Avenue Tree Species Diversity, Stand Volume and Natural Regeneration Status Along the Faculty of Agriculture Road to NUGA Gate, Ahmadu Bello University Zaria

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Abstract

Forest trees species growing in and around forest estates required information to ensure sustainable management especially avenue trees in our tertiary educational institutions in Nigeria, which provided many ecosystem services such as species conservation, preservation of habitat for plants and animals, reservoirs for biodiversity, habitat to diverse animal species, sources of timber, medicinal plants, recreation activities, carbon sequestration, watershed protection and also form the livelihood for many different human settlements. This study assessed avenue tree species diversity, stand volume, and regeneration status of avenue trees planted along Faculty of Agriculture Road, from East-West Seed Site Roundabout to NUGA Gate, Ahmadu Bello University Main Campus, Zaria. A total enumeration approach was used, covering all avenue trees along a 18,750 m² stretch on both sides of the road. Tree height was measured using a Haga altimeter, DBH was also measured using a diameter tape, and the number of wildlings counted and recorded (≤ 30 cm height) within 2 m of each mature tree. Biodiversity indices were analyzed using the Shannon–Wiener and Pielou's Evenness formulas. Results revealed 14 species from 8 families, dominated by Meliaceae. The mean tree volume ranges from a minimum of 2.60m^3 for the Malvaceae family to a maximum of 56.99m^3 in the Meliaceae family. Khaya senegalensis and Azadirachta indica of Meliaceae had the highest mean volume (56.99m^3), while the lowest was recorded in Adansonia digitata (2.60m^3) of the Malvaceae family. The family of Meliaceae was regarded as the dominant family in the avenue with 48 tree species. Shannon-Weiner diversity index and species equitability index according to Pielou are 1.80 and 0.68, respectively, obtained for the study. This shows that the avenue tree species is biologically diverse. The regeneration potentials of most species are zero, owing to anthropogenic pressure on the mother trees, which would have produced the wildlings within the avenue, apart from a few species like Albizia lebbeck, with moderately high regeneration potential, and Khaya senegalensis, with low *regeneration potential. It is recommended that fast-growing, disease-tolerant, and shade avenue trees should be raised and planted by the University authorities to fill the gaps to obtain maximum productivity and a conducive learning environment for students and to improve the aesthetic view of the entire campus landscape. Also, frequent surveys and inventories of trees on campus should be conducted by relevant stakeholders to assess their abundance, distribution, and density, as well as structural and physical changes necessary for sustainable management practices.*

Keywords: Avenue Tree Species Diversity, Tree Growth Variables, Stand Volume, Natural Regeneration Status, Urban Forestry

Introduction

Tropical forests represent one of the most species-diverse terrestrial ecosystems. Their immense biodiversity generates a variety of natural resources, which help to sustain the livelihoods of local communities (Sodimu, 2016). Tropical rainforest is the support of life because of its richness in plant species composition (>250 plant species/hectare) and fauna diversity (>50% of animal species in the world). (Zakaria *et al.,* 2016). 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, covering about 30% of the total Earth's surface containing about 90% of the world's terrestrial biodiversity. Over the years, the forest has been a continuous source of wood, charcoal, and land for agricultural purposes. Biodiversity conservation and carbon storage are two significant, linked environmental ecosystem services. The concept of biodiversity has evolved rapidly during the past decades. It is widely accepted that biodiversity can be divided into three spheres: genetic diversity (within-species diversity), species diversity (number of species), and ecosystem diversity (diversity of communities) (Harper & Hawksworth, 1995). Typically, the focus is on species diversity and volume of avenue tree species. The relationship between biodiversity and ecosystem functioning and productivity has received increasing attention within the scientific community during the past decades (Sodimu *et al.,* 2024).

Biodiversity assessment has, therefore, developed to become an important part of conservation biology and functional ecology. Avenue tree Species diversity is a crucial concept of biodiversity and is intuitively simple yet conceptually complex. A quantitative assessment of tree species diversity and volume is thus essential for effective biodiversity conservation and management (Magurran, 2004). Measures of tree species diversity usually include two components: richness and evenness. Richness represents the total number of tree species within a given area, while evenness measures how similar tree species are in their abundances (Hurlbert, 1971). Species richness and evenness are two independent criteria that may differ in their responses to local habitat factors. However, overexploitation of floristic composition has resulted in the rapid loss of tree diversity, which has been recognized as a major environmental and economic threat around the world (Mani & Parthasarthy, 2006). It has been stated that 25–50% of the world's tropical rainforest has been lost and degraded due to economic exploitation and land-use change, such as deforestation (palm oil plantations, agriculture expansion, cattle ranches, mining, and development of housing societies) (Houghton, 2003; Castella *et.al.,*2005), while the rest of the rainforest areas is under a major shift in the dynamic structure and productivity. (Zakaria *et al.,* 2016).

Avenue trees, commonly planted along streets and campuses, provide cooling effects, filter air pollutants, and contribute significantly to carbon storage (Nowak & Crane, 2002). Their linear arrangement also improves microclimate regulation and supports pollinator movement (Jim, 2004). Avenue trees play critical roles in the biodiversity of the immediate areas, improving air quality, enhancing aesthetics, reducing heat, and contributing to climate regulation. In many cities and communities, including Zaria, avenue trees form an important part of the green infrastructure, providing shade, mitigating dust, and acting as carbon sinks that sequester atmospheric CO_2. Due to urbanization, the condition in the cities as per the environment point of view is at risk and alarming. However, the roadside plantations/tree avenues in the urban cities play a role not only in improving climatic conditions but also in significantly contributing to increasing the area under vegetation in the country. Trees growing along the roadside, either planted or grown naturally, are performing the ecological function not only to reduce the pollution load but also to sequester carbon and help mitigate climate change (Da Silva *et al.,* 2010; Singh & Singh, 2015). Additionally, the avenue trees in the urban environment are contributing toward many benefits, e.g. social benefits(recreational opportunities, improving physical/mental health); aesthetic benefits (landscape variations through different colors/textures/forms and densities of plants); climatic benefits (cooling, wind control, air pollution reduction, atmospheric carbon storage, impact on climate) and economic benefits (increased property values, tourism, providing fruits and small timber) Beyond these tangible benefits, they contribute to the urban aesthetic, offering spaces for social gatherings, spiritual activities, and physical exercise (Sheona *et al.,* 2015), while also enhancing the psychological well-being (Kuruneri-Chitepo and Shackleton, 2011) and overall health (Canetti *et al.,* 2018) of urban dwellers.

Avenue tree regeneration potential is described as the act of renewing tree cover by establishing a young tree naturally or artificially, after the previous stand or forest has been removed (Teketay, 2005). The method, species density, is chosen to meet the goal of the landowner. Regeneration can be natural (coppicing, self–sown seeds and root suckers or artificial (planting) (Sankar & Devi, 2024). Successful regeneration is indicated by the presence of a sufficient number of seedlings, saplings, and young trees in a given population, and the number of seedlings of any species can indicate the regeneration potential of that species (Negi & Nautiyal, 2005). Avenue tree regeneration is a central component for tropical forest ecosystem dynamics, and it's essential for preservation and maintenance of biodiversity (Rahman et. *al.,*2011). A stand may have sufficient seedlings per hectare; there may be areas where seedling density is below what is required to maintain site productivity and good tree form. Thus, regeneration potential in urban/avenue contexts is often limited by soil compaction, heat, and maintenance practices. Evaluating regeneration potential helps identify resilient species suitable for sustainable landscaping (Jim, 2004). Armenteras *et. al.,* (2009) reported that trees provided many ecosystem services such as species conservation, prevention of soil erosion, preservation of habitat for plants and animals, raw materials, reservoirs for biodiversity, habitat to diverse animal species, sources of timber, medicinal plants, recreation activities, carbon sequestration, watershed protection and also form the livelihood for many different human settlements, including 60 million indigenous people. Besides this, it is seen to contain up to 82% of the terrestrial plant biomass, which is interlinked with atmospheric CO_2 levels through the carbon cycle.

However, for effective management of tropical forests in a sustainable way, there is a need to estimate the growing stock of the forest. Information on the estimation of the growing stock guides forest managers in timber valuation, sustainable management, conservation, as well as in the allocation of forest areas for harvest for timber harvest. An estimate of growing stock is often expressed in terms of timber volume, which can be estimated from easily measurable tree dimensions. (Shamaki *et al.,* 2010). Besides this, the assessment of stem volume is becoming of great global interest, especially in the context of Kyoto protocol rules, where each nation has to maintain CO_2 emissions under a certain threshold, which must be calculated by taking into account both sources and sinks of CO_2 absorbed and stored in the trees. (Lindner and Karjalainen 2007; Tonolli *et al.,* 2011). Thus, having a detailed knowledge of the forest stem volume of a forest estate is indispensable in terms of management, timber allocation, and its power to sequester carbon. Evidence has pointed to how inadequate information on diversity and volume assessment of tree volume has resulted in poor forest policies, planning, and management in the forest estate (Bisong & Mfon, 2006). It has hampered efforts to reduce illegal and unsustainable extraction of forest resources and improve transparency. Also, it has resulted in the undervaluation of forest resources. According to FAO (2011), such conditions, in turn, could contribute to a continuous decline in area, health, stock, and flows of avenue forest resources and management. This research, therefore, aims to estimate the avenue tree species diversity, stand volume and natural regeneration status using Ahmadu Bello University, Zaria's Faculty of Agriculture Road to NUGA Gate as a case study.

Materials and Methods

Study Area

The study was carried out along the Faculty of Agriculture Road, from East-West Seed Site Roundabout to NUGA Gate, Ahmadu Bello University Main Campus, Zaria (11°09′ N, 7°38′ E). The area falls within the Northern Guinea Savannah ecological zone, characterized by a wet and dry season. The dry season is between the middle of October, on average (Jahake, 1982). Zaria has an annual rainfall of 100- 114 mm with relative humidity that ranges from 70-80% in August and about 15-20% in December. Daily temperature averages about 23.6°C in the month of April and about 23.3°C in August (Tanko, 2005). The road hosts several institutional buildings and residences, lined with mature trees on both sides (Figure 1)

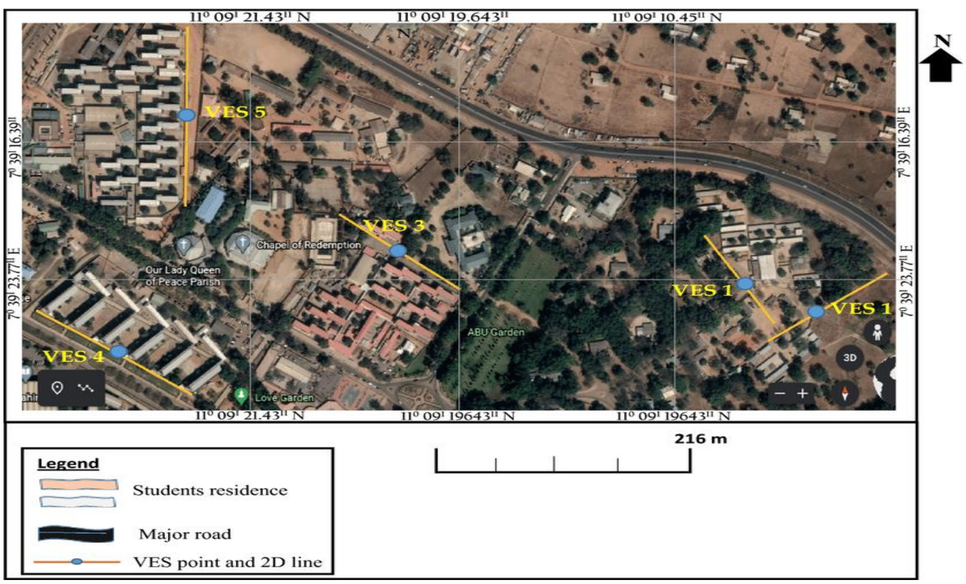

Figure 1: Map of ABU showing the major roads network

Sampling Techniques

A total enumeration approach was used, covering all avenue trees along a 1,250 m stretch on both sides of the road. The effective study area was approximately 1,250 m x 15m road = 18,750 m^2. Tree height was measured using a Haga altimeter, DBH was also measured using a diameter tape, and the number of wildlings counted and recorded (≤30 cm height) within 2 m of each mature tree**.** All trees that cannot be identified in the field were collected, placed in a plant press, and taken to the Department of Botany

Herbarium, Ahmadu Bello University, and Savanna Forestry Research Station for identification by taxonomists. DBH ≥10 cm was enumerated for the tree species diversity and abundance. Tree growth variables measured are the diameters at breast height (1.3m) using a diameter tape, and the total height using a Haga altimeter. Natural regeneration was evaluated by counting wildlings (≤30 cm in height) within 2 m of each mature tree. The average wildlings per tree were computed per species classes (Low: <0.2 wildlings/tree; Moderate: 0.2–0.5 wildlings/tree; High: >0.5 wildlings/tree)

Data Analysis

The data collected was analysed using the following formulae:

Basal area computation

The basal area of each avenue tree was calculated using the formula adopted from Zakaria *et. al.* (2016)

$$\mathbf{B.A}=\frac{\pi D^2}{4}\text{...}(1)$$

Where BA = Basal Area (m^2), D = DBH (m) and π=3.412

Tree volume computation

The total volume was calculated for each tree using the formula adopted from Onwumere (2004)

$$\mathbf{T.V}=\frac{\pi D^2}{4}\times h \text{ .... } (2)$$

Where TV = Total Volume of tree (m^3), h= height (m), d^2 = Diameter of the tree measured at DBH

Computation of diversity indices:

(i) Species relative density was computed using the equation adopted from Brashears *et. al.* (2004)

$$\mathbf{R.D}=\frac{ni}{N}\times 100 \text{ .... } (3)$$

Where: RD (%) = Species Relative Density; n_i = number of individuals of species i; N = total number of all tree species in the entire community.

(ii) Species Relative Dominance (RD_0 (%)) was computed using the equation of Foody and Culter (2003)

$$\mathbf{R.D_0}=\frac{\sum Bai\times 100}{\sum Ban} \text{ .... } .(4)$$

Where: Ba_i = basal area of individual tree belonging to species i, and Ba_n = stand basal area.

(iii)The Shannon's Diversity index:

Shannon–Wiener diversity index equation given by Price (Price, 1997) was employed to calculate the tree species diversity.

$$\mathbf{H}=-\sum_{i=1}^{s} p1 \ln(p1) \text{ .... } (5)$$

Where H' = Shannon diversity index, S = the total number of species in the community, pi = proportion of S (species in the family) made up of the Ith species, and ln = natural logarithm.

(iv)To determine the Species Evenness (E) in each community, Pielou's Species Evenness index equation was adopted as stated by Kent and Coker (Kent and Coker, 1992)

$$\mathbf{E}_{h}=\frac{H}{Hmax}=\frac{\sum pi\, ln(pi)}{ln(s)} \text{ .... } (6)$$

Where pi = proportion S (species in the family) made up of the ith species, S = the total number of species in the community, and ln = natural logarithm

(v) The Family Importance Value Index (FIV) was obtained using the equation adopted from Gillespie *et. al.* (2004)

$$\mathbf{FIV} = \frac{RD+RDo}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where: RD (%) = Species Relative Density and RDo (%) = Species Relative Dominance

Results

Stems And Tree Species in the Study Area

The number of stems and tree species encountered in the study area is presented in Table 1. *Khaya senegalensis* had the highest number of stems (36). This was followed by the species of *Azadirachta indica* (12) stems, closely followed by *Gliricidia sepium* (4) stems, while *Parkia biglobosa had* (3) stems. Species of *Celtis occidentalis, Albizia lebbeck, Cassia siamea, and Terminalia catappa* are represented by two (2) stems each. The other species are all represented by one (1) stem each.

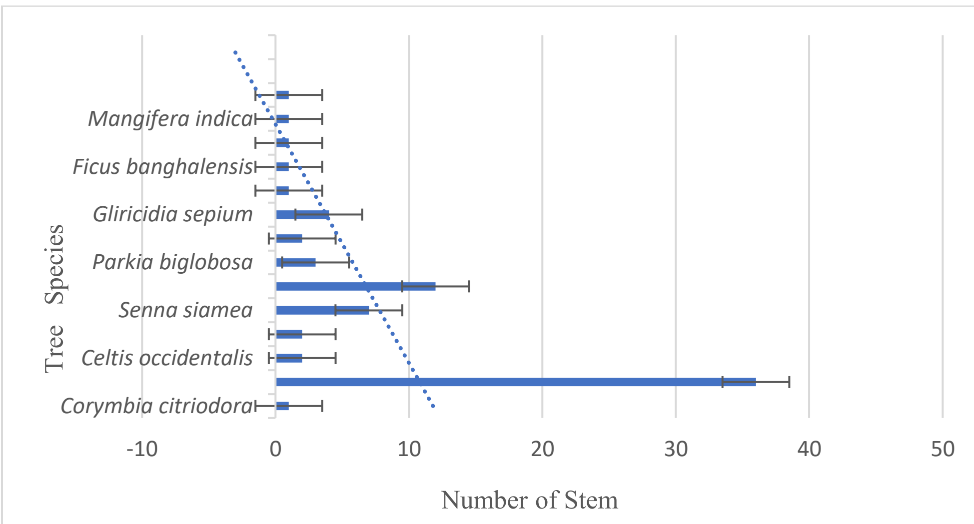

Figure 2: Species abundance of Avenue Tree Species in Ahmadu Bello University, Zaria's Faculty of Agriculture Road to NUGA Gate

Tropical ecosystem has been adjudged to be the richest single ecosystem of the world, due to its species richness and diversity (Akindele & LeMay,2006; Salami *et. al.,* 2022). Species in the ecosystem are useful for climate regulation, carbon sequestration, creation of microclimate, enrichment of soil fertility, and serve as timber resources (Sodimu *et. al.,*2024). The tree species encountered in the study area are of the typical Northern Guinea Savannah ecosystem (Sodimu *et. al.,*2022)

Volume Table of Tree Species Encountered in the Study Area

A total of 74 stems were distributed among the fourteen (14) tree species belonging to 8 families. Table 1 shows that the Moraceae family had the highest DBH of 351.74 cm, with a height of 17.05 m, volume of 74.85 m3, and mean basal area of 10.00 m^2. The lowest mean DBH, which is 105.00 cm, was recorded in the family of Malvaceae, with a mean height of 10.00 m, mean volume of 2.60 $m^{3,}$ and mean basal area of $0.87m^2$.

Table 1: Local volume table of avenue tree species encountered in the study area

S/N	Family	Species	Mean family DBH (cm)	Mean family Ht.(m)	Mean family BA (m^2)	Mean family Vol. (m^3)
1.	Meliaceae	*Khaya senegalensis* (Dear.) A.juss *Azadirachta indica* A. (Juss)	229.72	22.93	4.83	56.99
2.	Fabaceae	*Senna siamea* (Lam) Irwin et Barneby *Parkia biglobosa* (Jacq.) G.Don *Albizia lebbeck* (L.) Benth. *Gliricidia sepium (*Jacq.) Kunth ex Walp. *Tamarindus indica* L	190.00	15.50	3.14	25.89
3.	Moraceae	*Ficus sur* Forssk. *Ficus benghalensis* L.	351.74	17.05	10.00	74.85
4.	Combretaceae	*Terminalia catappa* L.	176.06	15.05	3.02	25.05
5.	Cannabaceae	*Celtis occidentalis* L	128.50	14.85	1.30	7.71
6.	Anacardiaceae	*Mangifera indica* L.	216.40	10.00	3.68	16.92
7.	Myrtaceae	*Corymbia citriodora* (Hook.) *K.D.Hill & L.A.S.Johnson*	139.00	31.00	1.52	22.58
8.	Malvaceae	*Adansonia digitata* L.	105.00	10.00	0.87	2.60
		TOTAL	1536.42	136.38	28.36	232.59

DBH=Diameter at breast height, Ht. =height, BA= Basal Area, Vol. =Volume

Tree Species Diversity Indices in the Study Area

Table 2 shows that the Shannon Wiener's index and Pielou's Species evenness index of 1.80 and 0.68 were obtained, respectively, in the study area.

Table 2: Tree species diversity indices in the study are

S/N	Diversity Indices	Values
1	No. of Trees	74
2	No. of Species	14
3	No. of Families	8
4	Shannon Weiner	1.80
5	Pielou's Evenness index	0.68

Source: Field Survey, 2025

Total Volumes for Each of the Families Encountered in The Study Area.

Figure 3 below shows the family of Moraceae had the highest volumes (74.85m^3). This was followed by the family of Meliaceae with a volume of 56.99 m^3, while the lowest was recorded for the family of Malvaceae with a volume of 2.60 m^3. Thus, the highest number of tree species was observed in the family of Moraceae, which could be regarded as the dominant family in the study area.

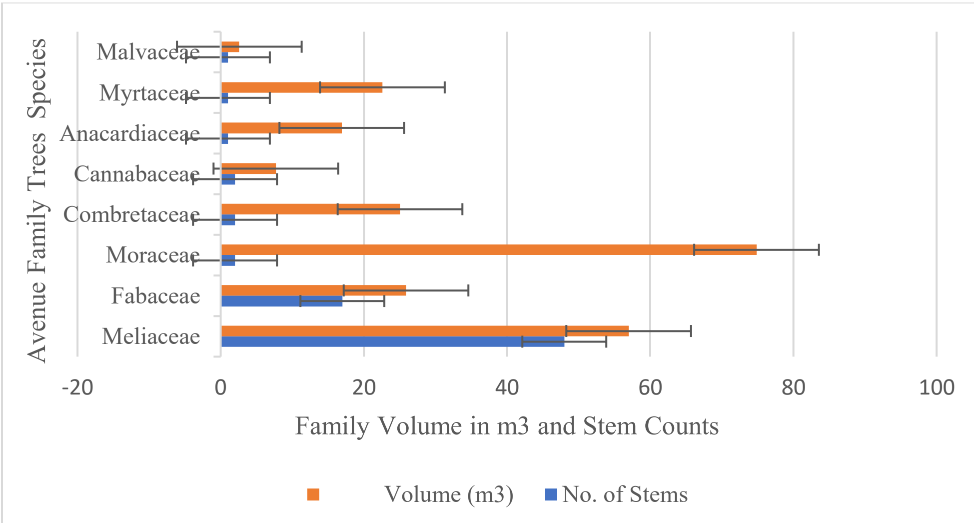

Figure 3: Total avenue tree volume of each family encountered and stem count in the study area

Family Importance Index of Avenue Tree Species in the Study Area

The highest number of avenue tree species was observed in the family of Meliaceae, so it could be regarded as the dominant family in the study area (Table 3). It has the highest family importance value (151.60%) with a total of two (2) tree species, while the lowest was observed in the families Anacardiaceae, Combretaceae, Cannabaceae, and Malvaceae with one species each.

Table 3: Family importance index of tree species in the study area

Family	No. of Species	No. of Individuals	RD (%)	RDo (%)	FIV (%)
Meliaceae	2	48	64.87	72.45	151.60
Fabaceae	5	17	22.97	16.71	75.40
Moraceae	2	2	2.70	6.25	23.24
Combretaceae	1	2	2.70	1.89	11.73
Cannabaceae	1	2	2.70	0.81	10.66
Anacardiaceae	1	1	1.35	1.15	9.64
Myrtaceae	1	1	1.35	0.48	8.97
Malvaceae	1	1	1.35	0.27	8.77

Source: Field Survey, 2025
RD = Relative Density, RD0 = Relative Dominance, FIV=Family Index Value

Regeneration Potential

Figure 4 below shows the regeneration potential of major species in the study area. However, the species with high regeneration value were found to be universally distributed, had less dormancy disturbance, and required little or no pre -treatment to germinate.

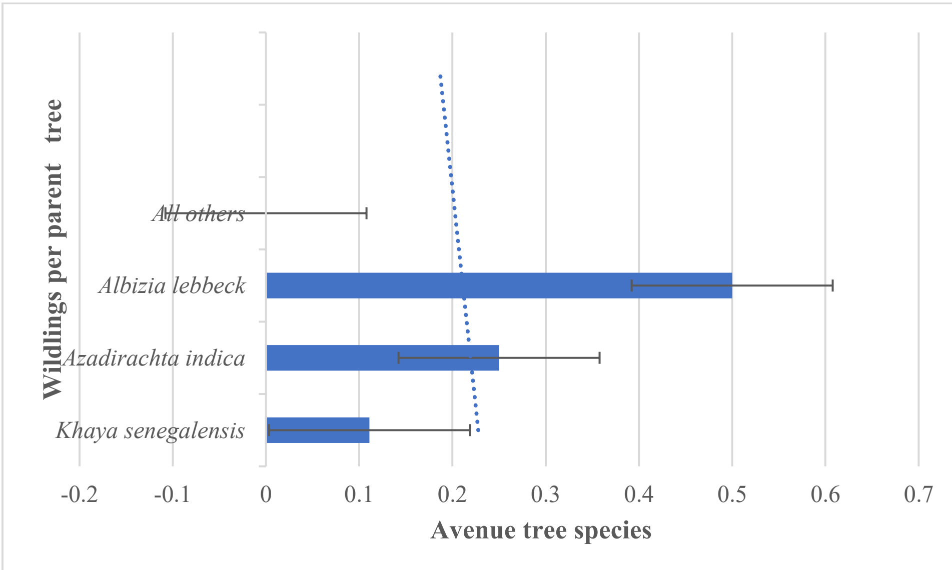

Figure 4: Natural regeneration status of avenue tree species in the study area

Discussion

Stems and Tree Species in the Study Area

One of the most important characteristics of the tropical rainforest ecosystems is the diversity richness. Regardless of the plot size, the number of tree species in this tropical ecosystem is far. greater than any other forest environment and surroundings (Adekunle, 2006; Adeduntan and Olusola, 2015). Tropical ecosystem has been adjudged to be the richest single ecosystem of the world, due to its richness and diversity (Akindele & LeMay,2006). Species in the ecosystem are useful for climate regulation, creation of microclimate, enrichment of soil fertility, and serve as timber resources. The stems and tree species encountered in the study area are of the typical Northern Guinea Savannah ecosystem (Sodimu *et al.,* 2024). A total of fourteen (14) species were distributed among eight (8) families encountered in the study area, as shown in Figure 2. Furthermore, Figure 2 further revealed that Stem volume at the stand level is very important for proper management of the avenue trees. However, volume estimation is very costly and time-consuming, as a field survey needs to be carried out. The volume obtained is in agreement with the work of Salami *et. al.* 2022) in Kurbal Forest Reserve and that of Sodimu *et. al.* 2022) in Afaka Forest Reserve of a similar ecosystem, but contrary to what was recorded by Adekunle (2006) in a logged forest.

Volume Table of Tree Species Encountered in the Study Area

The results in Table 1 indicated that in the ABU campus, tree species like *Khaya senegalensis*, *Azadirachta indica, Terminalia menta, Senna siamea, Parkia biglobosa, and Albizia lebbeck* are the most dominant avenue trees on the ABU campus. The reason for this occurrence for avenue trees on campuses might be because of their ability for fire resistance, microclimate amelioration, sources of timber, wood antimicrobial, and medicinal values. The above result is in agreement with the works of Olorunmaiye *et al*., 2004, Ahmadu *et al*., 2004 & Olorunmaiye *et al*., 2010. The family Fabaceae has the highest number of species spread (5), while the Meliaceae family has the highest number of stems (48), and the family Moraceae has the highest volume ($74.85m^3$). The results of this study confirmed that avenue trees are a repository of many indigenous tropical hardwood and exotic tree species in different families, as indicated by the tree species. richness on the campus, which is similar to or higher than what has been reported in some natural forest ecosystems in Nigeria. However, research conducted by IIRS (2002) & Oyerinde *et al.* (2018) noted that biodiversity indices are generated to bring the diversity and abundance of species in different habitats to a similar scale for comparison, and the higher the value, the greater the species' richness.

Tree Species Biodiversity Indices in the Study Area

Several authors have adopted the use of the Shannon-Weiner diversity index to investigate ecosystem diversity, as it considers both species richness and evenness in the forest community (Onyekwelu *et. al.,* 2005). Shannon index is an indicator of high species diversity and reflects the dominance of a few tree species in the avenue. The Shannon-Weiner diversity index (H^1) of 1.80 in Table 2 shows that the avenue tree species is biologically diverse. The diversity index in this study was within the range reported by Adekunle (2006) & Onyekwelu *et al*. (2008). They reported Shannon –Wiener index values ranged between 1.5 and 3.5, and this result falls within the range, but the result of this study was higher than the value (1.2–1.4) reported for sacred groves in Tanzania (Mgumia and Oba, 2003).

Total Volumes for Each of the Families Encountered in the Study Area

Figure 3 shows that the family of Moraceae had the highest volumes ($74.85m^3$). This was followed by the family of Meliaceae with a volume of 56.99 m^3, while the lowest was recorded for the family of Malvaceae with a volume of 2.60 m^3. Thus, the highest number of tree species was observed in the family of Moraceae, which could be regarded as the dominant family in the study area. The results align with the work and observation of Sodimu (2016), who observed that species under the Moraceae family show good girth growth in the northern savanna of Nigeria, especially the Northern Guinea savannah ecological zone.

Family Importance Index of Avenue Tree Species in the Study Area

Table 3 shows that Meliaceae has the highest family importance value (151.60%) with a total of two (2) tree species, (it could be regarded as dominant family in the study area) while the lowest was observed in the family Fabaceae, Moraceae, combretaceae, Cannabaceae, Anacardiaceae, Myrtaceae and Malvaceae, Fabaceae has five (5) species but low family importance value (75.40%). The fact that Meliaceae is the dominant family in the study area is in conformity with the studies of Sarumi *et. al. (*1996 and Adekunle 2007), who both reported that the Nigerian lowland rainforest ecosystem is dominated by members of the

Meliaceae, Fabaceae, Moraceae, and Anacardiaceae. This also is in support of the work of (Onyekwelu *et. al.,*2008) who observed that members of the Moraceae, Meliaceae, Anacardiaceae, and Fabaceae families are dominant in tree forest estate ecosystems in Nigeria. However, it's worth mentioning that the avenue trees on the ABU campus were either planted or reserved during the development of the University, which now serve for climate amelioration, shelter belts, shade, arboriculture, landscaping designs, control of water erosion, as well as production of various edible fruits. Avenue tree species have been reported to provide benefits such as contribution to aesthetic value (Schroeder 1989, Heisler *et al*., 1995). It has also been documented that shade provided by trees reduces summer energy use by 20-25%. More so, Akbari (2002) discovered that trees, especially avenue trees, reduce energy consumption, while McPherson and Simpson (2003) concluded that avenue trees reduce the need for air conditioning. According to Babalola (2016) and Nowak *et al*. (2001), a main focus in the past for developed countries was the management of urban forests for aesthetic purposes, whereas now, as the urban population has expanded and intensified, it has shifted to management for enhancing ecosystem services. However, urban trees have been reported to provide benefits such as contributing to aesthetic value (Schroeder 1989, Heisler *et al*., 1995) have documented that shade provided by trees reduces summer energy use by 20-25%. More so, Akbari (2002) discovered that trees reduce energy consumption, while McPherson and Simpson (2003) concluded that avenue trees reduce the need for air conditioning, ability to change the microclimate of the immediate area.

Natural Regeneration Status

The ability of the avenue tree species to regenerate itself shows a very positive way of contributing to dominancy. (Salami, 2022). *Albizia lebbeck* exhibited the highest regeneration potential, suggesting better adaptability and seed viability. The low regeneration rate in *Khaya senegalensis* indicates possible propagation challenges or anthropogenic disturbance effects along the avenue. The regeneration status of most species is zero, owing to anthropogenic pressure on the mother trees, which would have produced the wildlings within the avenue. The results align with the work and observation of Oduwaiye *et al.* (2002) and Sodimu *et al. (*2020). The different species established themselves in different microsites. These are light-demanding and shade-tolerant. However, the need for the canopy to be silviculturally manipulated in a manner which reduced the specific stress and the risk of damage, but at the same time, permits the trees to exploit the more favourable condition fully during an average situation cannot be overstressed.

Conclusion and Recommendation

Conclusion

Deforestation and degradation are threats that affect forest productivity. This research revealed the present status of avenue tree species from the Faculty of Agriculture Road to the NUGA gate at Ahmadu Bello University, Zaria, in terms of their tree species diversity, stand volume, natural regeneration status, and species composition. The Floristic composition of the avenue tree species shows diversity in the composition of both indigenous and exotic tree species. Fourteen species across eight families were identified, with *Khaya senegalensis* and *Azadirachta indica* of the Moraceae family dominating. The Computed Shannon Index and Evenness indicate high diversity. Natural regeneration status was poor for most species except *Albizia lebbeck.* The tree species portrayed a very rich floral diversity and potential for uses and values. The trees served as climate amelioration, shelter belts, shades, arboriculture, landscaping designs, control of water erosion, shelter for birds, medicinal values, as well as production of various edible fruits, among others. These outcomes highlight the ecological and climatic significance of avenue trees.

Recommendation

In view of these findings, it is therefore recommended that fast-growing, disease-tolerant, and shade-tolerant species be planted. Providing avenue trees should be raised and planted by the University authorities to fill the gaps, to obtain maximum productivity,Providing Avenueducive learning environment for students, and to improve the aesthetic view of the entire campus landscape. Also, frequent surveys and inventories of trees on campus should be conducted by relevant stakeholders to assess their abundance, distribution, and density, as well as structural and physical changes necessary for management practices. Threatened and endangered tree species on campus should be properly protected to maintain avenue tree diversity and prevent their total removal as a result of developmental projects.

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