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Make use of grey prediction model and other models to design a reasonable carbon sequestration and forest management plan

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Abstract: Because of climate change, greenhouse gases are increasing.This phenomenon can be alleviated by increasing carbon sequestration, increasing economic benefits and making human life better. For that purpose. We make use of grey prediction model and other models to design a reasonable carbon sequestration and forest management plan. Hangzhou was selected as the research object. The models calculate that forests need to be cut down to reach equilibrium. The vegetation and Carbon Density Change Model (CEVSA2) and forest Management model (FOERCAST) were used to calculate the carbon sequestration of tree species with relatively high carbon sequestration, long production cycle and relatively low economic efficiency. The formula calculated by ENVI can be used as the sequestration stock of carbon dioxide in the region for more than 100 years. $y = -4.0\times10^{-6}x^2 + 0.0026x - 0.243(R^2 = 0.64)$ The total fixed carbon dioxide is 414,266,771 tons. We conducted data testing and prediction. The results show that our model has good stability.

1. Introduction

As the amount of carbon in the atmosphere increases dramatically, global average temperatures rise, leading to frequent droughts around the world. In addition, various anthropogenic activities, such as the conversion of forests to arable land and the diffusion of high levels of CARBON dioxide, greatly reduce the carbon uptake by trees and exacerbate the concentration of carbon dioxide in the atmosphere.[1] Sustainable forest management plays an important role in promoting carbon sequestration, maintaining soil fertility, increasing species diversity and improving community stability. Due to the huge area of plantation in the world, the assessment of adaptive management and carbon sequestration potential of plantation in the context of global climate change has important research value. Realizing sustainable management of plantation is a systematic project, which needs to find a balance between economic and ecological benefits[2]. Therefore, it is urgent to develop effective land use management plans to enhance carbon sequestration and reduce carbon dioxide emissions, so as to slow down the continuous deterioration of the environment and bring higher economic benefits.

2. Question Restatement

This paper aims to find out which forest management strategies can effectively sequester CO_2 and achieve the best economic benefits. We need to solve the following problems:

1) Create a model to calculate the amount of carbon sequestration in an area.It includes the net primary productivity of vegetation and co2 sequestration under the influence of natural and man-made interventions.

2) Use this model to get a carbon sequestration scheme, add the impact on the economy to get a final forest management plan and get the transition point setting.

3) Apply the model to specific areas to verify the rationality and effectiveness of the model and forecast future data.

3. Model Hypothesis

In order to simplify the problem and apply the model to the actual park, we make the following basic assumptions:

1) The selected area only carries out the water, carbon and nitrogen cycling process of the terrestrial ecosystem and normal human activities, without considering the natural disasters such as fire

2) The growth cycle, growth rate and carbon sequestration of trees remain stable

3) The price of felled trees remains stable

4) The species of trees will not change dramatically

4. Carbon Sequestration of Forests

For the amount of forest carbon sequestration, there is a close correlation with net primary productivity (NPP).The net primary productivity (NPP) of vegetation was calculated, and the carbon density and carbon sequestration were calculated by using CEVSA2 model. The optimal cutting quantity and forest management strategy are given through data.

4.1 Net Initial Productivity

Since the 20th century, NPP has been estimated by site measurement and model estimation. With the development of 3S technology, remote sensing technology is increasingly applied to estimate wetland productivity (Lu Guang et al.,2019).Among many terrestrial NPP remote sensing estimation models, CASA(Carnegie-Ames-Stanford Approach) is suitable for dynamic estimation of regional NPP based on light energy utilization of different vegetation, combined with environmental stress factors such as water and temperature, and fully considering various environmental factors (Rong Jian et al., 2017).[4].

Through reading and searching the literature, we found a way to calculate the value of NPP. The value of NPP was obtained from the product of photosynthetically active radiation (APAR) absorbed by vegetation and solar energy efficiency ε[5], calculation formula

$$NPP(x,t) = APAR(x,t) \times \varepsilon(x,t) \tag{1}$$

In Formula (1), NPP(x,t) is the accumulated NPP(g C ·m) of vegetation in pixel X in time period T-2t.-1);APAR(x,t) is the photosynthetically active radiation (MJ · M-2 · T-1) absorbed by vegetation in pixel X in time period T.ε(x,t) is the actual light energy utilization rate (gC·MJ-1) of vegetation in pixel X in time period T.

1) In the formula, the amount of photosynthetically active radiation (APAR) absorbed by plants is equal to the amount of photosynthetically active radiation (FPAR) and 0.5 times of the total solar radiation energy (SOL) received.[5], the formula is:

$$APAR = FPAR \cdot SOL \cdot 0.5 \tag{2}$$

The ratio of plant photosynthetically active radiation absorption (FPAR) has a linear relationship with NDVI[6], the formula is:

$$FPAR(x,t) = \frac{(NDVI(x,t) - NDVI_{i,\min}) * (FPAR_{\max} - FPAR_{\min})}{(NDVI_{i,\max} - NDVI_{i,\min})} + FPAR_{\min} \tag{3}$$

Following optimization of the model, the calculation formula of FPAR obtained is:

$$FPAR(x,t) = \frac{(SR(x,t) - SR_{i,\min}) * (FPAR_{\max} - FPAR_{\min})}{(SR_{i,\max} - SR_{i,\min})} + FPAR_{\min}$$

$$SR(x,t) = \frac{1 + NDVI(x,t)}{1 - NDVI(x,t)} \tag{4}$$

Through data verification, the FPAR calculated by NDVI was higher than the measured value, while the FPAR calculated by SR was lower than the measured value. The final value of FPAR was determined by NDVI and SR, and the error was minimized by combining the two results, and the average value was taken[5], that is:

$$FPAR = \frac{FPAR_{NDVI} + FPAR_{SR}}{2} \tag{5}$$

2) ε depends on the maximum light efficiency of water, temperature stress coefficient and image coefficient, and the calculation formula is as follows:

$$\varepsilon = \varepsilon_{\max} \cdot T_{\varepsilon} \cdot W_{\varepsilon} \tag{6}$$

Type in the $\varepsilon_{\max}$ Is the maximum light utilization, is a constant, depends on the vegetation type; T_ε is the temperature stress factor and W_ε is the mirror coefficient of moisture stress.

4.2 NPP Estimation and Results Discussion

As can be seen from the construction and algorithm of CASA model obtained in 5.1, this paper mainly uses the light energy utilization model

In CASA model to calculate NPP, that is: $NPP(x,t) = APAR(x,t) \times \varepsilon(x,t)$.

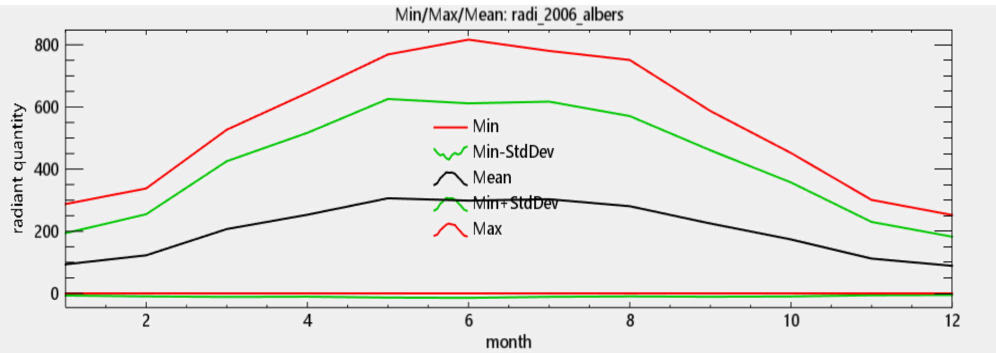
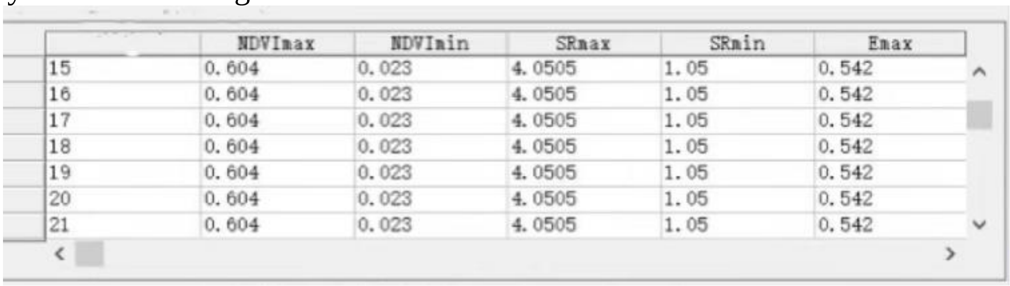


Figure 1. Total monthly solar radiation in China in 2006

The calculation of NPP is based on the IDL software platform developed by Professor Pan Yaozhong of Beijing Normal University. As shown in Figure 1.

Land use data from The Department of Resources and Forest Administration, Ministry of Forestry, China Forest Resources Report -- The seventh National Forest Resources Inventory, China Forest Resources Report (2009-2013)

Static parameter Settings include the maximum and minimum values of NDVI, SR and maximum light energy utilization ε of each vegetation type, and input the obtained data successively. As shown in Figure 2.



	NDVImax	NDVImin	SRmax	SRmin	Emax
15	0.604	0.023	4.0505	1.05	0.542
16	0.604	0.023	4.0505	1.05	0.542
17	0.604	0.023	4.0505	1.05	0.542
18	0.604	0.023	4.0505	1.05	0.542
19	0.604	0.023	4.0505	1.05	0.542
20	0.604	0.023	4.0505	1.05	0.542
21	0.604	0.023	4.0505	1.05	0.542

Figure 2. Static parameters of vegetation cover

The maximum value and minimum value of NDVI, as well as SR value and minimum value of NDVI of four different vegetation types were found respectively. The maximum value of NDVI does not refer to the actual maximum value of vegetation type, but to the NDVI value that vegetation happens to be in full coverage state.Zhu wenquan introduced vegetation classification accuracy to eliminate the inherent errors of vegetation classification accuracy and NDVI, so that the maximum and minimum values of vegetation classification accuracy vary according to different classification accuracy[7].The DN values corresponding to the probability distribution of 95% and 5% for the maximum and minimum NDVI values were taken respectively. This step is to eliminate the error caused by MODIS image noise[7], and then find out the maximum and minimum VALUES of NDVI of different vegetation types in 12 months, and finally take the maximum and minimum values of NDVI in 12 months. According to zhu Wenquan's research results, the maximum light energy utilization rate of forest land, sparse forest land, shrubby forest land and other forest land can be averaged for each vegetation type. As shown in Figure 3.

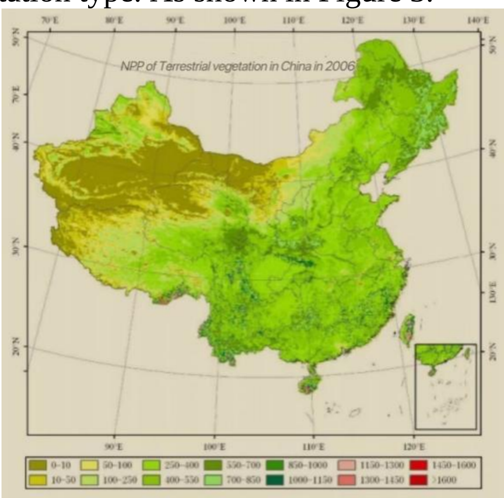


Figure 3. Distribution of carbon sequestration by region in China in 2006

Using the data and calculation methods obtained from the model, we calculate the carbon dioxide sequestration of forest ecosystem in hangzhou city in 100 years. As shown in Figure 4.

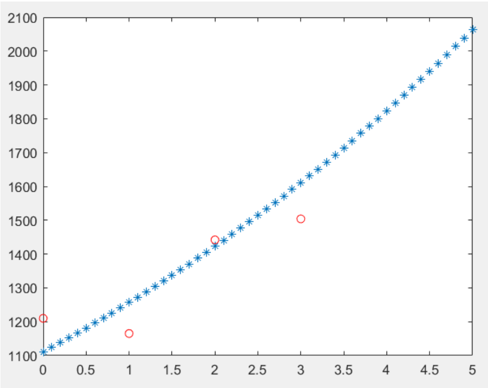


Figure 4. Annual mean value of NPP of forest ecosystem in Hangzhou from 2000 to 2015 $(gC/m^2/a)$

As shown in the figure, the relationship between carbon sinks of different types of forests and grasslands and THEIR NPP is as follows: in the equation, NPP is based on the CASA model of forest ecosystem service value evaluation in Hangzhou.Therefore, this paper establishes the model, because Chinese fir is a kind of artificial forest species mainly planted in various regions, and can form a mixed forest with a variety of tree species. Use a mixed fir forest as a template. FORECAST model and logging decision model are used as decision model and carbon sequestration cost accounting model to find the balance between natural value and economic benefits. Finally realize the forest evaluation management plan.

5. Forest management strategies

5.1 FORECAST model

The simulation scene is set as follows: Under medium site conditions (SI = 21, SI was the average height of dominant trees at the base age of 50 A in Chinese fir plantation), the mixed ratio of Chinese fir (target species) and P were 5:1, 3:1 and 2:1, respectively, and the afforestation density was 3 000 plants /hm2 (based on the conventional afforestation density in production practice, The rotation period of Cunninghamia lanceolata and Nanphoebe was 25 years and 40 years respectively. In order to avoid the normal growth of young Cunninghamia lanceolata forests affected by zhennan shading, in one zhennan round cutting period, not reforestation after cutting cunninghamia lanceolata; The pure cunninghamia lanceolata forest and pure phoebe forest were compared.[9] The results are analyzed by calculation.

According to the above data, cunninghamia lanceolata mixed forest can effectively increase carbon storage and play an important role in maintaining site productivity, which is an effective measure for planting artificial forest.The results showed that the ratio of Chinese fir and Nanphoebe should not be too large. Under normal management conditions, the ratio of Chinese fir and nanphoebe was 3∶1, and the carbon sequestration effect was the best in Chinese fir and nanphoebe mixed forest.

5.2 Optimal logging decision model under intergenerational equity principle

The principle of intergenerational equity (also known as the principle of sustainability) is the second important principle in resource economics. Specifically for forest resources, it is to ensure that every generation can get benefits from forests. Ensure every year, the amount of wood can be cut to reduce and be able to maintain forest wood storage quantity does not reduce, the purpose is to make various efficiency without reducing of forest, future generations have generations are not for less so than before, if you want to meet the requirements of intergenerational fairness, forest is best able to grasp the speed of afforestation, the area is expanding steadily.

It is assumed that the optimal cutting period of a certain tree can be calculated by the model, and the afforestation scale of a certain forester remains about the same every year. In this way, by the end of the year T, there will be approximately the same number of trees ranging in age from L to 7 years in this forest, and the total volume of wood storage is day (T).xhm^{2}The volume of trees felled in this year is: where: n is the density variable, indicating how many trees grow on each hectare of land;n · x · V(t)$_0$X represents planting area;Y (£) represents the volume of each T year tree. After one year, the sum of the volume of all newly grown trees can be calculated as follows:

$$n \cdot x \cdot \{V(1) + [V(2) - V(1)] + ... + [V(t) - V(T-1)]\} = n \cdot x \cdot V(t) \qquad (7)$$

It indicates that the total forest stock has not changed after one year, and the formula is as follows:

$$H(T+1) = H(t) - n \cdot x \cdot V(t) + n \cdot x \cdot V(T) = H(t) \qquad (8)$$

In the future, only trees that are T years old will be cut down each year, so that trees that are not T years old will not be cut down.

5.3 Carbon sequestration cost of plantation

Austrian scholar Friedrich explained "opportunity cost" from different angles in natural Value. In economics, opportunity cost is defined as "the other things that must be given up for choosing one thing, that is, the benefits that can be gained in other uses after a resource is used for one purpose".[10].Carbon sequestration cost is calculated as follows:

$$C_T = C_{i,0} + \sum[C_{m,t}(1+r)^{-t}] + \sum[C_{0,t}(1+r)^{-t}] + \delta(P_t - C_h)V_T(1+r)^{-T}, t = 0、1、2、...、T。 \qquad (9)$$

5.4 Conclusions of forest management Plan

According to the above data and results. Forecast model was used for tree mixing, optimal cutting decision model and carbon sequestration accounting cost model under the principle of intergenerational equity were used for forest management, and the optimal carbon sequestration scheme and economic benefits were obtained.

6. Best management plan transition method

From the current forest management in the time of transition to a new line of original forest can adopt the principle of intergenerational equity under the optimal decision model of the cutting, cutting the calculated the forest trees originally best cutting time, under the condition of no cover for artificial planting trees in line with the new management plan, regulate the percentage of all kinds of trees, Make the transition to the new time line in the process of forest managers don't because of the new forest management plan transition influence economic benefits, also can meet the needs of users of the forest, though the best management plan includes 10 years longer than current forest practice time between two harvest, but in the meantime also can satisfy the forest management and forest also can guarantee the demand.

7. Advantages and Disadvantages analysis

7.1 The advantages

1) The carbon sequestration model and forest management plan established by us are based on the research results of grey prediction model, so they are relatively strict.

2) The verified results are roughly consistent with the actual data, which indicates that our model is reasonable and effective.

7.2 Disadvantages

Our model ignores the impact of sudden natural disasters and extreme human intervention, and the data in our calculation of carbon sequestration is too ideal, which may reduce the accuracy of our model.

8. Improvement Plan

For the weight in the grey prediction model is not accurate, it should be accurately estimated, and the coincidence between the predicted value and the actual value is not very high, and the ratio of the number of mixed trees is not particularly accurate. In addition, we should also consider the increase and decrease of forest area.

9. Forest Management Report

To sum up, forest resources are extremely important to us.In daily life, we still need to rely on cutting a large amount of wood to provide fuel, paper and so on. Therefore, it is particularly important to choose which forest model, and we chose RECAST model to study the effects of different mixing ratios on carbon sequestration in mixed forests. It can not only increase the diversity of artificial forest species, but also have many advantages.

Therefore, in the process of forest management, managers should carry out appropriate logging. According to the latest published "Forest Law" overall consideration, according to local conditions, adopt appropriate methods and effective implementation.The government should also strengthen the management of forests, not only to meet the daily needs of local people, but also to drive economic development as far as possible to achieve real sustainable development.

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