

Green Is Not Enough: A Management Framework for Urban Biodiversity Friendly Parks

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Executive Summary

The potential of cities to conserve biodiversity is increasingly gaining more recognition and cities mainly contribute to biodiversity through planning and managing urban green spaces (UGS), for example, urban parks. Research finds that the ability of UGS to support biodiversity depends on several factors, and management activities are one of them. Urban parks are important urban infrastructures and are under a high level of management. Proper management after planning and construction is significant for meeting human needs as well as providing suitable habitats for wildlife. Therefore, understanding how urban parks are managed and operated is critical for urban biodiversity enhancement but accepts insufficient attention in China.

As urban infrastructures and public spaces, urban parks bear multiple functions for urban residents and hold the responsibility to fulfill basic safety and recreational requirements. The requirements of environmental hygiene and the need for horticultural aesthetics have shaped the current intensive management practices. Urban parks in Chinese cities face challenges when introducing biodiversity conservation into their missions, for example, the large size of monocultural turf-grass lawns, aesthetically pleasing shapes for trees and shrubs, pesticide and herbicide utilization for disease control, etc. Meanwhile, there are missing practices that impact biodiversity, e.g., domestic cat management, invasive species prevention and control, species monitoring, etc. Behind the challenges are the conflicts between human needs and biodiversity needs.

Urban parks and their management practices are not formed automatically. Understanding the root causes that shape Chinese urban parks is the key to changing current practices. The urban parks in China are promoted by the policy as well as driven by the market. Compared to the heavy greening trend, biodiversity conservation in

urban parks has not entered the goal-setting of policy-making. To achieve a visible and immediate green outcome within the limited time, large size of lawns and uniform woodland are feasible ways. Government failures exist in both policy design and policy implementation. The greening change in China's cities is also a process of production of the urban landscape. The supply of plant species in the existing market is limited and dominated by ornamental plants. The desire for economic benefit from companies that supply plants is the main driver. Biodiversity is an externality. The demand side doesn't ask for diversity, which limits parks' potential to support species richness. In addition, parks purchase companies to take charge of the daily maintenance work, which focuses on environmental hygiene and ornamental pleasing. The public goods feature of urban parks services may partially result in this imperfect outcome.

Even though conflicts exist between biodiversity conservation and other functions from current status. However, some of the management practices could be improved to minimize the trade-offs, and some trade-offs may be transformed into synergies from a short-term to a long-term view. To promote change, I propose a policy suggestion of a certificate for urban biodiversity friendly parks. By improving existing regulations, we could motivate urban parks to enhance biodiversity and change management practices. Interventions are also needed to address the market failure and remove institutional barriers for parks to make changes. I generate a management framework as a tool for urban biodiversity friendly parks evaluation. It is created based on maximizing the potential for reconciliation and synergies between the recreational, educational, and urban biodiversity enhancement of urban parks. The management framework could be adopted by local governments and used by urban parks.

1. Introduction

Rapid urbanization has been regarded as a main factor of biodiversity decline at the global level (McKinney, 2002). However, while this is true, the potential of cities to conserve biodiversity is increasingly gaining recognition (Soanes & Lentini, 2019). Urban biodiversity is defined as the biodiversity of animals and plants living within or at the edge of settled areas of a city (Nilon, 2010) and our knowledge related to it is accumulating since 1990. Researches on urban biodiversity mainly focus on taxonomic diversity, urban landscape, urban biodiversity-ecosystem service relationships as well as linking biodiversity to management and restoration (Rega-Brodsky et al., 2022). Current studies show that urban areas provide habitats for many species both native and non-native to the surrounding region (Aronson et al., 2014; Rega-Brodsky et al., 2022). Spotswood et al. (2021) identify five pathways by which cities can benefit regional ecosystems, including releasing species from threats in the larger landscape, increasing regional habitat heterogeneity and genetic diversity, acting as migratory stopovers, preadapting species to climate change, and enhancing public engagement and environmental stewardship. Urban biodiversity ensures ecosystem functioning and ecological service delivery in cities. Every tool matters, as illustrated in the other effective conservative measures (OECMs) framework (G. Gurney et al., 2021). While the impact of climate change on biodiversity accelerates (Spotswood et al., 2021), biodiversity conservation in cities will play an increasingly significant role to achieve global biodiversity targets.

The approaches that foster biodiversity in urban settings versus wild places could be fundamentally different, with different characteristics of ecosystems in biotic and abiotic terms (Aronson et al., 2014; McCleery, Moorman, & Peterson, 2014). Subject to strong societal constraints such as high population density and intensive human intervention, urban biodiversity conservation is facing unique and complicated conditions that conflictive goals keep existing (Dearborn & Kark, 2009). More insights and practices with a reconciliation conservation approach in urban settings could assist in achieving biodiversity conservation targets. After historical shaping and reshaping

of the landscape, today's cities mainly contribute to biodiversity conservation through planning and managing urban green spaces (UGS), including all-natural, semi-natural, and artificial ecological systems, for example, urban parks, private gardens, university campus, etc., (Cilliers et al., 2013). These UGS vary in habitat types, from remnant patches, riparian corridors, urban wastelands, to managed parks, green space in residential complexes, and green roofs, representing different levels of economic input and management intensity (Aronson et al., 2017). Among them, urban parks are one of the most important UGS in developing countries due to the lack of private gardens (Goddard et al., 2010) and therefore represent a great potential to provide habitats for many species. With the feature of multiple functions, public accessibility and non-profit, urban parks are facing unique opportunities and challenges when fulfilling biodiversity conservation.

Urban parks could directly generate effective conservation effects and how to achieve the desired outcomes is gaining much more attention in academic communities. Species diversity is related to the size, quantity, and quality of urban parks (Beninde et al. 2015). Aronson et al. (2017) summarize that the ability of urban parks to support biodiversity depends on several factors, including landscape configuration, biotic interactions, land-use history, human population density, and management activities. Proper management after planning and construction is important for providing relatively suitable habitats for multiple creatures in urban parks (Aronson et al. 2017). Therefore, understanding how urban parks are managed and why is critical for urban biodiversity enhancement. However, this issue has not received insufficient attention in China currently.

China is witnessing an urban greening trend along with public park construction, especially in megacities like Shanghai, Beijing, Shenzhen, and Chengdu. Take Chengdu as an example. Depicting the blueprint of its "park city" as its development strategy from 2017, Chengdu has proposed an urban future that is sustainable, green, and eco-friendly, and has received support from the central government for it (National Development and Reform Commission, 2022). Since 2013, multiple wetland parks,

forest parks, greenways, and community pocket parks have been built within the urban constructed areas. However, during the rapid and large green infrastructure construction process, their potential for biodiversity enhancement has not received enough consideration.

This research focuses on the management stage of urban parks, identifying the challenges and potential improvements that can be brought to urban biodiversity conservation. It asks the following questions: how are current management practices impacting the biodiversity protection potential of China's urban parks, and how could they more effectively enhance biodiversity by changing some of these practices or adopting new ones? Based on my findings, I seek to achieve two objectives: a) to provide a management framework for future urban parks' biodiversity conservation and evaluation; b) to promote potential policy change to support the implementation of such framework.

The remainder of this paper will proceed as follows. I describe the methodology and data in the next section, and then move to the analysis of my findings. To respond to the first research question, I identify the dilemma faced by urban parks introducing biodiversity conservation objective in their mission, in particular the current management mechanism and content, the management activities which may hurt biodiversity conservation, and the conflicting functions of urban parks. Next, I further explore the root causes that shape urban parks and analyze the institutional barriers that exist to the scaling up of conservation practices in urban parks. Then, I introduce some civil advanced practices promoted by civilian actors to enhance urban parks' biodiversity, both domestically and internationally, to address the management challenges. Based on this analysis, I propose a management framework as a potential tool that urban parks could use to boost their contribution to urban biodiversity conservation. Meanwhile, I propose policy changes addressing the factors that shape urban parks to scale up conservation practices.

2. Methodology

This research focuses on urban parks in China. Urban parks could be quite different in terms of history, size, structure, functions, etc. Even though it is hard to give a clear definition of urban parks, they do share some common features, e.g., urban infrastructures, public welfare properties, continuous economic input, and a high level of management. Due to the diversity of attributes, I use “urban parks” with a general meaning in this paper. I paid most attention to those parks which are located in urban built-up areas (*Chengshi Jianchengqu*) and serve as eco-system service providers for the city as one of their main functions. I selected some urban parks in Chengdu, Shanghai, and Shenzhen, as my empirical investigation sites to identify and analyze the common patterns of these urban parks’ management. In the section on advanced practices, I also include relevant experiences and practices which have been used in botanical gardens and rural parks.

A three-stage process was adopted in this study to answer the research questions. In stage one, attempts were made to identify the current regulatory status related to urban parks management and biodiversity conservation practices from existing literature and regulations. To do so, purposeful online searches, in particular policy documents, yielded some useful preliminary information, which was used also to prepare semi-structured questionnaires were prepared for the next stage. A preliminary framework for biodiversity friendly management was formed based on policy synthesis and online cases review, both national and international, at this stage.

In stage two, I carried out fieldwork to collect critical first-hand information case by case, with in-depth semi-structured interviews in ten urban parks or botanical gardens in China’s cities. Specifically, four parks located in Chengdu, three in Shanghai, two in Shenzhen, and one in Beijing were chosen to supplement the analysis with some first-hand data. In data analysis, these cases are coded to Park A to J. Interviewees include urban parks operators, scholars or experts who are familiar with urban biodiversity or parks management, NGO professionals who have experiences with urban biodiversity conservation in urban parks, and some designers from landscape companies who have participated in urban green spaces design. Two officers in

Chengdu have been involved in the interviews. There are 17 interviewees under coverage in total and are coded as number one to seventeenth. For different categories of interviewees, I generated different questionnaires, which are attached in the appendix. I also gained ideas from some of the interviewees about the framework contents, which enabled the identification and revision of unfeasible or improper elements.

In stage three, I further analyzed the management status based on first-hand data from the interviews and summarized potential solutions for the urban parks' biodiversity enhancement. The management framework was developed and finalized based on the findings. To promote biodiversity conservation in urban parks effectively, I also explored the institutional barriers to the scaling up of advanced practices from interview information.

3. Dilemma of biodiversity conservation in urban parks

Urban parks provide one of the main public places for urban citizens for recreation and entertainment. These parks' ecological and environmental benefits have also received more attention in recent years. The management and maintenance of urban parks are based on their functions and objectives. In this section, I first examine the current management status of urban parks, then I analyze the challenges that parks face when introducing biodiversity conservation into their missions, which derive in part from their conflicting objectives.

3.1 Current status: how is an urban park managed in a Chinese city?

In China, urban parks are municipal facilities with public welfare attributes. Many cities have published regulations on urban parks to provide principles for the parks' management and maintenance. The three cities covered in this research, including Beijing, Shanghai, and Chengdu, have released their urban park regulations (Beijing Municipal People's Congress Standing Committee, 2002; Shanghai Municipal People's Congress Standing Committee, 2017; Chengdu Municipal People's Congress Standing Committee, 2006). Shenzhen published its parks' regulation draft for comments in June

2021 (Shenzhen Urban Management and Comprehensive Law Enforcement Bureau, 2021). Unlike the situation that lots of urban green spaces are managed privately in developed countries (Aronson et al., 2017), Chinese urban parks are subject to administrative jurisdiction. Due to the land attributions, urban parks are generally managed by park management offices under the authority of the landscape or forestry departments at the municipal or district/county level in accordance with the principle of territoriality (Yuan et al., 2021). The specific names of the administrative authorities may vary slightly from place to place, for example, the Greening and Amenities Bureau in Shanghai, the Garden Bureau in Beijing, and the City Administration in Shenzhen.

For most urban parks, the specific matters of management are handled by public institutions (*shiye danwei*) that are guided and funded by the government. Since the 1990s, municipal governments have attracted investments from companies through the model of “built-transfer” (BT) or “built-operate-transfer” (BOT) to construct urban parks. These BOT parks were delivered to the local government after operation by the companies for a specific period of time written in the contract (Yuan et al., 2021). In recent years, many cities have fast-tracked the construction of parks and other urban green spaces through corporatization, and the management mechanism is experiencing adjustments. Under the strategy of its “park city”, Chengdu has developed a large number of parks in this decade. These new parks are mainly managed by companies that are in charge of construction and investment, while some old parks are also gradually incorporated into the management of investment companies. The park management office of the Chengdu Park City Construction Administration is the supervising authority for the management of urban parks at a city level but has limited influence on the management of a specific park due to the lack of adequate reward and punishment mechanisms (Interview 10). The companies involved are often self-financing in urban park operations and management (Interview 08).

Greening maintenance in urban parks generally implements the principle of “separation of management and maintenance” (Yuan et al., 2021), and the work of greening maintenance is usually devolved to third-party property companies or

landscaping companies through bidding processes. These companies are responsible for plant maintenance, environmental disinfection and cleanness, safety, and facility maintenance. According to the regulations on urban parks, the management affairs of urban parks broadly include basic infrastructure maintenance, plants and animals management, environmental management, security guarantee, cultural activities, and construction and renewal. The management activities which are related to biodiversity include vegetation management, protection of old and valuable trees, pest and disease control, water replacement, greenery renewal, flower exhibition, plant shaping, science education, part or overall renovation and renewal, etc. How to conduct these management and maintenance practices mainly depends on regulations for urban parks, landscape maintenance technical codes, and other related rules. Many cities have also introduced a park classification system. In Shenzhen, for example, the management standard is divided into four levels for the green space in the urban park and regulates the objectives needed to be achieved for each level (Shenzhen Market Supervision Administration, 2016). The strictest level requires 100% plant coverage on the ground cover plant, weeds proportion lower than 3% in lawns, and aesthetically pleasing shapes for trees and shrubs. Other detailed rules give requirements about environmental hygiene and cleaning, landscape effects, and plant maintenance at different levels, e.g., plant shaping, weeding, fertilizing, remove dead branches.

3.2 Challenges: how does urban parks' management impact biodiversity?

As appears from the above analysis, the focus of parks' management is focused on selective ecosystem services, such as maintaining neatness/hygiene, aesthetic improvements, and providing leisure and recreation spaces for residents (Klaus & Kiehl, 2020). Aronson et al. (2017) indicate that the intensive management of public parks has imposed barriers to biodiversity worldwide. They also identify four key challenges for biodiversity conservation in urban parks management, including turf-grass lawns, the removal of habitats, the simplification of habitat structures, and pesticide and herbicide application. Fieldwork in Chinese urban parks shows similar findings. The requirements of environmental hygiene, which is to keep the urban environment clean,

tidy, and disinfected, and the requirement for horticultural aesthetics, which focuses on visually pleasing for the public, have shaped the intensive management practices in urban parks for a long time.

- **Lawns maintenance**

Urban parks often feature at least one large area of turf-grass lawns, which is generally aimed at recreation and viewing, yet decreases the heterogeneity/diversity of habitats in the park. These lawns are usually compromised of single species or very limited species due to the requirement for the lawns to be green, resistant to trampling, able to recover quickly after impairment, and of a uniform appearance. These requirements make lawns improper environments for many species. Pollinators such as bees, butterflies, and beetles need rich floral resources (Lowenstein et al., 2014) and these species become rare due to constrained food provision in such monocultural turf-grass lawns. To maintain the uniformity of lawns, the height of the grass also needs to be controlled, the weeds need to be pulled off, and damaged turfs need to be replaced, all of which further decrease plant diversity. For example, the height of the grass for recreation is generally under 10 centimeters and maintains a uniform appearance. To control diseases and insects, pesticides and herbicides are also applied to lawns. One study shows that bee and butterfly communities in urban areas may be more vulnerable to pesticide and herbicide use than those in rural areas. Pollinators are less resilient to chemical control in fragmented urban habitats (Muratet & Fontaine, 2015).

These maintenance techniques result from national and international horticultural practices. They have been incorporated into the local urban park regulations (Shenzhen Market Supervision Administration, 2016) and have become common maintenance practices in urban green spaces in China.

- **Woodland maintenance**

Plant communities in woodlands have limited species diversity in some parks' design and construction, and lawns are predominantly used to green the understory space. However, woodland vegetation structure and complexity have a big impact on

bird diversity (Kang et al., 2015). Birds and other diversified creatures need the cover or shelter provided by complicated plant structures to nest, hide, feed, etc.

However, plant species selection in urban parks favors those that are aesthetically pleasing, survive easily, and are easy to maintain, which results in low diversity and a low proportion of native plants. Even though there are still debates on the significance of native species to support biodiversity as urbanization has modified local conditions, existing studies have justified their priority in urban plant arrangement (Berthon et al., 2021). Yet, it is estimated that exotic and ornamental species account for about over half of the plants in Chengdu's newly constructed urban parks (Interview 15). Such landscapes are not capable of providing a proper habitat for multiple local animal species. Moreover, branches pruning in shrubs and trees for aesthetical perception are quite common practices but tend to simplify the structures of habitats. Shelters needed by birds may disappear due to such management and then species richness reduces. Tree holes are also often plugged in some parks once discovered (Interview 05), but some are critical to providing nest sites for cavity-nesting birds, e.g., starling, woodpecker, during the breeding season.

Pesticides and herbicides are also applied to control pests and diseases in woodland, especially herbivorous insects, to maintain the healthy-looking of plants. Other targets of pesticides are rats and crickets in the Patriotic Health Movement, which is a long-term Chinese national strategy to mobilize citizens in public health and environmental hygiene, but other small mammals can get poisoned by them at the same time. Moreover, pesticides erode the capacity of soils to foster bacteria and fungi. Deadwood could also provide necessary habitat for species that rely on coarse woody debris (Kane et al., 2015) but they are usually cleared away.

Apart from that, leave clearance is another management routine for the parks' management team. Yet, Stagoll et al. (2010) indicate that the presence of leaf litter increases bird species richness partly by supporting a richer arthropod community. These organic materials are supposed to go back to the ground in nature but become waste in urban settings. Thus, clearing leaves in urban parks decreases the fertility of

the ground soil and further deteriorates its abiotic situation, e.g., nutrition content and water retaining capacity.

Woodland maintenance in urban parks is carried out mainly for aesthetic purposes, which focuses on keeping the plants to be beautiful, healthy-looking, and mainly green. Some of these maintenance techniques, e.g., branch pruning, are for aesthetical appreciation and are written in local maintenance standards (Shenzhen Market Supervision Administration, 2016; Chengdu Municipal Market Supervision Administration, 2021). Plants with beautiful flowers are preferred in gardening practices. Other considerations of woodland maintenance that are included in regulations include controlling infectious disease, preventing possible infectious disease transmission, and avoiding security accidents. Urban parks are inspected by local authorities to maintain the disinfection and clearness of the environment (Interview 05, Interview 07, and Interview 08).

- **Wetland maintenance**

Wetlands have been scaled up in urban areas in recent years as a result of an increasing emphasis on watershed treatment. Maintenance activities around wetlands include salvaging water plant waste and cutting off weeds alongside the banks. Cleaning water plants is generally done to keep the water surface clean and prevent possible water eutrophication, and cleaning up reeds may be done to prevent fire hazards in the dry season (Shanshui Conservation Center, 2022). Some parks also utilize water spaces to carry out water sports, boat touring, or other recreational activities. These activities may introduce disturbance to waterfowls. Introducing small unfettered wetlands in urban environments has not gained enough attention and is little applied in urban parks. Yet, these habitats are critical for native reptiles and amphibian species. Small creeks or temporary ponds also provide critical shower spots for birds.

The management intensity of ponds, wetlands, and lakes in urban parks is usually much lower compared to land landscapes, as the inherent nature of the water environment is relatively inaccessible and hardly controllable. The main objectives are

to maintain water quality and provide ecological services. There is a prohibition of pesticide use on wetland plants based on the project code for landscape architecture engineering (Ministry of Housing and Urban-Rural Development, 2021).

- **Other management elements**

While some maintenance work impacts biodiversity negatively, there are other elements in urban parks that pose threats to wildlife but lack attention. For instance, stray cats are significant predators in urban environments and a research estimates that 2.69 to 5.52 billion birds, 1.48 to 4.31 billion reptiles, and 3.61 to 9.8 billion mammals are predated by all free-ranging cats in China (Li et al., 2021). This issue has not received much attention from governments and even less from park operators in China. Secondly, some infrastructures in urban parks create barriers to connectivity within the green spaces, which impact wildlife. Glass walls or buildings may lead to bird collision directly. The first bird-building collision report in China described the bird collision cases that happened in an urban park in Shenzhen (Li et al., 2021). Thirdly, invasive species are becoming challenging issues in urban environments and effective measures for prevention and control are still limited. For example, *solidago canadensis L*, an invasive plant widely spread along wetland banks, is attracting more attention in cities from north to south in China. It has been a big issue for one park in Shanghai from my fieldwork (Interview 08). Fourthly, light pollution and noise pollution impacting animals have been ignored in both the design and maintenance stages (Interview 13). Although evidence is still lacking from a park scale but existing research shows that improper lighting use could create ecological traps and impact the behaviors and life cycle of wildlife, for example, the reptiles and birds' migratory behaviors (Robertson et al., 2013).

Moreover, visitors' behaviors play an important role in conservation but there is a lack of guidance and education for them relating to biodiversity. Ordinary people lack professional knowledge about species. As a consequence, some invasive species are directly introduced in urban parks by visitors through intentional or unintentional release. For example, a kind of turtle, *Trachemys scripta elegans*, is widely kept as pet

by urbanites. Lots of these turtles are released in urban parks by residents who do not want to keep them. Furthermore, some residents would complain to administrative authorities if they found the presence of specific animals, e.g., snakes and toads, even when they are not dangerous, and ask for their removal (Interview 07). These voices would pose significant barriers to conserving and restoring specific groups of species in parks and further the restoration or enhancement of biodiversity. The high intensity of human interventions and inappropriate disturbances from the public constrained the wildlife persistence in urban green spaces. Moreover, the focus of park management on aesthetical and recreational values is also to some extent due to the demand from the public. Yet, as we have seen, these demands are sometimes contradictory to the need of maintaining biodiversity.

Finally, tracking the status of plants and animals is critical to evaluate the biodiversity value of an urban park. However, for most urban parks, there is still no species monitoring plan. Municipal environmental and ecology authorities carry out environmental monitoring on wetlands, but these are usually limited to physical-chemical indicators. Some environmental NGOs or nature enthusiasts are collecting pieces of species data in urban settings, but this work needs to be sustained and widely scaled up to help understand urban biodiversity better.

- **Mechanism limitation**

As mentioned above, a public institution or a company are usually responsible for park management. They in turn usually hire a specialized property management company to provide maintenance services, including landscape and infrastructure management. This kind of work is not regarded as valuable and respectful in cities and the workers who carry out the specific maintenance tasks are generally middle-aged and elderly persons. In addition to following regulations that may not be biodiversity-friendly, these personnel usually lack awareness and training on biodiversity conservation. Therefore, although intensive management activities, e.g., pulling weeds and removing branches, require great human and resource input, they also tend to weaken the potential for biodiversity conservation.

Funding is another major issue. As more urban parks have been constructed, there has been a massive increase in financial need while there is a deficiency in the official management budget (Yuan et al., 2021). Park H and Park I both face a deficiency of funding in operation and management. While struggling with the gap between revenue and expense, Park I considered whether to introduce more entertainment facilities to generate more revenue (Interview 08). Among the latest constructed urban parks, the operation and management are increasingly being undertaken directly by the companies and even old parks are being handed over to them due to planning adjustments or lack of money (Interview 10).

Even when biodiversity has been considered in the design stage, the maintenance gap will jeopardize the intended outcome (Interview 14). Without proper management, it could hardly realize the desirable outcome of biodiversity conservation.

In general, the form and frequency of citizen engagement are limited in the design, construction, and management stages of urban parks. In Table 1, I summarize the main findings of challenges in urban parks management related to biodiversity.

Table 1. Summary of current management activities related to biodiversity

Categories	Activities	Objectives	Basis
Existing management practices	Large size of turf-grass	Recreation, aesthetic viewing	Not found
	Weeds removal	Maintain uniformity and beauty	Local maintenance standard
	Control of height of turf-grass	Maintain uniformity and beauty	Industry norms
	Pesticide and herbicide application	Environmental hygiene, aesthetic viewing and good growth of plant, and public health	Local maintenance standard
	Plants selection bias towards exotic, beautiful, and easy to maintain species	Aesthetical viewing	Industry norms
	Plant shaping and removal of branches	Maintain uniformity and beauty	Local maintenance standard

	Tree holes plugging	Environmental hygiene, maintain uniformity and beauty	Not found
	Leaves and wood debris clearing	Maintain uniformity and beauty	Local maintenance standard
	Cutting off weeds alongside wetland banks	Security, maintain good growth of plants	Industry norms
	Watersport in wetlands, e.g., boat, paddling, kayaking	Recreation, economic benefit	Industry norms
Missing management practices	Stray cat management	NA	NA
	Bird-building collision	NA	NA
	Invasive species prevention and control	NA	NA
	Light pollution on biodiversity	NA	NA
	Noise pollution on biodiversity	NA	NA
	Visitors' behavior on ecological conservation	NA	NA

3.3 Conflicting objectives: the inherent nature of the dilemma preventing biodiversity enhancement in urban parks

As we described the motives of existing management practices, it has become apparent that some of the challenges of biodiversity in urban parks come from the conflicting objectives of urban parks. As urban infrastructures and public spaces, urban parks bear multiple functions for urban residents and hold the responsibility to fulfill basic safety and recreational requirements. They are the spaces where millions of people have daily contact with nature, but they also need to satisfy other needs of a diversified population at the same time. According to the regulations on urban parks in different cities, I teased out the main functions of urban parks, including recreation and leisure, touring and viewing, disaster avoidance and prevention, enhancing local ecological environment, beautifying the city, public health, and scientific education. Some of them have long recognition among residents, for example, recreation and leisure, touring and viewing. On the contrary, other functions including enhancing the ecological environment have only been written in the official document very recently (Shenzhen Urban Management and Comprehensive Law Enforcement Bureau, 2021).

Some of these objectives seem hardly reconcilable with biodiversity conservation. Recreational or leisure public space is a basic component of parks, which emphasizes traditional aesthetical viewing, convenience and safety rather than nature exposure. To provide these fundamental services, open spaces such as grass lawns as well as other entertainment infrastructures are needed, then leads to a land-use conflict between wildlife habitats and human needs. The compositions of plants, species selection, and maintenance practices are based on horticultural preference and they could be quite different for the biodiversity conservation purpose. The simplification of habitats is applied as the parks are generally designed and intended as a horticultural ecosystem.

Furthermore, parks have to ensure the safety of thousands of visitors every day from diseases and animals. Wildlife, especially insects and some reptiles are viewed as harmful for public health or safety. Some species could be carriers of pathogens and threatens human health. For example, bats in urban cities generated public fear in the era of Covid-19. Some species of mosquitos are known as virus or bacteria reservoirs and contribute to infectious disease prevalence, especially in tropical areas. In addition, their habit of biting receives hate and dislike from humans. In Chengdu, some park operators are trying to introduce a specific machine to control or even kill annoying mosquitos in parks (Interview 03). Environmental disinfection through pesticide and herbicide utilization is a regular practice in urban environments including urban parks. It is obvious that there is a trade-off between biodiversity versus public health and safety concerns.

In terms of security, it is typical maintenance to remove the leaves on the ground to avoid fire risks in some parks. And the reed cutting during winter has the same rationale, apart from gardening practices that help the reed to grow better in the coming spring and summer. Some activities like the removal of trees' branches are for decreasing the risk of security accidents.

Most of the time, environmental service functions and climate mitigation are complementary to each other. Biodiversity also supports eco-services provision, for example, clean air, water, and soil (Mace et al., 2012). Biodiversity may increase

resilience and enhance the ability to avoid disasters, e.g., climate mitigation. However, conflict may occur under some specific conditions. Urban parks are nearly constructed ecosystems and some green spaces in the parks are designed to achieve specific ecosystem services, e.g., water purification, which may ignore its habitat function to support specific animals and impact later maintenance work. Figure 1 summarizes the trade-off and synergies between biodiversity and other functions of urban parks.

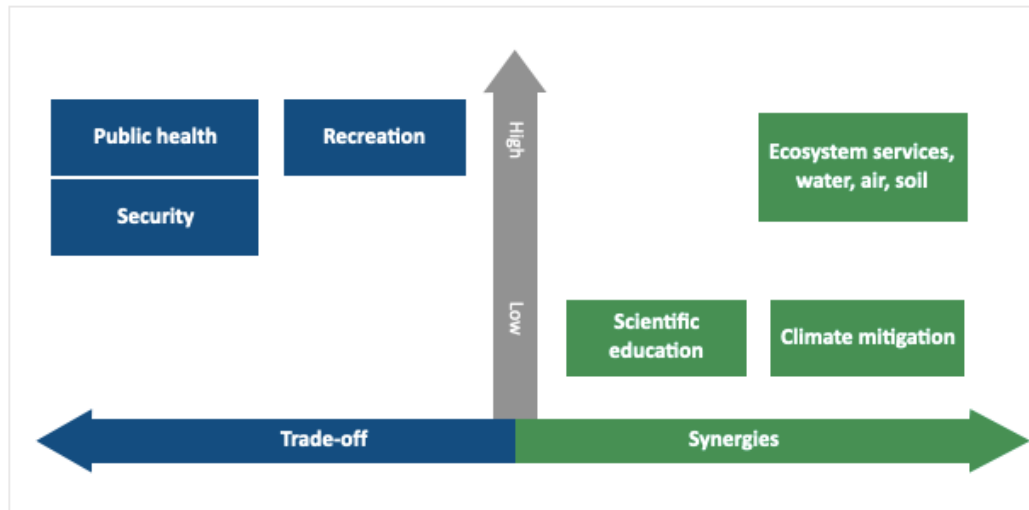


Figure 1. Trade-off and synergies between biodiversity and other functions in urban parks. The high and low ranks the relative importance and recognition of these functions

4. Beyond management: what shapes urban parks?

To deeply understand the root causes impacting parks' management and maintenance, I further involved a preliminary analysis of the planning and construction process in this section and tried to link them to the management stage. A double failure of the market failure and government failure, both affect the promotion of urban biodiversity conservation within the development of urban parks and other urban green spaces.

4.1 Urban greening movement promoted by policy

China has experienced rapid urbanization with land-use change in the past three decades. A research in 2021 indicated that urban areas in 31 provinces of China have

witnessed a remarkable greening from 2002 to 2015 (Feng et al., 2021). The Ordinance for Urban Greening, published in 1992 by the National State Council of China and revised twice in 2011 and 2017 (National State Council, 2017), was the first legal document that integrated greening into city planning. After that, a series of regulations and rules were successively introduced to improve the urban environment through greening. Urban Green Space Classification Standard in 2002 formally involved the greening rate of built-up areas in city planning as an indicator. This standard was revised in 2017 (Ministry of Housing and Urban-Rural Development, 2017), and new indicators such as green coverage and green space per capita have been added. The government's urban greening policies have played a key role to increase vegetation cover in urban environments (Feng et al, 2021).

Biodiversity conservation in urban parks is a public affair that enhances social welfare. Policy interventions through regulation and standards setting to enhance social utility are necessary to achieve positive externality. Government failures exist in both policy design and policy implementation. Compared to the heavy greening trend, biodiversity conservation in urban parks has not entered the goal-setting of policy-making. As a result, most of the current regulations or related standards are still barriers for urban parks to transfer to biodiversity-friendly standards. For example, in urban green space planning, only the quantitative indicators of greening, e.g., rate of green space, or environmental hygiene, are evaluated and inspected by the higher level of authorities, which probably leads to outcomes that low quality of the urban green spaces including the potential for biodiversity. In 2022, for the first time, Garden City, a national plan, has adopted native plant species as an indicator in the evaluation framework in newly constructed or renewed urban green space in its newest version (Ministry of Housing and Urban-Rural Development, 2022). In terms of management and maintenance, there is nearly no regulation, standard, or guidance mentioning biodiversity. Many existing management practices impact urban biodiversity negatively. Lack of information may partially result in a loophole in the urban greening policy design.

The implementation of the greening strategy needs huge financial input from governments. Under the promotion of national strategy, many cities set greening rates as development targets and pursue a large scale of “greening” within a limited period of time. The large size of lawns and uniform woodland are attractive ways to achieve these goals. Even though the park design principle encourages varied landscape configurations and plant diversity in recent years (Ministry of Housing and Urban-Rural Development, 2017), the lawns are relatively low cost and easier to scale up in construction. The preference of municipal leaders also impacts plant selection in many cities (Interview 06; Interview 13; Interview 16). This phenomenon reveals potential rent seeking issues in the policy implementation. In addition, the national government could also lack effective supervision on the specific implementation of policy at a local level. Big trees from surrounding rural areas were heavily replanted in cities in municipal practices to achieve desired greening for several years from 2009 to 2013, which was called “trees going to cities”. This movement across many cities in China actually led to ecological degradation. The Ministry of Forest published a notice for the prohibition of trees going to cities in 2013 (Ministry of Forest, 2013). However, even though native plants have been involved in the indicators of Garden City, there is no clear criteria or definition of native plants which may lead to the infeasibility of the policy (Interview 06).

4.2 The urban green spaces driven by the market

The greening process in China’s cities is also the production of urban landscapes. Several markets play critical roles in the supply chain of urban parks, including the nursery plant and flower market, the landscape designing market, the engineering construction market, and the property management service market.

Plant communities are one of the most important elements in shaping urban parks landscapes, and also the foundation of urban biodiversity. The supply of species available in the existing nursery plant and flower market largely shapes the plants we could see in urban parks. There are some basic requirements for plant species utilization in the urban context, for example, adaptation to specific urban environments and

climatic conditions changed by human activities. Many native species meet these requirements. However, plant composition in urban parks is dominated by exotic species mainly due to artificial selection along with gardening practices. The desire for economic benefit from companies that supply plants is the main driver. The rapid and large-scale greening movements don't pay attention to plant diversity. Species that are aesthetically pleasing, green, and flowering are selected and massively produced in productive green spaces, e.g., plant nurseries in rural areas, as economic products, and then are removed to urban green spaces. The gardening techniques in plant nurseries, e.g., cutting, further decrease genetic diversity among the flora taxa. On the other hand, the demand side from urban parks construction holds preferences including low cost and horticultural aesthetic (Interview 13). Moreover, landscape designing companies and construction companies require products that own a clear market price for easier budget-making and funding settlement. Biodiversity is an externality in urban landscape production since the existing demand side doesn't ask for plant diversity (Interview 14). This, in turn, limits the parks' potential to support species richness.

Limited plant species in the market, particularly native plants, further constrains the choices of parks' plant variation during the plant renewal. Current nursery plant and flower markets have formed for years by providing mainstream economic and horticultural plant products. With the change of national strategy that native species becoming an evaluated indicator in Garden City, cities and parks that would like to diversify their plants face the difficulty of limited supply, since they have to rely on the current purchasing chain. In some practices initiated by environmental NGOs (Interview 09), people pursue diversity through alternative pathways apart from mainstream markets. But for urban parks without flexible purchasing, it is nearly infeasible to access native plants seeds or tree seedlings even if they would like to increase the proportion of native species.

Moreover, parks purchase property management companies to take charge of the daily maintenance work. The maintenance expenditure has achieved equilibrium in the market with a guide-price setting by governments, around 10 to 25 RMB per square

meter (Interview 06; Interview 16). Existing property management services suppliers established standards, for example, how often to remove weeds in grass lawns. These practices can be hardly changed without significant incentives. How to view maintenance plays a role in this tradition forming. One of the interviewees thinks that the landscape is a static view but the ecosystem is changeable (Interview 09). Without the view of the ecosystem, biodiversity-friendly management is rootless. In addition, property companies pursue minimizing costs and sustaining benefits. Therefore, they would tend to maintain a status quo unless they find benefits increasing space. The public goods feature of urban park services may therefore result in imperfect outcomes, especially when the parks have huge budget constraints. Table 2 summarizes the main political and market factors that make influence urban parks' biodiversity at different stages.

Table 2. Political and market factors on urban parks at different stages

Urban parks	Policy, regulation, and standard	Market factors
Phase 1. Planning and establishment	Urban land use control; Urban planning; Urban greening target	Land transaction
Phase 2. Design and construction	Guidance of urban parks design and construction	Nursery and flower market, landscape design, landscape construction
Phase 3. Management and maintenance	Greening maintenance standard	Property management and maintenance market, Nursery and flower market

The policy driven and market power together shape the current urban parks. Conflicting objectives and institutional barriers due to policy and market constrain urban parks' motivation to enhance biodiversity. Figure 2 shows existing problems in a hierarchy.

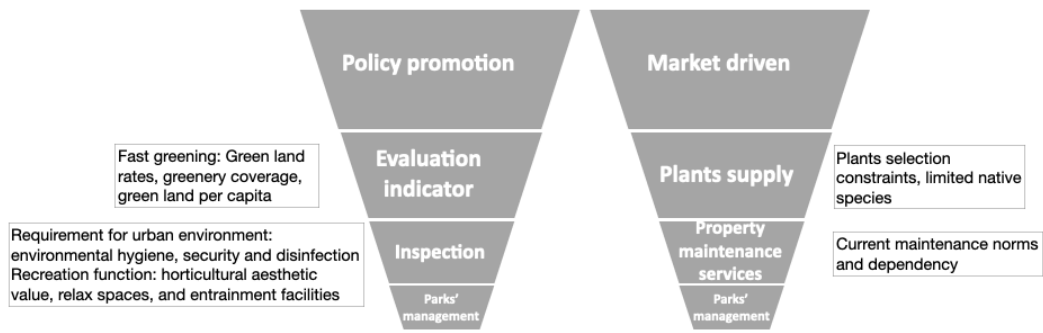


Figure 2. Hierarchy of existing challenges and barriers

5. Reconciliation: potential solutions from advanced practices

There are indeed conflicts between biodiversity conservation and other functions from current status. However, some of the management practices could be improved to minimize the trade-off and enhance biodiversity. Also, the trade-off may be transformed into synergies from a short-term to a long-term view. Inspiring efforts have occurred at national and international levels for years. In China, there are many local practices in different urban parks or botanical gardens. In this section, I provide potential solutions from advanced practices based on the idea of reconciliation between different objectives of urban parks.

5.1 Capture the state and change of biodiversity in a park

Biodiversity status provides a baseline for urban parks and the data foundation for understanding the biodiversity of the whole city. Natural spaces in urban parks and other green spaces provide the habitat for wildlife in urban environments. Plants, birds, and reptiles are common indicators for species monitoring in urban environments. Pollinators are regarded as good indicators of native plant restoration (Interview 09). As mentioned earlier, increasing the proportion of native plants has been incorporated into the national evaluation framework. In addition, invasive species proportion could tell potential ecological risks in urban parks. Of the ten parks/botanical gardens, only park H has comprehensive species data monitoring carried out by the operator, including birds, plants, reptiles, and small mammals. Considering the varied size of

urban green spaces, the different historic land use, and the heterogeneity of landscapes that impact biodiversity, the potential of different urban parks to conserve biodiversity could be varied. The change in species richness could reveal the efficacy of management improvement of urban parks.

5.2 Provide services related to biodiversity

Education plays a significant role in reconciliation strategies. Residents' preferences impact the outcome of biodiversity enhancement efforts in urban parks. Fisher et al. (2019) investigated public attitudes toward biodiversity-friendly greenspace in Europe and found that the young generation and people who were aware of biodiversity supported biodiversity-friendly greenspace management. The aesthetical value may be one of the urban parks' main functions, but engaging in scientific interpretation and visual guides can contribute to changing visitors' appreciation of nature (Interview 11). Another research shows that educational activities on biodiversity could increase people's knowledge, awareness, interest, and concern (Shwartz et al., 2012). Awareness improvement could decrease harmful behaviors such as disturbing wild creatures and the pursuit of cleanliness. In the case of Park H, the tolerance of visitors to mosquitos and other annoying insects increases and fear decreases through long-term education (Interview07). What's more, urban areas are the places where public policy is shaped and individual practices are taking place. Urban parks, as a venue where urbanites can reconnect with nature, may educate not only the general public but also decision-makers, which would then lead to a positive loop to address biodiversity challenges (Dearborn & Kark, 2009).

Urban parks cover thousands of citizens and provide nature exposure opportunities for them. Urban natural environments with biodiversity are regarded as providing lots of benefits to urbanites, from mental and physical health to aesthetic value (Bosh et al., 2017). After the shock of Covid-19, outdoor activities have increasingly prevailed among the pursuits of urbanites in their free time. Biodiversity enhancement contributes to scientific education, by creating educated venues for environmental education, and subjects education. Urban parks could serve as natural or environmental education

centers, by conducting educational activities related to biodiversity, and other scientific education, and installing visual guides to improve visitors' experience in the parks. Biodiversity status in the parks should be accessible to the public and sustaining monitoring could provide information.

5.3 Improve management activities to balance biodiversity and other functions

To balance multiple objectives, management activities must be improved to achieve the desired outcome. Even though there is a conflict between biodiversity and public health, fostering the richness of animals and microorganisms would also reduce the disease of plants and reduce the dependency on pesticide utilization which improves public health. Existing research suggested that appreciating natural elements would generate public interest in urban conservation (Bertram & Rehdanz, 2015) as well as raise empathic attitudes towards creatures. Nature appreciation and experience are also beneficial for human mental health (Bratman et al., 2019). Disease monitoring rather than large-scale disinfection is a better strategy to prevent infectious diseases. For security, proper distance between humans and wildlife, and regular monitoring, the threats could be minimized without sacrificing biodiversity.

Habitat enhancement is a key step for conserving local biodiversity in urban parks. The rewilding of urban green spaces could be achievable with a natural aesthetic preference different from the old horticultural style. A series of principles are widely recognized in ecologic restoration. In particular, utilizing native plants, avoiding invasive species, enriching the flora community, decreasing pesticide and herbicide utilization, and providing shelter, food, and water for animals (TNC, 2020). Some urban parks, e.g., England Olympic Park, are replacing turf grass with wildflowers, wild meadows, and/ or nectar plants. These measures could create habitats for insects, e.g. pollinators, as well as increase resilience to protect plants from pests and disease. Natural belt and habitat restoration projects are encouraged in some cities' parks (Beijing Municipal Forest and Parks Bureau, 2022). Other techniques including insect hotels and Ben Jass piles have also been utilized in Park F (Interview 05). Park H

introduces wetland restoration to ensure living shelter for reptiles (Interview 07). All of these projects focus on using more native plant species and consider animals' needs.

Diversified and refined management measures should be improved in urban parks to balance the need of humans and biodiversity. To deal with the problems introduced by human intervention, zone-varied and time-varied management methods can be adopted widely. For example, to decrease light pollution, parks could control the light use time-varied and zone-varied (Interview 02, Interview 09, and Interview 15). Park D is facing the trade-off between human water sports needs and waterfowl habitat in the migratory season. To deal with the conflict between waterfowls' habitat and human needs, zoning and time-varied could be a solution (Interview 02). In terms of greening maintenance, some adjustments are helpful for biodiversity fostering, e.g., reducing the leaf clearance frequency, and spraying pesticides in a more precise and targeted way like in Park H (Interview 07). To deal with mosquito issues, park H provides insect repellent to visitors. It is achievable to address threats posed by bees or snakes to visitors by zoning a temporary area and training maintenance workers (Interview 01; Interview 06; Interview 07). Park A is promoting the "do not cut *Aristolochia debilis*" action. *Aristolochia debilis* is a native plant species and provides food resources, mainly its leaves to an endangered butterfly species, which is crucial for its survival. What the park operators do is monitor the distribution areas of the plant and put a notice board to prevent maintenance workers from removing them. To avoid visitors' security accidents, some temporary and simple measures are proven effective in advanced practices. For example, bees' colonization could be a risk to public security in spring. But through actions such as monitoring, setting up a shelter, and giving reminders, this potential harm to visitors could be controlled while some benefits such as giving visitors an environmental education could be harvested in addition to all the ecosystem services provided by pollinators (Interview 01).

5.4 Adopt creative governance mechanism and increase citizen participation

These diversified management strategies need collaboration between departments. Security, environmental hygiene, environmental service, and scientific education are

responsible for different groups. Positive changes in biodiversity only happen when these different departments have more frequent communication. Other creative practices may happen when there is more cooperation. There is a trend happening that more newly constructed parks are operated by companies rather than local governments or public institutions (Interview 10), which creates more space to adopt flexible and open-minded initiatives (Interview 05). Based on this transition, the role of key leaders in the urban park's operating group could be a main driving factor for parks to participate in biodiversity conservation. Compared to the usual management by a public institution, the company operating model may be more flexible in the part of trying new things, especially if there are individuals on the operation team who are innovative. In Park F, the leader and the core team in urban parks are owing a high interest in nature, the environment, and biodiversity, which leads to the experiments of innovative management strategies. In this case, some key leads' attitudes and opinions can directly change practices at the bottom level.

In addition, how the management group interacts with the local government or the inspection authorities would decide the success or not of the long-term practices. Citizen' complaint is one of the important factors the government would consider. Sometimes, it poses a big obstacle to change. The zero pesticide use initiative in Park H had experienced opposition from some residents. Because of the administrative complaints, the operation group had to report to the government about why they would like to take this practice and the progress of education. To reduce the number of complaints in a short time, the management team resumed pesticide utilization in some specific areas and the complaints number decreased. At the same time, efforts are continually put into education works. Along with the negotiation back and force, the attitude of the official authorities also changed (Interview 07).

Due to the unique features of urban park settings, it is vital to involve citizens in urban biodiversity participation. Citizens participation approaches could help understand residents' needs, better balance varied values, and address potential conflicts among different perceptions. Researchers find that urban biodiversity

conservation succeeds when communities are actively engaged (Taylor et al., 2021). Another study suggests that involving individuals and families in the creation of park programming and giving them agency over how their local green spaces are managed creates a sense of community and shared ownership, and consequently increases sustainable use of the space (MacKinnon, 2019). Also, the high density of the educated population in urban environments could turn into a strength in urban ecology research and conservative practice, especially in the utilization of citizen science to generate big data (Yang, 2020). Several insightful cases in China have shown that citizen participation could contribute to urban biodiversity conservation in parks. The roles of citizens include supervising the parks' management, monitoring the biodiversity status, educating visitors, and participating in stewardship programs. In recent years, some operators have invited more people to participate in the governance of urban parks. In one park in Shenzhen, the opinions of residents were collected during the designing stage and they also were encouraged to join the maintenance work coordinated by a social organization. Other regular activities citizens could get involved including plant donation and voluntary social services provision. In Park F, bird watchers provided suggestions about when and how to cut weeds in wetlands, avoiding the significant habitats disappearing for birds' breeding needs (Interview 05). With limited human resources, it is difficult for parks to carry out biodiversity field surveys. However, multiple platforms of citizen science provide simple but effective ways to monitor, collect, and share species data, e.g., iNaturalist, or Life Observation. These data could further be used as supporting materials in biodiversity evaluation. In addition, parks can involve citizens in stewardship programs and activities, for example, ecological restoration programs. These programs provide first-hand experience of habitat creation and create a further positive impact on participants' future practices.

6. Policy change: scaling up the current practices

To promote policy change, I introduce a biodiversity-friendly management framework. To scale up the practices, market failure and government failure need to be

considered. Therefore, I also propose policy advice to cope with the institutional barriers.

6.1 A certificate for urban biodiversity friendly park

The motivation is still lacking for most of the urban parks to introduce biodiversity fostering in their missions. Policy changes at the national, provincial, or municipal level could encourage local authorities and urban parks to adopt a more biodiversity-friendly approach. However, this may take a long time. I propose a voluntary certificate for urban biodiversity friendly parks and thus encourage urban parks to participate in biodiversity conservation from the bottom up. Local government should support those who attempt to engage in this mechanism. To do so, I create a management framework based on national and international practices as a tool. Holding this certificate, urban parks could own honor as well as gain preferential access to funding to promote biodiversity related piloting programs or education projects. It is critical to scale up the advanced practices for biodiversity enhancement in urban contexts. Therefore, national standard modification and improvement are necessary to remove existing barriers.

The urban biodiversity friendly management framework provides a tool for evaluation in the certificate program. Table 3 summarizes the key findings in the potential solution section and shows where are the improvement potentials in urban parks management and maintenance activities. It also refers to the Singapore Index on Cities' Biodiversity (UNEP, 2021) and the Bird-friendly City Certificate program (Nature Canada, 2021). Piloting is needed to determine the weight of each indicator.

Table 3. Management framework for urban biodiversity-friendly parks

Category	Indicators	Data source	Existing practices or guidance
Biodiversity state and change	Natural area proportion (%), including green and blue spaces	Parks planning map; Spatial data from GIS	
	Plant richness	Monitoring data	Park J increases its plants species in plant renewal.
	Native trees or shrubs proportion (%)	Monitoring data	The latest version of Garden City evaluates native plants species rather than traditional ornamental

			plants in new constructed or renewal urban green space.
	Native ground cover plant proportion (%)	Monitoring data	Park J replaces parts of its large proportion of turf-grass into natural vegetation cover and the grass species are mainly native.
	Animal species richness/abundance change (%), birds, pollinators, reptiles	Monitoring data	
	Invasive species richness/abundance	Monitoring data	
Services related to biodiversity	Biodiversity information disclosure	Parks media platform	
	Biodiversity visual guides per thousand visitors	Parks report	Park A introduces a uniform visual guide to explicit its mission, plant species, and function of wetland purification.
	Frequency of biodiversity education projects	Parks report	Biodiversity educational activities are one of the main functions in park A, E, F, H, I, J.
	Number of other scientific education activities per year	Parks report	
Biodiversity management activities	Ecological restoration project	Parks report	Park H carry out several wetland ecological restoration project.
	Natural belt	Parks report	Beijing garden and landscaped department published a natural belt technical guide in urban parks.
	Time and zone varied management	Parks report	Park J recruited a social enterprise to separate part of land to conduct native species study and promotion.
	Limited pesticide use	Parks report	Park H only uses pesticide in some small water tank full of mosquito larva and provides insect repellent to visitors. Education is also necessary.
	Limited branches and weeds removal	Parks report	
	Stray cat management	Parks report	
	Invasive species prevention and control	Parks report	
	Green waste including leaves and branch self-utilization proportion (%)	Parks report	Park H almost reaches 100% self-digesting of green waste, through crushing, composting, and back to soil.
Biodiversity governance	Funding invest in biodiversity	Financial report	For Park H, the environmental NGO invest to take ecological restoration and enhance biodiversity.
	Number of professionals in biodiversity, permanent staff, consultants	Parks report	

	Training of biodiversity issues for maintenance workers	Parks report	Park A has biodiversity friendly notice for maintenance workers.
	Biodiversity monitoring	Parks report	Park H continuously monitor the species, e.g., plant, bird, reptile.
	Citizen science projects	Parks report	Park F, H, I, and J conduct initiative citizen science projects.
	Partnership with environmental NGOs or other institutes	Parks report	Park H are contracted with an NGO and operated by this environmental NGO.

6.2 Respond to the market failure

By providing a uniform and large number of plant products, with little consideration of biodiversity, the market including the supply side and demand side shapes the look of urban parks and urban green spaces. Biodiversity is an externality in urban landscape production. Current nursery and flower markets can hardly meet the requirement of diversified plants and increased native plants without profound changes in the perceived demand that would justify a scale change in their production choices. To fully achieve the positive externality, effective policy rules are necessary. Governments could pilot some programs at the municipal level to increase investments in native and diversified plant products in the plant nurseries.

For the management stage, existing industry norms, operational practices, and personnel composition/capacity need changes by government guidance to transition towards a biodiversity friendly future. It may cause cost increases in a short period of time due to learning by doing. Therefore, financial support could provide incentives to companies. Practices show that more ecologically friendly management techniques would ultimately result in less maintenance cost (Interview 09), and lead to sustainable practices.

7. Conclusion

Most urban parks are highly-managed artificial ecosystems that provide multiple functions for urban residents and habitats for wildlife in urban environments. Reconciliation ecology accepts that human-occupied landscapes can be ecologically

valuable even without being wild or pristine. The compromise might be the only solution in urban biodiversity conservation practices. This research examined the current management practices of urban parks, and how they impact biodiversity negatively. Based on my analysis of their conflicting functions, the factors that shape urban parks, and existing practices nationally and abroad, I proposed a reconciliation strategy to promote biodiversity friendly urban parks, which seeks to minimize the trade-offs between conflicting functions and maximize the synergies between mutually-beneficial functions. The management framework is derived from this reconciliation approach, meeting human needs as well as exploring spaces for biodiversity enhancement. In goal setting as well as implementation, a balance between ideals and pragmatism should be adopted, and an open-minded approach that is adaptive and changeable should be developed based on the understanding of the complexity of urban ecology.

Limitations of this research include brushing over the heterogeneities among China's cities and therefore among their urban parks, simplifying the variety of the urban environment, and the absence of existing solid preference regarding the actual preference of Chinese urban residents regarding urban parks and biodiversity. Further research could also conduct a deeper exploration of the existing plant market, especially to understand the details of the supply chain to better address the market failure.

Urban ecosystems are coupled human and natural ecosystems under the influence of interactions among economic, political, and social factors. As indicated by Hobbs et al. (2006), either a very engineered urban ecosystem or a passive acceptance of whatever ecosystem emerges at equilibrium is not feasible and desirable in urban contexts. To achieve a win-win city future, better management and maintenance practices are critical under the wise balance between human needs and biodiversity conservation.

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Interview Notes

Interview 01. Expert on environmental education. Nov 5, 2022.

Interview 02. NGO representative. Feb 7, 2023.

Interview 03. Retired government official. Mar 12, 2023.

Interview 04. Expert on plant. Feb 16, 2023.

Interview 05. NGO representative. Nov 15, 2022.

Interview 06. Expert on plant. Feb 6, 2023.

Interview 07. Urban park operator. Feb 16, 2023.

Interview 08. Urban park operator. Feb 20, 2023.

Interview 09. Expert on ecological conservation. Nov 11, 2022.

Interview 10. Government official. Feb 24, 2023.

Interview 11. Landscape company representative. Nov 3, 2022.

Interview 12. NGO representative. Dec 8, 2022.

Interview 13. Landscape company representative. Feb 12, 2023.

Interview 14. Landscape company representative. Apr 7, 2023.

Interview 15. Expert on plant. Mar 7, 2023.

Interview 16. Landscape society representative. Feb 11, 2023.

Interview 17. Retired government official. Feb 6, 2023.

Appendix

Semi-structured interview questions

Interviewees category:

Parks operators, from enterprise, public institution (*shiyedanwei*) and NGO

NGO representatives

Experts in biodiversity field

Government officials

Part One. Operators of parks

- Basic information
 - Location, size, boundary, map
 - Found year, supervised department, fund resource, operation model, staff number and structure
 - Landscape classification, quintessential species
 - Park philosophy/mission, function, facilities
 - Visitors per day, geographic coverage
 - Media platforms
- Park operation and management
 - Species monitoring (no/yes -> how)
 - Whether biodiversity conservation (e.g. landscape biodiversity, species richness) is part of park operation and management
 - Plantation management, e.g., standards/guidelines
 - Wetland management (if applicable)
 - Pesticide use
 - “Detrimental species” definition, identification, and management
 - Invasive species management
 - Ecological restoration
 - Practices of biodiversity conservation
 - Biodiversity conservation funds/budget allocation
- Public participation and environmental education
 - Survey on visitors’ behaviors, e.g., visit duration, utilization
 - Activities pertaining to biodiversity
 - Research on the environmental awareness of visitors
- Park evaluation
 - park evaluation program, e.g. content, standard, indicators
 - suggested indicators about biodiversity evaluation

Part Two. NGO representatives & Experts in biodiversity field

- Biodiversity education

- What kind of biodiversity activities have you organized in urban parks? How effective have they been?
- Has there been citizen scientist programs that involve urban parks?
- How can urban parks involve citizens in biodiversity activities; whether citizen participation contributes to conservation & how?
- Urban biodiversity conservation
 - Pros and cons of biodiversity activities held in urban parks?
 - What services or facilities can urban parks provide to foster biodiversity conservation (activities)?
 - What can urban parks improve on to enhance biodiversity conservation?
 - I intend to design an evaluation framework for urban park biodiversity. I would really appreciate it if you could kindly share some insights in terms of evaluation criteria or any concerns that you might have.
- Recommendations on urban biodiversity conservation.

Part Three. Government officials

- Urban parks governance mechanism
- Functions of urban parks, how to view the biodiversity potential of parks
- Political attitude to parks development
- Urban biodiversity conservation
 - Pros and cons of biodiversity activities held in urban parks?
 - What services or facilities can urban parks provide to foster biodiversity conservation (activities)?
 - What can urban parks improve on to enhance biodiversity conservation?
 - I intend to design an evaluation framework for urban park biodiversity. I would really appreciate it if you could kindly share some insights in terms of evaluation criteria or any concerns that you might have.
- Recommendations on urban biodiversity conservation.