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Assessment of Recreational Potential Dendrological Collections of the Federal Scientific Centre of Agroecology of the Russian Academy of Sciences

V.V. Vishnyakova[1], A.I. Belyaev[1], E.V. Kalmykova[1]

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ABSTRACT

Background: Dendrological collections and arboretums, being an integral part of the urban landscape, significant elements of its natural and ecological framework, as a rule, also perform recreational functions. The purpose of the study was to assess the recreational potential of dendrological collections and forest plantations of the Federal Scientific Center for Agroecology of the Russian Academy of Sciences for the formation of a program for the renovation of objects as significant elements of the natural-ecological framework of urbanized territories.

Methods: The objects of the study are the dendrological collections of the Federal Scientific Center for Agroecology of the Russian Academy of Sciences, which are located in the cities of Volgograd and Kamyshin, Volgograd region. A comprehensive assessment of objects was carried out according to a system of indicators that determine the qualitative characteristics of recreational potential, for each of which coefficients were calculated: CA- Attractiveness coefficient, CC- Comfort coefficient, CR- Resistance to recreational loads coefficient.

Result: Analysis of the spatial distribution of assessment results makes it possible to use research materials to develop a targeted program of measures to increase the sustainability of ecosystems.

Key words: Class of recreational value, Dendrological collections, Evaluation indicators, Recreational functions, Recreational potential.

INTRODUCTION

On the basis of the Federal Scientific Center for Agroecology, Integrated Reclamation and Protective Afforestation of the Russian Academy of Sciences (FSC Agroecology RAS), selection of tree species is carried out for protective afforestation and landscaping of settlements in treeless areas with an arid climate. For these purposes, in the first half of the 20th century, dendrological collections were formed in various soil and climatic conditions, including in the cities of Volgograd and Kamyshin. The collection fund included up to 500 species, hybrids and forms of trees and shrubs. The main factor in selecting positive trees for protective afforestation and landscaping is their resistance to adverse external influences, such as frost, drought, salinity, gas pollution, *etc*. At the moment, the denrological collections of the FSC Agroecology RAS represent particularly valuable material for positive selection since they consist of old-growth plantings that have survived the systematic impact of extreme conditions.

In the context of modern trends in the development of urban territorial systems, forests and other dendrological formations of natural and artificial origin, including dendrological parks and arboretums bordering directly on urban areas, are at risk for multiple parameters. First of all, the state of urban green objects is influenced by numerous negative anthropogenic and technogenic factors, the totality of which, with their constant influence, inevitably leads to the degradation of green spaces. The availability of urban engineering infrastructure and transport communications increases investment interest in green areas on the part of developers. Residential development is increasingly taking place at the expense of urban green areas. Modern plans and schemes for the territorial development of urbanized territories do not contain sufficiently complete information about the qualitative and quantitative indicators of the value of the recreational potential of a particular forest area or arboretum.

Dendrological collections and forest plantations of the FSC Agroecology RAS, located in the cities of Volgograd and Kamyshin, Volgograd Region, are significant elements of the natural-ecological framework and perform, among

[1]Laboratory of Bioecology of Woody Plants, Federal Scientific Centre of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences, Volgograd-400 062, Russia.

Corresponding Author: E.V. Kalmykova, Laboratory of Bioecology of Woody Plants, Federal Scientific Centre of Agroecology, Complex Melioration and Protective Afforestation of the Russian Academy of Sciences, Volgograd-400 062, Russia.
Email: kalmukova-ev@vfanc.ru

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other things, recreational functions, which are determined by the need to meet the needs of the population for recreation, restoration of vitality, physical, emotional and spiritual, healing in the natural environment (Semenyutina *et al*., 2015; Kaixuan *et al*., 2020; Brasales *et al*., 2019; Koshelev *et al*., 2024).

The assessment of recreational potential is mainly carried out based on factors of tourist attractiveness of objects (Ushakova *et al*., 2018; Rogach, 2018; Ushakova and Tsoy, 2020). It was noted that in the context of sustainable development, assessment of recreational potential expands the possibilities of using natural resources for various types of tourism and recreational activities (Ushakova *et al*., 2021).

When solving the problem of choosing methods, criteria and assessment indicators, many authors propose to use a comprehensive strategy for assessing the recreational potential of a territory with component and integral assessment of resources (Moiseev *et al*., 1990; Musin and Zaripov, 2013; Serikov, 2013; Rysin *et al*., 2015; Levandovskaya and Rysin, 2019; Ushakova *et al*., 2020; Mezenina *et al*., 2020; Rysin *et al*., 2020). Using the results of recreational potential assessments to inform spatial planning schemes allows for the development of management measures for urban natural and man-made green areas characterized by increasing year-round use and development encroachment (D'Antonio, 2016; Sinelnikova, 2019). Research shows that forests in close proximity to development are the most problematic for sustainable management due to their high levels of recreational use (Budruk and Manning, 2004). Urban forests, forest parks and dendroparks provide multiple ecosystem services (among which recreation is one of the most important) to city residents and at the same time ensure the preservation of bioresource potential and biodiversity. In the sustainable environmental management paradigm, it is necessary to determine the balance of recreational use while conserving resources, thereby maintaining a healthy ecosystem (Wolch *et al*., 2014; Voronina, 2017; Zotova, 2018). Recreation management strategies can be tools to protect biodiversity (Lupp *et al*., 2016; Ziganshin and Ivanov, 2017).

Thus, the purpose of the study is to assess the recreational potential of dendrological collections and forest plantations of the FSC Agroecology RAS in the cities of Volgograd and Kamyshin for the further formation of a program for renovation and sustainable development of objects as relevant elements of the natural-ecological framework of urbanized territories.

MATERIALS AND METHODS

The objects of the study are the dendrological collections of the FSC Agroecology RAS, located in the cities of Volgograd and Kamyshin, Volgograd region. The Lapshin Garden forest park includes the territory of the cultural heritage site of regional significance "The Former Lapshin E.F. Estate" and its security zone. The object is located in the Kirovsky district of the city of Volgograd, bordering on the territories of a shopping and entertainment center and large residential areas (Fig 1).

The complex of forest plantations in the city of Kamyshin is located in the eastern part of the city, adjacent to the urban development from the north, south and west, the eastern border runs along the P-228 highway (Fig 2).

A comprehensive assessment of the facilities was carried out according to a system of indicators that determine the qualitative characteristics of recreational potential (Moiseev *et al*., 1990; Chudetsky *et al*., 2014; Akatieva, 2023; Chechetin *et al*., 2021). According to the principle of cumulative impact, the estimated indicators were grouped into three groups (Table 1): attractiveness, comfort and resistance to recreational effects (Rysin *et al*., 2020). The indicators were evaluated on a three-point scale - from 0 to

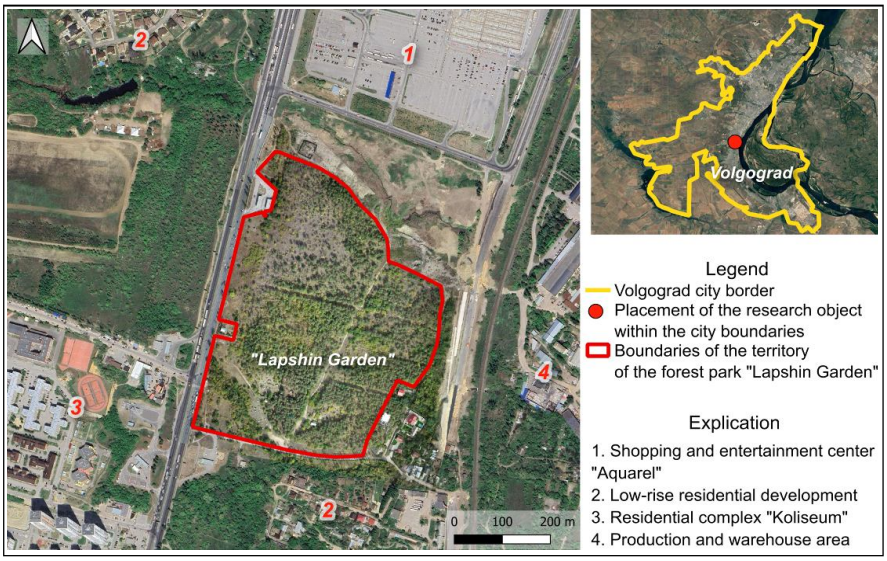


Fig 1: Forest park "Lapshin Garden" (Volgograd).

2 points. For each of the three groups of indicators of recreational potential, the corresponding coefficients were calculated: CA - the coefficient of attractiveness, CC - the coefficient of comfort, CR - the coefficient of resistance to recreational loads. This formula was used for the calculation (Levandovskaya and Rysin, 2019):

$$K = \frac{SB}{SB_{max}}$$

Where:

K = Directly calculated coefficient (CA, CC, CR),

SB = Sum of points obtained by adding up the results of the evaluation of indicators,

SB_{max} = The maximum possible amount of points for each group of indicators.

The recreational value of the plantings was determined by the ratio and range of values of the calculated indicators. According to the results of the assessment, the plantings were assigned classes of recreational value (CRV): Class 1 - with the values of each of the coefficients above 0.67; Class 2 - provided that the value of at least one of the coefficients is in the range from 0.34 to 0.66 and the value of the rest exceeds 0.33; Class 3 - with the value of at least one coefficient equal to or less than 0.33. The recreational value class of the site determines the prospects for recreational use of the territory, possible regulations or the need for strict restrictions before carrying out a set of measures to increase sustainability.

The work was carried out in the laboratory of bioecology of woody plants of the FSC Agroecology RAS. Field studies were carried out in the period from May to September 2023. At the stage of desk work, the collected materials were processed and digitized. Taxon names are given in accordance with the International Plant Name Index (IPNI). Satellite images of the Google base map were used as the initial cartographic material. Mapping and subsequent decoding of satellite images were carried out in the geographic information system Quantum GIS 3.18.

RESULTS AND DISCUSSION

To assess the recreational potential, the territories of the research objects were divided into areas with a more or less homogeneous landscape and recreational structure. The territory of forest park plantations in Kamyshin is represented by 30 plots ranging from 1.0 to 15.0 hectares. The “Lapshin Garden” forest park in Volgograd is divided into 7 plots - from 1.5 to 6.0 hectares. The division into sections was carried out mainly by existing communication links (park paths) or by natural or artificial visual boundaries.

The attractiveness of both forest park areas is at a fairly high level: the average value of the attractiveness coefficient of the “Lapshin Garden” forest park (Volgograd) was 0.73, the attractiveness coefficient of forest park plantations in Kamyshin is 0.68 on average. Evaluation of the attractiveness of plantings is usually subjective in nature, since it is associated with emotional, *i.e*. sensory perception of the object. The evaluation indicators in the methodology used allow an objective assessment in a quantitative system of points. High ratings are provided, first of all, by indicators of the age and breed composition of the stand. The “Lapshin Garden” (in Volgograd) has an almost homogeneous composition, as the main species are the planting of *Pinus silvestris*, the undergrowth and edges are formed by *Acer negundo* L., *Fraxinus americana* L., *Ulmus pumila* L., from the bushes of *Cotinus coggygria* Scop., *Frangula alnus* Mill. The array was laid in the 50s of the last century, respectively, the age of the plantings is up to 70 years. The considerable age of the stand contributes to the formation of a special emotional image (Fig 3a).

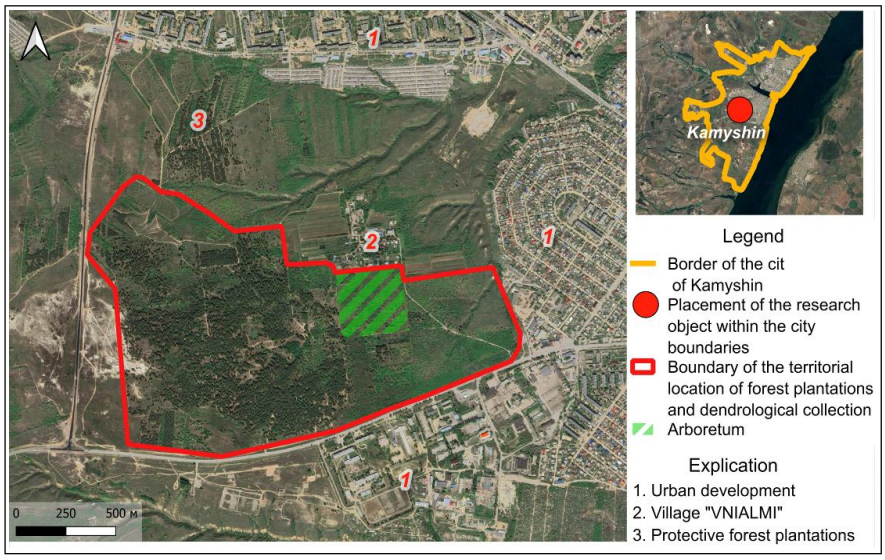


Fig 2: Complex of forest protection plantations in the city of Kamyshin.

The studied complex of forest plantations located in the city of Kamyshin is not homogeneous (Fig 3b). Its western part (sites 2, 3, 27, 28 and all located to the west) consists of protective plantings of *Pinus ponderosa* Douglas ex Loudon, *Pinus laricio subsp. pallasiana* (Lamb.) K.Richt. and their hybrids. Planted more than 100 years ago, the sand-fortifying plantings have turned into a picturesque coniferous forest park. Additional species are *Quercus rubra* L. and *Acer platanoides* L. The age and condition of the stand provide the plantings with a high indicator of attractiveness. Plots 1 and 4 represent the collection funds of the arboretum, organized at the arboretum nursery. On the territory of the arboretum there are more than 300 names of taxa with high potential for use in forest reclamation and landscaping plantings, including *Acer* L., Quercus L., *Đinus, Larix* Mill., *Picea, Juniperus virginiana* L., *Thuja, Celtis occidentalis* L., *Corylus avellana* L., *Tilia* L., *Elaegnus angustifolia* L., *Robinia pseudoacacia* L., *Sorbus* L., *Ulmus* L., *Aesculus hippocastanum* L., *Populus* L., *Padus* L., *Rosa* L., *Fraxinus* L., *Crataegus* L., *Amelanchie*, *Viburnum* L., *Caragana arborescens* Lam., *Cotinus coggygria* Scop., *Ptelea trifoliata* L., *Mahonia repens* (Lindl.) G. Don., *Cytisus* L., *etc*. Species diversity contributes to increase in ¸the level of attractiveness, but the high density of the tree stand in most stands, less pronounced layering of homogeneous plantings, as well as clutter with shoots and grass underestimate the assessment the corresponding indicators.

The plots located in the eastern part of the studied massif are geographically adjacent directly to urban development and represent protective forest plantations. The distribution of the value of the attractiveness coefficient by the sites of the studied territories is shown in Fig 4.

The level of comfort of plantings at both sites was determined as average - 0.45. The comfort level indicators chosen by us as evaluative ones determine the set of necessary conditions for the implementation of the recreation function on a landscape object, including the organization of spatial structure, engineering infrastructure and landscaping, the relationship with the external environment. In conditions of arid climate and, accordingly, excessively high summer temperatures and increased insolation conditions, special requirements for the implementation of recreational functions are imposed on the spatial structures of green objects. The ratio of open and closed spatial structures was evaluated for each section of objects according to the canopy closeness parameter. The closeness of the canopy of plantings was calculated as the ratio of the area of the horizontal projection of the canopy of a stand without gaps to the area of the plot (Moiseev *et al*., 1990). The projections of the canopy of the stand, as well as the area of the plots, were calculated from satellite images in the Qgis system. The highest 2 points were assigned if the values were 0.7 or more, the 1st point corresponded to values from 0.3 to 0.69, values less than 0.3 were estimated

Table 1: System of indicators for assessing the recreational potential of plantings.

Criteria of recreational potentialmax possible number of points	Estimated indicators
Attractiveness14	Age of the stand, years
	Breed composition
	Mixing of breeds
	Average height of the stand
	Vertical structure (tiering)
	Horizontal structure (mosaic)
	Littering and / or clutteriness of the site
Comfort18	Terrain of the site
	The ratio of open and closed
	Insolation (presence of shaded areas)
	Aeration (ventilation, wind protection)
	Availability of a road and path network
	The presence of elements of landscaping
	Accessibility (distance to public transport stops and/or residential areas)
	The presence of a water body
	Noise mode
Resistance to recreational effects12	Recreational disturbance (digression stage)
	Sanitary condition (pest damage and/or disease infestation)
	The presence of viable undergrowth
	Presence of undergrowth
	Stability of the lower tiers of vegetation
	Soil compaction

at 0 points. A significant indicator of comfort is the presence of infrastructure facilities on the territory of the system: A road and path network, equipped places for recreation, observation decks, glades, benches, *etc*. At both sites, we have identified only a conditional network of paths formed rather spontaneously by recreants, in accordance with the most popular directions, in easily passable places. Pedestrian communications are most clearly expressed on the territory of coniferous plantings of the forest park in Kamyshin, which confirms the attractiveness of the object for residents of the city. The distribution according to the indicator of the comfort of the studied territories is shown in (Fig 5).

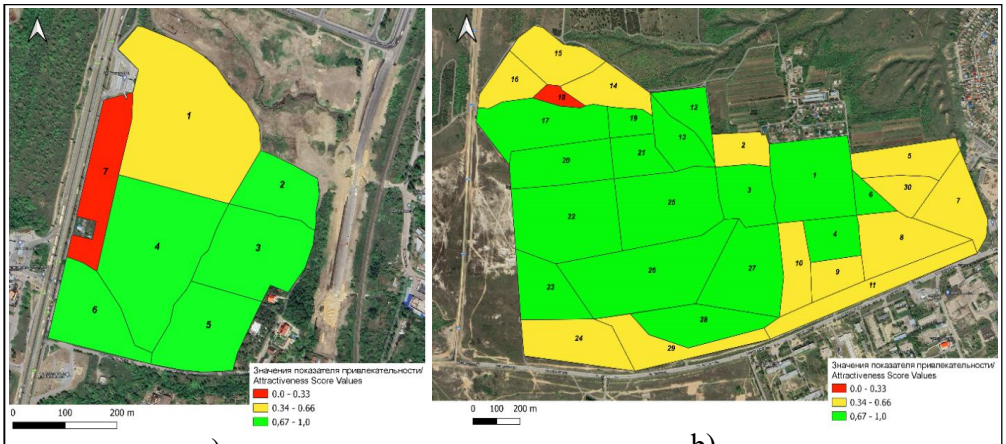
Stability shows an average value, which is explained, rather, not by a high degree of recreational load. Due to the lack of infrastructure and landscaping elements, potential recreational facilities are not particularly popular with the population. The assessment of the stability of plantings determines their ability to withstand negative external influences affecting the growth and development of plants, leading to premature decay of stands and deformation of the species composition (Fig 6).

The estimated indicators of resistance to recreational effects adopted in the study correlate with the external signs of determining the stability of plantings during taxation (Moiseev *et al*., 1990). The studied forest park

a) b)

a) Lapshin Garden (Volgograd); b) Forest plantations in Kamyshin.

Fig 3: Current state of forest parks (July-September 2023).



a) b)

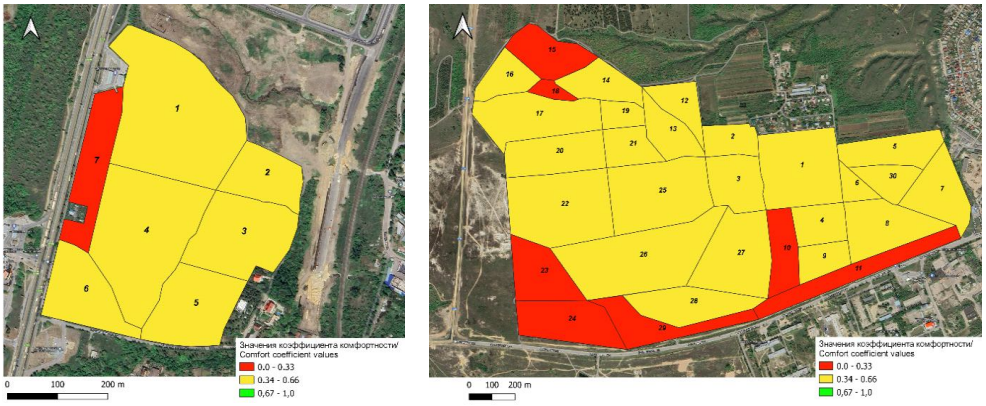
a) Lapshin Garden (Volgograd); b) Forest plantations in Kamyshin.

Fig 4: Distribution of forest parks by attractiveness indicator.

plantings according to the scale of plantings stability (Moiseev *et al*., 1990) belong to the 1st and 2nd classes. Healthy coniferous trees in plantings are noted from 71% to 90%, deciduous - at least 60%. Viable, reliable undergrowth and brushwood are noted in the plantings (Fig 7). The ground cover is mainly alive. At both sites in coniferous tracts, a moss cover is detected.

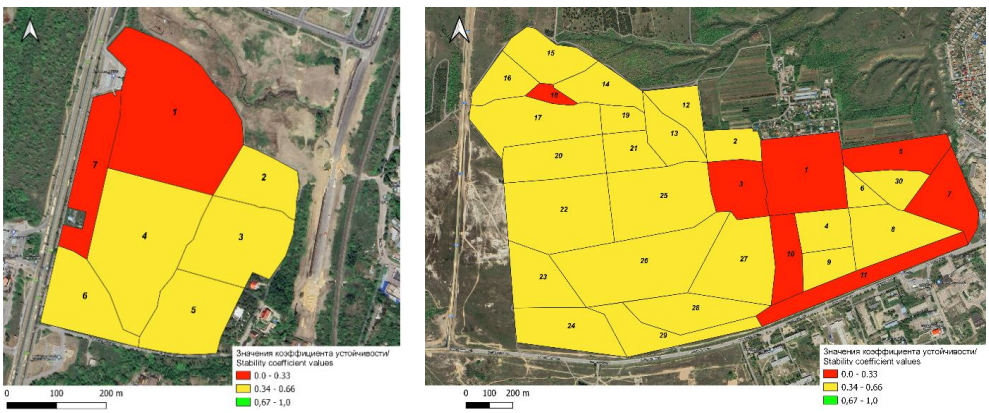
The predominance of annual weed species, as the main criterion of digression in arid zones (Solodovnikov and Kanishchev, 2012), is noted mainly in areas bordering transport highways, as well as on the territory of the Kamyshin's Arboretum (sections 1 and 4). In general, the satisfactory condition of the plantings is noted.

The results obtained allow us to draw an objective picture of the state of the objects under study to assess the prospects and consequences of further recreational use (Fig 8). The average attractiveness scores for both objects range from 1.03 to 2 points. The lowest score (1.03) is the indicator of horizontal density of plantings on the territory of the complex in the city of Kamyshin due to the large number of open spaces. The highest values at both sites are indices of tree stand age and vertical density (1.89/2 and 1.5/1.86 - Kamyshin/Volgograd, respectively). High ratings of the comfort indicator at the facilities are provided by the calm terrain (1.9/2) and the presence of a sufficient number of shaded areas (1.17/1.17). At the same time, both sites lack infrastructure and landscaping elements (0/0), as well as recreational reservoirs (0/0). Relatively comfortable noise conditions are provided in areas with high tree stands (1.77/ 1.14). The indicator of sustainability of plantings is one of the most important for measures of positive selection of trees for protective afforestation and landscaping. A comprehensive assessment of the indicator of 0.39 points for plantings in Kamyshin was formed due to the differentiation of types of plantings. The forest park complex in Volgograd shows greater stability - 0.5 points. The indicators of recreational impairment (1.14) and the presence of undergrowth (1.57) have high values.



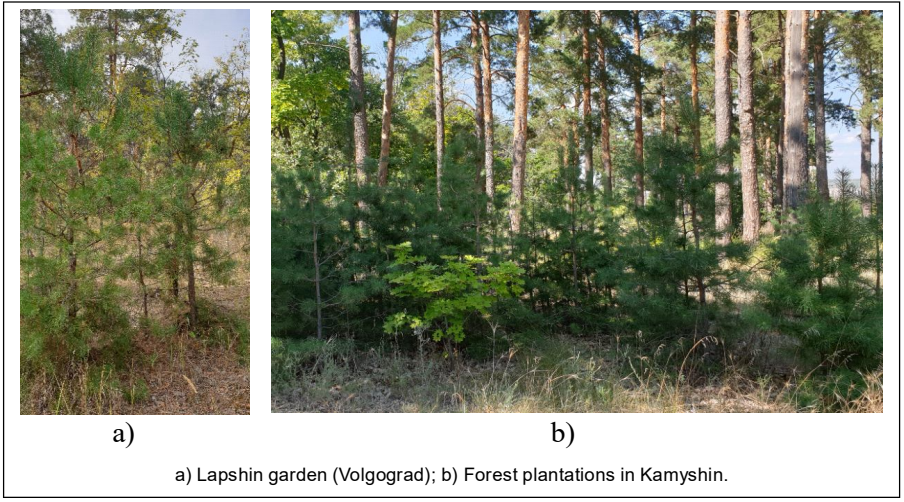
a) Lapshin Garden (Volgograd); b) Forest plantations in Kamyshin.

Fig 5: Distribution of forest park territories according to comfort indicator.



a) Lapshin Garden (Volgograd); b) Forest plantations in Kamyshin.

Fig 6: Distribution of forest park territories by sustainability indicator.

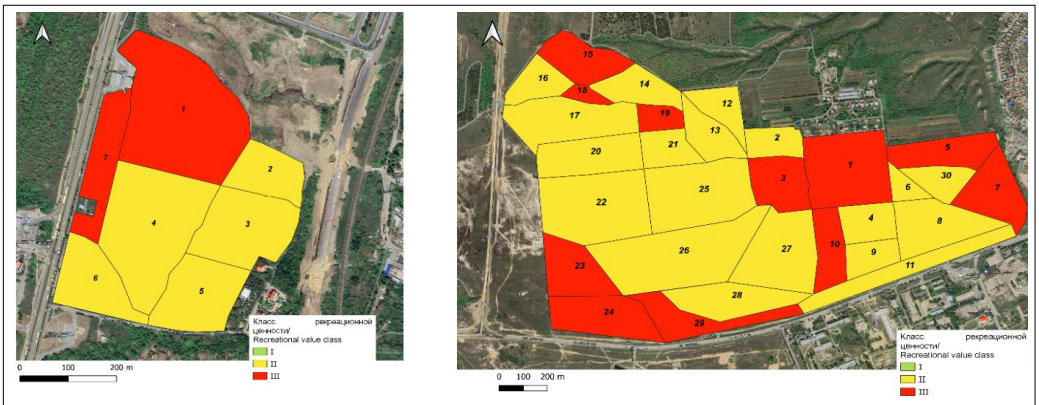


a) b)

a) Lapshin garden (Volgograd); b) Forest plantations in Kamyshin.

Fig 7: Viable undergrowth.

Fig 8: Results of a comprehensive assessment of recreational potential using a system of indicators.



a) b)

à) Lapshin Garden (Volgograd); b) Forest plantations in Kamyshin.

Fig 9: Results of assessing the recreational potential of plantings at the study sites.

Based on the results obtained, it was concluded that the recreational potential of the studied territories can be assessed as sufficiently high. Thus, of the total number of plantings of the Lapshin Garden forest park, most, *i.e*. 63% of the territory, belongs to the II class of recreational value (CRV) (Fig 9a) and 37% of the territory belongs to the III CRV. Plantings on the territory of the Kamyshin forest area were also divided into two classes: 67% - II CRV and 33% - III CRV (Fig 9b).

CONCLUSION

It was found that both objects of the study and the forest park "Lapshin Garden" in Volgograd and an array of forest plantations in the city of Kamyshin have a high recreational potential. At the same time, relevant for urban residents, green objects over time, without carrying out appropriate complex economic measures, may lose their recreational potential. It is obvious that objects can become more attractive and comfortable as a result of the formation of pedestrian and communication links, the placement and equipment of recreation areas, the arrangement of glades and viewing platforms, *etc*. Regulation of recreational flows in conjunction with sanitary measures also contributes to increasing the sustainability of plantings. The development of a program for the restoration of disturbed areas and further monitoring is relevant.

The evaluation system presented in the study helps to identify and specify the reasons for the decline in the quality of plantings according to the relevant indicators. The analysis of the spatial distribution of the evaluation results with reference to specific sites of objects allows using the research materials to develop a targeted program of measures to eliminate the identified deficiencies and a set of preventive measures to increase the stability of systems.

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Conflict of interest

All authors declare that they have no conflict of interest.

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