Urban Green Corridors: Plant Biodiversity and Pathways for Nature-Based Solutions in Perth and Beijing

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Abstract

This paper shares preliminary results of urban green corridors plant biodiversity study in Perth (Western Australia) and Beijing (China). Urban green corridors are essential linear greenways that connect different types of urban green spaces. Urban green corridors support biodiversity, provide species movement, and enhance recreational functions and aesthetics. Our research examined three typologies of urban green corridors: street plantings, waterway plantings, and railway-adjacent green spaces. Plant biodiversity was analyzed using a literature review, mapping transects involving floristic and vegetation fieldwork surveys, and comparative analysis. One of the goals of this research was to analyze urban green corridors' evolution to compare the two cities' biodiversity conditions and propose several Nature-based Solutions for Perth and Beijing. Perth was studied along an east-west transect to best sample the existing topography. In contrast, Beijing was analyzed along a north-south transect that followed the ancient city's Central Axis. In both case studies, surveys were conducted at 14 sites across the three types of urban green corridors. Analysis of plant dispersal revealed the dominant role of autochory and anemochory (wind) seed dispersion mechanisms in both cities. In Perth, life form (for both planted and spontaneous plants) and the analysis of species origin and richness demonstrated that planted trees and shrubs were mostly native species (56% and 62%, respectively), with species selection dependent on stakeholders' preferences. The groundcover layer was originally planted with lawns but then left to spontaneous succession and is now 100% composed of non-native plants, predominantly annuals. Perth streets also had the highest species richness among the three urban green corridor typologies. However, in Beijing's urban green corridors native species dominated, comprising 61% native trees, 63% native shrubs, 88% perennials, 71% annuals, and 88% vines, calculated within each life form. Findings indicate that there is potential to restore urban green corridors' spatial structure and plant composition using the capacity of native spontaneous plants in Beijing. Whereas, in Perth, limited options to return endemic native Western Australian plants to urban green spaces exist. In Beijing, the emphasis should be on increasing plant diversity (native and non-native) in all spatial layers, while in Perth, mixed native and non-native pioneer plants in understorey layers could be used. The next step in this research is to suggest design scenarios for biodiversity-friendly Nature-based Solutions for urban green corridors in both cities. In so doing, we may develop a potential blueprint for restoring ecosystems and enhancing biodiversity resilience.

Keywords: nature-based solutions, urban green corridors, street, waterway, railway, biodiversity-friendly design, transect, fieldwork survey, Perth, Beijing

Introduction

Anthropogenically induced urban sprawl and densification (Valencia, Levin, and Ketzel 2023) have led to habitat fragmentation, the decline of native biodiversity, and an increase in landscape homogenization (Müller et al. 2013; Kilbane and Roös 2023) worldwide. Nature-based Solutions

(NbS) are defined as cost-effective and nature-inspired strategies that offer environmental, social, and economic benefits by integrating natural elements into urban landscape planning and design (Krull et al. 2015; Lee et al. 2016; Ignatieva et al. 2023). These solutions integrate natural values, features, and processes into cities and landscapes by adapting the applied solutions to local conditions (IUCN 2020). Urban green corridors are linear networks of connected public open spaces within urban areas, such as parks, and natural/semi-natural areas, designed to integrate natural elements, support biodiversity, and provide cultural, recreational, and ecological benefits to communities (McMahon and Benedict 2000; Ibrahim et al. 2022; Aly and Amer 2010). Such corridors provide essential ecosystem services, promote sustainable transportation, link urban dwellers with nature, and contribute to environmental resilience, as well as social, economic, and overall quality of life (Che-Ani et al. 2012; Plantation and Pasoh 2014; Moreno et al. 2020).

Research aim and objectives

This research aims to propose design scenarios to direct future practices that are biodiversity-friendly, socially acceptable, and scalable across urban contexts. The main research question is: What are the similarities and differences in plant biodiversity between urban green corridors in Perth and Beijing? We hypothesize that even though cities have climatic, cultural, social, planning, and political differences, similarities in ecological compositions and spatial structures of green corridors exist. Additionally, we hypothesize that NbS for Perth and Beijing should aspire to hybrid vegetation scenarios that partly mimic the compositions and structures of original vegetation communities and allow some spontaneous natural processes to occur. However, the preservation and restoration of native vegetation remnants should first be prioritized in both cities.

Method

To better understand urban biodiversity and its ecological implications, this paper adopts a multi-method approach. While a comprehensive literature review forms part of the research (not fully covered here), this paper specifically emphasizes the transect approach, fieldwork surveys, and floristic urban biodiversity analysis of findings.

Transects are often used in the ecological sciences (Forman and Godron 1986; Pickett et al. 2001; Pickett et al. 2003) and offer a useful way to explore and reveal landscape complexity and to understand potential relationships between disparate levels and types of spatial information. Transects as a form of mapping are also increasingly used in Landscape Planning and Architecture (Kilbane and Rosa 2019; Kilbane 2017) . Fieldwork surveys and transects provide direct, on-the-ground observations of environmental conditions and patterns across different locations. Floristic analysis helps identify plant species, assess biodiversity, and understand the ecological health of these urban areas. Studying the three types within urban green corridors allows for an examination of species diversity, resilience, and how they contribute to urban environmental quality. Life form refers to the structural and vegetative form of an organism, particularly plants, which results from long-term evolutionary adaptations to their environment. Organisms sharing similar morphological features (e.g., trees, shrubs, perennials, biennials, annuals, and lianas) are classified into the same life form, irrespective of their taxonomic classification. In this research, we categorize lianas as vines, as this classification allows for the inclusion of certain herbaceous plants that share similar climbing characteristics. Furthermore, the life form concept emphasizes the harmony between an organism's structure and its environment, shaped through natural selection and fixed in hereditary traits, distinguishing it from minor variations (ecads) caused by immediate environmental factors (Cain 1950; Uzoqjonova Moxinur Diyorbek 2024).

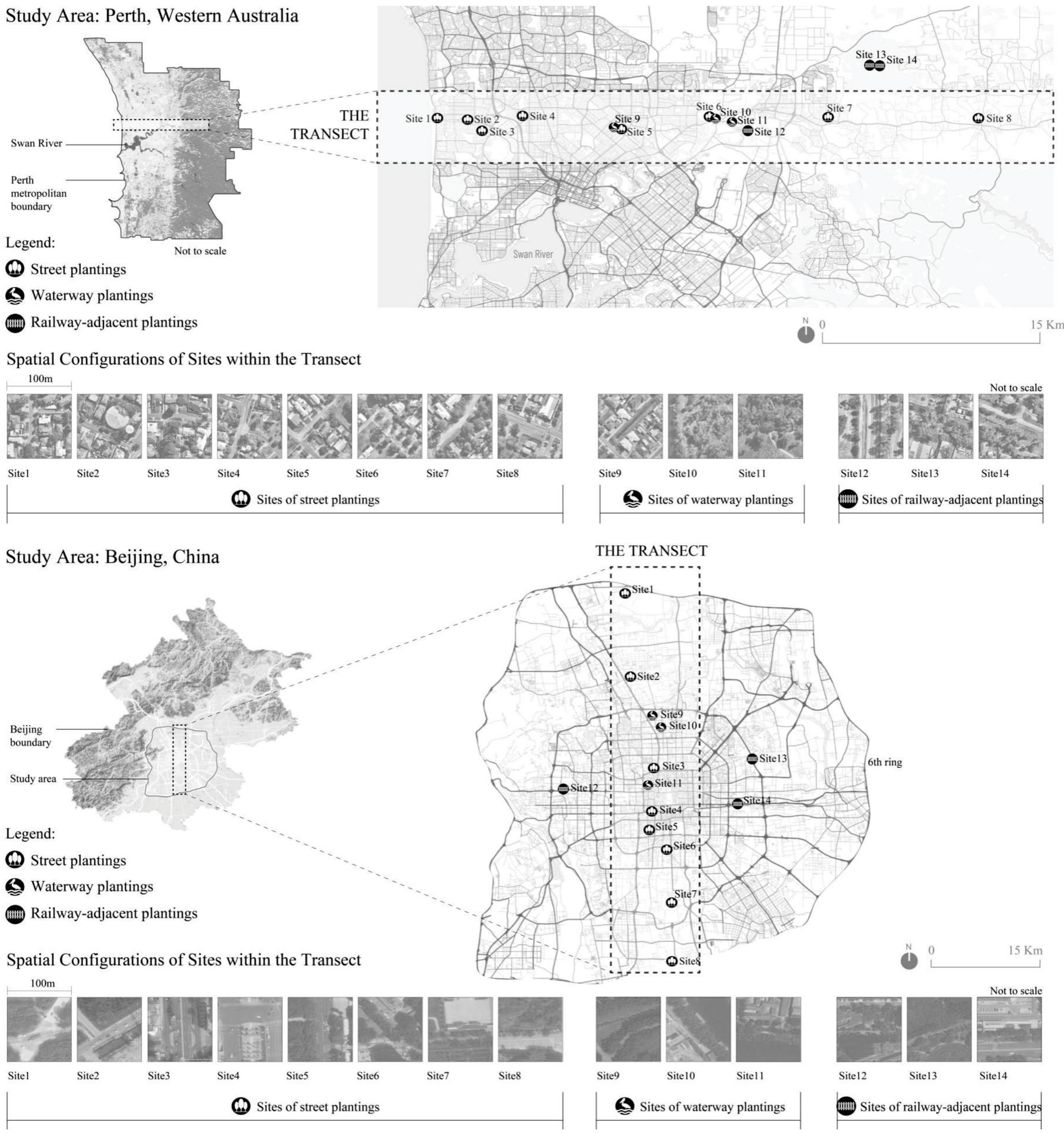

Figure 1. The study focused on transects in Perth and Beijing, with some selected sites outside the transect also being analyzed.

Transects, fieldwork surveys, the classification of urban green corridors and plant life forms, and floristic analysis were used to systematically study and understand the spatial distribution, biodiversity, and ecological functions of urban green spaces. Fieldwork surveys and site visits in this study, explored plant biodiversity along select transects in two cities – Perth and Beijing – for each urban green corridor typology in 2024 to provide a comparative analysis of two different city locations and contexts (Figure 1), and in this instance were used to record data and offer a comparative study of flora (vascular plants), plant origin (native/non-native), plant life forms, seed/fruit dispersal types, species richness, and current typical urban vegetation (plant communities). In Perth, a 47km east-west transect ranged from the western ocean coast, through suburban areas, to the eastern hills (Darling Range) to include streets, waterways, and railways. In Beijing, a north-south transect of 57km sampled the city's length and its planning structure based on Feng Shui principles, extending from the northern mountainous regions through the urban area within the six rings and finishing at the southern cultivated land.

Study area locations

Perth is located in one of the world's 35 global biodiversity hotspots (Pauli and Boruff 2016). It features a Mediterranean climate with hot, dry summers and mild, wet winters (Cargeeg et al. 1987). The city is governed by a decentralized system (Beasy, Lodewyckx, and Gale 2024). Beijing, on the other hand, has hot, wet summers and cold, dry winters due to its temperate semi-humid continental monsoon climate (Zhou et al. 2021). The city operates under a centralized government system (Chung 2016).

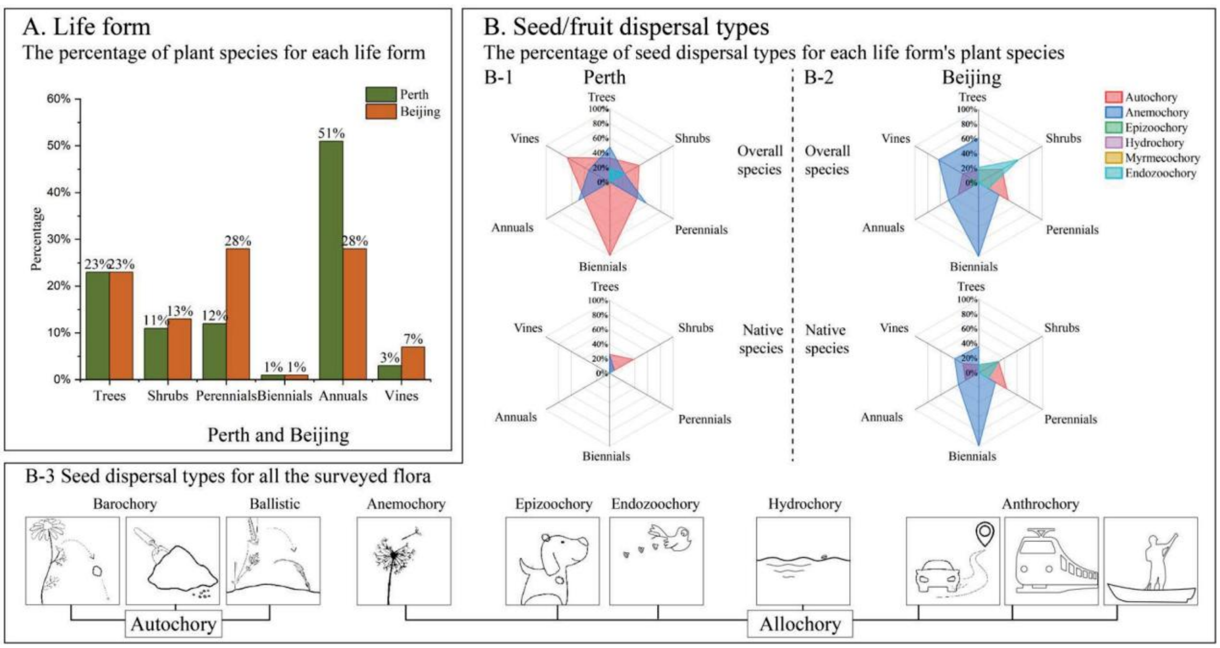

Figure 2. Comparison of surveyed plant species' life form, and seed dispersal types between Perth and Beijing.

Results

The analysis of plant life forms showed comparable distributions of trees, shrubs, and biennials (Figure 2. A). Perth had a higher proportion of annuals, while Beijing excelled in perennials and the presence of vines (vertical vegetation). As for species richness (Figure 3. D), all plant life forms of green corridors had relatively equal overall richness (170 in Perth and 184 in Beijing). In both cities, street corridors had higher total species richness, while species richness was lower in railway and waterway plantings.

In terms of plant origin, the calculation method divided the number of native plants by the total number of corresponding life forms in the survey. The purpose of this calculation was to assess the relative proportion of native plants within different life forms and to conduct a more accurate ecological analysis. In Perth, this revealed a reasonably high proportion of native tree species (56%) (Figure 3. C) and native shrub species (62%). However, all the examined spontaneous perennial, biennial, and annual plants, as well as vines, were 100% non-native. In comparison, Beijing had a substantially larger proportion of native species across all plant life forms, with a high proportion of perennials and vines (both at 88%). Trees and shrubs contained higher proportions of non-native species (39% and 38%, respectively) than other life forms in Beijing's green corridors. There was only one biennial species surveyed, and it was native to China.

In Perth, autochory was the most common seed dispersal type for native plants (Figure 2. B-1), used by 26% of native trees and 38% of native shrubs. The second largest group was anemochory (wind dispersal), which was used by mostly non-native groundcover plants (e.g., 57% perennials, 49% annuals, and 33% vines), and some native plants (e.g., 26% of native trees and 8% native shrub species). Endozoochory was the third most common seed dispersion method for some exotic trees and plants with one native shrub having endozoochory (*Solanum laciniatum*). In contrast, in Beijing, anemochory was the most common seed dispersion mechanism (Figure 2. B-2), with 36% of native trees relying primarily on this. The most common kind of seed dispersion among native shrubs was autochory and endozoochory (both at 31%). Lastly, native groundcovers primarily dispersed seeds by anemochory, followed by autochory.

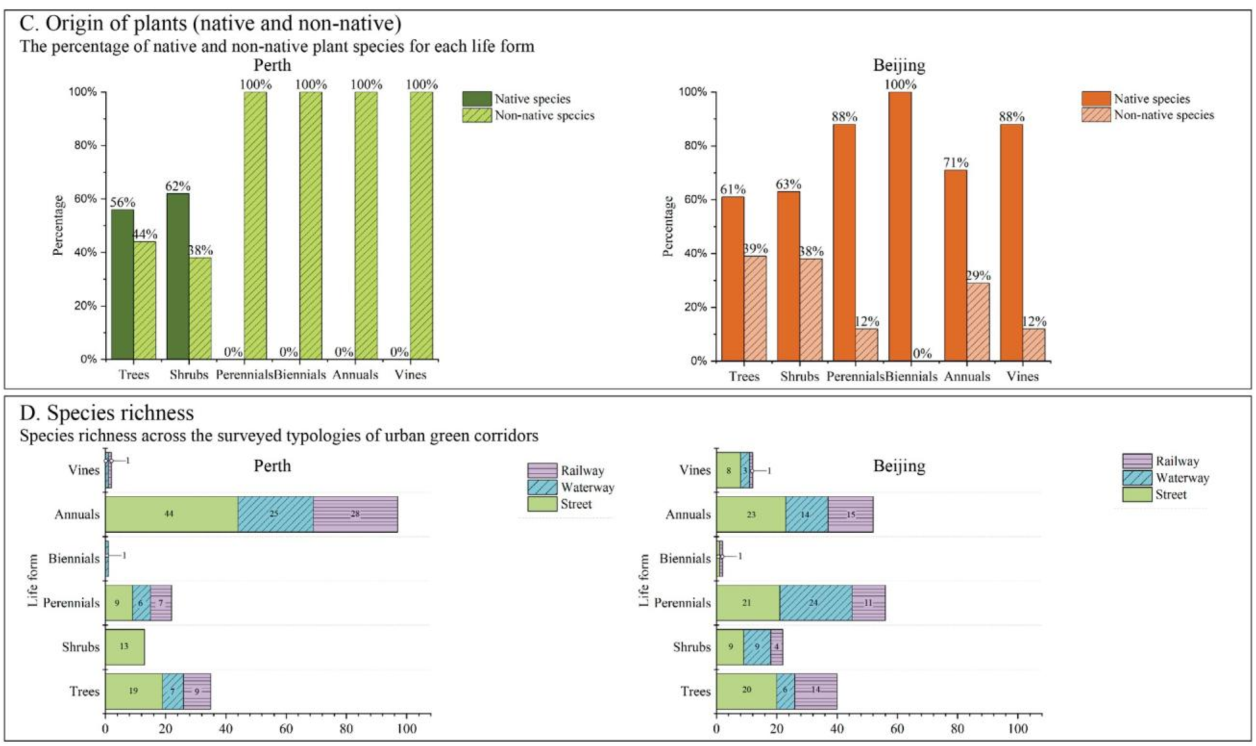

Figure 3. Comparison of surveyed plant species' origin (native/non-native), and species richness across different urban green corridor typologies (streets, waterways, and railways) in Perth and Beijing.

The two cities had similar vegetative spatial arrangements (Figure 4) with vegetation dominated by a ground cover layer and a park-like tree structure. A key difference however was that in Beijing, urban trees were accompanied by an understorey of hedges or groups of shrubbery in some urban green corridor plantings. Furthermore, Perth's average canopy layer was higher when compared to Beijing's. Interestingly, despite significant contextual differences, the two cities shared six plant species: *Hibiscus syriacus*, *Oxalis corniculata*, *Sonchus oleraceus*, *Cynodon dactylon*, *Lolium perenne*, and *Rumex patientia*. Additionally, there were two native tree seedlings observed in Perth's urban greenspace (e.g., *Corymbia citriodora*, and *Agonis flexuosa*) and several native tree seedlings in Beijing (e.g., *Broussonetia papyrifera, Ulmus parvifolia, Vernicia montana,* and *Ginkgo biloba*).

Discussion

The research developed two transects, fieldwork surveys, and floristic biodiversity analysis, to identify a range of flora biodiversity patterns and vegetation spatial layouts. These are discussed in detail below.

Firstly, the percentage of plant life forms (Figure 2. A) shows that, unlike Beijing with more perennials, Perth is primarily composed of annual plant species, reflecting climatic differences and the impact of human-induced disturbances. These include road construction, native vegetation clearance, soil disturbance, and trampling, as well as the availability of species seed banks and plant strategies (e.g., ruderals, competitors, and stress-tolerant plants) (Grime 1974). Conversely, perennial plants dominate native biomes in Beijing, and their seed banks can be found even in disturbed soils in urban areas.

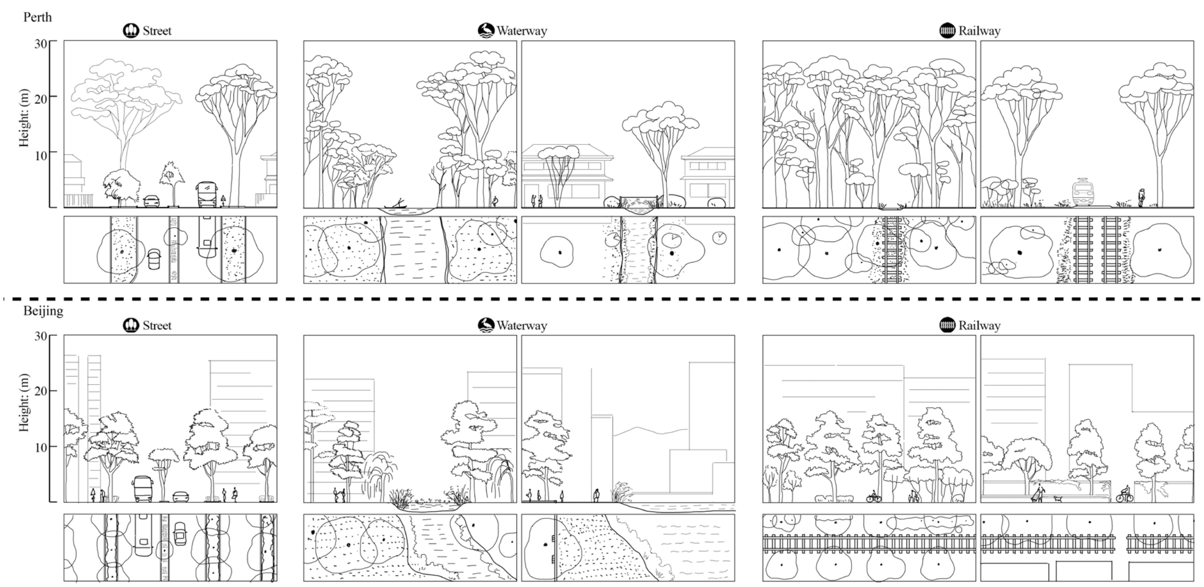

Figure 4. The current representative vegetation's vertical structures in Perth and Beijing for each typology of urban green corridors.

Secondly, within the three urban green corridor typologies, the species richness comparison (Figure 3. D), streets in both cities have higher overall species richness, predominantly with annuals, due to their seed dispersal strategies (primarily anemochory), responses to human-induced disturbance (pioneer plants, ruderals), and stakeholder preferences for planting and maintenance (e.g., sowing lawn species in the ground layer and then mowing/weeding this surface).

Thirdly, regarding species' origin, the percentages of tree species (native and non-native) surveyed were quite similar across the two cities, though the diversity of native tree species in Perth is greater. This is because in many cities around the globe, exotic trees are preferable for their better adaptation to urban soil, heat, disturbance, and limited growth space. Additionally, in Perth, annuals were entirely non-native plants belonging to the pioneer strategy group. In disturbed urban spaces, native woody and herbaceous plants have minimal opportunity to compete with spontaneously introduced non-native plants in disturbed urban areas since their seed/fruit dispersal strategies are mostly autochory and anemochory, respectively. Consequently, the urban ecology in Perth has a mixed character with native trees and shrubs lending a certain amount of identity, but at the ground level, of concern is the development of spontaneous non-native pioneer species. Given that the surveyed native shrubs are 62% which is higher than native trees at 56%, there might be a greater diversity of native shrub species appropriate for planting than native trees in Perth's urban areas.

In contrast, the dominance of native species among all plant life forms in Beijing, suggests that the ecosystem contains native seed banks, despite heavily disturbed and modified soils. Numerous pioneer plants among native perennial, annual, and tree species compete effectively with non-native plants. Most pioneer native plants are urbanophiles and could thrive in urban environments. Trees and shrubs contain a higher proportion of non-native species, indicating that the deliberate import of non-native species for landscape design or economic goals is common in Beijing. Native tree seedlings surveyed during this study show that planted trees can spread spontaneously. This demonstrates the ability to contribute more effectively to ecological recovery with minimal human interference, as natural processes (succession) could progressively return urban green spaces to semi-natural in Beijing.

Concluding thoughts and future research direction

When considering the application of these research findings into future urban contexts, specific NbS for Perth could include combining carefully selected native and non-native annuals and perennials to cover bare ground, prevent soil erosion (Ignatieva et al. 2023), and to offer habitats with greater diversity. With improving environmental conditions, more native perennial plants and shrubs could be gradually reintroduced by direct tube planting or seeding with species acquired from local nurseries to promote biodiversity-positive planting design. For Beijing, actions to further enhance urban biodiversity resilience could prioritize increasing native and selected non-native species diversity within its existing multi-layered vegetation structures. Through incorporating climate-resilient and native plant species, greater biodiversity and sustainable ecosystem function could be ensured.

The next step of this research is to explore a range of design scenarios for the studied locations in each city. This involves researching appropriate vegetation structures and plant compositions that mimic the pre-human intervention vegetation communities and creating a new hybrid planting design vision – including planting lists, vegetation structure, and maintenance strategy. This would incorporate the biodiversity of selected spontaneous plants while considering diverse stakeholder preferences, and planting limits (e.g., height and plant morphological characteristics) in urban green corridor type, thereby offering adaptive designs specific to the needs of each urban green corridor, including suburbs and districts.

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