



# GREEN INFRASTRUCTURE

By [Hannah Jane Brown](#) • Compilation of a 5-part series originally published August 2016 – January 2017 on [usgbc.org](#)<sup>1</sup>

## [1] Green infrastructure: Back to basics

*“Imagine this design assignment: Design something that makes oxygen, sequesters carbon, fixes nitrogen, distills water, makes complex sugars and foods, changes colors with the seasons, and self-replicates.” —William McDonough, Cradle to Cradle: Remaking the Way We Make Things*

Any technology that satisfied this design assignment would amaze us. We would praise it as the latest and greatest advancement toward a sustainable future. Fortunately for us, this assignment has already been satisfied. This quote refers, quite simply, to a tree. We often talk about new discoveries and technologies when we talk about climate action. In doing so, we overlook the most fundamental and efficient systems around us—the ecological ones. Natural ecosystems can not only provide climate benefits, but also make our cities healthier and more livable.

A prime example of this is the [Emerald Necklace](#) in Massachusetts, designed by landscape architect Frederick Law Olmsted. The Emerald Necklace is a linear network of parks and open spaces connecting Boston to Brookline. It is praised for giving city dwellers a chance to enjoy a connection to nature, and of course, for its aesthetic beauty.

However, the Emerald Necklace is primarily a water management project meant to control low-lying marshy areas. As HUD Principal Deputy Assistant Secretary [Harriet Tregoning](#) says, “Why would you ever build a berm or a levy if a waterfront park would provide the same level of flood and surge protection—but also be useful, beautiful, and place-making every single day?” The Emerald Necklace harnesses nature for human benefit. There is an intentional focus on preserving and imitating ecological systems in the built environment. This approach falls under the umbrella term “green infrastructure.”

### Green infrastructure basics and benefits

Green infrastructure is any practice that uses or replicates natural systems to achieve a desired outcome. This includes [green roofs](#), [bioswales](#) and [rain gardens](#). Green roofs replicate meadows to retain water and restore habitats on the top of buildings. Green infrastructure does not exclusively mean vegetation. [Permeable surfaces](#) are considered green infrastructure as well, because they handle rainfall the same way natural landscapes do. Green infrastructure looks to nature for advice, restoring and replicating ecological systems to create human benefits.

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<sup>1</sup> The series has been edited slightly from the original publication to reflect updated information (July 2017).

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This may seem obvious, but it is a radical departure from our dominant approach to infrastructure (often called “grey infrastructure”). To understand the difference, let's consider stormwater. Grey infrastructure is designed to quickly divert water. This approach views water as a hazard to be swiftly dealt with.

With green infrastructure, water is a resource. It is valuable for keeping landscapes and waterways healthy. With green infrastructure, climate challenges are reframed as opportunities. Green infrastructure not only reduces the load on aging grey infrastructure, but also provides opportunities to nourish plants and provide drinking water. Sounds pretty good, doesn't it?

Wait, there's more! The benefits of green infrastructure are numerous and multifaceted. Green infrastructure helps solve city challenges:

- **When it's hot**, we can rely on green infrastructure to reduce the urban heat island. Plants absorb solar energy for photosynthesis and provide cooling through evapotranspiration. Vegetation can also shade buildings and nearby surfaces, which decreases the demand for cooling. Cooler environments and less energy production means less smog. Green infrastructure is [very effective](#) at lessening the direct and indirect health effects of hot weather.
- **When it rains**, we can retain and infiltrate water where it falls with green infrastructure. The retained rainfall infiltrates the ground, increasing the groundwater supply. This reduces runoff, which limits the pollution of waterways and prevents combined sewer overflows. Combined sewers are the infrastructure responsible for collecting both sewage and surface runoff. When the volume of runoff exceeds the sewer's capacity, overflows occur. This contaminates cities with sewage, creating environmental and human health hazards.
- **When we need a dose of nature**, we can seek out green infrastructure projects that remediate unused urban areas. These spaces provide habitats for native species, as well as relaxation and recreation opportunities for people. Green space has been shown to [decrease stress](#), [reduce crime](#), and promote [community cohesion](#). Green infrastructure can provide the dose of nature you need and can also revitalize a community. Proximity to green space has been shown to increase [rent premiums](#) and improve [tenant satisfaction](#).
- **When greenhouse gas emissions are high**, we can sequester emissions with green infrastructure. Plant matter and soil media use and store carbon dioxide. Green infrastructure improves energy efficiency and reduces cooling loads, driving down emissions created by energy production.



*Figure 1. Charles River Esplanade, part of the Emerald Necklace in Boston. The "Emerald Necklace" park network in Massachusetts is a perfect example of how to build green infrastructure in an urban area.*

When planning for the cities of the future, let's make sure not to overlook green infrastructure—it's Mother Nature's own high technology, with so many benefits for us to enjoy.



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## [2] Green infrastructure: City climate action planning

The second installment in our **Green Infrastructures series** explores city planning.

We broke world records last year. And I'm not just talking about the Olympics. 2016 was the [hottest year](#) on record. Already, [15 of the 16 warmest years on record](#) have occurred during the young 21st century, and this year is adding yet another extreme to the list. This mounting challenge drove world leaders to come to the landmark [Paris agreement](#) which most of the world's countries have joined.

While in the United States, the federal government's role remains uncertain, states, cities, and businesses are committed and many are setting their own emissions reduction targets. Targets tell us *what* our emission levels should be, but if you're like me, you might be asking *how* we are going to get there. Thankfully, we know that green infrastructure boasts [many benefits](#) that could be part of the solution.

City [climate action plans](#) are steering cities in their implementation of policies and actions providing both tangible local benefits and contributing to global impact. Are cities leveraging the benefits of green infrastructure in their climate action planning? I decided to take a look.

The short answer is that cities can generally be doing more. USGBC® and [GBCI](#)® are well-positioned to help with market-leading tools such as [SITES](#)®, [LEED](#)® and [Parksmart](#) that can help plan, measure and verify city efforts to leverage green infrastructure approaches among their climate actions.

Here's a summary of findings from my review of climate action plans from 28 U.S. cities. On the whole, 21 of the 28 plans mention green infrastructure at various depths. Some plans detail robust implementation strategies and specific initiatives, while others mention green infrastructure as a general concept, but lack a developed discussion or implementation strategy. Most cities appear to be aware of green infrastructure as a possible solution set, but their climate action plans do not demonstrate a current understanding or commitment to put it to maximum use.

Whether or not the term "green infrastructure" is mentioned, most city climate action plans are outlining ways for green infrastructure to help, including:

- **Urban forests and urban agriculture:** 25 plans include urban forestry initiatives and 26 include urban agriculture programs. Considering only 21 plans mention green infrastructure, it is safe to say cities see the value in green infrastructure practices even if they don't identify them that way.



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- **Transportation and streetscapes:** 20 of the plans refer to green infrastructure in relation to street design and public rights-of-way. These plans encourage [permeable surfaces](#), [planted medians](#) and [stormwater planters](#) along streets and sidewalks. Green infrastructure is often coupled with initiatives to create safe and inviting street environments that promote walking and alternative transportation. A great example is the use of planters to create [protected bike lanes](#).
- **Green roofs:** 16 of the plans discuss green roofs. Some cities require green roofs for new development. It is common for cities to offer direct development incentives such as density bonuses, permit fast-tracking, or floor-area-ratio bonuses for projects with green roofs. Many cities also offer grants to assist building owners with retrofitting their roofs. Stormwater fees further incentivize green roofs by linking savings with reduced runoff.
- **Bioswales, rain gardens and water catchment systems:** [Bioswales](#) and [rain gardens](#) are mentioned in 11 of the plans, and [water catchment devices](#) in 13. City ordinances designed to manage stormwater tend to promote these strategies, and so can codes that guide street design. Cities are taking a more critical look at parking as well and encouraging these practices to reduce runoff and pollution.

It's clear that the elements of green infrastructure are recognized as effective strategies to address climate action, but more remains to be done to harness the full range of benefits. With the help of experienced professionals, advocates and tools such as SITES, LEED and ParksMart that detail best practices for green infrastructure development, cities can incorporate more robust and integrated implementation strategies into their climate action planning.

In addition to meaningful climate action, green infrastructure can move cities closer to achieving myriad other goals, including social equity. Next up: a look at the social equity rewards and risks of green infrastructure in cities.

## [3] Green infrastructure: Fostering equity

The third installment in our green infrastructure series explores social equity.

Far too often, those disproportionately impacted by environmental degradation and pollution are a city's most vulnerable people, including low-income and minority populations. This history of overlapping burdens compounds disparities for those with the greatest need. Today, green infrastructure development allows for community-level benefits across the triple bottom line.

The movement for a national consciousness of environmental justice began to foment in [Warren County, North Carolina](#) in 1982, when the predominantly African American community found that it had been selected, without community members' knowledge, to host a hazardous waste landfill. This conflict sparked protest and drew media attention. More than 30 years later, we can see the thread to recent examples such as the water crisis in [Flint, Michigan](#), demonstrating that environmental inequality has a long and harrowing history.



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Interventions to improve the conditions of these vulnerable communities are often the result of hard-fought, community-based organizing. These interventions aim to eliminate risks and, inadvertently, they also introduce another—the risk of displacement. This phenomenon has been named [environmental gentrification](#).

This may be green infrastructure's "Catch-22." Conceptually, green infrastructure development can improve environmental justice challenges, providing its [many benefits](#) to these communities. Yet, in practice, it can perpetuate inequality and spark gentrification.

## Avoiding equity pitfalls in green infrastructure development

Green infrastructure is primarily considered through a lens of how to increase distributed, low-impact city infrastructure with multiple benefits and uses, but its potential to also introduce or exacerbate inequity cannot be overlooked.

USGBC recognized a similar set of risks in green building development, and an opportunity to reward [LEED®](#) project teams that make intentional efforts to foster equity through [pilot credits](#) adopted in 2014. These credits build on one of USGBC's guiding principles, Fostering Social Equity, which was added in the [2013–2015 strategic plan](#).

In my [last article](#), I summarized my findings after reviewing more than two dozen climate action plans from cities across the U.S. Building on that, I have also reviewed literature on social equity risks and rewards in green infrastructure development, collecting a few best practices for cities to follow.

To reduce the risk of inequity in green infrastructure development, cities should:

- **Revamp community engagement strategies.** Cities need community involvement to understand a community's needs and create responsive, rather than prescriptive, green infrastructure projects. This means engaging communities before plans are developed and throughout the process. Community members are project consultants; cities might consider compensating them for their time.
- **Create holistic metrics.** Cities should strive for impact-driven planning that helps to more equitably share the benefits of green infrastructure with populations and areas that need it most. These metrics should evaluate socio-ecological risk reduction (e.g., reduction in pollution-induced asthma) rather than quantity created (e.g., number of trees planted). Mapping that overlays social and environmental data can be an effective tool for determining high-risk areas. Additionally, evaluation should include community indicators and qualitative data alongside quantitative data, which help to prioritize decision making and ensure a full picture of risks and rewards.
- **Dismantle detrimental policies and practices.** Environmental inequality is most commonly the result of long-standing structural and cultural contexts. Cities must evaluate and revise those policies and processes that both created and perpetuate disparities. To do this, cities should consider intentional interventions to ensure that planning efforts promote social equity. This could include the use of an equity specialist or equity toolkits, which lay out a process to explicitly integrate equity considerations into decision making.

If done right, green infrastructure development can play a role in creating more equitable, just and resilient cities.



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## [4] Green infrastructure: Best practices for cities

See a breakdown of the best practices for cities in implementing green infrastructure.

Next time you take a walk around your city, look around. Is there green infrastructure near you? If not, there might be soon! Green infrastructure is becoming a more widely adopted strategy for addressing city challenges and goals.

In addition to taking root in climate action planning, cities are weaving green infrastructure into sustainability efforts and throughout myriad other initiatives. Recent articles on [city climate action planning](#) and [fostering equity](#) highlighted trends and best practices.

Some leading U.S. cities have already taken steps to invest in green infrastructure in a way that ensures benefits across the triple bottom line:

- **Chicago, Illinois:** The city's [climate action plan](#) calls for 500 new green roofs each year, leading up to 2020, to help manage stormwater and the urban heat island. Chicago is well on its way already, with over [500](#), and it continues to be among the [national leaders](#) in green roof development. The city led by example, installing a green roof on its [City Hall building](#) in 2000. Since, green infrastructure has been further promoted through city ordinances and programs such as the [Green Alley](#) program, the [Sustainable Development Policy](#) and a [stormwater ordinance](#).
- **Baltimore, Maryland:** Since 2010, the city has been focused on reversing urban blight using green infrastructure and community spaces through the [Vacants to Value](#) program. Since the program launched, 700 new [community-managed spaces](#) have been created from previously vacant properties. Complementary city-run initiatives, such as [urban agriculture](#) and [arts programs](#), are expanding more equitable access to land and green spaces while harnessing the benefits of a greener city.
- **Portland, Oregon:** The city's [climate action plan](#) prioritizes [urban forest development](#) in underserved areas, helping to grow the urban canopy with a more equitable distribution. Unlike most plans, Portland's sets a minimum canopy coverage target, which prioritizes underserved neighborhoods. Portland's plan includes an initiative to revisit canopy targets in the future to ensure they better capture resiliency outcomes, equitable distribution, and biodiversity.

### Guiding principles for cities

These and other city-led initiatives have some important similarities. A city's green infrastructure initiative is most likely to be effective when it is:

- **Data-driven.** Cities use GIS mapping, census data and visualization tools to drive planning. This can include mapping current green infrastructure together with demographic information, as well as using models to understand future climate scenarios. Strategies are strongest when they consider cross-disciplinary information, both qualitative and quantitative.



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- **Place-based.** Green infrastructure projects are site-specific and community-based. Implementation involves community and stakeholder engagement to ensure the planning process recognizes distinctions within a city across ecological, social and cultural dimensions. Green infrastructure projects are best if they follow the local community's vision and meet its specific needs.
- **Integrated with other initiatives.** The myriad benefits of green infrastructure make it an excellent tool for addressing a number of challenges. Cities that break down silos and create cross-cutting green infrastructure projects are better able to garner public support, thus improving their attractiveness to diverse sources of funding. Urban farming is an excellent example; urban farms combat food deserts, provide STEM learning opportunities and contribute to ecological health.
- **Aligned with structural adjustments.** Cities can update their policies to align with green infrastructure initiatives. This can include creating new ordinances, rewriting codes, and facilitating green infrastructure through interagency alignment. Cities committed to unpacking the historical and political background of policies will be more prepared to implement projects that deliver equitable results.

When green infrastructure initiatives have these characteristics, they have the potential to create more resilient communities by strengthening climate adaptation and social equity at the same time. USGBC and [GBCI](#) can assist these efforts with impact-driven tools like [SITES](#), [LEED](#), and [Parksmart](#).

## [5] Green infrastructure: Exploring solutions in LEED, SITES and Parksmart

**LEED, SITES and Parksmart all help cities achieve their green infrastructure goals.**

Cities are looking to green infrastructure to align sustainable development efforts and to foster social and economic development. In this article series, we have reviewed green infrastructure's [many benefits](#), its presence in [climate action planning](#), ways to [optimize its impact](#) and strategies for how best to avoid [social equity pitfalls](#).

USGBC and [GBCI](#) are well positioned to help cities incorporate these strategies into tangible green infrastructure development with market-leading tools like [SITES](#), [LEED](#) and [Parksmart](#). These systems provide frameworks that validate best practices and that can be used as useful guides for green infrastructure development. Individually and collectively, these rating systems ensure that best practices are being strategically implemented through an array of initiatives.

These three rating systems can be used independently or in tandem to maximize a project's green infrastructure development. For example, if you are seeking to further define, improve or demonstrate the site sustainability aspects of a project, you can benefit from pursuing both LEED and SITES certification by taking advantage of the [synergies and equivalent credits](#) between LEED and SITES.

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## Driving green infrastructure through LEED

Green infrastructure is most prominently rewarded in LEED's Sustainable Sites and Location and Transportation credit categories. The Sustainable Sites category presents opportunities to incorporate naturally functioning landscapes that increase ecosystem services. Location and Transportation credits reward projects that protect sensitive land and that encourage high-density infill development that reduces impervious surfaces.

In addition, LEED drives project teams to improve energy efficiency by investing in green infrastructure that provides shading and wind protection. For example, green roofs [add insulation and extend the lifetime of roof materials](#), reducing both energy demand and life cycle material costs. Reduced building footprints preserve land for high-performing sites that can use permeable surfaces, catchment systems and water-efficient landscaping to reproduce natural conditions and achieve Water Efficiency credits.

[LEED for Neighborhood Development](#) advocates incorporating green infrastructure into buildings, landscapes and the many connecting spaces between. This rating system includes a [Green Infrastructure and Buildings](#) category, which accentuates the importance of green infrastructure at different scales throughout cities.

LEED for Neighborhood Development recognizes green infrastructure as a tool for creating complete and livable communities, which limit resource use and automobile dependence. Green infrastructure can support the intended outcomes for a range of credits related to habitat and sensitive land conservation, community space access, brownfield redevelopment, livable streetscapes and local food production.

## SITES as verified green infrastructure

SITES provides guidelines and verification for innovative practices in tailoring green infrastructure to achieve conservation, restoration and public health goals. As of October 2016, certain LEED and SITES credits can be [applied reciprocally](#).

SITES has a strong conservation focus and establishes guidelines for protecting sensitive land and habitats. It offers incentives for projects that restore landscapes to replicate natural site conditions, such as through reestablishing natural hydrology, soil makeup and vegetation.



*Figure 2. Phipps Center for Sustainable Landscapes, in Pittsburgh, Pennsylvania, used green infrastructure as one of its strategies to achieve SITES and LEED certifications.*



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Green infrastructure can also help contribute to credits that measure human health and well-being. Green roofs, green walls and bioswales turn underutilized areas into spaces that support recreation and relaxation, civic engagement and urban food production.

## Optimizing infrastructure through Parksmart

Parksmart addresses an often overlooked facet of the built environment: parking infrastructure. Parking structures often include large, dark, impervious surfaces, which make them a significant source of polluted runoff and a local heat island.

Parksmart recognizes projects that use green infrastructure, including green roofs, green walls and permeable pavers, to mediate these ecological challenges and to transform parking structures into community assets. Additionally, by encouraging carpooling, car sharing, bicycling, and alternative fuel vehicles, Parksmart helps expand more sustainable transportation choices.

## Advancing green infrastructure

To ensure these leading practices, strategies and tools are being used in planning and development, cities can require development projects to follow an [integrated process](#). This highly collaborative practice, which is integral to SITES, LEED and Parksmart, enables project teams to identify opportunities for using green infrastructure to meet project goals throughout the design process.

Considering green infrastructure early and often allows project teams to optimize its use for maximum benefit – such as retaining and infiltrating water and keeping cities cool. Green infrastructure initiatives help us build a brighter—and greener—future.

## Resources

- For more information on how USGBC and [GBCI](#)® programs are guiding superior green infrastructure development, see [SITES](#)®, [LEED](#) and [Parksmart](#).
- Check out this [paper](#) from the University of California at Berkeley about making cities “just green enough.”
- Read this [white paper](#) from the Adapting to Rising Tides project on social vulnerability in climate action planning.
- See this [article](#) from The Guardian about the dangers of environmental gentrification.

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