Composition, Structure, Spatial Organization and Current Condition of the Urban Forest in a Large City (on the Example of the Beyond the River Part of Nizhniy Novgorod, Russia)

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Abstract. The article presents the results of research on the current condition – the breed composition, quality characteristics and spatial organization of the urban vegetation in a city with a population of more than a million people on the example of the Beyond the river part of the city of Nizhny Novgorod. The research is based on field work, carried out by the authors in the period 2016-18, processed using GIS technologies, and supplemented by the results of analysis of remote sensing data, interpolation, statistical analysis, correlation of the composition and structure of tree stands and functional zones of the Beyond the river part of the city. In addition to the analysis of qualitative and quantitative characteristics of trees in the territory of the Beyond the river part of Nizhny Novgorod, the article presents the results of a comparative evaluation of the provision of urban forest areas of the Beyond the river part of Nizhny Novgorod (according to the results of interpolation). The main problems of the current condition and spatial organization of urban forest in the Beyond the river part of Nizhny Novgorod are identified.

1. Introduction

Urban vegetation in the city are an integral part of the overall complex of planning and buildings activities. Urban vegetation have a powerful environmental-forming effect, determining the quality characteristics of urban air [1], temperature regime, hydrographic network and soil cover [2]. Urban vegetation is a specific habitat in which peculiar communities of animals are formed [3]. Urban vegetation play a huge role in shaping the aesthetic appearance [4] and psychologically comfortable urban environment. Researching the functioning of urban ecosystems and ways to preserve [5] and increase of it’s biodiversity [6] is a relatively young, but extremely significant scientific, applied, ethical [7] economic [8, 9] and administrative problem [10].

In the dense buildings of a modern city the problem of insufficient city greening is acute. The object of the research is the territory of the Beyond the river part of Nizhny Novgorod, which has all the characteristic structural and qualitative features of a modern Russian city with a population of more than a million people. On the territory of the Beyond the river part of Nizhny Novgorod, 889 127 people live, which is 70% of the total population of the city.

Purpose of research: to research the current characteristics of urban vegetation (composition, structure and spatial organization) of the Beyond the river part of Nizhny Novgorod.

Research materials and methods: descriptive, field, key method, cartographic, statistical, interpolation, GIS analysis, correlation.

The research is based on field research, conducted in 2016-18 on the territory of the Beyond the river part of Nizhny Novgorod within the corridor of research length of 34 km and an area of 4.8 km² (1.6% of the area of the Beyond the river part N. Novgorod) (figure 1), which allowed to obtain materials, that reflect the composition, structure and spatial organization of the urban vegetation (figure 2) and it’s distribution to functional areas of the city (figure 3). More over, additional work was carried out in those parts of the research area where the research corridor covered a limited area – primarily residential areas and coniferous forests in the West of the city.
2. Results and Discussion

Using the key method, we delineated the distribution of major forest types in the city (figure 2).

Figure 1. Location of the research corridor in the Beyond the river part of Nizhny Novgorod

Figure 2. The distribution of major forest types in the Beyond the river part of Nizhny Novgorod
Figure 3. Functional zones of the Beyond the river part of Nizhny Novgorod

Using the key method, analysis of remote sensing data, GIS analysis and interpolation, calculations were made for the provision of the territory of the Beyond the river part of the city with trees, the total number of which was 16.1 million, and shrubs – 1.7 million.

The largest share of tree plantations falls on the territory of Moskovsky (29.6%), Sormovsky (28.2%) and Avtozavodsky (25.6%) districts, the smallest – on the territory of Leninsky district (2.9%) (figure 4).

Figure 4. The proportion of the number of trees in districts of the Beyond the river part of Nizhny Novgorod (based on extrapolation results), %

In tree composition of the Beyond the river part of the city are dominated **Bétula péndula** (about 7.358 million trees), **Pinus sylvéstris** (about 4.441 million trees) and **Acer negundo** (about 1.320 million trees). **Pópulus trémula**, fruit trees, and various types of willows are less common (figure 5).
Among the shrub species, various species of *Sálix* (about 0.644 million bushes), *Rúbus idáeus* (about 0.473 million bushes), *Physocarpus opulifolius* (about 0.363 million bushes) predominate. *Syringa vulgáris* and *Caragána arboréscens* are less common (figure 6).

Comparing the investment structure of trees with functional areas of the Beyond the river part of Nizhny Novgorod, it was found that the greatest number of trees are concentrated in natural-recreational areas (58.6%) and lowest in social-business and the areas of transport and street infrastructure (5.4% and 5.7%) (figure 7).
The vast majority of tree vegetation (96.7%) are in good and satisfactory condition (figure 8).

The proportion of trees in good and satisfactory condition is higher in the transport and street infrastructure areas (44%), while the lowest is in residential and public-business and communal areas (1% each) (figure 9).
Trees in unsatisfactory condition are more common in transport and street infrastructure areas (36%), with the lowest number in residential (2%) and public-business and communal areas (3%) (figure 10).

**Figure 10.** The proportion of the number of trees in unsatisfactory condition in the functional zones of the Beyond the river part of Nizhny Novgorod, %

Comparing the area of green space of the Beyond the river part of Nizhny Novgorod with the standards of urban planning, existing in Russia, it was found that the average performance of city greening of the Beyond the river part of the city meets the standards, but in a residential area of tree plantations made up only 25% of normal (figure 11 and 12).

**Figure 11.** Comparison of the area of green areas of the Beyond the river part of Nizhny Novgorod with the standards of urban planning, existing in Russia
Figure 12. Comparison of the actual provision of green areas in a residential area of the Beyond the river part of Nizhny Novgorod with the standards of urban planning, planning and development of urban planning, existing in Russia.

3. Conclusion

Nizhny Novgorod is one of the largest cities in Russia. The growth of industry and intensive development of transport have led to an increase in anthropogenic pressure on the environment. The environmental situation in cities, especially large ones, is becoming more and tenser.

The analysis of the results revealed the following problems:

- with good average indicators of city greening in the Beyond the river part of the city (the provision of green areas exceeds the minimum requirements by 3.2 times), there is an extremely uneven distribution of tree plantations in the city (there is a shortage of tree plantations in residential areas);
- the city's forest cover is high due to the formal addition of forest areas that are not actually urban areas to the city;
- there is a sharp discrepancy between the placement of residential areas – the very urban environment where citizens spend most of their lives, and the main woodlands.

References
[1] Steinbrecher R., Klauer M., Hauff K., Stockwell W.R., Jaeschke W., Dietrich T., Herbert F. Biogenic and anthropogenic fluxes of non-methane hydrocarbons over an urban-impacted forest, Frankfurter Stadtwald, Germany // Atmospheric Environment. 2000. T. 34. № 22. p 3779-3788.
[2] Zhu W.X., Carreiro M.M. Chemoautotrophic nitrification in acidic forest soils along an urban-to-rural transect // Soil Biology and Biochemistry. 1999. T. 31. № 8. p. 1091-1100.
[3] Mortberg U.M. Resident bird species in urban forest remnants; landscape and habitat perspectives // Landscape Ecology. 2001. T. 16. № 3. p. 193-203.
[4] Johnson R.L., Brunson M.W., Kimura T. Using image-capture technology to assess scenic value at the urban/forest interface: a case study // Journal of Environmental Management. 1994. 40. p. 183-195.
[5] Sawicka-Kapusta K., Zakrzewska M., Bajorek K., Gdula-Argasinska J. Input of heavy metals to the forest floor as a result of Cracow urban pollution // Environment International. 2003. T. 28. № 8. p. 691-698.
[6] Bakka S.V., Kiseleva N.Yu. Scientific and methodological approaches to the study and evaluation of the impacts of habitat fragmentation with elements of human infrastructure on biological diversity // Ecology, Environment and Conservation Paper Vol 23, Issue 4, 2017; Page No.(2236-2239) http://envirobiotechjournals.com/article_abstract.php?aid=8301&iid=240&jid=3
[7] Heynen N.C. The scalar production of injustice within the urban forest // Antipode. 2003. T. 35. 5. p. 980-998.
[8] Tyrvainen L. Economic valuation of urban forest benefits in Finland // Journal of Environmental Management. 2001. T. 62. № 1. p. 75-92.
[9] Pitt D.J. The fast lane of urban fringe forest economics // Forestry. 1992. 65. 2. p. 189.
[10] Jim C.Y., Liu H.H.T. Statutory measures for the protection and enhancement of the urban forest in Guangzhou city, China // Forestry. 2000. 73. 4. p. 311.