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Evaluation of Tree Size Diversity, And Soil Characteristics on Above Ground Biomass in Heterogeneous Tropical Savanna Woodland in Osara

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Abstract **Review Article**

One of the key components of productivity of tropical ecosystem is Above Ground Biomass. This factor was evaluated in Heterogenous Savanna woodland of Osara-ngada, Adavi Local Government Area Kogi State, and Using Diameter at Breast height, alongside with other environmental stressors such as soil nutrient capacity, Vegetation diversity Index, Annual Average rainfall over the area. The result showed that the family Combretaceae and Fabaceae produced 0.8381kgm-2ha-1 and 0.5363kgm-2ha-1 respectively, while other such as Rubiaceae, Lamiaceae, Ebenaceae, Annonaceae, Moraceae, Meliaceae, Verbenaceae, Mimmosoidae and Anarcadiaceae produced minimal above ground biomass, the herbage yield was averagely low about 107.83gm-2ha-1 though different experimental plots revealed different level of stability, species asynchrony was essentially similar, the DBH classes shows an inverted J-shape for the first plot while the second and third plot sampled revealed that 10-20, 20-30 DBH class is majorly represented, this categories reflects the critical stages of plant development and thus, The study underscores the need for targeted conservation and management strategies to sustain productivity and ecosystem stability in the area.

Keywords: Above Ground Biomass, Biodiversity, Conservation, Woodland.

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1.0 INTRODUCTION

Tropical savannas are complex and dynamic ecosystems that cover approximately 20% of the earth's land surface. (Laurance *et al.*, 2012). These ecosystems are characterized by a diverse array of tree species and sizes, and are often found in regions with high levels of biodiversity (Laurance *et al.*, 2012). The Osara tropical savanna woodland, located in the savanna region of Nigeria, is a prime example of such an ecosystem. This woodland is characterized by a heterogeneous landscape of trees, shrubs, and grasses, with a diverse array of tree species in different sizes.

They harbor biodiversity, maintain carbon stocks (thereby regulating climate), control soil erosion, provide shade, modify hydrological cycles and maintain soil fertility, all of which are essential ecosystem services (Jew *et al.* 2016) for the livelihood of local communities.

Apart from their significant importance, tropical forests are disappearing globally at a rate of 6 million ha per year (Keenan *et al.* 2015).

Their diversity across plant communities have been significantly affected by both natural processes and ongoing human activities such as charcoal exploitation, illegal timber harvesting and need for more agricultural land (Madoffe *et al.* 2012, Lupala *et al.* 2014). However, in tropical forest ecosystems soil nutrients play an important role in the formation of plant communities, their species and structural diversity.

Tree species diversity and tree size diversity are two important factors that influence AGB in tropical savannas (Bunker *et al.,* 2005). Tree species diversity refers to the variety of tree species present in an ecosystem, while tree size diversity refers to the range of tree sizes present in an ecosystem. Both of these factors can influence AGB by affecting the amount of biomass produced by individual trees, as well as the overall structure and function of the ecosystem.

Despite the importance of tree species diversity and tree size diversity in influencing AGB, there is a lack of understanding of how these factors interact to affect AGB in tropical savannas (Laurance *et al.*, 2012). This knowledge gap is particularly evident in the Osara tropical savanna woodland, where tree species diversity and tree size diversity are high, but the relationships between these factors and AGB are not well understood.

This study aimed to evaluate the relationships between tree species diversity, tree size diversity, and AGB in the Osara tropical savanna woodland. Specifically, this study will assess the tree species diversity and tree size diversity in the study area, evaluate the relationships between these factors and AGB, and identify the key tree species and size classes contributing to AGB. The findings of this study will contribute to our understanding of the complex relationships between tree species and size diversity, and AGB in tropical savannas, and will have important implications for sustainable forest management practices, conservation strategies, and climate change mitigation efforts in these ecosystems.

2.0 REVIEW OF RELEVANT LITERATURES

Above Ground Biomass (AGB) refers to the total dry mass of living vegetation above the ground, including stems, leaves, and branches. Methods for estimating AGB include:

Direct measurement (harvest methods), Indirect estimation (remote sensing, allometric equations), and Modeling approaches based on tree and soil characteristics.

Michael *et al*. (2013), analyzed the relationship between tree species diversity and AGB in Central African rainforests. The findings suggested that high species diversity often correlates with higher biomass, reinforcing the importance of biodiversity conservation in carbon sequestration efforts.

AGB is a very important component of forest ecosystems, representing the total biomass of living vegetation above the soil surface i.e the trees, shrubs, and herbs. (Chave *et al.*, 2005). It plays a vital role in carbon storage or carbon sequestration, nutrient cycling, and biodiversity maintenance (Malhi *et al.*, 2006). AGB is influenced by various ecological factors, including species composition, tree size distribution, and environmental conditions such as climate and soil properties (Feldpausch *et al.*, 2012). In tropical savannas, where vegetation is highly heterogeneous, assessing AGB is crucial for understanding ecosystem productivity and resilience (Bond, 2008).

While research on AGB in tropical savannas has provided valuable insights, gaps remain regarding the specific contributions of species and size diversity in heterogeneous ecosystems like Osara. Most studies have focused on large-scale assessments, with limited site-specific investigations (Slik *et al.*, 2013). This study aims to bridge these gaps by evaluating the relationships between tree species diversity, tree size diversity, and AGB in Osara, with implications for biodiversity conservation, sustainable forest management, and climate change mitigation.

The relationships between tree species diversity, tree size diversity, soil characteristics and above-ground biomass (AGB) in heterogeneous tropical savannas are not well understood, hindering the development of effective conservation and management strategies (Bunker et al., 2005). This knowledge gap is particularly evident in tropical savannas, where tree species diversity and tree size diversity are high, and AGB is a critical component of ecosystem function (Chave et al., 2005) Tree species diversity is a key determinant of ecosystem function and biomass accumulation (Loreau *et al*., 2001). Higher species diversity has been associated with increased AGB due to complementarity in resource use, where different species optimize the utilization of available resources such as light, water, and nutrients (Bunker *et al.*, 2005). Functional diversity among tree species can enhance productivity and stability, leading to greater biomass accumulation (Poorter *et al*., 2015). However, the relationship between species diversity and AGB can be context-dependent, influenced by disturbances, soil conditions, and climatic variability (Finegan *et al.*, 2015).

Tree species diversity refers to the variety and distribution of tree species within an ecosystem. Higher biodiversity contributes to ecosystem resilience, nutrient cycling, and carbon sequestration. Factors affecting tree species diversity include climatic conditions, soil type, and anthropogenic disturbances. (Feldpausch *et al.*, 2012).

Oladele (2025), found that species diversity indices were higher in riparian forests compared to old-growth forests, highlighting the role of habitat variation in maintaining biodiversity in Akure Strict Nature Reserve Nigeria.

Tree size diversity, including variations in tree height, diameter, and crown structure, significantly affects AGB (Lasky *et al*., 2014). Forests with a wide range of tree sizes often have higher AGB due to increased canopy layering and efficient light interception (West *et al.*, 2009). Large trees contribute disproportionately to AGB because of their extensive woody biomass, while smaller trees play essential roles in regeneration and recruitment (Slik *et al.*, 2013). In savanna ecosystems, size diversity can enhance biomass storage by promoting structural complexity and ecosystem stability (Lehmann *et al.*, 2011).

Tree size diversity is crucial for forest structure and function. Larger trees store more biomass and carbon, while smaller trees ensure regeneration and species stability. The balance between different tree sizes influences forest productivity and ecological health.

Yuanfa Li *et al.*, (2023), explored the relationship between species diversity and tree size in natural forests around the Tropic of Cancer. Findings indicated that species richness and abundance followed an inverted **J-shape** pattern with increasing diameter class, suggesting that tree size is a strong predictor of species diversity.

The interaction between Tree species diversity and size diversity can enhance AGB through complementarity effects, where species with different growth strategies and sizes contribute to overall biomass accumulation (Chisholm *et al.*, 2013). In heterogeneous tropical savannas such as Osara, these interactions are crucial in determining ecosystem productivity and resilience (Laurance *et al*., 2012). Despite extensive research on individual effects, studies focusing on their combined influence on AGB remain limited, highlighting the need for further investigation (Sullivan *et al*., 2017).

Savannah woodland soils vary in texture, nutrient composition, and moisture retention. Key soil parameters influencing biomass include:

Soil texture (sand, silt, clay proportions), Organic matter content, pH levels, Nutrient availability (nitrogen, phosphorus, potassium), and Moisture retention capacity.

David *et al.* (2021), examined long-term changes in plant ecology in African savanna landscapes. His research highlighted how soil properties and human activities influence plant diversity and biomass turnover, emphasizing the need for integrated ecosystem management.

The interaction between tree species diversity, soil properties, and biomass plays a key role in maintaining ecological balance. Liu and Yan (2024).

Tree diversity supports habitat stability and contributes to natural regeneration. Soil health affects tree growth, influencing biomass accumulation. Liu and Shudan (2024) Zhen and Shudan (2024), examined energy flow and trophic dynamics in African savanna ecosystems, their research emphasized the impact of climate and human activities on ecosystem resilience, highlighting the need for sustainable land management.

Moreso, Enrico (2024), showed that the role of human interaction in shaping savanna ecosystems is huge, his study explored conservation challenges and the importance of balancing ecological integrity with human land-use needs.

Maintaining ecological balance in tropical savannas requires a comprehensive understanding of the relationships between species diversity, size diversity, and soil characteristics. By addressing these factors and developing targeted conservation strategies, we can protect and enhance biodiversity, ecosystem productivity, and resilience in these vital ecosystems.

The relationships between tree species diversity, tree size diversity, soil characteristics and above-ground biomass (AGB) in heterogeneous tropical savannas are not well understood, hindering the development of effective conservation and management strategies (Bunker et al., 2005). This knowledge gap is particularly evident in tropical savannas, where tree species diversity and tree size diversity are high, and AGB is a critical component of ecosystem function (Chave et al., 2005)

3.0 MATERIALS AND METHODS

3.1. STUDY AREA

The study was conducted in Osara Ngada savanna woodland in Adavi Local Government Area LGA. Osara, located in Kogi State, Nigeria, has a tropical climate with varying temperature and rainfall patterns. While specific climate data for Osara is limited, here are few general information about the region:

Average Annual Temperature

Nigeria's mean annual temperature ranges around 34°C, but this value can fluctuate depending on the location and time of year. Given Osara's geographical coordinates (7°40’38.6″N 6°24’59.7″E), the temperature might be slightly lower due to its location in the southern part of Kogi State.

Average Annual Rainfall

Rainfall in Nigeria varies significantly across regions. Kogi State experiences a moderate to high level of rainfall. Although exact figures for Osara aren't readily available, the region's rainfall pattern is likely similar to nearby areas, with most rainfall occurring during the wet season.

Regarding vegetation values over ten years, research suggests that vegetation in Nigeria is sensitive to annual rainfall variations. There is a relatively uniform inter-annual trend in mean yearly rainfall, with slightly increasing rainfall amounts in recent years, which can impact vegetation growth and density.

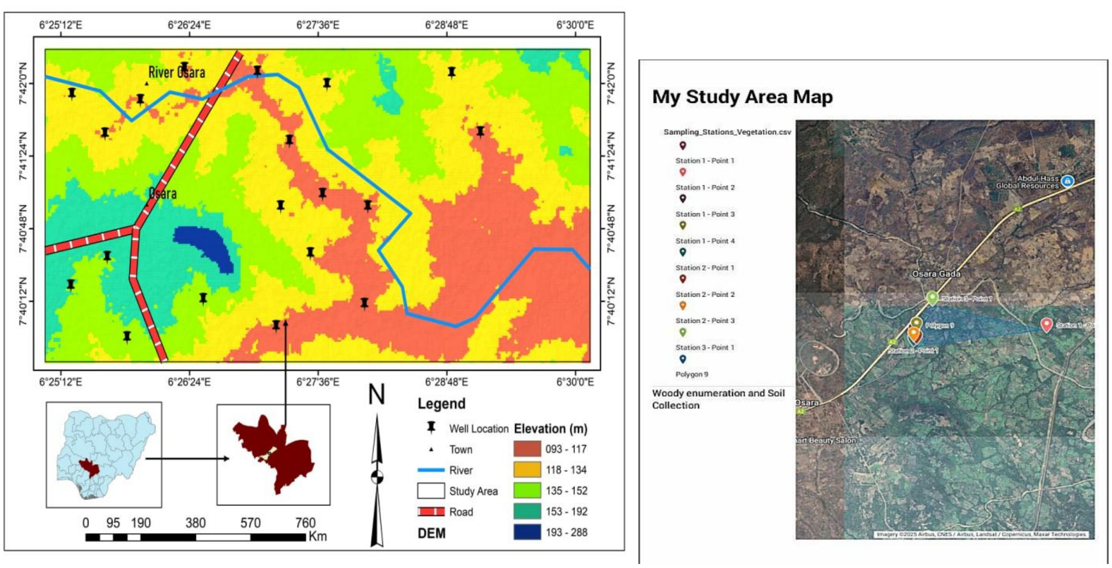

Fig.1. MAP OF OSARA NGADA LGA SAVANNA WOODLAND

Preliminary visit was made for initial survey of study sites. Three sampling plots 100m × 100m which was sectioned into (10×10) m each for total enumeration of woody species. Each plot was systematically taken to cover charcoal production area, the third plot from relatively undisturbed potion to serve as control.

3.2. FIELD DATA COLLECTION

Tree species was identified and enumerated within each plot and recorded. Diameter at breast height (DBH) was measured, average DBH for each species was recorded and tabulated appropriately

3.3. SOIL COLLECTION

Sub-soil was sampled with Auger (0-20cm) and Bulk (20-40cm). A total of organic carbon, organic matter, TN, EC, Na, K, Mg, Ca, TEB, EX, Acidity, ECEC, was determined using standard methods.

3.4. FIELD DATA ANALYSIS

Floristic data analysis was carried out

Diversity Study

D=

S/$\sqrt{n}$ ………………………………………………………………..…………………… eq 1

Where;

D = Diversity

S = Number of species

N = Total number of individuals

Shannon-Wiener Index

H' = $\sum_{i=1}^{s} \; pilnpi$ ……………………………………………………………………………………..……… eq 2

Where;

pi= Relative proportion of each species

H' = Shannon-Wiener Index

Species Evenness

E= H/LogS …..…………………………………………………..………………eq3

Where;

LogS =natural logarithm of the numbers of species in base 10

TREE ABOVE GROUND BIOMASS

Tree above ground biomass (ABG) of trees in subplots will be estimated using the following equation.

ABG=Exp (-2.024-0.896×E+0.920×log (WD) +2.795×log (DBH)-0.0461×log $(DBH)^2$) …………………………………………………………… eq4

Where;

WD= Wood density

E= Environmental stress factor

Source from global wood density data base and geographical coordination of the study sites. Chave *et al;* 2014.

Community Stability

S= μ/σ …………………………………………………………………………………… eq 5

Where **μ** and **σ** represents the mean and standard deviation of ABG calculated within each subplot in each study area.

Species Asynchrony

It occurs when changes in the abundance of one species are counterbalanced by changes in other species. This compensation primarily results from diverse response among species with different functional traits to environmental changes and inter specific competition.

Species asynchrony = 1- σ^2 / ($\sum_{i=1}^{n}$ δ1)^2 ……………………………………………eq 6

Where;

σ^2 = variance of commonly AGB

σ_1= Standard deviation of AGB for a specific species

This is assessed on a scale from 0; indicating complete synchrony to 1; denoting complete asynchrony.

Regeneration Analysis

Plants species was categorized into trees, shrubs, saplings and seedlings using arbitrary DBH class of 2.5-10cm, 10-20cm, 20-30cm, 30-40cm, 40-50cm, 50-60cm, 60-70cm, 70-80cm, 80-90cm, >90cm.

4.0 RESULT AND DISCUSSION

4.1. FLORISTIC ANALYSIS OF SAMPLED PLOTS

Table 1 summarizes and compares key ecological and productivity metrics across three different experimental plots. The parameters assessed include individual species count, diversity index (D), evenness, Shannon-Weiner index (H'), herbage yield, and environmental stress factor (E). Environmental stress factor (E) = (Average Rainfall per year × Vegetation index× TEB of soil) $^{1/3}$

Table 4.1: **VEGETATION CHARACTERIZATION**

	Plot 1	**Plot 2**	**Plot 3**
Individuals	154	164	126
Diversity (D)	0.081-3.950	0.078-4.683	0.178-8.913

Evenness	2.081	0.964	0.362
Shannon-Weiner(H')	4.552	2.135	0.761
Herbage yield	113gm^{-2} ha^{-1}	100.5gm^{-2}ha^{-1}	110gm^{-2} ha^{-1}
Environment Stress Factor (E)	32.40	24.67	19.15

Plot 1 showed the highest Shannon-Weiner index (H' = 4.552), indicating greater species diversity ompared to Plot 2 (H' = 2.135) and Plot 3 (H' = 0.761). Plot 1 also had a broader range in diversity (D) and better evenness, suggesting a more balanced and diverse plant community. Biodiversity is known to contribute to greater ecological stability and ecosystem service provision (Tilman *et al.*, 2016; Isbell *et al.*, 2017).

Evenness:

Evenness was highest in Plot 1 (2.081), indicating a more uniform distribution of individuals among species. Plot 3 had the lowest evenness (0.362), suggesting dominance by a few species. Higher evenness is typically associated with enhanced resistance to environmental perturbations (Wang *et al*., 2019).

Herbage Yield:

Plot 1 recorded the highest herbage yield (113 gm^{-2} ha^{-1}), followed closely by Plot 3 (110 gm^{-2} ha^{-1}), while Plot 2 yielded the least (100.5 gm^{-2} ha^{-1}). Studies have shown that diverse plant communities often have higher primary productivity due to niche complementarity and efficient resource use (Craven *et al*., 2016; Xu *et al.*, 2020).

Environmental Stress Factor (E):

Plot 1 experienced the highest environmental stress (E = 32.40), whereas Plot 3 had the lowest (E = 19.15). Interestingly, even with higher stress, Plot 1 maintained both high diversity and productivity. This supports the idea that biodiversity can buffer ecosystems against stress, enhancing their resilience (Loreau & de Mazancourt, 2016; Li *et al.*, 2018).

It is evident that, Plot 1 demonstrated superior ecological balance and productivity, despite facing the highest environmental stress. This indicates a potentially resilient ecosystem structure. Plot 3, while experiencing lower stress, showed reduced diversity and evenness, which could affect long-term sustainability.

Plot 2 performed moderately across most parameters but had the lowest herbage yield. These findings highlight the importance of biodiversity in maintaining ecosystem function and resilience under varying stress conditions (Isbell *et al*., 2017; Xu *et al., 2020).*

COMMUNITY STABILITY AND SPECIES ASYNCHRONY

Table 4.2 presents the values of community stability and species asynchrony across three different experimental plots. Community stability is a key indicator of how consistently an ecosystem maintains its productivity or biomass over time despite environmental fluctuations. Species asynchrony, on the other hand, measures the degree to which individual species in a community respond differently to environmental variations, thereby stabilizing overall community function (Loreau & de Mazancourt, 2008; Hautier *et al*., 2014).

Table 4.2: COMMUNITY STABILITY AND SPECIES ASYNCHRONY

	Plot1	**Plot 2**	**Plot 3**
Community Stability	1.385	15.89	0.302
Species Asynchrony	0.957	0.452	0.966

Plot 1 recorded a community stability of 1.385 and a species asynchrony value of 0.957, indicating a moderate level of stability likely influenced by a high degree of compensatory dynamics among species. This suggests that when some species experience a decline, others compensate by increasing in abundance, maintaining the overall stability of the community.

Plot 2 showed a significantly higher community stability value of 15.89 but a relatively lower species asynchrony of 0.452. This may imply that high stability here is not primarily driven by asynchrony among species but could result from dominance by one or a few highly stable species or favorable abiotic conditions this is in consonance with (Tilman *et al.*, 2006). Plot 2 was found to be dominated by members of Combretaceae.

Plot 3 recorded the lowest community stability (0.3024), despite having the highest species asynchrony (0.966). This indicates that although individual species responded differently to environmental changes, the community as a whole remained unstable—this is due to low species abundance or poor resilience of dominant species (de Mazancourt *et al.*, 2013).

From the foregoing, it is evident that, while species asynchrony can promote ecosystem stability, it is not the sole determinant. Other factors such as species diversity, functional traits, and environmental conditions also play crucial roles.

SOIL CHARACTERISTICS

Table 4.3 presents a comprehensive summary of the physicochemical properties of soil samples collected from three experimental plots. Soil quality and nutrient availability are key factors influencing plant productivity, species distribution, and overall ecosystem functioning (Brady & Weil, 2016; Lal, 2015). The parameters analyzed include soil pH, organic carbon (OC), organic matter (OM), total nitrogen (TN), electrical conductivity (EC), macro-nutrient concentrations (P, Na, K, Ca, Mg), total exchangeable bases (TEB), exchangeable acidity, and effective cation exchange capacity (ECEC).

Table 4.3: SOIL ANALYSIS RESULTS ACROSS THE STUDY AREA.

	Plot 1	Plot 2	Plot 3	$\bar{X}$
pH in H$_2$0	5.70	6.70	6.90	6.43
pH in KCL	4.60	5.24	5.30	5.04
% OC	0.48	1.01	1.24	0.91
% OM	1.95	2.15	1.50	1.86
%TN	0.038	0.095	1.01	0.381

EC Ms/kg	0.22	0.19	0.19	0.20
P mg/kg	2.99	2.89	3.56	3.15
Na	0.45	0.95	0.92	0.77
K	1.35	1.80	1.95	1.70
Mh	1.59	1.99	1.78	1.79
Ca	3.15	3.98	4.10	3.74
TEB	6.54	8.72	8.75	7.33
Ex Acidity	1.17	1.02	1.15	1.11
ECEC	8.99	10.35	10.80	10.05

OC= Organic Carbon, OM= Organic Matter, TN= Total Nitrogen, EC=Electrical Conductivity, P=Phosphorus, TEB= Total Exchangeable Bases, ECEC= Effective Cation

Exchange Capacity.

Soil pH: Plot 1 recorded the lowest pH in both water (5.70) and KCl (4.60), indicating more acidic conditions compared to Plot 2 (6.70 and 5.24) and Plot 3 (6.90 and 5.30). Soil pH is a critical factor affecting nutrient solubility and microbial activity. Soils with pH between 6 and 7 are generally optimal for plant growth (Fageria & Baligar, 2008).

Organic Carbon (OC) and Organic Matter (OM): Plot 3 showed the highest OC (1.24%) and OM (1.50%), followed by Plot 2. These values indicate moderate soil fertility levels, with organic matter playing a key role in soil structure, water retention, and nutrient supply (Six *et al.*, 2002).

Total Nitrogen (TN): Nitrogen availability varied significantly, with Plot 3 having the highest TN (1.01%), while Plot 1 had only 0.038%, indicating nitrogen limitation which can constrain plant productivity (Vitousek *et al.*, 2010).

Electrical Conductivity (EC) values were uniformly low (0.19–0.22 Ms/kg), suggesting that salinity is not a limiting factor in these plots.

Macronutrients:

- Phosphorus (P) levels ranged from 2.89 to 3.56 mg/kg, with Plot 3 having the highest value. This is beneficial as phosphorus supports root development and energy transfer in plants.
- Potassium (K) and Calcium (Ca) were highest in Plot 3 (1.95 and 4.10 respectively), which may contribute to stronger plant structure and stress resistance.
- Sodium (Na) levels were relatively low across all plots, minimizing the risk of sodicity.
- Magnesium (Mg) ranged from 1.59 to 1.99, with the highest in Plot 2.
- Total Exchangeable Bases (TEB) and Effective Cation Exchange Capacity (ECEC) were highest in Plot 3 (TEB = 8.75, ECEC = 10.80), indicating a high capacity to retain and supply essential nutrients, crucial for long-term soil fertility (Bationo *et al.*, 2012).
- Exchange Acidity was slightly higher in Plot 1 (1.17), potentially affecting nutrient availability negatively in more acidic soils.

These soil characteristics collectively suggest that Plot 3 has the most favorable conditions for sustainable plant growth due to its higher nutrient availability and buffering capacity. Plot 1, with low nitrogen, organic carbon, and higher acidity, may require soil amendments for improved productivity.

ABOVE GROUND BIOMASS

Table 4.4 presents the distribution of above-ground biomass (AGB) among different tree families across the three sampled plots in the study area. The values represent the estimated biomass contribution ($Kgm^{-2}ha^{-1}$) of each family, showing how biomass is partitioned across species groups and sites.

The *Combretaceae* family recorded the highest contribution to biomass across the plots, with a cumulative value of 0.8381 $Kgm^{-2}ha^{-1}$, largely due to its dominance in Plot 1 (0.6782 $Kgm^{-2}ha^{-1}$). This indicates the ecological importance of *Combretaceae* as a major biomass accumulator in the savanna woodland. The Fabaceae family followed closely with a total of 0.5363 $Kgm^{-2}ha^{-1}$, reflecting its wide distribution and ability to fix nitrogen, which enhances growth and contributes to ecosystem productivity.

Other families such as *Rubiaceae* (0.0941 $Kgm^{-2}ha^{-1}$), *Annonaceae* (0.0814 $Kgm^{-2}ha^{-1}$), and *Anarcadiaceae* (0.0671 $Kgm^{-2}ha^{-1}$) contributed moderately to the total biomass, while families like *Ebenaceae, Meliaceae, Verbenaceae*, *Moraceae*, and *Mimosaceae* showed relatively low biomass values, each below 0.06 $Kgm^{-2}ha^{-1}$. These variations reflect differences in tree size, abundance, and ecological strategies of the families.

The results suggest that biomass accumulation in the study area is unevenly distributed among families, with *Combretaceae* and *Fabaceae* contributing the bulk of the above-ground biomass. This dominance may be linked to their adaptive capacity in savanna ecosystems, particularly in terms of drought tolerance, resource acquisition, and regeneration strategies.

Conversely, the lower biomass values of other families may indicate either lower abundance or smaller individual tree sizes. Overall, the findings highlighted that a few dominant families drive biomass storage in the Osara savanna woodland, while several other families contribute only marginally. This pattern aligns with previous studies showing that tree biomass in tropical savannas is often concentrated in specific functional groups with high ecological competitiveness (Sankaran *et al.*, 2023; Lehmann *et al.*, 2011).

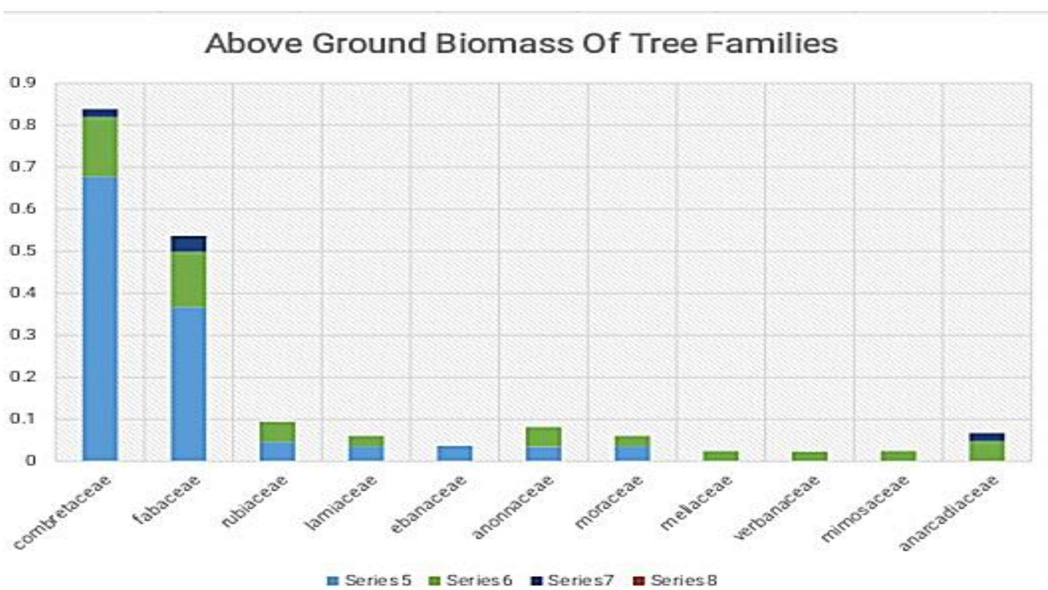

Fig 4.1. Above Ground Biomass of Tree Family.

DIAMETER AT BREAST HEIGHT (DBH) AND REGENERATION CAPACITY

Highest representative was observed in the 2.5–10 cm DBH class, dominated by members Fabaceae and Combretaceae. As diameter classes increases, the number of representative families declines, with minimal representation beyond the 30–40 cm class.

The total vulnerability count shows that Fabaceae is the most affected family, followed by Combretaceae and Rubiaceae.

This suggests that younger or smaller-sized individuals are more susceptible, likely due to environmental stressors or anthropogenic disturbances, this result is in accordance with the work of Chazdon *et al.*, 2009.

Plot 2 shows the highest number of vulnerable individuals in the 10–20 cm DBH range, indicating a concentration of susceptible vegetation in early sapling stages.

Vulnerable species here are more diverse, including families like Fabaceae, Combretaceae, Meliaceae, Verbenaceae, and others.

A notable drop-off occurs after the 30 cm DBH class, and no individuals was recorded above 30–40 cm. The high family diversity in this class implies that broad-spectrum ecological pressures might be influencing early plant growth stages, hence a very high community stability observed despite majority of individuals were mere saplings and juveniles of arborescent individuals under normal circumstances. (Laurance *et al*., 2011). Plot 3 also showed similar size diversity as plot 1 and 2, Only class group found in 10-20cm, and 20-30 cm DBH groups were represented. Only three families are involved: *Anarcadiaceae*, *Combretaceae, and Fabaceae*. The limited distribution and diversity suggest that this plot may be highly disturbed and hence hold a great potential ecologically stability as seen in the study, the fact that majority of the woody species here fall within this category may increase the regeneration capacity of the environment. (Parrotta *et al.*, 1997).

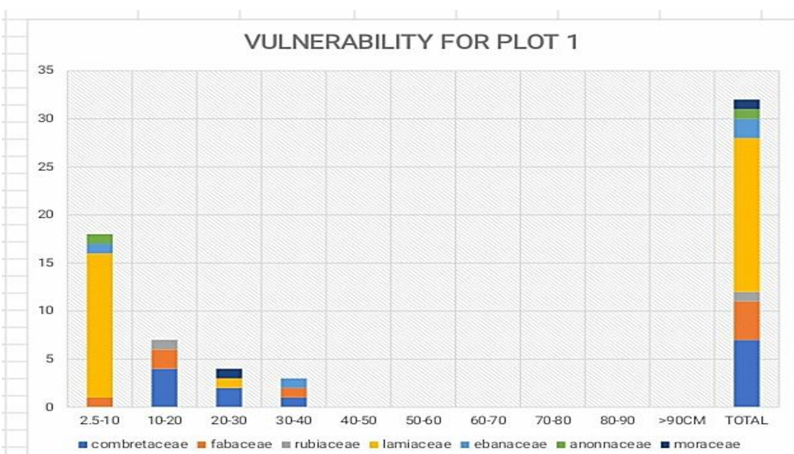

Fig 4.2. Vulnerability of Vegetation for Plot

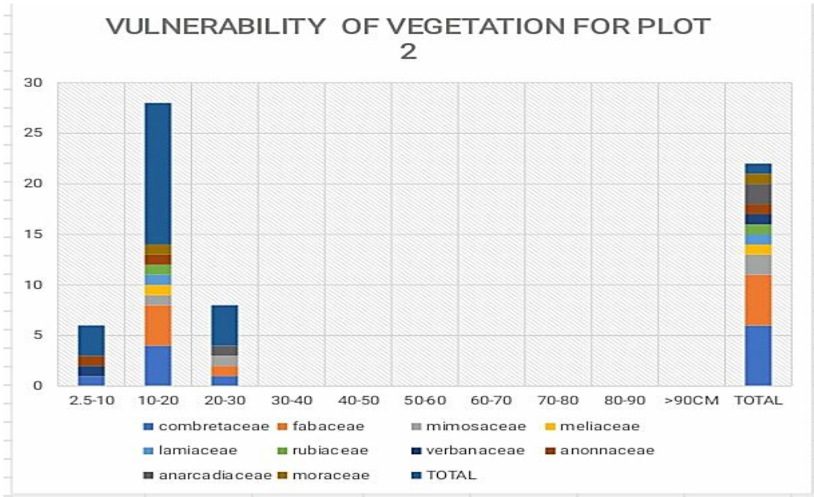

Fig 4.3. Vulnerability of Vegetation for Plot 2

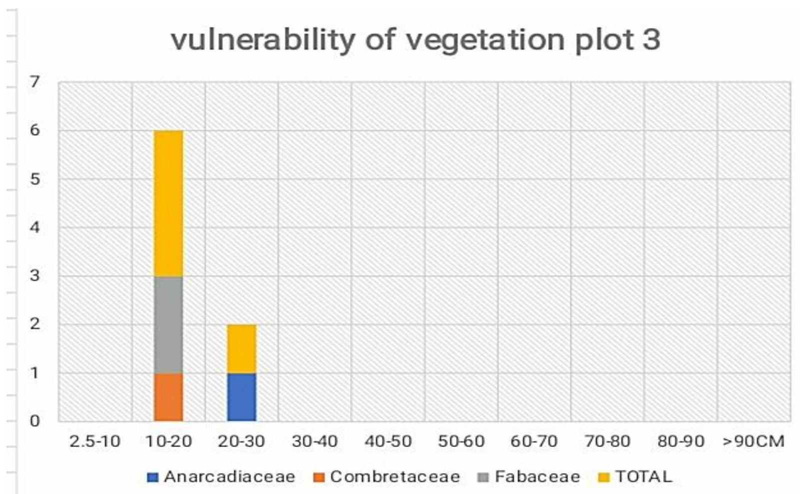

Fig 4.4. Vulnerability of Vegetation for Plot 3

Smaller DBH classes (2.5–30 cm) are consistently the most abundant plants across all plots, reflecting the critical stages of plant development they reflect ecological threats that the environment is exposed to over a long period of time like grazing, trampling, or drought, charcoal production, slash and burn Agriculture and lumbering activities as observed in the study area, similar results has reported by (Poorter *et al.*, 2016). Fabaceae and Combretaceae appear frequently across all plots, highlighting their ecological significance and vulnerability to further degradation in the studied environment. Plot 2 shows the widest diversity and highest vulnerability, while Plot 3 reflects minimal vulnerability, possibly indicating variations in land use, canopy cover, or soil conditions among the plots this results slightly deviate from the other two plots because of few species recorded in the study plot.

This study investigated how tree species diversity, tree size variation, and soil characteristics influence above-ground biomass (AGB) in the heterogeneous tropical savanna woodland of Osara, Kogi State, Nigeria. Three plots—representing charcoal production areas, cultivated/disturbed lands, and relatively undisturbed woodland—were assessed for vegetation composition, DBH, herbage yield, soil nutrients, and community stability. Results showed that Plot 1, despite facing the highest environmental stress, had the highest species diversity (H' = 4.552), evenness, and herbage yield, indicating resilience linked to biodiversity. Plot 2 exhibited the highest community stability (15.89) but low species asynchrony, while Plot 3 had the most fertile soil and highest nutrient retention capacity but the lowest diversity and stability.

AGB was dominated by the families Combretaceae (0.8381 kg/m²/ha) and Fabaceae (0.5363 kg/m²/ha), with other families contributing minimally. Vulnerability analysis revealed that smaller DBH classes (2.5–30 cm) were most susceptible across all plots, particularly in disturbed areas, with Fabaceae and Combretaceae consistently being the most dominant families and requires timely targeted conservation efforts. Soil analysis showed that higher organic carbon, nitrogen, and base cation levels corresponded with greater biomass potential, while nutrient-poor, acidic soils constrained productivity. Overall, the findings highlight that biodiversity and soil fertility jointly shape biomass accumulation and ecosystem resilience in savanna woodlands. Management strategies should prioritize protecting regenerating size classes, enhancing soil fertility, and curbing unsustainable human activities such as charcoal production and over-harvesting to sustain productivity and ecological balance.

5.0 CONCLUSIONS

The study revealed that balanced tree size distribution, supported greater AGB despite high environmental stress. This underscores the role of biodiversity in maintaining productivity and resilience in disturbed savanna ecosystems. The result showed that the family Combretaceae and Fabaceae accumulated more biomass in the area.

Soil fertility varied markedly between plots, while part of the study area having the highest nutrient levels (organic carbon, nitrogen, potassium, and calcium) and nutrient retention capacity (ECEC), part of the field had more acidic, nitrogen-poor soils that limited biomass growth. Nitrogen availability varied significantly, with Plot 3 having the highest TN (1.01%), while Plot 1 had only 0.038%, indicating nitrogen limitation which can constrain plant productivity (Vitousek *et al.*, 2010). Smaller DBH classes (2.5–30 cm) were most vulnerable across all sites, particularly in disturbed plots, indicating that regeneration is at risk from human activities such as charcoal production and cultivation. However, the presence of these size classes in all plots suggests ongoing but fragile regeneration potential. Human disturbances—charcoal production, logging, and cultivation—reduced diversity, altered size structure, and lowered AGB in affected plots. Less disturbed areas had better soil fertility and regeneration potential, emphasizing the need for sustainable land management to safeguard biomass and ecosystem stability.

REFERENCES

Bationo, A., Waswa, B., Kihara, J., & Kimetu, J. (2012). "Advances in integrated soil fertility management in sub-Saharan Africa" *Challenges and opportunities. Springer*.

Brady, N. C., & Weil, R. R. (2016). *The nature and properties of soils* (15th ed.). *Pearson Education*.

Bond, W. J. (2008). What limits trees in C_4 grasslands and savannas? *Annual Review of Ecology, Evolution, and Systematics*

39(1),641–659. https://doi.org/10.1146/annurev.ecolsys.39.110707.173411

Bunker, R. M., DeClerck, F., Bradford, J. C., Colwell, R. K., Perfecto, I., Phillips, O. L., ... & Naeem,

S. (2005). "Species loss and aboveground carbon storage in a tropical forest". *Journal of Science*310(5750),1029–1031. https://doi.org/10.1126/science.1117682

Chave, J., Réjou-Méchain, M., Búrquez, A., Chidumayo, E., Colgan, M. S., Delitti, W. B. C., ... & Vieilledent, G. (2014). "Improved allometric models to estimate the aboveground biomass of tropical trees". *Journal of Global Change Biology*, 20(10), 3177–3190. https://doi.org/10.1111/gcb.12629

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., ... & Yamakura, T. (2005). "Tree allometry and improved estimation of carbon stocks and balance in tropical forests". *Journal Global Change Biology*,11(4), 759–770. https://doi.org/10.1111/j.1365-2486.2005.00937.x

Chazdon, R. L., Peres, C. A., Dent, D., Sheil, D., Lugo, A. E., Lamb, D., ... & Miller, S. E. (2009). "The potential for species conservation in tropical secondary forests". *Journal of Conservation Biology*, 23(6), 1406–1417. https://doi.org/10.1111/j.1523-1739.2009.01338.x

Chisholm, R. A., Muller-Landau, H. C., Abdul Rahman, K., Bebber, D. P., Bin, Y., Bohlman, S. A., ... & Condit, R. (2013). "Scale-dependent relationships between tree species richness and ecosystem function in forests". *Journal of Ecology*, 101(5), 1214–1224. https://doi.org/10.1111/1365-2745.12132

Clinebell, H. J., Phillips, O. L., Gentry, A. H., Stark, N., & Zuuring, H. (1995). "Prediction of neotropical tree and liana species richness from soil and climatic data". *Journal of Ecology*, 83(3), 411–424. https://doi.org/10.2307/2261593

Fageria, N. K., & Baligar, V. C. (2008). "Ameliorating soil acidity of tropical oxisols by liming for sustainable crop production". *Advances in Agronomy*, 99, 345–399.

Craven, D., Eisenhauer, N., Pearse, W. D., Hautier, Y., Isbell, F., Roscher, C., ... & Reich, P. B. (2016). "Plant diversity effects on grassland productivity are robust to both nutrient enrichment and drought. Philosophical Transactions of the Royal Society B". *Journal of Biological Sciences*, 371(1694), 20150277. https://doi.org/10.1098/rstb.2015.0277

De Mazancourt, C., Isbell, F., Larocque, A., Berendse, F., De Luca, E., Grace, J. B., ... & Loreau, M. (2013). "Predicting ecosystem stability from community composition and biodiversity". *Ecology Letters*, 16(5), 617–625. https://doi.org/10.1111/ele.12088

Duivenvoorden, J. F. (1996). "Tree species composition and rainforest–environment relationships in the middle Caquetá area, Colombia, Amazonia". *Journal of Tropical Ecology*, 12(4), 445–466. https://doi.org/10.1017/S0266467400009626

Dybzinski, R., Fargione, J., Zak, D. R., Fornara, D., & Tilman, D. (2008). "Soil fertility increases with plant species diversity in a long-term biodiversity". *Journal of Oecologia*, 158(1), 85–93. https://doi.org/10.1007/s00442-008-1123-x

Enright, N. J., Goldblum, D., Ata, P., & Ashton, D. H. (1994). "Destruction of seed banks by ground fire in some Australian plant communities". *Journal of Ecology*, 82(2), 213–225. https://doi.org/10.2307/2261398

https://doi.org/10.1016/S0065-2113(08)00407-0

Feldpausch, T. R., Banin, L., Phillips, O. L., Baker, T.

R., Lewis, S. L., Quesada, C. A., ... & Lloyd, J. (2012). "Tree height integrated into pantropical forest biomass". *Journal of Biogeosciences*, 9(8), 3381–3403. https://doi.org/10.5194/bg-9-3381-2012

Finegan, B., Peña-Claros, M., de Oliveira, A., Ascarrunz, N., Bret-Harte, M. S., Carreño-Rocabado, G., ... & Poorter, L. (2015). "Does functional trait diversity predict above-ground biomass and productivity in tropical forests?". *Forest Ecology and Management*, 356, 21–31. https://doi.org/10.1016/j.foreco.2015.08.018

Hautier, Y., Isbell, F., Borer, E. T., Seabloom, E. W., Harpole, W. S., Lind, E. M., ... & Hector, A. (2014). "Anthropogenic environmental changes affect ecosystem stability via biodiversity". *Science*, 344(6181), 151–154. https://doi.org/10.1126/science.1248225

Higgins, S. I., Bond, W. J., & Trollope, W. S. W. (2000). "Fire, resprouting and variability: A recipe for grass–tree coexistence in savanna". *Journal of Ecology*, 88(2), 213–229. https://doi.org/10.1046/j.1365-2745.2000.00435.x

Isbell, F., Cowles, J., Dee, L. E., Loreau, M., Reich, P. B., Gonzalez, A., ... & Tilman, D. (2015). Laurance, W. F., Goosem, M., & Laurance, S. G. W. (2012). "Impacts of roads and linear clearings on

tropical forests". *Biological Conservation*, 156, 136–

Laurance, W. F., Camargo, J. L. C., Luizão, R. C. C., Laurance, S. G., Pimm, S. L., Bruna, E. M., … Lovejoy, T. E. (2011). "The fate of Amazonian forest fragments: A 32-year investigation". *Biological Conservation*, 144(1), 56–67. https://doi.org/10.1016/j.biocon.2010.09.021

Lehmann, C. E. R., Archibald, S. A., Hoffmann, W. A., & Bond, W. J. (2011). "Deciphering the

"Biodiversity increases the resistance of ecosystem productivity to climate extremes". *Nature*, 526(7574), 574–577. https://doi.org/10.1038/nature15374

Jakovac, C. C., Peña-Claros, M., Kuyper, T. W., & Bongers, F. (2016). "Land use as a filter for species composition in Amazonian secondary forests". *Forest Ecology and Management*, 362, 110–119. https://doi.org/10.1016/j.foreco.2015.11.035

Jew, E., Dougill, A. J., Sallu, S. M., O'Connell, J., & Benton, T. G. (2016). "Rapid land use change threatens provisioning ecosystem services in miombo woodlands". *Journal of Ecosystem Services*, 18, 75–86. https://doi.org/10.1016/j.ecoser.2016.02.004

Keenan, T. F., Prentice, I. C., Canadell, J. G., Williams, C. A., Wang, H., Raupach, M., & Collatz, G. J. (2015). "Recent pause in the growth rate of atmospheric CO_2 due to enhanced terrestrial carbon uptake". *Environmental Research Letters*, 10(9), 094020. https://doi.org/10.1088/1748-9326/10/9/094020

Lal, R. (2015). "Restoring soil quality to mitigate soil degradation". *Sustainability*, 7(5), 5875–5895. https://doi.org/10.3390/su7055875

148.

https://doi.org/10.1016/j.biocon.2011.12.020

distribution of the savanna biome". *Journal of Ecology*, 99(3), 923–935. https://doi.org/10.1111/j.1365-2745.2011.01821.x

Li, Y., Shipley, B., Price, J. N., De Frenne, P., & Ma, S. (2018). "Biodiversity maintains ecosystem productivity under environmental stress". *Global Ecology and Biogeography*, 27(9), 1033–1044. https://doi.org/10.1111/geb.12765

Loreau, M., & de Mazancourt, C. (2008). "Species synchrony and its drivers: Neutral and nonneutral community dynamics in fluctuating environments". *The American Naturalist*, 172(2), E48–E66. https://doi.org/10.1086/589746

Loreau, M., & de Mazancourt, C. (2016). "Biodiversity and ecosystem stability: A synthesis of underlying mechanisms". *Ecology Letters*, 16(S1), 106–115. https://doi.org/10.1111/ele.12073

Loreau, M., Naeem, S., Inchausti, P., Bengtsson, J., Grime, J. P., Hector, A., … Wardle, D. A. (2001). "Biodiversity and ecosystem functioning: Current knowledge and future challenges". *Science*, 294(5543), 804–808. https://doi.org/10.1126/science.1064088

Lupala, Z. J., Lusambo, L. P., Ngaga, Y. M., & Malimbwi, R. E. (2014). "Land use and cover change in miombo woodlands under community-based forest management in Tanzania". *Forest Ecology and Management*, 318, 96–106. https://doi.org/10.1016/j.foreco.2014.01.022

Madoffe, S. S., Hertel, G. D., Rodgers, W. A., O'Connell, B. M., & Killenga, R. (2012). "Forest condition assessment in the Eastern Arc Mountains of Tanzania". *African Journal of Ecology*, 50(1), 136–149. https://doi.org/10.1111/j.1365-2028.2011.01301.x

Malhi, Y., Wood, D., Baker, T. R., Wright, J., Phillips, O. L., Cochrane, T., … Vinceti, B. (2006). "The regional variation of aboveground live biomass in old-growth Amazonian forests". *Global Change Biology*, 12(7), 1107–1138. https://doi.org/10.1111/j.1365-2486.2006.01120.x

Parrotta, J. A., Turnbull, J. W., & Jones, N. (1997). "Catalyzing native forest regeneration on degraded tropical lands". *Forest Ecology and Management*, 99(1–2), 1–7. https://doi.org/10.1016/S0378-1127(97)00190-4

Poorter, L., Bongers, F., Aide, T. M., Almeyda Zambrano, A. M., Balvanera, P., Becknell, J. M., … Rozendaal, D. M. A. (2016). "Biomass resilience of Neotropical secondary forests". *Nature*, 530(7589), 211–214. https://doi.org/10.1038/nature16512

Poorter, L., van der Sande, M. T., Thompson, J., Arets, E. J. M. M., Alarcón, A., Álvarez-Sánchez, J., … Peña-Claros, M. (2015). "Diversity enhances carbon storage in tropical forests" *Ecology Letters*, 18(7), 727–735. https://doi.org/10.1111/ele.12494

Sankaran, M., Ratnam, J., & Hanan, N. P. (2023). "Woody cover in African savannas: The role of resources, fire and herbivory". *Nature Ecology & Evolution*, 7(1), 1–12. https://doi.org/10.1038/s41559-022-01987-9

Six, J., Conant, R. T., Paul, E. A., & Paustian, K. (2002). "Stabilization mechanisms of soil organic matter: Implications for C-saturation of soils". *Plant and Soil*, 241, 155–176. https://doi.org/10.1023/A:1016125726789

Slik, J. W. F., Aiba, S. I., Brearley, F. Q., Cannon, C. H., Forshed, O., Kitayama, K., … van Valkenburg, J. L. C. H. (2013). "Large trees drive forest aboveground biomass variation in moist lowland forests across the tropics". Global *Ecology and Biogeography*, 22(7), 685–695. https://doi.org/10.1111/geb.12092

Sullivan, S. D., Bullock, J. M., & Tallowin, J. R. B. (2017). "Ecological restoration of temperate grasslands": A comprehensive review. *Forest Ecology and Management*, 398, 85–94. https://doi.org/10.1016/j.foreco.2017.04.038

Tilman, D., Isbell, F., & Cowles, J. M. (2016). "Biodiversity and ecosystem functioning". *Annual Review of Ecology, Evolution, and Systematics*, 45, 471–493. https://doi.org/10.1146/annurev-ecolsys-120213-091917

Tilman, D., Reich, P. B., & Knops, J. M. (2006). "Biodiversity and ecosystem stability in a decade-long grassland experiment". *Nature*, 441(7093), 629–632. https://doi.org/10.1038/nature04742

Vitousek, P. M., Porder, S., Houlton, B. Z., & Chadwick, O. A. (2010). "Terrestrial phosphorus limitation: Mechanisms, implications, and nitrogen–phosphorus interactions" *Ecological Applications*, 20(1), 5–15. https://doi.org/10.1890/08-0127.1

Wang, S., Loreau, M., & Cardinale, B. J. (2019). "Ecosystem stability and compensatory effects in ecosystems". *Nature Communications*, 10(1), 1340. https://doi.org/10.1038/s41467-019-09229-2

West, D. C., Shugart, H. H., & Ranney, J. W. (2009). "Climate change and the distribution of tree species in temperate forests" *Ecology Letters*, 12(3), 234–245. https://doi.org/10.1111/j.1461-0248.2009.01289.x

Wright, S. J., Hernandez, A., & Condit, R. (2011). "Ecological effects of deforestation in tropical forests". *Ecology*, 92(7), 1232–1240. https://doi.org/10.1890/10-0033.1

Xu, X., Liu, W., Zhang, C., & Lu, P. (2020). "Plant diversity enhances productivity and soil carbon storage". *Science of The Total Environment*, 714, 136744. https://doi.org/10.1016/j.scitotenv.2020.136744

Yuanfa, L., Wei, L., Cheng, Z., & Ping, L. (2023). "Forest management practices and their impact on ecosystem services in temperate forests". *Forests*, 14(2), 373. https://doi.org/10.3390/f14020373

APPENDIX

Appendix 1 Plot 1 Above ground Biomass

Combretum laxifolia	Combretacea	0.0158kgm^{-2}ha^{-1}
Piliostigma thoningii	Fabaceae	0.1082kgm^{-2}ha^{-1}
Combretum molle	Combretaceae	0.0360kgm^{-2}ha^{1}
Combretum ghaselense	Combretaceae	0.1495kgm^{-2}ha^{-1}
Piliostigma Sp.	Fabaceae	0.1094kgm^{-2}ha^{-1}
Anogeisus leiocarpus	Combretaceae	0.1657kgm^{-2}ha^{-1}
Danielle oliverii	Fabaceae	0.0783kgm^{-2}ha^{-1}
Combretum laxifolia	Combretaceae	0.1422kgm^{-2}ha^{-1}
Combretum Sp	Combretaceae	0.1319kgm^{-2}ha^{-1}

Nauclea leucocephala	Rubiaceae	$0.0109kgm^{-2}ha^{-1}$
Tectona grandis	Lamiaceae	__
Diospyros mespiliformes	Ebenaceae	$0.0369kgm^{-2}ha^{-1}$
Gardenia aqualla	Rubiaceae	$0.0356kgm^{-2}ha^{-1}$
Anonna Senegalensis	Anonnaceae	$0.0346kgm^{-2}ha^{-1}$
Ficus polita	Moraceae	$0.0362kgm^{-2}hg^{-1}$
Gmelina arborea	Lamiaceae	$0.0361kgm^{-2}hg^{-1}$
Anogeissus latifolia	Combretaceae	$0.0370kgm^{-2}hg^{-1}$
Prosopis africana	Fabaceae	$0.0371kgm^{-2}hg^{-1}$
Pterocarpus erinaceus	Fabaceae	$0.0347kgm^{-2}hg^{-1}$

Mean $\bar{X}$= 0.0687//

S^2 and d

S^2= 0.00246173

***d*= 0.0496**

Appendix 2: Plot 2 Above Ground Biomass

Anogeisus leiocarpus	Combretaceae	$0.0239kgm^{-2}hg^{-1}$
Anogeisus laxifolia	Combretaceae	$0.0210kgm^{-2}hg^{-1}$
Daniella canadensis	Fabaceae	$0.0207kgm^{-2}hg^{-1}$
Pterocarpus Sp.	Fabaceae	$0.0206kgm^{-2}hg^{-1}$
Daniella oliveri	Fabaceae	$0.0207kgm^{-2}hg^{-1}$
Piliostigma thonningii	Fabaceae	$0.0207kgm^{-2}hg^{-1}$
Azadirachta indica	Meliaceae	$0.0241kgm^{-2}hg^{-1}$
Tectona grandis	Lamiaceae	$0.0240kgm^{-2}hg^{-1}$
Gardenia aqualla	Rubiaceae	$0.0237kgm^{-2}hg^{-1}$
Gmelina arborea	Lamiaceae	$0.0241kgm^{-2}hg^{-1}$
Anogeissus Sp.	Combretaceae	$0.0243kgm^{-2}hg^{-1}$
Vitex simplicifolia	Verbanaceae	$0.0231kgm^{-2}hg^{-1}$

Anonna senegalensis	Anonnaceae	$0.0228kgm^{-2}hg^{-1}$
Combretum ghaselense	Combretaceae	$0.0241kgm^{-2}hg^{-1}$
Combretum molle	Combretaceae	$0.0238kgm^{-2}hg^{-1}$
Pterocarpus Sp.	Fabaceae	$0.0242kgm^{-2}hg^{-1}$
Piliostigma Sp.	Fabaceae	$0.0240kgm^{-2}hg^{-1}$
Nauclea leucocephala	Rubiaceae	$0.0239kgm^{-2}hg^{-1}$
Anarcardium occidentale	Anarcardiaceae	$0.0241kgm^{-2}hg^{-1}$
Ficus Sp.	Moraceae	$0.0239kgm^{-2}hg^{-1}$
Combretum laxifolia	Combretaceae	$0.0240kgm^{-2}hg^{-1}$
Parkia biglobossa	Mimosaceae	$0.0243kgm^{-2}hg^{-1}$
Anonna senegalensis	Anonnaceae	$0.0240kgm^{-2}hg^{-1}$

$\bar{X}$= 0.0232

S^2=0.00000212

***d*=0.0014**

Appendix 1 Plot 3 Above Ground Biomass

Anarcardium occidentale	Anarcardiaceae	$0.0190kgm^{-2}hg^{-1}$
Anogeissus leiocarpus	Combretaceae	$0.0188kgm^{-2}hg^{-1}$
Daniella oliveri x	Fabaceae	$0.0189kgm^{-2}hg^{-1}$
Piliostigma thonningii	Fabaceae	$0.0189kgm^{-2}hg^{-1}$

$\bar{X}$=0.0189

S^2 = 0.00390

***d*=0.0625**

Appendix 2 Plot 1 Diversity Index

	Names	Family	n	Pi	lnpi	pilinpi	WD	D	DBH
1.	*Combretum laxifolia*	Combretaceae	12	0.078	-2.551	-0.199	0.791	0.960	19.41
2.	*Piliostigma thonningii*	Fabaceae	18	0.117	-2.145	-2.509	0.632	1.450	15.75
3.	*Combretum molle*	Combretaceae	10	0.065	-2.733	-0.178	0.758	0.806	18.14
4.	*Combretum ghaselense*	Combretaceae	4	0.026	-3.650	-0.095	0.791	0.322	21.85
5.	*Piliostigma Sp.*	Fabaceae	5	0.033	-3.411	-0.113	0.632	0.403	14.38
6.	*Anogeissus leiocarpus*	Combretaceae	49	0.320	-1.139	-0.364	0.800	3.950	14.21
7.	*Daniella oliverii*	Fabaceae	20	0.130	-2.040	-0.265	0.493	1.612	20.05
8.	*Combretum laxifolia*	Combretaceae	5	0.033	-3.411	-0.112	0.791	0.403	29.30
9.	*Combretum sp.*	Combretaceae	10	0.065	-2.733	-0.178	0.791	0.806	16.78
10.	*Nauclea leucocephala*	Rubiaceae	2	0.013	-4.343	-0.056	0.607	0.161	15.12
11.	*Tectona grandis*	Lamiaceae	8	-	-	-	0.601	-	-
12.	*Diospyros sp.*	Ebenaceae	1	0.006	-5.116	-0.031	0.697	0.081	33.73
13.	*Gardenia aqualla*	Rubiaceae	4	0.026	-3.650	-0.095	0.670	0.322	14.48
14.	*Anonna senegalensis*	Anonnaceae	6	0.039	-3.244	-0.130	0.511	0.483	8.020

15.	*Ficus polita*	Moraceae	1	0.006	-5.116	-0.031	0.411	0.081	25.46
16.	*Gmelina arborea*	Lamiaceae	3	0.020	-3.912	-0.078	0.429	0.242	23.97
17.	*Anogeissus latifolia*	Combretaceae	1	0.006	-5.116	-0.031	0.780	0.081	33.10
18.	*Prosopis africana*	Fabaceae	1	0.006	-5.116	-0.031	0.879	0.081	33.41
19.	*Pterocarpus errinaceus*	Fabaceae	2	0.013	-4.343	-0.056	0.056	0.161	7.79
	Total		**154**			**-4.552**			

D= 0.081-3.950

H'=4.552

E=2.081

Appendix 2 Plot 2 Diversity Index

Name	**Family**	**n**	**Pi**	*lnpi*	*pilinpi*	**WD**	**D**	**DBH**
Anogeissus leiocarpus	Combretaceae	60	0.366	-1.005	-0.370	0.800	4.683	14.08
Anogeissus laxifolia	Combretaceae	16	0.098	-2.322	-0.230	0.780	1.249	9.23
Daniella oliveri	Fabaceae	3	0.018	-4.017	-0.072	0.493	0.234	12.30
Pterocarpus Sp.	Fabaceae	1	0.006	-5.116	-0.031	0.587	0.078	17.50
Daniella Sp.	Fabaceae	20	0.122	-2.104	-0.260	0.460	1.156	20.13

Piliostigma thonningii	Fabaceae	2	0.012	-4.423	-0.053	0.632	0.156	13.21
Entalda africana	Mimosaceae	1	0.006	-5.116	-0.031	-	0.078	10.50
Azadirachta indica	Meliaceae	4	0.024	-3.730	-0.090	0.640	0.312	17.46
Tectona grandis	Lamiaceae	31	0.189	-1.666	-0.315	0.601	2.420	17.46
Gardenia aqualla	Rubiaceae	2	0.012	-4.423	-0.053	0.670	0.156	23.39
Gmelina arborea	Lamiaceae	1	0.006	-5.116	-0.031	0.429	0.078	21.96
Anogeisus Sp.	Combretaceae	5	0.030	-3.510	-0.105	0.811	0.390	22.46
Vitex simplicifolia	Verbanaceae	1	0.006	-5.116	-0.031	0.548	0.078	4.77
Anonna senegalensis	Anonnaceae	1	0.006	-5.116	-0.031	0.511	0.078	3.00
combretum ghaselense	Combretaceae	4	0.024	-3.730	-0.090	0.791	0.312	17.42
Combretum molle	Combretaceae	3	0.018	-4.017	-0.072	0.758	0.234	11.56
Pterocarpus Sp.	Fabaceae	1	0.006	-5.116	-0.031	0.587	0.078	22.28
Piliostigma Sp.	Fabaceae	2	0.012	-4.403	-0.053	0.632	0.156	18.14
Nauclea leucocephala	Rubiaceae	1	0.006	-5.116	-0.031	0.607	0.078	15.50
Anarcardium occidentale	Anarcardiaceae	1	0.006	-5.116	-0.031	0.446	0.078	22.48
Ficus Sp.	Moraceae	1	0.006	-5.116	-0.031	0.411	0.078	15.91
Combretum laxifolia	Combretaceae	1	0.006	-5.116	-0.031	0.791	0.078	15.70
Parkia biglobossa	Mimosaceae	1	0.006	-5.116	-0.031	0.525	0.078	25.50
Anonna senegalensis	Anonnaceae	1	0.006	-5.116	-0.031	0.511	0.078	18.46

Total	**164**	**-2.135**

D= 0.078-4.683

H’=2.135

E=0.964

Appendix 2 Plot 3 Diversity index

Names	**Family**	**n**	**Pi**	*linpi*	*pilinpi*	**WD**	**D**	**DBH**
Anarcardium occidentale	Anarcardiaceae	100	0.794	-0.231	-0.183	0.446	8.913	25.14
Anogeissus leiocarpus	Combretaceae	16	0.127	-2.663	-0.338	0.800	1.430	12.73
Daniella oliveri	Fabaceae	2	0.016	-4.135	-0.066	0.493	0.178	19.09
Piliostigma thonningii	Fabaceae	8	0.063	-2.764	-0.174	0.632	0.713	15.91
Total		**126**			**-0.761**			

D= 0.178-8.913

H’=0.761

E=0.362