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Carbon Sequestration Decision-Making Management Based on Model Construction

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Abstract: *Nowadays, forests are integral to mitigating climate change. Fully exerting the carbon sequestration capacity of forests is related to whether the concentration in the atmosphere can be reduced and the trend of global warming can be restrained. Because forest composition, climate, population, interests, and values vary widely around the world, it is impractical to develop a model of forest management that applies to all regions, and the optimal management strategy for each forest is different. Modeling the carbon footprint of forest areas, from which the carbon sequestration of trees, understory vegetation and forest litter per unit area can be obtained, and trees can be further divided into young forests, middle-aged forests, and near-mature forests according to their age , mature forest and over-mature forest, comprehensively evaluate the established indicators through the entropy weight method, establish 3 first-level indicators and 6 second-level indicators, and combine the Pearson correlation coefficient to formulate the most relevant indicators. The maintenance of ecological balance is a forest management plan in Carbon dioxide sequestration in the Greater Khingan Range is the most efficient.*

Keywords: *Forest Ecosystem, Carbon Sequestration Model, Carbon Footprint, Entropy Weight Method*

1. Introduction

In recent years, global climate change is closely related to the carbon cycle. With the continuous improvement of people's living standards and the continuous acceleration of industrial development, the emission of harmful gases such as carbon dioxide has increased to a certain extent. The forest is an important carrier of fixed carbon elements and an important carbon sink function system. Forests can absorb carbon dioxide gas, release a large amount of oxygen, and convert the fixed carbon elements into energy that can improve air quality. Therefore, the establishment of reasonable management measures for forests can quantitatively analyze the carbon sequestration of a certain forest within a certain period of time. With the help of forest management and management, the consumption of forest resources can be reduced as much as possible to ensure that the consumption is less than the production volume, thereby promote sustainable development of forest resources. At present, the existing forest management measures are only established for the felling of forest timber, the management of animals and plants, and forest construction.

However, forests also sequester carbon dioxide in living plants and products made from trees, including products such as furniture and lumber, which sequester carbon dioxide during their life cycle, some short-lived and others May outlive the trees that produce them. Carbon sequestered in certain forest products combined with carbon sequestered due to regrowth of young forests has the potential to allow more carbon sequestration over time than the carbon sequestration benefits of not deforestation at all. This article is based on the existing influencing factors, adding the impact of forest products on forest carbon sequestration and establishing more objective and reasonable forest management measures. This topic has not been involved by too many researchers.[1]

In this paper, the optimal forest management measures are reflected by the maximum carbon storage of forests in a certain area. The carbon footprint model is used to calculate the carbon dioxide emitted in this area, and then the carbon storage of forests and forest products in a certain area is calculated, and finally the maximum carbon storage is obtained through the index of the comprehensive evaluation model of the entropy weight method, and the optimal forest management measures are finally determined.

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2. Literature Review

Zhu Wanze (2020) summarized three hypotheses for carbon sequestration in mature forests, that is, the first is the carbon neutral hypothesis, the second is the carbon sink hypothesis, and the third is the carbon source hypothesis. This paper cites the international mainstream theory—the carbon sink hypothesis, and classifies trees according to their age into young forests, middle-aged forests, near-mature forests, mature forests, and over-mature forests, and establishes a corresponding carbon sink model. Determining which trees in a forest are mature or overripe and which trees can be felled for forest products.

In order to quantitatively estimate carbon storage, Xu Shanshan (2014) introduced the main estimation methods of forest carbon storage. This paper mainly adopts the continuous function method of the conversion factor of the sample plot method, which makes the carbon storage estimation more reasonable. At the same time, this method can be easily realized from plot survey to regional scale estimation. However, this method has the defect of insufficient sample size, and cannot estimate the model parameters of different tree species, and the processing of forest biomass and stock volume into a simple linear relationship remains to be explored.

This was followed by Mancni M S, Galli A, Niccolucci V et al. (2016) by reviewing the rationale and methodologies behind the carbon footprint components and updating a key factor to improve clarity and transparency of the ecological footprint in calculating average forest carbon sequestration. Chen Yike, Wang Jianjun and others (2022) took the key state-owned forest area of Greater Khingan Range in Heilongjiang as the research object, and calculated the carbon storage and carbon density of their forest vegetation on the basis of tree species and age groups. This paper uses the data of the article, combined with the improved combination entropy weight method of Li Fang et al. (2021), the method is simple to calculate and can take into account both subjective and objective factors. When, the results are prone to lack of stability, and finally the forest management model analysis indicators are established.

3. Establishment of carbon sequestration model

3.1 Establishment of carbon sequestration model

Quantitatively determine the amount of carbon sequestration and carbon storage in forests by establishing a carbon sink model.

3.1.1 Definition of carbon footprint

Before building a carbon sequestration model, we first need to understand what carbon sequestration is. According to the in-depth study of the background information, the process of carbon sequestration is that we increase the carbon dioxide storage in the atmosphere through the biosphere or mechanical means. We established the following model by consulting the literature [2]:

Carbon Footprint [2]: Also known as the ton carbon footprint, is a measure of the amount of carbon dioxide emitted by man-made greenhouse gases in tons.

Calculation formula:

$$Carbon_{EF} = \frac{P_C\,(S_O)}{Y_W} EQF \tag{1}$$

$$Y_W = \frac{AFCS}{0.27} \tag{2}$$

P_C represents the amount of anthropogenic carbon dioxide emissions per year; S_O represents the share of carbon dioxide produced by human activities that is absorbed by the ocean in a given year; EQF refers to the equivalent factor used for forest land weighting; Y_W represents the annual growth rate of the average CO_2 sequestration rate per hectare; $AFCS$ represents the average forest carbon sequestration ; 0.27 represents the fraction of carbon in the carbon dioxide molecule converted to carbon dioxide.

$$AFCS = \frac{NFP}{AF} \tag{3}$$

NFP represents the net forest production, which is the total annual production of forest biomass;

AF represents the forest area.

By consulting the IPCC, the formula for calculating NFP is as follows:

$$NFP = \left\{ \sum{}_{i,j,k} \left[A_{i,j,k} * G_{W_{I,J,K}} * (1 + R_{i,j}) \right] - B_W \right\} * cf - S_{Rh} + HWPs \tag{4}$$

A represents the forest area; i,j,k represents ecoregion; B_W represents the loss of biomass in tons due to forest fires at the global level; G_W represents the average annual growth value of aboveground biomass; cf represents the carbon content of dry matter ; R represents the ratio between below-ground biomass and above-ground biomass under a specific vegetation type; $1+R$ represents the value of underground biomass; S_{Rh} represents soil organic carbon loss; $HWPs$ represents China's annual carbon stock in harvested wood products.

$$S_{RH} = \sum_C (A * E_{mfact}) \tag{5}$$

A represents the area of soil under the condition of climate factor C; E_{mfact} represents the climate emission factor.

3.1.2 Calculating carbon sequestration in forests and forest products

Plant carbon storage can be estimated by establishing the relationship between biomass and stock. First, calculate the carbon storage density of the tree layer of each forest ecosystem type(P_C, mgC/hm^2). Then, according to the ratio of the biomass of the arbor layer to the total biomass, the carbon storage per unit of the total biomass of each forest type is estimated.

$$Pc = V.D.R.Cc \tag{6}$$

V represents the unit area stock of a certain forest type; D represents trunk density; R represents the proportion of trunk biomass to the arbor layer biomass; Cc represents plant carbon content.[3]

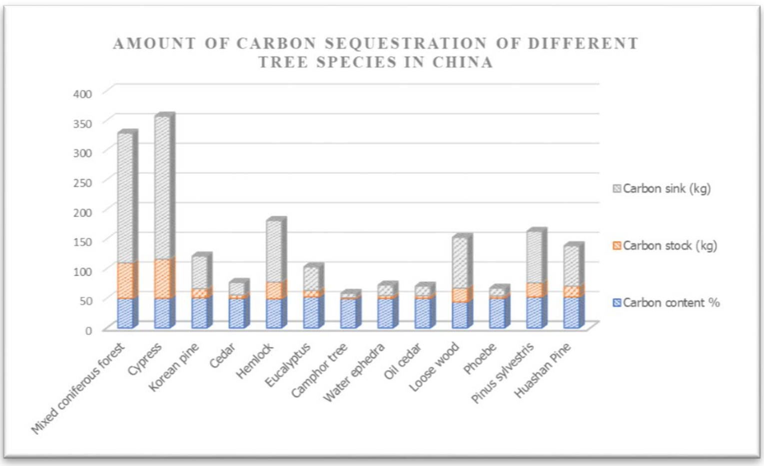

Figure 1: Carbon sequestration capacity of different types of trees

According to the forest age, it can be divided into young forest, middle-aged forest, near-mature forest, mature forest, and over-mature forest. According to the title, we need to determine the carbon sequestration amount of forest and forest products over time, then we can use Judging from the actual situation, which trees are mature or overripe in a forest, and then judge which trees can be cut down to make forest products[1] .

According to statistics, the carbon content, carbon storage and carbon sink of different types of trees in China are obtained[5]. As shown in Figure 1:

Statistically obtain the biomass ratio (BEF [4]) and dry matter carbon content (cf) of forest trunk and arbor layer of each forest type at each age, and merge these forest types into the statistical unit of China's forest resources census: forest dominant species types .C reserves of forest plants in various types and provinces in China can be obtained by using the following formula:

$$C=(V \cdot D \cdot BEF) \cdot (1+R) \cdot cf \tag{7}$$

The amount of carbon sequestered by trees per unit area(C_a) is calculated by the following formula:

$$C_1=M \cdot \frac{(w/v)}{a} \cdot b \cdot C_B \tag{8}$$

M represents the stock volume of tree dry wood per unit area; a represents the ratio of trunk wood biomass to total forest biomass; B represents the percentage of aboveground or underground biomass in the total forest biomass; C_B represents the average value of carbon content in 1 g of biomass.

The amount of carbon sequestered by understory plants per unit area(C_2) is calculated as follows:

$$C_2=0.61M \cdot \frac{(w/v)}{a} \cdot C_B \tag{9}$$

0.61 represents the ratio of understory plants to total tree biomass.

The carbon sequestration amount of forest litter per unit area(C_3) is calculated as follows:

$$C_3=D \cdot C_B \tag{10}$$

D represents the average value of dry matter storage of litter per unit area of various forests.

From the above formula, we can determine the amount of carbon dioxide absorbed by the forest and forest products over a period of time by collecting data such as the stock volume, biomass, density, etc. of the forest in a certain area.

3.2 Determine the best management plan based on entropy weight method evaluation

3.2.1 The establishment of comprehensive evaluation model of entropy weight assignment method

Entropy weight method is an objective weighting method, whose principle is to determine the weight according to the amount of information reflected by the variation degree of each index value in the process of index evaluation. To be specific, the smaller the entropy value is, the greater the amount of information is, and the greater the weight of this index is; Conversely, the larger the entropy value is, the smaller the amount of information is, and the smaller the weight of the corresponding index is[6]. The entropy weight can be calculated as follows:

Step 1: Index standardization processing. Where, I represents the year (i = 1,2... , n), j represents the index (j= 1,2... , m).

$$X'_{ij}=\frac{x_{ij}-\min x_{ij}}{\max x_{ij}-\min x_{ij}} \tag{11}$$

$$X_{ijn}'=\frac{\max x_{ij}-x_{ij}}{\max x_{ij}-\min x_{ij}} \tag{12}$$

Where, is normalized value; Is the original value of the i-th index in the j-th year; i = 1,2,3... , m(m is the number of evaluation indicators) 1,2,3... , n(n is the number of evaluation years)

Step 2: Normalization of indicators, calculate the proportion of the i-th indicator in the j year.

$$X_{ij}=\frac{x_{ij}'}{\sum_{i=1}^{n}x_{ij}'} \tag{13}$$

Step 3: calculate the information entropy of the index:

$$e_j=-\frac{1}{\ln n}\sum_{j=1}^{n}(X_{ij}\times\ln X_{ij}')\ ,\ (0\leqslant e_j\leqslant 1) \tag{14}$$

Step 4: Calculate the difference coefficient and weight of each index:

$$g_j=1-e_j \tag{15}$$

$$w_j=\frac{g_j}{\sum_{j=1}^{m}g_j} \tag{16}$$

Step 5: Weighted arithmetic average model. In the comprehensive evaluation of multiple indicators, it is necessary to synthesize indicators through mathematical model:

$$D_i=\sum_{j=1}^{m}d_{ij}w_j \tag{17}$$

3.2.2 Solution of entropy weight method model

First of all, we established a carbon sequestration model suitable for various forests. Then when we select a specific area and collect relevant data of this area, then the forest and the amount of carbon dioxide sequestered by forest products can be determined. For a forest, the amount of carbon dioxide that can be sequestered over a period of time will vary with the effective area of the forest, forming a positive correlation. Therefore, we selected the Greater Khingan Range in China to study the applicable forest management plan for carbon dioxide sequestration in this region by collecting data.

Depending on the data[7], in 2019, the forest land area of the Greater Khingan Range has reached 7.09 million hectares, and within five years, the forest land area of the Greater Khingan Range will increase by 1,012 square kilometers. For the original extra-large base, the growth is undoubtedly weak, so we believe that in the total forest area of the Greater Khingan Range remained unchanged for a period of time. According to the data, the effective area of forest = total forest land area * forest coverage rate. Therefore, we believe that within a period of time, the capacity of forests and products in the Greater Khingan Range to sequester carbon dioxide can be represented by the forest coverage rate.

In the first step, we established an evaluation system for carbon dioxide sequestration in the region using forest coverage.

In the second step, we created three first-level indicators, namely: environmental protection, maintaining ecological balance, and changes in climatic conditions, as shown in Table 1.

In the third step, We have established various secondary indicators, which include: Forest disease incidence, Negative growth rate in sand, Forest area coverage, Carbon dioxide absorption, Average precipitation, Average temperature.[8]

Table 1: Index establishment of entropy weight method

Environmental protection	Maintain ecological balance	Climate change
Forest disease incidence	Forest area coverage	Average precipitation
Negative growth rate in sand	Carbon dioxide absorption	Average temperature

Through the collected data of the secondary indicators, according to the idea of the entropy weight method, the ratio of the indicators is first obtained, and the information entropy of the indicators is calculated by obtaining the ratio, and then the difference coefficient and weight of each indicator are

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calculated, and the weighted arithmetic mean model is used for the comprehensive evaluation, the comprehensive evaluation of each first-level indicator can be launched according to each secondary indicators. Combined with the changes in the forest coverage rate in the Greater Khingan Range during the same period time, the comprehensive evaluation of the first-level indicator can be derived.

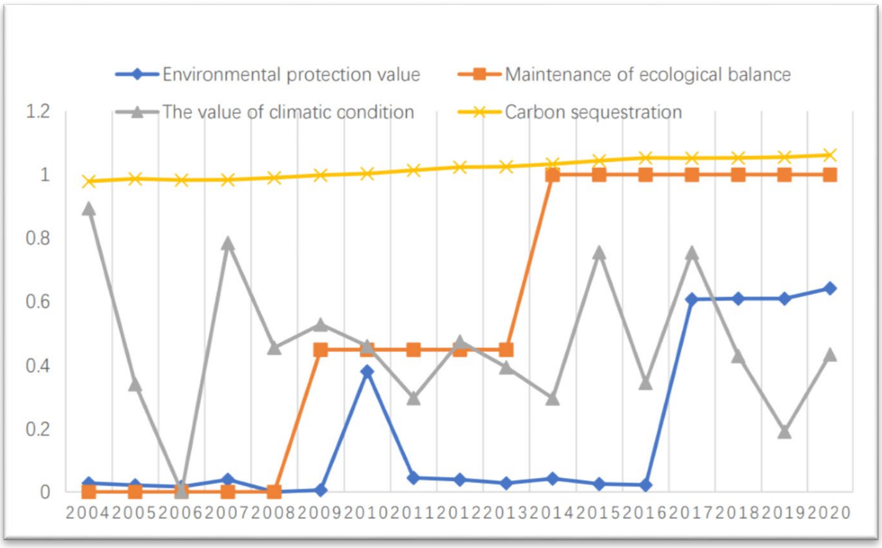

Figure 2: Comprehensive evaluation of first-level indicators

Calculate the weighted average of the three indicators, and measure the correlation of the three indicators according to the principle of the Pearson correlation coefficient, we can find the first-level indicator with the highest correlation coefficient, that is, the forest management conditions that best fit the changes in the forest coverage of the Greater Khingan Range. This indicator is the most effective forest plan for sequestering carbon dioxide.

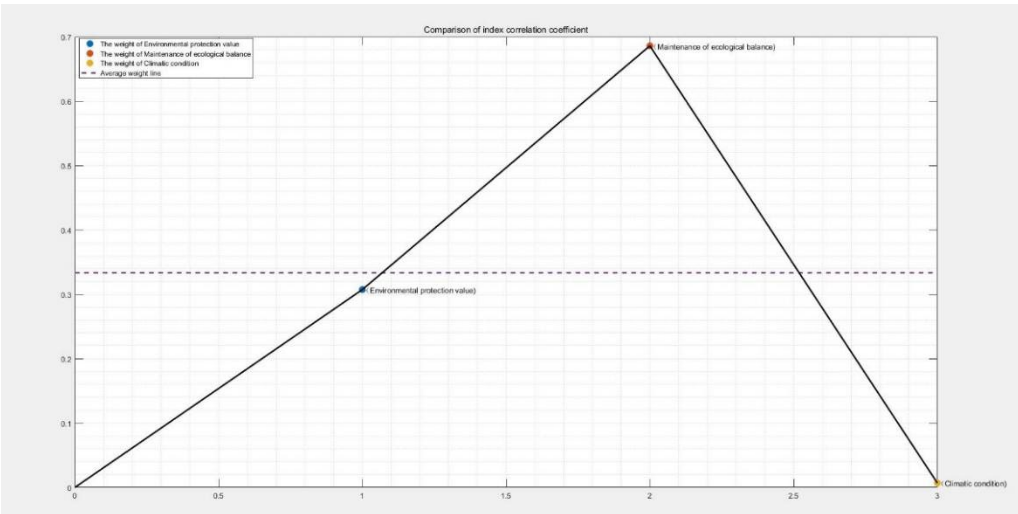

Figure 3: Index correlation coefficient comparison

From Figures 2 and 3, we can conclude that the correlation coefficient of the indicator maintenance of ecological balance is the largest, and the only one that exceeds the weighted average line, then if our assumption is established, we believe that the maintenance of ecological balance is a forest management plan in Carbon dioxide sequestration in the Greater Khingan Range is the most efficient.

4. Conclusion

This paper analyzes the forest land in the Greater Khingan Mountains of China, and calculates the amount of carbon sequestration in this area by using the forest coverage rate, forest age structure, and carbon footprint in this area, so as to establish a carbon sequestration evaluation system. After that, through

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the creation of three first-level indicators (environmental protection, maintaining ecological balance, and climate change) and six secondary indicators (forest disease incidence, negative growth rate of sandy land, forest area coverage, carbon dioxide absorption rate, average precipitation, and average temperature) were found by entropy weight method The first-level index with the highest coefficient is to maintain ecological balance, that is, the forest management conditions that are most suitable for the change of forest coverage in Greater Khingan Mountains.

The establishment of a reasonable forest management model must fully consider the carbon sequestration of forest products, so as to improve the quality and effect of forest carbon sequestration and forest protection, and at the same time maximize the economic benefits of forests and drive the people in the area. Therefore, in the implementation, it is necessary to formulate scientific and effective forest management strategies and management measures according to local conditions, so as to provide high-quality and economical forest resources for the long-term development of human beings and society, and ensure the sustainable development of forest resources.

References

[1] Zhou J, Yu S, Kang H, et al. Construction of multi-enzyme cascade biomimetic carbon sequestration system based on photocatalytic coenzyme NADH regeneration[J]. Renewable Energy, 2020, 156.

[2] Mancni M S, Galli A, Niccolucci V, et al. Ecological footprint: refining the carbon footprint calculation [J]. Ecological indicators, 2016, 61:390-403.

[3] Zhu Wanze. Research progress on carbon sequestration in mature forests [J]. Forestry Science, 2020, 56(03): 117-126.

[4] Xu Shanshan. A review of forest carbon storage estimation methods [J]. Forestry Survey and Planning, 2014, 39(06): 28-33.

[5] Wang Dawei, Shen Wenxing. Calculation of carbon storage and carbon sequestration potential analysis of artificial arbor forests of main tree species in China [J]. Journal of Nanjing Forestry University (Natural Science Edition), 2022, 46(05): 11-19.

[6] Li Fang, Li Dongping. Combination evaluation model based on entropy weight method [J]. Information Technology and Informatization, 2021 (09): 148-150.

[7] Chen Keyi, Wang Jianjun, He Youjun, Zhang Liwen. Evaluation of forest carbon storage and carbon sequestration potential in key state-owned forest areas of Greater Khingan Range, Heilongjiang [J]. Journal of Ecological Environment, 2022, 31(09): 1725-1734. DOI: 10.16258/ j.cnki.1674-5906. 2022.09.002.

[8] Huang Lin. Research progress on ecological effects of forest management [J]. Chinese Journal of Ecology, 2021, 41(10): 4226-4239.