ЛІСОВА ПОЛІТИКА І ТАКСАЦІЯ

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MODELLING HEIGHT GROWTH OF COMMON OAK STANDS IN UKRAINIAN POLISSYA

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Abstract. *Within this research height growth of Common oak stands was modelled for conditions of Ukrainian Polissya. Mensurational indices of stands that were established in course of laying out 91 sample plot, have served as an input data. On their basis, by means of multiple regression analysis methods, a guide curve for height growth of the studied stands was developed. Statistical adequacy analysis has shown a sufficient accuracy in describing empirical data. A dynamic site index scale was developed on the basis of the abovementioned findings. This scale will be further used when developing yield tables for the studied stands. The mentioned research results are presented in the article.*

Keywords: *Ukrainian Polissya, Common oak, height growth, guide curve, modelling.*

Introduction. A proper forest management and forest resources handling currently are seen as important means of achieving ecologically sustainable, economically viable and multi-purpose utilization, as well as a way for meeting the needs of the world's population in timber and non-timber forest products. Quantitative assessment of a range of benefits provided by forest ecosystems has no alternatives to application of a system of specialized regulatory and information support. From the viewpoint of developing standards for assessing forests' productivity (including biotic productivity), development of a dynamic site index scale and yield tables for modal stands are considered as important elements. Studying, describing and assessing dynamic processes is a more complex task than, for example, establishment of statistical relations between values, especially when the first three are linked with biological growth processes. Modelling dynamics of mensurational indices shall account for biological growth and development peculiarities of individual tree species [8].

Mean height of a forest stand is one of the most important mensurational parameters that has a strong correlation with the majority of other measurable stand's parameters [1]. Development of a dynamic site index scale enables accounting for the natural dynamics of forest stands, as well as contributes to

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solving practical tasks of grouping experimental material during elaboration of regulatory and information support.

Aim of research –establishment of height growth patterns and development of a dynamic site index scale for common oak stands in Ukrainian Polissya.

Materials and methods of research. This research is based on the sample plots database of empirical data created by two departments of the National university of life and environmental sciences of Ukraine – forest management, and forest mensuration and forest inventory. The amount of data used is 91 sample plot with continuous enumeration of trees and a total of 984 model trees cut and measured. The research material is predominantly represented by medium-stocked, highly-productive, mid-aged and maturing stands in typical forest growth conditions of Ukrainian Polissya.

To establish height growth patterns and develop a dynamic site index scale for oak stands in Ukrainian Polissya, we have analyzed growth of thickest trees in stands. Such trees occupy a dominant position in a forest canopy and experience minimal impact of intraspecific and interspecific competition, unlike medium-sized trees [5, 6, 7]. The analyzed model trees that were cut on the sample plots have the highest (75 and higher) ranks by diameter. The absolute heights of model trees were converted into relative heights, setting the base age at 40 years since a significant part of the experimental material was obtained from mid-aged stands [2, 4]. This has enabled us to develop a dynamic site index scale.

Analysis of the research dataset and further modelling were carried out through multiple regression analysis method on PC by means of commonly used office and specialized statistical software (Microsoft Excel, StatSoft Statistica 12).

Results. As a result of modelling efforts, we obtained a guide curve for the dynamic site index scale of Common oak stands in Ukrainian Polissya. Figure 1 presents dynamics of relative top heights of the studied model trees, modelling results and the abovementioned guide curve.

An analytical expression that corresponds to the guide curve depicted on Figure 1 was obtained as a result of research of discovered relations, which reliably reflect patterns in dynamics of experimental data for Common oak stands in Ukrainian Polissya:

$$H_в = (2{,}323 \cdot (1-\exp(-0{,}0201 \cdot A))^{1{,}413}) \cdot H_{40}^{баз}, \quad (1)$$

where: $H_в$ – stand's top height;

A – stand's age;

$H_{40}^{баз}$ – mean stand's height at base age.

Since top height has a limited application in industrial forestry and in forest inventory in Ukraine, we made a transition from top height to mean height. When modelling, it was found that these two mensurational parameters are strongly correlated. By means of multivariate search it was found that the following equation provides the most correct description of mean height dependency on top height and stand's age:

$$H = H_в \cdot 0{,}913 \cdot \exp(-0{,}676/A), \quad (2)$$

where H – mean height of a stand.

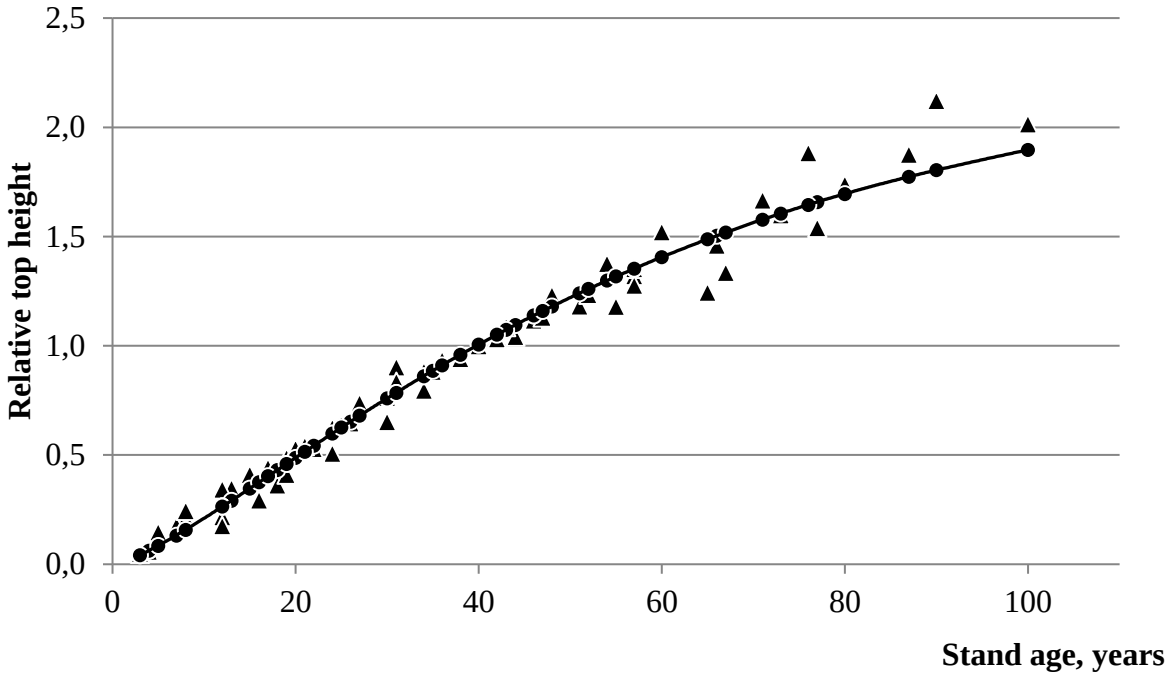

Figure 1. Guide curve by relative top height for dynamic site index scale for Common oak stands in Ukrainian Polissya (triangular markers – empirical data, round markers – modelling results, solid line – guide curve)

In order to evaluate adequacy of the developed models, we have performed a statistical analysis including analysis of proportion of variance in the dependent variable predictable from the independent variables, and analysis of residuals. This allows to declare a sufficient accuracy of empirical data description by the models and absence of systematic errors. For the purpose of linking the developed dynamic site index scale with the general site index scale after Prof. M.M. Orlov, we have brought base age of mean heights to 100 years for the general site index scale [3]. To do this, using the developed models, we calculated relative heights for age of 100 years and obtained a result of 1,720. As it is possible to observe from the models provided above, stand's base age depends exclusively on the first coefficient of the equation. This leads us to a conclusion about possibility for obtaining a model with base height for certain age by dividing the first coefficient by the index of relative height at the age of 100 years.

By substituting in equation (2) instead $H_в$ by model (1) we obtain the following analytical expression for finding H for Common oak stands in Ukrainian Polissya:

$$H = 2{,}323\cdot(1-\exp(-0{,}0201\cdot A))^{1{,}413}\cdot 0{,}913\cdot\exp(-0{,}676/A)\cdot H_{40}^{баз}. \quad (3)$$

It is well known that any model can be presented in analytical, graphical and tabular form. The latter is more used in industrial conditions, mainly due to ease of use and presentation of information in an easily perceivable form. The dynamic site index scale that was developed on the basis of the guide curve mentioned above is presented in the table in a form of a set of thresholds for

stand's mean height in I^b-V site index classes for Common oak stands in Ukrainian Polissya.

1. Dynamic site index scale for Common oak stands in Ukrainian Polissya

Stand age, years	Stand mean height by site index classes, m						
	I^b	I^a	I	II	III	IV	V
10	4,0-3,7	3,6-3,3	3,2-2,9	2,8-2,5	2,4-2,1	2,0-1,7	1,6-1,3
15	6,7-6,2	6,1-5,5	5,4-4,8	4,7-4,2	4,1-3,5	3,4-2,8	2,7-2,1
20	9,6-8,7	8,6-7,8	7,7-6,8	6,7-5,9	5,8-4,9	4,8-4,0	3,9-3,0
25	12,4-11,3	11,2-10,0	9,9-8,8	8,7-7,5	7,4-6,3	6,2-5,1	5,0-3,9
25	12,4-11,3	11,2-10,0	9,9-8,8	8,7-7,5	7,4-6,3	6,2-5,1	5,0-3,9
30	15,1-13,7	13,6-12,2	12,1-10,7	10,6-9,2	9,1-7,7	7,6-6,2	6,1-4,7
35	17,7-16,0	15,9-14,3	14,2-12,5	12,4-10,7	10,6-9,0	8,9-7,2	7,1-5,5
40	20,1-18,2	18,1-16,2	16,1-14,2	14,1-12,2	12,1-10,2	10,1-8,2	8,1-6,2
45	22,4-20,3	20,2-18,0	17,9-15,8	15,7-13,5	13,4-11,3	11,2-9,1	9,0-6,9
50	24,5-22,2	22,1-19,7	19,6-17,2	17,1-14,8	14,7-12,4	12,3-9,9	9,8-7,5
55	26,5-23,9	23,8-21,3	21,2-18,6	18,5-16,0	15,9-13,4	13,3-10,7	10,6-8,1
60	28,3-25,6	25,5-22,8	22,7-19,9	19,8-17,1	17,0-14,3	14,2-11,5	11,4-8,7
65	29,9-27,1	27,0-24,1	24,0-21,1	21,0-18,1	18,0-15,1	15,0-12,1	12,0-9,2
70	31,5-28,5	28,4-25,3	25,2-22,1	22,0-19,0	18,9-15,9	15,8-12,8	12,7-9,6
75	32,9-29,7	29,6-26,5	26,4-23,1	23,0-19,8	19,7-16,6	16,5-13,3	13,2-10,1
80	34,2-30,9	30,8-27,5	27,4-24,0	23,9-20,6	20,5-17,2	17,1-13,8	13,7-10,4
85	35,3-31,9	31,8-28,4	28,3-24,8	24,7-21,3	21,2-17,8	17,7-14,3	14,2-10,8
90	36,4-32,9	32,8-29,3	29,2-25,6	25,5-22,0	21,9-18,4	18,3-14,7	14,6-11,1
95	37,4-33,8	33,7-30,1	30,0-26,3	26,2-22,6	22,5-18,9	18,8-15,1	15,0-11,4
100	38,3-34,6	34,5-30,8	30,7-26,9	26,8-23,1	23,0-19,3	19,2-15,5	15,4-11,7
110	39,9-36,0	35,9-32,0	31,9-28,0	27,9-24,0	23,9-20,1	20,0-16,1	16,0-12,2
120	41,1-37,2	37,1-33,1	33,0-28,9	28,8-24,8	24,7-20,7	20,6-16,6	16,5-12,6

Graphic interpretation of the data presented in table for I^b, I and III site index classes is presented in Figure 2, where the developed dynamic site index scale, is compared against the general site index scale after Prof. M.M. Orlov. When analyzing the provided graphic information, it becomes possible to notice that at young age (under 50 years) there is a "bend" of the dynamic site index scale and, accordingly, significantly lower mean heights for the corresponding site index classes. At the same time, the following patterns are observed: with increasing stands' productivity, the difference between the two analyzed site index scales increases; with a decrease in productivity, the age at which the difference between these scales is the biggest also decreasing. Up to the base age of 100 years in the second and more productive site index classes, mean height upper thresholds of site index classes of the dynamic scale are higher than those of the general scale, for less productive stands the situation is opposite.

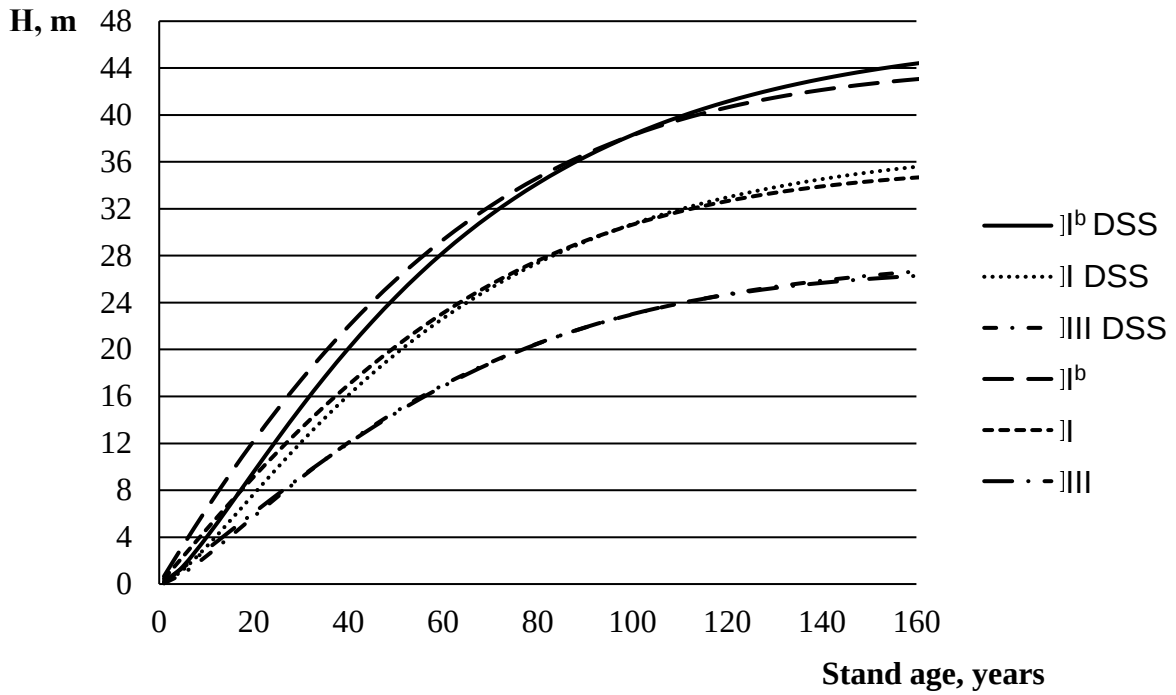

Figure 2. Comparison of values of mean height upper thresholds for the developed dynamic site index scale (DSS) and the general site index scale after Prof. M.M. Orlov

At older age, the first tendency is inherent in all site index classes. The above differences can be explained by the fact that the general site index scale after Prof. M.M. Orlov was developed in a purely statistical way using several types of growth [1, 8].

Conclusions. This research has enabled obtaining the guide curve for dynamic site index scale for Common oak forest stands in Ukrainian Polissya, and the corresponding dynamic site index scale itself. The conducted statistical analysis justifies acceptability of the obtained scientific results and possibility of their further application for purposes of experimental material grouping for analysis and modelling of growth and productivity of the Common oak stands in the study region. Speaking about the prospects for further elaboration of this research, it should be noted that there is a need to expand the experimental dataset by laying out additional sample plots and conducting analysis of model trees' growth patterns on them. This will enable differentiation of information support for Common oak stands in Ukrainian Polissya by origin, and contribute to obtaining more reliable results for low productivity forest stands.

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МОДЕЛЮВАННЯ РОСТУ ЗА ВИСОТОЮ ДУБОВИХ ДЕРЕВОСТАНІВ ПОЛІССЯ УКРАЇНИ

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Анотація. *У межах цього дослідження виконане моделювання росту за висотою дібров Полісся України. Вхідними даними слугували таксаційні показники деревостанів, встановлені при закладанні 91 пробної площі. На їхній основі за допомогою методів множинного регресійного аналізу отримано криву-гід росту досліджуваних деревостанів за висотою, яка представлена у статті. Виконаний статистичний аналіз адекватності показав достатню точність опису емпіричних даних розробленими математичними моделями. За*

результатами дослідження побудовано і наведено динамічну бонітетну шкалу, яку використовуватиуть для подальшого розроблення таблиць ходу росту.

Ключові слова: *Полісся України, дуб звичайний, ріст за висотою, крива-гід, моделювання.*

МОДЕЛИРОВАНИЕ РОСТА В ВЫСОТУ ДУБОВЫХ ДРЕВОСТОЕВ ПОЛЕСЬЯ УКРАИНЫ

А. П. Бала, И. П. Лакида

Аннотация. *В рамках данного исследования выполнено моделирование роста в высоту дубрав Полесья Украины. Входными данными служили таксационные показатели древостоев, установленные при закладке 91 пробной площади. На их основе с помощью методов множественного регрессионного анализа получена кривая-гид роста исследуемых древостоев в высоту, которая представлена в статье. Выполненный статистический анализ адекватности показал достаточную точность описания эмпирических данных разработанными математическими моделями. По результатам исследования построена и представлена динамическая бонитетная шкала, которая будет использоваться для дальнейшей разработки таблиц хода роста.*

Ключевые слова: *Полесье Украины, дуб обыкновенный, рост в высоту, кривая-гид, моделирование.*

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СУЧАСНИЙ СТАН ТА ПРОДУКТИВНІСТЬ МОДАЛЬНИХ БУКОВИХ ДЕРЕВОСТАНІВ УКРАЇНИ

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Анотація. *Букові ліси мають поширення на значній території як гірської, так і рівнинної частини України. Дослідження закономірностей росту модальних деревостанів потребує детального вивчення їхнього теперішнього стану. На основі повидільної бази даних ВО «Укрдержліспроект» станом на 01.01.2011 р. було проведено аналіз поширення, сучасного стану та детальну таксаційну характеристику букових деревостанів, які зростають на території України. Було пораховано їхні основні середні таксаційні показники та проведено*

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