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O. S. Bakhur, PhD student (BSTU)

STRUCTURE REGULARITIES OF PINE CANOPY

The article dwells on structure regularities of pine canopy. There have been described morphological characteristics of pine canopy, its classification methods of its investigation. The author highlights methods of performance and investigation results concerning structure regularities of pine canopy. The article describes crown forms and structure of pine canopy depending on forest type and age.

Introduction. Canopy of tree stand is a collection of tree crowns growing in certain part of forest in various combinations in species composition, shape and size crowns, nature, and location in space. Some trees, ranging in isolation from the others, have crowns located on the upper part of canopy, while other ones close canopy (either partially or completely) with branches of adjacent trees in horizontal and vertical directions. Even in a stand of one element of forest trees vary in shape, size and density of crowns, they are different in position to each other. All this leads to different nature of forest stand canopy structure, its appearance and significantly affects growth and development of trees, as well as possibility of plantations decoding based on remote sensing survey. Therefore, knowledge of growth conditions and development of trees in plantations is essential to ensure a higher level of forestry research [1].

The canopy of trees is of particular importance for measuring decoding of plantations on aerial and satellite photos, as most of inventory indexes are determined only indirectly on the basis of correlations between tree crowns characteristics and canopy of stands as a whole. Therefore, it is necessary to describe morphological structure of forest stand canopy during nature-sized taxation.

Investigations of forest stands canopy structure and relationships between taxation and decoding indexes have been done A. S. Ageenko, S. V. Belov, I. D. Dmitriev, G. G. Samoilovich, V. I. Suhih, I. A. Trunov and many others .

Investigation of structure regululiarities of forest stands structure is of practical importance in forest research. The shape, size and o crown length have a significant impact on the growth and development of trees. Therefore, investigation of structure regularities of crowns and forest stand canopy, as well as peculiarities of their images will allow to identify more accurately all taxation indexes when measuring decoding of digital GPS survey.

Main part. Investigation of crown forms of stands allows a deeper understanding of forest nature, especially in space and time. It was found that the trees of the same species and the same age, having the same crown shape and growing in the same forest types and forest conditions, grow faster than trees with different crown forms. The shape of crown projection within the stand is not the same, each species is characterized by its typical one, predominant form; it varies depending on age, site conditions and canopy structure [2]. Forms of vertical crown projection (according to G.G. Samoylovich) are combined into eight types, and each row is combined into 3-5 species depending on the nature of branching and form the upper and lower parts of crowns. The most common forms of horizontal crown projections are combined into four groups (round, elliptical, unilaterally compression and irregular), and in each of them comprises five species.

The variety of forms of horizontal crown projections is affected by not only biological properties of species and character of crown locations in the canopy, but other factors related to sunlight.

As objects of research there have been taken pure pine stands of brake and mossy forest types located on the territory of Baranovichi, Bykhov, Ivatsevichy, Lyakhovichi and Smolevichi forestries.

There have been formed circular plots (CP) in decoding stratums (DS) using GPS-receiver. Mensurational description of plantations DS was being established according to a selective taxation at CPs of constant radius. When evaluating a stand of timber there have been used systematic sampling. Distribution of CP numbers according to classes, age and forest types are shown in Table 1.

Within the CP there have been carried out a complete enumeration of trees with diameter measurement in two directions (North-South, East-West). When complete enumerating of crown presence in canopy forming, trees were divided into free, partially closed and closed. Tree trunk height, height to the largest diameter of crown and the height of crown end of 5 registrated trees nearest to the center have been measured.

Table 1

Distribution of circular plots depending on age class and forest type (pcs.)

Forest type	Age class			
	3d	4th	5th	6th
Brake pinery	9	12	11	7
Mossy pinery	10	13	10	8

Crown diameter was measured in two mutually perpendicular directions (1 - on the largest diame-

ter of the crown, 2 - perpendicular to it), shape of crowns have been described in the same way (according to the classification G.G. Samoylovych). By thickness, depending on the overall proportion of gaps between branches, crowns are divided into three categories (thick, medium and open). The percent of sampling depends on the size of survey area (the larger the area is the less the percent of sampling) and on the degree of variability of the characteristics of interest (the higher the degree of variability of the characteristic, the larger the sampling). The minimum observations can be determined from the required accuracy of [3]:

$$n = t^2v^2 / p^2,$$

where t – Student test for the accepted level of significance; v – coefficient of variation, defined according to previous observations, or on the basis of a model sampling; p – accuracy being planned in this experiment.

The results for determining the required number of measurements to assess the main indicators of forest stand canopy are shown in Table 2 with an accuracy of 90%. Analysis of the results obtained showed that for pure pine stands the required observation number with level of accuracy not less than 10% should comprise: from 25 to 42 measurements in dependence on age to determine the absolute length crowns in brake pineries, from 15 to 22 measurements – for mossy pine forests; from 13 to 25 measurements – to determine the relative length of the crowns in brake pine forests, – from 5 to 14 measurements – for the mossy pine forests.

Table 2

Required number of measurements for assessment of the main indicators for forest stand canopy (pcs.)

Age class	Forest type	Observation number		
		Crown length		Crown diameter
		absolute	relative	
3d	Brake pinery	38	24	33
	Mossy pinery	22	14	24
4th	Brake pinery	25	13	29
	Mossy pinery	19	12	35
5th	Brake pinery	42	25	40
	Mossy pinery	16	9	19
6th	Brake piner	27	13	34
	Mossy pinery	15	5	21

To determine the diameter of the crown the required number of observations is: for brake pine forests - from 29 to 40, for mossy ones - from 19 to 35. According to nature-sized taxation there have been found that age increment leads to clearer view of trees on the photo (we can see a larger quantity of trees) (Table 3). By morphological features of crown comprise diameter, length, crown length (absolute and relative) and height to the maximum width.

Table 3

Percent of visible tress on the photo depending on forest type and age class (%)

Forest type	Age class			
	3d	4th	5th	6th
Brake pinery	90	94	95	97
Mossy pinery	87	89	92	96

Crown form is primarily dependent on the height to the greatest width that divides the crown into the upper one and the lower one. Having the same tree height, width and length, the crown form is not identical.

The higher the maximum width of the crown the more rounded and insolated its surface, therefore the clearer its image on GPS photos.

Further investigations have shown that the shape of horizontal projection of crowns within the stand is not identical, each species is characterized by its own (typical or predominant) form.

It varies depending on the age class, site conditions and canopy structure. Field data are presented in Table 4.

Table 4

Trees distribution according to forms of crown horizontal projections depending on age class (%)

Crown form	Age class			
	3d	4th	5th	6th
Brake pinery				
Rounded	43	47	33	26
Elliptical	30	27	27	33
Unilaterally compressed	20	23	27	25
Irregular	8	3	13	16
Mossy pinery				
Rounded	13	29	23	20
Elliptical	43	42	46	44
Unilaterally compressed	30	27	20	16
Irregular	15	2	11	20
Total	100	100	100	100

Regular rounded shape of pine crown projections in young age achieving maturity under the influence of various factors becomes irregularly round or elliptical. Investigations show that typical form of the horizontal projection of crowns in brake pineries is rounded, but with age the ratio of

types of forms crowns are lined up. For mossy pineries the dominant form is elliptical. The predominant types of vertical projection of tree crowns in pine stands being under investigation are paraboloidal and ellipsoidal.

Distribution of trees by crown density in pure pine stands shows that tree plantations with average density predominate, there is also a reduction in number of trees with open crown with age increment (Table 5).

Table 5

Tree distribution be crown thickness depending on age class (%)

Crown thickness	Age class			
	3d	4th	5th	6th
Brake pinery				
Open	13	10	7	5
Medium	75	73	82	80
Thick	12	17	11	15
Mossy pinery				
Open	20	15	9	4
Medium	77	75	77	84
Thick	3	10	14	12
Total	100	100	100	100

Analysis of the data shown in Table 6 shows that the average crown length in pure pine stands is slightly increased with age increment from 7.5 to 8.0 m – for brake pineries and from 6.7 to 0.4 m – for mossy pine forests.

Table 6

Statistical indicators for distribution of absolute crown length in pine forest stands

Indicators	Age class			
	3d	4th	5th	6th
Brake pinery				
Value, m: minimal	2.6	2.5	2.1	2.4
maximal	12.8	11.3	12.7	12.5
medium	7.5	7.8	7.9	8.0
Standard deviation, m	2.29	1.96	2.57	2.62
Coeff. of variation, %	30.79	24.90	32.38	32.63
Mossy pinery				
Value, m: minimal	3.1	2.8	3.8	5.9
maximal	10.0	10.0	12.6	14.2
medium	6.7	7.3	9.1	10.4
Standard deviation, m	1.58	1.60	1.84	2.04
Coeff. of variation, %	23.70	22.00	20.21	19.62

Fig. 1 shows the dependence of medium crown length of pine stand of brake and mossy forest types according to age classes, which are expressed by polynomial functions of the second order.

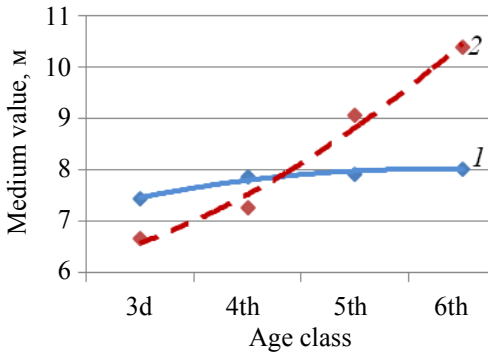

Fig.1. Dependency diagram of medium values for crown length in brake(*1*) and mossy (*2*) pineries by age class

Statistical analysis of relative e crowns length distribution in pine stands shows that the average value varies slightly (from 26.6 to 28.1 for brake pineries and from 28.0 to 32.7 – for mossy pineries), a decrease of the coefficient of variation in mossy pineries is being observed with age increment (Table 7).

Table 7

Statistical indicators for distribution of relative crown length in pine forest stands

Indicators	Age class			
	3d	4th	5th	6th
Brake pinery				
Value, m: minimal	11	15	11	14
maximal	40	37	39	41
medium	27.4	28.1	26.6	27.4
Standard deviation, м	6.73	5.07	6.67	6.83
Coefficient of variation, %	24.6	18.0	25.0	24.9
Mossy pinery				
Value, m: minimal	14	13	19	25
maximal	44	36	41	41
medium	28.8	28.0	32.7	32.3
Standard deviation, m	5.37	4.76	5.01	3.72
Coefficient of variation, %	18.6	17.0	15.3	11.5

Investigation of crown diameters distribution in pine stands according to statistical data (table 8) shows that the average diameter of the crown in the brake pine forest increases with age (from 3.46 to 4,38 m), the coefficient of variation varies from 28.56 to 31.27%. The average value of the diameters of crowns in mossy pine stands increases from 3.38 to 5.82 m, the lowest coefficient of variation is observed in the 5th age class and comprises 22.05%, the highest one is in the 4th one (29.69%).

Fig. 2 shows the dependence of medium crown length of pine stand of brake and mossy forest types according to age classes, which are expressed by polynomial functions of the second order.

Table 8

Statistical indicators for distribution of crown diameters in pine forest stands

Indicators	Age class			
	3d	4th	5th	6th
Brake pinery				
Value, m: minimal	1.66	1.8	1.33	1.52
maximal	6.08	7.13	7.02	7.63
medium	3.46	3.86	4.15	4.38
Standard deviation, m	0.99	1.05	1.31	1.37
Coefficient of variation, %	28.56	27.14	31.48	31.27
Mossy pinery				
Value, m: minimal	1.98	1.43	2.76	3.5
maximal	5.16	5.56	7.73	8.07
medium	3.38	3.55	5.17	5.82
Standard deviation, m	0.83	1.05	1.14	1.34
Coefficient of variation, %	24.68	29.69	22.05	23.07

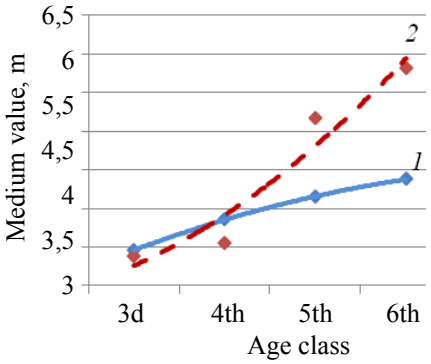

Fig. 2. Dependency diagram of medium values for crown length in brake(*1*) and mossy (*2*) pineries by age class

Conclusion. Investigation results show that age increment leads to clearer view of trees on the photo (we can see a larger quantity of trees). Typical form of the horizontal projection of crowns in brake pineries is rounded and for mossy pineries - elliptical, but with age the ratio of types of forms crowns is lined up. The predominant types of vertical projection of tree crowns in pine stands are paraboloidal and ellipsoidal.

Distribution of trees by crown density in pure pine stands shows that tree plantations with average density predominate; there is also a reduction in number of trees with open crown with age increment.

Statistical analysis of relative e crowns length distribution in pine stands shows that the average value varies slightly (from 26.6 to 28.1 for brake pineries and from 28.0 to 32.7 - for mossy pineries), a decrease of the coefficient of variation in mossy pineries is being observed with age increment.

The average diameter of the crown in the brake pine forest increases with age from 3.46 to 4,38m with the coefficient of variation being varied from 28.56 to 31 27%. The average value of the diameters of crowns in mossy pine stands increases from 3.38 to 5.82 m, the lowest coefficient of variation is observed in the 5th age class and comprises 22.05%, the highest one is in the 4th one (29.69%).

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