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PREREQUISITES FOR TRANSITION TO MULTIPURPOSE FOREST REPRODUCTION

Research article

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Abstract

To increase the productivity of the quantitative and the qualitative structure of the formed forest plantations, a transition to a high-power reproduction model is necessary. At present, silvicultural production is very different far from optimal, the proportion of artificial phytocenoses disappears under the leafy canopy, and reforestation passes through the natural change of species. Ultimately, this reduces the resource and ecological potential of the plantations being formed. In this regard, it is necessary to switch to another model - multi-purpose reproduction of forests. The technology developed and secured by copyright provides for the one-time use of silvicultural areas for plantation (use of deciduous tree species with improved hereditary properties to obtain marketable timber within 20-30 years) forest cultivation and traditional reforestation, (creation of industrial forest plantations, or implementation of a set of measures to promote natural forest formation process). This approach improves the quality and guarantees high efficiency (including economic efficiency) of forest reproduction.

The developed and scientifically substantiated technology has been implemented and is being tested at a production site in the Vologda region in the lease base of Tolshmenskoye LLC, where multi-purpose crops (plantation and traditional) are planted. The work was carried out within the framework of the current regulatory legal acts on reforestation on the basis of a forest development project for research and educational activities, specially developed reforestation projects that have passed all the relevant approvals. Approbation of the proposed approach was implemented on an area of 92.2 hectares.

Keywords: multipurpose forest reproduction, biotechnologies, forest management model, work techniques, intensification of forest reproduction, methods and ways of reforestation.

ПРЕДПОСЫЛКИ К ПЕРЕХОДУ НА МНОГОЦЕЛЕВОЕ ВОСПРОИЗВОДСТВО ЛЕСОВ

Научная статья

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Аннотация

Для увеличения продуктивности количественной и качественной структуры формируемых лесных насаждений необходим переход на высокомощную модель воспроизводства. В настоящее время лесохозяйственное производство значительно отличается от оптимального, доля искусственных фитоценозов исчезает под лиственным покровом, а лесовосстановление проходит через естественную смену пород. В конечном итоге это снижает ресурсный и экологический потенциал формируемых насаждений. В связи с этим необходимо перейти к другой модели - многоцелевому лесовосстановлению. Разработанная и закрепленная авторским правом технология предусматривает единовременное использование лесохозяйственных участков для плантационного выращивания леса (использование лиственных пород деревьев с улучшенными наследственными свойствами для получения готовой к продаже древесины в течение 20-30 лет) и традиционного лесовосстановления, (создание промышленных лесных плантаций, либо осуществление комплекса мероприятий по стимулированию естественного лесообразовательного процесса). Такой подход повышает качество и гарантирует высокую эффективность (в том числе экономическую) лесовосстановления.

Разработанная и научно обоснованная технология была внедрена и проходит испытания на производственном участке в Вологодской области на базе аренды ООО "Толшменское", где высаживаются многоцелевые культуры (плантационные и традиционные). Работа проводилась в рамках действующих нормативно-правовых актов по лесовосстановлению на основе проекта освоения лесов для научно-исследовательской и образовательной деятельности специально разработанных проектов лесовосстановления, прошедших все соответствующие согласования. Апробация предложенного подхода была осуществлена на площади 92,2 га.

Ключевые слова: многоцелевое воспроизводство лесов, биотехнологии, модель ведения лесного хозяйства, технология работ, интенсификация лесовосстановления, методы и способы лесовосстановления.

Introduction

According to Article 25 and Article 40 of the Forest Code of the Russian Federation, forest management is to ensure its multipurpose, rational, continuous and sustainable use as well as to contribute to the forest industry development [14, P. 3]. There are few forests, which have not been affected by human activities, both in Russia and in the world as a whole. Moreover, the area of such forests continues to reduce. At the same time, the quality of forest stands become worse and the area of natural stands, which are greatly both environmentally and economically valued, decreases [19].

In this regard, traditional reforestation methods seem to be unable to meet the growing timber needs of the national economy in future. It is particularly difficult to provide the fast-developing pulp and paper industry with raw materials. One of the ways to achieve this goal is to implement a multi-purpose and integrated approach to wood production and afforestation, being focused on accelerated wood reproduction under forest conditions that are relatively favorable for these purposes, with simultaneous and effective regeneration of indigenous forests.

The declared direction corresponds to:

- the research priorities in the field of forest use, its safety, protection and reproduction, that ensure sustainable forest management and timber industry development, approved by the order of the Federal Forestry Agency “Development of ecologically safe forest management and forest use systems, silvicultural and ecological requirements to technological processes and facilities, modern technologies and technical facilities of forest safety, protection, reproduction and reforestation”, no. 519, dated 19 December 2012;
- the basic principles of the government policy in forest use, its safety, protection and regeneration in the Russian Federation till 2030, which have been approved by the order of the Russian Federation Government, no. 1724-R, dated 26 September 2013;
- Forest Regeneration Subprogram, included in the Russian Federation State Program “Forestry Development for 2013-2020”, approved by the resolution of the Russian Federation Government, no. 318, dated 15 April 2014.

According to Article 42 of the Forest Code of the Russian Federation, forest plantations can be developed on the land areas of the forest fund and areas of other categories [7]. In the world practice, the cultivation of woody biomass, which is widely used in various sectors of the national economy, prevails in the forest plantations [11].

Annually, more than one million hectares of plantation forest species are developed in the world for pulpwood logging, lumber log, veneer log and raw materials to satisfy energy needs. More than a third of the wood being consumed in the world is harvested from plantation forest species. The United States and China are the leaders in this field [12].

In Russia, development of plantation forest cultivation is constrained by the widespread idea of forest inexhaustibility. However, the wood reserves available for exploitation are limited due to environmental and economic circumstances. For a long time, the issue of growing any wood assortment has been out of the question, since vast areas of ripe forest have been subjected to felling. Pulp and paper plants as well as woodworking plants used to solve their problems with the help of forest resource bases. Nevertheless, the problems of the wood processing industry have worsened in the period of transition to a market economy [2].

As for wood processing enterprises, developing targeted forest plantations from fast-growing tree species is the only way out of the impending raw material collapse. Moreover, plantation forest cultivation on leased areas inspires the tenants’ motivation for effective forest regeneration and promises them quite tangible and rapid benefits [5].

For a long time, the world pulp and paper industry has been dominated by Northern softwood trees, in particular conifers. These species have made it possible to produce high-quality long-fiber cellulose, which have been out of competition in the cardboard and paper manufacture until recently. However, the technologies have changed, and hardwood is gaining ground [4].

In the country’s forest fund, plantation conifers are located in small areas and are not concentrated near woodworking enterprises and other heavy wood consumers. A lack of separate account of the developed plantation forest species in the forest management documents makes it difficult to control the normative indicators of these stands [5].

A lack of the necessary forestry work finance has resulted in negative indicators of the plantation forest species productivity. Intensive agrotechnical and silvicultural care have been required on rich soils in order to preserve the desired stand composition and the density regime of woody plants. As a result, economically and ecologically valuable forest stands have been formed, but they have not met the objectives of plantation forest cultivation [19].

In our opinion, a special attention is to be paid to the possibility of implementing a multipurpose forest reproduction model, i.e. combining plantation forest cultivation and various methods of traditional reforestation (natural, artificial, combined) to improve the economic and environmental effect. It meets the basic principle of the forest legislation on ensuring the multipurpose, rational, continuous and sustainable use of forests to meet the social needs in forests and forest resources. Implementation of the model that uses modern biotechnologies makes it possible to improve the forest fund state as a whole [7]. The proposed model is a new promising direction developed to reduce pressure on natural forests [10].

In this regard, the modern state forest policy is to be aimed at motivating the forest managers to grow high-quality stands as well as to make conditions that allow the full use of forests and implementation of the long-term projects in forestry.

The long-term forest manager is interested in obtaining wood in a certain local proximity to the production site, and therefore, in permanent reforestation. To develop and improve the competitiveness of the domestic forest economy both in the domestic and foreign markets, it is necessary to develop new methods of economically and environmentally responsible use and methods of afforestation, aimed at strengthening and improving the quality of raw materials [9, P. 43-45].

The Integrated Program for Biotechnology Development in the Russian Federation for the period until 2020 can be a tool for realizing the idea. The program includes developing the network of DNA analysis laboratories for monitoring the state of forest genetic resources, forest pathology monitoring, government monitoring of forest reproduction, control of the legal wood origin and creating an *in vitro* (plant material bank) forest woody plant collection [16].

Research methods and principles

The object of the present research is a model and technology of a multipurpose forest reproduction by one-time use of forest areas for plantation forest cultivation (using deciduous wood species with improved hereditary properties for obtaining merchantable timber during 20-30 years) and traditional reforestation, by developing industrial forest species grown from the seeds of known origin as well as by combined and natural methods of forest reproduction. This approach is to improve the quality and efficiency of forest reproduction. Along with it, the use of fast-growing tree species is to increase the profitability of forestry operations and to provide good raw materials.

The introduction of deciduous forest species obtained by cell selection of valuable candidate genotypes *in vitro* into the species will allow increasing the forestry work profitability and to produce 350-450 m^3/ ha of merchantable timber within 25-30 years, which is important for logging enterprises during the life of lease agreements [3].

The main requirement for the plantation stand development is to use species, forms (clones) and varieties that correspond to the target characteristics (productivity, wood quality, etc.) and can be resistant to adverse environmental factors [6, P. 138]. The main requirements for the quality of forest sites, being suitable for developing target hardwood plantations in the taiga zone of the European part of Russia [1, P. 91] are presented in Table 1.

Table 1 - Forest vegetation characteristics of forest sites suitable for multipurpose forest reproduction

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Criteria	Main requirements
Hectarage of a specific site, ha, not less than	20
Quality class (lat. *Bonitas*), not less than	II
Forest site types, soil-hydrological conditions	B_2-B_3, C_2-C_3, green-moss and blueberry on loamy sand, wood sorrel and blueberry on loam; complex and mixed grass species
Content of physical clay in a mineral soil layer of 0-30 cm thick, %	5-30 (birch / *Betula pendula*) 10-50 (aspen / *Populus tremula*)
Depth to a dense root-proof soil layer, cm, not less than	60 (birch / *Betula pendula*) 40 (aspen *Populus tremula*)
Amount of wood residues at even distribution, m^3 / ha, not more than	15
Depth of groundwater by the beginning of vegetation, cm, above	30

First of all, in the Vologda region, fresh cuttings (1-2 years) of the blueberry and wood sorrel group of the forest site types are suitable for developing birch and aspen plantations.

To evaluate the multipurpose forest reproduction model, the experiment has been carried out for the first time in the Vologda region (Tot’ma municipal district) in 2016. The forest fund for reforestation and afforestation has been represented by fresh cuttings in the blueberry and wood sorrel group of the forest site types.

For setting out plantation birch and aspen species, fresh cuttings made 12 months ago have been selected (Table 2). The number of stumps on these cuttings ranged from 460 to 727 pcs / ha.

Table 2 - Initial characteristics of selected forest sites

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Compartment number	Subcompartment number	Usage type	Year of development	Land category	Forest type index	Quality class (lat. *Bonitas*)	Hectarage
41	10	Clear cutting	2015	Fresh cuttings	C_{sorrel}	Ia	9.0
	11					I	16.0
	21					I	10.0
48	6	Clear sanitary cutting			C_{sorrel}	I	7.0
	7				$C_{blueberry}$	II	12.0
	13				C_{sorrel}	I	10.0
59	21	Clear cutting			C_{sorrel}	I	10.0
64	6	Clear			C_{sorrel}	I	9.8

	26	cutting			$C_{blueberry}$	I	8.4

When selecting sites, being suitable for developing multipurpose species, the location of processing plants, soil conditions and biological species capabilities for the conditions of the taiga zone in the European part of Russia [19] have been taken into account as a result of an on-site survey, in accordance with the current guidelines of forest management [13]. The forest sites are distributed according to the quality class (lat. *Bonitas*) as follows:

Quality class Ia - 9.0 ha (about 9%);

Quality class I – 71.2 ha (79%);

Quality class II - 12.0 hectares (about 12%).

The forest sites allocated for plantation forest species are distributed according to the forest type as follows: sorrel pine forest - 79% and blueberry forests - about 21%. The forest sites under research have been developed by means of clear as well as clear sanitary cuttings in the summers and winters of 2015 and 2016. The technological process has included a cut-to-lengthwith the use of a foreign aggregate equipment complex.

Main results

In the course of the experiment at the production site, we have developed and implemented five options for a multipurpose forest reproduction by laying out fast-growing plantation birch and aspen species from ball-rooted planting stock (seedlings) with improved hereditary properties.

Table 3 - Characteristics of the research objects at the production site

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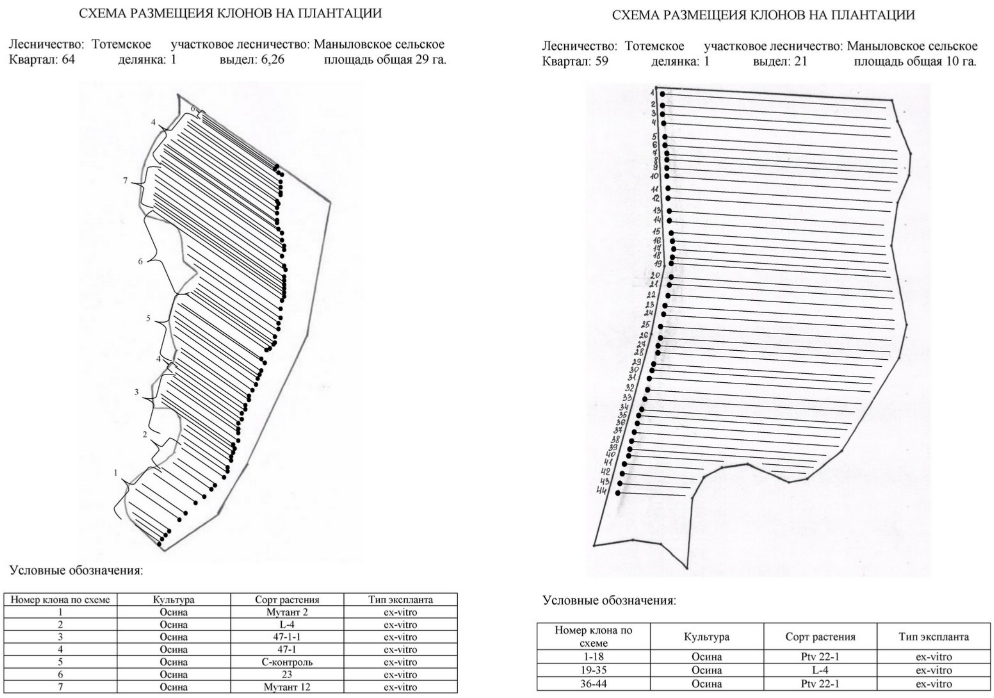
Forestry, divisional forestry	Purposive wood species	Compartment number	Subcompartment number	Hectarage	Stand composition	Number of planted plants, thousand pcs
Totemskoe, Manylovskoe rural	Birch Aspen Pine Fir tree	41	10	92,2	10Birches; 7Pines 3Fir trees	6.4; 31.2
			11		10Birches; 10Pines	24.5; 70.4
			21		10Aspens; 10Fir trees	9.6; 48.0
		48	6, 7, 13		8Aspens 2Birches; 5Pines 5Fir trees; 9Fir trees 1Birches+ Aspens	10.1; 58.7; 24.9
		59	21		10Aspens; 9Fir trees 1Birch + Aspen	21.2; 18.2
		64	6, 26		10Aspens; 9Fir trees 1Aspen	23.7; 36.6

Furthermore, industrial spruce and pine species (pure and mixed) have been developed at the same time on the same area by using the methods of combined reforestation and the methods assisting to natural reforestation (saving a viable generation of main forest stand species (undergrowth), which has renewed itself under the canopy of the forest stands and is capable to form new forest stands under these climatic conditions) under logging operations in the forest swaths preserving the forest environment (see figure).

Scheme of clone arrangement on the plantation site



Номер клона по схеме	Культура	Сорт растения	Тип эксплanta
1	Осина	Мутант 2	ex-vitro
2	Осина	L-4	ex-vitro
3	Осина	47-1-1	ex-vitro
4	Осина	47-1	ex-vitro
5	Осина	С-контроль	ex-vitro
6	Осина	23	ex-vitro
7	Осина	Мутант 12	ex-vitro

Номер клона по схеме	Культура	Сорт растения	Тип эксплanta
1-18	Осина	Ptv 22-1	ex-vitro
19-35	Осина	L-4	ex-vitro
36-44	Осина	Ptv 22-1	ex-vitro

Figure 1 - Preservation of a viable generation of main forest stand species (undergrowth), which has renewed under the canopy of forest stands and is capable to form new forest stands under these climatic conditions

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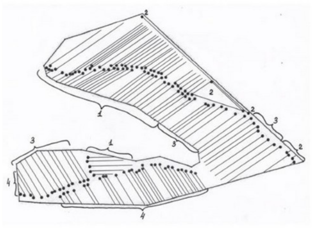
Note: clone number in the scheme, Species, Plant variety, Explant type, PFS - plantation forest species, FS - forest species, NR - natural regeneration

СХЕМА РАЗМЕЩЕИЯ КЛОНОВ НА ПЛАНТАЦИИ

Лесничество: Тотемское участковое лесничество: Маныловское сельское
Квартал: 41 делянка: 6 выдел: 21 площадь общая 10 га.

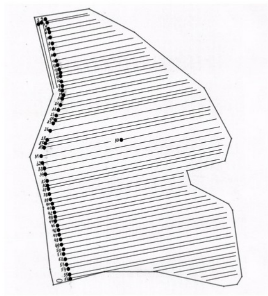


Условные обозначения:

Номер клона по схеме	Культура	Сорт растения	Тип эксплanta
1	Осина	47-1	ex-vitro
2	Осина	С-контроль	ex-vitro
3	Осина	Ptv-22-1	ex-vitro
4	Осина	47-1-1	ex-vitro

СХЕМА РАЗМЕЩЕИЯ КЛОНОВ НА ПЛАНТАЦИИ

Лесничество: Тотемское участковое лесничество: Маныловское сельское
Квартал: 41 делянка: 5 выдел:11 площадь общая 16 га.

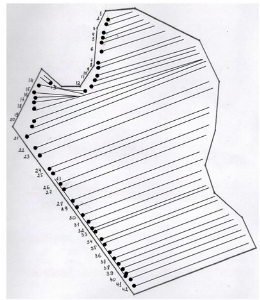


Условные обозначения:

Номер клона по схеме	Культура	Сорт растения	Тип эксплanta
1-2	Береза	Б-4	ex-vitro
3-15	Береза	ББ31-1	ex-vitro
16-29	Береза	Б-4	ex-vitro
30-47	Береза	БП-3Ф-1-1	ex-vitro
48-54	Береза	БП1Б-1	ex-vitro
55	Береза	БП-3Ф-1-1	ex-vitro
56	Береза	БП1Б-1	ex-vitro

СХЕМА РАЗМЕЩЕИЯ КЛОНОВ НА ПЛАНТАЦИИ

Лесничество: Тотемское участковое лесничество: Маныловское сельское
Квартал: 41 делянка: 7 выдел:10 площадь общая 9 га.



Условные обозначения:

Номер клона по схеме	Культура	Сорт растения	Тип эксплanta
1-2,43	Береза	БП1Б-1	ex-vitro
3-11	Береза	БП-3Ф-1	ex-vitro
12-13	Береза	ББ4А-1	ex-vitro
14-26	Береза	БП3Ф-1	ex-vitro
27	Береза	ББ4Б-1	ex-vitro
28-31, 36-37	Береза	4	ex-vitro
32-35, 40-41	Береза	БП-3Ф-1	ex-vitro
38-39, 42	Береза	ББ4Б-1	ex-vitro

Figure 2 - Artificial reforestation

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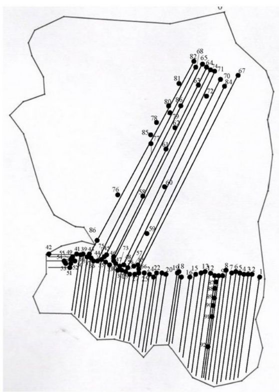
Note: clone number in the scheme, Species, Plant variety, Explant type, PFS - plantation forest species, FS - forest species, NR - natural regeneration

СХЕМА РАЗМЕЩЕИЯ КЛОНОВ НА ПЛАНТАЦИИ

Лесничество: Тотемское участковое лесничество: Маныловское сельское
Квартал: 48 делянка: 5 выдел: 6,7,13 площадь общая 29 га.



Условные обозначения:

Номер клона по схеме	Культура	Сорт растения	Тип эксплanta
1,2,7,8,89-90	Береза	Бб4б-1	ex-vitro
3	Береза	Бп4а-1	ex-vitro
4,5,6, 91-92	Береза	Дрв-1	ex-vitro
9,10,11,12,18,33,34,47-74,63-64,71-72,81-82	Осина	23	ex-vitro
13,14,20,21,61-62	Осина	47-1-2-53	ex-vitro
15, 19, 24,58-61	Осина	Мутант 2	ex-vitro
16,17, 22,23, 27,28,29,36,39,50,51,46-58	Осина	Ptv-22-1	ex-vitro
25,26, 30,31,35,44-77,65-86,	Осина	Мутант 12	ex-vitro
32, 37,48-72	Осина	Pt-2	ex-vitro
38,49,56-59,60-70,80-81	Осина	47-1	ex-vitro
40,41-42,52-53,54-55,83-84	Осина	L-4	ex-vitro
62-63,77-79,88-89	Береза	Бп3ф1	ex-vitro
87-88	Береза	Бп1б-1	ex-vitro
45-86,67-66,90-91	Береза	4	ex-vitro
59-60,78-85	Осина	Мутант 14	ex-vitro
68-79,78-80,76-86	Осина	Мутант 21	ex-vitro
76-85,43-86	Осина	С-контроль	ex-vitro

Figure 3 - Combined reforestation

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Note: clone number in the scheme, Species, Plant variety, Explant type, PFS - plantation forest species, FS - forest species, NR - natural regeneration

At the same time, different density and combination of deciduous and coniferous forest species as well as the multi-purpose species arrangement on the forest site (line and strip arrangement, consisting of two paired rows) have been considered (Table 3).

Before establishing plantations, the plot soils have been mechanically furrowed and artificial elevations (dumps) have been formed. The depth of tillage has been 0.20 m. The average distance between the furrows (elevations) has been 5.0 m. To increase the planted stand stability, the furrows (elevations) have been plowed nonlinearly, evenly throughout the forest area (Forest Development Project, 2017), except for the natural reforestation sites, where furrows have been plowed only near technological corridors. Plantation species as well as industrial ones have been planted manually with the use of Kolesov's sword in the side dump of the furrow, with the mandrel of the root system.

Experimentally specified density of plantation and industrial forest species has been provided for different options, depending on the developed mixing schemes (Table 4). Due to the fact, that there are no recommendations on the density of deciduous stands in the forestry literature for the taiga zone, we have proposed a sufficiently great variety of options to establish the optimal number of plants per an area unit. For plantation birch and aspen species, the initial number of plants per an area unit has been the following: 400 pcs / ha, 500 pcs /ha, 600 pcs / ha, 700 pcs / ha, 800 pcs/ ha, and 2000 pcs / ha. For the two-row planting of industrial pine and spruce species, a less variability has been provided: 3 thousand pcs / ha for spruce, 3.5 thousand pcs / ha for pine and spruce (when planting mixed stands) and 4.0 thousand pcs /ha for pine.

When developing species mixing, it is necessary to envisage resistance of the planted stand to fires, pests and other negative factors. For instance, in a dry forest it is desirable to develop a strip mix of pine and birch trees, which will grow together and serve as the simplest fire barrier [8, P. 315].

Genotypes of the forest species used for establishing a plantation have been tested for adaptability and stability in non-sterile conditions in 2015. During that period, some characteristics of genotypes (e.g. ploidy) have been specified. On the basis of the obtained data, representivity and species composition have been corrected when planning the production volume of the hardwood planting stock (birch and aspen) [18].

Table 4 - Parameters of plantation and production forest species

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Indicator	Technological approaches according to the species development options, depending on the machines, mechanisms and equipment in use							
	machines and mechanisms of foreign production							
Working Circle	deciduous					coniferous		
Density, pcs/ra	400	500	600	700	800	3000	3500	4000
Species	Birch (Aspen)	Birch (Aspen)	Birch (Aspen)	Birch (Aspen)	Birch (Aspen)	Fir tree	Pine+ Fir tree	Pine
Plant Spacing, m	1.5	1.25	1.0	0.9	0.8	0.4-0.5	0.3-0.4	0.3

The replication volume of No. 4 birch genotype has been reduced, but it has been left in the collection, since it has been the source genome for some elite forms and remains to be the control one. The share of Drv-1 genotype, taken as a promising elite variety in the 2015 production plan, has been significantly increased in the production volume. The performed adaptation works have confirmed its positive characteristics. The total collection includes eight birch genotypes: bp3f1-1, No.4, bp4a-1, bb31-1, Drv-1, bb4b-1, bp1b-1 and bp3f-1. The collection of aspen genotypes has also changed: Mutant 2, Mutant 21, 47-1-1-19; 47- 1-1-22; 47-1-1-27; 47-1-1-31; 47-1-2-53.

In total, 12 clonal aspens and seven clonal birches have been planted (Table. 2). In total, 107404 pieces of hardwoods have been planted on the area of 92.2 hectares. The clonal birches have represented about 30% of the total.

Three-year spruce seedlings (temporary nursery of Vashkinsky forestry, Vologda region) and two-year pine seedlings (permanent nursery of Ustyuzhensky forestry, Vologda region) grown from the seeds of known origin have been used as planting stock for the development of industrial forest species (Table 5).

In 2019, every forest site of the production site have been paid silvicultural management. Moreover, species inventory have been taken. As a result, the morphometric parameters (diameter at the root neck, height) of the planted plants, their survival and damage degree affected by abiotic factors have been established.

Table 5 - Inventory list of species implemented in multipurpose forest reproduction

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Species	Plant variety	Explant type	Total number, pcs
Aspen	47-1	ex-vitro	14410

	23	ex-vitro	9042
	mutant 12	ex-vitro	6845
	c-control	ex-vitro	6697
	mutant 2	ex-vitro	2667
	ptv 22-1	ex-vitro	13582
	l-4	ex-vitro	8008
	pt-2	ex-vitro	1724
	mutant 21	ex-vitro	843
	mutant 14	ex-vitro	916
	47-1-2-53	ex-vitro	2462
	47-1-1	ex-vitro	4894
Total			72090
Birch	bp3f1-1	ex-vitro	12133
	bp4a-1	ex-vitro	1860
	bp1b-1	ex-vitro	4672
	drv-1	ex-vitro	2321
	4	ex-vitro	8378
	bb31-1	ex-vitro	3002
	bb4b-1	ex-vitro	2331
	bp3f-1	ex-vitro	617
Total			35314
Broadleaved species in total			107404
Pine	-	-	120230
Fir tree	-	-	87780
Coniferous species in total			208010
Total			*315414*

From a legal point of view, until 2020, such a combination of traditional and plantation forest crops with improved hereditary properties was only possible when forests were used for research and educational activities. In connection with changes in regulatory legal acts, the list of main forest-forming species has been expanded with such hardwood as birch. Using a multi-purpose approach can now be implemented in production much faster. The foregoing does not exclude the possibility of applying such an approach on degraded lands or with longer rotation periods with a balanced approach to the risks of their creation. Nevertheless, it is not the creation of forest plantations that seems promising and sustainable, but more intensive forestry compared to modern forestry in areas of natural (albeit heavily transformed, degraded) secondary (derivative) forests using the approach of multi-purpose reproduction and forest use.

Discussion

The survey made by the international Aston Alliance consortium has shown that a similar model, technology, and approach are unavailable in the forest management practice in the Russian Federation, CIS countries, and abroad. The authors received the inventor's certificate no. EC-01-001414 Work of science: Model and technology of multipurpose forest reproduction.

Conclusion

In conclusion, the following should be noted (RF Government Decree No. 337-R, 2018; Forest Development Project for Forest Implementation, 2017; A. S., 2017):

1. The developed and proposed model intended to be implemented in production practice for testing a multipurpose forest reproduction approach allowed to transit to an intensive forest management model declared by the fundamentals of the state policy in the field of use, protection and reproduction of forests in the Russian Federation until 2030.
2. In accordance with the legislative and regulatory framework of the Russian Federation, Project of Forest Development for Research and Education has been developed.
3. Scientific and methodological justification of the model and technology of a multipurpose forest reproduction is secured by copyright.
4. Project and technical documents (forest development project, technological maps for soil treatment) on the model and technology of a multipurpose forest reproduction has been developed and agreed by the executive authorities.
5. In the coming period (the next 3-5 years), a forest-biological assessment of the multi-purpose approach to forest reproduction in the South taiga region of Russia's European taiga part is planned, with the account of the technological methods of their development. It will allow assessing the stand resistance to the effects of biotic and abiotic factors. The final assessment will be given for the species at the age of 10-15 years old (short-term trials of elite hardwood offspring).

6. Taking into account the scientific and methodical justification and testing, the stand productivity in the considered region as well as the economic benefits gained from forest use are to increase on the assumption of preserving the forest’s social and environmental values.

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Конфликт интересов

Не указан.

Conflict of Interest

None declared.

Рецензия

Все статьи проходят рецензирование. Но рецензент или автор статьи предпочли не публиковать рецензию к этой статье в открытом доступе. Рецензия может быть предоставлена компетентным органам по запросу.

Review

All articles are peer-reviewed. But the reviewer or the author of the article chose not to publish a review of this article in the public domain. The review can be provided to the competent authorities upon request.

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