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Assessment of species diversity of avenue and open grown trees in the Polytechnic Ibadan, Nigeria

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ABSTRACT

Avenue and open grown trees protect soils and moderate harsh urban climates. The importance and conservation of these trees as natural, cultural and literary icons is now gaining recognition across cities in developing countries. The polytechnic Ibadan is an institution with significant presence of avenue and open grown trees, but without any substantive record about biometric, management activities and plans that guarantee sustainable, effective and efficient conservation, despite diverse benefits derived from them. This study assessed the species diversity of avenue and open grown trees within the Polytechnic Ibadan, Nigeria. The trees were identified, enumerated and measured using both remote sensing and field data. All the trees were identified, enumerated and measured using both remote sensing and inventory data. Data were analyzed for species composition, stand structure and species diversity using percentage frequency, diameter and height class distribution, Shannon-Wiener diversity index, Simpson's Diversity index, and Shannon's equitability. A total number of 145 avenue trees (9 families and 9 species) and 210 open grown trees (15 families belonging to 22 species) were identified. The avenue and open grown trees were significantly dominated by *Gmelina arborea* and *Terminalia mentalis* species respectively. The avenue trees were dominated by > 200cm diameter class distribution, while open grown trees were dominated by > 200cm and 81-100cm diameter class distribution. The avenue and open grown trees were largely dominated by 16-20m and 6-10m height class distribution respectively. The diversity indices indicated that open grown trees have more species diversity than the avenue trees. The findings thus serve as baseline information for the sustainable management and conservation of these trees.

Keywords*:* Avenue trees, Tree assessment, Species composition, Species diversity

Introduction

Trees exist to serve man even as their products play critical roles in human environmental needs and lifeline (Adeyoju, 2001). Trees maintain and protect the environment against degradation and provide genetic materials for the improvement of cultivated tree crops (Merryweather. 2011; Chaven and Rasal, 2010 Chavan and Rasal, 2010). They also provide wood as industrial raw materials for building construction furniture and energy production; non-wood products such as leaves, fruits, nuts, oil, bark, root, gum, and other exudates for food, medicine and industrial purposes (Adeyoju, 2001). Avenue tree is generally described as a regular and linear planting of tree that often result from the impression of all having been planted at the same time (Parikh, et.al., 1994 Parikh, *et.al*., 1994). In most cases avenue trees are of the same species or cultivar so as to give formal and uniform appearance along the full length of the avenue (Wallace, et.al., 2009 Wallace, *et.al*., 2009). An open grown tree is a tree that as grown virtually all its life without competition from other trees (Lindenmayer *et al*., 2005 Lindenmayer *et.al*., 2005). Open grown trees are usually short squat fat trunk with a very large diameter spreading limbs

of which some grow out almost horizontally (Kiran, *et.al*., 2011).

Avenue and open grown trees play a vital role in maintaining the ecological balance of crowded and polluted environment (Adeyoju, 2001; Lindenmayer, et.al., 2005; Wallace, et.al., 2009 Lindenmayer, *et.al*., 2005; Wallace, *et.al*., 2009). They are most effective in providing true shade and a commanding visual contrast between dense landscaping and open space (Green, 2007; Kiran, et.al., 2011 Kiran, *et.al*., 2011). The importance and conservation of these trees as natural, cultural and literary icons is now gaining recognition across cities in developing countries. The polytechnic Ibadan is one of the fore most institutions in the city of Ibadan, Nigeria with significant presence of avenue and open grown trees, but without any substantive record about biometric, management activities and plans that guarantee sustainable, effective and efficient conservation, despite diverse benefits derived from them. Assessing these trees will help to establish a base-line information needed for their sustainable management and conservation.

Tree assessment helps to measure, monitor and improve tree cover and combat threats that can lead to tree canopy loss (Andersen, et.al., 2002 Andersen, *et.al*., 2002; Dobrilovic, 2009). The goal of tree assessment is to provide decision makers with detailed metrics regarding the tree canopy (FAO, 1993). Metrics helps in understanding trees current form and also in planning feasible approaches to increasing urban tree canopy (USDA, 2018). In tree assessment, variety of variables such as DBH, total height, and so on are measured for each tree, thereby forming the basis for species diversity. Species diversity often refers to the number of diverse species that are embodied in a given community (Tuomisto, 2010). It is a vital part of any ecosystem diversity (Rennolls and Laumonier 2000; Tchouto, *et.al*., 2006) and are useful for analyzing the impact of environmental change on a community and for identifying critical habitat for rare or threatened species (Fleishman, *et.al*., 2005). Here, both avenue and open grown trees within the premises of the institution were assessed using remote sensing data and field data.

Materials and Methods

Study area

The study was conducted within the Polytechnic Ibadan (PI), Oyo State, South-west region of Nigeria. Ibadan is one of the major cities in Nigeria and the largest city in Africa. PI is located on longitude 3^0 52' 7.66' 'E and latitude 7^0 23' 5.64" N (Figure 1). PI extent between latitude 7° 26.846' N - 7° 26.936' N and longitude 3° 52.597' E - 3° 52.837' E (Figure 1). It is a tertiary institution that accommodates wide varieties of urban trees. The location of the institution is characterized with both rainy (wet) and dry season. The rainy season start from the month of March till early October while the dry season starts from the month of October till April (Amanambu, 2015). There is usually harmattan between the month of December and February.

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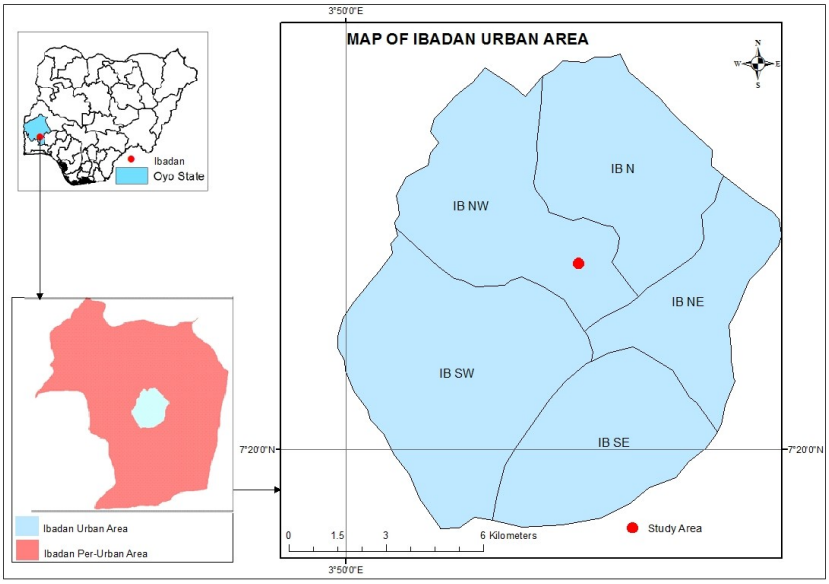

Figure 1: Map of Ibadan showing the Study Area

Data sources

Both primary and secondary data sources were used for this study. Satellite images were extracted from Google Earth Engine (GEE) and Google earth website. Inventory data such as taxonomy and mensuration were also sourced through field survey. A study flow chart representing the steps and methods followed is shown in Figure 2.

Tree enumeration and data analysis

The avenue and open grown trees were identified with reference to google earth image following Nagendra and Gopal (2011). The identified trees were then enumerated through field survey. The species and families of the trees were identified through the assistance of a taxonomist with the knowledge of plant identification from Forest Herbarium Ibadan (FHI), Forestry Research Institute of Nigeria (FRIN). Variables such as diameter at breath height (DBH) and total height (TH) of each tree were also measured and computed. The species composition was identified by calculating frequency and percentage frequency following Adeyoju (2001). The avenue and open grown trees structure was examined by categorizing the DBH and TH into ten (10) diameter and five (5) height classes respectively following Adeyoju (2001) and Hustch, et.al., (2003) Hustch, *et.al.*, (2003). The species diversity was estimated using Shannon-Wiener diversity index (H) and Simpson's Diversity index (D) following Magurran (2004) and Lu, *et al.*, (2010).

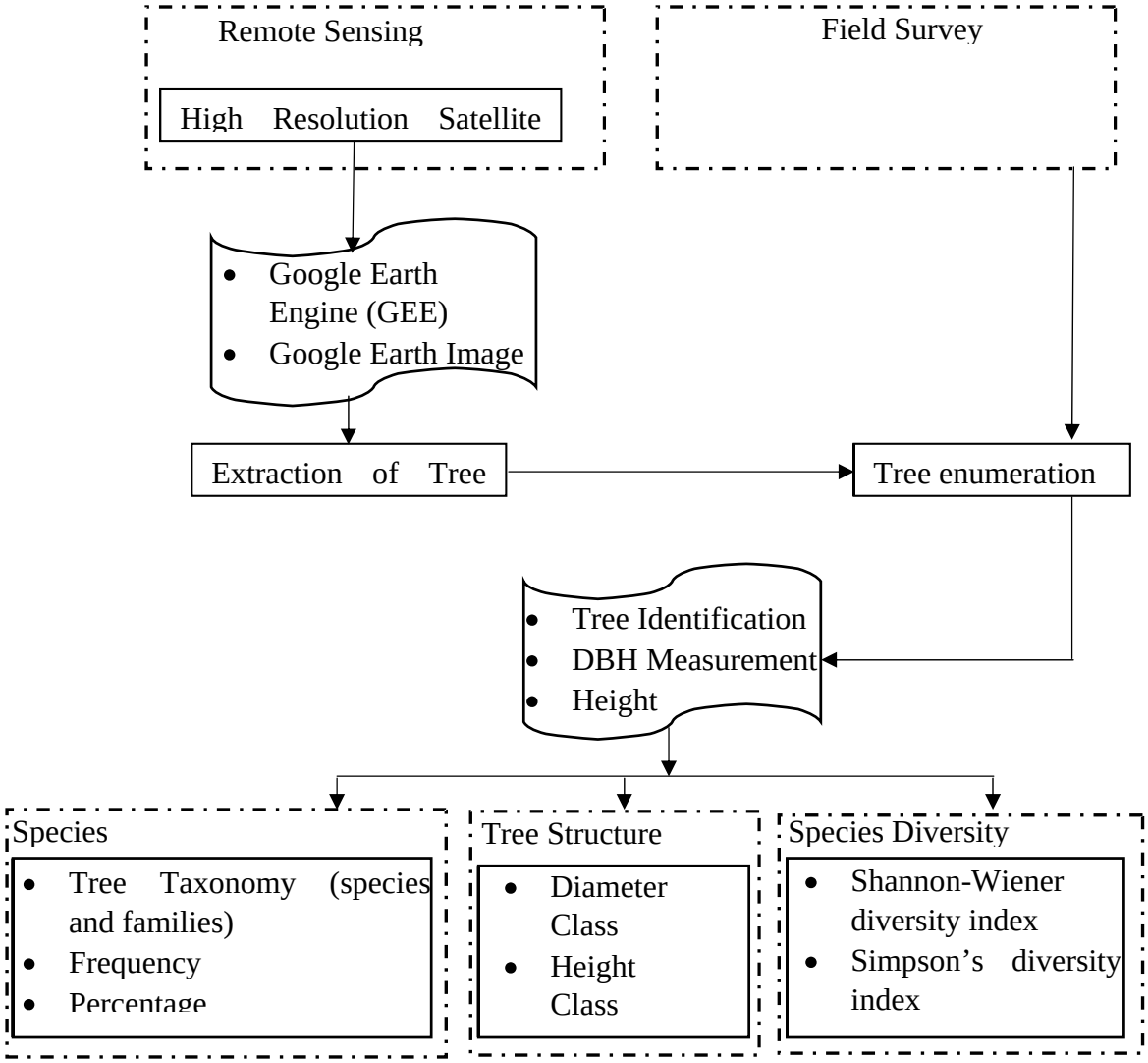

Figure 2: Schematic representation of steps involved in the study

Species diversity and evenness indices

The species diversity used includes;

I. Shannon-Wiener diversity index:

$$H' = -\sum_{i=1}^{R} Pi \ln Pi \qquad (1)$$

Where: H ' is the Shannon-Wiener diversity index; R is the total number of species in the study area; Pi is the proportion of R made up of the *i*th species and; In is natural logarithm.

II. Simpson's diversity index:

$$D - \sum\left(\frac{n_i(n_i-1)}{N(N-1)}\right) \qquad (2)$$

Where; D is Simpson's diversity; n_i is the abundance of the ith species and; N is the abundance of the total stand.

Results and Discussion

Tree species composition

The species composition of the avenue and open grown trees were presented in figure 3, table 1 and 2. Table 1 shows that there are 145 avenue trees consisting 9 species distributed among 9 families in the study

area. *Gmelina arborea* species had the highest percentage frequency of 51.72% followed by *Azadirachta indica* (38.62%), *Gliricidia sepium* (2.76%), *Tectona grandis* (2.07%), *Newbouldia laevis* and *Terminalia radii* (1.38%), while *Mangifera indica*, *Bridelia ferruginea* and *Albizia lebbeck* had the least (0.69%).

Table 2 revealed that there are 22 species of open grown trees distributed among 15 families in the study area. *Terminalia mentalis* species had the highest percentage frequency of 27.40%, follow by *Tabebuia rosea* (9.13%), *Gmelina arborea* (8.68%), *Azadirachta indica* (7.76%), *Terminalia catappa* (7.31%), *Polyalthia longifolia* (6.39%), *Delonix regia* (5.94%), *Terminalia radii* (5.48%), *Tectona grandis* (4.57%), *Casuarina equitifolia* (3.20%), *Holarrhena floribunda* (2.74%), *Newbouldia laevis*, *Parkia biglobosa* (1.37%), *Psidium quajava* (0.91%) while *Albizia andianthifolia*, *Anacardium occidentale*, *Irvingia gabonensis*, *Ficus thonningii*, *Leuceana leucocephalla*, *Cola millenii*, and *Morinda lucida* had the least (0.46%).

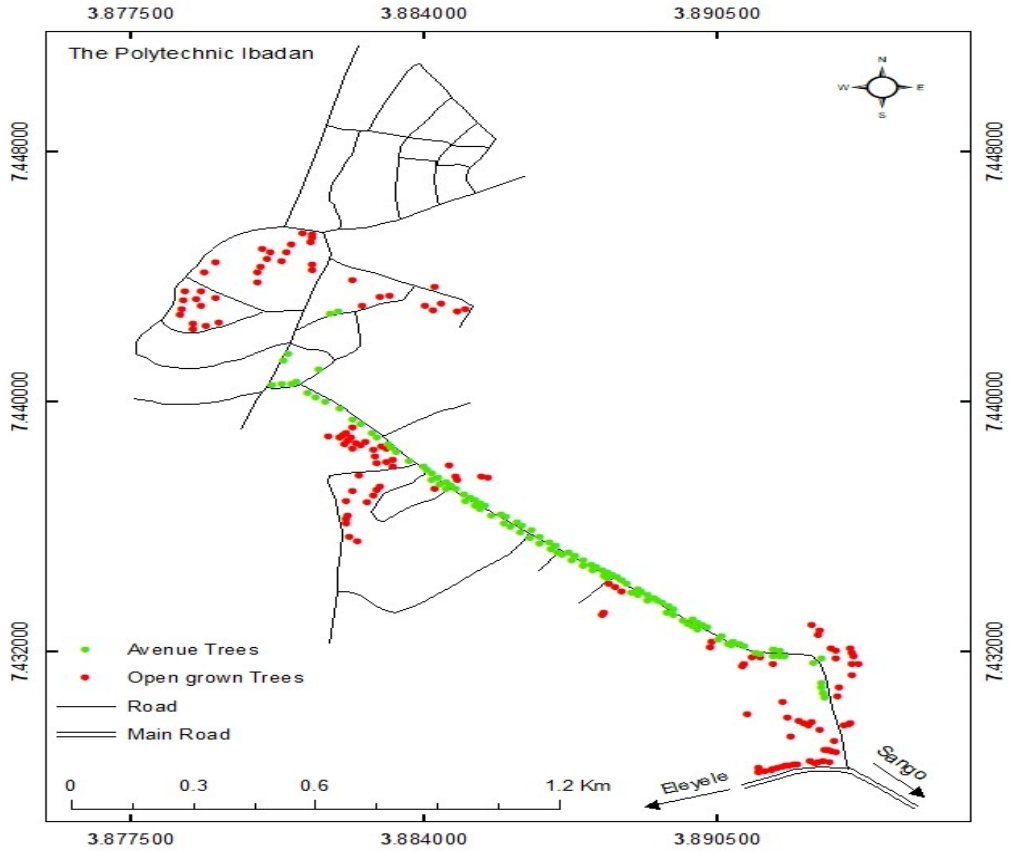

Figure 3: The Polytechnic Ibadan showing avenue and open grown trees identified on satellite image

Table 1: Taxonomy and frequency distribution of avenue tree species in the Polytechnic Ibadan

S/N	Family	Species	Frequency	Percentage Frequency (%)
1	Anacardiaceae	*Mangifera indica*	1	0.69
2	Bignoniaceae	*Newbouldia laevis*	2	1.38

3	Combretaceae	*Terminalia radii*	2	1.38
4	Euphorbiaceae	*Bridelia ferruginea*	1	0.69
5	Fabaceae	*Gliricidia sepium*	4	2.76
6	Labiatae	*Gmelina arborea*	75	51.72
7	Lamiaceae	*Tectona grandis*	3	2.07
8	Leguminosae	*Albizia lebbeck*	1	0.69
9	Meliaceae	*Azadirachta indica*	56	38.62
Total			**145**	**100**

Table 2: Taxonomy and frequency distribution of open grown tree species in the Polytechnic Ibadan

S/N	Family	Species	Frequency	Percentage Frequency (%)
1	Anacardiaceae	*Anacardium occidentale*	1	0.46
		Mangifera indica	10	4.57
2	Annonaceae	*Polyalthia longifolia*	14	6.39
3	Apocynaceae	*Holarrhena floribunda*	6	2.74
4	Bignoniaceae	*Newbouldia laevis*	3	1.37
		Tabebuia rosea	10	9.13
5	Casuarinaceae	*Casuarina equisetifolia*	7	3.20
6	Combretaceae	*Terminalia catappa*	17	7.31
		Terminalia mentalis	60	27.40
		Terminalia radii	12	5.48
7	Fabaceae	*Albizia andianthifolia*	1	0.46
		Delonix regia	13	5.94
		Leuceana leucocephalla	1	0.46
		Parkia biglobosa	3	1.37
8	Irvingiaceae	*Irvingia gabonensis*	1	0.46
9	Labiatae	*Gmelina arborea*	19	8.68
10	Lamiaceae	*Tectona grandis*	10	4.57
11	Meliaceae	*Azadirachta indica*	17	7.76
12	Moraceae	*Ficus thonnigii*	1	0.46
13	Myrtaceae	*Psidium guajava*	2	0.91
14	Rubiaceae	*Morinda lucida*	1	0.46
15	Sterculiaceae	*Cola millenii*	1	0.46
Total			**210**	**100**

Tree structure

The tree structure of avenue and open grown trees encountered in the study area are presented in tables 3 - 6. Table 3 shows the diameter class distribution of the avenue trees. The diameter class > 200cm had the highest number of trees with percentage frequency of 23.45%, followed by 161-180cm (18.62%), 181-200cm (17.93%) 141-160cm (12.41%), 101-120cm (11.03%), 121-140cm (6.90%) 81-100cm (4.83%), 61-80cm (2.76%), and 20-40cm 20-40cm (1.38%) diameter class, while 41-60cm

diameter class had the least (0.69%). Table 4 shows the height class distribution of the avenue trees. The height class 16-20m had the highest number of trees with percentage frequency of 44.14%, followed by 11-15m (37.24%), > 20m (9.66%), and 6-10m height class (8.28%), while 0-5m height class had the least (0.69%).

Table 5 shows the diameter class distribution of the open grown trees. The diameter class > 200cm and 81-100cm had the highest number of trees with percentage frequency of 17.14%, followed by 61-80cm (14.76%), 41-60cm (12.38%), 101-120cm (10%), 20-40cm (9.52%), 141-160cm (7.14%), 121-140cm (6.19%), and 181-200cm diameter class (3.33%), while 161-180cm had the least (2.38%). Table 6 shows the height class distribution of the open grown trees. The height class 6-10m had the highest number of trees with percentage frequency of 40.48%, followed by 11-15m (35.24%), 16-20m (13.81%), and > 20m height class (8.57%), while 0-5m height class had the least (1.90%).

Table 3: Diameter class distribution of avenue tree

S/N	Diameter Class (cm)	F	PF (%)
1	20-40	2	1.38
2	41-60	1	0.69
3	61-80	4	2.76
4	81-100	7	4.83
5	101-120	16	11.03
6	121-140	10	6.90
7	141-160	18	12.41
8	161-180	27	18.62
9	181-200	26	17.93
10	> 200	34	23.45
Total		**145**	**100**

Note: Frequency (F) and Percentage Frequency (PF)

Table 4: Height class distribution of avenue tree species

S/N	Height Class (m)	F	PF (%)
1	0-5	1	0.69
2	6-10	12	8.28
3	11-15	54	37.24
4	16-20	64	44.14
5	> 20	14	9.66
Total		**145**	**100**

Note: Frequency (F) and Percentage Frequency (PF)

Table 5: Diameter class distribution of open grown tree species

S/N	Diameter Class (cm)	F	PF (%)
1	20-40	20	9.52
2	41-60	26	12.38
3	61-80	31	14.76

4	81-100	36	17.14
5	101-120	21	10.00
6	121-140	13	6.19
7	141-160	15	7.14
8	161-180	5	2.38
9	181-200	7	3.33
10	> 200	36	17.14
Total		**210**	**100**

Note: Frequency (F) and Percentage Frequency (PF)

Table 6: Height class distribution of open grown tree species

S/N	Height Class (m)	F	PF (%)
1	0-5	4	1.90
2	6-10	85	40.48
3	11-15	74	35.24
4	16-20	29	13.81
5	> 20	18	8.57
Total		**210**	**100**

Note: Frequency (F) and Percentage Frequency (PF)

Species diversity

The species diversity of avenue and open grown trees were represented in table 7. The result show that open grown trees has more species diversity than the avenue trees. The Shannon-Wiener diversity index (H) for avenue and open grown trees are 1.109 and 2.492 respectively, while the Simpson's Diversity index (D) for avenue and open grown trees are 0.5816 and 0.8761 respectively. The tree species evenness (E) for avenue and open grown trees are 0.3368 and 0.5496 respectively.

Table 7: Diversity indices of the study area

Diversity	Avenue	open grown
Taxa_S	9	22
Individuals	145	210
Simpson(1-D)	0.5816	0.8761
Shannon(H')	1.109	2.492
Evenness (E)	0.3368	0.5496

Discussion

The results reported shows the species composition, structure and diversity of the avenue and open grown trees. The total number and species composition of identified avenue and open grown trees implies that the population and species of open grown trees is higher than avenue trees. The species encountered for avenue and open grown trees is a representation of good collection of various tree species suitable for esthetic and shade purpose in the institution, as well as for improving air

quality. According to Agbeja and Akindele (2016) the species of trees in Ibadan primarily provides environment services such as improved quality of air, shade, and esthetic values. Also, with *Gmelina arborea* and *Azadirachta indica* dominating the avenue trees in the study area, suggests that both species commonly planted in the forest or plantation could also be effective and efficient as avenue tree. Both species might have been selected based on the level of knowledge or technical knowhow and awareness of the people involved in the design and establishment of those avenue trees.

According to Dobrilovic (2009) in a designed landscape people represent the main factor in the nature, distribution and expansion of plants. People choose, arrange and remodel according to their needs and wishes. The selection of plants usually rested upon individual taste and fashion dictates of the period, rather than starting from and following directives determined by the objective of creating a certain space characteristic. Both species could serve as a seed source for plantation establishment. This is in line with Kohli, *et.al*., (1998) that the concept of urban forestry includes not only aesthetics, but also functions for environmental and socio-economic uplift. Furthermore, *Terminalia mentalis* dominated the open grown trees. This corroborate with the findings of Adeyemi and Adesoye (2012) and may be traceable to its structural value. According to Pretzsch (2014), the dominance of a tree species in an environment is greatly influenced by its structural value and functions. The species also could serve as a seed source. Dobbs, *et.al*., (2014), reported that the presence *Terminalia mentalis* tree stand in a specific environment serves primarily as a seed source.

The avenue trees are dominated by > 200cm diameter class and 16-20m height class. This is similar to the findings of Adeyemi and Adesoye (2012). This suggest that the avenue trees comprise of significant large trunks, indicating that most of the avenue trees have been planted over some years. Kohli, *et.al*., (1998) reported that avenue trees with long lifespan are usually characterized with large trunks. It also infers that most of the avenue trees are tall, mature and suitable for their object of management. According to Dobrilovic (2009), avenues tree height of 10m (or more), 5-10m and 5m (or less) can be classified as tall, middle, and low respectively. Furthermore, the open grown trees are dominated by > 200cm and 81-100cm diameter class, and 6-10m height class. Similar findings were reported by Adeyoju (2001), Adeyemi and Adesoye (2012), and Olokeogun, et.al., (2017) Olokeogun, *et.al*., (2017) for stem diameter and height distribution of assessed tree species. It also corroborates the assertion of Nowak, et.al., (2013) Nowak, *et.al*., (2013) who reported that urban trees including open grown trees are characterized with large stem size and height.

The species richness and diversity of the open grown trees is greater than the avenue trees, which is line with the assertion of IIRS (2002) that when the species richness is high, it is an indication that the diversity value is also high (IIRS, 2002). Several studies reported greater values for species richness and diversity in tropical forest ecosystems in urban and rural settings (Onyekwelu, *et.al*., 2008 Onyekwelu, *et.al*., 2008; Adeyemi and Adesoye, 2012; Adekunle, *et al*., 2013; Agbelade, *et.al*., 2016; Olokeogun, et.al., 2017; Adekunle, *et.al*., 2013; Agbelade, *et.al*., 2016; Olokeogun, *et al*., 2017; Olajuyigbe and Jeminiwa, 2018; Olajuyigbe and Akwarandu, 2019).

Conclusion

This study assessed the species composition, structure, and diversity of avenue and open

grown trees within the premises of the polytechnic, Ibadan. The result showed that there are 9 prominent families (belonging to 9 species) of avenue trees and 15 families (belonging to 22 species) of open grown trees in the study area. The > 200cm diameter class distribution of avenue trees had the highest percentage frequency (23.45%) while 41-60cm diameter class had the least (0.69%). The > 200cm and 81-100cm diameter class distribution of open grown trees had the highest percentage frequency (17.14%) while 161-180cm diameter class had the least (2.38%). The 16-20m height class distribution of avenue trees had the highest percentage frequency (44.14%) while 0-5m diameter class had the least (0.69%). The 6-10m height class distribution of open grown trees had the highest percentage frequency (40.48%) while 0-5m diameter class had the least (1.90%). The species diversity of the open grown trees is more than the avenue trees. The study confirmed the existence of abundant species composition in the study area, in which most of the species of the avenue trees are distributed in the higher diameter class distribution class (> 200cm), while the species of the open grown trees are distributed in the higher diameter class distribution class (> 200cm) and lower diameter class distribution class (81-100cm). The species of the avenue trees and open grown trees are distributed in the higher height class distribution class (44.14%) and lower class distribution class (6-10m) respectively. Also the species diversity of avenue and open grown trees are relatively high.

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