Structure, above ground biomass and carbon stocks in a Sal (Shorea robusta Gaertn. f.) forest of Goalpara district, Assam.

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Structure, Above Ground Biomass and Carbon Stocks in a Sal (*Shorea robusta* Gaertn. f.) Forest of Goalpara District, Assam

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Abstract Sal forests generally have very low species. Two hectare of secondary Sal forest was intensively studied to assess the structure, AGB and C stock of Goalpara district, Assam. Only three species were recorded and *Shorea robusta* was totally dominated in both the study sites. Density and basal area of trees were ranges from 127—334 tree ha^{-1} and 10.7—21.6 m^2 ha^{-1}. Above ground biomass was recorded as 162.97 Mg ha^{-1} and 92.91 Mg ha^{-1} in Site-I and Site II respectively. The study highlighted the structure, carbon storage and anthropogenic disturbances in Sal forests.

Keywords Regeneration, Anthropogenic disturbances, Rangjuli reserve forest, Sal forest.

Introduction

Forests are being considered as one option for stabilising or reducing atmospheric carbon dioxide by storing carbon in biomass, soils and its products. Tropical forests can store approximately 40% of terrestrial carbon [1] but when disturbed it release more CO_2 [2]. Estimations of above ground biomass play significant role in studying of carbon stocks, effect of deforestation and carbon sequestration on the global carbon balance [3]. The most reliable technique for estimating carbon stocks is through forest inventories followed by allometric relationships between the above ground biomass of a tree and its trunk diameter [4, 5].

Sal (*Shorea robusta* Gaertn. f.) is a semi-deciduous, light demanding tree that grows up to 45 m in height and frequently forms a mono-specific canopy [6]. In India Sal forests are spread over an estimated area of 10 million hectares [7]. Sal forests are typically categorized as Tropical Moist Deciduous Forest which in Assam can be further divided into Khasi Hill Sal forest (3C/C1 1a (ii) and Kamrup Sal forest (3C/C2 2d (iv)) [8]. The Sal forests of Goalpara district is part of "Kamrup Sal forest". Ahmed and Medhi [9] estimated that there was shrinkage of 1050.46 hectares reserve forests and proposed reserve forests areas of Goalpara district during the period 1981—2002 due to encroachment for human habitation, pasture and agricultural uses. Chitale and Behera [7] stated that moisture is one of the key factor that can influenced to shift distribution of Sal forests towards northern and eastern India due to changing climate. The present study provides important information on the structure, composition and carbon stocks with

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human influence in Sal forests of Goalpara district, Assam.

Materials and Methods

The study was conducted in Secondary Sal forest of Rangjuli reserve forest of Goalpara district of Assam. Two sites were selected from each side of NH–37 highways. Geographically the mid-point of Site–I and Site-II are 90°58´05.5´´E and 25°58´43.6´´N and 90°58´ 05.5´´E and 25°58´43.6´´N respectively. For the present study a non-destructive sampling method was adopted to estimate AGB and C stocks of tree species. One hectare plot in each site was delimited and girths of all the trees (≥10 cm DBH) were measured at 1.37 m height. The climate is damp and warm humid and average annual rainfall of last five-year period (2008—2012) was 2173.02 mm yr^{-1} [10]. Species-specific volume equations published by Forest Survey of India [11] were used to estimate the tree volume taking DBH as an independent variable. The above ground biomass of each individual tree was calculated by using following equation.

$$\text{Biomass} = \text{volume} \times \text{wood specific gravity}$$

Species wood specific-gravity data of each tree species in the present study region were collected from Forest Research Institute [12]. Estimation of C-stock in each tree was done by multiplying the tree biomass with 0.5 as in many other similar studies [13, 14].

Results and Discussion

Sal forest generally has very low species diversity and only three species were recorded. The density was recorded 334 tree ha^{-1} and 127 tree ha^{-1} in Site–I and Site–II respectively (Table 1).

We also encountered 17 fresh cut stems in Site–II, while in Site–I not even single cut stem has observed. Both the study sites are dominated by *Shorea robusta* and other species contributed only 1.5% and 1.6% density in Site–I and Site–II respectively. The basal area was recorded as 21.57 $m^2 ha^{-1}$ in Site–I and 10.73 m^2 ha^{-1} in Site–II.

The AGB and C were recorded 162.97 Mg ha^{-1} and 81.49 Mg ha^{-1} in Site-I whereas in Site-II the value were 92.91 Mg ha^{-1} and 46.45 Mg ha^{-1} respectively (Table 1). *Shorea robusta* contributed almost all AGB in both sites. More AGB in Site-I may be due to the presence of more density and basal area.

Table 1. Cumulative results of the sampled inventory of Sal forest in Goalpara, Assam.

Parameters	Site–I	Site–II
Species number	3	2
Density (stem ha^{-1})	334	127
Basal area (m^2 ha^{-1})	21.57	10.73
AGB (Mg ha^{-1})	162.97	92.91
AGC (Mg ha^{-1})	76.59	43.67

Distribution of density and basal area in different DBH classes was shown in Fig. 1. The density distribution curve showed the dominance of lower to middle diameter classes. The maximum AGB recorded in 30—40 cm DBH class in Site-I while in Site-II 40—50 cm DBH class has the maximum AGB (Fig. 2). In Site-I, 88% density belong to 20—30 cm and 30—40 cm DBH classes which contribute 85% of total AGB. Whereas in Site-II, 54% trees belong to 10—20 cm and 20—30 cm DBH classes contribute only 18% of total AGB and 25% trees (40—50 cm and 50—60 cm DBH classes) contribute 62% of total AGB. So in Site-II due to biotic pressure has less number of higher girth size trees which can contribute more AGB.

Species richness is very poor in present study (only 3 species) as described by Stainton [15] in Sal forests. The density in the present study ranges from 127—334 tree ha^{-1} and it seems comparatively low than other studies done in different Sal forests of the country such as 408 trees ha^{-1} in Gorakhpur [16], 484 tree ha^{-1} in Meghalaya [17], 294—559 tree ha^{-1} in Central India [18].

In the present study the basal area was ranges 10.73—21.57 m^2 ha^{-1} and similar basal area (7—29 m^2 ha^{-1}) was reported from Sal forest of Central India [18]. The upper limit for basal area in present study (21 m^2 ha^{-1}) was similar with the value 22.23 m^2 ha^{-1} from Sal forest of Gorakhpur division [19]. Uma Shankar [17] reported basal area 26.3 $m^2 ha^{-1}$ from Sal forest of Eastern Himalaya and 26.1 m^2 ha^{-1} form Sal

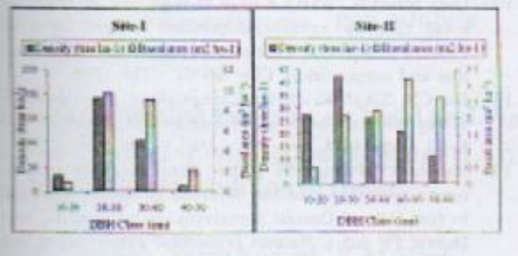

Fig. 1. Distribution of density and basal area in different DBH classes in two Sal forests of Goalpara, Assam.

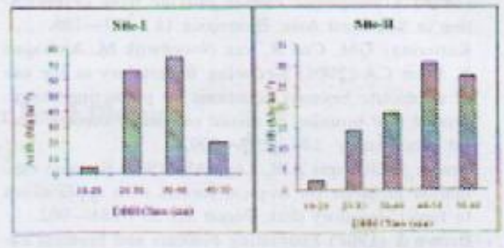

Fig. 2. Distribution of AGB in various DBH classes in two sites of Sal forest in Goalpara, Assam.

forest in subtropical Submontane Zone of Garhwal Himalaya [20] are also comparable to the upper range of the present study.

Comparing the AGB of similar forests dominated by *Shorea robusta* of North East India, the present study (92.91—162.97 Mg ha^{-1}) found much lower than Sal plantation forest of Meghalaya with the value 406.4 Mg ha^{-1} [21] and the upper rangeis slightly higher than the value 154.94 Mg ha^{-1} in open Sal forests of Satpura plateau, Madhya Pradesh [22]. The observed AGB is also comparable with other forest types of India such as 32.47—261.80 Mg ha^{-1} in the tropical forests of Cachar district of Assam [23], 179.14—246.38 Mg ha^{-1} in the sub-tropical broad leaved forests in Manipur [24]. The projected AGB was found much higher than secondary semi-evergreen tropical forest of Manipur (15.60—15.84 Mg ha^{-1}) [25].

The history of the present study sites is very old. Sal is a very important tree species and usually harvested for its timber. Due to the ongoing over-exploitation, deforestation, encroachment and alteration in land use and land cover the mother Sal forests gradually replace by secondary regenerated Sal forest of the low lying areas of Assam [26]. The Sal forests of Goalpara district were exposed to different intensities of fire and anthropogenic disturbances in the past. Mass regeneration is a characteristic of Sal forests where conditions (light, soil, moisture with good drainage) are favorable and form more or less even aged stands which are relating pure or bulk of the stocks in mixed stands [6]. Againregeneration was very poor where soil moisture is inadequate and which experienced higher degree of disturbances such as fire and different human activities [27, 28]. Sustainable management strategies are might be very effective to conserve the Sal forests [29]. In present study tree girth size recorded only up to 40—50 cm DBH class in Site-I while in Site-II maximum girth class is 50—60 cm DBH. Lack of large size trees indicate that the present study faced huge destruction in past, which at present regenerating and regain its natural habitat. In Site-I maximum density in 20—30 cm and 30—40 cm DBH classes indicates the uniformity of the stand. In Site-II presence of a respectable number (17 no.) of big cut stems hints the ongoing anthropogenic disturbances which depleted the canopy cover and may be due to that the density of lower DBH class is comparatively more. Again due to biotic pressure it has less number of higher girth size trees which can contribute more AGB. In Site-I, comparatively density was more and maximum individuals (88%) contribute the major (85%) portion of AGB and C while in Site-II only a few (25%) individuals contribute maximum (62%) of AGB. Carbon sequestration rate of Sal forests is comparatively low because of its slow growth rate but it can store carbon in its biomass efficiently with high specific gravity value (0.7). So it is highly recommended to conserve the Sal forest in climate change mitigation point.

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