On the issue of reforestation methods (using a substrate for planting seedlings)

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Abstract. The problem of forest conservation is currently the most acute. In the current extreme conditions due to global climate change, reforestation and protection of forest resources require special attention, as well as new methods and approaches to solving emerging problems in this direction. Wildfires destroy huge forests, this is a step towards an environmental disaster, since the functions of the forest are not only an "oxygen production factory", but also the protection and protection of water resources and soil. In this regard, great attention is paid to afforestation, various methods of growing tree species are proposed and used. Foresters are studying new progressive technologies of reforestation, using various substrates that contribute to the production of high-quality tree plantations. The article presents an analysis of data obtained during research on the cultivation of pine seedlings (Latin) using a substrate based on waste from the woodworking industry. The research was carried out as part of the research work of students and postgraduates of the Forestry Engineering University. The research results allow us to conclude that it is advisable to use a substrate, which will allow not only to preserve living green spaces, but also to effectively use waste from the woodworking industry.

1 Introduction

The problem of conservation of forest resources in the world is becoming increasingly important and urgent. This is due to global climate change, and is also greatly influenced by the anthropogenic factor, the importance of which cannot be ignored. Climate change entails unstable weather conditions in certain regions. Dry weather, low rainfall in some regions, as well as strong winds contribute to the massive spread of fires, both natural and human-caused.

Recently (namely, as of September 2024) according to the Federal State Budgetary Institution Avialesookhrana (Russian state Enterprise for the Control, Protection and Protection of forests from Fires) The statistics on fires are disappointing. In the last weeks of September alone, more than 20 forest fires were eliminated in 15 regions of Russia. The area covered by the fire was 159 hectares. Arkhangelsk, Vologda, Leningrad, Rostov, Irkutsk, Moscow, Samara, Tomsk, Republic of Karelia, Buryatia, Mari El, Chuvash Republic, etc. are among the regions affected by fires.

In July 2024, there were 25 forest fires on 6 hectares in the Krasnoyarsk Territory alone. And this is a small example from the main figure.

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The anthropogenic factor is of no small importance. Careless handling of fire leads to irreparable consequences, hundreds of hectares of valuable forests are destroyed.

The choice of effective methods and ways to increase the area of forests is one of the main measures for the cultivation of forests and the conservation of forest resources.

In this regard, the aim of the work is to study ways of an alternative method of forest restoration on a substrate obtained from waste from a woodworking enterprise. To achieve this goal, the following tasks were solved: to study waste recycling methods; to consider the technical conditions of the quality of the substrate used; to study the survival rate of Siberian pine seedlings.

This article presents the results of research conducted as part of the research work of students and postgraduates. We are talking about a method of planting forest seedlings using wood processing waste, namely, planting seedlings of Siberian pine (Pinus sibirica) in a substrate obtained on the basis of wood processing waste from the enterprise. The issues of the use of wood waste and their use as fertilizers are considered. The recommended technical conditions for the quality of the substrate used are given.

It has been noted more than once that more than half of the world's timber reserves are located on the territory of the Russian Federation. There are undisturbed, natural landscapes. These are significant natural areas of great importance for the life of the planet as a whole.

According to the Federal Forestry Agency, one hundred twelve and nine million cubic meters of wood were harvested in Russia from January to August 2023. But at the same time, at all stages of production of wood products from the stage of harvesting to processing of wood raw materials, a large amount of waste is generated. For example, only during logging, more than thirty percent of tree trunks are identified as waste. This indicates that both harvesting and processing of wood are accompanied by huge losses.

The problem of waste disposal has been global and relevant for many centuries. But in the sphere of intensive globalization of human activity, intensification of industry and other various segments of the economy, the issue of recycling waste into a secondary product has become the most urgent need. The reuse of waste mainly affects the economic and environmental aspects of life.

Recycling of waste into a secondary product necessary for consumption corresponds to the main environmental goals – restoration of the environment, conservation of natural resources, creation of a healthy ecosystem, reduction of landfills [1].

The wastes obtained as a result of wood processing is mostly burned and exported to the dump. Due to the fact that the woodworking industry is developing rapidly and dynamically, the issue of waste disposal of logging and woodworking enterprises becomes relevant [2].

Wood processing processes also do not exclude a large amount of waste. After the sawmilling process, humps, slats, board trimmings, sawdust, shavings, bark are included in the waste. After the drying process, about five to seven percent of the raw material is lost. The volume of bark waste is approximately 10-12% of the total volume of the log.

Necessary also keep in mind that about 65% of the waste is used as secondary raw materials, and the rest is simply sent to landfill, which exacerbates pollution of natural ecosystems.

The wastes of wood is generated in large quantities at almost all stages of the technological process, starting [3] from logging operations and ending with woodworking. These include the remnants of raw materials, materials and semi-finished products that are formed during the production of basic products.

Different types of waste are valuable raw materials for the production of various products and materials. The quantitative composition of wood waste depends directly on the technological process of production of manufactured products. Not the least important is the quality of the original raw materials, as well as the technical condition of the equipment used at all stages of the production cycle.

The composition of wood raw materials includes organic substances: lignin – 18-30%, cellulose – 39-52%, as well as minerals: phosphorus, potassium, nitrogen, carbon. The content of these substances in the composition of the feedstock contributes to the formation of humus in the soil. But since the composition of the substances does not include nitrogen (0.1 - 1.2%), it is ineffective to use wood residues as fertilizer. For this purpose, composting is used, with the addition of nitrogen with a concentration corresponding to the types of soils on which they will be used.

Woodworking waste is a valuable raw material for the production of various building materials, as well as for hydrolysis, pulp and other industries. The disposal of wood waste is of great economic importance. On the one hand, this allows us to meet the need for construction in many structural, cladding and thermal insulation materials, which in some cases surpass lumber in technical properties, and on the other hand, significantly reduce the volume of deforestation [4].

One of the main areas of application of waste from logging and woodworking enterprises in forestry is the production of non-traditional fertilizers and substrates, the use of which allows to increase soil fertility, intensifies the growth of woody and shrubby plants in forest nurseries, greenhouses and forest plantations.

An effective and wide range of applications of an unconventional substrate based on organic waste requires the development and implementation of the latest environmentally friendly technologies that reduce economic costs and negative effects on ecological ecosystems [1, 2].

The substrate made on the basis of sawdust, wood chips, bark and materials obtained during the burning of rocks (ash slag) is used for various purposes: for filling pits, recesses, swampy areas of forest lands. It is used for landscaping residential areas during landscaping with subsequent landscaping, including used in agriculture for mulching.

Special attention is paid to the methods and methods of afforestation, especially with the use of substrates made from complex mixtures [4,5]. This is due to the fact that different natural conditions of different climatic zones have their own characteristics.

The positive effect of using various variants of innovative compositions (a mixture of sawdust and soil) with the use of various additives on the growth and development of coniferous seedlings is considered in the works. A positive dynamics of morphological changes was revealed, namely, the growth of seedlings in all variants of mixtures [5,6].

2 The object of research

The object of the research is the timber processing enterprise of Kraslesinvest JSC, located on the territory of the Boguchansky municipal district, in the eastern part of the Krasnoyarsk Territory of the Russian Federation. The total land area of the forestry fund is 288618 hectares, with predominant small-leaved and light coniferous forests [7].

3 Characteristics of climatic conditions

The territory of the area where the research was conducted belongs to the West Siberian lowland forest area, along the Angara River. The northern part of the district is included in the zone of the middle taiga vegetation of the plateau beyond the Angara [7,8].

The forestry enterprise itself is located within the southern part of the Central Siberian plateau and represents a system of landscapes in the form of flat watersheds intersected (dissected) by deep valleys.

The terrain of the studied area is flat, with a predominance of low-mountain landscapes. In geological terms, the extracted minerals are of interest: deposits of natural gas, iron ores, non-ferrous and rare metals, coal, non-metallic minerals [8].

The soils of the research area have a diverse composition, mainly an acidic podzolic type. Podzolic and sod-weakly podzolic soils are the most common, to a lesser extent there are glee-podzolic (have low fertility) and alluvial soils with many organic substances in their composition, fertile.

According to humidity, most of the soils belong to the fresh category. There are swampy soils on the territory of the forestry enterprise, which occupy 7.8% of the forest area. The rocks are represented by light brown cover clays, heavy and light loess-like loams and sandy-pebble deposits. The mechanical composition of soils is mainly medium and heavy loamy [7, 9, 10].

The climate of the research area is quite complex: sharply continental with cold long winters, short summers and a rather prolonged autumn with a predominance of rains. The weather is extremely unstable regardless of the time and seasons of the year. The low temperature regime in winter contributes to the spread of permafrost. The hottest month is July, with a maximum temperature of +37 °C.

The hydrology of the research area is represented by the main waterway of the Angara River. It has numerous tributaries that make up a kind of water network.

The predominant coniferous species on the territory are scots pine (Pinus silvestris), siberian cedar pine (Pinus sibirica). Plantations of Daurian larch (Larix gmelinii) significantly predominate. Birch (Betula) is the predominant hardwood [8].

4 The methodology of the work. Production of the substrate and its use in planting plants

The use of the substrate during planting is based on its properties. These properties are expressed as follows:

- the substrate should not allow the soil to dry out in the absence of moisture for a long time;
- must protect sensitive plants from sudden temperature fluctuations;
- should prevent the growth of weeds and the formation of soil crust;
- the substrate used should help preserve the soil structure in the autumn and winter periods (i.e. it should not allow erosion processes);
- it is able to form a favorable climate for cultivated plants.

In this regard, the substrate has certain requirements for quality and composition. The properties of the substrate are determined by the processes of interaction of wood waste with ash and slag material and water. The appearance of the substrate is a homogeneous bulk mass of sawmilling waste (sawdust, wood chips, bark and ash-slag mixture).

According to physical and mechanical parameters, namely the percentage of the ingredient composition, particle size, humidity and density, the substrate must meet special requirements.

The necessary indicators are presented in table 1.

Table 1. Requirements for physical and mechanical parameters of the substrate.

The name of the indicator	Meaning
1 The content of sawdust and wood chips in 1 m^3. %	65-70
2 The content of the bark in 1 m^3. %	20-25
3 The content of ash and slag materials in 1 m^3. %	5-10
4 Particle size . mm	0.2-30
5 Humidity .%	20-70

6 Bulk density . g/cm^3	0.8-1.2
7 The content of metallomagnetic impurities	Not allowed

The composition of the substrate: 80% wood chips, sawdust, shavings, ash and slag materials and 20% sand.

The substrate was tested by the Center for Laboratory Analysis and Technical Measurements in the Siberian Federal District. Laboratory studies were conducted by the Center for Hygiene and Epidemiology in the Krasnoyarsk Territory. The tests were carried out using the sampling method according to GOST-17.4.4.02-2017 "Nature protection. Soils. Methods of sampling and preparation of samples for chemical, bacteriological, helminthological analysis" [12].

The substrate is laid on a prepared base after excavation. Each layer of the substrate is filled with soil previously removed from this site by leveling the soil and tamping the soil.

The technology of creating forest crops is experimental and is aimed at the formation of forest plantations for various purposes. The planting of seedlings was carried out by means of manual planting. Cedar seedlings with an open root system, the age of planting crops is 5-7 years. On the square, they are placed in rows at a distance of 2.0 m between the rows and 1.5 m between the platforms in a row.

The initial density of forest crops created by large-sized planting material will ensure, as trees grow, the formation of long-lasting forest plantations that meet the goals of afforestation and are resistant to adverse environmental factors.

After planting the seedlings, the soil is compacted and the rows are mulched with ash and slag with a layer of 5-10 cm and then with a second layer of tree bark of the same thickness.

After planting all seedlings in the site on bulk 6-meter strips, 3-meter strips are filled in, from which the soil was excavated, with a mixture of sawdust, chips, bark and ash slag with a layer 2.0-2.5 m.

The number of planting points per 1 hectare is 2000 pieces. The need for planting material: for an area of 58.9 hectares – 117,800 pieces of cedar pine seedlings. The rocks are arranged in solid rows.

The features of the technological process of creating forest crops and the use of large-sized planting material, as well as the use of a ready-made substrate, exclude agrotechnical care.

5 Results

The peculiarities of the location and climatic conditions of the afforestation area make it possible to use Siberian cedar pine as the main forest-forming species (Pinus sibirica).

The cultivation of Siberian cedar in urbanized areas is of great aesthetic and ecological importance. In addition to the fact that Siberian cedar is a majestic and very beautiful tree, it also has exceptional phytoncidal activity, the air in its growing areas is particularly clean and fresh.

Forest stands of Siberian cedar are able to retain moisture, ensuring the transfer of surface water runoff into the subsurface. In addition, they perform a soil protection function, resist soil erosion and strengthen the slopes.

The main advantage of Siberian cedar is its seeds (nuts) are nutritious, high–calorie and healing. Pine nuts are among the most valuable food products, surpassing many other natural sources in terms of phosphorus, lecithin, manganese, copper, zinc and iodine.

For the purpose of planting Siberian cedar, areas dominated by well-drained loamy and sandy loam soils are best suited. In the developed area, the soil is sandy loam sod-podzolic soils, which are characterized by a lack of moisture. To create an optimal water-air regime of the soil, an artificial substrate made on the basis of sawdust, wood chips, bark and ash and

slag materials will be used. The addition of sawdust to the soil helps to absorb and retain sufficient amount of available moisture for the plant, and acidify the soil, which is optimal for the growth of Siberian cedar.

The survival rate of seedlings in the first year after planting is 71%. Annual monitoring studies to control the safety of forests are planned to be carried out within three years after planting.

In case of loss of seedlings, instead of dead ones, crops are restored with a survival rate of 25 to 85%. Planting of forest crops in which seedlings have fallen out unevenly (in separate curtains) should be supplemented with any survival rate.

Annual monitoring of forest crops is planned to be carried out within three years after planting for their safety.

Planting of plants to replace the dead is carried out with the survival rate of forest crops from 25 to 85%.

In some places where plants have died, replacements are also planted, without taking into account the survival rate.

6 Conclusions

For many centuries, the problem of waste disposal has still been relevant on a global scale. The most urgent need has become the topic of recycling waste into a secondary resource in the context of intensive globalization of human activity, namely, the intensification of industry, the development of economic directions**.**

The reuse of waste is profoundly changing the economic and environmental aspects of our lives. It is the recycling of waste into a product necessary for consumption that will allow us to carry out the main tasks related to the conservation and restoration of natural resources, environmental protection, and will also contribute to the preservation of one of the main natural objects in the life of the planet – the forest community.

As noted above, the main application of waste from logging and woodworking enterprises in forestry is the production of fertilizers and substrates. The use of such products with the addition of various impurities will increase both soil fertility and contribute to the intensive growth of planted plants in greenhouses, forest nurseries and forest plantations.

Due to the processes taking place in the context of global climate change, the problem of conservation and restoration of forests is particularly acute. special attention is paid to the methods and methods of reforestation. The use of a substrate made from waste from woodworking industries will solve two problems: using the substrate as fertilizers for planting forest crops and using woodworking waste. The application of the technology of planting seedlings in the substrate will contribute to the improvement of green building technologies, landscaping of the territory, and the formation of highly productive plantings.

As a recommendation, we note that forest crops created using new technology can be used as experimental scientific objects by employees of various enterprises to study the features of forest cultivation using artificially created substrates.

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