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Tree species composition, diversity and structure of Finima Nature Park, Bonny Island, Nigeria

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Key words: Finima nature park, Forest structure, Tree species composition, Diversity

Abstract

This study evaluated the tree species composition, diversity and structure of Finima Nature Park, to ascertain its status and provide essential information that could enhance sustainable management of the Park. Random sampling was used to delineate 30 sample plots of 30x30 m size. All tree species≥ 10cm diameter at breast height (dbh) were identified to species level and enumerated. Total tree height and dbh were measured using clinometer and diameter tape, respectively. Shanon-Weiner and Simpson's indices were used to assess tree species diversity. Importance Value Index (IVI) and forest structure were estimated; data were analysed using descriptive statistics. A total of 52 tree species from 27 families were Identified; *Anthostema aubryanum*, and the Euphorbiaceae family, dominated the Park; *Alchornea cordifolia* and Cecropiaceae were the least encountered species and family, respectively. Low population density of many tree species and high percentage of low diameter class tree species were recorded. No tree with diameter above 90cm was encountered in the Park. Shanon-Weiner and Simpson's index values were 3.10 and 0.93, respectively. Finima Nature Park showed high species diversity and good regeneration potentials. However, there is the need to apprehend the low population density of many tree species and initiate plans to enhance their populations. Illegal logging should be checked and the protection of the Park enhanced to encourage the growth of tree species to larger diameter classes.

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Introduction

The roles of forest ecosystem in our world today cannot be over emphasized as they range from provision of regulatory services such as erosion control, water quality improvement, global warming mitigation, to provision of goods such as food, raw materials for pharmaceutical industries, pulp and paper industries and many other benefits.

The Millennium Ecosystem Assessment (2005) classified the roles of forest ecosystem into four distinct categories of: Provisioning, Regulating, Supporting and Cultural roles. Provisioning in terms of goods like timber, fodder; regulating – such as climate and flooding; supporting- such as pollination and pest control for food production; and cultural- in terms of recreation and spiritual engagements.

In view of the fact that forest ecosystem provides vast array of goods and services, understanding its status, in terms of composition, diversity, pattern and changes over time becomes imperative, especially in this era of high rate of forest ecosystem degradation.

Researches such as FAO (2005) and Adekunle *et al.* (2010) have reported high rate of forest ecosystem degradation mostly in developing countries, and these were attributed to high rate of indiscriminate logging in most reserves, human population explosion, poverty, hunger, weak forest policies, waning manpower and capacity in forestry departments. According to FAO (2005), developing countries have lost over half of their primary forest in the last 5 years and are recorded as the world's highest deforestation rate of primary forests. Between 2000 and 2005, FAO (2006) enlisted Nigeria among the 10 countries of the world with largest annual net loss in forest area. Adekunle *et al.* (2014) revealed that inadequate facilities for forest patrol, the stoppage of the payment of annual percentage to rural communities, and outdated forestry laws and regulations were the major factors that have contributed to the high rate of forest degradation in the Nigeria presently. Forest ecosystem degradation undoubtedly have series of negative impacts on ecosystem functioning and stability which directly and indirectly impact negatively on the environment and human survival. According to Jimoh *et al.* (2012), once a stable ecosystem is disturbed or destroyed, it is ecologically and economically very difficult to repair and rehabilitate; hence, there is the need to frequently monitor the status of forest ecosystem for its function and sustainability.

According to Horak *et al.* (2019) and LaRue *et al.* (2019) forest structure could be an important indicator of the forest biodiversity, productivity and sustainability; thus, its assessment is fundamental in many forest ecological studies and ecosystem management. It generally refers to the distribution and arrangement of different plant species and sizes and could be assessed by the frequency distributions of tree characteristics such as tree stem diameter, tree basal area and tree height, or by the stem density per hectare (Djomo, 2015; Clark *et al.,* 2019).

However, understanding of forest structure enhances the understanding of the history, pattern, function, interaction and future of a forest ecosystem (Franklin *et al.,* 2002). It is therefore pertinent to regularly study forest structure, in order to understand the attributes of forest community and provide the implications for forest protection and management (Franklin *et al.,* 2002). However, poor information on forest structure, composition and diversity will certainly affect forest management, functions and sustainability. Therefore, assessment of tree species composition, diversity and structure of Finima Nature Park, the only relic of natural forest in Bonny Island is pertinent in providing baseline information on the tree species composition, distribution, regeneration potentials, stability and ecosystem functions that will help to strengthen future management. Thus, this study evaluated the tree species composition, diversity and structure of FNP with a view to providing baseline information and a framework to facilitate effective sustainable management interventions for the forest.

Materials and methods

Study Area

The study was carried out in Finima Nature Park (FNP) Bonny Island, Rivers State. It is located within latitude 4°22'49" and 4°23'53" and longitude7°8'40" and 7°12'17". FNP remains the only relic of the natural forest and a refugium for biodiversity in Bonny Island where the Nigerian Liquefied Natural Gas (NLNG) Company is situated. It was established in the year 1999 by the NLNG Limited in order to safeguard the forest for its integrity and rich biodiversity. The Park which covers 1000 hectares, cuts across mangrove and fresh water habitats (Fig. 1), and is known to be home to many wildlife and plant species of conservation value (NCF, 2016).

The mean annual rainfall of the park is 3200mm while the relative humidity is about 65% in the dry season and 98% in the wet season, average temperature range is 26°C-32°C (NCF 2016).

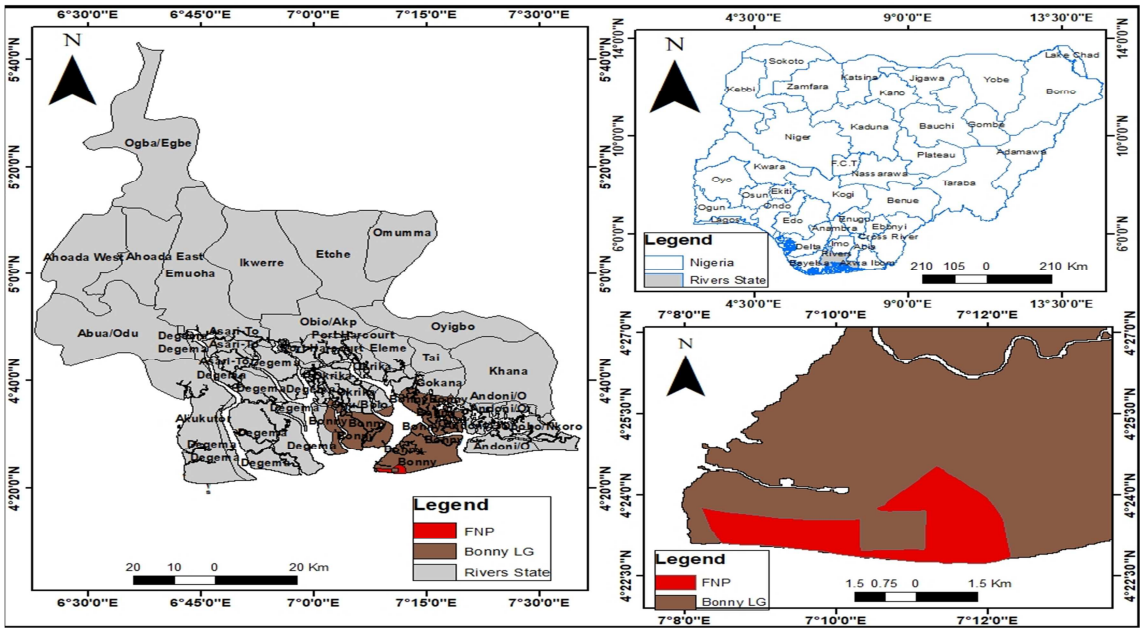

Fig.1. Map showing the study area (FNP).

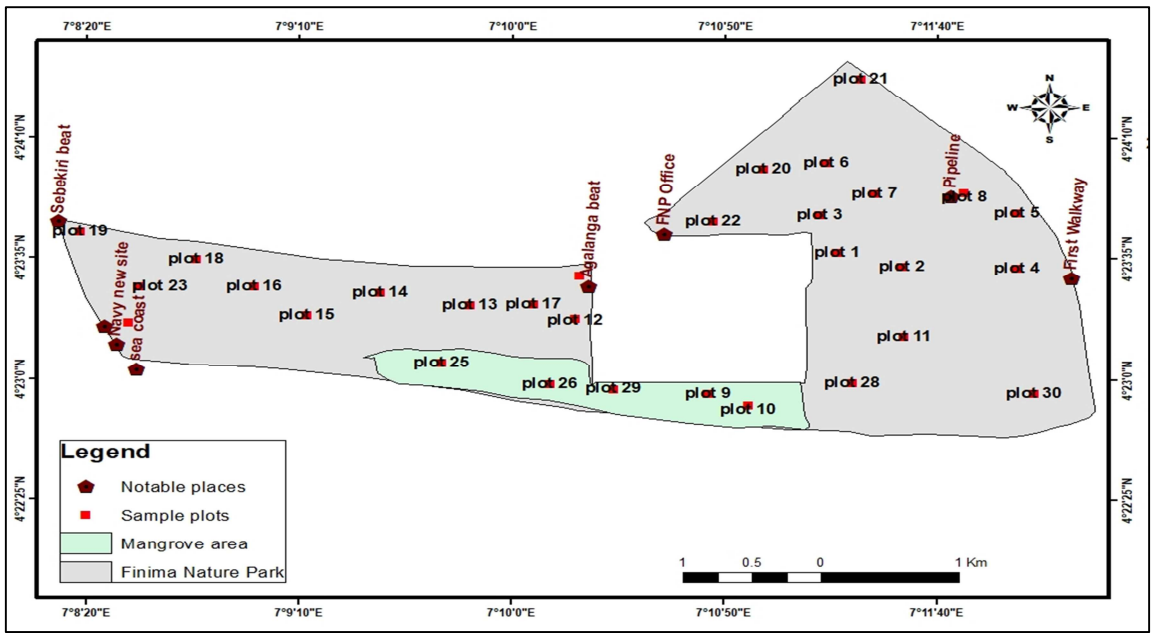

Fig. 2. Map of the study area showing the sample plots distribution.

Sampling and Data Collection

Random sampling technique was used to demarcate 30 sample plots of 30x30m size. In each plot, identification and enumeration were limited to all trees with diameter at breast height (dbh) ≥ 10cm. Tree height and diameter at the breast height, were measured using clinometers and diameter tape respectively. Fig. 2 below shows the distribution of the 30 sampled plots.

Data Analysis

The vertical structure of the Park was analysed by grouping all the trees enumerated into different height classes of under storey (1-10m), lower stratum (11-20m), middle stratum (21-30m), upper stratum (31–40m), and emergent stratum (>40m) (Hall *et al.*, 2003). Dbh was grouped into different class sizes to show the spatial distribution of the plant components. The IUCN Red List of Threatened Species version 2022.1 was used to compile the status of the identified tree species in the Park. Shannon-Weiner and Simpson's indices were used to analyse the diversity of tree species in the park using the equations described below:

- Shannon-Weiner diversity index (H)

$$H = -\sum_{i=1}^{s} p_i \ln p_i \ldots.(1)$$

Where: H' = Shannon-Weiner diversity index, S = Total number of species in the community; P_i = Proportion of S made up of the i^{th} species, ln = natural logarithm.

- Pielou's species evenness index (EH):

$$E_H = \frac{H}{lnS} \ldots\ldots\ldots(2)$$

- Simpson's index of diversity (1-D)

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right) \ldots\ldots(3)$$

Where n = is the total number of organisms of a particular species and N is the total number of individual species.

- The basal area (BA) of the tree stems of each species in the sampled plots was computed using the following equation:

$$BA = \frac{\pi d^2}{4} \ldots\ldots\ldots(4)$$

Where BA = basal area (m^2), π = 3.143, d = diameter (m)
The average BA per plot was scaled to per hectare basis using a scaling factor of (11.11) which is the equivalent number of sample plots in a hectare.

- Species relative density was computed with the equation of (Brashears *et al.* 2004):

$$RD = \left(\frac{n_i}{N}\right)X100 \ldots\ldots (5)$$

Where RD (%) is the species relative density, n_i is the number of individuals of species i and N is the total number of all individual trees.

- Relative dominance (RDo%) was estimated using the Equation below:

$$RD_o = \frac{(\sum Ba_i X100)}{\sum Ba_n} \ldots\ldots (6)$$

Where Ba_i is the basal area of all individual trees belonging to a particular species i; Ba_n is the stand basal area.

- The Species Importance Value Index (SIVI) expresses the share of each species' in the tree community (Rajkumar and Parthasarathy, 2008). It was assessed using equation... according to (Brashears *et al.* 2004):

$$SIVI = \frac{RD+RD_o}{2} \ldots\ldots\ldots (7)$$

$$FIVI = \frac{RD+RD_o}{2} \ldots\ldots\ldots(8)$$

Where RD = the family relative density
RD_o = family relative dominance

Results

One thousand six hundred and ninety six (1696) tree species in twenty seven families were enumerated in the park Table 1. The most abundant tree species were *Anthostema aubryanum* (302), *Rhizophora racemosa* (170), *Alstonei boonei* (118) and *Spondianthus preussii* (100) while the rarest tree species were *Pauridiantha afzelii* (1), *Uapaca*

staudtii (1) and *Alchornea cordifolia* (1) among others. *Albizia zygia* (19.53m), *Erythrophleum ivorense* (19.7m), *Sacoglottis gabonensis* (18.75m) has the highest mean height while *Uapaca staudtii* (3.56m), *Pandanus tectorius* (6.19m) and *Baphia nitida* (6.24m) has the least mean height respectively. The highest mean dbh were also recorded in *Erythrophleum ivorense* (49.24cm), *Sacoglottis gabonensis* (36.75cm), *Albizia adianthifolia* (36.20cm) and *Pierreodendron africanum* (35.55cm). While the least mean dbh were recorded in *Uapaca staudtii* (10.00cm), *Ouratea calophylla* (11.80cm), *Baphia nitida* (12.00cm) and *Laccosperma secundiflorum* (12.50cm) respectively.

The sum of basal area of individual tree species shows that *Anthostema aubryanum* has the highest value of basal area (110.64m²/ha)) in the park, followed by *Elaeis guineensis* (102.53m²/ha), *Rhizophora racemosa* (95.74m²/ha), *Pierreodendron africanum* (88.59m²/ha), while *Uapaca staudtii*, *Baphia nitida*, *Laccosperma secundiflorum* and *Alchornea cordifolia* has the least basal area of 0.01m² each respectively. SIVI results revealed that *Anthostema aubryanum*, *Rhizophora racemosa*, *Elaeis guineensis* were the most diverse and abundant tree species contributing 14.59%, 10.02% and 7.98% to the entire tree species population respectively, while *Uapaca staudti, Baphia nitida* and *Alchornea cordifolia* has least contribution of 0.03%, 0.04% and 0.04% respectively. Out of the 52 tree species enumerated in the park, 45 were categorized as Least Concern (LC) in the International Union for Conservation of Nature (IUCN) Red List of threatened species, two species were in the class of Vulnerable (VU), three (3) were Near Threatened while two species were Not Available (NA) in the Red List.

Fig. 2 shows the family distribution of individual tree species, Euphorbiaceae family dominated the park (511), followed by Apocyniaceae (207) and Rhizophoracea (170), while Cecropiaceae (1), Papilionaceae (1) and Pandanaceae (1) have the lowest population density in the park. In other words, Euphorbiaceae family has the highest FIVI contributing 25.27% to the entire tree species population in the park whereas Papilionaceae contributed 0.04%. Furthermore, Euphorbiaceae contributed highest to the basal area in the park (198.65m²/ha, while Pandanaceae and Papilionaceae (0.11m²/ha 0.78m³/ha) contributed smallest amount to the basal area in the park table 2.

Table 3 shows that the value of Shannon-Wiener Index (H) recorded was 3.10; Simpson's Index (D) 0.93, while relative dominance and Evenness were 0.07 and 0.43, respectively. However, table 4 highlighted the diversity of tree species per plot, and revealed that plot number 15 and 30 were most diverse with Shannonn index (2.47; 2.37 and Simpson index 0.90; 0.88) respectively while plots 25 had the least diversity value of 0.18 and 0.08 for Shannonn and Simpson index respectively.

It was observed that the higher the diversity values the lower the dominance; plot 15 had the least dominance value (0.10) while plot 25 had the highest dominance value (0.92).

However, plot number 22 contributed most to the basal area (57.33m²/ha) recorded in the park while plot 9 contributed least to the total basal area (8.00 m²/ha) obtained in the park respectively.

The vertical structure of the park was assessed in terms of height distribution. Fig. 3 & 4 reveals that the highest tree species frequency (881) occurred in the height class of 11-20m, followed by height class of 1-10m (616) while the least was in the height class of 41-50m (5). The population of the tree species in the lower stratum (1-10m) and middle stratum (11-20) were high when compared with the upper (21-30m) and emergent layers (>40m). The horizontal structure of the park was also assessed in terms of Dbh distribution. Dbh class of 11-20cm (789) has the highest number of tree species, followed by dbh class of 21-30cm (434), while the dbh class of 81-91cm and 71-81 have the least tree species of 1 and 8 respectively (Fig. 4).

Table 1. Tree species composition, importance value index and structural characteristics

Family	Tree Species	Freq	Mean Ht (m)	Mean dbh (cm)	BA m²/ha	% RD	% RDo	% SIV	IUCN Status
Annonaceae	*Cleistopholis patens*	80	16.67	22.69	45.9	4.72	4.72	4.72	LC
	Monodora myristica	5	6.43	16.67	1.38	0.29	0.14	0.22	LC
	Uvariodendron occidentale	2	13.32	14.75	0.41	0.12	0.04	0.08	VU
	Xylopia aethiopica	27	14.41	18.85	9.69	1.59	1	1.29	LC
Apocynaceae	*Alstonia boonei*	118	14.26	25.81	85.16	6.96	8.76	7.86	LC
	Funtumia africana	78	15.84	21.87	40.12	4.6	4.12	4.36	LC
	Rauvolfia vomitoria	6	13.58	15.88	1.37	0.35	0.14	0.25	LC
	Rauvolfia caffra	3	9.65	12.67	0.42	0.18	0.04	0.11	LC
Arecaceae	*Elaeis guineensis*	92	15.57	35.32	102.53	5.42	10.54	7.98	LC
	Laccosperma secundiflorum	1	12.96	12.5	0.14	0.06	0.01	0.04	LC
	Raphia hookeri	10	9.65	29.62	7.75	0.59	0.8	0.69	LC
Avicenniaceae	*Avicennia germinans*	73	12.27	20.99	31.18	4.3	3.21	3.75	LC
Burseraceae	*Dacryodes edulis*	4	10.41	14.58	0.79	0.24	0.08	0.16	LC
Cecropiaceae	*Musanga cecropioides*	1	7.99	28.5	0.71	0.06	0.07	0.07	LC
Chrysobalanaceae	*Chrysobalanus orbicularis*	67	13.88	23.82	40.54	3.95	4.17	4.06	LC
	Chrysobalanus icaco	17	15.69	25.11	10.77	1	1.11	1.05	LC
Combretaceae	*Laguncularia racemosa*	12	8.29	23.38	6.83	0.71	0.7	0.71	LC
Ericaceae	*Calluna vulgaris*	7	15.39	18.09	2.21	0.41	0.23	0.32	LC
Euphorbiaceae	*Alchornea cordifolia*	1	7.13	13.1	0.15	0.06	0.02	0.04	LC
	Anthostema aubryanum	302	12.59	18.64	110.64	17.81	11.38	14.59	LC
	Hevea brasiliensis	28	14.88	17.03	9.52	1.65	0.98	1.31	LC
	Macaranga barteri	52	12.11	18.98	18.29	3.07	1.88	2.47	LC
	Spondianthus preussii	100	12.7	21.33	51.09	5.9	5.25	5.57	LC
	Uapaca guineensis	28	14.78	18.25	9.09	1.65	0.93	1.29	LC
	Uapaca staudtii	1	3.56	10	0.09	0.06	0.01	0.03	LC
Fabaceae	*Albizia adianthifolia*	5	17.75	36.2	6.06	0.29	0.62	0.46	LC
	Albizia zygia	5	19.53	31.7	4.78	0.29	0.49	0.39	LC
	Erythrophleum ivorense	11	19.7	49.24	25.83	0.65	2.66	1.65	LC
	Parkia bicolor	19	14.74	26.69	18.06	1.12	1.86	1.49	LC
Guttiferae	*Symphonia globulifera*	12	15.78	18.9	4.13	0.71	0.43	0.57	LC
Humiriaceae	*Sacoglottis gabonensis*	4	18.75	36.75	5.52	0.24	0.57	0.4	LC
Irvingiaceae	*Klainedoxa gabonensis*	7	12.31	30.3	7.67	0.41	0.79	0.6	LC
Lamiaceae	*Vitex doniana*	9	14.84	28.28	8.34	0.53	0.86	0.69	LC
Loganiaceae	*Anthocleista djalonensis*	2	14.47	23.75	0.99	0.12	0.1	0.11	LC
	Anthocleista vogelii	75	13.84	20.53	33.66	4.42	3.46	3.94	LC
Moraceae	*Ficus spp*	20	18.19	28.88	18.58	1.18	1.91	1.54	LC
Myristicaceae	*Pycnanthus angolensis*	6	7.5	13.7	1.08	0.35	0.11	0.23	LC
Myrtaceae	*Syzygium cumini*	13	17.02	24.92	8.72	0.77	0.9	0.83	LC
Ochnaceae	*Lophira alata*	6	8.97	13.05	0.91	0.35	0.09	0.22	VU
	Ouratea calophylla	2	9.89	11.8	0.25	0.12	0.03	0.07	NA
Pandanaceae	*Pandanus tectorius*	1	6.19	13.1	0.15	0.06	0.02	0.04	LC
Papilionaceae	*Baphia nitida*	1	6.24	12	0.13	0.06	0.01	0.04	LC
Passifloraceae	*Barteria nigritana*	9	13.92	17	2.6	0.53	0.27	0.4	LC
Rhizophoraceae	*Rhizophora racemosa*	170	13.11	24.12	95.74	10.02	9.84	9.93	LC
Rubiaceae	*Massularia acuminata*	2	14.05	25.5	1.14	0.12	0.12	0.12	LC
	Mitragyna ciliata	39	13.89	19.74	15.97	2.3	1.64	1.97	NT
	Mitragyna stipulosa	38	13.89	19.03	16	2.24	1.64	1.94	NT
	Nauclea diderrichii	21	14.88	21.41	9.01	1.24	0.93	1.08	NT
	Pauridiantha afzelii	1	17.68	26	0.59	0.06	0.06	0.06	LC
	Rothmannia whitfieldii	29	8.45	13.89	5.29	1.71	0.54	1.13	LC
Sapotaceae	*Bequaertiodendron magalismontanum*	11	13	22.13	6.18	0.65	0.64	0.64	LC
Simaroubaceae	*Pierreodendron africanum*	63	15.94	35.55	88.59	3.71	9.11	6.41	NA

Table 2. Family composition, importance value and structural characteristics

SN	Family	Freq.	BA(m²/ha)	%RD	%RDo	%FIVI
1	Annonaceae	4	57.33	6.72	5.90	6.31
2	Apocynaceae	4	127.10	12.09	13.06	12.58
3	Arecaceae	3	110.43	6.07	11.35	8.71
4	Avicenniaceae	1	31.22	4.30	3.21	3.75
5	Burseraceae	1	0.78	0.24	0.08	0.16
6	Cecropiaceae	1	0.67	0.06	0.07	0.07
7	Chrysobalanaceae	2	51.33	4.95	5.28	5.11
8	Combretaceae	1	6.78	0.71	0.70	0.70
9	Ericaceae	1	2.22	0.41	0.23	0.32
10	Euphorbiaceae	7	198.65	30.13	20.42	25.27
11	Fabaceae	4	54.77	2.36	5.63	3.99
12	Guttiferae	1	4.11	0.71	0.43	0.57

SN	Family	Freq.	BA(m²/ha)	%RD	%RDo	%FIVI
13	Humiriaceae	1	5.56	0.24	0.57	0.40
14	Irvingiaceae	1	7.67	0.41	0.79	0.60
15	Lamiaceae	1	8.33	0.53	0.86	0.69
16	Loganiaceae	2	34.66	4.54	3.56	4.05
17	Moraceae	1	18.55	1.18	1.91	1.54
18	Myristicaceae	1	1.11	0.35	0.11	0.23
19	Myrtaceae	1	8.67	0.77	0.90	0.83
20	Ochnaceae	2	1.11	0.47	0.12	0.30
21	Pandanaceae	1	0.11	0.06	0.02	0.04
22	Papilionaceae	1	0.11	0.06	0.01	0.04
23	Passifloraceae	1	2.56	0.53	0.27	0.40
24	Rhizophoraceae	1	95.77	10.02	9.84	9.93
25	Rubiaceae	6	48.22	7.72	4.96	6.34
26	Sapotaceae	1	6.22	0.65	0.64	0.64
27	Simaroubaceae	1	88.55	3.71	9.11	6.41

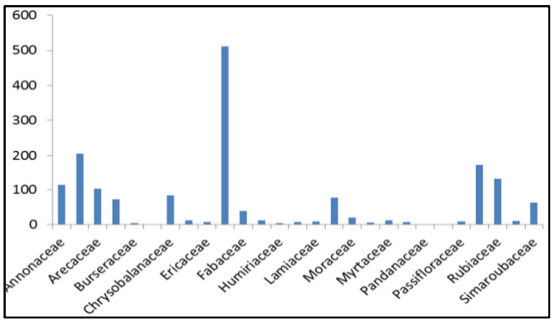

Fig. 3. Family distribution of species populations

Table 3. Summary of tree species diversity indices for FNP.

Biodiversity Indices	FNP
Species richness	52
Individuals	1696
Family richness	27
Dominance_D	0.07
Simpson_1-D	0.93
Shannon_H	3.10
Evenness_e^H/S	0.43

Table 4. Species diversity per plot

Plot	Spp richness	Spp pop.	Dominance	Simpson index	Shannon index	BA (m²/ha)
1	7	42	0.27	0.73	1.55	26.22
2	11	35	0.17	0.83	2.05	23.33
3	13	65	0.24	0.76	1.92	23.22
4	12	43	0.17	0.83	2.08	35.12
5	6	51	0.25	0.75	1.57	17.66
6	8	71	0.37	0.63	1.27	34.33
7	12	98	0.33	0.67	1.47	51.55
8	9	63	0.21	0.79	1.84	34.89
9	2	21	0.59	0.41	0.60	8.00
10	2	47	0.67	0.34	0.52	20.78
11	7	56	0.34	0.66	1.40	40.22
12	11	29	0.12	0.88	2.22	22.44
13	11	51	0.28	0.72	1.69	37.61
14	7	27	0.33	0.67	1.43	30.77
15	16	61	0.10	0.90	2.47	30.10
16	13	50	0.19	0.81	2.03	30.22
17	10	74	0.19	0.81	1.85	29.77
18	14	56	0.18	0.82	2.11	35.55
19	8	77	0.60	0.40	0.95	41.22
20	14	56	0.17	0.83	2.23	24.44
21	6	46	0.57	0.43	0.95	19.89
22	10	69	0.23	0.77	1.78	57.33
23	10	57	0.18	0.82	1.94	51.77
24	6	37	0.31	0.69	1.42	22.89
25	2	46	0.92	0.08	0.18	18.11
26	2	60	0.91	0.10	0.20	40.33
27	7	109	0.80	0.21	0.52	37.11
28	4	82	0.80	0.20	0.44	57.11
29	3	81	0.80	0.20	0.43	46.55
30	15	36	0.13	0.88	2.37	24.11
Av/ha						32.42

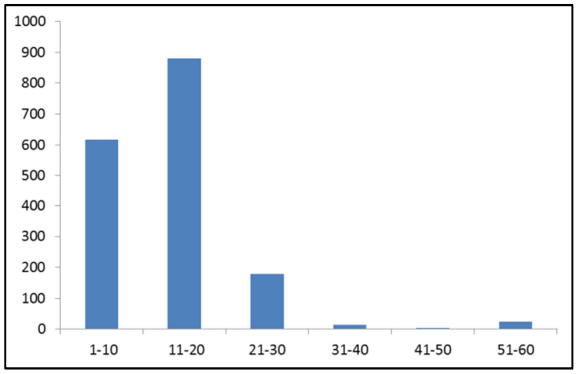

Fig. 4. Height (m) distribution of tree populations

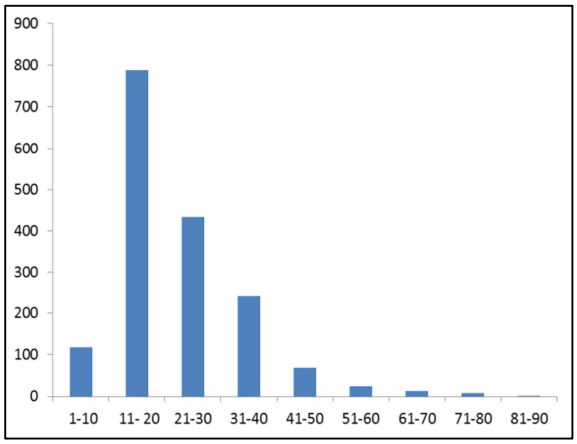

Fig. 5. Diameter (cm) distribution of tree populations

Discussion

The species richness and population recorded were high compared with what was recorded by Igu (2017), who reported 39 forest tree species from 19 families within freshwater swamp forest, Agbawa and Chimezie (2020) recorded 90 plant species (26 trees, 14 shrubs and 54 herbs) from 40 families. However, recent reports by Chowdhury *et al.* (2000) revealed that the range of the number of species in tropical forests is from 38 species to 123 species, hence 52 tree species recorded in FNP falls within what is plausible in the tropical forest.

The most dominant families and tree species in FNP corroborated the findings of Agbagwa and Chimezie 2020; and Igu 2017, who found that freshwater habitat of Niger Delta Nigeria are dominated by few specific families such as the Euphorbiaceae, Apocynaceae and rarest in Papilionaceae and Cecropiaceae with *Anthostema aubryanum*, *Rhizophora racemosa* and *Alstonia boonei* the commonest species while *Musangace cropioides* and *Alchornea cordifolia* were among the rarest tree species. The IUCN Red List Categories and Criteria have been accepted globally as the most ideal and reliable system for appraising the status of global risk of extinction for species; with the aim of providing a precise and objective framework for the classification of the broadest collection of species according to their extinction risk (Mace *et al.*, 2008 and Rodrigues *et al.* 2006). They classified species into Not Evaluated (NE); Data Deficient (DD); Least Concern (LC); Near Threatened (NT); Vulnerable (VU); Endangered (EN); Critically Endangered (CE); Extinct in the Wild (EW) and Extinct (Ex). They highlight those species that are facing a high risk of global extinction. However some Vulnerable and threatened tree species under the IUCN Red List of threatened tree species were found in Finima Nature Park, among which are *Uvariodendron occidentale*; *Lophira alata*; *Nauclea diderrichii* etc, hence the sustainability of these threatened species are encouraged.

The high values of diversity indices recorded in the park are indicative of high tree species diversity in the Park and a sign of a balanced forest ecosystem (Ojo 2004). The value of Shannon-Wiener Index (3.10) obtained in the park is higher than Akopi Forest (1.185–1.521) in Benue State (Chenge *et al*, 2020) and less than Oban Forest Reserve (3.79) in Southeastern of Nigeria (Jimoh *et al.*. 2012). The high diversity of tree species evaluated in the park is in line with the findings of Agbagwa and Chimezie (2011) in freshwater swamp forest; however, it disagrees with the report of Igu (2017) in Freshwater swamp forest of Niger Delta. There was unequal distribution of tree species diversity and abundance across the sampled plots, this could be as a result of physical, chemical and biological factors, as (Hughes *et al.*, 1996; Westgate *et al.*, 2014) had revealed that species distributions and population sizes are dependent on the above factors mentioned. Also, Guisan and Thuiller (2005) reported temperature, moisture and availability of macro- and micronutrients as the abiotic factors that regulate species distribution while Chong *et al.* (2015) recorded intra- and interspecific interactions, life history traits, and demography as the biotic factors that determine species distribution.

The mean basal area per hectare obtained in the park was higher than 22.54m²/ha reported by Adekunle *et al.* (2013) in a Nigeria Strict Nature Reserve Ondo State, but lower when compared with other tropical rainforest such as Addo-Fordjour *et al.* (2009) that recorded BA of 54.2m²/ha in a secondary rainforest, 41.6m2/ha recorded in close-canopy forest of Oban Division of Cross River National Park. The mean basal area per hectare obtained in the park is also within the range of a recommended mean basal area per hectare (25 $m^2 ha^{-1}$) of a fully stocked forest according to (Alder and Abayomi 1994). In other words, FNP is well stocked with abundance of small diameter trees.

The vertical pattern and horizontal structure of the park as shown by the height and diameter distributions show the presence of representative tree species stands for each population size class. There were more trees at the diameter and height classes of 21-30 and the populations of the lower and middle layers were high when compared with the upper and emergent layers. In other words, Finima Nature Park is dominated by lower canopy trees. Similar findings were reported in Freshwater swamp habitat in Niger Delta (Igu 2017); Tanzanian tropical forests (Huang *et al.*, 2003) and tropical rainforest of China (Lu *et al.*, 2010). The abundance of seedlings, saplings, young trees in any forest ecosystem according to Saxena and Singh 1984) portrays good regeneration behavior of that forest ecosystem. The horizontal structure showed a reversed J-shaped curve, which indicates the presence of few stems at higher diameter classes and abundant stems at lower diameter classes. This is a typical characteristic of stable or equilibrium condition of a natural forest ecosystem (Husch *et al.*, 2003). There was only one tree species within the 80-90cm diameter class, and none above 90cm; this could be attributed to the habitat terrain and the nature of the tree species in the forest. Hadi *et al.* (2009) and Jimoh *et al.* (2012) reported that presence of few species with larger stem diameter is attributed to limited number of species that naturally grow up to larger diameter. And shallow soil depth and frequent flooding in freshwater swamp region discourages the presence of trees with larger diameter (Igu 2017). It could also be an indication of illegal logging activities as Chenge *et al* (2020) suggested that absence of dbh>80cm in a natural forest is an indication of logging activities. The absence of large diameter could affect the productivity, diversity and aboveground biomass of the park as Bradford & Murphy (2019) revealed.

Conclusion and recommendation

This study analyzed the tree species composition, diversity and structure of Finima Nature Park and recorded that the Park has high tree species diversity. A total of 52 tree species from 27 families were identified; *Anthostema aubryanum*, and the Euphorbiaceae family, dominated the Park; *Alchornea cordifolia* and Cecropiaceae were the least encountered species and family, respectively. There were representative tree species in all the strata. However, more species exist in lower strata. Dbh measured were all below 90cm. SIVI reveals the relative importance of the species in a forest. Many species have as low population density as one, an indication that local extinction of such species is possible in the nearby future. This information will be useful in determining the best management practices for proper functioning and sustainability of the Park and will stand as a baseline for further studies and comparison. However, there is the need to apprehend the low population density of many species and initiate plans to fully stock the forest. Illegal logging should be guided to give room for the occurrence of tree species with larger dbh and protect tree species especially the global threatened species found in the park.

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