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Ecology and Determinants of a Tropical Rainforest Landscape

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ABSTRACT

Tropical ecosystems are bio-diverse ecosystems that differ according to varied environmental features. This work assessed the tree diversity and environmental variables that define a rainforest ecosystem in southeast Nigeria. 30 forest plots were used to identify trees ≥ 10 cm (DBH measured at 130 cm). Soil samples were collected up to 30 cm deep at four edges and middle of each plot, and bulked for analysis. The survey recorded a total of 2414 trees that belonged to 102 species and 32 families. Shannon-Wiener's diversity index (H') of 3.67, Inverse Simpson's index (C) of 1.06, species evenness of 0.79 and Margalef's index of species richness (M) of 12.97 were recorded. Fabaceae family recorded the highest number (1037) of individual tree (being 43% of total) observations, while Burseraceae had the least number (1). Species abundance status showed 2.9% of species as "Abundant", 73.5% as "Endangered", 2.9% as "Frequent" and 20.6% of species as "Rare". Soil variables namely phosphorus, magnesium, potassium, particle sizes (sand, silt and clay), CEC, calcium, pH, and aluminium, influenced the distribution of the vegetation in decreasing order. Edaphic factors (soil) determined the distribution of tree stems, growth and abundance of the species within the region. Efforts on conserving the ecosystem along environmental gradients and according to species status and indices are advocated.

Keywords: Biodiversity; Conservation; Environmental factors; Gradient; Tropical

1. Introduction

Plant species vary across geographical locations or regions due to environmental variables inherent in such zones [1,2]. Such variations in the environment are mainly due to the regional and local factors which are inherent in the environment and vary across different landscapes. Hence, what determines ecosystems such as the rainforest (lowland forests)

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differ from that of swamp forests. While regional factors such as climate (mainly annual rainfall and temperature) and edaphic factors (such as geology, elevation and soil) clearly delimit the forest zones from each other, other local factors distinguish them among themselves. Instances could be drawn from swamp forests which have mainly been linked to variables such as salinity, geomorphology, hydrology, local topography and drainage [3], and lowland forests (which though monotonous in appearance), differ across spatial scales due to variations in seasonality and soil fertility [4,5]. These environmental factors act as determinants of the ecological patterns for ecosystems by either being ecologically conducive or restraining (limiting) a wide range of biodiversity. Even though these environmental factors and gradients seem quite common and known across the tropics, their data are surprisingly scanty for many landscapes and zones, and how they vary at local scales, is still a subject of inquiry. Since these factors determine to a large extent the composition, abundance and in turn the management and conservation of the ecosystem, understanding them have become very necessary and essential.

There is still a general lack of fundamental biodiversity information for tropical African taxa, including accurate taxonomy, ecological studies and estimates of distribution, compared to temperate or other tropical regions outside Africa [6]. Thus, though interests in tropical forest ecosystems have been able to present a general view of the ecosystem following its long history of inquiries, the needed details at regional levels are lacking. With the seemingly advanced knowledge on tropical ecosystems being dominated by what is specific to a part of the tropical forest zones (in the Americas, Africa or Asia), the need to promote detailed ecological studies at sub-regional levels and specific ecosystem levels is crucial, rather than working with a generalized opinion. Instances of such assertions and generalizations have been reported for the freshwater swamp forest ecosystem [7] which is dominated by studies from Latin America and very few inventories or baselines elsewhere. Promoting ecological research for specific ecosystems (such as the rainforest) at different spatial scales (national, regional and local) are much needed. Continued efforts to acquire primary data from the field are vital and a necessity to provide reliable information on which the management of the ecosystem could be based.

With varied climates, forest ecosystems across Nigeria differ from the coasts to the inland zones and then to the central and northern zones. Alongside other bio-physical attributes, the ecosystems differ at regional and most importantly at smaller (local) scales where they are mostly patterned after local factors. Though early works such as Keay's [8] work, delimited the ecosystems across Nigeria, in-depth ecological surveys and consequent conservation measures and strategies are lacking. While these ecosystems are no longer as extensive as they used to be following decades of anthropogenic pressures- notably agriculture and population pressure (especially in south east Nigeria with high population density), the remaining portions need to be documented. This work hence assessed the tree diversity and environmental factors that define the composition of rainforest ecosystems in south east Nigeria. Such insights are much needed and will suitably guide in promoting conservation and mitigation of consequent environmental change impacts.

2. Materials and methods

2.1 Study area/region

The area for the research is a part of South East Nigeria (**Figure 1**). It is characterized by a humid tropical, tropical wet and dry climate, and marked with rainy and dry seasons. The region has a high annual rainfall which ranges from 1,400 mm in the North to 2,500 mm in the South, and a mean monthly temperature of 27.6 °C. The geology of the region comprises the ancient Cretaceous delta, with the Nkporo shale, the Mamu formation, the Ajali sandstone and the Nsukka formation as its main deposits [9]. The natural vegetation of the zone is mainly, rainforest-savanna ecotone ecosystem. The zone experiences about 3 dry months in its northern zone and

1-2 dry months in the south; making it much more humid and with sufficient rainfall.

Forest inventory was done in Maku in Awgu Local government area, Enugu-Achi in Oji river local government area and Inyi, in Oji river local government area of Enugu state. Elevation within the zone is quite varied and a characteristic hilly feature and rugged terrain typifies the zone. Forests within the zone are extensive and relatively undisturbed—mainly due to the hilly terrain, very poor accessibility of the forests and quite a distant from human dwelling units.

2.2 Data collection and analysis

30 forest plots were set up across the zone and used for eliciting information regarding the tree composition of the ecosystem. Each of the plots measured 50 m × 50 m and was used to enumerate tree species ≥ 10 cm diameter at breast height (DBH measured at 130 cm). DBH or girth tape was used to measure the tree stems while a rangefinder was used to measure the heights. Species found within all the plots were identified, measured and documented. Species identification followed the taxonomy of Nigerian plants [10] and The Plant List [11]. Soil samples were collected up to 30 cm deep at the four edges and then the middle of each plot and bulked for analysis. The samples were analyzed for carbon (C), N, pH, P, exchangeable aluminium (Al), exchangeable cations namely, Ca, K, Mg, Na and CEC, which was used in the determination of base saturation.

Organic carbon was derived with Walkey-Blacks titration method [12] after which the Van Bemmelan factor was used to calculate the organic matter. Exchangeable aluminium (Al) and exchangeable cations, namely calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K), were derived following Allen et al. [13] Summer and Miller [14] were employed for CEC determination; Semi-micro kjedahls distillation method [15] was used to get the nitrogen while pH employed the H_2O and 0.1 M KCl methods of Rowell [16].

Biodiversity variables were assessed with Shannon-Wiener's diversity index (H') and Inverse Simpson's index (C), Pielou's evenness [17], Margalef's index of species richness (M) and Relative density.

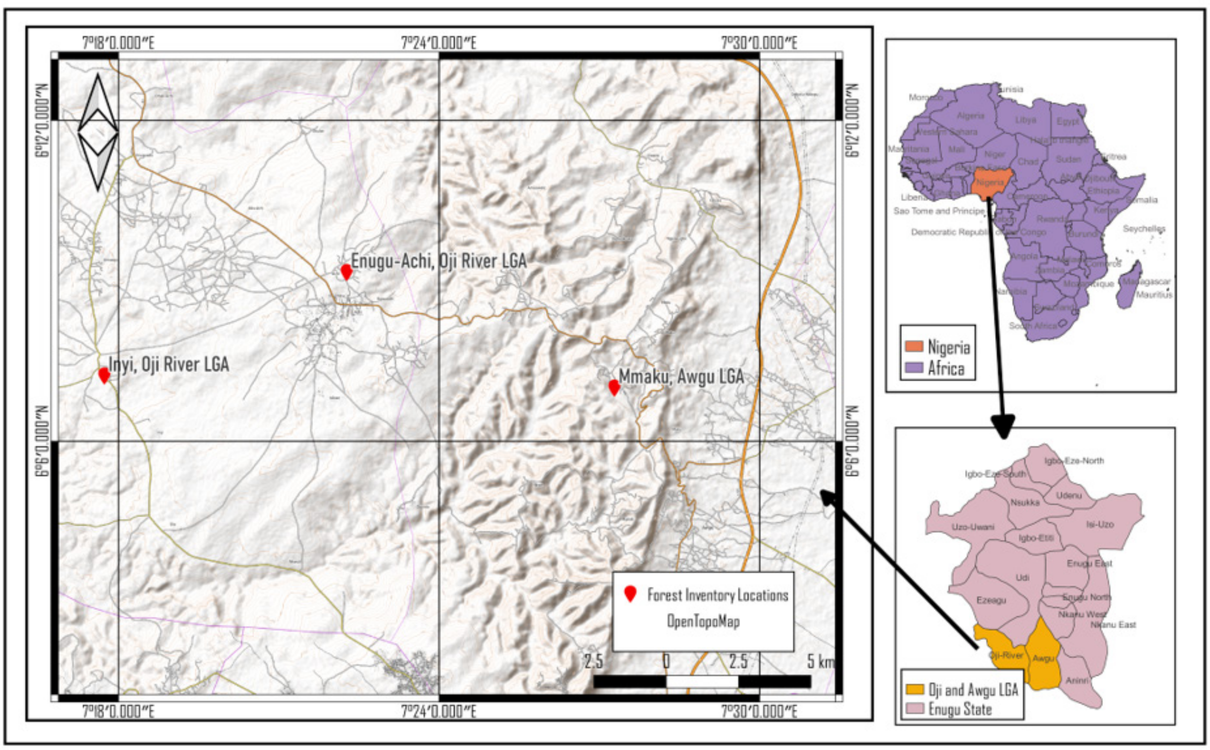

Figure 1. Map of the study area with the map of Nigeria and Africa inset.

Variations between elevation gradients were verified with descriptive statistics, while the soil gradients were verified with a Principal Component analysis (PCA).

The relative density (%) of each tree species was measured thus:

$$\text{Relative density} = \frac{\textit{Number of individual tree species}}{\textit{Total number of trees sampled}} \times 100\%$$

The various species were scored according to their relative densities (RD) as follows: Abundant (RD ≥ 5.00), frequent (4.00 ≤ RD ≤ 4.99), occasional (3.00 ≤ RD ≤ 3.99), rare (1.00 ≤ RD ≤ 2.99) and threatened/endangered (RD < 1.00) as adopted by Edet et al. [18] and Adeyemi et al. [19]

3. Results

3.1 Family, trees species composition, distribution and status in the study area

The results of tree distribution and status as presented in **Table 1** showed that a total of 2414 individual trees were recorded of 102 species in 32 families. The species with a high number of observations include: *Dialium guineense* Willd. (462), *Pentaclethra macrophylla* Benth. (161), *Daniellia oliveri* (Rolfe) Hutch. & Dalziel (135), *Margariteria discoidea* (Baill.) G.L (120), *Funtumia elastic* P. preuss. (109), *Pyrostria guinnensis* Comm. ex A. Juss (99) and *Sterculia tragacantha* Lindl. (66). Families with the highest relative densities were Fabaceae, Euphorbiaceae, Apocynaceae, Rubiacae and Sterculiaceae with relative densities of 19.14%, 6.67%, 5.59%, 4.97% and 4.52%, respectively. The lowest individual species recorded includes: *Anacardium occidentale* L., *Annona senegalensis* Pers., *Alstonia boonei* De Wild., *Newbouldia laevis* Seem., *Dacryodes edulis* (G Don.) H. J. Lam., *Bridelia leichardtii* Baill. Ex. Muell. Arg., *Enterolobium cyclocarpum, Khaya senegalensis* (Desr.) A. Juss., *Morus mesozygia* Stapf., *Morinda lucida* Benth. and *Pterygota macrocarpa* K. Schum. Species abundance status revealed that 2.9% (3) of species in the study area were "Abundant", 73.5% (75) were "Endangered", 2.9% (3) were "Frequent" and 20.6% (21) species were "Rare" (**Table 1**).

Table 1. Tree distribution and status in the study area.

Family	Species	Species frequency	Relative density	Status
Anacardiaceae	*Anacardium occidentale* L.	1	0.04	Endangered
	Lannea welwitsschii (Hien) Engl.	49	2.03	Rare
	Mangifera indica L.	3	0.12	Endangered
	Spondias mombin L.	33	1.37	Rare
Annonaceae	*Annona senegalensis* Pers.	1	0.04	Endangered
	Clesistopholis pathens Benth.	42	1.74	Rare
	Monodora tenuifolia Benth.	2	0.08	Endangered
	Xylopia aethiopica (Dunal) A. Rich.	31	1.28	Rare
Apocynaceae	*Alstonia boonei* De Wild.	1	0.04	Endangered
	Funtumia elastic P. preuss.	109	4.52	Frequent
	Holarrhena floribunda (G. Don.) Dur. &Schinz	9	0.37	Endangered
	Hunteria umbellata (K. Shum.) Hallier f.	8	0.33	Endangered
	Rauvolfia vomitoria Afzel.	20	0.83	Endangered
	Vocanga Africana Stapt.	12	0.50	Endangered
Bignoniaceae	*Markhamia lutea* (Benth.) K. Schum.	8	0.33	Endangered
	Newbouldia laevis Seem.	1	0.04	Endangered
	Spathodea campanulata P. Beauv.	25	1.04	Rare
Burseraceae	*Dacryodes edulis* (G Don.) H.J.Lam.	1	0.04	Endangered

Table 1 continued

Family	**Species**	**Species frequency**	**Relative density**	**Status**
Capparidaceae	*Boscia angustifoila* A.Rich.	5	0.21	Endangered
Cecropiaceae	*Myrianthus arboreus* P.Beauv.	9	0.37	Endangered
Combretaceace	*Combretum erythrophyllum* (Burch.) Sond.	5	0.21	Endangered
	Terminalia avicennoides Guill. & Perr.	36	1.49	Rare
	Terminalia glaucescens Planch.	7	0.29	Endangered
Dichapetalanceae	*Dichapetalum madagascariense* Poir.	6	0.25	Endangered
Euphorbiaceae	*Brachystegia eurycoma* Harms	28	1.16	Rare
	Bridelia ferruginea Benth	2	0.08	Endangered
	Bridelia leichardtii Baill. Ex. Muell. Arg.	1	0.04	Endangered
	Bridelia micrantha (Hochst.) Baill	7	0.29	Endangered
	Hymenocardia acida Tul.	17	0.70	Endangered
	Macaranga barteri Roberty	18	0.75	Endangered
	Margariteria discoidea Baill.) G.L Webster	120	4.97	Frequent
	Ricinodendron heudelotti (Baill.)	14	0.58	Endangered
	Drypetes gilgiana (Pax) Pax & K.	14	0.58	Endangered
Fabaceae	*Daniellia oliveri* (Rolfe) Hutch. & Dalziel	135	5.59	Abundant
	Enterolobium cyclocarpum	1	0.04	Endangered
	Hylodendron gabunense Tuub	6	0.25	Endangered
	Parkia biglobosa (Jacq.) G.Don	24	0.99	Endangered
	Pterocarpus santalinoides	17	0.70	Endangered
	Afzelia Africana Sm. Ex pers.	12	0.50	Endangered
	Albezia zygia DC.	41	1.70	Rare
	AlbIzia adianthifolia (Shumach.) W.Wight	32	1.33	Rare
	Albizia ferruginea Guill.	37	1.53	Rare
	Anthonatha macrophylla P. Beauv.	42	1.74	Rare
	Baphia nitida Lodd.	7	0.29	Endangered
	Milletttia thonngii (Shumach&Thonn.) Baker	34	1.41	Rare
	Pentaclethra macrophylla Benth.	161	6.67	Abundant
	*Periscopsis elata (*Harms) van Meeuwen	16	0.66	Endangered
	Piptandeniastrum africanum Hook.f.	10	0.41	Endangered
	Dialium guineense Willd.	462	19.14	Abundant
Gentianaceae	*Anthocleista nobilis* G.Don.	6	0.25	Endangered
	Anthocleista vogelii (Planch.)	29	1.20	Rare
Guttiferae	*Garcinia kola* Heckel	6	0.25	Endangered
Irvingiaceae	*Irvingia gabonensis*	15	0.62	Endangered
Lamiaceae	*Vitex doniana*	15	0.62	Endangered
Lecythidaceae	*Napoleona imperialis* P.Beauv.	21	0.87	Endangered
Leguminosae	*Daniela ogea* (Harms) Rolfe ex Holland	2	0.08	Endangered
	Parkia bicolor A.Chev.	4	0.17	Endangered
	Pterocarpus osun Craib	18	0.75	Endangered
Loganiaceae	*Anthocleista djalonensis* A. Chev.	12	0.50	Endangered
Malvaceae	*Ceiba pentandra* L.	6	0.25	Endangered
	Cola nitida (Vent.) Schott. & Endl.	2	0.08	Endangered

Table 1 continued

Family	**Species**	**Species frequency**	**Relative density**	**Status**
	Hildegardia bateri (Mast.) Kosterm	3	0.12	Endangered
	Sterculia oblonga Mast.	8	0.33	Endangered
Meliaceae	*Khaya senegalensis* (Desr.) A. Juss	1	0.04	Endangered
	Ekerberga senegalensis A. Juss	6	0.25	Endangered
	Entandrophragma angolense Welw.	24	0.99	Endangered
	Entandrophragma utile Dawe & Sprague	2	0.08	Endangered
	Guarea cedrata A.chev.	2	0.08	Endangered
	Lovoa trichilioides Harms	27	1.12	Rare
	Pseudocedre lakotschyi (Schweinf) *Harms*	31	1.28	Rare
	*Trichilia prieuriana*A. Juss	7	0.29	Endangered
Moraceae	*Antiaris africana* Engl.	3	0.12	Endangered
	Ficus capensis Thumb.	5	0.21	Endangered
	Ficus mucuso Welw. Ex Ficalho	6	0.25	Endangered
	Ficus polita Vahl.	3	0.12	Endangered
	Milicia excelsa Welw.	19	0.79	Endangered
	Morus mesozygia Stapf.	1	0.04	Endangered
	Treculia africana Decene	3	0.12	Endangered
Myristicaceae	*Pycnanthus angolensis* (Welw). Warb	35	1.45	Rare
Myrtaceae	*Eucalyptus globulus*	2	0.08	Endangered
Ochinaceae	*Lophira lanceolata* Tiegh. Ex Keay	38	1.57	Rare
	Lophira alata Banks ex.	2	0.08	Endangered
Olacaceae	*Strombosia pustulata* Blume	24	0.99	Endangered
Passifloraceae	*Barteria fistulosa* (Mast.)	2	0.08	Endangered
Rhizophoraceae	*Rhizophora racemosa* GFW Mey	2	0.08	Endangered
Rubiacae	*Mitragyna inermis* (Wild.) O Ktze	11	0.46	Endangered
	Cantium gabrifolium	30	1.24	Rare
	Morinda lucida Benth.	1	0.04	Endangered
	Nauclea latifolia Smith	3	0.12	Endangered
	Pyrostria guinnensis Comm. ex A. Juss	99	4.10	Frequent
Rutaceae	*Zanthoxylum zanthoxyloides* Lam.	3	0.12	Endangered
Sapindaceae	*Allophylus africanus* P.beauv.	23	0.95	Endangered
	Lecaniodiscus cupanioides Planch.	35	1.45	Rare
Sapotaceae	*Malacantha alnifolia* (Baker) Pierre	4	0.17	Endangered
Sterculiaceae	*Pterygota macrocarpa* K. Schum	1	0.04	Endangered
	Sterculia rhinopetela K.Schum.	5	0.21	Endangered
	Cola millenii K. Schum.	29	1.20	Rare
	Sterculia tragacantha Lindl.	66	2.73	Rare
Ulmaceae	*Celtis mildbraedii* Engl.	9	0.37	Endangered
Urticaceae	*Musanga cecropoides R.Br.*	8	0.33	Endangered
Verbenaceae	*Gmelina arborea* Roxb.	8	0.33	Endangered
Violaceae	*Rinorea dentate* Kuntze	5	0.21	Endangered

3.2 Tree species diversity indices and family composition

The summary results of tree species diversity indices for the study area are presented in **Table 2**. The total number of species recorded was 102, with Shannon-Wiener's diversity index (H') value of 3.67, Inverse Simpson's index (C) value of 1.06, species evenness value of 0.79 and Margalef's index of species richness (M) of 12.97. The family composition results for the study site are presented in **Figure 2**. The result revealed that the family Fabaceae had the highest number (1037) of individual tree observations, representing the 43% of the total observation in the study area. This was followed by the families: Euphorbiaceae, Apocynaceae, Rubiacae, Sterculiaceae, Meliaceae with 221,159, 144,101 and 100 respectively; with the total number of trees signifying 9.2%, 6.6%, 6.0%, 4.1% and 4.2% of the total observation. Burseraceae family had the lowest number of observations (1) and was followed by Myrtaceae (2), Passifloraceae (2), Rhizophoraceae (2) and Rutaceae (3).

Table 2. Biodiversity indices.

Indices	Values
No. of species	102
No. of family	36
Shannon (H')	3.67
Simpson (1/D)	1.06
Evenness (E)	0.79
Richness (M)	12.97

The number of stem occurrences decreased from the least diameter class (< 20 cm; dbh) to the highest diameter class of > 60 cm. Thus, lower stem sizes had a higher number of tree occurrences than the higher stem sizes (**Figure 3**).

3.3 Influence of edaphic variables

PCA analysis used Varimax with Kaiser Normalization and recorded 22 components. Among these, 7 components with a higher % of variance were extracted; recording 82.019 cumulative %. Results from the PCA (as seen in **Table 3**) showed the variables that had significant loadings and hence, had more influence on the vegetation.

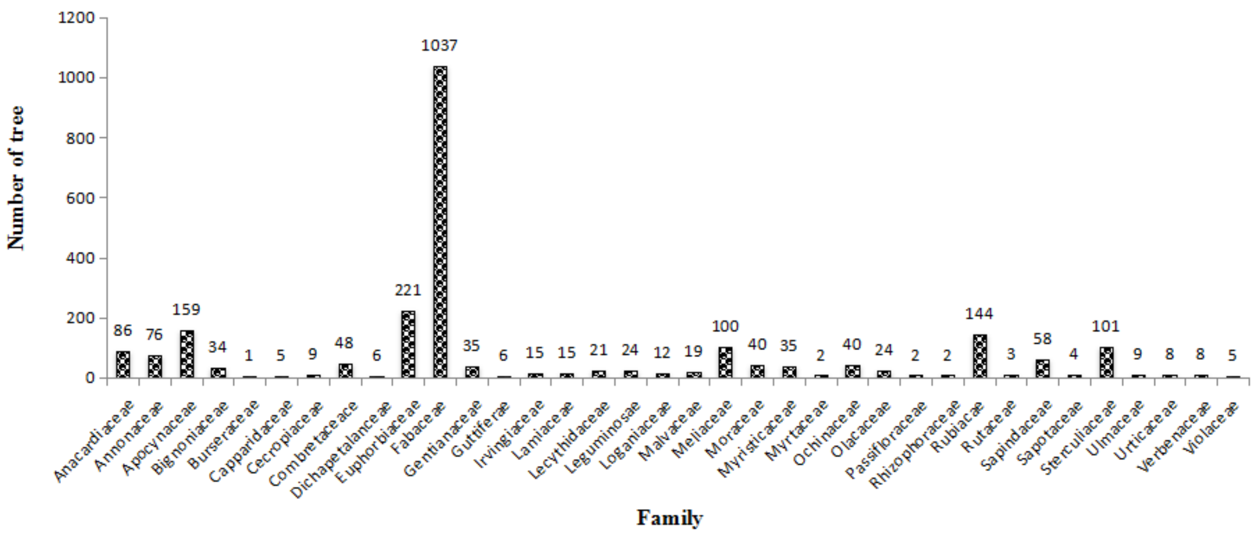

Figure 2. Frequency of trees distributed in various families was recorded in the study area.

Based on the significant level set, the following parameters were elicited: pH (0.775), magnesium ppm (0.930), magnesium cmolkg (0.927) for component 1, potassium ppm (0.925), potassium cmolkg (0.925) and CEC cmolkg (0.872) for component 2, % sand (0.917) and % silt (0.904) for component 3, phosphorus abs (0.935) and phosphorus conc (0.935) for component 4, calcium ppm (0.890) and calcium cmolkg (0.891) for component 5, aluminium ppm (0.64) for component 6 and % clay (0.793) for component 7.

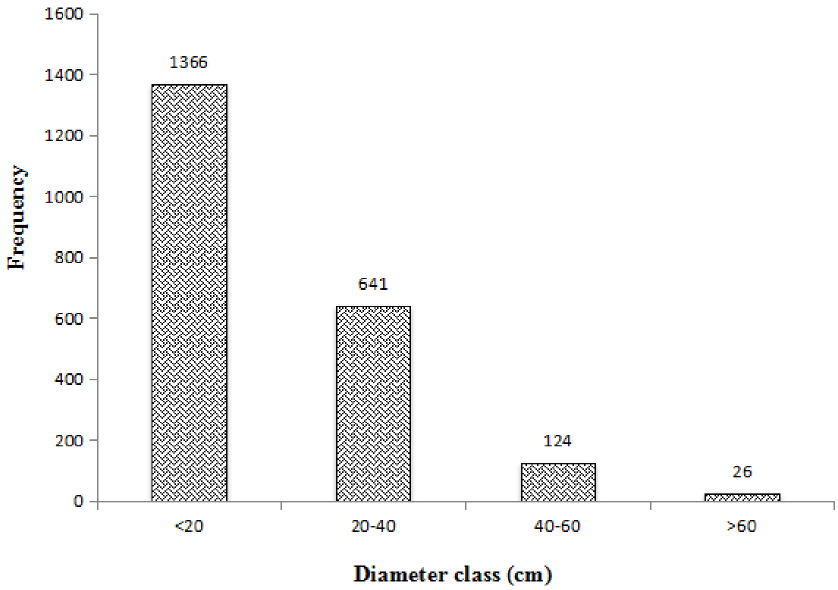

Figure 3. Frequency of stem distribution according to the diameter classes.

Table 3. Rotated component matrix.

Variable tested	**Component**						
	1	2	3	4	5	6	7
pH	0.775*	–0.147	0.361	0.034	–0.072	–0.071	0.104
Chloride mg/kg	0.390	0.230	0.522	–0.342	0.090	0.314	–0.167
Phosphorus (abs)	0.089	0.001	0.067	0.935*	0.259	–0.047	0.056
Phosphorus (conc)	0.095	–0.009	0.059	0.935*	0.255	–0.059	0.063
Magnesium ppm	0.930*	–0.157	–0.056	0.094	–0.145	–0.139	–0.071
Sodium ppm	0.153	–0.119	–0.189	0.390	0.420	0.054	–0.533
Manganese ppm	0.068	0.095	–0.367	0.025	–0.241	–0.649	0.336
Iron ppm	0.385	0.062	–0.239	–0.039	0.059	–0.565	0.035
Potassium ppm	–0.346	0.925*	–0.013	–0.034	–0.047	–0.035	0.065
Calcium ppm	–0.185	0.160	0.040	0.282	0.890*	–0.053	0.092
Aluminum ppm	0.132	0.022	–0.243	–0.157	0.010	0.647*	0.004
Calcium cmol/kg	–0.183	0.151	0.042	0.285	0.891*	–0.056	0.091
magnesiumcmol/kg	0.927*	–0.169	–0.052	0.097	–0.148	–0.142	–0.076
Potassium cmol/kg	–0.345	0.925*	–0.014	–0.034	–0.043	–0.033	0.067
CEC cmol/kg	0.047	0.872*	–0.016	0.165	0.334	–0.139	0.069
% Nitrogen	0.111	0.523	0.481	–0.269	0.157	0.325	0.177
% sand	–0.013	0.005	0.917*	0.100	–0.088	–0.060	–0.264
% Clay	0.149	0.028	–0.373	–0.043	0.295	0.091	0.793*
% Silt	–0.069	–0.026	–0.904*	–0.098	–0.078	0.013	–0.157

*significant loading ≥ 0.6.

4. Discussion

Tropical forest ecosystems host at least two-thirds of the world's biodiversity [20] and are reckoned as hotspots for biodiversity. Hence, as expected, the region under review recorded an ample amount of distinct species across the ecosystem as seen in tropical landscapes. While this is broadly the case, other site indices such as biogeography and management affected the stand structure in each region. 168 stems to 484 stems per hectare were recorded across the region. This is similar to that of other tropical zones such as 428 stems per hectare in a rainforest in China [21], 434 stems in a mixed tropical forest and 340 stems in a monodominant forest, both across Africa [22]. Variations in the stand structure of the ecosystem differed across the region based on its (local) biogeography and how the forest landscapes were managed. Disturbance arising from natural (such as windbreaks, floods and tree falls) and anthropogenic impacts (selective logging, unsustainable use of forest resources) affects tropical ecosystems greatly and affects not only the stand structure of the ecosystems, but furthermore its forest cover and density. While the biodiversity found in forest locations could differ also according to the biogeography of the landscapes, other factors such as the history of species dominance and dispersal patterns, determines largely its species composition at local scales. The total number of stems per family was hence much varied across the ecosystem; ranging from 1037 stems to 1 stem per family across the ecosystem (**Figure 3**). Dominant biodiversity has a higher chance of remaining the major biodiversity features of (relatively) undisturbed natural ecosystems; since they have already colonized the landscape. This will however change when there are disruptions emanating from disturbances, forest health or alien species impacts.

Biodiversity attributes of the ecosystem were generally similar to tropical landscapes. Species diversity: Shannon index (3.67) and inverse Simpson's index (1.06), and evenness (0.79) (**Table 2**) showed that the species were much varied and properly distributed accordingly. Much of this diverse ecosystem (with as many as 102 species and a richness index of 12.97) was dominated by families (**Figure 2**) that occur in other landscapes and ecosystems. Fabaceae (which is the most diverse and abundant) is adjudged to be the largest to third largest of the angiosperms and consists of between 650-770 genera and 18,000 to more than 19,500 species [23-25]. With a wider geographical range in a broader range of habitats, it can grow in all ecosystems and could be much more diverse as seen in the ecosystem; depending on how favourable or constraining the environmental features in the local area are. Similarly, other families that are much or less diverse, had varied geographical ranges as a result of the local factors in the ecosystem. As Fabaceae species distributions are known to be strongly related to the soil, other groups of plants (at species, genus and family levels) are inherently determined by similar factors such as the topography and edaphic factors; depending on their scale [26]. Other diverse families such as Euphorbiaceae, Apocynaceae, Rubiacae, Sterculiaceae, Meliaceae and least diverse ones such as Burseraceae, Myrtaceae, Passifloraceae, Rhizophoraceae and Rutaceae were all enhanced and restricted, respectively, according to the environmental factors inherent in the region.

Edaphic factors influence tree distributions and growth, and are useful for delimiting biogeographical zones and biomes. Among such factors, soil chemistry, soil texture and topography, are quite notable and have strong and deterministic effects on community composition [27]. Soil variables were seen to influence the vegetation of the zone and delimited the region into 7 units (components) (**Table 3**). Notably, phosphorus, magnesium, potassium, particle sizes (sand, silt and clay), CEC, calcium, pH, and aluminium, influenced the distribution of the vegetation in decreasing order and contributed to the growth of the plants mostly. Growth of necessary nutrients (such as phosphorus, magnesium and potassium), pH, CEC and particle sizes (which influences the biogeochemical and hydrological cycles), and possibly toxic element like aluminium [28], all contributed (to promoting or constraining) the growth and distribution of the species across the region. Soil nutrient contributes much to the growth of biodiversity in such landscapes and determines (through its quality) how luxuriant an ecosystem could be. It equally influences tree height, basal area and in turn, the composition of plants and their community features [29].

5. Conclusions

The ecosystem had synonymous attributes of tropical ecosystems, as seen in its species richness and diversity. Stand structure, tree densities and tree dominance of species and families were equally varied and differed across the ecosystem. Environmental factors, notably the edaphic factors determined the growth, tree distribution and plant community delimitations. Efforts to ensure that biodiversity, relative densities and status of the trees are improved and preserved are advocated in a bid to ensure ecosystem conservation.

Author Contributions

Nwabueze Igu designed the study. Both Nwabueze Igu and Jacinta Ezenwenyi conducted the fieldwork and writing of the manuscript.

Conflict of Interest

The authors declare that there is no conflict of interest.

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