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. Five plots each measuring 50 × 50 m were sampled in each protected area. Data were analyzed using descriptive and inferential statistics such as frequency, ANOVA and LSD. A total of 3760 individual woody stands were recorded in the study. A total of 60, 34 and 32 species were also encontered in Montane Forest, Southern and Northern Guinea Savanna, respectively. 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 2.96, 2.90, 2.48, 2.20, 2.46, 2.48 and 2.53 in Ngel Nyaki, Wasaji, Baissa, Jen Giginya and Gashaka, respectively while their corresponding evenness values were 0.76, 0.89, 0.77, 0.79, 0.86 and 0.76, respectively. The higher species richness and Shannon Wiener diversity indices can be attributed to low disturbance and habitat conditions of the ecosystems. While the lower diversity indices could be as a result of over exploitation of woody species. Sorensen's similarity indices between the ecological zones were 0.11, 0.01 and 0.84 for Montane Forest, Southern Guinea Savanna and Northern Guinea Savanna, 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, Richness of Species, Index diversity.**

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 [1], with relative proportions of being influenced predominantly by water availability, fire, nutrients, herbivores and people [2], [3].

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 [4]. 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 [5].

[6] 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 [7]. 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,

Comment [DCAN1]: Wrong spelling

Comment [DCAN2]: Not well written. The scientific expression is bad. Please re-write again following my earlier review suggestions.

Comment [DCAN3]: highest

Comment [DCAN4]: delete

Comment [DCAN5]: replace full stop with comma

Comment [DCAN6]: Change Capital letter "W" with small letter "w"

Comment [DCAN7]: lowest

Comment [DCAN8]: you can't start this as a paragraph, shift back.

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

2.1 *Study area*

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].

Comment [DCAN9]: The map of the study area is not legible. Increase its size.

2.2 *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. Five plots measuring 50 m × 50 m 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. Species 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. Instance 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') 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 1-4).

Comment [DCAN10]: Cite the authors for these indices.

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^{l}) = $-\sum(p_i)\ln p_i$……..…….2

Where:

H^{l} = 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^{l}/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.

In this study, Sorensen's similarity index was computed using the formula below:

Sorensen's Similarity Index (SI) = $\frac{2j}{a+b}$ ……..……4

Where:

a = Number of species present in habitat 1 but absent in habitat 2

b = Number of species present in habitat 2 but absent in habitat 1

j = Number of species common to both habitats

Shannon's Diversity Index across the plots were 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.

III. 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. A total of 60 species representing 57 genera and 30 families were found in Montane Forest (MF), while 34 and 32 species belonging to 31 and 27 genera, 25 and 21 families were encountered in Southern Guinea Savanna (SGS) and Northern Guinea Savanna (NGS), respectively. A total of 55 woody species found in MF were not found in SGS, and NGS. Only seven and one species were common to SGS and NGS, respectively. F*icus sur* species was common to MF, SGS and NGS (Figure 2).

Comment [DCAN11]: TThese equations are appear scattered or are in disarray. Re-write them again. Secondly, can you indicate which model did you use to measure species richness (include the author of the indices)

Comment [DCAN12]: Poorly written. Re-write again.

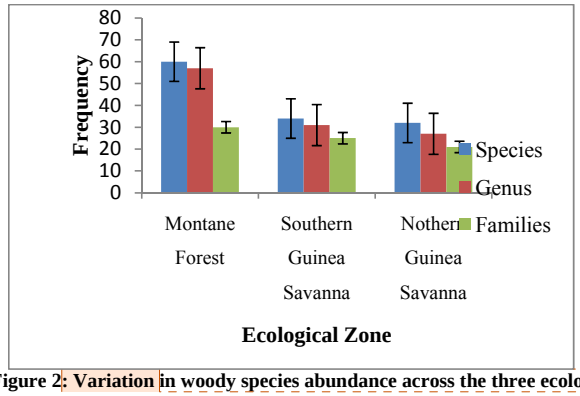

Figure 2: Variation in woody species abundance across the three ecological zones

*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 (J = 2.96) was the most diverse, followed by Wasaji (J = 2.90) while Gashaka (J = 2.20) was the least diverse. Shannon's evenness index revealed that species evenness was high in Wasaji (0.8889), followed by Bakin Dutse (E = 0.86), Gashaka (E = 0.83), Jen Giginya (E = 0.79), Baissa (E = 0.77) and Ngel Nyaki (E = 0.76) 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. **Similarity in woody species composition***

Sorensen's similarity indices ~~calculated in table 2~~ showed that there was a high level of similarity between Wasaji and Baisa protected areas (1.42). Gashaka and Ngel Nyaki recorded 0.03 while Jen Giginya and Bakin Dutse had 0.23. Similary, high level of similarity was recorded between Southern Guinea Savanna and Northern Guinea Savanna (0.84) ecological zones. Least similarity index (0.01) was observed between Montane Forest and Northern Guinea Savanna ecological zones.

Table 2: Sorensen's similarity indices *of woody species in the study area*

Pairing	Habitat 1	Habitat 2	Index
MF	Gashaka	Ngel Nyaki	0.03
SGS	Wasaji	Baissa	1.42
NGS	Jen Giginya	Bakin Dutse	0.23
MF - SGS	MF	SGS	0.11

Comment [DCAN13]: Check the legend in the graph and re-position it well. Also, remove the frame around the graph

Comment [DCAN14]: Variations

Comment [DCAN15]: (n = 49)

Comment [DCAN16]: (n = 26)

Comment [DCAN17]: was the least species rich (n = 13)

Comment [DCAN18]: (n = 13)

Comment [DCAN19]: delete

Comment [DCAN20]: insert (Table 2) here

Comment [DCAN21]: close extra line spacing

Comment [DCAN22]: Close extra line spacing

MF - NGS	MF	NGS	0.01
SGS - NGS	SGS	NGS	0.84

D. Comparison of species diversity between ecological zones and the protected areas

Comparatively, species diversity among the ecological zones (F - ratio = 6.29, p <0.05) and protected areas (F - ratio = 11. 73, p <0.05), were significantly different. 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.

E. Comparison between ecological zones

Least Significant Difference analysis on Shannon Weiner's diversity (Appendix I) showed 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).

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. Baissa, was the next protected area that does not differ significantly ($p>0.05$) with the remaining three protected areas (i. e. Gashaka, Bakin Dutse and Jen Giginya) but differs significantly ($p<0.05$) with Ngel Nyaki and Wasaji protected areas. Consequently, Gashaka was not significantly different ($p>0.05$) from all the other protected areas except Ngel Nyaki and Wasaji.

IV. 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

Comment [DCAN23]: Close extra line spacing

Comment [DCAN24]: This sub-heading is poorly written. Please delete it and write in prose, by continuing from the preceding write-up.

Comment [DCAN25]: Follow same comment as "E"

Comment [DCAN26]: This statement does not make sense and poorly constructed. Re-write again

Comment [DCAN27]: Delete. We already know that you used Shannon-weiner indices, which you indicated in the statistical analysis section of the manuscript. So you don't need to repeat it again.

Comment [DCAN28]: delete

Comment [DCAN29]: The diversity indices obtained in this....

with a corresponding Shannon diversity of 2.8 and 2.4. Other studies in woody habitats in Zimbwabwe [12], Ethiopia [18], Zimbwabwe [19] and Tanzania [20], found similar diversity indices, The Shannon diversity results of the study area were relatively higher than that found by [21] 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.

The 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. 7The 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 is an independent event that alters the population structure of different ecosystems thereby, causing drastic changes in resource availability [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 apparent similarity species diversity 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 relatively high species diversity in Ngel Nyaki and some protected areas, are an indication of conservation measures (sustainable exploitation of resources) and protection. 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.

V. 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. 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.

VI. 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.

VII. ACKNOWLEDGEMENTS

We are grateful to the Acting Conservator General, National Park Service, Alhaji Hassein, A. T., Conservator of Park, Gashaka Gumti National Park, Mr. Oladipo, O. C., Director of Nigerian Montane Forest Project, Professor Chapman, H., Honorable

Comment [DCAN30]: Re-write as: "similar findings in Tanzania [21]"

Comment [DCAN31]: Am wondering how you tested your hypothesis, when in fact, you did not indicate any hypothesis testing in your introduction. How possible? Secondly, the statement is poorly written.

Comment [DCAN32]: Delete the number 7

Comment [DCAN33]: delete

Comment [DCAN34]: Can you indicate these edaphic factors?

Comment [DCAN35]: Close extra line spacing

Comment [DCAN36]: This expression is not right. How can you refer to Wasaji and Ngel Nyaki ecosystems and used the phrase.."this protected area", instead of "these protected areas"

Comment [DCAN37]: What treatment are you referring to? Can you mention them?

Comment [DCAN38]: delete

Comment [DCAN39]: insert comma

Comment [DCAN40]: insert comma

Commissioner Ministry of Environment Taraba State, Mrs. Manasseh, R., Director, Forestry and Wildlife, Ministry of Environment Taraba State, Mr. Aziki, A. for giving us opportunity to conduct research in their various protected areas. Thanks are also due to Misa Z., George, G. and the I T students from Federal University Wukari, Abubakar Tafawa Balewa University, Bauchi and Gombe State University for their invaluable assistance in the field. We thank Mr. Mrs Twar, T. Y. Danjuma Foundation, Smithsonian Tropical Research Institute and Nigerian Montane Forest Project for their logistical support and also to all the forest guards/rangers of all the protected areas visited for providing security for us.

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 ($p<0.05$).

Appendix II: Species Composition of each Location According to Increasing Order of the Important Value Index

Gashaka

Species	Freq	RF	D	RD	BA	RDo	IVI
Vitex donianna	1	0.255102	0.8	0.255102	0.2376	4.84009	1.783431
Unknown Spp	15	3.826531	12	3.826531	0.0882	1.7967	3.14992
Elaesis guneensis	21	5.357143	16.8	5.357143	0.0817	1.66429	4.126192
Anogeissus leiocarpa	18	4.591837	14.4	4.591837	0.3188	6.494194	5.225956
Cola millenii	32	8.163265	25.6	8.163265	0.0706	1.438175	5.921568
Ancylobotrys anioena	33	8.418367	26.4	8.418367	0.0822	1.674475	6.170403
Tabernamontana holstii	30	7.653061	24	7.653061	0.2631	5.359544	6.888555
Uvaria chamae	11	2.806122	8.8	2.806122	0.8877	18.08311	7.898453
Landolphia owariensis	39	9.94898	31.2	9.94898	0.1895	3.860257	7.919405
Cola gigantean	18	4.591837	14.4	4.591837	0.8375	17.0605	8.748058
Uapaca togoensis	85	21.68367	68	21.68367	0.2419	4.927684	16.09834
Strombosia postulate	88	22.44898	70.4	22.44898	1.6053	32.70116	25.86637

Ngel Nyaki Forest Reserve

Species	Freq	RF	D	RD	BA	RDo	IVI
Goria sp	1	0.068966	0.8	0.068966	0.017674	0.095205	0.077712
Leea guineensis	2	0.137931	1.6	0.137931	0.002906	0.015656	0.097173
Trilepisium madagascariansis	3	0.206897	2.4	0.206897	0.010248	0.055205	0.156333
Daslepis sp	4	0.275862	3.2	0.275862	0.032402	0.174542	0.242089
Beilshmeidia manii	4	0.275862	3.2	0.275862	0.04931	0.265622	0.272449
Santeria sp	2	0.137931	1.6	0.137931	0.116922	0.629834	0.301899
Tabernamontan	5	0.344828	4	0.344828	0.091904	0.495066	0.394907

a cantata							
Rauvolfia vomiteria	3	0.206897	2.4	0.206897	0.165688	0.892529	0.435441
Symphonia glubolifera	1	0.068966	0.8	0.068966	0.301114	1.622038	0.586656
Isolona capensis	11	0.758621	8.8	0.758621	0.053614	0.288808	0.602016
Polyscias fulva	9	0.62069	7.2	0.62069	0.106749	0.575038	0.605472
Ritchea albesea	13	0.896552	10.4	0.896552	0.027825	0.149887	0.647663
Xymalus monospor	4	0.275862	3.2	0.275862	0.279874	1.507623	0.686449
Macaranga monandra	6	0.413793	4.8	0.413793	0.256138	1.379766	0.735784
Allophylus africana	1	0.068966	0.8	0.068966	0.384895	2.073352	0.737094
Schefferia abyssinica	3	0.206897	2.4	0.206897	0.354339	1.908753	0.774182
Psorospermum aurantiaca	3	0.206897	2.4	0.206897	0.358947	1.933577	0.782457
Eugenia gilgii	16	1.103448	12.8	1.103448	0.032471	0.174913	0.793936
Albizia gummifera	14	0.965517	11.2	0.965517	0.087022	0.468771	0.799935
Pychotria viridis	9	0.62069	7.2	0.62069	0.228371	1.230189	0.823856
Disloclaoxylum hexandrum	11	0.758621	8.8	0.758621	0.189741	1.022097	0.846446
Chrysophylum albedum	5	0.344828	4	0.344828	0.347081	1.869656	0.853104
Croton macrotachyus	1	0.068966	0.8	0.068966	0.490231	2.640773	0.926235
Weakenia sp	14	0.965517	11.2	0.965517	0.208797	1.124748	1.018594
Campylospermum perexilis	16	1.103448	12.8	1.103448	0.228846	1.232745	1.146547
Millettia barteri	11	0.758621	8.8	0.758621	0.380568	2.050041	1.189094
Ceitis zenkeni	8	0.551724	6.4	0.551724	0.465851	2.509444	1.204297

Entandrophragma angolense	4	0.275862	3.2	0.275862	0.594506	3.202483	1.251402
Voacanga africana	18	1.241379	14.4	1.241379	0.256797	1.383316	1.288692
Unknown	30	2.068966	24	2.068966	0.010248	0.055205	1.397712
Pavetta crombosa	1	0.068966	0.8	0.068966	0.7855	4.231331	1.456421
Oxyanthus sp	4	0.275862	3.2	0.275862	0.854329	4.602101	1.717942
Ficus sur	22	1.517241	17.6	1.517241	0.439187	2.365814	1.800099
Diospyros camarunensis	10	0.689655	8	0.689655	0.773725	4.167903	1.849071
Clausena anissata	39	2.689655	31.2	2.689655	0.031768	0.17113	1.850147
Drypetes floribunda	3	0.206897	2.4	0.206897	1.116091	6.012157	2.141983
Carapa oriophylla	28	1.931034	22.4	1.931034	0.497407	2.67943	2.1805
Anthonatha noldeae	42	2.896552	33.6	2.896552	0.350935	1.890418	2.561174
Ficus lutea	22	1.517241	17.6	1.517241	1.079784	5.81658	2.950354
Sherubapsis sp	6	0.413793	4.8	0.413793	1.803806	9.716743	3.514776
Zanthoxylum zanthoxyloidea	77	5.310345	61.6	5.310345	0.101638	0.547501	3.72273
Newtonia buchananii	45	3.103448	36	3.103448	1.092035	5.882575	4.029824
Poutaria altissima	12	0.827586	9.6	0.827586	2.165185	11.66342	4.43953
Rothmania hispida	88	6.068966	70.4	6.068966	0.324474	1.747876	4.628602
Strombosia postulate	94	6.482759	75.2	6.482759	0.293813	1.582709	4.849409
Deinbolia pinnata	122	8.413793	97.6	8.413793	0.128696	0.693258	5.840282
Garcinia smithmanii	157	10.82759	125.6	10.82759	0.182956	0.98555	7.546907

Rytignia umbellatum	221	15.24138	176.8	15.24138	0.256843	1.383563	10.62211
Pleiocarpa pycnantha	225	15.51724	180	15.51724	0.154669	0.83317	10.62255

Wasaji Forest Reserve

Species	**Freq**	**RF**	**D**	**RD**	**BA**	**RDo**	**IVI**
Afzelia africana	1	0.185529	0.8	0.185529	0.020109	0.258934	0.209997
Neocarya polyandra	1	0.185529	0.8	0.185529	0.101801	1.310852	0.560637
Maranthes polyandra	5	0.927644	4	0.927644	0.025152	0.32387	0.726386
Pilliostigma thorningii	4	0.742115	3.2	0.742115	0.107083	1.378873	0.954368
Bridelia ferruginea	10	1.855288	8	1.855288	0.118508	1.52599	1.745522
Strychnos innocua	6	1.113173	4.8	1.113173	0.256335	3.300732	1.842359
Nuclea latifolia	9	1.669759	7.2	1.669759	0.207005	2.665535	2.001684
Ficus sur	6	1.113173	4.8	1.113173	0.316936	4.081069	2.102471
Vetellaria paradoxa	10	1.855288	8	1.855288	0.246795	3.177889	2.296155
Syzigium guineense	9	1.669759	7.2	1.669759	0.284953	3.66924	2.336253
Khaya senegalensis	6	1.113173	4.8	1.113173	0.391114	5.036229	2.420858
Vitex donianna	17	3.153989	13.6	3.153989	0.092201	1.187233	2.498404
Pterocarpus erinaceus	10	1.855288	8	1.855288	0.336885	4.337951	2.682842
Crossopteryx febrifuga	18	3.339518	14.4	3.339518	0.209035	2.691664	3.123566
Lophira alata	17	3.153989	13.6	3.153989	0.292654	3.768403	3.358794
Parkia biglobosa	14	2.597403	11.2	2.597403	0.457391	5.889661	3.694822
Lenea alata	18	3.339518	14.4	3.339518	0.462031	5.949409	4.209481
Hymenocardia acida	30	5.565863	24	5.565863	0.180751	2.327471	4.486399
Anonna senegalensis	40	7.42115	32	7.42115	0.072341	0.931504	5.257935
Ficus lutea	25	4.638219	20	4.638219	0.614905	7.917913	5.73145
Uapaca togoensis	42	7.792208	33.6	7.792208	0.329908	4.248109	6.610841

Daniellia oliveri	24	4.45269	19.2	4.45269	0.866717	11.16041	6.688597
Parinari excelsa	56	10.38961	44.8	10.38961	0.278704	3.588769	8.122663
Terminalia sp	65	12.05937	52	12.05937	0.243449	3.134811	9.084516
Pericopsis laxiflora	64	11.87384	51.2	11.87384	0.613387	7.898366	10.54868

Baissa Forest Reserve

Species	**Freq**	**RF**	**D**	**RD**	**BA**	**RDo**	**IVI**
Elaesis guneensis	2	0.273973	1.6	0.273973	0.168568	1.831269	0.793071
Malacantha alnifolia	1	0.136986	0.8	0.136986	0.204309	2.219539	0.83117
Mangifera indica	6	0.821918	4.8	0.821918	0.1087	1.180881	0.941572
Bridelia ferruginea	8	1.09589	6.4	1.09589	0.097785	1.062302	1.084694
Khaya senegalensis	8	1.09589	6.4	1.09589	0.160134	1.739641	1.310474
Ziziphus mauritiana	10	1.369863	8	1.369863	0.136913	1.487373	1.409033
Maranthes polyandra	8	1.09589	6.4	1.09589	0.214353	2.32866	1.506814
Pilliostigma thorningii	11	1.506849	8.8	1.506849	0.193976	2.107286	1.706995
Terminalia glancosens	10	1.369863	8	1.369863	0.235862	2.562326	1.767351
Ficus sur	15	2.054795	12	2.054795	0.194469	2.112644	2.074078
Crossopteryx febrifuga	16	2.191781	12.8	2.191781	0.209557	2.276553	2.220038
Terminalia sp	11	1.506849	8.8	1.506849	0.412923	4.485856	2.499852
Lotera alata	22	3.013699	17.6	3.013699	0.153969	1.672664	2.566687
Vitex donianna	9	1.232877	7.2	1.232877	0.500416	5.436348	2.634034
Vetellaria	4	0.547945	3.2	0.547945	0.676198	7.345982	2.813958

paradoxa							
Lannea acida	22	3.013699	17.6	3.013699	0.269255	2.925096	2.984165
Parkia biglobosa	7	0.958904	5.6	0.958904	0.653873	7.103451	3.007086
Parinari polyandra	25	3.424658	20	3.424658	0.206555	2.243944	3.031086
Jatropha carcass	19	2.60274	15.2	2.60274	0.510745	5.548555	3.584678
Nuclea latifolia	58	7.945205	46.4	7.945205	0.185782	2.018268	5.96956
Anogeissus leiocarpa	52	7.123288	41.6	7.123288	373159	4.053876	6.100151
Parinari excels	75	10.27397	60	10.27397	0.258613	2.809482	7.785809
Daniellia oliveri	4	0.547945	3.2	0.547945	2.376786	25.82059	8.972161
Uapaca togoensis	105	14.38356	84	14.38356	0.266696	2.897294	10.55481
Hymenocardia acida	222	30.41096	177.6	30.41096	0.435491	4.731024	21.85098

Jen Giginya Forest Reserve

Species	**Freq**	**RF**	**D**	**RD**	**BA**	**RDo**	**IVI**
Combretum tomentosum	2	0.554017	1.6	0.692521	0.004163	0.028153	0.424897
Bridelia ferruginea	1	0.277008	0.8	1.385042	0.009505	0.064274	0.575441
Borassus aethiapum	10	2.770083	8	0.34626	0.011518	0.077892	1.064745
Diatarium senegalensis	2	0.554017	1.6	1.731302	0.239931	1.622526	1.302615
Parinari polyandra	3	0.831025	2.4	3.462604	0.061505	0.415923	1.569851
Hyphaene thebaica	4	1.108033	3.2	3.462604	0.026491	0.179144	1.583261
Nuclea latifolia	10	2.770083	8	1.038781	0.171019	1.156511	1.655125

Azadirachta indica	6	1.66205	4.8	3.462604	0.044211	0.298972	1.807875
Sterculia setijera	1	0.277008	0.8	4.501385	0.145239	0.982174	1.920189
Lannea acida	10	2.770083	8	3.462604	0.211606	1.430978	2.554555
Pteleopsis suberosa	23	6.371191	18.4	0.34626	0.144713	0.978617	2.565356
Acacia kirkir	22	6.094183	17.6	2.077562	0.050308	0.340204	2.837316
Combretum molle	29	8.033241	23.2	0.692521	0.127435	0.861776	3.195846
Combretum lecardii	2	0.554017	1.6	10.04155	0.081456	0.550846	3.715471
Terminalia sp	13	3.601108	10.4	5.193906	0.424919	2.873503	3.889506
Prosopis africana	23	6.371191	18.4	7.963989	1.075155	7.2707	7.20196
Pilliostigma thorningii	66	18.28255	52.8	7.963989	0.101922	0.689246	8.978594
Parkia biglobosa	10	2.770083	8	22.85319	0.280172	1.894655	9.172641
Hymenocardia acida	95	26.31579	76	1.385042	0.148307	1.002918	9.567916
Entada Africana	5	1.385042	4	32.89474	0.383481	2.593279	12.29102
Ceiba pentandra	4	1.108033	3.2	0.692521	10.55516	71.37891	24.39315
Ziziphus mauritiana	5	1.385042	4	125	0.371432	2.511794	42.96561

Bakin Dutse Forest Reserve

Species	**Freq**	**RF**	**D**	**RD**	**BA**	**RDo**	**IVI**
Ficus sur	3	1.041667	2.4	1.043478	0.076796	1.281585	1.122243
Bridelia scleroneura	2	0.694444	1.6	0.695652	0.241384	4.028274	1.806124
Parinari polyandra	8	2.777778	6.4	2.782609	0.034375	0.573665	2.044684

Bridelia ferruginea	7	2.430556	5.6	2.434783	0.241384	4.028274	2.964538
Parinari excels	12	4.166667	9.6	4.173913	0.103719	1.730882	3.357154
Pericopsis laxiflora	15	5.208333	12	5.217391	0.088437	1.475858	3.967194
Hyptis suaveolens	3	1.041667	2.4	1.043478	0.705091	11.76672	4.617289
Lonchocarpus laxiflorus	3	1.041667	2.4	1.043478	0.827053	13.80205	5.295732
Anonna senegalensis	24	8.333333	19.2	8.347826	0.090768	1.514754	6.065304
Khaya senegalensis	27	9.375	21.6	9.391304	0.132889	2.217685	6.994663
Acacia kirkir	32	11.11111	25.6	11.13043	0.018518	0.309034	7.51686
Daniellia oliveri	11	3.819444	8.8	3.826087	1.035225	17.27607	8.3072
Nuclea latifolia	35	12.15278	28	12.17391	0.18314	3.05629	9.12766
Hymenocardia acida	65	22.56944	52	22.6087	0.199873	3.335535	16.17123

REFERENCES

[1]. Taraba State Investment and Property Limited, (2014). *Jalingo, pp 1-5.*

[2]. Sankaran M, Hanan NP, Scholes RJ *et al* (2005) Determinants of woody cover in African savannas. *Nature* 438: 846-849.

[3]. Russell-Smith J, Edwards AC and Price OF (2012) Simplifying the savanna: the trajectory of fire-sensitive vegetation mosaics in northern Australia. *Journal of Biogeography* 39: 1303-1317.

[4]. Alamu LO and Agbeja BO (2011) Deforestation and endangered indigenous tree species in South-West Nigeria. *International Journal of biodiversity and conservation.* Vol. 3(7) pp. 291-297.

[5]. United States Agency for International Development (USAID) (2008) *Nigerian Biodiversity and tropical forest assessment report*. International Resources Group 1211 Connecticut Avenue, NW, Suite 700 Washington, DC 20036.

[6]. Neelo J,Teketay D, Kashe K *et al* (2015) Stand Structure, Diversity and Regeneration Status of Woody plant species in Open and Exclosed Dry Woodland Sites around *Molapo* Farming Areas of the Okavango Delta, Northeastern Botswana. *Open Journal of Forestry, 5, 313-328.*

[7]. Ssegawa P and Nkuutu, DN (2006) Diversity of Vascular Plants on Ssese Islands in Lake Victoria, Central Uganda. *African Journal of Ecology, 44,* 22-29. http://dx.doi.org/10.1111/j.1365-2028.2006.00609.

[8]. GIS Laboratory Geography Department (2017) MAUTECH, Yola.

[9]. Keller R (2004) *Identification of tropical woody plants in the absence of flowers and fruits.* A field guide. Birkhauser Basel, pp 1-328.

[10]. Jayarman K (2000) *A Statistical Manual for Forestry Research.* Bankok: FORSPA-FAO Publication, Bankok.

[11]. Kalema VN (2010) *Diversity, use and resilience of woody plants in a multiple land-use equatorial African Savanna, Uganda [Ph.D. thesis]*, University of the Witwatersrand, Johannesburg, South Africa.

[12]. Zimudzi C and Chapano C (2016) Diversity, Population Structure, and Above Ground Biomass in Woody plant species on Ngomakurira Mountain, Domboshawa, Zimbabwe. *International Journal of Biodiversity* Vol. 2016, Article ID 4909158, pp 1-12.

[13]. Zegeye H, Teketay D and Kelbessa E (2011) Diversity and Regeneration Status of Woody plant species in Tara Gedam and Abebaye Forests, Northwestern Ethiopia. *Journal of Forestry Research, 22,* 315-328.

[14]. Gonzales RS and Nakashizuka T (2010) Broad-leaf species composition in Cryptomeria japonica plantations with respect to distance from natural forest. *For Ecol Manag.* 259:2133–2140.

[15]. Bremer LL and Farley KA (2010) Does plantation forestry restore biodiversity or create green deserts? A synthesis of the effects of land-use transitions on plant species richness. *Biodiversity Conservation* 19:3893–3915 DOI 10.1007/s10531-010-9936-4.

[16]. Ihuma JO, Chima UD and Chapman HM (2011) Tree species diversity in a Nigeria montane forest ecosystem and adjacent fragmentation forests. ARPN, *Journal of Agricultural and Biological Sciences*. Vol. 6, No 2, pp. 17-22.

[17]. Barau BW, Tukur KU, Gabuin TG *et al* (2015) Tree species diversity in Kakulu Forest of Zing L. G. A., Taraba State, Nigeria. Ethiopian Journal of Environmental Studies and Management. 2(8), pp 916.

[18]. Woldemariam G, Demissew S and Asfaw Z (2016) Woody plant species Composition, Diversity and Structure of Kumuli Dry Evergreen Afromontane Forest in Yem District, Southern Ethiopia. *Journal of Environment and Earth Science*. www.iiste.org.ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) Vol.6, No.3, pp 1-13.

[19]. Kalaba FK, Quinn CH, Dougill AJ *et al* (2013)"Floristic composition, species diversity and carbon storage in charcoal and agriculture fallows and management implications in Miombo woodlands of Zambia," *Forest Ecology and Management*, vol. 304, pp. 99–109.

[20]. Mwakalukwa EE, Meilby H and Treue T (2014)"Floristic composition, structure, and species associations of dry Miombo woodland in Tanzania," *ISRN Biodiversity*, vol. 2014, Article ID 153278, p 15.

[21]. Shirima DD, Munishi PK and Lewis SL (2011) "Carbon storage, structure and composition of miombo woodlands in Tanzania's Eastern Arc Mountains," *African Journal of Ecology*, vol. 49, no. 3, pp. 332–342.

[22]. Giliba RA, Boon EK, Kayombo CJ *et al* (2011) "Species composition, richness and diversity in Miombo Woodland of Bereku Forest Reserve Tanzania," *Journal of Biodiversity*, vol. 2, no. 1, pp. 1–7.

[23]. Aguilar-Santelises R and Del-Castillo RF (2013). Factors affecting woody plant species diversity of fragmented seasonally dry oak forests in the Mixteca Alta, Oaxaca, Mexico. *Biodiversity Journal of Mexico*.84: DOI: 10.7550. pp 575-590.

[24]. Nigerian Montane Forest Project (NMFP) (2015) *Annual Report*. University of Canterbury. New Zealand, pp 1-5.

[25]. Nigerian Montane Forest Project (NMFP) (2016) *Annual Report*. University of Canterbury. New Zealand, pp 1-27.