Environmental Rationale for Arboraceous Flora Inventory: Victory Park of Saratov

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Abstract: We conducted a field study of natural and anthropogenic ecosystems of the Victory Park (Saratov, Russia), the largest of existing urban green spaces. The study included identification and description of floristic diversity of arboraceous vegetation within its limits. As a result, the first ever inventory of the park's green spaces was conducted and a taxonomic list of the woody plantsin Victory Park was compiled. The latter includes133 species of trees and shrubs belonging to 24 families. The families represented by most species are Rosaceae (37), Caprifoliaceae (10), Salicaceae (10), Cupressaceae (9), and Pinaceae (9).Other 19 families include 1–7 species each. Among identified tree and shrub species, there are many rare and exotic for this territory alien species that have natural habitats in North America, Western Europe, Mediterranean region, Siberia, Central Asia, the Far East and NorthAfrica. Besides intentional planting (61 species), some species obviously originate from nearby orchards and gardens (including abandoned), while some possibly come from the Botanical Gardens and arboretum of the local university. We think that berry-eating and seed-eating birds are a major agent of an "accidental planting" in the park (ornithochory), while anemochory in case of some species is also likely. Based on the results of the study, a comprehensive list of recommendations was developed to improve the state of green spaces of the park.

Keywords: urban environment, urban ecosystems, city parks, green spaces, arboraceous flora, biodiversity, ecological optimization, landscaping standards.

Introduction

Contemporary cities are complex formations of natural and anthropogenic origin with intensively used territories. Hence, an importance of their effective, scientifically-grounded environmental planning, first of all, of their green spaces, for which purpose it is necessary to have satisfactory information about ecological and physiological state of arboraceous vegetation, as well as floristic diversity in green areas of the cities [1]. It is possible to stabilize and optimize the urban environment solely by maintaining a high level of plant metabolism [2]. It is well known that high biodiversity is the basis for ensuring ecosystem stability [3]. Urban ecosystems are no exception: low diversity of urban flora and fauna implies a low ecological quality of the urban environment.

A specific feature of the urban environment is that, experiencing the powerful impact of anthropogenic factors, it becomes a very tangible factor in influencing natural ecosystems and humans [4,5]. The urban environment differs sharply from the natural environment in terms of illumination, the magnitude of solar radiation, temperature and humidity of air and soil [6,7].An invaluable role in ecological optimization of the urban environment and creation of a favorable microclimate is played by green spaces. They clean the air basin of the city from dust, harmful gases, smoke, soot, and smooth out temperature fluctuations. Being active components of the environment, they can act as indicators characterizing the state of the environment.Scientific studies around the world have found a significant environment-improving role of green spaces in regulating the quality of urban air, the microclimate of the urban environment, its protection from adverse anthropogenic factors, and also providing recreational opportunities for the urban population.One hectare of urban green spaces absorbs up to 10 l/h of CO_2 for photosynthesis. This amount corresponds to the volume of exhaled air by two hundred citizens over the same period of time [8–13].

Saratov, being a large industrial and cultural center of the Volga Region, cannot boast of its green zones: in a city with almost 860 thousand population, green recreational areas are very scarce. Here, there are just four large-size parks (a former *City Park*, *Children's Park*, *Provincial Park* in Solnechny District and *Victory Park*) and two rather small city gardens (*Radishchev's* and *Lime Trees*), along with several garden squares and boulevards.Currently, the city has 267.4 hectares of communal green spaces, which overall stands for just 3 m^2 per resident with the following variation by city districts: Leninsky – 1.3 m^2, Kirovsky – 1.4 m^2, Volzhsky – 15.6 m^2, Frunzensky – 0.3 m^2, Oktyabrsky – 2.3 m^2, Zavodskoy – 1.3 m^2. At the same time, Russian sanitary-and-hygiene standards prescribe 28 m^2 of green spaces per inhabitant, and the World Health Organization generally recommends at least 50 m^2 [14].

As of 2010, approximately 60 thousand trees grew on the streets of Saratov – just 40 % of the norm. The area of lawns and flower beds was only 10 % and 50 % of required values, respectively. Green spaces, functioning as"city lungs", occupy only 17 % of Saratov territory. For comparison: in Volgograd – 28 %, in Samara – 35 %, and in Moscow the total area of green areas occupies almost 55 % of the city area. To meet the required standards in Saratov, it would be necessary to allocate at least 100 hectares of parks and garden squares annually for five or six years. However, every day, the number of trees continues to decline. The main reasons for this are uncontrolled cutting, which has recently taken on simply disastrous proportions, and the lack of proper care for what is [14,15].

Of the four city parks listed above, only Victory Park is a significant area of urban green space: 85 hectares within officially designated boundaries of the park, and twice as much within the natural and man-made landscapes surrounding the park that are not affected by urban development. For this reason, the study of the Victory Park ecosystems, never conducted previously by anyone, is invaluable in identifying the role of this largest green area in the city in maintaining the overall biodiversity of the urban environment in Saratov, in the context of assessing its environmental safety.

Consequently, the goal of our study was assessment of floristic diversity of trees and shrubs within the Victory Park of Saratov and the green spaces directly adjacent to it. Additionally, we attempted to investigate the sources of origin for all arboraceous species of the study area and to develop recommendations for improving the state of green spaces in the park as a factor in the environmental optimization of urban ecosystems.

Materials and Methods

The study area of the Victory Park and adjacent natural and man-made ecosystems (about 2 km^2) is located on one of the ridges of the Volga Uplands, called Falcon Mountain, on the north-eastern outskirts of the city of Saratov. The maximum elevation is 165 m. The modern history of Victory Park dates back to 1975, when this recreational urban forest area was formally allocated within 85 ha of land planted with trees in 1956–1960. The formation of the park required forestry operations (cutting, thinning, rejuvenation, uprooting, removal of undergrowth, etc.) [16]. In the spring of 1982, many large-sized deciduous and conifer trees were planted in Victory Park: silver poplar (*Populus alba* L.), horse chestnut (*Aesculus hippocastanum* L.), warty birch (*Betula pendula* L.), lacebark elm (*Ulmus parvifolia* L.); blue spruce (*Picea pungens* L.), Norway spruce (*Picea abies* L.). Siberian larch (*Larix sibirica* L.),

eastern white cedar (*Thuja occidentalis* L.) and Korean fir (*Abies koreana* L). By 1987, 29 species of trees and 32 species of shrubs were observed in the park [17,18].

Environmental adequacy of big cities largely depends on their green spaces as an important infrastructural component [19]. Studying taxonomic diversity of trees and shrubs in the Victory Park allowed assessing the general biodiversity level accounting for ecosystem stability. The study was completed during 2018–2019, tree and shrub species were identified on random routes through the study area, including off-trail travel. Photos of general crown shape, bark, leaves, flowers, fruits/seeds were taken for subsequent use with conventional plant guides. Additionally, IT identification was employed via using the iNaturalist IOS software. Each identified species was investigated in terms of obtaining the information about its natural distribution and for the presence or absence in the catalogue of the Botanical Gardens and arboretum of the local university [20]. Thus, we could speculate about the species origin in the park, whether it was originally planted here [17,18], or possibly was subject to anemochory or ornithochory.

Results and Discussion

The problem of quality landscaping in the city of Saratov is extremely relevant in connection with deteriorating environmental situation. Lands occupied by woody vegetation are alienated in favor of urban development objects, which directly worsens the indicators of Saratov's already poor provision by green spaces for communal use. In addition, the quality condition of urban arboraceous plantings goes down from year to year. We can observe aging of green spaces and depressed condition of trees and shrubs. In recent years, barbaric "shaping" of essentially healthy trees has been widely used, after which the trees dry out, die or at least become damaged.

In Saratov, there is an extreme shortage of city parks and other green areas that are required to provide a decent life quality to the citizens. Those parks that are available to the residents are basically outdated. They are not modernized, no one replaces dead trees and shrubs, and no one is engaged in landscape design. It can be stated that arboraceous flora of the city has not been updated for a long time, the age of green spaces of Saratov ranges from 16–50 years, which implies the need for major maintenance and renovations.

Against the backdrop of all Saratov disgrace in the field of urban landscaping and maintenance of recreational areas, Victory Park is a green oasis in the city. The unique and rich floral composition of the park contrasts sharply with the poor natural diversity of woody plants in the region.

All detected species of trees and shrubs are presented in the table below. Areas of species origin and frequencies of occurrence in the park are also indicated in it. As can be seen, the diversity of woody plants includes 133 species, of which 13 can be found everywhere, 42 have frequent occurrence, while 49 are rare and 29 are represented by only few individuals.

TABLE.
Arboraceous Flora of the Victory Park, Saratov

Scientific names of trees and shrubs	Areas of species origin	Frequency of occurrence
FAMILY 1: *Aceraceae*		
1. Acer campestre L.	Europe	Frequent
2. A. negundo L.	North America	Frequent
3. A. platanoides L.	Europe, Asia Minor	Frequent
4. A. pseudoplatanus L.	Europe, Asia Minor	Rare
5. A. saccharinum L.	North America	Rare
6. A. tataricum L.	Europe	Frequent
FAMILY 2: *Anacardiaceae*		
7. Cotinus coggygria Scop.	Europe, Asia Minor, China	Rare
8. Rhus typhina L.	North America	Very rare

Scientific names of trees and shrubs	Areas of species origin	Frequency of occurrence
FAMILY 3: *Berberidaceae*		
9. Berberis vulgaris L.	Europe	Very rare
10. Berberis thunbergii DC.	Japan, China	Very rare
11. Mahonia aquifolium (Pursh) Nutt.	North America	Very rare
FAMILY 4: *Betulaceae*		
12. Betula pubescens Ehrh.	Europe, Siberia, Altai	Very rare
13. Betula pendula Roth.	Europe, Siberia, Altai	Frequent
14. Alnus glutinosa L.	Europe, Asia	Rare
15. Corylus avellana L.	Europe, Asia	Rare
FAMILY 5: *Bignoniaceae*		
16. Catalpa bignonioides Walt.	North America	Rare
FAMILY 6: *Caprifoliaceae*		
17. Lonicera tatarica L.	Asia	Ubiquitous
18. Lonicera xylosteum L.	Europe	Rare
19. Sambucus canadensis L.	North America	Rare
20. S. racemosa L.	Europe	Rare
21. Viburnum rhytidophylium L.	China	Rare
22. V. lantana L.	Europe	Rare
*23. V. plicatum*Thunb.	China, Korea, Japan	Very rare
24. V. opulus L.	Europe, North Africa	Rare
25. Symphoricarpos albus (L.) Blanke	North America	Rare
26. Weigela hortensis C.A. Mey	Eastern Asia	Very rare
FAMILY 7: *Celastraceae*		
27. Euonymus verrucosus Scop.	Europe, Asia Minor	Rare
28. E. europaea L.	Europe, Asia Minor	Rare
FAMILY 8: *Cupressaceae*		
29. Juniperus communis L.	Europe, Siberia, North America	Rare
30. J. davurica Pall.	Siberia, Far East, Mongolia	Rare
31. J. horizontalis Moench	North America	Rare
32. J. sabina L.	Europe, Mongolia, China	Rare
33. J. sibirica Burgsd.	Siberia, Far East, Mongolia	Rare
34. J. virginiana L.	North America	Rare
35. Thuja occidentalis L.	North America	Rare
36. T. plicata D.Don.	North America	Rare
37. Platycladus orientalis L.	China, Korea	Rare
FAMILY 9: *Elaeagnaceae*		
38. Elaeagnus argentea Pursh	North America	Frequent
39. E. angustifolia L.	Siberia, Asia, Mongolia, China	Frequent
FAMILY 10: *Fagaceae*		
40. Quercus robur L.	Europe	Frequent
41. Q. rubra L.	North America	Very rare
42. Q. macrocarpa Michx.	North America	Rare

Scientific names of trees and shrubs	Areas of species origin	Frequency of occurrence
FAMILY 11: *Hippocastanaceae*		
43. Aesculus hippocastanum L.	Balkans	Frequent
FAMILY 12: *Hydrangeaceae*		
44. Hydrangea arborescens L.	North America	Very rare
45. H. paniculata Siebold	Far East, Japan, China	Very rare
46. Philadelphus floribundus Schrad.	North America	Rare
47. P. floridus Beadle	North America	Rare
FAMILY 13: *Juglandaceae*		
48. Juglans regia L	Balkans, Central Asia, China, Japan	Rare
FAMILY 14: *Leguminosae*		
49. Amorpha fruticosa L.	North America	Very rare
50. Chamaecytisus ruthenicus Fisch. ex Woloszsz.	Europe, Siberia	Frequent
51. Caraganaar borescens Lam.	Siberia	Ubiquitous
52. Robinia pseudoacacia L.	North America	Frequent
FAMILY 15: *Moraceae*		
53. Morus nigra L.	Asia Minor, India, China, Japan	Frequent
54. Morus alba L.	Asia Minor, India, China, Japan	Very rare
55. Morus rubra L.	North America	Very rare
FAMILY 16: *Oleaceae*		
56. Fraxinus excelsior L.	Europe	Rare
57. F. pennsylvanica March.	Canada, USA	Ubiquitous
58. Fraxinus mandshurica Rupr.	China, Korea, Japan	Frequent
59. Ligustrum vulgare L.	Europe	Rare
60. Syringa meyeri Schneid	Europe	Very rare
61. Syringa josikaea L.	Europe	Rare
62. Syringa vulgaris L.	Europe	Ubiquitous
FAMILY 17: *Pinaceae*		
63. Abies koreana Wils.	Korea	Very rare
64. A. sibirica Ldb.	Europe, Siberia	Very rare
65. Larix sibirica Ledeb.	Siberia	Very rare
66. L. decidua Mill.	Europe	Very rare
67. Picea abies (L.) Karst.	Europe	Rare
*68. P. canadensis (*Mill.) Britt.	North America	Rare
69. P. pungens L.	North America	Rare
70. P. obovata Ldb.	Europe, Siberia	Rare
71. Pinus sylvestris L.	Europe, Siberia	Rare
FAMILY 18: *Grossulariaceae*		
72. Ribes americanum L.	North America	Frequent
FAMILY 19: *Rhamnaceae*		
73. Rhamnus alnus L.	Europe, Siberia, Central Asia, Asia Minor	Frequent
74. R. cathartica L.	Europe, Siberia, Central Asia,Asia Minor	Frequent
FAMILY 20: *Rosaceae*		
75. Amelanchier alnifolia Nutt.	North America	Frequent

Scientific names of trees and shrubs	Areas of species origin	Frequency of occurrence
76. A. ovalis Medik.	Europe, Asia Minor, North Africa	Frequent
77. Armeniaca vulgaris Lam.	Central Asia	Very rare
78. Aronia melanocarpa (Michx.) Elliott	North America	Rare
79. Cotoneaster integerrimus Medik.	Europe	Frequent
80. C. lucidus Schlecht.	Eastern Siberia	Frequent
81. C. melanocarpus Fisch.	Europe, Asia	Rare
82. Crataegus kytrostyla Fingerh.	Europe	Frequent
83. C. microphylla C. Koch	Europe	Ubiquitous
84. C. monogyna Jaeq.	Europe	Ubiquitous
85. C. nigra Waldst. et Kit	Europe	Frequent
86. C. pseudoheterophylla Pojark.	Europe	Frequent
87. C. sanguinea Pall.	Europe, Siberia, Asia, Mongolia	Ubiquitous
88. Crataegus curvisepala Lindm.	Europe	Frequent
89. Amygdalus nana L.	Europe, Siberia, Kazakhstan	Frequent
90. Malus baccata (L.) Borkh.	China	Very rare
91. Malus domestica Borkh.	Central Asia	Very rare
92. M. niedzwetzkyana Dieck.	Central Asia	Very rare
93. M. prunifolia L.	China	Very rare
94. Padus racemosa (Lam.) Gilib	Europe, Siberia, Himalaya	Frequent
95. P. mahaleb (L.) Vass.	Europe, Central Asia	Rare
96. P. virginiana (L.) Mill.	North America	Frequent
97. Physocarpus opulifolius (L.) Maxim.	FarEast, China, Korea	Very rare
98. Prunus domestica L.	Europe, Central Asia, Asia Minor	Rare
99. P. divaricata Ledeb.	Europe, Central Asia, Asia Minor	Very rare
100. P. spinosa L.	Europe, Central Asia, Asia Minor	Rare
101. P. cerasus L.	Europe, Asia	Frequent
102. P. fruticosa L.	Europe, Asia	Frequent
103. Pyrus communis L.	Europe	Frequent
104. Rosa majalis Herrm.	Europe	Ubiquitous
105. R. canina L.	Europe, Western Siberia, Central Asia, Asia Minor	Ubiquitous
106. R. lapidosa L.	Europe	Frequent
107. Sorbus aucuparia L.	Europe	Frequent
108. S. x *latifolia* (Lam.) Pers.	Europe, Asia Minor, North Africa	Very rare
109. S. sibirica Hedl.	Europe, Siberia	Very rare
110. Spiraea hypericifolia L.	Europe	Frequent
111. Spiraea crenata L.	Europe	Frequent
112. Rubus nessensis Hall	Europe	Very rare
113. R. caesius L.	Europe, Asia	Rare
FAMILY 21: *Salicaceae*		
114. Populu salba L.	Europe, Siberia, Caucasus, Mongolia, Central Asia	Frequent
115. P. x *sowietica pyramidalis* Jabl.	Europe, Asia	Frequent
116. P. tremula L.	Europe, Asia	Frequent
117. P. balsamifera	North America	Frequent

Scientific names of trees and shrubs	Areas of species origin	Frequency of occurrence
118. P. nigra L.	Europe, Central Asia, North Africa	Rare
119. P. deltoides L.	North America	Frequent
120. Salix acutifolia Willd.	Europe, Siberia, Asia Minor	Rare
121. S. caprea L.	Europe, Asia	Rare
122. S. fragilis L.	Europe, Siberia, Asia Minor	Rare
123. S. triandra L.	Eurasia	Rare
FAMILY *22: Tamaricaceae*		
124. Tamarix ramosissima L.	Europe, Asia, Africa	Very rare
FAMILY *23: Tiliaceae*		
125. Tilia americana L.	North America	Rare
126. T. platyphillos Mill	Europe	Rare
127. T. cordata Mill.	Europe, Siberia	Frequent
FAMILY 24: *Ulmaceae*		
128. Ulmus laevis Pall.	Europe	Ubiquitous
129. U. minor Mill.	Europe	Frequent
130. U. parvifolia Jacq.	Europe	Ubiquitous
131. U. glabra Huds.	Europe	Ubiquitous
132. U. laevis Pall.	Europe	Frequent
133. U. pumila L.	Siberia	Ubiquitous

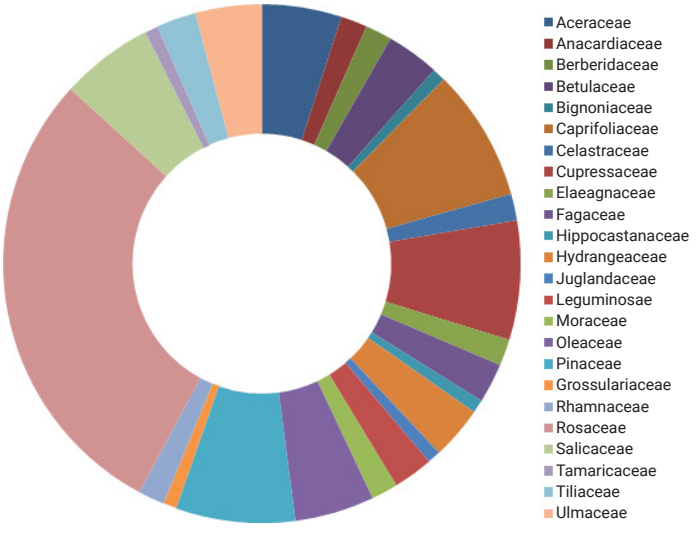

Figure 1. Arboraceous flora of Victory Park by families

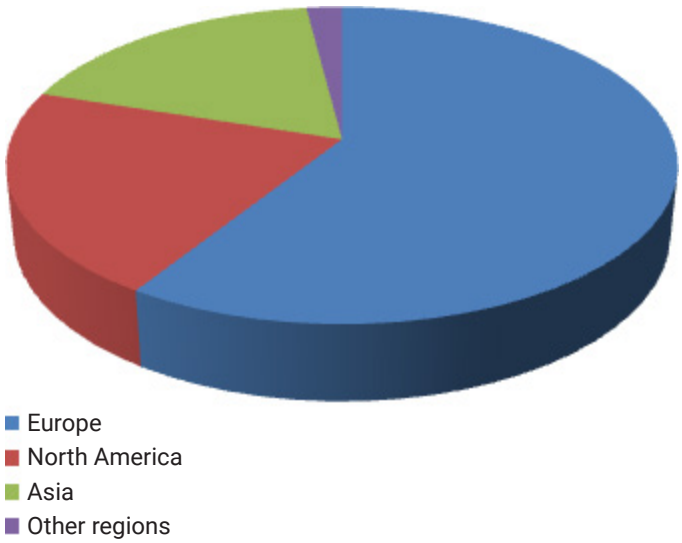

Figure 2. Arboraceous flora of Victory Park by regions of origin

Figure 1 demonstrates distribution of 133 species of trees and shrubs in the Victory Park of Saratov among 24 families. The families represented by most species are *Rosaceae* (37), *Caprifoliaceae* (10), *Salicaceae* (10), *Cupressaceae* (9), and *Pinaceae* (9). Other 19 families include 1–7 species each.

Figure 2 depicts distribution of trees and shrubs of the Victory Park by the continent of origin. As can be seen, 29 species originate exclusively from North America, 24 exclusively from Asia, 34 exclusively from Europe, 5 from North Africa, and the rest from several continents at once. Only about 45 species are

Figure 3. Some non-trivial exotic species in the Victory Park:
a – *Quercus rubra* L., b – *Cotinus coggygria* Scop., c – *Tamarix ramosissima* Ledeb., d – *Mahonia aquifolium* (Pursh) Nutt.

native to the Saratov Region, and the rest are exotic species.

Among identified tree and shrub species, there are many rare and exotic for this territory alien species that have natural habitats in North America, Western Europe, Mediterranean region, Siberia, Central Asia, the Far East and NorthAfrica. Besides intentional planting (61 species), some species obviously originate from nearby orchards and gardens (including abandoned ones), while some possibly come from the Botanical Gardens and arboretum of the local university. We hypothesize that berry-eating and seed-eating birds are a major agent of an "accidental planting" in the park (ornithochory), while anemochory in case ofsome-species with light-weight seeds (or winged seeds) is also likely.

During the study, quite a few very unusual exotic species for this area were identified. Among those, we should note very well acclimatized European smoketree (*Cotinus coggygria* Scop.), Oregon grape (*Mahonia aquifolium* (Pursh) Nutt.), southern catalpa (*Catalpa bignonioides* Walt.), red oak (*Quercus rubra* L.), salt cedar (*Tamarix ramosissima* L.), and some others (Figure 3).

On the other hand, the most common tree species in the park include exotic green ash (*Fraxinus pennsylvanica March.*), and various exotic and local poplars (*Populus*) and elms (*Ulmus*), while most numerous shrubs are represented by introduced Tatarian honeysuckle (*Lonicera tatarica* L.), naturalized Siberian peashrub (*Caragana arborescens* Lam.), common lilac from the Balkans (*Syringa vulgaris* L.), exotic Pacific serviceberry (*Amelanchier alnifolia*

Nutt.), and several species of hawthorns (*Crataegus*) and wild rose (*Rosa*).

Conclusion

Green spaces are an important and integral part of the planning procedure of any city, and they also perform many different functions. Currently, the city of Saratov is experiencing a severe shortage of green spaces. The lack of parks, garden squares and alleys affectsthe quality of residential life. Renovation of senile and diseased plantings is not carried out. The dendrological composition of the city is poor and very outdated.

Victory Park is the only full-fledged park in the city. At the same time, its location near the city center and major highways negatively affects the flora and fauna of the green oasis. The unique dendrological composition of Victory Park requires ongoing protection and high-quality professional care. The green spaces of Victory Park are an excellent example of successful landscaping, and they need constant inventory and protection.

In order to improve and maintain the green spaces of the Victory Park, in conditions of constant internal and external negative impact, it is necessary to observe a number of important recommendations:

1. At the legislative level, to develop a landscaping strategy for the city of Saratov and immediately begin its implementation, attracting highly professional specialists;

2. All commercial organizations operating within the territory of the Victory Park should strictly observe environmental laws;

3. To organize continuous monitoring of illegal logging, unauthorized landfills, uncoordinated construction and spontaneous picnic areas;

4. To carry out inventory of green spaceson an ongoing basis. A full account of all available urban vegetation makes it possible to conduct an entirely objective analysis of the state of the park and surrounding areas;

5. Inventory measures should set one of their goals to improve the assortment of arboraceous plantings;

6. To organize various environmental education activities in the park – e.g., to set ecological trails and create viewing platforms for bird watching.

7. To mark especially rare and exotic species of vegetation growing in the park with signs weather-proof signs.

8. Due to particular uniqueness and importance of the park, we recommend that competent authorities assign the territory of the Victory Park the status of Regional Protected Natural Area.

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