Reforestation in the Kirov region as an indicator of regional environmental risks

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Abstract. This article analyzes approaches to the selection of indicators of regional environmental risks, as well as the impact of risks on reforestation in a particular region. Indicators that characterize the main trends in the forestry industry in Russia were analyzed using monographic, economic, mathematical, and statistical methods. Factors that promote and hinder effective reforestation in the whole country and in the Kirov region are identified. The authors draw a conclusion about the degree of influence of various factors on reforestation in the region. The consolidated environmental rating of the region was determined based on the calculation of the nature protection, socio-ecological and industrial-ecological indices. A comparative analysis of official statistics and satellite monitoring results revealed significant differences in the results of estimating the area of lost forests. Promising areas for reforestation specified, using methods of abstract-logical assertions and expert assessments, as well as indicators of the regional project "Conservation of forests of the Kirov region»: provision of state institutions with specialized forestry machinery and equipment, training, increasing the area of artificial reforestation, formation of a reserve of forest seeds, attraction of investments, development of the foundation of logging roads. The implementation of the planned measures will make it possible to use the existing forest resources of the region more effectively, preserving and multiplying this invaluable resource.

1 Introduction

Environmental safety indicarors can be determined based on an assessment of the level of environmental risks. Anthropogenic impact on the environment, as well as its negative manifestation – anthropogenic pollution, are global in nature. This is due to the nature of the spread of the consequences of these manifestation, since they are associated not only with the development of a particular region, but also with natural and climatic processes that have a cross-border nature.

Kirov region is one of the forest regions of the Russian Federation. It is increasingly important to develop the forest complex and increase the efficiency of its activities for the regional economy.

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Intensive forest use, reduction of reforestation area and deterioration of its quality have a negative impact on the economic and environmental value of forests.

Reforestation is an important indicator in the system of regional environmental risks and it is the cultivation of forests in areas that have been cutting, wildfire, etc. Reforestation is used to create new forests or improve the composition of tree species in existing ones.

The purpose of the study is to analyze the place of the Kirov region in the environmental rating of the Russian Federation, determining the volume of reforestation as an important factor of environmental risks, the main regional problems in this area, and factors of intensification of reforestation in the region.

Level of development of the scientific problem. The theoretical foundations for studying environmental safety are laid in the works of V. I. Vernadsky, I. I. Dedyu, Yu. K. Efremov, A. P. Kapitsa, Yu. N. Kurazhkovsky, A. A. Mints, N. F. Reimers, T. S. Khachaturov, and others. [1,2,3]. The problem of environmental safety assessment is discussed in the works of domestic (S. N. Bobylev, I. I. Veselova, E. Ya. Vlasova, A.D. Dumnov, N. G. Rybalsky, I. N. Rubanov) and foreign scientists (Jiang Mingjun, J. Barnett, K. Hamilton, J. Dixon, L. MoE, P. R. Ehrlich, etc.) [4,5].

Problems of regional economy management, assessment and using of regional resources were considered in the works of such scientists as: V. N. Afanasyev, I. A. Boyko, A. L. Gaponenko, S. Yu. Glazyev, Yu. S. Dulshikov, I. P. Ivanitskaya [6].

At the same time, the problems related to the process of forming a mechanism for ensuring regional environmental security and the peculiarities of the functioning of individual components of this system remain insufficiently studied. The directions of improving forest management, ensuring fire safety in forests, conducting intensive reforestation activities, including increasing the share of artificial reforestation, as well as using special mechanisms for financial support of these works are insufficiently researched.

2 Materials and methods

Almost two-thirds of Russia's territory is covered by forest. The total land area of the forestry fund, according to the Federal forestry Agency, is 1 billion 146 million hectares [7].

One of the two main forest goals of the National project «Ecology» is the enhancement of the area of reforestation from 62.3% of the area of cut down and lost forest stands in 2018 to 72.8% in 2020 and 100% in 2024. According to Russian statistical Agency (Rosstat) (table 1), the situation with reforestation in Russia is not so optimistic: over the past 3 years, the area of forest protection has decreased by more than 16 times, while the area of forest reproduction does not change significantly.

Table 1. Protection and reproduction of forests in the Russian Federation [8].

Indicator	2017	2018	2019	2019 in % to 2017
Forest stands lost. thousand ha	217.8	223.3	169.1	77.64
Forest protection in the Russian Federation. thousand ha	1488.0	516.1	89.2	5.99
Including: destruction or suppression of the number of harmful organisms by aviation	1457.6	488.6	46.7	3.20
destruction or suppression of the number of harmful organisms by land method:	30.4	27.5	42.5	139.80
- with the use of chemicals	17.6	2.9	3.7	21.02
- with the use of biological drugs	12.8	24.6	38.8	303.13
Forest reproduction in the Russian	961.8	940.4	1067.5	110.99

Federation. thousand ha				
from it. artificial reforestation (creation of forest crops)	176.6	171.8	176.8	100.11
in % of the total reforestation area	18.4	18.3	16.6	-1.80

The Kirov region is positioned as an agricultural region with a large area of woodlands. The region has a significant forest resource base, which contains 1.2 billion cubic meters of wood reserves, including about 527 thousand cubic meters of ripe and overmature forests. According to the Department of forestry of the Kirov region, just over 8 million hectares of forests are currently occupied in the region. 63.2% of the territory of the Kirov region is covered with forest, the total wood supply is more than 1.26 billion m^3. This is about 1.6% of the total wood stock in the forests of the Russian Federation [9].

In terms of harvesting and woodworking, the region occupies a leading position in the Volga Federal district and is one of the largest producers in the European part of Russia. The annual sustainable volume of logging is 17.0 million cubic meters. Special attention is paid to the forest and woodworking industry, as the basis of the natural resource potential of the region is coniferous forest [9].

Table 2. Protection and reproduction of forests in the Kirov region [8].

Indicators	2015	2016	2017	2018	2019	2019 in % to 2015
Reforestation, ha	31136	35013	37181	33670,9	32917,3	105,72
Artificial reforestation (creation of forest crops), ha	6650	6473	5969	5569,3	4662,5	70,11
Forest stands lost, ha	2352	2436	1228	1222	201	8,55

During the analyzed period, the area of reforestation in the region changed unevenly, while artificial reforestation tends to decrease. Since 2017, the area of dead forest stands has been significantly reduced. The identified trends are indirect evidence of an increase in the effectiveness of reforestation activities in the Kirov region.

Preliminary analysis of reforestation indicators in the Kirov region shows that the topic requires more in-depth research based on the use of scientifically based methods and tools.

Theoretical and methodological basis was the conceptual research of the main provisions of micro- and macroeconomics, interrelations between their elements, based on the usage of modern achievements and innovative approaches to sustainable management and restoration of forestry fund given self-regenerational mechanism of forest ecosystems and planted forests with the aim of creating regional competitive and socially responsible forestry management, as well as research on financial and organizational problems of sustainable development of the region based on environmental indicators, analytical and expert methods, presented in domestic and foreign scientific literature.

A rating system, based on the conceptual scheme for the emergence of the noosphere proposed by V. I. Vernadsky, was used to assess environmental well-being. The logic for determining the rating was based on the principles of sustainable development in accordance with the UN Declaration on environment and development using the expert method. The group of experts evaluated events in three areas: ecosphere (environmental index), technosphere (industrial and environmental index), and society (social and environmental index). Each index was evaluated by seven indicators, which in turn were evaluated depending on the nature of the event with the numeric values +1 - positive rating, -1 - negative rating. To compare regions, the relation of positive and negative ratings is

automatically converted to a 100-point scale. The calculation is made online based on a single mathematical model.

Justification of the main provisions of the process of regional reforestation was carried out using methods of deduction and induction, abstract - logical judgments and evaluations, a systematic and integrated approaches. The empirical part of the work is based on the use of monographic methods of information analysis [6].

3 Results

Today, the environmental component of economic security is the most important category not only for the regional economy, but also for ensuring the stability of the socio-economic system as a whole. Environmental safety parameters of the region can be determined based on an assessment of the level of environmental risks (indicators).

Table 3. Place of the Kirov region in the national environmental rating as of 01.06.2020 [10].

Indicator	+/-	Indicator	+/-	Indicator	+/-
Atmosphere, air	No ratings for this period	Habitat	+---	Industrial environment	+
Water resources, water	++++-	Authority	No ratings for this period	Solid household waste	++++++++++++------
Land resources, soil	No ratings for this period	Civil society	++	Science and innovation	No ratings for this period
SPNA*	+	Information and psychological climate	+++++++	Environmental modernization	No ratings for this period
Biodiversity	No ratings for this period	Education and culture	+++	Products and services	No ratings for this period
bioresources	+-	Housing and communal services	No ratings for this period	Business responsibility	No ratings for this period
Climate	No ratings for this period	Law and order	++	Industrial waste	No ratings for this period
Environmental index	47	Social and environmental index	71	Industrial and environmental index	48
Summary environmental rating of the region	58				
Rating of the region	42				

* Remark: SPNA – indicator, reflecting the number and area of specially protected areas in the region, their status, events related to their protection, level of funding, holding various events on their territory. holding various events SPNA on their territory.

The Kirov region ranks nineteenth in terms of forest reserves, and eighth in Russia in terms of timber export.

One of the most important indicators of environmental safety is «Reforestation (share of restored forests)», which is calculated as the relation of the area of restored forests to the area of the territory, occupied by the region, multiplied by the forestry cover of the territories as a percentage.

In many parts of the world, especially in East Asian countries, reforestation is increasing the area of forest land. The number of forests has increased in 22 countries out of the 50 most forest-rich countries in the world. Asia received 1 million hectares of forest between 2000 and 2005 as a whole. The rainforest in El Salvador expanded by more than 20 % between 1992 and 2001. Based on these trends, one of the research projects claims that by 2050, the global number of forests on the planet will increase by 10 %, which is a huge territory the size of India [11].

There are two different ways of reforestation – artificial (planting or seeding forests) and promoting natural regeneration (creating conditions for rapid settlement of valuable tree species). Promotion of natural regeneration is carried out in areas, where the restoration of economically valuable species can be achieved by preserving undergrowth or soil mineralization. But the main method of reforestation is considered to be planting forest crops, which is performed manually using the Kolesov's sword.

Artificial reforestation usually requires a full set of treatments - agrotreatment, clarification, cleaning, at least one treatment each (something can be avoided sometimes, but something needs to be done more than once sometimes). Thus, on average, it can be assumed that the area of logging in young growth (lightening and clearing) should be twice the area where artificial reforestation is carried out. That is, even if you do not count the previously accumulated arrears for care, with an area of artificial reforestation of 6 thousand hectares per year, the area of felling care in young growth in total should be about 12 thousand hectares per year.

If you do not strive to get clean plantings with natural reforestation, theoretically you can do with one method of care - cleaning (such cleaning will be much more difficult and expensive than in previously well - groomed young growth-but it is possible in many cases theoretically). Thus, even if you do not count the previously accumulated arrears for care, with an area of natural reforestation of 28 thousand hectares per year, the area of felling care in young growth should be the same 28 thousand hectares per year.

In recent years, there has been a tendency to reduce the resource and environmental potential of forests, associated with the long-term use of an extensive model of forest management, focused on involving new woodlands in logging. The forest is the only renewable natural resource, so its conservation, multiplication and cost-effective use is a state task, a guarantee of environmental and social well-being of the country.

The main use of forests in the region remains the harvesting of wood for industrial production, as well as for the needs of the population.

As in most regions of the Russian Federation, forest management data in the Kirov region is very outdated. The last time such work in the region on a large scale was carried out in 1997-2003. Five years ago experts noted that 66% of the total land area of the forestry fund has been under forest management for more than 10 years, when developing the Concept for the development of the forest industry in the Kirov region for 2010-2015. The situation with the land, that was transferred to the forestry fund from agricultural land is even more deplorable: 85% of the land has a forest management statute of limitations of 25 years or more, with a statutory validity period of 10 years [12].

Reforestation on the scale that it is currently being carried out in the Kirov region was effective and efficient, the area of logging in young growth should be at least 40 thousand

hectares per year, and this does not take into account the previously accumulated arrears (table 4).

Table 4. Dynamics of reforestation on the lands of Kirov region forestry fund [13].

Indicators	2014	2015	2016	2017	2018	2019
Area of continuous logging of forest stands on the lands of the forestry fund. ha	39892.6	35037.2	38786	33675.2	37905	37095
Total land area of the forestry fund. where reforestation works were carried out. ha	27930	30829	35012	37181	33670	37905
Land area of the forestry fund. where artificial reforestation (creation of forest crops) has been carried out. ha	6678	6546	6473	5968	5569	6565
The relation of the area of reforestation in the current year and the area of continuous logging of forest stands on the lands of the forestry fund in the past year. %	76.9	77.3	99.9	64.4	99.9	100
The relation of the area of artificial reforestation in the current year and the area of continuous logging of forest stands on the lands of the forestry fund in the past year. %	18.4	16.4	18.5	15.3	16.5	100

As a result, many low-density young forests of natural and artificial origin with low reserves and operational qualities of wood were formed on the territory of the Kirov region [14].

In the area, where the reforestation will not be provided by cutting care in young growth, almost the same thing will grow that would have grown by itself without any additional special measures. According to the report cited above, logging of young growth - clarification and clearing - was carried out last year in the Kirov region on an area of 11.3 thousand hectares, which is almost four times less than the minimum area corresponding to the current scale of reforestation. This means, that even if we proceed from official statistics, the current reforestation in the Kirov region will be about three-quarters ineffective.

Therefore, there is nothing wrong with the fact that the volume of reforestation in the Kirov region has decreased. The bad thing is that in the Kirov region, the volume and quality of care for young plants, which primarily depend on the results of reforestation, remained approximately at the same level [15].

The Council for project management under the Governor of the Kirov region approved the regional project «Conservation of forests in the Kirov region». The goal is to ensure a balance of forest disposal and reproduction in the proportion of 100%.

One of the project operators - Kirov regional state specialized Autonomous institution «Kirov state forestry center», performing forest restoration activities, it will be equipped with the main specialized equipment and equipment for carrying out a set of measures for reforestation and afforestation (cumulative total): by 31.12.2021 – for 50%; by 31.12.2022 – 55 %; by 31.12.2023 – 60 %. It is planned that the damage from forest fires will decrease from 41 million rubles in 2019 to 25 million rubles by 2024.

In accordance with the project, it is also assumed:

- provision of state institutions with specialized forestry machinery and equipment by 31.12.2023 for 2.8 billion rubles (tractors, plows, cultivators, planting machines, harrows, seeders, brushcutters, rooters, etc.).

- provision of state institutions with specialized forest fire equipment and equipment mainly of domestic production by December 31, 2024 for 21.3 billion rubles (fire trucks, forest fire tractors, wheeled and tracked, bulldozers, forest fire all-terrain vehicles, forest fire boats, attachments and trailers for equipment, radio stations, motor pumps (portable, trailed), tractor with semi-trailer, chainsaws, blowers, etc.). The acquisition of forest fire equipment will increase the speed of response of forest fire services and as a result reduce damage from forest fires by 61%.

- training and professional development of employees, engaged in forest fire protection activities.

- attraction of cash resources from off-budget for artificial reforestation.

- the increase in the area of artificial forest regeneration.

- formation of a reserve of forest seeds for reforestation and afforestation in all areas, cut down and lost forest stands [13].

However, full-scale reforestation is hindered by a poorly developed network of forest and logging roads. In addition, according to experts, the lack of care for planting seedlings minimizes the effectiveness of such work.

The Kirov region may become one of the pilot regions of the Russian Federation, where reforestation will be carried out using cloned seedlings. On the official website of the Moscow region government it was announced that a project to grow such seedlings could be launched in Pushchino, near Moscow, in the summer: "The Branch of the Institute of Bioorganic chemistry from Pushchino near Moscow signed a Protocol on the implementation of micro - plant growth technology for forest reproduction with the Department of forestry of the Kirov region and the non-profit partnership "Biotechnological cluster of the Kirov region", - stated in the message. The volume of investment in this project may amount to more than 10 billion rubles.

It is also proposed to include in the territorial planning schemes of the Kirov region, where timber production is one of the priority areas of socio-economic development, proposals for the formation of a network of forest roads in the region, as well as to carry out the construction (reconstruction) of forest roads that will be used as public roads with the involvement of regional and (or) municipal budgets, and non-public forest roads on the principles of public-private partnership. Fire and chemical stations were created, equipped with forest patrol complexes, bulldozers, forest fire tractors, truck tractors and other specialized equipment specifically for fighting fire in the forest [12].

4 Discussion

Every year in Russia, from 9 thousand to 35 thousand forest fires are registered, covering an area of 500 thousand to 3.5 million hectares. The amount of damage from forest fires per year is about 20 billion rubles, of which from 3 to 7 billion - damage to forestry (loss of wood) on average. The other losses are expenses for extinguishing and subsequent clearing of burnt areas, damage from animal deaths, pollution by combustion products, costs for forest restoration and so on. [7].

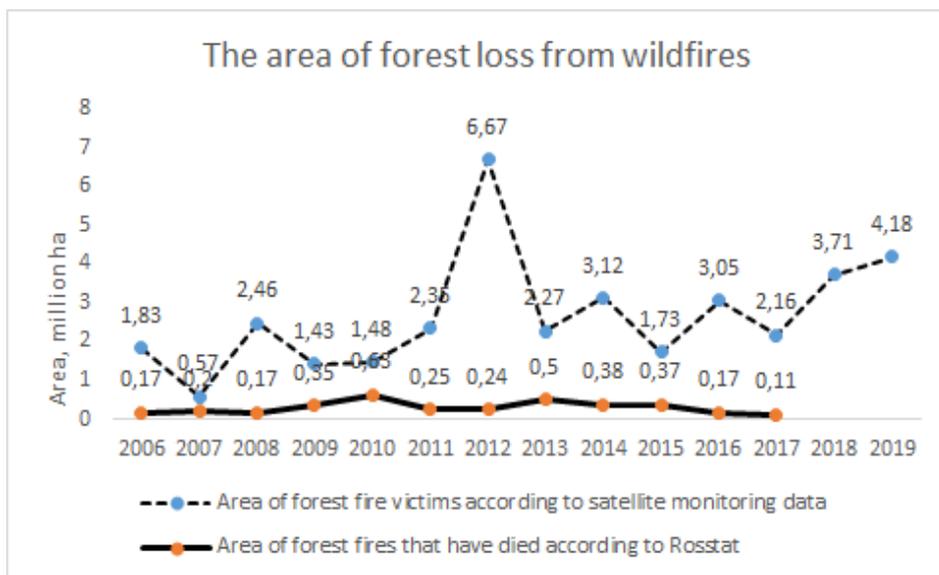Official statistics and satellite monitoring results (remote sensing method) differ [16].

Fig. 1. Area of forest loss from fires in Russia.

According To S. A. Bartalev and N. V. Lukina, reliable information on forest resources is virtually non-existent in the country at present. The average age of forest management in the country is 23 years, and only 15% of forests are provided with forest management data less than 10 years old. Official data on forests do not reflect reality in part:

- area, reserves, and species-age structure of forests and their dynamics. According to various estimates, the country's forest resources are underestimated by ~15-30%;

- the extent of forest loss from fires and other destructive factors. The underestimation of the area of forest loss from fires in comparison with remote sensing data is on average 10-15 times, and in some years it reaches 30 times;

Estimates of the carbon budget of Russian forests are characterized by 3-4-fold uncertainty, the source of which is, first of all, the lack of reliable information about forests. The problem of completeness and accuracy of accounting for the carbon budget of forests becomes extremely acute with the adoption of the Paris agreement [16].

Potential for using remote sensing techniques is quite high for the assessment and monitoring of Russian forests:

1) Modern features remote sensing techniques from space can provide up-to-date information about the resource and environmental potential of Russian forests with interest-free coverage (the entire country) and regularity (annually).

2) Methods and technologies of automated remote sensing data processing make it possible to obtain information about:

– areas of forested and treeless (burnt and lost plantings, felling, swamps) land;

– reserves, breed-age structure and forest bonitet;

– scale of impact of destructive factors on forests;

– the processes of reproduction of forests.

3) Integration of remote sensing information with forest dynamics models opens up opportunities for monitoring and forecasting the main components of their carbon budget at a fundamentally new level of completeness and reliability [16].

Thus, in order to obtain current information about the state of affairs in the forestry industry, as well as an objective assessment of the situation, it is recommended to use the remote forest monitoring methodology, which allows:

-    to ensure full reproducibility of the results obtained through the use of methods and technologies of automatic processing of remote sensing data;

-    to classify and evaluate the biophysical characteristics of forests using locally adaptive algorithms for remote sensing data processing;

-    to carry out the mapping of forests on the territories of any size;

-    to generate homogeneous time series of maps of forest characteristics with an assessment of their dynamics (the dynamic mapping).

5 Conclusions

According to socio-economic indicators, the Kirov region is a «typical» average region of Russia, and at the same time it has an indubitable personality. In financial terms the Kirov region is a subsidized region traditionally, this fact leads to funding problems in the development and implementation of environmental programs, including reforestation.

In terms of harvesting and woodworking, the region occupies a leading position in the Volga Federal district and is one of the largest producers in the European part of Russia. The annual sustainable volume of logging is 17.0 million cubic meters.

The favorable geographical location of the region, the availability of raw materials, transport routes, and labor force, allows the Kirov region to be recognized as one of the most promising regions for creating new capacities for the production of pulp and paper products, chipboard, plywood, low-rise buildings, that is, products of deep processing.

Therefore, reforestation is important both as a raw material base and a driver of economic development, and from an environmental point of view. The volume of reforestation decreased, and the volume and quality of care for young plants remained at the same level in the Kirov region. It is important to note that this work is preventive in nature and is aimed at effective use of natural resources and environmental protection [17].

Authorities launched a regional project «Conservation of forests in the Kirov region», this will make it possible to get funding and build a balanced system of forest management certainly. In addition, the Kirov region may become one of the pilot regions of the Russian Federation, where reforestation will be carried out using cloned seedlings. But these measures are clearly not enough. Territorial authorities should conduct research in this area to assess the state of the forestry fund using digital tools systematically in order to develop measures to preserve the forest ecosystem and improve the competitiveness of the Kirov region in the environmental rating of regions of the Russian Federation.

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