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Tree species composition, biomass and carbon stocks in two tropical forest of Assam

Maina Borah [a], Dhrubajyoti Das [a], Jatin Kalita [a], Hari Prasanna Deka Boruah [a,*], Barsha Phukan [a], Bijoy Neog [b]

[a] Department of Biotechnology, CSIR-North East Institute of Science and Technology, Jorhat 785006, Assam, India

[b] Department of Life Sciences, Dibrugarh University, Dibrugarh 786004, Assam, India

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ABSTRACT

Tropical forests store higher above ground biomass (AGB) and AGB carbon (AGBC) than any other forest ecosystems. In the present study the tree composition, diversity, dominance and carbon stocks in the AGB and soil of tropical forests *viz.*, the Gibbon wildlife sanctuary (GWS) and the Kholahat reserve forest (KRF) of Assam, India were assessed. Soil sampling, tree survey, girth above 1.3 m height of plants >10 cm girth of plants were assessed in 1000 m^2 quadrate. Allometric model for moist forest stands was used to determine AGB and AGBC. A total of 71 and 108 different tree species belong to 32 and 42 families were found in the GWS and KRF, respectively. In the GWF, the Shannon diversity index (1.22) and the Simpson index (0.085) were significant, while for the KRF these indices were insignificant. The basal area, AGB and AGBC in the GWS and KRF were 62.49–90.29 m^2 ha^{-1}, 135.30–146.42 Mg ha^{-1}, and 67.64–73.21 Mg ha^{-1}, respectively. The average soil carbon stock (SOC) in the upper, middle and lower layers was 57.74–78.44 kg m^{-2}, 39.22–64.93 kg m^{-2} and 30.32–42.86 kg m^{-2}, respectively, in the GWS and KRF. However, compared to GWS, a higher AGB and AGBC were found in KRF. This finding reveals that the higher AGB, AGBC and SOC in the KRF were due to old growth matured forest with big and diverse tree species.

1. Introduction

Forest ecosystems and their soils are major sinks of atmospheric carbon [1–4] and thus influence of forest in the global carbon cycle is now well recognized [5–7]. Forest vegetation captures atmospheric CO_2 through photosynthesis and stores it in their above and below ground biomass and in soil [8,9]. It has also been reported that the world's forest ecosystems are estimated to store more carbon than the entire atmosphere [5]. Interestingly, out of the various forest habitats, tropical forests store an estimated 350 Pg of carbon in their AGB that is more than any other biome [3]. As a result, there have been increased and continued efforts in the past to estimate carbon stocks in forest ecosystems and related anthropogenic activities that influence the alteration of the carbon cycle [5,6,10,11]. Studies also report that tropical forest carbon stocks are currently declining with losses due to deforestation and habitat degradation [11]. In addition, carbon stocks in intact old growth forests may be increasingly effected due to

* Corresponding author.
E-mail addresses: dekaboruah@yahoo.com, dekabaruahhp@rrljorhat.res.in (H.P. Deka Boruah).
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global environmental changes [12,13]. Thus, an accurate characterization of AGBC in tropical forest is utmost importance to estimate their contribution to global carbon stocks.

Although, carbon monitoring techniques have been improved recently in several aspects, including the development of generalized tree allometry theory [14] and the assembly of global wood density databases [15], uncertainty remains regarding their quantitative contribution to the global carbon cycle. One approach to quantifying carbon biomass stores consists of inferring changes from long-term forest inventory plots for which regression models are used to convert inventory data into an estimate of AGB [14]. The most common method for estimating tree biomass is through the use of regression analysis. Equations are developed by weighing entire trees or their components and relating the weight to easily measured tree dimensions, such as the diameter at breast height (dbh) and height [15]. Similar to AGBC, soil carbon is also an important determinant for its role in maintaining soil physical and chemical properties. Moreover, soil stores 2–3 times more carbon than the atmosphere in the form of CO_2 and 2.5–3.0 times more than terrestrial plants [16]. It has also been predicted that the majority of carbon in the terrestrial pool is stored below ground in soils and that the total global carbon in soils constitutes between 1.5 Eg and 2.0 Eg. However, due to the myriad human pressures on tropical forest ecosystems, the assessment AGB and SOC has gained importance. Moreover, the degradation of tropical forest in developing countries is enormous and base line data is yet to be established which show uncertainty regarding the contribution of large amount of carbon to the global carbon cycle.

Assam, in the northeastern (NE) part of India, is a part of the Indo-Burma mega biodiversity hotspot [17]. The forest types occurring in the state are tropical wet evergreen, tropical semi-evergreen, tropical moist deciduous, subtropical broadleaf hill, subtropical pine, littoral and swamp forests and grasslands and savanna [18]. Though there are a few referred publications on forest areas of Assam [19–23] however, information related to nature of forest, AGBC and SOC stocks are scanty under different forest habitats. In order to fill up this gap, it is necessary to assess representative forests in respect of characteristics and role in maintaining the environment. In this study, comparative tree diversity, basal area and carbon stocks in two forest areas of Assam, *i.e.*, the GWS and KRF including their nature were assessed.

2. Materials and methods

2.1. Study area

The GWS under the Jorhat district and the KRF under the Nagaon district of Assam, India were selected for the study. The GWS, formerly known as the Hollongapar Reserve Forest, is an isolated and protected area of evergreen forest patches located in eastern Assam and Created in 1881, the GWS was officially named in 1997. Previously, the sanctuary was named after Hollong (*Dipterocarpus macrocarpus*), a species of trees found abundantly in the reserve, but was renamed in 1997 as the GWS. In the early 20th century, a well-stocked secondary forest was developed that resulted in rich biodiversity at the site. The GWS lies between 26°40′-26°45′ N latitude and 94°20′-94°25′ E longitude at an elevation of 100–120 m above msl. The KRF lies between 26°07′-24°6′ N latitude and 92°26′20.3–94°25′ E longitude at an elevation of 250–270 m above msl. The climate of the region can be divided into four seasons: pre-monsoon (March–April), monsoon (May to September), retreating monsoon (October to November) and winter (December to February) [24]. The average temperature and humidity in both the place were within 18.95 °C–27.9 °C and 64.5% and 94.5%, respectively.

2.2. Survey of the tree species

Vegetation classification of the study area has been prepared from Cloud free IRS 1D LISS III imagery of December, 2008. Visual interpretation techniques were employed to delineate various land cover and vegetation features from the False Colour Composite (FCC) of band 2, 3 and 4 combinations of the satellite data. Geographic Information System (GIS) using Arc GIS 9.3 software was used for forest classification, based on which an inventory of the trees was prepared along transects oriented in a north-south direction and measured by a handheld GPS unit with accuracy of 10 m (GPSMAP 60 CSx, Garmin, USA). Based on the forest habitats determined from GIS, tree inventory were done in 0.1-ha plots quadrates in each habitat. In each plot, trees of >10 cm in diameter at breast height (breast height = 1.3 m) was measured, identified to the species level, and their diameters were measured to the nearest centimetre (using dbh tapes) for further analysis. When a bole irregularity was observed at 1.3 m, the measurement was taken 10 cm above the irregularity. To avoid edge effects, the quadrate was established 30 m inside of the plot. Entire survey was done during 2010 and 2011 in winter season and ten quadrates were taken into consideration.

2.3. Determination of plant diversity

Shannon Weaver diversity [25] was calculated as follows:

$$H = -\sum_{i=1}^{s} p_i \ln p_i \tag{1}$$

where, p_i is the proportion of individuals of ith species out of all of the individuals.

The concentration of dominance was calculated following Simpson [26] as follows:

$$Cd = \sum_{i=1}^{s} (p_i)^2 \tag{2}$$

where, p_i is the proportion of individuals of ith species out of all the individuals.

2.4. Determination of tree basal area

Eq. (3) was used to determine tree basal area.

$$\text{Basal Area (dbh in cm)} = 0.00007854 \times \text{dbh}^2 \tag{3}$$