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Assessment of the Present Status of Three Protected Areas in Ondo State, Nigeria: A Baseline Study

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Abstract – Regular assessment of protected areas is essential for preserving their sanctity and ensuring continuous ecosystem services. Anthropogenic activities and pressure in rainforest protected areas (PAs) have caused habitat degradation and loss of flora and fauna. Most PAs in Ondo State, Nigeria have been recklessly exploited, hijacked, and converted to other land uses. This study assessed three PAs in Ondo State to provide baseline information for sustainable management and identify rare and threatened species requiring urgent conservation. The study evaluated tree species diversity, abundance, and growth variables across Akure-Ofosu Forest Reserve (Ondo Central), Osse River Park (Ondo North), and Oluwa Forest Reserve (Ondo South). Data were collected using systematic line transects with 50 × 50 m plots at 250 m intervals. All trees ≥10 cm DBH were identified, measured, and recorded. Mean basal area and volume per hectare were highest at Oluwa (288.90 m² ha⁻¹; 2897.12 m³ ha⁻¹), followed by Akure-Ofosu (222.59 m² ha⁻¹; 1710.90 m³ ha⁻¹) and Osse (101.91 m² ha⁻¹; 1004.55 m³ ha⁻¹). Biodiversity indices showed Pielou's evenness was highest in Akure-Ofosu (1.05), Shannon-Wiener (H') peaked at 4.24 there, and Margalef's richness was greatest at Oluwa (13.66). Simpson's index exceeded 0.93 across all sites. Notably, Sterculiaceae, Combretaceae, Ulmaceae, Apocynaceae, Caesalpiniodeae, and Verbenaceae were the most species-rich families, with Oluwa showing superior structural complexity and diversity. The study recommends strict enforcement of PA regulations, targeted protection of threatened species, and developing alternative livelihoods for local communities to ensure long-term forest ecosystem sustainability.

Keywords – *Biodiversity assessment, deforestation, ecosystem management, forest conservation, protected areas*

Nijerya'nın Ondo Eyaletindeki Üç Koruma Alanının Mevcut Durumunun Değerlendirilmesi: Temel Durum Tespit Çalışması

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Araştırma Makalesi

Öz − Koruma alanlarının kutsallığını korumak ve ekosistem hizmetlerinin sürekliliğini sağlamak için bu alanların düzenli olarak değerlendirilmesi hayati önem taşımaktadır. Yağmur ormanı koruma alanlarında (PA'lar) insan kaynaklı faaliyetler ve baskılar, habitatların bozulmasına ve flora ile faunanın kaybına yol açmıştır. Nijerya'nın Ondo Eyaletindeki koruma alanlarının çoğu, pervasızca sömürülmüş, gasp edilmiş ve başka arazi kullanımlarına dönüştürülmüştür. Bu çalışma, sürdürülebilir yönetim için temel bilgiler sağlamak ve acil koruma gerektiren nadir ve tehdit altındaki türleri belirlemek amacıyla Ondo Eyaletindeki üç koruma alanını değerlendirmiştir. Çalışma, Akure-Ofosu Orman Rezervi (Ondo Merkez), Osse Nehri Parkı (Ondo Kuzey) ve Oluwa Orman Rezervi (Ondo Güney) genelinde ağaç türlerinin çeşitliliğini, bolluğunu ve büyüme değişkenlerini değerlendirmiştir. Veriler, 250 m aralıklarla 50 × 50 m'lik parsellerden oluşan sistematik hat kesitleri kullanılarak toplanmıştır. Çapı 10 cm ve üzeri olan tüm ağaçlar tespit edildi, ölçüldü ve kaydedildi. Hektar başına ortalama taban alanı ve hacim, Oluwa'da en yüksek seviyedeydi (288,90 m² ha⁻¹; 2897,12 m³ ha⁻¹) en yüksek değerlere sahipti; bunu Akure-Ofosu (222,59 m² ha⁻¹; 1710,90 m³ ha⁻¹) ve Osse (101,91 m² ha⁻¹; 1004,55 m³ ha⁻¹) izledi. Biyoçeşitlilik indeksleri, Pielou'nun eşitlik indeksinin Akure-Ofosu'da (1,05) en yüksek olduğunu, Shannon-Wiener (H') indeksinin burada 4,24 ile zirveye ulaştığını ve Margalef'in zenginlik indeksinin Oluwa'da (13,66) en yüksek olduğunu gösterdi. Simpson indeksi tüm alanlarda 0,93'ü aştı. Özellikle Sterculiaceae, Combretaceae, Ulmaceae, Apocynaceae, Caesalpiniodeae ve Verbenaceae en tür açısından zengin familyalardı ve Oluwa üstün yapısal karmaşıklık ve çeşitlilik sergiledi. Çalışma, uzun vadeli orman ekosistemi sürdürülebilirliğini sağlamak için koruma alanları yönetmeliklerinin sıkı bir şekilde uygulanmasını, tehdit altındaki türlerin hedefli bir şekilde korunmasını ve yerel topluluklar için alternatif geçim kaynaklarının geliştirilmesini önermektedir.

Anahtar Kelimeler − *Biyoçeşitlilik değerlendirmesi, ormansızlaşma, ekosistem yönetimi, orman koruma, koruma alanları*

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1. Introduction

Nigeria's natural vegetation is sustained by favorable climatic conditions that support different ecological zones. These include freshwater swamp and mangrove forests in the Niger Delta, tropical rainforest in the southwestern and southeastern regions, and savannah woodland in the north (Salami et al., 1990; Adekunle et al., 2014). Among these, the tropical rainforest is particularly significant due to its high biodiversity, structural complexity, and diverse ecological functions. These forests play critical roles in climate regulation, carbon sequestration, soil protection, hydrological cycle maintenance, and provision of habitats for numerous plant and animal species.

To ensure the conservation and sustainable management of these forest resources, approximately 10% of Nigeria's land area—comprising roughly 1,160 forest reserves—has been designated as protected forest areas (Ezealor, 2002). These reserves are essential for safeguarding biodiversity, maintaining ecological stability, and providing sustainable forest goods and services. They also support rural livelihoods through the production of timber and non-timber products, such as medicinal plants, fuelwood, herbs, and edible leaves (Adesina, 2001; Ige & Adekunle, 2021), while contributing to landscape preservation and environmental stability (Omiyale, 2001).

Despite these conservation efforts, many forest reserves face increasing threats from anthropogenic activities. Unsustainable resource exploitation and the conversion of forest land to agriculture have led to reduced forest cover and biodiversity (Ezealor, 2002). In southwestern Nigeria, protected areas are often encroached upon or cleared for crops such as cocoa, oil palm, and banana, resulting in habitat degradation, fragmentation, and altered forest structure. Tropical rainforests are particularly vulnerable due to their fertile soils and the high commercial value of their tree species (Onyekwelu et al., 2005; Lafrankie et al., 2006; Gbiri & Adeoye, 2019). Logging, timber extraction, and agricultural expansion have accelerated deforestation, disrupted ecological processes, reduced regeneration potential, and altered species composition (Adekunle, 2006; Onyekwelu & Fuwape, 2008; Popoola, 2008; WWF, 2020; Hansen et al., 2013; Aiyede, 2018; Ghazoul & Chazdon, 2017).

Baseline ecological data for protected areas in Ondo State remain limited, yet such information is crucial for evaluating conservation effectiveness and guiding sustainable forest management. This study therefore, assessed three protected areas in Ondo State by examining their phytosociological characteristics and tree species richness, under the hypothesis that variations in anthropogenic disturbance and management conditions lead to significant differences in these attributes.

2. Materials and Methods

2.1. The Study Area

This study was carried out in Ondo State, Nigeria, with one protected area randomly selected from each of the three senatorial districts. The PAs comprise two forest reserves (Oluwa and Akure-Ofosu from central and southern senatorial districts respectively) and one National Park (Osse River Park from Ondo North senatorial district). Ondo state lies within Lat. 6^0 - 8^0 N and Long. 4^0 - 6^0 E, bounded by Edo, Ogun, Osun, Kogi and Benin states. The climate features distinct rainy and dry seasons with high temperature and humidity year-round, mean annual temperature ranging between 26^0C and 28^0C (Adekunle and Olagoke, 2008), and mean annual rainfall between 1500-2200 mm (Fuwape et al, 2001). Akure-Ofosu forest reserve is located at Latitude $6^0$56'42"N and Longitude $5^0$21'01"E. Oluwa (OA3) Forest lies within Latitude $6^0$52'N and Longitude $4^0$33'E. Osse river park (formerly known as Ifon Game Reserve) is located at Latitude $7^0$14'N and Longitude 5^0' 54'E.

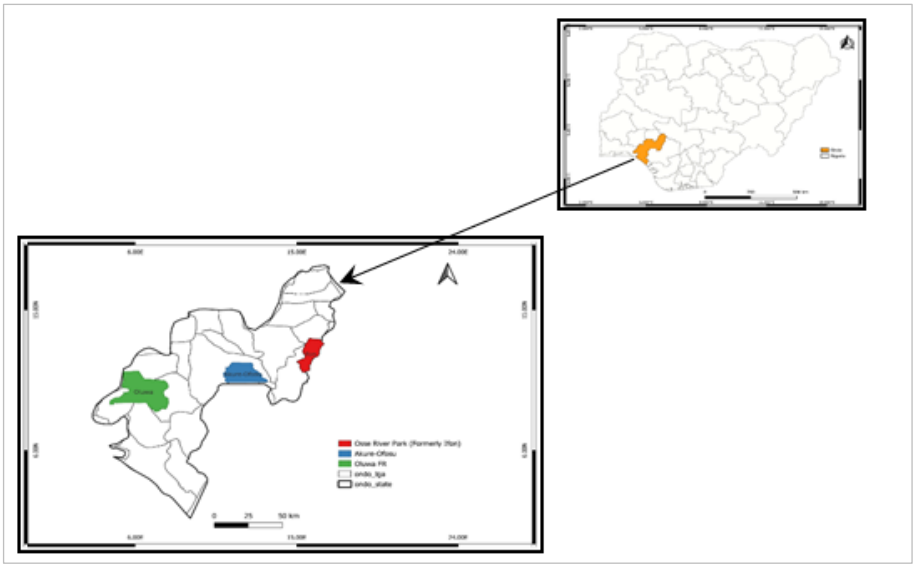

Figure 1: Map of Ondo State showing the location of the study area

Data collection employed systematic line transect sampling with 50m× 50m plots established at 250m intervals along each transect according to Ijeoma et al., 2022. Twelve plots were assessed across the protected areas. All trees with DBH ≥ 10 cm were identified, measured for diameter and height and used to estimate tree volumes, species diversity and abundance. Unidentified species were collected for herbarium identification using local names and plant parts.

2.3. Data Analysis

To quantify stand structure and growing stock within the study area, basal area and tree volume of each tree were calculated.

2.3.1. Basal Area Estimation

$$BA = \frac{\pi D^2}{4} \tag{2.1}$$

Where: BA= Basal Area; π= 3.142 and D= Diameter at breast height. The total BA for each plot was obtained by adding all tree BA in the sample plot.

2.3.2. Volume Estimation

The volume of individual trees was estimated using the Newtons' formula (Husch et. al., 2003)

$$V = \frac{\pi h}{24}(Db^2 + 4Dm^2 + Dt^2) \tag{2.2}$$

Where: V = Tree volume (m^3); D_b, D_m and D_t = Diameter at the base, middle and top (cm) respectively and H = height (m) Plot volume was also obtained by adding the volumes of all trees in the plot.

2.3.4. Biodiversity Indices and Tree Species Classification

Biodiversity analyses employed to evaluate species composition and ecological stability of the forest ecosystem are as follows:

(i) Species relative density (RD). This was calculated according to Brashears et al. (2004) equation:

$$RD = \left[\frac{n_i}{N}\right] \times 100 \tag{2.3}$$

Where n_i = Number of individual species I; N = Total number of individual in the entire population.

(ii) Species relative dominance (RDo) was calculated according to Curtes and McIntosh (1950);

$$RDo = \left(\frac{\sum BA_i \times 100}{\sum BA_n}\right) \quad (2.4)$$

Where: BA_i = Basal area of individual trees belonging to a particular species i and BA_n = Stand basal area.

(iii) Relative frequency (RF) was obtained using the formula according to Oduwaiye et. al (2002):

$$RF = \frac{\sum F_i \times 100}{F_n} \quad (2.5)$$

Where F_i = frequency of i species and F_n = Total frequency of all species.

(iv) Shannon- Wiener diversity index was calculated according to Shannon, 1948

$$H' = -\sum_{i=1}^{S} piLn(pi) \quad (2.6)$$

Where: S = Total number of species in the community; P_i = the proportion of a species to the total number of plants in the community and Ln = the natural logarithm

(v) Species evenness (E) was computed according to Pielou (1966):

$$E = \frac{H\prime}{Ln(S)} \quad (2.7)$$

(vi) Margalef's Index of species richness was calculated according to Margalef (1958)

$$D = \frac{S-1}{Ln\ N} \quad (2.8)$$

(vii) Simpson's Diversity index according to Simpson (1949)

$$D = 1 - \sum\left[\frac{n_1}{N}\right]^2 \quad (2.9)$$

(viii) Number 1 of Hill diversity index was calculated according to Hill (1973)

$$N1 = \text{Exp}\ (-\sum pi\ (Lnpi)) \quad (2.10)$$

2.3.5. Statistical Analysis

Linear relationships between tree growth variables and biodiversity indices in the selected PAs were evaluated using Pearson's correlation coefficient in SPSS 20.0 ($\alpha = 0.05$).

3. Results and Discussion

The results of this study shows the level of tree species diversity, distribution and abundance in three selected PAs in Ondo State, Nigeria. The list of all tree species encountered is presented in Tables 1, 2 and 3 for Akure-Ofosu forest reserve, Osse River Park and Oluwa (OA3) forest reserve respectively. A total of 330 tree/ha (29 families) were encountered in Akure-Ofosu, 242 stems per ha (36 families) in Oluwa (OA3) forest reserves and 177 trees/ha (33 families) in Osse River Park. While the highest number of trees were found in Akure-Ofosu forest reserve, the highest number of species and families were in Oluwa Forest Reserve. In Akure-Ofosu forest reserve, Terminalia superba has the highest frequency ha-1 (60), followed by Cola gigantea (42) and next to that is Funtumia elastica of (34). Single occurrence species accounted for approximately 36% of all species observed in this location. Example of such species include Trema Orientalis, Holoptelea grandis, Cola milleni, Newbouldia lewis (Table 1). The table also revealed the total highest mean height (18.8 m) for Canarian schweinfurthii. The species with the highest mean dbh (138 cm) was Canarian schweinfurthii, closely followed by Amphimas pterocarpoides (137 cm) and Distemonanthus benthamianus (132 cm). Terminalia superba had the highest basal area (46.36 m2) and volume (430.84 m3) per hectare. In Osse River Park, Vitex grandifolia had the highest frequency ha-1 (18), followed by Detarium microcarpum (13) and Balanite aegyptiaca (11) while about 54% of species recorded at this location were encountered

only once, including Trema orientalis, Celtis mildbraedi and Afrolicania elacosperma (Table 2). In this location, Pterocarpus osun had the highest mean height (11.30m) and highest Dbh (194 cm) while Vitex grandifolia recorded the highest volume (101.22 m3) per hectare and Celtis zenkeri recorded the highest basal area (14.15 m2) per hectare. In Oluwa forest reserve, the most abundant species ha-1 was Funtumia elastica (20) followed by Terminalia superba (16) and Celtis zenkeri (14). Erythrophleum suaveolens recorded the highest mean height and highest mean volume of 22.68m and 282.01m3 per hectare respectively, while the highest mean Dbh (167 cm) was obtained for Chrysophylum albidum, the highest mean basal area (20.81 cm2) was obtained for Ceiba pentandra. Approximately, 38% of the recorded species exhibited a single occurrence in this location.

The numbers of tree species and families encountered in the study sites correspond to the studies of Lowe, 1997; Adekunle, 2006; Onyekwelu et al., 2008; Salami and Jibo, 2019 who reported similar number of tree species and families for Tropical rainforest ecosystem of southwest, Nigeria. Conversely, the number of tree species recorded in this study was lower than those reported by Lu et al. (2010) and Rajkumar and Parthasarathy (2008), who documented 207 species in 53 families in the Xishuangbanna tropical forest of Southwest China and 105 species in 49 families in the Andaman evergreen forest, India, respectively. Despite similar climates, Ondo State forests support fewer tree species, likely due to human pressures, underscoring the importance of effective conservation and sustainable management. Certainly, many tree species described by Keay (1989) still exist in Ondo State forests, which remain rich in indigenous hardwoods. These complex, specie-rich rainforests provide vital resources supporting rural livelihoods (Parthasarathy 2001; Kumar et al., 2006).

The number of stems ha-1 obtained from the study sites (Akure-Ofosu- 330; Osse- 177 and Oluwa forest reserve- 242) were less compared to 387 stems ha-1 reported by Aigbe et al., 2014 for Strict Nature Reserve of Akure forest and relatively high value of 864 stem ha-1 reported by Salami and Jibo, 2019 for Owo forest reserve. The number of stems ha-1 obtained also corroborate the work of Duran et al., 2006 who reported 347 stems ha-1 distributed among 42 families for a Mexican tropical deciduous forest as cited by Salami and Jibo, 2019. The reason for the low floristic distribution obtained in this study cannot be far-fetched from impacts of anthropogenic disturbances such as indiscriminate logging, Agricultural expansion and Land cover changes (Lawal et al., 2025). All of these poses great threat to forest reserves. However, there is high tendency for these forest reserves to recover their primary genetic resources if properly and sustainably managed to meet the present need as well as future generation. Forest reserves establishment is a segment of the in situ conservation methods aimed to protect and conserve tree species basically for the benefit of mankind. Unfortunately, the establishment and management of forest reserves is under increasing threats resulting from factors that eliminated most of the natural tropical forests such as uncontrolled exploitation of valuable timber resources from the reserves, encroachment into the reserves by farmers who remove forest vegetation to make way for planting agricultural crops (Kadeba, 1993; Adebi, 2008 and Adekunle et al., 2010). The functioning and conservation of the biosphere is basically dependent on the forest ecosystems, as they are the source of many plants and animals (Agbelade et al, 2017). As a result of deliberate protection measures, forest reserves becomes rich in biodiversity.

Across the three selected locations, the highest volume of tree ha-1 (2897.12m3) was obtained from Oluwa (AO3) forest reserve, followed by Akure-Ofosu forest reserve (1710.91m3) and the least (1004.55m3) was obtained for Osse River Park. This findings is crucial for conservation and sustainable harvesting in each of the PAs. Funtumia elastica had the highest species importance values index (IVI) 0f 6.24 for Oluwa forest reserve, and Terminalia superba (19.25) for Akure-Ofosu forest reserve while Milicia exelsa recorded the highest IVI (9.34) in Osse River Park. These species and dominant pattern indicates distinct ecological conditions, soil types or climate factors influencing species composition in each site. The presence of Milicia exelsa in Osse River Park is noteworthy because of its economic importance. The relatively low volume but high IVI of this species suggests specialized conservation attention to protect this high value timber tree.

Table 1

Tree species diversity, relative frequency, volume and diversity index of Akure-Ofosu forest reserve

Families	Spicies	N/ha	MHt (m)	MDbh (cm)	Ba/ha (m^2)	Vol./ha (m^3)	PiLnPi	Rdo	RD	IVI
Ulmaceae	*Celtis zenkeri Engl.*	14	10.18	64	5.25	22.8	0.13	2.33	4.22	3.28
	Trema orientalis (L) Bl.	1	6.7	31	0.07	0.54	0.01	0.03	0.15	0.09
	Holoptelea grandis (Hutch.)	1	6.39	83	0.73	3.45	0.01	0.31	0.15	0.23
Sterculiaceae	*Sterculia oblonga K Schum*	5	12.86	111	3.77	7.37	0.06	0.02	1.51	0.77
	Pterygota macrocarpa K.Schum	17	11.45	81	10.64	79.34	0.16	4.81	5.28	5.05
	Triplochitin seleroxylon K Schum	12	13.29	95	9.5	53.02	0.12	4.21	3.77	3.99
	Mansonia altissima A. Chev	11	10.74	67	4.55	18.92	0.12	2.00	3.47	2.74
	Cola gigantea A, Chev	42	10.52	79	31.48	278.83	0.26	13.95	12.52	13.24
	Cola milleni Lindl	1	4.11	30	0.26	1.61	0.04	0.12	0.75	0.44
	Sterculia rhinopetala K Schum	1	15.8	76	0.26	1.21	0.01	0.1	0.15	0.13
Euphorbiaceae	*Ricinodendron hendelotii (Baill)*	9	12.36	111	9.98	64.47	0.1	4.42	2.71	3.57
Burseraceae	*Canarian schweinfurthii Engl*	1	18.8	138	0.75	9.12	0.01	0.33	0.15	0.24
Moraceae	*Milicia exelsa (Welw) Warb*	3	13.09	112	4.58	19.74	0.05	2.01	1.06	1.54
	Ficus exasperata Vahl	2	8.03	67	0.58	1.44	0.02	0.27	0.45	0.36
	Antiaris africana Engl	4	14.24	105	2.65	23.85	0.05	1.18	1.06	1.12
	Ficus capensis Forssk	2	6.1	42	0.19	1.85	0.01	0.17	0.85	0.51
	Ficus mucuso Ficalho	3	6.14	24	0.19	2.07	0.04	0.86	0.94	0.90
	Myrianthus arboreus P. Beauv	2	6.22	40	0.55	8.6	0.04	0.22	0.75	0.49
Ceoropiaceae	*Musanga cecropioides R Br*	2	6.7	38	1.85	1.12	0.03	0.82	0.06	0.44
Apocynaceae	*Funtumia elastica (Preuss) Stapf*	34	7.06	46	7.64	80.53	0.24	3.39	10.41	6.90
	Funtumia africana (Benth.) Stapf	1	7.27	109	1.0	6.03	0.02	0.44	0.3	0.37
	Alstonia boneii De Wild	11	12.01	94	8.83	77.73	0.11	3.94	3.17	3.56
Agavaceae	*Dracaena mannii Bak.*	1	8.4	59	0.13	0.68	0.01	0.06	0.15	0.11
Caesalpiniodeae	*Brachystegia eurycoma Harms*	4	4.62	15	9.3	24.62	0.58	4.12	1.36	2.74
	Diallium guinesense Willd	2	2.27	60	0.84	1.57	0.03	0.37	0.6	0.49
	Hylodendron gabunensis Taub	2	7.6	66	0.65	2.87	0.01	0.31	0.15	0.23
	Distemonanthus benthamianus Baill	1	16.2	132	0.63	8.32	0.01	0.3	0.15	0.23
Mimosoideae	*Albizia gumifera J. F Macbr*	1	7.8	96	0.36	1.72	0.01	0.16	0.15	0.16
	Albizia zygia (DC) Marcbr	5	9.54	83	3.7	16.54	0.06	1.64	1.51	1.58
Boraginaceae	*Cordia millenii Bak*	5	9.75	110	3.34	20.41	0.63	1.5	1.51	1.51
Bombacaeae	*Ceiba pentandra (L) Gaertn*	16	18.53	126	22.32	219.15	0.15	9.9	4.98	7.44
	Bombax buonopezense P.Beauv.	1	16.5	99	0.78	14.08	0.02	0.35	0.3	0.33
Miliacaeae	*Khaya ivorensis A Chev*	1	10.55	68	0.47	1.41	0.02	0.21	0.45	0.33
	Trichillia rubenscens (Thonn) J J DeWilde	5	10.21	79	0.26	12.83	0.06	0.12	1.36	0.74
	Entandrophragma cylindricum	2	15.38	99	1.62	17.38	0.03	0.74	0.6	0.67
Sapindeceae	*Lecaniodiscus cupanioides Planch*	4	2.31	40	0.54	1.17	0.05	0.26	1.21	0.74
	Blighia sapida K Konig	1	12.6	56	0.44	4.2	0.01	0.02	0.15	0.09
Anarcardiaceae	*Spondia mombin Linn*	2	7.25	53	0.55	1.04	0.04	0.24	0.75	0.50
	Lannea acida (Hiern) Engl	3	11.91	110	2.52	15.91	0.04	1.12	0.75	0.94
Sapotaceae	*Malacantha alnifolia (Baker) Pierre*	1	8.54	79	0.91	3.07	0.02	0.4	0.3	0.35
Combretaceae	***Terminalia superba Engl.&Diels (Limba)***	60	13.99	97	46.36	430.84	0.31	20.55	17.95	19.25
Rutaceae	*Fagara loprieurii (Guill &Perr)*	7	9.96	64	2.83	46.23	0.08	1.19	2.11	1.65
Capparaceae	*Boscia augustifola Guill. &Perr.*	2	9.8	76	0.68	2.63	0.02	0.3	0.45	0.38
Papilionoideae	*Pterocarpus osun Craib*	1	9.45	77	0.82	1.37	0.02	0.37	0.45	0.41
	Amphimas pterocarpoides Harms	1	10.4	137	0.74	3.44	0.01	0.03	0.15	0.09
Rubiaceae	*Morinda lucida Benth*	1	8.4	67	0.17	0.94	0.01	0.06	0.15	0.11
Lecythidaceae	*combretodendron macrocarpum (P. Beauv)*	1	10.46	119	1.8	10.13	0.02	0.8	0.45	0.63
Chenopodiaceae	*Chenopodium ambrosioides Linn*	7	8.05	43	1.66	4.07	0.08	0.73	1.96	1.35
Olacaceae	*Strombosia postulata Oliv.*	5	11.87	79	2.5	11.32	0.06	1.11	1.51	1.31
Myristicaceae	*Pycnanthus angolensis (Welw) Warb.*	2	10.62	107	4.61	28.5	0.05	0.45	0.09	0.27
Sirmaroubaceae	*Hannoa klainema Pierre & Engl,*	2	10.79	104	2.97	10.85	0.07	1.32	0.75	1.04
Annonaceae	*Cleistopholis patens (Benth.) Engl. & Diels*	1	15.5	124	1.62	12.13	0.02	0.72	0.45	0.59
	Enantia chlorantha Oliv	1	8.0	34	0.07	5.6	0.02	0.03	0.3	0.17
Vitaceae	*Cissus aralioides Welw ex Baker*	2	12.4	79	1.02	11.41	0.04	0.33	0.75	0.54
Bignoniaceae	*Newbouldia lewis Seemann ex Bureau*	1	6.2	22	0.08	0.86	0.01	0.04	0.3	0.17
	Total	330			222.6	1710.9	4.24			

Table 2

Tree species diversity, relative frequency, volume and diversity index of Osse River Park

Families	Spicies	N/ha	MHt (m)	MDbh (cm)	Ba/ha (m^2)	Vol./ha (m^3)	PiLnPi	Rdo	RD	IVI
Ulmaceae	*Celtis zenkeri Engl.*	9	6.86	63	14.15	19.5	0.16	9.41	6.23	7.82
	Trema orientalis (L) Bl.	1	3.05	23	0.21	1.44	0.03	0.21	0.59	0.40
	Celtis mildbraedi Engl.	1	7.5	80	0.25	1.5	0.02	0.26	0.3	0.28
Sterculiaceae	*Sterculia oblonga K Schum*	4	10.3	28	1.73	30.72	0.1	1.78	2.67	2.23
	Pterygota macrocarpa K.Schum	2	5.8	59	1.84	7.94	0.04	1.89	0.89	1.39
	Triplochitin seleroxylon K Schum	1	3.27	23	0.9	6.31	0.03	0.09	0.59	0.34
	Mansonia altissima A. Chev	1	1.78	24	0.05	5.64	0.03	0.04	0.59	0.32
	Cola lauriifolia Mast	7	4.16	45	1.26	13.73	0.13	1.29	4.15	2.72
	Sterculia tragacantha K. Schum	1	3.45	25	0.61	2.84	0.02	0.62	0.3	0.46
	Dombeya buettneri K Schum	1	4.75	70	0.38	4.21	0.03	0.39	0.59	0.49
Euphorbraceae	*Bridelia ferruginea Benth*	5	3.44	34	1.34	29.11	0.11	1.37	2.97	2.17
	Ricinodendron hendelotii (Baill)	8	6.23	72	4.05	51.25	0.12	4.15	3.56	3.86
	Maprounea africana Muell.Arg	1	2.15	22	0.18	1.72	0.03	0.18	0.59	0.39
Burseraceae	*Canarium schweinfurthii Engl*	1	6.5	71	0.2	4.47	0.02	0.2	0.3	0.25
Moraceae	***Milicia exelsa (Welw) Warb***	2	3.16	17	0.35	10.94	0.05	17.49	1.19	**9.34**
Apocynaceae	*Funtumia elastica (Preuss) Stapf*	8	1.85	24	0.98	32.62	0.15	1.01	5.04	3.03
	Funtumia africana (Benth.) Stapf	2	2.17	16	0.14	6.86	0.04	0.15	0.89	0.52
Agavaceae	*Dracaena mannii Bak.*	3	2.42	19	0.83	14.22	0.08	0.85	2.08	1.47
Caesalpiniodeae	*Brachystegia eurycoma Harms*	1	5.3	75	1.0	8.92	0.03	1.02	0.59	0.81
	Diallium guinesense Willd	1	3.25	80	1.01	2.11	0.02	1.03	0.3	0.67
	Afzelia africana Sm	2	6.45	118	2.23	7.13	0.05	2.29	1.19	1.74
	Daniellia olliverii (Roife) Hutch. &Dalz	6	6.24	108	8.52	91.25	0.12	8.76	3.56	6.16
	Brachystegia kennedyis Harms	1	4.6	168	1.11	10.08	0.02	1.14	0.3	0.72
	Detarium microcarpum Guill & Perr	13	3.65	50	5.47	86.71	0.2	5.63	7.72	6.68
Mimosoideae	*Acacia sieberina (DC)*	2	5.23	47	0.38	4.84	0.05	0.39	1.19	0.79
	Albizia zygia (DC) Marcbr	2	5.93	52	2.23	14.19	0.05	2.3	1.19	1.75
Boraginaceae	*Cordia millenii Bak*	1	3.23	14	0.07	3.14	0.03	0.07	0.59	0.33
Bombacaeae	*Ceiba pentandra (L) Gaertn*	1	1.6	9	0.02	4.15	0.02	0.01	0.3	0.16
Miliacaeae	*Khaya grandifolia A Chev*	1	9.75	87	0.61	6.91	0.03	0.63	0.59	0.61
	Guarea thompsonii Sprague	1	8.77	14	0.15	9.45	0.03	1.58	0.59	1.09
	Khaya senegalensis (Desr)	1	9.1	63	0.61	6.91	0.03	0.6	0.59	0.60
Sapindeceae	*Lecaniodiscus cupanioides Planch*	1	2.28	45	0.44	2.44	0.02	0.45	0.3	0.38
	Blighia sapida K Konig	2	3.62	58	0.52	14.76	0.04	0.6	0.89	0.75
Anarcardiaceae	*Spondia mombin Linn*	1	2.6	24	0.09	2.42	0.02	0.09	0.3	0.20
	Lannea acida (Hiern) Engl	1	6.06	75	1.42	4.73	0.04	1.46	0.89	1.18
Sapotaceae	*Malacantha alnifolia (Baker) Pierre*	1	2.7	16	0.04	1.68	0.02	0.04	0.32	0.18
	Chrysophylum albidum G Don	2	8.1	112	1.43	14.71	0.04	1.47	0.89	1.18
	Chrysophyllum perpulchrum G Don	1	2.1	24	1.18	17.84	0.04	1.21	0.89	1.05
Combretaceae	*Anogeissus leiocarpus (DC) Guill & Perr*	6	7.41	86	5.95	49.28	0.12	6.12	3.56	4.84
	Terminalia avicenniodies Guill & Perr	3	3.77	52	1.04	7.22	0.07	1.07	1.78	1.43
Rutaceae	*Fagara zanthoxyloides Lam*	1	3.62	40	0.05	2.51	0.03	0.05	0.59	0.32
	Fagara loprieurii (Guill &Perr)	1	2.95	35	0.93	5.52	0.03	0.92	0.59	0.76
Capparaceae	*Boscia augustifola Guill. &Perr.*	2	5.07	40	3.48	34.37	0.04	3.58	0.89	2.24
Papilionoideae	*Pterocarpus osun Craib*	1	11.3	194	1.89	5.15	0.03	1.94	0.59	1.27
Irvingiceae	*Irvingia gabunensis Baill. (Aubry.Locomto)*	1	9.51	98	1.69	25.85	0.04	1.74	0.89	1.32
Passifloraceae	*Barteria fistulosa Mast*	2	4.63	21	0.23	9.27	0.04	0.23	0.89	0.56
Erythroxylaceae	*Erythrophleum suaveolens (Guill &Perr)*	1	3.11	85	1.14	4.44	0.02	1.17	0.3	0.74
Rubiaceae	*Nuclea latifolia (De Wild.& T. Durand) Merill*	1	1.5	15	0.04	1.01	0.02	0.03	0.3	0.17
Annonaceae	*Annona senegalensis Pers*	7	2.55	25	1.63	32.91	0.14	1.64	4.45	3.05
Asteraceae	*Eclipta prostrata (L) Hassk*	1	3.73	76	0.88	6.54	0.04	0.91	0.89	0.90
Loganiaceae	*Strychnos spinosa Lam*	1	4.25	43	0.29	3.19	0.02	0.3	0.31	0.31
Pendanaceae	*Borassus aethiopum Mart*	1	3.9	64	0.93	10.63	0.03	0.96	0.59	0.78
Verbenaceae	*Vitex grandifolia Gurke*	18	5.39	62	7.5	101.22	0.24	7.71	10.39	9.05
Hymenocardiaceae	*hymenocardia acida Tul*	7	4.94	23	1.61	37.42	0.13	1.66	4.15	2.91

Table 2

Tree species diversity, relative frequency, volume and diversity index of Osse River Park (continued)

Families	Spicies	N/ha	MHt (m)	MDbh (cm)	Ba/ha (m^2)	Vol./ha (m^3)	PiLnPi	Rdo	RD	IVI
Tiliaceae	*Desplatsin lutea Bocq*	1	6.73	56	0.13	4.74	0.02	0.13	0.32	0.23
	Desplatsia dreweirei (De Wild &Th. Dur)	1	0.56	443	0.25	3.62	0.03	0.25	0.59	0.42
Balanitaceae	*Balanite aegypliaca Linn*	11	4.17	73	10.9	68.12	0.18	11.26	6.82	9.04
Ebenaceae	*Diospyros suaveolens Gurke*	2	8.35	65	0.68	2.86	0.05	1.54	1.19	1.37
Chrysobalanaceae	*Afrolicania elacosperma Mildbr*	1	2.19	10	0.02	3.44	0.02	0.01	0.36	0.19
	Maranthes polyandra (Benth)	5	6.12	54	2.49	24.13	0.1	2.55	2.67	2.61
	Asparagus africana Hook	2	2.15	22	0.18	1.72	0.03	0.18	0.59	0.39
	Total	177			101.9	1004.6	3.56			

Table 3

Tree species diversity, relative frequency, volume and diversity index of Oluwa (AO3) forest reserve

Families	Spicies	N/ha	MHt (m)	MDbh (cm)	Ba/ha (m^2)	Vol./ha (m^3)	PiLnPi	Rdo	RD	IVI
Ulmaceae	*Celtis zenkeri Engl*	14	9.6	70	14.95	143.5	0.17	5.15	6.0	5.58
	Trema orientalis (L) Blume	2	3.83	18	0.4	1.54	0.04	0.14	0.83	0.49
	Holoptelea grandis (Hutch) Mildbr	2	10.4	86	2.2	22.92	0.03	0.76	0.62	0.69
Sterculiaceae	*Sterculia oblonga K Schum*	4	9.73	81	5.06	49.19	0.07	1.74	1.86	1.80
	Pterygota macrocarpa K.Schum	1	10.54	83	5.09	53.67	0.07	1.76	1.66	1.71
	Triplochiton seleroxylon K Schum	6	11.67	73	7.89	91.53	0.10	2.72	2.69	2.71
	Mansonia altissima A. Chev	2	8.0	64	0.99	7.99	0.03	0.34	0.62	0.48
	Cola gigantean A, Chev	5	8.11	67	7.35	59.64	0.08	2.53	2.07	2.30
	Nesogordonia papaverifera A Chev	1	9.25	60	0.58	5.29	0.02	0.20	0.41	0.31
	Hildergia barterii (Mast.) Kosterm.	1	6.83	59	0.27	1.87	0.01	0.09	0.21	0.15
	Cola lauriifolia Mast	1	5.05	52	0.41	2.1	0.02	0.14	0.41	0.28
Euphorbiaceae	*Ricinodendron heudeloti (Baill) Heckel*	6	11.56	98	15.13	174.9	0.09	5.21	2.48	3.85
	Bridelia micrantha (Hochst.) Baill	1	7.23	41	0.45	3.27	0.01	0.31	0.21	0.26
	Macaranga barteri Muell. Arg	5	6.67	66	3.96	26.44	0.08	1.37	2.07	1.72
Burseraceae	*Canarium schweinfurthii Engl*	2	10.15	116	5.6	56.8	0.05	1.93	1.04	1.49
Moraceae	*Treculia africana Decne*	1	10.4	144	4.41	45.84	0.03	1.52	0.62	1.07
	Milicia exelsa (Welw) C.C Berg	4	8.94	95	8.49	75.88	0.06	2.92	1.45	2.19
	Ficus exasperata Vahl	2	5.75	39	1.68	9.68	0.04	0.58	0.83	0.71
	Antiaris africana Engl Lesch	4	8.13	79	3.89	31.58	0.07	1.34	1.66	1.50
	Ficus capensis Thunb	1	5.55	47	0.56	3.08	0.01	0.19	0.21	0.20
	Ficus mucuso Welw. Ex Ficalho	3	6.02	80	4.01	24.17	0.06	1.38	1.24	1.31
	Myrianthus arboreus P. Beauv	2	5.03	60	1.19	5.98	0.04	0.41	0.83	0.62
	Musanga cecropioides R Br ex Tedlie	6	6.0	39	1.48	8.88	0.09	0.51	2.48	1.50
Apocynaceae	***Funtumia elastica (Preuss) Stapf***	20	7.13	57	12.16	86.68	0.21	4.19	8.28	**6.24**
	Funtumia africana (Benth) Stapf	1	8.15	68	1.3	10.63	0.03	0.45	0.62	0.54
	Alstonia boneii De Wild	12	9.52	83	14.35	136.52	0.15	4.94	4.76	4.85
	Raufolvia vomitoria Afzel	2	4.03	30	0.29	1.15	0.04	0.17	0.15	0.16
	Landolphia owariens P. Beauv	2	5.25	37	0.22	1.15	0.02	0.08	0.03	0.06
Agavaceae	*Dracaena mannii Bak.J. J. Bos*	1	13.82	84	0.55	7.65	0.01	0.19	0.21	0.20
Caesalpiniodeae	*Brachystegia eurycoma Harms*	3	7.73	84	7.98	61.65	0.06	2.75	1.24	2.00
	Daniellia ogia (Harms) Rolfe ex Holl.	1	11.8	92	6.65	78.44	0.01	2.29	0.21	1.25
	Diallium guinesense Wild	1	5.7	35	0.92	5.26	0.01	0.32	0.21	0.27
	Hylodendron gabunensis Taub	1	6.78	63	1.82	12.32	0.05	0.63	1.04	0.84
Mimosoideae	*Albizia adianthifolia (Schum) W. F. Wight*	1	3.56	25	0.05	0.17	0.13	0.02	0.21	0.12
	Albizia zygia (DC) J.F. Marcbr	4	8.88	112	6.68	59.29	0.07	2.3	1.86	2.08
Boraginaceae	*Cordia millenii Bak*	3	6.76	80	3.48	23.51	0.05	1.22	1.24	1.23
Bombacaeae	*Ceiba pentandra (L) Gaertn*	6	13.09	162	20.81	272.58	0.09	7.17	2.48	4.83
Miliacaeae	*Trichillia rubenscens Oliv*	5	6.69	81	3.92	26.22	0.08	1.35	2.07	1.71
	Entandrophragma cylindricum (Sprague)	1	11.35	91	1.41	15.95	0.02	0.48	0.41	0.45
Sapindeceae	*Lecaniodiscus cupanioides Planch ex Benth*	2	3.67	27	0.17	0.63	0.03	0.06	0.62	0.34
	Blighia sapida Konig	1	7.22	84	1.12	8.04	0.01	0.21	0.38	0.30

Table 3
Tree species diversity, relative frequency, volume and diversity index of Oluwa (AO3) forest reserve (continued)

Families	Spicies	N/ha	MHt (m)	MDbh (cm)	Ba/ha (m^2)	Vol./ha (m^3)	PiLnPi	Rdo	RD	IVI
Anarcardiaceae	*Spondia mombin Linn*	3	5.53	95	2.18	12.01	0.06	0.75	1.24	1.00
	Lannea acida A. Rich	2	10.21	101	4.17	42.55	0.04	1.44	0.83	1.14
Sapotaceae	*Malacantha alnifolia (Baker) Pierre*	2	8.97	100	6.06	54.33	0.05	2.09	1.04	1.57
	Chrysophylum albidum G Don	1	14.8	167	2.19	32.42	0.01	0.75	0.21	0.48
	Aningeria rubosta (A. Chev) Aubrev& Pellegr	1	8.8	92	0.66	5.85	0.01	0.23	0.21	0.22
Combretaceae	*Terminalia superba Engl.&Diels*	16	11.03	82	12.72	140.36	0.18	4.38	6.63	5.51
	Terminalia ivorensis A Chev	3	11.03	93	2.68	29.58	0.05	0.92	1.04	0.98
Rutaceae	*Fagara loprieurii (Guill &Perr)*	5	8.0	75	4.34	34.73	0.08	1.5	2.07	1.79
Capparaceae	*Boscia augustifola A. Rich*	3	7.04	85	3.86	27.18	0.01	1.33	1.24	1.29
	Buchholzia coriacea Enechi	1	5.2	42	0.36	1.87	0.02	0.21	0.02	0.12
Papilionoideae	*Pterocarpus osun Craib*	1	8.2	96	0.72	5.94	0.01	0.25	0.21	0.23
	Amphimas pterocarpoides Harms	2	10	123	4.29	42.89	0.04	1.48	0.83	1.16
	Afromosia elata	1	8.1	103	0.83	6.75	0.01	0.29	0.21	0.25
Irvingiceae	*Irvingia gabunensis (O'Rorke) Baill.*	1	7.05	77	1.0	7.05	0.02	0.34	0.41	0.38
Passifloraceae	*Barteria fistulosa Mast*	1	8.4	58	0.26	2.22	0.01	0.05	0.21	0.13
Erythroxylaceae	*Erythrophleum suaveolens (Guill &Perr)*	1	22.68	158	12.52	284.01	0.05	4.31	1.04	2.68
	Erythrophleum ivorense A. Chev	1	14	162	7.19	100.66	0.05	2.48	1.04	1.76
Rubiaceae	*Nuclea diderrichii (De Wild.& T. Durand) Merill*	4	9.03	72	1.17	10.58	0.06	0.4	1.45	0.93
	Morinda lucida (Benth)	1	5.8	52	0.21	1.23	0.01	0.07	0.21	0.14
Lecythidaceae	*combretodendron macrocarpum (P. Beauv)*	3	10.44	120	6.81	71.14	0.06	2.35	1.45	1.90
Chenopodiaceae	*Chenopodium ambrosioides Linn*	7	5.81	48	4.45	25.85	0.1	1.53	2.9	2.22
Olacaceae	*Strombosia postulata Oliv.*	7	8.63	69	5.42	46.75	0.1	1.87	2.69	2.28
Myristicaceae	*Pycnanthus angolensis (Welw) Warb.*	3	11.18	96	3.84	42.88	0.06	1.32	1.24	1.28
Sirmaroubaceae	*Hannoa klainema Pierre & Engl,*	5	8.46	83	7.17	60.71	0.08	2.47	2.07	2.27
Annonaceae	*Cleistopholis patens (Benth.) Engl. & Diels*	2	10.2	89	2.33	23.78	0.05	0.8	1.04	0.92
	Xyloia villosa Chipp	1	5.2	48	0.41	2.12	0.02	0.14	0.41	0.28
Vitaceae	*Cissus aralioides Welw ex Baker*	4	6.6	53	3.45	22.75	0.07	1.19	1.66	1.43
Bignoniaceae	*Kigelia africana (Lam.)Benth*	2	5.6	56	0.29	1.62	0.04	0.3	0.83	0.57
	Newbouldia leavis (P.Beauv	1	9.4	67	0.35	3.31	0.01	0.12	0.21	0.17
Ochnaceae	*Lophira alata Banks ex Gaertn*	3	7.31	64	2.51	18.36	0.06	0.12	0.41	0.27
Guttifereae	*Harungana madagascariensis Lam*	5	5.24	46	1.81	9.47	0.07	0.62	1.24	0.93
	Pentadesma butyracea Sabine	3	4.0	54	1.79	7.17	0.06	0.62	1.86	1.24
Rosaceae	*Fragaria ananassa*	1	4.8	22	0.38	1.82	0.01	0.13	1.45	0.79
Malvaceae	*Urena lobata L. Linnaeus*	1	4.2	13	0.01	0.06	0.01	0.1	0.93	0.52
Asteraceae	*Malanthera scandens (Shum & Thonn)*	1	6.8	73	0.51	3.45	0.02	0.01	0.83	0.42
	Total	242			288.9	2897.1	3.95			

Family important indices and tree growth variables on family basis are presented in Table 4, 5 and 6 for Akure-Ofosu forest reserve, Osse River Park and Oluwa Forest Reserve respectively.

Akure-Ofosu recorded 29 families, with Sterculiaceae dominating in stem density (89 stems ha^{-1}), volume (440.3 m^3 ha^{-1}), basal area (60.45 m^2 ha^{-1}), and Family Importance Value (FIV = 76.63). Combretaceae (60 stems ha^{-1}) and Apocynaceae (46 stems ha^{-1}) followed in stem density, while Agavaceae and Rubiaceae showed the lowest FIV (0.51). Osse River Park contained 33 families, with Caesalpiniodeae leading in stem density (24 stems ha^{-1}) and FIV (32.13), followed by Verbenaceae (18 stems ha^{-1}) and Sterculiaceae (17 stems ha^{-1}). Mimosoideae achieved the second-highest FIV (30.15). Mimosoideae and Ulmaceae recorded the highest volume (138.13 m^3 ha^{-1}) and basal area (14.6 m^2 ha^{-1}). Oluwa Forest Reserve showed the highest diversity with 36 families. Apocynaceae recorded the highest stem density (37 stems ha^{-1}), followed by Ulmaceae (27 stems ha^{-1}) and Sterculiaceae (21 stems ha^{-1}). Erythroxylaceae and Apocynaceae achieved the

highest volume and basal area (384.68 m^3 ha^{-1} and 37.47 m^2 ha^{-1} respectively), with Apocynaceae recording the highest FIV (39.20). Malvaceae showed the lowest FIV (0.52).

The dominant family encountered in this study is Sterculiaceae, followed by Combretaceae and Ulmaceae. This corroborated the works of Isichei 1995, Onyekwelu et al, 2008, Adekunle 2006, Adekunle et al, 2010; Adekunle et al, 2014 and Adeseko et al, 2020 that the Nigerian rainforest ecosystem is dominated by members of Sterculiaceae, Combretaceae, Moraceae, Ulmaceae and Meliaceae.

The assessment of growth variables across the selected PAs revealed distinct variations in tree structural attributes, reflecting differences in forest productivity, and possibly the disturbance regimes among the sites. The highest mean basal area (288.9 m2) and mean Volume (2897.1 m3) exhibited by Oluwa Forest Reserve indicates a mature and well-developed forest stand as larger basal area and net volume are linked to higher biomass accumulation, carbon storage potential, and timber yield capacity (Agboola et al., 2021; Cailliez 1980). In contrast, the lower dominant height and diameter obtained in Osse River Park suggest that the PA is characterized by smaller, possibly younger or regenerating tree populations. This pattern may be attributed to past disturbances, selective logging, environmental stress, or natural successional stages within the Park.

Table 4
Families important index value for Akure-Ofusu forest reserve

S/N	Families	N/ha	No of Spp	BA/ha (m^2)	Vol./ha (m^3)	RD	Rdo	RF	FIV
1	Agavaceae	1	1	0.13	0.68	0.06	0.15	0.30	0.51
2	Anarcardiaceae	5	2	3.07	16.95	1.36	1.50	1.52	4.38
3	Annonaceae	2	2	1.69	17.73	0.75	0.75	0.61	2.11
4	Apocynaceae	46	3	17.47	164.29	7.77	13.88	13.94	35.59
5	Bignoniaceae	1	1	0.08	0.86	0.04	0.30	0.30	0.64
6	Bombacaeae	17	2	23.10	233.23	10.25	5.28	5.15	20.68
7	Boraginaceae	5	1	3.34	20.41	1.50	1.51	1.52	4.53
8	Burseraceae	1	1	0.75	9.12	0.33	0.15	0.30	0.78
9	Caesalpiniodeae	9	4	11.42	37.38	5.10	2.26	2.73	10.09
10	Capparaceae	2	1	0.68	2.63	0.30	0.45	0.61	1.36
11	Ceoropiaceae	2	1	1.85	1.12	0.82	0.06	0.61	1.49
12	Chenopodiaceae	7	1	1.66	4.07	0.73	1.96	2.12	4.81
13	Combretaceae	60	1	46.36	430.84	20.55	17.95	18.18	56.68
14	Euphorbraceae	9	1	9.98	64.47	4.42	2.71	2.73	9.86
15	Lecythidaceae	2	1	1.80	10.13	0.80	0.05	0.61	1.45
16	Miliacaeae	8	3	2.35	31.62	1.07	2.41	2.42	5.90
17	Mimosoideae	6	2	4.06	18.26	1.80	1.66	1.82	5.28
18	Moraceae	16	6	8.74	57.55	4.77	4.87	4.85	14.49
19	Olacaceae	5	1	2.53	11.32	1.11	1.51	1.52	4.14
20	Papilionoideae	2	2	1.56	4.81	0.40	0.60	0.61	1.61
21	Rubiaceae	1	1	0.17	0.94	0.06	0.15	0.30	0.51
22	Rutaceae	7	1	2.83	46.23	1.19	2.11	2.12	5.42
23	Sapindeceae	5	2	0.98	5.37	0.28	1.36	1.52	3.16
24	Sapotaceae	1	1	0.91	3.07	0.04	0.30	0.30	0.64
25	Sterculiaceae	89	7	60.45	440.30	25.21	27.45	26.97	79.63
26	Sirmaroubaceae	2	1	2.97	10.85	1.32	0.75	0.61	2.68
27	Ulmaceae	16	3	12.09	26.79	2.67	4.52	4.85	12.04
28	Myristicaceae	2	1	4.61	16.97	1.10	2.56	0.61	4.27
29	Vitaceae	2	1	1.02	11.41	0.04	0.33	0.61	0.97

Table 5
Families important index value for Osse River Park

S/N	Families	N/ha	No of Spp	BA/ha (m^2)	Vol./ha (m^3)	RD	Rdo	RF	FIV
1	Agavaceae	3	1	0.83	14.22	0.85	2.08	1.69	4.62
2	Anarcardiaceae	2	2	1.51	7.15	1.55	1.19	1.13	3.87
3	Annonaceae	7	1	1.60	32.91	1.64	4.45	3.95	10.04
4	Apocynaceae	10	2	1.12	39.48	1.16	5.93	5.65	12.74
5	Asteraceae	1	1	6.54	0.04	0.17	0.89	0.56	1.62
6	Balanitaceae	11	1	10.90	68.12	11.26	6.82	6.21	24.29
7	Bombacaeae	1	1	0.02	0.01	0.01	0.30	0.56	0.87
8	Boraginaceae	1	1	0.07	0.07	0.59	0.59	0.56	1.74
9	Burseraceae	1	1	0.20	4.47	0.20	0.30	0.56	1.06
10	Caesalpiniodeae	24	6	12.87	110.57	13.23	5.34	13.56	32.13
11	Capparaceae	2	1	3.48	34.37	3.58	0.89	1.13	5.60
12	Chrysobalanaceae	6	3	0.02	3.44	0.01	0.30	3.39	3.70
13	Combretaceae	9	2	6.99	56.50	7.19	5.34	5.08	17.61

Table 5
Families important index value for Osse River Park (continued)

S/N	Families	N/ha	No of Spp	BA/ha (m^2)	Vol./ha (m^3)	RD	Rdo	RF	FIV
14	Ebenaceae	2	1	0.68	2.86	1.54	1.19	1.13	3.86
15	Erythroxylaceae	2	1	1.14	4.44	1.17	0.30	1.13	2.60
16	Euphorbraceae	14	3	5.38	80.36	5.52	6.53	7.91	19.96
17	Irvingiceae	1	1	1.69	25.85	1.74	0.89	0.56	3.19
18	Hymenocardiaceae	7	1	1.61	37.42	1.66	4.15	3.95	9.76
19	Loganiaceae	1	1	0.29	3.19	0.30	0.30	0.56	1.16
20	Miliacaeae	3	3	1.37	23.27	2.80	1.78	1.69	6.27
21	Mimosoideae	7	2	6.17	138.13	11.96	14.24	3.95	30.15
22	Moraceae	2	1	0.35	10.94	17.49	1.19	1.13	19.81
23	Papilionoideae	1	1	1.89	5.15	1.94	0.59	0.56	3.09
24	Passifloraceae	1	1	0.23	9.27	0.23	0.89	0.56	1.68
25	Pendanaceae	1	1	0.93	10.63	0.96	0.59	0.56	2.11
26	Rubiaceae	1	1	0.04	1.00	0.03	0.30	0.56	0.89
27	Rutaceae	2	2	0.95	8.03	0.98	1.18	1.13	3.29
28	Sapindeceae	3	2	0.96	17.20	1.05	1.19	1.69	3.93
29	Sapotaceae	4	3	2.65	34.23	2.72	2.08	2.26	7.06
30	Sterculiaceae	17	7	6.76	71.38	6.11	9.79	9.60	25.50
31	Tiliaceae	2	2	0.37	8.36	0.38	0.89	1.13	2.40
32	Ulmaceae	11	3	14.60	22.44	9.88	7.12	6.21	23.21
33	Verbenaceae	18	1	7.51	101.22	7.71	10.39	10.17	28.27

Table 6
Families important index value for Oluwa forest reserve

S/N	Families	N/ha	No of Spp	BA/ha (m^2)	Vol./ha (m^3)	RD	Rdo	RF	FIV
1	Agavaceae	1	1	0.55	7.65	0.19	0.21	0.41	0.81
2	Anarcardiaceae	5	2	6.36	54.56	2.19	2.07	2.07	6.33
3	Annonaceae	2	2	2.74	25.89	0.94	1.45	0.83	3.22
4	Apocynaceae	37	5	37.47	291.93	7.97	15.94	15.29	39.20
5	Asteraceae	1	1	0.51	3.45	0.01	0.83	0.41	1.25
6	Bignoniaceae	3	2	0.64	4.46	0.20	0.62	1.24	2.06
7	Bombacaeae	6	1	20.82	272.58	7.17	2.48	2.48	12.13
8	Boraginaceae	3	1	3.48	23.51	1.20	1.24	1.24	3.68
9	Burseraceae	2	1	5.60	56.80	1.93	1.04	0.83	3.80
10	Caesalpiniodeae	6	4	17.37	157.67	5.99	2.70	2.48	11.17
11	Capparaceae	4	2	4.22	29.05	1.97	1.64	1.65	5.26
12	Chenopodiaceae	7	1	4.45	25.85	1.53	2.90	2.89	7.32
13	Combretaceae	19	2	15.41	169.94	5.30	7.67	7.85	20.82
14	Erythroxylaceae	2	2	19.71	384.68	6.79	2.08	0.83	9.70
15	Euphorbraceae	12	3	19.55	204.61	6.58	4.76	4.96	16.30
16	Guttifereae	8	2	3.60	16.63	1.24	3.31	3.31	7.86
17	Irvingiceae	1	1	1.00	7.05	0.34	0.41	0.41	1.16
18	Lecythidaceae	1	1	6.81	71.14	2.35	1.66	0.41	4.42
19	Malvaceae	1	1	0.01	0.06	0.10	0.01	0.41	0.52
20	Miliacaeae	6	2	5.32	42.17	1.83	2.48	2.48	6.79
21	Mimosoideae	5	2	6.73	59.46	2.32	2.07	2.07	6.46
22	Moraceae	17	8	24.22	196.21	7.93	6.01	7.02	20.96
23	Myristicaceae	3	1	3.84	42.88	1.32	1.24	1.24	3.80
24	Ochnaceae	3	1	2.51	18.36	0.12	1.24	1.24	2.60
25	Olacaceae	7	1	5.42	46.75	1.87	2.69	2.89	7.45
26	Papilionoideae	4	3	5.85	55.58	2.02	1.25	1.65	4.92
27	Passifloraceae	1	1	0.03	2.22	0.19	0.21	0.41	0.81
28	Rosaceae	1	1	0.38	1.82	0.01	0.18	0.41	0.60
29	Rubiaceae	5	2	1.38	11.82	0.47	1.66	2.07	4.20
30	Rutaceae	5	1	4.34	34.73	0.15	2.07	2.07	4.29
31	Sapindeceae	3	2	1.29	8.67	0.27	1.00	1.24	2.51
32	Sapotaceae	4	3	8.91	92.60	3.07	1.46	1.65	6.18
33	Sterculiaceae	21	8	27.66	271.28	9.52	9.52	8.68	27.72
34	Sirmaroubaceae	5	1	7.17	60.71	2.47	2.07	2.07	6.61
35	Ulmaceae	27	3	17.55	167.95	6.05	7.45	11.16	24.66
36	Vitaceae	4	1	3.45	22.75	1.66	1.19	1.65	4.50

The analysis of tree growth variables across three Protected Areas (PAs) revealed distinct patterns (Table 7). Akure-Ofosu recorded the highest mean DBH (80.71 cm) and tree height (11.10 m), followed by Oluwa Forest Reserve (75.37 cm DBH, 8.40 m height), while Osse River Park had the lowest values (56.09 cm DBH, 4.83 m height). For basal area, Oluwa Forest Reserve recorded 288.90 m^2/ha, compared to Akure-Ofosu's 222.59 m^2/ha and Osse River Park's 101.91 m^2/ha. Volume measurements showed Oluwa Forest Reserve with the highest values (2897.12 m^3/ha), followed by Akure-Ofosu (1710.90 m^3/ha) and Ose River

Park (1004.55 m³/ha). The tree growth metrics across the ecosystem reflect the success of in-situ conservation efforts and the health of these biodiversity protected areas. Dominant tree characteristics followed similar patterns across all sites. The highest mean basal area and mean Volume exhibited by Oluwa Forest Reserve indicates a mature and well-developed forest stand as larger basal area and net volume suggest higher biomass accumulation, carbon storage potential, and timber yield capacity. In contrast, the lower dominant height and diameter obtained in Osse River Park suggest that the PA is characterized by smaller, possibly younger or regenerating tree populations. This pattern may be attributed to past disturbances, selective logging, environmental stress, or natural successional stages within the Park. The findings from this study calls for the maintenance of mature forest structures to preserve ecosystem services and biodiversity integrity.

Table 7
Comparison of Tree growth variables for the 3 selected PAs

Variables	PAs		
	Akure-Ofosu	Osse River Park	Oluwa (A03)
M Dbh (cm)	80.71	56.09	75.37
M height (m)	11.10	4.83	8.40
M Ba/ha (m^2)	222.59	101.91	288.90
M V/ha (m^3)	1710.9	1004.55	2897.12
Dominant Ht (m)	13.99	7.65	12.01
Dominant dbh (m)	112.05	111.80	116.25

A very high value of the diversity indices indicate a forest with very high species diversity and abundance. Pielou's evenness index was highest in Akure-Ofosu (1.05), followed by Oluwa (0.90) and the lowest (0.86) in Osse River Park. Shannon-Wiener diversity index followed a similar trend, with Akure-Ofosu and Ose River Park recording the highest (4.25) and the lowest (3.56) values respectively. This is also an indication that the ecosystem is fairly diverse. Some researchers (Onyekwelu et al*.,* 2007; Adekunle and Olagoke 2008; Borah et al*.* 2014; Boboye and Jimoh 2016) have used Shannon-wiener diversity index to determine forest community diversity in the tropics. Values obtained in this study falls within the range reported by Adekunle, 2006 and Onyekwelu et al*,* 2008 who examined some natural tropical forest ecosystems of Nigeria. Conversely, the Shannon diversity Index obtained are above the values range of 0.70 to 3.57 reported for tropical forests by Bhuyan et al., 2003; Borah et al., 2014; Bajpai et al., 2015; Salami and Jibo, 2019. Meanwhile, Ige and Adekunle 2021 reported 3.37 as Shannon diversity index for Ora community in kwara state, Nigeria; a typical savanna ecosystem.

Table 8
Comparison of tree biodiversity indices for the 3 selected PAs

Biodiversity indices	PAs		
	Akure-Ofosu	Osee River Park	Oluwa (A03)
Density/ha	330	177	242
No of species	55	61	76
No of families	29	33	36
Pielou's evenness index (E)	1.05	0.86	0.90
Shannon-Weiner Index (H')	4.24	3.56	3.95
Margalef's index of species richness (M)	9.31	11.59	13.66
Simpson diversity index (D)	0.93	0.96	0.97
Species Relative Dominance	99.53	100.00	99.02
Family importance value (FIV)	295.67	318.17	292.07
Spp importance value (IVI)	96.96	109.25	99.45
Number 1 of Hill diversity index (N1)	69.41	35.16	51.94
Number 1 of Hill diversity index (N2)	1.08	1.04	1.03

The relatively high Margalef's index and Simpson's index exhibited by Oluwa forest reserve correspond with the range reported by Ige and Adekunle (2021) and Adekunle *et al,* 2014. This emphasizes the ecological complexity of the ecosystem

The subtle differences in evenness and Simpon's index pattern suggest that anthropogenic pressures may differentially impact community composition across the ecosystem. Conservation efforts should therefore be tailored to maintain both species richness and evenness, ensuring the long-term resilience and ecological stability of these Protected Areas.

The correlation matrix for tree growth variables and biodiversity indices in the selected PAs revealed a very strong and positive relationship between the basal area and Volume, Shannon and evenness (Table 9). Strong positive relationships also exist between basal area and Simpson's index, Volume and Simpsons' index.

The strong positive correlations shows that structurally mature stands support greater species diversity and evenness, confirming that forest structural integrity strengthens biodiversity conservation in PAs. Thus, protected areas should prioritize stringent actions to protecting large trees, reducing anthropogenic disturbances and implementing structure-based management and monitoring to simultaneously sustain biodiversity, carbon storage, and ecosystem resilience.

Table 9
Correlation matrix for tree growth variables and biodiversity indices in the selected PAs

	Height (m)	Dbh (cm)	Ba (m^2)	Vol. (m^3)	Shannon index	Simpson's index	Evenness
Height (m)	1						
Dbh (cm)	0.4873	1					
Ba (m^2)	0.38213	0.23155	1				
Vol. (m3)	0.42303	0.2556	0.93446	1			
Shannon index	0.04936	-0.0167	0.54159	0.44358	1		
Simpson's index	0.11272	0.01615	0.7729	0.70768	0.48399	1	
Evenness	-0.0049	-0.035	0.5386	0.45514	0.98078	0.47951	1

4. Conclusion

This study revealed the present status of the three selected PAs in Ondo State. Akure-Ofosu Forest Reserve provides the highest stem density and structural maturity, reflected in its large mean DBH, high Shannon diversity, and the strongest species evenness, indicating a moderately stable and well-balanced forest community with a high proportion of rare species. Oluwa Forest Reserve emerges as the most species-rich and functionally productive forest community, recording the highest number of species and families, and the greatest basal area and volume per hectare, highlighting its critical role in biomass accumulation and carbon storage. In contrast, Osse River Park exhibits lower stem density, reduced structural attributes, and lower diversity indices, indicating a forest system strongly influenced by disturbances. The strong positive relationships between basal area, volume, and biodiversity indices across all sites highlight the critical role of intact forest structure in supporting biodiversity and sustaining ecosystem services. Collectively, these patterns indicate differences in disturbance histories and management effectiveness, emphasizing that continued forest degradation poses a serious risk to biodiversity conservation and climate-change mitigation objectives. The study therefore provided essential baseline data to guide site-specific management, calling for strengthened protection in Osse River Park, conservation of mature stands in Akure-Ofosu, and biodiversity-focused management in Oluwa Forest Reserve to enhance resilience, carbon sequestration potential, and long-term ecological integrity of protected areas in Ondo State.

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Authors Contributions
Victor Adekunle: Conceptualization, Methodology, Reviewing and Editing
Faithful Iyagin: Data collection, Data analysis and paper writing

Conflicts of Interest
The authors declare that there is no conflict of interest.

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