



Research Paper

Spatial differentiation of heritage trees in the rapidly-urbanizing city of Shenzhen, China

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ABSTRACT

In China, heritage trees are actively surveyed and reported. Over 300 relevant published articles were reviewed to assess the contents, trends and geographical distributions of the investigations. The majority of the heritage trees studies in China were found in the eastern provinces and published within 2010–2014. Most studies reported surveys on all old trees. For studies focused on single species, Ginkgo (*Ginkgo biloba*) and Chinese Yew (*Taxus chinensis*) was most frequently reported. Unlike the champion tree registry in the US and other countries, the tree registry in China emphasized more on the tree age than the size. We then have studied the heritage trees in the rapidly-developed municipality of Shenzhen in South China in details. The species composition, diversity and spatial distribution were investigated using ecological indices and statistical techniques. Most trees were native with domination by *Ficus microcarpa*. Heritage-tree density was not correlated with land area, population density, green cover, or district development year. The oldest and youngest districts have relatively higher species diversity and tree density. It indicated the preservation of an old town plan and the creation of a new town plan conducive to accommodating pre-urbanization heritage trees. Village and forest habitats with rich tree endowments can be targeted for conservation in new urban areas. The importance of adopting a nature-friendly town plan, and the associated policies that can facilitate it, are instrumental in heritage-tree nurturing and protection. The findings can inform tree preservation and urban green infrastructure provision in fast-developing cities in China and beyond.

1. Introduction

Trees that have lived for a long time or are associated with culture are often highly valued in different societies. As the pride of local communities, they are commonly included in tourist guides. However, systematic surveys and records began only several decades ago. The assessment criteria and recording format of the tree registry differ notably around the world (Jim, 2017). North America and the UK emphasize tree size, whereas tree age is the key consideration in China. Many places adopt multiple criteria which are discussed in Section 1.1.

1.1. Examples of heritage trees register

In the US, for example, Maryland initiated the first official state registry in 1924 and the first National Big Tree Contest was held in 1940 (Gangloff, 1990; Maloof & Lindblom, 2008). The Big Tree Register 'was initiated to recognize and protect the spectacular specimens...and yet,

serves to promote the values of all trees everywhere by focusing on those large, rare specimens that capture people's imagination' (Gangloff, 1990). Individual trees were ranked by their scores that based on tree height, crown spread and trunk circumference (Culbert & Ward, 1997; Gangloff, 1990). *Champion Trees* scored the highest points amongst members of its species, and while *Challengers* would become the new champion when the current one died or declined (Culbert & Ward, 1997). The champions are categorized into a hierarchy: *national*, *state* and sometimes also *country*. Champion-tree registries are usually kept by conservation bodies or forestry services in some European countries and the US (Orłowski & Nowak, 2007). In 2015, over 750 trees were documented in the annual American Forests Champion Trees national register (American Forests, 2016).

In Canada and the UK, champion trees are similarly recorded by scores reckoned by size: height, trunk circumference, and crown spread. Established in 1986, the registry of big trees in British Columbia, Canada is now being managed by the Faculty of Forestry at the

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University of British Columbia. Currently, 43 champion tree records have been disseminated to the public (Faculty of Forestry, UBC, 2016). While in the UK, the Forestry Commission established the Tree Register of the British Isles, also known as the Tree Register of Britain and Ireland in 1995 (The Tree Register, 2013). It comprises > 200,000 trees in its database (Johnson, 2015).

The criteria for the Champion Trees Register in South Africa included biological attributes (diameter, height and crown spread), age of tree and heritage significance. With nominations by the public and the Department of Agriculture, Forestry and Fisheries (2017), 75 Champion Trees were registered in 2013. The 81.5 m *Eucalyptus saligna* was found as the tallest in Africa, known as one of the three Magoebaskloof Giants.

The concept of ‘Trees of Public Interest’ (TPI) (Árvores de Interesse Público) in Portugal was defined by law, and applied to forest stands, trees in gardens, isolated specimens, etc. They were identified by their species representativeness, rarity, size, age, historical, cultural and landscaping significance and public interest. The designated trees are protected by careful conservation measures. The first TPI was recognized in 1939. At present, about 550 TPI have been included (Lourenço, 2015).

In Australia, the National Trusts of Australia (Victoria) established a national register of significant trees in 1981 (Moore & Hughes, 2014). Trees with scientific, social, historic or aesthetic values can be nominated by the public, and assessed by the Significant Tree Committees. It holds the records of 2500 significant trees (National Trusts of Australia, 2013).

In Hong Kong, champion trees were evaluated on age, dimensions, tree form, health, and special features such as species rarity, ecological importance, landscape contribution, or association with notable historical or personnel events (Jim, 1994a, 1994b). A formulaic expert method, using residential property price as a basis, was developed to accord realistic and community-relevant monetary value to champion trees (Jim, 2006). In 2004, the Hong Kong government launched a Register of Old and Valuable Trees in urban areas and rural tourist spots, and confined the scope to public lands. About 500 trees satisfied one or more of the following criteria: (1) large size, (2) notable species, (3) aged 100 years or above, (4) cultural, historical or memorable significance, and (5) outstanding form (Leisure and Cultural Services Department, HKSAR Government, 2013).

In Bangkok, Thailand, nomination of the large trees with heritage value started with a ‘tree competition’ in 1999. In 2001, the Silviculture Department at Kasetsart University recognized 261 trees with notable DBH, tree height and species (Thaiutsa, Puangchit, Kjelgren, & Arunpraparut, 2008).

In China, old trees (*gushu* in Chinese) connote the meanings of old, ancient, heritage and historic trees, together with the famous trees (*mingmu* in Chinese) are included in the registry. It was guided by ‘Technical Guidelines for Document Establishment of General Survey of National Ancient – Famous Trees’ announced by the National Afforestation Commission. The old trees are classified into three types according to age: (1) grade one: > 500 years; (2) grade 2: 300–499 years and (3) grade 3: 100–299 years. The tree reports written in Chinese have been uploaded on the website: www.chinagreen.gov.cn managed by the National Afforestation Commission. The tree surveys were completed by different parties in provinces, counties and cities. The surveys are still on-going in remaining places, and no national list has been compiled.

The age threshold for ‘heritage trees’ differs notably by geographical areas. For example, in Colombia, ‘patrimonial tree’ (árboles patrimoniales) defines trees with environmental, landscape, historical or cultural significance that are at least 60 years old. Under these criteria, 19 trees were declared as ‘patrimonial tree’ in Bogota in 2004 (Cortés & Rodríguez, 2017).

The literature review indicates that the definitions, selection criteria and terminology for ‘heritage’, ‘notable’ or ‘champions’ trees are different. Their uniqueness mainly arises from special meaning to the

society or ecology.

1.2. Major studies of heritage trees

A community with a rich endowment of champion trees echoes local biodiversity and nature conservation. In some places, the prized trees receive much attention and written documentation. For example, 33 articles with descriptions, illustrations and locations of Michigan’s champion trees were published in *The Michigan Botanist* between 1992 and 2003 (Ehrle, 2003). The Big Tree Registry in Wicomico County, Maryland, were kept updated by adding new State Champion trees (Maloolf & Lindblom, 2008). Florida contributed 840 (20%) champions or co-champions in the US National Register of Big Trees. Over 1000 big trees qualified as valid nominations (Culbert & Ward, 1997).

The tree registries encourage the identification and accurate measurement of tree dimensions and age. Sophisticated techniques, including remote sensing, have been employed for tree assessment. Witcher and Griffith (2011) measured tree canopy height and density by Light Detection and Ranging (LIDAR) imagery and identified a Tropical Chestnut (*Pterygota alata*) as a Florida champion tree. The Eastern Native Tree Society provided improved protocols for measuring champion-sized trees after finding some under-measurements in the champion tree register (Blozan, 2006). Patrut, Karl, Mayne, Lowy, and Patrut (2013) investigated wood samples from a Baobab (*Adansonia digitata*) tree by Accelerator Mass Spectrometry (AMS) radiocarbon dating. The oldest tree in South Africa, found to be 1835 ± 40 years after calibration, was confirmed as the oldest specimen.

The community’s understanding of large and old trees has been investigated. Barro, Gobster, Schroeder, and Bartram (1997) conducted a qualitative analysis on the nomination forms of the big tree program in the Chicago area. The notes and letters attached to the nomination forms indicated that the big trees were far more than physical size, as they were closely linked with functional and aesthetic meanings, as well as emotional and symbolic values.

Economic valuation of champion trees can provide a new perspective and dimension to the community’s appreciation of nature’s ambassadors. Jim (2006) developed an in-depth evaluation of old trees in Hong Kong. He identified 6 primary criteria with 45 secondary criteria to assess the individual trees and converted the numerical scores into monetary values. The most outstanding champion trees were reckoned to value over HK\$4M (HK\$1 = US\$0.13). Cortés and Rodríguez (2017) also calculated the Monetary Environmental Value of 19 heritage trees known as patrimonial trees in Bogota by exceptionality and cultural value, value of soils, and the cost for the maintenance. They estimated that the 19 trees could provide 1,704,487.46 Peso (about US\$588) worth of ecosystem services.

Champion trees in human settlements could be subjected to different stresses. External influences are the major causes for tree mortality rather than aging (Brutovská, Sámelová, Dušička, & Mičieta, 2013). Environmental condition, which tends to vary notably by land use and habitat type, is a key determinant of tree performance.

Many studies of heritage trees in Asia focused in compact cities such as Guangzhou (Jim, 2004), Bangkok (Thaiutsa et al., 2008) and Hong Kong (Jim & Zhang, 2013). The old, heritage or valuable trees are concentrated in temple grounds, roadsides and urban parks with different modes of urban development and fabric. A study in Poland examined champion trees in rural areas, in which *manor parks* had the highest mean density (7 trees per ha) and *rural settlements* the lowest (0.03 trees per ha) (Orłowski & Nowak, 2007). The size and age of Hemlock tree distributions in the Great Smoky Mountains National Park were evaluated. The national champion trees and the oldest trees were located in poorly accessible sites with reference to timber loggers (Johnson, Hain, Johnson, & Hastings, 1999). Jones (1997) studied 91 big trees (29 with state champion size) in the old-growth forests in Congaree Swamp National Monument, South Carolina. They found that the topographic positions of the trees were species-specific, with biggest

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