Urban Forestry & Urban Greening 13 (2014) 272–284

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Contributions of landscape trees in public housing estates to urban biodiversity in Hong Kong

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ARTICLE INFO

Keywords:
Floristic diversity
Public housing estate
Species composition
Species selection strategy
Tree conservation
Urban biodiversity

ABSTRACT

Public housing estates (PHEs) in Hong Kong, accommodating 3.3 million of the 7-million population, have generous landscape planting in their grounds. The independent tree management regime generates a tree stock that deviates from the general urban-tree population. This study evaluated species composition, floristic diversity, importance value, and spatial distribution of trees in 102 PHEs (half of the total) occupying 8.31 km^2 (territory land area of 1104 km^2), assessed their contribution to urban biodiversity, and developed a species selection strategy to enrich urban biodiversity. 48,823 trees belonged to 232 species, 151 genera and 59 families. Natives contributed 69 species and 10,837 trees. Species profile was skewed toward exotic species and trees. The species were divided into six frequency groups. The signature group had 45 species each with >200 trees. The dominant, common and occasional groups had 20, 26 and 48 species, respectively. 59 species in the rare group and 34 in the solitary group denoted changing and diverse species selections, respectively. Nonmetric Multidimensional Scaling (NMDS) found that species distribution in PHEs was strongly associated with species diversity, estate area and estate age. However, district and region were not correlated with NMDS. Some 98 species were significantly correlated (Spearman) with one or both NMDS axes. Species groups were analyzed to inform a species selection strategy to improve future planting program and enrich urban biodiversity. The methods and findings could be applied to south-China and other cities to rationalize urban-forest programs with the help of objective research data.

Introduction

The maintenance of global biodiversity is identified as one of the most important goals of humankind by the Convention on Biological Diversity (CBD). Land-use change is the main driver of biodiversity loss at the local, regional and global scales, in which urbanization has played a key role (Czech et al., 2000; Tratalos et al., 2007; Müller and Werner, 2010). Sustainable urban development, including management and design to foster urban biodiversity, contributes crucially to the future of global biodiversity (Ignatieva, 2010). Most municipal authorities of developed and developing countries are earnestly enhancing urban greening to realize an ongoing city-level Biodiversity Strategy and Action Plan (BSAP) pledged under the CBD. Urban forestry is widely regarded as an integral component of urban green infrastructure. The quantity, quality and distribution of urban trees echo urban-development history and associated ecological changes (Jim, 2004; Jim and Zhang, 2013). Transcending diverse cultures, times and spaces, trees have been assiduously cultivated for their multiple benefits and functions (Dwyer et al., 1992; Konijnendijk, 2008). Urban trees have been adopted as the principal surrogate and icon of city-level biodiversity. In recent decades, urban greenery has been widely integrated into sustainable urban biodiversity initiatives (Dwyer et al., 1992; Kuo and Sullivan, 2001; Fang and Ling, 2005; Konijnendijk et al., 2006; Pickett et al., 2011; Gaffin et al., 2012; Jones et al., 2012).

An intricate interplay between inheritance and enrichment reflects the dynamics of floristic composition in cities (McBride and Jacobs, 1986). Some cities could bequeath trees from pre-urbanization vegetation, whereas others without natural inheritance have consciously planted them through public and private efforts (McPherson and Luttinger, 1998). Cultural factors such as geographical location, plantable area, site design, population size and density, urban development mode, citizen preferences, and urban forestry management systems, are key determinants of urban-tree species composition (Sanders, 1984; Jim and Liu, 2001; Jim, 2002, 2004). Natural factors including climate, soil and topography in conjunction with the urban planning and development regime define the envelope of plantable species (Sanders, 1984; Nowak et al., 1996). As humans are a main driver of the urban landscape and vegetation management can significantly influence urban biodiversity, the decisions and actions of the urban

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http://dx.doi.org/10.1016/j.ufug.2013.12.009

administration in tandem with residents are critical to sustaining biodiversity (Mörtberg et al., 2007). Species selection by managers for public areas and preference of property-owners of private lots have jointly contributed to urban-tree composition and diversity. Other aspects of urban forestry management, such as silvicultural or arboricultural techniques, nursery supply, administrative and legislative systems, and interaction with people, play additional roles in species screening and urban forest constitution.

Within a city, trees exist in a wide range of artificial and remnant-natural habitats (McBride and Froehlich, 1984; Welch, 1994). To provide accurate scientific information on urban trees and their growth environment, tree surveys have been widely conducted by urban foresters and arborists (Lewington and Parker, 1999; Browne, 2001; Jim, 2008a). The survey data could assess tree-habitat relationship and provide the basis to improve urban-forest management (Tate, 1985; Jim, 2008b). The composition and diversity of urban trees have been studied in different habitats, for example public trees at roadside (Chacalo et al., 1994; Poracsky and Scott, 1999; Frank et al., 2006; Sreetheran et al., 2011), heritage trees and landscape trees at public parks, gardens and greenspaces, government, institutional and community lots (Cheng et al., 2000; Jim and Liu, 2001; Banks and Brack, 2003; Jim, 2005; Jim and Chen, 2009; Jim and Zhang, 2013), residential trees at private gardens and grounds (Jim, 1995), and stonewall trees at embedded remnant natural enclaves (Jim, 1998, 2010; Jim and Chen, 2010, 2011).

Urban housing provision often ranges from private to quasi-public and public with government subsidies. Many countries have a significant amount of public housing, which represents the major housing policies of their governments, such as Singapore, Mainland China, Germany, United Kingdom, United States and Australia. Such affordable housing programs, differ significantly across and within economies around the world (Priemus, 2000; Leung et al., 2012). With a notable proportion of residents living in such subsidized housing, the environmental quality including green space provision in the grounds of the estates could influence the physical and mental health of many people. The associated sites also play a role in enhancing nature-in-city, urban ecology and ecosystem services, and contribute to climate-proofing of cities in the face of global warming.

In Hong Kong, this sector is predominant, accommodating 46.2% of the 7.0 million population, in which 29.1% are rental units and 17.1% subsidized home ownership (Census and Statistics Department, 2012). Public housing in Hong Kong was initiated in 1953, when a fire destroyed thousands of shanty homes leading to 50,000 homeless people (Smart, 2006), triggering a make-shift and subsequently a formalized massive public housing program. Large-scale public housing estates (PHEs) were initially built in the inner city, and since the 1970s they have spread with the New Town Program to previous rural areas. Mainly built by the rather autonomous Hong Kong Housing Authority (HKHA), they are found in every district except old Wan Chai. At present, the 206 PHEs include 1400 high-rise blocks and 1.15 million flats, making the government one of the largest urban-housing landlords in the world in terms of housing units, residents, land area, real-estate value, and urban-tree stock (Hong Kong Housing Authority, 2012).

Based on comprehensive planning, the PHE provides sizeable open spaces at ground level which are generously planted with trees and other ornamental vegetation. They present a pleasant outdoor environment, often better than the more expensive private housing developments. The vegetation in PHE furnishes a sizeable proportion of the city's easily accessible and enjoyable greenery stock, and contributes notably to quality of environment and life for 3.3 million residents as well as companion urban wildlife. Few studies have been conducted on the constituent trees planted and maintained under a different regime that is separated from public trees. In Hong Kong, open spaces and associated greeneries have been accorded a low priority within an inherently limited land resource base. Outside private lots, formal urban amenity spaces in total occupy merely 1.5% of the land area (Planning Department, 2013). Trees in Hong Kong's PHE, by virtue of decades of development, quantity and quality, denote a varied and valuable semi-natural endowment. They embody the resultants of different decisions and actions at different periods by different people, and subsequent modifications or enrichments by different generations of estate managers. They present a fertile realm for detailed investigations of intrinsic and extrinsic values. The principal objectives of this study are to: (1) elucidate species composition and diversity of landscape trees in PHE in urban Hong Kong and their contributions to urban biodiversity; (2) interpret the underlying determinants of the observed diversity and pattern; and (3) develop a species selection strategy in the context of urban biodiversity enhancement.

Study area and methods

Study area

Hong Kong is located at China's south coast and includes a mainland part (Kowloon and the New Territories), Hong Kong Island, and over 100 small islands. Mainly due to rugged topography, built-up areas occupy merely 22% of the territory (1104 km^2) (Census and Statistics Department, 2012; Planning Department, 2012), which supports a 7-million population. The humid-subtropical climate has a hot-wet summer (May–August) and a cool-dry winter (November–February), dominated by the seasonally contrasting Asian Monsoon system (Lam, 2011). The mean annual temperature attains 23.3 °C and annual rainfall 2398 mm (1981–2011), with over 80% falling in May to September (Hong Kong Observatory, 2013).

The HKHA offered a research grant to conduct a detailed survey of trees in 102 rental PHEs. The study was implemented in two stages, respectively from 2007 and 2009, and completed in 2012. About half of the PHEs was included. They were distributed in all three regions (i.e. Hong Kong Island, Kowloon, and New Territories) and 16 of the 18 districts, covering both old city core and new towns (Table 1 and Fig. 1). Five estates are older than 50 years (EC1, EC16, EC28, EC47 and EC92); 54 estates are 30–50 years; and 24 and 19 estates are in the 20–30 and 10–20 years brackets (Table 1).

Field assessment of floristic composition

For this study, a 'tree' is a woody plant with trunk diameter ≥95 mm at 1.3 m above the ground level. The survey covered all trees planted in the level sites of the target estates, plus some trees on slopes if they could satisfy three criteria: (1) very good amenity value such as very good tree form or rare species; (2) average distance between adjacent trees was >2.5 m; and (3) situated within the PHE boundary.

The species, location, site conditions and tree dimensions of sampled trees were evaluated in field surveys. For multiple-stemmed trees, the aggregate DBH was calculated by the square root of the sum of squared DBH of individual stems (USDA, 2013). A laser hypsometer (Measurement Devices Limited, York, UK) measured tree dimensions. Tree species identification and nomenclature followed Hong Kong Herbarium (2012) and Hong Kong Herbarium and South China Botanical Garden (2007, 2008, 2009, 2011).

Data and statistical analysis

The data were evaluated for diversity, evenness, and similarity. The diversity index of the species in each public housing estate was calculated from Margalef (1958) species richness as