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Urban tree cover change in Detroit and Atlanta, USA, 1951–2010

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ABSTRACT

We assessed tree cover using random points and polygons distributed within the administrative boundaries of Detroit, MI and Atlanta, GA. Two approaches were tested, a point-based approach using 1000 randomly located sample points, and polygon-based approach using 250 circular areas, 200 m in radius (12.56 ha). In the case of Atlanta, both approaches arrived at similar estimates of tree cover (50–53%) for both time periods, yet they show that roughly one-third of the tree-covered land area in 1951 was also tree-covered in 2010 and about 30–31% of the sampled land area lacked tree cover during both assessment periods. In the case of Detroit, the two approaches resulted in different estimates of tree cover (19.6% vs. 30.8% in 2010), yet similar levels of transitions over time. The only similarities between the two cities were that about 15–20% of each city's land area was covered with trees in 1951, yet lacked tree cover in 2010. While the polygon-based approach to estimating tree cover may result in a product that more explicitly represents covered areas, the point-based approach is recommended due to the time and effort involved with the polygon-based approach and potential error introduced through topographic displacement of trees and shadows. Overall, canopy cover over time remained stable while distribution varied greatly. However, while multi-decade change in aggregate is undetectable at the scale of a city, there seems to be substantial shifts in the spatial arrangement of the tree canopy.

Introduction

Urban forestry and tree programs have been found to provide a number of positive benefits including the reduction of energy costs, an increase in quality of life, and the mitigation of environmental extremes (i.e. increased temperatures and high levels of pollution) for people who live within, or who have access to these areas (Perkins, Heynen, & Wilson, 2004). Biomass that is created by urban forests has also been suggested as a potential source of bio-based fuel that could help lower human consumption of fossil fuels, reduce waste, and lessen commercial pressure on natural forests (MacFarlane, 2009). The amount of canopy cover, usually presented as a percent of land area, is often used as a basis for urban tree canopy assessments and management decisions, and, therefore, might be viewed as necessary information for goal setting in managing urban forest resources effectively (McGee, Day, Wynne, & White, 2012; Walton, 2008). For example, tree canopy assessments have been used in the Chesapeake Bay region to inform the management goal of reducing urban water runoff into the bay (Jantz, Goetz, & Jantz, 2005). McPherson, Simpson, Xiao, and Wu (2011) used urban tree canopy assessments to estimate the capacity of Los Angeles to add one million trees into the existing canopy with the goal of increasing long-term benefits such as air pollution reduction, water quality improvement, and decreased urban flooding. The amount of tree canopy cover in urban areas can be increased through planting efforts or other initiatives that promote urban tree cover. However, some suggest that urban tree planting efforts and natural regeneration of abandoned areas may be insufficient to counteract recent losses of established urban tree canopies in the United States (Nowak & Greenfield, 2012). Additionally, tree planting programs and associated policies may not be appreciated by the general public (Rae, Simon, & Braden, 2010), who may be opposed to tree planting efforts conducted on or near their property, given the maintenance required and the potential damage that may arise to both their homes and their property (lawns, sidewalks) (Perkins, 2011). Opportunities to increase urban tree canopy cover, such as allowing an abandoned lot to revegetate naturally, may also be inconsistent with desired positive changes in the socio-economic position of the urban area (Emmanuel, 1997). Identifying the amount of urban tree cover over time is a crucial part of identifying the effectiveness of current management practices, assessing the environmental impact of

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existing cover along with the potential impact of new canopy cover, and informing future management goals.

Our goal is to compare the change in urban tree canopy cover in two large United States cities (Atlanta, GA and Detroit, MI) that have different developmental histories with respect to human population change. Increases in population density have been found to negatively impact the quantity of the forest cover and, in turn, increase the detrimental effects associated with forest loss including poor air quality, decreased carbon sequestration and storage, and the urban heat island effect (Lo & Yang, 2002; McGee et al., 2012; Boone, Cadenasso, Grove, Schwarz, & Buckley, 2009; Cook, Hall, & Larson, 2012). However, both Atlanta and Detroit currently have urban tree programs that promote the management of trees and tree planting (The Greening of Detroit, 2012; Trees Atlanta, 2014). Ideally, tree planting programs and policies will have a positive impact on the quantity of urban tree canopy cover.

In order to understand tree canopy cover and how it changes over time, it is important to understand the developmental history of Atlanta and Detroit. Detroit is situated on the south side of what is now known as the Detroit River. The region is classified as a humid continental climate which is greatly influenced by proximity to the Great Lakes. Average temperatures range from 25.6°F (−3.6 °C) in the winter to 73.6°F (23.1 °C) in the summer. The forests of the broader southern Michigan region are dominated by broadleaf deciduous trees including oaks (*Quercus* spp.), aspens (*Populus* spp.), and maples (*Acer* spp.). Additional species include pines (*Pinus* spp.), cedars (*Cedrus* spp.), and northern hardwood species (Michigan Society of American Foresters, 2014). When it was first settled in the early 18th century, the land was described as a meadow, lined with fruit trees and surrounded by dense forests (Martelle, 2012). Given its strategic geographic location on the United States–Canada border between Lake Erie and Lake Huron, Detroit became a staging point for the European settlement and economic development of the northwestern (as it was called at the time) United States (Martelle, 2012; McCarthy, 1997). By the late 19th century, the city road system had become well-developed, and was lined with numerous shade trees (Martelle, 2012). Since the early 1900s, the fate of the city has been closely tied to the growth and success of the automobile industry (McCarthy, 1997). By 1910, seven of the top 10 automobile producers were situated in the Detroit area, and together they claimed a market share of 65% of the industry (Klepper, 2010). Between 1910 and 1950, Detroit's population rose 297% to approximately 1.85 million people. By the middle of the twentieth century, Detroit was encountering economic and racial tension, along with housing shortages, signaling the beginning of the collapse of an industrial society (Martelle, 2012). The resulting development of the urban fringe led to the core city of Detroit losing tax revenue, services declining, and the beginning of decay and disinvestment (McCarthy, 1997).

Between 1950 and 2010, the population of Detroit declined considerably (by about 61%) to 0.71 million (Bureau of the Census, 1952; U.S. Census Bureau, 2012), accompanied by a loss of job opportunities (Hall, 2011). In 2013, Detroit filed for bankruptcy, seeking protection from creditors of nearly $20 billion in debt. The evolution of Detroit is not unique for cities of the northern United States and revitalization efforts have been pursued for nearly four decades (McCarthy, 1997) including in Pittsburgh, PA (Detrick, 1999), Buffalo, NY (Shilling, 2008), and St. Louis, MO (Fey, 1993).

In addition to economic and demographic changes in Detroit, Dutch elm disease affected street trees in the mid-20th century. In the early part of the 21st century, the emerald ash borer (*Agrilus planipennis*) caused the death of millions of popular street trees, specifically ash (*Fraxinus* spp.), in the Detroit area (MacFarlane & Meyer, 2005). Some have suggested that the decline in urban forest quality is not yet complete, and educational and planting efforts have been mobilized to inspire local support (The Greening of Detroit, 2012). In the northern United States, it is estimated that it will cost nearly one billion U.S. dollars per year for treatment, removal, and replacement of urban trees due to the emerald ash borer (Kovacs et al., 2010). In some areas of Detroit, low land values have enabled residents to acquire adjacent properties, and thus there is localized transformation from former densely populated urban areas to areas with a housing and population density similar to suburban areas (Blanco et al., 2009). These drastic socioeconomic changes combined with losses from emerald ash borer infestations and Dutch elm disease led to losses in tree cover across the city. While reduced city budgets limit tree planting programs and policy implementation, abandon property may provide an opportunity for tree planting programs to restore the urban tree canopy cover (The Greening of Detroit, 2012). In Nowak and Greenfield's (2012) short-term analysis of multiple U.S. cities, they found a 0.18% per year loss of tree cover in Detroit between 2005 and 2009. They found this estimated loss to be lower than expected and attributed it, in part, to increased tree planting efforts conducted in response to the onset of the emerald ash borer problem.

The city of Atlanta is situated in the Piedmont ecoregion of Georgia and is classified as a humid subtropical climate with an average annual rainfall of 50.2 in. (1275 mm). Average temperatures range from lows around 10–20°F (−12 to −6 °C) in the winter and highs between 90° and 100°F (32 °C and 38 °C, respectively) in the summer. The Piedmont area of the state is dominated by pine species including loblolly pine (*Pinus taeda*), slash pine (*Pinus elliottii*), shortleaf pine (*Pinus enchinata*), and longleaf pine (*Pinus palustris*). Additional tree species in the region include tulip poplar (*Liriodendron tulipifera*), hickories (*Carya* spp.), beech (*Fagus* spp.) and oaks (Harper et al., 2009). Its early developmental history was heavily influenced by manufacturing activities and rail transportation. Atlanta was mainly developed in the early 19th century primarily in an area that was previously forested. Perhaps the main impetus for the development of the city was for it to become a transportation hub, and thus as Reed (1889) once suggested, "all the roads running through this favored territory lead to Atlanta." The early history of this region of the South is marked by the displacement of Native Americans through territorial expansion of the United States, the destruction of the city during the American Civil War, and racial unrest in following decades. During the early to mid-19th century, much of the original forest that had covered the main city area had been removed, except in a few places where trees were allowed to remain to form parks (Garrett, 1969). Between 1910 and 1950, the population within the administrative boundary of the city rose 114%, to about 330,000. Since 1950, the population has risen by about 27% to 420,000 (Bureau of the Census, 1952; U.S. Census Bureau, 2012). In partial response to demographic and economic forces, Atlanta's population growth continued at the end of the 20th century, resulting in the rapid suburbanization of surrounding counties (Miller, 2012). While the population within the administrative boundary of Atlanta is relatively small compared to Detroit, the larger metropolitan area around Atlanta is home to over 5 million people, and Atlanta is now viewed as the center of a larger regional transportation system (Dablanc & Ross, 2012; Redondi, Malighetti, & Paleari, 2011). Recent (2005–2009) losses in land area covered with trees were estimated to be about 0.46% per year in Atlanta (Nowak & Greenfield, 2012). Educational and planting programs have been mobilized to engage neighborhoods in tree planting and maintenance in an attempt to counteract deforestation in the city (Trees Atlanta, 2014).

Our definition of urban forests in both Atlanta and Detroit includes plants found within urban parks, street trees, trees on private residential land, and natural regeneration on abandoned sites (Fig. 1). It stands to reason that the vegetation growing today could