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Assessing the Properties of Tree Trunks in Forest Phytocenoses Depending on the Soil and the Climatic Conditions on the Territory of the Taiga Zone of the European North of Russia

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Abstract

The article presents the data about the effect of the soil and climatic characteristics on the properties of Scots pine trunks in the forest phytocenoses on the territory of the taiga zone of the European North of Russia. The research was performed in plantations of Scots pine in the form of laying sample plots, where inventory of forest stand was performed, and model trees were chosen for assessing trunks' branchiness. The obtained data were statistically processed in Microsoft Excel. The results indicate the differences in development of undergrowth, underbrush, live ground cover, and in soil conditions by the types of the forest stand. It should be noted that knots are absent in the bottom part of the trunks, and the considered pine cultures have entered the phase of natural branches' removal from the trunks. Sorrel and myrtillus pine stands, due to the favorable forest vegetation effect, are formed of large trunks with thick branches. Diameters at the base of branches gradually increase when moving up the trunk. More branches are formed in low-productivity forests. Creating pine cultures in the pleurocarpous moss types of forest stands will contribute to reducing the branchiness of tree trunks and to improving wood quality. The results obtained during the research can be used for developing targeted programs of growing timber with the lowest branchiness.

Key words: forest phytocenosis, forest crops, Scots pine, forest growth conditions, timber properties, round timber.

1. Introduction

The soil and climatic conditions have significant effect on growth and formation of various plant species, including trees, which has been the subject of many researches in the literature [1-5]. Thus, the natural grassland and woody phytocenoses, and plantings of agro-ecosystems in the Northern latitudes get sufficient amount of nutrients from soils of predominantly gley and podzolic types due to their low fertility levels [6-10], while the conditions in Central Russia and in the southern areas, due to the formation of zonal grey soil, black soil and chestnut soil forest bands and intrazonal sod-carbonate soil stains, allow to fully ensure the nutrition conditions for local plant communities due to the high efficient fertility of sod soil cover [11-13].

The habitat conditions may in some way influence the formation of qualitative properties of tree trunks and their branchiness [2, 14-19]. This issue was made the basis for our research.

2. Material and Methods

The objects of the research were mid-aged tree stands in various soil and climatic conditions (sorrel, myrtillus, vaccinium, lichenous) in the taiga zone of the European North of Russia.

The research was performed in the stands of Scots pine with laying sample plots, performing field inventories of the tree stand, choosing model trees for assessing trunks branchiness, and statistical data processing in MS Excel [20-23].

The location of pines of the myrtillus type is characterized by flat topography and poorly expressed microrelief.

To date, pine stands of the myrtillus type have been formed with minor share of renewed natural birch (10%). The live ground cover is represented by blueberry, cranberry, and sphagnum mosses. The soil of the plots of podzolic soil type has sandy loam mechanical composition and develops on alluvial deposits.

In the tree stands of sorrel type, predominance of Scots pine was also observed; however, the tree stand also included natural spruce (20%). The live soil cover is dominated by oxalis; there are goutweed, strawberry, Paris herb, and meadowsweet. The soil of podzolic soil type has sandy loam mechanical composition, and is developed on the covering calcareous loam. The cranberry phytocenosis is dominated by cultivated pine; natural common birch is also found. The live soil cover develops cranberry and blueberry on a background of continuous cover of green mosses and lichens. The soils are podzols of various thickness with sandy loam mechanical composition developed on moraine sand.

Lichen forest type is dominated by pines (100%). The live ground cover is a continuous cushion of lichens. The soils are represented by thin sandy podzols developing on aqueoglacial deposits.

The largest stock of stem timber is observed in pine stands of sorrel, vaccinium and blueberry growing conditions (230-340 m^3/ha). Poorness and dryness of soils in the lichen forest type determined low stock of wood (90 m^3/ha).

3. Results

The results above indicate differences in development of undergrowth, underbrush, live ground cover, and in soil conditions by the types of the forest stand [2, 24]. The results of assessing the quality timber in terms of branchiness are shown below. It should be noted that knots are absent in the bottom part of the trunks, the considered pine cultures have entered the phase of natural branches' removal from the trunks. In the pine stands of the pleurocarpous moss group, the trunks are free of branches on the average to the height of 0.49 to 0.86 m (Table 1).

Despite some advantage in terms of this indicator in the myrtillus pine stand, no statistically significant difference has been found in the obtained results among pleurocarpous moss pine stands ($t_{act.} \leq 1.8$; $t_{0.05} = 2.0$). Trunks in the lichenous pine stands are characterized by smaller length of the branch-free zone. Veracity of the difference has been proven between pleurocarpous moss and lichenous pine stands ($t_{act.} \geq 2.1$; $t_{0.05} = 2.0$). The relative indicators that characterize the degree of branches' removal from trunks in the pine stands, being 4-5%, do not have significant difference aming the types of pine stands.

Table 1. The length of the branch-free area of the pine trunk by the type of the pine stand

Tree stand type	The length of the branch-free area (m / %)
Lichenous	0.49±0.01 / 5
Sorrel	0.81±0.14 / 4
Myrtillus	0.86±0.11 / 4
Vaccinium	0.67±0.05 / 4

It should be added that the audit trunk diameter has no significant influence on the degree of trunks' debranching. Correlation analysis revealed only weak correlation (with the exception of myrtillus pine stands, where moderate correlation of r = 0.39 was noted) between the trunk diameter at breast height and the length of the branchless part in each of the variants (r = 0.13-0.33).

The average diameter at the base of branches in myrtillus pine stands reaches 2.2 cm, which is significantly more than the average values for other forest types ($t_{act.} \geq 2.1$; $t_{0.05}$= 1.96), (Table 2).

Table 2. The average diameter at the base of branches on pine trunks in various types of tree stands, cm

Tree stand type	Statistical indicators				
	M±m	σ	C, %	P, %	t
Sorrel	2.1±0.03	10.4	49.5	1.4	70.0
Myrtillus	2.2±0.04	9.6	43.0	1.8	55.8
Vaccinium	2.1±0.03	7.0	34.8	1.5	67.0
Lichenous	1.8±0.03	8.3	46.4	1.7	59.7

This indicator is characterized by significant variability (C = 34.8 to 49.5%). The average branch diameter increases with increasing the trunk inventory diameter. The results of regression analysis indicate the directly proportional dependence among these indicators in all types of tree stands ($r \geq 0.580$).

Diameters at the base of branches gradually increase when moving up the trunk. Reaching the maximum in the lower part of the crown, diameters of branches reduce (Fig. 1).

It should be noted that sorrel and myrtillus pine stands, due to the favorable forest vegetation effect, are formed of large trunks with thick branches. Their presence and accounting during the research explain the discovered advantage in the average diameter of branches in these forest conditions.

The correlation ratio among the interrelated statistical values in the tree stands varies between 0.96 and 0.98, which shows very high density between the average diameter at the base of branches and trunk height (Table 3).

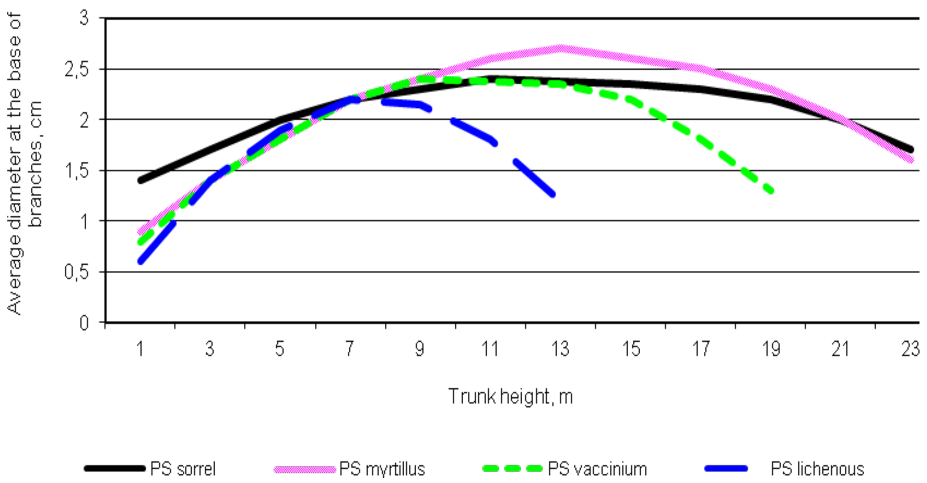

Fig. 1. Changes in the average diameter at the base of branches (y, cm) along the height of pine trunk (x, m) in tree stands by forest types

Table 3. The equations of the relationship between the average diameter at the base of branches (*y*, mm) and trunk height (*x*, m) in pine stands by forest types

Tree stand type	Regression equation	Correlation error	Equation error
Sorrel	$y = 11.54 + 1.65x - 0.08x^2$	0.96±0.01	±0.2
Myrtillus	$y = \frac{14.01 - 1.51x}{1 - 0.07x + 0.003x^2}$	0.98±0.01	±0.1
Vaccinium	$y = 4.44 + 3.56x - 0.18x^2$	0.97±0.01	±0.1
Lichenous	$y = 17.8 \cdot (1 - e^{-1.19x})$	0.97±0.01	±0.2

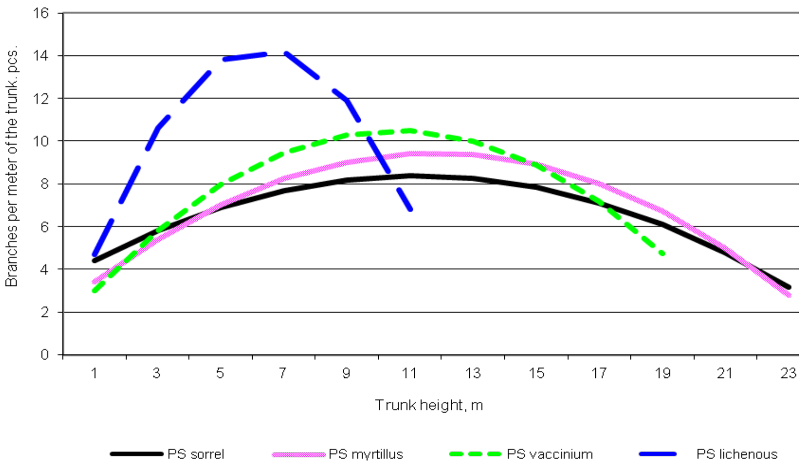

Fig. 2. Changes in the number of branches (y, pcs) along trunk height (x, m) in pine stands by forest types

Table 4. The equation of the correlation between the average number of branches (*y*, pcs/m) and trunk height (*x*, m) in pine stands by forest types

Tree stand type	Regression equation	η	*S*
Sorrel pine stand	$y = 2.22 + 2.26x - 0.27x^2 + 0.02x^3$	0.91±0.01	±1.3
Myrtillus pine stand	$y = 1.09 + 2.40x - 0.24x^2 + 0.02x^3$	0.97±0.01	±1.1
Vaccinium pine stand	$y = 0.30 + 6.1x - 1.20x^2 + 0.15x^3$	0.97±0.01	±1.2
Lichenous pine stand	$y = 0.06 + 9.39x - 1.97x^2 + 0.15x^3$	0.96±0.01	±0.9

Table 5. The relationship between trunk diameter at breast height (*x*, cm) and the maximum thickness at the base of branches (*y*, cm), and the grade of timber in pine stands

Thickness increment, cm	Sorrel pine stand		Myrtillus pine stand		Lichenous pine stand	
	The maximum branch diameter, cm	Grade [23]	The maximum branch diameter, cm	Grade [23]	The maximum branch diameter, cm	Grade [23]
8	2.0	I	1.4	I	2.1	I
10	2.4	I	1.7	I	2.5	I
12	2.7	I	2.1	I	2.9	I
14	3.1	I - II	2.4	I	3.3	I - II
16	3.5	I - II	2.7	I	3.6	I - II
18	3.8	I - II	3.1	I - II	4.0	I - II
20	4.2	I - II	3.4	I - II	4.4	I - II
22	4.6	I - II	3.7	I - II	-	-
24	4.9	I - II	4.1	I - II	-	-
26	5.3	I - II	4.4	I - II	-	-
Regression equation	y = 0.560+0.179x r = 0.84, S = 0.6		y = 0.080+0.170x r = 0.94, S = 0.4		y = 0.150+0.191x r = 0.97, S = 0.3	

In the sorrel pine stands, the average number of branches per 1 meter of the trunk varies between 6 and 13, in myrtillus pine stands – between 8 and 13, in vaccinium pine stands – between 6 and 15, and in lichenous pine stands – between 12 and 18. The values obtained indicate the formation of more branches in low productivity types of forest stands. The correlation between the trunk audit diameter and the average number of branches per 1 meter of the trunk is weakly expressed (η < to 0.4), nevertheless it reflects the inversely proportional correlation among these indicators: the number of branches decreases with trunk diameter increasing.

The results of regression analysis revealed a correlation between the number of branches and the height of the trunk, approximated by the third order parabola equation. At the same time, high and very high correlation among these parameters has been found (Fig. 2, Table 4).

Apparently, the presence of large trunks with fewer branches in high-productive forest types (sorrel and myrtillus pine stands) eventually determined the lower average number of branches in the tree stands in these site-specific conditions.

At this stage of ontogenesis, branches of large diameter formed in the most productive types of forests, however, their number was lower than that in low productivity forest types.

For round timber, there are restrictions in the diameter at the base of the branches, and their condition [22, 23]. These components are the basis for grading wood raw materials based on branchiness. Therefore, defining the diameter at the base of the thickest branches is of practical interest.

Branch thickness increases with increasing the trunk inventory diameter. The close relationship between these parameters in all considered forest types is approximated by the straight-line equation (Table 5).

As previously noted, finding the relationship between the trunk audit diameter and the maximum diameter of branches will further allow to calculate the diameters at the base of branches according to the recalculation data in the tree stand, and, therefore, to simplify timber grading.

The examination of model trees did not reveal tobacco knots on pine trunks, which allows to skip this indicator in subsequent analysis, and simplifies grading of coniferous timber [23].

With regard to the tolerance of the maximum branch diameters for timber of various sizes [23], it has been found that, based on the branchiness, it is possible to obtain gradings I and II at this stage of the ontogenesis.

4. DISCUSSION

Based on the obtained dependencies, it can be assumed that the maximum allowed branch sizes for grade II (10 cm) will be reached by the trunks when their audit diameter is 64, 58 and 48 cm in myrtillus, vaccinium, and lichenous pine strands, respectively. However, in case of targeted growing of the species for roundwood and general purpose sawtimber, it is unlikely that the timber will be required to grow to such diameters within the shortened felling cycle.

CONCLUSION

In the conditions of sorrel, myrtillus, and vaccinium types of pine stands, pine trunks with long branchless parts are formed, compared to the lichenous type of pine stand.

Creating pine cultures in the pleurocarpous moss types of forest stands will contribute to reducing the branchiness of tree trunks and to improving wood quality [2, 16, 24].

The results obtained during the research can be used for developing targeted programs of growing timber with the lowest branchiness.

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