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Green Infrastructure

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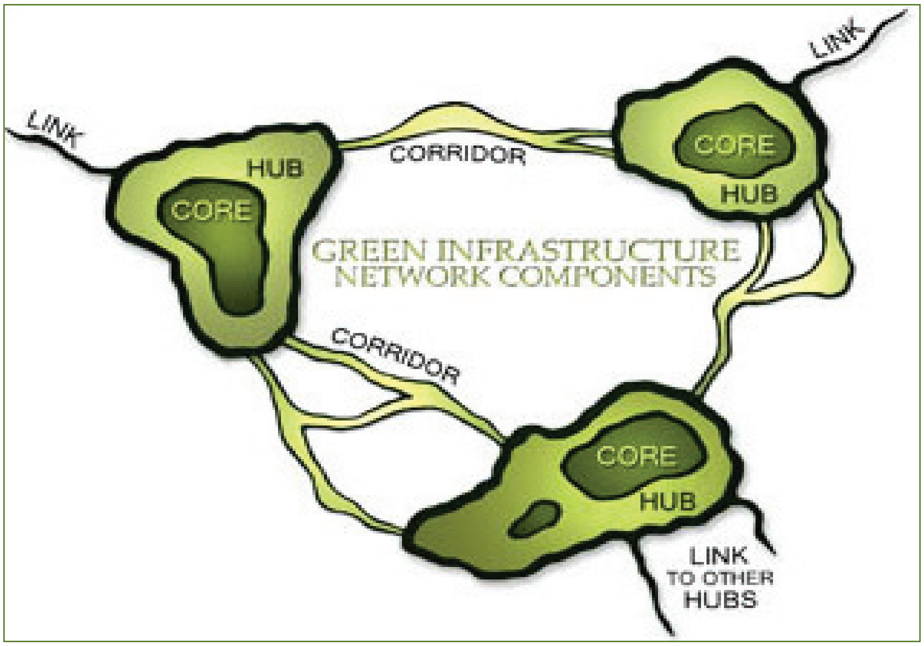
Overview

Green infrastructure is a relatively new term of art, but it's not an entirely new idea. Its roots began in the planning and conservation efforts that started over 150 years ago in the United States. Green infrastructure as we know it today has its origin in two important concepts: (1) linking parks and other green spaces for the benefit of people, and (2) preserving and linking natural areas to benefit biodiversity and counter habitat fragmentation. These concepts eventually evolved into the modern greenways movement and the science of conservation biology (Benedict and McMahon, 2003).

Green infrastructure can be broadly applied in two forms or scales - the large landscape scale and the site specific. Traditionally, green infrastructure has been thought of at a large scale as an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas that maintain natural ecological processes. These network systems are composed of core areas, hubs, and corridors. Core areas are the nuclei of the network and provide essential habitat for sensitive species. The hubs buffer the core areas and are the largest, least fragmented contiguous area of the natural feature. Hubs include anything from managed preserves to publicly owned lands, forests, wetlands and river corridors and serve as the anchors to green infrastructure networks. Corridors are the connections that tie the system together and provide connectivity for animal movement and plant migration (The Conservation Fund).

In practice, this form of green infrastructure means preserving, creating, or restoring vegetated areas and natural corridors such as greenways, parks, conservation easements, river corridors and riparian buffers. When linked together through a built environment, these lands provide benefits similar to natural undeveloped environments, thereby providing ecosystem services such as stormwater management, improved resilience to flooding, moderating the impacts of weather extremes and air and water purification.

In 2007, with the release of the US Environmental Protection Agency's Green Infrastructure Statement



Interconnected networks of waterways, wetlands, woodlands and wildlife habitats serve as green infrastructure at the large landscape scale. Source: The Conservation Fund

What's In A Name?

Infrastructure: "The substructure or underlying foundation on which the continuance and growth of a community or state depends."(Webster's Dictionary)

Gray Infrastructure: The man-made substructure that consists of engineered and built systems that support community functions, such as highways, utilities, water and wastewater systems, public buildings, culverts, and storm sewer systems.

Green Infrastructure (Ecosystem): "An interconnected network that encompasses the naturally occurring and human-built features that manage stormwater, remove pollutants, conserve energy, reduce erosion, and provide other ecological, cost-effective solutions and environmentally sustainable services." (Vibrant Cities Report)

Green Infrastructure (Stormwater): "Large scale and small-scale stormwater management approaches and technologies that infiltrate, evapotranspire, capture and reuse stormwater to maintain or restore natural hydrologies." (EPA)

Low Impact Development (LID): "A site-design strategy focused on micro-scale methods that mimic natural hydrologic functions and decrease the amount of impervious area and stormwater runoff from individual sites." (EPA) of Intent, EPA co-opted the term green infrastructure to generally refer to stormwater management systems and practices that use or mimic natural processes to infiltrate, evapotranspirate (the return of water to the atmosphere either through evaporation or by plants), or reuse stormwater on the site where it is generated. At this juncture, the terms "green infrastructure" and "low impact development" or "LID" began being used interchangeably. Consequently, green infrastructure today is more often associated with decentralized engineered stormwater controls such as: green roofs; urban tree planting; bioretention and infiltration practices such as rain gardens, vegetated swales and wetlands; pervious pavement and water harvesting.

What does green infrastructure look like?

Large Landscape Scale

Municipalities can implement these measures through regulations that direct the type, density and location of development to avoid adverse impacts to natural resources.

- Protect watersheds that decrease the need for man-made water treatment facilities
- Reforest slopes that help prevent the impacts from flooding and minimize landslides
- Restore natural connections linking previously isolated wilderness "islands"
- Protect river corridors and floodplains that prevent soil erosion, improve water quality, improve resilience to flooding, and provide wildlife habitat corridors
- Preserve natural drainage features and natural depression storage areas
- Conserve forestlands and wetlands that protect water quality, improve air quality, store carbon, provide wildlife habitat, and increase ecosystem biodiversity
- Provide urban forestry which intercepts rainfall and diminishes the impact of raindrops, reduces energy use, improves air quality and provides habitat
- Reduce risk of flood hazards by permanently removing flood-prone structures from floodplains and river corridors
- Plan for compact development where buildings and pavement serve multiple functions and are designed for walkability

Small Site Scale

Municipalities can implement these measures through the design of public buildings and through appropriate land use regulations and incentives:

- Install green roofs composed of waterproofing, a drainage system, planting soil and plants that reduce stormwater runoff, reduce energy use and improve air quality
- Minimize new impervious areas through careful site planning including: shared on-street and other strategies to reduce the size of parking lots; multi-story buildings; development clustered to reduce the length of driveways and walkways, and by applying other smart growth measures
- Reduce street widths to the minimum necessary for the context while applying complete streets principles
- Use pervious pavement and asphalt that reduce stormwater runoff and increase groundwater recharge
- Reduce hydraulic connectivity of impervious surfaces by routing roof runoff over lawns and reducing the use of storm sewers
- Apply rain gardens, vegetated swales, constructed wetlands and native landscaping practices that mitigate stormwater impacts
- Employ capture and reuse practices that intercept and store runoff from impervious surfaces that can be contained and reused for irrigation and to supplement gray water usage

Gray vs. Green Infrastructure Stormwater Management

Whether referring to a natural feature, a planning practice, or re-engineering the urban environment to restore the natural hydrological cycle, incorporating green infrastructure has become necessary in the transition away from gray infrastructure to manage stormwater. During a storm event, raindrops pound against surfaces they cannot infiltrate such as rooftops, parking lots and streets. The stormwater washes over these impervious surfaces, picking up sediment, nutrients, chemical and microbial pollutants. In most Vermont towns, stormwater management is still primarily addressed at the site development level using gray infrastructure practices such as culverts, storm sewer systems and detention ponds.

Some larger municipalities have a combined sewer system designed to collect stormwater runoff along with domestic sewage and industrial wastewater in the same pipe. Most of the time, combined sewer systems transport all of this wastewater to a wastewater treatment plant, where it is treated and then discharged to a waterbody. However, during periods of heavy rainfall or snowmelt the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. When this happens, untreated wastewater bypasses the system and is discharged directly into nearby rivers, streams and lakes. We refer to these systems as "CSO"s or Combined Sewer Overflow systems. Given the public health dangers of CSOs after a heavy storm event, towns are now separating stormwater and wastewater systems.

Gray infrastructure practices that function solely as stormwater systems rely on channeling stormwater quickly and efficiently away from the built environment. These practices increase stormwater volume, increase the frequency and magnitude of flood events, degrade water quality with contaminated runoff and erosion, degrade stream channels and decrease groundwater recharge. The goal of stormwater management through green infrastructure approaches is to reduce and manage stormwater through infiltration (water soaked into the ground), capture and reuse (water stored in a rain barrel or cistern for later use), and evapotransporation (water used by trees and plants).

Green infrastructure reduces stormwater runoff volumes and reduces peak flows by using the natural retention and absorption capabilities of vegetation and soils. By increasing the amount of pervious ground cover, green infrastructure techniques increase stormwater infiltration rates, thereby reducing the volume of runoff entering our combined sewer or separate stormwater systems, and ultimately our lakes, rivers, and streams. Green infrastructure techniques infiltrate runoff close to its source and help prevent pollutants from being transported to nearby surface waters.

Once runoff is infiltrated into soils, plants and microbes can naturally filter and break down many common pollutants found in stormwater. Additionally, the natural infiltration capabilities of green infrastructure technologies can improve the rate at which groundwater aquifers are 'recharged' or replenished. This is significant because groundwater provides about 40% of the water needed to maintain normal base flow rates in our rivers and streams, which is particularly important during the drier months of the year. Enhanced groundwater recharge can also boost the supply of drinking water for private and public uses. (For more information see U.S. Environmental Protection Agency. "Managing Wet Weather with Green Infrastructure." May, 2011.)

Bioretention area built at 133 State Street in Montpelier

Green infrastructure reduces stormwater runoff volumes and reduces peak flows by using the natural retention and absorption capabilities of vegetation and soils.

Roof Top Downspout Disconnection

Green infrastructure techniques infiltrate runoff close to its source and help prevent pollutants from being transported to nearby surface waters. Disconnecting your downspout from a sewer intake pipe (standpipe) and then redirecting the flow of water to a grassy area or garden is a simple way to keep runoff onsite and reduce runoff impacts to surface water resources. Similar strategies can be used to divert rainwater from roads and driveways.

Climate Adaptation and Community Resilience

Over the next century, climate change scenarios project extremes of precipitation and temperature, increased storm frequency and

The National Green Values Calculator

The Center for Neighborhood Technology (CNT) has developed the National Green Values Calculator to help users compare costs, benefits and performance of green infrastructure and low impact development when compared to conventional or "gray" stormwater infrastructure. Various "green interventions" can be entered into the tool such as: disconnecting downspouts and draining the roof to rain gardens; replacing lawn with native vegetation and tree cover; using porous pavement on driveways, sidewalks and other non-street pavement; green roofs; and the use of vegetated drainage swales in lieu of drainage pipes. The tool then calculates volumes for lot and site improvements for stormwater detention, annual discharge, reductions in peak flow, and groundwater recharge when compared to no improvements. Lastly, the tool shows the reduction in life cycle costs and money saved for each LID practice. (Source: CNT National Green Values Calculator at http://greenvalues.cnt.org/national/calculator.php) intensity and sea-level rise. According to The Northeast Climate Impacts Assessment (NECIA), the average amount of rain that falls on any given rainy day in the Northeast is projected to increase 8 or 9 percent by mid century and 10 to 15 percent by the end of the century. The number of heavy precipitation events is projected to increase by 8 percent by mid-century, and 12 to 13 percent by the end of the century.

Green infrastructure can help communities become more resilient to the likely impacts of climate change. The climate adaptation benefits of green infrastructure include better management of stormwater runoff, lowered incidents of combined sewer overflows, water capture and conservation, inundation, fluvial erosion and flash flood protection, and for coastal areas, storm-surge protection and defense against sea-level rise. (See Confronting Climate Change in the US Northeast, A report of the Northeast Climate Impacts Assessment, July, 2007.)

Urban Forestry

Planting and maintaining trees in urban settings is a quintessential green infrastructure practice with multiple benefits for resilience, adaptation and climate mitigation. According to the USDA Forest Service Center for Urban Forest Research a typical medium-sized tree can intercept as much as 2380 gallons of rainfall per year. In addition to intercepting and filtering stormwater runoff to prevent flooding and improve water quality, trees also contribute to adaptation by reducing surface temperatures through shading and evaporation and greatly improve aesthetics. Trees also absorb pollutants to clean the air and store carbon dioxide. For more information, see the Vermont Department of Forests, Parks and Recreation's Urban and Community Forestry (UCF) Program.

Local Implementation

Planning. Including specific language in town plans that support the protection and restoration of the natural hydrological cycle and improve a community's resilience to climate change through green infrastructure practices is a strategy that can help provide a vision for future development. A conservation or open space plan prepared by a local planning or conservation commission can be used to guide green infrastructure conservation strategies. In order to have legal standing, the plan should be incorporated by reference or adopted as an amendment to the municipal plan. (For more information on open space planning, see topic papers #18 and #19 on Open Space & Resource Protection Programs and Regulations.)

Regulations. The next step beyond community planning is the implementation of green infrastructure practices through local bylaws and ordinances. Communities can incorporate green infrastructure practices into a community's bylaws and ordinances in a variety of venues, including: zoning districts; subdivision regulations; planned unit developments; dimensional requirements; low impact development stormwater management standards; erosion prevention and sediment control standards; river corridor and floodplain management regulations; flood and erosion hazard area bylaws; wetland regulations; riparian buffer or setback ordinances; habitat protection standards; transfer of development rights; building codes; and public works specifications. (See topic papers #10 - Hazard Mitigation, #20 - Parking and others.) It is important for communities to evaluate their bylaws and ordinances to reduce potential barriers to green infrastructure implementation.

Conservation. In addition to regulatory approaches, green infrastructure can be implemented by protecting key land areas through means such as fee simple acquisitions and conservation easements. Fee simple acquisitions are the outright acquirement of land through purchase or donation. A conservation easement is a legal agreement a landowner makes to restrict development or use of a property while retaining ownership of the land and benefitting from reduced property taxes. (See topic paper #18 on Open Space & Resource Protection Programs for a complete discussion on conservation easements and stewardship programs.)

Example Bylaw Language

"The use of LID design approaches shall be implemented to the maximum extent practical given the site's soil characteristics, slope, and other relevant factors. To the extent that LID design approaches are not proposed in the stormwater management plan, the applicant shall provide a full justification and demonstrate why the use of LID approaches is not possible before proposing to use conventional structural stormwater management measures which channel stormwater away from the development site."

Source: Town of Fayston Land Use Regulations - December, 2011

Funding Community Green Infrastructure Projects

Securing adequate, sustainable sources of funding for implementing green infrastructure projects at the local level can present a challenge. Often green infrastructure approaches do not fit into existing funding frameworks. In many cases, green infrastructure is simply another item on the community "to-do" list that will not be addressed without developing alternative funding mechanisms.

For larger communities, one of the most common green infrastructure funding options is the use of stormwater fees. Stormwater fees generate a revenue stream to address the increasing investment communities make to control combined sewer overflows and stormwater runoff. Stormwater user fees are generally considered a fair and equitable method for charging those who benefit from the stormwater infrastructure, that is, the costs for stormwater management are directed toward those properties that generate the most runoff. Municipalities can set up a stormwater utility to manage the billing process and incoming revenue. In lieu of establishing a utility, municipalities can designate a department, such as a department of public works to manage fee collection and spending.

In addition to being equitable, stormwater fees are relatively easy for municipalities to set-up and implement. In many communities, new taxes require a vote of approval by the public, while a fee is a charge that municipalities have the authority to leverage for the services they provide. Also, many properties can be exempt from taxes. In Burlington Vermont, for example, the University of Vermont contributes approximately 14% of the city's overall impervious surfaces. These properties would be exempt from paying a stormwater tax, but are required to pay a fee for stormwater management services, just as they pay for electricity and water. Additionally, when incentives are tied to stormwater fees, they encourage retrofits of existing properties and implementation of green infrastructure in new developments. Fee discounts and credits provide an opportunity for property owners to reduce the cost of their stormwater fees through development incentives by using green infrastructure techniques that limit impervious cover and reduce the amount of runoff generated. (See topic paper #8 - Facilities Management.)

Smaller communities may look to grant programs to provide limited funding to support local green infrastructure projects. The Clean Water Act Section 319 grants and the Department of Housing and Urban Development's Community Development Block Grant Program (CDBG) can be useful in building demonstration projects or as seed money for building local support for green infrastructure practices. The Vermont Agency of Natural Resources Ecosystem Restoration Program also provides financial resources for projects that reduce sediment and nutrient pollution from stormwater into the State's waterways. (For more information, see the U.S. Environmental Protection Agency's publication Green Infrastructure Municipal Handbook Funding Options, September, 2008, and the Vermont Watershed Management Section's Ecosystem Restoration Program at http://www.vtwaterquality.org/erp.htm.)

The Vermont Green Infrastructure Initiative

The Vermont Green Infrastructure Initiative is an Agency of Natural Resources strategy with support from the Department of Environmental Conservation, the Ecosystem Restoration Program and the Department of Forests, Parks and Recreation. In 2010, the Green Infrastructure Roundtable was established as an offshoot of the Green Infrastructure Initiative to help identify development and retrofit practices and opportunities that incorporate green infrastructure stormwater management. The group consists of experts from across Vermont including engineers, landscape architects, professors, watershed coordinators, conservation districts, non-profit groups and municipal representatives.

In 2011, the Roundtable produced the Vermont Green Infrastructure Initiative Strategic Plan: 2011 - 2013, which has the overarching goal of restoring and maintaining the pre-development hydrology of the State's watersheds through the use of green infrastructure practices. To reach this goal, four key audiences are targeted: stormwater professionals, municipal governments, property owners, and Vermont State agencies. The first stage of implementing the Green Infrastructure Strategic Plan is an Executive Order requiring all Vermont state agencies undergoing development projects on state lands with state funds to use green infrastructure practices as a first line of defense in managing stormwater on site. The Strategic Plan also provides a tactical framework for integrating training opportunities, technical resources, incentives and regulatory support to promote the use of green infrastructure practices in Vermont. (For more information, see the State of Vermont Watershed Management Division's Green Infrastructure web page.)

References

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Green Values Stormwater Toolbox

Urban Forestry Fact Sheet #4: Control Stormwater Runoff with Trees

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Vermont DEC Stormwater Management Section: Green Infrastructure Best Management Practices

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