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Carbon absorption by forests in the Volga region and Siberia: state and prospects

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Abstract. The prospect of Russia's economic development will be inextricably bound up with the country's success in the implementation of global climate initiatives. The strategy for the development of the national economy with a low level of greenhouse gas emissions, which is currently being formed, implies the fullest use of the potential for carbon sequestration by forest ecosystems, including through the implementation of various forest-climatic projects.

The article shows that despite the world's largest forest areas, the carbon-absorbing capacity of Russian forests cannot balance anthropogenic greenhouse gas emissions. Using the examples of several regions of the Volga region and Siberia, the spatial dynamics of the forest carbon budget in the 2010s is considered. For the regions of Siberia rich in boreal forests, there is a significant disproportion between the quantitative and qualitative characteristics of forest resources and the absorbing capacity, which is explained by the ineffective forestry regime in the territory and the high intensity of forest disturbances. Taking into account the fact that building an effective system for combating forest fires and insect pests requires very voluminous and expensive measures, the effectiveness of which is difficult to assess, the above illustrations of the current situation lead to the idea that, in addition to using the potential for increasing carbon sequestration in traditional forest regions in the implementation of forest-climatic projects should pay attention to sparsely forested areas.

Keywords: economics of climate change, forest ecosystems, carbon-absorbing capacity of forests, carbon budget, greenhouse gases, Russia, global climate initiatives, forest-climate projects

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Introduction

The relevance of the problem of global climatic changes and their impact on various aspects of social and economic life has ceased to be questioned in recent years. The imminent introduction into the practice of international economic activity of regulation related to taking into account the emission and absorption of greenhouse gases by individual enterprises, regions and countries, actualizes the problem of correct accounting of the components of the carbon budget, as well as active measures to reduce greenhouse gas emissions in various ways. Political leaders of the world's leading economies have recently been competing in formulating national goals and contributions to solving the problem of global warming, trying to balance the ambitiousness of the promises made and the possibility of their practical implementation (Rogelj et al., 2021). Of course, this topic attracts close attention of the entire academic community and requires a comprehensive, interdisciplinary answer to many questions (Danilov-Daniliyan et al., 2020).

For Russia, this problem is especially important for the following reasons. Firstly, our country is the fourth largest emitter of greenhouse gases in the world after China, the United States and India (according to data for 2019, gross emissions amounted to 2.1194 billion tons of CO_2-equivalent). Secondly, the dynamics of emissions in recent years is quite stable and does not show a pronounced tendency to decrease. Thirdly, the currently being designed systems of cross-border carbon regulation imply the collection of the bulk of payments for greenhouse gas emissions mainly from producers of primary natural resources, which threatens primarily countries with a raw material structure of the economy (Porfir'ev et al., 2020; Kolpakov, 2021; Shirov et al., 2021).

In accordance with the norms of the IPCC (Intergovernmental Panel on Climate Change), the carbon budget is taken into account at the level of individual countries, while the norms of the Paris Climate Agreement of 2015 imply that countries have

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the right to independently determine their national contribution to the fight against global warming. For Russia, the goal is formulated as follows: by 2030, it is necessary to ensure a reduction in emissions to 70% of the 1990 level. It is known that this goal was actually achieved by the end of the 1990s due to the liquidation of many Soviet industrial enterprises, especially those related to the military-industrial complex and other sectors of the economy, which could not maintain their competitiveness in the new market conditions.

In addition to reducing anthropogenic emissions of greenhouse gases, measures to increase the absorption capacity of greenhouse gases by terrestrial ecosystems (primarily forests) are gaining importance. Such measures are, in fact, the only way to balance the global carbon equation. It is the systemic measures to rapidly increase the sequestration of carbon by forests that can significantly change the current and future situation with global warming without significant restrictions on economic growth. This approach will be implemented within the framework of various forest-climatic projects – systemic measures aimed at increasing the absorption of carbon by forest ecosystems relative to the natural level.

This article proposes to analyze the potential of using the carbon-absorbing capacity of Russian forests using the example of the regions of the Volga region and Siberia. Data processing and mapping were performed using the open, free-distribution statistical software package R (R Core team, 2021) with *tmap* (Tennekes, 2018) and *forecast* (Hyndman, Khandakar, 2008) modules.

The role of forests in the national balance of greenhouse gas emissions and absorbing

At first glance, the impression is that Russia, which has one fifth of the world's forests by area, has every chance to practically compensate for any industrial greenhouse gas emissions due to the enormous carbon-absorbing capacity of its forests. In reality, this statement is only partly true.

Earlier, we discussed the situation with differences in the methods of accounting for the carbon-absorbing capacity of forests from Russia (Pyzhev, Vaganov, 2019). In accordance with the national obligations to submit annual reports to the IPCC, our country annually calculates estimates of carbon sequestration by all forest ecosystems (more precisely, the LULUCF sector – Land use, land use change and forestry) based on the Regional Forest Carbon Budget (ROBUL) methodology according to the State Forestry register (GLR). This methodology has been repeatedly discussed and refined and is recognized by the IPCC experts as meeting the requirements of this organization. Despite the alternative estimates obtained by various research teams, which are 2-3 times higher than the official ones (Shvidenko et al., 2014; Filipchuk et al., 2018), it is the estimates obtained with the help of ROBUL that will continue to be used to account for carbon-absorbing the ability of Russian forests, including for the practical implementation of economic mechanisms for carbon regulation (Romanovskaya et al., 2020).

Recent work carried out with the participation of all of the above groups shows that the actual absorptive capacity of Russian forests is approximately 47% higher than that stated in the official national reporting to the IPCC (Schepaschenko et al., 2021).

It is interesting to trace the dynamics of anthropogenic greenhouse gas emissions against the background of carbon absorption by forest ecosystems over the entire available observation horizon: starting from 1990 (Fig. 1).

The previously noted trend towards a rapid reduction in greenhouse gas emissions is evident: from 3.1 million tons in 1990 to 1.9 million tons in 2000, that is, by almost 40%. Then, with the recovery growth of the Russian

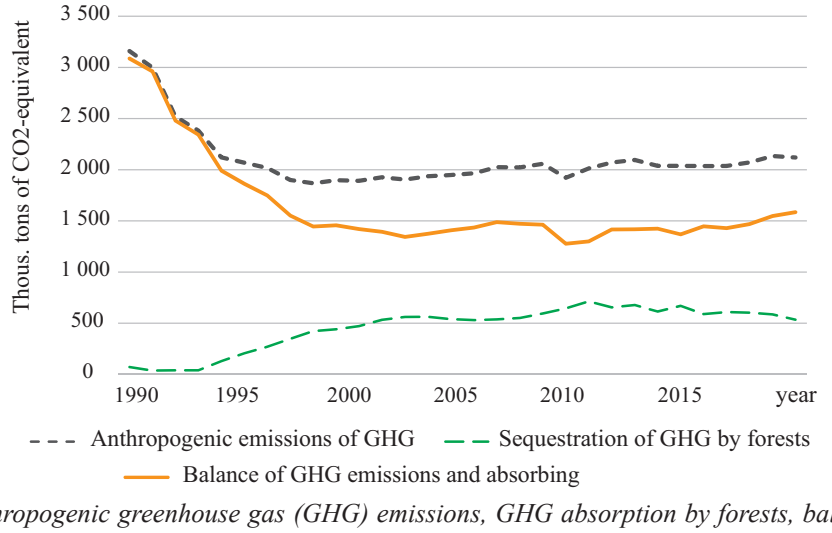

Fig. 1. Dynamics of anthropogenic greenhouse gas (GHG) emissions, GHG absorption by forests, balance of GHG emissions and absorption in Russia in 1990–2019. Source: National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of greenhouse gases not controlled by the Montreal Protocol. http://downloads.igce.ru/kadastr/rus-2021-nir-15apr21.zip

economy in the context of technological modernization, the indicator gradually increased, approaching to the present moment to 2.1 million tons.

A different dynamics is observed for the absorption of carbon by the LULUCF sector: in 1990 it was estimated at only 70 thousand tons, but by 2000 it was close to 500 thousand tons. Subsequently, the level of the indicator was in the range of 530–710 thousand tons annually. Very low indicators at the beginning of the observation period generally correlate with the results of known alternative estimates, which stated a high interannual variability of carbon sink in the range of 180–750 thousand tons per year (Nilsson et al., 2003).

In general, at the moment the LULUCF sector provides about 25% of the conditional compensation of anthropogenic greenhouse gas emissions in Russia, thus playing a really significant role in the national carbon balance. However, at the moment it is not necessary to speak about the full conditional compensation of anthropogenic greenhouse gas emissions due to the absorption of carbon by forest ecosystems. In addition, even if Russian forests could provide such an opportunity, this would not affect the economic burden of enterprises with new climate payments. The economic mechanisms developed under the Paris Agreement do not imply the possibility of offsetting natural carbon sequestration as offsetting anthropogenic emissions (Makarov et al., 2018). For such purposes, only purposeful anthropogenic changes in the flows of greenhouse gases can be applied (for example, the appearance of forests in places where they did not exist before; the creation of technical reservoirs for the accumulation of carbon, etc.).

Prospects for increasing the carbon-absorbing capacity of forests: a regional aspect

The sharply increased interest in the issues of increasing the absorptive capacity of Russian forests has led to a significant increase in the number of scientific publications on this topic. Traditionally, there are few works that would consider the regional profile, and even more so – the level of industries or enterprises. At the same time, with the practical implementation of any carbon regulation mechanisms, it is precisely such research that will become essential, since any proposed methods of levying carbon payments will ultimately concern specific producers who will face an increase in export costs of their products.

For example, the literature practically does not analyze the data of regional accounting of greenhouse gas fluxes within the LULUCF sector, which are published annually within the framework of National Inventories of anthropogenic emissions by sources and removals by sinks of greenhouse gases not regulated by the Montreal Protocol. The presented data are a valuable source of information on the spatial dynamics of the carbon budgets of forest ecosystems, despite the systematic underestimations of the absorptive capacity of forests described above.

For the purposes of this study, we will conduct a basic analysis of the spatial dynamics of forest carbon budgets in some large areas of the country. For contrast, we will consider two large Russian macroregions, distinguished by ecological and geographical features. It is proposed to elect five subjects of the federation located in the Volga region as the first macroregion: Samara and Ulyanovsk regions, the Republic of Tatarstan, Chuvashia and Mari El. These regions are geographically connected by the river basin. The Volga are located in the predominantly steppe, sparsely forested zone of the European part of the country (Fig. 2).

For example, the territory of the Republic of Tatarstan belongs to sparsely wooded areas: the total area of the forest fund in the region is about 1.3 million hectares, and the forest cover of the territory does not exceed 18%. Taking into account the history of the economic development of the forest and agricultural territories of the Republic, which led to massive soil erosion and high rates of deforestation during the Soviet period of the country's development, it seems that the region has a certain potential for increasing forest cover, which will increase the possibility of carbon absorption by forests. At the moment, even according to the official data of the Russian Greenhouse Gas Inventory, the estimates of which are likely to be quite significantly underestimated, the forests of Tatarstan annually absorb up to 4.8 million tons of CO_2-equivalent. At the same time, for example, the Tatneft Group annually emits about 3.8 million tons of CO_2-equivalent, that is, an almost comparable volume (A sustainable energy future. Tatneft Company Annual Report (2020). https://2020.tatneft.ru).

The dynamics of the carbon budget of the forests of the Volga regions is consistently stable (Fig. 3). In almost all cases, it repeats the country-wide lack of variation in this indicator, due primarily to the low quality and frequency of accounting of the forest fund, reflected in the State Forest Register. In addition, sparsely forested areas are expected to meet little with the main types of natural and anthropogenic forest disturbances (fires, outbreaks of insect pests, windfalls). The levels of the budgets themselves are comparable to each other with an average carbon removal of about 906 million tons of carbon per year.

On the contrary, the territories of the second macroregion are represented by densely overgrown Siberian boreal forests in the Krasnoyarsk Territory, Irkutsk and Tomsk Regions. This approach to the selection of regions provides sufficient contrast for the interpretation of the results of the comparative analysis (Fig. 4).

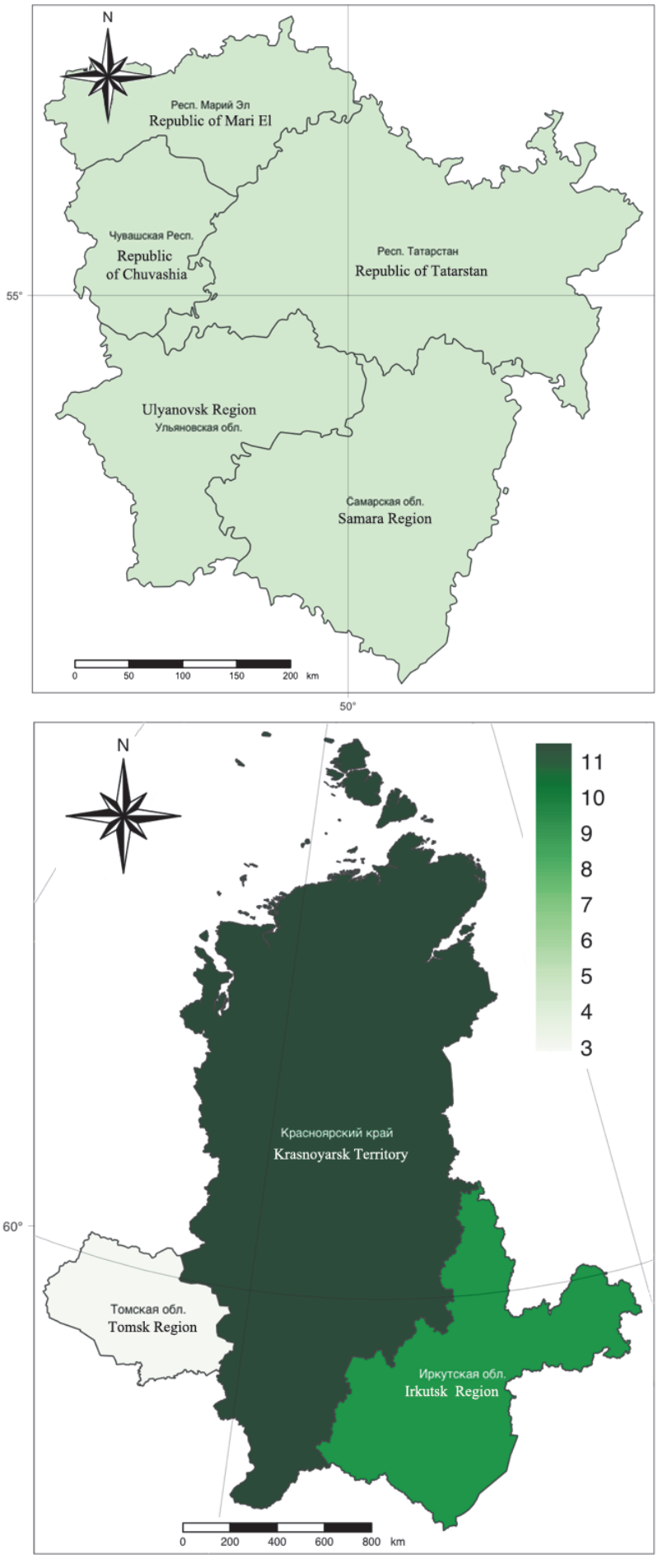

Fig. 2. Spatial distribution of timber reserves of the considered regions of the Volga region (left) and Siberia (right) as of 2018, billion cubic meters. Source: EMISS data on timber reserves in the regions of the Russian Federation

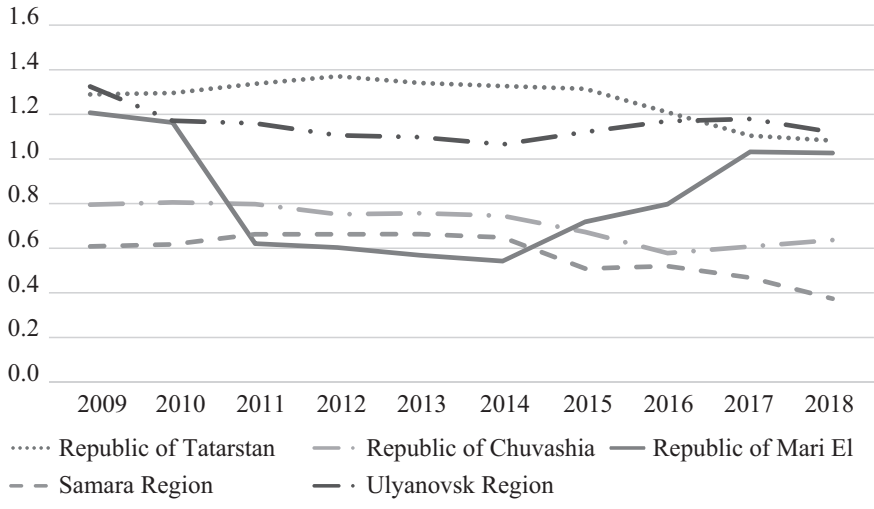

Fig. 3. Dynamics of the carbon budget for the forests of the considered regions of the Volga region in 2009–2018, million tons of carbon per year. Source: National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of greenhouse gases not controlled by the Montreal Protocol. http://downloads.igce.ru/kadastr/rus-2021-nir-15apr21.zip

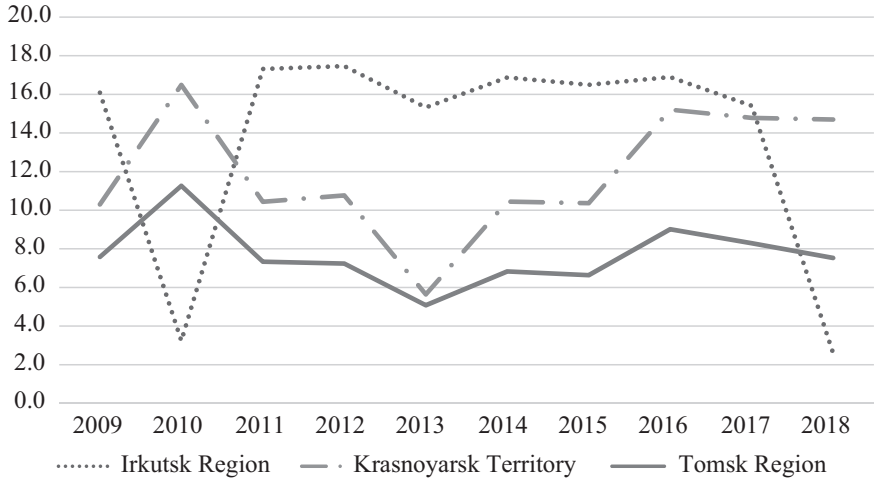

Fig. 4. Dynamics of the carbon budget of the forests of the considered regions of Siberia in 2009–2018, million tons of carbon per year. Source: National Inventory of Anthropogenic Emissions by Sources and Removals by Sinks of greenhouse gases not controlled by the Montreal Protocol. http://downloads.igce.ru/kadastr/rus-2021-nir-15apr21.zip

In the context of this discussion, the largest forest regions of Russia are of paramount importance: Krasnoyarsk Territory and Irkutsk Region.

Irkutsk region, one of the richest regions of the country (forest area – 71.5 million hectares, total timber stock – 8.8 billion cubic meters, that is, 10.7% of the total Russian reserves), and the largest logging company (31.7 million cubic meters in 2019, that is, 13% of all-Russian logging). The Krasnoyarsk Territory is the absolute leader in the country in terms of forest area (168 million hectares), yielding to the Irkutsk region in terms of logging (25.6 million cubic meters). Success in the extensive development of forest resources in the Angara-Yenisei macroregion turns into a paradoxical situation when the leader of the country's forest industry, which owns 1/5 of the world's forests, in the current situation cannot provide high rates of carbon sequestration.

According to the official data of the National Greenhouse Gas Inventory of Russia, the forests of the Irkutsk region absorbed 13.4 million tons of CO_2-equivalent in average annual terms in 2009–2018, which is only 2.3% of the all-Russian indicator, the same figure for the Krasnoyarsk Territory – in total 11.5 million tons of CO_2-equivalent. Such figures are explained by high volumes of felling and intense forest disturbances: forest fires and outbreaks of insect pests, including new aggressive species (Baranchikov et al., 2011; Ivantsova et al., 2020). In some years, the carbon budget practically vanished due to strong forest fires: this situation was observed in the Irkutsk region in 2010 (3.2 million tons) and 2018. (2.6 million tons). Thus, there is a significant disproportion between the quantitative and qualitative characteristics of forest resources and the absorbing capacity, which is explained by the ineffective forestry regime in the territory and the high intensity of forest disturbances.

Taking into account the fact that building an effective system for combating forest fires and insect pests

requires very voluminous and expensive measures, the effectiveness of which is difficult to assess, the above illustrations of the current situation leads to the idea that, in addition to using the potential for increasing carbon sequestration in traditional forest regions, attention should be paid to sparsely forested areas.

Conclusion

Russia's participation in global climate initiatives requires not only the reduction of anthropogenic emissions, but also the maximum use of the potential of forests as natural sinks of carbon dioxide. The examples given in the article convincingly show that forests also have a pronounced potential for partial compensation of industrial greenhouse gas emissions within the framework of the practice of climate regulation, subject to the implementation of appropriate forest-climatic projects. In addition to the work on the refinement of the carbon budget estimates, which can be carried out as part of the creation of carbon polygons (a monitoring network of stations and ground stations for monitoring carbon fluxes and stocks) in the region, attention should be paid to the intensive increase in the volume and quality of work on reforestation and afforestation.

It should be understood that it is impossible to talk about the possibility of direct compensation of emissions due to the natural absorption of carbon by forests, since only purposeful anthropogenic changes in the flows of greenhouse gases can be used for offsets (for example, the appearance of forests in places where there were no forests before).

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