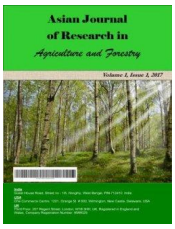

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Sustainability, Population and Structure of Woody Species Composition of Taraba State Forests

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Authors' contributions

This work was carried out in collaboration among all authors. Author MBB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors TI, MGS, NI, GS and CH managed the analyses of the study. Author MGS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Sustainability, population and structure of woody species composition of Taraba state forests were studied for future management strategies that allow a more sustainable use of woody species and a better conservation of forest ecosystems. The objectives of the study were to study the woody species dominance, important value index and population structure in different ecological zones of Taraba State forests. 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 and two protected areas were also sampled from each ecological zone. A total of 30 plots and 6 protected areas were sampled and all the woody species that occurred in the plots were also sampled. Data were analyzed using descriptive and inferential statistics such as Tables, percentages, frequency, ANOVA and LSD. A total of 3760 individual

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woody stands from 60, 34 and 32 species in Montane Forest, Southern and Northern Guinea Savanna respectively were recorded. *Strombosia postulate, Pleiocarpa pycnantha, Pericopsis laxiflora, Hymenocardia acida* and *Ziziphus mauritiana* were the dominance species while their corresponding rarest species were *Goria sp*, *Afzelia africana, Elaesis guneensis, Combretum tomentosum* and *Ficus sur*. *Strombosia postulate* and *Pleiocarpa pycnantha* were the dominant woody species with high important value indices in Montane forest zone as opposed to *Pericopsis laxiflora* and *Ziziphus mauritiana* which dominated the Southern and Northern guinea savanna respectively. The rarest species of *Goria sp*, *Afzelia africana, Elaesis guneensis, Combretum tomentosum* and *Ficus sur* in the study area could be connected to its usefulness as fodder species. The population structure of woody species was found to be very low in the middle diameter classes.The diameter class distribution resembles interrupted "U" shape indicating the removal of merchantable trees. There were no significant differences ($p>0.05$) among the protected areas and ecological zones due to the low dominance and important value indices. This needs appropriate management techniques to improve forest composition and structure in the study area for sustainability.

Keywords: Sustainability; population structure; forests; important value index; ecological zones.

1. INTRODUCTION

Woody species composition and structure in an area depend on climatic and adaphic factors, these factors have recently been overwhelmed by anthropogenic factors especially in the tropics. Tropical forests are the richest biological communities on earth and have been recognized to harbor a significant proportion of global biodiversity [1]. These forest ecosystems which constitute a major woody species play critical roles in providing goods and services necessary for the well-being of both humans and animals at a range of scale from local to global [2,3]. The composition and structure of the tropical forests, which are home to around half of the terrestrial plant and animal species, are being destroyed at rates unprecedented in ecological history [3,4,5] resulting to the extinctions of many species. Several authors [6,7] estimated that Nigeria habours 5,103 plant species; out of which 8.5% are threatened and 0.4% is endangered. The current estimates suggest that over 500 tree species are threatened with extinction [8].

Taraba State is one of the few States in Nigeria that possess a unique characteristic of natural forests. Many of the woody species found in these forests are characterized by short and irregular-shaped with many under growths including grasses that are burned annually. The woody plants and the environment in Taraba State have been used so much that the composition and structure of these species is gradually changing. The degradation of this environment continues and many ecosystems are increasingly vulnerable to collapse because of reduced habitat quality, unsustainable use and management of woody species which serves as the bedrock of the ecological communities. This necessitate the need to understand forest composition and structure [9] so that recommendations can be made for the restoration and future management [10]. The objectives of the study were to study the woody species dominance, important value index and population structure in different ecological zones of Taraba State forests.

2. MATERIALS AND METHODS

2.1 Study Area

Taraba State in Nigeria lies between latitudes 7°00' 00" N and 9° 58' 51" N and longitudes 9° 52' 28" E and 12° 39' 51" E. It occupies a total land mass of approximately 54, 473 km^2 (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 [11]. The state is made up of three (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 [12].

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

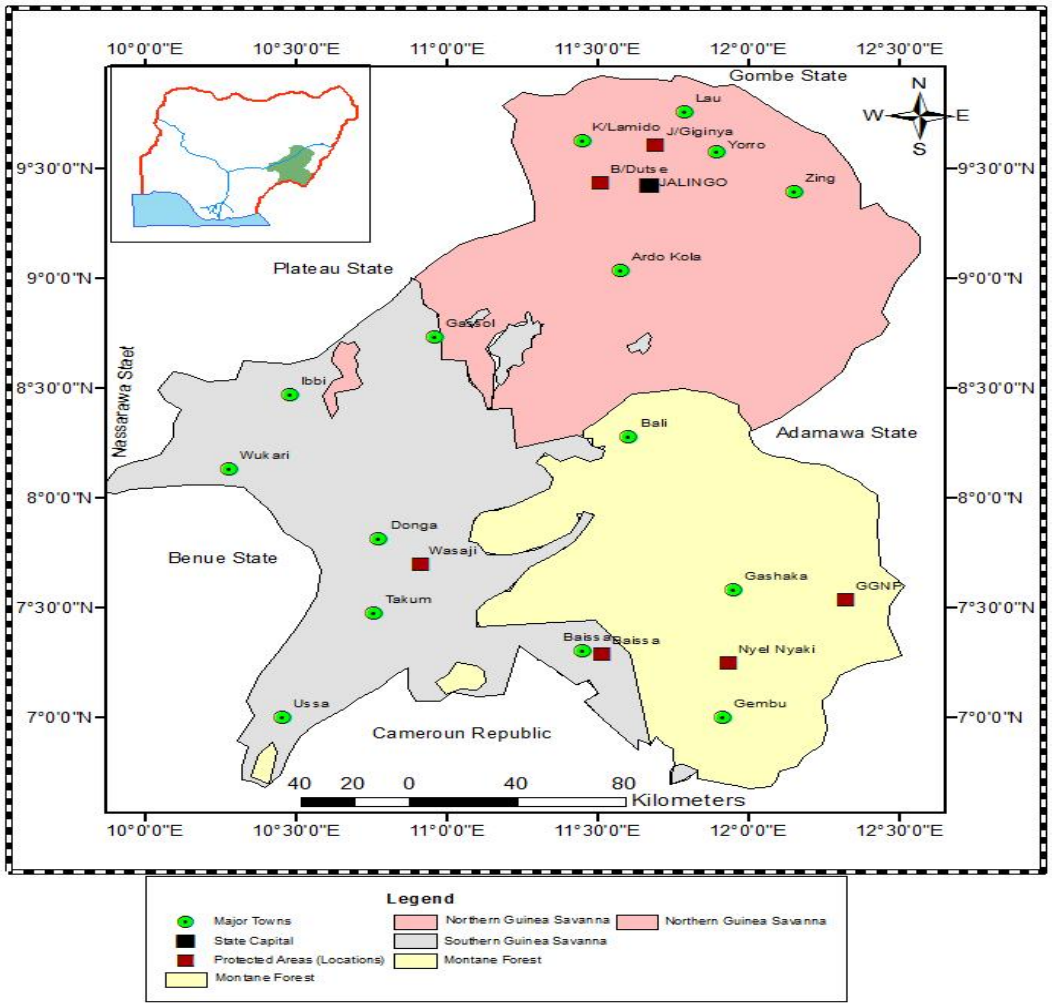

Fig. 1. Map of Taraba state showing the major ecological zones and the study area source: GIS MAUTEH Yola, 2017

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 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 and recorded. Woody species identification was done first directly on the field using the field identification guides developed by Keller, [13] 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. 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.

Data were analyzed on SPSS version 20 software using the statistical tools. The number of species i.e. species composition was determined by summing up the number of species identified directly in the field from each plot and the quantitative analysis was made using data from density, abundance, frequency of distribution of each species in the study sites.

Species density was determined by counting the number of individuals in the sample plots and converting the count into hectare basis.

i. Density of a species = $\frac{Total\ number\ of\ individuals\ of\ a\ species}{Sample\ size\ in\ hectares}$

ii. Relative density = $\frac{Density\ of\ individual\ species}{Total\ density\ of\ all\ species} \times 100$

iii. Relative dominance = $\frac{Total\ basal\ area\ for\ a\ species}{Total\ basal\ area\ of\ all\ species} \times 100$

iv. Relative frequency = $\frac{Frequency\ of\ individual\ species}{Sum\ of\ all\ frequencies} \times 100$

v. Basal area = π(Diameter)^2 /4.

vi. The Importance Value Index (IVI) = $(R_{dominance} + R_{Density} + R_{Frequency})/3$

Where,

R = Relative

The population structure of all the individuals of each species encountered in each protected area was grouped into diameter classes to analyze the woody species structure. This was assessed through Bar charts and diameter curve constructed by using the density of individuals of each species (Y-axis) categorized into eight diameter classes (X-axis) as it was used by Neelo, [3].That is 1 = < 11 cm; 2 = 11 - 20 cm; 3 = 21 - 30 cm; 4 = 31 - 40 cm; 5 = 41 - 50 cm; 6 = 51 - 60 cm; 7 = 61 - 70 cm; 8 = > 70 cm. Based on this profile, the population structures of woody species was determined.

Data collected was also subjected to two – way analysis of variance (ANOVA) using basal area on SPSS version 20 software to test for the significant difference among the protected areas and ecological zones. Frequencies and percentages were generated by SPSS and presented in tables or Figures.

3. RESULTS

3.1 Woody Species Compositions

Results of woody species composition in the study area shown in Fig. 2 was described in terms of its frequency, dominance, relative density, basal area and relative dominance (Appendix I). 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(Fig. 2). 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 (Appendix I).

Basal area provides the measure of the relative importance of the species. Species with largest contribution in dominance value through higher basal area were considered as the most important species in the study area. Analysis of species' important value index (Appendix I) in MF revealed that *Strombosia postulate* and *Pleiocarpa pycnantha* species were the most important species in Gashaka Gumti and Nyel Nyaki protected areas respectively. In SGS, *Pericopsis laxiflora* and *Hymenocardia acida* were among the abundant species in Wasaji and Baissa forest reserves respectively while *Ziziphus mauritiana* in Jen Giginya and *Hymenocardia acida* in Bakin Dutse were recorded in NGS*. Ziziphus mauritiana* was found to have the highest important value index (42.97) in the study area. *Mangifera indica*, *Goria sp*, *Afzelia africana, Elaesis guneensis, Combretum tomentosum* and *Ficus sur* stood out as the rarest species due to their low IVI in the Gashaka Gumti, Nyel Nyaki, Wasaji, Baissa*,* Jen Giginya and Bakin Dutse protected areas respectively (Appendix I).

3.2 Population Structure

Fig. 3 shows the result of population structure of woody species in the study area which indicated that the number of individual woody species was high in the lower diameter classes. Most individuals, 59 (15.05%) in Gashaka, 387 (26.69%) in Ngel Nyaki, 145 (26.90%) in Wasaji, 140 (19.18%) in Baissa, 97(26.87%) in Jen Giginya and 97 (27.43%) in Bakin Dutse were in the first diameter class (1 = < 11 cm) with a gradual decrease towards middle classes with many tree stands having branches at the breast height or below and a sharp rise in the highest diameter class, Ngel Nyaki had the highest number of individual woody stands in all the diameter classes. Consequently, the woody

species recorded from the three ecological zones exhibited stable population structures composed of the highest density of individuals [446 (24.21%) in MF, 285 (22.46%) in SGS and 176 (27.12%) in NGS] at the lowest diameter class (1 = < 11 cm) followed by an abrupt drop in diameter class 2 = 11-20 cm and little rise in diameter class 3 = 21-30cm in SGS and NGS. A gradual declining densities of individuals occurred in the increasing diameter classes with a sharp rise in the highest Diameter class giving it a "U" shape (Fig. 4).

3.3 Diameter Distribution in all the Ecological Zones of the Study Area

The results of diameter curve distribution are shown in Figs. 3 and 4. The results indicated that the diameter class distribution of the population structure produced an interrupted "U" shaped

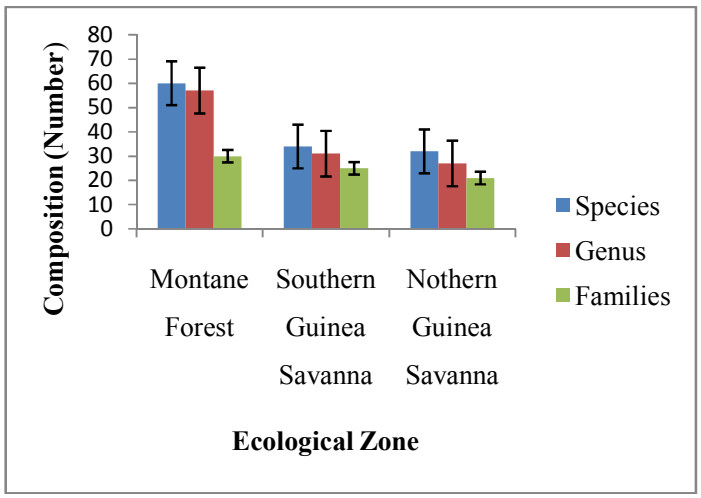

Fig. 2. Woody species composition in the study area

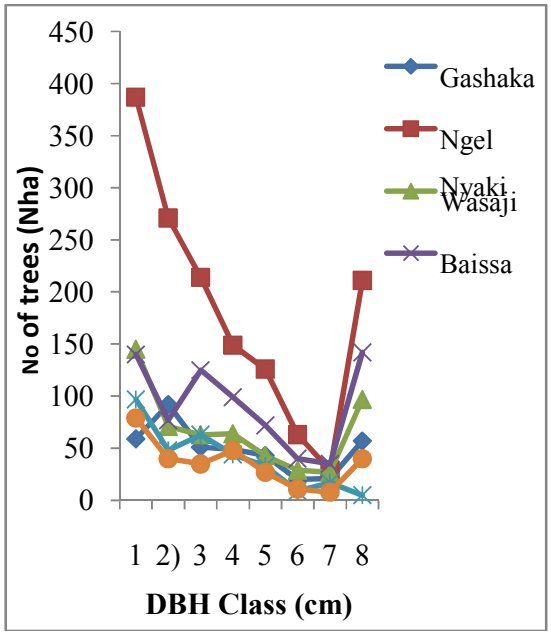

Fig. 3. Diameter curve distribution at the various protected areas

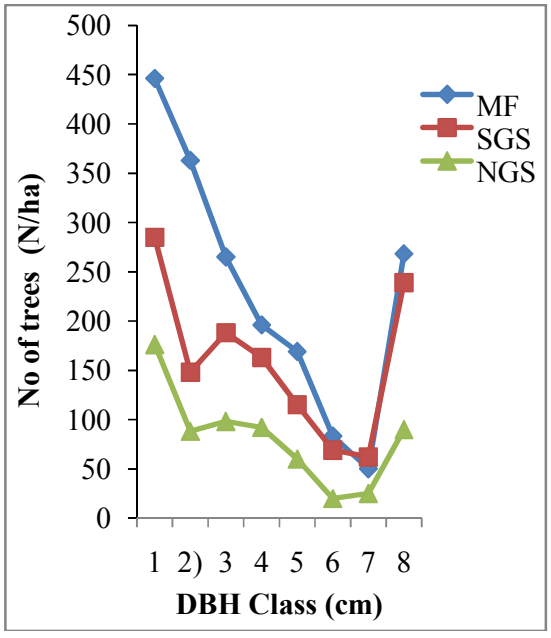

Fig. 4. Diameter curve distribution of the ecological zones in the study area

[Diameter class (DBH): 1 = < 11 cm; 2 = 11 - 20 cm; 3 = 21 - 30 cm; 4 = 31 - 40 cm; 5 = 41 - 50 cm; 6 = 51 - 60 cm; 7 = 61 - 70 cm; 8 = > 70 cm]

curve which seemed to show a pattern where species frequency distribution had the highest frequency in the lower diameter classes and a gradual decrease towards the middle diameter classes with a sharp rise in the highest class (8 = > 70 cm).

3.4 Comparison of Species Composition and Structure

Analysis of variance (ANOVA) result indicated that the F-calculated value (0.77) in woody species composition and structure was less than the F-tabulated value (4.23) at 0.05 level of significance among the protected areas of the study area. This means that there is no significant difference ($p>0.05$) among the protected areas. Similarly, the ANOVA revealed that F-calculated value (0.88) was less than the F-tabulated value (3.37) at 0.05 level of significance among the three ecological zones of the study area which also implies that the woody species composition and structure among the ecological zones of the study area is not significantly different ($p>0.05$).

4. DISCUSSION

The composition woody species from Montane forest zone was similar to the ones in our neighbouring Cameroon in Kalfou Forest Reserve where 28 families, 58 genera and 86 species were recorded [14]. In line with [15], which recorded 28 families, 54 genera and 75 species in non-cultivated plain of Moutourwa, Cameroon which shares boundary with the Montane forest ecological zone. A Large number of woody species occur in Ngel Nyaki forest reserve of Montane forest. However a modification of the species composition was observed in both the Southern and Northern guinea savanna having more similar species and different dominant species compared with the Montane forest, this could be attributed to differences in the climatic and edaphic conditions [3,16,17]; and difference of anthropogenic pressure [15] between Motane forest zone and the other two ecological zones.

Strombosia postulate and *Pleiocarpa pycnantha* were the dominant woody species with high important value indices in Montane forest zone as opposed to *Pericopsis laxiflora* and *Ziziphus mauritiana* which dominated the Southern and Northern guinea savanna respectively. These species indicate economic and ecological significant in these zones and this confirms the view of [18] that the important value index is an important parameter that indicates the economic and ecological significance of species in a given ecosystem. [15] identified *Ziziphus mauritiana* and *Parkia biglobosa* as one among the top sixteen most preferred and the most commercialized fruits producing species in Adamawa, Far-North and North Regions Cameroon and this is not exception in Nigeria, particularly Adamawa and Taraba States. Species with high important value indices are regarded as more important than those with low important value indices [19] and this is very important in conservation because those species with high important value indices need monitoring management only [20] while those with low important value indices are prioritized for conservation [21].

The rarest species of *Goria sp*, *Afzelia africana, Elaesis guneensis, Combretum tomentosum* and *Ficus sur* in the study area could be connected to its usefulness as fodder species. These species have also been found very useful for other purposes such as carving and firewood production, provision of tanning and dyeing materials, cultural and medicinal applications. *Combretum sp* is an important fodder species whose leaves are browsed by livestock. Its wood is very good for firewood, it produces good quality charcoal and various parts of the plant have been found to be of important medicinal value [22]. Identification of most valuable and threatened woody species and determination of their conservation status can provide a focus for future management strategies that allow a more sustainable use of plant resources and a better conservation of ecosystems [23]. IVI value of most woody species in the study fall below three (3) and according to [23], those woody species which have IVI value less than three are threaten and these need immediate conservation measures.

Woody species diameter class distribution is an important indicator of changes in population structure and species composition of a forest ecosystem. In this wise, the number of woody species in the study area was found to be very low in the middle diameter classes. This implies that the merchantable volume of woody species in the study area is adversely affected by the high degree of exploitation, farming and settlement. The lack of trees at the middle diameter classes of the study may be due to harvesting of such trees for sale in the urban areas as evidenced by numerous stumps in

Wasaji, Jen Giginya and Bakin Dutse Forest Reserves, leading to the conversion of these forests to non-forest lands. [24] also reported the conversion of forest areas to non-forest land use like logged areas, arable land and urban use through diameter class distribution analysis. These findings agreed with [3] that the status of tree populations can be revealed by way of size class distribution analyses.

The high number of individual woody species in the lower diameter classes implies that the application of sustainable management principles may successful restore woody species in the middles diameter classes of the study area. The pattern is also an indicator of healthy regeneration status of woody species [3,25,19,26,27,28] that ensures sustainability in the study area. This finding agrees with those reported by [29] from Panama, they observed over 80% of individuals species in the smaller diameter classes. The factors that cause the abrupt rise in the highest diameter distribution class could be poor formation, species deformation, low quality production, pest and disease infections, old age of the individual species, adaphic and environmental factors among others. The interrupted "U" shaped diameter distribution curve is a characteristic of tropical forests in general, which should have a greater number of young individuals to ensure the replacement of trees with larger diameters [29] for sustainable management.

Similar trends were reported from studies in dry evergreen forests of Gedo, West Shewa Zone by [30], Dallo Mena Districk by [31] and TaraGedam forest at South Gonder by [19] as well as Kumuli Dry Evergreen Afromontane Forest in Yem District by [32], all in Ethiopia. Generally speaking, only few species with few matured individuals dominated the ecological zones of the study area in their composition, and structure while many of the species were very rare or low in their composition and structure. Such a result reflects adverse environmental situations and random distribution of available resources [33,34].

The poor composition and structure of woody species in the study area that does not show significant difference may be connected to the high number of species with lowest densities, dominance and important value indices recorded in the study area which is a clear indication that the major population of woody species in the study area were young as confirmed by the diameter curve distribution of the study. This development may be due to the disturbance history [35] of the study area. This confirms [36] that basal area significantly declines with decreasing patch size.

5. CONCLUSION

The knowledge of the composition and structural characteristics of woody species is highly necessary to the understanding of woody species and other forest resources for effective conservation. These have led to calls for urgent conservation attention as most of the species in the study area were found to possess low dominance and basal area values leading to low important value index. The Important value indices revealed the most ecologically important woody species in the study area and those to be prioritized for conservation. The species having low important value indices need to be prioritized for conservation. The diameter class distribution pattern of woody individuals that showed an interrupted "U" shape is a reflection of more good regeneration profile in the study area; this needs appropriate management techniques to improve the nature of the forest population and structure in the study area.

6. RECOMMENDATIONS

There should be greater investment in research to improve the quality of information on woody species and to improve our understanding of woody species composition and structure for effective and sustainable management.

Recovery plans and blue prints for the restoration and afforestation of threatened species should be done as a matter of urgency through the use of traditional and in-situ means for optimal composition and forest structure. Rare and endangered species should be conserve using ex-situ strategy for proper care and attention.

More protected areas and area exclosures should be established to protect the structural population of the larger lowest diameter distribution classes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX I

Species Composition of each Protected Area According to Increasing Order of the Important Value Index

Species	Freq	RF	D	RD	BA	RDo	IVI
Gashaka							
Mangifera indica	1	0.255102	0.8	0.255102	0.005	0.101854	0.204019
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
Total	**392**	**100.00000**	**313.6**	**99.99997**	**4.9091**	**100.00203**	**100.00065**
Ngel Nyaki Forest Reserve							
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
Tabernamontana cantata	5	0.344828	4	0.344828	0.091904	0.495066	0.394907
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

Species Composition of each Protected Area According to Increasing Order of the Important Value Index

Species	Freq	RF	D	RD	BA	RDo	IVI
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
Total	**1392**	**96.00001**	**1160**	**100.00001**	**18.56392**	**100.00011**	**100.00004**
Wasaji Forest Reserve							
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
Unknown	32	5.93692	25.6	5.93692	0.639923	8.240063	6.704634
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
Total	**539**	**100.00001**	**431.2**	**100.00001**	**7.766073**	**100.00095**	**100.31**

Species Composition of each Protected Area According to Increasing Order of the Important Value Index

Species	Freq	RF	D	RD	BA	RDo	IVI
Baissa Forest Reserve							
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 paradoxa	4	0.547945	3.2	0.547945	0.676198	7.345982	2.813958
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	0.373159	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
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
Unknown	15	4.155125	12	1.731302	0.11782	0.796752	2.227726
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
Total	**1091**	**200**	**872.8**	**342.38228**	**23.99256**	**200.00065**	**247.460973**

Species Composition of each Protected Area According to Increasing Order of the Important Value Index

Species	Freq	RF	D	RD	BA	RDo	IVI
Bakin Dutse Forest Reserve							
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	3.33554	16.17123
Total	**247**	**85.76389**	**197.6**	**85.91304**	**3.9785**	**66.39668**	**79.35788**

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