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Research Article

Tree Species Diversity and Dominance in relation to Soil properties in University of Uyo Arboretum

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Abstract

Effects of nutrient variation on the abundance and distribution of tree species in University of Uyo Arboretum was investigated. Systematic sampling method was used in sampling soil and vegetation parameters. A total of eight (8) soil samples were obtained at two soil derpths (0 – 15cm and 15 – 30 cm) from four plots. The result revealed that six (6) species from 5 families viz :Lamiaceae, Fabaceace, Urticaceae, Moraceae, and Rubiaceae. *Nauclea diderrichii* (12.66m) was the tallest species while *Tectona grandis* (6.12m) was the shortest species. Dominance index ranged from 0.654 to 0.347. Also, Shannon and Simpson diversity indices ranged from 1.079 to 0.529 and 0.653 to 0.345 respectively. Correlation analysis indicated that soil pH significantly (P>0.05) influenced species dominance while silt and available phosphorus significantly (P>0.05) influenced tree species diversity indices in the forest. These results further confirm the notions that pedological indices and nutrient status of soil play critical roles in plant species distribution and vegetation morphology in natural ecosystems. The information obtained in this research could be useful in management of indigenous forest ecosystems.

1. Introduction

Forest is an important earth's natural resource and a driver of several ecosystem processes including nutrient

storage and recycling, air purification, wildlife habitat etc. Hence, Information on forest structure is an essential component for sustainable forest management planning. The value and importance of forest structure is very crucial especially when considering tropical rainforests which contain trees which can reach reasonable heights and diameters (Onyekwelu, Biber and Stimm 2003 [1]). Different researchers have shown that the forests together with the biotic and abiotic community it's supports structures play many essential roles in the ecosystem functioning thus it is necessary to investigate the influence of different plant communities on soil and vice versa because it will provide the necessary ecological data which will be used to generate better conservation and resource management decisions. In previous studies, it is quite indicative that there is an inevitable relationship existing between plant species abundance and the physico-chemical and nutrient properties of soil in many areas (Adekunle 2004 [2] ; Ubom, 2006 [3] ; Anwana 2018 [4]). This is so because soil contains nutrients that are required by plants to grow (Verma and Verma, 2007 [5]). Investigation on abiotic factors of an ecosystem such as the arboretum is therefore important because it will elucidate the possible limiting factors in the soil controlling tree species diversity and abundance. Specifically, it is worthy to know which soil properties presently are consistent with the tree species diversity and dominance pattern found in University of Uyo Aboretum.

Concurrently, as efforts are being intensified globally towards preventing utter destruction of the patches of the remnant or regenerated tropical rainforest and ensuring the conservation of its rich biodiversity, the need for adequate quantitative and qualitative ecological data on tree species diversity becomes imperative as this is needed for molding out realistic and effective conservation strategies to be used within and between native forests or similar ecosystems. This form the pivot of this research.

2. Method of Study

2.1 Study area

This study is carried out within the vicinity of The Department of Forestry and Wildlife Conservation Aboretum which is situated within University of Uyo Town campus Annex (Latitude 5 $^{0}23^{1}$ 90 ^{11} and Longitude 7^{0} 55^{1} 59 ^{11}). Uyo Local Government Area lies between longitudes 7° $55^{'}$ $21^{''}$ E and latitudes 4° $52^{'}$ $35^{''}$ N and is the capital of Akwa Ibom State which falls within the Niger-delta region of Nigeria. The major seasons in Uyo are the dry and wet seasons. Most specifically, the dry season spans mid-November to March whereas the wet season begins around April to October. The climate of the area favours luxuriant tropical rain forest which harbor large population of Fauna. The soil is fertile and so supports a wide range of subsistence and commercial agricultural practices (AKSG 2008 [6])

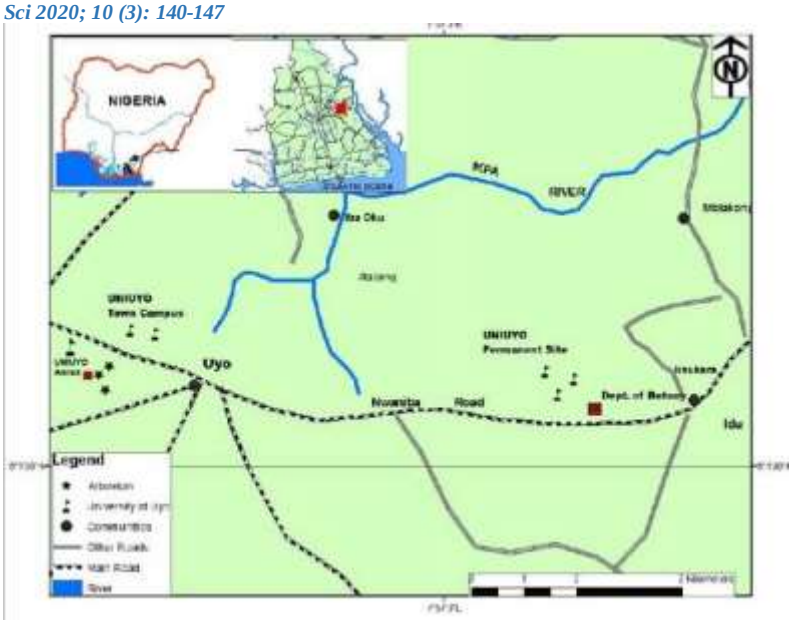

Figure 1: Map of University of Uyo Town Campus Annex showing study Area (Arboretum).

2.2 Vegetation and soil sampling

Sampling was done by transects (plots). Each plots contained four quadrats. Species were sampled in 10m x 10m quadrats, spaced at regular intervals of 20m according to the methods of (Knight 1978 [7]) In each quadrat, plants were enumerated and species were properly identified to the species level. Voucher specimens of unknown species were collected for proper identification at the Botany and Ecological Studies Departmental Hebarium, University of Uyo, Akwa Ibom State. Height of the plant species encountered were determined using Hagar altimeter according to the methods of (Ubom *et al.*, 2012 [8]). Also within each quadrat, Two soil samples were obtained at the depths of 0- 15 cm respectively which was later bulked to form a composite sample according to (Mbong and Ogbemudia 2013 [9]). The soil samples were air- dried and preserved for laboratory analysis. Soil pH and Electrical conductivity were determined using Hanna hand held multimeter. Total nitrogen was determined by Micro-Kjedahl method, Available phosphorus was determined using Bray No. 1 method while Exchangeable Ca and K was determined using Flame photometry (Adepetu 1984 [10]). Organic matter was determined using the Walkey-Black method (Black 1965 [11]). Particle size distribution was determined using hydrometer method. ECEC and Base saturation were computed according to the methods of (Ubom 2006 [3]).

2.3 Statistical data analysis

Mean and standard error were computed from three replicates of soil physico-chemical properties. Analysis of variance (ANOVA) and Fisher least significant different (LSD) test were employed to ascertain significant differences between the means of the physicochemical properties of the studied soils. The relationships between soil variables and vegetation variables within the study area were established by multivariate correlation technique using Statistical Package for Social Sciences (SPSS, Version 18.0). Species diversity indices such as Shannon-Wiener, Simpson, Dominance, were used to assess plant species population in the arboretum using Paleontological software (PAST 3).

3. Results

3.1 Tree species composition of university of uyo, arboretum by families

The floristic composition in the arboretum (Table 1) revealed a diversity of six (6) woody species belonging to five (5) plant families Lamiaceae, Fabaceae, Urticaceae, Moraceae, Lamiaceae and Rubiaceae. *Tectona grandis* had the highest number of stems (11) while *Treculia africana* and *Musanga cecropiodes* had the least number of stems (1 stem each).The tallest plant species was *Nauclea diderrichii* (12.66m) while *Tectona grandis* was the shortest species with height of 6.12m.

Species	Family	Number of stems	Height (m)
Gmelina arborea	Lamiaceae	6	7.71±3.82
Acacia auriculiformis	Fabaceae	2	8.15±2.90
Musanga cecropiodes	Urticaceae	1	6.00±0.00
Treculia Africana	Moraceae	1	7.00±0.00
Tectona grandis	Lamiaceae	11	6.12±3.90
Nauclea diderrichii	Rubiaceae	3	12.66±0.70

Table 1: Tree species composition of University of Uyo Arboretum by families.

3.2 Species dominance and diversity in the Aboretum

Trees population in the arboretum as shown by table 2 indicates that the highest number of individuals was in plot 4 (9 individuals) while the least was in plot 1(4 individuals). Dominance value was highest in plot 4 (0.654) but least in plot 3 (0.347). Also, Shannon and Simpson diversity was highest in plot 3 (1.079 and 0.653 respectively) but least in plot 4 (0.529 and 0.345 respectively).

	Plot 1	Plot 2	Plot 3	Plot 4
Individuals	4	5	7	9
Dominance	0.375	0.440	0.3469	0.6543
Shannon	1.041	0.950	1.079	0.5297
Simpson	0.6250	0.5600	0.6531	0.3457

Table 2: Tree species Dominance / Diversity by Plots in University of Uyo Arboretum.

3.3 Soil-vegetation relationships in the Arboretum

Table 3 also indicates the influence of soil properties on the dominance and diversity of tree species by plots in the arboretum. It shows that Shannon-weinner index (0.921*) and Simpson index (0.943*) significantly and positively correlated with silt particles. Again, Shannon-weinner index (0.957*) correlated significantly and positively with soil Available phosphorus. Similarly, there is a significant positive correlation (0.653*) between species dominance and pH.

	Dominance	**Shannon**	**Simpson**
Sand	.238	-.227	-.238
Silt	-.943	**.921***	**.943***
Clay	-.308	.245	.308
pH	**.653***	-.689	-.653
Electrical conductivity	-.104	.138	.104
Organic matter	-.089	.142	.088
Total N	-.201	.257	.201
Available P	-.941	**.957***	.941
Ca	-.315	.289	.314
Mg	-.177	.154	.177
Na	.572	-.562	-.573
K	-.260	.194	.259
Exchange Acidity	-.924	.897	.924
ECEC	-.372	.345	.372
Base saturation	.070	-.087	-.070

*Significant coefficients at 0.05

Table 3: Influence of soil properties on species Dominance/Diversity Indices.

4. Discussion

The vegetation attributes of the arboretum showed variations and much heterogeneity in terms of species composition, floristic attributes and numeric distributions. These variations relate to the fact that plant species adapt differently to changes in topographic, anthropogenic and edaphic factors in their environment (Ubom 1992 [12]). (Santamaria 2002 [13]) authenticated that spatial distribution of safe sites (microsites) can often determine where seed establishment occurs, thereby strongly influencing plant colonization and successional patterns. Hence, efficient reproductive strategies and good dispersal capabilities are the two factors which could explain the gap in number of individuals of tree species found in the study area. Also another possible explanation for this could be selective exploitation of highly priced tree species such as *Gmelina arborea* which is largely used in paper making industries. Similar to this observation is the findings of (Christie and Armesto 2003 [14]).

The variations in height of tree species in the reserve indicate a true reflection of the different levels of biomass production, age of species and levels of trees exploitation in the area. The presence of high profile economic trees such *Gmelina arborea, Tectona grandis* and *Musanga cecropioides* is suggestive of the fact that the arboretum is a secondary forest which enjoys a reasonable level of human impact. This view is in synchrony with the earlier report of (Ubom, Ogbemudia and Ita 2012 [15]). The dominance of *Gmelina arborea* and *Tectona grandis* in the study area invariably point to the suitability of the soil conditions which favoured the high frequencies of establishment of these species.

Also it portends their inherent ability to adapt persistently with high ecological tolerance. On the contrary, the low density values of tree species such as *Treculia africana and Nauclea diderrichii* signals their inability to adapt fully to the inherent factors such as soil nutrient status, intense exploitation, slow regeneration rates etc which may be precurssor to their growth and distribution patterns. This view is in consonance with the findings of (Wassie and Teketey 2006 [16]).

Shannon-Weinner and Simpson diversity indices recorded in this result is generally low when compared with other studies (Adekunle 2004 [2]). (Sharma and Joshi, (2003) [17]) in a related study recorded a major decline in diversity status and vegetation composition and structure of forest due to human settlement, timber harvesting, agriculture and developmental activities. In line with this observation, the low diversity status could be linked with anthropogenic disturbances.

Correlation techniques are often used to examine the strength of the relationship between two variables that may be unevenly distributed over an area (Dalton, 1972 [18]). The correlations between vegetation and soil variables were used to assess the nature of these relationships and to identify the key soil variables that strongly influenced the vegetation. The current result furnishes evidences showing significant soil-plant relationships in arboretum. Positive relationship between pH and dominance is well understood in keeping with the views of (Gould and Walker, 1999 [19]) that pH determine to a large extent the accessibility of soil nutrients to plants. Positive correlation between silt and species diversity indices indicates that both parameters vary together. This pattern shows that the different tree species in the arboretum show preference for silty substrate and this could be due to high water retension ability associated with this particle size class (Mbong, 2013 [20]). Also significant positive correlation between plot based Shannon diversity indexand available phosphorus is not unprecedented since phosphorus play vital roles in plant metabolic processes such as chlorophyll formation, fruit formation, healthy roots growth etc (Verma and Verma, 2007 [5]).

5. Conclusion

An investigation on physical factors of an ecosystem is necessary to elucidate the possible limiting or enhancement factors controlling plant species abundance. It is important to know whether the soil properties or nutrient variation is consistent with the floristic variables in the ecosystems. This result concludes that soil forms part of the constellation of factors affecting vegetation physiognomy and vice versa and that it is necessary to assess the influence of soil properties on vegetation in controlled and natural ecosystems. The current research has shown that the flora of the arboretum is a blend of different economical and significant timber species such as *Gmelina arborea*, *Musanga cecropiodes*, *Nauclea diderrichii*, *Tectona grandis* etc. It reveals that the forest is low in species diversity and high in species dominance compared to other forest ecosystems. The result has also confirmed that there is a relationship existing between soil nutrient status and its floral components (diversity and dominance). From the results the most valuable soil factors affecting diversity and dominance are silt, pH and available phosphorus. The information obtained in this result is expected to serve as a baseline data for other ecological studies and conservation activities within and between native forests.

Recommendation

- Upon the findings of this research, the following is recommended:
- Valuable researches on the mechanism of adaptability of the dominant species in the arboretum should be conducted.
- Selective exploitation of most abundant tree species and conservation of rare species.
- Soil conservation practices such as mulching and organic manuring should be carried out in order to improve nutrient status of the arboretum.

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