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Research on Forest Carbon Storage Capacity Based on the Method of Biomass Conversion Factor

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Abstract: *With the continuous progress of human society, global warming has gradually become a global environmental problem. The main cause of global warming is the greenhouse effect, i.e., rising carbon concentration. Forests and related forest products play an important role in alleviating the greenhouse effect and realizing carbon sequestration. In order to further explore the impact of forest management plan on its carbon sequestration capacity, this paper took pinus koraiensis and fir of the Lesser Khingan Mountains as examples, and implemented the cutting and non-cutting plans respectively with 160 years as a cycle, and calculated its carbon sequestration by the method of Biomass Conversion Factor. The results showed that the carbon storage capacity of cutting in one cycle is 22,290 t more than that of non-cutting, and the carbon sequestration capacity of pinus koraiensis and fir is 104,715 t and 86,757 t respectively under the cutting plan. This paper can provide reference for balancing the relationship among forest economic value, biodiversity and carbon sink storage and optimizing forest management plan.*

Keywords: *Carbon Sequestration, The Method of Biomass Conversion Factor, Forest Management, The Lesser Khingan Mountains*

1. Introduction

At present, the global climate change characterized by warming is occurring, which has become a common crisis and challenge faced by all countries in the world[1]. The main cause of global warming is the greenhouse effect, which is caused by the rising carbon concentration with economic development[2]. With the increasingly prominent contradiction between resources, environment and economic development, people in the 21st century are facing new changes in the mode of economic development, and people must take into account the huge impact on the climate system accumulated by the tiny feedback brought by the increase in carbon dioxide concentration[3]. Against this background, a low-carbon economy characterized by low energy consumption, low material consumption, low emissions and low pollution[4] has emerged.

How can we better reduce carbon emissions and achieve a low-carbon economy? To solve this problem, a large number of scholars have carried out relevant research. Lv Pengfei et al.[5] considered CO_2 geological storage as an important method to achieve emission reduction, and the wettability of the wall surface of rock porous medium was also one of the key factors affecting its storage capacity. Shan Tongwen et al.[6] proposed a distributed, centralized, and multi-mode cooperative CO_2 liquefaction storage scenario, and proposed suggestions for the development of large-scale offshore carbon storage. Zhang Yuan et al.[7] affirmed the carbon fixation capability of foamed concrete and believed that it also had good application space in solid waste and waste gas resource utilization in coal-electricity integrated mining area. Ge Zhipeng[8] studied the changes of carbon storage level of forest ecosystems under the influence of different factors.

Actually, forests can affect climate change through carbon sequestration. Growing forests have a large volume to absorb sufficient amount of carbon and increase the carbon storage of forests. According to statistics, China's forest coverage rate is 23%, and the area of artificial afforestation is 79,542,800 hectares, which has great potential to increase forest carbon sink. Forest management and public policy can strongly affect the sequestration process.

Forest live wood and its forest products play a significant role in carbon sequestration, and different forest management plans also affect carbon sequestration in forest ecosystems. In order to further explore the impact of forest management plan on its carbon sequestration capacity, this paper will take the Lesser Khingan Mountains as the research object, select its representative pinus koraiensis and fir, and implement the cutting plan and non-cutting plan respectively with 160 years as a cycle, in order to provide reference for balancing the relationship among forest economic value, biodiversity and carbon sink storage and optimizing the forest management plan.

2. The establishment of carbon storage model

Forest carbon sequestration includes forest tree carbon sequestration, forest plants and humus carbon sequestration, forest soil carbon sequestration and forest products. When wood products are discarded or recycled at the end of their life cycle, the carbon trapped in them is released to the atmosphere[9], when wood products do not have carbon sequestration function, so it is not considered. In this paper, the method of Biomass Conversion Factor was used to estimate the carbon sequestration of the aboveground part of the stand, the carbon content was calculated according to the selection parameters of different stand ages and species.

2.1 Overview of the study area

In this paper, the effects of different forest plans on the ability of carbon sequestration of the Lesser Khingan Mountains were studied. The Forest area of the Less er Khingan Mountains in Heilongjiang Province is located in the northeast of China and the central and northern part of Heilongjiang Province. It belongs to low mountains and hills with an altitude of 400-1000 m and a forest coverage rate of 80.60%. The zonal vegetation belongs to the mixed coniferous broad-leaved forest in the north temperate zone, with pinus koraiensis and fir as the dominant species.

Based on the investigation data of forest data and public statistical data, two forest types of pinus koraiensis and fir were selected in this paper, and divided into five age groups according to the stand growth status, forest species, forest age and other characteristics: young, middle age, near mature, mature and over mature. In order to ensure the scientificity of the samples, this paper only considered the first four age groups and took the survey data of Hu Haiqing et al.[10] as the starting point, set two 20m*20m pinus koraiensis and fir respectively to study their carbon sequestration capacity, due to the serious cutting in the Lesser Khingan Mountains.

2.2 Carbon sequestration model based on the method of Biomass Conversion Factor

Taking the Lesser Khingan Mountains as the experimental site, carbon sequestration was calculated according to the implementation of cutting plan, that is, every mature tree felled, a seedling of the same kind would be placed in the same position. Since the ages of pinus koraiensis and fir, were 120-160 years, 160 years was taken as an experimental cycle. Calculate the total carbon sequestration amount of two woodlands under the two plans respectively.

2.2.1 The cutting plan

If the cutting plan is implemented and mature trees are turned into forest products, the total carbon sequestration is:

$$C = U_{ijt} + D_{ijt} + P_{ijt} (1)$$

1) Biomass carbon sequestration in the forest

The aboveground biomass of the experimental site was obtained by multiplying the biomass expansion coefficient by the total stock volume of the forest type:

$$W_{ij} = \sum_{i=1}^{n=2} S_i * V_{ij} * BEF_{ij} * SVD_{ij} (2)$$

Among them, $i = 1,2$ represent the two forest types of pinus koraiensis and fir respectively; $j = 1,2,3,4$ stands for four ages from small to large. W_{ij} is the aboveground biomass of forest type i and the age of forest type j, S_i is the area of forest type i, V_{ij} represents the forest stock of forest type i and the age of j, BEF_{ij} is biological expansion factor of forest type i and the age of forest type j, SVD_{ij} represents the wood density of forest type i and the age of forest type j.

Since the age group classification of pinus koraiensis and fir is the same, the mature forest with a length of 40 years will be regarded as the forest product, multiplied by the carbon content rate, and the

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carbon sequestration amount of a total experimental site in 160 years can be obtained:

$$U_{ijt} = \sum_{i=1}^{n=2} * [\sum_{t=1}^{n=100} S_i * V_{i1} * BEF_{i1} * SVD_{i1} + \sum_{t=1}^{n=40} S_i * V_{i2} * BEF_{i2} * SVD_{i2} + \sum_{t=1}^{n=20} S_i * V_{i3} * BEF_{i3} * SVD_{i3}] * CF_i \quad (3)$$

Among them, U_{ijt} is the aboveground carbon sequestration amount of forest type i and the age of forest type j in the t year, CF_i represents carbon sequestration coefficient.

2) Underground biological carbon sequestration in the stand

The underground biomass was calculated by referring to the ratio of root to stem:

$$M_{ij} = W_{ij} * g_{ij} \quad (4)$$

Then, the carbon content was multiplied by the carbon content rate to obtain the carbon sequestration amount on the stand of the total experimental plot within a period:

$$D_{ijt} = \sum_{i=1}^{n=2} \sum_{t=1}^{n=160} M_{ijt} * CF_i = \sum_{i=1}^{n=2} * [\sum_{t=1}^{n=100} S_i * V_{i1} * BEF_{i1} * SVD_{i1} * g_{i1} + \sum_{t=1}^{n=40} S_i * V_{i2} * BEF_{i2} * SVD_{i2} * g_{i2} + \sum_{t=1}^{n=20} S_i * V_{i3} * BEF_{i3} * SVD_{i3} * g_{i3}] * CF_i \quad (5)$$

Among them, M_{ij} is the underground biomass of forest type i and the age of forest type j, D_{ijt} represents the underground carbon sequestration amount of forest type i and the age of forest type j in the t year.

3) Carbon sequestration of forest products

Excluding forest products as fuelwood, the average life of other forest products is about 30 years (as shown in Table 1), which is less than the life of mature wood. Therefore, the carbon sequestration of forest products is:

$$P_{in} = \sum_{n=1}^{n=30} S_{in} * h_{in} * \rho_{in} * CN \quad (6)$$

P_{in} represents the carbon sequestration amount of forest products of forest type i in the n year.

Table 1: Basic parameters of forest products

Forest products	Basic density ($t * m^{-3}$)	The service life(year)	The carbon content(%)
Firewood	0.485	1	50
Sawn timber	0.485	60	50
Man-made board	0.570	40	50
Other industrial logs	0.485	20	50
Paper and cardboard	0.900	10	50

2.2.2 The non-cutting plan

If the forest is allowed to die and grow naturally without any cutting measures, the total carbon sequestration is:

$$C' = U'_{ijt} + P'_{ijt} \quad (7)$$

According to the Paragraph 2.2.1, mature trees will not be cut down, and the biomass carbon sequestration on the ground of the stand is:

$$U'_{ijt} = \sum_{i=1}^{n=2} * [\sum_{t=1}^{n=60} S_i * V_{i1} * BEF_{i1} * SVD_{i1} + \sum_{t=1}^{n=40} S_i * V_{i2} * BEF_{i2} * SVD_{i2} + \sum_{t=1}^{n=20} S_i * V_{i2} * BEF_{i2} * SVD_{i2} + \sum_{t=1}^{n=40} S_i * V_{i4} * BEF_{i4} * SVD_{i4}] * CF_i \quad (8)$$

The underground biological carbon sequestration amount of the forest is:

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$$D'_{ijt} = \sum_{i=1}^{n=2} * [\sum_{t=1}^{n=60} S_i * V_{i1} * BEF_{i1} * SVD_{i1} * g_{i1}$$
$$+ \sum_{t=1}^{n=40} S_i * V_{i2} * BEF_{i2} * SVD_{i2} * g_{i2} + \sum_{t=1}^{n=20} S_i * V_{i2} * BEF_{i2} * SVD_{i2} * g_{i3} + \quad (9)$$
$$\sum_{t=1}^{n=40} S_i * V_{i4} * BEF_{i4} * SVD_{i4} * g_{i4}] * CF_i$$

3. Results

According to the calculation, after one cycle, the total carbon sequestration of forest management plan in the implementation of cutting is 22,290 t more than that in the non-implementation of cutting, and the two forest types also conform to this rule, 13,242 t more for pinus koraiensis and 9,048 t more for fir. In the same area and under the same external conditions, the carbon sequestration capacity of pinus koraiensis was slightly higher than that of fir, and the carbon sequestration capacity of the two forests was 104,715 t and 86,757 t respectively, under the implementation of the cutting plan, as shown in Figure 1.

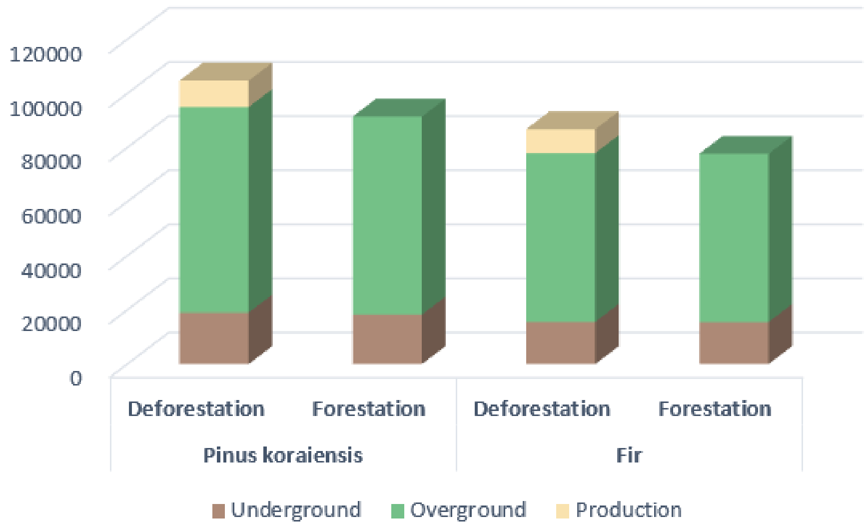

Figure 1: Carbon sequestration under different forest management plans

The amount of carbon sequestration from different sources also showed a higher level under the implementation of the cutting plan. The amount of carbon sequestration from aboveground biomass was nearly 6 times of that from underground biomass, which was much higher than the amount of carbon sequestration from forest products. Because the interval between harvesting and seeding of new seedlings is assumed to be shorter, forest organisms have a higher carbon sequestration level under the harvesting schedule. Under the premise of cutting planning, the carbon sequestration amount of forest products of pinus koraiensis and fir is 9,713 t and 8,784 t respectively, which supplement the carbon sequestration of forest ecosystem.

4. Conclusions

This paper selects the Lesser Khingan Mountains as the study area, taking 160 years as a planning period, applying two planning models of whether or not to implement cutting, and according to the function of Biomass Conversion Factor and the carbon content coefficient, it is found that the carbon storage capacity of cutting in one cycle is 22,290 t more than that of non-cutting. Under the cutting plan, the carbon sequestration capacity of pinus koraiensisX forest and fir is 104,715 t and 86,757 t respectively. It can be seen that the continuous updating of forest planning is more conducive to carbon sequestration, and the carbon absorption capacity of mature and over-mature trees in non-cutting forests is constantly reduced, resulting in weak vitality and carbon sequestration capacity.

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Forest not only plays an important role in ecological environment protection and carbon sequestration, but also its aesthetic, cultural, entertainment and ornamental values are increasingly recognized by people. Therefore, in forest planning, it is necessary to maximize the benefits of all aspects of value, rather than focusing on a single goal and ignoring the construction of other aspects. Proper forest management planning is helpful to maintain the growth of trees, protect biodiversity, prevent the decline of soil capacity and promote the sustainable and healthy development of forests, which are instrumental in mitigating the greenhouse effect.

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