The Green Infrastructure Guide

Planning for a Healthy Urban and Community Forest

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Prepared for The Regional Planning Partnership by

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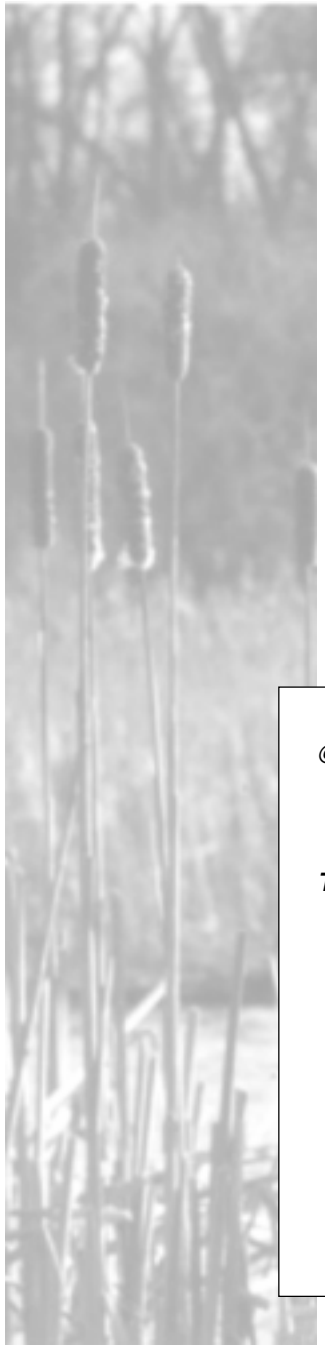

The Regional Planning Partnership

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The Regional Planning Partnership is a nonprofit, non-partisan planning organization committed to sound land use planning and regional cooperation in central New Jersey. The Planning Partnership was founded as Middlesex-Somerset-Mercer Regional Council in 1968 as a "watchdog" of the region. With over thirty years experience, the Planning Partnership has become the independent voice for sensible development in central New Jersey. Its programs and activities are supported by membership contributions form private citizens, area corporations and businesses, governmental bodies, and civic organizations. In addition, it receives funding for special projects from foundations and government contracts.

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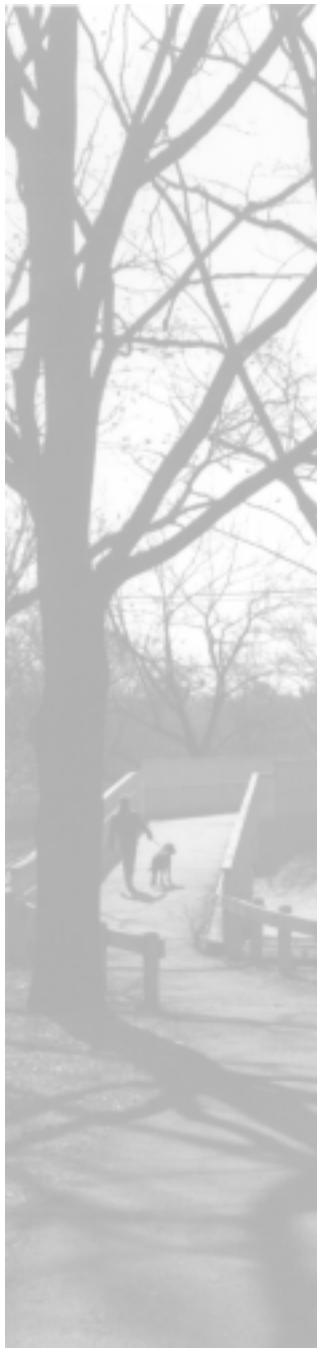


Introduction

A city or town can be viewed as an urban and community forest ecosystem – a place where the natural and built environments, the "green" and the "gray" infrastructures, are intertwined as an interdependent system supporting life within our neighborhoods. The plant communities, water systems, and open spaces within this ecosystem play an important role in determining the health of the urban and community forest. If local governments and the general public realize the environmental, economic, and social values of green infrastructure, then they will view the trees, vegetation, and open space as a vital part of their community's infrastructure.

This handbook builds the case for the value of green infrastructure and provides suggestions about how to integrate green infrastructure planning with planning for development.

Most municipal master plans embrace conservation and natural resource protection goals. Unfortunately, however, municipal zoning requirements for set-backs, density, and other bulk considerations often run counter to these goals and actually foster contradictory results. Most current development practices continue to fuel an environmental deficit by replacing trees, natural systems, and open spaces with buildings and impervious surfaces.

Similarly, many municipalities have adopted the use of advisory commissions (e.g., environmental commissions, shade tree commissions, and historic preservation boards) to assist in planning and zoning board decision-making. Their activities, however, remain largely separate and independent of one another, and they have minimal opportunity for valuable interaction.

However, planners across the nation are beginning to understand that smart growth is key to striking a sustainable balance between development and conservation. This handbook builds the case for the value of green infrastructure and provides suggestions about how to integrate green infrastructure planning with planning for development.

The application of the green infrastructure concept to growth and development can happen only when people understand and appreciate the value of their ecosystems and are determined to integrate them into their local and regional planning processes. The authors hope that this book advances the understanding of green infrastructure, provides tools to balance growth and preservation of natural systems, and begins to bridge the gap between planning and other professions.

The application of the green infrastructure concept to growth and development can happen only when people understand and appreciate the value of their ecosystems and are determined to integrate them into their local and regional planning processes.

Chapter 1

Green Infrastructure for Sustainable Development

Infrastructure is the foundation on which communities and regions are built. There are two important infrastructure elements: gray infrastructure (the built environment) and green infrastructure (the natural environment). Together with living things, they can be considered an ***ecosystem****, in which each element is dependent on the others. Ensuring that both types of infrastructure are functioning properly is key to* ***sustainability****. The two types of infrastructure play a vital role in maintaining the quality of community life.*

1.1 What is Green Infrastructure?

Planners have recently begun to refer to the natural and built environments as "gray" and "green" infrastructure. ***Gray infrastructure*** *includes man-made facilities such as roads, sewers, utilities, and buildings.* ***Green infrastructure*** *refers to natural resources such as trees, streams, wetlands and open space. Green infrastructure is not limited to rural landscapes, but also includes street trees, parks, waterfronts, lawns, landscaped buffers, and other "natural" features of urban and suburban landscapes.*

Recently, planners coined the term "green infrastructure" to emphasize that open space and natural systems are as important to us as roads, sewage treatment plants, and buildings.

Nature's infrastructure

Infrastructure refers to the systems that are needed to support a community. We usually think of infrastructure as the pipes, pumps, cables, wires, rails, and asphalt that support our lives. We know that without these things, our economy, and most of the amenities and services associated with our standard of living, would be impossible to support. Recently, planners coined the term "green infrastructure" to emphasize that open space and natural systems are equally important to us. Although we are aware that the other creatures on this planet are dependent on the quality of the water, air, soil and vegetation which make up the natural landscape, we must be reminded that it is equally important to our own economy, standard of living, and overall quality of life.

For instance, **wetlands** improve water quality by helping to cleanse pollutants from our drinking water supply. They help to control **stormwater runoff** and flooding, as well as provide habitat for many species of animals and plants. Trees also reduce runoff and provide habitat, and their shade mitigates the **urban heat island effect** in built-up areas. Trees also improve air quality by absorbing carbon dioxide and other pollutants. According to some studies, tree-lined streets are connected with

We usually think of infrastructure as the pipes, pumps, cables, wires, rails, and asphalt that support our lives.

Green infrastructure is a relatively new term coined to describe natural resources such as trees, streams, wetlands, and open space.

Wetlands filter pollutants and mitigate fluctuations of flow.

lower crime rates. Other studies connect hospital rooms overlooking trees to quickened patient recovery times. Trees and other vegetation reduce noise pollution by absorbing sounds. Vegetation protects our streams and ground water by stabilizing soils and filtering pollutants before they enter our water supply. **Open space** provides habitat for plants and animals and recreational opportunities for people. Open space and vegetation help to mitigate flooding by absorbing runoff. Larger areas provide refuge from noise levels associated with developed areas. Tree-lined streets, open space, and recreational amenities enhance community quality of life and thereby increase property values. These are only a few of the multiple benefits provided by green infrastructure.

The value of green infrastructure

Most of us understand the important role that gray infrastructure plays in the quality of our lives. With few exceptions, we support the enormous investments required to provide us with houses, schools, hospitals, wells, sewer plants, roads, and highways. These investments in gray infrastructure are promoted and protected by powerful institutions, such as school boards, highway departments, and sewer authorities, as well as other layers of government.

The value of green infrastructure, however, has often been overlooked. Consequently, investments in green infrastructure have suffered accordingly. No agencies or authorities equal in power to those overseeing gray infrastructure currently exist, despite most places' deriving some, if not most, of their value and character from green infrastructure — a river, a canopy of trees, or adjacent beaches, mountains, forests or farmland. As these resources degrade or improve, so do the value of the city or town and all of the individual properties within it.

Although people may readily see the aesthetic reasons for preserving open space and natural resources, they may never think about the more pragmatic reasons for doing so. Thinking only of the pleasure they give us, we overlook how essential trees and rivers are to the quality of the air we breathe and the water we drink and ignore the monetary value they add to our property. Aesthetics are usually not afforded high priority in any investment plan, and because decision-makers have failed to make the very real connections between our standard of living and the economy, investments in green infrastructure have suffered.

1.2 The Interrelationship of Green and Gray Infrastructure

Historically, much of our gray infrastructure has been designed to replace green infrastructure, and in many cases it has damaged green infrastructure. Though gray infrastructure is essential, we can reduce its impact on green infrastructure. Green and gray infrastructure work in concert, and thinking of them as components of a single system will improve ecology and the quality of life.

Thinking about green infrastructure will change the way we protect resources from being lost or polluted, and it will change the way in which we construct gray infrastructure.

How "natural" is green?

Green infrastructure includes the natural resources that exist within a community — its open land, rivers and streams, trees and vegetation. These natural systems accomplish important community functions. It is important to note, however, that green infrastructure does not necessarily imply that these natural resources should be untouched or valued only in their "natural" state. In fact, few parts of "natural" systems will continue to be healthy without careful planning, management, and maintenance.

Meadows and forests provide habitat for plants and wildlife as well as recreational opportunities like hiking and bird watching.

On the contrary, in many ways we have created our "natural environment." Many cities are built around rivers or bays whose banks, volume, and even direction of flow have been vastly altered. Virtually all urban areas include parks which are entirely landscaped or even completely paved except for tree wells or garden beds. We can, and do, use trees and vegetation for our own purposes — to shade and buffer, to bolster or reconstruct a stream to reduce pollutants or flooding or both.

Greening the gray infrastructure

Thinking about natural resources as infrastructure — the systems that support communities — will help us to appreciate their multiple functions which benefit the entire ecosystem (people, plants, animals, and other systems). Thinking about green infrastructure will change the way we protect resources from being lost or polluted, and it will change the way in which we construct gray infrastructure. In addition, once we begin to think of natural systems as infrastructure, we can begin to think about how natural systems can replace gray infrastructure. For example, a "natural" wetland and the surrounding areas can be engineered to perform to specifications for flood control. A stream long ago confined to a pipe can be **daylighted** to perform

Inter-relationship of Green and Gray

more functions — environmental, recreational, or aesthetic — for the community.

Some of the gray infrastructure is built to perform the functions of green infrastructure. For instance, when a building is constructed, we require provisions for storm drainage — either an on-site detention basin or access to a storm drain system (gray infrastructure). These are engineered to perform one function — flood control. Before the building was constructed, flood control had been performed by nature (green infrastructure) — with the soil absorbing the rain, perhaps with nearby streams collecting the runoff. As we pave over the soil with **impervious** surfaces, we increase the amount of water that simply runs off the property. If we did not provide a man-made stormwater collection system, it is likely that flooding would result. As we add more and more impervious surfaces, runoff increases; without careful planning, current man-made solutions are often ineffective in protecting areas from flooding and water pollution.

There is a growing awareness that engineered solutions can and should be designed to achieve more than one function. For example, on-site drainage can be designed and landscaped to mimic a more natural system and therefore fulfill more than one goal. A "natural" wetland and the surrounding areas can be engineered to perform to specifications for flood control. Urban streams that have been channeled underground can be daylighted. Engineered solutions can be designed to provide the habitat, filtration, and/or recreation opportunities that had been performed by the soil, vegetation, and streams. They can also be designed to connect to other natural systems, rather than to increase their fragmentation, as development takes place. As these "gray" systems become more multifunctional, they become more "green."

Lawns are a monoculture and can contribute as much stormwater runoff and pollution as a parking lot.

Greening the green infrastructure

In the past, green infrastructure has been undervalued because private, underdeveloped, open land was commonplace and taken for granted. In recent years, however, the public and elected officials have begun to place a greater emphasis on preserving open space, farmland, and other green resources. While preservation is an important and valuable tool for protecting natural resources, those resources must also be maintained. As with gray infrastructure, some undeveloped land may need to be "redesigned" or restored to perform its natural functions better. For example, lawns are a **monoculture** and can contribute nearly as much stormwater runoff and pollution as a parking lot. Allowing lawns or portions of a lawn to return to meadows and forests will reduce dependence on fertilizers and pesticides, increase diversity, and reduce stormwater runoff. Trees, especially in urban and suburban areas, need maintenance. They are susceptible to disease and vandalism and can become a liability. Runoff from development can fill streams with silt and destroy native species.

1.3 Levels of Green Infrastructure

We can protect and enhance green infrastructure on many scales: global, national, regional, local, and site. Our water resources and animal habitat are almost always regional, crossing municipal, county, and even state lines. Small streams and urban forests may be local, under the control of a single jurisdiction. Incorporating green infrastructure principles in the design of an individual site yields benefits not only for the site but also for the broader locality and region. But controls over each level of green infrastructure are scattered across three layers of government: national, state, and local.

The existing governmental framework has three basic layers — national, state, and local.

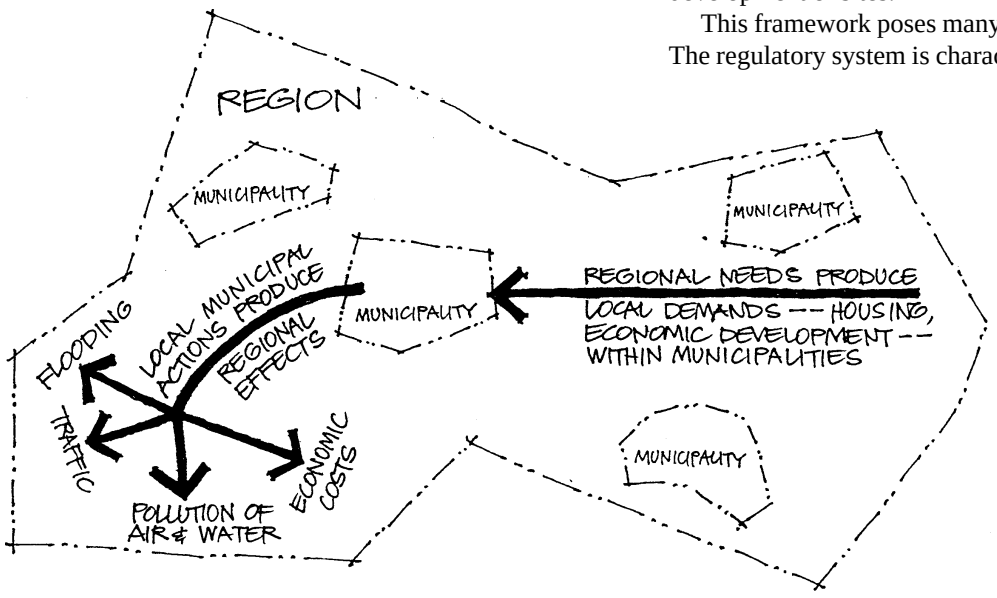
The tangled institutional framework

The existing governmental framework has three basic layers. At the national level, this framework includes federal policies and investments, such as state aid, transportation investments, the uses of military bases, the location of post offices, federal parks, protected lands, etc. It also includes the whole structure of federal laws and regulations, including tax law, the Clean Air Act Amendments, Clean Water Act, Endangered Species Act, etc.

At the state level, a similar structure of policies, investments, laws, and regulations exists. In addition, myriad authorities, commissions, and agencies have planning, regulatory, and investment responsibilities and authority which influence development.

Finally, the local level has the bulk of authority over development. Local **master plans**, **zoning** and other regulations — shaped by federal and state laws and regulations — govern the development of sites.

This framework poses many problems for green infrastructure. The regulatory system is characterized by fragmentation of



governing authority and a disconnect between the various agencies' cultures, time frames, and missions.

Local land use controls are on too small a scale to protect the region's water, air, and land resources that make up the urban and community forest ecosystem. In addition, most local master plans and zoning ordinances governing the growing municipalities in this country damage or destroy local green infrastructure because they are based on a sprawling pattern of development which alters virtually every acre of land. This alteration occurs even though most local master plans have goals and policies that express the desire to protect natural resources and avoid sprawl. Much of the suburban landscape today demonstrates that the laws, regulations, and practices that are in place to implement the plans do not accomplish these goals.

In the past, land-use patterns evolved with the dominant mode of transportation. As new technology was introduced, land use changed to reflect it. With the introduction of zoning and other land use laws and regulations, however, land use became less responsive to societal needs, being guided increasingly by the blind dictates of regulations, which in most places allow only auto-based development. Without changing the laws, regulations, policies, and practices that govern development, we will continue to spread out onto every available acre, polluting every stream with vehicle runoff and smothering diverse ecosystems.

To reduce and mitigate the impacts of development, we need to integrate local plans into regional, state, and multi-state plans.

Improving the framework by nesting plans and decisions

To reduce and mitigate the impacts of development, we need to integrate local plans into regional, state, and multi-state plans. These plans must then be implemented through zoning, regulations, and investments that are consistent with these plans.

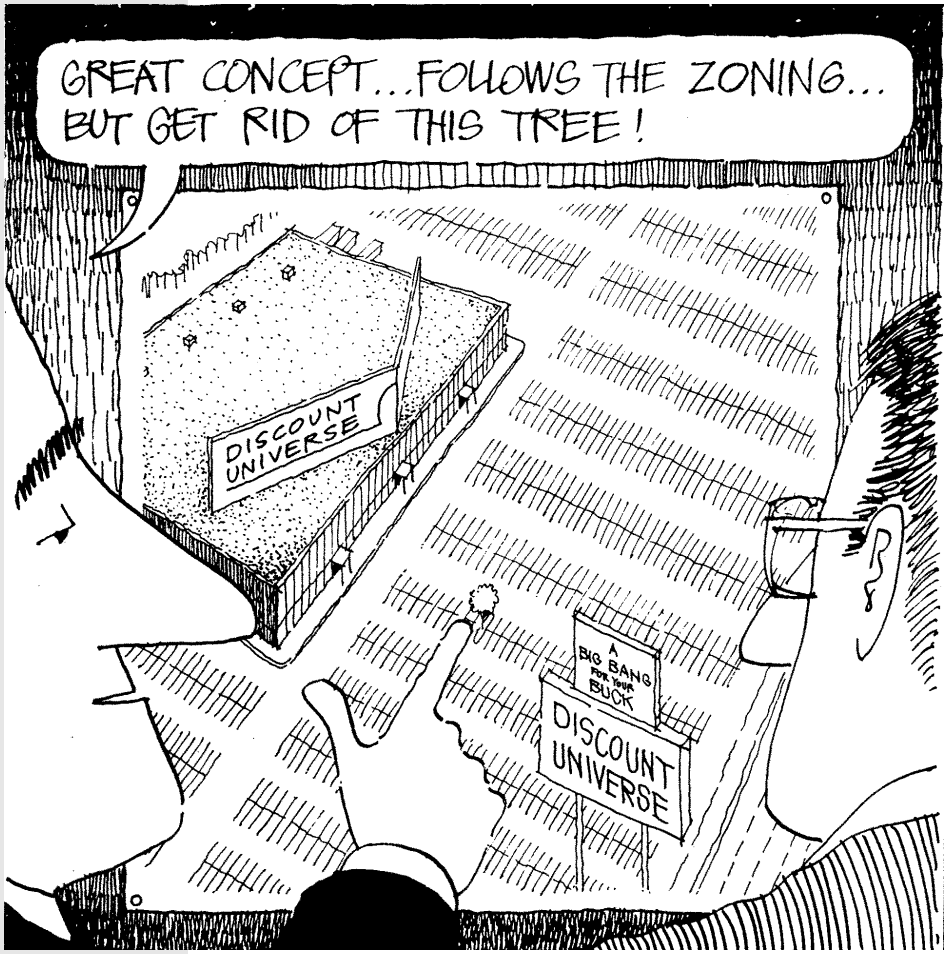
A useful concept toward reducing fragmentation is "nesting" plans. Nesting means to coordinate the plans, regulations, and investments of all levels of governmental decisions toward the same goals and outcomes. Adherence to a common plan based on the same **facts** and **choices** — one that states **goals**, **targets**, and **tools** for all levels of government — is one way to accomplish this.

Simply stating that we're for preserving open space, protecting streams, planting trees, and revitalizing cities won't get us anywhere. To really change development patterns to protect green infrastructure, we must become specific about the outcomes we want, and therefore how much growth we want, where we want it, and what are we going to do to make it happen that way. We must ask for more facts, consider more impacts, strive for multiple goals. We must reform the institutional framework to make the incentives built into the system ones that encourage Smart Growth. We must involve more people in decision-making and perhaps change the way they think about issues they feel strongly about. In other words, change is about being smart, not easy.

In the next section we discuss further how the planning process can be used to protect and enhance green infrastructure in urban, suburban, and rural environments. We also show how one state is attempting to nest its plans, regulations, and investments through reliance on a guiding statewide plan.

1.4 Planning for Green Infrastructure

Development — constructing buildings and paving over soil — has a direct and obvious impact on the vegetation and open land replaced. In addition, without sound planning, development on open land is also likely to exacerbate traffic congestion, urban disinvestment, and the cost of new facilities and services needed to support it. Redevelopment of cities and older suburbs, and the re-use of abandoned sites can avoid these problems, as well as offer opportunities for "re-greening" urban areas.



New development and green infrastructure

It is clear to most people that development requires gray infrastructure. Health and safety laws require a new development to have wastewater treatment. Green infrastructure, however, is often not recognized as equally essential, even though the consequences of losing green infrastructure can sometimes be felt instantaneously. Flooding may appear, for example, as soon as a parking lot is paved. Other times, it may take years to feel the impact. The number of migrating songbirds has only recently been recognized as having been significantly reduced as their habitat has disappeared over time. Once green infrastructure is lost, it may never be replaced. Even if restoration were possible, it may be too expensive and difficult to undertake.

The negative effects of growth can, and should, be addressed by goal-driven plans integrated at the local, regional, and state levels. Sustainable development encompasses all three elements of the community's ecosystem — human, gray, and green infrastructure.

Planning for the right development in the right place

If development takes place within the context of sound planning, it has many direct benefits to human beings by providing housing and job opportunities, as well as services and amenities. By planning for the right amount of development, in the right locations, at the right time, communities can also reduce the costs of infrastructure — both the costs of providing "gray" infrastructure, such as sewers and roads, and the costs of replacing "green" infrastructure to protect water and air quality, the habitats of other species, and the community from noise, flooding and

energy costs. Protecting and enhancing green infrastructure as development and redevelopment takes place — just as water and sewers are required — prevents these costs and provides many economic, environmental, and quality of life benefits to the community.

Most master plans contain lofty goals to "protect natural resources," "reduce impervious surfaces," and "preserve open space." It seems, however, that green infrastructure almost never really is protected in the planning and development process. Zoning requirements for drainage, parking, and height standards must be met first. Developers must often bulldoze a site just to meet these requirements. Protecting trees or other natural features on the site is last on the list.

Most master plans contain lofty goals to "protect natural resources," "reduce impervious surfaces," and "preserve open space." However, green infrastructure almost never really is protected in the planning and development process because there is a mismatch between master plans and zoning ordinances.

Planning for different amounts of green infrastructure

Obviously, different places need different approaches to perform the functions necessary to support the community ecosystem. Urban places have far more dependence on gray infrastructure than rural places, but all places will benefit from becoming more "green."

Because development alters how natural systems function, different amounts and types of green infrastructure will be found in different communities. For example, in rural areas green infrastructure is the dominant feature and performs its functions efficiently with proper stewardship. Because of the larger amount of impervious surfaces (paving and buildings), urban areas require more gray infrastructure to manage such things as sewage treatment and stormwater runoff. Restoration and maintenance programs are also required. In developing areas, sound land use planning and management will determine the amount and type of green infrastructure appropriate for that particular development pattern.

Frequent floods prompted costly and ecologically damaging mitigation for this stream to protect the nearby houses. A green infrastructure plan would have ensured that the stream was protected in a natural state for its entire length, thereby preventing erosion and flooding. Planning also would have ensured that the homes were built far enough from the stream to avoid naturally occurring floods.

The New Jersey State Plan

The New Jersey *State Development and Redevelopment Plan* divided the state into five planning areas based on land use patterns and established a hierarchy of five types of centers within the planning areas. This system of planning areas and centers provides state, county, and local governments with a framework to begin to determine the amounts and types of green infrastructure appropriate in different types of places.

The graphic at right depicts how each planning area and center has a combination of green and gray infrastructure. For example, the environmentally sensitive areas (Planning Area 5) includes some gray infrastructure, such as roads and utilities, as well as buildings and possibly sidewalks in the small hamlets and villages. Likewise, metropolitan areas (Planning Area 1) have green infrastructure, such as tree-lined streets, neighborhood parks, regional parks, streams, canals, and rivers. Planning Areas 2, 3, and 4 represent fringe, suburban, and rural land use with a corresponding mix of green and gray infrastructure.

The State Plan calls for the designation of planning areas and the regulations that affect them to be determined as part of a collaborative process by state and local governments. In addition, state agencies are to use the state plan as the basis for their investment decisions. The Office of State Planning works with and monitors agencies and local governments to promote further integration and coordination.

Types of Green & Gray Infrastructure
by Planning Area and Land Use Context

More "Green"

GREEN INFRASTRUCTURE

PA 5 Environmentally Sensitive	PA 4 Rural	PA 3 Fringe	PA 2 Suburban	PA 1 Urban
Protected Habitats	Wetlands	Upland Forests	Street Trees	Street Trees
Wetlands	Forests	Rivers	Rivers	Rivers
Forests	Rivers	Streams	Streams	City Parks
Rivers	Streams	Lakes	Corporate Meadows	Community Gardens
Lakes	Lakes	Meadows	Private Gardens	Bike Paths
Meadows	Agricultural Soils		Open Space Set Aside	
Steep Slopes	Hedge Rows		Bike Paths	
Coastal Areas				
Trout Bearing Streams				
Aquifer Recharge Areas				
Sensitive Soil Conditions				

GRAY INFRASTRUCTURE

PA 5 Environmentally Sensitive	PA 4 Rural	PA 3 Fringe	PA 2 Suburban	PA 1 Urban
Limited Roads	Limited Roads	Limited Roads	Collector & Arterial Roads	Major Multi-modal Roads
Utilities	Utilities	Utilities	Utilities	Utilities
Septic Systems	Septic Systems	Septic Systems	Community Scaled Wastewater Treatment	Septic Systems
		Community Scaled Wastewater Treatment	Regional Sewage Treatment	Sewage Treatment
			Stormwater Pipes	Stormwater Pipes
			Culverts	Culverts
			Curbs & Gutters	Curbs & Gutters
			Sidewalks	Sidewalks
			Sound Barriers	Subway Systems
			Light Rail Transport	Heavy Rail Transport

More "Gray"

Although there are more possibilities of each kind of infrastructure within each planning area specified, this graphic provides an indication of the level of infrastructure appropriate for the overall character and scale of the area.

Because transportation was slow, early American cities and towns were crowded near waterways — which made them lively, but often unhealthful for residents and damaging to the immediate environment.

1.5 Settlement Patterns, Transportation, and Green Infrastructure

In every period in history, the settlement patterns of human habitat have changed to reflect the style and technology of the day. Most recently, development associated with the automobile has led to what has been described as "sprawl" — low density, single use development, with each building having its own parking and separate driveway. Sprawl has a major impact on green infrastructure because it converts land to human habitat at a rapid rate and leads to pollution that is very difficult to control or mitigate.

For centuries, humans have relied on green infrastructure at the same time as their settlements have defiled it. In America, early compact cities radically altered local ecosystems as water bodies were appropriated for human use. Meanwhile, farming and logging depleted forest resources. Today's land-consumptive development patterns continue to threaten our nation's ecosystems.

Early settlement patterns were compact and mixed use, often located by rivers.

Early developments located near water

When Europeans settled the American continent, they created what modern planners would describe as compact, mixed-use centers. These centers were cities, towns, villages, and hamlets surrounded by farmland and open areas. Buildings in these centers were close together, reflecting the need for security as well as the dominant mode of transportation — walking.

Looking for the pattern of these settlements, we find most of them by water. Waterfronts were chosen not only for sources of drinking water, but also because travel between places was often by boat. The population of these original settlements grew enormously with each wave of immigration.

Throughout the nineteenth century, America's growing wealth was applied to the construction of infrastructure systems that expanded the number of people that could be supported in one location, as well as opened up new locations for development. Expansion of these historic cities and towns was very hard on the water systems on which they had been located. The bays, rivers, and streams were polluted; flooding along coasts and rivers

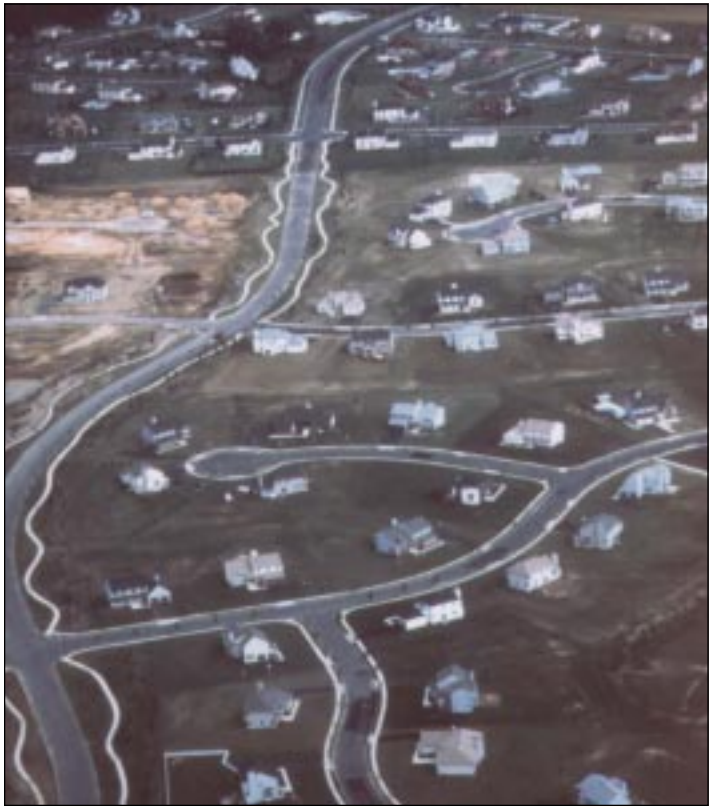
As the distances between buildings increased, the farmland and open spaces between towns and cities — and the habitats these natural places supported — disappeared.

became an increasing problem for people as development encroached upon, and sometimes eliminated, dunes and river banks.

In fact, the densities and pollution levels of cities, resulting in high levels of cholera and tuberculosis, led to the system of zoning and city planning that we know today. However, today's new spread-out landscape, which has been the result of these reforms, may be more damaging to ecosystems than any land use pattern in history.

Sprawl: A large-scale threat to green infrastructure

During the first part of the twentieth century, the extension of train lines, water and sewer pipes, electricity, and trolley lines led to the growth of new settlements farther from established cities and towns. Security, water supply, and proximity to markets no longer dictated development patterns. With the advancement of technology and continued growing wealth, the terrain was altered to suit development. Wetlands were filled, hills leveled, water piped in, and trees felled to make way for roads, houses, and industry.



The large lots and dispersed urban form associated with sprawl have consumed rural land at an unprecedented rate since World War II.

During the second part of the twentieth century, new development changed the landscape even more dramatically. Community layout was no longer dictated by walking, but rather by driving. The distances between buildings increased, making walking impossible in many places. Trolleys, trains, and even buses became difficult to support financially because development was too spread out to serve efficiently. As the distances between buildings increased, the farmland and open spaces between towns and cities — and the habitats these natural places supported — disappeared.

As automobile and home ownership became affordable to more people, suburbanization increased. Today, America's cities, which used to hold the majority of the population, now hold an ever-shrinking minority. Although many people thrive in an urban environment, many others are in cities because they cannot afford a car or single family home elsewhere.

In the rest of the country's communities, where most Americans now live, it is virtually impossible to walk or use public transport. The automobile has become the only viable mode of transportation. There are more vehicles per household than licensed drivers, and the number of vehicle miles traveled (a measurement of auto use) continues to increase exponentially.

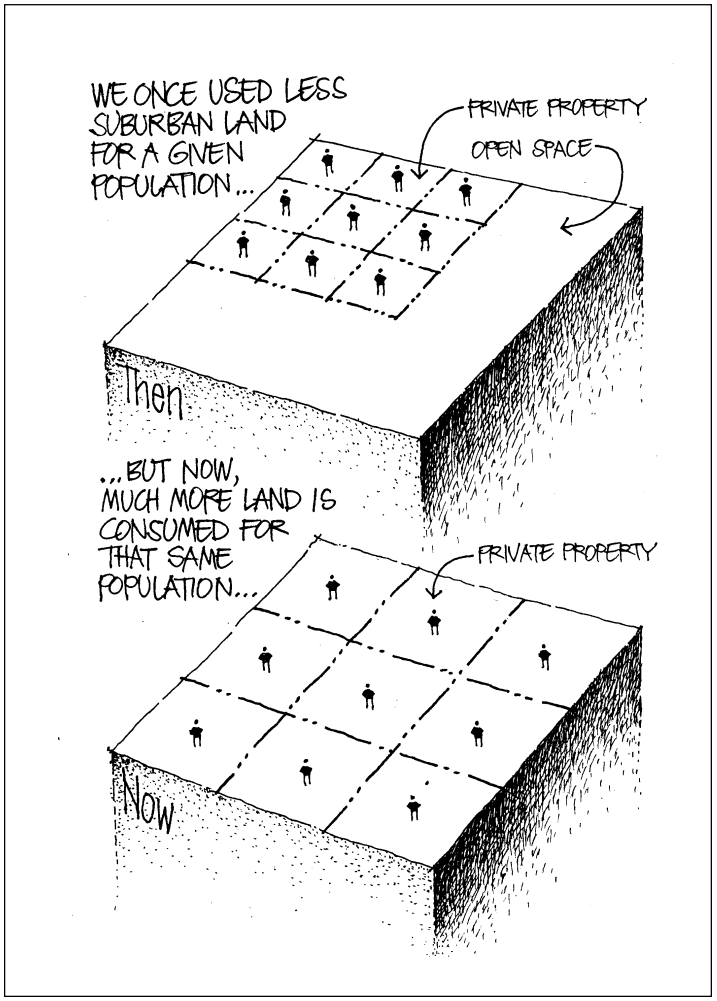
The recent introduction of telecommunications systems has further liberated the location of workers from the workplace and consumers from the market place. This may encourage even more development in remote areas — many of which have particularly fragile environmental resources. Although advancements in telecommunications may reduce the number of autos on the road at rush hour, they are increasing the number of autos on the road during the rest of the day and increasing travel in general. Although more people may be able to work and shop at home, it appears that travel in general — including travel by automobile — is on the increase in spite of telecommunications improvements.

For green infrastructure, the implications of the trend toward higher auto use are stark. As more vehicles fill the roads, more polluted runoff drains into creeks and streams. As roads are widened to accommodate additional traffic, trees are lost, and new areas outside existing cities and towns are opened to additional development.

1.6 Sprawl and the Environment

Why do we worry about auto-dependent land use patterns? As houses, shopping centers, and office parks march over the countryside, regional systems — water, forests and habitats — are damaged. Entire species of plants and animals have become extinct. What is not yet known is how much of that damage can be repaired by changing the direction of future growth.

Many of our original suburbs were laid out in a way that encouraged walking and public transportation, and in compact enough patterns to offer the nearby open land some protection from development.



Suburban design practices

In order to understand the problem of 20th century development, we must understand the difference between **suburbs** and **sprawl**. Although the words are often assumed to be interchangeable, they are not.

The pejorative term **sprawl** is used to mean a particular pattern of development — one shaped by zones of single-use buildings at a much lower density than is found in traditional cities and towns. Workplaces, homes, and other components of the city are thus located along highways and can be reached only by car.

Sprawl actually refers to the problems created by the specific design practices and land use regulations governing the creation of modern suburbs that result in the pattern of development described above. Sprawl results in **nonpoint source pollution**, flooding, loss of trees, and destruction of **habitat** over a wide area.

Suburbs do not have to be built that way. Many of our original suburbs — traditional market towns or communities along train and trolley lines — were laid out in a way that encouraged walking and public transportation, and in compact enough patterns to offer the nearby open land some protection from development. They are suburbs in that they are located outside of cities and their densities are lower than cities and higher than rural areas. Whereas cities are dominated by the built environment, and rural areas are dominated by the natural environment, suburbs are balanced between the two.

Reversing sprawl does not, therefore, mean eliminating the suburbs. No, reversing sprawl means revitalizing our existing cities, downtowns, and inner-ring suburban areas, creating new centers for future development, and redeveloping existing

suburban sprawl to be pedestrian and transit-friendly. In the process, we will be able to reserve large tracts of open space, farmland, forested uplands, wetlands, and other natural habitats.

Today's automobile and truck-dependent land patterns consume open land much faster than the population increases. This pattern creates the need for miles of roads and acres of parking lots, which in turn paves over terrain, destroys habitat and creates noise, polluted air, and stormwater runoff as well as urban heat islands and other microclimatic extremes. Cutting back on sprawl means protecting green infrastructure by more redevelopment of existing human habitat and less expansion onto **greenfields**.

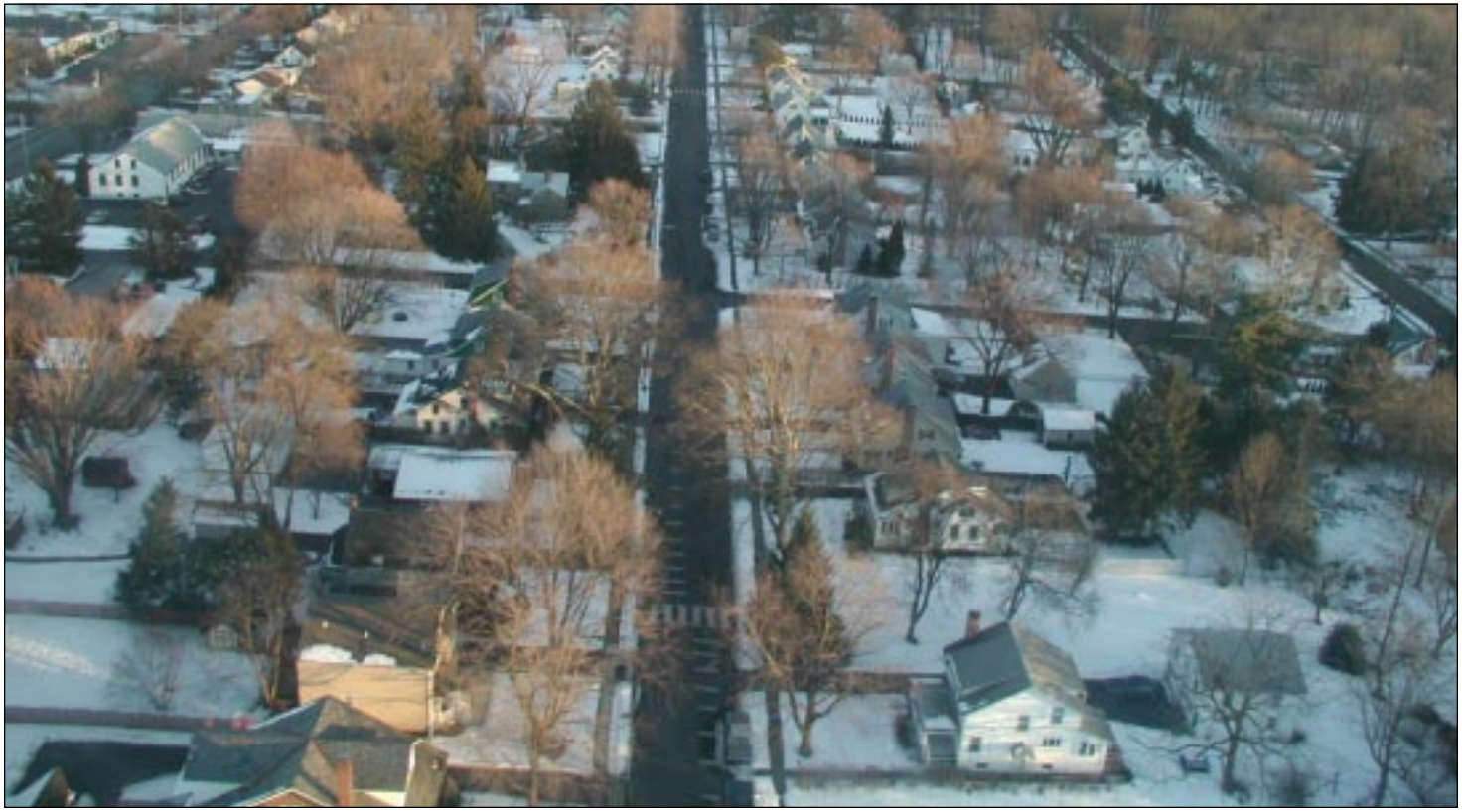
Regional systems vs. local controls

Although the value and function of natural resources are not limited by arbitrary political boundaries, the means to protect them are. The development may be all in one jurisdiction and the impact on the natural system in another. A regional approach to preserving, protecting, and managing natural resources is crucial to ensuring a sustainable future.

In order to reduce the undesirable effects of development and to protect natural resources, local planners must understand the broader systems that support the community. They must know the expected outcomes of their plans and how they fit in with plans at the state and regional level. They must know what impact their plans will have on the larger natural systems that support it.

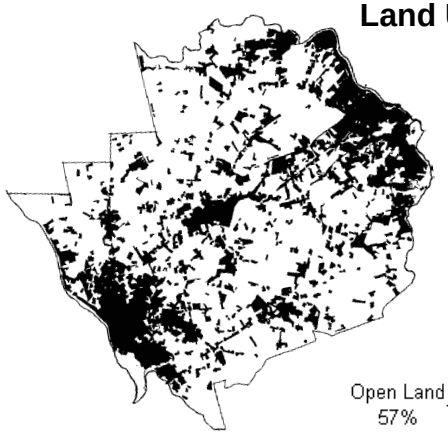
Although sensitive site design can help to mitigate the impacts of specific developments, protecting regional systems and large tracts of land cannot be addressed by site design alone. It is not enough to use pervious paving materials and design landscapes that can be maintained without toxic fertilizers and pesticides and

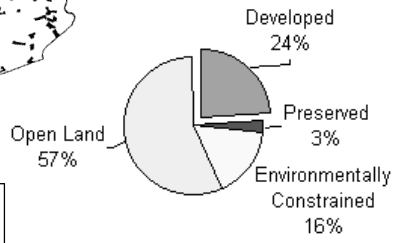
...reversing sprawl means revitalizing our existing cities, downtowns, and inner-ring suburban areas, creating new centers for future development, and redeveloping existing suburban sprawl to be pedestrian and transit-friendly.



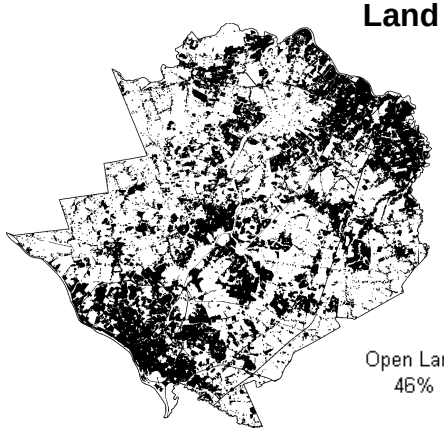
This neighborhood was built on a pedestrian scale and could support public transportation.

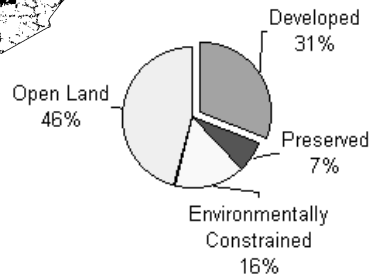
1976
Land Use Patterns





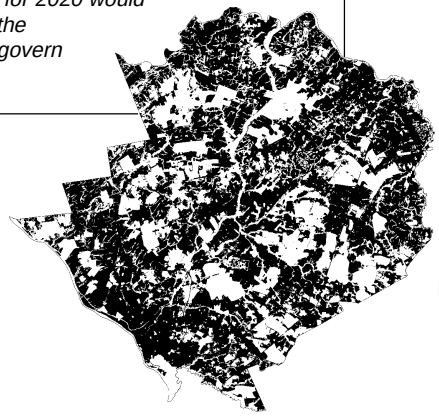
1996
Land Use Patterns

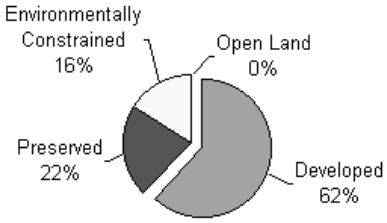




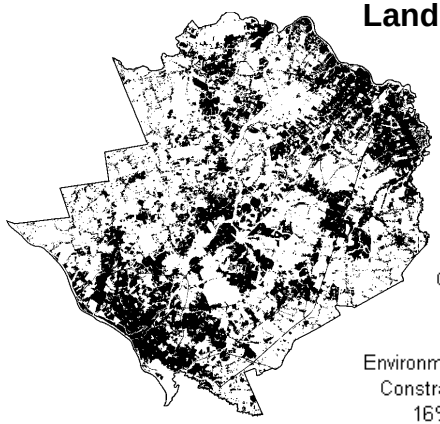
These land cover maps show how sprawl quickly consumed land in central New Jersey between 1976 and 1996. The amount of developed land increased 61% during that time, although the population only grew by 21%. At current rates of land consumption, all the land in the region will be developed by 2020, except permanently preserved and environmentally constrained land. Saving more land with an alternative land use pattern for 2020 would mean changing the regulations that govern development.

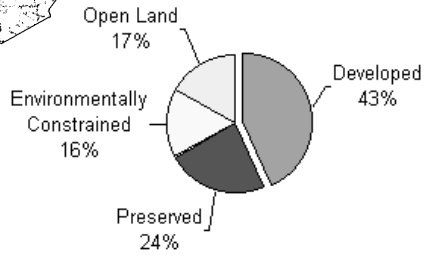
2020 Trend
Land Use Patterns





2020 Alternative
Land Use Patterns





Cutting back on sprawl means protecting green infrastructure by more redevelopment of existing human habitat and less expansion onto greenfields.

that can provide habitat as well as natural resource protection. Regional systems must be protected through a regional approach to land development.

Streams, rivers, and many animal habitats pass through many townships, counties, and even states. Increased runoff in one community will certainly have an impact on down-stream communities. A reduction in bear habitat in one community could have multiple consequences: displaced bears will invade other jurisdictions, and the total population may eventually be depleted. Local green infrastructure helps form regional systems.

Other natural resources such as open space, trees, and forests may be less obvious but are also part of an interdependent regional network. For example, Stuttgart, Germany is subject to frequent inversions, but the surrounding forested hillsides outside the city provide cool, clean air. On an international level, the quality and quantity of rain forests have proven to directly correlate to weather fluctuations in other parts of the world.

This rural area is being encroached upon by low density residential development.

Cumulative impact of decisions

The cumulative effect of many separate decisions accounts for most of the impact on green (or gray) infrastructure. Often the impacts may start out small and occur incrementally so that the initial effects may at first seem insignificant. However, the impact of many such decisions over time can be quite substantial. For example, a primarily rural community may approve a small housing development. This development only slightly increases traffic and slightly affects runoff and stream flow. Over time, however, as more and more small residential developments are approved, the small increase in traffic becomes a large increase, and the minimal impact on streams becomes a major impact. Flash flooding is more severe and occurs more frequently. Pollutant loads increase, and more open space and forests are lost to development.

Conversely, preserving open space, providing parkland, and/or implementing “green” infrastructure practices can provide benefits that reach beyond the boundaries of the host municipality. For example, a large park in one township probably attracts visitors from neighboring townships. Depending on their proximity to preserved open space or farmland, property values may increase in more than one township.

Plans take into account cumulative impacts because they tell us how much growth we can accommodate while maintaining healthy green infrastructure. They also inform communities about the enhancements to green infrastructure that are needed to accommodate expected growth.

1.7 The Range of Green and Gray Infrastructure

Gray infrastructure is a community's network of constructed facilities and systems that provide for the needs of people. Green infrastructure is a community's network of natural resources that provide for the needs of wildlife and people. Land use patterns determine the amount and type of a community's green and gray infrastructure. High density ***mixed use*** *areas require a greater amount of gray infrastructure than suburban and rural areas. However, green infrastructure has a role in all land use types.*

All land use types (urban, suburban, fringe, and rural) have a range of amounts and kinds of green and gray infrastructure.

Green and gray infrastructure in urban, suburban, and rural areas

All land use types (urban, suburban, fringe, and rural) have a range of amounts and kinds of green and gray infrastructure (see illustration on page 15). Urban areas consist of a network of buildings, streets, rail lines, sidewalks, parking lots and garages, and storm drains, etc. Street trees, community parks and, in some cases, large parks are also a part of the urban fabric.

The gray infrastructure of suburban and fringe areas has many of the characteristics of urban areas; it also consists of a network of buildings, streets, roads, sidewalks, culverts, stormwater pipes, light rail, and sound barriers etc. However, this network of gray infrastructure is less dense than in urban areas. In addition to street trees and community and regional parks, suburban areas have a larger amount of green infrastructure in the form of undeveloped land and corporate parks.

Just as the street shown at right is gray infrastructure, the trees and meadow shown at far right are green infrastructure. The photo at right also has trees — elements of green infrastructure — just as that at far right has a piece of gray infrastructure — the power lines. All these types of infrastructure perform functions necessary to sustain modern human life.

As more roads, parking lots, roofs, and sidewalks are built, more land becomes impervious, preventing water from infiltrating the ground and resupplying ground water.

Rural and environmentally sensitive areas have a small amount of gray infrastructure consisting of limited roads, utilities, and septic systems. The rural landscape is dominated by undeveloped land that can be wetlands, forests, farmland, meadows, streams, and rivers.

All land use types make up the fabric of human habitat and have an important role to play in how a region functions. Although our cities and towns have more gray infrastructure, these higher density areas use gray and green infrastructure more efficiently and therefore help preserve large amounts of natural resources in other areas. See Sections 1.5 and 1.6 for more information on development patterns.

Impacts of development

Very little land in America has not in some way been altered by human activity. As more roads, parking lots, roofs, and sidewalks are built, more land becomes impervious, preventing water from infiltrating the ground and resupplying ground water. Runoff from storm water over these impervious surfaces is all too frequently polluted and has become the major source of water quality degradation. In order to mitigate these impacts, we construct systems to perform the functions that the green infrastructure provided prior to development. For example, in many parts of the country, developers are required to build on site storm water management using a system of culverts, storm drains, and detention and retention basins.

Sometimes green infrastructure is "grayed" — in this case, for flood control. Though surrounding neighborhoods are now safer, the habitat that formerly existed in this stream is lost. Both green and gray infrastructure should perform multiple functions.

Greening the gray infrastructure to perform multiple functions

In suburban areas some gray infrastructure such as detention basins can be redesigned to perform more than one function. By utilizing different design standards, incorporating green infrastructure like trees and **vegetated swales**, and reducing the amount of impervious surfaces, many of the negative impacts of roads, parking lots, and buildings can be mitigated.

Urban areas can use redevelopment as opportunities to improve and enhance green infrastructure. Sidewalks can be redesigned to include tree pits for street trees; vacant lots can be converted to neighborhood or community parks. Streams that have been channeled underground can be restored (**daylighted**) to a more natural state (see Section 5.1 for more details).

The hard edges of this urban park (above) are softened by the presence of trees. Trees can provide relief from the built environment and a sense of place.

Chapter 2

Smart Growth: Planning for Green Infrastructure

In the creation of human habitat, we develop land. Development always alters and can pollute or destroy regional systems such as watersheds, forests, and open space. Reduction and mitigation of impacts of development are critical to the sustainability of our habitat and all the Earth's ecosystems. Smart Growth gives us a framework for doing so within the context of planning, regulating, and making capital investments.

2.1 Smart Growth: Moving Beyond the Rhetoric

Allowing growth to empty cities, to consume open land, and to add to pollution, traffic congestion, and costs is not "smart," although that is what we do now. Smart Growth means developing in a way which enhances existing communities as more people and jobs move in. Smart Growth is about improving the sustainability of our habitat and creating new ways to reduce and mitigate the impact of development, particularly on regional systems and costs. Smart Growth protects and enhances green infrastructure.

The most commonly given definition of Smart Growth has to do with growing in the right location by locating growth primarily in areas where there is already development and infrastructure.

Easy rhetoric masks ambiguous attitudes

Smart Growth is a relatively new term. Because it sounds easier to understand and snappier than older terms meaning essentially the same thing (growth management or sustainable development), people assume they know what it means. Smart Growth supporters fall into an easy rhetoric when they discuss it, rarely being specific about where and how much to grow, let alone how to grow.

Surveys reveal that when asked to be specific about Smart Growth, most respondents reveal contradictory views: they like open space, but don't want more density in developed areas to keep open space open; they like driving their cars, but hate new roads; they like nearby places to shop and work and facilities to get around, but not in their backyard; they want public transit, but not the density that makes it work; they talk about revitalizing cities, but won't consider what it would really take to do it. Faced with growth, most people don't want it, but they would oppose the serious population, immigration, and mobility controls that would be needed to avoid it. The result is we are going to have growth, and it is going to be contentious. But it need not destroy the natural environment.

Definition of Smart Growth

Being specific about Smart Growth means entering this mine field of ambivalence. And yet, if we don't reach beyond the easy rhetoric and confront the conflict directly, we will never achieve the benefits implied by being "smart." If we are going to make Smart Growth the basis for new public policies and an improved institutional framework, we had better come to an agreement about what it means.

Location

The most commonly given definition of Smart Growth has to do with growing in the right location by locating growth primarily in areas where there is already development and infrastructure.

Growing in developed areas is "smart" for green infrastructure primarily because of its efficiencies; it builds on investments previously made, leading to the conservation of land resources. It allows for multiple public goals to be achieved: revitalization of urban areas, saving open space, reducing pollution, etc.

This system is the opposite of the inefficiencies of sprawl, which locates growth on greenfields where new infrastructure must be built to support it; natural habitats and farmland are consumed; nonpoint source pollution is increased, such as air pollution from cars and fertilizers from lawns; and the fabric of downtown commercial districts and neighborhoods is destroyed, making them less viable locations for redevelopment and encouraging the sprawl cycle to continue.

1

2

[Photos courtesy of New Jersey Office of State Planning]

3

This series of photos illustrates how a failed strip commercial site can be redeveloped to incorporate smart growth goals of being mixed use and at a pedestrian-friendly scale. The project can be phased in over time.

Facts and choices

But if Smart Growth is about enhancing existing communities while adding more people and jobs, "smart" location decisions alone won't achieve it. In order to enhance the communities in which growth is located, Smart Growth must be based on the **facts**: facts about the impacts of growth on regional systems of habitat, air and water resources, and tree cover, as well as facts about the capacities of existing systems to support growth and the costs of expanding the infrastructure and mitigating the impacts of growth.

These facts then provide the context in which **choices** can be made about the right amount, type, layout, and timing of growth as well as the right location. Without these facts, growth, even in the right location, can destroy a community. Growth can overwhelm the green infrastructure and ruin the natural features that make the community special and support local ecosystems.

Outcomes

Smart growth helps ensure positive outcomes that enhance green infrastructure while accommodating growth. Enhancing green infrastructure means reducing the amount of impervious surface, clustering developments to reduce land consumption and auto use, protecting and expanding tree cover, and taking a variety of other measures. The final chapter in this book has a checklist of enhancements to green infrastructure that your community should undertake.

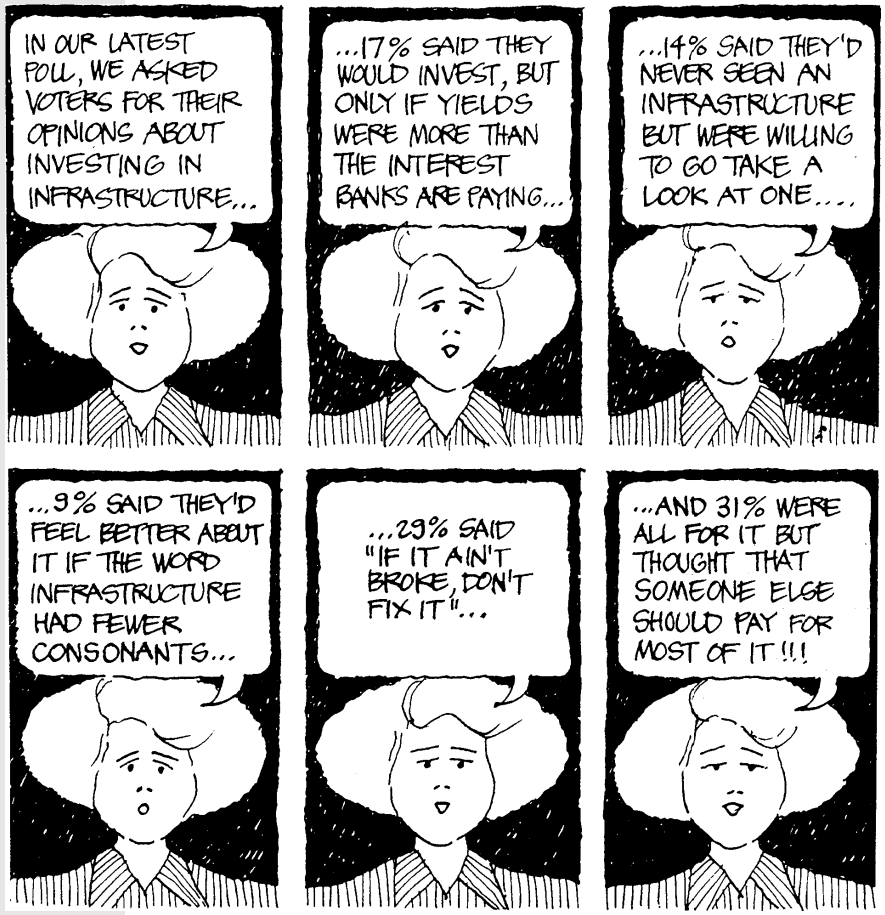
For growth to be "smart," it must pay attention to **outcomes**. It must result in optimizing the full range of goals that society strives for, not maximizing any one goal at the expense of others. For example, society needs both a healthy economy and a healthy environment. Pursuing only a healthy economy could harm the environment and ultimately harm our ability to sustain a healthy economy.

Besides providing economic security for all sectors of society as well as a healthy environment for people, plants, and animals, the results expected from Smart Growth include increasing the efficiency of public expenditures, reducing resource consumption, and providing opportunity and choice in neighborhoods, mobility, and quality of life.

In sum, Smart Growth is about a public policy arena in which we set goals, establish facts, make choices about how to implement the goals, and then evaluate the outcomes.

2.2 How Do We Get Smart Growth?

In order to avoid sprawl, we must change the things that shape land use patterns today. Laws, regulations, bureaucracies, and practices shape today's development decisions. This institutional framework controls how government spends the public's money and influences the private market through tax policy, permits, and other programs. It is clear that reforming this framework is essential if we hope to change land use patterns and achieve the expected benefits of Smart Growth.



Planning, regulating, investing

A good plan is created by following a good process. The more up to date that plan is, the more likely it is to be responsive to current concerns and directions for the future. The more comprehensive it is — the more goals it can pursue and the more mutually supportive they are — the better it can be. The more consistent a plan is with those of neighboring communities, the county and state agencies, and the more inclusive the process of developing the plan, the more likely it is to be supported and implemented.

The kind of planning we are discussing here is land use planning, which in most states is carried out at the local level. Communities develop and adopt master plans covering such topics as land use, transportation, natural resources, recreation, housing, and commerce. A community master plan is a particular kind of plan that is intended to help a community prepare for the future. It includes a description of current conditions and trends, an outline of opportunities and challenges, and alternative plans about future conditions. The master plan that is adopted by the community's planning commission describes the preferred future for that community.

Master plans should include a green infrastructure component, which we describe later in this chapter. The green infrastructure plan includes data, goals, targets, and tools for identifying and implementing enhancements and protection of water resources, forest resources, and wildlife habitat.

The plan is then translated into regulations about zoning, which covers land use, or special ordinances, like tree removal or sign

control. A capital improvement program, which outlines the investments the public sector must make to support the plan, is the next step in the process.

In the planning process:

- a community establishes a vision for itself,
- does some research to establish where it is in relation to that vision,
- develops a proposal for realizing that vision,
- tests for the outcomes if the plan is implemented,
- decides if the outcomes are desirable and makes revisions to the proposal as needed, and
- adopts a plan.

In the regulating process:

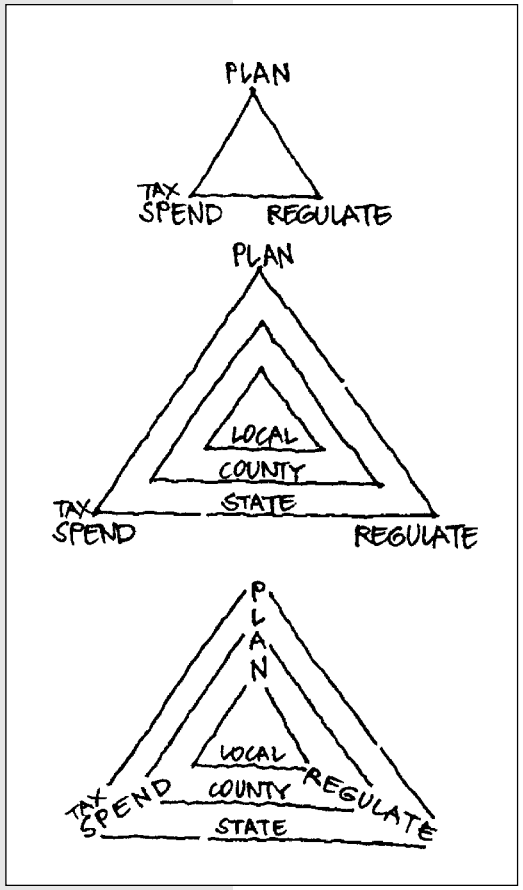
- a community adopts regulations which, if followed, will ensure that the community's vision and goals are implemented.

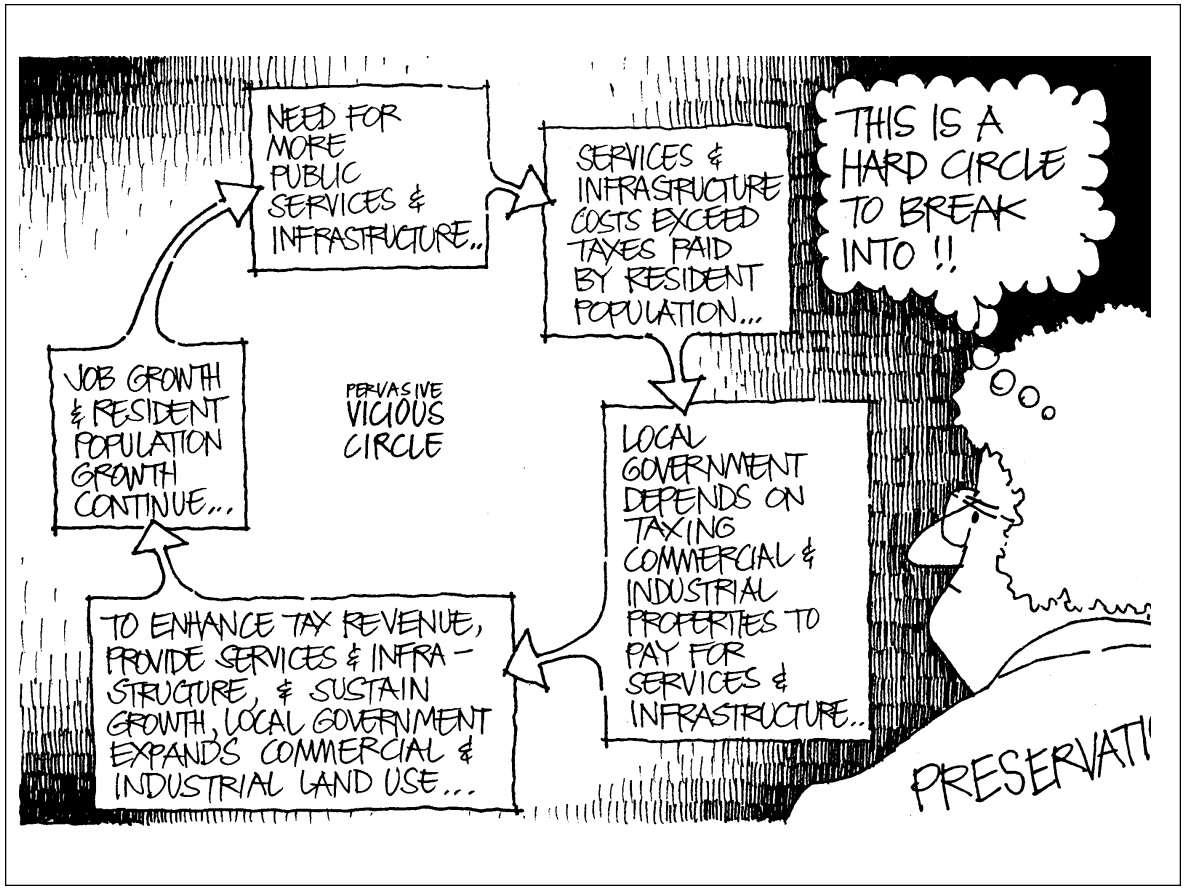
In the capital spending process:

- a community adopts a capital improvements program to support the implementation of the plan.

How the institutional framework frustrates Smart Growth

Local governments, within a complex framework of federal, state and regional governmental entities, control development in





Smart Growth means moving away from a prescriptive "command and control" approach toward a more flexible, performance standard approach.

the United States. The goals and policies in local master plans are translated into zoning and other regulations, which prescribe where and how development should be allowed within that jurisdiction.

What actually gets built, however, is often very different from what many people want, and may even be very different from what legislators and officials have specified in the countless laws and regulations that are aimed at protecting the environment and the quality of our communities. Some of the negative impacts on green infrastructure could be avoided if more thoughtfully coordinated and comprehensive plans, regulations, and practices were in place.

For example, state tax policy relies heavily on locally generated property taxes to pay for expensive infrastructure such as schools, wastewater treatment plants, and roads. The result is that local governments make land use decisions for fiscal reasons; they try to attract commercial development to pay for the costs of residential development. This practice frustrates Smart Growth, which would limit commercial development to only selective locations, thereby protecting green infrastructure in less developed areas.

State property tax policies rely heavily on locally generated property taxes to pay for expensive infrastructure such as sewer plants, schools, and roads.

This institutional framework affects market forces through the various laws, regulations, and investments made by the many layers of government. The market, in turn, influences what is built, as well as how much, when, and where.

The existing institutional framework creates three major problems for green infrastructure:

- lack of vertical coordination between different levels of government
- lack of horizontal coordination between governments at the same level
- lack of coherence between goals and outcomes.

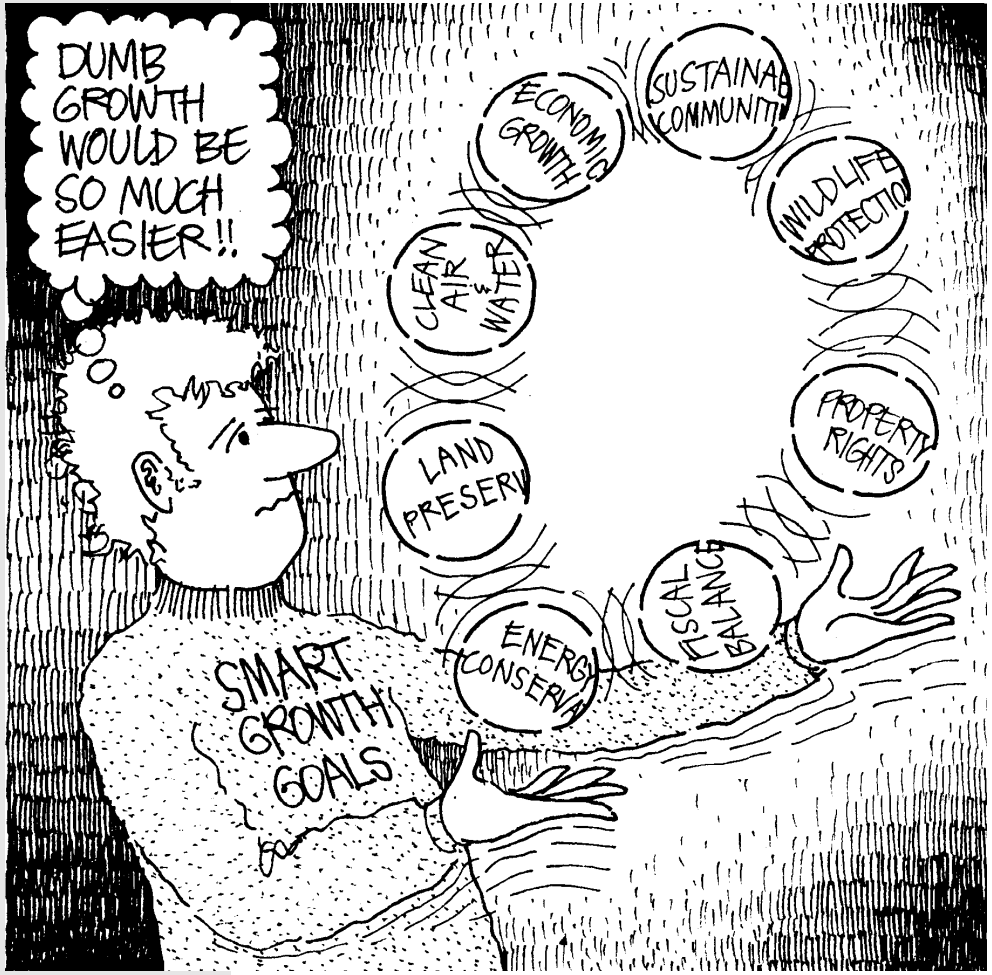
Lack of vertical coordination among the various levels of government means that local governments make decisions independently from regional, state, and federal governments, which make decisions independently from each other. Each level of government controls different parts of the system; that is, local governments mainly control land use, and other levels of government mainly control infrastructure investments. The result is, among other things, that development often takes place without the infrastructure in place to support it. Such development can cause traffic congestion and uncontrolled runoff, which in turn cause air and water pollution and flooding.

The second problem is the lack of horizontal coordination among the various agencies and entities at the same level of government. For example, one local government may permit a housing development at its border with another municipality which is trying to preserve farmland or a nature reserve. One municipality may have a 100-foot stream corridor buffer ordinance, while its neighbor across the river may have none.

The third problem is the lack of coherence between and among the stated goals of any or all of these entities and the outcomes "on the ground." This problem is partly the result of the previous two problems. The goals of one piece of legislation or level of government may be undermined by another level of government or by a neighboring municipality or sister agency. The mismatch

between the stated goals and the method of implementation adds to these problems. For example, although most local master plans state that their goal is preserving natural resources, these plans are implemented through zoning ordinances which encourage damaging development on every piece of property. The zoning requires drainage, parking, set back and bulk standards which require the regrading of the entire piece of property, thereby destroying the resources the goal was intended to protect.

In reality, the institutional framework we have is hopelessly disjointed and fragmented. It suffers from the different time frames and competing objectives of the many separate regulators, who, not surprisingly, since they operate so independently from each other, create regulations which are often at cross-purposes.



Multiple goals

Because Smart Growth aims to achieve many goals at once, it can be reached only through a well-coordinated, interdisciplinary approach, very different from the fragmented, single-purpose laws, regulations, bureaucracies, practices, and attitudes currently in place.

Smart Growth requires re-engineering these institutions to achieve multiple goals. In order to identify the multiple goals that should be pursued within each program, a multi-disciplinary approach to structuring the programs must be established.

Re-engineering institutions to achieve multiple goals has three other important aspects:

- It means moving away from a prescriptive "command and control" approach toward a more flexible, performance standard approach. Regulations should be designed to induce improved performance — that is, the outcome — rather than focus on controlling the path to the outcome.
- It means ensuring that the goals of the legislation and policy are actually achieved as a result of the regulations that are enacted and the spending decisions that are made. This requires that continual monitoring and evaluation be built into every program.
- It also may be more costly initially. Payoffs come in the future, so strong leadership is required to steer the reforms past short-term special interests that seek to derail them. ✱

2.3 Conducting Regional Watershed Planning

Planning at the regional level is crucial to efforts to protect green infrastructure. To protect water resources, regional planning should be watershed-based. Watershed plans should use land-use regulations and capital investments to direct growth into appropriate areas so that nonpoint source pollution into streams is minimized and undeveloped areas are preserved.

Perhaps the most difficult task in watershed planning is getting started, since no single agency has authority to prepare and implement a plan for an entire watershed.

Why conduct watershed planning?

Watershed planning is a multi-stage, continuing process that involves multiple jurisdictions and layers of government. Some states, such as New Jersey, mandate watershed planning. In other places, it is conducted voluntarily by county and local governments that are willing to work together to solve regional problems.

The ultimate goal of a watershed management plan is to protect water quality and quantity for the local jurisdictions within the watershed. Typically, watershed plans recommend that local governments adopt new land use policies in order to protect streams from both point and nonpoint source pollution.

New development causes nonpoint source pollution in the form of dirty auto-related runoff from roads and parking lots, as well as lawn-related runoff such as fertilizers and pesticides. This runoff can pollute both surface water and groundwater. New development also can result in additional point source pollution from sewage plants that must be constructed or expanded to serve the new growth. New industrial operations can also create point source pollution if their waste stream is dumped into a water body or groundwater recharge area.

Though they are often perceived as benign, farming operations can also contribute substantially to water pollution. Fertilizer, pesticides, and animal waste all find their way into water bodies from agribusiness operations.

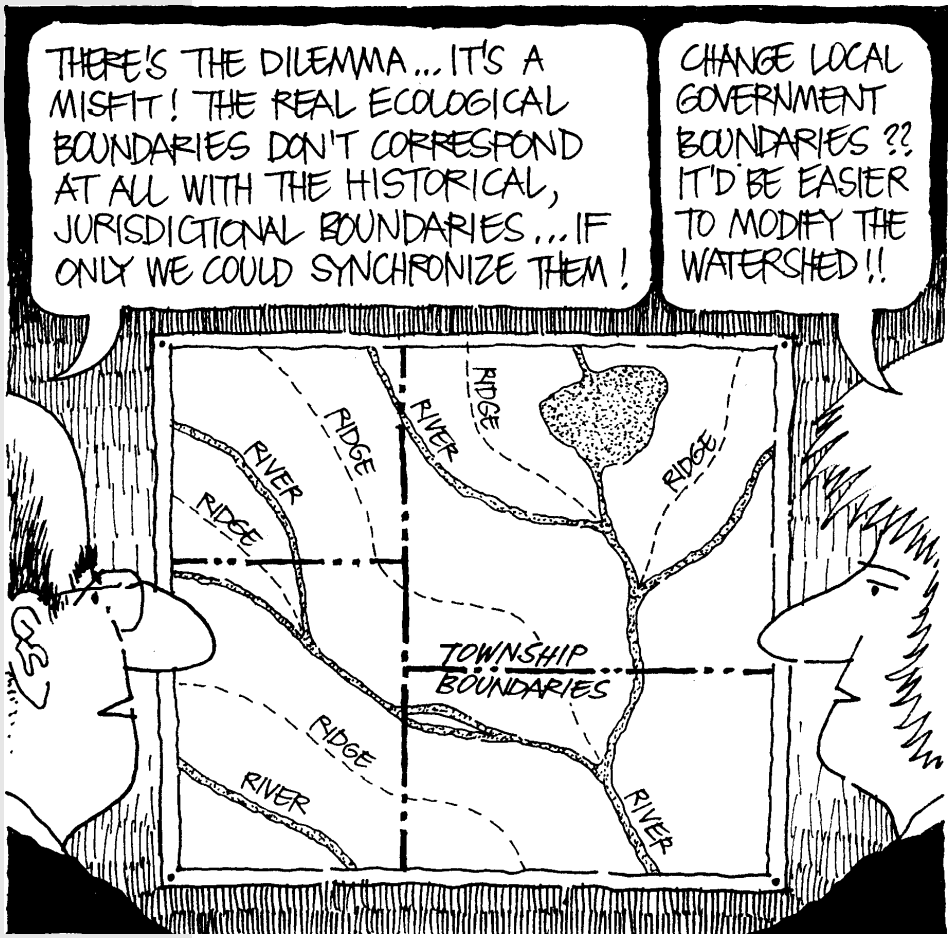
Preparing your region for watershed planning

Perhaps the most difficult task in watershed planning is getting started, since no single agency has authority to prepare and implement a plan for an entire watershed. State agencies may have the resources and jurisdictions to prepare plans for an entire watershed. But local governments, which usually cross multiple watershed lines but seldom have control over an entire watershed, have the powers needed to implement those plans. As a result, collaboration and cooperation are needed.

Collecting water quality data on area streams is a key early step in watershed planning.

Conducting Regional Watershed Planning

For a local government or civic organization seeking to involve its neighbors in watershed planning, education is often the first task. Many people are simply unaware of the potential of watershed planning to protect water by solving the problem of increasing nonpoint source pollution. Watershed planning can also help achieve other widely held goals, such as ensuring an adequate supply of water, revitalizing urban and older suburban areas, and protecting treasured rural land from development. Many groups offer educational resources for watershed protection; the U.S. EPA, state environmental protection departments, and the nonprofit Center for Watershed Protection are good places to start.



Once the need for watershed planning is established within the local community, a group — whether it be a regional planning entity, a state agency, or a nonprofit organization — should take a lead role in managing the process. However, the plan should be driven by a variety of interested stakeholders from the public at large. See Chapter 3 for tips on public involvement in green infrastructure planning.

Preparing a watershed plan

Once the planning process is in place, watershed management involves four major steps:

1) Divide the watershed into small sub-watersheds for data collection. Collect data on water quality and quantity in each sub-watershed, and classify the watersheds by level of impairment based on these data.

2) Evaluate the effects of current zoning and other land use regulations on the sub-watersheds.

3) Recommend changes to zoning and other regulations. Zoning should be changed to shift growth away from pristine watersheds (or those that are only marginally impaired) and toward already built-up areas. Then, capital investments such as roads and sewers should be made in areas targeted for growth. Other policy changes could include restrictions on pesticide and fertilizer use.

4) Establish a permanent monitoring and enforcement mechanism to ensure that changes are made and adhered to. This mechanism may take the form of a regional planning body. Because watershed planning is regional in nature, a decision to conduct watershed management planning is a strong incentive to consolidate planning functions that are dispersed among different jurisdictions.

Implementation mechanisms can include a broad range of items, many of which are discussed further in Chapters 4 and 5. These include zoning techniques, transfer of development rights, land purchases, stream **buffer** protection, site design, erosion and **sediment** control, stormwater control, septic systems, and sewer expansions. Remember, the goal is to protect water resources while accomplishing other objectives identified by the community, such as revitalizing urban areas or accommodating growth.

2.4 Creating a Green Infrastructure Plan

Just as municipalities need multi-year capital improvement plans to ensure that their gray infrastructure is adequate to serve future growth, they also need green infrastructure improvement plans. Community planning for green infrastructure should incorporate such things as wetlands preservation, tree planting, open space provision, and protection and enhancement of ecosystems.

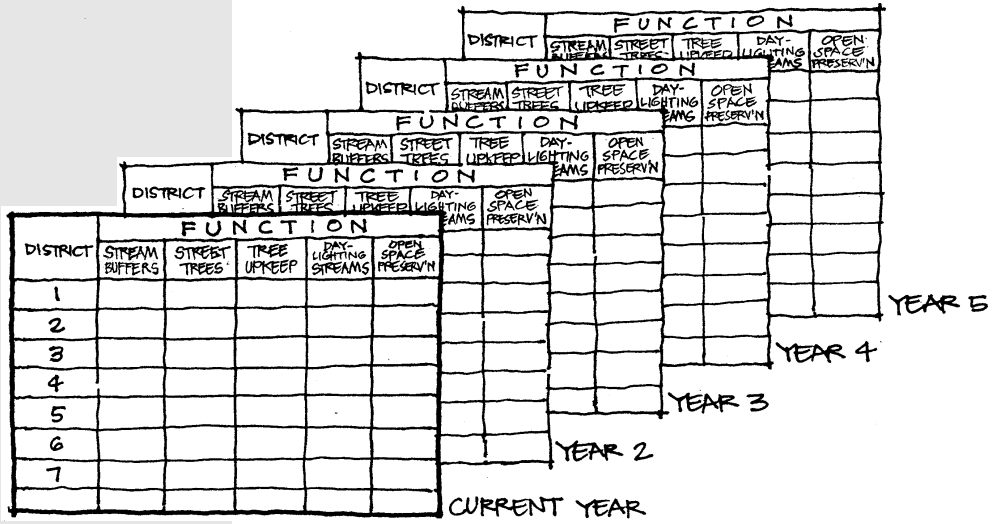
Municipalities are realizing they need multi-year planning for green infrastructure, and that includes planning for far more than parks to preserve environmental quality and community character.

Protecting green infrastructure through planning

Municipalities have **capital improvement plans** to tell them when and where they should build roads, water and sewer lines, treatment plants, schools, recreation facilities, and other elements of infrastructure. Traditionally, capital improvement plans have focused largely on gray infrastructure, the lone exception being parks.

But to preserve environmental quality and community character, municipalities are realizing that they need multi-year planning for green infrastructure, and that includes planning for far more than parks.

Plans for protecting existing green infrastructure and extending or enhancing that infrastructure where needed should be developed. The plans are then put into place through regulations governing the environmental impact of new development, as well as through capital outlays to purchase open space.



Stages in the green infrastructure planning process

1) Data collection — What are our existing conditions? The community should collect facts on the current status of its green

Pittsford, N.Y. Greenprint
Developing a Green Infrastructure Plan

Located just outside Rochester, N.Y., Pittsford is a suburban township that has experienced significant growth pressure for many years and is approaching buildout. For years, Pittsford's comprehensive plans called for preserving open space, but tools were not provided to translate those plans into action. In 1996, though, the township adopted a plan with a target, protecting 60 percent of the undeveloped land, and the tools to achieve it: mandatory cluster zoning, transfer of development rights, and purchase of development rights.

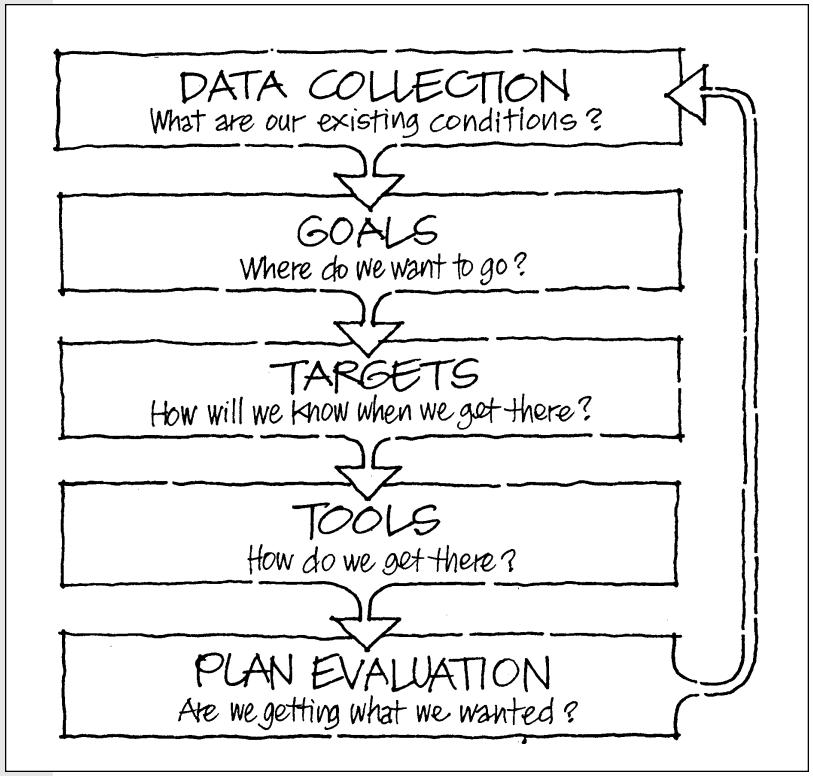
To determine which lands should be preserved, the township has adopted a priority ranking and rating scheme. The town's goals were to preserve farmland and historic resources, as well as land with high ecological value, so the ranking system reflects these three priorities.

The plan has proven popular with both landowners and other residents of Pittsford, and in 1998 it won an award from the American Planning Association.

infrastructure. Communities need to take a **natural resource inventory**. This inventory should identify wetlands, gaps in tree cover, wildlife habitats, and migration patterns. It should also assess the community's water quality and flooding problems.

2) Goals — Where do we want to go? Goals are broad statements of aspirations and intentions. They should be based upon community desires for improving green infrastructure — for example, increasing tree cover, protecting wetlands, providing park land.

3) Targets — How will we know when we get there? Unlike goals, targets should be specific and measurable. They function as indicators that tell when the goals have been reached. For example, a goal could be to cool the community by reducing urban heat island effects. Research might reveal that increasing tree cover by 25% in affected areas would provide the desired cooling. The target would then be to increase tree cover by 25% in designated areas.



4) Tools — How do we get there? Tools are the means by which a municipality strives to reach its targets. It is important to define the targets first and then decide what tools are necessary in order to reach those targets.

There are two basic types of tools:

A. Capital Improvements. These are investments that the municipality will undertake itself in order to reach its targets. Following are some examples of green infrastructure capital improvements:

- Purchasing land or development rights to preserve open space.
- Planting trees to help clean the air and provide shade and habitat.
- Using porous pavement instead of an impervious surface in a new municipally owned parking lot.

B. Regulations. While municipal capital improvements are important tools for implementing a green infrastructure plan, regulations that affect new private development are equally necessary. They are the means of ensuring that new development in the municipality conforms with the green infrastructure plan. The plan will likely require both new regulations and changes to existing regulations.

Examples of regulations that can be used to implement a green infrastructure plan:

- Zoning ordinances requiring or encouraging pervious surfaces
- Ordinances mandating the use of vegetative swales on little-used roads
- Ordinances allowing and encouraging environmentally sustainable land management practices (e.g., natural lawns)
- Conservation zoning and center-based zoning to ensure that large tracts of land are left undeveloped while future growth is accommodated.

5) Plan evaluation — Are we getting what we wanted? It is essential that any plan be evaluated at regular intervals to ensure that the goals and targets remain important to the community and that the tools are effective in implementing the plan. In our earlier example, once the target of planting 25% more trees has been reached (and the trees have had a few years to grow), the affected sites could be monitored to see whether temperatures were sufficiently lower. If not, a new target could be set.

Chapter 3

Land Use Planning for Green Infrastructure

Green infrastructure consists of water bodies, wetlands, forests, and other vegetation. Over millions of years, these elements evolved to work together, but in recent years, humans have altered their functioning with our increasingly rapid development of the land. With good land use planning, we can protect the elements of green infrastructure while providing places to live, work, and play.

3.1 Creating a Network of Protected Lands

Our park lands can serve as components of green infrastructure if they are properly planned and maintained. Communities should strive for a balance between recreation and conservation as they develop networks of parks and preserved lands.

Parks as green infrastructure

Parks can serve many functions, some of which contribute to green infrastructure and some of which detract from it. Besides serving as places for people to play, parks with trees and other vegetation support plant and animal habitat that could not otherwise exist in built-up environments. They also act as a cooling mechanism for cities and suburbs, reducing **urban heat island effects**. In rural areas, they conserve land that otherwise might be developed, and they provide habitat for species that cannot or should not live in farmland.

But heavily manicured parks and recreation facilities, while necessary for other community purposes, do not contribute as much to green infrastructure as do forested parks. Playing fields and grassy lawns do not provide habitat for as many species as does land in a more natural state, and the pesticides and fertilizers used to maintain these lawns further detract from their usefulness as green infrastructure. Chapter 5 describes techniques for making parklands more environmentally friendly.

Priorities for Different Land Preservation Goals

GOAL	PRESERVATION PRIORITY
Protect against flooding	Wetlands and lands near water bodies
Protect existing species diversity	Wetlands and mature forests, lands with more than one type of habitat, lands that are relatively undisturbed
Direct growth to centers	Land not in designated centers
Prevent erosion	Steeply sloping land
Bring nature back into urban areas	Stream corridors and river fronts
Protect habitat of multiple species	Connections between large areas of undeveloped land, especially stream and river corridors
Protect rare or endangered plant or animal species	Lands containing uncommon species or habitat types
Reintroduce species into former range	Lands near existing large areas of habitat
Protect important natural areas from effects of surrounding development	Buffer zone between heavily developed area and wilderness

Table 3.1 — *Priorities For Different Land Preservation Goals*

Preserving a network of lands

A major goal of green infrastructure is preservation of habitat for a wide variety of plant and animal species. Biologists agree that **habitat fragmentation** — the breaking up of natural lands by hodgepodge development — is a major threat to the survival of many species. To ensure that habitats are not fragmented, and also to provide for a community network of open space, communities should develop a network of preserved land.

What lands should be preserved? The answer to that question will vary by community and should be derived from the goals and targets decided upon in the planning process. Table 3.1 (at left) has some criteria that communities might adopt in response to their goals. For example, jurisdictions concerned about flooding would want to preserve land in floodplains and other areas susceptible to being saturated with water. Communities wanting to preserve plant and animal species would strive to preserve

corridors for wildlife and lands with prime habitat. Most communities will identify several goals; their task is to choose an optimal solution that uses different preservation tactics to move toward several goals at once.

Preservation and the planning process

Lands should be preserved through a rational planning process, as outlined in the previous section. In such a process, the community would specify specific land preservation targets to fulfill its goals. These targets should specify the types and amounts of land to be preserved. Then implementation tools are used to preserve specific tracts of land that fulfill the targets. The Greenprint plan adopted in Pittsford, N.Y., is an example of this type of planning (see sidebar, Section 2.4).

Some communities take a reactive approach, preserving only land that happens to become available or is threatened by development proposals. This strategy is not a good for two reasons. First, development that does not occur in one place is likely to occur in another. Unless you have a plan for redirecting growth to appropriate areas, blocking a development on one piece of undeveloped land will only result in unwanted development of other undeveloped land. Second, most communities have finite financial resources for preserving land. Because not all open space is created equal, communities that spend those funds wisely will do far better at protecting important components of green infrastructure than those that buy up land or development rights willy-nilly. Also, without a plan, wildlife habitat is highly susceptible to fragmentation.

Biologists agree that habitat fragmentation — the breaking up of natural lands by hodgepodge development — is a major threat to the survival of many species.

In the absence of a plan to preserve open space, fragmentation of habitat is likely to occur as development proceeds without regard for the bigger picture.

Boston's Back Bay Fens

An early example of a park built specifically to function as green infrastructure is the Back Bay Fens in Boston, designed for that city in 1879 by Frederick Law Olmsted as part of a large park system. The marshy fens, considered a public health menace by nearby residents, would have been filled in under the customary practice of the day. But Olmsted saw the value of returning them to their natural state. Thus, only half the park was designed to accommodate people; the rest was preserved as wetland in order to reduce flooding.

Today the fens are part of Boston's "Emerald Necklace," a world-renowned network of parks that winds through the city. The parks provide recreation opportunities as well as wildlife habitat. [Photo from Library of Congress]

3.2 Open Space Land Preservation Tools

Depending on what is allowed under state law, communities have several options for preserving large tracts of land as open space. The most obvious step is outright purchase, which may not always be affordable. Conservation easements preserve land at no direct cost to the community but allow less control over what land is preserved. Additional land preservation tools are discussed in the next two sections.

Easements should be carefully mapped and enforced by the local government as part of the natural resources inventory undertaken during the green infrastructure planning process.

Conservation easements

Local governments can enact ordinances enabling the enforcement of **conservation easements**. A conservation easement is a restriction placed on a deed to a piece of property requiring that the property be maintained in an undeveloped or natural state in perpetuity. The easement can be bought and sold; typically, an easement is granted to a local government or a nonprofit conservation group which agrees to enforce it. Most easements, particularly those held by governments and nonprofit groups, permit public access to the land, though typically site improvements that would disrupt green infrastructure while allowing better access are not made.

Because a conservation easement restricting development rights reduces the value of property, local governments should reduce property taxes for properties with easements. A reduction reflects the loss of economic value caused by the restriction on the future use of the land, and it gives landowners a financial incentive to place easements on their property. The federal government and many states also give income tax deductions for conservation easements.

Easements should be carefully mapped and enforced by the local government as part of the natural resources inventory undertaken during the green infrastructure planning process. Then conserved land can be mapped and made officially a part of the community's network of preserved land.

Developer set-asides

Many **subdivision ordinances** contain provisions requiring developers to donate land to the community for parks and open space. In most cases they may also pay a fee in lieu of the donation, the amount of which must then be used to purchase land for open space elsewhere in the community. To meet the "rational

Non-profit land preservation groups can work with local government to permanently preserve farmland and open space.

nexus" (*Nollan vs. California Coastal Commission*) and "rough proportionality" (*Dolan vs. City of Tigard*) tests typically employed by the courts, municipalities should design set-aside requirements so that the cost imposed on a home buyer is roughly equivalent to the benefit to that home buyer.

To take full advantage of developer set-asides, the jurisdiction should encourage developers to set aside land in stream corridors, mature forests, and other key environmental areas identified during the planning process, or it should use the in-lieu contributions to purchase this land. Using set-asides as a component of plan implementation ensures that they help preserve green infrastructure, rather than merely creating small, isolated patches of unused land.

To preserve land, all a community needs to own are the rights to develop *it.*

Outright purchase

The most unambiguous way to save property from development is the outright purchase of land by the municipality. This method is legal in every state, and there are no complicated ownership arrangements. Provided the jurisdiction is committed to maintaining the land in a natural state, it is the best way to ensure that land remains preserved.

Most communities will probably not be able to afford to purchase all the land needed for green infrastructure, so they will have to turn to other methods in addition to acquisition.

Also, making strategic purchases of land identified for preservation in the planning process often requires the use of eminent domain, a politically difficult procedure.

To preserve land, all a community needs to own are the rights to *develop* it. Land is not always valueless to a private owner without its development rights. Wilderness land sometimes has value to private owners as a hunting preserve or for scenic and passive recreation purposes. Such land could remain in private hands if the development rights were purchased by government and the owner's property taxes were reduced to reflect the resulting decline in market value. This protection is typically accomplished through a conservation easement.

Should communities use acquisition to preserve land? Absolutely! There is no better way to preserve ecologically crucial land. At the same time, to ensure fiscal and environmental responsibility, land purchases should be made only if based on a clear preservation plan. When feasible, only the development rights should be purchased. Non-acquisition strategies should be used whenever possible.

Permanently conserved land is a priceless gift to plants, animals, and future generations.

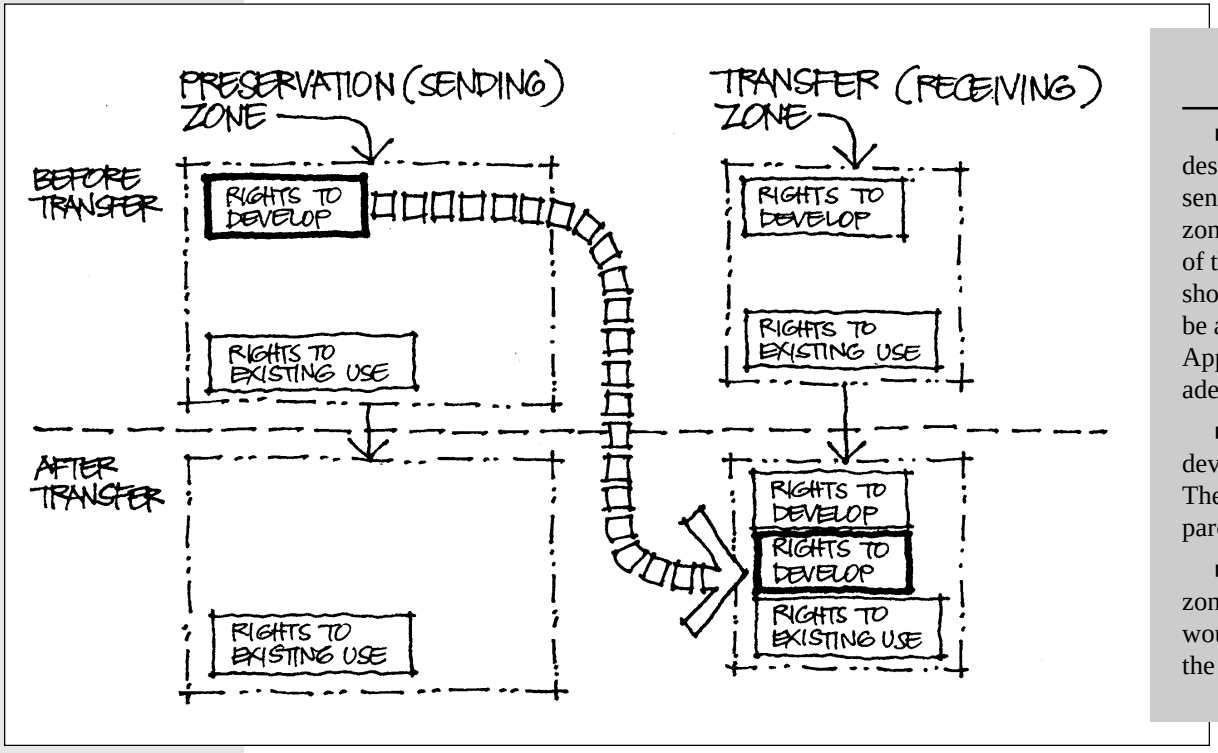
3.3 Transfer of Development Rights

Transfer of Development Rights is an important tool with a proven record of protecting green infrastructure. Through TDR, growth is shifted from natural areas at the edge of a locality to growth zones whose gray and green infrastructure can handle additional development. Because TDR assigns a value to development rights and allows them to be traded, the equity of preserved land is retained for its owners.

How TDR works

Transfer of Development Rights (TDR) is similar in concept to conservation easements, but it gives municipalities more leverage in selecting land to preserve, and it does not involve an absolute reduction in the amount of growth within the municipality. Rather, it shifts growth from **sending zones** to be preserved as undeveloped land to **receiving zones** with higher densities than would otherwise be permitted. (See below.)

Land whose development rights are not sold may only be developed at very low densities (say, 1 unit per 20 acres). How-



Sending and Receiving Zones

- A municipality using a TDR system designates certain areas of its jurisdiction as sending zones, and certain areas as receiving zones. These designations should be made as part of the master planning process; sending zones should be rural areas, and receiving zones should be areas intended to support additional growth. Appropriate plans should be made to provide adequate public facilities in the receiving zones.
- Landowners in the sending zones sell the development rights to their property to developers. These development rights are then "transferred" to parcels in the receiving zones.
- As a result, the parcels in the receiving zones are developed at a higher density than would otherwise be allowed, while the parcels in the sending zones remain entirely undeveloped.

ever, the development rights associated with land that participates in TDR are for much higher densities, providing a powerful inducement to landholders to participate in the TDR program.

Being able to ascertain the dollar value of the rights is important to both developers and landowners. Either the local government or a financial institution can set up a credit bank to facilitate transactions. By selling their development rights, which are then transferred to appropriate locations for growth, farmers and other rural landholders who rely on income from selling their land are ensured financial security.

A zoning density of 1 home per 5 acres preserves neither working farmland nor green infrastructure.

Purchasing development rights is one way to preserve farmland and open space.

Success in Montgomery County

Among the most successful TDR programs in the nation is that of Montgomery County, Maryland. Begun in 1980, it has successfully preserved approximately one-third of the county as open space at the same time as the county's population has risen from fewer than 600,000 to over 850,000.

In 1973, the county rezoned most of its rural area to a maximum density of 1 home per 5 acres. This type of zoning, when used in an area experiencing significant development pressure, preserves neither working farmland nor green infrastructure. So in 1980, the county downzoned the rural area to 1 home per 25 acres. However, to compensate landowners for their loss of equity, it assigned development rights at the previous zoning level of 1 home per 5 acres. The trick was that to be used, the development rights had to be transferred to a "receiving zone" outside the rural area.

The county established a development rights bank to facilitate the sale of development rights from landowners in the rural areas to developers in the receiving zones. Developers who purchase the rights may develop land in the receiving zones at a higher density than is permitted under ordinary receiving zone density.

The program's success is in no small measure due to the county's foresighted planning. It recognized that a sufficient number of receiving zones would have to be established and that infrastructure would have to be put in place in these receiving zones to accommodate the denser development. At the same time, the county saved money on infrastructure in the rural area because it did not have to accommodate new development there.

3.4 Zoning Tools to Protect Green Infrastructure

In addition to the land preservation tools identified in the previous section, goal-oriented zoning laws can be used to protect and enhance green infrastructure. ***Conservation zoning*** *protects open space, while forms of* ***cluster zoning*** *permit the concentration of development into compact centers, saving the surrounding land from development.*

... zoning should be explicitly designed to promote community goals, and it should be critically evaluated based on whether land-use changes made in accordance with the zoning meet those goals.

Goal oriented zoning

A municipality seeking to revise its zoning ordinances for any reason should place special emphasis on determining the likely outcomes of the new regulations. In other words, zoning should be explicitly designed to promote community goals, and it should be critically evaluated based on whether land-use changes made in accordance with the zoning meet those goals. The conservation and center-based zoning described in this section are two examples of **goal-oriented zoning**; the goal is to protect targeted open space from development, and the zoning is designed explicitly to meet that goal.

With goal-oriented zoning, communities decide what land they would like saved and what land they would like built upon, and write their zoning regulations to advance those goals.

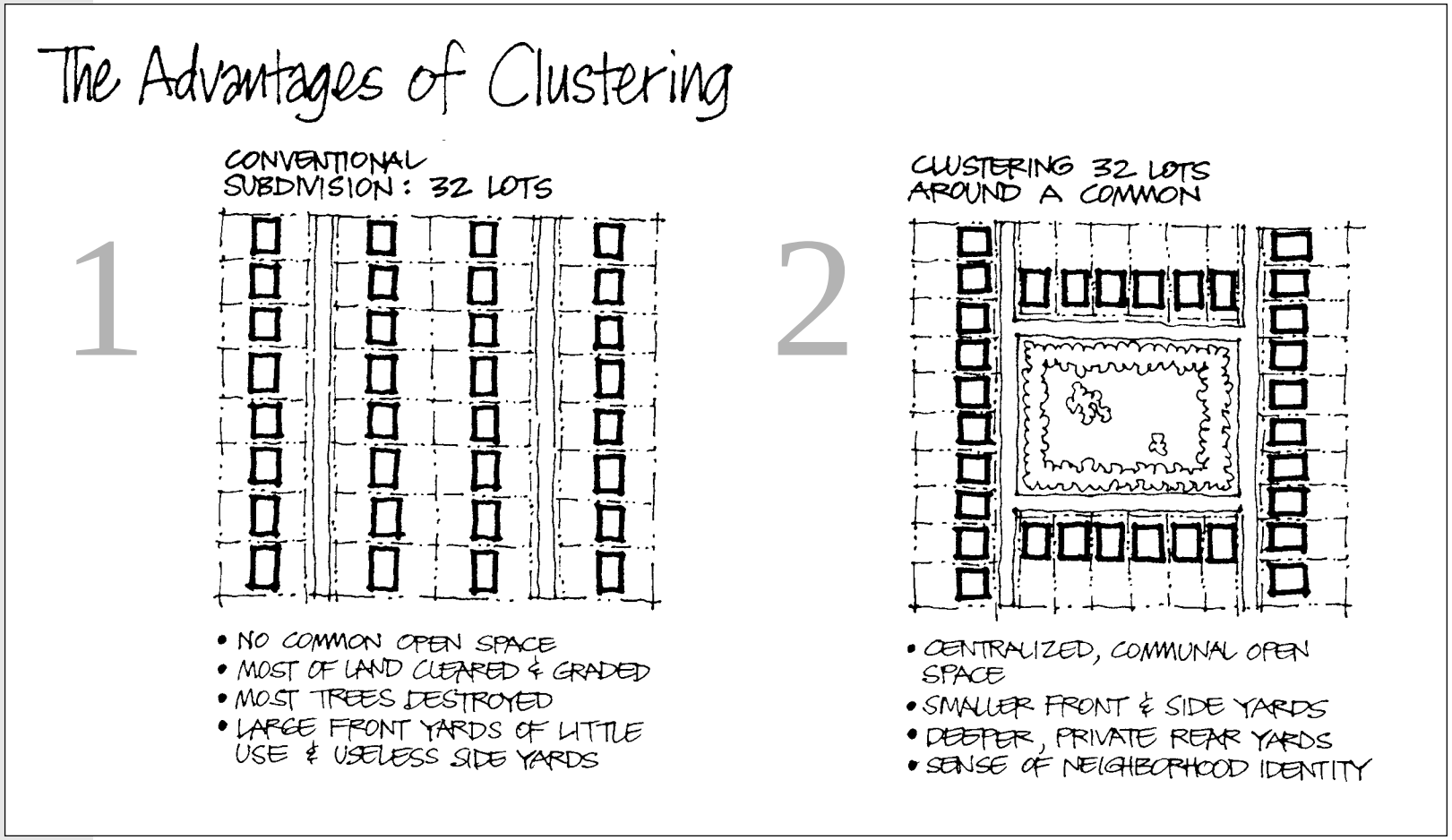
The outcomes of this planning process — the open space that is preserved or destroyed, the number of people that move in, the number of cars on the road, and so forth — are the result of implementing the plan through public and private investments that are controlled by these ordinances. These outcomes can be very far from those envisioned by the master plan. Most master plans embrace lofty goals such as "encouraging transit use" and "protecting natural resources." These goals, however, are often not supported by the regulations. In fact, zoning regulations may call for low density, single use development and require a considerable amount of free parking, which subverts transit use, as well as requires drainage and landscaping in such a way as to force the regrading of an entire property. Such a regrading can result in leveling every tree, changing habitats and water flows irreparably.

The mismatch between goal statements in the master plan and the results on the ground can be addressed by re-inventing zoning. The current structure, which separates uses and encourages the subdivision of open land into housing, shopping centers, and office parks, can be discarded. New zones can be put in their place; these new zones would discourage commercial strips along highways and encourage the clustering of permissible development into mixed use clusters, forming transit and pedestrian-friendly villages and downtowns.

Conservation zoning

Communities around the nation have developed a variety of forms of conservation zoning to keep land from being developed. Some forms of conservation zoning impose outright restrictions on the number of units that can be built on a tract of land, requiring very low densities. Other forms of conservation zoning allow the same amount of development to be built as is allowed under conventional zoning, but require that the development be clustered in a portion of the site, leaving a large area undeveloped. Still other conservation zoning ordinances impose stringent use restrictions to ensure that land remains in an undeveloped state.

1) Conservation density zoning. To be truly effective in preserving green infrastructure, allowable densities must be very low indeed. One unit per 40 acres is generally an accepted minimum standard, although local conditions could dictate much lower densities, as low as 1 unit per 640 acres. This type of zoning will be most effective in very rural areas where there is little demand for smaller lots. In areas under development pressure, these densities considerably reduce the value of land, so to avoid "takings" conflicts and protect landowners' equity, they must be implemented in concert with a mandatory transfer of development rights program, explained in the previous section. Note that

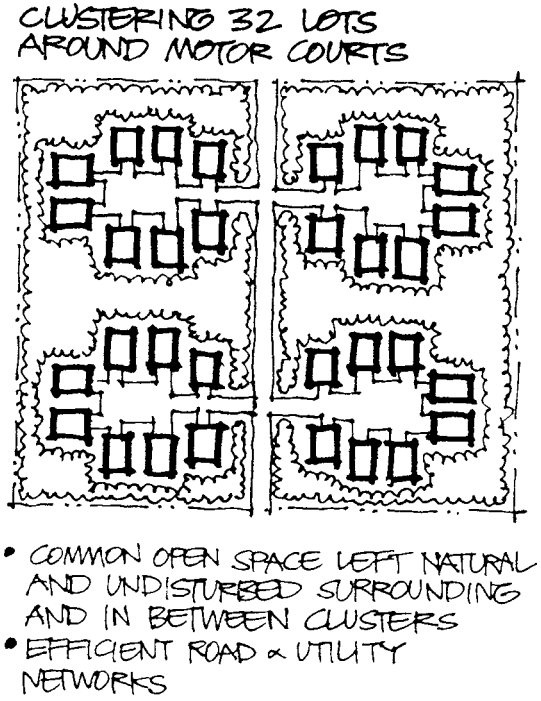


The mismatch between goal statements in the master plan and the results on the ground can be addressed by re-inventing zoning.

typical "large-lot" densities of 2 to 10 acres per unit are ineffective at protecting natural systems. Indeed, they often exacerbate problems for green infrastructure by causing low-density development to spread more quickly across the landscape, creating erosion and nonpoint source water pollution while seriously fragmenting animal habitat.

2) Cluster zoning. These ordinances let landowners build at a high net density on a portion of a tract, while leaving the remainder of the tract in a natural state. For example, a developer might be allowed to construct one house for each 5 acres. But the key to cluster zoning is that the units must be concentrated in one location. Thus, a corner of a tract of land is developed at, say, 4 units per acre, while the remainder is left in a natural state under a conservation easement held by the municipality or a nonprofit organization, so that the gross density is 0.2 units per acre. Jurisdictions allowing sites to be developed with cluster zoning should work with developers to ensure that the portions of the sites most important for green infrastructure are left undeveloped. Cluster zoning permits development in suburban areas with the infrastructure to serve new development, while ensuring that some open space is retained permanently.

3



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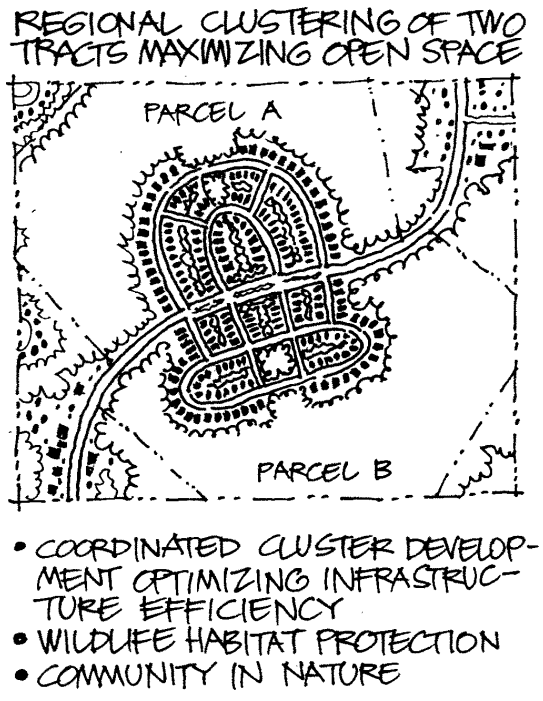


In any cluster zoning arrangement, the local government should coordinate its implementation with developers and landowners to ensure that its land preservation goals are fulfilled.

In any cluster zoning arrangement, the local government should coordinate its implementation with developers and landowners to ensure that its land preservation goals are fulfilled. A conservation easement should be placed on the preserved land, and either the local government or a nonprofit group should enforce the easement. A permanent allocation of resources for enforcement is a requirement.

3) Exclusive or conditional-use conservation zoning. This type of zoning allows only a few uses; structures are either prohibited altogether or allowed only after a review shows that they meet certain criteria. Utility structures and parks and recreation facilities are examples of allowed uses. Because this type of zoning substantially reduces the value of land, it exposes a municipality to "takings" challenges. Its use is most appropriate in areas that are already built up, where infill development threatens sensitive sites that were skipped over in the initial phases of growth.

Center-based zoning

Center-based zoning should be enacted hand-in-hand with agricultural zoning. Because effective conservation zoning restricts growth significantly in rural areas, communities experiencing growth pressure must provide other places for the growth to go. Increasing the allowed density in compact centers will compensate for the reduced capacity in agricultural areas. Chapter 2 includes more information on center-based zoning, but the basic concepts are summarized here:

1) Increased density and intensity. Depending on the size of the center and the amount of growth to be accommodated, zoning in centers could allow anywhere from 4 units per acre (a typical suburban density for detached single-family homes) to traditional urban densities allowing row homes and apartment buildings. Centers work best when they incorporate a range of densities, allowing for choice within the market.

2) A mix of uses in close proximity. Because lot sizes are smaller in centers than in traditional sprawl, center-based development makes it feasible for residents to walk to work and shopping. In centers, small-scale retail and office uses that facilitate pedestrian access should be encouraged in close proximity to homes. Larger, more urban centers can have larger office buildings and retail stores, again geared toward pedestrians.

3) A high level of connectivity. Multiple streets, sidewalks, and other paths must be provided to ensure a variety of convenient, direct routes. Cul-de-sacs are discouraged.

4) Ample community open space. A network of parks and protected stream corridors is a crucial part of any center. These features provide habitat for wildlife and places for recreation.

These large single-family homes are built on small lots, allowing for public access to open space elsewhere on the parcel.

3.5 Designing Greenways

As undeveloped land is converted to developed land, wildlife habitat becomes fragmented, upsetting nature's natural balance. Some species thrive on edge habitats, while others decline. The development and redevelopment process can provide opportunities to preserve tracts of land and to provide greenway connections.

In densely developed urban areas, greenway links may need to follow tree-lined streets to provide a continuous connection with less densely developed areas.

Greenways: Connections for humans and wildlife

Greenways are linear corridors of vegetated land; they can be pristine trails or vegetated paths in urban areas. They can range in width from a footpath to several miles, but they all act as connectors to other open space and community resources. Creating greenways during the development process is an excellent way to preserve open space, as well as protect and connect important natural habitat. When designed properly, greenways can be a cost effective way to achieve a variety of goals. A greenway can provide recreational opportunities for people, provide travel corridors, for people and wildlife, buffer disparate land uses and stream corridors, and connect larger parks and open space.

The specific location and design of greenways should reflect the goals and concerns of the community; to be successful, it should include a public involvement process from the planning phase through implementation. Greenways typically follow streams and rivers, ridge lines, abandoned rail lines, utility corridors, and transportation corridors such as canals. In densely developed urban areas, greenway links may need to follow tree-lined streets to provide a continuous connection with less densely developed areas. They can be designed to connect people to community facilities such as schools, parks, libraries, historic sites, and cultural centers.

Ideally, greenways should achieve a variety of goals. As discussed earlier, the amount of impervious surfaces has a direct correlation to water quality. Therefore, greenways that include bicycle trails should be designed to minimize the amount of impervious surface area. In most cases greenways provide connections to other types and size of habitat, but they can also act as a barrier to some wildlife. Constructing over- and underpasses for wildlife has proven an effective method of allowing wildlife to cross dangerous barriers. A combination of fences, tunnels, overpasses, and vegetation can be used to encourage animals to stay off of highways. In Canada, mountain goat road kill was reduced by 96% when crossings were constructed; in the

Greenways can be incorporated into stream buffers, providing multiple recreational benefits while protecting important wildlife habitat, preventing erosion, and reducing the impact of nonpoint source pollution.

Netherlands, the badger population doubled after fences, tunnels, and green space were provided. The Federal Highway Administration offers support for the construction of highway over and underpasses through TEA-21.

Involving the public in the planning and design is critical to a greenways success. Many myths surround the impacts of greenways on local residents. Many people fear that crime will increase and property values will decline. Studies show that property values along greenways increase. In Salem, Oregon, land next to a greenway drew $1,200 more than land only 1,000 feet away. The Minnesota Department of Natural Resources compared attitudes of landowners on proposed trails and existing trails. Seventy-five percent of those on the proposed trail expressed fear of crime and vandalism while those on existing trails nearly unanimously believed there were no crime problems.

Regional preservation and greenway plans should strive to connect large open space areas. This map shows how greenways can create a network of open space.

Using site design to create regional greenways

In the past, green infrastructure has been undervalued because private, undeveloped, open land was commonplace and taken for granted. In recent years, however, the public and elected officials have begun to place a greater emphasis on preserving open space, farmland, and other green resources.

The development process can provide opportunities for preserving and connecting open space. However, without a coherent regional land preservation and greenway plan, preservation may be disjointed and isolated, and thus less valuable.

Many suburbanizing communities have ordinances requiring a percentage of a subdivision's land to be set aside as open space. However, unless these open-space set asides are contiguous with larger open spaces or are connected to them by greenways, they can result in creating many small "islands" of undeveloped land that serves no particular environmental purpose. In addition, without an active homeowners' association or clear management guidelines, this open space is often neglected and also fails to serve human needs.

As undeveloped land is converted to developed land, wildlife habitat becomes fragmented, upsetting nature's natural balance. Some species such as geese and deer can thrive (sometimes causing new problems), while other species decline. At the very least, biological diversity is reduced.

Roads and culverts act as barriers for wildlife; many large animals such as deer, elk, bears, and moose are killed each year trying to cross highways. These encounters are also dangerous for people and cost millions of dollars in damages. Smaller animals such as turtles, snakes, frogs, and salamanders are also threatened. Culverts and dams prevent many fish from returning to spawning grounds.

A regional preservation and greenway plan can help to provide connections for wildlife. Although greenway connections are preferred, in some cases more gray infrastructure may be required to facilitate wildlife movement at certain locations, as described above.

Chapter 4

Protecting and Enhancing Community Forest and Lawn Infrastructure

In suburban and less intensively developed areas, natural ecological processes are hindered by landscaping and lawn management practices. Local governments can encourage businesses and homeowners to implement better practices. In urban and suburban areas, trees are a crucial part of green infrastructure, helping keep the community cool and providing habitat for many species. Local governments can help their trees flourish by taking an active role in community forest management and planning.

4.1 The Environmentally Unsound Suburban Landscape

Suburban and rural areas have relatively large amounts of green infrastructure in the form of publicly and privately owned undeveloped land. In many cases the value and function of much of this undeveloped land can be improved by protecting vegetation in the development process and by restoring undeveloped land (corporate lawns) to a more natural state.

Lawns and lawn maintenance can contribute to environmental degradation on many levels.

Lawns: The great suburban monoculture

The suburban landscape is made up of a combination of green and gray infrastructure. Unlike high-density urban areas, low-density residential, commercial, and office park development dominate the suburban landscape. The lawns that surround corporate parks and residential areas are an integral part of the suburban landscape. In the United States, more land is utilized for lawns than any other single crop. These lawns range in size from many acres to less than one acre and are accented with landscaping. Our lawns form a huge, mostly untapped source of green infrastructure.

Lawns are an ideal habitat for "wild" animals such as geese and deer. The resulting overpopulation burdens water bodies with biological waste.

Lawns and lawn maintenance can contribute to environmental degradation on many levels. Fertilizers, pesticides, herbicides, watering, and frequent mowing are required in order to maintain their lush green appearance. Pesticides and herbicides destroy pests as well as their natural predators. These chemicals are also toxic to humans. The chemicals that are not absorbed by plants are swept into area streams or infiltrate the ground water after a rainfall. This run-off feeds algae growth which blocks light and oxygen and threatens aquatic life.

The typical American lawn is what biologists call a **monoculture**, meaning that it supports only one type of vegetation — grass. Everything else is considered an undesirable weed. Monocultures lack variety and are susceptible to disease; they provide habitat for a limited number of types of wildlife. Suppose clover were also considered an acceptable yard element, as it was prior to the 1950's. Clover has a microorganism that converts nitrogen into a form that can be used by grass and adds nitrogen to the soil, reducing the need to manually fertilize. It can also support many more insects than grass alone.

Conventional grass is also typically vulnerable to drought, requiring frequent watering during dry periods. Using drought-resistant varieties of grass would save millions of gallons of water

each summer. Moreover, many homeowners do not know how much water their grass actually needs, so they over-water — often by twice as much as necessary.

While the chemicals used in lawn maintenance are compromising water quality, water supply is also being threatened. During the hot summer months, lawns require frequent watering. Traditional water-demanding landscapes can comprise 40 to 60 percent of a community's water consumption. As the number of lawns increases, so does the demand on water supplies.

The chemicals and frequent watering accelerate the grass's growth, thus requiring frequent mowing. Lawn mowers' two cycle engines are known to be one of the largest contributors to air pollution.

Areas that are already developed, such as corporate parks and residential neighborhoods, may consider reducing the amount of turfed land... Establishing a wildflower meadow in an area that is already turfed is not difficult...

Greening developed areas

Areas that are already developed, such as corporate parks and residential neighborhoods, may consider reducing the amount of turfed land and restoring streams to their natural state (**daylighting**, discussed in Chapter 5). These improvements can be addressed through the community planning process described in Chapter 2. Neighbors can rally around specific projects that address their shortcomings in green infrastructure, and they can see these projects through to completion by volunteering in the implementation and monitoring phases.

A diversity of plant species can be a part of even the most heavily urbanized environment.

Planting trees and shrubs and converting a portion of the existing lawn to a wildflower meadow can be effective in creating a more natural environment that will encourage greater species diversity, improve ground water recharge, and improve water quality. It is critical, however, to select plants that are appropriate for the climate and soil of the area or region. Native species are always a good choice; exotic and invasive species should be avoided.

Establishing a wildflower meadow in an area that is already turfed is not difficult; however, it does require some work and a small financial cost at the beginning. Once the meadow is established, only a yearly mowing is required; herbicides, pesticides, and fertilizers are no longer needed, reducing maintenance costs in the long run. Once the meadow is in place, less maintenance is required than for lawns. It takes approximately three years for wildflowers to become firmly established. If left alone, the meadow will, over a period of years, become a woodland. Local Extension Service or Soil Conservation Service District offices have information on how to prepare and maintain a site for wildflowers.

Lawn Facts

- $30 billion a year is spent on lawn care in the U.S.
- Lawns occupy more land than any other single crop — an area the size of Pennsylvania.

4.2 Creating a Greener Suburban Environment

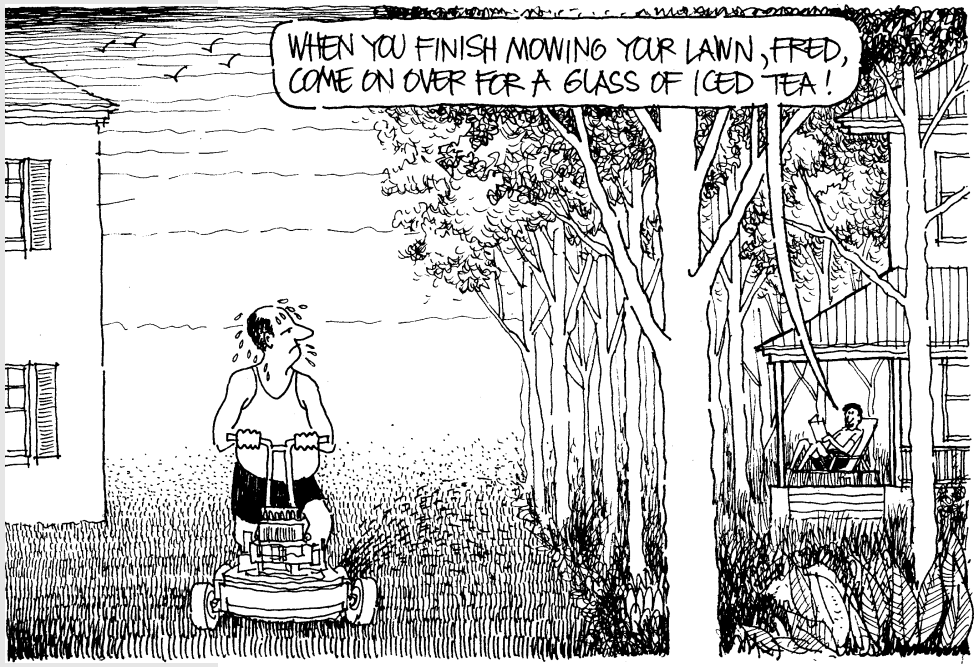
As described in the preceding section, traditional design practices have created a suburban environment whose green infrastructure does not work effectively. Through better site planning, communities can ensure that future suburban development is more ecologically sound.

Incorporating natural features in the site design can minimize many of the negative impacts of development.

Incorporating better design into site planning

Incorporating natural features in the site design can minimize many of the negative impacts of development. Prior to developing a site, an inventory must be made of important environmental features of the site and adjacent sites such as streams, slopes, trees and other vegetation.

Preserving existing natural characteristics on a site can minimize the need to construct detention basins to manage stormwater runoff. For example, trees and their understory can help reduce the amount and velocity of stormwater runoff. A stream that is allowed to meander and flow rather than channeled into a culvert can better manage natural fluctuations in water volume. Stream bank vegetation can also reduce velocity and filter pollutants.



Mature trees with a large tree canopy and massive root system provide a greater environmental and economic value to a site than newly planted trees. A study conducted by the Mercer County (New Jersey) Soil Conservation District using the CITYgreen program demonstrated a variety of impacts of newly planted trees until they reached maturity. The sidebar on the following page summarizes the results of the study quantifying the benefits of trees.

Natural features on a site include other benefits like reduced maintenance costs because it does not need to be seeded, fertilized, watered, or mowed. A National Association of Home Builders survey revealed that people are willing to spend more for wooded lots. The benefits of preserving natural portions of a site can be increased if they are contiguous with other preserved areas. Contiguous open space can provide more passive recreational opportunities, as well as providing habitat that is not fragmented.

Making lawns function as green infrastructure

Local governments can take steps to encourage sensible lawn management. The first step is removing restrictions on natural lawns. In rural and suburban areas with large lots, landowners should be required to preserve the natural landscape by placing grass on only a portion of their land. The remainder should be left

In rural and suburban areas with large lots, landowners should be required to preserve the natural landscape by placing grass on only a portion of their land.

as meadow, forest, or desert, depending on the region of the country. In more densely populated areas, shrubs, cacti, vegetable gardens, and trees can substitute for grass.

A sustainable lawn is not an unsightly or overgrown lawn. The addition of a few non-grass species, such as clover and native wildflowers, creates a lawn with much better support of insect populations; local governments should change their ordinances to allow these species. Also, portions of the yard can be planted with different forms of vegetation, while leaving other areas grassy. For example, most grasses were not meant to grow in shady areas; mosses, shrubs, and other non-grass vegetation are better suited to these spots. Many communities review landscape plans as part of the development review process for subdivisions and other residential developments; testing for sustainability of lawns could be a part of this process.

To encourage conservation, the water authority in Novato, California, gives a credit of up to $200 per home when residents replace their conventional lawns with water-conserving vegetation or vegetable gardens. A community could give similar incentives to homeowners who replaced their lawns with native vegetation to encourage ecosystem preservation. Other communities, such as Aurora, Colorado, mandate that drought-resistant grasses be used on at least a portion of all new lawns.

Trees can provide shade and co-exist with recreational functions.

Impacts of Trees

A study conducted by the Mercer County (New Jersey) Soil Conservation District using the CITYgreen program demonstrated a variety of impacts of newly planted trees until they reached maturity.

In the first year of planting:

- stormwater runoff was reduced by .4%
- retention basin volume was reduced by 179 cubic feet
- energy costs per home were reduced by $18.06
- the trees collected 1.30 tons of carbon

At maturity (same trees):

- stormwater runoff was reduced by 6.9%
- retention basin volume was reduced by 3,228 cubic feet
- energy costs per home were reduced by $36.12
- the trees collected 31.82 tons of carbon

(Mercer County SCD 1991)

4.3 Green Infrastructure and Microclimate Mitigation

Densely developed urban areas and suburban shopping centers can create their own microclimate of increased temperatures and winds. Urban parks, street trees, alternative paving materials, and preserving open space on the urban fringe can help mitigate urban and suburban ***microclimates****.*

One method of cooling our urban areas is to preserve, expand, and maintain the urban forest.

Urban weather phenomena

It is obvious to most people that urban areas and large, unshaded parking lots are hotter in the summer than the surrounding suburban and rural areas. Roads, parking lots, sidewalks, and roofs absorb and radiate heat, while cooling winds are blocked by buildings in high density areas. NASA has recently completed a study looking at block-by-block infrared maps of Salt Lake City, Sacramento, Baton Rouge, and Atlanta. The maps showed that the parks are cool, while parking lots are hot. Urban summertime temperatures can be 9 to 20 degrees Fahrenheit warmer than surrounding areas.

What most people do not realize is that urban areas can create their own weather patterns. As the hot air rises, it cools and condenses into clouds and rain.

The urban forest

One method of cooling our urban areas is to preserve, expand, and maintain the urban forest. It is well understood that trees and other vegetation can have a cooling effect; strategically located trees can reduce summertime as well as winter time energy costs.

American Forests recommends a tree cover of 40% in metropolitan areas. (American Forests, founded in 1875, is a conservation organization committed to communicating the benefits of trees.) This goal can be achieved by having a tree cover of 15% in downtown areas, 25% in urban neighborhoods and light commercial areas, with 50% coverage in suburban residential areas. In order to achieve these goals, communities need to assess what trees they have and establish maintenance practices to care for those trees. A plan to plant trees in areas that are deficient in tree cover must also be developed. All urban revitalization projects must include tree planting in the development plan.

Developing areas must require site plans to include a tree planting plan. Parking lots and street rights-of-way are ideal locations for trees. However, it must be noted that selecting the right tree for the right place is critical. Things to consider include sight distances, utility conflicts (above and below ground), tree

Parking lots can be designed to incorporate trees to help reduce the urban heat island effect and reduce stormwater runoff.

litter, soil types, drainage, and pavement heaving. It is recommended that an arborist be included in the planning process to help address some of these issues.

Rooftops

Rooftops are another contributor to the urban heat island effect, as well as an under-utilized urban resource. Reducing the amount of heat absorbed and radiated from roof tops can be as simple as changing the color of roofing materials or as complex as using roofs to store water. Black roofs store and radiate more heat than roofs with colors that reflect the sun's rays.

Flat barren roofs are similar to parking lots in that they absorb and radiate heat, as well as collect stormwater. Like parking lots, adding plant material can reduce roof temperatures as well as reduce the amount of stormwater runoff. Roof top gardens have the added benefit of providing an urban oasis for city dwellers.

Smart Growth

The current Smart Growth movement is encouraging development in places that already have gray infrastructure. Much of this growth will occur as **infill** development. Retrofitting our urban and suburban areas provides an ideal opportunity to add street trees and urban parks to the urban and suburban landscape. Development on greenfield sites should strive to preserve existing trees, incorporate open space in the site plan, and include street trees.

Although providing urban open space and increasing the urban tree cover are critical in mitigating the urban heat island, the importance of preserving open space and trees beyond the city limits cannot be overlooked. As described in Chapter 2, accommodating a community's growth through high density mixed use development is more efficient and uses less land. Land preserved outside urban areas can mitigate the urban weather patterns. Cities that have weak winds and experience inversion can benefit from preserving open space on surrounding hillsides to allow cleaner, cooler air to flow into the city. Stuttgart, Germany is such a city and has preserved hillsides outside the city to provide cool, clean air.

Development on greenfield sites should strive to preserve existing trees, incorporate open space in the site plan, and include street trees.

Green infrastructure and gray infrastructure are both necessary elements of infill projects.

4.4 Community Forest Management

Trees, a crucial component of green infrastructure, must be carefully managed. As part of the master planning process, municipalities should adopt a community forest element. After the plan is adopted, ordinances should be implemented that regulate the planting of new trees, protect existing trees throughout their life spans, and ensure that proper removal procedures are used.

Community forest plan element

As part of the green infrastructure component of the master planning process, an evaluation of the community forest should be undertaken. The forest plan element should include the following features:

1) An inventory of existing trees should be made. This need not be an exhaustive task; a map showing roughly the location and type of trees and forested areas will be sufficient to show gaps in tree cover, approximate age and condition of trees in each location, and type of trees prevalent in the community. The Shade Tree Commission and trained volunteers can be of invaluable help in preparing this inventory. See Chapter 3 for more information on community involvement.

2) Based on the inventory map, goals and targets for planting, maintenance, and handling of liability issues should be established. For example, the plan could recommend a no-net-loss target for publicly and privately owned trees.

3) A liability statement should be prepared declaring that the community, through the plan and subsequent ordinances, has taken steps to reduce its risk by managing trees properly. In New Jersey, a state statute gives jurisdictions whose plans include this statement additional protection from liability.

4) All existing ordinances that apply to trees should be reviewed. You will find that trees are already addressed in many ordinances, including those regarding zoning, utilities, and environmental protection.

5) If existing ordinances are found insufficient, new ordinances designed to meet the goals identified above should be proposed and enacted. In the no-net-loss example, an ordinance could be established requiring anyone who removes a tree to replace it.

Compacting soils during the construction process can damage tree roots. Trees in construction zones should be cordoned off to prevent construction equipment from damaging the tree and compacting the soil.

Tree ordinances can help prevent damage caused by urban street trees and protect municipalities from liabilities.

Tree ordinances

Tree ordinances serve a variety of purposes. They protect the community against liability in accidents involving trees. They regulate the planting of new trees to ensure that they will survive and enhance the community's ecosystems. They set up procedures to protect existing trees and ensure proper removal when necessary.

Before writing a tree ordinance, a community should have a forest element as part of its master plan, both to ensure that the ordinance is designed to meet community goals and to evaluate the extent to which current ordinances meet the goals.

Items addressed in other ordinances may be changed to reflect the plan, or they may be incorporated into a new tree ordinance. The following components should be addressed by city ordinances:

1) Tree planting, maintenance, and removal policies for municipal property.

2) Tree planting and subsequent maintenance requirements for new private developments.

3) Permitting procedures for tree removal and requirements for tree protection by utility companies, residents, and developers.

4) Maintenance, removal, and replacement of shade trees in public places and along streets.

5) Establishment of a Shade Tree Commission and related staff (for example, a municipal arborist) to care for trees and oversee the ordinances' provisions.

6) Declaring that dead, diseased, and broken trees are public nuisances and should be removed by property owners.

7) Prohibiting the defacement or topping of public trees.

8) Mandating the protection of trees near construction sites.

9) Defending against negligence and establishing a procedure to handle accidents.

The local government should also prepare to deal with liability issues pertaining to trees. Steps communities can take to reduce their risk are described in Section 4.6.

4.5 Urban Street Trees and Treed Lots

The urban and community forest plays an important role in the urban, suburban, and rural landscape. Trees absorb and intercept rainwater, filter pollutants, and lower urban and suburban temperatures. Selecting the right tree for the right place and proper planting and maintenance are critical to the long term benefits of the urban and community forest.

Benefits of Community Trees

In a study conducted in the Modesto, Calif., the U.S. Forest Service's Western Center for Urban Forest Research and Education found that one shade tree in a yard provides $111 in benefits each year, including:

- $45 worth of air pollution reduction. This amounts to 10 lb. of pollutants — including 4 lb. of ozone and 3 lb. of particulates. The researchers derived the value of this reduction in pollution using the local market price of emission reduction credits. The amount of nitrogen oxides absorbed by the tree is equal to those emitted by a car driven 3,600 miles.
- $30 less summertime air conditioning expense. Shading the building cools the interior air, reducing the yearly air conditioning cost by 9%.
- $6 less local expenditure for flood control and water quality management. The tree's crown intercepts 760 gallons of rainfall, reducing polluted stormwater runoff and flooding.
- $5 in reduced carbon dioxide emissions. The tree removes carbon dioxide from the air directly, and it also reduces power plant emissions by saving energy through natural cooling. The amount of the reduction in CO_2 is equivalent to that released by a car driven 500 miles.
- $25 each year is added to the value of the property. This reflects a 1% increase in property value for a $100,000 home, annualized over 40 years.

The costs? A street tree this size costs $20-$30 per year to maintain, and a large yard tree costs $10 per year in maintenance. The Forest Service researchers also found that $1.89 was returned annually for each $1 invested in maintaining the city of Modesto's 90,000 street and park trees.

(USDA Forest Service 1999)

The importance of tree cover

It is becoming increasingly understood that the loss of tree cover and the increase in impervious surfaces have a direct impact on the amount and quality of stormwater runoff. Trees intercept and absorb rainwater, their roots stabilize soils and prevent erosion, and leaf litter under trees creates an environment for earthworms and other organisms that also help stabilize soils. In addition, trees purify stormwater by absorbing many of the pollutants. Older and larger trees are able to intercept and absorb more water than younger, smaller trees, and groves of trees are healthier and more effective than individual trees.

Urban trees play many important roles in the urban landscape, including mitigating stormwater runoff. Street trees require special care because of factors like compacted soils and lack of microorganisms, higher temperatures, and conflict with human activities that can affect their health.

The impacts of construction

The construction process can be very damaging, depriving trees of three critical elements — oxygen, water and space. Large machinery compacts soils, making root penetration and water movement difficult and depleting oxygen levels. Trenching on construction sites can sever and expose roots, threatening the tree's stability and ability to take in water and nutrients. Other damage from construction includes damage to trunks and branches, allowing entry points for diseases and insects.

Before construction begins, the trees that have been identified for preservation must be clearly marked and segregated from construction with construction tape. All construction activities must occur away from the trees, including storage of construction materials, temporary and permanent roads, and storage of soils.

Urban trees play many important roles in the urban landscape, including mitigating stormwater runoff.

The soils on the remainder of the site must also be protected for future tree planting. A six-inch layer of wood chips can protect the soil from becoming too compacted.

The right tree for the right place

When planting street trees, it is important to select the right tree for the right place. Trees come in all shapes and sizes — columnar, vase-shaped, conical, broad spreading branching, broad upright branching, and broad-oval branching. Root systems can vary almost as much as the branching system. Some trees have strong branches that can withstand high winds and heavy snow; others have weak branches that break easily. Some trees attract pests (aphids, for example), produce berries, or drop twigs, nuts and leaves that could be a nuisance for pedestrians and parked cars. In addition, like humans, trees have a life cycle; they can become diseased and damaged.

Site conditions can vary almost as much as tree types — narrow strips between sidewalk and road, no unpaved spaces between sidewalk and road, broad expanses of open space. Soils can have poor drainage or may drain very well. Above and below ground utilities such as telephone and electric wires and cables and sewer pipes can cause conflicts with trees. Very urban areas with tall buildings can block sunlight on city streets, while parking lot conditions can mimic desert climates.

Community integration of land use planning with street tree planning *and* planting is critical. Because of the wide variety of factors listed above, it highly recommended that a community involve a certified arborist when selecting trees for its city streets and parking lots. In addition to using professionals, many communities have found that involving the community in the street tree planting process can provide a unique educational opportunity, instill a sense of ownership, and help minimize vandalism.

Trees should be added to urban environments with care and protected where they have been planted in the past. A community forest plan helps homeowners and businesses decide where to plant trees that will be most likely to thrive.

The Benefits of Trees

American Forests recently concluded a study in the Puget Sound analyzing vegetation and tree canopy over a 24-year period. During that time-frame, tree canopy declined by 37 percent. The study found that stormwater runoff increased by 29 percent, and the cost of building gray infrastructure to handle the runoff would be $2.4 billion! (Pinkham 1998)

4.6 Trees and Liability

Trees cool the community, provide habitat for birds and small mammals, and remove pollutants from the air. Yet local governments may be reluctant to plant trees because of concerns about liability. Communities can take a variety of measures to reduce their exposure to risk.

Communities should take care of their trees to prevent hazards from developing in the first place.

Typical legal challenges to communities with trees

Communities with trees face two main types of risk:

1) Damage caused directly by trees, for example, falling branches.

2) Injuries resulting from trips and falls on sidewalks that have been buckled by tree roots.

While no community is immune from being named in these types of lawsuits, communities can reduce their exposure to liability by following sound planning and management practices.

Reducing risk from damaged trees

The most important method of reducing liability is to establish clear guidelines for maintaining and replacing trees. The Community Forestry Plan should contain provisions specifying the routine maintenance measures to be undertaken. It should also identify the resources, both public and private, that will be used to perform the maintenance.

Communities should take care of their trees to prevent hazards from developing in the first place. Residents should be encouraged to water young trees and to treat older trees with care and respect. In addition, good maintenance such as pruning and mulching should be scheduled and practiced.

Blighted trees should be removed as soon as possible to prevent the blight from spreading to other trees. The Shade Tree Commission should have procedures in place to ensure that community trees are monitored for hazardous conditions and that work is done promptly to remove hazards (e.g., dead limbs and dead trees).

If the local government lacks the staff needed to perform all these tasks, volunteers from community groups can be recruited. Trees are a point of pride for most residents, and annual tree maintenance makes an ideal service project for civic groups, businesses, and schools.

Some communities choose not to monitor their trees, thinking that what they don't know can't hurt them — that is, when something goes wrong, if they were ignorant of the condition that caused it, they won't be held liable. Needless to say, this is the wrong attitude. As state legislation such as New Jersey's Community Forestry Act, which provides matching funds for local community forestry plans, becomes more prevalent, local governments will have fewer excuses for failing to take action.

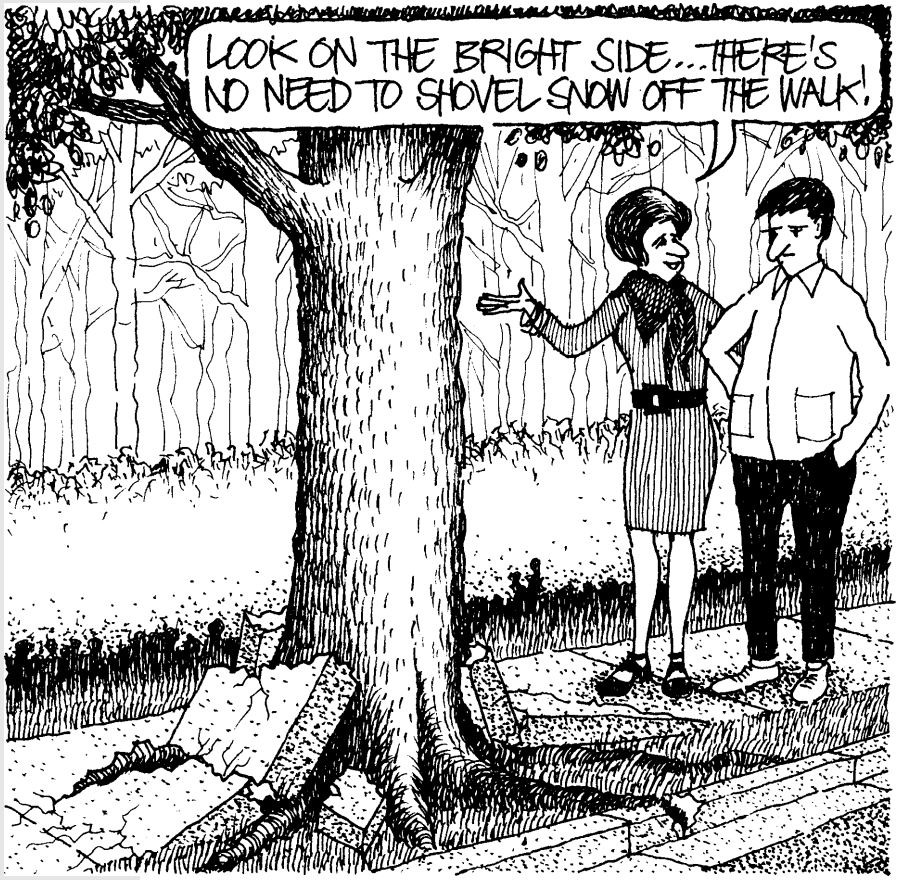
Community groups can work with local government to plant and maintain community trees.

For trees planted inappropriately in years past, actions can still be taken to reduce risk while saving the trees.

Reducing risk from buckled sidewalks

Insurance companies often refuse to insure property owners whose property is crossed by public sidewalks that are buckled by tree roots, believing the owners are likely to be subject to lawsuits. These property owners then call on the municipality to take corrective action.

The most obvious way to prevent lawsuits is to prevent the conditions that precipitate them. This can be accomplished by planting trees that are unlikely to cause sidewalk buckling in the future. The community forestry plan should include a list of trees that are appropriate to plant in each type of location. Different trees' roots grow differently, and planting the right tree can mean a 10- to 15-year difference in the amount of time it takes for the roots to interfere with the sidewalk.



Ultimately, all trees can cause sidewalk buckling once they reach a certain age. Simply planting all trees away from sidewalks is not necessarily the solution — roots can extend near the surface for hundreds of feet.

To encourage roots to remain near the tree, communities can place trees in specially designed soils with air pockets that provide space for the roots to expand into. Also, root barriers can be placed in the ground along sidewalks.

For trees planted inappropriately in years past, or whose roots have behaved unpredictably, actions can still be taken to reduce risk while saving the trees. Sidewalks can be rebuilt and relocated. In rural and low-density suburban areas with little vehicle traffic, paved sidewalks may not be needed and in fact may contribute to decreased water quality. In more built-up areas, tree protection can be incorporated into traffic calming projects such as narrowing streets, in which paved surfaces near street trees are removed.

A buckled sidewalk is a lawsuit waiting to happen. This sidewalk should have been placed farther from the tree. To reduce liability now without removing the tree, the sidewalk could be moved slightly.

Chapter 5

Protecting and Enhancing Water Resources

The green infrastructure that supports our water resources is perhaps most threatened by sprawling land use patterns. Polluted stormwater runoff from paved surfaces flows into our rivers, streams, and lakes. Streams have been piped in urban and even rural areas, destroying the ecology. Through investments and regulations, communities have the tools to recover what has been lost and improve green infrastructure in the future.

5.1 Water Quality and Stormwater Management

*Stormwater management is often achieved by constructing storm drains and detention and retention basins. In developing areas, a number of strategies — such as preserving natural features, retaining groves of trees, utilizing vegetated **swales**, eliminating curbs, and reducing **impervious surfaces** — can be utilized to reduce the dependence on storm drainage systems and to improve water quality. Urban parks and street trees can be used in urban areas to help manage stormwater and improve water quality.*

There is no perfect substitute for the earth's natural ability to absorb water. However, we can alter the way in which we develop to minimize the amount of impervious pavement.

Stormwater runoff

Converting land from meadows and woodlands to buildings, roads, and parking lots reduces the amount of natural land that can filter and absorb stormwater. As a result, **stormwater runoff** is dramatically increased, and ground water recharge is dramatically reduced. Not only does runoff from roads and parking lots collect and concentrate pollutants, but velocity and water temperatures are increased by the paved surfaces that absorb radiant heat.

When it rains, warm, polluted water flows off large paved surfaces such as this parking lot and into nearby streams.

This warm polluted water is quickly deposited into area streams. The pollution and increased temperatures degrade the water quality of the streams, threatening wildlife habitat. The increased velocity and volume further degrades the streams by causing erosion. Other negative impacts include undercutting bridges, which often require large public expenditures to repair.

There is no perfect substitute for the earth's natural ability to absorb water. However, we can alter the way in which we develop to minimize the amount of impervious pavement. Following that, we can change the type of materials we use for our roads and parking lots. And finally, we can design engineered systems to mimic nature.

On-site stormwater management

In most states, stormwater runoff is required to be managed on site. This management usually consists of building curbs, gutters, and detention basins. This gray infrastructure increases construction costs and addresses only one issue — stormwater runoff. A variety of techniques can be used to reduce the amount of runoff and therefore reduce the need for gray infrastructure. These alternatives have the added benefit of achieving more than one goal.

An obvious way to reduce runoff is to minimize the amount of impervious cover on a site and in a region. Although low density land use patterns may appear to have large amounts of green infrastructure, this land use pattern actually significantly contributes to the amount of stormwater runoff due to increased road miles, wide streets, and numerous parking lots.

Daylighted streams are effective in controlling downstream flooding and can be a key element in a regional drainage and water quality system.

Another relatively simple way to mitigate stormwater runoff is to reduce the connectivity of the impervious surfaces. Contiguous areas of impervious surfaces allow runoff volumes to build, and this runoff is eventually channeled into one detention basin. Breaking up impervious surfaces with vegetated areas allows some of the runoff to be absorbed. For example, runoff from roofs can be channeled to vegetated areas rather than to streets and parking lots. Vegetated swales can border roads; tree islands and vegetated strips can break up parking lots. The following sections have more detail about techniques that can be used to reduce the dependence on gray infrastructure to manage stormwater runoff.

Daylighting streams

In the past dumping sewage and other waste into our streams and rivers was commonplace. In urban areas, creeks and small rivers were channeled underground; stormwater and sewerage overflow were channeled into them. In the 1970's, Federal regulations were passed to clean up our waterways; today, many of our rivers and streams are supporting fish habitat and are considered a valuable economic development and natural resource. However, little has been done for those water bodies that were channeled underground.

Even in dense urban areas, daylighted streams can bring natural habitat back into the city, to the benefit of plants, animals, and humans alike.

Today, some urban public works departments are beginning to realize the many benefits of restoring streams to a more natural state. This practice has become known as **daylighting**. It involves locating underground streams and removing the pavement to restore the stream, or a portion of the stream, to resemble its former condition prior to development. Restoring streams can be an involved project requiring hydrologists, engineers, biologists, and planners. Heavy equipment is required to remove pavement and help relocate the streambed. After a stream has been exposed, the banks and stream corridor must be planted with suitable plant material to stabilize the banks and provide habitat for aquatic life. Tree planting along the stream corridor can contribute to a healthy stream by providing shade, erosion control, and nutrient and pollutant uptake.

The benefits of daylighting can easily outweigh the initial costs of restoration. Daylighted streams are effective in controlling downstream flooding and can be a key element in a regional drainage and water quality system. Daylighting streams removes them from combined sewer overflow systems and frees up sewer capacity. Finally, they can become an economic development asset to the community, providing a community focal point as well as recreational opportunities.

Seattle, Wash., recognizes the value of daylighting and protecting streams to control flooding and improve water quality. Seattle Public Utilities is currently launching an effort to restore three streams as part of the city's stormwater drainage system. The project includes improving drainage and constructing detention ponds to reduce downstream flooding and to use for irrigation during the summer. The urban forest will be replanted in stream corridors to control erosion, stormwater detention ponds will be redesigned to be more effective during small storms and provide trails and picnic areas, and culverts will be modified to allow fish to pass through.

Stream restoration projects can be done in conjunction with schools and other community groups and can be incorporated into a regional greenway system. Each of Seattle's projects includes an educational component, and many of the projects involve citizens and volunteers.

5.2 Water Resource Protection Tools for Local Government

Local governments can do much to encourage landowners to preserve and enhance green infrastructure, even on property that is already developed. Stricter requirements can be set for pesticide use and stormwater management, and regulations can be used to protect stream corridors and steep slopes.

...flooding caused over $2 billion in damage in 1998. Many of these losses could have been averted had local governments acted to protect streams and steep slopes — "critical areas" that serve as natural protection against environmental disasters.

Stream buffer ordinances

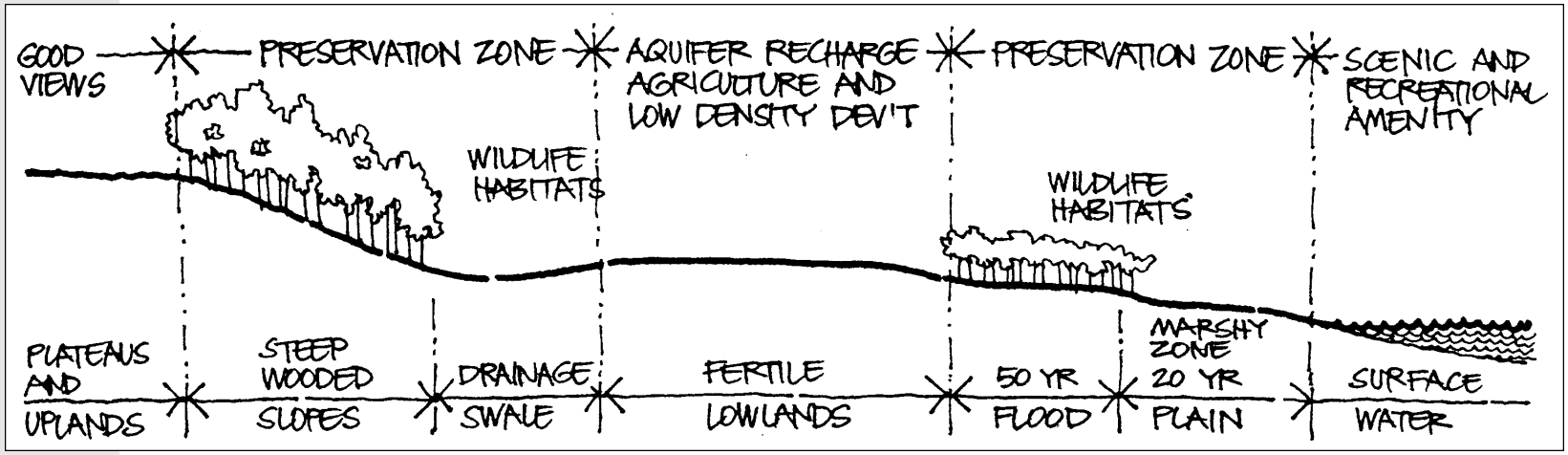
Vegetated buffers between streams and parking lots can filter pollutants and reduce the volume of water running off the parking lot into the stream.

Many communities protect stream corridors with ordinances mandating undisturbed buffer zones between streams and the developed areas of a site. Typically, these buffers extend 100 feet from the top of the stream bank, although many variations exist — for example, the ordinance in Mendham, New Jersey, requires differently sized buffers depending on whether the stream is present year-round or is only intermittent. Moorestown, New Jersey, meanwhile, mandates protection of the stream channel, its associated floodplain, and a 25-foot corridor beyond that.

Critical area zoning

Green infrastructure can protect not only the habitat of plants and animals, but also that of humans. According to the National Weather Service, flooding caused over $2 billion in damage in 1998. Many of these losses could have been averted had local governments acted to protect streams and steep slopes — "critical areas" that serve as natural protection against environmental disasters. Too often, inappropriate development is allowed in these areas.

Critical area zoning is one method that can be used to protect slopes and flood areas. Several townships in New Jersey have adopted various forms of density adjustment in critical areas. One method is the "density adjustment factor" — a multiple by which



the normally allowed density in a zone is multiplied to ascertain a reduced density for critical areas. For example, if the normally allowed density were 4 units per acre and the multiple were 0.25, the net allowed density would be 1 unit per acre. This type of zoning can be implemented as an overlay on top of existing zoning.

Various alternatives to density reduction methods exist. Many communities restrict the amount of impervious surface that may be constructed on steep slopes and in floodplains. An example is Mendham, New Jersey's ordinance. As steepness increases, the amount of allowable impervious surface drops from 25 percent impervious at a 15 percent slope to 15 percent impervious at a 20 percent slope to 5 percent impervious at a 25 percent slope.

Savings from critical area protection

Because critical area protection preserves natural flood control devices such as vegetation and wetlands, it provides an alternative to constructing expensive, habitat-destroying (and often ineffective) dams and dikes to control flooding.

Traditional approaches to natural hazard mitigation have emphasized gray infrastructure. Using green infrastructure to accomplish the same tasks can save a significant amount of money — in one instance in Massachusetts, the state, local, and federal governments together saved $90 million by acquiring wetlands to serve as a natural storage area rather than building a dam.

Pesticide and fertilizer use restrictions

In recognition of the importance of preventing polluted runoff from reaching ponds and streams, communities are increasingly placing restrictions on the use of pesticides and fertilizers on lawns. In Jefferson Township, Morris County, New Jersey, fertilizers may not be applied within 10 feet of a water body or on frozen ground. Also, fertilizers containing phosphorus are banned altogether.

Critical area protection provides an alternative to constructing expensive, habitat-destroying (and often ineffective) dams and dikes to control flooding.

Failing to protect flood zones and stream buffers can have costly results for public and private investment.

5.3 Critical Area Protection: Wetlands

All open space is not created equal — indeed, some open space, such as wetlands, is of critical importance to the functioning of entire regional ecosystems. The federal government exerts permitting authority over most wetlands through the Army Corps of Engineers. Many federal programs are intended to help communities enhance and maintain wetlands.

Wetlands remove chemical and organic wastes from stormwater runoff and from floodwaters, and they can expand temporarily to store floodwaters until there is sufficient downstream capacity to absorb the excess flow.

Wetlands: What are they, and why are they important?

A **wetland** is a marsh, bog, swamp, or any similar area that is frequently saturated with water to such an extent that it supports vegetation adapted to environments that are frequently waterlogged. Wetlands exist everywhere, and they are vital to maintaining life.

Wetlands are nature's richest source of plant material that animals use for food. When the stems and leaves of plants growing in wetlands decompose in the water, they create enriched organic material that is the primary source of food for fish. Indeed, for many animals and plants, wetlands are the only type of habitat in which they can survive. In coastal areas, fish use wetlands as spawning grounds; in inland areas, birds and freshwater fish use wetlands as nursery areas for their young, while mammals use them for food and shelter.

Of at least as much importance as their habitat value is the role of wetlands in improving water quality and protecting against floods. Wetlands remove chemical and organic wastes from stormwater runoff and from floodwaters. In addition, they can expand temporarily to store floodwaters until there is sufficient downstream capacity to absorb the excess flow. This prevents downstream erosion and flood damage. (Of course, wetlands can be overwhelmed by excessive pollution and flooding; that's one reason they need protection!)

Wetlands include marshes, bogs, swamps, and other areas that support vegetation adapted to waterlogged environments.

How can wetlands be damaged?

Human activities can hamper the effectiveness of wetlands in providing habitat for wildlife and treating pollution. The most obvious way in which humans damage wetlands is by filling them in. Until the mid-20th century, wetlands were generally regarded as wastelands, and as a result many were filled, particularly those near urban areas. Today it is recognized that wetlands have value, but filling continues; 290,000 acres of wetlands were filled each year from the mid 1970's to the mid 1980's.

Wetlands also suffer serious harm when they experience sedimentation, which occurs when runoff consisting of large

amounts of dirt and mud, such as that from construction sites, enters the wetland. This runoff leads to an increase in algae and other top-growing plants, but decreases the amount of bottom-growing plants and the animal life that depends on them.

Federal wetlands permitting and local regulations

Because wetlands are so important, the federal government has imposed regulations on development in wetlands. Any public or private entity must receive a permit from the Army Corps of Engineers to dredge or fill a wetland of more than ½ acre. Permits are granted based on three general criteria: the relative extent of public and private needs; the practicability of alternatives to accomplish the purposes of the project; and the extent and permanence of the effects of the project on other potential uses of the area. In addition, any proposal found contrary to the public interest will not be granted a permit. Even so, almost everyone who applies for a federal permit to fill wetlands is granted one, and filling of small wetlands does not even require that the Corps be notified.

These regulations give local governments a boost in protecting green infrastructure, of which wetlands are a crucial part. But there is much that local governments should do to complement the federal role in wetlands protection.

To emphasize the importance of wetlands, zoning ordinances should contain provisions to protect wetlands from development, just as they often restrict development in flood hazard zones. The allowed density in wetland areas can be reduced through critical area zoning (see Section 4.5 for information on how this works). Zoning regulations allowing cluster development can also help save wetlands by allowing builders to concentrate development on upland areas of sites.

Of at least as much importance as local regulation is local enforcement. Both paid staff and volunteers from local civic and environmental groups are needed to monitor construction sites to ensure that wetlands are not being filled or loaded with sediment. All municipal staff who regularly work in the field should be trained to identify and report wetlands violations.

Protecting wetland buffer zones

Communities can take a significant step toward protecting wetlands by protecting the "buffer zones" that form a transition area between wetlands and uplands. These transition zones typically have high water tables. Lowering the water tables to accommodate development reduces the amount of water in the adjacent wetland. Buffers also block sediments from reaching wetlands. Further, they serve as habitat for animals that reside in both wetland and upland areas. In areas with uplands that have been converted to development, protection of buffer zones is crucial to maintaining ecosystem health.

Local governments can protect buffers — and, by extension, wetlands — by establishing setbacks for wetland areas in which no development is allowed.

Local governments can protect buffers — and, by extension, wetlands — by establishing setbacks for wetland areas in which no development is allowed. The size of the buffer needed depends on the type of wetland and the goals of buffer zone protection. Smaller buffers are needed to protect water quality, for example, than to preserve wildlife habitat. Marshes typically require smaller buffers than do cypress or hardwood swamps.

None of this is to say that uplands should not be protected as well — but the reality is that development, whether it be agricultural, urban, or suburban, does the least harm to ecosystems in upland areas. Conservation of a network of upland areas, described elsewhere in this chapter, will ensure that upland habitat for plants and animals remains.

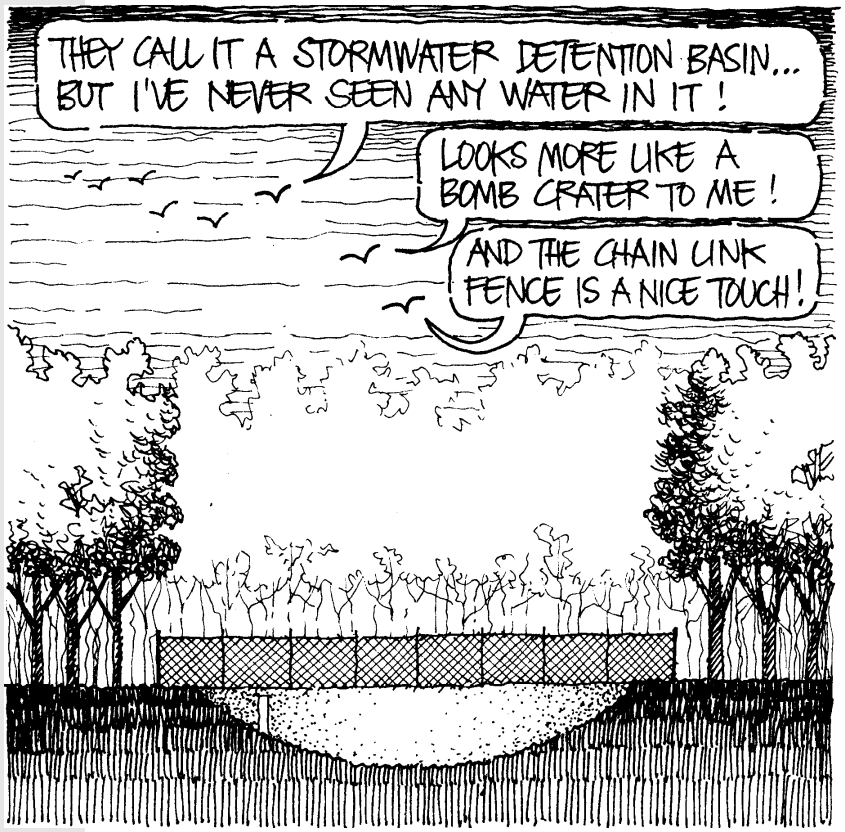
5.4 Swales and Basins

Managing stormwater runoff with on-site detention basins often requires altering natural features by cutting trees and regrading the site. Once constructed, these basins serve only one purpose: stormwater management. There are, however, ways to construct basins to perform multiple functions by providing biodiversity, creating habitat, and aesthetically enhancing the site.

An increasing body of evidence shows that to be effective stormwater management must be addressed at the regional (watershed) level.

Vegetated swales

One of the best ways to manage stormwater runoff is through **infiltration systems**. As mentioned earlier, curbs and storm drains channel and accelerate water flow into area streams, eliminating the possibility for water to infiltrate into the soil and recharge groundwater. Eliminating curbs and designing vegetated **swales** along residential streets can reduce velocity and pollutant loads as well as provide an opportunity to recharge groundwater.



Swales should be designed to have a very low velocity, allowing the stormwater to collect and infiltrate into the soil over time. The topography and the type of soils in an area will determine how the swale is designed. For example, **ponding** or check dams may need to be constructed at various intervals to slow the flow of water. Ponding time should be limited to 24 hours in order to maintain healthy vegetation.

In 1998 the Environmental Protection Agency awarded the Howland Swale™ the Environmental Technology Innovation Award for its ability to duplicate the pollutant removal capability of nature. The swale system uses plants and soils to remove pollutants from runoff. The elongated swale holds the same amount of runoff as a detention basin designed for a 100-year storm event. The swale is planted with extraordinary wetland plants to allow for greater storage of water. The plants uptake water, increase filtration capacity, and require less maintenance. (The Howland Swale™ is a copyrighted and patented design of Environmental Research Corps).

Detention basins

The requirement to manage stormwater on site was first conceived to prevent subsequent flooding downstream of the developed area. Traditionally, the approach to on-site stormwater management was achieved through a series of curbs, storm drains, and **detention basins**. Recent storms and the higher frequency of flooding demonstrate that this method of on-site management is

failing. An increasing body of evidence shows that to be effective stormwater management must be addressed at the regional (watershed) level.

In many cases, constructing on site detention basins requires destroying natural features. All too often, trees are clear-cut, the land is regraded, and detention basins are built to manage the site's stormwater runoff.

More often than not, these basins are large depressions that are planted with turf grass and serve no purpose during dry periods. They are prominently located, usually at the gateway to a residential neighborhood or entrance to commercial establishments. Their unsightliness is compounded by the practice of erecting chain link fences around them. Not only are they eye sores and perform only one function, but they often act as barriers to pedestrians and wildlife.

There are, however, ways to construct basins to perform multiple functions and aesthetically enhance sites rather than detract from them. One innovative way to "hide" an ugly detention basin is to construct a reservoir under the site's designated parking area. This has been done successfully at Smith-Kline Beecham's headquarters in Philadelphia. By combining the parking and stormwater management in the same space, other areas of the site are allowed to remain in a more natural state.

Including vegetation in the design of detention basins can help achieve a variety of goals. When properly designed, vegetation can help maintain soil's porous structure, allowing water to infiltrate the ground. The root system of the vegetation can absorb some of the volume of the stormwater as well as act as a filter for pollutants, thus improving the quality of the stormwater runoff. Basins with a variety of plant life eliminate the monoculture phenomena, creating a habitat for some wildlife such as birds. Finally, by adding vegetation and eliminating chain link fences, the aesthetics of the site are enhanced, potentially increasing property value.

Detention basins planted with wildflowers or trees are less costly to maintain and do a better job of improving water quality than turf grass.

Wet detention basins planted with appropriate plant material can improve the look and function of the basin.

Detention basins planted with wildflowers or trees are less costly to maintain and do a better job of improving water quality than turf grass. In Mercer County, New Jersey, annual maintenance cost of traditional turf grass detention basins range from $175 - $860 per acre. Turf grass maintenance requires fertilizers and pesticides as well as frequent mowing. The fertilizers and pesticides applied to detention basins can be conveyed by stormwater and wash into creeks and streams. Fertilizer applications are not recommended for wildflower plantings because they encourage weed growth. Depending on flower types, minimal maintenance consisting of mowing once or twice a year is all that is required once the wildflowers have been established.

A variety of wildflowers attracts a variety of wildlife such as insects, butterflies, birds, and small animals. Adding bird and butterfly houses in the vicinity can also encourage wildlife. Once a barren monoculture basin has been converted to a wildflower or wetland area, it can become an asset to the community by providing educational opportunities for bird and butterfly watching.

A Reservoir Under a Parking Lot

Cahill and Associates and Andropogon and Associates designed a reservoir for stormwater runoff under a parking lot at Smith-Kline Beecham's research headquarters outside Philadelphia. The underground "detention basin" satisfied and exceed requirements for the site's stormwater management. This design eliminated the need for a stormwater detention basin and allowed Smith-Kline Beecham to conserve natural features on the site that would otherwise have been converted to a detention basin.

5.5 Porous Pavement and Parking Lots

The greater the impervious cover, the greater the stormwater runoff and water quality degradation. Commercial sites and office parks typically have the largest percent of impervious coverage. In addition, parking lots in these areas are often under-utilized.

Trees can be planted in planting islands between parking spaces and at the end of rows in pop-outs at corners. Tree wells and planters can be used to retrofit existing parking lots.

Shared parking

Reducing the amount of land used for parking and redesigning parking lots to incorporate trees can mitigate runoff and its pollutant loads. Addressing a community's parking demands should be part of an overall planning process. Development patterns that reduce dependence on the automobile by integrating land use types, including pedestrian amenities and supporting public transportation, will reduce the need for parking lots. Many developed communities support the concept of **shared parking** as a way to reduce the need to build additional parking. Shared parking is the practice of two or more businesses or land use types that are in the same vicinity and have different parking "peak periods" sharing their spaces. For example, a church and a school could potentially share the same parking lot because their hours of use are usually different. Establishing a parking authority could help to evaluate and coordinate a community's parking. In addition, communities may want to consider passing ordinances to establish parking minimums rather than requiring maximum parking spaces.

Parking lot design

In addition to reducing size, parking lots can be redesigned to incorporate tree plantings to reduce the amount of stormwater runoff. Trees on the periphery of parking lots can be preserved prior to construction; if none exist or preservation is not possible, they can be planted after construction. Trees can be planted in planting islands between parking spaces and at the end of rows in pop-outs at corners. Tree wells and planters can be used to retrofit existing parking lots. Parking lots with a tree canopy have the added benefit of reducing summer temperatures.

Porous pavement is an under-utilized, but effective, material in reducing stormwater runoff. Porous pavement is similar conventional pavement except that it allows water to infiltrate the ground below. Structurally, porous concrete and asphalt are as good, if not better, than conventional pavement and can be used for parking lots, driveways, and highways. Porous pavement can be used in almost all conditions where soils are permeable.

Porous pavement is slightly more expensive, but because it allows stormwater to infiltrate, the size of the storm drainage system can be significantly reduced. By reducing stormwater volume, downstream impacts are also mitigated, saving public dollars from repairing damage from erosion and **sedimentation**.

Eliminating the curb or providing curb breaks in this parking lot would allow runoff to be filtered by this vegetated buffer.

More public dollars can be saved in areas that require snow removal. Snow on porous pavements tends to melt and drain into the soil below.

Another under-utilized method of reducing impervious cover is to use **open-celled pavers** in areas that may need structural support but are not often used, such as overflow parking lots. Grid or open-celled pavers are interlocking pavers that have open areas filled with porous aggregate or topsoil and then seeded. These pavers allow water to infiltrate the soil and have the added benefit of not contributing to the urban heat island effect.

Roadway design

Most suburban roads are over-engineered and over-built. Even though most residential streets are low volume, most zoning ordinances call for 40 foot street widths and the associated wide turning radii. The justification for these standards is to accommodate emergency vehicles like large fire trucks. Although providing access for emergency equipment is necessary, not all portions of streets need to be designed to maximum standards. Travel lanes can be designed with reduced widths, while the edges or shoulders can be paved with porous turf blocks which provide the structural support needed for large, heavy equipment, while at the same time allowing stormwater to infiltrate the soil.

Although providing access for emergency equipment is necessary, not all portions of streets need to be designed to maximum standards.

Many suburban streets are over-engineered for the small amount of residential traffic they receive.

Stormwater Runoff Facts

A one inch rainfall on a one-acre paved parking lot produces 16 times more runoff than a one-acre meadow. The runoff from the meadow would fill an average office to a depth of 2 feet (218 cubic feet); the runoff from the parking lot would fill your office and the two offices next to it. (Scheuler 1994)

Pavement is often not needed on little-used surfaces.

Chapter 6

The Players in Green Infrastructure Planning

Everyone has a stake in the community's green infrastructure, because everyone's quality of life is affected by the condition of the ecology. Educated volunteers are willing to do their part to help the community preserve and enhance green infrastructure, from planning to monitoring to maintaining. The planning commission, shade tree commission, and environmental commission have key roles to play as well. In addition, local government staff, such as arborists and environmental planners, bring important perspectives and technical expertise to the planning process.

6.1 Building Partnerships within the Community

Creating and implementing green infrastructure plans take everyone's cooperation and goodwill. Local governments serve as the linchpin in this needed cooperation, bringing all stakeholders together: residents, businesses, institutions, and organizations. Plan implementation requires funding and cooperation from all these organizations, as well as from local government in the form of tax revenue and federal grants.

By serving as leaders in the green infrastructure planning process, governments can encourage citizens and businesses to become involved in the process. Their involvement is the key to effective planning and implementation.

How local government can facilitate stakeholder involvement

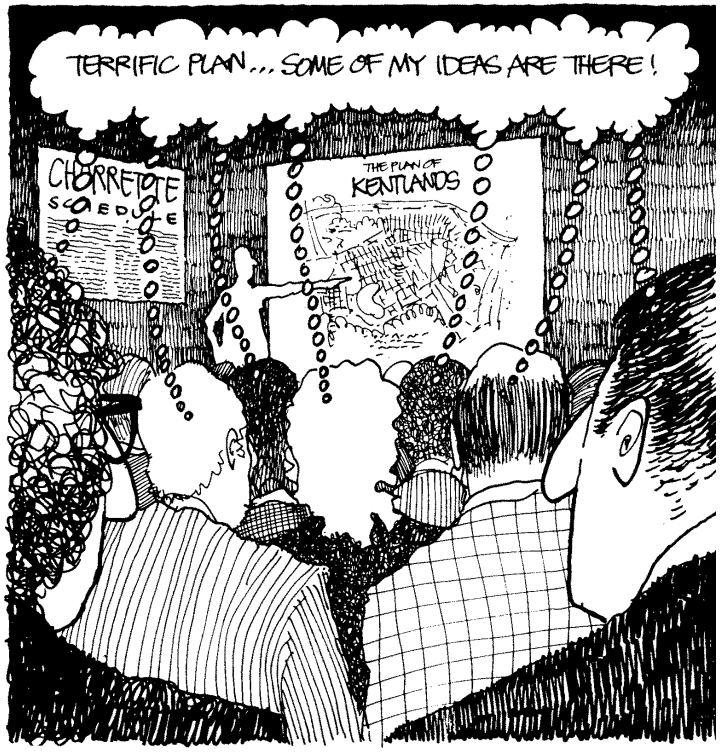
Since the first officially sanctioned local planning commissions were formed in the early 20th century, local governments have taken the lead in planning. Just as they plan for gray infrastructure, local governments should take primary responsibility for preparing stream management plans, tree planting and maintenance plans, and other plans relating to green infrastructure.

Local governments bring everyone in the community together: residents, businesses, institutions, and activist organizations. Local governments also typically lack the staff needed to prepare thorough plans and to follow through on those plans. By serving as leaders in the green infrastructure planning process, governments can encourage citizens and businesses to become involved in the process. Their involvement is the key to effective planning and implementation.

When constituents actively support plans, those plans are much more likely to be implemented. Particularly for green infrastructure, public involvement also reduces costs because citizens, businesses, and other organizations are often willing to take on tasks that would otherwise have to be performed by paid municipal staff. *Local government should provide guidance, leadership, and expertise, but much work can and should be done by volunteers.*

Setting goals and targets. Both citizens and environmental organizations will want to have input at this stage in the process. Citizens are often motivated by a desire to improve conditions in their neighborhoods. Trees may be dying, streams may be polluted, a nearby forest may be threatened by development, or the presence of wildlife (such as deer or bears) may be growing. Environmental groups may be concerned about the loss of particular open spaces, or by air and water pollution in the community. All these groups will want to ensure that the community-wide goals and targets encompass their own goals and targets.

Creating tools to achieve the targets. This stage is the "meat" of planning, where specific regulations and capital investments are floated as proposals. This stage is often where those who ignored the goal-setting stage become interested and



bring new issues to the table. To minimize this problem, every effort should be made to involve all stakeholders from the beginning.

Residents should be brought into the community-wide planning process, in addition to that for their own neighborhoods. This will give them a sense of perspective and an understanding of the trade-offs that must be made in governance.

Plan implementation. This is the stage at which volunteers are vital. Businesses can provide funding for tree planting and maintenance. Residents and community groups can be encouraged to participate in the maintenance of the trees on their street and to plant trees in their own yards. Planting trees properly and in the proper place is especially crucial at this stage. Cynicism is bred when trees fail to thrive, and must be removed after a few years because of interference with utilities or buildings, or are destroyed by vandalism. That's why green infrastructure volunteers must be educated about proper tree planting and maintenance procedures.

Putting together shade tree and environmental commissions to oversee maintenance and recommend further steps for implementation is also important at this stage. The commissions give citizens an official voice in the tree bureaucracy and create a liaison between municipal staff and private organizations.

Shade tree and environmental commissions give citizens an official voice in the tree bureaucracy and create a liaison between municipal staff and private organizations.

Stakeholder groups

Residents have an obvious interest in green infrastructure because they are most affected by it. The trees in their neighborhood help define their sense of place. Stormwater treatment systems built because of regulatory requirements become part of their landscape. They expect to be able to use preserved areas for recreation. They experience floods, erosion, and other consequences of inappropriate development. Their health benefits directly from improvements in groundwater and surface water quality.

In the 1800's and early 1900's, residents did not expect to have a voice in policies affecting development and conservation. If they felt their environment was aversely affected by government or industry, for the most part they accepted it and suffered quietly. That is no longer the case. Today, citizens expect that they will have a real say in the planning process, and they expect that when they complain about a problem, it will be fixed. In short, they expect an unprecedented level of accountability from government. Public officials ignore citizen demands for real involvement at their peril.

Businesses. The support of local businesses for a green infrastructure program is essential to its implementation. Developers in particular have an important role to play in implementing green infrastructure because green infrastructure regulations have a direct impact on their activities. Rural and suburban communities can encourage tree planting on property owned by private businesses. Also, their corporate campuses can be a vital part of community green infrastructure. Rather than the standard grass lawns, campuses can incorporate meadow and forest elements to provide habitat for a wider range of species and reduce the amount of summer watering needed. Businesses can also take small steps to improve habitat; they can set up nesting boxes for birds, create shrubby areas to provide hiding and nesting places, and plant a greater variety of trees and other plants.

In addition, businesses can educate their employees about ways they can help improve green infrastructure. Employees can be encouraged to use more environmentally friendly lawn management practices, to plant trees, and to take similar steps.

Institutions. Schools, libraries, and churches can play a special role in improving green infrastructure. Like businesses, these organizations own and maintain land, and their management practices can set an example for the rest of the community. In addition, schools could be used to educate young people directly about the importance of green infrastructure. As they learn about ecology and natural systems, pupils could be taught actions they could take as individuals to enhance their community's green infrastructure, in addition to actions the community needs to take as a whole.

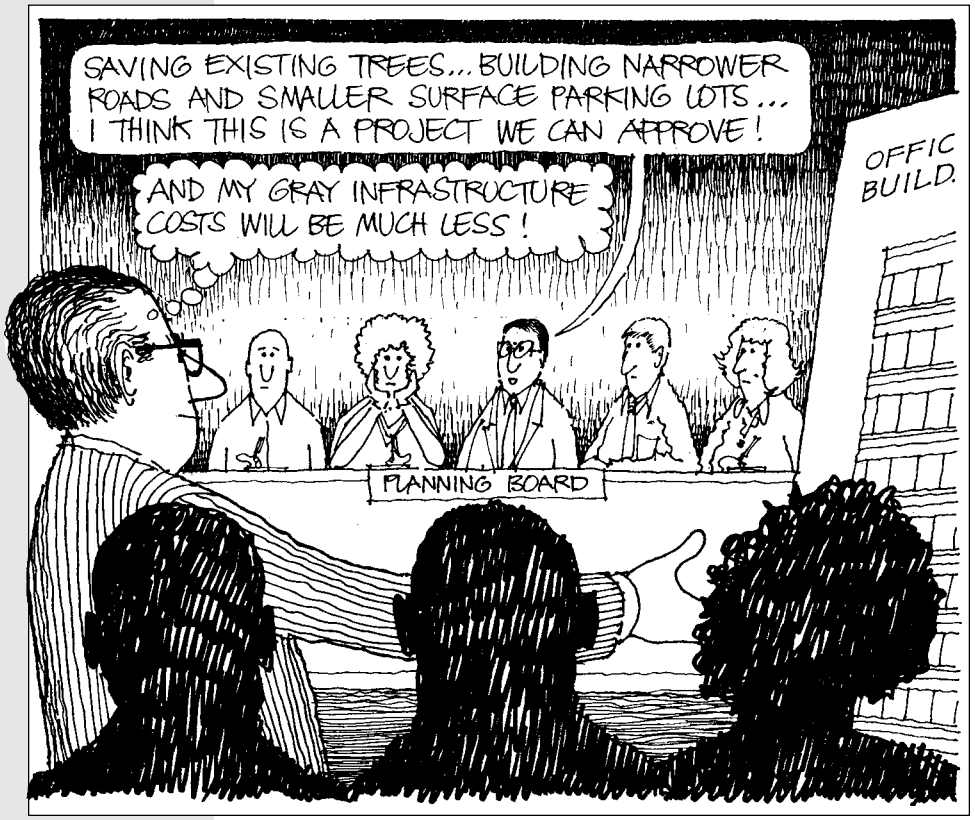
Organizations. Clubs and organizations, including youth clubs such as 4-H and Boys' and Girls' Clubs, are a major source of grassroots support for green infrastructure. Youth groups in particular are ideal places to encourage children to do their part for their community's environment. Local tree and environmental organizations are another obvious source of involvement; their input should be sought when developing a green infrastructure management plan, and they also form a source of volunteers for tree planting, monitoring, and maintenance.

6.2 The Role of Boards and Commissions

As part of the planning process for green infrastructure, both new and existing boards and commissions made up of citizen representatives have an important part to play. Because planning for green infrastructure is not mandated by higher levels of government, a successful green infrastructure program must be a citizen-directed process.

Local governing body

Although the task of for preparing and implementing plans will rest primarily in the hands of citizen bodies such as the planning commission and various other commissions, ultimate responsibility for caring for green infrastructure belongs to the city council (or town council, board of aldermen, county commission, etc.). Because this body controls the local government's purse strings, it can ensure that green infrastructure receives a high priority. This body provides major support for green infrastructure by ensuring adequate funding for planning, shade trees, and environmental commissions, as well as their paid staff.



Planning commission

It is vital that green infrastructure be considered an essential part of the planning process. As the main advisory body to local government on planning matters, the planning commission must make green infrastructure a priority. Planning commission members have primary input on master plans and new ordinances. The importance they attach to green infrastructure has a direct bearing on the degree of effort the community puts into maintaining and enhancing natural systems.

Planning commissions need good information on current local conditions and future goals for the community. To help them collect and evaluate this information, they should turn to other boards and commissions, as well as professional staff.

Because they work closely with the elements of green infrastructure, shade tree and environmental commission members provide valuable insight about environmental conditions. Members of these commissions should be included in discussions on master plans and ordinances pertaining to trees and environmental regulations.

Shade tree commission

A **shade tree commission** should oversee the municipality's planning for and maintenance of its urban trees. Representatives of a variety of constituencies who are affected by tree policy

It is vital that green infrastructure be considered an essential part of the planning process. As the main advisory body to local government on planning matters, the planning commission must make green infrastructure a priority.

should serve on commissions — environmental organizations, utility companies, real estate interests, the construction industry, neighborhood groups, and concerned citizens should all be represented. Broad-based representation ensures balanced recommendations that will be realistic and widely accepted.

Shade tree commissions are typically responsible for all trees on municipal property and in municipal rights of way (including street trees). They ensure that tree ordinances are being carried out faithfully, are intensively involved in master planning for trees, and work with citizen groups to protect trees. Indeed, community involvement is central to the idea of a shade tree commission; close ties to community members who are active in protecting (and cutting down!) trees make the commission's role an invaluable one.

In addition to their planning roles, shade tree commissions encourage tree planting (and teach planting methods that increase the chance of survival), educate citizens about caring for trees, and respond to complaints about nuisance trees and violations of tree ordinances.

Environmental commission

An **environmental commission** is similar to a shade tree commission, but its realm of influence is air and water quality and habitat preservation rather than only trees. As with shade tree commissions, environmental commissions should include representatives of a spectrum of the community: real estate interests, environmental groups, neighborhood groups, other citizens, and representatives of business and industry. It can also be useful to have knowledgeable experts, such as university professors who specialize in environmental policy, on the commission.

Like the shade tree commission, the environmental commission oversees the writing and enforcement of ordinances, participates in master planning, and serves as a liaison between citizen groups and the municipal government. Because most environmental regulations are written at higher levels of government, the environmental commission also serves a vital role in educating the community about state and federal requirements. Examples of roles played by the environmental commission include the following:

- Ensuring that the municipality and other levels of government enforce stormwater management rules.
- Advising the planning commission on open space and urban forest management plans.
- Working with businesses and government agencies to resolve local environmental conflicts.
- Participating in the planning process to encourage protection of groundwater, preserve and rehabilitate surface water, and reduce air pollution.
- Advocating for community recycling

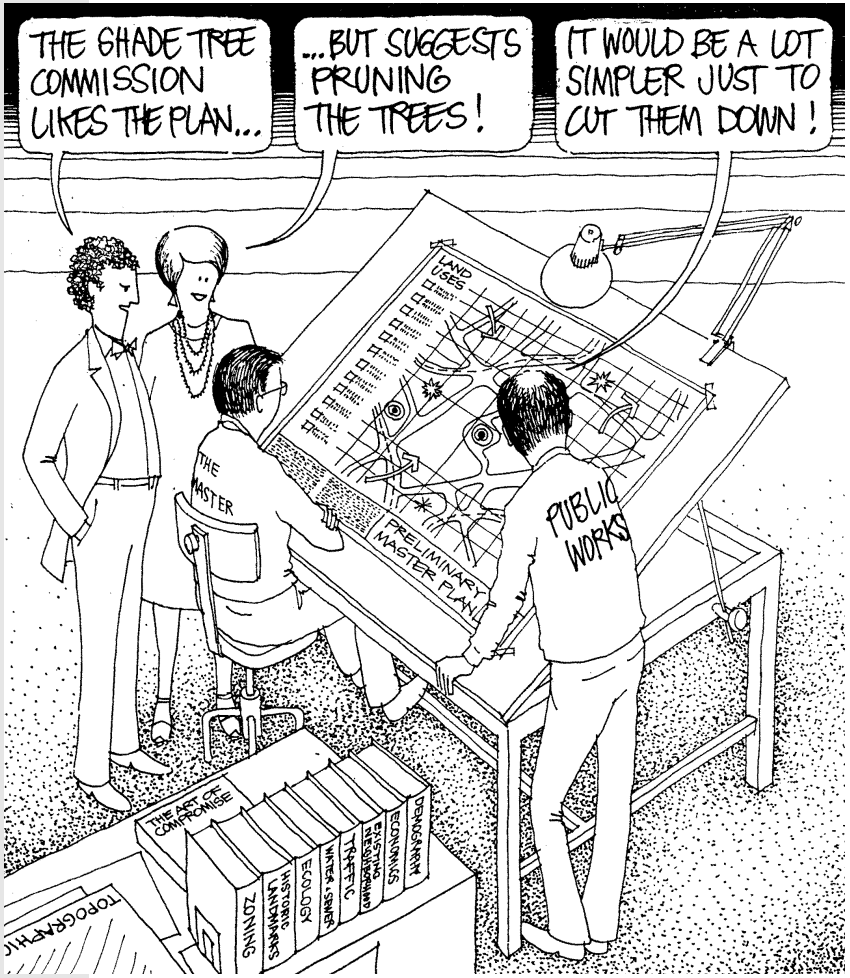
The role of training and volunteer advisers

Working together, the planning commission and shade tree and environmental commissions ensure a strong citizen voice in the planning process. At the same time, they should be augmented by professional staff (as described in the next section) and advisers, as well as training for members. To be effective, commission members must have the tools and knowledge needed to make decisions regarding trees and the environment.

Ideally, some members of the shade tree and environmental commissions will have prior experience in and knowledge of arboriculture and the environment. Such members could be biologists, environmental scientists, foresters, and planners in the community. However, this level of expertise is not always possible in reality. Assisted by advisers and professional staff, shade tree and environmental commissions should draw up a training program for new members. The program should include training in the roles of the commission and the basics of tree and environmental management.

6.3 Professional Staff and Consultants

Local governments should hire staff members who possess an understanding of green infrastructure and who are empowered to enforce regulations and work with developers, residents, and institutions. Both planners and arborists are needed in communities that wish to preserve their green infrastructure.



Urban forestry staff

Having municipal staff who understand and are responsible for the community's trees is important for several reasons. First, even if the community expects to rely largely on volunteers for maintenance and expansion of its tree stock, it is important to have at least one staff member with the expertise needed to direct tree planting and pruning.

Second, staff provide protection against lawsuits. Lawyers and insurance companies inevitably target local governments when accidents involving trees occur. When these situations arise, it is essential to have a staff **arborist** or engineer who can provide expert advice to the government's legal counsel.

Finally, shade tree commission members often lack the expertise needed to understand how to plant "the right tree in the right place." Professional staff can provide this knowledge. When the community prepares its forestry plan, staff provide the knowledge and experience needed to prepare maintenance plans and ensure proper tree planting.

Some communities have relied on public works staff with little knowledge of the needs of trees to maintain their urban forests. This practice has resulted in the loss of many trees to improper practices such as topping, which leads to the added expense of replacing trees. Urban forestry staff should understand trees' functions as part of the broader ecosystem. They should know how trees can be used to provide habitat for insects and birds, to provide shade and reduce urban temperatures, to absorb pollutants, and to protect against erosion and flooding.

Rather than having a narrow focus on keeping trees out of the way of utility lines (and lawsuits), tree management staff should take a holistic approach to tree management. They should talk to

Some communities have relied on public works staff with little knowledge of the needs of trees to maintain their urban forests. This practice has resulted in the loss of many trees and the added expense of replacing trees.

the community's planning staff and planning commissioners and understand planning practices as well as forestry practices. Urban foresters should have a thorough knowledge of the community. They should know its physical layout and have an understanding of its gray infrastructure — its streets, sidewalks, and utilities.

Environmental planning staff

Just as the community needs an urban forester with some knowledge of planning, so does it also need planners skilled in environmental preservation. The traditional emphasis in local planning has been on social issues, land use, and transportation; as a result, local planners have often received little training in environmental issues. Planning commissioners, too, often lack knowledge in this area.

Hiring a staff member with experience and expertise in water resources management, wildlife management, forestry, and the health sciences brings a different perspective to the planning process. Having a source of such knowledge on the staff helps to integrate a concern for green infrastructure into planning.

The traditional role of environmental planners is guarding citizens' lives and property against pollution and natural disasters. In addition, as our understanding of ecology improves, environmental planners are increasingly called on to protect natural systems from degradation. For example, the natural flooding of many rivers is essential to regenerating the ecosystems around them. Periodic flooding and shifting of the river course enriches the soil of the inundated land, and it prevents bigger floods from happening downstream. Environmental planners attempt to preserve ecosystems as well as protect private and public property from damage. For example, they might recommend that flood-prone areas be used as greenways — an action that not only provides recreational benefits for the community, but also results in significant cost savings over channeling the river with dikes and dams.

To accomplish their goals, environmental planners prepare environmental impact assessments (EIA's) for proposed projects. There are many kinds of EIA's, but they all seek to identify the consequences, both positive and negative, that a human action, such as a major development, will have on the natural environment. The most well-known EIA is the Environmental Impact Statement (EIS) required for all projects using federal funds. Many states require separate assessments for their own projects, and, increasingly, private projects are coming under environmental review as well.

Most EIA's use *alternatives analysis*, which means that they assess the impacts not only of the proposed project, but also of alternatives that would accomplish the same goals as the proposal. In many cases the effects of the "no-build" alternative, in which nothing is done, are also evaluated. Elected officials and planning commission members can use the results of an EIA to determine whether a project will be allowed to go forward as proposed, whether it should be dropped altogether, or whether changes should be made to the project to mitigate the negative environmental impacts.

All components of green infrastructure are potentially affected by environmental impacts. Environmental planners bring to the table an understanding of both the EIA process and the technical aspects of determining these impacts. Their expertise helps to imbue the entire planning process with the goals of protecting health and safety and protecting ecosystems.

6.4 Getting Past the Naysayers

Planning for green infrastructure requires effective public involvement. At a basic level, planning is about choices. These choices about the extent to which green infrastructure is to be protected and preserved must be made by the public. Therefore, these choices are political. They cannot be made by bureaucrats. Bureaucrats and professionals can provide the facts that make up the context in which the choices are to be made, but they should not make the choices on their own.

To protect green infrastructure, planners must attempt to meet a full range of goals rather than just one single goal.

Moving beyond NIMBYism

Smart Growth choices should not be made by a handful of Not In My Back Yard activists. Although **NIMBY's** force us to pay attention to the local effects of decisions made for the good of the broader community, they should not have veto power over those decisions. They are choices that should not be made, in fact, by any single issue group.

To protect green infrastructure, planners must attempt to meet a full range of goals rather than just one single goal. Doing so requires a full understanding, however, of each single goal so that the final plan incorporates the elements needed to meet those individual goals. While a traffic engineer will be quite clear about traffic needs of a site, he or she will not take stormwater management, the need for trees, etc. into consideration. A good planner tries to create a plan which considers all the goals and still meets the needs of the traffic engineer, the regulating agencies, green infrastructure etc.

Although citizens often complain that there is no planning, what they are complaining about is the result of planning as it is practiced today. Since zoning regulations control what is built, where and how, it is zoning which should take most of the blame. Despite goals set forth in the master plan, zoning often results in highways bordered by strip malls, shopping centers built on former farmland, and office parks and subdivisions which are isolated rather than integrated..

When residents express outrage about a developer who is proposing to build the zoned use, they are demonstrating that either they did not understand what was intended by the zoning, or they were not included in setting the vision, or both.

Smart Growth choices are important to everyone in a community, a region, or a state, because these choices are what will shape our future quality of life. Right now, although the public decision-making process is open to the public and enjoys coverage in the press, most people pay very little attention to what planning commissions or permit regulators are doing. Instead of becoming involved during the goal-setting and planning stages, when their input is most valuable, most people do not pay attention until the end of the process, when something is about to be built or an ecosystem is imminently threatened. At that stage, it's too late to pose questions about what the community wants. Planners must find a way to involve the broader community in the process. The following sections in this chapter outline a strategy for including the entire community in green infrastructure planning.

Market Forces

Opponents of Smart Growth often point to the market as having shaped our current land use patterns and reflecting "what people want." The argument is founded on the idea that we have an unfettered free market, in which players are free to make whatever choices they wish. Such a foundation is false on both counts; we do not have an unregulated market, and all citizens are not free to make whatever choices they wish. The institutional framework that we have been describing —the laws, plans, regulations, practices and infrastructure investments — influences

in a powerful way how development takes place. The market reflects this framework in land value and other ways. In addition, individuals in the market are not equal — people may be too poor, too old, too young, or too disabled to choose aspects of their environment from the "free" market.

Public policy is based on a dynamic tension between the needs and desires of the individuals versus the needs and desires of the community as a whole. We have decided that many of the components of green infrastructure — water, trees, land, and wildlife — should be regulated for the good of the community. How well we protect these resources within a free market economy is one test of our planning outcomes.

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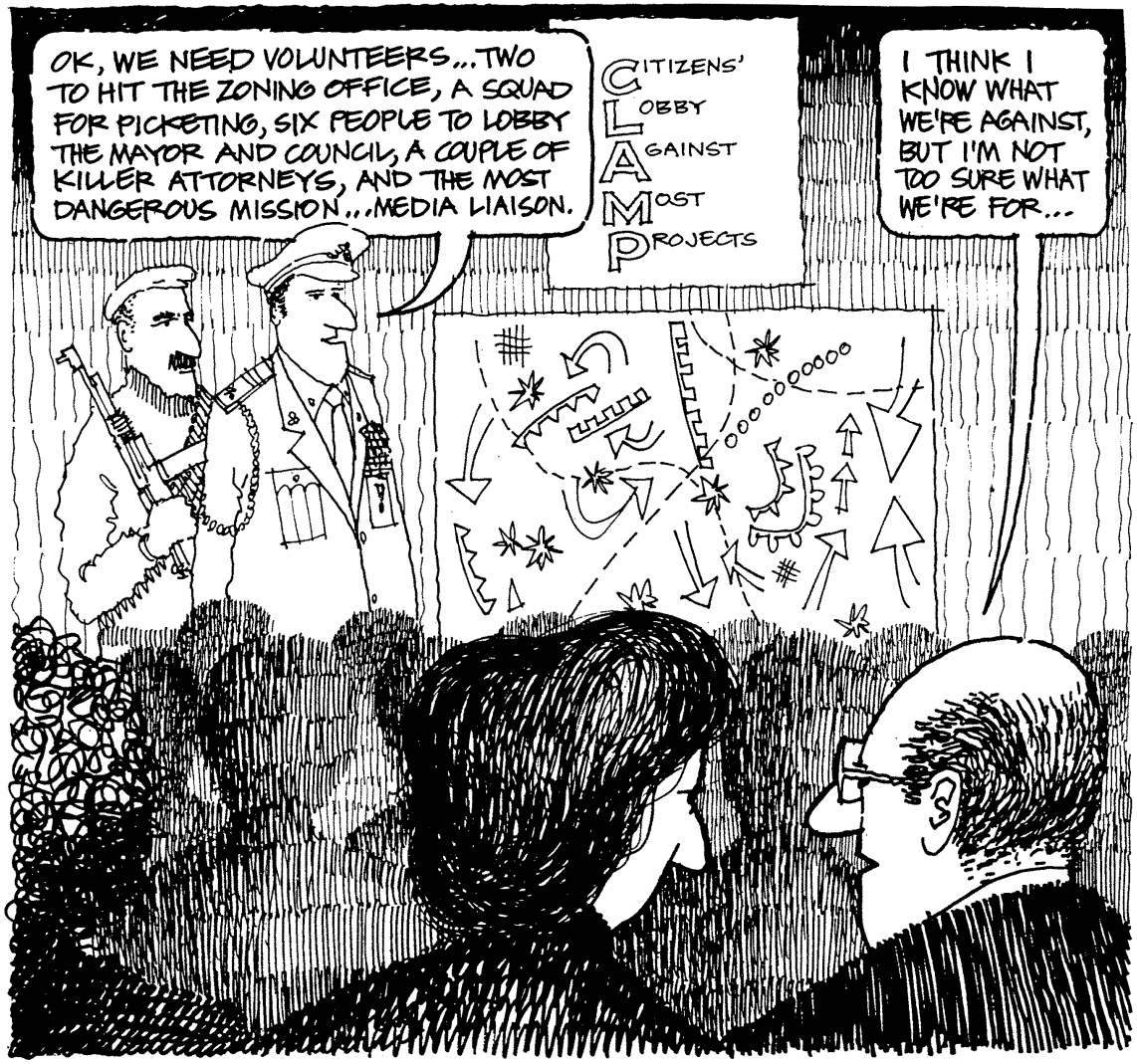


6.5 Geographic Information Systems (GIS)

With Geographic Information Systems, planners have a powerful tool for protecting and enhancing green infrastructure. GIS provides a way of integrating geo-spatial and other types of data, including data about habitat, water quality, tree cover, and other information related to green infrastructure. GIS also enables planners to assess the likely outcomes of policies and investments on green infrastructure.

The ability to present a multi-dimensional view of diverse pieces of information allows one to accurately assess the relationship of the natural world and human needs.

Managing information with a GIS

Geographic Information Systems (GIS) is a computerized mapping and data collection tool that allows the user to show the interrelationship of data in a spatial way. The data can be queried to produce maps depicting as many or as few "layers" of data (soils, land use, stream corridors, habitat, population, income etc.) as one desires. Once data is collected and stored on the computer, maps are easily created and updated. Prior to the use of GIS, it was difficult to compare social, economic, and physical data on the same map. GIS has allowed planners to maintain and manage comprehensive information on a regional as well as local basis. In addition, GIS data is easily shared among all users.

Geographic Information Systems help professional staff, citizens, and officials make decisions about planning for green infrastructure.

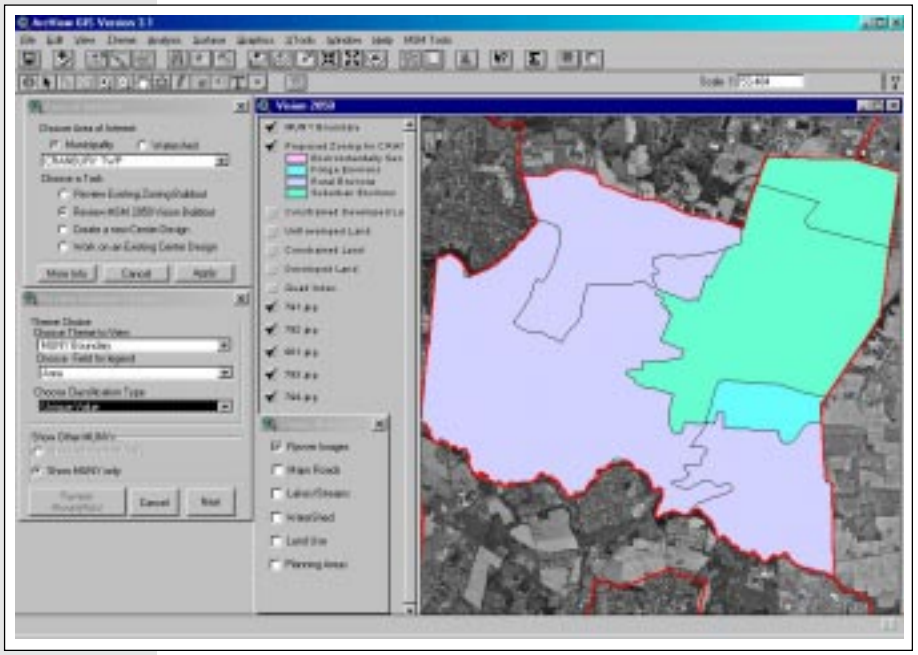
The types of data that can be depicted on a GIS are limited only by one's budget, imagination, and time. However, for planning purposes, the types of physical data that are mapped include such things as wetlands, streams, soil type, topography, hydrology, political boundaries, roads, utilities, and land use. The data attached to that information can identify open space, land use types, historic districts, zoning and schools. The socioeconomic features that can be overlaid include population density, income, race, and age. The ability to present a multidimensional view of diverse pieces of information allows one to accurately assess the relationship of the natural world and human needs. For example, by comparing socioeconomic data with information on parks and open space, one can determine where parks are scarce or abundant in relationship to population densities or income levels.

GIS data sources

Although GIS is relatively new, a vast amount of data is already available in New Jersey through the Department of Environmental Protection (DEP), the Office of State Planning (OSP), and in some county planning offices or departments of health. Some townships are beginning to consider either purchasing their own GIS or to collect data such as tax maps and public works information digitally by hiring consultants. Because the collection of data can be time consuming and costly, and because

the ability to share information is important, it is wise for townships to consider acquiring systems and data that are compatible with existing systems.

A common problem for planners is organizing and documenting the vast amount of information that is available regarding land use. For example, currently no standard way to document deed restricted properties, public access easements, and conservation easements exists other than through the deed or tax maps. As easements are purchased or properties deed restricted, this information can be entered onto GIS. This ability allows a planner to "tag" parcels by their function (along with other data such as size, land use type, zoning, etc.). Once the information is logged into the GIS, a planner can easily and quickly locate all deed restricted property. Without GIS capabilities, researching this type of information is arduous and time consuming.



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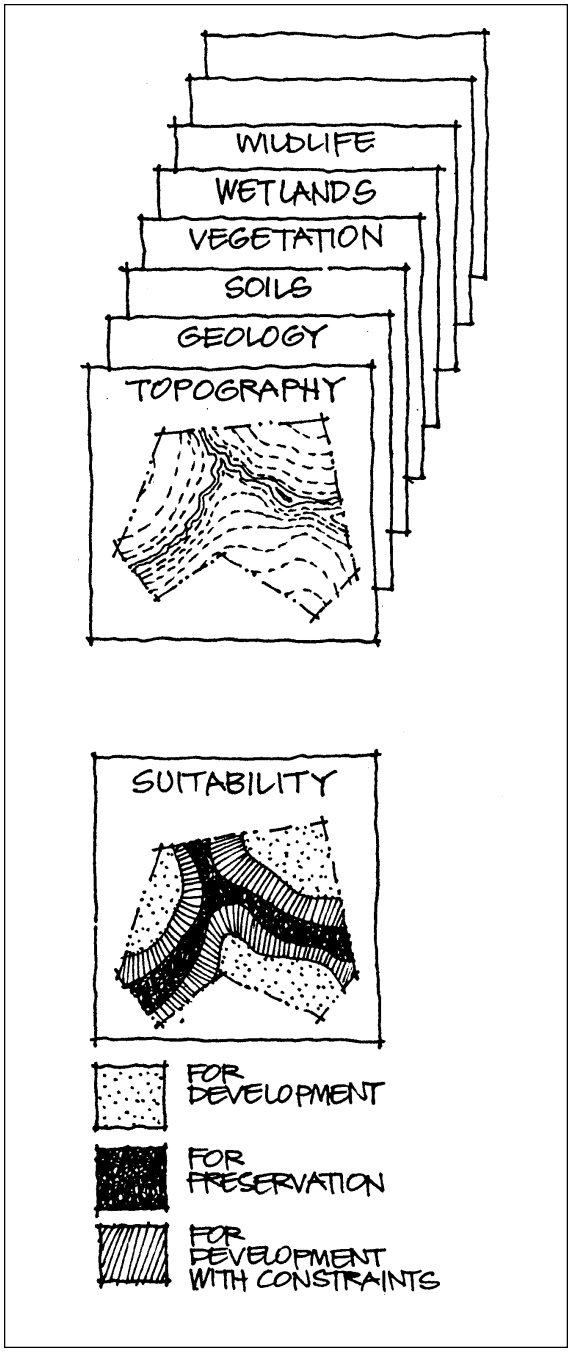


Chapter 7

How Green is Your Community?

The following section is a quick guide to help determine if your community's planning practices are working towards the goal of protecting your green infrastructure.

Water Quality

Imperviousness. Does your community have development practices that limit impervious cover? (Chapter 5) Ordinances should mandate or encourage narrow streets, porous parking lots, reduced parking requirements, vegetated swales, and green roofs. They should also contain provisions requiring that these structures be maintained and cleaned.

Buffers. Does your community have a stream buffer protection ordinance? (4.5) How far from the streams do the protected areas extend? Does your community use buffers to protect wetlands as well? (4.7) A stream buffer ordinance limits development on property close to streams. Nationally, 100 feet is the accepted standard.

Fertilizers and pesticides. Does your community have an ordinance limiting fertilizer and pesticide use near water bodies? (4.5) Fertilizers and pesticides are major contributors to nonpoint source water pollution. Ordinances can prevent them from being used in areas in which they would cause environmental damage.

Lawns. Does your community require lawns with drought-resistant grasses and allow lawns with a diversity of species? (4.5) Lawns can be altered to use water more efficiently and provide habitat for more species while remaining attractive.

Watershed planning. Does your community engage in comprehensive, watershed-based planning with surrounding jurisdictions? (2.3) Planning organized around regional drainage basins can accomplish multiple goals: redirecting growth to already built-up areas, protecting open space, and reducing point and nonpoint source water pollution. It can also promote efficiency by encouraging regional provision of services.

BMP's. Does your community require stormwater BMP's (Best Management Practices) for new development? (5.3) Infiltration systems, which filter stormwater through the soil, are a good way to manage stormwater runoff. They filter pollutants out of the water and allow for groundwater recharging. Detention basins can be placed underneath parking lots so they don't waste space and hamper pedestrian connections above ground.

Wetlands. Does your community ensure that wetlands are protected to the satisfaction of state and federal standards? (4.7) Wetlands are perhaps the most crucial component of green infrastructure. Communities should monitor their wetlands to ensure they are not damaged, and local ordinances should work in tandem with state and federal regulations to protect wetlands.

Site design. Does your community have an ordinance requiring better parking lot design? (5.5) Porous parking lots can reduce the overall imperviousness of a site. At the same time, both porous and conventional parking lots can be redesigned to incorporate trees and grassy areas that intercept polluted runoff.

Urban Forestry

Community forest management plan. Does your community have an urban or community forest management plan? (4.6) This plan can be a stand alone document or, better yet, an element of a broader master plan. It should address the current condition of the urban forest, goals and targets for tree planting and maintenance, liability for damage resulting from trees, and implementation measures.

Tree protection. Does your community have ordinances protecting trees from construction? (5.4) The ordinance should require that trees to be preserved be clearly marked and segregated from construction. Soils on the rest of the site should be protected from compaction to facilitate future tree planting.

Tree cover. Does your community meet the recommendations of American Forests for tree cover? (4.3) 15 percent of your downtown areas, 25 percent of your urban neighborhoods, and 50 percent of your suburban residential areas should be covered with trees.

Liability. Is your community protected against the risk of being sued over tree-related injuries or property damage? (4.8) Clear guidelines for maintaining and replacing trees, and for monitoring and repairing buckled sidewalks, go a long way toward reducing risk.

Staff and Community Groups

Staff. Does your community have arborists and environmental planners on staff? (3.3) These staff members bring necessary expertise to the local community and greatly assist shade tree and environmental commissioners and other volunteers.

Education. Are your community's government employees and utility crews who work with trees knowledgeable about the importance of caring properly for them? (3.1) Education and training for those who maintain trees and power lines can help your community forest stay healthy.

Community involvement in planning. Does your community actively involve stakeholders from businesses, organizations, institutions, utility companies, development interests, and the public at large in its forestry management planning? (3.1) The most effective plans are those that are conceived, designed, and implemented with community support. At the same time, the planning process gives stakeholders an opportunity to learn from one another about the need for effective forestry management.

Volunteers. Does your community have an ongoing tree maintenance program involving volunteer participation by stakeholders? (3.1) Residents often see their community's trees as a point of pride and are willing to help maintain them. Community organizations and local businesses are valuable resources when you need assistance for a service project to plant or maintain trees. Volunteering also helps educate residents about trees and helps them feel more connected to their environment.

Commissions. Does your community have a shade tree commission and an environmental commission? (3.2) These bodies oversee community forestry and environmental protection efforts and can help ensure that plans are implemented and regulations enforced. They also provide a way for citizens with particular interest in maintaining the community's trees and water resources to become more deeply involved in environmental protection.

Open Space and Natural Resource Protection

Greenways. Does your community have a greenway plan? (5.8) You don't necessarily need to design new trails; streams, utility corridors, and abandoned rail corridors can all be converted to greenways. You can also reclaim land for greenways by "daylighting" streams that were piped underground in years past.

Green Infrastructure planning. Does your community have a green infrastructure improvement plan? (4.1) Such a plan would identify the capital improvements and changes to regulations needed to protect trees, water resources, and wildlife habitat.

Preserved lands. Does your community have a plan to establish a network of protected lands? (4.2) Parks, stream corridors, and other preserved lands constitute vital habitat for many species of plants and animals. Through the planning process, your community can set clear goals and establish implementation mechanisms for land preservation.

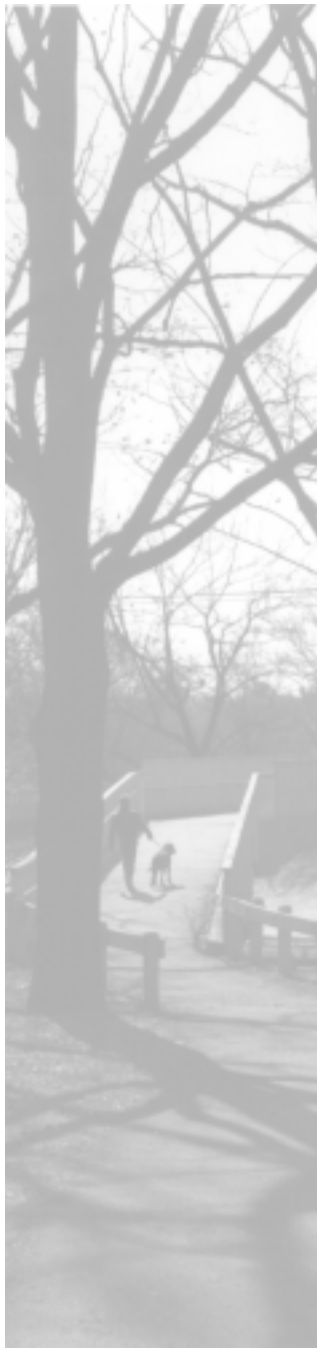
TDR's. Does your state allow you to use transfer-of-development-rights (TDR) to direct growth to certain areas while preserving others? (4.3) With this tool, you can build at high densities in areas with adequate infrastructure, keep rural areas protected from development, and ensure that farmers and other rural landholders are able to cash in on the value of their land.

Land purchase program. Does your community allocate resources to the outright purchase of key tracts of land? (4.3) Purchasing land is the most clear and effective way of preserving land. Communities should purchase land based on a plan with goals, targets, and strategies.

Conservation easements. Does your community record and actively enforce conservation easements? (4.3) These are deed restrictions initiated by private landowners. Often, it is up to the local government to ensure that landowners and government agencies respect these easements.

Open space set-asides. Does your community require developers to set aside open space as part of subdivisions and site plans? (4.3) Set-aside requirements are often needed to ensure that adequate open space is available for the use of new residents and to protect against the environmental impacts of new development.

Goal-oriented zoning. Does your community use conservation zoning and center-based zoning in tandem to send growth where it can be supported while preserving environmentally sensitive land? (4.4) Both types of zoning are components of goal-oriented zoning, a concept in which zoning regulations are used to achieve specific planning objectives.



Glossary

A Reference List of Terms

The following section is a quick guide to help you understand terms used throughout the book. Definitions appear for all terms that are highlighted in bold.

Glossary

Arborist — A specialist in tree planting and maintenance, trained through technical course work and on-the-job instruction and experience.

Buffer — A strip of land that provides protection to a sensitive area. Stream buffers include the stream bank and adjoining wetland and upland areas. Other types of buffers may protect the area around wetlands or separate an area of intense development from a natural area.

Capital improvements plan — A coordinated list of projects to be completed over a period of several years, along with their funding requirements. The link between planning and budgeting.

Center-based zoning — An approach to zoning that emphasizes high densities in city and town centers with the infrastructure to support growth, and very low densities elsewhere.

Cluster zoning — A type of zoning district that allows developers to cluster homes at a higher density on one portion of a site while leaving the remainder of the site undeveloped.

Conservation easement — A deed restriction that prohibits the development of a piece of land, typically enforced by local governments or nonprofit organizations.

Conservation zoning — A type of zoning district that preserves undeveloped land by prohibiting most uses or allowing only extremely low densities (for example, 40 acres per housing unit).

Daylighting — The practice of reconstructing streams that were once artificially channeled underground to flow above ground in a more natural streambed.

Detention basin — A structure that impounds runoff to control runoff rates and protect downstream channels by controlling velocity. Detention basins allow suspended solids and associated pollutants to settle into the basin, preventing them from entering the stream flow.

Ecosystem — The interaction and integration of people, the man-made environment, and natural systems. Also, the interaction of green and gray infrastructure with people and wildlife. Ecosystem boundaries can be defined as small as a single site, or as large as the entire planet.

Environmental commission — A local government board that oversees the writing and enforcement of environmental ordinances, participates in master planning, and serves as a liaison between citizen environmental groups and the municipal government.

Geographic Information Systems — A computerized mapping tool that links spatial data with other types of data such as population, soil types, and habitat.

Goal-oriented zoning — An approach to zoning in which the zoning ordinance is explicitly rewritten to fulfill the goals expressed in the comprehensive plan.

Goal — A general statement of intent for a plan. A goal can describe a desired future condition in broad terms.

Gray infrastructure — A community's network of constructed facilities and systems that provide for the needs of people. Includes, but is not limited to, buildings roads, sidewalks, telecommunications, and power and water supply. Gray infrastructure provides shelter, communication, transportation, wastewater treatment, energy, and drinkable water.

Green infrastructure — A community's network of natural resources that provide for the needs of wildlife and people. It includes, but is not limited to, naturally occurring things such as open space, stream corridors, rivers, wetlands, and riparian forests. It also includes built elements that are designed and/or managed by people such as street trees, parks, arboretums, community gardens, farmland, and greenways. Green infrastructure provides air and water filtration, transportation, recreation, habitat, flood control, groundwater recharge, and climate control.

Greenfield — An undeveloped site, typically perceived as open space, at the edge of a town or metropolitan area. Traditionally, cities expanded by converting greenfields to developed land.

Greenway — A permanently preserved linear corridor of undeveloped land that allows animals to travel between habitats and provides recreational opportunities for humans. Stream buffers form natural greenways.

Habitat fragmentation — The interruption of plant and animal habitat by scattered development. Can lead to a reduction in the population of a species and even extinction.

Impervious — Describes any surface that cannot absorb water. Built and paved surfaces are almost always impervious.

Infill — Development that occurs on small, undeveloped sites in areas that are already mostly built out.

Infiltration basin — A depression, usually vegetated, that allows runoff to be absorbed by percolating through the soil.

Master plan — The general or comprehensive plan for a community's future development. Covers such areas as land use, open space preservation, transportation, housing, parks, and economic development.

Microclimate — The climate of an area as small as a block or an individual site. High density and extensive impervious surface can result in extreme temperatures in a microclimate.

Mixed use — Development in which different uses, such as housing, offices, and retail, are located close enough to one another to facilitate pedestrian movement between them.

Monoculture — An area of land, such as a lawn, that supports only a single species, usually as a result of landscaping practices.

Natural resources inventory — A list of treasured natural sites, important habitat, endangered and threatened species, stream corridors, and the like, that currently exist in a community. Useful in determining base conditions for a master plan.

NIMBY — Not In My Backyard. People, institutions, and organizations that oppose all growth and change that would affect their lives.

Nonpoint source pollution — The pollution that drains from streets, parking lots, agricultural fields, and lawns. Enters surface waters (streams, rivers, lakes, and wetlands) and is not attributable to one discharge point such as a sewer plant.

Open-celled pavers — An innovative form of pavement that allows stormwater to filter into the ground through gaps between paving cells.

Point source pollution — Pollution deposited directly into a water body from a single, obvious source, such as a sewage plant, gas station, or factory.

Porous pavement — A type of pavement that allows water to filter through it into the ground.

Receiving zone — An area which "receives" additional new development in a Transfer of Development Rights plan. The development is "sent" from a sending zone, which remains undeveloped.

Sediment — Soils or other materials transported by surface water as a product of erosion

Sending zone — The protected area in a Transfer of Development Rights program. Development rights in the sending zone are transferred to the receiving zone.

Glossary *(continued)*

Shade tree commission — A board appointed by the governing body. Ensures that tree ordinances are being carried out faithfully, is intensively involved in master planning for trees, and works with citizen groups to protect trees

Shared parking — A means of reducing the number of parking spaces that must be constructed. Shared parking is used by two or more entities with parking demands at different times; for example, a church and an office building.

Sprawl — A pattern of development shaped by zones of single-use buildings, organized along highways, at a much lower density than is found in traditional cities and towns.

Stormwater runoff — The excess water that is not absorbed by vegetation and soils during and immediately after a storm.

Subdivision ordinance — An ordinance controlling the design of new subdivisions and the standards for developing them. May also require that developers set aside land for conservation.

Sustainability — The management of growth in a manner that meets the needs of the current population without compromising the needs of future generations. Sustainability requires optimizing many competing goals, such as economic development, transportation, affordable housing, and environmental protection.

Swale — A shallow, man-made ditch designed to prevent erosion, filter sediment and provide nutrient uptake.

Targets — Specific, measurable objectives that signal when a goal, or a step toward meeting a goal, has been met.

Tools — The means used to reach targets. For governmental activities, these usually include regulations and capital investments.

Transfer of Development Rights — A program in which landowners in rural "sending zones" sell the rights to develop their property to real estate developers, who apply the rights in urban "receiving zones." Allowable density is increased in the receiving zones.

Urban heat island effect — The increased temperatures felt in urban areas due to the trapping of heat by pavement and buildings in the absence of vegetation, which cools through evapotranspiration.

Watershed planning — A regional planning process conducted for an entire watershed, intended to protect water quality and quantity for the local jurisdictions within the watershed. Watershed planning maps out the locations for new growth and the tools needed to direct growth to those locations.

Wetland — Swamps, marshes, bogs, and similar areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

References and Suggested Resources

The following references have been used in compiling The Green Infrastructure Guide and may serve as a useful resource for readers.

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Suggested Resources

The Center for Watershed Protection is a good source for nationwide model ordinances regarding water resources. They can be reached at 8391 Main Street, Ellicott City, MD 21043-4605; phone (410) 461-8323; web site http://www.cwp.org/.

TreeLink is a source for urban and community forestry model and sample ordinances. The web address for TreeLink is http://www.treelink.org/.

The municipal codes of these New Jersey municipalities are suggested as sources of sample ordinances on the following topics. Many of these ordinances are available at the Resource Center of the Association of New Jersey Environmental Commissions, P.O. Box 157, Mendham, NJ 07945; phone (973) 539-7547; web site http://www.anjec.org/.

Comprehensive Tree Ordinances: Teaneck Township.
Conservation District: Millburn Township.
Critical Area Density Reduction (Density Adjustment Factor method): Mount Olive Township, Independence Township, Wantage Township.
Critical Area Density Reduction (Effective Land Area method): Boonton Township.
Critical Slope Area Zoning: Mendham Township, Bridgewater Township.
Environmental Commission: Voorhees Township, Maplewood Township.
Flood Hazard and Wetlands Critical Area Zoning (by soil type): Kinnelon Borough.
Pesticide Restrictions: Jefferson Township (Morris County).
Stream Corridor Protection: Moorestown Township, Harding Township, Mendham Township, Princeton Township, Far Hills Township, Long Hill Township.
Tree Removal Standards: Stafford Township.