Sustainable extended reproduction of chernozem forest

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Abstract. The problem of sustainable forest reproduction, belonging to the sparsely forested regions, is becoming more acute and urgent every year due to progressive aging and degradation of existing forests. The forest legislation in the Russian Federation is imperfect. Most legal acts do not have clear standards for assessing forest quality at different stages of their cultivation, necessary to control the reproduction of highly productive and sustainable stands of the main forest-forming tree species that successfully perform various useful functions. Accounting and measuring work was performed to assess the current state and trends of forest reproduction of the Chernozem region. The following has been found. Natural oak regeneration under the forest canopy is completely absent in mature and over-mature stands. Only two ways of oak forest reproduction are possible: either natural revegetation by preliminary acorning 1-2 years before the mother plantation cutting, or by artificial reforestation, which requires large financial and labor costs. Regeneration cutting should be restarted in mature and over-mature oak stands. The main reason for poor quality and unsatisfactory condition of closing and closed pine and oak forest stands under the age of 10-20 years is the lack of timely silviculture, leading to their inhibition by deciduous species. Therefore, artificial reforestation should include all types of thinning.

1. Introduction

According to the current Forest Code of the Russian Federation [1], cut down, dead and damaged forests should be reproduced. Forest reproduction is a multi-step, complex and lengthy process that includes forest seed production, reforestation (natural, artificial and combined), forest care and the assignment of land intended for reforestation to the land occupied by forest plantations. In fact, all the elements of forest reproduction and each stage must be completed with certain results in the form of concrete finished products. These products are subjects of monitoring, accounting and evaluation (seeds, planting material, unclosed and closed forest cultures, young plants with specified parameters of growth, composition, quality and productivity).

Accumulated historical experience of forest reproduction in Russia [2, 3] and abroad [4] suggests that all the issues related to this specialized area should be addressed by professionals who have both basic knowledge and skills in the field of forestry and motivation to get positive results of their work [5]. These results are forests with preset parameters.

The principle “a forest should be restored by those who use it” (currently used in the forest districts of the Russian Federation [6, 7]) does not and cannot give positive results in the current pseudo-market economic conditions due to the lack of motivation of forest users for complete and high-quality forest reproduction. Today, biological diversity of protective and operational forests, their sustainability, productivity and quality are declining in all forest vegetation zones and forest areas.

Species composition and commodity structure are deteriorating. These negative processes are evidenced by the studies by Russian [8, 9] and international scientists [10-13]. Official statistics, annually reflected in the state forest registry, eloquently testify to these negative processes [14].

Forest reproduction in Europe is no less relevant. Dozens of papers [10-13] are focused on sustainable forest management. They emphasize the need to comply with all foreseen technological processes and operations during artificial reforestation, which are strictly regulated by terms and quality. The need for continuous monitoring of the condition and quality of planted crops is also indicated. Particular attention is paid to selection, seed growing, as well as creation of timber-growing plantations of valuable and fast-growing species.

There are some indicators of the industry's statistical reporting as of January 1, 2014 for objective assessment of the issue relevance, its status and importance of an urgent solution in relation to the forest fund of the Russian Federation [14]:

- Area of valuable forest plantations in the composition of the forest fund lands covered with forest vegetation is 70.63 %;
- Share of forest plantations in the total reforestation on the forest land area is 21.2 %;
- Share of forest crops created by planting material with improved hereditary properties in the total volume of reforestation is 3.9 %;
- Proportion of planting material with a closed root system in the total amount of planting material is 5.4 %;
- Ratio of the artificial reforestation area to the area of forest disposal as a result of clear cutting and forest loss is 18.3 %;
- Ratio of the thinning area in the young stock to the area of young stock of economically valuable species is 0.33 %.

Prevailing unsatisfactory state of forestry shows the necessity to develop new principles and approaches to sustainable and expanded reproduction of forests. It is very important in connection with the decision of the Government of the Russian Federation at the beginning of 2019 to begin the work on the next Forest Code. To obtain positive results, it is necessary to eliminate the gaps and omissions in the current forest legislation that negatively affect the state of the entire forestry of the Russian Federation, including forest reproduction.

In this regard, the aim of the research is to substantiate and develop new ways and principles in the field of forest reproduction in the forest-steppe and steppe zones of the European part of the Russian Federation, providing positive dynamics, stability and high quality of plantings in the formation of target forests of the future.

2. Materials and methods

The objects of the research are:

- Current legal acts regulating the procedure and methods of forest reproduction, the mechanism for recording the area of land requiring reforestation, requirements for planting and sowing material, as well as the powers and interaction of forest participants in the implementation of a work complex on forest reproduction;
- Forests and forest areas, the territories of which are involved in the reproduction of forests, silvicultural and taxation characteristics of forest plantations of different ages, composition and productivity of natural and artificial origin.
- Trial plots were laid in accordance with the requirements of 56-69-83 Industrial Standard (OST) [15] in coniferous and hard-leaved stands of natural and artificial origin.

Over the years, more than 50 test plots were laid. During the desk processing, the average silvicultural and taxation indicators of plantations were determined: age, composition, diameter and height, yield class, density, wood stock and condition (Table 1).

Table 1. Silvicultural and taxation characteristics of forest plants.

No.	Age of the composition	Years, N	Height, m	Diameter, cm	Density	Forest site type	Bonitet	Stock, m^3/ha	State assessment
Pavlovskoe forestry of the Voronezh region									
1	8Eo 2Nm (f/p)	57	20.2	18.6	0.9	D_2	I	230	satisfactory
Rylskoe forestry of the Kursk region									
2	7Eo (f/p) 2As 1B	7 5-7	1.9 2.2	1.8 2.0	0.6	D_3	II	18	good
3	10 Eo (f/p)	6	1.7	1.6	0.7	D_3	I	16	good
Solntsevskoe forestry of the Kursk region									
4	5Sp 5Eo	13	5.0 2.5	12 6.1	0.82	C_2	I	50	good
Khrenovskoe forestry of the Voronezh region									
5	10P+B	53	17.3	18.2	0.65	B_2	III	183	satisfactory
6	9P1B	50	15.2	15.9	0.5	A_2	III	119	satisfactory
7	10P+B	95	26.7	29.9	0.7	A_2	I	551	good
8	10P+B	90	27.6	30.4	0.8	B_2	I	633	good
9	10P+B	68	26.2	26.4	0.8	B_3	I	350	good
10	10P	83	24.2	28.6	0.7	A_2	II	345	satisfactory
Savalskoe forestry of the Voronezh region									
11	10 Sp	58	20.1	26.1	0.9	B_2	II	332	good
12	10 Sp	56	19.7	21.9	0.5	A_2	II	179	good
13	10Eo	96	18.8	26.5	0.6	C_2	II	145	satisfactory

Note: Eo – English oak, Nm – Norway maple, As – aspen, B – birch, Sp – Scots pine, P – pine, f/p – forest plantations.

On the sample plots, trees were continuously enumerated with distribution according to the species, economic value (trade, semi-trade and fire-wood) and six categories of health status (healthy, weakened, severely weakened, drying out, dry fresh and dead wood from previous years) according to the standards "Rules of sanitary safety in forests" [16]. At the same time, the compliance of agrotechnical and silvicultural care with current standards was assessed and a degree of danger from fast-growing soft-leaved species (high, medium and weak) was determined.

During comprehensive studies, an analysis was also made of the content of departmental documents, the composition and structure of the sectoral regulatory legal framework governing the reproduction of forests, statistical reporting materials, concepts and forecasts for the development of the forest industry, as well as the main legislative and regulatory acts in the forestry. All the documents and papers are publicly available on official sites.

3. Results and discussion

Typically, the technology of creating and growing forest crops of the main forest-forming species, including pine and English oak, before converting them to forest-covered land, includes a set of activities, the set and sequence of which depend on the category of lands of the reforestation fund (cuttings, firewood, wastelands, etc.):

- Survey of the forest area determining the location of its borders;
- Additional clearing of the forest area from logging residues and undesirable vegetation (if necessary, in clearings);
- Lowering the stumps for the smooth passage of the chainsaw or MUP-4;
- Preplant tillage of strips and grooves using tracked and wheeled tractors with mounted and trailed tillage tools;

- Delivery of planting material to the forest area and saving it in a shaded place;
- Mechanized usage of a tree planting machine or manual planting of seedlings;
- Manual tamping of seedlings after planting;
- Mechanized or manual care at the side of the rows and between the rows of forest crops;
- Manually addition of forest crops (to the initial density) in cases of plant loss of more than 15 % using the Kolesov's planting iron;
- Weeding the rows of plants by hand using a hoe;
- Continuous mechanized or partial manual mowing of uncontrolled vegetation on the side rows of forest crops;
- Lightening the side rows of plants in converging and closed forest crops.

Most of the above-mentioned technological operations for reforestation are mandatory, and some of them are not. They must be performed on certain categories of land of the reforestation fund. For example, lowering of stumps to the soil level is applied only on fresh cuttings.

Depending on the land category (cutting, burned areas, failed plantation, wastelands, etc.), forest plantations are created either pure in composition, or mixed, but with a predominance of certain main species. At clearings, most forest plantation sites were created pure in composition, usually containing one main species.

The main cultivated species in the forestry areas of the Chernozem Region are: coniferous – pine, spruce and larch, hard-leaved – English oak, European ash, Norway maple; soft-wooded broadcasting can be seen less often (white birch and little-leaved linden).

Silvicultural and technological requirements for reforestation in the forests of forest-steppe and steppe forest-growing zones of the European part of the Russian Federation were developed by the author taking into account the current forest legislation [17, 18]. Practical experience shows that not all the legal entities and individuals using forests on leasehold and permanent (perpetual) use have appropriate forestry machines and tools for high-quality, timely and successful implementation of all types of activities on reforestation. Therefore, labor-intensive work on artificial reforestation is done manually in the majority of small areas, or they are left behind by natural overgrowing, dooming to an undesirable change of species.

In this regard, we recommend to make compulsory assistance to the natural renewal of oak using preliminary accentuation of acorns (local origin) for 1-2 years before felling (1-2 pieces per hole under the hoe at the rate of 600-800 pieces on 1 ha in all the forest areas of the forest-steppe and steppe forest-growing zones of the European part of the Russian Federation).

It is necessary to make continuous “reforestation logging”, used in the mid-1960s and 1970s and proven to be only from the positive side in mature and over-mature oak plantations.

Due to the prohibition [1] to carry out clear cutting in mature and over-mature stands since 2007 in most categories and varieties of protective forests, the cuttings are currently formed only as a result of clear sanitary cuttings and renewal cuttings. The size of the cutting areas is limited by current “Rules for timber harvesting...” [19].

Fresh felling is a predominant land category of the forest fund in the forest districts of the Chernozem Region (87-95 %). Most of the felling after narrow-cut cross-cut logging, including regeneration cutting of low-value forest stands, have a small area (1.0-1.5 ha). It is necessary to allow “regeneration cutting” in mature and over-mature stands of natural origin in order to ensure sustainable reproduction of oak forests in the region.

The main reason for the poor state and poor quality of closing and closed pine and oak forest cultures is still the lack of timely and adequate forest management. It leads to the overgrowth with soft-leaved species. Therefore, artificial reforestation should include all types of thinning up to 40 years as an integral part of it.

A differentiated scale was proposed to assess the quality of forest plantations of coniferous and hardwood trees by their species composition (Table 2).

Table 2. Scale for assessing the quality of forest plantations according to species composition.

Degree of quality	Category of quality	Qualities in points	Negative deviations from the optimal composition, unit	Intensity of thinning for the improvement of species composition in plantations
1	High	5	–	very weak
2	Good	4	1-2	very weak and weak
3	Satisfactory	3	3-5	moderate, moderately high
4	Unsatisfactory	2	6-8	moderately high and high

Note**.** The intensity of thinning is set depending on the degree of suppressing threat for cultivated plants: very weak – up to 10 % of the timber stock before cutting, weak – 11-20 %, moderate – 21-30 %, moderately high – 31-40 %, high – 41-50 %.

The scale is universal and suitable for assessing the quality of all-age stands: the less deviation from the optimal species composition of the stand is, the higher is its quality and the less is the need for improvement by thinning.

The main part of the forest crop area of the main and economically valuable forest tree species is created by planting of 1-2-year-old standard seedlings with an open root system. The share of planting material with a closed root system does not exceed 1 % in the total volume of reforestation.

In general, with a sufficiently high survival rate of seedlings, the state, growth and quality of forest crops transferred to the land covered with forest vegetation is largely determined by timeliness, intensity and quality of tree-building and silvicultural treatments.

The influence of different tillage methods and a number of agrotechnical measures affects the survival rate, condition, growth and development of plants only in unravelled forest cultures. This influence is leveled after the closure of the cultures. Later, by the age of 12–15, it no longer appears. The cultures created by sowing seeds and planting seedlings have a similar mean height and diameter at the age of 15 years. These indicators are determined by the specific type of growing conditions.

4. Conclusion

Natural regeneration under the forest canopy is completely absent in mature and over-mature stands of English oak. Therefore, there are only two ways of oak trees reproduction: either by low-cost assistance to the natural resumption (using preliminary accentuation of acorns for 1-2 years before felling), or by artificial reforestation, which requires large labor and financial costs.

Artificially created tree stands are significantly different from the stands of natural origin in silvicultural, taxation and biological terms throughout their lives. They require different approaches.

Artificial reforestation and afforestation should not end with the transfer of forest crops to a forested area. It should cover the entire initial period of the artificial plantation cultivation (not less than 40 years), including all types of thinning as an integral part of silvicultural production.

The obtained results may be useful and applicable in forestry and for authorities of the constituent entities of the European part of the Russian Federation, forest management and design enterprises, universities and forest research institutes.

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