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TREE SPECIES DIVERSITY AND GROWTH CHARACTERISTICS IN THE UNIVERSITY OF IBADAN BOTANICAL GARDENS, IBADAN, NIGERIA

Ige, P. O. and Adesina, A. S.
Department of Social and Environmental Forestry, University of Ibadan
Corresponding Author's Email: igepetero@gmail.com

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ABSTRACT

This study assessed the tree species diversity and growth characteristics in the University of Ibadan Botanical Gardens with a view to providing baseline information useful for development and conservation of the tree species in the study area. Stratified random sampling technique was used for this study. The study area was stratified into 4: Arboretum, Open field, Nursery Garden and Rock Garden. In each stratum, 20% sampling intensity was used to delineate Temporary Sample Plot (25 m x 25 m) using simple random sampling technique. A total of 14 temporary sample plots were used. Growth variables evaluated included: total and merchantable height, diameter at breast height, diameters at middle, base and top. Data were analyzed using descriptive statistics. The growth characteristics of the tree species revealed a mean volume and basal area of 5.020±0.75 m^2 and 0.494±0.074 m^2 for the Arboretum, 3.933±0.86 m^2 and 0.374±0.09 m^2 for the Rock Garden, 3.406±0.79 m^2 and 0.217±0.05 m^2 for the Open Field and 2.514±0.90 m^2 and 0.194±0.006m^2 for the Nursery Garden respectively. The highest mean total height was recorded for *Triplochiton scleroxylon* (42.1m) while the least mean total height and were recorded for *Ficus exasperata* (10m) and *Milicia excelsa* (10 m) which was observed in the Arboretum Stratum. A total of 509 tress were observed and 55 species identified in the Study area. Stand Growth parameters were estimated and tree diversity assessed. The species diversity assessed with the Shannon-Weiner (H) index in the study site yielded 3.132 for arboretum, which is high. This result indicates high tree diversity. The trees should be properly and adequately tended and conserved for improved management of the botanical garden.

Keywords: Species Diversity, Growth Parameters, Botanical Garden, Arboretum, Species conservation

INTRODUCTION

The relevance of trees cannot be overemphasized. There are several uses of trees to man. Trees are determinants of a forest ecosystem as they considerably influence forest microclimate such as (available light, wetness, temperature). For Nigeria, Keay (1989), Raji and Babalola (2018) and Ihenyen *et al*. (2009) reported are about 560 species of trees. The likelihood and spread of forest disturbances can be impacted by changes in forest structure and composition (Kuuluvainen, 2002). Since numerous micro- and macro-fauna rely on various forest canopy levels and massive, old trees for refuge, nesting, and food (Spies, 1998), variation in sizes of tree and species composition greatly contribute to the total species diversity.

Deadwood is a key part of the structural variety of forests and is included in the structure of forests (Sturtevant *et al*., 1997). Deadwood is essential for forest biodiversity because it provides habitat and resources for

a variety of animals, plants, and decomposers that are crucial for the health of the forest ecosystem (Linder 1998). Deadwood is also crucial for ecosystem functioning because it regulates carbon and nutrient cycling, as well as water availability (Graham and Cromack, 1982; Karjalainen and Kuuluvainen, 2002).

Diversity of tree species boosts forest resilience to shocks, improves productivity, and offers homes and resources for other forest species (Hooper and Vitousek 1997). According to Naeem *et al*. (1999), a loss in the diversity of tree species might negatively affect how well ecological functions are performing. Despite having fewer tree species than temperate and tropical forests, boreal forests can nonetheless have a very diverse and complex structure and dynamics (Lähde *et al*., 1999).

Furthermore, given the dearth of tree species with divergent ecological traits, the presence or disappearance of even a single tree species may have a significant effect on the forest's overall species diversity. Human forest use in boreal forests has typically had a detrimental effect on forest diversity (Paillet *et al*., 2009). More so than anywhere else in the boreal zone, forest management in northern Europe has likely had a greater impact on the ecology. This is due to the fact that clear-cutting-based forest management tends to simplify the composition and structure of forests by eliminating invasive species, putting out fires, and maintaining uniformly aged single-species stands to increase wood production. These methods have effectively eliminated uneven-aged, structurally complex forests from managed forest landscapes (Kuuluvainen and Gauthier, 2018), as well as a steady drop in the number of ancient trees and dead wood (Siitonen, 2001).

A university campus should be promoted as a model environment for sustainable development. Trees in academic institutions located in cities are part of forests resources and the trees can be used as its defining features. Planting of trees are deliberately carried out in academic environment for reasons which including aesthetic and other environmental services (Olajuyigbe and Akwarandu 2019; Egunjobi, 1989; Babalola 2010; Martens *et al*., 2011). Botanical gardens are uniquely positioned to help address the issues relevant to restoring ecosystems. They provide knowledge and expertise in plant taxonomy, horticulture, biodiversity inventory, conservation biology, restoration ecology and ethno-botany which are key elements for achieving successful restoration. Botanical gardens can therefore restore diverse and ecologically resilient places, avoiding the dangers and pitfalls associated with growing inappropriate trees in the wrong environment. Nowak and Dwyer, (2007) mentioned that urban forests provide vital roles such as tree species diversity conservation, place for relaxation and social activities, filtering the air and add aesthetics to the environment. The botanical gardens that achieved the species conservation could, partly, be assessed by the retention of genetic diversity that would otherwise have been lost. The information on tree species structure and function can provide basic information for conservation of the diversity of the trees.

This work therefore aims to examine the current status of species diversity, composition and abundance in order to protect trees from declining as it will provide guidance for their management and valuable reference for assessment as well as improve our knowledge in identification of ecologically useful species. The results would serve as a useful input in the management of the University of Ibadan Botanical Garden.

MATERIALS AND METHODS

Study Area

This study was carried out in the Botanical Garden, which belongs to the University of Ibadan (Fig 1). The garden is located approximately at 3km to the north of the city of Ibadan, Oyo State, Nigeria at the latitudes 7°26`N and 7°45`N, Longitudes 3°54`E and 3°89`N and at a mean altitude of 227 m above sea level. It has an annual rainfall of about 1220 mm, which has its peak at June and August that lasts for about 8 months (April to October). The dry season occurs between November and March.

The garden was established in 1984 by management of University of Ibadan to conserve and enhance plant diversity growth for tourism, teaching and research. University of Ibadan Botanical Garden has an area of about 19.26 hectares. It is situated along the course of river Ona, a sluggish perennial stream in the dry season but a turbulent river when in flood. The soil of the Garden is freely drained, mildly acidic and of moderate fertility. There are colluvial deposits in the river valley and numerous outcrops of basement complex rocks on higher ground.

Sampling Procedure

A Stratified random sampling technique was used for this study (Table 1). A total of 14 plots were sampled from 64 plots based on the stratification of the garden.

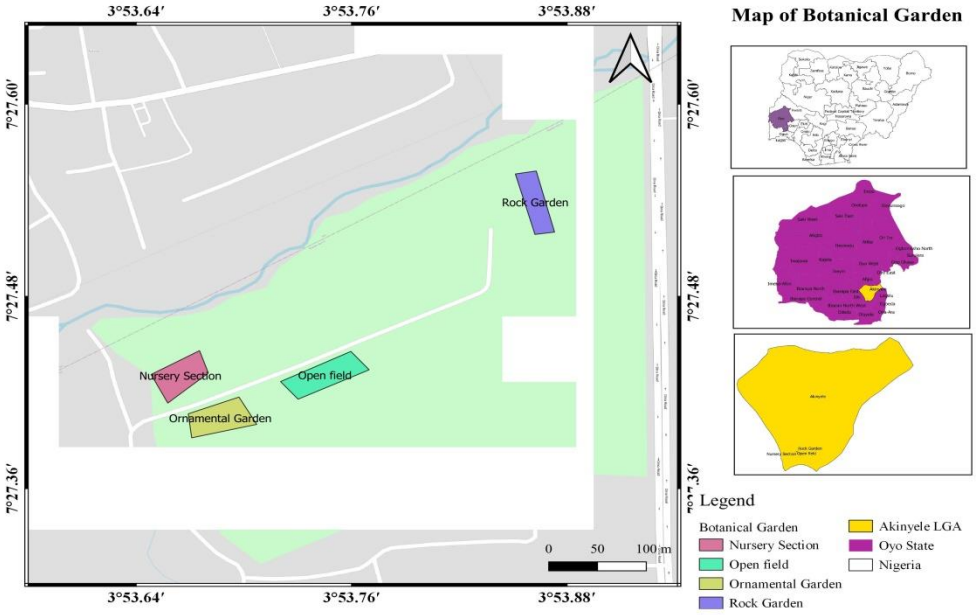

Figure 1: Map of the University of Ibadan Botanical Garden, Ibadan, Nigeria

Table 1: Selected sample plots

Strata	Total no of plots	No of sample Plots (20%)
Arboretum	45	9
Open field	9	2
Nursery	8	2
Rock garden	2	1
Total	64	14

Data Collection

All trees with Diameter at Breast Height (DBH) ≥ 10 cm encountered in each sample plot was tagged, identified to species level and measured. In each of the established temporary sample plot, the diameters at the base, middle and top; and the total height of all the trees (DBH ≥ 10 cm) were measured.

Data Analysis

Growth Variables

Volume Estimation

$$\boldsymbol{V = [\pi H(Db^2 + 4Dm^2 + Dt^2]/24} \quad \text{.....1}$$

Where, V = Volume of tree (m3),
Db = Diameter at the base (cm), Dm = Diameter at the middle (cm), Dt = Diameter at the top (cm), H = height (m)

Basal Area Estimation

The Basal Area (BA) of each trees sampled was estimated using the formula in the equation given by Husch *et al*., 2003). It can be mathematically expressed as;

$$\boldsymbol{Basal\ area\ (m^2) = \frac{\pi D^2}{4}} \quad \text{..... 2}$$

Where; D = DBH (cm), BA = Basal Area (m2), π = 3.142 (constant)

Slenderness Coefficient

This is the ratio of total height (HT) to diameter at 1.3m above the ground level. The estimation is achieved by:

SLC = Total Height/ DBH.....3

Where SLC is slenderness coefficient, the total height in meters and DBH is diameter at breast height.

Diversity Indices

The data collected during the tree survey were analyzed and calculated using different indices such as The Shannon-weiner diversity, Eveness (E), Margalef index and Simpson Dominance index.

The Shannon-Weiner Tree Species Diversity Index

The Shannon-Weiner diversity index has been the most widely used index in community ecology.

$$H = -\sum_{i=1}^{s} \boldsymbol{Pi} \ln \boldsymbol{Pi} \quad \text{.....4}$$

Where:
H = Shannon-Weiner tree species diversity index
S = Total number of species in the community
Pi = Proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N)
ln = natural logarithm

Simpson tree species diversity index (I-D)

Simpson's dominance index is weighed towards the abundance of commonest species.

$$D = 1 - \left(\frac{\sum \mathbf{n(n-1)}}{\boldsymbol{N(N-1)}}\right) \quad \text{..... 5}$$

Where:

n= total number of individuals of a particular species
N= total number of individuals of all species
Species Evenness Index (E)

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

$$E_H = \frac{H'}{H_{Max}} = \frac{\sum_{i=1}^{S} P_i \ln(P_i)}{\ln(S)} \quad \text{..... 6}$$

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, $\boldsymbol{H_{max=}}$Shannon diversity index maximum

Margalef's Index of Species Richness (M)

$$M = \frac{(S-1)}{\ln N} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 7$$

Where:

S = total number of species in the community
N = total number of all individual trees
Ln = natural logarithm

RESULTS AND DISCUSSION

From Table 3, a total of 509 tree species were observed in the study area (125, 192, 96 and 96 trees in the Arboretum, Rock Garden, Open field, Ornamental Garden and Nursery Garden respectively). The Simpson index value of 0.93, 0.83, 0.69 and 0.88 were observed in Arboretum, Rock Garden, Open field, Ornamental Garden and Nursery Garden stratum of the study area respectively. The Shannon-Weiner index value of 3.13, 1.94, 1.47 and 2.21 were observed in Arboretum, Rock Garden, Open field, Ornamental Garden and Nursery Garden stratum of the study area respectively. The Species evenness of 0.74, 0.87, 0.73, and 1.97 were observed for Arboretum, Rock Garden, Open field, Ornamental Garden and Nursery Garden respectively. The species diversity assessed with the Shannon-Weiner (H) index in the study site was found to be 3.132 for arboretum, 1.936 for Rock Garden, 1.561 for open field and 2.21 for nursery section. This result indicates high tree species diversity as stated by Magurran (2004) that a low Shannon-Weiner (H) value generally suggests a site with few species and a few dominant species, while a high H value suggests significantly more species. This result is similar to that reported by Aigbe and Omokhua (2015) who obtained 3.80 for the Rainforest of Oban Forest Reserve, Nigeria. The species diversity indices and evenness index revealed presence of high tree diversity and even representation of species in the studied forest compared to other forests (Adekunle *et al*., 2013; Aigbe and Omokhua, 2015; Boboye and Jimoh, 2016).

Table 3: Biodiversity indices of the Arboretum, Rock Garden, Open field, Ornamental Garden and the Nursery Section of University of Ibadan Botanical gardens.

	Arboretum	Rock garden	Open field	Nursery Section
Taxa_S	31	8	6	10
Individuals	125	192	96	96
Simpson_1-D	0.9335	0.8333	0.6944	0.875
Shannon_H	3.132	1.936	1.474	2.21
Evenness_e^H/S	0.7395	0.866	0.7274	0.9118
Margalef	6.213	1.331	1.095	1.972

The mean growth variables of the tree species for the study were presented in table 4. The minimum and maximum dbh for the arboretum section ranged from 15cm to 182 cm with mean value of 67.157±5.20 cm, while the total heights ranged from 7m to 51m with a mean value of 27.069±0.99 m. The minimum and maximum dbh for the Rock Garden ranged from 37 cm to 115 cm with mean value of 64.25±2.05 cm, while the total heights ranged from 9 m to 33 m with a mean value of 26.00±2.05 m. The minimum and maximum dbh for the Open field ranged from 18cm to 88cm with mean value of 48.583±6.00cm, while the total heights ranged from 18m to 45 m with a mean value of 28.417±2.35 m. The minimum and maximum dbh for the Nursery Garden ranged from 18cm to 86cm with mean value of 44.00±6.99cm while the total heights ranged from 16 m to 42 m with a mean value of 25.667±2.01 m. According to Ige *et al*.

(2021), an healthy forest is a forest that its growth variables are in the expected range of meeting management objective . The growth variables for the study indicates that the tallest tree was a tree having the height of 42.1m recorded in the arboretum while the lowest height was tree having 10.0m also in the arboretum (Table 5). The minimum height recorded was 10.0m while the maximum height was 42.1 m. Tree with height above 30 m could be regarded as emergent tree, this was in line with Iyagin and Adekunle (2017) findings in strict nature reserve of Ondo State and Oluwa forest reserve where trees above 30m are been considered emergent trees. Having this type of height is an indicator of protected forest with relatively few or no anthropogenic activities occurrence in the forest.

Summary of tree growth parameters presented in Figure 2 revealed the dbh ranged from 15 to >120. Most of the tress were in diameter class of 30.1-60cm (43 trees), followed by 60.1-90cm with 24 trees. The least diameter was 90.1-120cm with 6 trees in the study area.

Table 4: Growth characteristic of trees in the University of Ibadan Botanical Garden, Nigeria

VARIABLES	CATEGORY	ARBORETUM SECTION	ROCK GARDEN	OPEN FIELD	NURSERY SECTION
BA (m^2/ha)	Mean ± S.E	0.494±0.074	0.374±0.09	0.217±0.05	0.194±0.006
	Minimum	0.018	0.108	0.025	0.025
	Maximum	2.602	1.039	0.608	0.581
VOL (m^3/ha)	Mean ± S.E	5.020±0.75	3.933±0.86	3.406±0.79	2.514±0.90
	Minimum	0.094	0.368	0.321	0.219
	Maximum	33.726	9.745	9.160	10.903
SLC	Mean ± S.E	52.807±3.50	43.556±3.97	66.289±7.69	70.325±8.13
	Minimum	14.570	22.5	36.364	37.209
	Maximum	180	64.103	116.67	122.222
TH (m)	Mean ± S.E	27.069±0.99	26.00±2.05	28.417±2.35	25.667±2.01
	Minimum	7	9	18	16
	Maximum	51	33	45	42
DBH (cm)	Mean ± S.E	67.157±5.20	64.25±2.05	48.583±6.00	44.00±6.99
	Minimum	15	37	18	18
	Maximum	182	115	88	86

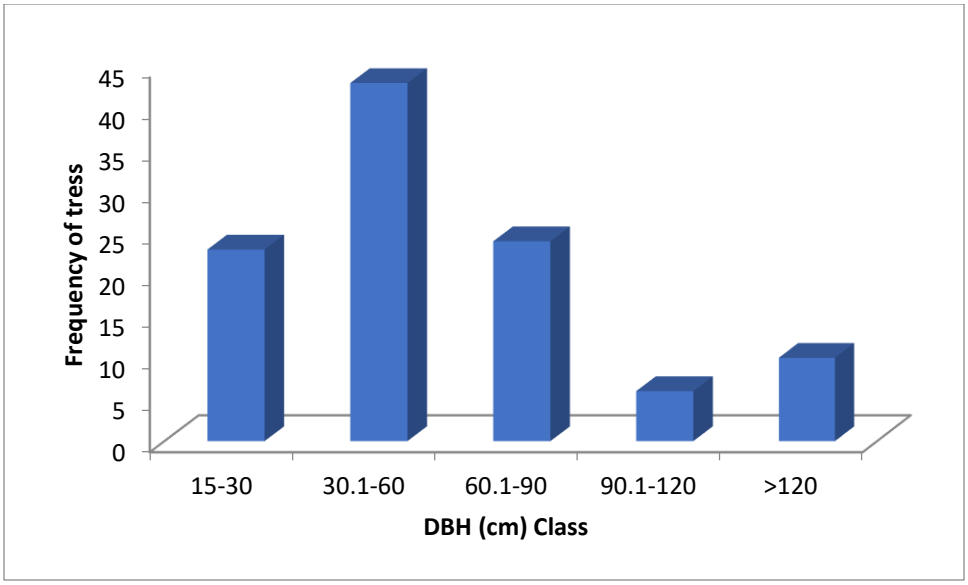

Figure 2: Distribution of dbh of trees in University of Ibadan Botanical Gardens, Nigeria

Tables 5-8 showed population distribution and growth parameters of sampled tree species in the four plots of the strata sampled (Arboretum, Rock Garden, Open field and Nursery Garden). A total of 509 trees were observed in the study area (125, 192, 96 and 96 trees in the Arboretum, Rock Garden, Open field, Ornamental Garden and Nursery Garden respectively). fifty-five (55) tree species were identified in the study area (31 for arboretum, 8 for rock garden, 6 for open field and 10 for nursery garden); and sixteen (16) families. Fabaceae, Meliaceae and Moraceae were the most dominating families.

This shows that the study area is rich in plants species. A high number of tree species increases the number of ecological niches for fauna (Wunderle, 1997) and under storey flora (Kanowski *et al*., 2003). Thus, the presence of high species abundance aid conservation of more trees and other organisms in the forest. When compared result of this study to a similar study by Boboye and Jimoh (2016) at Onigambari Forest Reserve Nigeria, they recorded higher number of families (54) tree species. The law (prohibition of tree felling) protecting this study area could be the major reason that reduces disturbances from human activities such as fuel wood collection, charcoal production, timber exploitation. This implies that conservation measures put in place have preserved many of these tree species in the study area. These measures will prevent some of the economic tree species from becoming threaten or extinct in the study area.

Table 5: Population and Growth Parameters of tree species in the Arboretum Stratum.

Species	Family	Frequency	N/ha	MDbh	MTh	MMh	BA/ha	Tvol/ha	SLC
Adenanthera pavonine	Fabaceae	3	5	35	25.33	14.5	0.12	1.847	82.12
Anogeissus leiocarpus	Combretaceae	1	2	117	40	27	1.08	10.384	34.19
Blighia sapida	Sapindaceae	1	2	45	22	16.1	0.16	1.602	48.89
Bosqueia angolensis	Moraceae	2	4	41	30.5	19	0.13	1.992	74.83
Brachystegia eurycoma	Fabaceae	1	2	147	36	20	1.70	15.657	24.49
Cedrela Mexicana	Meliaceae	2	4	143	38	33.5	1.61	13.572	26.57
Cedrela odorata	Meliaceae	14	25	58	27.71	18.54	0.32	3.646	57.83
Dalbergia sissoo	Fabaceae	1	2	39	28	9	0.12	1.597	71.79
Delonix regia	Fabaceae	4	7	65	22.38	16.75	0.34	4.129	35.32
Detarium segalense	Fabaceae	1	2	113	30	20	1.00	7.936	26.55
Enterolobium cyclocarpum	Fabaceae	4	7	72	31	16.5	0.47	6.235	43.24
Eucalyptus camadulensis	Myrtaceae	1	2	53	25	18	0.22	3.845	47.17
Ficus exasperata	Moraceae	1	2	17	10	7	0.02	0.115	58.82
Gmelina arborea	Lamiaceae	2	4	87	22.75	16.5	0.59	4.506	26.33
Hura crepitans	Euphorbiaceae	2	4	62	26.75	14.6	0.31	3.596	42.76
Khaya grandifoliola	Meliaceae	3	5	115	39.33	18.5	1.20	15.364	38.94
Khaya senegalensis	Meliaceae	2	4	49	18.5	8	0.26	2.712	38.19
Lagerstroemia speciosa	Lythraceae	2	4	36	23.5	13.1	0.10	1.079	65.62
Lannea welwitschia	Anacardiaceae	3	5	36	24.67	15	0.10	1.164	69.84
Leucaena leucocephala	Fabaceae	1	2	40	28	22	0.13	1.262	70.00
Mangifera indica	Anacardiaceae	1	2	40	24	16	0.13	2.040	60.00
Milicia excelsa	Moraceae	1	2	17	10	7.5	0.02	0.110	58.82
Pterygota macrocarpa	Malvaceae	1	2	59	34	22	0.27	8.585	58.12
Ricinodendron heudelotii	Euphorbiaceae	1	2	19	20	15	0.03	0.602	105.26
Tabebuia rosea	Bignoniaceae	2	4	53	27.5	16.5	0.22	2.621	52.65
Tectona grandis	Lamiaceae	2	4	20	24	21.75	0.03	0.791	133.75
Terminalia Glaucescence	Combretaceae	1	2	41	20	9	0.13	0.813	48.78
Treculia africana	Moraceae	4	7	146	27.75	21.25	1.68	10.216	19.07
Trichilia prieuriana	Meliaceae	1	2	30	22	12.2	0.07	0.946	73.33
Triplochiton scleroxylon	Malvaceae	1	2	182	42.1	23	2.60	28.982	23.13
Vitex doniana	Lamiaceae	1	2	55	19	9	0.24	1.629	34.55
TOTAL		67	125				15.40		

Table 6: Population and Growth Parameters of tree species in the Rock Garden Stratum.

Species	Frequency	Family	N/ha	MDbh	MTh	MMh	BA/ha	Tvol/ha	SLC
Afzelia africana	1	Fabaceae	16	75	33	23	0.44	5.236	44.00
Cedrela odorata	1	Meliaceae	16	60	25	20	0.28	2.201	41.67
Ceiba pentandra	1	Malvaceae	16	108	25	20	0.92	8.172	23.15
Senna siamea	1	Fabaceae	16	42	25	19	0.14	2.487	59.52
Enterolobium cyclocarpum	1	Fabaceae	16	55	27	15	0.24	2.460	49.09
Malancantha alnifolia	3	Sapotaceae	48	39	17	14	0.12	1.072	44.18
Milicia excelsa	3	Moraceae	48	88	32	28.33	0.64	7.115	37.57
Morus mesozygia	1	Moraceae	16	50	30	15	0.20	2.078	60.00
TOTAL	12		192				2.97		

Table 7: Population and Growth Parameters of tree species in the Open field Stratum

Species	Family	Frequency	N/ha	MDbh	MTh	MMh	BA/ha	Tvol/ha	SLC
Afzelia africana	Fabaceae	1	8	72	33	25	0.41	5.273	45.83
Albizia lebbeck	Fabaceae	1	8	42	18	7	0.14	1.362	42.86
Artocarpus integrifolia	Moraceae	1	8	88	32	20	0.61	4.523	36.36
Azadiractha indica	Meliaceae	1	8	38	22	11	0.11	1.135	57.89
Dalbergia sissoo	Fabaceae	2	16	24	23	16.5	0.00	0.480	101.44
Delonix regia	Fabaceae	6	48	49	31.67	16.5	0.21	4.602	68.27
TOTAL		12	96				1.48		

Table 8: Population and Growth Parameters of tree species in the Nursery Garden Stratum

Species	Family	Frequency	N/ha	MDbh	MTh	MMh	BA/ha	Tvol/ha	SLC
Blighia sapida	Sapindaceae	1	8	28	26	16	0.06	1.189	92.86
Bombax glabra	Malvaceae	1	8	19	19	13	0.03	0.563	100.00
Enterolobium cyclocarpum	Fabaceae	3	24	54	28.67	21.33	0.27	3.033	60.93
Funtumia elastica	Apacynaceae	1	8	65	30	25	0.33	2.633	46.15
Lannea welwitschii	Anacardiaceae	1	8	25	16	7	0.05	0.347	64.00
Polyalthia suaveolens	Annonaceae	1	8	53	25	21	0.22	2.523	47.17
Pterocarpus osun	Fabaceae	1	8	56	21	11.5	0.25	2.123	37.50
Terminalia superba	Combretaceae	1	8	82	42	32	0.53	10.903	51.22
Trichilia prieureana	Meliaceae	1	8	21	21	11	0.03	0.571	100.00
Zanthoxylum zanthoxyloides	Rutaceae	1	8	18	22	12	0.03	0.219	122.22
TOTAL		12	96	0			1.80		

CONCLUSION AND RECOMMENDATION

The relevance of trees is very important as it encourages all the beneficiaries of services of the trees to become involved in preservation and conservation of trees. This study found out that a total of 509 tree sspecies and 16 families were enumerated in the study area. Fabaceae, Meliaceae and Moraceae were the most dominating families. The results revealed that Fabaceae had the highest number of tree species (15) while Moraceae had eight (8) species and Meliaceae also had eight (8) species. This shows that the study area is rich in plants species. The presence of high species abundance aid conservation of more trees and other organisms in the forest. Therefore, the tree compositions in Botanical Garden, University of Ibadan could be described as relatively available and well diverse. However, there is need to properly and adequately handle and conserve the trees so as to ensure its continuous availability as the need arises.

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