

Green Infrastructure: Smart Conservation for the 21st Century

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Introduction

“Green infrastructure” is a term becoming more commonly used among natural resource professionals. While it means different things to different people, depending on the context in which it is used, for the purposes of this article, green infrastructure is *an interconnected network of green space that conserves natural ecosystem values and functions and provides associated benefits to human populations*. Green infrastructure is the ecological

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This article is based on a monograph published in February 2002 by the *Sprawl Watch Clearinghouse*. Copies of the monograph can be obtained by contacting the *Sprawl Watch Clearinghouse* (1400 16th Street NW, Washington, D.C., 20035, 202-332-7000) or by downloading the PDF file from the *Clearinghouse's website* (www.sprawlwatch.org). The authors thank the *Surdna Foundation, Tucker Foundation, Jackson Hole Preserve, Inc., Virginia Environmental Endowment, and USDA Forest Service* that have supported The Conservation Fund's green infrastructure program.

framework needed for environmental, social and economic sustainability—our nation's *natural life support system*. Planning utilizing green infrastructure differs from conventional open space planning because it looks at conservation values in concert with land development, growth management and built infrastructure planning.

This article introduces green infrastructure as a strategic approach to land conservation that addresses the ecological and social impacts of sprawl and the accelerated consumption and fragmentation of open land. It describes the concept and value of green infrastructure and presents seven principles for successful green infrastructure initiatives.

What Is Green Infrastructure?

Webster's *New World Dictionary* defines infrastructure as “the substructure or underlying foundation, especially the basic installations and facilities on which the continuance and growth of a community depends.” Most people think of infrastructure as roads, sewers and utility lines—*gray infrastructure*; or as hospitals, schools and prisons—*social infrastructure*. Taken together, these are often referred to as *built infrastructure*. Today, many people and organizations are talking about another type of infrastructure critical to the continuance and growth of a community—*green infrastructure*.

In 1999, The Conservation Fund and the USDA Forest Service formed a working group of government agencies and non-governmental organizations to develop a program that would help make green infrastructure an integral part of local, regional and state plans and policies. This Green Infrastructure Work Group developed the following definition for green infrastructure:

“Green infrastructure is our nation's natural life support system—an interconnected network of waterways, wetlands, woodlands, wildlife habitats and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for America's communities and people.”

Green infrastructure's components include a variety of natural and restored ecosystems and landscape features that make up a system of “hubs” and “links.” Hubs anchor green infrastructure networks, providing origins and destinations for the wildlife and ecological processes moving to or through them. Links are the connections tying the system together and enabling green infrastructure networks to work. Hubs and links range in size, function and ownership. In order to be successful, these elements need long-term protection through long-range planning and

management, as well as an ongoing commitment.

Green Infrastructure's Origins

Green infrastructure is a new term, but not a new idea. It has roots in planning and conservation efforts that started 150 years ago. The concept evolved from two important precedents: (1) the linking of parks and other green spaces for the benefit of people, and (2) the linking of natural areas to benefit biodiversity and counter habitat fragmentation.

In 1903, landscape architect Frederick Law Olmsted stated that, "no single park, no matter how large and how well designed, would provide the citizens with the beneficial influences of nature." Instead, parks needed "to be linked to one another and to surrounding residential neighborhoods."¹ This idea of linking parks for the benefit of people sparked the modern greenways movement.

Additionally, wildlife biologists and ecologists have long recognized that the best way to preserve biological diversity and ecological processes is to create an integrated conservation system to counter habitat fragmentation. Creating and restoring connections between parks, preserves and other important ecological areas is a key concept for the science of conservation biology and the practice of ecosystem management.

The President's Council on Sustainable Development identified green infrastructure as one of five strategic areas that provide a comprehensive approach for sustainable community development. The Council's 1999 report stated, "Green infrastructure strategies actively seek to understand, leverage, and value the different ecological, social, and economic functions provided by natural systems in order to guide more efficient and sustainable land use and development patterns as well as protect ecosystems."² This re-

port, along with innovative projects at the state, regional and local levels, has led to a rapid increase in the use of the term "green infrastructure" and the application of its concepts and values.

The modern greenways movement also has influenced green infrastructure planning and implementation. Although green infrastructure and greenways share a common origin, green infrastructure differs from greenways in at least three major ways:

Ecology vs. Recreation—Green infrastructure emphasizes ecology, not recreation.

Bigger vs. Smaller—Green infrastructure includes large, ecologically important hubs, as well as key landscape linkages.

Framework for Growth—Green infrastructure can shape urban form and provide a framework for growth. It works best when the framework pre-identifies both ecologically significant lands and suitable development areas.

Why Do We Need to Plan and Protect Green Infrastructure?

Land is being developed faster than ever. The accelerated consumption and fragmentation of open land is America's primary conservation challenge. The following statistics illustrate the problem:

According to the December 2000 update of the Natural Resource Conservation Service's National Resources Inventory, over the 15-year period from 1982 to 1997, the total acreage of developed land in the United States increased by 34 percent (25 million acres). From 1982 to 1992, land was converted at 1.4 million acres per year; from 1992 to 1997, land was converted at 2.2 million acres a year. This rate is more than 1.5 times the previous 10-year rate.³

The 1997 American Housing Survey conducted by the Census Bureau and HUD found that between 1993 and 1997, 2.3 million acres of open space

were converted to new single-family homes each year. Almost 90 percent of this conversion occurred where lots were one acre or larger. These lots were purchased by only 33 percent of new homebuyers.⁴

According to a July 2001 report by the Center on Urban & Metropolitan Policy at The Brookings Institution, "between 1982 and 1997, the amount of urbanized land in the United States increased by 47 percent . . . During this same period, the nation's population grew by only 17 percent (See Table 1)."⁵

In many major metropolitan areas, green space is rapidly disappearing. The Atlanta metropolitan area has lost 25 percent of its tree cover since 1973, nearly 350,000 acres. This loss equals nearly 50 acres of trees every day.⁶ From 1970 to 1990, metropolitan Chicago experienced a 35 percent increase in developed land, but a population increase of only four percent.⁷ Some of our most threatened lands are in urban fringe counties, which produce nearly 80 percent of America's fruit and vegetables and more than half of its dairy products. Many rural communities also are rapidly developing.⁸

U.S. Region	Change in Population	Change in Urbanized Land
Midwest	7.06%	32.23%
Northeast	6.91%	39.10%
South	22.23%	59.61%
West	32.21%	48.94%
U.S.	17.02%	47.14%

Table 1. Population Growth versus Land Development, 1982-1997. (From: William Fulton, Rolf Pendall, Mai Nguyen and Alicia Harrison, Who Sprawls Most? How Growth Patterns Differ Across the U.S., The Brookings Institution, Survey Series, July 2001.

Consequences of Haphazard Development

Over the past several decades, growth has leapfrogged cities and older suburbs into many once rural areas. Development is overtaking farms and forests at an increasingly rapid rate. This expansion often occurs without well-designed land-use plans, resulting in urban sprawl, which fragments natural areas, isolates productive farmland and disrupts ecological functions. This has led to the:

Loss of Natural Areas—For example, about 25,000 acres of wetlands continue to be lost each year to sprawl. As natural areas are diminished, so is habitat diversity. The result is a decline in the number of species and in the number of individuals of those species that survive.

Fragmentation of Open Spaces—As we convert land, it is fragmented into isolated patches of open space, greatly altering the function of its natural systems by increasing edge habitats and isolating patches, reducing both the number and diversity of native species.

Degradation of Water Resources—Developing wetlands and riparian zones reduces their capacity to control floods, trap sediments, filter out toxins and excess nutrients, and support wildlife and plant species.

Decreased Ability for Nature to Respond to Change—Development has hindered nature's ability to respond to climate change and has reduced the viability of wildlife populations by limiting genetic diversity and wildlife movement.

Loss of "Free" Natural Services—Natural systems provide important services such as flood control, stormwater management and pollution filtration. The loss of these services increases the risk of floods and natural disasters, costing communities billions in mitigation and disaster relief efforts.

Increased Costs of Public Services—Haphazard development often requires huge investments in roads, sewers, schools and other public infrastructure. As new communities are built, new infrastructure needs to expand to accommodate them.

Increased Taxes—Many studies show that farming and forestry generate more revenue than they require in public services. Haphazard residential development has the opposite effect. It forces communities to provide services across a larger geographic area, stretching municipal services and resulting in increased infrastructure costs that lead to higher taxes.

Smart Growth

The United States grows by 2.7 million people every year, requiring an annual increase of at least 1 million new housing units. To control how and where this growth will occur, many communities have started smart growth initiatives.

Smart growth has been defined as development that is economically sound, environmentally friendly and supportive of community livability—growth that enhances our quality of life. A recent study by Rutgers University found that the annual operating and maintenance costs for roads and other public facilities in New Jersey could be reduced by \$400 million a year by developing in a more compact manner.

Additional studies by the Brookings Institution and others show that the pace of land development far exceeds the rate of population growth in America. This suggests the problem is not growth itself, but the pattern of growth.

Simply put, some places are better for development than others. The first principle of better development is determining where not to develop. Green infrastructure planning can help communities figure this out. Communities need to make better use of existing in-

frastructure to encourage more compact, walkable communities and to develop a framework for shaping where growth will go.

Smart Conservation

Smart growth programs are designed to address the problems of haphazard development and sprawl. Likewise, we need smart conservation programs to strategically direct conservation practices. Smart conservation promotes resource planning and protection in a way that is proactive not reactive; systematic not haphazard; holistic not piecemeal; multifunctional not single purpose; multi-jurisdictional not single jurisdictional; and multiple scale not single scale.

Green Infrastructure Functions and Benefits

Green infrastructure systems help protect and restore naturally functioning ecosystems by providing a framework for future development that fosters a diversity of ecological, social, and economic benefits. These include enriched habitat and biodiversity; maintenance of natural landscape processes; cleaner air and water; increased recreational opportunities; improved health; and better connection to nature and sense of place. Green space also increases property values and can decrease the costs of public infrastructure and services such as, flood control, water treatment systems and storm water management.

Investing in green infrastructure is often more cost effective than developing conventional public works projects. For example, in the 1990s, New York City saved spending \$4-6 billion on new water filtration and treatment plants by purchasing and protecting watershed land in the Catskill Mountains for about \$1.5 billion. Likewise, Arnold, Missouri, has dramati-

cally reduced the need for costly disaster relief and flood damage repair efforts by purchasing threatened flood plain properties and replacing them with greenways.

Trends Influencing the Shift to Green Infrastructure

In the past, many communities considered open space to be unutilized land. The legal and philosophical framework of our land use system assumed land was a commodity to be consumed. Communities that did plan for open space focused almost exclusively on preserving land for parks, which were viewed as a community amenity. Most open space preservation efforts were site-specific and were rarely coordinated with local land-use planning. However, shifts in the way government officials think about green space, and a growing awareness among states and localities of the need to plan for green infrastructure, have resulted from a number of positive trends including:

- Increased recognition of the problems associated with urban sprawl and landscape fragmentation;
- Federal water quality mandates;
- Endangered species protection, particularly the emphasis on habitat conservation plans that protect multiple species and link isolated preserves;
- Increased marketability and resale value of homes near open space, parks and greenways;
- Community revitalization emphasizing the value of urban natural areas;
- Smart growth policies and programs at the state, regional and community levels;
- Green development practices designed to promote environmental and economic sustainability.

Green Infrastructure Planning Approaches

Like our transportation system, green infrastructure should be carefully planned, designed, and expanded as communities grow. Green infrastructure planning should be the first step in developing land-use plans, and should be coordinated with planning roads, sewers, water lines, and other essential gray infrastructure. Integrated planning and design should connect green and gray in a more effective, economic and sustainable network. Open space planners should use approaches similar to those of transportation planners. Green infrastructure should be:

Designed Holistically—Green infrastructure should be designed to link elements into a system that functions as a whole, rather than as separate, unrelated parts.

Planned Comprehensively—Our green space systems need to be planned to include ecological, social and economic benefits, functions and values.

Laid Out Strategically—Green space systems need to be laid out strategically to cross multiple jurisdictions and incorporate green space elements at each level of government.

Planned and Implemented Publicly—Green infrastructure systems should be planned and implemented with input from the public, including community organizations and private landowners.

Grounded in the Principles and Practices of Diverse Professions—Green space systems should be based on sound science and should build on the knowledge of professional disciplines such as landscape ecology, urban and regional planning, and landscape architecture.

Funded Up-Front—Like other infrastructure systems, our green space systems need to be funded as primary public investments rather than with money left over after all other services have been provided.

Benefits of Integrating Green Infrastructure Into the Land Planning Process

There are many benefits to utilizing a green infrastructure approach to conservation and development planning. Green infrastructure planning:

- Recognizes and addresses the needs of people and nature;
- Provides a mechanism to balance environmental and economic factors;
- Provides a framework for integrating diverse natural resource and growth management activities in a holistic, ecosystem-based approach;
- Ensures that both green space and development are placed where they are most appropriate;
- Identifies vital ecological areas prior to development;
- Identifies opportunities for the restoration and enhancement of naturally functioning systems in urban areas;
- Provides a unifying vision for the future;
- Enables communities to create a system that is greater than the sum of its parts;
- Provides communities and developers with predictability and certainty; and
- Enables conservation and development to be planned cooperatively.

Green Infrastructure Principles

Across America, states, communities, private landowners, public agencies and conservation organizations are working to conserve and restore our country's natural life sustaining system. Although these projects are called different names (greenway planning, ecosystem management, watershed protection, conservation development, habitat restoration, greenprints, etc.), successful initiatives are based on common principles and strategies.

The following principles are critical to the success of green infrastructure initiatives. They provide a strategic approach and a framework for conservation that can advance sustainable use of land while benefiting people, wildlife and the economy.

This approach includes design, planning, acquisition and decision-making guidance for agencies and organizations. It is our hope that public officials and private citizens will use these principles as benchmarks for incorporating a green infrastructure approach into land use and economic development plans and policies.

Principle 1: Green infrastructure should function as the framework for conservation and development.

Most of our nation's land conservation programs have focused on protecting individual parks, preserves, or other isolated areas with important natural or cultural resources. Yet, conservation biology teaches us that, because wildlife populations cannot flourish and ecological processes cannot function if natural connections are severed, these "islands" are unlikely to meet their conservation objectives. By contrast, the roads and highways upon which America depends—and which provide a framework for future growth and development—are planned, built, and maintained as a system of interconnected parts.

By making green infrastructure the framework for conservation, communities can plan for interconnected, green space systems. Where isolated "islands" of nature exist, green infrastructure planning can help identify opportunities to restore the vital ecological connections that will maintain those protected areas. Green infrastructure planning also minimizes the adverse impacts of rapid growth on ecosystem functions and services, such as the disruption of wildlife migration corridors or the loss of riparian areas that absorb nutrients, recharge ground

water supplies and reduce stormwater runoff.

Principle 2: Design and plan green infrastructure before development.

Restoring natural systems is far more expensive than protecting undeveloped land, and man-made wetlands and other restoration projects often fail to function as well as their natural counterparts over the long term. Because green infrastructure provides communities with an ecological framework, it is essential to identify and protect critical ecological hubs and linkages in advance of development. Central Park could not be created today nor could Cook County, Illinois', Forest Preserve System or many other of the nation's best parks and preserves. Protecting green infrastructure up front ensures that existing open spaces and working lands are seen as essential community assets and not left vulnerable to development.

In situations where development has already occurred, it is still important to assess where restoring green infrastructure would benefit people and nature. Green infrastructure plans should set acquisition and restoration priorities and help communities identify opportunities to reconnect isolated habitat islands as redevelopment opportunities occur.

Principle 3: Linkage is key.

The desired outcome for all green infrastructure initiatives is a green space "network" that functions as an ecological whole. A strategic connection of system components—parks, preserves, riparian areas, wetlands, and other green spaces—is critical to maintaining vital ecological processes and services (e.g., stormwater runoff, cleaning fresh water, etc.) and to maintaining the health of wildlife populations. In addition, green infrastructure requires linkages between different agencies, nongovernmental organizations, and the private sector.

The nation's federal, state, and local highway networks holistically create a functional transportation system funded and supported by different levels of government. Why not design green infrastructure in the same way, taking advantage of natural stream networks and terrain features to create physically connected green space systems that protect and restore vital ecological functions and linkages?

Principle 4: Green infrastructure functions across jurisdictions and at different scales.

We need to design green infrastructure systems to connect across urban, suburban, rural and wilderness landscapes and to incorporate green space elements at the state, regional, community and parcel scales. Green infrastructure strategies can be used for initiatives of any size or scale, including:

- Individual parcels of land or within single real estate developments;
- The community and regional scale, including park, recreation and other open-space projects;
- The landscape scale, encompassing statewide and national conservation and open space resources.

Green infrastructure may be most successful when it functions at multiple scales in concert. For example, Toronto's "Greening the Portlands" project focuses on regional parks, neighborhood parks, wide habitat corridors, narrow trail corridors, and greenspace within developments.

It is important to note that green infrastructure systems do not require, or even imply, public ownership of all land in the system. Clearly, privately owned land, particularly working farms and forests, can play an important role in any green space system.

Principle 5: Green infrastructure is grounded in sound science and land-use planning theories and practices

Conservation biology, landscape ecology, urban and regional planning,

landscape architecture, geography and civil engineering contribute to the successful design and planning of green infrastructure systems. Initiatives should therefore engage and incorporate the expertise of professionals from all relevant disciplines and should be based on sound science and up to date information.

Principle 6: Green infrastructure is a critical public investment.

Interconnected green space systems benefit people, wildlife and the economy. More importantly, strategic placement of green infrastructure reduces the need for gray infrastructure, freeing public funds for other community needs. Green infrastructure also reduces a community's susceptibility to floods, fires, and other natural disasters. Documenting these public benefits is an important first step toward providing adequate funding. We need to actively promote green infrastructure systems to secure the funding to build and maintain green space systems.

Green infrastructure should be funded in the same way as our nation's built infrastructure—as primary budgetary items to spread the costs of construction and maintenance across a large pool of users and to ensure that all parts connect to achieve maximum functionality. While not funded at the same level as public works, states and communities have begun using conventional mechanisms to finance green infrastructure projects—including bond referenda, real estate transfer taxes, lottery proceeds, dedicated development fees, direct appropriations and other mechanisms.

Principle 7: Green infrastructure engages key partners and involves diverse stakeholders.

Green infrastructure stakeholders have diverse backgrounds and needs.

Therefore, successful efforts forge alliances and relationships between public and private organizations. A few examples of how diverse organizations have come together include:

- Chicago Wilderness, a grassroots collaboration of over 100 organizations representing all sectors with an interest in the region.
- Keep America Growing, designed to create partnerships to balance the demands for growth and development with the protection of vital working lands.
- The Cooper River Wildlife Corridor Initiative in South Carolina, which uses an agreement for common land management practices with DuPont, Amoco, Medway Plantations, Cypress Gardens, and the Francis Marion National Forest.

Conclusion

Every state and local government has a long-range transportation plan. Growing communities also have detailed plans for improving their airports, sewage treatment plants, telecommunications facilities and other public infrastructure. Just as these communities need to upgrade and expand their gray infrastructure, they need plans to upgrade and expand their green infrastructure.

Green infrastructure plans provide a blueprint for conservation in the same way that long-range transportation plans provide a blueprint for future roads or transit lines. Green infrastructure plans can create a framework for future growth while ensuring that significant natural resources will be preserved for future generations. They can even reduce opposition to new development by assuring civic groups and environmental organizations that growth will occur only within a framework of expanded conservation and open space lands.

Savvy states and communities are starting to think about green space in a more thoughtful and systematic way. They realize that green infrastructure is not a frill—it is smart conservation for the twenty-first century.

Endnotes

- ¹ Charles E. Little, *Greenways for America*, The Johns Hopkins University Press, Baltimore and London, 1989.
- ² The President's Council on Sustainable Development, *Towards a Sustainable America—Advancing Prosperity, Opportunity, and a Healthy Environment for the 21st Century*, U.S. Government Printing Office, 1999.
- ³ United States Department of Agriculture, Natural Resource Conservation Service, National Resources Inventory, revised December 2000 (available at www.nrcs.usda.gov/technical/NRI/1997/summary_report/index.html).
- ⁴ United States Census Bureau and Department of Health and Urban Development, American Housing Survey, 1997.
- ⁵ William Fulton, Rolf Pendall, Mai Nguyen and Alicia Harrison, *Who Sprawls Most? How Growth Patterns Differ Across the U.S.*, The Brookings Institution, Survey Series, July 2001 (available at www.brook.edu/dybdocroot/urban/fulton-pendall.htm).
- ⁶ Fen Montaigne, "There Goes the Neighborhood," *Audubon*, March-April 2000.
- ⁷ Chicago Wilderness, Summary of the Biodiversity Recovery Plan, 1999 (available at <http://www.chicagowilderness.org/index.cfm>).
- ⁸ American Farmland Trust, see www.keepamericagrowing.org.

Reprinted from *Renewable Resources Journal*, Volume 20, Number3, Autumn 2002, Pages 12–17

The *Renewable Resources Journal* (ISSN 0738-6532) is published quarterly by the Renewable Natural Resources Foundation, 5430 Grosvenor Lane, Bethesda, Maryland 20814 USA. Telephone: (301) 493-9101. Fax: (301) 493-6148. Email: info@RNRF.org. Web site: <http://www.rnrf.org> © RNRF 2002.

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One major objective of the Agenda 21 initiative is that every local government should draw its own local Agenda 21. Its aim initially was to achieve global sustainable development by 2000, with the "21" in Agenda 21 referring to the original target of the 21st century.[2].
Agenda 2030, also known as the Sustainable Development Goals, was a set of goals decided upon at the UN Sustainable Development Summit in 2015.[5] It takes all of the goals set by Agenda 21 and re-asserts them as the basis for sustainable development, saying, "We reaffirm all the principles of the Rio Declaration on Environment and Development"[6] Adding. smart growth, sustainable communities, transportation, greening infrastructure, product-service systems, leapfrogging and megacity challenges. education, women's rights, public health, holistic approaches to community development, South-South science, social entrepreneurship and micro-lending, and philanthropy. They have a sane optimism about the future that carries through the book, which covers topics as diverse - yet interconnected - as biomimicry, clean energy, water, disaster relief, green design and architecture, transportation, megacities challenges, education, public health, South-South science, social entrepreneurship, microfinance, start-ups, ecological economics, networked politics, transparency, citizen media, climate foresight, etc. Green Infrastructure: Smart Conservation for the 21st Century.
"Infrastructure" the substructure or underlying foundation on which the continuance and growth of a community or state depends. WEBSTER'S NEW WORLD DICTIONARY Mark A. Benedict, Ph.D. Edward T. McMahon, J.D. This monograph is derived from Modules 2 and 4 of the Participants Manual for the May 2001 pilot offering of the Conservation Leadership Network course, Green Infrastructure: A Strategic Approach to Land Conservation. Mark Benedict and Lydia Bjornlund drafted these pilot course modules in spring, 2001.