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Research on Comprehensive Evaluation Model of Forest Carbon Sequestration Based on Gray Correlation Analysis

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Abstract: Increasing levels of greenhouse gases have seriously affected climate change and endangered human lilfe and health. How to sequester carbon dioxide most effectively and how to make an optimal forest management plan to balance the rights and interests of forests, managers, and users, and maintain the sustainable development of forests have become urgent issues. For the carbon sequestration of forests and their forest products, we established a Gray Correlation Model and a Comprehensive Evaluation Prediction Model to obtain the final sum of carbon sequestration. We analyzed the carbon sequestration in each forest globally and defined the forest into three periods: young, middle, and mature according to the growth period of trees. We found that most forests have the highest contribution to carbon sequestration in the mid-aged period and that the most efficient and sustainable way to sequester carbon is to selectively harvest mature trees to produce forest products.

1. Introduction

Carbon Sequestration, refers to the technology of capturing carbon and storing it safely instead of emitting CO_2 directly into the atmosphere [1]. With the continuous development of human civilization, greenhouse gas emissions have seriously affected climate change and was a threat to human life, and building an ecological civilization is a matter of the human future. In order to address the harm caused by greenhouse gases, the biosphere plays an important role in increasing the amount of carbon dioxide storage isolated from the atmosphere through measures in the biosphere and mechanical means, and the biosphere plays an important role in sequestering carbon dioxide in other environments through forests. Sequestering CO_2 in plants or some forest products like furniture and wood gives them the opportunity to maintain absorbing CO_2, while other young forests and forest products may absorb more carbon over time.

2. Effect of Different Old Forests on Carbon Sequestration Based on Gray Correlation Analysis

This task requires calculating the amount of carbon sequestered by the forest and its products, and

going directly to the calculation there are too many dependent variables to consider, and the independent variables are not well determined, and the errors that exist are relatively large. Therefore, a centralized comparison of data series responding to the characteristics of the variation of each factor by means of a gray correlation model compensates for the regret caused by using mathematical and statistical methods to do the analysis.

The gray correlation model was used to determine which forest period had the greatest effect on carbon sequestration by selecting the reference series of each influencing factor and further dimensionlessizing the data for each forest period by calculating the correlation coefficient and the correlation degree.

Select the year as the reference series x_0, Young forest x_1, Middle-aged forest x_2 and Mature forest x_3. For the year reference series x_0, comparing the series $x_1, x_2, \ldots, x_n$, by comparing the difference between each curve and the reference curve at each point, we arrive at the value of the correlation coefficient [2]:

$$\xi_i(k) = \frac{\min\limits_i(\Delta_i(\mathrm{m}\ )) + 0.5\max\limits_i(\Delta_i(\mathrm{m}\ ))}{|x_0(k) - x_i(k)| + 0.5\max\limits_i(\Delta_i(\mathrm{m}\ ))}\ ,\ (0.5\text{: Resolution factor})$$

To calculate the correlation coefficient, use the formula:

$$\begin{aligned}\min_i(\Delta_i(\mathrm{m}\ )) &= \min_i\left(\min_k|x_0(k) - x_i(k)|\right)\\ \max_i(\Delta_i(\mathrm{m}\ )) &= \max_i\left(\max_k|x_0(k) - x_i(k)|\right)\end{aligned}$$

One of the things we should note is to homogenize the individual sequences first, i.e:

$$f(x_k) = \frac{x_k}{\bar{x}} = y_k, \bar{x} = \frac{1}{n}\sum_{k=1}^{n} x_k$$

Finally, the correlation is calculated using the following formula:

$$\xi_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k)$$

By testing and surveying the forests in the Xiaoxinganling region of China, combined with data reviewed decades ago, [3] the final correlations were derived as follows:

Table 1: Relevance results

Evaluation items	Relevance	Ranking
Young forest	0.563	2
Middle-aged	0.795	1
Mature forest	0.561	3

Ultimately, we have the data to conclude that forests sequester the most carbon at Middle-aged.

3. Evaluation Model of Forest Carbon Sequestration Based on Gray Correlation Analysis

We constructed a comprehensive evaluation model to evaluate which natural factors affect trees at mid-age, and which of these effects are most significant.The indexes are analyzed and evaluated for different tree species, different temperatures, different climates, different temperature zones, etc.

With x evaluation objects, each evaluation object has y evaluation indicators, and the nth indicator of the m th evaluation object is:

$$L_{mn}(m = 1,2,\ldots,x; n = 1,2,\ldots,y)$$

Next, the optimal set of indicators is determined, and the following formula can be used for the optimal set of indicators:

$$L_{0n} = \text{ Optimum } (L_{mn})\ (n = 1,2,\ldots,y)$$

Construct the original matrix using the optimal indicators and the indicators of the evaluation subject:

$$Y = \begin{bmatrix} L_{01} & L_{02} & \cdots & L_{0y} \\ L_{11} & L_{12} & \cdots & L_{1y} \\ \cdots & \cdots & \cdots & \cdots \\ L_{x1} & L_{x2} & \cdots & L_{xy} \end{bmatrix}$$

Finally, the grey correlation coefficients and grey correlations were calculated to evaluate the most influential elements:

$$r_{mn} = \frac{\min\limits_{m}\min\limits_{n}|x_{0n} - x_{mn}| + \xi\max\limits_{m}\max\limits_{n}|a_{0n} - a_{mn}|}{|a_{0n} - a_{mn}| + \xi\max\limits_{m}\max\limits_{n}|a_{0n} - a_{mn}|}(m = 1,2,\ldots,x; n = 1,2,\ldots,y)$$

$$b_m = \sum_{n=1}^{y} w_n \times (r_{mn})^r (m = 1,2,\ldots,x),\ (w_n\text{: Weights })$$

By substituting and calculating the data, we finally concluded that the temperature is the greatest for the carbon sequestration of middle-aged trees. The results are shown in the figure below [4]:

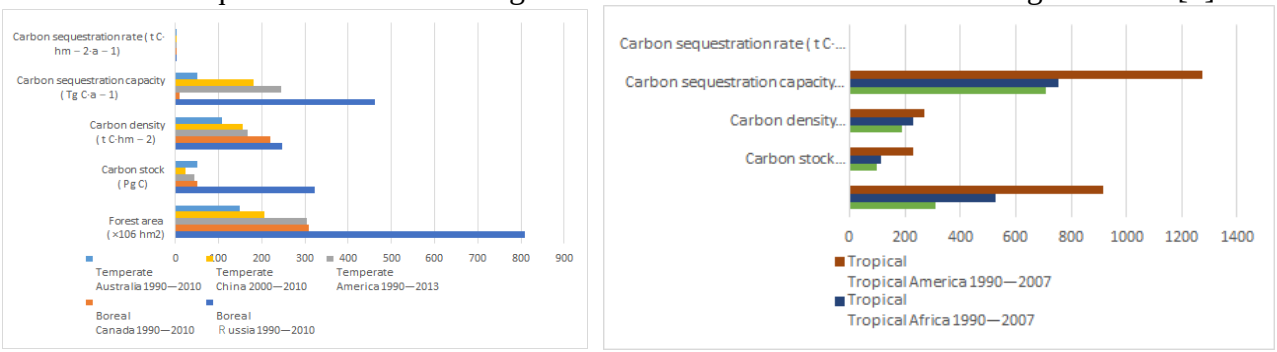

Figure 1: Forest carbon sequestration in different temperature bands

For the carbon sequestration capacity of forest products, which is far less than that of trees, in order to avoid the influence of forest products on the carbon sequestration capacity of trees, we make them into forest products when trees reach maturity, and for the carbon sequestration capacity of forest products, we use a gray prediction model to predict and conclude the following:

Table 2: Carbon sequestration by forest products

Years	1995	1996	1997	1998	…	2005	2006	2007	2008
Amount of solid carbon	0.505	0.535	0.546	0.549	…	0.505	0.524	0.540	0.560

4. Conclusion

The gray correlation analysis method is based on the gray correlation model to complete the calculation of the corresponding analysis work, with the continuous expansion of the scope of gray

correlation analysis theory, some of the existing models have been inadequate so that it can not well solve some aspects of the actual problem, but also make the gray correlation analysis of the whole theoretical system is relatively not very perfect, its application is subject to certain restrictions. In this paper, several quantitative models are further improved so that they can overcome their own problems to the maximum extent and gradually expand the scope of application of gray correlation theory and methods, so that they are more suitable for solving real problems.

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