An exploration of urban green equity in North America

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APPLICANT BACKGROUND

I am a PhD Candidate in the Department of Forest Resources Management, Faculty of Forestry, UBC. I hold a BSc (Hon) in Ecology and a Masters of Forest Conservation. In my doctoral studies I use widely-available remotely sensed data and qualitative interview data to help solve large-scale urban planning problems. My recent research has made me a competent GIS user and I am very excited about the technology's potential to support innovative urban planning that improves urban residents' daily lives. For example, the research described below could be used to identify opportunities for green infrastructure investment to reduce climate change vulnerabilities and improve urban quality of life for marginalized populations.

PROJECT DESCRIPTION

Can we manage our urban forests to ensure equitable access to their associated benefits?

I am using GIS to help me understand how urban green equity is affected by the distribution of trees and green spaces in cities. Urban forests generate many widely-accepted benefits, from microclimatic regulation to climate change adaptation to improved public health (Ulrich et al., 1991; Kuchelmeister, 2000; Thompson, 2002; Konijnendijk, Nilsson, Randrup, & Schipperijn, 2005; Heidt & Neef, 2008; Poudyal, Hodges, & Merrett, 2009). As more and more people make cities their home, we need to consider how best to maximize the benefits of urban greenery and ensure that urban residents are all able to experience these benefits.

Despite the importance of greenery in urban environments, it appears that urban residents have inequitable access to its benefits (Heynen & Lindsey, 2003; Landry & Chakraborty, 2009; Ogneva-Himmelberger, Pearsall, & Rakshit, 2009; Nesbitt & Meitner, 2016). The disparities of access to urban greenery give rise to the idea of *urban green equity*, defined here as: *equitable access to urban greenery regardless of differentiating factors such as socioeconomic status, race, cultural background, or age*. Given the importance of urban greenery to human health and well-being discussed above, cities will need to address these inequities and their underlying causes as they manage and grow their urban forests.

While it is clear that most cities experience some form of urban green inequity, it is still unclear what causes it. Green equity research to date has been focused on individual cities or regions rather than integrating data from a variety of cities or regions across a country or continent (Heynen & Lindsey, 2003; Barbosa et al., 2007; Lafary et al., 2008; Landry & Chakraborty, 2009) and present often-contradictory findings that cannot be extrapolated and applied to a larger area with confidence (Heynen & Lindsey, 2003; Barbosa et al., 2007; Landry & Chakraborty, 2009). In addition, the perceptual and sociological literature shows that preference and quality are important factors to consider when evaluating cultural ecosystem services and should be brought into spatial analyses of green inequity (Fraser and Kenney, 2000; Rishbeth, 2004; Buijs et al., 2009)

METHODS

To address this gap, I have conducted spatial analyses of the relationship between socioeconomic factors and the availability of urban vegetation in ten North American metro areas and core cities. This analysis uses multiple linear regression to examine correlations between urban vegetation (mixed and woody) and socioeconomic data, using 1 m resolution land cover imagery from the National Agricultural Imagery Program (NAIP) and nationally-available census data. I have also conducted interviews with urban forestry key informants in three of the ten cities examined in the spatial analysis (New York, Phoenix, and Portland) to begin to explore urban forest quality and preferences and their effects on urban green equity at the local level. The case study interviews were completed with 11 subjects per city. This project is part of my doctoral dissertation research. This portion of my research began in the fall of 2015 and is nearing completion.

To allow for broad comparability across the study cities, I measured the availability of urban vegetation using the Normalized Difference Vegetation Index (NDVI). NDVI measurements derived from 4-band NAIP imagery are accurate to 1 m, where the density and type of green vegetation are represented by calculating the red and near-infrared light reflected by the vegetation in that 1 m^2 pixel according to the following formula: NDVI = (NIR – Red)/(NIR + Red).

Green vegetation measurements were then aggregated by census block group and linked to census data for analysis (Figure 1). Socioeconomic and land use factors examined in the analyis include: cultural heritage, race,

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age, level of education, level of employment, per capita income, age of housing stock, and population density. Initial results suggest that the socioeconomic factors most strongly associated with patterns of vegetation cover are variable by location but often include population density and per capita income.

While the spatial analysis described above provides useful large-scale comparative data, it does not consider local preferences for urban forest characteristics or factors such as urban forest condition and aesthetics. To begin to address this gap, I asked interview subjects to identify and describe their preferred and least-preferred areas of the urban forest in their city and mark them on a map. I then digitized the interview maps and analyzed subjects' descriptions of the identified areas. In the New York case study presented in Figures 1 and 2, factors most often mentioned in association with preferred areas were large, mature trees, natural vegetation, recreational green spaces, areas near subjects' home or work, and trees or green spaces that reflect the cultural character or history of the area. Factors most often mentioned in association with least-preferred areas were trees in poor condition, sparse vegetation, and an industrial urban environment. Interestingly, subjects were much more willing to identify preferred than least-preferred areas, identifying over three times more preferred than least-preferred areas (59 preferred vs. 18 least-preferred).

The interview analysis prompted further examination of the characteristics of the identified areas. I thus overlaid the identified areas on maps of average vegetation per block group, and local, regional and national parks (Figure 2) to examine the characteristics of the identified areas. Subjects' preferred areas were significantly more green than least-preferred areas (0.28 m^2 of vegetation vs 0.20 m^2 of vegetation per m^2 of land; $p<0.001$) and contained more parks (96 parks) than least-preferred areas (31 parks). Preferred areas also contained larger parks than least-preferred areas on average (0.2 sq. miles vs. 0.1 sq. miles), although this difference was not statistically significant.

CONCLUSION

The goal of this research is to understand how the distribution and quality of urban vegetation affects how urban residents engage with it and how this influences the distribution of benefits. This research project has clear practical applications in urban forest planning and management. Cities can use our methods to identify areas of high green inequity and conduct targeted urban forest management to maximize urban forest access experienced by residents and improve their quality of life.

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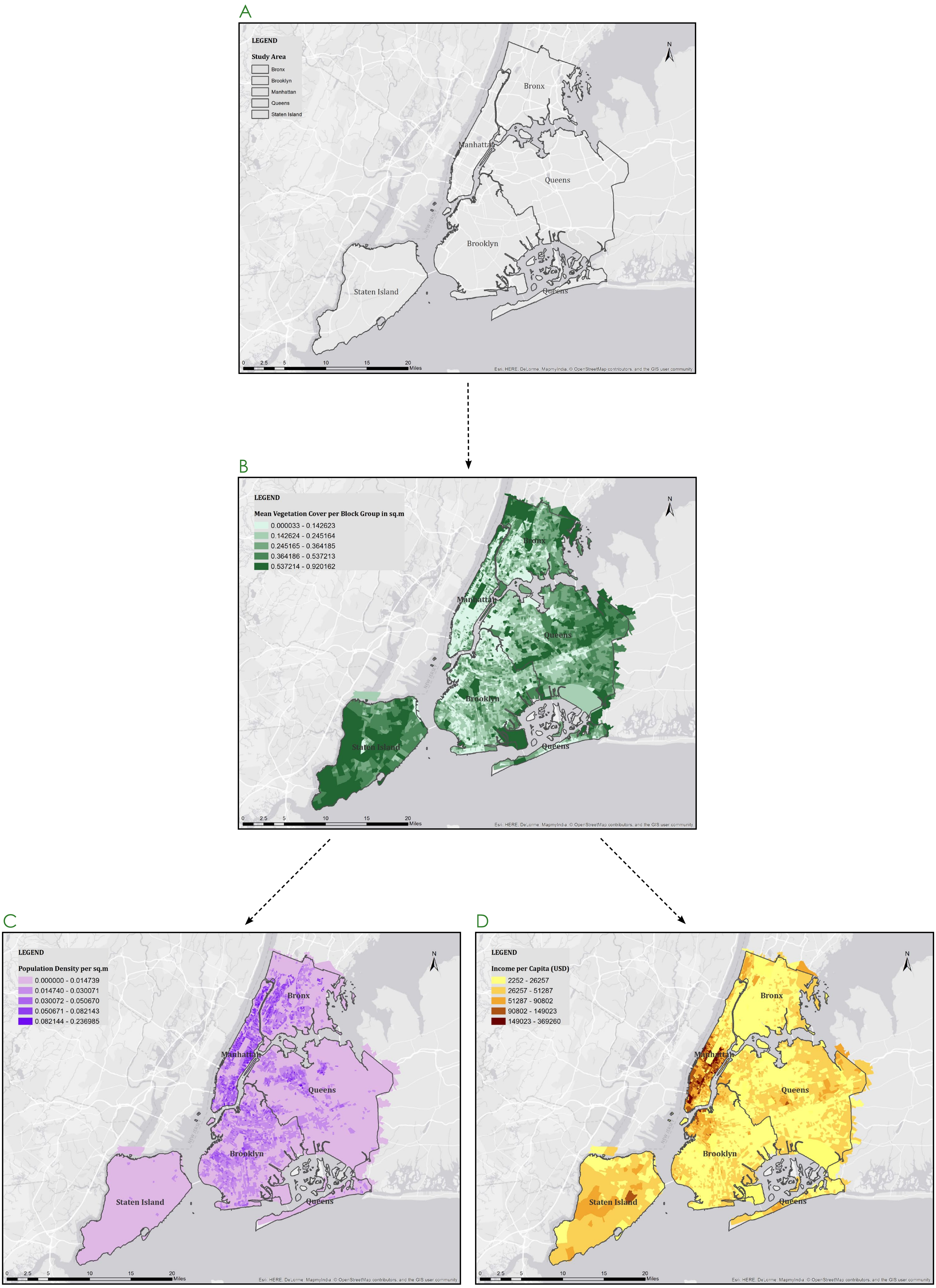

Figure 1. Map of (A) New York City Study Area; (B) Mean mixed vegetation cover per block group (defined as pixels with NDVI values of 0.1 and above divided by total land pixels); Two of the strongest predictors in the regression model: (C) population density per block group (per m²) and (D) per capita income per block group.

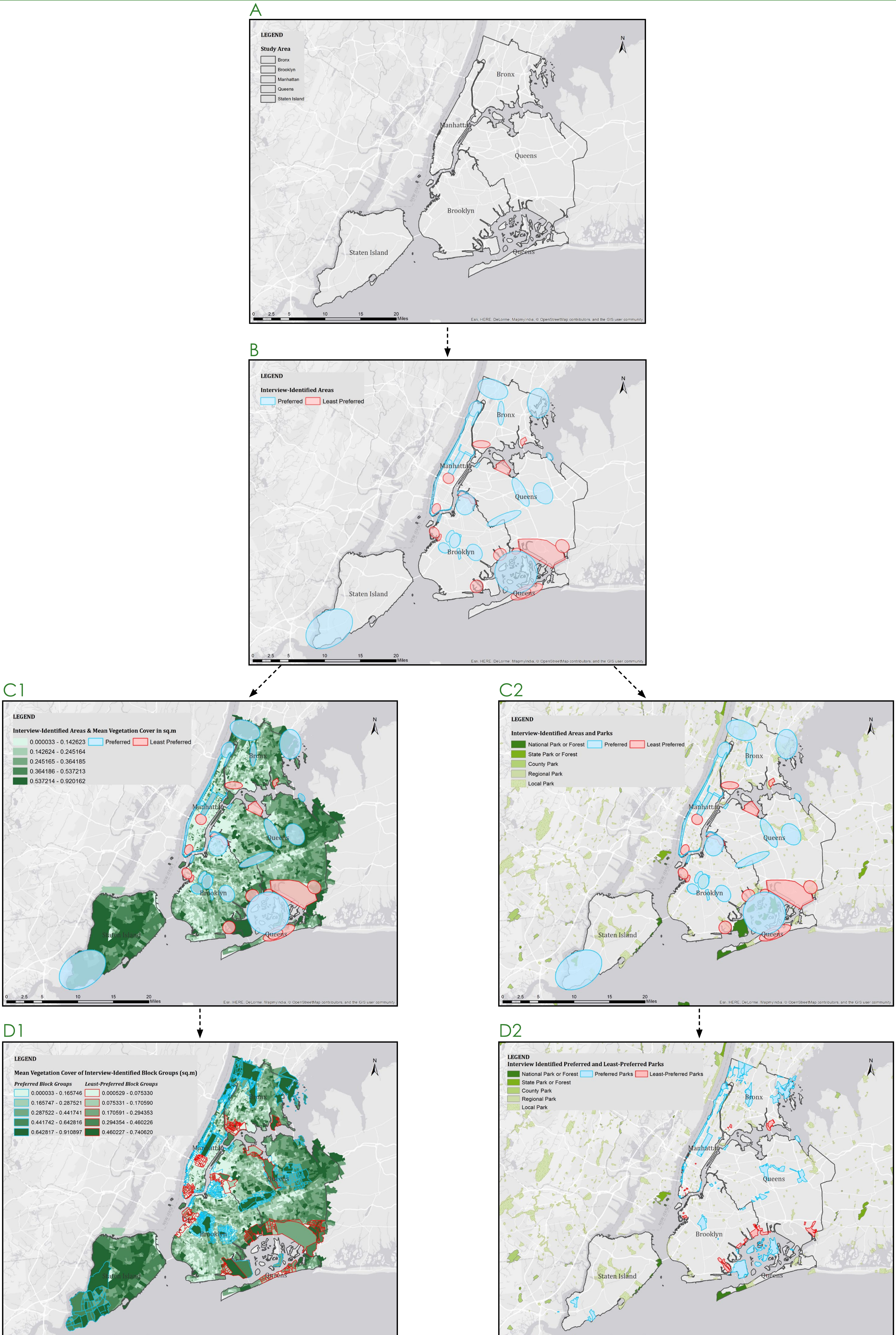

Figure 2. Map of (A) New York City Study Area; (B) Preferred and least-preferred areas identified by interview subjects; Preferred and least-preferred areas overlaid on (C1) mean mixed vegetation by block group and (C2) parks; Preferred and least-preferred (D1)block groups with vegetation cover and (D2) parks.