Forest management plan based on carbon sequestration model

Yili Yang [1, *], Huixin Lv[2], Zixuan Wang [1]

[1]Department of economics, Beijing technology and business University, Beijing,100048, China

[2]School of business, Beijing technology and business University, Beijing, 100048,China

*Corresponding author: yyl20230906@163.com

Abstract. The main purpose of this question is to establish a carbon sequestration model that is the most effective in sequestering carbon dioxide to determine the carbon sequestration capacity of forests and their products. A comprehensive evaluation model was established by the entropy weight method on the basis of the three indicators that affect the carbon sequestration amount, social factors such as "residents near the forest" and social and economic benefits are introduced to determine the scope of the forest management plan. We incorporate factors such as tree age change rate and forest area change rate into the forest management plan. We also establish a multiple regression prediction model to predict the carbon sequestration amount of forests in each year, and then added up to obtain the carbon sequestration carbon amount in 100 years.

Keywords: Carbon Sequestration; Forest management plan; Tree age change rate; Entropy weight method; Multiple Regression.

1. Background

The primitive atmosphere of the earth lacks oxygen. After the forest is formed, plants use photosynthesis to fix carbon and produce oxygen. Oxygen increases greatly and becomes one of the main components of the atmosphere, which satisfies the survival needs of human beings to expel carbon and absorb oxygen. The function of carbon sequestration and oxygen generation of forests also addresses the issue of carbon emissions in modern industry and energy consumption (the greenhouse effect of carbon increase), which has become the premise to protect the sustainable survival and development of human beings.

In the context of global warming, the urgent problem for mankind is to keep the greenhouse gas emissions from energy production not exceeding the amount they can absorb, retain and even sequester. In addition to reducing emissions by finding alternative clean energy sources, it is extremely important to achieve an accurate assessment of the carbon sequestration capacity of forest ecosystems to achieve long-term carbon balance.

Forests provide a colossal natural vehicle for carbon sequestration, with plants and products made from trees (including furniture, wood, paper, etc.) sequestering carbon over time in an effort to mitigate climate change. But at the same time, considering many factors: the age and type of trees; the geographical and climatic zone in which the forest is located; forest degradation, the benefits of forest products, etc., can carbon sequestration capacity be effectively utilized? Or are there better and less costly ways to achieve the equivalent carbon sequestration effect and thus slow global warming due to competition for land use, appropriate tree-cutting, and social and economic factors? This is an issue we need to consider. This paper not only considers the carbon sequestration of forests and their products, but also is taken into account other ways of using forest values, sets up a carbon sequestration model, and proposes the most effective, universal, and economic forests possible. Management plans to achieve carbon sequestration, conservation of biodiversity, and meeting social needs.

2. Assumption

In the entropy weight method model for determining the most effective carbon sequestration amount, in a given forest, only the changes in carbon sequestration caused by precipitation, temperature, and forest age are considered as independent variables, and other influencing factors are included in random errors. item.

Assume that the effects of deforestation are not considered when studying transition points.

In the multiple regression model for predicting carbon sequestration in ten years, in a given forest, only the changes in carbon sequestration caused by forest area, tree age change rate, and forest area change rate are considered as independent variables, and other influencing factors are included in random errors. item.

3. A comprehensive evaluation model

3.1 Model Establishment And Results

To scientifically and rationally establish a carbon sequestration model in forest ecosystems, it is necessary to construct an evaluation index system. After searching for data to calculate the average carbon sequestration of the Daxing'anling ecosystem, and after reviewing a large number of documents, we establish an evaluation index system for carbon sequestration in forest ecosystems consisting of two primary indicators and three secondary indicators. Forests sequester carbon dioxide in living plants and products produced by their trees, including furniture, lumber, plywood, paper and other wood products. These forest products can sequester carbon dioxide. Therefore, two first-level indicators can be defined as: the carbon sequestration amount of the forest itself and the carbon sequestration amount of forest products made from forest trees. The three second-level representative indicators that affect carbon sequestration in forest ecosystems are precipitation, temperature, and forest age.

Secondary indicator 1: Precipitation can promote plant growth, increase plant productivity and biomass, and promote carbon sequestration in forest ecosystems. In dry regions, precipitation is the main limiting factor for NPP (net primary productivity of plants), NPP decreases as the ratio of precipitation to potential evaporation decreases, and the corresponding carbon sequestration capacity of plants decreases as productivity decreases . Therefore, precipitation is one of the main factors affecting carbon sequestration in forest ecosystems.

Secondary indicator 2: Temperature is also the main factor affecting carbon sequestration in forest ecosystems, because increasing temperature can increase vegetation photosynthesis and NPP, increase the decomposition rate of organic matter in boreal forests, promote soil respiration, and increase the amount of litter and soil carbon input. In addition, warmer temperatures also increase transpiration, decreased soil moisture, and increase drought frequency and intensity, potentially reducing soil respiration and decomposition of organic matter.

Secondary indicator 3: The amount of carbon sequestration in forest ecosystems is also related to tree age. Generally, forests can be divided into young forests, middle-aged forests, near-mature forests, mature forests and over-mature forests according to their ages. Among them, the carbon sequestration rate is the largest in the middle-aged forest ecosystem, and the carbon absorption and release of mature forests and over-mature forests basically stop growing because their biomass basically stops growing. It can be seen that the carbon dynamics of forests depends to a large extent on changes in their age classes.

After establishing the evaluation index, we need to determine the weight of the evaluation index. Each index has different degrees of impact on the sequestration of forest ecosystems, and their respective weights need to be clarified during evaluation. Each index is originally assigned 0 to 10 points, and the weight of each index is determined by the entropy weight method in the objective weighting method.

The entropy weight method organically integrates qualitative indicators with quantitative values, and uses the method of numerical morphology to express and process, which can minimize the subjective impact and make the evaluation results more reliable. According to the degree of change between the indicators, the information entropy is used to calculate the entropy weight between the indicators, and the weight of each indicator is objectively determined. The calculation steps are as follows.

3.2 The spectrum of our management plans in the decision model

Forests, as the main body of terrestrial ecosystems, are the largest source of carbon storage. The role of forest resources is reflected in the fact that the forest maintains the balance of the natural environment and the living space of human beings,and it optimizes the environmental conditions in the forest, and promotes economic growth. In order to balance the various values of forests, even after considering other social factors, forests can still achieve the goals of reducing total carbon emissions and mitigating climate change at a lower cost.Based on the review of a large number of documents and the analysis of forest ecological resources, the management of forest ecosystem has multiple goals. Therefore, in order to balance the various ways of valuing forests (including carbon sequestration), we introduce social factors on the basis of Question 1, and the range of management plans suggested by our decision model includes ecological aspect and social aspect.

In terms of ecology, based on the precipitation, temperature, and the age of the forest in task 1, climate influence factor is added. In the context of global warming, exploring the response and mechanism of forest soil organic carbon storage to temperature change is of great significance for understanding the trend of future climate change and the carbon cycle of forest ecosystems.Global warming prolongs the growing season and photosynthesis time of forest vegetation, which may increase the net primary productivity (NPP) of forest vegetation. Through a large number of studies, it is found that the NPP of tropical forest vegetation increases linearly with the increase of temperature, and the two have a good correlation.The increase of forest vegetation NPP can correspondingly increase the amount of litter and the amount of organic carbon input to the soil, thereby increasing the storage of organic carbon in the soil. Therefore, climate is also a factor that affects the carbon sequestration of forest ecosystems and should be included in the scope of management plans.

Social aspects should include "forest neighbors" and socioeconomic benefits. The researchers quantified the global population and spatial distribution of people living in and around forests, using the term "forest neighbors" to refer to these quantified people who live in or around forests.They also focused on explaining two concepts: "forest proximity" and "forest dependence". Forest proximity is related to forest dependence, but not the same as forest dependence. The orientation of forest proximity emphasizes geographic location, while forest dependence emphasizes the subjective needs of residents.Organizations supporting forest conservation and sustainable development projects around the world are interested in understanding how many people live in or near forests in order to prioritize and target funding, and to measure the impact of their projects on people's lives. Its findings have implications for researchers and policymakers interested in forest conservation, forest livelihoods, and sustainable socioeconomic development of communities within and outside forests.Forests are also complex social-environmental systems that are important for carbon sequestration and biodiversity conservation, and they make a range of important social-economic contributions, including health benefits and support for the many people who live in and around forests survival and income-generating livelihoods. Given these values, social economy should also be included in the scope of the management plan suggested by the decision-making model.

3.3 The conditions that forest should not be left uncut

Considering the common goals of carbon sequestration and socioeconomic benefits, deforestation appears to be an inevitable option: on the one hand, forest products will sequester some carbon, and some older trees, retaining middle-aged trees, allow young forests to grow Space can improve the carbon sequestration capacity of forests to a certain extent; on the other hand, forests provide local residents with wood fuel, water, self-sufficient agricultural and grazing space, and commercial work in mining, agriculture, grazing, tourism and logging, especially It is for some inhabitants in the mountainous and surrounding areas of developing countries who rely on forest products to make a living.

Have regard to the above two considerations, we consider extreme cases, are there any conditions that would lead to not deforestation? We provide an affirmative answer, yes, there are conditions that prevent us from clearing certain forests - ecological factors.

According to data, in order to achieve economic benefits, the world's forest area has been reduced by more than 30% since the mid-19th century, and most of this loss have occurred in developing countries. Deforestation peaked in the 1990s, with a net loss rate of about 83,000 square kilometers per year.

Human activities directly affect the structure and function of forest vegetation ecosystems. Due to human interference, timber felling is serious, and timber production drops sharply, which destroys the natural organizational structure of forest distribution and causes a large amount of carbon stored in vegetation to be released into the atmosphere. In addition, carbon stored in forest soils is also lost as land uses changes.

Under the conditions of climate warming, combining with natural forest resource protection projects and returning farmland to forest (grass) projects for forest vegetation protection and restoration and reconstruction of degraded forest ecosystems may significantly restore the carbon sink function of forest vegetation. Qualified scholars have studied poplar plantations with different periods of returning farmland to forests (5, 10, and 15 years). The total carbon storage of the poplar plantation ecosystem increased by approximately 2-fold and 5-fold, respectively.

In addition, excessive deforestation will lead to soil erosion. After deforestation, the exposed land will be exposed to the sun, the ground temperature will rise, and the process of decomposing organic matter into soluble mineral elements will accelerate. Mineral elements are brought into rivers, which greatly affect the quality of water resources. It estimates that more than 5 billion tons of soil are washed into rivers in my country every year. Quicksand silted up and blocked the reservoirs and rivers. The sediment content in the Yellow River is the highest in the world. When the flood arrives, due to the accumulation of quicksand, the riverbed in some places in the lower reaches of the Yellow River is 12 meters higher than the land outside the embankment, which seriously threatens people's lives and property safety.

Combining the above factors, especially for areas where the ecological environment has been severely damaged, we can no longer continue to cut down forests, otherwise the ecological environment will continue to deteriorate, which does not contribute to the survival and development of organisms.

3.4 Apply to all forests transition points between management plans

There are transition points between management plans that apply to all forests, and the characteristics of specific forests and their locations are used to determine the transition points between management plans using Net Primary Productivity (NPP).

Considering other ways of valuing forests, the best forest management plan for carbon sequestration is not necessarily the best for society. In order to accurately judge the best forest management plan for carbon sequestration, it is the forest management plan to determine the amount of carbon sequestered by the forest. an important groundwork. There are many factors that affect forest carbon sequestration, and the climate zone where the forest is located is a major variable in the study of forest management plans. By studying the climate zone where the forest is located, we can understand whether the model has transition points in all forest management plans. The net primary productivity of vegetation in one of the areas is the main research content in this question, which represents the evaluation index of forest carbon sequestration capacity.

The data sources in this question include the collection of relevant monographs and journals at all levels, the forest inventory data of the forest survey institutes of various provinces and autonomous regions, and the sample plot survey data of the Central South Planning Institute of the Ministry of Forestry. These data are widely distributed in the tropics, subtropics, warm temperate, temperate and cold temperate zones, which are widely representative and can reflect the distribution pattern of forest biomass and NPP in China. According to the division of climate zones in "China Vegetation", China's forests are divided into cold temperate coniferous forest, temperate coniferous and broad-leaved mixed forest, warm temperate deciduous broad-leaved forest, subtropical evergreen broad-leaved forest, and tropical forest according to the longitude and latitude of each sample point in the data. (including montane rainforest and monsoon rainforest).

At present, the world's forest area is about 2.8 billion hectares, with a coverage rate of 22%. The main distribution is shown in the figure:

Tropical rainforest: mainly distributed in the equatorial latitude 5° -10° north and south, under high temperature and rainy conditions, there are many forest layers, evergreen all year round, and rich forest resources. Subtropical evergreen broad-leaved forest: It is mainly distributed in the eastern coast of the continent in the subtropical region, the eastern region, and the vast area south of the Huaihe River in Fengling, China, is the largest distribution area in the world. Temperate mixed forest and temperate deciduous broad-leaved forest: Mainly distributed in eastern Asia, broad-leaved forest has obvious seasonal changes, with warm and humid summer, low temperature resistance in winter, and cool and humid summer.

Using the statistical function of EXCELL, the NPP of the roots, branches and leaves of each climatic zone in different climatic zones and different forest ecosystems were calculated respectively. The NPP characteristics of various types of forest NPP statistical types of forests are shown in Table.

The variation range of forest NPP in China is 1.81~30.44($/t \cdot hm^{-2} \cdot a^{-1}$), The average variation range of NPP of each forest type is 7.20~23.30($/t \cdot hm^{-2} \cdot a^{-1}$). The distribution law of NPP was tropical forest>subtropical evergreen broad-leaved forest>warm temperate deciduous broad-leaved forest>temperate mixed coniferous and broad-leaved forest>cold temperate coniferous forest.

The quantity of NPP is close to the world average level, and its variation trend is also in line with the law of gradual increase along the cold temperate to the tropics. The changing trends of biomass and NPP were consistent with the changing trends of water and heat gradually increasing with decreasing latitude from north to south in China.

3.5 Model Selection

(1)Using a multiple linear regression model.

Suppose there is a relationship between the dependent variable and the independent variable: $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + u_i$. Among them, β_0 is the intercept term, β_1 , β_2 , β_3 is the regression coefficient, and u_i is the random error term.

(2)Observe the dependent variable Y and the independent variables X1, X2, X3

Ten observations were made on the dependent variable and the independent variable, where the dependent variable represents the amount of carbon sequestered in the forest (10,000 tons), the independent variable X_1 is the forest area (10,000 hectares), and X_2 is the change in forest area (caused by changes in tree age) (10,000 hectares), X_3 is the change in forest area (caused by logging/planting) (10,000 hectares).

3.6 Results

Through the multiple regression model, it can be predicted that by 2029, the average annual carbon sequestration of vegetation in the Great Khingan Mountains ecosystem will be 5,084,800 tons, which takes into account the effects of tree age change rate and forest area change rate on carbon sequestration capacity.

Therefore, in order to give full play to the ecological service functions of forests for carbon sequestration and oxygen release, under the premise of considering social and economic benefits and ecological protection projects, forest managers should continue to pay close attention to the reduction of forest area due to force major factors such as natural disasters, and take timely measures. Adjust whether to plant new forests; within a suitable timed interval, continue to measure the changes in tree age and make cutting decisions.

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