

Architectonics of woody plants in an urbanized environment

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Abstract. Urban landscaping objects are ecosystems, to a certain extent adapted to unfavorable man-made impacts. They have low environmental sustainability, they need constant support, their development, functioning and even appearance is significantly different from natural plantings. Urban plantations are affected by both natural, specific for the area, and specific technogenic factors, under the influence of which there is a change in architectonics, a decrease in viability, stability, life expectancy and even premature death of plants. The article presents the results of a comparative analysis of the proportions of the vertical structure of Siberian larch trees growing in natural and urban plantations that showed that under the conditions of the urban environment there are changes in the habitus of plants that are not characteristic of them at a certain calendar age under natural conditions. This allows us to judge the state, level of development and harmony of the tree and the comfort of the environment for the population's living. Plants, the proportions of which largely deviate from the "golden", are perceived less aesthetically, worsen the appearance of the surrounding space, affect emotionally depressing. Thus, the criteria for deviation from gold proportions should serve as a basis for assessing the conformity of plant species to external environmental conditions and when selecting an assortment of plants.

Introduction

In the face of growing urbanization, the value of the beauty of urban landscapes is immeasurably increasing. It is recognized that proportionality, harmony and flexibility of forms, elegance, proportionality, naturalness are inherent in beauty, and it is perceived as a merged image, synthesis of form and content, especially the beauty of such a large and diverse object as the city [1, 2, 3]. Man has always felt the need for beauty. Initially intuitively, guarding individual objects of nature, later consciously, preserving the landscape panorama, creating objects of landscape art, which in the complex process of biological and social connections were filled with aesthetic significance. Aesthetic perception is a complex process in which sensory abilities are combined, both innate (intuitive) and acquired by the individual in the course of education, social development. Therefore, the individual perception of the surrounding world is subjective. Subjectivity is a factor that depends on the emotional sensitivity of a person, his life experience, previous impressions and experiences, other individual qualities, and especially on knowledge of the integrity of the natural environment. In the process of perception, an involuntary comparison of the observed with the aesthetic ideals formed by a



particular person with a cultural, social or ethnic community of people occurs. The evaluation of the aesthetic merits of the surrounding space in different subjects can vary. Therefore, the assessment of the aesthetic properties of urban green spaces should be based on the totality of the results of mathematical and statistical research, while combining sensory, intellectual and evaluation approaches.

Scientific significance

Analysis of the literature shows that plants growing under conditions of urban environment, developing a special state - fitostress - as a result of the fact that in an environment different from the sum of the natural background situation hinders the existence of a natural plant. Emerging external loads lead to an increase or reduction of metabolism and development, which is reflected in the appearance of plants. At the same time, the applied radical (rejuvenating) methods of pruning plants do not contribute to their healing and the aesthetics they give. In the studies of VA. Filin [4] in the field of videoecology of the environment found that the visual environment, its saturation with visual elements constantly exerts a strong influence, especially on the organ of vision, as well as on the general mental state of a person, i.e. acts like any other environmental factor that makes up the human habitat. Indicators for assessing the visual environment are the aesthetic parameters of its objects, in particular, the green plantations of the city.

The study of the state and the forecast for the development of woody vegetation, especially in urban environments, must combine quantitative and qualitative criteria. The architectonics of the plant reflects changes in the size of crowns, the size of the photosynthetic apparatus of the plant, since the productivity of the plant depends on the quantity, quality and nature of its placement in space, and consequently its functional potential is manifested with the greatest force. Investigations by a number of authors show that when studying the dynamics of plantations, special attention should be given to changes in the shape and size of crowns, their interrelationships with the characteristics of the habitat [5, 6].

When selecting the assortment of plants for the creation and reconstruction of landscaping objects, it is necessary to take into account the aesthetic properties of woody plants, which are determined by the biological and decorative features of the species and their continuous changes under the influence of the time factor and transformation by various environmental stresses in the cities. The plant's habitus is formed as a result of growth and development and is an expression of its fitness for conditions. For the life form of a tree of a forest type, the presence of the main vertical axis (trunk - primary shoot) is characteristic, from which several lateral axes (first-order branches or skeletal branches) branch off each year. From them branches of higher orders depart. The number of orders of branching in the crown is limited in most forest trees by four or five, with shoots of 3 and 4 orders prevailing. With an increase in the branching order, the size of the shoots decreases, which indicates the presence of a subordination, strict hierarchy of shoots in the crown or self-organization, which creates «harmony of the crown» [7, 8]. Maintenance of this harmony is connected with apical domination, with the suppression of the growth of lateral shoots by a developing apical shoot, occupying a leading position. The upper buds give rise to elongated shoots, the lower ones either form shorter shoots or remain asleep. The crown of a tree develops according to the principle of acrotonia [9]. The considered change in the structure of woody plants refers to a «normal» («ideal») tree, i.e. growing in favorable conditions, without anomalies in development.

Objects and methods of research

However, the appearance of a tree that forms in urban plantations depends on the diverse conditions of growth that have developed in the greened areas of cities. The habit of seedlings or young trees is formed in nursery conditions. During this period of development, the shape of the crown depends on the stage of ontogenesis. With the age of the tree, its external appearance significantly changes under the influence of growing conditions, which leads to the creation of a habitus of the plant, which is characteristic of specific for specific growth conditions.

The structure of the tree crown is characterized by illuminated and shaded parts, ohvonenny - "clothing of the crown, part of the crown without needles - the" core of the crown ", the height of the location of the maximum diameter of the crown. Architectonic properties of green plantations determine the possibilities of compositional spatial arrangement of plants and aesthetic perception of them on the sites of gardening. At great distances, the main role is played by the height and silhouette of the tree, on the nearest - the decorative details: the foliage, its texture, the color of the bark, the pattern of the branches become more important.

Conifers bring aesthetic originality to the greening of cities, they not only keep the green dress in winter, but also the volume of their forms. Their clear, pyramidal silhouette is decorative already at a young age, they in landscape paintings are both a beautiful accent and background. Siberian larch, despite the fact that it sheds needles, is the most valuable kind for decoration of landscaped spaces due to the characteristic architectonic silhouette, a peculiar pattern of branches and the coloring of needles changing during the growing season.

Investigations by a number of authors show that the components of the natural environment are characterized by a common set of harmonic combinations, regularities due to which objects that are very far in essence are isomorphs. For example: the crown of trees, the river network, the circulatory system; spiral structure of shells of mollusks, climbing plants, etc. As a result, the harmony of nature appears as a collection of repeating structural canons. A number of harmonic canons serve as criteria for the complex evaluation of the structural, functional and aesthetic state of woody vegetation growing in an urbanized environment: golden proportions («golden» section, «golden» wurf), symmetry, fractality, rhythm.

A number of harmonic canons serve as criteria for the complex evaluation of the structural, functional and aesthetic state of woody vegetation growing in an urbanized environment: golden proportions («golden section», «golden wurf»), symmetry, fractality, rhythm. The mathematical essence of the «golden section» consists in the logical division of the whole segment into two unequal parts in such a way that the greater part so refers to the smaller, as the whole segment refers to the greater part. The proportion is expressed by an irrational quantity and is 1.6180339 ..., rounding it, it is considered to be equal to $\approx 1.618 \dots \approx 1.62, \approx 1.6$ [9].

Studies of the structure of the tree and the degree of development of the crown showed that it consists of three blocks: the illuminated and shaded parts of the crown, part of the tree without the crown, that is, it can be described by four points that divide the segment into three parts. In a number of studies it has been established that in the proportions of three-membered blocks of biological objects, the invariant of projective transformations, the double relation or wurf, is invariant in the process of growth, which is calculated from expression 1:

$$W = \frac{(CA) \cdot (DB)}{(CB) \cdot (DA)}, \quad (1)$$

where the corresponding lengths of the links between the four dismembering points A, B, C, D of the trinomial segment are given in parentheses.

For woody plants, the shape of which consists of three links: the illuminated and shaded parts of the crown, as well as part of the tree trunk without the crown, the formula 2 for calculation will look like:

$$W = \frac{(L_1 + L_2) \cdot (L_2 + L_4)}{(L_2) \cdot (L_3)}, \quad (2)$$

where W - wurf, the length of parts of the crown: L_1 - illuminated, L_2 - shaded; L_3 - the height of the tree, L_4 - part of a tree without a crown.

Biometric parameters of Siberian larch (*Larix sibirica* Ledeb.) At the age of 8 to 50 years were used as experimental basis of the research. The volume of the material used is represented by 68 landscaping objects of the city of Krasnoyarsk, where about 900 trees were surveyed.

Research results

Research and Comparative Analysis of the vertical structure of proportions larch trees anthrax, growing in natural and urban plantings, have shown that in the urban environment is changing plant habit, not peculiar to them in a certain calendar age in the wild, that gives an indication of the condition, level of development and harmony of the tree:

- in the cleanest conditions city (satisfactory type growing conditions of the plant) depending on the spatial structure of landings tracked changes in the relative values of the wood pieces sizes for unconstrained landings quantities parts (lit, shaded, without crown) trees change only slightly - to 2% for all considered elements; in plantations of group type in trees, the ratio of the illuminated, shaded parts of the crown and the part of the trunk without the crown changes with time, the total length decreases, and the amount of the illuminated part of the crown decreases. For thickened larch plantings in groups, the decrease in the length of the crown and its uplift is largely manifested, the difference between the parameters of freely growing trees and trees in the group at the age of 50 is 14%;

- the ratio of similar parameters in trees growing in a more complex environmental conditions (III - conflicting type conditions) several smoothed: the difference in the crown length is 5%, which is explained in more sparse plantings and reduced reactions of plants due to the suppression of their growth and development of man-made impacts;

- the deviation of the correspondence of real structures from the "golden" proportions varies depending on environmental conditions, while the average deviation of the real tree sizes from gold proportions is:

- with a free structure of plantations growing in the best conditions of the city, within the period under study (from 10 to 50 years): from the «gold vurf» - 1.6%, from the golden section - 0.9 and 2.3;
- for trees in group thickened plantations, the deviation from the «gold vurf» is: at 40 years, 5.4%, by 50 years it increases to 10%;

- these characteristics for trees growing against the background of type III of the conditions are also closer to each other and average 6 and 8%, increasing to 50 years of age to 9.5% and 14.5%;

- there is a tendency of the greatest approximation to the golden proportions in plants aged from 25 to 35 years, which corresponds to the maximum degree of phytosaturation of plants;

- the cumulative effect from the influence of harmful factors of the urban environment is manifested. Thus, for plantings with a free type of planting, growing under the influence of the 1st level of man-made loads, deviations from the «gold vurf» from the age of 25 do not exceed 1%, over time the tree is perceived proportionally, proportionately, harmoniously. The proportions of Siberian larch growing in type IV gradual conditions, at the age of 10 years, are accurate enough, with a deviation of 2%, to correspond to the values of the «gold vuorf». During the 40-year period of growth in the increase took place in Krasnoyarsk urban environment technological impacts that affected the habit of plant parameters: the absolute value of the height of the tree cut, there was a redistribution of effective and ineffective parts of the crown, that by 40-50 years of age affected the appearance of the tree. The deviation of sizes from the aesthetic proportions is: from the golden section for the crown as a whole - 25, the illuminated and shaded parts - 80%, and for the shape of the tree as a whole from the «golden vurf» - 30%;

- the level of transformation of plant proportions reflects the degree of pathological (deviation from the norm) state of trees. Plants, the proportions of which largely deviate from the "golden", are perceived less aesthetically, worsen the appearance of the surrounding space, affect emotionally depressing. Thus, the criteria for deviating from gold proportions should serve as a basis for assessing the conformity of plant species to external environmental conditions and when selecting the range of plants;

- woody vegetation, depending on its decorative state, emotionally enough affects a person and causes synesthetic sensations, i.e. When one stimulus acts simultaneously, sensations of different nature arise: spatial and color images are combined, causing certain emotional experiences (feelings of satisfaction, pleasure and joy, or irritation, depression and even fear). Synesthetic comparisons help to accurately and fully convey figurative emotional experiences:

positive - "emerald needles", "warm color", "soft whispering of leaves" and negative "flashy colors", "cold tone", etc. Thus, the plantations with traditional aesthetic qualities cause a response to aesthetic reactions and create a special emotional mood among the inhabitants of cities;

- harmonious proportions of the tree, confirmed by the calculated values of the «golden section and vurf», reflect the principle of optimality, which can be traced in the space-time correlation of structural and functional characteristics.

Conclusion

The results obtained on the basis of methods for the quantitative evaluation of the aesthetics of plant development in urban areas should be used in various areas of green construction: in the technology of pruning plantations, when selecting the range of vegetation, in creating a three-dimensional image of the planting object, when identifying as particularly valuable specimens, promising for preservation as dendroacents, and plants that have low aesthetic properties to be removed. Decorative haircut plants in accordance with the proportions that correspond to the "golden", can be one of the ways to improve the decorative quality of the visual aesthetic quality of the urban environment. The results of the assessment of the main indicators of the state of the tree as a whole, and in particular its crowns, such as architectonics, resource and aesthetic potential, should be taken into account when creating landscaping objects and determining the level of comfort of the urban environment for the population living in it.

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