Ecological and economic management tools in forestry

T L Bezrukova1,*, V G Larionov2 and I V Kuksova1

1Department of Economics and Finances, Voronezh State University of Forestry and Technologies named after G.F. Morozov, 8 Timiryazeva Street, 394087, Voronezh, Russian Federation
2Department of Economics and organization of production, Bauman Moscow State Technical University (National Research University), 5/str.1 2-nd Baumans Street, 105005, Moscow, Russian Federation

E-mail: ef_bezrukovatl@vgltu.ru

Abstract. The importance of this article is related to the development of new policies for the management of the forestry business. The emergence of new business practices requires a revision of existing business management systems or the acquisition of new unique management skills. This article highlights the key ecological and economic management tools in forestry, identified as a result of the study of the works of domestic and foreign authors, as well as the provisions of regulatory legal acts. The developed environmental and financial forestry management tools make it possible to consider both industries and economic entities for the impact on the environment, aimed at the prospects for the creation of a certain entity. Upon completion of this work, important environmental and economic management tools were adopted that will contribute to the formation of a management idea for forestry. When modeling the ecological and economic management of forestry, a rational option for regulating the instruments was chosen, which would bring the system to the desired state. It was concluded that it is necessary to maximize the coefficients regulating the instruments of environmental and economic management of forestry. It is also necessary to improve the environmental audit and insurance, the legislative mechanism, the introduction of trade rights in certain territories.

1. Introduction

The topic “Ecological and economic management tools in forestry” reflects a significant number of publications on various topics. However, in this matter, the importance of the author should be recognized along with modern economics, it should be noted that in this vast area of economic research, related to many important issues, there are significant differences. In general, there is a generally accepted definition of environmental and economic instruments. With sustainable and stable development for the current economic desire, it is a modern economy to manage the necessary condition, there is a balance of the economic environment to achieve this development, involved and supporting, and the economics aspects. Human economic activity in the production process is the exchange of materials and energy in the environment, within which ecological products are produced. Entering into a relationship with the natural environment, the form of a forestry enterprise is a dynamic ecosystem and a combination of the economy and that. Balance of ecological – economic subsystem of fixed assets, proportionality, balance of natural and food subsystems. In this regard, for forestry organizations, a prerequisite for change is a new management philosophy by introducing production with environmental intensity, which will be reduced by sustainable development based on a green process. Environmental
activity, as one of the components of management development for the use of the economy together with it, to prevent negative consequences for the environment.

It should be remembered that forest science has a considerable scientific reserve, which is not fully used in practice due to extensive forest management. For the scientific support of the research of the forest complex, there is no more important and urgent problem than the justification of effective ecological and economic tools for forest management, stabilization and sustainable development, as well as sustainable forest management. Scientists should be the main participants in the development of the state forest policy, and on the basis of it – appropriate programs for the development of the forest complex and sustainable forest management. The problems of interaction between nature and society remain relevant. A number of natural resources necessary for the implementation of social production began to be depleted. There is no doubt that humanity exists at the expense of the natural environment, and it is the biosphere that provides a person with the substances, energy and information necessary for his normal life. Without scientifically based control and regulation, the intensive development of mankind can lead to the complete depletion of the biosphere and make it impossible for people to exist on Earth. In many countries, development has proved impossible due to catastrophic changes in the natural environment. Therefore, the issues of environmental management regulation in modern conditions are very relevant. The question of the possibility of implementing the idea of sustainable forest management within the framework of the modern economic organization of forestry production and the existing forms of enterprises engaged in forest management is of great independent importance [1]. The problems of the correlation of economic and environmental development are widely discussed in society. According to the degree of preference of environmental criteria over economic ones, all approaches can be divided into 3 main ones:

1) a reasonable person should not focus only on economic rationality, he should pay more attention to the benefits of common use, the use of which causes external effects.

2) a new approach to economic development requires the reproduction of the economic system itself and all its components on a sustainable basis.

3) technical improvements are designed to minimize the damage caused to the environment as a result of production activities. The laws of physics do not allow us to bring the anthropogenic impact to zero. Therefore, the proponents of this approach propose to freeze economic growth in the interests of preserving the environment.

Sustainable forest management is closely connected with the need for significant changes in forest exploitation: the intensification of forest use without a scientifically based study means, in essence, unproductive spending of public funds. Thus, sustainable forest management can be effectively implemented as an element of a new forest management system that differs significantly from the traditional one. To develop forestry measures for the rational use of forest resources, it is necessary to take into account two main provisions of sustainable management of them. Firstly, forests should be considered as a sustainable ecological and economic system, and secondly, it is necessary to create a scientifically based mechanism for the integrated use of forest resources, taking into account their economic, social, environmental and aesthetic significance [2]. The modern concept of sustainable development assumes a harmonious interaction of the economy, nature and society, linking them into a single system, and is the target setting for the development and implementation of programs aimed at achieving the objectives of sustainable development of territories. The preparation of programs is possible only on the basis of comprehensive statistical studies that require systematic improvement of applied analysis methods and methods for a comprehensive assessment of the socio-economic and environmental condition of territories.

Despite the proclamation of guidelines for innovative development in forestry, Russia's significant lag behind the world leaders in terms of technological level did not allow us to achieve success in creating an innovative system in forestry. In the domestic economy, there are still enterprises with outdated technologies, inefficient business processes that are balancing on the verge of survival [2]. Since the 1970s, the USSR has already begun to lag behind the West in terms of general scientific and technological development. This lag in the early 1990s was one of the main justifications for the urgent
transition from a planned centralized system that hindered progress to a free market economy, from scientific and technical isolation from the West to integration into the global economy [2]. Despite significant investments in forestry management in recent years, Russia continues to lag significantly behind the world leaders in terms of the main indicators that determine the level of scientific and technological development. Thus, the share of Russia in the world market of forest products is only 0.3-0.5%, while the share of the United States is 36%, Japan – 30%, Germany – 17%. A significant problem is the immunity of the forestry economy to innovations, the lack of demand for them from the industry, as well as the lack of proper motivation of the participants in the process. The main goal of creating and using innovations in forestry has an impact on the standard of living of people, since no economic activity can be recognized as successful if it does not ultimately lead to improving people's living conditions and improving their well-being. Thus, a kind of spiral is created when the development of society stimulates innovative technologies, and those, in turn, raise the quality of forestry to an even higher level [2].

The first studies of ecological and economic management tools in forestry began in the United States and the most famous developer is the famous American scientist Michael Porter, who believes that management tools can be a new form of production organization, and which can be identified as new objects developed by state policy, and which will contribute to the growth of competitiveness [3]. In Europe, a lot of attention is paid to the policy on environmental and economic management tools in forestry and it is believed that they should be created not at the government level, but on the ground under the influence of the market situation, so that any interference from state structures can be excluded.

At the International Forest Forum 2020, it was announced that Russia accounts for a quarter of the world's forest reserves. But instead of profit, our forests are burning, getting sick, getting old, being affected by pests, being stolen, changing their breed composition for the worse. The reason is poor management of forest resources. Since 1917, the forest industry has changed the forest management system eleven times, i.e. once every 8 years. For example, Finland's forest resources are 80 times less, but the country receives more than $ 12 billion in annual income, Russia - $3 billion. Therefore, the country faces a task: to improve the quality of state management of forest resources.

The disadvantages of the Russian forest management are the lack of a long-term forest policy in the industry as a whole; the lack of forest protection, the most important component of agricultural activities (methods of logging, forest care, soil preparation for forest crops, selection and allocation of forest plots for rent, accounting and control, planned work). Experts agreed that one of the main ways to the European way of nature management is the development of a road forest map of the country. It should simplify the procedure for monitoring forest resources and regulating legal aspects. The problems of the LPC of the region are diverse: illegal logging, lack of state control, incomplete use of the estimated cutting area, especially hardwoods and in the economic inaccessibility of a significant part of the forest fund; shallow wood processing, lack of modern equipment, forest fires, shortage of seed material (due to the lack of cone dryers), low payment for wood, poorly developed forest legislation, etc. Illegal logging leads to the destruction of the most ecologically valuable undisturbed virgin forests.

In ensuring the problematic woodworking industry at enterprises that are important for environmental safety, it is the largest consumers who have various chemical and toxic substances, raw materials and energy sources that have too negative an impact.

2. Methods and materials
Many scientists have questioned the development of forest business activities related to environmental impacts. But there are very few studies aimed at developing methods for managing the development of regional forestry entrepreneurship, and existing ones touch on this problem only indirectly. The research carried out allows us to interpret this problem in several directions. Representatives of the first direction [2] investigated the meaning of green entrepreneurship, its problems, and also investigated the main institutional elements. Representatives of the second direction [2] made important contributions to understanding the legal framework of environmental entrepreneurship. The work of representatives of the third direction [3] describes the mechanisms for the implementation of various aspects of
environmental entrepreneurship in forests, which are effectively used for state regulation of this type of activity. Thus, all the directions presented in the studies were not paid attention to due to the importance and role of environmental and economic management tools in forests.

An environmentally important strategy for business and the economy in general. Sustainable development makes an important contribution to sustainable production and environmental cooperation programs in the supply chain. These questions were studied by S Seuring, M Müller [4], P Seuring, M Müller [5], S Vachon, R D Klassen [6].

The authors understand ecological and economic resources as powerful levers of greening the system of production and consumption. Practical managerial application of probable opportunities in combination with other methods of management allows humanely solving extremely complex environmental and economic problems within the framework of ensuring the safety of the environment and the economy. The diversity of economic and environmental resources creates a wide range of objective, environmentally oriented interests in the economic interests of economic institutions.

When using forest management tools in market conditions, it is necessary to optimize forest reproduction with minimal material and labor costs, by creating favorable conditions for the natural renewal of forests with valuable economically viable tree species, this is the purpose of the study.

The ecological and economic instruments of forestry are:

- trade permits, the purpose of which is the rational additional use of natural ecological resources and the reduction of emissions of pollutants into the atmosphere.
- environmental costs introduced to compensate for the costs of activities of organizations in the field of environmental protection;
- environmental subsidies and incentives to create new niches for environmentally friendly goods, stimulating the active introduction of resource-saving technologies in economic activities;
- environmental tax, which is based on environmentally harmful products;
- standardization of activities in accordance with international requirements;
- responsibility and timely compensation. Used to neutralize the effects of environmentally harmful activities.
- assessment of environmental sustainability, for example, an indicator of environmental sustainability.

The existing forest system has some limitations [7, 8]. When designing a forest management system, it is important to choose the right management tools that can bring the system to the right level. The combination of forest management with economic and natural resources reflects the visibility of urban forests and the well-being of people. For example, the most common mathematical methods are those most affected by environmental insurance, fundraising, taxes and limits on the disposal and disposal of hazardous materials, environmental permits and economic development. This is due to the fact that mathematical and statistical methods that allow finding a solution for using objects directly depend on the situation in the global economy [7, 8]. With regard to environmental development, economic and mechanical regulation, economics, forestry, transport, forestry and landscape are changing [7, 8].

The choice of the number of species only occurs when a small amount of money is allocated to the environment. The use of mathematical forms can help shape not only the economy, but also the environment, culture and skills of their work [9].

In order to select the correct method for any measurement, it is important to know the amount of damage \( D_i \) and the requirements to achieve it \( i(i = 1, n) \). In order to choose the best method, it is important to know the amount of damage and cost that will be required to use this method \( C_i \). Improving the mathematical models used in the design and analysis of natural and economic resources in forests can be done to reduce ecosystems; identify areas that enhance the effect of economic activity and reduce environmental risks. The challenge is to select strategies that, together, can reduce the amount of natural resources within the allocated amount. One of the ways to solve this problem would be to use the methods of Fohr and Malgrange [10]. The aim of the article was to improve the management of forestry and economic resources. This release is only taking advantage of the opportunity to get another nice
moment. The transaction process can be powerful, time consuming, and all funds are expended. As a result, the task of the mathematical program is created, which, in principle, is written as follows:

$$\sum_{i=1}^{n} D V_i \rightarrow \max,$$

$$\sum_{i=1}^{n} C V_i \leq F,$$

where \( V_i \) – is a binary variable; \( V_i = 1 \) – if the event is included in the plan, \( V_i = 0 \) – if the event is not included in the plan.

One of the ways to solve this problem can be the use of the Faure and Malgrange method [10]. This problem considers only the possibility of single-period optimization. The process of conducting events can also be dynamic, covering several periods, in each of which certain funds are allocated. The purpose of the considered task was to maximize the efficiency coefficients of the tools for regulating the ecological and economic management of forestry. It was necessary to obtain the maximum coefficient of reduction of environmental costs:

$$\max \sum_{i=1}^{n} CO_i \rightarrow \max,$$

where \( i \) – is the tool number; \( CO_i \) – coefficient of reduction of environmental costs.

To solve the problem, a heuristic algorithm was used, which simplified the calculation procedure and gave a good result, but did not guarantee the choice of the optimal result. The optimal result could be found using a simple brute force method. But then it would be necessary to go through too many options. Let's introduce the notation. Let be \( n \) – the number of possible regulatory instruments. In the problem under consideration \( n = 20 \), \( m \) – the number of years (periods) for which the problem is considered.

Since in the original problem, the objective function is the product of the coefficients \( \prod CO_i \) by the numbers \( i \) that correspond to the input tools, in order to bring this objective function to a linear form, we resort to logarithm \( \ln(CO_i) \) – the logarithm of the coefficient of reduction of environmental costs from the introduction of the tool \( i \).

Setting constraints on the values of variables. It is logical that \( 0 \leq x_{ij} \leq 1 \), but since you can only enter a certain tool once, the following restriction is used \( \sum_{j=1}^{m} x_{ij} \leq 1 \), which is true for all \( i \).

If the optimal solution is not an integer, then you will also have to additionally use integer programming methods. From table 1, you can see the strategic three-year plan.
the global index depend not only on assessments of the effectiveness of forest management tools and conditions for their development, but also on modifications in the practice of rating formation (changes in the composition of the countries under consideration, adjustments to the methodology for evaluating indicators, updating data sources, accounting for data emissions and missing values, etc.). The final rating is calculated as the average of two sub-indices – innovation resources in forestry and innovation results. The innovation efficiency coefficient is defined as the ratio of the sub-index of innovation results to the sub-index of innovation resources, thus reflecting the aggregated effectiveness of innovation activity with a given innovation potential. In the final ranking of 2020, Russia took 43rd place, improving its position by 5 lines compared to 2021. Taking into account statistical variations, it can be stated with 90% certainty that Russia's position in the overall ranking varies from 40 to 47 places. Dynamics of indicators from 2019 to 2013 indicates that Russia is steadily improving its position in the sub-index of innovation resources in forestry, but the country's position is noticeably weaker in terms of the effectiveness of forestry management (69th place), which reflects the insufficiently effective implementation of the existing potential of forestry.

Solving the problem of using ecological and economic tools of forest management. The "W" symbol indicates the years in which a particular tool operates.

| Tool                                    | 1st year | 2nd year | 3rd year |
|----------------------------------------|----------|----------|----------|
| Making environmental forecasts         |          |          | W        |
| Collection of fees for the use of land | W        |          |          |
| Differentiation of the Board           |          | W        |          |
| Setting limits on emissions and discharges | -        | -        | W        |
| The establishment of penalties for excess pollution | -        | W        | -        |
| Introduction of the best technologies | W        |          | W        |
| Recycling of waste                     |          | W        | -        |
| The system of environmental insurance  |          | W        |          |
| Introduction of environmental expertise| W        | W        | W        |
| Implementation of environmental audit  | W        |          |          |
| Environmental quality control system   |          |          |          |
| Licensing of environmental protection activities | -        | W        | W        |
| Creation of environmental funds        |          | W        | W        |
| Establishing tax benefits              | W        | W        |          |
| Use of the "pledge-return" system      |          | W        |          |
| Implementation of the environmental education system | -        | -        | W        |
| Environmental labeling                 |          | W        | W        |
| The system of material compensation for damage | -        | -        | W        |
| Trade in pollution rights              | W        |          |          |
| Investment loans                       |          | -        | W        |

This framework can be used to develop medium-term projects to integrate various sound forest and environmental management tools [11, 12]. Although the difference in the cost of installing and operating the equipment, as well as the opportunity to make money on its use, leads to the fact that implementation has been going on for a long time. The total number of devices installed is 18. Some devices that are not included in the set of selected algorithms do not match the profitability in the proposed task [13-15].

3. Results and discussion
Let’s systematize the existing tools of environmental and economic management (figure 1) and present a meaningful analysis. The purpose of using environmental and economic management tools is to obtain the maximum possible / best economic result, some benefits due to the economical use of the resources at its disposal, the use of modern technologies, zero waste, etc. [16, 17]. At the same time, enterprises
have the opportunity to choose in terms of costs or benefits, obtained from a number of possible measures in the field of environmental protection and nature management. It is a certain freedom that distinguishes economic and regulatory instruments.

The action of regulatory instruments is aimed at:
- determination and consolidation of the legal status of state and municipal authorities, the establishment of their work and management functions in the environmental sphere[18, 19];
- training in the main directions of state policy in the field of ecology;
- determination of the procedure, rules for the implementation of environmental legislation, development of programs for environmental protection and assessment of the effectiveness of environmental protection;
- development of requirements for products, services and works to ensure compliance with the set goals, safety for the environment, life, health, etc.;
- confirmation of compliance of processes, works, products, services with the requirements of technical regulations, provisions, terms of the contract, set of rules, etc.;
- determination of uniform rules and methods for the implementation of certain actions / functions by performers using the standards and principles of green activity [12, 20];
- to improve the efficiency of state supervisory authorities.

The results of using economic and environmental instruments to promote corporate governance are:
- maintain the ecological balance of the system "environment - people - producers - people - consumers";
- improving the state of environmental safety of business entities;
- increasing environmental efficiency and the effectiveness of environmental management;
- increased responsibility for waste management;
- compliance with environmental and sanitary conditions and epidemiology;

**Figure 1.** Environmental and economic management tools.
- increase funding for environmental projects;
- activation of investment policy.

4. Conclusion
Currently, there is an objective need for environmentally oriented management of the labor process of forestry specialists, increasing its forestry, ecological and economic efficiency, improving and improving the relevant criteria and indicators (meters) for evaluating the work of engineering and technical personnel, in material and moral stimulation of their activities with comprehensive, maximum consideration of environmental factors. Ultimately, it is the specialists (managers) of forestry who are called upon to ensure the best possible implementation of the goals and objectives of an environmentally oriented economic policy of forestry enterprises.

Taking into account the specifics of the problems caused by the socio-economic and environmental features of forestry, as well as their insufficient study, it is important to single out the so-called suburban forestry economy as a special direction of the general theory of the country's economy. This will contribute to the intensification of scientific research in the field of studying socio-economic and environmental problems of suburban areas of forestry, studying the problems of classification and typologization of management tools, interaction of economic systems of forestry, determining methods and approaches to analyzing the economy of forestry in dynamics. The study of theoretical and practical aspects of forest economy management is of great importance. So, taking into account the close relationship of socio-economic and environmental economics of forestry, which will contribute to the development of a socio-economic model of managing the forestry economy. The model of functioning and management of any socio-economic and ecological system includes several tools, first of all, a development strategy, a multivariate forecast and regulatory documents defining the features of its functioning.

The use of the latest results of scientific research, fixed in the objects of intellectual property, is the most important condition for ensuring the competitiveness of the forestry economy.

The proposed environmental and economic instruments are aimed at ensuring full recovery of the costs of resource restoration, reducing the gap between private and social costs, reimbursing the full or partial cost of environmental damage, aligning development needs with possible environmental problems and their implications to develop an economic strategy.

References
[1] Bezrukova T L, Bezrukov B A, Bryantseva L V, Orobinskaya I V, Kazmin A G and Pozdeev V L 2017 Conceptual aspects of tax system development in cyclic economy. Integration and Clustering for Sustainable Economic Growth Pages eds. Popkova E G et al. (Springer) pp 287-303 DOI: 10.1007/978-3-319-45462-7_31
[2] Leopold C, Vogler S, Mantel-Teeuwisse A K, Joncheere K, Leufkens K and Laing R 2012 Differences in external price referencing in Europe – a descriptive overview. Health Policy 104(1) 50 https://doi.org/10.1016/j.healthpol.2011.09.008
[3] Van Bommel H W 2011 A conceptual framework for analyzing sustainability strategies in industrial supply networks from an innovation perspective. J. Clean Prod. 19(8) 895 https://doi.org/10.1016/j.jclepro.2010.12.015
[4] Rao P, Holt D 2005 Do green supply chains lead to competitiveness and economic performance? International Journal of Operations & Production Management 25(9) 898 https://doi.org/10.1108/01443570510613956
[5] Seuring S, Müller M 2008 From a literature review to a conceptual framework for sustainable supply chain management. Journal of Cleaner Production. 16(15) 1699 https://doi.org/10.1016/j.jclepro.2008.04.020
[6] Vachon S, Klassen R D 2006 Extending green practices across the supply chain: the impact of upstream and downstream integration. International Journal of Operations & Production Management 26(7) 795 https://doi.org/10.1108/01443570610672248
[7] Bezrukova T L, Kuksova I V, Kirillova S S and Gyiazov A T 2018 Forecasting of the forest complex development in the formation. *IOP C.Ser. Earth Env.* **226** 012063 DOI: 10.1088/1755-1315/226/1/012063

[8] Bezrukova T L, Gyiazov A T and Kuksova I V 2020 Socio-ecological and economic efficiency of the territories of forestry. *IOP Conf. Ser.: Earth and Environm. Sci.* **595** 012050 doi: 10.1088/1755-1315/595/1/012050

[9] Lobovikov T S and Petrov A P 1976 Economics of complex wood processing. *Forestry Industry* 168 [in Russian]

[10] Denis-Papin M, Faure R and Kaufmann A 1974 *Theorie und Praxis der Booleschen Algebra.* (Vieweg: Braunschweig) pp 186-224 https://doi.org/10.1007/978-3-322-86335-5_9

[11] Bonilla-Bedoya S, Mora A, Vaca A, Estrella A and Herrera M A 2020 Modeling the relationship between urban expansion processes and urban forest characteristics: An application to the metropolitan district of Quito. *Computers, Environment and Urban Systems* **79** 101420 https://doi.org/10.1016/j.compenvurbsys.2019.101420

[12] Ludvig A, Weiss G, Sarkki S, Nijink M and Zivojinovic I 2018 Mapping European and forest related policies supporting social innovation for rural settings. *Forest Policy Econ.* **97** 146 https://doi.org/10.1016/j.forpol.2018.09.015

[13] Pliuta V 1980 *Comparative analysis in economic research: methods of taxonomy and factor analysis* (Moscow: Statistika) p 151 [in Russian]

[14] Wu X, Wang S, Fu B, Feng X and Chen Y 2019 Socio-ecological changes on the Loess Plateau of China after Grain to Green Program. *Sci. Total. Environ.* **678** 565 https://doi.org/10.1016/j.scitotenv.2019.05.022

[15] Ortega M, Pascual S, Elena-Rosselló R and Rescia A J 2020 Land-use and spatial resilience changes in the Spanish olive socio-ecological landscape. *Appl. Geogr.* **117** 102171 https://doi.org/10.1016/j.apgeog.2020.102171

[16] Ture C A 2013 Methodology to analyse the relations of ecological footprint corresponding with human development index: eco-sustainable human development index. *Int. J. Sust. Dev. World* **20** 9 https://doi.org/10.1080/13504509.2012.751562

[17] Markowski-Lindsay M, Borsuk M E, Butler B J, Juveneck M J, Holt J, Kittredge D B and Thompson J R 2020 Family forest owner reactions to invasive forest insects. *Ecol. Econ.* **167** 106461 https://doi.org/10.1016/j.ecolecon.2019.106461

[18] Raymbaev C, Kulueva C, Gifyazov A, Bezrukov B and Bezrukova T 2017 Concept of Innovative development of entrepreneurial potential of small enterprises. *Integration and Clustering for Sustainable Economic Growth* Eds. Popkova E G et al. (Springer) pp 143-150 https://doi.org/10.1007/978-3-319-45462-7_16

[19] de Mello N G R, Gulinck H, Van den Broeck P and Parra C 2020 Social-ecological sustainability of non-timber forest products: A review and theoretical considerations for future research. *Forest Policy Econ.* **112** 102109 https://doi.org/10.1016/j.forpol.2020.102109

[20] Gingrich S and Kraussmann F 2018 At the core of the socio-ecological transition: Agroecosystem energy fluxes in Austria 1830-2010. *Sci. Total Environ.* **645** 119 https://doi.org/10.1016/j.scitotenv.2018.07.074