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Plant Diversity in City Parks under the Concept of Landscaping: A Case Study of Hefei City

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Abstract Driven by the concept of landscaping, this paper analyzed the impact of plant diversity on landscaping function, arrangement methods and community structure by taking plot sampling method as the experimental axis and 3 urban parks in Hefei as the blueprint. Six plots with the size of 20 m × 20 m were selected for investigation. There were 56 species of plants belonging to 50 genera and 42 families in the plots of Zhongshan Road City Park, 48 species of plants belonging to 44 genera and 40 families in the plots of Four Seasons Flower Sea City Park, and 69 species of plants belonging to 57 genera and 45 families in the plots of Xiaoyaojin Park. The survey results show that there are following problems in city parks: lack of plant effectiveness, too homogeneous plant community, disharmony between landscape and environment, poor plant maintenance and lack of attention to ecological maintenance. Based on this, the optimization measures are put forward: increasing evergreen plants to avoid no scenery in autumn, developing plants with excellent landscape effects and a variety of colorful plants, paying attention to the shaping of spatial structure and landscape pattern, regularly taking care of plants and their surrounding environment. It is expected to provide some reference for the construction and development of Hefei city parks, ensure the healthy and stable development of city parks, and provide ideas and methods for the improvement of plant landscaping in city parks.

Keywords Landscaping concept, City park, Plant diversity
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1 Introduction

1.1 Research background and significance

The 20th National Congress of the Communist Party of China emphasized the importance of ecological civilization construction and proposed to promote modernization construction on the basis of harmonious coexistence between human and nature, which provides guidance and impetus for promoting high-quality development of landscaping in the capital. It can be said that the report of the 20th CPC National Congress regards the modernization of harmonious coexistence between human and nature as an important feature of socialist modernization, further highlighting the strategic position of ecological civilization construction. This also means that in the ecological greening construction, we should adhere to the concept of green development, pay attention to protecting the ecological environment, and promote the harmonious coexistence between human and nature[1]. Lucid waters and lush mountains are invaluable assets, and ecological greening construction is becoming more and more important. In recent years, the concept of green development has also been deeply rooted in people's mind[2]. City park is the most representative place of urban biodiversity. In the design of park plants, plant diversity and ecosystem function must be fully considered in addition to their ornamental and economic value.

In 1999, *Classification of City Parks* pointed out that "city park refers to urban public green space open to the community with relatively complete facilities and good green environment for the public to visit, appreciate, rest, carry out scientific, educational and cultural activities and exercise"[3]. Plants are indispensable in city parks, and plant diversity refers to the phenomenon that there are many different plant species and varieties in a certain geographical area, including the number, classification, composition, structure, function and genetic diversity of plant species[4].

The development of modern cities pays attention to not only economic development but also garden art. Urban landscape plants have many ecological effects, such as urban greening and landscaping effects, reducing noise, increasing air humidity, carbon fixation and oxygen release, reducing ambient temperature, and purifying the environment[5]. The plant diversity of city parks is essential for improving urban ecosystems. The plants in these parks can not only provide residents with beautiful landscapes and leisure space, but also exert many ecological benefits, playing an important role in improving residents' living conditions and the quality of life. It will contribute to a better understanding of the role and value of plants in urban environments by studying the impact of plant diversity in city parks on urban life and ecology.

At present, Hefei is actively building an ecological garden city and vigorously developing the construction of parks, while creating park ecological landscape is the top priority of modern city construction. Therefore, the study of plant diversity in city parks is of great practical significance for urban ecological construction, ecological sustainable development and urban housing[6].

Plants are one of the most important biological resources on Earth, and studying plant diversity can better understand and conserve these ecosystems. Plant diversity can help restore ecosystems when they are disturbed or damaged, and studies of plant diversity can assess and monitor environmental changes and the health of ecosystems. Meantime, plants are also part of human food, and studying the diversity of different species of plants can provide better variety selection and improvement for agriculture in different regions, and plants can extract the ingredients required in many modern medicines, so plants make an important contribution to

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human medicine.

1.2 Research status at home and abroad

The historical study of Western flora began in China. *The Plant History*, written in 300 BC, is considered to be the earliest work on flora in the West, after which the term plant distribution was coined. At abroad, the study of plant community diversity is one of the hot spots in ecology. Developed countries such as Europe and the United States have a high research level of plant community diversity, and the findings have global implications. Research at home focuses on species composition, ecosystem function, ecosystem location and biodiversity of plant communities (Fig.1). At the same time, Chinese scholars have also actively carried out related researches on the conservation and restoration of plant community diversity, which provides a scientific basis for the protection and management of natural resources. In general, the study of plant community diversity has important research value and application prospects at home and abroad, and international cooperation should be further strengthened in the future to jointly promote the development of plant community diversity research.

At the beginning of the 20th century, city parks were only to meet the needs of people's entertainment and leisure, and there were limitations in plant cultivation. With the acceleration of urbanization and the continuous growth of urban population, people pay more and more attention to the value and function of city parks. In the ecosystem, plant diversity is a very critical component, so it is increasingly being concerned closely[7]. Since the 21st century, plant cultivation in city parks has adopted a multi-level and multi-combination method with herbaceous plants, ground cover plants, shrubs and trees to achieve the maximum ecological benefits. Meantime, city parks have also become one of the important places for plant diversity in the world, promoting the continuous improvement of urban greening and ecological environment.

With the continuous improvement of people's spiritual pursuit, it is difficult for city parks with single functions to meet people's use needs. Only the diversification of city parks is in line with the development trend of urban spirit[8].

2 Application of landscaping theory in parks

The landscaping theory is to design and arrange park space that has ecological, beautiful, harmonious, comfortable, cultural and other characteristics to meet people's needs and pursuit of natural environment[9]. Specifically, it includes the following aspects.

(1) Landscape design needs to consider the changes in seasons and time, and pays attention to effectiveness and renewal[10].

(2) Landscaping design should consider people's comfort feelings, including air quality, temperature, humidity and other factors, and create a pleasant environment through reasonable vegetation arrangement, rest facilities and other measures.

(3) Landscape is composed of various landscape elements and spaces, so we must pay attention to shaping spatial structure and landscape pattern, and use the overall design to create visual spatial effects[11]. Landscaping design should be coordinated with the surrounding environment, integrated with urban architecture and natural landscape, etc., to form a harmonious overall effect.

(4) Landscaping design should pay attention to simplicity and ecological issues. The primary goal of landscaping is to create beautiful landscapes that create pleasant visual effects through the combination of plants, waterscapes, architectures and other elements. Meanwhile, landscaping design should pay attention to the protection of ecological environment and create an ecologically balanced environment.

(5) Landscaping design should reflect the characteristics of regional culture, and show the charm of local culture through the selection of local unique plants, architectural styles and other elements.

3 Analysis of present situation of Hefei city parks

3.1 Basic overview of Hefei

Hefei City is located in the middle of Anhui Province in eastern China, with advantageous geographical location. The region has perfect surface water system and relatively abundant water resources. The whole territory of Hefei includes three landforms: hilly land, low mountain monadnock and low lying plain, among which hilly land is the main landform type. Hefei belongs to monsoon humid climate, with four distinct seasons, suitable temperature and moderate rainfall[12].

3.2 Experimental scheme and plot selection

Four ropes 20 m long were prepared in advance, and similar plots with trees, shrubs and herbs to be studied were selected in the park and framed with ropes (Fig.2). According to the *Flora of Anhui* and other books, the plant species in the plots were summarized and sorted out through tables, and the plant diversity, plant arrangement, beautification degree, plant structure and so on were studied. Six plots were selected from 3 city parks.

3.3 Hefei Zhongshan Road City Park

The plant theme of Zhongshan Road City Park in Hefei is positioned as ecology and beautification. Planting forest belts is the major form, and a variety of plant varieties such as *Osmanthus fragrans*, *Magnolia grandiflora* and *Ginkgo biloba* are selected to form a large ecological forest belt. Such arrangement of plants makes the entire landscape turn yellow in autumn, leading to very good landscape effect. Meantime, *Cinnamomum camphora*, *Metasequoia glyptostroboides* and other trees constitute a beautiful ecological mood.

Through the investigation of Zhongshan Road City Park, the plants found in the plots were recorded statistically. Later, the plants were identified by consulting to the *Flora of Anhui*, and the plant species in the parks were sorted out. There were 56 species of plants in the studied plots (20 m × 20 m), belonging to 50 genera and 42 families, including 24 species of herbs, 19 species of shrubs and 13 species of trees. There were only 6 species of gymnosperms belonging to 6 genera and 5 families, accounting for 10.71% of the total species. There were 50 species of angiosperms in 44 genera and 37 families, and 12 species of which were monocotyledons belonging to 12 genera and 9 families, accounting for 24.33% of the total species. There were 38 species of dicotyledons belonging to 32 genera and 28 families, accounting for 75.67% of the total plant species in the plots (Table 1 and Fig.3).

Based on research findings, it was found that Poaceae was the largest among the plots studied in Zhongshan Road City Park in terms of genera number. As for species number, Asteraceae was the largest. It can be seen from the survey of the parks that *C. camphora* was one of the main plants that constituted street trees. Other trees and shrubs were sometimes planted on both sides of the road in the parks to enrich the landscape nodes through these plants, such as the plant community consisted of *Pittosporum tobira*, *Photinia* × *fraseri*, *Trachelospermum jasminoides,* etc. The main arrangement methods of plants in the parks were trees + shrubs, and trees + shrubs + herbs. These plant arrangement methods were mainly seeking for visual effect, giving people a sense of physical and mental pleasure, and these planting methods paid attention to the continuous maintenance effect and the overall beautification effect.

3.4 Hefei Four Seasons Flower Sea City Park

Four Seasons Flower Sea City Park is located between Shushan Forest Park and Dongpu Reservoir in Hefei. It is composed of 4 plots: A, B, C and D, each of which has different positioning and themes, and varying landscapes. Among them, plot A is positioned as an urban garden area, featured by flower appreciation in the four seasons and fragrance of flowers in the months. The entrance is decorated with flower border, with *Podocarpus macrophyllus*, *Acer buergerianum*, *Ligustrum* × *vicaryi*, etc. as skeleton plants, supplemented with *Canna indica*, *Muhlenbergia capillaries*, *Verbena officinalis* and other perennial flower border plants[13].

There were 48 species of plants belonging to 44 genera and 40 families in the plots located in plot A of Four Seasons Flower Sea City Park, and the proportion of trees, shrubs and grasses was about 2.98 : 3.23 : 3.48. There were relatively rich and diverse plant communities in the park, including aquatic plants, shrubs, various grasses, trees and various types of flowers. These plant communities were successively distributed near water and on land, forming a rich and magnificent visual effect.

The plants along the river were mainly herbs, and those along the roadside were mainly trees and shrubs. With defoliation and the growth of leaves, most trees can show rich seasonal changes in color, texture, and shape. Even in autumn and winter, deciduous trees can still show the beauty of their branches. The arrangement mode of shrubs + herbs in Four Seasons Flower Sea Park receives better ornamental effect. The combination of flowering and foliage herbs as foreground plants and foliage shrubs as background plants can produce very high ornamental effects during flowering.

3.5 Hefei Xiaoyaojin Park

Xiaoyaojin Park, located in the southeast of Luyang District, Hefei City, Anhui Province, is an open green space integrating cultural experience, ecological recreation, sports sightseeing, education and science popularization. Land and water in the park cover the area of 20.1 and 11.2 hm^2, respectively, and the green land covers an area of 18.8 hm^2. The functional zones in the park are composed of historical and cultural area, commercial activity area, children's entertainment area, and citizen leisure area[14].

A total of 69 species of plants, belonging to 57 genera and 45 families, were found and summarized from the plots set up in Xiaoyaojin Park. Trees were dominant plants, followed by shrubs, herbs and vines. The trees, herbs and shrubs in Xiaoyaojin Park were dominated by deciduous trees, perennial herbs, and evergreen plants. There were 4 dominant families in the surveyed plots, and the evergreen trees in dominant species mainly included *Platycladus orientalis*, *O. fragrans*, *C. camphora*, etc., while the deciduous trees mainly included *M glyptostroboides*, *Platanus acerifolia*, *Lagerstroemia indica*, etc. The ratio of evergreen species to deciduous species was about 3 : 2.68, and that of coniferous species to broad-leaved tree species was 1 : 4.45. Ancient and famous trees usually refer to trees with a history of more than 100 years or precious and commemorative

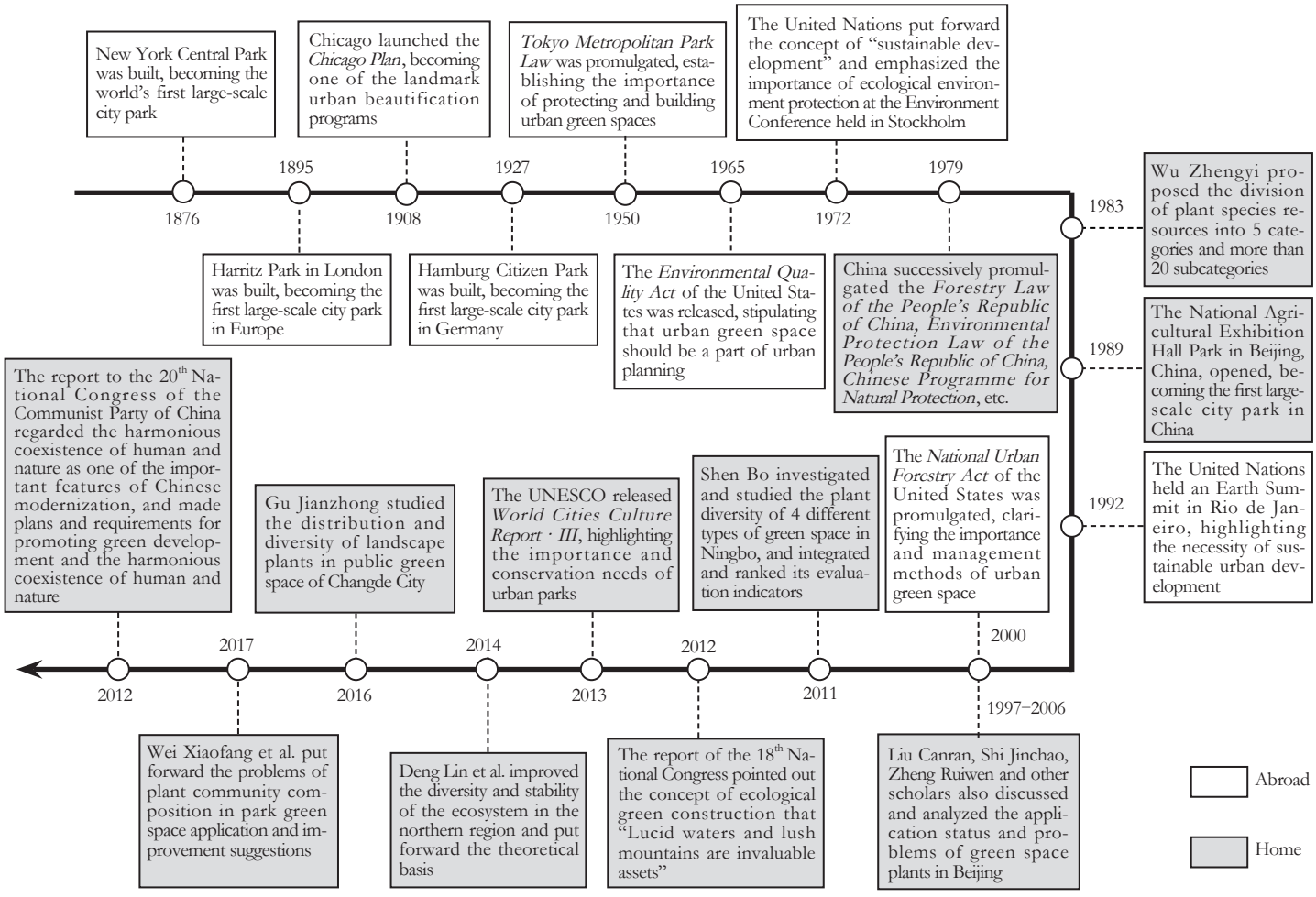

Fig.1 Research timeline at home and abroad

significance. According to the protection level, ancient trees can be divided into three levels: national first-level protected ancient trees (more than 500 years old), national second-level protected ancient trees (aged 300−499 years), and national third-level protected ancient trees (aged 100−299 years)[15]. After the survey, the statistical analysis of Xiaoyaojin Park shows that there are currently 25 ancient trees in the park, including *Pinus bungeana*, *Celtis sinensis*, *G. biloba* and other national protected ancient trees.

From the perspective of ornamental characteristics, there are plants with ornamental stem, bud, fruit, leaf, root, flower, posture and aromatics, and ornamental plants are the basis of plant landscaping[16]. There were 27 species of foliage plants in the plots of Xiaoyaojin Park, accounting for 39.7% of the total plants in plots; there were 19 species of flowering plants, accounting for 27.9% of the total plants; there were 6 species of plants with ornamental fruits, accounting for 8.9% of the total plants; there were 16 species of plants with ornamental posture, accounting for 23.5% of the total plants. Among them, there were many species of foliage and flowering plants, but relatively few species of plants with ornamental posture and fruit (Fig.4). There are rivers in Xiaoyaojin Park, so 3 species of floating-leaved plants were found in the plots set in the waterfront area, mainly *Nymphaea tetragona*, but there were 6 species of emergent aquatic plants.

The plant landscape in the park is designed according to different functions of the place, so as to give people different visual effects in different places. In the process of plant landscaping along the park road, the shading effect of trees and the mixing and matching of shrubs, herbs and other plants are fully taken into account, thus enhancing the ornamental value of plants. At the same time, the combination of plant landscape and visual guidance in the park creates an open and orderly plant space, increasing the enjoyment of visitors.

According to the survey of plants in the 6 plots of 3 city parks, the plant species of Four Seasons Flower Sea City Park was less than that of the other two city parks. The reason is that the plants in plot A of Four Seasons Flower Sea Park City studied divided planting blocks according to species, so the herbs + shrubs + trees in the plots were relatively simple. Due to the renovation of Xiaoyaojin Park in 2021, unreasonable and non-standard areas were improved and plants were added and adjusted, so there were a lot of plant species in the plots surveyed (Fig.5).

3.6 Existing problems of urban parks

Based on the landscaping theory, the field survey results and data analysis of Hefei urban parks show that there are abundant plant species in the plots, but the plants in the 3 urban parks surveyed have the following 5 problems.

(1) The effectiveness of plants is not considered in the plots set up in some parks. Deciduous plants are planted in some areas, and in autumn and winter, these areas will produce a desolate and cold feeling because of the decline of plants. Meantime, fallen leaves will also bring trouble to garden management workers.

(2) People's comfort feelings have not been taken into account in the landscaping design of the parks, and the overall design or arrangement of plant communities has not been not carried out according to local conditions in some plots, and only single plants are planted, which result in poor landscape construction and poor expression of spatial hierarchy.

(3) The plant communities in some areas of plots are not in harmony with the surrounding environment, and some plant communities are too messy. Due to inadequate planning, the vertical canopy density of plants in some areas is high, resulting in poor growth of upper, middle and lower plants. The arrangement methods of

Fig.2 Tools used and pictures of similar plots

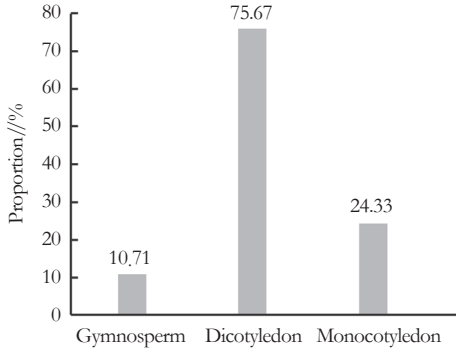

Fig.3 Proportion of different types of plants

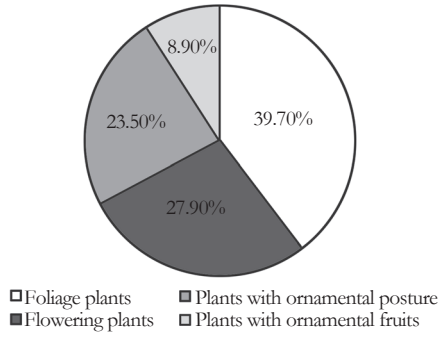

Fig.4 Proportion of plant ornamental characteristics in the plots of Hefei Xiao–yaojin City Park

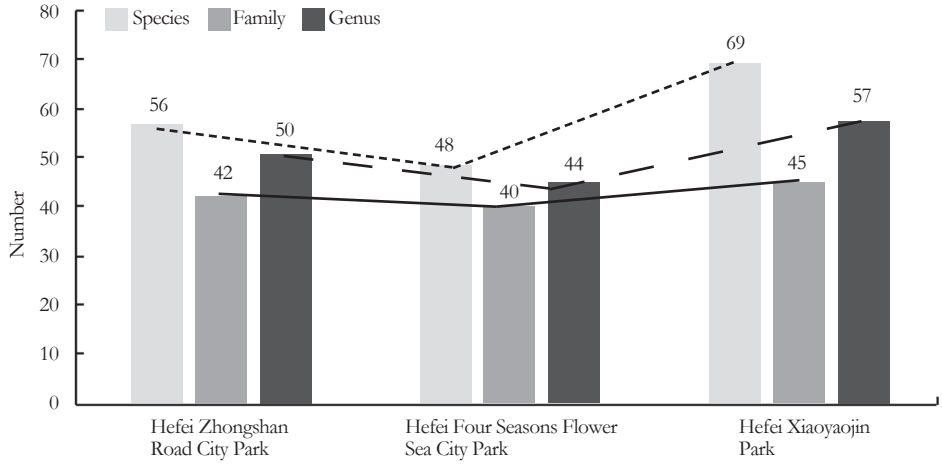

Fig.5 Number of plant species in the plots of 3 urban parks

some plants do not meet the requirements of function and beautification. Some areas have too much concentration of plant species, resulting in insufficient diversity of plant communities, while a small number areas have poor site environment and poor landscaping effect. Plants in some parks lack the characteristics of park plants and cultural characteristics. In the late stage of park plant management, plants such as *Ophiopogon japonicus* are planted on dead trees, resulting in mixed understory plants.

(4) The landscaping design of some plots in urban parks does not pay attention to simplicity and ecology. One fifth of the plots surveyed contain invasive plants. However, the planting of these plants would compete with other plants in the area for water, nutrients and other survival factors, thus affecting the growth of other plants in the area. More importantly, some parks lack the protection mechanism of ancient and famous trees, and there are diseases and pests and empty phenomena.

City parks are open to the outside world, and the visitors flow rate is relatively large, resulting in local baldness of some low plants or absence of large areas of vegetation due to human trampling. Some deciduous plants will be planted in the water and on the shore of the park, and leaves and dead branches will accumulate on the water surface due to the plant characteristics in autumn and winter, but it can not create a pleasant visual effect because no one takes care in time.

(5) Due to the low abundance of plants, some areas lack the characteristics and regional cultural characteristics of parks, and some areas do not show cultural charm through the selection of local unique plants, architectural styles and other elements.

4 Optimization measures of urban park plants based on landscaping theory

4.1 Rational use of plant characteristics

Plants can be rationally used and middle and lower vegetation can be increased, to form ecological landscape community. The landscape of plant communities should be improved to meet the most appropriate human needs. City parks can increase the types of shrubs, improve the landscape level, and combine coniferous leaves with deciduous and evergreen plants, so as to achieve a spectacular scenery in all seasons. By making full use of diverse colors of various ornamental plants, a rich and colorful plant gathering area is created to form a unique landscape of parks.

4.2 Adding landscape features and local plants

Local plant resources should be developed and appropriately used. Local plant varieties will be more adapted to the local natural conditions, and also facilitate the maintenance and management of plants in the later period, while reflecting the local style and characteristics. Developing excellent local plants can enhance regional cultural connotations, improve the stability of ecological plant communities, and avoid the application of invasive plants. In the overall design or arrangement of plant communities, reasonable combinations should be made according to the ecological characteristics and geographical environment of different plants to achieve better growth and landscape effects.

According to the survey and data analysis, there are few vines planted in urban parks, so vines can be planted appropriately as landscape features. Meantime, fern resources should be fully used to improve ecological stability, and more efforts should be made to protect wild and rare vegetation.

4.3 Paying attention to the shaping of spatial structure and landscape pattern

The design of aquatic plants in the park requires a special arrangement of plant communities, thus making visitors enjoy the beauty of water surface and highlighting the landscape characteristics. At the same time, the creation and design of plant community landscape in the park needs to be in harmony with the environment, and create a harmonious overall effect by combining the nature of the surrounding buildings. Plants with strong purification capacity should be selected to increase the ornamental value of water surface in some areas, such as *Iris tectorum*, *Eichhornia crassipes*, etc., and the litters should be cleaned regularly to make the water quality better. For too high vertical canopy of upper trees, upper plants should be repaired regularly to remove too dense leaves or too long branches, maintaining natural tree type and ornamental characteristics of trees or shrubs. According to the growth characteristics of the understory and the light intensity it receives, some plants such as *P.* × *fraseri*, *Hedera helix* and *Pittosporum tobira* should be added in the form of clusters. In the arrangement of herbs and shrubs, a variety of plants can be combined by mixed planting, to increase the richness of landscape.

4.4 Paying attention to ecological and environmental issues, and protecting ancient and famous trees

Ornamental trees should be used wisely in the park, and the ornamental effect of the landscape should ensure that there are flowers worth appreciating in all seasons, and that there are impressive views in all seasons. Park roads should be added in places where more people walk, and plants should not be planted to avoid the destruction of plant communities. The plants in the park should be managed regularly to avoid free growth, and litters on the water surface should be cleaned up promptly. When selecting plants for cultivation, special attention should be paid to the combination of slow growing plants and fast growing trees, and the ratio of evergreen trees to deciduous trees should be controlled, which can provide long-term ornamental value. Meanwhile, in order to create a diversified and eye-catching plant community landscape, ornamental tree species should be actively developed in urban parks, including the characteristics of plant morphology and color, and the protection of old and famous trees must be strengthened.

4.5 Reflecting regional cultural characteristics

The landscaping design should fully reflect the regional cultural characteristics, and the park can appropriately select some local unique plants, architectural styles and unique colors and other elements to show the charm of local urban park's characteristic culture.

5 Conclusions

By selecting plant communities in a total of 18 plots (20 m × 20 m) in Zhongshan Road City Park, Four Seasons Flower Sea City Park and Xiaoyaojin Park in Hefei as the research objects, this study systematically analyzed plant arrangement mode of plant diversity in urban parks, and landscape function and beautification. This study combined theoretical research with practice, and recorded the survey data by observing plant diversity, arrangement

Table 1 Phyletic classification of plants surveyed

Plant type	Family number	Genera number	Species number
Gymnosperm	5	6	6
Monocotyledon	9	12	12
Dicotyledon	28	32	38
Total	42	50	56

pattern and structural distribution in the plots. These data will become the basis for analyzing problems, and landscaping evaluation research will be conducted based on landscaping theory, to sort out, conclude and summarize the problems and shortcomings of plant diversity and landscaping construction in urban parks in Hefei. The corresponding optimization measures are put forward. For example, plants can be rationally used to improve plant community landscape; local plants can be appropriately used to improve the interior landscape of urban parks; when creating and designing plant community landscape, it is necessary to coordinate with the surrounding environment, pay attention to protecting the ecological environment in the urban park, and avoid destroying the natural ecological balance at will; plants can be used to reflect cultural characteristics.

The research is carried out in accordance with the concept of landscaping service. It is hoped that through the investigation and study of plant diversity and landscaping characteristics in 3 urban parks in Hefei, the plant diversity of urban parks can be further promoted, which will provide a theoretical support for the future application of plant diversity, and play a role in further beautifying and improving the urban park environment and creating good ecological landscape benefits. The conclusions of this study can provide certain references for the construction and development of urban parks in Hefei, ensure the healthy and stable development of urban parks, and provide ideas and methods for the optimization of plant landscape in urban parks, so as to make the planning and application of plant diversity more reasonable.

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