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Social disparities in tree canopy and park accessibility: A case study of six cities in Illinois using GIS and remote sensing

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ABSTRACT

Easy access to green space and the presence of lush tree canopy in neighborhoods provide substantial psychophysical benefits to residents. However, these urban amenities are often unevenly distributed between white and racial/ethnic minority residents. In this study, we investigated racial/ethnic disparities in access to parks and tree canopy using a geographic information system (GIS) and remote-sensing techniques in six Illinois cities. An accessibility index based on a new Google Maps application programming interface (API) was used to calculate walking distances between points of origins and parks, and integrated classification techniques were applied to calculate the amount of tree canopy. Kernel-smoothing function was applied to both canopy and park layers to transform point value to continuous surface value. Both ordinary regression and spatial regression were used to find the relationship.

The results of this study show that racial/ethnic minorities have less tree canopy in their neighborhoods, but it did not find significant differences in terms of access to parks. Spatial regression was determined to be an effective modeling approach for the data used in this study. Methods used in this study can be extended to study accessibility to various destinations using different means of transit, and the results can guide intervention programs to help reduce environmental inequity.

Introduction

Parks in neighborhoods are critical components of the built environment (Zhang et al., 2011). Aside from their important environmental and economic benefits, parks offer a great number of social benefits. They provide opportunities for recreation, exercise, and social activities that can promote health, well-being, and a sense of community. Easy access to urban parks contributes to increased amount of physical activity (Hilisdon et al., 2006; Maroko et al., 2009), which is strongly associated with better physical health. Parks also provide space for revitalization and relaxation, which are conducive to mental well-being (Guite et al., 2006; Velarde et al., 2007). Urban parks also create an environment that facilitates social contact and community attachment (Kearney, 2006; Arnberger and Eder, 2012).

While parks serve as fixed green hubs in the built environment, trees are more "flexible" in that they form green corridors in neighborhoods and along streets, thus providing green space outside the context of parks. Like parks, trees play an important role in the overall living conditions of neighborhoods, providing constant—but sometimes unnoticed—benefits:

- Views of trees tend to reduce mental and physical stress (Parsons et al., 1998; McPherson et al., 2011).
- The presence of street trees is associated with a lower risk of childhood asthma (Lovasi et al., 2008).
- A walkable green environment may increase the longevity of older people (Takano et al., 2002).
- Mental fatigue and aggression can be moderated by having green space nearby (Kuo and Sullivan, 2001).

The presence of trees may also influence people's behaviors; for example, streets with more canopy encourage children to walk to school (Larsen et al., 2009), and the greenways also motivate people to walk and bicycle (Coutts, 2008).

Parks and tree canopy are critical components of the green infrastructure. However, studies on environmental equity have not yet focused adequately on the distribution of these important elements of green infrastructure. Instead, they have focused on the uneven distribution of disamenities, such as pollution sources that disproportionately affect racial/ethnic minorities and economically disadvantaged groups (Landry and Chakraborty, 2009). The presence of parks and tree canopy is an indicator of quality of life in a neighborhood due to the importance of positive externalities

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(Heynen, 2003). The equitable distribution of these green infrastructures is critical but somehow underrepresented in a sustainable urban development. The unbalanced distribution of green space and the structural impediments to reforestation for certain places make an important environmental injustice problem (Perkins et al., 2004). Many studies on environmental justice also looked at the neighborhood disparities in access to food environment, such as the impacts of the uneven distribution of the fast-food on public health (Hilmers et al., 2012). Pedestrian environment for low-income and minority populations is also investigated (Cottrill and Thakuriah, 2010).

Some recent environmental equity studies have focused on desirable features, such as playgrounds and golf courses (Smoyer-Tomic et al., 2004; Wells et al., 2008). The issue of spatial equity in terms of urban park access has been examined in different studies (Boone et al., 2009; Dai, 2011; Lotfi and Koohsari, 2011). However, few empirical studies have investigated the equity issue in the spatial distribution of urban tree canopies (Landry and Chakraborty, 2009).

Prior studies reported disparities in access to parks across neighborhoods of varying socioeconomic status (SES). Gobster (2002) reported that racial/ethnic minorities must travel longer distances than white residents to use green spaces, and another study found few parks in socioeconomically deprived neighborhoods (Wolch et al., 2005). However, some studies do not support the general expectation that socioeconomically deprived areas have less park access (Timperio et al., 2007). Additional studies to investigate this mixed relationship in different geographic locations will provide more insight.

The composition and configuration of urban green space is affected by many social factors at individual and neighborhood levels (Swyngedouw, 1996). Population density is found to be associated with vegetation covers and populated area tends to hold less vegetation (Boone et al., 2010; Nowak et al., 1996). The association between neighborhood average income and vegetation cover rate is also observed in some studies. The self-reinforcing mechanism of the green space is explained in affluent neighborhood. Wealthy neighborhoods usually have better green space, which in turn, attracts more residents with higher income (Boone et al., 2010). Education is suggested to be another factor. Neighborhood with more educated people tends to have green space in better shape (Heynen and Lindsey, 2003). Additionally, legacy effect and group identity are some other important factors that shape neighborhood green space. Legacy effect is the effect that neighborhood characteristics in the past determine the composition and configuration of green space more than current social influences (Boone et al., 2010). In many historical neighborhoods, new residents usually inherit the landscape and pass it on. Group identity is manifested through a set of ways that represent the characteristics of the neighborhoods. At household level, vegetation patterns are also influenced by neighbors because of the mimicry (Anderson, 2001; Boone et al., 2010). Because of the complexity, this study does not look into the cultural or household level influences (group identity and neighbor mimicry etc.), but rather focuses on the association between the racial/ethnic groups and green space distribution at a neighborhood scale adjusting other influences (education, income, population density etc.).

Different methods are used for measuring accessibility to green spaces. One common method for determining park access is the "container approach," which measures the presence or number of parks within a particular aggregated geographic unit (e.g., census tract or neighborhood) (Maroko et al., 2009). However, the problem of the container approach lies in the "edge effect", which misrepresents actual park space exposure of people who reside close to the boundary. Another approach to measure accessibility is to calculate the distance to the nearest green space using either Euclidean distance or distance traveled by roads or other networks (Kessel et al., 2009; Dai, 2011). One flaw associated with these methods is the simplified assumption that the nearest park is the park being visited most, which is not always the case. Another flaw is that network distance is based primarily on driving route. Few studies have calculated the walking distance. In addition, few studies have used sufficiently high-resolution data for analyzing geographically detailed information (i.e., parcel-level land use) (Landry and Chakraborty, 2009). Likewise, not many studies have investigated the link between SES and distribution of tree canopy at a fine geographic scale.

Inspired by these methodological challenges and research gaps, we attempted in our study to answer the research question: Is there spatial inequity in access to urban parks and in distribution of tree canopy for racial/ethnic minorities? We tested two hypotheses: First, racial/ethnic minorities are associated with less accessibility to nearby parks. Second, racial/ethnic minorities have a lower percentage of tree canopies in their neighborhoods.

This study contributes to the research in environmental equity in several ways. First, most equity studies related to green space focus on access to park facilities, but availability and amount of tree canopy are not considered adequately. In our study, we simultaneously consider two important elements in the green infrastructure—park access and tree canopy in terms of location and distribution for racial/ethnic minorities. Second, few studies measured the access to green space based on walking which is arguably the most convenient and common way to interact with nearby environment. In this study, we developed a new approach based on the Google Maps application programming interface (API), which realistically reflects the walking distance from sampling points to nearby parks. We also created an integrated index to address the edge-effect problem. Third, we examined six cities for the credibility and consistency of our results.

We hope our study will offer a better understanding about socioeconomic disparities in access to parks and tree canopy. This knowledge can be used in the critical task of planning urban forests and developing targeted intervention programs to reduce these inequities.

Study area and data

Six mid-sized cities in Illinois—Rockford, Bloomington, Decatur, Urbana-Champaign, Peoria, and Springfield—were selected for this study based on their similarities in population and racial/ethnic diversity (non-white populations of approximately 25–40% in all six cities) (US Census Bureau, 2010) and because they are all located in the midwestern United States (Fig. 1).

- Rockford, in the far northern region of Illinois, is the first most populous city outside the Chicago metropolitan area, with a population of 153,000.
- Bloomington, in the central part of the state, has a population of 77,000.
- Decatur, also in the central part of the state, has a population of 76,000.
- Urbana-Champaign, in east-central Illinois, has a population of 122,300. Although its ethnic/racial population is similar to that of other cities in this study, Urbana-Champaign is a university town and has greater variation in racial/ethnic makeup.
- Peoria, in northwest-central Illinois, has a population of 115,000, and is the largest city along the Illinois River.
- Springfield, in southwest-central Illinois, is the state capital. It has a population of 116,000 and is the second most populous city outside of the Chicago metropolitan area.