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Spatial distribution of vegetation in and around city blocks on the Island of Montreal: A double environmental inequity?

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ABSTRACT

Recent studies have shown that urban vegetation is unevenly distributed across numerous North American cities: neighbourhoods predominantly inhabited by low-income populations and/or by certain ethnic groups have less vegetation cover. The goal of this paper is to examine the existence of environmental inequities related to access to urban vegetation on the Island of Montreal for four population groups (low-income people, visible minorities, individuals 0–14 years old and persons 65 years old and over). Six indicators of vegetation in and around residential city blocks (within 250 m and 500 m) are computed by using QuickBird satellite images. These indicators are then related to socioeconomic data by using different statistical analyses (T-test, seemingly unrelated regression and multinomial logistic regression). The results show that low-income people and, to a lesser degree, visible minorities reside in areas where vegetation is less abundant. On the other hand, the opposite situation is found for children and the elderly. The use of indicators computed in and around city blocks leads to the finding of a double inequity in certain neighbourhoods. This points to the need to target vegetation-deprived areas for urgent greening in order to improve vegetation cover within city blocks (in residential yards or through alternatives such as green walls and green roofs) and around these blocks (along streets and in parks).

1. Introduction

Most large cities around the world have acknowledged the crucial role of nature in the city. North American cities are no exception: they have recognized the important part that urban vegetation plays in the quality of life by implementing tree preservation and tree planting measures in both the United States (Hubacek & Kronenberg, 2013) and Canada (City of Montréal, 2011; City of Toronto, 2013). Moreover, the many benefits of urban vegetation have recently been documented, on the biophysical, health, social and economic levels. Numerous studies have shown that vegetation helps to improve the quality of the urban environment by reducing air and noise pollution, capturing a portion of the carbon in the air, helping to save energy, and, more vitally, minimizing the negative impacts that heat islands have on the health of populations (Mullaney, Lucke, & Trueman, 2015; Roy, Byrne, & Pickering, 2012). In terms of people's well-being and social benefits, a number of authors from various disciplines note that the presence of vegetation helps to lower stress levels and contributes to the social integration of the elderly, children and adolescents, especially in multiethnic urban areas (de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013; Taylor, Wheeler, White, Economou, & Osborne, 2015). Finally, on the economic level, other scholars emphasize that vegetation can be profitable for cities (Mullaney et al., 2015), for example by reducing electricity consumption and increasing property values (Donovan & Butry, 2010).

Several recent studies have however shown that urban vegetation is not equitably distributed across North American cities, to the detriment of certain population groups such as low-income households and visible minorities (e.g. Landry & Chakraborty, 2009; Pham, Apparicio, Séguin, Landry, & Gagnon, 2012; Schwarz et al., 2015; Tooke, Klinkenberg, & Coops, 2010). These studies frequently use high resolution satellite images (e.g. QuickBird, Ikonos imagery, etc.) to build vegetation indicators, spatial census data integrated into Geographical Information Systems (GIS) and statistical methods to explore the associations between vegetation

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indicators and socioeconomic variables. The approach taken here is in line with this type of studies: its objective is to verify the existence of environmental inequities regarding access to urban vegetation on the territory of the Island of Montreal for the four population groups most often examined in studies on environmental equity: that is, low-income populations, visible minorities, children and the elderly. The article focuses in particular on access to vegetation within residential city blocks, as well as around these blocks, in order to determine whether some groups are more likely to be affected by a double inequity than others.

The study attempts to answer three research questions. The first question is: Where are the areas located that have little vegetation both in and around the city block, and, conversely, that have a large amount of vegetation in and around the city block? The second question is: Do children, seniors, low-income populations and visible minorities live in areas with little vegetation in and around their city block? The third question is: After controlling for the characteristics of the built environment (population density and age of the neighbourhoods), do the four population groups studied live in residential areas with proportionately more or less vegetation?

The paper is organized as follows. It begins by discussing the notion of environmental equity as applied to urban vegetation, in emphasizing the use of vegetation indicators on a number of scales. It then describes the methodological approach taken in this study, which combines multisource data (satellite images, GIS data from the City of Montreal and census data) and various methods from the fields of GIS, remote sensing, and spatial analysis. After this, a concise presentation of the results is followed by a discussion of the findings.

2. Literature review

Walker (2012) identifies and defines three dimensions of environmental justice: distributive justice, procedural justice and justice as recognition. The first is understood in terms of the distribution or sharing of beneficial elements (resources) and negative elements (sources of risk). The second dimension refers to the ways that decisions are made, who is involved, and who has the power to influence such decisions. The third is based on the idea of respect for all individuals in a given society and rejects the manifestation of disrespect toward particular social groups. Environmental justice thus recognizes that all individuals in a given society, regardless of their status, have the right: 1) to live in a healthy environment with access to basic territorial resources; and 2) to participate in the process of formulating laws, policies and environmental regulations.

This study is interested in the first dimension: that is, environmental equity or distributive justice. Several studies carried out in North America and based on different methodologies have demonstrated the existence of environmental inequities in terms of access to vegetation for low-income populations (Heynen, 2006; Landry & Chakraborty, 2009; Pham et al., 2012; Tooke et al., 2010). In Canada, Tooke et al. (2010) find that the amount of vegetation is negatively associated with the percentage of low-income persons per census tract, whereas it is positively associated with median and average incomes for both individuals and households, in Montreal, Toronto and Vancouver. However, the correlation between the percentage of immigrants and the amount of vegetation is only negatively significant in Toronto. In Montreal, Pham et al. (2012) conclude that low-income populations and, to a lesser degree, visible minorities, live in city blocks where there is less vegetation on average. In the United States, the results are however less conclusive for racial minorities. In Tampa, Landry and Chakraborty (2009) show that, the percentage of tree cover on streets declines as the proportions of African-American and Hispanic residents rise. In Baltimore and Milwaukee, on the other hand, African Americans do not seem to have more limited access to vegetation, unlike the case for Hispanic residents (Heynen, 2006; Troy, Grove, O'Neil-Dunne, Pickett, & Cadenasso, 2007).

Many studies on environmental equity and vegetation look at vegetation within city blocks or census block groups (Landry & Pu, 2010; Pham, Apparicio, Landry, Séguin, & Gagnon, 2013; Pham et al., 2012; Troy et al., 2007). This spatial approach, although interesting, leaves room for improvement. An individual may in fact live in a block with largely impervious surfaces—in other words, in a block with little vegetation—whereas there is a large amount of vegetation cover around that block, and vice versa. For example, a person may live in a block with very little vegetation, primarily consisting of high-density housing, but that faces a large park. On the other hand, little vegetation in the immediate environment around the residential block would represent a double disadvantage. In other words, evaluating the existence of vegetation cover should not be spatially limited to the block where the person lives, but should also include the immediate environment around the block. Indeed, if, compared with the rest of the population, a population group is overrepresented in spaces with little or no vegetation both in and around the residential city block, this constitutes a double environmental inequity. Because some authors (Bowen, 2002; Cutter, Holm, & Clark, 1996) have emphasized the relevance of examining exposure to nuisances or access to benefits on a number of spatial scales (e.g. census tracts, block groups, census blocks, buffer zones), this study uses a method of evaluating distributional inequity that involves measuring the access to vegetation on several scales: within the city block, and within 250 and 500 m around the residential block.

In environmental equity studies related to the distribution of vegetation, it has been shown that the presence of vegetation is negatively associated with residential density and the age of the built environment (Grove et al., 2006; Landry & Chakraborty, 2009; Mennis, 2006; Pham et al., 2013; Pham et al., 2012). In the case of the Island of Montreal, low-income populations and visible minorities are concentrated in central City of Montreal neighbourhoods that often have the highest residential densities and an older built environment (Séguin, Apparicio, & Riva, 2012). Conversely, young children are more often found in suburban municipalities with a recent built environment and low residential density. The elderly, on the other hand, are concentrated both in central neighbourhoods and in the first-ring suburbs of the Island of Montreal (Séguin, Apparicio, & Negron-Poblete, 2016). It is therefore appropriate to control for these two characteristics of the built environment in order to arrive at an accurate environmental equity assessment.

3. Study area and methodology

The study covers the territory of the municipalities on the Island of Montreal, which extends over roughly 500 km^2 and included 1.85 million inhabitants in 2006. This territory is the central part of the Montreal census metropolitan area (CMA), which is the second most populous metropolis in Canada (with 3.92 million inhabitants).

3.1. Data processing

To answer the research questions, two sets of data were employed. QuickBird images (acquired in September 2007, 60 cm resolution) were used to map two types of vegetation, that is, trees/shrubs and grass/lawn, based on an object-oriented classification performed in e-Cognition (Pham, Apparicio, Séguin, & Gagnon,