Landscape and Urban Planning 181 (2019) 51–79

Contents lists available at ScienceDirect

Landscape and Urban Planning

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

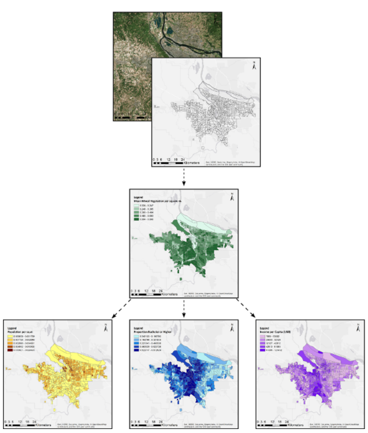
Research Paper

Who has access to urban vegetation? A spatial analysis of distributional green equity in 10 US cities

Lorien Nesbitt[a,*], Michael J. Meitner[a], Cynthia Girling[b], Stephen R.J. Sheppard[a], Yuhao Lu[a]

[a] Department of Forest Resources Management, Faculty of Forestry, University of British Columbia, 2424 Main Mall, Vancouver, BC V6T 1Z4, Canada
[b] School of Architecture and Landscape Architecture, University of British Columbia, 2260 West Mall, Vancouver, BC V6T 1Z4, Canada

GRAPHICAL ABSTRACT



ARTICLE INFO

Keywords:
Urban vegetation
Environmental justice
Green equity
Health
Climate change
Cities

ABSTRACT

This research examines the distributional equity of urban vegetation in 10 US urbanized areas using very high resolution land cover data and census data. Urban vegetation is characterized three ways in the analysis (mixed vegetation, woody vegetation, and public parks), to reflect the variable ecosystem services provided by different types of urban vegetation. Data are analyzed at the block group and census tract levels using Spearman's correlations and spatial autoregressive models. There is a strong positive correlation between urban vegetation and higher education and income across most cities. Negative correlations between racialized minority status and urban vegetation are observed but are weaker and less common in multivariate analyses that include additional variables such as education, income, and population density. Park area is more equitably distributed than mixed and woody vegetation, although inequities exist across all cities and vegetation types. The study finds that education and income are most strongly associated with urban vegetation distribution but that various other factors contribute to patterns of urban vegetation distribution, with specific patterns of inequity varying by local context. These results highlight the importance of different urban vegetation measures and suggest potential solutions to the problem of urban green inequity. Cities can use our results to inform decision making focused on improving environmental justice in urban settings.

* Corresponding author.
E-mail addresses: lorien.nesbitt@ubc.ca (L. Nesbitt), mike.meitner@ubc.ca (M.J. Meitner), cgirling@sala.ubc.ca (C. Girling), stephen.sheppard@ubc.ca (S.R.J. Sheppard).

https://doi.org/10.1016/j.landurbplan.2018.08.007
Received 13 February 2018; Received in revised form 18 June 2018; Accepted 10 August 2018

1. Introduction

The majority of the world's population lives in urbanized areas and urban populations continue to grow (United Nations, 2015). In North America, urbanization is particularly widespread, especially in Canada and the United States (US), where approximately 80% of the population lives in urban environments (McPhearson, Auch, & Alberti, 2013). As urbanization continues, urban vegetation, and the services it provides, are playing an increasingly important role in creating liveable urban spaces and helping to maintain the well-being of the majority of North American residents (Hansmann, Hug, & Seeland, 2007; Sanesi, Gallis, & Kasperidus, 2011).

Urban vegetation provides important ecosystem services to urban residents. Mixed urban vegetation can reduce stormwater runoff via infiltration and evapotranspiration (McPherson, Simpson, Xiao, & Wu, 2011), and support a range of urban biodiversity (Goddard, Dougill, & Benton, 2009; Morimoto, 2011), while green views can reduce stress and improve psychological well-being (Kaplan, 2001; Tyrväinen et al., 2014; Ulrich et al., 1991). Woody vegetation, such as urban trees, can reduce the urban heat island effect via shading (Donovan & Butry, 2009; McPherson et al., 1997), improve air quality (Escobedo & Nowak, 2009; Nowak, Crane, & Stevens, 2006), sequester carbon (Nowak & Crane, 2002), and improve property values (Crompton, 2005), and may reduce crime rates (Troy, Grove, & O'Neil-Dunne, 2012). Urban parks offer opportunities for recreation that can improve physical health (Konijnendijk, Annerstedt, Nielsen, & Maruthaveeran, 2013; McCormack, Rock, Toohey, & Hignell, 2010) and increase social cohesion (Gehl, 2010; Kweon, Sullivan, & Wiley, 1998), and are often recreation destinations. As more and more people make cities their home, a case can be made that urban vegetation provides ecosystem services that influence the well-being of the majority of the world's population. In light of this, societies should consider how best to ensure that all urban residents are able to benefit from these ecosystem services.

Unfortunately, despite the clear positive influence of urban vegetation in the lives of urban residents, there is evidence that the distribution of urban vegetation is inequitable in some cities (Landry & Chakraborty, 2009; McConnachie & Shackleton, 2010; Nesbitt & Meitner, 2016; Ogneva-Himmelberger, Pearsall, & Rakshit, 2009). This suggests that the distribution of urban vegetation, and residents' access to it, should be subjected to an equity analysis on a larger scale. This research defines equitable access as fair access to urban vegetation, regardless of differentiating factors such as socioeconomic or racialized status, ethnicity, or age, drawing on theories of environmental justice and political ecology that posit that environmental amenities are inequitably low in low-income and minority communities (Boone, Buckley, Grove, & Sister, 2009; Heynen, 2003; Nesbitt & Meitner, 2016; Schwarz et al., 2015). While truly equal access is impractical, and perhaps undesirable, equitable access implies that those who want to access urban vegetation have the opportunity to do so (Nesbitt, 2017). Thus, if urban vegetation were equitably distributed, we would not expect to find consistent disparities in access to urban vegetation for traditionally disadvantaged groups such as lower socioeconomic groups and racialized minorities (Schwarz et al., 2015). Importantly, equitable access or proximity to urban vegetation helps ensure that urban residents have equitable access to the services that vegetation provides and that are often associated with higher levels of well-being, particularly among disadvantaged and lower socioeconomic groups (Mitchell & Popham, 2008; Sanesi et al., 2011).

While many cities likely experience some form of urban green inequity, research to date has produced variable results among different geographical areas, different cultures, and urban areas with different development histories (Boone et al., 2009; Lafary, Gatrell, & Jensen, 2008). With few exceptions, most studies to date have focused on individual cities or regions and have produced seemingly contradictory results. For example, research has found that canopy cover in Indiana, US, was positively associated with higher levels of education and older housing stock, but found no correlation with household income (Heynen & Lindsey, 2003). In contrast, research in Tampa, FL, found that canopy cover on public land was lower in low-income neighbourhoods (Landry & Chakraborty, 2009) while research in Baltimore, MD, and New York, NY, showed that lifestyle and life stage, derived from combinations of demographic and socioeconomic factors, affect residents' access to urban vegetation (Grove et al., 2006; Grove, Locke, & O'Neil-Dunne, 2014). Research in the US has found that racialized and ethnic minorities generally have lower access to urban vegetation (Heynen, Perkins, & Parama, 2006; Jesdale, Morello-Frosch, & Cushing, 2013; Lowry, Baker, & Ramsey, 2012; Ogneva-Himmelberger et al., 2009; Watkins & Gerrish, 2018), although research in Baltimore has found that African American residents have higher access to urban vegetation by some measures (Boone et al., 2009; Troy, Grove, O'Neil-Dunne, Pickett, & Cadenasso, 2007). A further source of variation is the variety of vegetation measures used in the research, including canopy cover (Heynen & Lindsey, 2003), distance to a public green space (Barbosa et al., 2007), street tree abundance (Landry & Chakraborty, 2009), and overall greenness (Lafary et al., 2008).

The research described above has made important contributions to the field of urban green equity and environmental justice and has identified key socioeconomic, demographic, and contextual factors that should be included in green equity analyses. However, it has yet to clarify the relative roles that these factors play across a wide range of urban environments and in relation to different types of urban vegetation (Lafary et al., 2008; Landry & Chakraborty, 2009; McConnachie & Shackleton, 2010; Ogneva-Himmelberger et al., 2009; Schwarz et al., 2015). To begin to fill this gap, this paper presents an analysis of the relationships between urban vegetation and socioeconomic and demographic factors in 10 urbanized areas in the US, while controlling for key contextual factors that approximate the built environment and have been shown to affect urban vegetation distribution (Heynen & Lindsey, 2003; Lafary et al., 2008; Ogneva-Himmelberger et al., 2009; Troy et al., 2007). This research also analyzes access to multiple types of urban vegetation that represent different ecosystem services, painting a more complete picture of the state of green equity in US cities. The US was chosen as the study location because it contains many urban areas for which comparable, very high resolution urban vegetation data are available. These areas also represent diverse urban cultures, development histories, and geoclimatic conditions. This study goes beyond previous research in the field in that it examines urban green equity in multiple large metro areas that represent a range of urban development types and examines relationships with various measures of urban vegetation (Lafary et al., 2008; Landry & Chakraborty, 2009; Schwarz et al., 2015).

2. Methods

2.1. Data collection

2.1.1. Study sites

The study sites consisted of 10 urbanized areas in the US, as defined by the US Census Bureau for the most recent census year (2010) (Fig. 1) (U.S. Census Bureau, 2012): Chicago, IL – IN ("Chicago"); Houston, TX ("Houston"); Indianapolis, IN ("Indianapolis"); Jacksonville, FL ("Jacksonville"); Los Angeles – Long Beach – Anaheim, CA ("Los Angeles"); New York – Newark, NY – NJ – CT ("New York"); Phoenix – Mesa, AZ ("Phoenix"); Portland, OR – WA ("Portland"); Seattle, WA ("Seattle"); St. Louis, MO – IL ("Portland"). The study sites were restricted in Chicago, Portland, and St. Louis due to inconsistencies in available aerial imagery. Areas falling within the state of Indiana were excluded from Chicago, areas falling within the state of Washington were excluded from Portland, and areas falling within the state of Illinois were excluded from St. Louis. The Census Bureau defines an urban area as "…a densely settled core of census tracts and/or census blocks