ISSN: 2695-2556 (Online)
ISSN: 2651-5679 (Print)

AKSU Journal of Agriculture and Food Sciences 9(1) 1-17, 2025

Density and Regeneration Potentials of Trees in Isolated Tracts of Disturbed Rainforest in the University of Uyo, Nigeria

Atakpa Ikemesit Oscar[1*], Etigale Egor Bassey[1] and Olajide Opeyemi[1]

[1]Department of Forestry and Wildlife, Faculty of Agriculture, University of Uyo, Nigeria
*Corresponding Author's E-mail: atakpaikemesit@gmail.com

Abstract

Rainforest is the most biologically diverse ecosystem and self sustaining natural ecosystem in the world when healthy. The trees are the main determinants of the rainforest and therefore, indiscriminate felling, results in degradation and destruction of the rainforest. Information on stand density and regeneration potentials of trees is crucial for sustainable forest management; hence, it is necessary to estimate the level of degradation before initiating any form of restoration strategies. Thus, the study was designed to determine the density of each species and assess their regeneration potentials in the disturbed rainforests of University of Uyo, Akwa Ibom State, Nigeria, using the combination of systematic and random sampling techniques for data collection. This gave a total of 8000 m^2 for each of the forests for enumeration and identification of adult and juvenile tree species. Two isolated tracts of the degraded rainforests were identified as forests contiguous with the Botanical Garden (Site 1) and former Directorate of Physical Planning Directorate Building (Site 2). Data collected were analysed using statistical analysis. Twenty-five (25) tree species were encountered in site 1 and Twenty-two (22) in site 2. Site 1, recorded Sterculia tragacantha as the highest population with 253 individuals (317 stems/ha), while the least were Dacryodes edulis, Dracaena aborea and Unonopsis stipitata with 3 individuals (4 stems/ha) each. Baphia nitida had the highest basal area of 0.45045 m^2 (0.56306 m^2/ha) while the least was Irvingia gabonensis with 0.00785 m^2 (0.00982 m^2/ha). Regeneration potential was also higher in site 1 with Sterculia tragacantha as the highest (0.3264), and Dracaena arborea as the least with (0.0027). Both disturbed rainforests revealed a scanty representation of trees suggesting low regeneration potentials especially, in site 2. The study recommended enrichment planting *and restrictions in both disturbed rainforests.*

Key words: Sustainable forestry, Forest degradation, Tree density, Regeneration potential index

1.0 Introduction

Rainforest is the most biologically diverse and complex ecosystem in the world that it is essentially self-sustaining when it is healthy (Okekunle, 2021). It remains among the ecosystems on earth that is still in service despite human perturbations (Udofia *et al*., 2015; Byrne *et al*., 2020). Its importance cannot be over-emphasized. Rajwar (2021) describes the rainforest as the earth's thermostat, having the capacity to regulate temperatures and stabilize the climate globally by absorbing greenhouse gases and producing about 20 % of oxygen. The trees are of great determinants of the rainforest as they influence forest microclimate.

Jeje *et al.* (2021) stated that by estimation, the temperature in a city if planted with more trees can be reduced by up to 7ºC. The rainforests are described as the treasure home of biodiversity (WWF, 2015), the largest pharmacy in the world (Olajide and Etigale, 2017; Olajide, 2018) and have been reported to absorb almost 5 billion tons of carbon dioxide yearly which slows the rate of global warming (Olajide and Egor, 2013). Despite the importance of the rainforest, it is being degraded each year by anthropogenic activities. Nigeria ranks the highest in Africa with annual deforestation rate of 4.5 %, representing a loss of about 410,000 ha per annum (FAO, 2015; Nelson *et al*., 2015; Okekunle, 2021). With this estimation, the rainforest should be protected rather than being degraded for short-term income and profit.

Rainforest degradation is the reduction in the capacity of a forest in rendering ecosystem services such as carbon storage and wood products as a result of anthropogenic disturbances (Thompson *et al*., 2013). Forest degradation is caused either by human actions or natural causes. It reduces the diversity of tree species, which in turn, affects the wildlife which depends on them for food and shelter. It may result in the reduction or disappearance in the number of seed dispersal agents, thereby, complicating the regeneration process (Vasquez-Grandon *et al*., 2018). This is why forest degradation is a global concern because when once a forest is degraded, it alters the structure and function of its ecosystem thereby posing serious environmental threat (Alamgir *et al*., 2016), which leads to loss of property and lives**.** To further buttress this point, Atakpa & Atapka (2015) reported that the former President of the United States of America, Barack Obama expressed that climate change was one of the most serious threat facing the United States of America, despite all its sophistication in science, technology and military might.

Tree species density in a forest considers the number and the different types of trees that exist (Falade, 2021). Having many diverse trees in a forest increases tree population and creates a resilient forest. Thus allowing abandoned land to regenerate is the cheapest way to large scale forest recovery (Magnus *et al*., 2019).

Forest regeneration is the basis of sustainable forestry. It is the process whereby the forest is allowed to re-grow or renew either naturally or artificially by the establishment of tree seedlings after the forest has been removed (Chazdon, 2014; Downie *et al.*, 2016). Rainforest regeneration is obtained in the forest through natural, artificial and enrichment planting (Directorate of Forest, 2016; Chazdon *et al.,* 2021). Various factors influence the ability of tree species to regenerate successfully such as seed production, seed germination, seedling establishment, vegetative reproduction, site suitability, and disturbance regime (Burslem *et al*., 2021; Chazdon, 2014).

1.1 Statement of Problem

Trees have seriously undergone different levels of disturbances due to the increase in human population which has led to the harvesting of trees and destruction of the rainforest ecosystem for several purposes such as for timber, infrastructural development, road expansion, agricultural development and many more (Antia-Obong *et al.,* 2024). Unfortunately, these anthropogenic activities have continually disrupted the underlying functions of many tropical rainforests globally (Downie *et al*., 2016). Without effective conservation, Nigeria and the global environment will experience a major impact as a result of any loss of the rainforest including huge impact on biodiversity, abnormal weather condition and other weather related disasters (Rajwar, 2021). Lack of data on tree density and regeneration is a hindrance to sustainable natural forest management in the disturbed forests on the Main Campus of the University of Uyo.

Regeneration of forest tree plays a vital role in determining the future biodiversity, conservation value of the rainforest and achieving global targets on environmental greening (Akpan-Ebe, 2021; Jeje *et al*., 2021). The regeneration potential index (RPI) of a tree species in a natural forest ecosystem expresses its ability to regenerate naturally (Chazdon *et al*., 2021). Understanding RPI of tree species can also contribute to climate change mitigation by promoting the establishment of resilient and adaptive forests capable of sequestering carbon and providing other valuable ecosystem services (Burslem *et al*., 2021).

Thus, information on stand density and regeneration potentials of trees is very important for sustainable forest management (Mbong *et al*., 2020). The data collected in this study will be useful in fashioning out conservation strategies to check degradation of the two isolated tracts of the disturbed rainforest in the University of Uyo Main Campus.

2.0 Materials and Methods

2.1 Study Area

The study was carried out in two isolated tracts of disturbed rainforest on the main campus of the University of Uyo, Akwa Ibom State, Nigeria. The two tracts of the disturbed rainforests are contiguous with the Botanical Garden (Site 1) and the area aroud the former Directorate of Physical Planning Building (Site 2). The study area lies within the rainforest belt of latitudes 4º 03´ N to 5º 08´ N and longitudes 7º 51´ E to 8º 03´ E (Department of Geography and Natural Resources Management, University of Uyo, 2022). (Figure 2.1). The minimum and maximum annual temperatures are 22° C and 30° C respectively (Esiere and Achibong, 2015), while annual relative humidity ranges from 70-86 % (Akpan-Ebe *et al*., 2016). The soil texture is predominantly loamy in nature (Akpan-Ebe and Dan, 2015).

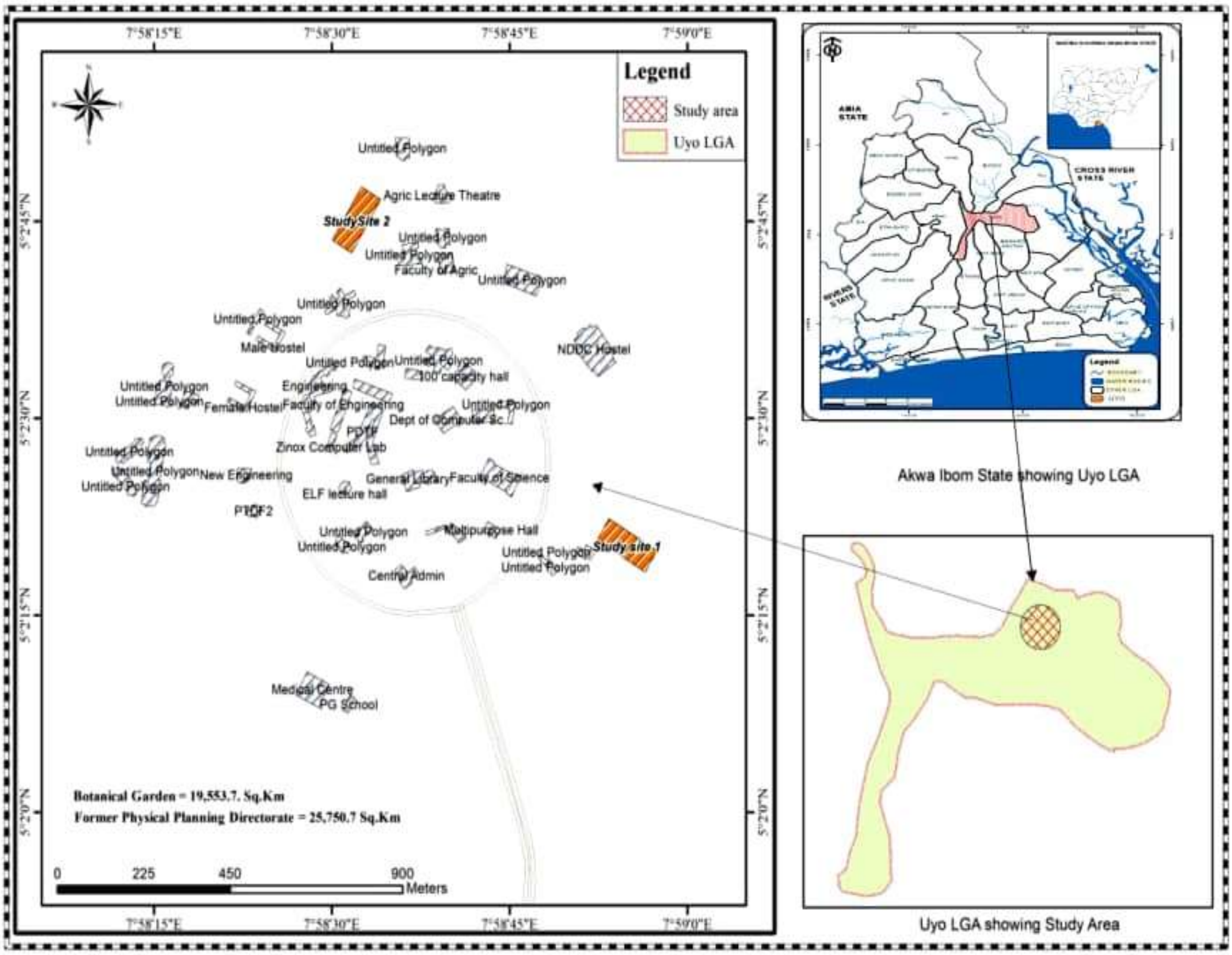

Figure 2.1: Map of Akwa Ibom State showing the study areas and sites

Source:Department of Geography and Natural Resources, University of Uyo (2022)

2.2 Sampling Technique and Data Collection

Following a reconnaissance survey of the two tracts, each forest was measured to determine its area. Site 1 was 19,553.7 m^2 and site 2 was 25,750.7 m^2 (Figure 2.1). A 400 m baseline was laid 5 m away from the main access route into the forest. Eight (8) points of 50 m apart from one another were marked along the baseline, thereafter four (4) points were randomly selected for laying of belt transects. Accordingly, four 200 m belt transects were laid from the four randomly selected points on the baseline into the forest. Five 20 x 20 m quadrats were laid in an alternate order on each belt transect at an interval of 20 m for each site (Figure 2.2) for identification and enumeration of adult and juvenile trees in each of the forest. Thus, the total sample area assessed in each site was 8000 m^2 (0.8 ha). All trees measured at diameter at breast height (≥ 10 dbh) were referred to as adult trees while those < 10 cm dbh were juvenile trees as adopted by Etigale *et al.* (2014a, 2014b) and Olajide *et al.* (2015). Encountered species were identified by a Forest Taxonomist in the team, while Etukudo (2000, 2003), were consulted for those species whose full taxonomic classifications were uncertain. All the tree species enumerated were sorted into their respective families according to the documentation of Keay (1989).

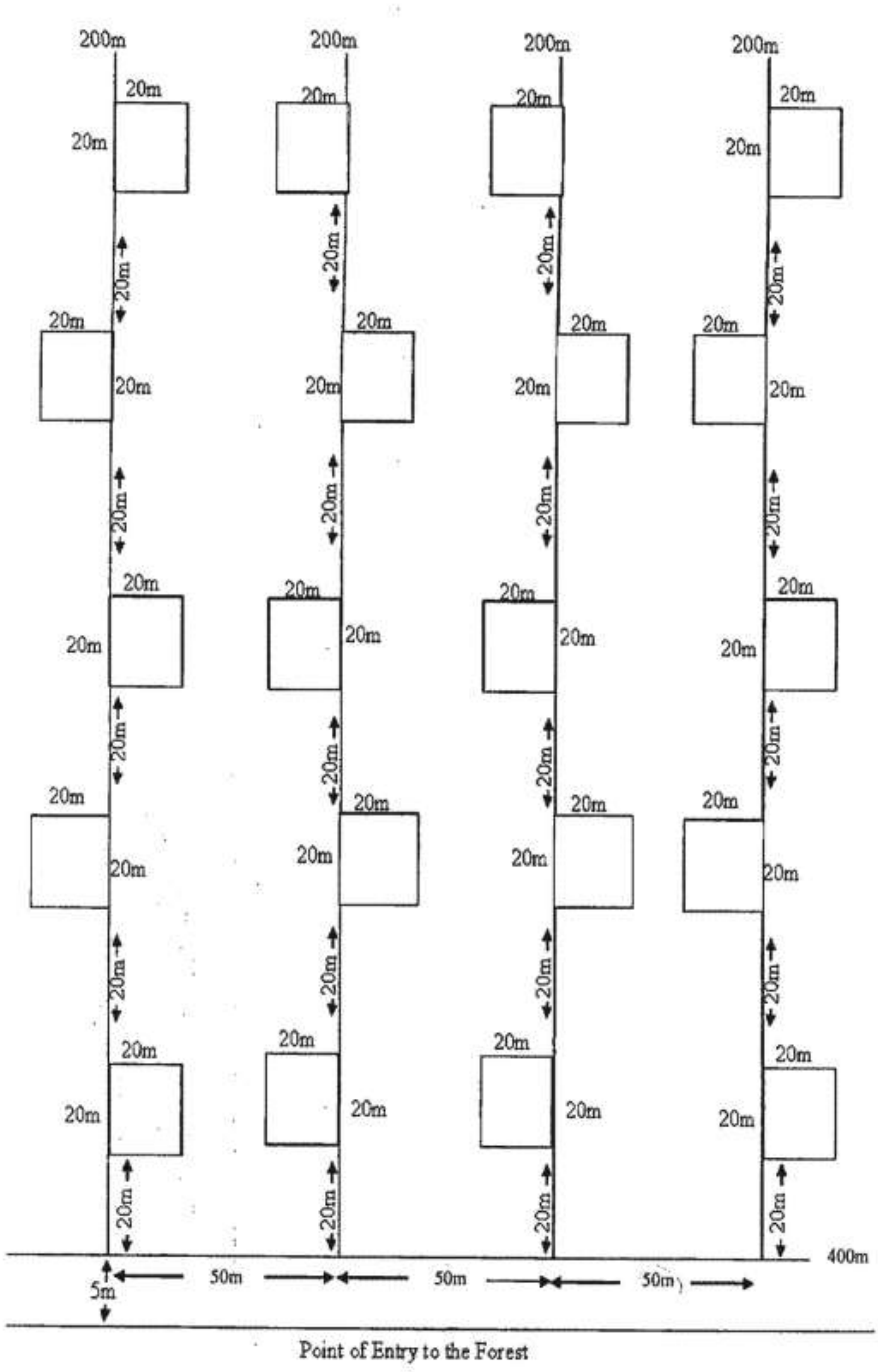

Figure 2.2: Layout of the sampling technique

2.2 Data Analysis

Data obtained were subjected to statistical analysis using Microsoft Excel. The data were first sorted by species into mature trees and juvenile at plot level. Their densities in each plot (No. of stem/ha) and their average densities in the study areas were calculated using Equations 2.1 and 2.2, respectively (Etigale *et al*., 2023).

$$P_D = \frac{n_p}{A} \qquad \text{Equation 2.1}$$

Where:
P_D= Population density of mature trees or juvenile of ith species in ith plot (No. of stems/ha)
n_p = Number of individuals of mature trees or regeneration of ith species in ith plot and
A = Area of one sample plot (0.04ha).

$$\bar{P}_D = \frac{\sum P_D}{NP} \qquad \text{Equation 2.2}$$

Where:
$\bar{P}_D$= Mean population density of mature trees or juvenile of ith species in the study area (No. of stems/ha)
NP = Number of sample plots enumerated (20 plots)
P_D= as defined in equation 2.1.

Basal Area: The basal area of the species per hectare was also used to determine the population density of each tree species. The basal area of each tree was computed with the modified version of the formula for calculating the cross-sectional area of tree stem as used by Avery and Burkhart (2002), Husch *et al*. (2003), Etigale *et al*. (2014a), Etigale *et al*. (2021) and Etigale (2022). The formula is expressed in Equation 2.3.

$$\mathrm{BA} = \frac{\pi \mathrm{d}^2}{40000} \qquad \text{Equation 2.3}$$

Where:
BA = the basal area of each tree (m^2)
π = the Constant (3.142) and
d =the diameter at breast height (cm)

The basal areas of the species per hectare at plot level and in the study areas were estimated with equations 2.4 and 2.5 as applied by Avery and Burkhart (2002), Husch *et al*. (2003), Etigale *et al*. (2014a), Etigale *et al*. (2021) and Etigale (2022).

$$\mathrm{BA_d} = \frac{\sum \mathrm{BA}}{\mathrm{A}} \qquad \text{Equation 2.4}$$

Where:
BA_d = the basal area of ith species per hectare in ith plot (m^2/ha),
BA = the basal area of individual trees of ith species (m^2) and
A = the area of one sample plot (0.04ha)

$$\mathrm{BA_D} = \frac{\sum \mathrm{BA_d}}{\mathrm{NP}} \qquad \text{Equation 2.5}$$

Where:
BA_D = the basal area of ith species per hectare in the study area (m^2/ha)
BA_d = the basal area of ith species per hectare in ith plot (m^2/ha) and

NP = the number of sample plots enumerated (20 plots)

Regeneration potential index: This was determined for individual tree species in each site using the modified natural regeneration potential function as applied by Ananah and Olajide (2016), which is expressed in Equation 2.6 as:

$$\mathrm{Rp} = \frac{\left(\frac{\mathrm{r_i}}{\mathrm{r_t}} \times \mathrm{T_a}\right)}{100} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. \text{Equation 2.6}$$

Where:
R_p = the regeneration potential index,
r_i = the number of regeneration or juvenile of species encountered
r_t = the total number of regeneration of all the species and
T_a=the total number of all adult tree species

3.0 Results and Discussion

A total of 25 tree species (both adult and juvenile trees) belonging to 24 genera and 18 families were encountered in site 1. The *Fabaceae* family had the highest number of trees (3), while the least numbers of trees (1) each was found in 14 families (Table 3.1). Total tree population were 1565 individuals (1963 stems/ha) and population density of trees ≥ 10 stems/ha was 17, while 8 recorded < 10 stems/ha (Table 3.1). The highest population of 253 individuals (317 stems/ha) was recorded for *Sterculia tragacantha,* while the least population of 3 individuals (4 stems/ha) each was recorded for *Dacryodes edulis*, *Dracaena arborea* and *Unonopsis stipitata* (Table 3.1).

A total of 22 tree species (both adult and juvenile trees) belonging to 22 genera and 14 families, were encountered in site 2 (Table 3.2). The *Fabaceae* family had the highest number of trees (6), while the least numbers of trees with (1 each) was found in 10 families. Total tree population was 1197 individuals (1499 stems/ha). Population density of trees ≥ 10 stems/ha was 21, while only 1 tree recorded < 10 stems/ha. *Barteria nigritana* recorded the highest population of 186 individuals (233 stems/ha), while the least population of 6 individuals (8 stems/ha) was recorded for *Mangifera indica*.

The result of basal areas of 18 adult tree species encountered in site 1, are presented in Table 3.3. *Baphia nitida* had the highest basal area of 0.45045 m^2 (0.56306 m^2/ha), while *Irvingia gabonensis* had the least with 0.00785 m^2 (0.00982 m^2/ha). The total basal area for trees in site 1, was 2.26170 m^2 (2.82713 m^2/ha).

The basal areas of 14 tree species encountered in site 2 are presented in Table 3.4. *Pentaclethra macrophylla* had the highest value of 0.32195 m^2 (0.40244 m^2/ha), while *Albizia lebbeck* recorded the least value of 0.00866 m^2 (0.01082 m^2/ha). The total basal area for trees in site 2, was 1.31983 m^2 (1.64979 m^2/ha).

3.1 Tree Species Regeneration

The regeneration potential indices of all the trees in site 1 and site 2 are presented in Table 3.5. In site 1, nine (9) trees had regeneration potentials ≥ 0.1, with *Sterculia tragacantha* recording the highest (0.3264), followed by *Millettia abonesis* (0.2455), *Lovoa trichiloides* (0.2037), *Baphia nitida* (0.1753), *Elaeis guineensis* (0.1538), *Harungana madagascariensis* (0.1538), *Pentaclethra macrophylla* (0.1430), *Barteria nigritana* (0.1160) and *Anthocleista* *djalonensis* (0.1025), while sixteen (16) trees recorded < 0.1, with *Dracaena arborea* having the least (0.0027).

For site 2, two (2) trees had regeneration potentials ≥ 0.1 with *Barteria nigritana* recording the highest index with 0.1648, followed by *Anthocleista djalonensis* (0.1177), while twenty (20) trees had < 0.1, with *Mangifera indica* having the least of 0.0028.

3.2 Discussion

Information on tree population and basal area are sufficient for revealing population density. Population density of tree species predicts the number of individuals of a particular species in a forest and tells how crowded or scattered the trees of that species are within an area (Falade, 2021). It also reveals endangered trees as indicated in their population per/ha, which is less than 10 stems/ha and is considered scanty and rare (Newin, 2014; Olajide and Etigale, 2021). Being rare may be linked to factors such as habitat type, dispersal mechanism, disturbances and forest degradation (Salami *et al*., 2021; Soba *et al*., 2023). This scanty representation of tree species in both sites suggest a typical disturbed rainforest as affirmed by Etigale *et al*. (2014a), that a sparsely forest is an indication of severe disturbances. However, tree population was higher in site 1, than in site 2. A high population of species were recorded in site 1, with *Sterculia tragacantha* having 253 individuals (317 stems/ha) as the highest. The increase in population of trees in site 1 could be attributed to the conservation measures taken by the Department of Botany and Ecological Studies through the use of protective wires to demarcate some designated areas. However, the low population of trees in both sites could also be due to species adaptability to their environment which agrees with the assertion of Mbong *et al*. (2020), that species react differently to changes in anthropogenic and environmental factors in their habitat which could lead to increase or decrease in population.

Site 1 indicated more numbers of rare species than site 2, as individuals were less than 10 stems/ha. This indicated possible signs of threatened species which aligns with the assertions of Nelson *et al*., 2015 and Olajide and Etigale (2021) that tree species in a rainforest with population < 10 stems/ha is considered endangered. It also revealed low population densities of each tree species especially in site 1. These low population densities of some tree species in both sites could be attributed to severe exploitation for timber and other uses. Related observations of low population densities of trees in tropical rainforests as a result of severe exploitations have been reported by Ananah and Olajide (2016), Newin (2014), Olajide and Etigale (2017; 2021) and Mbong *et al*., (2020).

Basal area considers the size of trees, age, species composition and diameter distribution which gives an idea of tree stocking in a forest to ascertain regeneration needs (Oke *et al*., 2017; Soba *et al*., 2023). It indicates if a forest is fully stocked, under stocked or over stocked, as the standard recommended range of basal area per hectare for a fully stocked forest is 9.18 m^2/ha to 22.96 m^2/ha (Etigale *et al*., 2014a). Higher basal area of trees indicates a dense and undisturbed forest with larger trees, this leads to overstocked forest with high competition for available space and growth among species (Asifat and Orimoogunje, 2020; Etigale *et al*., 2014b). Disturbed forest suggests low basal areas indicating sparser forests with smaller trees leading to under stocked forest with less utilization of forest resources (Asifat and Orimoogunje, 2020; Etigale *et al*., 2014b).

Table 3.1: Names, families and population of trees encountered in site 1 (forests contiguous with the Botanical Garden) of the study area

S/N	Family	Scientific Name	Common Name	Adult Tree Population	Juvenile Tree Population	Total Tree Population	Adult Tree Population Density/ha	Juvenile Tree Population Density/ha	Total Tree Population Density/ha
1	*Aracaceae*	*Elaeis guineensis* (Jacq).	Oil palm	22	114	136	28	143	171
2	*Anacardiaceae*	*Millettia abonesis* (Hook.) Baker	Odudu	40	182	222	50	228	278
3	*Annonaceae*	*Unonopsis stipitata* Diels		0	3	3	0	4	4
4	*Boraginaceae*	*Cordia sabestena* L.	Tree scarlet	0	13	13	0	16	16
5	*Burseraceae*	*Dacroyodes edulis* (G.Don.) H.J.Lam.	African pear	0	3	3	0	4	4
6	*Caesalpiniaceae*	*Anthonotha macrophylla* P. Beauv.	African bean	1	11	12	1	14	15
7	*Caesalpiniaceae*	*Dialium guineense* Wild	Black velvet	2	22	24	3	28	31
8	*Calophyllaceae*	*Mammea africana* (Sabine)	Mammea	3	9	12	4	11	15
9	*Dracaenaceae*	*Dracaena arborea* Wild. Link.	Dragon tree	1	2	3	1	3	4
10	*Dracaenaceae*	*Dracaena manii* Baker.	Dragon tree	1	3	4	1	4	5
11	*Euphorbiaceae*	*Macaranga barteri* (Mull.Arg.)	African thorn tree	0	5	5	0	6	6
12	*Fabaceae*	*Baphia nitida* Lodd.	Camwood	39	130	169	49	163	212
13	*Fabaceae*	*leucocephala* (Lam. de Wit).	Lead tree	0	5	5	0	6	6
14	*Fabaceae*	*Tetrapleura tetraptera* S & Taub.	Gum tree	0	5	5	0	6	6
15	*Hypericaceae*	*Harungana madagascariensis* Lam. Ex. Poir.	Blood tree	11	114	125	14	143	157
16	*Irvingiaceae*	*Irvingia* gabonensis	Bush mango	1	18	19	1	23	24
17	*Loganiaceae*	*Anthocleista djalonensis* A. Chev	Cabbage tree	3	76	79	4	95	99
18	*Meliaceae*	*Lovoa trichiloides* (Harms).	African walnut	12	151	163	15	189	204
19	*Mimosaceae*	*Albizia lebbek* Benth.	Siris tree	4	17	21	5	21	26
20	*Mimosaceae*	*Pentaclethra macrophylla* (Benth.)	African oil bean	11	106	117	14	133	147
21	*Moraceae*	*Ficus elastic* Roxb. Ex Hornem	Indian rubber	0	4	4	0	5	5
22	*Pasifloraceae*	*Barteria nigritana* Hook F.	Ant tree	15	86	101	19	108	127
23	*Olacaceae*	*Strombosia postulate* Oliv.	Itako	2	25	27	3	31	34
24	*Rubiaceae*	*Nauclea latifolia* (Smith.)	Negro peach	7	33	40	9	41	50
25	*Sterculiaceae*	*Sterculia tragacantha* Lindl.	Gum tragacanth	11	242	253	14	303	317
	Total			**186**	**1379**	**1565**	**235**	**1728**	**1963**

Source: Atakpa (2022)

Table 3.2: Names, families and population of trees encountered in site 2 (former Directorate of Physical Planning) of the study area

S/N	Family	Scientific Name	Common Name	Adult Tree Population	Juvenile Tree Population	Total Tree Population	Adult Tree Population Density/ha	Juvenile Tree Population Density/ha	Total Tree Population Density/ha
1	*Anacardiaceae*	*Mangifera indica* (L.)	Mango	3	3	6	4	4	8
2	*Anacardiaceae*	*Spondias mombin* L.	Hog plum	4	34	38	5	43	48
3	*Aracaceae*	*Elaeis guineensis* Wild	Oil palm	3	18	21	4	23	27
4	*Burseraceae*	*Canarium schweinfurthii* Engl.	Bush candle	5	36	41	6	45	51
5	*Caesalpiniaceae*	*Anthonotha macrophylla* Beauv.	African bean	13	57	70	16	71	87
6	*Callophyllaceae*	*Mammea africana* (Sabine)	Mammea	0	27	27	0	34	34
7	*Euphorbiaceae*	*Macaranga barteri* (Mull. Arg.)	African thorn tree	4	77	81	5	96	101
8	Fabaceae	*Acacia auriculiformis* Cunningham ex Benth.		0	29	29	0	36	36
9	*Fabaceae*	*Baphia nitida* Lodd.	Camwood	14	77	91	18	96	114
10	*Fabaceae*	*Berlinia grandiflora* Vahl. Hutch & Daziel	Ebiara	0	28	28	0	35	35
11	*Fabaceae*	*Brachystegia eurycoma* Hams.	Okwen	0	9	9	0	11	11
12	*Fabaceae*	*Dalbergia latifolia* Roxb.	Indian rose wood	0	29	29	0	36	36
13	*Fabaceae*	*Millettia abonesis* (Hook.) Baker	Odudu	23	55	78	29	69	98
14	Hypericaceae	*Harungana madagascariensis* Lam.Ex. Poir	Blood tree	0	35	35	0	44	44
15	*Lamiaceae*	*Vitex doniana* Sweet	Black plum	0	8	8	0	10	10
16	*Longaniaceae*	*Anthocleista djalonensis* A,Chev.	Cabbage tree	3	125	128	4	156	160
17	*Mimosaceae*	*Pentaclethra macrophylla* (Benth.)	African oil bean	13	101	114	16	126	142
18	*Mimosaceae*	*Albizia lebbek* Benth.	Siris tree	1	41	42	1	51	52
19	*Myristicaceae*	*Coelocaryon preusii* Warb.	Ekoune	2	18	20	3	23	26
20	*Pasifloraceae*	*Barteria nigritana* Hook F.	Ant tree	11	175	186	14	219	233
21	*Sterculiaceae*	*Sterculia tragacantha* Lindl.	Gum tragacanth	4	102	106	5	128	133
22	*Sterculiaceae*	Cola millenii Schum.	Monkey cola	0	10	10	0	13	13
	Total			**103**	**1094**	**1197**	**130**	**1369**	**1499**

Source: Atakpa (2022)

Table 3.3: Basal areas of adult trees in site 1 of the study area

S/N	Species	Basal Area (m^2)	Basal Area (m^2)/ha
1	*Albizia lebbeck*	0.03578	0.04472
2	*Anthocleista djalonensis*	0.03338	0.04172
3	*Anthonotha macrophylla*	0.00950	0.01188
4	*Baphia nitida*	0.45045	0.56306
5	*Barteria nigritana*	0.17083	0.21354
6	*Dialium guineense*	0.02555	0.03194
7	*Dracaena arborea*	0.00950	0.01188
8	*Dracaena manii*	0.01131	0.01414
9	*Elaeis guineensis*	0.41029	0.51286
10	*Harungana madagascariensis*	0.12657	0.15821
11	*Irvingia gabonensis*	0.00785	0.00982
12	*Lovoa trichilioides*	0.15306	0.19133
13	*Mammea Africana*	0.02598	0.03248
14	*Millettia aboensis*	0.42143	0.52679
15	*Nauclea latifolia*	0.06626	0.08283
16	*Pentaclethra macrophylla*	0.17921	0.22401
17	*Sterculia tragacantha*	0.10903	0.13629
18	*Strombosia pustulata*	0.01571	0.01963
	Total	**2.26170**	**2.82713**

Source: Atakpa (2022)

Table 3.4: Basal areas of the adult trees in site 2 of the study area

S/N	Species	Basal Area (m^2)	Basal Area (m^2)/ha
1	*Albizia lebbeck*	0.00866	0.01082
2	*Anthocleista djalonensis*	0.02734	0.03417
3	*Anthonotha macrophylla*	0.14190	0.17738
4	*Baphia nitida*	0.12175	0.15218
5	*Barteria nigritana*	0.14532	0.18165
6	*Canarium schweinfurthii*	0.04533	0.05667
7	*Coelocaryon preussii*	0.01618	0.02023
8	*Elaeis guineensis*	0.06236	0.07795
9	*Macaranga barteri*	0.03434	0.04292
10	*Mangifera indica*	0.06699	0.08374
11	*Millettia aboensis*	0.24207	0.30259
12	*Pentaclethra macrophylla*	0.32195	0.40244
13	*Spondias mombin*	0.04534	0.05667
14	*Sterculia tragacantha*	0.04029	0.05036
	Total	**1.31983**	**1.64979**

Source: Atakpa (2022)

Table 3.5: Regeneration potential index of individual species in sites 1 and 2 of the study areas

S/N	Scientific Name	Regeneration Potential	
		Site 1	**Site 2**
1	*Acacia auriculiformis*	-	0.0273
2	*Albizia lebbek*	0.0229	0.0386
3	*Anthocleista djalonensis*	0.1025	0.1177
4	*Anthonotha macrophylla*	0.0148	0.0537
5	*Baphia nitida*	0.1753	0.0725
6	*Barteria nigritana*	0.1160	0.1648
7	*Berlinia grandiflora*	-	0.0264
8	*Brachystegia eurycoma*	-	0.0085
9	*Canarium schweinfurthii*	-	0.0339
10	*Coelocaryon preusii*	-	0.0169
11	*Cola millenii*	-	0.0094
12	*Cordia sabestena*	0.0175	-
13	*Dacroyodes edulis*	0.0040	-
14	*Dalbergia latifolia*	-	0.0273
15	*Dialium guineense*	0.0297	-
16	*Dracaena arborea*	0.0027	-
17	*Dracaena manii*	0.0040	-
18	*Elaeis guineensis*	0.1538	0.0169
19	*Ficus elastic*	0.0054	-
20	*Harungana madagascariensis*	0.1538	0.0330
21	*Irvingia gabonensis*	0.0243	-
22	*Leucaena leucocephala*	0.0067	-
23	*Lovoa trichiloides*	0.2037	-
24	*Macaranga barteri*	0.0067	0.0725
25	*Mammea Africana*	0.0121	0.0254
26	*Mangifera indica*	-	0.0028
27	*Millettia aboensis*	0.2455	0.0518
28	*Nuclea latifolia*	0.0445	-
29	*Pentaclethra macrophylla*	0.1430	0.0951
30	*Spondias mombin*	-	0.0320
31	*Sterculia tragacantha*	0.3264	0.0960
32	*Strombosia postulate*	0.0337	-
33	*Tetrapleura tetraptera*	0.0067	-
34	*Unonopsis stipitata*	0.0040	-
35	*Vitex doniana*	-	0.0075

All tree species in both sites recorded low values, though *Baphia nitida* tree in site 1 was the highest basal area with 0.45045 m^2 (0.56306 m^2/ha) in the study. The total basal areas per hectare of trees in both sites were low though site 1 was higher than site 2. Thus, both sites are not in conformity with this assertion as their total values are not within the recommended range of basal area per hectare. This is because trees in both sites of the study were of smaller stems, which indicate the secondary nature of the rainforest. This is in agreement with Asifat and Orimoogunje (2020) and Etigale *et al*. (2014a, 2014b) that low basal area suggests a forest with over exploitation of mature big trees.

The regeneration potential indices (RPI) recorded for trees in both forests revealed that site 1 was higher with *Sterculia tragacantha* as the highest (0.3264). Aside 9 trees in site 1 and 2 trees in site 2, all the other trees were not capable of sufficient natural regenerations (Table 3.5), because a tree with RPI ≥ 0.1 indicates sustainable natural regeneration capacity (Olajide and Etigale, 2021). Most of the tree species were not capable of sufficient natural regenerations in both sites. This could be attributed to the felling of the parent trees during timber harvesting. It could also be linked to the rarity of the seeds in some of these species, through the collection of the seeds of some of these trees by both man and animals for consumption, such as *Brachystegia eurycoma, Dialium guineensis, Dacryodes edulis, Irvingia gabonensis, Mangifera indica, Tetrapleura tetraptera* and others, which are largely consumed in the rainforest belt of Nigeria (Olajide and Etigale, 2017, 2021). Also, farming, grazing and construction in the study areas could have severely hindered natural regeneration as observed by Magnus *et al*. (2019), that overgrazing severely slows down natural regeneration as the animals trample upon the young seedlings.

4.0 Conclusion and Recommendation

Trees form the principal structure on which forests exist. The conservation of the disturbed rainforest on the main campus of University of Uyo depends on the management of the constituent trees and the regeneration. It is therefore recommended that enrichment planting and an effective protection mechanism through restrictions, signage and parameter fences in the disturbed rainforest will facilitate the restoration of the rainforest to its primary state. Further studies should be undertaken on diversity and similarities of trees in the two isolated tracts of disturbed rainforests for a sustainable management of both rainforests.

References

Akpan-Ebe, I. (2021). Sustainability of Nigerian rainforest ecosystem, In: L. Popoola and S. Jimoh (Editors) *Readings in Forest Ecology*, Lagos, Nigeria, pp.163 – 180.

Akpan-Ebe, I. and Dan, I. (2015). The rate of deforestation and its impact on climate change in Akwa Ibom State, Nigeria. In: M. Akpan and S. I. Udofia (Editors) *Forests and Climate Change.* Proceedings of the National Workshop of the Forestry Association of Nigeria (FAN), Akwa Ibom State Branch in Collaboration with the Department of Forestry and Natural Environmental Management, University of Uyo, Uyo and Directorate of Forestry and Environmental Conservation, Ministry of Environment and Mineral Resources, Uyo, pp.120 – 130.

Akpan-Ebe, I., Udotong, I. and Ekpenyong, R. (2016). Ecological consequences of urbanization of Uyo Capital City, Akwa Ibom State, Nigeria. *Journal of Agriculture and Ecology Research International*, 79(3): 1-12.

Alamgir, M., Turton, S., Pert, P., Edwards, W. and Laurance, W. (2016). Degraded Tropical RainForests Possess Valuable Carbon Storage Opportunities in a Complex Forested Landscape. https://www.nature.com/articles/srep30012 (Retrieved on 15th September 2021).

Ananah, A. and Olajide, O. (2016). Population structure and regeneration potential of the most abundant timber tree species in a rainforest reserve in South Eastern Nigeria. International *Journal of Agricultural Research and Food Production*, 1: 43 – 55.

Antia-Obong, E.A., Eno, W.C., Obot, A.P (2024). Analysis of Coconut Production Trends under Three Policy Phases in Nigeria. *KSU J. Agric Nat* 27 (3), 665-673. DOI:

10.18016/ ksutarimdoga.vi.1309549.

Asifat, J. and Orimoogunje, O. (2020). Forest cover change and species distribution in Ago-Owu Forest Reserve, Osun State, Southwestern Nigeria. *Journal of the Society for Tropical Plant Research*, 7(2): 357–365.

Atakpa, I. and Atakpa, O. (2015). Climate Change and National Security: The Role of Akwa Ibom State Forestry Department, pp. 23-27. In: M. Akpan and S. I. Udofia (Editors) *Forests and Climate Change.* Proceedings of the National Workshop of the Forestry Association of Nigeria (FAN), Akwa Ibom State Branch in Collaboration with the Department of Forestry and Natural Environmental Management, University of Uyo, Uyo and Directorate of Forestry and Environmental Conservation, Ministry of Environment and Mineral Resources, Uyo, 130p.

Avery, T. and Burkhart, H. (2002). *Forest Measurement.* 5th Edition. McGraw Hill, New York, pp. 144-167.

Burslem, D., Philipson, C. and Cutler, M. (2021). Re-growing a Tropical Forest- Is it Better to Plant Trees or Leave it to Nature? https://www.weforum.org/agenda/2021/03/active-planting-vs-natural-regeneration-which-is-a-better-solution-to-deforestation/ (Retrieved on 7th October 2021).

Byrne KA, Efretuei A, Walz K, Clay GD (2020) Characterization of elemental ratios and oxidative ratio of horticultural peat. *Soil Use and Management.* 37 (3) 640-647**.** https://doi.org/10.1111/sum.12621

Chazdon, R. (2014). *Second Growth: The Promise of Secondary Forest Regeneration in an Age of Deforestation.* The University of Chicago Press, Chicago and London, 486p.

Chazdon, R., Calixto, B., Oliveira, M., Messinger, J., Alves, J., Calmon, M., and Anderson, W. (2021). What is Assisted Natural Regeneration? https://www.wri.org/insights/what-assisted-natural-regeneration-benefits-definition (Retrieved on 10th January 2022).

Department of Geography and Natural Resources Management (2022). Plan Showing Study Areas and Location of Uyo Local Government Area on the Map of Akwa Ibom State. Uyo: Department of Geography and Regional Planning, University of Uyo.

Directorate of Forests, Government of Bengal (2016). *Regeneration Methods.* Development Circle, Directorate of Forests, Aranya Bhavan Kolkata, West Bengal, 154p.

Esiere, N. and Archibong, M. (2015). Socio-Economic Importance of Major Forest Vegetables in Akwa Ibom State, Nigeria, pp125-130. *In*: M. Akpan and S. Udofia (Editors). *Forests and Climate Change*. Proceedings of the National Workshop of the Forestry Association of Nigeria (FAN), Akwa Ibom State Branch in Collaboration with the Department of Forestry and Natural Environmental Management, University of Uyo, Uyo and Directorate of Forestry and Environmental Conservation, Ministry of Environment and Mineral Resources, Uyo, 130p.

Etigale E. (2022). Adaptation of Geometric Functions for Calculating Tree Volume and Biomass in One Step, pp319-324. *In*: A. Oluwadare, O. Akinyemi, O. Idumah, D. Akintunde-Alo and A. Lawal (Editors). *Forestry and the Challenge of Insecurity, Climate Change and Covid-19 Pandemic in Nigeria*. Proceedings of 8th Biennial National Conference of the Forests and Forest Products Society, Forestry Research Institute of Nigeria, Ibadan, Nigeria. 568p.

Etigale, E., Ajayi, S., Udofia, S. and Moses, M. (2014a). Assessment of stand density and growth rate of three tree species in an arboretum within the University of Uyo, Nigeria. *Journal of Research in Forestry, Wildlife and Environment*, 6(1): 8-16.

Etigale, E., Oke, O., Akindele, S., Adekunle, V. and Olajide, O. (2023). Floristic composition and stand structure of the mangrove forest in Cross River State, Nigeria. *International Journal of Agriculture Research & Life Science*, 4(1): 1-22.

Etigale, E., Oke, O., Adekunle, V. and Akindele, S. (2021). Allometric equation for estimating stem biomass of Rhizophora species in cross river state mangrove Forest, Nigeria. *Journal of Forestry, Environment and Sustainable Development*, 7(1): 21-38.

Etigale, E., Olajide, O. and Udo, S. (2014b). Stand structure, density and yield of tree community in Ukpon River Forest Reserve, Cross River State, Nigeria. *Journal of Natural Science*, 12(11): 1-8.

Etukudo, I. (2000). *Forest our Divine Treasure*. Diamond Publishers, Uyo, 194p.

Etukudo, I. (2003). *Ethonobotany: Conventional and Traditional Uses of Plant*. The Verdict Press, Uyo, Nigeria, 191p.

FAO (Food and Agriculture Organization) (2015). Global Forest Resources Assessment 2015- How are the World's Forests Changing? FAO, Rome.

Falade, O. (2021). Woody Plant Population, Dynamics and Regeneration in Tropical Dry Forest Formations. *In*: L. Popoola and S. Jimoh (Editors). *Readings in Forest Ecology (Essay in Honour of Professor Saka Obafemi Bada).* Zenith Book House Ltd., Bodija, Ibadan, Nigeria. Pp.172 - 180.

Husch, B., Beers, T. and Kerhaw Jr., J. (2003). *Forest Measuration*. 4th Edition. John Willey and Sons Inc., New Jersey, USA, 949p.

Jeje, A., Olanikpekun, M. and Otoide, J. (2021). Assessment of the diversity and abundance of tree species in Afe Babalola University, Ado Ekiti State, Nigeria. *International Journal of Biodiversity and Conservation*, 13(3): 144-151.

Keay, R. (1989). *Trees of Nigeria*. Oxford University Press, New York, 476p.

Magnus, L., Madsen, P., Metslaid, M. and Jacobs, D. (2019). Restoring forests: Regeneration and ecosystem function for the future. *New Forest*, 50: 139 - 151.

Mbong, E., Ogbemudia, F. and Samuel, E. (2020). Tree species diversity and dominance in relation to soil properties in University of Uyo Arboretum. *International Journal of Plant, Animal and environmental Sciences* 10: 140-147.

Nelson, I., Udoakpan, U. and Jacob, D. (2015). Population density and diversity of plants species in Ikot Efre Itak community forest, Akwa Ibom State, Nigeria. *International Journal of Molecular, Ecology and Conservation*, 5(5): 1 – 6.

Newin, R. (2014). Population dynamics of commercial tree species after selective logging in Myanmar. *Tropical Forest Update,* 22(4): 22-25.

Olajide, O. (2018). Non- timber values and sustainability of biodiversity wealth of Nigerian Lowland Rainforest. *Journal of Forestry, Environment and Sustainable Development,* 4(2): 12-20.

Olajide, O., Eniefiok, S., and Dan, O. (2015). Stock density of 'timber plus tress' and their economically valuable non-timber products in Cross River North Forest Reserve, Nigeria. *Journal of Forestry, Environment and Sustainable Development,* 1(1): 47-51.

Olajide, O. and Etigale, E. (2017). Stand population and regeneration of trees producing non-timber products of economic values in a rainforest estate in Cross River State, Nigeria. *International Journal of Agricultural Research and Food Production*, 2(2): 91-102.

Olajide, O. and Etigale, E. (2021). Stand population analysis and regeneration potentials of tree species in *Fabaceae* Family in Oban Forest Reserve, Cross River State, Nigeria. *Journal of Forestry, Environmental and Sustainable Development*, 7(1): 79-86.

Olajide, O. and Egor, E. (2013). Forestry actions for greening a fast-growing economy: Nigerian perspective, *In*: L. Popoola, O. Y. Ogunsanwo, V. A. J. Adekunle, I. O. Azeez. (Editors). *The Green Economy: Balancing Environmental Sustainability and Livelihood in an Emerging Economy*. Proceeding of the 36th Annual Conference of the Forestry Association of Nigeria, held in Uyo, Akwa Ibom State, Nigeria, pp.549 - 572.

Oke, O., Akindele, S. and Onyekwelu, J. (2017). Tree species richness, diversity and structure of a strict conservation natural tropical rainforest ecosystem in Nigeria, *Forests and Forest Products Journal*, 10:39-51.

Okekunle, A. (2021). Tropical Forest Conservation and Management Options, pp1-15. In: L. Popoola and S. Jimoh (Editors) *Readings in Forest Ecology*. 180p.

Rajwar, J. (2021). Impact of Rain Forest Degradation. https://www.sun.edu.ng/knowledge-update/impact-of-rain-forest-degradation (Retrieved on 13th October 2021).

Salami, K., Shuaibu, R., Adekunle, V., and Ogunsola, J. (2021). Comparative analysis of density, diversity and similarity of forest tree species in three selected states of Northern Nigeria. *Journal of Research in Forestry, Wildlife & Environment*, 13(3): 25 – 30.

Soba, T., Abdulazeez, B., Clement, S., Ndagi, H., and Ibrahim, I. (2023). An ecological assessment of tree species diversity, richness and status in Faculty of Agriculture Shabu-Lafia, Nasarawa State University Keffi, Nasarawa State Nigeria. *Journal of Research in Forestry, Wildlife & Environment*, 6(7): 12 – 22.

Thompson, I., Guariguata, M., Okabe, K., Bahamondez, C., Nasi, R., Heymell, V. and Sabogal, R. (2013). An operational framework for defining and monitoring forest degradation. *Journal of Ecology and Society*, 18(2): 1-20.

Udofia, S., Uluocha, O., Ekpa, N. and Oruh, E. (2015). Consequences of Climate Change on Forest Production. In: M. Akpan and S, Udofia (Editors) *Forests and Climate Change*, Proceedings of the National Workshop of the Forestry Association of Nigeria (FAN), Akwa Ibom State Branch, pp.116. 130.

Vasquez-Grandon, A; Donoso, P. and Gerding, V. (2018). Forest degradation: When Is a forest degraded? *Journal of Forests Ecology and Management*, 9(11): 726.

WWF (2015). Forest for Life. www.panda.org/.../deforestation/forest (Retrieved on 25th February 2024).