GREEN STORMWATER INFRASTRUCTURE

IMPACT ON PROPERTY VALUES

photo credit: Philadelphia Water Department

SBFRIEDMAN

CNT

SUMMARY

Green stormwater infrastructure (GSI), such as rain gardens, swales and porous pavement allows us to use natural systems to control stormwater and urban flooding. GSI brings dozens of benefits to neighborhoods that traditional "gray" stormwater infrastructure does not, including places to play, habitats for other species, and cooling on hot days.

This report shows that GSI also adds value to homes. The Center for Neighborhood Technology (CNT) worked with SB Friedman Development Advisors to model the impact of GSI installations, such as rain gardens and swales, on property sales data in two cities and found statistically significant higher sales prices of homes near GSI. These findings add to a growing body of research that shows that nature-based solutions to stormwater management provide many benefits in addition to flood control.

photo credit: NACTO

What we found:

- **Doubling the square footage of rain gardens, swales, planters, or pervious pavement near a home is associated with a 0.28% to 0.78% higher home sale value, on average.[1]**

What this means:

- A homeowner with a $250,000 home could see an increase of $700 to $1,950 in home sales value with a doubling of nearby GSI.
- Property value benefits can be part of funding and financing plans for GSI. If the impact we found holds at scale, a community of 10,000 homes could see $7 million to $20 million in value created by doubling the size of GSI near each home.
- However, property value increases can create housing insecurity for renters, seniors and other residents. Communities must take pre-emptive action to address any potential displacement risk or financial stress caused by GSI's impacts on home values.

1. Findings are % change in residential sales price per 100% increase of square footage of GSI within a 250-foot buffer of the home.

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IMPORTANCE OF GSI AND PROPERTY VALUES

Stormwater management is critical to community resilience needs as we face the impacts of a changing climate, including more frequent and stronger storms. Asphalt and concrete that prevents rainwater from soaking into the ground leads to urban flooding. Better performing solutions, such as swales and pervious pavement, allow stormwater to infiltrate into the ground instead of flowing into streets and homes. We know that adapting our communities to prevent flooding will save money when storms hit. What the Center for Neighborhood Technology (CNT) and SB Friedman Development Advisors (SB Friedman)'s new research shows is that Green Stromwater Infrastructure (GSI) is also associated with higher property sales prices that create value for residents even during blue skies.

The benefits of trees and parks to property values have been well documented and are already considered in home appraisals and purchase decisions, but newer types of GSI, such as swales and rain gardens, have been less well documented. Accounting for the full economic benefit of GSI is essential to increasing the scale at which it is used as an infrastructure solution. As communities calculate the lifecycle costs and benefits of GSI they can now include a property value benefit based on this research.

This paper documents our research findings on GSI and property values and their implications for communities in terms of GSI finance and preventing household displacement. This research adds to the suite of tools and information CNT provides on GSI benefits, including:

- Green Values Calculator (coming December, 2020), which includes these latest findings on property value impacts in an interactive online tool.
- Green Values Strategy Guide (2020), which provides information on how to document other health, economic, climate and transportation benefits of GSI.
- Increasing Funding and Financing Options for Sustainable Stormwater Infrastructure (2020), which lays out funding and financing models, including lessons learned from the energy and transportation sectors.

IMPACTS OF GSI ON PROPERTY VALUES

We used geocoded data from Seattle and Philadelphia on GSI installations along with real estate sales data to assess the impacts of GSI on property values. Our hedonic pricing model controls for other factors affecting home sales price, including property characteristics like number of bedrooms, location characteristics like distance to transit, and season of sale, to isolate the impact of GSI on home sales price. The following describes our findings for four groups of GSI types.

Rain Gardens, Swales and Planters

Rain gardens, swales and planters are quintessential applications of distributed GSI that are typically vegetated and allow stormwater to infiltrate into the ground. Their stormwater control impacts are well documented, but they also provide aesthetic appeal and other benefits that may impact property values.

What we found

In Seattle and Philadelphia, we found that a 100% increase in square footage of rain gardens, swales or planters within 250 feet of a home is associated with a **0.38% to 0.69%** higher residential sale price.

What this means

That implies that going from 100 square feet to 200 square feet of rain gardens or swales could create $950 to $1,725 in additional value for a $250,000 home.

photo credit: Leonel Ponce on Flickr

Stormwater planter, Philadelphia.

Pervious Pavement

Pervious pavements are materials that allow stormwater to infiltrate sidewalks, driveways or even some roads. Depending on the material and design, pervious pavement may incorporate vegetation or look similar to traditional pavement, but its stormwater management performance is significantly better.

What we found

In Seattle and Philadelphia, we found that a 100% increase in square footage of pervious pavement within 250 feet of a home is associated with a **0.28% to 0.78%** higher residential sale price.

What this means

That implies that going from 100 square feet to 200 square feet of pervious pavement could create $700 to $1,950 in additional value for a $250,000 home.

Pervious pavement

Wetlands, Basins and Trenches

Wetlands, Basins and Trenches are larger-scale stormwater management forms typically designed for stormwater detention, although they may also allow infiltration. These GSI types can be designed to provide aesthetic or recreational value to a community or have relatively utilitarian design features.

- In Philadelphia, the relationship between wetlands, basins, trenches and home sales prices was not as strong as it was for other GSI types. We found that a 100% increase in square footage of wetlands, basins or trenches within 250 feet of a home was associated with a **0.23%** higher residential sale price when controlling for homeownership in the census tract at a 0.1 level of statistical significance. We did not find any statistically significant relationship when controlling for education or poverty rates in the census tract.
- In Seattle, there were only 9 wetlands, 2 basins and no trenches in our data, which may be why we did not find a statistically significant relationship with these GSI types and home sales prices in Seattle.

photo credit: Christopher B. Hoffman Landscape Architect

Green Roofs and Cisterns

Green roofs and cisterns retain and reduce runoff. Green roofs can also be designed for recreation or urban agriculture. The economic benefits of green roofs to commercial building owners, rental property owners and more are well documented in the literature (see Bibliography). However, our findings in Philadelphia showed a negative correlation with residential sales values and the Green Roofs and Cistern GSI types. We hypothesize that this negative correlation may be because green roofs and cisterns in Philadelphia are often on commercial properties.[2] Therefore, the residential home sales near these green roofs and cisterns in our dataset may be impacted by lack of residential neighborhood amenities, commercial operations or other factors that are not captured in our model. This is an area worthy of further research.

- We found that a 100% increase in square footage of green roofs and cisterns within 250 feet of a home is associated with a **-0.61% to -1.5%** lower residential sale price. However, as described above, we hypothesize that this value may not be representative of residential green roofs and recommend caution in using this finding. See the bibliography for additional research on green roof impacts.
- In Seattle, there was only one green roof in our data, and that sample was too small to find meaningful results.

photo credit: areedie on Flickr

Green roof on the 17th floor of
the Russell Investments Center in Seattle

2. Philadelphia offers a business tax credit of up to 50% for green roofs, which is a significant incentive for commercial installation. The city also has a grant program for non-residential stormwater projects, and commercial developments face stormwater requirements that can be met in part with green roofs and cisterns. As a result, there are grocery stores, office buildings, hospitals, and other non-residential facilities with green roofs throughout the city. These are a great benefit to the city's stormwater management needs and provide many co-benefits, including heat island mitigation.
See also: City of Philadelphia. "Green Roof Tax Credit." Accessed October 2020. https://www.phila.gov/services/payments-assistance-taxes/tax-credits/green-roof-tax-credit/
City of Philadelphia, Philadelphia Water Department. "Stormwater Grants, Application Guide. Vol 2.0." December 2019. https://www.phila.gov/water/wu/Stormwater%20Grant%20Resources/StormwaterGrantsManual.pdf

IMPLICATIONS FOR FUNDING AND FINANCING GSI

Overall, the findings that rain gardens, swales, planters and pervious pavement are associated with higher home sales prices is evidence of their value creation. This additional value can play a role in funding and financing green infrastructure installation by individual property owners, municipalities or stormwater utilities.

As with most infrastructure investment, the capital cost of GSI must occur before its stormwater management benefits or its impact on property values can be realized. Communities use a variety of financing mechanisms to address this gap between investment and return. The research presented in this paper shows statistically significant evidence of residential value creation that can be leveraged to fund GSI, such as through special service districts or tax increment financing-like tools.

Special Service Districts

Special service districts—also called special assessments, Local Improvement Districts, or other names depending on where they are implemented—are distinct areas in a city that choose to invest in additional amenities or infrastructure and pay for the increased service over time through an added tax or fee on real property. One example is a business improvement district that elects to add benches, public recycling bins, wayfinding signs and other amenities for tourists.

In the context of GSI, managing stormwater at the neighborhood-scale with GSI could be financed through a special service district and paid back over time with an assessment to property owners. Knowing that GSI may add 0.28% to 0.78% to their home sales price may make property owners more likely to participate.

Tax Increment Financing

In communities that regularly re-assess properties, our findings that GSI is associated with a 0.28% to 0.78% higher home sales price may mean the presence of GSI is increasing the property tax base. This also indicates there will likely be property tax growth following GSI investment. Tax Increment Financing (TIF) and other TIF-like structures use future tax growth like that to fund infrastructure investment.

Our findings mean GSI could be installed in a neighborhood and paid for, at least in part, over time using the increased property tax that it generates. To make a full TIF worthwhile, including financing costs and other associated expenses, distributed GSI like we are describing in this research would likely need to be part of a broader community development or climate resilience infrastructure package.

Consider a city block with 20 homes. If each home were worth $250,000 today, our findings show that doubling the GSI on that block could mean those homes sell for $700 to $1,950 more. If that is incorporated into their tax assessments each home would generate $21 to $59 in additional property taxes annually at a 3% tax rate—or $8,000 to $23,000 total for the block over the next 20 years. That value could be used to help pay for the capital cost of the GSI or to fund ongoing GSI maintenance to ensure the installations continue to provide value.

A specific TIF may not be necessary to create this kind of value capture, and the relatively modest benefits of distributed GSI alone may not warrant a stand-alone value capture mechanism. However, the evidence of increased property value associated with GSI could make it easier to use non-TIF financing tools that are paid back through municipal general funds. These mechanisms can also be used to meet other community needs and address displacement risk, as discussed in the next section of this report.

In areas with new development, these property value findings can make the case for exploring additional GSI development fees to create neighborhoods that are resilient in the face of a changing climate.

CNT's report Increasing Funding and Financing Options for Sustainable Stormwater Infrastructure (2020), lays out funding and financing models for GSI, including lessons learned from the energy and transportation sectors. Value capture has been used with Transit Oriented Development in recent years and may serve as a model for GSI financing.

GSI AND ANTI-DISPLACEMENT STRATEGIES

The findings of this research on the property value benefits of GSI poses a challenge:

- **On the one hand,** the many benefits of GSI make it an even better financial investment than if it only mitigated flooding. This can increase the range of funding and financing available for GSI installations in flood-prone neighborhoods, which is important as we face climate-change-driven storms and flooding.

- **On the other hand,** in a time when housing costs are stretching families to the brink, anything that might increase those costs is a risk to communities unless specific steps are taken to prevent displacement.

This section looks at strategies that can be used together with GSI to improve housing security and financial security for neighborhood residents. This is a crucial consideration and must be brought to the forefront in any community before GSI planning and financing are underway. Consider this statement from the University of Minnesota's CREATE Initiative on the interactions between green investments and other systems:

> "What green gentrification shows us is that sustainability policies must be viewed within their political and social context. Green investments interact with an economic system that incentivizes property speculation, private profit, and growth. Any reference to environmental justice without a sincere consideration for who will benefit from green investments in a context of privilege and power is merely an appropriation of the movement."[3]

Flooding, housing and stormwater infrastructure are intertwined in many ways. As we have paved over our communities the water has nowhere else to go and finds its way into homes. Urban flooding can damage homes, destroy furnishings, and create unhealthy conditions as dampness leads to mold.

The environmental injustices that have been placed on frontline communities, especially Black and Latinx residents, have been compounded by a lack of infrastructure investment. Climate change is making these disparities even worse. As we seek to address the very real problem of urban flooding, we cannot do it in a way that puts residents at risk of displacement.

Groundwork USA's Climate Safe Neighborhoods shows how flooding, impervious surfaces, lack of trees and high heat relates to historical redlining housing discrimination in cities. The areas suffering from urban flooding and lacking green infrastructure today are often the same areas that were "redlined" and denied federal home loans because they had large numbers of immigrants and residents of color.

The red outlined areas in the maps of Richmond, VA below were determined to be the "riskiest" investment areas for federal homeownership dollars in the 1930's. Today the areas with the most impervious surface (dark gray areas on left map), least tree cover (white areas in center map), and highest temperatures (orange/red areas in right map) align closely with those redlined areas.[4] This makes the need for GSI and climate resilience action all the more important.

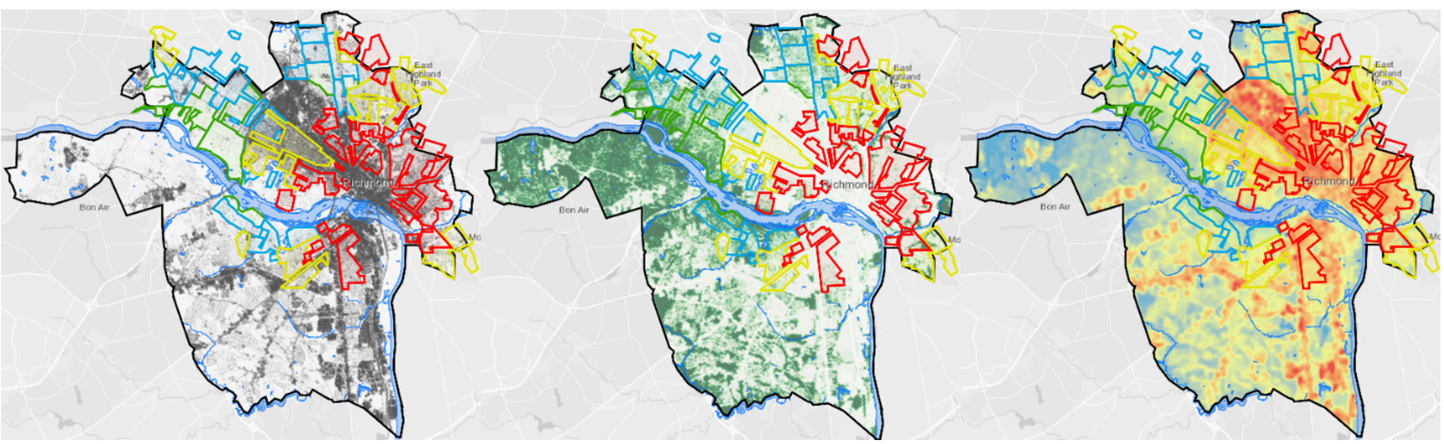


Figure 2. Historical Redlining and Current Impervious Surface (left), Tree Cover (center), and Temperatures (right) in Richmond, VA. Source: Groundwork USA https://groundworkusa.org/climate-safe-neighborhoods/

3. University of Minnesota, CREATE Initiative, "Green Gentrification," May 2019. https://canvas.umn.edu/courses/136810/files/8231845/download For more tools and information from the CREATE Initiative see https://create.umn.edu/

4. Groundwork USA, "Climate Safe Neighborhoods," 2019. https://groundworkusa.org/climate-safe-neighborhoods/

There is a great deal of discussion among scholars and practitioners about the definitions of gentrification and displacement. While it is true that increased neighborhood wealth need not lead to displacement, without careful planning and intent it *can* and *does*. Dr. Devin Michelle Bunten describes the interconnections as follows:

> "Gentrification is the territorial expansion of a wealthy community into a disinvested neighborhood, the installation of the social and legal regimes of the newcomers, and the deployment of new physical capital, both on a small scale—by homeowners undertaking renovations—and on a larger scale, by landed capitalists and public-sector officials keen to raise revenue. It is the disruption and displacement of the original residents and their spatially realized social networks."[5]

Investment without Displacement

So, how do we encourage the investment needed in communities to fight flooding without putting existing residents at risk of displacement? The best practices around the country look at GSI as part of a suite of actions that are neighborhood-driven. GSI is not treated as a standalone activity that is unrelated from other neighborhood needs. In that spirit this paper includes strategies that are not purely GSI-related but will help stabilize neighborhoods and ensure residents are able to receive the benefits of GSI investment.

Too often parks, greenspace and other green investments have come to a neighborhood from outside and created consequences that, while likely unintentional, cause real harm: residents reporting feeling excluded from their own landscape, the alienation of culturally-illiterate urban design, investment dollars and jobs that flow to outside contractors, housing and community instability as higher-wealth entities are drawn to the neighborhood, and frustrations as other basic neighborhood needs remain unmet.[6]

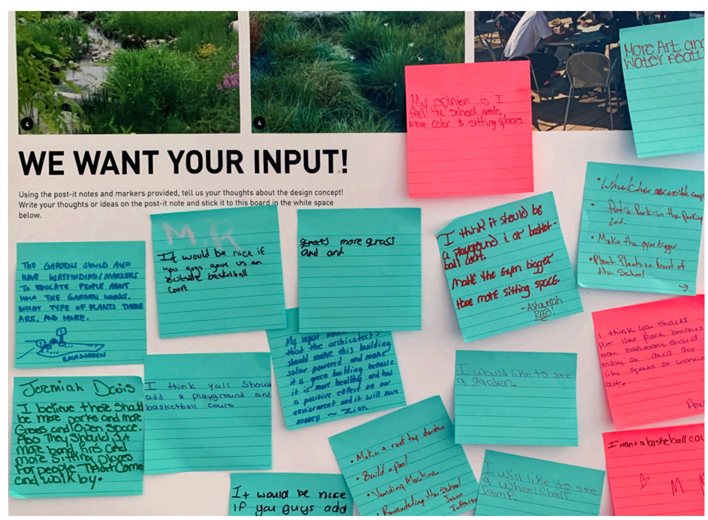
Addressing more than one issue at a time might seem like a high bar to clear in a community that is struggling for GSI funds alone, but we live in an era of disruption from climate change and we recognize that every action we take must lead to racial justice, so it is no longer viable to solve for one problem in a vacuum. We must start working smarter and our investment choices need to have multiple measures of impact.

The good news is that our findings show that a dispersed set of GSI strategies on public and private property can add to home values, but we did not find that rain gardens, swales, planters or pervious pavement cause home prices to skyrocket. While the impacts of well-known large-scale green investments, such as the High Line in New York or the 606 in Chicago have been large,[7] rain gardens, swales, porous pavement and other stormwater strategies can be implemented in meaningful ways without the same degree of shock to a neighborhood.

This is not to dismiss the many benefits of these GSI strategies, but to say that with some careful planning the benefits can be realized while minimizing negative impacts. The strategies we highlight here to do that include community planning, community ownership, renters rights, affordable housing, job creation, value capture, and equity-focused program design. This is not a comprehensive list, and we expect knowledge of successful strategies to grow over time as communities approach GSI as part of comprehensive, neighborhood-driven climate resilience.

Community Planning

A commitment to GSI investment without displacement must begin with meaningful engagement of communities from day one and throughout the process of identifying needs, setting priorities, design, implementation and beyond. A good starting point is to create common ground on investment principles. As an example in the housing and infrastructure policy field, California-based ClimatePlan has done this with a multi-stakeholder platform agreed to by 20 organizations.[8]



5. Devin Michelle Bunten. "Untangling the Housing Shortage and Gentrification," *CityLab*. October 23, 2019. https://www.citylab.com/perspective/2019/10/neighborhood-gentrification-affordable-housing-california/598135/

6. For example, see: Pendarvis Harshaw. "Do Parks Push People Out?" *Bay Nature*. October 1, 2018. https://baynature.org/article/do-parks-push-people-out/

7. Institute for Housing Studies at DePaul University. "Measuring the Impact of the 606: Understanding How a Large Public Investment Impacted the Surrounding Housing Market." 2016. https://www.housingstudies.org/media/filer_public/2016/10/31/ihs_measuring_the_impact_of_the_606.pdf

8. "ClimatePlan's Commitment to Investment without Displacement." 2019. https://d3n8a8pro7vhmx.cloudfront.net/climateplan/pages/348/attachments/original/1554421571/ClimatePlan's_Commitment_to_Investment_without_Displacement_4.4.2019.pdf?1554421571

GSI planning at the Overton Campus near Bronzeville, Chicago developed a plant voting board for the rain garden to collect feedback on the types of plants and gathering space amenities folks wanted to see at the site.

If there are essential community needs—such as inability to pay utility bills, food insecurity, or community safety—the planning process should make space for incorporating those in a real way. GSI that reduces a street's flooding problem can also be designed to mitigate public health emergencies from high heat days. This is not to say that a community has to solve all of its problems at once, but rather that resilience planning can't leave urgent needs off the planning table.

Identifying needs can also create opportunities to involve other entities that might not usually be involved in stormwater discussions, such as energy utilities or affordable housing agencies, that might bring creative solutions—and additional funding—to solve multiple problems at once. An example might be a comprehensive housing rehabilitation strategy to address flooding, install GSI, improve energy efficiency and mitigate health hazards like mold all together instead of through 3-4 separate programs.

In addition to identifying needs and setting community priorities, planning should include developing agreed-upon performance standards and metrics. Is there agreement on the existing conditions and the forces affecting the community today? Does everyone have the information they need to make informed decisions? Are there investments that would be "green enough" and meet the resilience needs of the community without signaling gentrification? How will the community track and score equity impacts over time? How will the city or utility respond if maintenance of GSI declines? Though often used for larger-scale investments, Community Benefits Agreements (CBAs) can be a tool for documenting commitments to a community in a binding way.[9] Additionally, community-based participatory research (CBPR) is a useful framework for partnering on data collection, analysis, and benchmarking.

Another element of community planning is incorporating the cultural aspects of the existing neighborhood in GSI. Are there cultural touchstones that would continue to give the community a sense of belonging as GSI is added?[10]

Community Ownership

There are several aspects of "ownership" to consider as part of GSI investment planning. The first is the ownership of the vision and goals, which should be addressed through meaningful community-based planning as discussed previously. The second is ownership of the benefits created by GSI. If GSI is adding financial value to a neighborhood, how are existing residents accessing that?[11]

9. PolicyLink. All In Cities. "Community Benefits Agreements." https://allincities.org/toolkit/community-benefits-agreements

10. See examples of several Chicago sites that combine art, culture and green infrastructure at: https://www.cnt.org/blog/public-art-installations-meet-green-stormwater-infrastructure

11. For a good discussion of policy options see: Anna Cash and Miriam Zuk. "Investment Without Displacement: From Slogan to Strategy." *Shelterforce*. June 21, 2019. https://shelterforce.org/2019/06/21/investment-without-displacement-from-slogan-to-strategy

For current owners, an example might be a property tax freeze or credit for seniors and fixed income households to prevent them from facing housing insecurity due to property value increases.

Another example is improving housing security and ownership for existing residents through the transition of rental property to ownership models through cooperatives or land trusts. Land trusts discourage speculation and improve home ownership opportunities by holding land in trust and separating land value from the value of the structure on it.[12]

The financial benefits of green investment could also be channeled into investments prioritized by existing community members and managed by community organizations, such a community development corporation. Once established, this can be a common platform for multiple types of investment, such as if the community chooses to pursue affordable housing development or community solar investment. The financing tools discussed in the previous section of this report could also be part of this structure.

Renters Rights and Affordable Housing

Renters are often most at risk for displacement as investment occurs in neighborhoods. The article, "Investment Without Displacement: From Slogan to Strategy," outlines many good examples for addressing renter needs.[13] These interventions can range from voluntary to regulatory. Strategies like code enforcement can ensure rental homes are safe and meeting resident needs. Enabling renters to act through tenants unions, a renters bill of rights, or legal assistance can also be powerful. Stronger tools may be necessary to permanently protect existing residents from the tides of investment, gentrification and displacement. These can include rent control, acquisition of naturally affordable housing by a non-profit affordable housing provider, inclusionary zoning, or the development of new subsidized housing.

Consideration should also be given to the commercial renters in the neighborhood. Legacy businesses essential to community culture or those affordably meeting existing resident needs may need the same type of protections as renter households.

Portland's Living Cully is an example of combining affordable housing needs with green infrastructure. In 2018, a 25-acre park was created in the neighborhood, but new affordable housing was created at the same time.[14] Job training, local hiring and the inclusion of local priorities, such as a new commercial kitchen and day care center in the development are all part of the neighborhood coalition's comprehensive approach.

Job Creation

GSI investment creates near-term cash flows for the workers and companies that design, install and maintain it. Directing those funds to the community can add to local economic stability. For example, job training that begins long before shovels hit the ground in the community—perhaps through paid apprenticeships at other GSI sites—can enable residents to be hired to build their community's GSI. Local sources of materials and contracts for the GSI can support community businesses and entrepreneurship. If GSI is going to require long-term maintenance, perhaps work with community members to create a business that can meet that need.

Consider, also, paying residents for their expertise throughout the process—including during the planning phase. This has the benefit of creating a team of equals, rather than community volunteers and paid staff and consultants from the city or utility, which can result in better projects and a greater long-term sense of ownership and personal investment in success.

The individual strategies listed here are unlikely to prevent displacement from occurring as property values rise on their own. But several of them together, as part of a comprehensive strategy that starts even before GSI planning, have a real chance to create intentional neighborhood change that is beneficial to existing residents, rather than unintended changes that result in their displacement.

The remainder of this document further describes our research approach and findings of property value impacts associated with GSI investment. It is our intention that by incorporating these research findings with the anti-displacement strategies discussed above future GSI investment will channel its value creation toward both climate and economic resilience for existing residents.

12. Miriam Axel-Lute and Dana Hawkins-Simons. "Community Land Trusts Grown from Grassroots: Neighborhood Organizers Become Housing Developers." Lincoln Land Institute. July 2015.
https://www.lincolninst.edu/publications/articles/community-land-trusts-grown-grassroots

13. Anna Cash and Miriam Zuk. "Investment Without Displacement: From Slogan to Strategy." *Shelterforce*. June 21, 2019..
https://shelterforce.org/2019/06/21/investment-without-displacement-from-slogan-to-strategy/

14. CNT. Urban Opportunity Agenda, Case Study, Living Cully, 2019.
https://uoa.cnt.org/case-studies/living-cully/

RESEARCH METHOD

City Selection

We compiled GSI project and program information into a matrix of 17 cities based on literature and partners in the field. We then began paring the list down based on several variables—1) Number of GSI installations in a city, to ensure we had a robust data sample; 2) GSI installations before 2015, so there has been time for GSI to potentially impact property sales; 3) Geospatial GSI data in a format we could match to property sales records; and 4) Accessible home sales data with detailed home attribute information. Using these criteria and conversations with our network of GSI experts we selected three cities for analysis—Philadelphia, PA; Seattle, WA; and Milwaukee, WI. Unfortunately, the Milwaukee GSI data were not ultimately a good match to the study design and home sales data, so this document presents findings for Philadelphia and Seattle. We have included a discussion of data in the "Areas for Further Research and Action" section later in this document.

GSI Typology

To facilitate modeling we grouped the GSI installations in each city into a set of four types based on their characteristics as follows:

- Group 1 incudes swales, planters, rain gardens, and bumpouts, which are distributed forms of GSI that are typically vegetated, smaller in scale, and designed for stormwater infiltration.
- Group 2 includes wetlands, basins and trenches, which are larger-scale stormwater management forms typically designed for stormwater detention. Infiltration and storage trenches are included in this group, but trenches specifically designated as tree trenches were excluded, because the property value impact of trees is well documented and we wanted to examine the impacts of other GSI types.
- Group 3 includes only pervious pavement, which is a hard surface that allows stormwater to infiltrate.
- Group 4 includes green roofs and cisterns, which both reduce stormwater runoff.

Table 1 lists the GSI types included in this study by group along with counts of each type in the Philadelphia and Seattle data sets along with GSI definitions from Philadelphia's GSI Planning and Design Manual.

Table 1. GSI Typology and Count of Installations in Philadelphia and Seattle

GSI Group	GSI Type	Philadelphia Count by Type (2019)[15]	Seattle Count by Type (2019)[16]	Definition[17]
1	Swale	29	101	"A depressed channel designed to convey stormwater. It can be designed to attenuate and/or infiltrate runoff where feasible."
1	Planter	114	29	"A structure filled with soil media and planted with vegetation or trees. Designed to detain and release stormwater runoff and/or infiltrate where feasible. Planters often contain curb edging or fencing as barrier protection around the planter."
1	Rain Garden	544	14	"A shallow depressed area designed to detain and release stormwater runoff and/or infiltrate where feasible. Vegetated and non-mowed. May also be referred to as bio-infiltration basins and bio-retention basins."
1	Bumpout	28		"A vegetated curb extension that intercepts gutter flow. Designed to detain and release stormwater runoff and/or infiltrate where feasible."
2	Wetland	5	9	"A vegetated basin designed principally for pollutant removal. It typically holds runoff for periods longer than 72 hours and may include a permanent pool. Can also detain and release stormwater runoff."
2	Basin	130	2	"A depression that is vegetated with mowed grass. Designed to detain and release stormwater runoff and/or infiltrate where feasible."
2	Trench	1198		"A subsurface structure designed to detain and release stormwater runoff and/or infiltrate where feasible. Infiltration / storage trenches are frequently installed underneath of other SMP's such as rain gardens, planters, and bump-outs."
3	Pervious Pavement	345	37	"A hard permeable surface commonly composed of concrete, asphalt, or pavers. It is designed to detain and release stormwater runoff and/or infiltrate where feasible."
4	Green Roof	196	1	"A vegetated surface installed over a roof surface. Effective in reducing the volume and rate of stormwater runoff."
4	Cistern	17		"A tank or storage receptacle that captures and stores runoff and can thereby reduce runoff volume. The stored water may be used to serve a variety of non-potable water needs (e.g., irrigation)." May also include Rain Barrels.

15. GSI data from OpenDataPhilly as of 2019.
https://www.opendataphilly.org/

16. GSI data from City of Seattle Open Data Portal as of 2019.
https://data.seattle.gov/

17. City of Philadelphia, Philadelphia Water Department. "Green Stormwater Infrastructure Planning & Design Manual, Version 2.0, Appendix A.3." April 2018.
http://documents.philadelphiawater.org/gsi/GSI_Planning_and_Design_Manual.pdf

Model Development

Hedonic price modeling is a well-established type of statistical analysis that looks at the impact of a particular factor—in this case GSI—on home sales prices while holding other factors constant. We examined the existing literature on home value impacts of trees, parks, and GSI in the development of our model:

- We classified the variables used in the literature, such as building size, number of bedrooms or distance from transit, and tracked which variables were identified as statistically significant. The variables we used in our model were:
    - Property characteristics: living area square feet, # bathrooms, # bedrooms, fireplace, garage, basement, whether the home is detached, whether the home is an apartment unit
    - Geographic factors: within .25 or .5 miles of parks, water, and fixed-rail public transit (separate variables for each)
    - Time of sale: year (2009 through 2019), quarter (spring, summer, fall, winter)
    - Sales which occurred in the intervention area prior to GSI installation are used to control for unobserved spatial effects.
- Most models of this type also include one or more census tract-level variables to control for demographic factors. We model our findings three times using three separate demographic variables: education (percentage of residents with a bachelor's degree or higher), poverty rate, and homeownership rate. Due to the way mixed-effect models are calculated and the level of correlation between tract-level variables, it was not possible to incorporate more than one tract-level variable in the same model run.
- The majority of the studies we documented in the literature modeled sales price as their outcome variable, which is what we did in this study.
- The literature uses several different approaches to defining the main effect they were studying, but most models used distance in their definition—such as whether a home value goes up as it is closer to a park or whether trees within 100 feet of a home impact its value—so we have included a distance element in our model as well. GSI within 250 feet of a home was examined for its impact on the home's value.

Home Sales Data

For the home sale data, we used residential property sales, both single- and multifamily, from 2009 through early 2020 for each case study city. The home sale data for Philadelphia were obtained from the city's MLS provider – BrightMLS. Seattle home sale data was obtained from the publicly-accessible platform provided by the King County Department of Assessments. All home sale data were reviewed and edited to remove any duplicate sales records and non-arm's length transactions, as well as identifiable judicial or tax sales.

After obtaining, reviewing and filtering the data, our home sale datasets included approximately 127,000 sales records for Philadelphia and 66,000 for Seattle. We also examined 44,000 sales records for Milwaukee from MetroMLS, but as mentioned previously, we did not find a good match between the study design, home sales and GSI data in that city and so were not able to use it in our model.

Impacts by Number of GSI Installations

In addition to analyzing GSI impact by square footage as described earlier, we also looked at the relationship between number of GSI installations and home sales price. These results using GSI counts are more complex, which may speak to the variability of GSI types—being located near a single stormwater planter is quite different than having a swale filled with native plantings lining the entire front of your property.

- Effect of proximity to any one or more GSI installations:
    - As Table 2 shows, we found that proximity to one or more rain garden, swale, or stormwater planter was associated with a 2.8% higher home sales price in Seattle, but no statistically significant relationship was found for that in Philadelphia.
    - We found 3.1% to 3.2% higher home sales prices near wetlands, basins, trenches and pervious pavement in Philadelphia when controlling for education and homeownership.
        - When controlling for the poverty rate in the census tracts the observed impact diverged, with a 6% home sales value increase near pervious pavement and no statistically significant increase associated with wetlands, basins or trenches.
    - As discussed previously, the nearby presence of green roofs and cisterns was associated with a lower home sales price, which we hypothesize may be due to the commercial, rather than residential nature of many of those GSI types in Philadelphia.
- Another way to look at the impact of the number of GSI installations is to consider the incremental impact of each additional GSI installation on sales price.
    - In this case we found that each additional rain garden, swale, stormwater planter or pervious pavement was associated with a 1.5 %to 1.9% higher home sales price in Philadelphia when we controlled for education or homeownership levels in the census tract, but the impact again diverged when we controlled for poverty rates in the census tract.
    - In Seattle, we found a 0.19% to 0.33% increase in home sales price was associated with an additional rain garden, swale, planter or pervious pavement installation.
    - The variability between the cities on this finding is not immediately explainable. The values for effect per hundred percent increase in GSI square footage are more consistent across the two cities, so we recommend using that metric of value creation.

Table 2. Effect of Nearby GSI Installations on Residential Sales Prices in Philadelphia and Seattle

Effect of Proximity to Any (One or More) GSI Installations ^

Site	Philadelphia			Seattle		
Census Tract Control Variable	**Education**	**Poverty**	**Homeowner**	**Education**	**Poverty**	**Homeowner**
Group 1: rain gardens, swales, planters	--	--	--	2.8% ***	2.8% ***	2.8% ***
Group 2: wetlands, basins, trenches	3.1% **	--	3.1% **	--	--	--
Group 3: pervious pavement	3.2% *	6.0% ***	3.2% **	!	!	!
Group 4: green roofs, cisterns	-5.2% **	-13.1% ***	-5.8% **	!	!	!
Conditional R^2 (LMM)	0.96	0.95	0.91	0.85	0.85	0.84
Number of sales		126,898			65,767	
Number of sales within 250 ft of a GSI		10,073			29,384	

Effect per Hundred Percent Increase in GSI Square Footage ^

Site	Philadelphia			Seattle		
Census Tract Control Variable	**Education**	**Poverty**	**Homeowner**	**Education**	**Poverty**	**Homeowner**
Group 1: rain gardens, swales, planters	*0.69% ***	*0.50% **	*0.63% ***	0.40% ***	0.38% ***	0.39% ***
Group 2: wetlands, basins, trenches	--	--	*0.23% '*	--	--	--
Group 3: pervious pavement	*0.52% ***	*0.78% ****	*0.53% ***	0.30% ***	0.28% ***	0.29% ***
Group 4: green roofs, cisterns	*-0.61% **	*-1.5% ****	*-0.69% ***	--	!	--
Conditional R^2 (LMM)	0.96	0.95	0.91	0.86	0.93	0.86
Number of unique SF estimates		1,356			6,849	
Average and Standard Deviation of GSI SF		115 (2,037)			117 (921)	

Effect of Each Additional GSI on Sale Price ^

Site	Philadelphia			Seattle		
Census Tract Control Variable	**Education**	**Poverty**	**Homeowner**	**Education**	**Poverty**	**Homeowner**
Group 1: rain gardens, swales, planters	*1.9% ***	--	*1.9% ***	0.20% ***	0.23% ***	0.19% ***
Group 2: wetlands, basins, trenches	*0.51% **	--	*0.36% '*	--	--	--
Group 3: pervious pavement	*1.5% ***	*1.8% ****	*1.5% ***	0.33% ***	0.24% ***	0.33% ***
Group 4: green roofs, cisterns	--	--	--	--	--	--
Conditional R^2 (LMM)	0.96	0.95	0.91	0.83	0.92	0.84
Maximum Numbers of GSI per Sale		52			37	

*Significance levels: " ' " = .10, " * " = .05, " ** " = .01, " *** " = .001.*

"--" indicates no significant relationship. "!" indicates that the parameter was too similar to the spatial control to create a reliable estimate.

^After controlling for property characteristics, time of sale, and geographic features.
Property characteristics: living area sf, # bathrooms, # bedrooms, fireplace, garage, basement, is detached, is apartment unit
Geographic factors: within .25 or .5 miles of parks, water, and fixed-rail public transit (separate variables for each)
Time of sale: year (2009 through 2020), quarter (spring, summer, fall, winter)
Sales which occurred in the intervention area prior to GSI installation are used to control for unobserved spatial effects.

AREAS FOR FURTHER RESEARCH AND ACTION

GSI Data

The trend of cities making geocoded GSI data available through their open data portals made this study possible, and we strongly support expanding the capacity for more cities to geocode their GSI assets and publish that data publicly. This would not only enable research like this, but is crucial to tracking, maintaining, and valuing GSI like the significant infrastructure it is.

There are GSI characteristics like square footage, that were essential to this study, but not tracked by every city consistently. A survey of GSI installations including detailed descriptive data, much like many cities have done for their tree inventories, would be valuable in any city. As more GSI information is tracked it will be most useful if it is done so using a common data structure across cities, so we support the creation of a GSI data standard. The General Transit Feed Specification (GTFS) standard used in the public transportation field in recent years allows transit service to be shown on tools like Google Maps and is a great example of how a common data format can bring value.

Interactions of Benefits

While we have documented an association between GSI and property value to a high degree of statistical significance for many GSI types, we do not know exactly what benefits are driving that value. Is it because GSI installations full of flowers and native plants looks nice? Is it because a neighborhood full of GSI is a neighborhood managing its stormwater? Or, as at least one study theorizes, is the presence of GSI a social signal of environmentalism or community-cohesion that influences home buyers?[18]

Additionally, GSI is often implemented together with other improvements—for example, pervious pavement might be part of a complete streets project that adds pedestrian and bicycle infrastructure. The large number of home sales data in our study means some of our control group homes are near bicycle and pedestrian infrastructure, so we are finding a real association with pervious pavement and other GSI types, but teasing out the impacts of individual project and design elements in a community would be of value.

Similarly, we do not know the factors that may be limiting GSI's benefits in our dataset. We hypothesize that commercial areas may have elements that offset the benefits of commercial green roofs to neighboring homes. A study of stormwater basins in Baltimore County, Maryland theorizes that stormwater basins perceived as "unkempt, overgrown, or unsightly" may drive down home values. This could speak to the need for upfront design that prioritizes aesthetics, ongoing maintenance and community education to transform the perception of native plants and nature-based landscapes from unkempt to beautiful.[19]

Incorporation in Appraisal and Financing

Incorporation of GSI in home value appraisals can help solidify its value as an infrastructure system, and, as discussed in the funding and financing section, enable GSI investment. Trees are an example of GSI that is regularly included in home appraisals. The findings presented here for other GSI types make a case for including them as well.

This study looked at GSI impacts on residential property values, but similar research on commercial and institutional property values would benefit the field of knowledge and provide further tools for funding and financing.

Displacement

By documenting the property value impact associated with GSI investment we are hoping to bring to light a financial force that has been implicitly understood in communities around the country but has rarely been explicitly quantified. We have provided several best-practice-strategies for avoiding displacement in this paper. However, we would like to see these findings and strategies applied together by GSI implementers as a cohesive community-driven strategy to create community resilience followed by quality evaluation to track outcomes.

18. Wachter, S. M., & Wong, G. "What Is a Tree Worth? Green-City Strategies, Signaling and Housing Prices." Real Estate Economics,36(2), 2008.
https://repository.upenn.edu/cgi/viewcontent.cgi?article=1036&context=real-estate_papers

19. Irwin, Nicholas B. & Klaiber, H. Allen & Irwin, Elena G. "Do Stormwater Basins Generate co-Benefits? Evidence from Baltimore County, Maryland," Ecological Economics, Vol. 141, 2017.
https://par.nsf.gov/servlets/purl/10054859

BIBLIOGRAPHY

Anderson, L. M., and H. K. Cordell. "Influence of Trees on Residential Property Values in Athens, Georgia (U.S.A.): A Survey Based on Actual Sales Prices." *Landscape and Urban Planning,* vol. 15, no. 1–2, June 1988, pp. 153–64. https://www.srs.fs.usda.gov/pubs/ja/ja_anderson003.pdf

ARUP. *San Francisco Living Roof Cost-Benefit Study Report: Summary Report, Draft 2.* June 2016. https://default.sfplanning.org/Citywide/livingroof/SFLivingRoofCost-BenefitStudyReport_060816.pdf

Axel-Lute, Miriam and Dana Hawkins-Simons. "Community Land Trusts Grown from Grassroots: Neighborhood Organizers Become Housing Developers." Lincoln Land Institute. July 2015. https://www.lincolninst.edu/publications/articles/community-land-trusts-grown-grassroots

Bark, R. H., et al. "Habitat Preservation and Restoration: Do Homebuyers Have Preferences for Quality Habitat?" *Ecological Economics,* 2009. https://www.sciencedirect.com/science/article/pii/S0921800908004679

Bianchini, Fabricio, and Kasun Hewage. "Probabilistic Social Cost-Benefit Analysis for Green Roofs: A Lifecycle Approach." *Building and Environment,* vol. 58, Dec. 2012, pp. 152–62. doi:10.1016/j.buildenv.2012.07.005.

Braden, John B. and Douglas M. Johnston. "Downstream Economic Benefits from Storm-Water Management." *Journal of Water Resources Planning and Management,* vol. 130, no. 6, November 2004. https://doi.org/10.1061/(ASCE)0733-9496(2004)130:6(498)

Bunten, Devin Michelle. "Untangling the Housing Shortage and Gentrification." *CityLab,* October 23, 2019. https://www.citylab.com/perspective/2019/10/neighborhood-gentrification-affordable-housing-california/598135/

Cash, Anna and Miriam Zuk. "Investment Without Displacement: From Slogan to Strategy." *Shelterforce.* June 21, 2019. https://shelterforce.org/2019/06/21/investment-without-displacement-from-slogan-to-strategy/

Center for Neighborhood Technology. "Urban Opportunity Agenda, Case Study, Living Cully." 2019. https://uoa.cnt.org/case-studies/living-cully/

City of Philadelphia, Philadelphia Water Department. "Green Stormwater Infrastructure Planning & Design Manual, Version 2.0, Appendix A.3." April 2018. http://documents.philadelphiawater.org/gsi/GSI_Planning_and_Design_Manual.pdf

City of Philadelphia, Philadelphia Water Department. "Stormwater Grants, Application Guide. Vol 2.0." December 2019. https://www.phila.gov/water/wu/Stormwater%20Grant%20Resources/StormwaterGrantsManual.pdf

City of Philadelphia. "Green Roof Tax Credit." Accessed October 2020. https://www.phila.gov/services/payments-assistance-taxes/tax-credits/green-roof-tax-credit/

Clements, Janet, et al. *The Green Edge: How Commercial Property Investment in Green Infrastructure Creates Value.* https://www.nrdc.org/sites/default/files/commercial-value-green-infrastructure-report.pdf

ClimatePlan. "ClimatePlan's Commitment to Investment without Displacement." 2019. https://d3n8a8pro7vhmx.cloudfront.net/climateplan/pages/348/attachments/original/1554421571/ClimatePlan's_Commitment_to_Investment_without_Displacement_4.4.2019.pdf?1554421571

Colby, Bonnie G. and S. Wishart. "Quantifying the Influence of Desert Riparian Areas on Residential Property Values." The Appraisal Journal, vol. 70, no. 3, pp. 304-308, January 2002. https://www.researchgate.net/publication/285136968_Quantifying_the_influence_of_desert_riparian_areas_on_residential_property_values

Crompton, John L. "The Impact of Parks on Property Values - A Review of the Empirical Evidence." *Journal of Leisure Research,* vol. 33, no. 1, 2001, pp. 1-31. http://www.actrees.org/files/Research/parks_on_property_values.pdf

Dombrow, Jonathan, Mauricio Rodriguez, and C.F. Sirmans. "The Market Value of Mature Trees in Single-Family Housing Markets." *Appraisal Journal,* vol. 68, 2000. http://www.actrees.org/files/Research/mature_trees_single_family_housing.pdf

Donovan, Geoffrey H., and David T. Butry. “Trees in the City: Valuing Street Trees in Portland, Oregon.” *Landscape and Urban Planning,* vol. 94, no. 2, Feb. 2010, pp. 77–83. https://www.fs.fed.us/pnw/pubs/journals/pnw_2010_donovan001.pdf

Econsult Solutions, Inc. *“The Economic Impact of Green City, Clean Waters - the First Five Years.”* Prepared for the Sustainable Business Network of Greater Philadelphia. January 2016. https://econsultsolutions.com/wp-content/uploads/2016/02/SBN_FINAL-REPORT.pdf

Espey, Molly, and Kwame Owusu-Edusei. “Neighborhood Parks and Residential Property Values in Greenville, South Carolina.” *Journal of Agricultural and Applied Economics,* vol. 33, no. 3, Dec. 2001, pp. 487–92. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.545.7830&rep=rep1&type=pdf

Gibbs, Julie P., et al. “An Hedonic Analysis of the Effects of Lake Water Clarity on New Hampshire Lakefront Properties.” *Agricultural and Resource Economics Review,* vol. 31, no. 1, Apr. 2002, pp. 39–46. https://ageconsearch.umn.edu/record/31475/files/31010039.pdf

Green Stormwater Infrastructure data from City of Seattle Open Data Portal as of 2019. https://data.seattle.gov/

Green Stormwater Infrastructure data from OpenDataPhilly as of 2019. https://www.opendataphilly.org/

Groundwork USA, “Climate Safe Neighborhoods.” 2019. https://groundworkusa.org/climate-safe-neighborhoods/

Hagen, Bjoern, et al. “Longitudinal Analysis of Ecosystem Services’ Socioeconomic Benefits: Wastewater Treatment Projects in a Desert City.” *Ecosystem Services,* vol. 23, Feb. 2017, pp. 209–17. doi:10.1016/j.ecoser.2016.12.014.

Harnik, Peter and Ben Well, Trust for Public Land, *Measuring the Economic Value of a City Park System.* 2009. https://www.tpl.org/sites/default/files/cloud.tpl.org/pubs/ccpe-econvalueparks-rpt.pdf

Harshaw, Pendarvis. “Do Parks Push People Out?” *Bay Nature.* October 1, 2018. https://baynature.org/article/do-parks-push-people-out/

Henry, Mark S. “Landscape Quality and the Price of Single Family Houses: Further Evidence from Home Sales in Greenville, South Carolina. Journal of Environmental Horticulture, vol. 17, no. 1, pp. 25-30, 1999. http://www.actrees.org/files/Research/landscaping_house_prices.pdf

Hobden, Gary E., et al. “Green Space Borders—A Tangible Benefit? Evidence from Four Neighbourhoods in Surrey, British Columbia, 1980–2001.” *Land Use Policy,* vol. 21, no. 2, April 2004, pp. 129-138. https://doi.org/10.1016/j.landusepol.2003.10.002

Ichihara, Kiku, and Jeffrey P. Cohen. “New York City Property Values: What Is the Impact of Green Roofs on Rental Pricing?” *Letters in Spatial and Resource Sciences,* vol. 4, no. 1, Mar. 2011, pp. 21–30. doi:10.1007/s12076-010-0046-4.

Institute for Housing Studies at DePaul University. “Measuring the Impact of the 606: Understanding How a Large Public Investment Impacted the Surrounding Housing Market.” 2016. https://www.housingstudies.org/media/filer_public/2016/10/31/ihs_measuring_the_impact_of_the_606.pdf

Irwin, Nicholas B., et al. “Do Stormwater Basins Generate Co-Benefits? Evidence from Baltimore County, Maryland.” *Ecological Economics,* vol. 141, Nov. 2017, pp. 202–12. https://par.nsf.gov/servlets/purl/10054859

Kousky, Carolyn, and Margaret Walls. *Floodplain Conservation as a Flood Mitigation Strategy: Examining Costs and Benefits.* Resources for the Future. 2013. https://media.rff.org/documents/RFF-DP-13-22-REV.pdf

Laverne, Robert J., and Kimberly Winson-Geideman. “The Influence of Trees and Landscaping on Rental Rates at Office Buildings.” *Journal of Arboriculture,* vol. 29, no. 5, September 2003. http://www.actrees.org/files/Research/laverne_trees_and_rent.pdf

Lee, Jae & Li, Ming-Han. “The Impact of Detention Basin Design on Residential Property Value: Case Studies Using GIS in the Hedonic Price Modeling.” *Landscape and Urban Planning,* vol. 89, pp. 7-16, 2009. 10.1016/j.landurbplan.2008.09.002

Lewis, An, et al. *Measuring the Effect of Vacant Lots and Green Infrastructure Improvements on Home Values in Allegheny County, 2012-2014.* Tri-COG Collaborative. 2018 https://steelriverscog.org/wp-content/uploads/2018/09/Effects-of-Vacant-Land.pdf

Lutzenhiser, Margot, and Noelwah R. Netusil. "THE EFFECT OF OPEN SPACES ON A HOME'S SALE PRICE." *Contemporary Economic Policy,* vol. 19, no. 3, July 2001, pp. 291–98. http://greenstogreen.org/pdfs/resources/resources-openspaces-homesaleprices.pdf

MacMullan, Ed and Sarah Reich, ECONorthwest. *The Economics of Low-Impact Development: A Literature Review.* November 2007. https://www.epa.gov/sites/production/files/documents/LID_Economics_Literature_Review.pdf

Madison, Catherine. "Impact of Green Infrastructure on Property Values within the Milwaukee Metropolitan Sewerage District Planning Area." *Center for Economic Development Publications.* 2013. https://dc.uwm.edu/cgi/viewcontent.cgi?article=1015&context=ced_pubs

Mazzotta, Marisa, et al. "A Meta-Analysis of Hedonic Studies to Assess the Property Value Effects of Low Impact Development." *Resources,* vol. 3, no. 1, Jan. 2014, pp. 31–61. https://cfpub.epa.gov/si/si_public_record_report.cfm?Lab=NHEERL&dirEntryId=267771

Mohamed, Rayman. "The Economics of Conservation Subdivisions: Price Premiums, Improvement Costs, and Absorption Rates." *Urban Affairs Review,* vol. 41, no. 3, Jan. 2006, pp. 376–99. doi:10.1177/1078087405282183.

Netusil, Noelwah R. "Economic Valuation of Riparian Corridors and Upland Wildlife Habitat in an Urban Watershed." *Journal of Contemporary Water Research & Education,* vol.134, no. 1, July 2006, pp. 39-45.
https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1936-704X.2006.mp134001008.x

Netusil, Noelwah R., et al. "Valuing Green Infrastructure in Portland, Oregon." *Landscape and Urban Planning,* vol. 124, Apr. 2014, pp. 14–21. doi:10.1016/j.landurbplan.2014.01.002.

Netusil, Noelwah R., Sudip Chattopadhyay, & Kent F. Kovacs. "Estimating the Demand for Tree Canopy: A Second-Stage Hedonic Price Analysis in Portland, Oregon." *Land Economics,* vol. 86, no. 2 , May 2010, pp. 281-293. https://www.jstor.org/stable/27821424

Nordman, Erik E. et al. "Benefit-Cost Analysis of Stormwater Green Infrastructure Practices for Grand Rapids, Michigan, USA." *Journal of Cleaner Production,* vol. 200, November 2018, pp. 501-510.
https://www.sciencedirect.com/science/article/abs/pii/S0959652618321413

Pincetl, Stephanie, et al. "Toward a Sustainable Los Angeles: A "Nature's Services" Approach." February 2003.
https://johnwilson.usc.edu/wp-content/uploads/2016/05/2003-Pincetl-Wolch-Wilson-Longcore.pdf

PolicyLink, All In Cities. "Community Benefits Agreements." Accessed September 2020.
https://allincities.org/toolkit/community-benefits-agreements

Poor, P. Joan, et al. "Exploring the Hedonic Value of Ambient Water Quality: A Local Watershed-Based Study." *Ecological Economics,* vol. 60, no. 4, Feb. 2007, pp. 797–806. doi:10.1016/j.ecolecon.2006.02.013.

Raucher, Robert, and Janet Clements. "A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds." *Proceedings of the Water Environment Federation,* vol. 2010, no. 9, Jan. 2010, pp. 6776–804. doi:10.2175/193864710798207233.

Roseen, Robert M., et al. "Economic and Adaptation Benefits of Low Impact Development." *Low Impact Development Technology: Implementation and Economics,* American Society of Civil Engineers, 2015, pp. 74–92.
https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/JEE%20FTL%203-30-12.b.pdf

Shultz, Steven, and Nick Schmitz. *How Water Resources Limit and Promote Residential Housing Developments in Douglas County.* University of Nebraska at Omaha, Real Estate Research Center, April 2008.
https://www.unomaha.edu/college-of-business-administration/finance-banking-real-estate/_files/Water_Study.pdf

Thorsnes, Paul. "The Value of a Suburban Forest Preserve: Estimates from Sales of Vacant Residential Building Lots." *Land Economics,* vol. 78, no. 3 August 2002, pp. 426-441 DOI: 10.2307/3146900

Tomalty, Ray, Bartek Komorowski, and Dany Doiron. *The Monetary Value of the Soft Benefits of Green Roofs.* Prepared for Canada Mortgage and Housing Corporation (CMHC). 2010. https://web.archive.org/web/20161020093820/
http://www.greenroofs.org/resources/Monetary_Value_of_Soft_Benefits_of_Green_Roofs.pdf

Trust for Public Land. *The Economic Benefits of Denver's Park and Recreation System.* July 2010.
https://www.tpl.org/sites/default/files/cloud.tpl.org/pubs/ccpe-denver-park-value-report.pdf

U.S. Environmental Protection Agency. *Boone Boulevard Green Infrastructure Conceptual Design, Atlanta GA.* EPA 830-R-14-001. 2012. https://www.epa.gov/sites/production/files/2015-10/documents/boone-blvd-report-508-report.pdf

University of Minnesota, CREATE Initiative, "Green Gentrification." May 2019. https://canvas.umn.edu/courses/136810/files/8231845/download For more tools and information from the CREATE Initiative see https://create.umn.edu/

Urban Land Institute and Center for Sustainability and Economic Performance. *Harvesting the Value of Water: Stormwater, Green Infrastructure, and Real Estate.* 2017. http://libraryarchives.metro.net/DPGTL/uli-urban-land-institute/2018-harvesting-the-value-of-water-stormwater-green-infrastructure-real-estate.pdf

Voicu, Ioan, and Vicki Been. "The Effect of Community Gardens on Neighboring Property Values." *Real Estate Economics,* vol. 36, no. 2, 2008, pp. 241–283 https://furmancenter.org/files/publications/The_Effect_of_Community_Gardens.pdf

Wachter, Susan M., and Grace Wong. "What Is a Tree Worth? Green-City Strategies, Signaling and Housing Prices." *Real Estate Economics,* vol. 36, no. 2, June 2008, pp. 213–39.
https://repository.upenn.edu/cgi/viewcontent.cgi?article=1036&context=real-estate_papers

Wachter, Susan. *The Determinants of Neighborhood Transformations in Philadelphia Identification and Analysis: The New Kensington Pilot Study.* 2004. https://nkcdc.org/wp-content/uploads/2019/08/The-Determinants-of-Neighborhood-Transformations-in-Philadelphia-Identification-and-Analysis-The-New-Kensington-Pilot-Study-2004.pdf

Ward, Bryce, et al. "The Effect of Low-Impact-Development on Property Values." *Proceedings of the Water Environment Federation,* vol. 2008, no. 6, Jan. 2008, pp. 318–23. http://www.12000raingardens.org/wp-content/uploads/2013/03/The-Effect-of-Low-Income-Development-on-Property-Values.pdf

Wolf, Anna. "Public Art Installations Meet Green Stormwater Infrastructure." Center for Neighborhood Technology Blog. September 2020. https://www.cnt.org/blog/public-art-installations-meet-green-stormwater-infrastructure

Wolf, K.L. "Community Economics - A Literature Review." *Green Cities: Good Health.* College of the Environment, University of Washington. 2010. https://depts.washington.edu/hhwb/Thm_Economics.html

ACKNOWLEDGEMENTS

This report was written by Jen McGraw based on modeling by Maximilian Eisenburger, Ranadip Bose, and Michael Lampl of SB Friedman Development Advisors. Peter Haas provided analytical oversight to the project and CNT's Urban analytics team, including Paul Esling and Preeti Shankar, assisted with the data used for this analysis, and Jon Kuta designed this report.

This research was made possible by The Kresge Foundation.

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