ANALYSIS OF FLORISTIC COMPOSITION AND DIVERSITY OF SAKPOBA FOREST RESERVE, NIGERIA.

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ABSTRACT
Tropical rainforest which isa major reservoir of timber resources for meeting the growing demand for wood is intensely under pressure. The long term consequences of this are forest degradation and loss if not effectively managed. An assessment offloristic composition and diversity of forests in Sakpoba Forest Reserve, Nigeria was carried out. Systematicline transect was usedinlaying of plots. One transect each measuring 1000 m long were laid in disturbed and undisturbed area of the reserve. Along each transect 20 m x 20m (0.04 ha) sample plot were laid in alternate position after every 200m point, and thus adding up to 4 sample plots per transect and a total of 8 sample plots for study sites.Diameter at breast height (dbh) ≥ 10cm weremeasured at 1.3m and botanical names of the tree species determined within each plots. The results showed that the mean number of trees per hectare were 1025 (56 species) and 319 (30 species)in undisturbed and disturbed forest areas respectively. Population densities of the tree species ranged from 3 to 74 $ha^{-1}$and 2 to 112 ha^{-1}in undisturbed and disturbed forest areas respectively, that makes some tree species to be threatened. The mean basal area/ha estimated was lesser in disturbed forest area (10.49 m^2) than in undisturbed forest area (222.22m^2). The implication for the difference in varied basal area is that the undisturbed forest area is fully stocked while the disturbed forest area is not well stocked. The values of Shannon-Wiener diversity index (H^I) for undisturbed and disturbed forest areaswere 3.628 and 2.591 respectively. The study revealed that there is low floristic similarity between the forest areas judging from the value of Sorenson's index (34.88 %).

Key words; per hectare estimate, tropical forest, floristic composition, Sakpoba Forest Reserve, biodiversity indices

INTRODUCTION
Sakpoba Forest Reserve is located in tropical rainforest belt of Nigeria.According to Onyekwelu *et al*., (2007), tropical rainforest is the most species-rich terrestrial ecosystem having 70% of all living organisms, which account for only 7% of land area.It has a tremendous number of plant species with diverse sizes (Richard, 1996). The rainforest has between 100 and 300 tree species per hectare (Onyekwelu*et al.*, 2007) which makes it a major reservoir of timber resources for meeting the growing demand for wood (Etigale *et al*., 2014). The rainforest is intensely under pressure because most of these tree species are used by the rural dwellers and timber contractors for many purposes. The long term consequences of this activities are forest degradation and loss, if not effectively managed.

Managing forest effectively ensuressustainable forest management which requires information on growing stocks within the forest. Such information guides forest supervisors in timber appraisal and proper management prescriptions. For timber production and proper stock taking, one of the parameters to consider is floristic composition and diversity of the tree species. Correct management of forests is based on having accurate information about status of the forest and the types of species (Aigbe, 2014). There is paucity of information necessary to sustain effective management of the forest and forest resources.

Consequent upon the inadequate information for proper management planning and deteriorating state of the forest reserves, there is no guarantee for their sustainable management. Current growing stock assessment of the reserves is essential given the fast and alarming rate at which their resources are being depleted. Hence, a study on floristic composition and tree diversity of Sakpoba Forest Reserve was carried out.

METHODOLOGY
The Study Location
This study was carried out in Sakpoba Forest Reserve, Edo State, Nigeria. The reserve lies on latitude 6^0 34^1 N and longitude 5^0 54^1E (Figure 1). It occupies an area of 502.5 km^2 (Isikhuemen, 1998).Sakpoba Forest Reserve is splitted into two main areas of Area BC 29 and BC 32/4. It has 176 compartments. 101 are located in BC 29 and 75 in BC 32/4 (Isikhuemen, 1998).

The annual temperature and precipitation in Sakpoba Forest Reserve has anaverage values of 22.5^0 C and 1755mm respectively. It has the lowest precipitation value in January with an average of 10mm (en Climate-data, 2015).

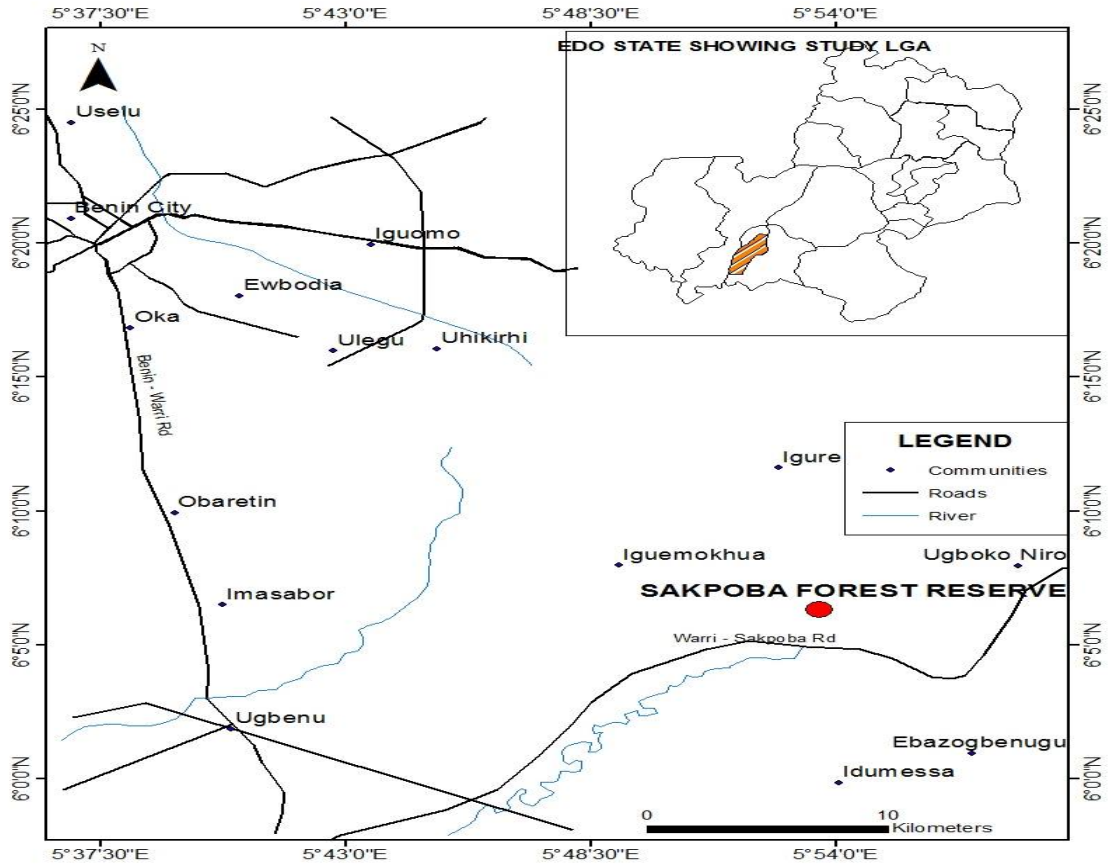

Fig. 1: Map of Edo State Showing the Study Area (Sakpoba Forest Reserve)

Method of Data Collection

Systematic line transects was adopted for laying of plots. One transect each measuring 1000 m long was laid in disturbed and undisturbed area, respectively, making a total of two transects. Along each transect 20 m x 20 m (0.04 ha) sample plot were laid in different position after every 200 m point, and thus adding up to 4 sample plots per transect and a total of 8 sample plots for research area. Within each plot, tree species with diameter at breast height (dbh) ≥ 10cm were measured (at 1.3m above ground level) and botanical names identified.

Floristic Composition

(i) *Basal Area*

The basal area of all trees in the sample plots were estimated using the formula:

$$BA = \pi D^2/4 \quad \text{-------Equation 1}$$

Where BA = basal area (m^2)

π = 3.142

D = Dbh (m)

(ii) *Species Relative Density (%)*

Brashears*et al*., (2004) equation was used for computation of relative density (RD) of each species:

$$RD = \left(\frac{n_i}{N}\right) \times 100 \quad \text{-----} \textit{Equation 2}$$

Where n_i = the number of species individuals and N = the overall number of all individual trees.

(iii) *Species Relative Dominance (%)*

Species Relative Dominance (RD_0) were calculated for each species using the equation below:

$$RD_0 = \frac{\left(\sum B_{a_i} \times 100\right)}{\sum B_{a_n}} \quad \text{--}\textit{Equation 3}$$

Where, B_{a_i} = the basal area of all individual trees belonging to a particular species; B_{a_n} = the basal area of the stand.

(iv) *Importance Value Index (IVI)*:

The share of each species in tree community is expressed from Importance Value Index (Rajkumar and Parthasarathy, 2008). The sum of the RD and RDo divided by 2 $\left[(\text{RD} + \text{RDo}) / 2\right]$ equal to the IVI for each species (Yang *et al.* 2008).

Tree Species Diversity

Formulae below were used following Magurran, (2004) and Lu *et al*., (2010):

(i) Shannon-Wiener Diversity Index (H')

$$H' = \sum_{i=1}^{s} \text{pi} \ln(\text{pi}) \quad \text{--}\textit{Equation 4}$$

Where H' = Shannon-Wiener diversity index; pi= proportion of species in the family that constitute the i^{th} species; ln = natural logarithm

(ii) Species Evenness Index (E)

$$\text{Evenness Index} = \frac{H}{\log S} \quad ---Equation\ 5$$

Where *H* is H' = Shannon-Wiener diversity index and S is the total number of species.

(iii) Species Richness

The Margalef index was adopted for species richness Margalef' Index (d)

$$= \frac{S-1}{\ln(N)} \quad ---Equation\ 6$$

Where S is the total number of species, 'N' is the total number of individuals and '*ln*' is the natural logarithm.

(iv) Similarity Index

The similarity index was determined using the Sorenson index. The equation below was used to derived Sorensen similarity index.

Sorenson index is expressed as

$$Cs = \left[\{2j/(a+b\}x100\right] \quad --Equation\ 7$$

Where: j = number of species common to both sites being compared; a = number of species in site A; b = number of species in site B; Critical level of significance = 50% for similarity.

RESULTS AND DISCUSSION

Stand growth attribute

A total of 364 trees were encountered in the study sites from eight temporary sample plots of size 20 m x 20 m (0.04 ha). The results showed that the mean Dbh is 48.52 ± 3.30 cm and 18.95 ± 1.10 cm for undisturbed and disturbed area of the Forest Reserve respectively (Table 1). The mean basal area were 222.22 ± 35.59 m^2 for undisturbed area and 10.49 ± 1.96 m^2 for disturbed area (Table 1). The high value of the standard error for undisturbed forest is an indication of varied disparity in tree size. This agreed with the report of Adekunle*et al.*, (2004) in Ala and Omo Forest Reserve in southwest Nigeria that high standard deviation is an indication of wide variation in tree sizes. The undisturbed area had significantly greater tree basal area than disturbed area at $p < 0.05$ (Table 2). Thedisparity between the basal area per ha of the undisturbed and disturbed forest area could be attributed to excessive timber exploitation in the disturbed forest which left fewer trees standing. The implication for the value of average basal area per hectare for undisturbed forest area is that the forest is fully stocked while in disturbed forest area, it is not well stocked. This is true when compared proportionally with the recommended value of 23 m^2 for a fully stocked rainforest in Nigeria (Alder and Abayomi, 1994). The values obtained in the two forest areas differ significantly ($p < 0.05$) than what was reported for some tropical forests. For example (14.5 - 71.8 m^2 ha^{-1}) reported for Sal forests of India (Shukla and Pandey, 2000, Kumar *et al*., 2011); Adekunle*et al.*, (2004) and Onyekwelu*et al.*, (2008) for some tropical forests in southwestern Nigeria; 51 - 77 m^2 ha^{-1} reported for Garo Hill in north east India (Baishya *et al*., 2009, Thapa *et al*., 2011); Aigbe *et al*., (2014) reported 102.77 m^2 for Afi River Forest Reserve in Cross River, Nigeria; and 34.67 m^2 was reportedfor Oban Forest Reserve, Cross River, Nigeria (Aigbe and Omokhua, 2015).

The mean number of trees per hectare were 1025 ± 127 and 319 ± 28 in undisturbed and disturbed forest area respectively (Table 1). The value of the number of trees in undisturbed area was significantly different from the disturbed area (Table 2). The evidence of this number of trees per hectare for the two study sites is an indication that the reserve is a repository of many indigenous tropical hardwood tree species. The mean number of trees per hectare in undisturbed forest area (1025 trees ha^{-1}) reported in this study was within the range of other tropical forests (387 - 1561 trees ha^{-1}) (Campbell *et al*., 1986; Jaffr**é** and Veillon, 1990; Onyekwelu*et al*., 2008; Adekunle *et al*., 2013 and Baithalu *et al*., 2013. While in disturbed forest area the mean number of trees per hectare was comparable to 385/ha reported by Sidiyasa, (2001) in Wain River, East Kalimantan; 323/ha by Aigbe *et al.*, (2014) in Afi River Forest Reserve in Cross River, Nigeria; and 306/ha by Aigbe and Omokhua, (2015) in Oban Forest Reserve, Cross River, Nigeria. Adekunle *et al*., (2013) reported that tree density can be affected bysoil properties, anthropogenic activities and natural calamities.

Table 1: Stand growth characteristics of undisturbed and disturbed area of Sakpoba Forest Reserve

	Undisturbed Area				Disturbed Area			
	Min	**Max**	**Mean**	**Std Error**	**Min**	**Max**	**Mean**	**Std Error**
Dbh(cm)	2.83	244.62	48.52	3.30	11.01	49.65	18.95	1.10
Basal Area/ha (m^2/ha)	151.87	321.07	222.22	35.59	8.23	16.36	10.49	1.96
Number of Tree/ha	550	1025	769	127	275	400	319	28

Dbh=diameter at breast height,

Table 2: Paired t – test of mean basal area and number of trees per hectare for undisturbed and disturbed of Sakpoba Forest Reserve.

Mean per hectare estimate	t Stat	t - Critical	R
Basal area	6.260	3.183	0.917
Number of trees	4.148	3.183	0.735

A total of 56 tree species distributed among 28 families and 46 genera were encountered in undisturbed forest area while a total of 30 tree species distributed among 17 families and 27 genera were encountered in disturbed forest area (Tables 3 and 4). The order of family dominance varied in each area. The first four dominant families in undisturbed forest area were Meliaceae (7), Leguminaceae (6), Ebenaceae (4) and Apocynaceae (4) while for disturbed forest area, Euphorbiaceae (5), Leguminaceae (5), and Moraceae (3) were the dominant families. It was observed that the representative tree species of Meliaceae was not encountered in disturbed forest which was prominent in undisturbed forest. Dominant families in the two forest areas were slightly different from those reported for rainforest ecosystems in Afi River and Oban Forest Reserve, Nigeria (Aigbe, 2014). For example, in Afi River Forest Reserve, Euphorbiaceae, Mimosoideae, Caesalpinioideae and Meliaceae were the dominant families. Adekunle*et al.,* (2013) also reported Caesalpinioideae, Sterculiaceae, Meliaceae and Moraceae as dominant families in Akure Forest Reserve, Ondo State, Nigeria. However, in a similar study, Meliaceae, Euphorbiaceae and Moraceae were reported as the dominant families in tropical rainforest of DoiInthanon, Thailand (Kanzaki*et al*,.2004) and the Xishuangbanna forest in southwest China (Lu *et al*.,(2010).

Out of the 56 species documented in undisturbed forest area, *Rauvolfiavomitoria, Baphianitida, Albizia zygia* and *Musanga cercopiodes* had the highest density with 74, 52, 50 and 41 trees per hectare respectively, which accounted for 9.7 %, 6.8 %. 6.5 % and 5.4 % of the total tree density per hectare respectively. In disturbed forest area, out of the 30 tree species, *Rauvolfiavomitoria, Musanga cercopiodes, Anthonotha macrophylla, Trema orientalis* and*Spondias mombin* had the highest density with 112 trees, 29 trees, 24 trees, 17 trees and 17 trees per hectare respectively, accounting for 35.2 %, 9.2 %, 7.6 %, 5.3 % and 5.3 % of the total tree density per hectare, respectively. Some few species have two to three trees per hectare, signifying that these species might be under threat of extinction due probably to anthropogenic factor. FORMECU (1999) reported that tropical tree species (less than 10 individual per hectare) that are vulnerable and threatened with extinction are endangered species. Dominant species in the two forest areas were at variance from those reported for some tropical rainforest ecosystems in Nigeria. For example, Adekunle*et al.,* (2013), reported *Mansonia altissima* and *Triplochiton scleroxylon* as the dominant species in Akure Forest Reserve; Aigbe *et al.,* (2014) reported *Berlinia grandiflora, Brachystegia eurycoma, Albizia zygia, pycnathus angolensis* and *Staudtia stipitata* as the dominant species in Afi River Forest Reserve, Nigeria.

Importance Value Index (IVI) shows share of species importance in forest community. IVI is a good indication of knowing the important tree speciesin the floristic composition of a forest and a measure of how dominant a tree species is in a specified forest expanse. A high importance value index indicates that the species is well represented in the stand. In the undisturbed forest area, *Brachystegia eurycoma* (Caesalpiniodeae) had the highest species IVI of 6.69 %. This was closely followed by *Albizia zygia* (Leguminosae) and *Nauclea diderrichii* (Rubiaceae) with IVI of 6.43 % and 5.99 % respectively (Table 3). While in the disturbed forest area, *Musanga cecropioides* (Moraceae) had the highest species IVI of 6.47 %, which was closely followed by *Hylodendron gabunense* (Leguminosae) and *Pentaclethra macrophylla* with IVI of 6.11 % and 6.10 % respectively (Table 4).The implication of this is that not necessarily tree species with the highest density or basal area is the dominant species.

Table 3: Tree species abundance, BA/ha, RD, RDo and IVI of undisturbed area in SakpobaForest Reserve

Species name	Family	Number per ha	RD(%)	BA/ha	RDo(%)	IVI
Albizia adianthifolia	Leguminosae	14	1.792	17.51	8.07	4.93
Albizia zygia	Leguminosae	50	6.452	13.91	6.41	6.43
Alchornea cordifolia	Euphorbiaceae	17	2.151	1.897	0.87	1.51
Allanblackia floribunda	Guttiferae	19	2.509	1.954	0.9	1.7
Anthonotha macrophylla	Leguminosae	25	3.226	2.396	1.1	2.17
Baphia nitida	Leguminosae	52	6.81	2.251	1.04	3.92
Barteria fistulosa	Passifloroceae	8	1.075	0.459	0.21	0.64
Blighia sapida	Sapindaceae	19	2.509	2.32	1.07	1.79
Bosqueia angolensis	Moraceae	8	1.075	3.591	1.66	1.37
Brachystegia eurycoma	Ceasalpiniodeae	6	0.717	27.46	12.7	6.69
Carapa procera	Meliaceae	11	1.434	0.599	0.28	0.85
Cleistopholis patens	Annonaceae	3	0.358	0.431	0.2	0.28
Combretodendron africanum	Lecythidaceae	11	1.434	0.609	0.28	0.86
Diospyros mespiliformis	Ebenaceae	3	0.358	1.38	0.64	0.5
Diospyros piscartoria	Ebenaceae	8	1.075	1.043	0.48	0.78
Dispyros canaliculata	Ebenaceae	3	0.358	1.198	0.55	0.46
Dispyros dendo	Ebenaceae	3	0.358	0.211	0.1	0.23
Elaeis guineensis	Palmae	17	2.151	0.656	0.3	1.23
Entandrophragma cylindricum	Meliaceae	33	4.301	5.377	2.48	3.39
Erythrophleum ivorense	Leguminosae	3	0.358	2.279	1.05	0.7
Fagara zanthoxyloides	Rutaceae	5	0.717	2.401	1.11	0.91
Funtumia elastisca	Apocynaceae	30	3.943	3.588	1.65	2.8
Glyphaea brevis	Tiliaceae	8	1.075	4.122	1.9	1.49
Hannoa klaineana	Simaroubaceae	5	0.717	1.45	0.67	0.69
Homalium letestui	Samydaceae	5	0.717	1.705	0.79	0.75
Hylodendron gabunense	Leguminosae	3	0.358	1.677	0.77	0.57
Lovoa trichiliodes	Meliaceae	6	0.717	3.411	1.57	1.14
Macaranga barteri	Euphorbiaceae	30	3.943	10.46	4.82	4.38
Microdesmis puberula	Pandaceae	19	2.509	3.415	1.57	2.04
Maesobotrya barteri	Euphorbiaceae	19	2.509	0.072	0.03	1.27
Monodora myristica	Annonaceae	3	0.358	0.381	0.18	0.27
Musanga cecropioides	Moraceae	41	5.376	1.659	0.76	3.07
Myrianthus arboreus	Moraceae	3	0.358	3.494	1.61	0.98
Nauclea diderrichii	Rubiaceae	14	1.792	22.11	10.2	5.99
Olaxsubscorpioidea	Olacaeae	6	0.717	0.004	0	0.36
Pentaclethra macrophylla	Leguminoceae	28	3.584	47.08	21.7	12.6
Picralima nitida	Apocynaceae	11	1.434	0.232	0.11	0.77
Pierreodendron africanum	Simaroubaceae	3	0.358	1.38	0.64	0.5
Piptadeniastrum africanum	Legumionceae	3	0.358	2.277	1.05	0.7
Rapaneamelanophloeos	Myrsinaceae	5	0.717	0.662	0.31	0.51
Rauvolfia vomitoria	Apocynaceae	74	9.677	1.207	0.56	5.12

Rinorea welwitschii	Violaceae	3	0.358	0.229	0.11	0.23
Rinorea dentata	Violenceae	8	1.075	0.915	0.42	0.75
Rinorea oblongifolia	Violenceae	5	0.717	4.123	1.9	1.31
Sterculia setigera	Sterculiaceae	17	2.151	0.839	0.39	1.27
Sterculia tragacantha	Sterculiaceae	28	3.584	5.295	2.44	3.01
Stereospermum acuminatissimum	Bignoniaceae	6	0.717	1.38	0.64	0.68
Strombosia pustulata	Olacaceae	19	2.509	0.764	0.35	1.43
Trema orientalis	Ulmaceae	5	0.717	0.229	0.11	0.41
Trichilia tessmannii	Meliaceae	3	0.358	1.38	0.64	0.5
Trichilia sonadelpha	Meliaceae	8	1.075	2.612	1.2	1.14
Trichilia martineaui	Meliaceae	3	0.358	0.228	0.11	0.23
Trichilia prieuriana	Meliaceae	3	0.358	0.228	0.11	0.23
Triplochitonscleroxylon	Sterculiaceae	19	2.509	0.45	0.21	1.36
Voacanga africana	Apocynaceae	5	0.717	2.547	1.17	0.95
Zanthoxylumrubescens.	Rutaceae	3	0.358	0.683	0.31	0.34

BA – Basal area; RD – Species Relative Density; RDo – Species Relative Dominance; IVI – Importance Value Index

Table 4: Tree species abundance, BA/ha, RD, RDo and IVI of disturbed area in SakpobaForest Reserve

Species name	Family	Number per ha	RD(%)	BA/ha	RDo(%)	IVI
Albizia adianthifolia	Leguminosae	7	2.29	0.748	7.92	5.11
Albizia zygia	Leguminosae	10	3.05	1.809	19.2	11.1
Alchornea cordifolia	Euphorbiaceae	3	0.76	0.067	0.71	0.74
Allanblackia floribunda	Guttiferae	12	3.82	0.147	1.56	2.69
Alstonia boonei	Apocynaceae	3	0.76	0.552	5.85	3.31
Anthocleist adjalonensis	Loganiaceae	3	0.76	0.128	1.36	1.06
Anthonotha macrophylla	Leguminosae	24	7.63	0.176	1.86	4.75
Blighia unijugata	Sapindaceae	5	1.53	0.552	5.84	3.69
Bombax buonopozense	Bombacaceae	2	0.76	0.057	0.61	0.69
Ceiba pentandra	Bombacaceae	2	0.76	0.176	1.86	1.31
Elaeis guineensis	Palmae	2	0.76	0.053	0.56	0.66
Ficus exasperata	Moraceae	7	2.29	0.254	2.69	2.49
Glyphaea brevis	Tiliaceae	7	2.29	0.176	1.86	2.08
Hylodendron gabunense	Leguminosae	3	0.76	1.082	11.5	6.11
Macaranga barteri	Euphorbiaceae	5	1.53	0.257	2.73	2.13
Macaranga heudelotii	Euphorbiaceae	3	0.76	0.169	1.79	1.28
Margaritaria discoidea	Euphorbiaceae	2	0.76	0.278	2.94	1.85
Microdesmis puberula	Pandaceae	2	0.76	0.386	4.09	2.43
Musanga cecropioides	Moraceae	29	9.16	0.356	3.78	6.47
Pentaclethra macrophylla	Leguminosae	7	2.29	0.935	9.91	6.1
Pycnanthus angolensis	Myristicaceae	5	1.53	0.322	3.41	2.47
Rauvolfia vomitoria	Apocynaceae	112	35.1	0.308	3.26	19.2
Ricinodendron heudelotii	Euphorbiaceae	5	1.53	0.544	5.76	3.65
Solanum torum	Solanaceae	2	0.76	0.064	0.67	0.72

Spondias mombin	Anacardiaceae	17	5.34	0.119	1.27	3.3
Sterculia tragacantha	Sterculiaceae	15	4.58	0.153	1.62	3.1
Treculia africana	Moraceae	3	0.76	0.176	1.86	1.31
Trema guineensis	Ulmaceae	3	0.76	0.061	0.65	0.71
Trema orientalis	Ulmaceae	17	5.34	0.242	2.56	3.95
Vernonia conferta	Compositae	2	0.76	0.145	1.54	1.15

BA – Basal area; RD – Species Relative Density; RDo – Species Relative Dominance; IVI – Importance Value Index

Biodiversity Indices

According to IIRS (2002a and b), biodiversity indices are computed to bring the relative abundance and diversity of species in different ecosystem habitats to comparable scale and the higher the value, the more the species richness. The species richness indices were 10.300 and 5.949 for undisturbed and disturbed forest areas, respectively (Table 5). The results indicated that undisturbed forest area has higher tree species richness than disturbed forest area of the Sakpoba Forest Reserve. This was corroborated by the result of t - test (t - stat = 3.366 > t - critical = 3.183) at $p < 0.05$, which showed that species richness of undisturbed forest area was significantly higher than that of disturbed forest area. The values of the species richness can be compared with the values 7.54-8.20 for Kasyoha-Kitomi forest in Albertine rift, Uganda (Eilu*et al.*, 2004), 10.444 for Afi River Forest Reserve in Nigeria (Aigbe *et al.*, 2014), 10.605 for Oban Forest Reserve (Aigbe and Omokhua, 2015), and 6.92 - 8.64 for Ehor Forest Reserve, Nigeria (Aigbe and Odulami, 2016). Several factors which include anthropogenic activities and soil quality could influence species richness and high species richness can indicate stability of forest environment (Aigbe, 2014).

According to Onyekwelu*et al.*(2005), the use of Shannon-Weiner diversity index to investigate ecosystem diversity have been adopted by manyscientistsand takes into consideration both theevenness and species richness in a plant community. The values of Shannon-Wiener diversity index (H^{l}) for undisturbed and disturbed forest areas were 3.628 and 2.591 respectively (Table 5). The results of t-test (t - stat = 1.483 < t - critical = 3.183) shown that there is no significant difference ($p < 0.05$) in species diversity indices of the two forest areas. The trend is consistent with the report of Nath*et al.*, (2005), that species diversity decreases as the rate of forest degradation increases. The results of Shannon- Wiener diversity Index in the study areas were higher compared to 2.20–2.65 for tropical forests of Kodayar, Western Ghats of southern India (Sundarapandian and Swamy, 2000). More comparable values were reported from humid tropical rainforest region, Nigeria with diversity index values of 3.12, 3.31 and 2.82 in Oluwa, Queen's and Elephant forests, respectively (Onyekwelu *et al.*, 2007). Tree species diversity values in tropical forests of Afi River Forest Reserve in Cross River, Nigeria was reported as 3.827 (Aigbe *et al.*, 2014), while in tropical forests of Oban Forest Reserve in Cross River, Nigeria, the value was given as 3.795 (Aigbe and Omokhua, 2015). The value of the Shannon- Wiener diversity Indices of the two study area is an indication that the forest reserve is still a high biodiversity hotspot and the biological diversity is adequately conserved.

Species Similarity Index

Sorenson's similarity index between undisturbed and disturbed forest areas was 34.88 % (Table 6). This value indicates that there is wide variation in the species composition of the two forest areas. This implies that about 34.88 % of the species in the two areas are similar, which means that undisturbed and disturbed forest areas have low floristic similarity. It has been shown that the lower the species similarity index values, the higher the variation in the species composition of two forest communities. The similarity of species in undisturbed and disturbed forest areas is lower than reports of some tropical rainforest ecosystems in Nigeria. For example, Aigbe *et al*., (2014) reported higher species similarity index of 84 % between Afi River and Oban Forest Reserves, respectively in tropical rainforest ecosystems of Cross River State, Nigeria. Also, Gebreselasse, (2011) reported range of 25% to 39% of similarity indices for some tropical forest ecosystems in Kenya, which is within the range of result from the present study.

Table 5: Summary of the Various Diversity indices computed for Undisturbed and Disturbed Forest Area

Characteristic	Undisturbed Forest Area	Disturbed Forest Area
Species Richness (d)	10.300[a]	5.949[b]
Shannon Wiener Index (H^I)	3.628[a]	2.591[a]
Evenness Index (E)	0.890[a]	0.762[a]

Means (rows) followed by different superscripts are significantly different at 0.05 level of significance.

Table 6: Sorenson's Index of Undisturbed and Disturbed Forest Area

Site	Undisturbed Forest Area	Disturbed Forest Area
Undisturbed Forest Area	-	34.88
Disturbed Forest Area	34.88	-

CONCLUSION

The results of this research indicate that the undisturbed area of Sakpoba Forest Reserve is stable while the disturbed area is relatively unstable. With a population of 1026 and 319 trees per hectare for undisturbed and disturbed areas of Sakpoba Forest Reserve shows the reserve is dynamic. The results of the values of mean basal area per hectare for undisturbed area is an evidence of fully stocked forest but the reverse is the case for disturbed area of the reserve. The high species richness and diversity in tree species of the study area does not correlate well with the abundance because the abundance of majority of the tree species were quite low and density poor. Some tree species encountered translates to two stands per hectare. With presence of economically viable timber species, hence urgent steps should be taken to protect these timber species from environmental, biodiversity and sustainable management perspective. Timber resources exploitation needs to be significantly reduced to let the forest regenerate itself.

REFERENCES

Adekunle V.A.J., Akindele S.O. and Fuwape J.A. (2004): Structure and yield models of tropical lowland rainforest ecosystem of southwest Nigeria, Food, Agriculture and Environment 2 (2) 395-399.

Adekunle V.A.J., Olagoke A.O. and Ogundare L.F. (2013): Logging impacts in tropical lowland humid forest on tree species diversity and environmental conservation. Applied Ecology and Environmental Research, 11(3): 491 – 511.

Aigbe H. I. (2014): Development of diameter distribution models and tree volume equations for Afi River and Oban Forest Reserves, Nigeria. Ph.D thesis (unpublished), Federal University of Technology, Akure.

Aigbe H.I., Akindele S.O., Onyekwelu J, C. (2014): Tree Species Diversity and Density Pattern In Afi River Forest Reserve, Nigeria. International Journal of scientific & Technology Research, 3(10):178 -185.

Aigbe H. I. and Odulami S. S. (2016): Tree diversity status and abundance in Ehor Tropical Forest Reserve, Edo State, Nigeria. Journal of Research in Forestry, Wildlife & Environment Vol. 8(3): 97 – 107.

Aigbe. H. I and Omokhua G. E. (2015): Tree composition and diversity in Oban Forest Reserve, Nigeria. Journal of Agricultural Studies 3(1) 10-24. Doi: 105296/jas.v311.6461.

Alder D. and Abayomi J. O. (1994): Assessment of data requirement for sustained yield calculations unpublished report prepare for the Nigeria Tropical Action Programme FORMECU, Federal Department of Forestry, Ibadan Nigeria. 28p.

Baishya, R., Barik S. K. and Upadhaya K. (2009): Distribution pattern of aboveground biomass in natural and plantation forests of humid tropics in northeast India. Tropical Ecology 50: 295-304.

Baithalu, S., Anbarashan M. and Parthasarathy N.. (2013): Two-decadal changes in forest structure and tree diversity in a tropical dry evergreen forest on the Coromandel Coast of India. Tropical Ecology 54: 397-403.

Brashears M. B., Fajvan M. A and Schuler T. M (2004): An assessment of canopy stratification and tree species diversity, following clear cutting in the central Appalachian hardwoods, Forest Science, 50:54-64.

Campbell, D. G., Daly D. C., Prance G. T. and MacielU. N. (1986): Quantitative ecological inventory of Terra firma and the Varzea

tropical forest on the Rio Xingu, Brazilian Amazon. Brittanica,38, 369–393.

Eilu. G., Hafashimana D.L.N. and Kasenene J.M. (2004): Density and species diversity of trees in four tropical forests of the Albertine rift, Western Uganda. Diversity and Distribution. Vol. 10. P. 303-312.

en-Climate data. (2015): Ehor - climatedata.org./Ambiweb.www.ambiweb.de (assessed in 16/11/2015).

Etigale B. E., Olajide O. and Udo S. E. (2014): Stand structure, density and yield of tree community in Ukpom River Forest Reserve, Cross River State, Nigeria Nature ad Science 12 (11) 1 – 8.

FORMECU, (1999): Forest Resources Study of Nigeria. Overview revised national report prepared for forestry management evaluation and coordinating unit. Volume one. 108p.

Gebreselasse G. V. (2011): Plant communities' species diversity seedling bank and resprouting in Nandi Forest, Kenya. PhD Thesis, Universitat Koblenz-Landau.

IIRS (Indian Institute of Remote Sensing). (2002a): Biodiversity Characterization at Landscape Level in Western Ghats India Using Satellite Remote Sensing and GIS. Indian Institute of Remote Sensing, National Remote Sensing Agency), Dept. of Space, Dehradun 248001, Uttaranchal.

IIRS (Indian Institute of Remote Sensing). (2002b): Biodiversity Characterization at Landscape Level in North East, India Using Satellite Remote Sensing and GIS. Indian Institute of Remote Sensing, National Remote Sensing Agency), Dept. of Space, Dehradun 248001, Uttaranchal.

Isikhuemen, E.M. (1998). Effect of Intensive and Uncontrolled logging on Treated Ecosystem, M.sc. Thesis, Department of Forestry and Wildlife University of Benin, Benin City. 166p.

Jaffré, T. and Veillon, J. M. (1990). Etude floristique et structurale de deuxforêtsdenseshumides sur rochesultrabasiquesen Nouvelle-Calédonie. Bull. Natl. Hist. Nat., Paris, 12, 243–273.

Kanzaki, M.,Hara M., Yamakura T., Ohkubo T., Tamyra M. N., Sri-Ngernyuan G. K.,Sahunalu P, Teejuntuk S.andBunyavejchewin S. (2004): Forest diversity and dynamism: findings from a large-scale plot network. pp. 474-481. In: E. C. Losos& E. G. Leigh (eds.) The Diversity of Tropical Trees: Background. Chicago University Press, Chicago.

Kumar, R., Gupta S. R., Singh S., Patil P. and Dhadwal V. K. (2011): Spatial distribution of forest biomass using remote sensing and regression models in northern Haryana, India. International Journal of Ecology and Environmental Sciences 37: 37-47.

Lu X. T., Yin .J. X and Tang .J. W (2010): Structure tree species diversity and composition of tropical seasonal rainforest in Xishuangbanna, south-west China Journal of Tropical Forest Science. 22:260-270

Maguran A.E (2004): Measuring biological diversity, Blackwell,Oxford UK. 3:18-27.

Nath, P.C., Arunachalam, A. Khan, M.L., Arunachalam, K. and Barbhuiya, A.R., (2005): Vegetation analysis and tree population structure of tropical wet evergreen forests in and around Namdapha National Park, northeast India. Biodiversity and Conservation 14, 2109–2136.

Onyekwelu, J.C., Adekunle, V.A.J., Adeduntan, S.A. (2005): Does Tropical Rainforest Ecosystem Possess the Ability to Recover from Severe Degradation? – In: Sustainable Forest Management In Nigeria: Lessons and Prospects. Popoola, L., Mfon, P., Oni, P.I. (eds) Proceeding of the 30th Annual Conference of the Forestry Association of Nigeria, Kaduna, Nigeria. 07th -11th Nov. 2005, pp. 145-163.

Onyekwelu J. C., Mosandl R. and Stimm B. (2007): Tree species diversity and soil status of two natural forest ecosystems in lowland humid tropical rainforest region of Nigeria. Tropentag 2007. University of Kassel-Witzenhausen and university of Gottingen, October 9 – 11. Conference of International Agricultural Research Development.

Onyekwelu, J.C., Mosandl, R. and Stimm, B (2008): Tree species diversity and soil status of primary and degraded tropical rainforest ecosystems in South-Western Nigeria. Journal of Tropical Forest Science, 20 (3): 193 – 204.

Rajkumar, M. and Parthasarathy .N. (2008): Tree diversity and structure of Andaman giant evergreen forests in India. Taiwania53: 356-368.

Richards, P. W. (1996): The tropical rainforest: an ecological study. 2nd edition.Cambridge University Press, London.

Sidiyasa, K. (2001): Tree Diversity in the Rain Forest of Kalimantan. The Tropenbos Foundation, Wageningen, the Netherlands.

Sundarapandian, S. M. and Swamy, P. S. (2000). Forest ecosystem structure and composition along an altitudinal gradient in the Western Ghats, South India. Journal of Tropical Forest Science.12, 104–123.

Shukla, R. P. and Pandey S. K. (2000): Plant diversity and community features of the forested landscape adjacent to foot-hills of Central Himalyas. pp. 15-37. In: S. C. Tiwari & P. P. Dabral (eds.) Natural Resources, Conservation and Management for Mountain Development.International Book Distributor, Dehradun.

Thapa, N., Upadhaya K. Baishya R. and Barik S. K. (2011): Effect of plantation on plant diversity and soil status of tropical forest ecosystems in Meghalaya, northeast India. International Journal of Ecology and Environmental Sciences 37: 61-73.

Yang, K. C., Lin J. K. Hsieh C. F.,. Huang C. L, Chang Y. M., Kuan L. H., Su J. F. and Chiu S. T. (2008): Vegetation pattern and woody species composition of a broad-leaved forest at the upstream basin of Nantzuhsienhsi in mid-southern Taiwan.Taiwania 53: 325-337.