Green plants in environmental monitoring of the environment of the large industrial city

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Abstract. The urgency of the problem is determined by the unfavorable ecological situation in the large industrial centers of Siberia, formed under the influence of man-made loads that determine the modification of the environment. This leads to changes in the properties of individual biotic components and, as a result, the quality of life of the population. An important element of the natural framework of urban ecosystems and a means to improve its urban planning qualities is the system of gardening. Currently, the existing methods of creating a system of greening the city of Krasnoyarsk and other cities of Siberia, the landscape-aesthetic principles of its formation, as well as the regulatory and technical design base do not provide the comfort of the urban environment. The basis for the development of directions and principles for the reconstruction of the greening system should be the results of environmental studies of landscape processes, the identification of the main sources of environmental stress, the study of the integrated impact of man-made stressors.

1. Introduction
The priority problem of optimizing the quality of life in the urban environment is a systematic approach to the study of woody plants as the main link in the city's ecological framework. This will allow them to evaluate their productivity, classify and model the transformation of green spaces, to reveal the features of their functioning in conditions of anthropogenic processes and landscape dynamics. Analysis of works studying the performance of the functional role of green plantations, taking into account the conditions of their growth, allowed to substantiate the methods of research and the system of parameters characterizing the processes of vital activity of woody plants under conditions of urban environment, to establish the laws of growth, the performance of ecological functions, the aesthetic perception of woody plants, territories [1-5]. The analysis of published works confirms the relevance of studies of growth processes, as well as the practical contribution of woody plants to improving the quality of life of the population. The results of the research are used as basic tools for monitoring the urban environment and for the scientific substantiation of regional concepts of landscape gardening of large industrial cities.

2 Results and Discussion
A retrospective analysis of the development and current state of greening in Krasnoyarsk has shown that the green plantations of the city are not a system of gardening, but a set of park, line, courtyard, sanitary protection areas that do not provide favorable environmental conditions in various zones of the city. An important indicator of the state of comfort of urbanized is the provision of residents with green areas of all categories, thanks to which an integral environmental and aesthetic effect develops. Analysis of the studies and the results of practical approbation showed that reaching the desired level
of comfort in industrial cities of Siberia is possible with a total area of green plantations of at least 30% of the area of urban land [5]. Currently, the greenery of the city is 60% of the above-mentioned optimal ratio of built-up area and "green" areas. The lack of landscaping of public use makes up 67% of existing and 75% of promising standards. It is required to carry out works on the expansion of green common areas for two thousand hectares.

The main composition of woody plants in urban gardening is currently represented by a limited number of species: Populus balsamifera is 42; Malus baccata - 11, Ulmus - 8, Larix sibirica - 11, Betula pendula - 8, Acer negundo - 6, Picea obovata and Picea abies -5, Tilia cordata -5 and other species - 4%. At the same time, the analysis of the species composition of green plantations showed that, taking into account the collections of botanical gardens and arboreums, the range of woody plants in the city's gardening is quite diverse - more than 400 species and varieties [5].

The results of the analysis of the risk of air and soil pollution in the main street of the streets showed that at all sites there is an excess of concentrations of harmful substances for plants from 2 to 14. The data obtained allowed zoning of streets and highways of the city, determining the area of areas where the plants are under active impact of vehicles. Four levels of impact of the road-transport system on green spaces in the main spaces have been established. As the evaluation criteria, biological norms of maximum permissible concentrations (MPC) were used. It is established that only 30% of the plantings along the city's roads grow in satisfactory conditions, where excess pollution standards for individual impurities from the impact of motor vehicles are up to three MPCs, to which background concentrations of harmful substances are added [6-9].

To assess the conditions for the growth of green plantations, the authors developed a methodology that allows to classify territories as urban types of growth conditions, that is, to allocate territories with a certain natural resource potential and density of man-made loads that determine the growth and development of urban green spaces. Urban types of growth conditions reflect the intensity of anthropogenic impact on landscaping objects and allow predicting the productivity and transformation of green plantations under given growing conditions. Examination of plantations using this technique allowed us to distinguish four types of tree growth conditions in Krasnoyarsk - satisfactory (I), tense (II), conflict (III) and critical (IV). The developed methodology is a tool for monitoring the assessment of the state of green spaces and the quality of life of the population in the urban environment.

In the urban environment, it is actual to conduct a diagnosis of its ecological state by the reaction of changes in the biometric indicators of vegetation. Morphological features of woody plants are quite informative for determining the degree of stability of growth of individual plant species under the conditions of the industrial press and the state of the urban environment. Woody plants that grow in urban environments experience stress throughout their lives, that is, they are constantly in a state where additional costs are needed to compensate for stressful effects. Achieving threshold values of limiting anthropogenic factors violates the established balance, which leads to loss of stability and premature death of plants. To describe the relationship between the mean values of tree heights with age within the height growth series, we used the formula of Micherlich [10, 11]:

$$H = b_t \times \left(1 - \exp\left(-\frac{1}{b_2}\right)\right)^{b_3},$$  \hspace{1cm} (1)

where $A$ - is the age, $b_1$, $b_2$, and $b_3$ are the coefficients of the equation.

The adequacy of the equations to the experimental material was estimated by the determination coefficient ($R^2$) and the Fisher criterion (F). Analysis of the results showed that tree species react differently to anthropogenic loads of the environment and structural features of the plantations. The results of the analysis made it possible to distinguish four types of growth of Larix siberica in height, which corresponds to the number of types of plant growth conditions in Krasnoyarsk. The coefficients and parameters of the Larix siberica growth models are represented by formulas (2).

$$Y_{(I)} = 20.82 \left(1 - \exp\left(-\frac{1}{b_2}\right)\right)^{0.69}, R^2 = 0.990$$  \hspace{1cm} (2)

$$Y_{(II)} = 15.07 \left(1 - \exp\left(-\frac{1}{b_2}\right)\right)^{0.23}, R^2 = 0.993$$

$$Y_{(III)} = 12.18 \left(1 - \exp\left(-\frac{1}{b_2}\right)\right)^{0.65}, R^2 = 0.996$$

$$Y_{(IV)} = 9.85 \left(1 - \exp\left(-\frac{1}{b_2}\right)\right)^{0.41}, R^2 = 0.976$$
Analysis of ecological growth models of Larix sibirica in height showed:

1. The growth of *Larix sibirica* plantations in height in an urbanized environment is reliably described by the Micherlich equation ($R^2$ varies from 0.98 to 0.99 for all dependencies).

2. Beginning at the age of 15, there is a tendency for trees to differ in height due to changes in ecological loads in green areas. For plantings of *Larix sibirica*, 4 types are distinguished, which corresponds to the number of types of conditions of growth in the city of Krasnoyarsk. The method of variance analysis established the reliability of their differences. The difference in mean height of trees growing in types I and II of growth conditions at the age of 45 years is 2.3 m, in II and III - 2.7 m, in III and IV - 2.6 m.

3. With increasing density of the complex of negative factors in the environmental conditions of the environment, a decrease in the plantation height is observed, reaching 19% by the age of 45 in growth type II, 34% in III, and 43% in IV compared to the satisfactory type of tree growth. Thus, the character of growth in height is determined by the cumulative influence of growing conditions. The type of growth in height is a clear indicator of this effect.

4. The spread of values relative to the growth series is 0.2 to 0.9 m in height. The greatest variance of values is observed for plantations growing in the conflict type of growth conditions, which indicates the adaptation of plants to environmental conditions. In the IV (critical) type - the range of variation of values is reduced, which reflects a significant suppression of the mechanisms of plant growth and development.

5. *Larix sibirica* is an effective indicator-indicator in environmental monitoring of large industrial cities.

3. Conclusion

Analysis of the conformity of the height and age of the plantation allows us to determine the type of growth conditions in a given area and, consequently, to predict the nature of plantation growth, coordinate the spatial structure and technology of care in order to improve the condition of plantations, and establish the level of ecological comfort for the population living in the urban environment. *Larix sibirica* has the greatest plasticity, reflects the stressful effects of the urban environment and is an effective kind of indicator. Dynamics of growth in tree height and trunk diameter are the main signifiers in monitoring the environment and assessing the level of ecological comfort in urban areas.

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