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SIMULATION PRODUCTION OF BRANCHES OF CROWN OF BLACK ALDER TREES IN POLISSYA OF UKRAINE

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For the first time a new method for estimation of biotic production of trees crown components are approbated. The statistical characteristics of model trees and branches, the coefficients of correlation and regression models are presented. The results of the study can be used to construct a regional carbon budgets.

Key words: model branch, crown components, production, current annual increment, coefficients of correlation, model

Primary production is one of the most important characteristics of ecosystem from the standpoint of the production process. It is measured out the annual values of gross, net, ecosystem and biome production and its appraisal is of great importance for global problems solution, specifically the problem of climate change. These changes are often united with anthropogenic increase of greenhouse gas content in the atmosphere (especially of carbon dioxide). Therefore the studying of bioproduction is necessary and important part to build global and regional budgets of carbon, for climate modeling in accordance with different scenarios of society development.

In Ukraine, under the P. I. Lakyda guidance and methodology [7], with the direct participation of scientists of his school [2, 4–6] was developed a system of regulatory informational provision assessment of trees and stand of the main forest-formating wood species phytomass components, including black alder. However, in total extent of researches of Ukrainian forests bioproductivity there is a limited information on the annual production of tree components (stem, branches, roots, etc.).

The aim of the article is to learn the production of black alder branches of crown in Polissya of Ukraine for the individual components and to develop mathematical models of assessment.

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Study methods. Filled of temporary sample plots (TSP) using the model trees (MT) cutting for estimation of the components of trees and stands phytomass was carried out by the previously tested technique [7]. Assesment of production of branches of crown on model trees was made by using some improved techniques [3], essence of which is performed in :

– selected model tree crown is divided into three equal in length areas: bottom, middle and upper;

– out of each area are taken three model branches (MB) of the first order (the biggest in its diameter and length, and the average and the smallest);

– from the MB the branches of higher orders, woody herbs are detached and weighed;

– the age, height of attachment to the stem, its length (l_{br}) and growth (Δl_{br}) for n years (n = 5, 10 years) of the branches of the first order is measured;

– depending on the length of the branch, it is divided into sections (0,5 m for l_{br} to 6 m; 1,0 m for l_{br} from 6 to 12 m; 2,0 m for l_{br} over 12 m);

– diameter in the bark (d_b), double thickness of bark (τ) and the diameter increase (Δd_n) are measured at zero cut (the point of attachment of the branch to trunk is 2–3 cm) and middle sections;

– with weighting the mass of studied MB is determined and from its middle part the sample for defining the density of wood and bark is cutted.

Results of the research. In total it was filled 6 TSP of alder stand in Zhytomyr and Kyiv regions. At these TSP 20 MT of black alder were studied. From them it there were taken 145 MB for determination of their production. On the base of spreadsheet *MS Excel*, it was created a special program to calculate the absolute and relative values of increments along the known formulas in forest inventory [1] sincet imagination of biotic production has much in common with the teachings of the trees and stands increment.

To identify patterns of distribution parameters characterizing the model trees and branches of black alder and to determine the homogeneity of experimental data it was formed a working data set and was held their statistical analysis.

The meaning of basic statistics (the average ($\overline{X}$), average quadratic deviation (σ), skewness (A) and kurtosis (E)) in actual size for model trees and branches of black alder are given in Table 1.

1. Statistical characteristics of model trees and branches

Characteristic	Value		Statistics			
	minimum	maximum	$\overline{X}$	σ	A	E
a, years	8	67	41,8	19,6	-0,391	-1,147
d, cm	4,4	35,8	20,4	8,6	-0,182	-0,813
h, m	8,5	27,5	20,7	6,0	-0,479	-1,280
l_{cr}, m	2,9	10,3	6,8	1,7	0,372	-0,158
a^{br}, years	1	20	7,9	4,4	0,491	-0,663
h_{att}^{br}, m	5,6	26,7	16,9	5,9	-0,285	-1,389
m_{WH}^{br}, kg	0,04	2,60	0,44	0,39	2,594	10,120
m_{bho}^{br}, kg	0,02	2,10	0,38	0,47	2,146	4,486
m_{MB}^{br}, kg	0,01	12,30	0,77	1,34	5,894	44,244
l_{MB}^{br}, m	0,3	7,0	2,4	1,0	1,224	3,253
p_v^{br}, %	6,4	50,0	19,6	8,2	1,535	2,839
p_v^{st}, %	2,7	19,8	6,9	5,4	1,096	-0,393
$m_{abs.}^{br}$, kg	0,02	6,68	0,52	0,9	4,955	30,895

The statistical distribution of the model trees parameters (age *(a)*, diameter at a height of 1,3 m ($d_{1,3}$), height (h), length of crown (l_{cr}), current increment persantage of stem (p_v^{st})) and black alder branches (age (a^{br}) and height of branches attachment to the trunk (h_{att}^{br})) does not satisfy the conditions of a normal distribution (skewness and kurtosis values are dinstinct from zero). However, skewness and kurtosis do not exceed the permissible value for the studied parameters ($A \leq 1,0$; $E \leq 1,2$). The only exception is tree height and the height of branches attachment to the stem where the kurtosis is slightly higher than the critical value. For MB mass (m_{MB}^{br}), mass of its woody herbs (m_{WH}^{br}), and the mass of branches of higher orders (m_{bho}^{br}), MB length (l_{MB}^{br}), absolutely dry mass of MB ($m_{abs.}^{br}$) and current increment persantage of MB (p_v^{br}) is typical right-sided asymmetry and high steepness. Applying logarithm method to studied variables one can reduce the total variance and draw closer this distribution to a normal one.

In determining the coefficients of the regression equation it is necessary to take into account the correlations between the independent variables. Table 2 shows the correlation matrix of MB valuation signs with a percentage of the current increment of branches and stem of the tree.

2. The correlation coefficients of the model branches valuation

Characte-ristic	a^{br}, years	h_{att}^{br}, m	m_{WH}^{br}, kg	m_{bho}^{br}, kg	m_{MB}^{br}, kg	l_{MB}^{br}, m	p_v^{br}, %	p_v^{st}, %	$m_{abs.}^{br}$, kg
a^{br}, years	1	–	–	–	–	–	–	–	–
h_{att}^{br}, m	0,67	1,00	–	–	–	–	–	–	–
m_{WH}^{br}, kg	0,68	0,38	1	–	–	–	–	–	–
m_{bho}^{br}, kg	0,60	-0,08	0,67	1,00	–	–	–	–	–
m_{MB}^{br}, kg	0,59	0,19	0,57	0,76	1	–	–	–	–
l_{MB}^{br}, m	0,70	0,29	0,59	0,56	0,78	1,00	–	–	–
p_v^{br}, %	-0,80	-0,62	-0,51	-0,59	-0,44	-0,58	1	–	–
p_v^{st}, %	-0,73	-0,86	-0,45	0,02	-0,29	-0,47	0,79	1	–
$m_{abs.}^{br}$, kg	0,64	0,22	0,71	0,87	0,97	0,77	-0,47	-0,31	1

From the analysis of these figures we conclude that for the MB current increment persantage is typical the close inverse correlation with almost all valuation data. The link is strongest, inverse with branches age (-0,80) and direct with a percentage of the current increment of stem (0,79).

Taking into account classical methods of forest valuation using to determine current increment of each element of the forest, the further modeling of wood of branches of crown production needs assessment of their relative values: persantage of increment of wood of branches of crown as well as their interrelation with the persantage of current increment of tree. To determine these connection the regression analysis is used. It allows to analyze the value of one (dependent) variable quantity starting with the value of another (independent) variable quantity.

Multiple regression equations of persantage of current increment of model branches of trees of black alder in the region stands that is under studying and their coefficients of determination are shown in Table 3.

3. Equations characteristic of the current increment persantage of the black alder model branches of trees

Number equation	Type of equation	Q^2
1	$p_v^{br} = 59{,}2 \cdot a^{br\ -0{,}727} \cdot h_{att}^{br\ 0{,}092}$	0,91
2	$p_v^{br} = 71{,}1 \cdot a^{br\ -0{,}653} \cdot l_{MB}^{br\ -0{,}086}$	0,91
3	$p_v^{br} = 61{,}2 \cdot a^{br\ -0{,}627} \cdot m_{MB}^{br\ -0{,}034}$	0,91
4	$p_v^{br} = 8{,}9 \cdot p_v^{st\ 0{,}479}$	0,62

All coefficients in equations 1–4 are significant. Analysis of these equations remnant distribution demonstrates the adequacy of developed models according to real processes. Such models are suitable for the development of the regulatory base of valuation of biometric parameters of trees crown components of black alder.

Conclusions:

1. Collected experimental data show the stands of black alder studied and are suitable for estimation production of the components of the crown of these wood species in Ukrainian Polissya.

2. The results of study of alder stands bioproduction in the given region can significantly refresh existing information base of biotic potential of forest ecosystems in Ukraine and can facilitate the resolution of global climate change problem.

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