Eco-Social and Economic Benefits of Parks and Green Infrastructure in New Orleans

Literature Review

June 2023

Background

Trust for Public Land (TPL) is working with the City of New Orleans to develop a Climate-Smart Cities Decision Support portal to help align neighborhood development projects with resilience and green infrastructure best practices and strategies. (For the purposes of this study, TPL considers green infrastructure interventions nature-based strategies that capture or slow rain where it falls to mitigate flooding impacts; in the literature, it was also referred to as low-impact development.) To further support innovative green stormwater infrastructure (GSI) implementation in New Orleans, TPL also developed this literature review to describe the economic benefits of GSI interventions in New Orleans.

This information can be used by conservation and park advocates, policymakers, elected officials, emergency management and planning staff members, and other interested residents who seek to better understand the diverse benefits that GSI provides above and beyond flood mitigation.

An initial review examined planning documents, websites, and presentations published by the City of New Orleans (e.g., NOLA Ready: The City of New Orleans Green Infrastructure website; Sewer and Water Board of New Orleans Green Infrastructure Plan) and the New Orleans Climate Resilient City Tool documentation. In the initial review, TPL reviewed 15 plans, websites, presentations, published papers, and fact sheets that discussed GSI in New Orleans, and identified the suite of benefits of GSI described in them. TPL leveraged this list (see Table 1) to research economics benefits of specific interventions.

Both quantitative and qualitative data were identified in the overall literature review. Quantitative data included dollar estimates of the benefits where possible, or gallons of water collected or treated otherwise, while qualitative data included social, cultural, or otherwise anecdotal benefits (e.g., future research could quantify the benefit, but that information was not observed in the literature review).

The second component of the literature review focused on the economic benefits of GSI commonly implemented in New Orleans, including:

- Bioswales
- Planting trees
- Rain Gardens
- Pervious Surfaces
- Detention Basins and Dry Ponds
- Stormwater Parks (with Underground Tanks)

The interventions were selected because they are frequently used in New Orleans; are applicable at neighborhood scales; and/or have or will have funding available for implementation.

Search terms included in the review were *green stormwater infrastructure*, *nature-based solutions (for flooding/stormwater), ecosystem service value,* and names of the individual interventions.

TPL reviewed 59 papers and reports published between 2013 and 2023 using Google Scholar. The review is grouped by topic, highlights key findings for quantitative and qualitative benefits of each intervention type (and GSI generally), describes case studies, and suggests future areas of research based on gaps in the quantified data.

Literature Review

Benefits of GSI Projects (General)

The co-benefits of GI, summarized in the initial literature review, are described in Table 1 below.

Table 1. Co-Benefits of Green Stormwater Infrastructure.

Reduced flooding impacts to individual properties, including private and public structures.[1] *Urban flooding impacts include those to individual homeowners (lower property values, increased insurance rates, wet structures with mold and associated health issues like respiratory problems) and the broader community (streambank erosion and degraded water quality, affecting drinking water and aquatic ecosystems).[2] Improving drainage, on the other hand, increases nearby home values and improves the local property tax base.*
Reduced stormwater management and drinking water treatment costs.[3] *GSI can reduce stormwater management costs by (a) increasing infiltration through vegetation and pervious surfaces, filtering out pollutants naturally, or (b) storing stormwater during peak flow periods, collecting water and slowly releasing it over time. Both reduce the burden on (often older) gray infrastructure, especially during significant storm events. The cost of upgrading facilities or maintaining older ones is expensive and disruptive to the community, and integrating GSI into stormwater management planning mitigates those costs and impacts.*
Reduced urban heat island effect.[4] *Many forms of GSI, including the grasses and shrublands of bioswales and planting trees, rely on vegetation to soak up or slow down stormwater. This vegetation reduces ambient temperatures and can increase shade, improving both public health (see below) and reducing the energy cost of buildings (especially when implementing green roofs and increasing tree canopy).*
Improved drinking water quality.[5] *GSI improves water quality when stormwater can infiltrate plants, soils, and pervious surfaces, reducing pollutant loads to nearby water bodes. This is especially important with the "first flush" of stormwater runoff, which may contain high concentration of pollutants. This in turn improves public health through clean drinking water, and reducing the cost of drinking water treatment.*
Improves air quality.[6] *Increasing vegetation through GSI improves air quality by absorbing and filtering pollutants and reducing smog. Reducing exposure to air pollution reduces health care impacts and costs, especially in high-risk and urban communities that have higher than average rates of respiratory diseases, lung cancer, and asthma.*
Provides job creation and enhances economic development.[7] *Investing in GSI creates employment and wage opportunities for residents. Key sectors will be manufacturing, landscape design, paving, construction, and technology. Reduced flooding impacts and its associated risks through GSI also encourages businesses to relocate to or stay in an area that previously faced repeated flooding events, including areas with street flooding. GSI can be a way to reactive vacant land, reducing blight*

in communities and helping improve property values. GSI can also attract customers to businesses when they are surrounded by healthy trees and landscaping.
Provides public health benefits.[8] *The vegetation associated with GSI can improve community physical and mental health and wellbeing. Planting additional trees and increasing vegetation reduces ambient temperatures, leading to fewer heat-related illnesses (HRI), reduced HRI mortality, and mitigate respiratory issues. Improved drainage reduces risks of mosquito-borne disease by infiltrating otherwise standing water. It also facilitates emergency management access that may otherwise be hampered by street flooding, especially during extreme weather events. By reducing urban flooding, GSI ultimately reduces people's risk of injury or loss of life.*
Improves quality of life and social connectedness for residents.[9] *GSI can improve social cohesion and resiliency in a community, increasing possibilities for interaction by creating meeting places for residents. It can dampen the effects of noise disturbances (such as that caused by traffic) and reduce stress; decrease crime rates; and improve neighborhood aesthetics. Improving drainage through nature-based solutions will maintain or increase access to outdoor recreation opportunities as well. Planting fruit trees and other types of urban agriculture as components of GSI can also provide the community with food sources, as well as increasing place attachment, food knowledge, and social capital.*
Improves ecosystem health.[10] *Increasing GSI improves the quality and resiliency of an environment in several ways, including improved soil quality and animal and plant biodiversity and attracting and supporting pollinators. Additional habitat also helps facilitate wildlife movement and connectivity, especially in urban areas. Vegetation increases carbon sequestration in urban areas and reduces greenhouse gases in the atmosphere, while improved water quality also increases the health of local aquatic ecosystems, reducing the sediment and pollutant flow into rivers, lakes, and ponds.*
Increases carbon capture.[11] *Plants and trees in GSI sequester carbon from the atmosphere and reduce greenhouse gases. Integrating compost and/or biochar into GSI projects can further increase sequestration capacity, as well as increasing water-holding capacity, avoiding methane release due to landfill diversion, and improving soil carbon storage.*
Reduced risk of subsidence[12] *Implementing GSI and improving drainage can help stabilize soil, minimize erosion, and reduce the risk of subsidence, a significant problem in New Orleans. Subsidence also exacerbates flooding issues, increasing the amount of damage (and associated costs) that storm events can cause. GSI implementation can improve property values and avoid associated repair costs.*

Some studies focused on valuing benefits of GSI broadly, on a per-project basis, and/or for multiple types of interventions. One such study by the Center for Neighborhood Technology (CNT) and SB Friedman Development Advisors looked at avoided costs of treatment due to the reduction of runoff attributed to GSI (valued at $29.94 per acre-feet) and due to groundwater replenishment due to GSI (valued at $86.42 per acre-feet).[13]

This study also found that "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. [For example,] 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."[14]

The findings from this study and others were integrated into CNT's Green Values® Stormwater Management Calculator (https://greenvalues.cnt.org/index.php). The calculator allows users to define one or more properties (i.e., at a site or neighborhood scale) and evaluate how GSI can be used to meet stormwater capture goals, comparing capital and maintenance costs of the intervention to the potential increased capacity to capture runoff. The estimated capacity improvements due to several interventions are integrated throughout the literature review sections below.

A 2020 study by Santamouris and Osmond reviewed the impacts of urban GSI and found a statistically significant correlation between a decrease in the peak daily temperature due to increased GSI, and heat-related mortality: “When the peak daily temperature drops by 0.1 ◦C, then the percentage of heat-related mortality decreases on average by 3.0%.”[15] The rates of heat-related illnesses and mortality are only projected to increase due to climate change in the coming years. Increasing greenspace through GSI can mitigate some of these impacts, as Stone et al (2014) found in their study of Atlanta (GA), Philadelphia (PA), and Phoenix (AZ): “Employing separate health impact functions for average warm season and heat wave conditions in 2050, we find combinations of vegetation and albedo enhancement to offset projected increases in heat-related mortality by 40 to 99% across the three metropolitan regions.”[16]

GSI Co-Benefits in New Orleans

GSI provides many co-benefits to residents, neighborhood, and the broader New Orleans community above and beyond mitigating flooding impacts.

In 2023, Earth Economics updated a study with Water Wise Gulf South (WWGS) in New Orleans, *The Benefits of Community-Driven Green Infrastructure.* The report values select ecosystem services or co-benefits of GSI and applies them to specific projects in New Orleans, including flood regulation and reduced heat exposure, installed by WWGS and their partners[1]. The report notes that “as of 2023, this collaboration has planted over 770 trees, installed 146 rain barrels, and implemented over 113 other green infrastructure projects that have added over 189,000 gallons of stormwater retention capacity to [multiple] neighborhoods,” installing projects at private residences, small businesses, churches, community centers, vacant lots, and in public rights-of-way. The GSI projects include rain gardens, concrete removal, French drains, rain barrels, stormwater planter boxes, pervious pavement and bioswales. In this study, economic values are available at the project scale, which may contain multiple interventions in one location; the economic value of individual interventions was not identified.

Across all projects, the annual ecosystem service values ranged from $2,000 (due to carbon sequestration) to $8.2 million (for habitat provision) (Table 3). [17] Their report documents their methodologies for ecosystem service valuation, including what is and is not included under each benefit type.

Benefits of Specific Green Stormwater Interventions

In the following sections, values and case studies are described for individual intervention types.

Bioswales

Bioswales are shallow tracts of land planted with native, hydrophilic plants intended to convey water from one place to another, slowly filtering and releasing it back into the landscape.

[1] Since 2013, WWGS has worked in partnership with the Greater Tremé Consortium, Healthy Community Services, Upper 9th Ward Bunny Friend Neighborhood Association, Hollygrove-Dixon Neighborhood Association, New Orleans East Green Infrastructure Collective (Idlewood-Parkwood Neighborhood Association), and the Lower 9th Ward Homeownership Association.

Case Studies

- **Loyola University New Orleans**: The university campus is frequently impacted by flooding due to storm events. Loyola University is installing bioswales (starting in spring 2022) to help improve drainage and prevent excess stormwater runoff.[18]
- **Lower Ninth Ward**: Louisiana State University civil and environmental engineering students worked with a nonprofit organization, A Community Voice, to transform a blighted property into a bioswale to reduce localized flooding.
- **Lafitte Greenway:** The bioswales across Lafitte Greenway can hold up to 1.45 million gallons of water above ground.[19] (More information about the Greenway is included in Tree Planting below)

Quantitative Benefits

- The Green Values® Stormwater Management Calculator estimates that the volume capture potential of 100 feet of bioswale would be 424 gallons or 56.7 ft^3. (TPL used the default settings in the Calculator for an Urban Park.)
- Bioswales (and rain gardens) improve the air quality of surrounding areas and are often created from a combination of grasslands and shrublands. In their 2023 study of economic benefits of green infrastructure in New Orleans[20], Earth Economics cited Gopalakrishnan et al (2018) when valuing the air pollution benefits of bioswales.[21] Gopalakrishnan et al used iTree Eco to estimate the average pollutant removal rates of grasses and shrubs in urban areas ($127 per hectare of grassland, and $67.30 per hectare of shrubland). Earth Economics averaged the two for an average value for bioswales, or $37.15 per hectare.

Qualitative Benefits

- Bioswales help recharge groundwater through stormwater infiltration and reduce greenhouse gas emissions.[22]

Tree Planting

Planting trees and expanding tree canopy can directly reduce stormwater impacts in several ways: they absorb water through their roots, and then evapotranspirate water back into the atmosphere; reduce pollutant loads in stormwater runoff; their canopy intercepts falling rain; their roots stabilize the surrounding soil; and long-term, they sequester carbon that exacerbates climate change impacts.[23] They may be planted along streets, in urban forests, or in tree trenches[24] (rows planted into an underground infiltration structure made to store and filter stormwater).

In recognition of the multitude of benefits they provide, the New Orleans Department of Parks & Parkways has been conducting a large-scale planting of 32 native and adapted species of trees. The Department has focused on restoring the canopy and re-greening the city following the devastating impacts of Hurricane Katrina. The City released a Reforestation Plan in December 2022, laying out their vision and strategy, as well as individual Pilot Neighborhood Plans to increase canopy cover in communities that need it most.[25]

Case Studies

- **Touro Street Project**: Groundwork New Orleans is planting trees in an area of New Orleans that frequently floods due to inadequate drainage infrastructure. The drainage issues also contribute to a substantial increase in mosquitos due to the standing floodwaters. Groundwork New Orleans has pledged to plant 36 mature trees (and install 36 bioswales) to improve water management and mitigate the urban heat island effect.[26]
- **Lafitte Greenway:** The Greenway is a 2.6-mile-long linear park over more than 40 acres in New Orleans in a former railroad corridor. The park is designed to help residents "live with water," and features hundreds of trees, permeable pavement, and bioswales to mitigate flooding impacts. The Department of Parks and Parkways and its partners have been working to plant at least a thousand additional trees. Volunteers are helping plant cypress trees in a bioswale as part of the Greenway GROW! program, to increase the stormwater management benefits of the park and build its resiliency while beautifying the area.[27]

Quantitative Benefits

The benefits provided by planting trees can vary widely, depending on the species, age, and location of the tree.

- The Green Values® Stormwater Management Calculator estimates on average that 10 trees could increase the volume capture potential of an urban park by 3,112 gallons or 416 ft^3. Additionally, CNT found that planting trees saves communities on average \$0.18 per tree due to reduced air pollution and \$0.12 per tree due to carbon sequestration. Trees also increase property value an average of \$275 per tree. (The methodology documentation for the Calculator does not specify that age or species of tree.)[28]
- Researchers often estimate the economic benefits of street trees by using the iTree suite of tools (https://www.itreetools.org/tools). For example, the New Orleans Reforestation Plan noted that while new trees may only consume a few gallons of water a day, mature trees require significantly more. iTree estimates a large Live Oak can capture over 21,000 gallons of water every year.[29] [30]
- A beta tool released by the iTree researchers, OurTrees, estimates the value of community-scale impacts of tree canopy. In New Orleans, trees provide an annual value of \$209,978 based on runoff avoided and rainfall intercepted, in additional to the carbon dioxide uptake benefits and air pollution removal due to the trees (Figure 1). [31] The value of individual trees can also be calculated using the iTree tool, MyTree.[32]
- Other researchers have also estimated the impacts of tree canopy on reducing stormwater runoff. For example, Selbig et al (2022) looked at the stormwater volume reduction benefits for green ash and Norway maple trees in Fond du Lac, Wisconsin. The runoff volume reduction benefit for these deciduous trees was estimated

OurTrees Benefits

i-Tree

Trees in New Orleans, LA

Serving Size:
12.01% tree canopy on 13,021 acres
22.84% impervious surfaces over 24,762 acres

Total benefits for this year:	**\$3,870,686**
	Annual values:
Carbon Dioxide Uptake	**\$3,594,158**
Carbon Sequestered	21,074 tn
CO_2 Equivalent[1]	77,271 tn
Storm Water Mitigation	**\$209,978**
Runoff Avoided	23 MG/yr
Rainfall Intercepted	1,056 MG/yr
Air Pollution Removal	**\$66,549**
Carbon Monoxide	16,575 lb/yr
Ozone	697,358 lb/yr
Nitrogen Dioxide	60,749 lb/yr
Sulfur Dioxide	41,936 lb/yr
$PM_{2.5}$	51,572 lb/yr
	Values are totals to date:
Carbon Dioxide Uptake	**\$71,189,177**
Carbon Storage	417,408 tn
CO_2 Equivalent[1]	1,530,495 tn

Benefits are based on USDA Forest Service research and are meant for guidance only. Visit www.itreetools.org to learn more. Get more data at i-Tree Landscape!

Figure 1. OurTree Results for New Orleans. May 2023.

at 6,376 liters per tree.[33] Similarly, the U.S. Environmental Protection Agency estimates that on average a tree with a 25-foot diameter canopy and associated soil can manage the 1-inch rainfall from 2,400 square feet of impervious surface, though this may vary with tree species.[34] (However, this estimate depends on local hydrology and climate conditions; given the high levels of rainfall in New Orleans, this value would likely be conservative for Louisiana.)

Qualitative Benefits

- Planting trees improves the surrounding micro-climate, providing shade and improving people's thermal comfort. This effect is essential during heat waves, in addition to mitigating the urban heat island effect for city residents.[35]
- Increasing tree canopy improves stormwater management through intercepting rainfall, delaying runoff, improving infiltration, and transpiring captured stormwater. [36] These benefits improve as the tree ages and grows.
- Planting trees reduces impervious area; promotes infiltration to the groundwater table; increases water storage capacity in the soil; improves biodiversity and provides wildlife habitat; and increases city-wide aesthetics.[37]
- Streets with more shade need to be repaved less frequently than streets with little to no shade.[38]
- Planting fruit trees (as well as community gardens and other forms of urban agriculture) provides the community with a food source. Research has shown that urban agriculture also provides co-benefits in the form of increasing place attachment, social capital, and food knowledge. [39]
- To further increase the stormwater benefits of tree planting, communities may wish to add biochar to the soil medium.[2] Studies have shown that planting trees in soils that contain biochar can increase their vitality and resilience, with an average increase of 41% in tree biomass due to biochar additions.[40]

Rain Gardens

Rain gardens are shallow basins full of deeply rooted, water tolerant native plants. They reduce runoff by allowing stormwater to soak directly into the ground rather than run off impervious surfaces and into storm drains. They are also sometimes referred to as bioretention or bioinfiltration basins.[41]

Case Study

- **Aurora Rain Gardens**: The Sewerage and Water Board of New Orleans (SWBNO) hired a consultant to design and build two rain gardens on the Aurora site on a half-acre parcel next to the Algiers pump station. The project helps collect and filter rainwater on the site through its sandy soils. The gardens are also constructed with underdrains to prevent standing water from becoming mosquito-breeding habitat. The Aurora site will help slow the rate at which water reaches pump stations and helps filter pollutants out of the stormwater in the process.[42]
- **Broadmoor neighborhood**: SWBNO funded a project, Water Effectiveness in Broadmoor, that includes two connected bio-retention cells that drain into rain gardens. The rain gardens help

[2] The Carbon Neutral Cities Alliance defines biochar as "a carbon-rich solid resulting from the thermal decomposition of organic matter in a low- or no-oxygen environment."

filter pollutants out of the stormwater, allow the water to infiltrate into pervious surfaces, and reduces the burden on the drainage system while mitigating flooding issues.[43]

Quantitative Benefits

- The Green Values® Stormwater Management Calculator estimates that 100 square feet of rain garden could increase the volume capture potential of an urban park by 632 gallons or 84.5 ft^3.

Qualitative Benefits

- Rain gardens increase vacant land reactivation and reduce greenhouse gas emissions.[44]
- A 2018 study in Champaign, IL looked at the stormwater impacts of two retention basins with a total storage capacity of 58,000 m^3, 1011 m^2 rain gardens, as well as paved pathways, main promenade, and amphitheater. The rain garden created 526 m^2 of wetland habitat and manages stormwater runoff from a high-traffic avenue. Researchers interviewed nearby business owners and noted there had been an anecdotal increase in the number of restaurant visitors, but overall, the time horizon was too short post-construction to quantify any economic benefits.[45]

Permeable Surfaces

Permeable surfaces (also referred to as pervious or porous surfaces) are designed to infiltrate rain runoff, unlike impermeable surfaces like asphalt. Water can flow between joints of pervious pavers, which can be made of materials like fired clay or concrete. "Floating streets," as described in the Greater New Orleans Urban Water Plan (2013), are made of a pervious concrete on a stable sub-base that can store and infiltrate runoff.[46]

The New Orleans City Council voted in 2019 in favor or a pavement ordinance, requiring new commercial parking surfaces to use porous pavement.[47]

Case Studies

- **Union Street:** The City of New Orleans used porous concrete for the 700 block of Union Street in the Central Business District block. The porous pavement covers a wide perforated pipe that helps hold water, with demonstrations showing how much faster water sinks into the street compared to traditional concrete.[48]
- **Lakeview Neighborhood Alleyways:** The City launched a pilot project in 2020 covering two blocks of Lakeview neighborhood alleyways, made of a combination of traditional and permeable concrete; the permeable concrete has a perforated pipe underneath to collect stormwater.[49]

Quantitative Benefits

- The Green Values® Stormwater Management Calculator estimates that 100 ft^2 of a permeable parking area or a street could potentially increase the volume capture potential of an urban park by 155.8 gallons or 20.8 ft^3.

Qualitative Benefits

- Permeable pavements reduce flooding and protect water quality.[50]

- Depending on its surface type, permeable pavement removes total suspended solids, metals, and nutrients from stormwater. Porous asphalt, for example, can remove 94-99% of total suspended solids (TSS) that otherwise cause sedimentation in water bodies, impacting aquatic environment and degrading drinking water.[51]

Green and Blue Roofs

Green roofs are systems planted on buildings to soak up rainfall and helping to cool the building.[52] Green Roofs for Healthy Cities describes them as "an extension of the existing roof which involves, at a minimum, high quality waterproofing, root repellent system, drainage system, filter cloth, a lightweight growing medium, and plants."[53]

Blue roofs are a growing field for stormwater GSI. They slow the release of stormwater into storm drains by using flow control devices or structures (rather than vegetation) constructed on the roof.[54]

Case Study

- **Sewerage and Water Board of New Orleans**: SWBNO added a green roof and a blue roof to its headquarters building in the Central Business District. The green and blue roofs were installed to keep rainwater from flowing directly off the roof and into storm drains. The green roof is 10,592 square feet and can manage more than 15,000 gallons of water per storm.[55] The green roof also has the added co-benefit of reducing energy costs through helping keep the building cooler.[56] The blue roof, which holds stormwater temporarily during weather events, has a smart drain that closes when a certain threshold is surpassed to prevent hundreds of gallons of rain from entering storm drains during peak flow.[57]

Quantitative Benefits

- The Green Values® Stormwater Management Calculator estimates that 100 ft^2 of a green roof could potentially increase the volume capture potential of an urban park by 143.4 gallons or 19.2 ft^3. Additionally, CNT found that on average, the reduced energy use from green roofs equals $18 per 100 ft^2 of green roof.
- Because of their vegetation, green roofs cool ambient temperatures by 5 degrees, mitigating the urban heat island effect, and cut summer air conditioning costs by 7%.[58] (The Green Roofs for Healthy Cities website provides a Green Roof Energy Calculator to calculate the annual energy performance for individual buildings with vegetated, green roofs compared to a traditional roof.[59])
- A 2021 literature review by Nguyen, Muttil, Tariq, and Ng on green roof benefits estimation describes the range of values for runoff reduction, human thermal comfort improvement, energy use reduction, runoff quality improvement, air quality improvements, noise reduction benefits, and other ecological, social, and economic benefits.[60]

Qualitative Benefits

- Green roofs improve the aesthetics of the built environment; reduce waste (either through using recycled materials in the growing medium or prolonging the life of buildings' HVAC system through decreased use); improve stormwater management by retaining water; mitigate the

urban heat island effect; provide community spaces like community gardens or recreational space; and help create local jobs in manufacturing, construction, and plant care/maintenance.[61]
- Green roofs provide habitat for plants, birds, and insects, which are especially valuable in urban areas; they also improve air quality through filtering pollution.[62]

Detention Basins and Dry Ponds

Detention basins or dry ponds capture stormwater for a period of time and slowly releases it into the ground, filtering the water and minimizing reducing rainwater at peak flow periods.[63]

Case Study

- **Central City Stormwater Lot**: This lot is a detention basin that handles over 26,000 gallons of stormwater runoff, diverting stormwater slow from catch basins into vegetated areas of the lot to allow it to infiltrate the pervious area. The Central City Stormwater Lot is also designed with a special drain to slowly release the water into the city system within 48 hours to reduce the likelihood of mosquitos breeding in standing water.[64]

Quantitative Benefits

- When also used for recreational purposes, detention basins can improve property value for nearby homes. A study in College Station, Texas showed that for every 10 meters (33 feet) a house was located further from a multi-use detention basin, it lost $164.82 in property value.[65]

Qualitative Benefits

- Detention ponds reduce impacts of flooding on buildings and roadways and help clean and filter rainwater before it enters the ground. [66]
- These areas may be designed to provide recreational areas (such as sports fields) or wildlife habitat. Naturally Resilient Communities notes there are many similarities with waterfront parks that are designed to accommodate flooding during storm events.[67]
- Because they are vegetated, detention basins can improve air quality, reduce the urban heat island effect, store carbon in the plants, and improve the aesthetics of the surrounding area.[68]
- Several studies noted the benefits of using compost as a component of bioretention projects and other green infrastructure. Compost increases the water-holding capacity of soil, slowing stormwater during peak flows and reducing irrigation requirements. Adding compost slowly releases nutrients into the soil and improves its quality over time, while increasing the capture of chemical contamination. Compost also enhances microbial processes and encourages root establishment, increasing the overall resilience of the vegetation.[69]

Stormwater Parks

Stormwater parks are recreational spaces that are designed to flood during extreme storm events while also facilitating park access and outdoor recreation. [70]

Case Studies

- **Bayou St. John Green Project**: This site has been designed to hold 55,800 gallons of water (about 1,100 bathtubs of rain and runoff), increasing the city's stormwater storage capacity. Designed by Dana Brown & Associates, interventions in the park included tree plantings, a rain garden, permeable pavements, and a berm that channels stormwater flow and offers seating to visitors. Benefits of the stormwater park are expected to increase over time as trees and native plantings mature, but the aesthetic improvements and recreation opportunities have already begin providing significant benefits to the community.[71]

- **Buffalo Bayou Park, Texas** – Buffalo Bayou is a linear park in Houston covering ten-miles and 2,500 acres. It was designed to help reduce the impacts of flooding on people and nearby property. The park was significantly impacted by Hurricane Harvey in 2017 with floodwaters rising nearly 40 feet, but the park's design was so successful that the park's restaurant was open before the rains had even stopped, and a week later bike rentals had resumed. Buffalo Bayou Park also provides a safe outlet for outdoor recreation activities to residents and visitors.[72] A 2020 study on Buffalo Bayou Park found that "the park enhances biodiversity remarkably, sequesters 9.19 tons of atmospheric carbon, and intercepts 84,000 gallons of stormwater runoff annually. It contributes to economic benefits as well as improves access to the park within a 10-minute walk to almost 40,000 residents and promotes cultural value and public health outputs as demonstrated by over 90% of survey respondents regarding the quality of life and sense of well-being."[73]

Quantified Benefits

- Earth Economics analyzed the benefits and costs of the proposed 25-acre Mirabeau Water Garden urban park, which was designed to use GSI to reduce flooding during heavy rain events. The park would be capable of storing and infiltrating 10 million gallons of stormwater. Due to its economic, social, and environmental co-benefits, for each dollar invested in the project the return was $6.[74]

Qualitative Benefits

- Stormwater parks provide a high-level impact to the following categories of co-benefits: improved indoor environmental air quality (e.g. building dampness and pests), reduced heat stress and urban heat island temperatures, improved community cohesion and mental health; improve workforce development and job creation; increased vacant land reactivation; increased property values; increased recreation revenue; reduced flooding; protected water quality; reduced greenhouse gases; and increased opportunities for active transportation (leading to improved physical health outcomes for people who use the parks for exercise).[75]

Conclusion

Nature-based solutions for stormwater management can provide a multitude of co-benefits for residents on the individual, neighborhood, and community scale. The results of this literature review describe the benefits of improvements to public health, environmental quality, and resilience in addition to the quantitative and qualitative impacts to reduced flooding. The information can be used to strengthen the environmental, economic, and social benefits for implementation and long-term maintenance of GSI in New Orleans.

The overwhelming body of evidence suggests communities experience net benefits from GSI, but there is also some published literature on economic disservices as well. There can be unintended negative consequences, for example, when a top-down approach is taken for siting and designing GSI, as opposed to a community-driven approach.[76] Similarly, failing to maintain GSI limits the benefits they can deliver in the medium-to-long term.

Areas for Future Research

Several papers identified a strong need for comprehensive cost-benefit analyses for nature-based solutions generally. Hobbie and Grimm (2020) and Santamouris and Osmond (2020) both identify a need to evaluate the extent to which GSI provides both co-benefits and disservices; how these fare relative to traditional/gray alternatives; and how costs and benefits are distributed across different communities.[77] Kuehler, Hathaway, and Tirpak called out the need for quantifying the benefits of urban trees, for example, in order to provide a basis for a potential credit system in designing stormwater systems.[78] Similarly, Hewitt, Ashworth, and MacKenzie highlighted the need for a systematic methodology to analyze the effectiveness of GSI for air quality specifically.[79]

Decision support tools like the Green Values® Stormwater Management Calculator are helpful in estimating the benefits of GSI and can be used when engaging with elected officials, policymakers, and residents about cost-benefit analyses and expected returns on investments.

There were several studies on the quantitative benefits of GSI, but had been conducted in Australia, China, and Europe. Research on co-benefits (e.g., during maintenance periods) in the context of New Orleans would be greatly beneficial, as performance of GSI can rely heavily on local climatic conditions.

Endnotes

[1]City of New Orleans, "Resilience & Sustainability: Hazard Mitigation Grant Program." https://nola.gov/resilience-sustainability/areas-of-focus/green-infrastructure/hazard-mitigation-stormwater-projects/; City of New Orleans, "Drainage Pump Station 01 Watershed, Phase I: Stormwater Parks and Lots Fact Sheet." https://nola.gov/resilience-sustainability/resources/fact-sheets/dps01-factsheet/; Federal Emergency Management Agency, "Building Community Resilience with Nature-Based Solutions: A Guide for Local Communities." June 2021, https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf; City of New Orleans, "Resilience + Sustainability: Mirabeau Water Garden Project," Community Outreach Presentation, August 5, 2017, https://nola.gov/resilience-sustainability/resources/community-outreach/mirabeau-comm/; Sewerage & Water Board of New Orleans, "Using Green to Aid the Gray: The Sewerage & Water Board and Green Infrastructure StoryMap https://www.swbno.org/Projects/InteractiveGuideToGreenInfrastructure ."

[2] Coville, Robert, Ted Endreny, and David J. Nowak. "Modeling the impact of urban trees on hydrology." *Forest-Water Interactions* (2020): 459-487.)

[3] City of New Orleans, "Drainage Pump Station 01 Watershed, Phase I: Stormwater Parks and Lots Fact Sheet"; Federal Emergency Management Agency (2021); City of New Orleans, "Resilience & Sustainability: Hazard Mitigation Grant Program"; Sewerage & Water Board of New Orleans, "Using Green to Aid the Gray."

[4] Santamouris, Matthaios, and Paul Osmond, "Increasing green infrastructure in cities: Impact on ambient temperature, air quality and heat-related mortality and morbidity." *Buildings* 10, no. 12 (2020): 233; City of New Orleans, "Resilience & Sustainability: Hazard Mitigation Grant Program"; Deltares, "Climate Resiliency City Tool (New Orleans) Key Performance Indicators." May 16, 2022. https://publicwiki.deltares.nl/display/AST/Key+Performance+Indicators;

[5] City of New Orleans, "Drainage Pump Station 01 Watershed, Phase I: Stormwater Parks and Lots Fact Sheet"; Sewerage & Water Board of New Orleans, "Using Green to Aid the Gray"; U.S. Environmental Protection Agency, "Green Streets Handbook." February 2021. https://www.epa.gov/sites/default/files/2021-04/documents/green_streets_design_manual_feb_2021_web_res_small_508.pdf; City of New Orleans, "Resilience

& Sustainability: Hazard Mitigation Grant Program"; Sewerage & Water Board of New Orleans, "Green Infrastructure Overview." https://www.swbno.org/Projects/GreenInfrastructureOverview

[6] City of New Orleans, "Drainage Pump Station 01 Watershed, Phase I: Stormwater Parks and Lots Fact Sheet"; Federal Emergency Management Agency (2021); City of New Orleans, "Resilience & Sustainability: Hazard Mitigation Grant Program."

[7] Diringer, Sarah, S. Morgan, C. Heather, G. Madeline, W. Jennifer, and L. Sharlene. "Scaling green stormwater infrastructure through multiple benefits in Austin, Texas." *Oakland, CA: Pacific Institute* (2020). Federal Emergency Management Agency (2021). Center for Neighborhood Technology, "Green Values Strategy Guide." 2020, https://cnt.org/sites/default/files/publications/Green%20Values%20Strategy%20Guide.pdf; Casey Trees, "Growing a Healthier DC: Greening Business Districts." A Casey Trees Issue Brief. https://www.milliontreesnyc.org/downloads/pdf/28-Casey%20Tree%20BusinessBrief.pdf

[8] City of New Orleans, "Drainage Pump Station 01 Watershed, Phase I: Stormwater Parks and Lots Fact Sheet"; Management Agency (2021). Center for Neighborhood Technology, "Green Values Strategy Guide." 2020, https://cnt.org/sites/default/files/publications/Green%20Values%20Strategy%20Guide.pdf.

[9] Deltares, "Climate Resiliency City Tool (New Orleans) Key Performance Indicators"; City of New Orleans, "Resilience + Sustainability: Mirabeau Water Garden Project"; Sewerage & Water Board of New Orleans, "Using Green to Aid the Gray"; Hoover, Fushcia-Ann, and Matthew E Hopton. "Developing a framework for stormwater management: leveraging ancillary benefits from urban greenspace." *Urban ecosystems* vol. 22,6 (2019): 1139-1148 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6913040/. Center for Neighborhood Technology, "Green Values Strategy Guide." 2020, https://cnt.org/sites/default/files/publications/Green%20Values%20Strategy%20Guide.pdf; City of New Orleans, "Resilience & Sustainability: Hazard Mitigation Grant Program"; Colinas, Juliette, Paula Bush, and Kevin Manaugh. "The socio-environmental impacts of public urban fruit trees: A Montreal case-study." *Urban Forestry & Urban Greening* 45 (2019): 126132.

[10] Deltares, "Climate Resiliency City Tool (New Orleans) Key Performance Indicators"; U.S. Environmental Protection Agency, "Benefits of Green Infrastructure." https://www.epa.gov/green-infrastructure/benefits-green-infrastructure; Center for Neighborhood Technology, "Green Values Strategy Guide." 2020, https://cnt.org/sites/default/files/publications/Green%20Values%20Strategy%20Guide.pdf; City of New Orleans, "Resilience & Sustainability: Hazard Mitigation Grant Program."

[11] Brown, Sally and Ned Beecher, "Carbon Accounting for Compost Use in Urban Areas." *Compost Science & Utilization* 27, no. 4 (2019): 227-239.

[12]City of New Orleans, "Drainage Pump Station 01 Watershed, Phase I: Stormwater Parks and Lots Fact Sheet"; City of New Orleans, "Resilience + Sustainability: Mirabeau Water Garden Project,"

[13] CNT noted that "an acre foot is a common unit of measure in hydrology, and is equal to the volume of one foot of water on an acre of land; this is equal to 42,550 cubic feet.) Source: CNT, "Green Values Calculator Methodology," https://greenvalues.cnt.org/Green-Values-Calculator-Methodology.pdf

[14] https://cnt.org/sites/default/files/publications/GSI-Impact-on-Property-Values.pdf

[15] Santamouris, Matthaios, and Paul Osmond. "Increasing green infrastructure in cities"

[16] Stone Jr, Brian, Jason Vargo, Peng Liu, Dana Habeeb, Anthony DeLucia, Marcus Trail, Yongtao Hu, and Armistead Russell. "Avoided heat-related mortality through climate adaptation strategies in three US cities." *PloS one* 9, no. 6 (2014): e100852.

[17] Earth Economics, "The Benefits of Community-Driven Green Infrastructure (Updated)," Technical Report. Commissioned by Water Wise Gulf South. *Report forthcoming, 2023*.

[18] Acharya, Ava. "New bioswale addresses campus flooding concerns." *The Maroon*. May 5, 2022. Accessed April 19, 2023. https://loyolamaroon.com/10035064/news/new-bioswale-addresses-campus-flooding-concerns/

[19] Friends of Lafitte Greenway, "Water and Wildlife," accessed April 21, 2023. https://www.lafittegreenway.org/water

[20] Earth Economics, "The Benefits of Community-Driven Green Infrastructure (Updated)"

[21] Gopalakrishnan, Varsha, Satoshi Hirabayashi, Guy Ziv, and Bhavik R. Bakshi. "Air quality and human health impacts of grasslands and shrublands in the United States." *Atmospheric Environment* 182 (2018): 193-199.

[22] Center for Neighborhood Technology, "Green Values Strategy Guide." 2020, https://cnt.org/sites/default/files/publications/Green%20Values%20Strategy%20Guide.pdf.

[23] USGS, "Loss of Street Tree Canopy Increases Stormwater Runoff," https://pubs.usgs.gov/fs/2022/3074/fs20223074.pdf and Baptista, Mariana D., Marco Amati, Tim D. Fletcher, and

Matthew J. Burns. "The economic benefits of reductions in nitrogen loads from stormwater runoff by street trees." Blue-Green Systems 2, no. 1 (2020): 267-281. https://iwaponline.com/bgs/article/2/1/267/75821
[24] https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf
[25] City of New Orleans, "New Orleans Reforestation Plan," December 2022, https://soulnola.org/wp-content/uploads/2023/01/Final-Reforestation-Plan-1.pdf.
[26] Groundwork New Orleans, "What We're Working On: Community-Based Green Infrastructure, Collaboration, and Equity Project," accessed April 26, 2023. https://groundworkusa.org/network/groundwork-new-orleans/?pp=2
[27] Friends of Lafitte Greenway, "Greenway Grow!" accessed April 28, 2023. https://www.lafittegreenway.org/grow. Margolies, Jane, "How to Grow a Greenway," *Landscape Architect* magazine, July 2022.
[28] Center for Neighborhood Technology, "The Green Values ® Stormwater Management Calculator Methods, accessed April 28, 2023, https://greenvalues.cnt.org/Green-Values-Calculator-Methodology.pdf
[29] City of New Orleans, "New Orleans Reforestation Plan," December 2022, https://soulnola.org/wp-content/uploads/2023/01/Final-Reforestation-Plan-1.pdf.
[30] Note: Crosby, McConnell, and Holderieath (2020) also leveraged iTree tools to estimate forest canopy benefits in Louisiana, although the analysis focused on smaller urban areas with populations between 20,000-50,000). However, the analysis focused on the value of pollutant reduction rather than stormwater impacts directly, and was ultimately excluded from the literature review. Crosby, Michael, T. Eric McConnell, and Jason J. Holderieath. "Forest canopy benefits in small urban areas of Louisiana." *Mathematical and Computational Forestry & Natural Resource Sciences* 12, no. 2 (2020): 79.
[31] i-Tree, "OurTrees online tool," https://ourtrees.itreetools.org/#/.
[32] i-Tree, "MyTree online tool," https://mytree.itreetools.org/#/
[33] Selbig, William R., Steven P. Loheide II, William Shuster, Bryant C. Scharenbroch, Robert C. Coville, James Kruegler, William Avery, Ralph Haefner, and David Nowak. "Quantifying the stormwater runoff volume reduction benefits of urban street tree canopy." *Science of the Total Environment* 806 (2022): 151296.
[34] U.S. Environmental Protection Agency, "Stormwater Trees: Technical Memorandum." September 2016. https://www.epa.gov/sites/default/files/2016-11/documents/final_stormwater_trees_technical_memo_508.pdf
[35] Salmond, Jennifer A., Marc Tadaki, Sotiris Vardoulakis, Katherine Arbuthnott, Andrew Coutts, Matthias Demuzere, Kim N. Dirks et al. "Health and climate related ecosystem services provided by street trees in the urban environment." *Environmental Health* 15, no. 1 (2016): 95-111.
[36] Kuehler, Eric, Jon Hathaway, and Andrew Tirpak. "Quantifying the benefits of urban forest systems as a component of the green infrastructure stormwater treatment network." *Ecohydrology* 10, no. 3 (2017): e1813.https://www.srs.fs.usda.gov/pubs/ja/2017/ja_2017_kuehler_001.pdf
[37] U.S. Environmental Protection Agency, "Stormwater Trees: Technical Memorandum." September 2016. https://www.epa.gov/sites/default/files/2016-11/documents/final_stormwater_trees_technical_memo_508.pdf
[38] Ibid.
[39] Colinas, Juliette, Paula Bush, and Kevin Manaugh. "The socio-environmental impacts of public urban fruit trees"
[40] Carbon Neutral Cities Alliance, "Biochar Benefits Analysis: CNCA Biochar-Urban Forest Strategy." June 2022. https://static1.squarespace.com/static/5d1e51dd2a98da000183bc20/t/6318fd722c9697389218f9d4/1662582131435/%28Cambium+Carbon%29+Biochar+Benefits+Analysis_FINAL.pdf
[41] City of New Orleans, "NOLA Ready: The City of New Orleans Green Infrastructure," accessed May 4, 2023, https://ready.nola.gov/green-infrastructure/.
[42] The Sewerage and Water Board of New Orleans, "Aurora Rain Garden Fact Sheet," accessed April 27, 2023, https://www2.swbno.org/documents/Environmental/GreenInfrastructure/Aurora_Factsheet.pdf.
[43] The Sewerage and Water Board of New Orleans, "Interactive Guide to Green Infrastructure," https://swbno.org/Projects/InteractiveGuideToGreenInfrastructure
[44] Center for Neighborhood Technology, "Green Values Strategy Guide." 2020, https://cnt.org/sites/default/files/publications/Green%20Values%20Strategy%20Guide.pdf.
[45] Kim, Jinki. "Exploring green infrastructure benefits at house and neighborhood scale: Case study of Illinois, USA." *Landscape and ecological engineering* 14, no. 1 (2018): 165-174.
[46] https://wbae.com/wp-content/uploads/2021/11/GNO-Urban-Water-Plan_Urban-Design_23Oct2013_compressed.pdf

[47] City of New Orleans, Permeable Pavement Ordinance, August 22, 2019. https://cityofno.granicus.com/MetaViewer.php?view_id=3&clip_id=3420&meta_id=459857

[48] Williams, Jessica. "New Orleans unveils $445K porous paving project, part of plans to reduce subsidence." The Times-Picayune New Orleans La. February 16, 2020. https://www.nola.com/news/environment/new-orleans-unveils-445k-porous-paving-project-part-of-plans-to-reduce-subsidence/article_60d3109e-4f46-11ea-b24f-e7c272bf2b8c.html

[49] New Orleans CityBusiness, "Pilot project aims to minimize Lakeview street flooding," July 21, 2020. https://neworleanscitybusiness.com/blog/2020/07/21/pilot-project-aims-to-minimize-lakeview-street-flooding/

[50] Center for Neighborhood Technology, "Green Values Strategy Guide." 2020, https://cnt.org/sites/default/files/publications/Green%20Values%20Strategy%20Guide.pdf.

[51] U.S. Environmental Protection Agency, "NPDES: Stormwater Best Management Practice – Permeable Pavements." June 2021. https://www.epa.gov/system/files/documents/2021-11/bmp-permeable-pavements.pdf

[52] https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf

[53] Green Roofs for Healthy Cities, "About Green Roofs," https://greenroofs.org/about-green-roofs.

[54] ReduceRunoff.org, "Solutions," https://www.reducerunoff.org/green-blue-roofs.

[55] Tafur, Suzanne Pfefferle. "Green roof atop the S&WB building helps handle stormwater runoff through the beauty of flowers." The Times-Picayune New Orleans LA. April 22, 2021. https://www.nola.com/entertainment_life/home_garden/green-roof-atop-the-s-wb-building-helps-handle-stormwater-runoff-through-the-beauty-of/article_5d1294e4-a12e-11eb-a5c1-e347bfa31fa4.html

[56] Adelson, Jeff. "'Green roof' on S&WB headquarters building to help keep rainwater out of city's drainage system." The Advocate. February 17, 2016. https://www.theadvocate.com/baton_rouge/news/green-roof-on-s-wb-headquarters-building-to-help-keep-rainwater-out-of-city-s/article_712031c7-31a2-5561-adb5-129647f86c90.html

[57] Tafur, Suzanne Pfefferle. "Green roof atop the S&WB building helps handle stormwater runoff through the beauty of flowers." The Times-Picayune New Orleans LA. April 22, 2021. https://www.nola.com/entertainment_life/home_garden/green-roof-atop-the-s-wb-building-helps-handle-stormwater-runoff-through-the-beauty-of/article_5d1294e4-a12e-11eb-a5c1-e347bfa31fa4.html

[58] Baurick, Tristan, Tegan Wendland, and Chris Granger. "Pour It On: How Dutch Cities Are Soaking up Rain and Reducing Flooding." Pulitzer Center. March 10, 2020. https://pulitzercenter.org/stories/pour-it-how-dutch-cities-are-soaking-rain-and-reducing-flooding

[59] Green Roofs for Healthy Cities, "Green Roof Energy Calculator," https://greenroofs.org/green-roof-energy-calculator

[60] Nguyen, Cuong Ngoc, Nitin Muttil, Muhammad Atiq Ur Rehman Tariq, and Anne WM Ng. "Quantifying the benefits and ecosystem services provided by green roofs—A review." *Water* 14, no. 1 (2022): 68.

[61] Green Roofs for Healthy Cities, "About Green Roofs," https://greenroofs.org/about-green-roofs

[62] Baurick, Tristan, Tegan Wendland, and Chris Granger. "Pour It On: How Dutch Cities Are Soaking up Rain and Reducing Flooding." Pulitzer Center. March 10, 2020. https://pulitzercenter.org/stories/pour-it-how-dutch-cities-are-soaking-rain-and-reducing-flooding

[63] U.S. Environmental Protection Agency, "Dry Detention Ponds." December 2021. https://www.epa.gov/system/files/documents/2021-11/bmp-dry-detention-ponds.pdf

[64] The Sewerage and Water Board of New Orleans, "Interactive Guide to Green Infrastructure," https://swbno.org/Projects/InteractiveGuideToGreenInfrastructure

[65] Lee, Jae Su, and Ming-Han Li. "The impact of detention basin design on residential property value: Case studies using GIS in the hedonic price modeling." *Landscape and Urban Planning* 89, no. 1-2 (2009): 7-16. Another study in Houston, TX also found that for neighborhoods with retention ponds, there was a higher mean housing price, seeing an average increase of $2,253 in housing value over 10 years. Source: Sohn, Wonmin, Hyun Woo Kim, Jun-Hyun Kim, and Ming-Han Li. "The capitalized amenity of green infrastructure in single-family housing values: An application of the spatial hedonic pricing method." *Urban Forestry & Urban Greening* 49 (2020): 126643.

[66] City of New Orleans, "NOLA Ready: The City of New Orleans Green Infrastructure" https://ready.nola.gov/green-infrastructure/.

[67] Naturally Resilient Communities, "Floodwater Detention and Retention Basins," https://nrcsolutions.org/floodwater-detention/

[68] Local Action, "Detention Basin," http://urbanwater-eco.services/project/detention-basins/

[69] Compost Research & Education Foundation, “Bioretention Media: Using Compost as a Component.” https://compostfoundation.org/Portals/2/Images/Bioretention.pdf
[70] https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf
[71] Mid-City Messenger, “S&WB’s Bayou St. John Green Project Opens to the Public.” April 19, 2023. https://midcitymessenger.com/2023/04/19/swbs-bayou-st-john-green-project-opens-to-the-public/
Baurick, Tristan. “New Mid-City park could hold 56,000 gallons of water, aiming to ease stormwater stress.” April 19, 2023. https://tinyurl.com/nrbnvdbc
[72] Urban Land Institute: Developing Urban Resilience, “Buffalo Bayou Park: Houston, Texas.” https://developingresilience.uli.org/case/buffalo-bayou-park/
[73] Yildirim, Yalcin, Golnaz Keshavarzihaghighi, and Amanda Renee Aman. "Sustainable responses of an urban park for disaster resilience: a case study of Hurricane Harvey." *International Journal of Sustainable Development & World Ecology* 28, no. 8 (2021): 720-732.
[74] Earth Economics, “The Benefits of Community-Driven Green Infrastructure (Updated),” Technical Report. Commissioned by Water Wise Gulf South. Report forthcoming.
[75] Center for Neighborhood Technology, “Green Values Strategy Guide.” 2020, https://cnt.org/sites/default/files/publications/Green%20Values%20Strategy%20Guide.pdf.
[76] Arnold, Craig Anthony, Ra'Desha Williams, Holden Pederson, Andrew Schuhmann, Audrey Ernstberger, Tiago de Melo Cartaxo, Connor Cafferty et al. "Resilience justice and community-based green and blue infrastructure." *Wm. & Mary Env't L. & Pol'y Rev.* 45 (2020): 665.
[77] Hobbie, Sarah E., and Nancy B. Grimm. "Nature-based approaches to managing climate change impacts in cities." Philosophical Transactions of the Royal Society B 375, no. 1794 (2020): 20190124; Santamouris, Matthaios, and Paul Osmond. "Increasing green infrastructure in cities”
[78] Kuehler, Eric, Jon Hathaway, and Andrew Tirpak. "Quantifying the benefits of urban forest systems as a component of the green infrastructure stormwater treatment network." *Ecohydrology* 10, no. 3 (2017): e1813.
[79] Hewitt, C. Nick, Kirsti Ashworth, and A. Rob MacKenzie. "Using green infrastructure to improve urban air quality (GI4AQ)." *Ambio* 49 (2020): 62-73.