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Quantitative Analysis of Tree Species Composition and Diversity in Gashaka Gumti National Park Nigeria

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ABSTRACT

Quantitative analysis of tree species composition and diversity was investigated. Stratified sampling technique was employed. In each stratum, five (5) plots of 50m x 50m in size were laid alternately at an interval of 50 m along each transect. Tree variables were measured and recorded while other variables used in these studies computed from the measured tree parameters. The result shows that Parinari excelsa has the highest number of trees (199), while Entada africana has the least frequency of trees (4). In terms of species stand density, an average stand density of 54.96 and 22.11trees/ha was recorded in the LD and HD. The characterization of the species into tree dbh class shows that almost 386 trees and 137 trees has reached diameter limit (dbh > 30 cm) in the LD and LD study sites respectively, while, 988 trees and 460 trees are still below girth limit (dbh < 30 cm) in the two study sites. The species diversity obtained was 2.813 and 2.987, with evenness values of 0.874 and 0.896 in LD and HD sites respectively. Conclusively, the finding revealed a great significant difference in terms of composition, stock density and diversity of tree species in the two study sites.

Keywords: *Quantitative, Species Composition, Parameters, Species Diversity.*

INTRODUCTION

Tree species diversity and composition in an area depends on environmental factors, such as temperature, humidity, nutrition, sunlight, topography, bedrock geology, soil characteristics, canopy structure and land use history. Tropical rain forests are the most important plant species diversity centers in the world (Turner, 2004). These forests are the richest biological communities on earth and have been recognized to harbor a significant proportion of global biodiversity (Myers *et al.*, 2000; Baraloto *et al.*, 2013). The forests provide many ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals (Armenteras *et al.*, 2009). The world tropical forests are interestingly diverse; they contain the vast majority of plants and animals and have high genetic resources because of variation in elevation, climate and soil ranging from the steamy jungles of the rain forests to the dry forests and savannas. More than 2.5 million people live in areas adjacent to forests. They rely on forest for their water, fuel wood and other resources (Gebrehiwot, 2003). Biotic factors such as seed quality, seedling survivorship, and recruitment are important in maintaining the tree diversity and composition of tropical forests (Naidu and Kumar, 2016).

Gashaka Gumti National Park vegetation in Nigeria is one of the most endowed tropical forest in Africa, containing almost all the vegetation types that exist in Nigeria and other African countries and widely distributed in different zones of the park. Nigeria harbors about 7,895 species of plant dominated by tree species; and this makes it one of the richest countries in the continent in terms of biodiversity (Ayodele and Yang, 2012). However, ecosystem degradation proceeds at alarming rates in many parts of Nigeria, including some protected areas which are meant to be conserved (Gumnior and Sommer, 2012). Ladipo (2010) indicated that nearly 90 % of rainforests in Nigeria has been cleared as at 2006. This clearance is not restricted to the forests alone, as all habitats are under threat from civilization and other unsustainable human

activities. The careless attitude of the populace and high rate of poverty in the country has also resulted in this heavy loss (Ayodele and Yang, 2012).

Tropical forests are disappearing at alarming rates worldwide, reducing annually by 14% of their current area (Naidu and Kumar, 2016). Also relatively increased anthropogenic pressures had led to agricultural expansion and overgrazing of livestock (Anitha *et al.*, 2010). Over exploitation of forest products was noted to reduce soil aggregate stability index, porosity, humidity, vegetation cover and litter quantity. Demolished vegetation cover not only exposes soil to erosion, but also decreases soil stability and resistance (Mapfumo *et al*., 2000). Constant exploitation of forest resources in general induces hemispherical growth forms, resulting in small bonsai-type shrubs and trees with unusual shapes and forms. These species protect the soil below them from erosion and also accumulate litter, seeds and soil particles, acting as a sink and generating patches of soil fertility.

Human impact has to varying degrees, led to a reduction in biodiversity in much of the forested area, and conservation of such forests requires an understanding of the composition of the particular forest. In order to understand the phyto-sociological structure of the gazzetted park there is, therefore needs to understand the distribution, girth classes, associations among species, patterns of dispersion and various indices of diversity of such individual plant species. The study aims to analyze tree species composition and diversity quantitatively in Gashaka Gumti National Park.

MATERIALS AND METHODS

Study Area

The experiment was conducted in Gashaka Gumti National Park (GGNP), the park lies between latitude 06^0 35' and $08^0$19' North and longitudes 10^0 51' and 12^0 14' East (Fig. 1) Ecologically, the park bears many similarities with Nigeria's southern regions (Dunn, 1993).

In general, GGNP is broadly characteristic as one of the Guinea savanna zone of Nigeria. the climate of the park differs from most other central habitats because of its prolonged and marked dry season. The rainy season commences in March or early April to mid-November while, the dry season starts from November to March with very little or no rainfall. Rainfall ranges from 1200 mm in the North to early 3000 mm in the South of the park. The park consists of seven habitat types (Lowland gallery forest, Riverine or Riparian forest, Montane forest, Derived savanna, Southern and Northern guinea savanna and Montane grassland). The Northern sector (Gumti) is more of woodland, characterized by tall grasses and trees with usually short boles and broad leaves (Dunn, 1993). Some of the commonly tree species found in the Northern sector, as reported by Chapman (1993) and Akinsoji (1996) includes: *Acacia spp*., *Afzelia africana, Khaya senegalensis, Danielia oliverii, Isoberlinia doka* and *Vitelleria paradoxa*. While those in the southern (Gashaka) sector, include: *Albizia gummifera, Afzelia africana, Symphonia globulifera, Malletia spp., Triplochiton schleroxylon* and *Aubrevillea kerstingii*. Trees are often engulfed by woody climbers that are a substantial food source for primates.

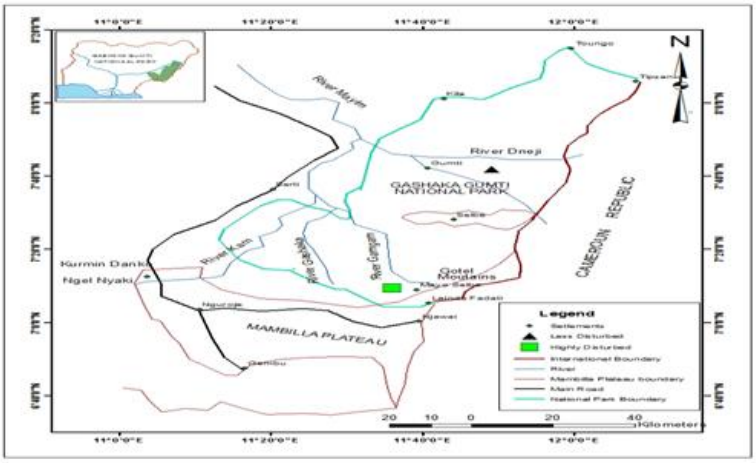

Figure 1: Map of Gashaka Gumti National Park Showing the Study the Area
Source; Warren, 2004

Data Collection

The study area was stratified into two strata[Less Disturbed (LD) and Highly Disturbed (HD)]. In each stratum, two (2) transects of 450m in length was laid along each transect, Five (5) plots of 50 × 50 m in size were laid in each of the transect alternately at an interval of 50m., In each plot, the number of trees were enumerated and the species names were recorded according to the International Plant Nomenclature Index (IPNI, 2008). In addition, the tree diameter at breast height was measured at 1.3 m above the ground level. Crown area and total height of trees encountered were also measured.

Tree Species Composition

The tree species composition were measured in terms of Density, Basal area, canopy closure and Volume, using equation 1, 2, 3 and 4 respectively.

Density of a species =

$$\frac{\text{Total number of individuals of a species}}{\text{Sample size in hectares}} \ldots \quad (1)$$

$$BA = \pi D^2/4 \ldots \quad (2)$$

$$\text{CC} = \pi(D_1 + D_2)^2/4 \ldots \quad (3)$$

$$V = BA \times H \ldots \quad (4)$$

Where:

V = Volume

π = Constant

H = Height

D = Diameter of Trees

D_1 and D_2 = Horizontal and Perpendicular Diameter

BA = Basal Area

CC = Crown Cover

Analysis of Species Diversity

Shannon Wienner Index (H), Equation (5) was used to estimate the species diversity in the study area, while student t-test (Equation 6.) was used to compare the diversity in the two sites.

$$(H) = -\sum P_i \ln (P_i) \ldots \quad (5)$$

Where:

P_i = Proportion of the total number of trees belonging to species i

Ln = Natural logarithm

$$t = \frac{\bar{X}_A - \bar{X}_B}{\sqrt{S_P\left(\frac{1}{n_A} - \frac{1}{n_B}\right)}} \ldots \quad (6)$$

Where:

t = Student t-test

n = Number of observation

$\bar{X}_A$ = Mean of observation A

$\bar{X}_B$ = Mean of Observation B

S_P = Pooled variance

RESULTS

Tree Species Composition in the Study Area

A total of fifty-two (52) tree species were identified in all the ten laid sampled plots, out of which, twenty five and twenty seven species belonging to different families were identified in less disturb (LD) and highly disturbed (HD) area respectively (Figure 2). The result shows that *Parinari excelsa* has the highest number of trees (199), this was followed by *Uapaca togoensis* with (162) trees, while, *Entada africana* has the least number of trees (4) in the less disturbed area (Figure 3). On the other hand (Figure 4) *Parinari excelsa* had the highest number of tree species (96), this was followed by *Terminalia glancosens* with 55 trees, while, *Entada africana* has the least number of trees (2) in the highly disturbed area. This shows that both *Parinari excelsa* and *Entada africana* are the most prominent trees in the study areas.

The results (Table 1) on species density revealed that the average stand density of 54.96 and 22.11trees/ha was recorded in the less and highly disturbed area of the study sites respectively. The characterization of the species into tree diameter class (Figure 5.) shows that almost 386 and 137 trees has reached diameter girth limit (dbh >30 cm) in the LD and HD study sites respectively, while, 988 and 460 trees are still below girth limit (dbh < 30 cm) in the LD and HD respectively. The distribution of tree species in the two study sites was negatively skewed towards the lower diameter class, also, the less disturbed area exhibit a leptokurtic curve (High peakedness) as against the mesokurtic (Low peakedness) curve exhibited in the highly disturbed area (Figure 5). In addition, in the less disturbed area, the highest frequency of trees (586) fell into diameter class 11–20 cm, this was followed by diameter class 21-30 and 31-40 with 380 and 197 trees respectively, while in the highly disturbed area, the highest number of trees (282) fell in the dbh class 11-20cm and

the least number of trees (8) felled in the dbh class greater than 60 cm.

An average basal area of 7.071 m^2/ha was recorded in Less Disturbed site, while that of the highly disturbed area was 4.127m^2/ha (Appendix 2). The results (Table 2) on the species volume revealed that Less Disturbed site has an average volume of 173.176 m^3/ha, while that of highly disturbed site was34.810 m^3/ha.

Table1. *Mean Density of Tree Species in the two Sites*

Site	Number of Specie	Density of Trees per Hectare	Mean Density
Less disturbed	25	1,374	54.96
Highly disturbed	27	597	22.11

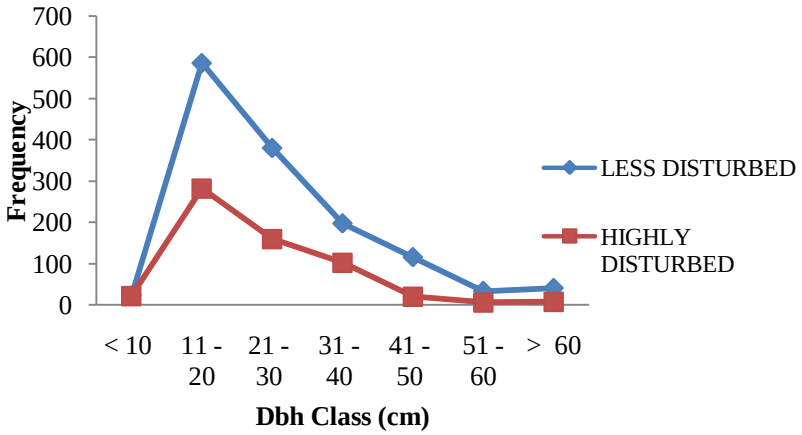

Figure3. *Diameter Curve Distribution of Stand Density*

Table2. *Diameter Distribution for Tree Height, Per Tree and Class Volume of the Study Area*

Dbh Class (cm)	Mid-class	No. of Trees	Average Height (m)	Average Basal Area (m^2/ha)	Per Tree Volume (m^3/ha)	Class Volume (m^3/ha)
L Less disturbed						
< 10	5	22	3.54	0.001	0.006	0.152
11-20	15.5	586	7.92	0.018	0.149	87.651
21-30	25.5	380	10.90	0.051	0.556	211.561
31-40	35.5	197	13.80	0.098	1.366	269.121
41-50	45.5	115	16.20	0.162	2.634	302.957
51-60	55.5	33	18.16	0.241	4.393	144.997
>60	56.5	40	19.52	0.250	4.894	195.786
Mean		196.1	12.86	0.118	2.000	173.175
H **Highly disturbed**						
< 10	5	21	2.40	0.001	0.004	0.098
11-20	15.5	282	5.27	0.018	0.099	28.045
21-30	25.5	159	7.28	0.051	0.371	59.122
31-40	35.5	102	9.97	0.098	0.986	100.669
41-50	45.5	20	12.93	0.162	2.102	42.053
51-60	55.5	6	6.73	0.241	1.628	9.770
>60	56.5	8	1.95	0.250	0.488	3.911
Mean		85.4	6.64	0.118	0.811	34.810

Tree Species Diversity

The results (Table 3) on the tree species diversity encountered in the study sites showed that species richness in Less Disturbed site was 25 while, that of Highly Disturbed site were 27. Whereas, Shannon's diversity indices were 2.813 and 2.987 in Less Disturbed and Highly Disturbed site respectively, while their corresponding evenness values were 0.874 and 0.896 respectively.

The paired t-test conducted shows a significant difference ($p < 0.05$) between the two study sites (Table 4.) This may be due to the anthropogenic effect in the disturbed area.

Table3. *Diversity Indices of the Study Sites*

Site	Species Richness	Shannon' Evenness	Shannon' Diversity
Less Disturbed	25	0.874	2.813
Highly Disturbed	27	0.896	2.987

Source: *Field Survey, 2016*

Table4. *Paired sample Test for Comparing the Species Diversity Index*

Site	No. of observation	Mean Difference	Standard deviation	Standard error	t-Cal	t-Tab
Less disturbed	25	0.1125	0.0765	0.0153	7.354	2.011*
Highly disturbed	27	0.1103	0.6634	0.0122		

*****Significant*

DISCUSSION

Woody Species Compositions in the Study Area

From clear indications, the study shows that the stocking density in terms of number of trees, Basal Area and Volume in the less disturbed is more than that of the highly disturbed, area due to the closeness of the villages to the buffer zone in the area. Similar reports were made by several authors (Khera *et al.*, 2001; Attua and Pabi 2013; Naidu and Kumar, 2016; Markum *et al.*, 2013) in the tropical forest, that most tree species are disappearing at unprecedented rate human activities. According to Akinsoji *et al.* (2016), who also reported that, the decrease in the ecosystems of GGNP was due to the use of the species by the inhabitant of the park for their survival. This results is also in conformity with Hejda *et al.*, (2009) that reported an approximately 90 % decreases in species numbers per plot at the buffer zones of protected areas come from human disturbances.

The basal area results of the study area were relatively lower than those obtained by Mialla (2002) and Kijazi (2007), who had a basal area of 69.3m^2ha^{-1} and having 42.096m^2/ha^{-1} all in Tanzania. The differences in the basal area of tree species among the study sites may be due to differences in altitude, species composition, age of trees, and extent of disturbances and succession strategies of the stands (Naidu and Kumar, 2016).

The high volume of tree stand and average height as well as crown cover of tree species in the study area implies high tree species distribution, growth and functions in less disturbed site thereby giving rise to high density. This could be attributed to the absence of disturbance activities in the site which increase carbon and nutrient cycles. This agreed with Adekunle *et al.*, *(*2013) that assessment of stand volume is important indicator in evaluation of the forest ecosystem productivity especially the current increased consumption of bio-energy obtained from forests. On the contrary, the low tree species volume, distribution, growth and functions in highly disturbed site could be attributed to increased deforestation which results in reduced infiltration, accelerated runoff and soil erosion. This result is in conformity with Azarniv *et al.*, (2011) who reported that deforestation as a driver responsible for decrease in soil humidity, low microbial activities due to anthropogenic activities at the buffer zones.

Species Diversity in the Study Area

Biodiversity indices are generated to bring the diversity of species in different habitats to a similar scale for comparison and the higher the value, the greater the species richness. The tree species diversity index value (2.813) and (2.918) obtained in less and highly disturbed area of the study site respectively were a relatively higher than that obtained by Saka et al,. (2013) in which a lower diversity index value (2.613) was reported in a study carried out in Girei Local Government Area of Adamawa State. This indicated that, in terms of species abundances, GGNP in Taraba State is fully enriched with many different species than Adamawa State; these variations in species abundant may be due to climatic or environmental factors existing in the two States. This result also agreed with that of Skarpe and Hester (2008) who enunciated that high disturbances can have a profound influence on the physiognomy, composition and function of tree species from the landscape scale to a single plant.

The higher values of the diversity indices revealed a forest with high tree species diversity (Adekunle *et al.*, 2013). The tree species richness in the tropics showed a wide variation, ranging from a low value of (20 species/ha) in Ngovayang's lowland forests in Cameroun (Gonmadje *et al.*, 2011) to a very high (307

species/ha) in Amazonia Equadar (Naidu and Kumar, 2016). The study area had been one among the tropical forest that fall within the low value; this development could be connected to the disturbances history of the study area. Shannon diversity index values observed in the two study sites fall within the range (0.70 - 36.57) reported for other dry forests of the savanna woodland region (Obiri *et al.*, 2002; Venter and Witkowski, 2010 and Ihuma *et al.*, 2011.

CONCLUSION

The study revealed a great differences in terms of tree species composition between the less and highly disturbed sites. The Less disturbed site had the highest stock density (basal area, volume and crown cover) as compared to highly disturbed site. The fast growths and normal functions of tree species that had resulted to the higher density implies good soil quality, water and favorable weather conditions which mean less human disturbances. It was also noticed that diversity indices in the highly disturbed site were higher than less disturbed site. If the buffer zones can be managed sustainably, these will increase the diversity of tree species in the area which can enhanced increase in productivity of these species and other resources within the area.

Conclusively, Anthropogenic activities had clearly shown substantial impacts on trees, most especially in Gashaka Gumti National Park by reducing trees and stuck density and crown cover thereby leading to more open and simplified structures at the buffer zones of the park. The difference in density and composition of the two studied sites arise out of differences in their disturbance regimes and microclimatic conditions.

RECOMMENDATIONS

Based on the outcome of the research findings, the following recommendations are hereby proffered:

- Government and other concerned stakeholders especially Non Governmental Organizations should embark on intensive and extensive enlightenment campaigns on the negative impacts of human disturbances.
- Government should formulate and implement policies that will ensure the sustainability of tree species and other natural resources in the park and other protected areas.
- Conservation strategies to protect tree species against anthropogenic factors like protection from the frequency and intensity of disturbance, especially indiscriminate felling and bushfires should be taken to increase the diversity of rare species.

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