GREEN VALUES STRATEGY GUIDE

Linking Green Infrastructure Benefits to Community Priorities

CNT

The Value of Green Infrastructure

In 2010, CNT and partners developed a first of its kind report that quantified and valued the benefits of green stormwater infrastructure (GSI). The report, "The Value of Green Infrastructure: A Guide to Recognizing its Economic, Environmental and Social benefits," has been used by policy makers, advocates, and organizations across the country to make the case that GSI has a significant and quantifiable value beyond stormwater management. In celebration of the 10th anniversary of the release of the original document, CNT is revisiting green infrastructure valuation with this strategy guide. The sections of this guide compile the latest findings on how GSI provides broad benefits to communities. In some cases, community benefits from the 2010 Guide have not been included because there wasn't conclusive evidence of a quantifiable benefit. This document will be updated periodically as new research becomes available.

A GUIDE TO USING THIS RESOURCE

This guide is divided into four sections, each of which provides the reader with case examples of topic-specific benefits associated with different green infrastructure practices (see Table 1).

Case User: Maria, the Chief Engineer in Public Works needs to address a chronic flooding issue near a low-income housing complex. The Mayor has directed staff to prioritize projects with economic development impact. Maria can use the Economic Development guide to show the Mayor that a GSI investment would have several measurable economic benefits for the community.

CONTENTS

LINKING GREEN INFRASTRUCTURE BENEFITS TO COMMUNITY PRIORITIES

Communities across the U.S. face increasingly severe storm events that have grown in both size and frequency due to climate change, resulting in disruptive and costly coastal and urban flooding. Associated impacts include property loss, displacement, physical health issues, lost wages, and economic disruption. These impacts exacerbate existing community challenges, like economic disinvestment, un(der)employment, and poor health outcomes, many of which disproportionately affect low-income communities and communities of color.

As municipal leaders look to invest in their community's highest priorities, whether they be economic development or addressing urban flooding, they must do so in ways that prioritize equitable outcomes and acknowledge the interconnectedness of urban infrastructure systems.

One investment strategy that is proven to help places thrive in a changing climate, while addressing other community goals is green stormwater infrastructure (GSI). GSI is a stormwater management approach that uses nature-based techniques (like infiltration or evapotranspiration) that manage and treat stormwater and innately provide additional community benefits (U.S. EPA). This Guide looks at how strategic investments in GSI, when made with an eye to community equity and affordability, provide broad benefits to all individuals. See Table 1 for an outline of the GSI techniques and associated community benefits explored in this Guide.

Residents win when local infrastructure investments give equal or higher importance to environmental and societal outcomes, rather than solely prioritizing economic outcomes. Municipal leaders can use this Guide to inform a holistic, triple-bottom line approach to infrastructure improvements in pursuit of healthy, equitable, and resilient communities.

TABLE 1. COMMUNITY BENEFITS OF GREEN STORMWATER INFRASTRUCTURE

	GREEN STORMWATER INFRASTRUCTURE									
	Linear Buffer Park / Trail	Stormwater Park	Stormwater Planter	Parkway Bioswale	Rain Garden	Street Trees	Green Roof	Permeable Pavement	Permeable Bike Lane	District Stormwater
HEALTH BENEFITS										
Improved Outdoor Air Quality	•••	•	••	•	••	••	•			••
Improved Indoor Environmental Quality	•	•••	••	•	•	•••	•	••	••	•
Reduced Noise Pollution	•••						•••	••	••	••
Reduced Heat Stress	••	•••	•	•	•	••	•			••
Improved Community Cohesion + Mental Health	•	•••	••	•	•	••	•			••
ECONOMIC BENEFITS										
Improved Workforce Development / Job Creation	•••	•••		•		•••	•	•	•	•••
Increased Vacant Land Reactivation	•••	•••			•••					•••
Increased Property Values	••	•••	•	••	•	••	•••			•••
Increased Sales Revenue			••	••	••	••			••	••
Increased Recreational Revenue	•••	•••							•••	
CLIMATE ADAPTATION / RESILIENCE										
Reduced Flooding	•••	•••	••	••	••	•••	••	•••	••	•••
Reduced Urban Heat Island Temperatures	••	•••	•	•	•	•••	•••	•	•	•••
Protected Water Quality (reduced runoff and combined sewer overflows)	•••	•••	••	••	••	•••	••	•••	••	•••
CLIMATE MITIGATION / AVOIDANCE										
Reduced Greenhouse Gases	•••	•••	•••	•••	•••	•••	•••	•	•	•••
Reduced Energy / Fuel Use	••	••				•••	•••			••
TRANSPORTATION BENEFITS										
Reduced On-Street Flooding	••	••	••	••	••	•••	•	•••	•••	•••
Improved Safety	••		•	•					••	••
Increased Opportunities for Active Transportation	•••	•••	••	•••	••				•••	••

••• high benefit •• medium benefit • low benefit

GLOSSARY

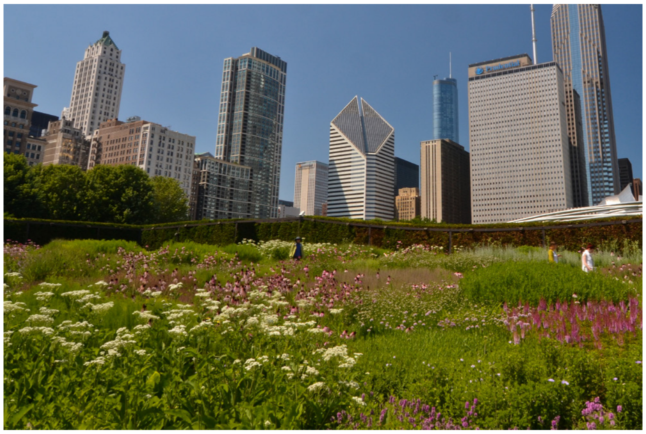
GREEN STORMWATER INFRASTRUCTURE STRATEGIES

Buffer Parks

Buffer parks protect residents by creating a physical barrier between homes and air pollution from vehicles, manufacturing facilities, and other sources. The vegetation also relieves mental stress, lessens heat stress, beautifies the environment, and can provide local economic opportunities through local hiring and job training for landscape installation and maintenance.

Linear Buffer Parks

Typically longer than they are wide, these multifunctional urban parks manage stormwater and navigate through neighborhoods, often linking residents to alternative transportation (e.g., walking, biking). They are connected to benefits such as increased property values in the neighborhood and revitalized brownfields, and they increase neighborhood service provision.



Stormwater Parks

Stormwater parks serve a dual role as recreational parkland that also hold a large amount of water during storms. These parks treat rain as an asset, by incorporating stormwater management into the overall landscape design.

Stormwater Planters and Parkway Bioswales

Stormwater planters and parkway bioswales use water-loving, deep-rooted plants planted in porous soil to capture and treat rain. Bioswales also move rain from one location to another; they are typically installed within parkways or other sites next to paved areas, like roads, sidewalks, and parking lots.

Rain Gardens

Like bioswales, rain gardens use plants and soil to capture and treat stormwater. Rain gardens are bowl-shaped to capture rain that flows overland or enters from a disconnected downspout. Some cities offer grants or other incentives to residents and non-profits who want to create and maintain a rain garden on their land.

Street Trees

Trees provide many social, economic, and environmental benefits, including improved air quality, reduced stormwater runoff, energy use, and atmospheric CO2.

Green Roof

Green roofs are partially or completely covered with a growing medium and vegetation planted over a waterproofing membrane. They may include additional layers, such as a root barrier, and drainage and irrigation systems. In addition to providing onsite stormwater management, green roofs mitigate urban heat island impacts and reduce building energy costs.

Permeable Pavement and Bike Lanes

Permeable pavement is a hard surface that lets rain pass through to the soil beneath it. Permeable pavement can be made from interlocking pavers, or specially engineered concrete or asphalt. Streets, bike lanes, parking lanes, alleys, and parking lots can be depaved and reconstructed with porous pavement.

District Stormwater Management

District stormwater management is a combination of green infrastructure strategies installed throughout a neighborhood, with the goal of maximizing the community benefits produced by each individual strategy. In addition to managing stormwater runoff, district stormwater management reduces air pollution, heat stress, and mental stress. Vegetation also provides opportunities for local landscaping jobs and workforce development. Larger-scale practices, such as stormwater parks, can reactivate vacant land. Smaller-scale practices, such as a home rain garden or bioswale, lower household expenses by reducing the potential for costly flood damage repairs to buildings.

HEALTH BENEFITS

GREEN STORMWATER INFRASTRUCTURE

GREEN STORMWATER INFRASTRUCTURE : COMMUNITY HEALTH BENEFITS

In order to foster healthy communities, we need to look at the underlying causes of negative health impacts and ways they can be addressed. Implementing a variety of green stormwater infrastructure (GSI) practices offers a unique mix of health benefits to communities in addition to stormwater protection.

The community health benefits guide will help municipal officials quantify the health benefits of green stormwater infrastructure.

THE HEALTH BENEFITS OF GREEN STORMWATER INFRASTRUCTURE

Overall, greener environments are linked to improved health outcomes. Factors may include more opportunities for physical activity (and reduced risk of cardiovascular disease), the stress-relieving benefits of nature, and the facilitation of social contact[1]. In communities where health disparities exist, green space can be an important strategy for achieving health equity for disproportionately burdened populations.[2]

Green stormwater infrastructure can also be designed to combat climate-related conditions that are known to create negative health impacts, such as air pollution, extreme heat, and noise. As shown in Figure 1, a single GSI strategy can provide multiple health benefits. For example, a linear buffer park can act as a barrier to outdoor air and noise pollution, while providing shade to reduce urban heat island effect, absorbing stormwater runoff, and link to recreational trails.

Figure 1. Health Benefits of Green Stormwater Infrastructure

HEALTH BENEFITS	GREEN STORMWATER INFRASTRUCTURE: Linear Buffer Park / Trail	Stormwater Park	Stormwater Planter	Parkway Bioswale	Rain Garden	Street Trees	Green Roof	Permeable Pavement	Permeable Bike Lane	District Stormwater
Improved Outdoor Air Quality	•••	•	••	•	••	••	•			••
Improved Indoor Environmental Quality	•	•••	••	•	•	•••	•	••	••	•
Reduced Noise Pollution	•••						•••	••	••	••
Reduced Heat Stress	••	•••	•	•	•	••	•			••
Improved Community Cohesion + Mental Health	•	•••	••	•	•	••	•			••

••• high benefit   •• medium benefit   • low benefit

1. Richardson et al. (2013). Role of physical activity in the relationship between urban green space and health. Public Health.
2. Jennings & Johnson Gaither. (2015). Approaching Environmental Health Disparities and Green Spaces: An Ecosystem Services Perspective. International Journal of Environmental Research and Public Health.

BURDEN OF HEALTHCARE COSTS

The healthcare cost of climate-related stressors is significant. One study of six climate disasters in the United States was estimated to cost approximately $14 billion in lost lives and medical care.[3] While premature death accounts for most of the cost of climate events, non-fatal illness impacts far more people.[4]

Table 1. Total Health Impact Cost, By Case Study Climate Event, in 2008 Dollars (Knowlton et al., 2011)

Climate Related Health Stressor	Normalized Cost per 1,000 people ($)
Ozone Air Pollution	$22,705
Heat Wave	$148,792
Hurricane	$80,162
Infectious Disease Outbreak	$46,449
River Flooding	$145,495
Wildfires	$28, 819

Table 1 provides costs from Knowlton, et al. (2011), "Six Climate Change-Related Events in the United States accounted for about $14 Billion in Lost Lives and Health Costs." The authors analyzed the health costs of health impacts of six typical climate events, including outpatient visits, emergency department visits, hospitalizations, and premature death. Valuation methods included published ratios, "willingness to pay," and "value of a statistical life." The costs do not capture lost work and leisure time for caretakers, lost school days, activity-restricted days, pain and suffering, or the health and financial inequities experienced by disproportionately impacted populations.

Photo: Alex Proimos, Flickr

COST OF ILLNESS

Morbidity Cost *= Medical Cost + Productivity Loss*

Medical Cost *= (Attributable Emergency Department Visits or Emergency Department Visits followed by Hospitalization) * Cost of Healthcare per Visit*

Productivity Loss *= Length of Hospital Stay * Daily Production Value for Age Group*

Methodology based on Liu et al. (2019), "Degrees and dollars – Health costs associated with suboptimal ambient temperature exposure." Daily Production Value is published in Grosse et al. (2009); however, this study does not account for lost work hours of caretakers.

3. Knowlton et al. (2011). Six Climate Change-Related Events in the United States accounted for about $14 Billion in Lost Lives and Health Costs. *Health Affairs.*
4. Knowlton et al. (2011). Liu et al. (2019). Degrees and dollars - Health costs associated with suboptimal ambient temperature exposure. *Science of the Total Environment.*

IMPROVED OUTDOOR AIR QUALITY

GSI strategies that incorporate vegetation directly improve outdoor air quality by absorbing pollutants into the plants. The health impacts of air pollution are significant. Particulate matter is ranked first among nine environmental risk factors with the highest health impact.[5] Exposure to high levels of ozone pollution leads to increased rates of hospitalizations and emergency room visits. Nationally, ozone and particle pollutants are estimated to cause between 1,000 – 4,300 additional premature deaths, per year, by 2050.[6] The exact air quality benefits of GSI will vary, depending on plant species, length of the growing season, and landscape design.

Linear buffer parks, made of closely-spaced trees and plants, reduce air pollution impact in two ways:

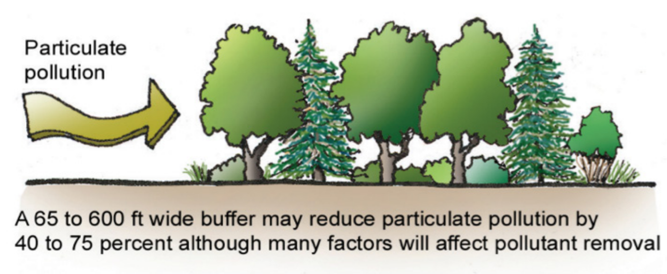
1. Absorbing pollutants from the air, and
2. Physically blocking the flow of pollutants to residential areas.

Use the free modeling software iTree (www.itreetools.org) to quantify the amount of air pollution reduction offered by street trees and buffer parks in your community.

5. Hanninen, et al. (2014). Environmental Burden of Disease in Europe: Assessing Nine Risk Factors in Six Countries.
6. Luber et al. (2014). Ch. 9: Human Health. Climate Change Impacts in the United States: The Third National Climate Assessment

Effective buffer parks are properly designed with layers of closely spaced vegetation of the correct species. They act as an effective barrier along high air pollution sources like roadways, railroad yards, and industrial campuses. Research shows that buffer parks have the potential to improve respiratory health, and lower the number of cases of heart attacks, irregular heartbeat, cardiovascular disease, low birth weight infants, and cancer.[7,8]

Figure 2. *Illustration of particulate pollution reduction effect from a linear buffer park. Source: USDA Forest Service*



Other types of vegetated green infrastructure also provide air quality benefits. For example, a green roof absorbs particulate matter, ozone, sulfur dioxide, and nitrogen dioxide.[9] The actual amount of pollutants removed by green roofs will vary by community, depending on the growing season, weather conditions, and the amount and type of vegetation and pollution.

Quantity of Air Pollutants removed by Green Roof (Annual)[10]

Low Estimate: *152 pounds of air pollutant per hectare of vegetation*
High Estimate: *213 pounds of air pollutant per hectare of vegetation*

IMPROVED INDOOR AIR QUALITY: BUILDING DAMPNESS AND PESTS

Green stormwater infrastructure can also indirectly improve indoor air quality, by reducing the risk of indoor dampness due to flooding (see Climate Benefits strategy guide).

Research indicates that adverse health effects, most commonly respiratory conditions such as asthma, are associated with building dampness and mold. One study suggests that 21% of asthma cases are associated with building dampness or mold conditions.[11]

Asthma Cases related to Building Dampness

*A*0.21*
A = Total number of asthma cases in community

Climate change may also increase the risk and severity of infectious diseases spread by pests in and around homes, such as West Nile virus. West Nile virus can result in fever, paralysis, and even death.[12] GSI reduces the likelihood of West Nile virus by improving drainage around homes, eliminating ponded water that can serve as a breeding ground for the mosquitoes that spread the virus.

7. U.S. EPA (2015). Nearby Roadway Air Pollution and Health
8. California Environmental Protection Agency Air Resources Board. (2005). Air Quality and Land Use Handbook: A Community Health Perspective.
9. Currie and Bass (2008). "Estimates of air pollution mitigation with green plants and green roofs using the UFORE model." *Urban Ecosystems.* 11:409-422.
10. Yang, Yu and Gong (2008). "Quantifying air pollution removal by green roofs in Chicago." *Atmospheric Environment.* 42:7266–
11. Mudarri and Fisk (2007). "Public health and economic impact of dampness and mold." *Indoor Air.* 17: 226-235.
12. Knowlton, et al. (2011). Six Climate Change-Related Events in the United States accounted for about $14 Billion in Lost Lives and Health Costs. *Health Affairs.*

REDUCED NOISE POLLUTION

Half of the U.S. population lives in areas that exceed recommended noise levels. One national survey revealed that road and aircraft noise was the number one reason for residents' desire to move out of a neighborhood.[13] Fortunately, vegetated green stormwater infrastructure and permeable pavement can reduce noise pollution.

Quieter Neighborhoods are Healthier

A study in Madrid found that a 1 decibel reduction in daily noise levels prevented up to 500 deaths due to respiratory and cardiovascular causes in individuals over 65 years old.[14]

In some cases, vegetation can even replace conventional noise mitigation strategies, such as using linear tree buffers instead of concrete noise walls. Commercial noise modeling software is available to calculate the noise reduction benefits.

Table 2. *Estimated Noise Mitigation Benefit of GSI*

Strategy	Added Noise Reduction (Decibels)
Cover conventional noise wall with vegetation[15]	8
Street hedgerows[16]	5
Porous Pavement[17]	10
Green Roof[18]	13

The health impacts of noise extend beyond annoyance and hearing loss – noise is associated with cardiovascular and respiratory disease, diabetes, and adverse health outcomes.[19] In fact, road traffic noise is ranked second among nine environmental risk factors, resulting in 400 to 1,500 healthy life years lost per million people.[20]

13. U.S. EPA (1981). Noise effects handbook: A desk reference to health and welfare effects of noise
14. Tobias et al. (2015). *Health impact assessment of traffic noise in Madrid.* Environmental Research.
15. Van Rentergehm et al. (2015). *Using natural means to reduce surface transport noise during propagation outdoors.* Applied Acoustics.
16. IBID
17. Olek et al (2003); Gerharz (1999)
18 Connelly and Hodgson (2008). British Columbia Institute of Technology's Centre for the Advancement of Green Roof Technology
19. Recio et al. (2015). Road traffic noise effects on cardiovascular, respiratory, and metabolic health: An integrative model of biological mechanisms. Environmental Research.
20. Hanninen et al. (2014). Environmental Burden of Disease in Europe: Assessing Nine Risk Factors in Six Countries. Environmental Health Perspectives.

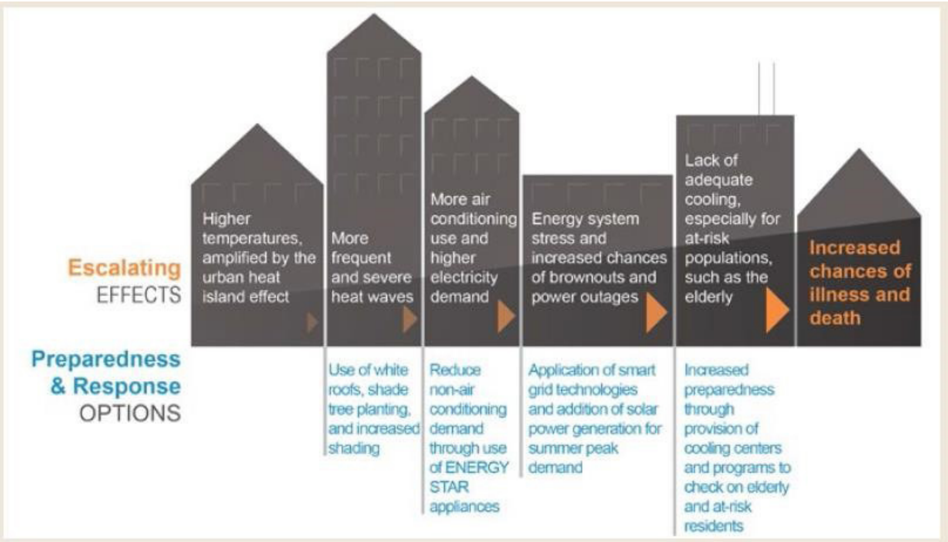
REDUCED HEAT STRESS

Extreme heat is the leading cause of weather-related deaths in the U.S. Extreme heat exposure is associated with heatstroke, hyperthermia, and other illnesses, and can worsen chronic conditions such as cardiovascular disease and respiratory disease. Heat waves are associated with increased hospital admissions for cardiovascular, kidney, and respiratory disorders.[21] In addition, suicide rates rise with heat waves; some medications interfere with body temperature regulation; and dementia is a risk factor for heat-related death.[22] Urban heat island is also linked to degraded air quality in our communities, by directly creating ground-level ozone, which has adverse health impacts as discussed above.[23]

Extreme temperature conditions disproportionately impact youth, causing high numbers of emergency room visits, and the elderly, causing high numbers of emergency hospitalizations and deaths.[24]

GSI strategies with vegetation lessen urban heat island impacts (see Climate Resilience guide), by providing direct shade and cooling the air through evapotranspiration. Shaded surfaces can be 20 to 45°F cooler than unshaded surfaces during peak summer temperatures. Evaporation can reduce peak temperatures by 2 to 9°F.[25]

Figure 3. Extreme heat has cascading impacts on health. Source: Third National Climate Assessment (2010).



IMPROVED COMMUNITY COHESION AND MENTAL HEALTH

Green stormwater infrastructure has several positive community cohesion benefits. Neighborhood greenery helps residents feel less stress, encourages neighborliness, and even improves community safety. Studies of urban neighborhoods demonstrated measurably lower rates of both violent crime and property crime, after greenery was introduced into formerly barren areas.[26, 27] Neighborhood green space has also been demonstrated to significantly lower the risk of poor mental health, which is strongly related to cardiovascular disease.

21. USGCRP. (2016). The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. *U.S. Global Change Research Program.*
22. Luber et al. Ch. 9: Human Health. Climate Change Impacts in the United States: The Third National Climate Assessment
23. U.S. EPA (n.d.). Heat Island Impacts.
24. Liu et al. (2019). Degrees and dollars – Health costs associated with suboptimal ambient temperature exposure. *Science of the Total Environment.*
25. U.S. EPA (n.d.). Using Trees and Vegetation to Reduce Heat Islands
26. Kuo & Sullivan (2001). Aggression and Violence in the Inner City: Effects of Environment via Mental Fatigue.; Kuo & Sullivan (2001). *Environment and Crime in the Inner City: Does Vegetation Reduce Crime?*
27. Kardan et al. (2015). Neighborhood greenspace and health in large urban center. *Nature: Scientific Reports.*

GETTING STARTED

Here are key actions for capturing the health benefits of green stormwater infrastructure in your community:

1. Develop or expand an interdepartmental health task force to integrate health and green stormwater infrastructure into existing plans and programs, and lead new initiatives. Include health benefits as a project selection criterion in cross-departmental municipal decision-making.
2. Conduct a community health assessment to identify localized poor air quality, elevated noise, and high surface temperature, and the locations of the most vulnerable resident groups.
3. Identify opportunities for green stormwater infrastructure on public rights-of-way, institutional land, vacant and underutilized parcels, and by greening existing infrastructure. During the project design process, model the health impacts of "business as usual" development scenario versus GSI designs, including air quality and noise impacts.
4. Involve health institutions and residents in planning new GSI projects, to maximize public health benefits and address priorities identified by community members.
5. Seek funding for health and GSI-focused projects, and health and GSI metrics to grant applications.

FOR MORE INFORMATION

- View the Green Values Stormwater Calculator at https://greenvalues.cnt.org
- Browse additional Green Values Strategy Guides and other resources at CNT.org

GREEN VALUES STRATEGY GUIDE

ECONOMIC BENEFITS

GREEN STORMWATER INFRASTRUCTURE

GREEN STORMWATER INFRASTRUCTURE: A STRATEGY TO ADDRESS ECONOMIC DEVELOPMENT

As municipalities contend with limited budgets, communities must stimulate new economic opportunities, while addressing other community priorities. Green stormwater infrastructure (GSI) can play a crucial role in addressing this challenge.

The economic development benefits guide offers techniques to quantify the economic benefits of green stormwater infrastructure. The guide can be used by municipal officials, chambers of commerce, economic development planners and managers.

THE ECONOMIC BENEFITS OF GREEN STORMWATER INFRASTRUCTURE

Green stormwater infrastructure (GSI) provides multiple economic benefits, as shown in Figure 1. For example, GSI fosters green job creation and workforce development in communities while addressing growing stormwater management needs; reactivates vacant land which improves property values; and provides opportunities for creative placemaking.

Figure 1. Economic Benefits of Green Stormwater Infrastructure

ECONOMIC BENEFITS	GREEN STORMWATER INFRASTRUCTURE: Linear Buffer Park / Trail	Stormwater Park	Stormwater Planter	Parkway Bioswale	Rain Garden	Street Trees	Green Roof	Permeable Pavement	Permeable Bike Lane	District Stormwater
Improved Workforce Development / Job Creation	•••	•••		•		•••	•	•	•	•••
Increased Vacant Land Reactivation	•••	•••			•••					•••
Increased Property Values	••	•••	•	••	•	••	•••			•••
Increased Sales Revenue			••	••	••	••			••	••
Increased Recreational Value	•••	•••							•••	

••• high benefit •• medium benefit • low benefit

WORKFORCE DEVELOPMENT AND JOB CREATION

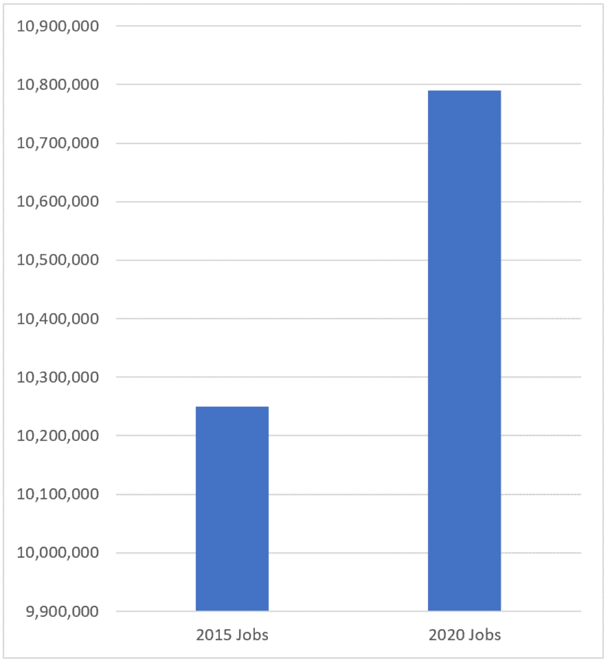
The U.S. Department of Labor, Bureau of Labor Statistics defines jobs that provide services with environmental benefits, support green infrastructure practices, and conserve natural resources as "green jobs."[1] From design through maintenance, municipal-scale green infrastructure offers an additional layer of "green" skills within traditional industries such as roofing, tree care, landscape design, landscaping and groundskeeping, and construction.[2]

GSI projects present opportunities to facilitate green jobs training programs to train a workforce to install, maintain and operate GSI. GSI projects require many trades, from landscapers to heavy equipment operators, which can accommodate individuals with a wide range of educational attainment, work histories, and language skills. These projects provide a "missing middle" that is disappearing – higher wage than retail, but not requiring a college degree.

The demand for "green job" skills continues to rise, spurring economic development, and supporting workforce development. The U.S. Bureau of Labor Statistics projects "green" jobs to have the most rapid employment growth from 2016 to 2026.[3]

Figure 2 shows the projected 5% growth (or nearly 600,000 jobs added) from 2015-2020 in occupations that are linked to GSI.[4] Figure 3 shows the specific occupations related to green infrastructure expected to see growth between 2015 and 2020.[5] Precise "green job" projections are not quantified due to the lack of distinctive infrastructure-specific jobs. Trends within occupations that have a green infrastructure component were used to estimate "green job" growth.

Figure 2. *Projected Job Growth 2015-2020 in Green Jobs*



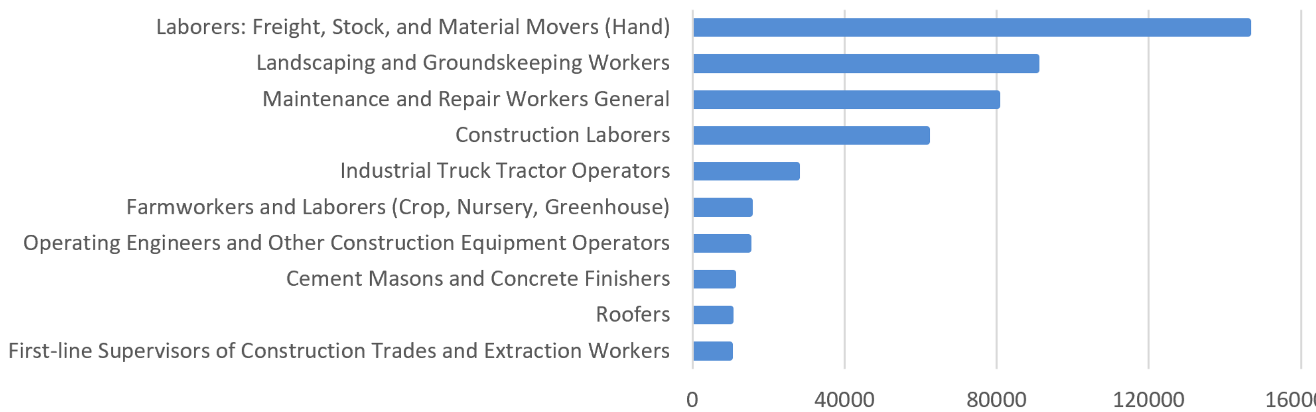
Green Job Growth Examples

Portland, Oregon, an early adopter of green stormwater infrastructure, began installing GSI in the 1990s. The City estimates that roughly 5 percent of its workforce holds a "green job." 10,600 new "green jobs" were posted in 2015.[6]

Detroit, Michigan has also been making strides to create more green jobs. Faced with a $1.2 million gray infrastructure price tag to build a seven-mile underground tunnel to collect stormwater, the City opted to invest $50 million in green infrastructure initiatives by 2029. According to research findings, approximately 11,700 jobs postings in the Detroit metro area included occupations in green infrastructure, installation, maintenance and inspection.[7] Detroit is also developing a training program for contractors to include native plants and other nature-based solutions to mitigate stormwater.[8]

1. International Labour Organization. (2018). Greening with Jobs World Employment - Social Outlook.https://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_628654.pdf
2. U.S. Department of Labor. (n.d.). Green Jobs. https://www.bls.gov/green/#definition
3. U.S. Department of Labor. (2018). Bureau of Labor Statistics. https://www.bls.gov/careeroutlook/2018/data-on-display/green-growth.htm?view_full
4. Jobs for the Future. (2017). Exploring the Green Infrastructure Workforce – A Nature Works Issue Brief. https://jfforg-prod-prime.s3.amazonaws.com/media/documents/NatureWORKS-Issue-Brief-032317_v3.pdf
5. IBID
6. IBID
7. Burning Glass Technologies. (n.d.). Labor Insight. Data extracted by S. Lamback.
8. Jobs for the Future. (2017).

***Figure 3.** Projected National Employment Job Growth in Occupations Linked to Green Infrastructure, 2015-2020*



Source: Emsi Analyst. 2016.3 data set.

REACTIVATE VACANT LAND

Vacant land can discourage investment, devalue surrounding properties, and increase government expenses to secure these properties. These same properties can serve as potential assets for a community, once reactivated with GSI.

Example 1: Spur Redevelopment

Installing green infrastructure on vacant and underutilized land, including brownfields, can spur interest in redevelopment. One example of a successful initiative to revitalize vacant land includes Philadelphia's Green City, Clean Waters stormwater management initiative. The Plan committed $1.2 billion of investments in green infrastructure over 25 years, starting in 2011. Of the City's 40,000 vacant lots, 11,000 have more than ten years of tax delinquency, costing the City of Philadelphia and the School District of Philadelphia $2 million annually. The Initiative is estimated to encourage the development of 8.5% (or 3,400) of the City's 40,000 vacant parcels for green spaces and other residential uses.[9]

As of 2019, Philadelphia has implemented over 1,000 GSI projects on public and private property, and an additional 600 projects are in the planning stages.[10] The City has not expressly stated what percentage of green projects are installed on formerly vacant lots.

Example 2: Funding and Developing Open Space by Leveraging Partnerships

Communities can ramp up the development and long-term maintenance of open space by establishing public, nonprofit, and private partnerships.

In 1993, Chicago's Department of Community Development (now the Department of Planning and Development), the Chicago Park District (CPD), and other partners initiated the CitySpace program, an effort to increase park/open space throughout Chicago. Early research by CitySpace estimated that 61% of Chicago residents lived in neighborhoods with fewer than 2 acres of open space per 1,000 residents, and that vacant land accounted for approximately 14% of Chicago's land area.

To address the surfeit of vacant land and inequities in access to open space, the City developed a conversion and acquisition plan of privately held, tax-delinquent properties. Once in the City's ownership, it deeded the properties to CPD if over 2 acres or NeighborSpace, a public-private land trust that supports community-managed open space, if under 2 acres. Between 1998 and 2012, Chicago and its partners acquired, converted, and continue to maintain more than 1,344 acres of neighborhood parks, wetlands, natural areas, neighborhood parks, campus parks, and community gardens.[11]

9. Natural Resources Defense Council (NRDC). (2013). Greening Vacant Lots Planning and Implementation Strategies. https://www.nrdc.org/resources/greening-vacant-lots-planning-and-implementation-strategies
10. Sustainable Business Network of Greater Philadelphia. (2019). The Economic, Social, and Enivronmental Case for Green City, Clean Waters: An Update. https://gsipartners.sbnphiladelphia.org/research-publications/
11. NRDC. (2013).

INCREASED PROPERTY VALUES

Property values increase when a neighborhood has more open space. The potential for new revenue is substantial. A report from the Philadelphia Residential Authority concluded that homes within a ¼ mile of green lots developed by the Philadelphia LandCare program "increased in value by 2% to 5% annually – equal to $35,000 over five years – generating $100 million in additional annual property taxes," a return of $7.43 in tax revenues for each public dollar spent.[12]

Trees and Property Values

- A tree canopy cover study found that homes with greenery benefit from an increased sale price of up to 5%.[13]
- Another study found that trees add nearly $9,000 to a home's sale price and reduce days on the market by 1.7 days.[14]
- Rental prices go up, as well: a study in New York City found that apartment buildings with green roofs "rented for 16.2% higher on average than apartments in buildings without green roofs."[15]

However, any strategy that aims to create economic benefits by increasing property values must be paired with affordability efforts to avoid displacement of long-time residents. Homeownership strategies, like co-ops, land trusts, and property tax freezes can help stabilize existing neighborhoods. Preservation of affordable rental housing through purchase or partnerships with landlords are complementary strategies.

The Rose, Minneapolis, Minnesota

The Rose is an example of an affordable housing development that employs high performance green infrastructure to improve livability and building sustainability. The 90-unit, mixed-income residential development property, developed by Aeon, includes 33% green space, including rain gardens (infiltrating 75% of stormwater on-site), a 5,000 square foot community garden, and tree-lined walkways.[16] Of the 90 units, 52% are affordable, and 25% of those are designed for famlies experiencing homelessness.[17]

The Weidt Group, an independent third-party research group, estimated payback for the project at 11.4 years, due to its energy efficiency and other sustainability features.[18] In 2016, Aeon and U.S. Bank estimated that the value of market-rate, two-bedroom units would be $1,600 per month, which would be unprecedented at an intersection with little to no development activity 15 years ago.[19] In 2020, the building still maintains its mixed-income development ratios, and market-rate two-bedroom units are available for betweeen $1,400 and $1,750 per month.[20]

Figure 4. *Annual Property Value Gains from 1 tree, 40-year average, Midwest Region*

			
	Small tree: Crabapple 22 ft. tall, 21 ft. spread	Medium tree: Red Oak 40 ft. tall, 27 ft. spread	Large tree: Hackberry 47 ft. tall, 37 ft. spread
Residential Yard	$4.50	$10.73	$23.44
Public Space	$5.32	$12.67	$27.69

Source: McPhearson, E et al. 2006

12. Gillen, K. (2012). Testimony to the Philadelphia City Council [PDF].
13. Netusil, N.R.,Chattopadhyay, S., & Kovacs, K. (2010). Estimating the Demand for Tree Canopy: A Second-Stage Hedonic Price Analysis in Portland, Oregon. *Land Economics*. 86. 281-293. 10.3368/le.86.2.281.
14. Bryce Ward, Ed MacMullan, & Sarah Reich (2008). *The Effect of Low Impact Development on Property Values.* http://www.12000raingardens.org/wp-content/uploads/2013/03/The-Effect-of-Low-Income-Development-on-Property-Values.pdf
15. Ichihara, K., Cohen, J. P. (2011). New York City property values: what is the impact of green roofs on rental pricing? *Letters in Spatial and Resource Sciences.* Volume 4, Number 1, Page 21..
16. Urban Land Institute. (2015). ULI Case Studies: The Rose. https://casestudy.test.uli.org/wp-content/uploads/2015/12/TheRose_CaseStudy.pdf
17. National Association of Home Builders. (2017). Marrying Affordability and Sustainability at The Rose . https://bestinamericanliving.com/2017/09/marrying-affordability-and-sustainability-at-the-rose/
18. Urban Land Institute. (2018). Developing Urban Resilience: The Rose, Minneapolis, Minnesota. https://developingresilience.uli.org/case/the-rose/
19. Urban Land Institute. (2015).
20. CoStart Group: apartments.com. (2020). The Rose. https://www.apartments.com/the-rose-minneapolis-mn/843b4e1/

INCREASED SALES REVENUE

Green infrastructure can improve neighborhood desirability and change travel patterns, directly impacting retail sales.

New York City's Department of Transportation's (NYDOT) sustainable development agenda seeks to transform its large arterial streets from traffic-dominated corridors to streets designed to reduce roadway congestion, improve the pedestrian experience, and incorporate GSI to manage stormwater. NYDOT's study, "The Economic Benefits of Sustainable Streets," makes the direct connection between its "complete streets" and their potential to contribute to New York's economic viability. NYDOT reported increased patronage of local businesses, increased job opportunities, and reinvestment within neighborhoods impacted by "complete street" improvements.

Vanderbuilt Avenue (Plaza Street to Dean Street), Brooklyn

Source: New York City DOT

For instance one of the City's "complete streets," along Vanderbilt Avenue, yielded improved economic performance and an upward trend in retail sales among businesses directly impacted, in contrast to comparison sites. During the first year of construction, baseline quarterly sales totaled $894,673. Three years after construction, retail sales had increased by 102%.[22]

INCREASED RECREATIONAL REVENUE

Green infrastructure installations such as trees, parks, and trails create increased recreational opportunities, such as walking, jogging, and habitat viewing in public spaces.[23, 24]

In Philadelphia, GSI installed at the City's 220-acre Cobbs Creek Park is projected to create 70% "new visits," an increase of "$3.9 million recreation-related benefits each year," and an increase of "user days", or additional recreational trips, of more than 40 years. As of 2016, the City had installed close to 20 GSI projects along Cobbs Creek, diverting, holding, and/or infiltrating nearly 400,000 gallons of stormwater across all projects during a 1- to 2-year storm event, improving water quality, preventing localized flooding, and improving recreation access.[25]

Valuing Recreational Use in Philadelphia[26]

User days were established in a triple bottom line assessment of green infrastructure benefits in Philadelphia and may provide a helpful starting point for valuing the benefit of improved recreation from green infrastructure and increased vegetation.

- **1 additional greened acre provides**
  ~1,340 user days per year
  ~27,650 user days over a 40-year period
- **1 user day provides**
  ~$0.85 in present value (2020)

As of 2017, 226 greened acres have been implemented on public property across Philadelphia. If half of these greened acres provide a recreational benefit, the acres provide an additional 150,000 user days per year, and present day dollar value of about $130,000 annually.

21. New York City Department of Transportation. (n.d.). The Economic Benefits of Sustainable Streets. http://www.nyc.gov/html/dot/downloads/pdf/dot-economic-benefits-of-sustainable-streets.pdf
22. IBID
23. CNT. (2010). The Value of Green Infrastructure.
24. Terkenli T.S., et al. (2017). Recreational Use of Urban Green Infrastructure: The Tourist's Perspective. In: Pearlmutter D. et al. (eds) *The Urban Forest*. Future City, vol 7. Springer, Cham
25. Philadelphia Water Department. (2016). A Virtual Walking Tour: Cobbs Creek Green Improvements. Green City, Clean Waters. https://www.arcgis.com/apps/MapJournal/index.html?appid=c68733f61bab44a4be0470995809566f
26. Stratus Consulting. (2009). A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds. SC11737.

GETTING STARTED

Long-term planning goals to reduce overflows and manage flooding can be designed to meet other community goals using green stormwater infrastructure practices. Achieving enough density of distributed GSI throughout a community requires the development of new strategies to support GSI implementation on public and private land, including forging new relationships with City staff, the community, and the private sector to achieve economies of scale.

Here are some critical actions for capturing the economic benefits of green stormwater infrastructure in your community.

1. Incentivize economic community benefits through implementation of green infrastructure on private land by detailing the associated property value benefits, implementing a stormwater utility fee, expediting permit processes, reducing building permit fees for green infrastructure installations, and offering grants for homeowners.[27]
2. Make the connection between economic development and city streetscape design that incorporates green infrastructure design by accessing data on retail impacts of improved street design. Pairing qualitative and quantitative data creates a compelling case for green infrastructure.
3. Identify workforce development programs that train community members in green infrastructure installation and maintenance. Require a percentage of work hours on green infrastructure projects to be performed by "green job" workers.
4. Use the National Green Values Stormwater Calculator to calculate the economic benefit of green infrastructure, including annual and life-cycle benefits. (https://greenvalues.cnt.org)
5. Engage local workforce development groups in the operations and maintenance of GSI. Examples of successful workforce development initiatives include the City of Chicago's Greencorps, whose mission is to train individuals with barriers to employment in green industry jobs, including horticulture, forestry, and GSI maintenance, or Sustainable South Bronx, whose mission is to provide "green jobs" that address environmental and social needs of the community.[29]

FOR MORE INFORMATION

- View the Green Values Stormwater Calculator at https://greenvalues.cnt.org
- Browse additional Green Values Strategy Guides and other resources at CNT.org

27. USEPA.(2014). Enhancing Sustainable Communities with Green Infrastructure. https://www.epa.gov/sites/production/files/2014-10/documents/green-infrastructure.pdf.
28. IBID
29. American Rivers. (2016). Staying Green and Growing Jobs: Green Infrastructure Operations and Maintenance as Career Pathway Stepping Stones. http://www.americanrivers.org/wp-content/uploads/2016/05/staying-green-and-growing-jobs.pdf

GREEN VALUES STRATEGY GUIDE

CLIMATE BENEFITS

GREEN STORMWATER INFRASTRUCTURE

BENEFITS OF GREEN STORMWATER INFRASTRUCTURE IN A CHANGING CLIMATE

Climate change is bringing historic storms, flooding, drought, and heat to our communities. Green stormwater infrastructure (GSI) can play a role in our communities adapting to the impacts of a changing climate by capturing rain where it falls, rather than sending it into an overburdened sewer system. It can also help us adapt to and mitigate climate heat impacts by countering the urban heat island effect and shading buildings to reduce energy needs.

The climate benefits guide provides brief methods to quantify and document those benefits to make the case for scaling up green infrastructure to address these issues across our communities.

GREEN STORMWATER INFRASTRUCTURE REDUCES URBAN FLOODING

When a large rainstorm or significant snowmelt occurs, urban areas can flood—even if they're not near a body of water—causing property damage and community hazards. GSI prevents urban flooding by retaining water and allowing it to infiltrate into the ground—rather than water standing in paved areas and running off into homes, businesses, and overcapacity sewer systems.

Green roofs, permeable pavement, bioswales, trees, and rain gardens are all types of GSI that can reduce urban flooding. An EPA study found that the U.S. could save at least $63 to $136 million in flood losses per year by 2040 (in 2011 dollars) by expanding adoption of GSI practices to prevent flooding in 5 and 10 year floodplains.[1] A study of bioswales in San Francisco, CA found that they reduced stormwater volume entering the sewer system by 53% in their drainage management areas.[2]

Figure 1. Climate Benefits of Green Stormwater Infrastructure

	GREEN STORMWATER INFRASTRUCTURE									
CLIMATE ADAPTATION / RESILIENCE	Linear Buffer Park / Trail	Stormwater Park	Stormwater Planter	Parkway Bioswale	Rain Garden	Street Trees	Green Roof	Permeable Pavement	Permeable Bike Lane	District Stormwater
Reduced Flooding	•••	•••	••	••	••	•••	••	•••	••	•••
Reduced Urban Heat Island Temperatures	••	•••	•	•	•	•••	•••	•	•	•••
Protected Water Quality (reduced runoff and combined sewer overflows)	•••	•••	••	••	••	•••	••	•••	••	•••
CLIMATE MITIGATION / AVOIDANCE										
Reduced Greenhouse Gases	•••	•••	•••	•••	•••	•••	•••	•	•	•••
Reduced Energy Use	••	••				•••	•••			••

••• high benefit   •• medium benefit   • low benefit

1. U.S. Environmental Protection agency & Atkins. (2015). Flood Loss Avoidance Benefits of Green Infrastructure for Stormwater Management.
2. San Francisco Water Power Sewer. (2015). Cesar Chavez Streetscape Improvement Project Report: Rainy Season 2014-15. *Sewer System Improvement Program.*

PROTECTED WATER QUALITY

Green stormwater infrastructure protects water quality by reducing the volume of water entering the sewer system. During heavy rain or snow melt events, significant volumes of water can enter municipal sewer systems, causing sewer backups into homes and businesses, or releases of untreated water into lakes and rivers. In communities with older combined sewer systems that handle both wastewater and stormwater, discharges (called combined sewer overflows) of untreated water are extremely hazardous to human and ecosystem health.

By reducing the amount of water that a system has to handle during rain events, through on-site stormwater capture and infiltration, GSI can reduce or prevent combined sewer overflows. In this way, GSI can be an important and cost effective part of a community's sustainability, resilience, and compliance with environmental regulation.

Onondaga County's Save the Rain Program

Onondaga County, New York's Save the Rain program is an award-winning initiative to improve the water quality of Onondaga Lake and its tributaries.[3] Since 2010, the initiative has advanced over 130 green infrastructure projects, capturing over 170 million gallons of stormwater annually, improving the overall water quality and avoiding expensive treatment investments. See Table 1 for green and gray infrastructure cost comparisons.

Table 1. Save the Rain Green and Grey Infrastructure Project Details[4]

	Green Infrastructure	Grey Infrastructure
Number of projects implemented between 2010 and 2019	132	7
Total Gallons Captured	170,000,000	220,000,000
Total Project Costs	$53,000,000	$142,000,000
Average Project Cost	$420,000	$20,000,000
Cost per gallon of stormwater captured per year	$0.32	$0.65

3. Onondaga County Department of Water Environment Protection. (n.d.). *Save the Rain.*
4. IBID

- The iTree software tools (www.itreetools.org) can calculate the benefits of trees in their community, including storm water run-off reduction, carbon sequestration, and energy.

- The value of stormwater services can add up substantially over the lifetime of a tree. A study of street trees in California[5] found that each tree intercepts an average of 750 gallons of stormwater per year for an annual value of $4.55 in stormwater interception—based on an average value of stormwater interception of $6 per 1000 gallons. The annual stormwater interception value goes up significantly in the Midwest region - $17 in Indiana and $30 in Missouri – due in large part to larger volumes of rainfall.

REDUCED URBAN HEAT ISLAND IMPACTS

In addition to providing shade, GSI can reduce temperatures by providing direct shade and by cooling the air through evapotranspiration. Shaded surfaces can be 20 to 45°F cooler than unshaded surfaces during peak summer temperatures. Cities with large amounts of asphalt and built areas generate a "heat island" effect that exacerbates the impacts of climate change. GSI counteracts that by changing the albedo of surfaces to reflect back heat and introducing the cooling effects of evapotranspiration which can reduce peak temperatures by 2 to 9°F.[6]

Moreover, GSI can assist in mitigating extreme heat, which is tied to several serious health impacts.[7] See the Public Health Strategy Guide to learn more.

5. McPherson, E. Gregory; van Doorn, Natalie; de Goede, John. (2016). Structure, function and value of street trees in California, USA. *Urban Forestry & Urban Greening.* 17: 104-115. https://www.fs.usda.gov/treesearch/pubs/50951
6. U.S. EPA (n.d.) Using Trees and Vegetation to Reduce Heat Islands
7. Liu et al. (2019). Degrees and dollars – Health costs associated with suboptimal ambient temperature exposure. *Science of the Total Environment.*

REDUCED GREENHOUSE GASES

Green stormwater infrastructure sequesters carbon dioxide and other forms of carbon. By taking carbon out of the atmosphere, plants and soil help combat climate change. The U.S. EPA estimates the social cost of carbon at $36 per metric ton of atmospheric carbon dioxide. Urban trees sequester approximately 0.8 tons of carbon per hectare of tree cover per year. For reference, a 2009 study found that one acre of a newly restored wetland can sequester more than 1.5 metric tons of carbon a year in its early years. Other GSI types can be managed to sequester carbon, although they do so at lower rates.[8]

Tree Carbon Calculator

The US Forest Service has developed a Tree Carbon Calculator, which helps communities determine the carbon sequestration and heating/cooling benefits that existing or future trees can provide.

REDUCED ENERGY USE

Climate change is creating more extremely hot days, resulting in dangerous conditions for the elderly, youth, and other vulnerable populations, increasing energy use for cooling purposes, and subsequently higher utility bills for households and businesses. Green stormwater infrastructure can shade buildings, lowering indoor temperatures and reducing utility bills, rooftop gardens can provide insulation, and trees can buffer wind.

A 2017 study found that household heating and cooling bills would be 7% higher nationally if not for our street trees.[9] This can be especially important as utility bills make up a larger share of expenses for lower income households. The study models the average residential utility bill savings due to trees at $455 per hectare of tree cover per year, ranging from $123 in Montana to $1,811 per hectare per year in Washington, DC.[10] Reducing our energy needs makes us more resilient, but it also addresses the root cause of climate change– the study estimates the value of reduced CO2 associated with lower energy demand at $129 per hectare of tree cover per year.[11] The Sacramento Municipal Utility District (SMUD)–a California energy utility–provides free shade trees for customers to reduce peak air conditioning use in summer months. Since 1990, SMUD and its partner, the Sacramento Tree Foundation have planted over 500,000 shade trees throughout the community.[12]

Table 2. Energy savings from green roofs from a 2011 US General Services Administration report[13]

Green Roof Area	Energy Savings per Square Foot per Year
5,000 square feet	$0.15
50,000 square feet	$0.19

COMMUNITY BENEFITS

At scale, GSI can transform a community, adding beauty, providing new opportunities for recreation, absorbing noise, and providing a sense of calm. These benefits all contribute to the long-term resiliency of our communities. These community benefits are discussed further in the accompanying guides.

8. Hansen, L. (n.d.). The Viability of Creating Wetlands for the Sale of Carbon Offsets. *Journal of Agriculture and Resource Economics. 34(2): 350-365*
9. Nowak, D et al. (2017).Residential building energy conservation and avoided power plant emissions by urban and community trees in the United States. *Urban Forestry and Urban Greening.* 21: 158-165
10. IBID
11. IBID
12. Sacramento Municipal Utility District. (n.d.). Shading Sacramento – Improve air quality and cool your home.
13. United States General Services Administration. (2011). The Benefits and Challenges of Green Roofs on Public and Commercial Buildings.

GETTING STARTED

Here are some critical first steps to take when working to capture the climate mitigation and adaption benefits of green stormwater infrastructure in your community.

1. Organize a community-led stormater management planning process to identify key locations to install GSI and embed these learnings into other municipal plans and implementation efforts.
2. Require or incentivize the inclusion of GSI in municipal land use planning and economic and community development planning efforts. Incentives could include a reduction on the land owner's stormwater fee (if applicable), credits, rebates, etc.
3. Work with your energy provider to expand energy and water efficiency investments in your community, with a particular focus on low-income households and those most impacted by high utility bills.
4. Use the US Forest Service's iTree Tool and Tree Carbon Calculator to evaluate the adaptive and mitigative benefit of your community's tree canopy and explore ideas to expand that canopy.

FOR MORE INFORMATION

- View the Green Values Stormwater Calculator at https://greenvalues.cnt.org
- Browse additional Green Values Strategy Guides and other resources at CNT.org
- CNT's 2018 urban flooding study developed six policy strategies to mitigate negative flooding impacts in Chicago communities.[19]

19. CNT. (2019). Assessing Disparities of Urban Flood Risk for Households of Color in Chicago. https://www.cnt.org/sites/default/files/pdf/Draft_Flooding_Disparity_6-10-19.pdf

TRANSPORTATION BENEFITS

GREEN STORMWATER INFRASTRUCTURE

GREEN STORMWATER INFRASTRUCTURE: IMPROVED MOBILITY

Transportation and mobility are central to a thriving community, and keeping streets clean, safe, and open are imperative to making this possible. Green stormwater infrastructure (GSI) improves community mobility by reducing street flooding and improving safety for pedestrians.

The transportation and mobility guide will help municipal officials quantify and value the transportation benefits of GSI.

THE TRANSPORTATION BENEFITS OF GREEN STORMWATER INFRASTRUCTURE

Among those who walk, ride a bike, take the bus or train, drive, design, or maintain streets, there is growing consensus that complete streets, or streets that are designed for all transportation users, not just cars, are green streets. GSI improvements to the public right-of-way, like planters, bioswales, rain gardens, and networked stormwater features can provide opportunities for active transportation while reducing the impacts of urban flooding. Trails, district stormwater systems, and permeable bike lanes can also reduce traffic collisions.

The Environmental Protection Agency defines a "green street" as one that uses plants, soil, and/or permeable pavement to capture and clean stormwater where it falls.[1] In contrast, traditional street design uses gutters, pipes, and tanks to capture water and take it to a central location, where it can be cleaned and eventually released back into the environment.

Figure 1. Transportation Benefits of Green Stormwater Infrastructure

TRANSPORTATION BENEFITS	GREEN STORMWATER INFRASTRUCTURE									
	Linear Buffer Park / Trail	Stormwater Park	Stormwater Planter	Parkway Bioswale	Rain Garden	Street Trees	Green Roof	Permeable Pavement	Permeable Bike Lane	District Stormwater
Reduced On-Street Flooding	••	••	••	••	••	•••	•	•••	•••	•••
Improved Safety	••		•	•					••	••
Increased Opportunities for Active Transportation	•••	•••	••	•••	••				•••	••

••• high benefit •• medium benefit • low benefit

1. U.S. EPA. (n.d.). Learn About Green Streets. https://www.epa.gov/G3/learn-about-green-streets

REDUCED ON-STREET FLOODING

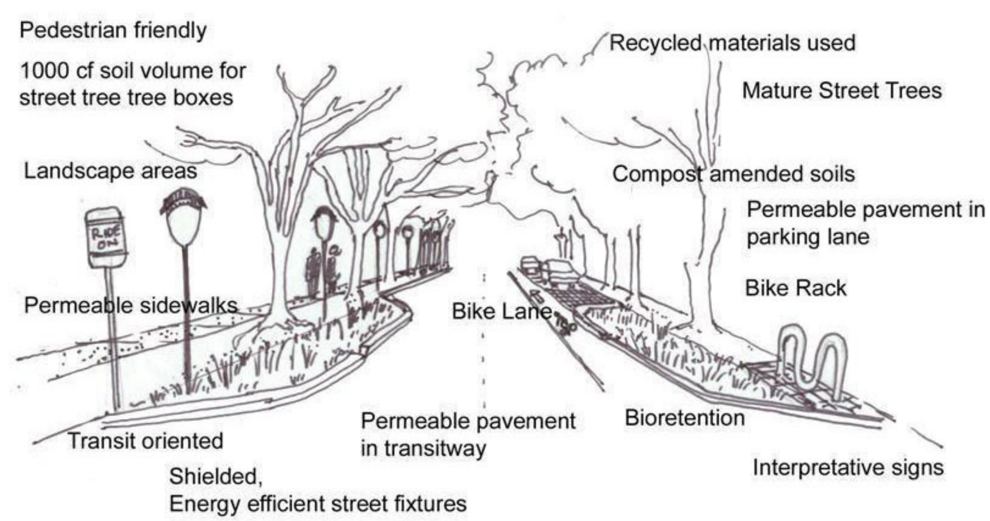
As intense storms occur more frequently due to climate change, sewer capacity is exceeded and streets flood more often. Rain causes reduced vehicle traction, maneuverability, and visibility. This causes drivers to travel at lower speeds, reducing roadway capacity and increasing delays and crash risk. Nearly 5,700 people are killed and more than 544,700 are injured in crashes on wet pavement annually. Every year, over 3,400 people are killed and over 375,300 people are injured in crashes during rainfall. Flooding reduces roadway capacity by limiting/preventing access to submerged lanes. Urban flooding has typically been the greatest source of fatalities and caused the most damage to roadway infrastructure. Green streets reduce on-street flooding and flooding in surrounding communities by increasing the capacity of existing sewer systems.

By installing and maintaining the features highlighted in Figure 2, local governments add capacity to the existing sewer system by creating natural spaces in publicly-owned transportation infrastructure rights-of-way. Right-of-way infrastructure typically includes sidewalks, parkways, parking lanes, and travel lanes. Frequently, retention and infiltration features are designed for use in the grassy area between the sidewalk and the street, called the "parkway." However, sidewalks and roadways can be partially depaved, widened, or narrowed to create more space for green infrastructure and meet other mobility goals.

Figure 3: *Partial depaving and replacement with natural retention features can reduce on-street flooding and encourage active transportation (from "Narrow Local Streets", Charlier Associates, Inc. Page 9)*

Green street features reduce the volume and/or speed at which stormwater enters the sewer system. In combined sewers, this means less runoff to treat and less energy expended on treatment. In aging sewer systems, this means extending the useful life of existing pipes and treatment facilities. In considering any infrastructure solution, it is important to conduct a rigorous cost-benefit-analysis. These analyses should compare the cost savings of extending the useful life of existing gray infrastructure as well as the cost of maintaining green infrastructure.

Figure 2. Anatomy of a Green Street



from https://www.epa.gov/G3/learn-about-green-streets

Green Streets

- *Reduce flooding on streets and in surrounding communities*
- *Improve pedestrian safety*
- *Encourage active transportation*
- *Strengthen local businesses*

2. U.S. EPA. Learn About Green Streets.

IMPROVED SAFETY AND ACTIVE TRANSPORTATON OPPORTUNITIES

Green streets can improve safety for walkers and cyclists. While lowering the speed limit is a good way to start lowering traffic speeds, other measures are often helpful complements. Transportation engineers have designed features, called speed management countermeasures, that can be installed in the roadway to reduce auto traffic speeds and pedestrian collisions[3]. These include speed humps, enhanced signage, and road diets, among others. Slower traffic means fewer collisions. Instead of adding more pavement to the public right-of-way, countermeasures that include natural retention and infiltration features (as seen in the picture to the right) make streets safer for cyclists and pedestrians while reducing flooding.

Figure 3: Impact Speed and a Pedestrian's Risk of Severe Injury or Death (AAA Foundation for Traffic Safety). September 2011[4]

Medians can be defined by pavement markings, raised medians, or islands that separate motorized from pedestrian traffic.[5] They should be designed to include stormwater trees and/or planters for bioretention or infiltration. While, the primary purpose of the vegetated features may be to manage stormwater runoff, they also may improve air quality and encourage active transportation users, like walkers and cyclists.

> ***Where DOT simplified a difficult intersection with new public space and traffic pattern changes, stores in the area saw sales rise 48%, beating the Manhattan average for the same period and substantially outpacing performance on nearby streets.***[7]

> ***According to FHWA, speed management countermeasures, including bioinfiltration planters on pedestrian refuge islands, can reduce pedestrian crashes by 56% .***[8]

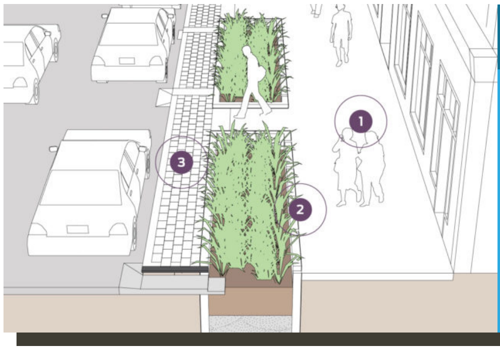
A pivotal 2013 study by New York City's Department of Transportation looked at the impact of building streetscapes aimed at enhancing pedestrian, bicycle, and transit rider safety. Overall, installing enhancements like pedestrian refuges, bicycle lanes, and widened sidewalks was shown to improve retail sales (learn more by visiting the Economic Development Strategy Guide).

Natural landscapes can also assist with speed control. A 2006 study of 10 urban arterial and highway sites in Texas found that landscape improvements decreased overall crash rates by 46% in those sites, and pedestrian fatalities dropped from 18 to two. A 2010 report by the School of Forest Resources at the University of Washington also showed that natural roadside views helped decrease the levels of stress and frustration in drivers compared to a fully built environment without natural roadside views.[9]

3. US Department of Transportation Federal Highway Administration. (n.d.). *Speed Management Countermeasures*. Safe Roads for a Safer Future. https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa16077/fhwasa16077.pdf
4. AAA Foundation for Traffic Safety. *Impact Speed and a Pedestrian's Risk of Severe Injury or Death* digital image (September 2011). Retrieved from: https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasa16076/
5. USDOT Federal Highway Administration. (n.d.). *Medians and Pedestrian Crossing Islands in Urban and Suburban Areas*. Safe Roads for a Safer Future. https://safety.fhwa.dot.gov/provencountermeasures/ped_medians/
6. NACTO. (2013). *Stormwater Elements - Green Infrastructure Configurations*. Urban Street Stormwater Guide. https://nacto.org/publication/urban-street-stormwater-guide/stormwater-elements/green-infrastructure-configurations/floating-island-planter/
7. NYC Department of Transportation. (2013). Economic Benefits of Sustainable Streets. http://www.nyc.gov/html/dot/downloads/pdf/dot-economic-benefits-of-sustainable-streets.pdf
8. Marritz, Leda. *Trees are a Tool for Safer Streets*. October 2011. Retrieved from: www.deeproot.com/blog/blog-entries/trees-are-a-tool-for-safer-streets
9. IBID

GREEN STREET INFRASTRUCTURE

The National Association of City Transportation Officials' Urban Street Stormwater Guide[10] describes several stormwater elements that can support these goals. Some of these appear below for consideration:



from the NACTO Urban Street Stormwater Guide

Bioretention Planters (stormwater planters)

***Bioretention planters (stormwater planters)** use public rights of way to capture, treat, and manage stormwater that falls on streets within a flat-bottomed pit with vertical walls. Water loving plants, sand, soil, and rocks help to clean stormwater of pollutants. Flexible placement allows them to be installed in parking lanes, parkways, or sidewalks. In areas with special considerations, bioinfiltration planters can help reduce flow rates and partially treat water before it enters the sewer system.*

from the NACTO Urban Street Stormwater Guide

Bioretention Swales (parkway bioswales)

***Bioretention swales (parkway bioswales)** are shallower and wider than planters, with sloped sides that capture, treat, and infiltrate stormwater as it flows naturally. They are less expensive to build. However, they use more space and can handle only low-to-moderate runoff flows.*

from the NACTO Urban Street Stormwater Guide

Hybrid bioretention cells (parkway bioswales)

***Hybrid bioretention cells (parkway bioswales)** use one sloped side and one walled side to provide more room for plants while keeping sidewalks free from tripping hazards for those walking. Where oddly shaped intersections make it difficult to build planters and swales, hybrid cells can be designed more flexibly to capture, treat, and manage stormwater.*

10. NACTO. (2013). Urban Street Stormwater Guide. https://nacto.org/publication/urban-street-stormwater-guide/

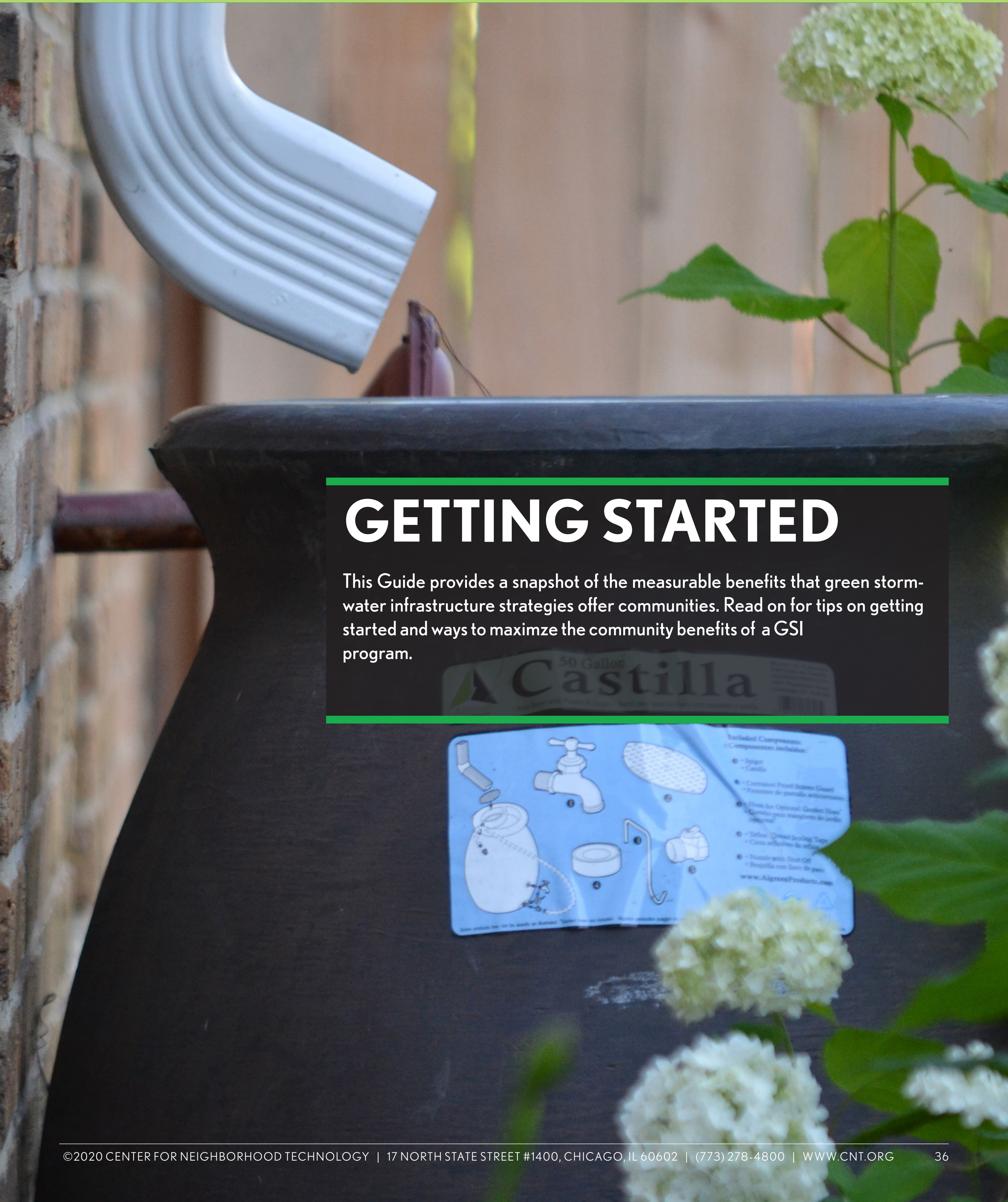
GETTING STARTED

In places where people are not accustomed to seeing native plants on sidewalks or in the middle of wide streets, in the case of raised stormwater medians, it can be intimidating to begin the process of greening your streets. Consider the following first steps.

1. Review the literature of regulators and trusted advocates.
2. Consider green streets features in capital improvement plans.
3. Commission a study to compare the benefits of green streets features to gray infrastructure in managing stormwater in the public right of way.
4. Identify if transportation revenues can be used for stormwater management and treatment of runoff in the public right of way.
5. Include green options when evaluating the cost benefits of different stormwater management features in the public right of way.
6. When designing traffic calming features, include planters or trees that help manage stormwater and treat runoff.

FOR MORE INFORMATION

- View the Green Values Stormwater Calculator at https://greenvalues.cnt.org
- Browse additional Green Values Strategy Guides and other resources at CNT.org
- NACTO Urban Street Stormwater Guide (https://nacto.org/publication/urban-street-stormwater-guide/)
- HWA Proven Safety Countermeasures (https://safety.fhwa.dot.gov/provencountermeasures/



GETTING STARTED

This Guide provides a snapshot of the measurable benefits that green stormwater infrastructure strategies offer communities. Read on for tips on getting started and ways to maximze the community benefits of a GSI program.

READY TO INVEST IN GREEN INFRASTRUCTURE?

Here are some general tips to get started:

1. Inventory the existing GSI assets in your community—the iTree website has a lot of resources to help you make an assessment.

2. Develop a sustainable community and green infrastructure vision and plan.
   a. Identify your community's top priorities and how green stormwater infrastructure investments can help achieve these priorities. Seek community input to help identify your communities identify opportunities for interdepartmental coordination.
   b. Incorporate green stormwater infrastructure into existing department plans, programs, and ordinances.
   c. If applicable, seek guidance from the USEPA to invest green infrastructure as a component of the municipality's combined sewer overflow long-term control plan.

3. Estimate the scale of additional GSI deployment your community is planning or setting as a target by type.

4. Use the examples included in these guides to inform a rough estimate of potential benefits.

5. Find local data to refine your estimates, such as from local water and energy utilities.

6. Identify sustainable funding sources to implement green infrastructure. Examples might include stormwater utilitie fees, partially or fully forgivable loans, or grants.

7. Locate opportunities for green stormwater infrastructure on public rights-of-way, institutional land, vacant and underutilized parcels, and as incorporated within existing infrastructure.

8. Incentivize green stormwater practices on privately-owned land through grant programs, regulations, or code updates.

9. Maximize the benefits of district stormwater strategies by identifying alternative financing strategies to implement stormwater management approaches. Examples include green bonds which provide debt-financing for projects with positive environmental benefits; mini-bonds; public-private private partnerships; and development impact fees with incentives for developers who exceed the minimum required on-site stormwater retention requirements.

OPPORTUNITIES TO MAXIMIZE COMMUNITY BENEFITS

As with all community investment practices, green infrastructure investment should be coupled with other practices to maximize community benefits and resident support. Green stormwater infrastructure should incorporate community programs and policies such as:

1. Co-designing green stormwater features with residents to incorporate preferences for visual appearance, aroma, and other characteristics;
2. Training and hiring residents to install and maintain green infrastructure in the neighborhood;
3. Establishing local hire requirements for green infrastructure installation and maintenance;
4. Procuring plants and soil mixes from urban farms located within the neighborhood;
5. Beautifying local community spaces, such as school and parks, with new landscaping;
6. Providing grants, technical assistance, donated materials, or utility bill credits to local building owners who install and maintain green infrastructure;
7. Establishing an ongoing monetary payment or tax credit for local landowners who make their land permanently available for larger-scale green infrastructure.
8. Establishing property tax freezes for low- or fixed-income residents who could be vulnerable to displacement if property values increase due to improved green amenities.
9. Maximize the benefits of district stormwater strategies by identifying alternative financing strategies to implement stormwater management approaches. Refer to Point 9 on page 37 for examples.