



Description and Composition of Tree Species in a Tertiary Institution Agricultural Faculty Arboretum, Ibadan, South-West Nigeria

*¹HAASTRUP, NO; ²BOLAJI, OW; ¹NURUDEEN, TA; ¹BABALOLA, YO;
¹JEMINIWA, OR; ¹OLADIPUPO-ALADE, EO; ¹OYEDELE, MD; ¹LAWAL, MO;
¹BOLAJI, OO

¹Forestry Research Institute of Nigeria, Ibadan, Oyo State, Nigeria

²Federal College of Forestry Mechanization, Afaka, Kaduna State, Nigeria

*Corresponding Author Email: haastrup.no@frin.gov.ng; Tel. 08065567335

Other Authors Email: owbolaji@yahoo.com, tunywise@gmail.com, babalolayetunde0209@gmail.com, jeminiwaoluremi@gmail.com, bukolamomoh@gmail.com, modupedorcas014@gmail.com, oladokunlawalmbasiru@yahoo.com, bolajioyelola@gmail.com

ABSTRACT: The Arboretum of the Agricultural Faculty of a tertiary institution in Ibadan is known for its rich diversity of trees. Therefore, the study investigates the tree growth variables in the arboretum such as diameter at breast height (dbh), diameter at the base, middle and top of the bole, total height, merchantable height and crown diameter. The basal area and volume were then calculated per species and per family. Several models were fitted for the height – diameter relationship and crown diameter – diameter relationship and crown diameter – dbh relationship. Positive linear relationships were observed among the growth variables. The fitted models showed that cubic models exhibit a more reliable function than quadratic and linear models for crown diameter – dbh predictions as it has R² above 0.75. Endangered species were observed too and this was indicated through the diversity index obtained. The highest basal area encounter belongs to myrtaceae family (9.61m²) while the lowest belongs to pinaceae family (0.24m²). The total basal area obtained at (31.72m²) from the faculty trees indicates that they are exhibiting better growth and yield.

DOI: <https://dx.doi.org/10.4314/jasem.v26i6.25>

Open Access Article: (<https://pkp.sfu.ca/ojs/>) This an open access article distributed under the Creative Commons Attribution License (CCL), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Impact factor: <http://sjifactor.com/passport.php?id=21082>

Google Analytics: <https://www.ajol.info/stats/bdf07303d34706088ffffbc8a92c9c1491b12470>

Copyright: © 2022 Haastrup *et al*

Dates: Received: 21 March 2022; Revised: 25 June 2022; Accepted: 30 June 2022

Keywords: Arboretum; Merchantable; Linear; Endangered; Tree species

A tree inventory is a collection of data for description and analysis of the status, quantity, quality or product of a resource and provides information such as tree health, species, size and location; this information is used to generate reports that can help urban foresters in their strategic planning, such as the development of maintenance plans and management plans, as well as to help educate residents about their urban forest.

Kangas *et al.*, (2006) and Michael *et al.*, (2008) is of the opinion that for sustainable forest management to be attained there is need for up-to-date forest inventories to assess the composition, structure, and distribution of forest vegetation that, in turn, can be used as base information for management decisions. Hence, this paper is aimed at describing the composition of tree species in a tertiary institution

agricultural faculty arboretum in Ibadan, South-West Nigeria.

MATERIALS AND METHODS

Study Area: The study was carried out at the Arboretum in the Faculty of Agriculture and Forestry at The University of Ibadan, Oyo State, Nigeria.

Tree Growth Variable Measurement: Measurement was limited to woody plants of 20 cm diameter at breast height and above as done by FORMECU (1997) while identification was limited to woody plants of 10 cm diameter at breast height and above (Okali and Ola-Adams, 1987, Swaine and Hall, 1987). The following tree data were collected in the study area for further analysis:

*Corresponding Author Email: haastrup.no@frin.gov.ng; Tel. 08065567335

- i. Diameter at breast height: Diameter at breast height is the stem diameter at a position of 1.3m above the ground level.
- ii. Diameter at the base
- iii. Diameter at the middle
- iv. Diameter at the top
- v. Crown length
- vi. Merchantable height using Spiegel relascop.
- vii. Total height of all trees using Spiegel relascop

Data Analysis

Basal Area Calculation: The basal area of each tree in the enumerated plots was calculated using the formula:

$$BA = \pi D^2 / 4$$

Where BA = Basal area (m²), D = Diameter at breast height (cm) and π = pie (3.142).

Volume Calculation: The volume of each tree was calculated in every plot using the Newton's formula of Husch et al (1982).

$$V = h/6(Ab + 4Am + At)$$

Where: V = Tree volume (in m³); Ab, Am and At = tree cross-sectional area at the base, middle and top of merchantable height, respectively (in m²); h = total height (in meters).

However, all data collected are been subjected to descriptive statistics, regression analysis, analysis of variance etc. Using various statistical packages like excel, SPSS and Statistical.

Species diversity indices: Species diversity indices according to Dearth and Winterborn (1995), the choice of index is complicated by the fact that diversity comprises two main components namely species richness and specie evenness. However, the diversity indices were calculated from mathematical formula that takes into account of both species richness and relative abundance of each species in the community. Relative abundance refers to the number of individuals of a given species divided by the total number of individual of all species found.

$$= RF - ni/N100$$

Where, RF is the relative frequency or abundance; n_i is the number of individual in the entire population; N is the total number of the entire population

Also, using Shannon Weiner diversity index to calculate habitat diversity.

$$H = - \sum Pi \ln Pi$$

Where 'H' is the Shannon diversity index; \sum is the total number of species in the habitat; Pi is the relative abundance i.e number of specie divided by the total number of individual in the habitat.

In is natural logarithm.

For specie evenness we used Magurran (1988) formulae

$$E = H / \ln S$$

Where H = Shannon Weiner diversity index; $\ln S$ = Natural logarithm of number of species in the habita; E = Species evenness.

Models Generation: In the course of this study, models were generated for height – diameter at breast height distributions and also models were generated for crown diameter – diameter at breast height distribution to show their relationships. Consequently, the models used in this study were linear, quadratic and cubic multiple regression models as shown in the table below.

Models generated for tree total height – diameter at breast height (dbh)

Code function	Function form	Designation
1	$h = b_0 + b_1 \text{ dbh}$	Linear
2	$h = b_0 + b_1 \text{ dbh} + b_2 \text{ dbh}^2$	Quadratic
3	$h = b_0 + b_1 \text{ dbh} + b_2 \text{ dbh}^2 + b_3 \text{ dbh}^3$	Cubic

Models generated for crown diameter – diameter at breast height (dbh)

Code function	Function form	Designation
1	$cd = b_0 + b_1 \text{ dbh}$	Linear
2	$cd = b_0 + b_1 \text{ dbh} + b_2 \text{ dbh}^2$	Quadratic
3	$cd = b_0 + b_1 \text{ dbh} + b_2 \text{ dbh}^2 + b_3 \text{ dbh}^3$	Cubic

Where: H = Total height (m); Dbh = Diameter at breast height taken at 1.3m above ground level
Cd = Crown diameter

RESULTS AND DISCUSSION

Table 1, this shows the species and families of trees encountered in the faculty of Agriculture and forestry, University of Ibadan, Nigeria. The table further shows that the species with the highest frequency was *Eucalyptus camadulensis* followed by *Terminalia spp*, *Gmelina arborea*, *Delonix regia*, *Tectona grandis*, *Senna spp* e.t.c. The total trees encountered were fifty-five in all where fifteen different species were found. Meanwhile, all the species encountered fell into the category of indigenous and exotic species as this ia an indication of typically mixed forest ecosystems, it can

HAASTRUP, NO; BOLAJI, OW; NURUDEEN; TA, BABALOLA; YO; JEMINIWA, OR; OLADIPUPO-ALADE, EO; OYEDELE, MD; LAWAL, MO; BOLAJI, OO

also be deduced that the soil in this location supported the growth of both plantation and natural forest. The total families of trees encountered (table 2) were eight in all, from which Myrtaceae family dominated by having the highest frequency followed by Papilionaceae, Meliaceae, Verbanaceae, Caesalpiniaceae, Bignoniaceae, Pinaceae and Sapindaceae with frequency of 18, 15, 7, 7, 5, 1, 1 and 1 respectively. The total tree volume encountered were 965.45m³ while the total merchantable height was found to be 448.85m³ and the total basal area were found to be 31.72m². However, it was discovered that

the least total volume belongs to *Pinus caribea* (0.39m³) while the highest total volume belongs to *Eucalyptus camadulensis* (21.53m³). The least merchantable volume were found to be 0.22m³ and the highest merchantable belongs to *Eucalyptus camadulensis* with volume of 18.35m³, all these values were found to be in accordance with the findings of Adekunle (2000) who noted the least volume to be 0.42m³ in the natural forest and further justify that the forest was supported by good soil that is rich in nutrients needed for plant growth.

Table 1: Showing the Species Family and Variables Collected

S/N	Species	Family	THT (m)	MHT (m)	CL (m)	DB (cm)	DBH (cm)	DM (cm)	DT (cm)	CD (m)
1	Melicia excels	Meliaceae	12.5	6	8	124.12	108.21	118.5	95.2	20.2
2	Eutadrophragma cytidaricum	Meliaceae	8	3.2	5	60.79	52.51	22	17.5	7
3	Pericopsis alata	Papilionaceae	19	7.5	12.5	124.12	112.99	38	29.5	18.9
4	Zanha gologolensis	Sapindaceae	26.6	5	21.5	117.76	105.03	87.6	68	22.3
5	Khaya grandifoliola	Meliaceae	28.4	8.5	19.9	140.04	128.26	65	46.5	19.9
6	Terminalia superba	Papilionaceae	25	10.5	14.5	130.49	95.48	72	56	17.1
7	Tectona grandis	Verbenaceae	11	5.5	5.5	50.93	46.15	10.1	9.5	10.75
8	Khaya senegalensis	Meliaceae	14	4	10	128.9	114.58	108	104.2	17.7
9	Tectona grandis	Verbenaceae	12.5	6	6.5	41.37	35.01	26.5	11	8.6
10	Terminalia catappa	Papilionaceae	11	7.5	3.5	60.47	47.74	34.5	18	13.7
11	Terminalia superba	Papilionaceae	15.5	10.5	6.5	59.83	41.37	30.2	23	8.62
12	Gmelina aborea	Verbenaceae	14	8.5	6.5	87.52	79.57	22	15	13.05
13	Terminalia superba	Papilionaceae	29	16	13	132.08	92.3	75	69	11.65
14	Terminalia ivorensis	Papilionaceae	28.5	17	11.5	109.8	81.16	82	57.4	15.5
15	Eucalyptus camadulensis	Myrtaceae	30.5	26	4.5	117.76	95.48	90	87.5	18.85
16	Delonix regia	Caesalpiniaceae	12.5	6	7.5	55.7	49.33	21	18	6.7
17	Eucalyptus camadulensis	Myrtaceae	8	5	3	81.16	70.02	60	47	21.9
18	Eucalyptus camadulensis	Myrtaceae	11.5	9	2.5	46.79	36.6	15	14.5	10.95
19	Eucalyptus camadulensis	Myrtaceae	27	14.5	12.5	91.66	76.38	72.5	58	13.1
20	Eucalyptus camadulensis	Myrtaceae	21	9.5	11.5	66.2	60.47	60	53.4	18.05
21	Eucalyptus camadulensis	Myrtaceae	22	11	11	52.83	42.97	31	28.5	16
22	Eucalyptus camadulensis	Myrtaceae	17	10.5	6.5	47.74	39.78	35.6	32.5	13.55
23	Eucalyptus camadulensis	Myrtaceae	18.5	8	10.5	48.7	42.97	34	28	22.35
24	Eucalyptus camadulensis	Myrtaceae	18	6	12	47.74	38.19	35	28.5	24.25
25	Eucalyptus camadulensis	Myrtaceae	22	7	15	47.74	39.47	36.5	31	22.9
26	Eucalyptus camadulensis	Myrtaceae	25	13.5	11.5	74.79	57.29	49	32.4	23.18
27	Eucalyptus camadulensis	Myrtaceae	17	6.5	11.5	52.51	42.97	38	32.5	23.3
28	Eucalyptus camadulensis	Myrtaceae	22	13.5	8.5	81.16	60.47	52.5	35.6	18.1
29	Eucalyptus camadulensis	Myrtaceae	20	12	8	50.92	39.15	51	40	21.45
30	Eucalyptus camadulensis	Myrtaceae	19.5	5.5	14	66.52	63.34	53.5	41.5	20.95
31	Eucalyptus camadulensis	Myrtaceae	18	6.5	11.5	69.38	60.79	32	28.5	15.4
32	Eucalyptus camadulensis	Myrtaceae	27	14	13	44.56	42.65	31	25	11.45
33	Eucalyptus camadulensis	Myrtaceae	16	7.5	8.5	68.43	51.56	34	25.5	11.65
34	Gmelina aborea	Verbenaceae	15.5	9	6.5	65.25	39.78	18	11.5	10.7
35	Gmelina aborea	Verbenaceae	18.5	3.5	10.5	112.99	84.34	70.2	59	23.48
36	Tectona grandis	Verbenaceae	23	6.5	14.5	79.57	63.65	62	45.6	12.45
37	Terminalia superba	Papilionaceae	25.5	14.5	11	63.65	55.7	37	32.5	11.25
38	Pinus caribea	Pinaceae	15	10.5	9	28.64	24.19	16	12.5	3.45
39	Melicia excels	Meliaceae	15	7.5	7.5	35.01	28.64	15	12.5	9.55
40	Gmelina aborea	Verbenaceae	14	8.5	5.5	35.65	28.64	18	11.5	10.8
41	Terminalia catappa	Papilionaceae	11	5	6	47.74	35.01	24	20	12.45
42	Terminalia catappa	Papilionaceae	12	2.15	10.15	52.51	41.37	28.5	15	12.58
43	Terminalia catappa	Papilionaceae	13.95	6.5	7.45	49.97	31.83	22.5	19	11.03
44	Terminalia catappa	Papilionaceae	15.5	6	9.5	82.75	61.43	30.2	18	15.35
45	Senna spp	Caesalpiniaceae	14	6.5	7.5	60.47	50.92	21	18	13.08
46	Senna spp	Caesalpiniaceae	18.5	6	12.5	46.15	28.64	22	15	11.6
47	Azadiracta indica	Meliaceae	8.5	4	4.5	24.82	19.1	13	11.5	11.75
48	Tabebuia rosea	Bignoniaceae	22	8	14	109.48	102.48	85.4	78	17.95
49	Terminalia catappa	Papilionaceae	19	7.5	12.5	55.38	44.56	33	22	12.22
50	Terminalia catappa	Papilionaceae	19.5	3	16.5	62.06	49.01	30	18.5	13.34
51	Terminalia catappa	Papilionaceae	19	7.5	12.5	89.11	71.61	55	52.5	17.12
52	Delonix regia	Caesalpiniaceae	8	2.5	6.5	58.88	52.51	32.5	30	17.55
53	Terminalia radaii	Papilionaceae	7.5	4	3.5	18.14	14	9.5	8	7.22
54	Delonix regia	Caesalpiniaceae	9	4.5	4.5	82.11	69.7	32.1	28	21.84
55	Azadiracta indica	Meliaceae	14	3.5	11.5	31.83	24.82	15	9.5	9.44
	TOTAL		965.45	443.85	531	3872.67	3172.17	2312.9	1855.8	831.95

Where: THT – Total height (m); MHT – Merchantable height (m); BA – Basal area (m²)

HAASTRUP, NO; BOLAJI, OW; NURUDEEN; TA, BABALOLA; YO; JEMINIWA, OR; OLADIPUPO-ALADE, EO; OYEDELE, MD; LAWAL, MO; BOLAJI, OO

Table 2.The Total Volume (M3), Merchantable Volume (M3) and the Basal Area per Species

S/N	Species	Family	TVOL (m ³)	MVOL (m ³)	B AREA (m ²)
1	Melicia excels	Meliaceae	13.19604	6.3341	0.919774
2	Entadrophragma cylidricum	Meliaceae	0.621872	0.248749	0.216586
3	Pericopsis alata	Papilionaceae	5.485257	2.165233	1.002827
4	Zanha gologolensis	Sapindaceae	17.12861	3.219664	0.866509
5	Khaya grandifoliola	Meliaceae	14.37892	4.303549	1.292197
6	Terminalia superba	Papilionaceae	13.38611	5.622167	0.716096
7	Tectona grandis	Verbenaceae	0.445296	0.222648	0.167298
8	Khaya senegalensis	Meliaceae	13.58658	3.881881	1.03125
9	Tectona grandis	Verbenaceae	0.759558	0.364588	0.096279
10	Terminalia catappa	Papilionaceae	1.258866	0.858318	0.179024
11	Terminalia superba	Papilionaceae	1.574014	1.066268	0.134437
12	Gmelina aborea	Verbenaceae	1.79998	1.092845	0.49733
13	Terminalia superba	Papilionaceae	16.97305	9.364443	0.66919
14	Terminalia ivorensis	Papilionaceae	15.76281	9.402377	0.517405
15	Eucllyptus camadulensis	Myrtaceae	21.5315	18.35472	0.716096
16	Delonix regia	Caesalpiniaceae	0.849402	0.407713	0.191147
17	Eucllyptus camadulensis	Myrtaceae	2.429389	1.518368	0.385115
18	Eucllyptus camadulensis	Myrtaceae	0.496762	0.38877	0.105222
19	Eucllyptus camadulensis	Myrtaceae	11.59064	6.224604	0.458253
20	Eucllyptus camadulensis	Myrtaceae	5.947727	2.690639	0.287228
21	Eucllyptus camadulensis	Myrtaceae	2.144935	1.072467	0.145036
22	Eucllyptus camadulensis	Myrtaceae	1.870558	1.155344	0.124301
23	Eucllyptus camadulensis	Myrtaceae	1.884209	0.814793	0.145036
24	Eucllyptus camadulensis	Myrtaceae	1.883163	0.627721	0.114563
25	Eucllyptus camadulensis	Myrtaceae	2.468046	0.785287	0.122372
26	Eucllyptus camadulensis	Myrtaceae	5.317607	2.871508	0.257812
27	Eucllyptus camadulensis	Myrtaceae	2.134234	0.816031	0.145036
28	Eucllyptus camadulensis	Myrtaceae	5.437555	3.336681	0.287228
29	Eucllyptus camadulensis	Myrtaceae	3.821941	2.293165	0.120395
30	Eucllyptus camadulensis	Myrtaceae	4.49208	1.266997	0.315139
31	Eucllyptus camadulensis	Myrtaceae	2.29095	0.827288	0.290276
32	Eucllyptus camadulensis	Myrtaceae	2.281537	1.183019	0.142884
33	Eucllyptus camadulensis	Myrtaceae	2.085642	0.977645	0.20882
34	Gmelina aborea	Verbenaceae	1.15377	0.669931	0.124301
35	Gmelina aborea	Verbenaceae	8.709338	1.647713	0.558745
36	Tectona grandis	Verbenaceae	7.162387	2.024153	0.318231
37	Terminalia superba	Papilionaceae	3.533193	2.009071	0.243701
38	Pinus caribbia	Pinaceae	0.392848	0.274994	0.045964
39	Melicia excels	Meliaceae	0.448118	0.224059	0.064431
40	Gmelina aborea	Verbenaceae	0.494713	0.300362	0.064431
41	Terminalia catappa	Papilionaceae	0.717609	0.326186	0.096279
42	Terminalia catappa	Papilionaceae	0.978937	0.175393	0.134437
43	Terminalia catappa	Papilionaceae	0.891776	0.415523	0.079583
44	Terminalia catappa	Papilionaceae	2.195547	0.849889	0.29642
45	Senna spp	Caesalpiniaceae	1.052893	0.488843	0.203668
46	Senna spp	Caesalpiniaceae	1.039219	0.337044	0.064431
47	Azadiracta indica	Meliaceae	0.158493	0.074585	0.028656
48	Tabebuia rosea	Bignoniaceae	13.60663	4.947866	0.824944
49	Terminalia catappa	Papilionaceae	1.966787	0.776363	0.155968
50	Terminalia catappa	Papilionaceae	1.989633	0.306097	0.188676
51	Terminalia catappa	Papilionaceae	5.670524	2.238365	0.402804
52	Delonix regia	Caesalpiniaceae	0.899854	0.281204	0.216586
53	Terminalia radaii	Papilionaceae	0.074039	0.039488	0.015396
54	Delonix regia	Caesalpiniaceae	1.372389	0.686195	0.381603
55	Azadiracta indica	Meliaceae	0.36719	0.091797	0.048389
	TOTAL	8	252.1907	114.9447	17.4258

Where: T vol – Total volume (m³); M vol- Merchantable volume (m³)

Table 3, this shows the total height, merchantable height and basal area with their mean values. per family. The table further revealed that the highest total height was found in Myrtaceae family while the least were also found in Pinaceae family with the value of 18.06m and 15.00m respectively. This was supported by the work of Onyekwelu and Akindele (2006) who reported that the least height obtained in Gmelina plantaion was 7.6m and it was referred to as tree, so this is an indication that plant with height above 7m

are suitable to be called a tree. The mean basal area (table 3) ranges from 0.24- 1.05m² and this is in accordance with what Adekunle (2000) obtained from simple random sampling in Ala forest reserve. However, it is an indication that the trees vary widely in size a situation of typical un-even aged forest while the high level of standard deviation (table 5) for the dbh is indications that the trees encountered were well formed and vary widely in size and have high economic value for timber production. Meanwhile, the

HAASTRUP, NO; BOLAJI, OW; NURUDEEN; TA, BABALOLA; YO; JEMINIWA, OR; OLADIPUPO-ALADE, EO; OYEDELE, MD; LAWAL, MO; BOLAJI, OO

skewness obtained (table 5) for both dbh and basal area is positive (0.53 & 1.50) is an indication that there are more trees in the lower dbh than upper dbh (Adekunle, 2000).

Table 3. Showing the families and the values of their variables encountered in the study area

S/N	Family	Frequency	THT (m)	MHT (m)	BA (m ²)	Mean THT (m)	Mean MHT (m)	Mean BA (m ²)
1	Meliaceae	7	100.40	36.70	4.76	14.34	5.24	0.68
2	Myrtaceae	18	360.00	185.5	9.61	20.00	0.31	0.55
3	Papilionaceae	15	270.95	125.15	8.76	18.06	8.34	0.58
4	Verbanaceae	7	108.50	47.50	3.77	15.07	6.78	0.54
5	Caesalpinaceae	5	62.00	25.50	2.51	12.40	5.10	0.50
6	Bignontaceae	1	22.00	8.00	1.02	22.00	8.00	1.02
7	Pinaceae	1	15.00	10.50	0.24	15.00	10.50	0.24
8	Sapindaceae	1	26.60	5.00	1.05	26.60	5.00	1.05
Total	8	55	965.45	448.85	31.72	143.47	49.27	5.16

Table 4. The families, total and merchantable volumes

S/N	Family	Frequency	T Vol (m ³)	M Vol (m ³)	Mean T Vol (m ³)	Mean M Vol (m ³)
1	Meliaceae	7	42.75	19.30	6.12	2.76
2	Myrtaceae	18	80.10	32.96	4.45	1.83
3	Papilionaceae	15	72.45	28.07	4.83	1.87
4	Verbanaceae	7	20.52	7.84	2.93	1.12
5	Caesalpinaceae	5	5.21	2.86	1.04	0.57
6	Bignontaceae	1	13.60	4.78	13.60	4.78
7	Pinaceae	1	0.39	0.23	0.39	0.23
8	Sapindaceae	1	17.12	4.43	17.12	4.43
Total	8	55	252.14	100.43	50.48	17.59

Table 5. Descriptive statistics for DBH and Basal Area

Mean	58.24	0.33
Standard error	3.634	0.04
Median	51.241	0.21
Mode	42.966	0.15
Standard deviation	26.7008	0.32
Sample Variance	712.933	0.0999
Kurtosis	-0.00287	1.47
Skewness	0.828996	1.50
Range	144.2584	1.277
Minimum	14.004	0.0015
Maximum	128.262	1.29
Sum	3147.358	18.64
Count	54	54
Confidence Level (9)	7.288	0.0085

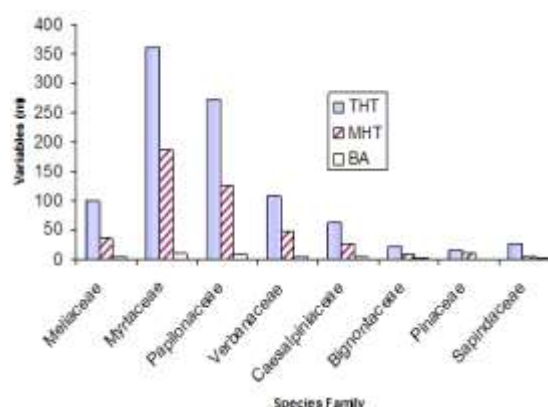


Fig. 1: Showing the relationship between total heights, total merchantable and total basal area per family

Figure 1 shows the graph of the relationship between total height, total merchantable height and total basal area for all the families encountered. The graph further reveals that the basal area were found to be significantly low compared to total height and total merchantable height. The highest basal area belongs to Myrtaceae family while the least belong to Pinaceae family. However, the height observed shows that there is variation in species and families observed, as it is normally observed in a typical uneven aged forest as this was also observed in Fig 2, which shows the graph of the relationship between mean total height, mean merchantable height and mean basal area.

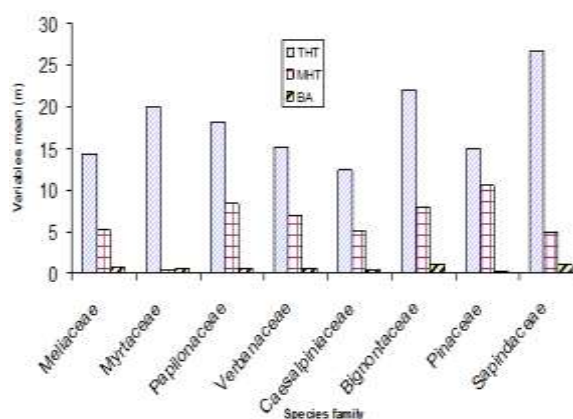


Fig 2. The relationship between the mean total heights, mean merchantable height and the mean basal area per species

Figure 3 this shows the regression model for the relationship between the total volume and the merchantable volume.

HAASTRUP, NO; BOLAJI, OW; NURUDEEN; TA, BABALOLA; YO; JEMINIWA, OR; OLADIPUPO-ALADE, EO; OYEDELE, MD; LAWAL, MO; BOLAJI, OO

Meanwhile, the coefficient of determination (R^2) at 95% significant level shows that there is a strong relationship between total volume and merchantable volume with $R^2=0.76$ and this explains how best the data fit in to the model also the equation obtained shows that the two volume were not statistically different from each other as similar findings were observed by Onyekwelu and Akindele (1995) who reported that there is a strong relationship between the total volume and merchantable volume that it is an indication of how well the data fit into the model and how suitable the model is for further use.

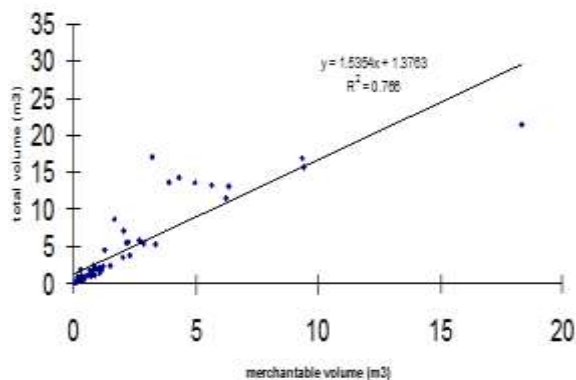


Fig 3: The regression between the total volume and merchantable volume per species

Fig 4, shows the regression analysis for the relationship between total height and merchantable height. The figure further reveals that there is a noticeable relationship between the total height and the merchantable height with $R^2=0.50$ as this is an indication of positive relationship as this is in accordance with the findings of Adekunle (2000) who reported that there is positive relationship between all the growth variable measured for model generation which aids the suitability of the models for growth and yield predictions.

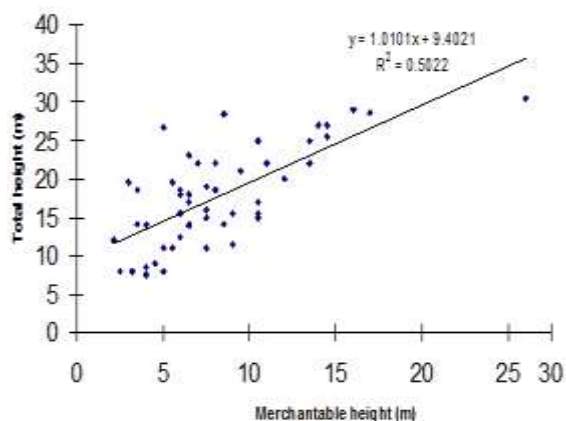


Fig 4: Regression equation for the relationship between total heights and merchantable height

In addition, Fig 5 and 6 shows the regression equation between the total volume and basal area, and between the merchantable volume of the basal area. Meanwhile, the model proved very strong between total volume and basal area ($R^2=0.68$) while there is a very weak relationship between merchantable volume and basal area ($R^2=0.35$). However, this is an indication that the former is in accordance with the findings of Adekunle (2000) who reported that basal area is a function of volume which follows the assumptions of normality, also similar findings were observed by Onyekwelu and Akindele (1995) when predicted volume were validated for Gmelina arborea plantation in Oluwa forest reserve who reported that a very small bias value (less than 20%) obtained as this is an indication for the reliability of the model for further use.

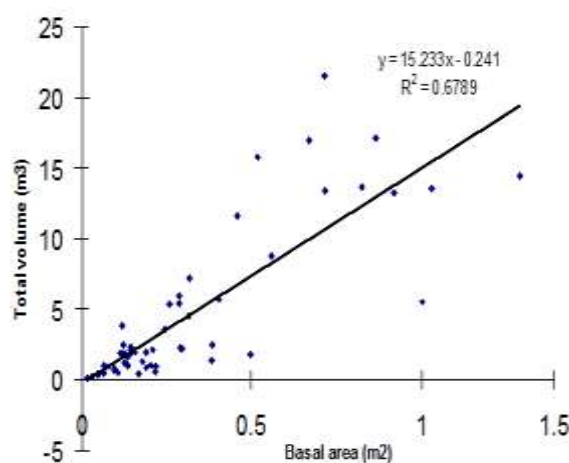


Fig 5: The regression equation between total volume and basal area

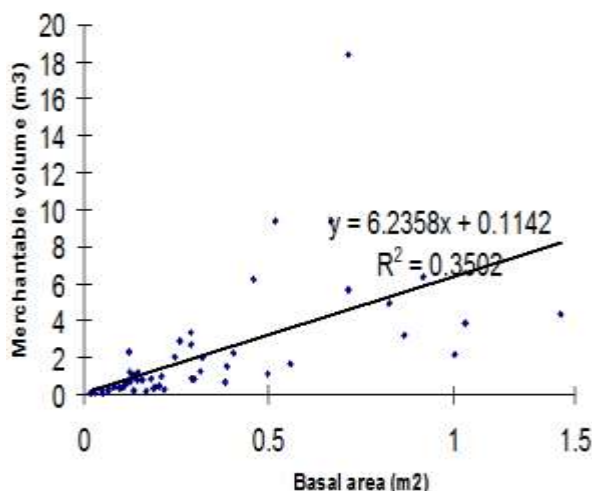


Fig 6: Regression equation between merchantable volume and basal area

The regression for the relationship between the crown diameter and dbh (fig 7). The model shows a very weak relationship ($R^2=0.22$) and this is an indication

HAASTRUP, NO; BOLAJI, OW; NURUDEEN; TA, BABALOLA; YO; JEMINIWA, OR; OLADIPUPO-ALADE, EO; OYEDELE, MD; LAWAL, MO; BOLAJI, OO

that there is significant difference between the crown diameter and the dbh as this oppose the findings of Adekunle (2000) who noted that all the growth variables are not significantly difference from each other.

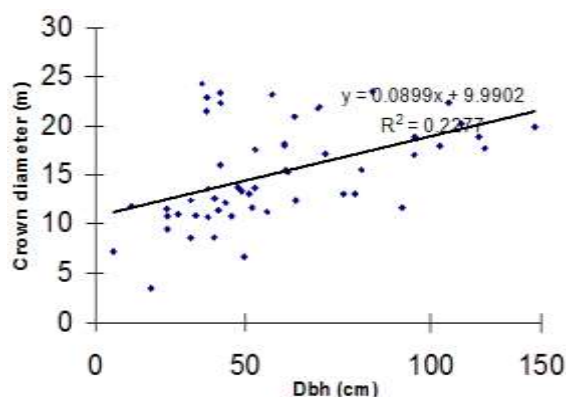


Fig 7. Regression for the relationship between crown diameter and diameter at the breast height

Table 6, this shows the model generated for the total height, merchantable height, total volume and the merchantable volume in equation 1,2,3, and 4 respectively for all the species. Model 1,3&4 indicates a significant different ($p \geq 0.05$) while model 2 shows that there is no significant different between the growth variables. However, based on the level of coefficient of determination (R^2) and standard error of estimates it can be seen that all the models generated exhibits a positive relationship and are linearly stable. This is an indication that all the variables fit well into the model and can also be deduced that the trees were well formed. Consequently, according to the value of statistics used to compare the models in the fitting phase model 4 was found to be more suitable for volume prediction $Mvol = -3.37 + 0.49 MHT + 4.79 BA$ while the coefficient of determination and standard error of estimates were found to be $R^2 = 0.78$ and $SEE = 1.49$ respectively.

Table 6. Showing the model generated through multiple linear regression

S/N	Multiple Regression Model	R ²	SEE	Sig (p≤0.05)
1	THT= 6.62+0.96 CL – 0.50 CD+4.30 DBH	0.54	4.32	0.00
2	MTH =7.74 – 0.04 CL – 1.12 CD + 4.37 DBH	0.53	4.295	0.43
3	T vol = 1.58+ 0.9 THT + 14.09 BA	0.70	3.112	0.00
4	M vol = -3.37+0.49 THT + 4.79 BA	0.78	1.49	0.00

Where: THT – Total height; MTH – Merchantable height; T vol – Total volume; M vol – Merchantable height
CL – Crown length; CD – Crown diameter; DBH – Diameter at breast height; BA – Basal area

The diversity index carried out for the trees family encountered (table 7) shows that the highest diversity was found in Myrtaceae family followed by Papilionaceae, Meliaceae, Verbanaceae and Caesalpinaceae (2.81, 2.70, 1.94,1.94 and 1.60) respectively and others with zero indices. From the diversity index it can be deduced that there is high diversity among five families while the others show zero diversity due to the fact that they have a very low frequency (1). However, the evenness carried out indicates that there is high evenness among the five families while the other three shows zero values. This was in accordance with the findings of Adeduntan *et al* (2006) who reported that the frequency and abundance is a function of diversity as this is an indication that the higher the frequency the higher the diversity level and vice-versa. The result of the correlation analysis carried out to examine the relationship among growth parameter is presented in table 8. There is generally a positive linear relationship between the variables. The highest correlation coefficient was obtained between diameter at the middle and diameter at the top (0.97) followed by db and dbh, db and dm, dbh and dm, THT and DT and CD (0.97, 0.82, 0.81, 0.79, 0.71, 0.71 and 0.50) respectively. However, the least relationship existed between MTH and dbh (0.19).

Table 7. The diversity index and evenness for family of species encounter

S/N	Family	H-Index	Evenness
1	Meliaceae	1.94	2.02
2	Myrtaceae	2.89	8.35
3	Papilionaceae	2.70	7.31
4	Verbanaceae	1.94	2.02
5	Caesalpinaceae	1.60	2.57
6	Bignontaceae	0.00	0.00
7	Pinaceae	0.00	0.00
8	Sapindaceae	0.00	0.00

Consequently, this shows a positive relationship among all the growth variables as it was also supported by the findings of Adekunle (2000) who also noted a positive linear relationship between the growth variable measured in Omo and Ala forest reserves. In addition, this is an indication that tree growth variable exhibits a positive linear relationship when correlated. The models generation for the tree height and diameter distributions (table 9 – 13) for the family of tress up at least five in frequency. The predication models used were linear, quadratic and cubic models respectively. However, for the five differently selected families all the models proved in adequate for myrtaceae and verbanaceae family. While such models were very adequate for meliaceae, papilionaceae and caesalpinaceae families.

HAASTRUP, NO; BOLAJI, OW; NURUDEEN; TA, BABALOLA; YO; JEMINIWA, OR; OLADIPUPO-ALADE, EO; OYEDELE, MD; LAWAL, MO; BOLAJI, OO

Table 8. The correlation matrix for the association between tree growth variables

	THT	MHT	CL	DB	DBH	DM	DT	CD
THT	1							
MHT	0.706854	1						
CL	0.715049	0.038709	1					
DB	0.504258	0.257874	0.436388	1				
DBH	0.460385	0.190357	0.455036	0.972173	1			
DM	0.524888	0.30614	0.418583	0.823903	0.815284	1		
DT	0.490642	0.318005	0.359459	0.794232	0.794072	0.975328	1	
CD	0.273036	-0.01862	0.347753	0.446833	0.477163	0.527011	0.506604	1

Where: Tht = total height, Cl =crown length, Db = Diameter at the base; Mht = merchantable height, Dm =Diameter at the middle, Dt = Diameter at the top, Cd = crown diameter, Dbh = diameter at breast height.

Considering the coefficient of determination and standard error of estimates it can be deduced that cubic regression models were seen to be very much adequate for the prediction of the height diameter relationships.

Consequently, the work of Turan (2009) noted that cubic model gives best performance according to the value of test statistics (R^2 and SEE).

Table 9: Height - diameter at breast height relationship models for Meliaceae Family

Function code	Model statistics		Parameter estimates			
	R ²	SEE	Bo	b1	b2	b3
1	0.34	6.02	8.63	0.84		
2	0.68	4.68	22.75	-0.53	0.004	
3	0.91	2.83	1.68	0.79	0.017	9.97x10 ⁻⁵

Table 10: Height - diameter at breast height relationship models for Myrtaceae Family

Function code	Model statistics		Parameter estimates			
	R ²	SEE	Bo	b1	b2	b3
1	0.14	5.20	13.08	0.13		
2	0.21	5.16	29.28	-0.443	0.005	
3	0.22	5.13	24.49	-0.17	32.79	2.54x10 ⁻⁵

Table 11: Height - diameter at breast height relationship models for Papilionaceae Family

Function code	Model statistics		Parameter estimates			
	R ²	SEE	Bo	b1	b2	b3
1	0.52	4.71	7.74	0.17		
2	0.63	4.35	-2.05	0.54	-0.03	
3	0.71	4.02	9.18	-0.20	0.01	-7.5x10 ⁻⁵

Table 12: Height - diameter at breast height relationship models for Verbanaceae Family

Function code	Model statistics		Parameter estimates			
	R ²	SEE	Bo	b1	b2	b3
1	0.224	3.91	10.81	0.087		
2	0.271	4.24	2.29	0.429	-0.03	
3	0.422	4.36	52.73	-2.68	0.057	0.00

Table 13: Height - diameter at breast height relationship models for Caesalpiniaceae Family

Function code	Model statistics		Parameter estimates			
	R ²	SEE	Bo	b1	b2	b3
1	2.60	24.60	-0.24			
2	0.764	2.88	33.96	-0.65	0.004	
3	0.766	2.87	31.18	0.46	144.42	2.91x10 ⁻⁵

The crown diameter / diameter at breast height relationship models (table 14, 15, 16, 17 & 18) for meliaceae, myrtaceae, papilionaceae, vernabaceae and caesalpinaceae respectively. The result of the models

HAASTRUP, NO; BOLAJI, OW; NURUDEEN; TA, BABALOLA; YO; JEMINIWA, OR; OLADIPUPO-ALADE, EO; OYEDELE, MD; LAWAL, MO; BOLAJI, OO

shows that all the models proved inadequate for myrtaceae family while linear model (model 1) was found to be inadequate for caesalpinaceae family in which quadratic model and cubic model (model 2 & 3) were found to be very adequate for this family with high coefficient of determination ($R^2=0.62$ and 0.82) for model 2 and 3 respectively. Hence model 3 (cubic regression model) were found to be more suitable for the prediction and can therefore be consider for future use. Consequently, all the three models perform very well for meliaceae, papilionaceae and verbanaceae family with high coefficient of determination and low standard error of estimates. However, this is an indication that the data fits well into the models. In addition, considering the level of adequacy of the model using modeling statistics indicators (R^2 and SEE) it can be seen that cubic model (model 3) were found to be more suitable for crown diameter / diameter at breast height predication for meliaceae, papilionaceae, vernabaceae and caesalpinaceae families.

$$cd = 36.31 - 160.51dbh + 228.51 dbh^2 - 88.48 dbh^3 = \text{meliaceae}$$

$$cd = 18.40 - 0.45dbh + 1.56 dbh^2 - 8.16 dbh^3 = \text{papilionaceae}$$

$$cd = -15.88 + 175.82 dbh - 378.58 dbh^2 + 263.19 dbh^3 = \text{vernabaceae}$$

$$cd = 18.58 - 31.97 dbh + 281.76 dbh^2 + 76.61 dbh^3 = \text{caesalpinaceae}$$

Consequently, these results were in accordance with the findings of Turan (2009) for crown diameter /

diameter at breast height relationships as be noted that cubic regression model is more suitable for crown diameter predictions. However, the regression models between dbh and crown diameter variables were found to be statistically significant ($P < 0.05$) that the R^2 value is more than 0.75 (Turan, 2009) in the models estimated. This indicates that dbh and crown diameter. From the results of this study it was seen that dbh and crown diameter could be estimated by means of dbh which is easy to measure for the studies in ground based forest inventory.

Table 14: Crown diameter - diameter at breast height relationship models for Maliceae Family

Function code	Model statistics		Parameter estimates			
	R^2	SEE	Bo	b1	b2	b3
1	0.534	5.272	5.345	10.88		
2	0.769	4.14	17.599	-42.57	36.91	
3	0.938	2.483	36.31	-160.51	228.51	-88.48

Table 15: Crown diameter - diameter at breast height relationship models for Myrtaceae Family

Function code	Model statistics		Parameter estimates			
	R^2	SEE	Bo	b1	b2	b3
1	0.00	4.74	18.33	-0.26		
2	0.10	4.30	18.18	0.24	-0.14	
3	0.00	4.90	18.40	-0.45	1.56	-8.16

Table 16: Crown diameter - diameter at breast height relationship models for Papilionaceae Family

Function code	Model statistics		Parameter estimates			
	R^2	SEE	Bo	b1	b2	b3
1	0.61	2.05	7.84	9.17		
2	0.63	5.70	17.18	-6.17		
3	0.66	2.09	3.39	39.30	-47.32	21.99

Table 17: Crown diameter - diameter at breast height relationship models for Verbanaceae Family

Function code	Model statistics		Parameter estimates			
	R^2	SEE	bo	b1	b2	b3
1	0.59	3.40	3.59	17.15		
2	0.73	3.09	21.31	-54.03	62.11	
3	0.79	3.16	-15.88	175.58	-378.58	263.19

Table 18: Crown diameter - diameter at breast height relationship models for Caesalpinaceae Family

Function code	Model statistics		Parameter estimates			
	R^2	SEE	bo	b1	b2	b3
1	0.41	5.09	1.27	25.65		
2	0.62	4.98	26.83	-87.68	116.44	
3	0.82	5.03	18.58	-31.97	281.76	76.61

Conclusion: The result of the inventory carried out in the faculty of Agriculture and Forestry University of Ibadan reveals that there is no significant difference among the growth variables. Sustainability, as an objective of forest management demands that forest inventories be planned to look far beyond the assessment of marketable timber volume only. The assessment of a baseline data for the continuous monitoring of forest condition is absolutely essential. Therefore, as a way of recommendation, remote sensing through the use of modern technology should also be incorporated into forest inventory practical as this will widen the scope of the students and further strengthen their horizon.

HAASTRUP, NO; BOLAJI, OW; NURUDEEN; TA, BABALOLA; YO; JEMINIWA, OR; OLADIPUPO-ALADE, EO; OYEDELE, MD; LAWAL, MO; BOLAJI, OO

REFERENCES

- Adeduntan SA; Fuwape, JA; Ofuya, TI (2005) Environmental effects of insect herbivores and logging on tree species diversity in Akure forest reserve (Aponmu). *J. Appl. Tropical. Agric.* 9: 12-18.
- Adekunle, VAJ (2000): inventory techniques and models for yield and tree species assessment in Ala and Omo forest reserves, southwestern Nigeria.. A Phd thesis submitted to the department of forestry and wood technology, Federal university of technology Akure. Pg 105-144
- Ajewole, OI; Popoola, L; Aiyeloya, AA. (2005). Forestry potentials in actualizing natural economic empowerment development strategy. Proceedings of the 30th Annual Conference of the Forestry Association of Nigeria held in Kaduna, Kaduna state, Nigeria. 07-11 Nov. 2005.
- Akindele, SO; Abayomi, JO. (1993): Stem-diameter distribution in permanent sample plot of *Nauclea diderrichii* in southwest Nigeria. In (Vanclay, J.K., Skovsgaard, J.P. and Gertner, L.Z. (Editors): Growth and Yield estimation from successive inventories. Proceeding of IUFRO Conference. 14-17 June 1993, Copenhagen 281pp.
- Akinsanmi, F.A (1981): Sampling for inventory in Nigeria dry high forest. Ph.D thesis, Department of Forest Resources Management. University of Ibadan, Nigeria, 358 pp.
- Busing, RT; Mailly J. (2004). Advances in special, individual based modeling of forest

- dynamics. *J. Vegetative Sci.* 15:831-842.
- FORMECU (1997): National Forest Resource Survey, Training Manual. 47p
- Leckie, DG; Gillis, MD. (1995): Forest Inventory in Canada with Emphasis On Map Production. *The Forestry Chronicle*, Jan/Feb 1995 Vol. 71, No. 1: 74 - 95.
- Lund, HG; Thomas, CE. (1989): A primer on stand and forest inventory designs. General Technical Report WO-54 USDA Forest Service New Orleans, Los Angeles 89p. Lund, H.G., V.A. Rudis; Stole, F.W (1996): Plots, Pixels and Partnerships Prospects for Mapping, Monitoring and Modeling Biodiversity. USDA, Forest Service WO-Fier Washington, DC 35pp.
- Okali, DUU; Ola-Adams, BA (1987): Tree Population Changes in Threatened Rainforest at Omo Forest Reserve, S. W Nigeria. *J. Tropical Ecol.* 3. 4: 291 – 314
- Oliver, CD; Larson, BC. (1996). Forest stand dynamics. John Wiley and sons. Toronto. 520.
- Oluyeye, AO (2007). Wood: A versatile material for national development. Inaugural lecture. Series 45 delivered at the Federal University of Technology Akure. Tuesday, 26th June 2007. 21-24
- Onyekwelu, JC; Akindele SO. (1995): Stand Volume Equation for Gmelina Arborea Plantation in Oluwa Forest Reserve, Nigeria. *Nig. J. Forestry.* 25: 1&2: 92 - 95.
- Palmer, J; Synnott, TJ. (1999). The management of natural forests in NP Sharma. *Managing the World's forests looking for balance between conservation and development.* 337-373.
- Papka, PM (2005). Sustainable forest management opportunities and Challenges for Nigeria. Proceedings of the 30th Annual Conference of the Forestry Association of Nigeria held in Kaduna, Kaduna state, Nigeria. 07- 11 Nov. 2005. Popoola L., Mfon, P., Oni P.I Eds. 1-17.
- Swaine, MB; Hall, JB. (1987): Forest Structure and Dynamics. In: *Plant Ecology in West Africa - Systems and Processes.* G.W. Lawson (Ed) Pp. 47 – 93. John Willey and Sons Ltd Chichester.
- Thomas, JJ. (1977): An Introduction to Statistical Analysis for Economists. Weidenfeld and Nicholson Ltd, London 286pp.
- Turan S (2009): Diameter at breast height- crown diameter prediction models for *Picea orientalis*. *Afri. J. Agric. Res.* 4 (3) 215-219