FLORISTIC DYNAMICS OF WOODY TREE SPECIES IN ORA COMMUNITY FOREST, KWARA STATE, NIGERIA

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Abstract
Tropical forest ecosystem plays an important role in the welfare and economy of man especially in the Savannah where charcoal production is at the peak. It is at the center of human activities which greatly influence the structure, composition and abundance of all plant's life forms. In recent time, there is increase awareness in conservation of African Savannah; however, there is dearth of accurate data on conservation and distribution of tree species in many parts of Africa. This study therefore assessed woody tree species composition and distribution in Ora community forest, Kwara State. Systematic line transects were used to lay Temporary Sample Plots (TSP) in the study area. Five transects (500 m each) were centrally located in the forest where three TSP of 50 m x 50 m were laid in alternate side at 100m internal on each transect making a total of 15 TSP. In each plot, all tree species (dbh ≥ 10 cm) were identified and their height, diameter at breast height (dbh) and diameters at the top, middle and base were measured. There were 135 stems ha-1, belonging to 43 tropical hardwood species and 23 families. The most abundant species and family were *Daniella oliverai* of Fabaceae (14 stems ha-1) and Meliaceae (6 species), respectively. The Shannon-Wiener index (3.37) and evenness (0.68) and other diversity indices were relatively high, indicating that the forest is a potential savannah biodiversity hotspot. The indices compared favourably with Savannah species distribution. In addition, the total basal area and volume of $673m^2$ and $4,204.5m^3$ and the vertical and horizontal structure implies that the forest is perpetuating. This forest, therefore, is a potential biodiversity hotspot that requires improved conservation and management efforts, and intensive research of all the biodiversity indicators through adequate community conservation efforts.

Keywords: *Community Forest, Woody Species, Savannah and Conservation*

Introduction

Tropical forest ecosystem has been identified as the reservoir of genetic diversity and potential variability. However, with population pressure and the need to satisfy the demands for food, fuel wood, shelter and developmental projects, millions of hectares of forests have been cleared and the wood burnt off or used as fire wood (Igboanugo, 2008). The world's forest ecosystems are in a state of permanent flux at a variety of spatial and temporal scales (Coppin and Bauer, 1996). Causes of these changes can be natural (disasters such as diseases, insects, wildfire, flood and drought) as well as anthropogenic (deforestation, logging, burning, and clear-cutting) or may be a combination of the two. It is estimated that129 million ha of forests are lost from 1990 to 2015, at an annual rate of –0.13 percent (FAO, 2015). Forest degradation is a problem with severe environmental, socio-economic consequences, especially in developing countries. Forest degradation has adverse impacts on forest ecosystems and on the goods and services they provide.

According to Salami (2011), it was reported that the protected forest reserves of Nigeria, are mainly located in the southern part of the country and it occupied 93,345sqkm in 1993, that is 9.6% of the total land area of the country. Oriola (2009) also reported that the rainforest of the southern, Nigeria had been degraded to secondary forest through pressure on the forest reserves due to high population density, shifting cultivation and annual bush burning, changing the forest into derived Savanna. Also, Salami (2011) reported on high pressure and over exploitation of the rich biodiversity in Nigeria rainforest through uncontrolled logging and conversion of forest land into agricultural plantations and as a result of this, the area covered by rainforest is rapidly shrinking at alarming rate. Adekunle *et al.,* (2002) put it straight that the loss of forest genetic resources means the loss of their potential value to man in the supply of timber, herbs, wildlife conservation, erosion control, weather amelioration and other Non-Timber Forest Products.

In forest management operations, inventories on biodiversity are used to determine the nature and distribution of biodiversity. Quantification of tree species diversity is an important aspect as it provides resources for many species. To protect forests from declining, it is essential to examine the current status of species diversity as it will provide guidance for the management of forest areas. Information from this quantitative inventory will provide a valuable reference for forest assessment and improve knowledge in identification of ecologically useful species as well as species of special concern. Thus identify conservation efforts to assess the tree species diversity and stand structure of Ora Community Forest, one of the major savanna forest area in Nigeria.

Savannas occupy sixty percent vegetation cover of sub-Saharan Africa and they are typified by the coexistence of woody plants and grasses (Sankaran *et al*., 2005). The relative proportions of each of these species are being influenced predominantly by water availability, fire, nutrients, herbivores and people (Sankaran *et al*., 2005). Savanna ecosystem plays important roles in the welfare and economy of man. It is at the center of human activities that greatly influence the structure, composition and abundance of all plant's life forms, but during the last century fragmentation and disturbance have accelerated (Lykke 1998). In Nigeria, for instance there is limited accurate data on flora composition. Thus, species currently perceived as abundant might actually be endangered while those previously perceived as endangered might be nearing extinction (Ikyaagba *et al.,* 2015).

Ora Community forest was selected for this study mainly because it is one of the few unnoticed savanna natural forest in Kwara State, Nigeria. The present study will not only constitute a base material for the study area but will also be available for reference in future as the environment and ecology of the area degenerate as a result of agriculture and charcoal producers' activities. Ecological degradation is a gradual process as often silent changes in the ecology which may not be easily noticed cumulate into a big environmental degeneration with time. Hence, if the present study is compared with future studies, changes in the ecology will be easily recorded and causes and effect easily determined for appropriate remedial actions.

Materials and Methods

Study Area

Ora community forest is located in Ifelodun Local Government Area, Kwara State, Nigeria. It lies on Latitude 8.2420°N and 8.2530°N and Longitude 5.105°E and 5.150°E covering a total area of 500ha (Figure 1). The forest has been in the custody/management of the Community Head. The climate is of tropical savanna where it exerts enormous influence on the area. This climate exhibits a well-marked rainy season and a dry season with a single peak known as the summer maximum due to its distance from the equator. The average monthly temperature of the site is 26.18°C with highest value recorded in March (28.1°C) and minimum in June and July (24.5°C each) and an annual rainfall of about 1,500 mm with single rainfall maxima in September. The number of raining days was highest in September (16 days) while January and December each recorded No raining days. The single Dry season experienced in this climate is hot and dry with the Harmattan wind, a continental tropical (CT) airmass laden with dust from the Sahara Desert prevailing throughout this period. Generally, the soil is sandy loam and slightly acidic (pH = 6.5) with outcrop of rocks. The soil contains 0.999% of Organic Carbon, a range of 0.87% - 2.48% was observed for Organic Matter content and the Phosphorus constituent ranges between 0.59mg/kg and 3.22mg/kg.

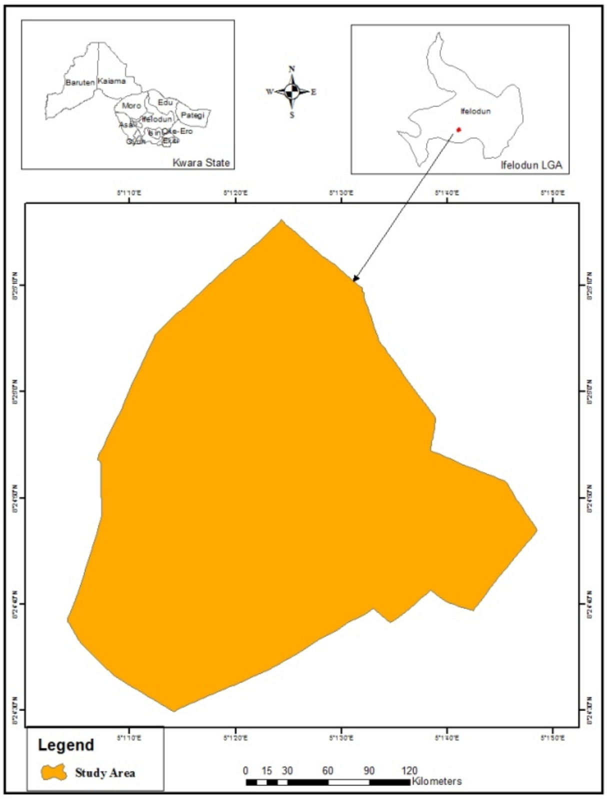

Fig 1: The study area

Data Collection

Systematic line transects were used to lay Temporary Sample Plots (TSP) in the study area. Five transects (500 m each) were centrally located in the forest where three TSP of 50 m x 50 m were laid in alternate side at 100m internal on each transect making a total of Fifteen TSP. In each TSP, all living trees with Diameter at Breast Height (DBH) ≥ 10 cm were enumerated. Samples of species whose identification were in doubt were collected, coded, pressed and taken to herbarium of the Forestry Research Institute of Nigeria, Ibadan for proper identification. A small plot of 1 x 1 m was also located at the centre of each main plot for enumeration of sapling. The undergrowth (saplings) was identified and their girths were measured using electronic caliper.

Data Analysis

Tree species diversity

The following indices were employed following Kent & Coker (1992), Magurran (2004) and Lu *et al*. (2010):

(I) Shannon-Wiener diversity index:

$$H' = -\sum_{i=1} p_i \ln(p_i) \quad \text{..... 1}$$

Where, H' is the Shannon-Wiener diversity index; S is the total number of species in the community; pi is the proportion of S made up of the ith species; ln is natural logarithm

(ii) Pielou's species evenness index:

$$E_H = \frac{H'}{H_{max}} = \frac{\sum_{i=1}^{s} p_i \ln(p_i)}{\ln(S)} \quad \text{..... 2}$$

(iii) Margale f's index of species richness (M)

$$M = \frac{(S-1)}{lnN} \quad \text{..... 3}$$

(iv) Simpson concentration index

$$\lambda = \sum \left(\frac{ni}{Ni}\right)^2 \quad \text{..... 4}$$

Forest dynamics analysis

Basal area

The basal area of all trees in the sample plots were calculated using the formula:

$$\text{BA} = \frac{(\pi D^2)}{4} \quad \text{..... 5}$$

where, BA = Basal area (m^2), D = Diameter at breast height (m) and π = pie (3.142).

The total BA for each plot was obtained by adding all trees BA in the plot.

Volume

The volume of each tree was calculated in every plot using the Newton's formula (Hush *et al.*, 2003):

$$V = \left({}^{h}/_{6}\right) \times (Ab + 4Am + At) \quad \text{..... 6}$$

Where: V = Tree volume (m^3), Ab, Am and At = tree cross-sectional area at the base, middle and top of merchantable height, respectively (m^2) and h tree height (m). Plot volumes were also obtained by adding the volumes of all the trees in the plot.

Values for the entire stand were obtained by multiplying the value of one ha with the forest size (500 ha).

Tree Slenderness Coefficient (SLC)

$$\text{SLC} = \frac{\text{THT}}{\text{DBH}} \quad \text{..... 7}$$

Where BA = Basal area (m^2), D = dbh (cm) and THT = Total height

According to Navratil *et al.*, (1996), slenderness coefficient values were classified into three categories

TSC values > 99.............. High slenderness coefficient (Prone to wind throw)

70 < TSC values > 99.........Moderate slenderness coefficient (Moderate)

TSC values < 70 ....Low slenderness coefficient (Withstand wind throw)

Relative density (RD %)

RD of each species was computed following the equation of Brashears *et al.* (2004):

$$\text{RD} = \left(\frac{ni}{Ni}\right) \times 100 \quad \text{..... 8}$$

where, RD is the relative density of the species; ni is the number of individuals of species i and N is the total number of all individual trees.

Relative dominance (RDo%)

RDo of each species was estimated using:

$$\text{RDo} = \frac{(\sum Ba_i \times 100)}{\sum Ba_n} \quad \text{..... 9}$$

where, RDo is the relative dominance of the species; Bai is the basal area of all individual trees belonging to a particular species i; Ban is the basal area of the stand.

Importance Value Index (IVI)

The sum of the RD and RDo divided by 2 (RD x RDo)/2 gave the importance value index for each species (Brashears *et al*., 2004; Yang *et al.*, 2008). This was used to express the share of each species in the tree community (Rajkumar and Parthasarathy 2008). Based on the forest structural analysis of Adekunle *et al.*, (2013), Proctor *et al*. (1983) & Newbery (1991), the size class distributions were classified under four distinct categories, namely, smaller (10 - 20 cm dbh); medium (21 - 50 cm dbh); large (51- 100 cm dbh) and largest (> 100 cm dbh). The stems were further classified into 10 diameter and six height classes to show the graphical pattern of tree population distribution and vertical stratification respectively. To examine the relationship among the growth variables, Pearson Correlation Coefficient was used.

Result and Discussion

Forests contain the greatest diversity in terms of species, genetic material and ecological processes of all ecosystems. Forest habitats play a central role in the functioning of the biosphere, as they are the origin of many cultivated plants and animals (EU 2008). Community forests are one of the potentials of methods of protecting the natural forest against anthropogenic activities. The results of this study revealed that the study area is a repository of many indigenous savanna tropical hardwood tree species in different families. This is evidenced by the 135 stems/ha (dbh ≥ 10 cm) that belonged to 43 indigenous hardwood species, distributed in 23 important families in this forest (Table 1). The number of tree species encountered in a sample survey was adopted as a surrogate for the actual species richness in this study (Magnussen *et al.* 2010). High Shannon-Weiner index (3.37) and equitability index, using Pielou's evenness index of 0.68 were obtained (Table 1). The results of the other biodiversity indices were 8.56 for Margalef's index of species richness and 0.96 for Simpson concentration index. Generally, the mean dbh encountered in the forest was 15.46cm while the stand dominant dbh and maximum dbh were 11.0cm and 52.5cm respectively (Table 1). The mean stem height, dominant height and maximumheight were 7.27m, 7.0m and 13.0m respectively (Table 1). The mean tree SLC, dominant SLC and maximum SLC were 49.78, 50.0 and 100.0 respectively. Meanwhile, the total basal area and volume per hectare in the study area were 1.35m^2 and 8.41m^3 respectively (Table 1).

Biodiversity indices are generated to bring the diversity and abundance of species in different habitats to similar scale for comparison and the higher the value, the greater the species richness (IIRS 2002 a & b). The estimate of species diversity could come from different sources of which forest surveys, adopted in this present study, and biodiversity monitoring programmes have been reported as major sources (Baffetta *et al*., 2007). But, Beck and Kitching (2007) reported that the observed richness can only be a good approximation of the true richness when it can be demonstrated that the survey is very unlikely to have missed any forest tree species. *Daniella oliverai* (Fabaceae) had the highest number of occurrence (14 stems ha-1) and a relative density of 10.37 (Table 2). So, it could be regarded as the most abundant species in the forest while *Anarcardium occidentale* (Anarcardiaceae), *Ceiba pentandra* (Bombacaceae) among others were the least occurred (1/ha) species in the study area (Table 2). This is typical of savanna forests as against 387 stems/ha observed in some rainforest zone of Nigeria (Adekunle *et al*., 2013). Meliaceae family dominated the forest (6 species/ha) with species such as *Azadiracta indica, Ekebergia senegalensis, Khaya grandifololia, Khaya senegalensis, Pseudocedrela kotschyi* and *Trichilia purpunea* encountered in the family (Table 2). *Mangifera indica* belonging to Anarcardiaceae family had the highest mean dbh (41.5cm) while the least was observed in *Trichilia purpunea* (10 cm). *Anthocleista djalonensis* had the highest mean stem height of 10.5m while the least was observed in *Grewia carpinifolia* (4.7m). The highest mean basal area and volume per hectare of 0.34m^2 and 15.68m^3 were contributed by *Pterocarpus erinaceus* and *Mangifera indica* respectively. The least mean basal area and volume per hectare of 0.03m^2 and 0.05m^3 were recorded for *Anarcardium occidentale* and *Memecylon blakeoides* respectively. However, *Daniella oliverai* (Fabaceae) had the highest species importance with an IVI of 5.23%.

The horizontal and vertical structures of the forest as revealed by the diameter and height distribution (Fig 2 and 3) show a forest whose population structure is expanding, ensuring its stability. The floristic composition is dominated by a suite of understorey species because of the dominance of small-stemmed trees. It was observed that the forest diameter distribution curve (Fig 2) followed inverted J shape which is typical of tropical natural forest (Adekunle *et al*., 2013; Husch *et al*., 2003). The smaller diameter trees were more than the larger diameter class trees. It was observed that 116 individuals, 27 species and 12 families per hectare were found in 10 – 20 cm diameter size class (Table 3). This implies that the forest is healthy and still perpetuating and if sustainably managed, it has ability to serve as biodiversity hotspot for the savanna region of the country. The tree height distribution curve (Fig 3) implies that most of the trees belongs to height class of 6 – 10m. The total individual tree, number species and families per hectare in this class size were 120, 27 and 12 respectively (Table 3). Trees that could be referred to as emergent (height up to 40 m) were not encountered in the study area. The stand health status was assessed in this study through slenderness coefficient index (Fig 4). It was observed that 92.59% of the trees in the forest were found in the class < 70 (Low SLC). According to Navratil *et al.*, (1996), this is an indication can the 92.59% of trees in the forest can withstand wind throw while only 0.74% of the trees are prone to wind throw.

Table 1: Summary of diversity indices and tree growth variables

Biodiversity indices		**Tree growth variables**	
Indices	**Values**	**Variables**	**Values**
No of Individual/ha	135	Mean dbh (cm)	15.46±0.336
No of Species	43	Dominant dbh (cm)	11.00
No of Families	23	Maximum dbh (cm)	52.50
Shannon-Weiner Index (H')	3.373	Mean height (m)	7.27±0.173
Pielou's Evenness Index (E)	0.678	Dominant height (m)	7.00
Margalef's Index of Species Richness (M)	8.562	Maximum height (m)	13.00
Simpson Concentration Index (λ)	0.955	Mean SLC	49.78±0.626
		Dominant SLC	50.00
		Maximum SLC	100.00
		Total Basal Area/ha (m^2)	1.346
		Total Volume/ha (m^3)	8.409

Table 2: Summary of woody tree species abundance

Family	Species	N/ha	MDbh (cm)	MTHT (m)	V (m^3/ha)	BA (m2/ha)	SLC	RD	RDo	IVI
Anarcardiaceae	*Anarcardium occidentale*	1	18.7	9	0.253	0.027	48.128	0.741	0.003	0.372
	Lannea schimperi	6	17.5	7.8	0.210	0.026	44.571	4.444	0.084	2.264
	Mangifera indica	1	41.5	9.5	1.285	0.135	22.892	0.741	0.015	0.378
Annonaceae	*Axonopous brevis*	1	12	6	0.068	0.011	50.000	0.741	0.001	0.371
Bombacaceae	*Ceiba pentandra*	1	24	10	0.452	0.045	41.667	0.741	0.005	0.373
Caesalpiniaceae	*Detarium microcarpum*	9	12.7	6.5	0.101	0.014	51.181	6.667	0.039	3.353
Chrysobalanaceae	*Parinary macrophyllum*	9	12.7	6.3	0.083	0.014	49.606	6.667	0.023	3.345
Combretaceae	*Annogiessus leocarpus*	2	14.4	8.3	0.151	0.017	57.639	1.481	0.017	0.749
	Combretum nigricans	2	12.6	7.2	0.097	0.013	57.143	1.481	0.020	0.751
	Terminalia glaucescens	4	14.4	7.3	0.117	0.016	50.694	2.963	0.028	1.496
Euphorbiaceae	*Bridelia ferruginea*	5	14.1	6.5	0.099	0.015	46.099	3.704	0.025	1.864
Fabaceae	*Afzelia africana*	9	16.8	8.1	0.190	0.023	48.214	6.667	0.035	3.351
	Daniella oliverai	14	17.1	7.7	0.187	0.024	45.029	10.370	0.083	5.227
	Parkia biglobosa	4	26.2	9.5	0.586	0.058	36.260	2.963	0.122	1.542
	Pterocarpus erinaceus	1	13.3	7.1	0.552	0.337	53.383	0.741	0.038	0.389
	Tamarindus indica	1	12	5.5	0.062	0.011	45.833	0.741	0.001	0.371
Lamiaceae	*Vitex grandifolia*	1	17	8.5	0.244	0.073	50.000	0.741	0.008	0.374
Loganiaceae	*Anthocleista djalonensis*	1	12.5	10.5	0.129	0.012	84.000	0.741	0.001	0.371
	Anthocleista vogelli	1	11.5	7.2	0.073	0.010	62.609	0.741	0.001	0.371
Melastomatacea	*Memecylon blakeoides*	1	11	5.4	0.051	0.010	49.091	0.741	0.001	0.371
Meliaceae	*Azadiracta indica*	1	12	5	0.057	0.011	41.667	0.741	0.001	0.371
	Ekebergia senegalensis	4	14.6	7.1	0.133	0.019	48.630	2.963	0.046	1.504
	Khaya grandifololia	1	14	4.6	0.071	0.015	32.857	0.741	0.002	0.371
	Khaya senegalensis	1	20.2	7.2	0.262	0.036	35.644	0.741	0.020	0.380
	Pseudocedrela kotschyi	4	16.9	7.5	0.173	0.023	44.379	2.963	0.053	1.508
	Trichilia purpunea	1	10	7	0.055	0.008	70.000	0.741	0.001	0.371
Mimosaceae	*Adenanthera pavonina*	3	15.9	7.8	0.119	0.032	49.057	2.222	0.004	1.113
	Entada mannii	5	14	7.5	0.139	0.018	53.571	3.704	0.041	1.872
Moraceae	*Ficus capensis*	2	13.4	7.1	0.105	0.014	52.985	1.481	0.016	0.749
	Ficus mucuso	1	15.2	6.1	0.111	0.018	40.132	0.741	0.002	0.371
	Ficus polita	1	27.3	7.5	0.459	0.054	27.473	0.741	0.012	0.376
Ochnaceae	*Lophira alata*	4	14.9	8.3	0.160	0.019	55.705	2.963	0.025	1.494
Papilionoideae	*Pericopsis laxiflora*	9	12.5	7.2	0.088	0.012	57.600	6.667	0.031	3.349
Phyllanthaceae	*Margeritaria discoidea*	1	11.3	6.3	0.061	0.010	55.752	0.741	0.002	0.371
	Hymenocardia acida	4	11.8	6.8	0.079	0.011	57.627	2.963	0.021	1.492
Polygalaceae	*Securidaca longepedunculata*	1	13.9	6.5	0.098	0.016	46.763	0.741	0.003	0.372
Rubiaceae	*Canthium vulgare*	3	13.2	7.2	0.103	0.014	54.545	2.222	0.022	1.122
	Leptactina involucrata	3	15.6	8.2	0.147	0.019	52.564	2.222	0.015	1.119
Sapindaceae	*Chytranthus macrobotrys*	1	17.3	6.9	0.162	0.024	39.884	0.741	0.016	0.378

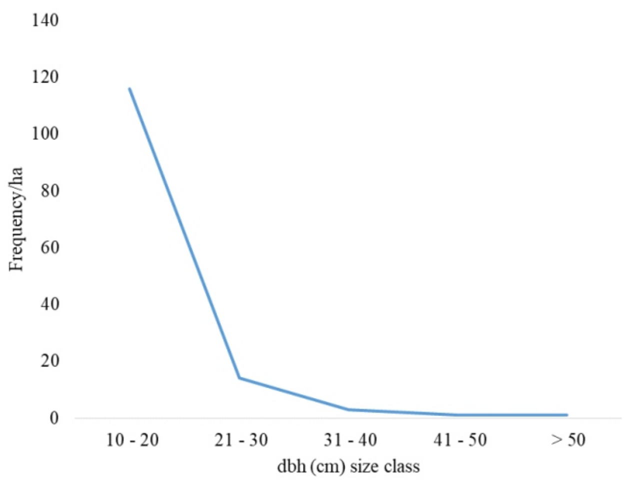

Fig 2: Tree diameter size class distribution

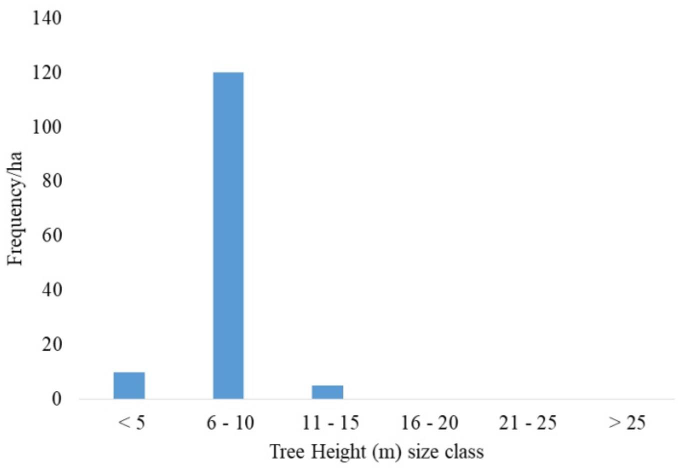

Fig 3: Tree height (m) size class distribution

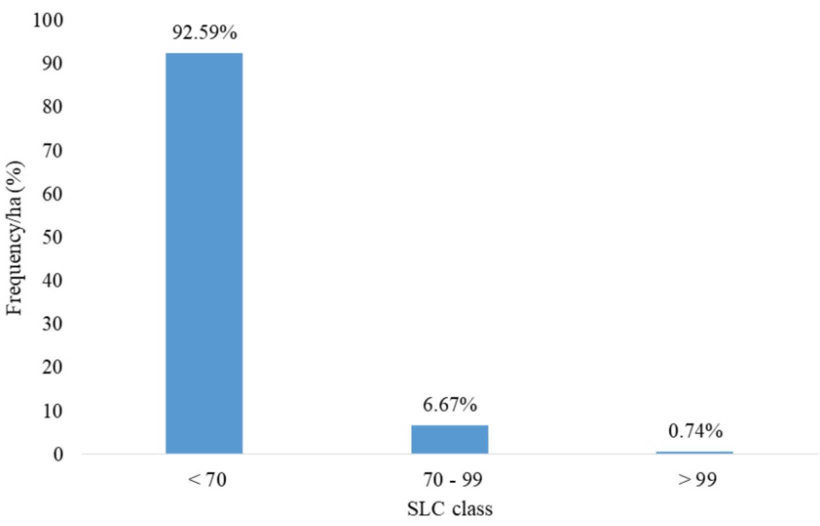

Fig 4: Slenderness coefficient distribution

		NS/ha	NF/ha	NI/ha	BA/ha	Vol/ha
Dbh (cm) class	10 - 20	27	12	116	5.656	41.140
	21 - 30	11	7	14	2.106	15.456
	31 - 40	3	2	3	0.879	10.039
	41 - 50	1	1	1	0.135	1.285
	> 50	1	1	1	0.217	2.663
Total				**135**	**8.993**	**70.583**
Height (m) class	< 5	10	6	8	0.634	3.260
	6 - 10	27	12	120	7.488	57.549
	11 - 15	6	5	7	0.871	9.775
	16 - 20	0	0	0	0	0
	21 - 25	0	0	0	0	0
	> 25	0	0	0	0	0
Total				**135**	**8.993**	**70.583**

Conclusion

The results of this study revealed the potential savanna community forest in nature conservation. The phytosociological assessment as well as the species diversity and abundance were unique and compared favourably with other forest ecosystems. This forest, therefore, is a potential biodiversity hotspot that requires improved conservation and management efforts, and intensive research of all the biodiversity indicators through adequate community conservation efforts. Species with low rarity index value should be considered as rare. Conservation efforts should be stepped up for such species to prevent them from going into extinction. By virtue of their narrow range, they are usually vulnerable to extinction. The results of this work will serve as baseline data that could be helpful in the appraisal of plant resources of the tropical savanna ecosystem for its effective management. The continuous involvement of rural communities around the forest should be rewarded, in form of incentives, by the government agency. This is to avoid encroachment which may occur immediately the communities are no more satisfied with its continue protection without tangible benefit.

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