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DIVERSITY AND VOLUME ASSESSMENT OF TREE SPECIES IN AHMADU BELLO UNIVERSITY, BOTANICAL GARDEN IN SAMARU – ZARIA, KADUNA STATE, NIGERIA

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ABSTRACT
The study focused on the volume assessment of tree species diversity and abundance at Ahmadu Bello University Botanical Garden in Samaru, Zaria. The research was carried out from June 2023 to July 2023. The use of a quadrat line transect sample technique was employed, where by three (3) 30m x 30m plots was laid, all tree species with DBH > 0.1m that fell on the transect line was enumerated, height was measured using Haga altimeter, DBH was also measured using diameter tape for volume estimation. Baulunia monandra kurz had the highest number of stems (15), so it was a dominant species. The result shows that mean tree volume ranges from a minimum of 0.86m^3 for Bignoniaceae family, to a maximum of 92.45m^3 for Malvaceae family Bombax pentandrim. L. Malvaceae family had the highest mean volume (92.45m^3) while the lowest was recorded in Tacoma stans (L) juss.ex kunt with a volume of 0.86m^3. The family of Fabaceae was regarded as the dominant family in the botanical garden with 23 tree species. Shannon Weiner Diversity index and species equitability index according to Pielou's of 1.16 and 0.53 were respectively obtained for the study area. This study revealed the efficacy of a partial disturbed Botanical Garden in in-situ conservation. Active regeneration and enrichment planting can be carried out for proper stocking of the Botanical Garden so as to make it potential biodiversity hotspot especially in Northern Guinea Savannah Eco- region.

Keywords: Diversity indices, Biodiversity, tree growth variables, tree volume, botanical garden.

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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's species in the world). (Zakaria *et. al.*, 2016). They are mostly dominated by a wide variety of broad-leaved trees which form dense canopy and make it one of the most complex ecosystems, which cover about 30% of the total earth surface containing about 90% of the world's terrestrial biodiversity. Over the years, forest has been a continuous source of wood, charcoal and land for agricultural purpose. 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. Beside 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.

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 and Hawksworth,1995). Typically, the focus is on species diversity and volume of tree species. The relationship between biodiversity and ecosystem functioning and productivity has received increasing attention within the scientific community during the past decades (McNaughton, 1994). Biodiversity assessment has therefore developed to become an important part of conservation biology and functional ecology. 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 andParthasarthy,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).

However, for effective management of tropical forest in a sustainable way there is need to estimate the growing stock of the forest. Information on the estimation of the growing stock guide forest managers in timber valuation as well as in allocation of forest areas for harvest for timber production, an estimate of growing stock is often expressed in terms of timber volume, which can be estimated from easily measurable tree dimension. (Shamaki *et. al.,* 2010). Beside 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 emission under certain threshold, which must be calculated by taking into account both sources and sink of CO_2 absorbed and store in the trees. (Lindner and Karjalainen 2007; Tonolli *et al.,* 2011). Thus, having a detailed knowledge of forest stem volume of a forest estate is therefore 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 and Mfon, 2006). It has hampered efforts to reduce illegal and unsustainable extraction of forest resources, and improve transparency. Also, it has resulted in undervaluation of forest resources. According to FAO (2011), such conditions, in turn, could contribute to continuous decline in area, health, stock, and flows of forest resources and management. This research therefore, aims to estimate the tree volume for sustainable forest management and investigate the present status of tree species diversity and abundance of Northern Guinea Savannah ecosystem using Ahmadu Bello University Botanical Garden as a case study in North – Western Nigeria, despite the global changes affecting tropical forest.

MATERIALS AND METHODS

Study area

The study was conducted in the Botanical Garden of Ahmadu Bello University Zaria. The garden lies at latitude 11° 11'N, longitude 7° 38'E. Zaria is located in the Northern sub humid Guinea savannah ecological belt with distinct rainy and dry seasons with variation in temperature and relative humidity. The Botanical Garden was established in 1962 as an in-situ conservation site that is rich in plant species. The dry season is between middle of October on the 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 approximately (Tanko,2005). The garden covers an area of about 41,886.04 m^2 (Tanko,2005). The entire garden is divided into sections for management purposes. (Ahmed *et. al.*, 2014). Concrete walkways in the garden divide the vegetation into sections. The flora of the garden comprises of both indigenous and naturalized exotic plant species (Fig.1) The garden was formerly relatively unexploited area, but today parts of the garden are cultivated for experimental purposes by the Department of Botany and Biology ABU Zaria. Nonetheless, no hunting and grazing activities are allowed. Thus, exotic plant species in the garden are not native to Nigeria or West Africa but were introduced into the garden.

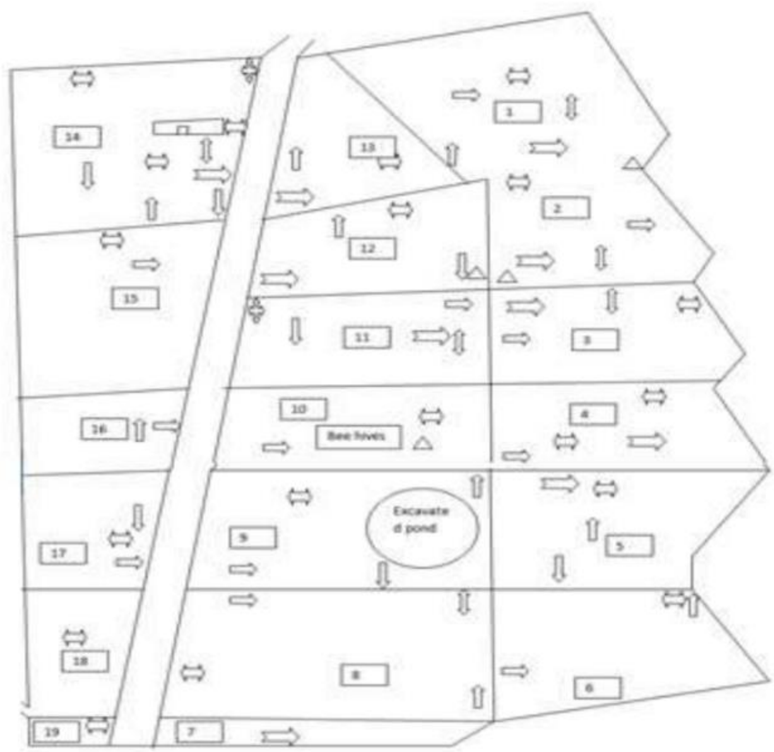

Fig.1: Map of the study area Ahmadu Bello University Botanical garden, Zaria.
Source: Ahmed *et. al.* (2014)

Sampling technique

The use of a quadrat line transect sample technique was employed, where by 30m x 30m quadrant plot was established and a transect line was drawn and pegged perpendicular to the baseline, at an interval of 10m, resulting in the formation of three (3) line transect for each plot, all tree species with DBH > 0.1m that fell on the transect line was enumerated. Tree height was measured using Haga altimeter, DBH was also measured using diameter tape and the number of wildlings was counted and recorded at 0.5m radius around the trees on the transect. A total of Three (3) plots were laid in all and the methodology was repeated in each of the plots, with an interval of 15m from each established plot. All trees that cannot be identified on the field were collected, place in plant press and taken to the Department of Botany Herbarium Ahmadu Bello University and Savanna Forestry Research Station for identification by taxonomists. DBH ≥0.1 m 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, the total height using Haga altimeter and number of wildlings at 0.5m radius around the trees on the transect.

Data analysis

The data collected were analysed using the following formulae:

Basal area computation

Basal area of each tree was calculated using the formula adopted from Zakaria *et. al.*, (2016).

$$\mathbf{B.A} = \frac{\pi D2}{4} \quad \text{....(1)}$$

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

Tree volume computation

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

$$\mathbf{T.V} = \frac{\pi d2}{4} \times h \quad \text{.......... (2)}$$

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)

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

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).

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

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.

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

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

$$\mathbf{E_h} = \frac{H}{Hmax} = \frac{\sum pi \ln(pi)}{\ln(s)} \quad \text{....... (6)}$$

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 equation adopted from Gillespie *et. al.*, (2004).

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

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 below. A total of 32 stems were distributed among the nine (9) tree species belonging to 6 families *Baulunia monandra* kurz had the highest number of stems (15). This was followed by the species of *Tecoma stans* (L) juss. Ex kunth (05) stems. *Delonix regia* (Boj.

ex Hook) Raf., *Senna siamea* (Lam) Irwin et Barneby and *Blighia sapida* K.D. Koenig, *Bombax pentandrum* L., *Mangnifera indica* L., *Khaya senegalensis* (Desr.) A. Juss. and so, on were all represented by one stem each.

Table 1: Number of stems and tree species in the study area

S/N	Species	No. of Stems
1	*Albizia lebbeck* (L.) Benth	01
2	*Baulunia monandra* Kurz	15
3	*Blighia sapida* K.D. Koenig	01
4	*Bombax pentandrim* L	01
5	*Delonic regia* (Boj.ex Hook) Reg	04
6	*Mangnifera indica* L	01
7	*Senna siamea* (Lam)irwin et barneby	03
8	*Tacoma stans* (L) juss. ex kunth	05
9	*Khaya senegalensis* (Dear) A. juss	01
	Grand Total	**32**

Volume table of tree species encountered in the study area

Table 2 Shows that Malvaceae family had the highest DBH of 255.00 cm, with a height of 18.10 m, volume of 92.45 m^3 and mean basal area of 2.55 m^2. The lowest mean DBH which is 40.33 cm was recorded in the family of Fabaceae, with a mean height of 11.28 m, mean volume of 23.96m^3 and mean basal area of 2.12 m^2. The family of Malvaceae had the highest volumes (92.45m^3). This was followed by the family of Sapindaceae with a volume of 28.00m^3, while the lowest was recorded for the family of Bignoniaceae with a volume of 0.86m^3.

Tree species diversity indices in the study area

Table 3 below shows that Shannon Weiner's index and Pielou's Species evenness of 1.16 and 0.53 were obtained respectively in the study area.

Table 2: Local volume table of tree species encountered in the study area

S\N	Family	Species	Mean DBH (cm)	Mean Ht. (m)	Mean BA (m^2)	Mean Vol.(m^3)
1	Fabaceae	*Albizia lebbeck* (L.) Benth	111.00	13.90	0.97	13.87
		Baulunia monandra Kurz	40.33	11.28	2.13	23.96
		Delonic regia (Boj.ex Hook.) Reg	43.75	13.98	0.19	2.64
		Senna siamea (Lam)irwin et barneby	122.33	11.99	2.28	27.35
2	Sapindaceae	*Blighia sapida* K.D. Koenig	100.31	11.00	2.55	28.00
3	Malvaceae	*Bombax pentandrim* L	255.00	18.10	5.11	92.45
4	Anacardiaceae	*Mangnifera indica* L	160.00	13.43	2.01	27.01
5	Bignoniaceae	*Tacoma stans* (L.) juss. ex kunth	100.31	11.01	0.08	0.86
6	Meliaceae	*Khaya senegalensis* (Dear.) A.juss	44.00	7.00	0.15	1.06
			977.03	**111.69**	**15.47**	**244.55**

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

Table 3: Tree species diversity indices in the study area

S/N	Diversity Indices	Values
1	No. of Tree	32
2	No. of Species	09
3	No. of Families	06
4	Shannon Weiner	1.16
5	Pielou's evenness index	0.53

Total volumes for each of the families encountered in the study area

Table 4 below shows that the family of Malvaceae had the highest volume (92.45m^3). This was followed by the family Spindaceae 28.00m^3 while the lowest was recorded for the family of Bignoniaceae with a volume of 0.86m$^{3.}$ The highest number of tree species was observed in the family of Fabaceae, it could be regarded as the dominant family in the study area.

The highest number of tree species was observed in the family of Fabaceae, so it could be regarded as the dominant family in the study area. It has highest family importance value (26.72%) with a total of four (4) tree species, while the lowest was observed in the family Anacardiaceae, Bignoniaceae, Malvaceae, Meliaceae and Sapindaceae with one species each.

Table 4: Total volumes for each of the families encountered in the study area

Family	No. of Stems	Volume (m^3)
Anacardiaceae	01	27.01
Bignoniaceae	05	0.86
Fabaceae	23	16.96
Malvaceae	01	92.45
Meliaceae	01	1.06
Sapindaceae	01	28.00

Table 5: Family importance index of tree species in the study area

S/N	Family	No. of Spp.	R.D(%)	RD$_0$ (%)	FIV (%)
1	Anacardiaceae	01	11.11	13.01	12.06
2	Bignoniaceae	01	11.11	0.50	5.81
3	Fabaceae	04	44.44	9.00	26.72
3	Malvaceae	01	11.11	33.05	22.08
4	Meliaceae	01	11.11	0.98	6.05
5	Sapindaceae	01	11.11	16.45	13.75

RD =Relative Density, RD$_0$ = Relative Dominance, FIV=Family Importance Index Value

DISCUSSION

Tropical ecosystem has been adjudged to be the richest single ecosystem of the world, due to its species richness and diversity (Akindele and LeMay,2006) Species in the ecosystem are useful for climate regulation, creation of microclimate, enrichment of soil fertility and serves as timber resources. The stems and tree species encountered in the study area are of the typical Northern Guinea Savannah ecosystem. A total of nine (9) species was distributed among six (6) families encountered in the study area as shown in Table 1.

Furthermore, table 2 revealed that Stem volume at stand level is very important for proper management of the forest. However, volume estimation is very costly and time consuming as field survey needed 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 similar ecosystem. but contrary to what was recorded by (Adekunle, 2006) in a logged forest and that of (Tonolli and Rodeghiero,2011) for a multilayer forest area of the Italian Alps. The basal area obtained in this study is below the average basal area of $15m^2$ reported by (Alder and Abayomi,1994) for a well-stocked tropical forest in Nigeria, which implies that the forest used in this study is not very stock. However, the study area could still serve as a reference for similar ecosystem.

Several authors have adopted the use of Shannon Weiner diversity index to investigate ecosystem diversity, as it considers both species richness and evenness in the forest community (Onyekwelu *et. al.,* 2005). Biodiversity indices are produced to bring the diversity and abundance of species in different habitats to similar scale for comparison and the higher the value, the greater the species richness. According to Hawthorne *et al*. (Hawthorne *et. al*.,2011), Shannon index is an indicator of the high species diversity and reflects the dominance of a few tree species in the forest. The Shannon Weiner diversity index (H^1) of 1.16 in table 3 shows that the forest is biologically not diverse. The value is not close to the range of values (3.34 - 3.66) reported for some tropical forest sites in Nigeria (Adekunle, 2006). However, the Shannon index of this study is low. The lower species evenness obtained in this study revealed that the trees species in this botanical garden are not evenly distributed; this can be attributed to the fact that parts of the garden are cultivated for experimental purposes by the Department of Botany and Biology ABU Zaria.

The results in table 4 are in agreement with the work of Gillespie et al, (2004) who observed that species richness and number of stem availability decreases in a disturbed reserve which tend to have overall effects on volume estimation of the tree species present in such reserve. Table 5 shows that Fabaceae has the highest family importance value (26.72%) with a total of four (4) tree species, (it could be regarded as dominant family in the study area) while the lowest was observed in the family Anacardiaceae, Bigoniacea, Malvaceae, Meliaceae and spindaceae with one species each. The fact that Fabaceae is the dominant family in the study area is in conformity with the study of (Sarumi *et. al.,* 1996 and Adekunle, 2007) who all reported that Nigerian lowland rainforest ecosystem is dominated by members of the Sterculiaceae, Moraceae, fabaceae and Euphorbiaceae. This also is in support of the work of (Onyekwelu *et. al.*,2008) which observed that members of Euphorbiaceae, Sterculiaceae, Meliaceae, Mimosoideae and fabaceae families are dominant in three forest estate ecosystems in s Nigeria. The tree species distribution according to this family corresponds with what was reported by Isichei (1995) in Omo biosphere reserve.

CONCLUSION

Deforestation and degradation are threats that affect forest productivity. This research revealed that present status of Botanical Garden at Ahmadu Bello University, Zaria in term of its volume and species composition and the efficacy of a partial disturbed botanical garden in biodiversity conservation. The Floristic composition of this garden shows that the forest will grow until it becomes a mature forest. In view of the above, it is recommended that active regeneration and enrichment planting should be carried out for proper stocking of the botanical garden so as to improve tree volume. Proper management of the study area should be enhanced so that the forest biodiversity is conserved. Periodic assessment of tree species diversity of the study area should also be carried out. The department should however, limit the usage of the garden for experimental purposes involving cultivation and if it must be done it should be under close monitoring.

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