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THE SPECIFICS OF INFLUENCE OF URBAN ENVIRONMENT ON BIOMETRICAL PARAMETERS OF TREES IN URBAN FORESTS

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The development of the modern city is accompanied by the formation of a specific urban environment which has some affect on people. Urban forests play significant role in improving living conditions and recreation of citizens. Maintenance of green spaces according to modern standards of landscape architecture requires some measures to improve their performance that sometimes lead to complete reconstruction of urban forests. Significant volumes of wood are cut down that need to be assessed in accordance with accuracy of methods of forest mensuration.

During last decades reliable reference data was developed and now widely used in state forest enterprises for wood assessment. However, existing standards can not provide the required level of precision of urban trees volumes estimation. Long experience of use of volume tables [11] in urban forestry of the city Kyiv has proved their incompability for these purposes. Significant differences between estimated and actual values of wood volumes can be explained by conditions of urban environment that significantly affect on the biometrical parameters of trees during their growth. This fact complicates the urban forest assessment.

Taking into account the abovementioned consideration, it becomes very important to study the actual biometric parameters of trees in urban forests and to develop an appropriate reference data [5, 12]. This is important not only from practical point of view, but also for theory of tree volume estimation, since new objects of forest mensuration are appearing and requirements of accuracy of their assessment are increasing.

Objective of the research is to explore the specifics of influence of urban environment on the main biometrical parameters of trees and justification of appropriate approaches for wood volume assessment in urban forests.

Materials and methods of the research. Data collections were carried out on the territory of Kyiv during the reconstruction of urban forests. Such tree species were included in the base of experimental materials: Lombardy poplar (*Populus italica* Rosier.), White poplar (*Populus alba* L.), Black locust (*Robinia pseudoacacia* L.), Fluttering elm (*Ulmus leavis* Pall.), Boxelder maple (*Acer negundo* L.) and Silver maple (*Acer saccharinum* L.). Model trees were selecting from different categories of green spaces according to their distribution [7] in the structure of the urban forests (Table 1). This allowed to achieve the representativeness of the data. Trees were measured by 2-meters sections to calculate their volumes using Huber's formula. There were about 400 trees measured of these tree species.

1. Distribution of model trees on urban forests categories

Tree species	Number of model trees by category of urban forests			Total
	public	restricted use	special	
Lombardy poplar	24	34	14	72
White poplar	21	55	11	87
Black locust	31	43	12	86
Boxelder maple	8	28	9	45
Silver maple	14	15	8	37
Fluttering elm	34	26	6	66
Total	132	210	51	393

The data of this table show that most of the field material was obtained from urban forests that grow near residential buildings, schools, child care centers. The other two categories of green areas represent less model trees, so that correspond to the actual distribution of the total area of urban forests of Kyiv city into their categories.

On the first stage of research statistical analysis was performed aimed to test the homogeneity of the materials. Two statistical hypotheses were tested:

– significance of the differences between stem form of trees that represent different categories of green spaces;

– existence of significant differences between stem form of Boxelder maple and Silver maple trees.

Using the *F*-test and *t*-test [4] both statistical hypotheses were refused at the 5% level. This fact allowed do not take into account the existing division of urban forests by their categories and combine together all field materials for Boxelder and Silver maples (hereinafter – maple trees).

Results of the research. Based on the collected experimental materials the system of mathematical models for tree volume estimation in urban environment was developed. Methodological principles of their development are highlighted in the relevant scientific publications [12]. Subsequently, the analysis of the results was conducted by comparing the main biometric parameters of the object of research and forest stands: the stem form of trees, the ratio between height and diameter of trees, the ratio between the volume of stems and crowns, the merchantability of stem wood. To fulfill this task series of volume tables was chosen that were developed for different objects and regions [2, 6, 8–11].

Comparison of values of tree form-factors in a residential area of city with corresponding parameters of trees grown up in forest stands showed that urban trees have weaker tree form (Table 2). This can be explained by the peculiarities of tree growth in a built-up part of the city, as well as the influence of spatial and parametric characteristics of trees on stem form. In general, the deviations are systematic and increase for trees with bigger diameter at breast height, while the largest differences are typical for Black locust trees. For instance, small (2.4 %) systematic error of volume tables by M. Davydov [2] is accompanied unacceptable for forest inventory value of standard deviation which exceeds 10 %. Volume tables [11] are also based on volume equations of Black Locust trees that have less stem taper.

It should be noted that the vast majority of standards used in the forestry have been neglected precise assessment of marketable wood from tree crown, which always has been of secondary importance. However, study shows that in the urban environment crown volume has a much larger value comparable with trees that grown up in forest environment, and may have some economic value. Analyzing this issue, it had been found the percentage of tree crown volume in urban areas increases with the absolute size of the trees more rapidly than in the forest environment. Based

on collected experimental material this parameter for maple trees can reach 70 %, White poplar and Black Locust trees – 50 %.

2. The accuracy of tree volume estimation in urban forests

Tree species (comparable volume table)	Systematic error, %	Standard deviation, %
Lombardy poplar (volume tables for Black poplar [10])	11.8	2.2
Lombardy poplar (volume tables for forests of Kazakhstan [9])	6.5	3.3
White poplar (volume tables by G. Porytski [6])	3.2	2.2
White poplar (volume tables by G. Red'ko [8])	-1.9	3.4
White polar (volume tables for forests of Kazakhstan [9])	5.4	6.3
Black locust (legal volume tables [11])	15.7	12.3
Black locust (volume tables by M. Davydov [2])	2.4	10.8

Thus, for trees from urban green spaces there are two opposing tendencies: on the one hand –stems of trees have large taper, on the other – proportion of crown volume in total tree volume increases. So, the conclusions of some scientists [1, 3] that growth area of individual tree has big influence on biometrical parameters of trees become evident.

During the research it was found that the total volume of trees in urban forests exceeds the same parameter of trees grown up under forest environment. As a result, the following values of systematic error were obtained: Lombardy poplar – 0.4%, White poplar – 12.4%, Black locust – + 3.6%, maples – +3.1%. There is tendency to increase the difference between the volumes of trees with increasing their size. Volume tables systematically underestimate the total volume of White poplar and maples trees that reached 28–32 cm in diameter. It is possible to conclude that the loss of volume due to big taper of stems is fully compensated by the development of a strong crown, which accumulates considerable timber resources. As an example, Fig. 1 displays these peculiarities for White poplar trees [6], that also are typical for other tree species.

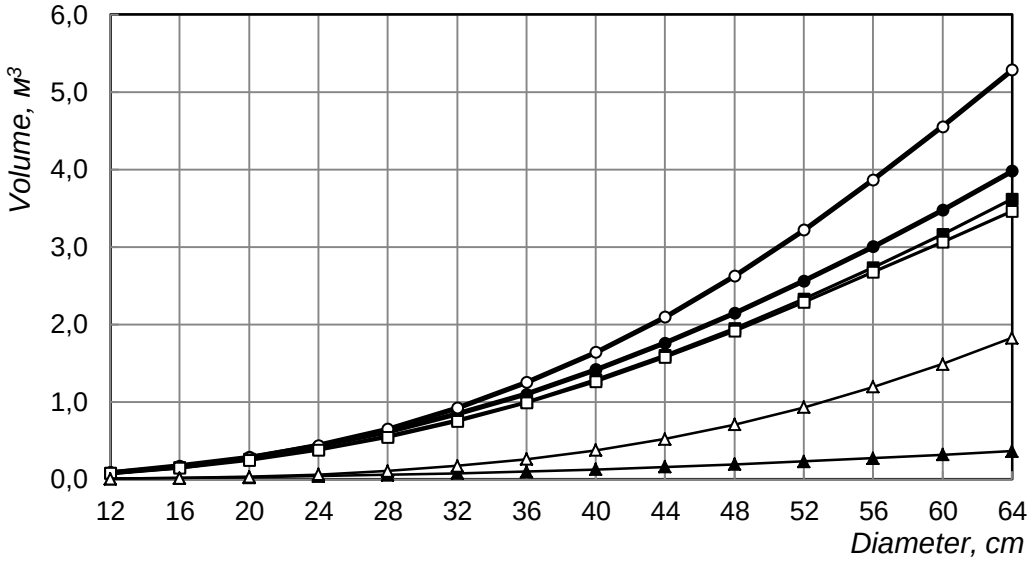

Fig. 1. Volume of White poplar trees depending on the diameter

Thus, the reasons for these differences are big taper of stems and peculiarities of tree crowns formation in the urban environment. According to Fig. 1, the increase of the total volume of trees mainly caused by crown volume rather then stem.

In most cases, the actual ratio between the height and diameter of trees does not correspond to mathematical models of existing volume tables. In particular, it was found that the trees in open space of the same diameter are reaching less height than in forest environment. This can be seen from the Table 2. Distribution of model trees by height classes determined using the following volume tables: Lombardy poplar – the tree height curves for Black poplar [10]; White poplar – the tree height curves by G. Red'ko [8]; Black locust and maples – the tree height curves of legal volume tables [11]. The information (Tabl. 2) indicates that the vast majority of model trees are in the last height classes or even out of their boundaries.

2. Distribution of model trees by height classes

Tree species	Number of trees by height classes				Number of trees out of height classes	Total
	1–2	3	4	5		
Lombardy poplar	5	26	–	–	41	72
White poplar	–	4	3	17	63	87
Black locust	–	2	27	30	27	86
Maple	–	3	11	9	59	82
Total	5	35	41	56	190	327

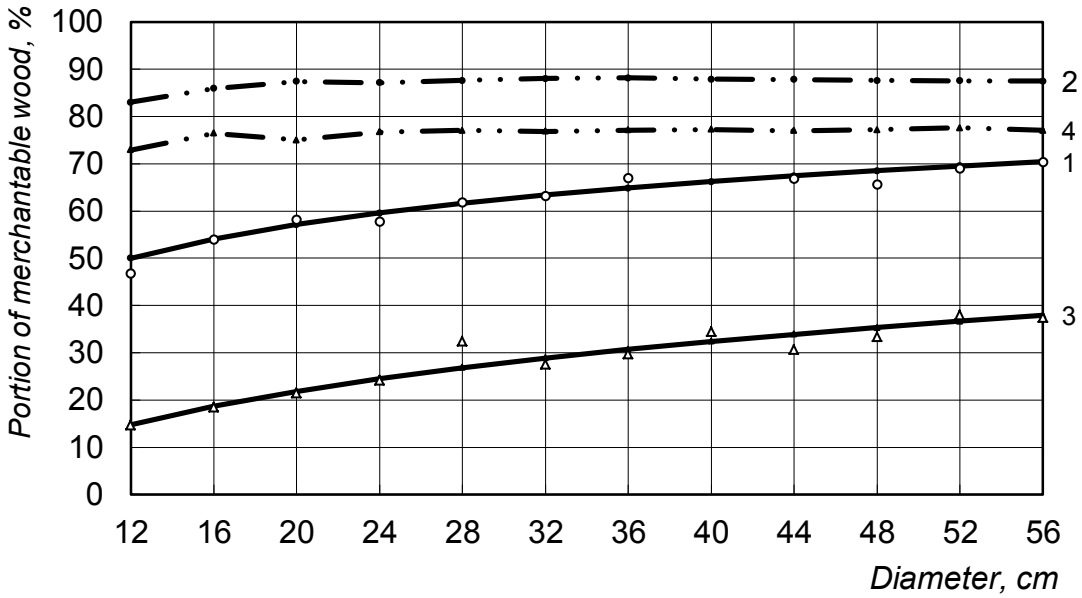

Fig. 3. Portion of merchantable wood depending tree diameters

1) White poplar (model); 2) White poplar (by G. Red'ko [8]);

3) Black locust (model); 4) Black locust (legal volume tables [11])

Analysis of biometrical parameters of trees in urban environment indicates that the yield of merchantable wood for the object of research is much lower compared with trees of forest stands (Fig. 3). The factors that have direct impact on quality of wood are curvature of tree stems and large crown that reduce the merchantable sawlog height. This parameter for different species has such values: Lombardy poplar – 60 %, White poplar – 35 %, Black locust – 15 % of the total tree height. Under this condition there are differences not only in the output of merchantable wood in general, but between individual dimension categories. All these indicate that usage of existing volume tables for the specified object is unreasonable.

Conclusions and the prospect of further research. System of mathematical models developed during research can expand an understanding of the biometric parameters of trees that have grown up in urban environments. It has been found that the errors in determining volume of wood that is harvested from urban forests caused by specifics of tree growth in urban environment. Morphometric parameters of such trees have their own specifics, thus the standards used in forestry can not provide the required accuracy of volume assessment.

In summary, some features of urban trees should be mentioned:

– tree stems have big taper;

– tree in urban environment reach a lower height than in forest environment;

– a large proportion of volume is concentrated in the crown of tree;

– wood quality is worse compared with forest environment.

Thus, these features confirm the importance of the new reference data [5] for tree volume assessment in urban environment.

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