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Phyto-Geographical Approach in Creation Urban Landscapes (By The Example of Kazan City).

Ilnar Mamedovich Gasanov[1]*, Nina Borisovna Prokhorenko[2], and Saniya Gasimovna Kurbanova[1].

[1] Institute of Management, Economics and Finance, Kazan Federal University, [2] Institute of Fundamental Medicine and Biology, Russian Federation, 420008, Kazan

ABSTRACT

A great emphasis in the urbanized landscapes is laid on the reconstruction of the existing natural vegetation and the formation of artificial greenery. Green construction projects must take into account data on the biological characteristics of tree species and their adaptation to the specific growing conditions, as well as understand the peculiarity of the geographical conditions and abiotic environmental factors emerging in urban environment. We have identified 99 species and forms on the territory of the residential areas of Kazan, as well as held biomorphological analysis of the morphostructural and ecological features of dendroflora. Based on data on landscape features within the urban areas we have distinguished 10 types of plants subject to their anthropogenic transformation. For each of them, we have conducted assessment of their habitat conditions by indication methods, as well as proposed groups of species of trees and shrubs able to form sustainable plant communities.

Keywords: urbanized landscape, residential area, indication of environmental conditions, life form.

Corresponding author

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INTRODUCTION

The formation of urban settlements has deep geographical, natural, historical, and socio-economic roots. The territory of the modern city is a landscape, which preserves natural environmental conditions with the elements of human impact. A hallmark of the urbanized territories is a significant degree of contamination of all components of the geographical shell [1; 2; 3]. Urban soils are characterized by high density, acidity, contamination by heavy metals and petroleum products, which causes poor species diversity of soil mesofauna and microorganisms, reduction in the root layer mass and, as a consequence, deceleration of the humus formation processes [3; 4; 5; 6; 7; 8]. In urban environment, natural complexes are interlaced with a variety of buildings, parking lots, asphalt areas, etc., which leads to a decrease in soil water regime and increase in surface runoff, as well as decrease in water infiltration processes [9].

Urbanized areas require application of the phyto-geographical approach to the creation of various elements of green building. The creation of sustainable plant communities in urban areas requires considering the habitat conditions of cultivated landscapes and ecological and biological characteristics of the species.

Objective of the research is to determine the characteristics of composition and the ways of formation of plant communities in urban landscapes of the city of Kazan, including assessment of habitat conditions of trees and bushes by indication methods; characterization of ecological and biological characteristics of species typical to a certain dendroflora; and identification of certain groups of species resistant to the urban conditions.

MATERIALS AND METHODS OF RESEARCH

We conducted our studies of vegetation in the territory of Kazan and the nearby suburbs in 2013-2015. In the course of studies, we examined in details the greenery growing on various forms of relief with a different type of humidification. Field work was based on the methods of establishment of sample plots [10]. Each group of plant communities had 500m² sample plots of different configuration established. We conducted identification of the features of micro- and mesorelief, quantitative and morphometric parameters for all species of trees and shrubs, their number and life form on these sample plots. All morphometric data (height and diameter) were processed by the statistical-information methods. Environmental conditions can be characterized according to vegetation features by using ecological scales. Research and evaluation of abiotic environmental factors was conducted by regional scales of humidification (Hd), consisting of 23 stages, and of soil mineral content (Tr), consisting of 19 stages, developed by D.N. Tsyganov [11] for the zone of coniferous-deciduous forests.

RESULTS AND DISCUSSION

Kazan is a city with a million population, situated on the left bank of the Volga river. Kazan relief is represented by a system of river terraces, dissected by the system of four rivers and their tributaries. The terraces within the area of Kazan locate about 190 lakes of natural and anthropogenic origin. Low floodplain terraces are composed of sand and sandy loam fractions and the high ones - of clay loam and heavy sandy loam [12]. According to the phyto-geographical zoning, the territory of Kazan lies within subtaiga zone, commonly represented by the widespread boreal-immoral forest [13].

We have identified 10 categories of green areas in the modern landscapes of Kazan subject to their anthropogenic modification (Table 1).

Table 1. Types of green areas in the residential area of the city of Kazan

Origin	Greenery categories	Characteristics
Natural greenery	1. City recreational forests	Plots of preserved natural forests
	2. Water-conservation sites	
	3. Forest parks	Landscaped forest lands
Man-made greenery	4. Artificial water body and embankment greenery	Territories with shallow groundwater occurrence
	5. Parks	Interquarter greenery

	6. Gardens; 7. Mini-parks	
	8. Yard greenery	Local greenery
	9. Industrial site greenery	Industrial premises
	10. Roadside greenery	Single- or multi-row planting

Urban greenery 1-3 are natural, and differ in degree of landscaping and incorporate some architectural elements. Greenery 4-10 are man-made, with the ground surface covered with asphalt.

According to our research, habitat conditions in the complex pine forests, common to low upland terraces, and in the deciduous forests, located on high upland terrace within the suburban area of Kazan are characterized by varying degrees of humidification and mineral nutrition. Soil humidification ranges from grade 12 to 13 of the humidification scale (Hd) and is defined as the freshly-meadow and wet-forest-meadow, and the mineral nutrition covers grade 5 - 7 of the appropriate scale (Tr) ranging from the class of poor to quite fertile soil [14]. Based on graduation data, we have characterized the habitat conditions of urban landscapes of the city of Kazan (Table 2).

Table 2. Characteristics of the greenery habitats in areas with varying degrees of anthropogenic reclamation (Kazan).

Cultivated landscapes	Humidification degree (acc. D.N. Tsyganov)	Soil humidification	Nutrition degree (acc. D.N. Tsyganov)	Mineral content of soil
Artificial water body and embankment greenery	13-13.9	Wet, periodically fresh	7-7.9	Poorly anthropogenized naturally fertile
City recreational forests	12.9-12	Fresh, periodically wet	6-6.9	Poorly anthropogenized naturally fertile
Forest parks, water-conservation sites	11.9-11	Fresh	6-6.9	Poorly anthropogenized fertile
Gardens, parks, mini-parks Yard greenery, industrial site greenery	10.9-10	Fresh, periodically dry	5-5.9	Greatly anthropogenized poorly fertile
Roadside greenery	9-9.9	Dry, periodically fresh	4-4.9	Skeletal, poor

According to Table 2, the areas of recreational forests and forest parks, and water-conservation sites have the conditions similar to the natural, and characterized by fresh, periodically wet naturally fertile, poorly antropogenized soil. Greenery in the coastal areas grow primarily in wet, periodically fresh, naturally fertile soil. Artificial objects of green building, with the greatest degree of gas contamination and changes in soil characteristics, taking into account their remoteness from the motorways, are characterized by fresh, periodically dry poorly fertile or dry, periodically fresh skeletal, poor soils.

Different types of greenery growing in the territory of residential areas of Kazan are represented by 99 species and forms of trees and shrubs relating to 48 geni and 26 families. The proportion of native species is 24.2%, the rest are introduced plants. Most part of dendroflora is *Rosaceae* representatives that is 11% by the number of geni and 25% by the number of species. Dendroflora species belong biologically and morphologically to life forms (Table 3).

Table 3. Composition of the life forms of Kazan dendroflora

Life forms		Total species	% of total number
By height	By biological characteristics		
Large and medium trees (> 15 m)	Large broad-leaved tree	16	16.1
	Large small-leaved tree	7	7.1
	Large dark coniferous tree	5	5.1

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	Large light coniferous tree	1	1
	Large summergreen coniferous tree	2	2.1
Small trees (up to 15 m)	Small broad-leaved tree	10	10.1
	Small small-leaved tree	2	2
	Small narrow-leaved tree	3	3
	Small dark coniferous tree	3	3.1
Shrubby tree	Dark coniferous shrubby tree with scale and acerous needles	4	4.1
	Aeroxulos shrubby tree	14	14.1
Large shrubs (> 2 m)	Large geoxylos shrub	10	10.1
Small shrubs (1-2 m)	Small geoxylos shrub	21	21.2
Climbers	Woody climber	1	1.1
Total		99	100

Large trees in the investigated greenery include *Acer platanoides, Querqus robur, Tilia cordata, Betula pendula, Larix sibirica,* etc. Small trees were represented by *Padus avium, Sorbus aucuparia, Salix caprea,* etc. Large shrubs in the greenery of Kazan are *Caragana arborescens, Lonicera tatarica, Rosa glauca,* etc., small shrubs - *Berberis vulgaris, B. vulgaris f. atropurpurea, Mahonia aquifolium,* etc. A life form of shrubby tree is typical of *Acer ginnala, Amelanchier canadensis, Cotinus coggygria, Juniperus chinensis,* etc.

The comparative study of the biometric parameters of trees in natural suburban forests and greenery of Kazan showed significantly lower values of height and diameter of tree stems in the urban environment (Table 4).

Table 4. Morphometric parameters of the stems of forest-forming species in the cultivated landscapes of Kazan

Life form	Species	at maturity in natural environment		In artificial greenery of Kazan	
		Height, m	Diameter, cm	Height, m average min-max	Diameter, cm average min-max
Large broad-leaved tree	*Quercus robur*	24	55	10.83±0.93 4-16.5	23.57±2.41 9-40
	Acer platanoides	18	28	11.43±1.43 3-20	27.53±3.74 5.5-49
	Tilia cordata	24	36	14±1.56 3.5-26	27.5±4.03 5-49.5
Large small-leaved tree	*Betula pendula*	27	37	15.5±1.01 7-21.5	24.5±2.36 12-36
Large dark coniferous tree	*Picea x fennica*	29	32	6.92±0.71 2.5-23	12.3±1.05 3-29
Large light coniferous tree	*Pinus sylvestris*	30	42	4.87±0.34 3-10	10.62±0.84 7.5-23
Small broad-leaved tree	*Sorbus aucuparia*	12	14	4.94±0.36 2.5-9.5	10.2±1.05 2-23
	Padus avium	14	16	5.79±0.47 3.5-9	9.14±0.81 4-12

At maturity, large hardwood and softwood species of zonal vegetation reach 24-30 m in height at diameter of 32-55 sm. At the same time, the mature plantation of *Betula pendula* in the artificial plantings of Kazan reach 17-21 m in height at diameter of 27-46 cm, and *Tilia cordata* – 17-26 m in height at diameter of 37-45 cm. Height of small hardwood species in natural environment does not exceed 12-14 m at diameter of 14-16 cm, and in the urban environment of Kazan the mature plantations of *Sorbus aucuparia* reach 6-9 m in height at diameter of 14-23 cm, and *Padus avium* - 6-9 m at diameter of 10-19 cm.

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According to the degree of adaptation to the soil humidification conditions, the species of residential areas were included in a specific ecological group (Fig. 1). The first place in the composition of dendroflora belongs to mesophytes, which account for 60% of the total number of species. They prefer fresh loamy soil textures, which are formed in the natural urban plantations such as recreational forests, forest parks and water conservation sites. The second largest group (20%) - hygromesophyte and mesohygrophyte. Their growth is associated with fresh, periodically wet and wet, periodically fresh soils, which are typical of natural wetland habitats. Xeromesophyte, accounting for 16%, tend to fresh, periodically dry soils and can grow on the interquarter and local territories. Dry, periodically fresh soil, typical of significantly transformed areas, are suitable for mesoxerophyte and xerophyte adapted to the deficit of moisture. Their share in Kazan greenery does not exceed 5%.

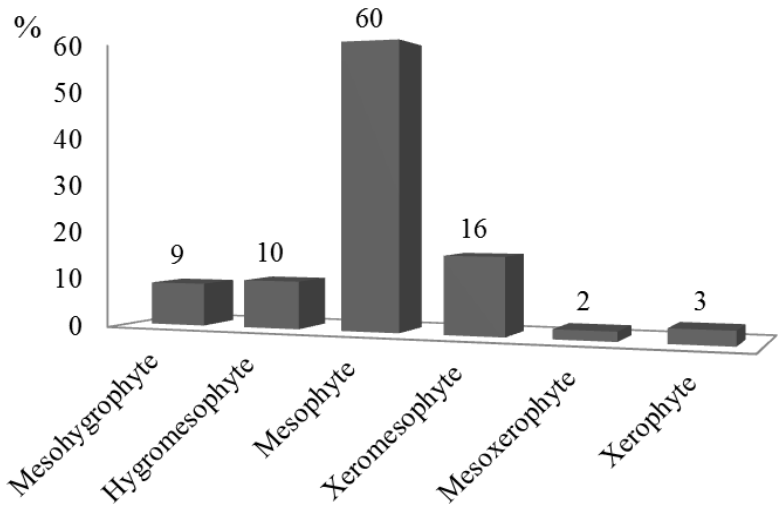

Figure 1. The range of trees and shrubs of the residential area of Kazan in relation to soil humidification.

The range of dendroid plants of Kazan in relation to soil humidification, presented in Figure 1, was taken into account in the formation of the species composition of landscapes with different habitat conditions in order to create plantations resistant to the influence of natural and anthropogenic factors (Table 5).

Table 5. Three and shrub species recommended for the creation of cultivated landscapes in Kazan

Cultivated landscapes	Ecological groups of species	Species	
		Trees	Shrubs
Artificial water body and embankment greenery	Mesohygrophyte, hygromesophyte	*Acer saccharinum 'Laciniatum Wieri' , Betula pubescens, Juglans mandshurica, Populus alba, Salix matsudana f. tortuosa)*	*Sorbaria sorbifolia, Spiraea douglasii, Swida alba, Symphoricarpos rivularis, Viburnum opulus*
City recreational forests	Hygromesophyte, mesophyte	*Acer platanoides, Picea x fennica, Tilia cordata, Ulmus glabra, U. laevis*	*Euonymus europaeus, E. verrucosa, Sorbaria sorbifolia, Lonicera xylosteum*
Forest parks, water-conservation sites	Mesophyte, xeromesophyte	*Acer ginnala, Aesculus hippocastanum, Betula pendula, Querqus robur, Picea pungens, Picea pungens f. glauca, Padus avium, P. maakii, P. virginiana, Pinus sibirica, Populus simonii, P. tremula, Ulmus pumila*	*Amelanchier canadensis, A. ovalis, Mahonia aquifolium, Sambucus racemosa, S. sibirica, Sorbaria sorbifolia, Symphoricarpos rivularis, Syringa vulgaris, Thuja occidentalis, Crataegus sp.*
Gardens, parks, mini-parks Yard greenery, industrial site greenery	Mesophyte, xeromesophyte	*Betula pendula, Elaeagnus angustifolia, Fraxinus pennsylvanica, Pinus sylvestris, Querqus rubra, Robinia pseudoacacia, Sorbus*	*Juniperus virginiana, J. chinensis, Pinus mugo 'Gnom', Lonicera tatarica, Berberis vulgaris, Caragana arborescens, C. frutex, Cotoneaster lucidus,*

		aucuparia, Tilia platyphyllos	*Spiraea x vanhouttei, Physocarpus opulifolus*
Roadside greenery	Mesoxerophyte, xerophyte	*Populus balsamifera, Larix sibirica*	*Physocarpus opulifolus, Caragana arborescens*

According to the phyto-geographical approach, the coasts of water bodies and rivers integrated in the cultivated landscapes can be reconstructed through the creation of sustainable plantations of hygromesophytic and mesohygrophytic species of Kazan dendroflora, both indigenous (*Populus alba, Betula pubescens*), and invasive plants (*Juglans mandshurica, Sorbaria sorbifolia, Spiraea douglasii*). The restoration and reconstruction of the recreational forests, forest parks and water conservation sites was performed primarily with the use of mesophytic indigenous species from the zonal vegetation: *Picea x fennica, Querqus robur, Tilia cordata, Euonymus verrucosa* or invasive plants with the appropriate ecology: *Picea pungens f. glauca, Pinus sibirica, Aesculus hippocastanum.* Highly asphalted parks, gardens and small parks, and areas with periodic lack of moisture are quite suitable for mesophytic and xeromesophytic species, which are mainly the invasive species (*Robinia pseudoacacia, Fraxinus pennsylvanica, Lonicera tatarica, Berberis vulgaris, Caragana arborescens*, etc.). Areas along the roadways and public transport stations have the most unfavorable conditions of dry, occasionally fresh poor skeletal soils, which can be successfully planted with mesoxerophytic and xerophytic species of trees and shrubs that able to create a relatively stable plantations in urban landscapes (*Populus balsamifera, Larix sibirica, Physocarpus opulifolus,* etc.).

SUMMARY

The conducted studies have shown that the plantations of residential areas of Kazan are represented by 99 species and forms of trees and shrubs relating to 14 biomorphs. The proportion of native species is 24.2%, the rest are introduced plants. The composition of Kazan dendroflora is mainly represented by mesophytic species (60%), demanding of moderate soil humidification, and the smallest part (5%) is mesoxerophyte and xerophyte, able to withstand quite dry conditions. Subject to the ecological features of species and characteristics of habitat conditions in a variety of landscapes it was shown that areas of the preserved urban recreational forests are similar to natural habitat environment, and suitable for mesophytic species. The banks of ponds and embankments with wet, periodic fresh poorly anthropogenized soils are mostly suitable for the communities of hydrophilous species of hygromesophytes and mesohygrophytes. Artificial objects of green building such as parks, gardens, small parks, local greenery have less humidified and poorly fertile soil, suitable for the formation of plantations with mesophytes and xeromesophytes. Areas along the streets with the most unfavorable conditions of humidification and soil fertility are suitable for the creation of sustainable plantations of mesoxerophytic and xerophytic species.

CONCLUSION

The territory of Kazan has been studied for species composition of its dendroflora on various parameters, which resulted in the identification of 10 categories of green areas subject to the degree of landscape urbanization and the habitat conditions. This allowed us to propose our own variant for the creation of sustainable landscapes.

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