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AESTHETIC EVALUATION OF LANDSCAPES (ON THE EXAMPLE OF PERMANENT STUDY AREAS IN NEGORELOYE FORESTRY EXPERIMENTAL STATION)

The article analyzes the possibility of aesthetic evaluation of landscapes be means of mathematical models on the basis of taxation characteristics of permanent study areas. The author analyzes equations used for this purpose and gives a comparative analysis of calculated parameters and data of eye - measurement evaluation of the same characteristics. The possibility of the use of complex mathematical equations in order to calculate quite subjective parameters and their conversion into a mathematical form has been considered.

Introduction. Landscape characteristics of study stands are determined visually during observation in forest or forest park areas. Aesthetic evaluation of landscapes reflects brilliance and harmony in the combination of all vegetation components . Identified ways of improvement of aesthetics properties of the sites are important for the planning economic activities and prioritizing work.

Aesthetic evaluation of stands is determined by landscape areas. It is based on the quality of decorative trees and shrubs and in combination with other components of the micro-landscapes . This factor reflects the brilliance and harmony in the relationships of all components of animate and inanimate nature. Objectivity of aesthetic evaluation is obtained by combining a relatively subjective visual impression (depends on the time of year, weather conditions, amount of light, mood) and considering taxation and landscape features.

In such a case, the most important things are position on the terrain, humidity and soil fertility, habitat conditions area, forest type, species composition, shape, performance, age, spatial arrangement of trees on the area, canopy cover , its ruggedness and beauty, form of crowns and trunks, the energy of growth and development, the degree of visibility and nature of passability; correspondence of current state of area to the type of the landscape being designed.

However, there remains the subjectivity of such a technique. In determining the aesthetic evaluation of forest stands there have been used the scales based on the description of the visual characteristics of the landscapes . Thus, each class of evaluation is described according to three - point scale after N. M. Tyulpanov [1]. Taxation of aesthetic value of forest stands in Belarus is being carried out on the basis of " Technical Guidelines for forest organization of recreational destination in the Republic of Belarus" according to a 5 – point scale after L.N. Rozhkov [2]. It is possible to define these factors on the basis of ratios of prevailing species, mixture of forest and forest types according to 5-point scale after A. G .Steinbock [2], but in this case there is no complete description of the area.

In park and forest management there are attempts to carry out the aesthetics evaluation of landscapes based on mathematical models. Complex mathematical equations allow us to calculate quite subjective parameters and convert them into a strict logical form . Writers of the most common models of interrelations between taxation factors and landscape characteristics are L. N. Yanovsky , V. S. Moiseev , N. M. Tyulpanov and others [1-3].

Main part. In this study based on forest inventory characteristics of permanent study areas there have been identified aesthetic evaluations of landscapes and a comparative analysis of the calculated factors and data visual assessment of the same characteristics have been made.

According to the L. N. Yanovsky and V. S. Moiseev, aesthetic evaluation of landscapes can be calculated as follows:

$$y = \left(e^{R}\right)^{B};$$

$$R = -0,0516(x_1 - 3,5)^2 - 0,0244\left|x_2 - 5,5\right|^3 - -5,66(x_3 + x_4 - 0,65)^2 + (3,49 \times \times 10^{-11} e^{22,28x_3}) - \left[x_5 - \frac{3}{x_6}x_7\right]^2 \times \left[\frac{18,21}{x_6}x_7\right]^{-2}; \quad (1)$$

$$B = 0,167x_8x_{9i} / (x_{9i}(x_{10i} \exp(-0,295 \times \times (\ln x_{11i} - \ln x_{12i} + 0,4)^2 - 0,454 \times \times (\ln x_{13i} - \ln x_{12i} + 0,05)^2)^{0,333}); \quad (2)$$

$$x_{10i} = \exp\left[-0,301\left(b_i - 1\right)\right]; \quad (3)$$

$$x_6 = \frac{A}{a}, \quad (4)$$

where x_{1i} – stock i-x elements of forest in the stand, m^3/ha; x_{2i} – the average height of the i-x elements of forest, m; x_{3i} – average diameter of crowns i- x elements of wood, cm; x_{4i} – the average length of crowns i-x elements of forest, m; x_{5i} – value of i-x elements of forest ; b_i – the value of species in points (pine – 1, spruce and birch – 2, aspen and alder – 3); A – age of major species;

a – class period, age; x_7 – rank of forest types; x_8 – quality class of stands after M. Orlov ; x_9 – relative forest density of the 1st story , x_{10} – forest density of the 2nd story; x_{11} – density of undergrowth, thousand pieces/ha, x_{12} – average height of undergrowth, m.

The average diameter of crowns x_{3i} is calculated as follows:

$$x_{3i} = m_0 + m_1 d + m_2 h + m_3 dh. \quad (5)$$

The lengths of crowns x_{4i} are determined by the formula :

$$x_{4i} = r_0 + r_1 d + r_2 h + r_3 dh, \quad (6)$$

where m_0, m_1, m_2, m_3 and r_0, r_1, r_2, r_3 – parameters depending on the species (Table 1); d – diameter of the trunk at breast height, cm ; h – tree height, m.

Table 1

The parameters of interrelation model between sizes of tree crowns and tree heights and diameters

Species	Models coefficients for x_{3i}			
	m_0	m_1	m_2	m_3
pine	0.194	0.224	0.001	–0.004
spruce	1.272	0.113	–0.007	0.001
birch	1.002	0.089	–0.016	0.004
alder	–0.073	0.150	0.064	–0.002
Species	Models coefficients for x_{4i}			
	r_0	r_1	r_2	r_3
pine	–0.537	0.737	0.026	–0.017
spruce	1.214	0.251	0.209	0.002
birch	0.743	0.465	0.192	–0.007
alder	–1.673	1.560	–0.212	–0.036

Submitted formula imply full information about areas. To calculate the aesthetic value of landscapes in Negoreloye forestry experimental station we used the data of the following permanent study areas: No. 8 – 41 compartment, the 11th area, station No. 16 – 41 compartment, 9th area; station No. 24 – 50 compartment, the 24th area; station No. 39 – 51 compartment 18th area. These study areas had the greatest difference in structure and aesthetic perception .

Thus, a permanent study area No. 8 represents mature pine forest stand with a small proportion of the second story of spruce with thin undergrowth and brushwood; No. 16 – pure mature pine forest stand with thin brushwood; No. 39 – mixed pine and birch forest stand with pine undergrowth forked road net on the river bank and intensive recreational load; No. 24 – complex pine and birch forest stand mixed with spruce, thick undergrowth and thick brushwood .

According to eye measurement taxation held at Negoreloye forestry experimental station, aesthetic evaluation of mentioned areas was carried out according to a 5- point scale: No. 8, 16, 39 – 1 point. No. 24 – 2 points.

On each station there have been identified a taxation index of each tree: species, age, height, diameter , length, width and shape of a crown, the state and the class of tree growth after Kraft, and also there have been conducted the mapping of spatial structure of forest stands in the coordinate system . With the help of software developed in the Excel, average taxation characteristics of the area have been calculated (Figure).

quarter	50	unit	24	area	0.6

average parameters of dead growing stand										average parameters of dead standing trees					
species	age	D	H	per sa			per 1 ha			per sa			per 1 ha		
				G	quantity	stock	G	quantity	stock	G	quantity	stock	G	quantity	stock
p	65	30.2	22.9	8.308	116	90.6	13.846	193.33	150.9	0.172	6	0.9	0.287	10	1.4
s	48	21.3	14.3	2.175	61	21.7	3.625	101.67	36.1	0.000	0	0.0	0.000	0	0.0
o	0	0.0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0
b	60	29.9	22.9	4.704	67	68.1	7.840	111.67	113.5	0.215	4	2.4	0.359	6.67	4.0
as	60	42.3	23.0	0.140	1	2.2	0.234	1.6667	3.6	0.000	0	0.0	0.000	0	0.0
alb	0	0.0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0	0.000	0	0.0
Total				15.327	245	182	25.545	408.33	304	0.387	10	3	0.645	16.67	5

tree No.	coordinates		species	age	trunk					crown				growth	
	X	Y			dn-s	de-w	dav	h	trunk volume	dqn-s	dqe-w	dqav	length	acc. to Kraft	wood category
1	70.75	0.35	Б	65	32.5	30.5	31.5	20	0.714	6.75	5.7	6.225	25	2	comm.
2	69.95	2.5	Б	60	23	23.5	23.3	21.5	0.416	3	2.9	2.95	20	2	comm.
3	64.1	4.2	С	65	24.5	27	25.8	21.5	0.497	3.56	3.83	3.695	20	2	comm.

Fig. Calculation of taxation indexes on permanent study areas

The results of calculations, according to the authors , should be interpreted into a 3 -point scale of aesthetic evaluation. Indeed, adjusted data allow us to move to a scale, and the use of a 5-point scale only increases the determination accuracy of aesthetic evaluation index. Thus, the calculated values of aesthetic evaluation on permanent study areas No. 8, 16, 39 are adjusted to 1.0, which corresponds to the 1st class of aesthetic evaluation, and for the station No. 24, this value is rounded up to 1.5, which can be estimated as the 2nd grade (Table 2). This assessment is fully corresponded to that obtained by eye measurement taxation.

Table 2

Aesthetic evaluation

Station	Landscape indexes			
	Crown diameter, sm	Crown length, m	Cofficient, B	Aesthetic evaluation
No. 8	4.67	11.99	0.157	0.979
No. 16	4.22	10.77	0.169	0.914
No. 24	4.22	10.56	0.195	1.365
No. 39	7.11	15.67	0.151	0.983

Conclusions. Definition of aesthetic evaluation of landscapes for forest stands and open spaces in various regions of the country is based on specially designed scales [1–4]. However, the results obtained by them are a little comparable and do not always provide unbiased information for solving problems of organization and allocation of recreational areas.

Possibility of numerical interpretation of subjective described features allows to avoid common errors, to organize the results into a uniform system of evaluation , to use the maximum number of taxation and forest management indexes accurately when determining aesthetic evaluation of study areas.

However, the proposed formulae do not take into account such factors as passability of area, allocation of trees on the area, visual range of area and canopy cover, presence of highly decorative living ground cover, assortment composition, site conditions and other natural features of particular stands, which create different emotional impression, what in turn, dictates necessity of correspondent subjective correction of landscape evaluation.

Part of factors not previously considered is possible to formalize and to form a kind of mathematical relations which are then to be used to calculate the aesthetic value of landscapes. It is generally considered that natural landscapes, not subjected to anthropogenic influences, are highly aesthetic and may be classified as the 1st class of aesthetic evaluation according to a 5-point classification. In this case, one should consider a reduction of aesthetic evaluation as a function of human exposure and sanitarian evaluation of landscapes, which can reduce both the last and work on its increasing with proper organization of economic activities.

The obtained formal interrelations can greatly simplify the processing of information and evaluation of correcting forestry activities in forest stands with a pronounced recreational function.

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