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RELATIONSHIPS BETWEEN MENSURATION CHARACHTERISTICS IN COMPETITION CIRCLES ON THE EXAMPLE OF MOSSY PINE FORESTS OF ARTIFICIAL ORIGIN

The research was conducted to identify the relationships between mensuration characteristics and spatial structure of forest stands using electronic models of spatial distribution of trees in plots with automated calculation of distances between them. Analysis of the material was held and the patterns of spatial structure of forest stands were found. The models of relationship between mensuration characteristics and spatial structure of plantings were built.

Introduction. In recent years, there is an increased interest in studying the spatial structure of plants, which was associated with competition and classification trees. Changing spatial structure of forest stands occurs throughout life areas and is reflected in the internal structure of the stand, as well as on the overall productivity [1].

With vigorous way of forestry management, when a person controls all stages of development, it is important to know the optimal spatial structure of forest stands, as it is an indicator of the state of the forest ecosystem. Knowledge of the optimal placement of trees is important for planning activities considering esimation, care and rehabilitation of forest stands [1]. But in order to form this structure, you first need to examine the placement of trees in plantations. The knowledge gained will help to achieve the desired results as soon as possible, and this is one of the main aspects in forest cultivation.

Formation of the desired spatial structure is carried out by means of thinning, one of the major events in the forest growing. Thinning the forest - is actual, mandatory, but at the same time the most difficult of all forestry activities. The complexity increases due to different theoretic disagreement, conflicting advice and errors in modern practices aimed at obtaining a quick profit. [3] Knowledge of optimal spatial structure can improve the effect of thinning through proper selection of trees for cutting.

Improving the productivity and sustainability of forest is the most important task for forestry management. Study of forest stands reaction to the systematic felling trees allows to know better the structural and functional relationships in cenoses through which their stability is ensured. Experience in silvicultural research not only expands the knowledge about the properties of forest ecosystems, but also provides the basis for proper forest management [2].

Main part. In these investigations there have been used 19 sample plots set out in 13 state forestries (Volozhin, Glusk, Grodno, Ivacevichi, Krasnopolsk, Luninetsk, Negoreloye experimental station, Orsha, Postavy, Smolevichy, Khoiniki experimental station, Shumilino and Shchuchin forestries). Age of forest stand where sample plots have been set out vary from 25 to 70 years. For coupe demarcation there have been selected mossy pine forests with density of 0.8-0.9 and type of forest and vegetation conditions correspond to A_2.

On each sample plot tree mapping have been carried out by the method angles and distances in the polar coordinate system. Each tree was measured in height as well as in two perpendicular diameters of stem (N - S, W - E) and 8 crown radii (N, NE, E, SE, S, SW, W, NW).

With the help of QGIS program there have been created electronic models of all sample plots [3].

To eliminate random measurement errors in the selection of data there have been used confidence interval with a probability of 0,95.

In the study of the influence of the spatial structure of plants on inventory indices, data showing the relationship between the trees have been taken into account.

In this investigation used such criteria as the distance between trees (L) and crown projection area (S_kr) have been considered.

There have been analyzed crown projected areas and the graph has been plotted (Fig. 1). From the graph it can be concluded that, regardless of stand age there are oppressed trees in plantations with crown projection area being not higher than 1 m^2. The line showing the maximum value has a similar nature to the line of average ones. Their behavior can be explained by frequency of thinning. In periods after felling open space appears and crowns grow.

There have been also analyzed the dependencies of crown projected areas on average distance between trees (Fig. 2). This dependence is sufficiently accurate ($R^2 = 0.9362$) describes the second-order polynomial. Concept of competition circle of tree has been used in the investigation.

Competition circle is a circle around a tree with a radius being equal to average radius of the crown. In order to determine competition circle for each tree crown projection areas (S_kr) have been calculated.

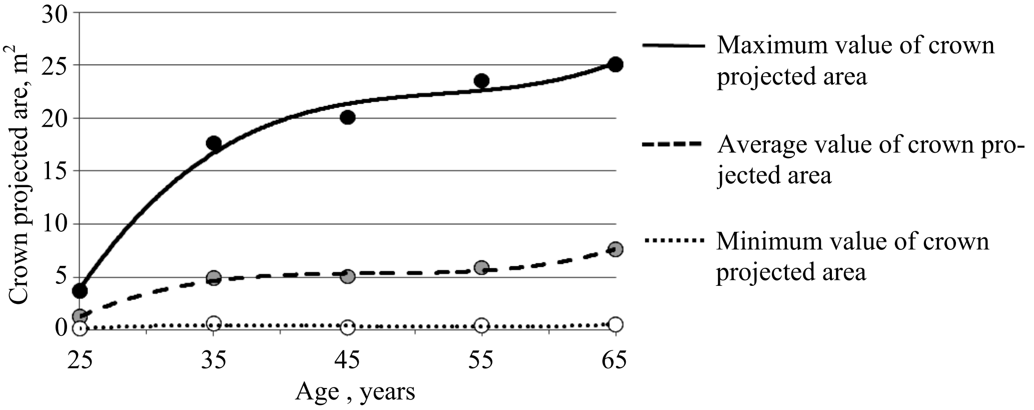

Fig. 1. Dependence of crown projected area on age

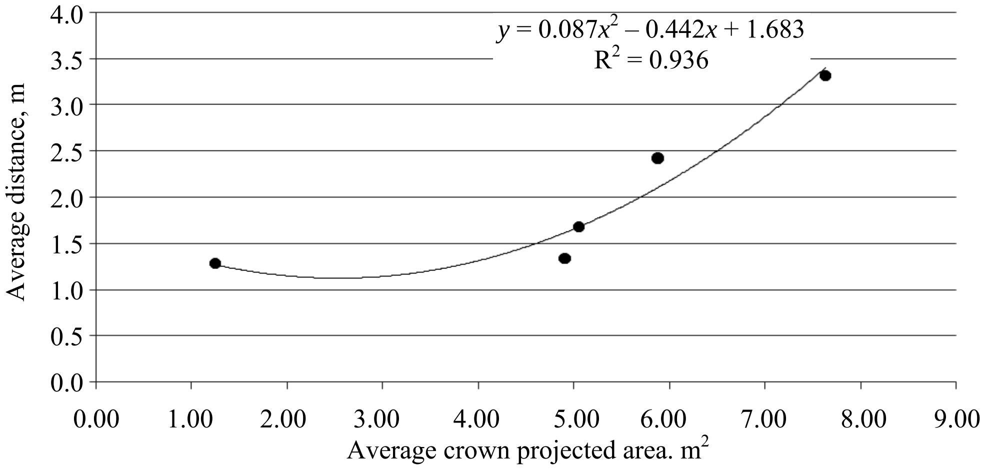

Fig. 2. Dependence of crown projected area on average distance between trees in forest stand

They have been taken into account when calculating crowns radii (R_kr) and competition circles for each tree have been determined (Fig. 3). There have been considered the hypothesis that tree is affected by trees with competition circles overcrossing with its own ones. Based on this thesis all the plots have been analyzed and areas of competition circles crossing have been calculated (Fig. 4).

Calculation have been done by the formulas shown below.

$$S = S_1 + S_2, \tag{1}$$

where

$$S_1 = \frac{R_1^2(F_1 - \sin(F_1))}{2}; \tag{2}$$

$$S_2 = \frac{R_2^2(F_2 - \sin(F_2))}{2}, \tag{3}$$

where

$$F_2 = 2\cos\frac{R_1^2 - R_2^2 + D^2}{2R_1D}; \tag{4}$$

$$F_1 = 2\cos\frac{R_2^2 - R_1^2 + D^2}{2R_2D}, \tag{5}$$

where R_1 - the radius of the first circle; R_2 - the radius of the second circle; D - distance between the centers of the circles.

In the calculation of areas of competition circles crossing there have been selected biogroups with central tree and influencing it, as well as to calculate the number of trees affecting the central one within a biogroup. The maximum number of influencing trees in biogroups varies from three to seven on different plots. This is due to the different density and modes of forests maintenance. In sparse stands the competition between trees is not hard, because there is enough free space after cutting. Therefore, the maximum number of trees crossing the circle of competition is three. In dense stands there is another situation, the tree is affected by up to seven neighboring trees.

Analyzing the data from sample plots there have been observed logic relationships between ratio of the volumes of the central stems of trees and affecting ones in biogroups of different ages. As seen in the graph (Fig. 5), in all ages maximum stem volumes are observed in central trees, which average distance to influencing trees is less than the maximum. It means that it is possible to identify optimal distance within biogroups.

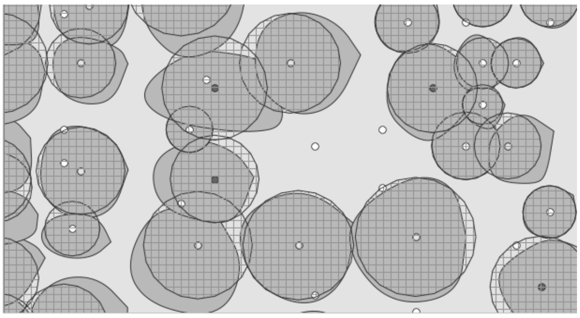

Fig. 3. Competition circles tracing

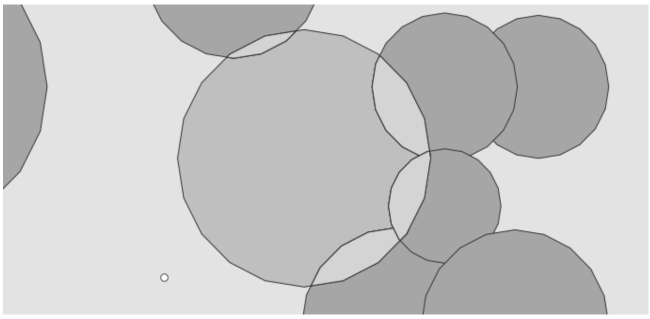

Fig. 4. Areas of competition circles crossing

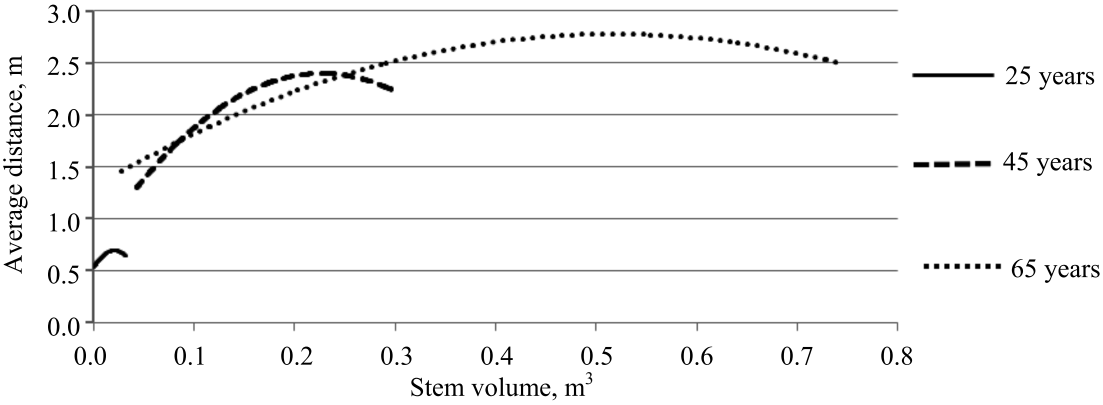

Fig. 5. Dependecy of stem value on average distance to the nearest trees

To determine the influence of neighboring trees within biogroups on the central ones there have been calculated average indeces of affecting) trees: height (H_sr_s), diameter (D_sr_s), crown projection area (S_sr_s), the distance to the central tree (L_sr), the sum of the area of circles competition crossing (S_per_sum), the percentage of the sum of competition circles crossing of the central area of a circle competition tree (Pr_per).

Having calculated the above mentioned indicators for all sample plots there have been constructed correlation matrices. The maximum and minimum values of the correlation volume of the stem to the indicators characterizing space structure are given in the table.

The correlation analysis revealed the relationships between the volume of central stem of the tree and the average inventory indices of neighboring trees (H_sr_s, D_sr_s).

Correlation coefficient of data pairs being investigated varies from 0.05 to 0.20. Consequently, the relationships between these parameters is negligible and they are not included in the model being constructed.

Since the aim was to plot dependences of forest indices on the spatial structure, we selected one of the main criteria - stem volume and the parameters characterizing the spatial structure and having great correlation coefficients (crown projection area S_kr, the average area of crown projections of neighboring trees S_sr_s, the average distance to the central tree L_sr, as a result of of different models in all sample plots was chosen as follows:

$$V = a + bS + cS^2 + eS\_sr^2 + kL\_sr. \qquad (6)$$

Minimum (R^2_{min}) and maximum (R^2_{max}) values of correlation coefficient between central tree volume and special structure characteristics

Indeces	R^2_{min}	R^2_{max}
Crown projected area of central tree (*S_kr*)	0.4	0.9
Sum of areas of competition circles crossing (*S _per_sum*)	0.2	0.4
Percent of sum of areas of competition circles crossing to competition circle area of central tree (*Pr_per*)	– 0.3	– 0.6
Average crown projected are of neighboring trees(*S_sr_s*)	0.1	0.5
Average distance to central tree (*L_sr*)	0.2	0.6

The correlation coefficient of the equation on sample plots varies from 0.50 to 0.95 and has a maximum value among all the tested models.

Conclusion. To study the spatial structure of the plantations biogroup approach has been used. It establishes the relationship between affect each other trees. According to the research revealed the possibility of determining the optimum distance between the trees in biogroups based on characteristics such as the average distance to the nearest tree and crown projection area.

The resulting model satisfies stipulated problem and further studies will be used to determine optimal spatial structure. Knowledge of these parameters will allow the rational use of forest soil fertility and to obtain the necessary wood resources as soon as possible.

The issue being studied is related to tree inventory and transfer forestries to a new level.

References

1. Грабарник П. Я. Моделирование асимметричной конкуренции между растениями // Математическое моделирование в экологии – ЭкоМатМод: материалы конф. Пущино, 1–5 июня 2009 г. / Ин-т физико-хим. и биол. проблем почвоведения РАН; Ин-т матем. проблем биологии РАН. Пущино, 2009. С. 82–83.

2. Factors influencing the amount and distribution of leaf area / James M. Vose [etc.] // EcologicalBulletins. Copenhagen, 1994. P. 102–114.

3. Севко О. А., Коцан В. В. Методика создания цифровой модели пространственного распределения деревьев по материалам постоянных пробных площадей с использованием ГИС-технологий // Труды БГТУ. 2011. № 1: Лесное хоз-во. С. 53–57.

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