Study on Russian Botanical Garden construction characteristics – on the example of Russia Northern-West botanical gardens

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Abstract. Botanical garden is an important symbol of modern urban civilization. The botanical garden not only protects the ecological environment, but also increases the urban green space area and improves the urban environment and quality of life. This paper analyses and summarizes the construction of 12 botanical gardens of the northwest European part of Russia from three aspects: regional, cultural and plant’s characteristics. What’s more, analysing its spatial layout, concludes that it is mainly affected by the existing natural characteristics and cultural diversity. The purpose of this study is to provide reference for the development and construction of botanical garden in China.

1. Research background
The research on the planning and design of botanical garden has attracted the attention of many scholars. On the basis of emphasizing the importance of planning and design, Zhang Deshun reviews the historical context of traditional botanical garden construction, and introduces the concept of planning and design [1]. Zhao Shudi summarized the key points and design methods of the planning and design of the new medicinal botanical garden from the aspects of layout, zoning, terrain, planting, recreational sketches, sustainability and participatory design, in order to provide reference for the future planning and design of the new medicinal botanical garden [2]. By discussing the regional characteristics of the botanical garden, Hu Nan takes 15 botanical gardens in Tokyo as the research object, combs their basic situation, and analyzes the deep-seated factors of the formation and change of Tokyo botanical garden in combination with social background and policy changes [3]. On the spatial layout of botanical gardens, the basic view of foreign scientist M Burgi [4] is that the study of spatial patterns needs to conceptualize the diversity of current and past human influences, as well as the feedback between people and landscape. An important purpose is to find out the factors that affect the spatial pattern of botanical garden and reveal the complex relationship between people and landscape. A Leitao and J Ahern [5] briefly reviewed the historical role of ecology in the field of sustainable development planning, and considered that the spatial pattern involves the process and relationship among different land, ecosystems and biota at different scales.

Tian Zhenfeng expounded the premise of planning and design of contemporary botanical garden, and also discussed the site selection requirements and functional zoning of botanical garden. [6] Taking the botanical garden on the campus of China Pharmaceutical University as an example, Chen Ping discussed the planning and design methods of medicinal botanical garden from the perspective of zoning planning and landscape elements. [7] Fang Weiyuan studied the development trend and
characteristics of the regional landscape and the regional landscape of the world botanical garden, and focused on the process and methods of shaping the regional landscape characteristics of the botanical garden. [8] Peng Menghong takes Singapore botanical garden as an example to study the special construction of botanical garden, and points out that the construction experience of Singapore botanical garden provides a model for promoting the aesthetic and cultural transformation of Chinese botanical garden landscape. [9]

2. Basic situation of Russian Botanical Garden

Russia is the country with the largest area in the world. It spans more than 170 degrees longitude from east to west and about 40 degrees latitude from north to south. It spans four climate zones, namely subtropical zone, temperate zone, sub frigid zone and frigid zone. Its vast region and different climate environment make its botanical garden rich in flora and fauna [10]. However, due to Russia's vast territory, complex terrain, and the influence of different air currents, there are great differences in regional climate. According to the terrain, climate, humanities and other factors, the Russian Botanical Garden Committee divided the whole country into five regions: the northwest part of Europe; the center of Europe; the South; Urals and Volga; Siberia and the Far East [11]. There are 114 botanical gardens in Russia, including 12 in the northwest of the European part; 18 in the center of the European part; 26 in the South; 32 in the Urals and Volga; and 26 in Siberia and the Far East (Table 1).

The number of botanical gardens in northwest part of Europe in Russia is the least, and the vast area of northwest part of Europe in Russia has two types of temperate grassland climate and temperate monsoon climate, which are similar to those in Northeast China. Therefore, the botanical garden in northwest Europe of Russia is selected as the research object in order to provide reference for the theme design of botanical garden in China.

| Part                      | State name                                                                 | Number of botanical gardens |
|---------------------------|----------------------------------------------------------------------------|-----------------------------|
| Northern - West           | Karelia, Komi, Arkhangelsk, Vologodskaya, Kaliningrad, Leningrad, Murmansk, Novgorod, Pskov, Lenets Autonomous region | 12                          |
| Central                   | Belgorod, Bryansk, Vladimir, Voronezh, Ivanovo, Kaluga, Kostroma, Kursk, Lipetsk, Moscow, Oryol, Ryazan, Smolensk, Tambov, Tver, Tula, Yaroslavl | 18                          |
| Southern                  | Adygea, Kalmykia, Crimea, Krasnodar, Astrakhan, Volgograd, Rostov           | 26                          |
| Ural and Volga region     | Bashkortostan, Mari El, Mordovia, Tatarstan, Udmurtia, Chuvashia, Perm, Kirov, Nizhny Novgorod, Orenburg, Penza, Samara, Saratov, Ulyanovsk, Kurgan, Sverdlovsk, Tyumen, Chelyabinsk, Khanty-Mansiysk Autonomous region, Yamalo-Nenets Autonomous region | 32                          |
| Siberia and Far East      | Altai, Irkutsk, Kemerovo, Krasnoyarsk, Novosibirsk, Omsk, Tomsk, Tuva, Khakassia, Amursk, Buryatia, Jewish Autonomous region, Transbaikal, Kamchatka, Magadan, Primorsky, Yakutia, Sakhalin island, Khabarovsk, Chukot Autonomous region | 26                          |
| Whole country             |                                                                            | 114                         |

Based on the geographical location, construction time, park scale, park ownership and other aspects of the botanical garden, 12 botanical gardens in northwest Europe of Russia were selected (Table 2, figure 1). The selected botanical gardens are distributed in 7 states, including 1 in Karelia, 2 in Komi, 3 in Arkhangelsk, 1 in Vologodskaya oblast, 1 in Kaliningrad, 3 in Saint Petersburg and 1 in Murmansk. In terms of construction time, there are 8 botanical gardens built in the 20th century, 2 in the 19th century and 1 in the 18th century. In terms of Park ownership, there are 6 public botanical
There are 11 botanical gardens and 5 private botanical gardens. In the private botanical garden, you can only see the plant collection in the tour conducted by experts. In terms of park scale, there are 6 botanical gardens covering an area of 10-100 hectares, 2 botanical gardens covering an area of less than 10 hectares, and only 1 botanical garden covering an area of more than 300 hectares.

### Table 2. General situation of Botanical Gardens

| State        | N°  | Name of Botanical Garden                                      | Ownership | Time of establishment | Garden area (hectare) |
|--------------|-----|----------------------------------------------------------------|-----------|----------------------|-----------------------|
| Karelia      | BG-1| Botanical garden of Petrozavodsk state University              | public    | 1951                 | 366.6*                |
| Komi         | BG-2| Botanical garden of the Komi Institute of biology              | public    | 1936                 | -                     |
|              | BG-3| Botanical garden of Syktyvkar state University                 | private   | 1974                 | 31.95                 |
| Arkhangelsk  | BG-4| Arboretum garden of the Northern research Forestry Institute  | private   | 1960                 | 44.4                  |
|              | BG-5| Laboratory "Dendrological garden" of the Northern Federal University | private   | 1934                 | -                     |
|              | BG-6| Botanical garden of the Solovetsky Museum reserve             | public    | 1822 (1982)          | 5*                    |
| Vologodskaya | BG-7| Dendrological garden of the Vologda state Academy              | public    | 1999                 | 12.5                  |
| Kaliningrad  | BG-8| Kant's Botanical garden                                       | public    | 1904                 | 13.57                 |
| Leningrad    | BG-9| Botanical garden of the Russian Academy of Sciences            | public    | 1714                 | 22.9                  |
|              | BG-10| Botanical garden of Saint Petersburg state University         | private   | 1840                 | 2.6                   |
|              | BG-11| Botanical garden of the Saint Petersburg forestry Academy     | public    | 1827                 | 43.7                  |
| Murmansk     | BG-12| Polar-Alpine Botanical Garden-Institute                       | private   | 1931                 | 80*                   |

1. "**" National Nature Reserve,
2. "." refers to the area that cannot be obtained by searching for data,
3. In order to make the chart concise and clear, 12 botanical gardens are replaced by "BG-number" in the following chart.

Figure 1 Distribution of Russian botanical garden (the serial numbers is consistent with table 2)
3. Russian Botanical Garden construction characteristics

Study construction of any landscape object, we must consider the regional characteristics, including natural landscape and historical context. Among all the public gardens in the city, botanical garden is the only one with scientific connotation. Therefore, on the basis of reflecting the historical context characteristics as other parks, the regional characteristics of botanical garden should emphasize the natural landscape and highlight its scientific characteristics. [12]

3.1. Regional characteristics

The planning and design of the botanical garden should try to maintain the original topography, avoid large-scale topographic transformation, and try to retain the original trees, shrubs and herbs. In this way, can not only make use of the features of the original topography to create features, but also save a lot of money on the terrain reconstruction. The preserved natural landscape plays an important role in the formation of a beautiful botanical garden.

One of the botanical gardens which preserve natural landscapes is the Botanical garden of the Solovetsky Museum reserve, one of the highest latitude botanical gardens in Europe, less than 200 kilometers from the Arctic Circle, on the territory of an ancient monastery. [13-14] The botanical garden is located on a flat ground in the middle of Solovetsky island. The climate of the island is characterized by strong cold wind on the coast, mainly in the tundra zone, with lichens and mosses. The main vegetation is taiga forest. The botanical garden is located between the two lakes and surrounded by mountains, which creates favorable conditions for planting plants. There is no contrast with the surrounding nature, only natural materials are used in the construction of the botanical garden. Another example is Botanical garden of Petrozavodsk state University – it is located on the north bank of lake Onega in a coniferous forest. The botanical garden belongs to the "devil chair" domain, which is located in the south slope of volcanic relics, and has obtained the status of national natural geological relics. One third of the "devil chair" area is occupied by natural plant communities. Other areas are divided into functional areas: plant exhibition area, economic area and administrative area. The unique landscapes created by volcanoes, glaciers and pine forests enable us to conduct an exhibition based on the geographical principles of flora in Europe, Asia and America. In order to protect the natural environment from the influence of human beings, the plant exhibition area restricts visitors to see the plant collection only in the tour conducted by experts. [15] Polar Alpine Institute is the northernmost botanical garden in Russia, located in the mountains within the Arctic Circle on the Kola Peninsula. The scope of the botanical garden is a nature reserve. In order to protect the natural environment of the botanical garden, visitors can only enter the greenhouse, and the plant exhibition area is used for sightseeing along the ecological footpath. [16]

3.2. Cultural characteristics

Most of Russian botanical gardens are the monuments to human culture. It is not only natural parks that have special cultural value, but also buildings of some times, such as greenhouses, museums and libraries within the scope of botanical gardens. Cultural monuments include sculptures in botanical gardens and structures in landscape art gardens. Many botanical gardens also have memorial functions, named after famous scientists.

The best examples of botanical gardens with cultural features are located in Saint Petersburg. The main building in the botanical garden of the Saint Petersburg forestry Academy is protected by the state as a monument of landscape art of the first half of the 19th century. Botanical garden of Saint Petersburg state University is famous for the bench of Aleksandr Blok, a famous Russian poet, and protected by the state. Botanical garden of the Russian Academy of Sciences is one of the oldest botanical gardens in Russia. There is a 18th century landscape architecture monument in its territory called "Medicinal garden", created by Peter the Great.

In addition to historical and cultural characteristics, special activities are also held in the botanical garden. The art activities of the botanical garden include special plant exhibition, painting, photography, music exhibition, etc. Russian botanical garden sets up different types of exhibition
activities with its own characteristics to enhance interaction with citizens’ life, create a strong artistic and cultural atmosphere, and use the beautiful environment of the park to enhance space vitality and create independent income. For example, Botanical garden of the Russian Academy of Sciences holds annual Japanese Festival, flower exhibition, plant history and evolution exhibition, illustration exhibition, etc. (Table 3).

| Activity title | Theme | Time | Characteristics |
|----------------|-------|------|-----------------|
| “Spring dream”| flower exhibition | February, 29 – March, 6 | exhibition |
| “St. Petersburg Lily” | flower exhibition | March | lily exhibition, lecture |
| “Succulent plants” | flower exhibition | April | plant exhibition, lecture |
| Night in the Museum | festival | Every year; May, 19 | lectures, concerts, master classes, photography |
| “Unusual garden” | tea festival | September, 22-23 | tea tasting, lecture |
| Christmas in the botanical garden | ecological hiking | December, 24-25 | ecological excursion |
| “Magic Garden” | festival | December, 31 | ecological excursion |

3.3. Plant’s characteristics

In addition to protecting the local rare plants and the world's unique plants, the Russian botanical garden also carries out a rich display collection of plants. The variety of collected plants depends on the local climate conditions, the education and scientific research direction of the University, the management and supervision department, the botanical garden history and targeted funding, etc. [17] Combined with the theme classification of specialized gardens, the themes of 54 specialized Russian Botanical gardens were classified and sorted into six categories, namely: the exhibition of plant germplasm resources, the exhibition of regional characteristics, the exhibition of ecological landscape, horticulture exhibition, the exhibition for natural experience and the memorial exhibition. All of these types are presented at the table 4. Among them, the exhibition of plant germplasm resources involves 30 themes, accounting for 56%; the exhibition of regional characteristics involves 12 themes, accounting for 22%; the exhibition of ecological landscape involves 5 themes, accounting for 9%; horticulture exhibition involves 2 themes, accounting for 4%; the exhibition for natural experience involves 3 themes, accounting for 5%; and the memorial exhibition involves 2 themes, accounting for 4%; presented at figure 2-3.

| Botanical garden specialty Park’s Theme | Name of specialty Park | Number |
|----------------------------------------|-----------------------|--------|
| the exhibition of plant resources (30) | Coniferous garden, cactus garden, fruit garden, herbal garden, tropical flower garden, tropical rain forest garden, flower garden, experimental garden, invasive plants garden, narcissus garden, flower and shrub garden, pine garden, lilac garden, birch garden, willow garden, rose garden, pine garden, poplar garden, tea garden, lime garden, oak garden, climbing plants garden, perennial garden, tulip garden, fern garden, lily garden, iris garden; | BG1-12 |
| the exhibition of regional characteristics (12) | native garden, Japanese garden, Asian garden, European style garden, American garden, Chinese garden, Australian Garden, Caucasian garden, Far East garden, Karelia garden, African garden, Siberian garden | BG1,4,7-11 |
| the exhibition of ecological landscape (5) | rock garden, shade garden, aquatic garden, wetland garden, sunshine garden | BG1, 8-11 |
| horticulture exhibition (2) | four seasons garden, winter garden | BG9, BG12 |
the exhibition for natural experience (3)  
children's experience (2)  
horticultural therapy (1)  
the memorial exhibition (2)  
memorial garden, rare plants garden  
BG8, 12

| Theme Type                        | Number | Description                                      | Gardens |
|-----------------------------------|--------|--------------------------------------------------|---------|
| children's garden, learning garden| BG6, BG9| sensory garden                                    |         |
| BG9                               |        |                                                  |         |
| BG8, 12                           |        |                                                  |         |

4. Russian Botanical Garden spatial layout

The spatial layout of botanical garden mainly refers to the arrangement and combination of landscape elements in the space of botanical garden. Layout include not only natural landscape elements considered in landscape ecology, but also human landscape elements. [18]

4.1. Natural landscape layout

The spatial location of the botanical garden is significantly affected by natural conditions (such as mountains, water, topography and site topography). Ignoring these conditions will not only affect the external composition of the botanical garden, but also destroy the natural environment. In order to improve the spatial layout of botanical garden and create valuable natural space, we must make full use of the advantages of natural conditions in the region.

After the 19th century, the British natural landscape park became popular in Europe. This idea also showed in Russian garden construction. The layout of botanical garden gradually changed from rule to nature, and there was no more obvious artificial trace and building group. The botanical garden design integrated the plant exhibition with natural scenery through winding Garden Road, tortuous water body and rich forest community. Since then, the expansion and development of botanical garden is based on natural landscape, focusing on the coordination between architecture and surrounding environment, and retaining the existing regular garden, combining regular composition with natural garden. Regular layout is now in the planning of the entrance, core area, building surroundings and main garden roads. In the aspect of water, garden road and plant configuration, natural design methods are adopted to pursue the real imitation of Russian regional landscape.

The north of the Botanical garden of the Russian Academy of Sciences has a clear cross axis of the original botanical garden, while the south uses abstract organic forms, natural style paths and plant group profiles (Figure 4). In the course of many years of development, natural and regular landscape layout methods gradually blend, and exist in the planning structure of botanical garden. Therefore, the whole landscape effect is controlled by the combination of axis and natural space structure. The regular layout is applied to the special garden display. This landscape structure which has been transformed from rule to nature also shows Russian garden art for hundreds of years and the transformation of social natural concept.
4.2. Ecological layout
One of the most important functions of botanical garden is to protect the ecological environment. Botanical garden has become an important urban green space because of its large number and rich species of plants. Like urban parks, it has satisfactory ecological functions in preventing soil erosion, sterilization and dust retention, purifying air, regulating microclimate, reducing heat radiation and slowing down heat island effect. Therefore, the ecological layer of botanical garden is an important factor to be considered. [19]

The ecological core of northwest part of Europe in Russia is three Botanical Gardens: Botanical garden of Petrozavodsk state University, Botanical garden of the Solovetsky Museum reserve, Polar-Alpine Botanical Garden-Institute, all of which are national nature reserves. Its unique ecological importance was one of the reasons why Soviet scientists chose it as a botanical garden. This kind of botanical garden not only grows some plants, but also is the habitat of many fish, birds, reptiles and amphibians. It has a high degree of biodiversity and plays a role in forest ecological benefits from all aspects all the time. In order to protect the original environment, access to these botanical gardens is strictly controlled. For example, a visit to the polar Alpine Institute botanical garden may only be part of a short trip led by a research assistant at the garden. As a result, all science buildings, greenhouses and plant exhibition areas are located outside the reserve to reduce their impact on natural forests. Located on the territory of the polar Alpine Institute botanical garden, the tundra is a unique mountain range, with all geographical areas closely alternating, from forests to rocky polar deserts in relatively small spaces. To sum up, an important part of the botanical garden in Northwest Russia is a nature reserve with high ecological value. In order to protect it, we need to "isolate" the natural area from the high human load area.

4.3. Cultural diversity layout
Cultural diversity is a distinctive feature of human beings and their society, which is also a key driving force for the progress of civilization. How to reflect the cultural diversity of a region and even the world in the future botanical garden spatial layout is an important topic that cannot be ignored in botanical garden construction. [19] However, the study found that only one botanical garden in Russia set up a garden representing the culture of other countries in the world, which showed the diversity of world culture through spatial layout. Most of the Russian botanical gardens which showed the diversity of world culture are located in central or southern Russia. In Russia's northwest Europe, only the St. Petersburg Academy of Sciences botanical garden

Figure 4. Botanical garden of the Russian Academy of Sciences layout
has a traditional Japanese garden. The garden was built by Russian and Japanese landscape architects in accordance with Ikenobo school with the participation of the Japanese General Consulate in St. Petersburg. The Japanese garden, presented at figure 5-6, can only be visited as part of the tour group.

Figure 5. Japanese garden. Teahouse
Figure 6. Japanese garden. Stone garden

5. Conclusion
With the world's attention to biodiversity conservation, botanical garden as a plant protection base has attracted more and more attention. Recently, the development focus of Russian botanical gardens has changed, from closed or semi closed scientific or educational institutions to public institutions, with significant environmental and historical characteristics. This paper analyses and summarizes the characteristics of 12 botanical gardens, and concludes that the overall spatial layout of botanical gardens is mainly affected by the existing natural characteristics and cultural diversity. The construction of Russian botanical garden has come to the following two conclusions.
(1) High value of the core of history, culture and nature: in terms of regional characteristics, it can be said that the modern Russian botanical garden is a model for the preservation of historical sites and cultural relics, as a good place for the display and classification system of local rare plants and world unique plants.
(2) The integration and coexistence of natural and cultural landscape elements in space: through the study of respecting the site characteristics, protecting the ecological core and blending foreign culture, this paper briefly expounds the relevant enlightenment on the spatial layout of botanical garden, which can provide reference for the reasonable spatial layout of Chinese botanical garden in the future.

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