Forest Management Plan Based on Ecological Economic Forest Management Decision Model——Taking Purple Mountain in Nanjing, China as an Example

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Abstract: In response to the second question, we clarified the scope of the management plan, including geographic location, species of trees to be harvested, and management methods adopted. The idea of linear programming is used to carry out corresponding asset evaluations in the early production period, the initial production period, the peak growth period, and the recession and dormancy period. Combined with the actual situation, the situation that the forest has not been cut down is analyzed and illustrated with examples.

Keywords: Linear Programming; Forest Management Decision-Making Models; Management Plan

1. Determination of the Scope of Forest Management Decision-Making Model

Our decision-making model proposes a wide range of management. In terms of terrain, it is suitable for areas with diverse landforms and various terrains, covering low mountains, hills, plains, etc., and can adapt to most of the world's forests. In terms of environment, Nanjing City we selected belongs to the north subtropical monsoon climate zone, with four distinct seasons and abundant heat. The average annual temperature is 15 to 22 degrees Celsius, the average temperature in the coldest month is between 0 to 15 degrees Celsius, and the warmth index is 135 degrees Celsius per month to 240 degrees Celsius per month. The temperature in summer is high, the temperature in winter is low, and the duration of spring and autumn is short. At the same time, there is sufficient sunshine and abundant precipitation. The annual precipitation is mostly 800 to 1600 mm, which is suitable for the growth of various types of trees. The favorable environment promotes the diversity of forest species. The types of trees in Nanjing cover most of the common trees. Among them, we focus on the area of Purple Mountain, which has obvious transitional vegetation, rich plant resources, and arbor, shrubs, vines, herbs, a total of 113 families, more than 600 species, common conifer species include masson pine, black pine, slash pine, cedar, arborvitae, etc., deciduous broad-leaved tree species include hemp oak, cork oak, sweetgum, hackberry, elm et al., evergreen broad-leaved tree species are mainly ganglia, kuchu, heather and holly [1], which makes our decision-making model less limited. In terms of area, the data we use is the data of the second-class survey of forest resources in Nanjing in 2018, with a total of 171,922 small classes, and the total area of forest land surveyed is 169,360.98hm^2 . At the same time, we combine the continuous inventory data of forest resources in Nanjing in 2010 and 2015, the field survey data in 2017, and the forest resources survey results of the State Forestry Administration in the Purple Mountain area over the years, fully integrate the data, and the investigation is meticulous and comprehensive. The accuracy and reliability of the model are higher, which is conducive to promotion to a larger area.

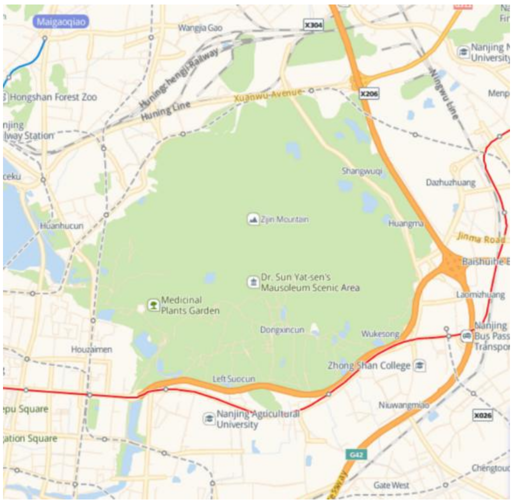

Figure 7: Purple Mountain Map

Based on our analysis in the three major directions of terrain, environment and survey area, the management plan recommended by the decision model ranges (by climate type) as subtropical monsoon and subtropical humid climate, temperate oceanic climate, temperate monsoon climate, and tropical rainforest climate, tropical monsoon climate, mediterranean climate.

2. Using Linear Programming Thought to Find the Balance Point of Carbon Sequestration and Economic Benefit

According to the known information, we establish a linear programming model, and set X_i as the volume of logs that can be made after the original trees are cut down (unit: m^3), where X_1 represents the volume of pine logs, X_2 represents the volume of fir logs, X_3 represents the volume of oak logs, X_4 represents the volume of bamboo logs, and X_5 represents the volume of economic forest logs. Let x_i be the felling volume of each log, m_i the economic value of each log, and G_i the carbon sequestration per unit volume of each tree. Let w_1 be the weight of forest economic value, and w_2 be the weight of forest ecological value (mainly carbon sequestration). According to the data and the actual situation, we take the value of w_1 as 0.38 and the value of w_2 as 0.62. Due to the restrictions of the ecological environment and the government's control, the felling of pine, fir and oak trees shall not exceed half of their original quantities, while the cutting of economic forests and bamboo forests is not restricted. The growth of pine trees reaches a state of decline after 300 years, the prosperity of cedar trees is about 180 years, and the growth rate of oak trees slows down after 230 years of growth. The growth cycle of bamboo is 4-8 years. The growth cycle of most trees in economic forests In 20-50 years, so we can get a rough relationship between x_i : $x_1 < x_3 < x_2 < x_5 < x_4$.

3. Asset Valuation Model

We can easily find that the price of pine logs per cubic meter is 2,280 yuan, the price of fir logs is 1,700 yuan per cubic meter, and the price of oak logs is 3,600 yuan per cubic meter, but we cannot directly obtain bamboo and economic forest logs. price. Subsequently, we conducted asset evaluation on bamboo forest and economic forest logs per cubic meter. Subsequently, we conducted asset evaluation on bamboo forest and economic forest resources. Due to the large differences in the economic benefits and management characteristics of bamboo forest and economic forest resources at different growth and development stages, the applicable evaluation methods have changed, the pre-production period the initial period, the peak growth period, the recession period to carry out the corresponding asset assessment.[2]

(1) Pre-production

The pre-production period refers to the stage from when the tree is planted to when it is about to bloom and bear fruit. We use the replacement cost method for measurement and calculation. Considering that new afforestation needs to remove debris, prevent diseases and insects, regularly prune, fertilize, etc., our calculation formula is

$$E_{\mathrm{n}} = K \times \sum_{j=1}^{\mathrm{n}} C_i \times \left(1 + P\right)^{\mathrm{n}-i+1} \quad (15)$$

(2) The initial production period

The initial production period refers to the stage when the tree enters the stage of producing fruit, and we use the present value method of income. When the economic life of each variety is known, the average yield from this time to the peak of production is estimated.

$$E_{\mathrm{n}} = K \times \left\{ \sum_{i=n}^{m} \frac{B_i}{\left(1 + P\right)^{i-n+1}} + E_m \times \frac{\left(1 + P\right)^{\mathrm{u-m}} - 1}{P \times \left(1 + P\right)^{\mathrm{u-n}}} \right\} \quad (16)$$

(3) The peak growth period

The peak growth period refers to the stage when the product yield of forest land resource assets reaches the highest level and the income is stable. According to this characteristic, we adopt the present value method of income, which is expressed as follows:

$$E_{\mathrm{n}} = A_{\mathrm{u}} \times \frac{\left(1 + P\right)^{u-n} - 1}{P \times \left(1 + \mathrm{p}\right)^{\mathrm{u-n}}} \quad (17)$$

(4) The recession period

The recession period refers to the stage of gradual aging of trees. At this time, the product output of forest resource assets declines slowly, and timely cutting is needed to avoid large losses. The cut trees can be used to make furniture, wood, paper and other wood products.

Through calculation, we get the price of bamboo logs is 300 yuan per cubic meter, and the price of economic forest logs is 860 yuan per cubic meter. The objective function is

$$\mathrm{Max}\ w_1 \sum \mathrm{x}_{\mathrm{i}} \times m_i + w_2 \sum \left(X_i - x_i\right) G_i \quad (\mathrm{i} = 1,2,3,4,5) \quad (18)$$

The constraint

$$x_j \leq \frac{1}{2} X_j \quad (\mathrm{j} = 1,2,3)$$

$$x_k \leq X_k \quad (\mathrm{k} = 4,5)$$

$$\mathrm{x1} < \mathrm{x3} < \mathrm{x2} < \mathrm{x5} < \mathrm{x4}$$

At the same time, there is a correlation between Gi and XI. With the increase of forest area, nitrogen fixation shows a complex increase. Therefore, with the increase of deforestation xi, Gi gradually decreases, The relationship between them is expressed in an algebraic form:

$$G_i = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{\left(x_i - \mu\right)^2}{2\sigma^2}} \quad (19)$$

Considering that different types of data units may be different, we first input the data in sequence according to the format, and then use the scale function in R language to centralize and standardize the data and eliminate the dimensional influence. After that, we input the objective function and constraint conditions into Lingo to solve the problem, and the obtained balance plan is felling 2.1% pine in the total pine, 4.6% Chinese fir, 3% oak in the total oak, 23% bamboo in the total bamboo and 15.2% economic trees in the total economic forest every year. It should be noted that: We should first consider cutting down over-mature and mature forests and avoid cutting down young and mature forests.

4. Analysis Without Deforestation

In extreme cases, such as floods and forest fires, deforestation will be stopped for 2-3 years. How long the trees need to grow naturally, that is, the length of deforestation will be stopped, depending on the severity of the disaster. When the government strictly controls and launches protection policies for the nature reserve, there may be no logging. At the same time, logging should be stopped for one or two years every ten years as planned to avoid damaging the local ecosystem.

References

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