**Logging Impact on Tree Species Diversity and Forest Structure in Nigerian Tropical Forests**

**Abstract**

This study assessed logging impacts on tree species diversity in the tropical rainforest ecosystems, southwest, Nigeria. Here, we compared tree species diversity between forest reserves (undisturbed) and free areas (disturbed) in Akure and Oluwa Forest Reserves. Systematic line transect was used for data collection. Our results revealed a significant reduction in species richness and diversity in the disturbed areas compared to undisturbed forests. In Oluwa Forest Reserve, the undisturbed site had a Shannon-Wiener index of 3.47, while we recorded diversity index of 2.97 for the disturbed site. Similarly, in Akure Forest Reserve, the undisturbed site had a diversity index of 3.00 compared to 2.67 in the disturbed area. These results show a clear decline in species diversity due to logging. In Akure Forest Reserve, the undisturbed site recorded a higher mean Dbh (34.75 cm) and height (14.98 m) compared to the disturbed site (24.42 cm and lower height classes dominating). Similarly, in Oluwa Forest Reserve, the undisturbed site exhibited a mean Dbh of 33.50 cm and height of 13.07 m, while the disturbed site recorded 25.34 cm and lower height dominance. Height class distribution showed that trees in undisturbed sites were predominantly in the 11–20 m range, with very few in the <5 m class, while disturbed sites had a higher proportion of trees in the 5–10 m range, indicating structural degradation. The findings from our study highlight the ecological consequences of unsustainable logging and the need for improved forest management, stricter enforcement of logging regulations, and active restoration strategies to safeguard biodiversity and forest structure in Nigeria’s tropical ecosystems.

**Keywords: Logging, Tree Species, Diversity, Forest Structure, Tropical Forests**

**Introduction**

Tropical forests are globally recognized as biodiversity hotspots, and one of the main repositories of global biodiversity (Myers et al., 2000, FAO, 2003),). They support life because of their richness in plant species composition and fauna diversity (Rennolls & Reynold, 2007; Sarkar & Devi, 2017). Parthasarathy, (2001) reported that Tropical Rainforest Ecosystems have been described as one of the most complex and species-rich single ecosystems of the world. They are mostly dominated by a wide variety of broad-leaved trees, which form a dense canopy and make it one of the most complex ecosystems. The tropical rainforest is a vital ecosystem that provides essential goods and services, such as raw materials, reservoirs for biodiversity, habitat to diverse animal species, soil protection, sources of timber, medicinal plants, carbon sequestration, watershed protection and also forms the livelihood for many different human settlements (Brandon, 2014; Nwabueze et al., 2023). The forest plays crucial roles in promoting the economic, social advancement and welfare of the people and it is accepted as a veritable means of alleviating poverty among rural communities. The forestry sector is one of the main pivots on which the nation’s welfare is built.

Biological diversity is critical to the maintenance of tropical ecosystems. Each species within the forest plays a fundamental role in sustaining its ecological balance. Among these, tree species diversity is central to overall rainforest biodiversity (Cannon et al., 1998). It is widely accepted that species distribution, structural patterns, and their responses to environmental factors are core concepts in ecological studies (Amissah et al., 2014). Logging has been reported to negatively impact tree species diversity and forest structure (Adekunle 2006; Adekunle et al., 2014). Logging does not only reduces tree species diversity but also disrupts the important ecological processes and interactions that uphold forest health (Adeseko et al., 2023; Akinbowale et al., 2020). In the southwestern Nigeria, for instance, states such as Ondo and Ekiti, once home to dense and species-rich forests are experiencing forest loss at an alarming rate (Adekunle, 2006). Satellite-based monitoring reports a deforestation rate of approximately 1.36% per annum in the region (Salami, 2006), underscoring an urgent need for conservation and sustainable forest management efforts. Despite the ecological and socio-economic significance of tree species diversity, there remains a notable lack of comprehensive data on the current status and trends within Nigeria’s tropical forests. Existing inventories are often outdated, limited in scope, or focused on specific regions, making it difficult to assess broader patterns and drivers of biodiversity loss (Adekunle et al., 2014; Daramola et al., 2021). Moreover, the encroachment of invasive species, selective logging, and changes in land use have led to shifts in species composition, frequently favoring generalist or fast-growing species over rare or endemic trees.

Understanding tree species diversity is essential for shaping effective conservation strategies and policy interventions (Adekunle, 2006). Accurate, up-to-date data on species richness, distribution, and abundance can guide the designation of protected areas, inform restoration efforts, and support the sustainable management of forest resources. Such data also provide a critical baseline for assessing the impacts of environmental change and human activities on forest ecosystems.

In the context of global climate change, maintaining diverse tree communities is particularly important for enhancing forest resilience and mitigating greenhouse gas emissions through carbon sequestration (Malhi, 2010; Akinbowale et al., 2022). However, efforts to conserve tree species diversity in Nigeria face several challenges, including weak institutional capacity, inadequate funding, and limited public awareness. Forest policies and regulations are often poorly enforced, and many reserves suffer from illegal logging, agricultural encroachment, and infrastructural development. Community participation in forest management remains low, despite evidence that involving local stakeholders can significantly improve conservation outcomes (Tole, 2010). Addressing these challenges requires integrated approaches that combine scientific research, policy reform, community engagement, and sustainable land-use practices. This study aims to assess logging impacts on tree species diversity and abundance in selected Nigerian tropical forests, along with forest structure. By highlighting the ecological implications of tree diversity loss, the study seeks to contribute to ongoing efforts to promote sustainable forest management and biodiversity conservation.

**METHODOLOGY**

**Description of the study areas**

This research was carried out in two selected forest reserves in Ondo State, Nigeria, because they are among the most significant forest reserves in the state, representing key examples of tropical rainforest ecosystems in southwestern Nigeria. These reserves have relatively well-preserved forest cover compared to other areas, making them ideal sites to assess tree species diversity and forest health.Akure and Oluwa Forest Reserves feature locations where active logging activities have occurred, as well as relic areas that have not experienced logging for several decades, including strictly protected nature reserves with little or no human activity. Akure Forest Reserve is situated within the tropical rainforest ecosystem of southwestern Nigeria, specifically in Akure South Local Government Area of Ondo State. It lies at latitude 7° 17′ 39″ N and longitude 5° 2′ 3″ E. Constituted as a reserve in 1936, it covers a total land area of 69.93 km². The dry season lasts from November to March, while the wet season runs from April to October, with peak rainfall recorded between July and August. The average daily temperature ranges between 21°C and 29°C throughout the year. Mean annual rainfall varies from 2,000 mm in the southern area to 1,500 mm in the northern area, with relative humidity ranging between 80% and 85% annually in the southwest. Oluwa Forest Reserve is also located in Ondo State, Nigeria, between latitude 6° 83′ and 6° 91′ N and longitude 4° 51′ and 4° 59′ E, and it covers over 829 km². It was formerly part of the combined Omo-Shasha-Oluwa Forest Reserves, but it has since been separated from the other two, which themselves have also been separated. The rainy season at this location starts in March and ends in November, while the dry season spans December to February. The average rainfall in the reserve is 1,700 mm, relative humidity is approximately 80%, and the annual temperature is 26°C, with an average elevation of 100 m (Adekunle et al., 2011).The map of the study areas is presented in Figure 1.



**Figure 1: Map of Ondo state showing the study areas**

**Sampling Technique and Selection of Sample Plots**

Systematic line transects was used for plot location in each of the selected forest reserves (Figure 2). Two parallel transects of 200 m apart were laid in each of the study sites after a 50 m off set has been measured from the road. Thereafter, two samples plots of equal size (50x50 m) were alternately laid on each transect for tree diversity measurements and diversity assessment

50m

50m

50m

50m

200m

 50m

50m

200m

 50m

50m

50m

50m

200m

**Figure 2: Systematic line transect sampling technique for plot layout**.

 **Biodiversity Assessment**

In each sample plot, all trees were tagged, measured, identified and classified into families and their frequency of occurrence were obtained to ascertain tree species diversity and abundance. The scientific names of all the tree species encountered on the field plot were recorded. Local names were used for tree species whose scientific names were not known immediately on the field. Parts (such as leaves, backs and fruits) of trees that cannot be identified were collected and taken to the herbarium for identification.

**Measurement of Tree growth variables**

The tree growth variables in each plot were diameter at the breast height (Dbh), diameter at the top (Dt), diameter at the middle (Dm) diameter at the base (Db) and the total height (Ht). Tree diameters were measured using girth tape and the total height using Spiegel relaskop.

**Method of data Analysis**

1. **Basal Area Estimation-**

Tree basal area was estimated using equation 1

……………………………………………………………………….. (Equation 1)

Where BA = Basal area (m2),

D = Diameter at breast height (cm)

π = Pie (3.142).

1. **Volume Estimation**

The volume of individual trees was estimated using the Newton’s formula (Husch *et. al.,* 2003). ……………………………………………………….(Equation 2)

Where: V = Volume of tree (m3)

Db = Diameter at the base (cm)

Dm = Diameter at the middle (m)

Dt = Diameter at the top (m)

Ht = height (m)

**(c ) Biodiversity Indices and Tree Species Classification**

(i) Species relative density was computed with equation 3

 ……………………………………………………………………….(Equation 3)

Where: RD (%) = species relative density;

ni = number of individuals of species i

N = total number of all tree species in the entire community

(ii)Species relative dominance (RDo (%)) was computed using the equation 4:

…………………………………………………………………….. (Equation 4)

Where: Bai = basal area of individual tree belonging to species i

Ban = stand basal area

(iii) The Shannon’s maximum diversity index in equation 5 was employed to calculate the tree species diversity because it takes into account the richness and abundance of each species in different ecosystems (Kent & Coker, 1992).

……………………………………………………………………… (Equation 5)

Where H’ = Shannon diversity index,

S = the total number of species in the community

pi = proportion S (species in the family) made up of the *i*th species

ln = natural logarithm.

(iv) Species evenness was calculated using equation 6

………………………………………………………………… (Equation 6)

**Results**

**Tree species diversity and abundance per hectare in the selected forest reserves.**

The tree species diversity of the study area is summarized in Table 1. A total of 482 stems were recorded across all the study sites. In Oluwa Forest Reserve, the undisturbed site had 155 stems per hectare, while the disturbed site had 57 stems per hectare. In Akure Forest Reserve, tree densities were 175 and 95 stems per hectare in the undisturbed and disturbed forests respectively. *Hylodendron gabunense* Taub. was the most frequently encountered species in Oluwa Forest Reserve, with 18 stems in the undisturbed site and eight stems in the disturbed site, making it the dominant species in both forests. In Akure Forest Reserve, *Mansonia altissima* was the dominant species, represented by 26 stems in the undisturbed site and 20 stems in the disturbed site. *Cleistopholis patens* was found in the undisturbed site of Oluwa Forest Reserve, represented by 10 stems, but was absent in disturbed and undisturbed sites of Akure Forest Reserve. *Albizia lebbeck* had a single stem in the disturbed plots of Akure Forest Reserve, and *Ceiba pentandra* (L.) Gaertn. appeared as a single stem across all study sites. *Anthocleista vogelii* Planch was represented by three stems in the undisturbed plot of Oluwa Forest Reserve. *Alstonia boonei* De Wild. was present in both the undisturbed and disturbed sites of Akure Forest Reserve with one and four stems respectively. Species represented by just two stems in the disturbed site of Akure Forest Reserve include *Azadirachta indica, Ricinodendron heudelotii* (Ball.) Pierre, *Khaya ivorensis* A. Chev., *Cola gigantea* A. Chev., and *Chrysophyllum albidum* G. Don.

Table 1: Tree Species Abundance per hectare in the study areas

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S/N | Species | OFR(undisturbed) | OFR(disturbed) | AFR(undisturbed) | AFR(disturbed) |
| 1 | *Albizia lebbeck (L.) Benth* | 0 | 0 | 0 | 1 |
| 2 | *Albizia zygia* | 0 | 0 | 0 | 0 |
| 3 | *Alstonia boonei De Wild*  | 0 | 0 | 1 | 4 |
| 4 | *Anonidium mannii (Oliv.) Engl. & Diels*  | 0 | 0 | 25 | 0 |
| 5 | *Annona arenaria* | 0 | 0 | 0 | 0 |
| 6 | *Anogeissusleio carpus* | 0 | 0 | 0 | 0 |
| 7 | *Azadirachta indica* | 0 | 0 | 0 | 2 |
| 8 | *Anthocleista vogelii Planch* | 3 | 0 | 0 | 0 |
| 9 | *Baphia nitida Lodd* | 3 | 2 | 0 | 0 |
| 10 | *Brachystegia eurycoma* | 0 | 0 | 0 | 0 |
| 11 | *Anthonotha macrophylla* | 0 | 0 | 0 | 0 |
| 12 | *Allanblackia floribnda* | 0 | 0 | 0 | 0 |
| 13 | *Blighia sapida K Konig*  | 1 | 1 | 0 | 0 |
| 14 | *Bucholzia corrazea Engl.* | 6 | 2 | 1 | 0 |
| 15 | *Canarium schweinfurthii Engl.* | 2 | 1 | 0 | 1 |
| 16 | *Ceiba petandra(L) Gaertn* | 1 | 1 | 1 | 1 |
| 17 | *Celtis mildbraedii Engl. Blanco* | 1 | 1 | 5 | 0 |
| 18 | *Celtis occidentalis Engl.* | 0 | 0 | 2 | 0 |
| 19 | *Celtis zenkeri Engl.* | 6 | 4 | 23 | 7 |
| 20 | *Celtis brownie* | 0 | 0 | 0 | 0 |
| 21 | *Cleistopholis patens (Benth)Engl.& Diels* | 10 | 3 | 0 | 0 |
| 22 | *Cola acuminata (P.Beauv.) Schott & Endl.* | 0 | 0 | 1 | 0 |
| 23 | *Pterygota macrocarpa.* | 10 | 5 | 13 | 4 |
| 24 | *Cola gigantea A.Chev. .* | 4 | 2 | 5 | 2 |
| 25 | *Cola heterophylla (P. Beauv.) Schott & Endl.* | 4 | 0 | 0 | 0 |
| 26 | *Cola hispida (Beauv.) Schott & Endl.* | 0 | 0 | 2 | 0 |
| 27 | *Chrysophyllum albidum G.Don.*  | 0 | 0 | 4 | 2 |
| 28 | *Chrysophyllum pulpucrum* | 0 | 0 | 4 | 0 |
| 29 | *Cordia mellenii Bak.* | 0 | 0 | 0 | 5 |
| 30 | *Cordia plathyrsa* | 0 | 0 | 0 | 0 |
| 31 | *Dracaena mannii* | 0 | 0 | 0 | 0 |
| 32 | *Diallium angolenseOliv* | 0 | 0 | 0 | 2 |
| 33 | *Diospyros dendo Welw.ex Hiern* | 4 | 1 | 0 | 0 |
| 34 | *Diospyros mespilifomis Hochst* | 3 | 3 | 0 | 0 |
| 35 | *Diospyros mobutensis* | 0 | 0 | 1 | 0 |
| 36 | *Diospyros spp* | 1 | 1 | 0 | 0 |
| 37 | *Drypetes gildani Hutch* | 0 | 0 | 1 | 0 |
| 38 | *Drypetes spp* | 0 | 0 | 0 | 0 |
| 39 | *Distermonanthus benthamianus* | 0 | 0 | 0 | 0 |
| 40 | *Entandrophragma angolense(Welw.) C DC* | 0 | 0 | 2 | 0 |
| 41 | *Entadrophragma cylindricum* | 0 | 0 | 1 | 7 |
| 42 | *Entandrophragma utile C. DC* | 0 | 0 | 4 | 0 |
| 43 | *Ficus exasperata Vahl* | 8 | 3 | 0 | 1 |
| 44 | *Futumia elastic* | 0 | 0 | 2 | 1 |
| 45 | *Garcinia cola Heckel.* | 0 | 0 | 1 | 0 |
| 46 | *Hylodendron gabunense Taub.* | 18 | 8 | 0 | 0 |
| 47 | *Hylodendron pabe Taub.* | 1 | 1 | 0 | 0 |
| 48 | *Ixora guinnesis Benth.* | 0 | 0 | 1 | 0 |
| 49 | *Khaya grandifoliola C. DC.* | 0 | 0 | 2 | 0 |
| 50 | *Khaya Ivorensis A. Chev.* | 0 | 0 | 0 | 2 |
| 51 | *Lannea welwitschii (Hiern)* | 2 | 2 | 0 | 0 |
| 52 | *Lecaniodiscus cupanioides Ex Bth* | 0 | 0 | 1 | 0 |
| 53 | *Pseudospondia microcapal spp* | 0 | 1 | 0 | 0 |
| 54 | *Macaranga barteri Mull-Arg* | 2 | 0 | 0 | 0 |
| 55 | *Maesopsis emi8nii* | 1 | 0 | 0 | 0 |
| 56 | *Malacanta alnifolia (Baker) Pierre* | 3 | 0 | 7 | 0 |
| 57 | *Mansonia altisima A. Chev* | 1 | 0 | 26 | 20 |
| 58 | *Microdesmis puberula Hook.f. ex Planch* | 2 | 0 | 0 | 0 |
| 59 | *Milicia excelsa (Welw.) C. Berg* | 1 | 0 | 0 | 3 |
| 60 | *Mitragyna ciliate (Myta)* | 1 | 0 | 0 | 0 |
| 61 | *Morinda lucida* | 0 | 0 | 0 | 0 |
| 62 | *Musanga cecropioides R. Br.* | 4 | 0 | 0 | 0 |
| 63 | *Myrianthus arboreus P. Beauv* | 3 | 0 | 2 | 0 |
| 64 | *Nesogordonia papaverifera A.Chev.* | 0 | 0 | 1 | 4 |
| 65 | *Newbouldia laevis (P. Beauv.)* | 1 | 0 | 0 | 0 |
| 66 | *Nochocarpus sericeus (Poir) HB & K.* | 1 | 0 | 0 | 0 |
| 67 | *Nuclea diderrichii De wild. & Th. Dur.* | 1 | 0 | 0 | 0 |
| 68 | *Picralima nitida (Stapf) T.Durand & H.Durand* | 1 | 0 | 0 | 0 |
| 69 | *Pseudospondia Microcapal spp* | 5 | 0 | 0 | 0 |
| 70 | *Pterocarpus osun Craib* | 0 | 0 | 1 | 0 |
| 71 | *Pycnanthus angolensis (Welw.) Warb.* | 4 | 0 | 0 | 0 |
| 72 | *Rauvolfia vomitoria Afzel.* | 3 | 0 | 0 | 0 |
| 73 | *Ricinodendron heudelotii (Ball.) Pierr* | 3 | 0 | 1 | 2 |
| 74 | *Rothmannia spp* | 1 | 0 | 0 | 0 |
| 75 | *Spathodea campanulate* | 0 | 0 | 0 | 0 |
| 76 | *Spondiathus preussii Engl.* | 3 | 0 | 0 | 0 |
| 77 | *Sterculia melagantha K. Schum* | 0 | 0 | 2 | 0 |
| 78 | *Sterculia oblonga K. Schum* | 0 | 0 | 1 | 0 |
| 79 | *Sterculia rhinopetala K. Schum* | 8 | 3 | 10 | 8 |
| 80 | *Sterculia tragacantha K. Schum* | 2 | 0 | 0 | 0 |
| 81 | *Strombosia pustulata Oliv.* | 1 | 1 | 2 | 0 |
| 82 | *Terminalia ivorensis Chev* | 0 | 0 | 0 | 1 |
| 83 | *Terminalia superba Chev* | 3 | 3 | 1 | 1 |
| 84 | *Trichilia heudelottii Planch. ex. Oliv.* | 6 | 4 | 0 | 0 |
| 85 | *Trichilia monadelpha A. Juss* | 0 | 0 | 3 | 0 |
| 86 | *Trilepisium madagascariense Dc. Fl. Cam* | 0 | 0 | 5 | 0 |
| 87 | *Triplochiton scleroxylon K. Schum* | 5 | 3 | 10 | 13 |
| 88 | *Voacanga Africana* | 0 | 0 | 0 | 0 |
| 89 | *Zanthoxylum leprieurii (Gril. & Perr.)* | 1 | 1 | 0 | 0 |
| 90 | *Zanthoxylum macrophylla* | 0 | 0 | 0 | 1 |
| 91 | *Zanthoxylum zanthoxyloides* | 0 | 0 | 0 | 0 |
|  | **Total** | **155** | **57** | **175** | **95** |

*AFR-Akure Forest Reserve OFR-Oluwa Forest Reserve*

**Biodiversity indices and Importance Value Index (IVI) of Tree species in the disturbed and undisturbed sites of Oluwa Forest Reserves.**

The results of biodiversity indices for tree species in Oluwa Forest Reserve are presented in Table 2. In the disturbed forest, species relative density (RD%) ranged from 1.89% to 15.09%. Trees with the lowest RD (1.89%) included *Blighia sapida, Canarium schweinfurthii, Ceiba petandra*, and *Celtis mildbraedii*, while *Hylodendron gabunense* recorded the highest of 15.09%. Relative dominance (RDo) in this site ranged from 0.22% to 16.82%. *Hylodendron gabunense* and *Cola exasperata* had the lowest RDo (0.22%), whereas *Terminalia superba* had the highest RDo at 16.82%. The Shannon-Wiener index values in the disturbed forest ranged from 0.07 to 0.29. Tree species with a low Shannon-Wiener index of 0.07 included *Blighia sapida, Canarium schweinfurthii, Ceiba petandra,* and *Celtis mildbraedii*, while *Hylodendron gabunense* had the highest value of 0.29. In the undisturbed site, trees with low RD (%) included *Hylodendron pabe* Taub, *Maesopsis eminii, Milicia excelsa, and Mitragyna ciliata,* while *Hylodendron gabunense* had the highest RD at 12.33%. Special relative dominance (RDo) ranged from 0.23% to 13.23%, with *Maesopsis eminii* recording the lowest and *Rothmannia spp*. the highest. The Shannon-Wiener index values in this site were also low for *Hylodendron pabe Taub, Maesopsis eminii, Milicia excelsa*, and Mitragyna ciliata (each at 0.03), while *Hylodendron gabunense* had the highest at 0.26. In terms of Importance Value Index (IVI) for the disturbed site, *Hylodendron gabunense* Taub had the highest IVI at 13.83%, followed by *Celtis zenkeri* Engl (11.85%) and *Terminalia superba* Chev (11.24%). *Cola exasperata* Vahl and *Hylodendron pabe* Taub recorded IVI values of 1.06% each. In the undisturbed site, IVI values were 7.09% for *Hylodendron gabunense* and 6.95% for *Rothmannia spp.*

**Table 2: Biodiversity indices and Importance Value Index (IVI) of Tree species in the disturbed and undisturbed plots of Oluwa Forest Reserves**

|  |  |  |  |
| --- | --- | --- | --- |
|   |   | **Disturbed Forest** | **Undisturbed Forest** |
| S/N | **Species** | **No/ha** | **RD(%)** | **RDo(%)** | **IVI(%)** | **H1** | **No/ha** | **RD(%)** | **Rdo(%)** | **IVI(%)** | **Hi** |
| 1 | *Anthocleista vogelii Planch..* |  *-* |  - |  - |  - | - | 3 | 2.05 | 1.39 | 1.72 | -0.08 |
| 2 | *Baphia nitida Lodd* | 2 | 3.77 | 0.9 | 2.34 | -0.08 | 3 | 2.05 | 9.28 | 5.67 | -0.08 |
| 3 | *Blighia sapida K Konig*  | 1 | 1.89 | 0.67 | 1.28 | -0.07 | 1 | 0.68 | 0.23 | 0.46 | -0.03 |
| 4 | *Bucholzia corrazea Engl.* | 2 | 3.77 | 1.35 | 2.56 | -0.12 | 6 | 4.11 | 2.09 | 3.1 | -0.13 |
| 5 | *Canarium schweinfurthii Engl.* | 1 | 1.89 | 0.45 | 1.17 | -0.07 | 2 | 1.37 | 2.09 | 1.73 | -0.06 |
| 6 | *Ceiba petandra(L) Gaertn* | 1 | 1.89 | 0.9 | 1.39 | -0.07 | 1 | 0.68 | 1.39 | 1.04 | -0.03 |
| 7 | *Celtis mildbraedii Engl. Blanco* | 1 | 1.89 | 1.57 | 1.73 | -0.07 | 1 | 0.68 | 0.23 | 0.46 | -0.03 |
| 8 | *Celtis zenkeri Engl* | 4 | 7.55 | 16.14 | 11.85 | -0.20 | 6 | 4.11 | 2.32 | 3.21 | -0.13 |
| 9 | *Cleistopholis patens(Benth)Engl.& Diels* | 3 | 5.66 | 7.4 | 6.53 | -0.16 | 10 | 6.85 | 1.39 | 4.12 | -0.18 |
| 10 | *Cola exasperata Vahl.* | 1 | 1.89 | 0.22 | 1.06 | -0.07 | 1 | 0.68 | 1.86 | 1.27 | -0.03 |
| 11 | *Cola gigantea A.Chev. .* | 2 | 3.77 | 0.45 | 2.11 | -0.12 | 4 | 2.74 | 3.71 | 3.23 | -0.10 |
| 12 | *Cola heterophylla (P. Beauv.) Schott & Endl.* |  - |  - |  - |  - | 0.00 | 4 | 2.74 | 2.78 | 2.76 | -0.10 |
| 13 | *Cordia mellenii Bak.* |  *-* |  - | - | - | 0.00 |  - |  - |  - |  - | 0.00 |
| 14 | *Diallium angolenseOliv* |  |  |  |  | 0.00 |  |  |  |  | 0.00 |
| 15 | *Diospyros dendo Welw.ex Hiern* | 1 | 1.89 | 0.9 | 1.39 | -0.07 | 4 | 2.74 | 1.62 | 2.18 | -0.10 |
| 16 | *Diospyros mespilifomis Hochst* | 3 | 5.66 | 12.11 | 8.88 | -0.16 | 3 | 2.05 | 1.86 | 1.96 | -0.08 |
| 17 | *Diospyros mobutensis* |  |  |  |  | 0.00 |  |  |  |  | 0.00 |
| 18 | *Diospyros spp* | 1 | 1.89 | 1.35 | 1.62 | -0.07 | 1 | 0.68 | 1.62 | 1.15 | -0.03 |
| 19 | *Ficus exasperata Vahl* | 3 | 5.66 | 8.07 | 6.87 | -0.16 | 8 | 5.48 | 6.26 | 5.87 | -0.16 |
| 20 | *Hylodendron gabunense Taub.* | 8 | 15.09 | 12.56 | 13.83 | -0.29 | 18 | 12.33 | 1.86 | 7.09 | -0.26 |
| 21 | *Hylodendron pabe Taub.* | 1 | 1.89 | 0.22 | 1.06 | -0.07 | 1 | 0.68 | 0.46 | 0.57 | -0.03 |
| 22 | *Lannea welwitschii (Hiern)* | 2 | 3.77 | 1.79 | 2.78 | -0.12 | 2 | 1.37 | 3.94 | 2.66 | -0.06 |
| 23 | *Pseudospondia microcapa*  | 1 | 1.89 | 6.73 | 4.31 | -0.07 |  - |  - |  - |  - | 0.00 |
| 24 | *Macaranga barteri Mull-Arg* |  - |  - |  - |  - | 0.00 | 2 | 1.37 | 0.46 | 0.92 | -0.06 |
| 25 | *Maesopsis eminii* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 0.23 | 0.46 | -0.03 |
| 26 | *Malacanta alnifolia (Baker) Pierre* |  - |  - |  - |  - | 0.00 | 3 | 2.05 | 1.86 | 1.96 | -0.08 |
| 27 | *Mansonia altisima A. Chev* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 0.46 | 0.57 | -0.03 |
| 28 | *Microdesmis puberula Hook. f. ex Planch* |  - |  - |  - |  - | 0.00 | 2 | 1.37 | 2.32 | 1.85 | -0.06 |
| 29 | *Milicia excelsa (Welw.) C. Berg* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 5.57 | 3.13 | -0.03 |
| 30 | *Mitragyna ciliate (Myta)* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 0.23 | 0.46 | -0.03 |
| 31 | *Musanga cecropioides R. Br.* |  - |  - |  - |  - | 0.00 | 4 | 2.74 | 1.16 | 1.95 | -0.10 |
| 32 | *Myrianthus arboreus P. Beauv* |  - |  - |  - |  - | 0.00 | 3 | 2.05 | 1.16 | 1.61 | -0.08 |
| 33 | *N2ewbouldia laevis (P. Beauv.)* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 0.93 | 0.81 | -0.03 |
| 34 | *Nochocarpus sericeus (Poir) HB & K.* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 1.16 | 0.92 | -0.03 |
| 35 | *Nuclea diderrichii De wild. & Th. Dur.* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 0.23 | 0.46 | -0.03 |
| 36 | *Picralima nitida (Stapf) T.Durand & H.Durand* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 0.46 | 0.57 | -0.03 |
| 37 | *Pseudospondia Microcapal spp* |  - |  - |  - |  - | 0.00 | 5 | 3.42 | 0.7 | 2.06 | -0.12 |
| 38 | *Pycnanthus angolensis (Welw.) Warb.* |  - |  - |  - |  - | 0.00 | 4 | 2.74 | 7.89 | 5.31 | -0.10 |
| 39 | *Rauvolfia vomitoria Afzel.* |  - |  - |  - |  - | 0.00 | 3 | 2.05 | 0.23 | 1.14 | -0.08 |
| 40 | *Ricinodendron heudelotii (Ball.) Pierr* |  - |  - |  - |  - | 0.00 | 3 | 2.05 | 0.7 | 1.38 | -0.08 |
| 41 | *Rothmannia spp* |  - |  - |  - |  - | 0.00 | 1 | 0.68 | 13.23 | 6.95 | -0.03 |
| 42 | *Spondiathus preussii Engl.* |  - |  - |  - |  - | 0.00 | 3 | 2.05 | 0.23 | 1.14 | -0.08 |
| 43 | *Steculia rhinopetala K. Schum* | 3 | 5.66 | 3.36 | 4.51 | -0.16 | 8 | 5.48 | 2.55 | 4.02 | -0.16 |
| 44 | *Sterculia tragacantha K. Schum* |  - |  - |  - |  - |  | 2 | 1.37 | 2.55 | 1.96 | -0.06 |
| 45 | *Strombosia pustulata Oliv.* | 1 | 1.89 | 0.67 | 1.28 | -0.07 | 1 | 0.68 | 1.16 | 0.92 | -0.03 |
| 46 | *Terminalia superba Chev* | 3 | 5.66 | 16.82 | 11.24 | -0.16 | 3 | 2.05 | 0.7 | 1.38 | -0.08 |
| 47 | *Trichilia heudelottii Planch. ex. Oliv.* | 4 | 7.55 | 1.79 | 4.67 | -0.20 | 6 | 4.11 | 3.02 | 3.56 | -0.13 |
| 48 | *Triplochiton scleroxylon K. Schum* | 3 | 5.66 | 0.67 | 3.17 | -0.16 | 5 | 3.42 | 0.93 | 2.18 | -0.12 |
| 49 | *Zanthoxylum leprieurii (Gril. & Perr.)* | 1 | 1.89 | 2.91 | 2.4 | -0.07 | 1 | 0.68 | 3.48 | 2.08 | -0.03 |
|   | ***Total*** | **53** | **100** | **100** | **100** | 0.00 | **146** | **100** | **100** | **100** |  |

*RD-Relative Density, RDo- Relative dominance, IVI-Importance Value Index*

Biodiversity indices of tree species in Akure forest reserve is presented in Table 3. In the disturbed site of Akure forest reserve, RD% ranged from 1.1- 21.98%. *Albizia lebbeck, Ficus exasperata Vahl, Futumia elastica,* etc., all had a low RDo value of 0.55% and the highestof 16.64%was recorded for *Triplochiton scleroxylon*. IVI ranged from 0.82-16.47% and Shannon Wiener index ranged from 0.05 to 0.33. Some of the tree species with a low RD (0.62%) in the undisturbed site were *Alstonia boonei, Bucholzia corrazea, Cola acuminata, Drypetes gildani* etc,. The lowest and highest RDo of 0.06% and 17.74% were recorded for *Ceiba petandra and Anonidium mannii* respectively. Importance Value Index values ranged from 0.38 to 15.33% and Shannon Wiener ranged from 0.03-0.29 in the undisturbed forest.

**Table 3: Biodiversity indices and Importance Value Index (IVI)of Tree species in the disturbed and undisturbed plots of Akure Forest Reserves.**

|  |  |  |  |
| --- | --- | --- | --- |
| S/N | **Species** | **Disturbed Forests** | **Undisturbed Forests** |
|   |   | **No/ha** | **RD(%)** | **Rdo(%)** | **IVI(%)** | **H’** | **No/ha** | **RD(%)** | **Rdo(%)** | **IVI (%)** | **H’** |
|
| 1 | *Albizia lebbec k(L.) Benth* | 1 | 1.1 | 0.55 | 0.82 | -0.05 | - | - | - | - | 0.00 |
| 2 | *Alstonia boonei De Wild*  | 4 | 4.4 | 5.12 | 4.76 | -0.14 | 1 | 0.62 | 0.15 | 0.38 | -0.03 |
| 3 | *Anonidium mannii (Oliv.) Engl. & Diels*  | - | - | - | - | 0.00 | 25 | 15.43 | 17.74 | 16.58 | -0.29 |
| 4 | *Azadirachta indica* | 2 | 2.2 | 1.83 | 2.01 | -0.08 |  - |  - |  - |  - | 0.00 |
| 5 | *Bucholzia corrazea Engl.* |  - |  - |  - |  - | 0.00 | 1 | 0.62 | 0.15 | 0.38 | -0.03 |
| 6 | *Canarium schweinfurthi6i Engl.* | 1 | 1.1 | 1.65 | 1.37 | -0.05 | 6- |  - |  - |  - | 0.00 |
| 7 | *Ceiba petandra(L) Gaertn* | 1 | 1.1 | 1.28 | 1.19 | -0.05 | 1 | 0.62 | 0.06 | 0.34 | -0.03 |
| 8 | *Celtis mildbraedii Engl. Blanco* |  -  |  - |  - |  - | 0.00 | 5 | 3.09 | 1.4 | 2.25 | -0.11 |
| 9 | *Celtis occidentalis Engl.* | - |  - |  - |  -  | 0.00 | 2 | 1.23 | 0.89 | 1.06 | -0.05 |
| 10 | *Celtis zenkeri Engl* | 7 | 7.69 | 21.76 | 14.72 | -0.20 | 23 | 14.2 | 10.88 | 12.54 | -0.28 |
| 11 | *Cola acuminata (P.Beauv.) Schott & Endl.* | - |  - |  - |  - | 0.00 | 1 | 0.62 | 6.68 | 3.65 | -0.03 |
| 12 | *Cola gigantea A.Chev. .* | 2 | 2.2 | 1.1 | 1.65 | -0.08 | 5 | 3.09 | 1.7 | 2.39 | -0.11 |
| 13 | *Cola hispida (Beauv.)Schott & Endl.* | - |  -  |  - |  - | 0.00 | 2 | 1.23 | 0.92 | 1.08 | -0.05 |
| 14 | *Chrysophyllum albidum G.Don.* | 2 | 2.2 | 0.73 | 1.46 | -0.08 | 4 | 2.47 | 5.62 | 4.04 | -0.09 |
| 15 | *Chrysophyllum pulpucrum* | - | - | - | - | 0.00 | 4 | 2.47 | 6.74 | 4.6 | -0.09 |
| 16 | *Cordia mellenii Bak.* | 5 | 5.49 | 6.4 | 5.95 | -0.16 |  - |  - |  - |  - | 0.00 |
| 17 | *Diallium angolenseOliv* | 2 | 2.2 | 0.73 | 1.46 | -0.08 |  - |  - |  - |  - | 0.00 |
| 18 | *Diospyros mobutensis* |  - |  - |  - |  - | 0.00 | 1 | 0.62 | 0.74 | 0.68 | -0.03 |
| 19 | *Diospyros spp* |  - |  - |  - |  - | 0.00 |  |  |  |  | 0.00 |
| 20 | *Drypetes gildani Hutch* | - |  - |  - |  - | 0.00 | 1 | 0.62 | 0.19 | 0.4 | -0.03 |
| 21 |  *Entandrophragma angolense(Welw.) C DC* | - |  - |  - |  - | 0.00 | 2 | 1.23 | 0.56 | 0.9 | -0.05 |
| 22 | *Entadrophragma cylindricum* | 7 | 7.69 | 3.84 | 5.77 | -0.20 | 1 | 0.62 | 0.43 | 0.52 | -0.03 |
| 23 | *Entandrophragma utile C.DC* |  |  | 0.00 | 4 | 2.47 | 1.6 | 2.03 | -0.09 |
| 24 | *Ficus exasperata Vahl* | 1 | 1.1 | 0.55 | 0.82 | -0.05 |  |  |  |  | 0.00 |
| 25 | *Futumia elastica* | 1 | 1.1 | 0.55 | 0.82 | -0.05 | 2 | 1.23 | 3.81 | 2.52 | -0.05 |
| 26 | *Garcinia cola Eng.* |  - |  - |  - |  - | 0.00 | 1 | 0.62 | 0.28 | 0.45 | -0.03 |
| 27 | *Ixora guinnesis Benth.* |  - |  - |  - |  - | 0.00 | 1 | 0.62 | 0.34 | 0.48 | -0.03 |
| 28 | *Khaya grandifoliola C. DC.* |  - |  - |  - |  - | 0.00 | 2 | 1.23 | 0.8 | 1.02 | -0.05 |
| 29 | *Khaya Ivorensis A. Chev.* | 2 | 2.2 | 1.46 | 1.83 | -0.08 |  - |  - |  - |  - | 0.00 |
| 30 | *Lannea welwitschii (Hiern)* |  - |  - |  - |  - | 0.00 |  - |  - |  - |  - | 0.00 |
| 31 |  *Lecaniodiscus cupanioides Ex Bth* |  - |  - |  - |  - | 0.00 | 1 | 0.62 | 0.81 | 0.72 | -0.03 |
| 32 | *Mal2acanta alnifolia(Baker) Pierre* |  - |  - |  - |  - | 0.00 | 7 | 4.32 | 3.93 | 4.13 | -0.14 |
| 33 | *Mansonia altisima A. Chev* | 20 | 21.98 | 10.97 | 16.47 | -0.33 | 26 | 16.05 | 14.6 | 15.33 | -0.29 |
| 34 | *Milicia excelsa (Welw.) C. Berg* | 3 | 3.3 | 5.48 | 4.39 | -0.11 |  - |  - |  - |  - | 0.00 |
| 35 | *Myrianthus arboreus P. Beauv* |  |  | 0.00 | 2 | 1.23 | 1.18 | 1.21 | -0.05 |
| 36 | *Nesogordonia papaverifera A.Chev.* | 4 | 4.4 | 2.19 | 3.29 | -0.14 | 1 | 0.62 | 1.29 | 0.95 | -0.03 |
| 37 | *Pterocarpus osun Craib* |  |  |  | 0.00 | 1 | 0.62 | 1.02 | 0.82 | -0.03 |
| 38 | *Pycnanthus angolensis (Welw.) Warb.* |  - |  - |  - |  - | 0.00 |  - |  - |  - |  - | 0.00 |
| 39 | *Rauvolfia vomitoria Afzel.* |  - |  - |  - |  - | 0.00 |  - |  - |  - |  - | 0.00 |
| 40 | *Ricinodendron heudelotii (Ball.) Pierr* | 2 | 2.2 | 1.83 | 2.01 | -0.08 | 1 | 0.62 | 0.19 | 0.4 | -0.03 |
| 41 | *Rothmannia spp* |  - |  - |  - |  - | 0.00 |  - |  - |  - |  - | 0.00 |
| 42 | *Spondiathus preussii Engl.* |  - |  - |  - |  - | 0.00 |  - |  - |  - |  - | 0.00 |
| 43 | *Sterculia melagantha K. Schum* |  - |  - |  - |  - | 0.00 | 2 | 1.23 | 1.21 | 1.22 | -0.05 |
| 44 | *Sterculia oblonga K. Schum* |  - |  - |  - |  - | 0.00 | 1 | 0.62 | 0.67 | 0.64 | -0.03 |
| 45 | *Steculia rhinopetala K. Schum* | 8 | 8.79 | 7.31 | 8.05 | -0.21 | 10 | 6.17 | 7.39 | 6.78 | -0.17 |
| 46 | *Strombosia pustulata Oliv.* |  - |  - |  - |  - | 0.00 | 2 | 1.23 | 1.27 | 1.25 | -0.05 |
| 47 | *Terminalia ivorensis Chev* | 1 | 1.1 | 7.31 | 4.21 | -0.05 |  - |  - |  - |  - | 0.00 |
| 48 | *Terminalia superba Chev* | 1 | 1.1 | 0.18 | 0.64 | -0.05 | 1 | 0.62 | 0.19 | 0.4 | -0.03 |
| 49 | *Trichilia monadelpha A. Juss* |  - |  - |  - |  - | 0.00 | 3 | 1.85 | 1.33 | 1.59 | -0.07 |
| 50 | *Trilepisium madagascariense Dc. Fl. Cam* |  - |  - |  - |  - | 0.00 | 5 | 3.09 | 2.36 | 2.73 | -0.11 |
| 51 | *Triplochiton scleroxylon K. Schum* | 13 | 14.29 | 16.64 | 15.46 | -0.28 | 10 | 6.17 | 0.89 | 3.53 | -0.17 |
| 52 | *Zanthoxylum macrophylla* | 1 | 1.1 | 0.55 | 0.82 | -0.05 |  - |  - |  - |  - | - |
|   | ***Total*** | **91** | **100** | **100** | **100** |  | **162** | **100** | **100** | **100** |  |

*RD-Relative Density, RDo- Relative dominance, IVI-Importance Value Index*

**Family Importance Value (FIV) for Akure and Oluwa forest reserves**

Table 4 presents the Family Importance Value (FIV) across disturbed and undisturbed sites of Akure and Oluwa Forest Reserves. The undisturbed site at AFR is dominated by Sapotaceae (38 stems), Apocynaceae (26), Ebenaceae (23), and Sterculiaceae (21), while families such as Cannabaceae, Capparaceae, Olacaceae, and Sapindaceae are represented by a single species. The disturbed site of Akure is dominated by Sterculiaceae (43 stems) and Meliaceae (11), with Burseraceae and Rutaceae each having one stem. Within Oluwa Forest Reserve, both disturbed and undisturbed sites exhibit strong representation from Fabaceae and Sterculiaceae, although their ecological roles diverge under different disturbance regimes. The undisturbed section displays higher species richness (45 species across 26 families), with notable contributions from Moraceae (16 stems), Fabaceae (19), and Sterculiaceae (21). Single-species families such as Malvaceae, Guttifereae, Bignoniaceae, Rutaceae, and Olacaceae.

**Table 4: Family Importance Value (FIV) for Akure and Oluwa forest reserves**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | S/n | Family | no/ha | No of spp | BA/ha (m2) | Vol./ha(m3) | RD(%) | RDo(%) | FIV (%) |
| AFR (undisturbed) | 1 | Annonaceae | 3 | 2 | 11.78 | 15.68 | 1.85 | 52.12 | 26.99 |
| 2 | Apocynaceae | 26 | 3 | 0.67 | 6.52 | 16.05 | 2.96 | 9.51 |
| 3 | Cannabaceae | 1 | 1 | 0.03 | 0.25 | 0.62 | 0.13 | 0.38 |
| 4 | Capparaceae | 1 | 1 | 0.02 | 0.12 | 0.62 | 0.09 | 0.35 |
| 5 | Cecropiaceae | 5 | 3 | 0.09 | 0.56 | 3.09 | 0.4 | 1.74 |
|  | 6 | Combreteceae | 2 | 1 | 0.03 | 0.23 | 1.23 | 0.13 | 0.68 |
|  | 7 | Ebenaceae | 23 | 4 | 0.12 | 0.99 | 14.2 | 0.53 | 7.36 |
|  | 8 | Euphorbiaceae | 4 | 1 | 0.03 | 0.32 | 2.47 | 0.13 | 1.3 |
|  | 9 | Malvaceae | 5 | 2 | 0.24 | 5.14 | 3.09 | 1.06 | 2.07 |
|  | 10 | Meliaceae | 14 | 2 | 0.85 | 7.45 | 8.64 | 3.76 | 6.2 |
|  | 11 | Moraceae | 2 | 1 | 0.41 | 3.37 | 1.23 | 1.81 | 1.52 |
|  | 12 | Olacaceae | 1 | 1 | 0.21 | 2.41 | 0.62 | 0.93 | 0.77 |
|  | 13 | Sapindaceae | 1 | 1 | 0.14 | 2.43 | 0.62 | 0.62 | 0.62 |
|  | 14 | Sapotaceae | 38 | 4 | 2.93 | 31.37 | 23.46 | 12.96 | 18.21 |
|  | 15 | Sterculiaceae | 21 | 6 | 4.66 | 64.43 | 12.96 | 20.62 | 16.79 |
|  | 16 | Ulmaceae | 15 | 3 | 0.39 | 1.71 | 9.26 | 1.73 | 5.49 |
|  |  | **Total** | **162** | **36** | **22.6** | **142.98** | **100** | **100** | **100** |
| Akure (disturbed) | 1 | Apocynaceae | 5 | 2 | 0.31 | 1.35 | 5.49 | 5.31 | 5.40 |
| 2 | Boraginaceae | 5 | 2 | 0.37 | 1.5 | 5.49 | 6.34 | 5.91 |
| 3 | Burseraceae | 1 | 1 | 0.09 | 0.47 | 1.1 | 1.54 | 1.32 |
| 4 | Combretaceae | 2 | 1 | 0.41 | 1.64 | 2.2 | 7.02 | 4.61 |
| 5 | Euphorbiaceae | 2 | 1 | 0.11 | 0.58 | 2.2 | 1.88 | 2.04 |
|  | 6 | Fabaceae | 3 | 2 | 0.09 | 0.36 | 3.3 | 1.54 | 2.42 |
|  | 7 | Malvaceae | 5 | 2 | 0.37 | 1.41 | 5.49 | 6.34 | 5.91 |
|  | 8 | Meliaceae | 11 | 2 | 0.38 | 1.81 | 12.09 | 6.51 | 9.30 |
|  | 9 | Moraceae | 4 | 2 | 0.34 | 0.92 | 4.4 | 5.82 | 5.11 |
|  | 10 | Rutaceae | 1 | 1 | 0.03 | 0.11 | 1.1 | 0.51 | 0.81 |
|  | 11 | Sapotaceae | 2 | 1 | 0.04 | 0.19 | 2.2 | 0.68 | 1.44 |
|  | 12 | Sterculiaceae | 43 | 4 | 2.08 | 7.47 | 47.25 | 35.62 | 41.43 |
|  | 13 | Ulmaceae | 7 | 2 | 1.2 | 4.26 | 7.69 | 20.55 | 14.12 |
|  |  | **Total** | **91** | **23** | **5.84** | **22.23** | **100** | **100** | **100** |
| Oluwa FR (undisturbed) | 1 | Anacardiaceae | 7 | 2 | 0.49 | 4.91 | 4.79 | 3.28 | 4.03 |
|  | 2 | Annonaceae | 10 | 4 | 0.59 | 6.47 | 6.85 | 3.94 | 5.4 |
|  | 3 | Apocynaceae | 3 | 1 | 0.03 | 0.1 | 2.05 | 0.2 | 1.13 |
|  | 4 | Bignoniaceae | 1 | 1 | 0.04 | 0.47 | 0.68 | 0.27 | 0.48 |
|  | 5 | Burseraceae | 2 | 1 | 0.18 | 1.39 | 1.37 | 1.2 | 1.29 |
|  | 6 | Capparaceae | 6 | 2 | 0.57 | 2.77 | 4.11 | 3.81 | 3.96 |
|  | 7 | Cecropiaceae | 4 | 1 | 0.22 | 1.83 | 2.74 | 1.47 | 2.11 |
|  | 8 | Combereteceae | 3 | 1 | 0.09 | 0.68 | 2.05 | 0.6 | 1.33 |
|  | 9 | Ebenaceae | 8 | 2 | 0.57 | 3.81 | 5.48 | 3.81 | 4.64 |
|  | 10 | Euphorbiaceae | 4 | 1 | 0.09 | 0.47 | 2.74 | 0.6 | 1.67 |
|  | 11 | Fabaceae | 19 | 5 | 1.46 | 11.22 | 13.01 | 9.76 | 11.39 |
|  | 12 | Guttifereae | 1 | 1 | 0.02 | 0.19 | 0.68 | 0.13 | 0.41 |
|  | 13 | Loganaceae | 3 | 1 | 0.19 | 1.73 | 2.05 | 1.27 | 1.66 |
|  | 14 | Malvaceae | 1 | 1 | 0.06 | 0.68 | 0.68 | 0.4 | 0.54 |
|  | 15 | Meliaceae | 6 | 2 | 0.8 | 6.25 | 4.11 | 5.35 | 4.73 |
|  | 16 | Moraceae | 16 | 3 | 3.88 | 26.73 | 10.96 | 25.94 | 18.45 |
|  | 17 | Olaceae | 1 | 1 | 0.05 | 0.32 | 0.68 | 0.33 | 0.51 |
|  | 18 | Pandaceae | 2 | 1 | 0.21 | 2.22 | 1.37 | 1.4 | 1.39 |
|  | 19 | Papinonaceae | 5 | 2 | 1.27 | 8.43 | 3.42 | 8.49 | 5.96 |
|  | 20 | Phylianthaceae | 3 | 1 | 0.04 | 0.32 | 2.05 | 0.27 | 1.16 |
|  | 21 | Rhamnaceae | 1 | 1 | 0.01 | 0.03 | 0.68 | 0.07 | 0.38 |
|  | 22 | Rubiaceae | 3 | 1 | 0.59 | 2.42 | 2.05 | 3.94 | 3 |
|  | 23 | Rutaceae | 1 | 1 | 0.15 | 1.06 | 0.68 | 1 | 0.84 |
|  | 24 | Sapotaceae | 8 | 2 | 0.77 | 6.79 | 5.48 | 5.15 | 5.31 |
|  | 25 | Steculiaceae | 21 | 4 | 2 | 12.44 | 14.38 | 13.37 | 13.88 |
|  | 26 | Ulmaceae | 7 | 2 | 0.59 | 3.44 | 4.79 | 3.94 | 4.37 |
|  |  | **Total** | **146** | **45** | **14.97** | **107.19** | **100** | **100** | **100** |
| OluwaFR (disturbed) | 1 | Anacardiaceae | 3 | 1 | 0.39 | 3.27 | 5.66 | 8.65 | 7.15 |
|  | 2 | Annonaceae | 3 | 1 | 0.32 | 1.75 | 5.66 | 7.1 | 6.38 |
|  | 3 | Burseraceae | 1 | 1 | 0.02 | 0.14 | 1.89 | 0.44 | 1.17 |
|  | 4 | Capparaceae | 2 | 1 | 0.07 | 0.4 | 3.77 | 1.55 | 2.66 |
|  | 5 | Combereteceae | 3 | 1 | 0.63 | 7.48 | 5.66 | 16.63 | 11.15 |
|  | 6 | Ebenaceae | 5 | 3 | 0.64 | 2.19 | 9.43 | 14.19 | 11.81 |
|  | 7 | Fabaceae | 9 | 4 | 0.59 | 1.91 | 16.98 | 13.08 | 15.03 |
|  | 8 | Meliaceae | 4 | 1 | 0.08 | 0.63 | 7.55 | 1.77 | 4.66 |
|  | 9 | Moraceae | 3 | 1 | 0.37 | 1.68 | 5.66 | 8.2 | 6.93 |
|  | 10 | Olaceae | 1 | 1 | 0.03 | 0.32 | 1.89 | 0.67 | 1.28 |
|  | 11 | Papinonaceae | 3 | 1 | 0.07 | 0.3 | 5.66 | 1.55 | 3.61 |
|  | 12 | Rutaceae | 1 | 1 | 0.13 | 0.62 | 1.89 | 2.88 | 2.38 |
|  | 13 | Steculiaceae | 9 | 5 | 0.23 | 1.75 | 16.98 | 5.1 | 11.04 |
|  | 14 | Ulmaceae | 6 | 2 | 0.82 | 3.39 | 11.32 | 18.18 | 14.75 |
|  |  | Total | 53 |  | 4.31 | 25.83 | 100 | 100 | 100 |

**Summary of Biodiversity Indices for the study area**

Table 5 shows the biodiversity indices for the study areas. A total 45 tree species distributed among 26 families were encountered in the undisturbed site of Oluwa Forest reserve with a Shannon wiener index value of 3.47 and species evenness of 0.91. The disturbed site had 24 tree species distributed among 14 families with a Shannon wiener index and species evenness of 2.97 and 0.93. A Shannon wiener index value of 3.00 and 2.67 were recorded for the undisturbed and disturbed sites of Akure Forest Reserve. A total of 23 and 36 tree species were encountered in the disturbed and undisturbed sites of Akure forest reserve respectively.

**Table 5: Summary of Biodiversity Indices for the study area**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Study sites | Density/ha | No of Families (NF) | No of Species(NS) | Shannon-Wieners(H1) | Spp. evenness index(E) |
| OFR (undisturbed) | 155 | 26 | 45 | 3.47 | 0.91 |
| OFR (disturbed) | 57 | 14 | 24 | 2.97 | 0.93 |
| AFR (disturbed) | 95 | 13 | 23 | 2.67 | 0.85 |
| AFR (undisturbed) | 175 | 16 | 36 | 3.00 | 0.84 |

**Correlation matrix for the selected forest reserves**

The correlation matrix for the study sites is presented in Table 6. The results showed that a strong, moderate and weak correlation were found among the tree growth variables in the disturbed and undisturbed site. In the undisturbed site of AFR, a strong positive correlation with a correlation coefficient of 0.95 was found between the Dbh and basal area. Similarly, a strong positive correlation of 0.84 was observed between Dbh and volume. In the disturbed plots, a strong correlation of 0.96 was also observed between the Dbh and the basal area and 0.98 between the basal area and the volume. In the disturbed forest of Oluwa forest reserve, the volume had a strong correlation with the basal area with a correlation coefficient of 0.85 and moderate positive relationship was found between the height and volume with a correlation coefficient of 0.58. The volume and Dbh had a strong correlation value of 0.90 in the undisturbed site

**Table 6: Correlation matrix for the selected forest reserves**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Study sites | Growth Variables  | No of trees | Dbh(cm) | Ht(m) | BA(m2) | Vol.(m3) |
| AFR (undisturbed) | Dbh(cm) | 162 | 1.00 |  |  |  |
|  | Ht(m) |  | 0.51 | 1.00 |  |  |
|  | BA(m2) |  | 0.95 | 0.47 | 1.00 |  |
|  | Vol(m3) |  | 0.84 | 0.67 | 0.88 | 1.00 |
| AFR (disturbed) | Dbh(cm) | 91 | 1.00 |  |  |  |
|  | Ht. |  | 0.31 | 1.00 |  |  |
|  | BA(m2) |  | 0.96 | 0.30 | 1.00 |  |
|  | Vol(m3) |  | 0.93 | 0.41 | 0.98 | 1.00 |
| OFR (disturbed) | Dbh(cm) | 53 | 1.00 |  |  |  |
|  | Ht(m) |  | 0.36 | 1.00 |  |  |
|  | BA(m2) |  | 0.97 | 0.36 | 1.00 |  |
|  | Vol(m3) |  | 0.81 | 0.58 | 0.85 | 1.00 |
| OFR (undisturbed) | Dbh(cm) | 146 | 1.00 |  |  |  |
|  | H(m) |  | 0.59 | 1.00 |  |  |
|  | BA(m2) |  | 0.96 | 0.48 | 1.00 |  |
|  | Vol(m3) |  | 0.90 | 0.64 | 0.90 | 1.00 |

*Dbh -Diameter at breast height, Ht-Height, BA-Basal area, Vol.- Volume*

Figure 3 shows the Dbh class distribution of the trees encountered in the disturbed site and undisturbed sites of the selected forest reserves. In the disturbed site of Oluwa forest reserve, twenty-three (23) stems fell in the lower diameter class and nineteen (19) fell in the diameter class of 20-30cm. Only one tree fell in the diameter class of 60-70 cm and 70-80 cm each and eight stems was found in the diameter class >40cm. In the undisturbed site, the highest number of trees (64) fell in the lowest diameter class. This was followed by the 30 stems in the diameter class of 20-30 cm. Only 14 and 10 trees were in the diameter class of 40-50 cm and 50-60 cm respectively. The disturbed site of Akure forest reserve was dominated by trees (46 stems) in the lower diameter class 2) tree stems were in the diameter class of 20-30 cm. Diameter classes of 50.0 cm-60.0 cm, 60.0 cm-70.0 cm, 70.0 cm-80.0 cm were represented by two stems each. The majority of the trees in the undisturbed site of Akure forest reserve were in the diameter class of between 20-30 cm. Thirty-nine (39) stems were encountered in the diameter class of 10 cm-20 cm and 30 cm-40 cm each. Sixteen (16) trees were in the diameter class of 40-50 cm. Two stems each were observed in the diameter class of 60 cm-70 cm and 90 cm-100 cm and only two trees were in the diameter class of above one hundred (100)

**Figure 3: DBH distribution of trees encountered in the selected forest reserves**

Figure 4 shows the height distribution of trees encountered in the study area. In the undisturbed site of Akure forest reserve, most of the trees (81) were in the height class of 11-20 m and only two stems were in the height class of less than 5 m. Thirty-nine trees were in the height class of 5-10 m and thirty-three (33) fell in the height class of 21 m-30 m. Seven trees were encountered in the height class of 31-40 m. In the disturbed site of this reserve, most of the trees encountered were in the height class of 11-20 m,44% in the lower height class of 5-10 m and 5% of the trees fell in the class of 20-30 m. Most of the trees (78 stems) observed in the undisturbed site of Oluwa forest reserve fell in the height class of 11-20 m and just wo stems were in the height class of less than 5 m. Most of the trees (29) encountered in the disturbed site of Oluwa forest reserve fell in the height class of 5-10 m. This was followed by the diameter class of 10-20 m that had 20 stems.

**Figure 4 : Height distribution of trees encountered in the study area**

Summary of tree growth variables is presented in Table 7. Mean Dbh of 33.50 cm and 25.34 cm were recorded in the undisturbed and disturbed forest of Oluwa forest reserve respectively. Mean Dbh of 34.75 cm and 24.42cm were recorded for the undisturbed and disturbed plots of Akure Forest reserve respectively. The undisturbed sites of Oluwa Forest Reserve and Akure forest reserve had the highest mean height of 13.07 m and 14.98 m respectively. Mean basal area of 0.14 m2 and 0.10 m2 were obtained in the undisturbed site of Akure Forest reserve and Oluwa Forest Reserve respectively. The undisturbed site of Akure forest reserve had the highest mean volume of 0. 88 m3. This was followed by the undisturbed plots of Oluwa forest reserve with a volume of 0.73 m3 and the lowest was recorded for disturbed site of Akure Forest reserve (0.24 m3).

**Table 7: Summary of the tree growth variables**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Study sites | Mdbh (cm) | MH t(m) | MBA (m2) | BA/ha (m2) | MVol (m3) | Vol/ha (m3) |
| OFR (undisturbed) | 33.50±2.02 | 13.07±0.50 | 0.10±0.01 | 0.40 | 0.73±0.09 | 2.92 |
| OFR (disturbed) | 25.34±2.82 | 11.37±0.61 | 0.08±0.02 | 0.32 | 0.49±0.14 | 1.96 |
| AFR (undisturbed) | 34.75±1.88 | 14.98±0.56 | 0.14±0.02 | 0.56 | 0.88±0.10 | 3.52 |
| AFR (disturbed) | 24.42±1.44 | 10.15±0.24 | 0.06±0.01 | 0.24 | 0.24±0.03 | 0.96 |

*Mdbh-Mean Diameter at breast height, MHt-Mean height, MBA-Mean basal area, MVol-Mean volume.*

**Discussion**

**Logging impact on tree species diversity and abundance in the study areas**

Our study showed that most of the trees recorded in all the study sit**es** are tropical timber hardwood species that dominate the tropical rainforest ecosystem, that are of high economic values to rural livelihood and national development (Shi and Singh, 2002). In terms of stem density, the undisturbed site known as forest reserve recorded more stems per hectare than the disturbed site. This suggests that logging activities have led to a substantial reduction in tree density in disturbed areas, underscoring the impact of anthropogenic pressures on forest structure. A total of 45 tree species were identified in the undisturbed site of the Oluwa Forest Reserve, and 36 species in the undisturbed site of the Akure Forest Reserve. These figures are comparable to the findings of Adekunle (2010), who reported 46 tree species in the Nigerian Strict Nature Reserve within the Akure Forest Reserve. However, species richness in our study sites is lower than the 56, 55, and 54 species per hectare reported for Sapoba, Shasha (Lowe, 1997), and Ala Forest Reserves (Adekunle, 2006), respectively. The current degraded status of disturbed forests of Akure and Oluwa Forest Reserve could be attributed to repeated logging activities which have reduced the number of tree species per hectare and consequently resulted to loss of biodiversity. (Lawal el al., 2025). Overall, the undisturbed forests had more species richness than the disturbed forests (Webb & Peralta 1998, Foody & Cutler 2003). This aligns with Chapin *et al.,* (2000) and Putz *et al*., (2000) who reported that logging may negatively impact species diversity and their abundance.

The impact of logging was also evident in the variation in family dominance between disturbed and undisturbed sites in our study. This shift in species composition of both sites suggests that logging favors certain families that may be more resilient or better adapted to altered conditions. The Shannon-Wiener diversity index values obtained were as follows: Oluwa Forest Reserve (OFR) undisturbed site: 3.47; OFR disturbed site: 2.97; Akure Forest Reserve (AFR) undisturbed site: 3.00; and AFR disturbed site: 2.67. These values fall within the range reported by Adekunle (2006) and Onyekwelu et al. (2008), who found that Shannon-Wiener diversity indices for tropical rainforests in southwestern Nigeria typically range between 2.82–3.66. Although there is some similarity in Shannon index (H′) values between the disturbed and undisturbed forests, the consistent decline in the index in disturbed forests suggests the ecological impact of logging on species richness.

Interestingly, the analysis also revealed a slightly higher species evenness in the disturbed forests compared to the undisturbed sites. This suggests that while species richness is reduced by logging, the remaining species in disturbed areas are more evenly distributed. This pattern may be attributed to canopy openings created during timber extraction, which increase light availability and promote the growth of a wider variety of subdominant or pioneer species, thereby temporarily balancing species distribution.

The Importance Value Index (IVI), which combines the attributes of relative density, relative frequency and relative dominance, measures the relative importance of a family or a tree species in a forest (Anning *et al*., 2009). The Importance Value Index (IVI) is a widely used metric for determining the ecological significance of a species or family within an ecosystem (Suganthi et al., 2017). In this study, low IVI values were recorded for several species, including *Blighia sapida* K. König, *Celtis mildbraedii* Engl. Blanco, *Cola exasperata* Vahl., *Hylodendron gabunense* Taub., *Maesopsis eminii*, *Mitragyna ciliata* (Myta), and *Nuclea diderrichii* De Wild., across all study sites where they were present. These consistently low IVI values suggest that these species may be considered rare or potentially endangered within the surveyed ecosystems Jadhav, 2021). The disappearance or severe depletion of some species in disturbed areas raises conservation concerns about species vulnerability and local extinction risk (Falaye et al., 2006). The vulnerability of these species suggest that, without deliberate efforts to promote their regeneration and conservation, their populations may continue to decline. If unchecked, this trend could result in a shift from endangered to extinct status.

**Logging impact on forest structure**

Tree diameter distribution is widely recognized as a proxy for forest population structure and regeneration dynamics (Rao et al., 1990; Adekunle, 2013). Our study areas showed typical tropical rainforest structure characterized by a high number of small-diameter trees indicating active recruitment (Adekunle et al., 2004; Adekunle & Olagoke, 2008). However, the undisturbed sites in both Akure and Oluwa reserves contained a significantly greater proportion of large-diameter trees (DBH > 40 cm), reflecting mature, well-established forests with closed canopies and structural complexity (Zheng et al., 2006; Stephenson & Van Mantgem, 2005). In contrast, the disturbed sites in both reserves had markedly fewer large-diameter trees, consistent with the selective removal of valuable timber species through logging. This reduction in mature trees compromises forest structure and long-term ecological stability (Saiter et al., 2011). Similar patterns of reduced tree size classes due to logging have been reported in other tropical forests (Huang et al., 2003; Lu et al., 2010).

We found that basal area was significantly higher in the undisturbed forests of both reserves compared to their disturbed forests. This finding supports the assertion by Brown and Lugo (1990) that undisturbed forests accumulate greater biomass and have larger tree diameters due to the absence of disturbance. Differences in basal area can also reflect varying species composition, stand age, and anthropogenic pressure. The high tree stem volume per hectare in the undisturbed forests further illustrated the impact of logging in our study sites. The significant decline in stem density, basal area, and volume in disturbed sites clearly demonstrates the adverse effects of logging on forest structure and productivity.

**Conclusion and Recommendations**

This study demonstrated that disturbed sites in both Akure and Oluwa Forest Reserves exhibited significantly lower species richness, diversity indices, and abundance compared to undisturbed areas. The removal of large, mature trees disrupts forest structure and alters habitat conditions, leading to declines in both tree species composition and overall biodiversity. The reduction in species diversity in logged forests threatens ecosystem resilience and function, as many species play key roles in maintaining ecological balance. Furthermore, the loss of valuable timber species due to excessive exploitation places them at risk of local extinction, undermining conservation efforts and the long-term sustainability of forest resources. These findings emphasize the critical importance of conserving undisturbed forest areas and implementing sustainable logging practices to minimize biodiversity loss and maintain forest ecosystem health. This study recommends the Adoption of selective logging methods that minimize disturbance and retain key species to maintain species diversity and ecosystem function and prioritize the conservation of intact forest areas as reservoirs of biodiversity and sources for natural regeneration. More so, local communities should be involved in forest management and raise awareness about the ecological importance of species diversity to ensure collective responsibility for conservation.

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1.

2.

3.

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