

Optimized forest carbon sequestration&Better homeland

Jingyu Xia, Yibo Wei *, Haitian Xu

Business School, Beijing Technology and Business University, Beijing, China, 100037

* Corresponding Author Email: 1465974395@qq.com

Abstract. In the past few years, the problem of climate change has become more and more serious. Carbon sequestration as a technical means was proposed as early as the 1970s, but it has only been widely used in recent years. As the "lungs of the earth", forests play an irreplaceable role in carbon sequestration. Therefore, the efficient use of forest resources and the establishment of adaptive carbon sequestration models will provide new ideas for determining forest management plans. In this paper, we divide two types of basic models. One is a prediction model based on the carbon sequestration data of a certain forest in previous years, and the other is an evaluation model. In the evaluation model, we select several factors, and then evaluate the importance and sensitivity of each influencing factor.

Keywords: forest management plan; carbon sequestration; grey model; entropy weight meth

1. Introduction

Today, the problem of climate change is becoming more and more serious, and it has challenged every country in the world. How to effectively deal with this problem has become urgent. Carbon sequestration, a technology for capturing and safely disposing of carbon dioxide, has great potential to reduce atmospheric carbon dioxide concentrations. In response to the current problems in the application of carbon sequestration technology, we decided to model an effective carbon sequestration mechanism and then establish an adaptive forest management plan [1].

2. GM model

The differences between regions and between forests are huge. A carbon sequestration model that is related to many factors and variables is difficult to simulate well. Therefore, we use the method of statistical prediction to predict the amount of carbon sequestration in the next few years based on the year-by-year changes in carbon sequestration in previous years. In this simple model, we use these quantities: i , f , C_i , $C(i+f)$, F , $\sum C(i+f)$. They represent respectively: year, year to be predicted, the carbon sequestration amount in year i , the forecast amount in the $i+f$ year, the most predictable year, and the total amount of carbon sequestration in the next f years [2].

Gray model, referred to as GM model, is to establish a gray differential prediction model through a small amount of incomplete information [3], and to make a fuzzy long-term description of the development law of things. We use grey prediction model to fit the time-dependent changes in forest carbon uptake in previous years, and predict the forest's carbon uptake in F years in the future [4].

The principle and overview of the grey model gm (1,1) are as follows:

Let $x(0)$ be the original sequence

$$x(0)=(x(0)(k) \quad xk=1,2,\dots,n)=(x(0)1,x(0)2,\dots,x(0)(n)) \quad (1)$$

Denote $x1$ as the generated sequence

$$x(1)=(x(1)(k) \quad xk=1,2,\dots,n)=(x(1)(1),x(1)(2),\dots,x(1)(n)) \quad (2)$$

$$x^{(1)}(k) = \sum_{i=1}^k x^{(0)}(i) \quad (3)$$

Let $x(0)=(x1, x2, \dots, x(n))$ Make a cumulative build

$x(k)=\sum x(m)$, Eliminate randomness and volatility in your data

$m=1$, then, $x=(x(1),x(2),\dots,x(n))= (x(1),x(1)+x(2),\dots,x(n-1)+x(n))$

x can establish the whitening equation: $dx/dt + ax=u$ i.e. gm (1,1), Calculate a,u using least

3. Fitting diagram of grey model

The known annual carbon sequestration will be brought into the grey model, $x(0)$ is our known annual carbon sequestration C_i , and $x^{(1)}(k+1)$ is the annual carbon sequestration forecast in the next F years[5] .

The total amount of carbon sequestered in these F years is equal to the sum of the annual forecasts $\sum C(i+f)=C(i+1)+C(i+2)+\dots+C(i+F)$.

According to the problem-solving idea, we build a gray model in the software, and use this model to substitute the mastered original data, we get the Figure 1 and the error analysis between the actual value and the predicted value. Error analysis of grey model is shown as figure2[6].

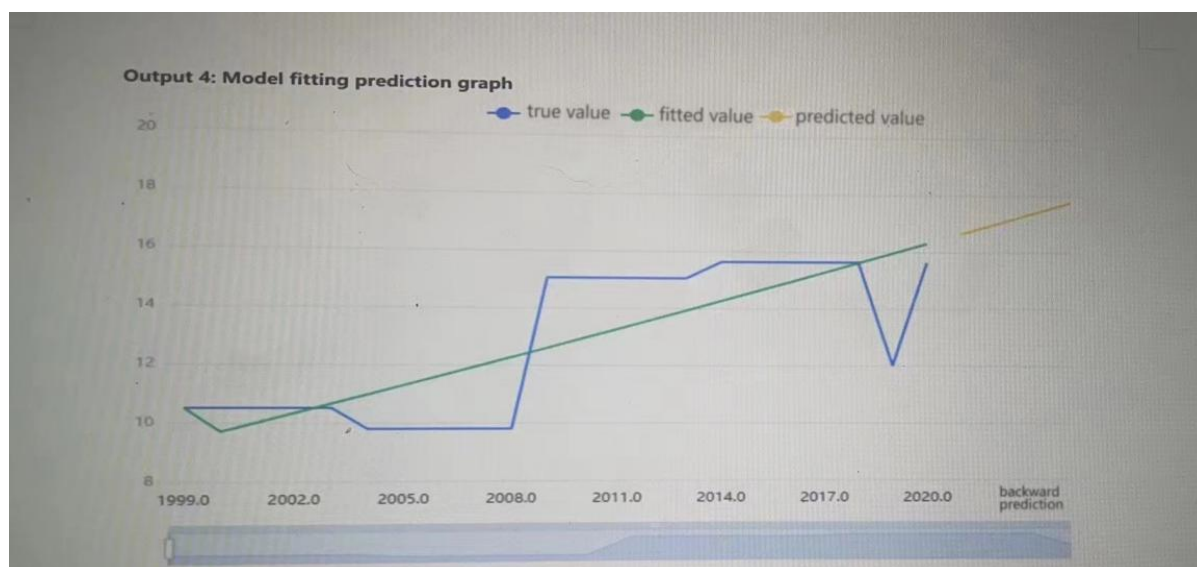


Figure 1. Fitting diagram of grey model

Output 3: Model fitting result table

index entry	Original value	Predictive value	residual	Relative error(%)
1999.0	10.512	10.512	0	0
2000.0	10.512	9.703	0.809	7.699
2001.0	10.512	10.019	0.493	4.692
2002.0	10.512	10.336	0.176	1.672
2003.0	10.512	10.655	-0.143	1.361
2004.0	9.792	10.975	-1.183	12.084
2005.0	9.792	11.297	-1.505	15.368
2006.0	9.792	11.62	-1.828	18.667
2007.0	9.792	11.944	-2.152	21.98
2008.0	9.792	12.27	-2.478	25.307
2009.0	15.048	12.597	2.451	16.286
2010.0	15.048	12.926	2.122	14.102
2011.0	15.048	13.256	1.792	11.908
2012.0	15.048	13.588	1.46	9.705
2013.0	15.048	13.921	1.127	7.493
2014.0	15.624	14.255	1.369	8.763
2015.0	15.624	14.591	1.033	6.613
2016.0	15.624	14.928	0.696	4.454
2017.0	15.624	15.267	0.357	2.286
2018.0	15.624	15.607	0.017	0.108
2019.0	12	15.949	-3.949	32.907
2020.0	15.624	16.292	-0.668	4.276

Figure 2. Error analysis of grey model

Studies have shown that forests can be divided into young forests, middle-aged forests, near-mature forests, mature forests and over-mature forests according to their ages [7]. Since its biomass basically stops growing, its carbon absorption and release are basically balanced. This shows that

appropriate deforestation can increase the rate of carbon sequestration in forests, so deforestation is an indispensable part of forest management. We take the ratio of C_{it}/V_{it} as the deforestation rate in the i th year and C_i/S_i as the carbon sequestration rate in the i th year. We can draw a scatter plot of the deforestation rate C_{it}/V_{it} and carbon sequestration rate C_i/S_i from the forest data of previous years, find the deforestation rate under the maximum carbon sequestration rate and apply this deforestation rate to the next year.

4. Establishing and evaluating forest management plans

4.1. Reasons for choosing these factors

By reading a large number of documents and encyclopedia materials, and analyzing and comparing the statistical results of recent forest resource inventories in China and the precipitation from 1999 to 2020 provided by the National Meteorological Administration of China, we can preliminarily explore the impact of forest carbon dioxide absorption. several major factors. Several factors are forest area (10,000 hectares), precipitation (mm), deforestation (100 million cubic meters), and disaster area (10,000 hectares).

Forest area. Forest area is the factor that has the most direct impact on carbon dioxide absorption. When the area increases within a certain range, that is, the number of green plants increases, so that the photosynthesis of the forest as a whole will be strengthened, and the absorption of carbon dioxide will naturally increase when other conditions remain unchanged.

Precipitation. Photosynthesis in plants is the chemical reaction of water and carbon dioxide to produce oxygen under light conditions. Therefore, moisture is also an important factor affecting carbon dioxide absorption. The main source of water for forests is rainfall, and some forests with favorable geographical conditions near rivers and lakes can be more nourished. We selected the annual average rainfall data of the past 20 years, which will play a crucial role in our analysis of the weights to build the model [8].

Deforestation. In the context of global climate change, in order to meet the needs of climate change, increasing carbon sequestration and reducing carbon emissions have become an important part of plantation management. Harvesting is the most important forest management method affecting the carbon sequestration capacity of forests. Harvesting directly reduces forest vegetation density or removes forest vegetation, resulting in a decline or disappearance of forest productivity and a reduction in carbon absorption capacity. At the same time, logging transfers vegetation carbon into wood products and biofuels, resulting in a reduction in carbon storage and carbon sequestration capacity in forest ecosystems. Therefore, it is an important part of forest management to formulate a reasonable harvesting period.

Disaster area. In this article, we focus on the relationship between fire and forest carbon sequestration. According to statistics, about 1% of the world's forests are seriously affected by fires every year, and the forest carbon emissions caused by fires account for about 5.8% of the global carbon emissions. Fire can not only directly decompose forest organic matter into inorganic matter, water vapor and carbon dioxide, causing greenhouse gas emissions, but also indirectly alter forest productivity, affecting vegetation structure and composition, soil properties, and nutrient cycling processes, thereby affecting forest ecosystem carbon cycling. Correctly assessing the impact of fire on the carbon sequestration capacity of forests will help to develop forest management plans tailored to local conditions [9].

4.2. The establishment and solution of the model

Next, we use the entropy weight method and the topsis model to quantify the weights of these four influencing factors, and the results are shown in Figure 3. Then, we can formulate the most appropriate forest management plan according to the obtained weights.

Output 1: indicator weight calculation

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Entropy weight method			
item	Information entropy value e	Information utility value d	Weights
Precipitation (mm)	0.982	0.018	0.109
Forest area (10,000 hectares)	0.901	0.099	0.608
Disaster area (10,000 hectares)	0.971	0.029	0.176
Deforestation (billion cubic meters)	0.983	0.017	0.107

Figure 3. Each factor and its weight

In addition to this, the amount of carbon dioxide absorbed also has a lot to do with the type of tree, and we can choose in terms of tree species to get a more optimized forest management plan. By reading Huang Liyuan's literature, we can know that the average annual carbon sequestration per unit area of fir is 0.2315mg/mu·year, Masson pine is 0.1878mg/mu·year, eucalyptus is 0.2061mg/mu·year, that is, fir > eucalyptus > masson pine. In summary, when we formulate a forest management plan, we set the tree species planted as fir, which will get better carbon sequestration [10].

In order to find the conditions for not deforestation while maintaining its carbon sequestration, we first assumed that the various influencing factors are linear influencing factors, and then we performed linear regression analysis on the data of four factors from 1999 to 2020, and obtained the coefficient of each factor, so that a multiple linear regression equation can be established:

$$Ci = -9.512 + 0.493 * Cuti - 0.045 * Sdi + 0.079 * Pi + 0.001 * Si \quad (4)$$

Next, If we make the amount of felling equal to 0, it is easy to find that the forest needs to be planted (493*Cut_i) to restore the amount of carbon sequestration in the current year, so it can be concluded that cutting down trees is beneficial to increase the amount of carbon sequestration to some extent. The linear regression analysis is shown in Figure 4.

Linear regression analysis results (n = 22)									
	Unstandardized coefficients		standardized coefficient		t	p	VIF	R ²	Adjusted R ²
	B	Standard Error	Beta						
constant	-9.512	4.758	-		-1.999	0.062	-		
Deforestation (billion cubic meters)	0.493	0.519	0.142		0.950	0.355	1.179		
Disaster area (10,000 hectares)	-0.045	0.035	-0.201		-1.297	0.212	1.268	0.677	0.601
Precipitation (m)	0.079	0.563	0.023		0.141	0.890	1.417		
Forest area (10,000 hectares)	0.001	0.000	0.673		3.607	0.002**	1.833		

Figure 4. Linear regression equation

4.3. The economic and social value of the plan

The assessment of forest carbon sink value is to judge the market value by taking the forest carbon sink function as the evaluation object. The assessment of forest carbon sink value has commonalities with general asset assessment, and is a market-oriented dynamic social and economic activity. Taking the forest in Hainan Province as an example, using the conversion factor continuous function method, and using the research results of the existing literature: the carbon transaction price is 15\$/t, referring to the exchange rate of RMB to the US dollar, and then the value of the forest carbon sink in Hainan Province is obtained as 4718405970.6525 yuan.

Research data show that the annual average carbon sink of China's forests is increasing. From 200 million tons of carbon in the fifth forest inventory to 418 million tons of carbon in the eighth forest inventory. If the supply potential of forest carbon sink is roughly regarded as the market supply capacity, that is to say, the market supply capacity of my country's forest carbon sink is constantly increasing. That is, in terms of social value, its potential is huge.

5. Applicability detection and application of the model

In this step, we first verify the applicability of the model. We selected more than 20 forests in China and substituted their data into our forest management plan model. In the end, it was found that the conclusions drawn by substituting the Daxing' anling forest were in good agreement with our

expectations, and the calculated carbon dioxide absorption was very close to the real absorption (the data of the Daxing' anling forests are shown in Figure 5. That is to say, our model is most suitable for this forest in the selected sample, that is, the Daxing' anling forest is suitable for our forest management plan.

	A	B	C	D	E	F	G	H
1	Forest name	Tree species	Forest area (10,000 hectares)	Affected area (10,000 hectares)	geographical location	Precipitation(mm)	CO2 absorption (100 million tons)	Harvesting volume (10,000 hectares)
2	Daxing'anling Forest	Xing'an larch	683.66	0.077006	Daxing'anling, Heilongjiang Province	400	0.752686	18.0014
3								
4								
5								

Figure 5. Data of Daxinganling forest

Next, we need to explore the projected carbon sequestration of the Daxinganling forests over the next 100 years. Here, we assume that the forest will be in an ideal state in the next 100 years, with extremely abundant resources and ample growth space, and there will be no competing species and no predators. So increasing forest density does not affect the rate at which each tree absorbs carbon dioxide. And the precipitation and disaster area remain the same every year. The forest area is expanding at a rate of 0.01 per year. We set N as the carbon dioxide absorption amount of the forest in the current year, so the carbon sequestration amount of the forest after 100 years is $N \cdot (1 + 0.01)^i$.

6. The importance of integrating logging into forest management

Forest resources are the natural conditions for human survival. In people's traditional cognition, deforestation is the destruction of forest resources. With the increasingly severe problems brought about by climate change, in recent years, countries around the world have realized the importance of strengthening forest management to protect natural ecology. In the past, there was a lack of scientific calculation and analysis of the amount of forest harvesting in the process of forest harvesting [6]. The blindness and randomness of forest harvesting led to more and more serious forest harvesting problems. This is probably the reason why deforestation has always been thought to be harmful and not beneficial.

However, with the integration of various technologies into forest management, forest managers can use models and algorithms to calculate the most reasonable forest harvesting period and harvesting method. We must realize that deforestation and forest protection are not opposites, on the contrary, they are a unified organic combination. In the process of forest harvesting, scientific calculation methods are used to calculate the amount of forest harvested, and a reasonable forest harvesting plan is formulated in combination with various factors such as the growth cycle of trees in forest resources and changes in the natural environment [7]. Moderate deforestation can effectively protect forest resources. Therefore, in order to achieve organic unity with forest protection in the process of forest harvesting, it is necessary to determine the comprehensive factors such as forest type, forest growth cycle and natural environment. and then calculate the number of forest trees to be harvested, so as to achieve orderly and moderate harvesting, realize the organic unity of forest harvesting and forest protection, and achieve sustainable development of forest resources.

Aiming at the current overall level of forest resource management, further build a sound forest resource harvesting and forest management system. Combined with the specific situation of forest resource management in the region, rationally apply the calculation model and measurement indicators of forest harvesting volume, fully grasp the local forest resources, scientifically determine the specific area and specific target of forest harvesting, regularly supervise, inspect and evaluate the forest harvesting volume, and strictly prohibit random cutting deforestation, etc. Through various means of publicity, guide the people to actively participate in the supervision and management of deforestation and forest protection, continuously improve the supervision and management level of forest resources management, and take effective punishment measures. In the process of forest harvesting, on the basis of meeting the conditions for forest protection, the scientific method of calculating the amount of forest harvesting is used, combined with the seasonal changes of local forestry resources, the growth cycle of forest trees, and the natural environment to organize and carry out forest harvesting operations. In the process of forest harvesting, the relevant regulations and

principles of harvesting should be followed, so that the forest resources have a good growth space and environment.

7. Model Evaluation And Further Discussion

The prediction model we used is the grey model, which is used to predict carbon sequestration over the next 100 years. The disadvantage of this model is that we only use the year in the selection of independent variables, and we do not consider the changes of other influencing factors. To a certain extent, this is an empirically derived model. But its advantages are significant. It is easier to collect and calculate data, and it is very convenient to apply it in short-term forecasting. When screening the optimal deforestation rate, this model is relatively reliable for forests with more deforestation data.

8. Conclusion

We search for information and data, select the model to be applied, write code to implement the model, and finally substitute the collected data into the model. We ended up with the conclusions we wanted, establishing a carbon sequestration model that met our expectations. According to the obtained carbon sequestration model, we determined the forest management plan based on the entropy weight method and the topsis model, and analyzed the role of deforestation in forest management. In order to cope with the growing problem of climate change, how to tap the maximum potential of forest ecosystems in maintaining ecological balance is the top priority of all forest managers. Our research will provide new ideas for forest management.

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