development Goals [2] has contributed in increasing the number of protected areas to become a central component of biodiversity conservation across the Globe [3] covering 15.4 per cent of the planet's terrestrial and inland water areas by 2014 [4]. But PA coverage alone does not effectively measure the overall effectiveness of the protected areas performance or conservation success [1].

Therate of deforestation in tropical countries is so immense such that forests are now mostly limited only to designate protected areas. As of 2005, Nigeria has the highest rate of deforestation in the world according to the Food and Agriculture Organization of the United Nations. Between 2000 and

2005 the country lost 55.7% of its primary forests, and the rate of forest change increased by 31.2% to 3.12% per annum [5]. In total, between 1990 and 2010, Nigeria lost 47.5% of its forest cover, around 8,193,000 hectares [6]. The worse hit region is the northern part of the country that falls under an ecological Sahel, conspicuous Sudan and little of Guinea Savannah vegetation zones which are characterized by low population of trees. Within the North, North-east is typically characterized by Sahel and Sudan savannah type of vegetation which is less densely populated than Guinea savannah (that lay south to it) even before the pressure of human perturbation. Thus, the impact of deforestation is more evident here. But Forests are believed to contain roughly 90% of terrestrial biodiversity and are known to provide a wide variety of ecosystem services that gives support to the livelihoods of more than 1 billion people globally. Therefore, forests need to be conserved for sustainable development. But forest degradation and deforestation are advancing at alarming rate of 0.6km every year [7] thereby putting at risk, a high diversity of species and habitats sustained by forest ecosystems [8].

Since the global demand for conservation of biodiversity and ecosystem services has resulted in the establishment of protected areas (PAs) as one of the major strategies to curtail deforestation, especially in the tropics [9], PAs are covering more than 12% of the total world's land surface [10] and 13.5% of the world's forests [11]. Despite this effort, the effectiveness of biodiversity and forest conservation measures are under question as the rate of biodiversity loss is not decelerating [12] with some of the protected areas, themselves, not much spared from human encroachment mostly due to poor socioeconomic status of the adjoining community [13]. Thus, the effectiveness of the curved or designated PAs needs to be monitored.

International union for conservation of nature (IUCN) has categorized protected areas into seven different types. This categorization is recognized, on a global scale, by national governments and international bodies such as the United Nations and the Convention on Biological Diversity (CBD) [14]. Gashaka-Gumti National Park (GGNP) and Yankari Game Reserve (YGR) falls within Category II: National park– a natural area of land and/or sea designated to, protect the ecological integrity of one or more ecosystems for present and future generations, exclude exploitation or occupation inimical to the purposes of designation of the area and, provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible [15]. But their management approaches differs. While Gashaka-Gumti is managed by the federal government, Yankari is managed by Bauchi state government,

In most African countries, indigenous woodlands provide both urban and rural populations with the greatest proportion of their fuel requirements, where firewood is harvested from both live and dead sources [16, 17]. In Nigeria, for example, firewood used for cooking accounts for nearly 80% of the energy consumption [18, 19] and there are currently no pragmatic alternatives to fuel wood for domestic purposes, especially in the rural areas [20, 21]. This is one major factor for deforestation in Nigeria as a whole and northern-eastern Nigeria in particular.

Northern Nigeria is situated in the semi-arid areas with average annual rainfall of less than 600 mm bordering on the Sahara Desert [22] and is considered as the hottest and longest desert in the world [23]. The soil in this area face a lot of threats ranging from deforestation for cooking fuel, overgrazing by livestock and Agricultural practices that fail to conserve soil. Another ugly menace is desertification which affects eleven (11) Northern states of Nigeria referred to as the frontline state, these include, Adamawa, Borno, Yobe, Bauchi, Gombe, Jigawa, Kano, Katsina, Zamfara, Sokoto and Kebbi [24, [23, 25]. Out of these states, the first five are part of the six states that constitutes the North-eastern states.

According to a 2005 UN Food & Agriculture Organization report, Nigeria has the world's highest deforestation rates of primary forests, putting her on track to lose virtually all of its primary forests within few years [5, 26, 27]. Deforestation is responsible for about 75% of environmental problems in Northern Nigeria [27] and quest for firewood is the major factor for this ugly phenomenon in the region.

It is against this background that this research studied the effectiveness of GGNP and YGR in North east Nigeria in forest resources conservation so as to recommend the best approachto sustain the little forest that is leftin the region.

**Objectives of the study**

This research has the main aim of investigating the effectiveness of national park and game reserve in conservation of forest resources in the dry region of north-east Nigeria. It has the following specific objectives:-

- To determine the basal area of species in each of the protected areas
- To determine the percentage frequency of individual tree species encountered
- To determine the relative density of species in each of the protected areas
- To determine the relative dominance of species in each of the protected areas
- Assessment of importance Value Indices (IVI) of tree plants species to determine species diversity and richness in each of the selected protected areas

- To assess Mean distance between trees and Mean Area of trees and density of Trees per hectare in each of the protected area selected

## MATERIALS AND METHODS

### Study Area

Sampling sites:

Two PAs were were selected, based on their management approaches. These were Gashaka-Gumti national park (Managed by federal government) and Yankari Game reserve (managed exclusively by state government). Wandering quarter method of vegetation analysis was employed as instrument for data generation where five sampling points (five vegetation zones in GGNP and four angles and centre in YGR) were established in each of the PA for data collection.

### GGNP

GGNP is the largest protected area within Nigeriaand about 6,670 $km^2$ (Figure-1). It is located spanning across two states in north-eastern Nigeria (Adamawa and Taraba states) along the Eastern border highlands on the Cameroon volcanic line. It is located on 06º58' -08º05' N and 11º10' N-12º13' E co-ordinates [28]. The park was established in 1991 with the name, Gashaka-Gumti, a name derived from two of the region's oldest and most historic settlements of Gashaka village in Taraba State and Gumti village in Adamawa State [29]. The annual temperature range is approximately 21°- 32.5°C (69.8°- 90.5°F). It is characterized by dry and rainy seasons. The rainy season is during the months of April to October with annual precipitation around 1897 mm of rainfall. Humidity ranges between 26 - 78%. Incidence of fog is high in this area especially during the rainy season, when the more temperate earth makes contact with the air; fog occurs [30]. During the dry season, which occurs between Novembers to March, higher temperatures are experienced which may be higher than annual temperature range. The park has a multitude of crucial ecological functions by encompassing most of the catchment of the Taraba River which is the largest tributary to the river Benue, one of the two major rivers in Nigeria. Topography of the park can be divided into two; the undulating Gumti sector in the north and the hilly to mountainous Gashaka sector in the south, where elevations rise to 2,419 meters at Gangirwal which is also referred to as Chappal Wade, Nigeria's highest altitude [31].

GGNP is within the middle of the African Plate [30]. Since it is not located near a fault line, major earthquakes do not occur here. At times, some tremors can be felt and this can be due to proximity to the mostly inactive Ifewara fault line which is linked into the Atlantic Fracture System [30]. Gashaka-Gumti is located on land underlain by pre-Cambrian Basement Complex. The pre-Cambrian Basement Complex and the Ifewara fault line have previously contributed to the movement and formation of geology and landforms in the area [30].

The major problem that affects the national park is landslides. This geologic hazard occurs because of the sedimentary rocks that are in the area. The sedimentary rocks in the region are known to be mineralized with lead and zinc. The pre-Cambrian Basin also is considered the oldest, crystalline, solid foundation in the country and contains the igneous and metamorphic rock. The sedimentary rock is found in the basins that separate the basement complex landmass. The hazard of landslides and the main type of rock is defined as sedimentary, which leads to erosion and weathering of landforms within the park [30].

North-eastern area of the park is relatively flat allowing for savanna woodlands, typically Sudan Guinea savanna woodlands, covered in coarse, tall grasses and fringing forests with some striking vegetation, such as the intense red leaves of *Brachystegia eurycoma* and the great white flowers of *Berlinia grandiflora* [30]. As one move eastward, the highlands, specifically the montane grasslands and shrub lands, occur within the mountainous regions of the park. The canopy of the montane forest is rarely closed, allowing for rich vegetation on the highland floor. The tallest trees are often stragglers, like the *ficus* spp and other species of fig. Within and near the highlands, vast lowland rainforests, tropical and subtropical moist broadleaf forests, begin to take over. The rainforests are dense, hot, and humid. The forest vegetation is dominated by woody species, mainly tall trees [30].

Vegetation patterns have been strongly influenced by increasing human impact since historic time. Deforestation and dry season burning are believed to have turned considerable parts of semi-deciduous forests into pyrophytic woodlands and led to the prevalence of extensive grasslands at the expense of montane forests [32, 33].

### Yankari Game Reserve (YGR)

Yankari is located within Duguri, Pali and Gwana districts of Alkaleri Local Government Area of Bauchi state. The local Government has a population of 208,202 people occupying a total land area of 7,457.78$Km^2$ [29].

The reserve, located at latitude $9^0$ 50'N and longitude $10^0$ 30' E, lies in the southern part of Sudan savannah in the north-eastern part of Nigeria (Figure-2). The reserve's tourist centre (Wiki camp) is situated 71 km from Dindima, off Bauchi- Gombe road with its main entrance at Mainamaji village, 29 Km from Dindima.

It was designated in 1956 and opened to public in 1962 and has become one of the most popular eco-

destinations in West Africa. The Park is bisected by Gaji River but that is not the only source of water in the reserve. It features five warm springs namely; Wikki, Dimil, Gwana, Tudun-Maliki and Mawulgo water springs with Wikki as the largest and flavours the reserve's beauty. Wikki has a constant temperature of 31.1$^{o}$C all year round which makes it the most fascinating sites of the reserve. Yankari is a region of rolling hills, mostly between 200m and 400m with Kariyo Hill having the highest point of 640m [34]. Two major habitats- types namely dry Savannah Woodlands and Riperian vegetation occur which includes areas of Fadama (Floodplains).

Annual rainfall in the reserve is between 900mm and 1,000mm and rainy season is from May to September. Mean temperature ranges between 18 - 35$^{o}$C [34].

The park lies on Kerri formation, of Tertiary age, which composed of sandstone, silt stones, kaolite and grits. Underneath this lies the Gombe formation, of Cretaceous age, composed of sandstones, silt stones, and ironstones. The valleys of Gaji, Yashi and Yuli Rivers are filled with Alluvium of more recent age. Sandy loam and clayey soils of riverine alluvium occur in the valley of the Gaji, Yashi and Yuli Rivers. To the east of Gaji valley is a 5-7 Km wide band of poor sandy soils that support a shrub Savanna formation 35].

As dry savanna woodland and riparian vegetation characterized the reserve, common woodland trees found includes *Afzeliaafricana*, *Burkeaafricana, Pterocarpuserinaceus, Isoberliniadoka, Monoteskerstingii, Combretum glutinosum, Detariummicrocarpum and Anogeissusleiocarpus*. The shrub layer of the vegetation is dominated by *Gardenia aqualla* and *Dichrostachys glomerata* while *Hyparrhenia involucrate* and *Hyparrhenia bagirmica* are the dominant grasses.In the riparian forest, *Khaya senegalensis, Vitex doniana, Acacia sieberiana, Tamarindus indica, Borassus aethiopum* and *Daniella oliveri* are the common trees. Characteristics of Yankari are large monodominant stands of *Pteleopsis habeensis* which grows 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* spp are the dominant trees, while tangles of *Mimosa pigra* dominate the shrub stratum [29].

**Sampling method and Data Collection**

Wandering quarter method of vegetation analysis was conducted. Where five sampling points were randomly selected (four angles and center), in YGR whereas in GGNP, which is very large and has distinct vegetation zones, site sampling was done in each of the five vegetation zones in the PA. Wandering quarter method of vegetation analysis [36] was adopted for quantitative data generation in this study. It is a method of sampling plant community using plotless survey technique whereby a researcher obtain data on the community by zig-zag movement from one tree to another heading in the same general compass direction [36]. Data collected were used to calculate several common measures of plant community structure including, species richness, species diversity, relative basal area, Tree density per hectare, mean distance between tree stands, relative dominance, relative density and importance value indices of plant species.

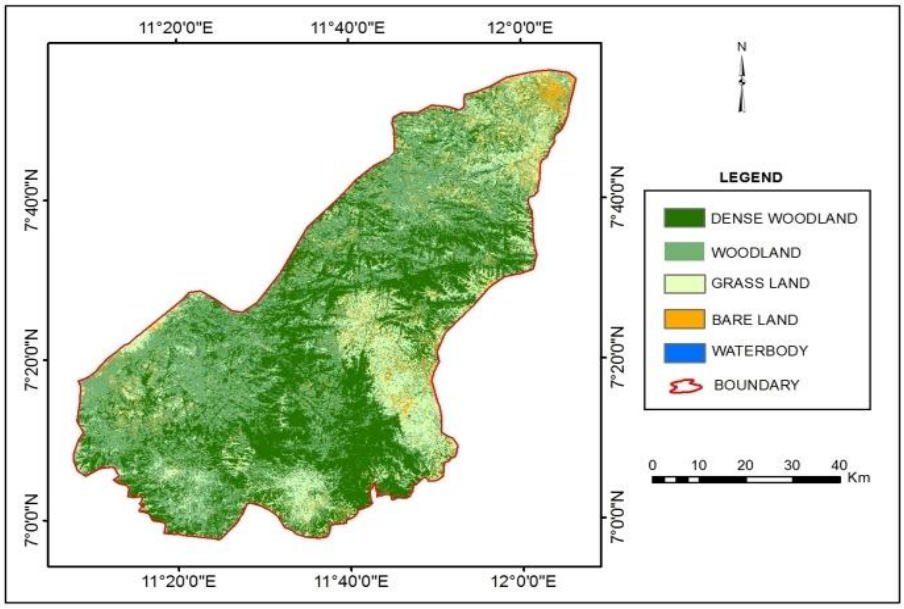


**Fig-1: Map of Gashaka Gumti National Park**

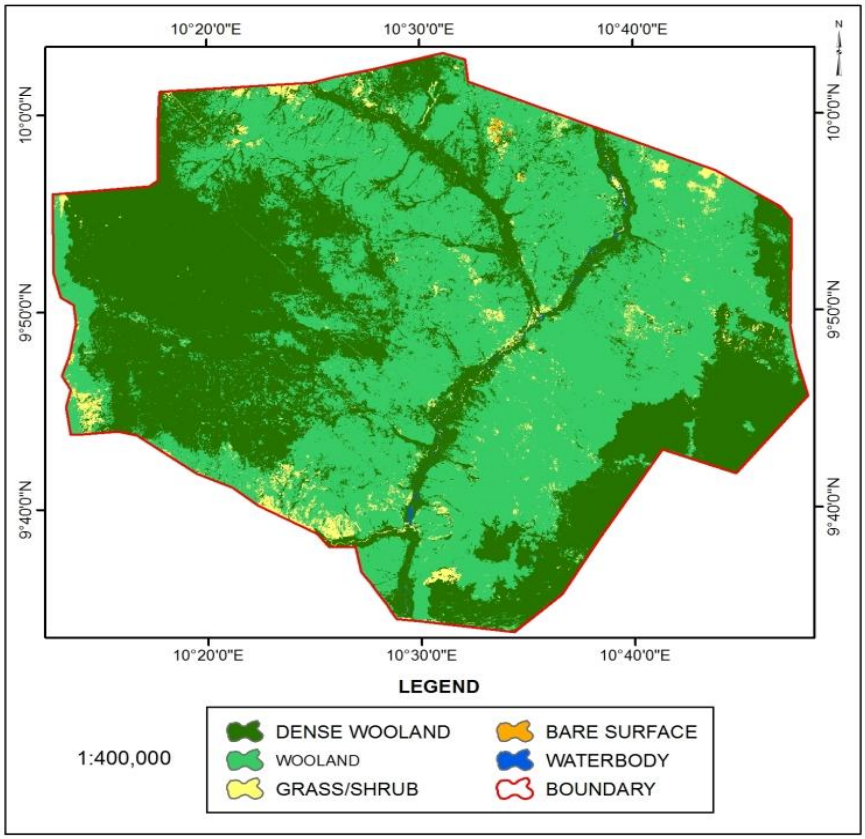


**Fig-2: Map of Yankari Game Reserve**

**Materials for the Study**

The following materials were used during the field work: -

- A dichotomous key to trees in savanna
- Flexible Measuring tape (100m)
- GPS (Model: GPSMAP 60CSX)
- Directional compass
- Hard cover notebook
- Calculator
- A laptop with spreadsheet and SPSS Version 16.0 program and software for geometric and radiometric image analysis

**Method of Data Collection**

The procedure for collecting data using above mentioned instruments was as follows:-

- A starting point was randomly selected avoiding edge area of vegetation in the site of study. A compass line (Imaginary line) was then selected from the starting point that led into the stands of the trees to be studied
- While standing at the starting point and sighting within an angle of 90$^o$, (45$^o$ on either side of the general compass line) the nearest tree (of not less than 10cm circumference) whose center lies within the inclusion angle was considered the first sampled tree.
- The species name was determined using the dichotomous key. In case of failure to properly name the species encountered, sample of leaves, flowers and fruits (where found) was collected and taken to Abubakar Tafawa Balewa University Bauchi herbarium for identification.
- Circumference (in cm) at breast height (CBH) of the tree; and distance from the starting point was also recorded.
- From the first tree sampled, sighting along the compass line again, the second nearest tree within the 90$^o$ inclusion angle was determined. The same parameters were again recorded.
- Step five was repeated several times thus wandering about until 100m of distance was covered while maintaining the same general compass direction.

**Method of Data Analysis**

Data from wandering quarter method was calculated using the following formulae [36]: -

(1) Calculating Relative Density of each species

Relative Density= Number of Individuals of a species / Total number of trees counted x 100

(2) Calculating Percentage Frequency

Number of points a species occurred over total number of points sampled (5) x 100

(3) Calculating Basal area of each tree

Basal area= $\pi$ $(r)^2$. But r= circumference at breast height/ $2\pi$

(4) Calculating basal area of each species
Total the basal area of trees of the same species

(5) Calculating basal area for all species
Total the basal area of all species encountered

(6) Calculating relative dominance
Relative dominance= Basal area per species/ Total basal area of all species x 100

(7) Calculating IVI of each species
IVI= Relative density+ relative dominance

(8) Calculating mean distance ($d_m$) between trees (in metres)
$d_m$ = sum of all distances/ number of distance measurements

(9) Calculating the mean area (MA) of all trees
MA= $(d_m)^2$

(10) Calculating density (D) of all trees (in trunk) per unit area
D= A/MA (where A= unit area i.e. a hectare, which is 10,000$m^2$)
Thus D= 10,000$m^2$ /MA which gives density of trees in trunk per hectare.
This quantified number of trees per hectare of land

## RESULTS

### Species Identified in the Two PAs

Total of 53 species (Table-1) where encountered in GGNP belonging to 33 different families, whereas only 22 species of Trees (Table-2) were observed in YGR belonging to 9 families.

### Basal Area and Percentage Frequency of Species Analyzed

In GGNP (Table-3), the highest basal area recorded was 34,552.6cm on *Uapaca togoensis* with the lowest value of 9.1cm on *Grewia mollis* whereas in YGR (Table-4), the record of highest value (25, 598.2 cm) was on *Khaya senegalensis* with lowest records of 8.1cm each on *Dichrostachys cinerea* and *Feretia apodanthera*. The results of percentage frequency in GGNP (Table-3) revealed highest value of 60% on four species namely *Combretum nigricans*, *Crossopteryx febrifuga*, *Hymenocardia acida* and *Trichillia gilgiana* and the lowest value of 20% on 30 species (56.6%) of the species encountered in that PA. But YGR (Table-4) revealed the highest value of percentage frequency of 80% each on *Anogeissus leiocarpus*, *Combretum glutinosum* and *Combretum nigricans* with its lowest value of 20% on 16 species (72.7%) observed in the PA.

### Relative Density, Relative Dominance and Importance Value Index

Relative density values at GGNP (Table-5) had its highest value (8.2%) on *U.togoensis* and the lowest value (0.7%) recorded on 21 species (39.6%) encountered. However, YGR (Table 6) had the highest value (38.7 %) of same parameter on *Combretum nigricans* with a corresponding lowest value (1.3%) on 12 species (54.5%) 0bserved in the park.

Relative dominance values in GGNP had the highest record (27.4%) fell on *U. togoensis* and the lowest record (0.0%) was observed on 12 species (22.6%) of the PA. But YGR had the highest value (50.5%) on *Khaya senegalensis* with a corresponding lowest value (0.0%) on 5 species (22.7%) observed in the Game reserve. The importance value indices showed the highest record in GGNP on *U. togoensis* (35.6) and the lowest record (0.7) on 11 species (18.9%) of the PA. YNP showed its highest IVI record (51.8) on *Khaya senegalensis* and the lowest value (1.3) on 5 species (22.7%) in that PA

### Mean Distance, Mean Area and Density of Trees per Hectare

With respect to mean distance ($d_m$) between trees, GGNP recorded average of 3.4m against YGR that showed 6.2m from one tree to another. The mean area (MA)occupied by stand of a tree showed 11.6m in GGNP against 38.4m in YGR. The density of trees per hectare showed approximately 862 individual trees per hectare in GGNP while YGR showed only 260 stands of trees per hectare.

**Table 1: Tree Species inventoried in Gashaka-Gumti National Park (GGNP) in Nigeria in2018**

| Species | Family | Species | Family |
|---|---|---|---|
| *Albizia zygia zigia* (DC.) J.F. Macbride | Mimosoideae | *Lophira alata Banks* ex C.F. Gaertn | Ochnaceae |
| *Allophylus africanus* P. Beauv. | Sapindaceae | *Nauclea latifolia* Smith. | Rubiaceae |
| *Anacardium occidentale* L. | Anacardiaceae | *Nuxia congesta* R.Br.ex Fresen. | Stilbaceae |
| *Annona senegalensis* Pers. | Annonaceae | *Parinari excelsa* Sab | Chrysobalanaceae |
| *Anogeissus leiocarpus* (DC.) Guill. & Perr. | Combretaceae | *Parkia bicolor* A. Chev. | Fabaceae |
| *Afzelia africana* SM.ex Pers. | Caesalpinioideae | *Piper capensis* Linn.f. | Piperaceae |
| *Bombax costatum* Pellegr. & Vuillet. | Malvaceae | *Piliostigma thonningii* Schumach. | Fabaceae |
| *Brachystegia eurycoma* Harms. | Fabaceae | *Pseudocedrela Kotschyi* (schweinf.) Harms | Meliaceae |
| *Bridelia ferruginea* Benth. | Euphorbiaceae | *Psidium cattleianum* Afzel.ex Sabine. | Myrtaceae |
| *Bridelia speciosa* Mull. Arg. | Phyllanthaceae | *Rauwolfia vomitoria* Afzel. | Apocynaceae |
| *Carapa procera* DC. | Meliaceae | *Senna alata* (L.) Roxb. | Fabaceae |
| *Chrysobalanus icaco* L. | Chrysobanaceae | *Streospermum kunthianum* Chamn | Bignoniaceae |
| *Clausena anisata* (Wild.) Hook.f.ex Benth. | Rutaceae | *Strephonema monnii* Hook.f. | Combretaceae |
| *Coffea canephora* Pierre ex A. Froehner | Rubiaceae | *Strombosia pustulata* Oliv. | Olacaceae |
| *Cola gigantea* A. Chev. | Sterculiaceae | *Symphonia globulifera* L.f. | Clusiaceae |
| *Cola hispida* Brenan & Keay | Malvaceae | *Syzygium guineense* (Wild.) DC. | Myrtaceae |
| *Combretum nigricans* lepr. | Combretaceae | *Syzygium macrocarpum* Bahadur & R.C.Gaur | Myrtaceae |
| *Crossopteryx febrifuga* Afzel.ex G.Don | Rubiaceae | *Terminalia glaucescens* planch. | Combretaceae |
| *Daniellia oliveri* (Rolfe)Hutch. & Dalziel | Fabaceae | *Terminalia macroptera* Guill. & Perr. | Combretaceae |
| *Elaeis guineensis* Jacq | Arecaceae | *Terminalia superba* Engl. & Diels | Combretaceae |
| *Ficus thonningii* Blume | Moraceae | *Trichillia gilgiana* Harms. | Meliaceae |
| *Gardenia aqualla* Stap. & Hutch. | Rubiaceae | *Trema orientalis* (L.) Blume | Cannabaceae |
| *Grewia mollis* Juss. | Malvaceae | *Uapaca togoensis* Pax | Phyllanthaceae |
| *Hymenocardia acida* Tul. | Phyllanthaceae | *Vitellaria paradoxa* C.F. Gaertn | Sapotaceae |
| *Isolona campanulata* Engl. & Diels. | Annonaceae | *Vitex doniana* Sweet | Lamiaceae |
| *Khaya grandifoliola* C.DC. | Meliaceae | *Xymalos monospora* (Harv.) baill. | Monimiaceae |
| *Lannea schimperi* (Hochst.ex A. Rich.) Engl. | Macardiaceae | | |

**Table 2: Tree Species inventoried in Yankari Game Reserve (YGR) in Nigeria in 2018**

| Species | Family | Species | Family |
|---|---|---|---|
| *Anogeissus leiocarpus* (DC.) Guill. & Perr. | Combretaceae | *Gardenia sokotensis* Hutch. | Rubiaceae |
| *Bombax costatum*Pellegr. & Vuillet. | Malvaceae | *Guiera senegalensis* J.F. Gmel. | Combretacea |
| *Borassus aethiopum* Mart. | Arecaceae | *Khaya senegalensis* (desr.) A. Juss | Maliaceae |
| *Burkea africana* Hook. | Fabaceae | *Maerua angolensis* Dc. | Capparaceae |
| *Catunaregem nilotica* (stapf.) Tirveng. | Rubiaceae | *Mitragyna inermis* (Wild.) Kuntze | Rubiaceae |
| *Combretum glutinosum* Perr. & ex Dc. | Combretaceae | *Nauclea latifolia* Smith. | Rubiaceae |
| *Combretum molle* R.Br. ex G.Don | Combretaceae | *Prosopis africana*(Guill. & Perr.) Taub. | Fabaceae |
| *Combretum nigricans* lepr. | Combretaceae | *Pterocarpus erinaceous* Poir. | Fabaceae |
| *Commiphora africana*.(A.Rich.) Engl. | Burseraceae | *Terminalia avicennioides* Guill. & Perr. | Combretaceae |
| *Dichrostachys cinerea* (L.) Wight & Arn | Fabaceae | *Terminalia macroptera* Guill. & Perr. | Combretaceae |
| *Diniellia oliveri* (Rolfe.) Hutch. & Dalziel | Fabaceae | | |

**Table 3: Basal Area (BA) and percentage frequency of species measured in 2018 in GGNP in Nigeria**

| **Species** | **Basal Area (cm)** | **Frequency (%)** | **Species** | **Basal Area (cm)** | **Frequency (%)** |
|---|---|---|---|---|---|
| *Albizia zygia zigia* | 961.6 | 20 | *Lophira alata Banks* | 1946.8 | 20 |
| *Allophylus africanus* | 277.5 | 40 | *Nauclea latifolia* | 105.6 | 40 |
| *Anacardium occidentale* | 206.0 | 20 | *Nuxia congesta*. | 38.5 | 20 |
| *Annona senegalensis* | 162.8 | 40 | *Parinari excelsa* | 2171.9 | 40 |
| *Anogeissus leiocarpus*. | 248.7 | 40 | *Parkia bicolor* | 69.4 | 40 |
| *Afzelia africana* | 824.1 | 20 | *Piper capensis* | 12.6 | 20 |
| *Bombax costatum* . | 248.7 | 20 | *Piliostigma thonningii* | 346.2 | 40 |
| *Brachystegia eurycoma* | 1169.6 | 20 | *Pseudocedrela Kotschyi* | 60.8 | 20 |
| *Bridelia ferruginea* | 167.3 | 20 | *Psidium cattleianum*. | 26.4 | 20 |
| *Bridelia speciosa* | 102.0 | 20 | *Rauwolfia vomitoria* | 13.8 | 20 |
| *Carapa procera* | 116.8 | 20 | *Senna alata*. | 16.6 | 20 |
| *Chrysobalanus icaco*. | 283.4 | 20 | *Streospermum kunthianum* | 113.0 | 20 |
| *Clausena anisata*. | 589.3 | 40 | *Strephonema monnii* | 38.5 | 20 |
| *Coffea canephora* | 84.9 | 40 | *Strombosia pustulata*. | 803.8 | 20 |
| *Cola gigantea* | 4849.7 | 20 | *Symphonia globulifera* | 393.9 | 40 |
| *Cola hispida* | 1231.0 | 20 | *Syzygium guineense* | 120.7 | 20 |
| *Combretum nigricans* | 2426.7 | 60 | *Syzygium macrocarpum* | 1978.2 | 40 |
| *Crossopteryx febrifuga* | 32925.3 | 60 | *Terminalia glaucescens* | 1719.3 | 40 |
| *Daniellia oliveri* | 16824.9 | 40 | *Terminalia macroptera* | 1719.3 | 40 |
| *Elaeis guineensis* | 624.3 | 20 | *Terminalia superba* | 4534.2 | 40 |
| *Ficus thonningii* | 116.8 | 20 | *Trichillia gilgiana*. | 1424.6 | 60 |
| *Gardenia aqualla*. | 50.2 | 20 | *Trema orientalis* | 697.1 | 20 |
| *Grewia mollis* Juss. | 9.1 | 20 | *Uapaca togoensis* | 34552.6 | 40 |
| *Hymenocardia acida* | 6190.1 | 60 | *Vitellaria paradoxa* | 32.2 | 20 |
| *Isolona campanulata* | 45.3 | 20 | *Vitex doniana* t | 1206.3 | 40 |
| *Khaya grandifoliola*. | 58.1 | 20 | *Xymalos monospora* | 132.7 | 40 |
| *Lannea schimperi* | 950.7 | 40 | | | |

**Table 4: Basal Area (BA) and percentage frequency of species measured in 2018 in YGR in Nigeria**

| Species | Basal Area (cm) | Frequency (%) | Species | Basal Area (cm) | Frequency (%) |
|---|---|---|---|---|---|
| *Anogeissus leiocarpus*. | 2743.7 | 80 | *Feretia apodanthera* | 8.1 | 20 |
| *Bombax costatum* | 624.3 | 20 | *Gardenia sokotensis* . | 31.0 | 20 |
| *Borassus aethiopum* | 998.2 | 20 | *Guiera senegalensis* | 9.6 | 20 |
| *Burkea africana* | 616.3 | 20 | *Khaya senegalensis* | 25598.2 | 20 |
| *Catunaregem nilotica* | 8.8 | 20 | *Maerua angolensis* | 28.8 | 20 |
| *Combretum glutinosum*. | 479.5 | 80 | *Mitragyna inermis* | 1023.7 | 20 |
| *Combretum molle* | 95.8 | 40 | *Nauclea latifolia* | 153.9 | 20 |
| *Combretum nigricans* | 892.5 | 80 | *Prosopis africana* | 93.6 | 20 |
| *Commiphora africana*. | 8.2 | 20 | *Pterocarpus erinaceous* . | 2019.0 | 60 |
| *Dichrostachys cinerea* | 8.1 | 20 | *Terminalia avicennioides* | 667.2 | 20 |
| *Diniellia oliveri* | 12666.3 | 40 | *Terminalia macroptera* | 1877.6 | 20 |

**Table 5: Relative Density, Relative Dominance and Importance Value Indices of species in inventoried in 2018 in GGNP in Nigeria**

| Species | Relative Density | Relative Dominance | Importance Value Indices |
|---|---|---|---|
| *Albizia zygia zigia* (DC.) J.F. Macbride | 0.7 | 0.8 | 1.5 |
| *Allophylus africanus* P. Beauv. | 2.0 | 0.2 | 2.2 |
| *Anacardium occidentale* L. | 0.7 | 0.2 | 0.9 |
| *Annona senegalensis* Pers. | 2.0 | 0.1 | 2.1 |
| *Anogeissus leiocarpus* (DC.) Guill. & Perr. | 1.4 | 0.1 | 1.6 |
| *Afzelia africana* SM.ex Pers. | 0.7 | 0.7 | 1.4 |
| *Bombax costatum* Pellegr. & Vuillet. | 0.7 | 0.2 | 0.9 |
| *Brachystegia eurycoma* Harms. | 2.7 | 0.9 | 3.6 |
| *Bridelia ferruginea* Benth. | 0.7 | 0.1 | 0.8 |
| *Bridelia speciosa* Mull. Arg. | 1.4 | 0.1 | 1.5 |
| *Carapa procera* DC. | 1.4 | 0.1 | 1.5 |
| *Chrysobalanus icaco* L. | 0.7 | 0.2 | 0.9 |
| *Clausena anisata* (Wild.) Hook.f.ex Benth. | 1.4 | 0.5 | 1.9 |
| *Coffea canephora* Pierre ex A. Froehner | 1.4 | 0.1 | 1.5 |
| *Cola gigantea* A. Chev. | 5.5 | 3.8 | 9.3 |
| *Cola hispida* Brenan & Keay | 2.0 | 1.0 | 3.0 |
| *Combretum nigricans* lepr. | 2.0 | 1.9 | 3.9 |
| *Crossopteryx febrifuga* Afzel.ex G.Don | 5.5 | 26.1 | 31.6 |
| *Daniellia oliveri* (Rolfe)Hutch. & Dalziel | 4.1 | 13.4 | 17.5 |
| *Elaeis guineensis* Jacq | 0.7 | 0.5 | 1.2 |
| *Ficus thonningii* Blume | 0.7 | 0.1 | 0.8 |
| *Gardenia aqualla* Stap. & Hutch. | 0.7 | 0.0 | 0.7 |
| *Grewia mollis* Juss. | 0.7 | 0.0 | 0.7 |
| *Hymenocardia acida* Tul. | 6.1 | 4.9 | 11.0 |
| *Isolona campanulata* Engl. & Diels. | 1.4 | 0.0 | 1.4 |
| *Khaya grandifoliola* C.DC. | 0.7 | 0.0 | 0.7 |
| *Lannea schimperi* (Hochst.ex A. Rich.) Engl. | 2.0 | 0.8 | 2.8 |
| *Lophira alata Banks* ex C.F. Gaertn | 1.4 | 1.5 | 2.9 |
| *Nauclea latifolia* Smith. | 2.0 | 0.1 | 2.1 |
| *Nuxia congesta* R.Br.ex Fresen. | 1.4 | 0.0 | 1.4 |
| *Parinari excelsa* Sab | 1.4 | 1.7 | 3.1 |
| *Parkia bicolor* A. Chev. | 1.4 | 0.1 | 1.5 |
| *Piper capensis* Linn.f. | 0.7 | 0.0 | 0.7 |
| *Piliostigma thonningii* Schumach. | 1.4 | 0.3 | 1.7 |
| *Pseudocedrela Kotschyi* (schweinf.) Harms | 0.7 | 0.0 | 0.7 |
| *Psidium cattleianum* Afzel.ex Sabine. | 0.7 | 0.0 | 0.7 |
| *Rauwolfia vomitoria* Afzel. | 0.7 | 0.0 | 0.7 |
| *Senna alata* (L.) Roxb. | 0.7 | 0.0 | 0.7 |
| *Streospermum kunthianum* Chamn | 0.7 | 0.1 | 0.8 |

| | | | |
|---|---|---|---|
| *Strephonema monnii* Hook.f. | 0.7 | 0.0 | 0.7 |
| *Strombosia pustulata* Oliv. | 4.1 | 0.6 | 4.7 |
| *Symphonia globulifera* L.f. | 1.4 | 0.3 | 1.7 |
| *Syzygium guineense* (Wild.) DC. | 0.7 | 0.1 | 6.8 |
| *Syzygium macrocarpum* Bahadur & R.C.Gaur | 4.7 | 1.6 | 6.3 |
| *Terminalia glaucescens* planch. | 2.6 | 1.4 | 4.0 |
| *Terminalia macroptera* Guill. & Perr. | 1.4 | 1.4 | 2.8 |
| *Terminalia superba* Engl. & Diels | 2.0 | 3.7 | 5.7 |
| *Trichillia gilgiana* Harms. | 3.4 | 1.1 | 4.5 |
| *Trema orientalis* (L.) Blume | 4.1 | 0.6 | 4.7 |
| *Uapaca togoensis* Pax | 8.2 | 27.4 | 35.6 |
| *Vitellaria paradoxa* C.F. Gaertn | 0.7 | 0.0 | 0.7 |
| *Vitex doniana* Sweet | 1.4 | 1.0 | 2.4 |
| *Xymalos monospora* (Harv.) baill. | 1.4 | 0.1 | 1.5 |

**Table 6: Relative Density, Relative Dominance and Importance Value Indices of species in inventoried in 2018 in YGR in Nigeria**

| Species | Relative Density | Relative Dominance | Importance Value Indices |
|---|---|---|---|
| *Anogeissus leiocarpus* (DC.) Guill. & Perr. | 10.0 | 5.4 | 15.4 |
| *Bombax costatum* Pellegr. & Vuillet. | 1.3 | 1.2 | 2.5 |
| *Borassus aethiopum* Mart. | 1.3 | 2.0 | 3.3 |
| *Burkea africana* Hook. | 1.3 | 1.2 | 2.5 |
| *Catunaregem nilotica* (stapf.) Tirveng. | 1.3 | 0.0 | 1.3 |
| *Combretum glutinosum* Perr. & ex Dc. | 11.3 | 0.9 | 12.2 |
| *Combretum molle* R.Br. ex G.Don | 3.7 | 0.2 | 3.9 |
| *Combretum nigricans* lepr. | 38.7 | 1.8 | 40.5 |
| *Commiphora africana*. (A.Rich.) Engl. | 1.3 | 0.0 | 1.3 |
| *Dichrostachys cinerea* (L.) Wight & Arn | 1.3 | 0.0 | 1.3 |
| *Diniellia oliveri* (Rolfe.) Hutch. & Dalziel | 2.4 | 25.0 | 27.4 |
| *Feretia apodanthera* Del. | 1.3 | 0.0 | 1.3 |
| *Gardenia sokotensis* Hutch. | 2.4 | 0.1 | 2.5 |
| *Guiera senegalensis* J.F. Gmel. | 1.3 | 0.0 | 1.3 |
| *Khaya senegalensis* (desr.) A. Juss | 1.3 | 50.5 | 51.8 |
| *Maerua angolensis* Dc. | 1.3 | 0.1 | 1.4 |
| *Mitragyna inermis* (Wild.) Kuntze | 3.7 | 2.0 | 5.7 |
| *Nauclea latifolia* Smith. | 1.3 | 0.3 | 1.6 |
| *Prosopis africana* (Guill. & Perr.) Taub. | 1.3 | 0.2 | 1.5 |
| *Pterocarpus erinaceous* Poir. | 7.4 | 4.0 | 11.4 |
| *Terminalia avicennioides* Guill. & Perr. | 2.4 | 1.3 | 3.7 |
| *Terminalia macroptera* Guill. & Perr. | 2.4 | 3.8 | 6.2 |

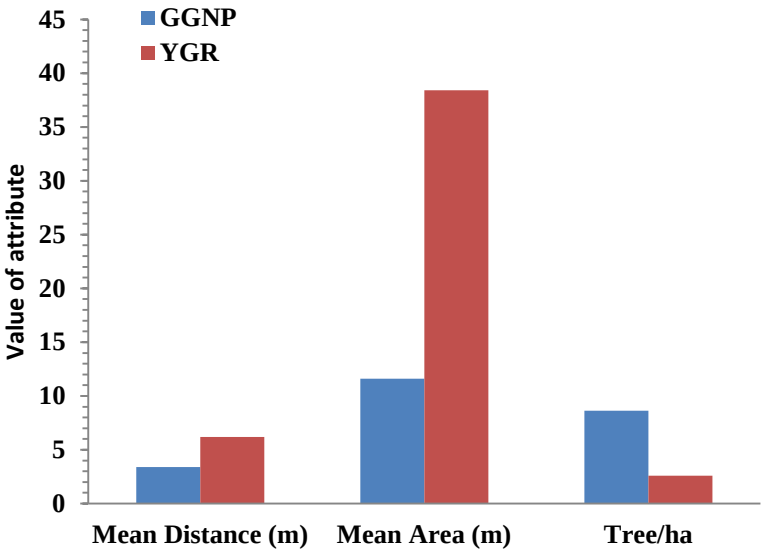


**Figure 3: Mean distance, mean area and density of trees per hectare at the two game reserves inventoried in 2018 in Nigeria (Note: Tree/ha should be multiplied by 100)**

## DISCUSSION

### Species Identified

The species diversity of GGNP having 53 species stood well over YGR with 22 species. This indicated that the management approach of national park is better than that of Game reserve since the two PAs are in the same dry region of Sudan savannah vegetation zone which is characterized by dry and wet seasons [30, 34] which, invariably, should not have shown this wide difference except for a good management approach. This concord with the findings of Umar *et al*., [37] which revealed better staff, better staff training and better logistics in managing GGNP than what was obtained in YGR. However, the predominant species with the highest percentage frequencies (60-80%) in both PAs belongs to Combretaceae family among others, which further proves the similarity in vegetation zone of the two PAs.

### Relative Density, Relative Dominance, and Importance Value Index

Due to the high species diversity of GGNP, a factor attributed to good management approach, the highest records of relative density was 8.2% on *Uapaca togoensis* as against 38.7% recorded at YGR on *Combratu nigricans*. This low value of 8.2% relative density, yet ranked the highest in GGNP can be attributed to the high species density of national park over the Game reserve and the high record of same parameter (38.7%) in YGR an attestation to the low species of a Game reserve.

On relative dominance, the trend followed same where its highest value at GGNP was 27.4% on *Uapaca togoensis* while YGR had its highest record of 50.5% was on *Khaya senegalensis*. The same reason may be attributed to this trend in the relative dominance of these PAs. It will therefore, undoubtedly, follow same with the importance value indices since it is the sum of relative density and relative dominance. GGNP had its highest IVI (35.6) on *Uapaca togoensis* while YGR recorded its highest value (51.8) on *Khaya senegalensi*.

From the IVI values, the vegetation of GGNP can be described as *Uapaca-Crossopteryx-Danielli* complex whereas that of YGR can be described as *Kyaya-Combretum-Danielli* type of vegetation. The explanation for the change of *Combretum spp* in GGNP by *Uapaca spp* may not be unconnected with the proximity of GGNP to the plateau of Mambila where the vegetation is that of a Guinea savannah as against the Sudan savannah of the study areas

### Mean Distance, Mean Area and Density of Trees per Hectare

Other measures that clearly differentiated the effectiveness of management techniques of the two PAs are the Mean Distance, Mean Area and Density of Trees per Hectare. While GGNP has a mean distance between trees standing at 3.4m, that of YGR recorded 6.2m. This clearly speaks volume on how far apart are the Trees of YGR as against that of GGNP.

It is not different with the mean area which signifies a mean space occupied by each tree in each of the study area. The lower the value, the more populated the area with tree stands. GGNP recorded 11.6m as mean area against 38.4m in YGR.

Density of tree per hectare said it all where GGNP indicated a staggering 862 individual trees per hectare as against 260 individual trees per same space

in YGR, which agreed with the findings of Umar [38] who reported 207-775 individual trees per hectare in eight different locations of YGR. This great difference in population of trees per hectare between the two PAs can be attributed to the better management approach of national parks over Game reserves.

## CONCLUSION

From the forgoing discussions, the analyzed parameters of GGNP and YGR vegetations indicated better conservation in the former than the later. It is therefore logical to conclude that national parks have better management techniques over Game reserves in terms of forest resources conservation in the dry region of north east Nigeria.

### Recommendations

In view of this, the following recommendations are suggested:-

- All the Game reserves in the north east geopolitical zone should be upgraded to national parks so as to enjoy better management approach
- If the above will not be feasible, then some prominent Game reserves be selected and upgraded to the status of national park so as to enjoy the better management approach of national parks which are directly under the federal government for better conservation and sustainable development of the remaining forest resources of this geopolitical zone
- Another alternative is to create a supervisory body under the office of the conservator general of the federation to monitor and impose strict compliance to the standards of national parks management approaches by the state Game reserves so as to improve their management techniques

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