

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

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### Authors' contributions

This work was carried out in collaboration between both authors. Author BBM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author IT managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

### Article Information

DOI: 10.9734/AJRAF/2018/42038

#### Editor(s):

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Complete Peer review History: <http://www.sciencedomain.org/review-history/26081>

Original Research Article

Received 11 May 2018  
Accepted 01 August 2018  
Published 03 September 2018

### 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 the 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 analysed 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 encountered 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

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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 overexploitation 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.

*Keywords: Protected areas; conservation; woody species; richness of species; index diversity.*

## 1. 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].

Neelo et al. [6] estimated that Nigeria possesses 5,103 species of the 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, 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.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

Taraba State lies between latitudes  $6^{\circ} 34' 36''$  N and  $9^{\circ} 58' 51''$  N and longitudes  $9^{\circ} 52' 28''$  E and  $12^{\circ} 39' 51''$  E. It occupies a total land mass of approximately 54, 473km<sup>2</sup> (Fig. 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].

### 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 coloured plant identification guides developed by Keller [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 1.3 m 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).

$$\text{Species Richness (SR)} = S/\sqrt{N} \quad (1)$$

Where:

S = number of species in a collection  
N = number of individuals collected

$$\text{Shannon's Diversity Index (H')} = -\sum(p_i)\ln p_i \quad (2)$$

Where:

$H'$  = species diversity index.  
 $P_i$  = the proportion of  $i$ th species in the sample  
 $\ln P_i$  = natural logarithm of species proportion.

$$\text{Shannon's evenness index (E)} = H'/H_{\text{MAX}} \quad (3)$$

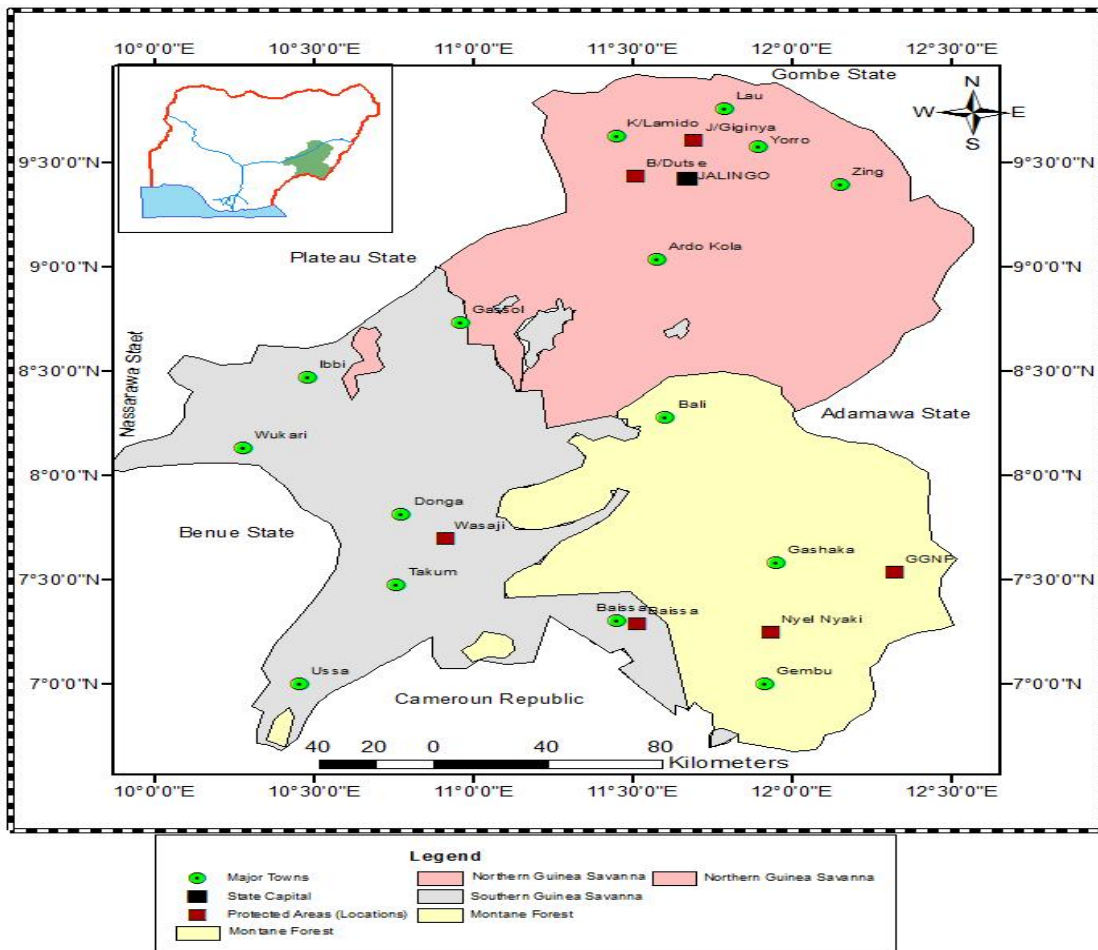


Fig. 1. Map of Taraba State showing the major ecological zones and the study area  
Source: GIS MAUTECH Yola, 2017

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:

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

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.

### 3. RESULTS

#### 3.1 Density of Woody Species

Results shown in Fig. 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. *Ficus sur* species was common to MF, SGS and NGS (Fig. 2).

#### 3.2 The Diversity of Woody Species in the Study Area

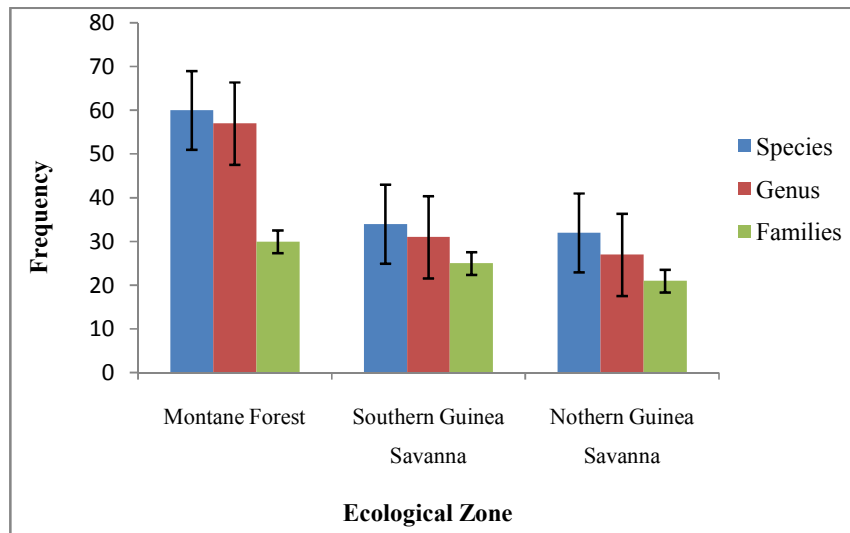
The results on Table 1 revealed that the Ngel Nyaki Forest Reserve had the highest species richness value (49); followed by Wasaji Forest Reserve (26) while Gashaka Gumti National Park had the lowest value (13). Generally, MF was the richest ecological zone while NGS was the least. Shannon-Wiener's diversity 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).

#### 3.3 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. Similarly, 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 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') = $-\sum (p_i) \ln p_i$	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



**Fig. 2. Variation in woody species abundance across the three 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
MF - NGS	MF	NGS	0.01
SGS - NGS	SGS	NGS	0.84

### 3.4 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.

### 3.5 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).

### 3.6 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.

#### 4. 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 area, comparable to those reported by Ihuma et al. [16] and Barau et al. [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. Other studies in woody habitats in Zimbabwe [12], Ethiopia [18], Zimbabwe [19] and Tanzania [20], found similar diversity indices. The Shannon diversity results of the study area were relatively higher than that found by Shirima et al. [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. 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]. The 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 a 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 determinants 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.

#### 5. 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.

#### 6. 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.

### 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 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.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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## Appendix I: Pair comparison of species diversity in the study area using LSD

Ecological zone	Protected areas	Mean difference	Standard error	Significant
<b>Comparing the differences between the ecological zones</b>				
MF		0.478284*	0.1624480	0.007
NGS	SGS	-0.517061*	0.1624480	0.004
SGS		0.038777	0.1624480	0.813
<b>Comparing the differences within the ecological zones</b>				
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
<b>Comparing the differences of species diversity among the protected areas</b>				
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
<i>Vitex donianna</i>	1	0.255102	0.8	0.255102	0.2376	4.84009	1.783431
<i>Unknown Spp</i>	15	3.826531	12	3.826531	0.0882	1.7967	3.14992
<i>Elaeis guineensis</i>	21	5.357143	16.8	5.357143	0.0817	1.66429	4.126192
<i>Anogeissus leiocarpa</i>	18	4.591837	14.4	4.591837	0.3188	6.494194	5.225956
<i>Cola millenii</i>	32	8.163265	25.6	8.163265	0.0706	1.438175	5.921568
<i>Ancylobotrys anioena</i>	33	8.418367	26.4	8.418367	0.0822	1.674475	6.170403
<i>Tabernamontana holstii</i>	30	7.653061	24	7.653061	0.2631	5.359544	6.888555
<i>Uvaria chamae</i>	11	2.806122	8.8	2.806122	0.8877	18.08311	7.898453
<i>Landolphia owariensis</i>	39	9.94898	31.2	9.94898	0.1895	3.860257	7.919405
<i>Cola gigantea</i>	18	4.591837	14.4	4.591837	0.8375	17.0605	8.748058
<i>Uapaca togoensis</i>	85	21.68367	68	21.68367	0.2419	4.927684	16.09834
<i>Strombosia postulate</i>	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
<i>Goria sp.</i>	1	0.068966	0.8	0.068966	0.017674	0.095205	0.077712
<i>Leea guineensis</i>	2	0.137931	1.6	0.137931	0.002906	0.015656	0.097173
<i>Trilepisium madagascariensis</i>	3	0.206897	2.4	0.206897	0.010248	0.055205	0.156333
<i>Daslepis sp.</i>	4	0.275862	3.2	0.275862	0.032402	0.174542	0.242089
<i>Beilshmeidia manii</i>	4	0.275862	3.2	0.275862	0.04931	0.265622	0.272449
<i>Santeria sp.</i>	2	0.137931	1.6	0.137931	0.116922	0.629834	0.301899
<i>Tabernamontana cantata</i>	5	0.344828	4	0.344828	0.091904	0.495066	0.394907

Species	Freq	RF	D	RD	BA	RDo	IVI
<i>Rauvolfia vomitaria</i>	3	0.206897	2.4	0.206897	0.165688	0.892529	0.435441
<i>Symphonia glubolifera</i>	1	0.068966	0.8	0.068966	0.301114	1.622038	0.586656
<i>Isolona capensis</i>	11	0.758621	8.8	0.758621	0.053614	0.288808	0.602016
<i>Polyscias fulva</i>	9	0.62069	7.2	0.62069	0.106749	0.575038	0.605472
<i>Ritchea albesea</i>	13	0.896552	10.4	0.896552	0.027825	0.149887	0.647663
<i>Xymalus monospor</i>	4	0.275862	3.2	0.275862	0.279874	1.507623	0.686449
<i>Macaranga monandra</i>	6	0.413793	4.8	0.413793	0.256138	1.379766	0.735784
<i>Allophylus africana</i>	1	0.068966	0.8	0.068966	0.384895	2.073352	0.737094
<i>Schefferia abyssinica</i>	3	0.206897	2.4	0.206897	0.354339	1.908753	0.774182
<i>Psorospermum aurantiaca</i>	3	0.206897	2.4	0.206897	0.358947	1.933577	0.782457
<i>Eugenia gilgii</i>	16	1.103448	12.8	1.103448	0.032471	0.174913	0.793936
<i>Albizia gummifera</i>	14	0.965517	11.2	0.965517	0.087022	0.468771	0.799935
<i>Psychotria viridis</i>	9	0.62069	7.2	0.62069	0.228371	1.230189	0.823856
<i>Dislocloaxylum hexandrum</i>	11	0.758621	8.8	0.758621	0.189741	1.022097	0.846446
<i>Chrysophyllum albedum</i>	5	0.344828	4	0.344828	0.347081	1.869656	0.853104
<i>Croton macrotachyus</i>	1	0.068966	0.8	0.068966	0.490231	2.640773	0.926235
<i>Weakenia sp.</i>	14	0.965517	11.2	0.965517	0.208797	1.124748	1.018594
<i>Campylospermum perexilis</i>	16	1.103448	12.8	1.103448	0.228846	1.232745	1.146547
<i>Millettia barteri</i>	11	0.758621	8.8	0.758621	0.380568	2.050041	1.189094
<i>Ceitis zenkeni</i>	8	0.551724	6.4	0.551724	0.465851	2.509444	1.204297
<i>Entandrophragma angolense</i>	4	0.275862	3.2	0.275862	0.594506	3.202483	1.251402
<i>Voacanga africana</i>	18	1.241379	14.4	1.241379	0.256797	1.383316	1.288692
<i>Unknown</i>	30	2.068966	24	2.068966	0.010248	0.055205	1.397712
<i>Pavetta crombosa</i>	1	0.068966	0.8	0.068966	0.7855	4.231331	1.456421
<i>Oxyanthus sp.</i>	4	0.275862	3.2	0.275862	0.854329	4.602101	1.717942
<i>Ficus sur</i>	22	1.517241	17.6	1.517241	0.439187	2.365814	1.800099
<i>Diospyros camarunensis</i>	10	0.689655	8	0.689655	0.773725	4.167903	1.849071
<i>Clausena anissata</i>	39	2.689655	31.2	2.689655	0.031768	0.17113	1.850147
<i>Drypetes floribunda</i>	3	0.206897	2.4	0.206897	1.116091	6.012157	2.141983
<i>Carapa oriophylla</i>	28	1.931034	22.4	1.931034	0.497407	2.67943	2.1805
<i>Anthonatha noldeae</i>	42	2.896552	33.6	2.896552	0.350935	1.890418	2.561174
<i>Ficus lutea</i>	22	1.517241	17.6	1.517241	1.079784	5.81658	2.950354
<i>Sherubapsis sp</i>	6	0.413793	4.8	0.413793	1.803806	9.716743	3.514776
<i>Zanthoxylum zanthoxyloidea</i>	77	5.310345	61.6	5.310345	0.101638	0.547501	3.72273
<i>Newtonia buchananii</i>	45	3.103448	36	3.103448	1.092035	5.882575	4.029824
<i>Poutaria altissima</i>	12	0.827586	9.6	0.827586	2.165185	11.66342	4.43953
<i>Rothmania hispida</i>	88	6.068966	70.4	6.068966	0.324474	1.747876	4.628602
<i>Strombosia postulate</i>	94	6.482759	75.2	6.482759	0.293813	1.582709	4.849409
<i>Deinbolia pinnata</i>	122	8.413793	97.6	8.413793	0.128696	0.693258	5.840282
<i>Garcinia smithmanii</i>	157	10.82759	125.6	10.82759	0.182956	0.98555	7.546907
<i>Rytignia umbellatum</i>	221	15.24138	176.8	15.24138	0.256843	1.383563	10.62211
<i>Pleiocarpa pycnantha</i>	225	15.51724	180	15.51724	0.154669	0.83317	10.62255

### Wasaji Forest Reserve

Species	Freq	RF	D	RD	BA	RDo	IVI
<i>Azelia africana</i>	1	0.185529	0.8	0.185529	0.020109	0.258934	0.209997
<i>Neocarya polyandra</i>	1	0.185529	0.8	0.185529	0.101801	1.310852	0.560637
<i>Maranthes polyandra</i>	5	0.927644	4	0.927644	0.025152	0.32387	0.726386
<i>Pilliosigma thorningii</i>	4	0.742115	3.2	0.742115	0.107083	1.378873	0.954368

Species	Freq	RF	D	RD	BA	RDo	IVI
<i>Bridelia ferruginea</i>	10	1.855288	8	1.855288	0.118508	1.52599	1.745522
<i>Strychnos innocua</i>	6	1.113173	4.8	1.113173	0.256335	3.300732	1.842359
<i>Nuclea latifolia</i>	9	1.669759	7.2	1.669759	0.207005	2.665535	2.001684
<i>Ficus sur</i>	6	1.113173	4.8	1.113173	0.316936	4.081069	2.102471
<i>Vetellaria paradoxa</i>	10	1.855288	8	1.855288	0.246795	3.177889	2.296155
<i>Syzigium guineense</i>	9	1.669759	7.2	1.669759	0.284953	3.66924	2.336253
<i>Khaya senegalensis</i>	6	1.113173	4.8	1.113173	0.391114	5.036229	2.420858
<i>Vitex donianna</i>	17	3.153989	13.6	3.153989	0.092201	1.187233	2.498404
<i>Pterocarpus erinaceus</i>	10	1.855288	8	1.855288	0.336885	4.337951	2.682842
<i>Crossopteryx febrifuga</i>	18	3.339518	14.4	3.339518	0.209035	2.691664	3.123566
<i>Lophira alata</i>	17	3.153989	13.6	3.153989	0.292654	3.768403	3.358794
<i>Parkia biglobosa</i>	14	2.597403	11.2	2.597403	0.457391	5.889661	3.694822
<i>Lenea alata</i>	18	3.339518	14.4	3.339518	0.462031	5.949409	4.209481
<i>Hymenocardia acida</i>	30	5.565863	24	5.565863	0.180751	2.327471	4.486399
<i>Anonna senegalensis</i>	40	7.42115	32	7.42115	0.072341	0.931504	5.257935
<i>Ficus lutea</i>	25	4.638219	20	4.638219	0.614905	7.917913	5.73145
<i>Uapaca togoensis</i>	42	7.792208	33.6	7.792208	0.329908	4.248109	6.610841
<i>Daniellia oliveri</i>	24	4.45269	19.2	4.45269	0.866717	11.16041	6.688597
<i>Parinari excelsa</i>	56	10.38961	44.8	10.38961	0.278704	3.588769	8.122663
<i>Terminalia sp</i>	65	12.05937	52	12.05937	0.243449	3.134811	9.084516
<i>Pericopsis laxiflora</i>	64	11.87384	51.2	11.87384	0.613387	7.898366	10.54868

#### Baissa Forest Reserve

Species	Freq	RF	D	RD	BA	RDo	IVI
<i>Elaeis guineensis</i>	2	0.273973	1.6	0.273973	0.168568	1.831269	0.793071
<i>Malacantha alnifolia</i>	1	0.136986	0.8	0.136986	0.204309	2.219539	0.83117
<i>Mangifera indica</i>	6	0.821918	4.8	0.821918	0.1087	1.180881	0.941572
<i>Bridelia ferruginea</i>	8	1.09589	6.4	1.09589	0.097785	1.062302	1.084694
<i>Khaya senegalensis</i>	8	1.09589	6.4	1.09589	0.160134	1.739641	1.310474
<i>Ziziphus mauritiana</i>	10	1.369863	8	1.369863	0.136913	1.487373	1.409033
<i>Maranthes polyandra</i>	8	1.09589	6.4	1.09589	0.214353	2.32866	1.506814
<i>Pilliosigma thorningii</i>	11	1.506849	8.8	1.506849	0.193976	2.107286	1.706995
<i>Terminalia glaucosens</i>	10	1.369863	8	1.369863	0.235862	2.562326	1.767351
<i>Ficus sur</i>	15	2.054795	12	2.054795	0.194469	2.112644	2.074078
<i>Crossopteryx febrifuga</i>	16	2.191781	12.8	2.191781	0.209557	2.276553	2.220038
<i>Terminalia sp</i>	11	1.506849	8.8	1.506849	0.412923	4.485856	2.499852
<i>Lotera alata</i>	22	3.013699	17.6	3.013699	0.153969	1.672664	2.566687
<i>Vitex donianna</i>	9	1.232877	7.2	1.232877	0.500416	5.436348	2.634034
<i>Vetellaria paradoxa</i>	4	0.547945	3.2	0.547945	0.676198	7.345982	2.813958
<i>Lannea acida</i>	22	3.013699	17.6	3.013699	0.269255	2.925096	2.984165
<i>Parkia biglobosa</i>	7	0.958904	5.6	0.958904	0.653873	7.103451	3.007086
<i>Parinari polyandra</i>	25	3.424658	20	3.424658	0.206555	2.243944	3.031086
<i>Jatropha carcass</i>	19	2.60274	15.2	2.60274	0.510745	5.548555	3.584678
<i>Nuclea latifolia</i>	58	7.945205	46.4	7.945205	0.185782	2.018268	5.96956
<i>Anogeissus leiocarpa</i>	52	7.123288	41.6	7.123288	0.373159	4.053876	6.100151
<i>Parinari excelsa</i>	75	10.27397	60	10.27397	0.258613	2.809482	7.785809
<i>Daniellia oliveri</i>	4	0.547945	3.2	0.547945	2.376786	25.82059	8.972161
<i>Uapaca togoensis</i>	105	14.38356	84	14.38356	0.266696	2.897294	10.55481
<i>Hymenocardia acida</i>	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
<i>Combretum tomentosum</i>	2	0.554017	1.6	0.692521	0.004163	0.028153	0.424897
<i>Bridelia ferruginea</i>	1	0.277008	0.8	1.385042	0.009505	0.064274	0.575441

Species	Freq	RF	D	RD	BA	RDo	IVI
<i>Borassus aethiapum</i>	10	2.770083	8	0.34626	0.011518	0.077892	1.064745
<i>Diatarium senegalensis</i>	2	0.554017	1.6	1.731302	0.239931	1.622526	1.302615
<i>Parinari polyandra</i>	3	0.831025	2.4	3.462604	0.061505	0.415923	1.569851
<i>Hyphaene thebaica</i>	4	1.108033	3.2	3.462604	0.026491	0.179144	1.583261
<i>Nuclea latifolia</i>	10	2.770083	8	1.038781	0.171019	1.156511	1.655125
<i>Azadirachta indica</i>	6	1.66205	4.8	3.462604	0.044211	0.298972	1.807875
<i>Sterculia setijera</i>	1	0.277008	0.8	4.501385	0.145239	0.982174	1.920189
<i>Lannea acida</i>	10	2.770083	8	3.462604	0.211606	1.430978	2.554555
<i>Pteleopsis suberosa</i>	23	6.371191	18.4	0.34626	0.144713	0.978617	2.565356
<i>Acacia kirkir</i>	22	6.094183	17.6	2.077562	0.050308	0.340204	2.837316
<i>Combretum molle</i>	29	8.033241	23.2	0.692521	0.127435	0.861776	3.195846
<i>Combretum lecardii</i>	2	0.554017	1.6	10.04155	0.081456	0.550846	3.715471
<i>Terminalia sp</i>	13	3.601108	10.4	5.193906	0.424919	2.873503	3.889506
<i>Prosopis africana</i>	23	6.371191	18.4	7.963989	1.075155	7.2707	7.20196
<i>Pilliosigma thorningii</i>	66	18.28255	52.8	7.963989	0.101922	0.689246	8.978594
<i>Parkia biglobosa</i>	10	2.770083	8	22.85319	0.280172	1.894655	9.172641
<i>Hymenocardia acida</i>	95	26.31579	76	1.385042	0.148307	1.002918	9.567916
<i>Entada Africana</i>	5	1.385042	4	32.89474	0.383481	2.593279	12.29102
<i>Ceiba pentandra</i>	4	1.108033	3.2	0.692521	10.55516	71.37891	24.39315
<i>Ziziphus mauritiana</i>	5	1.385042	4	125	0.371432	2.511794	42.96561

#### Bakin Dutse Forest Reserve

Species	Freq	RF	D	RD	BA	RDo	IVI
<i>Ficus sur</i>	3	1.041667	2.4	1.043478	0.076796	1.281585	1.122243
<i>Bridelia scleroneura</i>	2	0.694444	1.6	0.695652	0.241384	4.028274	1.806124
<i>Parinari polyandra</i>	8	2.777778	6.4	2.782609	0.034375	0.573665	2.044684
<i>Bridelia ferruginea</i>	7	2.430556	5.6	2.434783	0.241384	4.028274	2.964538
<i>Parinari excels</i>	12	4.166667	9.6	4.173913	0.103719	1.730882	3.357154
<i>Pericopsis laxiflora</i>	15	5.208333	12	5.217391	0.088437	1.475858	3.967194
<i>Hyptis suaveolens</i>	3	1.041667	2.4	1.043478	0.705091	11.76672	4.617289
<i>Lonchocarpus laxiflorus</i>	3	1.041667	2.4	1.043478	0.827053	13.80205	5.295732
<i>Annona senegalensis</i>	24	8.333333	19.2	8.347826	0.090768	1.514754	6.065304
<i>Khaya senegalensis</i>	27	9.375	21.6	9.391304	0.132889	2.217685	6.994663
<i>Acacia kirkir</i>	32	11.11111	25.6	11.13043	0.018518	0.309034	7.51686
<i>Daniellia oliveri</i>	11	3.819444	8.8	3.826087	1.035225	17.27607	8.3072
<i>Nuclea latifolia</i>	35	12.15278	28	12.17391	0.18314	3.05629	9.12766
<i>Hymenocardia acida</i>	65	22.56944	52	22.6087	0.199873	3.335535	16.17123

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