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Biomass and Carbon Stock in Subtropical Broad-Leaved Forest Ecosystem of Meghalaya, Northeast India

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ABSTRACT

The subtropical broadleaved forests of Meghalaya, northeast India, occur in fragmented patches most of which are treated as sacred forests. Three subtropical broad-leaved forests located near Cherrapunjee were selected to estimate the biomass and allocation of carbon stock in different ecosystem components and the total ecosystem. The aboveground biomass (AGB) of trees ranged from 187 to 293 Mg ha^{-1} whereas AGB of lianas comprised < 2% of the total forest AGB. The AGB accounted for 81%, whereas belowground biomass (BGB) contributed 18% of the total biomass for trees and lianas. The total biomass carbon stock for trees and lianas ranged between 109 and 172 Mg C ha^{-1}. The carbon stocks from understory biomass ranged between 0.055 to 0.098 Mg C ha^{-1}, whereas from detritus biomass had 6.66 to 10.44 Mg C ha^{-1}. The carbon in soil to a depth of 0-20 cm was 26-46 Mg C ha^{-1}. The total ecosystem carbon in the three sites ranged from 157 to 205 Mg C ha^{-1}. Such information on different carbon pools would be useful in understanding the potential of carbon storage in subtropical broad-leaved forests and their role in the regional and global carbon balance in response to future climate change.

Key Words: Aboveground Biomass; Carbon Storage; Cherrapunjee; Sacred Forests; Tree Allometric Equations

INTRODUCTION

Global warming is one of the important universal challenges pressing mankind today. The reason behind increasing atmospheric temperature is human-induced emissions of the greenhouse gases, of which carbon dioxide (CO_2) is of immediate concern because it persists in the atmosphere for a long period of time. The Intergovernmental Panel on Climate Change (IPCC) advocates to limit the rise in global atmospheric temperature to 2ºC, so that the concentration of CO_2 is retained at 490-540 parts per million (Pachauri and Reisinger 2007). However, atmospheric CO_2 has reached an appalling concentration of 400.14 ppm, which is the highest recorded value in 650,000 years (Dlugokencky and Tans 2015). In view of the rising concern about growing levels of atmospheric CO_2, the introduction of forestry has been widely recognized to enhance carbon storage in forest ecosystems and thus maintain global carbon balance (UNFCCC 1998, IPCC 2000, FAO 2011). Carbon regulating services provided by forest biomes have the potential for mitigation of global warming and climate change. Depending upon the succession stage, specific disturbance, or management intervention, the forest ecosystem acts both as a source and a sink of carbon (Masera et al. 2003, Usuga et al. 2010). Forests absorb CO_2 from the atmosphere and sustain the sequestered carbon as biomass within the system. However, with increasing atmospheric temperature, the carbon regulating services of forests might be hindered, as there is a possibility of land ecosystems turning into a net source of CO_2 (Seppala et al. 2009).

Carbon stocks across different pools in the forest ecosystem can be quantified by evaluation of forest biomass. It is estimated that tropical and subtropical forests together store 550 Gigatonnes (1Gt=10^{15}g) of carbon (Olson et al. 2001). The current global carbon stock in the world's forests has been estimated to be 861 Peta gram (1Pg=10^{15}g), which are stored in aboveground and belowground biomass (42%), dead wood (8%), litter (5%) and soil (44%) component (Pan et al. 2011). However, the carbon stocks in different components vary with forest types, climates, disturbance- and landuse-histories, management types and soils (McKinley et al. 2011). In a typical forest tree, about 50% carbon is stored in the trunk, 30% in branches and stems, and 3% in foliage (Birdsey 1992).

The north-eastern states of India cover only about 8% of the total geographical area of the country but accounts for one-fourth of the total forest cover (FSI 2013). Recently, a few studies on the assessment of aboveground biomass and carbon stock of forests have been conducted in the region, which includes the tropical semi-evergreen forests of Manipur (Devi and Yadava 2009), Meghalaya (Baishya et al. 2009, Upadhaya et al. 2015), Assam (Borah et al. 2013) and plantation forests of Meghalaya (Baishya et al. 2009, Upadhaya et al. 2015). However, there is a paucity of studies on carbon stock assessment and inventories of the subtropical forests of the region (Thokchom and Yadava 2013). The subtropical broad-leaved forests comprise 41% (9195 sq. km) of the total forest cover in the state of Meghalaya. These forests occur in the form of highly fragmented patches and are exposed to various kinds of anthropogenic activities (Upadhaya et al. 2008). Such forest patches are also located in Cherrapunjee area of the state, one of the wettest places on earth. These fragmented forests amidst degraded grasslands treasure a myriad of plant species which are thriving under highly leached and nutrient-deficient soil conditions (Upadhaya et al. 2014, Upadhaya 2015). The landscape is on the verge of further degradation, as a consequence of forest clearing for shifting cultivation, forest fires, grazing by animals, coal mining and extraction of sand and limestone (Upadhaya et al. 2014).

Therefore, the present study was aimed at (1) estimation of the biomass and allocation of carbon stock across different ecosystem components and (2) assess the contribution of these carbon stocks to the total ecosystem carbon. Such information on different carbon pools would be useful in understanding the potential of carbon storage in subtropical broad-leaved forests and also to predict their role in the regional and global carbon balance in response to future climate change.

MATERIALS AND METHODS

Study Area

We studied three forest patches of Cherrapunjee plateau, located at Mawsawa (25° 15.1' 26" N and 91° 42' 12.42" E), Nongthymmai (25° 15' 2.87" N and 91° 44' 8.52" E) and Pdengshnong (25° 17' 8.26" N and 91° 43' 30.53" E). These patches, abbreviated as MW, NT and PD, cover an area of 50 ha, 5 ha and 11 ha, respectively. These are sacred forests which have been preserved on account of religious beliefs of the local people. Their vegetation represents the remnants of the climax forest in the area. These are dense evergreen forests of short stature with tree height rarely exceeding 18 m. There is dense ground vegetation during the rainy season (Upadhaya 2015).

The climate of the area is tropical monsoonal and is directly influenced by winds from the Bay of Bengal. It has a distinct wet and dry period. The wet period extends from May to October, during which more than 80% of the total rainfall occurs. The dry period prevails from November to March with <22 mm rainfall. The mean annual rainfall of the area for the period 2008-2010 was 11,309 mm. The average maximum and minimum temperature is 22°C and 14°C, respectively (Upadhaya 2015). The soil of the area is acidic (pH 5.5) and sandy.

For the present study, a belt transect of 20m x 500m (1 ha) was laid in each forest. The transect was further divided into 100 quadrats of 10m x 10m, within which all woody individuals with ≥5cm diameter at breast height (dbh) were measured and recorded. A total of 131 woody species belonging to 93 genera and 57 families were documented at the three study sites (Table 1). Altogether, there were 3479 individuals with mean value of 1160±0.4 individuals ha^{-1}. In site MW, *Syzygium tetragonum* (Wt) Kurz (165 individuals ha^{-1}) and *Elaeocarpus lancifolius* Roxb. (43) were the dominant and co-dominant species. *E. lancifolius* (25) and *Castanopsis kurzii* (Hance) Biswas (24) in site NT, whereas *C. tribuloides* (Sm.) DC (238) and *C. purpurella* (Miq.) Balak. (235) in site PD were the dominant species, respectively.

Table 1. Stand characteristics for individuals with ≥5 cm dbh in three subtropical broadleaved forests of Cherrapunjee.

Community parameters	Sites		
	MW	NT	PD
Number of species	84	79	78
Number of genera	70	63	55
Number of families	46	43	35
Density (individuals ha^{-1})	1167	908	1404
Basal area (m^2 ha^{-1})	39.75	39.19	59.44

Allometric Equations for Biomass Estimation

We used mixed-species allometric models to quantify aboveground biomass (AGB). Individual values of D (diameter at breast height) were fitted into the regression models developed by Brown et al. (1989), Brown and Iverson (1992), Chambers et al. (2001) and Chave et al. (2001). On the basis of statistical parameters such as coefficient of correlation (R), coefficient of determination (R^2), mean square error (MSE), root mean square error (RMSE), standard deviation (SD), standard error (SE) and F statistics, the model developed by Chambers et al. (2001) was observed to be best fitted (R^2 = 0.87) for the present study. For lianas, biomass was computed using the model

$$Y = \exp\{-1.484 + 2.65 \ln(D)\}$$

developed by Schnitzer et al. (2006). The belowground biomass (BGB) was estimated following the equation

$$Y = \exp\{-1.059 + 0.884 \ln(AGB) + 0.284\}$$

developed by Cairns et al. (1997). The carbon stock in AGB and BGB was taken as 47.4% of the biomass (Martin and Thomas 2011, Thomas and Martin 2012).

Understory Biomass and Carbon Stock

To estimate understory biomass, 10 sub-plots of 5m x 5m for shrubs and 2m x 2m for herbaceous species were randomly laid in each forest. All understory vegetation within these sub-plots was harvested during August when their growth was at maximum. The harvested biomass was immediately weighed in the field and brought to the laboratory, where it was oven-dried at 65°C for 48 hours till a constant weight. Understory carbon storage was calculated as 50% of the dry mass (Dar and Sundarapandian 2015).

Detritus Biomass and Carbon Stock

Detritus biomass comprised of woody debris and litter (leaves, bark, flowers/floral parts, fruits, etc.). 10 sub-plots (1m x 1m) were laid in each forest and the detritus was collected on monthly basis over a period of 2 years. The samples were oven-dried at 65°C for 48 hours and weighed. The values for detritus biomass presented in this study are an average of 2 years. For conversion to carbon mass, the dry weight of detritus was multiplied by a factor of 0.5 (Pearson et al. 2007, Li et al. 2015).

Soil Carbon Pool

Soil samples were collected from 10 random sub-plots at two depths, (0-10 cm and 10-20 cm) and brought to the laboratory. Soil organic carbon (SOC) was analyzed following the colorimetric method as outlined by Anderson and Ingram (1993). Soil carbon stock was calculated as follows:

Soil carbon stock (Mg ha^{-1}) =
bulk density (g cm^{-3}) * soil depth interval (cm) * SOC (%)

The total soil carbon was then determined by summing the carbon stock at each soil depth (Pearson et al. 2007, Kauffman and Donato 2012).

Total Biomass and Carbon Stock

The total biomass in each study site was computed by adding up the AGB, BGB, understory biomass and detritus biomass. Similarly, the total ecosystem carbon stock was estimated by summing up the total biomass carbon for all components (AGB, BGB, understory and detritus) and the total soil carbon.

RESULTS

Biomass and Carbon Stock in Trees and Lianas

The aboveground biomass of trees was 187 Mg ha^{-1} in site NT, 191 Mg ha^{-1} in MW and 293 Mg ha^{-1} in PD, with a mean value of 223.5±34.7 Mg ha^{-1} (Table 2). AGB of lianas comprised < 2% of the total forest AGB (trees + lianas), with highest AGB from site MW (8.09 Mg ha^{-1}). Mean belowground biomass among the forests was 52.2±8.2 Mg ha^{-1} (range 42- 68 Mg ha^{-1}). Total biomass for trees (AGB+BGB) ranged between 229 and 361 Mg ha^{-1}, with highest value in site PD and least in NT. Total

Table 2. Biomass (Mg ha^{-1}) and Carbon stocks (Mg C ha^{-1}) of different ecosystem components in the three sites (MW, NT and PD).

Ecosystem component	MW		NT		PD	
	Biomass	C stock	Biomass	C stock	Biomass	C stock
Aboveground trees	190.95	90.51	186.84	88.56	292.98	138.87
Aboveground lianas	8.09	3.83	1.67	0.79	0.78	0.37
Total Aboveground	199.04	94.34	188.51	89.35	293.76	139.24
Belowground trees	43.99	20.85	42.25	20.02	68.43	32.43
Belowground lianas	1.37	0.65	0.41	0.2	0.21	0.1
Total Belowground	45.36	21.5	42.66	20.22	68.64	32.53
Shrubs	0.09	0.05	0.15	0.08	0.18	0.09
Herbs	0.009	0.005	0.014	0.007	0.016	0.008
Total Understory	0.10	0.06	0.16	0.09	0.20	0.10
Woody Detritua	6.09	3.04	5.53	2.77	4.32	2.16
Other Litter	14.8	7.4	10.79	5.4	9	4.5
Total Detritus	20.89	10.44	16.32	8.17	13.32	6.66
Soil	-	46.36	-	39.32	-	26.13
Total Ecosystem	265.39	172.70	247.65	157.15	375.92	204.66

biomass of lianas (AGB+BGB) was highest in site MW (9.46 Mg ha^{-1}), followed by NT (2.08 Mg ha^{-1}) and PD (0.99 Mg ha^{-1}). Overall, biomass from the arbor layer (trees and lianas) ranged from 231 to 362 Mg ha^{-1} (Table 2). AGB accounted for 81%, whereas BGB contributed to 18% of the total biomass for trees and lianas.

The AGB carbon stock for trees was 90, 88 and 139 Mg C ha^{-1} in sites MW, NT and PD respectively, with a mean value of 105.9±16.4 Mg C ha^{-1} (Table 2). For lianas, AGB carbon had a mean value of 1.66±1.09 Mg C ha^{-1}. Mean BGB carbon was 24.7±3.9 Mg C ha^{-1}. On the whole, biomass carbon from the arbor layer (trees and lianas) ranged between 109 and 172 Mg C ha^{-1}, with a mean value of 132.3±19.7 Mg C ha^{-1} (Table 2).

Biomass and Carbon Storage in Understory Vegetation and Detritus

Herbaceous biomass ranged between 0.01 and 0.02 Mg ha^{-1} in the present study (Table 2). More than 91% of the understory biomass was contributed by the shrub layer in site PD. The total understory biomass ranged from 0.10 Mg ha^{-1} in site MW, to 0.16 Mg ha^{-1} in NT and 0.20 Mg ha^{-1} in PD, with a mean of 0.15±0.03 Mg ha^{-1} (Table 2). Similar trend was observed in case of carbon stocks of these components. In shrubs, carbon stock was 0.07±0.01 Mg C ha^{-1}, but the herbaceous carbon stock (0.005-0.008 Mg C ha^{-1}) was considerably low. Total carbon stock in understory layer was maximum in site PD (0.09 Mg C ha^{-1}), followed by NT (0.08) and MW (0.05) (Table 2). Detritus biomass was the highest in site MW (20.8 Mg ha^{-1}), whereas in NT it was 16.3 Mg ha^{-1} and in PD it was 13.3 Mg ha^{-1} (Table 2). Woody debris accounted for 31% of the total detritus biomass, while litter biomass contributed to 68%. Carbon stock in detritus showed greater value in site MW (10.4 Mg C ha^{-1}) followed by NT (8.1) and PD (6.6) (Table 2). Overall, mean carbon stocks in woody debris and litter were 2.6±0.2 and 5.7±0.8 Mg C ha^{-1}, respectively.

Total Ecosystem Biomass

Total ecosystem biomass was 248-376 Mg ha^{-1} (mean 296.3±40.1) in the present study (Table 2), with lowest and highest values in sites NT and PD, respectively. The site MW showed an intermediate value of 265 Mg ha^{-1}. Overall, percentage contribution of AGB, BGB, understory biomass and detritus biomass to the total ecosystem biomass were 76%, 17%, 0.05% and 6%, respectively.

Soil Organic Carbon (SOC) and Stock in Soil

Soil organic carbon decreased with the increase in soil depths in all the forests stands (Table 3). Mean value of SOC at 0-10 cm soil depth was 4.03%, whereas in 10-20 cm depth it was 3.62%. On the other hand, irrespective of soil depth, SOC was highest in site MW (4.76 %) than in sites NT (3.74 %) and PD (2.96 %). Total carbon stock in soil was lowest in PD (26.13 Mg C ha^{-1}) that increased in NT (39.32) and MW (46.36), respectively (Table 3).

Table 3. Total Carbon stocks in soil at different depths in the three study sites.

Study site	Depth (cm)	Bulk density (g cm^{-3})	SOC (%)	Carbon Stock (Mg C ha^{-1})	Mean C Stock (Mg C ha^{-1})
MW	0-10	0.92	4.87	44.93	46.36
	10-20	1.03	4.66	47.78	
NT	0-10	1.03	4.02	41.45	39.32
	10-20	1.07	3.47	37.19	
PD	0-10	0.84	3.2	27.00	26.13
	10-20	0.93	2.72	25.26	

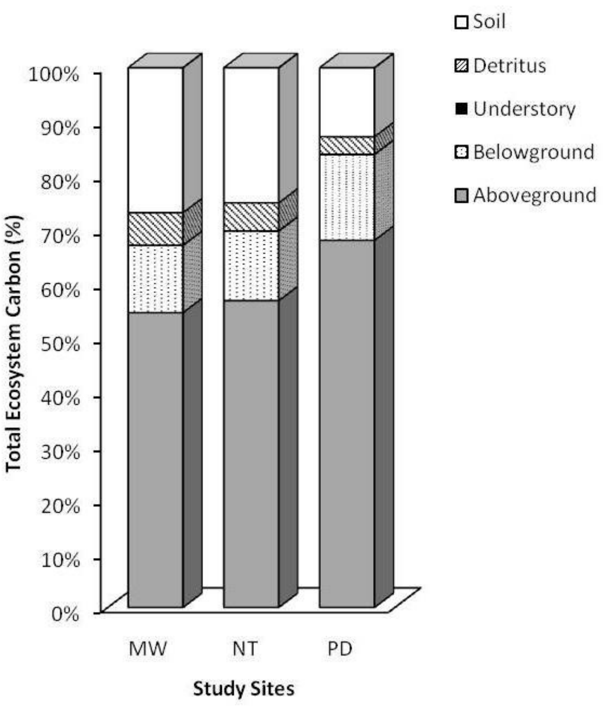

Figure 1. Percentage contribution of carbon pools in different ecosystem components in the three study sites.

Total Ecosystem Carbon

Each forest showed different patterns of carbon allocation in the different ecosystem components. AGB carbon (trees and lianas) contributed 59% to the total ecosystem carbon, while BGB carbon (trees and lianas) accounted for 13% of the total ecosystem carbon (Figure 1). Carbon input from trees and lianas together was higher at site PD (83%), while sites NT and MW contributed 69% and 67%, respectively. Understory carbon, detritus carbon and soil carbon accounted for 0.05%, 4.8% and 21% respectively (Figure 1). The total ecosystem carbon in sites MW, NT and PD were 173, 157 and 205 Mg C ha^{-1} respectively, with an over-all mean value of 178.16±14 (Table 2).

DISCUSSION

The distribution of biomass and carbon stocks in forest ecosystems differ with forest types, species composition, stand age, soil conditions, etc., as well as topographic and micro-climatic factors (Mani and Parthasarathy 2007, Terakunpisut et al. 2007, Lin et al. 2012, Rosenfield and Souza 2013, Ming et al. 2014). In tropical and subtropical forests, there is considerable variation in biomass due to high species richness and the different environmental factors affecting plant growth (Clark and Clark 2000).

The range (187-293 Mg ha^{-1}) of AGB of trees observed in the present study corroborates (180-261 Mg ha^{-1}) with those from other subtropical forests of the world (Nizami et al. 2009, Lin et al. 2012, Thokchom and Yadava 2013, Ali et al. 2014, Rosenfield and Souza, 2014, Cao et al. 2014). Borah et al. (2013) reported AGB values of 32-261 Mg ha^{-1} from tropical evergreen forests of Assam. However, the values are lower than that of tropical areas (204-324 Mg ha^{-1}) of Meghalaya (Baishya et al. 2009, Upadhaya et al. 2015). The low input (mean 1.74%) of liana AGB to total AGB of the forest contradicts the findings of Gerwing and Farias (2000) where liana biomass accounted for 30% of the aboveground live biomass in low stature forests. Nevertheless, this value falls within the range (1.7-5.6%) observed from tropical Atlantic forests (Alves et al. 2011).

Abino et al. (2014) reported an average live biomass (AGB+BGB) of 401.07 Mg ha^{-1} in mangrove stands of Philippines, which is higher than the values obtained in the present study (mean 279.3±41.7 Mg ha^{-1}). But the results are in compliance with the average biomass estimates of 164 Mg ha^{-1} from subtropical forests of China (Fang et al. 1998) and wet subtropical forests (285 Mg ha^{-1}) of Puerto Rico (Frangi and Lugo 1985). The percentage contribution of AGB and BGB (81% and 18%, respectively) to the total biomass for the arbor layer is similar to that observed by Chhabra et al. (2002) and Dar and Sundarapandian (2015). Cairns et al.

(1997) had concluded that the BGB of an ecosystem can reach up to 25% of the total tree biomass.

The understory vegetation biomass values (0.10-0.20 Mg ha^{-1}) reported in the study is close to that of the herbaceous (0.1 Mg ha^{-1}) and shrub (0.6 Mg ha^{-1}) biomass of subtropical pine dominated forests of Meghalaya (Baishya and Barik 2011). The results are also congruent with the values (0.03-0.15 Mg ha^{-1}) reported from subtropical forests of Pakistan (Nizami 2012) and from the temperate forest (0.08-2.46 Mg ha^{-1}) of China (Zhang and Wang 2010). However, these values are lower than those reported (0.19-14.3 Mg ha^{-1}) from other subtropical forests of the world (Zeng et al. 2013, Sun and Guan 2014, Chen et al. 2015). Zhang et al. (2016) concluded that higher biomass accumulation in the overstorey tree layer leads to resource filtering, with the consequence of decreased abundance of understory vegetation and biomass. According to Brown and Lugo (1992), shrubs, herbs and vines contribute up to 3% to the total forest AGB.

The values of detritus biomass (13-21 Mg ha^{-1}) obtained in the present study are close to those observed from subtropical forests (13.3±1.4 Mg ha^{-1}) of US Virgin Islands (Oswalt and Brandeis 2008) and subtropical broadleaved forests (0.4-6.3 Mg ha^{-1} from litter biomass and 1.1-6.5 Mg ha^{-1} from woody litter biomass) of China (Zeng et al. 2013). However, the values were higher than that (2.3±7.6 Mg ha^{-1}) from subtropical pine dominated forests of Meghalaya (Baishya and Barik 2011). According to Zeng et al. (2013), the broadleaved trees produce N-rich litter, which accelerates the decomposition of soil organic matter, thereby decreasing the thickness of the litter layer and increasing overall vegetation biomass.

Saatchi et al. (2011) illustrated regional patterns and estimates of carbon stocks across three continents, wherein a global biomass carbon stock of 247 Gt C (1Gt =10^{15} g) was reported, with 193 Gt C stored aboveground and 54 Gt C stored belowground. Among other components, woody debris, litter, soil and harvested products together account for 35% of the global carbon sink and 60% of the global forest carbon stock (Pan et al. 2011). Carbon estimates in forests depend upon variability in habitat, species, stand density, stand age, forest types, site conditions, biomass and relative carbon contents in the plant tissues (Kang et al. 2006, He et al. 2013, Ming et al. 2014). The total ecosystem carbon values (157-205 Mg C ha^{-1}) obtained in the present study regardless of individual contributions from the different carbon pools, are within the range of the results (6-288 Mg C ha^{-1}) obtained from evergreen subtropical forests of China (Zeng et al. 2013, Sun and Guan 2014) and broadleaved forests of Southern Brazil (59 Mg C ha^{-1}, Rosenfield and Souza 2014). The total ecosystem carbon values reported from different forest types of the world is 28-513 Mg C ha^{-1} (Sharma et al. 2010, Gairola et al. 2011, Zhang et al. 2013, Abino et al. 2014, Dar and Sundarapandian 2015).

Biomass carbon from the arbor layer (109-172 Mg C ha^{-1}) obtained in the present study is well in conformity with the findings (48-156 Mg C ha^{-1}) from other subtropical forests (He et al. 2013, Zeng et al. 2013, Ming et al. 2014). The results are also within the range (16-181 Mg C ha^{-1}) of studies from north-east India (Borah et al. 2013, Thokchom and Yadava 2013, Upadhaya et al. 2015) and elsewhere (Nizami et al. 2009, Sun and Guan 2014, Ali et al. 2014). However, these values are lower than those reported from tropical forests of Meghalaya (161-203 Mg C ha^{-1}; Baishya et al. 2009) and the Philippines (297 Mg C ha^{-1}; Abino et al. 2014). The understory biomass carbon (mean 0.08±0.01 Mg C ha^{-1}) of the present study is similar to the subtropical forests of Pakistan (0.07-0.15 Mg C ha^{-1}; Nizami 2012) and Meghalaya (0.4 Mg C ha^{-1}; Baishya and Barik 2011). But these values are much lesser than those reported (0.7-12.8 Mg C ha^{-1}) from several other studies (Zeng et al. 2013, Sun and Guan 2014, Chen et al. 2015).

The carbon stocks of woody debris and litter (6.6-10.4 Mg C ha^{-1}) obtained in the present study is within the range (0.7-13 Mg C ha^{-1}) as reported from other forests (Oswalt and Brandeis 2008, Baishya and Barik 2011, Zeng et al. 2013, Sun and Guan 2014, Chen et al. 2015). Carbon stocks in detritus are influenced by vegetation, site conditions and forest management practices (Takahashi et al. 2010). Standing stock of carbon in detritus is lower in broadleaved forests because of the fast rate of litter decomposition (Kang et al. 2006) as well as detritus inputs associated with type of vegetation (Dar and Sundarapandian 2015). The carbon content of litter varies with factors such as tree species, litter productivity, decomposition rate and micro-environment (Zhou et al. 2000, Kang et al. 2006).

Soil carbon stocks depend largely on soil properties, forest type, stand age, litter productivity and litter decomposition rate (IPCC 2003, Jandl et al. 2007). The values of soil carbon stocks computed in the present study (26-46 Mg C ha^{-1}) are lower than the reported values (72-105 Mg C ha^{-1}) from subtropical forests in China (Sun and Guan 2014), and from forest soils (69-172 Mg C ha^{-1}) in Japan (Takahashi et al. 2010). Baishya and Barik (2011) reported 58 Mg C ha^{-1} in the soil from subtropical pine forest of Meghalaya. The lower values of soil carbon obtained in all the three forests can be attributed to the hilly topography, coarse texture of soil and high precipitation in Cherrapunjee area (Khiewtam and Ramakrishnan 1993, Upadhaya et al. 2014).

CONCLUSION

Estimation of terrestrial carbon at the regional level is very important for accounting the carbon budget of a country while addressing global climate change mitigation. Aboveground biomass and carbon stock values obtained in the present study corroborates with the findings of other subtropical and temperate forests located elsewhere in the world. However, the low contribution of understory vegetation and soil to the total carbon stock may be attributed to the extreme precipitation and erosion in the area. The results of the present study on carbon storage across different ecosystem components would pave a way in understanding the sequestration potential of subtropical forests in one of the wettest places in the world. It also gives an insight of the contribution of traditionally managed forests in storage of carbon for mitigating climate change.

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CONFLICT OF INTEREST: We declare that there is no conflict of interest.

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