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Environmental inequities in terms of different types of urban greenery in Hartford, Connecticut

Xiaojiang Li[a,*], Chuanrong Zhang[a], Weidong Li[a], Yulia A. Kuzovkina[b]

[a] Department of Geography, University of Connecticut, Storrs, CT, 06269, USA
[b] Department of Plant Science, University of Connecticut, 1376 Storrs Rd., U-4067, Storrs, CT, 06269, USA

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ABSTRACT

Urban greenery has long been recognized as an important component of urban ecosystem and provides many benefits to urban residents. However, different types of urban greenery provide different kinds of natural experiences to people. In this study, green metrics calculated based on multisource spatial datasets were used to quantify the spatial distribution of different types of urban greenery in Hartford, Connecticut. Geo-tagged Google Street View images, which capture the profile view of cityscape, were used to quantify street greenery by considering the time information. Land cover map and urban parks map were used to measure residential yard greenery and proximity to urban parks, respectively. We analyzed the associations of the calculated green metrics with socio-economic variables derived from census data. Statistical results show that: (1) people with higher income tend to live in neighborhoods with more street greenery; (2) census block groups with a higher proportion of owner-occupied units tend to have more yard vegetation and yard tree/shrub coverage; (3) Hispanics tend to live in block groups that have less yard vegetation but African Americans mostly live in block groups with more yard greenery; and (4) there are no significant environmental disparities among racial/ethnic groups in terms of proximity to urban parks. In general, this study provides an insight into the environments of urban residents in terms of urban greenery, and a valuable reference data for urban planning.

1. Introduction

Urban greenery, which includes urban parks, woodland, street and square trees, lawns and other kinds of vegetation (Konijnendijk et al., 2006), has long been recognized for its importance in the urban environment (Li et al., 2015a). Urban greenery provides many economic, environmental, social, and health benefits to residents (Chen et al., 2006; Jim and Chen, 2008; Onishi et al., 2010; Gidlow et al., 2012; van Dillen et al., 2012; Wendel et al., 2011). The spatial distribution of urban greenery is thus regarded as an important environmental amenity (Nichol and Wong, 2005; Dwivedi et al., 2009; Seymour et al., 2010).

Previous studies have reported environmental inequities in terms of urban greenery in North American cities (Heynen et al., 2006; Boone et al., 2009; Zhou and Kim, 2013; Dai, 2011; Pham et al., 2012; Landry and Chakraborty, 2009; Li et al., 2015b). Heynen et al. (2006) found that the degree of canopy coverage varies among the neighborhoods of different racial/ethnic groups in Milwaukee, Wisconsin. Compared with non-Hispanic Whites, Hispanics tend to live in places with less canopy coverage. Boone et al. (2009) investigated the residents' proximity to urban parks in Baltimore, Maryland, and found that Whites have access to a larger acreage of parks than other residents, but a higher proportion of African American residents have access to parks within walking distance. Zhou and Kim (2013) developed an accessibility index based on Google Maps application programming interface to evaluate the disparities in canopy cover and accessibility to parks in six cities in Illinois. Their results showed no significant disparities in terms of access to parks, but racial/ethnic minorities tend to have less tree canopy cover in their neighborhoods. Li et al. (2015b) developed a novel Google Street View–based method to study the distribution of street greenery in Hartford, Connecticut. Unlike green metrics derived from remotely sensed data, the Google Street View–based method quantifies how much street greenery people can see and feel on the ground. Their results showed that people with higher incomes tend to live in neighborhoods with more street greenery (Li et al., 2015b).

Different types of urban greenery play various roles in providing benefits to urban residents. Therefore, it may not be suitable to use the overall green vegetation cover numbers to represent the distribution of the environmental amenities. In addition, different types of greenery are maintained and managed in very different ways,

* Corresponding author.
E-mail address: lixiaojiang.gis@gmail.com (X. Li).

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which may influence the spatial distribution of urban greenery. For example, street greenery and urban parks are publicly financed and managed. They provide benefits to the public. However, the vegetation in a private yard provides more benefits to the property owner than to others and it is maintained by the private property owner. Therefore, different types of urban greenery should be considered differently in studying the environmental inequities. However, a few studies have explored the uneven distribution of different types of urban greenery (Heynen et al., 2006; Pham et al., 2012; Shanahan et al., 2014). In this study, we categorized the greenery of Hartford, Connecticut, into four major types: street greenery, private yard total vegetation, private yard trees/shrubs, and urban parks. Four green metrics were calculated based on the Google Street View images, the land cover map, and the urban park map to indicate the spatial distribution of street greenery, yard total vegetation, yard trees/shrubs, and proximity to urban parks. Statistical analyses were then conducted to investigate the associations between those green metrics and urban residents' socio-economic status.

2. Literature review

2.1. Benefits of different types of urban greenery

Different types of urban greenery provide different kinds of natural experiences to human being (Shanahan et al., 2014). Private yard vegetation is usually managed by private owners and it is immediately accessible for private owners (Lachowycz and Jones, 2012; Li et al., 2014). The urban greenery in public parkland and Right-of-Way are maintained in very different ways compared with private backyard vegetation, and this may further influence people's nature experiences (Shanahan et al., 2014). View of greenery through windows is helpful in increasing restorative potentials and improving psychological wellbeing (Ulrich, 1984; Pazhouhanfar and Kamal, 2014; Kaplan, 2001). Residential tree canopy cover reduces cooling energy use in summer (Akbari et al., 2001). As a kind of public facilities, urban parks are also important for the quality of life in densely populated cities. Urban parks provide public places for recreations, physical exercises, interactions with nature, and social activities that can promote both personal health and social cohesion within communities (Zhou and Kim, 2013; Maas et al., 2006; Ellaway et al., 2005; Dai, 2011; Wolch et al., 2011). Street greenery on the public Right-of-Way makes an important contribution to the attractiveness and walkability of residential streets (Schroeder and Cannon, 1983; Wolf, 2005; Bain et al., 2012; Lachowycz and Jones, 2012). Street greenery also provides a range of health benefits by promoting outdoor exercises (Wolch et al., 2005; Takano et al., 2002) and beautifying neighborhoods while mitigating the visual intrusion of traffics (Li et al., 2015a). Planting street trees may provide more benefits to urban residents than planting trees in parks and private yards (Kardan et al., 2015).

2.2. Green metrics for urban greenery

There are many developed green metrics for different types of urban greenery in literature of environmental inequity studies. Vegetation/canopy coverage and the visiting distance to a green space are the two most widely used indices to quantify the spatial distribution of urban greenery.

Vegetation/canopy coverage, which literally represents the percentage of land covered by vegetation or canopy, has been widely used to study the yard vegetation (Pham et al., 2012; Shanahan et al., 2014; Troy et al., 2007; Grove et al., 2006). Remotely sensed data is the major data source for vegetation/canopy cover mapping. By overlapping vegetation/canopy cover maps with GIS boundary layers (parcels or blocks), the vegetation/canopy coverage can be then calculated and aggregated at different geographic units and compared with census data. There are a few studies about environmental inequities in terms of street greenery (Landry and Chakraborty, 2009; Li et al., 2015b). The spatial distribution of street greenery can be indicated by canopy cover. Landry and Chakraborty (2009) studied the street tree coverage on public Right-of-Ways based on a land cover map derived from high-resolution remotely sensed imagery. While high-resolution remotely sensed imagery provides a good data source for delineating green spaces at a fine level, it may not be very suitable for measuring the street greenery. The aesthetic benefits provided by street greenery can be greatly influenced by the amount of greenery that people can see or feel on the ground (Li et al., 2015a). In fact, there is little agreement between remote sensing based green metrics and human perceived greenness (Leslie et al., 2010). Recently, Li et al. (2015a) developed a novel Google Street View–based method to study the distribution of street greenery. Unlike green metrics derived from remotely sensed data, the Google Street View–based method quantifies how much street greenery people can see or feel on the ground, which could better represent the distribution of street greenery. However, the time information of the Google Street View images was not considered in their study.

Several methods have been developed for measuring people's proximity to urban parks (Dai, 2011; Zhou and Kim, 2013; Maroko et al., 2009; Boone et al., 2009; Wolch et al., 2005). The visiting distance method is one of the most widely used methods to measure human proximity to urban parks (Boone et al., 2009; Zhou and Kim, 2013). The visiting distance can be defined as walk distance (Zhou and Kim, 2013; Leslie et al., 2010; Wolch et al., 2005), travel distance by roads or other networks (Dai, 2011), or Euclidean distance (Kessel et al., 2009). In literature, the centroids of geographic units or randomly created points within those units were usually used to represent the points of origin (Kessel et al., 2009; Zhou and Kim, 2013). However, it is difficult to define the destination points, because parks often have multiple entry points or destinations (Boone et al., 2009). For a small park, it is reasonable to use the centroid of the park to indicate the destination point; however, for a large park, this designation will be less accurate, because any point along the boundary can serve as the destination (Boone et al., 2009). It seems using buffer analysis of the urban parks is a simple and efficient way to measure accessibility of parks at different geographic units (Boone et al., 2009; Wolch et al., 2005). By overlapping buffer zones of urban parks with census data, different metrics can be defined to indicate accessibility to urban parks (Wolch et al., 2005; Boone et al., 2009).

3. Study area and data sources

Hartford is the capital city of Connecticut, USA (Fig. 1), with a population of approximate 125,000. The Hispanics and African Americans are the two largest racial/ethnic groups in the city, which account for 43% and 38% of the total population, respectively. Recent satellite imagery–based analysis showed that more than 2870 acres of the city are covered by tree canopy, representing 26% of all lands in the city. A previous study reported the environmental inequity in terms of street greenery in Hartford, CT (Li et al., 2015b). Recently, Hartford began to implement the U.S. Environmental Protection Agency's (EPA) Greening America's Capitals program, which incorporates innovative green building and green infrastructure strategies to develop more environmental friendly neighborhoods.

Block group is the smallest area unit defined by the US Census Bureau in Hartford, therefore, block group was used as the geographic unit for measuring the spatial distribution of neighborhood greenery in this study. Among the 96 block groups in Hartford, nine