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Forest Tree Composition: A Comparative Study of Timber Species in Bayelsa State Nigeria

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ABSTRACT

Measuring tree species diversity is critical for forest management, particularly where timber species suffer undue anthropogenic pressure. This study was carried out in Bayelsa State, Nigeria. A sample plot was systematically chosen from randomly selected communities in each of the three senatorial districts Bayelsa West (BW), Bayelsa East (BE) and Bayelsa Central (BC) of the State. Each sample plots measured 25 m x 25 m and all timber tree species that were at least six feet above ground level within each sample plot were identified, counted and measured. Fifty individual timbers were encountered in the sample plot at Ogobiri community in BW, fifty-two at Kolo 1 community in BE and fifty-six at Gbarain community in BC belonged to 18, 16 and 14 different families respectively. Families with the largest number of species in the plots were Gentianaceae and Meliaceae, and the highest diversity indices were recorded from BE senatorial district. Generally, the basal area of the sample plots increases with an increase in diameter at breast height. The forested zones were on flat terrain characterized by seasonal flood inundation, and the similarities of timber species in the plots occurred as (BW-BC)> (BW-BE)> (BC-BE). Also, four tree species *Coelocaryon preussii*, *Sacoglottis gabonensis*, *Milicia excelsa* and *Triplochiton scleroxylon* were identified as rare species, and management options that would ensure *ad infinitum* supply of timber species were proposed.

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INTRODUCTION

Trees are an important constituent of terrestrial life. They exist in the major terrestrial biomes of the world and are the most conspicuous species in the forest estate upon which humanity depends for variety of services (Aigbe & Omokhua, 2015; MEA, 2005). The tropical forest is one of the principal vegetation types of the globe (Whitmore, 1998); they are a reservoir of densely packed trees, which their diversity is fundamental to the total rainforest biodiversity (Ihinmikaiye & Unanaonwi, 2018). They are essential for human survival, economic wellbeing, ecosystem function and stability (Singh, 2002). According to Cunningham and Lindenmaye (2005) timber account for over half of global wood consumption, an underlying reason behind the clearing of about 90% of natural vegetation and the loss of a considerable number of flora and fauna annually in developing countries (Ossai, 2018).

Although West Africa possesses an enormous diversity of forest trees, extending over the major part of the zone. Aigbe *et al*. (2015) observed that anthropogenic pressure puts forest trees in West Africa under severe threat. The rate of timber species loss in the region is in stark contrast to those of other tropical regions of the world (FAO, 2012; Okonkwo *et al*., 2012). Forest canopy structure provides a good indicator for predicting the ecological soundness and susceptibility of forests to rapid degradation (Magurran, 1988). Okuda *et al*. (2003) asserted that the canopy structure of a forest is determined by the tree species present in the forest, and the loss alters the abundance of timber trees within a forest zone.

Forest communities in Nigeria especially in the Niger Delta region have suffered severe biological diversity loss at both local and regional scales for decades. Currently, in Bayelsa State, there is a massive onslaught of timber trees (Ihinmikaiye & Unanaonwi, 2018). Although the State appears to be rich in tree species, logging activities and timber processing focus only on a limited number of species in demand. The conversion of forest land to agriculture militate with the maintenance of pristine forest, biodiversity and ecosystem function (Suratman, 2012; Mwakalukwa *et al*., 2014).

A critical gauge for determining the level of tree species diversity, as well as biodiversity conservation, involves measuring of tree species diversity within the forest estate of a region (Magurran, 2004). Hence, forest inventory that involves a systematic sampling design was conducted in the Senatorial districts of the State. This study determines the forest timber composition, similarity level and identifies the tree florae within sampled plots. Management options

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that would guarantee constant supply with a focus on tree species conservation were proposed.

METHODOLOGY

Study Area

The study was carried out in the lowland forest zones within Bayelsa State between January 2019 and March 2020. Bayelsa is one of the six states that constitute the South-South geopolitical zones of Nigeria. It is constitutionally delineated into three senatorial districts.

A forest site was randomly selected from a community in each of the districts, namely: Ogobiri community in Bayelsa West (BW) Senatorial district; Gbarain community in Bayelsa Central (BC) Senatorial district and Kolo 1 community in Bayelsa East (BE) Senatorial district. Geographically, the sites are within latitudes 4°50'N and 5°05'N and longitude 6°10'E and 6°40'E (Oborie & Nwankwoala, 2017). The temperature ranges between 26 ^{0}C to 31 ^{0}C with high relative humidity depending on the season of the year, high rainfall occurs between April and November, and dry season with sparse rainfall occurs between December and March yearly. The soil consists of sedimentary alluvium and abandoned beach ridges, formed in the early Holocene (Akpokodje, 1989). Physiographically, the soil types vary yet imbued with nutrients that support biological diversity and arable crop production (Diri & Joseph, 2020).

Data Collection and Analysis

Three sample plots were selected by simple random sampling technique. Each of the plots measured 25 m by 25 m in length and all timber tree species that were 6 feet above ground level within each sample plot were counted, identified by their botanical and family names, and were measured at diameter at breast height (dbh ≥ 4.5 feet) after Hall *et al*. (2003). A d-tape calibrated in centimetres was used to determine the diameter of the timber trees. Specimens of the trees (such as fruits, flowers and twiglets) that could not be identified immediately were collected for proper identification at the University Herbarium, Federal University Otuoke, Nigeria.

Determination of Species Diversity in the Sampling Plots

Diversity indices have been used to gauge the quality of forest community structure because they are considered ecological indicators (Kerkhoff, 2010). Thus, the tree species diversity was determined using the Simpson index (C), Shannon-Wiener index of diversity (H), Pileou's index of evenness (E), Margalef's index (d) and Menhinick's index (D).

Simpson index (C) $= \sum_{i=1}^{S} \mathrm{Pi}^2$

Pi is the proportion of individuals of the *i*th species. Where, Pi = n*i*/N, n*i* = number of individuals of the ith species in the plot; N= total number of individuals in the plot; S= number of species in the plot; The value of 'C' range between 0 and 1. 1 represents infinite diversity and 0, no diversity.

Shannon-Wiener index (H) = -Pi∑(logPi)

Where, Pi is the same as Simpson's index.

Pileou's index of evenness (E) = H/M_{max}= H/logS

Where H = Shannon Wiener index and, S = total number of species recorded. Evenness assumes a value between 0 and 1, 1 being complete evenness.

Margalef's index (D) = S-1/logN

Where S= total number of species and N = total number of individuals in the plot.

Menhinick index (d) = $S/\sqrt{N}$

Where, S and N are the same as in Margalef's. Margalef and Menhinick indices are used to calculate species richness.

Similarity Measures in the Occurrences of the Identified Tree Species in the Sampling Plots

Similarity measures in the occurrence of the species in the sampling plots were determined using:

1. Index of Similarity (IS)

IS = 2C x 100 / (A + B)

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2. Jaccard Index (SJ)

SJ = C / (A+B+C)

3. Sorenson-Dice Index (S_{SD})

SSD = 2C / (A+B+2C)

4 Ochoi Index (SO)

SO = C / √(A+C) + √(B+C)

5. Asymmetrical Similarity (S_{AS})

S_{AS} = B / (B+2C)

Where A is the number of species in the first zone; B is the number of species in the second zone, and C is the number of species common to both first and second zones.

Estimation of Basal Area and Relative density

The basal area of each tree was computed using the equation BA= $\pi D^2/4$, where D=dbh (m). The basal area of each plot was estimated by summing the BA of all individual trees within the sampling plots.

Relative Density (%) of each species was computed as follows: RD = (*n/N*) ×100%, where RD is the relative density of the species; *n* is the number of individual tree species and *N* is the total number of trees sampled per plot.

Identification of the Rare Species in the Study

The sample plots were considered as representative of the forest estate in the districts. Thus, tree species that are singleton (i.e., species represented by only one stand and peculiar to a sample plot) are considered rare. The indigenous knowledge on the identified rare species was determined and used to propose conservation strategies that would ensure the protection of the species.

RESULTS

The relative density, size and timber species diversity of trees encountered in the three sample plots are presented in *Table 1, 2* and *3*. Families with a large number of species in the plots include Gentianaceae (with three species encountered in the sampling plot at Kolo 1 of Bayelsa East (BE)), Meliaceae (with three species encountered at Ogobiri community in Bayelsa West (BW), as well as in Bayelsa East (BE)). *Table 1* shows that *A. djalonensis* and *E. guineensis* had the highest number of individual tree species (4) and relative density (RD). While seven timber species (*C. procera, C. preussii, G. brevis, P. Oleosa, P. angolensis, S. gabonensis and M. stipulosa*) were identified in the sample plot at Kolo 1 (BE) as singletons with low relative density.

Table 1: Relative Frequency, Sizes and Tree Diversity of the Sample Plot in Kolo 1 Community of Bayelsa East

Tree Species	Family	No. of sp.	RD	Mdbh	TBA/sp
Alstonia boonei	Apocynaceae	3	5.77	24.33	0.16
Anthocleista djalonensis	Gentianaceae	4	7.69	28.29	0.29
Anthocleista vogelii	Gentianaceae	2	3.85	17.4	0.05
Berlinia grandiflora	Fabaceae	2	3.85	32.5	0.20
Carapa procera	Meliaceae	1	1.92	25.20	0.05
Ceiba pentandra	Malvaceae	3	5.77	23.07	0.16
Coelocaryon preussii	Myristicaceae	1	1.92	38.00	0.11
Cynometra vogelii	Gentianaceae	2	3.85	33.00	0.19
Elaeis guineensis	Arecaceae	4	7.69	43.43	0.69
Ficus capensis	Moraceae	2	3.84	27.2	0.13
Glyphaea brevis	Malvaceae	1	1.72	16.1	0.02
Irvingia gabonensis	Irvingeaceae	3	5.77	36.67	0.35
Khaya ivorensis	Meliaceae	2	3..84	30.65	0.17
Lophira alata	Ochnaceae	2	3.85	43.00	0.29
Mitragyna stipulosa	Rubiaceae	1	1.92	8.2	0.01

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Tree Species	Family	No. of sp.	RD	Mdbh	TBA/sp
Musanga cecropioides	Urticaceae	3	5.76	33.4	0.32
Nauclea diderrichii	Rubiaceae	2	3.84	8.4	0.01
Panda oleosa	Pandaceae	1	1.92	46.3	0.17
Pycnanthus angolensis	Myristicaceae	1	1.92	45.6	0.16
Raphia hookeri	Arecaceae	2	3.85	39.5	0.25
Sacoglottis gabonensis	Humiriaceae	1	1.92	45.20	0.16
Spondias mombins	Anacardiaceae	3	5.77	24.17	0.16
Treculia africana	Moraceae	3	5.77	33.83	0.31
Vitex grandifolia	Lamiaceae	3	5.77	14.63	0.06

T. africana had the highest number of individual timber species (4) in the sample plot at Ogobiri community of BW (*Table 2*); while *M. excelsa, C. englerianus, M. stipulosa* and *L. alata* had one individual each in the sample plot with corresponding low relative density.

Table 2: Relative Frequency, Sizes and Tree Diversity of the Sample Plot in Ogobiri Community of Bayelsa West

Tree Species	Family	No. of sp.	RD	Mdbh	TBA/sp.
Alstonia boonei	Apocynaceae	3	6	16.67	0.09
Berlinia grandiflora	Fabaceae	2	4	22.15	0.08
Brilinia stenocarpa	Phyllanthaceae	2	4	36.55	0.22
Carapa procera	Meliaceae	2	4	29.35	0.16
Ceiba pentandra	Malvaceae	2	4	15.67	0.05
Cynometra vogelii	Gentianaceae	3	6	8.130	0.02
Ctenolophone englerianus	Ctenolophonceae	1	2	34.80	0.10
Elaeis guineensis	Arecaceae	3	6	39.17	0.43
Ficus capensis	Moraceae	2	4	15.70	0.04
Irvingia gabonensis	Irvingeaceae	2	4	21.90	0.10
Khaya ivorensis	Meliaceae	3	6	16.83	0.07
Lophira alata	Ochnaceae	1	2	33.10	0.09
Mammea africana	Clusiaceae	2	4	31.30	0.17
Milicia excelsa	Moraceae	1	2	23.40	0.43
Mitragyna stipulosa	Rubiaceae	1	2	10.20	0.01
Musanga cecropioides	Urticaceae	2	4	8.85	0.01
Panda oleosa	Pandaceae	3	6	18.93	0.09
Pycnanthus angolensis	Myristicaceae	2	4	19.00	0.06
Spondias mombins	Anacardiaceae	2	4	24.95	0.11
Synsepalum stipulatum	Sapotaceae	2	4	15.80	0.04
Tetrapleura tetraptera	Fabaceae	2	4	12.05	0.03
Treculia africana	Moraceae	4	8	30.20	0.32
Uapaca heudelotii	Phyllanthaceae	3	6	25.37	0.16

U. heudelotii had the highest RD and number of individual species in the sample plot at Gbarain community of Bayelsa Central (BC) (*Table 3*); whereas, *N. diderrichii and T. scleroxylon* had one individual each in the sample plot.

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Table 3: Relative frequency, sizes and tree diversity of the sample plot in Bayelsa Central

Tree Species	Family	No. of sp.	RD	Mdbh	TBA/sp
Alstonia boonei	Apocynaceae	4	7.14	23.00	0.18
Anthocleista vogelii	Gentianaceae	2	3.57	21.45	0.07
Anthostema aubryanum	Euphorbiaceae	3	5.36	18.47	0.12
Cleistopholis patens	Annonaceae	2	3.57	21.65	0.09
Ctenolophone englerianus	Ctenolophonceae	3	5.36	27.2	0.22
Elaeis guineensis	Arecaceae	4	7.14	9.38	0.03
Erythrophleum ivorense	Fabaceae	3	5.36	35.4	0.42
Ficus capensis	Moraceae	2	3.57	31.45	0.17
Ficus exasperata	Moraceae	4	7.14	19.3	0.13
Garcinia mannii	Clusiaceae	2	3.57	23.7	0.11
Irvingia gabonensis	Irvingeaceae	3	5.36	28.73	0.25
Khaya ivorensis	Meliaceae	3	5.36	17.93	0.09
Mammea africana	Clusiaceae	3	5.36	25.47	0.21
Musanga cecropioides	Urticaceae	3	5.36	11.00	0.03
Nauclea diderrichii	Rubiaceae	1	1.79	53.40	0.22
Raphia hookeri	Arecaceae	3	5.36	14.07	0.05
Tetrapleura tetraptera	Fabaceae	2	3.57	22.55	0.10
Treculia africana	Moraceae	3	5.36	31.00	0.25
Triplochiton scleroxylon	Sterculiaceae	1	1.79	11.90	0.01
Uapaca heudelotii	Phyllanthaceae	5	8.92	17.24	0.15

Field observation revealed that six of the timber species (*A. boonei*, *E. guineensis*, *I. gabonensis*, *K. ivorensis*, *M. cecropioides* and *T. africana*) were common to the three sampling plots. While *A. djalonensis*, *C. preussii*, *G. brevis*, *S. gabonensis*, and *V. grandiflora* were peculiar to the sample plot at Kolo 1 community of BE; *B. stenocarpa*, *M. excelsa*, and *S. stipulatum* were peculiar to the sample plot at Ogobiri community of BW; and *A. aubryanum*, *C. patens*, *G. mannii*, *K. ivorensis* and *X. staudtii* were peculiar to the sampling plot at Gbarain community in BC. The total number of timber species encountered per sampling plot is presented in *Table 4*. Fifty individual timber species were encountered in the sample plot at Ogobiri community (BW), fifty-two in Kolo 1 community (BE) and fifty-six in Gbarain community (BC), the species belonged to 18, 16 and 14 different families respectively. The Table also reveals the level of timber species diversity indices in the sampling plots.

Table 4: Biodiversity indices of the tree species in the three sampling plots

Diversity indice	BW	BC	BE
C	0.470	0.723	1.04
H	3.033	2.931	3.081
E	0.060	0.052	0.059
D	5.624	4.720	5.821
d	3.253	2.673	3.328
No. of individual	50	56	52
No. of species	23	20	24
No. of family	18	14	16

Key:* *C= *Simpson, H= Shannon-Wiener, E= Evenness, D= Margalef,* ***d****= Menhinick*

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Although the timber species diversity varies reasonably yet, the highest Simpson (C), Shannon-Wiener (H), Evenness (E), Margalef (D) and Menhinick (d) values occurred in the sample plot at BE. Whereas, the highest values of the individual number of trees present (56), and species with the highest number of family (18) occurred in BC and BW sample plots respectively. Table 5 shows the timber species growth variables. The Basal area (Ba) increases with an increase in diameter at breast height (dbh). The highest values of Ba and dbh occurred in the sample plot at Kolo 1 in BE, while the least Ba was recorded in Ogobiri community in BW. The Field observation revealed that the sample plots were located in flat terrain characterized by seasonal flood inundation.

Table 5: Species Growth Variables and Land's Surface Feature

Variables	Values		
Sample plot location	BW	BC	BE
Mean dbh (cm)	22.17	23.22	29.95
Total Basal Area	2.85	2.89	4.44
Local Terrain	Flat and prone to inundation	Flat and prone to inundation	Flat and prone to inundation

The species encountered in the sample plots were quite similar to one another (Table 6), the level of similarities of the species in the three sampling plots is represented as (BW-BC) > (BW-BE) > (BC-BE).

Table 6: Similarity Measures on the Occurrence of Tree Species in the Three Sampling Plots of the Study Area

Similarity Indices	BW-BC	BW-BE	BC-BE
IS (%)	59.58	46.51	45.46
S_{SD}	0.37	0.32	0.31
S_J	0.23	0.19	0.19
S_{AS}	0.51	0.51	0.50
S_O	1.14	0.89	0.89

Four indigenous tree species were identified as rare timber species in the sample plots (*Table 7*) and the Table provides conservation inference on the species: though the species are some of the choice trees with high market values in the State.

Table 7: Conservation Inference on the Rare Species

Confirmed rare species	Ecological knowledge				
	Ecology	Propagation	Utility	Habit	Conservation inference
Coelocaryon preussii	Rainforest /swamp tree	Seeds, wildlings	timber, carpentry furniture, building, carving	Tree	Locals are quite familiar with the trees; however, an enlightenment campaign on the importance of trees that necessitates tree cultivation by the aboriginals is required.
Sacoglottis gabonensis	Rainforest , swamp	Seeds, wildlings	timber, furniture, building, carving	"	The swamp forest vegetation of the study area will support the cultivation of this rare species

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Confirmed rare species	Ecological knowledge				
	Ecology	Propagation	Utility	Habit	Conservation inference
Milicia excelsa	Rainforest	Seeds, wildlings	timber, furniture, building, carving	"	Investment in the species will meet future needs of the indigenous people and provide valuable economic returns. Planting of the species is a way of preserving them, and this will provide the rural dwellers themselves sufficient use indefinitely.
Triplochiton scleroxylon	Rainforest	Seeds, wildlings	timber, carving medicine, storage	"	Locals are familiar with the trees hence enlightenment campaign on the conservation of the species by the natives is required. The aborigines' familiarity with seeds propagation could be exploited through the provision of seeds and or seedlings of the species

DISCUSSION

Lowland forests with flat terrain are prone to flood inundations, with its attendant impacts on flood intolerant tree species. The values of timber species obtained from the sample plots signify that the plots are well stocked and rich in timber species, but the majority of the timber species encountered are immature. Most of the timber species were common to the three sample plots, and typified post extraction secondary forest trees of lowland forest. The mean diameter at breast high (dbh) and Total Basal area (TBa) of the species in Bayelsa West (BW) and Bayelsa Central (BC) are relatively low compare to Bayelsa East (BE) with a greater number of closely packed species. This finding is inconsonant with Ihinmikaiye & Unanaonwi (2018) who asserted that the level of standing stock indicates the degree of resilience and/or the extent of forest perturbation, and the magnitude of disturbance to a forest community determines its content of tree species diversity.

Evenness (E) value close to 1 indicates less variation among timber species of compared sites (Rosenzweig, 1995). Thus, low E values obtained imply a degree of dissimilarity of timber species population across the three plots; however, the diversity index gives credence to the density and richness of timber species in the plots. The sample plot at BE was the most diverse in terms of timber species, this is because the level of timber species richness in the plot is impressively large compare to those of BW and BC. The slight variation observed in the similarity indices, confirmed a shift in the level of the timber species diversity, affirming that logging activities directly influence forest structure and timber composition (Reich *et al.,* 2001; Adekunle *et al.*, 2013).

Conservation of rare timber species are best observed by keeping their native habitat healthy (FAO, 2018). The confirmed rare species identified in the sample plot were choice trees; this alludes to the market value and the high level of the species usefulness. The more the utility worth of a species, the susceptible it becomes to logging and the faster it declines in the wild. Logging of peculiar tree species creates sparse distribution and affects the overall structure of a forest zone. Previous findings of Lindenmayer *et al.* (2000); Hall *et al*. (2003) and Bieri (2011) revealed that exhaustive selective logging reduces the abundant status of choice forest species, sometimes up to the point of local extinction.

The rate of depletion of existing forest in Bayelsa State is a cause of concern, a focus that reduces the present and future options for using forests (FAO, 2016). Therefore, an effective and integrated approach for the conservation of both rare species and indigenous tree in general is inferred. And these must consider the documentation of individual taxa, provision of effective and protective legislation, preservation of populations in the wild as well as in cultivation, and education of the general public. Besides, it may become necessary to propagate these plants *ex-situ* and replant the seedlings back into their natural habitats

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