Analysis of Carbon Sequestration Potential of Forests of the Asian Russia

E.V. Gubiy

Melentiev Energy Systems Institute of Siberian Branch of Russian Academy of Sciences, Irkutsk, Russia

Abstract — **This study provides estimates of the amount of carbon dioxide (CO_2) sequestration and release by managed forests in Siberia and the Russian Far East. The data from "National report of the Russian Federation on the inventory of human-induced emissions by sources and removals by sinks of greenhouse gases not controlled under the Montreal Protocol for 1990–2010" served as input data. We calculated the amounts of CO_2 taken up and released. The net CO_2 flux is the difference between the CO_2 sequestrated and CO_2 released. The sequestration potential of forests depends on the climatic conditions of the area and the species of woody plants growing there. Many forests die every year, and the CO_2 release by forests is caused by clear-cuttings and natural disasters. The highest sequestration rate of forests was observed in Omsk and Irkutsk regions, the lowest – in the Chukotka autonomous district and Magadan region. The largest amounts of CO_2 were sequestrated in the Republic of Sakha (Yakutia) and Krasnoyarsk territory. The highest release rates were observed in the Chukotka autonomous district and the Khabarovsk territory, the lowest – in the Novosibirsk region, Kemerovo region, and Kamchatka territory. We conclude that nearly half of the total CO_2 sequestration by managed forests in Russia was contributed by its Asian regions, with 27.5% by the Siberian Federal District and 20.9% by the Russian Far East.**

Index Terms: **sequestration potential of forests, sequestration of human-induced emissions, carbon dioxide sequestration, managed forests in Russia.**

* Corresponding author.
E-mail: egubiy@isem.irk.ru

http://dx.doi.org/10.25729/esr.2022.05.0011
Received April 06, 2023. Revised April 21, 2023.
Accepted April 23, 2023. Available online April 30, 2023.

I. Introduction

In 2015, the Paris Climate Agreement [1] was adopted to strengthen the global response to the threat of climate change by keeping the global average temperature increase to 2°C by 2050 and preferably 1.5°C by 2040. In the future it is planned to build a climate-neutral world. The Agreement also aims to strengthen the ability of countries to cope with the effects of climate change.

As many scholars and politicians believe, it is greenhouse gas emissions that cause global climate change [2]. Therefore, among the key measures aimed at combating climate change within the framework of the Paris Agreement, the Parties to the agreement emphasize the following: the use of renewable energy sources, the development of hydrogen power and smart technologies, a radical reduction in energy losses. However, the principle of carbon neutrality implies not only the reduction in greenhouse gas emissions to zero, but also the possible compensation of emissions by sequestration of greenhouse gases by terrestrial ecosystems, in particular forests [3]. Therefore, another measure that is anything but unimportant is to expand the area of managed forests and significantly reduce the area of wildfires and clear-cutting.

Given the abundant forest resources of the Asian part of Russia, it is through the sequestration potential of the forests that the country can make a significant national contribution to achieving the goal of the Paris Climate Agreement [4]. As part of this study, we estimated the amount of carbon dioxide (CO_2) sequestration and removal as the main component of greenhouse gases by managed forests in Siberia and the Russian Far East by pools (aboveground and belowground portions of live biomass, deadwood, litter, soil). Data on the amount of carbon (C) sequestration and removal by managed forests in Russia by federal districts and subjects from 1990 to 2020 were taken as input data for the study [5, 6]. Based on these data, we calculated the amount of CO_2 sequestration and removal for all subjects of the Siberian and Far Eastern Federal Districts, as well as the net CO_2 flux of managed forests.

Table 1. Sequestration and emissions of greenhouse gases in the LULUCF sector in 2020

Category of land	Greenhouse gas emissions (+) and sequestration (–), million tons co2-eq year-1
Forest lands	– 622.3
Cropland	69.6
Grassland	– 31.8
Wetlands	2.6
Settlements	2.5
Other land	0.9
Harvested wood products	9.2
Indirect emissions from managed land	0.1
Total	– 569.2

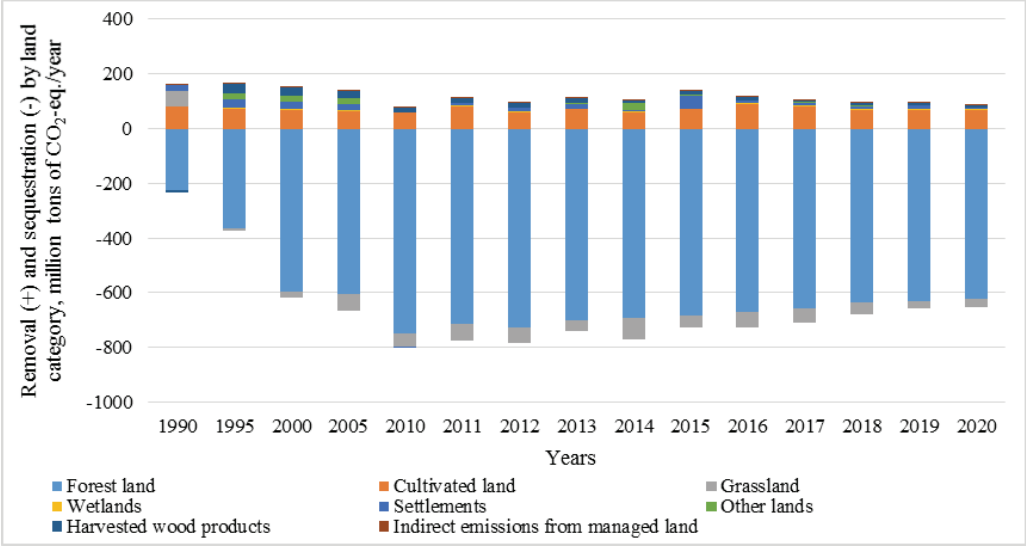

Fig. 1. Greenhouse gas emissions and sequestration in the LULUCF sector.

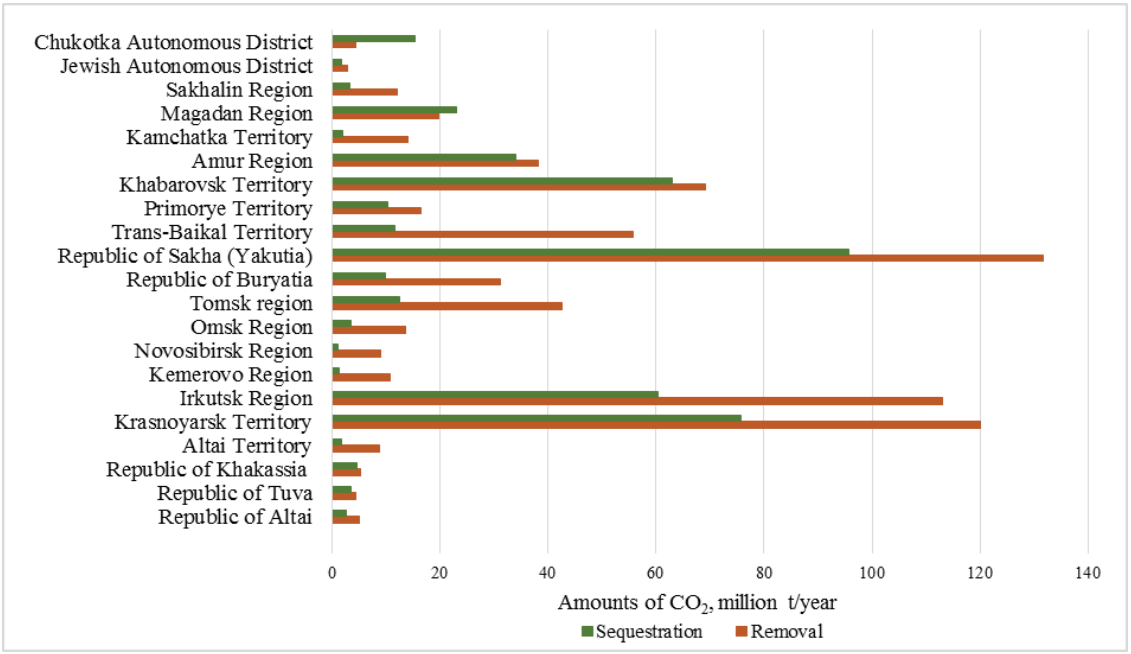

Fig. 2. Amounts of carbon dioxide sequestration and removal by managed forests by subjects of the Siberian and Far Eastern Federal Districts.

II. Methods and Data

The basis of the study was the National report of the Russian Federation on the inventory of human-induced emissions by sources and removals by sinks of greenhouse gases not controlled under the Montreal Protocol for 1990–2010 [5, 6], which was drawn up and submitted in accordance with the obligations of the Russian Federation under the UN Framework Convention on Climate Change and the Kyoto Protocol to the UN Framework Convention on Climate Change.

We processed the data for 1990-2020 on removal and sequestration of greenhouse gases that result from human-induced activities in the course of land use, land-use change, and forestry (LULUCF) [5, 6].

The conversion of C emissions to CO_2 emissions was done by multiplying carbon by a carbon-to-carbon-dioxide conversion factor of 44/12 (molar weights are as follows: C is 12 g/mol, $O_2 = 2 \cdot 16 = 32$ g/mol, $CO_2 = 12 + 2 \cdot 16 = 44$ g/mol, respectively).

III. Contributions of Different Land Categories to Greenhouse Gas Sequestration

According to the principles of the Intergovernmental Panel on Climate Change (IPCC) for national greenhouse gas inventories, there are the following categories of land use in the LULUCF sector (land use, land-use change, and forestry): forest land, cropland, grassland, wetlands, settlements, other land, harvested wood products, indirect emissions from managed land.

The greenhouse gases sinks are forest land as well as grassland. The remaining categories of land are emission sources. Cultivation of agricultural land and logging have the highest emissions associated with these activities (Table 1).

As shown in Table 1, the net flux of greenhouse gases is most dependent on forestry. Accounting for the contribution of all other land categories in 2020 reduced sequestration by as little as 8.5%.

Fig. 1 shows that from 1990 to 2020 the amounts of both sequestration and emissions of greenhouse gases have changed significantly for all categories of land. This is due to the transfer of land from one category to another. For example, the area of managed forests was increased due to the transfer of some of the unmanaged forest land to this category. And it was decreased, among other reasons, due to designating some of managed forests as settlement land. Cropland and grassland are annually transformed into unmanaged forest land when naturally overgrown with shrubs and small woods.

CO_2 is the main cause of climate change. In addition, methane (CH_4) and nitrogen oxide (NO_2) emissions are present in the LULUCF sector, which are mainly caused by wildfires. Their share in the net flux of greenhouse gases over the entire area of Russia is less than 4% [5].

Without having sufficient statistical data on the spatial distribution of lands of each category over the territory of Russia and data on emissions and sequestration of greenhouse gases on lands of different categories, it is the contribution of managed forests as the main sink of CO_2, which will be detailed below.

IV. Contribution of Managed Forests in the Asian Part of Russia to Carbon Dioxide Sequestration

Currently, managed forests in Russia include forest lands of the forest fund (except reserve forests), defense and security lands, protected natural areas (PNA), and urban forests [8]. Combined, they occupy 691.2 million hectares (or 77.1% of the forest lands of the Russian Federation). In [5, 6] the amounts of emissions and sequestration of CO_2 in urban forests was not estimated. Therefore, these metrics will be considered in detail for managed forests of the forest fund, defense and security lands, and protected natural areas (a total of 690 million hectares, or 77.0% of the forest lands of the Russian Federation).

The sequestration potential of forests is related to the climatic features of the area and the species of woody plants that grow there. Carbon dioxide release by managed forests is caused by clear-cutting, destructive fires, and other causes of loss of standing forest cover.

Data on CO_2 sequestration and removal rates by managed forests of each subject of the Siberian and Far Eastern Federal Districts are presented in Table 2. Table 2 shows that the highest sequestration rate of forests was observed in Omsk (2.93 t/ha) and Irkutsk (2.41 t/ha) regions, and the lowest – in the Chukotka autonomous district (0.45 t/ha) and the Magadan region (0.74 t/ha). Among the subjects of the Siberian and Far Eastern Federal Districts, the highest removal rates were observed in the Khabarovsk territory, Chukotka autonomous district, and the Republic of Khakassia – 1.72; 1.58 and 1.51 t/ha, respectively. The lowest emission rates were in Novosibirsk and Kemerovo regions, and the Kamchatka territory – 0.24; 0.26 and 0.28 t/ha, respectively.

The largest amounts of CO_2 were sequestrated and removed by managed forests in the Republic of Sakha (Yakutia), Krasnoyarsk territory, Irkutsk region, and Khabarovsk territory (Fig. 2). This is due to the fact that the area of forests in these subjects of the Russian Federation is the highest.

The net CO_2 flux was calculated as the difference between CO_2 sequestrated and CO_2 removed. Data on the net CO_2 flux of managed forests in the Siberian and Far Eastern federal districts are shown in Fig. 3. The largest contribution to CO_2 sequestration in the eastern part of the country comes from managed forests in the Irkutsk region (56.0 million tons/year), Krasnoyarsk territory (46.3 million tons/year), Trans-Baikal territory (45.9 million tons/year), and the Sakha Republic (Yakutia) (36.7 million tons/year). The negative net flux was observed in two subjects of the Far Eastern Federal District with the least favorable climatic conditions: Chukotka autonomous district (–11.1 million tons per year) and Magadan region

TABLE 2. CO_2 Sequestration and Removal Rates by Managed Forests in the Siberian and Far Eastern Federal Districts

Federal districts and subjects of the Russian Federation	Area, million hectares	Rate of CO_2 sequestration, t/ha	Rate of CO2 removal, t/ ha
Siberian Federal District	181.9	1.83	0.92
Altai republic	3.9	1.27	0.66
Republic of Tuva	3.5	1.29	1.04
Republic of Khakassia	3.1	1.76	1.51
Altai territory	3.9	2.27	0.44
Krasnoyarsk territory	86.1	1.40	0.88
Irkutsk region	47.0	2.41	1.29
Kemerovo region	5.2	2.09	0.26
Novosibirsk region	4.8	1.89	0.24
Omsk region	4.7	2.93	0.74
Tomsk region	19.6	2.18	0.64
Far Eastern Federal District	265.6	1.49	1.02
Republic of Buryatia	15.9	1.96	0.62
Republic of Sakha (Yakutia)	100.0	1.32	0.96
Trans-Baikal territory	26.3	2.11	0.44
Primorsky territory	10.5	1.57	0.98
Khabarovsk territory	36.5	1.89	1.72
Amur region	24.7	1.55	1.38
Kamchatka territory	7.2	1.96	0.28

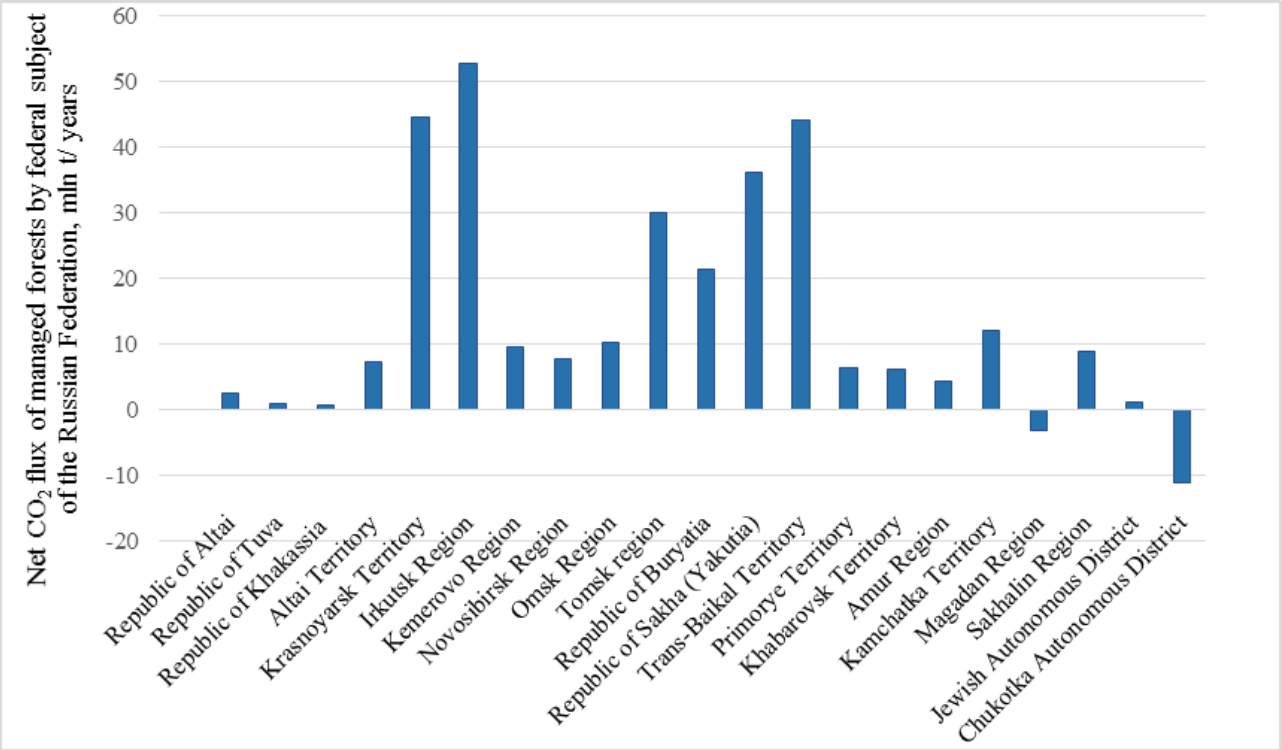

Fig. 3. Amounts of carbon dioxide sequestration and removal by managed forests by subjects of the Siberian and Far Eastern Federal Districts.

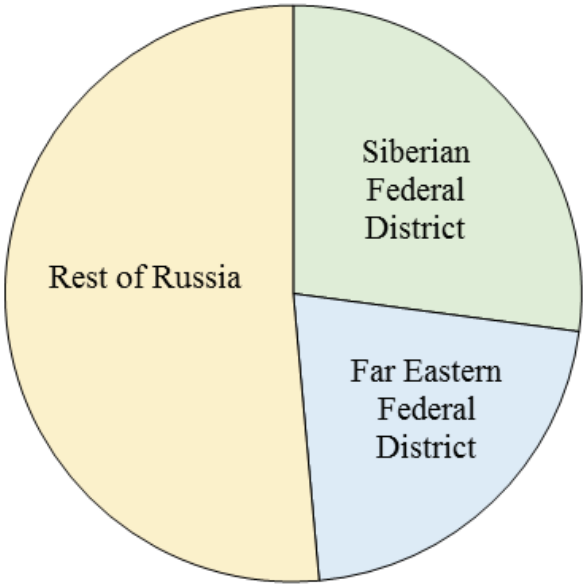

Fig. 4. Contribution to carbon dioxide sequestration by managed forests in the Siberian and Far Eastern Federal Districts.

(–3.2 million tons per year). In almost all federal subjects of the eastern part of the Russian Federation, the net flux of CO_2 of the forest fund accounted for more than 80% of the total net flux of managed forests. The exception was the Primorsky territory, where the net CO_2 flux of the forest fund accounted for 69.4%, and 27.1% was contributed protected natural areas. The net CO_2 flux of defense and security lands accounted for no more than 3.5%.

Overall, almost half of the total contribution to CO_2 sequestration by managed forests in Russia comes from its Asian regions. As can be seen from Fig. 4, the Siberian Federal District accounted for 27.1% and the Far Eastern Federal District for 21.5%.

V. Conclusion

The forest resources of the Asian part of Russia, due to the sequestration potential of forests, can make a significant national contribution to the country's achievement of the goal of the Paris Climate Agreement. The study estimated the amount of sequestration and removal of CO_2 as the main component of greenhouse gases by managed forests in Siberia and the Russian Far East. Since the net flux of greenhouse gases depends to the greatest extent on the sequestration and removal of CO_2 by forests, we studied their amounts by federal districts, and in the case of the Asian part of Russia – also by subjects of the Russian Federation.

The study found out that the contribution of managed forests in the Asian part of Russia accounted for almost half of all CO_2 sequestrated by managed forests in Russia, despite much harsher climatic conditions than in the western part of the country, the main reason for this being large areas of forested land.

Acknowledgments

The research was carried out under State Assignment Project (no. FWEU-2022-0001) of the Basic Research Program of the Russian Federation 2021–2030 and made use of the resources of the «High-Temperature Circuit» shared research facilities center (Ministry of Science and Higher Education of the Russian Federation, project no 13.CKP.21.0038).

References

[1] Paris Agreement. United Nations, 2015. [Online]. Available: https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_russian_.pdf

[2] Australian Academy of Science. 2. The science of climate change: Questions and answers, 2015. [Online]. Available: https://www.science.org.au/files/userfiles/learning/documents/climate-change-r.pdf

[3] United Nations Climate Change. Nationally determined contributions, 2021. [Online]. Available: https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx.

[4] P. Leskinen, M. Lindner, P. J. Verkerk and other, *Russian forests and climate change*. Joensuu, Finland: European Forest Institute, 2020. [Online]. Available: https://efi.int/sites/default/files/files/publication-bank/2021/efi_wsctu_11_2021_ru.pdf.

[5] National report of the Russian Federation on the inventory of human-induced emissions by sources and removals by sinks of greenhouse gases not controlled under the Montreal Protocol for 1990-2010, part 1. Moscow, Russia: Rosgidmet, 2022, 468 p. (In Russian)

[6] National report of the Russian Federation on the inventory of human-induced emissions by sources and removals by sinks of greenhouse gases not controlled under the Montreal Protocol for 1990-2010, part 2. Moscow, Russia: Rosgidmet, 2022, 111 p. (In Russian)

[7] A. V. Stetcenko, G. V. Safronov, *Investing in Russia's Forests: Methodological Framework.* Moscow, Russia: Maks, 2010, 134 p. (In Russian)

[8] Forest Code of the Russian Federation of December 4, 2006, No. 200-FZ (as amended on December 30, 2021) (as amended and supplemented, effective from March 1, 2022). [Online]. Available: http://www.consultant.ru/document/cons_doc_LAW_64299. (In Russian)

Elena V. Gubiy graduated from Irkutsk State University in 2009 and received her PhD in 2020. She is a Researcher at the Melentiev Energy Systems Institute, Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia. Her research interests include bioenergy, biomass, and renewable energy.