Introduction of woody plants in the Botanical Garden of St. Petersburg State Forest-Technical University from the moment of its foundation up to our days

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Abstract. The history of the Botanical Garden of St. Petersburg State Forest-Technical University is given. The specialists who participated in the introduction of woody plants since 1841 are listed. The names and quantitative composition of introduced plants are given. Attention is drawn to the individual introduction failures and the reasons for them. The total number of woody plants in the Botanical Garden today is more than 1200 taxa (including subspecies, varieties, forms and cultivars). 39 species from the collection are listed in the Red Book of the Russian Federation. The role and place of the Botanical Garden of St Petersburg State Forest-Technical University among the botanical gardens of Russia is noted.

1. Introduction
On April 22, 2017, the Botanical Garden of St. Petersburg State Forest-Technical University (SPbSFTU) turned 190 years old. Officially, the status of the Botanical Garden was granted to the garden in 1970. It is an object of historical and cultural heritage of federal (all-Russian) significance, which was approved by Decree of the President of the Russian Federation No 176 dated 02.02. 1995. The history and information on the evolution of the botanical garden's woody plant collection is of interest not only for dendrologists, but also for a wide range of amateur gardeners involved in the introduction of plants in the North-West region of Russia.

After the foundation of the garden in 1833, an Arboretum was laid, and in 1841 a nursery of woody plants was created. The first documentary source of information about the introduced woody plants is the work of the “patriarch of Russian gardening” R I Schröder (1822-1903) "Observations on trees and shrubs bred in the St. Petersburg Forest Institute regarding their simplicity with special attention to the unusually harsh winter of 1860-1861” [1]. At that time, 498 species and forms of woody plants grew in the nursery. All plants, according to the winter hardiness index of Schroeder, were divided into 4 groups - from completely winter-hardy to freezing.

E L Wolf (1860 - 1931) carried out the most intensive and long-lasting introduction of woody plants from 1886 to 1931. In 1917, E L Wolf in his work “Observations on the Frost-Resistance of Woody Plants” wrote that “... out of (approximately) 3350 species given in the list, 1650 can be considered as suitable for breeding near Petrograd.” Wolf proposed his own assessment of the adaptation of introduced species, proposing a 5-point scale for assessing frost resistance, taking into account whether plants of the a taxon blossoms or bears fruit [2]. Thus, we owe E L Wolf the acclimatization (this property of the plant itself) and the introduction of a number of valuable tree
species capable of to live (in the words of Wolf) on the threshold of the gloomy north. These species are widely distributed in the St. Petersburg and Leningrad region gardening now. Some specimens occur in the SPbGLTU Arboretum since the days of E L Wolf.

In 1928, prof. V N Sukachev, E L Wolf, G Anufriev, A Shennikov for the first time published a list of seeds of collection plants (delectus), which included 173 species and forms for mutually beneficial exchange with other botanical institutions [3]. This contributed to the expansion of the introduction work.

In the 20s of the XX century the unique Mongolian species of woody plants, obtained from director of Arnold Arboretum of Harvard University (Cambridge, Massachusetts, USA) prof. C. S. Sargent, were added to the collection of Arboretum. Of great value was the collection of species of the genus Salix L., compiled by prof. V N Sukachev from Transbaikalia. A culture of this plant was carried out at the Forestry Institute, and material was collected from different parts of Russia, mainly from Siberia. About 300 species of willows were included in the specially organized Salicetum [4]. Due to the lack of care and subsequent reconstruction of the park, Salicetum was lost.

From 1931 to 1936 associate prof. P A Akimov was a head of the dendrological collection. According to the inventory data in 1935-1936 in the Arboretum grew 1212 species and forms of plants. Many new species and forms obtained from the Pamirs, the Himalayas, from the North America and other floristic zones were added to the Arboretum by associate prof. P A Akimov and gardener V D Budylin [5].

From 1936 to 1971 associate prof. N M Andronov was the head of the Arboretum. During this time, the dendrological collection, which suffered during the war, managed to not only restore, but also significantly increase its taxonomic composition. In 1947 after the dramatic war years, less than 800 species and forms, including 25 conifers (out of 112), remained in the Arboretum. By 1967, the collection of Arboretum increased to 1400 taxa [6].

In the same period, prof. P L Bogdanov added to the dendrological collection several varieties of poplars of his selection ("Nevsky", "Leningradsky", etc.) [7]. In 1951 assoc. prof. N O Sokolov created a new dendrological exposition of the introduced species at the territory of the Upper Dendological garden, where approximately 300 plants of 127 species were planted [8].

From 1971 to 1997, V I Drozhzhin was a head of the Arboretum. The scientific leaders were employees of the Department of Botany and Dendrology, prof. N E. Bulygin and assoc. prof. F A Chepik. V I Drozhzhin paid a great attention to not only the care of plants, the choice of place for plants for permanent exhibition, but also the decoration of the Arboretum. Thus, works of the famous sculptor B. A. Pork: "Abduction of Europe" (1970, bronze, author's copy), "Poet's Youth" (1983, bronze and timber), "Helios" (1992, bronze) were installed in the Arboretum. The collection was added with a large number of new exotic flowering plants (rhododendrons, spiraeas, roses), and the exhibition of the garden with interesting compositions.

From 1972 to 1978 S G Sakharova was the head of the nursery of the Botanical Garden. In addition to the introduction of woody plants that were necessary for the educational process in the course of dendrology, she paid a special attention to the introduction of representatives of the genus Rhododendron, thereby helping to restore the lost unique collection of species of this genus. The result of this work was an increase in the taxonomic composition of the Arboretum dendrological collection to 1700 species, forms, and cultivars [9]. Several hundreds of introduced species that have not previously been tested by E L Wolf were tested at the same time.

However, despite the annual adding to the dendrological collection of new species and forms, a reduction in the taxonomic composition of cultivated introductions did occur. First, it was connected with the freezing of insufficiently winter-tolerant introduced species during the anomalously severe winters of 1978/79, 1984/85 and especially in 1986/87 [10].

From 1978 to the present L A Semenova is the head of the works on the introductory nursery. After V I Drozhzhin from July 1997 to January 2009 V Yu Neverovsky was the head of the laboratory of woody plants. Further, the leadership of the laboratory changed several times.
L M Kostyleva for a long time was engaged in the exchange of seeds with other botanical institutions in Russia and abroad. Dendrologists at a modern, international level carry out the preservation and adding of the collection of woody plants, as well as their accounting.

However, there was no exact actual information on the taxonomic composition of the plants collected at the Botanical Garden. The main goal of the article is to fill this gap with the results of the last inventory of the plants of the SPbSFTU Botanical Garden and seed exchange data.

2. Methods and Material
The main source of data was survey ow woody plants of the Botanical Garden carried out in 2017 including Arboretum and its nursery.

One of the main tasks of the Botanical Garden is the collection SEMENIUM” or delectus. Delectus of seeds (from Lat. delectus - selection, selection) is a kind of catalog of the botanical garden, which publishes information about the collected seeds. On average, the Botanical Garden sends every year approximately 200–300 copies of the delectus, which is updated once a year, following the results of seed collection at the Arboretum and in expeditions. The essence of its creation is to exchange seeds. The botanical garden, which received a delectus from another garden, may subsequently place an order to send the seeds it needs. To place an order for seeds, you need to fill desiderata (from the Latin. desiderata - the subject of desire) and send it by mail. The seeds offered in this list are the result of free pollination, therefore, the purity of the species is not guaranteed. Currently, the database of botanical gardens has 418 institutions. The regular exchange of delectuses, bids, and seeds is carried out since 1970. The exchange geography is extensive, it includes 43 countries located on 4 continents. The most intensive exchange is carried out with the botanical gardens of Germany, USA, Italy, France, Czech Republic. The interest of foreign and domestic botanical institutions to exchange seeds with the Botanical Garden of SPbSFTU is not waning. At the same time, it is worth mentioning the difficulties with the exchange of seeds with foreign countries through catalogs at present, which adds to the unpredictability of efforts in the introduction work. In this regard, the irretrievable loss, thus, of the introduced plants, obviously, can be considered unacceptable.

We compiled the list of seeds offered in the exchange of the botanical garden of SPbSFTU from 1970 to 2016, and counted the number of species of certain families, classes, divisions.

3. Results and discussion
The total number of woody plants in the Botanical Garden today is more than 1200 taxa (including subspecies, varieties, forms and cultivars). 39 species from the collection are listed in the Red Book of the Russian Federation. Part of the introduced plants came to the nursery from trips to other botanical gardens and from nature. The main amount of plants grown from seeds obtained by exchanging of seeds with other botanical institutions.

The plants grown in the introduction nursery is the main source of the supplement of the Arboretum collection. Currently, the nursery has 1274 species and taxa of subspecific rank, including 357 species, forms, and cultivars of woody plants, as well as 53 interspecific hybrids. They are representatives of 71 families, 188 genera. Many of the plants that grow in the introduction nursery are absent in the main collection of the Arboretum. In the period from 1970 to 2017, the Arboretum have obtained 10690 samples of seeds, cuttings, seedlings, saplings of woody plants.

In general, from 1970 to 2017 in the garden, a large number of coniferous plants were introduced, especially representatives of the Cupressaceae family, flowering shrubs, the most prominent representatives of which are rhododendrons and lilac varieties. Among introducens there are trees of the largest size, shrubs, and a wide range of lianas, including species of the genus Clematis Dill. ex L. According to the 2017 inventory data, 1204 taxa from 51 families, 147 genera including 958 species and 246 forms and cultivars of woody plants grow in Arboretum.

In the list of seeds offered in the exchange of the botanical garden of SPbSFTU from 1970 to 2016, the number of taxa was the next:

PINOPHYTA: Pinaceae - 14 taxa; Cupressaceae - 12 taxa; Taxaceae - 3 taxa;
MAGNOLIOPHYTA: Rosaceae - 102 taxa; Caprifoliaceae - 40 taxa; Ericaceae - 29 taxa; Hydrangeaceae - 15 taxa; Acaeracea - 12 taxa; Celastraceae - 11 taxa; Fabaceae - 11 taxa; Grossulariaceae - 11 taxa; Oleaceae - 11 taxa; Viburnaceae - 9 taxa; Juglandaceae - 8 taxa; Berberidaceae - 6 taxa; Cornaceae - 6 taxa; Betulaceae - 5 taxa; Carylaceae - 5 taxa; FAGACEAE - 5 species; Hypericaceae - 5 species; Tiliaceae - 5 species; Araliaceae - 4 taxa; Ranunculaceae - 4 species; Rhamnaceae - 4 species; Vitaceae - 4 species; Hamamelidaceae - 3 taxa; Rutaceae - 3 taxa; Asclepiadaceae - 2 taxa; Elaeagnaceae - 2 taxa; Hippocastanaceae - 2 species; Lamiaceae - 2 taxa; Thymelaeaceae - 2 taxa; Actinidiaceae - 1 taxon; Bignoniaceae - 1 species; Buddlejaaceae - 1 species; Cercidiphyllaceae - 1 species; Cleracea - 1 species; Menispermacaeae - 1 species; Schisandraceae - 1 species; Ulmaceae - 1 taxon.

Outside the natural range in the Botanical Garden of SPbSFTU, the following taxa currently grow: Callitopsis nootkatensis (D. Don) Spach, Microbiota decussata Kom., Hedera colchica S. Koch, Periploca graeca L., Buddleja davidii Franch., Tripterygium regelii Sprague et Takeda, several species and cultivars of the genus Helianthemum Mill., Liriodendron tulipifera L., Magnolia acuminata (L.) L., M. stellata (Siebold. Et Zucc.) Maxim., Morus alba L., Morus nigra L., Pterostyrax hispidus Siebod & Zucc., Pyracantha rogersiana (A. B. Jacks.) Bean Chitt hort. ex L. H. Bauley, Pyrcantha coccinea M. Roem., Halesia carolina L., Tilia iataquei C.K.Schneid.; Ampelopsis aconitifolia Bunge.

In the Arboretum we currently testing 59 taxa of the genus Rhododendron. According to the IUCN (International Union for Conservation of Nature and Natural Resources) version among this genus there are 3 VU vulnerable species (Rhododendron makinoi Tagg ex Nakai, Rh. Smirnovii Trautv., Rh. Vaseyi A Gray). There are 26 species of Rhododendrons that cause the least concern (LC); one species – Rh. sichotense Pojark. belongs to lack of data type – DD. Total 30 species of Rhododendrons, i.e. half of the total number are included in the IUCN Red List [11] and are grown in the experimental collection of the Botanical Garden of the University.

Of the 30 taxa of the genus Rhododendron included in the IUCN Red List, progeny were grown from seeds of local reproduction of 19 species. There are 5 species of Rhododendrons, which produced fruits (but the seeds for progeny were not sown) and 6 species only bloom [12].

Special attention should be paid to the following endemic species from China successfully growing in the Botanical Garden of St. Petersburg State University of Forest-Technology: Ginkgo biloba L., Pseudolarix amabilis Gord. (P. kaempferi) [13], Metasequioa glyptostroboide Hu et Cheng, Tilia tian Szyzysze, Phelodendron chinense C.K. Schneid. (Wolf’s frost resistance classification it belongs to the group V), Rhamnus utilis Decne. (it bloomed and produced fruits, Wolf’s frost resistance classification it belongs to III-IV group, with shelter to the II group), Kolkwitzia amabilis Graebn., Sorbus koehneana C.K. Schneid. The last two species bloom, bear fruits, and give germinating seeds (seed progeny of these species is grown).

It is known that fruiting is an objective criterion for the success of the introduction of plants and their adaptation to new conditions. If the introduction mothers grows in the conditions of introduction over 20-40 years, then the seed yield and their high sowing qualities may indicate a favorable ratio of environmental factors for this species. In this connection, it is necessary, along with the introduced plants, to include in the exposition of Arboretum plants grown from seeds of local reproduction. For example, Rosa arvensis Huds. in the collection of the Upper Arboretum, was introduced in 1978 (at the 8th plot, No. 70), then transplanted to a permanent place in 1999, the offspring in the nursery has been grown since 1990.

It should be noted that at present there are many deciduous evergreen woody plants in the nursery and garden: species of the genus Rhododendron L., Leucotho fontanesiana (Steud.), Mahonia aquifolium (Pursh.) Nutt. and M. repens (Lindl.) G. Don, Cotoneaster dammeri C.K. Schneid., C. horizontalis Decne., Buxus sempervirens L., Vinca minor L. (including white-flowered forms and form with golden - variegated leaves), Pachisandra terminalis Siebold et Zucc. Among the representatives of the Pinophyta division are varieties of Thuja occidentalis L., Chamaecyparis pisifera (Siebold et Zucc.) Endl. have been popular for many years. The successful introduction of
these plants allows us to recommend them for widespread use mainly in parks and gardens of St. Petersburg [14].

Particularly relevant is the introduction to the culture of endangered species, such as *Sorbotoneaster pozdnjakovii* A. Rojark, that is the extremely rare endemic of South Yakutia. *Rhododendron smirnowii* Trautv., *Rh. schlippenbachii* Maxim., *Rh. makinoi* Tagg ex Nakai and other relict species are included in the IUCN Red List and are grown in the experimental collection of the SPbSFTU Botanical Garden [11]. For them, as for other taxa of the collection, seed reproduction techniques have been developed at the nursery.

4. Conclusion

In taxonomic terms, the introducents and reproducers of the Arboretum are represented by 51 families, 147 genera and 1204 taxa. Of the conifers, the *Cupressaceae* and *Pinaceae* are the most widely represented. Of the deciduous plants, the following families are the most numerous in the number of taxa: *Rosaceae, Ericaceae, Berberidaceae, Oleaceae, Caprifoliaceae*. According to the developed by A. L. Takhtadzhyan [15] floristic subdivision of the Earth, the largest number of winter-hardy species and forms of the experimental collection of the St. Petersburg State Technical University Botanical Gardens belong to one Holarctic kingdom and two sub kingdoms: Boreal and Madrean (Sonor). The Boreal sub-kingdom is represented by all four areas: the Circumboreal, East Asian, Atlantic-North American, and the Rocky Mountain region. For further introduction, the most promising are the North European, Eastern European, Balkan, Asian and Canadian provinces, the Circumboreal floristic region, Appalachian and the provinces of the Rocky Mountains of North America, the Manchurian, Sakhalin-Hokkaido, Japan-Korean, North-China, Tibetan and Mongolian regions, Djungaro-Tien Shan and Central Tien Shan provinces of East Asian and Iranian-Turan regions.

Currently, taking into account the number of species of woody plants and taxa of subspecific rank, the Arboretum of SPbSFTU is among the top of five botanical gardens of Russia. The experimental collection is used as a repository of the gene pool of rare and valuable species and for research. University staff, graduate students, applicants, postgraduate students write articles, monographs, defend graduation projects, candidate and doctoral dissertations on materials collected in the Botanical Garden. On the territory of the Botanical Garden, studies are conducted on various sections of botany: ontogenesis, antecology, anatomy, morphology, soil science, plant ecology, the introduction of ornamental and economically valuable woody plants.

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