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Carbon Sequestration and Optimal Forest Management Program

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Abstract: *Forests provide us with many resources in our daily lives, and forest products can be seen everywhere in our lives. Research on the use of forest resources and forest carbon sequestration has always attracted much attention. To this end, we have built several models to predict the carbon sequestration of forests and to develop optimal management plans for forests.*

Keywords: *Entropy weight evaluation; GM (1, 1); PCA; Time series*

1. Introduction

Between 76% and 98% of organic carbon in terrestrial ecosystems is stored in forest ecosystems, and the carbon content of forest ecosystems is a key factor in estimating their uptake and emission of carbon gases to the atmosphere, as well as a fundamental parameter for studying their exchange with the atmosphere. In recent years, the effect of organic carbon on atmospheric CO_2 concentrations has received increasing scientific attention [1].

Studies have demonstrated that over time, regeneration of young trees may achieve more carbon sequestration than the carbon sequestration benefits of forests that do not cut trees at all [2]. Therefore, forest managers have to make optimal forest management decisions based on the multiple ways in which forests are valued.

At the global level, forest management strategies that take various factors into consideration can be effective in sequestering carbon. Investigating carbon sequestration in different regions is beneficial to the management and use of local forests [3]. For these reasons, we face up to the following questions.

Develop a forest carbon sequestration model that can determine the amount of carbon dioxide sequestered over time, and that can identify the most applicable forest management plan.

2. Model building

2.1. Model Preparation

Entropy method: Entropy weight method [4] can be used for the comprehensive evaluation of multiple objects and indicators, and its evaluation results are mainly based on objective factors, almost independent of subjective factors. Since the unit of measurement of each indicator is not uniform, they should be normalized before calculating the comprehensive weight, that is, the absolute value of the indicator is converted into a relative value, and make $x_{ij} = \left| x_{ij} \right|$.

Positive indexes:

$$x_{ij} = 0.998 \frac{x_{ij} - \min\left\{x_{1j}, Lx_{nj}\right\}}{\max\left\{x_{1j}, Lx_{nj}\right\} - \min\left\{x_{1j}, Lx_{nj}\right\}} + 0.002$$

Negative Indicator:

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$$x_{ij} = 0.998\frac{\max\left\{x_{1j}, Lx_{nj}\right\} - x_{ij}}{\max\left\{x_{1j}, Lx_{nj}\right\} - \min\left\{x_{1j}, Lx_{nj}\right\}} + 0.002$$

Calculate the weight of the indicator value of program i under the jth indicator P_{ij}

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^{n} X_{ij}} \left(j = 1, 2, L, m\right)$$

Where $k = \ln(n);$,satisfying e > 0.

Calculate the information entropy redundancy of the jth metric g_j

$$g_j = 1 - e_j$$

Calculate the weight of the jth indicator

$$W_j = \frac{g_j}{\sum_{j=1}^{m} g_j}$$

Calculate the composite score of the ith evaluation object:

$$S_i = \sum_{j=1}^{m} w_j x_{ij}$$

2.2. Model building and solving

Forest carbon sequestration is influenced by various factors, and different factors have different weight on the effect of forest carbon sequestration. We perform entropy weighting method through the searched data, and by analyzing the weights of different factors affecting the carbon sequestration of this forest, we come up with the main factors that determine the amount of carbon sequestration in this forest, and then further analyze how to effectively control the main factors, and calculate the weights of different factors affecting the main factors through entropy weighting method, and come up with a scheme to effectively control the main factors. [5].

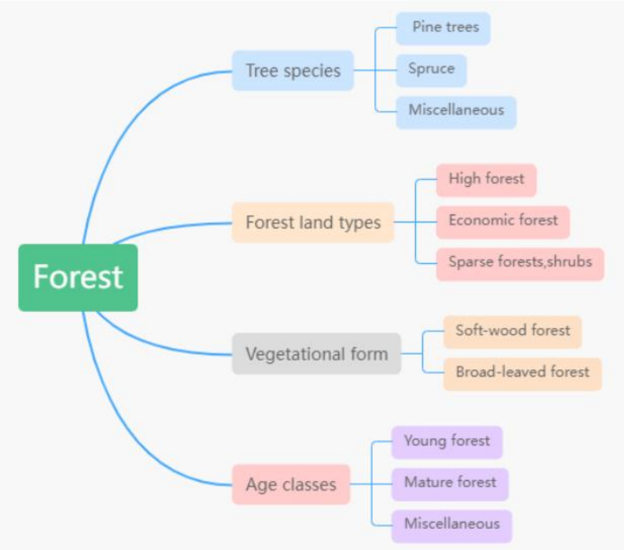

Figure 1: The mind map for issue analysis

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In this paper, we take four main factors, namely, tree species, woodland species, vegetation type, tree age type, and tree age type, and study them. We selected a forest in Liaoning Province, China, as the basis of our model, and analyzed the carbon sequestration of different factors by using the actual data of the forest from 1990 to 2010, and weighted the weights of the above factors by using the entropy weighting method, and obtained results in Figure 2.

Figure 2: Average carbon sequestration and weight

We can see that the weight of tree species, stand species, vegetation type, and tree age type is approximately 1:1:1:1, indicating that they have a similar degree of influence on forest carbon sequestration. Improving all the above four factors can effectively increase the carbon sequestration of forests.

Carbon stocks of different tree species differed greatly, and trees with more carbon sequestration per unit area were more capable of sequestering carbon. We analyzed the carbon sequestration of different tree species in this forest and calculated the carbon sequestration weight of trees such as pine, spruce and broadleaf mixed using the entropy weight method. The following picture4 is shows.

Figure 3: Carbon sequestration and weights of trees

The results of the entropy weighting method obtained that the weight of spruce trees was 13.257%, with the largest share, indicating that this type of trees had better carbon sequestration performance than other trees in the above table [6]. The weights of pine tree is 5.155%, which is the smallest, indicating that the carbon sequestration capacity of pine tree is lower in this forest.

The actual data showed that spruce trees contributed the least to carbon sequestration in this forest, and the broadleaf mix, pine species, and oak trees were the main contributors to carbon storage [3]. Based on the weighting results, we can improve the carbon sequestration capacity of this forest by appropriately increasing the number of spruce trees and decreasing the number of pine trees.

We distinguish the types of forest land by tree forest, economic forest, and open forest and shrub forest, and find the dominant forest land by weighting the average of the weight of carbon sequestration.

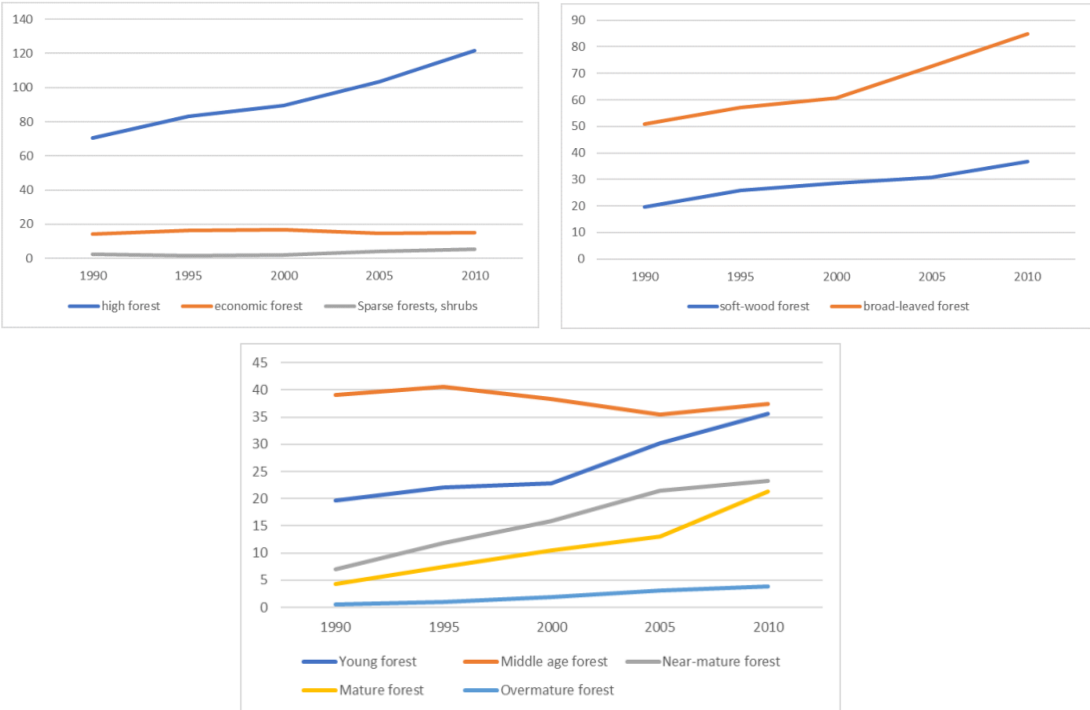

Figure 4: Carbon sequestration

3. Conclusion

Forest management plans are not determined by any single factor. This is an interdisciplinary problem controlled by multiple influencing factors. We first established an assessment model of forest carbon sequestration, and analyzed the limit of forest carbon sequestration from multiple perspectives. The principal component analysis model focuses on raw data and data analysis, and also takes into account social, economic and environmental factors, and develops an optimal forest management plan based on the evaluation results. From the case studies and research results, it can be seen that the time-prediction series model can effectively estimate the carbon storage of forests whose carbon storage increases linearly. Our model shows that it is possible for forest managers to find a balance between the benefits that forest managers receive from harvesting forest products and the value of allowing forests to continue to grow and absorb carbon, and that the most important factor to consider is the impact of indicators on economic value.

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