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Green Infrastructure Planning: Recent Advances and Applications

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To have a green, sustainable community, both economic development and land conservation are necessary. Achieving conservation outcomes that are truly meaningful while allowing for balanced growth requires planners to identify and protect an integrated system or "green infrastructure network" for their region. Nine years ago, in a *PAS Memo* article, Mark Benedict described a compelling vision for green infrastructure as an innovative planning framework (Benedict 2000). This article is an excellent introduction to green infrastructure, outlining the reasons why it is a useful planning framework and the steps planners can take to introduce green infrastructure to their communities. In the years since, green infrastructure planning has been applied to a variety of landscapes at different scales across the country.

Increasingly, "gray" infrastructure projects such as highways or natural gas pipelines are undertaken using the results from green infrastructure plans to help complete natural resource inventories, assist with siting decisions, and identify potential mitigation areas. This linkage of green and gray infrastructure has been encouraged by a combination of new regulatory approaches and funding priorities of federal agencies as well as an increased awareness that solutions to problems such as global climate change rest at the landscape level.

This article focuses on how green infrastructure has matured. It highlights the next stage of its evolution as a planning process confronting perennial problems, such as the linking of land conservation with development planning, and it looks at the role of green infrastructure in confronting emerging problems such as global climate change.

What Is Green Infrastructure Planning?

Webster's dictionary defines "infrastructure" as "the substructure or underlying foundation on which the continuance and growth of a community or state depends." The very existence of our communities depends on the health of infrastructure, which must be viewed at a regional scale, above the individual parcel or project level. This message is clear when planners and the public think of "gray" infrastructure such as highways, utilities, and water lines. However, the definition holds equally true for ecological systems and green infrastructure, which function at a regional scale and provide crucial services such as clear air, drinking water, and local food, while promoting both our physical and mental health.

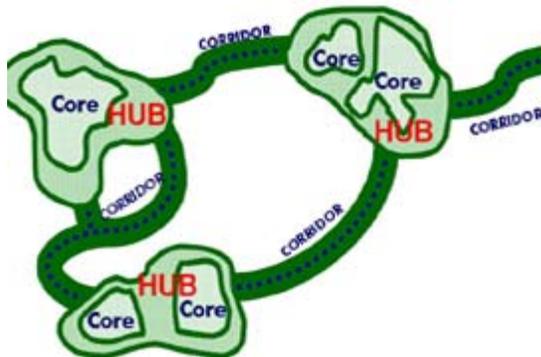
In recent years the term "green infrastructure" has been used to refer to everything from green roofs to more ecologically friendly stormwater management systems and large networks of natural areas (Wise 2008, Schwartz 2009). What these different usages have in common is a basic recognition that our built environment and our ecological environment are connected and interrelated. When the term is used at a landscape scale such as a watershed, municipality, or region, our definition of "green infrastructure" is an interconnected system of natural areas and open space that conserves ecosystem values, helps sustain clean air and water, and provides benefits to people and wildlife (Benedict and McMahon 2006).

Why Is Green Infrastructure Planning Important?

1. Supports working lands (farms and forest) and the landscapes for tourism
2. Prioritizes limited financial resources wisely
3. Helps a community or region visualize its future
4. Provides more information to decision makers to improve outcomes
5. May help with compliance with regulatory review and requirements
6. Provides predictability and a level playing field for both developers and conservationists
7. Supports ecosystem services that provide benefits to communities without additional

financial investment

8. Makes communities more disaster resistant by using the landscape to protect communities from flooding and focusing development in appropriate areas
9. Supports biodiversity and facilitates ecotourism
10. Supports a high quality of life, attracting businesses and retirees.



A conceptual model of a green infrastructure network.

Image courtesy of the Maryland Department of Natural Resources and The Conservation Fund



Green Infrastructure Transect

Image courtesy of The Conservation Fund and the Center for Applied Transect Studies

Green infrastructure systems are composed of core areas, hubs, and corridors. *Core areas* are the nucleus of the network and provide essential habitat for sensitive species. Buffering the core areas are *hubs*, which are the largest, least fragmented contiguous area of forest, wetlands, stream systems, or other native landscape type. *Corridors* maintain connectivity in the landscape and provide for animal movement, seed and pollen dispersal, and plant migration.

Green infrastructure is both a process and product. The planning framework of green infrastructure is a collaborative process that fosters a strategic approach to land conservation, engages a broad community of both conservation and development interests, and identifies crucial areas and corridors that benefit people and nature in the community. The product of the planning process may be a map, a report, or part of an existing planning effort such as a comprehensive plan or an open space plan. Green infrastructure plans may be led by municipal or county governments, or a nonprofit such as a land trust or private sector organization may serve as the convener of the planning process.

Basic Resources for Green Infrastructure Planning

The following books, articles, websites, and courses provide a basic orientation on why green infrastructure is important, how to start a green infrastructure planning process, and how to implement a green infrastructure network. Several green infrastructure training courses with AICP CM credit are offered each year through the Conservation Leadership Network.

Mark A. Benedict and Edward T. McMahon. 2006. *Green Infrastructure*. Washington DC: Island Press.

Mark A Benedict. "Green Infrastructure: A Strategic Approach to Land Conservation." *PAS Memo*, October 2000.

Conservation Leadership Network (courses on Green Infrastructure planning with AICP certificate maintenance credit available)

www.conservationfund.org/training_education

Green Infrastructure Network

www.greeninfrastructure.net

The Conservation Fund Strategic Conservation Planning Program

www.conservationfund.org/strategic_conservation

The Evolution of Green Infrastructure Planning

Since the term *green infrastructure* was first proposed in the *PAS Memo* article in 2000, this planning framework has expanded from the East Coast across the country. Green infrastructure methods have been adapted to address both a wider range of ecological landscape types as well as a variety of scales. Over the past decade, green infrastructure planning has evolved from a novel planning practice concentrated in regions with strong regulatory planning traditions into a national planning method that is capturing the public's imagination. It has been accepted by local decision makers in a way that few planning tools have. The following examples illustrate how green infrastructure is used at different scales and has evolved.

Maryland

Maryland was one of the first states to apply green infrastructure planning with the release of the *Atlas of Greenways, Water Trails and Green Infrastructure* in 2000. Accompanying the atlas was a Green Infrastructure Assessment (GIA) of the state of Maryland, a detailed mapping exercise that highlighted 33 percent of the state as providing important green infrastructure.

The real value of the GIA, however, was the field work that validated the locations of sensitive landscapes such as wetlands and the presence of important indicator species. State agencies used the GIA to help evaluate potential land acquisition opportunities and spend their limited funding wisely. Recently, the Maryland Department of Natural Resources has updated the plan and launched a user-friendly web version of the mapping effort called Maryland GreenPrint.

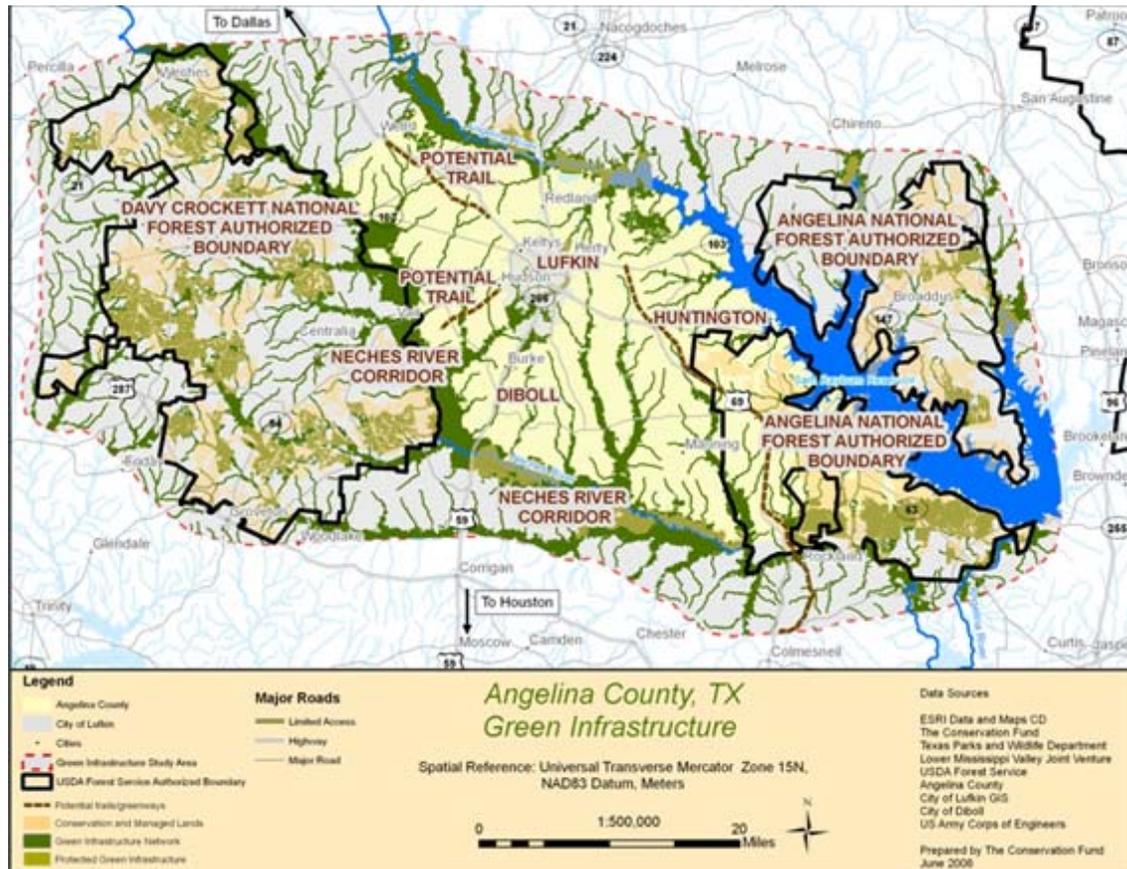
Maryland's green infrastructure planning efforts caught the attention of county government officials. Since the release of the state plan, nine counties have launched their own green infrastructure planning efforts. While the state plan is a useful starting point in providing a large-scale ecological framework, the county plans are able to be more refined and detailed, accommodating microhabitats and addressing the connection with local land use planning and zoning. In Prince George's County, the county green infrastructure plan serves as a functional master plan, a policy guide for development and planning decisions. The green infrastructure plan is actively used in the development review process, leading to meaningful changes in proposed subdivision design. As with the state green infrastructure plan, the county plan is used as a tool to help identify conservation lands and prioritize land conservation actions.

The county plans also provide the opportunity to update information on land use and the conservation opportunities remaining in a region. The movement of green infrastructure planning from a state plan template to the county level indicates how flexible, transferable, and scalable the planning methodology of green infrastructure has become.

Angelina County, Texas

The western movement of green infrastructure can best be demonstrated by two Texas planning efforts. Angelina County, Texas, completed a green infrastructure planning process in the fall of 2008 to help build a comprehensive approach to nature-based tourism. Located only a two-hour drive from the City of Houston, Angelina County is nestled between two national forests and bordered by the scenic Neches River and Lake Sam Rayburn, one of the largest reservoirs in Texas.

Municipal officials and stakeholders needed a countywide green infrastructure plan to determine how to best bundle all of the county's resources together to offer both visitors and residents a rewarding experience. The *Angelina County Green Infrastructure Plan* proposes a series of canoe launch sites along the Neches River and highlights corridors for wildlife movement and passive recreation. It also proposes a conservation strategy for the region's forests that balances the ecological health and economic needs of the communities with those of the timber companies that have long been a part of East Texas history and development.



Angelina County Green Infrastructure Map

Image courtesy of The Conservation Fund

El Paso, Texas

The City of El Paso, Texas, is home to Franklin Mountain State Park, which at 24,248 acres is one of the largest urban parks in the county. However, outside of the state park there is very little preserved land and few corridors providing linkages between the city and Franklin Mountain. With the assistance of Half Associates, El Paso used a green infrastructure approach to complete its open space plan in 2007. Rather than focusing on individual parcels, the city looked at conserving the system of arroyos (streams and creeks) between Franklin Mountain and the city. An inventory of arroyos and their ownership revealed that roughly 30 percent of intact arroyos could connect the city to Franklin Mountain, and that one arroyo directly connected the mountain to the Rio Grande River.

Most importantly, the city saw its gray infrastructure — drainage channels, detention areas, levees, and utility corridors — as linkages to create a viable green infrastructure network. The plan sets modest goals to restore native vegetation and changes in management practices of gray infrastructure in order to harness the green infrastructure benefits. Focusing on the opportunities that existing gray infrastructure may furnish for parks and ecological systems makes good planning sense.

Joint Gray–Green Infrastructure Planning

As the El Paso plan demonstrates, existing gray infrastructure can, with a little bit of restoration work, have conservation value. Increasingly, gray and green infrastructure projects are being planned as complementary systems. Gray infrastructure plans can incorporate the results from green infrastructure network designs to help complete natural resource inventories, assist with siting decisions, and identify potential mitigation areas.

The conservation value of gray infrastructure can be greatly improved by incorporating green infrastructure planning as part of the development process for major projects such as highways, pipelines, and water and sewer systems.

One of the main tenets of green infrastructure is to plan for environmentally sensitive areas before

developing the gray infrastructure. This is not a new idea: Ian McHarg asserted that the "intrinsic landscape attributes" of a place should be the basis for land use planning, and his approach pioneered the use of map overlays and suitability analysis to assess natural processes (McHarg 1969). Kevin Lynch and Randall Arendt have advocated for similar planning processes at the parcel scale where sensitive lands are set aside and development is planned around those constraints.

Benefits of Using a Green Infrastructure Approach on a Gray Infrastructure Project

1. Efficient use of financial resources because of economies of scale of planning and mitigation
2. Leveraging federal, state, and local financial resources in support of mitigation and stewardship
3. Improved risk management and long-term predictability of regulatory outcomes
4. Useful long-term stewardship document
5. Development of solid relationship with the community, public, and regulatory agencies
6. Improved disaster resistance from project design that avoids floodprone or other sensitive areas
7. Passive policing of infrastructure with passive recreation use

One of the new uses of green infrastructure plans is to help with planning gray infrastructure projects and mitigating the impact of those projects. When a large public works project, such as a highway or a natural gas line, affects a federally listed rare and endangered species or damages a wetland, those impacts must be compensated for through the protection or restoration of alternative habitat. In the past, this compensatory mitigation was required to be located adjacent to the project site or the community in which the project was taking place. However, this approach often resulted in the protection of marginal habitat that did not serve the best interests of the impacted species. Green infrastructure networks, which are developed at a watershed or ecosystem scale, provide an opportunity to find the best mitigation sites. They can also help to identify mitigation opportunities that at the same time advance community planning objectives outlined in comprehensive plans and other resource assessments. Today, green infrastructure planning is rewriting the process for how to undertake mitigation for gray infrastructure projects.

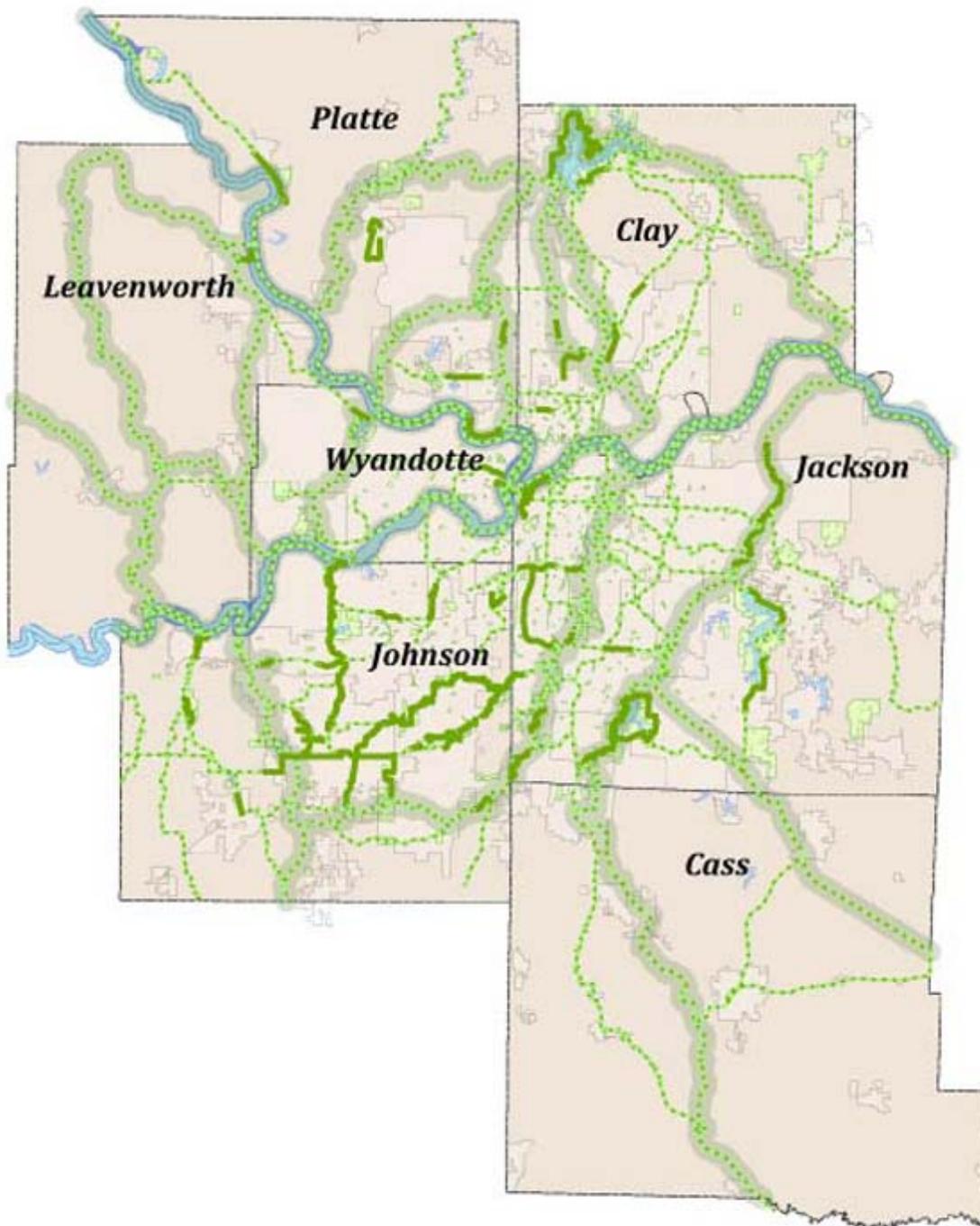
Transportation Planning and Green Infrastructure

Green infrastructure plans are helping transportation agencies meet federal guidelines for consultation, use of natural resource inventories, and consideration of environmental mitigation as specified in section 6001 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) legislation enacted in 2005. The regional vision proposed by a green infrastructure plan outlining hubs and corridors for the system is exactly the type of information that transportation agencies currently seek as part of their requirements to identify potential mitigation areas as part of the long-range planning process. In addition, the Federal Highway Administration (FHWA) advocates this approach as part of the Planning and Environmental Linkages initiative and as part of the Eco-Logical framework espousing the need for goal-driven, ecosystem-based mitigation.

The evolution of the use of green infrastructure planning with transportation planning can be seen with the MetroGreen Plan that was first released in 2001 by the Mid-America Regional Council (MARC), the regional planning organization for greater Kansas City. The MetroGreen Plan and the subsequent Natural Resource Inventory completed in 2004 produced useful information for identifying mitigation opportunities that offset the impacts of transportation projects.

This analysis was enhanced by MARC staff with the successful award of one of the first Eco-Logical grants from FHWA. The MetroGreen Plan prepared MARC staff to take advantage of the grant opportunity by providing data and information for the grant application. It also contributed to recommendations in a final report, the *Linking Environment and Transportation Action Plan*. The MetroGreen Plan was used beyond the usual confines of open space or park and recreational plans, making it a dynamic tool. The connection between the MetroGreen Plan and highway mitigation was a natural outgrowth of the scale of both types of projects and the common factor that both green and gray infrastructure planning rely on networks to achieve their respective goals.

The plan outlines a 1,144-mile network of public parks, with 16 corridors connecting seven counties in the Kansas City metropolitan area. The corridor network provides residents with bike paths linked to on-road bike lanes, forming an alternative transportation network. This regional planning effort spans two states with the established goal of conserving 42,800 acres by 2020 in priority corridors through a mixture of public and private conservation efforts and helping communities adopt stream buffer ordinances and ecologically friendly stormwater planning. To date, more than 17,000 acres have been protected.



The map produced by the MetroGreen Plan for the greater Kansas City region.

Image courtesy of MARC

In the context of a highway project, the Maryland State Highway Administration used the green infrastructure approach for proposed improvements to US Route 301 near Waldorf. They engaged the Maryland Department of Natural Resources, the U.S. Fish and Wildlife Service, and The Conservation Fund to help to identify green infrastructure conservation and restoration priorities that went well beyond the compensatory mitigation required by law. A series of community meetings obtained input on environmental stewardship priorities of public agencies and local residents. The public input was combined with ecological analysis to create a green infrastructure network including core areas and connecting corridors. This plan will assist an Interagency Work Group in selecting a portfolio of mitigation and environmental stewardship projects based on a selected road alignment and its associated community and environmental impacts.

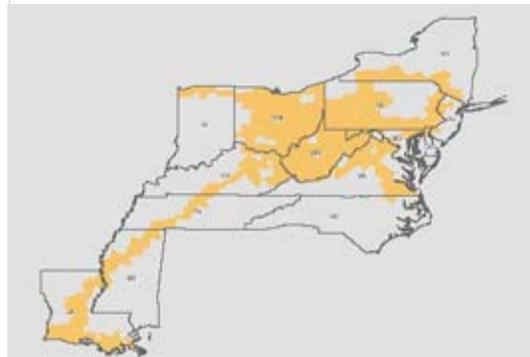
Energy Projects

As of February 2009 the Federal Energy Regulatory Commission estimates that there are close to 4,000 miles of new pipeline projects on the horizon nationwide. This marks one of the largest increases in the national pipeline network since the federal government began tracking these projects. Based on figures compiled by the American Petroleum Institute and the Association of Oil Pipe Lines, our current natural gas pipeline network, including both onshore and offshore lines, totals approximately 278,000 miles of transmission lines. As the El Paso Green Infrastructure Plan demonstrated, gray infrastructure networks can serve a valuable role within a green infrastructure network. Future use of green infrastructure planning is focused on expanding the ecological benefits of gray infrastructure networks as well as more accurately offsetting the impacts caused by new construction and maintenance activities.

As pipeline projects tend to cross state lines and impact many different ecoregions, a comprehensive green infrastructure process and plan is needed. Companies with projects that may have impacts on federally listed rare and endangered species typically approach the U.S. Fish and Wildlife Service (FWS) about undertaking a Habitat Conservation Plan (HCP). A HCP addresses how the company will both minimize and mitigate the impact of its activities upon listed species. A HCP can be focused on one species or multiple species. The scale of their study area can vary from an acre to more than 9.3 million acres. While HCPs have been around for many years, applying a green infrastructure approach to help identify potential mitigation areas on a multi-state basis had not been attempted until recently.

In 2005, NiSource, a natural gas distribution company, approached FWS to explore the feasibility of developing a multi-species habitat conservation plan for its 15,414 mile existing pipeline network that passes through 14 states, starting in Louisiana, reaching up to northern Indiana, and over to New York, and ending in North Carolina. In the course of routine pipeline and gas field operation and maintenance, NiSource undertakes over 90 annual consultations with FWS over potential impacts on well over 40 rare and endangered species. Both NiSource and FWS were interested in streamlining the Endangered Species Act consultation procedures as well as securing a more holistic approach to conservation of listed species and protection of their habitat. In 2006 NiSource began preliminary discussions with FWS and state regulatory agencies on submitting a multiple species HCP. It soon became apparent that a system-wide approach to mitigation was needed.

The affected states and the FWS asked The Conservation Fund to design a green infrastructure network as a decision tool to identify potential mitigation sites. Unlike previous mitigation plans that would consider only sites near the actual pipeline, the green infrastructure network extends the mitigation analysis beyond NiSource's pipeline network to look for high-quality mitigation opportunities within adjacent counties, eco-regions, and watershed units in the 14-state area.



NiSource Transmission Network Map

Image courtesy of The Conservation Fund

Using a green infrastructure approach will help NiSource, FWS, and the states to integrate species habitat mitigation within the context of an interconnected network of lands and waterways, providing multiple benefits across the entire range of NiSource's natural gas pipeline transmission activities. In addition, this approach will also ensure that a consistent methodology is used to determine the selection of mitigation sites across the 14-state region.

It is hoped that state officials will use the green infrastructure network prepared for the NiSource project as a general tool in prioritizing conservation resources and assisting with their Wildlife Action Plans. For local and regional planners, the green infrastructure network may provide a large-scale assessment of conservation priorities and connecting corridors, helping with local land use decision making.

This is the first application of a green infrastructure network method as part of a multiple species HCP. State wildlife agencies can use the green infrastructure network as a mapping tool that complements their State Wildlife Action Plans and their Statewide Comprehensive Outdoor

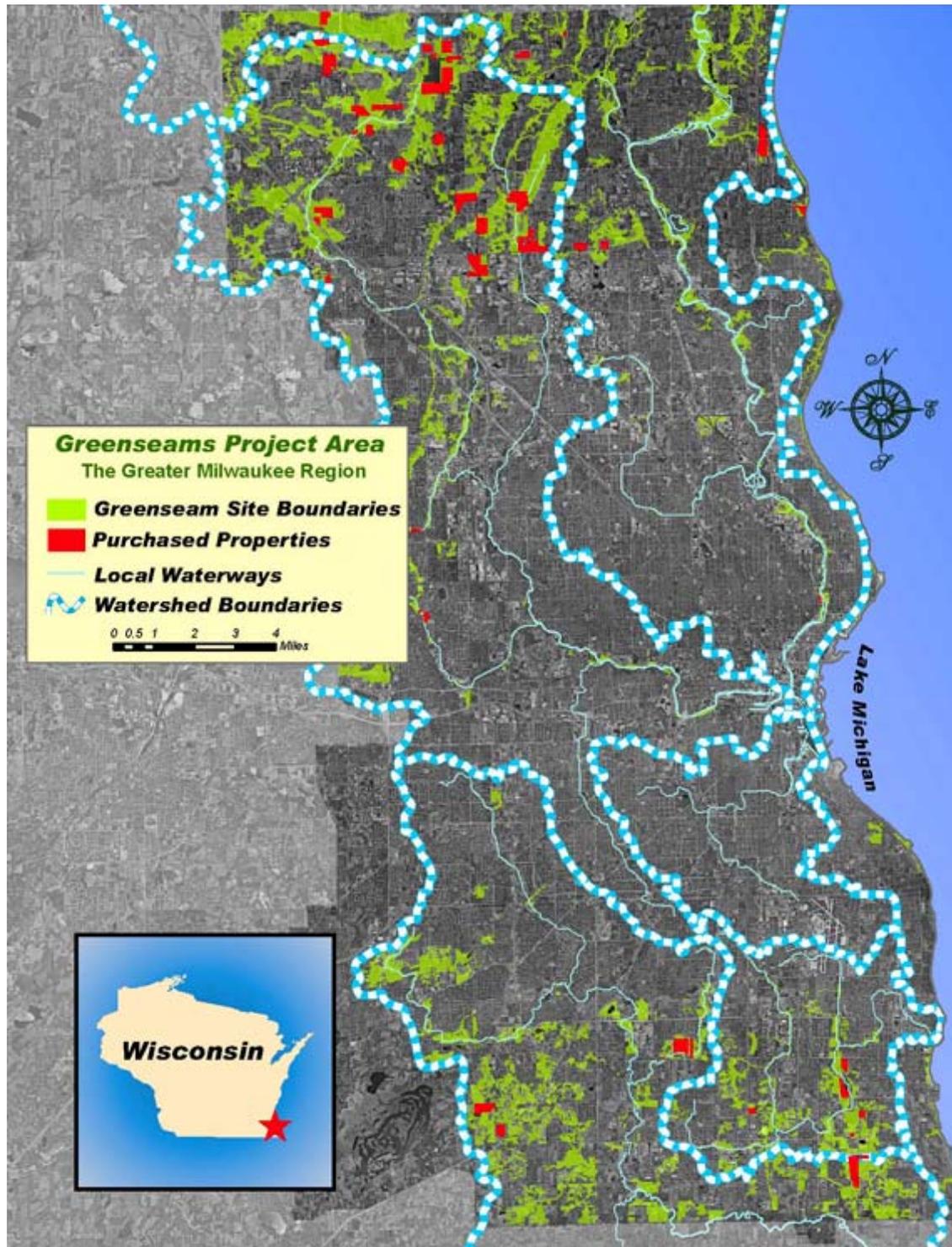
Recreation Plans. The landscape scale of pipeline projects lends itself to a green infrastructure approach because it crosses many political jurisdictions. This pairing of gray and green infrastructure in the realm of energy projects such as pipelines is a new approach that could begin to bridge the longstanding gap between planning for development and planning for conservation.

Water Resource Projects

At the municipal scale, gray infrastructure for water resources and stormwater management has been largely focused on replacing natural systems for dealing with flood events. The man-made engineering approach is frequently expensive, adversely affects the environment, and has at times failed to correct the problem of flooding. Increasingly, municipal sewer districts and flood control authorities are using green infrastructure planning to identify undeveloped lands that could provide significant flood prevention benefits if acquired and conserved.

The Greenseams Program was launched by the Milwaukee Metropolitan Sewerage District (MMSD) in 2002 as a green infrastructure approach to address the region's flooding and storm water management issues. Through voluntary transactions, the program purchases land in areas expected to have major growth in the next 20 years as well as open space along streams, shorelines, and wetlands. Each year MMSD authorizes between \$1.5 to \$5 million for land acquisition activities by Greenseams. MMSD hired The Conservation Fund to run the acquisition program.

Greenseams identifies and protects undeveloped, privately owned properties in three types of areas: hydric soils, river corridors, and mature forests. Greenseams planning efforts identified 29,000 acres in four counties and four watersheds as properties that need to be protected to achieve the program goal of reducing flood risk.



The Greenseams Project Area, Wisconsin.

Image courtesy of The Conservation Fund and Greenseams Program

The main focus of the green infrastructure plan has been conserving lands with hydric soils. A hydric soil is formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions. These soils have an increased capacity

for water storage and have a history of flooding. If development occurs on lands with hydric soils, this capacity to hold floodwaters is reduced. To date, the Greenseams program has conserved over 1,221 acres with hydric soils.



Before and after photographs of farm fields preserved and converted to wetlands and open meadow through the Greenseams program.

Image courtesy of The Conservation Fund and Greenseams Program

The Greenseams team uses the migratory bird flyway corridor plans developed by The Nature Conservancy, the State of Wisconsin's natural areas maps, and the Southeast Wisconsin Greenways plan as guidance documents to identify property acquisitions. At the local level, they work with existing comprehensive plans, respecting their priorities and local land use classifications. Several Greenseams properties have been transferred to the parks and open space programs of local governments. In the City of Oak Creek, the Greenseams team works with local officials to implement the *Oak Creek Environmental Corridor Plan*. To date they have acquired 10 corridor properties totaling 186 acres.

The Greenseams program provides a range of public benefits. All land acquired by the program will remain undeveloped, protecting water quality and providing the ability to store rain and melting snow. Wetlands maintenance and restoration at these sites will provide further water storage. Greenseams also preserves wildlife habitat and creates hiking, bird watching, and other passive recreational opportunities for people living in the region.

New Funding Opportunities

Nationally, an additional development that will strengthen the link between green infrastructure and infrastructure for water resources is the potential use of State Revolving Funds (SRF) for land acquisition. A large portion of water-related gray infrastructure projects, such as municipal wastewater facilities are funded by SRF loans to local governments. In recent years, several states including New York, Massachusetts, and Ohio have experimented with making loans to land trusts and local governments for land acquisition to protect drinking water supplies, reduce nonpoint source pollution, and reduce stormwater runoff.

As part of the federal stimulus package, Congress has required 20 percent of SRF set-asides to be used for projects that address "green infrastructure, water or energy efficiency improvements and other environmental innovative activities" (Schwartz. 2009). As these are new funding categories for SRF, the Environmental Protection Agency (EPA) is encouraging states to conduct appropriate planning activity to guide the use of the funding. The EPA guidance memo's definition of green infrastructure ranges from small-scale structures such as green roofs and porous pavements to landscape-scale preservation and restoration. The inclusion of green infrastructure within SRF

marks a new level of gray/green infrastructure coordination and collaboration, and signals the maturity of green infrastructure methodology.

Emerging Issues

While green infrastructure has gained acceptance as a planning framework, it is flexible enough to address new planning challenges. Green infrastructure is at the forefront in the development and application of ecosystem services, a new method for planners to account for impacts and benefits of both development projects and conservation lands. Green infrastructure can help address a region's response to global climate change, the greatest ecological challenge of our time.

Ecosystem Services

Ecosystem services represent a new accounting strategy for tracking the impacts of development and the benefits of conservation. Natural systems provide benefits to people and communities. Often these benefits are not paid for and are thus underestimated by the public. For example, wetlands filter pollutants, improving water quality. If these wetlands are degraded, water quality suffers and the public may have to build a facility to improve water quality.

For many years ecosystem services were an abstract concept studied by economists. With green infrastructure planning the benefits and costs of using a green infrastructure template can be documented and then used by planners to guide development patterns. For example, the ecosystem service of filtering pollutants provided by many wetlands can be more effectively measured with a green infrastructure network. With the highest quality wetlands identified in the network, a model can be constructed to predict the cost savings of conserving the wetlands and itemizing the service that these wetlands provide to the surrounding community.

Types of Ecosystem Services Provided by Green Infrastructure Networks (Breunig, 2004)

1. Climate regulation
2. Freshwater supply and hydrologic regulation
3. Waste assimilation and water quality
4. Nutrient regulation
5. Soil retention and peat formation
6. Disturbance prevention
7. Pollination
8. Recreation and aesthetic benefits

As part of a green infrastructure plan for Cecil County, Maryland, The Conservation Fund undertook an analysis of the ecosystem services provided to county residents by the forest, wetlands, and aquatic systems. The assessment found that green infrastructure networks provided an estimated \$1.7 billion in ecosystem services per year. The regions highlighted by the green infrastructure network provided 81 percent of the total ecosystem services for the entire county. It follows that if these lands are developed or degraded, there is a disproportionate effect on these benefits to the community. Large, contiguous blocks of forests and wetlands, which represent green infrastructure hubs, are more likely to contain fully functioning ecosystems that provide these corresponding values to humans. The assessment confirmed that protection of these areas is a vital investment.

With the prospect of regional, national, and global carbon trading to stem global climate change, the use of ecosystem services will only increase. However, much work remains to make the measure of both the benefits and supplies of these services as accurate and meaningful as possible.

Responding to Climate Change

For this century the central challenge to the conservation community and planners is how to address the impacts of climate change. Many conservation models and planning efforts are snapshots in time, using existing information on the presence or absence of species or habitat types. Global climate change will force green infrastructure methods and models to become dynamic, taking into account both current environmental conditions as well as forecasting what the landscape could look like in 70 to 100 years.

Green infrastructure methods rely heavily on using maps of vegetation or landcover to classify a landscape into broad categories such as forests, grasslands, or wetlands. Climate change models over the past several years have started to produce predictive maps of future landcover types, providing planners with a broad view of shifts in landscape types. These models predict the need

for migratory corridors to accommodate shifting vegetation patterns as well as animal species. The corridor networks outlined in green infrastructure frameworks will be useful in facilitating the mass migration of many animal and plant species, as the corridors have been sized using ecological parameters that tend to be broader than the requirements for designing corridors solely for human recreation, such as bike paths or rail-to-trail networks.

One constant lesson in ecology is that size matters. The large hub areas outlined by a green infrastructure plan are designed at a scale to be useful to accommodate changes in land cover from climate change. If a green infrastructure network in the Northeast outlined a series of forest hub areas of 25,000 acres for sugar maple forest, these same areas would still make useful forest hubs for new oak-hickory forest. As long as the underlying land ownership is managed in an ecologically sensitive way by either public or private landowners, a forested green infrastructure hub will serve the needs of whatever forest type emerges because of changes in climate.

Another use of green infrastructure plans will be in identifying prime areas to facilitate carbon sequestration through reforestation or restoration of native grassland species. Directing restoration efforts in the area of climate change will be as much about a landscape's ability to hold carbon as well as overall habitat quality for a particular species.

Both green infrastructure network design and climate change forecasts are best used at a regional scale, making the green infrastructure approach a relevant method to address climate change. Unfortunately, there are still many regions of the country without green infrastructure networks in place to help with the expected ecological shift and mass migration.

Tips for Planners: How Green Infrastructure Can Augment Existing Plans

Planners work on many different types of plans. Green infrastructure can provide value to each type of plan, making it more meaningful and lasting and bringing tangible benefits to both planners and residents.

Neighborhood or Area Plan: A plan focused on a specific geography with detailed guidance on design and land use can benefit from a green infrastructure network by highlighting resources such as corridors created by neighborhood creeks, floodplains that require additional setbacks, or vacant wood lots that could form the basis of new urban wildlands. A green infrastructure network helps both residents and planners see the value in their local natural resources and how those assets relate to the surrounding region.

Comprehensive Plan: A comprehensive plan creates a vision for both the present and the future of the community in terms of land use and growth. A green infrastructure plan can add value by highlighting the critical ecological systems that need to remain intact to provide services to residents, create a sense of place, and focus development and conservation in appropriate areas. The coordination of zoning, overlay districts, and flood control regulations are all enhanced with the information provided by a green infrastructure network.

Open Space or Parks and Recreation Plans: These plans inventory and help manage local lands for passive and active recreation. A green infrastructure network provides a method for linking open spaces together as well as connecting those lands outward to regional and state parks. While rivers and streams can provide important recreational opportunities for the public, their treatment as core areas or corridors in a green infrastructure network articulates additional value for these areas that is often missed by open space plans. A green infrastructure approach can be used to fulfill many of the aspects of a traditional open space plan, provided that it is augmented with sections on active recreation.

Strategic Plan: Based on developing goals and objectives to guide an organization's approach to meet specific challenges with concrete actions, strategic plans have often lacked a view of the physical world. A green infrastructure network is a strategic approach for future land use, highlighting key areas where protection is necessary to ensure the vital health of a community. It can be used to illustrate the goals, objectives, and actions articulated in a strategic plan. Green infrastructure networks are action-oriented and compel public officials and residents to follow through on implementation steps.

Transportation Improvement Program (TIP): This is a formal planning document that outlines a state or region's major highway construction projects and balances anticipated construction costs against projected revenues. The use of green infrastructure networks can help transportation planners by outlining sensitive lands that should be avoided, highlighting areas for potential mitigation for project impacts, and bringing attention to corridors that could be used for recreation as part of an improvement package. As discussed earlier, green infrastructure plans can help with meeting federal guidelines.

Capital Improvement Plans: These plans finance multi-year outlays for fixed assets like facilities and equipment, linking the needs of diverse government departments such as a school

district, a department of public works, and a parks department to an annual budget. A green infrastructure network is a region's approach to ensuring that future ecosystem services such as water filtration and flood control are provided by nature and not outlays of public capital. A green infrastructure network can help public officials with complex multi-year projects such as providing municipal services to a new part of a community.

Conclusions

After a solid decade of use, green infrastructure has proven to be a vibrant, flexible, and comprehensive planning methodology. Communities across the country have found the green infrastructure planning process helpful for imagining and building their future. The increasing use of green infrastructure planning in tandem with gray infrastructure projects promises to fulfill the long awaited goal of addressing both environmental issues and economic issues in a holistic manner.

While significant challenges such as global climate change will require modifications to aspects of green infrastructure planning, the basic green infrastructure method holds the key to addressing these vexing problems. Fundamentally, green infrastructure is about community, and understanding the web of interrelated features that make our communities able to support life of all kinds. This is an important tool for planners to learn how to use to its full potential.

About the Authors

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Technical Resources

The Federal Highway Administration
SAFETEA-LU Environmental Provisions and Related Information
<http://environment.fhwa.dot.gov/strmlng/es2safetealu.asp>

The Eco-Logical framework
http://environment.fhwa.dot.gov/ecological/eco_entry.asp

Environmental Law Institute. 2003. Conservation Thresholds for Land Use Planners, Washington, D.C.
www.elistore.org/reports_detail.asp?ID=10839

Environmental Law Institute, 2008. Planner's Guide to Wetland Buffers for Local Government, Washington, D.C.
www.elistore.org/reports_detail.asp?ID=11272

U.S. Fish and Wildlife Service
Habitat Conservation Plans
www.fws.gov/Endangered/hcp/index.html

USDA Forest Service Climate Change Atlas
Trees and Birds, see www.nrs.fs.fed.us/atlas/

U.S. Global Change Research Program
www.usgcrp.gov/usgcrp/default.php

Case Studies

New Maryland Greenprint Plan
www.greenprint.maryland.gov/

Angelina County, Texas, Angelina County GI Plan
www.conservationfund.org/strategic_conservation/lufkin-angelina

El Paso, Texas, El Paso Open Space Plan
www.elpasotexas.gov/development_services/green_home.asp

Mid-America Regional Council MetroGreen Plan. [http://www.marc.org/metrogreen/Linking Environmental and Transportation Planning](http://www.marc.org/metrogreen/Linking_Environmental_and_Transportation_Planning)
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