Trees Species Structure and Diversity in the Lowland – Rain Forest Zone of Bayelsa State

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Abstract

Bayelsa State was divided into three zones (Bayelsa East, Bayelsa West and Bayelsa West) based on Nigeria political delineation, and a sample plot measuring 30m by 30m was selected from a forest in each zone. Tree species structure and diversity of selected sample plots were assessed. Sampling technique was employed to collect data of trees; and trees that were 2meter high at diameter at breast height (dbh) ≥4m in the sampling plots were identified and classified accordingly. Scale of abundant in relation to relative density was used to determine the abundant status of tree species encountered. A total of 164 living trees of different dimension belonging to 22 families were encountered, all trees encountered were indigenous trees. The highest and least basal areas (0.64m² and 0.04m²) in the sample plot at Imringi community in Bayelsa East Senatorial district were contributed by Pycnanthus angolensis and Uapaca guineensis respectively. While Laccosperma secundiflorum and Garcina manii had the least and highest basal area of 0.002m² and 0.87m² respectively in Tombia community, Bayelsa Central Senatorial district. Eleais guineensis and Laccosperma secundiflorum with 0.74m² and 0.01m² respectively contributed the highest and least basal areas in the sample plot at Amatolo community, Bayelsa West Senatorial district. The sample communities had high tree species diversity, yet the tree species distribution skewed with respect to the intermediate class. This study is a pointer to the fact that forest communities in the area are rich in tree species yet, pressure from illegal logging, oil exploration and constant inundation by flood threaten tree species survival. Thus management plans to sustain and preserve forest tree species diversity in the State were proposed.

Keywords: Diversity; Trees Species Structure; Forest community; Low-land rain forest; Forest communities

Introduction

Forests throughout the earth are vital for local communities around, and to the entire world on a global scale. Aside from being a source of carbon sequestration and climate control, they serve in various categories of ecosystem services- provisioning (of food and water), supporting (such as nutrient recycling and primary production) as well as cultural (such as spiritual, and recreational benefits) [1]. However, forests in the tropical rainforest belt are distinct from others in terms of species richness and high level of diversity. Physiognomically,

they feature a closely pack evergreen canopy trees with mesophyllic leave [2] and are the most complex ecosystems and major vegetation type of the globe [3] and Gebreselasse, [4]. According to Wilson [5], rainforest cover only 7% of the earth's land surface; and contain more than half the species in the entire world, an indication of the presence of a correspondingly great diversity of food webs and trophic relationship connection. Despite their extraordinary richness, tropical forests are the most fragile of all habitats [5], and trees species plays significant role in their multiplicity. According to Cannon, et al. [6] the diversity of trees is fundamental to total rainforest biodiversity, and trees are often the most conspicuous plant life form in a tropical forest [7]. Yet, tropical forest habitat are vulnerable to deforestation and degradation [8], and might plummet into sparsely distributed standing stock and resultant loss of species diversity in due course, as continue timber cutting without replacement had been observed to be one of the factors responsible for biodiversity loss [9]. Habitat lost to deforestation reduces not only the number of species in the ecosystem, but also the member and extent of place where of species coexist [10].

In Nigeria, specifically in the tropical rainforest zone, tree species diversity and resilience are mainly affected by human-caused disturbance: logging, slash and burn agricultural practice, shifting cultivation cycle, exploration and exploitation of crude oil, urbanization and anthropogenic activities as well as oil spill. Wanton removal of trees species through these activities is very inimical to biological conservation and are fast acting especially on species with narrow range. While tightly packed trees with high levels of endemicity dominates the vegetation types–lowland rainforest, fresh water swamp

forest and mangroves of Bayelsa State, deforestation takes its toll on the forest communities. In fact, vast portion of the forests has either been degraded by exploration activities, logging or converted to farmland. According to Marcia, et al. [11]. disturbance caused by logging strongly change environmental conditions for plant growth and survival in tropical forests. At presently, a gross dearth of literature on tree species composition, diversity and conservation plans abound in Bayelsa State. Consequently, sampling aim to assess the status of tree species in the lowland forest zone of the State is carried out and management plan that could ensure sustainable use and effective conservation is suggested. The data presented in this study form an important basis for comparison of tree species composition and diversity in the lowland forest of Bayelsa State senatorial districts.

Study Area

The study was conducted in forest communities at Bayelsa State. Three (3) sites were chosen for the study, a site in Imiringi, Tombia and Amatolo community at Bayelsa East (BE), Bayelsa Central (BC) and Bayelsa West (BW) senatorial distinct respectively. The sites lie within Lat. 4° 39' N and 5° 25'S; Long. 6°19' E and 5° 22 'W. The area is a lowland belt about 30 metres below sea level [12], in the core section of the Niger Delta region of Nigeria. The prevalent climate is humid sub-tropical with annual rainfalls approximately 4900mm and a relative humidity of about 85%; temperature varies from 25°c to 31°c annually. The vegetation type is the lowland rainforest type mainly in the north and mangrove swamp forest type in the southern end. Bayelsa State is rich in fertile soil and plant species diversity, a factor that endears the rural dwellers mostly to agriculture related occupations.
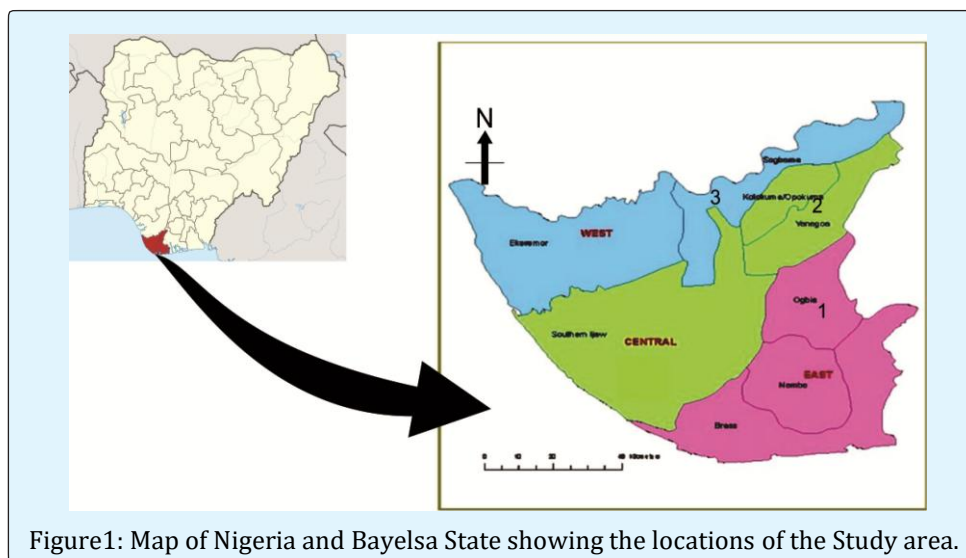

Figure1: Map of Nigeria and Bayelsa State showing the locations of the Study area.

Data collection

Systematic sampling design was used for the selection of the sampling plots. Sampling was done in forested area of three (3) communities namely: Imringi, Amatolo and Tombia located in BE, BW, and BE senatorial district respectively. The sample plots measured 30m by 30m in size (i.e. 900sqm). All living trees above 2metres high with diameter at breast height greater than or equal 4m (dbh≥ 4m) within the sample plots were identified and classified accordingly. The dbh were measured with metal rule calibrated in centimeter (cm). Fruits, twigs and flowers were collected to confirm the identity of the species assessed in the sample plots. Botanical names of the trees that were measured in each sample plot were recorded for each of the study plot. Specimen voucher of trees that could not be identified immediately were collected and preserved for identification at the herbarium of Plant Science and Biotechnology Department, University of Port Harcourt Rivers State.

The diversity indices of the tree species identified in the three sampling plots were extrapolated according. Also, the relative abundance status of the tree species from each plot was determined.

Analysis of Tree Species Diversity

The following indices of diversity were used:
(i) Shannon-wiener index of diversity (H') = -pi$\sum$ (logpi)
Where pi= number of individual
Log pi= Natural log of pi
(ii) Simpson index (S): S =$\sum$ pi^2
Pi is the same as in Shannon-wiener index

(iii) Equitability index (E) as: E=H'/logS
Where "H'" is Shannon wiener index and "S" is the total number of species.
The Basal area (Ba) (i.e. the cross-sectional area at breast height) of all trees in the sample plots were calculated using the formula
Ba= $\pi d^2/4$, where d= diameter at breast length in cm and π=3.142.
The Total Basal area (TBa) for each sample plot was obtained by summing the Ba of all trees in the plot.
The relative density (Rd) of each tree species in the sample plots was calculated as follows:
Rd (%) = number of individual tree species/total of number of trees sampled X 100%.
Abundance of the tree species assessed was determined using the scale of abundant in relation to their relative densities (Rd) as adopted by Edet, et al. [13]: Very abundant (Rd ≥ 5.00); Abundant (Rd, 4.99 – 4); Frequent (Rd, 3.99 – 3); Occasional (Rd, 2.99 – 2) and Rare (Rd, 1.99 – 0).

Results

Within the sample plots in the 3 geopolitical zones of the state a total of 164 living trees (in different dimension) belonging to 22 families were encountered and their girths measure at 1.37m dbh. Tables 1-3 show the tree species structure and their abundant status in the sample plot at Imringi community, Tombia (community) and Amatolo community. 56 trees belonged to 19 families were encountered in the (30m X 30m) sample plot at Imringi in Bayelsa East Senatorial district (Table 1).

FAMILIES	Species name	NS*	†Mdbh	RD**	††BA	-(PiLNPi)
Anacardiaceae	Spondias mombin (L)	**2**	38.8	3.57	0.24	0.12
Annonaceae	Monodora myristica (Gaertn.)	1	50.2	1.79	0.02	0.07
	Cleistopholis patens (Benth.)	2	21.75	3.57	0.08	0.12
Apocynaceae	Alstonia boonei (De. Wild)	2	29.8	3.57	0.19	0.12
	Funtumia elastica (Preuss)	2	31.8	3.57	0.18	0.12
Arecaceae	Eleais geineensis (Jacq.)	2	41.65	3.57	0.27	0.13
Clusiaceae	Garcina manii (L.)	1	33.8	1.79	0.09	0.07
	Mammea africana (L)	1	57	1.79	0.26	0.07
Euphorbiaceae	Anthostema aubryanum (Baill.)	1	49	1.79	0.19	0.07
	Mucaranga barteris (Mull. Arg.)	1	40.2	1.79	0.13	0.07
Gentianaceae	Anthocleista vogelii (Planch.)	2	26.5	3.57	0.11	0.12
	Anthocleista djalonensis (A. Chev.)	1	44.9	1.79	0.16	0.07
Humiriaceae	Sacoglottis gabonensis (Baill.)	1	54.6	1.79	0.23	0.07
Irvingiaceae	Irvingia gabonensis (Baill.)	4	40.15	7.14	0.56	0.19
Lamiaceae	Vitex grandifolia (Gurke)	1	39.7	1.79	0.12	0.07
Meliaceae	Carapa procera (DC.)	2	32.3	3.57	0.16	0.12

	Ficus exasperata (Vahl)	3	34.27	5.36	0.29	0.16
Moraceae	Ficus capensis (Thunb.)	3	35.7	5.36	0.33	0.16
	Treculia africana (Decne.)	2	43	3.57	0.34	0.12
	Ficus mucuso (Welw.)	3	35.7	5.36	0.33	0.16
Myristicaceae	Pycnanthus angolensis (Welw.)	5	39.1	8.93	0.68	0.22
Pandaceae	Panda oleosa (Pierre)	3	32.43	5.36	0.31	0.57
Passifloraceae	Barteria nigritaria	1	51.6	1.79	0.21	0.07
Phyllanthaceae	Uapaca heudelotii (Baill.)	3	37.2	5.36	0.4	0.16
	Uapaca guineensis (Mull. Arg)	1	22.6	1.79	0.04	0.07
Rutaceae	Zanthoxylum gilletii (De Wild.)	2	18.8	3.57	0.11	0.12
Sapotaceae	Pachystela brevipes (Baker) Engl.	2	41.65	3.56	0.28	0.12
Urticaceae	Musanga cecropoides (R.Br.)	2	37.35	3.56	0.22	0.12

Table 1: Tree Species Structure & Abundant Status in the study area at Imiringi community of Bayelsa East Senatorial District.
*Number of Species, **Relative Density, ***Species Abundant Status, BA (Basal Area), Mdbh (Mean diameter breast height)

Members of the moraceae family were the prevalent species in the plot; however, P. angolensis was the dominant tree encountered and with the highest relative density (RD) in the sample plot. Also, the scale of abundant (Table 1) reveals that 10 of the tree species encountered are **rare**, 11 are **Frequent** and 7 others are **very abundant**: representing 35.7%, 39.3% and 25% in the plot respectively. The highest and least basal areas (0.64m^2 and 0.04m^2) were contributed by Pycnanthus angolensis and *Uapaca guineensis* respectively. *Mammea africana* had the highest Mdbh (57cm) in the sample plot at Imringi. Table 2 reveals that 47 trees belonged to 18 different families were encountered in the (30m X 30m) sample plot at Tombia community in Bayelsa Central Senatoria district. *Spondias monbins*; *Alchornia cordifolia*, *Carapa procera* and *Uapaca heudelotii* were the dominant tree species encountered, each have 3 individual trees; while Clusiaceae family had the highest members of tree species (4 species) with six individual trees. On the scale of abundant: 4, 11 and 11 species out of the trees encountered in the plot were **very abundant**, **abundan**t and **rare** respectively: corresponding to 15.4%, 42.3% and 42.3%. *Nauclea diderrichii* (53.80cm) had the highest mean diameter at breast height (Mdbh). *L. secundiflorum* and *G. manii* had the least and highest basal area 0.002m^2 and 0.87m^2 respectively.

FAMILIES	Species name	NS*	Mdbh†	RD**	BA††	-(PiLNPi)
Anacardiaceae	Spondias mombin (L)	3	20.97	6.38	0.1	0.18
Annonceae	Cleistopholis patens (Benth.)	1	28.4	2.13	0.06	0.08
Apocynaceae	Alstonia boonei (De. Wild)	2	31.45	4.26	0.17	0.13
Arecaceae	Eleais geineensis (Jacq.)	2	43.4	4.26	0.3	0.13
	Laccosperma secundiflorum(Kuntze)	2	3.6	4.26	0.002	0.13
Clusiaceae	Garcina manii (L.)	1	22	4.26	0.87	0.13
	Symphonia globulifera (L.)	1	32.1	2.13	0.08	0.08
	Harungana madagascariensis (Lam.)	2	20.4	2.13	0.03	0.08
	Mammea Africana (L)	1	40.35	4.26	0.29	0.13
Euphorbiaceae	Mucaranga barteris (Mull. Arg.)	3	12.9	2.13	0.01	0.88
	Alchornea cordifolia (Mull. Arg.)	1	13	6.38	0.04	0.04
Fabaceae	Afzelia bipindensis (Harms.)	2	28.8	2.13	0.07	0.08
Gentianaceae	Anthocleista vogelii (Planch.)	1	23.1	4.26	0.09	0.13
	Anthocleista djalonensis (A. Chev.)	2	43.1	21.6	0.15	0.08
Humiriaceae	Sacoglottis gabonensis (Baill.)	1	47.05	4.26	0.35	0.13
Irvingiaceae	Irvingia gabonensis (Baill.)	2	39.7	2.13	0.12	0.08
Meliaceae	Carapa procera (DC.)	1	31.47	6.38	0.24	0.18
	Khaya ivorensis (Chev.)	3	49.3	2.13	0.19	0.08
Moraceae	Ficus mucuso (Welw.)	1	37.6	4.26	0.23	0.13

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	Treculia africana (Decne.)	2	50.25	4.26	0.41	0.13
Myristicaceae	Pycnanthus angolensis (Welw.)	2	47.47	4.26	0.36	0.13
Pandaceae	Panda oleosa (Pierre)	1	43.6	2.13	0.15	0.08
Phyllanthaceae	Uapaca heudelotii (Baill.)	3	22.2	6.38	0.13	0.18
Rubiaceae	Nauclea diderrichii (De Wild.)	1	53.8	2.13	0.23	0.08
	Mitragyna stipulosa (DC.)Kuntze	1	49.9	2.13	0.2	0.08
Sapotaceae	Pachystela brevipes (Baker) Engl.2	2	35.25	4.26	0.2	0.13
Urticaceae	Musanga cecropoides (R.Br.)	2	33.35	4.26	0.18	0.13

Table 2: Tree Species Structure & Abundant Status in the study area at Tombia Community of Bayelsa Central Senatorial District.
*Number of Species, **Relative Density, SAS=Species Abundant Status, ††Basal Area, Mean †diameter breast height

In the sample plots at Amatolo community of Bayelsa West senatorial district (Table 3); 24 tree species were encountered, members of Arecaceae, Clusiaceae, Euphorbiaceae and Meliaceae families were the major tree species in the plot. Yet, *Eleais geineensis, Carapa procera*, *Panda oleosa* and *Nauclea diderrichii* (each with 4 individuals) were the dominant tree species encountered in the sample plot. The scale of abundant reveals that 4 (16.7%) of the tree species were **very abundant**, 8 (33.3%) were **abundant**, 9 (37.5%) were **frequent** and 3 (12.5%) were **rare**. RD in the sample plots increased with increase in the number of each tree species encountered, but varies with the Mdbh. *E. guineensis* and *L. secundiflorum* with the values $0.74m^2$ and $0.01m^2$ respectively contributed the highest and least basal area in the sample plot.

FAMILIES	Species name	NS*	Mdbh†	RD**	BA††	-(PiLNPi)	SAS***
Anacardiaceae	Spondias mombin (L)	2	33.8	3.28	0.18	0.11	F
Annonceae	Cleistopholis patens (Benth.)	2	36.55	3.28	0.22	0.11	F
Apocynaceae	Funtumia elastic (Preuss)	3	27.1	4.92	0.19	0.15	A
Arecaceae	Eleais geineensis (Jacq.)	4	48.23	6.56	0.74	0.18	VA
	Laccosperma secundiflorum(Kuntze)	1	8.2	1.64	0.01	0.07	R
Clusiaceae	Garcina manii (L.)	2	17.5	3.28	0.05	0.11	F
	Symphonia globulifera (L.)	3	42.6	4.92	0.51	0.15	A
Ctenolophonaceae Ctenolophon englerianus(Mildbr.)	Ctenolophon englerianus(Mildbr.)	2	44.55	3.28	0.32	0.11	F
Euphorbiaceae	Anthostema aubryanum (Baill.)	2	48.8	3.28	0.19	0.11	F
	Mucaranga barteris (Mull. Arg.)	1	20.6	1.64	0.03	0.07	R
Fabaceae	Piptadeniastrum africanum (Hook. F.)	3	32.35	4.92	0.45	0.15	A
Gentianaceae	Anthocleista vogelii (Planch.)	2	31.55	3.28	1.43	0.11	F
Irvingiaceae	Irvingia gabonensis (Baill.)	3	35.05	4.92	0.37	0.15	A
Lamiaceae	Vitex grandifolia (Gurke)	3	31.57	4.92	0.26	0.15	A
Meliaceae	Carapa procera	4	32.33	6.56	0.28	0.18	VA
	Ficus exasperata (Vahl)	3	32.63	4.92	0.18	0.15	A
Myristicaceae	Pycnanthus angolensis (Welw.)	2	33.55	3.28	0.19	0.11	F
Ochnaceae	Ouratea schoenleiniana (Oliv.)	1	14.2	1.64	0.02	0.07	R
Pandaceae	Panda oleosa (Pierre)	4	33.15	6.56	0.37	0.18	VA
Phyllanthaceae	Uapaca heudelotii (Baill.)	2	36.2	3.28	0.21	0.11	F
Rubiaceae	Nauclea diderrichii (De Wild.)	4	29.75	6.56	0.38	0.18	VA
Rutaceae	Zanthoxylum gilletii (De Wild.)	2	38.4	3.28	0.23	0.11	F
Sapotaceae	Pachystela brevipes (Baker) Engl.	3	43.23	4.92	0.45	0.15	A
Urticaceae	Musanga cecropoides (R.Br.)	3	35.03	4.92	0.3	0.15	A

Table 3: Tree Species Structure & Abundant Status in the study area at Amatolo Community of Bayelsa West Senatorial District.
*Number of Species, **Relative Density, ***Species Abundant Status, †Mean diameter at breast height, ††Basal Area

Table 4 shows that slight variation occurred in species richness of the sample plots. Shannon-wiener index (H') obtained from the sample plots at Imringi, Tombia and Amatolo are 3.216, 3.218 and 3.111 respectively.

Indices	Senatorial Districts		
	Bayelsa East	Bayelsa Central	Bayelsa West
	Imringi	Tombia	Amatolo
Shanon-Weiner (H)	3.216	3.218	3.111
Simpson (S)	0.045	0.835	0.047
Equitability (E)	0.057	0.068	0.051
*TBA (BA/900Sqm)	6.816	4.454	7.549

Table 4: Summary of floristic indices of tree species in the selected communities' forest in Bayelsa State Senatorial Districts.
*Tree Basal Area

The highest Simpson(S), 0.835 and Equitability index (E), 0.835 occurred in the sample plot at Tombia, no significant different (p>0.05) occur in the Equitability (index) values of the 3 plots when compared. While the highest Tree Basal Area (7.549m^2) occurred in the sample plot at Amatolo community followed by 6.814m^2 at Imringi community.

Discussion

The results reveal the distribution pattern of the tree species encountered in the three (3) sample plots. All tree species encounter are indigenous trees. The total number of trees species obtained within the sample plot suggests that the sampled communities have high tree species diversity, and dense vegetation cover. However, the distribution of the trees in the 3 sample plots skewed with respect to the intermediate (mdbh) classes. This can be attributed to forest degradation activities which may have removal wider diameter at breast height (dbh) individuals as well as the fact that some large sized trees would have been removed though logging operation [14]. The dominant families (Arecaceae, Clusiaceae, Euphorbiaceae, Meliaceae, Moraceae, Gentianaceae, Rubiaceaeae, Phyllanthaceae, Apocynaceae and Annonaceae) in the sampled plots confirmed the claims of Akinyemi, et al. [15]; Adekunle and Olagoke [16]; Humphrey and Godwin [7]; Edet, et al. [13] and Ojo [17] among others who reported the prevalence of the members of Euphorbiaceae, Moraceae, Meliaceae, Clusiaceae, Rubiaceae and Gentimaceac families in the rainforest ecological zone of Nigeria. Perhaps the prevalence of *I. gabonensis* in the sample plot at Imringi is simply borne out by the facts that the species is preserved because of its economic values, and the strict penalty attached to illegal logging of the species [18]. High Shannon-wiener values in the sample plots (3.216, 3.218 and 3.111 at Imringi, Tombia and Amatolo respectively) reveal that no significant different (p>0.05) occurred in the tree structure of the 3 plots: this suggests a correspondingly high level of species richness and evenness in the communities. Essentially, the H' values (obtained in the 3 sample plots) favourably compare with the values (3.69, 3.32 and 3.516) obtained in the three sites around Sengaltheri west Ghats as reported by Parthasarathy [19]. And 3.827 obtained by Aigbe, et al. [13] in Afi river forest; and to 3.656, 3.621 and 3.342 obtained by Adekunle [20] for Shasha, Ala and Omo forest reserved respectively. Sampson (S) index with high species dominance indicates lower diversity [21]; unequivocally, a highly dissimilar tree species population would indicate higher diversity level more so, the species indices obtained here clearly implies that the sample plots are in fine fettle. Also, the Equitability (E) index obtained suggests that most of the tree species encountered in the sample plots are similar in their abundant. While the highest level (7.549 Ba/900sqm) of crowdedness (i.e. Basal area) in the standing stocks recorded at Amatolo suggests lowest level of disturbance and high rate of resilience.

The sustainability of tree species diversity is critical for ecosystem functioning. This study is a pointer to the fact that forest communities in the area is rich in tree species (at intermediate sizes by dbh); unfortunately, no precise management plan to sustain and preserve tree species diversity in the State; as pressure from illegal logging, oil exploration and constant inundation by flood threaten tree species survival. It is recommended that the existing reserves in the State be reconstituted; besides, people living in rural villages around forest communities in the State should be enlightened on the danger of tree species diversity loss.

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