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Taxonomic Assessment of Diversity of Tree and Shrub Species in Three Tropical Forest Sites in Anambra State, Nigeria

Chisom Finian Iroka[1,*], Kenneth U. Ekwealor[1], Consolata A. Onyili[2], Patrick U. Nwaogaranya[1], Adaugo O. Nwakuche[1], Onyinye A. Mbaukwu[1], Chukwu N. Okereke[1], Clara N. Ikegbunam[1]

[1]Department of Botany, Nnamdi Azikiwe University, Awka, Nigeria
[2]Department of Forestry and Wildlife, Nnamdi Azikiwe University, Awka, Nigeria

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Abstract In Anambra State, the accelerated loss of plant diversity due to habitat destruction and changing land use patterns has endangered the survival of tree and shrub species. This research investigated the taxonomic diversity of tree and shrub species in three tropical forests in Anambra State using line transects and plot sampling. The study reported taxonomic diversity as alpha diversity (species richness, abundance, Shannon diversity index, and Simpson diversity index) and beta diversity (Sørensen similarity coefficient). Python programming language was used for data analysis, utilizing libraries such as Pandas, NumPy, and Scikit-Learn for data manipulation. In the species abundance study, *Elaeis guineensis* had the highest Importance Value Index (IVI) at Nnamdi Azikiwe Conservation Forest (NACF) with a value of 7.128, followed by *Carapa procera* (6.585) and *Newbouldia laevis* (6.177). At the Ishigwu Forest Umuomaku (IFU) site, *Elaeis guineensis*, *Cananga odorata*, and *Nauclea latifolia* were the most common IVI-based species. The most abundant species in Umuikwu Forest Anam (UFA) were *Elaeis guineensis*, *Newbouldia laevis*, and *Dacryodes edulis*. The Simpson diversity index indicated that NACF and IFU had lower dominance of a few species compared to UFA, which had a more even distribution of species. The Sørensen similarity coefficient revealed a significant overlap in species composition between Ishigwu Forest Umuomaku (IFU) and Umuikwu Forest Area (UFA). These findings provide valuable insights for informed decisions regarding conservation and sustainable management based on species relationships, environment, and ecosystem services.

Keywords Phytodiversity, Alpha Diversity, Beta Diversity, Importance Value Index, Taxonomic, Sørensen Similarity Coefficient, Sustainable Management

1. Introduction

Assessing tree species in Anambra State's forests presents a considerable challenge. Although these forests are ecologically significant, there is insufficient comprehensive documentation of the various tree and shrub species present in the region. The lack of accurate taxonomic information hinders conservation initiatives, sustainable management practices, and informed decision-making regarding forest resources. It is essential to acknowledge that forests are crucial for regulating climate, controlling water runoff, providing wildlife habitats and food, as well as purifying the air. Furthermore, they supply vital resources for humans, such as timber and paper pulp. Among Earth's many terrestrial ecosystems, tropical forests are recognized as the largest and most diverse [1].

Although tropical forests currently encompass less than 10% of the Earth's land surface, they host over two-thirds of all higher plant biomass and at least half of all plant, animal, and microbial species globally. Barnosky et al. [2] have strongly asserted that we are experiencing a significant extinction event surpassing the five previous mass extinctions in Earth's history. The current trend of biodiversity loss is primarily driven by factors such as habitat destruction, habitat alteration, and climate change [2, 3]. Numerous studies have noted that habitat loss contributes to a decline in biodiversity across various taxa, including plants and other living organisms [4, 5]. The repercussions extend beyond mere species loss; they also entail a reduction in evolutionary history and ecological processes, ultimately impacting the capacity of forests to maintain self-sustainability over time [6]. However, many of these studies focused on species richness (SR), and there is a consensus indicating that species richness provides limited insights into evolutionary history and functionality [7].

This study aims to assess the biodiversity of trees in selected forests throughout Anambra by utilizing taxonomic diversity as an additional measure alongside species richness. By examining the point, mean, and cumulative alpha taxonomic diversity of plant communities independently, comparisons will be facilitated. Citing previous research by Castillo-Campos et al. [8], it was found that secondary vegetation shows greater alpha diversity of species when compared to primary forests. Although the number of plant families in both types of vegetation may be similar, their representation differs significantly. In primary forests, each family comprises one to twenty-one genera, whereas secondary vegetation can have between one and thirty-four genera per family [9]. A taxonomic classification that considers the greater species and genus counts per family would suggest a smaller mean distance between two species in secondary vegetation compared to those in primary forests, indicating that secondary vegetation species exhibit less taxonomic diversity than those in primary forests.

Plant diversity is notable in areas characterized by exceptionally high levels of richness and varies both globally and regionally. Tropical and subtropical regions exhibit greater taxonomic diversity among higher plants, which largely correlates with latitude. Because these areas were thought to represent both the complexity and uniqueness of ecosystems, species richness and endemism were commonly used metrics for identifying biodiversity priorities. As a consequence, initial discussions centered around the conservation of tropical rainforests and oceanic islands. In 1986, the World Fund for Nature (WWF) and the International Union for Conservation of Nature (IUCN) initiated a project aimed at identifying critical centers of plant diversity [10].

The regions with a Mediterranean climate host approximately 20% of all plant species, featuring an estimated 124,000 endemic species across 24 hotspots, which account for 40% of global plant species [11]. In several areas, the transformation of natural habitats into agricultural fields has led to a decrease in both biodiversity and genetic variability. This conversion has contributed to the decline of populations and the extinction of various species [12, 13]. Nevertheless, the remaining habitat fragments can serve as vital refuges for endangered species and can be prioritized for upcoming restoration initiatives [14, 15].

At the regional level, notable variations in species richness have been documented between different habitats, including forests and open grasslands [16]. These spatial distributions have helped establish three tiers of species diversity: alpha, beta, and gamma diversity [17]. Alpha diversity refers to local diversity and describes the richness of species within a functioning community. The scale of ecological units used to measure alpha diversity varies depending on the organism group in question; for instance, for birds, it may range from several hundred square meters to several kilometers, whereas for insects, it could be as small as an individual tree. In plants, alpha diversity is typically assessed by counting the number of species found within a specified vegetation plot [18].

The aim of this study was to perform a taxonomic assessment of the diversity of tree and shrub species across three tropical forest sites in Anambra State, Nigeria. The research included identifying and evaluating the species distribution within these forest locations, determining the abundance status of species in each area, and conducting an analysis of taxonomic diversity and richness specifically, focusing on the trees and shrubs present in the study locations.

2. Materials and Methods

2.1. Study Area

The research was conducted in Anambra state, Nigeria, from April 2022 to December 2023. This state is situated within the tropical rain and evergreen forest zone, characterized by a humid tropical climate throughout the year; however, humidity levels fluctuate with the seasons. The rainy season extends from March to October and features a bimodal pattern, including a two-week pause in rainfall during August (known as the August break). The average annual rainfall in the southeastern region is 2000 mm, while the typical annual temperature ranges from 25 ℃ to 28 ℃, with relative humidity reaching about 98% during the rainy season and between 50% and 60% in the dry season [19].

Three tropical forests were selected from different zones of the study area based on their high floristic composition as can be seen in Figures 1-3 below:

1. Unizik Conservation Forest Nnamdi Azikiwe University, Awka (6^{O}15’14”N 7^{O}06’37”E).
2. Ishigwu Forest, Umuomaku Orumba South LGA (5^{O}57’36”N 7^{O}08’52”E).
3. Umuikwu Forest, Anam Anambra West LGA (6^{O}14’12”N 6^{O}45’50”E).

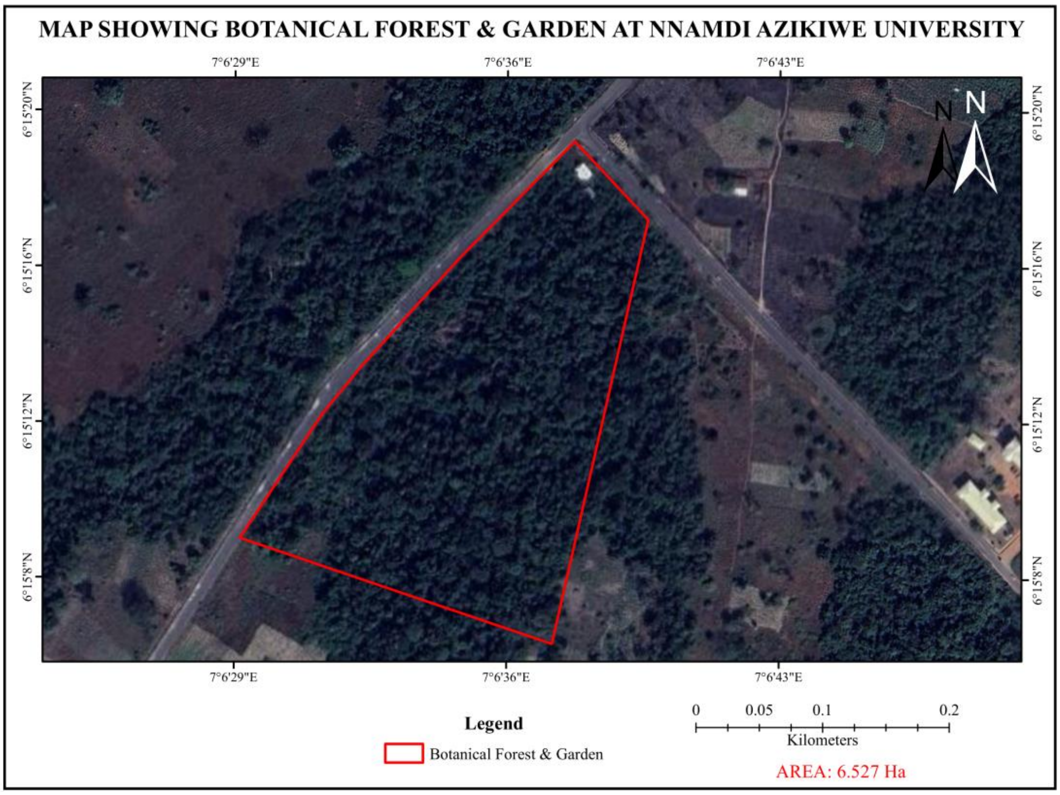


Figure 1. Aerial Map Showing the Nnamdi Azikiwe Conservation Forest Awka South LGA [20, 21]

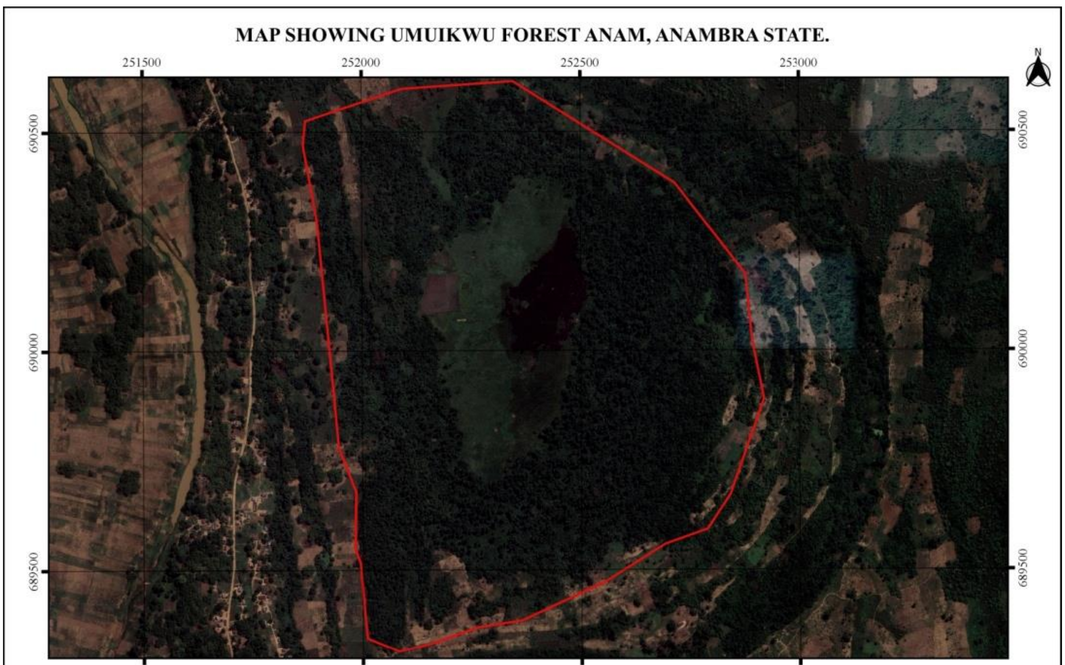


Figure 2. Aerial Map Showing the Umuikwu Forest Anam Anambra West LGA [20, 21]

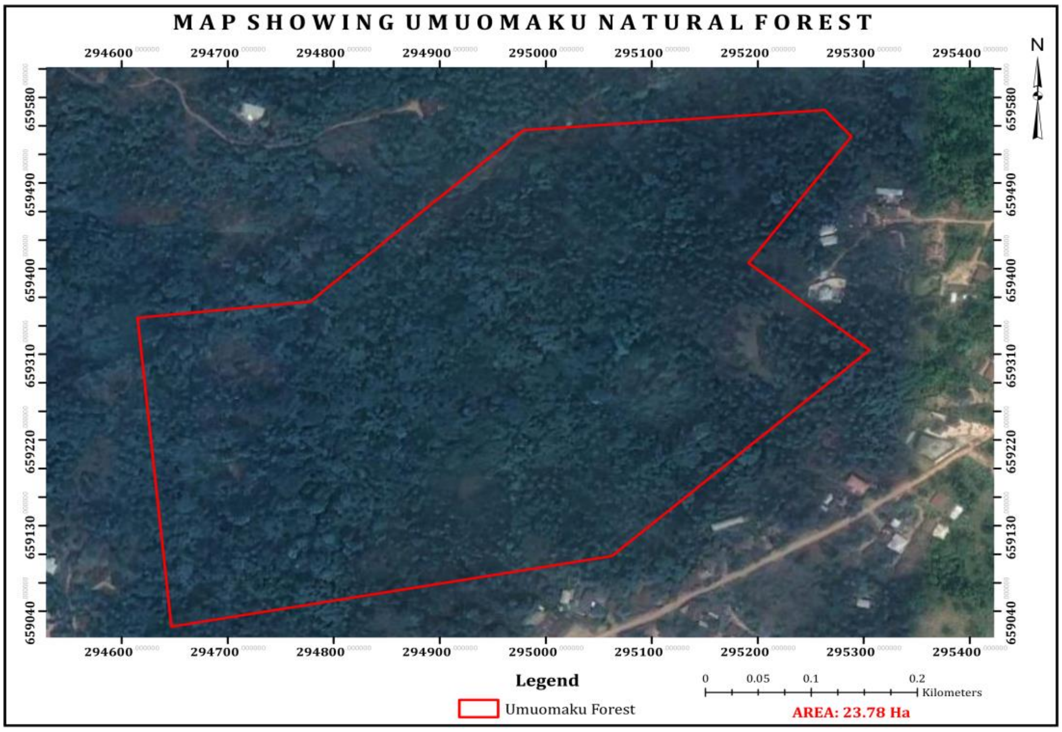


Figure 3. Aerial Map Showing the Ishigwu Forest Umuomaku Orumba South LGA [20, 21]

2.2. Study Design

A multistage sampling approach was adopted to ensure adequate representation across Anambra State.

- Stage 1 (Site Selection): Three forest sites were purposively selected from the north, central, and southern zones of the state to capture variations in floristic composition and human disturbance gradients.
- Stage 2 (Transect Layout): At each site, a line transect was established to provide systematic coverage of the vegetation.
- Stage 3 (Plot Sampling): Along each transect, six plots measuring 10 × 10 m were randomly located for detailed floristic inventory. This combination of transects and random quadrats ensured both systematic spread and unbiased representation of species.

2.3. Species Inventory and Density

All tree and shrub species ≥2 cm diameter at breast height (DBH) within the plots were identified using plant keys and floras. Species density was calculated as the number of individuals per hectare (stems/ha), standardized from the sampled plots.

2.3.1. Alpha Diversity (Species Richness and Abundance)

Species richness was computed as the number of species per unit area, following McGill *et al.* [22].

$$\mathrm{AD} = \frac{\mathrm{TS}}{\mathrm{A}}$$

Where:
AD is the alpha diversity
TS is the total number of species, and
A is the total area

2.3.2. Shannon-Wiener Index of Species Diversity

The Shannon index was calculated using the formula [23]:

$$H' = -\sum_{i=1}^{R} pilnpi$$

Where:
H= the Shannon diversity index
Pi = fraction of the entire population made up of species
S = number of species encountered
∑ = sum from species 1 to s
In = natural logarithm

Sørensen Similarity Coefficient (CS): Calculates the similarity in species composition across two or more locations, A, B, and C, following the approach outlined by Ogunleye *et al.* [24]; this method was utilized to assess the overlap in species composition between site pairs.

$$\mathrm{CS} = \frac{\mathrm{D}}{\mathrm{D+A+B+C}} \times \frac{100}{1}$$

Where:
D = Number of species found in both sites

A = Number of species found only in site A
B = Number of species found only in site B
C = Number of species found only in site C. Expressed as a percentage of similarity or dissimilarity.

$$\text{CS for forest 1 and 2} = \frac{D}{D+A+B} \times \frac{100}{1}$$

$$\text{CS for forest 2 and 3} = \frac{D}{D+B+C} \times \frac{100}{1}$$

$$\text{CS for forest 1 and 3} = \frac{D}{D+A+B} \times \frac{100}{1}$$

2.3.3. Biodiversity Index

Biodiversity index was calculated by using Simpson's Diversity index [25] thus:

$$\text{Simpson's index (D)} = \frac{\sum n\ (n-1)}{N\ (N-1)}$$

Where n = Total no. of plants of a particular species.
N = Total no. of plants of all species.
For easier understanding, the inverse I/D of Simpson's index was used.

2.4. Data Analysis

All statistical analysis was conducted in Python (version 3.10) using the pandas, NumPy, and scikit-learn libraries within the Jupyter Notebook environment. Significance was tested at $p < 0.01$.

3. Result

3.1. Species Accumulation and Sampling Adequacy

Species accumulation curves approached an asymptote by the fourth quadrat in each site, indicating adequate sampling effort (Figure 4). This suggests that most tree and shrub species present were effectively captured.

3.2. Alpha Diversity Status of the Forest Sites

3.2.1. Species Abundance Status Nnamdi Azikiwe Conservation Forest (NACF)

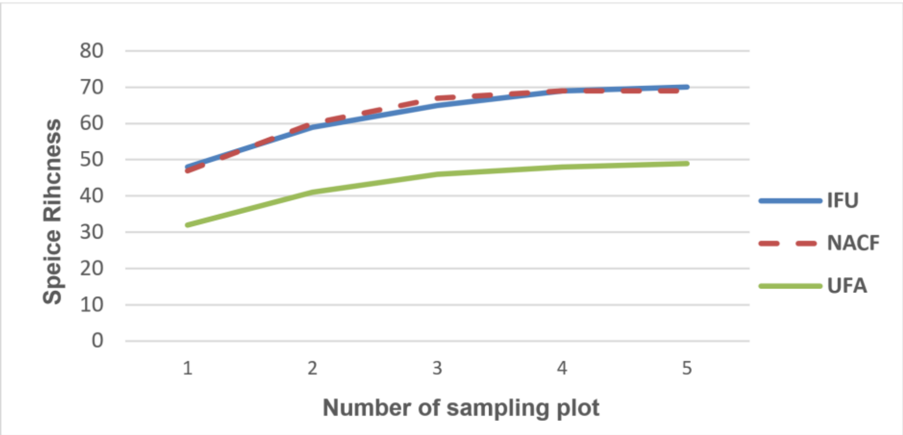
At the Nnamdi Azikiwe Conservation Forest (NACF) (Figure 1), Elaeis guineensis (Arecaceae) recorded the highest IVI (7.128), reflecting its ecological dominance. Other important species included Carapa procera (Meliaceae; IVI = 6.585) and Newbouldia laevis (Bignoniaceae; IVI = 6.177). These species contribute significantly to canopy cover and ecosystem structure (Table 1).

3.2.2. Species Abundance Status of Ishigwu Forest Umuomaku (IFU)

In Ishigwu Forest Umuomaku (IFU) (Figure 2), E. guineensis again showed dominance (IVI = 7.065), alongside Cananga odorata (Annonaceae; IVI = 6.624) and Nauclea latifolia (Rubiaceae; IVI = 6.624). The prominence of fruit-bearing species here suggests strong ecological and ethnobotanical value (Table 2).

3.2.3. Species Abundance Status of Umuikwu Forest Anam (UFA)

At Umuikwu Forest Anam (UFA) (Figure 3), the community was characterized by high dominance of E. guineensis (IVI = 10.258), N. laevis (IVI = 7.749), and Dacryodes edulis (Burseraceae; IVI = 7.749), highlighting both ecological importance and local use as food resources (Table 3).



KEY:
NACF = Nnamdi Azikiwe Conservation Forest
IFU = Ishigwu Forest Umuomaku
UFA = Umuikwu Forest Anam

Figure 4. Species accumulation curves of tree and shrub species in the forest sites

Table 1. Species Abundance Status of Trees and Shrubs at Nnamdi Azikiwe Conservation Forest (NACF)

S/N	Botanical Name	Family	Density (s/ha)	Freq (%)	Rel Density (%)	Rel Freq (%)	IVI	Rank within Family	Rank within Site
1	*Spondias mombin* L.	Anacardiaceae	0.026	100	1.766	2.101	3.867	1	12.5
2	*Cleistopholis patens* (Benth.) Engl. et Diels	Annonaceae	0.058	100	3.940	2.101	6.041	1	4
3	*Annona senegalesis* Pers. A.	Annonaceae	0.004	40	0.272	0.840	1.112	3	64.5
4	*Uvaria chamae* P.Beauv.	Annonaceae	0.020	80	1.359	1.681	3.040	2	26.5
5	*Funtumia elastica* (Preuss) Stapf.	Apocynaceaae	0.020	80	1.359	1.681	3.040	1	26.5
6	*Holarrhena floribunda* (G.Don) Dur. &Schinz	Apocynaceae	0.030	80	2.038	1.681	3.719	1	14.5
7	*Picralima nitida* Stapf.Th. & H. Dur.	Apocynaceae	0.012	80	0.815	1.681	2.496	4	39.5
8	*Rauvolfia vomitoria* Afzel	Apocynaceae	0.022	100	1.495	2.101	3.596	2	16.5
9	*Tabernaenontana pachysiphon* Stapf.	Apocynaceae	0.006	40	0.408	0.840	1.248	5	61.5
10	*Alstonia boonei* De Wild.	Apocynaceae	0.024	60	1.630	1.261	2.891	3	34.5
11	*Elaeis guineensis* Jacq.	Arecaceae	0.074	100	5.027	2.101	7.128	1	1
12	*Newbouldia laevis* P. Beauv ex Bureau.	Bignoniaceae	0.060	100	4.076	2.101	6.177	1	3
13	*Kigelia africana* (Lam.)	Bignoniaceae	0.006	40	0.408	0.840	1.248	2	61.5
14	*Cordia millenii* Bak.	Boraginaceae	0.010	60	0.679	1.261	1.940	1	50
15	*Dacryodes edulis* (G.Don) H.J. Lam	Burseraceae	0.018	80	1.223	1.681	2.904	1	31.5
16	*Trema orientalis* (L.) Blume	Cannabaceae	0.054	100	3.668	2.101	5.769	1	5.5
17	*Buchholzia coriacea* Engl.	Capparaceae	0.010	40	0.679	0.840	1.519	1	56
18	*Myrianthus arboreus* P. Beauv.	Cecropiaceae	0.012	80	0.815	1.681	2.496	1	39.5
19	*Terminalia glaucescens* (Planch. ex Benth	Combretaceae	0.006	20	0.408	0.420	0.828	1	67
20	*Terminalia catappa* L.	Combretaceae	0.004	20	0.272	0.420	0.692	2	68.5
21	*Draecena arborea* (Wild.)Link	Dracaenaceae	0.012	40	0.815	0.840	1.655	1	54
22	*Macaranga barteri* Mull.Arg.	Euphorbiaceae	0.014	60	0.951	1.261	2.212	4	46.5
23	*Bridelia micrantha* (Hochst.) Baill	Euphorbiaceae	0.022	80	1.495	1.681	3.176	3	19.5
24	*Ricinodendron heudelotii* (Baill.) Pax.	Euphorbiaceae	0.048	100	3.261	2.101	5.362	1.5	8
25	*Tetrorchidium didymostemon* (Baill) Pax& K. Hoffm.	Euphorbiaceae	0.010	60	0.679	1.261	1.940	5	50
26	*Alchornia cordifolia* (Schum. &Thonn.)Muell.Arg.	Euphorbiaceae	0.048	100	3.261	2.101	5.362	1.5	8
27	*Afzelia bipindensis* Harms	Fabaceae	0.012	40	0.815	0.840	1.655	13	54
28	*Pentaclethra macrophylla* Benth.	Fabaceae	0.028	60	1.902	1.261	3.163	3	22
29	*Pterocarpus santalinoides* (Harms)	Fabaceae	0.010	60	0.679	1.261	1.940	12	50
30	*Piptadeniastrum africanum* (Hook.f.) Brenan	Fabaceae	0.010	80	0.679	1.681	2.360	8	43
31	*Leonardoxa africana* (Baill.) Aubrev.	Fabaceae	0.004	20	0.272	0.420	0.692	18	68.5
32	*Pterocarpus milbraedii* Harm.	Fabaceae	0.006	40	0.408	0.840	1.248	15.5	61.5
33	*Parkia biglobosa* (Jacq.)R.Br. ex G.Don	Fabaceae	0.006	40	0.408	0.840	1.248	15.5	61.5
34	*Dalium guineense* Willd	Fabaceae	0.024	80	1.630	1.681	3.311	2	18

Table 1 continued

35	*Entada abyssinia* Steud.	Fabaceae	0.020	80	1.359	1.681	3.040	4	26.5
36	*Daniella oliveri* (Rolfe) Hutch &Dalz.	Fabaceae	0.016	60	1.087	1.261	2.348	10	45
37	*Baphia pubescens* Hook. f.	Fabaceae	0.012	60	0.815	1.261	2.076	11	48
38	*Erythrina senegalensis* DC.	Fabaceae	0.010	80	0.679	1.681	2.360	8	43
39	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	0.018	80	1.223	1.681	2.904	5	31.5
40	*Albizia lebbeck*(L.) Benth	Fabaceae	0.010	20	0.679	0.420	1.099	17	66
41	*Berlinia confuse* Hoyle	Fabaceae	0.016	80	1.087	1.681	2.768	6	36.5
42	*Dalbergia latifolia Roxb.*	Fabaceae	0.008	40	0.543	0.840	1.383	14	58
43	*Lonchocarpus cyanescens* (Schumach. &Thonn.) Benth.	Fabaceae	0.022	100	1.495	2.101	3.596	1	16.5
44	*Anthonotha macrophylla* P. Beauv	Fabaceae	0.010	80	0.679	1.681	2.360	8	43
45	*Anthocleista djalonensis* A. Chev.	Gentianaceae	0.048	100	3.261	2.101	5.362	1	8
46	*Harungana madagascariensis* Lam. ex Poir.	Hyperiaceae	0.016	80	1.087	1.681	2.768	1	36.5
47	*Vitex doniana* L.	Lamiaceae	0.036	100	2.446	2.101	4.547	1	10
48	*Tectonia grandis* L. f.	Lamiaceae	0.024	60	1.630	1.261	2.891	3	34.5
49	*Gmelina arborea* Roxb. ex. Sm.	Lamiaceae	0.028	60	1.902	1.261	3.163	2	22
50	*Napoleona imperialis* (P.Beauv)	Lecythidaceae	0.018	80	1.223	1.681	2.904	1	31.5
51	*Cola cordifolia* (Cav.) R. Br.	Malvaceae	0.042	80	2.853	1.681	4.534	1	11
52	*Ceiba pentandra* (L.) Gaertn	Malvaceae	0.026	100	1.766	2.101	3.867	2	12.5
53	*Bombax buonopozense* P. Beauv.	Malvaceae	0.014	60	0.951	1.261	2.212	3	46.5
54	*Khaya senegalensis* (Desr.) A. Juss.	Meliaceae	0.012	80	0.815	1.681	2.496	3.5	39.5
55	*Carapa procera* DC.	Meliaceae	0.066	100	4.484	2.101	6.585	1	2
56	*Entandrophragma utile* (Dawe & Sprague) Sprague	Meliaceae	0.018	80	1.223	1.681	2.904	2	31.5
57	*Trichilia dregeana* Sond.	Meliaceae	0.012	80	0.815	1.681	2.496	3.5	39.5
58	*Milicia excelsa* (Welw.) CC Berg	Moraceae	0.008	40	0.543	0.840	1.383	2.5	58
59	*Ficus sycomorus* L.	Moraceae	0.012	40	0.815	0.840	1.655	1	54
60	*Musanga cecropioides* R. Br	Moraceae	0.008	40	0.543	0.840	1.383	2.5	58
61	*Pycnanthus angolensis* (Welw.) Warb.	Myristicaceae	0.022	80	1.495	1.681	3.176	1	19.5
62	*Heisteria parvifolia* (Sm.)	Olacaceae	0.028	60	1.902	1.261	3.163	1	22
63	*Rothmannia whitfieldii* (Lindl.) Dandy	Rubiaceae	0.020	80	1.359	1.681	3.040	3	26.5
64	*Morinda lucida* Benth	Rubiaceae	0.030	80	2.038	1.681	3.719	2	14.5
65	*Nauclea latifolia* Smith.	Rubiaceae	0.054	100	3.668	2.101	5.769	1	5.5
66	*Citrus aurantium* L.	Rutaceae	0.014	40	0.951	0.840	1.791	1	52
67	*Zanthoxylum zanthoxyloides* (Lam.)Zepern. &Timler.	Rutaceae	0.004	40	0.272	0.840	1.112	2	64.5
68	*Sterculia tragacantha* Lindl.	Sterculiaceae	0.020	80	1.359	1.681	3.040	1.5	26.5
69	*Cola hispida* Brenan &Keay	Sterculiaceae	0.020	80	1.359	1.681	3.040	1.5	26.5

Table 2. Species Abundance Status of Trees and Shrub at Ishigwu Forest Umuomaku (IFU)

S/N	Botanical Name	Family	Density (s/ha)	Freq (%)	Rel Density (%)	Rel Freq (%)	IVI	Rank within Family	Rank within Site
1	*Mangifera indica* L.	Anacardiaceae	0.012	80	0.884	1.646	2.530	1	36
2	*Anacardium occidentalis* L.	Anacardiaceae	0.016	60	1.178	1.235	2.413	2	38
3	*Spondias mombin* L.	Anacardiaceae	0.018	40	1.325	0.823	2.148	3	43
4	*Annona muricata* L.	Annonaceae	0.018	80	1.325	1.646	2.971	2	28
5	*Cananga odorata* Hook. f.& Thomson	Annonaceae	0.062	100	4.566	2.058	6.624	1	2.5
6	*Annona squamosa* L.	Annonaceae	0.008	40	0.589	0.823	1.412	6.5	60
7	*Dennettia tripetala* Bak. f.	Annonaceae	0.006	40	0.442	0.823	1.265	8	62.5
8	*Enantia chlorantha* Oliv.	Annonaceae	0.012	60	0.884	1.235	2.119	3.5	45
9	*Uvaria chamae* P.Beauv.	Annonaceae	0.012	60	0.884	1.235	2.119	3.5	45
10	*Xylopia aethiopica* (Dunal) A. Rich.	Annonaceae	0.008	40	0.589	0.823	1.412	6.5	60
11	*Monodora tenuifolia* Benth.	Annonaceae	0.016	40	1.178	0.823	2.001	5	47.5
12	*Voacanga africana* Stept ex. Elliot	Apocynaceae	0.016	60	1.178	1.235	2.413	2	38
13	*Rauvolfia vomitoria* Afzel	Apocynaceae	0.024	100	1.767	2.058	3.825	1	17
14	*Elaeis guineensis* Jacq.	Aracaceae	0.068	100	5.007	2.058	7.065	1	1
15	*Newbouldia laevis* P. Beauv ex Bureau.	Bignoniaceae	0.048	100	3.535	2.058	5.593	1	5.5
16	*Spathodea campanulata* P. Beauv.	Bignoniaceae	0.018	100	1.325	2.058	3.383	2	20.5
17	*Bombax buonopozense* P. Beauv.	Bombacaceae	0.004	40	0.295	0.823	1.118	1	64.5
18	*Dacryodes edulis* (G.Don) H.J. Lam	Burseraceae	0.016	40	1.178	0.823	2.001	1	47.5
19	*Canarium schweinfurthi* L	Burseraceae	0.006	60	0.442	1.235	1.677	2	55
20	*Trema orientalis* (L.) Blume	Cannabaceae	0.034	100	2.504	2.058	4.562	1	9
21	*Buchholzia coriacea* Engl.	Capparaceae	0.010	40	0.736	0.823	1.559	1	57.5
22	*Myrianthus arboreus* P. Beauv.	Cecropiaceae	0.018	60	1.325	1.235	2.560	1	35
23	*Hannoa klaineana* Pierre & Engl.	Chrysobalanaceae	0.006	20	0.442	0.412	0.854	1	67
49	*Garcinia kola* Heckel.	Clusiaceae	0.008	40	0.589	0.823	1.412	1	60
24	*Terminalia superb* Engl. & Diels	Combretaceae	0.018	80	1.325	1.646	2.971	1	28
25	*Dichapetalum barteri* Engl.	Dichapetalaceae	0.004	20	0.295	0.412	0.707	1	69.5
26	*Diospyros suavolens* Gurke	Ebanaceae	0.020	80	1.473	1.646	3.119	1	23.5
27	*Ricinodendron heudelotti* (Baill.) Pierre	Euphorbiaceae	0.048	100	3.535	2.058	5.593	2	5.5
28	*Hevea brasiliensis* (Willd.) Mull.- Arg.	Euphorbiaceae	0.016	80	1.178	1.646	2.824	4	31.5
29	*Bridelia micrantha* (Hochst.) Baill	Euphorbiaceae	0.030	100	2.209	2.058	4.267	3	12
30	*Alchornia cordifolia* (Schum. & Thonn.) Muell. Arg.	Euphorbiaceae	0.056	100	4.124	2.058	6.182	1	4
31	*Tetrorchidium didymostemon* (Baill) Pax & K. Hoffm.	Euphorbiaceae	0.006	20	0.442	0.412	0.854	5	67
32	*Pterocarpus soyauxii* Taub.	Fabaceae	0.020	80	1.473	1.646	3.119	6	23.5
33	*Pentaclethra macrophylla* Benth.	Fabaceae	0.030	100	2.209	2.058	4.267	2	12

Table 2 continued

34	*Entada abyssinia* Steud.	Fabaceae	0.010	80	0.736	1.646	2.382	12	40.5
35	*Baphia pubescens* Hook. f.	Fabaceae	0.020	80	1.473	1.646	3.119	6	23.5
36	*Erythrina senegalensis* DC.	Fabaceae	0.016	80	1.178	1.646	2.824	9	31.5
37	*Parkia biglobosa* (Jacq.) R.Br. ex G.Don	Fabaceae	0.022	100	1.620	2.058	3.678	4	19
38	*Pterocarpus santalinoides* L'Her. ex DC.	Fabaceae	0.026	100	1.915	2.058	3.973	3	15
39	*Afzelia africana* Smith	Fabaceae	0.020	80	1.473	1.646	3.119	6	23.5
40	*Dalium guineense* Willd	Fabaceae	0.036	80	2.651	1.646	4.297	1	10
41	*Piliostigma thonningii* (Schumach) Milne-Redh	Fabaceae	0.012	60	0.884	1.235	2.119	14	45
42	*Daniella oliveri* (Rolfe) Hutch &Dalz.	Fabaceae	0.016	80	1.178	1.646	2.824	9	31.5
43	*Tetrapleura tetraptra (*Schumach. & Thonn.) Taub.	Fabaceae	0.010	100	0.736	2.058	2.794	11	34
44	*Brachystagia eurycoma* Harms	Fabaceae	0.008	60	0.589	1.235	1.824	15	50.5
45	*Acacia macrostachya* Reichenb. ex Benth.	Fabaceae	0.014	60	1.031	1.235	2.266	13	42
46	*Berlinia macrophylla* Pierre ex Pellegr	Fabaceae	0.004	40	0.295	0.823	1.118	16	64.5
47	*Dalbergia latifolia* Roxb.	Fabaceae	0.016	80	1.178	1.646	2.824	9	31.5
48	*Anthocleista djalonensis* A. Chev.	Gentianaceae	0.042	100	3.093	2.058	5.151	1	7
50	*Harungana madagascariensis* Lam. ex Poir.	Hyperiaceae	0.010	60	0.736	1.235	1.971	1	49
51	*Icacinia trichanta* Oliv.	Icacinaceae	0.018	20	1.325	0.412	1.737	1	52
52	*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill.	Irvingiaceae	0.024	100	1.767	2.058	3.825	1	17
53	*Vitex doniana* Sweet	Lamiaceae	0.016	60	1.178	1.235	2.413	1	38
54	*Napoleona imperialis* (P.Beauv*)*	Lecythidaceae	0.030	100	2.209	2.058	4.267	1	12
55	*Adansonia digitata* L.	Malvaceae	0.006	40	0.442	0.823	1.265	3	62.5
56	*Cola nitida* (Vent) Schott &Endl.	Malvaceae	0.010	80	0.736	1.646	2.382	1	40.5
57	*Hildegardia barteri* (Mast.) Kosterm.	Malvaceae	0.008	60	0.589	1.235	1.824	2	50.5
58	*Trichilia lanata* A. Chev.	Meliaceae	0.004	20	0.295	0.412	0.707	4	69.5
59	*Trichilia dregeana* Sond.	Meliaceae	0.018	80	1.325	1.646	2.971	1	28
60	*Milicia excelsa* (Welw.) CC Berg	Moraceae	0.006	60	0.442	1.235	1.677	2	55
61	*Musanga cecropioides* R. Br	Moraceae	0.014	100	1.031	2.058	3.089	1	26
62	*Pycnanthus angolensis* (Welw.) Warb.	Myristicaceae	0.012	40	0.884	0.823	1.707	1	53
63	*Morinda lucida* Benth.	Rubiaceae	0.040	100	2.946	2.058	5.004	2	8
64	*Nauclea latifolia* Smith.	Rubiaceae	0.062	100	4.566	2.058	6.624	1	2.5
65	*Porterandia cladantha* (K. Schum)	Rubiaceae	0.010	40	0.736	0.823	1.559	4	57.5
66	*Nauclea diderrichii (*De Wild. & T. Durand) Merr.	Rubiaceae	0.018	100	1.325	2.058	3.383	3	20.5
67	*Sapindus saponaria* L.	Sapindaceae	0.032	80	2.356	1.646	4.002	1	14
68	*Chrysophyllum albidum* G.Don	Sapotaceae	0.024	100	1.767	2.058	3.825	1	17
69	*Sterculia tragacantha* Lindl.	Sterculiaceae	0.006	20	0.442	0.412	0.854	1	67
70	*Glyphae brevis* (Spreng) Monachimo	Tiliaceae	0.006	60	0.442	1.235	1.677	1	55

Table 3. Species Abundance Status of Trees and Shrub at Umuikwu Forest Anam (UFA)

S/N	Botanical Name	Family	Density (s/ha)	Freq (%)	Rel Density (%)	Rel Freq (%)	IVI	Rank within Family	Rank within Site
1	*Anacardium occidentalis* L.	Anacardiaceae	0.014	80	2.509	2.759	5.268	2	11
2	*Mangifera indica* L.	Anacardiaceae	0.010	40	1.792	1.379	3.171	3	32.5
3	*Spondias mombin* L.	Anacardiaceae	0.016	80	2.867	2.759	5.626	1	8.5
4	*Cleistopholis patens* (Benth.) Engl. & Diels	Annonaceae	0.010	60	1.792	2.069	3.861	2	26.5
5	*Annona muricata* L.	Annonaceae	0.008	40	1.434	1.379	2.813	3	36.5
6	*Uvaria chamae* P.Beauv.	Annonaceae	0.022	100	3.943	3.448	7.391	1	4
7	*Voacanga africana* Stept ex. Elliot	Apocynaceae	0.012	80	2.151	2.759	4.910	1	15
8	*Rauvolfia vomitoria* Afzel	Apocynaceae	0.010	80	1.792	2.759	4.551	2	19
9	*Tabernaenontana pachysiphon* Stapf.	Apocynaceae	0.004	40	0.717	1.379	2.096	3	42
10	*Elaeis guineensis* Jacq.	Aracaceae	0.038	100	6.810	3.448	10.258	1	1
11	*Newbouldia laevis* P. Beauv ex Bureau.	Bignoniaceae	0.024	100	4.301	3.448	7.749	1	2.5
12	*Spathodea campanulata* P. Beauv.	Bignoniaceae	0.010	60	1.792	2.069	3.861	2	26.5
13	*Bombax buonopozense* P. Beauv.	Bombacaceae	0.008	40	1.434	1.379	2.813	1	36.5
14	*Dacryodes edulis* (G.Don) H.J. Lam	Burseraceae	0.024	100	4.301	3.448	7.749	1	2.5
15	*Buchholzia coriacea* Engl.	Capparaceae	0.010	40	1.792	1.379	3.171	1	32.5
16	*Myrianthus arboreus* P. Beauv.	Cecropiaceae	0.018	80	3.226	2.759	5.985	1	6.5
17	*Hannoa klaineana* Pierre & Engl.	Chrysobalanaceae	0.004	40	0.717	1.379	2.096	1	42
35	*Garcinia kola* Heckel.	Clusiaceae	0.004	20	0.717	0.690	1.407	1	47.5
18	*Diospyros zenkeri* (Gurke) F.White	Ebanaceae	0.016	80	2.867	2.759	5.626	1	8.5
19	*Ricinodendron heudelotti* (Baill.) Pierre	Euphorbiaceae	0.008	20	1.434	0.690	2.124	2	40
20	*Hevea brasiliensis* (Willd.) Mull.- Arg.	Euphorbiaceae	0.004	20	0.717	0.690	1.407	3	47.5
21	*Hura crepitens* L.	Euphorbiaceae	0.008	40	1.434	1.379	2.813	1	36.5
22	*Pterocarpus soyauxii* Taub.	Fabaceae	0.010	60	1.792	2.069	3.861	5.5	26.5
23	*Pentaclethra macrophylla* Benth.	Fabaceae	0.014	80	2.509	2.759	5.268	1	11
24	*Cananga odorata* Hook. f.& Thomson	Fabaceae	0.008	40	1.434	1.379	2.813	9	36.5
25	*Baphia pubescens* Hook. f.	Fabaceae	0.012	60	2.151	2.069	4.220	4	22
26	*Parkia biglobosa* (Jacq.) R.Br. ex G.Don	Fabaceae	0.008	60	1.434	2.069	3.503	7	30.5
27	*Piptadeniastrum africanum* (Hook. f.)	Fabaceae	0.004	20	0.717	0.690	1.407	11.5	47.5
28	*Pterocarpus santalinoides* L'Her. ex DC.	Fabaceae	0.016	60	2.867	2.069	4.936	2	13
29	*Afzelia africana* Smith	Fabaceae	0.014	60	2.509	2.069	4.578	3	17
30	*Dalium guineense* Willd	Fabaceae	0.008	40	1.434	1.379	2.813	9	36.5
31	*Daniella oliveri* (Rolfe) Hutch &Dalz.	Fabaceae	0.008	40	1.434	1.379	2.813	9	36.5
32	*Tetrapleura tetraptra* (Schumach. &Thonn.)Taub.	Fabaceae	0.004	20	0.717	0.690	1.407	11.5	47.5
33	*Brachystagia eurycoma* Harms	Fabaceae	0.010	60	1.792	2.069	3.861	5.5	26.5
34	*Anthocleista djalonensis* A. Chev.	Gentianaceae	0.016	100	2.867	3.448	6.315	1	5
36	*Icacinia trichanta* Oliv.	Icacinaceae	0.004	40	0.717	1.379	2.096	1	42

Table 3 continued

37	*Irvingia gabonensis* (Aubry-Lecomte ex O'Rorke) Baill.	Irvingiaceae	0.018	80	3.226	2.759	5.985	1	6.5
38	*Vitex doniana* Sweet	Lamiaceae	0.010	80	1.792	2.759	4.551	1	19
39	*Napoleona vogelii* Hook. & Planch.	Lecythidaceae	0.012	80	2.151	2.759	4.910	1	15
40	*Cola nitida* (Vent) Schott &Endl.	Malvaceae	0.008	60	1.434	2.069	3.503	2	30.5
41	*Hildegardia barteri* (Mast.) Kosterm.	Malvaceae	0.010	60	1.792	2.069	3.861	1	26.5
42	*Psidium guajava* L.	Myrtaceae	0.012	60	2.151	2.069	4.220	1	22
43	*Microdesmis puberula* Hook. F. ex Planch	Pandaceae	0.014	80	2.509	2.759	5.268	1	11
44	*Morinda lucida* Benth.	Rubiaceae	0.012	60	2.151	2.069	4.220	2	22
45	*Nauclea diderrichii* (De Wild. & T. Durand) Merr.	Rubiaceae	0.010	80	1.792	2.759	4.551	1	19
46	*Zanthoxylum zanthoxyloides* (Lam.) Zepern. &Timler.	Rutaceae	0.012	80	2.151	2.759	4.910	1	15
47	*Chrysophyllum albidum* G.Don	Sapotaceae	0.010	60	1.792	2.069	3.861	1	26.5
48	*Sterculia tragacantha* Lindl.	Sterculiaceae	0.006	20	1.075	0.690	1.765	1	44.5
49	*Glyphae brevis* (Spreng) Monachimo	Tiliaceae	0.006	20	1.075	0.690	1.765	1	44.5

3.3. Species Richness of the Forest Sites

A comparative analysis of species richness per unit area (alpha diversity) revealed distinct patterns across the three forest sites (Table 4). The total floristic composition encompassed 38 plant families distributed among the sites. Ishigwu Forest Umuomaku (IFU) exhibited the greatest familial diversity with 32 families, followed by Umuikwu Forest Anam (UFA) with 27, and Nnamdi Azikiwe Conservation Forest (NACF) with 26. At the familial level, Fabaceae demonstrated the highest species richness per unit area at each site, with values of 0.036, 0.032, and 0.024 for NACF, IFU, and UFA, respectively, underscoring its ecological dominance in these ecosystems. At the site level, IFU also registered the highest overall alpha diversity (0.140), indicating the greatest concentration of species per unit area. In contrast, UFA displayed the lowest value (0.098), suggesting a comparatively less dense aggregation of species.

3.4. Correlation Coefficient of Alpha Diversity

The result of Pearson Momentum Correlation Coefficient in Table 5 showed that there was a significant positive correlation in the alpha diversity values between the forests ($p<0.01$), indicating that the species richness values were similar across the forest sites.

3.4.1. Shannon Weiner and Simpson Index of Diversity of the Experimental Site

Diversity indices, encompassing the Shannon-Wiener Index (H'), and Simpson's Index (D), revealed variations in community structure among the three forest sites (Table 6). Nnamdi Azikiwe Conservation Forest (NACF) supported 69 species and yielded the highest Shannon-Wiener value (H' = 4.007), coupled with a high species evenness (J' = 0.946). A similar pattern was observed in Ishigwu Forest Umuomaku (IFU), which, despite having the highest species richness (70 species), recorded a marginally lower Shannon diversity (H' = 3.987) and evenness (J' = 0.939).

In contrast, Umuikwu Forest Anam (UFA) exhibited the lowest species richness (49 species) and Shannon diversity (H' = 3.761). However, it demonstrated the highest level of species evenness (J' = 0.967) among the sites. This disparity between richness and evenness is further illustrated by Simpson's Index (D). The higher Simpson's Index value in UFA (D = 0.997) indicates a greater concentration of dominance of a few species, whereas the lower values at NACF (D = 0.979) and IFU (D = 0.982) suggest a more equitable distribution of individuals among a larger number of species. Consequently, the results indicate an inverse relationship between dominance (Simpson's D) and community evenness.

3.4.2. Sørensen Similarity Coefficient between Species of the Experimental Site (Beta Diversity)

The Sørensen similarity coefficient revealed substantial overlap between IFU and UFA (Cs = 49%), moderate overlap between NACF and IFU (Cs = 25%), and the lowest similarity between NACF and UFA (Cs = 16%) (Table 7). This pattern reflects both geographic proximity and shared disturbance pressures.

Table 4. Species Richness per Unit Area of the Forest Sites

		FOREST SITE		
S/N	**FAMILY**	**NACF**	**IFU**	**UFA**
1	Anacardiaceae	0.002	0.006	0.006
2	Annonaceae	0.006	0.016	0.006
3	Apocynaceae	0.012	0.004	0.006
4	Aracaceae	0.002	0.002	0.002
5	Bignoniaceae	0.004	0.004	0.004
6	Bombacaceae	-	0.002	0.002
7	Boraginaceae	0.002	-	-
8	Burseraceae	0.002	0.004	0.002
9	Cannabaceae	0.002	0.002	-
10	Capparaceae	0.002	0.002	0.002
11	Cecropiaceae	0.002	0.002	0.002
12	Chrysobalanaceae	-	0.002	0.002
20	Clusiaceae	-	0.002	0.002
13	Combretaceae	0.004	0.002	-
14	Dichapetalaceae	-	0.002	-
15	Dracaenaceae	0.002	-	-
16	Ebanaceae	-	0.002	0.002
17	Euphorbiaceae	0.010	0.01	0.006
18	Fabaceae	0.036	0.032	0.024
19	Gentianaceae	0.002	0.002	0.002
21	Hyperiaceae	0.002	0.002	-
22	Icacinaceae	-	0.002	0.002
23	Irvingiaceae	-	0.002	0.002
24	Lamiaceae	0.006	0.002	0.002
25	Lecythidaceae	0.002	0.002	0.002
26	Malvaceae	0.006	0.008	0.004
27	Meliaceae	0.008	0.002	-
28	Moraceae	0.006	0.004	-
29	Myristicaceae	0.002	0.002	-
30	Myrtaceae	-	-	0.002
31	Olacaceae	0.002	-	-
32	Pandaceae	-	-	0.002
33	Rubiaceae	0.006	0.008	0.004
34	Rutaceae	0.004	-	0.002
35	Sapindaceae	-	0.002	-
36	Sapotaceae	-	0.002	0.002
37	Sterculiaceae	0.004	0.002	0.002
38	Tiliaceae	-	0.002	0.002
	Total n Family	**26**	**32**	**27**
	Total Alpha Diversity	**0.138**	**0.140**	**0.098**

KEY:
NACF = Nnamdi Azikiwe Conservation Forest
IFU = Ishigwu Forest Umuomaku
UFA = Umuikwu Forest Anam

Table 5. Pearson Momentum Correlation Coefficient of Alpha Diversity Values between the Forest Sites

Site	NACF	IFU	UFA
NACF	1		
IFU	0.875**	1	
UFA	0.960**	0.945**	1

**. Correlation is significant at the 0.01 level (2-tailed)

KEY:
NACF = Nnamdi Azikiwe Conservation Forest
IFU = Ishigwu Forest Umuomaku
UFA = Umuikwu Forest Anam

Table 6. Shannon Weiner and Simpson Index of Diversity of the three Forest Site

				Shannon Weiner Diversity			**Simpson Index of Diversity**	
SN	**Site**	**No of Species**	**Total Individual Species**	**Hmax**	**LN (S)**	**Equitability**	**D**	**1/D**
1	NACF	69	736	4.007	4.234	0.946	0.979	1.021
2	IFU	70	679	3.987	4.248	0.939	0.982	1.018
3	UFA	49	279	3.761	3.891	0.967	0.997	1.003

- **Hmax** represents the highest possible value of species diversity that could occur if all species in the community were equally abundant.
- **S** is the total number of species in the community (species richness).
- **ln(S)** is the natural logarithm of species richness.

Table 7. Sørensen Similarity Coefficient between Species of the Forest Site

SN	**Site1**	**Site2**	**No of Common Species**	**Sørensen similarity coefficient**
1	NACF	IFU	28	25%
2	IFU	UFA	39	49%
3	UFA	NACF	17	16%

KEY:
NACF = Nnamdi Azikiwe Conservation Forest
IFU = Ishigwu Forest Umuomaku
UFA = Umuikwu Forest Anam

4. Discussion

This study documented significant variations in diversity indices among the three forest sites, with Ishigwu Forest Umuomaku (Figure 2) exhibiting the highest species richness (0.140), followed by Nnamdi Azikiwe Conservation Forest (Figure 1) 0.138 and Umuikwu Forest Anam (Figure 3) 0.098. This disparity in diversity is likely attributable to a gradient of anthropogenic pressure. IFU's relative isolation and its cultural status as a sacred grove likely afford it a higher degree of protection from logging and habitat disturbance, despite isolated incidents of fire from hunting activities. In contrast, NACF and UFA are situated in closer proximity to areas of intense and moderate human activity, respectively, aligning with established findings that human disturbance significantly alters species richness [26, 27].

Beyond anthropogenic factors, abiotic conditions including: precipitation, temperature, topography, and soil properties are critical determinants of community composition. The higher diversity at IFU coincides with a cooler average temperature (26 ℃), moderate humidity (66%), and clay-loam soils, as compared to the warmer, more humid conditions and sandier soils of UFA and NACF [26, 28]. Such edaphic and microclimatic gradients create distinct ecological niches, influencing species' germination, survival, and competitive interactions [26]. The minimal variation in richness between NACF and UFA may reflect their shared climatic affinities, a pattern consistent with observations in other Nigerian savanna ecosystems [29, 30].

The recorded species richness values are comparatively lower than those documented for other Nigerian tropical rainforests [31, 32]. This suggests potential degradation driven by illegal logging, agricultural expansion, and urban encroachment. Anthropogenic exploitation disrupts forest structure and stability [33], while urbanization poses a significant threat to woody species globally [34]. The significant positive correlation in alpha diversity values between sites ($p<0.01$) nonetheless indicates an underlying similarity in floristic composition across the regional landscape.

The distribution and abundance of species are further mediated by soil physicochemical properties. Water retention capacity, nutrient availability (e.g., calcium, magnesium, phosphorus), and organic matter content are known to influence plant physiological performance and community assembly [35, 36, 37]. The swampy nature of NACF and UFA during rainy seasons contrasts with the better-drained soils of IFU, potentially filtering species based on their hydrological tolerances. On a broader scale, climatic variables such as rainfall and temperature are primary drivers of species distribution [38, 40, 41], with topography and soil fertility modifying these patterns at local scales [39, 42]. The study area's location within Nigeria's humid forest zone supports a flora including native species such as *Parkia biglobosa*, *Alstonia boonei*, and *Khaya senegalensis*.

The Importance Value Index (IVI) highlighted species of high ecological dominance and those requiring conservation priorities. Species with low IVI values, such as *Terminalia glaucescens* (NACF), *Hannoa klaineana* (IFU), and *Hevea brasiliensis* (UFA), were rare and showed poor regeneration, marking them as vulnerable to local extinction. Conversely, the high IVI of species like *Elaeis guineensis*, *Newbouldia laevis*, and *Dacryodes edulis* across all sites indicates their wide ecological amplitude and dominance in these communities.

Analysis of diversity indices revealed that NACF and IFU supported higher species richness (69 and 70 species, respectively) and Shannon diversity (H' = 4.007 and 3.987) compared to UFA (49 species, H' = 3.761). However, UFA exhibited the highest species evenness (J' = 0.967) and Simpson's dominance (D = 0.997), indicating a community structured by a few highly abundant species rather than a rich array of evenly distributed ones. This inverse relationship between dominance and evenness underscores the multifaceted nature of diversity. The values recorded here fall within the range reported for other tropical forests [43, 44, 45, 46, 47, 48], though direct comparisons are constrained by methodological differences in plot size and sampling intensity [49].

The Sørensen similarity coefficient indicated a stronger floristic overlap between IFU and UFA (49%) than between both forest and NACF (25% and 16%, respectively). This significant shared composition between IFU and UFA may be facilitated by comparable environmental conditions, such as soil moisture and microclimate. The overall moderate to low similarity coefficients suggest that each forest retains a unique species assemblage, necessitating individualized conservation strategies.

Generally, the findings of this study elucidate the patterns of woody species diversity in Anambra State's forests, highlighting the interplay of anthropogenic disturbance and environmental gradients in shaping community structure. The identification of both dominant and rare species provides a critical foundation for conservation prioritization. To safeguard these ecosystems, sustainable management plans must address the pressures of urbanization and resource exploitation. Future research integrating molecular techniques for taxonomic validation and ecological modeling for predicting species responses to climate change would be valuable extensions of this work. This study ultimately contributes to the scientific basis for informed policy-making and the preservation of biodiversity and ecosystem services in the region.

5. Conclusions

This study provides a comprehensive taxonomic assessment of tree and shrub diversity across three tropical forests in Anambra State, Nigeria. The findings reveal distinct floristic compositions and distribution patterns, underscoring a significant gradient of ecological richness across the sites. The analysis of species abundance and importance values elucidated unique community structures and population dynamics, characterized by a mix of widespread dominant species and site-specific rare taxa. The identification of keystone dominant species, such as *Elaeis guineensis* and *Newbouldia laevis*, alongside rare species with low Importance Value Indices (IVI), provides a critical empirical basis for formulating tailored conservation strategies. Furthermore, the benchmark data on species composition and diversity established here are vital for developing climate change resilience models and informing sustainable forest management practices. Ultimately, this research delivers an essential foundational dataset for long-term ecological monitoring. It will enable future studies to track temporal changes in species composition, population health, and overall ecosystem integrity, thereby making a significant contribution to the conservation of Anambra State's threatened forest ecosystems.

Conflict of Interest

Authors have declared that there are no conflicts of interest.

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REFERENCES

[1] N. Myers, R. A. Mittermeier, C. G. Mittermeier, G. A. Da Fonseca, J. Kent, "Biodiversity hotspots for conservation priorities," *Nature*, vol. 403, no. 6772, pp. 853-858, 2000. https://doi.org/10.1038/35002501.

[2] A. D. Barnosky, N. Matzke, S. Tomiya, G. O. Wogan, B.

Swartz, T. B. Quental, C. Marshall, J. L. McGuire, E. L. Lindsey, K. C. Maguire, B. Mersey, "Has the Earth's sixth mass extinction already arrived?," *Nature*, vol. 471, no. 7336, pp. 51-57, 2011. https://doi.org/10.1038/nature09678.

[3] C. P. Carmona, R. Tamme, M. Pärtel, F. De Bello, S. Brosse, P. Capdevila, R. M. González, M. González-Suárez, R. Salguero-Gómez, M. Vásquez-Valderrama, A. Toussaint, "Erosion of global functional diversity across the tree of life," *Science Advances*, vol. 7, no. 13, pp. 1-13, 2021. https://doi.org/10.1126/sciadv.abf2675.

[4] D. M. G. Rigueira, P. L. B. da Rocha, E. Mariano-Neto, "Forest cover, extinction thresholds and time lags in woody plants (Myrtaceae) in the Brazilian Atlantic Forest: resources for conservation," *Biodiversity and Conservation*, vol. 22, no. 13, pp. 3141-3163, 2013. https://doi.org/10.1007/s10531-013-0569-2.

[5] B. J. Spiesman, B. D. Inouye, "Habitat loss alters the architecture of plant-pollinator interaction networks," *Ecology*, vol. 94, no. 12, pp. 2688-2696, 2013. https://doi.org/10.1890/13-0977.1.

[6] N. G. McDowell, C. D. Allen, K. Anderson-Teixeira, B. H. Aukema, B. Bond-Lamberty, L. Chini, J. S. Clark, M. Dietze, C. Grossiord, A. Hanbury-Brown, G. C. Hurtt, R. B. Jackson, D. J. Johnson, L. Kueppers, J. W. Lichstein, K. Ogle, B. Poulter, T. A. M. Pugh, R. Seidl, M. G. Turner, M. Uriarte, A. P. Walker, C. Xu, "Pervasive shifts in forest dynamics in a changing world," *Science*, vol. 368, no. 6494, pp. 1-10, 2020. https://doi.org/10.1126/science.aaz9463.

[7] N. G. Swenson, "The role of evolutionary processes in producing biodiversity patterns, and the interrelationships between taxonomic, functional and phylogenetic biodiversity," *American Journal of Botany*, vol. 98, no. 3, pp. 472-480, 2011. https://doi.org/10.3732/ajb.1000289.

[8] G. Castillo-Campos, G. Halffter, C. E. Moreno, "Primary and secondary vegetation patches as contributors to floristic diversity in a tropical deciduous forest landscape," *Biodiversity and Conservation*, vol. 17, no. 7, pp. 1701-1714, 2008. https://doi.org/10.1007/s10531-008-9353-4.

[9] C. E. Moreno, G. Castillo-Campos, J. R. Verdu, "Taxonomic diversity as complementary information to assess plant species diversity in secondary vegetation and primary tropical deciduous forest," *Journal of Vegetation Science*, vol. 20, no. 5, pp. 935-943, 2009. https://doi.org/10.1111/j.1654-1103.2009.01115.x.

[10] N. Myers, R. A. Mittermeier, C. G. Mittermeier, G. A. Da Fonseca, J. Kent, "Biodiversity hotspots for conservation priorities," *Nature*, vol. 403, no. 6772, pp. 853-858, 2000. https://doi.org/10.1038/35002501.

[11] R. A. Mittermeier, N. Myers, J. B. Thomsen, G. A. B. da Fonseca, S. Olivieri, "Biodiversity hotspots and major tropical wilderness areas: Approaches to setting conservation priorities," *Conservation Biology*, vol. 12, no. 3, pp. 516-520, 1998. https://doi.org/10.1046/j.1523-1739.1998.012003516.x.

[12] N. M. Haddad, L. A. Brudvig, J. C. Damschen, D. M. Evans, B. J. Heijl, J. D. Knops, W. E. Kraft, E. I. Damschen, "Habitat fragmentation and its lasting impact on Earth's ecosystems," *Science Advances*, vol. 1, no. 2, pp. e1500052, 2015. https://doi.org/10.1126/sciadv.1500052.

[13] A. Young, T. Boyle, T. Brown, "The population genetic consequences of habitat fragmentation for plants," *Trends in Ecology and Evolution*, vol. 11, no. 10, pp. 413-418, 1996. https://doi.org/10.1016/0169-5347(96)10046-8.

[14] J. Fischer, D. B. Lindenmayer, "Landscape modification and habitat fragmentation: A synthesis," *Global Ecology and Biogeography*, vol. 16, no. 3, pp. 265-280, 2007. https://doi.org/10.1111/j.1466-8238.2007.00309.x.

[15] B. L. Foster, G. R. Houseman, D. R. Hall, S. E. Hinman, D. E. Bunker, "Does tallgrass prairie restoration enhance the invasion resistance of post-agricultural lands?" *Biological Invasions*, vol. 17, no. 12, pp. 3579-3590, 2015. https://doi.org/10.1007/s10530-015-0979-z.

[16] J. Chave, "Neutral theory and community ecology," *Ecology Letters*, vol. 7, no. 3, pp. 241-253, 2004. https://doi.org/10.1111/j.1461-0248.2004.00594.x.

[17] R. H. Whittaker, "Vegetation of the Siskiyou Mountains, Oregon and California," *Ecological Monographs*, vol. 30, no. 3, pp. 279-338, 1960. https://doi.org/10.2307/1943566

[18] R. Revermann, M. Finckh, M. Stellmes, B. J. Strohbach, D. Frantz, J. Oldeland, "Linking land surface phenology and vegetation-plot databases to model terrestrial plant α-diversity of the Okavango Basin," *Remote Sensing*, vol. 8, no. 4, pp. 370, 2016. https://doi.org/10.3390/rs8040370.

[19] NIMET, "Nigerian Meteorological Agency Annual Report on Climate and Rainfall Trends," *Nigerian Meteorological Agency*, Abuja, Nigeria, 2020.

[20] C. F. Iroka, R. N. Okigbo, K. U. Ekwealor, C. N. Ikegbunam, C. A. Onyili, C. N. Okereke, "Checklist of Trees and Shrubs in Forests across Anambra State Nigeria," *African Journal of Environment and Natural Science Research*, vol. 7, no. 3, pp. 184-202, 2024.

[21] C. F. Iroka, R. N. Okigbo, K. U. Ekwealor, C. N. Ikegbunam, C. A. Onyili, O. A. Nwakuche, "Functional Trait and Phylogenetic Diversity of Tree and Shrub Species in Three Tropical Forests across Anambra State, Nigeria," *Asian Journal of Research in Agriculture and Forestry*, vol. 10, no. 3, pp. 168-185, 2024.

[22] B. J. McGill, R. S. Etienne, J. S. Gray, A. Alonso, M. J. Anderson, H. K. Benecha, M. Dornelas, B. J. Enquist, J. L. Green, F. He, A. H. Hurlbert, A. E. Magurran, P. A. Marquet, B. A. Maurer, A. Ostling, C. U. Soykan, K. I. Ugland, E. P. White, "Species abundance distributions: Moving beyond single distribution models," *Ecology Letters*, vol. 10, no. 10, pp. 995-1007, 2007. https://doi.org/10.1111/j.1461-0248.2007.01075.x.

[23] C. E. Shannon, "A mathematical theory of communication," *Bell System Technical Journal*, vol. 27, no. 3, pp. 379-423, 1948.

[24] A. J. Ogunleye, A. O. Adeola, L. O. Ojo, "Impact of farming activities on vegetation in Olokemeji Forest Reserve, Nigeria," *Global Nest: The International Journal*, vol. 6, no. 2, pp. 131-140, 2004.

[25] A J. Schwarz, "The Jolly-Seber model: More than just abundance," *Journal of Agricultural, Biological, and Environmental Statistics*, vol. 6, no. 2, pp. 195-205, 2001. https://doi.org/10.1198/108571101750524706.

[26] S. K. Dimnwobi, E. Chukwunonso, C. Madichie, S. Asongu, "Population Dynamics and Environmental Quality in Africa," *Science of the Total Environment*, vol. 797, pp. 149172, 2021. https://doi.org/10.1016/j.scitotenv.2021.149172.

[27] M. F. Goodchild, "Citizens as sensors: the world of volunteered geography," *GeoJournal*, vol. 69, no. 4, pp. 211-221, 2007. https://doi.org/10.1007/s10708-007-9111-y.

[28] J. C. Onyekwelu, R. Mosandl, B. Stimm, "Tree species diversity and soil status of primary and degraded tropical rainforest ecosystems in South-Western Nigeria," *Journal of Tropical Forest Science*, vol. 20, no. 3, pp. 193-204, 2008.

[29] J. I. Amonum, J. H. Dau, S. Gbande, "Composition and distribution of economic tree species in Nagi Forest Reserve, Benue State, Nigeria," *Journal of Research in Forestry, Wildlife and Environment*, vol. 8, no. 4, pp. 101-108, 2016.

[30] L. Wakawa, A. Suleiman, Y. Ibrahim, L. Adam, "Tree species biodiversity of a Sahelian ecosystem in Northeast Nigeria," *Journal of Bartin Faculty of Forestry*, vol. 19, no. 2, pp. 166-173, 2017.

[31] V. A. J. Adekunle, S. O. Akindele, J. A. Fuwape, "Structure and yield models of tropical lowland rainforest ecosystem of Southwest Nigeria," *Food, Agriculture and Environment*, vol. 2, no. 2, pp. 395-399, 2004.

[32] V. A. J. Adekunle, A. O. Olagoke, "Diversity and bio-volume of tree species in natural forest ecosystem in the bitumen-producing area of Ondo State: A baseline study," *Biodiversity and Conservation*, vol. 17, no. 12, pp. 2735-2755, 2008. https://doi.org/10.1007/s10531-008-9359-y.

[33] O. M. Johnson, A. H. Marcellinus, "The Nagi forest and need for protection," *Journal of Research in Forestry, Wildlife and Environment*, vol. 7, no. 2, pp. 14-26, 2013.

[34] F. B. Vahdati, S. S. Mehrvarz, D. C. Dey, A. Naqinezhad, "Environmental factors-ecological species group relationships in the Surash lowland-mountain forests in Northern Iran," *Nordic Journal of Botany*, vol. 35, no. 2, pp. 240-250, 2017. https://doi.org/10.1111/njb.01363.

[35] G. V. Gebreselasse, "Plant communities species diversity seedling bank and re-sprouting in Nandi Forest, Kenya," Ph.D. dissertation, Dept. Environ. Sci., Universität Koblenz-Landau, Landau, Germany, 2011.

[36] L. J. Zhao, W. H. Xiang, J. X. Li, P. F. Lei, X. W. Deng, X. Fang, C. H. Peng, "Effects of topographic and soil factors on woody species assembly in a Chinese Subtropical Evergreen Broadleaved Forest," *Forests*, vol. 6, no. 6, pp. 650-669, 2015. https://doi.org/10.3390/f6060650.

[37] M. Toledo, M. Peña-Claros, F. Bongers, A. Alarcón, J. Balcázar, J. Chubiña, C. Leaño, J. C. Licona, L. Poorter, "Distribution patterns of tropical woody species in response to climatic and edaphic gradients," *Journal of Ecology*, vol. 100, no. 1, pp. 253-263, 2012. https://doi.org/10.1111/j.1365-2745.2011.01890.x.

[38] M. Sakar, A. Devi, "Assessment of diversity, population structure and regeneration status of tree species in Hollongapar Gibbon Wildlife Sanctuary, Assam, Northeast India," *Tropical Plant Research*, vol. 1, no. 1, pp. 26-36, 2014.

[39] L. Asanok, D. Marod, "Environmental factors influencing tree species regeneration in different forest stands growing on a limestone hill in Phrae Province, Northern Thailand," *Journal of Environmental Sciences*, vol. 32, pp. 237-252, 2016.

[40] M. N. Adel, H. Pourbabaei, S. J. Alavi, "Response curves of seventeen woody species to soil factors along a riparian forest in northern Iran," *Russian Journal of Ecology*, vol. 48, no. 3, pp. 219-225, 2017. https://doi.org/10.1134/S1067413617030031.

[41] R. John, J. W. Dalling, K. E. Harms, J. B. Yavitt, R. F. Stallard, M. Mirabello, S. P. Hubbell, R. Valencia, H. Navarrete, O. Vallejo, "Soil nutrients influence spatial distributions of tropical tree species," *Proceedings of the National Academy of Sciences*, vol. 104, no. 3, pp. 864-869, 2007. https://doi.org/10.1073/pnas.0604666104.

[42] L. Amissah, G. M. J. Mohren, F. Bongers, W. D. Hawthorne, L. Poorter, "Rainfall and temperature affect tree species distribution in Ghana," *Journal of Tropical Ecology*, vol. 30, no. 4, pp. 435-446, 2014. https://doi.org/10.1017/S0266467414000215.

[43] S. K. Maharjan, L. Poorter, M. Holmgren, F. Bongers, J. J. Wieringa, W. D. Hawthorne, "Plant functional traits and the distribution of West African rainforest trees along the rainfall gradient," *Biotropica*, vol. 43, no. 4, pp. 552-561, 2011. https://doi.org/10.1111/j.1744-7429.2011.00762.x.

[44] D. S. Kacholi, A. M. Whitbread, M. Worbes, "Diversity, abundance, and structure of tree communities in the Uluguru forests in the Morogoro region, Tanzania," *Journal of Forestry Research*, vol. 26, no. 3, pp. 557-569, 2015. https://doi.org/10.1007/s11676-015-0078-0.

[45] M. Toledo, L. Poorter, M. Peña-Claros, A. Alarcón, J. Balcázar, C. Leaño, J. C. Licona, O. Llanque, V. Vroomans, P. Zuidema, F. Bongers, "Climate is a stronger driver of tree and forest growth rates than soil and disturbance," *Journal of Ecology*, vol. 99, no. 1, pp. 254-264, 2010. https://doi.org/10.1111/j.1365-2745.2010.01741.x.

[46] N. A. Sobuj, M. Rahman, "Assessment of plant diversity in Khadimnagar National Park of Bangladesh," *International Journal of Environmental Sciences*, vol. 2, no. 1, pp. 1-13, 2011.

[47] O. F. Falade, D. A. Aruwajoye, "Tree species and size diversity of Akure Strict Nature Reserve, Nigeria," *American Journal of Agriculture and Forestry*, vol. 11, no. 4, pp. 128-135, 2023. https://doi.org/10.11648/j.ajaf.20231104.12.

[48] J. C. Onyekwelu, R. Mosandl, B. Stimm, "Tree species diversity and soil status of primary and degraded tropical rainforest ecosystems in South-Western Nigeria," *Journal of Tropical Forest Science*, vol. 20, no. 3, pp. 193-204, 2008.

[49] O. C. Ariyo, "Comparative Analyses of Diversity and Similarity Indices of West Bank Forest and Block A Forest of the International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State, Nigeria," *International Journal of Forestry Research*, vol. 2020, pp. 4865845, 2020. https://doi.org/10.1155/2020/4865845.