Plant community structure and species diversity in Lingang wetland park in Tianjin China

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Abstract. Lingang wetland park is a newly built wetland park in Lingang district, Tianjin, China. The community composition, community structure, frequency of occurrence of arbor and shrub layer and dominant species of plant community in lingang wetland park were investigated. The results showed that the community of Lingang wetland park was mainly characterized by the structure of trees-shrubs-lawns, and the ratio of species and number of evergreen trees to deciduous trees was 2:15 and 1:23. Wetland park is rich in plant diversity, the dominance index at park's east gate and “qushuihuajing” were 0.8183 and 0.8152, which were far higher than other quadrants and the dominant species is golden elm. Among the tall trees, *Ulmus pumila*, *Salix babylonica*, *Aureus locustae* with the highest application frequency accounted for 23.8%. For shrubs, *Lonicera japonica*, *Euonymus japonicus* and *Lonicera maackii* had the highest frequency of application. *Festuca elata* and *Hemerocallis fulva* had highest application frequency in lawns. They accounted for only 13.2% in herbs. It indicated that only several plants in the park have high frequencies.

1. Introduction

This park green space is the main part of urban green space, which can not only beautify the city, but also balance the urban weather changes, improve the urban air quality and maintain the urban ecological balance [1]. People's growing spiritual needs can be met in the appreciation and use of high-quality urban parks. With the development of social economy, the requirements for park construction are becoming higher and higher, and the ecological integrity, diversity and ecological interaction of park vegetation are gradually taken into account.

Lingang wetland lies in Tianjin Lingang industrial zone. It is located in the downstream of Hai river basin, the central area of the east of Tianjin, on the verge of the Bo Sea. It is located in the temperate semi-humid continental monsoon climate zone. Obviously, weather changes along the seasons, with a hot and humid summer and a dry and cold winter. Annual average temperature is 12.3℃ and annual average rainfall is 617 mm.

Wetland park in Lingang is predominantly a water treatment artificial ecological wetland park with both landscape and ornamental value. The park's water area is about 170000 square meters; all kinds of nursery stock are planted with more than 120 varieties in total. Among the plants, number of trees is 261200, number of individual shrubs is 384000, number of tufty shrubs is 193600, number of
ground cover plants is 344500, lawn area is 493500 square meters. And wetland park is a combined artificial and natural park. Sewage are been treated and recycled through an international advanced ecological sewage treatment technology [2]. It not only beautifies the park landscape, but also reduces sewage pollution. The Binhai new area will become an outdoor leisure base and an ecological demonstration base for residents.

The plant community structure and diversity of the wetland park were investigated in the harbor economic zone in this paper. The purpose is to master the research of plant growth status and plant diversity, grasps the plant diversity and the natural law, establish scientific and suitable system mechanisms for the ecological construction and maintenance of the wetland park and improve the provision of basic data and theoretical background.

2. Materials and methods

2.1. Site selection
Quadrons were selected from seven typical scenic spots in wetland park, such as Yousiting, Tanghaixunyou, Qushuihuajing science center, Jinweichaosheng, Shuidanggutian and park’s east gate, with a size of 100 ×100 m. In the research of plant diversity of wetland park, trees and shrubs in the quadrants were investigated and analyzed with the method of registering each tree, and the frequency and dominant species of plants and other important indicators were analyzed.

2.2. Calculation method

2.2.1. Calculation formula. The Dominance index is on the basis of the important value of each species in the community and reflects the concentration of dominant species in the community [3]. The calculation formula is as follows:

\[ C = \sum_{i=1}^{s} \left( \frac{n_i}{N} \right)^2 \]

2.2.2. Importance value. Importance value = (relative density + relative frequency + relative significance /300) [3]. Relative density (RD) = (the density of a plant/the total density of all plants) 100% = (the number of individual plants/the number of individuals of all plants) 100%; Relative frequency = (the frequency of this species/the total frequency of all species) 100%; Relative significance (relative Dominance) = (sum of individual chest area in the sample square and total individual chest area in the sample square) 100%.

2.2.3. Species diversity index. Species diversity index is a comprehensive quantitative index that reflects the number, structure, individual number and evenness of species in a community [4]. The most commonly used ones are species richness index (S), Simpson index (D), Shannon-Weiner index (H) and Pielou's evenness index (J) [5], which measure community dominance and judge community diversity.

3. Results and analysis

3.1. Community composition
The quadrants were representative of the landscape areas in the wetland park. It can be seen that most local tree species are planted to assist the introduction of trees from other places, the natural succession of ground cover plants is utilized, and the planting of tree species is reasonably arranged. Due to its geographical location in saline-alkali land, the park attached great importance to the promotion and application of local native species, especially salt-tolerant species.
perspective of engineering, the park was mainly represented by the classic structure of trees, shrubs and grasses. In the tree layer, poplar, willow, locust and jujube are used as the most important tree species. In the shrub layer, the easy pruning varieties were mostly chose such as spindle tree, virgin bulb and purple berberis. According to the geographical characteristics, the development and introduction of new species, large size of seedlings for embellishing and other ways to gradually enrich the variety of ornamental plants and reasonable dense planting, has contributed to the park being clearly structured, fascinating and with a harmonious landscape collocation.

3.1.1. Common native plants in Tianjin

The local tree species in Tianjin are closely related to soil, water and climate conditions. 33 species of local tree species were identified there [6]. Common deciduous trees include weeping willow, golan tree, Chinese toon, Chinese pear, elm, national locust, apricot, persimmon, mulberry, coniferous tree, jujube tree, apple, dry willow, walnut, poplar, ginkgo, pear, etc. Commonly used deciduous shrubs are: midget crabapple, lilac, gold and silver wood, forsythia, begonia fruit, cypress, wild Martin incense, tamarix, Chinese rose. Comparing with the plant management account of Lingang wetland park, more than 80% of the plant species applied in Lingang wetland park coincide with the local tree species in Tianjin, which conformed to the assumption that the adaptability of local plants to the environment was much higher than that of alien species. On this basis, the plant diversity can be reasonably enriched through grafting, introduction and other means.

3.1.2. Composition of plant types.

The relationship of plant type composition was an indispensable aspect to study the characteristics of plant species composition. Evergreen The percentage of evergreen species was the least, accounting for 2.7%, and that of deciduous tree species was the largest, accounting to 37.4% in the park (Figure 1). The species ratio of evergreen trees and deciduous trees in wetland park was 1:13.9 and the number ratio is 1:23, showing that the park was dominated by deciduous trees, and there were significant differences in the species and number of evergreen and deciduous trees. Shrub species accounted for about 30.8%; and ground covers and aquatic plants accounted for 29.1%. The both ratio were similar (Figure 1). The shrub layer was divided into solitary shrub and secondary shrub, with a species ratio of 2:1 and a number ratio of 1:1. Therefore, it can be seen that the design of solitary shrub and cluster shrub was more scientific and average. Under the condition of meeting the phenological conditions of Tianjin, the species and quantity of evergreen trees should be increased through introduction and cuttage, so as to improve the species richness and the ornamental value of the park.

![Figure 1. Percentage of species distribution in wetland park.](image)

3.1.3. Composition of ornamental species.

Flowering plants were mostly rosaceae, and other species of the genera were also planted in the shrub layer. Due to factors such as soil and climate conditions in wetland park, people were very fond of landscape areas formed by flowering plants. Therefore, that kind of plants, especially shrubs, were widely used in wetland park. The main flowering plants such as rose, begonia, plum, cherry blossom, jasper and other rose shrubs have a flowering period
concentrated from April to June, the flower color being red, pink, white, purple and other colors. They have a very important garden landscape value.

In the foliage plants, except purple plum, gold privet and evergreen cypress, most autumn leaves are yellow, such as weeping willow, national locust, golden elm, gold and silver wood, goldenrod tree and so on. Because of the influence of Tianjin’s geographical location and climate, deciduous plants were larger than others, and there were abundant ornamental effects in autumn. There were fewer spring leaf plant and evergreen.

3.2. Community structure

3.2.1. Dominant species of tree layer in the quadrants. Among the 7 quadrants, the dominance index of the meander path and the park’s east gate was significantly higher than that of other landscape areas, reaching to 0.8, and the dominant species were gold leaf elm (table 1). It was shown that gold leaf elm had a prominent dominant position in wetland park. In addition, it had beautiful leaf color, developed root system, resistance to cold, drought and barren, and strong adaptability. Therefore, the planting of gold leaf elm in wetland park had great landscape significance and value.

| Quadrants            | Dominance index | Dominant species                                |
|----------------------|-----------------|-------------------------------------------------|
| Yousi pavilion       | 0.7001          | 107 poplar                                      |
| Haitangxunyou        | 0.7968          | Mmidget crabapple, Malus halliana               |
| Qushuihuajing        | 0.8152          | Gold leaf elm                                   |
| Science centre       | 0.6852          | Elm                                             |
| Jinweichaosheng      | 0.1953          | Mmedlar                                         |
| Park east gate       | 0.8183          | gold leaf elm, Acer negundo                     |
| Shuidanggutian       | 0.7275          | Robinia idaho                                   |

3.2.2. application frequency of plants in the sample plot. The commonly used trees in wetland park were poplar (*Populus L*), Pagoda tree (*Sophora japonica*), weeping willow (*Salix babylonica*), golden elm (*Ulmus pumila*), accounting for 23.8% in the total tree species in the park. The results showed that, except for a few trees with high presence rate, the frequency of other tree species in the vegetation community of wetland park was not high (table 2). The frequency of deciduous trees was relatively large. Due to the characteristics of northern weather, the frequency of evergreen trees in wetland park was relatively small, and it can be seen that there were more presence of foliage species, which was suitable for the design characteristics of northern gardens. Among them, species such as *Malus micromalula* and *Albizia julibrissin* can be planted on both sides of the road to form a landscape of flowers, which had high ornamental value but low appearance frequency. It was worth to be popularized and enlarged.

| Frequency (%) | Plant names                                | Species |
|---------------|--------------------------------------------|---------|
| 20≤f<25       | *Populus L*, *Sophora japonica*, *Salix babylonica*, *Ulmus pumila* | 4       |
| 15≤f<20       | *Crataegus pinnatifida*, *Amygdalus persica*, *Robinta pseudoacacia*, *Sabina chinensis*, *Sophora japonica* | 5       |
| 10≤f<15       | *Malus micromalula*, *Malus halliana*, *Sabina chinensis*, *Salix matsudana* | 4       |
| f<10          | *Rhus Typhina*, *Morus alba*, *Zelkova serrata*, *Albizia julibrissin*, *Acer negundo*, *Armeniaca vulgaris* | 7       |

Among shrubs, *Rosa, Lonicera japonica* etc., were commonly used shrubs in gardens (table 3).
**Buxus megistophylla** was often trimmed into a low giant sphere in the park, or planted as a single plant, or symmetrically arranged in a regular way, forming a characteristic landscape with flowers and leaves set off against each other for years. Although winter jasmine (*Jasminum nudiflorum*) and Flowering plum (*Euonymus maackii*) were both less than 15% in frequency, their flowers were blooming like broomfuls and sea of flowers, which had high ornamental value and can form beautiful and rich levels of garden landscape, so they should be popularized and favored.

| Frequency (%) | Plant names                                                                 | Species |
|---------------|-----------------------------------------------------------------------------|---------|
| 20≤f<25       | *Lonicera japonica, Buxus megistophylla, Lonicera maackii*                   | 3       |
| 15≤f<20       | *Rosa sp, Hibiscus syriacus, Ligustrum lucidum, Ribes mandshuricum*          | 4       |
| 10≤f<15       | *Euonymus maackii, Jasminum nudiflorum*                                     | 2       |
| f<10          | *Berberis thunbergii, Forsythia suspensa, japonica, Prunus ceraifera, Amygdalus triloba, Sabina chinensis* | 6       |

**Table 3. Application frequency of common shrubs.**

The most frequent herbs used for cover ground were *Festuca elata* and *Hemerocallis fulva* (table 4). In the park, they are often planted under the trees to form a better landscape under trees with other shade tolerant plants, but it only accounted for 14.2% of all herbaceous species. This indicated that the repeated use of these herbaceous plants in wetland park green space was serious, while the appearance frequency of most ground covers with good ornamental effect was generally low. Single application of plants was easy to cause monotony, so the species of ground covers, such as compositae, should increase. Compositae are the most commonly used flowers in the park in spring, they can be planted around in the spring, and help to the landscape of the park. Compositae plants with good ornamental effect such as *Echinacea purpurea*, *Coreopsis drummondi*, *Gomphrena globosa*, *Nepeta cataria* and others, had beautiful shape and strong adaptability and, can be used to shape a beautiful landscape with richer park species.

**Table 4. Application frequency of common herb ground covers.**

| Frequency (%) | Plant names | Specials |
|---------------|-------------|----------|
| 20≤f<25       | *Festuca elata, Hemerocallis fulva* | 2        |
| 15≤f<20       | *Iris lactea, Phalaris arundinacea, Echinacea purpurea, Gaillardia pulchella* | 4        |
| 10≤f<15       | *Coreopsis drummondi, Gomphrena globosa, Nepeta cataria* | 3        |
| f<10          | *Physostegia virginiana, Salvia japonica, Aster novi-belgii, Sedum spectabile, Parthenocissus quinquefolia* | 5        |

4. Discussion

**4.1. Common local species in the parks**

In this paper, the species of common native plants in wetland parks were investigated, but the genera and families of these plants including exotic and native plants were not counted and classified. Data and proportions of all plants lacked data. The number, species and proportion of native plants and exotic plants in the park will have an important impact on the landscape construction of the park. Therefore, these aspects should be further studied so that more perfect guidance and suggestions can be put forward for the reconstruction of the park in the future.

**4.2. Selection of evergreen and deciduous trees**

In the selected quadrat, when tall trees are selected and configured, the species and number of
deciduous species in wetland park were significantly higher than those of evergreen species and the difference was obvious. However, evergreen and deciduous tree species can only play a good ecological function in a reasonable combination, so the presence rate of woody plants in the park should be increased, especially the proportion of evergreen trees. It can enrich the winter garden landscape, and bring into play important ecological, aesthetic and socio-economic benefits.

4.3. *Waterfront plants in park*
Lingang wetland park had both ecological and landscape construction uniqueness. Its land is surrounded by water, the park covered a large area, the water body was unevenly distributed and the coastal plant species were simple, so investigation quadrants were not divided into water samples separately. We did not have a thorough understanding of the waterfront plants in the wetland park, lack basic data support in the selection of their species and number and their distribution and configuration and cannot put forward scientific suggestions on the ecological construction, conservation and improvement of water bodies in the wetland park.

4.4. *Ornamental plant configuration*
After investigating the ornamental and seasonal features of plants in the park, it was found that there were still some problems in the design of the park. There are few varieties of plants flowering in autumn in the park, and the flowering period was mainly concentrated in spring and summer. Green form was simpler, lawn area was bigger and herbaceous plant chooses collocation simply. Therefore, wetland park should improve the structure of green space community on the basis of the original plant community, species selection and plant configuration. It would be important to enrich the winter plant landscape by focusing on the cultivation of flower plants; and bring more autumn flowers such as hollyhock to beautify the wetland park landscape effect and make the best of the characteristics of different plants.

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