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Carbon Sequestration-Based Forest Management Plans

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Abstract: Greenhouse gases have changed the climate, and carbon sequestration is an important way to reduce the amount of carbon dioxide in the atmosphere. As the lungs of the earth, forests are an important part of the carbon cycle and play a very important role in the process of carbon sequestration. We take the Purple Mountain in Nanjing, China as an example, and tailor a forest management plan for it.
Keywords: Grey Prediction Model; Forest Management Plan; Carbon Sequestration

1. Introduction

Climate change will have a great impact on our lives, and the picture of large-scale decertify-cation and the increase of decertified land is very shocking. The burning of fossil fuels releases a large amount of greenhouse gases. The atmospheric carbon dioxide concentration is increasing year by year, from about 280 ppm before the middle of the 18th century to 360 ppm now, within average annual increase of 1.5 ppm. If it continues to grow at this rate, the concentration of carbon dioxide in the atmosphere will increase to 720 ppm by the middle and late 21st century.[1]

The greenhouse effect has attracted the attention of governments and scientific communities around the world to protect climate resources. From the International Biosphere Program proposed in the 1960s to the Kyoto Protocol and the Bali Conference in 2007, various methods have been proposed to mitigate the impact of greenhouse gas emissions on the environment, such as energy conservation and emission reduction, offset emissions.[2] We need to take effective actions to reduce the amount of greenhouse gases in the atmosphere. We must not only reduce the production of greenhouse gases, but also maximize the storage of carbon dioxide obtained from the atmosphere through the biosphere or ecological means and promote the process of carbon sequestration.

2. Restatement of the Problem

In the face of climate change caused by the greenhouse effect, we have identified the key role of forests in the carbon sequestration process, and it is important to balance the economic benefits of harvesting trees to make wood products and allowing trees to continue to grow and sequester carbon. We will take Zijin Mountain, Nanjing, China as an example to formulate a forest management plan.

We will complete the following tasks: Establish a carbon sequestration model, use scientific carbon sequestration calculation methods, and gray prediction models to determine the forest carbon sequestration in the next few years and formulate an effective carbon sequestration forest management plan based on the actual situation.

3. Establishment of Carbon Sequestration Model and Preliminary Formulation of Forest Management Plan

Forest is the main part of the global carbon cycle and forest carbon fixed by green plants absorb CO2 in photosynthesis after fixed CO2 from the atmosphere in the form of organic matter in plants in vivo, the process of the main body of forest carbon sequestration roughly trees, undergrowth, and forest litter, which trees part and underground part is divided into the ground. Trees through Net Primary Production (NPP). Ultimately, carbon is stored in the stem, which is reflected in an increase in the biomass of the tree.[3]

3.1 Calculation of Carbon Sequestration in Purple Mountain Forest

We collected the basic situation of tree species on Purple Mountain in 2006.Due to space constraints, we do not present detailed data, but we divide them into four categories, as shown in the following figure:

Figure1 Classification map of Purple Mountain in 2006

Carbon sequestration per unit area of forest trees (C_1) is calculated according to formula (1):

$$C_1 = M \times \frac{w}{v} \div a \times b \times C_B$$

Where C_1 is the carbon sequestration per unit area of the overground part or underground part of trees; M is the accumulation amount of forest dry wood per unit area; $\mathrm{w/v}$ is the ratio of biomass to stock, with a value of 1.9 to 2.5 tm^{-3}. a is the ratio of trunk wood biomass to total tree biomass in coniferous forest: 41.6%; 64.0% in broad-leaved forest. b is the percentage of abovementioned or underground biomass in the total forest biomass. The percent ages of abovementioned and underground biomass of Pinus tableful are 77.6% and 22.4% respectively the percentages of other coniferous forests are 79.6% and 20.4% respectively the percentages of broadleaf forests are 86% and 14% respectively. C_B is the average carbon content in 1g biomass and its value is 0.5.

3.2 Forestland Area, Forestland Accumulation and Carbon Sequestration Prediction Model

We use grey prediction model to predict forest area by Python, forest accumulation and carbon sequestration. Grey system theory is a theoretical system that defines grey derivative and grey differential equation based on related space and smooth discrete function, and then establishes dynamic model in the form of differential equation with discrete data columns.[4] In other words, the grey model is a differential equation model established by using the random number which is significantly weakened and relatively regular after the random number is generated, to facilitate the research and description of its change process.

When we use the model, we define the grey derivative of $X^{(1)}$ to be zero.

$$d(k) = x^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1)$$

Let $z^{(1)}(k)$ be the adjacent value of the sequence $x^{(1)}(k)$ to generate the sequence.

$$d(k) = x^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1)z^{(1)}(k) = \alpha x^{(1)}(k) + (1-\alpha)x^{(1)}$$

Thus, the grey differential equation model of GM(1,1) is defined as:

$$d(k) = x^{(0)}(k) = x^{(1)}(k) - x^{(1)}(k-1)z^{(1)}(k) = \alpha x^{(1)}(k) + (1-\alpha)x^{(1)}d(k) + \alpha z^{(1)}(k) = bx^{(0)}(k) + \alpha z^{(1)}(k)$$

Where $x^{(0)}(k)$ is called gray derivative, α is called development coefficient, $z^{(1)}(k)$ is called whitening background value, and *B* is called gray action.

The moment $k = 2, 3, ...N$ goes into the above equation.

$x^{(0)}(n) + \alpha z^{(1)}(n) = b$

Introduce matrix vector notation:

$x^{(0)}(n)$ $\quad -z^{(1)}(n) \quad 1$

So the GM(1,1) model can be expressed as $Y = Bu$.

So now the problem is to find the values of a and b, and we can use unary linear regression, which is the least square method to get an estimate of them.

b

(a) Data processing

To ensure the feasibility of GM (1,1) modeling method, it is necessary to test the known data.

Let the original data be listed as $x^{(0)} = (x_0(1), x_0(2) \cdots x_0(n))$, calculate the level ratio of the sequence.

$$\lambda(k) = \frac{x^{(0)}(k-1)}{x^{(0)}(k)}, k = 2,3,\cdots,n$$

If all the stage ratios fall within the tolerable coverage range X = (e2n + 1, e2n + 1), the GM(1, 1) model can be established for the sequence X(0) and gray prediction can be made. Otherwise, perform proper transformation on the data, such as translation transformation:

$$y^{(0)}(k) = x^{(0)}(k) + c, k = 1,2,\cdots,n$$

Set c so that the level ratios of the data columns fall within the tolerable coverage.

(b) Establish GM(1,1) model

Might as well set $x(0) = (x^0(1), x^0(2), \cdots, x^0(n))$

$x^0(k) + \alpha z^{(1)}(k) = b$ To meet the above requirements, GM(1,1) model is established with it as the data column.

The estimates of A and B are obtained by regression analysis, so the corresponding bleaching model is

$$\frac{dx^{(1)}(t)}{dt} + \alpha x^{(1)}(t) = b$$

$x^{(1)}(t) = \left(x^{(0)}(1) - \frac{b}{a}\right) e^{-a(t-1)} + \frac{b}{a}$ Solution for

So, you get the predicted value.

$$\widehat{x^{(1)}}(k+1) = \left(x^{(0)}(1) - \frac{b}{a}\right) e^{-ak} + \frac{b}{a}, k = 1,2,\cdots,n-1$$

Thus, the predicted value can be obtained accordingly:

$$\widehat{x^{(0)}}(k+1) = \widehat{x^{(1)}}(k+1) - \widehat{x^{(1)}}(k), k = 1,2,\cdots,n-1$$

The data collected from 1953 to 2006 are shown in the following table:

Table 1: Basic situation of forests from 1953 to 2006

Time	Forested area (hm^2)	Forest land accumulation (m^3)	The total amount of carbon (t)
1953	1050.3	41207	76986.99
1959	1298	66749	95143.4
1963	1413.2	96278	103587.56
1972	1602.8	132030	117485.24
1978	1700	163894	124610
1982	1800.9	186282	132005.97
1987	1982	208797	145280.6
2002	2076.9	224551	152236.77
2006	2401.255	251020	176011.9915

Thus, our predictions for 2025 and 2030 are as follows:

Table 2: Basic situation of forests in 2025 and 2030.

Time	Forested area (hm^2)	Forest land accumulation (m^3)	The total amount of carbon (t)
2025	3201.5	340930	134669.95
2030	3431.8	360876	251550.94

Below is the forecast graph.

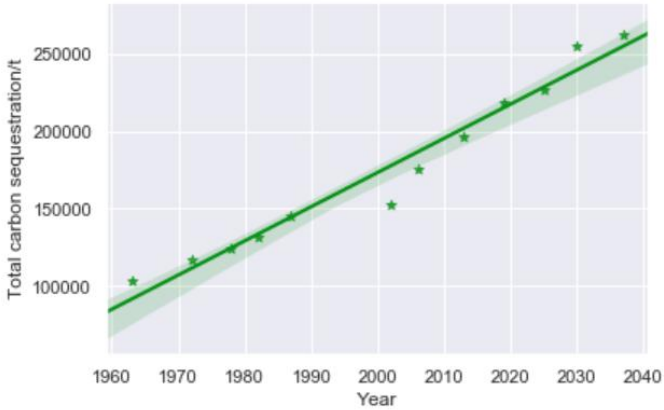

Figure 2 Prediction of the total amount of carbon.

4. Development of a forest management plan

We have designed the following steps for implementing the forest management plan.

⁜ Arrange special forest inspectors to carry out liquidation of forest tree resources every year to understand the situation of trees in the forest.

⁜ In autumn and winter every year, the trees with low carbon sequestration capacity or low potential after evaluation should be felled to avoid excessive accumulation of dead branches and leaves, which may cause fire hazards, and the sites with possible fire hazards should be checked.[5]

⁜ Properly treat the felled trees to make wood products of good quality and carry out effective carbon sequestration.

⁜ Plant new trees in the forest in spring.

⁜ Understand the growth of forest trees and take targeted measures.

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