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ESTIMATION OF CARBON STOCKS IN UNDERGROWTH OF THE KAPTAI NATIONAL PARK OF BANGLADESH

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Abstract

Undergrowth is the most essential component in the forest areas and play a vital role to carbon sequestration. The present study was conducted on undergrowth in the Kaptai national park under Rangamati Hill Tracts district at South Forest Division of Bangladesh. The main objectives of the study were to estimate biomass and carbon of undergrowth in six forests areas of the Kaptai national park. The study was based on track selection, sampling collection and laboratory analysis. Tracks were selected using global positioning systems. The total number of tracks were 77 and each track had four plots of 1 m radius at north-south and east-west directions being 100 m apart from each other. A systematic sampling and destructive method were used for the estimation of undergrowth carbon. On an average, undergrowth biomass stock was 2.93 t ha^{-1} in six forests areas. The highest biomass was 4.36 t ha^{-1} in *Gmelina arborea* and the lowest was 1.53 t ha^{-1} in *Lagerstroemia speciosa*. The results revealed that undergrowth biomass was greatly influenced by species to species in the same regions and showed that *Gmelina arborea* > *Swietenia macrophylla* >*Dipterocarpus turbinatus* > *Acacia auriculiformis* > *Tectona grandis* > and *Lagerstroemia speciosa* respectively. The average carbon was 0.87 t ha^{-1} and the maximum carbon was 1.23 t ha^{-1} in *Gmelina arborea* forest and the lowest was 0.65 t ha^{-1} in *Lagerstroemia speciosa* forest. The findings of the results will be helpful to investigate the role of forest tree species in the improvement of undergrowth of tropical forest areas.

***Keywords*:** Protected area, tropical forest, biomass, carbon stock, undergrowth, destructive method.

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Introduction

A forest is comprised of plants and animals in, on and above the soil. Undergrowth (shrubs and herbs) is naturally grown and regenerated in the forest areas. Undergrowth is mainly all live under story herbs, shrubs and seedlings (Hudak *et al.*, 2012). Undergrowth biomass is converted into litter biomass in the dead condition. Undergrowth play a crucial role to protect soil, increase of organic matter in the soil, maintaining diversity of plants and helps to continue ecosystem stability and sustainable productivity of forest ecosystems (Yarie, 1980; Mallik, 2003; Biswas and Choudhury, 2007). Undergrowth is the second living resource of forest areas and contributes to germination, regeneration and helps to develop the forest tree species for the survival in the forest areas (Gillam, 2007; Moore *et al.*, 2007). Soil temperature and moisture also depend on undergrowth. Many scientists suggested that biotic and abiotic components of the forest environment directly related to undergrowth (Gurlevik *et al*., 2004). Undergrowth reduces the atmospheric carbon dioxide through photosynthesis process (Islam, 1979). Scientists observed that the capacity of carbon sequestration of undergrowth biomass is the second in a healthy forest areas and its quality and quantity are variable due to various causes. It is reported that undergrowth vegetation contains about 4.70% of biomass in the terrestrial forest areas (Smith *et al*., 2013) and also plays a major role in the sustainable ecosystem function and the terrestrial carbon cycle (Hou *et al*., 2015; Saith *et al.*, 2014). Undergrowth is significantly influenced both of the biotic and abiotic components in the forest ecosystems. It has important in the forest ecosystems and has also contributed to reduce the global warming. But some studies have been conducted on undergrowth in the whole of the world. The contribution of undergrowth in the carbon sequestration is essential for forest management and sustainable development of forests. Research papers are insufficient on undergrowth biomass and carbon in forest areas of Bangladesh. More research should be started on the undergrowth in the protected forest areas of Bangladesh. The Kaptai National Park is the most important protected forest in Bangladesh which is covered by evergreen, semi-evergreen, deciduous forest tree species. A comprehensive baseline information on the undergrowth biomass and carbon storage of the Kaptai National Park area is necessary for its sustainable management. Considering this fact, the study was undertaken to estimate biomass and carbon storage of undergrowth in the tropical forest of Kaptai National Park of Bangladesh.

Materials and Methods

The study area is in the Kaptai National Park and is under the Kaptai Range, Rangamati Hill Tracks South Forest Division, Bangladesh (Fig. 1). It lies between 22^0 27′ to 22^0

32′ N latitudes and 92^0 30′ to $92^0$16′ E longitudes. Its area is 5464 ha and the elevation ranges from 5 to 95 meter above mean sea level. The mean annual temperature, rainfall and humidity are 20.50 °C, 2513 mm and 80% respectively. About 90% rainfall occurs during monsoon (June to August) (Source: Kaptai hydroelectricity project). The area was known Sitapahar reserved forest before declaration as the Kaptai national park (Feeroz *et al.*, 2011). Historically Teak (*Tectona grandis*) was introduced from Myanmar in 1871 and massive plantation was started by the forest department in 1873 (Uddin *et al.,* 1998). About 90% land of the area is hilly, 4% area covers with settlement and 6% land is arable (Alam *et al.*, 1993). The hills are composed of Upper Tertiary rocks in sedimentary rock largely predominates along siltstones. Soil is brown sandy loams and classified according to the USDA Taxonomy (Ahmad, 1970).

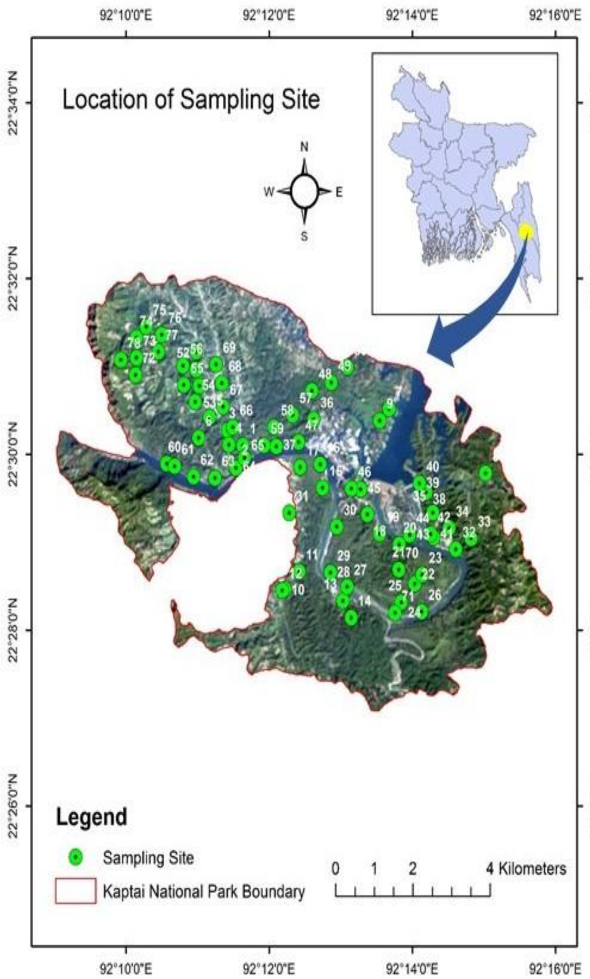

Fig. 1 : Map showing the location of the study area in Kaptai National Park, Bangladesh.

Samples were collected from the field and biomass and carbon were measured in the laboratory. The study was conducted in the period of January 2014 to December 2016. A systematic sampling method was used for identification of each point in the study area. For convenience of the study, Kaptai National Park was divided into three hundred eight (308) which were 100 m apart from each other and each plot was identified by using GPS in the field levels. Each plot was circular size with 1 meter radius (Fig. 2).

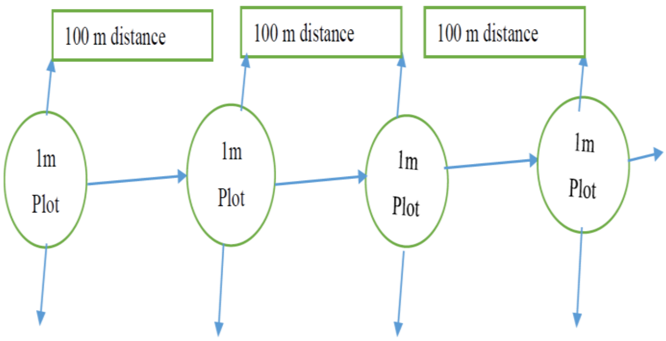

Fig. 2 : Schematic representation of the arrangement of sampling plots

The total number of plots became three hundred eight (308). In each sampling plot, total undergrowth samples were collected. The samples were cut into small pieces and mixed uniformly with its components and then measured green weight (in kg) by field balance. From the green sample of each plot, a sample of 1 gm was collected for laboratory analysis. The Loss of Ignition method was used to estimate biomass carbon stock in the study. The sample was dried at 65ºC in the oven for 48 hours. Then the dry weight from oven of each sample was measured. The sample was burned at 650ºC for one and half hour in the muffle furnace. After cooling, the crucibles with ash were weighted and then the percentage of carbon was calculated according to the following method (Allen *et al*., 1986).

$$\text{Ash (\%)} = (W_3 - W_1)/(W_2 - W_1) \times 100$$

$$\text{C (\%)} = (100\text{-Ash}) \times 0.58$$ (Considering 58% carbon in ash-free litter material)

Where,

C= Biomass carbon

W_1= Weight of crucibles

W_2=Weight of the oven-dried grind sample and crucible,

W_3= Weight of ash and crucible

After calculation the carbon stock per track and total carbon stock per hectare was calculated in the area.

Statistical analysis

Analysis of Variance (ANOVA) for carbon stock per hectare were performed by using SPSS (version, 20) package to determine levels of significance.

Results and Discussion

The present study was conducted to estimate the biomass and carbon of undergrowth in six forests areas. The results revealed that the lowest and the highest undergrowth biomass values were 1.53 and 4.36 t ha^{-1} in the study area (Table 1). On an average, undergrowth biomass stock was 2.93 t ha^{-1} in six forest areas. The highest biomass was 4.36 t ha^{-1} in *Gmelina arborea* and the lowest was 1.53 t ha^{-1} in *Lagerstroemia speciosa.* The results revealed that undergrowth biomass were greatly influenced by species to species in the same regions showed that *Gmelina arborea* > *Swietenia macrophylla* >*Dipterocarpus turbinatus* > *Acacia auriculiformis* >*Tectona grandis* >and *Lagerstroemia speciosa* respectively (Table 1).

Table 1 : Estimation of undergrowth biomass density in different tree species (t ha^{-1}).

Name of forest tree species	Age (yrs.)	undergrowth biomass	Mean
Acacia auriculiformis	5	2.17±0.13	2.32*
Acacia auriculiformis	8	2.36±0.15	
Acacia auriculiformis	12	2.44±0.14	
Dipterocarpus turbinatus	15	2.58±0.16	2.87
Dipterocarpus turbinatus	20	2.94±0.17	
Dipterocarpus turbinatus	25	3.10±0.19	
Gmelina arborea	5	3.97±0.17	4.36
Gmelina arborea	7	4.13±0.28	
Gmelina arborea	10	4.99±0.33	
Lagerstroemia speciosa	12	1.34±0.09	1.53
Lagerstroemia speciosa	16	1.52±0.012	
Lagerstroemia speciosa	18	1.75±0.15	
Swietenia macrophylla	10	4.02±0.28	4.19
Swietenia macrophylla	16	4.36±0.33	
Tectona grandis	15	2.11±0.10	2.31*
Tectona grandis	20	2.31±0.14	
Tectona grandis	25	2.37±0.17	
Tectona grandis	30	2.48±0.21	
Mean			2.93

*Figures followed by the same letter in a column do not differ significantly at $p<0.001$ from each according to DMRT. The variance ratio (F-value=1.999; degree of freedom =5) was significant at $p<0.001$.

Table 2 : Estimation of undergrowth carbon density in different tree species (t ha^{-1}).

Name of forest tree species	Age (yrs.)	Undergrowth carbon	Mean
A. auriculiformis	5	0.66±0.06	0.79*
A. auriculiformis	8	0.75±0.05	
A. auriculiformis	12	0.96±0.09	
D. turbinatus	15	0.88±0.10	0.92
D. turbinatus	20	0.86±0.07	
D. turbinatus	25	0.94±0.07	
G. arborea	5	0.99±0.09	1.23
G. arborea	7	1.31±0.07	
G. arborea	10	1.41±0.08	
L. speciosa	12	0.59±0.06	0.65
L. speciosa	16	0.64±0.07	
L. speciosa	18	0.73±0.07	
S. macrophylla	10	0.81±0.05	0.87
S. macrophylla	16	0.93±0.08	
T. grandis	15	0.66±0.10	0.76*
T. grandis	20	0.74±0.14	
T. grandis	25	0.79±0.17	
T. grandis	30	0.87±0.21	
Mean			0.87

*Figures followed by the same letter in a column do not differ significantly at $p<0.001$ from each according to DMRT. The variance ratio (F-value=1.926; degree of freedom =5) was significant at $p<0.001$.

Ullah and Al-Amin (2012) reported that the range of undergrowth biomass was 1.89 to 2.46 t ha^{-1} in Tankawati natural hill forest of Bangladesh and their results were lower than the present findings. The anthropogenic pressure and other abiotic factors were influenced the undergrowth biomass and carbon. Their study area was comparatively less protected and the present study area was protected forest area and strictly prohibited for public entering. Some studies were conducted on undergrowth in different regions as sporadic conditions. Miah *et al*. (2001) estimated undergrowth biomass in the Chittagong University forest areas and reported that an average biomass was found 0.79 t $ha^{-1.}$ Their value's also lower than the findings of this study.

The present study revealed that undergrowth carbon storage values of *Acacia auriculiformis, Dipterocarpus turbinatus, Gmelina arborea, Lagerstroemia speciosa, Swietenia macrophylla* and *Tectona grandis* of different ages (Table 2). The results indicated that maximum carbon stock was found in *Gmelina arborea* area followed by *D. turbinatus, S. macrophylla, A. acacia, T. grandis* and *L. speciosa* forest areas respectively. The average carbon was 0.87t ha^{-1} and the maximum was 1.23 t ha^{-1} in *G. arborea* forest and the lowest was 0.65 t ha^{-1} in *L. speciosa* forest (Table 2).

The total undergrowth biomass and carbon depend on different parameters such as elevation, forest structure, types etc. (Zheng *et al*., 2008). Undergrowth biomass also depends on regional criteria such as tropical and non-tropical etc. (Zhang *et al.*, 2013). Many scientists worked on region based and they suggested that tropical region is more suitable for the development of undergrowth (Thokchom and Yadava, 2013). It was reported that some species inhibit the growth of undergrowth such as needle shaped planted forest species (Li *et al.*, 2011; Zhao *et al.*, 2014). Some investigators also reported that, undergrowth naturally grown in the forest areas and degraded due to the local people and forest land encroachment (Shin *et al*., 2007). It was also reported that more undergrowth was found in young forest areas than mature forest areas. In this case, undergrowth became weak to weaker due to lack of sufficient light, wind and temperature. Humidity etc. (Lugo, 1992).

Conclusion

Undergrowth is the most important component in the forests and helps to increase the development of other forest species. Forest management, stand structure, grazing intensity, anthropogenic disturbances, altitude and edaphic conditions may have great influences on undergrowth vegetation. Incidence of forest encroachment is very high in the present sites and this could be the reason of low undergrowth carbon. It is an urgent need to educate local people by creating awareness on the importance of undergrowth in reducing the concentration of atmospheric carbon dioxide. In the study, the carbon stock estimation can be directed to researchers and administrators to analyze for global carbon stock which can be helpful to improve the forest resources and environmental sectors like Bangladesh and other tropical countries with similar conditions.

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