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O. A. Sevko
Belarusian State Technological University

THE EVALUATION OF DEPENDENCE OF THE CURRENT INCREMENT OF A PINE PART OF THE MIXED PINE-BIRCH FOREST STANDS ON THEIR SPATIAL STRUCTURE

To determine the level of dependence of the current growth of the pine part of mixed pine-birch forest stands on their spatial structure the materials of the taxation of trees on 408 plots: taxation parameters, parameters of crowns, as well as coordinates of *X* and *Y* were used. The construction of the spatial distribution model on the tree area indicating the diameter of crowns area and the areas of intersection of circles of the competition of the trees of both species was performed with the use of Quantum GIS. To determine the dependence of the current growth of the pine part of the stand on the influence of admixture of birch trees in 44 pines a radial growth was determined, the data were divided into three groups according to the intensity of growth: weak – radial growth for 10 years, 0–10 mm, average – 10–20 mm and intensive – 20 mm and more. The current growth for the selected trees was determined by different methods based on the taxation indices of trees. With Quantum GIS it was possible to determine the distance of the birches trunks closest to the pine.

The dependence of the current increment of pine trees on the forest indices and spatial stand structure was determined with the help of the regression analysis. The main criteria for the evaluation of equations served the correlation coefficient, the explanation of the proportion of variance and standard error of the individual factors. As a result of the studies the regression equations with correlation coefficients for pine-intensive growth – 0.84, pine average growth – 0.56 for the dominant-term – 0.95 were obtained.

Key words: growth, spatial structure, pine-birch forest stands, regression analysis.

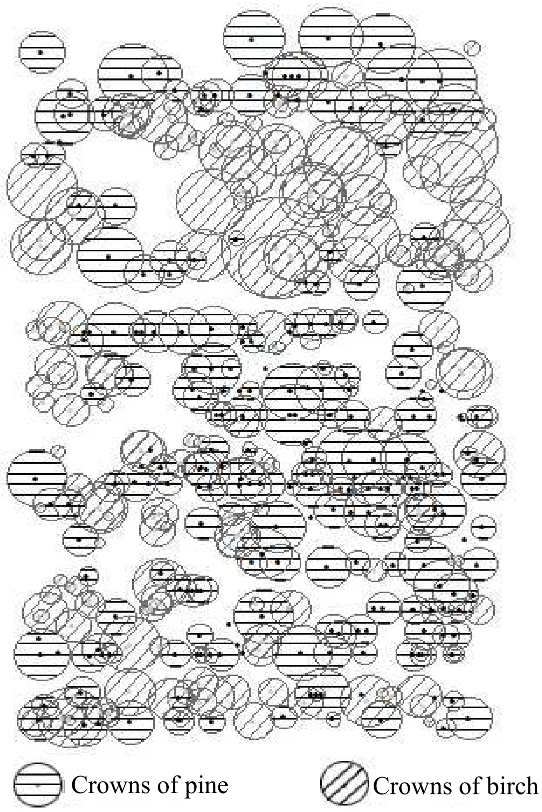
Introduction. The analysis of silvicultural experience shows that it is better to create mixed pine, spruce and other plantings, even under extreme habitat conditions. Relations between tree species can be very different depending on the climatic and soil conditions. But these plantings are certainly more resistant to fungal diseases.

The investigations of the dynamics of taxation indicators of mixed pine and birch stands are presented in various literary sources both by Belarusian and foreign authors [1, 2]. The urgency of this issue points to the need to clarify the significance of interspecies influence in pine and birch stands, revealing the numerical parameters of these relations and use them for further the formation of stands.

Main part. Impact evaluation of birch admixture on the current growth of pine trees was carried out according to the taxation of 408 trees of the pine-birch stand of the 1st yield class of the fern forest type at the age of 67 years old. The diameter of the N–S and W–E, height, age, diameter of the crown N–S and W–E, length of the crown, quality category, feature of the crown, cross sectional area and volume of each trunk, as well as *X* and *Y* coordinates in the conventional coordinate system are determined on a trial area for each tree.

Impact evaluation of the spatial structure was based on the layout of trees on the plot constructed by software Quantum GIS.

The chart indicates the diameters of the crowns and their intersections, a rather strong competition in the birch and pine plantations is clearly visible.



Layout of trees arrangement as well as overlapping of the crowns of birch and pine trees on the plot

To determine the dependence of the current increment of the pine on the admixture of birch a radial growth of 44 pine trees was measured (processed data of core samples). The data were divided into three groups according to the intensity of growth for the last 10 years: weak – radial growth for 10 years, 0–10 mm, average – 10–20 mm and intensive – 20 mm and more.

Schneider methods were used to determine the percentage of the current increment in terms of volume (P_V) in the studied trees:

$$P_V = \frac{Ki}{d_a};$$

G. M. Tursky:

$$P_V = (k+2)P_d = (k+2)\frac{200}{n}\frac{d_a - d_{a-n}}{d_a + d_{a-n}}$$

and Pressler:

$$P_V = \frac{200(r^x - (r-1)^x)}{n(r^x + (r-1)^x)},$$

where r – relative diameter, defined as the ratio of the diameter without bark at the height of 1.3 m at present to the current periodic increase in diameter at the height of 1.3 m; x – an exponent which depends on the energy of the growth in height and length of crown; n – period of increment, years.

One-year percentage of increment in terms of volume, and then directly, the current annual increment in terms of volume (Table 1) was calculated.

The calculation results for the three methods were very close. Current increment figures obtained by the formula of Schneider were taken for further processing.

To assess the current increment depending on the spatial structure of pine and birch stands the average distance to the birch trunk located at a distance equal to the diameter of the crown of the central group of pine with a known current increment was determined.

Next, the correlation between the current growth of pine trees and the parameters of spatial structure and taxation parameters of birch trees in each group were determined. The greatest influence on the current increase in the volume of pine trees on the results of the correlation analysis have: the average distance to the birches in the group, height, crown diameter and volume of the trunk of birch trees.

Based on the regression analysis in the software package STATISTICA 10.0 the correlation between the current growth of pine trees and these parameters was defined.

When selecting the regression equations that best describe the relationship of the current radial growth and increment in terms of volume (Z_V) with taxation-spatial indices of a birch part of the stand (height (H), diameter of the crown (D), volume (V) and the average distance to the trees (L)), the main criteria of selection of equations were the correlation coefficient (R) and the proportion of explained dispersion indicator.

The regression equations for the pine trees with the lowest and highest current growth, selected as a result of multivariate analysis have quite high indicators of these criteria (Table 2).

Table 1

Taxation and spatial parameters of investigated trees

Characteristics of pine trees					Indicators of birch trees			
Radial growth for 10 years, mm	Diameter, cm	Growth percentage, %	Volume of trunk, m^3	Annual growth in terms of volume, m^3	Average distance to a pine tree in the group, m	Height, m	Crown diameter, m	Volume of trunk, m^3
Weak growth of pine trees								
6	10.25	2.93	0.05	0.0015	2.63	19.5	3.3	0.1967
9.5	20.90	2.27	0.34	0.0078	4.13	23.3	3.7	0.2282
9	9.40	4.79	0.05	0.0024	2.82	20.2	3.0	0.2699
4	11.95	1.67	0.06	0.0010	2.40	17.5	1.7	0.1401
5	15.45	1.62	0.43	0.0070	2.52	27.8	3.8	0.3977
6	13.00	2.31	0.33	0.0076	3.00	22.1	3.4	0.2383
3.5	14.10	1.24	0.11	0.0013	3.28	16.3	2.2	0.0997
5.5	18.80	1.46	0.09	0.0013	3.35	21.2	3.3	0.1934
6	16.40	1.83	0.22	0.0041	2.28	23.9	3.0	0.2981
6.5	16.60	1.96	0.12	0.0039	3.22	22.1	2.7	0.2318
5	12.50	2.00	0.08	0.0016	3.69	26.3	7.0	0.7240
5	19.05	1.31	0.29	0.0038	3.21	24.3	4.7	0.4411
5.5	16.40	1.68	0.20	0.0034	2.86	24.7	4.0	0.3945
6	16.50	1.82	0.18	0.0033	2.65	18.8	1.7	0.1129

End of Table 1

Characteristics of pine trees					Indicators of birch trees			
Radial growth for 10 years, mm	Diameter, cm	Growth percentage, %	Volume of trunk, m^3	Annual growth in terms of volume, m^3	Average distance to a pine tree in the group, m	Height, m	Crown diameter, m	Volume of trunk, m^3
Average growth of pine trees								
10	17.75	3.21	0.20	0.0064	2.03	18.1	3.3	0.1873
16	21.65	4.21	0.35	0.0149	1.96	21.6	3.6	0.1578
14.5	20.70	3.99	0.31	0.0123	2.59	19.8	3.3	0.2177
17.5	22.70	4.39	0.38	0.0166	5.07	16.8	2.7	0.1200
15.5	16.35	5.40	0.19	0.0102	3.21	20.0	2.3	0.2300
18	23.00	4.46	0.38	0.0170	3.77	23.7	3.0	0.2642
14	19.90	4.01	0.29	0.0116	3.02	22.2	2.9	0.2297
12.5	28.25	2.52	0.32	0.0080	3.03	21.1	3.0	0.2150
12.5	20.40	3.49	0.31	0.0109	3.50	21.2	2.5	0.1954
10.5	20.40	2.93	0.22	0.0063	3.87	19.3	2.4	0.1462
13.5	21.80	3.53	0.33	0.0116	3.63	21.1	3.5	0.2316
15	18.50	4.62	0.26	0.0120	2.45	18.5	2.7	0.1702
12	18.45	3.71	0.22	0.0083	3.39	23.9	3.0	0.2981
10	19.25	2.96	0.29	0.0086	2.50	20.3	2.9	0.1996
15	19.40	4.41	0.29	0.0130	3.90	22.7	1.8	0.2892
18	16.05	6.39	0.14	0.0088	4.19	22.5	5.8	0.3756
18.5	20.40	5.17	0.33	0.0169	3.58	17.8	2.2	0.1284
19.5	25.65	4.33	0.48	0.0209	4.44	20.6	3.3	0.2426
11	29.35	2.14	0.67	0.0144	6.70	21.3	4.3	0.2977
Intensive growth of pine trees								
26	27.10	6.04	0.62	0.0377	4.74	25.4	3.5	0.3237
24.5	28.75	5.37	0.80	0.0431	3.99	22.5	2.9	0.2170
22.5	15.45	9.17	0.16	0.0151	4.13	26.3	3.3	0.3336
30	19.90	9.50	0.79	0.0748	5.17	20.7	3.4	0.1932
23	25.30	5.73	0.54	0.0309	2.86	20.8	2.3	0.2143
25.3	28.70	5.55	0.70	0.0389	7.42	22.9	4.5	0.5181
25.4	24.90	6.43	0.47	0.0301	5.43	22.3	5.0	0.3786
32	25.85	7.80	0.52	0.0407	5.25	20.6	4.8	0.3081
20	17.25	7.30	0.21	0.0150	3.45	22.0	2.6	0.2318

Table 2

Regression analysis of the influence of forest taxation and spatial parameters of the birch parch in the forest stand on the current increase in the terms of volume of pine trees

Equation	Explained proportion of dispersion	Correlation coefficient R
Low growth of pine trees		
$Z_V = b_0 + b_1H + b_2D_k^2H + b_3V^3 + b_4L / (b_5L^2 + b_6H + b_7)$	0.71	0.84
$Z_V = b_0 + b_1H^2 + b_2D_k^2 + b_3 / V + b_4L^2$	0.64	0.80
$Z_V = b_0 + b_1 (\log(D_k))^2 + b_2 / V + b_3 (\log(L))^2$	0.294	0.54
$Z_V = b_0 + b_1 (\log(D_k))^2 + b_2 / V + b_3 (\log(L))^2 + b_4 (\log(H))^2$	0.604	0.78
Average growth of pine trees		
$Z_V = b_0 + b_1H + b_2D_k^2H + b_3V^3 + b_4L / (b_5L^2 + b_6H + b_7)$	0.31	0.56
$Z_V = b_0 + b_1H^2 + b_2D_k^2 + b_3 / V + b_4L^2$	0.23	0.48
$Z_V = b_0 + b_1 (\log(D_k))^2 + b_2 / V + b_3 (\log(L))^2$	0.21	0.46
$Z_V = b_0 + b_1 (\log(D_k))^2 + b_2 / V + b_3 (\log(L))^2 + b_4 (\log(H))^2$	0.23	0.48
Intensive growth of pine trees		
$Z_V = b_0 + b_1H + b_2D_k^2H + b_3V^3 + b_4L / (b_5L^2 + b_6H + b_7)$	0.90	0.95
$Z_V = b_0 + b_1H^2 + b_2D_k^2 + b_3 / V + b_4L^2$	0.88	0.94
$Z_V = b_0 + b_1 (\log(D_k))^2 + b_2 / V + b_3 (\log(L))^2$	0.86	0.93
$Z_V = b_0 + b_1 (\log(D_k))^2 + b_2 / V + b_3 (\log(L))^2 + b_4 (\log(H))^2$	0.87	0.94

Thus, the correlation coefficient of the current increment in terms of volume for pine trees with a radial growth for the period of 10 years to 10 mm was 0.84, and intensive (radial growth for 10 years – more than 20 mm), the correlation coefficient of the individual equations reached 0.94–0.95. The relatively high correlation (to 0.56) is observed in the analysis of the impact of taxation-spatial indicators of a birch part in the forest stand for the current increase in the volume of pine trees with an average radial growth (10 to 20 mm for 10 years).

It should be noted that the lowest correlation between the taxation-spatial indices of birch and the current increase in the volume of pine trees was observed in coniferous species with the current growth of an average rate. Moreover, the correlation of these characteristics of birch trees with a radial growth of pine for all increment intensities was lower than in the evaluation of the regression equations for increment in terms of volume.

As a result, the analysis of distances between the pine and birch trees within a bio-group revealed:

– the average distance to the nearest birch in bio-groups with oppressed pine is 3.0 m or less in average;

– pine has average growth in that point where the there are trunks of birch within two diameters of its the crown, and the distance between them is about 3.5 m;

– pine dominates in bio-groups with the average distance to the birch trees 4.7 m.

Identified regularities will allow in future to simulate the optimal spatial structure of mixed pine and birch stands, on the basis of it will later be possible to develop programs for the formation of stands, or use them as a recommendation to the thinning or target forest growing.

Conclusion. Studies have shown a significant impact of the taxation data of a birch part of the forest stands and their spatial structure on the growth of pine trees. The possibility of a numerical evaluation of such effect will allow in the future to create a model of optimization of species composition of stands aimed at growing target forest stands. One should take into account the spatial structure of the grown forest stands for the more justified choice of trees for felling and forming plantings with a growth of the set parameters, and hence the size and quality characteristics of grown timber.

References

1. Miroshnikov V. S. *Sosnovo-berezovyye nasazhdeniya BSSR, ikh stroeniye, lesovodstvennoye i hozyaystvennoye znacheniye* [Pine-birch stands BSSR, their structure, silvicultural and economic value. Abstract of thesis cand. of agr. sci.]. Minsk, 1955. 128 p.

2. *Problemy lesovedeniya i lesovodstva na radioaktivno zagryaznennykh zemlyakh* [Problems of Forest science and Forestry in the contaminated land]. Gomel, 2004, issue 60, 474 p.

Information about the author

Sevko Oksana Aleksandrovna – Ph. D. Agriculture, assistant professor, assistant professor, Department of Forest Management. Belarusian State Technological University (13a, Sverdlova str., 220006, Minsk, Republic of Belarus). E-mail: o.sevko@belstu.by

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