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Research on Plant Landscape in Urban Wilderness Space: A Case Study of Jiangyangfan Ecological Park in Hangzhou

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ABSTRACT

In recent years, with the acceleration of urbanization, the construction and management of urban wilderness space has become an important research field. The study of plantscape in urban wilderness space is one of the key points. Plant landscape is the core element of urban wilderness space, which plays an important role in improving urban environment and ecosystem service function. In this study, we chose Hangzhou Jiangyangfan Ecological Park as an example, and identified two main areas, the habitat island and the lake area, to be used as the research sites for plant species. The distribution of plant species, community structure, seasonal variation and spatial characteristics of these areas were studied and evaluated in detail. Based on the actual data collection, we will propose the following plant construction strategies: introduction of native species, creation of communities close to nature, use of temporal characteristics of plants, and the use of plants to shape the aesthetics of horticultural spaces.

KEYWORDS

Wilderness space; Plant landscaping; Spatial structure; Hangzhou Jiangyangfan Eco-Park.

1. INTRODUCTION

As urbanization continues to advance, urban construction inevitably occupies substantial amounts of land, disrupting and degrading the original natural ecosystems. The extensive construction activities associated with urbanization have led to a high degree of spatial intensification and environmental stress, making urban wilderness spaces an increasingly important component of urban ecosystems. Urban wilderness space refers to fragmented and scattered patches of natural vegetation that persist or re-emerge in disturbed urban environments, characterized by spontaneous vegetation growth, minimal human intervention, and complex ecological dynamics[1]. These spaces, as vital elements of urban green infrastructure, play crucial roles in enhancing urban biodiversity, regulating climate, and providing recreational and aesthetic value to urban residents[2].

With the growing urban population and increasing demand for improved urban living conditions, the ecological, social, and economic benefits of urban wilderness spaces have gained significant attention. These spaces not only serve as important refuges for biodiversity but also help mitigate the urban heat island effect, improve air and water quality, and offer opportunities for environmental education and community engagement[3]. The rising emphasis on ecological sustainability and urban resilience underscores the importance of integrating urban wilderness spaces into broader urban planning and development strategies[4].

Hangzhou Jiangyangfan Ecological Park is a model of successful integration of urban wilderness within a rapidly urbanizing context. The park is characterized by its natural succession of vegetation communities and highly self-regulating ecological processes, making it a prime example of urban

wilderness that supports a diverse range of plant species, ecological functions, and landscape aesthetics. Ecological processes such as natural regeneration and species adaptation in the park highlight the potential of urban wilderness spaces to enhance urban biodiversity and ecological stability[5]. Studying the plant landscape of Jiangyangfan Ecological Park can provide valuable insights into the ecological functions and landscape characteristics of urban wilderness spaces, offering scientific foundations and references for urban ecological planning and environmental management.

This study aims to explore the plant landscape of urban wilderness spaces, focusing specifically on Jiangyangfan Ecological Park in Hangzhou. By analyzing the composition, structure, and ecological processes of the plant communities within the park, this research seeks to deepen the understanding of the effective integration of urban wilderness spaces into urban environments. The findings will contribute to the field of urban ecology and provide practical guidance for urban planners and environmental managers in the creation and conservation of urban wilderness spaces.

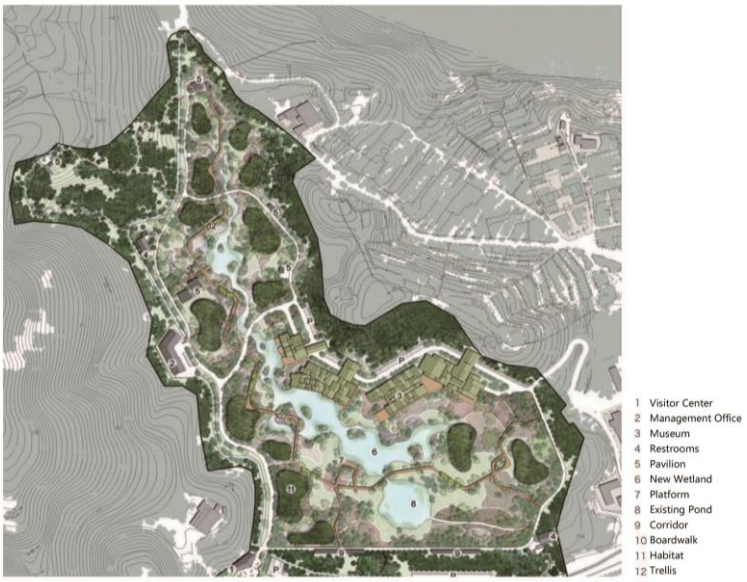

Figure 1. General Plan

2. OVERVIEW OF URBAN WILDERNESS SPACE

2.1. Definition and Development of Urban Wilderness Space

Urban wilderness space includes both native natural land parcels that have not been disturbed by development in the city, as well as wilderness areas that have undergone natural succession or secondary succession established through rewilding methods due to neglect of management[6]. Based on the formation and development time of wilderness, as well as the intensity of human interference, scholars have constructed a classification system for urban wilderness: urban wilderness is divided into natural wilderness, primary wilderness, secondary wilderness, and potential wilderness according to the degree of wildness. (Figure 2)

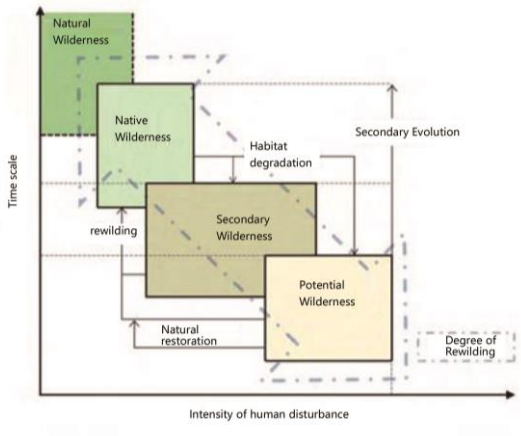

Figure 2. Urban Wilderness Classification System

The concept of wilderness space has a long history of development. In ancient China, when early scholars and scholars began to promote landscape culture, they had already begun to explore the development of "wilderness landscape". The earliest interpretation of "wilderness landscape" in China was described in Zong Bing's "Preface to Painting Mountains and Rivers" as "a wilderness without people" and "the way mountains and waters are enchanting in form". In addition, the concepts of "harmony between heaven and man" and "the way of nature" advocated in classical gardening also reflect the "wilderness" concept of governing by inaction. The famous ancient garden designer Ji Cheng's "Yuanye" also demonstrates the emphasis on wilderness naturalness in ancient landscape construction, as mentioned in the phrase "although some people have created it, it seems to bloom from heaven". In modern times, the United States promulgated the Wilderness Act in 1964[7], which was the first time in the world to initiate the establishment of a wilderness protection system in legislative form and emphasized the characteristic of wilderness that is "not subject to human constraints". Leopold was a pioneer in wilderness conservation in the United States. He believed that the size of urban wilderness should not be limited and proposed that "urban wilderness can exist on any small plot of land. In recent years, scholars at home and abroad have gradually diversified their research perspectives on wilderness spaces, but a basic consensus has also been formed that urban wilderness is the source of species for urban biodiversity conservation, as well as the last habitat for endemic species and extremely small populations within urban areas. Therefore, urban wilderness spaces play a crucial role in the natural ecological system of cities.

2.2. Ecological Value and Function of Urban Wilderness Space

2.2.1. More complex terrain and space

Compared with artificial green spaces, urban wilderness dominated by natural processes has higher environmental spatial heterogeneity. Urban wilderness preserves the complex terrain patterns shaped by natural hydrological and geomorphological processes, such as isolated highlands, valleys, and micro landform combinations such as gullies, ridges, depressions, hills, and slopes. These conditions contribute to the formation of richer hydrothermal combinations, improve environmental spatial heterogeneity, and facilitate the maintenance and enhancement of species diversity.

2.2.2. More stable self-regulation ability

Compared to artificial green spaces, urban wilderness has a richer composition of plant species, which can generate higher biomass and community structural diversity, providing effective food security and more diverse habitats for urban wildlife, thus forming more complex interspecific relationships and food web structures[8]. In addition, urban wilderness can provide stepping stones for wildlife and plants during migration, increase the ecological connectivity of urban green space networks, and play

a key role in ensuring the material and genetic flow of urban ecosystems. The most important thing is that urban wilderness can minimize dependence on external inputs such as artificial maintenance, and achieve a more stable self-regulation process through natural processes, thereby providing higher ecological benefits.

2.2.3. More Potential for Ecological Benefits

Urban wilderness has the characteristic of not being disturbed by human activities, so it basically does not require human maintenance and management, which can save a lot of manpower, material resources, and energy consumption required for plant production, planting, and management and maintenance. Urban wilderness can be seen as a low investment, high-efficiency green infrastructure, and is one of the important directions for urban carbon neutrality. In addition, the ecological service functions of urban wilderness are more abundant and have good potential for multifunctional coupling. In contrast, artificial green spaces are more likely to enhance the viewing effect and cultural services such as leisure and recreation, while weakening or even damaging other ecological service functions. However, there is currently a lack of quantitative research on the differences in ecological service functions between urban wilderness and artificial ecosystems, which limits the understanding and decision-making of urban residents and managers towards urban wilderness.

3. DESIGN METHODS FOR HANGZHOU JIANGYANGFAN ECOLOGICAL PARK

3.1. Park Overview

The Hangzhou Jiangyangfan Ecological Park is located between Fenghuangshan Road in the south of Hangzhou and Hupao Road in the north. Its original form was once a place for storing silt from West Lake[9]. However, with the sowing of a large number of aquatic and terrestrial plant seeds, this place gradually transformed into a secondary natural wetland mainly composed of weeping willows and wetland plants[10]. In 2008, the Hangzhou government decided to transform it into China's first urban second-class wilderness park - Jiangyangfan Ecological Park, and this task was entrusted to Professor Wang Xiangrong from Beijing Forestry University for on-site investigation and overall planning and design work. The park covers an area of approximately 19.8 hectares and was officially opened to the public on October 1, 2010. (Figure 3)

Figure 3. Entrance Sign of Jiangyangfan Park

3.2. Design Methods

3.2.1. Protection of self-produced plant resources

Jiangyangfan Ecological Park fully utilizes the abundant vegetation resources. Firstly, it clears the chaotic and harmful vines, dead branches, etc., and selects some areas with good vegetation coverage as natural evolution specimen areas to avoid human interference. This area is called "habitat island",

and weather resistant steel is used to isolate the surrounding plants[11]. In the non habitat island areas, excessive density of tall trees such as willows has been appropriately pruned to provide sufficient growth environment for healthy plants and to create a suitable environment for the survival of vegetation[12]. In the lake area, designers actively utilize the existing water environment and scientifically arrange the layout of aquatic and wetland vegetation to enhance the diversity and complexity of the wetland vegetation population; At the same time, introduce some locally grown herbaceous plants with strong adaptability and low management requirements, in order to find an economical management method to achieve a virtuous cycle of plant ecosystems.

3.2.2. Setting up viewing walkways and strengthening ecological science popularization

In order to help the public better understand the impact of natural environment and the changes caused by human activities, a trail standing on the swamp has been set up in Jiangyangfan Park, guiding visitors to enter this ecological system and experience nature firsthand. The boardwalk is about 1 kilometer long, curved and extending in a flat form, while the three-dimensional structure presents a staggered pattern of high and low. Facilities such as corridors, seats, and guardrails are set up in it, which not only enriches the landscape experience but also provides visitors with multiple viewing points and rest areas (as shown in Figure 2-1). The park also has complete ecological teaching conditions, making it an open nature classroom museum.

3.2.3. Material Technology Innovation

3.2.3.1. Material selection for walking trails

The setting of walking trails is a characteristic of ecological parks, carrying the main transportation and tourism functions. Based on the current conditions within the site, the biggest challenge in selecting materials for the boardwalk is the accumulation of silt and weak bearing capacity within the site. Therefore, in the treatment of silt, strict quality control is adopted to address the problem of weak bearing capacity of silt foundation by arranging sand wells, drainage boards, and vacuum preloading [13]. In the selection of construction materials, strict quality control is implemented, using convenient and lightweight new materials. At the same time, through the principles of mechanics, the bearing pressure on the surface is reduced by weakening its own buoyancy; Various buoyancy bearing modes such as foam board, bamboo and wood raft, steel box and PE pipe have effectively solved the problem of wood trestle construction under poor foundation conditions.

3.2.3.2. Rainwater utilization and recycling system

Due to the fact that the current site is formed by the accumulation of silt, with weak stability and susceptibility to external environmental influences, in order to solve this problem, engineering techniques were used to collect rainwater and introduce it into the site as a supplementary water source, ensuring the sustainable circulation of the water body and forming a good ecological cycle of the water body[14]. The Hangbang Cuisine Museum in the ecological park adopts a rooftop greening form to allow rainwater to naturally infiltrate and dissipate energy, thereby effectively collecting and utilizing rainwater.

4. INVESTIGATION AND STUDY ON PLANT LANDSCAPE OF HANGZHOU JIANGYANGFAN ECOLOGICAL PARK

4.1. Investigation Methods

This study mainly relies on the methods of field investigation and sample collection. We will first grasp the basic situation of Jiangyangfan Park by reading relevant literature. Then, on November 20, 2023, we went to the site for on-site research, including observing and recording the distribution status of plants in Jiangyangfan Ecological Park, and conducting preliminary analysis on the species,

color, group composition, and spatial layout of these plants, in order to explore how to construct an ideal urban ecological park landscape.

4.2. nvestigation Content

4.2.1. Plant species selection

After field research, the main plant species in our Jiangyangfan Ecological Park are Nanchuan willow and reed. Among them, Nanchuan willow is the main plant group in the park, generated from willow seeds that have been grown for thousands of years at the bottom of West Lake. In addition, the garden also has large reed beds with strong growth ability, reaching up to six meters in height, which is extremely wild. For the ecological environment damaged by human interference, Jiangyangfan Ecological Park did not plant artificial communities on a large scale. Instead, it chose to start with wild plant seeds preserved from the original silt area to maintain and promote the development of natural plant communities.

4.2.2. Seasonal plant combinations

One of the key factors in plant landscaping is the combination of seasonal landscapes. By making reasonable use of plant features such as spring flowers, summer green leaves, autumn leaf color and fruit, and winter withered tree branches, a landscape effect with beautiful scenery throughout the four seasons can be created. Combining plants from different viewing periods according to their seasonal changes can achieve a comprehensive landscape value experience that can be enjoyed throughout the four seasons.

The autumn landscape of Jiangyangfan Park is rich in color, with the distribution of fir plants such as Metasequoia and Taxus chinensis, as well as the red and yellow colors of Wuxianzi, creating a sense of depth and color hierarchy in the landscape space. The color changes in spring are mainly white snowflakes, while in summer they are cosmos and goldenrod with pink and yellow flowers. Overall, there is not much difference in the landscape of the other three seasons, and the diversity of plant colors still needs to be improved.

4.3. Analysis of Plant Landscape Design in Jiangyangfan Ecological Park

4.3.1. Analysis of Habitat Island Plants

Habitat Island is a dynamic specimen that showcases the natural succession process of plants. (Figure 4) Within the habitat island of Jiangyangfan Ecological Park, the original vegetation is preserved without artificial intervention, continuing the natural succession. As the soil dries, the vegetation presents a dynamic state of change, with a relatively single plant species mainly consisting of Nanchuan willow and elderberry, as well as a small amount of Chinese fir and elm. (Figure 5)

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For other parts of the site, plant thinning was moderately carried out to leave more space for stronger plants and bring more sunlight to the trees, allowing for better growth of understory plants. The understory plants have certain ornamental and ecological values, such as a food source for herbivorous animals, host plants for insects, and nectar plants. The introduction of these makes the landscape more attractive and also facilitates the survival of small animals and plants.

After comprehensive analysis, the habitat island has rich seasonal changes, good plant growth, and presents a relatively complete natural succession process.

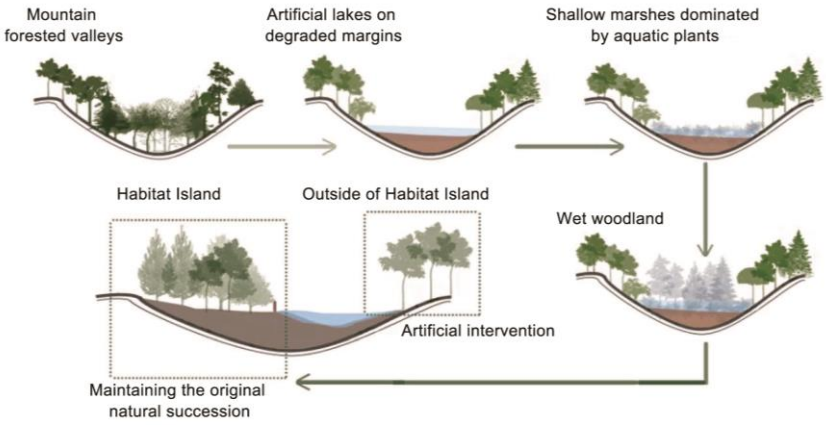

Figure 4. The self succession process of Jiangyangfan Park

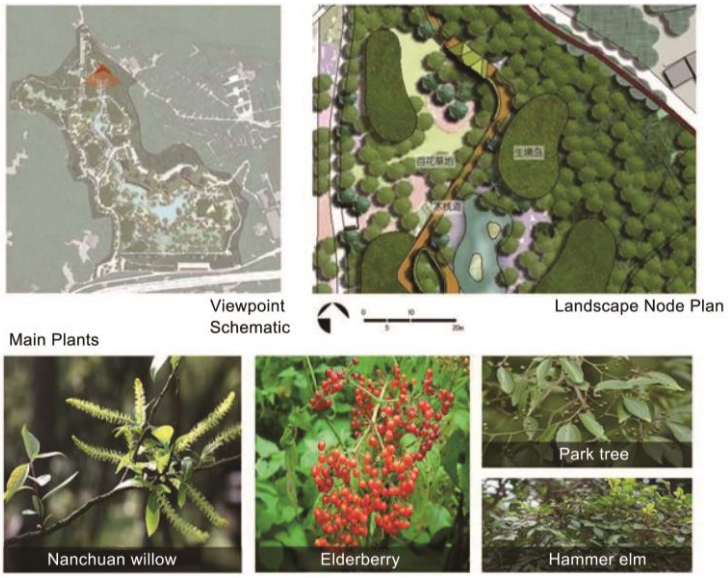

Figure 5. Habitat Island Region and Main Plants

4.5.2. Plant analysis in lake water area

4.5.2.1. Analysis of Plant Landscaping in Puxiu Lake

The formation of Puxiu Lake occurred after the restoration of some water bodies and aquatic vegetation in the original ecological environment. The wetland landscape is characterized by extreme humidity or swampification, including a distinct hierarchical structure of lakes and ponds.

In the artificial environment around Puxiu Lake, there are a large number of wild vegetation such as reeds, cattails, cattails, and red knotweeds planted. Lakes come in various sizes and shapes, curved and circuitous, and their plant landscapes coexist in both open and closed spaces, making the scene rich and colorful. Through the design of the spatial form and plant layout of the Puxiu Lake water area, a variety of spatial types have been formed, including open, semi open, and enclosed spatial patterns. Among them, plant elements are one of the key factors in constructing these spaces, which can divide the entire water area into three main spatial categories. (Figure 6)

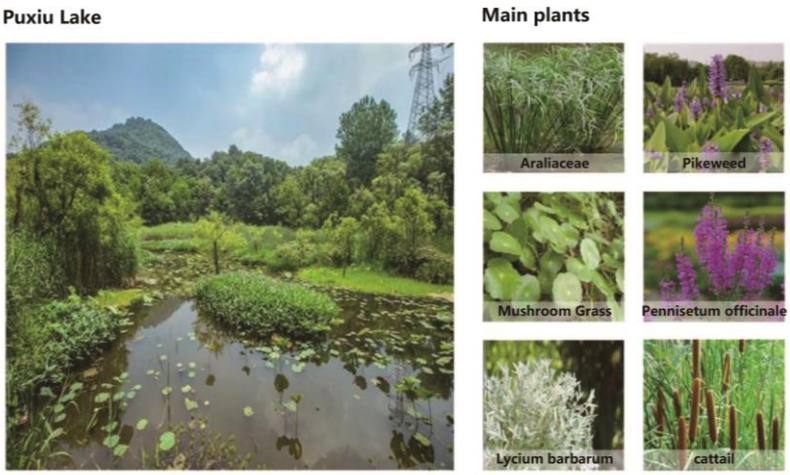

Figure 6. Puxiu Lake Area and Main Plants

At the northern end of Puxiu Lake, the integrity of the water is maintained and the form of the water is restricted by planting grass and cattail. At the same time, linear aquatic organisms such as Quetzalcoaths, Barracuda, and Parachute are planted along the coast to enhance the visual depth sensory experience. This combination forms a multi-level ecosystem composed of Nanchuan willow, dry umbrella grass, barracuda, millenia cordata, polygrass, and seagrass. Although this area is not large, it can effectively form a tight spatial closed loop effect, especially the Nanchuan Willow, which can effectively block people's view and enhance the safety and privacy of the environment here.

In the southwest of Puxiu Lake, the park is planted with plants such as Jucao, Laocai, and shiitake mushrooms; At the same time, varieties such as Salix matsudana, Haloxylon ammodendron, Trifolium repens, and Long bract cattail were planted along the waterfront, and Nanchuan willow was planted around them, jointly building a plant ecosystem mainly composed of Nanchuan willow Salix matsudana, Haloxylon ammodendron, Trifolium repens, Long bract cattail, Eucommia ulmoides, Houttuynia cordata, and Shiitake mushroom. Due to the relatively narrow and curved water bodies in this area, from an ornamental perspective, the width of the water gradually decreases, and all trees and aquatic plants grow around the edges of the water, resulting in a spatial form with a strong sense of depth.

In the eastern part of Puxiu Lake, wetland vegetation such as shiitake mushroom grass and cress have been planted; In the south, the main landscape element is the willow trees of Nanchuan. The water body in this area is relatively narrow in shape and of moderate length. By setting up two small artificial islands to demarcate its boundaries and increase the sense of depth, it enhances the depth and visual appeal of the scene. The divided site has a contrasting view, with one side being the riverside area adjacent to the houses, with a relatively open and clear view, and the other section being the part near the residential area, with a unidirectional open space and obstructed view. The visual space on both sides forms a semi open area.

Tourists can enjoy the scenery of Puxiu Lake on the wooden boardwalk, and through the change of perspective, achieve the transformation of enclosed space, semi open space, and open space, achieving the effect of moving to different scenery.

4.5.2.2. Landscape Analysis of Reed Pond Plants

As a primitive lake left by the Jiangyangfan, Weichi has undergone a transformation from a water body to a wetland environment in most other areas. And this place is the only permanent water source that has been preserved. Surrounded by numerous reed beds, thanks to its unique ecological environment, this place has become a home for many animals and plants. At the same time, the

characteristics of reeds themselves enable them to exhibit significant biological succession processes with seasonal changes, and the spatial structure formed is full of temporal suddenness, providing a good example for observing biological succession processes. (Figure 7)

Figure 7. Main Plants in Reed Pond Area – Reed

In terms of plant space, the trees around the reed pond have formed a stable shape with a certain degree of permeability, and the growth of the reeds has quickly reached a high level. Using trees of these heights as backgrounds can create clear visual layers, forming a landscape painting of distance, middle, and near.

In terms of plant species, although reed is the main vegetation type in the reed pond ecological zone, the ornamental effect is relatively good in spring, summer, and autumn. However, in winter, the area appears dull and lacks the embellishment of evergreen plants.

In terms of planting management, due to the strong reproductive and expansion ability of reeds, appropriate techniques such as enclosure should be used to control the growth space of reeds within specific water bodies, thereby ensuring the openness of water bodies for a longer period of time. At the same time, phytoplankton on the water surface, such as green algae and diatoms, should be promptly inspected and removed. These phytoplankton grow and reproduce on the water surface and are an important part of aquatic ecosystems, with significant impacts on nutrient cycling, oxygen supply, water quality stability, and other aspects of the water.

5. CONCLUSION AND DISCUSSION

5.1. Investigation Summary

After research and evaluation, the plant landscape features of Jiangyangfan Ecological Park are distinct in terms of vegetation characteristics, preserving the differences in the original vegetation and basic characteristics of the plant community on the site, maintaining the special ecological structure[15], and continuing the natural succession process of the site. In terms of functional requirements, the boardwalk in the park meets the functions of line viewing and resting, and the science popularization signs on the boardwalk and beside the garden road play an educational role in science popularization and research. The setting of the habitat island is in line with the ecological function of "governing by inaction and secondary succession". In terms of recycling, Jiangyangfan Ecological Park has achieved perfect water body recycling, and the natural inflow of water bodies has achieved good natural infiltration and effective collection of rainwater.

5.2. Exploration of Plant Landscaping Methods

5.2.1. Mainly local plants

The selection of plants in the park should mainly focus on local native plants, and try to choose plant species that are attractive to insects, birds, and flowers, in order to provide a good habitat for wildlife. When configuring plant communities, a mixed planting of trees, shrubs, and herbaceous plants should be utilized to achieve ecological balance, improve stress resistance, and enable the system to achieve self sustainability.

5.2.2. Creating Multiple Ecological Scenarios

Based on the unique properties of the site, we should flexibly utilize them to create different types of ecological environments, such as arid, humid, and aquatic environments, in order to construct communities that are close to nature and increase the variety of flora and fauna. For example, Camley Street Ecological Park is one of the most representative parks in London, which includes three main ecosystems: forests, swamps, and lakes. These different ecosystems can introduce a large amount of wildlife and plant resources and serve as a "gene bank" for animals[16].

5.2.3. Achieving scenery in all seasons

The seasonal changes in the park are mainly displayed through vegetation, and the garden vegetation satisfies the diverse visual experience of the four seasons through seasonal changes in plant characteristics, making the landscape more dynamic and dynamic, and also making its seasonal structure more diverse, thus achieving the effect of year-round scenery. This not only improves the quality of life for urban residents, but also provides a beautiful and enjoyable space for sightseeing.

5.2.4. Enhance the spatial perception of plants

By using borrowed scenery, obstacle scenery, and other methods, we can transform plants in space, creating open, semi open, and closed spatial environments. In addition, plants in gardens can also be integrated with various spatial forms to construct interconnected spatial systems; In this spatial system, the opening and changing of plant landscapes can guide or obstruct people's view, enhance or weaken their sense of space, and ultimately achieve a step-by-step change effect of scenery.

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