Species composition dynamics of woody plants by the example of gardens and squares of the historical center of St. Petersburg

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Abstract. Preserving the historical appearance of objects of landscape architecture is one of the most important tasks of protecting historical heritage. This task would not be feasible without studying the species composition and dynamics of the historical range of ornamental plants. A change in the species composition during the operation and restoration of such objects naturally leads to a serious change in their historical appearance. An analysis of the species composition of the vegetation in historical gardens, monitoring its state in harsh urban environment, and finding solutions to preserve the appearance of historical objects without violating historically defined features of the area are relevant today.

1. Introduction
Gardens and parks located in Admiralteysky and Central districts of St. Petersburg - the historical center of the city and categorized as objects of cultural heritage of federal and regional importance, are the most significant objects for research.

From multiple points of view the significance of the study is unquestionable, both for determining the role of a green space in maintaining the ecological balance of St. Petersburg, considering the environmental conditions of its location, and for preserving parks and gardens historical originality.

Preservation of the historical appearance of gardens in St. Petersburg is impossible not only without preserving the character of the spatial layout, but also the historical species composition of ornamental plants. The historical woody species of gardens and parks of St. Petersburg, certainly, did not remain the same - the vegetation changed in the process of development, however, these changes are not as radical as in architecture, still trees planted in 18th and 19th centuries are found in urban green areas.

2. Methods and Materials
For a comparative analysis of the historical species composition of city's green areas, the following sources were studied: "Description of the tree plantations of the city of St. Petersburg", published in 1907 as an appendix to "The bulletin of the St. Petersburg City Council", it contains both historical information about urban green areas, and information about their condition at the beginning of the 20th century, as well as plans for gardens and squares [1], and the main source was the publication “Gardens and Parks of St. Petersburg of the 19th – early 20th century” [2].

To reveal the species composition throughout the history of the existence of gardens, archival documents which were provided by the committee for the state preservation of historical and cultural monuments were processed: heritage passports, preservation responsibilities, certificates of technical condition [3]. Furthermore, the information from the publication “Gardens and Parks of St. Petersburg of the 19th – early 20th century” [2] and archival documents of the Central State Historical Archive of St. Petersburg and the Russian State Historical Archive were used.

Determination of conformity of trees and shrubs names in historical documents and in modern sources is an important stage in the historical study of city vegetation. When analyzing the green areas at different stages of planting development, the species composition was compared with the catalog data of the
pomological garden and nurseries of E L Regel and Ya K Kesselring. In 1736, the first catalogue of plants of the Botanical Garden was compiled and published by the Director of the Botanical Garden I G Sigezbek [4]. In 1793, M M Terekhovsky compiled a list of the garden's collection (later published by V I Lipsky, 1913). In 1796, Terekhovsky published a catalog of plants under the name "Catalog of Plants of the Medical Botanical Garden" [5]. In the list of propagated by the Imperial Botanical Garden plants of 1913 – 1915, the years of the appearance plants are recorded: 1816, 1824, 1840, 1852, 1864, 1873. The list was compiled by V I Lipsky and K K Meissner [6]. There is a number of species introduced into the culture around 1750 mentioned in the book of O A Svyazeva “Trees, shrubs and lianas of the park of the Botanical Institute named after V.L. Komarov Botanical Garden (On the History of Introduction to Culture)” (2005) [7]. The assumed names of the plants were also correlated with the presence in the catalog of the N V Schmelling’s tree nursery, 1899 [8].

The surveys were conducted at five objects of cultural heritage of federal importance: “Alexander Garden”, “Voronikhinsky Garden Square”, “Catherine Garden Square”, “Kazan Garden Square”, “Garden square on the Field of Mars” and at two objects of cultural heritage of regional importance: “Novo-Manezh Garden Square”, “Pushkin Garden Square”.

During the field survey, the current species composition at the study objects was recorded. The modern plant material on the studied cultural heritage sites, as well as the total number and share of species and their origin was described. The species composition was obtained using similar data from the inventory records provided by OJSC “SPP Tsentralnoye”. Also, the information from Parks and Gardens Maintenance enterprises (“SPP”) of the Central and Admiralteysky districts of St. Petersburg was used (obtained in 2007 and 2018) [9].

3. Results and Discussion
The Alexander Garden, cultural heritage object of federal importance, as a part of Historic Centre of Saint Petersburg is included in the UNESCO World Heritage List. It is located on a site bounded by the Admiralteyskaya embankment, Senate Square, Admiralteysky Prospekt, Palace Square, Admiralteysky proyezd. At the beginning of the XIX century, the boulevard was laid out here. The author of the project is the architect Luigi Rusca, the main gardener is William Gould.

Voronikhinsky Garden Square is an object of cultural heritage of federal importance. The layout of the square has the features of a formal garden. The first project of a garden inside the Voronikhinsky fence was created by architect Heinrich Christian Staegemann in 1865. The plan included a round central area, a lawn, landscape pathways [9].

Catherine Garden Square is an object of cultural heritage of federal importance. Built in 1832 in front of the Alexandrinsky Theater by the project of architect Carlo Rossi, the work was executed by Yakov Fedorov.

Kazan Garden Square was laid out in 1899 on the square near the Kazan Cathedral, between the monuments of M I Kutuzov and M B Barclay de Tolly. The author of the project is R F Katzer, the main garden master – V I Wiese.

The garden square on the Field of Mars includes 2 objects of cultural heritage of federal importance: the “Parterre garden” and the memorial “To the Fighters of the Revolution”. Parterre Square was created in 1920-1926 by the architect I A Fomin.

Novo-Manezh Garden Square was built on the site of the demolished building of the old circus of Gaetano Ciniselli (1879). The city gardener A. Wiese selected the following species for planting in the garden square: elm, poplar, maple, "non-maple" (author's note – Acer tataricum L.), ash, honeysuckle, jasmine (author's note – Philadelphus pubescens Loisel.), rose. The garden square belongs to the objects of cultural heritage of regional importance.

Pushkin Garden Square was laid out in 1874. It is an object of cultural heritage of regional importance. The area of the garden square is 0.1 ha, it has an oval-shape layout, surrounded by a metal fence with four entrances - on the major and minor axes. I P Wiese noted the poorly compacted paths and lack of shade due to the improper location of the garden. In 1887 one birch, several species of spiraeas, fly honeysuckle, three varieties of roses were planted in the park [2].

At the studied objects of cultural heritage of federal and regional importance, the history stages can be traced based on changes in the species composition (figure 1). It is not possible to trace the exact amount of plants until 2007, so only the presence or absence of the plant is noted. In the last two stages the total number of plants in all studied sites is shown.
The minimum number of species and genera is observed in the period before the 1850s. There were only *Betula pendula* Roth. and *Tilia cordata* Mill. in the described species composition. It is not possible to assume their presence from 1800 to 1830s. *Betula pendula* Roth. has been identified in small numbers at various stages of city development and is currently in green spaces. *Tilia cordata* Mill. was recorded in almost all time periods and remains in the plantings.

The greatest species diversity was recorded in the 1851-1900s, 56% of those belonged to the genus of deciduous trees, the maximum number were: *Acer* L. (5 species), *Populus* L. (7 species), *Salix* L. (10 species) [10].

Also during this period, the greatest amount of coniferous species was planted (100%). In the following years, only 44% of conifers species are remained, this was caused by the loss of the genus *Abies* Mill. and *Pinus* L., as well as species *Picea engelmannii* Parry ex Engelm. and *P. schrenkiana* Fisch. et C. A. Mey. Two species of the genus *Larix* Mill. appeared. At the first stages of development, conifers were absent in the plantings of the studied objects. The minimum number of species was recorded in a period between 1901–1950.

The studies have shown that in quantitative terms, species diversity decreased by 31%, and qualitatively it changed even more significantly (table 1).

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**Table 1.** Species composition dynamics of woody plants in the research objects.

| №  | Research objects          | Number of species: Total, coniferous / deciduous trees / shrubs |
|----|--------------------------|---------------------------------------------------------------|
| 1  | Alexander Garden         | records before 1900-s: 68, incl. | records before 1960-s: 13, incl. | current species composition: 48, incl. |
| 2  | Voronikhinsky Garden Square | none | records before 1900-s: 4, incl. | records before 1960-s: 0 / 3 / 1 | current species composition: 9, incl. |
| 3  | Catherine Garden Square  | records before 1900-s: 9, incl. | records before 1960-s: 13, incl. | current species composition: 15, incl. |
| 4  | Kazan Garden Square      | records before 1900-s: 8, incl. | records before 1960-s: 3, incl. | current species composition: 3, incl. |

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**Figure 1.** The ratio of plant species at the stages of objects development.
Certainly, the species richness of the Alexander Garden plantings has not been preserved in a form as it recorded in the catalog of E. Regel. However, the current species composition of the garden is presented by species that can demonstrate the possibility of using the historical species in the landscape architecture objects of the historical center of St. Petersburg. The vegetation of historical gardens and squares located in the city center are constantly influenced by anthropogenic factors. This provokes the gradual loss of native species which are constituting the historical species composition. Vast number of introduced species and varieties of ornamental trees and shrubs, diverse in environmental sustainability and decorative qualities are increasingly taking part in the plantings of gardens, squares and parks, both historical and modern, which is justified in terms of the creation of environmentally and functionally sustainable urban green spaces.

*Abies balsamea* (L.) Mill. and *A. sibirica* Ledeb., *Picea abies* (L.) Karst. as well as *Pinus schrenkiana* (Fisch. & C.A. Mey.) Antoine, *Pinus cembra* L. and *P. silvestris* L. which are very vulnerable in urban environment, have disappeared from the conifer plantings. Also, *Picea engelmannii* Parry ex Engl. and *Pinus strobus* L. are missing. Instead of these species of conifers, *Larix decidua* Mill. and *L. sibirica* Ledeb. were introduced, these species demonstrate high resistance in the city.

*Acer tataricum* L. and *A.-platanoides* “Laciniatum”, the species requiring adequate lighting, disappeared from the diversity of deciduous trees. Excluded from the plantings *Alnus glutinosa* L. and *A. incana* L. require rich soils which are rarely found in urban environment. *Corylus cornuta* marsh. and *C. avellana* L. – do not tolerate soil salinization. Moreover, from the plantings of historical gardens have disappeared: 10 species of the genus *Salix* L., *Malus baccata* (L.) Borkh. and *M. domestica* Borkh., *Populus x sibirica f. pyramidalis*, *N. nigra* L., *P. laurifolia* Ledeb., *P. candidans* Aiton, *P. balsamifera* L., *P. tremula* L., *P. alba* L., *Padus avium* Mill., *Tilia americana* L. and *T. europaea* L.

Thereby, the following types of historical species composition were preserved in the plantings of the selected garden squares: 2 species of conifers - *Picea abies* (L.) Karst. and *Picea pungens* Engelm.; 20 species of deciduous trees – *Aesculus hippocastanum* L., *Acer platanoides* L., *Acer platanoides* “Schwedleri”, *Acer negundo* L., *Betula pendula* Roth., *Betula pubescens* Ehrh., *Frangula alnus* Mill., *Fraxinus excelsior* L., *Padus virginiana* (L.) Mill., *Padus maackii* (Rupr.) Kom., *Populus berolinensis* Dippel, *Quercus robur* L., *Salix alba* L., *Salix fragilis* L., *Sorbus aucuparia* L., *Sorbus intermedia* (Ehrh.) Pers., *Tilia tomentosa* Moench, *Tilia cordata* Mill., *Ulmus glabra* Huds., *Ulmus laevis* Pall.; as well as 12 species of deciduous shrubs - *Berberis vulgaris* L., *Jasminum fruticans* L., *Crataegus sanguinea* Nutt., *Cotoneaster lucidus* Schlecht., *Loniceratatarica* L., *Rosa hibrida*, *Rosa rugosa* Thumb., *Syringa josikaea* Jacq. fil., *Syringa vulgaris* L., *Spiraea x vanhouettei* (Briot) Zabel, *Spiraea x cinerea* “Greffeshaim”, *Viburnum lantana* L. All these species have fairly high levels of resistance in the urban environment even in the central districts of the city.

The biggest changes have occurred in the following deciduous genera: nine representatives of the genus *Salix* L., six from the genus *Populus* L., two from the genus *Malus* P. Mill., all representatives (5 species) from the genus *Rhododendron* L. Genus *Spiraeae* DC. increased by 4 species (5 species in total). The genus *Rosa* L. increased by several genera, including the genus *Rosa × hybrida* Schleich., which is represented by at least 4 identified varieties. The genus *Crataegus* Tourn.ex L. has become 2 species larger.

All species of the following genera disappeared of shrubs from the plantings: *Corylus* L., *Sambucus* L., *Rhododendron* L., *Cornus* L., *Hippophae* L., as insufficiently winter-hardy in conditions of St. Petersburg. At the same time, the shrubs species of following genera were introduced into the plantations: *Berberis* L., *Cotoneaster Med.*, *Crataegus*, *Dasiphora Rafin.*, *Weigela* Thumb., *Hydrangea* L., *Rosa* L., *Syringa* L., *Symphoricarpos Juss.*, *Spiraea* L., *Forsythia Vahl.*, *Philadelphia* L.
4. Conclusion
An analysis of archival documents and various sources reflecting the history of landscape art in Russia reveals the used species composition of gardens and parks of St. Petersburg in chronological order. Studies suggest that the species of most genera planted from the 18th and 20th centuries are not recorded in the documents, the species composition is repeated at the study objects. Most of the studied species belong to the first catalogs of 1736 and 1793.

The dynamics of the species composition of woody plants of historical objects reflects objective changes that have occurred over time for a number of reasons:
- due to the changed growing conditions;
- by the introduction into the culture of new species with pre-adaptive traits that define resistance to the modern city environment;
- by the introduction into the plantings of new cultivars of ornamental plants, allowing to preserve the physiognomic features of historical gardens with the participation of plants with different taxonomic affiliations.

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