Assessment of Woody Species Diversity in Different Ecological Zones of Taraba State, Nigeria: A Strategy for Conservation

Abstract

This study assessed woody species diversity in different ecological zones of Taraba State. The objectives were to determine the abundance, distribution and comparison of woody species diversity in order to protect and monitor the forest ecosystems. Data were obtained through woody species survey and the study area was stratified into three ecological zones and two protected areas. 5 plots each measuring 50×50 m were sampled in each protected area and 2 urred in the plots were also sampled. Data were analyzed using descriptive and inferential statistics such as Tables, frequency, ANOVA and LSD. A total of 3760 individual woody stands from 60, 34 and 32 species in Montane Forest, Southern and Northern Guinea Savanna respectively were recorded. Ngel Nyaki Forest Reserve had the highest species richness value (49) followed by Wasaji Forest Reserve (26) while Gashaka Gumti National Park had the lowest value (13). The Shannon diversity index of woody species in the protected areas were 2.955, 2.897, 2.480, 2.201, 2.462, 2.480 and 2.525 in Ngel Nyaki, Wasaji, Baissa, Jen Giginya and Gashaka respectively while their corresponding evenness values were 0.759, 0.889, 0.765, 0.791, 0.858 and 0.759 respectively. Species diversity differs significantly (P<0.05) among the ecological zones and protected areas. Therefore, more priority areas should be identified and conserved for sustainability.

***Key Words*: Protected areas, Conservation, Woody species.**

I. INTRODUCTION

Taraba State has a vast array of diverse indigenous biodiversity including woody species hence the nickname 'Natures gift to the nation'. The State is made up of three major ecological zones that are typified by the co-existence of woody plants (TRIP Ltd, 2014), with relative proportions of being influenced predominantly by water availability, fire, nutrients, herbivores and people [1], [2].

In Nigeria, the total value of both the wood and non-wood forest product derived from woody species as well as their environmental functions is enormous though not completely quantifiable [3]. Nigerian woody vegetation resources include the high Forest, woodland, bush lands, plantations and trees on farms. Each of these various resources contributes to production, protection and conservation functions [3].

[4] estimated that Nigeria possesses 5,103 species of plant out of which 484 species are threatened at the point of extinction. Taraba State is one of the few States in Nigeria that possess a unique characteristic of woody species vegetation and the diversity of this vegetation seems to decrease in most of the ecological zones. This has resulted in decreasing size and quality of natural forests at alarming rates [5]. The objectives of the study were to evaluate abundance and distribution of woody species as well as the comparison of woody species diversity among the ecological zones of Taraba State. Assessment of woody species diversity of forest communities is useful in identifying important elements of plant diversity, protecting threatened and economic species, and monitoring the forest communities, among others [6]. This calls for need to identify sustainable management practices that have less negative impact on woody species.

II. MATERIALS AND METHODS

Taraba State lies between latitudes 6^0 34' 36" N and 9^0 58' 51" N and longitudes 9^0 52' 28" E and 12^0 39' 51" E. It occupies a total land mass of approximately 54, 473km^2 (Figure 1). The State is bordered on the northwest by Gombe State, west by Plateau and Nassarawa States and by Adamawa State in the northeast. It also shares its southwest boundary with Benue State. An international boundary on the east separates Taraba State from the republic of Cameroon [7]. The state is made up of 3 major ecological zones which include Southern guinea savanna located in the south western part of the State, Northern guinea savanna in the northeast and Montane Forest in the southeast [8].

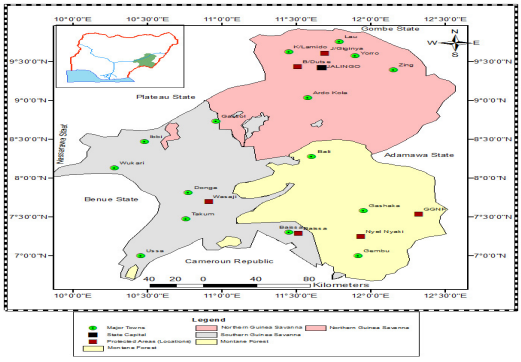

Figure 1: Map of Taraba State Showing the Major Ecological Zones and the Study Area
Source: G I S MAUTECH Yola, 2017

III. DATA COLLECTION AND ANALYSIS

The study site was stratified into three ecological zones namely; Northern Guinea Savanna (NGS), Southern Guinea Savanna (SGS) and Montane Forest (MF). Two protected areas were randomly selected from each of the ecological zones. A grid of plots that cover the entire survey protected areas was generated first, all the plots were given a sequential number and the sampled plots were randomly selected from the grids. ~~5~~ plots measuring 50m×50m were randomly sampled from each protected area and a total of 30 plots and 6 protected areas were sampled in the study. The number of individuals of each woody species occurring within a sample plot was counted, recorded and sum up directly in the field. For the sake of species identification, local names of all woody species was also listed and then scientific names were identified following colored plant identification guides developed by [9] for tropical ecosystems. In cases where identification was not possible, tree species specimens were taken to experts for later identification. In addition, Tree diameter at breast height (DBH) was measured using diameter measuring tape and ranging poles. DBH of all trees above 1.3m from the ground was measured. In cases where a tree bole branched at breast height or below, the diameter was measured separately for the branches and averaged as one DBH and in cases where tree boles buttressed, DBH measurement was taken from the point just above the buttresses.

The species diversity index is the combination of the species richness (the number of species in the sample plots) and evenness of species (abundance distribution among species). Based on these results, the species richness (SR), Shannon-Wiener diversity index (H^I) and Shannon's evenness index (E) were used to calculate the woody species diversity and evenness of the sampling units across the study plots respectively. Diversity indices were calculated as follows [10] (Equations 1-3).

Species Richness (SR) = $S/\sqrt{N}$……..…1

Where:

S = number of species in a collection

N = number of individuals collected

Shannon's Diversity Index (H^I) = $-\sum(p_i)\ln p_i$…….....2

Where:

H^I = species diversity index.

P_I = the proportion of ith species in the sample

ln*Pi* = natural logarithm of species proportion.

Shannon's evenness index (E) = H^I/H_{MAX}……..……..3

Where:

E= evenness index which has values between 0 (a situation in which the abundance of all species are completely disproportional) and 1 (all species are equally abundant).

H = Shannon Index

H_{MAX} = Natural logarithm of total number of Species.

Data collected was also subjected to two – way analysis of variance (ANOVA) using SPSS version 20 software to test for the significant difference among the protected areas and ecological zones. Fisher's Least Significant Difference (LSD) was used to separate means of treatment (Protected Areas) found to differ significantly. Frequencies and percentages were generated by SPSS and presented in tables or figures.

IV. RESULTS

A. *Density of woody species*

Results shown in Figure 2 was described in terms of woody species frequency, A total of 3760 individual woody plants were identified and enumerated in the study area. ~~60~~ species representing 57 genera and 30 families were found in Montane Forest (MF), while 34 and32 species belonging to 31 and 27 genera, 25 and 21 families were encountered in Southern Guinea Savanna (SGS) and Northern Guinea Savanna (NGS) respectively, together

with unknown species. A total of 55 woody species found in MF were not found in SGS and NGS. Only 7 and 1 species were common to SGS and NGS respectively. F*icus sur* species was common to MF, SGS and NGS (Figure 2).

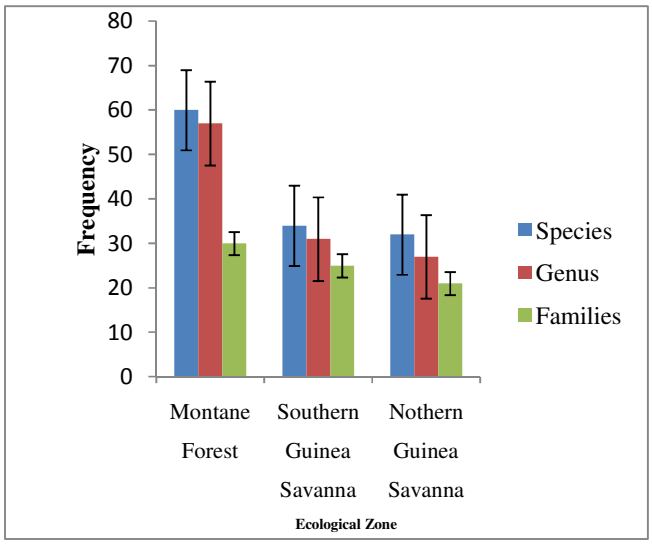

Figure 2: Woody Species Frequencies in the Study Area

B. The diversity of woody species in the study area

The results on Table 1 revealed that the Ngel Nyaki Forest Reserve had the highest species richness value (49); followed by Wasaji Forest Reserve (26) while Gashaka Gumti National Park had the lowest value (13). Generally, MF was the richest ecological zone while NGS was the least. Shannon-Wiener's diversity index indicated that Ngel Nyaki (2.9550) was the most diverse, followed by Wasaji (2.8965) while Gashaka (2.2013) was the least diverse. Shannon's evenness index revealed that species evenness was high in Wasaji (0.8889), followed by Bakin Dutse (0.8575), Gashaka (0.8341), Jen Giginya (0.7911), Baissa (0.7649) and Ngel Nyaki (0.7593) protected areas in that sequential order (Table 1).

Table 1: Diversity Indices for Woody Species in each Protected Area of the Study Area

Diversity Measure	Species Richness (SR) $=S/\sqrt{N}$	Wiener Diversity Index (H') = -$\sum$ (p_i) lnp_i	Shannon's Evenness (E) = H/H_{MAX}
Gashaka	13	2.2013	0.8341
Ngel Nyaki	49	2.9550	0.7593
Wasaji	26	2.8965	0.8889
Baissa	25	2.4621	0.7649
J/Giginya	23	2.4803	0.7911
B/Dutse	19	2.5250	0.8575

C. Pair comparison of species diversity in the study area

The results of pair comparison of species diversity in the study area showed that the F-calculated values in the diversity of ecological zones and protected areas were 6.29 and 11.73 respectively. While their F-tabulated values at 0.05 level of significance were 3.37 and 4.23, these values are less than the F-calculated which therefore, revealed significant differences ($p<0.05$) in the diversity between the ecological zones and protected areas of the study area.

All the studied ecological zones and protected areas in the study area were further compared using Least Significant Difference (LSD) to identify which ecological zone and protected area differed significantly. The pair comparison was classified into three (3) categories. These include: Comparison between Ecological Zones, Within Ecological Zones and Among Protected areas.

D. Comparison between ecological zones

Least Significant Difference analysis (Appendix I) displayed that woody species diversity was not significantly different ($p>0.05$) between Montane forest and Southern guinea savanna, while significant differences ($p<0.05$) existed between Northern guinea savanna and the other two ecological zones (Appendix I).

E. Comparison within ecological zones

LSD result within ecological zones indicated that significant differences ($p<0.05$) in diversity were noted between the following pair of protected areas: Gashaka and Nyel Nyaki in Montane forest as well as

Wasaji and Baissa in Southern guinea savanna but no significant difference ($p>0.05$) was detected between Bakin Dutse and Jen Giginya in Northern guinea savanna (Appendix I).

F. Comparison among protected areas

LSD test showed significant differences ($p<0.05$) between the following pairs of protected areas: Ngel Nyaki and Baissa, Ngel Nyaki and Bakin Dutse, Gashaka and Wasaji, Ngel Nyaki and Jen Giginya, Wasaji and Bakin Dutse as well as Jen Giginya and Wasaji while Gashaka and Baissa, Ngel Nyaki and Wasaji, Gashaka and Bakin Dutse, Gashaka and Jen Giginya, Bakin Dutse and Baissa as well as Jen Giginya and Baissa pairs of protected areas were not significantly different ($p>0.05$) in diversity. Ngel Nyaki and Wasaji protected areas were significantly different ($p<0.05$) from all the other protected areas in the study area except among themselves. Followed by Baissa, this protected area does not differ significantly ($p>0.05$) with three protected areas (Gashaka, Bakin Dutse and Jen Giginya) but differs significantly ($p<0.05$) with two protected areas (Wasaji and Ngel Nyaki). Consequently, Gashaka was not significantly different ($p>0.05$) from all the other protected areas except Ngel Nyaki and Wasaji.

V. DISCUSSION

Species diversity assessment is a way of auditing an ecosystem to understand its dynamics and quality and how disturbance factors are impacting on it [11], [12]. Montane forest is devoid of large water bodies, terrains, sleepy soil textures, natural forests, plantations, research and recreational areas that may have reduced some of the anthropogenic activities like logging, farming, timber and non-timber forest products harvest. The higher species richness and Shannon Wiener diversity index in Ngel Nyaki can be attributed to low disturbance, habitat conditions and species characteristics [13], [5]. While the lower species richness and Shannon diversity index in Gashaka Gumti National Park, and Bakin Dutse compared to Ngel Nyaki and Wasaji could be as a result of over exploitation due to none or little protection measure and its proximity to settlements of the local resource users. It may also be due to the paucity of conservation strategies, seed sources, and regeneration practices [14], [15].

The Shannon Wiener diversity index results in the study ~~are~~ comparable to those reported by [16] and [17]. They conducted their research in Montane forest (Ngel Nyaki Forest Reserve) and Northern guinea savanna (Kukuru Forest Reserve) zones respectively with a corresponding Shannon diversity of 2.8 and 2.4. The results ~~are~~ also comparable to those reported in Zimbabwe by [12], Shannon 3.0; Ethiopia by [18], Shannon 2.97 and Zambia by [19], Shannon 2.8 as well as Tanzania by [20], Shannon 3.0. The Shannon diversity results of the study area were relatively higher than that found by [21], Shannon 1.05 in Tanzania. Higher Shannon value of 4.27 has also been recorded from Tanzanian study of woody species diversity [22]. Evenness values of woody species at the protected areas of the study area were more or less similar; implying that individuals of the different species recorded exhibited moderately similar abundance and distribution.

Findings further inferred about the study of woody species diversity in the study area that the null hypothesis (H_0) was not accepted which therefore, concluded that there were significant differences ($p<0.05$) in diversity among the ecological zones and protected areas. The differences in the diversity of woody plants in the study area possibly result from differences in management [15] and rainfall regimes as well as disturbance history [12]. Disturbance is another important factor affecting woody species diversity. It's a more or less discrete event in time and space, altering the structure of populations, communities or ecosystems, causing drastic changes in resource availability or in the physical environment facilitating the spreading of short-lived early successional species and the invasion of exotic species that compete with native species for resources [23].This calls for more conservation strategies and efforts in the study area especially northern guinea savanna and other parts of the study area with low diversity to improve the quality of woody species in terms of composition, structure and diversity.

The diversity of species between Bakin Dutse and Jen Giginya in Northern guinea savanna did not show significant difference ($p>0.05$), this could be attributed to the close distance that guarantee the same climate and adaphic factors as well as human disturbances. Many studies [11], [23] and [12] have shown that climate and adaphic factors couple with human disturbances are the major determinant of species diversity in natural forests. The significant differences ($p<0.05$) that existed between Ngel Nyaki and other protected areas apart from Wasaji ~~are~~ indicative of the level of conservation and protection enjoyed by Ngel Nyaki forest reserve and the consequent level of exploitation and resource utilization. A clear documentation of forest restoration in Ngel Nyaki started in 2005 [24]. Over 4,000 tree seedlings were regenerated with the support of Non-Governmental Organizations [25] and the fencing project is near completion. Wasaji shared some common features with Ngel Nyaki, this means that the ecosystem of this protected area will improve more if equal treatment and protection measures are given. To protect these species, there is need to integrate conservation strategies into economic development oriented projects.

VI. CONCLUSION

The low values of species richness and Shannon Wiener diversity index as well as the differences recorded in some protected areas indicate the need to identify priority areas for conservation in order to decrease the deleterious biotic and abiotic pressure on woody species for sustainable management. The natural conditions

of Taraba State have been changed from this, it can be predicted that until acceptable alternatives can be found, woody species disappearance will undoubtedly continue and the natural forest resource will be exhausted in the few coming years. This therefore, calls for an urgent need for their restoration, proper management, sustainable utilization and conservation, which, in turn, require a good understanding of their diversity.

VII. RECOMMENDATIONS

Increasing protection and environmental hazards prevention measures to increase the diversity of woody species in areas with low diversity indices should be a major priority. Biodiversity policy formulation, implementation and law enforcement should be given due consideration and the legal protection of the protected areas should be strengthened to make more effective protection mechanisms that promote woody species diversity. Some cultural and technical activities such as prescribed burning, selective cutting and minimum tillage should be encouraged while those practices like clear cutting that endanger the diversity of woody species should be avoided.

Appendix I: Pair Comparison of Species Diversity in the Study Area using LSD

Ecological Zone	Protected Areas	Mean Difference	Standard Error	Significant
Comparing the Differences between the Ecological Zones				
MF		0.478284*	0.1624480	0.007
NGS	SGS	-0.517061*	0.1624480	0.004
SGS		0.038777	0.1624480	0.813
Comparing the Differences within the Ecological Zones				
MF	Gashaka vs Ngel Nyaki	-0.857252*	0.2050722	0.000
NGS	Bakin Dutse vs Jen Giginya	-0.008504	0.2050722	0.967
SGS	Wasaji vs Baissa	-0.497086*	0.2050722	0.023
Comparing the Differences of Species Diversity among the Protected areas				
MF vs NGS	Gashaka vs Bakin Dutse	-0.053910	0.2050722	0.795
	Gashaka vs Jen Giginya	0.045406	0.2050722	0.827
	Ngel Nyaki vs Bakin Dutse	0.911162*	0.2050722	0.000
	Ngel Nyaki vs Jen Giginya	0.902658*	0.2050722	0.000
MF vs SGS	Gashaka vs Wasaji	-0.715946*	0.2050722	0.002
	Gashaka vs Baissa	-0.218860	0.2050722	0.296
	Ngel Nyaki vs Wasaji	0.141306	0.2050722	0.497
	Ngel Nyaki vs Baissa	0.638392*	0.2050722	0.005
NGS vs SGS	Bakin Dutse vs Wasaji	-0.769856*	0.2050722	0.001
	Bakin Dutse vs Baissa	-0.272770	0.2050722	0.196
	Jen Giginya vs Wasaji	-0.761352*	0.2050722	0.001
	Jen Giginya vs Baissa	-0.264266	0.2050722	0.210

[MF=Montane Forest, NGS=Northern Guinea Savanna, SGS=Southern Guinea Savanna].
Means difference followed by asterisk (*) are significantly different ($p<0.05$).

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