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Above-Ground Biomass and Carbon Stocks in Sigogor Mountain Nature Reserve, Ponorogo, East Java, Indonesia

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Abstract. Forests have ecological functions that play a role in absorbing carbon dioxide. This study aims to predict the above-ground biomass and carbon stocks. This research has been carried out in February - March 2016 at Sigogor Mountain Nature Reserve, Ponorogo, East Java, Indonesia (07°48′-07°50′ SL dan 111°36′-111°38′ EL) with an area of 190.5 ha. Tree biomass calculation analysis was done at Soil Laboratory of University of Muhammadiyah Malang. Biomass calculation used is allometric method. The results showed that total biomass stocks at tree level > 30 cm diameter was 0.21 ton / ha and tree level of 5 - 30 cm diameter was 0.02 ton/ ha, while the biomass of lower plant was 5.88 ton/ ha and for total litter yield of 8.47 ton/ha. Total biomass stocks on above-ground of the Sigogor Mountain Nature Reserve with an area of 190.5 ha is 1,438.78 tons. Trees of > 30 cm in diameter with the most biomass are found in Kemadu (Laportea sinuata Bl.), Dali (Radermachera gigantea), Marasawa (Engelhardis spicata), Pasang (Quercus sondaica) and Wesen (Dodoneca viscusa). The prediction of carbon stock in Sigogor Mountain Nature Reserve area is 426.05 tons and able to absorb carbon dioxide 1,601.93 tons.

1. Introduction

Forests have an ecological function that plays an important role in maintaining the balance of ecosystems. This is related to the ability of the forest stand to absorb carbon dioxide and release oxygen in the process of photosynthesis. The more carbon dioxide absorbed by the plant and will be stored in the form of carbon biomass the greater the adverse effect of the greenhouse effect can be controlled [1-3].

Related to climate change and global warming in the world, one way to maintain the ecological function of the forest is by maintaining and maintaining and maintaining forest vegetation from the possibility of damage (deforestation and degradation) [1-3]. The world's attention to the importance of forests in climate change mitigation is evident from the emergence of the Clean Development Mechanism and REDD (Reducing Emissions from Deforestation and Degradation) in carbon trading [4-7].

Biomass calculations also can not be separated from activities related to climate change mitigation. Measurement of carbon stocks stored in an area is expected to provide information on how much carbon will be released if the area is managed with inappropriate land management techniques [6].

Indonesia is one of the tropical countries that has the largest forest in the world. Sigogor Mountain Nature Reserve is designated as a nature reserve with an area of 190.5 ha whose forests need to be aware of its existence and should be kept its sustainability. In these areas trees play an important role in the forest and serve as a buffer for life to prevent erosion and maintain global climate stability.

Sigogor Mountain Nature Reserve is one type of mountain forest that is still good and has a high diversity of tree species and has large reserves of carbon stored. Carbon stock measurements have been carried out by researchers in the world. Ullah and Al-Amin [8] have measured natural forest carbon stocks in Bangladesh. Nautiyal and Singh [9] have predicted the potential for Pine carbon reserves in India. Ngo et al. [10] has examined primary and secondary forest carbon stocks in Singapore. Jones et al. [11] have predicted carbon stocks of mangrove ecosystems in Madagascar forests. Tanner et al. [12] have researched carbon sinks in Costa Rica. Youkhana [13] has predicted carbon stocks in Hawaii. Meriem et al. [14] have reviewed carbon stocks in tropical forests of Sumatra, Indonesia. Gedefaw [15] has predicted forest carbon stocks in Ethiopia. Sundarapandian et al. [16] has examined the carbon stocks of woody plants on various land uses in natural forests in India. Gao et al. [17] has evaluated four methods of predicting carbon stocks in China. Gibbs et al. [18] have predicted tropical country-scale tropical forest carbon stocks. Wilson et al. [19] has also predicted country-scale carbon stocks. Bhattarai et al. [4] have predicted forest carbon stocks using remote indexing and geographic information systems. But there has never been a study of carbon stocks stored in the area of Sigogor Mountain Nature Reserve.

2. Research method

2.1. Data collecting

The sampling of biomass of lower plant was done by destructive method. Lower plant taken for example are all living plants in the form of trees <5 cm in diameter, herbs and grasses. Sampling foliage is all that is above ground of branches, twigs and leaves.

Biomass estimation method used is algometric method that is estimation is done by measuring the diameter of tree trunk at chest height found in research plot [20].

Allometric methods are used to determine the amount of carbon that can be absorbed by a tree. Allometric calculations use wood density of a tree and tree diameter measured at 1.3 m altitude from the ground (dbh-diameter breast height) [20].

2.2. Data analysis

Live tree biomass was estimated using equation 1 [20]:

$$B = 0.11 \times D^{2.62} \times \beta \quad (1)$$

B = Living Tree Biomass (kg)
D = Tree Diameter (cm)
β = Density of tree (g/cm^3)

To know the weight of carbon stock used equation 2 [20].

$$C = 0.46 \times Y \quad (2)$$

Where :
C = Carbon Stock (ton / ha)
Y = Tree Biomass above ground (ton / ha)

This method has been used by several researchers. This method has been used to predict the biomass of *Mimosa scabrella* Benth. (bracatinga) in southern Brazil [21-25], for predicting national-scale biomass in America [26], for six boreal tree species of northern Manitoba [27], in China [28], to predict carbon stocks in secondary forests in Central Panama [29], in Central Africa [30], using this coupled with LiDAR [31].

3. Results and discussion

3.1. Sigogor mountain nature reserve

Sigogor Mountain Nature Reserve is a nature reserve area managed by Natural Resources Office Madiun. The Sigogor Mountain nature reserve is located in Pupus Village, Ngebel Subdistrict, Ponorogo Regency, located between 07 ° 48'-07 ° 50 'SL and 111 ° 36'-111 ° 38' EL. The area is about 190.5 ha with an altitude of 1,834 m above sea level. Borderline in the division of the northern region is protected forest areas and production forests of PT. Perhutani, south of the protected forest area of PT. Perhutani, west of protected forest area and PT. Perhutani and east of Madiun Regency.

Sigogor Mountain Nature Reserve area has a hilly land, located on the slopes of Mount Wilis with moderate to steep terrain at an altitude of 100-1700 m above sea level. The highest peak of the area is located in the southern part of Patok Banteng and Batu Blandar area and in the eastern part of Cenger area.

The Sigogor Mountain reserve area has a C climate type according to Schimdt and Ferguson, with an average annual rainfall of 2,582 mm and 142 days of rainy days. The rainy season in this region occurs in November to May in each year. The night time temperatures in the Sigogor Mountain nature reserve range from 15-20 ° C, while the day time air temperature is around 30-35 ° C. The geographical and topographical situation is the presence of several types of plants such as grasses, Orchids, mountain Pine (*Casuarina junghuniana*), Pairs (*Quercus sondaica*), Jamuju (*Podacarpus imbricatus*), Rasamala (*Altingia excelsa*), Kodokan (*Macropanax dispermum*), Dali (*Radermachera gigantea*), Wesen (*Dodoneca viscusa*), and Marasawa (*Engelhardis spicata Bl*).

3.2. Biomass

The weight of woody biomass, lower plant and foliage is presented in Table 1.

Table 1. Weight of wood biomass, lower plant and foliage.

Biomass Category	Weight of Biomass (ton/ha)	Weight of Biomass (ton)
Wood Biomass Ø >30 cm	0.07	13.34
Wood Biomass Ø 5-30 cm	0.0067	1.28
Lower Plant	1.96	373.57
Foliage	2.82	537.99
Total		926.18

Based on Table 1, the total biomass above the soil surface of the Sigogor Mountain Reserve area is 926.18 tons. Each species has a distinct contribution to the biomass and total carbon reserves present in the study site.

The value of carbon stocks reflects the carbon dynamics of different land use systems, which are then used to calculate Timeaveraged carbon above the soil surface in each system. Timeaveraged depends on the rate of accumulation of carbon, maximum and minimum carbon stored in a land use, time that will reach maximum carbon and rotation time [20].

3.3. Estimation of carbon stock

In a study conducted in the area of Sigogor Ponorogo Nature Reserve with an area of 190.5 ha obtained by biomass weight of 926.18 tons so it has a stored carbon of 426.05 tons.

The value of carbon stocks reflects the carbon dynamics of different land use systems, which are then used to calculate averaged carbon above ground in each system. Timeaveraged depends on the rate of accumulation of carbon, maximum and minimum carbon stored in a land use, time that will reach maximum carbon and rotation time [20].

Carbon stocks in various classes of land cover in natural forest have considerable variation between 7.5-264.7 ton C / ha. When compared to carbon in protected forests is 211.86 ton C/ha, lowland natural forest 230.10-264.7 ton C/ha, primary highland forest and lowland secondary forest, respectively 103.16 and 113.2 ton C/ha [5].

Carbon stored in tree components, it can be seen that the largest carbon content is in the tree trunk. This is because most photosynthetic results are stored on the stem for either horizontal or vertical growth. The total value of carbon stock is stored at tree level and pole level is 0.077 ton C/ha, so the total value of carbon content of natural forest vegetation at pole and tree level in research sites with an area of 190.5 ha is 14.62 ton/ ha.

The carbon stock represents the amount of carbon that can be absorbed by plants in the form of biomass. The increasing amount of carbon at this time must be balanced by the amount of uptake by plants in order to avoid global warming. Thus can be formulated how many plants that must be planted a land to compensate for the limited amount of carbon in the air [23].

Predicting the carbon dioxide absorbed it can use the method by multiplying the carbon value by conversion factor 3.76 so that 426.05 ton x 3,76 = 1,601.93 ton.

The results of photosynthesis are stored in the form of biomass that makes vegetation grow larger and higher. This growth will continue until the vegetation physiologically stops growing [21].

This is because the value of carbon content is stored in the Sigogor Mountain reserve is lower so that the amount of carbon dioxide that can be absorbed by plants in the area is also lower. This is indicating that in preserving and keeping forests to remain lush and sustainable without illegal logging and the occurrence of forest fires, so that the carbon released slightly and potentially less in absorbing concentration CO_2 in atmospheric, which can affect global warming can be prevented [32].

In addition, the absorbing vegetation CO_2 in the atmosphere through the process of photosynthesis and stores the carbon in the structure of the plant. Carbon in the forest can be used to calculate CO_2 that is absorbed by vegetation or released into the atmosphere, by conversion of biomass and carbon [24].

From the above calculation can be seen that the total CO2 absorbed by the existing vegetation in the area of Sigogor Mountain Nature Reserve with an area of 190.5 ha that is as much as ± 1,601.931 Ton.

The Sigogor Mountain nature reserve has a function to fix the carbon and store it in ecosystems stored in vegetation known as CO_2 sinks. Compared with other research, the amount of CO_2 that can be absorbed by plants in the Sigogor reserve forest area is lower, such as in the nature reserve of Martelu by Purba (2011) obtained higher value of 816.70 tons CO_2/ha. Further explained that in the area of nature reserves of Mount Tilu obtained value of 547.97 tons CO_2/ha [22].

4. Conclusions

The research concluded that:

- The carbon stock estimation in Sigogor Mountain Reserve which area 190.5 ha is 426.05 tons.
- Vegetation's in the Sigogor Mountain nature reserve have a considerable carbon dioxide uptake of 1,601.93 tons.

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