Study on the Effect of Plant Configuration Optimization Strategy on Improving the Biodiversity of Urban Green Space

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Abstract: As urbanization accelerates, urban biodiversity faces significant challenges. Optimizing plant configurations in urban green spaces has become a key strategy to enhance biodiversity. This study focused on the effect of plant configuration optimization strategy on biodiversity improvement in urban green spaces. The biodiversity within the existing plant configuration model was analyzed through field research on various types of urban green space, including park green spaces, road green spaces, and residential green spaces. The results show that scientific and reasonable plant configuration strategies can significantly improve the biodiversity of urban green spaces. The methods proposed in this paper include increasing local plant species, constructing multi-level plant communities, and creating heterogeneous habitats. On the one hand, native plants are well-suited to local ecosystems, offering habitats and food sources for native organisms. On the other hand, multi-level plant communities increase the complexity of spatial structure and provide living space for organisms with different ecological niches. Creating a variety of habitats is beneficial for addressing the specific needs of diverse organisms. The purpose of this study is to provide scientific basis for urban planners and landscape designers to formulate more effective plant configuration strategies, and ultimately promoting the protection and development of urban biodiversity.

1. Introduction

As urbanization progresses rapidly, ecological challenges in cities are becoming more pronounced, making biodiversity conservation a global priority. Urban green spaces are essential to urban ecosystems. They provide recreational areas for residents and serve as critical habitats for various species. However, current plant configurations in many urban green spaces exhibit significant limitations, such as monoculture of plant species and simplified community structures. These issues hinder fully realizing their ecological functions and substantially weaken their capacity to support biodiversity. Exploring optimization strategies for plant configuration in urban green spaces is crucial for enhancing biodiversity. By optimizing plant configurations, urban green spaces can enhance ecological conditions, creating suitable habitats for a wider variety of organisms and increasing the diversity and population of urban species. Such improvements enhance ecosystem stability and service functions, ultimately fostering sustainable urban development [1]. Consequently, in-depth research into the relationship between plant configuration optimization and biodiversity improvement is imperative. This exploration will provide a scientific foundation for urban green space planning and management, addressing a pivotal challenge in contemporary urban ecological studies.

2. Analysis of the Current Situation of Urban Green Space Plant Configuration

2.1 Types and Distribution of Urban Green Space

Green spaces, including parks, production areas, protective zones, and affiliated spaces, are crucial in the urban ecosystem [2]. The park's green space serves as a public area for residents' leisure and entertainment in the city, including comprehensive parks, community parks, and specialized parks. They are typically found in many places in the city, making them convenient for residents. Production

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green spaces are primarily used for cultivating and producing seedlings, flowers, and other plants and are generally situated in the suburbs. Protective green spaces serve the purpose of providing isolation and protection. For example, green belts are often found on both sides of city roads, and isolation belts are established between industrial and residential areas. Green spaces are usually found on the outskirts of cities or within specific areas. Affiliated green spaces refer to areas associated with different types of urban land use, such as residential, public facilities, and industrial green spaces. These areas are commonly distributed throughout the city. Other green spaces include scenic spots and forest parks, usually in natural areas around the city. The distribution of urban green spaces is uneven. In some urban areas, green space is relatively limited due to the shortage of land resources. In contrast, in the suburbs or new development areas, the area of green space is relatively large. The uneven distribution makes it difficult for some residents to enjoy a good green space environment and affects the overall function of the urban ecosystem [3].

2.2 Introduction to Plant Configuration

The plant configuration of urban green spaces exhibits distinct characteristics in species selection and spatial arrangement. Regarding species selection, ornamental species such as *Prunus serrulate* (cherry blossom), *Lagerstroemia indica* (crape myrtle), and *Osmanthus fragrans* (sweet osmanthus) are commonly utilized for their high aesthetic value, enhancing urban landscapes through a variety of colors. In terms of configuration patterns, two predominant approaches are observed: formal configuration and naturalistic configuration. The formal configuration uses symmetrical and orderly layouts, exemplified by aligned street trees along roads and geometrically designed flowerbeds in public squares. Naturalistic configuration emphasizes the emulation of native plant community structures, fostering ecologically coherent landscapes with a spontaneous appeal, as seen in parkland vegetation clusters designed to replicate wild ecosystems. Notably, advanced urban planning integrates seasonal phenological variations into design strategies. By combining species with staggered flowering/fruiting periods, such as spring-blooming *Prunus serrulata* (cherry blossom) and *Prunus persica* (peach), summer-flowering *Nelumbo nucifera* (lotus) and *Lagerstroemia indica* (crape myrtle), autumn-harvested *Chrysanthemum morifolium* (chrysanthemum) and *Ginkgo biloba* (ginkgo), alongside winter-blooming *Chimonanthus praecox* (wintersweet), these configurations ensure year-round aesthetic diversity within urban green spaces [4].

2.3 Existing Problems

2.3.1 Single Plant Species

The problem of single plant species in urban green spaces is prominent. Many cities' green spaces often feature a limited variety of common plants, resulting in simple community structures and reduced ecological functions. For example, the street trees in some cities are mainly *Cinnamomum camphora* (camphor tree) and *Ginkgo biloba* (ginkgo), showing a lack of variety. A single plant species can easily attract diseases and pests, weakening its support for biodiversity. Different plants provide food and habitat for different creatures. Therefore, the single plant species means that the food source and habitat are limited, and it is difficult to attract more biological species to survive and reproduce in urban green space.

2.3.2 Unreasonable Configuration Model

The plant configuration model of some urban green spaces is unreasonable. Many standard landscaping designs prioritize uniformity, often at the expense of natural beauty and ecological functionality. For instance, extensive lawn areas are covered in certain squares with a few plastic shrubs. While this creates a neat and attractive appearance, it offers minimal ecological benefits, and the maintenance costs for the lawn can be quite high. However, in practice, some natural configurations fail to fully consider plants' ecological habits and relationships due to the lack of scientific planning and design. Hence, the plants grow poorly, and the landscape effect is not good. During the plant configuration process, plants' height, crown width, and flowering period were not fully considered, leading to an unclear plant community hierarchy and a poor landscape effect [5].

3. Optimization Strategy of Plant Configuration in Urban Green Space

3.1 Optimization Principle

3.1.1 Ecological Priority

Ecological priority is the primary principle of urban green space plant configuration. Urban green spaces provide landscapes for people and play a crucial role in the urban ecosystem. They perform essential functions such as enhancing the environment, regulating climate, and maintaining ecological balance. Plants' ecological habits and functions should be fully considered in plant configuration. For example, priority is given to plants with strong air purification capacity, such as oleander, which can absorb harmful gases like sulfur dioxide and chlorine; *Ginkgo biloba* has a certain adsorption effect on heavy metals in the air. It is necessary to pay attention to the construction of plant communities and simulate the structure and function of natural ecosystems. Taking the multi-level structure with arboreal species, shrubs, and herbaceous plants as an example, the upper trees can provide shade and protection for the lower shrubs and herbaceous plants, form a relatively stable ecological environment, and improve the ecological stability and self-healing ability of green space. In addition, considering the ecological niche of plants is essential to prevent excessive competition among species and to ensure that diverse plants can coexist harmoniously.

3.1.2 The Principle of Diversity

Biodiversity is essential for ecosystem stability and health. In urban green spaces, the principle of plant diversity should be followed to enhance species richness. From the perspective of species diversity, it is necessary to introduce plants of different families, genera, and species to avoid large-scale planting of a single species [6]. For example, in a city park, in addition to the common camphor tree and willow tree, some rare local tree species, such as *Davidia involucrata* (dove tree) and *Liriodendron chinense* (Chinese tulip tree), can be introduced appropriately to enrich the plant species. Attention should be paid to the seasonal changes of plants. Integrating species that have staggered blooming or fruiting times, like the spring-blooming *Prunus serrulata* (cherry blossom) and *Prunus persica* (peach), the summer-flowering *Nelumbo nucifera* (lotus) and *Lagerstroemia indica* (crape myrtle), the autumn-harvested *Chrysanthemum, morifolium* (chrysanthemum) and *Ginkgo biloba* (ginkgo), along with the winter-blooming *Chimonanthus praecox* (wintersweet), these arrangements promote continuous aesthetic variety throughout urban green spaces. From the perspective of genetic diversity, plant individuals with different genetic backgrounds should be selected to improve plant populations' adaptability and stress resistance. In addition, it is recommended that some wild plant resources be introduced and applied to urban green spaces after domestication and cultivation to increase their genetic diversity.

3.1.3 The Principle of Adaptability

The urban environment is intricate and varied, featuring differences in soil, climate, and light across various regions. In selecting plants, we should adhere to the principle of adaptability by choosing species that thrive in local environmental conditions. First, we should consider the adaptability of plants to soil. Different plants have different requirements for soil pH, fertility, and air permeability. For example, *Rhododendron* (azalea) likes acidic soil, while *Tamarix* (Chinese tamarisk) can grow in saline-alkali soil. In the process of plant configuration, suitable plants should be selected according to the actual situation of the local soil, or the soil should be improved to meet plant growth needs. Second, we should consider the adaptability of plants to climate. Factors, including temperature, precipitation, and light, should be taken into account. It is advisable to select plants that exhibit strong cold tolerance in cold regions, such as conifers (e.g., *Pinus, Cupressaceae*). It is a good idea to opt for plants with high drought resistance, such as *Cactaceae* and *Agave*, in hot and dry areas. Additionally, consider the light requirements of the plants; it is important to balance sunny plants with those that tolerate shade, ensuring that you make the most of the available light conditions.

3.2 Optimization Strategies

3.2.1 Selection of Plant Species

In the selection of plant species, many factors should be considered comprehensively. It is suggested that local plants be given priority. After extensive natural selection, native plants demonstrate strong adaptability to their local environments and exhibit greater efficiency in growth and reproduction. In addition, local plants are often interdependent with the local ecosystem, which is conducive to maintaining ecological balance. For example, plants such as *Bombax ceiba* (kapok) and *Ficus spp.* (banyan) are good choices in Guangzhou. We should carefully evaluate the ecological safety of exotic fine plant varieties when introducing them. Some exotic plants provide high ornamental value and grow quickly, but they can also pose invasion risks. Therefore, when introducing exotic plants, strict quarantine and evaluation should be carried out to ensure that they will not cause damage to the local ecosystem. For instance, cultivated exotic flowers like *Lavandula angustifolia* (lavender) and *Tulipa gesneriana* (tulips) can enhance urban green spaces [7]. Finally, pay attention to the functionality of plants. In addition to their decorative purposes, plants serve various other functions worth considering, such as medicinal uses, edibility, and providing honey. For instance, growing plants with medicinal value, like *Mentha spp.* (mint) and *Lonicera japonica* (Japanese honeysuckle), will enhance the environment's beauty while offering valuable resources for health and wellness.

3.2.2 Innovation of Configuration Model

The traditional plant configuration model is often simple, and its innovation and ecology must be improved. Therefore, it is necessary to innovate it. A multi-layer mixed configuration mode can be adopted. The thoughtful arrangement of trees, shrubs, and herbs will create a multi-layered plant community. This design will enhance green space and provide ecological benefits, enrich the landscape, and increase its ornamental value. For example, in an urban green space, tall trees such as *Ginkgo biloba* (ginkgo) and *Cinnamomum camphora* (camphor tree) can be planted on the upper layer. Plant flowering shrubs in the middle layer, such as *Lagerstroemia indica* (crape myrtle) and *Cercis chinensis* (Chinese redbud). Grass flowers and ground cover plants, including *Ophiopogon japonicus* (mondo grass) and *Zephyranthes candida* (white rain lily), are planted in the lower layer.

It is recommended to implement ecological planting ponds and vertical greening. Ecological planting ponds can accommodate a variety of plants in a limited space, thereby increasing planting density [8]. For vertical greening, plants can be planted on the walls and roofs of buildings to improve the utilization of urban space. For example, it is suggested that vertical greening components, such as *Epipremnum aureum* (pothos) and *Hedera helix* (ivy), be installed on the external walls of some commercial buildings and hanging and climbing plants. In this way, it can not only beautify the appearance of the building but also improve the ecological environment of the city. Create a plant configuration that integrates landscape sketches. Combine all kinds of plants with sculptures, fountains, rockeries, and other landscape elements to enhance the visual appeal and create a more attractive landscape effect. For example, aquatic plants, such as *Nymphaea spp.* (water lily) and *Acoruscalamus* (sweet flag), can be planted around fountains to establish a harmonious balance between dynamic and static elements.

3.2.3 Enhancement of Ecological Functions

Strengthening the ecological functions of urban green space is one of the important goals in optimizing plant configuration. First, the carbon sink function of green space should be enhanced. Choose plants with high carbon sequestration capacity, such as poplar and willow, to increase the carbon storage of green spaces. Second, it is important to strategically design the layout of green spaces to increase their area and enhance the city's capacity for carbon sequestration. Third, we should focus on improving the rainwater retention capabilities of these green spaces. By implementing permeable pavements and constructing rainwater gardens, we can facilitate better infiltration of rainwater into the ground, which helps replenish groundwater supplies. In plant configuration, some plants with water and humidity resistance, such as reed and calamus, are selected and planted in the

rain garden, which can purify the rain and increase the landscape effect. Fourth, protect and attract wild animals. It is suggested that some plants be planted to provide food and habitat for wild animals. For example, berry plants can attract birds, and honey plants have the potential to attract insects such as bees and butterflies. In summary, creating a suitable ecological environment is conducive to improving urban biodiversity.

4. Countermeasures and Suggestions

4.1 Improve Regulations and Policies

Perfect laws and policies are the basis to ensure the optimization of plant configuration and the promotion of biodiversity in urban green space. The government should formulate and improve relevant laws and regulations and define urban green space construction and management standards and norms. It is necessary to formulate strict urban green space planning laws and regulations. Clearly define the area, layout, and functional requirements of urban green space, ensure the rational distribution of urban green space, and provide suitable habitat for organisms. For example, it is stipulated that newly-built residential quarters and commercial districts must be equipped with a certain proportion of green spaces and specific requirements must be put forward for the plant configuration of green space to ensure the establishment of plant protection laws and regulations. It is essential to enhance the protection of local rare and endangered plants and to prohibit their illegal collection, sale, and destruction. In addition, strict examination, approval, and supervision are carried out when introducing exotic plants to prevent the invasion of exotic species from damaging the local ecosystem. For violations of plant protection laws and regulations, severe punishment should be given. Moreover, incentive policies should encourage businesses and social investments to engage in constructing urban green spaces and optimizing plant arrangements. For instance, companies actively participating in urban green space development could receive tax incentives and financial subsidies, enhancing their motivation to get involved.

4.2 Promotion of Native Plant Cultivation

Native plants adapt well to local climate, soil, and ecological environment and are the first choice for urban green space plant configuration. Promoting the planting of native plants is of great significance for enhancing biodiversity. On the one hand, there is a need to increase the research and development of native plants. It is necessary to increase investment in scientific research, deeply examine the ecological habits, ornamental values, and ecological functions of native plants, and screen out native plant varieties suitable for urban green space planting. The government should establish a local plant germplasm resource bank to protect and preserve the genetic diversity of native plants. On the other hand, publicity and education improve the public's understanding and acceptance of native plants. Various forms, including media and science popularization activities, can be applied to publicize the advantages and importance of native plants so that the public can recognize the role of native plants in maintaining ecological balance and providing ecological services. In the construction of urban green space, native plants are given priority, and signs are set up to introduce the names, characteristics, and ecological values of native plants so as to enhance public awareness and love for them. Furthermore, a demonstration base of native plants can be established to show the planting effect and application mode so as to provide a reference for promoting the planting of native plants. Finally, garden enterprises and nurseries should be encouraged to increase the cultivation and productivity of native plants and ensure their supply.

4.3 Promotion of Public Awareness

The public is the user and guardian of urban green spaces, and it is very important to improve the public's awareness of ecological protection for the optimization of urban green space plant configuration and the promotion of biodiversity. Developing diversified science popularization activities is an effective way to enhance public awareness. It is recommended that lectures on ecological protection, training in plant identification, and nature observation activities be organized

in schools, communities, and parks to promote knowledge about biodiversity and concepts of ecological protection to the public. These activities are conducive to raising public awareness of the importance of biodiversity and enhancing their responsibilities and obligations in protecting biodiversity.

In addition, using new media platforms for publicity is an important means to enhance public awareness. Using social media platforms like Weibo, WeChat, and TikTok to share information and videos about urban green space plant configuration and biodiversity protection effectively attracts public attention and engagement. Citizens are encouraged to share their observations and experiences in urban green spaces to foster a positive interactive atmosphere. In addition, a public participation mechanism can be established to encourage the public to participate in urban green spaces' planning, construction, and management. For example, it is suggested that community events that involve the public in planting green spaces and providing volunteer services be organized. It allows individuals to actively participate in creating urban green areas and protecting biodiversity, fostering a greater sense of responsibility and belonging within the community. To sum up, by raising public awareness, a good situation will be formed in which the whole society will participate in optimizing urban green space plant configuration and biodiversity protection.

5. Conclusion

This study focuses on the role of the optimization strategy of urban green space plant configuration in promoting biodiversity and puts forward targeted optimization strategies, countermeasures, and suggestions after an in-depth analysis of the current situation of urban green spaces. Research findings showed many problems in urban green space, including few plant species and unreasonable configuration modes, which seriously restrict the expansion of biodiversity. Based on the principles of ecological priority, diversity, and adaptability, the plant configuration optimization strategies proposed in this paper, such as scientific selection of plant species, innovative allocation mode, and strengthening ecological functions, can significantly improve the ecological environment of urban green space, creating more suitable living space for organisms, and enhancing biodiversity. Moreover, the suggestions put forward in this study, including perfecting laws and regulations, promoting native plant planting, and raising public awareness, provide a strong guarantee for optimizing plant configuration and biodiversity protection of urban green spaces. In the future, urban planners and landscape architects should fully utilize research findings to develop and implement effective strategies for plant configuration. They should focus on protecting biodiversity, promoting the sustainable development of urban biodiversity, and ensuring that urban green spaces effectively fulfill their ecological, social, and economic roles.

References

[1] Şerif Hepcan. Analyzing the pattern and connectivity of urban green spaces: A case study of Izmir, Turkey[J]. Urban Ecosystems, 2013, 16(2):279-293.

[2] Lepczyk C A, Aronson M F J, Evans K L, et al. Biodiversity in the City: Fundamental Questions for Understanding the Ecology of Urban Green Spaces for Biodiversity Conservation[J]. BioScience, 2017.

[3] Threlfall C G, Mata L, Mackie J A, et al. Increasing biodiversity in urban green spaces through simple vegetation interventions[J]. Journal of Applied Ecology, 2017, 54.

[4] Ding Y. Effects of different aquatic plant configuration patterns on water quality[J]. International Journal of Environment and Sustainable Development, 2024, 23(2/3):194-207.

[5] Wang Z, Wei W. Effects of modifying industrial plant configuration on reducing air pollution-induced agricultural loss[J]. Journal of Cleaner Production, 2020, 277(277):124046.

[6] Meda H A. Using plant synthetic biology to benefit from evolutionary diversity in primary metabolism[J]. Biology and medicine, 2021, 13:1-5.

[7] Wang Z S. Application of Plant Configuration in Urban Garden Ecological Restoration Construction[J]. International Journal of Ecology, 2022.

[8] Chen L, Wang Y. Study on Plant Configuration and Planning of Landscape Architecture in Coastal Cities[J]. Journal of Coastal Research, 2020, 115:17 - 20.