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Research Paper

Analysis of factors affecting urban park service area in Beijing: Perspectives from multi-source geographic data

Sihui Guo[a,b], Gege Yang[a,b], Tao Pei[a,b,c,*], Ting Ma[a,b], Ci Song[a,b], Hua Shu[a,b], Yunyan Du[a,b], Chenghu Zhou[a,b]

[a] State Key Laboratory of Resources and Environmental Information System, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, 100101, China
[b] University of Chinese Academy of Sciences, Beijing 100049, China
[c] Jiangsu Center for Collaborative Innovation in Geographical Information Resource Development and Application, Nanjing 210023, China

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ABSTRACT

The rapid process of urbanization aggravates the imbalance between the supply and demand of urban public services. Urban parks are among the most important urban public services, and their use efficiency has been an important index for urban planning. Therefore, it is essential to estimate well their service area and influencing factors. Traditional survey data used to analyze the characteristics of urban park services are limited by small samples and high cost. Owing to thriving information communication technologies, vast amounts of human activity data have become available that enable understanding of human travel behavior. In this study, we analyzed a park service area, which is defined as the zone of influence of individual parks, in Beijing, and the factors that influence the service area. First, the service area was estimated using 1-SDE based on mobile phone signaling data. A multiple linear regression model was then used to analyze the influence of factors on the park service area. The results show that (1) external factors including population density, the number of commercial facilities, and traffic convenience have significant influences on the park service area; (2) employment places positively influence the park service area on the weekday; and (3) other factors such as park design and park reputation had inconsistent effects on the park service area, in either sign or significance, regarding the weekday and the weekend. The findings of this study will be of practical value when designing parks or undertaking city planning in the future.

1. Introduction

The imbalance between supply and demand for public services is aggregated under the rapidly advancing process of urbanization (Bai, Shi, & Liu, 2014; Shah & Garg, 2017). To address the imbalance, it is essential to assess the utilization of urban public services (Shah & Garg, 2017). Urban parks are one of the critical urban public services, and their environmental, social and economic values have gained much attention (Bedimorung, Mowen, & Cohen, 2005; Chiesura, 2004; Wolch, Byrne, & Newell, 2014). Because serving the public is the major objective of urban parks, whether the provision of parks is efficiently used has become the fundamental concern for both policy makers and urban designers.

To address this question, an increasing amount of research has tried to estimate the service potential of urban parks, and they have striven to reveal the factors that influence the use efficiency of park provisions (Evenson, Jones, Holliday, Cohen, & Mckenzie, 2016; Mccormack, Rock, Toohey, & Hignell, 2010). As utilization frequency and service area most directly reflect park use efficiency, research is mainly focused on these two aspects. Regarding utilization frequency, the times of park visitations were surveyed by self-reports (Kaczynski, Potwarka, & Saelens, 2008; Neuvonen et al., 2007; Schipperijn, Bentsen, Troelsen, Toftager, & Stigsdotter, 2013; Zhang, Yang, Ma, & Huang, 2015) or recorded by observation method (Chow, Mckenzie, & Sit, 2016; Evenson et al., 2016). Through regression methods, both park attributes (such as park size, aesthetics, amenities, maintenance and proximity) and demographic characteristics (such as age, gender, and educational level) were found to be associated with park use (Evenson et al., 2016; Mccormack et al., 2010; Wang, Brown, & Liu, 2015).

However, from the aspect of park service area, which is defined as

* Corresponding author at: 11A, Datun Road, Chaoyang District, Beijing 100101, China.
E-mail addresses: guosh@lreis.ac.cn (S. Guo), yanggg@lreis.ac.cn (G. Yang), peit@lreis.ac.cn (T. Pei), mting@lreis.ac.cn (T. Ma), songc@lreis.ac.cn (C. Song), shuh@lreis.ac.cn (H. Shu), duyy@lreis.ac.cn (Y. Du), zhouch@lreis.ac.cn (C. Zhou).

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the zone of influence of individual parks (Lancaster, 1983), there is no consensus among scholars regarding how to measure them. Previous researchers sought to measure the park service areas based on distance measurement by using Geographical Information System (GIS) analyses (Boone, Buckley, Grove, & Sister, 2009; Oh & Jeong, 2007; Sister, Wolch, & Wilson, 2010). Oh and Jeong (2007) determined the park service areas as the 20 m buffers of pedestrian routes within the network extent. Their results demonstrated differences of park service areas between different pre-defined measurements of distance. In order to avoid the problem of pre-defined distance, Sister et al. (2010) delineated the park service area by Thiessen polygons which were generated around each park. Both of the two methods (buffer areas and Thiessen polygons) delineating the park service area are based on the assumption that citizens were to use the closest park most (Sister et al., 2010). This kind of method was reasonably able to reflect park use for people who favor nearby parks for recreation but failed to capture actual park usage due to the overlook of distant visitors (Wolch et al., 2014). For example, Schipperijn, Stigsdotter, Randrup, and Troelsen (2010) found that almost half of residents did not primarily use the nearest park in their survey. This showed that the park's actual service area may not limited that of nearby residents. Considering the difference between actual distances and modal access distance to the park, an ideal measurement of park service area is needed by involving both the pattern of distribution of visitors and distance instead of simple distance alone (Hendon, 1974). Therefore, in this study, we estimate the park service area by the distribution area of park visitors.

To acquire people's travel behaviors of visitations to parks, traditional data include questionnaire survey data (Kaczynski et al., 2008; Neuvonen et al., 2007; Schipperijn et al., 2013; Zhang et al., 2015) and observation data of Systems for Observing Play and Recreation in Communities (SOPARC) (Chow et al., 2016; Evenson et al., 2016). For questionnaire survey data, they have the advantage of acquiring specific information according to the research goal by questionnaire design, however they also have disadvantages of potential implicit bias (Donahue et al., 2018) and limited sample size (Schipperijn et al., 2013; Sugiyama, Francis, Middleton, Owen, & Giles, 2010; Wang et al., 2015), respectively due to subjective answers and low response rates. For observation data of SOPARC, they are good for statistics on utilization frequency and physical activity preferences of park users, because they contain abundant information about the characteristics of park users such as gender, age grouping and physical activity levels (Chow et al., 2016; Evenson et al., 2016). However, for lack of geographical information, SOPARC data are not suitable for spatial analysis of park users. Considering the pros and cons of traditional data, new sources of data are demanded to map and measure park visitation (Shoval & Ahas, 2016).

Owing to the widespread use of information communication technologies (ICT) such as mobile phones, the daily activities of citizens can be easily captured, and we therefore try to derive the park users and their spatial distribution using mobile phone signaling data. Therefore, taking Beijing City as a case study, we aimed to (1) analyze the characteristics of park service area based on the visitor identification results and (2) explore the relationship between the park attributes and park service area using a multiple linear regression (MLR) model.

The remainder of this paper is organized as follows: Section 2 introduces the methods used in this study. Section 3 shows the results of the characteristics of park service area and how the park service area is influenced by park attributes. Section 4 conducts the discussions on the results. Section 5 presents our conclusions.

2. Methods

To explore the relationship between the influencing factors related to park attributes and park service area, a multiple linear regression (MLR) was used in this study. To quantify park service area (dependent variable) and the influencing factors (independent variables) in the regression model, multi-source geographic data were used, including mobile phone signaling data, urban infrastructure data and volunteered comments data. In this section, we describe the study area and introduce the multi-source data. Then we introduce the delineation of park service areas and calculation of influencing factors. Last, we show the MLR model developed in this study.

2.1. Study area

Beijing is the capital city of China. The territory of Beijing is located between longitudes 115.25 °E and 117.30 °E and latitudes 39.28 °N and 41.25 °N. According to the Beijing Municipal Bureau of Statistics, at the end of 2015, the city contained 16 administrative regions, the total administrative division area was 16,410 km^2, and the permanent population was 21.705 million. With the rapid urbanization in Beijing, a growing imbalance between supply and demand of public services existed in this city (Song et al., 2014; Song, Pijanowski, & Tayyebi, 2015). To improve the situation, the Beijing government undertook efforts to optimize spatial structure such as encouraging the construction of urban parks (Li, Wang, Paulussen, & Liu, 2005).

Considering the statistics on urban parks provided by the Capital Greening Office, a total of 403 parks had been registered with the municipal governments by 2015. Based on the main functions undertaken by the park (Tao, Chen, Zhang, & Bai, 2013) and the classification standards of Beijing parks (Standard for Classification of Urban Green Space, CJJ/T85-2002), these parks are divided into six categories (Table 1) including comprehensive parks, community parks, historical parks, cultural theme parks, forest parks and country parks. We choose parks which are (1) open to the public; (2) with a certain size (larger than 1 ha); and (3) locating inside the urban area (here within the sixth ring). On this basis, 48 parks are selected for further analysis. These parks vary in type, size and management which represent diverse

Table 1
The classification standards of Beijing parks based on the park's main functions.

Types of parks	Features of functions	Minimum size	Suitable size
Comprehensive parks	Fully equipped with recreation facilities and developed infrastructure; used for activities such as sightseeing, resting, research, recreation and sports; provide multiple services for most visitors; include municipal comprehensive parks and regional comprehensive parks	≥ 5 ha	≥ 10 ha
Community parks	Mainly for residents living in certain residential areas, focusing on children's amusement and the elderly's recreational activities such as rest, sports and recreation	≥ 0.5 ha	≥ 1 ha
Historical parks	Be of profound historical significance and cultural value; have influence in urban change or cultural and artistic development during a certain historical period or in a certain region of Beijing; be able to embody the traditional gardening skill and have been included in the historical park list	/	/
Cultural theme parks	Featured for special theme or culture, include theme parks, botanical parks, zoos and amusement parks	/	/
Forest parks	Featured for original ecology or natural environment with little human disturbance; mainly satisfy the needs of being close to nature for citizens; also function as ecological education places	≥ 20 ha	≥ 50 ha
Country parks	Refer to the country forest belt far away from the center of the city; provide a good place for the general public to return and enjoy the vast nature and play of the nature	/	/