FOREST MANAGEMENT, FOREST INVENTORY AND INFORMATION SYSTEMS IN FORESTRY

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SIZE AND QUALITY CHARACTERISTICS OF WOOD STOCKPINE STANDS AND THEIR RELATION TO TAXATION PARAMETERS

The taxation cost of the growing stock of wood is a minimum value, which determines the profitability of forestry in Belarus. In many ways this value depends on the size characteristics of the wood stock. These characteristics are determined by taxation indices, which, in turn, through the forestry measures can be affected by people. Therefore in this study we set a goal – to reveal the dependence of size and qualitative characteristics of growing tree stock on its taxation indices.

The data from taxation on 26 plots of mature pine stands of different forest types were used to study the dependence of size and quality characteristics of the stock of pine stands on their inventory indices.

Factors (stand characteristics) were identified to determine the size and patterns of formation of qualitative characteristics of stocks, they are influence these long-indicators. The first priority was to identify those factors which may affect the forehead-century as a result of economic activity. According to the results of the correlation analysis four inventory indices were selected: the average age of the stand, its density, relative fullnessand forest type.

As a result of the regression analysis were obtained depending on the model size and quality characteristics of the stand from the previously selected major forest indices. The coefficients of determination were analyzed and we can conclude that the regression-equations describe well analyzed according to (R^2 for most size-quality characteristics of greater than 0.7). These models can be used in the design of forest management activities aimed at building stands with the required size and quality characteristics of wood stock.

Key words: size and quality characteristics of wood stock, stand density, middle ages, the relative completeness of the stand, type of wood, regression model.

Introduction. At present, the main income of the forest management is evaluated by the sell stock of stem wood per hectare. The minimum quantity that determines the profitability of forestry in Belarus can be considered the taxes cost of standing timber [1]. This value depends on the following parameters: category of fees, species and size-term characteristics of the stock. Upon the sale of harvested timber in addition to the size characteristics qualitative indicators (grade, defect and knot free zone) are also recorded. Improving the quality of the wood stock increases its value and, consequently, profits forestry enterprise. A person can influence the formation of the forest stand (including basic inventory indices) through those or other forest management activities. Therefore in this study we set a goal – to identify the impact of different taxation indicators of mature pine stands on the size and qualitative characteristics of their stocks. A significant contribution to the study of this issue has been made by professor V. E. Ermakov [2].

Main part. The taxationdata on 26 plots of mature mossy pine stands, bilberry, fern, sour/marshy, long moss and cranberry forest types, laid down by N. P. Demid, were used to study the dependence of the size and quality characteristics of the stock of pine stands upon their taxation indicators. The age of forest trees ranged from 72 to 160 years old. This paper examines the impact of different taxation figures of the tree stand: forest type, forest type group (forest types with similar forest conditions), density, fullness, average diameter and height, standing available supplies – on their size and quality characteristics. Size categories: large, medium, small timber, determined by the Belarusian standards and with the division of these categories into subcategories, as well as wood kinds of I and II types were used as dependent variables. Large work timber was divided into three sub-categories: large of the 1st subcategory – the diameterat the upper edge is over 40 cm; large of the 2nd subcategory – 32 to 38 cm; large of the

third subcategory – 26 to 30 cm. Medium work timber was divided into two subcategories: 1st subcategory – the diameterat the upper edge was 20 to 24 cm; 2nd subcategory – the diameter at the upper edge of 14 to 18 cm (this division was suggested by N. P. Demid) [3].

Before determining the regularities of the formation of the size-quality characteristics of growing stock, you must first identify the factors that affect these characteristics. The correlation coefficients between the basic biometrical and size and quality indicators and stock of forest stands were calculated in the mathematical program Statistica 10 (Table 1).

As can be seen from Table 1, all the relevant factors (taxation parameters) influence the size and quality characteristics of the stand to varying degrees. Thus, the output of large commercial timber essentially depends on the average diameter and the height of stand (R = 0.96 and R = 0.85), forest type (R = 0.64) and age (R = 0.65). In all these cases there is a direct relationship. There is also a strong connection of the specifications and thickness (R = –0.75), but this relationship is inverse, i.e. with an increase in density the output of large merchantable timber decreases. The opposite pattern is observed for the output of medium and small merchantable timber. With an increase in all the main indicators of taxation, except for density, the output of these categories of industrial wood is reduced. The percentage of defect and knot free length of the trunk (I sort R = 0.91, II sort R = –0.88) has a great impact on the grade, the average age of the stand (I sort of R = 0.56, II sort R = –0.50) has a moderate influence. The remaining inventory indices analyzed do not affect or very little effect the grade.

When choosing factors (taxation indicators) to construct models of dependence of the size and quality characteristics upon the stock we followed three criteria:

1) taxation indices, that a person can adjust directly in the course of forest management activities;

2) taxation indices with the greatest degree of influence on the size and quality characteristics of the stand;

3) taxation indices defined by natural and environmental growing conditions.

Based on these principles, we have chosen four factors that meet the above criteria: the average age of the forest stand, its thickness, relative fullness and type of wood.

Table 1

The coefficients of correlation of the size and quality characteristics and taxation figures of the forest stand

Size and quality characteristics*	Taxation indicators**								
	Tl	Tlg	A	N	P	M	Bz%	Dsr	Hsr
M	0.75	0.00	0.54	–0.41	0.84	1.00	–0.19	0.78	0.86
Dall	0.57	0.05	0.39	–0.41	0.24	0.60	0.16	0.53	0.33
Drall	–0.40	0.03	–0.22	0.36	–0.01	–0.31	–0.11	–0.30	0.68
Otall	–0.49	–0.13	–0.40	0.26	–0.42	–0.67	–0.13	–0.56	–0.38
Sr1	–0.58	–0.08	–0.43	0.31	–0.37	–0.53	–0.12	–0.53	–0.70
Sr2	–0.45	–0.28	–0.61	0.73	–0.40	–0.68	–0.30	–0.91	–0.61
Srall	–0.60	–0.26	–0.65	0.66	–0.47	–0.75	–0.27	–0.91	–0.76
k1	–0.47	–0.31	–0.64	0.69	–0.37	–0.62	–0.34	–0.82	–0.84
k2	–0.16	0.17	–0.03	0.07	–0.19	–0.27	–0.10	–0.20	–0.76
k3	0.60	0.15	0.43	–0.67	0.46	0.75	0.18	0.85	–0.21
kall	0.64	0.20	0.65	–0.75	0.48	0.79	0.28	0.96	0.85
sort1	0.06	0.39	0.56	–0.24	0.00	0.30	0.91	0.38	0.89
sort2	0.05	–0.38	–0.50	0.26	0.10	–0.15	–0.88	–0.29	0.55
sort3	0.07	0.45	0.11	–0.20	0.16	0.19	0.02	0.28	–0.26
Mall	–0.54	–0.07	–0.53	0.81	–0.41	–0.67	–0.23	–0.90	0.21

* The size and quality characteristics of the growing stock: M – growing stock, Dall – yield of commercial timber, Drall – yield of firewood, Otall – output of waste, Sr1, Sr2 – yield of medium commercial timber of the 1st and 2nd subcategories, respectively, Srall – output of medium commercial wood (total), k1, k2, k3 – output of large commercial timber of the 1st, 2nd and 3rd subcategories, respectively, kall – yield of large commercial category (total), sort1, sort2, sort3 – yield of commercial timber I, II and III sorts, respectively, Mall – output of small timber.

** Inventory indices of the stand: Tl – forest type, Tlg – group of forest types, A – average age, N – density, P – relative fullness, M – available supplies on a root, Bz% – the percentage of defect and knot free zone of the tree trunk, Dsr – average diameter, Hsr – height.

So, a person can adjust the age with the cutting age (to determine the order of admission to the cutting), density and relative fullness – by means of cleaning cuttings (the choice of the method of harvesting, selection of trees for cutting, etc.), and the type of wood is a mandatory factor, as it determines the initial conditions for the formation of the forest stand.

With the help of program Statistica 10 we analyzed different models of dependence of the size and quality characteristics of the growing stock and our chosen factors. According to the analysis, it was decided to stop at the regression of the following form:

$$\mathrm{SQC} = a_0 + a_1 \cdot P + a_2 \cdot N + a_3 \cdot A + a_4 \cdot P \cdot N + \\ + a_5 \cdot A \cdot N + a_6 \cdot A \cdot P + a_7 \cdot P^2 + a_8 \cdot A^2 + a_9 \cdot Tl + \\ + a_{10} \cdot Tl^2 + a_{11} \cdot P \cdot N \cdot A,$$

where SQC – size and quality characteristics of the growing stock, m^3; a_0, ..., a_{11} – regression coefficients; P – relative fullness of the tree stand; N – density, per hectare; A – average age of the forest stand, years old; Tl – forest type, presented numerically (Table 2).

The regression coefficients, correlation and determination coefficients obtained by the least squares method using Statistica 10, for the analyzed size and quality characteristics are shown in Table 3. Also, the standard deviation and the mean error of approximation are presented in the Table.

Table 2

Numeric expression of forest types

Forest types	mature mossy	mature cowberry	mature long moss	mature bilberry	mature fern	mature sour
Numeric values	1	2	3	4	5	6

Analyzing the data in Table 3, we can conclude that the regression equations used in our work describe well the size and dependence of the qualitative characteristics of the growing stock on its taxation indicators. The average error of approximation does not exceed 5%.

The regression coefficients are significant at the 5% level, valid on the F-criterion with a relative error of 5–10%.

The coefficient of determination for commercial timber, including the categories of size, exceeds the value of 0.9. Less accurate models describe the distribution of the stock on grades (the coefficient of determination being 0.5–0.7).

Knowing the regularities of changes of the size and quality characteristics of taxation indices, we can choose such a combination there of to obtain the required timber size and quality, which would meet the demands of the market. With the help of forest management activities and determining the age of admission of forest plot for felling we can provide the necessary combination.

Table 3

Statistical characteristics of regression equations

Size and quality characteristics of the growing stock (subcategory)	Regression coefficients												R	R^2	Mean-square deviation	The average error of approximation
	a_0	a_1	a_2	a_3	a_4	a_5	a_6	a_7	a_8	a_9	a_{10}	a_{11}				
Commercial	–740.80	361.48	1.69	9.47	–0.56	–0.016	–0.66	–78.64	–0.022	–6.68	4.87	0.011	0.96	0.91	25.73	1.7
Firewood	–247.79	201.76	0.47	3.33	–0.41	–0.006	–1.33	–51.62	–0.008	–5.88	0.88	0.005	0.75	0.56	4.71	11.6
Medium (1)	–1,228.25	1,283.7	2.13	11.22	–1.30	–0.016	–6.77	–344.27	–0.020	13.2	2.57	0.016	0.86	0.74	17.51	5.4
Medium (2)	692.02	–982.5	–1.44	–2.54	1.65	0.010	2.74	252.34	–0.003	15.03	–1.14	–0.010	0.95	0.90	10.24	0.4
Medium total	–440.81	165.25	0.45	8.05	0.63	–0.004	–3.32	–68.14	–0.023	2.88	1.35	0.004	0.95	0.90	16.60	1.4
Large (2)	339.87	–465.35	–0.50	–3.94	0.21	0.005	4.82	153.10	0.006	9.13	–0.79	–0.007	0.98	0.97	7.83	2.5
Large (3)	–1,379.52	1,522.3	3.02	11.61	–2.70	–0.028	–7.92	–296.81	–0.011	–16.2	3.40	0.027	0.92	0.84	16.99	–1.2
Large total	–640.25	506.07	1.89	4.21	–1.72	–0.018	1.16	–78.79	–0.003	–11.0	3.54	0.012	0.97	0.94	19.11	–1.6
Small	439.44	–452.6	–0.89	–3.42	0.82	0.007	2.18	97.14	0.004	2.81	–0.16	–0.007	0.95	0.90	4.92	293.2
I sort	580.63	–1,103.1	–1.82	–3.71	2.65	0.015	12.76	–157.69	–0.016	4.30	–0.42	–0.024	0.74	0.55	40.81	48.1
II sort	–1,455.70	1,749.3	3.64	12.61	–3.48	–0.032	–14.7	28.64	0.001	–5.60	4.63	0.036	0.86	0.74	8.08	120.1

Conclusion. In this paper we have identified the factors (taxation indices) directly affecting the size and quality characteristics of forest stands. The following taxation indices were chosen as the factors: the average age of trees, density, relative fullness and type of wood. We have developed the regression models for the dependency of the size and quality characteristics of the stock of pine stands on the selected factors. The basic statistical characteristics of the given models were determined. An average error of approximation equations error does not exceed 5%.

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