**Logging Impact on Tree Species Diversity and Forest Structure in Tropical Forests: A Case Study of Akure and Oluwa Forest Reserves, Southwest Nigeria**

**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 and free areas in Akure and Oluwa Forest Reserves. We used systemmatic line transects for data collection and plot layout. Trees within the each sampled plots were tagged, identified and classified into families and their frequency of occurrence were obtained to ascertain tree species diversity and abundance. Also, tree basal area and volume were estimated and all variables were compared between reserves and free areas for logging impacts. Assessment. Our analysis revealed a significant reduction in species richness and diversity in the disturbed areas compared to undisturbed ones, suggesting that logging activities have negatively affected tree species diversity and abundance. In Oluwa Forest Reserve, the undisturbed site recorded 45 tree species with a Shannon-Wiener index of 3.47, while the disturbed site had 24 species and a diversity index of 2.97. 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. Additionally, disturbed areas showed a marked decline in both tree volume and basal area, reflecting the removal of mature and economically valuable trees. 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.

**Introduction**

Tropical forests are globally recognized as biodiversity hotspots, and one of the main repositories of global biodiversity (Myers et al., 2000). 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 ecosystem of the world. The tropical forest occupies a total area of 1,818.43 million hectares representing 47% of the total land area occupied by all forest types of the world with over 4,600 plant species which have been identified in Nigeria (FAO ,2003). 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.

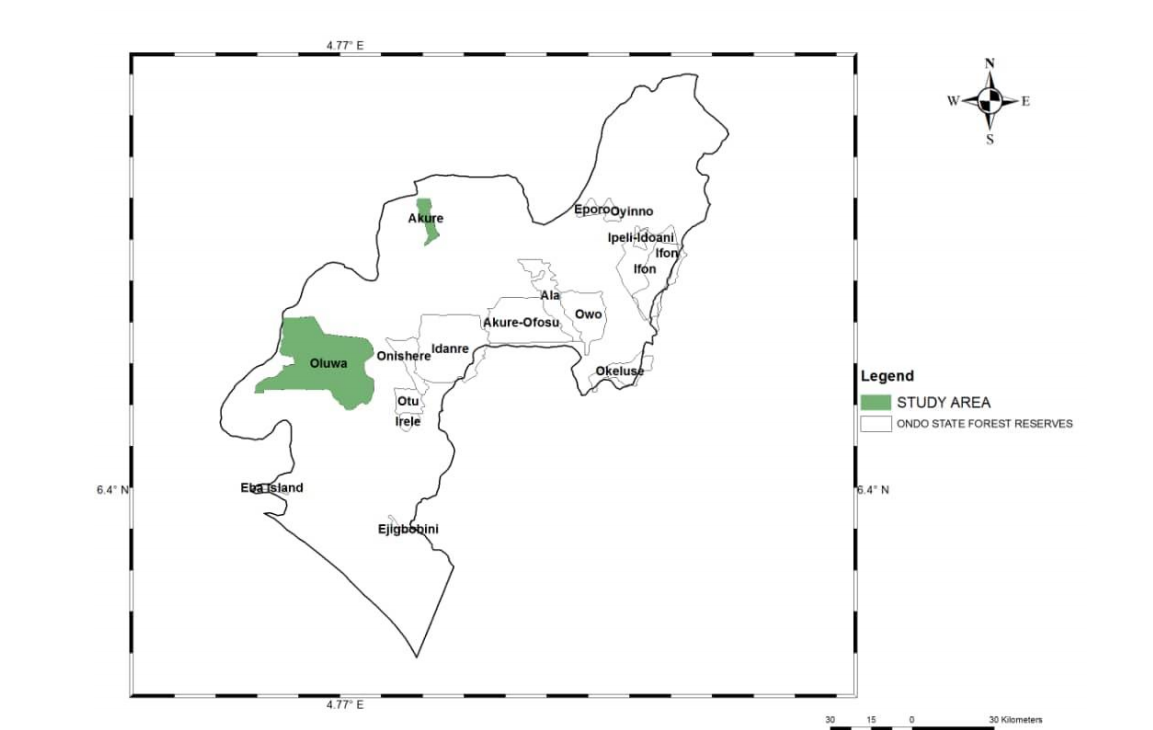
Biological diversity is critical for the maintenance of tropical ecosystems. Each species in the forest plays a fundamental role in the maintenance of the forest ecosystem. The tree species diversity is fundamental to total rainforest biodiversity (Cannon et al.,1998). It has been broadly accepted that species distribution and structure and their response to environmental factors are core concepts for ecological study (Amissah et al.,2014). The threat tree species as a result of human activities has increased today (Adeseko et al., 2023. ). In southwestern Nigeria, for instance, states like Ondo and Ekiti, which once had dense and species-rich forests, are experiencing forest loss at an alarming rate (Adekunle, 2006). According to satellite-based monitoring, the deforestation rate in the region is approximately 1.36% per annum (Salami, 2006), indicating a pressing need for conservation and sustainable forest management efforts. The degradation of forest ecosystems not only leads to a reduction in tree species diversity but also disrupts the intricate ecological processes and interactions that sustain forest health (Adeseko et al., 2023; .Akinbowale et al., 2020). Despite the ecological and socio-economic importance of tree species diversity, there is a notable lack of comprehensive data on the current status and trends of tree diversity in Nigeria’s tropical forests. Existing inventories are often outdated, limited in scope, or focused on specific regions, making it difficult to assess the 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, often favoring generalist or fast-growing species at the expense of rare or endemic trees.

Understanding tree species diversity is essential for informing conservation strategies and policy interventions (Adekunle, 2006). Accurate and up-to-date information on species richness, distribution, and abundance can guide the designation of protected areas, restoration efforts, and the sustainable management of forest resources. It also provides a 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 adaptability and mitigating greenhouse gas emissions through carbon storage (Malhi, 2010; Akinbowale et al., 2022). 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 forest 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). To address these challenges, there is a need for integrated approaches that combine scientific research, policy reform, community engagement, and sustainable land-use practices. This study seeks to assess the tree species diversity and abundance in selected Nigerian tropical forests, and their distribution patterns. By highlighting the ecological implications of tree diversity loss, the study aims to contribute to ongoing efforts to promote sustainable forest management and biodiversity conservation in Nigeria. The findings are expected to provide valuable insights for policymakers, conservationists, and forest managers in developing effective strategies to preserve the rich tree biodiversity that characterizes Nigeria's tropical rainforests.

**METHODOLOGY**

**Description of the study areas**

This research was carried out in two selected forest reserve in Ondo State Nigeria because they are among the most significant forest reserves in Ondo 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 have locations where active logging activities have taken place and relics of forest that have not witnessed logging activities for some decades and Strict nature reserve with little or no human activities.n Akure Forest Reserve is located with the tropical rainforest ecosystem of southwest Nigeria. It is situated in Akure South Local Government Area of Ondo State, Nigeria. Latitude of 7° 17′ 39″ N and Longitude of 5° 2′ 3″ E. It was constituted as a reserve in 1936 and the total land area is 69.93 km2. The relief pattern is low lying, elevation ranges from 216 m to 504 m and gently undulating in southern part while the northern part is hilly rock outcrops occurring at close intervals. The underlying rock is crystalline and gneiss. It is slightly neutral; pH of 6.7-7.3 and sandy-loam in nature. The dry season lasts from November to March while the wet season commences from April and end8s in October with the highest rainfall records between July and August, Average daily temperature ranges between 21ºC and 29ºC almost throughout the year. The mean annual rainfall varies from 2000 mm in southern area to 1500 mm in northern area with relative humidity of 80-85% annually experienced in south-west. Oluwa Forest Reserve is located in Ondo State, Nigeria. It falls between latitude 6 83” and 6.91” and longitude 4 51” and 4 59” and covers over 829 km2. It was formerly together with Omo-Shasha- Oluwa Forest Reserves. But it has been separated from the other two reserves and the two have also been separated from each other. The raining season at this location starts from March and ends in November while the dry season starts from December and ends in February. The average rain fall of this reserve is 1700 mm; the Relative Humidity is 80%, and the annual temperature is 260C 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 1). 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: Systemmatic line transects 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. Such species was temporarily referred to as unknown.

**Measurement of Tree growth variables**

The tree growth variables that were measured on all trees in each plot were diameter at the breast height (DBH), diameter at the top (Dt), diameter at the middle (Dt) diameter at the base (Db) and the total height. 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

……………………………………………………………………….. (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 formula (Husch *et. al.,* 2003). ……………………………………………………….(2)

Where: V = Volume of tree (m3)

Db= Diameter at the base (cm)

2 Dm = Diameter at the middle (m)

Dt = Diameter at the top (m)

H = height (m)

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

(i) Species relative density was computed as

 ……………………………………………………………………….(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)

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

Ban = stand basal area

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

……………………………………………………………………… (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) To determine the Species evenness (E), in each community Shannon's equitability equation will be used (Kent and Coker 1992)

………………………………………………………………… (6)

**Results**

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

The tree species diversity for 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 stems per hectare in the undisturbed area and 95 stems per hectare in the disturbed area. *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 areas. 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* was recorded with a single stem in the disturbed plot 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 selected forest reserves.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| S/N | Species | Oluwa FR  (undisturbed) | Oluwa FR  (disturbed) | Akure FR  (undisturbed) | Akure FR  (disturbed) |
| 1 | *Albizia le8bbeck (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 Eng.* | 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** |

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

Biodiversity indices of tree species in Oluwa forest reserve is presented in Table 2. Species Relative Density (RD%) ranged from 1.89-15.09% in the disturbed forest of Oluwa Forest Reserve. Trees with low RD (1.89%) were *Blighia sapida, Canarium schweinfurthii, Ceiba petandra, Celtis mildbraedii* while *Hylodendron gabunense* had the highest of 15.09. Lowest RDo of 0.22% was recorded for *Hylodendron gabunense* and *Cola exasperate* while *Terminalia superba* had the highest of 16.82%. Some of the trees with low RD (%) in the undisturbed site were *Hylodendron pabe Taub, Maesopsis eminii, Milicia excelsa, Mitragyna ciliate etc* while *Hylodendron gabunense* had the highest of 12.33%. RDo also ranged from 0.23%-13.23%, it was lowest for *Maesopsis eminii* and highest for Rothmannia spp. Shannon Wiener index ranged from 0.07- 0.29 in the disturbed forest of Oluwa Forest Reserve. Tree species with low Shannon Wiener (0.07) were *Blighia sapida, Canarium schweinfurthii, Ceiba petandra, Celtis mildbraedii* while *Hylodendron gabunense* had the highest of 0.29. *Hylodendron pabe Taub, Maesopsis eminii, Milicia excelsa, Mitragyna ciliate* all had a low Shannon Weiner index of 0.03 and *Hylodendron gabunense* had the highest value (0.26) in the undisturbed site. *Hylodendron gabunense* Taub in the disturbed site of Oluwa forest reserve had the highest IVI value of 13.83%. This was followed by *Celtis zenkeri* Engl with IVI of 11.85%. The third tree species with a high IVI in the site was *Terminalia superba* Chev with IVI of 11.24%. *Cola exasperata* Vahl. and *Hylodendron pabe* Taub. all had IVI of 1.06%. An IVI of 7.09% was recorded for *Hylodendron gabunense* in the undisturbed site of Oluwa forest reserve, followed by *Rothmannia spp* with an IVI value of 6.95%. Species with IVI values of 0.46% in this site were *Blighia sapida* K Konig, *Celtis mildbraedii* Engl. Blanco, *Celtis mildbraedii* Engl. Blanco, *Maesopsis eminii*, *Mitragyna ciliate* (Myta), *Nuclea diderrichii* De wild.

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

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **Disturbed** | | | | | **Undisturbed** | | | | |
| 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** |  |

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% for *Albizia lebbeck* and *Mansonia altisima, Albizia lebbeck* all had the lowest RDo value of 0.95% and the highestof 16.64%was recorded for *Triplochiton scleroxylon*. Some of the tree species with low RD (0.62%) in the undisturbed site were *Alstonia boonei, Bucholzia corrazea, Cola acuminate, Drypetes gildani* etc. *Ceiba petandra* had the lowest RDo of 0.06% while *Anonidium mannii* had the highest of 17.74%. IVI ranged from 0.82-16.47% in the disturbed site and 0.38-15.33% in the undisturbed site. Shannon Wiener index ranged from 0.05-0.33 in the disturbed portion and 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** | | | | | **Undisturbed** | | | | |
|  |  | **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 | - | - | - | - | 0.00 |
|  | ***Total*** | **91** | **100** | **100** | **100** |  | **162** | **100** | **100** | **100** |  |

**Family Importance Value (F for Akure and Oluwa forest reserves**

Table 4 shows the Family Importance Value (FIV) of disturbed and undisturbed sites of Akure and Oluwa Forest Reserves. The undisturbed site of Akure forest reserve is dominated by the family of Sapotaceae with 38 stems, Apocynaceae with 26 stems, Ebenaceae with 23 stems, and sterculiaceae with 21 stems. Some of the family represented by one species are Olaceae, Sapindaceae, Capparaceae and Canabacaea. The undisturbed part of this reserve was dominated by the family of Sterculiaceae with a total of 43 stems and Meliceae with 11 stems. Only Burseraceae and Rutaceae were represented by a single stem. The disturbed and undisturbed sites of Oluwa forest reserve was dominated by the family of Fabaceae and Sterculiaceae. Malvaceae, Guttifereae and Bignoniaceae were all represented by single tree species was represented by one tree species in the undisturbed forest and Rutaceae and Olaceae were also represented by single species.

**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 area. 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 sites of both for8est reserves. 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 found between Dbh and volume in the undisturbed site of Akure forest reserve. In the disturbed plots, a very positive strong correlation of 0.96 was also observed between the Dbh and the basal area.,0.98 was obtained between the basal area and the volume and a moderate positive correlation of correlation coefficient of 0.41 was observed between the height 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.

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

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Study sites | Growth Variables | No of trees | Diameter (cm) | Height(m) | Basal area(m2) | Volume (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 |  |
|  | Volume(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 |

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. Two trees each were in the diameter class of 70-80 cm and 90-100 cm and only one tree fell in the diameter class above 100cm. The disturbed site of Akure forest reserve was dominated by trees (46 stems) in the lower diameter class (120-20 cm), twenty-two (22) 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 plots 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 of the Oluwa Forest Reserve recorded 146 stems per hectare, while the disturbed site recorded 53 stems per hectare. Similarly, in the Akure Forest Reserve, 162 stems per hectare were recorded in the undisturbed site, compared to 91 stems per hectare in the disturbed site. These results suggest 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 were recorded 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. This discrepancy may reflect differences in disturbance intensity, forest management practices, or ecological conditions across these sites.

As observed in our study, the current degraded status of disturbed forest of Akure and Oluwa Forest Reserve including 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). Although some disturbed forests could be as rich as undisturbed ones depending on the logging method employed. This contradicts the findings of our study because the undisturbed forests contain more species and are more diverse than disturbed ones (Webb & Peralta 1998, Foody & Cutler 2003). This aligns with Chapin *et al.,* (2000) and Putz *et al*., (2000) who reported that logging may impact most on species evenness, with disturbed forests being more uneven than undisturbed forests.

The impact of logging was also evident in the variation in species family dominance between disturbed and undisturbed sites. Families with high number of species in undisturbed forest of Akure Forest Reserve include, Sterculiaceae, Annonaceae, Apocynaceae, and Sapotaceae. Meliaceae and Sterculiaceae are the dominant families in the disturbed site of this reserves. Meanwhile, the undisturbed and disturbed sites of Oluwa Forest Reserve were dominated by the families of Fabaceae, Miliceae, Moraceae and Sterculiaceae. This finding corroborates the works of Adekunle (2006) and Adekunle *et al.* (2010) who found that tropical rainforest of southwest Nigeria is dominated by the families of Sterculiaceae, Meliaceae, Moraceae and Ebenaceae.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.A similar pattern was observed in the Oluwa Forest Reserve. Both disturbed and undisturbed sites were dominated by Fabaceae, Miliciaceae, Moraceae, and Sterculiaceae, though logging may influence the relative abundance within these family groups. These findings are in agreement with the observations of Adekunle (2006) and Adekunle et al. (2010), who reported that tropical rainforests of southwest Nigeria are commonly dominated by Sterculiaceae, Meliaceae, Moraceae, and Ebenaceae families.

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 3.34–3.66 and 2.82–3.31, respectively.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. (2007), who found that Shannon-Wiener diversity indices for tropical rainforests in southwestern Nigeria typically range between 3.34–3.66 and 2.82–3.31, respectively.

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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 scores suggest that these species may be considered rare or potentially endangered within the surveyed ecosystems.

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. According to the International Union for Conservation of Nature (IUCN, 2004), a species is considered endangered if its population has declined by more than 80% over the past ten years, or if such a decline is projected, particularly when the number of mature individuals falls below 2,500 and the risk of extinction within 20 years exceeds 20%. Hubbell (1979) also emphasized that low species abundance may result from a combination of unfavorable regeneration conditions, inadequate habitat availability, and intense interspecific competition. Moreover, overexploitation of specific species for timber or other uses can further suppress their populations, exacerbating their decline and threatening their survival in the ecosystem.

**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). Both forest reserves 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).

Basal area was significantly higher in the undisturbed forests of both reserves compared to their disturbed counterparts. This finding supports the assertion by Brown and Lugo (1990) that unlogged 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. Tree stem volume per hectare further illustrated the impact of logging. Undisturbed sites in Akure and Oluwa recorded higher volumes, while the disturbed sites showed reduced tree volume due to the removal of large, high-biomass trees. These volume reductions not only reflect timber loss but also reduced carbon storage capacity and habitat complexity. 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. Moreover, the disappearance or severe depletion of some species in disturbed areas raises conservation concerns about species vulnerability and local extinction risk, as also observed in similar Nigerian forests (Falaye et al., 2006).

**Conclusion and Recommendations**

Logging has a profound negative impact on species diversity within tropical forest ecosystems. This study demonstrated that disturbed (logged) 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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