Carbon Sink Calculation and Time Variation in Hainan Tropical Rainforest National Park——A Case Study of Diaoluo Mountain Forest Area

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Abstract. A suitable system for estimating changes in carbon storage and carbon emissions from tropical forests was constructed to study the carbon sink function of the Hainan Tropical Rainforest National Park. This article takes Diaoluo Mountain Forest Area as an example. Inventory calculation of forest resources with the help of the calculation method of the provincial greenhouse gas inventory compilation guide. Carbon sink measurement model is constructed in Diaoluo Mountain Forest Area. Changes in forest carbon storage and carbon emissions in five different periods from 1998 to 2018 were calculated. The results show that the forest carbon storage in Diaoluo Mountain Forest Area was 6.4 T, 1.1 T, 1.2 T, 1.5 T and 2.1 Tons in the past five periods. Arbor forest has the largest proportion of carbon storage and is dominant; Carbon emissions in the five periods were 497T, 545 T, 263 T, 21 T and 19 Tons. The moral is that, the total amount of forest net carbon has increased continuously, arbor forest is an important dominant position of carbon storage, the main gas absorbed and emitted by forest carbon sinks is carbon dioxide, the trend of increasing carbon storage and reducing carbon emissions is significant. It is suggested to continuously improve the community structure and promote the development of the forest carbon sink industry through the establishment of national parks and scientific management. Social capital participates in protecting national parks. This can increase the number of carbon sinks in public rainforest parks.

1. Introduction

With the continuous increase of population, rapid development of industry, increasing consumption of fossil fuels and shrinking forest area, the atmospheric content is rising at the rate of 3.8pg per year[1-2]. As the largest terrestrial ecosystem, forests have the largest biomass and carbon reserves [3], which are transferred from the air to vegetation or soil [4]. Research on forest carbon sink originates from abroad. Scholars have studied forest carbon sink in the United States[5], the United Kingdom [6], Russia [7], India [8] and other countries, and reached effective conclusions. At home, LiKeRang (2003) CEVSA model is used to estimate forest vegetation such as carbon, temperature, precipitation and vegetation types change [9], XiTingTing (2006), such as using the method of forest carbon sequestration of calculation analysis our country forest biomass carbon potential [10], (2007) for carbon sequestration functions such as SunYuJun, carbon density, biomass and carbon, and many other indicators evaluation analysis [11], summer snow (2011) of terrestrial ecosystems such as the development progress of organic carbon and carbon analysis [12], YanXueJun (2008), such as conversion factor continuous function method is used, The forest value and carbon sink amount of Hainan province were estimated [13].
In conclusion, at present, the research methods of forest carbon sink have been gradually improved and the accuracy of the research results has been continuously improved, but there is almost no comprehensive research on the carbon sink function of Hainan Tropical Rainforest National Park. Therefore, this study Diaoluo Mountain Forest Area, for example, in 1998, 2003, 2009, 2014 and 2018, five times the inventory data as the foundation, with the help of a provincial greenhouse gas list preparation guide calculation method, to Diaoluo Mountain Forest Area carbon capacity at different periods of change and carbon emission estimation and analysis, for the future of Hainan tropical rain forest national park, forest carbon sequestration estimation to provide the reference.

2. Data and Methods

2.1 Overview of the Research Area
Diaoluo Mountain Forest Area is located in the Hainan tropical rain forest national park east, terrain northwest high southeast low, in the east longitude 109° 40’~ 111° 39’ 4’, north latitude 18° 39’ ~ 18° 50’, plenty rainfall, annual rainfall of 1900 ~ 2700 mm, as well as abundant light and heat conditions, 98.8% forest cover rate, stocking volume 13.875 million, an area of 38000 and the rainforest area of 37200 (98%), more than 3500 kinds of tropical plants resources, more than 1000 kinds of animal resources, It is the most complete, most primitive and most natural rainforest in China[14].

2.2 The Data Source
Application data from Diaoluo Mountain Forest Area in 1998, 2003, 2014 and 2018, 2009 annual statistical data and forest resources subcompartment survey data, the natural forest resource conservation project implementation plan in 2000 and 2010 natural forest resource conservation project implementation phase ii, forest management plan, survey reports, scientific examination and stock map aspects of resources, using the theory of forestry related knowledge of data mining [15], with the help of ArcGIS software platform for vector quantization processing, specification table field name and attribute value[16-17], Microsoft Excel 2017 was used for statistical analysis and chart making of area and volume.

Because the interval years between the actual forest resources survey are different, in order to obtain the corresponding year, take 2005 as an example in the data processing, the corresponding data of the last three forest resources surveys should be found at least. Consider first the rate at which indicators such as annual area and accumulation increase or decrease. If 2005 is equal to or less than \( t_3 \) (the annual share of the last second adjustment of the forest area), then the area of each land type in 2005 can be calculated by using the interpolation method to calculate the data of the last two forest resources surveys, and calculate the accumulations by referring to the calculation method of area. If 2005 is greater than \( t_3 \), then the area and volume of various land types in 2005 are calculated by extrapolating the results of the last three forest resource surveys. The statistical data of arbor forest, bamboo forest, shrub forest area, arbor forest and dynamic wood volume in different years such as 1998, 2003, 2009, 2014 and 2018 are obtained (see Table 1 for details).
Table 1. Forest area and stocks by year

| Tree species                  | Indicator | 1998   | 2003   | 2009   | 2014   | 2018   |
|------------------------------|-----------|--------|--------|--------|--------|--------|
| Arbor                        | Area      | 29487  | 31394  | 36347  | 37100  | 37543  |
|                              | Accumulate| 357573 | 596742 | 779280 | 970963 | 138750 |
| Bamboo forest                | Area      | 854    | 181    | 0      | 0      | 0      |
|                              |           | 2      | 1      | 8      | 2      | 2      |
| Economic forest              | Area      | 1      | 3      | 4      | 1      | 0      |
|                              |           | 0      | 2      | 5      | 4      | 6      |
| Shrubbery                    | Area      | 3008   | 1808   | 0      | 0      | 0      |
| Scattered wood and four trees and sparse forest | Accumulate | 456181 | 980774 | 2245   |        |        |
| Living Timber (Total)        | Accumulate| 4031954| 6948195| 7795046| 970963 | 138750 |
| Deforestation in the last 5 years | Area | 100    | 70     | 30     | 2      | 1.3    |

Unit: hm$^2$, m$^3$

2.3 The Research Methods

In this paper, the main contents of land use change and forestry are used for reference, and the calculation method of carbon sink function in inventory guide[18] is adopted to estimate the change of biomass carbon storage of forest and other woody biomass ($\Delta C_{\text{ Biomass}}$), using the following formula:

$$\Delta C_{\text{ Biomass}} = \Delta C_{\text{ Arbor}} + \Delta C_{\text{ Scattered wood and four trees and sparse forest}} + \Delta C_{\text{ Bamboo forest and Economic forest and Shrubbery}}$$

$\Delta C_{\text{ Arbor}}$: On behalf of the arbor forest (stand) growth biomass carbon absorption, unit is ton.

$\Delta C_{\text{ Scattered wood and four trees and sparse forest}}$: Represents the carbon absorption of the growth biomass of loose wood, adjacent trees and open forests, and the unit is ton.

$\Delta C_{\text{ Bamboo forest and Economic forest and Shrubbery}}$: Represents the change sum of biomass and carbon storage capacity of bamboo forest, economic forest and shrub forest, and the unit is ton.

$\Delta C_{\text{ Consumption}}$: Represents the carbon emissions consumed by living trees, the unit is ton.

3. Results and Analysis

3.1 Estimation of Annual Carbon Stocks and Carbon Emissions

This paper study on forest carbon sinks function in the process of research, focus on estimating arbor, bamboo forest, economic forest, shrub and woodlands, such as bulk raw wood and its sides tree forest category of carbon dioxide ($CO_2$), carbon (C) the absorption and emission, at the same time to produce the methane ($CH_4$) and nitrous oxide ($N_2O$), and other gases, estimates that the total emission amount of greenhouse gases absorb and summary analysis. Therefore, forest and other woody biomass carbon storage changes and forest conversion carbon emissions will be estimated.
In 1998, the net uptake of greenhouse gas in the Area was 6367.41 million tons, including 6367538 tons of carbon storage change and 497 tons of carbon emissions from forest conversion. In the change of carbon storage capacity: arbor forest 29058066 tons, bamboo forest 107217 tons, economic forest 13556 tons, shrub forest 99209 tons, open forest, loose wood and four side trees 3707099 tons, living wood consumption 26617609 tons; In the forest conversion carbon emissions, according to the emission mode is divided into: combustion emissions 383 tons, decomposition emissions 114 tons; By type of greenhouse gas emitted: 491 tons of carbon dioxide, 6 tons of methane (see table 2).

Table 2. Estimates of carbon storage and carbon emissions in 1998

| 1998 Year                     | Carbon dioxide (Ton) | Methane (Ton) | Nitrous oxide (Ton) | Greenhouse gases (Ton) |
|-------------------------------|----------------------|---------------|---------------------|------------------------|
| Changes in carbon storage     | -1736601             | -6367538      | -6367538            | -6367538               |
| Arbor                         | -7924927             | -29058066     | -29058066           | -29058066              |
| Bamboo forest                 | -29241               | -107217       | -107217             | -107217                |
| Economic forest               | -3697                | -13556        | -13556              | -13556                 |
| Shrubbery                     | -27057               | -99209        | -99209              | -99209                 |
| Scattered wood and four trees and sparse forest | -1011027     | -3707099      | -3707099            | -3707099               |
| Living Consumption Timber    | 7259348              | 26617609      | 26617609            | 26617609               |
| Forest converted carbon emissions | 134               | 491           | 6                   | 0                      |
| Combustion emissions          | 103                  | 378           | 5                   | 0                      |
| Decomposed emissions          | 31                   | 113           | 1                   | 0                      |
| Total                         | -1736467             | -6367047      | 6                   | 0                      |

Note: Use negative values to represent net absorption and positive values to represent net emissions.

It can be seen from Table 2 that in 1998, arbor forest was dominant in the carbon storage of tropical rain forest in the Diaoluo Mountain forest region, followed by open forest, loose wood and peripheral trees, which were at least economic forests. Emissions from forest burning are about 3.3 times greater than those from decomposition. Forest conversion carbon emissions of greenhouse gases important for carbon dioxide, followed by methane, nitrous oxide only a small amount, negligible to zero.

In 2018, the Net uptake of greenhouse gas in the Diaoluo Mountain forest region will be 2,1168,613 tons, including 2,116,685 tons of carbon storage change and 22 tons of carbon emissions from forest conversion. In the change of carbon storage capacity: arbor forest 112753436 tons, economic forest 13299 tons, living wood consumption 91598100 tons; In the forest conversion carbon emission, it is divided according to different emission modes: combustion emission is 15 tons, decomposition emission is 4 tons; By greenhouse gas emission type: 19 tons of carbon dioxide (see Table 3)
Table. 3 Estimates of carbon storage and carbon emissions in 2018

| 2018 Year | Carbon storage (Ton) | Carbon dioxide (Ton) | Methane (Ton) | Nitrous oxide (Ton) | Greenhouse gases (Ton) |
|-----------|----------------------|----------------------|--------------|--------------------|-----------------------|
| Changes in carbon storage | -5773158 | -21168246 | -21168246 | 0 | 0 |
| Arbor | -30750937 | -112753436 | -112753436 | 0 | 0 |
| Bamboo forest | 0 | 0 | 0 | 0 | 0 |
| Economic forest | -3521 | -12910 | -12910 | 0 | 0 |
| Shrubbery | 0 | 0 | 0 | 0 | 0 |
| Scattered wood and four trees and sparse forest | 0 | 0 | 0 | 0 | 0 |
| Living Consumption | 24981300 | 91598100 | 91598100 | 0 | 0 |
| Forest converted carbon emissions | 5 | 19 | 0 | 0 | 19 |
| Combustion emissions | 4 | 15 | 0 | 0 | 15 |
| Decomposed emissions | 1 | 4 | 0 | 0 | 4 |
| Total | -5773153 | -21168227 | 0 | 0 | -21168227 |

Note: Use negative values to represent net absorption and positive values to represent net emissions.

It can be seen from Table 6 that in 2018, the carbon storage in the Diaoluo Mountain Forest Area is more dominant in arbor forest, and the economic forest only accounts for a small part. Forest combustion emissions produce about 3.75 times more forest conversion carbon emissions than decomposition emissions. Forest conversion of carbon emissions of greenhouse gases important for carbon dioxide, methane and nitrous oxide only a small amount, negligible to zero.

3.2 Analysis of Carbon Storage and Carbon Emission Changes

3.2.1 Analysis of carbon storage change

From 1998 to 2018, the carbon storage capacity of Diaoluo Mountain Forest Area showed a continuous growth posture, from 6367,538 tons in 1998 to 10761,663 tons in 2003, with an increase of 4394,125 tons, a growth rate of 69%, and an average annual growth rate of 14%. From 10761,663 tons in 2003 to 11939,722 tons in 2009, an increase of 1178,060 tons, with a growth rate of 11% and an average annual growth rate of 2%. In 2009, 11939722 tons increased to 14818173 tons in 2014, an increase of 2878,450 tons, with an annual growth rate of 24% and an average annual growth rate of 5%. The 1,4818,173 tons in 2014 increased to 2,1168,635 tons in 2018, an increase of 63,50,462 tons, representing a growth rate of 42% and an average annual growth rate of 10%.

3.2.2 Carbon emission change analysis

From 1998 to 2018, the carbon emission in the Diaoluo Mountain Forest Area increased slightly at first and then decreased rapidly successively, from 497 tons in 1998 to 545 tons in 2003, an increase of 48 tons, with a growth rate of 10% and an average annual growth rate of 2%. From 545 tons in 2003 to 263 tons in 2009, a decrease of 282 tons, with a reduction rate of 52% and an average annual reduction rate of 9%. In 2009, 263 tons were reduced to 21 tons in 2014, an increase of 242 tons, with a reduction rate of 92% and an average annual reduction rate of 18%. The 21 tons in 2014 decreased to 19 tons in 2018, an increase of 2 tons, with a reduction rate of 10% and an average annual reduction rate of 2.5% (See Figure 2).

3.3 Analysis of Changes in Net Carbon Sink Storage

From 1998 to 2018, the net carbon sink in the Diaoluo Mountain Forest Area showed a continuous growth trend, from 6367,041 tons in 1998 to 10761,118 tons in 2003, with an increase of 4394,077 tons, with an annual growth rate of 69% and an average annual growth rate of 14%. From 10761,118
tons in 2003 to 11939,459 tons in 2009, an increase of 1178,342 tons, an increase of 11% and an average annual growth rate of 2%. From 11939,459 tons in 2009 to 14818,152 tons in 2014, an increase of 2878,692 tons, a growth rate of 24%, with an average annual decrease rate of 5%. From 14818,152 tons in 2014 to 21168,227 tons in 2018, an increase of 635,0075 tons or 43%, with an average annual decrease rate of 11%.

4. Conclusions and Recommendations
The change of forest carbon storage and carbon emission from forest combustion in the Diaoluo Mountain Forest Area are estimated, and the main conclusions are as follows:

(1) the total net forest carbon sink is increasing continuously. The carbon storage of the forest in the Diaoluo Mountain forest area increased from 6367,538 tons in 1998 to 14818,173 tons in 2018, an increase of 8450,635 tons, an increase of more than 1.3 times. Carbon emissions from forest combustion decreased from 497 tons in 1998 to 21 tons in 2018, a reduction of 476 tons or 95 percent. The net forest carbon sink increased from 6367,041 tons in 1998 to 1,4818,152 tons in 2018, an increase of 8,451,111 tons or more than 1.3 times. In 2018, the carbon content of the carbon sink in the Diaoluo Mountain Forest Area was 5773,153 tons, accounting for 7.2% of the carbon content of the forest sink in Hainan Island.

(2) Arbor forest is an important leading position in carbon storage. In the five periods, the net carbon sink of the forest reached 29058,066 tons, 48493,493 tons, 63327,213 tons, 78904,096 tons and 112753,436 tons. It accounts for the vast majority of total forest carbon storage and increases year by year. In 2018, in addition to non-forest land, auxiliary production land and economic forest, the majority of the forest area is mixed arbor forest, so the carbon storage of arbor forest accounts for about 100%.

(3) Carbon dioxide is the main gas absorbed and emitted by forest carbon sink. In the change of carbon storage, the main absorption is carbon dioxide and other greenhouse gases. Carbon dioxide is also emitted by forest conversion, followed by greenhouse gases such as methane and nitrous oxide.

(4) Carbon storage growth and carbon emission reduction trend is significant. The comparison results of five periods show that the change of carbon storage is increasing and the carbon emission is decreasing, which shows that the carbon sink function of The Forest area is constantly enhanced.

In order to further promote the functional study of carbon sink in Hainan Tropical Rain Forest National Park, it is suggested to improve the carbon sink from the following two perspectives. First, the establishment of national parks, scientific management, and constantly improve the community structure. In order to establish the opportunity of national park, scientific management measures such as closing mountains for forest cultivation, tending of middle and young forests and forest transformation and cultivation should be taken in Order to promote the healthy and rapid growth of trees, improve the community structure of forest resources, and realize the double increase of forest area and stock amount. Second, promote the development of forest carbon sequestration industry and realize the participation of social capital in the protection of national parks. Diaoluo Mountain Forest Area may be considered by promoting the development of forestry carbon sequestration, construction of forestry carbon sequestration project, for domestic and foreign investment, a large number of financing from the market, promote carbon sinks trade and economic development, realize the protection of forest resources of government investment into the transition of the social investment goals, thereby easing the burden on the government financial resources, to solve the contradiction between forest protection and forestry development.

5. Reference
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