Green Streets: More Than Just Drainage

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Writer's Comment: When I took Landscape Design 1 in the fall, my professor mentioned the environmental design concept of green streets, specifically in Portland, Oregon. The topic really captured my attention, so I did a little extra research on my own. When my Landscape Design 3 professor assigned our research paper on a sustainability topic of our choice, I knew I wanted to research everything green streets can do. Not many people have heard of green streets, and those who have mostly know about their stormwater management capabilities. However, I was interested in presenting the argument that Green Streets have many other beneficial and sustainable effects. I hope my research can help more people realize the multitude of advantages that green streets can bring.

Instructor's Comment: As the instructor of a large, wide-ranging lower-division class such as LDA 3: Sustainable Development Theory and Practice, what I care most about is not that students memorize what I say, but that they get truly excited about some topic related to the course. I assign a 10-page, open-subject paper with that hope—that each student will find some facet of the sustainability challenge to passionately explore. Audrey McLane has certainly done that in her paper on Green Streets. She clearly and logically explores every aspect of this subject, and her enthusiasm shines through. Audrey is entering the second year of our new Sustainable Environmental Design major and is active in the UCD Environmental Club. Based on this paper, I am sure that 5 or 10 years from now she'll be designing, if not green

streets, then some other closely related feature to make cities and towns more sustainable.

– Stephen M. Wheeler, Department of Human Ecology

Picture a street lined with trees and low lying vegetation. The trees provide shade, fresh air, and a pleasant appearance. The street is walkable and cyclists pass you in the bike lanes. On rainy days, the planters collect water and filter it naturally. The whole street feels peaceful and connected with a sense of care and community. This is how a green street can feel to its users.

Green streets have different meanings to different organizations. The Environmental Protection Agency (EPA), focusing on their water treatment effects, describes green streets as "Urban rights-of-way combined with green techniques [that integrate] storm water treatment."

Seattle, Washington has a more pedestrian-centered defintion, noting that green street design "gives priority to pedestrian circulation and open space over other transportation uses." Regardless of the exact phrasing, green streets provide solutions to environmental, infrasturcture and social issues that cities face. Green streets do much more than help with drainage issues. They provide green space, improve bicyclist and pedestrian transportation, reduce the urban heat-island effect, and lower crime rates.

Green streets offer a better alternative to city storm water management. In typical city storm water systems, all storm water enters the system through storm drains located along the streets. These streets create impermeable barriers (CWP 2016); unable to soak into the ground, excess storm water floods streets and picks up pollutants from the surface. All pollutants - sediment, pesticides, oil, grease, etc. - are then carried to storm water treatment facilities (CWP 2016). These facilities are costly to maintain and often cannot keep up with excess storm water. Some water stays in the city streets, flooding properties and making streets unsafe (EPA 2008). Alternatively, green streets mimic a site's natural hydrology, allowing water to infiltrate the ground where it is then filtered and stored close to where it fell, replenishing the local ground water table. This is accomplished through the use of plants, soils, and microbes that filter pollutants from the water (EPA 2008). Using green streets improves water

quality and lowers the cost of water treatment while also reducing the risk of sewer storage overflow during episodes of high rain (EPA 2008).

A significant benefit of implementing green streets is more efficient infrastructure. The city of Portland, Oregon had an increase in the efficiency of its pipe infrastructure after implementing green streets (City of Portland, Oregon, 2013). The city built 920 green streets, with an emphasis on partnerships with other city bureaus and agencies in Portland (Portland 2010). These new areas help to reduce an estimated 90% of storm water runoff, saving the city "142,100 kWh annually" (Portland 2010). Replenished water tables also help to minimize the amount of water cities have to import (Center for Watershed Protection). Cities that do not have room for whole new systems can be retrofitted to create a localized solution for storm water management issues. This approach "reflects the city as part of rather than separate from the ecosystem" (Church 2005). By including the city in the ecosystem, a more holistic course toward sustainability is enacted. A reduction in storm water running through city infrastructure also has the benefit of reducing energy consumption for production.

Neighborhoods with green streets also have increased access to green space and nature. With the outdoors being more appealing, social connections among neighbors are more likely to occur, . Especially in inner-city neighborhoods, it has been shown that "treed outdoor spaces are consistently more well used by youth, adults, and mixed-age groups than treeless spaces" (Kuo & Sullivan 2001). People also have increased opportunity for outdoor recreation, further increasing the chances of social connections within neighborhoods (City of Portland, Oregon 2010). Children are more likely to be seen playing outside, adding to the pleasant atmosphere of a neighborhood (PSU 2010). When residents see neighbors out and about, they are compelled to go outside as well. Offering aesthetically pleasing spaces for people outside plays an integral part in the likelihood of neighborhood interactions occurring on the street. Psychological studies have also found that access to green space helps improve concentration and memory. People tend to shift into a more rested mindset, which helps to foster the psycho-physiological activation that is necessary for complex work (Kellert 2004). Through their urban form and incorporation in street design, green streets provide calming and inspiring environments that encourage learning, inquisitiveness, and alertness (Heerwagen, 1993). Mental fatigue from overstimulation

throughout the day can be lowered with engagement with nature. Taking a break in an area with greenery can help to combat the effects of traffic, phones, and daily stresses (Kaplan 1995). Having a space that allows for both social connections and mental recharging is important, and green streets provide that opportunity.

Neighborhoods with green streets see improvements in actual and perceived safety, especially through lowered crime rates. On average, 3.8% of the U.S. population is the victim of a crime each year (FBI 2008). Kuo & Sullivan found a 48% decrease in property crimes and a 56% decrease in violent crimes in neighborhoods with high vegetation levels (2001). The cause of this crime rate reduction comes from an "increase in community cohesion" (City of Portland, Oregon 2010) and more people on the streets discouraging crime by having "eyes on the street." The likelihood of being discovered is a deterrent for many would-be criminals. Another explanation is that a "green and groomed appearance…is a cue to criminals that owners and residents care about a property and watch over it and each other" (Kuo & Sullivan 2001). This improvement in exterior aesthetics can help homeowners alleviate the problem characteruzed by the "broken windows" theory. Some argue that adding more vegetation to the streets decreases visibility. While it is true that large shrubs and dense woods do so, there are other vegetation options that would not. Flowers and low growing shrubs, as well as high-canopy trees do not affect visibility (Kuo & Sullivan 2001). Resident's perceived safety is also increased when green streets are added to neighborhood design. A study found that residents with more vegetation outside their buildings "reported a greater sense of safety than did their counterparts living in relatively barren settings" (Kuo, Bacalcoa & Sullivan 1998).

The improved safety of neighborhoods can also be felt through the prioritization of bike and pedestrian traffic over cars. Traffic calming elements, such as extended curbs and medians not only "provide site opportunities for bioswales, street trees, and rain gardens" (Dumbaugh 2005), they slow traffic, making streets safer for bicyclists and pedestrians alike, while widened sidewalks provide extra distance between pedestrians and the street, adding to their sense of safety. Use of permeable streets to complement green streets also helps drivers, as flooding and the risk of hydroplaning are lessened. This decrease in street flooding allows for increased visibility of the terrain for bikers, allowing them to avoid cracks and other potentially dangerous features in the street (National Complete

Streets Coalition 2009). Increased road visibility may motivate more bikers to travel in less favorable conditions.

Cities such as Seattle, Washington, prioritize pedestrian traffic through "strengthened connections between residential enclaves and other Downtown amenities" (City of Seattle 1993). "Strengthened connections" are created through focusing the street improvements on how they will affect pedestrians, bicyclists, and users of public transit. Seattle has used these guidelines to create a "shared street" with reduced vehicular travel at the popular Pike Place (City of Seattle 1993). Pedestrians, bicyclists, and cars are all accommodated in the street, with priority given to pedestrians, so any vehicles on Pike Place have to move at very slow speeds.

By emphasizing commuters who do not use cars, green streets help to combat CO2 emissions and poor health due to inactivity. It is estimated that the amount of walking and biking that occurs in replacement of automobiles saves $4 billion of gasoline and emits 14 million fewer tons of CO2 (Rails to Trails 2016). Of course, 'active transportation,' – walking and biking – can improve citizens' health, leading to lowered healthcare costs for state and federal governments. As much as $235 billion per year could be saved, according to the Health Economic Assessment Tool (National Highway Traffic Safety Administration 2009). The implementation of green streets can help cities lower their emissions in addition to improving citizen health.

Poor air quality can also be improved through the vegetation included in green streets. The plants sequester carbon dioxide emitted through combustion in cars. This sequestering of carbon dioxide helps with air quality and pollution in cities, but only in small increments. Certain trees, such as conifers, remove aerosols and other airborne particles from the surrounding air (Manning 2008). With this in mind, cities do have to be careful about what trees to plant, as some release biogenic volatile organic compounds (BVOCs) that assist in ozone formation. This phenomenon can be seen in Atlanta, Georgia (Manning 2008). Formation of ozone led to a 20% loss of the urban forest, which led to further release of BVOCs from the remaining trees (Nowak 2002). More research is needed into the quantitative effects that vegetation has on air quality in cities. Though they provide relief of CO2 emissions, the release of potential BVOCs released into the environment may offset the benefits of trees (Manning, 2008). However, scientists are not in

agreement on this topic. Some believe trees are eight times more effective in filtering nitrous oxide and particulate matter from the air. Yet it is advised that "care is taken to avoid trapping pollutants beneath their crowns" (Nowak, 2002). Grasses and other plants have been found to "reduce the concentration at street level of NO2 by as much as 40% and PM [particulate matter] by 60%" (Green, 2012). For vegetation in green streets to effectively reduce air pollution, where and how it is planted needs carefully consideration.

Green streets help lower the effects of the urban heat-island effect, or the "rise in temperature of any man-made area, resulting in a well-defined, distinct 'warm island'" (Arrau & Peña, 2015). This warming is caused when excess heat is absorbed by concrete pavement and buildings. Urban areas are the most susceptible to this as they have high concentrations of pavement with few to no pauses of green space. However, the effects of this warming can be mitigated through tree and plant cover in green streets. Plant cover releases excess water through transpiration when the surrounding air heats up, cooling itself and the surrounding environment (NASA, 2016). Additionally, the carbon sequestering that plants provide helps to reduce the amount of heat trapped in the atmosphere. Trees provide shading that cools the air in their immediate vicinities and that also covers any concrete that would otherwise absorb and emanate heat. Trees that are placed on the south sides of buildings are beneficial in lowering the energy used for cooling, thereby reducing the amount of CO2 emitted from cooling processes (Hoffman & Shashua Bar, 2000). During the winter, this placement also allows for "maximum solar gain" when the leaves have fallen (Manning, 2008). Trees that have closely spaced, light colored leaves provide the greatest cooling benefits to their surroundings (Biomimicry Institute, 2016). Rough leaf texture also helps, since the added surface area provides more space for evapotranspiration to cool the leaves. Green streets provide plant cover and trees that help to mitigate the urban heat-island effect.

While planting trees in green streets can have huge benefits, the lack of space in planters means insufficient space for roots to grow. However, this problem can be solved through the installation of silva cells. Silva cells are a suspended pavement system that uses soil volumes to support large tree growth. They are 92% space, allowing for essential city utilities to still be placed and for soil to avoid compaction from the overlying pavement (deeproot, 2016). Openings in the deck also allow for air and

water to penetrate the soil, further enhancing the growth of trees in green streets and cityscapes. Even when trees are not a possible element in green streets, the presence of soil and ground cover plants will help cool ambient temperatures. Water evaporating from the soil or exiting the plants through transpiration releases water into the air, helping to cool it. Well-watered plants help the most, as air can move through the leaves and be cooled significantly (EPA, 2006). Cities can also increase the albedo of the pavement and buildings. This is an option in areas where green streets cannot be placed. To further conserve water, all vegetation in green streets should be native, drought-tolerant species (EPA, 2015).

Aside from positive environmental effects, green streets also provide economic benefits. It is difficult to monetize and quantify the environmental benefits and impacts that green streets provide though (EPA, 2015). Many of their benefits are not immediately felt, but are long-term. One immediate saving is from lowered cooling energy costs. By providing shade to buildings and surrounding pavement, trees reduce the amount of cooling necessary. This is also a long term benefit, as the less energy used now, the less is contributed to climate change. There is no tangible way to measure this, however, so it cannot be easily marketed as an economic benefit. However, green streets raise property values. This is a large incentive for homeowners to agree to green streets, as it is something they can own directly. The aesthetic qualities from additional greenery in a neighborhood is directly linked to the price of a house on the market. For every additional point a community has for a Walk Score (a number between 0 and 100 that reflects how easy it is to get around without a car) the assessed values of real estate increase from $700 to $3,000 (Pedestrian and Bicycle Information Center, 2009). Additionally, with more greenery, more people are inclined to walk outside, making a neighborhood seem more desirable. Increases in walking and bicycling can lead to decreases in car ownership, which accounts for 19.5% of a typical household's income (AAA, 2012). Comparatively, the cost of using a bike for a year is only $308 (League of American Bicyclists). Even if car ownership remains the same, walking or biking instead of driving lowers the amount spent on gasoline (Pedestrian and Bicycle Information Center, 2014). Replacing conventional streets with green streets leads to economic benefits that directly impact residents.

Homeowners experience fewer property damages from flooding (Sample, Heaney, Wright, Fan, Lai, & Field, 2003). Cities also have

a lowered cost for cleanups and stream bank restoration, because of the lowered need to repair and maintain storm water infrastructure. For business owners, having their businesses located on green streets means an increase in pedestrian traffic. More shade from trees outside storefronts creates a "welcoming 'front door' for pedestrians" (City of Seattle, 1993) that encourages them to enter the stores. The Water Environment Research Program found that shops located on tree-lined streets experienced a 12% increase in sales over those on streets without trees (2009). In Portland, Oregon, businesses with bike lanes and bike parking outside of their storefronts had "one-quarter or more of their customers arrive by bicycle" (TR News, 2012). Even in the creation of more walkable and bike friendly streets, 11-14 jobs are created for every $1 million spent. This is twice as many jobs as are created by highway projects (Pedestrian and Bicycle Information Center, 2012). There are many economic benefits that can be had from implementing green streets in neighborhoods.

Green streets provide a multitude of benefits - from storm water management to decreased urban heat-island effect to transportation advantages - making them a lucrative environmental investment. However, given the cost-to-immediate gratification ratio, investments in green streets are not yet common. Green streets, while a very successful and important part of sustainability, are not the only answer. They are only a small step to attaining sustainability in cities. There are many different social, economic, and aesthetic factors to be considered when striving to attain a sustainable landscape. True sustainability incorporates multiple solutions into one and thinking holistically makes the greatest impact.

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