Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.5, No.8, 2015

Supplementary Methods Adapted to Determine Standing Woody Plants Height and Biomass in Ph. D. Geography Research

Edwin Nyaku Gandapa
Department Of Geography,Nigerian Defence Academy, P.M.B 2109, Kaduna, Kaduna State, Nigeria
E-mail: edwingandapa@yahoo.com

ACADEMIC BACKGROUND

S.No.	INSTITUTIONS	YEAR	QUALIFICATIONS
1	T.C.Bazza	1982-1987	Grade II
2.	C.O.E. Hong	1987-1990	NCE (Bio/Geo)
3.	Uni. Maiduguri	1992-1996	B.Sc. Geography
4.	Uni. Maiduguri	1998-2003	M.Sc. Geo. (Res. & Devt.)
5.	NDA Kaduna	2006 to Date	Lecturer I

Abstract
Vegetation structures such as density, height and biomass are important in protection of the earth's surface. The study was embarked upon to determine the woody plant height, girth and crowdiness in order to estimate the Total Above Ground Biomass of community of woody plant stands. The materials and methods used in the study are clinometers, measuring tape, plastic netting ropes and pegs to construct the sample quadrats. To measure the woody plants height using a clinometer there were challenges encountered due to insignificant space for the base line and line of sight. The scope covered Hong Local Government Area, Adamawa State, Nigeria to generate empirical data on woody plant heights, girths and crowdiness with a focus to determine the total above ground biomass of community of woody plant stands. The results come up with the empirical methods on how to determine a tree height in a crowded community of vegetation and how to estimate the total above ground biomass of a single and community of woody plant stands. The supplementary methods should be further researched to come up with empirical method on how to determine precise tree height and biomass. The physical measurements should be adopted to generate precise data on woody plant stands such as height, girth, crowdiness and biomass.

Introduction
Field observations and measurements were carried out to generate data on woody plants distribution and height for research on 'Analysis of Effects of Human Activities on Vegetation of Hong Local Government Area, Adamawa State, Nigeria'. The result reveals that there exist difference in both quality and quantity of woody plant stands on the affected and restricted land management practices. From this perspective, there is a need to assess the woody plant height and biomass on continuous cropping, fallow and reserve lands as well as to determine the magnitude of difference in the biomass. However, to determine the height and to compute the biomass, supplementary methods was adapted by climbing tall trees on reserve lands, and deriving equation from the physical measurements of individual woody plant height and girth as well as distribution per sample quadrat.

Quadrat is used in statistical sampling of both plants and animals (Curtis, 1980). Quadrat sampling is the most widely used method to measure numbers, densities, and distribution of plants in terrestrial communities (Vodopich, 2010). Studies by Curtis and Bignal (2005) used quadrat to demarcate sample plots within which they generate data on vegetation characteristics such as crowdiness, height and species frequency of plants present in a habitat.

There has been an increase in the use of the clinometers to determine the height of trees (Minnesota Project, 2012). However, the use of the instrument is applicable where tall tree stands are well spread out, but inadequate for determining the height of individual plant stand in a community of crowded woody plants in a quadrat sample. Furthermore, the use of the tangent (triangle) method could affect the height adversely.

Zhang and Kondragunta (2006) estimated forest biomass using generalized allometric models and MODIS land products. The technique is species and site specific which is inadequate in communities of woody plants with diverse species that are distributed on different land management practices. Vodopich (2010) adopted equation $B = \sum w/A$ to estimate biomass of weight per unit area; where,

B = is the biomass (grams per sq. m. or kg. per hectare),

$\sum w$ = the sum of the weights of the individual organism in a sample, and

A = the total area sampled.

From the equation, the weight and organisms were not specified neither the purpose of estimating the weight nor

the processes adopted.

Yarie *et al* (2007) stated that for calculation of Total Above Ground Biomass of woody plants requires the use of equations that are derived from measurements of its physical components. Barry (2006) in a study on monitoring vegetation cover utilized physical observation and measurements as against the use of scientific tools such as Geographic Information Systems and satellite images, because the adoption of physical measurements of woody plant parameters is more precise.

The researches of Vodopich (2010), Yarie *et al* (2007), Zhang and Kondragunta (2006), and Curtis and Bignal (2005) are important by identifying methods of sampling plants, how to determine plant height using trigonometry, and biomass of plants using generalized allometric models, but was insignificant in detailed description of the physical structures of individual woody plant that was measured neither their generalization to all species of plants nor restricted to savanna region. However, the methods cannot be generalized in determining woody plant height, girth and biomass because of species diversity and plants distribution. It is from this perspective that this research was embarked upon to solve at micro-scale study by devising a method to determine individual woody plant height and girth in a crowded community, and the biomass of woody plant stands.

Materials and Methods.

The materials and methods adopted in the research are clinometers to observe the heights of tall trees. Others include measuring tape, pegs and rolls of plastic netting rope to construct the simple square quadrat on purposively selected land management practice for measuring the height, girth and stands of woody plants per quadrat, and a saw to cut the saplings of woody plants. The uniform quadrats (100sq.m.) were distributed using stratified sampling method. The study area was divided into 6 strata. Within each stratum, 3 sample quadrats were purposively located on continuous cropping, fallow and reserve lands. The woody plant statistical population measured includes girth, height and stands with a focus to determine the biomass.

To determine the height of tall trees on the reserve land management practice where the woody plant stands are crowded with insignificant space for observation of the tree apex at a fixed position to the base of the tree. The supplementary method of physical measurements was adopted to eliminate the need for trigonometry.

Process on the Generation of the Supplementary Method on Tree Height

The supplementary method was derived from variety of physical measurements of woody plant parameters as presented below:

1. It was carried out by climbing the tall tree to come close to the apex.
2. A long, narrow and fairly erect pole (bamboo) on which a measuring tape was nailed at the tip was directed to the person at the bole that raised the pole to reach the remaining height of the tree.
3. The *h* (height) of the sample tree was determined on the ground surface at the base in metres.

Presentation of the Supplementary Methods on Calculation of Total Above Ground Biomass.

To obtain the plants' cylinder the following experimental process were carried out:

1. Sapling of woody plant stands that have soft and weak stems were sought for. After several trails with different species of woody plants, *Adansonia digitata* (baobab) and *Annona squamosa* (custered apple) were identified to have soft and weak stems. The reason for using two different species was to identify if there could be significant difference in the height and girth of different species after wilting.
2. The girths of the standing saplings were measure at the ground surface and height before cutting with a saw.
3. The saplings were allowed to wilt so that the branches become malleable for ease compaction to form a cylinder, and to shed leaves so as to reduce exaggeration or over estimation of the circumference (girth) when the branches are compacted.
4. The branches were fastened tight together with a tape (sticky plastic material) into a cylindrical shape. The aim of producing a cylinder from the sapling of woody plant stand is to facilitate the application of formulae ($\pi r^2 h$) for finding the amount of material in a length of a cylinder.
5. The girths of the samples were measured at the base, middle and top as well as the height with insignificant difference with the previous standing saplings.
6. The *c* (circumference) of the tree was determined by direct measurement from which the *r* (radius) was obtained ($r = c/2\pi$) while π (pi) is constant (3.14), and *h* (height) of woody plant.
7. The $\bar{x}r$ (average radius) and $\bar{x}h$ (average height) was obtained by dividing the sum of radius and heights of individual woody plant by the number of stands measured per quadrat.
8. In conformity with the formulae ($\pi r^2 h$), *r* was adapted for radius of single woody plant per quadrat

while *h* for height. Furthermore, $\bar{x}r$ was adapted as average radius of woody plant stands that are more the one per quadrat while $\bar{x}h$ for average height.

9. Biomass of the cylinder was computed from area of the cross section (πr^2) multiplied by (*h*) for single woody plant stand per quadrat while ($\pi(\bar{x}r^2)$) multiplied by ($\bar{x}h(n)$) for more than one woody plants.

From the above process, equation $B = (\pi r^2 h)$ and ($B = \pi(\bar{x}r^2) \times \bar{x}h(n)$ was adapted to estimate the Total Above Ground Biomass of all species of standing woody plants observed in sample quadrats which include branches, but exclude the leaves. The equation was adapted by relating the plant girth, height and sum of all species of woody plants on the unit area of 100sq.m. Thus, $B = (\pi r^2 h)$ for single woody plant stand while $B = \pi(\bar{x}r^2) \times \bar{x}h(n)$ for more than one stand; where,

B = the biomass of all woody plants (m),
π = 3.14 was adopted as a reasonable chance because all the statistical samples are in the same decimal of quantities.
r = radius of woody plant stand
h = height of woody plant stand
$\bar{x}r^2$ = average radius of girth of community of woody plants in the quadrat (m),
$\bar{x}h$ = average height of community of woody plants in the quadrat (m), and
n = total number of woody plants in the quadrat.

The equation is essential by incorporating physical measurements of diverse species, height and girth of all standing woody plants in the quadrat samples.

The approach has an advantage over others because the procedures are significantly explained, the components are easy to obtain, and the procedures does not involve woody plants removal.

Conclusion

The protection of ecosystem, natural habitat and the maintenance of viable populations of species of plants and animals in natural surrounding are significantly influenced by biomass**.** The study was conceived to determine the height of individual woody plant stand and the Total Above Ground Biomass in relation to unit area. The use of numerical value is essential in presentation of data generated from field observations because of its objectivity. This has created the ecological necessity to determine the spatio-temporal height and quantity of standing woody plant biomass.

The equation presented represent a compilation of woody plant structures such as height, girth, distribution and biomass of woody plant stands on different land management practice such as continuous cropping, fallow and reserve lands.

The supplementary methods was adopted to eliminate the short coming of the clinometer to generate data on individual woody plant height, girth and distribution in a crowded community with focus to estimate the total above ground biomass of plants.

Recommendations for Further Research

There is a need to embark on further studies that will come up with a precise method of determining Total Above Ground Biomass of woody plants that includes all the braches and leaves.

Study should further be embarked upon to come up with a precise method on how to determine the height of a sample woody plant stand within a crowded community on isolated unit area with insignificant open space for the adaption of trigonometry.

More importantly, further research should be embarked upon to assess the importance of woody plants biomass on the ecology of Hong Local Government Area.

Acknowledgements

I thank Brig. Gen. P.M. Atere Ph.D. (rtd) for valuable inputs on the manuscript. Special thanks to Mr. Jackson I. Matapa for his contribution to the field work.

References

Barry, S. (2006). Monitoring Vegetation Cover. http://www.sciencedirect.com Retrieved 20th November, 2013

Curtis, D.J. (1980). Quadrat Sampling Method. http://resources.metapress.com Retrieved 31st May, 2010

Curtis, D.J. and Bignal, E.M. (2005). Quantitative Description of Vegetation Physiognomy Using Vertical Quadrat. http://resource.metapress.com Retrieved 22nd August, 2009.

Minnesota Project Learning Tree (2012). Ecological Sampling Methods. www.habitats.freeserve.co.uk Retrieved 25th October, 2013

Vodopich, D.S. (2010). Ecology Laboratory Manual. Mc Graw Hill, New York. Pp. 92, 200

Wikipedia Project (2013). Inclinometer. http://en.wikipedia.org/wiki/trigonometry Retrieved 25th October, 2013

Yarie, J., Kane, E. and Mack, M. (2007). Aboveground Biomass Equations for the Trees of Interior Alaska. http://www.uaf.edu/files/snras/B115/pdf Retrieved 25th October, 2013

Zhang, X. and Kondragunta, S. (2006). "Estimating Forest Biomass in USA Using Genealised Allometric Models and MODIS Land Products". In: Geophysical Research Letters, Vol. 33, L09402. http://www.star.gov Retrieved 20th January, 2014

The IISTE is a pioneer in the Open-Access hosting service and academic event management. The aim of the firm is Accelerating Global Knowledge Sharing.

More information about the firm can be found on the homepage:
http://www.iiste.org

CALL FOR JOURNAL PAPERS

There are more than 30 peer-reviewed academic journals hosted under the hosting platform.

Prospective authors of journals can find the submission instruction on the following page: http://www.iiste.org/journals/ All the journals articles are available online to the readers all over the world without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. Paper version of the journals is also available upon request of readers and authors.

MORE RESOURCES

Book publication information: http://www.iiste.org/book/

Academic conference: http://www.iiste.org/conference/upcoming-conferences-call-for-paper/

IISTE Knowledge Sharing Partners

EBSCO, Index Copernicus, Ulrich's Periodicals Directory, JournalTOCS, PKP Open Archives Harvester, Bielefeld Academic Search Engine, Elektronische Zeitschriftenbibliothek EZB, Open J-Gate, OCLC WorldCat, Universe Digtial Library , NewJour, Google Scholar