IOSR Journal Of Environmental Science, Toxicology And Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399. Volume 6, Issue 5 (Sep. - Oct. 2013), PP 27-31
www.Iosrjournals.Org

Accumulation and Distribution of Aboveground Biomass in Gmelinaaborea Age Series of Acid Soil in Ukpon River Forest Reserve of Cross River State Nigeria.

Idiege, D.A.,* Ijomah, J.U.,**Amadi,D.C.A.,*Lifu, M***

**Department of Forestry and Wildlife, Federal University Wukari, Taraba State, Nigeria*
***Department of Forestry and Wildlife Resources Management, Cross River University of Technology, Obubra Campus, Nigeria.*
****Department of Soil Sciences and Agro-climatology, Michael Okpara University of Agriculture Umudike, Abia State, Nigeria.*

***Abstract**: Total dry matter production per hectare by whole stands of Gmelina arborea plantation age series, ranging from 20 to 30 years and planted at an espacement of 2.4 x 2.4m on acid soils of Ukpon River Forest Reserve in Cross River State Nigeria was estimated, using the mean tree method, to be 144830.870kg, 150383.438kg, 238446.836kg, 239630.868kg, 251934.720kg and 252355.180kg at age 20, 22, 23, 24, 26 and 30 years respectively. The values indicate that biomass accumulation varies considerably with age as found out by other experimenters. The oldest stand of 30 years accumulated the highest biomass while the youngest of 20 years stand has the lowest. Biomass accumulation in the stemwood, stembark, branches and leaves consistently increased, though at different rates, within the period while the foliage mass tends to decreased with increasing age.*

The distribution of the above ground biomass along the various tree components also changed with age and tree development. At all the stages, the stemwood consistently formed the highest proportion of the biomass in all the ages, followed by branches, stembark and leaves in descending order.

***Key words:** Above Ground Biomass, Age series, Accumulation and Distribution*

I. Introduction

In forest ecosystem, biomass accumulation provides an index of carbon sequestration and the re-establishment of biological control onbiomass in aggrading plantation forest (Borman and Likens, 2009), including those controlling water and nutrient cycles and losses (Swanke *et al*, 2001). However, this has an implication when defining forest growth and nutrient cycling model (Makela *et al*, 2000; Johnson *et al*, 2000). Numerous studies have shown that biomass production following disturbance is a function of climate (O'Neil and De-Angelis 2008; Pastor and Post 2012; Gholz *et al,*1990; Mickler and Fox, 2008), soil nutrient status (McGuire *et al*, 2002; Kimmins, 2006; Reich *et al*, 2007), disturbance size and intensity (Runkle, 2005; Kimmins, 2006), species composition prior to disturbance and life history strategies of surviving and colonizing species (Peet and Christensen 2008; Canham and Marks 2005; Huston and Smith, 2007). It has been recognized that the biomass of standing crop of each species in a community could be used to measure the productivity of ecosystem, this shows that biomass studies are essential for estimating net primary production understanding nutrient cycling and organic matter and the effects of tree utilization and management stands.

Biomass is an alternative to volume in the inventory, yield and growth assessment of the forest. It emphasizes the use of practically all parts of the tree. By focusing on biomass the potentials of leaves, roots, stumps, needles, and logging residues for pulp and paper, chemicals, medicine and animals fodder are evaluated. Hence, the forest is viewed as production system not only as for its stem-wood but its total organic material (Obisanya, 2008). Understanding the biomass production of some species such as Gmelinaarborea is fundamental to the management of natural and disturbed vegetation growing on tropical soil of low fertility, such an understanding is necessary for the assessment of potentials impact, the amelioration of the effects of disturbance, optimization of plantation productivity and the rehabilitation of degraded ecosystem (Nicholson et al, 2009). Extensive plantation of Gmelinaarborea was established by the then post colonial era over 50 years in Cross River State Nigeria as a source of raw material for the Oku Iboku paper wood industry now Akwa Ibom State. However, the first rotation stands appear generally healthy and productive; the long term consequence of such intensive harvest which sometimes involves the removal of stems and branches, the site productivity is not known and cannot be evaluated owing to lack of data on biomass and its nutrients relation in such forest ecosystem. This study is therefore aimed at estimating the above ground biomass accumulationand distribution of the tree components in a Gmelinaarborea age series of 20-30 years using the harvest means method on acid soil of Ukpon Forest Reserve which is relatively low in fertility.

II. Materials And Methods

Study Area: The study was carried out in Ukpon River Forest Reserve, in Obubra local Government Arae of Cross River State, Nigeria. It lies on latitude $5^0 57^l$ N and longitude$8^0 28^l$ E, with a total area of $129.50km^2$ (12950 hectares). It was declared a forest estate by government gazette order 56 of 1930(Annon, 1985) and is managed by the Cross River State Forestry Commission. The annual rainfall of the area ranges between 2000-2500mm, with eight (8) months duration which starts from late march to late October (Udo,R.K. 1986). The annual temperature ranges from 23.2^0C in July to 33^0C in February, strong wing usually marks the on-set of dry season which is caused by Northeast wind which is hot and dry. The reserve lies within lowland rainforest with fresh water swamp at the fringes of Ukpon River and derived savanna north of the reserve. The floristic composition is highly heterogeneous in nature. The savanna areas are believed to have been derived from moist evergreen forest by a process of degradation which arises through farming activities and annual grass fiber. It is also possible that the vegetation type reflects soil condition to some degree (Greaves, 2003). Some common shrubs, herbs and grass found within the vegetative area includes Lophiralanceolata, Erythrophyleumsauvaeolens, Danielaoliverii,Fagarazynthoxyloids, Steriuliatrangancantha, Scotellia and Anthocleistra spp. Heymenocardiaacida, Penisetum spp. Hyperthenia and Athropogen spp. for the tree species they includes Ricinodendron spp., Terminalia spp., Triplochitonscleroxylon, Sterculia spp., Pterocarpus spp., Khayaivorensis, Chlorophoraexcelsa,Garciniacola, Chrystophyllum spp., Astonia spp., Ceibapetandra, Gambiaalbidium etc.The soil have been developed on sedimentary rocks mostly unconsolidated sand and sandstone, flats to gently rolling country, slopes 1-3%, brown, reddish and brown and red ferralitic sands (Nsor, M. E. 2011). Vine (1956), in a description of the deep, porous, well drained, non mottled and non concretionary reddish brown soils which covers much of the area, noted that the topsoil are usuallymoderately acidic in cultivated forest or savanna and the sub-soil strongly acidic (pH 4.66) and deficient in plant nutrient. The area is gently sloping with an average height of 709.9m to 1350m above sea level. A low ridge runs on the southern portion of the southern border of the reserve. It drains northward into the river cross and westward into the Ukpon River.

Methods and Data: The plantations selected for the study were distributed by year of planting an area in hectares as shown in table 1. All the plantation were established by the taungya system using Gmelina stumps at a planting spacement of 2.4 x 2.4m (8^l x 8^l) on the square. There had been no silvicultural treatment after the establishment stage (Greaves, 2003). The plantation has closed canopy except in areas where there had been cases of wind throws in the 1957, 1964 and 1967 stands. Trees growing in the entire plantation showed no sign of nutrient deficiencies. Stocking was satisfactory in all the other compartments except in those mentioned above and compatible with the condition to be expected in an unthinned crop (survival percentage greater than 50%) Greaves,(2003).

Six annual plantation series or coups ranging from 20-30 years were sampled. In each coup, temporary plots of dimensions 22.5 x 22.5m (about 0.05ha.) were randomly located and diameters at breast height (DBH) of all trees within the plot were measured. All trees within each plot were put into four (4) DBH class (size of each class was determined from the range of diameter measurements) table 2, and within each, one tree whose diameter at breast height was nearest to the class mean DBH was chosen as the sample tree. A total of 24 trees covering the age and diameter ranges from 20-30 years were used in this study. Each sample tree was felled near the ground line and the total height merchantable stem length (measured to the first major living branch, and the diameter over bark at both ends of the stem were measured). All leaves, branches and small stems were weighed fresh in the field and representative samples taken for dry weight determination. For large stems, fresh weights were calculated using the volume and average densities of tree specific gravities determined on tree disc removed from the middle and both ends of the stem. The volume of the stem was calculated by using the Smalian formula (Spurr, 1954).

$$V = \frac{(Sb+Se)}{2} \times L$$

Where: V- Volume of the bole of tree
Sb- Basal area at base of bole of tree
Se- Basal area at end of the bole of tree
L – Bole length of tree.

The mean specific gravities of stem wood and stem bark were also determined over the disc remove from the butt, middle and top end of the bole of the tree. Their volumes and fresh weights were determined in the field and from there d= m/v was calculated, where d= densities of disc; m= mass of disc; v= volume of disc. The densities of the mean tree were also obtained from the average densities of the tree disc using the relationship:

$$\text{Densities of mean tree} = \frac{d_b + d_m + d_e}{3}$$

Where: d_b = Density at butt of bole
d_m = Density at middle of bole

d_e = Density at end of bole.
The dry weights of the components of the tree (stem wood, stem bark, branches and leaves) were derived from the percentage dry weights of the sample dried to constant weight in the oven at 70%C for 48 hours.

III. Results And Discussion

In table 3, the total above ground biomass values accumulated for ages 20, 22, 23, 24, 26 and 30 years were 144830.870kg, 150383.438kg, 23446.836kg, 239630.868kg, 251934.720kg, and 252355.180kg hectare respectively. The total biomass values consistently increased with increasing age from 144830.870kg per hectare in the 20 years old stand to 252355.180kg per hectare in the 30 years old stand. Biomasses accumulated in the mean trees at various ages are summarized in table 4. The respective values are 1038.2357kg, 843.9088kg, 1091.8106kg, 666.3596kg, 1845.833kg, and 2533.8283kg per hectare for the 20, 22, 23, 24, 26 and 30 years old stands. This value tends to follow the same pattern as total biomass accumulation in that they also vary with age. They range from 1038.2387kg in the 20 years old stand to 2533.8283kg in 30 year old stand. Biomass accumulation in the stem wood, consistently increased though at different rates, while the stem bark and branches increased initially and decreases within the period while the foliage mass tends not to be affected with increasing age. The foliage mass recorded for the 20 years old stand is 4442.0kg, decreasing in mass until age 24 where it rises probably because it has the highest stocking, and decreases thereafter to 2989.5kg per hectare at age 30. The distribution of the above ground biomass among the various tree components also changed with age and tree development. Data for the percentage distribution of the total biomass in the tree components are presented in table 5. At all stages the stem wood consistently formed the highest proportion of the biomass in all the ages. It accounted for 71.77% (103939.16kg) of the total biomass accumulatedat age 20; 56.73% (85308.07kg) at age 22, 70.39% (167845.39kg) at age 23; 71.88% (170814.684kg) at age 24; 82.53% (207911.3081kg) at age 26 and 82.60% (208451.178kg) at age 30. The next highest value was the branches with 25880.0kg (representing 17.87%) of the total at age 20; 52792.0kg (35.10kg) at age 22; 50070.0kg (21.0%) at age 23; 394498.5kg (16.6%) at age 24; 29073kg (11.54%) at age 26 and 26972.92kg (10.69%) at age 30. Quantities of dry matter contained in the stem bark are 10499.754kg for age 20 (representing 7.24% of the total for that year); 7173.356kg per hectare or (4.77%) at age 22; 15991.446kg per hectare or (6.71%) at age 23; 21761.684kg or per hectare (9.16%) at age 24; 19466.412kg per hectare or (7.73%) at age 26 and 13834.02kgf per hectare at age 30. Throughout the period biomass in the foliar apparatus accounted for only 3% in the 20th year which was the highest recorded and accounted for 1.18% of the totalbiomass at age 30.

Discussion: The trees within the various stands varied considerably in their dimensions. Such variation had been observed in studies on various monocultures (Egunjobi, 2001). The variation may be attributed to genetically differences of the trees, late planting of some of the trees to replace those that died at the initial stage of the plantation establishment and soil variation. Jerome, et al. (2009) suggested that in a single species stand, important variation developed between individual due, not only to random variation in the specific environmentof particularly in the soil to which individual had access, but also partly on heritable physiological basis such as differences in seed size, in the rateof initiation and expansion of new leaf and the primordial and thus of the branch and leaf systems in the earlier stage. Because of the variability between these dimension and dry weight, the determination of plant weight in this way may lead to an underestimate (Feller, 2012). Also, bole length rather than total height has been used to estimate the above ground biomass for the entire plantation for various age but (Feller, 2012) states that biomass estimation using merchantable height for the calculation of bole weight gives lower biomass figures compared with using total height. This may in part be responsible for the relatively low values of biomass accumulated within a period of 30 years in the Gmelina arborea stands used in this study. In all the ages, the stem wood consistently dominated the biomass produced in each stand, followed by the branches, stembark and leaves in a descending order. The same also observed in the mean tree. Total biomass accumulation was also found to vary with the age of the stand. The oldest stand of 30 years accumulated the highest value while the youngest stand of 20 years accumulated the lowest value. This finding conform to other literature Feller, (2012); Singh and Shema, (2006); Egunjobi and Bada (2009); Decei, (2008); Stoiculescu, S. (2008).

IV. Conclusion

<u>Gmelinaaborea</u> have been established on the Ukpon Forest Reserve in Cross River State as a pulping source because of their potential for rapid growth. It is shown here that this potential can be fulfill to yield high storage ecosystems at young ages which are amongst the most productive in terms of standing biomass that have been measured in Nigeria.

Table 1: Distribution of Gmelina arborea by year of planting and area (in ha.) within the plantations selected for the study.

Year of Planting and Areas in Hectare (ha).											
Forest Reserve	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967
UkopnRiver series	9.0				8.0	8.0	12.0	16.0	12.0		12.0

Table 2: Enumeration Sheet of Trees in Sample Plots

	FOUR DIAMETER RANGE CLASSES					
No. of trees in each DBH class with age	A(smallest)	B	C	D(largest)	Total no. of trees in 0.05ha. plot	Total no. of trees /hectare
20 years	4.7-11.1	11.2-17.6	17.7-24.1	24.2-30.6		
No. of trees in DBH class	8	7	8	7	30	600
22 years	7.2-12.9	13.0-18.7	18.8-24.5	24.6-30.3		
No. of trees in DBH class	20	27	11	3	61	1220
23 years	7.4-13.2	13.3-19.1	19.2-25.0	25.1-30.9		
No. of trees in DBH class	25	21	11	5	62	1240
24 years	6.0-10.3	10.4-14.7	14.8-19.1	19.2-23.5		
No. of trees in DBH class	15	27	21	14	77	1540
26 years	7.8-14.8	14.9-21.9	22.0-29.0	29.1-36.1		
No. of trees in DBH class	17	29	5	1	52	1040
30 years	7.6-16.6	16.7-25.7	25.8-34.8	34.9-43.9		
No. of trees in DBH class	27	25	2	1	55	1100

Table 3: Quantities of dry matter in kg/ha. in Gmelina arborea stands of various ages.

Tree Components	20 years	22 years	23 years	24 years	26 years	30 years
Leaves	4442.0	4970.0	4370.0	5460.0	5390.0	2989.0
Branches	25880.0	52792.0	50070.0	39449.5	29073.0	26972.92
Stemwood	103939.16	85308.072	16785.39	170814.684	207911.308	208451.178
Stembark	10499.754	7173.356	15991.446	21761.684	19466.412	13834.02
Total	140760.914	150243.438	238279.836	239485.868	251840.72	2522247.68

References

[1]. Annon, R. O and Baskerville, O. L (1985). Use of logarithmic equation in the estimation of plant Biomass. Canadian Journal of Forestry Resources. 2:49-53.

[2]. Borman, F. H and Likens, G. E (2001). Pattern and process in forested ecosystem. Spring-verlage. New York.

[3]. Canham, C. D and Marks, P. L (2005). The process of woody plants to disturbance pattern of establishment and growth In: The Ecology of Natural Disturbance and Patchy Dynamics. Ed (S.T.A. Pickett and P.S. White) academic press. New York pp. 197-216.

[4]. Decei, G. and Penner, M. (2009). Measuring leaf area index with the LI-COR LAI 2000 in pine stands. Ecology 75: 1507-1511.

[5]. Egunjobi, J. K (2001). An evaluation of five methods of estimating biomass of an even-age plantation of Pinuscaribean. L. Decol. Plant 11: 109-116.

[6]. Egunjobi, J. K and Bada, S. O (2009). Biomass and Nutrient distribution in stands of Pinus caribaea L. in the dry forest zone of Nigeria. Biotropica 11(2): 130-135.

[7]. Feller, M.C. (2012). Biomass and Nutrient Distribution in two Eucalyptus forest ecosystem. Australian Journal. Ecological. 5:309-33.

[8]. Greaves, A. (2003). Site studies and associated productivity of Gmelinaarborea in Nigeria, M.Sc thesis. University College North Wales. Bangor. pp. 163.

[9]. Johnson, C.M., Zaring, D. J. and Johnson, A. H (2000). Post disturbance above ground biomass accumulation in global secondary forests. Ecology 81: 1395-1401.

[10]. Jerome, *et al* (2009). Spatial and Temporal variations on biomass in a tropical forest Journal of Ecology. Vol. 91: 2440-252.

[11]. Kimmins, J. P (2006). Future stock in forest field forecasting. The need for a new approach. For. Chron 61: 503-512.

[12]. Makela, A., Landsberg, J., Ek, A.R., Burk, T.E., Ter-Mikaelian, M., Agren, G.I., Oliver, C.D and Puttonen, P (2000). Process based models for forest ecosystem management: current state of the arts and challenges for practical implementation tree physiology 20:289-298.

[13]. McGuire, A.S (2002). Interaction between carbon and nitrogen dynamics in estimating net primary productivity for potential vegetation in North America. Global Biogeochem. Cycles , 6: 101-124.

[14]. Mickler, R.A and Fox, S. (2008). The productivity and sustainability of Southern forest ecosystem in a changing environments. Ecological Studies 128.

[15]. Nsor, M.E (2011). Classification and Survey of Soil Parents' Material in the central part of Cross River State. Unpublished Ph.D. Dissertation.

[16]. O'Neil, R.V and DeAngelis, D.L (2008). Comparative productivity and biomass relations of forestecosystem, In dynamic properties of forest ecosystem. Ed. D.E Reichle. Cambridge University press London pp. 489-506.

[17]. Pastor, J. and Post, W.M (2012). Information on climate and soil moisture and succession on forest carbon and nitrogen cycles. Biogeochem. 2: 3-27

[18]. Peet, R.K and Christensen, N.L (2008). Succession: a population process, vegetation 43:131-140.

[19]. Reich, P.B., Grigal, F., Aber, J.D and Gower, S.T (2007). Nitrogen mineralization and productivity in 50 hard wood and conifer stands on diverse soils. Ecology 78: 335-347.

[20]. Runkle, J.R (2005). Disturbance regimes in Temperate forest. In the ecology of natural disturbance and patch dynamics. Ed. S.T.A Pickett and R.S White academic press New York pp. 17-34.
[21]. Spur, S.H and Barnes, B.V (1954). Forest Ecology 2nd Ed Ronald press Co. New York pp. 571
[22]. Swankle, p.s., Beown, J.M., Bidsey, R and Ceiszewshi, C (2001). Biomass estimation for temperate broadleaf forest of the United State using inventory data. Forest Sci. 43: 424- 434.
[23]. Singh, R.P and Shema, V.K (2006). Biomass estimation in five different aged plantation of Eucalyptusterreticornis in Western Utah Pradesh. In: Oslo biomass studies. Paper presented during the meeting of S4.01 in Oslo Norway June 22. 2006.XVIth International congress of IUFRO.
[24]. Stoiculescu, S (2008). Biomass estimation of Bald Cypress Tree in Romania forest culture. In: Kyoto Biomass studies. Complete tree Institute of the school of Forestry Resources, University of Maine at Orono.
[25]. Udo, R.K (1986). Regional Geography of Nigeria and West Africa. Macmillan.
[26]. Vine, H. (1954). Studies of soil profile at the WAIFOR main station and at some other sites for Oil Palm experiments. Journal of West Africa Institute for Oil Palm Research. 4: 8-59.