Environmental efficiency of the cluster method of analysis of greenery objects' decorative advantages

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Abstract. An original method of assessment of decorative advantages of the species structure based on the cluster analysis and indexes of biological diversity was developed. It was revealed that measures for enrichment of the species structure with decorative arboreal plants help to improve not only aesthetical but also sanitary functions (the correlation ratio is 0.73). It shows the efficiency of the correlation analysis for revealing the mechanism and methods of optimization of greenery objects of urban agglomerations.
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Introduction

In the areas with small amount of forests and poor species diversity of the natural dendroflora, greenery is of special environmental and social importance [1, 2, 3]. Application of mainly line planting of single species culture in the Volgograd metropolitan area resulted in emergence of large areas of rapidly ageing greenery, which was exposed to degradation in view of increasing anthropogenic burden. The necessity of analysis of the contemporary state of greenery in the dry Steppe emerged. In the arid regions, the task of decorative optimization of greenery is to enrich the species diversity of arboreal plants, change their structure by means of correlating the life forms and placement in urban agglomerations.

The decorativeness of plants is one of the main factors in compositions of greenery (parks, public gardens, boulevards, etc.). The existing methods of determining the decorativeness mainly reflect the quality characteristics and cannot be applied in some cases at express ranking of greenery objects by this indicator due to their subjectivity. Quantitative methods of study allow for more unbiased assessment. They are necessary for quick revelation of ways and directions of optimization of the decorative advantages of stands and the greening objects.

The objective of the research was to determine the efficiency of using the cluster method at the analysis of the decorative advantages of greenery.

Methodology

The research was carried out during the period between 2006 and 2013. Experiments were fulfilled in the territory of the Volgograd agglomeration. The research object was greenery of public and limited usage (Table 1).

Table 1. Characteristic of the research objects

Indicators of research subjects	Planting crops				
	limited use spaces				public spaces
	university square	schoolyard planting	plantation hospital complex	intradistrict planting	boulevard
Year of planting	1957-1980	1975	1980	1950-1980	1975
Area, ha	32.0	1.62	1.90	0.16	5.50
Dominant tree species	*Ulmus pumila*, *Robinia pseudoacacia*, *Fraxinus pennsylvanica*	*Ulmus pumila*, *Populus pyramidalis*, *Populus deltoides*	*Pinus sylve-stris*, *Betula pendula*, *Aesculus hippocastanum*	*Fraxinus pennsylvanica*, *Ulmus pumila*, *Robinia pseudoacacia*	*Ulmus pumila*, *Catalpa bignonioides*, *Populus balsamifera*

Collection of the source material for developing the methodology of assessment of the decorative advantages was carried out with account of common recommendations [4, 5]. Their system belonging was clarified with reference publications [6, 7]. The climatic potential is not very advantageous for greening; therefore, it is necessary to approach development of measures for formation of greenery substantially. Increase of the environmental stability and decorative durability of greenery in urban

landscapes is achieved through expanding the variety of trees and bushes and increasing the diversity of species and types of greenery.

Body of the work

In order to identify the link between decorativeness and diversity of greenery, we used the Margalef index (the index of species richness) and the Berger-Parker index (the dominance index), which are the most acceptable ones in terms of methodology and which honestly reflect the situation. The Margalef index of species richnessis calculated by the formula: $D_{Mg}=(S-1)/lnN$ based on the number of revealed tree species (S) and the general number of trees (N).

The greater the value of the index is, the more versatile the greenery and its decorative properties are. In view of the fact that the existing greenery in larger areas is represented by single species cultures, assessment of dominance can be provided by the Berger-Parker index. It expresses the relative significance of the most widely spread species and is determined by the formula: $d=N_{max}/N$, where N_{max} is the number of trees of the most widely spread species [8-11].

The cluster analysis allows to understand the biological diversity and to compare the greenery objects by this attribute. With this purpose, species were broken up into homogeneous groups (clusters) with account of their versatile decorative properties (flowers, leaves, fruits, the crown form and the color of the bark, etc.). The compiled matrices of likeliness for the compared greenery objects were broken up into groups by the degree of their similarity. This method can be successfully used for comparison of decorative elements in the structure of greenery stands. Based on the cluster analysis, it is possible to develop recommendations on improvement of the decorativeness of greenery. These events are based on extension of the diversity of decorative range of trees and bushes. As applied to the research objects, the Margalef index of species richnessshowed that the greenery stand at the public garden at VolGAU are biologically versatile (Figure 1).

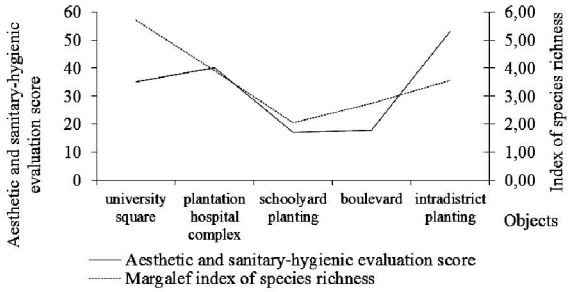

Figure 1. Comparative assessment of biological diversity (by Margalef and Berger-Parker indexes) on the greenery objects

The value of the Berger-Parker's dominance index is below 0.2, which evidences the necessity to take measures on enrichment of the species structure of the greenery. Enrichment of the greenery structure of the community accordingly results in improvement of sanitary and aesthetical functions (the correlation ratio is 0.73). The multivariance analysis allows identifying objectivity of grouping species by the likeliness of displayed aesthetical properties into homogeneous clusters (Figure 2).

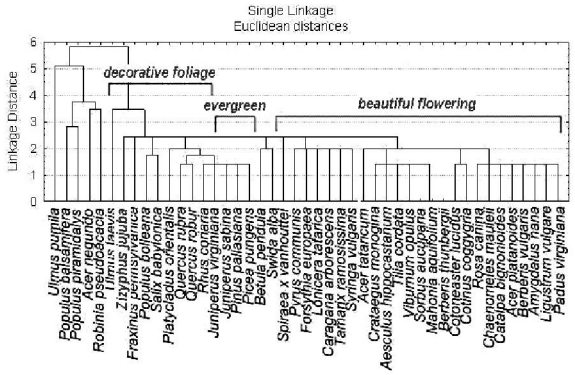

Figure 2. The tree diagram of the cluster analysis of decorative species' aesthetical attractiveness.

In order to form aesthetically attractive greenery in a dry region, four groups of tree plants were identified and recommended, which will help to improve the recreational volume of the landscape throughout the year (Figure 3).

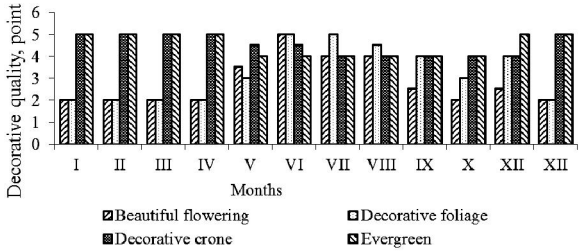

Figure 3. Breakdown of tree plants by decorativeness throughout the year

Special focus should be made on the evergreen trees with decorative tops, which are most attractive in winter. It was revealed that group planting of decorative bushes in the researched objects of greenery achieve maximum decorativeness 3-4 times sooner (at the age of 3-5 years) compared to pure tree groups and monocultures, which is determined by expedition of formation of the trees' habit.

The correlation analysis shows strong connection of aesthetical attractiveness of the

landscape with the species diversity of decorative plants. Increase in the number of trees in a landscape quarter up to 15-20 and of bushes – up to 20-25 allows raising the aesthetical attractiveness to 45 out of 50 scores (r = 0.89, r = 0.84). Mixed (multispecies) multilevel group planting is aesthetically more attractive (Table 2).

Conclusion

Based on the complex assessment of the state of greenery, criteria of selection of adapted range were developed with account of its sanitary and landscape-aesthetical advantages.

Table 2. Comprehensive assessment of decorativeness displays in groups of various structure

Group structure	Species	Decorative properties of plants	Displays of decorative properties of the group, days a year
Pure	Cottonwood	autumn color of leaves	15
	Common catalpa	shape, size and color of flowers	15
	Crimean pipe	umbrella crown	365
	Drooping willow	bright color of the bark, weeping shape of the crown	365
	Common lilac	shape, size and color of flowers	15
	European forsythia	shape, size and color of flowers	30
	Drooping birch	lace crown, color of the bark	134
	Common snowberry	berry color	90
Mixed	Colorado spruce Drooping birch Horse chestnut	conic shape of the crown lace crown, color of the bark shape, size and color of flowers	365
	Red juniper Savine juniper	shape of the crown, fir needles' color	365
	Staghorn Philadelphus coronarius	autumn color of leaves bright abundant blossom	150

The dispersion analysis of certain elements (aesthetical attractiveness and number of species) is provided in Table 3.

Table 3. The extent of factors' effect in the dispersion system

Values	Factors			
	Organized/random factors	life form, architectonics	peculiar features of the species, decorative properties	combination of factors
Dispersions		10,512.50	195,227.11	15,633.33
Influence ratio	0.82/0.18	0.04	0.72	0.06
%	82/18	3.9	72.3	5.8

The decorative properties are determined by the biological peculiarities of the species. The influence ratio of this factor is 72.3%. The influence of the combination of factors is not significant (3.9% and 5.8% accordingly).

Summary

Thus, the methodology of assessment of decorative properties of the species structure of greenery is based on the modern approaches and targets express analysis of greenery. It is necessary to take measures on optimization of the decorativeness of greenery, which is evidenced by the values of the determined index of species weald and dominance. The cluster analysis by the similarity of displays of the decorative properties allows substantiating the nonpartisanship at selection of the range of species. It was stated that measure on enrichment of the species structure of tree plants and optimization of the structure of greenery in agglomerations contribute in improvement of the aesthetical and sanitary functions (the correlation ratio is 0.73).

Credits

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