

# Evaluation Methods of Carbon Storage Environmental Response Coefficient of Plantation Considering Carbon Balance

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**ABSTRACT.** Under the background of global warming, it is one of the effective methods to alleviate the climate warming and environmental deterioration by planting a large number of trees, and the artificial forest regulates greenhouse effect by carbon, so the carbon storage has a positive impact on the climate and environmental ecology. From this point of view, it is positive and effective to realize the objective evaluation of plantation carbon storage by evaluation method of carbon storage environmental response coefficient of plantation considering carbon balance considering carbon balance, then the evaluation method of environmental response coefficient of plantation carbon storage mainly include sample plot investigation, micrometeorology, chamber method, model simulation, remote sensing estimation, etc. The carbon storage of plantation can be obtained by these evaluation methods of environmental response coefficient. This paper mainly analyzes main principles and application examples of various methods, and points out availability and shortcomings of these methods. It is considered that multi-disciplinary comprehensive application of various methods is an effective way to accurately estimate the carbon storage of plantation ecosystem, and the balance should be taken into account when studying the carbon storage of the large-scale plantation ecosystem.

**KEYWORDS:** Carbon storage of plantation, Estimation method, Sample plot inventory method, Micrometeorology method, Chamber method, Model simulation method, Remote sensing estimation method

## 1. Introduction

The world is getting warmer and warmer. The greenhouse effect not only destroys the natural ecology, but also poses a great threat to the survival of human beings in a sense. Therefore, the world is dealing with it through various ways. For us, in the past decade, China's artificial afforestation area is the largest in the world, which also confirms that the Party and the government attach great importance to afforestation, and artificial afforestation has several functions. First, from the perspective of carbon balance, as the largest ecosystem on land, the carbon storage of plantation plays a role of metronome to reduce the global greenhouse effect. It can fully adjust the global carbon balance to realize its own value. Second, it can release more oxygen to achieve green environmental protection, so it acts a very important role. How to better and accurately estimate carbon storage of plantation is a very important foundation. Third, it can improve the relationship between man and nature, between man and lower animals, and between nature and animals, so that the original ecosystem and self-healing ability of nature have been comprehensively improved. In this process, the main methods to estimate the carbon storage of plantation are needed. This paper summarizes the main methods of carbon storage estimation in plantation, elaborates the applicability and shortcomings of various methods, and lays a theoretical foundation for further research on carbon sink of plantation.

## 2. Sample Plot Inventory Method of Plantation

The plantation sample plot inventory method is mainly to meet the field registration of all the carbon storage of the complete plantation. In the whole plantation ecology, the sample plot investigation method is a very huge work, but also the most accurate work, and is also the classic method of carbon storage research of plantation ecosystem. The method of sample plot inventory of plantation is mainly through establishing typical sample plot samples, starting from the original registration established in the scope of sample plot, cutting samples, completing planning and dimensional analysis through the preliminary work, and analyzing the collected data, so as to preliminarily estimate the carbon storage of plantation ecosystem and the accumulation and growth space in the future. According to different calculation basis, plot storage method can be divided into biomass method, accumulation method and biomass inventory method.

Through this method, we can do a good job of inventory and complete the accumulation of data, which provides some help and basis for other estimation methods, so the sample plot inventory method is often and common.

### **2.1 Biomass Method**

As early as the 1950s, foreign scientists had made new progress in the evaluation method of environmental response coefficient for measuring carbon storage of plantation from the biological point of view. Based on biodiversity of this research, driven by the International Biological Program (IBP) with biomass research as the core, it can be said that it played a positive role in the past 50-60 years. However, with the rapid development of the research on the biomass of plantation, there were also some problems, that is, the number of samples, so this measurement method can only be used to estimate for a large range, but this research method was becoming increasingly advanced and mature<sup>[1]</sup>. By the end of the 1970s, the research method of biomass calculation of plantation in China was relatively mature. Abundant research results laid a solid scientific foundation for the estimation of carbon storage on a national scale. From the perspective of biomass method, it has laid a solid foundation for other research methods. From the actual effect of biomass method itself, it also needs to be combined with other methods and flexibly used to play a real measurement effect.

### **2.2 Volume Method**

The main principle of volume method is to multiply biomass per unit volume by the total volume, and then multiply the carbon storage coefficient to get the total biomass. From the actual application of the volume method, compared with other methods, the volume method for carbon storage algorithm is faster because this method is a simple and intuitive method to calculate the carbon storage of global plantation. The inventory data of plantation resources provided by the forestry department include the volume and area of tree layer (after 1994) with canopy density of 0.2, and carbon storage of plantation calculated according to the statistics of trees and seedlings. This method ignores the existence of many other factors in plantation ecosystem and impact caused by them. The content of soil respiration and the respiration of non-assimilated organs also need to be taken into account. If not, the estimated results may have large deviation<sup>[2]</sup>.

### **2.3 Biomass Inventory Method**

This method can be used in the long-term and large-area monitoring of carbon storage of plantation. Because of its advantages of intuitionistic, clear and simple technology, it has been widely used. The disadvantage is that the volume data of plantation is obtained through the inventory of plantation resources, while the first kind of survey (continuous inventory of plantation resources) is usually conducted once every five years, which can not realize the real-time monitoring of carbon storage. At the same time, the comparability of the research results is poor because of the differences of sample plot setting and estimation methods.

## **3. Micro Meteorology of Plantation**

Micro meteorology is a micro meteorological application discipline, which has been applied to many fields at present. For example, the method of micro meteorology to measure CO<sub>2</sub> flux of plantation mainly includes eddy correlation method. Micro meteorology is an open and effective measurement method for micro meteorology. From the actual application of micro meteorological method, no matter which micro meteorological method is used, there will be some common characteristics in the following aspects: first, there is a certain limit for the range, that is to say, the measured gas flux value is a large range, generally in the average range of 100-1000m. Therefore, from this point of view, the closed system sampling error will be reduced to some extent, and the observation results can be better improved, which is representative. Second, from the point of view of the micro meteorological method measuring device, it is often selected to be located in the downwind direction of the measured area. This is because the whole wind speed at the lower area is closer to the average value, so from this point of view, the artificial micro meteorology method is a relatively convenient method, and the experimental device and observation activities of the micro meteorological method will not interfere with the natural environment of the measured area. Third, from the observation time of micro meteorology method, generally it lasts a long time. Relatively speaking, it is easy to maintain, update and power supply the equipment of micro meteorology method. Therefore, from this perspective, it can better complete the situation of micro meteorological elements in the measured area and the results of different time changes, and then obtain meteorological temporal variation of measured gas exchange characteristics. Based on the above basic characteristics of micro meteorology method, this method is mainly suitable for large-scale macro uniform regions. Under the condition that the atmospheric conditions are basically unchanged during the measurement, the gas flux

measured at a certain height in the constant flux layer can be considered as representing the surface gas emission (absorption) flux.

### **3.1 Eddy Correlation Method**

Eddy correlation method is a micrometeorological method to measure the turbulent exchange between the canopy and the atmosphere by using a three-dimensional ultrasonic anemometer. In order to analyze the process and mechanism of carbon cycle in plantation ecosystem and soil observation system such as temperature sensor, humidity sensor and heat flow plate, all components of each system should be included. The more stringent requirement is to combine the analysis with measurement of photosynthesis, community respiration of plantation and soil system respiration.

### **3.2 Eddy Covariance Method**

Eddy covariance method is a direct and continuous measurement method of carbon flux of plantation ecosystem based on micrometeorology. Through this method, direct measurement of plantation ecosystem can be effectively carried out, but the basic idea of this method is to measure the concentration of CO<sub>2</sub> / H<sub>2</sub>O in the atmosphere at the acquisition frequency of 10Hz, so it is necessary to carry out scientific calculation of this concentration. CO<sub>2</sub> flux of plantation can be obtained by calculating its covariance with the original vertical wind speed data.

## **4. Chamber Method of Plantation**

Chamber method is one of commonly used methods in study of regional carbon balance. Its basic idea is encapsulating part of plantation in a closed space, and the change of CO<sub>2</sub> concentration with time is CO<sub>2</sub> flux. Compared with other micrometeorological methods, such as eddy correlation method and relaxation eddy accumulation method, chamber method is simple in principle and low in equipment cost. The disadvantage of chamber method is that the closed space changes the environmental factors such as temperature, light, humidity and so on, which naturally affects the photosynthesis and respiration of green plants, resulting in big errors. In addition, the existing equipment can not be used for long-term automatic observation, nor is it suitable for measuring the CO<sub>2</sub> flux of the whole plantation ecosystem.

## **5. Model Simulation Method of Plantation**

### **5.1 Climate-Vegetation Correlation Model**

Climate-vegetation correlation model is actually a kind of correlation based on vegetation productivity, which reflects the close relationship between vegetation and climate factors, as well as the empirical model dominated by this correlation. There are representative models, such as Miami model and Chikugo model.

### **5.2 Biogeography Model**

Biogeography model is actually a simulation method. Its accuracy may not be so high, but compared with climate-vegetation correlation model, biogeography model has the basis of physics. It simulates the ecophysiological constraints and resource constraints of vegetation structure, some of which are obtained from experience. Therefore, the premise of the model still needs the sample data collection and experience judgment to form its scientific data source and application analysis, so it needs to determine the constraints of its ecological physiology and resources according to some seasonal changes, through which to evaluate the climate and temperature, so as to determine the advantages of different plant life forms and the distribution of vegetation types. The main idea of the model is to calculate the exchange capacity of carbon dioxide flux through soil temperature, moisture, respiration, microbial decomposition and climate conditions, such as temperature, humidity, light, precipitation.

## **6. Remote Sensing Estimation Method**

Remote sensing estimation method is a relatively advanced method. It is developed with the improvement of modern technology and information level, such as remote sensing, geographic information system and global positioning system. At the same time, it is widely welcomed by scientists and workers. It plays a positive role in the application of continuous inventory of plantation resources and large-area biological inspection materials. At the same

time, there are more and more remote sensing data for plantation resources, and with the improvement of its efficiency and frequency, this remote sensing estimation method has gradually become the main method for estimating carbon storage of plantation biomass. It can be said that the remote sensing estimation method is based on the development of modern science and technology, and it has more advantages than the traditional method in biomass estimation of plantation. It is characterized by comprehensiveness, dynamics and rapidity, and it can monitor the ecosystem accurately and nondestructively. The multi-temporal characteristics of remote sensing provide a technical basis for researchers to locate and analyze the non-interference changes in a certain area after a period of time, so as to realize dynamic analysis which can not be solved by traditional carbon storage estimation method of plantation.

## 7. Conclusion

Among these main methods of carbon storage estimation of plantation, every method has its own advantages and disadvantages. We should choose appropriate method according to the actual situation of the research object. In the study of large-scale carbon sink in plantation ecosystem, the method of combining sample plot investigation, model simulation and remote sensing estimation should be used as much as possible. If conditions permit, the carbon storage of plantation can be estimated from the perspective of plant physiology and ecology on the micro-scale, and the spatial dynamic changes of carbon storage of plantation can be analyzed, so as to improve the accuracy of carbon storage estimation and carbon cycle research of plantation.

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