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Decision models to improve the overall efficiency of forests to mitigate global warming

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Abstract: The World Meteorological Organization (WMO) reported that global greenhouse gas concentrations reached a new high in 2020, accelerating the process of global warming. The worsening climate situation has led to frequent extreme weather in many parts of the world. This paper will find out how to mitigate global warming by maximizing the overall benefits of forests based on the optimal period of deforestation. According to the triple bottom line theory, we define the comprehensive benefits of forests as ecological benefits (carbon sequestration benefits and other benefits), social benefits, and economic benefits. Therefore, we first constructed three benefit models respectively, and obtained the linear relationship between the three benefits of five functional forests through grey relational analysis. Based on this, a decision-making model of forest management plan based on ESE was constructed, and the optimal deforestation period and the optimal comprehensive benefit of forest were deduced. In addition, we select China, the country with the largest carbon emission, for a specific case analysis to prove the effectiveness of the decision. Visualize the comprehensive benefit analysis of various regions in China, which is highly consistent with the facts and effective in decision-making. And even if the optimal forest management plan is delayed for 10 years and enters the felling period, its comprehensive benefit in the T+10 year is higher than that of the current forest management plan that has entered the cutting period for 10 years.

1. Introduction

On 31 October 2021, the World Meteorological Organization (WMO) released its interim report on the State of the Global Climate 2021. Record concentrations of greenhouse gases and heat buildup in the atmosphere are pushing the planet into uncharted territory and will have profound consequences for present and future generations, according to the World Meteorological Organization[1].

According to the report, the average global temperature in 2021 (from January to September) will be about 1.09 degrees Celsius higher than the 1850-1900 period, currently ranked by the World Meteorological Organization as the sixth or seventh warmest year on record globally. The worsening climate situation has led to frequent extreme weather events in many parts of the world, such as major forest fires, floods and droughts. The rising frequency and intensity of extreme weather events is creating a "dangerous combination" of violent conflicts, economic downturns and pandemic shocks, undermining decades of global progress in improving food security. To solve these problems, we need to focus on solving the climate problem. The mainstream view of the scientific community believes that the greenhouse effect caused by greenhouse gas emissions in recent years is the main cause of global warming. In 2020, the global greenhouse gas concentration has reached a new high, making the world climate situation more severe. Carbon sequestration and sequestration is one of the important ways to ease the tension of global climate change. Using natural ecosystems such as forests to absorb atmospheric carbon dioxide and thus reduce the overall greenhouse gas content is one of the best methods with low cost, high return and large-scale application. With the increasing improvement of carbon sink metering technology and the rapid development of related industries, Forest carbon sinks play an irreplaceable role in climate change adaptation and mitigation[2]. Many countries and regions have gradually increased the importance of forest ecological benefits, social benefits and economic benefits, the importance of forest comprehensive benefits has been widely recognized.

2. Construction of decision-making model of forest management plan based on ESE

Forest management may have different meanings in different contexts, but generally refers to forests that are directly affected by human activities. Lin Xuanzuo (2019) believes that the influence from national policies is crucial and indispensable for the overall development and continuous advancement of forest management plans. When formulating relevant forest management plans, the country will fully consider the relevant benefits of forests, so as to limit the species and quantity of felled trees, regulate the cutting schedule and how to regenerate forests, so as to achieve sustainable forest development. According to the triple bottom line theory, Senli management plan decision-making must adhere to the social bottom line, ecological bottom line, and economic bottom line, and correspondingly should also assume social responsibility, ecological responsibility, and economic responsibility, that is, to achieve a balanced development of social benefits, ecological benefits, and economic benefits.

2.1. Construction of Social Benefit Model

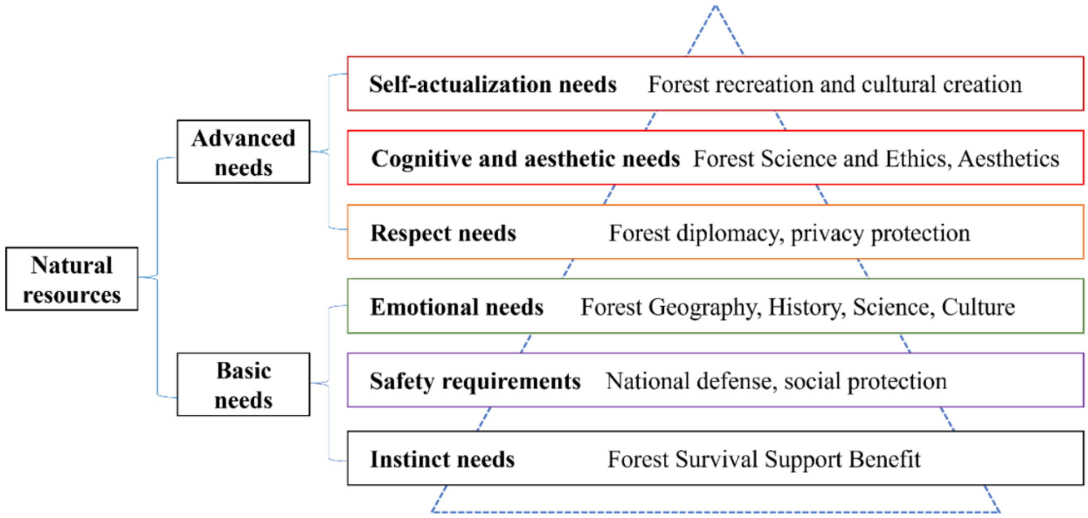

Figure 1: Construction system of forest social benefit

The social benefits of forests are the contributions, benefits or beneficial effects that the forests make or may provide to the society in terms of culture, science, education, aesthetics, psychology, history, geography, security, etc. Based on Maslow's demand theory framework, this paper proposes a three-level comprehensive evaluation system of forest social benefits, indicating the importance of each demand. The system systematically reflects the main social benefits of forests, and the specific framework is shown in the figure1[3].

Based on this framework, we can see the order of importance of each need: instinctive needs > safety needs > emotional needs > esteem needs > cognitive and aesthetic needs > selfactualization needs. However, because the indicators are difficult to quantify, we only consider the benefits of forest social security, through the employment rate of the forestry industry, the average wage level, and the development level of the tourism and leisure industry[4].

- Employment rate refers to the percentage of employed population in the total population.
- The development degree of tourism and leisure industry can indicate the degree of promoting poverty alleviation in forest areas and improving the sense of well-being of residents in forest areas.

2.2. Construction of ecological Benefit Model

With the development of social economy and the development and utilization of forest resources, the value of forest ecological environment is increasing, and the impact on the national economy is becoming more and more extensive. In recent years, forest ecological benefits have been further developed in the direction of sociology, which is the extension of forest ecological benefits to the selection value and existence value of forests. Therefore, we look for "substitute commodities" for specific forest ecological benefits as the basis for value estimation, and construct a monetary estimation model for forest ecological benefits:

$$E_i = \sum P_i * R_i * C_i * S_i \, , i = 1,2, \dots ,7$$

In the formula: Ei is the monetary amount of forest water conservation, soil consolidation, fertilizer conservation, carbon dioxide absorption, air purification, and forest suppression of sandstorms; Pi is the effective area coefficient; Ri is the market approximation coefficient; Ci (yuan ·hm-2) is the replacement Commodity price; Si is the forest area.

According to the relevant data such as the "Forestry Statistical Yearbook" and the United Nations Resources Agency, we use the average price of farmland, industry, and domestic water as a substitute for water conservation. Through calculation, the price of the substitute commodity is 0.5 yuan/hm2 . Specific "substitute commodities" of forest ecological benefits and their indicators are shown in the table 1 below:

Table 1: Monetary Quantity Construction Model of Forest Ecological Benefit

Ecological Benefit	Pi	Alternative commodity types	Ci	Ri
water conservation	1.0	Average price of water	[0.65,0.66]	[0.5,0.9]
Soil fixation	1.0	Farmland fixed soil price	[9.07,21.80]	[0.4,0.6]
Keep fertilizer	1.0	fertilizer price	[833.40,847.60]	[0,0.1]
absorption of CO2	1.0	Average price of artificial carbon sequestration and afforestation costs	[861.50,875.50]	0.1
purify the atmosphere	1.0	Average price of artificial oxygen production and afforestation costs	[1253.60,1270.00]	0.2
Restrain wind and sand	1.0	Artificial sand fixation cost	450.00	[0.1,0.9]
maintain biodiversity	1.0	Average price of forest maintenance species	41448.00	0.9

2.3. Construction of economic Benefit Model

In addition to the social and ecological benefits of the forest industry, economic benefits are the third largest benefit of the forest industry. Forestry resources are one of the important renewable resources, which can effectively promote social progress and market economic development. For example, some trees have extremely high economic value and can be used in industries such as construction and paper making, producing a series of forest products and integrating them into all aspects of public daily life. In recent years, with the continuous development of carbon sequestration-related industries, the return on investment has increased. If the ecological benefits of forests can be measured in a clear monetary form, the economic value embodied in forest construction can be evaluated more comprehensively and reasonably, and the rational planning and decision-making process of forestry can be realized[5].

Because the economic benefits of forests occur every year, and with the different forest ages, the benefits and costs are also different. Therefore, we choose the tree production cycle calculated by forest products as the evaluation period, and in a production cycle, the forest benefits show different values at different time points[6]. Due to the objective existence of the concept of time value (that is, a certain amount of currency value in the future is smaller in value than the same amount of currency value now, this is mainly due to the profit rate of funds and the existence of time preference rate), that is, the forest in a cycle The amount of economic benefit value should be converted into the amount of monetary value at the same time point using the principle of discount or compound interest, so as to facilitate comparison.

If we want to evaluate the future benefits of the forest, we need to discount, the calculation formula is:

$$PV = \sum_{t=1}^{n} \frac{R_t}{(1+r)^t}$$

If we want to evaluate the existing benefits of the forest, we should carry out compound interest calculation, the formula is:

$$PV = \sum_{t=0}^{n-1} R_t (1+r)^{n-t}$$

Where PV is the total present value of economic benefits (costs); n is the evaluation period; t is the year; r is the discount (or compound interest) coefficient; Rt is the value of benefit (cost) in year t[7].

This paper adopts the total value of primary, secondary and tertiary industries (except forestry tourism and leisure services) in year t. The output value represents the benefit value in year t.

2.4. Construction of decision-making model of forest management plan based on ESE

Under the current environment of rapid global economic development but sharp deterioration of the ecological environment, giving full play to the ecological and economic efficiency of forests and protecting the environment will inevitably become a major theme of forest management. Therefore, it is necessary to integrate the ecological benefits, economic benefits and social Beneficial inclusion of a model of the rotation period. Add ecological, economic and social benefits to 3.4 Rotation model based on carbon sequestration benefits.

$$V_1 = V_s + V_c + V_3 + aPV_1 + bPV_2 + cPV_3 + dE$$

Among them, V3 represents the social benefit mentioned above, PVi (i=1, 2, 3) is the economic benefit of the three major industries, and E is the ecological benefit of the above structure. We represent a, b, c, and d here by the obtained correlation between trees and benefits. The model solution is the same as the carbon sequestration benefit model, and the optimal rotation period in this case is obtained by derivation.

3. Result analysis and conclusion

The decisionmaking model of the management plan in this paper is applicable to the five functio nal forests defined by the international forest law, which are shelterbelt, shelterbelt, special purpose forest, timber forest, fuel forest and economic forest[8].

For the above, we can stipulate that Article 31 of the Forest Law stipulates that the logging of for ests and trees must comply with the following provisions. The logging of historical sites in special-purpose forests, forests in revolutionary memorial sites, and forests in nature reserves is strictly pro hibited. Therefore, for this specialpurpose forest, there is no need to consider the rotation period mo del, and no felling is required.

Through the grey relational analysis, it is obtained that the comprehensive benefits of different tr ees are different, that is to say, the four parameters a, b, c, d of different trees in the rotation period model of the forest benefit are different, then the optimal rotation is obtained. The cutting period is different. This can explain that there will be excessive points in forest management plans. For exam ple, timber forests, in the young, middle and near ripening stages, will produce ecological and social benefits, but no economic benefits[9]. At this time, the a, b, c parameter can be considered as 0. Afte r the transition reaches the mature stage, economic benefits will be produced, while the ecological b enefits will decline. The society will only consider the parameters a, b, and c because logging is req uired in the mature stage[10].

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