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Evaluation of Tree Species Composition and Density in Bisaula Forest Reserve Taraba State, Nigeria.

Abel A MAIGURU[*1]

[1] Department of Forestry and Wildlife Management, Federal University Wukari –Taraba State, Nigeria.

E-Mail: ngamuabel@gmail.com

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Abstract: This study investigated tree species composition and density in Bisaula Forest Reserve in Taraba State, Nigeria. In recent decades, there has been an increase in population among the communities living adjacent to the Bisaula Forest Reserve who rely so much on the forest resources for their livelihoods. As a result, the forest has been under pressure for decades, and before any forest management plan can be suggested, it is proper to investigate its status. Twenty-hectare plots were laid across the forest; each hectare was re-demarcated into four plots with equal sizes of 50m x 50m, of which one was selected by a simple random sampling technique. A total of twenty sample plots covering a land area of 50,000 m^2 (5ha) were used for the study. The results revealed that a total of 48 different tree species belonging to 16 families were recorded. The average number of trees per hectare, basal area of trees per hectare, and volume of trees per hectare were 99 trees, 0.9524 m^2, and 19.354 m^3, respectively. Findings from the factors investigated in measuring the status of the forest revealed that the forest is understocked. The forest therefore needs to be reforested by planting fast-growing tree species, and the cutting of trees in the forest must be regulated.

Keywords: Bisaula Forest Reserve; Species Composition; Density; Basal area.

INTRODUCTION

Forests and woodlands contribute significantly to economic development and environmental security. They support many people, including farmers, herdsmen, rural dwellers, and many others. They provide protection for watersheds and constitute a major source of income and employment (Umotong, 2015). The poor depend on forests for their basic needs, such as food, fodder, fibre, fuel wood, timber, and medicinal plants. They provide the global community with biological diversity, generic materials, and carbon sequestration. Deforestation, chiefly caused by the conversion of forest land to agriculture and livestock areas, threatens not only the livelihoods of foresters, forest communities, and indigenous peoples but also the variety of life on our planet (FAO, 2018; Umotong, & Udofia, 2023). It is a major threat, and it occurs in forest lands where a rapidly growing population is driven by their basic needs. It becomes wasteful when trees essential for watershed protection and biodiversity conservation are removed or cleared for agricultural production. These then led to the erosion of the forest resource base and environmental instability. Loss of forests and trees often also affects the poor directly by destroying a valuable asset on which their livelihood depends and indirectly by destroying biodiversity and ecosystems, which are essential for the maintenance of life support systems (Umotong, 2004).

According to Edmond (2005), Nigeria was once covered by widespread vegetation, comprising dense tropical forest in the south and savanna grassland in the north. A great percentage of this luscious vegetation has been cleared by the pressure exerted by human activities. FAO (2005) reported that Nigeria had the largest deforestation rate in the world, having lost 55.7% of its primary forest. The Nigerian forest is being depleted at an annual rate of 3–5%. The total change in forest cover from 1900 to 2000 stood at about 40 million hectares. As a result, the forest areas in the country are disappearing at a rate of 2.3% a year. Activities such as agriculture, urbanisation, road construction, and mining, among others, were the driving factors behind forest depletion globally. Bisaula Forest Reserve, like many other reserves in the world, continues to suffer from human-destructive activities that degrade them. Despite the fact that this forest is one of the oldest in the area, it is an important biodiversity hotspot in Taraba State. It is surrounded by many communities, of which the majority are poor and rely on the forest, coupled with poor management of the forest (World Bank 1990; Umotong, 2020). The forest's natural resources are likely to be degraded. The reason for the examination of the forest composition and structure is to know the available variety in the reserve and the distribution of the stands that form the forest structure.

[*] *Corresponding E-mail:* ngamuabel@gmail.com

MATERIAL AND METHODS

The Study Area

The study was conducted in Bisaula Forest Reserve in Taraba State, Nigeria. The total land covered by the reserve is 147.63 ha, with its gazette number NE18, 15/6/69. The reserve is situated in the high-rain forest of the southern part of Taraba. It lies between latitude 70 10' north and longitude 100 43' east. The topography of the reserve is fairly dominated by highlands to the Benue River valley. The forest is characterised by gently undulating flats. Wetland soils are prevalent and are present within the floodplains of the Benue River and its tributaries, like the Bisaula and Sunkuru Rivers, and many others that are the headwaters of the Donga River. Because of its proximity to the former Baissa Timber Corporation, its high-quality timber tree species were used in the Baissa Timber Company. As a result of several years of illegal activities, including farming, logging, settlements, and overexploitation, the forest is fragmented and a larger part of the reserve is degraded.

Sampling Technique

Twenty hectares of land were laid out across the reserve. Each hectare plot was re-demarcated into four sample plots of 50m x 50m (2,500 m^2) sizes, of which one was randomly selected for assessment. A total land area of 50,000 m^2 (5ha) was used for the study. Individual tree species with dbh ≥ 5cm in each sample plot were considered for enumeration.

Data collection and analysis

The data collected were the names of tree species, number, diameter at breast height (dbh), and total height in each plot. The collected data were analysed by grouping the tree species into their taxonomic families, frequency, and percentage. The density of each plot was determined using the number of trees, the calculation of the basal area per tree per plot, and the volume of each tree per plot. The numbers of trees in each plot were extrapolated per hectare using the Avery and Burkhart (2002) formula.

$$N = \frac{h}{a} \times c \qquad \text{(Equation 1)}$$

Where:

h = one hectare.
a = area of plot in hectare.
c = number of trees counted in the plot.
N = estimated number of trees/hectare.

The basal area of each tree in each plot was calculated using Avery and Burkhart (2002) formula as follows:

$$BA = \frac{\wedge D^2}{4(100)^2} \qquad \text{(Equation 2)}$$

Where:
BA = Basal Area (m^2)
π = constant (3.142)
D = Diameter at breast height (dbh)

The total basal area per hectare was extrapolated using this formula:

$$BA = \frac{h}{a} \times d \qquad \text{(Equation 3)}$$

Where:
BA = basal area per hectare.
h = One hectare

a = Area of plot in hectare.
d = Basal area in each plot
VTH= Basal area x Height (Equation 4)

RESULTS AND DISCUSSION

The Tree Species Composition.

The results of this study in Table 1 show the tree species composition in Bisaula Forest Reserve, Taraba State, Nigeria. A total of 48 different individual tree species were recorded and were classified accordingly into 16 families. The tree species composition (48 species) was lower than the tree species composition in Amoro Forest (57 species) and other Aforomontane forests in Ethiopia (Berhanu et al. (2018). Berhanu et al. (2016) also recorded (66 species) in Kuandisha Aforomontane Forest in Ethiopia, while Maiguru et al. (2019) recorded (111 species) in the Amboi forest reserve in Taraba State, Nigeria; Zegeye et al. (2011) recorded (143 species) in Tara Gedam and Abebaye forests in Ethiopia; and Joshimuddin and Inoue (2012) recorded (163 species) in Chittagong Forest, Bangladesh.

The family of Moraceae in the forest was the most dominant, being represented by an (8) number of tree species with a total frequency of (65), 13.1%, followed by the family of Meliaceae with (7) tree species with a total frequency of (71), 14.3%, and the family of Sterculiaceae with (4) with a total frequency of (47), 9.4%. Others are the families of Mimosoidae, Apocynaceae, and Papillioidae with (3) each and a total frequency of (109), 21.9%, while the families of Euphorbiaceae, Guttiferae, Myristicaceae, and Rubiaceae had (2) each with a total frequency of (78), 15.7%, and the families of Combretaceae, Ochnaceae, and Verbenaceae had (i) each with a total frequency of (33), 6.6%. The families with the highest number of tree species frequency were Mimosoidae, Apocynaceae, and Papillioidae with (109), 21.9%, followed by families of Euphorbiaceae, Guttiferae, Myristcaceae, and Rubiaceae with (78), 15.7%, while the least are the families of Combretaceae, Ochnaceae, and Verbanceae with (33) 6.6%.

Funtumia elastica in the family of Apocynaceae was the most predominant tree species in the forest, with a total frequency of 6.0% of the total species enumerated, followed by Erythrophleum suaveolens in the family of Caesalpiniodae with (26) 5.2%, Treculia africana in the family of Moraceae with (22) 4.4%, and Mitragyna ciliate with (21) 4.2%. The species with the least representation and frequency were Treculia heudilotii in the family of Moraceae and Vitex grandifolia in the family of Verbenaceae with (1) 0.2%. The reasons for the low tree species composition in the study area may be due to overexploitation of the forest resources, and according to Chen et al. (2004), environmental heterogeneity, regeneration success, and competition are also important factors that shape the species composition of forests.

Table 1. Tree species composition in Bisaula Forest Reserve

S/N	Name of species	Family	Frequency	Percentage (%)
1	Funtumia elatica	Apocynaceae	30	6.0
2	Alstonia congensis	Apocynaceae	5	1.0
3	Alstonia boonei	Apocynaceae	11	2.2
4	Ceiba pentandra	Bombacaceae	16	3.2
5	Berlinia confuse	Caesalpiniodae	12	2.4
6	Afzelia africana	Caeaslpiniodae	18	3.6
7	Erythrophleum suaveolens	Caesalpiniodae	26	5.2
8	Detarium macrocarpa	Caesalpiniodae	17	3.4
9	Brachystegea eurycoma	Caesalpiniodae	12	2.4
10	Terminalia ivorensis	Combretaceae	3	0.6
11	Diospyrus crassiflora	Ebenaceae	11	2.2
12	Ricinodendon africanum	Euphorbiaceae	9	1.8
13	Uapaca heudelotii	Euphorbiaceae	12	2.4
14	Allablacka florinbunda	Gutteferae	9	1.8
15	Mammea africana	Gutteferae	16	3.2
16	Khaya senegalensis	Meliaceae	17	3.4
17	Trichilia preuriana	Meliaceae	10	2.0
18	Khaya grandifoliola	Meliaceae	13	2.6

19	Milicia excelsa	Meliaceae	10		2.0	
20	Quarea thompsonii	Meliaceae		8		1.6
21	Carapa procera	Meliaceae	7		1.4	
22	Khaya ivorensis	Meliaceae		6		1.2
23	Albizia feruginea	Mimosoidae		13		2.6
24	Tetrpleura tettraptera	Mimosoidae		14		2.8
25	Albizia gumifera	Mimosoidae		3		0.6
\26	Piptadiniastrum africanum	Mimosoidae		5		1.0
27	Treculia africana	Moraceae		22		4.4
28	Ficus mucuso	Moraceae		6		1.2
29	Treculia obovoidea	Moraceae		3		0.6
30	Antiaris welwitchii	Moraceae		4		0.8
31	Bosquia angolensis	Moraceae		7		1.4
32	Antiaris africana	Moraceae		15		3.0
33	Treculia heudelotii	Moraceae		1		0.2
34	Sacocephalus probeguin	Moraceae		3		0.6
35	Pycnathus angolensis	Myristcaceae		6		1.2
36	Staudia stipitata	Myristcaceae	3		0.6	
37	Lophira alata	Ochnceae		2		0.4
38	Pterocarpus erinaceus	Papillioidae		16		3.2
39	Pterocarpus mildbraedii	Paplioidae	10		2.0	
40	Pterocarpus osun	Papilioidae		2		0.4
41	Mitragyna ciliate	Rubiaceae		21		4.2
42	Nauclea dedirrichii	Rubiaceae		3		0.6
43	Mansonia altisma	Sterculiaceae		13		2.6
44	Cola gigantean	Sterculiaceae	18		3.6	
45	Pterygota macrocarpa	Sterculiaceae		5		1.0
46	Sterculia oblonga	Sterculiaceae		11		2.2
47	Syncephalus stipulatum	Sapotaceae	2		0.4	
48	Vitex grandifolia	Verbenaceae		1		0.2
Total				**496**		**100**

Source: Field survey (2023)

The Density of Tree Species in the Reserve.

The result in Table 2 revealed the number of trees per hectare in the study area. The tree species ranged from 64 to 124 per hectare, with an average of 99/ha. Plot 31 had the highest (32) number of trees, followed by plot 5 with (28) and plots 6 and 16 with (26) each, and the least was plot 2 with (16). The study revealed further that the forest has an average number of 99 trees per hectare, which is lower than the number of trees reported by Adekunle et al. (2004) and Jimoh et al. (2012). The average number of trees per hectare in this forest is also far below the average of 323 trees per hectare recorded in the Afi River Forest Reserve in the south-south part of Nigeria, as reported by Aigbe et al. (2014). Although Nwoboshi (1982) observed that as a forest stand developed and individual trees grew larger, the number of trees per unit area decreased, observing further that the gaps created can stimulate the diameter growth rate of individual trees and can also cause a reduction in stand and yield, leading to low density. The reason for the low tree density in the study area might be due to continued overexploitation and a lack of a definite forest management plan that will keep the forest from degrading.

The basal area of trees per hectare was equally found in the range of 0.6048 m^2 to 1.3952 m^2. Plot 4 had the highest (1.3952 m^2) basal area of trees, followed by plot 16 with (1.2524 m^2)), plot 18 with (1.2280 m^2), plots 5 and 12 with (1.1216 m^2) each, and plot 6 with (1.1124 m^2), while the least was plot 17 with (0.6048 m^2). Table 2 further shows the total basal area of trees in the study area. The result indicated that a total basal area of 19.048 m^2 was recorded, with an average of 0.9524 m^2 per hectare. Plot 4 had the highest basal area of trees with 1.3952 m^2, followed by plot 16 with 1.2524 m^2, and plot 18 with 1.2280 m^2. Others are plots 5 and 12 with 1.1216 m^2 each, and plot 17 had the least with 0.6048 m^2. Holland et al. (1990) recommended that a fully stocked forest have a basal area ranging from 9.18

m^2 to 22.96 m^2 as the proper basal area per hectare. The Bisaula Forest Reserve basal area range was far below standard.

Table 2. Number of Trees / Ha (NTH) and Basal Area of Trees / ha (BAT) in the study area

Plot No	Plot	ha(m^2)	ba/plot	ba/ha(m^2)
1	18	72	0.1606	0.6424
2	16	64	0.1534	0.6136
3	27	108	0.2684	1.0736
4	24	96	0.3488	1.3952
5	28	112	0.2292	1.1216
6	27	108	0.2781	1.1124
7	20	80	0.1938	0.7752
8	26	104	0.2733	1.0932
9	19	76	0.1938	0.7752
10	25	100	0.2316	0.9264
11	23	92	0.2684	0.8548
12	25	100	0.2804	1.1216
13	24	96	0.2017	0.8068
14	32	128	0.2620	1.0480
15	15	60	0.1698	0.6792
16	26	104	0.3131	1.2524
17	30	120	0.1512	0.6048
18	30	120	0.3070	1.2280
19	30	120	0.2029	0.8116
20	31	124	0.2745	1.0980
Total	**496**	**1,984**	**4.7620**	**19.048**
Mean	24.8	99.2	0.2381	0.9524

Source: Field survey (2023)

Table 3 shows the volume of trees per hectare in the study area. A total of 387.08m^3 volume of trees was recorded in the study area with a mean volume of 19.354m^3 of trees per hectare. The volume of trees per hectare was in the range from 10.431m^3 to 33.372m^3. Plot 6 had the highest 33.372m^3 volumes of trees, followed by plot 3 with 32.208m^3 and plots 12 and 20 with 30.283m^3 and 30.744m^3 respectively, while plot 2 had the least with 10.431m^3

Table 3. The Volume of Trees per Hectare (VTH) in Bisaula Forest Reserve

Polt No	Plot(m^3)	Hectare(m^3)
1	4.818	19.272
2	2.607	10.431
3	8.052	32.208
4	5.232	20.928
5	3.438	16.824
6	8.343	33.372
7	2.907	11.628
8	3.826	15.304
9	2.907	11.628
10	3.474	13.896
11	3.757	11.967
12	7.570	30.283
13	3.428	13.715
14	4.192	16.768
15	3.056	11.546
16	5.635	22.543
17	4.536	18.144
18	5.219	20.876

19	6.087	24.348
20	7.686	30.744
Total	**96.770**	**387.08**
Mean	4.838	19.354

Source: Field survey (2023)

CONCLUSION AND RECOMMENDATIONS

The study revealed that the forest reserve is understocked and is faced with the problems of overexploitation and illegal cutting of trees, which are reducing the tree species composition and density. The local communities that are benefiting from the forest should be sensitised and encouraged to depend more on non-timber forest products than on the illegal cutting of trees for timber. The forest needs restocking through massive reforestation activities.

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