**Abstract**

Green stormwater infrastructure (GSI) is an ecologically friendly and effective method for managing stormwater runoff. By absorbing stormwater, GSI may decrease the frequency of combined sewer overflows (CSOs). This would reduce individuals’ exposure to bacteria, pathogens, and toxins, such as those deposited on roadways by passing vehicles. In addition, GSI increases access to urban green spaces, which provide added health benefits. Philadelphia’s recent Green City, Clean Waters (GCCW) initiative is a 25-year plan to use GSI to manage stormwater. Geographic Information Systems (GIS) mapping techniques and clustering metrics were used to evaluate the distribution of GSI projects in Philadelphia through an environmental justice lens. The Philadelphia Water Department’s online database of GSI was used to map these projects and U.S. Census data provided demographic information for Philadelphia. The analyses explored associations between census tract-level demographic and economic variables and the number of GSI projects within that neighborhood. This evaluation provides another metric of success for the GCCW initiative and its impact on the diverse city of Philadelphia.

**Background**

Like many cities, Philadelphia has a combined sewer system. During rain events, the large volumes of stormwater runoff entering these systems may cause them to overflow and discharge untreated sewage into waterways. Combined sewer overflows (CSOs) are used to discharge untreated sewage to prevent overloading of wastewater treatment plants, which is a common problem during precipitation events (Donovan et. al, 2006). Philadelphia has 164 CSOs (Sunger et. al, 2015). Previously, grey stormwater infrastructure was used to manage runoff in most cities. Grey infrastructure employs pipes and collection systems to collect water from impervious, built surfaces to funnel it to a water treatment plant or waterway (Why You Should Consider Green Stormwater Infrastructure for Your Community, 2019). Green stormwater infrastructure uses soil, plants, and other elements to restore the natural absorption processes typically absent in urban environments (What is Green Infrastructure?, 2019). GSI also confers the benefits typically associated with green space, such as improving air pollution, resolving the urban heat island effect (Whitford et. al, 2001), and increasing physical activity (Humpet et. al, 2002).

Philadelphia’s Green City, Clean Waters initiative is a 25 year plan that includes large-scale GSI implementation on public land and public sector requirements and incentives. The Philadelphia Water Department is commiting $2.4 billion of investments over the 25 year period. The lower cost of green infrastructure and the added benefits, aside from stormwater management, are cited by the city as the main reasons to move forward with the plan initiative (City of Philadelphia, 2011). There is a residential stormwater charge based on the average impervious surface area of residential properties in Philadelphia. The city also offers subsidized pricing on residential improvements that can help with stormwater management (Residential Stormwater Billing, n.d.). There is also a commercial stormwater charge based on each property’s percentage of impervious surface area, so businesses can reduce their fees by making stormwater management improvements (Non-Residential Stormwater Billing, n.d.). Retrofit projects on non-residential properties are eligible for Stormwater Grants (Stormwater Grants, n.d.).

Environmental justice movements focus on distributing environmental burdens and assets evenly across neighborhoods (Cutter, 1995). Previous research shows that urban green spaces are inequitably distributed. Using data from 2011 to 2015, Mandarano and Meenar showed that GSI projects were inequitably distributed in Philadelphia (2016). This project expands on their research with more recent data.

**Methods**

Analysis and visualization for this project were done in RStudio (RStudio Team, 2015). Census files for the county of Philadelphia were downloaded in RStudio using the tigris package (Walker, 2016). The location of public and private GSI projects were accessed from OpenDataPhilly (Your Source for Open Data in the Philadelphia Region, n.d.). The data files were last updated in For each census tract, the number of GSI project points was divided by the area to calculate the density of points. This was done for all projects, public projects, private projects, private projects necessitated by regulation, and private projects that were done as retrofits. The ggplot2 package was used to visualize the map of Philadelphia with this data (Wickham, 2016).

United States Census demographic data was retrieved from American FactFinder (American FactFinder, n.d.). The data included race and income by census tract. The correlation between these variables and the density of points per census tract was tested using linear regression.

**Results**

**Discussion**

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