Continuous development of silvicultural systems as the basis for solving problems of efficient maintenance, use and conservation of forests

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Abstract. The present article discusses the problems of systemic development of forestry in the current historical period, that is, in the first decades of the twenty-first century. At the same time, the solution to a set of existing complex problems of forest conservation, effective maintenance and rational use is envisaged on the basis of the nodal development of “priority-target systems of silvicultural activities” in combination with the development of organizational and economic support for the effective implementation (application) of these systems in practice, including the design, planning and implementation of all forest management activities.

1. Introduction
The problems of protection of the environment including one of its most important components, forests, such as maintaining forest stability and the condition of forests ensuring the stable performance of ecological functions under the global climate change and anthropogenic pressure emerged at the end of the twenties – beginning of the twenty-first century and have not been solved yet, despite the existing measures to protect forests; in many respects these problems continue to escalate. This, to a large extent, determines the need to find new forest management approaches and / or improve existing ones, and develop adequate mechanisms for their implementation.

The objective of this research is to determine the direction and content of the development of silvicultural systems to ensure sustainable forest management, maintenance, utilisation and preservation of forests in the first decades of the twenty-first century, in the current climatic, socio-ecological and economic conditions.

To achieve this goal, a set of questions has been identified and addressed:

(1) we highlighted the main problems of forest conservation, maintenance and utilization to be addressed by silvicultural activities;

(2) we determined the silvicultural principle of solving the aggravated historical problems and newly emerging problems of forest conservation, maintenance and utilization based on the scientific historical heritage, new results of forestry research and development;

(3) we defined the key features of innovative development of forestry to effectively address the problems of forest conservation, maintenance, utilization and management.

2. Methods and Materials
To address the set of research questions listed in the Introduction, we used results of forestry and ecological research and development activities available from the Russian and international literature, as well as data of generalization of practical experience in forest management. As the main method of problem solving we used a historically developed silvicultural method of systematic study of the whole variety of forests and sylvicultural objects, their classification according to geographic, zonal, landscape, typological properties and priority usages, as well as the effectiveness of forest management and utilisation, development of priority-target systems of silvicultural activities corresponding to the formed natural objects (defined by a combination of the natural properties and purpose) that maintain them in the intended dynamics.
3. Results and Discussion

3.1. Identification of the main problems of forest conservation, maintenance and utilisation to be solved through a set of forest management activities

During the last decades of the twentieth century and the beginning of the twenty-first century, with increasing anthropogenic pressure on the environment including forests, as well as due to the manifesting trends in the dynamics of natural processes and other trends with negative consequences, such as the decrease in forest resilience and ecological potential, increase in health and fire threats, and susceptibility to pests, a set of problems emerges, including those of forest conservation, the efficiency of performance of environmental functions by forests, and the provision of forest services.

The classical concept of forestry is focused on cultivation of forest stands consisting of valuable, predominantly coniferous species, often monocultures, implemented in the forest management in general and, with some variations, in different countries in particular, proved to be environmentally untenable. This concept has been critically assessed by the Russian and international applied forestry and is currently being replaced by principles of sustainable forest management, including principles of sustainable forest utilisation, which essentially took shape of the world forest management paradigm only in the early 1990s, and has been slowly and with difficulty implemented in practice since then [1-4].

In Russia, despite that the principles of forest management used in practice in the twenty-first century were also used in the twenties century, including cultivation of highly productive coniferous forest stands of silvicultural origin, the negative consequences of those sylvicultural approaches were less pronounced, since the main volumes of reforestation aimed to offset the large areas of clear-cuttings, including those in the seasonally transport-accessible areas (in the winter period) were inevitably implemented through natural forest regeneration, which was actively promoted in the Russian forestry science [5]. This resulted in the preservation, development and practical implementation of the sylvicultural principles aimed at re-creation of forests similar to the originally existed native forests. At the same time, in the absence or inadequate care of the newly emerged forests, in many cases the result was a change of species (replacement of the native forests by secondary forests). Such forests (often with coniferous undergrowth under the canopy) formed over large logging areas (with cutting areas up to 200 ha, logging continued until the middle of the twenties century), at the end of the twenties - the beginning of the twenty-first century became a special object of forestry: they were subject to reorganization of forest plantations and restoration of conifers.

As part of the principles developed by the world community for sustainable forest management in Russia and other countries, and taking into account the diversity of natural forests, geographical, regional and zonal conditions, and differences in the socio-economic level of development, to achieve sustainable development goals, indicators of forest condition and forest management should include not only traditional values (such as the value of timber and other forest resources), but also social and environmental values [1, 3, 4, 6].

At the same time, despite the large reserves of timber in Russia's natural forests, the forest management system should take into account that, to a large extent, the problem of meeting the growing demand for forest resources, primarily wood, in many countries of the world has been solved by creating and using forest plantations while preserving ecologically valuable natural forests [7, 8]. The positive effect of the creation of such plantations is manifested not only in an increase in timber harvesting, especially of the target assortments produced under special conditions of forest growing. As a result, the pressure on natural forests, as well as on the forests with areas of assisted natural and artificial regeneration, traditionally maintained and moderately used, which quite efficiently perform environmental functions, decreases. The creation of forest plantations on non-forested degrading lands, especially not only for commercial but also for environmental purposes, leads to an increase in the ecological potential of forests.

On the other hand, when developing regulations for plantation forestry, it should be taken into account that, according to the results of numerous studies, the creation of forest plantations is associated with significant risks to the ecological potential of forests. In particular, a significant danger is associated with potential replacement of ecologically valuable forests by plantations. When establishing highly intensive forest plantations, especially with shorter than usual reproduction cycles for obtaining valuable timber and specific assortments, there is a very real possibility and high probability of depletion of forest ecosystems, biodiversity loss, and reduction of biodiversity functions in comparison with the natural and semi-natural moderately managed forest ecosystems [2, 7, 9]. In this case, it is quite logical to ask whether plantation forestry enhances biodiversity conservation or creates "green deserts" [2]. In planted forests created with the use of chemicals (herbicides, fertilizers), threat to flora and fauna increases, and not only in the planted areas themselves, but also in the neighbouring areas, including water bodies [7, 9].
A brief analysis of the existing problems of forest maintenance and utilization, of the negative trends, historical and modern, and principles of forest management and forest use implemented in practice in the current historical period suggests that along with the complexity of these problems and inconsistency of the goals of forest use, one (most important) of the reasons for the low effectiveness of managerial decisions and actual actions on conservation, protection, reproduction and use of forests is the lack of an adequate (adaptable to modern conditions) mechanism to ensure systematic forest management, forest maintenance and use at all levels of territorial administration and economic entities.

3.2. Defining the silvicultural principle of solving problems of conservation, maintenance and use of forests based on scientific historical heritage, and new results of forestry research and development

In accordance with the general conceptual and methodological principles of forestry, the solution of the whole set of modern problems (that is, of the first decades of the twenty-first century) is based on a systematic study of the characteristics of forest dynamics in changing environment with maximum consideration and use of all accumulated scientific and practical experience in solving similar problems in the past, as well as methodological approaches and principles for the maintenance and use of forests developed for these purposes throughout the entire history of forestry.

Despite the ongoing crisis of socio-economic development that adversely affects science in general, the scientific foundations of forest science laid in the past are currently supplemented by research data on protection, maintenance and enhancement of forest ecosystems and their environmental functions in conditions of environmental degradation due to natural and anthropogenic pressures. The aim of research is to find optimal solutions to pressing environmental problems, by developing landscape and ecosystem approaches in forest management, methods of biodiversity conservation and protection of old growth forests including those of high conservation value and other valuable forests of native tree species, as well as through the development and application of sustainable forest management approaches [1, 7, 10, 11, 12].

Based on the results of the above and other studies, the evaluation of the experience of the past and the current historical periods of forestry development and the future prospects with different scenarios of socio-ecological-economic conditions, of the creation and use of scientific research to effectively maintain and use forests, and of the attempts to address existing and emerging problems leads to the conclusion that the basis for the development of forestry is the use and improvement of the developed systematic approach (method) in forestry [5, 13, 14, 15].

The formation and development of the silvicultural method as a systematic integrated method for studying forest objects and processes, developing instruments of influence and control, and practical application of these instruments, took place over several decades in a variety of ways and “naturally”, that is, due to objective reasons with the development of solutions to emerging problems (specific and general). This was reflected in the development of the “natural-target” classification of forest objects, the corresponding systematization of silvicultural activities, the development of methodological issues of the formation (objectively necessary diversity) of silvicultural measures - block staged, formational (species-growing) and integrated priority-targeted formation-forest growing systems of activities on the zonal landscape-forest-typological basis [15, 16].

3.3. Key features of innovative development of forestry to effectively address the problems of forest conservation, maintenance, utilisation and management

The systemic priority-target method of silviculture and the “Priority-Target Systems for Forestry Activities, PTSFA” created on its basis can be defined as the key development of forestry in the first decades of the twenty-first century. At the same time, this development of forestry is only relatively “new”, successively “growing up” from the previous one, that is, from the methodology for creating and applying “Regional forest management systems”, and represents, in fact, its historically advanced form [13, 15, 16].

PTSFAs with different levels of detail and specificity, from the framework-methodological to project-regulatory, with the establishment of certain types and standards of all activities are being developed according to specific hierarchical taxa of the silvicultural classification of forests for the intended purpose, from the complex types of PTSFA to elementary types, including those consistently related to legally established types of forest divisions for their intended purpose, categories of protective forests, and specially protected forest areas.

At the same time, the conceptual scheme for the formation of priority-target systems for silvicultural activities is based on three complex factors: silvicultural zonation of the country, the formation-typological classification of forests within silvicultural districts and regions, which can be consistently correlated with forest areas established according to the Forest Code of the Russian Federation (or forest areas with
silvicultural areas), as well as the silvicultural classification of forests by their intended use, covering all classification units of legislative divisions of forests for their intended use.

To achieve common goals and solve specific problems of silviculture to ensure effective maintenance, conservation and use of forests as part of the implementation of a general methodological approach to creating and applying priority-targeted silvicultural systems, PTSFAs are being developed (formed) based on the forest formation (forest-typological) forest objects as specific as possible according to the diversity of soil and biological characteristics or forest tree species and forest stands, taking into account the intended use of the forests, as well as according to the priority-purpose objects (types of CNL) on a zonal-landscape-forest-typological basis, differentiated according to the required functional value and according to the intended use of the forest areas.

At the same time, the composition of the PTSFAs and their distribution among the objects of formation-forest-typological and purposeful use is formed within specific territorial formations characterized by certain zonal landscape-typological conditions, the needs of the socio-ecological-economic systems of territorial formations in forests and forest resources, preserving complex silvicultural, ecological and economic security, including ecological, economic, and resource security within a certain area.

4. Conclusion

In general, effective solution of topical issues of forest maintenance, use and preservation, state forest management (in the first decades of the twenty-first century) is possible on an innovative basis by creating and improving a key development in forestry, the multivariate “priority-target forest management measures” and combining them with new, borrowed, unused (for various reasons) in the three-component complex being developed, that is, economic and organizational development of forest management.

5. References

[1] Pisarenko A I and Strakhov V V 2004 Forestry of Russia: from use to management (Moscow: Publishing House Jurisprudentsija) p 552
[2] Leah L B and Kathleen A F 2010 Does plantation forestry restore biodiversity or create green deserts? A synthesis of the effects of land-use transitions on plant species richness. *Biodivers. Conserv.* 14 pp 3893-3915
[3] Bartniczak B and Raszkowski A 2018 Sustainable forest management in Poland. *Management of Environmental Quality* 4 pp 666-677
[4] Bosela M, Larocque G R., Baycheva T, Valbuena T and Lier M 2016 *Ecological Forest Management Handbook*. Chapter 14, *Criteria and Indicators of Sustainable Forest Management* (CRC Press, Taylor & Francis) pp 381-413
[5] Melekhov I S 1989 *Forestry* (Moscow: Agropromizdat) p 302
[6] Torres-Rojo J M, Moreno-Sanchez R and Mendoza-Briseno M A 2016 Sustainable Forest Management in Mexico. *Current Forestry Reports* 2 pp 93–105
[7] Pisarenko A I and Strakhov V V 2014 Prospects for the development of forest plantations as the basis for reforestation. *Lesnoye Hozyaistvo* 5 pp 2-6
[8] Christersson L 2010 Wood production potential in poplar plantations in Sweden. *Biomass & Bioenergy* 9 pp 1289-1299
[9] Sedjo R A 1999 The potential of high-yield forestry for meeting timber needs. *New Forests* 1-3 pp 339-360
[10] Yanitskaya T 2008 *A Practical Guide to the Allocation of High Conservation Value Forests in Russia*. (World Wide Fund for Nature, WWF) p 136
[11] Modern problems of near-tundra forests. 2012 (Conference proceedings, FGAOUVO «North (Arctic) University named after M.V. Lomonosov») p 348
[12] Danilov-Danilyan V I and Losev K S 2000 *Ecological Challenge and Sustainable Development* (Moscow: Progress-Tradition) p 416
[13] Moseev N A and Pobedinsky A V 1986 Zonal systems of forest regeneration. *Lesnoye Hozyaistvo* 10 pp 15-19
[14] Morozov G F 1970 Selected Works vol 1 (Moscow: Lesnaya Promyshlennost’) p 460
[15] Zheldak V I 2005 Forestry Systems. *Lesnyi Vestnik* 5 pp 119-126
[16] Zheldak V I, Sidorenkov V M, Doroschenkova E V and Proka I Y 2017 The use of forest management systems in forest inventory. *Forest Engineering Journal* 27 pp 22-40