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ASSESSMENT OF NATURAL REGENERATION POTENTIALS AND STAND STRUCTURES OF AGO-OWU FOREST RESERVE, OSUN STATE, NIGERIA

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Abstract: This study investigated the natural regeneration potentials and stand structures of Ago-Owu Forest Reserve, Osun State, Nigeria. The forest is a critical ecosystem facing pressures such as illegal logging and agricultural encroachment. Through cluster sampling, 15 temporary sample plots (35m x 35 m) were systematically laid. All trees with diameter at breast height (DBH) ≥ 5 cm were identified, and parameters such as DBH, height, crown diameter, and regeneration status were measured. Diversity indices (Shannon-Wiener, Simpson, and Pielou's Evenness) and structural parameters like tree density and basal area were analyzed. Results indicated moderate species diversity (Shannon-Wiener Index = 3.1, Simpson's Index = 0.85, Pielou's Evenness = 0.78). *Theobroma cacao, Cola millenii, Terminalia orientalis* were among the most abundant species. About 43.48% of species showed good regeneration, while 21.74% showed no regeneration. These results highlight both the resilience and threats to this forest, indicating urgent need for conservation efforts.

Keywords: Ago-Owu Forest Reserve, Forest management, Natural regeneration, Species diversity, Stand structure1.

1.0 INTRODUCTION

Forests are essential ecosystems providing ecological, economic, and social services, including carbon sequestration, habitat for biodiversity, and livelihoods for local communities. In Nigeria, forests are under severe pressure from anthropogenic activities such as illegal logging and agricultural expansion. Ago-Owu Forest Reserve, located in Osun State, represents a significant forest resource that is increasingly threatened. Natural regeneration is a critical process for forest sustainability, but its effectiveness can be hindered by disturbances. Natural forest regeneration is critical for restoring biodiversity and ecological functions in tropical regions. Forests play a vital role in carbon sequestration, and their regeneration can mitigate the adverse effects of climate change (MacDicken, 2015). Natural regeneration has led to significant recovery of tree species diversity and forest structure as highlighted in his previous studies. Natural regeneration relies on the natural processes of seed dispersal, germination, and growth. It is cost-effective and often leads to the development of diverse and resilient ecosystems (Chenge *et al.,* 2020).

Deforestation and habitat degradation are one of the major issues affecting forest reserves in Nigeria at large and Ago-Owu forest reserve is not excluded. These problems are primarily driven by illegal logging, agricultural encroachment, and other anthropogenic activities. These activities lead to the loss of mature trees, fragmentation of habitats, and a decrease in forest cover, which in turn affects the forest's ability to regenerate and maintain its biodiversity (Adepoju, 2018). The reduction in forest cover also disrupts the ecological balance, leading to soil erosion, reduced water quality, and loss of wildlife habitats. As a result of these anthropogenic activities, there is loss of biodiversity. Ago-Owu Forest reserve serve as home to numerous plant and animal species, many of which are endemic or threatened. The destruction of habitats due to deforestation and other human activities results in the decline of species populations and even local extinctions (Akinyemi, 2015). Furthermore, effective management and conservation strategies are often lacking in this forest reserve. This deficiency can be attributed to insufficient data on the forest's current state, including its regeneration potential and stand structures (Coops *et al.,* 2020). Without this information, it is challenging to develop and implement strategies that promote sustainable forest management and conservation.

For effective management, detailed knowledge of the forest's current state is necessary, this study aimed at providing information for the forest managers about the forest's health, its capacity to regenerate, and the effectiveness of its current management practices. This information is crucial for developing strategies that ensure the forest's long-term sustainability and productivity according to Canton, 2021. Conducting research on the regeneration potentials and stand structures of trees in this forest reserve could provide essential data to help preserve the unique flora and fauna of the region. Understanding which species are successfully regenerating and which are declining will guide conservation efforts and help prioritize actions to protect endangered species according to Akinyemi, (2015).

2. MATERIALS AND METHOD

2.1 Study Area

The study was conducted in Ago-Owu Forest Reserve, located in Osun State, Nigeria. The forest lies within a coordinate of latitude: 7.1°N and 7.2° N and between longitude: 4.18° E and 4.29° E, and it covers 30541.23 ha of land (Asifat *et al*, 2020)

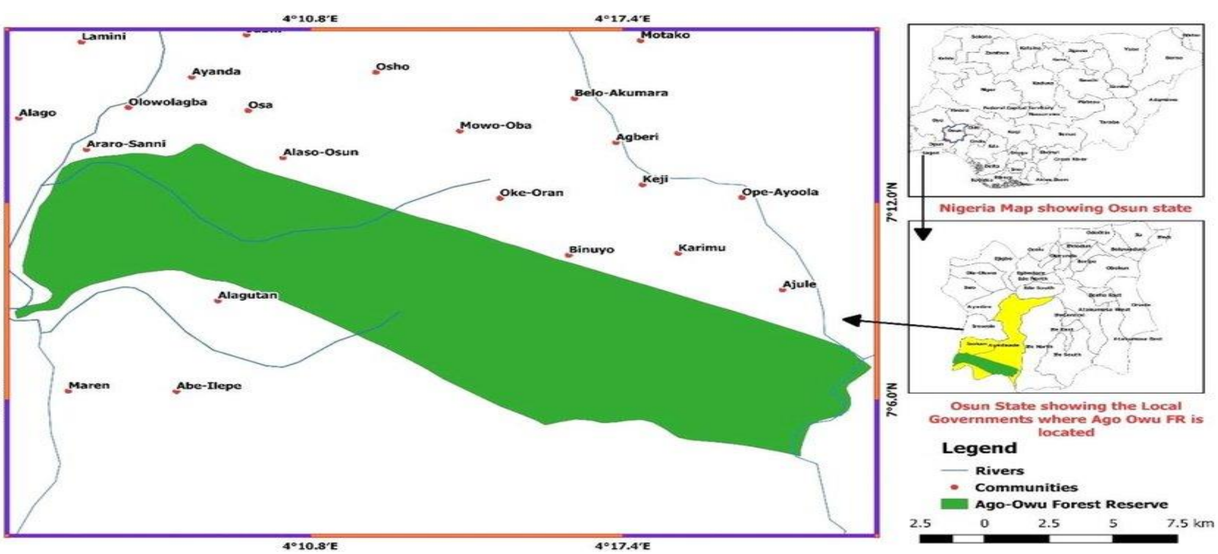

Figure 1: Ago-Owu Forest Reserve, Ago-owu, Osun state (Source: Asifat *et al*, 2020).

2.2 Data Collection Method

The sampling design for this study was cluster sampling design, it is composed of a set of three-square plots of 35 m x 35 m each; two of which was positioned at right angles to the apex of a central plot, in an L-shape transect arrangement, and at 100m apart (Fig 2). The plots are referred to as Elbow plot, East plot and North plot. Plot size of 35 m x 35 m was adopted in this study and a total of 4 clusters were laid. In the main 35 m x 35 m plot, all living trees with 40 cm dbh and above were enumerated. In the 25 m x 25 m nested sub-plot, all trees within the dbh range of 20 cm to 40 cm were enumerated while in the 7 m x 7 m nested sub-plot, dbh range of 5 cm to 20 cm were enumerated. The third nested sub-plot (2 m x 2 m) was laid and all seedlings with colar diameter ranges from 1 cm to 5 cm were identified and enumerated. All saplings (Dbh >1.0 cm but < 5cm) were identified and their dbh were measured also. All species were classified into families and their frequencies were obtained. Trees were grouped into diameter distribution classes based on the dbh measurements. The following variables were measured: diameter at the base (DB, cm), diameter at breast height (DBH, cm) diameter at the top (DT, cm), and diameter at the middle (DM, cm), merchantable height (m), total height (m) and crown length (m) were measured using diameter tape and Spiegel relaskop. Crown diameter (m) was obtained and recorded through the use of the meter tape.

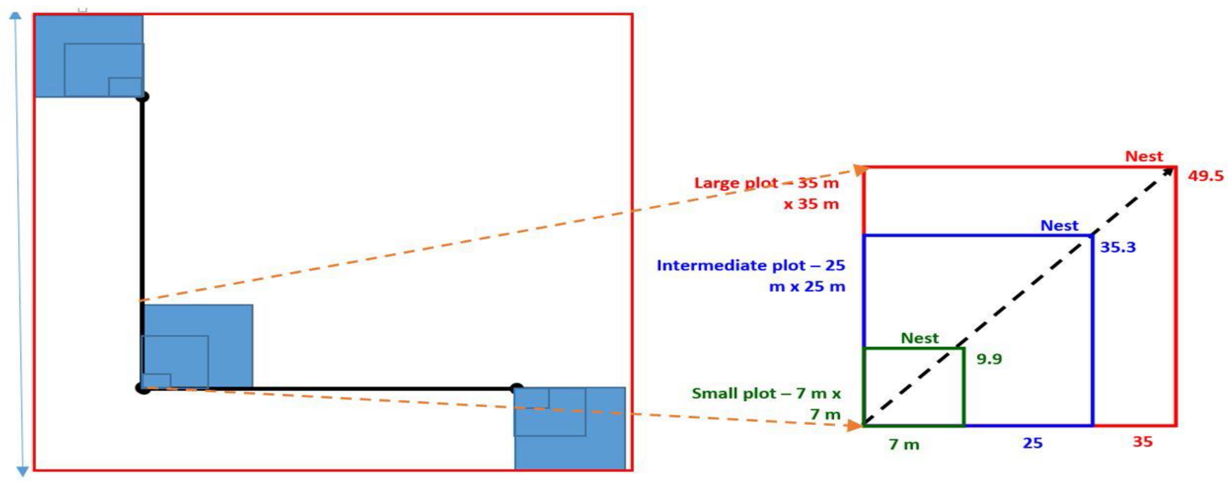

Figure 2: The Plot demarcation design

2.3 Method of Data Analysis

$$BA = \frac{\pi D^2}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 1$$

Where, BA = basal area (m²) for each tree, π = pie constant (3.142) and D = diameter at breast height (1.3m above the ground level) (m).

$$CPA = \frac{\pi CD^2}{4} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 2$$

Where, CD = crown diameter and π = Pie constant (3.142).

$$TSC = \frac{THt}{DBH} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 3$$

Where, TSC = Tree slenderness coefficient, THt = Total Height, and Dbh = Diameter at the breast height. The TSC was classified according to Ige and Komolafe, (2020)

TSC > 99.......................... High slenderness coefficient

TSC 70-99.................Moderate slenderness coefficient

TSC <70............................Low slenderness coefficient

CL = THt –MHt …………………………………….. 4

Where, CL = Crown length, THt = Total height and MHt = Merchantable height.

$$CR = \frac{CL}{THt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 5$$

Where, CL is the individual crown length and THt is the total height of the tree.

Newton volume formula was used to estimate the volume as shown in equation 6

$$V = \frac{\pi H\left(D_b^2 + 4D_m^2 + D_t^2\right)}{24} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 6$$

Where, V = Volume over bark (m³), H = stem height (m), Db = Diameter at the base, Dm = Diameter at the middle, Dt = Diameter at the top and π = 3.142 (constant).

Shannon-Weiner Diversity Index (Shannon and Weiner, 1948)

$$H' = -\sum_{i=1}^{s} \text{pi In}(pi) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 7$$

Where, H′ = Shannon-Wiener diversity index, S = Total number of species (species richness), pi = Proportion of individuals species (relative abundance) and ln = Natural logarithm.

Simpson Tree Species Diversity Index (Simpson, 1949)

$$D = \sum \text{ni}(\text{ni} - 1)\; N(N1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \; 8$$

Where, D = Simpson's Diversity Index (ranges between 0 and 1, with higher values indicating greater diversity), ni = Number of individuals of species and N = Total number of individuals of all species.

Pielou Evenness Index E (Pielou, 1969)

$$E = \frac{H'}{\ln(S)} \quad \text{...... 9}$$

Where, E = Pielou's Evenness Index (ranges from 0 to 1, with values closer to 1 indicating more even distributions), H′ = Shannon Diversity Index, S = Total number of species and ln(S) = Natural logarithm of the total number of species.

Margalef Index MI (Sina and Zulkarnaen, 2019)

$$MI = \frac{S-1}{\ln(N)} \quad \text{...... 10}$$

Where, MI = Margalef Index, S = Total number of species (species richness), N = Total number of individuals, ln(N) = Natural logarithm of the total number of individuals.

Species Relative Density (RD)

$$RD = \frac{\text{Number of an individual species}}{\text{Total Number of all species}} \times 100 \quad \text{...... 11}$$

Species Relative Frequency (RF)

$$RF = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100 \quad \text{...... 12}$$

Where frequency was computed as:

$$F = \frac{\text{Number of sampled plots where the species occured}}{\text{Total number of sampled plot}} \quad \text{...... 13}$$

Species Relative Dominance (RDO)

$$RD_0 = \frac{\text{Total basal area of a species}}{\text{Total basal area of all species}} \times 100 \quad \text{...... 14}$$

Importance Value Index (IVI)

$$IVI = RD + \text{RF} + \text{RD}_0 \quad \text{...... 15}$$

Where, RD = Relative Density, RF = Relative Frequency, RD_0 = Relative Dominance

Family Importance Value Index (IVI)

$$FIVI = RD\ of\ Family + \text{RF of Family} + \text{RD}_0\ of\ Family \quad \text{...... 16}$$

Where

$$RD = \frac{\text{Total Number of an individuals of a family}}{\text{Total Number of individuals of all families}} \times 100$$

$$RF = \frac{\text{Total frequencies of species in a family}}{\text{Total frequency of all species}} \times 100$$

$$RD_0 = \frac{\text{Total basal area of a family}}{\text{Total basal area of all families}} \times 100$$

Tree Canopy and Diameter Classification
All trees (THt ≥ 10cm) in each plot were classified into four canopy strata according to Ige and Komolafe (2020):
Dominant (TH≥ 35m),

Co-dominant (TH=26m to 35m),

Intermediate (TH = 16m to 25m) and

Suppressed (TH = 6m to 15m)

Tree Diameter Classification:

Class I: DBH ≥ 40cm,

Class II: DBH = 20cm - 40m,

Class III: DBH = 5cm - 20cm and

Class IV: DBH = 1cm - 5cm.

Natural Regeneration Classification

Regeneration status was determined based on population sizes of seedlings, saplings (Rachele *et al.,* 2019), and overstory trees. Regeneration was categorized as:

I. Good regeneration**:** seedlings > saplings > adults;

II. Fair regeneration: seedlings > or < saplings < adults;

III. Poor regeneration: the species survives only in the sapling stage, but no seedlings (saplings may be or = adults);

IV. Non-Regenerating**:** species present only at the adult stage were considered as not regenerating

V. New Recruitment: species present at only the seedlings stage that has no adults and saplings stage were considered as 'new' (recruitment).

3. RESULTS AND DISCUSSION

3.1 Stand Growth Characteristics

The observed DBH in the study area indicates that the trees are at the transitional stage from saplings to adult tree and are yet to be matured. However, they had a good vigor between their crown size and stem length. The moderate variation in DBH shows that the trees are of relatively the same ages and sizes. The tree growth characteristics in the study area was closely related to the previous findings by Ige and Komolafe (2023) in the tropical forest of IITA Ibadan, Nigeria, where they assessed key stand growth characteristics such as basal area, tree density, aboveground biomass (AGB), and species diversity. Their findings provided valuable insights into the ecological dynamics of these forests. Additionally, the average volume suggests the forest is yet to reach the rotation period to obtain significant amount of timber in the forest as there were very few trees with larger diameter and crowns.

A worthy observation is the average tree slenderness coefficient of the study indicating that the trees had a moderate TSC, which means that trees tend to become relatively more stable and less susceptible to wind throw as they become mature. This is because mature trees have thicker trunks as supported by their large DBH (which is a better predictor of TSC) to help support their larger crowns. This findings is in consistency with a study by Ige and Silas (2023) conducted in the Oluwa Forest Reserve, Ondo State, Nigeria. This research also found that most trees exhibited low to moderate TSC values, indicating a higher resistance to wind damage. Specifically, species like *Picralima nitida* and *Ricinodendron heudelotii* had no individuals in the high slenderness category (>99), suggesting inherent stability as they mature.

Table 1: Statistical summary of the tree stands growth characteristics

Standard Growth Variable	Mean ± SE	Min	Max	Total/ha
DBH (cm)	20.94 ± 0.83	7.5	77.1	
THt (m)	14.34 ± 0.42	6.5	33.5	
MHt (m)	11.87 ± 0.38	4.2	29.3	
CD (m)	3.86 ± 0.13	1.5	8.9	
CL (m)	2.47 ± 0.07	0.5	5.7	
BA (m²)	0.044 ± 0.005	0.0044	0.47	7.5279
CPA (m²)	0.0014 ± 0.0001	0.0001	0.006	
TV/ha (m³)	2.99 ± 0.41	0.25	44.1	515.015
MV/ha (m³)	2.53 ± 0.35	0.16	38.57	435.3681
TSC	73.12 ± 1.60	31.71	173.79	
CR	0.18 ± 0.005	0.04	0.35	

Where: DBH = diameter at breast height, THt = total height, MHt = merchantable height, CD = crown diameter, CL = crown length, BA = basal area, CPA = crown projection area, TV = total volume, MV = merchantable volume, TSC = tree slenderness coefficient, CR = crown ratio.

3.2 Tree Species Diversity and Stand Structure

The diversity indices like Simpson's Index (1-D = 0.9239) and Shannon-Weiner Index (H′ = 2.924) indicate a moderately high diversity and species richness, signifying a balanced and resilient ecosystem (Esor *et al.*, 2023). However, moderate evenness suggests a need to monitor species that might be under-represented or at risk and therefore the greater the value of the Shannon-Weiner Diversity Index, the more diverse the population (Youkparigha and Dudutari, 2019). Margalef's Index (M: 5.634) also suggests significant species richness and Species Evenness (e = 0.6205) which shows moderate uniformity in species distribution in the study area.

Table 2: Tree Species Diversity Indices of the Study Area

Diversity Indices	Value
Number of Individual Trees	144
Number of Tree Species	30
Number of Families	13
Dominance (D)	0.0761
Simpson Diversity Index (1-D)	0.9239
Shannon-Weiner Diversity Index (H′)	2.924
Species Evenness (e^H/S)	0.6205
Margalef Index of Species Richness (M)	5.634
Equitability (J)	0.8597
Brillouin	2.671
Menhinick	2.287
Fisher-alpha	10.51
Berger-Parker	0.1919

A total of 30 tree species belonging to 13 various families were recorded in the study area, the family Malvaceae was the most represented, contributing six species and constituting 20% of the species composition, families like Fabaceae and Moraceae were also significantly present, with contributions of 16.67% and 13.33%, respectively. However, the presence of a wide array of species contributes to overall ecosystem diversity. This dominance of specific families indicates their ecological adaptability, resilience, growth and role in shaping the forest structure (Esor *et al*., 2023). The high representation of Malvaceae family is due to the changing ecological structure of the study area due to the deliberately intervention of humans by establishing the species' plantation thereby resulting to the dominance of the species on the overall forest ecological function, and also due to its adaptable ability to various ecological and growth conditions which emphasize the role of dominant families in maintaining forest productivity and resilience, underscoring their importance in maintaining forest balance as these families are integral to ecosystem services, such as nutrient cycling and carbon storage (Adeyemi *et al*., 2015).

Table 3: Families Composition of Tree Species in the Study Area

Families	NS	NS/ha	Percentage
Apocynaceae	2	16	6.67
Cannabaceae	2	16	6.67
Combretaceae	2	16	6.67
Ebenaceae	1	8	3.33
Euphorbiaceae	2	16	6.67
Fabaceae	5	40	16.67
Irvingiaceae	2	16	6.67
Lamiaceae	1	8	3.33
Malvaceae	6	48	20
Moraceae	4	32	13.33
Rutaceae	1	8	3.33
Sapindaceae	1	8	3.33
Urticaceae	1	8	3.33
Total	**31**	**240**	**100**

The total number of sampled stands (≥ 5cm Dbh) assessed in the study area were 172 stands per hectare, unevenly distributed among 31 species and 14 families. The highest number of individual trees recorded, with 79 and 98 trees per hectare, falls within the diameter class 1-5cm and 5-20cm, respectively. This indicates a large number of saplings and juvenile trees that are in the early stages of development. The prevalence of trees in these diameter classes is indicative of a reproductive or regenerating phase, where natural recruitment of seedlings and saplings is occurring. The diameter class (20-40 cm) with the highest species richness of 29 species suggests that trees in this indicates a transition phase between juvenile and mature trees. The intriguing observation is that the largest and most mature trees (diameter class ≥40) had the least species richness, indicating that the forest is in a state of imbalance due to disturbances or harvesting as large trees are often cropped due to their economic value. The classification of trees into dominant, co-dominant, intermediate, and suppressed height classes provides insights into canopy structure, light competition, and forest dynamics. The absence of trees in the dominant canopy class suggests that the forest is relatively not mature or disturbed.

Table 4: Tree species diameter class distribution and their relative status

DBH CLASS (cm)	NF	NF/ha	NS	Total BA (m^3/ha)	TV (m^3/ha)
1-5	79	632	12		
5-20	98	784	20	13.76	104.76
20-40	63	504	29	24.68	223.79
≥40	11	88	6	21.14	192.31

Where, DBH = diameter class (cm), NF= number of frequency, NF/Ha = number of frequency per hectare, NS = number of species, BA = basal area and TV = total volume of trees.

Table 5: Height Class Distribution of trees species based on canopy classification in the study area

Height Class (m)	NF	NF/ha	NS
6-15	116	928	19
16-25	51	408	24
26-35	5	40	5
≥35	0	0	0

Where, NF = number of frequency, NF/Ha = number of frequency per hectare, NS = number of species.

3.3 Forest Regeneration Potential

Species like *Celtis zenkeri, Blighia sapida, Dialium guineense, Malacantha alnifolia* and *Ficus exasperata* demonstrated good regeneration potential, characterized by high densities across the three life stages of seedlings, saplings, and trees. This suggests that these species have prolific seed production and efficient seed dispersal mechanisms which is likely facilitated by fauna interactions. This finding is in consistent with the past study carried out in the Majang Forest Biosphere Reserve of southwestern Ethiopia by Tadese *et al*., (2021), Celtis zenkeri demonstrated robust regeneration, with high densities observed across all growth stages. This indicates its strong regenerative capacity and adaptability in tropical forest environments and likewise a research conducted in Benin by Ekué et al., (2008) has documented the successful propagation and management of Blighia sapida, emphasizing its significance in agroforestry systems. The species' ability to regenerate effectively is attributed to traditional knowledge and practices that support its cultivation and conservation. Poor regenerating species observed in the study area included *Alstonia boonei, Citrus sinensis, Cola gigantea, Cola millenii* and *Irvingia wombolu*, reflecting challenges in their sapling transition to mature trees or environmental suitability, characterized by their dominance only in sapling and tree stage, no seedlings presence. Limited seed sources, poor seed banks, vegetation competition and predation may also be the cause of their poor natural regeneration status. This observation is corroborated by past research in southeastern Nigeria done by Nzekwe et al., (2008), which reported low densities of Irvingia wombolu (approximately 2.4 trees per hectare), with occurrences mainly in outlying farms, the study attributed its poor regeneration to factors such as limited seed sources and soil heterogeneity. Also, Onyekwelu *et al*., (2021), highlighted that in the Osun-Osogbo Sacred Grove, Cola millenii was among the species with high importance value indices (IVI) due to its presence as mature trees. However, the study noted a lack of corresponding seedling and sapling stages, indicating poor natural regeneration. Species such *as Milicia excelsia, Myrianthus arboreus, Ricinodendron heudelotii, Magnitarian discoidea* and *Ceiba pentandra* were non-regenerating because they were only recorded in tree stage. This could be as a result of various factors like ecological stress or unsuitability, predation, high susceptibility of seeds or seedlings to pest and disease especially in the case of *Milicia excelsia* which is grossly attack by *Phytolyma lata* (Adeniji *et al*., 2019; Olajuyigbe *et al.,* 2015). Overall, it was observed that 43.48% of the species exhibited good regeneration, 30.43% showed poor regeneration, and 21.74% of the species were not regenerating while the new recruitment was only 4.35%.

Table 6: Composition of Seedlings, Saplings and Trees species in the study area with their regeneration status

Species	**Family**	**Seedlings**	**Saplings**	**Trees**	**RS**
Albizia ferruginea	*Fabaceae*	0	0	8	NR
Albizia zygia	*Fabaceae*	2500	204	24	GR
Alstonia boonei	*Apocynaceae*	0	204	8	PR
Blighia sapida	*Sapindaceae*	17500	204	40	GR
Ceiba pentandra	*Malvaceae*	0	0	8	NR
Celtis zenkeri	*Cannabaceae*	42500	816	64	GR
Citrus sinensis	*Rutaceae*	0	816	56	PR
Cola acuminate	*Malvaceae*	0	0	24	NR
Cola gigantean	*Malvaceae*	0	1020	48	PR
Cola millenii	*Malvaceae*	0	2040	136	PR
Dialium guineense	*Fabaceae*	15000	1428	80	GR
Diospyros mespiliformis	*Ebenaceae*	0	0	8	NR
Ficus exasperate	*Moraceae*	27500	1428	88	GR
Ficus mucuso	*Moraceae*	0	0	8	NR
Irvingia gabonensis	*Irvingiaceae*	5000	816	48	GR
Irvingia wombolu	*Irvingiaceae*	0	204	16	PR
Macaranga barteri	*Euphorbiaceae*	2500	612	48	GR
Magnitarian discoidea	*Malvaceae*	0	0	8	NR
Malacantha alnifolia	*Apocynaceae*	7500	408	64	GR
Melanthera scandens	*Asteraceae*	45000	0	0	New
Milicia excelsia	*Moraceae*	0	0	8	NR
Myrianthus arboreus	*Urticaceae*	0	0	8	NR
Pterocarpus santalinoides	*Fabaceae*	1500	408	48	GR
Ricinodendron heudelotii	*Euphorbiaceae*	0	0	8	NR
Tectona grandis	*Lamiaceae*	0	1224	64	PR
Terminalia orientalis	*Combretaceae*	0	1836	104	PR
Terminalia superba	*Combretaceae*	0	204	32	PR
Tetrapleura tetraptera	*Fabaceae*	0	204	8	PR
Theoboma cacao	*Malvaceae*	0	5508	264	PR
Trema orientalis	*Cannabaceae*	0	204	8	PR
Trilepisium madagascariense	*Moraceae*	2500	204	40	GR
Total		**185000**	**19992**	**1376**	**GR**

Where: RS = regeneration status, GR = good regeneration, PR = poor regeneration, NG = non-regenerating, NR = new recruit and FR = fair regeneration.

CONCLUSION

This study has provided an in-depth evaluation of the growth characteristics, species diversity and stand structure, and regeneration potential of a secondary regrowth forest. The findings underscore the forest's transitional state, characterized by its species composition, structural attributes, and dynamic ecological processes. The assessment of tree growth characteristics revealed a secondary regrowth tree stand dominated by transitional species and moderate tree dimensions, reflecting its recovery phase. The observed basal area, DBH, and crown projections highlight the forest's gradual progression towards maturity and its role as a critical reservoir for biodiversity, this is indicative of a regenerative phase. The relative scarcity of dominant canopy species and mature trees indicates ongoing disturbances, especially from anthropogenic activities which could hinder the forest's long-term stability. The species diversity level is revealed to be moderately high as the forest ecosystem is dominated by varieties of tree species at each level of life with the species' richness and evenness unevenly distributed, contributing to the forest stability and resilience even at the face of various disturbance. Overall, the study area demonstrates a promising trend in tree regeneration, with many species showing resilience and a strong ability to regenerate effectively, which could enhance the diversity levels of the forest. The relatively moderate crowns of the young and transitional trees allow sufficient sunlight to penetrate the undergrowth, thereby promoting the growth of seedlings and various species.

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