Environment, Resource and Ecology Journal (2022)
Clausius Scientific Press, Canada
DOI: 10.23977/erej.2022.060314
ISSN 2616-3756 Vol. 6 Num. 3

Forest management plans based on different conditions

Xinyi Zhang[1,#], Yutong Wang[2,#], Bingbing Li[1,#]

[1]*China University of Geosciences, Beijing, School of Water Resources and Environment, Beijing, 100089, China*
[2]*China University of Geosciences, Beijing, School of Science, Beijing, 100089, China*
[#]*These authors contributed equally.*

Keywords: carbon sequestration, Linear programming, forest management plan

Abstract: Forest ecosystems play an important role not only in carbon sequestration and climate change, but also in economic and social impacts. We introduce the concept of tree species biomass into the carbon sequestration model. The carbon sequestration of different tree species and ages was obtained by regression analysis and linear data analysis. According to the total carbon sink model, the most reasonable forest management plan is obtained: within 50 years, the carbon sequestration capacity of the forest will reach 165,10g /m^2; 73% of the trees will be reserved for ecological conservation, and 23% of the trees will be cut down to produce forest products. According to the interests of different needs, appropriate forest management plans should be planned from different perspectives.

1. Introduction

In recent years, with the rapid development of economy, continuous climate change has posed a great threat to life and ecological environment. To mitigate the effects of climate change, we can reduce carbon dioxide emissions by means of carbon sequestration.The carbon sequestration capacity of forests is high. According to statistics, although the global forest area only accounts for 1/3 of the total land area of the world, the carbon stored by forest ecosystem accounts for 77% of the total terrestrial carbon pool, the carbon pool of forest vegetation accounts for about 86% of the total terrestrial carbon pool, and the carbon fixed by forest annually accounts for about 2/3 of the total terrestrial ecosystem. [1]. Forest ecosystems reduce atmospheric carbon dioxide concentrations by absorbing carbon dioxide from the atmosphere and fixing it in forest vegetation and forest products. [2] Therefore, as an important terrestrial ecosystem, forests play an important role in mitigating climate change, reducing the content of greenhouse gases in the atmosphere and regulating the global carbon balance.

But more than 80% of the global forest degradation due to human activity, different degree, forest managers faced with enormous challenges, effective forest management measures can promote the forests to absorb carbon, improving the function of forest, reduce carbon emissions, at the same time can reduce the waste of forest resources, improve the utilization efficiency of forest resources. [3-4]The composition, climate, population, interests and values of forests vary greatly in different parts of the world, and forest management needs to be optimized to meet ecological, economic, social, cultural and other multi-dimensional functional needs, so as to be applicable to all parts of the world.[5]

2. Forest management planning model construction

2.1 Forest carbon sequestration model

Forests under different climate conditions and geographical conditions contain different tree species, and the longevity and carbon sequestration capacity of various types of trees are also different. Therefore, we believe that management plans for different types of forests should vary according to actual conditions [6]

Table 1 Regression equation

Edge species(group)	The regression equation	R^2	The carbon content
Juniperus chinensis Linnaeus	B=0.4904V+30.427	0.9608	0.4661
Picea asperata Mast.	B=0.3933V+56.65	0.8015	0.4606
Larix gmelinii (Rupr.) Kuzen.	B=0.6079V+17.062	0.8948	0.521
Betula	B=0.8101V+11.682	0.8815	0.5055
PopulusL.	B=0.6251V+11.462	0.8537	0.4502

Note: B is biomass of different tree species, and V is stand stock

Calculating the biomass of different tree species, the following formula was used to calculate the carbon sequestration capacity of different tree species.

$$B \times TCC = NCF \tag{1}$$

Since it takes about 50 years for trees to grow from young age to middle age and from middle age to maturity, and the life span of good forest products is usually 100-200 years, we regard 50 years as a logging cycle and set our prediction time as 50 years, thus establishing the model as follows:

$$Q_{\max} = F_1 \times x_1 \times 50 \times 365 + F_2 \times x_2 \times 50 \times 365 + F_3 \times x_3 \times 50 \times 365 \tag{2}$$

$$s.t. \begin{cases} x_2 + x_3 < 1 \\ x_3 < \frac{a}{4} \\ x_1 \leq x_3 \\ x_1 > 0.3x_2 \\ x_1, x_2, x_3 > 0 \end{cases} \tag{3}$$

After calculating the data with MATLAB and considering the influence of planting density and other factors.As can be seen from Table 5, the carbon sequestration capacity of the forest and its products in this model is expected to reach 165,310 g/m ²in 50 years. This forest needs to retain 73 percent of its mid-age trees for sustainable development and forest stability, while 23 percent of its mature trees are expected to be cut down for forest products and to give more room and nutrients to young trees. In consideration of proper planting, 22% will be given to young trees. Adopting such forest management plans can make forests the most efficient for carbon sequestration.

Table 2 Carbon sequestration model calculation value

Weight of x_1	Weight of x_2	Weight of x_3	Total projected carbon sequestration
0.22	0.73	0.23	165310g/m ²

2.2 Forest management plan model—From the perspective of forest manager

We find that the most effective forest management plan model only considers the optimization of carbon sequestration. But in practice, only considering carbon sequestration is not enough and does not maximize the value of forests. Therefore, we need to develop a model of forest management plan. This plan balances various approaches to assessing the value of forests, including potential carbon sequestration, biodiversity conservation, recreational use, cultural considerations, economic benefits of forest products, and water conservation.

In order to determine the concrete and feasible forest management plan of the decision model, we analyzed the primary and secondary indicators, and use analytic hierarchy process to determine the weight of each indicator. For balancing various evaluation methods, maximize forest value, and apply to most forests as far as possible, the weight of each indicator we finally determined is shown in Table 3.

Table 3 Using analytic hierarchy process to get the weight

First grade indexes	PCS	BD	RU	CC	EBFP	ACW
weight	0.1783	0.1947	0.1369	0.1513	0.1758	0.163
PCS Second grade indexes	AD	TD	SD	TIBTF	TSC	
weight	0.0358	0.0324	0.0422	0.0304	0.0374	
BD Second grade indexes	TD	TSC				
weight	0.0885	0.1062				
RU Second grade indexes	AD	TD	SD	TIBTF	TSC	
weight	0.0297	0.0248	0.0324	0.0226	0.0274	
CC Second grade indexes	AD	TD	SD	TIBTF	TSC	
weight	0.0358	0.0303	0.0274	0.025	0.0328	
EBFP Second grade indexes	AD	TD	TIBTF			
weight	0.0641	0.0584	0.0533			
ACW Second grade indexes	AD	TD	SD	TIBTF	TSC	
weight	0.0327	0.0353	0.0295	0.0269	0.0385	

The total weight of the five second-level indicators is shown in table 4.

Table 4 Sum of weights of secondary indicators

Second grade indexes	AD	TD	SD	TIBTF	TSC
total	0.1981	0.2697	0.1315	0.1582	0.2423

From what has been discussed above, we can see that a moderate amount of forest cutting has certain benefits. When the proportion of trees, shrubs and other trees in a forest is unbalanced, the amount of soil organic matter may be less than the amount of organic matter consumed by trees and other trees, and soil fertility will continue to decrease significantly, while carbon storage is unbalanced; When the canopy of trees in a forest is connected with each other and the degree of covering the ground (canopy density) is too high or too low [7], it may cause the increase of dead objects in the forest or the occurrence of fire easily [8]; As the local climate, temperature, humidity and other natural conditions change, the forest may appear serious diseases and insect pests, fire, wind break and so on. In view of the above situations, reasonable forest management plans should be made based on local conditions, and certain measures of forest harvesting or planting should be carried out to maintain the ecological balance of the forest.

In order to quantify the applicability and differences of different types of forests using the same forest management plan, we selected some data values of the forests in Shandong and Guangxi provinces in China for quantitative calculation and model evaluation. We chose the carbon sequestration and fire loss of forests in the two regions to measure the ecological value of forests. We chose the forest product value in the two regions to measure the economic value of forests. Since only the total stock volume of each place can be obtained in the data and there is no statistical data of tree species, we adopted the estimation model established by Fang J.Y. et al. based on biomass (B) and stock volume (x).Although there is some error in the model, the error is small for a large area. The model formula is as follows:

$$B = 0.5751x + 38.706 \qquad (n = 120, R^2 = 0.83) \tag{4}$$

Then the calculated biomass B is multiplied by the carbon sequestration coefficient (Cc) to obtain the carbon sequestration amount (Cm). To calculate the value of carbon sequestration amount, we use the formula:

$$Cn = Cm \times \delta \tag{5}$$

After data processing and data search, the index data finally obtained is shown in the following table 4.We use the above data and the calculated weight of the first-level indicators to establish a comprehensive evaluation model:

$$F = CSV \times W_{PSC} - AFD \times W_{BD} + FPV \times W_{EBFP} \tag{6}$$

Table 5 Second grade indexes index data of the two provinces

	Timber output (ten thousand m^3)	FPV(CNY Million Yuan)	AFD(CNY Ten Thousand Yuan)	Total forest carbon sequestration (t)	CSV(CNY Million Yuan)
Guangxi Zhuang Autonomous Region	3600	630.9	247.1	331884472.8	298696.03
Shandong province	507	40.56	36	177918360.6	160126.52

Guangxi and Shandong have different climatic conditions and geographical locations, and the growth of trees is also different. We obtained the NPP value of Shandong and Guangxi in 2020 through ArcGIS software, and the results are shown in Figure 1.

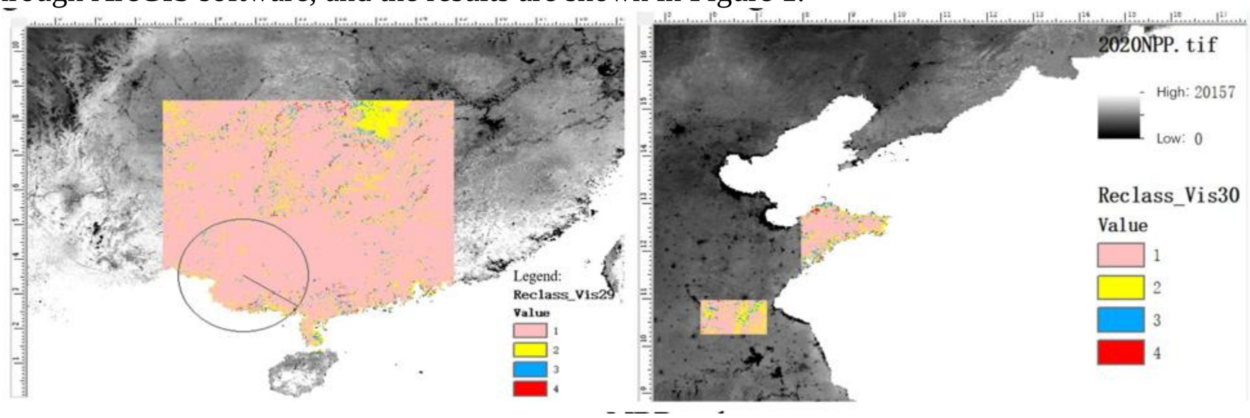

Figure 1. NPP data classification map of the two provinces (Shandong province on the left and Guangxi Province on the right)

As can be seen from the figure 1, Shandong province has more NPP of 1 and 2 types, while Guangxi Province has more NPP of 3 and 4 types, indicating a large difference in NPP values between the two regions. There is also a large gap between forest yield and carbon sequestration value, and a large gap between the comprehensive evaluation index values calculated based on figure 1. Therefore, based on the differences in forest location, growth conditions and tree species composition, we use comprehensive indicators to carry out evaluation, and the corresponding conditions of the forest with low evaluation value are the transition points between management plans.

3. Improvement and prediction of forest management models

Applying the established model to a certain forest, we selected the Greater Khingan Range of Inner Mongolia Autonomous Region of China. Through data query, we learned that in 2015, the State Forestry Administration decided to completely ban commercial wood cutting in the Greater Khingan Range Forest Area of Inner Mongolia on November 14, so the forest products yield is small, so in the next 100 years, The value of carbon dioxide absorbed by this forest will be predicted by the value of biomass and carbon storage in recent years. Due to the small amount of data, we used the known data to calculate the trend of biomass and carbon reserves over time and fitted the formula for calculation, as shown in figure 2:

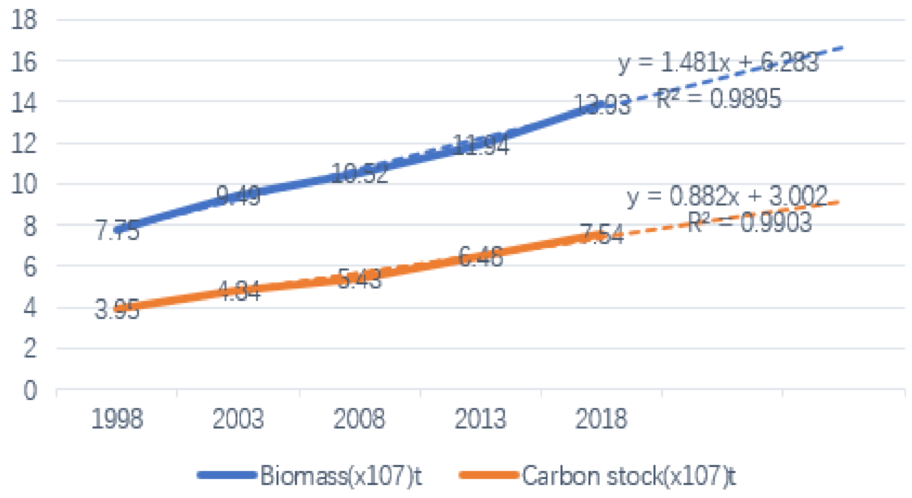

Figure 2 Prediction of correlation value of Larch

The formula, fitting degree and predicted value obtained by fitting are shown in table 6.

Table 6 Correlation value prediction equation and predicted value

	Fitting formula	R^2	2023year	2123year
Biomass	y = 1.481x + 6.283	0.9895	15.169	44.789
Carbon stock	y = 0.882x + 3.002	0.9903	8.294	25.934

The value of carbon dioxide absorbed by forests is related to the change of forest carbon reserves. Therefore, by subtracting the carbon reserves in 2023 from the carbon reserves in 2123, the amount of carbon dioxide absorbed by Xing'an Larch Forest in 100 years is 1.764×108t.

Even though commercial timber harvesting is not allowed in Xing'an larch forest at present, through the query of data, we found that larch forest needs to take thinning and tending measures to maintain the sustainable development of the forest to a certain extent, and give sufficient sunshine and water to retain the trees by cutting down the naturally eliminated trees. According to the data, the best thinning time of larch forest is when the crown height ratio is 1:3 and the canopy density is greater than 0.9. Because the timber volume and DBH of the trees after thinning will grow to the maximum after about 5.0a. Without considering other factors, the optimal thinning interval of the stand is between 5.0a and 10a, and the maximum is no more than 15a.Relevant data of Larix gmelinii Forest are shown in table 7.

Table 7 Inventory of forest resources in Greater Khing an Range authority

Age group	The measure of area (thousand hm2)	Accumulation (thousand m2)	Arbor layer carbon storage amount (thousand t)	Shrub carbon storage amount (thousand t)	Carbon storage in herb layer (thousand t)	Carbon storage in soil layer (thousand t)
Young forest	27	1328	244	47	89	1482
Middle age forest	211	25287	3125	669	622	19625
Near mature forest	39	4056	7273	58	76	3899
Mature forest	58	7984	5289	71	66	6231
Over mature forest	49	6207	4680	49	52	5452
Total	384	43962	20611	894	905	36689

From the above table, we can find that the carbon storage of over mature forest is less than that of medium-aged forest and near mature forest, while the recommended cutting intensity of larch forest is to cut 20% ~ 25% of the plants on the basis of the original forest. This part of cutting can be selected from over mature forest, so as to ensure that the medium-aged forest and near mature forest account for a large proportion as far as possible, which not only ensures the sustainable development of the forest, At the same time, it also increases economic benefits. Therefore, the above corresponding index values are the most reasonable forest management plan.

Forest managers and all forest users and their needs are shown in the figure below.

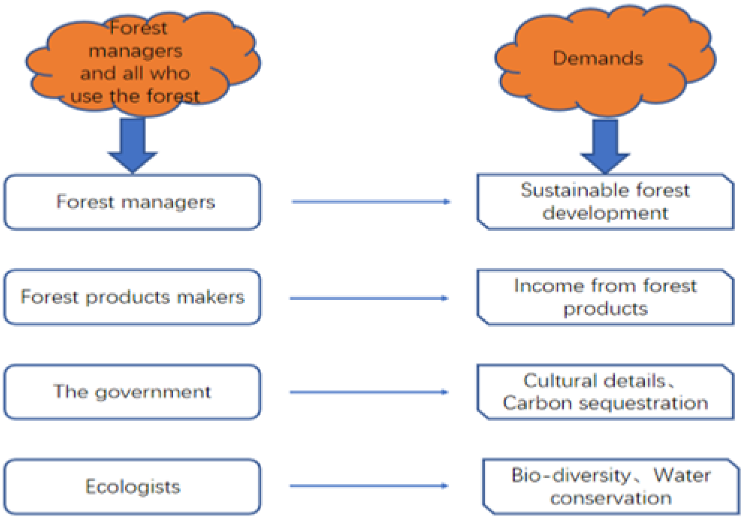

Figure 3 Needs of different groups

Transition from the current forest management plan to the best management plan, and transfer the work center of forest management to the new stage of forest protection. If the cutting interval becomes longer, for forest managers, the number of felling per unit time will be reduced, promote the sustainable development of forests, and forests can be used in an orderly manner. At the same time, it is more conducive to land, increase forest biodiversity, improve the ecological environment, and strengthen the capacity of forest water conservation.

However, for forest product producers, the cutting interval is longer and the wood production is reduced, the economic income is reduced. Therefore, the state should establish an effective ecological compensation mechanism, increase support and advocate "who benefits, who pays"[17]. The government should also accelerate the reform of the forest property right system, promote the establishment of the carbon sink trading market, so as to realize the triple benefits of forest economy, ecology and society.

4. Conclusion

Diversity of modeling methods. In the process of constructing the model, various methods such as regression analysis, hierarchical analysis, linear programming and comprehensive evaluation model are applied to process the data. To some extent, it makes the model more usable.The forest management planning model considers many factors to plan. In the establishment of the model, after comprehensive consideration of various factors, the model can be more fit with the actual situation, so that the forest ecology and economy in many aspects of sustainable development.In the establishment of the model, after comprehensive consideration of various factors, the model can be more fit with the actual situation, so that the forest ecology and economy in many aspects of sustainable development.

References

[1] Shang, G. D. Forest management research based on CBM-CFS3 model [D]. Shandong Normal University,2012.

[2] Xu, Y.M., Li, H., Li, X., et al. Forest and environmental science,2018,34(01):123-131.

[3] He, Z. f. Try to analyze the function of forest resource management in forestry industry development [J]. Southern agriculture, 2017, 11 (30): 43-44, DOI: 10.19415 / j.carol carroll nki. 1673-890 - x. 2017.30.024.

[4] Huang L. Research progress in ecological effects of forest management[J]. Acta ecologica sinica, 2021,41(10):4226-4239.

[5] Yang, Y. S., Chen, G. S., Xie, J.S., et al. Management strategy of forest carbon sink in China[J]. Journal of Forest and Environment, 2015,35(04):297-303.

[6] Lu, Q. L., Li, Y. H., Carbon storage and carbon density of forest vegetation layer in Sanjiangyuan Nature Reserve[J]. Forest resource management, 2018(04):146-153.

[7] Sun, S. S., Study on remote sensing estimation method of forest canopy density [D]. Chinese Academy of Forestry,2019.

[8] Chief editor of Liaoning Forestry School. Trial textbooks for national secondary forestry schools Forest fire prevention: China Forestry Publishing House, 1993.