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Lodgepole pine of Yukon origin in the European North of Russia

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Abstract. The article is devoted to the study of Lodgepole pine plantations of northern Canadian (Yukon) origin, created in 1988 in the Arkhangelsk region on three sites with different growing conditions using different methods of the soil preparation for planting. The main research objective was studying the growth, sustainability and productivity of Lodgepole pine of Yukon origin in the conditions of introduction. The objects of research were three experimental plots of Lodgepole pine, created in 1988 in the Arkhangelsk region with two-year-old seedlings from seeds of Yukon origin. The results of Lodgepole pine growth in height, diameter and trunk volume indicate that this pine responds well to improved soil cultivation conditions and, undoubtedly, to pre-plant soil preparation. Lodgepole pine is characterized by good growth and straightness in the myrtillosum forest type and special microclimatic conditions on the Solovetsky Islands. Resulting from the study of growth and development of Lodgepole pine of Yukon origin, it was concluded that the creation of fast-growing forest plantations of this species is recommended in productive forest types of the hylocomiosa group (oxalidosum and fresh myrtillosum).

1. Introduction

One of the objects of woody plants introduction to the European North of Russia is a North American species – the lodgepole pine (*Pinus contorta* Loud. var. *latifolia* S. Wats). The choice for the introduction of this pine was determined, first of all, by positive Swedish experience of its cultivation and desire to apply it when creating a permanent forest raw material base for the pulp and paper industry in the European-Ural zone of the Russian Federation [1].

Lodgepole pine naturally grows in North America. This species is distributed on the territory of 6 million hectares in the USA and 20 million hectares in Canada [2-6]. Lodgepole pine of the most northern Canadian origin (Yukon), where it grows in permafrost on the northern limit of forest distribution, is of great interest for introduction into the European North of Russia.

Yukon Province is located in northwestern Canada within two large natural zones: taiga and tundra. A part of the territory extends beyond the Arctic Circle. The climate is subarctic, characterized by relatively long and harsh winters and short summers. Lodgepole pine reaches its extreme northern range in the central part of the Yukon [7].

The advantage of lodgepole pine appears mostly in industrial forest plantations, where it reaches the felling age for balance and exceeds by 70% the productivity of local spruce and ordinary pine by the age of 40 [8-11].

The lodgepole pine cultures have been created since the 1920s, mainly in Karelia, the Leningrad Region and the Baltic Republics [12]. Subsequently, lodgepole pine has been spread south to the



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forest-steppe and north to the Arkhangelsk region. However, its cultivation was rather spontaneous, almost without regard to the origin of the raw material. Research and creation of experimental trials were carried out by industry and academic research institutions without any coordination, based on their capabilities.

Introducing lodgepole pine under new conditions, it is necessary to concentrate the efforts not only on studying the growth course but also on obtaining seeds of local reproduction with high indicators of sowing qualities from the acclimatized plant. Such an approach, while creating forest plantations, allows increasing the probability to receive generations that are more resistant to unfordable environmental factors [11]. An equally important task is to determine forest seed areas of the natural lodgepole pine range, wherefrom the transfer of seeds during primary introduction will be most appropriate [13].

During 40 years (1979-2019) scientists of SevNIILH have created experimental plantations of lodgepole pine on a total area of 53 hectares [9-11] in various regions of the European North of the Russian Federation (Arkhangelsk, Vologda Regions, Komi Republic), including one plot created on the Big Solovetsky Island.

Arkhangelsk region is located in the north of the East European Plain. Most of the territory is of the Far North regions; it is a vast plain with a weak slope towards the White and Barents Seas, where the plain is somewhere disturbed by terminal moraine hills formed as a result of the activity of an ancient glacier [14].

The climate of the Arkhangelsk region is transitional between marine and continental. Winter is usually long (up to 250 days) and cold, with a low average temperature -26° Celsius and strong winds. Spring comes to the southern regions in April, to the northern ones in May. The average summer temperature is about $+15^{\circ}\text{C}$.

The taiga part of the region extends for 700 km from west to east and 600 km from north to south, which is the reason for a diverse climate. The average annual temperature of the forest zone is only slightly higher (and sometimes lower) than zero. The duration of the period with average daily negative temperatures in the south is 160 days, in the north – about 200.

The annual amount of precipitation in the forest zone varies from 400 to 540 mm with the number of days with precipitation up to 200. Precipitation falls in the form of small prolonged snowfalls in winter and long drizzling rains in autumn [14]. Relative air humidity in winter and autumn is 85-95% and in summer and spring 7% -90%. This is due to low temperatures and a large number of cloudy days. In winter, a 60-70-cm-thick snow cover is formed on the territory of the region.

In terms of vegetation, the Arkhangelsk region is entirely part of the natural zone of the taiga, which is subdivided into subzones: the subzone of the northern taiga (north of the 64-65th parallel), middle (the main part of the region) and south taiga.

The most common species of Arkhangelsk forests is spruce (65%). The best considered are spruce-hylocomiosa forest type, where blueberries and lingonberries rise above a continuous moss cover, and undergrowth is almost absent. Pine forests, driven by spruce to less favorable places, make up 20% of the forest stand of the region and form several types similar to spruce forests, from the most productive pine-hylocomiosa forests to dry forests on sandy terraces and sphagnum pine forests in swamps. Fir and larch in significant quantities are found only in the east of the region [14].

Tree species introduction on the Big Solovetsky Island has a long history since the founding of the Botanical Garden in 1822. The Solovetsky Islands are the largest archipelago in the White Sea. It is located in its western part, 165 km from the Arctic Circle. The total area of the archipelago is 347 km². Administratively, the Solovetsky Islands are part of the Primorsky municipal district of the Arkhangelsk region.

The landscape of the Solovetsky Islands was determined by an ancient glacier. Three main relief zones are distinguished on the Big Solovetsky Island: the central part of the island with a hilly elevated landscape and a developed network of lakes; the southern part, which is a hollow surrounded by hills, filled with peat bogs and lakes, and the coastal area. The proximity of the Arctic Circle and the breath of the Arctic, of course, leaves its mark on the local climate. The climate of the Solovetsky

archipelago is marine, with the transition to the continental, and is warmer in average annual characteristics than on the mainland. The Solovetsky Islands belong to the regions of the Far North. The climate is determined by the location of the archipelago in the polar latitudes and the circumference of the sea. Due to the softening influence of the White Sea, the Solovetsky Islands are in relatively favorable temperature conditions: mild winters and cool summers. Due to the slow warming and cooling of the sea, seasonal changes on the archipelago occur later than on the mainland. The average delay of the seasons is two to three weeks. Most of the islands are covered with pine-spruce forests, partially boggy. The zonal biocenoses of the Solovetsky Islands are the pre-tundra forests and forest-tundra crooked forests, since the middle July isotherm 12 °C passes here marking the border between northern taiga and forest-tundra in northern Europe. According to forest vegetation zoning, the territory of the Solovki belongs to the subzone of the northern taiga [15].

2. Methods and Materials

The objects of research were three experimental plots of lodgepole pine created in 1988 in the Arkhangelsk region (table 1).

Table 1. Location and characteristics of lodgepole pine plots.

Plot	Location	Growing conditions	Area, ha
88 (Lukovetsky)	Kholmogorskoe lesnichestvo Lukovetsky, 64° north	fresh spruce-myrtillusum forest type	3.0
1-88 (Bobrovo)	Arkhangelskoe lesnichestvo, Bobrovo, 64° north	former territory of the forest nursery	2.7
2-88 (Solovky)	Big Solovetsky Island, Solovetskoe lesnichestvo, 65° north	fresh spruce-myrtillusum forest type	0.86

Creating the plantations, they used seedlings with an open root system which were grown in the nursery of the SevNIILH Dendrological garden from seeds of the most northern Canadian (Yukon) origin (table 2).

Table 2. Origin of lodgepole pine seeds.

Registration №	Origin	Geographical coordinates latitude	longitude	Height above sea level, m
31-86	Canada, Yukon, Rusty Creek	63°25'(28)	136°25'	800

The experimental plantings of the Yukon origin lodgepole pine (2-88) created at the Solovetsky Leskhoz (currently the Solovetskoe lesnichestvo) were located in the area of forest fire occurred in 1980. The area was of fresh spruce-myrtillusum forest type. Later the area of the forest fire was regenerated by fireweed and birch with the amount of about 2 thousand self-seeding per ha. The soil was low-podzol, sandy, fresh; with lots of boulders. A selective sanitary cutting was carried out in 1987. The relief was hilly (figure 1). The land area was 0.86 ha. Two-year-old seedlings with bare roots were planted manually according to the 2.5 × 2.5 m scheme without soil preparation.

According to the results of the 1st year inventory, the survival rate was 68.6%, and seedlings of good condition accounted for 64.5% of the total 768 plants growing on the plot. The low survival rate can be explained by the long shelf life of seedlings from digging to planting (within a month), as well as the lack of pre-planting soil preparation.

An unused site, which had been previously an uprooted cutting area of fresh spruce-myrtillusum forest type in the Bobrovsky nursery, was used for *Pinus contorta* planting in Arkhangelskoe lesnichestvo (1-88) (figure 2). The relief was flat with small pits. The soil was podzolic, loamy, underlain by clay at a shallow depth. In the fall of 1987, the soil on the site was plowed and disked, and mineral fertilizers were introduced in the dosage: phosphorus 120, potassium 80 kg per ha of

active substances. The planting was carried out by two-year-old lodgepole pine seedlings of Yukon origin with bare roots according to the 2.5×2.5 m scheme. The soil on the plantation area was milled in two tracks with a FLU-0.8 milling cutter on an MTZ-80L tractor in August 1988. The planting area was 2.7 ha. According to the results of the 1st year inventory, the survival rate of lodgepole pine was 95.9%.

A Lodgepole pine plantation (88) was created in the Kholmogorskoe lesnichestvo (figure 3). The site occupied the upper part of the slope of the western exposure, where the felling in a fresh spruce-myrtillosum forest has been done in 1985–1986. A strip clearing of the cutting area from logging residues with the uprooting of stumps has been carried out in 1987. The width of the strips was 1.5–2.0 m, with a distance between them of 4 m. The soil was plowed with a PLN plow of 1.3 on most of the felling area of uprooted strips. According to the 1989 inventory, the survival rate of the lodgepole pine on these plantations was 89.9%. The survival rate was lower than on the site in Bobrovo because part of the plants has been accidentally destroyed by forestry workers during forestry operations on an adjacent site to the plantation. The safety of lodgepole pine according to the accounting for 2018 was 84.3%.



Figure 1. 2-88 (Solovky).



Figure 2. 1-88 (Bobrovo).



Figure 3. 88 (Lukovetsky).

The study of the growth and productivity of lodgepole pine was carried out according to the generally accepted method: complete counting of trees with measurement of height and diameter at a height of 1.3 m with an accuracy of ± 1 mm. The measuring plug “Mantax Precision 11–100–1032” was used for diameter measurement; the measuring pole “MODEL – 202 12 m” and the laser range finder “Vertex Laser VL 400” were used for height measurement. The growth progress in diameter was studied by selecting 5 cores at a height of 1.3 m ($d_{1.3}$) using an incremental drill on each thickness level. Studying growth progress in height (h) on three medium-tall trees by whorl counting, the age was determined at $\frac{1}{4}$; $\frac{1}{2}$ and $\frac{3}{4}$ heights.

Methods of mathematical analysis and applied computer programs were used to determine the average growth indicators (average value, coefficient of variability, experimental accuracy, reliability of the average value).

The coefficient of variation gives an objective idea of the amplitude of the variability of parameters [16]: $C \leq 10\%$ - small variability; $C = 10 - 30\%$ - average variability; $C \geq 30\%$ - large variability.

The stands stocks were determined using standard formulas and tables [16]. Due to the lack of standard materials for lodgepole pine for the European North of Russia, tables for Scots pine were used. Growth graphs were done for height, diameter and stem volume at the final stage of the analysis of a tree trunk [17, 18].

Periodic surveys and analysis of these plantations state were carried out.

3. Results and Discussion

The average taxation indicators of lodgepole pine of Yukon origin in height and stem diameter, obtained from the results of continuous counting, are presented in table 3. The smallest average height of lodgepole pine was found at the plantation 2-88 (Solovki) and was 10.7 ± 0.40 m. The average height in the other two plots exceeded 12 m, and at the plantation-88 (Lukovetsky) was 12.1 ± 0.37 m. The best growth of lodgepole pine in diameter was found on the plantation Lukovetsky, and was 16.0 ± 0.20 cm. The lowest growth in diameter was of the lodgepole pine on Solovki where the average stem diameter was 12.3 ± 0.26 cm. The variability in assessed indicators (in diameter and height) on the plantation-88 (Lukovetsky) was small (8%). The accuracy of the measurements, both in diameter and height of the lodgepole pine, was sufficient (less than 3%). The average values were quite reliable even with the strictest assessment, i.e. at a 0.1% significance level, which means that the data obtained can be used for comparisons and conclusions.

Table 3. Average taxation indicators of lodgepole pine of Yukon origin.

Plantation	Taxation indicators	Average indicators					
		M	&	c	m	p	t
2-88	Diameter, cm	12.3	2.97	24.07	0.26	2.14	46.82
	Height, m	10.7	1.61	15.00	0.40	3.75	26.67
1-88	Diameter, cm	14.9	3.96	26.52	0.23	1.52	65.64
	Height, m	12.1	1.87	15.50	0.26	2.19	45.63
88	Diameter, cm	16.0	2.85	17.77	0.20	1.23	81.15
	Height, m	12.1	0.97	8.00	0.37	3.03	33.06

The presented results on the average growth indicators of lodgepole pine of Yukon origin show that this pine responds well to improved soil conditions and, undoubtedly, to pre-plant soil preparation. The best growth both in diameter and height was noted at the Lukovetsky, lodgepole pine at the Bobrovo plantation is slightly inferior in average diameter. The plantation on Solovki, created on a site without soil preparation, is significantly behind in growth.

Trees with defective trunks are often found on plantations, represented by two-and-multi-tops, multi-stem and trunk crookedness. Other authors also pay attention to the appearance of stem defects in lodgepole pine under the conditions of introduction [19, 20]. The plantings of lodgepole pine on Solovki are characterized by the smallest proportion of trees with trunk crookedness (3.1%), multi-tops (14.2%) and multi-stems (4.8%). In the myrtillosum forest type and special microclimatic conditions that are present on the Solovetsky Islands, lodgepole pine is characterized by good growth and straightness.

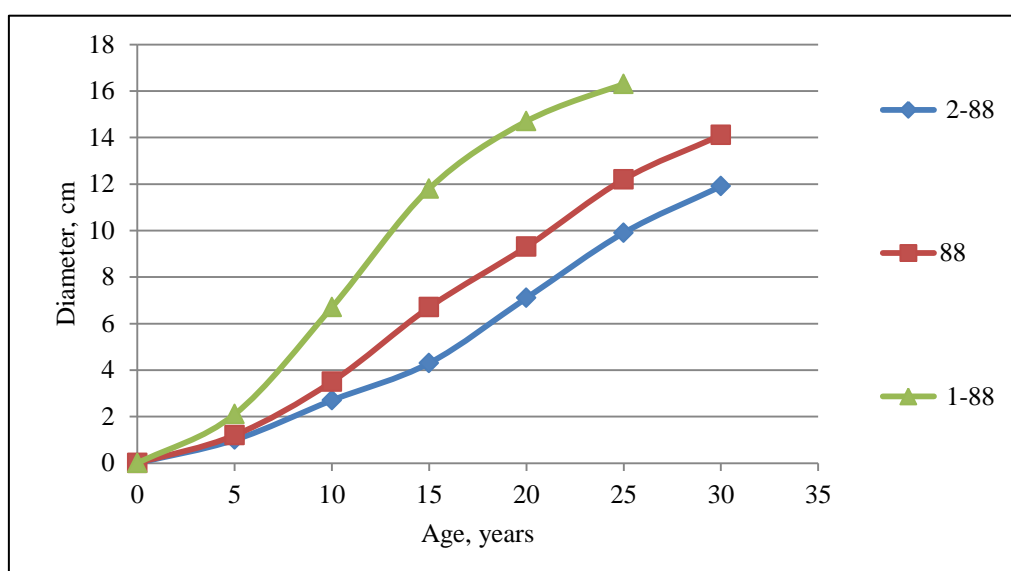
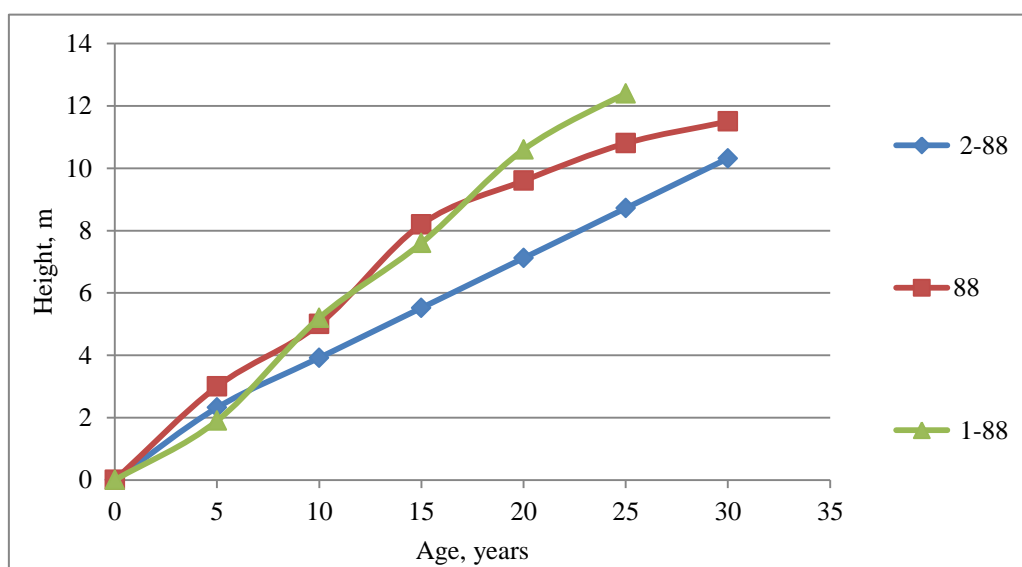
Table 4 presents the dynamics of taxation indicators (diameter, height, stem volume) by the age of lodgepole pine of Yukon origin. In all three sites up to the age of 5 years, taxation indices did not differ much from each other but starting from the age of 10 years, lodgepole pine began to grow more intensively on the plantation 1-88 (Bobrovo) for all the indicators.

Figures 4-6 show the growth progress of lodgepole pine of Yukon origin in diameter, height and volume on plantations with different pre-plant soil preparation: 2-88 - without soil preparation; 88 - partial soil preparation; 1-88 - preliminary soil preparation with fertilizer application.

The best indicators either in height or diameter or stem volume were identified at the plantation 1-88 (Bobrovo) with soil preparation and the application of mineral fertilizers. This suggests that soil preparation is of great importance in increasing plantation productivity. It is clearly shown that plantings of lodgepole pine created without soil preparation (Solovki) are significantly behind in growth in all respects.

Table 4. Dynamics of taxation indicators of lodgepole pine of Yukon origin with age.

Age, years	Diameter, cm			Lodgepole pine Height, m			Volume, m ³		
	2-88	1-88	88	2-88	1-88	88	2-88	1-88	88
0	0	0	0	0	0	0	0	0	0
5	1	2.1	1.2	2.3	1.9	3.0	0.0001	0.00098	0.0002
10	2.7	6.7	3.5	3.9	5.2	5.0	0.0012	0.0132	0.0025
15	4.3	11.8	6.7	5.5	7.6	8.2	0.0043	0.04876	0.0151
20	7.1	14.7	9.3	7.1	10.6	9.6	0.0151	0.09182	0.0340
25	9.9	16.7	12.2	8.7	12.4	10.8	0.0359	0.13141	0.0657
30	11.9	-	14.1	10.3	-	11.5	0.0614	-	0.0935

**Figure 4.** Growth progress of lodgepole pine of Yukon origin in diameter.**Figure 5.** Growth progress of lodgepole pine of Yukon origin in height.

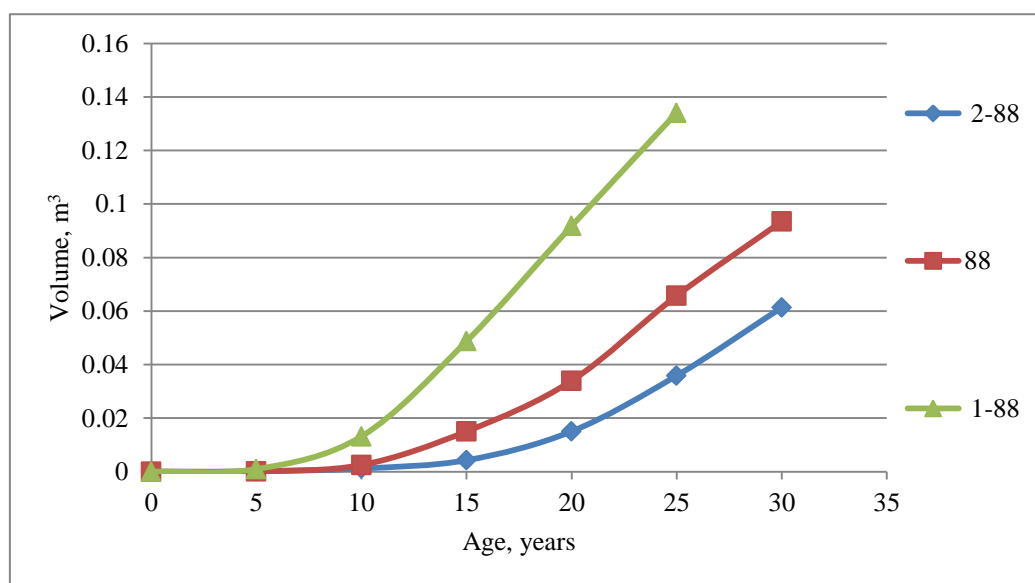


Figure 6. Growth progress of lodgepole pine of Yukon origin in volume.

Thus, soil preparation and mineral fertilizing before planting are of great importance in increasing the productivity of lodgepole pine plantations. As a result of studying the condition, growth, and development of *Pinus contorta* of Yukon origin, it can be concluded that the planting of this species is recommended to be carried out in productive forest types of the hylocomiosa group (oxalidosum and fresh myrtillosum).

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References

- [1] Drozdov I I and Drozdov Yu I 2005 Lodgepole pine forest cultures in solving the raw problem of pulp wood [In Russian – Kul'tury sosny skruchennoj v reshenii syr'evoj problemy balansovoj drevesiny] *Forestry bulletin* **5** pp 83-84
- [2] Ericsson T 1994 Lodgepole pine (*Pinus contorta* var. *latifolia*) breeding in Sweden – results and prospects based on early evaluations: PhD thesis, Swedish University of Agricultural Science. Faculty of Forestry. Dep. Of Forest Genetics and Plant Physiology (Umea: Swedish University of Agricultural Sciences), p 325
- [3] Ruotsalainen S and Velling P 1993 *Pinus contorta* provenances in northern Finland *Pinus contorta: From untamed forest to domesticated crop* (Umea: Swedish University of Agricultural Sciences) pp 122–136
- [4] Varmola M Salminen H, Rikala R, Kerkela M and Varmola M 2000 Survival and early development of lodgepole pine / *Scandinavian Journal of Forest Research* **15** p 410–423
- [5] Ruotsalainen S 2006 Tree Species Experiments at the Northern Timberline Region in Finland *Eurasian J. For. Res.* pp 51-60
- [6] Elfving B, Ericsson T and Rosvall O 2001 The introduction of lodgepole pine for wood production in Sweden A review. *Forest Ecology and Management* **141** pp 15-20.
- [7] Planet Earth. North America 2020 [In Russian – *Planeta Zemlya. Severnaya Amerika*] 01.03.2020 [Elektronnyj resurs] <https://geosfera.org/severnaya-amerika/kanada/913-territoriya-yukon.html>

- [8] Raevsky B V 2004 Experience of lodgepole pine introduction in the European North of Russia [In Russian – Opyt introdukcii sosny skruchennoj na Evropejskom Severe Rossii] *Environmental problems of the northern regions and ways to solve them [Ekologicheskie problemy severnyh regionov i puti ih resheniya]* (Apatity) chapter 2 pp 78-80
- [9] Demidova N A, Durkina T M, Gogoleva L G, Demidenko S A, Bykov Yu S and Paramonov A A 2016 Growth and development of lodgepole pine (*Pinus contorta* Loud. var. *latifolia* S.Wats) in the conditions of boreal forest [In Russian – Rost i razvitie sosny skruchennoj (*Pinus contorta* Loud. var. *latifolia* S.Wats) v usloviyah severnoj tajgi] *Proceedings of the Saint Petersburg Forestry Research Institute (SPbNIILH)* **2** pp 45-59
- [10] Demidova N A, Durkina T M, Gogoleva L G, Bykov Yu S and Paramonov A A 2017 Lodgepole Pine (*Pinus Contorta* Loud. var. *latifolia* S. Wats.) growth in the Republic of Komi [In Russian – Rost sosny skruchennoj (*Pinus contorta* loud. var. *latifolia* s. Wats.) v Storozhevskom lesnichestve Respubliki Komi] *Forestry Information* **1** pp 24-33 http://lhi.vniilm.ru/PDF/2017/1/LHI_2017_01-03-Demidova.pdf
- [11] Demidova N A, Durkina T M, Gogoleva LG, Bykov Yu S and Paramonov A A 2018 The results of 35-years lodgepole pine tests in the European North of Russia [In Russian – Rezultaty 35-letnego ispytaniya sosny skruchennoj na Evropejskom Severe Rossii] *Izvestiya SPbLTA* **225** pp 90-105
- [12] Alekseev V M, Zhigunov A V, Bondarenko A S and Burcev D S 2014 Introduction of *Pinus contorta* in the Leningrad Region [In Russian – Introdukciya sosny skruchennoj v usloviyah Leningradskoj oblasti] *Lesnoj zhurnal* **3** pp 24-33
- [13] Nekrasov V I 1973 *Fundamentals of seed science of woody plants during introduction* [In Russian – Osnovy semenovedeniya drevesnyh rastenij pri introdukcii] (Moscow: Nauka) p 279
- [14] Regions of Russia. Arkhangelsk region 2020 [In Russian – Regiony Rossii. Arhangel'skaya oblast'] 02.03.2020 Electronic resource <http://www.russian-travels.ru/?p=694>
- [15] Shvartsman Yu G and Bolotov I N 2005 Mechanisms of the formation of extrazonal biocenoses on the Solovetskiye Islands [In Russian – Mekhanizmy formirovaniya ekstrazonal'nyh biocenozov na Soloveckih ostrovah] *Ekologiya* **5** pp 344-352
- [16] Tyurin A V 1961 Basics of variation statistics applied to forestry [In Russian – Osnovy variacionnoj statistiki v primenenii k lesovodstvu] (Leningrad: Goslesbumizdat) p 103
- [17] Vojnov G S, Chuprov N P, Yaroslavcev S V, Torhov S V and Shusharin A P Forest taxation reference book on the northeast of the European part of the Russian Federation: regulatory materials for the Nenets Autonomous Okrug, Arkhangelsk, Vologda Oblasts and the Republic of Komi 2012 [In Russian – Lesotaksacionnyj spravochnik po severo-vostoku evropejskoj chasti Rossijskoj Federacii: normativnye materialy dlya Neneckogo avtonomnogo okruga, Arhangel'skoj, Vologodskoj oblastej i Respubliki Komi] (Arhangel'sk: OAO IPP Pravda Severa) p 672
- [18] Gusev I I and Kalinin V I 1988 Forest taxation: A training manual for field practice [In Russian – Lesnaya taksaciya: Uchebnoe posobie k provedeniyu polevoj praktiki] (Leningrad: LTA) p 61
- [19] Raevsky B V and Mordas' A A 2005 Growth progress of lodgepole pine plantations in the middle taiga subzone [In Russian – Hod rosta kul'tur sosny skruchennoj v podzone srednej tajgi] *Lesnoj zhurnal* **1-2** pp 23-33
- [20] Fedorkov A L and Turkin A A 2010 Test of Shore pine in the Republic of Komi [In Russian – Eksperimental'nye kul'tury sosny skruchennoj v Respublike Komi] *Russian journal of forest science* **1** pp 70-74