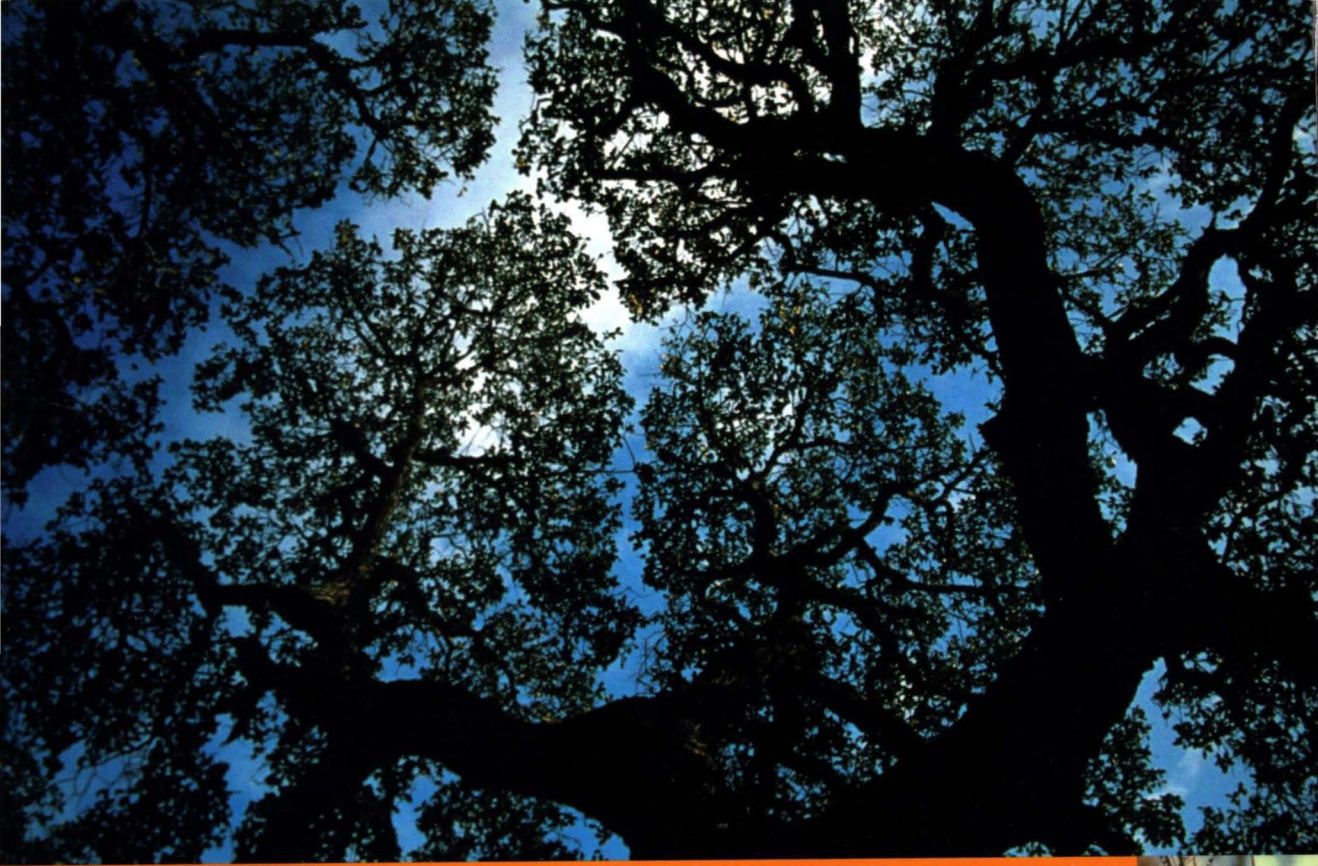
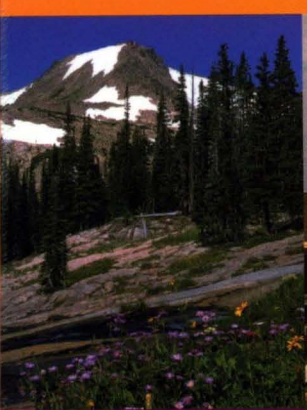
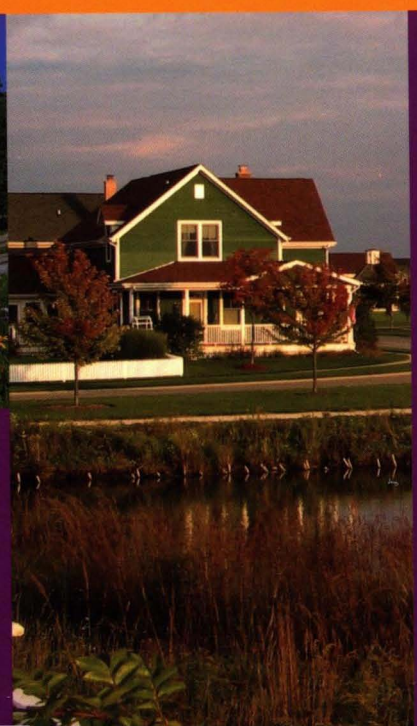


Green Infrastructure





Linking Landscapes and Communities

Mark A. Benedict
Edward T. McMahon

CONTENTS

Figure 1.1
Green infrastructure provides an opportunity to protect our nation's valuable lands and natural beauty. The John Heinz National Wildlife Refuge is a welcome respite from urban life for Philadelphians. Credit: John and Karen Hollingsworth, U.S. Fish and Wildlife Service.

as parts of interconnected systems that are protected and managed for the ecological benefits they provide. While green space is often viewed as something that is *nice* to have, green infrastructure implies something that we *must* have. Protecting and restoring our natural life-support system is a necessity, not an amenity. While green space is often viewed as self-sustaining, green infrastructure implies that green space and natural systems must be actively protected, managed, and in some cases restored.

Green infrastructure differs from conventional approaches to land conservation and natural resources protection because it looks at conservation in concert with land development and man-made infrastructure planning. Other conservation methods typically are undertaken in isolation from—or even in opposition to—development, but green infrastructure provides a framework for conservation and development that acknowledges the need for providing places for people to live, work, shop, and enjoy nature. Green infrastructure helps communities identify and prioritize conservation opportunities and plan development in ways that optimize the use of land to meet the needs of people and nature.

What Is Green Infrastructure?

Used as a noun, green infrastructure refers to an interconnected green space network (including natural areas and features, public and private conservation lands, working lands with conservation values, and other protected open spaces) that is planned and managed for its natural resource values and for the associated benefits it confers to human populations. Used as an adjective, green infrastructure describes a process that promotes a systematic and strategic approach to land conservation at the national, state, regional, and local scales, encouraging land-use planning and practices that are good for nature and for people.

Taking a green infrastructure approach provides benefits both as a concept and as a process. As a concept, the planning and management of a green infrastructure network can guide the creation of a system of open space hubs and links that support conservation and associated outdoor recreational and other human values, connect existing and future green space resources, and "fill in" gaps. As a process, the approach provides a mechanism for diverse interests to come together to identify priority lands for protection. Green infrastructure provides a framework that can be used to guide future growth and future land development and land conservation decisions to accommodate population growth and protect and preserve community assets and natural resources. Taking a green infrastructure approach facilitates systematic and strategic conservation activities, adds value to project results, and provides predictability and certainty for both conservationists and developers. In areas anticipating growth, a green infrastructure plan can pre-identify key lands for future

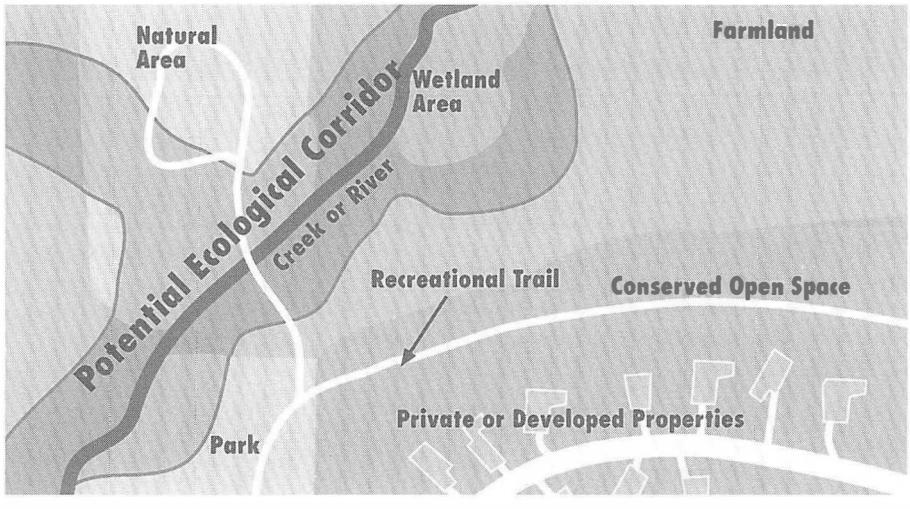


Figure 1.2
By focusing on the lands to be conserved as well as developed, green infrastructure helps communities plan for land conservation and land development in a way that optimizes land use to meet the needs of nature and people. Credit: Conservation Resource Alliance, Michigan.

Table 1.1

Advances in the History of American Infrastructure

Era	Growth Issue	Infrastructure Solution
Mid–Late 1800s	Public health and welfare	Sanitation, hospitals, parks, schools
	Communication	Telegraph
	Industrialization	Planned communities, company towns
	Energy	Coal, oil, gas, electricity
	Transportation	Canals, railways
Early 1900s	Automobiles	Roads
	Food production (Dust Bowl)	Crop rotation, agricultural practices
	Communication	Radio, telephone
Mid-1900s	Energy	Hydro and nuclear power
	Nuisances	Community zoning and planning
	Pollution	Air/water/sewage treatment
	Transportation	Interstate system, airports
	Mass communication	Television
Late 1900s	Garbage	Recycling
	Traffic congestion	Mass transit, alternative transportation
	Flooding	Storm water management, detention
	Information management	Computers/Internet
2000+	Sprawl, globalization	Sound land use, smart growth
	Sustainability	Green infrastructure

Source: Karen S. Williamson, *Growing with Green Infrastructure*, Heritage Conservancy, 2003, 1.

conservation and restoration efforts and help shape the pattern and location of future growth.

Green infrastructure uses planning, design, and implementation approaches similar to those used for roads, water management systems, and other community support facilities. The approach can be applied at multiple scales (e.g., across landscapes, watersheds, regions, jurisdictions) and can help move communities beyond jurisdictional and political boundaries.

Green infrastructure also provides a strong rationale for funding green space conservation and management. Just as roads, sewer systems, hospitals, and other aspects of the built or gray infrastructure provide for the critical needs of communities, green infrastructure is integral to a community's health and viability. Like gray infrastructure, green infrastructure has evolved to meet specific needs that have resulted from growth (see Table 1.1).

A green infrastructure network connects these ecosystems and landscapes in a system of *hubs*, *links*, and *sites*. Hubs anchor green infrastructure networks and provide space for native plants and animal communities, as well as an origin or destination for wildlife, people, and ecological processes moving through the system. Hubs come in all shapes and sizes, including large reserves and protected areas, such as national wildlife refuges or state parks; large publicly owned lands, including national and state forests, which are managed for resource extraction (e.g., mining or timber) as well as natural and recreational values; private working lands, including farmland, forests, and ranch lands; regional parks and reserves; and community parks and green spaces where natural features and processes are protected and/or restored.

Links are the connections that tie the system together. These connections are critical to maintaining vital ecological processes and the health and biodiversity of wildlife populations. Landscape linkages, which are especially long and wide links, connect existing parks, preserves, or natural areas and provide sufficient space for native plants and animals to flourish while serving as corridors connecting ecosystems and landscapes. Landscape linkages may also provide space for the protection of historic sites and opportunities for recreational use. Links and conservation corridors, such as river and stream floodplains, serve as biological conduits for wildlife and may also provide opportunities for outdoor recreation, while greenways and greenbelts

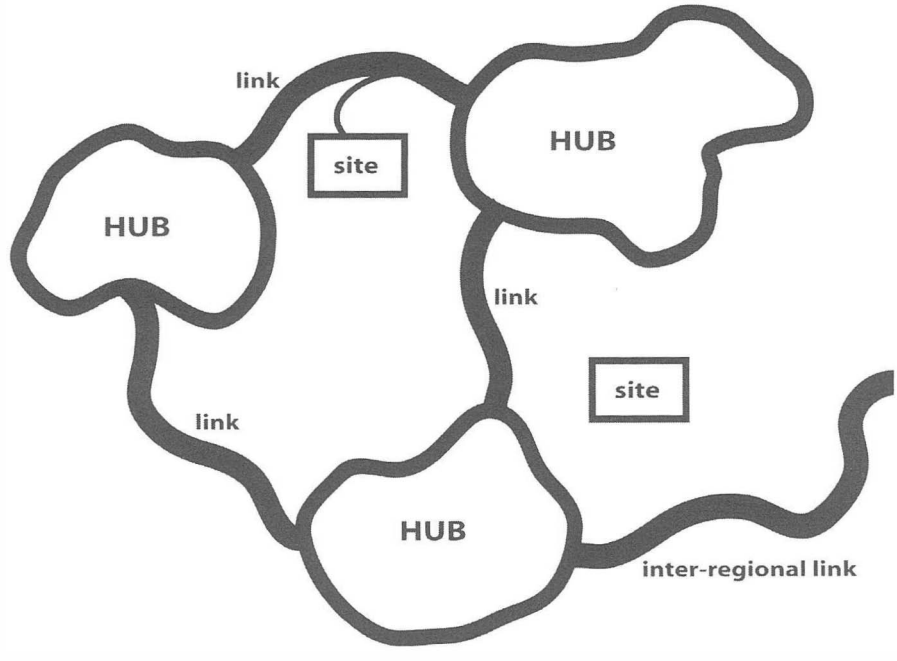


Figure 1.5
A green infrastructure network connects ecosystems and landscapes in a system of hubs, links, and sites. Credit: Maryland Department of Natural Resources.

Figure 2.1
Philip Lewis was among the early advocates of considering land's potential value in land-use planning, focusing particular attention on the importance of environmental corridors. Shown here is an analysis of environmental corridors in Wisconsin.
Credit: Philip Lewis.

landscape and habitats became more fragmented, the theory of island biogeography became a tool for understanding the nature and pattern of species diversity for these isolated habitats.

The discipline of conservation biology evolved from this new field of research. Based on the theories of ecology, genetics, biogeography, and wildlife ecology, conservation biology focuses on the protection of biological diversity and related critical habitats. Conservation biology strives to provide information to manage the dynamic evolutionary processes in a changing ecological background. Together, the fields of landscape ecology and conservation biology provide green infrastructure with the scientific knowledge and tools to plan for viable plant and animal populations over the long term.

Among the tools that landscape ecologists and conservation biologists promoted to meet biodiversity goals is the design of reserves. The purpose of reserves is to protect areas of high biological value that would otherwise likely be degraded and to preserve biodiversity and protect rare, threatened, and endangered species. The

important habitats, green infrastructure helps to protect the biodiversity present today.

Green infrastructure protects the forests and wetlands that provide habitat for the vast array of species on earth today. Wetlands, for example, serve as reservoirs of biodiversity and support a wide range of wildlife, from shorebirds to alligators. Although freshwater ecosystems cover only 1 percent of the Earth's surface, they hold more than 40 percent of the world's species and 12 percent of all animal species. A range of products can be gleaned from the system of marshes and bogs, including cranberries and other fruits, fish and shellfish, resins, timber and fuel wood, and reeds that can be woven into baskets. Two-thirds of all species used for seafood are dependent on coastal wetlands at some stage in their life cycle, a critical function that far surpasses the actual area covered by these wetlands. Wetlands also support large rice plantations, the staple diet of over half the world's population.

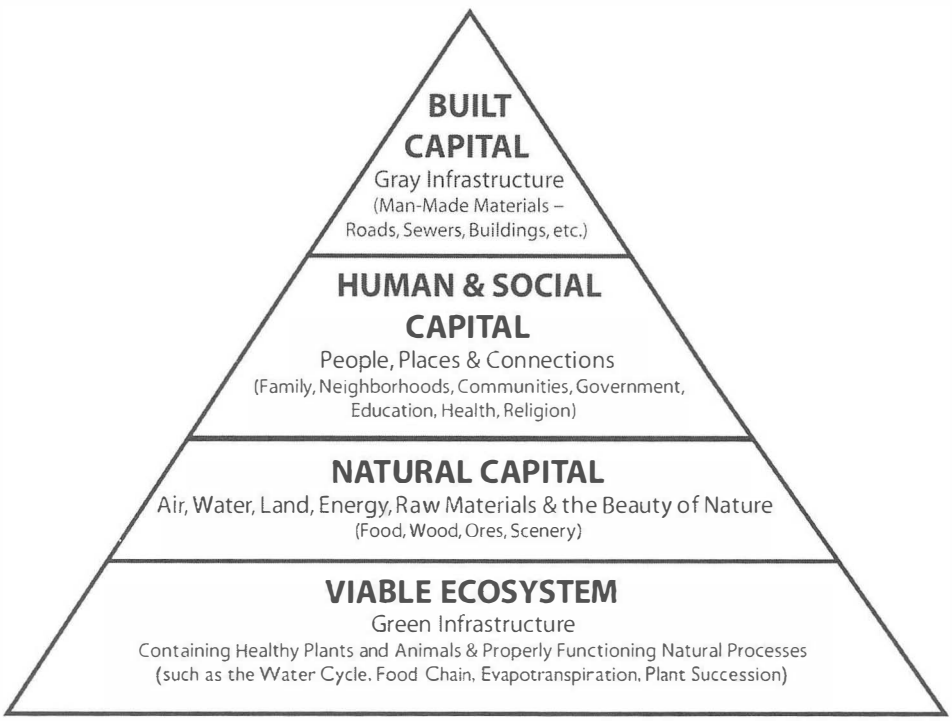


Figure 3.1
This sustainability pyramid illustrates how viable ecosystems preserved as green infrastructure serve as society's foundation by providing the natural resources that support our human systems and man-made surroundings. A variety of natural processes interact to create a healthy environment and allow us to harvest the food we eat and obtain the raw materials to build our communities. Credit: Adapted from Karen S. Williamson, *Growing with Green Infrastructure*, © 2003 by Heritage Conservancy. All rights reserved.

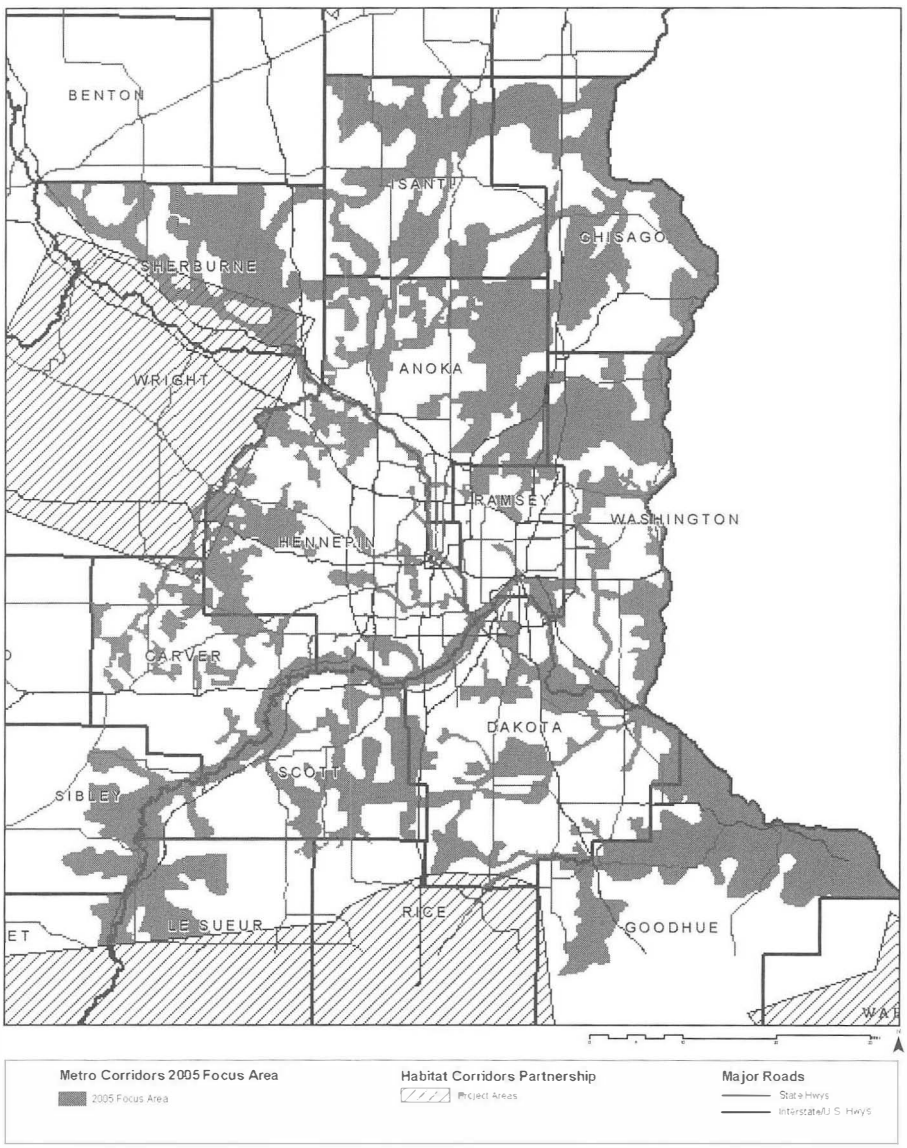


Figure 3.7
The Minnesota Department of Natural Resources worked with several nonprofit organizations to map wildlife corridors in the Twin Cities region. Using findings from an ecological assessment, the partners identified twelve focus areas for protection and restoration efforts. These areas include parks and the surrounding landscapes that buffer, connect, and protect the natural resources in regional parks. Credit: Metro Greenways, Minnesota Department of Natural Resources.

data for the Twin Cities metropolitan region has been generated. As of September 2004, land cover analysis was complete for 67 percent (1.28 million acres) of the region. In addition, Metro Greenways has awarded nearly $1 million in matching grants to communities to help them undertake such resource inventories and develop local plans for preserving and managing their natural infrastructure.

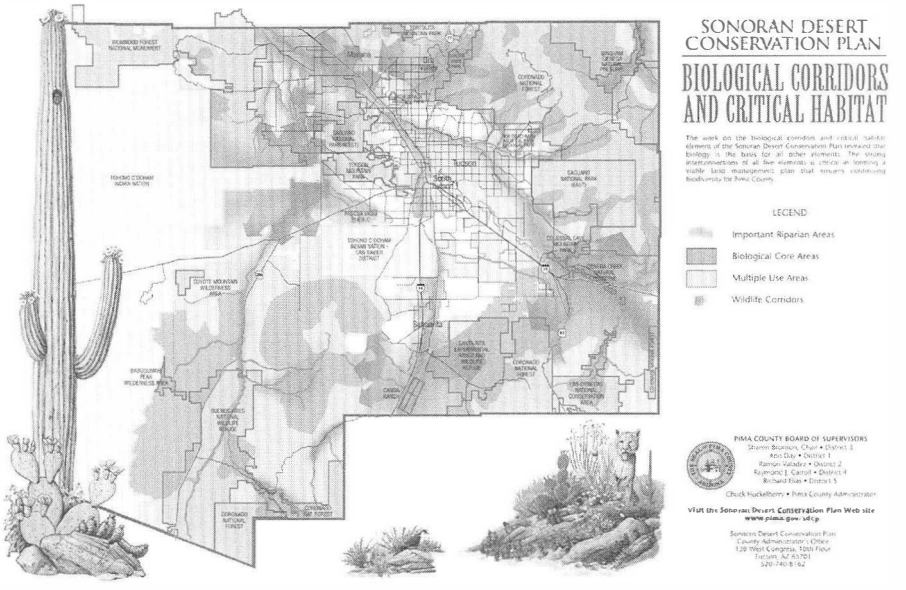


Figure 4.4
Pima County used GIS to map the most biologically important lands and develop an interconnected system of conservation lands that would provide long-term protection for sensitive plant and wildlife species in southern Arizona. Credit: Pima County Graphic Services.

prehensive land-use plan to incorporate the Science Technical Advisory Team's map of habitat to be protected (known as the Conservation Lands System). The Conservation Lands System gives extra protection to hillsides and riparian areas for their habitat value and uses relative habitat value to determine how much land should be left in its natural state when a parcel is developed. In a groundbreaking display of green infrastructure-based strategic conservation planning, in 2001 Pima County adopted the Conservation Lands System map as the basis for its updated comprehensive land-use plan.

County officials emphasize that this, the SDCP, and other land-use planning efforts are not about stopping development but about fostering responsible growth while preserving the landscapes that make the area special. County officials realized the county would save money if they could redirect growth to areas where infrastructure such as roads and sewer lines already exist and used this advantage to sell the community on the idea of strategically planning for growth. Having a countywide strategy enables developers to plan further into the future because there is less uncertainty about which land uses will be permissible where.

Tremendous public participation and volunteer work enabled the effort to succeed. All interested parties were invited to join the citizens' steering committee, giving voice to the many constituencies involved in land-use issues in the county. The sheer number of members and the wide diversity of interests sometimes

Table 5.1

Attributes that Could Be Part of a Green Infrastructure Network

Natural ecosystem values and functions (biodiversity, ecological processes, and ecological services)		
Attributes	**Examples of places**	**Examples of functions provided**
Ecological communities and other natural attributes	Public, private, and nonprofit parks, preserves and reserves at state, regional, and local levels; lands in native habitat, waterfalls, gorges, canyons	Protect and restore native plant and animal communities, enrich biodiversity, maintain/ restore natural landscape attributes
Fish and wildlife resources	Wildlife refuges, game reserves, landscape linkages/wildlife corridors, ecobelts, streams and lakes	Provide habitat for wildlife, support animal migration, maintain population health
Watersheds/ water resources	Riparian and associated nonriparian lands, wetlands, floodplains, groundwater recharge areas	Protect and restore water quality and quantity, provide habitat for aquatic and wetland organisms
Working landscapes with ecological values	Forestlands, rangelands, and farmlands with native habitats and natural attributes; working landscapes with potential for restoring ecological values	Habitat for fish and wildlife species, protection of water resource values (floodplains, wetlands), connecting and/or buffering network components, protecting soils
Associated benefits to human populations (ecological services, societal values, and economics)		
Attributes	**Examples of places**	**Examples of functions provided**
Recreation and health resources	Parks, greenways, blueways, trails	Encourage exercise and active lifestyles, provide space for outdoor activities, create places of solitude and respite, connect people with nature, connect communities, provide alternative transportation
Cultural resources	Historic/archaeological sites, interpretative/educational sites/facilities, town/county open spaces/commons	Preserve link to natural and/or cultural heritage, foster education and involvement through "nature's classroom," encourage resource stewardship, protection of cultural site context/integrity
Growth pattern and community character	Greenbelts, scenic vistas/ viewsheds, community open spaces/commons, greenways, river corridors, developing lands in proximity to ecological resources lands	Guide patterns of growth, create appealing visual landscapes, enhance character of development, foster community identity and pride, attract and retain businesses, residents, visitors
Water resources	Watersheds, wetlands, floodplains, groundwater recharge areas	Protect water quality and quantity, manage storm water, provide sites for regional wetland mitigation banks
Working lands with economic values	Farms, orchards, ranches, managed forests	Protect working lands as a business as well as a place, maintain rural character and traditions, support sectors of the economy

Table 6.1

Potential Tools for Green Infrastructure Implementation

	Local	State	Federal[1]	Private
Land acquisition	• Fee-simple acquisition • Conservation and/or agricultural easements • Purchase of development rights • Transfer of development rights	• Conservation easements • Fee-simple acquisition • Forest-legacy program • Historic preservation easement • Smart growth initiatives	• Land and water conservation fund • Fee-simple acquisition • Conservation easements • Farmland Protection Policy Act • Community development block grants	• Conservation easements • Conservation and wetlands banking • Fee-simple purchase • Local corporations • Local land trusts • National land trusts • Riparian easement
Regulation	• Buffer or landscaping ordinances • Building permitting • Comprehensive plans • Conservation banks • Development impact fees • Environmental impact regulations • Mitigation banking • Special assessment districts • Storm water regulations • Subdivision ordinances • Zoning, including dawnzoning, cluster or open space zoning, and performance zoning	• Scenic highway or byway legislation • Scenic rivers legislation • Conservation and/or mitigation banking • Wetland, river setback and shoreline permitting programs • Rare and endangered species permitting programs • Water management and water resource permitting	• Clean Air Act • Clean Water Act • Endangered Species Act • National Environmental Protection Act • National Historic Landmarks • National Natural Landmarks • National Oceanic and Atmospheric Administration • National Register of Historic Places • Safe Drinking Water Act • Wild and Scenic Rivers Act	• Privately owned mitigation banks • Private/NGO remediation programs to address permit violations
Incentives	• Management agreements • Notification and education recognition and rewards • Tax incentives; estate management strategies • Technical assistance and local government support	• Best management practices • Smart growth initiatives • Tax benefits	• Agricultural best management practices • Conservation Reserve Enhancement Program (Farm Bill) • Environmental Quality Incentives Program • FEMA Flood Insurance Program • Landowners Incentive Program • Partners for Wildlife • Reforestation Tax Credit, Federal Water Bank Program • Wetlands Reserve Program • Tax benefits	• Conservation and wetlands banking • Environmental trading • Landowner recognition

	Local	State	Federal[1]	Private
Funding	• Developer fees • Environmental impact fees • Environmental mini-bonds • Open space protection bonds • Special assessment fees • Transfer tax	• Transfer tax • Transportation equity funds • Transportation enhancement funds	• Clean Air Act • Clean Water Act • Cooperative Endangered Species Fund • Environmental Quality Incentives • Farmland Protection and Policy Act • Landowners Incentive Program • Migratory Bird Conservation Fund • North American Wetlands Conservation Act • Partners for Wildlife • State revolving fund • Transportation Equity Act (TEA-21)	• The Conservation Fund • The Nature Conservancy • The Trust for Public Land • Local, regional and statewide land trusts

[1] For a summary of federal conservation initiatives, go to www.biodiversitypartners.org/incentives/programfed.shtml.

can be made at fair market value, at assessed value, or at a reduced rate. Landowners may accrue tax benefits for bargain sales or land donations.

Fee-Simple Acquisition

Purchasing high-priority conservation land may be the fastest way to ensure its immediate protection and long-term preservation. Governments often acquire land in green infrastructure networks, using bonds or other capital financing mechanisms. Land may also be purchased by a local land trust or a national conservation organization such as The Conservation Fund, The Nature Conservancy, or the Trust for Public Land. Acquisition can include outright purchase (known as *fee-simple acquisition*) or the acquisition of undivided interests, which involves the purchase of a percentage ownership in a property and allows for a legal interest in its management.

Some land acquisition programs are funded through earmarked taxes or fees. In Monroe County, Florida, for example, a tourist impact tax of 1 percent on hotel and motel rooms is used to finance land acquisition. (The county is the gateway to the Florida Keys and home to four national wildlife refuges.) Half of the revenue goes to the county general fund as compensation for the loss of property-tax revenue from publicly owned land. The other half supports the Monroe County Land Authority, a local agency that has bought over one thousand acres of wetlands, wildlife habitat, recreation areas, and sites for affordable housing.

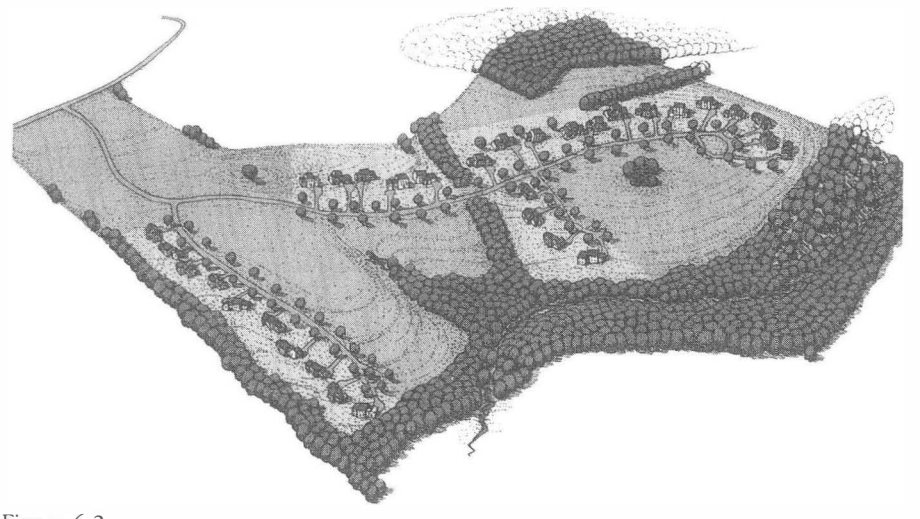
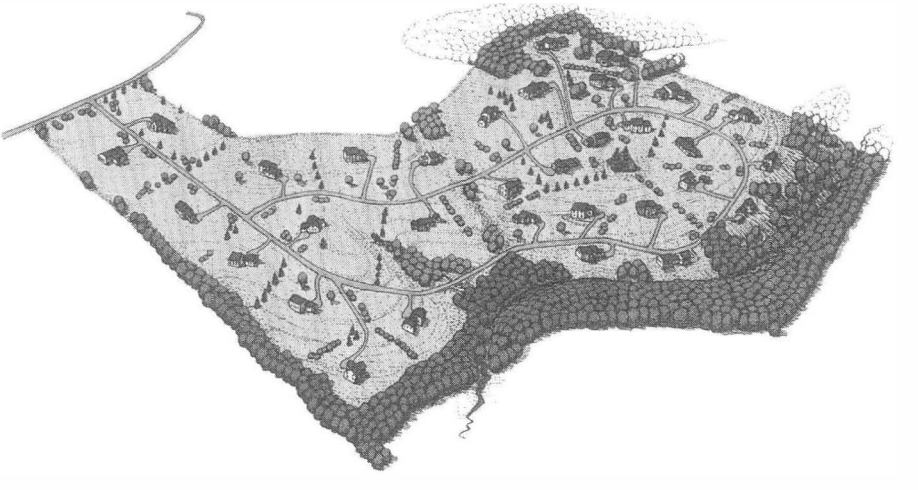


Figure 6.2
Cluster development *(above)* versus traditional development *(below)*, from Randall Arendt's landmark book *Rural by Design*. Credit: Randall Arendt.



vegetated buffers to moderate peak flows and neutralize excess nutrients and contaminants. Buffer ordinances can be used to protect the linkages in a green infrastructure network.

Subdivision ordinances, which set standards for the division of larger parcels into smaller ones and specify the location of streets, utilities, other improvements, and open space, can also be used to encourage the protection of green infrastructure components. The lands set aside as a result of the subdivision process can provide valuable green infrastructure links at local scales.

Although they are not truly a regulatory tool, a local government's comprehensive plan can also be used as a green infrastructure tool. The comprehensive plan (also sometimes called a master plan, development plan, or general plan) is characterized by emphasis on physical development, a long span of time, and comprehensiveness,

was marketed as an opportunity for citizens "to discuss protection of open space in Fluvanna as a way of preserving our rural character in the context of change." The resulting Open Space Plan was formally adopted by the Fluvanna County Board of Supervisors as a component of the county's comprehensive land-use plan. The county also undertook the revision of its zoning ordinances and subdivision codes, in part to implement actions recommended in the Open Space Plan.[2]

Green infrastructure visioning is not that different from other community visioning efforts. In fact, protecting green space and preserving community character are often priorities that come out of community visioning workshops, fueling the drive for green infrastructure. For example, in 1995, the town of Pittsford, New York, a suburb of Rochester, embarked on a visioning process aimed at building consensus on the issues of concern to the community, including the town's character. The process confirmed a shared understanding among Pittsford residents that "the working agricultural and natural landscape is a living testament to the history, scenic beauty, and natural resource wealth of the community." Citizens agreed that these resources were part of the essential character of Pittsford. They also agreed

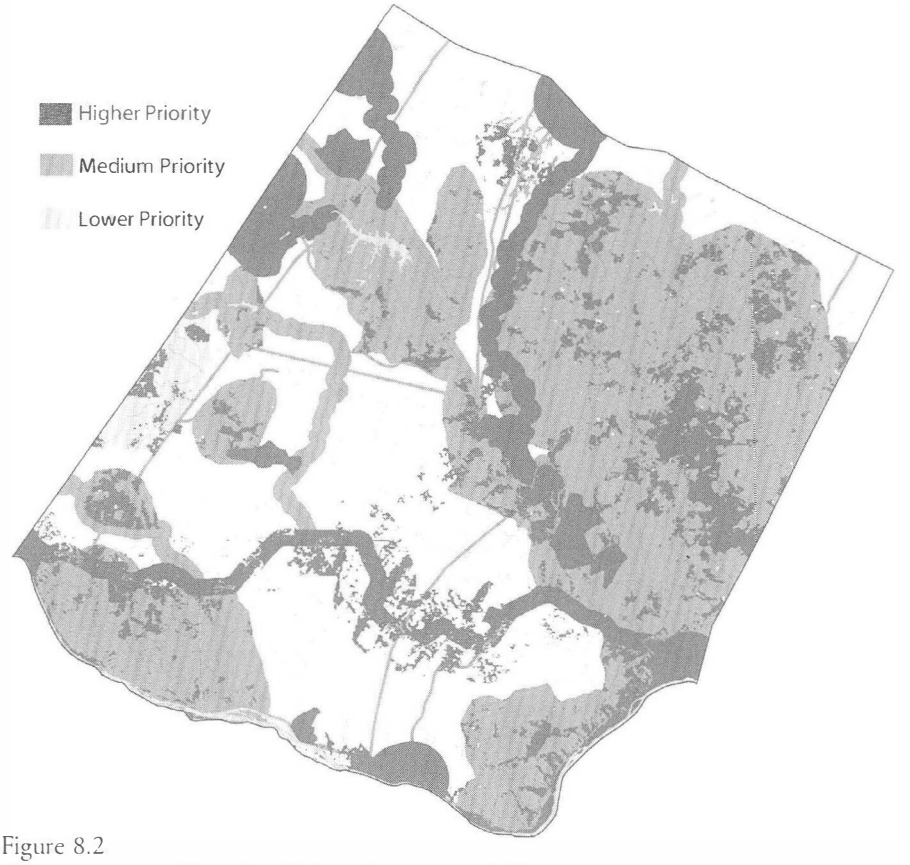


Figure 8.2
Open space priorities identified during the third Fluvanna Heritage Forum (Virginia). Credit: The Fluvanna Heritage Forum 2002.

LAND USE / PLANNING

Green Infrastructure

Linking Landscapes and Communities

"The protection of land is an expression of faith in the future: it is a pact between generations. *Green Infrastructure* is a groundbreaking publication that introduces a balanced, strategic, and comprehensive approach to conservation."
—from the foreword by Charles Jordan, chairman, and Lawrence Selzer, president, The Conservation Fund

Those engaged in land conservation and management increasingly have come to envision a process that connects environmental, social, and economic health: *Green Infrastructure*. For the landscape designer, conservation-minded planner, and the concerned citizen, this far-reaching work presents principles and practices to create conceptual and real links in communities across the country.

With illustrative and detailed examples, *Green Infrastructure* advances smart conservation: large-scale thinking and integrated action to plan, protect, and manage our natural and restored lands. Providing both the historical framework for the importance of greenways and green space networks and practical advice on how to design and implement them, Benedict and McMahon's book is a valuable resource for anyone who wants to understand innovative approaches to conservation-minded land use. From the individual parcel to the multi-state region, *Green Infrastructure* helps us look at the landscape in relation to the many uses it could serve, for nature and people, and determine which uses achieve the most benefits for both.

ADVANCE PRAISE FOR *Green Infrastructure*

"Benedict and McMahon make a compelling case that the long-term health and viability of our communities and countryside depend upon connecting parks, trails, and farmland to create a tapestry of protected land spanning the American landscape."
—Keith Laughlin, president, Rails-to-Trails Conservancy

"*Green Infrastructure* is a remarkable guidebook, brimming with vision, practical step-by-step guidance, and detailed case studies. It will be invaluable to all who seek to conserve significant networks of open lands and to build truly livable communities."
—Jean Hocker, president emeritus of the Land Trust Alliance and president, Conservation Service Company, LLC

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The Conservation Fund is located in Arlington, Virginia.

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