

Tree vegetation viability of the Murmansk urban ecosystem

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Abstract. This paper aims to analyze the woody vegetation viability of northern territories. The research objectives were as follows: (1) to study the predominant species of woody vegetation in public gardens and alleys in Murmansk; (2) to identify groups and categories of trees quality conditions; and (3) to calculate the average coefficient of trees condition for the city. To conduct the research, we used the method guidelines for the stand viability assessment in July 2020, and we studied a total of seven sites (1,252 specimens of trees). According to the methodology, we identified three groups of trees conditions. We noted that the public green spaces in Murmansk are within the minimum norm for the cities in the tundra zone, with landscaped objects slightly below the normative values. The predominant trees in the studied public gardens and alleys are *Sorbus* species. The research showed that most trees are of satisfactory quality and belong to the “weakened category.” We recorded the following types of damage: frost cracks, bare trunk, insufficient leafage, small leaf plates, trunks’ bending and tilting. The main factors affecting the condition of woody vegetation in Murmansk are abiotic factors (wind, frost, heavy rain, hail, sharp temperature fluctuations). Biotic factors and human activity have a lesser impact. The city annually carries out sanitary work to cut down dead branches and give the landscaping objects aesthetic value. The novelty of the research is in the fact that the assessment of the trees in Murmansk in 2020 was carried out for the first time; the previous works are dated 2013–2017.

1 Introduction

The urban plantations’ condition ecological monitoring has become particularly popular in recent years. Several current studies present trees viability analysis under increasing anthropogenic load in various cities: A. A. Ievskaya, V. V. Ieronova, V. B. Kalmanova, A. N. Kryuchkov, O. E. Tokar, A. A. Tikhonova et al. [1, 60–66]. To assess the condition of the trees, the authors use such taxonomic indicators as trunk curvature and damage, the height of branch attachment, dry branches presence, crown density and shape, discoloration, diseases, decoration, etc.

The authors pay special attention to the decline of trees under the influence of increasing

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technogenic pressure from motor vehicles and industrial enterprises.

Most studies on the woody vegetation assessment in the Murmansk region focus on conifers, which grow in significant numbers in the region's natural ecosystems. There are not many studies on the viability of trees; mostly, they are conducted in areas with high anthropogenic pressure: O. A. Kostromina, T.A. Sukhareva, L.G. Isaeva et al.

Murmansk does not organize comprehensive studies of the trees' vital state every year: O. B. Gontar [4], N. V. Saltan et al. As these authors note, the condition of the trees in the Murmansk region is satisfactory; there are plants' damages associated with natural and anthropogenic factors. At the same time, data on the trees' vitality in Murmansk require systematic updating.

A special feature of Murmansk is the predominance of introduced tree species in urban plantings: hybrids from *Betula* species (*B. pendula* Roth, *B. pubescens* Ehrh.), *Porulus tremula* L., *Porulus suaveolens* F., p. *Sorbus gorodkovii* Pojark., *Larix sibirica* Ledeb, as well as shrubs (*Rosa rugosa* Thunb., *Sorbaria sorbifolia* (L.), *Spiraea media* Franz Schmidt, *Spiraea salicifolia* L., *Syringa josikaea* J., *Crataegus sanguinea* Pall., *Lonicera tatarica* L., *Caragana arborescens* Lam., *Prunus padus* L., etc.) that have good growth and quickly achieve decorative effect [6]. In terms of the number of species, the family *Rosaceae* prevails (18 species). A third of the trees growing in the city is old-growth and has not lost their decorative qualities at the moment.

In Murmansk, there are many species and tree varieties that are used for the northern cities greening. For the Murmansk region, this list includes more than 130 names [4].

Studies conducted by the Polar-Alpine Botanical Garden-Institute of the Russian Academy of Sciences [8] show a decrease in the *Syringa josikaea* shrubs' vitality; for *Larix sibirica* in street plantings, no trees of the first category of vitality were found. In street plantations close to roads, the condition of the trees is considerably worse due to the high degree of air dustiness. The trees' physiological activity suppression is primarily due to natural factors.

The main factor determining woody vegetation vitality in Murmansk is the chemical composition of soils [8]. One of the important sources of the negative impact on woody vegetation is the air pollution from motor vehicles, large industrial facilities in the city, including "MurmanErgoSbyt" and "MMTP" JSCs. There is an annual increase in concentrations of benzopyrene, sulfur dioxide, formaldehyde, and nitrogen oxides in the city's air, while at the same time, Murmansk is classified as a city with a low level of pollution [5].

2 Materials and methods

The vitality of trees in public gardens in Murmansk was assessed in July 2020 under the "Methodological Recommendations for Assessing Tree Viability and the Rules for Selecting and Designating Trees for Cutting and Replanting" [5; 7]. The assessment was carried out visually according to the criteria specified in the methodology. The analyzed trees were divided into three quality condition groups: "unsatisfactory," "satisfactory," and "good." Then the state (or vitality) category was established under the trees' assessment sanitary rules: "no weakening," "weakened," "severely weakened," "withered," "current year deadwood," and "previous years deadwood."

In total seven public gardens in different city districts were examined: "Muzikalnaya alleya" (ulitsa Vorovskogo), skver "Studencheskiy" (ulitsa Chelyuskintsev), "Skver pogranichnikov Arktiki" (prospect Lenina), "Teatralniy bulvar", public garden at ulitsa Tortseva, public garden at 2prospect Geroev-Severomortsev, public garden at 2prospect Kolsky ("Tsarskaya Okhota").

This article presents survey data for 1,252 trees from *Sorbus*, *Betula*, *Salix*, *Populus*, and

Larix species; shrub vegetation was assessed separately. Fig. 1 shows the quantitative ratio of the studied trees in the city’s squares and alleys.

We determined the arithmetic mean for each species; then, we estimated the overall condition (or condition coefficient, K) of the studied object (square). For the overall trees’ condition assessment, we used a standard scale (K): up to 1.5 – healthy condition, 1.6 to 2.5 – weakened condition, 2.6 to 3.5 – severely weakened condition, 3.6 to 4.5 – declining condition, over 4.6 – death.

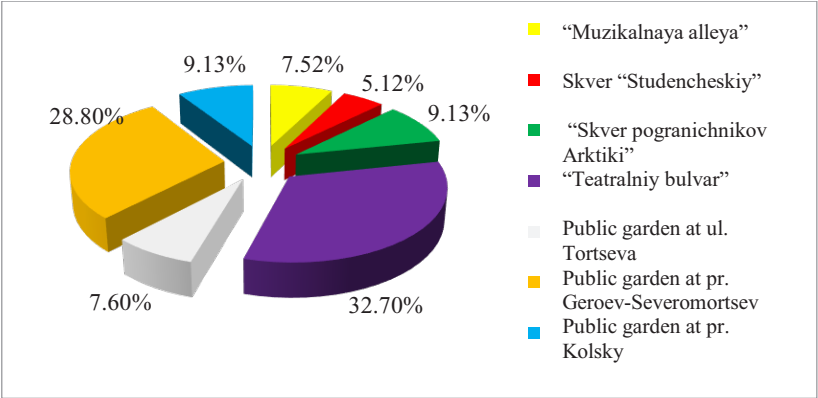


Fig. 1. Quantitative distribution of the surveyed trees in public gardens and alleys in the city. *Source:* Compiled by the authors.

3 Results

Public green spaces (squares, boulevards, public gardens) in Murmansk occupy 68.5 ha of the area – 2.18 m² per person (i.e., it corresponds to the minimum norm for cities in the tundra zone, which is 2 m²) [9; 10]. At the same time, landscaping facilities occupy a smaller area (for example, in 2015 – only 0.97 m² per person) [2].

The analysis of the tree plantings quantitative ratio in the surveyed public gardens shows that *Sorbus gorodkovii* trees predominate in Murmansk: a total of 842 specimens were surveyed.

The distribution of trees by the qualitative condition is presented in Table 1.

Table 1. The distribution of trees by the qualitative condition.

Studied object	Qualitative condition		
	good	satisfactory	unsatisfactory
“Muzikalnaya alleya” (ulitsa Vorovskogo)	17%	63%	20%
Skver “Studencheskiy”(ulitsa Chelyuskintsev)	44%	46%	10%
“Skver pogranichnikov Arktiki” (prospect Lenina)	37%	40%	23%
“Teatralniy bulvar”	32%	62%	6%
Public garden at ulitsa Tortseva	46%	36%	18%
Public garden at prospekt Geroev-Severomortsev	18%	52%	30%
Public garden at prospekt Kolsky (“Tsarskaya Okhota”)	10%	58%	32%

Source: Compiled by the authors.

Based on the stand condition coefficient, the surveyed sites were classified as “weakened” (K 1.85 to 2.21) (Fig. 2).

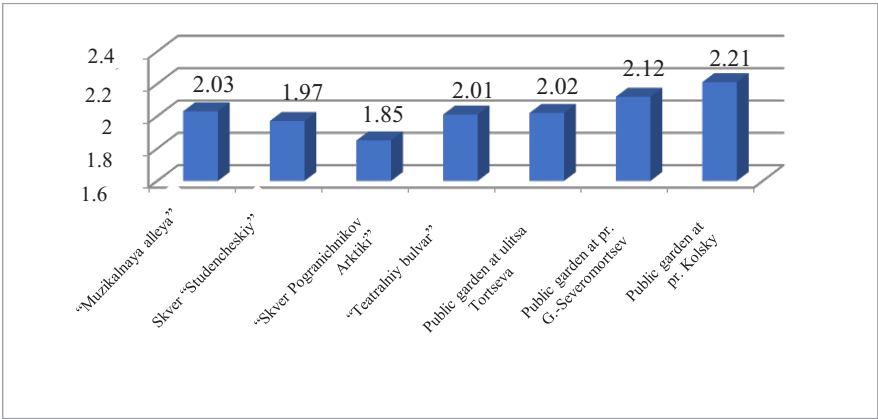


Fig. 2. Trees condition coefficients for the landscaping sites under the study.
Source: Compiled by the authors.

In the course of the research, the damage was found, such as bare wood at the trunk and individual branches, frost cracks, disruption of the tree crown, reduction of leaf plate size, trunks' bending and tilting. This can pose a danger to the public, especially in northern conditions where strong winds prevail.

4 Discussion

Trees growing in the urban ecosystem of Murmansk can perform their aesthetic and sanitary-hygienic functions. The list of introduced species presented in the city is optimal for the northern conditions. Abiotic factors (mechanical damage under the influence of negative meteorological phenomena: wind, frost, solar activity, heavy rain, hail, sharp temperature fluctuations), biotic factors (damage due to the vital activity of living organisms), and anthropogenic factors (human activity) remain among the main factors affecting the condition of tree vegetation in the urbanized environment of Murmansk. The increased sensitivity of the response to meteorological factors on the part of the stand is associated with the peculiarities of growth (landforms, slope orientation, etc.), as well as due to anatomical, morphological and physiological features of the tree vegetation.

The results obtained confirm the data of previous studies. At the same time, the question of preventive measures aimed at preserving and maintaining a healthy stand in the conditions of Murmansk (sanitary cutting and pruning, treatment of damage with special solutions, rejuvenation of the trees) remains important).

5 Conclusion

The research results are as follows: (1) introduced *Sorbus gorodkovii* dominates the dendroflora at the surveyed sites; (2) general condition of the trees is assessed as satisfactory, weakened; and (3) average trees' condition factor was 2.03 (weakened).

The theoretical significance of the research is information about species diversity and vitality of the trees in Murmansk public gardens update. The practical significance of the research is that the assessment of trees in Murmansk allows tracing trends in the development of introduced tree species in the northern urban ecosystems and suggesting further preventive measures for the conservation of dendroflora.

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