ASSESSMENT OF ABOVE GROUND TREE BIOMASS IN ERUKOT FOREST OF OBAN DIVISION, CROSS RIVER NATIONAL PARK, NIGERIA

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Abstract

This study estimated the above stand Biomass of Erukot Forest of Oban Division, Cross River National. A total of 872 individual trees were identified and measured for diameter at breast height and total height (dbh ⩾ 5cm). The 872 individual trees spread across 51 species belonging to 25 different tree families. Simple random sampling was used with sampling intensity of 0.3% to lay 15 nested plots (7m x 7m, 25m x 25m and 35m x 35m). Diameter at breast height, total height and specific density of each wood species were used to determine aboveground biomass for each tree. Conversion factors were applied to estimate stand levels green and dry biomass, sequestered carbon and carbon dioxide (CO_2) emission in the study area. The mean diameter at breast height and mean total height were 38.5cm and 18.5m respectively. Mean basal area of 39.8 $m^2 ha^{-1}$ was obtained with a mean volume of 177.3 $m^3 ha^{-1}$. Average green biomass, dry biomass, carbon stock and carbon-dioxide emission of 521.8113 ton ha^{-1}, 341.5880 ton ha^{-1}, 183.196 ton ha^{-1} and 694.2067 ton ha^{-1} respectively were obtained in the study area. These are very useful tools for wood productivity studies, carbon trade and assessment of carbon-dioxide emissions through deforestation in the study area.

Keyword: *Sequestered carbon, aboveground biomass, dry biomass, conversion factor and predicted biomass.*

Introduction:

FAO (2005) has defined biomass as the organic material both above and below the ground, and both living and dead, e.g., trees, grasses, tree liters, roots etc. Aboveground biomass, belowground biomass, dead wood, liter, and soil organic matter are the main carbon pools in any forest ecosystem (FAO, 2003; IPCC, 2005; IPCC, 2006). Above-ground biomass (AGB) includes all living biomass above the soil, while below-ground biomass (BGB) includes all biomass of live roots excluding fine roots (<2mm diameter). Forest biomass is measured either in terms of fresh weight or dry weight. For the purpose of carbon estimation, dry weight is preferred as dry biomass roughly contains 50% carbon (Brown, 1997; IPCC, 2003). Majority of biomass assessment are done for aboveground of trees because these generally account for the greatest fraction of total living biomass in a forest and do not pose too many logistical problems in the field measurement (Brown, 1997).

Biomass assessment is important for national development planning as well as for scientific studies of ecosystem productivity, carbon budgets, etc. (Parresol 1999; Zheng *et al.,* 2004; Pandey *et al.,* 2010). Biomass analysis is an important element in the carbon cycle especially, carbon sequestration. Recently, biomass is increasingly used to help quantify pools and fluxes of greenhouse gases (GHG) from terrestrial biosphere associated with land use and land cover changes (Cairns *et al.,* 2003). The importance of terrestrial vegetation and soil as significant sinks of atmospheric CO_2 and its other derivatives is highlighted under Kyoto Protocol (Wani *et al*. 2010). Vegetation especially, forest ecosystems store carbon in the biomass through photosynthetic process, thereby sequestering carbon dioxide that would otherwise be present in the atmosphere. Undisturbed forest ecosystems are generally highly productive and accumulate more biomass and carbon per unit area compared to other land use systems like agriculture. A recent estimate indicates that tropical forests account for 247metric tons vegetation carbon, of which 193 billion tons is stored above ground (Saatchi *et al*. 2011).

For estimating tree biomass, the tree analysis is conducted by measuring weights of different components of tree and by taking biomass samples of the components (Repola, 2009). The general principle in biomass estimation is the relationship between fresh biomass of the tree components measured in the field, fresh biomass of the sample and oven-dried biomass of the sample. Because different parts of the tree have different density and moisture content, the tree is divided into the following compartments: the stem (trunk), the wood distinguished from the bark and saw logs to determine the wood density and moisture content in sections of different diameters; branches usually sampled by size classes; foliage, leaves and needles including buds, flowers and fruits; stump and lastly roots by diameter classes. Furthermore, explicit estimates of biomass and other forest structures are required to understand how forest will respond to climate change. Estimating aboveground biomass is therefore a critical step in quantifying and monitoring the change in tropical forests. At a time when the issue of reducing GHG emissions is seriously growing, the carbon sequestration potentials of the Erukot division is still unknown. Again, forest biomass assessment is important for national development planning as well as for scientific studies for ecosystem productivity, carbon budget (Hall *et al.,* 2006); therefore, this research was keyed to determine aboveground tree biomass, aboveground carbon stock and carbon dioxide emission in the Erukot tropical high forest

Methodology

Study Area

The study was carried out in Oban East, Erukot forest of Oban Division of the Cross River National Park (CRNP). The Cross River National Park (CRNP) lies between latitudes 5^0 05'and 6^0 29'N and longitudes 8^0 15' and 9^0 30'E in Cross River State, Southeastern Nigeria. The Cross River National Park was created by a Federal decree in 1991, consolidating the existing Oban and Boshi-Okwangwo Forest Reserves which are some of the richest areas of tropical rainforest in West Africa. The annual rainfall ranges between 2000 m to 3000m; relative humidity in and around the park is well over 30%. The temperature rarely falls below 19°C with an annual mean of 27°C.The moist green vegetation cover makes the forest an excellent place to view birds and butterflies (Eniang, 2001).

Sampling Technique and Data Collection

At first, the geo-position of the forest was determined using GPS (Global Positioning System). Simple random sampling was used with sampling intensity of 0.3% to lay 15 nested plots (7mx7m, 25m x 25m and 35m x 35m). The estimate of mean and the variance of a population or subdivision within a stratum are independent of the number of sampling units that was used. Therefore, both parameters were estimated from relatively few sampling units measured in a pilot survey (Avery and Burhart, 2002). Ratio of confidence interval to the mean was used to determine sampling intensity:

$$n = \left(t \, X \, \frac{cv}{E}\right)^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

$$CV = \frac{s}{\bar{X}} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

$$n = t^2 \times \frac{s^2}{E^2 \bar{x}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

where n= number of sample plots required

CV = coefficient of variation, t= t-value (n-1) degree of f

E = allowable margin of error (ratio of confidence inter

S = standard deviation $\bar{X}$ = mean

Primarily, the land use of each intercession was identified. In the fixed lines, tree stems were counted, diameter tape and Sunto clinometer were used for diameter at breast height and height respectively, Diameter at breast height (1.3cm above ground) and height were measured for all trees of the plot while density of each of the tree measured was determined from the default values of the Pan tropical table (Chudoff, 1984) and wood density for tropical tree species (Gisel *et al,* 1992). The obtained values were used to estimate the biomass of each tree within the sample plots in the tropical high forest (Ajayi and Adie, 2018).

Large plot =35mx35m
Trees >50cm DBH
Intermediate plot =25mx25m
Trees =30cm-49cm DBH
Small plot=7mx7m
Trees- 10cm-29cm DBH

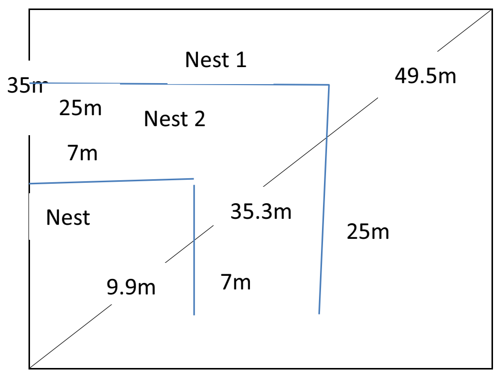

Figure 1: Schematic Diagram of Three-nest 35mx35m Square Sampling Plots

Data Analysis

Basal Area Estimation

The diameter at breast height was used to calculate the basal area.

$$\text{Basal Area } (BA) = \frac{\pi D^2}{4} \ldots\ldots 4$$

where: D = diameter at breast height (cm) $\pi = 3.142$ BA = Basal Area.

Volume Estimation

Individual tree volume was estimated using the regression model below:

$$LnV = -8.2525 + 2.209LnD \text{ (Ajayi and Obi, 2016)} \ldots\ldots 5$$

Where, V= Tree volume (m^3)

D= Diameter at breast height (cm)

Ln = natural log

Aboveground Biomass Estimation for Single Live/Dead Tree

$$AGB = 0.0673 \times (P \times D^2 \times H) \times 0.976 \ldots\ldots 6$$

where AGB= aboveground biomass (kg)

P = species specific wood density (g/cm^3),

D= diameter at breast height (cm), H= tree height (m)

Aboveground Live Green Biomass Estimation per Hectare

The summation of the biomass calculated for all trees in a sample produced the total plot biomass (AGBplot). This per plot estimate of aboveground (in kg) was divided by 1000 to express it in metric tons. This was then converted to per hectare estimate (AGBha) by using the equation

$$AGBper\ ha = \left(\frac{Ah}{Ap}\right) \times AGBplot \ldots\ldots 7$$

where: AGBha= aboveground biomass (metric tons per hectare)

Ah= area of one hectar in m^2

Ap= area of the plot (m^2)

3. 5.6 Aboveground Dry Biomass Estimation

Aboveground dry biomass estimation was calculated from:

$$W = \frac{AGBh \times 0.725}{1000} \ldots\ldots 8$$

where W= aboveground dry biomass (metric tones)

AGB_h = aboveground green biomass (kg ha^{-1})

However, average tree is 72.5% dry matter and 27.5% moisture (Chaven and Rasal., (2010) and 1000kg is equal to 1 metric ton).

Estimation of Carbon-dioxide Equivalent from Carbon Stock

The content of carbon in woody biomass of any forest is generally 50% of the tree total volume. Hence, to compute the weight of carbon stock in a tree was obtained by multiplying the dry weight of the tree by 50% (Eneji *et al.,* 2014). Therefore the equation for the measurement of carbon sequestered per hectare is given as:

$$Sc = W \times 0.5 \ldots\ldots 9$$

where, Sc = sequestered carbon W = aboveground dry biomass (t ha).

Results

Results in table 1 below show that a total of 872 individual tree species spread across 51 species belonging to 25 different tree families were measured for DBH and height. The mean diameter at breast height and total height of 38.5cm and 12.5m were obtained. Mean basal area of 39.8 $m^2 ha^{-1}$ was obtained with a mean volume of 177.3 $m^3 ha^{-1}$. Average green biomass, dry biomass, carbon stock and carbon-dioxide emission of 521.8113 ton ha^{-1}, 341.5880 ton ha^{-1}, 183.196 ton ha^{-1} and 694.2067 ton ha^{-1} respectively were obtained in the study area.

Table 1: Summary of the Characteristics Data of the Erokut Forest

Parameters	Results
Number of sample plots	15
Average number of trees measured	250
Mean DBH/Range (cm)	38.5 (1.00-250.00)
Mean height/ range (m)	12.5 (0.40-105.25)
Mean basal area/Range (M^2ha^{-1})	39.8 (22.95-49.20)
Mean volume (M^3ha^{-1})	177.3
Family	25
Total species	51
Individual species	872

Stand Level Aboveground Biomass and Sequestered Carbon for Erokut Forest of the Cross River National Park

Average green biomass, dry biomass, carbon stock and carbon-dioxide emission of 521.8113 ton ha^{-1}, 341.5880 ton ha^{-1}, 183.196 ton ha^{-1} and 694.2067 ton ha^{-1} respectively were obtained in the study area (Table 2).

Table 2: Stand level Aboveground Biomass and Sequestered Carbon for Erokut Forest-CRNP

S/N	BASAL AREA (M^2ha^{-1})	VOLUME (M^3ha^{-1})	GREEN BIOMASS (ton ha^{-1})	DRY BIOMASS (ton ha^{-1}) (Green biomass x 0.725/1000)	CARBON STOCK (ton ha^{-1}) (dry biomass x 0.5)	CARBONDIOXIDE EMMISSION (ton ha^{-1}) (carbon stock x 3.67)
1	48.24	217.41	629.78	456.58	228.30	837. 83
2	30.71	223.76	753.10	545.99	272.99	1001.90
3	40.04	228. 84	632.11	458.28	229.73	840.94
4	39.91	216.31	534.41	387.45	193.72	710.97
5	46.91	205. 80	351.31	254.7	127.35	467.38
6	33.48	197.37	601.95	436.41	128.20	800. 81
7	44.77	174.23	340.18	246.63	123.32	452.57
8	33.32	204.17	363.15	263.28	131.64	483.12
9	46.42	225.10	659.49	478.13	239.07	877.37
10	22.95	207.24	494.17	358.28	179.14	657.44
11	34.86	201.54	604.30	438.12	219.06	803.94
12	49.20	187.76	332.31	240.93	120.47	442.11
13	43.67	204.08	409.35	296.78	148.39	544.59
14	41.60	220.40	759.83	550. 88	275.44	1010. 89
15	40.92	179.60	361.73	262.26	131.13	481.24

Discussion

The Erukot Forest of the Cross River National Park shows high species abundance with a mean volume per hectare of $177.2647m^3h^{-1}$. This volume is slightly below that reported by Ajayi and Adie, (2018) ($212.588m^3h^{-1}$), which is greatly below the volume of $250m^3h^{a-1}$ recommended by Dianyuan Han (2012) for a normal tropical high forest. This therefore reflects high encroachment level in the park. Thus, efforts should be made to control and reduce encroachment level through good management approach such as integrated management system and anti-poaching patrol. Mean basal area was $38.8000m^{2/}h^{-1}$, this agrees with findings made by Ajayi, and Adie (2018) (38.5 m^2h^{-1}) in Okpon Forest Reserve, Cross River State, while mean dbh and height were determined to be 38.47cm and 12.52m, respectively. The results in table 2 show that the mean aboveground green biomass, dry biomass, carbon stock and carbon emission were 521.8113tons ha^{-1}, 341.58803ton ha^{-1}, 183.19673ton ha^{-1} and 694.20673ton ha^{-1}, respectively. The results of this finding are slightly below the report made by Dianyuan Han (2012) who reported that for a protected area, a normal aboveground green biomass per hectare should be 670.903tons ha^{-1}. The result is almost the same with the findings made by Ajayi, and Adie (2018) who reported average green biomass of 558.14 m^2h^{-1} in Okpon Forest Reserve, Cross River State. However, globally, there is a growing concern on the sustainability of the forest estate so that the benefit from it can be available in perpetuity

(Akindele *et al.,* 2001). This concern needs to be fully expressed in the Cross River National Park and generally in the state to manage the remaining forest resources in the natural and plantation forests and reserves sustainably given that the state is the pilot state in Nigeria for effective implementation of United Nation-Reducing Emission from Deforestation and Forest Degradation (UNREDD+) Program.

Conclusion

Aboveground biomass assessment is critical to understanding the influential role of forest in global carbon stock cycle and climate change. From the result of this research, the aboveground biomass of the Cross River National Park is relatively low when compared with results from other protected areas. This can be attributed to high level of encroachment into the park by enclave communities. The result of this research is a useful tool for wood productivity studies, forest conservation and carbon trade. The estimation of the amount of forest carbon stocks will enable the assessment of the amount of carbon that will be lost during deforestation or the amount of carbon that the forest can store when such forests are regenerated. Efforts therefore should be geared towards reducing the high encroachment level in the park, and integrated sound management approaches should be put in place to promote tree lateral growth and sustainability of the park. Based on the findings of this research, the following recommendations are therefore made:

a. Efforts should be geared towards reducing the high encroachment level in the park, and integrated sound management approach should be put in place to promote tree lateral growth and sustainability.

b. Permanent sample plots should be established in the study area to enhance and promote accurate data collection for informed management decisions.

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