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IN FORESTRY, FOREST PRODUCTS
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MANAGEMENT**

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Assessment of Tree species in the Faculty of Agriculture and Forestry, University of Ibadan, Nigeria



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Abstract

Sustainable tree and/or forest management require information on the growing stock. Such information guides the resource manager in appropriate valuation and efficient utilization of the resources. However, where the objective of management is not timber production, little or no emphasis has been placed on the adequate assessment of the growing stock. For timber production, estimates of the growing stock are often expressed in terms of timber volume, which can be estimated from measurable characteristics of the trees. This study assessed the yield, diversity and abundance of tree species in the Faculty of Agriculture and Forestry, University of Ibadan, Nigeria. Total enumeration of all the tree species in the faculty was carried out. Tree species diversity, stem volume and the relationships among growth variables were investigated. All the trees encountered were grouped into species, diameter and height classes and their basal area and tree stem volume were computed. Stem volume equations were developed for the tree species in the area. The variables used for the equations consisted of basal area, diameters at breast height, merchantable height, crown length and tree total height. The species were distributed among 14 genera and 8 families. *Eucalyptus camadulensis* had the highest population of trees in the study area. The family Myrtaceae has the highest number of observation (32.7%) with only one species belonging to the group. This is followed by the Papilionaceae (12.7%) with five species. The third in the series being the families of Meliaceae and Verbenaceae with 12.7% each of the species encountered in the study area. The family of Caesalpiniaceae had 9.1% of the total observations while Bignoniaceae, Pinaceae and Sapindaceae had 1.8% each. The diameters at breast height (Dbh) ranged between 14.0cm and 128.2cm while tree total height ranged between 7.0m and 30.5m. About 33% of the tree species falls into the middle diameter class (40-60cm). This is followed by the diameter class 60-80cm with about 24%. The diameter class 20-40cm was made up of about 22%. The fifth diameter class (> 80.0m) ranked fourth, with about 18% of tree frequency in the study area. The least represented diameter class is 0-20cm with 3.6% of the species encountered in the study area. The best volume equation obtained was

Introduction

Forest inventory is the procedure for obtaining information on the quantity and quality of the forest resource and many of the characteristics of the land area on which trees are growing (Husch *et al.*, 2003). Regardless of the forest management objectives, whether, timber, wildlife, recreation, water, or non-wood values, the forest overstorey must be quantified for informed decision-making. Forest cover is an important part of wildlife habitat, and the understorey component can often be related to overstorey characteristics (Avery and Burkhart 1994).

Sustainable tree and/or forest management require information on the growing stock. Such information guides the resource manager in valuation and allocation of forest areas for exploitation. For timber production, estimates of the growing stock are often expressed in terms of timber volume, which can be estimated from easily measurable dimensions of the tree (Husch *et al.*, 2003; Akindele, 2005). However, where the objective of management is not timber production, little or no emphasis has been placed on the adequate assessment of the growing stock. The most common procedure for volume estimation is to use volume equations, which are based on the relationship between volume and variables such as diameter, height, etc., and an appropriate classification procedure for species grouping. The reliability of the volume estimates depends on how well the volume equation fits the data (Adekunle *et al.*, 2004; Akindele, 2005; Adeyemi and Adesoye, 2010).

In the University of Ibadan, much work has been done in this regard for timber species stands, most of which are exotic (e.g. Adesoye and Oluwadare, 2008; Adeyemi and Adesoye, 2010). The pronounced heterogeneity in species composition and structure even within small areas has precluded the development of volume functions for the Faculty of Agriculture, which is a similitude of a mixed stand. Without reliable volume equations for this mixed stand, there is no basis for planning their sustainable use. More over, this has been worsened, in a case where the objective of management is not timber-tied. There is therefore the need to develop volume equations, which can be used to obtain reliable estimates of the stock in the faculty, which is a good example of a non-timber centred estate. Following the installation of sawmill in the

University of Ibadan, there is the need for assessment of trees in the faculty and ultimately in the university. This will enable effective management of the forest cover and prevent indiscriminate removal of trees which is rampant all over the country.

Methodology

The study area

This study was conducted in the faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Nigeria. The faculty has seven academic departments as at the time of the study: Agricultural Economics; Agronomy; Animal Science; Crop Protection and Environmental Biology; Agricultural Extension and Rural Development; Forest Resources Management; Wildlife and Fisheries Management. It is located on latitude 07° 26.992' and longitude 003° 53.734'. It shows the location coordinates of the seven departments in the Faculty.

Table 1: Coordinates of the Departments in the Faculty of Agriculture and Forestry

Department	Latitude	Longitude	Elevation
Agricultural Economics	07°27.00'	003°53.693'	207.2m
Agronomy	07°27.062'	003°53.752'	214.7m
Animal Science	07°27.031'	003°53.695'	207.5m
Crop Protection and Environmental Biology	07°27.024'	003°53.805'	217.2m
Agricultural Extension and Rural Development	07°26.992'	003°53.734'	208.2m
Forest Resources Management	07°26.935'	003°53.821'	212.2m
Wildlife and Fisheries Management	07°26.957'	003°53.809'	213.1m

The Data

The data used for this study was collected from the Faculty of Agriculture and Forestry, University of Ibadan. Data were individual tree measurements for diameter (over-bark) at base, breast height, middle and top positions along stem, tree total height, merchantable height, stem quality, crown length and crown diameter. The tree species were grouped and classified up to family level. The minimum Dbh in the data was 14 cm. The data were also examined to check if there were erroneous data-points in form of questionable or unrealistic values.

Data Analysis

Data Analysis

Tree basal area was computed using the expression

$$BA = \frac{\pi D^2}{4} \quad \text{..... 1}$$

Where BA = Basal area (m²); D = Diameter at breast height (1.3m above the ground level).

In this study, volume was estimated for both the stem and merchantable portion of the stem. Based on the data collected in this study, merchantable volume was estimated using the Newton's formula (FAO, 1980) expressed as:

$$V = \frac{h}{6} (A_b + 4A_m + A_t) \quad \text{..... 2}$$

Where V = tree volume (in m³); A_b, A_m and A_t = tree cross-sectional area at the base, middle and top of merchantable height respectively (in m²) and h = total height (in meter). Merchantable height is defined as the usable portion of the tree stem, it is, the part for which volume is computed or the section expected to be utilized in a commercial logging operation (Avery & Burkhardt, 2002). Following the computation of tree basal area and volumes, the data were summarized by computing some descriptive statistics for each species. The statistics included number of observations, range, mean and standard error of the mean. Graphs were also plotted to examine the relationship between the variables. Only the graphs for the pooled data (all species combined) are presented in this report.

Development of Volume Equations

Several models were considered and tried for the combined species. The combination was necessary because of the limited number of species in the study area. However, the generalised logarithmic model was found to be the most

appropriate. The model was therefore selected for this study. In its original form, the model was the Schumacher-Hall volume model (Schumacher and Hall, 1933) expressed as:

$$V = b_0 + b_1 D^2 H + E_i \quad \dots\dots\dots 3$$

Where, V = tree volume (m^3);
 D = diameter at breast height (cm);
 H = merchantable height (m);
 b_0 and b_1 are the regression parameters, while E_i is the error term. The model indicates that tree volume increases proportional to certain powers of D and H . In some previous works (e.g. Vancly, 1991 and Akindole, 2005) the D was fixed to the power of 2 while H was fixed to the power of 1. The tree volume equations developed in this study were:

$$\ln SV = b_0 + b_1 \ln BA + b_2 \ln THT \quad \dots\dots\dots 4$$

$$\ln SV = b_0 + b_1 \ln BA \quad \dots\dots\dots 5$$

$$\ln SV = b_0 + b_1 \ln Dbh^2 + b_2 \ln THT \quad \dots\dots\dots 6$$

$$\ln SV = b_0 + b_1 \ln BA + b_2 THT \quad \dots\dots\dots 7$$

$$\ln SV = b_0 + b_1 \ln D_m + b_2 \ln THT \quad \dots\dots\dots 8$$

$$\ln SV = b_0 + b_1 \ln D_m + b_2 THT \quad \dots\dots\dots 9$$

$$SV = b_0 + b_1 Dbh + b_2 THT \quad \dots\dots\dots 10$$

$$\ln SV = b_0 + b_1 D_m + b_2 THT \quad \dots\dots\dots 11$$

$$SV = b_0 + b_1 Dbh + b_2 Cl \quad \dots\dots\dots 12$$

$$SV = b_0 + b_1 Dbh^2 + b_2 THT \quad \dots\dots\dots 13$$

$$SV = b_0 + b_1 \ln Dbh + b_2 MIT \quad \dots\dots\dots 14$$

Adequacy of the models

The major fit statistics calculated for each volume equation were the co-efficient of determination (R^2) and the standard error of estimate (SEE).

Coefficient of determination (R^2) was computed as:

$$R^2 = 1 - \frac{SSE}{SST} \quad \dots\dots\dots 15$$

Standard Error of Estimate (SEE) was computed as:

$$SEE = \sqrt{\frac{\sum_{i=1}^n \hat{e}_i^2}{n - k}} \quad \dots\dots\dots 16$$

Where, $\hat{e}_i$ is the difference between the observed (y_i) and the predicted volume values ($\hat{y}_i$); SSE is the error sum of squares, SST is the total sum of squares, n is the number of trees in the model-fitting data set and k is the number of coefficients in the fitted equation.

Results and Discussion

Eighteen tree species were identified. These species belong to 8 different families as indicated in Table 2. For ease of local referencing, the local names of each tree species are also presented in the Table. A summary of the data for the 18 species

showing number of observations means, standard error minimum and maximum for each variable is presented in Table and 5.

Table 2: Data distribution according to family with the species local names

S/N	Species	Local Name	Family	Frequency	%
1	<i>Azadirachta indica</i>	Dongoyaro	Meliaceae	2	3.6
2	<i>Delonix regia</i>	Panseke	Caesalpiniaceae	3	5.5
3	<i>Entadrophragma cylindricum</i>	Jobo		1	1.8
4	<i>Eucalyptus camadulensis</i>	Ukaliputosi	Meliaceae		
5	<i>Gmelina aborea</i>	Meliana	Myrtaceae	18	32.7
6	<i>Khaya grandifoliola</i>	Ogano	Verbenaceae	4	7.3
7	<i>Khaya senegalensis</i>	Ogano	Meliaceae	1	1.8
8	<i>Milicia excelsa</i>	Ogano	Meliaceae	1	1.8
9	<i>Pericopsis alata</i>	Iroko	Meliaceae	2	3.6
10	<i>Pinus caribaea</i>	Sedun	Papilionaceae	1	1.8
11	<i>Senna alata</i>	Christmas tree	Pinaceae	1	1.8
12	<i>Tectona grandis</i>	Asunwo	Caesalpiniaceae	2	3.6
13	<i>Terbebuca rosea</i>	Gedu	Verbenaceae	3	5.5
14	<i>Terminalia catapa</i>	Tabebuia	Bignoniaceae	1	1.8
15	<i>Terminalia ivorensis</i>	Furuntu	Papilionaceae	8	14.5
16	<i>Terminalia montalis</i>	Alara	Papilionaceae	1	1.8
17	<i>Terminalia superba</i>	Igi aburada	Papilionaceae	1	1.8
18	<i>Zaha gologolensis</i>	Idigbo	Papilionaceae	4	7.2
		N/A	Sapindaceae	1	1.8
Total				55	100

Table 3: Summary of statistics of the data for the 18 species

S/N	Species	THT (m)		MHT (m)		CL (m)		DB(cm)		DBH (cm)	
		Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E
1	<i>Azadirachta indica</i>	11.25	2.75	3.75	0.25	8.00	3.50	28.33	3.50	28.33	2.81
2	<i>Delonix regia</i>	9.83	1.36	4.33	1.01	6.17	0.89	65.56	8.32	57.18	6.31
3	<i>Entadrophragma cylindricum</i>	8.00	*	3.20	*	5.00	*	60.79	*	52.51	*
4	<i>Eucalyptus camadulensis</i>	20.00	1.29	10.31	1.18	9.75	0.86	64.25	4.63	53.36	3.75
5	<i>Gmelina aborea</i>	15.50	1.06	7.37	1.30	7.25	1.11	75.40	16.40	58.1	14.1
6	<i>Khaya grandifoliola</i>	28.40	*	8.50	*	19.90	*	140.04	*	128.26	*
7	<i>Khaya senegalensis</i>	14.00	*	4.00	*	10.00	*	128.90	*	114.58	*
8	<i>Milicia excelsa</i>	13.75	1.25	6.75	0.75	7.750	0.25	79.6	44.60	68.40	39.8
9	<i>Pericopsis alata</i>	19.00	*	7.50	*	12.50	*	124.12	*	112.99	*
10	<i>Pinus caribaea</i>	15.00	*	10.50	*	9.00	*	28.64	*	24.19	*
11	<i>Senna alata</i>	16.25	2.25	6.25	0.25	10.00	2.50	53.31	7.16	39.8	11.1
12	<i>Tectona grandis</i>	15.50	3.77	6.00	0.29	8.83	2.85	57.3	11.50	48.27	8.35
13	<i>Terbebuca rosea</i>	22.00	*	8.00	*	14.00	*	109.48	*	102.48	*
14	<i>Terminalia catapa</i>	15.12	1.30	5.64	0.74	9.76	1.46	62.50	5.42	47.82	4.68
15	<i>Terminalia ivorensis</i>	28.50	*	17.00	*	11.50	*	109.80	*	81.16	*
16	<i>Terminalia montalis</i>	7.50	*	4.00	*	3.50	*	18.14	*	14.00	*
17	<i>Terminalia superba</i>	23.75	2.89	12.88	1.40	11.25	1.74	96.50	20.1	71.2	13.4
18	<i>Zaha gologolensis</i>	26.60	*	5.00	*	21.50	*	117.76	*	105.03	*

* = there is no S.E. since the observation for such species is singular

Assessment of tree species in the Faculty of Agriculture and Forestry, University of Ibadan, Nigeria
 Table 4: Summary of statistics of the data for the 18 species continues

Species	THT (m)		MHT (m)		CL (m)		DB(cm)		DBH (cm)	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
1 <i>Acacia indica</i>	8.50	14.00	3.50	4.00	4.50	11.50	24.82	31.83	19.18	24.82
2 <i>Delonix regia</i>	8.00	12.50	2.50	6.00	4.500	7.50	55.70	82.11	49.33	69.70
3 <i>Entadrophragma cylindricum</i>	8.00	8.00	3.20	3.20	5.00	5.00	60.79	60.79	52.51	52.51
4 <i>Eucalyptus camadulensis</i>	8.00	30.50	5.00	26.00	2.50	15.00	44.56	117.76	36.60	95.48
5 <i>Gmelina aborea</i>	14.00	18.50	3.50	9.00	5.50	10.50	35.70	113.00	28.8	84.30
6 <i>Khaya grandifoliata</i>	28.40	28.40	8.50	8.50	19.90	19.90	140.04	140.04	128.26	128.26
7 <i>Khaya senegalensis</i>	14.00	14.00	4.00	4.00	10.00	10.00	128.90	128.90	114.58	114.58
8 <i>Milicia excelsa</i>	12.50	15.00	6.00	7.50	7.50	8.00	35.00	124.10	28.60	108.20
9 <i>Pericopsis alata</i>	19.00	19.00	7.50	7.50	12.50	12.50	124.12	124.12	112.99	112.99
10 <i>Pinus caribaea</i>	15.00	15.00	10.50	10.50	9.00	9.00	28.64	28.64	24.19	24.19
11 <i>Senna alata</i>	14.00	18.30	6.000	6.50	7.50	12.50	46.15	60.47	28.60	50.90
12 <i>Tectona grandis</i>	11.00	23.00	5.50	6.50	5.50	14.50	41.40	79.60	35.01	63.65
13 <i>Terbebea rosea</i>	22.00	22.00	8.00	8.00	14.00	14.00	109.48	109.48	102.48	102.48
14 <i>Terminalia catapa</i>	11.00	19.50	2.15	7.50	3.50	16.50	47.74	89.11	31.83	71.61
15 <i>Terminalia ivorensis</i>	28.50	28.50	17.00	17.00	11.50	11.50	109.80	109.80	81.16	81.16
16 <i>Terminalia montalis</i>	7.50	7.50	4.00	4.00	3.50	3.50	18.14	18.14	14.00	14.00
17 <i>Terminalia superba</i>	15.50	29.00	10.50	16.00	6.50	14.50	59.8	132.10	41.40	95.50
18 <i>Zaha gologulensis</i>	26.60	26.60	5.00	5.00	21.50	21.50	117.76	117.76	105.03	105.03

* = there is no S.E since the observation for such species is singular

Table 5: Summary of statistics of the data for the 18 species continues

S/N	Species	DT (cm)		CD (m)		BA (m ²)		MV (m ³)	
		Mean	S.E	Mean	S.E	Mean	S.E	Mean	S.E
1	<i>Acacia indica</i>	10.50	1.00	10.60	1.16	0.04	0.01	0.08	0.01
2	<i>Delonix regia</i>	25.33	3.71	15.36	4.51	0.26	0.06	0.46	0.12
3	<i>Entadrophragma cylindricum</i>	17.50	*	13.70	*	0.22	*	0.25	*
4	<i>Eucalyptus camadulensis</i>	37.22	5.86	18.19	1.09	0.24	0.04	2.62	0.98
5	<i>Gmelina aborea</i>	24.20	11.6	14.51	3.04	0.31	0.12	0.93	0.29
6	<i>Khaya grandifoliata</i>	46.50	0	19.90	*	1.29	*	4.30	*
7	<i>Khaya senegalensis</i>	104.20	*	17.70	*	1.03	*	3.88	*
8	<i>Milicia excelsa</i>	53.80	41.4	14.87	5.33	0.492	0.43	3.28	3.06
9	<i>Pericopsis alata</i>	29.50	*	18.90	*	1.00	*	2.17	*
10	<i>Pinus caribaea</i>	12.50	*	3.45	*	0.05	*	0.27	*
11	<i>Senna alata</i>	16.50	1.50	12.34	0.74	0.13	0.07	0.41	0.08
12	<i>Tectona grandis</i>	22.00	11.8	10.60	11.1	0.19	0.07	0.87	0.58
13	<i>Terbebea rosea</i>	78.00	0	17.95	*	4.72	*	4.95	*
14	<i>Terminalia catapa</i>	22.88	4.29	13.47	0.69	0.19	0.04	0.74	0.23
15	<i>Terminalia ivorensis</i>	57.40	*	15.50	*	0.52	*	9.40	*
16	<i>Terminalia montalis</i>	8.00	*	7.22	*	0.02	*	0.04	*
17	<i>Terminalia superba</i>	45.10	10.6	12.16	1.78	0.44	0.15	4.52	1.80
18	<i>Zaha gologulensis</i>	68.00	0	22.30	*	0.87	*	3.22	*

* = there is no S.E since the observation for such species is singular

Family composition

A total of 8 species were encountered (Table 6) in the study area. The family, *Myrtaceae* has the highest number of observation (32.7%) with only one species belonging to the group. This is followed by *Papilionaceae* (27.3%) with 6 species belonging to the family. The third being the families of *Meliaceae* and *Verbenaceae* with 12.7% each of the species encountered in the area. The family of *Caesalpiniaceae* has the fourth highest number of 9.1% of the total observations while those of *Bignoniaceae*, *Pinaceae* and *Sapindaceae* have 1.8% each. The details of family composition are presented in Table 6.

The richness of the species in the Faculty is noteworthy. For tree species diversity in the study area, 18 species distributed among 14 genera and 8 families were present in the study area. The breakdown of species into families shows the numbers of species present are 7, 5, 18, 7, 1, 15, 1 and 1 for *Meliaceae*, *Caesalpiniaceae*, *Myrtaceae*, *Verbenaceae*, *Pinaceae*, *Papilionaceae*, *Bignoniaceae* and *Sapindaceae* respectively.

The values obtained in this study are lower than what they were some couple of years back. The reason for this sharp decline is mainly due to the removal of many tree species for the Faculty expansion and partly due to the accidental removal of wind throws and other forms of disturbance in the ecosystem. This could indicate the extent to which man has interfered with the continued existence of these species in the study area, since species diversity of a given area would largely depend on the extent of human interaction in the past and present (Parthasarathy, 2001).

Table 6: Data distribution according to family

S/No.	Family	No. of species	No. of observations	% of the total
1	Bignoniaceae	1	1	1.8
2	Caesalpiniaceae	2	5	9.1
3	Meliaceae	5	7	12.7
4	Myrtaceae	1	18	32.7
5	Papilionaceae	5	15	27.3
6	Pinaceae	1	1	1.8
7	Sapindaceae	1	1	1.8
8	Verbenaceae	2	7	12.7
	Total	18	55	100

Stand density, Basal area and Stem Volume

Fifty-five (55) stems of trees were obtained in the entire study area. *Myrtaceae* family has the highest tree density of 18 stems followed by *Papilionaceae* with 15 stems while *Meliaceae* and *Verbenaceae* have 7 stems each in the study area. The basal area of the trees per species is presented in the Table 7. *Terbebea rosea* has the largest basal area per species (4.7243m²) which is about 26% of the total in the study area. This is followed by *Terminalia superba* with 1.7634m² and *Eucalyptus camadulensis* with 1.3708m², which represent 9.58% and 7.44% respectively. For the stem volume, *Eucalyptus camadulensis* has the largest volume in the study area with 80.1085m³, which represents about 32% of the tree stem volume in the area. This is expected as they were more frequently seen in the Faculty with their highest concentration at the back of the department of Forest Resources Management. The merchantable volume per species followed a similar pattern as the stem volume per species. The details of the tree density, stem volume and the merchantable volume per species are presented in Table 7.

Table 7: Distribution of basal area, stem volume and merchantable volume per species

Tree Species	BA/SP	MV/SP
<i>Azadiracta indica</i>	0.1664(0.90%)	0.1664(0.14%)
<i>Delonix regia</i>	0.7893(4.28%)	1.3751(1.20%)
<i>Entadrophragma cylindricum</i>	0.2166(1.77%)	0.2487(0.22%)
<i>Eucalyptus camadulensis</i>	1.3708(7.44%)	47.205(41.07%)
<i>Gmelina aborea</i>	1.2448(6.76%)	3.7101(3.23%)
<i>Khaya grandifoliola</i>	1.2922(7.02%)	4.3035(3.74%)
<i>Khaya senegalensis</i>	1.0313(5.60%)	3.8819(3.38%)
<i>Melicia excelsa</i>	0.9842(5.34%)	6.5582(5.71%)
<i>Pericopsis alata</i>	1.0028(5.45%)	2.1652(1.88%)
<i>Pinus caribaea</i>	0.0464(0.25%)	0.275(0.24%)
<i>Senna spp</i>	0.2681(1.46%)	0.8259(0.72%)
<i>Tectona grandis</i>	0.5818(3.16%)	2.6114(2.27%)
<i>Terbebusa rosea</i>	4.7243(25.66%)	4.9479(4.30%)
<i>Terminalia catapa</i>	1.5332(8.33%)	5.9461(5.17%)
<i>Terminalia ivorensis</i>	0.5174(2.81%)	9.4024(8.18%)
<i>Terminalia montalis</i>	0.0154(0.08%)	0.0395(0.03%)
<i>Terminalia superba</i>	1.7634(9.58%)	18.0619(15.71%)
<i>Zaha gologolensis</i>	0.8665(4.71%)	3.2197(2.80%)
Total	18.4145(100%)	114.9439(100%)

Stem diameter and height distribution

The distribution of the tree species into diameter classes is presented in Table 8. About 33% of the tree species falls into the middle diameter class (40.1-60.0cm). This constitutes the largest percentage of the tree species in the area. This is followed by the diameter class 60.1-80.0cm, which has about 24% of the species in the Faculty. The second diameter (20.1-40.0cm) class captured about 22% of the tree species in the study area. The fifth diameter class (>80.0m) is the fourth with only about 18% of the species encountered in the area. The least represented diameter class is the first one (0.1-20.0cm). This captured only 3.6% of the species encountered. The details are shown in Table 8.

The distribution of tree species into height classes reveals that 60% of the tree species belong to the second height class (10.1-20.0m). This constitutes the largest percentage of the trees in the study area. About 26% of the species is captured by the third height class (20.1-30.0m), which makes it the second largest in the area. Seven stems (12.7%) are in the first height class (0.1-10.0m). Furthermore, only one stem is in the largest height class (>30.0m). This constitutes only 1.8% of the tree species in the area. The details of the height classification are presented in the Table 9.

Table 8: Distribution of tree species into Dbh Classes

Tree Species	6-20cm	20-40cm	40-60cm	60-80cm	> 80cm	Species Frequency	Species %
<i>Azadirachta indica</i>	1					2	3.6
<i>Delonix regia</i>		1				3	5.5
<i>Entadrophragma cylindricum</i>			2	1		1	1.8
<i>Eucalyptus camadulensis</i>			1			1	1.8
<i>Gmelina aborea</i>		5	6	6	1	18	32.7
<i>Khaya grandifoliola</i>		2	1	1		4	7.3
<i>Khaya senegalensis</i>				1		1	1.8
<i>Melicia excelta</i>				1		1	1.8
<i>Pericopsis alata</i>		1				2	3.6
<i>Pinus caribaea</i>					1	1	1.8
<i>Senna spp</i>		1				1	1.8
<i>Tectona grandis</i>		1	1			2	3.6
<i>Terbebusa rosea</i>		1	1	1		3	5.5
<i>Terminalia catapa</i>					1	1	1.8
<i>Terminalia ivorensis</i>			4	2	2	8	14.5
<i>Terminalia montalis</i>					1	1	1.8
<i>Terminalia superba</i>	1					1	1.8
<i>Zaha gologolensis</i>			2		2	4	7.3
Sub- total					1	1	1.8
Total	2(3.6%)	12(21.8%)	18(32.7%)	13(23.6%)	10(18.2%)		
						55	100

Table 9: Distribution of tree species into height classes

Tree Species	0.1-10.0m	10.1-20.0m	20.1-30.0m	>30m	Species Frequency	Species %
<i>Azadirachta indica</i>	1	1			2	3.6
<i>Delonix regia</i>	2	1			3	5.5
<i>Entadrophragma cylindricum</i>	1				1	1.8
<i>Eucalyptus camadulensis</i>	1	9	7	1	18	32.7
<i>Gmelina aborea</i>		4			4	7.3
<i>Khaya grandifoliola</i>			1		1	1.8
<i>Khaya senegalensis</i>		1			1	1.8
<i>Melicia excelta</i>		2			2	3.6
<i>Pericopsis alata</i>		1			1	1.8
<i>Pinus caribaea</i>	1				1	1.8
<i>Senna spp</i>		2			2	3.6
<i>Tectona grandis</i>		2	1		3	5.5
<i>Terbebusa rosea</i>		1			1	1.8
<i>Terminalia catapa</i>		8			8	14.5
<i>Terminalia ivorensis</i>			1		1	1.8
<i>Terminalia montalis</i>	1				1	1.8
<i>Terminalia superba</i>		1	3		4	7.3
<i>Zaha gologolensis</i>			1		1	1.8
Sub- total	7(12.7%)	33(60%)	14(25.5%)	1(1.8%)		
Total					55	100

Volume models

For the volume models (Table 10), all the assessment criteria revealed that they are all suitable for use in the study area. The fit index, which is the coefficient of determination (R^2), for all the categories of models, was very high, with values ranging between 66.6% and 95.4% for the transformed models. For the linear models, it ranges between 61.4% and 87.1%. Furthermore, all the models were significant at $p < 0.05$ level.

Table 10: Models generated for tree volume estimation in the Study Area

SN	Model	R^2 (%)	SEE	F-ratio	P-value
1	$\ln SV = -2.2 + 0.84 \ln BA + 1.53 \ln THT$	95.3	0.4	284.09	0.000
2	$\ln SV = 2.47 + 1.09 \ln BA$	75.0	0.6	139.21	0.000
3	$\ln SV = -2.1 + 0.94 \ln Dbh^2 + 1.48 \ln THT$	92.6	0.4	325.09	0.000
4	$\ln SV = -1.9 + 0.62 \ln BA + 0.14 \ln THT$	66.6	0.8	51.81	0.000
5	$\ln SV = 1.49 + 1.65 \ln D_m + 0.10 \ln THT$	95.4	0.3	338.66	0.000
6	$\ln SV = 1.48 + 1.44 \ln D_j + 0.10 \ln THT$	92.1	0.4	302.74	0.000
7	$SV = -9.06 + 0.13 Dbh + 0.34 THT$	80.2	2.5	105.28	0.000
8	$SV = -6.68 + 0.16 D_m + 0.26 THT$	87.1	2.0	174.91	0.000
9	$SV = -5.61 + 9.41 Dbh^2 + 0.37 THT$	81.5	2.4	114.52	0.000
10	$SV = -7.79 + 0.15 \ln Dbh + 0.44 MHT$	79.7	2.5	102.20	0.000
11	$SV = -6.03 + 0.16 \ln Dbh + 0.16 Cl$	69.7	3.1	59.7	0.000

In this study, 75% of the models generated have negative intercepts (Table 10). This is in line with the report by Avery and Burkhart (2002) that tree volume prediction usually gives negative intercept. The standard error of estimate, which measures the overall predictive value of regression models (Akindele and LeMay, 2006) and also, a common measure of goodness of fit in nonlinear regression models (Glantz and Slinker, 2001), with low value indicating better fit. In this study, the SEE ranged between 0.3 for model (5) to 3.5 for model (10). These results suggest that all the models have good fit within the context of the field data. Evidently, the transformed models give better fit going by their coefficient of determination and standard errors of estimates.

Considering the relationship between stem volume and tree variables for all the species combined together, they are reliable on a general basis. Apparently, the pooling of all the observations helped to suppress the variability among the different species. The equation can therefore be used in situations where the objective is to obtain rough estimates of tree volumes for tree species in the Faculty of Agriculture and Forestry. Its major weakness is the implicit assumption that trees of various species have the same form. This is certainly not true in the tropical rainforest area. Consequently, a great deal of caution is required in using the equations.

Correlation among tree growth variable

Generally, there is high correlation between most of the tree growth variables. This implies that most of the variables rise and fall together. For instance, there is very high correlation between the Dbh and D_h (0.98); between SV and D_h (0.90 each). However, there are very weak correlations between MHT and BA. The details of the correlations between tree growth variables are presented in the table 11.

Table 11: Correlation Coefficients for tree growth variables in the Study Area

	THT	MHT	SQ	CL	D_h	Dbh	D_m	D_s	CD	BA
MHT	0.7									
SQ	0.7	1.0								
CL	0.7	0.03	0.03							
D_h	0.5	0.3	0.3	0.4						
Dbh	0.5	0.2	0.2	0.4	0.97					
D_m	0.5	0.3	0.3	0.4	0.8	0.8				
D_s	0.3	0.3	0.3	0.8	0.8	0.98	0.5			
CD	0.3	0.004	0.04	0.3	0.5	0.5	0.6	0.5		
BA	0.3	0.1	0.1	0.3	0.6	0.5	0.6	0.3	0.3	
SV	0.7	0.5	0.5	0.5	0.8	0.9	0.9	0.4	0.5	0.5

The four strata common in natural tropical vegetation were identified in this study. Most of the species encountered are in the second stratum (height between 10-20m) and only one tree can be referred to as emergent (height >30 m). The basal area obtained in the study area is lower than 24m² suggested by previous workers for a well-stocked forest (Alder and Abayomi, 1994; Adekunle et al., 2004).

Conclusion

The results of this study reflects the composition and abundance of species and yield status of faculty of Agriculture in terms of its. Most of the tree species are distributed in the middle diameter class (40-60cm) and the percentage in the upper diameter class (>80cm) is considerably small. This is because trees with very large diameters are usually the unfortunate ones during the expansion drive of the Faculty. The small number of tree species in the study area shows that the area has been disturbed in the recent past for expansion and the associated erection of many building to accommodate more areas of specializations. Obviously, the Faculty is sparsely rich in tree species compared to what it used to be some years back. Therefore, it is recommended that the yet-to-be-built-up area be planted up to compensate for those lost to the faculty expansion.

The stand volume equations, which incorporated various tree growth variables, will enhance future yield prediction of the Faculty since they provide quantitative basis for estimating stand growth. All the models generated are adequate and are recommended for stand volume assessment in the study area.

The volume prediction equations provide the means through which the production potential of the existing stands can be estimated in the study area. It is believed that the equations obtained in this study will enhance sound and informed management decisions for the Faculty tree management.

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