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Research Paper

Diversity and influencing factors on spontaneous plant distribution in Beijing Olympic Forest Park

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ABSTRACT

With intensive management practices on highly cultivated urban vegetation resulting in the over-consumption of natural resources and urban green spaces losing ecological function, interest is growing in spontaneous plants. Our goal was to improve knowledge of the biodiversity and distribution patterns of spontaneous vegetation in urban parks, which may benefit sustainable and low-maintenance planting design in future green spaces. To disentangle these patterns, a field survey was carried out at both habitat (determined by position in the park) and microhabitat (determined by the planted plants) scales. A total of 102 spontaneous plant species were recorded, and most of them were herbaceous plants. The habitats located between road and building (R-B) and waterside (WS) showed maximum levels of diversity and evenness; the two microhabitats showing maximum levels of diversity and evenness were the waterside unplanted plot (WUP) and the flower bed (FB). Microhabitat affected spontaneous plants more significantly than did habitat. Furthermore, canopy density (CD) and intensity of disturbance (ID) were influencing factors at both scales, while community structure of planted plants (P-CS) was only influential at the habitat scale and slope gradient (SG) was influential at the microhabitat scale. Additionally, the impact of specific planted trees was not significant, but some associated species were notable. Species composition showed markedly different characteristics in different habitats and microhabitats. Understanding these patterns and influencing factors could provide helpful references for any future construction of sustainable urban vegetation with low-maintenance, high-biodiversity and local character.

1. Introduction

During the past few decades, with the acceleration of urbanization in developing countries, buildings and other hard surfaces have increased substantially in urban areas. As cities continue to sprawl, more and more environmental problems arise. Meanwhile, urbanization has modified the ecology and features of urban areas, resulted in the loss of native species and driven the homogenization of the urban landscape (Dunn & Heneghan, 2011; Hope et al., 2003). Previous studies have shown that due to a common inclination in choosing ornamental plants, planting design forms and management practices, human activities have altered urban plant communities in both species composition and diversity (Ignatieva, 2011; Quigley, 2011; Smart et al., 2005; Sudha & Ravindranath, 2000). For example, large areas of lawn with low species diversity are still dominant in urban parks and are preferred by many designers (Müller, 2010). Moreover, the intensive management of planted vegetation has resulted in the overconsumption of natural resources. Therefore, a sustainable approach towards landscape design, combined with biodiversity conservation, has become a pressing need to ensure the health of the urban ecosystem.

Spontaneous vegetation is a typical component of any urban environment, and it consists of plants not intentionally planted by humans and not belonging to the remnants of natural habitats (Cervelli, Lundholm, & Du, 2013). Spontaneous plants can respond quickly to the urban environment, given their strong vitality. They can be found growing in any type of urban green space, as well as on hard sites such as walls, rooftops and brownfields (Millard, 2004; Sousa, 2006). For a long time, people have defined them as “weeds,” which are indicators of an abandoned messy site and are not acceptable in parks and gardens. Fortunately, rising awareness about the overlooked ecological benefits they produce has enabled us to reconsider “weeds.” For the sake of biodiversity conservation in urban ecology, “weeds,” also referred to as “wild plants” or “spontaneous plants/vegetation,” have been discussed in a few studies by ecologists, most of which occurred in

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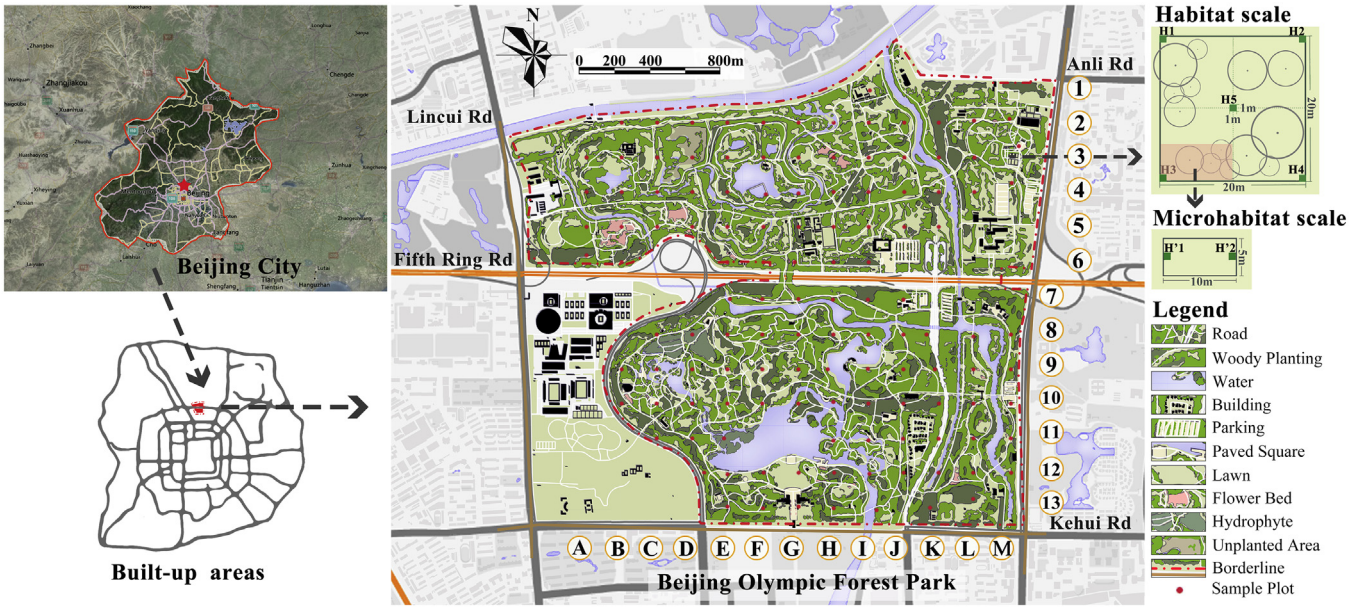

Fig. 1. Study site and sampling design.

urban environmental conditions and were biased towards species composition along the urbanization gradient and the assessment of invasive alien plants (e.g., Celestigrapow, Pyšek, Jarošík, & Blasi, 2006; Cervelli et al., 2013; Knapp et al., 2012; Thompson & McCarthy, 2008). Additionally, a number of experiments have been carried out to observe the spontaneous succession process (e.g., Novák & Prach, 2003; Rehounková & Prach, 2006). Furthermore, on long-term contaminated sites, the effects of spontaneous plant communities on accumulation and translocation of heavy metals has been evaluated (e.g., Boechat, Pistoia, Gianelo, & Flavio, 2016; Cavalca, Corsini, Canzi, & Zanchi, 2015). In China, over the past few decades, most studies on these plants have been aimed at weed control (e.g., Han, Xu, & Deng, 1997; Hu, Huang, Guo, & Fang , 2007; Yao, Zhao, Yao, Wan, & Fei, 2014). It is only recently that some ecologists have begun to pay attention to these "weeds" or "wild plants" in urban areas, focusing on species composition, diversity and response mechanisms to urban conditions (e.g., Chen, Liang, Song, & Da, 2014a, 2014b; Tian, Chen, Da, & Gu, 2008; Tian, Chen, & Da, 2011; Wu & Qiang, 2003; Zhao et al., 2010).

Since the early 21st century, "weeds" have drawn attention from landscape designers in Europe and America for their self-reproduction, low maintenance, and ecological benefits, leading to them being re-defined as urban spontaneous plants/vegetation. The idea of introducing these plants as an alternative to ornamental cultivars and demonstrating their value in the construction of a sustainable and low-maintenance landscape has been emphasized by a series of researchers (e.g., Adelina, et al.. , 2011; Choi, 2004; Tredici, 2010; Kühn, 2006; Sagoff, 2005; Smith & Mark, 2014). Such an understanding would somehow change our traditional urban planting forms and make more people recognize their importance as a sort of green infrastructure, thriving in hard-condition sites and providing substantive ecological benefits. As the largest constituents of green space, urban parks play an important role in urban ecology and recreation for citizens. Given that the majority of the area in urban parks is occupied by artificial communities that need highly maintained practices, it would be extremely meaningful to seek innovative plant communities and landscape forms integrating with "messy" ecosystems to enhance sustainability (Nassauer, 2017). However, few studies consider fine spatial scales of habitat in urban parks where environmental conditions can be rather subtle and sophisticated, and it is crucial to plan the park habitats for the survival of spontaneous plants, since, the powerful anthropogenic influences have made the mixtures of planted and spontaneous vegetation bewildering (Gilbert, 1989). Little is known about the maintenance mechanism of spontaneous species diversity in green space, and their association with planted vegetation is rarely studied.

In Beijing, the highly-developed capital city of China, the acceleration of city sprawl has led to a decrease in native species and the homogenization of the urban landscape. Additionally, given the severe water shortage, it is important to develop a sustainable approach to urban landscaping. Therefore, to provide helpful references, we took Beijing's largest park—Beijing Olympic Forest Park—as an example, and the objectives of our study were to disentangle, for the first time, the diversity of spontaneous plants and to determine the main environmental factors influencing their colonization on two pre-determined scales. Specifically, we investigated (1) what taxonomic composition characteristics presented in these spontaneous plants, (2) how spontaneous plant diversity and evenness changed across various habitats and microhabitats in the park, (3) to what extent these factors explained the diversity and composition of spontaneous plants at these two scales and which factors were most influential, and (4) whether specific planted tree species influenced the diversity of spontaneous plants and how these two types of vegetation associated with each other.

2. Methods

2.1. Study area

The study was carried out in Beijing Olympic Forest Park, which is situated in the northern part of Beijing (40°00′N, 116°22′E). It is the green remnant of the 2008 Beijing Olympic Games, and it covers approximately 680 ha, with 122 ha of water. Its design proposal, "Axis to Nature," aimed at balancing large-scale development with an urban ecological buffer and the creation of bio-diversity zones, including distinct and varied areas of water, wetlands, meadows, and forests (Fig. 1). Mixed forests, mainly composed of *Koelreuteria paniculata*, *Populus tomentosa* and *Pinus tabuliformis*, and 158 plant families commonly used and suitable for the local conditions of Beijing were chosen and planted (Hu, Wu, & Lu, 2006).

Beijing has a typical temperate, semi-humid, monsoonal, and continental climate. Bounded by the Taihang and Yanshan Mountains in the northwest and the alluvial plains of the Chaobai and Yongding Rivers in the south, Beijing covers a total area of 1.68 million km^2 and