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ASSESSMENT OF SECOND GENERATION *GMELINA ARBOREA* STOCK IN AWI, NIGERIA

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ABSTRACT: *Second generation Gmelina arborea coppice plantation in Awi, Cross River State, Nigeria was assessed for stocking and yield. The plantation was divided into five strata (A-E), a stratified random sampling technique was used to select sample plots, Gmelina arborea trees that were 30cm and above were measured. Results revealed that the plantation had 246 trees/ha stocking rate; representing 19.2% stocking density and mean volume of 172.54M^3/ha. It was observed that improved silvicultural operations such as thinning, pruning, fire tracing and prevention illegal farming activities would have increased the yield in the plantation. Government should maintain and fill the existing gaps in the plantation by replanting*.

KEYWORDS*:* Second Generation, Coppice, Stocking Rate, Stoking Density, Yield, Awi.

INTRODUCTION

Gmelina arborea is presently regarded as the most important exotic plantation species in Nigeria; being the main source of short fiber of desirable quality for the pulpwood industry as well as a major utility timber species. It has been noted that Gmelina has the following characteristics: fast growth rate, ease of establishment, high productivity and a wide range of site tolerance (American National Academy of Sciences, 1980). These characteristics had led to a large scale *Gmelina* plantation being jointly established by the Federal Government of Nigeria and former southeastern state government between 1971 and 1983. The Awi *Gmelina* plantation covers a total of 5,265 hectares (Cross River Forestry Commission, 1994). *Gmelina arborea* does well in the tropics with heavy rainfall, well- drained soil, and high temperature.

Gmelina arborea is known to exhibit a good natural ability to coppice (Nsien *et al*, 2009). Coppice is a forest crop raised from shoots produced from the cut stumps/stools of previous crop (Evans, 1992). *Gmelina* and *Tectona* species belong to the family *Verbenaceae*. It has been observed that it is less expensive to establish and maintain coppice than growing from seedlings (Johnston, Grayson and Bradley, 1983). Apart from its pulping properties, the tree has a great potential in Nigeria economy due to its several other valuable uses such as match boxes and splint production, core stock for plywood and pit prop production in coal mines. In addition, the tree grows to 30 meters or more in height with straight bole, which renders its wood useful in diverse ways including construction, furniture, joinery, veneers and pulpwood production.

The excellent *Gmelina arborea* wood properties, makes the demand for *Gmelina* wood very high. This inevitably led to an extensive exploitation of the trees in the plantation. The rate of exploitation far out- stripped the rate of natural regeneration through coppicing leading to the over

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exploitation of the plantation. Ogar and Ettah (1994) stated that the plantation had been logged for pulpwood between 1986 and 1993. The study assessed the stocking density, yield and standing volume of the second generation *Gmelina arborea* plantation in Awi, Cross River State, Nigeria.

Despite the fact that *Gmelina arborea* is in high demand, the cost of establishing the plantation is soaring in Nigeria,knowledge on the stocking density and yield of second generation Gmelina arborea coppice is inadequate in the country. Gmelina coppices grow faster and are less expensive to establish than planting other planting stock (Nsien, 2009).

Knowledge on the stocking density and yield of this crop is well documented in many countries including India and Malaysia (American Academy of Sciences, 1980). The study will provide baseline information on the appropriate stocking density and yield of second generation *Gmelina arborea* coppice in Nigeria. Findings from the study will complement the existing silvicutural knowledge on stocking density of *Gmelina arborea* coppice stand that will enhance sustainable forests management in the country.

MATERIALS AND METHODS

Study area

Awi *Gmelina* plantation lies within latitude $5^{0.}14$'N and longitude $8^{0}.22$' E. On average, rainfall in this region was 238.9mm per annum with minimum and maximum temperature of 23^{0} and 30^{0}C respectively. The soil is cambisol of acid crystalline rocks of basement complex of gneiss, granites and quartzites (Egbai, 2011). The plantation was established from 1971 to 1983 at 2.44m x 2.44m spacing using *Gmelina* stumps.

Sampling Techniques

A reconnaissance survey of the plantation was undertaken; in which all access routes/footpaths were cruised using the geographical positioning system (GPS). These points were mapped and located on ground to facilitate ground point's location on the map (Figure1).

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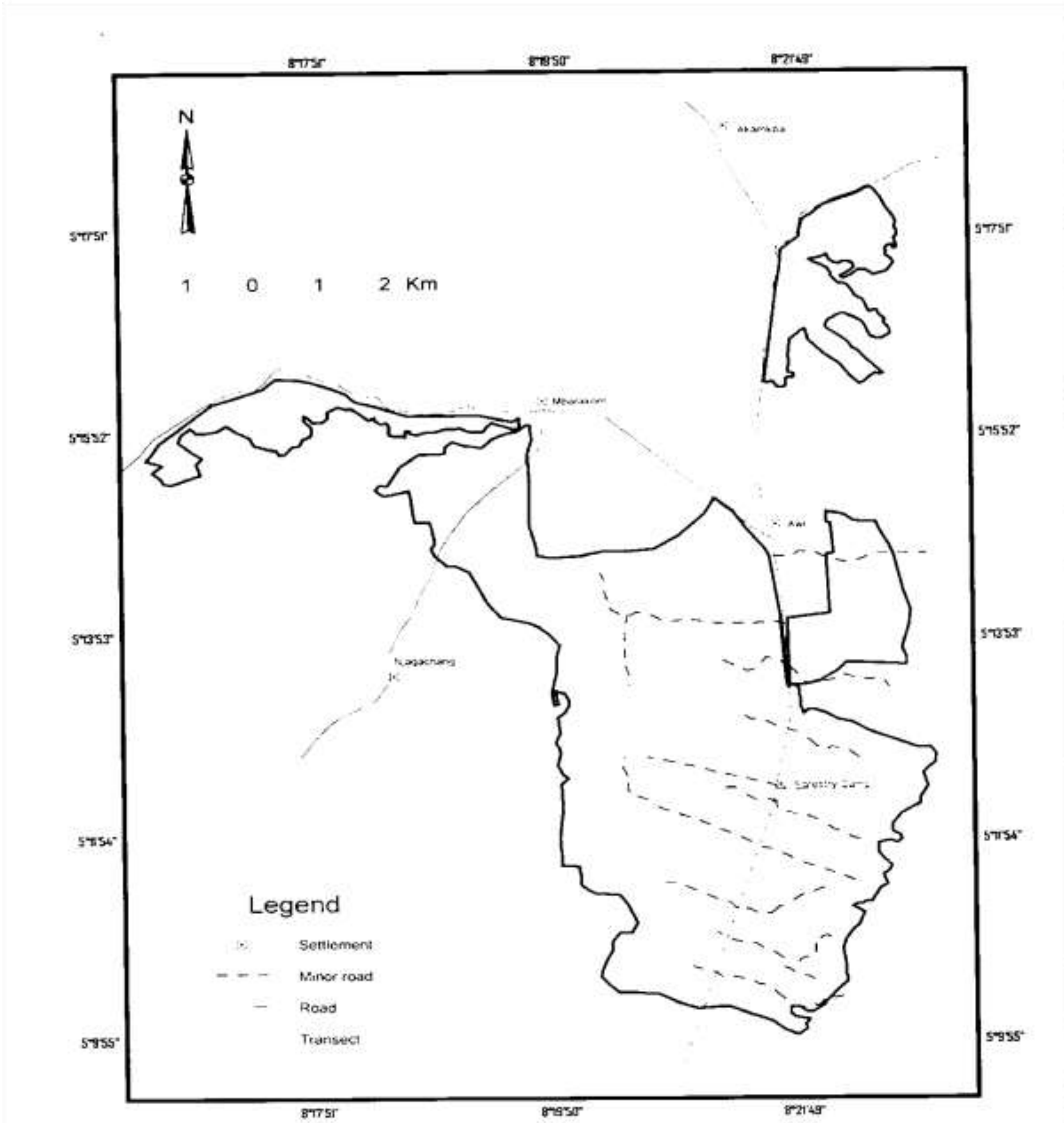

Figure 1: Gmelina Plantation Map Showing Gridlines

Visual inspection of the plantation enabled the confirmation of the information on the map and changes that have taken place in the plantation (Figure 2). Plantation boundaries were also identified and area confirmed. The total area of the plantation was 5,265 hectares. The plantation was divided into five strata (A – E) based on locality, contiguity and accessibility (Table 1). A stratified random sampling method was adopted in the selection of sample plots for measurement.

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Grid lines representing 100m x 100m or 1 hectare frame were drawn on the map of the plantation. Sample plots were randomly selected from each stratum using a table of random numbers. Precision of the sampling was necessary to provide an estimated gross volume for all *Gmelina* trees with girth of 30 cm and above within the accuracy limit of 95% probability level. Twenty-five (25) sample plots were randomly laid within the study area and the following tree parameters (tree density, girth and total height of all trees) were measured and recorded.

Table 1: Allocation of sample plots to various strata

Stratum	Description of area	Area (Ha)	Number of plots
A	The plantation area from Oban Okoroba road to Awi and Ayeabam	572	2
B	The plantation on the right side of Calabar/Ikom Highway from km 18 up to Oban Okoroba road	1068	5
C	The plantation on the left from km 18 up to Awi/Mbarakom/Njagachang road	2890	14
D	The plantation from Mbarakom to Calaro	344	2
E	The plantation opposite Anekin and toward Nsan	391	2
	Total	**5,265**	**25**

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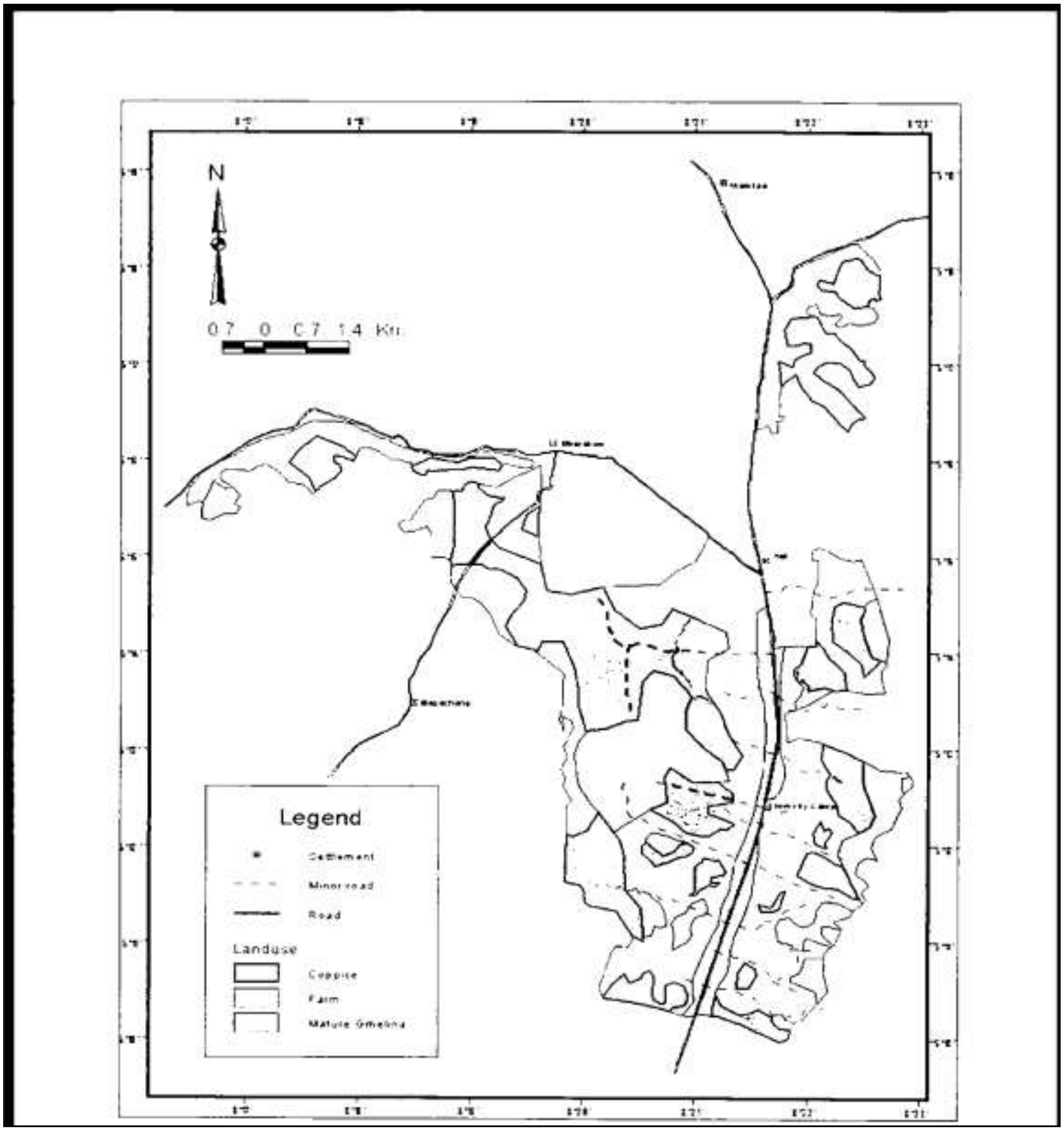

Figure 2: Gmelina Plantation Map Showing Land-use

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DATA COLLECTION

In each sample plot, all *Gmelina* trees from 30cm in girth at breast height and above were enumerated and the diameter and height were measured. Diameter measurement of each tree was taken using diameter tape while total height was obtained using Sunto Clinometers. Stands of multi-stem trees were separately measured and treated as separate trees. The total number of trees in each sample plot was noted while all diameter measurements were taken at 1.3 meters above the ground. Girth readings were grouped into 10cm girth classes. The quantity of wood and its corresponding basal area per hectare, girth at breast height of all trees in each sample plot were measured. The corresponding heights of all trees were estimated with the aid of the Sunto Clinometers. The basal area for each tree was calculated using the formula:

$$BA = \frac{G^2}{4\pi}$$

Where; BA =Basal area (m^2); π =3.142, G represents girth at breast height in meter (m^2) while 4 and π are constant. Similarly, over-bark volume for each tree was then computed using the volume formula:

$$V = \frac{G^2}{4\pi}h$$

Where; h represents the height in meters. The total basal area stated in m^2 and the wood volume in m^3.

The density of *Gmelina* tree was combined with estimated average volume for the conversion to the standing weight of *Gmelina* trees on hectare basis. Therefore the standing weight is given as 86.27 metric tons/ha.

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RESULTS AND DISCUSSION

Table 2: Tree Stocking and Wood Volume

Age of Coppices (years)	Stratum	Plot Nos.	No. of trees/plot	Mean Girth per plot (cm)	Mean total height (m)	Basal area (M^2)/plot	Total volume (m^3) plot	Current percentage stocking /ha
14-21	A	212	230	62.3	14.59	7.1	103.0	17.97
		219	150	75.9	14.8	6.88	101.77	11.72
	Sub-Total		380	69.2	13.6	13.98	204.77	
	B	37	407	59.1	13.6	11.31	153.85	31.79
		116	301	92.8	15.2	20.62	313.54	23.53
		194	228	85.9	13.7	13.39	183.41	17.81
		832	128	84.8	16.1	7.32	117.93	10.00
		838	210	82.6	14.5	11.4	165.32	16.40
	Sub-Total		2034	81.04	14.62	64.04	934.05	
	C	26	274	74.5	12.8	12.1	154.9	21.40
		324	171	81.6	13.4	9.06	121.41	13.35
		456	240	83.4	14.3	13.28	189.96	18.80
		528	268	79.7	15.8	13.55	214.04	20.93
		699	189	56.8	14.7	4.85	71.33	14.76
		702	208	85.3	15.2	12.04	183.06	16.25
		889	338	78.8	14.6	16.70	243.84	26.41
		938	398	67.9	15.5	14.60	226.33	31.09
		1078	145	83.6	17.6	8.06	141.93	11.33
		1294	411	78.5	15.4	20.15	310.38	32.11
		1427	305	72.8	14.9	12.86	191.66	23.83
		1571	364	80.0	31.5	18.33	247.52	28.44
		2147	197	85.3	15.1	11.41	272.24	15.39
		2355	205	79.2	14.9	10.23	152.47	16.02
	Sub-Total		**3713**	**77.67**	**14.83**	**177.22**	**2621.47**	
	D	143	277	72.4	13.9	11.55	160.61	21.64
		178	264	85.2	14.1	15.25	215.03	20.63
	Sub-Total		**541**	**78.8**	**14.15**	**26.80**	**375.64**	
	E	157	121	82.5	13.2	6.55	86.51	9.45
		266	112	83.06	14.7	6.23	91.57	8.75
	Sub-Total		**233**	**83.05**	**13.95**	**12.78**	**178.08**	
	Total		641	1954.48	366.22	294.82	4313.61	19.2
	Mean		246	78.17	14.65	11.79	172.54	19.21
	STD DEV.		89.68	8.836	0.899	5.59	60.6	

Stocking is an important characteristic in forestry because it determines the density of species in an area. Evans (1992) stocking density changes with age of plantation, some trees die naturally;

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some are thinned and environmental factors impact on others. He further stated that mortality is higher in plantation with high stocking than in low stocking plantation. The initial stocking of the plantation that was 1600 trees/hectare were found to have reduced to 80.8 percent in the 14-21 years coppices; with the mean girth at breast height increasing from 30cm to 190cm within the same period (Table 2). The stocking per hectare in the plantation did not reflect any pattern but varied from stratum to stratum. The highest number of trees per hectare was obtained in stratum D where average stocking was 271 trees/ha, stratum C was 265 trees/ha, while it was 255 trees/ha in stratum B, stratum A and stratum E had the lowest stocking of 117 trees/ha each.

The average tree height per stratum varied from 13.95M to 14.83M. Onyekwelu et al (2003) recorded the mean annual dbh, height and volume increment ranges of 0.8-4.0 cm per year, 0.7-3.3M per year and 40-51.7M^3ha per year respectively in the South West of Nigeria for Gmelina arborea. The standing Basal area increases from 6.55M^2 /ha to 20.62M^2/ha as indicated in table 2. The standing volume increased from 86.5/M^3/ha to 313M^3/ha. Troups (1952) recorded a mean annual increment of 40m3 ha a^{-1} in *Eucalyptus globules* coppice in India in a 25-year rotation plantation. These volumes were generally higher than that reported for *Gmelina arborea* trees by Ugbechie (1973). He reported 29m^3/ha to 102m^3/ha for *Gmelina arborea* under a highly protected area (permanent sample plot). Normally, the yield from the first coppice crop is higher than the seedling crop; meaning that yield decline with each coppice crop. In India, yield from coppice of E. globulues declined by 9% in the third year and 22% in the fourth year after initial seedling crop.

Gaps were measured and it was observed that gaps covered an area of 3586.68ha, which required urgent artificial regeneration to guarantee future availability of raw materials. The initial stocking was 1600/ha. This stocking continues to decrease with increase in the age of the plantation. As such, the current estimate on the average number of trees was 246 trees per ha (Table 2). The expected number of trees within 5,265ha was 5,683,200 while the estimated number of trees for the 4400ha is 1,092,240. Therefore, the percentage current stocking was 19.2% and the existing gap was 80.8 percent. The current low stocking perhaps was due to factors such as: encroachment by unauthorized farmers; competition among individual trees; lack of maintenance of the coppice plantation and numerous access routes/roads within the plantation. The estimated mean girth was 78.17cm while the mean total height was 14.65m indicating that the estimated mean basal area was 11.79m^2/ha and estimated mean volume was 172.54M^3/ha.

CONCLUSION

The number of shoots on a stool should be reduced since a stool produces many shoots and if left untended, it will produce poor quality wood products; large quantity of stick and firewood are produced. To increase productivity, the *Gmelina* coppice plantation should be maintained through the application of appropriate silvicultural techniques and discourage encroachment by people. It was observed that appropriate stocking density of *Gmelina arborea* coppice stand, yield better than the overstock. Thinning down the coppice crop to a reasonable number of 246 stands per hectare is recommended in the study area.

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