

Vegetation and Soil Carbon Storage of Some Typical Subtropical Evergreen Broad-leaved Forest in Dagang Mountain

Qiugen Zhang^{1,a} Junyi Che^{1,b} Suqin Wang^{1,c} Qun Cao^{1,d} Yuqiong Huang^{1,e}
Nina Xiao^{1,f}

¹ School of Environment and Chemistry Engineering, Nanchang Hangkong University, 330063, Nanchang, Jiangxi, PRC

^a904644628@qq.com, ^b1085626289@qq.com, ^c81414770@qq.com, ^d365128286@qq.com

^e1143327024@qq.com, ^f2574227335 4@qq.com

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Abstract. With the rapid development of human society and economy, the greenhouse effect caused by greenhouse gases had become one of the three major environmental problems in the world. Forest ecosystems mitigate the greenhouse effect by absorbing CO₂ through the photosynthesis of green plants. Based on field investigation of three subtropical evergreen broad-leaved forests including *Schima superba* forest, *Cyclobalanopsis glauca* forest, and *Castanopsis sclerophylla* forest in Dagang Mountain Nature Reserve of Jiangxi Province, the vegetation and soil carbon storage and carbon density were calculated. The results showed that the organic carbon content of three subtropical evergreen broad-leaved forest species in the Dagang Mountain Nature Reserve was very close, and the content of organic carbon was between 0.47 and 0.49. The order of organic carbon content in different organs was leaf > stem > branch > root. The average carbon density of vegetation layer was 7.56kg/m², and the carbon density of the arbor layer was 7.16 kg/m², the shrub layer was 0.17kg/m², the litter layer was 0.15kg/m², and the herb layer was 0.08 kg/m². The carbon density of the *Schima superba* forest was the highest which was 9.68kg/m², the carbon density of the *Cyclobalanopsis glauca* forest was the smallest which was 6.44kg/m², and the carbon density of the *Castanopsis sclerophylla* forest was 6.56kg/m². The content of soil organic carbon in subtropical evergreen broad-leaved forest in Dagang Mountain Nature Reserve decreased with the increase of soil depth. The average soil carbon density was 20.926kg/m², and the soil carbon density of *Schima superba* forest, *Cyclobalanopsis glauca* forest and *Castanopsis sclerophylla* forest was 16.634 kg/m², 29.554 kg/m² and 16.591 kg/m² respectively. The carbon storage of the standard samples of the *Schima superba* forest, *Cyclobalanopsis glauca* forest and *Castanopsis sclerophylla* forest were 14.971t, 26.599t and 14.932t respectively.

Introduction

With the development of social economy and improvement of people's living level, green housing gases over-polluted CO₂ by human's social economical activities has caused greenhouse effect, which has threatened existence and development of human being's society. It is necessary to control the emission of greenhouse to slow down "green housing effect" for existence and development of humankind and society. Therefore, "carbon sink" issue of CO₂ has been a key point of carbon storage study.

As an important part of global ecological system, forest ecological system plays an important role of carbon cycling regulation in global ecological system. Photosynthesis and respiration of forest plant have created favorable condition for carbon cycling of forest carbon storage.

Jiang xi Situates in subtropical region and Jiang xi province's forest coverage rate ranks the second in China. Evergreen broad-leaved forest is zonal vegetation in Dagang Mountain. Therefore, Dagang Mountain Nature Reserve was chosen as studying region, carbon storage and carbon density of several typical subtropical evergreen broad-leaved forest were calculated. It will have significance to

maintain carbon balance in Jiangxi's ecological system and suppress green housing effect in this region.

Overview of the Study Area

Dagang Mountain Natural Reserve is located in the central and western part of Fenxi County in Xinyu City, the geographical location is 27°30'~27°50' North latitude, 114°30'~114°45' East longitude. The reserve is a mountain of Wugongshan, and the ridge line is mainly north and south, and the main terrain is west high and east low, the terrain of the area changes large, and relatively high is 1km, the highest altitude is 1091.8m; the average annual temperature is 15.8°C, the annual rainfall is 1590.9mm. The average annual amount of sunshine is 1656.9h; The Vertical zone spectrum of Dagang Mountain Natural Reserve is successive red soil, yellow-red soil, red-yellow soil, yellow soil and yellow-brown soil. Evergreen broad-leaved forest is the zonal vegetation in Dagang Mountain. The main vegetation is subtropical evergreen broad-leaved forest, including *Castanopsis sclerophylla* forest, *Cyclobalanopsis glauca* forest, *Schima superba* forest, *Castanopsis fargesii* forest, *Castanopsis fabri* forest, *Carpinus turczaninowii* forest, and so on^[1-2].

Research Methods

Sample Plot Investigation

Three subtropical evergreen broad-leaved forests distribution area of the *Castanopsis sclerophylla* forest, *Cyclobalanopsis glauca* forest and *Schima superba* forest were chosen in Dagang Mountain Natural Reserve. Three standard sample plots were set in each subtropical evergreen broad-leaved forest type by opposite angles method. Each standard sample plot was 30m×30m. Three different 2m×2m shrubs samples were set in each forest standard sample plot. 1m×1m herbals sample and 1m×1m litter sample were set in the shrubs samples. Then the vegetation biomass and soil related to the vegetation and soil carbon storage in each standard sample plot was investigated.

One section was randomly selected in the standard sample, which was undisturbed lot and vegetation structure and soil were representative. A 100 cm deep soil profile was excavated. Then stratified at 0-10 cm, 10-20 cm, 20-30 cm, 30-50 cm and 50-100 cm along the soil profile and collected all layers soil by using the ring knife. At the same time, a small sample of 1m² was set up in each bush sample. The soil was drilled in the center position of each sample by 0-10cm, 10-20cm, 20-30cm, 30-50cm and 50-100cm though soils drill with a diameter of 9 cm. Then three drilled soil of each layer in the same standard sample plot were mixed as a soil sample.

Sample Lab Processing

The plant samples collected during the survey were taken back to the laboratory, 24-hour drying under 85°C, and then determine the dry weight, moisture content and biomass of the sample. Then cut it into the pulverizer and shatter, sift out (100mu, 0.154mm). Put in a sealed seal bag; keep it in the dryer to be tested. The organic carbon content in plant tissue was measured in the element analyzer by the dry combustion method.

Soil samples obtained with the ring knife were dried under 105°C for 24 hours to constant weight. Then the moisture content and dry weight were measured. And soil bulk density was calculated. Soil samples obtained from 3 shrubs quadrats were unfolded in a ventilated room for about 15 days to let it dry naturally. Pick out the fine roots in the drying process. Gently crushed and sifted (100 mesh, 0.154 mm) soil, and put it in a sealed bag which placed in a dryer for test. The content of soil organic carbon was determined by potassium dichromate oxidation-spectrophotometer.

Calculation of Vegetation Biomass

Arbor layer biomass

The biomass model was used to estimate the arbor biomass. In this paper, diameter at breast height,

tree Height and D^2H three factors were selected which were easy and high accuracy to measure. The regression equation of single-wood biomass of the typical subtropical evergreen forest in Jiangxi province was created through regression analysis. Then the biomass of the arbor layer in the whole sample plot was estimated by D^2H -biomass model which was $\ln(B)=0.057\ln(D^2H)+0.0529$.

Shrub layer biomass

In the sample plot, the biomass average value of three shrub sample unite area was selected as the biomass of the shrub sample unite area. Then the biomass of the shrubs sample plot by multiplying the sample plot area.

Herbaceous layer biomass

In the sample plot, the biomass average value of three herbaceous sample unite area was selected as the biomass of the herbaceous sample unite area. Then the biomass of the herbaceous sample plot by multiplying the sample plot area.

Litter layer biomass

In the sample plot, the biomass average value of three litter sample unite area was selected as the biomass of the litter sample unite area. Then the biomass of the litter sample plot by multiplying the sample plot area.

Calculation of Soil Bulk Density

Soil bulk density was calculated by Equation (1).

$$P = \frac{M}{V - \frac{m}{\rho}} \quad (1)$$

In the Equation (1): P is the soil bulk density ($\text{g}\cdot\text{cm}^{-3}$), M is the soil stoving quality (g), V is the soil volume (cm^3), m is the debris quality of soil (g), ρ is the debris density ($\text{g}\cdot\text{cm}^{-3}$).

Calculation of Vegetation and Soil Carbon Storage and Carbon Density

Calculation of vegetation carbon storage and carbon density

In the standard sample plot, the carbon storage of each vegetation layer is calculated by the biomass of the vegetation layer multiplying the related organic carbon content. All the carbon storages of each vegetation layer were the vegetation carbon storage of the standard sample plot. The vegetation carbon storage of the standard sample plot was divided by the total area of the sample plot, which is the carbon density of the vegetation. The average value of the carbon storage and carbon density of all the samples was taken as the carbon storage and the carbon density of the standard sample.

Calculation of soil carbon storage and carbon density

The soil carbon density can be calculated by soil bulk density, organic carbon content and depth of soil layers, it was shown in Equation (2).

$$r_c = P \times H \times C \quad (2)$$

In the Equation (2): ρ_c is the soil carbon density ($\text{t}\cdot\text{hm}^{-2}$), P is the soil bulk density ($\text{g}\cdot\text{cm}^{-3}$), H is the soil depth (cm), C is organic carbon content (%).

The sum of carbon density of each soil layer is the total carbon density of the forestland soil. The soil carbon storage can be calculated by the soil carbon density multiplying standard sample area^[3-5].

Results and Analysis

Vegetation Carbon Storage and Carbon Density

Organic carbon content of main organs

The organic carbon content of main organs of several subtropical evergreen broad-leaved forests in Dagang Mountain was shown in table 1.

Table.1 Organic carbon content of main organs of evergreen broad-leaved forest in Dagang Mountain

organ	The carbon content (%)			Average value
	<i>Schima superba</i>	<i>Cyclobalanopsis glauca</i>	<i>Castanopsis sclerophylla</i>	
Leaf	50.4	49.8	49.3	49.8
Branch	47.4	48.0	47.5	47.6
Stem	48.0	47.4	49.1	48.2
Root	47.5	44.9	46.8	46.4
* Average value	47.9	47.4	48.5	47.9

Note: * The average organic carbon content was the weight value of tree species biomass.

The table1 showed that the organic carbon content of subtropical evergreen broad-leaved forest species in Dagang Mountain was *castanopsis sclerophylla* (48.5%) > *Schima superba* (47.9%) > *Cyclobalanopsis glauca* (47.4%). The average organic carbon content of different broadleaf forest species was about 0.5. It was close to the results of wang bing and other research^[6]. The organic carbon content of different organs in the evergreen broad-leaved forest of Dagang mountain was leaf (49.8%) > stem (48.2%) > branch (47.6%) > root (46.4%). Evergreen broad-leaved forest tree species can enhance the forest carbon reserve capacity.

Vegetation carbon density

The carbon density of different vegetation layers in several subtropical evergreen broad-leaved forests was shown in table 2.

Table. 2 Carbon density of different vegetation layers in subtropical evergreen broad-leaved forest in Dagang Mountain

Vegetation layer	The carbon density (kg/m ²)			Average carbon density
	<i>Schima superba</i> forest	<i>Cyclobalanopsis glauca</i> forest	<i>Castanopsis sclerophylla</i> forest	
Arbor layer	9.24	6.08	6.17	7.16
Shrub layer	0.18	0.16	0.17	0.17
Herb layer	0.1	0.05	0.08	0.08
Litter layer	0.16	0.15	0.14	0.15
Total density	9.68	6.44	6.56	7.56

The table2 showed that the average carbon density of subtropical evergreen broad-leaved forests in Dagang mountain was 7.56kg/m², which was different from that of Wei Wenjun's research result(3.091kg/m²)^[7]. It may be the difference of standard sample. The average carbon density of subtropical evergreen broad-leaved forests in the Dagang Mountain was *Schima superba* forest (9.68kg/m²) > *Castanopsis sclerophylla* forest (6.56kg/m²) > *Cyclobalanopsis glauca* forest (6.44kg/m²). The carbon density of arbor layer had an absolute advantage in the vegetation layer. The carbon density of different vegetation layers in the evergreen broad-leaved forest of Dagang Mountain was arbor layer (7.16kg /m²) > shrub layer (0.17kg/m²) > litter layer (0.15kg/m²) > herb layer (0.08 kg/m²).

Carbon storage distribution of vegetation

The carbon storage of main organs of several subtropical evergreen broad-leaved forest in Dagang Mountain was shown in table 3.

Table.3 Carbon storage of main organs of evergreen broad-leaved forest in Dagang Mountain

organ	Carbon storage (t)		
	<i>Schima superba</i> forest	<i>Cyclobalanopsis glauca</i> forest	<i>Castanopsis sclerophylla</i> forest
Leaf	0.48	0.27	0.20
Branch	1.68	1.26	0.63
Stem	5.17	3.25	4.29
Root	0.98	0.69	0.44
Total storage	8.30	5.47	5.56

Note: the calculation value of carbon storage was based on the sample area (900m²).

It can be seen from table3 that the carbon storage of subtropical evergreen broad-leaved forest in Dagang was *Schima superba* forest (8.3t) > *Castanopsis sclerophylla* forest (5.56t) > *Cyclobalanopsis glauca* forest (5.47t). The *Schima superba* forest had played an important role in the carbon balance of forest ecosystem.

It was basically consistent with carbon content of the main organ of the arbor layer of *Schima superba* forest, *Cyclobalanopsis glauca* forest and *Castanopsis sclerophylla* forest, that were basically stem>branch>root>leaf. It showed that the carbon absorbed by plants through photosynthesis was mainly stored in stems and branches.

Soil Carbon Content and Carbon Density

Soil carbon content

The soil carbon content of subtropical evergreen broad-leaved forests in Dagang Mountain was shown in table4 and figure1.

Table.4 Soil Organic Carbon Content of Subtropical Evergreen Broad-leaved Forest In Dagang Mountain

Depth (cm)	Soil organic carbon content (%)		
	<i>Schima superba</i> forest	<i>Cyclobalanopsis glauca</i> forest	<i>Castanopsis sclerophylla</i> forest
0-10	7.99	12.54	8.07
10-20	6.35	9.87	4.69
20-30	3.86	7.70	4.49
30-50	2.88	6.34	2.92
50-100	2.29	4.71	2.26

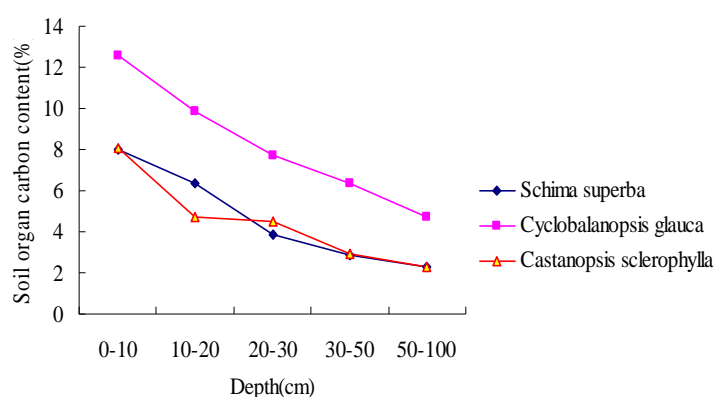


Fig.1 Soil organic carbon content of evergreen broad-leaved forest in Dagang Mountain

It could be seen in table4 and picture1 that the difference of soil organic carbon content changed with the change of forest vegetation type and soil depth. The sequence of soil organic carbon content of subtropical evergreen broad-leaved forest in Dagang Mountain ranged was *Cyclobalanopsis glauca* forest > *Castanopsis sclerophylla* forest > *Schima superba* forest. Carbon content of different soil layers decreased with the increase of soil depth.

Soil carbon density

Table.5 Soil Carbon Density of Subtropical Evergreen Broad-leaved Forest In Dagang Mountain

Depth (cm)	Soil carbon density (kg/m ²)			Average
	<i>Schima superba</i> forest	<i>Cyclobalanopsis glauca</i> forest	<i>Castanopsis sclerophylla</i> forest	
0-10	3.629	5.656	3.794	4.360
10-20	3.071	4.879	2.220	3.390
20-30	1.968	3.330	2.177	2.492
30-50	2.818	5.67	2.973	3.820
50-100	5.148	10.019	5.426	6.864
Total	16.634	29.554	16.591	20.926

The soil carbon density of subtropical evergreen broad-leaved forest was shown in table5. It could be seen in table5 that soil carbon density was different in soil layers. The average soil carbon density of different soil layer was 50-100cm layer's > 0-10cm layer's > 30-50cm layer's > 10-20cm layer's > 20-30cm layer's. It was calculated on average 10cm, soil carbon density in different soil depth decreased with the increase of soil depth, which was basically consistent with the change of soil organic carbon content.

Soil carbon density of subtropical evergreen broad-leaved forest was average 20.926kg/m² in Dagang Mountain. Soil carbon density of *Cyclobalanopsis glauca* forest was 29.554 kg/m², *Schima superba* forest was 16.634kg/m² and *Castanopsis sclerophylla* forest was 16.591 kg/m². It was indicated that the soil organic carbon storage of *Cyclobalanopsis glauca* forest was the largest in the evergreen broad-leaved forest in Dagang Mountain. *Schima superba* forest and *Castanopsis sclerophylla* forest were relatively in terms of the ability of organic carbon storage. The average carbon density of forest soil in China was 19.355 kg/m²^[8], which indicated that the carbon density of *Cyclobalanopsis glauca* forest in Dagang Mountain was higher than the national average, and the carbon density of *Schima superba* forest and *Castanopsis sclerophylla* forest was lower than the average carbon density of forest soil in China.

Soil carbon storage distribution

The soil carbon storage of subtropical evergreen broad-leaved forests in Dagan Mountain was shown in table 6.

Table. 6 Soil carbon storage in subtropical evergreen broad-leaved forest in Dagang Mountain

Depth (cm)	Carbon storage (t)		
	<i>Schima superba</i> forest	<i>Cyclobalanopsis glauca</i> forest	<i>Castanopsis sclerophylla</i> forest
0-10	3.266	5.090	3.415
10-20	2.763	4.391	1.998
20-30	1.771	2.997	1.959
30-50	2.536	5.103	2.676
50-100	4.633	9.017	4.883
Total	14.971	26.599	14.932

Note: The calculated carbon storages were based on the sample plot area (900m²).

It was showed that the soil carbon storage of subtropical evergreen broad-leaved forest in Dagang Mountain was *Cyclobalanopsis glauca* forest > *Schima superba* forest > *Castanopsis sclerophylla* forest, which was consistent with the order of soil carbon density.

Conclusions

The organic carbon content of subtropical evergreen broad-leaved forest in Dagang Mountain Nature Reserve was very close, with the content ranging from 0.47 to 0.49. The organic carbon content of different organs in three evergreen broad-leaved forests was leaf> stem> branch> root. The average carbon density of forest vegetation layer was 7.56kg/m², the carbon density of each forest layer was arbor layer> shrub layer> litter layer> herb layer. The carbon density of each forest were *Schima superba* forest > *Castanopsis sclerophylla* forest > *Cyclobalanopsis glauca* forest. The soil organic

carbon content of subtropical evergreen broad-leaved forest in Dagang Mountain Nature Reserve decreased with the increase of soil depth. The soil carbon density of forest was *Cyclobalanopsis glauca* forest > *Schima superba* forest > *Castanopsis sclerophylla* forest, which was consistent with the content of soil organic carbon. The carbon storage of each forest standard sample plots was *Cyclobalanopsis glauca* forest > *Schima superba* forest > *Castanopsis sclerophylla* forest, which was in accordance with the carbon density of forest soil.

The total carbon storage of forest vegetation in the sample plots was 19.33t, the total carbon storage in forest soil was 62.779t, and the carbon storage of forest soils was 3.25 times that of forest vegetation. The average carbon density of forest vegetation in the sample plots was 7.56kg/m², the average carbon density of forest soil was 20.926kg/m², and the average carbon density of forest soil was 2.76 times that of forest vegetation. The carbon density and carbon storage of forest vegetation was lower than that of forest soil. The main reason was that the vegetation layer involved in the forest ecosystem carbon cycle was relatively short, and the carbon of vegetation had fallen from the dead leaves into the upper layer of the earth, and it had entered the soil layer under the action of soil microorganisms. While the involvement of the soil layer in the ecosystem carbon cycle lasts longer and often requires conversion to atmospheric carbon under certain chemical conditions.

The carbon density of soil layer in Dagang Mountain Nature Reserve was 20.926kg/m², the carbon density of arbor layer was 7.16kg/m², the forest shrub layer was 0.17kg/m², the herb was 0.08kg/m², the litter was 0.15kg/m², the carbon density of the soil layer was 2.93 times of the carbon density of the arbor layer.

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