مجلة جامعة كركوك للعلوم الزراعية ... المجلد (9) العدد (4) 2018
Journal of kirkuk University for Agricultural Sciences ...Vol (9) No. (4) 2018

Evaluation of Coniferous Forest Growth in Pirmam Forest Supported by Geographic Information System (GIS) Techniques

Fuad M. Ahmad [1] Halmat A. Sabr[1] Talaat M. Muhammed[1]

- [1]**University of Salahaddin- College of Agriculture**
- Date of research received 30/1/2017 and accepted 22/6/2017

Abstract

The aim of the present study is to Evaluate of Coniferous Forest Growth in Pirmam Semi Natural Forest Supported by GIS Techniques. For this purpose, five regression equations used for predicting the above-ground biomass (AGB) distribution in studied area. Trees of this forest do not shed their leaves in any season of the year. Major evergreen tree species of Pirmam forests are *pinusbrutia* Ten., *Cupresses semperivernes* vertical and *Cupresses semperivernes* Horizontal. Different regression equations were tested, using the diameter (d) and the height (h) as independent variables and the most suitable equation were determined. Using these models, above-ground biomass amounts can easily be acquired for single trees and stands. On using method 1, 2, 3 and 5 the AGB different from 15.45 to Mgha^{-1}and by method 4 it different from 24.26 to 244.20 Mgha^{-1}. The AGB estimation found in this study represents is difficult to be more realistic picture of tree biomass of a forest.
Key words: tree biomass, GIS, coniferous forest, height, stand density.

تقييم نمو أشجار الغابات الصنوبرية في غابة بيرمام بدعم من تقنيات نظم المعلومات الجغرافية (GIS)

فؤاد محمد أحمد[1] هه لمه ت ابوبكر صابر[1] طلعت محمدامين محمد[1]

- **[1] جامعة صلاح الدين- كلية الزراعة**
- تاريخ تسلم البحث 2017/1/30 وقبوله 2017/6/22

الخلاصة

الهدف من هذه الدراسة هو تقييم نمو اشجار الغابات الصنوبرية بأستخدام تقنيات نظم المعلومات الجغرافية GIS حيث تم اختيار غابة بيرمام كمنطقة لهذه الدراسة. لتحقيق الغرض من الدراسة تم استخدام خمسة نماذج (معادلات انحدار) للتنبؤ بطبيعة توزيع الكتلة الحيوية السطحية (AGB) لأشجار منطقة الدراسة. تتميز الغابة المدروسة بكون اشجارها مستديمة تحتفظ بأوراقها طيلة فصول السنة ومن اكثرها انتشارا في المنطقة هي اشجار الصنوبر و السرو الأفقي و السرو العمودي.تم أختبار المعادلات المختلفة بأستخدام قطر و أرتفاع الأشجار كمتغيرات مستقلة لتحديد المعادلة الأكثر ملائمة للدراسة. يمكن حساب AGB لأي شجرة بسهولة بأستخدام المعادلات المستخدمة في هذه الدراسة، أعطت المعادلات الأولى والثانية والثالثة والخامسة نتائج متشابهة عند تحويلها الى خرائط تمثل طبيعة توزيع AGB مع اختلاف بسيط في طبيعة توزيع الكتلة الحيوية عند استخدام المعادلة الرابعة. ومن البديهي انه من الصعب التنبؤ بحقيقة طبيعة توزيع الكتلة الحيوية بشكل مطابق للواقع الا أنه تزداد دقة النتائج بزيادة عدد النماذج المأخوذة لأشجار منطقة الدراسة.
الكلمات المفتاحية : الغابات الصنوبرية ، نظم المعلومات الجغرافية (GIS)

Introduction

The measurement of field data is the straightest method for estimating the forest biomass. Even though, this method can be the most precise method for the purpose, it is hard, expensive, time consuming. Moreover, it is appropriate for only a small sample of trees and small-scale analysis [1]. Forest biomass can be defined by as the above-ground portion of live trees per unit area. There are benefits of measuring forest biomass such as for a broad range of applications, comprising: characterizing forest conditions and processes and estimating forest productivity [2]. In addition to this, monitoring changes to biomass over time has also developed as a main activity for many of these above-mentioned applications. Biomass estimates may range from local to global scales, and for some regions. Global and national estimates of forest above-ground biomass (AGB) are often a spatial estimate, bring together through the tabular generalization of national level forest inventory data [3].

A variety of approaches and data sources have been used to estimate forest above ground biomass (AGB). A comprehensive review of remote sensing-based estimates of AGB has been completed, categorized by data source: (i) field measurement; (ii) remotely sensed data; or (iii) ancillary data used in GIS-based modeling [4]. Estimation from field measurements may involve destructive sampling or direct measurement and the application of allometric equations [5]. Allometric equations estimate biomass by regressing a measured sample of biomass against tree variables that are easy to measure in the field (e.g., diameter at breast height, height). Although equations may be species- or site-specific, they are often generalized to represent mixed forest conditions or large spatial areas [6]. Relationships between biomass and other inventory attributes (e.g., basal area) have also been reported [7]. The use of existing forest inventory data to map large area tree AGB has been explored [8]; conversion tables were developed to estimate biomass from attributes contained in provincial forest inventory data, including species composition, crown density, and dominant tree height. Large area forest inventories generally are based on field plot sampling, and small area forest inventories usually are deal with forest stand units. These two traditional inventories can be integrated by combining ground inventory with Global Positioning System (GPS) and remote sensing data and processing them in geographical information systems (GIS).

It is now comparatively not difficult to measure the locations of survey plots, forest stands, and stand boundaries in the field with accuracy of within three meters using differential GPS. Generally, there are two ways to predict fine scale spatial forest information, non-spatial modeling and spatial modeling. Non-spatial modeling methods widely applied in forest research with linear and nonlinear regressions are the common models applied for estimations of forest variables[9].On the other hand,a few studies have been publicized on estimations of forestry related variables using spatial models, even though a large number of spatial-statistical and prediction models are available in the literature [9] used geostatistical models to estimate forest variables, such as leaf area index, and to classify forest lands based on remote sensing data. No work is conducted by using GIS software for forest biomass estimation in Erbil City. The aim of the study is to evaluate of coniferous forest growth in Pirmam District supported by GIS techniques.

Methods and materials

The climate of the area is monsoonal with different warm (May to August) and cold (December to March) periods. The rainy season starts from November and extents up to March. About 90% of the total annual rainfall happens during this period. The meteorological data were obtained from the station of the General Director Agriculture office of Erbil Governorate. Pirmam plantation project is located at longitude (44 188128) and latitude (36380125). Elevation Evergreen forests are represented by forest patches in high-elevation sites (above 1000 m a.s.l) ranged between 718-1020 m a.s.l which receive high rainfall (about 2000 mm year-1).

The total area of studied forest is (49860) Donam mainly consist of natural forest (45341 donam) and planted (4519) (Ministry of Agriculture and Natural resources, 2013). In general, trees of these forest do not shed their leaves in any season of the year. Major evergreen tree species of Pirmam forests are *pinusbrutia*, *Cupresses semperivernes* vertical and *Cupresses semperivernes* Horizontal. The trees of studied area were representative of forest types relating to species abundance, altitude and other factors such as stand density, microclimate and crown conditions. Results obtained in the plots were extrapolated to respective forest types and geographical area. The use of satellite imagery Landsat-8 to determine the study area for the year of 2015. Statistical analysis of the results was carried out using SS and MS Excel software. ArcGIS 9.3 software was used to create maps and boundary determination. For data analyzing height and diameter at breast height (1.3 m) (DBH) were classified into three range classes individually (H1, H2 and H3) and (D1, D2 and D3). Forest structure characteristics of the studied site is shown in table (2). In a study area, all trees diameter at breast height at 1.3m from the base were measured by caliper tool, recording its height using Hagameter. For multi-stemmed trees, bole circumference was measured separately, tree biomass estimation was calculated and summed by using five different equations and then the best equation was chosen for biomass estimation for tree present in a forest, only equation (4) used height for biomass estimation (Table, 1).

Table 1. Regression Equations used for predicting tree biomass in Pirmam forest.

Equation number	Expression	Units	References
1	$Y= 21.297- 6.953 (D) + 0.740(D^2)$	$Mg\ ha^{-1}$	FAO. 3.2.3. (1997)
2	$Y= 21.297- 6.953 (D) + 0.740(D^2)$	$Mg\ ha^{-1}$	FAO. 3.2.5. (1997)
3	$Y= 38.4908-11.7883 (D) + 1.1926 D^2$	$Mg\ ha^{-1}$	Brown *et al*. (1989)
4	$Y= 1.276+0.034 (D^2*H)$	$Mg\ ha^{-1}$	Brown and Iverson (1992)
5	$Y=0.88492+ (D^{2.2672})$	$Mg\ ha^{-1}$	Sun *et al*.(1980)

Table 2: Forest structure characteristics of the studied site.

Variables	Range classification	NO.
H1	3.5-6	44
H2	6.5-8	40
H3	8.5-10.5	16
D1	6-10	22
D2	10-15	43
D3	15 ≥	35

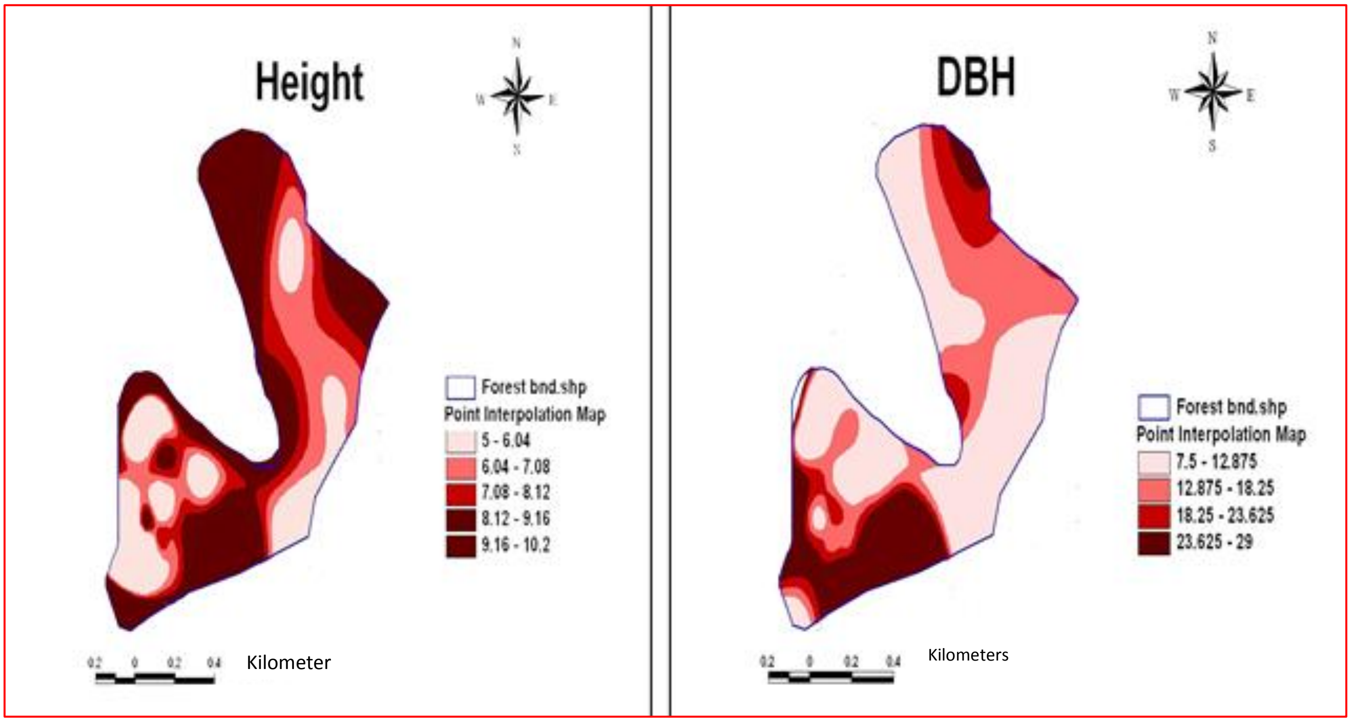

Figure 1: Height and DBH diameter at breastheight distribution in studied area.

Result and discussion

Due to of different tree species are growing in studied area. It is not easy to use a species-specific regression model to estimate above ground tree biomass for this reason five different methods were used in this study. It is shown that from table (3) and figure (2) the best equation will be chosen for biomass estimation especially evergreen tree species. The data of the study showed that the best equation were (Equation 1, 2, 4 and 5), and the values of R^2 were (R^2 = 0.998, R^2 = 1, R^2 = 0.999) respectively.).

Table 3: The R^2values for Predicting Tree above ground Biomass in Pirmam forest.

Sources	Equation 1	Equation 2	Equation 3	Equation 4
Equation 5	0.998	0.998	0.644	0.998
Equation 4	1	1	0.639	
Equation 3	0.638	0.640		
Equation 2	0.999			

The result of data are collected in table (4) indicated that Duncan's multiple range test showed that (H3) is significantly different with (H1) but, not with (H2) for equation 1 and this was the same for equation 2 and 4 (Table, 4). However, this was not the same for equation 3 that was (H3) highly significant different from (H1) and (H2), and (H2) was significant from (H1) (Table, 4). Furthermore, in equation 5 (H2) and (H3) were shown the same letter that were not significantly different, but they were significant with (H1).

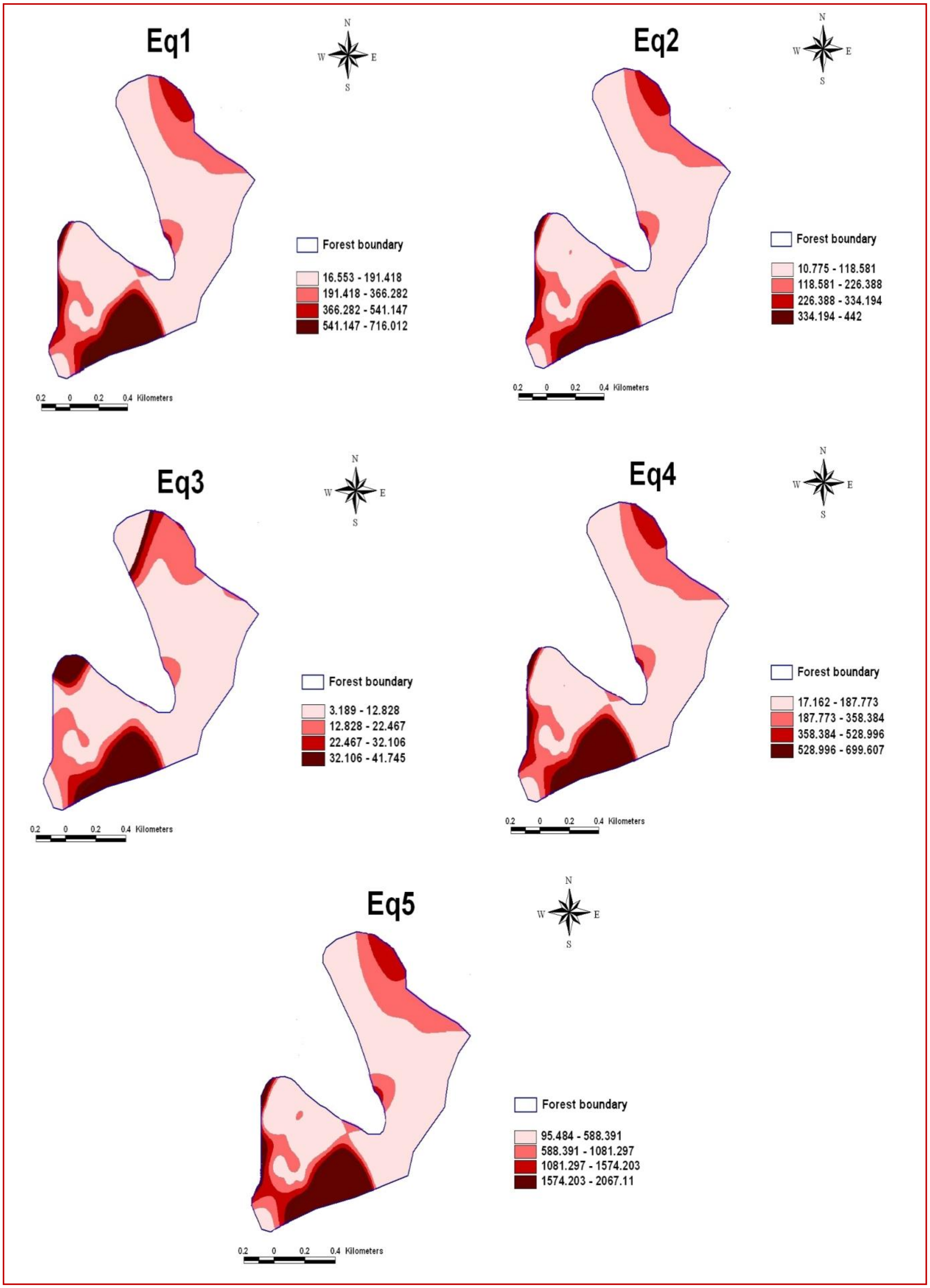

Figure 2: Shows applying kriging for predicting tree above biomass estimation.

Table (4) shows a significant effect of diameter at breast height (1.3 m) on biomass with applying 5 different equations for above ground biomass estimation. A best result of (D3) that was significant with (D1) and (D2) for all parameters, and (D2) was also significant with (D1) for all parameters for all equations. The highest values of mean AGBM was recorded for (D3) (247.21, 155.64, 13.373, 244.20 and 787.89 respectively). The minimum values of mean AGBM was recorded for (D1) (23.55, 15.45, 3.641, 24.26 and 122.54 respectively) (Table, 4).

Table 4 The estimation and comparison of height and diameter at breast height for each equation.

Variance	Equation 1	Equation 2	Equation 3	Equation 4	Equation 5
H1	87.55 b	55.97 b	6.545 c	87.36 b	318.61b
H2	152.45 a b	97.1 a b	9.693 b	151.65 a b	521.79 a
H3	186.67 a	117.96 a	13.276 a	184.86 a	614.61a
D1	23.55 c	15.45 c	3.641c	24.26 c	122.54 c
D2	85.29 b	55.27 b	7.749 b	85.81 b	329.2 b
D3	247.21 a	155.64 a	13.373 a	244.20 a	787.89 a

The different letters for parameters per each equation is significant at ($P \leq 0.05$) by Duncan's Multiple Range Test.

The finding data of the study shown that there was a variation in height and DBH for trees in an area. It is shown that tree height and DBH had an impact on AGB. The forest is not highly fertile soil, by far may have a significant effect on species distribution, but rather reflects the occurrence of treeless area because of localized frequent rocky soil. Figure (1) and (2) explain that both soil type and topography effect on tree above ground biomass on the way effect on height and DBH. A study is conducted by [10] that topography of moderate to steep slopes usually ≤ 50 in length, because this degree may relief minor factors in determining forest ABG. The variance in height and DBH of studied trees are expected that forest dynamics on steeps slopes may quite different in comparison to flat areas.

The data from the present study indicated that all equation (1, 2, 4 and 5) can be used for AGB except equation (3). The linear regression analysis (adjusted R^2) performed using the variables height and DBH as an independent yield with a low value (0.63) for equation (3) and a high value (1) for equation (1, 2 and 4). Based on above data that equation (1, 2,4 and 5) obtained a strong relationship can be used for measuring ABG (with Duncan's Multiple Ranges Test, P ‹ 0.05), thus using the H and DBH of trees is well-substantiated measure of above ground biomass in Pirmam forest. It has been recognized that no vigorous methods have been developed for biomass estimation. Furthermore, a comparison of tree above ground biomass estimations of the present study with other studies is not easy due to variation in the methods employed for ABG in different work. On the other hand, it is essential to obtain more accurate biomass estimation for Pirmam Forest in order to increase understanding of the role of present study in carbon cycle in Kurdistan region.

The recorded AGB value of 787.89 Mg ha^{-1} in the present study was higher in comparable with the results observed by [11] with a value of 307 Mg ha^{-1} for the tropical evergreen forests of eastern coast of Tamil Nadu, India. In addition to this, [12] conducted a study for tropical wet evergreen forest and tropical semi evergreen forest of Western Ghats of India that the numbers from theour study were recorded higher than the AGB values of 607.7 Mg ha^{-1}. Due to there is not present works about of AGB in Kurdistan region, particularly at Pirmam forest for this reason it is difficult to compare with other studies. The greater contribution of large trees to AGB was in conformity with the findings of contribution to AGB by the large trees (>15 cm dbh). However, smaller trees added to most AGB in forests with <244.20Mg ha^{-1} aboveground biomass. Data have revealed that forests with reduced biomass either had their large trees removed by past human disturbance or newly planted trees which do not yet have large trees.

There are many works consider on carbon management is a serious fear challenging the world today. It is shown that a higher percentage of AGB in the higher diameter classes does show the essential role of large trees in carbon storage, but does not undermine the role of small trees (< 6cm dbh) which would improve the future carbon stock due to their high carbon sequestration potential. It is well-known that forest plantations sequester carbon till maturity that varies from 25 to 75 years depending upon the forest type [13]. Further than the maturity, the trees generally have marginal carbon sequestration capability. The higher AGB in the semi natural may be recognized to the more or less uniform stand structure that results from a combination of site factors and adopted management practices. On the other hand, wide variation in stand structure and tree growth in the natural forest resulted may have lower above ground biomass, Furthermore, other factors responsible for such low total AGB are, different stages of forest growth cycle, habitat and species variability, and varying tree density [14].

Conclusion and recommendation

The measurement of field data is the straightest method for estimating the forest biomass, for the present study satellite imagery Landsat-8 was used to determine the study area for the year of 2015. Nevertheless, this method can be the most accurate method for the aim, it is hard, expensive, time consuming. The choice in any specific study is essential, as different methods can give rise to very different AGB estimates when applied to the same forest inventory data. It is indicated that equation choice therefore poses a problem for regional-scale comparisons of AGB estimates, because differences caused by environmental, structural, and compositional slopes, may be confounded with variation resulting from the use of different equations. If at all possible, therefore, comparisons of AGB estimates over large spatial scales need to be based on a consistent regression approach and to be more realistic picture of tree biomass of a forest, it is better a relatively large number of trees should be sampled.

References

1. Anaya JA, Chuvieco E, Palacios-Orueta A (2009) Aboveground biomass assessment in Colombia: A remote sensing approach. Forest Ecology and Management 257: 1237-1246.
2. Keeling, H.C. and Phillips, O.L., 2007. The global relationship between forest productivity and biomass. *Global Ecology and Biogeography*, *16*(5), pp.618-631.
3. Rokityanskiy, D., Benítez, P.C., Kraxner, F., McCallum, I., Obersteiner, M., Rametsteiner, E. and Yamagata, Y., 2007. Geographically explicit global modeling of land-use change, carbon sequestration, and biomass supply. *Technological Forecasting and Social Change*, *74*(7), pp.1057-1082.
4. Lu, D., 2006. The potential and challenge of remote sensing-based biomass estimation. *International journal of remote sensing*, *27*(7), pp.1297-1328.
5. Montagu, K.D., Düttmer, K., Barton, C.V.M. and Cowie, A.L., 2005. Developing general allometric relationships for regional estimates of carbon sequestration—an example using *Eucalyptus pilularis* from seven contrasting sites. *Forest Ecology and Management*, *204*(1), pp.115-129.
6. Zianis, D., Muukkonen, P., Mäkipää, R. and Mencuccini, M., 2005. *Biomass and stem volume equations for tree species in Europe*. FI.
7. Szwagrzyk, J. and Gazda, A., 2007. Above-ground standing biomass and tree species diversity in natural stands of Central Europe. *Journal of vegetation Science*, *18*(4), pp.555-562.

8. Sales, M.H., Souza, C.M., Kyriakidis, P.C., Roberts, D.A. and Vidal, E., 2007. Improving spatial distribution estimation of forest biomass with geostatistics: A case study for Rondônia, Brazil. *Ecological Modelling*, *205*(1), pp.221-230
9. Berterretche, M., Hudak, A.T., Cohen, W.B., Maiersperger, T.K., Gower, S.T., Dungan, J., 2005. Comparison of regression and geostatistical methods for mapping Leaf Area Index (LAI) with Landsat ETM+ data over a boreal forest. Remote Sensing of Environment 96 (1), 49_61.
10. Laurance, W.F., Laurance, S.G., Ferreira, L.V., Rankin-de Merona, J.M., Gascon, C. and Lovejoy, T.E., 1997. Biomass collapse in Amazonian forest fragments. *Science*, *278*(5340), pp.1117-1118.
11. Ramachandran, A., Jayakumar, S., Haroon, R.M., Bhaskaran, A. and Arockiasamy, D.I., 2007. Carbon sequestration: estimation of carbon stock in natural forests using geospatial technology in the Eastern Ghats of Tamil Nadu, India. *Current Science*, *92*(3), pp.323-331.
12. Swamy, H.R., 1992. Organic productivity, nutrient cycling and small watershed hydrology of natural forests and monoculture plantations in Chikmagalur district, *Karnataka* (No. CONF-9102202--). John Wiley and Sons, Inc., New York, NY (United States).
13. Baishya, R., Barik, S.K. and Upadhaya, K., 2009. Distribution pattern of aboveground biomass in natural and plantation forests of humid tropics in northeast India. Tropical Ecology, 50(2), p.295.Terakunpisut, J., N. Gajaseni& N. Ruankawe. 2007.Carbon sequestration potential in abovegroundbiomass of Thong phaphun national forest,Thailand. Applied Ecolog