

# Green Infrastructure Distribution in Portland, Oregon



**Reed College  
Environmental Studies Junior Seminar  
April 2018**

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Special thanks to Kristin Bott for help with ArcGIS, data formatting, and data analysis. Thank you also to the numerous city employees for providing datasets and for taking time out of their busy schedules to consult with us, particularly those at Portland Bureau of Environmental Services and Portland State University.



## Executive Summary

Flooding has historically been, and remains, a central environmental challenge facing the city of Portland. One of the city's newest initiatives to manage flooding is the Green Infrastructure program. Here, we look specifically at "Green Streets," one type of Green Infrastructure with particular potential to reduce flooding risk. However, Green Streets can also change other neighborhood characteristics, including property values, which can lead to gentrification. Thus, the city must strike a delicate balance between failing to address flooding in socioeconomically vulnerable areas and driving up housing costs as streets become more visually appealing with the installation of Green Streets. We set out to determine what the goals of the Green Street Program are, the extent to which the distribution of Green Streets meet these goals, and the ways in which this distribution might be improved.

Based on GIS mapping and multilinear regression analysis, we find that the distribution of Portland's Green Streets are likely driven primarily by preexisting risk of flood, but that socioeconomic factors may also play a role. We also use field surveys and questionnaires sent out to city employees and volunteer Green Street stewards to develop a more qualitative analysis of the Green Streets installed so far and the motivations behind their installment and use. We find that poorer neighborhoods with higher levels of "social vulnerability" have proportionately higher rates of Green Street placement. Thus, we discuss the possible gentrification that often occurs with the implementation of new infrastructure, including Green Infrastructure, and we offer policy proposals to improve the effectiveness of the Green Streets program overall.

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# Introduction

## Portland, Climate Change, and Stormwater

In the face of climate change, Portland, Oregon, aims to strengthen the city's adaptive capacity to minimize its impacts, especially to reduce the risks it poses to the City's most vulnerable populations. A range of climate impacts are anticipated. Broadly, Portland's future will be hotter, drier summers with more frequent high heat days, and warmer winters with the potential for more intense rain events. Although climate models predict that Portland's total annual precipitation will not change significantly, the location, duration, and timing of rainfall is likely to change.<sup>1</sup> Hotter, drier summers result in drier soils which are less absorbent, so when rain does fall, flooding is more likely to occur. Additionally, if the rainfall happens all at once instead of even rainfall throughout the winter, the rapid increase in water is more likely to result in flooding.

These intense rain events will contribute to increased incidences of flooding. Typically, Portland experiences flooding after more than three days of rain or when heavy rain falls on already saturated soil. Today, Portland's most severe floods are winter pluvial floods occurring between December and February. The Portland region is subject to flooding from stressed stormwater drainage (urban flooding) and overflow from rivers (river flooding). Urban flooding is the "flooding of streets, underpasses, low lying areas, or storm drains."<sup>2</sup> In a natural environment, soil and plants absorb rain. However, when rain falls on impervious surfaces like concrete or pavement, it cannot be absorbed. Stormwater drains are installed to carry this water off the streets and into the rivers, but when these are overwhelmed or clogged, urban flooding occurs. Rain washing over these hard surfaces also carries dirt, oil, and other pollutants into the rivers that could otherwise be filtered out by plants.

Most of Portland's stormwater pipes and infrastructure have been in place for decades and were built based on the historic climate record. Since some of these stormwater systems continue to have problems handling the increased runoff caused by development and additional

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<sup>1</sup> *Climate Change Preparation Strategy* (Portland, OR: City of Portland, 2014).

<sup>2</sup> "Severe Weather 101," The National Severe Storms Laboratory, National Oceanic and Atmospheric Administration, <https://www.nssl.noaa.gov/education/svrwx101/floods/>.

impervious area coverage, more intense rain events during the winter due to climate change would exacerbate this problem. In particular, older Portland neighborhoods have a combined sewer system that mixes untreated sewage with stormwater runoff in a single pipe. During heavy rainstorms, runoff from impervious surfaces can fill the combined sewers to capacity. This causes it to overflow, releasing excess untreated wastewater and stormwater into the Willamette River and Columbia Slough. These overflows contribute to river pollution and ecosystem degradation.

## Green Infrastructure

In response to these climate changes, the City of Portland and Multnomah County completed their most recent Climate Action Plan in 2015.<sup>3</sup> The resulting climate change preparation strategy highlights the importance of a coordinated effort to mitigate these dangers where possible by developing adaptive resilience strategies in the face of growing climate instability. Objective 6 in Portland’s Climate Change Preparation Strategy is to “increase the resiliency of the natural and built environment to increased winter rainfall and associated flooding.”<sup>4</sup> As discussed earlier, a greater area of continuous, impervious surfaces can increase runoff leading to flooding. Therefore, in response to the environmental changes Portland is facing, Objective 6h calls for “better manage[ment] [of] stormwater by reducing the overall impervious area within the city through depaving, green infrastructure (Green Streets, ecoroofs, trees, and rain gardens), and expanding the urban forest canopy, natural areas, and open spaces.”<sup>5</sup> The City implemented several green infrastructure projects involving green roofs, swales, rain gardens, etc. in a variety of locations. These pilot projects ultimately led to Portland’s adoption of a Green Streets Policy in 2007. Under this policy, Green Streets facilities must be incorporated into all city-funded development, redevelopment, or enhancement projects. The policy ultimately seeks to encourage cross-departmental interest in water quality and watershed

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<sup>3</sup> *Climate Action Plan: Local Strategies to Address Climate Change* (Portland, OR: City of Portland, 2015).

<sup>4</sup> *Climate Change Preparation Strategy*.

<sup>5</sup> *Climate Change Preparation Strategy*.

programs. Further, it helps to connect neighborhoods, save on infrastructure costs, and engage the general public in sustainable stormwater projects.

In order to comply with the federal Clean Water Act (CWA), Portland has also developed a stormwater management plan over the past twenty years to decrease the frequency of combined sewer overflow events. Portland's stormwater management plan outlines improving management practices by reducing impervious area, increasing infiltration, and removing pollutants.<sup>6</sup> Increasing the resilience of watersheds and stormwater facilities increases the City's resilience to changes in climate. In addition to building a conventional sewage tunnel to divert combined sewer overflows from the Willamette River to a treatment plant, Portland is acquiring natural areas, restoring floodplains, and installing Green Infrastructure to limit the overall runoff volume. Green Streets, ecoroofs, trees, urban streams, wetlands, and parks all help protect water quality and improve watershed health.

The United States Environmental Protection Agency (USEPA) and Clean Water America Alliance (CWAA) define Green Infrastructure as “a set of techniques, technologies, management approaches, and practices that can be used to eliminate or reduce the amount of stormwater and nonpoint source runoff including water and pollutants that run into combined sewer overflow systems.”<sup>7</sup> Green Infrastructure projects attempt to address urban ecological concerns at the source by creating a “green space” in urban settings. These green spaces utilize vegetation, trees, and soil capable of managing water through biological processes instead of solely relying on drains, sewers, and other “grey” stormwater collecting methods. Stormwater Green Infrastructure include vegetated swales (or bioswales/Green Streets), green roofs, rain gardens, and parks, all of which decrease the total impervious area in the city. In cities where rainfall is abundant for most of the year, urban green spaces are extremely useful in minimizing stormwater runoff and maintaining local water quality.

The overall goal for Green Infrastructure in Portland is to reduce the amount of stormwater runoff that flows out of the combined sewer system and directly into water bodies that leads to the pollution of the Willamette River. In 2008, Portland launched the \$55 million “Grey to Green” program to control stormwater runoff. Program goals include planting 33,000

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<sup>6</sup> *Stormwater Management Manual* (Portland, OR: City of Portland Bureau of Environmental Services, 2016).

<sup>7</sup> Clean Water America Alliance (2011): 8.

yard trees and 50,000 street trees, adding 43 acres of ecoroofs, controlling invasive plant species, purchasing over 400 acres of natural areas, and constructing 920 new Green Street facilities.<sup>8</sup>

In addition to managing excess stormwater runoff, other types of Green Infrastructure can be built to improve wildlife habitats, manage urban heat islands, and improve local air quality. Moreover, in addition to their ecological benefits, Green Infrastructure and urban green spaces have known social benefits including increased human physical and psychological health.<sup>9</sup> For example, Green Infrastructure may bring communities together to work on neighborhood gardens or volunteer for cleanup projects. One study indicates that urban green spaces even have a strong ability to foster a sense of safety within a community.<sup>10</sup> Green Infrastructure has also been used in attempts to “beautify” urban spaces by bringing in parks and other visually appealing focal points where local residents can take walks and enjoy nature within their neighborhoods.



Figure 1. Green Street stormwater capture device on SE Division street in Portland, OR.<sup>11</sup>

<sup>8</sup> Noelwah Netusil, Zachary Levin, Vivek Shandas, and Ted Hart, “Valuing Green Infrastructure in Portland, Oregon,” *Landscape and Urban Planning* 124 (April 2014).

<sup>9</sup> Konstantinos Tzoulasa, Kalevi Korpelab, Stephen Venn, Vesa Yli-Pelkonenc, Aleksandra Kaźmierczaka, Jari Niemelac, and Philip Jamesa, “Promoting Ecosystem and Human Health in Urban Areas Using Green Infrastructure: A Literature Review,” *Landscape and Urban Planning* 81, no. 3 (June 2007).

<sup>10</sup> Edwin Gomez, Joshua Baur, Eddie Hill, and Svetoslav Georgiev, “Urban Parks and Psychological Sense of Community,” *Journal of Leisure Research* 47, no. 3 (2015).

<sup>11</sup> “SE Division/Mail Street Green Street, Portland, Oregon,” Nevue Ngan Associates Landscape Architecture, <https://nnala.com/se-division-main-street-green-street-portland-oregon/>.

Another type of Green Infrastructure that attempts to manage stormwater runoff are ecoroofs (or green roofs). These roofing designs consist of vegetation and soil over a synthetic, waterproof membrane. Ecoroofs are beneficial to local environments in several ways: reducing stormwater runoff, mitigating local heat island effects, and insulating homes.<sup>12</sup> Portland has a total of 410 ecoroofs as of 2016—most are installed on behalf of private property owners. The typical lifespan of an ecoroof is approximately 40 years.<sup>13</sup>



Figure 2. Example of an ecoroof on the Reed College performing arts building.<sup>14</sup>

## Green Streets

Our study specifically focuses on Portland’s installation of Green Streets, which are a major component of Portland’s efforts to manage and treat street runoff. Portland has installed 1,927 Green Streets as of January 2018. Map 1 below shows how Green Streets are dispersed in Portland in relation to the flooding risk in the area. Green Streets utilize a natural systems

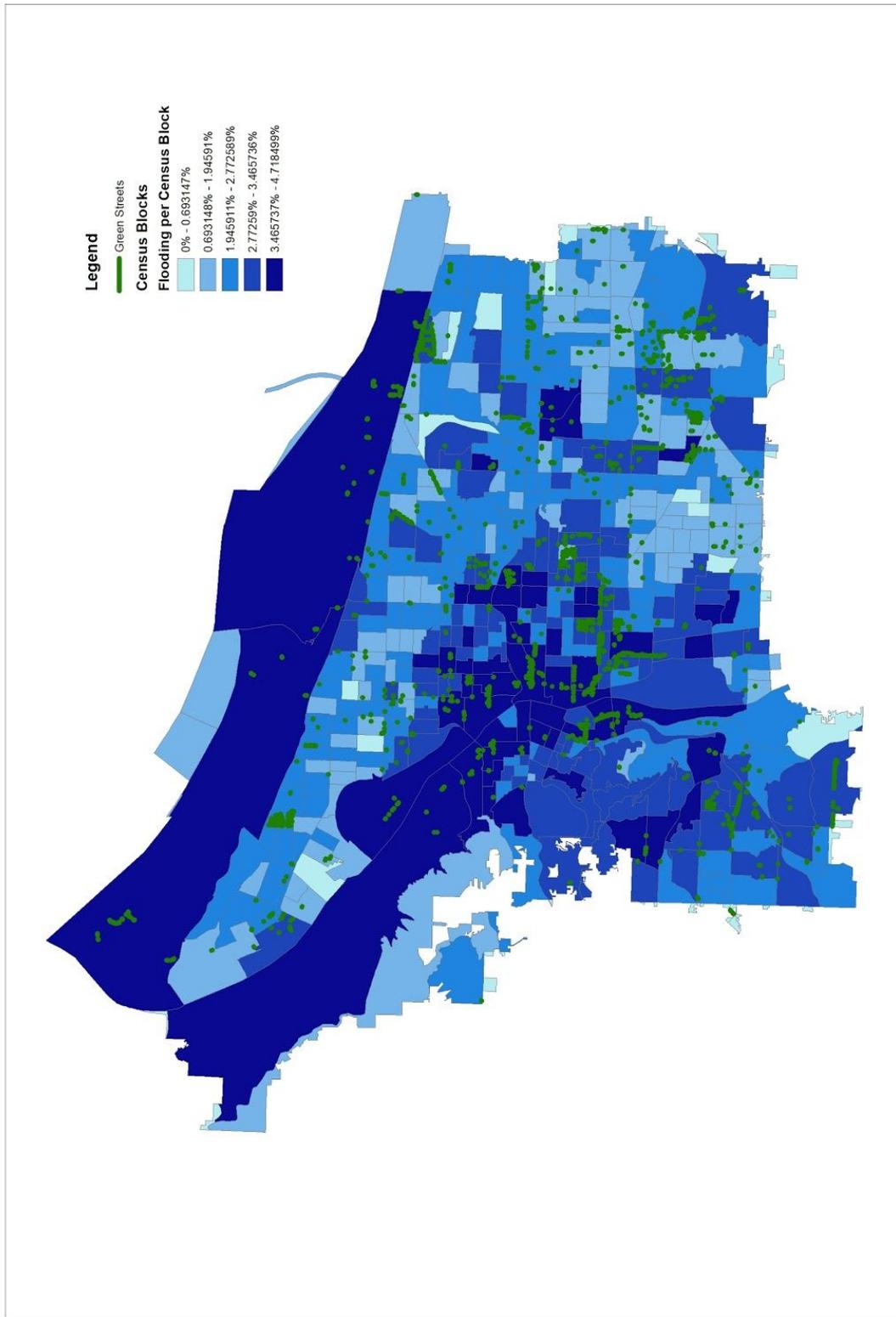
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<sup>12</sup> “Portland Ecoroofs,” City of Portland Bureau of Environmental Services, <https://www.portlandoregon.gov/bes/44422>.

<sup>13</sup> “Portland Ecoroofs.”

<sup>14</sup> “Ecoroof Incentive,” City of Portland Bureau of Environmental Services, <https://www.portlandoregon.gov/bes/article/547491>.

approach to reduce stormwater flow speed, improve water quality, and enhance watershed health. They are gently sloping depressions, similar to rain gardens, adjacent to sidewalks planted with dense vegetation, trees, and grass. As the runoff flows from the streets into the Green Street, vegetation and soil slows the flow of water and filters out sediments and pollutants.



Map 1. Dispersion of Green Streets in Portland compared to flooding risk. Flooding risk is assessed here as the sum of sewer backups + plugged inlets, normalized for the population of each census block.

Bioswales can be planted with a variety of trees, grasses and shrubs. In the case of Portland, the Department of Environmental Services has published a “Suggested Plant Guide” recommending plants based on their adaptability to both periodic inundation and extreme drought.<sup>15</sup> There are two zones comprising a Green Street, one on higher ground and one at the bottom of the depression, and the City recommends different plants for each. The plants recommended for the lower zone prefer wetter conditions. These include camas (*Camassia*), and daffodil (*Narcissus* species), while those adapted to drier soil include common yarrow (*Achillea millefolium*), fescue (*Festuca californica*, *Festuca glauca*, *Festuca idahoensis*, and *Festuca idahoensis* ssp. *roemerii*), and lily turf (*Liriope muscari*). Most plants used in Green Streets are native to the Portland area and the overwhelming majority are grasses.

These facilities are often built into or extending from pavement along roadsides, converting street pavement or grass strips into natural landscapes. In preventing sewer backups and combined sewer overflows into the Willamette, these facilities convert stormwater from waste into a resource.



Figure 3. Diagram of the stormwater capture function of a bioswale, with delivery to an outlet.<sup>16</sup>

<sup>15</sup> *Green Street Stewards Suggested Plant Guide: Options for Adding Plants to a Green Street Facility* (Portland, OR: City of Portland Bureau of Environmental Services, 2017).

<sup>16</sup> Photo referenced from “Portland’s Bioswales Give a New Look to Water Management Practices,” MJLARSONSITE (May 2014), <https://mjlarsonsite.wordpress.com/2014/05/19/portlands-bioswales-give-a-new-look-to-water-management-practices/>.

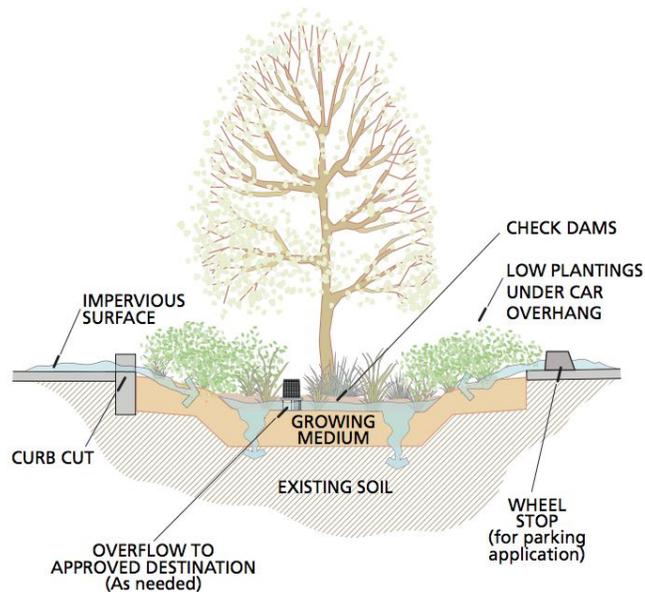


Figure 4. Diagram of the stormwater capture function of a bioswale, with infiltration of captured stormwater into the ground.<sup>17</sup>

Green Streets provide multiple community and environmental benefits to an urban landscape. Streets represent a 35 percent of Portland’s impervious areas.<sup>18</sup> Converting these streets to Green Streets can significantly decrease stormwater runoff by increasing the capability of these streets to absorb water. Green Streets are effective in reducing peak flows and flow volume to solve basement sewer backups and combined sewer overflows, thereby reducing the amount of polluted stormwater entering Portland’s rivers and streams. By reducing impervious surfaces, stormwater is able to infiltrate the soil to replenish groundwater. The vegetation and soil of the bioswale filter the stormwater, removing contaminants and cooling the water before it encounters rivers, streams, and groundwater. Green Streets have been shown to reduce total suspended solids, organic pollutants, and oils found in stormwater by 90%, and heavy metals by more than 90%.<sup>19</sup> The Green Streets thereby improve water quality and benefit overall watershed

<sup>17</sup> Photo referenced from *When it Gets to the Ground: Stormwater Solutions Handbook* (Portland, OR: City of Portland Bureau of Environmental Services), <https://www.portlandoregon.gov/bes/article/129057>.

<sup>18</sup> “Building a Nationally Recognized program through Innovation and Research,” Water Environment Research Foundation, accessed April 20, 2018, [http://www.werf.org/liveablecommunities/studies\\_port\\_or.htm](http://www.werf.org/liveablecommunities/studies_port_or.htm).

<sup>19</sup> Cited in *Green Streets Policy*, (Portland, OR: City of Portland Bureau of Environmental Services), <http://www.epa.gov/owmitnet/mtb/biortn.pdf>.

health. Other environmental enhancements include urban wildlife habitat and soil rehabilitation. Green Streets can also benefit a neighborhood economically as a cost effective alternative to sewer pipe replacement.<sup>20</sup> While Portland has been installing green streets to help cost effectively manage today's stormwater runoff, these same facilities will help the community be more resilient to more intense rain events in the future due to climate change.

## Equity Concerns

Green infrastructure adds both aesthetic and functional value to urban landscapes, but this can have some drawbacks. One major concern with the implementation of certain Green Infrastructure projects is closely related to green “beautification” projects. Projects that are highly visible, as many Green Infrastructure projects are, can focus on aesthetic value and promoting economic development rather than addressing community needs. Most new infrastructure, including Green Infrastructure, tend to have a positive impact on urban aesthetics and property values. However, implementing spacious green areas in lower-income urban spaces can create what is known as an “urban green space paradox.”<sup>21</sup> As a community's overall aesthetic and access to outside green spaces increases, the area becomes more desirable and housing prices rise. “Such housing cost escalation can potentially lead to gentrification: the displacement and/or exclusion of the very residents the green space was meant to benefit.”<sup>22</sup> Displaced residents may be forced into neighborhoods with even fewer resources and/or worse ecological problems.

The EPA documents a number of studies that discuss the economic impacts of Green Infrastructure.<sup>23</sup> Studies done in Portland show that street trees add \$8,870 to the sales price of houses and reduce their time on the market by 1.7 days.<sup>24</sup> An increase in tree canopy in parts of

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<sup>20</sup> *When it Gets to the Ground: Stormwater Solutions Handbook* (Portland, OR: City of Portland Bureau of Environmental Services), <https://www.portlandoregon.gov/bes/article/129057>.

<sup>21</sup> Jennifer Wolch, Josh Byrne, and Joshua Newell, “Urban Green Space, Public Health, and Environmental Justice: The Challenge of Making Cities ‘Just Green Enough’,” *Landscape and Urban Planning* 125 (May 2014).

<sup>22</sup> Wolch, “Urban Green Space, Public Health, and Environmental Justice.”

<sup>23</sup> “Green Infrastructure Cost-Benefit Resource,” United States Environmental Protection Agency, <https://www.epa.gov/green-infrastructure/green-infrastructure-cost-benefit-resources>.

<sup>24</sup> Geoffrey Donovan and David Butry, “Trees in the City: Valuing Street Trees in Portland, Oregon,” *Landscape and Urban Planning* 94, no. 2 (February 2010).

the city with small amounts of tree canopy increases the sale price of properties.<sup>25</sup> Researchers with the U.S. Forest Service estimate that existing street trees increase the sale price of properties located on the east side of Portland by about 3% based on the median sale price, which aligns with Netusil et al. 2014's estimate that "the full effect of existing tree canopy coverage in Green Street facilities is \$11,583 (4.39% of median sale price) of which \$5955 (2.26%) is a direct effect and \$5628 (2.13%) is an indirect effect."<sup>26</sup> Netusil et al (2014) studied the effect of proximity, density (abundance of facilities), and characteristics of Green Street stormwater facilities on the sale price of single family residential properties in Portland and found that an abundance of Green Streets, and Green Streets that add tree canopy cover, increases property values.<sup>27</sup>

Many suggestions exist, however, for cities and urban planners regarding their role in meeting community needs when designing and implementing new infrastructure. For example, a study on the gentrification effects of biking infrastructure in Portland suggests that "planners and decision makers should assume that all community members have a unique vision for their local environment and that their input is a critical mechanism for truly sustainable outcomes."<sup>28</sup> Engaging community members and community organizations in the design and implementation of infrastructure is a critical step in ensuring that community needs come first.

When it comes to environmental or green urban infrastructure in particular, methods of implementing "just green enough" solutions may also help mitigate gentrification concerns. "Just green enough" solutions focus on small-scale and evenly distributed sites that have major ecological functions other than beautification.<sup>29</sup> Thus, focusing on several small projects such as bioswales and ecoroofs—which do not take up much space and are able to be scattered evenly throughout the city—may be city planners' best opportunity to address ecological concerns while remaining wary of the equity implications of Green Infrastructure. This paper will further explore the distribution of Green Infrastructure in Portland, OR in order to better understand the

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<sup>25</sup> Noelwah Netusil, Sudip Chattopadhyay, and Kent Kovacs, "Estimating the Demand for Tree Canopy: A Second Stage Hedonic Price Analysis in Portland, Oregon," *Land Economics* 82, no. 2 (May 2010).

<sup>26</sup> Donovan, "Trees in the City."; Netusil, "Valuing Green Infrastructure in Portland, Oregon."

<sup>27</sup> Netusil, "Valuing Green Infrastructure in Portland, Oregon."

<sup>28</sup> Amy Lubitow and Thaddeus Miller, "Contesting Sustainability: Bikes, Race, and Politics in Portlandia," *Environmental Justice* 6, no. 4 (2013).

<sup>29</sup> Wolch, "Urban Green Space, Public Health, and Environmental Justice."

societal and ecological implications as well as to offer more advice for developers and planners regarding future Green Infrastructure design and implementation.

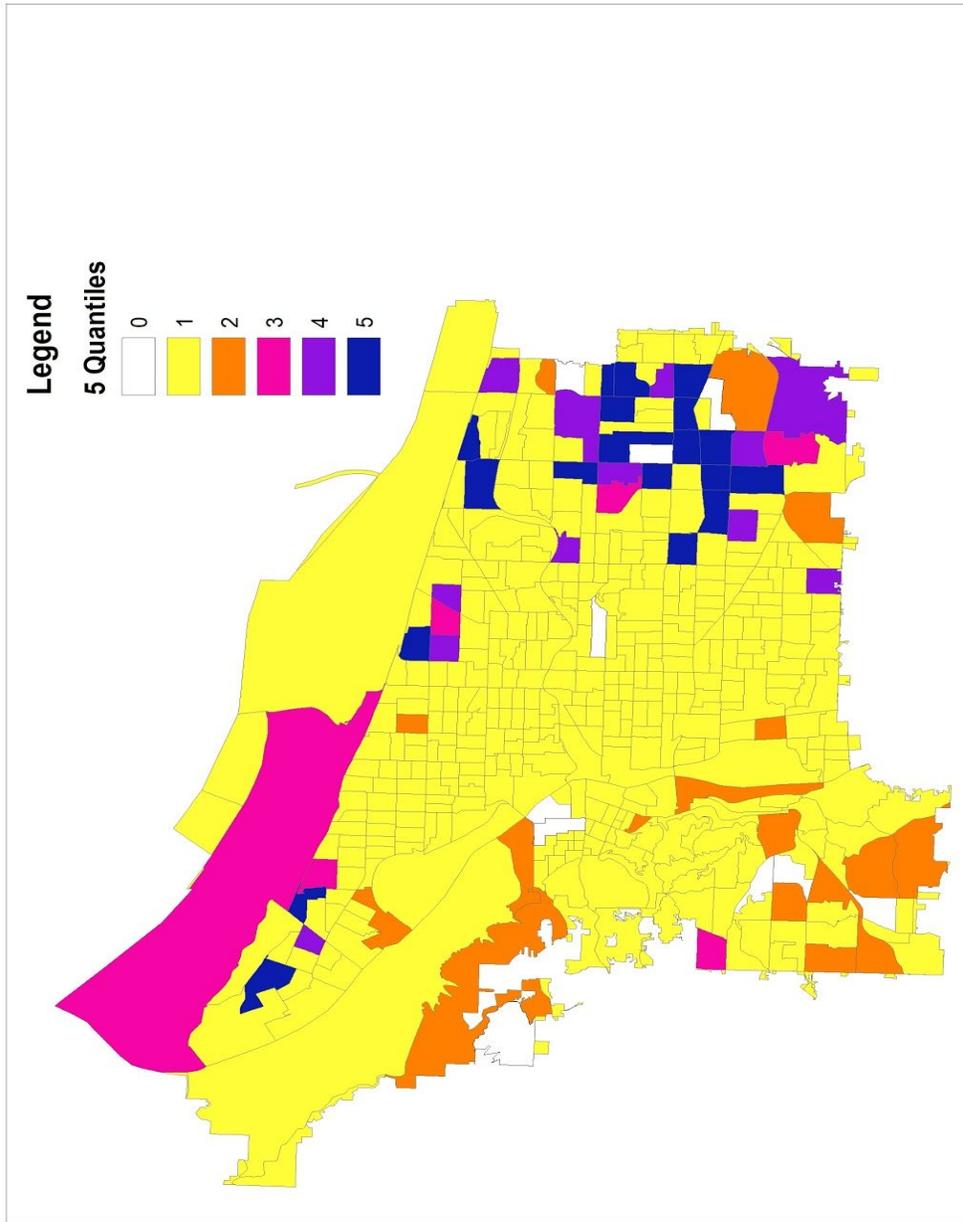
## Social Vulnerability

The City of Portland's 2014 Climate Risks and Vulnerabilities Assessment identifies a list of local hazards that climate change will exacerbate, including the frequency and magnitude of flooding events. While all populations are affected by climate change, the distribution of risks and harms of such events are not equal. Floods have geographically concentrated impacts. Elderly people and children, single parents, people living alone, people of low socioeconomic status (Low-SES), and communities of color are often especially vulnerable to these hazards and are less likely to have access to the resources needed for recovery. Among the twelve 2030 Objectives identified in the 2014 Risks and Vulnerabilities Assessment are several objectives related to improving the city's capacity for identifying vulnerable areas and populations. Objective 10, for example, suggests that the city "apply an equity lens to climate action efforts and where possible prioritize benefits to populations most vulnerable to the impacts of climate change" and "improve the understanding of local climate change impacts." The consequences of urban flooding on Portland's economic, social, and environmental systems are significant. These impacts include damage to homes, businesses, roads and public transit, as well as additional costs due to business closures, lost productivity, and cleanup. A combination of social factors can make a community more vulnerable to environmental hazards and less able to adapt to damaging events.

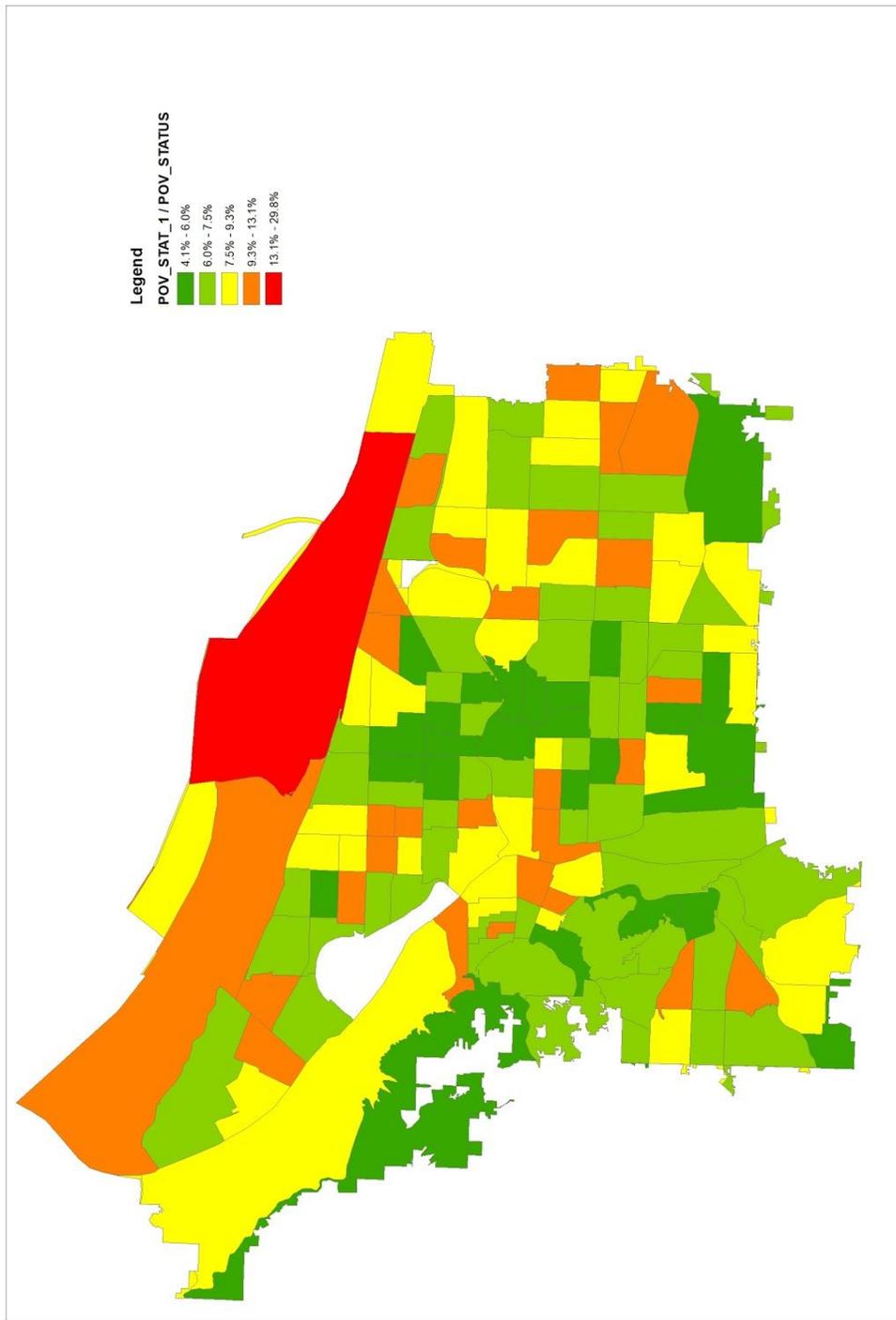
The Reed College Environmental Studies Junior Seminar course (ES 300) developed a Social Vulnerability Index (SoVI) in its 2017 ES 300 class project (Report available here: <http://www.reed.edu/es/courses.html>) that we will use again here. It aligns it with a biophysical vulnerability analysis as a strong indicator of overall hazard vulnerability to understand who will be impacted and where future climate hazards will be localized within Portland. Fifteen variables were chosen for the SoVI: socio-economic status (household income, percent population at or below poverty line, percent unemployed, population density), age (% population greater than 65,

percent population less than 10), race and ethnicity (% hispanic, african american, native american, asian, non white), gender (% female), family structure (% children in single parent household, % female head household, % live alone), housing and tenure (% renters), low educational attainment (% population 25 or older w/o high school diploma), social dependence (% on social security). The Portland census blocks were divided into quintiles based on their concentrations of these variables. Communities with high concentrations (above the city average) of several of these factors are considered part of the 5th quintile, a marker of extreme social vulnerability to climate hazards. Flood risk (the biophysical vulnerability) is strongly dependent on proximity to the hazard, i.e. location location within a floodplain or in an area of the city with an elevation less than 30ft. According to these two measures of vulnerability, the ES-300 2017 report identified a few key vulnerable areas. North Portland and Portland east of Lents, Pleasant Valley, and Powellhurst-Gilbert are particularly susceptible to flooding and are located within the 5th quintile –a marker of particular social vulnerability.

While vulnerability is defined as how susceptible a community is to harm, resilience is the capacity of the community to absorb harm and recover. These neighborhoods in the 5th quintile have fewer resources to respond to flooding events, such as ability to evacuate, access to food, or financial resources to rebuild. As a result, it is even more important to decrease the frequency and magnitude of these events in the 5th quintile. Green Infrastructure minimizes the local impact from flooding events and reduces the demand for emergency and social service responses.



Map 2. Quantiles of Portland based on socio-economic variables. Quantile 5 is the “most-disadvantaged,” by an analysis of socio-economic variables (ES 300 Report 2017).



Map 3. Percent of individuals below the poverty level in Portland, out of ACS survey participants who release poverty status.

## Goals of the Project

As a city located at the intersection of two major rivers, Portland and its metro area have always faced frequent flooding events. As previously discussed, these small but significant floods are projected to increase with time as global climate change increases winter precipitation in the Northwest.<sup>30</sup> While bioswales are not equipped to handle more severe twenty-five or fifty-year floods, they are shown to have a significant effect on smaller overflows by diverting rainwater and effectively increasing sewer capacity. This is most important in reducing sewer outflow to the Willamette, which as of 2004 was occurring over 100 times per year with serious consequences for the quality of the city's water.<sup>31</sup> Reducing this outflow was the number one goal of the Green Streets Program, and the city of Portland accordingly locates its Green Streets based on modeled impact on the sewer system.<sup>32</sup> There are obvious reasons why this must remain the city's primary motivation in the placement of Green Streets, but as the program progresses, it is becoming clear that bioswales have consequences on the neighborhoods where they are located which demand a more nuanced analysis of their distribution and maintenance.

Thus, this project aims to answer two questions: Is green infrastructure rationally distributed? And how can Green Infrastructure be distributed better? As mentioned previously, Green Infrastructure serves several purposes that may ultimately influence decisions as to where it is located. This particular study looks at the influence of pluvial flooding and social vulnerability on the placement of Green Infrastructure, broadly, and bioswales more specifically. From this investigation, we hope to make suggestions as to how pluvial flooding and equity concerns should be considered when building green infrastructure in the future.

To answer these questions, we ran multiple regression and time lag statistical analyses, conducted a field study of bioswales around Portland, and surveyed Green Street stewards. For the multiple regression analyses, we constructed three models: the influence of physical factors

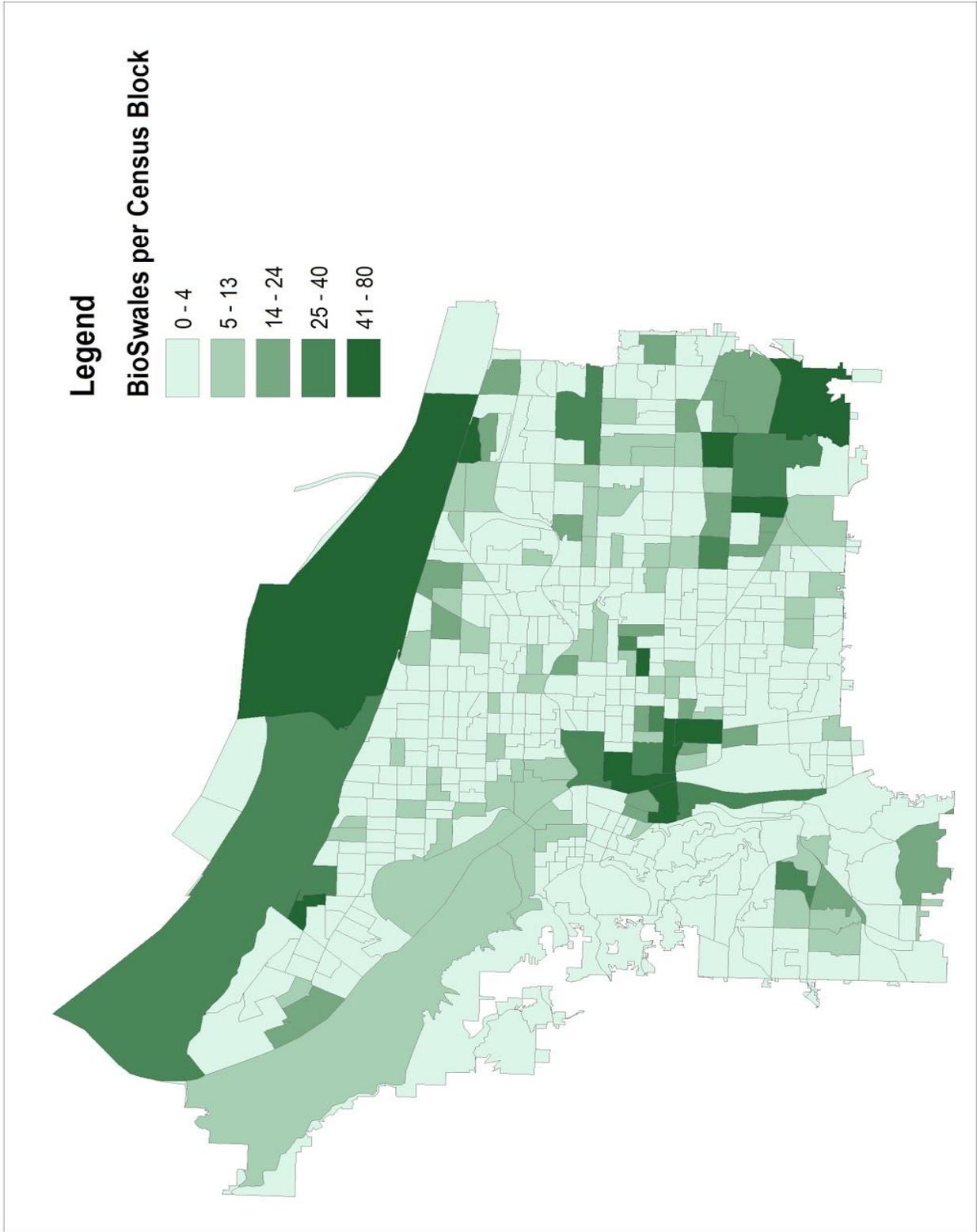
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<sup>30</sup> Heejun Chang, Martin Lafrenz, Il-Won Jung, Miguel Figliozzi, Deena Platman, and Cindy Pederson, "Potential Impact of Climate Change on Flood-Induced Travel Disruptions," *Annals of the Association of American Geographers* 100, no. 4 (October 2010).

<sup>31</sup> "Innovative Wet Weather Assessment Program," City of Portland Bureau of Environmental Services, <https://www.portlandoregon.gov/bes/35941>.

<sup>32</sup> "How Does The City Choose Green Street Locations?" City of Portland Bureau of Environmental Services, <https://www.portlandoregon.gov/bes/article/319879>.

on green infrastructure density, the influence of social vulnerability on green infrastructure density, and the influence of both flooding and social vulnerability on green infrastructure density. The time lag analysis help us determine the directionality of causation between bioswales and flooding. The bioswale field study compared bioswale area, non-weed plant cover, weed plant cover, and trash count between the highest and lowest social vulnerability quintiles. As we did not have enough time to obtain a large data set of real bioswales, no statistically significant quantitative data was obtained. Instead, this aspect of the study gave us an opportunity to go into the field and observe what bioswales look like in practice. The Green Street steward survey allowed us to obtain personal accounts of what the Green Street Stewards Program entails and gave us a limited sense of community impacts regarding bioswales.



Map 4. Number and distribution of bioswales by census block.

# Placement of Green Infrastructure

## Methods

### *Multiple Regression*

To determine what factors may influence the placement of Green Infrastructure in Portland, we ran several multiple regression analyses exploring three models of influence: physical factors, social factors, and both of those combined. Physical factors include flooding, population, and area of census block. Social factors were combined into a single index of social vulnerability derived from work by the Environmental Studies Junior Seminar of Spring, 2017, divided into quintiles.<sup>33</sup> Analyses were run with the quintile variable treated as an ordinal variable and a continuous variable. The measure of Green Infrastructure is the count of bioswales and ecoroofs per census block area.<sup>34</sup> The measure of pluvial flooding was taken as all recorded accounts of reported plugged inlets and sewer backups within a census block area in 2017.<sup>35</sup> The data was corrected for skew.

### *Time Lag*

A time lag analysis was conducted in order to try to discern the cause and effect relationship between Green Streets and pluvial flooding. Does the correlation revealed in the multiple regression suggest that flooding occurs around bioswales (and, thus, that bioswales are not functioning to reduce pluvial flooding) or does it suggest that flooding informs the placement of bioswales?

In the time lag analysis, only plugged inlet reports are used as a proxy for pluvial flooding due to limitations of the data set. The total number of plugged inlet reports in Portland was determined for each year (2011-2015). The total number of bioswales in Portland was determined each year for (2008-2017). To determine whether or not Green Streets reduce the amount of flooding, we analyzed the relationship between the number of flooding reports each year ( $F_t$ ) and the change in the number of bioswales ( $\Delta B$ ) time lagged by one ( $\Delta B_{t+1} = B_{t+1} - B_t$ ) and

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<sup>33</sup> See Map 2.

<sup>34</sup> See Map 1 for a map of bioswales and flood report density.

<sup>35</sup> Illustrated in blue on Map 1.

two ( $\Delta B_{t+2}=B_{t+2}-B_{t+1}$ ) years. To determine whether or not plugged inlet reports influence the placement of bioswales, we analyzed the relationship between  $\Delta B$  and  $F$  time lagged by one ( $\Delta B_{t-1}=B_t-B_{t-1}$ ) and two ( $\Delta B_{t-2}=B_{t-1}-B_{t-2}$ ) years.

## Results

According to Model 1, there is a significant, positive relationship between the number of instances of green infrastructure and both flooding by area and population. The relationship between flooding and green infrastructure is further confirmed in Models 3.1 and 3.2. Although there was no significant relationship found between green infrastructure and a specific quintile in neither Model 2.1 nor 3.1, regressions run with quintiles as a continuous variable in Models 2.2 and 3.2 imply a significant positive relationship.

Table 1. Linear regression models using green infrastructure, flooding, and social vulnerability quintiles.

<b>IV</b>	<b>Model 1 Physical Factors</b>	<b>Model 2.1 Social Factors</b>	<b>Model 2.2 Social Factors</b>	<b>Model 3.1 Combined</b>	<b>Model 3.2 Combined</b>
Flooding	0.2567 ( $<0.0001$ )*			0.266 ( $<0.0001$ )*	0.268 ( $<0.0001$ )*
Population	0.1749 (.00168)*			0.045 (.484)	.079 (.181)
Quintile**			0.0868 (.002)*		0.1113 (.0001)*
Quintiles					
1		-0.2018 (.262)		-0.1884 (.284)	
2		-0.2043 (.362)		-0.1213 (.566)	
3		0.1598 (.582)		0.2456 (.369)	
4		-0.0259 (.914)		0.1131 (.619)	
5		0.2243 (.307)		0.3447 (.097)	

Information to create the quintiles was obtained from the U.S. Census Bureau, as was population data. Flooding and Green Street counts and location were obtained from Portland BES; n=480.

\*p < 0.05

\*\* Quintile variable used as a continuous variable

The only significant time lag result is Entry 1, which shows that a change in the number of Green Streets installed in a given year significantly decreases the number of flood reports the following year (Table 2).

Table 2. Time lag analyses between flood reports and bioswale counts lagged by one and two years.

Entry	Regression (y by x)	Coefficient
1	$F_t$ by $\Delta B_{t-1}$	-6.53 (0.0089)*
2	$F_t$ by $\Delta B_{t-2}$	3.72 (0.49)
3	$\Delta B_{t+1}$ by $F_t$	0.011 (0.89)
4	$\Delta B_{t+2}$ by $F_t$	-0.065 (0.54)

Flooding and Green Street dates were provided by Nicholas McCullar (City of Portland); n=5.  
\* p<0.05

## Bioswale Field Study

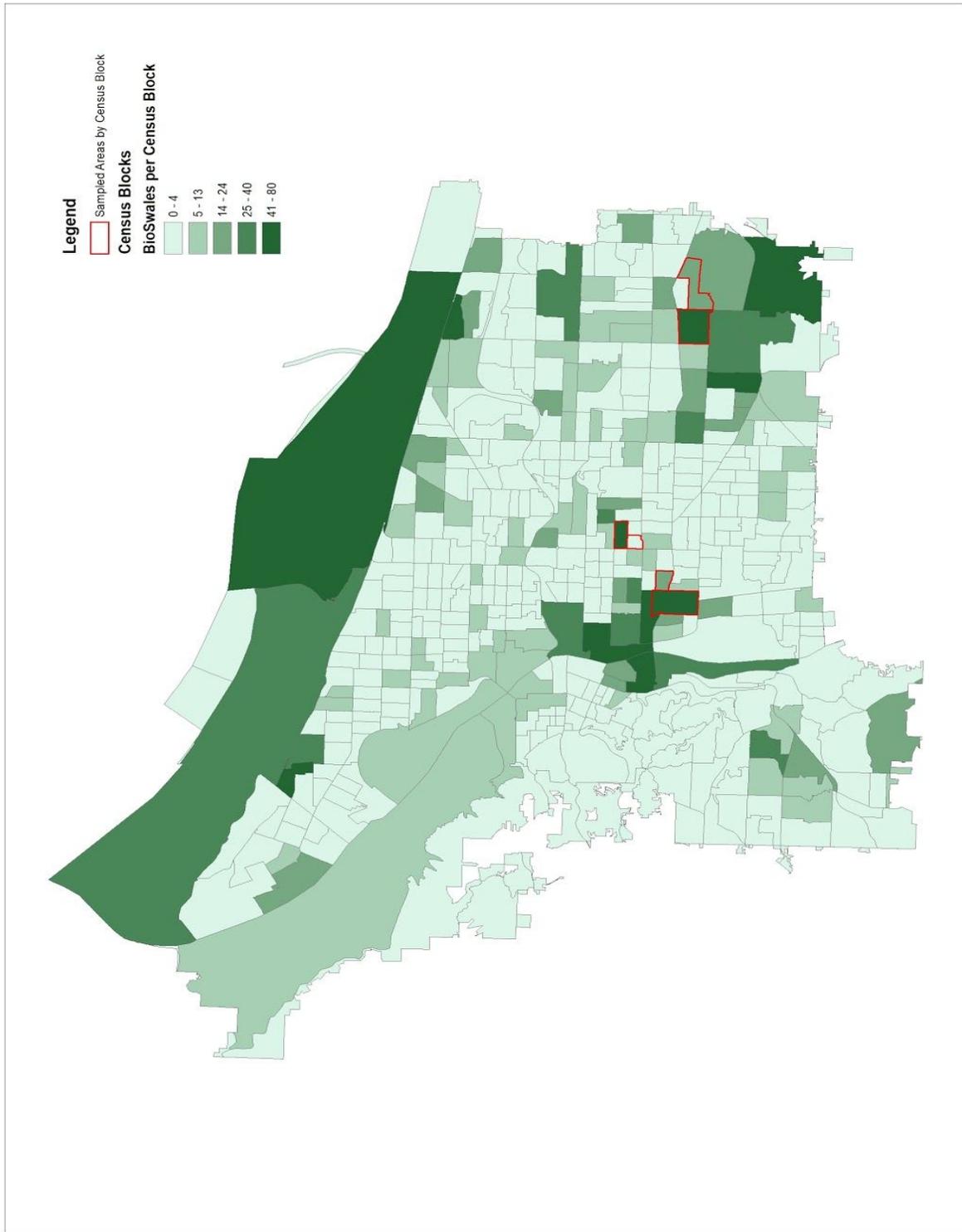
### Methods

Field data were collected from twelve Green Street locations<sup>36</sup>, two each in neighboring high (5) and low (1) quintile<sup>37</sup> census blocks in social vulnerability, number of flood reports, and green infrastructure density. Sites were selected from the center of each census block, not the edge, in attempt to select sites that are more representative of the census block. Sites were selected from neighboring high and low quintile census blocks to minimize additional variability introduced by locational differences. None of the Green Streets surveyed had volunteer stewards.

While we initially struggled to formulate how to measure the efficacy of a Green Street installation, we concluded that maintenance levels would be easier to quantify and would most likely correlate with efficacy. Each Green Street was measured for total area, and the area covered by weed and non-weed plants was estimated visually. The trash items present in each Green Street were counted and removed. Data were collected on April 8, 2018, during and directly following a heavy rain event.

<sup>36</sup> Depicted in Maps 6-8 in the appendix.

<sup>37</sup> Refer to Map 2 for quintiles.



Map 5. Areas in red are census blocks which contain sampled BioSwales. The sample sites were randomly selected as locations with neighboring high and low quintiles for each variable. Sites are as follows Site 1, Site 2, Site 3. From right to left. There are a total of 6 ID-unique BioSwales, two in each site.



Figure 5. Example of Green Street survey methods, at 4103 SE 132nd Ave.

## Results

Table 3. Mean area, weed cover, non-weed (intended) plant cover, and number of trash items found per area in Green Streets surveyed in the city of Portland.

		<b>Area</b>	<b>Non-weed plant cover</b>	<b>Weed cover</b>	<b>Trash cover</b>
Flooding reports	Lowest quintile	21.7 m <sup>2</sup>	87.5 %	0%	0.26 items/m <sup>2</sup>
	Highest quintile	20.9 m <sup>2</sup>	77.5 %	1 %	0.56 items/m <sup>2</sup>
Social vulnerability	Lowest quintile	26.6 m <sup>2</sup>	72.8 %	1.9 %	0.28 items/m <sup>2</sup>
	Highest quintile	41.5 m <sup>2</sup>	57.9 %	1.23 %	1.3 items/m <sup>2</sup>
Green Streets per area	Lowest quintile	27.4 m <sup>2</sup>	78.1 %	2.49 %	1.0 items/m <sup>2</sup>
	Highest quintile	30.1 m <sup>2</sup>	71.5 %	0.76 %	0.32 items/m

n=2 Green Streets for each row, 12 surveyed total.

Green Streets surveyed in high and low flooding report areas varied in plant cover, but not significantly (due to small sample size). Standing water was observed in one each of the high and low quintile bioswales. Green Streets in high and low social vulnerability quintiles varied in area, plant cover, and amount of trash. Green Streets surveyed in areas within the high social vulnerability were larger, had less non-weed plant cover, and had more trash items present per area. Additionally, Green Streets in high social vulnerability areas were composed of dirt and appeared older, while Green Streets in areas of low social vulnerability had younger plants and were composed of mulch instead of dirt beds. Green Streets surveyed in high and low Green Street concentration areas varied somewhat in terms of weed cover, but statistical significance cannot be inferred due to small sample size.

# Steward Survey

## Methods

We were put in contact with a set of volunteer Stewards through Svetlana Pell, the organizer of the volunteer program. This therefore wasn't a random sample, but given privacy concerns it wasn't practical to find the information of over 170 Stewards to do a proper random sampling. As a result, we spoke with Pell to ensure that our survey sample was representative. The Green Street Stewards we interviewed included a resident, business and community advocates, and a green team lead to provide a few different perspectives. Nonetheless, the limited provenance of the data should be kept in mind when interpreting our results. Once our group was identified, we sent them the following questions over email:

1. What is the address of the Green Street that you are responsible for located?
2. How far is it from your place of residence?
3. How did you hear about the Green Street Stewards program?
4. What activities do you do to maintain the Green Street?
5. How long does this typically take? And how often do you do complete maintenance?
6. Why did you sign up to be a Green Street Steward?
7. What kind of training/information did you receive when you became a Steward?
8. What do you think being a good Steward looks like?
9. Has being a Steward changed your relationship to your neighborhood?

Of our initial sample, only five responded, but each of those 5 submitted complete surveys. We also sent the following questions to the program coordinator Svetlana Pell and watershed ecologist at Bureau of Environmental Services, Chris Prescott:

1. How are the Green Street sites selected? Is there a central plan for the next streets to be built? If so, how far into the future does it stretch? If not, how are decisions made?
2. What does funding for Green Streets look like? Does it come entirely from the city

government, or are there also private sponsors or state/federal subsidies?

3. What does training Green Street stewards entail? What are the goals for training?

4. Is there any data on differences between steward-maintained and non-steward-maintained Green Streets?

5. What is the primary aim of the Green Street Stewards program? Maintenance of the streets themselves, or getting the community engaged and educated?

## Results

These Green Streets were all fairly close to their businesses or place of residence and were all within 5 blocks. Most people said that their maintenance activities usually take around two hours per month and include weeding, removing trash, and clearing openings, while a few volunteers also water and add new plants. Volunteer training usually involves a quick talk and demonstration with program coordinator Svetlana Pell as well informational materials.

Volunteers said that their main responsibilities are to help keep Green Streets functional and attractive while also helping to spread awareness among their communities. Most volunteers also cited their volunteering as a way to connect more with the people in their neighborhood, and appreciate the health of their local environment.

## Discussion

### Placement of Green Infrastructure

Trends among specific quintiles and green infrastructure relationships found in Models 2.1 and 3.1, in addition to the significant relationships found between green infrastructure and the quintiles as a continuous variable in Models 2.2 and 3.2 demonstrate that there is a relationship between the placement of green infrastructure and social vulnerability factors. It is likely that no significant relationship was found for any specific quintile due to the small and varying sample sizes. However, the significant positive relationship found between quintile as a continuous variable and green infrastructure implies that the higher the quintile (i.e. the more socially vulnerable) of the census block, the more green infrastructure is present. In addition, as

implied by the significant relationships found in Models 2.1, 3.1, and 3.2, a higher amount of flooding is positively correlated with green infrastructure. As this trend is consistent across the models, it is apparent that flooding is likely the primary factor in determining green infrastructure placement, and social vulnerability variables may be secondary.

Four time lag analyses were done to assess the relationship between the input of Green Streets and the resulting number of plugged inlet reports (Entries 1 and 2), and the number of plugged inlet reports and the resulting input of Green Streets (Entries 3 and 4). The directionality of the relationships is as expected for one-year lags (Entries 1 and 3). Entry 1 indicates that increasing the number of Green Streets results in a significant decrease in the number of flood reports within the following year. Entries 2-4 do not show any significant correlation in the direction implied by the multiple regressions. However, this is likely because the time lag was conducted on at the city-wide scale rather than on the census block level like the multiple regression

From the time lag analysis, we can infer that the direction of causality shown in the multiple regression. Particularly, since the time lag shows that Green Streets reduce instances of flooding, it is likely that flooding informs the placement of Green Streets rather than Green Streets causing flooding. To definitively discern the directionality of causation between flooding and Green Streets, a time lag analysis would have to be conducted on the census block level.

## Field Study

The data obtained were helpful in getting a general idea for what bioswales look like, but because of the small quantity of data, no conclusions or generalizations can be made with authority. Qualitative differences in the neighborhoods around the Green Streets surveyed were noted in the high and low social vulnerability quintiles. These differences visibly reflected the socioeconomic variables analyzed to create the social vulnerability index. This calls into question the variation in trash observed as an indicator of Green Street maintenance, as it could instead be due to differences in social standards, or garbage services in the area. As the areas designated as highly vulnerable are also largely underserved, this could be reflected in the general state of trash in the area. Regardless of trash however, the Green Streets in less

vulnerable areas having mulch might indicate that they are at least marginally better taken care of.

The field study would have benefited from a larger dataset. After surveying the bioswales, it seems feasible to collect a lot more data. Instead of selecting two bioswales from each quintile, all the bioswales on one or two streets or blocks could have been surveyed. This would not have taken much more time and would have resulted in a better representation of the bioswales in the area. There was an example of how this would have benefited the data from the “Number of Green Streets” survey: one of the bioswales surveyed (ID) had no standing water in it, but three of the four bioswales on the same block had standing water in it. Consequently, the survey was not representative of the area. More data could also help address the question of how continued function of greenstreets is related to continued maintenance and upkeep, that is raised by the time lag analysis of greenstreet implementation and flooding reports. It could be that those greenstreets function to reduce flooding only to the extent that they are maintained.

One factor that might be observed in future field studies could be which side of the street a bioswale is on (if the street is sloping). It would be beneficial to control for this variable when trying to analyze a different factor, like social vulnerability, because there might be a difference between two bioswales that is due to its location relative to the slope of the street and not the difference in social vulnerability. This issue would have been avoided if the method suggested above (surveying many bioswales on a street/block) had been used because variation between sides of street would be accounted for.

## Steward Survey

One of the major aspects of civic outreach which the city of Portland uses to gauge and maintain public support for bioswales is a program known as “Green Street Stewards.” According to the City of Portland’s Green Street Steward website, the main goal of this program is to train volunteers to maintain bioswales near their homes and businesses in order to improve city services and to make bioswales a more integral part of individual communities. This program is not only the main public face of Portland’s bioswale project, but also one of the few areas where citizen volunteers are able to interact with government employees on a regular basis.

Given the emphasis which the city puts on this program, we decided to investigate how it works, the rationale behind it, the specific goals it is meant to achieve, and the extent to which it appears to be fulfilling expectations. Our primary methods were direct interviews of both government employees and volunteer ‘Stewards,’ supplemented with a review of the secondary literature and the city of Portland’s own published materials on the Green Street Steward program.

Everett et al. found that one of the main ways in which public support for Green Streets can be improved is through greater public engagement.<sup>38</sup> This makes intuitive sense; when people are involved in the maintenance of community infrastructure, they are more likely to understand and advocate for the role of that infrastructure. In Portland, the Green Street Steward program has been operative since 2010, based initially on homeowner interest rather than government planning. The over 430 bioswales in Portland are now watched over by over 170 stewards, in addition to the city’s professional maintenance crew. These volunteers are disproportionately involved in local businesses, which also provide significant sources of funding for the program.<sup>39</sup> Many Green Streets are maintained in partnership with local businesses, as participation in the program is one of the qualifications for becoming a Portland certified sustainable business through the Sustainability at Work initiative. Eighty percent of our interviewed volunteers viewed their volunteer work as part of the mission of their place of employment, rather than simply as a personal duty or hobby. It is also interesting to note that many businesses may complete regular Green Street maintenance that may be similar to activities carried out by official Green Street Stewards. Although this unofficial work helps to keep Green Streets functional, it may be motivated by a desire to promote the appearance and general environment of their business.

It is clear that 170 stewards working a few hours per week are not a primary factor in the protection of the city’s stormwater capacity. However, given that infrastructure must be placed with the consent of Portland citizens, it is vitally important for the success of the Green Street program to maintain community links. In this sense, the work of the stewards—cleaning trash,

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<sup>38</sup> G. Everett, J.E. Lamond, A.T. Morzillo, A.M. Matsler, and F.K.S. Chan, “Delivering Green Streets: An exploration of changing perceptions in Portland, Oregon,” *Journal of Flood Risk Management* 11, no. 54 (November 2015).

<sup>39</sup> See “Green Street Steward Partners,” City of Portland Bureau of Environmental Services <https://www.portlandoregon.gov/bes/article/435054>.

removing invasive weeds—can be seen as largely devoted to maintaining a sense of Green Streets as positive contributions to the urban landscape. These contributions should not be dismissed as marginal in a situation where greater public engagement and positive publicity make a significant potential difference in the program’s ability to expand.

## **Conclusions and Policy Implications**

Overall, our study has verified that when Green Streets are installed and properly managed, they can be extremely beneficial to the surrounding area. They decrease instances of flooding and can be a mechanism for connecting communities. Moreover, small-scale projects such as bioswales and ecoroofs also allow the city to address ecological harms while avoiding equity concerns such as gentrification, which is known to occur as a result of highly visible “beautification” infrastructure. As long as the city follows the “just green enough” ideal, Green Infrastructure has the potential to decrease flooding throughout the city. However, one important question that should be addressed in future installations is whether bioswales are placed in areas where they are most needed.

The city currently chooses Green Street locations based on a few factors. First, bioswales are installed close to storm drains, where they will benefit the sewer system. As Green Streets decrease the total amount of water entering the sewer system, this reduces the possibility of combined sewer overflows. Other factors the city considers when deciding where to build Green Streets are the width of planting strips, the age and size of existing street trees, and parking impacts. However, a social equity component is not built into the city’s mechanism for determining Green Street locations. This is possibly because flood risk is generally based on physical location rather than social vulnerability. For example, the Johnson Creek floodplain in SE Portland covers much of Eastmoreland, which is one of the wealthiest neighborhoods in Portland. Although many of the most vulnerable populations are not at significant risk of flood hazards, there are still a few key vulnerable areas whose risk increases due to an inability to adapt or respond in the face of flooding events. These vulnerable areas include the East Portland

neighborhoods of Lents, Pleasant Valley, and Powellhurst-Gilbert, which are particularly susceptible to flooding and are located in the 5th social vulnerability quintile.

Portland's Climate Preparation Strategy involves identifying populations that would be significantly at risk from climate change and targeting adaptation efforts to those neighborhoods. Therefore, after noting which areas are susceptible to flooding based on sewer drain locations, flooding complaints, and physical factors like floodplain and elevation, the city should determine which of these areas are highly vulnerable. Our recommendation to the city is to focus flood preparation in those neighborhoods.

Intentional and focused efforts to identify and repair inadequate program and project designs for these communities must also be a priority. Some guiding questions that are important to consider are, first, whether the green steward program is active in these communities, and whether the Green Street facilities in these areas are well maintained or aging. Climate change adaptation must be a collaborative effort, and the City of Portland should coordinate outreach in highly vulnerable areas to increase awareness of the benefits of the Green Streets. This is all the more consequential as vulnerable areas are found to be largely underserved infrastructurally, and bioswales have higher instances of trash and are poorly maintained in those areas. Green Stewards programs in these areas can help create a sense of community, increase investment in the Green Infrastructure program, and improve the function of the bioswales through weeding and removing trash.

Second, when installing new stormwater management systems, those quintiles that are most susceptible to flooding should be a priority. The city should then tailor outreach, service delivery, and green infrastructure design that is relevant to the primary needs of these at-risk communities. Green Streets facilities, in particular, may change the "greenness" of a neighborhood by increasing the amount of grass, shrubs, and trees near a property. This can increase the property values in those neighborhoods leading to gentrification and pricing out vulnerable populations. Therefore, the city of Portland has the dual challenge of mitigating climate change risk equitably without gentrifying those neighborhoods. Since trees and high density of large bioswales specifically have been shown to increase property values and

potentially lead to gentrification, the bioswales installed in these neighborhoods should be planted with low lying plants and distributed within those neighborhoods diffusely.

The City of Portland is already experiencing evidence of climate change, with a 1-1.5 °C increase in temperature that is expected to be accompanied by extreme weather events, according to the 2014 Portland Climate Preparation Strategy. This contributes to the immediacy of addressing the issue of stormwater capture as it is expected to become more pressing in the near future. Rethinking city infrastructure and design is crucial for reducing current and future flooding, extreme weather, and other climate risks at the local level. Green Infrastructure has the potential to mitigate these risks, as our study has shown. However, a transition to greener infrastructure must be just at its core; in other words, cities should remain cognizant of equity concerns when it comes to new infrastructure. While more research is still needed, our study shows that city environmental efforts have the potential to create “just green enough” infrastructure that takes these equity concerns into account while still mitigating ecological risks.

## **Postscript: Interviews with Portland BES**

We spoke with two employees at the Portland Bureau of Environmental Services (BES): Environmental Program Manager Dawn Uchiyama, and Green Street Steward Coordinator Svetlana Pell on May 4th to understand the administrative perspective on the Green Streets program. We learned that green infrastructure such as Green Streets are required by new developers who disturb an area larger than 500 square feet. However, initial Green Streets weren't ideal since they were usually built by street contractors inexperienced with green infrastructure instead of landscaping companies. Over time, BES took a greater role in building Green Streets and one of their pilot projects involved putting several hundred Green Streets in a combined sewer basin to alleviate capacity issues from excess stormwater. When building new Green Streets, BES looks at the whole city and focuses on areas of highest risk problems such as sewer backups and pipe structural conditions. They use Green Streets as a tool to solve inventoried problems (mainly sewer backups) in sewer basins. In addition to accounting for potential conflicts from transportation, pedestrian, and utility corridors, Green Street location selection includes strong public involvement and education.

Federal money was only initially provided to pilot 12 ‘vegetated stormwater facilities’ which included infrastructure on private property in addition to Green Streets. Funding for Green Streets today comes mostly from utility fees charged to ratepayers which is also the largest source of BES funding for capital investment and operating work. However, new developers who are required to install Green Streets fund initial construction and the first two years of maintenance before the BES takes over.

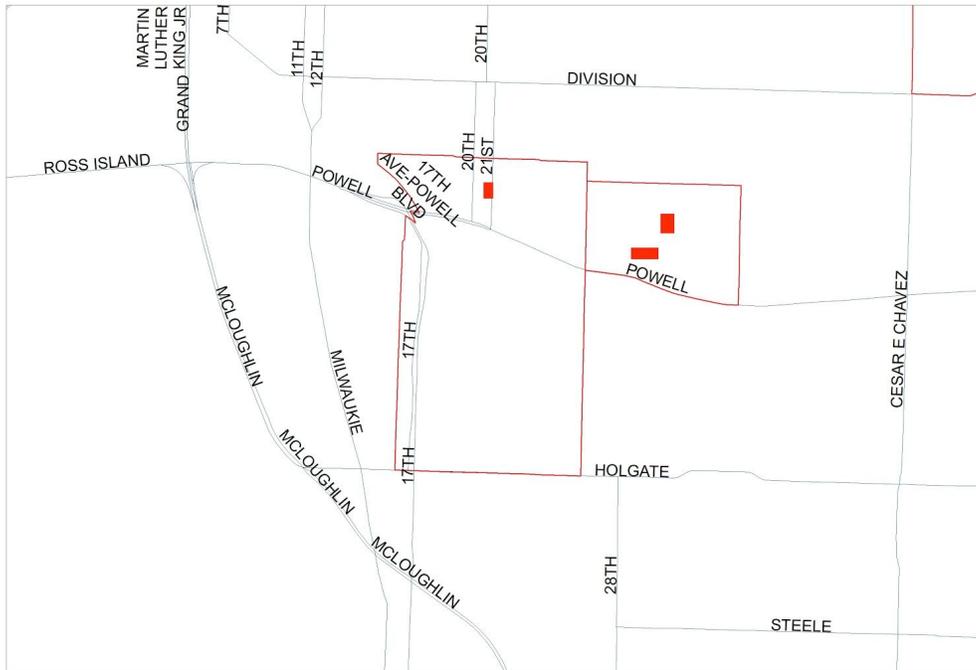
The Green Street Stewards program began due to community interest in getting involved from those living in neighborhoods with newly constructed Green Streets. Although BES provides some training and tools, ultimately this program is a bottom up initiative that seeks to involve community members in a meaningful way. While BES is ultimately responsible for these facilities, any work accomplished by Stewards helps to maintain the condition of Green Streets between scheduled maintenance visits while also lessening the workload of maintenance crews. Apart from maintenance, the main goal that BES has for this program is educating community members and increasing community awareness about the function of Green Streets in order to create a sense of ownership. Increased public engagement helps create more visibility for BES which may otherwise only be known by community members for utility bills that they issue. Education also sheds a more positive light on BES and fosters a sense of trust and respect among community members who previously may have resented the city for displacing marginalized people through new infrastructure development.

Although using Green Streets for storm water management is a fairly simple technology, future plans aim to refine the design to increase function, ease of maintenance, and integration into street design. Planning will also improve with better implementation of GIS mapping and other risk assessment tools. Future goals for the Green Street Stewards program are to continue to increase community involvement and provide people with the ability to install plants themselves into Green Streets. People from cities around the nation have contacted them asking how a program like this can be implemented. Svetlana and Dawn cited community involvement fostered through education, as well as an existing environmental awareness ingrained in the Portland community.

## Appendix

Table 4. Locations of all Green Streets included in the field study.

<b>Attribute</b>	<b>Quintile</b>	<b>Hansen Unit ID</b>	<b>Location</b>
Flooding reports	1	APN472-APN473	2904 SE Kelly St
		APN499-APN500	3326 SE 28th Place
	5	APN441-APN442	3228 SE 23rd Ave
		APA086-APA087	3029 SE 21st Ave
Social vulnerability	1	APG419-APG420	4030 139th Ave
		APB524-APB525	13805 SE Gladstone St
	5	APQ502-APQ501	4103 SE 132nd Ave
		APV162-APV163	4220 SE 130th Ave
Green Street density	1	AQD171-AQD173	4207 SE Division St
		AQH912-AEE809	4315 SE Division St
	5	APG615-APG616	4206 SE Clay St
		APG711-APG712	4434 SE Clay St



Map 6. Site 1 BioSwales indicated in red blocks. Census tracts outlined in red as illustrated in Map 5; Street names in black.



Map 7. Site 2 BioSwales indicated in red blocks. Census tracts outlined in red as illustrated in Map 5; Street names in black.



Map 8. Site 3 BioSwales indicated in red blocks. Census tracts outlined in red as illustrated in Map 5; Street names in black.



Figure 6. From left to right: Zoe, Maryam, Gayle, Edward, Isabelle, Partrick, Chris, Julie, Bella, Sarah, Tiffany, Mary. Not pictured: Cassandre.

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