Jiqin Ren[3] – ***Xiangyu Qi***[4] – ***Sijia Yang****Hiba! A könyvjelző nem létezik.Hiba! A könyvjelző nem létezik.*[5] – ***Jingjing Li***[6] – ***Guoliang Liu***[7] – ***Jianghong Feng***[8]

Beijing Forest Carbon Storage Potential Capacity

Forests serve as a crucial carbon reservoir. Therefore, optimizing forest carbon storage is a pathway towards achieving carbon neutrality. In this study, the Forest Simulation Optimization System (FSOS) was used to simulate the carbon storage in Beijing forests over 250 years (2018-2268). It was found that under the no management scenario, carbon storage fluctuates with the natural growth and death of trees, with peaks of more than 90 million tons. It proves that forests have a strong capacity of carbon storage. In the management scenario, harvest trees and make them into furniture, total carbon storage is high and maintains a stable level of 108 million tons. This is almost 1.6 times higher than in the no management scenario on average. In addition, the growth rate of carbon storage is fastest in the middle-aged forest and the near-mature forest. Therefore, in order to optimize the carbon sequestration benefits of forests, the forestry sector must pay attention to the age structure of forests in the future. Based on the results of this study, recommendations were made to optimize carbon storage in Beijing forests and to integrate forest managements of Beijing forests into regional economic and environmental planning.

Keywords: carbon storage; forest management; FSOS model.
JEL code: Q54

https://doi.org/10.32976/stratfuz.2024.14

1.INTRODUCTION

Rising levels of atmospheric carbon dioxide (CO_2) and the resulting greenhouse effect have caused global climate change. As one of the four major carbon reservoirs, the terrestrial ecosystem plays a major role in regulating the concentration of atmospheric CO_2 (Liu et al. 2012). Forests are the main body of the terrestrial ecosystem, and a crucial part of the global carbon cycle (Daigneault and Favero 2021). Approximately 80% of above-ground carbon storage, and 40% of underground biological carbon storage are in the forests (Wang et al. 2015). Effective use of forest carbon sinks can significantly mitigate climate change (Liu and Wu 2017) and bring economic benefits under good forest governance (Lin and Ge 2019).

To combat climate change, China has proposed to become carbon neutral by 2060. In order to increase forest carbon storage and achieve carbon neutrality on schedule, Beijing has carried out afforestation activities to promote the growth of forest resources reserves (Ren et al. 2023). In this context, it is of great significance to evaluate and optimize forest carbon storage in Beijing for forest management and urban development.

2.LITERATURE REVIEW

Scholars around the world have evaluated and analyzed forest carbon storage, which reflects the important role of forest carbon sequestration (Tu et al. 2023). Jiang et al. evaluated and analyzed the carbon storage of forest ecosystems in Beijing mountain area, and compared the total carbon storage performance of different stand types (Jiang et al. 2019). Chen et al. measured the forest

---

[3] Beijing University of Chemical Technology, Beijing,100029, P.R. China.

[4] Beijing University of Chemical Technology, Beijing,100029, P.R. China.

[5] Beijing University of Chemical Technology, Beijing,100029, P.R. China.

[6] Beijing University of Chemical Technology, Beijing,100029, P.R. China.

[7] Haikou University of Economics, Haikou, 571132, China

[8] Beijing University of Chemical Technology, Beijing,100029, P.R. China.

Corresponding: Beijing University of Chemical Technology. fengjh@buct.edu.cn carbon storage in the Greater Khingan Mountains and assessed the forest carbon sequestration potential (Chen et al. 2022). Jo et al. and Nowak et al. investigated the forests of Seoul city Park and American city respectively, quantified the carbon storage and sequestration capacity of forests, and confirmed the importance of urban forests in climate change (Jo et al. 2019; Nowak et al. 2013). The results of these studies reflect the strong carbon sequestration capacity of forests. However, their discussions and studies on practical forest management plans are still insufficient.

Studies have shown that sustainable forest management leads to enhanced carbon storage, for example, effective management, and diversified tree species (Robert et al. 2022). Bishnu et al. showed that regular management effectively protects ecologically significant tree species in Nepal's subtropical forest when compared with other management approaches (Bishnu et al. 2019). Roth et al. pointed out that potential for future carbon accumulation in the soil was higher in uncut forests and retention-cuts than in clear-cuts in boreal Scots pine (Roth et al. 2023). Composition of tree species has direct and indirect impact on carbon storage (Jia et al. 2022). The direct impact is that different tree species have different carbon storage capacity through their growth rates, wood density and mortality rates (Sugiyama et al. 2024). Tree species diversity also has a direct impact on carbon storage, for example, it has a positive impact on above-ground carbon storage (Rius et al. 2023; Wei et al. 2023). The indirect impact is that tree species diversity can increase carbon storage through multiple factors such as stem density, functional diversity and functional dominance of species (Rius et al. 2023; Wondimu et al. 2021). As for Beijing, the tree species with the largest carbon storage and the largest carbon density is poplar (Ren et al. 2023). It is well known that the carbon storage level of a forest is related to its area, timber volume, tree species, and age classes. However, optimization of forests' carbon storage in Beijing remains challenging.

To optimize forest carbon storage and establish a scientific forest management model, it is essential to consider tree species characteristics and optimize the age structure of the forest through timely and rational harvesting (Zheng et al. 2019). Traditional methods for calculating timber harvest volume include area-based harvesting, maturity-based methods, and second age formula methods (Wu et al. 2022). However, these methods have certain limitations when applied to the complex environment of forests. For example, formula-based methods may struggle to deal with mixed forests, and different methods may yield significantly different results (Dai et al. 2020). Forest simulation optimization system (FSOS) (SFSCCP 2022; Liu 2000) fully considers the age structure, tree species composition, and evolution of forests. It has been applied in the province of British Columbia in Canada and in the Changbai Mountain region of China, achieving good results (Liu et al. 2012; Liu and Han 2009; Liu et al. 2000). FSOS can effectively address forest carbon storage optimization issues, such as determination of forest cutting volume (Wu et al. 2022; Dai et al. 2020).

This research focuses on the optimization of the carbon storage capacity in Beijing. Different management scenarios were analyzed, and the carbon storage was estimated using FSOS. The results can be used by the Forestry and Grassland Administration for management practices and forest management in Beijing, optimizing its carbon storage capacity and contributing to broader goals of carbon neutrality and sustainable development, and mitigating the impacts of climate change.

3.METHODOLOGY AND DATA

3.1 FSOS model

FSOS (Liu et al. 2000) was used in this study to simulate carbon storage over 250 years. Simulation was designed for 250 years, considering the lifespan of platycladus orientalis is 140 years, the start year is 2018.

The input information include: (1) Tree species, area distributions of tree species in Beijing forests. (2) Tree species growth parameters. (3) Parameters require to calculate carbon storage.

All data are described in Section 3.2. Forest stands were generated according to this information. Two different management scenarios were set.

FSOS utilizes these parameters as initial values to generate timber volume and carbon storage over 250 years of each forest stand under the two scenarios with the simulated annealing algorithm (Liu et al. 2000). Output information include: (1) Timber volume of each and all forest stand in each year in the 250-year study period. (2) Carbon storage of each and all forest stand in each year in the 250-year study period.

For scenario two, to optimize forest carbon storage, FSOS was used to simulate multiple times. The objective function is carbon storage of each stand. Control variables are harvest time and harvest percentage.

3.2 Data sources and data processing

3.2.1 Tree species parameters

According to the Twelfth Five-Year Plan Survey Statistical Report of Beijing Forest Resource Planning and Design Survey (BFSDI 2016), nine dominant tree species in Beijing forests were selected. They are platycladus orientalis, larch, Chinese pine, toothed oak, birch, populus davidiana, black locust, poplar,and broad-leaf tree. However, other tree species in terms of market value or carbon storage capacity were not considered. The growth parameters of these species are from Biomass and Its Allocation of Forest Ecosystems in China (Luo et al. 2013), shown in (*Table 1*). The carbon storage parameters of tree species are from Forest Management Carbon Storage Project Methodology (SFAC 2014), shown in (*Table 2*).

Table 1 Growth parameters of the nine dominant tree species

Tree species	MAI	TMax	MValue
platycladus orientalis	0.4735	80	3
larch	2.3992	60	3
Chinese pine	1.1166	30	3
toothed oak	0.8384	60	3
birch	1.6637	40	3
populus davidiana	1.4959	30	3
black locust	1.8010	18	3
poplar	1.4959	30	3
broad-leaf tree	1.3643	60	3

Source: Biomass and Its Allocation of Forest Ecosystems in China (Luo et al. 2013).

MAI: Maximum Mean Annual Increment (m^3/year).

TMax: The age when a stand reaches the maximum Mean Annual Increment (years).

MValue: A constant for timber volume, usually equaling 3.

Table 2 Carbon storage parameters of tree species

Tree species	Biomass carbon content	Litter carbon content	Underground/ above-ground biomass ratio	Dead wood/ forest biomass carbon storage ratio	Trunk density
platycladus orientalis	0.510	0.37	0.220	0.021	0.478
larch	0.521	0.37	0.212	0.021	0.490
Chinese pine	0.521	0.37	0.251	0.021	0.360
toothed oak	0.5	0.37	0.292	0.021	0.676
birch	0.491	0.37	0.248	0.021	0.541
populus	0.496	0.37	0.227	0.021	0.378

davidiana					
black locust	0.497	0.37	0.261	0.021	0.598
poplar	0.496	0.37	0.227	0.021	0.378
broad-leaf tree	0.490	0.37	0.370	0.021	0.482

Tree species	Equation of above-ground biomass (B_{AB}) and accumulation (V) $B_{AB}=a*V^b$		Equation of percentage of litter biomass to above-ground biomass (LI%) and above-ground biomass (B_{TREE_AGB}) $LI\% = c*e^{d*BTREE\_AGB}$	
	Parameter a	Parameter b	Parameter c	Parameter d
platycladus orientalis	1.985	0.794	3.76	-0.005
larch	1.642	0.802	67.413	-0.014
Chinese pine	2.632	0.697	24.827	-0.023
toothed oak	1.341	0.896	7.732	-0.005
birch	1.076	0.902	6.978	-0.004
populus davidiana	0.943	0.871	12.311	-0.007
black locust	3.322	0.687	6.978	-0.004
poplar	0.943	0.871	12.311	-0.007
broad-leaf tree	3.322	0.687	6.978	-0.004

Source: Forest Management Carbon Storage Project Methodology (SFAC 2014).

3.2.2 Establishing forest stands

Each forest stand has the same tree species and age group. Five age groups were considered, young, middle-aged, near-mature, mature and over-mature. The Five age groups for the nine tree species (Table 1) were obtained from the Regulations for age-class and age-group division of main tree-species and were shown in (Table 3) (SFAC 2017). Each stand's age was then set. With nine tree species and five age groups, there are 45 forest stands.

Table 3 Classification of five age groups of the nine tree species

Tree species	Young stand	Middle-aged stand	Near-mature stand	Mature stand	Over-mature stand
platycladus orientalis	≤60	61-100	101-120	121-160	≥161
larch	≤40	41-60	61-80	81-120	≥121
Chinese pine	≤30	31-50	51-60	61-80	≥81
toothed oak	≤40	41-60	61-80	81-120	≥121
birch	≤30	31-50	51-60	61-80	≥81
populus davidiana	≤20	21-30	31-40	41-60	≥61
black locust	≤10	11-15	16-20	21-30	≥31
poplar	≤20	21-30	31-40	41-60	≥61
broad-leaf tree	≤40	41-60	61-80	81-120	≥121

Source: the Regulations for age-class and age-group division of main tree-species (SFAC 2017).

3.2.3 Polygon generation

The area of each forest stand is different. According to the Twelfth Five-Year Plan Survey Statistical Report of Beijing Forest Resource Planning and Design Survey (BFSDI 2016), the area of each forest stand in 2018 was obtained and was shown in (*Table 4*). Thus, virtual polygons for each forest stand were created, the area of each polygon is 10 hectares. The smaller polygon size will result more accurate analysis and longer calculation time. Areas less than 10 hectares are also considered as one polygon. For example, the area of young birch (Stand 1) is 87009.48 hectares, consisting of 8,701 polygons.

Table 4 Area distributions of dominant tree species in Beijing forests (hm^2).

Tree species	Young stand	Middle-aged stand	Near-mature stand	Mature stand	Over-mature stand
platycladus orientalis	87009.48	35012.38	13111.02	10578.21	3277.75
larch	9899.83	3983.66	1491.76	1203.58	372.94
Chinese pine	78426.60	31558.65	11817.71	9534.741	2954.43
toothed oak	118797.91	47803.95	17901.05	14442.90	4475.26
birch	12715.37	5116.63	1916.02	1545.88	479.00
populus davidiana	13532.79	5445.56	2039.19	1645.25	509.80
black locust	17710.70	7126.74	2668.74	2153.18	667.18
poplar	63531.45	25564.88	9573.23	7723.86	2393.31
broad-leaf tree	52496.32	21124.38	7910.41	6382.26	1977.60

Source: Beijing Forest Survey and Design Institute, Twelfth Five-Year Plan Survey Statistical Report of Beijing Forest Resource Planning and Design Survey (BFSDI 2016).

3.2.4 Setting management scenarios

To optimize forest carbon storage, two management scenarios were devised. Scenario 1 is the no management scenario. When trees grow to over-maturity, they will die, at which point the stored carbon will be reduced. At the same time the same tree species will be planted. Scenario 2 is the management scenario. Trees are harvested when they are going to natural succession, and new trees are planted at the same time. The harvested trees will be used for wood products and every wood product has its own lifespan. The carbon will be stored in the wood product and will be released after the lifespan.Furniture is the only wood product considered in this research, and its lifespan is 30 years. Based on Regulations for age-class and age-group division of main tree-species (SFAC 2017), the succession ages of the nine tree species are shown in (*Table 5*).

Table 5 The succession ages of the nine tree species (year)

Tree species	Natural age of death	Harvest age	Wood product	Lifespan
platycladus orientalis	140-165	140-165	furniture	30
larch	100-125	100-125	furniture	30
Chinese pine	70-85	70-85	furniture	30
toothed oak	100-125	100-125	furniture	30
birch	70-85	70-85	furniture	30
populus davidiana	50-65	50-65	furniture	30
black locust	25-35	25-35	furniture	30
poplar	50-65	50-65	furniture	30
broad-leaf tree	100-125	100-125	furniture	30

Source: Regulations for age-class and age-group division of main tree-species (SFAC 2017).

3.RESULTS AND DISCUSSION

3.1 Comparison of timber volume of two scenarios

(*Figure 1*) illustrates timber volume over 250 years. In the no management scenario, at the beginning (2018), the timber volume was 33 million cubic meters. As trees naturally grow and mature, the timber volume increases and will reach 52 million cubic meters in 2068. From the year 2068, many trees will go to succession, and the timber volume will decline to 25 million cubic meters. Then, newly planted trees grow, allowing timber volume to continue to increase. The variation of timber volume is large.

In the management scenario, timber volume was similar to the no management scenario in the first 50 years (2018-2068), but significantly different over the next 200 years. Because some trees were harvested to make wood products before death, and the results of this study count not only the timber volume in the forests, but also the additional timber volume stored in harvested trees. After the wood products reach their life, their own accumulation will be reduced, so the timber volume will not grow indefinitely. The amount of a single harvest is 25% of the trees that have reached harvest age. Over the next 200 years (2068-2268), timber volume in the management scenario was higher than in the no management scenario because new trees of the same species were planted in time after deforestation. Since then, although the timber volume has fluctuated slightly, it has remained roughly at the same level, at about 56 million cubic meters. Because the forest is harvested in time, the timber volume in the management scenario is higher and more stable than that in the no management scenario, which is suitable for long-term management.

Figure 1 Comparison of timber volume of two scenarios from 2018 to 2268
Source: own work based on FSOS

3.2 Comparison of carbon storage of two scenarios

(*Figure 2*) illustrates carbon storage over 250 years. In the no management scenario, as trees naturally grow and mature, the carbon storage increases and exceeds 92 million tons. The trees will then succession, and carbon stocks will gradually decline, falling to a minimum of 44 million tons in 2133, and gradually rising to a peak of 94 million tons in 2248. The variation of carbon storage is large. Over the course of 115 years, the increase in carbon storage is about 50 million tons, with a growth rate of about 113.6%. It indicates that forests have a strong capacity for carbon sequestration, mainly through trees' growth.

In the management scenario, carbon storage was similar to the no management scenario in the first 50 years (2018-2068). However, over the next 200 years (2068-2268), carbon storage in the management scenario was higher than in the no management scenario because some trees were harvested and new trees of the same species were planted in time. As new trees and trees that have not yet reached harvest age continue to grow, forest carbon storage continues to increase. At the same time, the harvested trees are made into furniture, and the carbon is stored in this furniture. If this additional carbon storage is added, the total carbon storage reaches and remains at 108 million tons. Therefore, over the long term, on average, the carbon storage in the management scenario is almost 1.6 times greater than that in the no management scenario. In the long term, in management scenario, forests create greater value in terms of carbon sequestration. The longer the period, the greater the value relative to the no management scenario. The management of forests is necessary for more and more stable carbon storage.

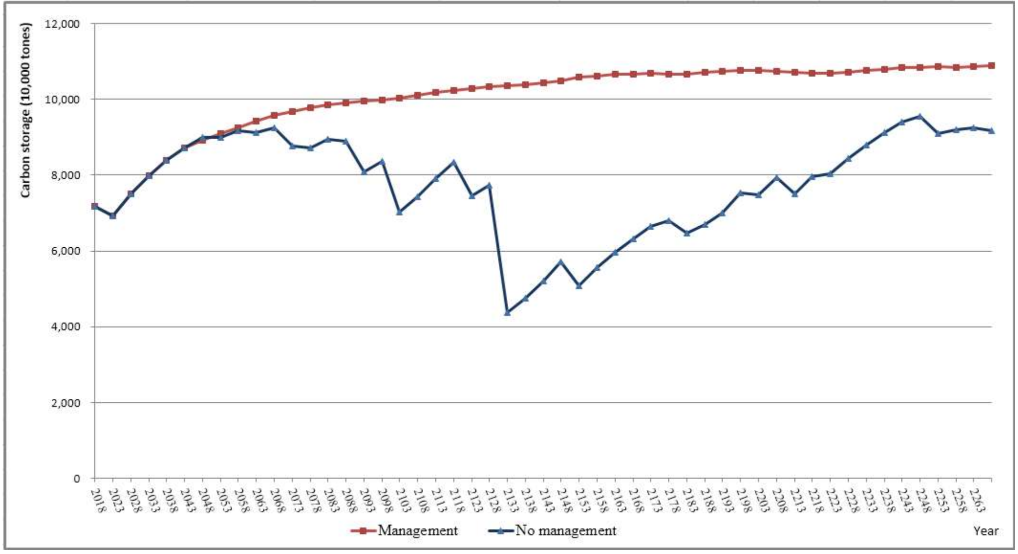

Figure 2 Comparison of carbon (CO_2) storage of two scenarios from 2018 to 2268
Source: own work based on FSOS

3.3 Carbon storage of platycladus orientalis

Taking young platycladus orientalis (Stand 1) as an example, under the management scenario, the timber volume and carbon storage of Stand 1 are shown in (*Figure 3*) and (*Figure 4*), respectively.

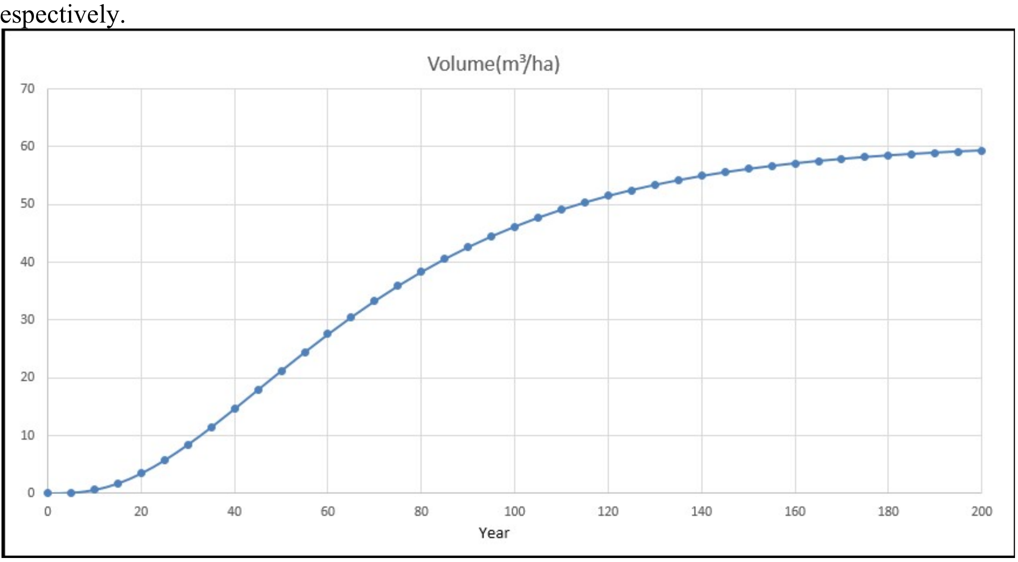

Figure 3 Young platycladus orientalis (Stand 1) timber volume in 200 years

Source: own work based on FSOS

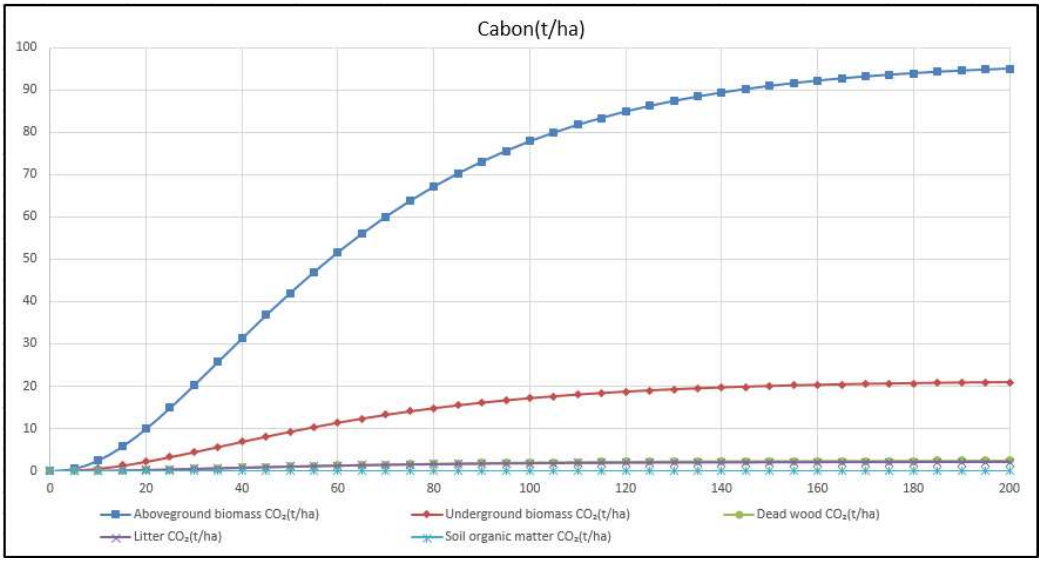

Figure 4 Young platycladus orientalis (Stand 1) carbon (CO_2) storage in 200 years
Source: own work based on FSOS

At the beginning, because Stand 1 is a young forest stand, its timber volume and carbon storage are both very low. Then, its timber volume and carbon storage continue to increase with increasing age till maturity (121-160 years). The timber volume and carbon storage continue to increase slowly, reaching their maximum values at the same time in 200 years, reaching 60 m^3 per hectare of timber volume which is equivalent to 120 tons per hectare of carbon storage.

Among the five carbon pools, the carbon storage of above-ground biomass is the largest, followed by litter, with much lower values in dead wood, soil organic matter, and underground biomass. All five pools exhibited the same trends of carbon storage, gradually increasing until the trees over-mature, and then leveling off.

For different growth stages, the growth rates of timber volume and carbon storage of forests are different. The growth rate is the fastest in the middle-aged forest and the near-mature forest, the slowest in the over-mature forest, followed by the mature forest. Therefore, in order to optimize the carbon sequestration benefits of forests, the forestry sector must pay attention to the age structure of forests in the future. Reasonable cutting can adjust the age group structure of forest well, which is helpful to optimize carbon storage.

For other stands, under the management scenario, timber volume and carbon storage also gradually increase and then remain stable. Due to the different tree species and different initial age of trees in each forest stand, the time to reach a stable timber volume and carbon storage is different.

The result of this study should be reasonable. On the one hand, the results show that Beijing forests can store more than 90 million tons of carbon at most, which proves that Beijing forests have a strong carbon sequestration capacity, which is consistent with the results of Jiang et al. and Ren et al. (Jiang et al. 2019; Ren et al. 2023), and other studies on forest carbon storage capacity have also reached similar conclusions (Jo et al. 2019; Nowak et al. 2013). On the other hand, the results obtained by the simulation show that harvesting is an influential factor that significantly affects forest carbon storage, which is consistent with the results of Štraus et al. and Roth et al.(Štraus et al. 2023; Roth et al. 2023). The results also show that age group influences carbon storage, and middle-aged forests make the greatest contribution to carbon storage, which is consistent with the conclusion of Li et al. (Li et al. 2023). Other studies using FSOS to analyze forest management have reached similar conclusions (Wu et al. 2022; Dai et al. 2020).

In addition, in this study, the strategy of harvesting forests and making wood products can achieve sustainable carbon storage and optimize forest carbon storage.

There are a few limitations in the results of this study. We only analyzed the carbon storage capacities in this study and believe that the management scenarios can produce a lot of wood and have greater socioeconomic capacities. Further studies are needed to explore more different management scenarios with socioeconomic capacities and other ecological capacities. For example, our research studies carbon storage in furniture made from harvested trees, but there are many wood products that can be made, and future studies could include the effects of more different wood products. In addition, Our study considers long-term management, with a study period of 250 years, which fails to think about the effect of climate change on the selected tree species during 250 years. Further study is needed to include the growth and yield changes caused by climate changes.

4.CONCLUSIONS AND RECOMMENDATIONS

In this study, two different management scenarios were analyzed to predict forest carbon storage over 250 years based on the tree species composition and age groups of Beijing forests.

In the no management scenario, forest carbon storage reaches a peak of 94 million tons, and reaches a low of 44 million tons. In the management scenario, forest is harvested to make furniture, to maintain the total carbon storage at a stable level of 108 million tons throughout the rest of the study period of 250 years. Between the two scenarios, the management scenario yields a 60% higher and more stable forest carbon storage. Further, the management strategy will generate significant economic and environmental benefits to the region. The case study was carried out for Beijing forests. However, the approach could be applicable in other region in and out of China to optimize carbon storage thus to curb atmospheric CO_2 levels and climate change.

Based on the above research, the following recommendations are put forward:

Firstly, optimizing tree species. The results show that most tree species grow fastest when they are young and have high carbon sequestration rates. Therefore, it is suggested that Beijing plant more fast-growing valuable species to increase its carbon sequestration capacity, select proper silvicultural methods to maintain the heathy forests.

Secondly, adopting a proactive and dynamic forest management strategy. Forest carbon storage is related to the age of trees, as demonstrated in this study. When the forest ages, over-mature trees need to be replaced. Considering that natural events such as wildfires and extreme droughts are inevitable, cutting and replacing over-mature or dead trees should be scheduled based on the status of each forest, utilizing technological innovations such as remote sensing and other tools. Those proactive, dynamic, science-based, and data driven management approaches will lead to a higher level of carbon reserves while protecting the ecosystem and the environment.

Thirdly, developing a comprehensive approach of forest management, carbon storage, product utilization, and economical benefit. Forest products are a valuable resource. Products of some tree species could yield a high market price. This should be considered when selecting tree species in addition to carbon storage. Further, the forest product output should be incorporated into regional economic planning to promote effective utilization. Overall, active and effective forest management is a win-win-win situation for the ecosystem, the environment, and the economy.

Fourthly, managing forest with long-term strategies. Long-term strategic forest planning and carbon storage strategies are important for the national carbon-neutral strategies. The study was conducted over a period of 250 years, and the results show that forest carbon stocks under the management scenario are about 1.3 times greater and more stable over the long term than under the no management scenario. Therefore, forest management should be viewed in terms of long-term development.

Funding: This work was supported by the funds for First-class Discipline Construction (Grant numbers XK1802-5), the Beijing Social Science Foundation of China (Grant number 18GLB029), the National Social Science Foundation of China (Grant number 22FGLB011 and G2022106001L) .

Acknowledgements: The authors thank Gao Meng Meng from Nanjing Jialin System Engineering Technology Co., Ltd. for his help on the simulation model.

References

BFSDI (Beijing Forest Survey and Design Institute). (2016): Twelfth Five-Year Plan Survey Statistical Report of Beijing Forest Resource Planning and Design Survey. Beijing: BFSDI.

Bishnu, H. P.; Tek, M.; Geoff C. (2019): Impacts of forest management on tree species richness and composition: Assessment of forest management regimes in Tarai landscape Nepal. *Applied Geography*, 111. 102078. https://doi.org/10.1016/j.apgeog.2019.102078

Chen, K.Y., Wang, J.J., He, Y.J., et al. (2022): Estimations of forest carbon storage and carbon sequestration potential of key state-owned forest region in Daxing'anling, Heilongjiang Province. *Ecology and Environmental Sciences*, 31. 1725-1734.

Daigneault, A., Favero, A. (2021): Global forest management, carbon sequestration and bioenergy supply under alternative shared socioeconomic pathways. *Land Use Policy,* 103. 105302. https://doi.org/10.1016/j.landusepol.2021.105302

Dai, Q.L.; Zhang, C.; Shang, K.R.; et al. (2020): Rational annual cutting volume of forest management units based on FSOS. *Journal of Zhejiang A & F University*, 37. 833-840.

Jia, B.; Guo, W.W.; He, J.Y.; et al. (2022): Topography, Diversity, and Forest Structure Attributes Drive Aboveground Carbon Storage in Different Forest Types in Northeast China. *Forests*, 13. 455. https://doi.org/10.3390/f13030455

Jiang, J.H, Qi, S., Hu, J., et al. (2019): Carbon storage assessment and analysis of forest ecosystem in Beijing mountainous area based on InVEST model. *Earth Environ*, 47. 326-335. https://doi.org/10.14050/j.cnki.1672-9250.2019.47.049

Jo, H., Kim J., Park H. (2019): Carbon reduction and planning strategies for urban parks in Seoul. *Urban For Urban Gree*, 41. 48-54. https://doi.org/10.1016/j.ufug.2019.03.009

Li, Q.; Xia, X.; Kou, X.; et al. (2023): Forest Carbon Storage and Carbon Sequestration Potential in Shaanxi Province, China. *Forests*, 14. 2021. https://doi.org/10.3390/f14102021

Lin, B.Q., Ge, J.M. (2019): Valued forest carbon sinks: How much emissions abatement costs could be reduced in China. *Journal of Cleaner Production*, 224. 455-464. https://doi.org/10.1016/j.jclepro.2019.03.221

Liu, G.L. (2000): A simulated annealing method for target-oriented forest landscape blocking and scheduling. doctoral thesis, the University of British Columbia, Canada.

Liu,G.L.; Han, Shijie. (2009): Long-term forest management and timely transfer of carbon into wood products help reduce atmospheric carbon. *Ecological Modelling*, 220. 1719-1723. https://doi.org/10.1016/j.ecolmodel.2009.04.005

Liu,G.L., Nelson, J., Wardman, C. (2000): A target-oriented approach to forest ecosystem design－changing the rule of forest planning. *Ecological Modelling*, 127. 269. https://doi.org/10.1016/S0304-3800(99)00217-3

Liu, J.H., Wu, F.P. (2017): Forest Carbon Sequestration Subsidy and Carbon Tax as Part of China's Forestry Policies. *Forests*, 8. 58. https://doi.org/10.3390/f8030058

Liu, J., Liu, Y.M., Liu, G.L., et al. (2012): Multi-objective Sustainable Business Planning Study－A Case Study of Baihe Forest Bureau. *Forestry Economics*, 7. 105-108. https://doi.org/10.13843/j.cnki.lyjj.2012.07.017

Luo, Y.J.; Wang, X.K.; Zhang, X.Q.; et al. (2013): Biomass and Its Allocation of Forest Ecosystems in China, 1st ed. Beijing: China Forestry Publishing House.

Nowak, D.J., Greenfield, E.J., Hoehn, R.E., et al. (2013): Carbon storage and sequestration by trees in urban and community areas of the United States. *Environ Pollut*, 178. 229-236. https://doi.org/10.1016/j.envpol.2013.03.019

Ren, Y.M.; Wen, Z.Y.; Wang, M.N.; et al. (2023): Evaluation of forest carbon sequestration capacity in Beijing. *Journal of Beijing Forestry University*, 45. 108-119. https://doi.org/10.12171/j.1000-1522.20220436

Robert, A. G.; Colleen M. R.; Ethan P. B.; et al. (2022): Storing More Carbon by Improving Forest Management in the Acadian Forest of New England, USA. *Forests*, 13. 2031. https://doi.org/10.3390/f13122031

Roth, E.-M.; Karhu, K.; Koivula, M. et al. (2023): How do harvesting methods applied in continuous-cover forestry and rotation forest management impact soil carbon storage and degradability in boreal Scots pine forests?. *Forest Ecology and Management*, 544. 121144. https://doi.org/10.1016/j.foreco.2023.121144

SFAC (State Forestry Administration of China). (2014): Forest Management Carbon Storage Project Methodology. Beijing: SFAC.

SFAC (State Forestry Administration of China). (2017): Regulations for age-class and age-group division of main tree-species (LY/T2908-2017). Beijing: SFAC.

SFSCCP (Smart Forest Simulation model-Cloud Computing Platform). Available online: http://forestcloud.cn (accessed on 25 January 2022).

Štraus, H.; Podvinšek, S.; Klopčič, M. et al. (2023): Identifying Optimal Forest Management Maximizing Carbon Sequestration in Mountain Forests Impacted by Natural Disturbances: A Case Study in the Alps. *Forests*, 14. 947. https://doi.org/10.3390/f14050947

Sugiyama, A.; Game, E. T.; Wright, S. J. (2024): Planting exceptional tropical tree species to increase long-term carbon storage in assisted secondary succession. *Journal of Applied Ecology*, 61. 7-12. https://doi.org/10.1111/1365-2664.14533

Tu, H.T., Zhou, H.B., Ma, G.Q., et al. (2023): Characteristics of Forest Carbon Storage in Yunnan Based on the Ninth Forest Inventory Data. *Journal of Northwest Forestry University*, 38. 185-193.

Wei, Y.; Jim, C.-Y.; Gao, J.; Zhao, M. (2023): Determinants of Aboveground Carbon Storage of Woody Vegetation in an Urban–Rural Transect in Shanghai, China. *Sustainability*, 15. 8574. https://doi.org/10.3390/su15118574

Wondimu, M. T.; Nigussie, Z. A.; Yusuf, M. M. (2021): Tree species diversity predicts aboveground carbon storage through functional diversity and functional dominance in the dry evergreen Afromontane forest of Hararghe highland, Southeast Ethiopia. *Ecological Processes*, 10. 1-15. https://doi.org/10.1186/s13717-021-00322-4

Wu, L.Q.; Sun, Y.B.; Sun, H.; et al. (2022): Determination of annual full cycle cutting volume of main forest types in Saihanba Mechanized Forestry Farm based on Forest Simulation Optimization System (FSOS). *Forestry and Ecological Sciences*, 37. 134-141. https://doi.org/10.13320/j.cnki.hjfor.2022.0019

Zheng, Q.Y.; Wei, H.H.; Chen, J.; et al. (2019): Study on Carbon Sink Value Evaluation of Three-north Shelterbelt Program in the Past 40 Years. *Forestry Economics*, 41. 67-73+112. https://doi.org/10.13843/j.cnki.lyjj.2019.02.012