EVALUATION OF TREES SPECIES DIVERSITY, ABUNDANCE AND SOIL PHYSICOCHEMICAL PROPERTIES OF UKPON RIVER FOREST RESERVES, CROSS RIVER, NIGERIA.

Abstract

Current status of species diversity, composition and abundance provides guidance for their management and assessment of their ecological usefulness. In this study trees species diversity, abundance and soil properties of Ukpon River Forest Reserve was assessed. Line transect method was using to establish 4 sample plots of 50 x 50 m. Data on vegetation were collected using the appropriate tool and soil samples from the plot were collected with the aid of soil auger. Tree species composition, abundance and diversity indices were estimated using the appropriate formulae and soil samples analyzed following standard methods. A total of 194 individuals in 60 species belonging to 26 families were encountered in the study area. The dominant families are Leguminaceae, Moraceae, Fabaceae, Burseraceae, Apocynaceae, Calsalpinaceace and Euphorbiaceae. The total basal area estimated for tree species was 147.615m^2 with *Bombax bounpozen* having the highest of 11.09m^2 and relative dominance (RDo) of 7.51% while *Piptadeniastrum africana* has the highest relative density (RD) of 7.73% and importance value index (IMI) of 15.63%. Based on their relative density, 68.34% of the trees were Rare, 18.33% Threatened or Endangered, 5% Abundant/ Occasional and 3.33% Frequent. The study had a high Shannon – Weiner index value of 3.04 and Margalef richness of 20.67 and low dominance index of 0.06. The soil properties such as Clay, Organic matter, Phosphorus, Calcium, Cation Exchangeable capacity and Base Saturation were high. The pH value of 5.77 shows the soil were moderately acidic. These properties have been shown to improve soil fertility status and moisture content needed plant growth. Although the tree species diversity in the study area was high, some species appears to have been threatened while majority were rare, sustainable conservation effort should be geared towards ensuring their continuous existence.

Keywords: Tree species, abundance, diversity indices, soil properties, Forest Reserve

Introduction

The tropical rainforest has been identified as the most biologically diverse and complex terrestrial ecosystem on earth (FAO 2010; IUCN 2010; Gebreselasse, 2011). This high species diversity is partly responsible for the intense pressure under which rainforests are subjected to the effects of forest degradation and deforestation. Forest degradation is usually accompanied by species extinction, reduction in biodiversity, and decrease in primary productivity. About ten million hectares of rainforests are degraded annually worldwide and according to WRM (1999) 200,000 hectares of rainforest in Cameroon and Nigeria are degraded annually, with over 40 trees and wildlife species being threatened with extinction. The Nigerian rainforest ecosystems occupy only 9.7% of the country's land mass of 983,213 km^2 but it is the most densely populated and source of the bulk of Nigeria's timber (FAO 2010). The acceptance of Nigerian timber species in the international market in the early 20th century, coupled with rising domestic demand, led to the situation where exploitations became unregulated. This led to serious forest degradation that left less than 5% of the country's rainforest ecosystems as undisturbed (Gillespie *et al.*, 2004). Global forest resources assessment revealed Nigeria as one of the five countries in the world with the highest annual rate of deforestation for the period 2000 –2010 (FRA, 2010).

According to Adekunle et al., (2010), 111,377 timber stems, belonging to 62 indigenous hardwood species in 16 families of tropical rainforest ecosystem were exploited from Ondo State forest ecosystem between 2003 and 2005. Maliyat and Datt (2010) reported that the expansion of anthropogenic activities is also responsible for overexploitation of natural resources, and this has subsequently disturbed the delicate equilibrium that exists between living organisms and their environment. Many rainforests are severely threatened and persist as forest fragments leading to a reduction in species richness, thereby resulting in biodiversity loss and establishment of Forest Reserves. Forest Reserve is one of the in-situ methods of conservation that are required to restrict human activities and degradation of the forest. The process of biodiversity in protected areas begins with the assessment of the status of species composition and abundance. According to USAID/ Nigeria (2008) the problem is lack of documented data on the status in the country which have caused the loss of some plant species and a decline in the biodiversity conservation status of the forest and its environmental quality.

Due to unprecedented increase in human population over the years, trees species have undergone different levels of disturbance which has adversely impacted on their abundance, composition, diversity and conservation (Omoro *et al.*, 2010). Species composition and abundance will provide guidance for their management and valuable reference for assessment as well as improve our knowledge in identification of ecologically useful species (Suratman, 2012). Higher numbers of species increases the number of ecological niches as well as the numbers of associated species (Kanowski *et al*., 2003). According to Adeyemi *et al.* (2015) 125 tree species belonging to 36 families and 96 genera were recorded in the area with Margalef's index of species richness of 2.2754 and almost (99) of the tree species encountered were threatened/endangered. High trees species composition in Okwango forest, Cross River, Nigeria with dominant species to include *Terminalia ivorensis, Pterocarpus soyauxii*, *Melicia excelsa*, *Bailonella toxisperma* and *Afzelia bipindensis*. Edet *et al.* (2011) reported a total of 102 species belonging to 35 families in Afi Mountain Wildlife Sanctuary. Most tropical forest is characterized by abundance of trees with small diameter at breath high (dbh). Jimoh *et al* (2012) noted that Oban Division of Cross River National Park was characterized by dominance of tree species in lower diameter classes. Ogwu *et al*. (2016) recorded 214 individual of 20 trees species from 12 families with Arecaceae and Fabaceae as the most abundant in Ugbowo, Benin City, Nigeria. Two hundred and ten (210) trees distributed among 54 species in 25 families with Fabeceae and Euphorbiaceae as the most

dominant enumerated in Akure Forest Reserve, Nigeria (Akindele *et al*., 2021). Iheyen *et al*. (2009) reported Fabaceae family as the most abundant in Ehor Forest Reserve.

The relationships between vegetation and fertility are closely linked to the quality and quantity of litter and soil organic matter (Maro *et al.,* 1991). According to Van Bremen (1993) organisms appear to affect soil fertility, soil moisture content and other soil properties in such a way that the substrate becomes more favorable for the growth of plants and soil organisms with time. Availability of soil moisture availability has been reported to be the main factors affecting habitat associations of tropical trees, shrubs and herbs (Chuturvedi and Raghubanshi 2018). Studies on the relationship between species diversity and soil physicochemical properties of soil are the basis of community ecology and biodiversity conservation and management (Peng *et al*., 2015). Nirmat-Kumar *et al.,* (2010) investigated nutrients content in different sites of an Indian rainforest and found that there was a strong positive relationship between tree species richness and the concentration of nitrogen, phosphorus and organic carbon. In Cross River past researches on Forest Reserves have focus more on assessing tree species diversity, abundance and composition ignoring its relationship with soil properties (Edet *et al*., 2012; Jimoh *et al*., 2012; Adeyemi *et al*., 2015). Akindele et al., (2021) stated that Potassium, Cation Exchangeable Capacity, Sodium, Phosphorus, Clay and pH were fundamental soil properties that determine the quality and diversity of trees species in Akure Forest Reserve.

Trees are important in ecosystem as the provide species conservation, prevention of forest soil erosion and habitat for animals (Armenteras et al 2009). Overexploitation has led to rapid loss of trees diversity which is the major environmental and economic problem worldwide (Mani and Parthasarathy, 2006). Sustainable management and use of forest resources is essential for the nation's economic and environmental security (Akinsanmi, 1999). The need to provide adequate quantitative and qualitative ecological information to guide forest owners and managers in providing realistic and effective management strategies in protected areas is imperative. There is still insufficient information on trees species diversity, abundance and the physicochemical properties of Ukpon River Forest Reserve. Therefore, this study is aimed to determine the trees species diversity, abundance and physicochemical status of Ukpon River Forest Reserve.

Materials and Methods

Study Area

The study was carried out at the Ukpon River Forest Reserve located on latitude 5^0 78' – 5^0 46' N and longitude 8^o 32' – 8^0 19' E. The Reserve which is located in Obubra L.G.A has a total area of 12,950 hectares and is managed by the Cross River State Forestry Commission. The mean annual rainfall ranges from 2400 – 4000mm and is fairly distributed throughout the months of April to October with an annual temperature range of 27.6 - 33.1^{o}C. The Reserve lies within the lowland rainforest with fresh water swamp at the fringes of Ukpon River and Derived Savannah north of the Reserve with heterogeneous in floristic composition. The topography varies from undulating land on the south and southwestern parts to rugged and hilly land on the North and Northeastern part of the Forest reserve. The main occupation of the communities around the Forest Reserve is farming, hunting and lumbering.

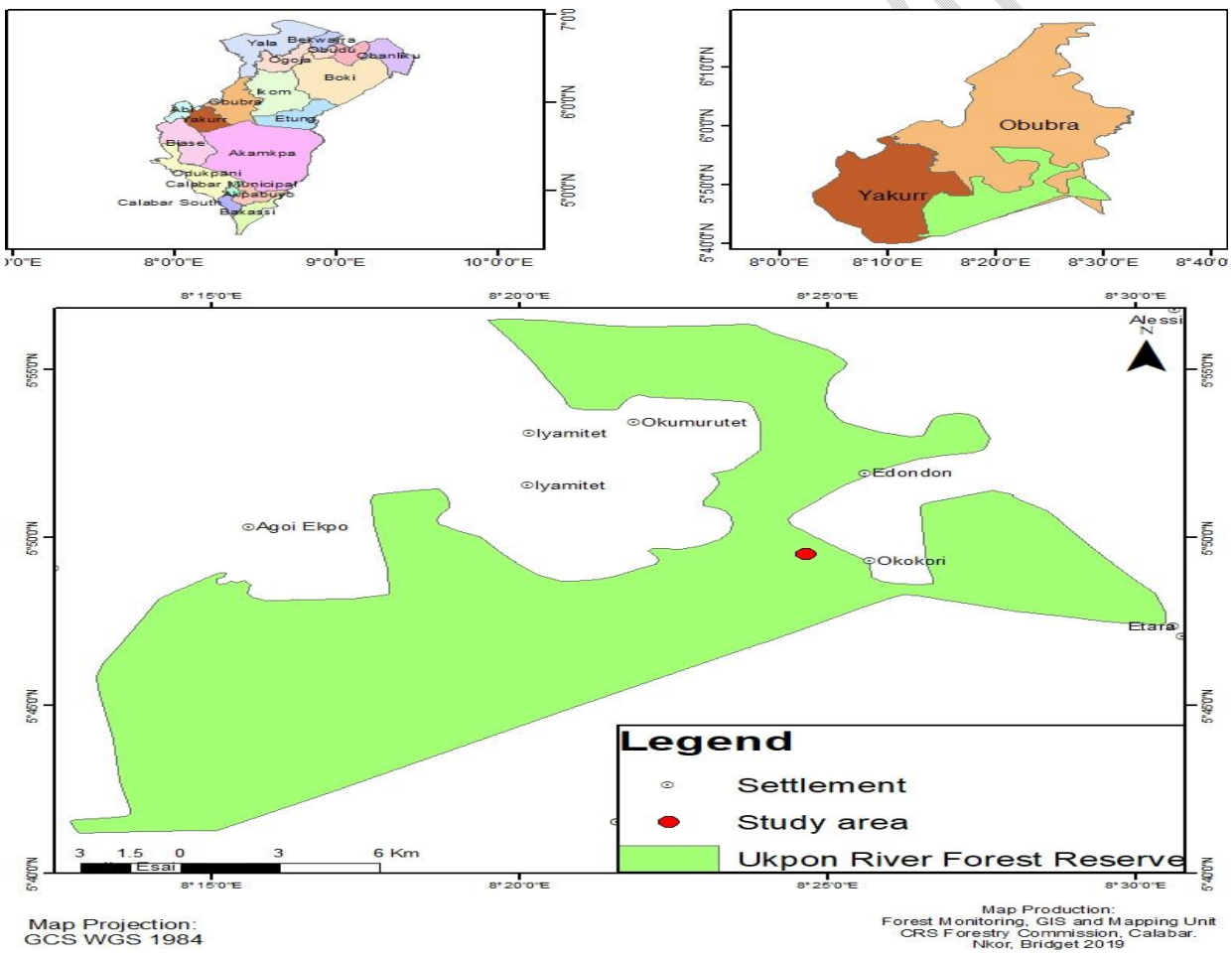

Figure 1: Map of Cross River State showing the location of the Forest Reserve

Method of sampling and data collection

A random sampling Techniques was used to established 4 Temporary Sample plots of 50m x 50m in using a systematic line transect method according to Akindele *et al*. (2021). A total of 12 samples, 4 from each sample plot were collected for soil analysis. Global Positioning System (GPS) was used to locate the sample plots.

All trees species on each sample plot were tagged, measured, identifies and classified into families. The number and scientific names of all the tree species encountered in each plot were recorded. Leaves of trees not identified on the field were collected and taken to the herbarium for proper identification using botanical identification manual (Okpeke, 1987). Tree growth variables such as diameter at breast height (DBH) ≥ 10 cm and the total height was measured using Spiegel relaskop.

Diameter at breast height (DBH) and Height (H) were used to calculate Basal Area, Frequency, Relative Frequency, Relative Density, Relative Dominance, and Importance Value Index (IVI) according to Ogwu et al (2016)

$$Basal\ Area\ (BA) = \frac{\pi D^2}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where D = Diameter at breast height (cm) and π = Pie (3.142)

Where; $$Frequency = \frac{\text{No of quadrat in which species occurred}}{\text{Total No of quadrat studied}} \text{ x } 100 \quad \ldots\ldots\ldots\ldots (2)$$

$$Relative\ Frequency = \frac{Frequency \text{ of occurrence of species}}{\text{Total frequency of occurrence of all species}} \text{ x } 100 \quad \ldots\ldots\ldots (3)$$

$$Relative\ density = \frac{No\ of\ individual\ species}{\text{Total No of individual of all species}} \text{ x } 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$Relative\ Dominance = \frac{Total\ basal\ area \text{ of a species}}{\text{Total basal area of all species}} \text{ x } 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$\text{Relative abundance} = \frac{\text{Relative Density (RD)}}{100} \quad \ldots\ldots\ldots\ldots\ldots (6)$$

The various trees species were classified according to their relative densities (RD) as abundant (RD ≥ 5.00), Frequent (4.00 ≤ RD ≥ 4.99), occasional (3.00 ≤ RD ≥ 3.99), rare (1.00 ≤ RD ≥ 2.99) and threatened (0.00 < RD ≥ 1.00) according to Ogwu et al (2016)

Importance Value Index (IVI) $= \frac{\text{RD + RF + RDo}}{\ldots\ldots\ldots\ldots\ldots\ldots} (7)$

Where RD = Relative Density; RF = Relative Frequency, RDo = Relative Dominance (Panwar and Bhardwaj, 2012)

Species diversity index was calculated using Shannon-Weiner diversity index

$$H' = -\sum_{i=1}^{s} Pi \ln(Pi) \quad \text{..... (8)}$$

Where H'= the Shannon-Wiener index

pi= the proportion of individuals belonging to species i

ln=the natural log (i.e., 2.718)

Margalef species richness index (D) used to measure the species richness according to Margalef (1948)

$$D = \frac{(S-1)}{\ln N} \quad \text{..... (9)}$$

Where S = Number of species and N = Number of individuals

The species Evenness (E_H): Shannon's equitability equation was adopted to obtain the species evenness in each plot (Kent and Coker, 1992).

$$E_H = \frac{H'}{H_{max}} = \sum_{i=1}^{s} P_i \, In(P_i) \div In(S) \quad \text{.....(10)}$$

Physicochemical Properties Analysis

Soil samples at the depths of 0 – 15cm, 15 – 30cm and 30 – 45cm were collected along the diagonal using the soil auger according to Akindele et al. (2021). The samples collected within each sample plot and depth were bulked together and air dried, sieved with a 2mm net and transferred to the laboratory for physicochemical analyses. The selected soil properties investigated were sand, clay, silt, phosphorus, calcium, magnesium, potassium, aluminum, sodium, pH, total nitrogen, organic carbon, organic matter, exchangeable cation capacity (ECC) exchangeable acidity (EA), electric conductivity (EC), base saturation (BS) and bulk density. The chemical properties were analyzed using various standard laboratory methods. Total nitrogen was determined using micro Kjeldahl apparatus according to Martins et al. (2015). Sodium (Na) and potassium (K) concentrations were done using the flame photometer while calcium (Ca) and magnesium (Mg) were determined using the Atomic absorption spectrophotometer (AAS). Soil

pH was determined using glass electrode pH meter while conductivity will be determined following the procedure of Clay et al (2012).

Statistical data analysis

Data obtained from the soil physicochemical properties were subjected to descriptive statistics to compute for means and standard deviation of each parameter. The analyses were computed using statistical package for social sciences (SPSS) version 20.

Results

The result presented in Table 1 shows the list of identified tree species and classification into their families in the study area. A total of 194 individual trees distributed among 62 different tree species belonging to 26 families were documented during the study. The family leguminaceae shows dominance with 11 tree species followed by Moraceae and Fabaceae with 7 and 6 species respectively. The family Burseraceae had 4 while Apocynaceae, calsalpinaceace and Euphobiaceae recorded 3 tree species each. Other such as the Bombacaceae, Flacourtaceae ,Myristicaceae, Sapindaceae and Sapotaceae has 2 tree species while Anisophilleacea, Cercropaceae , Compretaceae, Malvaceae, Saccoglobiaceae and Ulmaceae have 1 tree species each. The family Leguminaceae had the highest individuals with a total number of 44 followed by Fabaceae, 31 and Moraceae 24.

Table 1: Families, number of species and individual trees within the study area.

Family	**Number tree species**	**Number of individual trees**
Anisophylleacea	1	1
Apocynaceae	3	11
Bombacaceae	2	6
Burseraceae	4	6
Caesalpiniaceae	3	12
Cluciaceae	1	2
Cercropiaceae	1	2
Compretaceae	1	3
Euphobiaceae	3	14
Fabaccae	6	31
Flacourtiaceae	2	4

Irvingiaceae		2	4
Leguminioseae		11	44
Meliaceae		1	1
Malvaceae		1	1
Merbebaceae		1	2
Moraceae		7	24
Myristicacene		2	4
Rutiaceae		1	5
Rubiaceae		1	1
Sapindaceae		2	4
Saccogobiaceae		1	1
Sapotaceae		2	4
Sterculiaceae		1	4
Simaroubaceae		1	1
Ulmaceae		1	3
Total	**26**	**62**	**194**

The result in Table 2 represents the trees species and their basal area, relative densities (RD), relative dominance (RDo), relative abundance (RA) and importance value index (IVI). The basal area ranged from 0.031 -11.089 m^2 for diverse species of trees in the study area, the total basal area of tree species recorded was 147.615m^2. *Bombax bounopozense*, belonging to the family *Bombacaceae* recorded the highest basal area of 11.089m^2 followed by *Recinodendron heudelotii*, 8.301m^2 and *Piptadeniastrum africana*, 7.318m^2. Other include *Hylodendron garbonenses* with 7.104m^2, *Pentaclethra macrophylla* had 7.054m^2 while *Triplochiton scleroxylon* recorded the lowest basal area of 0.031m^2. The relative density ranged from 0.05-7.73% with *P. africana* which belong to the family *Fabaceae* recorded the highest density of 7.73% while, *C. gabonensis, S. gabonensis, T. triplochitin* and *L. trichiloides* recorded the lowest of 0.05% each. The relative dominance varied between 0.02 (*Triplochiton scleroxylum)* and 7.51 (*Bombax bounopozens)*. The highest relative abundance of 0.08 was recorded in *P. africana* followed by *R. heudelotii* with 0.06 while, *C. gabonensis, S. gabonensis, T. triplochitin* and *L. trichiloides* had the lowest value of 0.001 each. Importance value index (IVI) shows that, *Piptadeniastrum africana* has the highest (IVI) of 15.65 followed closely by *Ricinodendron heudelotii* which recorded 13.99 while *Tryplochiton scleroxylon* has the least dominant value of 0.85 in the study area. The IVI also shows that *P. africana, R. heudelotii, B. bounopozens, A. ptercarpoides* and *P. macrophylla* were the most dominant tree species with IVI value above 10.00.

Table 2: Tree species, their basal area, relative density, dominance, abundance and importance value index in the study area.

S/N	Species	No of individual	Basal Area (m^2)	Relative density (RD)	Relative dominance (RDo)	Relative Frequency(RF)	Relative Abundance	Importance Value Index (IVI)	Classification based on (RD)
1	*Piptadeniastrum africana*	15	7.318	7.73	4.96	3.13	0.08	15.63	Abundant
2	*Ricinodemdron heudelotii*	10	8.301	5.15	5.62	3.13	0.06	13.99	Abundant
3	*Bosqueia angolensis*	10	1.368	5.15	0.93	3.13	0.03	9.3	Abundant
4	*Gosweilorodendron balsalmiformis*	5	6.440	2.58	4.36	2.34	0.02	9.32	Rare
5	*Blighia sapida*	3	2.910	1.55	1.97	3.34	0.03	5.88	Rare
6	*Daniella ogea*	3	3.309	1.55	2.24	1.56	0.02	5.37	Rare
7	*Bombax bounopozens*	4	11.087	2.06	7.51	3.13	0.02	12.73	Rare
8	*Baphia gracilypis*	8	3.462	4.12	2.35	3.13	0.04	9.67	Frequent
9	*Picralima nitida*	6	2.985	3.09	2.02	3.13	0.03	8.29	Occasional
10	*Allanblankia floribunda*	2	1.040	1.03	0.7	0.78	0.01	2.53	Rare
11	*Terminalia superba*	3	5.782	1.55	3.91	3.13	0.03	8.61	Rare
12	*Alstonea boonei*	3	2.772	1.55	1.88	2.34	0.02	5.79	Rare
13	*Nuclea diderachi*	2	1.229	1.03	0.83	0.78	0.01	2.66	Rare
14	*Antiaris africana*	2	0.622	1.03	0.42	1.56	0.01	3.03	Rare
15	*Stautia stipitata*	2	1.232	1.03	0.83	1.56	0.01	3.44	Rare
16	*Mitrigyna cyliata*	2	1.213	1.03	0.82	1.56	0.01	3.43	Rare
17	*Mammea africana*	4	3.157	2.06	2.14	2.34	0.02	6.57	Rare
18	*Hylodendrom gabonensis*	4	7.104	2.06	4.81	1.56	0.02	8.46	Rare
19	*Celtis philipense (spp)*	3	1.901	1.55	1.29	1.56	0.02	4.42	Rare
20	*Vitex doniana*	2	0.984	1.03	0.67	1.56	0.01	3.28	Rare
21	*Lanmea welwiitchii*	1	0.245	0.52	0.17	0.78	0.01	1.47	Threatened
22	*Sterculia oblonga*	4	0.188	2.06	0.13	1.56	0.02	3.78	Rare
23	*Amphimas ptericarpoides*	9	3.880	4.64	2.63	3.13	0.05	10.47	Frequent

24	*Albizia ferruginea(Spp)*	3	1.756	1.55	1.19	2.34	0.02	5.1	Rare
25	*Musanga cercropioides*	2	6.284	1.03	4.26	1.56	0.01	6.87	Rare
26	*Fagara Macrophylla*	5	2.454	2.58	1.66	3.13	0.03	7.41	Rare
27	*Cryptosepalum pellegriniamin*	3	2.837	1.55	1.92	1.56	0.02	5.05	Rare
28	*Treculia affricana*	3	1.339	1.55	0.91	1.56	0.02	4.04	Rare
29	*Dedelota africana*	2	0.490	1.03	0.33	1.56	0.02	2.94	Rare
30	*Dialum guniensis*	1	0.113	0.52	0.08	0.78	0.01	1.38	Threatened
31	*Pycnanthus angolensis*	2	1.961	1.03	1.33	0.78	0.01	3.16	Rare
32	*Deterium microcarpum*	6	1.087	3.09	1.74	2.34	0.03	7.22	Occasional
33	*Brachystegia eurycoma*	3	5.574	1.55	3.78	1.56	0.02	6.91	Rare
34	*Afzelia Africana*	3	1.138	1.55	0.78	1.56	0.02	3.91	Rare
35	*Belinia auriculata*	2	0.313	1.03	0.21	1.56	0.01	2.82	Rare
36	*Anthonatha macrophylla*	5	2.781	2.58	1.88	2.34	0.02	6.84	Rare
37	*pentaclethra macrophylla*	6	7.054	3.09	4.78	2.34	0.03	10.26	Occasional
38	*Gambeya albida*	2	3.036	1.03	2.06	1.56	0.01	4.67	Rare
39	*Pterocarpus osun*	3	4.123	1.55	2.79	2.34	0.02	6.7	Rare
40	*Erioceolum macrocarpum*	1	0.044	0.52	0.03	0.78	0.01	1.33	Threatened
41	*Dacryoides edulis*	2	0.283	1.03	0.19	1.56	0.01	2.8	Rare
42	*Irvingia garbonensis*	3	1.998	1.55	1.35	1.56	0.02	4.48	Rare
43	*Garcinia cola*	1	0.987	0.52	0.67	0.78	0.01	1.97	Threatened
44	*Anisophyllia purpurasens*	1	1.910	0.52	1.21	0.78	0.01	2.51	Threatened
45	*Homalium letistus*	3	0.588	1.55	1.4	0.78	0.02	3.75	Rare
46	*Millettia mecrophylla*	2	0.666	1.03	0.45	1.56	0.01	3.06	Rare
47	*Lophyria alata*	2	2.316	1.03	1.57	1.56	0.01	4.18	Rare
48	*Poga Oleosa*	2	2.542	1.03	1.76	1.56	0.01	4.37	Rare
49	*Ceiba pentandra*	2	1.913	1.03	1.3	1.56	0.01	3.91	Rare
50	*Parkia bicolor*	2	1.948	1.03	1.32	1.56	0.01	3.93	Rare

51	*Millicia elelsa*	3	3.142	1.55	2.13	0.78	0.02	3.43	Rare
52	*Distemanthus bentamianus*	2	1.791	1.03	1.21	0.78	0.01	3.04	Rare
53	*Discordis cliamiaper*	1	1.530	0.05	1.04	0.78	0.001	1.87	Threatened
54	*Santira trimera*	2	0.952	1.03	1.64	0.78	0.01	3.47	Rare
55	*Honoa Klaineana*	1	0.386	0.05	0.26	0.78	0.001	1.09	Threatened
56	*Cylincodiscus gabonensis*	1	0.987	0.05	0.67	0.78	0.001	1.5	Threatened
57	*Parinaris Africana*	2	2.111	1.03	1.43	0.78	0.01	2.26	Rare
58	*Sacoglotis gabonensis*	1	0.364	0.05	0.25	0.78	0.001	1.08	Threatened
59	*Triplochiton scleroxylon*	1	0.031	0.05	0.02	0.78	0.001	0.85	Threatened
60	*Lovoa trichiloides*	1	0.257	0.05	0.17	0.78	0.001	1	Threatened
Total		**194**	**147.615**	**100.0**	**100.00**	**100.00**	**1.07**	**300.00**	

The result of the tree growth variables and biodiversity indices as presented in table 3 revealed that in 26 families with 62 tree species and 194 individual trees their basal area was 147.62m^3. The result also showed that only 5% of the tree species were categorize as Abundant and Occasional. Majority of the trees representing 68.34% were Rare species and 18.33% were either threatened or endangered species while 3.33% of the trees were Frequent species.

Table 3: Summary of tree growth variables and biodiversity indices of the study area.

Growth variables and Biodiversity indices	**Values**
Number of families	26
Number of species	62
Number of trees	194
Total basal area (m^3)	147.62
Abundant (Relative density; RD $\geq$ 5)	3 (5%)
Frequent (4.00 $\leq$ RD $\geq$ 4.99)	2 (3.33%)
Occasional (3.00 $\leq$ RD $\geq$ 3.99)	3 (5%)
Rare (1.00 $\leq$ RD $\geq$ 2.99)	41 (68.33%)
Threatened/ Endangered (0.00 < RD $\leq$ 1)	11 (18.33%)
Shannon – wiener index (H)	3.04
Margalef Species Richness (M)	20.67

Species Evenness (E_H)	2.19
Index of Dominance	0.06

The result of the physicochemical properties of soil of Ukpon River Forest is presented in Table 4. The properties showed 30.46% sand, 60.16% clay and 9.30% silt. The soil is slightly acidic (5.77) with higher available phosphorus (25.05 Cmol/kg) followed by Calcium (17.15 Cmol/kg) with the lowest value of sodium (0.12 Cmol/kg). The result also recorded a base saturation level of 91.41%, organic matter of 4.32% and a bulk density of 1.62 g/cm^3.

Table 4: The mean values of the physicochemical properties of soil in the study area

Parameter	**Mean**	**Standard deviation**
Sand (%)	30.46	7.66
Silt (%)	9.30	2.34
Clay (%)	60.16	5.62
pH	5.77	1.77
Electric conductivity (µS/cm)	0.23	0.19
Organic matter (%)	4.32	1.99
Total nitrogen (%)	0.11	0.05
Phosphorus (Cmol/kg)	25.05	8.99
Calcium (Cmol/kg)	17.15	4.27
Magnesium (Cmol/kg)	5.79	1.49
Sodium (Cmol/kg)	0.12	0.04
Potassium (Cmol/kg)	0.20	0.11
Aluminum (Cmol/kg)	0.71	0.33
Effective Cation Exchange Capacity (Cmol/kg)	26.41	5.24
Exchange acidity (Cmol/kg)	2.24	0.89
Base saturation (%)	91.41	4.72
Bulk density (g/cm^3)	1.62	0.37

Discussion

Forest play important role in maintaining fundamental ecological processes by providing livelihood and supporting economic growth. There is a growing concern for developing new global, regional and national programme for conserving and managing forest biodiversity. The creation of protected areas is considered the most effective means to stop and reverse degradation of our forest (Jekins and Joppa, 2009). The result obtained from this study show that trees are

diverse in Ukpon River Forest Reserve of Cross River, Nigeria. A total of 194 individual trees in 62 species belonging to 26 families encountered in this study was higher than the 20 tree species in 12 families encountered by Ogwu et al. (2016) in University of Benin campus and 54 species in 25 families reported by Akindele et al (2021) in Akure Forest Reserve. Ikaagba et al. (2015) and Edu, (2017) have both reported a lower trees species of 52 in University of Agriculture, Makurdi and selected forest reserves in cross river respectively. The slight high in population recorded in the study area may be attributed to favourable microclimate within the forest and availability of viable seeds of trees to sustain regeneration. However, Aigbe and Omokhua (2015) recorded a much higher tree species 72 in 30 families in Oban Forest Reserve of Cross River. The dominance of the tree species of the families *Leguminaceae, Moraceae, Meliaceae* and *Fabaceae* in this study is in line with those of Edu (2017) and Edet *et al.,* (2012) at Ukpon River and Afi Forest Reserves respectively. Akindele et al (2021) also reported these families as dominant except Leguminaceace which was not encountered in Akure Forest Reserve. The representation of most families by more than (5) species is typical of the rainforest vegetation of Nigeria (Edet *et al.,* 2012: Aigbe and Omokhua 2014). Ihenyen et al. (2009) and Akindele et al (2021) reported the Fabaceace family as the most abundant in Ehor and Akure Forest Reserves respectively as against Leguminaceace reported in this study. Dominance of a family may be attributed to their efficiency in seed dispersal mechanism and soil fertility status (Udo *et al.,* 2007). However, some families such as *Ebenaceae* and *Malvaceae*, had less than (3) species each which is also typical of West African families (Abbey 2006; Richard 2007). This low species representation in these families could due to poor regeneration abilities and/or anthropogenic activities (Zhigila *et al.,* 2016). *Piptadeniastrum africana* (15.63%) of the family Leguminaceace and *Ricinodendron heudeltii* (13.99%) of the family Euphorbeceace had the highest importance value indices. Akindele et al. (2021) also reported *Ricinodendron heudeltii* (10.49%) as the second highest after *Celtis zenkeri* (15.49%) of the family Ulmaceace. According to Zhigila *et al.* (2016) high importance value index of a species indicated its dominance and ecological success, its good power of regeneration and greater ecological amplitude. Some such as *Triplochiton scleroxylon* (0.85%), *Lovoa trichiloides* (1%), *Erioceolum macrcarpum* (1.33%) and *Cylincodiscus gabonensis* (1.5%) have low importance value index indication their low potential for regeneration hence require high conservation efforts. Most species had relative density of less than 1 about 18.33% and are considered a Rare and threatened or endangered species within the study area. These species may soon be absent in Ukpon Reserve if sustainable management practices are not adopted. According

to Iroko et al (2008) over exploitation and replacement of natural forest ecosystems with human amenities results in the decimation of trees species.

The diversity index values of Shannon – Werner (3.04), Species Richness (20.67) and Species Evenness (2.19) was considered as high compare to those reported by Sundaranpandian and Swamy (2000) tropical forest of kodayar in the western Ghats of Southern India and Edu (2017) in selected Forest Reserves of Cross River. These were however, similar to those obtained by Adekunle et al (2013) and Akindele et al. (2021) in Akure Forest Reserve; Aigbe and Omokhua, (2015) and Edet et al. (2012) in Oban and Afi mountain Reserves respectively in Cross River State. Species richness index measures the variety of species. It takes into consideration the total number of a particular species in relation to the total number of individuals within the forest stand (Gebreselasse, 2011). The species richness obtained in this study was higher than the 10.444 reported for Afi Forest Reserve (Aigbe *et al.,* 2014) and 13.26 in Akure Forest Reserve (Akindele et al (2021) all in Nigeria and 6.36-8.08 for Kibale Forest and 7.54-8.20 for kasyoha-kitomi Forest in the rift of Uganda (Eihe *et al.*, 2004). Species evenness is a measure of the relative abundance of species that make up the richness of an area. The higher the values of evenness the more even the species are in their distribution (Kent and Corker 1992). In this study the evenness index values of 2.19 was higher than the 0.887 recorded Aigbe and Omokhua, (2014) in Oban Forest Reserve, 0.907 obtained by Aigbe *et al.,* (2014) in Afi River Forest Reserve and 1.90 for Cross River South Forest Reserve by Edu, (2017). Akindele et al. (2021) obtained a lower value of 0.86 in Akure forest Reserve. Index of dominance shows, that two individuals drawn at random from a population belong to the same species. The higher the index of dominance values the lower the diversity of the species Aigbe *et al.*, 2014). The values of 0.06 obtained in this study is considered as low compared with the 0.78 reported by Akindele *et al* (2021) in Akure Forest Reserve, indicating, that one particular tree species is dominating more than the others. This also implies that tree diversity is higher in the study area than in Akure Forest Reserve. This corroborates the findings of Egom and Umerod (1990) and Aigbe *et al.* (2014), who reported that species diversity varies across vegetation in tropical rainforest which may either be abundance or scanty in a particular location.

The influence of soil property on the distribution of flora has been documented by some scholars in the past. Aweto (1981) identified high organic matter and clay proportion as soil variables that exerted marked influence on the distribution and abundance of tree species. This study recorded high values of clay (60.16%), organic matter (4.32%) and pH (5.77) indicating high fertility.

Ukpong (1994) identify nutrients and salinity as factors influencing species variation in mangrove swamps whereas John *et al.,* (2007) identify soil pH as the strongest soil factor that influenced the distribution of species in the tropical forest. According to Zare *et al.* (2011) soil texture, Salinity, effective depth, available Nitrogen, Potassium, Organic matter, lime and moisture are major factors influencing variation in the pattern of vegetation. Brady and Weil (2008) reported that Clay have specific surface area giving them a tremendous capacity to absorb water and nutrients. However Sandy soil has low specific surface area with little capacity to hold water and nutrients, making them infertile and to leaching (Eynaw *et al.,* 2004). Edu (2017) reported that a low pH of the some selected soils of Cross River Forest Reserve was responsible for the lower species diversity, dominance index and high evenness in the study areas. This finding also agrees with the assertion of John *et al.* (2007) and Zare *et al.* (2011) that tree species distribution, dominance and evenness correlates with soil chemical properties and possibly topography. Long et al. (2018) found a positive significant correlation between tree species diversity and Potassium content in a tropical secondary forest. The results from this study compares favourably with those of Nadeau et al. (2015) and Onyekwelu et al. (2008) on the effects of soil properties on trees diversities, abundance and composition.

Conclusion

The result in this study revealed a fundamental information of tree species diversity and soil physicochemical properties of Ukpon River Forest Reserve. The family Leguminaceace shows dominance and the species *P. africana* belonging to the family Fabaceace have the highest relative abundance and importance value index. The highest basal area was recorded in *Bombax bonnopozens* while *Triplochiton scleroxylon* had the lowest area. About 68.34% of the trees were Rare while 18.33% were Threatened or Endangered. The diversity indices showed that tree species composition was high with low Dominance index (0.06). Soil properties such as Clay, Organic matter, Phosphours, Calcium, Cation Exchangeable capacity and Base Saturation were high with mildly acidic pH. This may have been responsible for the high species diversity recorded in this study although some species are endangered. Therefore conservation measures should be recommended to checkmate the disappearance of these species by safeguarding the areas from anthropogenic activities to avoid degradation and deforestation.

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