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EVALUATING AND CONSERVING GREEN INFRASTRUCTURE ACROSS THE LANDSCAPE:

A Practitioner's Guide

By Karen Firehock

Arkansas Guide

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By Karen Firehock, Chapter Seven by Charles Kline
The Green Infrastructure Center Inc.

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Green Infrastructure Center Inc.
P.O. Box 317
Charlottesville VA 22902
434-244-0322
www.gicinc.org

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PREFACE

This guide is based upon seven years of research and field tests by the Green Infrastructure Center Inc. (GIC) that sought to evaluate, prioritize and map natural and cultural assets. The GIC is a nonprofit organization which serves federal, state and local government agencies, conservation groups, land trusts and other associations and helps them to make better informed decisions about how to balance growth and development with conservation of their highest quality natural assets.

The GIC seeks to insure that land-use decisions about what to conserve and how to do it are well informed by the best possible data and objective information. Its overarching goal is to focus development into those patterns that maximize resource conservation and economic efficiency.

This guide is intended to help people make land management decisions which recognize the interdependence of healthy people, strong economies and a vibrant, intact and biologically diverse landscape. Green infrastructure consists of our environmental assets – which GIC also calls 'natural assets' – and they should be included in planning processes. Planning to conserve or restore green infrastructure ensures that communities can be vibrant, healthful and resilient. Having clean air and water, as well as nature-based recreation, attractive views and abundant local food, depends upon considering our environmental assets as part of everyday planning.

While there are other books and guides about the benefits of green infrastructure planning, this guide provides practical steps for creating green infrastructure maps and plans for a community. It draws from twelve field tests GIC has conducted over the past six years to learn how to evaluate and conserve natural resources. These field tests were conducted in a diversity of ecological and political conditions, at multiple scales, and in varied development patterns – from wildlands and rural areas to suburbs, cities and towns.

During these field tests, the GIC determined three things:

- How to create green infrastructure maps that highlight the most significant resources for conservation.
- Steps to integrate those maps into local and regional plans.
- How to communicate the importance of this work to local officials, planners, developers and others.

While we also drew upon outside case studies, the steps and advice offered here are the GIC's own interpretation of the most effective ways to evaluate and conserve natural assets. We hope our advice and practical tips can help you become even more effective in your work.

ABOUT THE AUTHORS

Karen Firehock

Ms. Firehock is the author of this guide. She is the executive director and co-founder of the GIC and is on the adjunct faculty in Planning and Landscape Architecture at the University of Virginia. In 1999, she became certified as a mediator to help groups realize common visions for their environmental plans. She also served as the national Save Our Streams program director at the Izaak Walton League of America, where she directed stream and wetland conservation and education programs. She has been the recipient of numerous local, state and national awards for her work, such as a National Greenways Award, a Renew America Award, a United Nations Environment Programme Award and a Virginia River Conservationist of the Year Award, among others. She holds a Bachelor of Science Degree in Natural Resources Management from the University of Maryland and a Master of Planning Degree from the University of Virginia.

Charles Kline

Mr. Kline is the Geographic Information Systems Analyst and Modeler at the Green Infrastructure Center. He is a geographer and urban and environmental planner. He manages GIC's mapping and land planning and provides technical assistance to local governments, regional planning agencies, communities, land trusts and conservation groups. He has worked in Arkansas, New York, North Carolina and Virginia. He also creates case studies, handbooks and web content. Prior to coming to GIC, Mr. Kline was a data management specialist at the Virginia Department of Conservation and Recreation (DCR), where he processed and controlled the quality of field data for DCR databases, conducted literature reviews and case studies, and assisted field biologists with site surveys, including species diversity transect lines and plots, canopy cover analysis and element occurrence (rare species) evaluation. He holds a Bachelor of Arts degree in Environmental Studies from the Department of Environmental Studies and also in Geography and the Environment from the Department of Geography at the University of Richmond and a Masters Degree in Urban and Environmental Planning from the University of Virginia.

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REVIEWERS

Jason Bulluck, PhD, Virginia Department of Conservation and Recreation, Division of Natural Heritage.

Patti Erwin, Urban and Community Forester, Arkansas Forestry Commission

Jim Jolley, Forest Legacy and GIS Forester, Arkansas Forestry Commission

Ethan Inlander, Ozark River Program Director, The Nature Conservancy

Barbara Boland, Fayetteville Natural Heritage Association Project Coordinator, GIS Technician, Cartographer

Bill Jenkins, Director, Office of Environmental Information and Analysis, U.S. Environmental Protection Agency, Region III.

Buck Kline, Director, Forestland Conservation Division, Virginia DOF

Alan Moore, Regional Urban Forestry Specialist, North Carolina Forest Service

Richard Roth, PhD, Professor and Chair, Geospatial Science Department, and Director, Radford University Environmental Center, Department of Geography.

Nancy Stairs, Urban Forestry Program Coordinator, North Carolina Forest Service

Allison (Schwarz) Weakley, NC Natural Heritage Program, North Carolina Department of Environment and Natural Resources

INTRODUCTION

Imagine a world where clean water is plentiful, air in our towns and cities is clean and fresh, native species of plants and animals are abundant, access to outdoor recreation is plentiful, natural beauty and verdant landscapes envelop our communities, historic landscapes are well preserved and protected and locally grown food is easily accessible. And imagine that these resources are available to everyone, regardless of income or social status.

While this vision may seem difficult to achieve, it is not impossible. However, it requires greater awareness and more thoughtful attention to how we plan our communities and care for our natural resources. We can have communities that are healthful and people that are healthy – but only if we plan for it. And the time to do that is now.

As far back as 1863, George Perkins Marsh, long considered the father of America's conservation movement, cautioned in his book *Man and Nature* that, "The earth is fast becoming an unfit home for its noblest inhabitant…[and]…to threaten the depravation, barbarism, and perhaps even extinction of the species."

Since Marsh wrote that statement, the United States has come a long way in recognizing the need to actively protect its natural resources. It now has an impressive array of national and local regulations to protect and clean its air, water and soil which compliment voluntary actions, such as reforestation or adopt-a-stream programs. Yet we have been developing landscapes in patterns that are not sustainable over the long term and do not account for the many ecological services provided by forests, wetlands, rivers, aquifers, soils and geology.

Consider the enormously aggregated ecological consequences of more than 39,000 local government entities – counties, municipalities and townships – that are regulating the use of 70 percent of the U.S. land base. At the site scale, add to that those private landowners and consumers who are making decisions about how they develop or manage their land, such as which forest to harvest, where to channel water flow, or how to draw water from a river or aquifer or how to fertilize their lawns. Without offering all these decision-makers a comprehensive understanding of the interconnectedness of our air, water and land systems, we risk taking steps that could inadvertently compromise or damage the present and future health of our environment. Until we see our natural resources as being part of a connected infrastructure that supports our everyday lives by providing clean air, water and soil, we may not recognize the need to actively conserve them.

While most people would prefer to make land-use decisions that restore rather than deplete our environment, land planners and decision makers may still overlook key natural resources. Just as we plan for our gray infrastructure – roads, bridges, power lines, pipelines, sewer systems, and so on – so should we plan to conserve landscapes and natural resources as our 'green infrastructure.'

Green infrastructure is "a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life for America's communities and people."

— Benedict and McMahon, *Green Infrastructure,* 2006.

GREEN INFRASTRUCTURE

Green infrastructure can be thought of as the sum of all our natural resources. It includes all the interconnected natural systems in a landscape, such as intact forests, woodlands, wetlands, parks and rivers, as well as those agricultural soils that provide clean water, air quality, wildlife habitat and food. In their book *Green Infrastructure*, Benedict and McMahon defined it as "a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands with conservation value that supports native species, maintains natural ecological processes, sustains air and water resources, and contributes to the health and quality of life for America's communities and people" (2006).

Conserving green infrastructure is critical to building and sustaining wildlife and human communities that are healthy, both ecologically and economically. For example, American Forests has estimated that trees in the nation's metropolitan areas contribute $400 billion in storm water retention by eliminating the need for expensive storm water retention facilities (Benedict and McMahon 2006).

This is *not* a guide about how to stop development or to limit population growth. Rather, it describes the steps a community can take to determine what is important and to develop a rationale for what to protect. Development can then occur in a manner that recognizes and protects the area's most important landscape resources. This guide presents a way to think about and catalogue a community's natural assets as its 'green infrastructure.' It shows how to evaluate the different natural assets and to prioritize them for long-term stewardship. This guide provides the steps for determining how to *facilitate* development in ways that reduce its impact on the landscape, or to restore environmental functionality where it has been lost. Its application can benefit residents, businesses and government.

AUDIENCE

The intended audience for this guide comprises local land-use decision-makers, such as appointed and elected officials (planning commissioners, planning boards, boards of commissioners, boards of supervisors, city and town councils, town or city managers, and the staff of planning district commissions); college students and faculty in fields such as architecture, natural resources management, conservation biology, environmental science and landscape architecture; natural resource agencies and professionals (rural and urban foresters, extension agents, game and inland fisheries, wildlife managers and conservation groups); associations that manage significant land holdings (land conservancies and land trusts); homeowner associations charged with taking care of open-space lands; and realtors, developers and builders.

While the above list covers an extremely diverse audience, it includes those people who make decisions on how, when and where to develop and conserve land. It is a challenging audience to address because the level of its members'

knowledge of natural resources and planning regulations varies greatly. In order to ensure a level playing field for all readers, the guide includes several definitions of the field's more common technical terms. Text boxes and sidebars are utilized whenever possible to avoid slowing down the more advanced reader.

The guide also includes examples that demonstrate several different approaches to creating green infrastructure plans, as well as examples of the GIC's field tests. It is hoped that this guide will spur its users to evaluate, map and conserve their natural assets. Finally, citizens who read this guide can use its ideas to educate local officials about the importance of planning to conserve their community's natural assets.

STRUCTURE OF THIS GUIDE

This guide is structured as follows:

In **Chapter One**, we provide an overview of green infrastructure planning, its definitions and a short history of the field.

In **Chapter Two**, we provide the reasons for undertaking a green infrastructure planning process.

In **Chapter Three**, we provide the steps to organize a planning initiative including stakeholder engagement and expert consultation.

In **Chapter Four** we cover steps to evaluate and prioritize natural assets.

Chapter Five provides a case example for mapping natural assets.

Chapter Six includes ideas to build community support for a green infrastructure plan, key messages and options for expanded engagement.

Chapter Seven covers state-specific natural asset models and data sources.

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CHAPTER 1 - Green Infrastructure

Chapter one provides a rationale for why we need to think of environmental resources as 'green infrastructure.' It includes a definition, explanation and short history of the term 'green infrastructure,' along with basic ecological concepts and the reasons for undertaking an inventory of natural assets to create a green infrastructure network.

WHAT IS GREEN INFRASTRUCTURE?

The natural assets that sustain us including:

- **Forests**
- **Water resources: Rivers, wetlands, lakes, estuaries, aquifers**
- **Soils that support agriculture**
- **Unique geologic features and landscape forms**

WHY ARE ENVIRONMENTAL RESOURCES PART OF OUR GREEN INFRASTRUCTURE?

Thinking about environmental resources as 'green infrastructure' is a way to recognize that they have value to people. Unfortunately, many of us take natural resources for granted, even though they sustain our very existence. Without clean air, water and agricultural soils, we could not survive. How we manage our landscape directly translates into whether we have the high-quality air, water and nutrients to keep us healthy.

In addition, these natural resources are valuable to us in social terms – terms that are difficult to quantify, but include the social and emotional benefits provided by natural beauty and the open, unspoiled vistas that many of us appreciate. In short, they should be considered our 'green infrastructure.'

Thinking of natural resources as 'green infrastructure' helps us recognize that they provide life-sustaining functions, along with tangible economic and social benefits. It also emphasizes that these natural resources need to be *connected* as a network because they are interdependent and because connected landscapes allow species to recover and repopulate areas that may have been damaged by such disturbances as drought, forest fires, diseases and hurricanes.

"Green infrastructure (GI) planning is a strategic landscape approach to open space conservation, whereby local communities, landowners and organizations work together to identify, design and conserve their local land network, in order to maintain healthy ecological functioning."

In the wake of Hurricane Katrina which devastated New Orleans and Hurricane Sandy which bludgeoned states in the mid-Atlantic, states are looking to restore and protect their 'green infrastructure.' New York and New Jersey, which suffered many billions of dollars of damage from Hurricane Sandy in 2012, are beginning to look towards green infrastructure as a way to mitigate risk and prevent damage.

In New York they are looking to replenish the marshes that once acted as natural storm surge protectors and restore the wetlands that once provided water filtration and flood control. Many scientific studies demonstrate that restoring 'natural infrastructure' can reduce significantly the damage from storm surges. "A 2007 study of New Jersey's wetlands, for example,

estimated that freshwater wetlands saved the state $9.4 billion per year in filtrating and flood control costs, while its saltwater wetlands delivered $1.2 billion per year in protection. Hackensack, NJ – one of the hardest hit states in Hurricane Sandy – lost more than 75% of its wetlands between 1889 and 1995, according to the US Geological Survey" (Cassin 2012).

WHAT IS GREEN INFRASTRUCTURE PLANNING?

The recognition of the need to plan for conserving our natural assets has led to the field of green infrastructure (GI) planning, in which local communities, landowners and organizations work together to identify, design and conserve their local land network to maintain healthy ecological functioning. In short, it is an organizing construct that enables us to think about our natural resources as a critical part of our life support system. They are 'green' because they are part of the natural environment, and they are 'infrastructure' because they provide those basic services that we all need for healthful and restorative living.

Green infrastructure planning evaluates the types of natural and cultural resources available today and prioritizes those assets that are most important to us, or that best meet our current and future needs. In other words, a green infrastructure strategy includes the process of identifying, evaluating and prioritizing those areas we deem critical to preserving a healthy community for the future. Most importantly, we need to not only prioritize them; we need to implement actions to ensure their conservation over the long term.

THE SIX STEPS

To create a green infrastructure plan, you should follow these six steps:

Step 1. Set Goals:
What does your community or organization value? Determine which natural assets and functions are most important to you.

Step 2. Review Data:
What do you know or need to know, to map the values identified in Step 1?

Step 3. Make Asset Maps:
Map your community's highest-valued natural assets that contribute to a healthy ecology and also support cultural and economic values –Based on the goals established in Step 1 and data from Step 2.

Step 4. Assess Risks:
What assets are most at risk and what could be lost if no action is taken?

Step 5. Determine Opportunities:
Determine Opportunities for protection or restoration. Based on those assets and risks you have identified; determine which ones could or should be restored or improved? And which need the attention soonest?

Step 6. Implement Opportunities:
Include your natural asset maps in both daily and long-range planning such as park planning, comprehensive planning and zoning, transportation planning, tourism development and economic planning.

SIX STEPS FOR COMMUNITY GREEN INFRASTRUCTURE PLANNING

During its field tests, the GIC identified six steps necessary to create a natural asset inventory and strategy. The following is a summary of those steps; they are explained in more detail in the following chapters.

STEP 1. Set Your Goals: What Does Your Community or organization Value? Determine Which Natural Assets and Functions Are Most Important To You.

All GI planning efforts must start with the establishment of goals. What does your community or organization most value about your natural resources? Is it:

- Forests that provide clean air, water filtration, wildlife habitat or wood products?
- Recharge areas to replenish aquifers used for drinking water supplies?
- Water quality to support healthy fisheries?
- The landscape settings around historic landscapes and battlefields?
- Working farms?
- Nature based recreation, such as hiking trails and recreation areas?
- Landscape features, such as key views and vistas?
- Connections across the landscape for wildlife corridors?

STEP 2. Review data: what do you know, or need to know, to map the values identified in step 1?

Once you have established your goals, it is time to assemble and review all the existing relevant data for your local area:

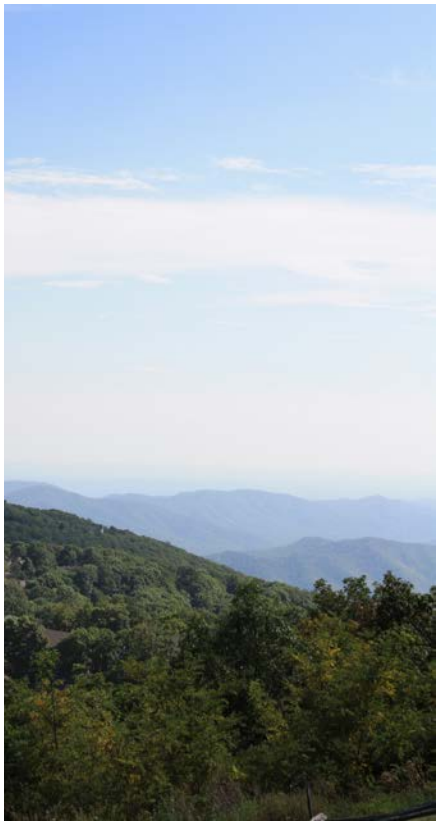
- Research existing studies and available data: What are their findings and are they relevant? Are the data accurate?

  Examples of data include watershed plans, wildlife plans, open space plans, ecological inventories, groundwater studies and air studies.

- Determine what data are still needed if you are to implement your goals: If you are using a Geographic Information System (GIS), you will require data to be arranged spatially in digital layers, which can be analyzed by overlaying them to show patterns and priorities.

  Examples of data that you might need to collect include stream buffers, watersheds, key agricultural soils, recreation routes, forested areas, historic structures and wetlands.

A ***viewshed*** is a landscape that can be seen from a particular vantage point. It is particularly important in the context of historical sites, such as battlefields and historic houses, where it forms part of those assets' history or supports scenic vistas for nature-based recreation.



Peter Stutts

Agritourism is tourism based upon local agricultural products, such as pick-your-own fruit orchards and farms, wineries, cideries, honey producers, local organic beef, pork and chicken farms, or fruit and vegetable stands.

STEP 3. Make Asset Maps: Map Your Community's Highest-valued Ecological and Cultural Assets – Based On the Goals Established In Step 1 and Data From Step 2

Once you have assembled all the existing data and collected additional data to match your goals, it is time to create a natural asset map. This is not a map of all your natural resources, but only those you rank as most important because they fulfill a key goal or are the most unique example of a community value. Depending on your goals, and what your community has valued as of high importance, your maps may include elements such as:

- Large intact forests that provide interior habitat for wildlife.
- Watersheds that provide municipal water supplies.
- Key geological features, such as unique rock outcrops or bluffs.
- High-quality agricultural soils that support farms and farming districts.
- Streams, rivers, wetlands and groundwater recharge areas.
- Nature-based recreational areas (for fishing, boating, hiking, biking, birding, etc).
- Tourist sites that depend on the landscape.
- Historic and cultural features (such as battlefields and historic landscapes).
- In urban areas: street trees, the tree canopy, parks and streams.
- Locations and routes for agritourism (such as pick-your-own fruit orchards and farms, wineries, honey producers, local beef, pork and chicken farms, and permanent vegetable stands).
- Scenic views (viewsheds) or routes through historic or cultural assets that should be protected.

STEP 4. Assess Risks: What Assets Are Most at Risk and What Could Be Lost If No Action Is Taken?

Once you have created your natural assets map, it is time to assess those assets most at risk:

- Which areas are zoned for development and do they overlap key natural assets?
- Where are new roads or subdivisions planned – will they fragment key assets?
- Which steams are impaired and need restoration or, which streams are in good condition but may decline in the future?
- Which historic structures are in danger of destruction if no action is taken?
- Are there impaired areas where habitat can be restored?
- What viewsheds are threatened?
- Is any mining, drilling or quarrying planned for your region that might affect air or water quality?
- Which assets are most impacted by present zoning and currently planned developments?

STEP 5. Determine Opportunities: Determine Opportunities For Protection or Restoration. Based On Those Assets and Risks You Have Identified; Determine Which Ones Could or Should Be Restored or Improved? And Which Need the attention Soonest?

- Which forests or woodlands that are most threatened, or that offer the most value for forestry, recreation and wildlife habitat, are at risk? Specify why.
- Which historical structures are most important and most under threat? Again, specify why.
- Which recreational areas are of most value and are most threatened? (Perhaps an important hunting area is threatened by a new housing development, or is zoned for industrial purposes, or a trout steam is at risk of pollution from expanded land development and runoff.)
- Explore the extent to which current zoning adequately addresses your county's or region's land assets.
- Where should towns or developments be located in the future, so as to allow retention of key resources or to take advantage of access to outdoor recreation?
- Where are new roads or transportation projects likely to impact your assets – should those projects be modified to minimize or prevent impacts?

STEP 6. Implement Opportunities: Include Your Natural Asset Maps In Both Daily and Long-range Planning

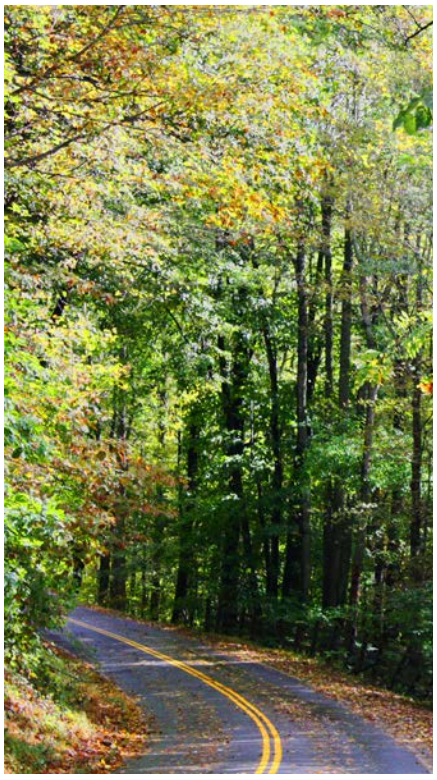
Based on how you have ranked the key natural assets in your area, and which assets are at risk, you may need to implement projects or policies or make changes in local laws, zoning and comprehensive plans to ensure that the priorities you have outlined are achieved. Here are some examples of questions to consider:

- Given your rankings of your landscape's top natural assets, where should towns or developments be located in the future?
- Should zoning or the comprehensive plan be changed to better conserve high-priority assets?
- How can the key forests, farms and waterways you have identified be preserved?
- Should funding be sought to acquire development rights?
- Should there be a landowner education program to encourage voluntary conservation action?
- Could the area's natural assets be utilized in marketing campaigns to expand tourism or attract new businesses?
- Can highly-ranked natural assets be used to prioritize locations for future parks?
- What further data need to be collected, in order to monitor future changes and threats to the area?
- How can local communities, businesses and farmers be best involved in your green infrastructure plan?
- Determine areas important for growth and development, as well as for conservation.

CREATING A GI STRATEGY

To create a green infrastructure strategy, you need to:

- **Determine which natural assets and functions are most important to your community.**
- **Make an inventory of the location and extent of your natural assets and determine which are of the highest quality and how they are (or could be) connected.**
- **Identify opportunities for the protection or restoration of these highest-quality assets.**
- **Develop a coordinated strategy to channel development and redevelopment to the most appropriate locations.**



Peter Stutts

NATURAL RESOURCES *ARE* GREEN INFRASTRUCTURE

The following are examples of how you can think of natural resources as assets within a green infrastructure planning effort.

Forests and Wildlife Habitats

Forests play a key role in the water cycle, helping to evapotranspire water into the atmosphere while slowing overland runoff and providing better infiltration of rain into underground aquifers. New York City relies on the vast forests of upstate New York to filter its drinking water and provide some of the cleanest water in the country to its five boroughs. This slowing and storage of runoff water also reduces flooding, since water is released much more slowly from forested landscapes to surface waters than from open fields or impervious areas, such as parking lots.

A forest is not only its trees but also includes the structures and assemblages of forest soils, accumulated leaf litter – also known as the 'duff' layer – soil microbes, fungus and the myriad habitat niches provided by overstory and understory trees, shrubs and plants (e.g. herbaceous plants and vines).

Forest cover is the most effective land cover type for reducing runoff pollutants. Tree canopy breaks the energy of rain drops, while the duff layer of the forest floor acts like a sponge, soaking up water, reducing the velocity of overland runoff and breaking down pollutants. In addition, forests absorb air pollutants such as volatile organic compounds, sequester carbon (which helps to abate climate change impacts) and produce oxygen.

Forests also provide habitat for wildlife. Larger forests can support a greater diversity of habitat types and thus more wildlife diversity. In general, the larger an intact forested area, the more likely it is to support a greater diversity of species. In order to support a diversity of wildlife, plant and insect species, a good rule-of-thumb for the size of a forest in the eastern U.S. is a minimum interior size of 100 acres made up of native tree species (e.g. not a pine plantation, but a natural forest with a diversity of tree species). In the semi-arid and mountainous regions of the western and southwestern U.S., a much larger area is needed to support many native forest species. Consult your state's Natural Heritage Program or wildlife department to determine a good minimum size of forest to support a high diversity of native species in your locality.

Alternatively, some regions may recognize the value of non-forested areas as functioning ecosystems and habitat for viable suites of plant and animal species. For example, throughout the midwest, only minute remnants of native prairie remain, relative to pre-European settlement. As a

result, conservation priorities in these regions are focused on preserving those patches that remain and on finding opportunities to restore native vegetation assemblages. In parts of the country, marshland and open water are the preservation priorities, and not forests, which may actually be encroaching on those areas. Natural resource agencies in your region can provide guidance on the priorities for your locale and the minimum size requirements for such areas.

Trees Within the Built Environment

Natural resources are not just found in wild and rural areas. They also protect and enhance our urban life. Street trees and woodlots keep cities cooler, reduce air-conditioning costs, absorb stormwater and provide habitat for birds and other wildlife. They also provide habitat values for people by producing oxygen and absorbing pollutants. Within new subdivisions, yard trees increase property values and wooded lots are advertised as an amenity.

By raising the attractiveness of an urban area, natural assets improve both aesthetic and economic values. Even individual trees have value. A recent five-city study discovered that, on a per-tree basis, cities accrued benefits from their trees ranging between $1.50 and $3.00 for every dollar invested in their management (McPherson et al, 2005). For example, a large mature oak can transpire 40,000 gallons of water per year; this is water that is not entering storm drains and thereby causing runoff, excessive stream flows and downstream erosion (EPA: *Reducing Urban Heat Islands: Compendium of Strategies*).

The main street in Charlottesville, Virginia is now an urban park.

ADVANTAGES OF TREES TO THE URBAN LANDSCAPE

Trees offer many advantages to an urban landscape. They can:

- **Raise the attractiveness of an urban area.**
- **Form part of the ambiance of shopping districts.**
- **Shade a pedestrian walkway or open-air mall.**
- **Draw businesses, such as shops and street vendors.**
- **Revive blighted urban areas.**
- **Keep city streets cooler and reduce indoor air-conditioning costs.**
- **Filter pollutants from the air and provide oxygen.**
- **Reduce stress and otherwise improve health.**
- **Offer shade for seating, children's play areas and other recreation sites.**
- **Reduce stormwater runoff.**
- **Provide respite from the heat and opportunities for social gathering as pocket parks and squares.**
- **Provide recreational opportunities and wildlife corridors, such as urban river walks and other tree-lined routes.**
- **Provide habitat for birds and other wildlife.**

Trees are also part of the ambiance of many shopping districts. On a visit to Charlottesville, Virginia, Ian McHarg, the Scottish landscape architect who wrote the landmark book *Design With Nature*, praised the city for replacing what was once the city's main street with a pedestrian walkway shaded by large willow oaks.

Forested urban green spaces, such as the well-known Central Park in New York City or Rock Creek Park in Washington, DC, are large urban parks that provide respite and enjoyment for people from every social and economic background. Even small parks – often called pocket parks – make some cities very special, as, for example, the green tree-covered squares and gardens of Savannah, GA., which create both an identity as well as a degree of connectivity. Similarly, urban river walks, such as the 13-mile Tennessee River Walk through Chattanooga, TN, or the river walk park along the Connecticut River through Hartford, CT, have led to the revivals of those area's downtowns, spurring new businesses and greater opportunities for community fitness.

Rivers, Wetlands, Lakes, Estuaries, Aquifers

Most people realize that water is vital to our existence. The cleaner the water available, the healthier our human population will be.

All types of surface water, such as streams, wetlands, lakes and groundwater aquifers, springs and seeps, support life: birds and mammals, aquatic plants, fish, invertebrates, crustaceans and mollusks, reptiles and amphibians and people. Estuaries support vital nurseries for young fish, clams and crabs, as well as provide wonderful places to enjoy water sports and scenic views. Surface water also generates opportunities for recreation, such as fishing, boating and birding, and provides aesthetic qualities, such as scenic beauty. Local governments know that rivers, lakes and other water features translate into higher property values and directly support their tax base.

Keeping water supply sources clean can be supported through a thoughtful green infrastructure plan. For example, New York City spent 1.5 billion dollars to acquire 80,000 acres of the watershed that provides its drinking water, in order to restrict development and protect water quality. While this was a large sum of money, it was far less than the $8 billion required to build an adequate filtration plant and an additional $300 million annually for its operating costs (Tibbets, in Benedict and McMahon 2006).

Soils

While soil is defined as the unconsolidated mineral or organic material on the immediate surface of the earth that serves as a medium for the growth of vegetation, we can also think of it as part of our infrastructure. It serves as a medium for growing food, supports vegetation, absorbs water, breaks down wastes and absorbs carbon.

In terms of food production, certain soils are better for supporting agricultural uses, such as row crops or forage for livestock. If we have a map of where those soils are located, we can ensure that areas designated for agriculture can best support those uses. USDA-classified agricultural soils are available as GIS data layers and can be used to evaluate where those soils are located. (For more on this, see Chapter Five.)

In addition, soil data can promote smart planning by showing where soils are well drained and viable for septic systems, or where rural development is *not* appropriate because the soil is not suitable for septic treatment. Even good soils are becoming important in urban areas as farming takes off in many cities, including Richmond, VA, Asheville, NC and Little Rock, AR.

Geologic Features and Landscape Forms

Geologic features such as rock outcrops, cave and karst features, mountain ridges and unique rock formations are part of what we consider natural assets. These landscape resources contribute to its aesthetic value, whether it is El Capitan in Yosemite, Carlsbad Caverns in Texas, or the Grand Canyon. People place an aesthetic value on types of rocks and minerals, as well as on vistas of ridge tops and valleys.

Geology can also determine the location and extent of unique natural communities/vegetation. The minerals within the rocks as well as physical elements of slope and aspect can determine whether it supports certain species. A landscape's geology of mountains, hills and valleys also plays a significant role in agriculture, especially for crops such as fruit, that do well on slopes, or those crops that need the fertility of lowlands where soils are deposited. In addition, many developers seek to take advantage of outstanding geological features and emphasize them to their prospective buyers.

Karst and limestone features, such as springs, sinking springs and caves, are also critical natural assets. Not only do those areas provide habitat for many rare, threatened and endangered species (such as cave arthropods or the Indiana bat), they are directly linked to groundwater quality. So are many other types of rock. As a result, impacts above ground might not only affect beautiful natural features, but may have quick and potentially detrimental impacts on drinking water and wildlife habitat. The residents of several coal mining areas in Tennessee, Kentucky and West Virginia are acutely aware of this, as mountain

top removal for mining and filling of narrow stream valleys have impaired water quality. Thus, an understanding of rock types and geologic resources in an area may help prevent a future need to mitigate impacts to the quality and supply of drinking water or wildlife.

Floodplains are also key natural assets because they absorb the energy of floodwaters by allowing them to spread out and slow down during high-water events; accordingly, they reduce the downstream erosive force caused by flooding. Similarly, dune systems buffer coastal areas from floods and erosion associated with storms and protect both man-made structures and coastal land from damage.

Areas that possess a unique geology, such as rare mineral deposits, might be included on a map of natural assets, perhaps for future extraction, but perhaps also for aesthetic reasons. Examples of this are the staurolite 'Fairy Stones' of southern Virginia, which are cross-shaped and were formed under the great heat and pressure of the Appalachian Mountain orogeny; the zircon crystal mines in the Wichita Mountains; and the shale barrens of Canada. These are all unique geologies that, while mostly open, serve as hosts to suites of uncommon and rare plants found almost exclusively in these habitats.

Unique geologic features can span many states, such as the quartz crystal deposits that are 30-40 miles wide and run from Little Rock Arkansas to eastern Oklahoma. There are cliff escarpments and mountain ranges that run for hundreds of miles, each of which forms a unique geology that supports rare plant and animal assemblages, such as the Catskill Escarpment (referred to as the Catskill Front by geologists), a range forming the northeastern corner of the Catskill Mountains in New York state, or the unique vegetation of the "Islands in the Sky" of Arizona and New Mexico.

GREEN INFRASTRUCTURE PLANNING TODAY

Across the U.S., communities are mapping and evaluating natural resources as they recognize that their integrity and the interconnections between them are key to long-term community well-being. Historically, these efforts have been known by different names – greenways, greenprints, conservation plans and asset maps. They are often initiated by state agencies, such as forestry and park departments, but other organizations also promote them: natural heritage programs and regional planning districts; university departments; conservation groups, such as the Nature Conservancy, Defenders of Wildlife, the Conservation Fund, the Trust for Public Land and the Green Infrastructure Center; and associations such as the National Arbor Day Foundation and the American Planning Association.

Virginia Outdoors Foundation

Federal agencies, such as the U.S. Forest Service, the U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration and even the U.S. Department of Defense (as a large landholder of significant environmental resources) are taking an active role in supporting green infrastructure conservation and planning efforts. In 2006, federal agencies collaborated on a national publication called *Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects*, which was developed primarily to promote conservation and avoid habitat fragmentation by road projects.

In 2007, a consortium of federal agencies supported the Conservation Fund to develop a national self-reporting database of projects (www.greeninfrastructure.net). Also in 2007, the USFS published *Forest Service Open Space Conservation Strategy: Cooperating Across Boundaries to Sustain Working and Natural Landscapes*, in which Strategy #10 calls for the "development of tools to help communities strategically connect open spaces to build a functioning green infrastructure." In addition, the joint USFS and EPA's *Healthy Watersheds Initiative* have supported the use of green infrastructure as a way to achieve watershed protection.

A ***greenprint*** is another name for a green infrastructure plan. For example, Miami-Dade calls its GI plan *GreenPrint: Our Design for a Sustainable Future* and describes it as "a fully collaborative process among the many diverse stakeholders of our community."

A ***greenway*** is a strip of natural land or riverside that passes through areas where the public can walk, ride bicycles and horses, picnic, or otherwise enjoy recreation. It also serves as a wildlife corridor that provides species with access to the inner cities.

GREEN INFRASTRUCTURE PLANNING CONCEPTS

Green infrastructure planning is not an entirely new concept and its underpinning principles arise from multiple disciplines.

The term 'green infrastructure' was first coined in Florida in 1994 in a report to the governor about land conservation strategies. Combining the words 'green' and 'infrastructure' was intended to reflect the notion that natural systems are equally, if not more, important components of our 'infrastructure' and should be included in the planning process. Since it is generally accepted that we have to plan for gray infrastructure, the idea of planning to conserve or restore our natural resources, as in taking care of our 'green infrastructure,' was intended to help people recognize its key role in civil society.

"Green infrastructure planning provides an opportunity for communities to approach land-use planning in a new way by evaluating, prioritizing and managing the landscape as a connected and interdependent system."

Low-Impact Development

In 2007, twelve years after the application of the term 'green infrastructure' to refer to natural resources, the EPA began to apply the same term to site-scale best-management practices, such as biofilters (rain gardens), planted (green) rooftops and other stormwater management structures. Previously, these practices were primarily referred to as *low-impact development* (LID). An LID approach offsets runoff pollution from the built environment by the use of integrated best management practices, such as a series of rain gardens to slow and filter stormwater within recessed planting beds whose plants and soil break down pollutants.

The application of the term 'green infrastructure' to site-scale, engineered stormwater management has led to confusion. This guide employs the term strictly as it was first coined by Florida – as a landscape-level evaluation of natural assets for a region, county, town or city. We also introduce the term *natural asset evaluation and mapping* to more directly reflect the GIC's focus on evaluating *natural* landscape resources and conserving them first, before seeking engineered solutions to mitigate impacts from the built environment.

However, while this guide focuses on the larger landscape scale, it does not ignore the importance of these site-scale solutions at all. Rather, it explores how to think at *multiple scales* – from the site to the neighborhood, to the town, city, county, watershed and region – and then back again. In fact, it is important to realize that natural assets need to be assessed and reconnected at multiple scales. So *first*, protect natural assets and minimize land disturbance while keeping the landscape connected. *Then second,* employ LID features to mitigate stormwater runoff at the site scale.

GREEN INFRASTRUCTURE'S KEY ELEMENTS

Several disciplines have addressed the idea of a connected landscape and the importance of selecting and connecting large habitat areas, including the fields of planning, landscape architecture, ecology and conservation biology, forestry, and more recently, transportation. The following is a brief summation of the key concepts they have developed.

Greenways or ***green corridors*** are "linear open spaces that preserve and restore nature in cities, suburbs and rural areas…to link parks and open spaces and provide corridors for wildlife migration."

Green Corridors

The notion of a connected landscape was popularized by the greenways movement. In the late nineties, Charles Little wrote *Greenways for America (Creating the North American Landscape)*, which popularized an existing movement to get Americans out of their cars and into the landscape through what he called "greenways" (Little, 1995). These were loosely defined as "linear open spaces that preserve and restore nature in cities, suburbs and rural areas…to link parks and open spaces and provide corridors for wildlife migration." Later, the concept of *green corridors* was introduced, with much the same meaning.

However, green infrastructure is far more than greenways.

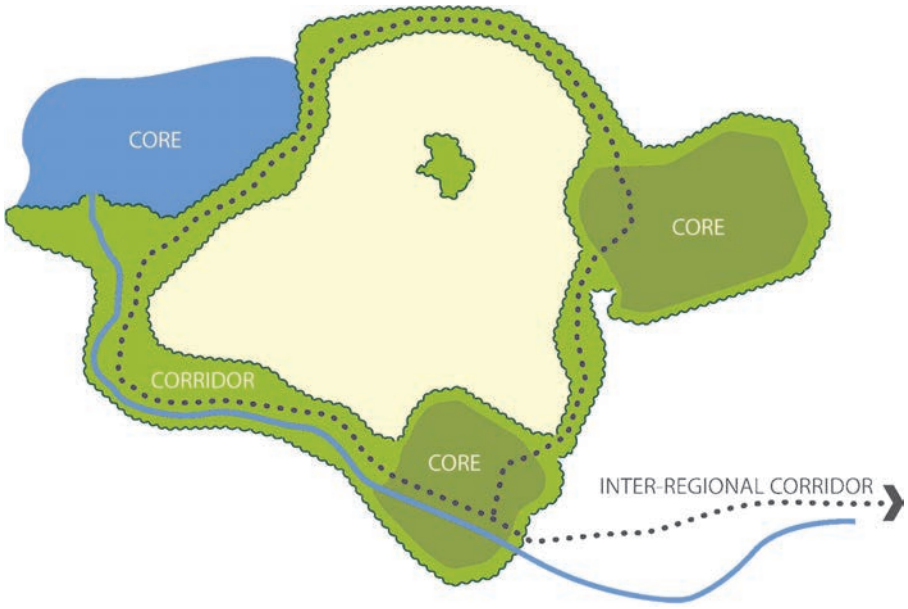
Core Habitats

In the early 21st century, authors such as Benedict and McMahon defined green infrastructure as "a strategically planned and managed network of wilderness, parks, greenways, conservation easements, and working lands…" They defined this network in terms of "hubs" that were joined by "links." They also brought in the notion of *multiple scales*, and stressed the importance of connecting specific local sites into a wider system of links and hubs. Other writers then developed the concept, though they often used different terms.

Around the same time, Hellmund, Smith and Somers updated the notion of greenways to incorporate the connection of large-scale habitats in their book *Designing Greenways: Sustainable Landscapes for Nature and People* (2006). Significantly, they developed a more useful and wider description of green infrastructure that built upon the greenways movement but also incorporated theories of landscape ecology from earlier work by noted landscape ecologist R.T.T. Forman. They discussed Forman's notion's of edges, patches, and why the shape and size of habitat areas are extremely important as drivers for the dynamic flow of materials, insects, plants and animals into and out of these habitats.

A Connected Network

Green infrastructure encompasses much more than river greenways or green corridors. While GI planning appreciates corridor greenways as critical connectors between habitats, it sets them within a wider structural context. Rather than regarding the corridors as the focal point of a green strategy, it emphasizes the role of those corridors as links between larger blocks of intact habitat that provide sizable, wildlife-sustaining cores capable of supporting a diversity of species. It places a significant value on these core habitats, depending on their integrity, size and quality. The corridors are important, but without the cores, there is significantly less overall diversity in the landscape.



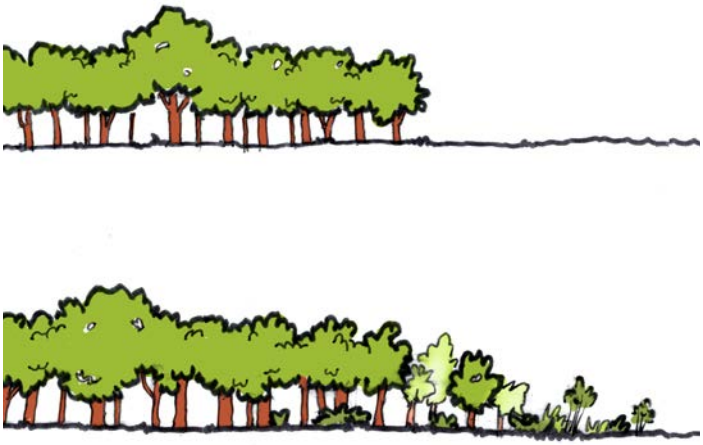
Whether you prefer to use the terminology of "hubs, links and sites," "patches, cores, corridors and sites," or "cores, corridors and sites," (which we use in this guide), the principle is still to conserve large blocks of intact habitat that are connected by corridors that allow for species movement. Species use the corridors to forage, nest, breed, and move and disperse between core areas.

Note also that each core consists of two parts: a *central area* of undisturbed wildlife habitat, which is surrounded by an *edge area* that absorbs impacts from outside the core (such as erosion, wind, human intrusion and invasive species). This *edge habitat* serves as a buffer; protecting the inner core habitat from encroachment.

Patch: a relatively homogeneous, nonlinear area of natural cover (such as a forest, desert region, marshland, or grassland) that differs from its surroundings.

Core: A core is an area or patch of relatively intact habitat that is sufficiently large to support more than one individual of a species. Consider that the greater the number of interior species present and the greater the diversity of habitats, the more important it is to conserve the core intact.

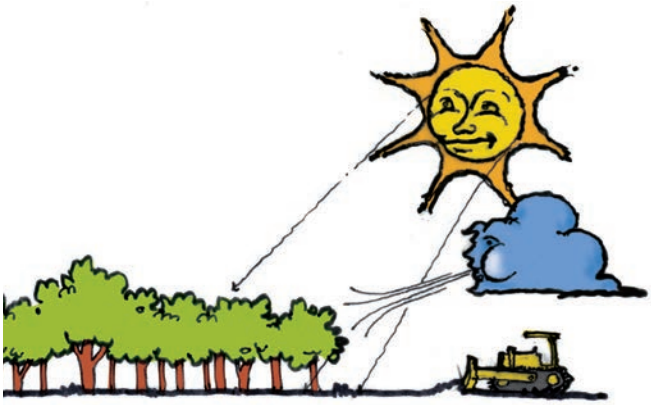
Edge: The transitional boundary of a core, where the vegetation assemblage and structure differs markedly from the interior, such as forest edges. The structural diversity of the edge (with different heights and types of vegetation) affects its species diversity, as well as the prevalence or abundance of native or invasive species.



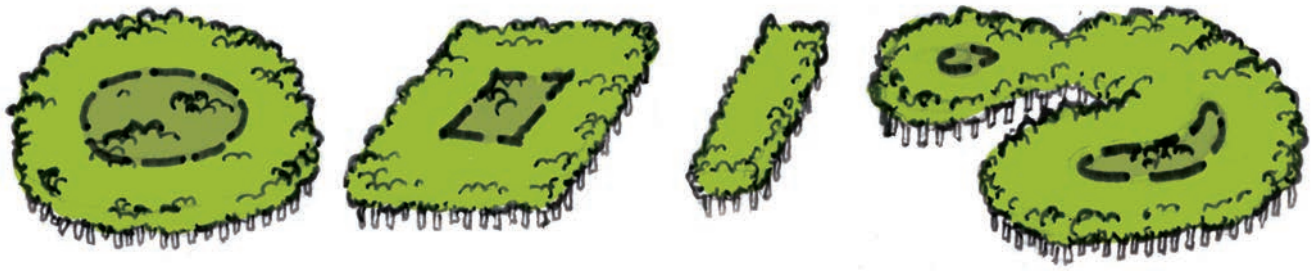
A hard edge, where the habitat changes abruptly is common along man-made fields. A softer edge can serve as a transitional zone or buffer and may support species specifically adapted to take advantage of edge areas.

Corridor: A more or less linear arrangement of a habitat type or natural cover that provides a connection between cores and differs from adjacent land. Corridors are used by species to move between cores, so they need to be wide enough to allow wildlife to progress across the landscape within conditions similar to their interior habitat. For this reason, it is recommended that these connections be at least 300 meters wide: a central 100-meter width of interior habitat, with a 100-meter edge on either side to protect safe passage and buffer against human intrusion and invasive species. Streams are natural corridors and the width of the vegetative corridor on either side should reflect the stream order (i.e. larger streams need wider forested buffers).

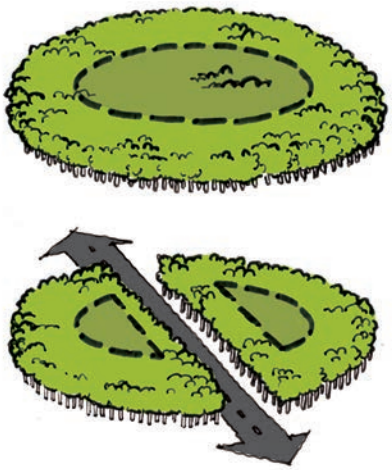
In addition to wildlife movement, corridors allow populations of plants and animals to respond to changes in land cover, surrounding land use and microclimate changes over the long term. For example, if a species in a core area is compromised because habitat conditions become unsuitable, it is more likely to survive if it can occupy corridors outside its core that provide some connection to surrounding areas. Thus, the larger a network of interconnected corridors and cores happens to be, the more likely it is that overall species diversity and functioning ecosystems can be maintained amidst a changing landscape.



Effects of sun, wind and human disturbance can cause impacts to the edge area. This disturbed area or edge is not counted as part of the interior of the habitat. The interior is mostly protected from these edge effects.

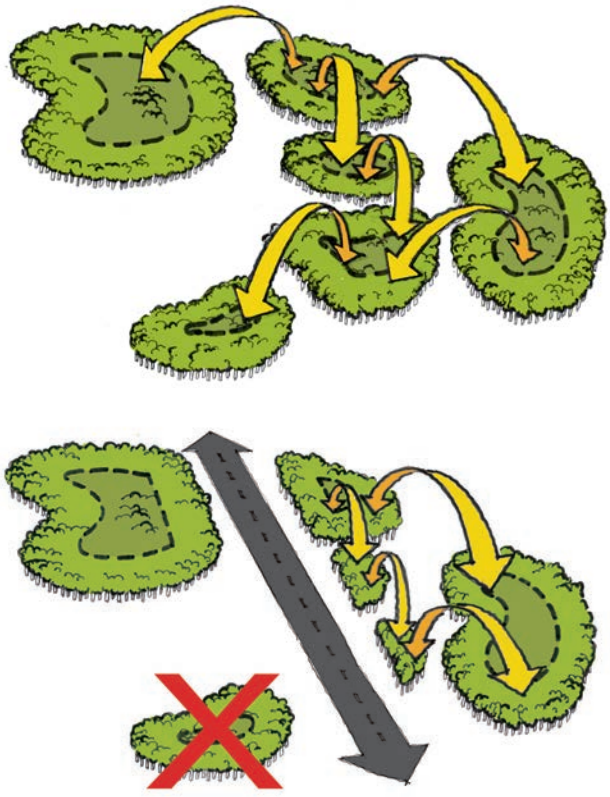


The edge width is determined by taking the average tree height, e.g. 100 feet, and multiplying that values times three. So in the eastern U.S. where average tree heights are 100 feet, the width of the edge is 300 feet. Whatever is leftover equals the interior habitat. Notice how the shape of the core affects the amount of interior. When there is more length of edge, three is less interior.



Bisecting a core with a disturbance such as a road, creates more edge and less interior habitat needed by many species. This is why bisecting a core should be avoided whenever possible.

Stepping Stone: Throughout this network of core areas and corridors, certain smaller areas can provide 'stepping stones' between cores. A stepping stone tends to be a smaller area of intact habitat that may not be large enough to sustain a species on its own, but is vital to a population's success over the network as a whole, as it provides a way to move across the landscape.



Stepping stones of habitat areas can facilitate animal movement. Roads or other impedences can block them sometimes.

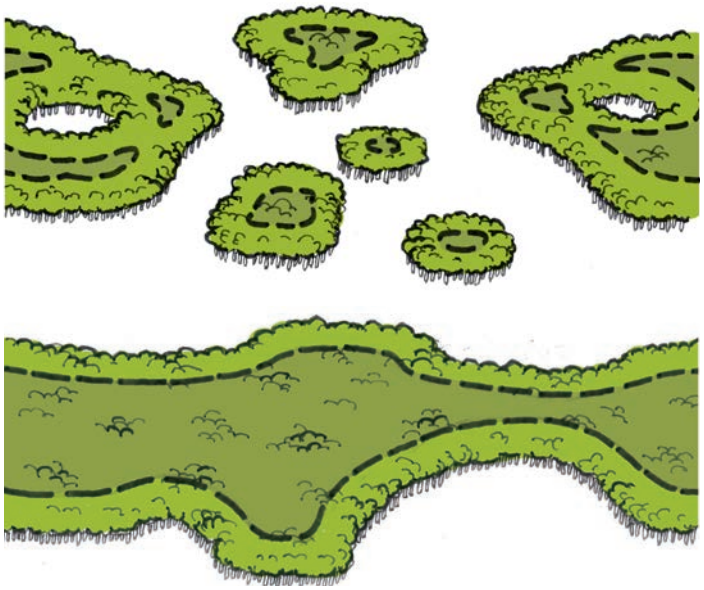
If you wish to ensure species diversity, particularly for native species, it is critical to identify, map and protect a series of intact core habitats and their connecting corridors, as well as identify those smaller areas of habitat that serve as stepping stones between larger cores.

In the image below left, a stepping stone has been lost. As a result, if something causes a decline of a species in an isolated core, such as a hurricane, forest fire, disease or over-harvesting of vegetation, the species may be unable to re-colonize it.

Although a similar scenario can occur when a corridor is breached, a cluster of closely-related stepping stones can provide substitute connections and alternate routes for plants and animals. The size and spacing of these areas will determine whether or not the species can cross between them and maintain viability.

Fortunately, corridors can be restored through replanting. Also, some species have a remarkable ability to adapt and discover new paths between core habitats. There was a mountain lion that recently journeyed the hills and prairies of the Midwest from South Dakota to Connecticut, an incredible journey of 1,100 miles (Patch News, Greenwich Connecticut, July 26, 2011). In the summer of 2011, a similarly adventurous black bear migrated from the coastal plain up to Chapel Hill and Greensboro, presumably using the riparian buffers along the Cape Fear River and its tributaries as corridors (Weakley 2012).

Together these cores and corridors form a network. A green infrastructure network seeks to connect habitats to allow species movement.



Corridors can be restored by replanting bare areas between patches of core habitats..

KEY GREEN INFRASTRUCTURE PLANNING ADVANTAGES

There are several key advantages of a green infrastructure planning approach:

1. **A green infrastructure strategy protects species. The key point to focus on when embarking on a GI planning process is to *think at multiple scales*. Begin with the wider landscape and consider how connections can be made across multiple areas. By thinking about connections in this way, your strategy will avoid isolating core areas and unintentionally aggravating species loss.**

2. **A green infrastructure approach can create a more resilient ecosystem. And a resilient ecosystem is better able to maintain its core functions. Here, 'resilience' refers to the amount of change a system can undergo and still retain the same controls on its function and structure. (Holling 1973). A resilient ecosystem has the ability to withstand more impacts, such as storm damage, human impact or diseases, and still maintain its core functions.**

   In order to maintain resilience, it is critical to protect the natural state of an ecosystem as much as possible. Permit as little disturbance to it as you can: as little human intrusion, such as road building; as little fragmentation; as little noise; and as few introductions of alien species.

3. **A green infrastructure strategy allows multiple objectives to be met at once. Often referred to as *multi-objective planning*, a green infrastructure plan should include multiple objectives for open space recreation, habitat conservation and biodiversity, tourism and economic development. Cores, corridors and other land areas that meet multiple goals can be targeted for conservation.**

In this chapter we have covered definitions. In the next chapter, we will focus in more detail on the benefits of green infrastructure planning.

Pollinators also benefit from habitat protection.

Certain species, such as the scarlet tanager, prefer interior forests.

2

PLANNING WITH NATURAL ASSETS FIRST

- Avoiding risk
- Ecosystem services
- Cultural assets
- Vibrant communities

CHAPTER 2 - The Need to Evaluate and Map Natural Features

By considering environmental resources as 'natural assets,' based on the functions described in previous chapters, we can begin to assign appropriate values to them and recognize their importance to our lives and livelihoods. Determining how to evaluate and manage these resources as key assets will help us meet important community values – for example, if you value wildlife or recreation, assessing your natural assets will help you protect them.

Other values you might wish to emphasize are stormwater treatment, energy savings, aesthetic values, improved community health or a sustainable local economy.

FIRST STAGE OF LAND PLANNING BEGINS WITH GREEN INFRASTRUCTURE

While the idea of natural resources as 'green infrastructure' (GI) has been around for several decades, most local governments are not familiar with it. As a result, it is important to articulate and promote GI's benefits to staff planners and both appointed and elected officials. We need to stress that these assets need to be evaluated and catalogued as the *first stage of land planning*, in order to ensure the long-term ecological, social and economic health of our communities, and to enable them to benefit from the considerable financial savings of a green infrastructure approach.

When Ian McHarg was putting forward his ideas in his book *Design With Nature* (1969), planners had to rely on trace paper, transparencies and long hours of coloring to show the relationships between the land's natural features, laying one transparent sheet over the other to see where critical drainage or key soils overlapped or intersected. Today, we have digital Geographic Information Systems (GIS), through which we can see these relationships almost instantly by turning on and off digital layers that are spatially related.

However, even with the advent of computer software, remote sensing technology and much faster computers that can analyze as much data on a laptop in seconds as it once took days to process on a mainframe, we do not always utilize the wealth of data available to us. But we need to. We need to do it consistently and *as a first step*.

Peter Stutts

Right Order Thinking: Begin With a Map of Natural Features

A natural asset planning effort identifies and evaluates existing natural and cultural resources and prioritizes those assets that are most unique, or that best meet current and future needs. To achieve this, any strategy should include a *prioritization process* to select, rank and conserve those areas that are most critical to a resilient and healthy community.

Ideally, if enough natural assets are protected in the first place, there will be less need to build engineered structures to deal with such problems as stormwater runoff or sea encroachment over coastal areas. Once you have conserved your key natural resources and buildings have been sited to minimize impacts and landscape fragmentation, your focus can turn to mitigating the impacts from buildings and developed surface areas. For example, you can treat stormwater runoff through site-scale low-impact development approaches using rain gardens, green rooftops, permeable paving and a host of other best-management practices that contain, detain and filter runoff.

An illustration of the need to assess existing natural assets on a site as the first step was witnessed by the author. A developer of an affordable housing program proposed cutting down several mature oak trees and replacing them with rain gardens. The trees were already absorbing and filtering the rainwater, while also providing the proposed homes with shade and wind shelter. Fortunately, when the benefits of the existing trees were pointed out by the local planning commission, the developer changed his plans to cut them down. Whenever possible, natural infrastructure should be conserved before seeking an engineered solution to replicate its functions.

"Whenever possible, natural infrastructure should be conserved before seeking an engineered solution to replicate its functions."

While saving a handful of trees on one site may seem to have a small impact, these site-scale conservation approaches can soon add up. A national study of the value of urban tree cover in reducing stormwater problems and improving air quality showed that the trees in our cities are worth more than $400 billion in terms of money saved by not having to build such structures as stormwater ponds or biofilters (Benedict and McMahon 2006).

While it is useful for future contingencies to map your natural assets, their links to key cultural resources and their desired future uses, it is also very useful for everyday planning. To quote a past president of the Virginia Homebuilders Association, when he was addressing county planners, "I just want to know what you want and where you want it. You can save us both time and money by telling me in advance what the community desires."

If you have your key assets mapped out in advance, it allows developers to propose projects that meet current and future community needs. It also saves time later by not having to make multiple reiterations of site plans when yet another key resource is discovered or a new community concern is brought up.

With a map already in place, your community can also choose to enhance its green infrastructure by proactively selecting areas to restore through new plantings, acquisition of land or the creation of new conservation easements that re-link disconnected landscapes.

A Map Avoids Future Risk

The key to maximizing a community's success is to ensure that it has as many choices and options available to it as possible. This is a similar approach to creating an investment portfolio – risk is minimized by having multiple kinds of investments.

In some respects, a healthy community needs to have a diversity of options to provide it with its necessary ecosystem services and ensure that today's decisions do not unduly foreclose on future options. Evaluating resources now and making sure there are enough of each type ensures that future populations can have abundant natural services and sufficient community character to build a successful community.

If you identify those assets that are at risk and that you wish to conserve, a map can mitigate against future economic challenges and threats to public safety. For example, if you identify those assets within floodplains and make them off-limits to future development, you can meet your needs to conserve wildlife corridors, while also preventing the loss of life and property damage.

Every community that has a zoning ordinance can decide whether or not to allow building in flood zones. However, those that choose to allow it must still follow federal regulations. The United States guaranteed flood insurance opportunities for communities through the Flood Disaster Protection Act of 1973 and amended regulations

of 1994, but those laws only allow localities to develop their floodplains as long as they follow Federal Emergency Management Act (FEMA) guidance for floodwater ingress and egress.

You can also identify other areas of high risk, such as regions vulnerable to sea level rise, and you can include them on your map as areas to avoid. There are currently models and maps available from NOAA that identify these sections of coastline. For more, see Chapter Seven.

Development has caused new backyard flooding and hazards.

ECOSYSTEM SERVICES

In the past ten years, there has been a renewed interest both in landscape-scale planning and in linking ecological services and community needs. Increasingly, localities recognize that livable and healthy communities require the conservation and restoration of healthy forests, accessible open spaces and connected landscapes, in order to provide clean air, clean water, public fitness, wildlife diversity and aesthetic benefits. Often referred to as ecosystem services, these largely free environmental functions are key to creating livable communities. *Ecosystem services* have quantifiable economic benefits which reduce the cost of providing services within a community.

Ecosystem services are those positive benefits nature provides us, generally for free, that are essential for a thriving community. They include clean air and water, recreational opportunities, beautiful vistas, natural heritage sites, stormwater remediation, healthy foods and places to rest the soul and recuperate.

The notion of *ecosystem services* has now begun to gain credibility with economists and land planners. For example, as land managers and municipalities search for ways to abate the damage and costs of flood events, such as the repeatedly devastating floods of the Mississippi-Missouri river system, many are realizing that the most cost-effective way to alleviate future costs and minimize risk is to avoid building in hazardous areas in the first place, and to infiltrate a lot more water throughout our watersheds by planting far more forested land. Instead of continually trying to flood-proof buildings, some managers are realizing it is cheaper to let floodplains perform their natural function of absorbing floodwater. As a result, the economics of a green infrastructure approach have gained increased recognition, even though we may not always realize that we need to expend time and effort to ensure that these ecosystem services are well maintained. See the text box for an example.

If land planning begins within the context of a local ecological system, it ensures that development is channeled into the most appropriate areas, while environmental functions are protected. This saves both money and energy. In already developed areas, green assets can be reconnected while new development takes place in more suitable areas. And you can even begin to restore lost areas vital to the ecosystem.

AVOIDING FLOOD RISKS

A very wet fall in 1992, followed by heavy snowmelt in 1993, caused dramatic runoff to swell the banks of the Mississippi River and its tributaries. Streams and rivers overran the levees in the Dakotas, Minnesota, Wisconsin, Illinois, Iowa, Nebraska, Kansas and Missouri. The result was the death of 48 people and $15–$20 billion in property and land damage.

Flood waters covered 2.6 million acres of land. A total of 74,000 people became homeless as navigation was closed on the system's major rivers for almost two months. The government declared 525 counties in nine states – including all of Iowa – disaster areas.

As a result, the towns of Pattonsburg, and Valmeyer in Illinois and Rhineland in Missouri agreed to relocate to higher ground, thereby letting the floodplain perform its natural function of absorbing flood energies without placing people and property in the watershed at risk. (*Los Angeles Times*, July 12, 1998).

Lack of forest cover can lead to more flooding and damage to grey infrastructure.

Even at environmentally impaired sites where some contamination has occurred, natural systems and habitats can be restored. And, more importantly, plans that seek to conserve natural assets can create or sustain linkages so that animals and people are able to move across the landscape.

We need to consider the values that these natural resources provide, in order to ensure that we can be intentional about conserving, protecting and restoring them. We need to understand where these natural assets are located, how abundant they are and what is their current condition. This will enable us to determine how best to manage them.

FISCAL CONSIDERATIONS

Perhaps the greatest long-term obstacle to local governments adopting new ways of planning that include evaluating and conserving natural assets are the fiscal challenges they face. An often-heard refrain is, "We can't afford to do more planning in these tough economic times. We need to get rid of rules, plans and regulations in order to attract more development."

However, that is a false economy. Local governments, chambers of commerce and others should be aware that green infrastructure planning is not an additional burden; it is a way to plan more efficiently and effectively. Having better information at one's fingertips can both *speed up* the planning process and make it easier to develop in a way that benefits *both* the environment and the economy and avoid pitfalls from poor decisions later on. They need not be seen as enemies. Rather, they are compatible elements that will *both* improve our communities if they are *both* considered.

We can think of 'green infrastructure' as an environmental insurance policy that enables traditional economic growth and development in focused growth areas without compromising the health and well-being of the community. If we identify key watershed recharge areas, the best agricultural lands and the most unique and productive forests as a first step, we can ensure that growth does not deplete the resources upon which we all depend for healthy and strong communities. This is especially true when trying to ensure a long-term water supply or seeking to comply with mandates for clean water. If we avoid damaging our best areas and identify opportunities for restoration, we will save both our ecological and economic health over the long term.

"We can think of 'green infrastructure' as an environmental insurance policy that enables traditional economic growth and development in focused growth areas without compromising the health and well-being of the community."

Economic Value of Green Assets

If a community wants to be more effective in luring businesses and growing during tough economic times, it should remember that green communities attract companies. Sound planning also helps to ensure predictability for those locating to a new area.

This is also true for real estate development; studies have shown that those who include green space or natural areas into development plans sell homes faster and for higher profits than those who take the more traditional approach of building over an entire area without providing for community green space (Benedict and McMahon 2006).

There is one other compelling fiscal reason for planning the conservation of natural assets as part of a green infrastructure strategy: avoiding costly natural disasters. By including the natural landscape as part of infrastructure planning, it is possible to reduce the threat of extensive flooding by identifying and protecting floodplains, allowing for natural drainage and avoiding building in hazard locales. The risks and costs associated with wildfires can also be reduced or eliminated by evaluating where forests are most sensitive to disturbance and avoiding overdevelopment in those areas. And, if you live in an earthquake zone, you can put strict building codes in place that are intended to mitigate future damage and seek to avoid building close to or on top of fault lines.

GI PLANNING *SAVES* MONEY

It is not a new idea to evaluate natural assets at the beginning of the land development process. Ian McHarg published his seminal book *Design With Nature* in 1969, in which he proposed that planning must begin with a consideration of the land's natural features: its soils, slopes, waters and drainage. He proposed the notions of *layering information* and considering landscape features as *resources that must be evaluated in tandem*, in order to create a development plan that worked *with* nature instead of against it.

His approach actually *saved* money, since it avoided problems of improper site development – such as poor drainage and flooding – and created developments that were more attractive and less destructive.

Land Values

A study by the National Association of Realtors found that 57 percent of voters surveyed were more likely to purchase a home near green space and 50 percent were willing to pay 10 percent more for a home located near a park or other protected area. A similar study found that homes adjacent to a greenbelt in Boulder Colorado were valued 32 percent higher than those 3,200 feet away (Correll *et al* 1978). Ensuring property values are maintained is important for localities that need stable tax revenues and for homeowners who need to maintain the investment value of their properties.

Jobs

Preserving open space helps attract companies that offer good jobs. Small companies, especially those that have a well-paid and skilled workforce, place strong importance on the 'green' of the local environment (Crompton Love and Moore 1997). The creative class – artists, media workers, lawyers, and analysts – makes up 30 percent of the U.S. workforce and its members place a premium on outdoor recreation and access to nature (Florida 2002).

In addition, many jobs are dependent on large intact landscapes. A high proportion of southern forest lands that are suitable for harvest are within a zone denoted as the *wildland-urban interface* – the zone where human encroachment occurs within a largely forested landscape – making it more difficult to harvest trees and manage forests there. For example, controlled burns may be needed to restore forests or encourage native species. When people live close to or within these areas, such management practices become unpopular or unsafe (*2003 Southern Wildland-Urban Interface Assessment*). For many states in the Southern U.S., forest industry revenues are in the billions of dollars, so continued urban encroachment into rural areas threatens their rural economies.

A ***wildland-urban interface*** (WUI) is a zone of transition between unoccupied land and urban development where development begins to encroach upon and within previously undeveloped areas.

SAVING COSTS OF MITIGATION AND WATER TREATMENT

A survey by the American Water Works Association found that a 10 percent increase in forest cover reduced the chemical and treatment costs of providing safe drinking water by 20 percent (Barten and Ernst 2004). Since half of the country depends on surface waters for its potable water supply, reducing treatment costs will benefit more than half the nation and have considerable cost savings.

There are multiple studies of the benefits of urban forest canopy in mitigating the cost of urban impacts. For example, USFS researcher David Nowak studied Washington, D.C.'s urban canopy and found that it stored about 526,000 tons of carbon, which he calculated provides benefits to the city of $9.7 million. The urban canopy also removed about 16,200 tons of carbon per year, at an estimated value of $299,000, along with 540 tons of air pollution, estimated to be worth an additional $2.5 million per year (Nowak 2006).

For those who depend on well water, forests recharge aquifers by holding water, filtering it and allowing it to slowly infiltrate down, instead of running off quickly (and causing other problems, such as downstream flooding). The longer a well can remain in service, the lower the cost, since it will not need to be relocated or re-drilled to reach a deeper water table.

URBAN TREES PROVIDE MULTIPLE BENEFITS

American Forests has estimated that "the value of urban tree cover for reducing stormwater problems and improving air quality in cities is worth more than $400 billion." (*Human Influences on Forest Ecosystems: The Southern Wildland-Urban Interface Assessment, 2003*).

MEETING REGULATORY REQUIREMENTS BEFORE THEY BECOME TOO COSTLY

The Clean Water Act, the Safe Drinking Water Act and a host of other state and local regulations require us to protect the quality of our environment. We can reduce the costs of pollution prevention and cleanup by ensuring that our landscape is as forested as possible. We can also prevent pollution in the first place. Forested landscapes are the most effective land cover for infiltrating water and for filtering and cleaning polluted runoff. Sediment, nitrogen and phosphorus are the three primary types of pollution targeted for reduction as part of the mandatory plan to clean up the Chesapeake Bay, which affects the states of Maryland, Virginia, West Virginia, New York and Pennsylvania, as well as the District of Columbia. And trees and forested landscapes are the most effective way of reducing all three of those pollutants in our waterways.

Protecting watersheds with forested land cover and buffering streams from runoff also help prevent future water quality impairments that are expensive to mitigate under the Clean Water Act's Total Maximum Daily Loading (TMDL) provisions. These mandate modeling and cleanup plans for waters found to be impaired, something that affects every state. Planning, with water issues in mind is far less costly in the long run, than trying to rehabilitate an impaired stream.

IMPROVING HUMAN HEALTH

Forest cover reduces surface temperatures, which keeps cities cooler and more livable. Furthermore, trees absorb volatile organic compounds and particulate matter from the air, improving air quality.

Forests and other natural areas also benefit people who suffer from Attention Deficit Hyperactivity Disorder (ADHD). A study of children who moved closer to green areas found that those who relocated tended to have the highest levels of improved cognitive functioning following the move, regardless of level of affluence (Wells 2000). Green outdoor settings appear to reduce ADHD symptoms in children across a wide range of individual, residential, and case characteristics (Kou and Taylor 2003).

Kids who spend time outside have lower rates of ADHD.

NATURAL ASSETS SUPPORT CULTURAL ASSETS

As you evaluate your natural assets, it is important to consider how they link to or support *cultural assets*. A cultural asset is a place or feature that is important to the human experience. It forms part of the daily life of a community and is supported by, or includes, natural assets. For example, an historic plantation manor home and its associated outbuildings are set within a landscape. Both the structures and the setting of trees and vegetation are what we consider to be assets.

A ***cultural asset*** is a place or feature that is important to the human experience. It forms part of the daily life of a community and is supported by, or includes, natural assets.

A cultural asset is a place or landscape resource that is important to the human experience and is landscape dependent. For example, an historic plantation, a battlefield or an historic district are not simply the obvious and immediate features, but are dependent on the landscape that surrounds them. Imagine Vicksburg without the Mississippi River.

It is important to identify those natural assets that surround and support key cultural and historic features, in order to preserve their context and setting and to buffer them from intrusion. Taken together with other natural and culturally important structures and land uses across a larger scale, these features may comprise a particular cultural landscape.

A cultural landscape has been defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person, or exhibiting other cultural or aesthetic values" (Birnbaum 1994). For more, see the text box on page 30.

While National Register nominations document the significance and integrity of historic properties, in general, they may not acknowledge the significance of the landscape's design or historic land uses, and may not contain an inventory of landscape features or characteristics. Additional research is often necessary to provide the detailed information about a landscape's evolution and significance that is useful in making decisions for the treatment and maintenance of a historic landscape. Existing National Register forms may be amended to recognize additional areas of significance and to include more complete descriptions of historic properties that have significant land areas and landscape features.

Cultural and Historic Features

When creating a map of natural assets, it is important to identify which natural features also support cultural assets.

Sara Hollberg/Valley Conservation Council

A historic plantation home depends upon the landscape context.

Sara Hollberg/Valley Conservation Council

This gas station destroys the historic context for this historic home's site.

An example of such a landscape surrounds the Jamestown Settlement in Virginia, where the neighboring James River, the surrounding tidal marshes and the small island itself need to be preserved to maintain the feel of those early settlement years.

CULTURAL LANDSCAPES AND CULTURAL ASSETS

A *cultural landscape* has been defined as "a geographic area, including both cultural and natural resources and the wildlife or domestic animals therein, associated with a historic event, activity, or person, or exhibiting other cultural or aesthetic values" (Birnbaum 1994).

There are four general types of cultural landscapes, but they are not mutually exclusive: historic sites, historic designed landscapes, historic vernacular landscapes, and ethnographic landscapes.

- **Historic sites:** These are particular structures or highly localized areas, such as battlefields, colonial houses, historic bridges, Indian mounds, lighthouses and tobacco barns.
- **Historic designed landscapes:** These are wider, more encompassing landscapes that offer an historic context to an important aspect of our past, such as that around the Cahokia Indian Mounds in Illinois.
- **Historic vernacular landscapes:** These evolved through use by the people whose activities or occupancy shaped them. Their alterations to the landscape determined its current physical, biological, and cultural character. The cultural region of the Ancient Pueblo in southern Arizona and New Mexico, encompassing such sites as Chaco Canyon and Canyon de Chelly, is one example. The Oregon Trail is another.
- **Ethnographic landscapes:** These contain a variety of natural and cultural resources that people have defined as heritage resources. Contemporary settlements, religious sacred sites and geologic structures can comprise these landscapes. Small plant communities, animals, subsistence and ceremonial grounds are often components. For example, Acoma Pueblo in New Mexico is such a landscape as it is a settlement carved into a massive rock formation that is occupied by indigenous peoples. Another example might be Bear Lodge (Mathó Thípila, or Devil's Tower) in Wyoming, which is sacred to the Indians of that region.

Community Character

Oftentimes, when people think about what makes their community special, they have difficulty in pinpointing exactly what makes up its character. When they say they like the rural character or the feel of their neighborhood, it can be challenging to define exactly what they mean. This is due, in part, to the fact that the landscape they see is made up of an assemblage of features that are so familiar, they take many of them for granted.

When asked to define rural character in GIC's workshops, participants often reply vaguely, in terms similar to, "It looks like home." Similarly, in urban areas, community members may say imprecise things like, "The street where I live and my neighborhood are important," "I like the sunset from that bridge," or "That's the place where we like to ride our bikes." No matter how non-specific these comments are, they are part of the notions that build an individual's and a community's sense of place.

Indeed, the character of a place largely comprises familiar, non-specific stimuli that create these vague individual feelings – such as a pretty view where you went on your first date, a tree filled streetscape that you helped plant as a child, the park where you've walked your dog for the last ten years, or an historic area where your grandfather lived – along with the memories, stories and shared community experiences that together create something indefinably special. Many of these special or unique experiences are tied to our immediate surroundings – the built and natural resources of our landscape. Their vagueness does not mean they should be disregarded. Rather, we need to find ways to define them and incorporate them into our planning.

It is important to identify these culturally significant landscapes, natural features and settings as part of a green infrastructure planning effort. A Civil War battlefield, the spot where people were sold into slavery, or the view from a family-run orchard can be essential to a community's sense of identity. For example, a 2012 ceremony recognized the importance of the Rappahannock River in central Virginia, across which hundreds of slaves escaped to freedom during the Civil War. The river is a natural resource, but it is also a cultural artifact that is part of community history and identity. Recognizing that natural resources serve as a context for the built environment and often serve as the historic feature themselves, is key to evaluating the importance of natural assets.

Viewsheds

Often, those areas that can be seen from a particular vantage point are referred to as *viewsheds*. A viewshed is made up of key landscape features and includes those iconic components – cultural resources, ridgelines or geology – that form part of a landscape's context. An important viewshed can be identified by a community and included in a map of its natural and cultural assets. It may be an attractive view from a scenic road or include cultural resources such as an old barn, a 19th century church or an historic mill.

A few years ago, a large, privately owned observation tower was removed from the viewshed of Gettysburg in an attempt to restore the view looking across the battlefield. At Monticello, President Jefferson's former home in Virginia, the summit of a nearby hill was recently purchased to prevent any development taking place on it that would ruin the view Jefferson once appreciated. Similarly, at President George Washington's home, the Mount Vernon Ladies Association, which owns and runs his estate, worked with the State of Maryland and landowners across the Potomac to avoid building in ways that would mar the view from Mount Vernon across the river.

Usually, a community will have already identified those iconic views that are important to its character and provide the context for the statement that, "It feels like home." However, they may not have been recognized as such by the local government in its policy or planning documents, nor be protected by regulations. An historic house may be protected, but the land around it might remain open to a variety of possible developments, such as a quarry or huge retail distribution warehouse.

A ***viewshed*** is made up of key landscape features and includes those iconic components – cultural resources, ridgelines or geology – that form part of a landscape's context and can be seen from a particular vantage point.

A common refrain often relayed in community meetings and public hearings is, "Why did someone put that eyesore (a billboard, cell tower, giant gas station canopy, etc.) in the middle of our favorite view?" Oftentimes, it is because the viewshed was not identified on any maps or planning documents. Yet, once the damage is done and the view is obstructed, it is often very difficult to restore it.

A view of The Priest and Three Ridges wilderness in Virginia.

While those who own the resources in a viewshed have certain rights to develop their properties (based on existing regulations, such as zoning), there are many steps that can be taken to reduce visual impact to other users while still allowing development. Buildings can be shielded from view by putting them in places that take advantage of topography (low areas or areas screen by hills), or they can be screened with trees and vegetation to hide or disguise those built resources that would otherwise detract from the scenic view. For example, structures can be positioned below grade or towers can be disguised. Furthermore, the need for additional cell towers can be reduced by co-locating them with existing towers or attaching them to existing structures, such as grain silos and church steeples.

Sky Meadows State Park in Virginia works with their neighbors to preserve this historic landscape view seen from the park.

Scenic Routes

From the standpoint of economic development, protecting the vistas that visitors can see from a scenic road is very important to ensure a positive experience for tourists. The first impression of an area often influences how long tourists stay and explore, which translates into direct financial benefits for the region in terms of the number of nights of lodging, meals purchased, visits to gift and craft shops, money spent on entrance fees and gas, and other travel-associated spending. Tourists are less likely to travel through blighted areas to reach an historic or natural area. However, if an area's scenic roadways are designed to enhance the locality's historic and architectural character and its beautiful landscape, they will be more inclined to stop and visit its towns and landmarks.

Natural setting is very important to property values. They decline when areas begin to look rundown or overcrowded with signage and dilapidated buildings. It is important to have strong standards for signage size and design, as well as good building codes to address blight, in order to protect a landscape's natural beauty and its cultural and historical context.

In addition, many businesses depend on key views. Quite a few microbrewers have located to Nelson County, VA, to take advantage of its scenic vistas. People are willing to drive 40 or more miles to drink their beers, not just so they can enjoy a fine glass of malted hops, but to do so while gazing out at a beautiful forested mountain landscape. These microbreweries also depend on the mountainous forested landscape to absorb and filter the water they use in their brewing processes. Similarly, many hotels, inns and restaurants depend on their views to attract visitors. Wineries offer patios with vistas to entice visitors to spend a few hours imbibing both nature and their best chardonnays.

The challenge is to identify those supporting landscapes and natural features and ensure a mutual cooperation between landowners to protect them. The brewer or vintner depends on his view to lure customers, but he usually does not own it.

VIEWS ATTRACT TOURISTS

In Virginia, visitors spend $9.1 billion each year visiting historic and cultural sites (Hollberg and McMahon 1999). Most of them come to experience historic settings, such as Mount Vernon or Monticello, to visit Civil War sites such as Appomattox, The Wilderness and Chancellorsville, or to experience the wondrous vistas from the Blue Ridge Parkway. All of those sites are enhanced by preserving their viewsheds.

In some Western states, landowners who want to preserve a viewshed will pay neighboring landowners to keep it that way. Some ranchers are reimbursed by adjacent homeowner associations to maintain their ranches because the viewshed is what attracted the homebuyers to the area in the first place, and is what continues to support their property values.

This viewshed attracts customers to the brewery.

How To Determine Whether To Include a Cultural Asset On Your Map

When assessing cultural assets as part of your green infrastructure map, it is important to ask yourself two questions:

- Is this feature landscape-dependent?
- Does it need to be supported by neighboring green infrastructure resources, such as mature trees, a forest vista, protective sand dunes, an estuary, or any other unique geologic feature, if it is to retain its character?

If the answer to both is no, then the resource may not be critical to include on your green infrastructure map. If the answer to either is yes, you should consider preserving its viewshed in addition to preserving the feature itself.

If your community has already conducted an historic survey, then those maps can be overlaid with green asset maps (and possibly topography) to determine which areas are supported by the landscape and are dependent on landscape settings.

PROTECTING YOUR WATER SUPPLY

Water supply is another key application for natural asset plans. If a community is likely to need to draw from other surface or groundwater sources to supply future population growth, additional land use covenants may be needed now to protect any drainage area that will supply a future reservoir, groundwater aquifer or drinking water intake pipe. All too often, lax zoning regulations and overdevelopment around reservoirs mean that, when communities seek to tap those supplies, they learn that treatment costs have risen substantially or that reservoirs have silted in and lost capacity. Groundwater aquifers may also lose capacity when impervious paved surfaces prevent rainfall from filtering into the soil and recharging them.

An illustration of why you need to have a map of key watershed areas was witnessed by the author when a senior university environmental scientist asked the chair of a board of supervisors in 2007, "Why did you permit a large subdivision to be built on top of land that is the groundwater recharge area for our community's drinking water supply?" One can reasonably guess at the reply from the supervisor; "We didn't know it was a recharge area."

All too often, we plan first and ask questions later. This is not the result of a lack of caring; it is simply that local governments are not always in the habit of planning with natural assets in mind as a *first* step.

The consequences of considering environmental impacts too late in the game can be numerous and very expensive: impaired waters; expensive cleanup plans; higher costs to treat drinking water; flooded towns and neighborhoods; fires that inflict high property damage and loss of life; landslides that destroy neighborhoods; contaminated rivers; brownfield sites; dredging costs; new reservoirs and dams; deeper and more costly wells; lost opportunities for recreation, clean air, attractive landscapes and strong economies... The list goes on and on.

Conserving natural assets also avoids risk. One particular example of risk avoidance is to reduce exposure to wildfires in the high-risk areas of the wildland-urban interface (WUI), which include a large proportion of Southern forest lands. From a risk perspective, homeowners and firefighters face a higher threat when trying to save properties in these areas. Furthermore, the suppression of natural fires in WUI areas has other consequences. It reduces the diversity of the landscape while increasing the frequency of insect infestations. Avoid development in these areas to keep forests healthy and people safe.

MANAGE YOUR NATURAL ASSETS AS PART OF A LOCAL LAND-USE PLANNING PROCESS

By better managing your natural assets as part of a local land-use planning process, you can:

- **Preserve biodiversity and wildlife habitat.**
- **Combat climate change impacts (through carbon sequestration) and improve air quality.**
- **Protect and preserve local water quality and supply.**
- **Provide cost-effective stormwater management and hazard mitigation.**
- **Improve public health, quality of life and recreation networks.**
- **Ensure food security by conserving good agricultural soils and preserving local farms.**
- **Preserve cultural resources, such as historic landscapes and scenic vistas.**
- **Support rural economies dependent on forest products.**

CREATING A VIBRANT COMMUNITY: THE EFFECTS OF AGING IN PLACE AND THE DEMAND FOR RECREATION

If you want to create a vibrant and healthful community and incorporate demographic trends into your land conservation plans it is key to have a vision for how you want your community to look in the future. A well established trend being discussed today is that of 'aging in place.' Baby boomers (those born between 1946 and 1964) are tending to stay in their homes after retirement, rather than move into an elder care facility.

As people age, they are less able to drive to natural areas, parks and trails and they appreciate having them closer to their residences. If you can identify those areas that could be future pocket parks, greenway or rail-to-trail pathways, not only will they serve a population that chooses to age in place, but they will provide extra habitat for wildlife, birds and pollinators.

This bridge forms part of a Nelson County, VA greenway trail which provides relaxation and fitness opportunities for nearby residents.

Similarly, the younger generation, those under 30, who are sometimes called the "millennials" or "generation Y," are trending towards urban areas and yet they still want access to green spaces for hiking, biking, kayaking and other recreational activities. Growing populations demand new schools and walking routes that include natural trails, so that their children can walk to school and learn about nature and science locally.

There are many abandoned rail lines, such as the one to the left, that could be re-purposed as trails. A ***rail-to-trail pathway*** or ***bikeway*** is an old railway line that has been converted into a hiking or biking trail. One notable recent example of this approach is the High Line Park in New York which took an abandoned elevated subway track in West Manhattan and turned it into a greenway that runs right through the heart of the borough. Another example is the American Tobacco Trail (ATT) which is a 20 mile long rail trail built from an abandoned railway that served the American Tobacco Company in the 1970s. Today it crosses through the city of Durham and the counties of Durham, Chatham and Wake in North Carolina. It then links into the larger East Coast Greenway spanning multiple states.

Now that we have laid out the reasons for undertaking a green infrastructure planning and mapping process, we can delve into the steps for organizing your initiative, which is the focus of Chapter Three.

3

PROJECT STRUCTURE

- Determine the scope
- Get organized
- Engage stakeholders

CHAPTER 3 - Organize Your Initiative

In this chapter, we focus on two key steps to organize a green infrastructure planning initiative: first, how to create a process to engage stakeholders; and second, how to formulate relevant goals.

However, before we start, it is important to consider two other points: the scope of your effort – how extensive it will be; and the geographic scale of your effort: will it cover your community, county, city, region, or an even wider area?

DETERMINE THE SCOPE OF YOUR EFFORT

It is vital that you consider the amount of work you are prepared to do, the amount of time and effort you are willing to put in, the resources you have available, and the finances you have to see it to completion. You need to assess these factors before you delve into data collection and analysis. You should develop a clear rationale for what you want to achieve and why you feel there is a need to evaluate and map certain critical natural assets. Otherwise, you may become lost and collect too much, or not the right type of data.

Plan For Green Infrastructure Conservation at Multiple Scales

As part of discussing the scope of your project, you need to consider the geographic scale of your effort. There are various scales you can consider, bearing in mind that it is often best to take a multi-scale approach. This means seeing your local effort in terms of a wider regional, or multi-state connective scale. So, even though you may be simply considering your local community park and a river greenway, be aware that it fits into a larger network of green spaces. By taking a wider approach to your green infrastructure plan, you may be able to achieve far more than otherwise.

When considering how best to develop a particular site, a developer should consider how it links to neighboring

Site visits are important to help evaluate landscape health.

sites and into the larger landscape. Similarly, when planning at a regional, county or city scale, a planner should consider how areas of regional or county-wide importance can link to and influence individual sites. No matter which scale you start from – large to small or small to large – you need to think about impacts and influences at multiple scales.

Regional, Landscape and Cityscape Scales

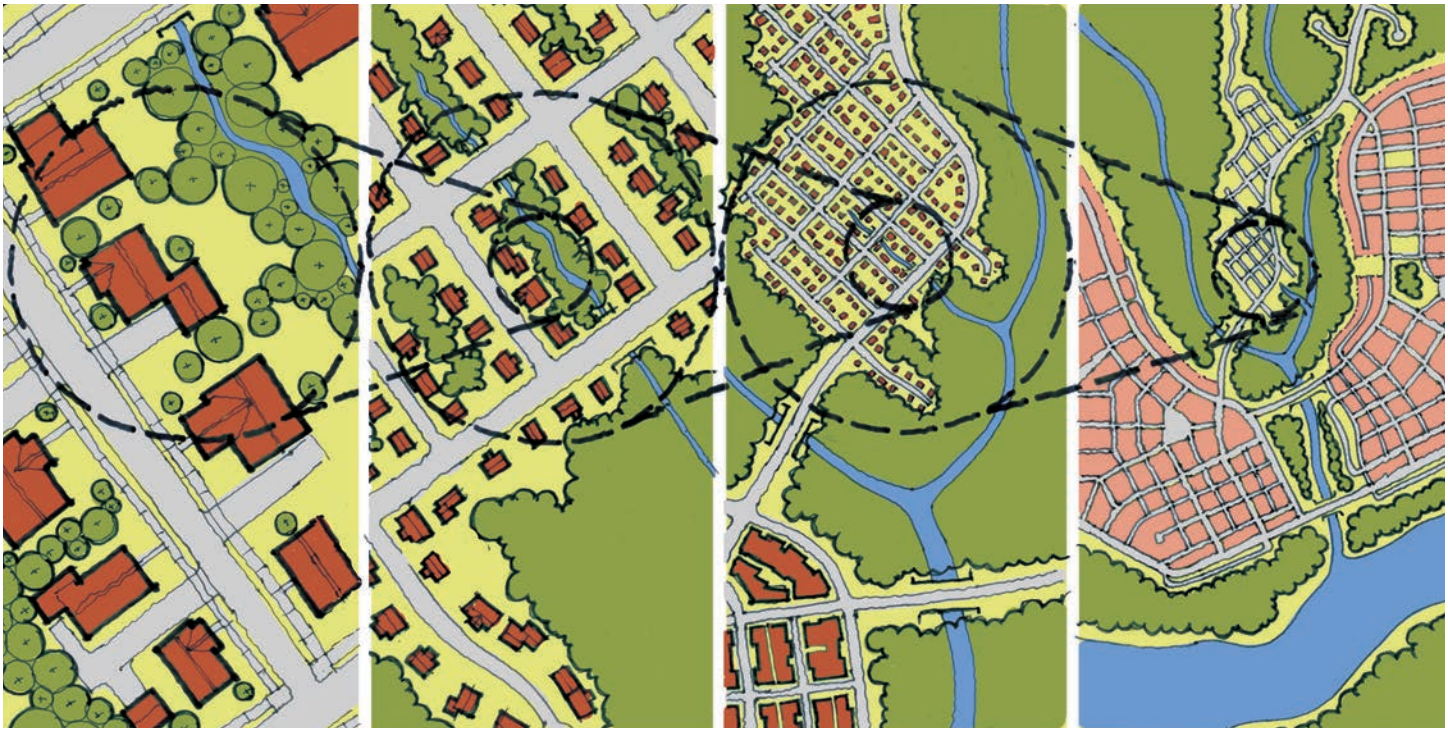
Even when working at the level of a specific landscape or defined area, it is helpful to consider the overall distribution of natural assets in the region and determine how your area fits into such ecological systems as wildlife migration routes, watersheds, bird flyways or other cross landscape features. How does a city or town park fit within a wider scheme that allows wildlife to move into and out of the city, or that allows for a variety of recreation opportunities and wildlife interactions for your population (both people and wildlife) as a whole? For example, could individual parks be linked to regional trails? Frederick Law Olmsted's 'Emerald Necklace' was an early attempt to think of Boston's city parks as a connected network. Today, we can think about linkages across a city to the region beyond. The Appalachian Trail is a multi-state trail to which there are many spur trails and links to other parks.

In practice, mapping your natural assets as part of a green infrastructure scheme should focus at a landscape scale, looking across multiple parcels and ownerships. Ideally, this occurs before land development begins. This allows land managers, landowners and planners to consider which areas should be selected for protection or restoration, in order to provide such ecological services as wildlife habitat, recreation areas, stormwater treatment, energy savings, aesthetic values, improved community health and a sustainable economy. This ensures that areas are not cut off, or that ecosystem functions, such as groundwater recharge, are not unintentionally disrupted.

Even inner suburbs, towns and cities can contain unique habitats within them, as well as substantial open spaces. In such urban areas, green infrastructure planning focuses on different scales and types of data. For example, it assesses the citywide tree canopy and the condition of public trees, riparian habitats and stream corridors, as well as the trees and streams in a local district, neighborhood or watershed. It looks at where there are connected blocks of habitat, such as large city parks, trail systems, good locations for community gardens and opportunities for small-space habitat restoration, water features or water infiltration.

Site Scale

Once your plan has identified the types of resources that are important at your chosen scale, you will need to prioritize which resources to conserve and to determine how these resources can best be connected or restored.



Then, once you have prioritized those assets, you should evaluate what opportunities you have to implement your goals at the site scale. If specific sites are proposed for development, you should determine how to best connect their natural resources to your area's larger, landscape-scale assets.

The illustrations to the right show why it is important to think regionally and act locally. In the first picture, each developer has independently established his own little parcel of green space, conserving green assets locally but fracturing the habitat at a larger scale.

In the second picture, land is developed more densely on the far-right parcel and at medium density in the middle parcel, while the far-left parcel has been entirely preserved as green space through the use of one or more planning tools.

Each development conserved green spaces but did not connect them.

These sites maintained connections between them while achieving the same level of development.

Examples of tools that could be used to avoid development on the left-hand parcel include *purchasing development rights* (PDRs), *transferring development rights* (TDRs) and establishing *conservation easements* to restrict further development, while allowing some existing uses, such as farming or forestry, in exchange for a tax break.

HOW TO ORGANIZE A GREEN INFRASTRUCTURE PLANNING INITIATIVE

You are now ready to begin your community engagement process by engaging stakeholders and formulating relevant goals.

If you have already organized a group to evaluate and map your natural assets, or if your group consists of an appointed or elected body, such as a planning commission or city council, you may not need to read the following chapter sections. Similarly, your group may be a local land trust and you may be consulting primarily with your board of directors and not seeking broader community engagement. Or you may be conducting an internal evaluation of assets to decide on where to put a conservation easement. Whichever is your scope, you may still need to engage outside stakeholders to review your plan at some point, so you may want to at least skim this chapter for pertinent ideas.

Why Engage Community Members?

Community members should be engaged in a green infrastructure planning process as early as possible. They should not learn about the plan for the first time after it is completed. Local citizens should have a role in setting or reviewing a project's goals so that they have buy in. And they should be re-engaged before the plan is completed, while there is still time to provide meaningful input.

Deciding which natural assets are the most important to identify and conserve is a value-driven process. Determining what is valuable, requires some form of community engagement in order to determine which are the most important natural assets to include. For example, while the best available science can tell us the types of habitats that are important for wildlife, we must first decide that wildlife conservation is important. Furthermore, community support is usually needed for implementation, so establishing goals that meet community needs can be key to ensuring that any strategy to protect those assets is implemented. However, public engagement adds a layer of complexity to any mapping effort because of the multiple and often conflicting perspectives that will be offered.

Notwithstanding the difficulty of public engagement concerning issues that can be highly technical and may lead to conflict, there are many good reasons for engaging the broader community. Daniel Fiorino notes that there are substantive, normative and instrumental reasons why the public should be involved in environmental decision-making (1990). Substantive reasons are that citizens are often able to see problems, issues and solutions that experts miss. Community knowledge can inform and enrich environmental understanding of both problems and potential solutions. Normative reasons are that community engagement can legitimize the committee and its conclusions, while also legitimizing the citizens themselves; giving them a sense of ownership and control based on their participation. Lastly, instrumental reasons include citizens' ability to aid in implementing the chosen solutions. Simply put, communities are more likely to 'buy into' ideas that meet goals which they helped to create.

"Simply put, communities are more likely to 'buy into' ideas that meet goals which they helped to create."

A good beginning is usually essential to a good ending, so how you begin and with whom you engage are worth careful consideration as a first step in your process. It is important to ensure that the results of your planning efforts will actually be utilized by the community by engaging stakeholders early in the process. If key stakeholders are not engaged at the beginning, they may not accept or adopt the final outcomes. For example, a state park agency developed a detailed green infrastructure map, but did not first gain agreement from end users that it was needed. The result was a plan that was nice to look at, but was not actually utilized (Duerksen and Snyder 2005). Citizens may even try to thwart the process because they were not part of its inception.

Lastly, change is often initiated from outside of local government. It may be that a community land trust, watershed coalition or other local stakeholder group is the one to begin a process and seek to engage their local government, so their involvement will naturally be from the beginning. The outside group may be able to foster new innovation and may become the key catalyst for green infrastructure planning.

Challenges of Community Engagement

While we have stressed the importance of community engagement; it is not without challenges. Often, when the public is engaged, it is difficult, if not impossible, to incorporate or address the multiple perspectives that are offered. Some ideas can be detrimental or run counter to a project's goals, while others may challenge you to achieve more with your plan than you first thought possible. However, even if you disagree with the public's comments or cannot fit their requests into changes or expansion of the project, it is important to allow time for *genuine* input. This is an important distinction. Genuine input means that each public comment will be considered thoughtfully and may potentially result in a change to the project.

When requesting public comments, it is important to understand that the public is not a monolithic body. Consider that there are actually many publics. Sometimes, they have been characterized as "communities of place," based on where they live, or as "communities of interest," based on a particular concern, such as hunters, hikers or heritage tourists.

The diversity inherent in the term "public" can result in conflicts over perspectives. Since communities are made up of individuals and organized sub-groups, they may offer suggestions that are polar opposites, such as, "Open this area to recreation," or "Close this area to protect rare species."

It is often possible to reach some common ground between differing opinions. In the above example, it may be possible to provide some public access while also protecting other, more fragile habitat areas.

Some opinions, however, might be impossible to reconcile, and a decision will have to be made about which route to take. For example, GIC staff heard these two non-resolvable comments arise in the same meeting: "Bring back the beaver!" and "Kill all the beaver!"

While it is important to consider all comments, you should communicate to stakeholders that your project will not be able to solve or address all community needs and desires, nor should it. If possible, document all comments received, whether or how they were addressed and the reasons for the decisions made.

A Pre-assessment

Before you engage anyone, you may want to conduct a pre-assessment of the key issues and stakeholders for your effort. This can be useful in formulating or refining your project's vision. You may want to conduct interviews with those stakeholders to get a sense of community priorities and gain insights on which issues are accepted or controversial.

Some counties and states like the term 'green infrastructure,' while others prefer to use the term 'natural assets.' Some communities do not want to use the term 'green' for anything, out of concern that some members of the public will be afraid of a 'green agenda.' These types of hot button issues, which include climate change, green ideas and other terms you might want to avoid, can be learned about during the pre-assessment effort and can help you sidestep unnecessary conflicts later on.

To conduct a pre-assessment, utilize experienced interviewers who can maintain confidentiality. Encourage stakeholders to be as frank and open as possible by assuring them that their identities and responses are kept confidential. You may also decide to conduct several confidential interviews on your own as part of scoping your project. Who to interview is up to you, but one way to frame your assessment is to limit it to those who will have a say in implementing the project, such as the board of supervisors, city council, leaders of conservation groups and agency representatives.

Engage Potential Skeptics

It is advisable to engage potential skeptics early on. People often fear new initiatives because they are not sure what they are about. They may wonder, "Is this a plot to take away my property rights?" or "Is it going to raise my taxes or waste time?" Find out early on what are likely to be people's concerns. If it is property, development or hunting rights, make sure you have framed your project in a way that alleviates, rather than adds to, those fears. For example, a green infrastructure plan can help to connect habitat that facilitate wildlife movement. This benefits other users such as hunters who need populations of animals to be healthy and abundant to enjoy their sport.

INTERVIEW QUESTIONS

Devise questions based on what it is you need to learn and utilize interview responses to determine how to frame your project in a way that is non-controversial. You can also use them to ensure that you are consulting the key people and data sources, that you have thought through all the possible end uses for the mapping effort, and as a way to build support for your initiative. Prepare a short summary introduction about the project and share that with participants before seeking their input.

Examples of questions that could be used in a stakeholder pre-assessment to scope your project and mapping needs include:

- **What is it you want to be able to do (that you can't do now) e.g protect sensitive watersheds or identify the best lands for agricultural uses?**
- **At what scale do you want to plan to restore or conserve your assets (town, city, region, watershed)?**
- **What is most important to you (clean water, forestry, scenic vistas, etc)?**
- **How would you like to be engaged (as advisors during the process, end-users, or both)?**
- **What themes (topics) are most important to evaluate and map (wildlife habitats, water, working lands, nature-based recreation)?**
- **What are some of the key sources of information that we should consult as we try to map our natural resources?**
- **What areas are at greatest risk from changes to their current land use and which areas might need greater effort to ensure they are maintained?**
- **Who should be engaged in a mapping effort and why?**

Keep in mind that there are many ways and multiple venues – you can utilize to gather community input, such as open houses, presentations, workshops and online questionnaires. These can be collated and used as part of on-going review and engagement.

Consider creating a "Frequently Asked Questions" document and add it to your website, if you have one, to answer questions or concerns that you have anticipated, or learn about during your pre-assessment.

You can also conduct assessments periodically throughout your project by using a focus group or other surveys to gauge community support and address concerns before the project is concluded.

Misinformation can lead to a great deal of headaches for project organizers and conveners. Many times, GIC staff have observed people who come to meetings with the intent to protest a project, but who then change their minds and offer to support it once they understand what it is about. So, the best way to gain community support is to fully understand and address community concerns as early and as often as possible.

ANTICIPATE KEY QUESTIONS

Consider creating a "Frequently Asked Questions" document and add it to your website, if you have one, to answer questions that you have anticipated, or learn about during your pre-assessment.

If you are inexperienced in running meetings where multiple and conflicting viewpoints may arise, consider whether you need to hire a professional facilitator. There are many excellent guides for how to facilitate groups, set clear agendas and goals, and resolve conflicts about what is important to include on a map.

All too often, GIC staff have been contacted by localities or planning districts who have created an overly long and impossible list of everything that is important (*aka* the kitchen sink approach) and have asked the GIC to help them map everything they have listed. Usually the GIC staff begin by first asking, what is important and from there help the community to determine what could or should be mapped.

In practice, the assets that can be mapped and the actions that can be taken are limited. One helpful approach can be to mine existing documents (such as the comprehensive plan, open space plans, vision statements from the board of supervisors or city council) to see what are their existing goals. Then ask, are these goals things that can be mapped and evaluated?

Chapter Four has more details about how to create goals that can be represented with mapping.

THE THREE STAGES OF THE ADVISORY PROCESS

Most advisory processes can be separated into three distinct stages – and you need to be aware of the different tasks allotted to each stage.

These three stages are visioning, asset evaluation, and implementation:

Visioning

At the start of any advisory process, agencies, community leaders, elected and appointed officials, and the general public should consider what kind of community process they want to create and what they would like it to achieve. These discussions will inform the process's values and goals and will highlight the type of natural assets participants feel it is important to map. Be sure to consider whether your community has an existing vision that can be utilized or modified to suit your project's needs.

Asset Evaluation

Following on from the visioning stage, scientists, land managers and designers need to evaluate and rank the area's natural and cultural resources according to the goals and values already set in place. Examples of such experts include landscape ecologists and architects; environmental and open space planners; wildlife biologists; floodplain managers; foresters; and agricultural experts. Those who will be most active in developing the asset map should also be engaged at this stage, so bring in your GIS analysts as well. If you are creating a local plan, you may want to engage laypeople who have local knowledge about where unique resources can be found. You will probably find that many such assets have not been monitored or evaluated and may be missed entirely if you only rely on existing data. And note that expert review will be required of any new data you collect.

Implementation

This final part of the advisory process involves federal and state land managers, local and regional conservation groups, land trusts, developers, sports groups and others who have a role in managing or conserving the land affected by your goals. At this stage, it is important to re-engage participants from the visioning stage, such as planning commissioners, landowners and local stakeholders, in order to help with implementation. Lastly, consider if the effort will require additional funds to carry it out – whether it is for staffing, land acquisition or public education and outreach.

STAKEHOLDERS YOU MIGHT WANT TO ENGAGE		
WHO TO ENGAGE	WHY	HOW TO ENGAGE*
Planning commission, planning board, environmental review board, appearance commission, agriculture advisory board or other relevant local planning group.	Responsible for comprehensive plans, zoning recommendations, land use and area plans.	Presentation to seek their input on goals and learn of key needs that could be met by a study.
Local resource agencies Extension Service Soil and Water Districts County/Regional Forester Game and Inland Fisheries Farm Bureau	Determine their priorities for resource conservation (specific types and locations) and programs to help with implementation.	Personal meetings or in one meeting.
Land trusts Agencies holding easements	Determine current land that is conserved. Determine if new maps can help them prioritize.	Personal meetings, or in one resource meeting. If working at a regional scale, consider one meeting with all land trusts.
Conservation and environmental groups or associations	Learn about conservation priorities and current programs to help with implementation. Some groups may have science experts and own or manage key land reserves.	Personal meetings, as part of a committee, or through meetings with individual groups.
Scientists and resource experts	You may need to consult with experts to rank the value of natural resources, such as which forests have more biodiversity or which rivers are most ecologically unique or at risk.	Personal visits or a committee meeting. May consider having committees by theme, such as water, agriculture, forests, recreation, history and culture.
Large land holders	May have a significant role in land management or may be able to add land to conservation (programs or easement).	Personal visits or a landowners' meeting.
Homeowners or homeowner associations	If working at smaller scales where joint or coordinated management of open space would make a difference.	Neighborhood meetings or a community workshop.
Developers and homebuilder associations	Those who are making plans to develop large tracts of land can help to ensure the right pieces are conserved and open space connections are made/maintained.	Participate on stakeholder committees and through personal contacts.
Representatives of local or regional financial institutions and potential funding organizations.	Engaging those who will or could fund the effort is important to do early on.	As advisors or on a committee.
Regional governance agencies Regional planning district commissions Watershed basin commissions Regional transportation agencies	If working at a regional scale or including resources that cross jurisdictional boundaries. If crossing state boundaries, consider agencies from other state(s).	Individual meetings or presentations to the board or regularly scheduled board meetings.

*Any of these groups may also be part of an advisory committee.

OPTIONS FOR STRUCTURING AN ADVISORY PROCESS

There are several ways to structure an advisory process. A key consideration is that people may not agree on priorities and may need some assistance to reach consensus and manage their competing perspectives. Given that possibility, consider what may be the best structure to enable consensus to happen.

The following are a variety of options to consider. For additional ideas – both traditional and unusual – about how to build support for the effort, see Chapter Six. Enlisting the help of a professional facilitator also can be a useful way to manage the process.

Stakeholders

Stakeholders include anyone with a key stake in the outcome of the process. This may include owners of large and significant land parcels, conservation groups or land trusts who are targeting lands for conservation

and protection, managers of natural area reserves, farmers, foresters, hunt clubs, businesses engaged in forestry, tourism or outdoor recreation, or any category of people who will be affected by or have important knowledge to assist your mapping and prioritization process.

It is key to engage the owners of large land holdings early on. For example, if your plan depends on cooperation and collaboration with a national park or large timber tracts owned by a corporation, you may want to have them serve on your committee from the start. If they do not want to serve on a group, you may want to meet with them individually to share the project's aims and learn about their concerns and priorities. For example, a land developer may not want to serve on a committee, but may be amenable to adopting a land development plan that maintains a wildlife corridor, as long as they are consulted early on.

Implementation Stakeholders

If your group wants its green infrastructure maps formally adopted by an appointed or elected body (such as the planning commission, planning board, supervisors or town or city council) you may want to ask a representative of that body to serve on your stakeholder committee. In this way, they can ensure some level of buy in/support for the effort early on, as well as to help guide your committee and share key insights with your group. For example, if your group labels an area for conservation that the county has already identified as a future growth area, this conflict can be highlighted, discussed and evaluated.

Alternatively, the elected or appointed body may actually *be* your committee. During a project run by the GIC in Madison County, VA, the planning commission was the review body and it reviewed information, data and applications for the data over several meetings.

Also consider that not all stakeholders will be local, especially key funders such as foundations or state and federal grant-makers. It can be critical to your success to engage those funders early on.

One of the best examples of this was the Healing Waters Retreat initiated by Nancy Ailes, Director of the Cacapon and Lost River Land Trust in West Virginia. In 2002, before the trust began its work, she engaged both stakeholders and funders to create maps and formulate a unified vision. According to the trust, this approach was the foundation for its success, and it is now the largest land trust in West Virginia, and the seventh largest in the Chesapeake Bay Watershed.

Experts

It is unlikely that you will have all the expertise you need within your organization. Based on the types of things you may wish to map and the issues you may want to address, you should invite experts to serve as reviewers. For example, if you want to map key cultural assets, such as historic buildings, you may want to invite local historians to provide advice. Similarly, if you want to map key habitats, you may want to engage scientists from your state's natural heritage program. For an example see text box on the Northern Virginia Regional Commission on page 49.

NATURAL HERITAGE PROGRAMS

If you want to map key habitats, you may want to engage scientists from your state's natural heritage program. Some of these programs are run by a state agency while others are maintained by universities or libraries. To find your state's listing, see http://www.natureserve.org/visitLocal/

One key caution is that experts may want you to map everything or conduct extensive new surveys. You'll need to provide them with the limits to the project's scope. For example, when the GIC asked local historians to tell it what historic resources to include on a five county regional map, they got so excited they suggested we categorize resources into multiple separate data sets: as colonial, antebellum, post-industrial, and so on. This was too much detail for a map at a five-county scale. Later, when we asked a biologist which key landscapes to include his response was that, first, we needed to establish field plots in all the forests across all five counties, then create a map of forest diversity types, then... This was not necessary for the scale of the project or for the goals the group had established.

So, engage experts, but provide clear guidance for what you need to know, why you need to know it, and how the information will be applied. This will help them to give you the appropriate information at the right scale. Natural heritage programs (NHP) will advise on using the best available data instead of unnecessarily creating new data. Additionally, if new data are needed, NHPs may be able to assist in creating that data in a timely manner for that region.

Assigning Roles

A simple way to structure engagement in your project is to determine the role each person or group will play. You need to assign roles for everyone (advisor, reviewer, modeler, end-user) and determine who will make the final decisions. But note that, depending on the stage of your project, you may need to involve different persons with different types of input at different times. If you analyze your stakeholders by their role in each stage of the process, you can utilize each person effectively and efficiently. Essentially, you will be creating a vision for what you hope to achieve, evaluating your natural assets and developing an implementation plan.

While some organizations recommend that you form a multi-stakeholder committee at the beginning of your process that comprises all possible interests, it can be difficult for all these groups to agree on what to evaluate, how to prioritize and how to map landscape features. As a result, you may want to restrict your consultation with a multi-stakeholder group to just asking it: "How would you use a GI map?" Or, a thoughtful survey can be used to help gauge the interest and priorities from diverse groups.

Since you will almost certainly need some level of expert, scientific help, it is important at the beginning of your advisory process to think about what types of expertise and what levels of technical knowledge are needed to inform your mapping effort – taking into consideration the awareness levels of your lay participating members, as well as the final product you want to see. If you are building a model that will rank natural resources, you will probably want a technical (science) committee that is familiar with the extent and importance of the area's natural resources. They will also likely be aware of available data that can be utilized. If you want to ensure that the information you map is in a form that can be readily applied, you will want to consult those who will be using the information regularly – the end users – such as planners, state natural resource agencies and land trusts.

In summary, you may want to form a technical committee and consult with stakeholders periodically. The technical committee made up of modelers, scientists and other experts can collaborate to actually create your map or model. You can re-engage your end users once you have a draft in hand, to learn if the way the information is presented is useful, applicable and accurate.

OPTIONS FOR YOUR ADVISORY PROCESS

- **Involve local and regional stakeholders, including local government bodies and grant-funders.**
- **Meet with potential stakeholders to discuss issues and decide on your approach.**
- **Discover potential objections early on and engage potential opponents.**
- **Consider bringing in a facilitator to work through potential issues and disagreements.**
- **Engage experts, but give them clear parameters.**
- **Assign precise roles to group members.**

COMMITTEE OPTIONS

You may decide you want to set up a standing committee or you may choose not to utilize a committee at all. On the other hand, you might decide that you need *several* committees, or sub-committees, to handle different aspects of your process: for example, one committee can gather GIS data and create your asset map; another can provide a forum for stakeholders.

The following are examples of the types of committee you could utilize during your process, along with their pros and cons. They include the option to forgo a committee process altogether.

The process recommended by GIC is found in the text box on page 46.

A Technical Committee

A technical committee is a core group of experts who create a mapping protocol and map and evaluate the results. This committee can identify and evaluate the best available data, and identify any data gaps; this group can also document the methods used to evaluate and rank data for use in mapping.

It may include those scientists who can determine which landscape types are most significant for wildlife, water resources, agricultural uses, habitat corridors, and so on. It may also include those staff who will be responsible for the mapping, since data will need to be evaluated for consistency and whether it can be represented spatially on a map – for example, are the data consistently available, accurate and represented across the entire study area?

THE GIC'S RECOMMENDED PUBLIC ENGAGEMENT PROCESS

The GIC has found this four-part engagement process to be very effective in soliciting community input.

This process does not include all technical review. It gives you several options, depending on specific circumstances:

PART 1 - PRE-ASSESSMENT: Conduct preliminary interviews or surveys to determine which key issues to investigate, how to frame the project, and who to engage.

PART 2 - STAKEHOLDER REVIEW: Implement a stakeholder review committee, made up of key groups to help frame the project's goals. If the goals have already been established, move onto discussing what needs to be mapped to help achieve them.

Option 1: Form a small technical sub-committee to work on data and maps.

Option 2: Have the review committee be the planning commission or other decision body.

This process involves three two-hour committee meetings with the following formats:

Meeting 1: Introduction to Natural Asset Mapping and Discussion of Community Goals and Values
- This meeting requires some prior research on what data are available and what could be mapped.
- Which of the community's goals and values can be translated into a map?

Meeting 2: Proposed Mapping Strategy
- The strategy should be based on Meeting 1 outcomes.
- During the meeting, review options for what to map and why, and gain agreement about how to create your maps.

Meeting 3: Review Maps
- The format of this meeting should include several aspects: a review of accuracy; a prioritization of assets; and whether the maps present their messages clearly.
- During this meeting, make edits to your maps based on feedback; then create final versions for further review and final adoption.

Option: Instead of the three-meeting process, have a focus group review the maps prior to public release of the information; then revise them based on the focus group's input.

Following the three meetings, you have several options before you:

Option 1: Host a fourth meeting to review and adopt the final version. Celebrate!

Option 2: Have a community open-house to show the draft maps, in addition to or instead of a committee meeting.

Option 3: Make individual presentations to key stakeholder groups who cannot attend public meetings, such as sportsmen's groups and civic groups, in addition to or instead of a committee process.

PART 3 - FINALIZE YOUR MAPS: Make final changes to your maps based on feedback, and present them to the decision makers. Make revisions as needed.

PART 4 - STRATEGIZE AND BREAK INTO TASKS: Create a strategy for implementation of your goals and break it into specific tasks.

Option: Form an implementation committee to ensure your strategy and its allocated tasks are completed. Establish a timeframe to achieve your strategy, as well as each specific task.

For ideas on strategies, see Chapter Five.

Keep in mind that your 'experts' may comprise citizens who are very familiar with the landscape, such as retired ornithologists or experienced birders who have kept accurate records of key nesting sites. The main challenge in consulting any person about the ecology or habitat of an area is to ensure that whatever knowledge is tapped, it represents an accurate and reliable picture of the entire region under investigation. It is important that one area not be labeled as particularly unique or important, simply because there were more data collected in that location. The area in question may be actually less unique; it may simply have been studied more.

A Stakeholder or Implementation Committee

This is a larger group of key-interest representatives who can inform the technical committee about what is important and why. For example, they may place a high value on nature based recreation -- sports that require a large and connected landscape, such as hunting, hiking or cross country horseback riding, or they may want to map key scenic vistas that are important to tourism, or areas that are important to future drinking water supplies (reservoirs or river intakes) or drinking water recharge zones.

A group such as this can be consulted both at the beginning of a process, to determine the community's key values, and again at the end, to evaluate if the mapping effort has met its needs.

It is important to note that not all values can be met and anyone running the stakeholder process should clearly articulate what can and can't be mapped or what is outside the scope of the project. For example, it is not uncommon for a group to identify something that is important to them, but for which no data exist. To put something on a map for a region two things must be true:

1. The data must exist (or be readily obtainable in the near term).
2. The data must be spatially represented and consistent.

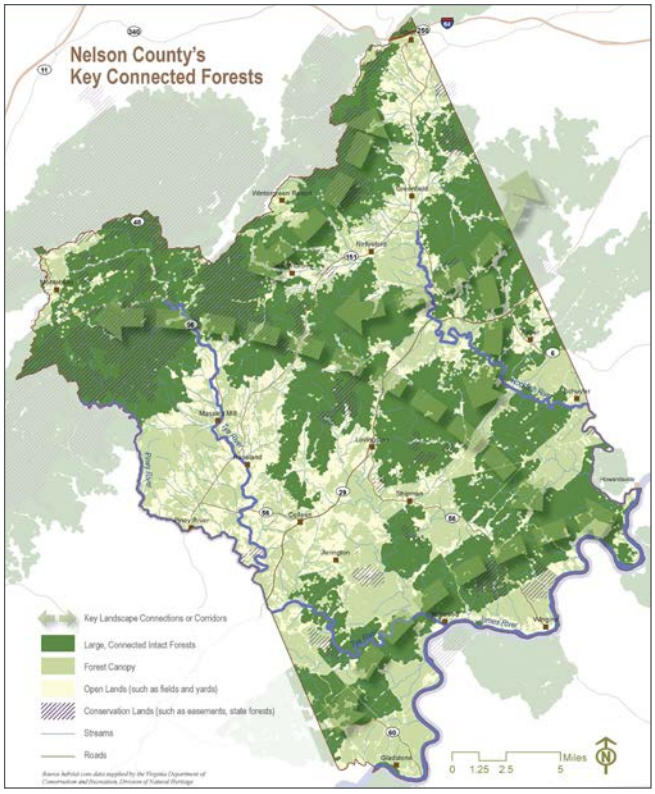
MAPPING RULES

To put something on a map two things must be true:

1. The data must exist (or be readily obtainable in the near term).
2. The data must be spatially represented and consistent.

A Focus Group

Rather than have a standing committee, you may instead (or in addition) enlist a focus group to test out ideas before proposing them to the broader public or to appointed or elected bodies. Focus groups are often used by marketing firms to test consumer preferences for products, such as cereal, or by political or advertising campaigns to test key messages. A focus group comprised of key interests can determine if current green infrastructure maps best represent key assets or to test the popularity of implementation ideas, such as conservation easements, land swaps or purchases of development rights.



Key messages or strategies can be tested within the group by having them react to ideas, either through discussion or by ranking them on charts or in ballots. This approach was one of several used by the GIC in Nelson County, VA. The focus group was appointed by the board of supervisors and was very helpful in pointing out how to best represent key messages on the maps. It also let GIC staff know which policy ideas would be more or less likely to be viewed favorably by citizens, businesses and elected officials. This information was then used to modify the data representation (graphics) of the maps and to inform a policy implementation document prepared for the county's planning commission.

Another approach to diversify input, without having to form multiple committees and sub-committees or host focus groups, is to visit experts individually and then share their perspectives with the larger group. This allows you to focus the review on their particular area of expertise, such as providing wildlife corridors or choosing the highest quality agricultural areas.

No Committee At All

Lastly, you may not need to have any committee at all. Your effort may be for a government agency or other singular entity. For example, if you are conducting your study for a land trust or conservation group, your board of directors or your membership may already serve as your review group.

Alternatively, you may prefer to solicit input through a series of one-on-one meetings with key stakeholders and presentations (see the earlier chart on who to engage). In this form of engagement, you will need to consider the various functions of your stakeholders. A downside to this approach, however, is that experts will not be able to readily inform one-another's views because they are not listening to each other and engaging in live dialogue. However, an upside to holding individual expert consultations is that interviewees may offer you more candid viewpoints when they are not being observed by others.

Instead of trying to have all needs met through one committee or focus group, you may want to base your engagement with them upon the needs and timing of your work. For example, if you need the planning commission and board of supervisors to adopt your plan or maps when they are completed, it is a good idea to engage them early on to review the goals and work plan. This will ensure that they agree with the project's direction and are prepared to play an active role in its implementation. If you need to prioritize your natural resources, you may require a science or technical committee to rank or rate the quality of various assets and assign weights or scores to them. For example, a waterway could be valued more highly by the community if it also provided drinking water.

A Last Word On the Benefits of a Committee

One advantage of a committee is that stakeholders can hear and learn from one another. A common refrain experienced in GIC's field tests was that developers will not support an idea, or that the board of supervisors would never vote for it. If you have a member of the body present to say, "Actually, we *can* support that," or "Oh, we never thought of things that way, let's see how we can make it work," then it can smooth the way for agreement within the stakeholder group, and for its adoption and implementation later on.

Another advantage is that most natural asset maps and strategies include lands that fall under multiple ownership, as well as numerous zoning or land use regulations that require cooperation amongst diverse interests to manage them effectively, in order to maximize conservation and community values. The committee brings these varied interests together under one aegis, which allows them to discuss differences and resolve them.

In conclusion, all projects will need to have some level of community consultation and coordination. However, each community is unique and coordinators of natural asset planning efforts will need to consider the best way to advance their goals for strategic landscape conservation.

Experts can be any age. In this picture from a workshop for the GIC's Walkable Watershed's Project in Richmond, VA, 5th graders identify their preferred new routes to walk to school. This helps to guide where re-greening projects will be implemented and tells project organizers where children are most likely to walk.

NORTHERN VA REGIONAL COMMISSION PROCESS

In the Northern Virginia Regional Commission (NVRC) project there were multiple levels of expertise needed to create regional themed maps. Rather than having every possible expert sit on one very large committee, they decided to have one core committee and create additional subcommittees to explore particular issues or themes in greater depth.

A standing committee was formed of representatives from the localities in the region, along with regional conservation groups and land trusts. They worked collaboratively to advise the NVRC about what to include or exclude from the regional asset map.

They convened subgroups of experts from the committee, as well as additional experts on the subject area – such as watershed health and heritage and culture experts to create overlay maps on particular themes. This allowed professionals to advise the project by providing their expertise in key areas.

The NVRC Natural Assets Committee meets to review their maps.

We have covered how to get organized and create a structure for your mapping process. In the next chapter, Chapter Four, we provide guidance about what can be mapped and how data can be evaluated in terms of meeting a community's goals.

4

CHAPTER 4 - How to Identify, Evaluate and Prioritize Natural Assets as Part of a Green Infrastructure Plan

In this chapter, we present the steps you should take to identify, evaluate and prioritize your natural assets as part of a green infrastructure plan. These six steps were initially presented in Chapter One, but are expanded upon here.

This is a key chapter to read before Chapter Seven, where we present specific suggestions regarding the data and models to use when creating your maps.

SIX STEPS FOR GREEN INFRASTRUCTURE PLANNING

- **Step 1: Set Goals**
- **Step 2: Review Data**
- **Step 3: Make Maps**
- **Step 4: Assess Risks**
- **Step 5: Opportunities**
- **Step 6: Implement**

There are Six Steps you should consider to identify, evaluate and prioritize your assets as part of a green infrastructure plan:

Step 1. Set Goals: What does your community or organization value? Determine which natural assets and functions are most important to you.

Step 2. Review Data: What do you know or need to know, to map the values identified in Step 1?

Step 3. Make Asset Maps: Map your community's highest-valued natural assets that contribute to a healthy ecology and also support cultural and economic values –Based on the goals established in Step 1 and data from Step 2.

Step 4. Assess Risks: What assets are most at risk and what could be lost if no action is taken?

Step 5. Determine Opportunities: Determine opportunities for protection or restoration. Based on those assets and risks you have identified; which ones should be restored or improved? And which need the attention soonest?

Step 6. Implement Opportunities: Include your natural asset maps in both daily and long-range planning such as park planning, comprehensive planning and zoning, transportation planning, tourism development and economic planning.

We will now outline these steps in detail.

STEP 1: SET GOALS: WHAT DOES YOUR COMMUNITY OR ORGANIZATION VALUE? DETERMINE WHICH NATURAL ASSETS AND FUNCTIONS ARE MOST IMPORTANT TO YOU

All GI planning efforts that involve the public must start with the establishment of goals. However, before asking people what their goals are for evaluating an area's natural assets, they may need an introduction on what natural assets are and why cataloging them is important.

Introduce Key Terms

It is likely that lay members of your community will be new to the concepts of green infrastructure (GI), natural assets and ecological services and not understand why it is important to evaluate and map them. In fact, some may not realize the need for mapping assets at all; they may assume that this information is already taken into account as part of everyday planning activities. It is worth spending some time at your initial meeting, or in your preliminary engagement process, to ensure that they fully grasp these – and other – basic ideas and understand their central role in the GI planning process. You may also need to explain the overall process to them, so that they can see how their interests and values are incorporated into your plans and will be realized on the ground.

Create A Vision

Before you discuss goals, you may need to spend some time helping your community develop a vision of what it would prefer its landscape to look like.

On the other hand, if you are a local authority or organization that already has a clear vision statement or comprehensive plan that includes a proposal for the future, you may not need to do anything more than reaffirm that vision and apply it to the particular process you now have in mind. However, you might still need to ensure that the community as a whole understands the inspiration and participates in translating it into specific planning goals.

Be Strategic

Since it is likely that you are being strategic in your approach, your mapping effort will not simply entail taking everything that is 'natural' and might be construed as an 'asset' and putting it on a map. Rather, the purpose of mapping is to identify key priorities based on the values and goals they fulfill. So, establishing your goals has to be your first step. And those goals should arise from the vision you have established, either as part of your established purpose, or from engaging stakeholders in a visioning exercise.

You may recall from Chapter One that a map of natural assets is a "strategically planned network," and is not simply an inventory of assets. Yet it is common for groups engaged in green infrastructure mapping to start by making lists, with statements such as, "Clean the water!" or, "Provide recreation." However, you need to give careful thought to how those values can be translated and represented on a map, as well as managed for long-term conservation or restoration. A list answers the question, "What do we have?", while a strategy answers, "Of those things we have, which are the most important to conserve and how can we do that?"

Green infrastructure planning involves the prioritization of catalogued assets to create a strategy for conserving what is most important. To prioritize, you must have some way of setting aside ideas that are not critical or relevant. The only way to achieve that is to strictly adhere to your goals. The more specific your goals are, the easier that will be.

"Green infrastructure planning involves prioritization of catalogued assets to create a strategy for conserving what is most important. To prioritize, you must have some way of setting aside ideas that are not critical or relevant. The only way to achieve that is to strictly adhere to your goals. The more specific your goals are, the easier that will be."

Set Clear And Consensual Goals

When you initiated your mapping project, you clearly had a reason for doing so. In a rural area, your initial goals might have been as broad or vague as, "To identify large, intact habitats that will conserve our region's biodiversity." Or they may have been as specific as, "To identify critical natural resources, habitat areas and key viewsheds that can support and sustain a strong, natural resource-based economy."

Once people understand why you are undertaking a natural asset mapping initiative, they can consider what goals need to be addressed. However, before you begin asking your group or community to establish goals, be sure to avoid the pitfalls of generating a long, cumbersome laun-

dry list. The challenge is to create some consensus around a limited, defined set of goals that everyone can agree on – in other words, which four or five goals can people agree are the most important?

You may want to utilize goals that already exist for the community by consulting existing documents, such as the comprehensive plan or zoning ordinance. Since these have been adopted already, it may make it easier for them to gain acceptance. Another simple way to begin is by asking stakeholders what is important to them.

A goal for an urban area might simply state, "To identify and protect the city's natural resources and restore habitat and natural area connections wherever possible, in order to create a livable, resilient, attractive and healthful city." Or it might specify particular natural aspects to focus on, such as stream buffers or the tree canopy.

A goal might focus less on wildlife and more on human-based ecosystem services, such as clean air, clean water or recreation, and might be framed in such a way: "To conserve the city's natural areas, urban tree canopy and forested stream buffers, in order to protect native species, keep the city cool, maintain clean streams, and provide abundant opportunities for nature-based recreation."

EXAMPLES OF GOALS THAT CAN JUSTIFY CONSERVING KEY NATURAL ASSETS

- **To preserve regional forests for wildlife.**
- **To ensure biodiversity and a healthy ecosystem.**
- **To protect a rural economy (that comprises, say, timber stands, farms and grazing lands).**
- **To maintain forested land cover in order to facilitate recharging groundwater aquifers for drinking water supplies.**
- **To conserve community character and heritage by protecting an historic landscape.**
- **To preserve and promote natural-resource-based recreation, such as hiking, birdwatching and hunting.**
- **To save money by directing development into areas where services (roads, schools, power lines) already exist.**
- **To protect public safety and prevent future hazards by identifying hazards such as unstable slopes, floodways and areas prone to sinkholes.**

An example of linking goals to natural assets is to promote outdoor recreation by protecting landscape corridors for those activities, such as hunting, that rely on intact habitats – the better connected a landscape is, the easier it is for animals to move and repopulate areas and for hunters to enjoy their sport without conflict. Other non-consumptive outdoor sports, such as cross-country skiing or long-distance hiking also require a connected landscape.

Set Goals For Various Timeframes

As we have discussed, your community may have undergone a visioning process to determine what it wants to achieve. Now, you can set your goals for that vision over several time periods: say, 10, 20 or 50 years. For example, after 10 years, your goal might be to preserve the following natural assets and ecological services: abundant clean water; clean air, a strong natural, resource-based economy; an intact landscape that supports outdoor recreational activities; abundant and biologically diverse native species; attractive vistas; and so on. Then, after 50 years, it might be to have a truly connected landscape that further enhances all those assets.

Or your community might have a more singular goal in mind, which it wants to achieve relatively quickly, say over just five years. An example would be an immediate economic goal to protect an agriculturally-based economy by identifying and conserving areas with high-quality agricultural soils though zoning protections and support for farmers markets. Another example might be to map your city's tree canopy and target gap areas where canopy can be restored through city and citizen-based planting programs to meet a target canopy level.

Do Your Goals Address Your Major Issues?

You will need to consider if your adopted goals address all the issues your community or organization thinks are important and whether they are specific enough to provide direction for your evaluation of assets. If not, you may need to modify your goals to add specific qualifying statements. For example, if you already have a community goal, "To keep the county's water clean," you may need to add specifics such as, "To keep the county's water clean by protecting forested buffers along streams." You may also need to add specific objectives, such as details of how wide the buffers should be and whether there are areas of higher priority, such as headwater streams or streams that feed into the drinking water supply. One way to flesh out specific parameters for your objectives is to have a panel or committee of topical experts discuss them and suggest refinements.

Also, you may not be exactly sure what your goals should be, without looking at existing data and assessing it. So use those maps and GIS layers you already have, or gather new data if you feel you need additional information to make an informed decision on what your goals should be. For example, your initial goal might be to protect core forest habitats and corridors, but you have little idea where they are, or which ones to prioritize. So you decide to consult existing GIS layers and county forest maps to make an initial determination of those that are the most important. You then enter a full data-gathering and mapping process, and as you do so, discover another key core piece of forest, or decide to remove one from your list.

Thus, you will probably need to take an *iterative approach* when establishing and refining your goals. An iterative approach involves setting goals, creating a map and then determining the condition of the resource and what should be prioritized. For example, you may find that forested land cover is more fragmented that you realized and that there are less cores than originally supposed. This may lead you to put greater priority on conservation actions for certain areas of the landscape. Or, you may determine new corridor possibilities to connect intact core areas.

Decision Metrics

One challenge that all projects face at some point is how to address conflicting perspectives. Some stakeholders will want to target an area for growth, while others will want to preserve it. One way to minimize this is to develop clear *decision metrics* early on.

A ***decision metric*** is a standard that helps you prioritize what to conserve first and why. Creating decision standards early on can help resolve potential conflicts in the future.

These metrics define priorities into a ranking of what is considered most important by the community, and might include such things as:

- Protect the area that shelters rare or endangered species first.
- Protect the habitat cores with the highest rankings first.

Decision metrics can provide a way to sort through data and decide more quickly which aspects of your landscape are most suited for conservation. Evaluating natural assets within a green infrastructure context means conserving those resources that offer the greatest conservation and community values first, and not simply trying to protect everything that is natural or green. You'll need to keep asking yourself, "Does this meet our highest priorities?" and "Will it ensure achievement of the multiple community values or goals we identified earlier?"

As described previously, an area may be deemed more valuable because it provides multiple community benefits, such as a forested area that helps with groundwater recharge and buffers runoff into an existing drinking water reservoir. However, you are likely to find more conflicts around such areas, because there will be more demands on them. For example, a high-value habitat area for recreation may also be indicated by the locality as the best location for a new school or shopping center, precisely because of its proximity to an existing population center.

Similarly, if you are evaluating your soils for food production as part of your green infrastructure network, you may find that the best soils for growing food are also the best soils for septic systems. This was the case in Accomack County, VA, where soils with lower clay content that were well drained were less common and were thus in high demand by both farmers and developers since both groups needed well-drained soil; one needed this for crops and the other for septic.

Achieving Your Goals

Next, consider how a green infrastructure map can help you achieve your goals. For example, if you map forest cover, that will help you protect your forests, which will help you facilitate groundwater recharge. If you map forest

corridors, you can protect them and identify where there are gaps, which can help you promote biodiversity. Those corridors can also help you draw up plans to facilitate animal movement and support hunting, hiking and cross country horseback riding, since they all depend upon a connected landscape. Similarly, if you map your soils, you can protect your agricultural economy by identifying and conserving those landscapes that have the best soils for growing crops. The key is to match community needs and interests to the functions you want to achieve by identifying natural assets on a green infrastructure map.

Can Your Goals Be Mapped and Turned Into Actions?

You will need to determine if your goals can be evaluated spatially (on a map) and whether they can be used to create real on-the-ground actions. As part of this, you need to consider those resources you will have available to you to collect data and implement your goals. For example, if your community relies on local water from wells or from a stream-fed reservoir, both surface water protection and groundwater recharge may be important. However, you will need an existing study of groundwater recharge areas in order to map them.

If you do not have data on exactly which areas are best for recharge, you can still undertake actions to help your drinking water. It is well known that forests help with retaining and infiltrating water, so if you protect the forest cover across the headwaters of local streams, around your reservoirs and across watershed areas that are upstream of your reservoirs, you can link your goals for clean and abundant drinking water to land management actions, such as protecting your forests through easements, stewardship plans or replanting.

The aim here is to have realizable goals that are practicable, can be mapped and are actionable in order to help you realize the vision defined for your local landscape.

STEP 2: REVIEW DATA: WHAT DO YOU KNOW, OR NEED TO KNOW, TO MAP THE VALUES IDENTIFIED IN STEP 1?

Once your community, locality, land trust, or other organization has established the purpose of its project (what it is seeking to conserve or restore, and why), the next step is to determine how to implement that purpose. To do that, you need to assess what information you already have and what you still need to gather. Keep in mind that the goal is not to put everything on your map, but rather to prioritize. A green infrastructure map – a map of natural assets that support community functions – is most effective as a strategic tool if your natural resources are ranked in terms of importance for *achieving* your goals. It is not uncommon for communities to make long lists of what should go on their maps without having first investigated if the data are available. That is frustrating, time-wasting and ultimately pointless. Natural resources should be ranked in large part based on how well the data represent the conservation value of those resources.

"A green infrastructure map – a map of natural assets that support community functions – is most effective as a strategic tool if your natural resources are ranked in terms of importance for achieving your goals."

Prioritization, Prioritization, Prioritization

If *everything* currently known is put on your map (such as all forested land and all agricultural soils), it is likely to result in a map that does not show priorities and is lacking in definable strategies. To avoid this, decide how the available data relate to each of your goals, and how they data can be catalogued, evaluated, prioritized and mapped.

For example, if your community decides that it values clean water, then rather than mapping all watersheds, it could identify and conserve just those with high levels of forest cover and intact stream buffers. This can be mapped in GIS by creating a watershed boundary layer, adding in forest cover and determining the highest value forest cover you desire for a watershed, e.g., at least 70 percent cover overall, with extra buffering for headwater streams.

Every community is different and you will need to evaluate whether or not such a simple mapping metric makes sense for your area. For example, in mountainous areas, it is not uncommon to have highly forested slopes that are not developed, since they are difficult to clear for farming or housing, and to have open lands with grazing or crops located alongside valley streams. This could mean that, even though you have a high-forest-cover watershed, it lacks adequate forest buffers in the right places – alongside streams where

they can help protect water quality. So you could add an equation into your GIS mapping to select ('clip') areas of 100 feet alongside each stream and determine if they are also adequately forested for filtering land runoff.

Since forested streams often make good wildlife corridors, this is another reason to select them as a high conservation priority in your green infrastructure prioritization process. If you are also seeking to protect or create a wildlife corridor, then 300 feet on either side of the stream will be needed. In this case, both wildlife and water quality are supported.

If your community decides that locally-sourced food is important, you might want to map the locations of good agricultural soils. Thinking strategically, you should map only the highest quality agricultural soils instead of selecting every soil classification. Then compare these class IV and V soils (from the USDA) with land cover to ensure that they are actually available for farming (and not underneath a factory or urban area).

There are many other site-specific criteria for all types of crops. For example, vineyards may perform well on poorer soils and most fruit production does best on slopes between 1.5 and 15 percent and at higher elevations than valley floors, to avoid spring and fall frosts. Vineyards also do best in open areas with good airflow that avoid interaction between cultivated grapes and wild grapes (which carry a fungus that can harm cultivars). So, if you are interested in areas that are best for fruit growing, these can be included on your agricultural asset map as well.

With guidance from your local extension agent, you can identify areas suitable for each crop and include them on a map of key agricultural zones. In Madison County, VA, the extension service mapped areas with soils and conditions most suitable for grape growing, to make it easier for prospective vineyards to locate within the county.

Find the Right Data

In order for something to be mapped, data must already be available. Stating this seems obvious, yet it is common for groups to identify things that they want to include in a map for which no data currently exist. A data table of available state data is found in the last chapter of this guide. You may also have additional local data such as a groundwater study conducted by your county.

WHAT CAN BE MAPPED?

Simple rules of thumb for what can be mapped are:

- **The data must exist (or be readily obtainable in the near term).**
- **The data must be represented spatially.**
- **The data must be consistently available over the entire area.**

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- The data must exist (or be readily obtainable in the near term).
- The data must be represented spatially.
- The data must be consistently available over the entire area.

If your group identifies something it wishes to map, but for which there are no data, consider how this data might be collected. Given that field studies could take years and require grant funds to support, think carefully about how to create a map with the data now available and how you might update and reprioritize the map in the future, when new or more accurate data become available. For example, can you map known high-value habitats now, and then update the map later when a more comprehensive inventory can be conducted?

If groundwater recharge is important to your community, a detailed study can take time and resources to complete. In the meantime, you could create a map that only includes watersheds that currently supply a large number of existing wells; that have community wells (usually those wells serving 20 or more users); or that feed into public reservoirs.

Proxies

When the desired data are not available, *proxies* may be used. A proxy is a way to simulate (create a surrogate for) what you want to map. For example, most localities have not completed extensive surveys of all of their wildlife. While it is likely that some rare species have been catalogued and recorded at your state's Natural Heritage Program, you are only allowed to show these data with large buffers around the sites, in order to blur the actual locations of the rare species. This is to prevent anyone from locating, stealing or destroying them.

Your state's wildlife action plan may have also identified locations that are *likely* to contain key species, but these areas may not have been monitored to confirm the actual existence of those species. Thus, even the wildlife mapping data that *are* available may not be very useful.

If you want to take a proxy approach and map likely locations that can support native species, pick areas of your landscape that are still intact (as undisturbed and unfragmented as possible) and large enough to support a diversity of habitat types or *niches*. For example, in Virginia, the state uses a proxy of 100 acres of intact interior forest as a minimum size and land cover type of forest to support a diversity of native, interior forest species. The larger the area, the more likely there will be suitable habitat for area-sensitive species, such as forest-breeding migratory songbirds, black bears and mountain lions. Consult with your state to determine a minimum acreage. If you also know that a specific area supports rare species or rare habitat types, you may rank those areas higher.

A ***proxy*** is a way to simulate data that represents what you want to map.

Tying Data To Location

Since the mapping rule requires that all data be represented spatially, it must all be tied to location.

Some studies randomly select species in order to characterize abundance for an area, such as an entire county, and do not record actual locations. You will not be able to use that data for your map. Other data may cover too large an area, lacking in the precision necessary for mapping. An example of this is bird flyways, which are often represented as large swathes many miles wide. To make matters worse, these flyways can change year-by-year depending on weather, temperature, food sources and other factors. To learn more see http://www.birdnature.com/flyways.html

Another point to be aware of is that, when you look at the habitat demanded by a particular species, it may require the entire area of your project, making it difficult to prioritize one part of it over another. For example, when the GIC reviewed the bear habitat needs for one Virginia county, the entire county was highlighted.

If you face a similar problem in your locality, a better way might be to select those core areas and corridors that offer the very best of all possibilities. It is important to contact scientists/experts for guidance on what can be mapped, including natural heritage programs and wildlife resource agencies.

You also need to consider data consistency. This means that all your data must have been evaluated in a consistent manner, as opposed to collected sporadically. It is often a common desire for members of the public or local stakeholders to want to add something on a map that they happen to know about – such as their favorite duck pond or beaver dam. If you allow these personal *ad hoc* details to be included, as opposed to using data that were gathered consistently across a landscape or in all potential habitats, you will probably create an inconsistent mishmash on an inaccurate map that is not useful for identifying anything, let alone the highest priority areas.

Consider the following two examples (both are real examples):

In the first, a stretch of river had been included on a map as significant for bald eagles because canoeists had seen an eagle nest there and a single breeding pair; in the second, an area had been mapped as significant for trilliums because one particular researcher had established a study plot on a slope and noted that it had abundant numbers of the locally rare woodland plant.

The question is, why trilliums, why eagles? And why there? Putting data on a map just because it is

available, absent of a defined rationale and protocol for doing so, can result in a map that is full of data points but lacks any clear way to prioritize those areas that need better stewardship or management.

While certain areas may, indeed, contain bald eagles and trilliums, there is no way to determine whether or not they represent the *best* areas for eagles and trilliums in the locality. In fact, eagles and trilliums may be far more abundant in other, less disturbed areas, or in areas with more suitable soils or more abundant food sources.

If these communities had wanted to create maps of the best bald eagle and trillium habitats, so they could prioritize them, it would have been better to conduct a county-wide eagle survey or an examination of soils and slopes where trilliums are most likely to be found. In addition, these data should be provided to natural resources professionals and heritage programs so that they can be included in broader inventories and incorporated into your state's existing assessments.

STEP 3: MAKE ASSET MAPS: MAP YOUR COMMUNITY'S HIGHEST-VALUED NATURAL ASSETS THAT CONTRIBUTE TO A HEALTHY ECOLOGY AND ALSO SUPPORT CULTURAL AND ECONOMIC VALUES – BASED ON THE GOALS ESTABLISHED IN STEP 1 AND DATA FROM STEP 2.

Once you have at least an initial sense of what data are available, consider which data could help you meet the goals you established in Step One. Then assemble them.

Once you have brought together all the existing data you want and collected any additional data that matches your goals, it is time to create your natural asset map. Depending on what those goals are, this map might include:

- Large intact forests, native meadows, marshlands.
- Key geological features.
- Farms and farming communities.
- Streams, rivers, wetlands and reservoirs and ground-water recharge areas.
- Recreational areas.
- Historic and cultural features.
- Viewsheds.
- In urban areas: street trees, the tree canopy, parks, community gardens and streams.

GIS Models

Although several states have models covering the entire state, each intra-state regional or community natural asset mapping project still needs to develop its own locally relevant model or base map. Some states that lack comprehensive models have statewide datasets, which are very useful for creating a local natural asset map. However, for any local project, whether or not there is a state model available, creating a local base map of natural assets will require the addition of new data from both state and federal sources and locally sourced data.

HOW GIS WORKS

In GIS, data are collated in *layers.* Each layer represents a specific type of data, such as forest cover, roads, or streams and is often called a *theme* because it focuses on one specific type of data. These themed layers are saved together as *projects*. A project is a series of overlain layers that build into a composite map that contains all the information you have added to it.

Data Layers, Themes and Projects

In order to show as many pictures and patterns as possible, it is recommended that you keep your data sets in discrete *layers*, often called *themes* because each one focuses on a specific type of data.

In GIS, data layers are saved as *projects*. A project is a map that contains all the information you have added to it.

It is recommended that you keep each type of information as a separate layer of information so you can grab it and add it to any map to show new patterns and relationships. This will allow you to create new projects easily as you compare different data sets. For example, you may want to overlay your Protected Lands data layer onto your Highest-Quality Agricultural Soils layer to answer such questions as, "How many areas with high-quality agricultural soils are already protected from development under conservation easements?"

Another example applies to historic resources. You might add your Conservation Easement layer to your Key Cultural Resources layer to determine how many of historic sites are within landscapes protected from development or encroachment by incompatible uses.

Keeping your data as discrete layers allows you to use

your data for multiple applications and to build maps as and when you want to, with the specific information you wish to have represented. You can combine these layers to see new relationships such as areas that are important for both water quality and habitat (water theme map + wildlife habitat map).

Data Tables

The data for each GIS layer are kept in a linked data table. Each table can then be used to sort and compare data, perform data analysis and create new maps. The data can also be used to run calculations and categorize and rank information.

A GIS user can run calculations or sort the data tables in those ways that are most helpful to your local needs. For example, you may be able to calculate the acreage of all habitat cores that have been given the highest ranking or sort the data for all habitat cores that contain rare, threatened or endangered species. Similarly, you may be able to select all habitat cores that intersect or are within 50 feet of a waterway that has a high priority for conservation.

Scalability

Green infrastructure maps have been created at many different scales. The mapping and modeling that have occurred in the past few decades have been made possible by advances in GIS software, as well as improvements and increased access to high-resolution satellite imagery, new data management tools and the increased processing power of the desktop computer. These all allow you to create data layers that are scalable and that enable you to view your data at various different 'heights' – much like zooming in and out of Google Maps.

This allows you to see connections at multiple levels, such as between core areas or development areas, over a regional as well as local scale, and to understand how your local efforts fit into a much wider network.

Using GIS Software

The approach recommended by the GIC requires that you use GIS software to overlay data, in order to see the emergence of patterns and priorities. You can use this GIS software and its associated data tables to establish your priorities. For example, if you want to protect water quality, you can overlay watershed boundaries with forest canopy to determine whether the canopy is sufficient to protect your water quality. Does the canopy cover most of the watershed (e.g. 80 percent) or just 10 percent? Will you need to reforest part of the watershed, or nearly all of it? Where is forest cover most needed? Are forests located along streams to buffer runoff and stabilize banks?

If you want to determine whether or not streamside buffers are adequate, you may want to draw a boundary polygon 100 feet either side of the center line of the stream to determine if adjacent forest coverage is adequate and if there are sections of the stream that would benefit from a reforestation effort.

IMPAIRED WATERS

Your state's Impaired Waters List will indicate if there are known impairments for your surface waters. Contact your state's department of environmental quality or department of conservation (or equivalent).

Which GIS Software Should You Use?

It is worth a reminder that, while there are several more simplistic mapping programs available to you, many of them do not include analytical properties available in GIS programs, such as the Environmental Systems Research Institute's ArcGIS software products.

Simpler programs, such as Green Maps, and graphic tools such as Google Maps, do not allow you to run more complex calculations such as, "Select all cores that include 200 acres of habitat and slopes greater than 20 percent."

ArcGIS is the easiest GIS software to use and is more translatable if you want to share your data with local, state or regional government agencies. It can also perform calculations that analyze information. Once you draw boundaries (polygons) around key areas, you can calculate the total acreage of those polygons, the distances between them, and so on. This is very helpful when you want to discover such information as, "What percentage of the region contains land protected by conservation easement?" or, "How many miles of rivers and streams have a linear forested buffer of 100 feet wide to filter nutrients?"

Metadata

Every data layer should have an associated set of *metadata* attached to it that describes where the data came from, as well as a data table that includes source data for the layer and other associated attributes, such as accuracy information (resolution) and details on how data were collected. Your GIS expert should help you with this, but make sure that he or she is including it in all your data layers.

Metadata is information about data that gives details such as where, how and when the data was collected. A data table is an Excel spreadsheet that lists every data unit in columns that you can select, compare and analyze, just like any other digital spreadsheet. An *attribute table* contains information about a set of geographic features, usually arranged so that each row represents a feature (such as soil type) and each column represents a feature attribute (such as loam, clay, sand, etc.).

You may find this web page useful. It is a dictionary of GIS terms:

http://support.esri.com/en/knowledgebase/GISDictionary/term/attribute%20table

If you use existing data from another source, then modify or update it, you should make a note of this in the metadata and *attribute table*. For example, if your data layer maps water features, your metadata should always record the source of the data (for example, that it came from the National Hydrography Data Set), the year of the data collection (for example, land cover from 2010), and other key data regarding such attributes as resolution scale (e.g. 30-meter resolution).

Your attribute table will contain all the data in a map layer in tabular format. Since this is usually in the form of an Excel spreadsheet, you can open that spreadsheet and perform a number of different calculations from the table, such as adding up the total acreage of your parks or the linear length of your streams.

If you do not have GIS capabilities, consider hiring a consultant or a local university student proficient in GIS to work with you. There are new, low-cost software licenses available for just $100 for nonprofits from ESRI, so it is more affordable to own and use GIS than ever before. Universities and colleges usually have their own GIS licenses, so students can use their school's software to help create maps.

Your Base Map

The first step is to create a *base map*.

A base map is a master map of your prioritized natural assets. It is used to compare other key land use concerns or management needs. If you want to add more nature-based recreational trails, your base map can be used to determine if your trails take advantage of key natural assets, such as exceptionally unique forests or connecting wildlife corridors. Similarly, you can use your base map to overlay key cultural assets, such as tourist destinations, and ask, "Does this priority landscape also support key views from these sites?" In general, we recommend you begin with your state's model of intact interior habitats and connecting corridors – if it has one – and then create themed maps to show how this base map supports other cultural and community values.

Here, we give a list of the steps we recommend you follow to create your base map. Turn to the chapter on your specific state, to learn how these steps relate to your own situation. Your state chapter also outlines how your base map can be modified or updated to meet your community's needs.

We recommend you follow this procedure to create your base map:

1. Begin with your state's basic land-cover model of cores and corridors, if one is available, and determine the date of the version you are using to ensure you have the most up-to-date data available.
2. Consider core habitat distribution.
3. Consider what corridors and steppingstones you will need between cores to create a viable habitat network.
4. Identify those habitat cores and corridors that have the highest priority for conservation.
5. Identify gaps in the network of cores and corridors.
6. Identify and rank any additional local priorities.
7. Assess the risks to those areas.
8. Review the levels of protection you have assigned.
9. Reality test your model and finalize its data.

Determining Priorities

Once collected, your data can be utilized to demonstrate the relationship between your priorities. For example, if you overlay your digital layer of protected lands (such as lands under easement or within national parks), it may show you that the natural assets you have identified as key resources are not, in fact, as protected as you thought; in fact, they may be at serious risk of disappearance without

concerted conservation action. You may also notice that a large tract of habitat ranked as average connects two highly ranked areas. As a result, you may decide to raise the ranking of that 'average area' and add it to your map as a priority area because it is a key corridor that helps connect your local landscape and facilitates a more resilient natural network that can better withstand change.

The more connections you have across a landscape, the greater its potential to ensure that species diversity is maintained. Likewise, expanses of connected areas of natural cover can also allow for recreational uses such as cross country sports (skiing, riding or hunting) which depend upon a connected landscape.

Using Data To Establish New Goals

Each natural asset map needs to include a map of the natural and cultural assets that are most significant and of highest priority to your local community. Determining 'significance' requires that you set goals for what is most important. This was covered earlier in this chapter.

The process of creating maps allows new priorities to emerge. You may discover that an asset you thought was abundant is actually in short supply, thus driving a new goal for restoration. Or you may find that overlaying additional data layers highlights previously unrecognized landscape features worthy of protection. For example, a forest may gain greater local significance because an historic event occurred there, such as a Civil War encampment, an Indian burial mound, or a battle at a frontier fort.

In one county, considering this historic data overlaid with the forest layer, turned an otherwise insignificant piece of woodland into one worthy of protection. It led the local county to prioritize that woodland for its historic significance. From an ecological standpoint, that piece of forest was not the most remarkable in the county, but its historic resources elevated its preservation importance. It also turned out that the site provided a wonderful setting for a newly constructed 'green' elementary school adjacent to the woodland, because it afforded the children an accessible place to study nature while also learning about Civil War history. Without its historical significance and educational opportunities, it is likely that the woodland would have been developed long ago.

Similarly, an area could be ranked more highly based on local knowledge of its ecological function. For example, a local river or wetland could contain a unique feature such as a heron rookery (a place where many herons breed and nest) to be more highly valued at the local level and thus increase the ranking for that feature. In this way, overlays of data sets help bring out new priorities. Combining data sets in new ways can bring out hidden values and can lead to new conservation or restoration goals.

These examples show why it is important to use your data layers to look at land development patterns and compare that with known problems. In urbanized areas, even streams with wide forested stream buffers can be polluted by stormwater runoff, if there are pipes carrying untreated stormwater from urban areas directly into waterways.

For each problem known or suspected, use the data to help answer the question, "Can a green infrastructure strategy help address the problem?"

Mapping Ecological Assets

A community may hold in high regard certain intrinsic values, such as wildlife, or promoting a landscape that is biologically diverse. But how do you map such values? Well, you can map the desire to protect wildlife by including those habitats that support the greatest species diversity. But how do you do determine that?

Your community will need to establish a series of *metrics* and *protocols* for what types of habitats to conserve and where. A metric is a measurable quantity, such as buffer width, acreage, the number of tree species, the age of a forest, or water quality. A protocol is a scientific method that turns those measurable quantities into discrete spatial data that suit your needs.

When you try to capture community values on a map of natural assets, be sure to use appropriate and defensible scientific protocols. For example, to map corridors for wildlife, consult the academic and scientific literature. A local expert can also help – such as a qualified employee from your state natural resources or wildlife agency. Use this information to determine how wide the corridors need to be, where might be the best locations, and so on. For example, as part of the 1996 federal Farm Bill, the Natural Resources Conservation Service (NRCS) encourages landowners to install buffer strips ranging from a minimum of 30 feet for some herbaceous filter strips to a maximum of

150 feet for forested riparian buffers (Fischer and Fischenich 2000). Most states have their own requirements as well. Similarly, if you wanted to protect drinking water intakes, your state likely has guidance on how far upstream the river needs to be protected, so use your legal standards when establishing protection zones on a map. The specific models, data sources and suggested methods for doing this are covered in Chapter Seven.

Your community will need to establish a series of ***metrics*** and ***protocols*** for what types of habitats to conserve and where. A metric is a measurable quantity, such as buffer width, acreage, the number of tree species, the age of a forest, or water quality. A protocol is a scientific method that turns those measurable quantities into discrete spatial data that suit your needs.

Mapping Cultural Assets

So far, we have discussed natural assets and the protocols for mapping them. But your project may also want to include assets that are valued for cultural reasons. Green infrastructure is a construct that helps us think about the importance of natural resources for people. Yet because people place an intrinsic value on nature and biodiversity – in other words, they value something because it exists, even if they have never experienced it personally – human use of a natural feature is not a prerequisite for including it in a natural asset map. That said, there are cultural resources and values that depend upon the support or context provided by neighboring natural areas.

It can be a complex undertaking to help communities make the link between culture and nature. However, when community members are asked to think about a cultural place that they really enjoy, such as a plantation, a battlefield or an historic farmhouse, it is often the setting that makes it particularly special.

The setting can be made up of forested hills or mountains, large trees around a building, an adjacent river or marsh, or an uninterrupted vista of green. A view looking out from the structure is part of the experience of enjoying it. Similarly, many recreational pursuits depend upon nature and intact landscapes to make them possible – such as hunting, cross country horseback riding, skiing, landscape and nature photography, birding, canoeing and kayaking.

In Nelson County, VA, views of the intact forested landscape pay dividends to businesses that bring in clients largely to enjoy those vistas while eating or drinking their products. Several local breweries have sprung up in the past five years that depend upon on the county's clean, clear spring-fed streams, as well as on the breathtaking scenery that lures urbanites from nearby densely populated counties and cities. These views keep tourists, hikers, bikers and birders in the county longer, offering refreshment after a fun day in the field or touring local amenities.

According to one Nelson County brewer, "The water in this region is an integral part of the success of our brewery process." One forester called the all-important views of the mountains from the breweries, cideries and wineries "the brewshed" – those views afforded to each brewery that lure and retain customers throughout the seasons. In fact, Nelson County has combined marketing for nature-based recreation on the Appalachian Trail and Blue Ridge mountains with enjoyment of beer in natural settings by creating a "Brew Ridge Trail," which links hikers, birders and boaters to the many breweries and wineries in the area.

Built Structures

Built structures, which include features such as plantation houses, historic log cabins, old, one-room schoolhouses and 18th century mills, are likely to have a country setting and their backdrop landscapes of hills, forests, marshes, or streams contributes to their historic character.

A simple way to identify these cultural assets is to contact your state's office of historic resources to learn the location of its historic features. It is then relatively easy to map them at a large scale (county or region), where you plot each point and create a buffer around it. Draw the buffer as large as it needs to be. One suggestion is to include contributing natural resources within 500 feet, with a 1300 feet (¼ mile) boundary around areas dependent on a larger setting.

A more accurate (and more time consuming) approach is to use digital mapping tools. There are several add-ons to GIS that can map elevations, and thus sightlines, such as using the GIS-based digital elevation model and Crystal Reports. These can map elevations, which determine where vistas are more or less visible and thus more or less important for a visitor's or resident's experience from a site. It only takes a few minutes to run a digital elevation model and output an elevation map. The time-consuming aspect is to analyze the results, which will likely require site visits to confirm what is actually visible. ESRI's web site provides guidance on mapping viewsheds as well.

Another method of collecting data about culturally significant features is to ask community members and stakeholders about them. Just be careful to verify the data, as anecdotal information is not always reliable.

PREVENT VANDALISM

Some cultural resources may need to have their locations masked, such as Native American burial mounds or other sacred sites where artifacts could be plundered or compromised by disturbance. Adding a buffer – say 1000 feet -- around those sites can hide their exact locations.

Linking Cultural And Natural Assets

The advantage of linking cultural and natural resources is that it helps a community recognize the importance of natural resources to its well being, identity and sense of place. These natural resources may be taken for granted until they are destroyed. County boards are often asked, why did the cell phone company propose to put their tower (or other obstruction) in our most iconic view? Besides the obvious answer that the location was probably in a good reception area for cell signals, it may also be because most localities have not taken the time to create cell-tower location guidance that avoids mapped viewsheds.

An important caveat when adding cultural resources to a mapping effort is to carefully bound the discussion; otherwise, people begin to add in 'everything.' At some GIC workshops, participants have even requested we map the locations where things *used to be* – as in the place where an old store burned down in 1942, or the location of the old school they attended before it closed.

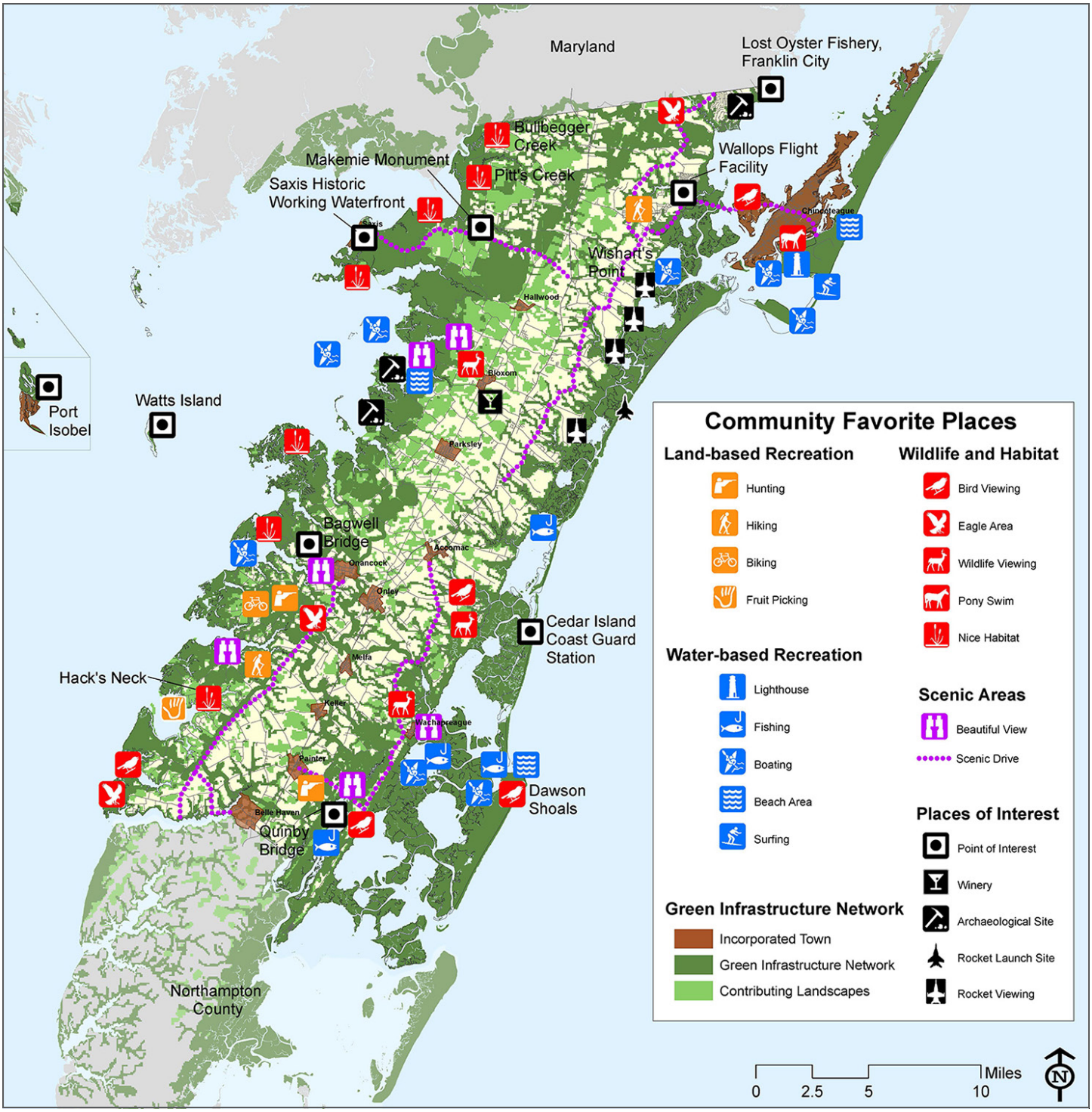
It is important that people understand they are not making a map of *everything* they value, but rather those key cultural items that depend on a natural setting for their enjoyment and function. So nature-based recreation means a walking trail through the woods or along a river greenway trail, but does not mean a pedestrian walk through the mall; it means a field set aside for birding, but not one for drag racing.

'Favorite Places Maps'

If people in your community really want to put their favorite nature- and culture-based resources on a map, let them. The GIC calls these maps 'Favorite Places Maps' or 'Peoples' Maps.'

As long as a resource relates to green infrastructure in some way it can be recorded on its own GIS layer. Allow people to write on a map at a community meeting (or have them add their 'data' digitally through programs such as Green Maps). Create a common nomenclature or symbology (such as different colored dots) for the different classes of features on the maps, such as "fishing spots," "best hiking," "best sunset view," and use the symbols to create a coherent and readable map (see the illustration for Accomack County, Virginia on page 64).

Such a 'favorite places map' can prove useful when it comes to evaluating your green infrastructure priorities. For example, you may find that it closely overlaps



Accomack County Favorite Places Map.

areas that had already been prioritized by your local county administration as natural assets and thereby provides community validation for what local government and conservation groups had already identified as priorities to conserve.

The following chart provides examples of goals and potential data sources to indicate spatially how values and goals can be translated into a map of natural and cultural assets. The degree to which they are achieved – for example, how much natural area is protected or how much acreage of intact forests are preserved within the locality – will be determined by the specific objectives you set to achieve each goal. The purpose of the chart is to help you match your goals with resources that can be represented and evaluated spatially.

EXAMPLE GOALS AND DATA			
GOAL	DATA TYPE TO MEET GOAL	DEFINITION/APPLICATION	SOURCE
Protect habitat for native species.	Intact Forests or other habitat types (i.e. large dune systems, wetlands, marshes, natural heritage areas)	Habitats that have adequate interior area which is unfragmented by intrusions such as roads or power lines that create edges which facilitate problems from invasive species or predators. In the eastern U.S., 100 acres of interior conditions (that do not include the necessary 300 foot buffer from surrounding land use) is a minimum size to accommodate a diversity of native forest-dwelling animals, bird and plants.	States such as VA and MD have mapped intact forested, wetland and dune areas (cores) already. The National Land Cover Dataset can be used to create a core layer. A fragmentation layer can then be used to determine which areas remain intact. Those areas that have at least 100 intact acres that are not bisected may form a new core.
Prevent urban heat islands. Protect aesthetics. Reduce stormwater (developed areas). Sequester carbon to mitigate climate change. Clean the air.	Forest Canopy	Canopy is the coverage by forests (bird's eye view) and is more commonly applied to urban areas where other values (besides forest interior) also become important, such as tree cover to keep cities cooler, aesthetic values of trees to downtown areas, and habitat for urban birds and other animals. Trees also mitigate urban stormwater and sequester carbon and clean the air.	Forest canopy may be available from the Department or Division of Forestry. In urban areas, along with the canopy (or if no canopy data, you can use street tree inventories, if available, or create your own). I-Tree is a software tool to help evaluate canopy.
Protect habitat. Protect water quality. Protect aesthetics. Support fish nurseries (if tied to waterways or ocean).	Wetlands	Wetlands include forests, meadows, bogs, shrub swamps, ponds, lakes, streams or bays, and depending on location, may be tidal or non-tidal. Many species can only thrive in wetlands and they provide nurseries for many birds, fish, crustaceans, insects and animals.	National Wetlands Inventory Data (NWI). The NWI may not be very precise. If local or county wetland data are available, add that to this layer.
Promote agriculture row crops.	Agricultural Soils	Prime (best) agricultural soils occur in certain locations. If crops are important to the area, then agricultural soils can be mapped.	USDA Soils Data Mart, select classes IV and V (top ranked). Use land cover to select and remove areas already covered by urban uses (cities, towns, industrial parks) since not suited to large scale farming.
Promote fruit orchards or vineyards.	Slopes Soil Type	Fruit trees and vineyards do best on south or west facing slopes in well drained soils. A local extension agent can help suggest the best areas for orchards or vineyards.	Use a digital elevation model to select slopes. Use the USDA Soils Data Mart, select appropriate soil classes.
Protect watersheds and clean water.	Watershed Boundary Forest Cover Stream Buffers Municipal Water Supply Watershed Boundaries Water Quality Data	Streams should be included in most GI maps as they provide habitat and are often good corridors for wildlife, as well as sources of drinking water. To determine how well forested the watershed is, the forest cover can be clipped in GIS to match up to the watershed boundary and used to determine the percentage of area covered by forests. For water quality, map stream buffers by using GIS to find center lines of streams and map 100 feet widths on either side to see extent of forested stream buffers for buffering runoff. For large rivers use stream edge if known. If using streams for wildlife corridors, select 300 meters on either side of stream and intersect with forest layer to see if adequate forest buffer to provide a protected corridor. If protecting headwater streams, use steep slopes and elevations to select upland streams for protection.	National hydrography data set for stream locations and augment with additional local data. See forest canopy above. In Virginia, a new modeling tool InFOREST can be used to map land cover and get N, P, Sediment loadings by watershed. State 305B Reports contain water quality ratings and the 303D lists contains impaired waters.

EXAMPLE GOALS AND DATA - CONTINUED			
GOAL	DATA TYPE TO MEET GOAL	DEFINITION/APPLICATION	SOURCE
Protect settings of cultural resources.	Historic Sites (in rural areas), battlefields, cemeteries, tribal lands, etc.	Historic sites are often dependent on the context of the surrounding landscape. Buffer each point (building) by 300 meters. You may also want to protect the views from this site for visitors.	Obtain historic data from State Division of Historic Resources. Some sensitive data, such as Indian burial sites, may not be available. Viewsheds can be mapped using the ArcMap Viewshed tool. It uses point data and Digital Elevation Models to calculate the visible area. Moderate to advanced GIS skill necessary.
Promote vibrant business districts.	Tree Canopy Street Trees Parks/Other green spaces	Trees provide aesthetics, shelter, and stormwater management. Treed business districts see higher revenues per shopper. Parks, river greenways and trails also attract business to downtowns. Offices are more likely to locate in greener downtowns.	See forest canopy. Also, use local data for trail and park locations.
Promote healthy lifestyles and nature based-recreation.	Parks Trails State Forests Wildlife Management Areas	Parks whose primary or majority of uses requires natural areas. Existing regional trails, rail trails, wildlife viewing areas. Select areas that are close to existing or proposed trails, to either buffer the users' experience or provide for potential new connections in the future.	State or locality park data. Wildlife and Birding Trails. State Parks. Open space lands. State Forests (if open for visitors). Rail to Trail Routes/regional trails. Important Birding Areas (publicly accessible).

STEP 4: ASSESS RISKS: WHAT ASSETS ARE MOST AT RISK AND WHAT COULD BE LOST IF NO ACTION IS TAKEN?

Making a map of your assets is just the first step to conserving those resources. While it is important to know what your organization or community values and to be able to represent those values spatially on a map, these mapped assets must be evaluated to determine if they are at risk from roads, redevelopment, dams, or other factors.

'Risk' refers to whether a natural asset is likely to remain intact or not and will help to prioritize which areas to conserve, how to rank them, and what actions may or may not be needed to protect them.

Remember that a map of natural resources is a snapshot in time. Land uses can change and land may be converted from one use to another. It is important to conduct even a cursory analysis of which resources are likely to remain and which may change or disappear.

To do this, we need to ask such questions as:

- Which areas are zoned for development and do they overlap key natural assets?
- Which forests and other key natural areas are threatened with fragmentation by roads or subdivisions?
- Are there areas threatened by natural enemies, such as pests or diseases?
- Are there areas at risk from natural disasters, such as extreme floods or wildfires?
- Which streams are likely to be impaired in the future?
- Are there impaired areas where habitat can be restored?
- What viewsheds are threatened?
- Which assets are most threatened by present zoning and currently planned developments?

In the future, zoning can be reviewed, land may change ownership, natural events such as floods or tornadoes can alter landscape conditions, populations may increase or decrease, and localities may have more or less money to spend on roads, land acquisition and conservation easements. Thus, it will be important to update maps and data along the way.

The chart of risks and associated actions provides a checklist of possible actions to forestall potential or unforeseen risks to natural assets. For each threat to an asset ask, "How can we change our plans to better protect it?"

But first, before taking action, it is best to evaluate how great the actual threat is. For example, if a highly ecologically sensitive area has been zoned for development, it may be worth finding out just how likely the land is to be developed, and how soon. If it turns out that there are already plans in process, then prioritize the area and search for alternative ways to protect it.

EXAMPLES OF RISKS AND ASSOCIATED ACTIONS		
RISK FACTOR	HOW TO EVALUATE	OPTIONS AND CONSIDERATIONS FOR WHAT TO DO
Incompatible Zoning	Overlay existing zoning with current natural resource priorities. Identify areas where uses are incompatible, such as industrial or residential zoning overlain with large intact forests or wetlands.	Zoning can be changed if a comprehensive evaluation is conducted. Zoning can also be changed if a 'mistake' is shown to have been made, such as information that was unknown or incorrect when the zoning was determined. Consider a rezoning effort to channel new development into other areas or build more densely and consider infill options. Even within areas zoned for development, is there room to include wildlife/recreation corridors to keep the landscape connected?
Future Land Use Changes	Review future land use maps to see where the community plans to grow in the future. Where are proposed service districts? Consider if people will encroach into forested areas. This can cause problems for wildlife as well as increase the risk of wildfire impacts to people. Invasive species may also be introduced by new residents.	Is the map still current? Is it based on actual/accurate population projections? Should it be changed? And when is the next update scheduled? Does the community need more education about the risks of living within these forested zones (also known as the wildland urban interface).
Impaired Waters	Waterways, lakes and bays can be designated as impaired and placed on the 303 list as required under the federal Clean Water Act. Overlay this list with those water features you consider to be important, in order to see which waters are polluted. For example, are impaired waters a threat to drinking water or trout fishing? Consider whether more waters could become polluted in the future: Are currently pristine areas zoned for more growth?	Determine why the surface water is impaired. If the impairment is caused by land runoff, you could help meet the regulatory requirements under the Total Maximum Daily Loading (TMDL) requirements by conserving more land in the watershed. When reviewing impaired waters, consider which are harmed by a cause that can be addressed through habitat or land-use mitigation. For example, if a stream suffers from excessive sediment or habitat destruction, your strategy could address needs for reforestation or enhanced stream buffers. If a cleanup plan has not yet been created, determine whether setting aside land for conservation could help to restore the water quality. Protecting key habitat cores for wildlife could also benefit a stream's health, depending on its location in the watershed.
Population Growth	If the area is likely to grow at a fast rate, where will people live? Evaluate whether there are currently enough housing units in the right places to meet this growth.	Where are designated growth areas relative to key natural assets? Do people have opportunities for recreation near to where they will be living? Consider whether land could be set aside to accommodate future recreation needs. Also consider whether waterway impairments could increase the costs of cleanup requirements, or if additional environmental regulations and incentives (such as density bonuses to encourage infill that also provide for low-impact development measures, such as rain gardens to mitigate stormwater runoff) could help modify development patterns.
Transportation Plans	Will planned roads bisect natural features? Will new roads lead to increased development that may also impact natural features?	Can other, less impactful routes be considered? Are the roads needed? Are transportation demand models based on up-to-date population projections? Can alternative transportation models solve some of the demand to move people? If road projects need to purchase land to mitigate impacts, such as wetlands or open space, can the natural asset map be used to prioritize which land to acquire? Also consider new approaches to green highway design that are less impactful to wildlife.
Impaired Landscapes	Are there areas that have a high degree of pavement causing excessive runoff and high urban temperatures? Are there old industrial sites? In rural areas are there overgrazed fields or streams without forest buffers? Are there restoration opportunities to reconnect core wildlife habitats?	Which areas could be reforested? Which streams could be planted with forested buffers? Could impervious areas be demolished and re-greened? Can brownfields be remediated through state and federal grant programs?

Just because a parcel or tract is currently zoned for development does not mean that it will be developed. A developer may be willing to swap land that is desirable to a locality in exchange for land closer to existing roads or transportation, or that offers him other benefits.

Remember that green infrastructure asset planning does not try to halt development *per se*; rather, GI planners should evaluate and map their natural assets to be as strategic as possible in using land for its best functions, so communities can achieve a balance of ecological, economic and health goals.

The risk chart includes examples of common resources to evaluate for risk and what to address. This list will likely need to be informed by local planners. Other risks within the community, such as abandoned mines, Superfund sites and large paved areas lacking adequate stormwater controls, will need to be evaluated as well to determine their risk and what actions, if any, can and should be taken.

It is important to evaluate the potential that any identified risk has to affect your natural assets and what you can do, if anything, to remediate that threat. For example, a risk can exist, but its impact could be low, even though you could easily remedy the situation. Alternatively, it could have a high impact but not be changeable at all. Consult with local planners, the development community, land trusts and conservation groups and others to evaluate whether the potential risk actually exists and if the development plan has already been proposed. You can also use this process to determine whether or not it is not too late to propose an alternative land development scenario that leaves some of the area as open space.

Sometimes, land can be swapped or traded so that areas more valuable for natural resource conservation or hazard mitigation can be protected in exchange for moving development to places more suitable for new growth. In an example from Albemarle County, Virginia, a nonprofit housing agency, Habitat for Humanity of Greater Charlottesville, owned land that is surrounded by the borders of newly designated state park land. Working with the county and state, the nonprofit housing provider proposed to swap some acreage of land inside the park for land outside the park, thus preventing interior land uses incompatible with a state park. This allows Habitat for Humanity to create habitat for people and land for the county to construct an active-use recreational facility. All sides – the park agency, the nonprofit housing agency and the county – thus get a better deal. Both habitat for animals and for people can now be in their appropriate locations.

A challenge can arise in trying to plan for your locality when an adjacent or nearby locality has created plans that conflict with your goals. Frederick County, Maryland has a border with Pennsylvania. It has designated this area as its agricultural preservation area, but Pennsylvania is allowing development to amass on its side of the border.

Such conflicts are also found between cities and counties. While it makes sense from a 'smart growth' perspective for counties to encourage development near urban areas, tall buildings and encroachment into once-forested areas are troubling for some city residents in low residential density areas, who are now faced with buildings and denser development just across the county boundary.

Your evaluation of risk should also consider the quality or health of the natural asset in question. For example, an area that seems to be worth preserving because it is covered by forest canopy and seems to provide good habitat for many species may, on closer examination, reveal that the trees are second or third growth, mainly pines and scrub oaks, and are suffering from diseases or pest infestations. If this is the case, additional management or forest restoration would be needed to help bring the forest back to a state that would be found naturally, had not logging, invasive species or pests altered it.

STEP 5: DETERMINE OPPORTUNITIES. BASED ON THOSE ASSETS AND RISKS IDENTIFIED; WHICH ONES SHOULD BE RESTORED OR IMPROVED? AND WHICH NEED THE ATTENTION SOONEST?

Based on assets and risks, determine what land can or should be conserved or restored. This may also point to areas that are more appropriate for development, either because they do not contain rare or unique natural assets, or because they could provide recreation and other benefits to residents.

Once assets most at risk have been identified, rank them – to prioritize those natural assets that should be preserved or restored. Engage your community in ranking the key areas of importance. Map opportunities and draft strategies to conserve them.

Be sure to indicate *why* each asset is of greater significance. *Also, how assets are ranked should conform to pre-established goals.* If one of the goals is to avoid impacts from new development on existing forests and woodlands, then prioritize those parcels of forest and woodland most at risk from new development.

Basically, there are two things to consider here: Which assets meet your community's goals for conservation? And which are most threatened? It is those that fall into both categories that should have the highest ranking to protect first.

Here are some things to consider:

- Which are the top five/ten areas of forest or woodland that are most threatened, or that offer the most value for forestry, recreation and wildlife habitat? Specify why.
- Which are the top waterways to preserve, and why?
- What are the top geological features and viewsheds that need to be preserved, and why?
- Which historical landscapes are most important and most under threat?
- What recreational areas are of most value and are most threatened?

Your map can also include desired future assets:

- Where should future parks and recreational areas be located?
- Suitable locations and routes for future agritourism businesses (such as pick-your-own fruit orchards, wineries, honey producers, local beef, pork and chicken farms, and vegetable stands).
- Scenic views or routes through historic or cultural assets that should be protected and enhanced.
- The best areas for future industrial parks and housing developments.

Consider areas that will not be preserved or which may require extra care:

- Growth areas already set aside for new development.
- Industrial zones that may be incompatible with conservation.
- Areas that are currently contaminated, such as brownfield sites, and which may be reclaimable in the future.

Ranking Data

Ranking is another way to assign human values to data. Everything that is included on a green infrastructure map is based on a value. A specific value may be more objective or more subjective, but each resource included on a natural assets map is there because a value has been assigned to it.

An example of an objective approach would be: "Put all third-order or higher-order streams on the map." The parameter that the streams should be "third order" is objective, in that it was chosen to provide a specific size stream. Another example is to select all forested corridors at least 300 meters wide that connect large intact forest cores, to help facilitate wildlife movement.

Both parameters for mapping listed above are objective because they provide specific decision metrics for their selection and inclusion on a green infrastructure map. However, the *reason* for choosing them is more subjective. You may have selected large streams because they are more likely to serve as significant corridors for wildlife. Large forested corridors may have been selected because of a value placed on the importance of wildlife movement and enhanced opportunities for biodiversity from a connected landscape.

If you are planning a green infrastructure network without the aid of an existing state model, you may need to create your own data layers and overlay them to create your green infrastructure network. This will still require making a determination of what is most important. If you are following a community consensus-based project then you may have to resolve diverse or conflicting values for what is most important. People will value things differently and the values assigned may depend on their purpose.

Following clear scientific principles for how much habitat species need to survive and thrive can help to create more objective mapping guidelines. If you do not know this information, create a technical advisory committee of qualified scientists.

Assuming that clear goals have been established for why you are mapping the natural resources of your landscape, you may want to rank those resources. One way to do this is to incorporate *weighted overlays* to establish your conservation network.

Weighted Overlay

Weighted overlay is a standard technique used with rasterized GIS data to determine the suitability of a landscape to meet existing objective criteria (determined previously). Each raster is a matrix of cells containing data, such as aerial images (captured in a grid and made up of individual cells).

Weighted overlay is a standard technique used with rasterized GIS data to determine the suitability of a landscape to meet existing objective criteria. Weighting allows an area that has a higher value to be selected.

Cells can be selected based on their values (e.g. they have a certain color denoting tree cover) and these values can be weighted. This allows you to select an area that has a higher value. You can create a technical committee to assign weights and help in ranking.

Certain values could be added to a green infrastructure map to give some areas more points (weights) for human values, such as a watershed area that supports drinking water uses (+3 points), known endangered species (+4 points), and so on. When Virginia created its Natural Landscape Assessment, it assigned values (points) to different attributes that were used to rank forest cores. So areas that were larger received more points, as did areas that had more surface waters, unique geology and other factors. As a result, it came up with five different levels of ranking. In order to assign values, a science review panel is recommended to ensure that values relate to known importance.

What Can Be Restored?

Remember that many natural landscape elements can be restored. A successful green infrastructure strategy often includes, not only protecting existing natural assets, but improving their quality and extent.

When reviewing a map of existing natural assets, you may find areas that are disconnected or degraded. If two habitat cores lack a connection, a new corridor could be planted. Similarly, a forest or wetland core could be expanded by planting more trees or removing invasive vegetation. You may also need to manage specific rare habitats if they support a particular species that has been deemed important. An example of this are bogs that might need to be cleared of trees periodically to ensure that water elevations remain high enough to support rare amphibians.

Landscape Features As Key Corridors

Landscape features that tend to remain in place, such as streams, can be selected as corridors for a green infrastructure network. Their permanence in the landscape makes them well suited to serve as long-term corridors. However, to provide an adequate passage for wildlife, native vegetation may need to be re-established. This is especially true in livestock areas, where farmers may have cleared land right down to the stream edge.

If your goal is to provide a buffer to protect a stream's water quality, then a minimum width of 100 feet is recommended (for more on buffer design, see Bibliography). However, if you wish to encourage wildlife passage and protect the buffer from invasive species, a wider strip is recommended, say 300 meters (approximately 1000 feet) on both sides of the watercourse.

Ridges can also serve as key corridors. They are often undeveloped because of their elevation and steeply sided slopes. They are important because many species, such as bears, migrating butterflies, bats and raptors, rely upon high elevations to survive or migrate. They use them as corridors.

For other species, such as bighorn mountain sheep or the north American pika, these higher elevation ridges and meadows are their special habitat niches – places with the unique conditions necessary for their survival.

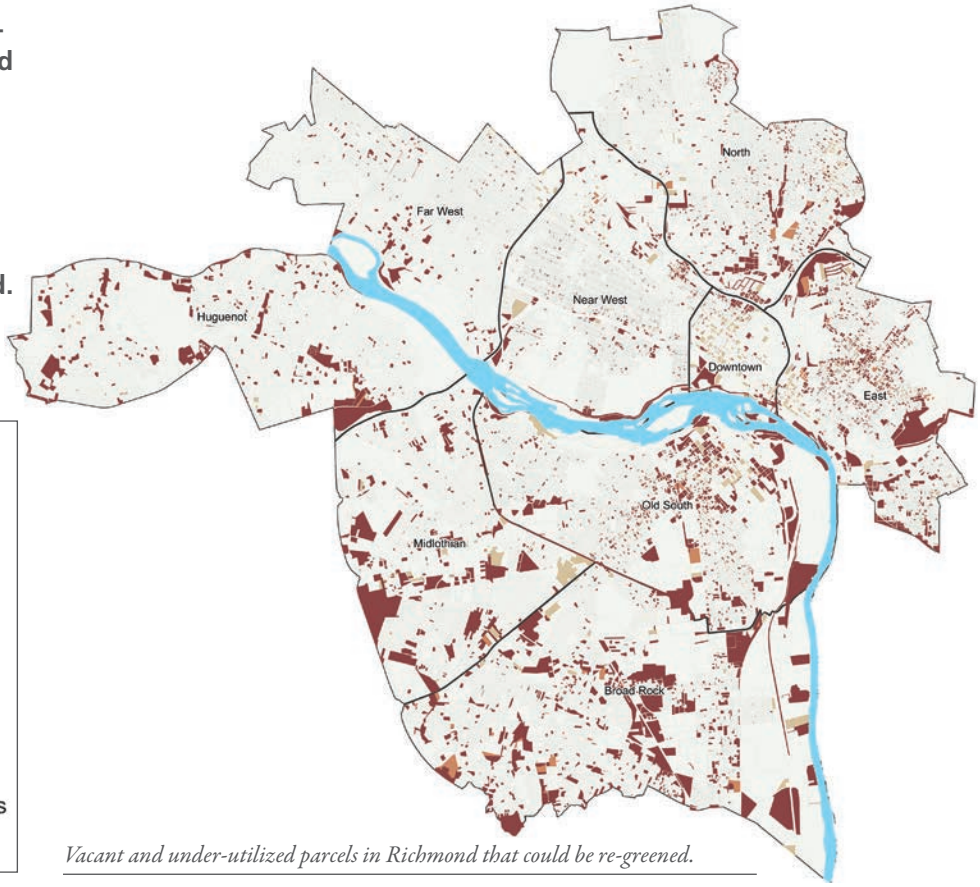
Pica can only live at colder, high elevation ranges.

Urban Restoration

In most urban areas, green spaces have become disconnected. City parks and waterways can serve as the core resources of a revitalized urban green infrastructure network. Your city may also have large vacant lots that have become overgrown as people moved to the suburbs and businesses relocated. Some of these can be quite large – if a foundry or steelworks closed, a paper mill or a car factory, there can be hundreds of acres of land available.

These vacant, abandoned spaces can become part of a restored green infrastructure network, though they will

These maps show opportunities for re-greening Richmond Va. The top map shows vacant parcels and the bottom map intersects those parcels with water features. This helps to show which vacant parcels could provide water quality benefits if re-greened.

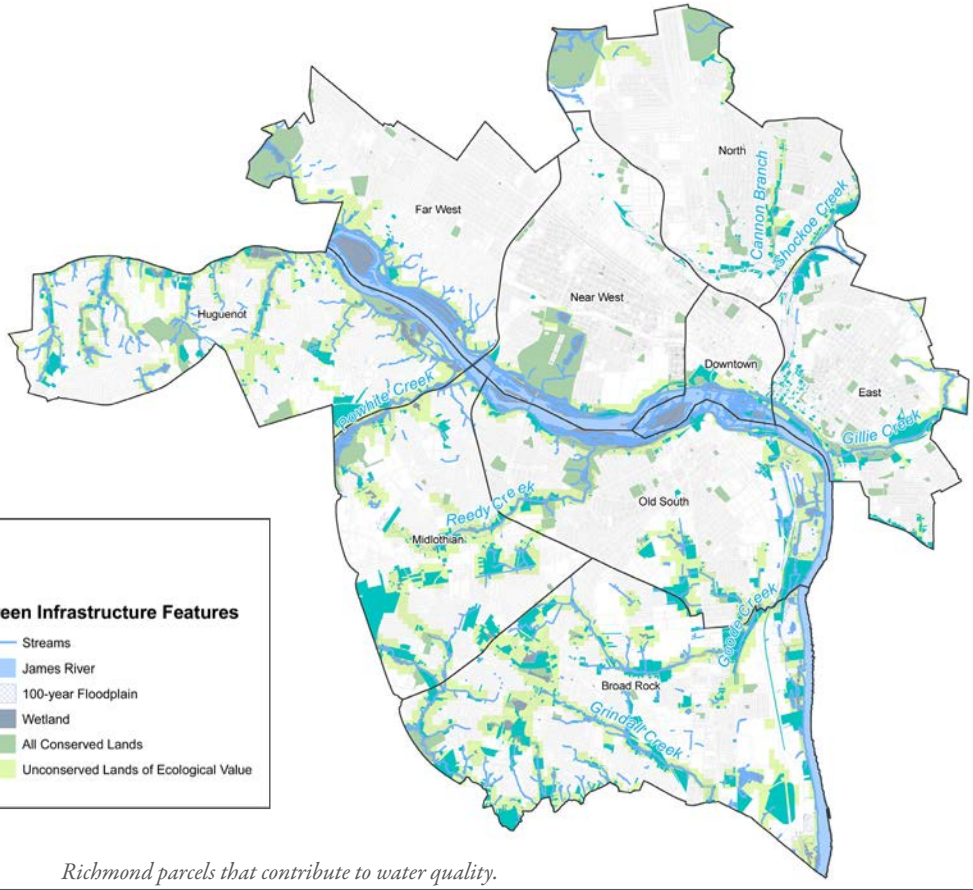


LEGEND

Vacant Parcels
- Vacant Lots
- Vacant Structures
- Other Vacant Properties

General Features
- Parcels
- City Boundary
- Planning District Boundaries
- James River

Vacant and under-utilized parcels in Richmond that could be re-greened.



City of Richmond

All Vacant Parcels Intersecting the Green Infrastructure Network
- Vacant Parcels Meeting Selection Criteria

Other Urban Features
- Primary Road
- Interstate Highway
- Parcels
- Planning District

Green Infrastructure Features
- Streams
- James River
- 100-year Floodplain
- Wetland
- All Conserved Lands
- Unconserved Lands of Ecological Value

Richmond parcels that contribute to water quality.

almost certainly need to be replanted, cleansed of invasives and pollutants, or otherwise regenerated. If it is a brownfield site, there may have been past industrial uses that need to be remediated, if you want the public to be able to access it.

In cities, even paved areas can become part of a green infrastructure network. There may be large areas of concrete or asphalt that are no longer occupied or utilized. Abandoned car lots. Derelict factories. Demolished warehouses. Such areas are not uncommon in cities that are going through a post-industrial reorientation of their employment base.

Such areas can be nothing more than large expanses of cracked, trash-strewn, scrubby pavement that lack any respectable urban trees. However, even these old paved areas can be regreened by removing the pavement, regrading, bringing in good quality topsoil, opening up culverts to recover streams, and replanting them. On the other hand, if left alone, vacant areas can sometimes regenerate themselves, and over time, come to possess significant natural habitats or even rare species.

Vacant lots and large paved areas can also be connected to form new corridors and urban greenway trails. In its Richmond Project, the GIC created a database of all vacant and underutilized parcels by combining several city databases into one master, sortable data source. This resulted in a list of 9000 vacant and underutilized parcels! This was then overlain with the city's green infrastructure network to determine where vacant parcels could support a wider green infrastructure's existing natural assets. It further identified those lots that were vegetated and those that needed to be re-greened if they were to become part of a connected network. In fact, several key parcels needed to complete the network were found to already be owned by the city, thus facilitating creation of an integrated network!

When you consider which vacant or abandoned parcels could be targeted for re-greening, you can rank them according to their ability to contribute to a wider green infrastructure network. By developing a series of questions and scoring each question by importance (weighting the answers), you can develop a systematic approach to determine which parcels to acquire, where to obtain an easement, where to conduct a restoration project, and so on.

There is often enough vacant land in an urban landscape that a green corridor or 'green finger' could stretch across the back of several parcels. Planners may want to consider whether to request additional protections for parcels that contain unique natural assets or offer an opportunity to create a connected network.

"There is often enough vacant land in an urban landscape that a green corridor or 'green finger' could stretch across the back of several parcels."

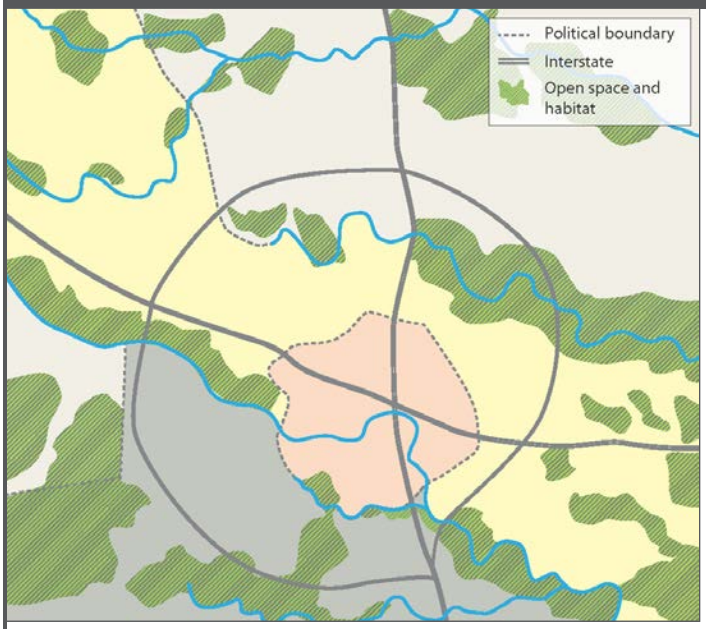
The illustration on the following page depicts an approach for recognizing regreening potential. Note that adding new green spaces and corridors does not necessarily preclude new development or redevelopment.

Urban Tree Canopies

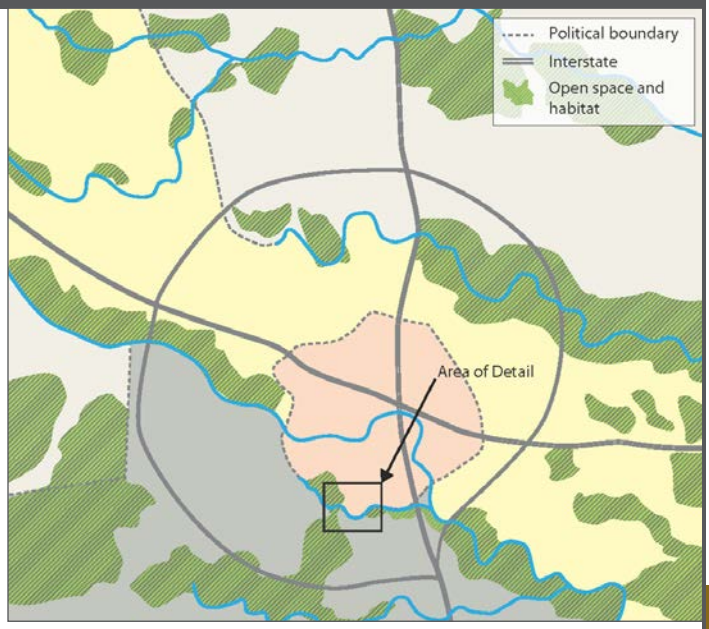
In urban areas, when evaluating natural assets at smaller scales (fractions of acres instead of hundreds of acres), minor landscape resources become important to consider and can make a large cumulative difference. An example of this concept is the urban tree canopy, which can be restored one tree at a time.

An urban tree canopy (UTC) does not constitute a forest per se, but taken city-wide, can serve a vital role in keeping built-up areas cool. Urban forests also intercept stormwater, which many cities need to reduce or better control. Studies have shown that the urban canopy can reduce a city's stormwater runoff by anywhere from two to seven percent.

Even one tree can play an important role in stormwater management and the benefits of many trees can mitigate the impact of a city's surface water runoff considerably. For example, estimates for the amount of water a



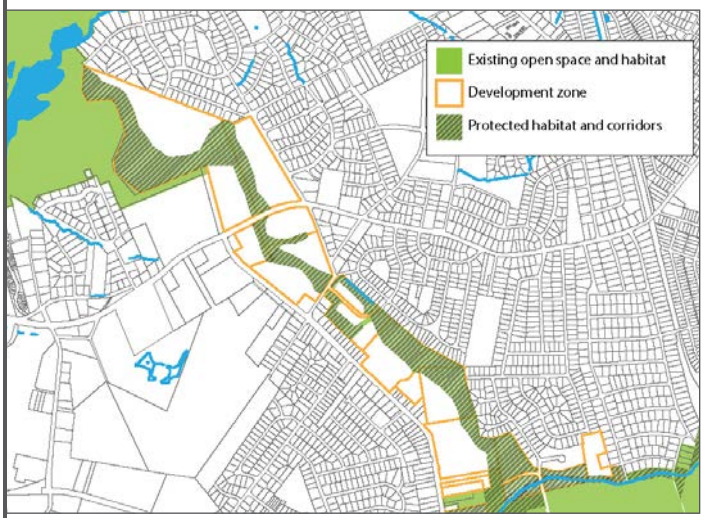
1. Area View



2. Zoom

3. Can these disconnected habitats be joined?

3. Identify vacant connecting parcels.



4. Replant a green corridor on part or all of the parcels.

5. Find additional connections to access green corridor.

Catherine Brown

typical street tree can intercept in its crown range from 760 gallons per tree per year to 4000 gallons per tree per year, depending on the species and age.

If you have access to an UTC assessment, you will see that, while your town, city or urbanized county may have an acceptable city-wide percentage of trees (American Forests recommends at least a 40 percent canopy for urban areas east of the Mississippi), certain areas will have far fewer trees than others. For example, In Virginia, Richmond City's canopy is 42 percent overall, but some downtown areas are as low as 9 percent.

Tree canopy assessments can be used to target priorities for reforestation of those areas most in need.

Urban Agriculture

You can use small-scale raised beds and greenhouses to locate agriculture in areas where it would not naturally occur, or where contaminated soils on brownfield sites require you to do so for health reasons. While raised beds are not dependent on locations of good agricultural soils, you can use GIS to map areas where community gardens exist and also notice where they are lacking and could be added.

A CHECKLIST FOR URBAN GREEN INFRASTRUCTURE OPPORTUNITIES

Once land has been prioritized for its importance in a green infrastructure network, the question needs to be asked, "What is the best way to include it?"

Should it be acquired, or would a partnership or management agreement with the landowner ensure that it is managed in a way that contributes to the locality's ecological health or to other goals, such as stormwater infiltration and attractive views?

Sometimes, a parcel is already under government ownership and simply requires a joint management arrangement with the appropriate agency. Or only part of the parcel may be needed to meet conservation goals. A large parcel might be improved to contain an office building in the front half and a restored stream buffer on the back half.

This checklist is intended to help planners prioritize the land they want to conserve in urban areas at the parcel scale. Add additional questions that meet your own specific goals.

- ☐ Does the parcel help maintain an existing goal for the city, such as infiltrating water or providing recreation?
- ☐ Does the parcel contain natural features, such as mature trees, a meadow or a waterway?
- ☐ Is the parcel adjacent to a stream, such that its conservation can contribute to good water quality?
- ☐ Does the parcel contain a wetland?
- ☐ Does the parcel contain any rare, threatened or endangered species?
- ☐ Does the parcel contribute to a larger natural network?
- ☐ Does the parcel provide a key recreation opportunity?
- ☐ Does the parcel offer an opportunity to change a noxious use into a productive one?
- ☐ Does the parcel provide an environmental educational opportunity, such as open space next to a school, community center, or other community facility?
- ☐ Would the parcel help form a corridor between two or more key landscape features?
- ☐ Is the parcel near to another significant natural area? For example, in urban areas, wildlife, bees, butterflies and birds can utilize a stepping stone approach to movement, so that even areas that are close, but not touching, can create a connected habitat network and support biodiversity.
- ☐ Does the parcel present a restoration opportunity? For example, are the trees invasive, non-native species that could be removed and the area replanted with native species?
- ☐ Does the parcel provide a buffer to an existing priority feature? For example, does it abut a Civil War or Revolutionary War site? Is it part of the viewshed for a key cultural asset? Does it shelter a sensitive area, such as a bog?
- ☐ What are the quality of the existing trees/vegetation on the neighboring properties? Are there re-development plans that could impact the site?

Cities such as Cleveland Ohio have begun using their large vacant parcels to create urban farms, thus creating a more livable city with a future that includes abundant local food. This also creates a new urban economy for residents who can now sell produce to their neighbors. Urban agriculture can be done on rooftops, on school grounds, on vacant lots and many places where there is open land and people need access to healthy food. These garden spaces (or garden potentials) can be included on an urban green infrastructure plan. See the community gardens map created for Southside Richmond. In this map, existing gardens were mapped as well as vacant parcels to determine options to add more gardens to the area.

Urban farms are also green infrastructure.

COMMUNITY GARDENS AND POTENTIAL LOTS FOR GARDENING IN SOUTHSIDE RICHMOND

Map community gardens as green infrastructure. Can more be added?

Some Assets Cannot Be Restored

Restoration is not always feasible from a practical or a financial standpoint. For example, high-quality agricultural soils cannot be relocated. Similarly, areas that have a unique geology, or contain old-growth or high quality forests or other rare habitats should be protected wherever they are found, and whenever possible. Wetlands also may have unique hydrology, plant assemblages and amphibians, as well as recharge processes that cannot be fully replicated when moving (recreating) the wetland somewhere else. And, of course, once a unique local species has become extinct, it can never be brought back.

GREEN INFRASTRUCTURE APPLICATIONS

Green infrastructure plans can fit into existing city and county planning efforts and can compliment already-identified conservation goals. The following are examples of how green infrastructure assessments may be utilized to inform planning:

- **Environmental chapters in comprehensive plans, or to implement existing comprehensive plan goals for resource assessments and conservation.**
- **Park, open space and recreational planning or strategic land acquisition.**
- **Strategies for determining where to zone land for conservation or growth.**
- **Lands for the purchase, or transfer, of development rights.**
- **Heritage tourism strategies and viewshed protection.**
- **Urban tree canopy surveys and management.**
- **Transportation planning for roads and multi-modal planning.**
- **Targeting land for conservation easement programs.**
- **New ordinance development, (stream buffers, watershed protection, historic landscape or other conservation district overlays, codification of requirements for landscaping within developments).**
- **A rezoning decision for more or less dense development (upzoning or downzoning).**
- **Conserving forest cover to protect surface water quality and supply, mitigate stormwater runoff and facilitate the infiltration of water into groundwater aquifers.**
- **The identification of areas where conservation is appropriate or needed.**

STEP 6: IMPLEMENT OPPORTUNITIES: INCLUDE YOUR NATURAL ASSET MAPS IN BOTH DAILY AND LONG-RANGE PLANNING

This section includes examples of how to ensure that your maps are utilized for informing daily land-use decision-making: what is meant by 'implementation.' However, it does not cover all aspects of planning regulations and practices, as it assumes some familiarity by the reader.

Of course, natural asset planning is not limited to 'natural' or pristine areas. It is often needed because of the challenges posed to those remaining green areas in suburbs and towns when more and more gray infrastructure is being built. In already developed areas, green assets can be reconnected through new corridors. They can also be restored by revitalizing a brownfield site with trees and shrubs.

Planning to conserve natural assets involves more than identifying what to protect. The converse is also true. Once you have identified areas to conserve, you can identify areas where development may be more appropriate. If an area does not contain rare species, key water features or does not meet other conservation objectives, it may meet development goals such as, proximity to an existing urban development area, access to a primary road, or lies in a service district for urban wastewater and drinking water treatment. Thus your map can also be used to point to areas less suited for conservation and more suited to development.

Of course, all developed land should also have some 'green resources' (parks, open spaces, tree canopy). The key is to think at multiple scales, of how resources connect, and to ensure that the best use is envisioned for each parcel and region based on its actual landscape features and infrastructure conditions.

Utilizing Green Infrastructure Data In Day-To-Day Planning

Once you have evaluated and mapped your community's natural and cultural assets, it is time to utilize this information as part of everyday planning and conservation work. It is likely that, unless you take some action, your assets will decrease over time. For example, fragmentation caused by roads, buildings and other disturbances is the single greatest threat to forests in the southern U.S. (USDA Southern Research Station). And, left uncontrolled, it will get worse. But this fragmentation could be

avoided by careful planning to prevent bisecting critical natural areas that may be serving key purposes that should be recognized.

Of course, you can also *increase* your natural assets by setting new areas aside for restoration, such as replanting forests, restoring stream buffers and habitat and removing invasive species. You may also suggest additional measures to buffer a high-value asset from adjacent or potential disturbances.

Since decisions affecting land uses occur within many different branches of government, you may need to hold briefings and workshops for other agency staff, as well as local conservation groups, in order to explain your project's goals, outcomes and priorities. Hopefully, some of this already occurred during your stakeholder engagement and outreach efforts, but it is common for people to prefer to engage with a process at the end, when there is a product (maps) to work with.

The following are examples of how to use GI information in your planning efforts. In addition, the GIC's website has factsheets on implementation ideas and examples:

http://www.gicinc.org/resourcesonlinelit.htm#gifactsheets

Turning Asset Maps Into Policy – Prioritizing Opportunities

We have discussed two concepts: first, the notion of risk assessment – determining which assets will be lost if no action is taken; and second, the notion of opportunity mapping – figuring out where there are opportunities to achieve community goals. Prioritizing opportunities, however, is key to ensure you can move from ideas to implementation.

Consider which opportunities are the most timely. For example, you may already have a mandate to create a new water supply plan in the next twelve months, in which case it will be key for you to identify and conserve the watershed around any new reservoirs you are planning. Similarly, if the new reservoir's construction will require mitigation actions, consider which landscape elements are highest priority to restore. Also, consider whether there are some objectives that can be achieved more easily than others, or right away. For example, have your community work to reforest a stream buffer as part of Earth Day activities. Or incorporate your natural asset maps into a current update process for the local comprehensive plan.

You may decide you want to have a formal strategy just to implement the conservation of your natural assets. However, consider how to make use of your natural asset evaluation as part of everyday planning to ensure that your maps are consistently applied to planning activities.

The following are examples of how green infrastructure information can be implemented in specific fields.

Park And Open Space Planning

Could an area that is already large and has intact habitat be acquired as a park to ensure its long-term conservation?

If your community is currently developing plans for future parks, consider adding a natural asset criteria for location selection: Does the location support a key natural asset identified on your community's natural asset map?

You may also want to co-locate parks with features that provide other community benefits. For example, would placing a park in a particular location also protect an area around a reservoir? Could existing parks be better protected and buffered by conserving large landscape blocks adjacent to them? Current and potential trails and tourism routes can be overlaid with natural asset maps to show how they support the locality's tourism. In addition, they can be used to lure new businesses to the area.

Make sure your parks department or open space committee is aware of (and using!) your natural asset maps.

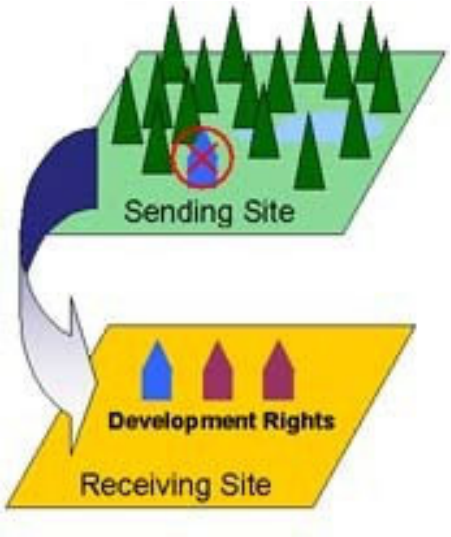
Identify Lands For PDR or TDR Programs

Purchase of Development Rights (PDR) programs allow local governments to purchase these rights from willing landowners. Ensure that your state allows PDR programs. These programs allow landowners to reap some of their land's financial development potential without having to sell it. They also help local government agencies conserve land they do not want to develop because it provides other, more important values, such as watershed protection. Localities

usually have ranking criteria to allow them to objectively determine which lands are most strategic to conserve through PDRs.

The Transfer of Development Rights (TDR) program has similar aims. It allows a local government to adopt an ordinance that enables existing development rights to be transferred from a *sending zone* to a *receiving zone*. Sending zones are those areas where development should be limited because the area will not support it (e.g. the area lacks the necessary infrastructure, such as roads, rescue facilities and schools; or the local government is trying to keep development density low there). A receiving zone is an area that is more desirable for development.

Sending and receiving zones must be ascertained in advance by local governments as part of their ordinances. Their natural asset maps can inform decisions about which zones to allocate by highlighting high-priority natural asset areas for their sending zones and, similarly, avoiding them when establishing receiving zones. If your state allows TDR programs, your local government will probably require an implementing ordinance.



Comprehensive Plans and Zoning

As noted earlier in this guide, comprehensive plans provide goals and data about how a community should grow and develop in the future. When zoning is changed from its original designated use, it generally requires a demonstration that there is new information – a substantial change – that warrants a new zoning class.

Or, if a comprehensive analysis has been completed, this can also be a basis for rezoning. A natural asset evaluation and map can form the basis for why new zoning is needed. Overlay future land use and zoning maps to see where natural assets may conflict with existing zoning. Then decide, should zoning and land use be changed? Should we try to work with landowners to conserve a buffer or corridor through the area? If these areas will be lost, does other land need to be set aside to make up for these losses in the future?

Species Protection

Use natural asset maps to set aside areas for conservation of key species.

Are there areas where rare, threatened or endangered species are known to exist? Local governments can usually obtain this information from their state's natural heritage program. Also, consult the state wildlife action plan for key strategies. Areas containing rare species can be ranked higher or given greater priority for conservation. It is easier to protect species than to try to restore populations later on. Also, ensure that areas are linked by corridors to allow species movement and repopulation. Of course, protecting species ahead of time to avoid having to list them not only save the species but also saves valuable staff time and money later. It is much more expensive (and sometimes ineffective) to seek to restore something once it has been lost.

Heritage Tourism And Viewsheds

Work with the tourism director to explain how to use natural asset maps to bolster your visitor's experience and conserve key natural assets. Create a map that overlays key recreation areas, trails and activities with natural assets. Which activities do these assets support? For example, a connected network may support cross-country horseback riding, or a large lake may require a forested watershed to adequately protect water quality and support fishing.

One tourism director from a very rural county recently used their natural asset maps to show a business why they should locate its outdoor adventure camp in their county. They were able to search their digital maps of natural assets to find parcels with intact forests, water features, views and access to meet the client's demands.

Also consider whether there are special routes and key heritage features that should be added to your asset maps, in order to be better protected. Consider partnerships with state and local land trusts to seek permanent protection for key heritage assets and viewsheds that support local businesses and tourism.

Agricultural and Forestal Districts

Agricultural and forestal districts provide a way to recognize and foster agriculture and forestry operations. Most states require parcels to be contiguous, but some distance gap is usually allowed, to account for roads or other intersections. These districts allow member parcels to pay lower taxes based on their use for agriculture or forestry. Some localities offer both ag and forestal districts and use value assessments or present use value. These use values allow for lowered tax rates based on the actual use, such as a farm use which is operating in an area zoned for commercial development. In localities with use value assessment this is less helpful, but having a district can also signal to landowners and decision-makers where agriculture is desired.

A natural asset map can be used to inform where there are key agricultural soils for row crops, or you can utilize other data from your state department of forestry to determine which areas are most conducive to timber management. Overlay your green asset maps with existing districts or areas which have use value assessments in place. Should forestal districts be expanded to include natural assets or should new districts be created?

Transportation Planning

Most localities follow multi-year plans for transportation. Incorporate natural asset awareness and review of natural asset maps as part of this planning. Use your natural asset maps to inform environmental impact assessments. Mitigating road impacts could mean conserving a key natural asset somewhere else. The key is to have an already-prioritized map for what should be protected next.

Similarly, think about trails as part of transportation plans. They are not just for bird watching; people use them to commute by foot or bike. In Charlottesville, VA, the GIC helped the city identify trails and new routes to create a multi-modal plan for transportation that included off road routes – even through the woods! Similarly Lynchburg VA found people commuted to work on their trail network following creation of a convenient trail that linked city neighborhoods to the business district. Cities such as Portland Oregon or Arlington Virginia have also had long standing trails that serve as commuting routes for bikers and walkers.

In the Richmond project, the GIC combined the themes of watersheds and healthy water with community walkability – the Walkable Watersheds Project is gaining traction by linking healthy people to healthy landscapes. It is creating new green routes though the community and to key sites, such as schools, community centers and parks. For more information visit the Walkable Watershed Project at http://www.gicinc.org/projectbellemeade.htm.

Regulatory Mandates

Total maximum daily loadings (TMDL) assessments and implementation plans are required for waters that have not met state standards and are listed as impaired. Natural asset maps can be used to prioritize which lands to set aside to buffer impaired waters and to avoid future risks. For example, if your locality has a TMDL based on bacteria and human fecal coliform, is this occurring in an area that is already mapped as having poor soils for septic systems? Consider evaluating areas where septic function is poor and making them off limits to development, in order to avoid future TMDLs. In Virginia, you can use tools such as InFOREST to model current and future loadings of nitrogen, phosphorus and sediment based on various future development scenarios.

Watershed Improvement Plans (WIP) affect states in the Chesapeake Bay Drainage. Consider how they can help you conserve areas of natural assets and help your state or local governments achieve credits for pollution reduction. Conversely, since restoration of natural assets will be important in many WIPs, conserving the existing natural assets can serve as an insurance policy to protect investments in restoration. For example, large amounts of money have been spent on restoration, only to have these projects literally washed away because of a lack of conservation planning upstream.

As noted earlier, natural asset maps can show where land should be conserved to meet mandates for water supply plans. Will current and future zoning allow enough forested land cover to adequately protect drinking water supplies? Will current drinking water intakes be affected by changes in land use that may degrade the quality of intake water? Although water can be treated, it is much cheaper to keep water clean to begin with by maintaining the drainage's buffering potential with natural land cover.

Hazard mitigation is another planning need that is often mandated and can be met by identifying areas that are more likely to be subject to problems such as floods, landslides or wildfire. These areas may be set aside as places to conserve or avoid developing to protect future property damage and loss of life. They may also meet other goals for conservation. And if you live in a coastal or tidal area, you may need to consider future threats such as sea level rise and plan on how to protect your low-lying areas now.

Some groups are already addressing climate change. They are mapping current and predicted future water levels in 25, 50 and 75 years. They are asking whether communities at risk will need to be moved and if they will need financial assistance to do so. And they are wondering if their public parks will soon be underwater, necessitating the acquisition of new areas that will be waterside in the future, as lakes, bays and rivers migrate inland.

Long-Term Financing

A major, and too often overlooked, part of developing your implementation strategy is figuring out how you will finance it over the long term. This necessitates that you develop a strategy to ensure you have the fiscal resources to implement, monitor and manage your strategy over many years. It requires financial resources to be available for individual projects over their entire lifespan. The University of Maryland's Environmental Finance Center has some good information on these approaches, and the distinction between funding and financing.

If you foresaw that your project would need funds for both its implementation and long-term viability, hopefully you included members of the funding community early on. If you did not, and you need implementation funds, it is time to engage them now!

If you already have a strategy for land conservation and natural asset/green infrastructure priority maps in place,

IDEAS FOR FUNDING LAND CONSERVATION

Ideas for funding land conservation are listed below:

- **Conservation Easements: Partner with local land trusts (*you may be* the land trust) to seek easements for those lands assessed at the highest conservation value. Many land trusts have used green infrastructure maps to prioritize their efforts and create a connected landscape.**

- **Ask landowners to donate the highest-value lands. For example, both North Carolina and Virginia, have a conservation tax credit that can reimburse developers for loss of development value if they put land under easement. Development rights can also be purchased if the locality has such a program.**

- **Work with developers to create schemes that develop homes in new patterns and possibly on smaller lots to conserve open land as part of their development. Publish maps of key resources and examples of how landscapes could be connected. (Contact GIC for permission to use illustrations from this guide.)**

- **If your locality has *proffers*, let the development community know which land resources, viewsheds or trails you want to acquire or protect. In states that accept proffers in exchange for new zoning or variances, it is perfectly okay to have a wish list of items; it helps developers know exactly what you want and have available.**

- **Transportation programs will fund viewshed protection. Showing how a GI network gives added value to viewsheds from designated scenic roads has been used to secure funds to conserve land within the viewshed.**

***Note*: A *proffer* offsets the impacts from new development by conserving land or providing walking access and can be seen as offsetting the impact of new residents on existing parks and infrastructure. As noted before, apply natural assets to criteria for PDR or TDR programs.**

they can be very effective fundraising tools. They demonstrate to funders that you have engaged in a strategic and science-based process to determine your priorities and that you are serious about them. You are not just full of empty idealism. You have a plan in hand.

If you establish clear goals based on your priorities, it will show funders that your effort is worthy of funding because it has used a logical and defensible approach and (assuming you engaged the community in your process) that it represents and meets real community needs.

You may want to seek planning grants to provide funding for more staff time for a local government or nonprofit agency to develop maps and conduct community engagement. If a local government is not eligible for grants, partner with a nonprofit that is. The GIC has partnered with local governments to help fund projects. In addition, urban and community forestry grants are available at the state level to conserve forests in developed and developing areas. Similarly, NOAA's Sea Grant program has funds available for coastal work.

Most importantly, consider how much of this work can be done with existing resources. If the staff planner, GIS expert and parks and tourism staff each spent a few hours a week creating and reviewing maps and strategies, a new set of asset maps and action steps could be created in fairly short order.

Also consider the tremendous resources available from local universities. Students have provided free mapping, model building and implementation assistance to local governments. Students who do this work receive valuable work experience and often college credit if the work is part of a class.

Additional data may be needed to help create priorities. These college students are analyzing stream organisms to determine the health of local streams.

In this chapter, we presented the steps to create a green infrastructure strategy along with myriad ways to implement long term stewardship. In the next chapter, we re-visit the steps in an actual project to help you envision how to utilize maps to create your priorities.

5

A CASE STUDY OF MAPPING GREEN INFRASTRUCTURE

- Step 1: Set Goals
- Step 2: Review Data
- Step 3: Make Maps
- Step 4: Assess Risks
- Step 5: Rank Assets
- Step 6: Implement

CHAPTER 5 - Case Study: Mapping Fayetteville and Washington County, Arkansas

This case study provides an example of a project implemented in Arkansas. While it utilizes a different approach to derive the cores and corridors, it is included as a living example of how a community utilizes data to create priorities for conservation, preservation or restoration.

To enable localities and communities to do this work more easily, the GIC has built a computer script for GIS that will provide cores and corridors for consideration by any locality interested in doing this work. Instructions for building a green infrastructure network are provided in Chapter Seven. Those who are interested in creating a natural asset map(s) for their locality or region should refer to Chapter Seven and Appendix A for technical instructions.

This case example is excerpted from the report "Green Infrastructure Planning: Linking Arkansas Communities." It is worth noting that this case example is unique in that it was able to tap an abundance of qualified experts and people with local knowledge who dedicated their time to evaluating data and conducting field assessments. In many cases, this level of volunteer expertise will not be readily available to localities and regions.

Since many localities and conservation organizations will not have the capacity to conduct extensive field work, we have provided a standardized method and instructions to create a green infrastructure network using widely available data. The methods proposed in Chapter Seven of this guide provide instructions for creating a green infrastructure map(s). Anyone with general GIS knowledge can use it to develop a model for their area. To revise the model, such as changing the minimum size of a habitat core, knowledge of Python Scripting is necessary.

Any green infrastructure assessment will still require the determination of local goals and priorities to guide selection of areas for inclusion in a green infrastructure network. Setting clear goals is a prerequisite to this process and Chapter Three provides a more concise version of the committee process than was utilized in this case.

COMPONENTS OF THE FAYETTEVILLE, ARKANSAS, GREEN INFRASTRUCTURE NETWORK MAP

The Fayetteville Natural Heritage Association (FNHA) created a green infrastructure network model to strategically guide its planning efforts. Their green infrastructure map depicts the geography important to functioning natural systems.

The FNHA's effort focused on identifying large, intact and connected habitat hubs, cores and corridors as part of a regional strategic conservation planning effort. The FNHA conducted this work in partnership with the Beaver Water District and was funded by the U.S. Forest Service through the Arkansas Forestry Commission's Urban Forestry Program.

The study area included the USFS Wedington Wildlife Management Area of the Ozark St. Francis National Forest, the cities of Farmington, Greenland, Fayetteville, Johnson and part of Washington County. The series of GIS maps and reports provide a basis for integrating land conservation and other community needs and interests.

The impetus for the project began with the acquisition of 131 acres of land for the community. The City of Fayetteville purchased 81 acres, FNHA helped get 30 acres donated and 20 acres were placed under a city conservation easement. FNHA determined that it needed to rank conservation site opportunities and provide detailed mapping, in order to identify valuable natural sites in and around the city. This was needed, both to protect the land purchased as well as to avoid impacts from outside the boundary. This mapping effort recognized the interdependence of the site to the larger landscape.

A student GIS intern from the University of Arkansas conducted research to determine possible strategies. After interviewing local officials, planners, conservationists, scientists and developers, the student recommended a "Conservation Priority Ranking" to evaluate conservation needs and necessary improvements in land-use policy. Project partners included The Nature Conservancy's Ozark Highlands Office and the Landscape Architecture Department at the University of Arkansas. A major endorsement of the Fayetteville Natural Heritage Association's Green Infrastructure Plan came with its recent incorporation into Fayetteville's City Plan 2030.

The FNHA report notes that the area is indeed special and worthy of attention since it supports a high diversity of species. The great variety of plants and animals in Northwest Arkansas is due to its transition zone location between the Eastern Temperate Forests and the Great Plains, where the Ozark Ouachita-Appalachian Forests meet the Temperate Prairies. Hills there are dominated by upland oak-hickory forests, while the lowlands contain riparian forests and rare remnants of the prairie. The predominant karst topography provides for numerous caves supporting rare and endangered species, such as the white cave fish.

Butterflies and Milkweed Near Kingston by Joe Neal.

Building Stakeholder Support and Setting Priorities

The project included an intensive stakeholder engagement process and pre-work to build support for the project and to identify participants. The FNHA contacted political representatives, including mayors, city councils, the county judge and planning staff. To make their case, the group highlighted trends in farmland loss, as well as statistics

concerning the ecosystem services that could be realized by the area's green infrastructure. For example, they cited a study by American Forests which showed that increasing the current forest canopy from 27 percent (year 2000 coverage) to 40 percent would increase air quality benefits from $1.64 million to $2.5 million and stormwater savings would increase from $92 million to $135 million.

Four working groups (Environmental, Heritage, Land Use, and Parks and Trails) collected existing green infrastructure information on geographic features, habitats, cultural resources, working lands, recreational resources and lands that are already protected.

Devil's Eyebrow Natural Area by Joe Neal.

Environmental Working Group

In order to create habitat hubs, cores and corridors, the Environmental Working Group created three sub-committees: Upland Forests; Wetlands/Prairies; and Watershed/Water Quality.

The **Upland Forest Subcommittee** classified five 'Forested Green Belts' that deserved recognition, protection, and conservation efforts. These included:

- The Green Belt from Lake Fayetteville to Wedington.
- The Green Belt beginning at the Wilson Lake area.
- The Green Belt from Kessler Mountain toward the SSW.
- Those Fayetteville Urban Forest Sites listed on the map titled "Urban Forest Conservation Assessment for Fayetteville Arkansas" prepared by FNHA.
- Webber Mountain in eastern Springdale (just beyond the study area's northern boundary).

The **Wetlands/Prairie Subcommittee** derived 13 potential wetland/prairie/savanna sites ranging in size from seven to 70 acres. Each site was characterized for its habitat type: aquatic resources; potential habitat for avian, mammal and/or amphibian/reptile use; non-native/invasive plant species cover; landscape context of the surrounding area; site structure/ecological integrity/unique features; and potential to be a critical hub/link. While a site evaluation was completed for eight sites, time limitations precluded full evaluation of the last five sites.

The next step was to classify the sites into categories for preservation or restoration:

1. Category One: A prime candidate.
2. Category Two: A possible candidate
3. Category Three: An unlikely candidate.

The **Watershed/Water Quality Subcommittee** included streams and their riparian zones. They found that, while many riparian areas were intact, some were moderately degraded or substantially altered and degraded. They recommended protecting second order and higher streams and their associated floodplains with a minimum vegetated buffer of at least 100 feet. They also had a spring team which recommended prioritizing 44 springs for protection.

Heritage Working Group

The Heritage Working Group focused on elements and issues of heritage and historical and cultural significance, such as historical buildings and localities, heritage trails, and maintenance of the cultural uniqueness of the area. The group defined heritage sites as, "Places that have a number of regionally distinctive natural, cultural, historic, or scenic resources that, when linked together, tell a unique story about our community."

The group determined the most important themes for their "Areas of Highest Resource Value with Conservation Priority" plan. They defined them as the University of Arkansas, working family farms, farm remnants, conservation sites, historic parks, camps and recreation areas, historic building sites, heritage routes, historic railroads, gardens, and historic settlement sites such as springs, mills, bridges, churches, cemeteries and historic communities.

Land Use Working Group

The Land Use Working Group focused on issues relevant to the built environment, such as relating existing city plans to one another, zoning, land use and land-use conversion, identifying opportunities for linking across jurisdictions, and land-use issues that affect the area's economic vitality. They also identified policies for land protection or conservation, such as easements, the transfer of development rights, clustered development, rural villages and conservation subdivisions, viewshed and hillside protection ordinances, and partnership opportunities, such as a regional partnership with Washington County and with municipal governments for regulatory or incentive approaches.

Parks and Trails Working Group

The Parks and Trails Working Group focused on existing and potential recreational resources and issues that pertain to connectivity, access, corridors, linkages, parks, trails, and greenways. They studied existing and proposed trail plans as well as citizen surveys to determine priorities.

The project also formed an **Awareness Working Group** to build local knowledge, support and communication for the project. They worked on key themes such as "Green Infrastructure supports opportunities for recreation and improved health."

Public Meetings

Meetings were held with community leaders, including mayors, city council members, planning commissioners and citizens. At each meeting, the project was explained, maps were displayed for review and support was requested. Meetings elicited a great deal of interest and some of the later public meetings added key details. The committee classified recommendations as either site-based or programmatic. For example, some citizens requested maintenance of tree cover near creeks and streams, the creation of wildlife corridors that would not be affected by human use, and consideration of sensitive ecosystems, such as karst, prairies, woodlands and floodplains. Citizens also suggested specific locations for preservation or cultural uses.

Upper Buffalo from Cave Mountain by Joe Neal.

THE MAPPING PROCESS:

The Urban Forest Conservation Assessment (UFCA) assessed parcels in the Fayetteville area for their conservation value. The study was completed in 2006 as a partnership between the Fayetteville Natural Heritage Association, The Nature Conservancy and the Arkansas Forestry Commission's Urban Forestry Program. The assessment looked at aquatic and terrestrial habitat, forest cover and other characteristics. It ranked areas on a scale from one to ten, with the most conservation worthy sites receiving a value of one or two. This provided the basis for ranking and was completed prior to the green infrastructure planning effort.

Le Conte's Sparrow Woolsey Wet Prarie by Joe Neal.

Hubs

Hubs are larger, possibly fragmented, areas surrounding high-quality habitat cores. They were defined by the working group as "diverse areas with limited modification from the original native land cover" and provide the opportunity to contain a representative sample of the common species of the region. They often contain rare and fragile ecosystems.

THEMED MAPS

A themed map highlights a particular land use or resource as it relates to the green infrastructure base map of intact habitats and locational information such as towns and highways. As noted in earlier chapters, not everything can go on one map because it becomes unreadable and unusable. Selecting themes to focus on allows a map to highlight one or two key topics of interest. For example, a themed map about agricultural soils can show where there are lands containing high quality agricultural soils not currently covered by forests that may be suitable for farming.

Themed maps can also show relationships. For example, you can place a recreational activity layer that highlights key areas for birding, hunting or hiking over a map of high-quality habitats to see how large intact landscapes also support activities that depend upon a connected landscape.

A minimum hub size of 100 acres was determined for the Fayetteville study. Those areas smaller than 100 acres were ranked as *sites* (also called *patches* or *habitat fragments* in this guide). They were chosen based on their level of existing protection, such as whether or not they were under federal ownership. Those that were likely to remain protected, based on current ownership or management, were good candidates for hubs.

Hubs On Public Lands

The working groups chose all those lands for public, recreational use currently held by federal, state, city and county entities as hubs. They include such land uses as city parks, trails, county parks, state and national parks, forests and wildlife management areas. This was based on the assumption that these lands were more likely to have favorable management practices for conservation and were not likely to be converted to other land uses.

Hubs On Protected Lands

Areas that are under protection are significantly less likely to have their natural areas disturbed by land use change or unfavorable management practices. These hubs were identified from land trust holdings and conservation easements, and also included an Army Corps of Engineers wetland mitigation site.

Ranking Hubs

Hubs were ranked according to three factors, each on a scale of one to three, with one being the best value. These three factors were: the hub's source; habitat diversity data – obtained from the UFCA (habitat quality); and hub size. These factors each received a score.

The three scores were combined into an overall rank on a scale ranging from three to nine, with three representing the best hubs, down to nine, the lowest ranking. Overall ranking of the hubs only required a simple addition of the rank values for source, size, and habitat quality.

The study did not consider the degree of fragmentation of the hubs – rather, it employed a simple raster analysis – overlaying factors to see which areas, when combined, had at least one or more desired attribute.

Pawpaw Flower Lake Atalanta by Joe Neal.

Monkey Flower Clabber Creek Trail by Joe Neal.

The 25 Hubs more than 100 acres ranged in size from just over 100 acres to more than 30,000 acres and were divided into classes (size ranges) based on natural breaks in the data set to depict small, medium and large hubs.

Cores

Cores were defined by the working groups as the most intact, highest-quality habitat areas. There were three types of cores defined by the working groups and identified in the network map: Aquatic Cores; Upland Forest Cores; and Wetland, Prairie and Savannah Cores.

Aquatic Cores

Aquatic Cores are a combination of 2nd order or higher streams and named lakes. Streams were buffered by either 100 feet or the width of the flood zone, whichever was wider.

Upland Forest Cores

Upland Forest Cores consist of interior forest blocks. They were identified by buffering paved roads by 300 feet to remove the area of edge effect from forested areas. The minimum core size identified by the working groups was 20 acres. This was based on research by working group member and ornithologist Doug James. Twenty acres was deemed the minimum patch size that would support a varied population of birds and so the group chose this standard for a core size.

Wetland, Prairie and Savannah Cores

These cores were identified by the working groups as remnant habitats consisting of oak barrens, perennial forested wetlands, seasonal wetlands, upland prairie and wet prairie. Based upon their habitat rarity, all wetland, prarie and savannah cores were given equal consideration, regardless of size.

Corridors

Likely corridors were mapped using least-cost path analysis. This identified the general 'cost' for species to travel across individual pixels in the study area. Habitat and land cover features, such as cores, forested areas and streams, provided a travel bonus to underlying pixels, while features such as roads, steep slopes and urban areas counted as travel impedances. The project only analyzed corridors between the six largest cores.

Sites

Sites were defined as areas not large enough to be a hub or core, but that possessed habitat qualities that warranted their inclusion in the network map. Sites included cores smaller than 20 acres, hubs less than 100 acres, cemeteries and springs. They were not assessed for connectivity with the rest of the network.

Each site was individually analyzed by FNHA volunteer scientists in the field. They were divided into three categories for preservation and restoration: Category 1 sites were the best candidates to restore and provide habitat with minimal financial investment; Category 2 sites also were candidates for preservation or restoration but were more expensive to protect or restore; and Category 3 sites were the lowest priority for restoration because of significant degradation in quality or difficulty in protection. The purpose of categorizing sites was to identify the best opportunities for preservation and restoration of habitat.

An example of a Category One site is the Woolsey Wet Prairie, which has been restored to allow the plant community to increase from 47 to 334 species and is listed as a national birding 'hotspot' with abundant songbirds, shorebirds, wading birds, waterfowl and birds of prey. In the end, the project did not evaluate any sites meeting Category 3 criteria.

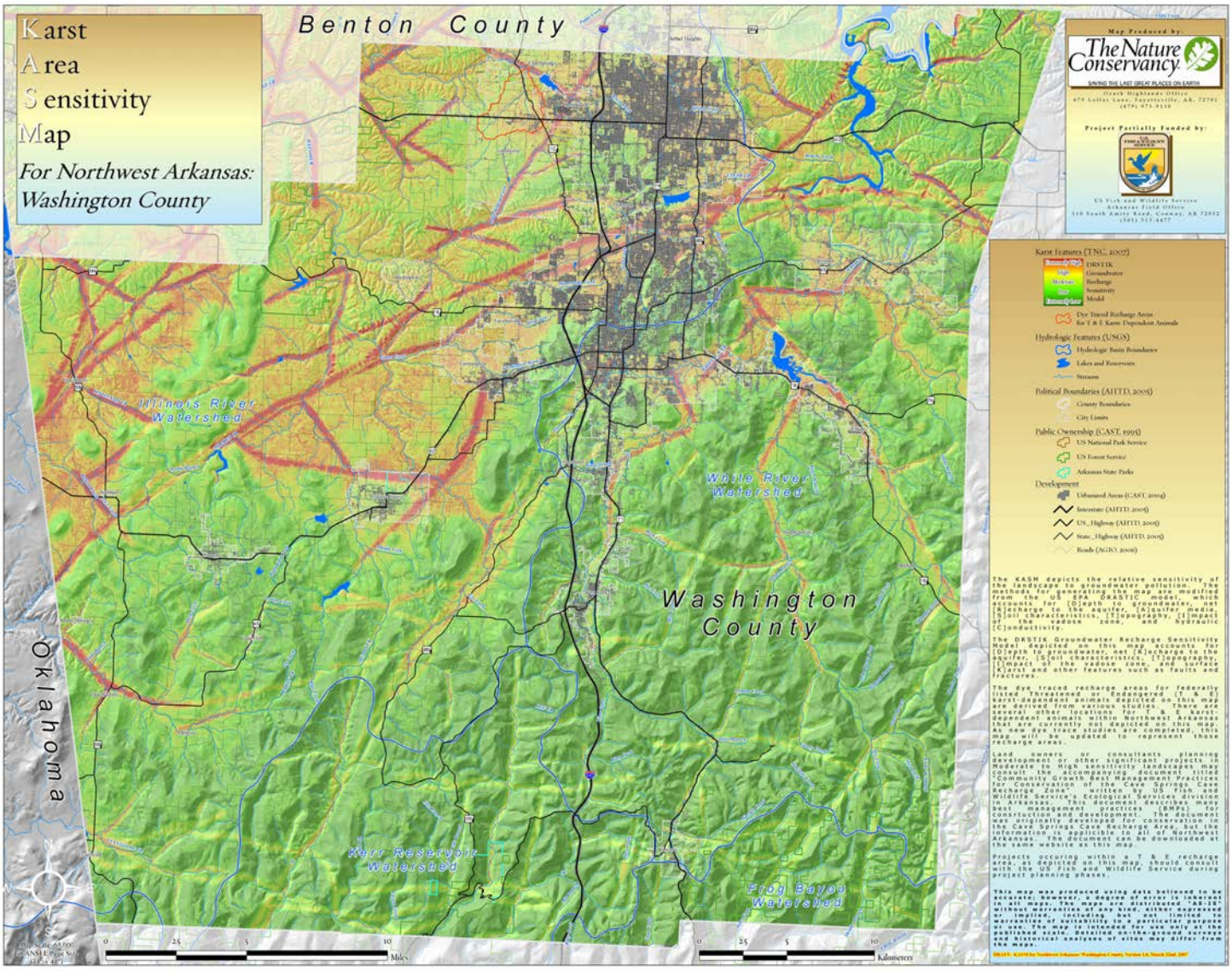
The Woolsey Wet Prairie site is an example of a Category One site due to its rarity and diversity of species.

FAYETTEVILLE NATURAL HERITAGE ASSOCIATION RESOURCE MAPS

The FNHA combined the green infrastructure network map with a series of other spatial analyses. These additional maps helped prioritize efforts and assess risks for different resources. Resource-based thematic maps greatly aid planning efforts for natural resources.

Sensitive Groundwater Recharge Areas Formed In Karst Geology

Karst geology is a unique landscape that consists of a carbonate bedrock partially dissolved by water. It results in underground drainage of streams and springs and other features, such as sinkholes and unique underground ecology. Karst is important for groundwater recharge and should be protected. The Fayetteville area hosts significant karst areas. The FNHA utilized the Nature Conservancy's karst map to inform land management decisions.

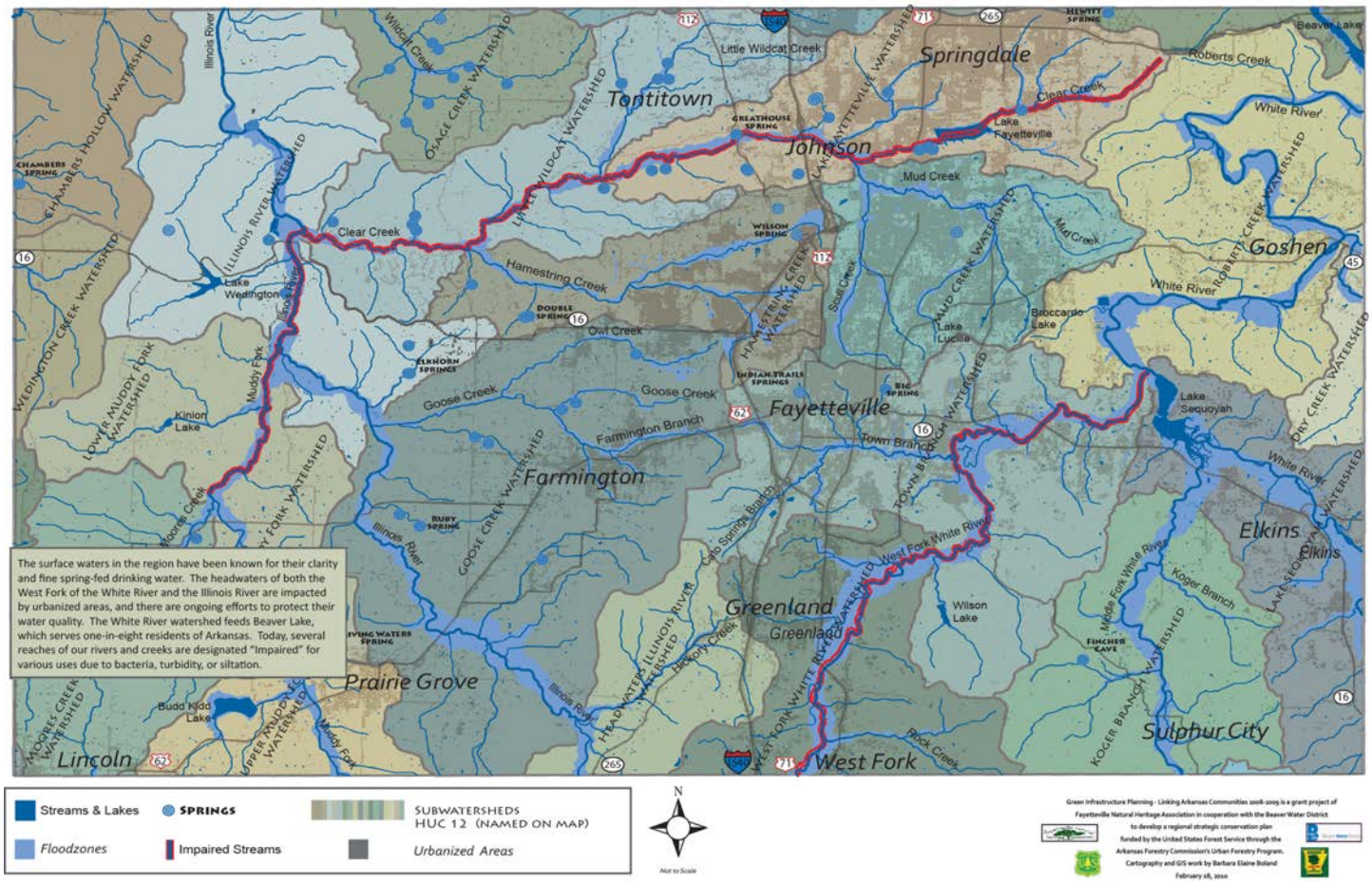


Washington County Karst Area Sensitivity Map by The Nature Conservancy.

Surface Water

The FNHA included streams and their floodplains as "important" surface water features.

The FNHA recommended protection of the full floodplain for streams to maintain maximum ecological function. This map helps prioritize areas where streams could use additional buffering within the floodplain to protect water resources.

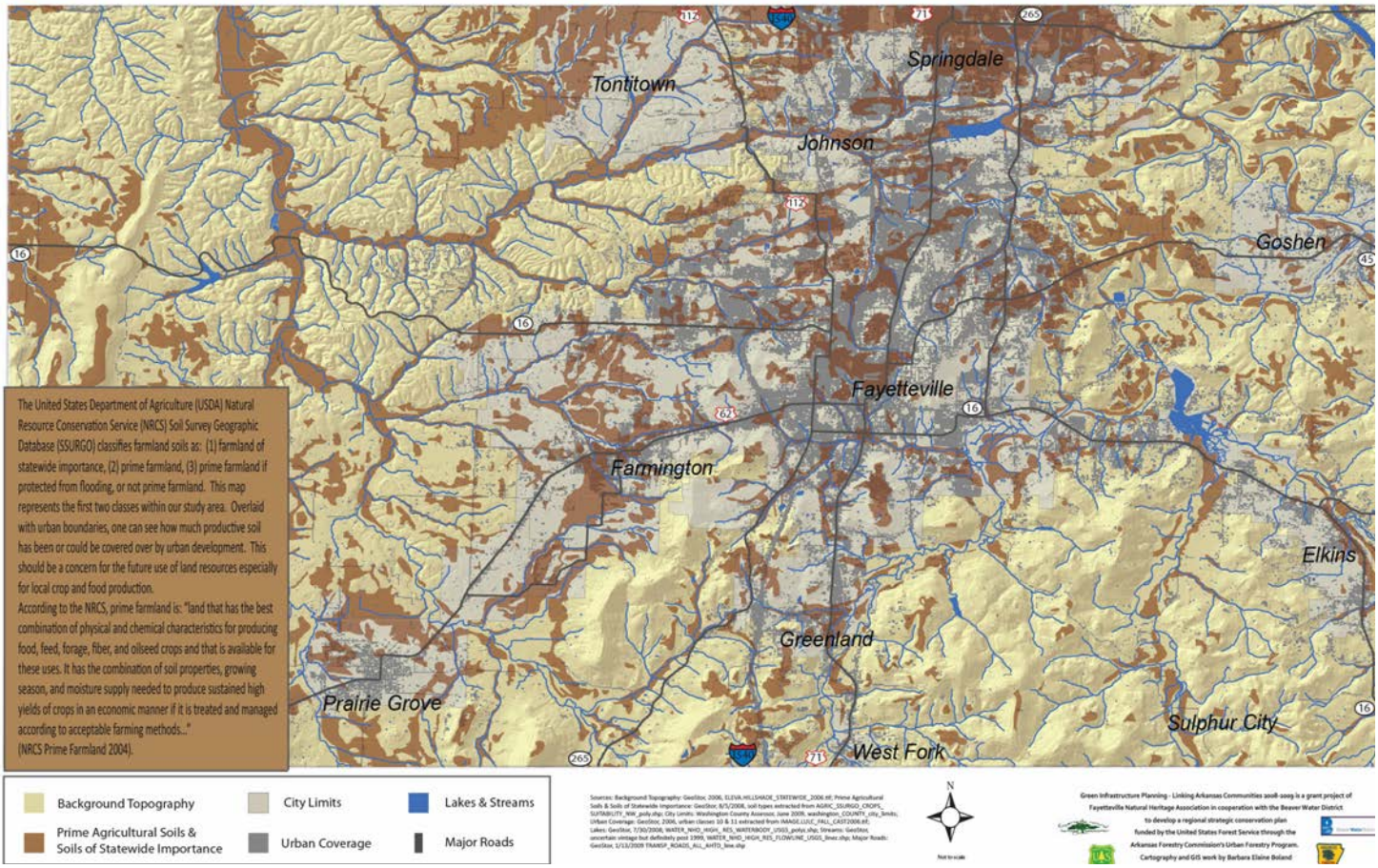


Surface Waters Map prepared by the Fayetteville Natural Heritage Association.

White-Faced Ibis Woolsey Wet Prarie by Joe Neal.

Prime Agricultural Soils and Urban Coverage

The FNHA mapped prime agricultural soils and the extent of urban development. This allows land planners to determine whether an area is more suitable for agriculture or development uses. Conserving those lands most suitable for agriculture can help facilitate local food production.

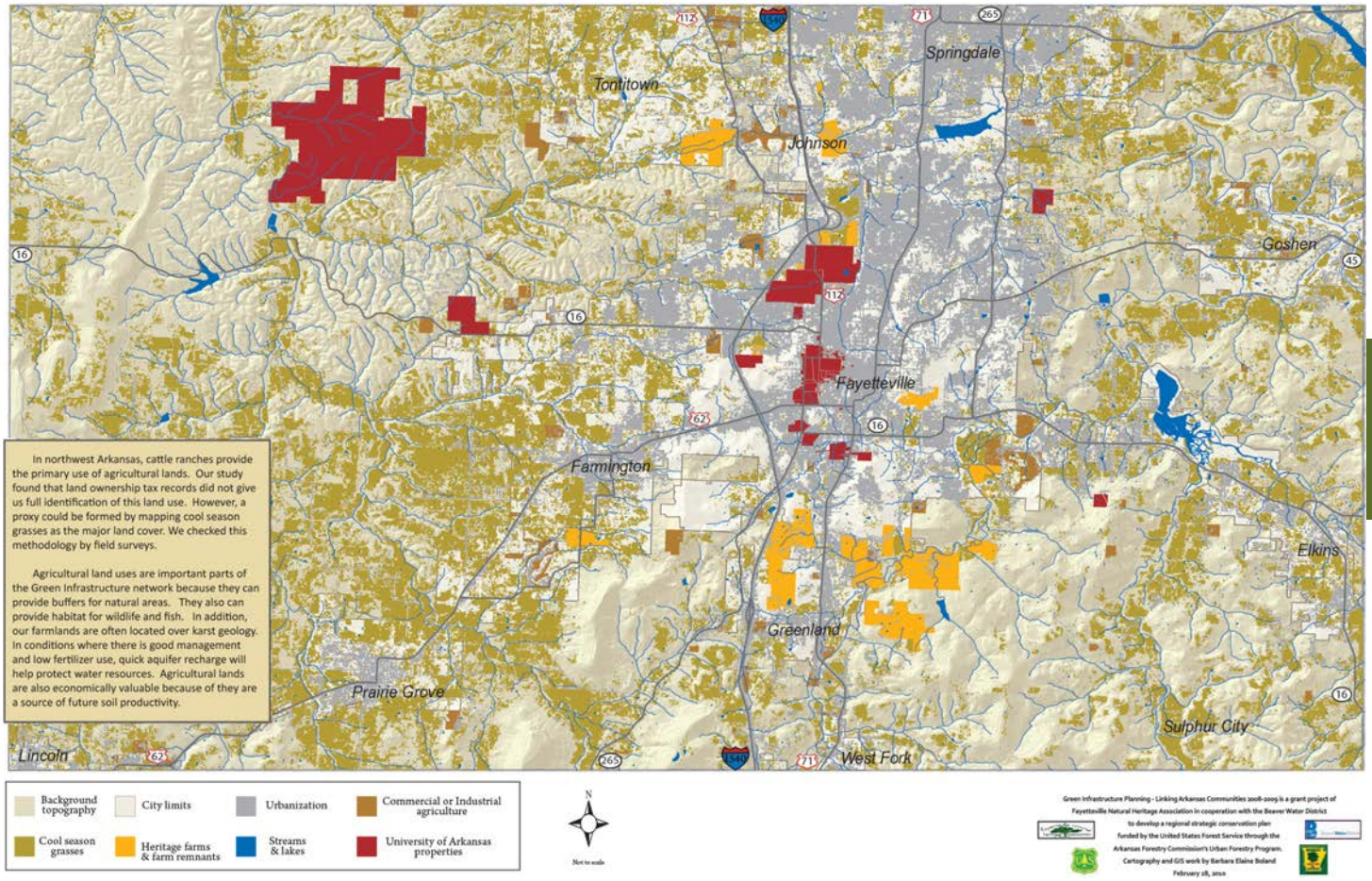


Prime Agricultural Soils and Urban Coverage prepared by the Fayetteville Natural Heritage Association.

Stump Prarie by Joe Neal.

Working Lands

The FNHA mapped farmland to address concerns about the conversion of farmland to development. They considered farmland to be important to the area's culture and history, as well as to the local economy. The Heritage Working Group interviewed numerous farm owners to identify heritage farms that had been family owned and operated for at least a generation. The working group identified issues affecting farmland in the Fayetteville area, including land conversion and parcelization.



Working Lands Map prepared by the Fayetteville Natural Heritage Association.

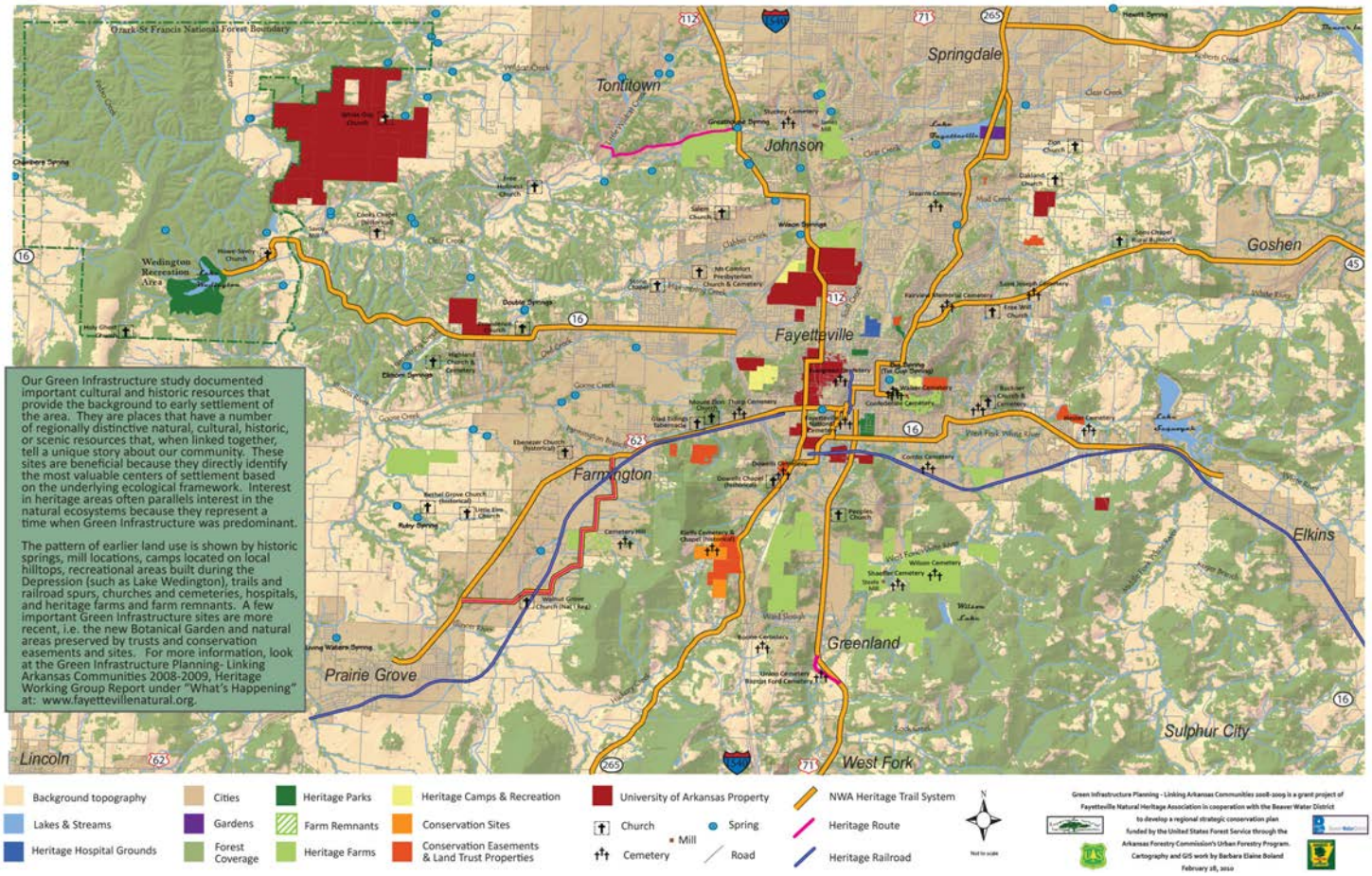
Ashy sunflower, big bluestem grass in Chesney Prairie by Joe Neal.

Heritage and Cultural Resources

There are many significant cultural features that depend upon green infrastructure in order to function optimally. The FNHA identified a variety of significant heritage and cultural resources: University of Arkansas lands; Division of Agriculture lands; historic parks; religious campgrounds and public recreation areas; historic military cemeteries; community springs; a botanical garden; historic transportation routes; other areas that are community icons; areas accessible by trails and greenways; places that have a relationship to other cultural sites; areas that are influential in the local history or culture; and endangered sites.

For example, three heritage routes listed by the Heritage Working Group include Highway 170 in Farmington, Highway 265 in Greenland, and Reed Valley Road as a western extension of Greathouse Springs Road near Johnson. These routes provide a sense of the land from the early 20th century and are key links for farms, springs, churches and settlements. Reed Valley Road and Highway 170 may lose that character as nearby development expands.

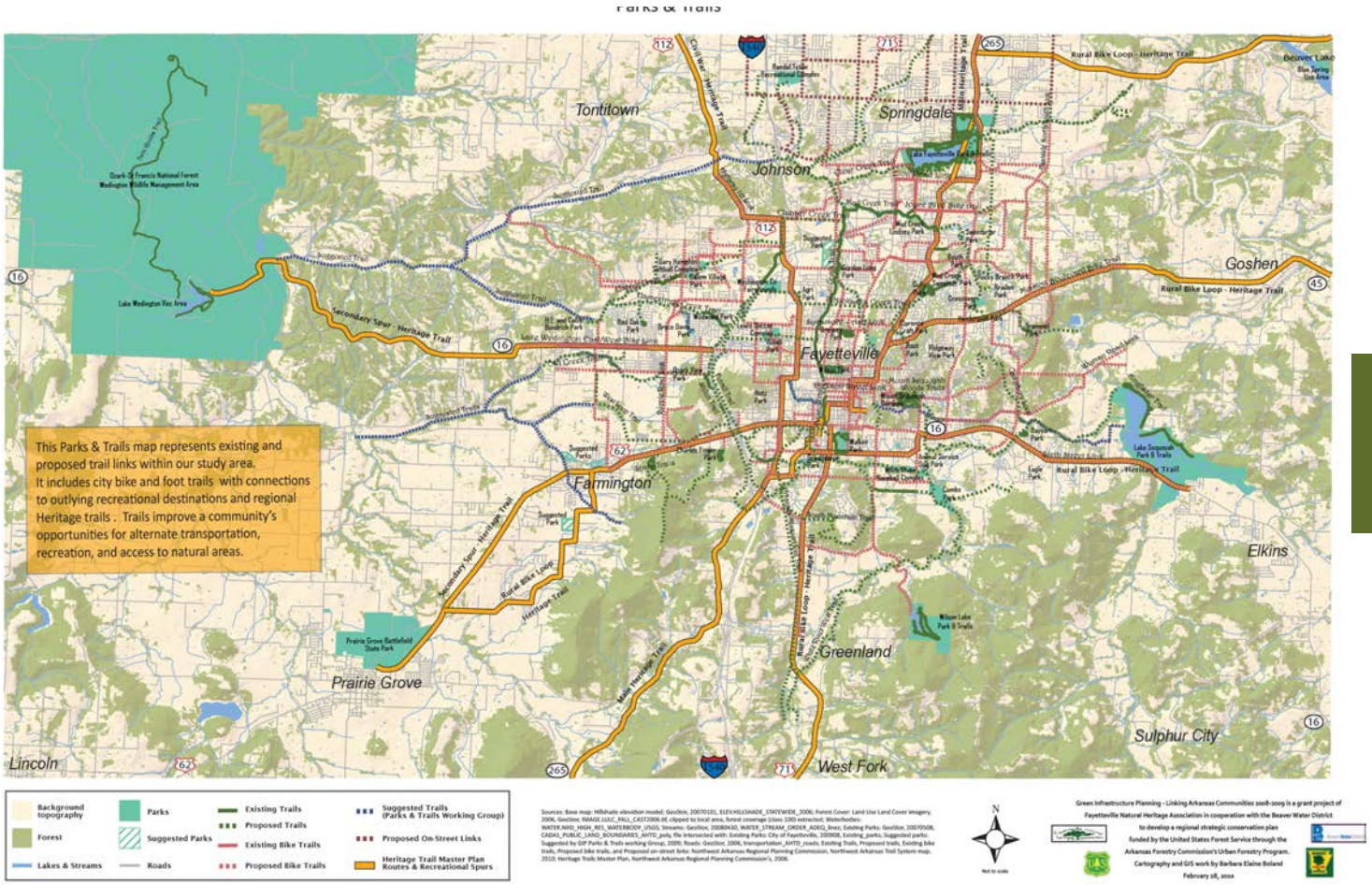
A "Northwest Arkansas Heritage Trail Plan" adopted by local communities, is included on the Heritage Green Infrastructure map and connects Northwest Arkansas citizens and visitors the regions rich heritage, recreational and cultural assets.



Heritage and Culture Map prepared by the Fayetteville Natural Heritage Association.

Parks And Trails

Each community in the region has trail plans for bicycles and pedestrians. Many of these trails are compatible with the green infrastructure network. They also promote the recreational, historic and cultural values of the region. The Parks and Trails Working Group proposed a number of trails based on their ability to highlight other components of the green infrastructure network, such as culture and history. For example, historic routes are associated with three significant events and uses: the Trail of Tears: the Butterfield Stage Coach Route; and Civil War Troop Movements.



Map 7 - Parks and Trails Map prepared by the Fayetteville Natural heritage Association

Planning Analysis Maps

The FNHA utilized the network map and a number of the resource maps to show how they can inform planning efforts in the region. At the regional level, the FNHA examined risks to karst habitat and the green infrastructure network from a proposed bypass and corresponding development.

Conservation-oriented development opportunities were also assessed at the site level. For example, a parcel containing an aquatic core was assessed for redevelopment potential using green infrastructure principals. The FNHA also looked into incorporating proposed trails into regional trail plans and the possibility of using highway transportation grants to fund trail development and habitat restoration.

Lake Alma Wildlife Observation Trail and Park

GREEN INFRASTRUCTURE PLAN "IMPLEMENTATION"

- **The GI Network was adopted by the City of Fayetteville as part of its City Plan 2030. It defines the Enduring Green Network and provides guidance for land use planning discussions.**

- **The Parks & Trails Working Group's recommendations were included in a recently adopted Northwest Arkansas Planning Commission Alternate Transportation Plan. The plan is being updated and the GI Network concepts are likely to guide trail corridor placement for the two-county area.**

- **An upland prairie remnant of approximately 40 acres was identified in the study located next to the Butterfield Coach Trail. Restoration efforts involving FNHA and City Parks Department are having success. The area has been named Callie's Prairie, based on research of the area's history.**

- **The methodology is being used by the Beaver Watershed Alliance, Northwest Arkansas Land Trust and the Water Conservation Resource Center to develop a Watershed Opportunity Assessment to guide water quality protection efforts. The first target sub-watershed is the West Fork of the White River.**

- **FNHA conservation efforts have focused on about 400 acres on Mt. Kessler. This area was identified in the study as including about 1500 acres of excellent and diverse habitat. It touches on both major watersheds and has excellent trails for walking, running and trail biking. A regional park is being built in the area. Three conservation easements are now in place.**

Summer Tanager at Beaver Lake Nursery Pond by Joe Neal

This case study demonstrated the committee process for establishing goals and criteria for hubs, cores, sites and corridors. A great deal of effort was made by dozens of volunteers to build community support and interest. The plan and associated maps serve as a living strategy for guiding growth and conservation. Examples for how the plan is being utilized to inform decision making are found in the side bar on implementation.

For those who would like to build their own green infrastructure model, a set of instructions and technical commands for GIS are included in Chapter Seven. In the next chapter, Chapter Six, we provide options for making the case to decision makers and building community support for this work.

This case study was excerpted from the report, "Green Infrastructure Planning: Linking Arkansas Communities" (2010) published by the Fayetteville Natural Heritage Association, written by Barbara Elaine Boland, Karen Rollet-Crocker, Bob Caulk and Dot Neely. The report is available on line at:
http://goo.gl/YJmORp

6

ENGAGE THE COMMUNITY

- Building Consensus
- Outreach
- Key Messages

CHAPTER 6 - Building Community Support

This chapter provides a number of options for gaining community support for a green infrastructure plan. As described earlier in this guide, citizens will usually work to help implement ideas that they had a hand in creating. Similarly, elected and appointed officials should feel some ownership of ideas if they are expected to carry the implementation torch. In this chapter we describe options and ideas on how to build broader community support for your green infrastructure plan along with examples of 'key messages' you may want to use to build community support for conserving natural assets.

OPPORTUNITIES AND OPTIONS FOR OUTREACH AND CONSENSUS BUILDING

There are many ways to engage people. However, you are not likely to have unlimited funds for public engagement or to build community support, so whatever methods you pick should be those that are most likely to engage key stakeholders. Note that not every member of a community will be interested in your project.

Assuming that you have developed some clear target groups to reach out to, the following are some options, both traditional and non-traditional, for community engagement.

There are many methods of engagement. We discussed committee formation and consensus building in Chapter Three. In this chapter we discuss:

- targeted presentations
- online surveys and maps
- open houses
- engaging with decision makers

Targeted Presentations

We recommend that you make presentations to your appointed and elected officials about your project at least three times: at the beginning; during the middle; and near the end. This will ensure that people are not caught off guard – or that they worry the process was hidden intentionally from public view.

In addition to government officials, key groups to target for presentations include conservation groups, land trusts, hunt clubs, cross country horse clubs, or nature groups. Many people will not attend committee meetings, public meetings, open houses or other civic events, but they may be very active in other civic groups, such as the Lions Club, the Rotary or their church. Make plans to outreach to those groups as well.

Consult with community leaders and local planners to learn which groups are key to engage. If the locality is not yet on board with the need to evaluate its assets, it may be necessary to conduct your own research to obtain community input. Contact agencies that interact with key stakeholders, such as your forestry division, soil and water district, or watershed council for suggestions on whom to reach out to. If possible, find out if there are meetings at which several groups will be present, such as a community faith day in which multiple churches participate, an Earth Day event or a county fair.

Next, plan how to target your message to the group's interests. For example, if you are speaking to a chapter of the National Wildlife Federation, focus your message on wildlife habitat and access to nature. If you are addressing a hunt club or the local equestrian club, discuss the importance of a protected landscape for wildlife movement and uninterrupted cross country rides.

More ideas about targeting your messages are found later in this chapter.

On-line Surveys and Maps

One option for reaching more people is to create an on-line survey, where you can ask people to comment on your goals or rank areas as top priorities for conservation. Off-the-shelf on-line survey tools, such as *Survey Monkey*, allow you to make a short, simple on-line survey for free or a more complex and longer survey for a small fee.

To ensure that you collect objective information, enlist help from a local university or survey research firm to review your questions and ensure they are not misleading. One caveat is to determine first whether your community has access to adequate computer resources and the requisite computer skills; some rural areas or areas with high poverty rates may not be able to access on-line resources. In these cases, if possible, project information and surveys can be deposited at local libraries or other public places to be filled in and picked up later.

You could also have people mark up a map through programs like *Green Maps* or your own custom software application. You can make your on-line map more interactive by setting it up so that people can click to turn layers on and off. While this will require some engineering on your part (and possibly the use of GIS add-on software, such as ArcEditor), it allows members of the public to see relationships easily. Keep in mind that if people add information or factual comments to your map, you will need to ground truth and fact check them before adding them. You may want to ask for their emails or phone numbers, so you can follow up with questions, if needed.

Open Houses

You may recall from Chapter Three that 'no committee' was an option. It is quite possible that you prefer to simply conduct expert consultations and then hold a public 'open house' to invite review of the work. An open house may or may not involve an introductory presentation but remember that the central notion of an open house is that it has an informal setting, allowing people to drop in when it's convenient for them. Perhaps you can videotape a presentation or provide an automated introductory slide show for people to watch when they do drop in.

An open house allows participants to interact with project staff in small groups or one-on-one. Engaging people in this way can be much more interactive and meaningful than the traditional public meeting, where people sit in an audience and offer short comments into a microphone. In addition, if you are seeking input on maps of natural and cultural assets, it is important that people can see the maps up close, ask questions and offer corrections or suggestions.

Engaging With Decision Makers

Most localities have comprehensive plans that describe community goals, as well as future land-use plans that depict where and how they plan to grow in the future. However, these plans may not include key green infrastructure information, such as soils data, which can designate the best areas for agriculture.

If your board of supervisors, planning board, planning commission or other elected or appointed officials are unfamiliar with the new green infrastructure information you are presenting, they will need to understand the system you used to prioritize key natural assets. They will need to know what values led to your decision to select certain areas as high value. Make your decision process as transparent as possible by writing down your process. And be sure to carefully document the methods you used for prioritization, as well as special considerations for features added to your map (e.g. a natural area which supports outdoor learning for a nearby school).

Despite your efforts, decision makers may still decide to replace or impact the highest-quality natural area with a

TIPS FOR AN ENGAGING OPEN HOUSE

- To maximize options for public participation, offer flexible hours to drop in, such as from 3pm to 8pm, to allow people to arrive when it suits their schedules.
- Avoid meeting conflicts by checking calendars for other related or popular community events.
- Allow more families to participate by offering child-sitting services, kid-friendly activities, and advertise that families are welcome.
- Advertise the event through public service announcements on radio and television and post flyers in places where people will see them, such as at schools, libraries or grocery stores.
- Offer refreshments. Seek corporate or community sponsorship for snacks or a light meal – food is a great magnet for busy families and singles.
- Use separate areas for commenting, to avoid overcrowding. If you are using themed overlay maps, begin with a base asset map and have a table for each of the themed overlays. For fun, use a train motif and emphasize that people should visit each 'station.'
- If you forgo a formal presentation, have an orientation 'station' where a team member ('conductor') explains the project and the purpose of each map before the participants chug around the stations.
- To avoid overcrowding by too many people at one station, stagger participants as they enter. Begin with an orientation at the base map for everyone, but change which map each participant visits next. If adopting the train motif, provide each participant with a numbered ticket and stagger the starting location so the first person starts at station one and moves to station two, while the next person begins at station two, then goes to three, and so on. This avoids participants overcrowding each station as they move around the room.
- At each 'station,' provide introductory information concerning the themed map's purpose and graphics. Prepare a series of questions, such as, "Does this look accurate to you?," "Is the map easy to understand?," and "Are the map symbols and graphics easy or difficult to interpret?" You may also have specific data-related questions, such as, "Does this map include all the key areas for natural resource-based recreation?"
- Provide a map for people to contribute their own data or favorite places, to validate or correct assumptions about community priorities. However, try to avoid non-uniform or inconsistent methods of adding data to maps. Consider asking key questions such as 'Where is your favorite place to view nature?'
- Avoid overcrowding maps with notes by using numbered sticky dots that reference corresponding numbers on a flip chart. For example, dot #1 = favorite bird watching area; dot #2 = best area for a forested buffer; dot#3 = best fishing spot. Alternatively, heavy clear plastic sheeting (available from art supply stores) can be overlaid on maps to allow people to mark key areas with permanent markers. Once a sheet gets overly congested with illustrations, save it and lay down a new sheet. Once comments have been reviewed, the favorite places and priorities data can be digitized to provide common symbology and phraseology, such as fishing, hunting, best views, and then included as a reference map.
- Let people know where information will be posted and how they can follow the process to completion. Be sure to have a sign-in sheet for people's contact information so they can be included in future updates.

new industrial park or school, but if they have a map of key natural and cultural resources, at least it allows them to make their decision with a fuller understanding of what may be lost.

Acknowledging that something will be given up to permit development could also lead to conserving other areas through acquisition or zoning changes to compensate for the loss of a key area. They may decide to compensate for that loss by adding better protection to another high-value area or taking on a habitat restoration project to mitigate the loss.

MESSAGING: HOW TO MARKET NATURAL ASSET CONSERVATION TO GOVERNMENT, CONSERVATION AND PRIVATE SECTORS

In Chapter Two, we made the case for why mapping and evaluating natural assets makes good sense for the economy, public health, safety and aesthetic reasons. In this section, we provide some of the facts and studies that we have used to best communicate key messages. Feel free to utilize these arguments and create your own local examples. Much of the advice in this section is based on the GIC's experience in effectively targeting messages to multiple audiences across the U.S.

Messaging is shorthand for how you communicate your project's purpose and goals. How and what you communicate is critical to your project's success and could make the difference between a project that is widely accepted or one that is turned down before it begins. The way you describe or frame your project's aim can affect whether it appeals to a wide range of interests or whether it is seen as overly narrow or something to be stopped.

Messaging is shorthand for how you communicate your project's purpose and goals in a way that people can understand and find meaningful to them.

Politics in the United States has been growing more acrimonious by the day. The poor state of the economy has led to a great deal of worry, concern and fear about the future. Related to this, many environmental efforts and institutions are under attack or suffering from excessive criticism. Anything labeled as 'green' may be attacked and accused of trying to take property rights away, or of adding to regulation and red tape. In addition, the accusations that regulations stifle industry and prevent 'progress' have been levied against the environmental movement, although there exists much evidence to support the claim that having clean water, clean air, healthy communities and safe and productive workers actually benefits the economy and can reduce future costs for environmental cleanup and public health.

One central point you can make to answer these concerns is a cost-benefit analysis: If we identify and protect resources before they are damaged, we can avoid future cleanup costs of polluted waters and soils. And prevention of air quality impacts will save money in the long run. You will not face the costly expenses of establishing a Total Maximum Daily Loading of Pollutants (TMDL) for an impaired water or preventing your area being listed as a Non-attainment Area under the federal Clean Air Act. You can also protect public safety and future loss of both life and property by conserving sensitive areas and identifying areas that are at high risk from impacts of storms or sea level rise.

Know Your Audience

The first step in developing a key message is to know your audience. So you may want to conduct a pre-assessment of stakeholder interests and values before you begin your project, in order to learn what are the hot-button issues and to get different community perspectives on the key issues involved with your project.

You can also utilize a focus group to test your ideas, review the effectiveness of your message and map graphics before presenting them to the public or to decision makers. The worst time to find out that you have created an unintentional controversy is in the middle of a public meeting. It is best to pre-anticipate and address potential conflicts before they come to a head. However, it is likely that you will still need to actively respond to tough questions throughout the duration of a project. Having well-informed answers at the ready can help you to navigate the pitfalls and firestorms inherent in most land planning efforts.

Tailor Your Message

Assuming you know who your audience is and what are its main concerns, you can tailor your message to pre-address many of them. When possible, it is better to answer the question that has not yet been asked and allay concerns and fears during your presentation, as opposed to afterwards. Develop a set of key messages and put them on your web pages, in project brochures, in presentations,

in a Frequently Asked Questions (FAQ) document, or in other written, filmed or on-line communications.

Which topics are most relevant to your audience will vary depending on your community and the specific setting. One evening you might be presenting your project to the chamber of commerce, on another it might be to the biodiversity council. You should not actually change your project's mission and purpose, but you may utilize arguments and descriptions that most resonate with your intended audience. You may also modify the format (making it more formal or informal), depending on the setting and timing of your presentations.

You will also have to decide if your audience will resonate more with one of the following types of information:

- evidence based on studies (e.g. academic journals)
- stories and anecdotes (especially local or familiar)
- pictures and evidence they can see for themselves (take a field trip)
- support from key community members and respected community representatives (testimonials)

Seeing is believing. This group decided to visit the wetlands they were discussing to 'ground truth' their knowledge of conditions.

State the Benefits of Natural Assets

Your central message needs to share the benefits of protecting and restoring key natural assets as part of your green infrastructure strategy. Whichever arguments you decide to use, remember that positive points resonate more effectively. In addition, many psychological studies have shown that people respond best when told what they can do, rather than what they can't. Studies of signage in national parks saying do not do X, Y, or Z have sometimes made it more likely people will do those things. Similarly, we tend to copy what our peers do. Peer pressure originates not just from verbal communications from your peers, but also your own tendency to copy your colleagues' and neighbors' behavior.

Much of the academic literature about peer pressure influences stems from studies of recycling or littering behavior, which examined people's motivations. Recycling studies found that the most effective way to gain participation in recycling programs was not to tell people to avoid making excessive waste, but rather to place recycling bins strategically at several homes and watch people ask to join once they saw their neighbors recycling. Similarly, programs that tried to reduce littering by posting negative signage (Don't litter, big fines!) were not as effective as ensuring that places were kept clean, since people would throw trash in areas where there was trash already, but tended not to litter in cleaned areas (Reiter and Samuel 2006).

The tone and approach of your message is relevant because you want to make evaluating and mapping your community's assets the 'normal' thing to do. So, instead of discussing what you will lose if you do not evaluate and map your assets, present the many benefits of doing this work and point out how many other communities are doing it already, and with what success (try to pick communities similar to your own to model exemplary behaviors with which people can resonate).

Key messages are short statements (stated directly or implied) that get to the heart of the argument you wish to make.

Economic reasons are probably the most important benefits to highlight in the early 21st century, when most of the world's economies are struggling. They also provide a way to use economic analogies to which most people can relate.

Earlier, we introduced several of these ideas. Here, we will show how these concepts can be structured as arguments for why it's important to map and evaluate natural assets. Each sub-section has a 'key message' that you may wish to utilize when making your case for natural asset planning; it is then followed, either by scientific evidence or by examples that you can use to back up the message's claim.

The Personal Finance Analogy

MESSAGE: You Make Informed Decisions About Managing Your Own Financial Assets, So Make Sure You Are Also Well Informed About the Values of Your Natural Assets!

Do you hand out blank checks to the cashier at the grocery store or sell your home or stocks for just a dollar? Of course not! That is because we sell or buy things based on some understanding of their economic value. So, just as we know the value of our financial assets, we should know the value of our natural assets before we decide what to do with them. By mapping our natural assets, we can determine which land features are the most valuable and make wise, informed decisions about their management.

Green Areas Spur Investment

MESSAGE: Mapping Green Assets Saves Both Kinds of "Green"!

Utilize the argument that restoring green spaces attracts redevelopment. For example, "By converting an old levee on the Savannah River to a riverwalk, the town's investment of $8 million in the trail has attracted $198 million in new commercial investments" (Benedict and McMahon 2006).

The creation of a new riverfront park in downtown Hartford Connecticut led to $1 billion dollars in new reinvestment within walking distance of the park, according to the nonprofit group Riverfront Recapture, which developed and runs the park (Riverfront Recapture 2012).

MESSAGE: Creating or Restoring Natural Areas Protects and Increases Property Values!

Property values and real estate revenues rise 10 to 30 percent when green spaces are preserved, raising property values without raising tax rates. Properties near green spaces sell faster and for more money.

For example: "The National Association of Realtors found that 57% of voters would be more likely to purchase a home close to green space, and 50% said they would be willing to pay 10% more for a home located near a park or other protected area" (Benedict and McMahon 2006.) And, "a developer who donated a forty-foot-wide, seven-mile-long easement along a popular trail in Front Royal, Virginia, sold all fifty parcels bordering the trail in just 4 months" (Benedict and McMahon 2006).

There are many studies of the benefits of parks and natural areas on property values and some make a distinction concerning the size and type of green space. One of the evaluation methods used in a study of home sales in Portland, Oregon, found that the 193 public parks analyzed had a significant, positive impact on nearby property values. The existence of a park within 1,500 feet of a home increased its sale price between $845 and $2,262 (in 2000 dollars) (The Economic Benefits of Recreation, Open Space, Recreation Facilities and Walkable Community Design 2010).

MESSAGE: Size and Quality of Natural Areas Matter For Benefitting Property Values (and Quality of Life).

The size of natural areas matters not only for wildlife but also real estate values. The Portland study also showed that the larger the park, the more significant the property value increase.

Another study found that large natural forest areas have a greater positive impact on nearby property prices than small urban parks or developed parks, such as playgrounds, skate parks and even golf courses. Homes located within 1,500 feet of natural forest areas enjoy statistically significant property premiums, on average $10,648, compared to $1,214 for urban parks, $5,657 for specialty parks and $8,849 for golf courses (in 1990 dollars).

Similar studies in Howard County, Maryland, Washington County, Oregon, Austin, Texas, Minneapolis-St. Paul, Minnesota, and other areas used data from residential sales, the census and GIS to examine marginal values of different types of parks. They too found that the type of open space affects the benefits for property values (The Economic Benefits of Recreation, Open Space, Recreation Facilities and Walkable Community Design 2010).

MESSAGE: Protect Natural Areas – Especially Trails – To Attract Home Buyers.

When citing sources for economic studies, the National Association of Realtors (NAR) proves very useful since it is in the business of selling homes and is considered to be an avid supporter of economic growth. It compiles many useful statistics, such as the NAR national study, which

has found that, of all homebuyers polled about what they were looking for in recreational amenities, "1-2% golf, 5-6% swim and more than 50% use paths." This shows that creating trails in a development is a very appealing investment.

The Hartford River Park includes may wild areas downtown for urban residents to enjoy.

Green Assets and Jobs

MESSAGE: To Attract a Well-Paid Workforce, Offer Abundant Green Areas and Outdoor Recreation.

The goal of attracting companies with well-paid jobs is shared by most localities. However, well-paid positions are often harder to come by than low-paid service jobs. To attract good paying jobs, the focus should not be on 'industrial parks,' but actual parks.

Small companies, especially those that have a well paid and skilled workforce, place a strong importance on the 'green' of the local environment (Crompton Love and Moore 1997). Also, the creative class of artists, media personnel, lawyers, analysts, and so on, tend to reflect a better paid workforce. They make up 30 percent of the U.S. workforce and place a premium on outdoor recreation and access to nature (Florida 2002). So, to attract a skilled, creative workforce (and thereby the companies that employ them), it is key to provide them with green areas and outdoor recreation.

MESSAGE: Clean and Abundant Natural Resources Support the Economy

Many businesses depend on clean water for their production process. For example, computer chip manufacturers require a great volume of water that is as pristine as possible. Of, course, bottled water plants require clean water, but so do beer and spirits companies. In addition, those type of businesses that depend on a healthful environment tend to be good stewards of the earth.

In addition to clean water and recreation, remember that green infrastructure includes natural resources that we depend on for agriculture, timber, honey and other non-extractive and regenerative assets. These resources support a large economy. For example, in Virginia, forests and associated forest products bring the state $27.5 billion dollars in annual revenue while agriculture brings in $55 billion annually and provides more than 357,000 jobs. Similarly in North Carolina, the state's top grossing industries are agriculture (farms and forestland) and tourism; both highly dependent on existing natural resources and the quality of those resources.

In rural areas, these numbers can be used to justify a focus on conserving those landscapes that contribute to the rural economy – they are both economic and ecological assets!

Green Assets and Tourism

MESSAGE: Nature-Based Recreation Spurs New Businesses!

While service jobs are usually low paid, those that require some skill, such as guides for hunting, fisheries and whitewater rafting, depend on a green and well-connected landscape. These types of businesses bring in hotels, bed and breakfast inns, restaurants, craft and boutique stores, and all the other services needed, such as gas stations, groceries and outdoor gear shops.

The Creeper Trail in Virginia has lured $2.5 million in new tourism dollars to Virginia and $1.5 million to Grayson County, along with 27 new jobs in new businesses near the trail (Bowker and Bergstrom 2004). These include everything from trail-side cafes to bike and equipment rentals and lodging.

MESSAGE: Nature and Heritage Resources Attract Tourists Who Will Spend More Money.

Green assets tend to attract tourists who are high spenders. Those people whose outdoor sport requires the purchase of expensive gear, such as ATVs, snowmobiles, powerboats, mountain bikes and fishing equipment, will often shop locally and get their equipment serviced locally as well. They will spend money on boats, camping gear, high-powered cameras, camouflaged survival gear and other equipment.

Some tourists also tend to spend more on amenities. Even birders, who may appear to need nothing more than a pair of binoculars, a chewed pencil and a notebook, spend more than other types of tourists. This is due, in part, to the type of recreation, as well as the type of individual who engages in that sport. In addition, they tend to stay in bed and breakfast inns (which cost more and generate more revenue in taxes than budget inns) and eat out at finer restaurants (e.g. a nice bistro, not fast food), which results in higher bills and greater tax revenue per person. They will also buy better binoculars, more bird guides and more expensive scopes. Those sales add up.

Charlottesville's pedestrian tree-lined mall has revitalized the city's downtown economy.

Similarly, heritage tourists, those who like history and culture as part of their tourism experience, spend, on average, two and half times more per person than all other types of tourists (Thomas Jefferson Planning District Heritage Tourism Project). However, they also are choosy about the areas they visit – therefore protecting scenic vistas, conserving viewsheds along scenic roadways and preventing the encroachment of development into historic landscapes are important to lure them and keep them visiting as long as possible. They will not want to travel through multiple blighted areas simply to reach a historic site.

As noted earlier, people shop longer and spend more money per item in shopping areas with trees, so providing and restoring the tree canopy in business districts and downtowns is critical to getting and keeping dollars from residents and tourists alike. Charlottesville, Virginia, bricked its main street in the 1970s. Today, this pedestrian, mall with many trees planted where there was once a street offers a unique outdoor and green café scene, with which modern malls are not able to compete.

Ecological Reasons

MESSAGE: Bigger Is Better – Especially For Wildlife!

A general rule of thumb is that the larger the natural area, the greater the diversity of habitat types that are possible. A minimum size for forested cores is 100 acres, but most models assign higher points for larger areas. Seek to conserve as large an intact area as possible.

MESSAGE: Connections Count!

A connected landscape helps with species diversity by providing multiple pathways for plants, pollinators and animals to live and travel. If a species is reduced in one area (due to disturbance or disease), connections facilitate colonization. They also ensure that, if one pathway is lost or broken, there will be other ways to cross the landscape.

An analogy that is easy to relate to and that the GIC has used in college towns

is, if you are hungry when the big football game is on and game day traffic has closed down the roadways, you'll be out of luck if you only have one route to the grocery store. But if you know a favorite shortcut, or where there's an alternative store, you have more chance of getting what you require. In nature, we also need to have multiple routes and pathways to ensure we don't get stuck, go hungry – or go extinct!

Existence value or ***intrinsic value***, is a human value that something should exist and possesses its own independent value in and of itself, whether or not the person perceiving that value has ever experienced it directly.

One theory posited about why people relate to and care about nature is known as *biophilia*. First proposed by Erich Fromm and later popularized by noted ecologist E.O. Wilson, it is described as "the connections that human beings subconsciously seek with the rest of life." These connections are thought to be deeply rooted within our own biology as animals. Whether or not one subscribes to this notion, it is true that simply looking at something natural or 'green' improves our attitude and state of mind.

Social Benefits

MESSAGE: People Value Natural Assets For Their Own Sake!

Many people appreciate nature and wild things just because they exist. Known as *existence value* or *intrinsic value*, many people take heart in knowing something exists, even if they have never, or will never, see it in real life – the Emperor penguin is an exotic example, but think of how many people get excited by the possibility of a mountain lion in the nearby hills? As famous naturalist Aldo Leopold once said in his *Sand County Almanac,* "There are some who can live without wild things and some who cannot. I am one of those who cannot."

TREES PROVIDE MANY VALUES – AND THEY WORK FOR FREE!

Trees:

- **Provide habitat and food for wildlife.**
- **Provide oxygen.**
- **Remove particulate pollution, sequester carbon and mitigate global climate change.**
- **Absorb and filter runoff, and protect water quality.**
- **Conserve land by preventing soil erosion.**
- **Mitigate urban heat islands and reduce energy demand.**
- **Increase property values.**
- **Improve children's performance in school.**
- **Reduce levels of domestic violence.**
- **Attract shoppers and tourists who stay longer and spend more.**
- **Reduce mental fatigue and stress.**

Urban Forestry News, Spring 2004.

MESSAGE: Natural Assets Make You Nicer and Smarter!

Simply looking at pictures of natural objects can improve your attitude and make you more altruistic. In a recent study, participants immersed in natural environments reported a higher valuing of intrinsic aspirations and a lower valuing of extrinsic aspirations. In essence, seeing nature made people more caring (Weinstein, Przybylski, Ryan 2009). It might seem incredible to link them, but occurrences of both attention deficit disorder and domestic violence are significantly reduced around trees, while people's IQs actually increase (Southern Forest Research Station).

MESSAGE: Natural Assets Make You Healthier!

Increasingly, green infrastructure planning is being linked to the field of public health. According to the US Centers for Disease Control, as of 2010, 25.6 million, or 11.3% of all people over the age of 20 have

diabetes and it rose to the seventh leading cause of death in 2007. Twice that number of Americans are at risk of contracting diabetes. However, many studies show that diabetes can be prevented by weight loss and exercise. Green infrastructure planning can help communities link people to trails and parks that reduce stress while getting them fit and healthy.

Doctors are beginning to prescribe walking to lower the risk of heart disease, obesity and diabetes from lack of fitness and weight gain by ordering trail walks for their patients (Washington Post 2009). Walking just 30 minutes a day significantly increases your health, avoiding metabolic syndrome – the cluster of risk factors that raise the odds of developing heart disease, diabetes and stroke (American Journal of Cardiology 2007).

recovery. Dr. Ulrich measured patient's alpha rates, which are associated with stress and levels of relaxation. He found that those patients who could experience natural scenery were more relaxed than those who had urban views and, as a result, those experiencing nature views had "shorter post-operative stays, fewer negative comments from nurses, took less pain medication and experienced minor post-operative complications" (Ulrich 1984). Many hospitals are beginning to provide views from their rooms. Since it is likely that most hospitals do not own those views, they depend on local planners and developers to maintain the green space that is helping their patients heal faster. They are also incorporating 'healing gardens' and outdoor trails for their more ambulatory patients, as well as for the enjoyment of staff and visitors, who also experience their own forms of stress.

"The last word in ignorance is the man who says of an animal or plant, "What good is it?" If the land mechanism as a whole is good, then every part is good, whether we understand it or not. If the biota, in the course of eons, has built something we like but do not understand, then who but a fool would discard seemingly useless parts? To keep every cog and wheel is the first precaution of intelligent tinkering."

— Aldo Leopold, in *Round River: From the Journals of Aldo Leopold.*

A great deal of research shows that residents within lower-income urban neighborhoods have higher rates of health problems. While less income and lack of access to health care are certainly factors, the surrounding environment also plays a role in a community's emotional and physical health.

Most articles also find that having access to recreation opportunities makes it more likely that people will exercise. The fitter employees are, the lower the health care costs for businesses. That is why businesses are attracted to areas that offer abundant recreation and opportunities for people to walk near to where they work.

Dense urban areas often lack trees and vegetation. Trees' role in improving air quality is fairly well-known. They

Even having a view of green spaces can reduce illness. One study found that employees without views of green spaces, in response to questions concerning 11 different ailments, reported 23 percent more incidences of illness in the prior six months (Kaplan 1989). Less illness means more productive workers.

Similarly, studies of hospital patients by the Center for Health Systems and Design at Texas A&M University found that physical or visual contact with natural spaces leads to faster

absorb volatile organic compounds and other contaminants from the air while also providing oxygen. However, what may be less well known is that they influence our propensity to walk and exercise. The green of our environment exerts a positive influence on our desire to walk outdoors. Downtown urban areas often have less trees. For example, the GIC's urban canopy maps of Richmond, Charlottesville and Staunton show less trees in these cities' downtowns. The closer one gets to the urban core, the less trees are found. In the case of Charlottesville and Richmond, these less-treed areas correlate to areas suffering from greater poverty.

Studies concerning factors that motivate people to walk show that, while having opportunities to stroll on sidewalks and other pathways is important, it is also important, if not equally so, to have trees to walk under and alongside. Research has shown that residents in neighborhoods with abundant green spaces have better health than those in areas without green space. People are more likely to walk in areas with green space, a correlation that is strongest for the elderly, homemakers, and lower socio-economic groups.

Destinations that must be reached through areas without trees and vegetation are perceived to be farther away, perhaps influencing people's reluctance to walk through them (Wolf 2008). Thus, residents of inner city urban areas with less trees have greater poverty, poorer health and less desire to walk and exercise outside. This demonstrates why urban green spaces, the tree canopy, a connected landscape and other natural assets are key factors to include in any green infrastructure plan.

People's lack of access to outside spaces, as well as their reluctance to venture outside, have received new attention in recent years. The term *nature deficit disorder* refers to the effects that occur when children do not have access to outdoor natural areas. The popular book *Last Child in the Woods* by Richard Louve synthesized literature concerning

the importance of nature to reduce attention deficit disorder and create healthier kids. It also stressed why we need to actively ensure that our kids are out in nature as part of their emotional, physical and cognitive development.

In this chapter, we have covered opportunities for building public support and examples of key messages that can be tailored and utilized to appeal to your community. In Chapter Seven, we provide detailed information about data sources and models.

7

A CASE STUDY OF MAPPING GREEN INFRASTRUCTURE

- Building a Habitat Model
- Ranking Habitat Cores
- Connecting Corridors
- Themed Map Overlays
- County Data

CHAPTER 7 - Using Spatial Data to Create a Natural Asset Map in Arkansas

by Charles Kline

This chapter summarizes the specific natural asset models and data sources for Arkansas.

Before applying the methods summarized in this chapter, read prior chapters. Earlier chapters will help you set clear goals and priorities for what to prioritize in your green infrastructure network. Chapter Five highlights a case study of natural asset mapping in Fayetteville, Arkansas, which used methods similar to those summarized in this chapter. The methods described in this chapter are an update to the Fayetteville methodology that allow you to create a green infrastructure map at the state, region or county scale.

This chapter contains specific instructions on using state data to create a locally-relevant map of natural assets. In addition, it summarizes the components needed to build a green infrastructure model. This modeling process identifies and values intact interior habitat. Appendix A contains technical instructions for GIS users to create a green infrastructure model using ArcGIS software.

Mapping identifies the natural resources of greatest importance. Recall from earlier chapters that a map of natural assets is not an inventory of everything. Creating maps of your natural assets is a process to determine your unique and highest-quality natural assets and to make plans to conserve or restore them. Natural features are considered 'assets' because they have been prioritized and identified as the most important, using objective and consistent methods to evaluate data and fulfill one or more community goals.

A map can be created for any scale, from a state level, to regional, county or watershed levels. When creating a map that crosses county or other jurisdictional boundaries, you will need to obtain the same data sets maintained by each county or jurisdiction in order to run your model. The key is to ensure that all the data utilized originate from the same relative scale and level of accuracy, in order to validate comparisons and conclusions across the region. For a complete list of datasets required to run the model, see Appendix A.

Evaluating landscape resources across boundaries accurately assesses core habitats for their significance. Some habitats may appear small or insignificant, or tucked away at the edge of a county, but may form part of a much larger core that extends into the neighboring area, when reviewed at a larger scale.

Identifying cross-boundary natural assets that are owned or managed by another locality or other landowners points out areas that may be important to manage cooperatively in order to foster conservation of their high-value habitats. While rivers and bays are common examples of cross-boundary natural resources, large intact interior forests and wetland complexes are other significant systems that often require assessment at a larger scale, both to truly appreciate their magnitude and contribution to biodiversity, and to ensure the resilience of the area.

This section is for technical staff charged with building a similar model for their own county or region.

Swamp Milkweed and Clearwing Moth Along Clabber Creek Trail by Joe Neal.

ABOUT THE GREEN INFRASTRUCTURE MODEL

Fayetteville conducted the first large-scale initiative to map green infrastructure resources in Arkansas. (See Chapter Five.)

Large tracts of intact interior habitat, or cores, are the building blocks for a connected landscape. The Fayetteville model identifies those cores and assigns values based on interior features. These values include information on core shape and size, interior water quantity and interior biodiversity surrogates such as habitat, elevation and soil diversity. Based on these categories, each core receives a rank to help decision-makers conserve the best areas as part of land-use planning.

The cores and corridors that are mapped provide a network map upon which other natural resource themes can be overlain. Additional data and explicit goals set by localities are necessary to develop thematic maps. For example, a map of habitat cores combined with a trail map identifies the role that habitat cores play in supporting recreational trails. Additional data also answer questions such as: Does this small and otherwise minor core gain additional value when its historic context is evaluated?

The green infrastructure model provides an at-a-glance prioritization of natural habitat based on relevant environmental data. It does not account for local goals and priorities, so determining which habitats are most important requires local review. Chapter Four describes strategies for how to best use the green infrastructure model in concert with thematic maps representing local goals.

Please keep in mind that, once built, the model should be treated as a 'living document.' It should be consulted regularly and updated as new information and priorities emerge.

Using automation tools available with GIS make building a habitat model easily replicable at the county level and across the state. The model is a 'snapshot' of cores at the time of the model's construction. Conditions on the ground change. Land conversion from new development or increased habitat caused by forest re-growth and other factors change the landscape. Priorities also change. This should be reflected in the attributes and ranking of cores within the model. Create a system to keep the model up-to-date and ensure its usefulness in daily planning.

This model relies on remotely sensed data at a coarse landscape scale. It does not reflect fine, site-scale ground conditions. Additional high-resolution data are necessary to

evaluate the impact of such issues as deer browse, damage from invasive species and other concerns.

Identification and prioritization of core habitat greatly aids in green infrastructure planning. This model facilitates the definition and measurement of goals that depend upon an interconnected landscape. It identifies and prioritizes intact core habitat by using GIS technology.

This chapter summarizes a step-by-step methodology to create a county-scale base map of core habitats. This data aids analysis of different natural resources priorities, with topics ranging from water quality and biodiversity to recreation, culture and working landscapes.

BUILDING A HABITAT MODEL

This methodology draws extensively from the Fayetteville Natural Heritage Association's *Green Infrastructure Planning – Linking Arkansas Communities* (2009) project. The *Linking Arkansas Communities'* model benefited from high-quality, local level data that large numbers of volunteer scientists collected and digitized over the course of the project. Unfortunately, most localities do not have armies of volunteers awaiting the call to collect relevant green infrastructure data.

While this habitat model borrows from the Fayetteville case study, statewide available surrogate data has replaced localized data from the case study. If a group interested in creating a green infrastructure habitat model has the funds or volunteers available to gather additional local data, they could refine the findings generated by the model. For example, if an additional research study found a particularly rare wetland or species, a habitat core might be ranked more highly. See the *Linking Arkansas Communities* report for methodologies and inspiration.

Using the Model Builder Tools

The Green Infrastructure Center created a set of GIS tools that automate the methodology described in Appendix A. The model tools require a license for the Spatial Analyst extension and ESRI's ArcGIS for Version 10 or later. If these are not available to you, partner with a nonprofit or educational institution that has GIS capabilities. Both the extension and the newer version of ArcGIS are available at significantly reduced rates to nonprofit and educational institutions.

GIS staff using this methodology will also benefit from a working knowledge of Python scripting. The model tools also require a number of datasets, which are all available for free online at either Arkansas's GeoStor website or from the Natural Resources Conservation Service's Geospatial Data Gateway. For more information on the model tool requirements and data needs, please see Appendix A.

The model creates two main outputs. These are shapefiles called GI Cores and Wildlife Corridors. The model calculates a number of attributes for each core. They include geometric attributes, such as core size, perimeter and thickness. Thickness measures the depth from the edge of a core to the deepest interior part. Thickness shows the amount of interior habitat in a core. Other attributes are surrogates for biodiversity, such as standard deviation of elevation for each core, the amount of grassland and wetland area, the amount of surface waters, and the variety of soil types.

The automation of the methodology with GIS Model Builder and Python scripting provides a number of advantages. First, the model is extremely scalable. It can run for any size of study area. The model automatically ranks cores in a comparative manner by sorting attributes described above into quintiles. The cores that rank within the highest quintile for all combined attributes receive a rank value of 5. The fourth highest quintile receives a value of 4, and so on, down to the lowest ranked cores with a value of 1. This ranking system identifies the highest value cores in the current study area.

Goldenrod and Bumblebees Woolsey Wet Prairie by Joe Neal.

Defining a Study Area

Defining a study area is an important first step in creating a green infrastructure model. Unfortunately, planning usually occurs along political boundaries instead of natural ones, so you will need to include cross-boundary natural assets in your assessment. In order to represent the importance of these assets, collect data from beyond the limits of the designated planning area. The standard extent is 10 kilometers (about 6 miles), but you can include more if you wish. This will help to fully assess the best natural resources, and could highlight opportunities for regional collaboration with neighboring localities, watersheds or planning districts.

Green Heron on Lake Atalanta by Joe Neal.

Identifying Cores

Cores are the most fundamental building blocks of a green infrastructure network. They contain the highest quality intact habitat and connect corridors across a landscape. Cores can be of different habitat types. In Arkansas, potential core habitat types include forests, wetlands, prairies, savannahs and aquatic habitats. Identified cores are from land cover imagery and other data layers. Please see Appendix A for data sources and GIS procedures that identify and assess cores.

Core size is important. Contiguous habitat of more than 100 acres qualify as cores at the landscape scale, although *Linking Arkansas Communities* established 20 acres as the minimum core size in their analysis, as a good minimum size for supporting a diversity of bird species. Indeed, areas even less than 20 acres can still be important at smaller, site level scales. However, this model for the statewide application in this guide selects 100 acre minimum size as the acreage most conducive to a wide diversity of species including large mammals. It also assesses cores for fragmentation and disturbance. Development features such as roads and buildings heavily fragment core areas.

Once all habitat cores are identified and assessed for minimum size and fragmentation, they are combined into a final dataset and ranked based upon interior features.

Identifying Impedances

Impedances are obstacles that prevent or discourage animals and plants from moving across the landscape. The model identifies impedances from a variety of sources, which are described in detail in Appendix A.

When using GIS to identify impedances, identify land cover that either prevents or encourages animal movement across the landscape. The list below covers major categories of features assessed in GIS for impedance value. A plus sign after an item on the list shows that it helps creatures move across the landscape. A minus sign shows that it inhibits animal movement.

Cores (+)
Interior Forests (+)
Land Cover (+/-)
Proximity to Urban Development (-)
Riparian Forests (+)
Roads (-)
Slopes (+/-)
Proximity to Address Points (-)

The model combines all impedance values into a single layer. This layer helps develop corridors in the green infrastructure network by showing which areas best facilitate animal movement Keep in mind that there are other uses for corridors, such as supporting pollinators or for recreation.

Developing Corridors

Corridors connect high-ranking cores. They allow for animals and plants to move across the landscape and are fundamental to a properly functioning green infrastructure network. Corridor analysis requires the most intense GIS work when creating a green infrastructure model. The more connections in a network, the more calculations and time it will take to analyze them. Python scripting automates the corridors analysis component of the model. The script, named Corridor Analysis, uses the output from the network GIS Model Builder model to connect the highest ranked cores (values 4 and 5) and undergoes a series of calculations for each one.

The calculations find the 'cost of travel' between each of these cores based on the impedances discussed above. It then creates corridor shapes based on the least costly (easiest) path of travel between each of the highest ranked cores. The output is a shapefile called Wildlife Corridors. The maintenance of a functional green infrastructure network will require the protection and potential expansion of these corridors.

For more information about the GIS procedures required to create corridors to connect cores, see Appendix A.

Thematic Natural Asset Maps

Creating a series of themed maps illustrates the relationship between the green infrastructure network and other diverse natural resources priorities and issues. A single map that attempts to show all issues at once is unreadable.

Data availability is the main limiting factor in thematic mapping. You can potentially fill missing data gaps by engaging local organizations. Bird watching groups, historical societies, professional farming or forestry groups, outdoor recreation enthusiasts and tourism departments can all provide valuable information for themed resource maps. Community workshops with relevant local groups are other excellent opportunities to determine local priorities.

The following section presents suggested themed maps. Create additional thematic maps based upon local priorities, goals and resource risks.

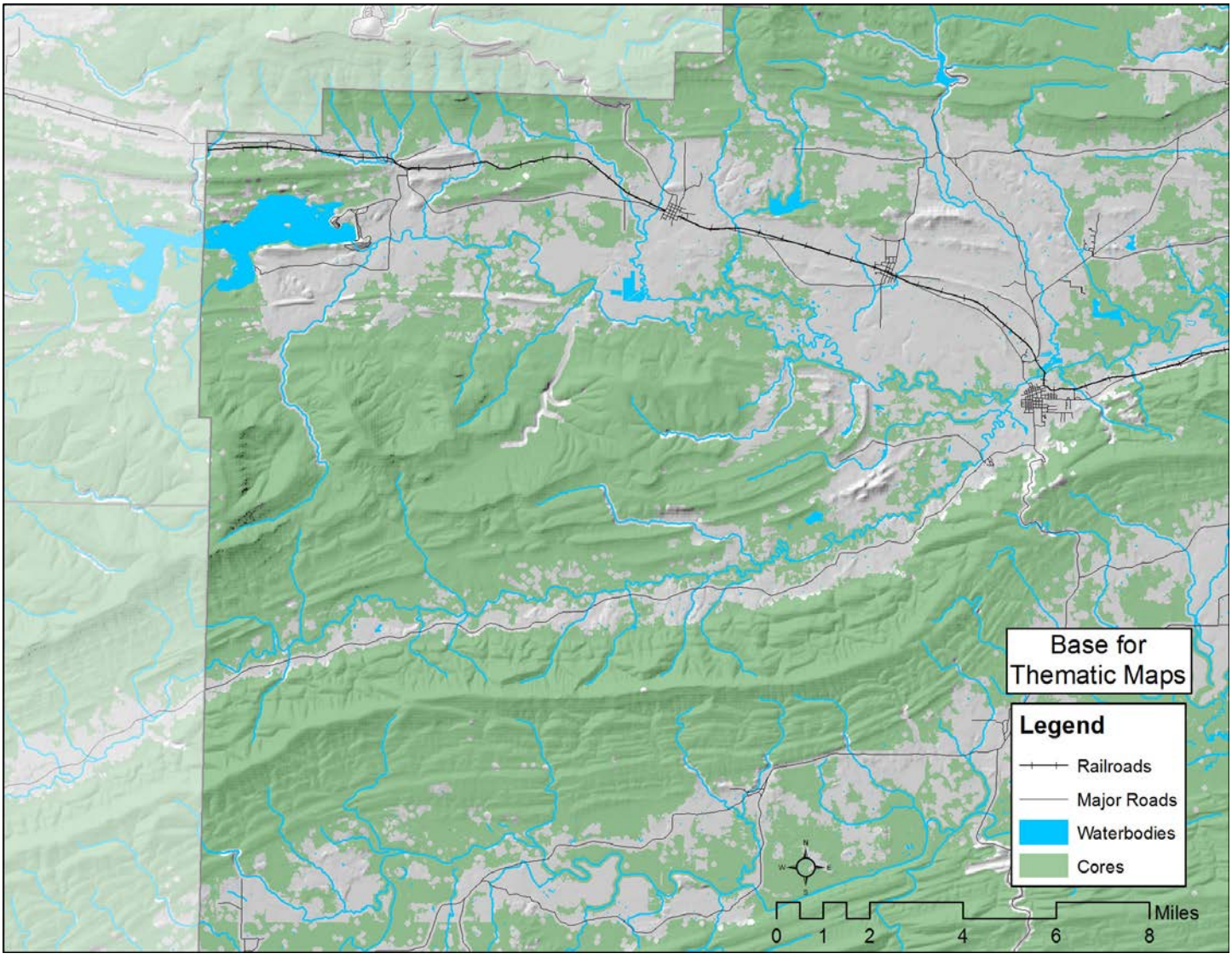
THEMATIC MAPS COULD INCLUDE THE FOLLOWING:	
Adjacent Water Features	A map showing all wetlands, floodplains and habitat cores.
Agriculture Map	A map showing prime and important agricultural soils, agricultural districts, and habitat cores.
Base Map	A map showing all of the habitat cores displayed by their overall Core Rank.
Birds Map	A map showing important bird habitat, bird watching opportunities and habitat cores.
Drinking Water	A map showing important reservoirs, reservoir catchments, aquifers, waters classified for drinking water use and habitat cores.
Favorite Places	A map created by the community during an open house which has their favorite places.
Forestry	A map showing forestry tax use lands, forestry stewardship plans, potentially viable silvicultural lands and habitat cores.
Historic, Cultural, and Scenic Resources	A map showing cultural trails, scenic roads, mountain peaks, wineries, breweries, distilleries, historic areas, agricultural tourism trails and locations, and habitat cores.
Hunting and Fishing	A map showing public hunting lands, private hunting lands, trout waters, top fishing waters and habitat cores.
Recreation	A map showing publicly accessible recreational features such as hiking, equestrian and bicycle trails, swimming areas, etc.
Water Resources	This map shows state regulated wetlands, waters ranked for biodiversity, major watersheds and habitat cores.

The Base Map

The base map contains the underlying set of layers for all other thematic maps. It orients viewers to the area under examination. The map should include familiar features such as the transportation network, towns and cities, major water bodies and rivers, a hillshade layer and the green infrastructure network.

All data suggested for the base map are either generated by the green infrastructure network model or are available from the Arkansas GeoStor GIS Platform simply by searching for the layer name. Layers for the base map that are available on GeoStor include the Arkansas road Inventory; railroads; and stream order classification. Those data sets that are high resolution include: the National Hydrography Dataset Waterbody Feature (2006); the Five Meter Resolution Hillshade Model; and county boundaries.

The Green Infrastructure Center has worked extensively with many localities to create thematic resource maps. It has learned that some cartographic steps can help communicate the resources displayed in maps clearly to a wide variety of audiences. Since the base map underlies all other themes, it needs to be free of clutter and avoid distracting colors. For example, road and stream networks can be extremely busy. Removing less-important features can reduce the visual clutter that make such maps difficult to interpret. You can remove unnamed streams and lakes or unpaved roads or, if the network is still overwhelming, remove all non-highway roads.



Map 1 – Base Map

A semitransparent mask around the study area will show features outside boundaries, which will emphasize cross-boundary connections while simultaneously muting them, so they can be seen but do not interfere with the overall visual comprehension of the project or jurisdictional boundary.

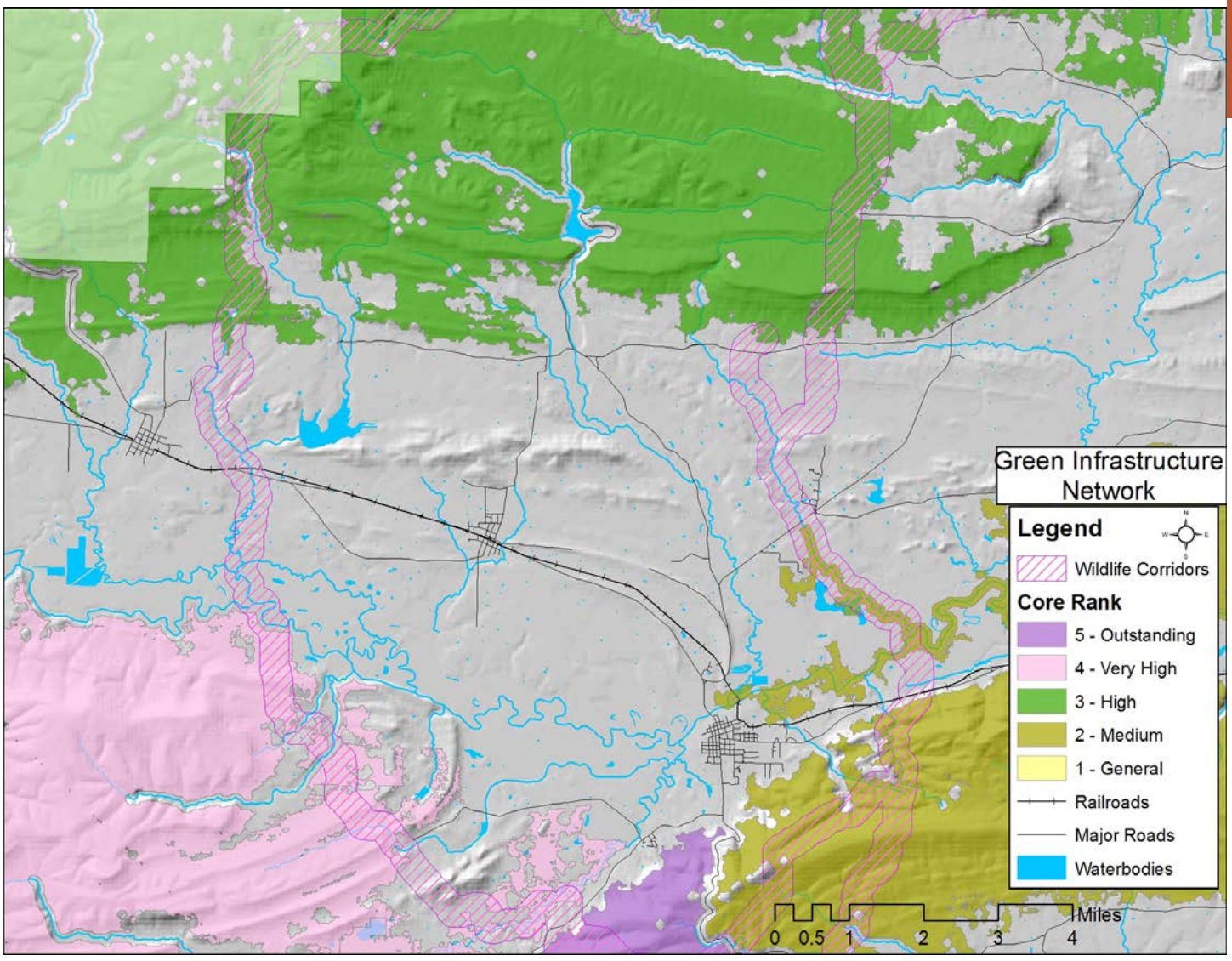
On most maps, the green infrastructure network should be included as a single color. This will show the relationship between key resources and the natural assets of the study area.

Any colors chosen for layers should be consistent throughout all maps to avoid confusion. They should also include a legend, north arrow, scale bar and labels on appropriate major features, such as cities, major towns, highways, and significant water bodies and mountains. Page 116 shows an example base map.

The Green Infrastructure Network Map

Display the green infrastructure network on a map and color cores by their core rank. Display wildlife corridors. These ranks are the only difference between this map and the base map. They help audiences identify the most important cores in the area's network. A project may also wish to generate a map that shows all the cores and another on which only the highest ranked cores are displayed.

Below is an example of a GI Network Map.



Map 2 – Green Infrastructure Network

Cultural, Historic and Scenic Resources Map

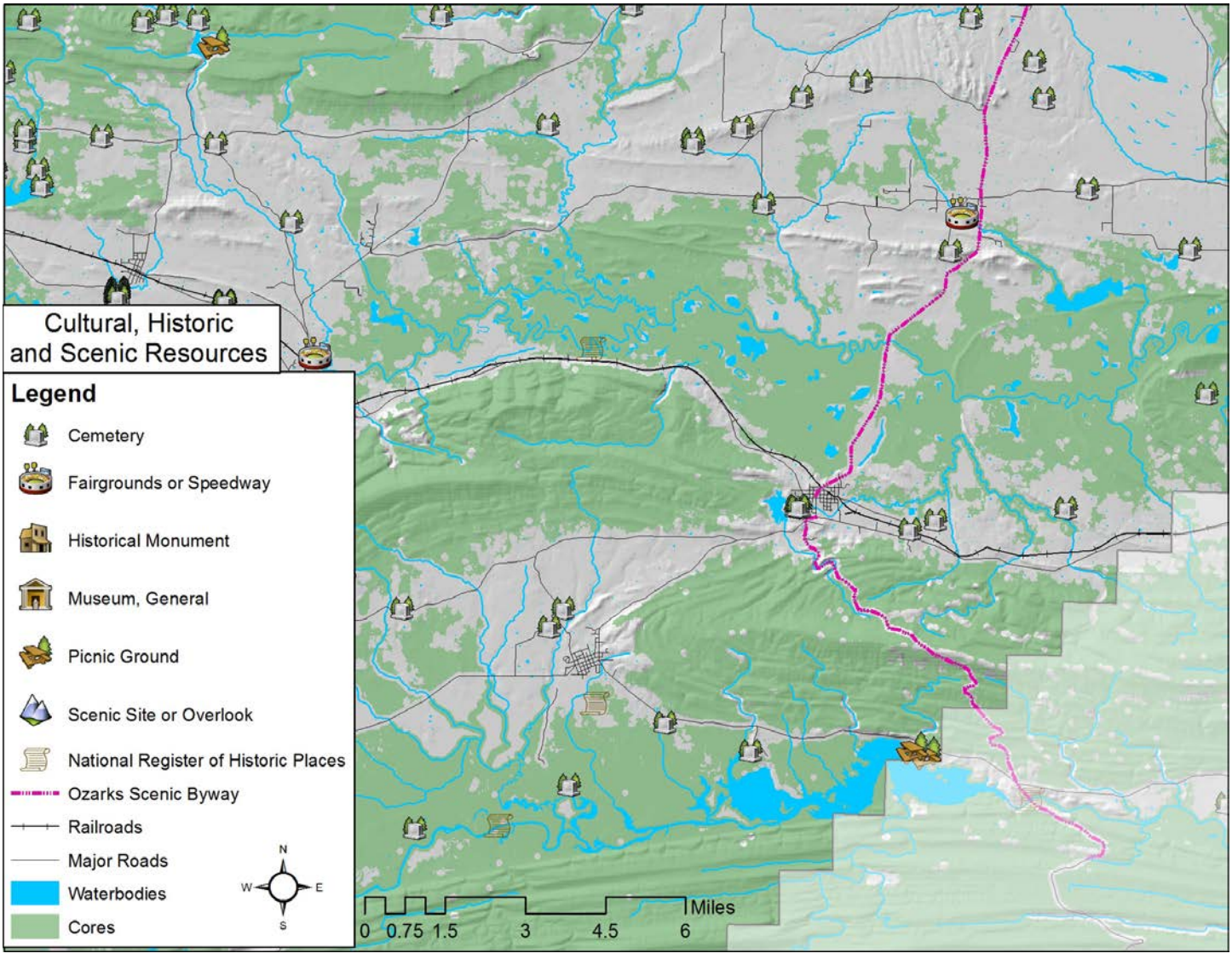
Cultural, historic and scenic resources play an important role in green infrastructure networks. These include such cultural assets as old mills and churches, scenic roads, tourist and bicycle routes, county court houses, and other key locales. Many of these resources rely on beautiful vistas and abundant natural resources. For example, bed and breakfast establishments and restaurants benefit from having scenic vistas that attract visitors. A single map or a series of maps can highlight the connection between these resources and a natural asset network.

Historic buildings, natural areas, and scenic drives and trails all need attractive viewsheds. A potential visitor can experience cultural treasures anywhere, but the natural landscape of Arkansas is a large part of why they choose to visit or live there. As future parks are created, areas that include key resources can be selected with their viewsheds in mind.

The Arkansas Geographic Information Office's GeoStor GIS Platform contains many statewide datasets that highlight cultural, historic or scenic resources. These layers include:

- The Ozark National Forest Scenic Byway and Scenic River Corridor
- National Register Properties
- Historical Monuments
- Natural and Scenic Waterways
- A large dataset called All Cultural Feature that contains many different resources, ranging from cemeteries and monuments to boat ramps, picnic areas and scenic overlooks.

Below is an example of a Culture, Scenic and History Resource Map.



Map 3 – Cultural, Historic and Scenic Resources

Water Resources – Assets

Water resources deserve a dedicated map or set of thematic maps. These resources provide clean and abundant water for people and industry, opportunities for recreation, and habitat for fish and wildlife. The landscape around water resources has a great influence on their quantity and quality and habitat cores are extremely important for maintaining good water quality. They filter pollutants, reduce erosion, increase water storage capacity and provide shade that cools waters and maintains oxygen levels.

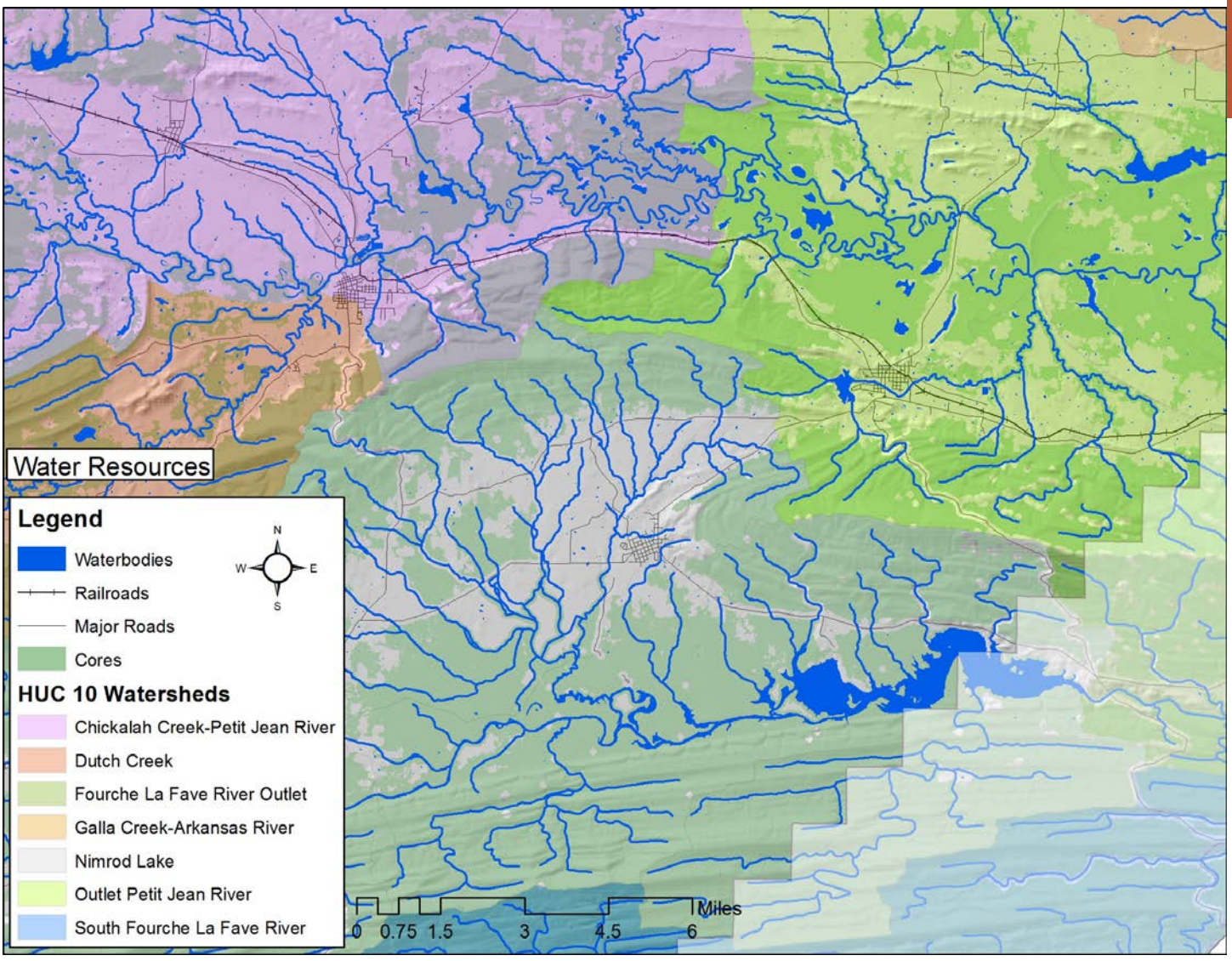
GeoStor has a wide variety of water-resource-related datasets available for download. Those layers available include: dams; extraordinary resource waters; ecologically sensitive streams and water bodies; high resolution national hydrography datasets; natural and scenic waterways; watersheds; public water systems; and trout streams.

Water resources can be very important and numerous in a locality. Multiple water resource maps divided by sub-theme may be required to adequately communicate this importance and variety. Some sub-themes could include recreational waters or drinking water supply.

Below is an example of a General Water Resource Map.

Water Resources - Risks

Once green infrastructure assets have been mapped, they should be analyzed for risk. For example, impaired waters pose a risk to downstream waters. This problem will need to be rectified to ensure the long-term health of the waterway and downstream waters. Consider whether improving streamside forested



Map 4 – Water Resources

buffers or improved reservoir management practices could restore the health of a waterway.

Towns can also overlay their zoning and ask questions such as: "Are these cores likely to be conserved or more likely to be developed?"; "Should zoning be changed to a less intensive use to protect the cores?"; "Should they be removed from the map?"; and, "Can these landowners develop their land using conservation approaches that leave cores connected and reduce their development footprint?"

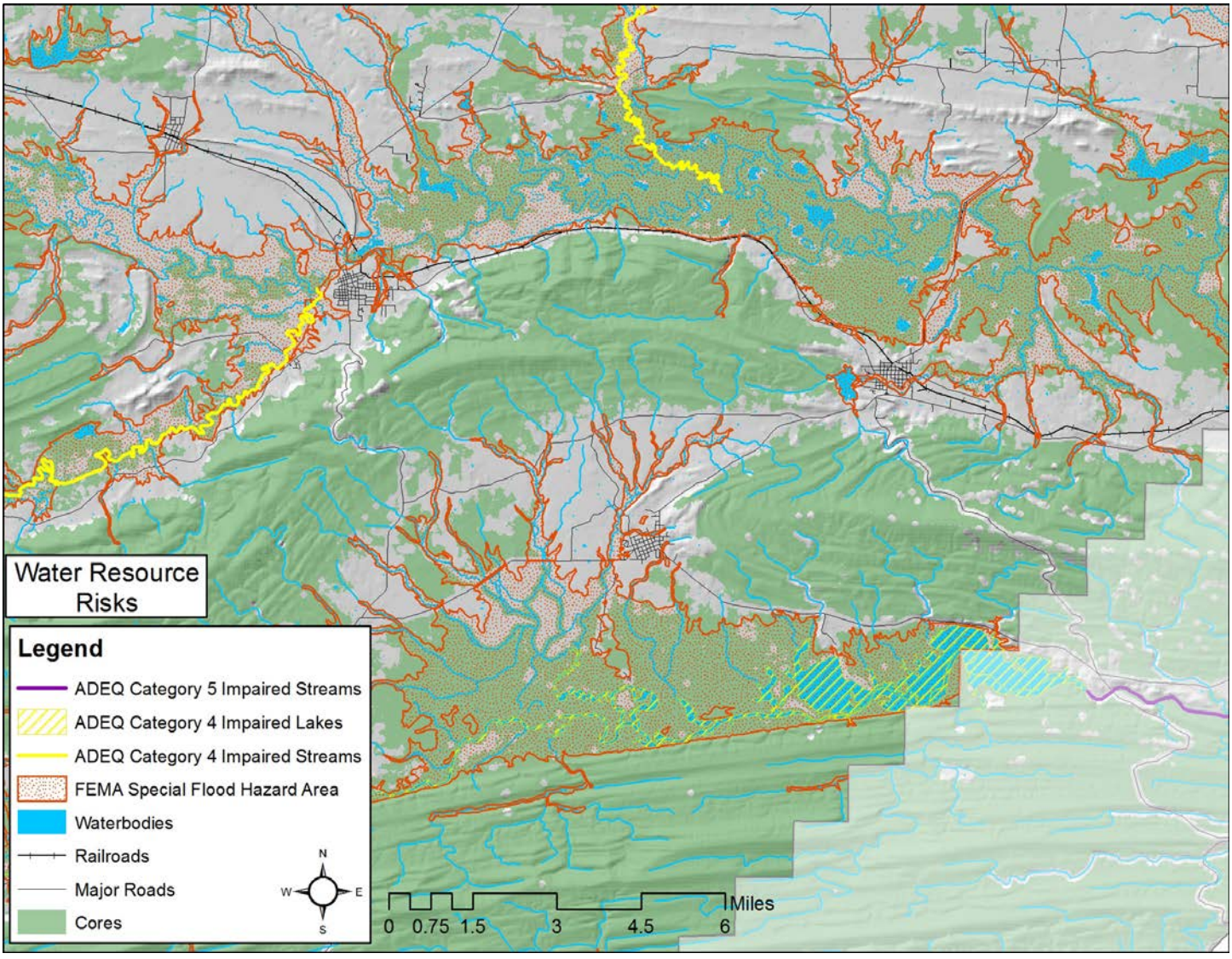
Other types of risk include areas subject to flooding. For example, floodplains can be evaluated to determine if their location threatens existing development and to avoid building there in the future.

The example map below highlights water risks using GIS data available for free from GeoStor. These layers include Impaired Lakes and Streams 303 D list and flood hazard zone polygons from the Federal Emergency Management Agency (FEMA).

For more information about FEMA flood hazard zone definitions, visit http://www.fema.gov/floodplain-management/flood-zones.

Another water risk dataset available on GeoStor (not included in the example map) contains nutrient surplus area polygons.

Below is an example of a Water Resource Risk Map. This map can be used to inform where protecting or restoring forested land cover is most important, especially if the stream is impaired by land runoff.



Map 5 – Risks to Water Resources

Working Lands

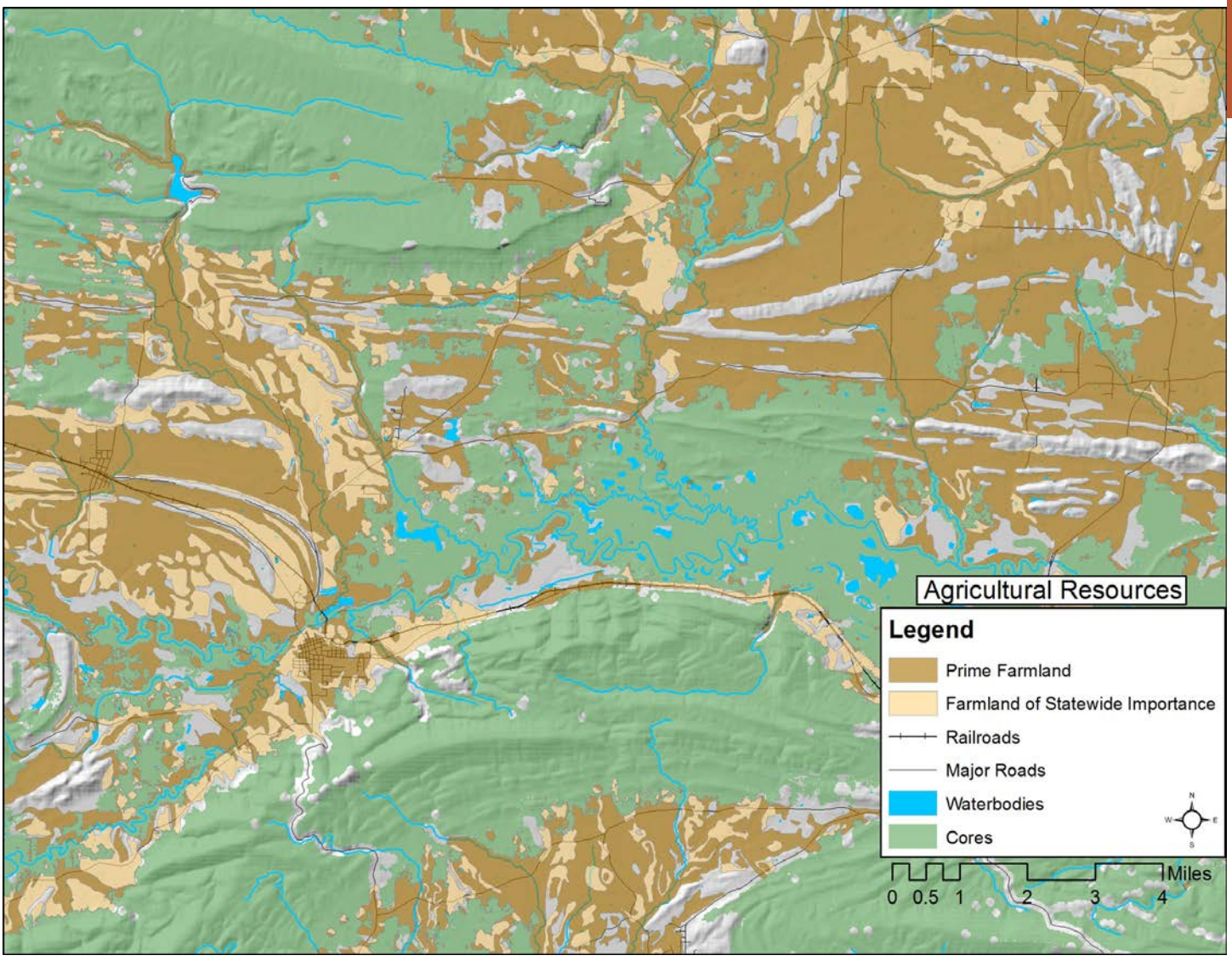
The agriculture and forestry industries provide jobs, food and other products. They are an integral part of Arkansas's identity and are a source of cultural pride. Both rely on the surrounding landscape for a number of services. For example, habitat cores create additional food sources for pollinators and provide habitat for a number of species that are predators of crop-harming invasive pests. Farms and forested lands also provide scenic views that attract customers to the state's tourism industry.

Agriculture

Proper farm management can create connections between cores, protect streams and other waters, and keep land in viable rural economic use while providing a source of local food. Agriculture is an important land use, not only for supplying food and contributing to the local economy but also for keeping land in rural uses. A map of agricultural assets can be produced on its own, to show agricultural potential, or be overlaid onto habitat cores, to show its relationship to the green infrastructure core network.

The main dataset for agriculturally themed maps is not available via GeoStor. However, Soil Survey Spatial and Tabular Data (SSURGO) that identify different soil types nationwide are available free of charge from the United States Department of Agriculture's Natural Resources Conservation Service's GeoSpatial Data Gateway (http://datagateway.nrcs.usda.gov/). Some pre-processing is required to use this data in GIS and all instructions included in downloaded files should be read thoroughly.

When mapping agricultural soils, the FarmIndcl field



Map 6 – Agricultural Resources

in the SSURGO's attribute table can identify prime farmland and farmland of statewide importance. These are the best soils to map for an agriculturally themed map.

Further processing can help determine viability for farming on these soils. Removing soils that overlap the green infrastructure network model's cores and corridors will show agricultural areas that can be productive without damaging the natural habitat network.

Parcelization, or the splitting of large areas of land into small parcels for development, is a serious threat to the viability of local agriculture. Parcel data are available for most counties via GeoStor or locally from the county tax assessor's office. Identify this threat by finding parcels that contain prime agricultural soils.

The dissolve tool in GIS can identify parcels based on ownership. To do this, you will need parcel ownership data from the locality. This determines if a landowner has more than one parcel.

Removing parcels dissolved by ownership below a minimum size threshold will highlight potentially viable farmland. Oftentimes, one farm is made up of several parcels acquired over time so it is important to understand the actual size of the farm when determining if it is large enough to actually support agriculture. To determine the minimum size for a farm to be successful, speak with your local agricultural extension office. For example, certain row crops, such as soy and corn, require larger acreage than other types of crops to be economically viable. Additional data for an agricultural themed map are available on GeoStor. These include chicken houses, grain elevators and nutrient surplus areas. These data can help highlight areas where a viable agricultural economy is present. Local data for farmers markets and stands, breweries, agricultural districts, or other agri-tourism should also be mapped if available. This will show the importance of working lands to the local culture and economy.

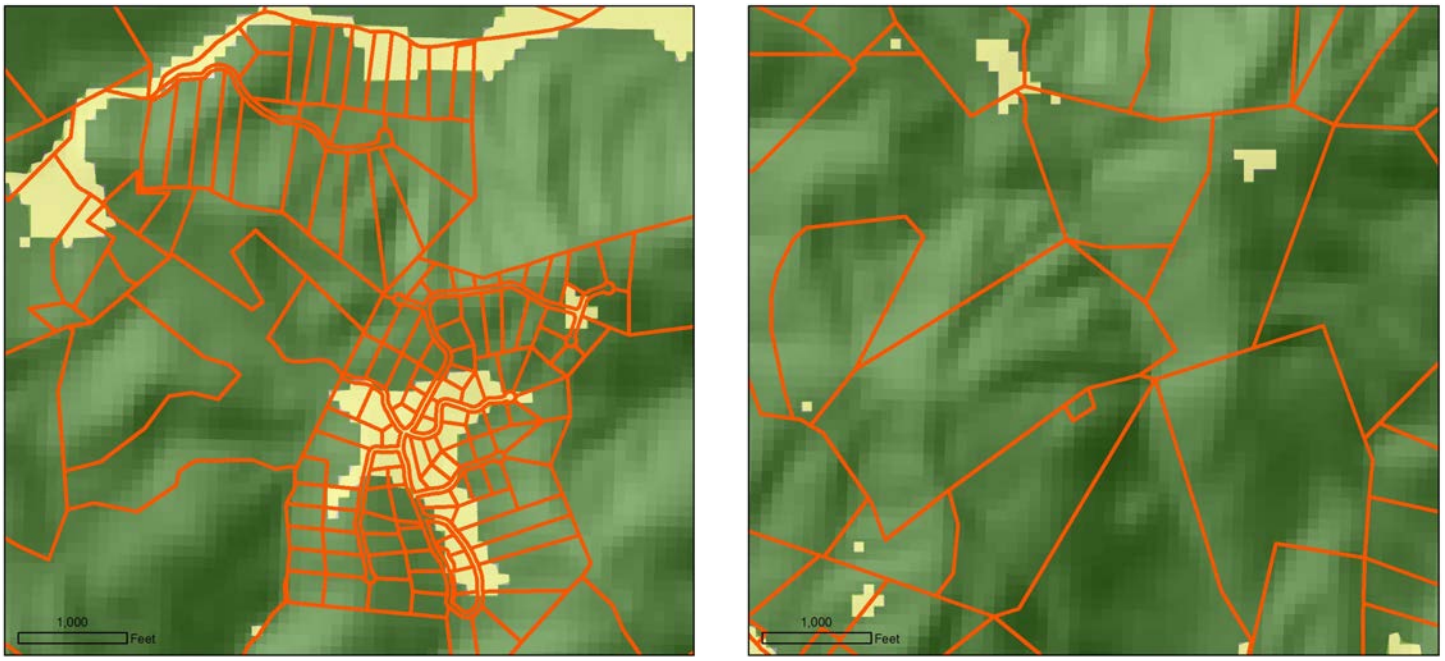
Forestry

Forests provide multiple economic and environmental benefits. A forest absorbs and cleans pollutants from land runoff while also reducing flooding that damages homes and property. A forest performs this work more cost-effectively than an engineered stormwater pond and provides additional services, such as recreation, natural beauty and sequestration of carbon and other pollutants that contribute to climate change. A national study of urban tree cover's capacity to reduce stormwater problems and improve air quality concluded that trees in cities provide more than $400 billion in cost savings from not having to build facilities to clean our air and water. According to the Trust for Public Land, studies have documented that

the larger the forest cover in a watershed, the lower the cost to treat drinking water. Finally, the county's forests are an important component of the county's working lands, with timber products helping to sustain the local and regional economy.

Similar to agriculture, a sustainable forestry industry requires sufficient land to maintain economic viability. In general, sustainable management is possible for forests greater than 25 acres. Forests greater than 100 acres in size can be managed both for timber and wildlife. A potential thematic map could identify parcels by owner, as described above, and then calculate forest cover for those parcels. If an owner has more than 25 or 100 acres of forested land, effective outreach could help an owner properly manage their land for timber or wildlife.

Another potential forestry thematic map is a fragmentation potential map. Forest fragmentation is the creation of smaller tracts of land by road building and property subdivision. While the network model assesses fragmentation by roads, analysis did not include parcelization. By overlaying parcels onto a land cover map that shows only forests, platted, but not yet developed, parcels become apparent. By identifying these at risk areas, preventative efforts can focus on working with landowners to change the plat or working with developers to create less fragmentation with different development patterns. See the example parcelization analysis maps below.



Map 7 – Forest Resources Parcelization Analysis. LEFT: Too many small parcels are not viable for sustainable forestry. RIGHT: Large parcels with little development are viable for forestry.

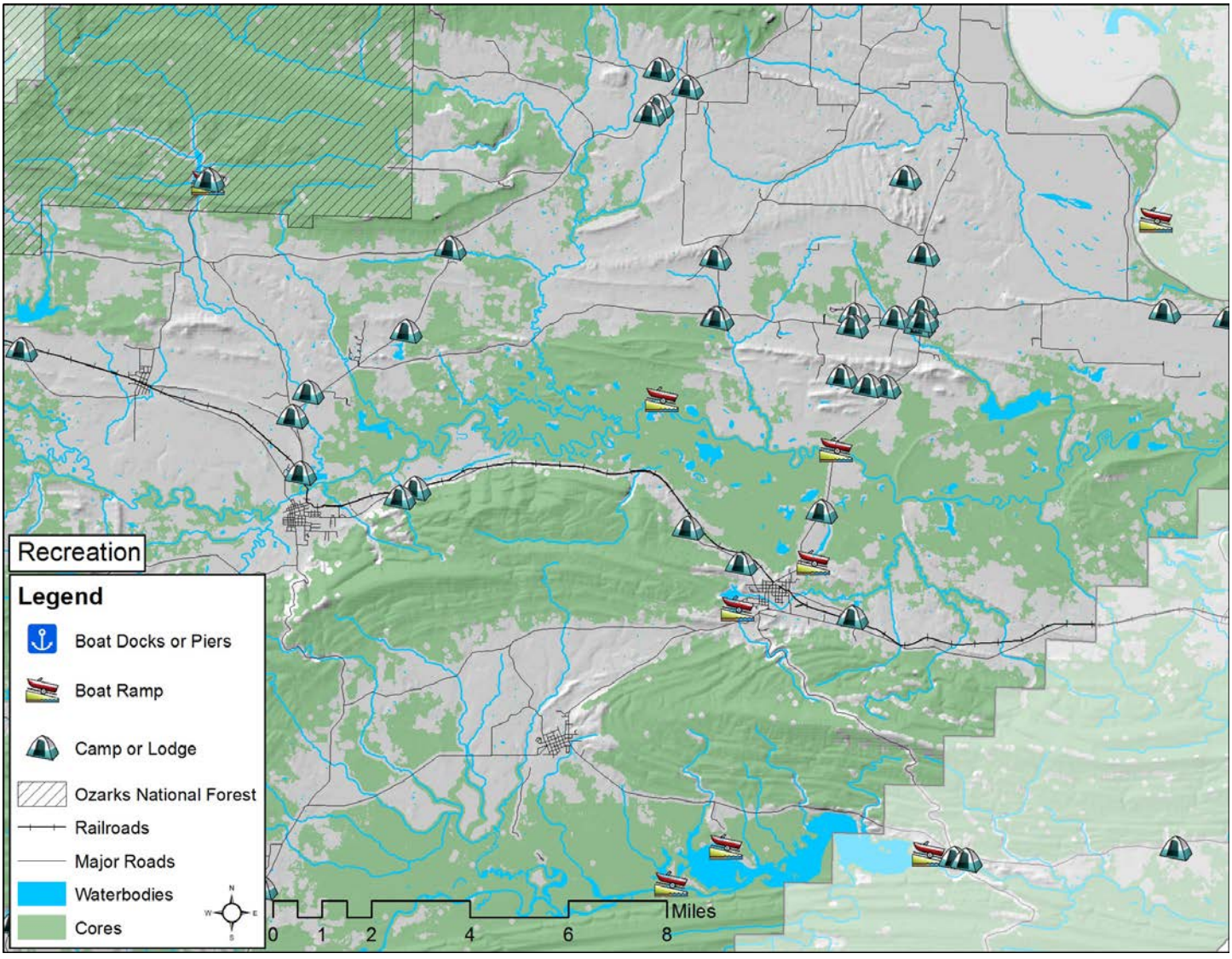
Recreation

Recreational and adventure tourism provide ways for communities to generate employment and revenue while simultaneously protecting and enhancing their natural assets. They also increase local quality of life by providing access to healthy, outdoor recreational activities. Recreationally themed maps highlight areas where recreational activities are economically sustainable as part of viable natural habitat land use and advertise these areas to potential visitors.

Multiple themed maps will clearly communicate the variety of recreational opportunities available locally. Local data from tourism offices and sport or hunt clubs, such as those dedicated to bicycling or hunting can flesh out these maps.

Potential recreational sub-themes could include bird watching, recreational trails of different types (biking, hiking, driving, and more), boating, hunting, camping, and fishing.

Datasets for recreational themed maps are available on GeoStor. These datasets include: trout lakes and streams; public land boundaries; boat docks, piers and ramps; and Ozarks National Forest trails and recreation sites. See the example of a Recreation Map below.



Map 8 – Recreational Resources

Favorite Places

As part of its projects, the Green Infrastructure Center often creates a thematic map it calls the Favorite Places Map. This highlights places of interest for the community.

The GIC creates such favorite places maps by providing a large printed map at a community open house. Attendees are encouraged to add areas to the base map that are important to them within the context of green infrastructure.

Project staff can digitize these maps in GIS, categorize them and add appropriate symbology. The favorite places map is useful to build support for green infrastructure planning by helping the community understand how green infrastructure plays a role in their daily lives and in supporting landscape elements and uses they care most about. It also gives the community a voice in the planning process and presents an opportunity to add data that may have been missed.

In this chapter, we have provided examples of themed maps and how green infrastructure mapping supports multiple community values and land uses as well as analysis and everyday planning needs. In Appendix A, we provide the technical instructions for how to create the maps. A CD is available with the GIS mapping instructions for those who would like to paste the instructions into their script (this requires GIS ArcView Version 10 or later).

APPENDIX A - Technical Instructions for GIS Model

BUILDING A HABITAT MODEL

This appendix is written for GIS technicians who are skilled in using ArcView GIS.

DISCLAIMER: This model draws heavily from the *Green Infrastructure Planning – Linking Arkansas Communities* GIS methodologies. *Linking Arkansas Communities* draws significantly from Maryland's Green Infrastructure Model. The model built for this guide by GIC updates *Linking Arkansas Communities* with several new datasets and includes surrogates for some of the data collected for that project. The *Linking Arkansas Communities* project described in Chapter Five of this guide benefited from thousands of volunteer hours from scientists, students, naturalists and other committed citizens.

The model presented in this appendix assumes that a large volunteer pool of experts is not available for the project. It makes use of as much standardized, statewide data as possible to ensure that data are uniform and comprehensive. It also ensures that any locality or organization has the necessary data to build a green infrastructure network. The emphasis for this model is on fast and simple replication. The cheaper and easier it is for a locality to create a green infrastructure network model, the more likely a locality will create and use it. If additional new data can be collected by trained volunteers or experts and it is collected consistently across the entire project area, then it may also be used to build a more detailed or precise model. For example, new data about rare species could be collected and utilized to more highly rank a core if new species are found in field surveys.

Please note that this is a suggested methodology. Additionally, model users must treat any green infrastructure network model as a living model. This means regularly updating the model with newer versions of data incorporated into the model and with completely new datasets as well. The model should change to reflect new knowledge as well as changing priorities, risks and opportunities. This is why this guide provides the full methodology and the model is available as a geodatabase containing all of the tools used to create the model. Request a DVD from GIC if you would like to have the script to run the model.

Special Thanks To the Reviewers Who Provided Feedback On This Methodology For Arkansas:

Jim Jolley, Arkansas Forestry Commission
Ethan Inlander, The Nature Conservancy
Barbara Boland, FNHA Project Coordinator, GIS Technician, Cartographer

Use of Models

This methodology:

- Requires the Spatial Analyst extension.
- Was created using ArcGIS 10.1.
- Was developed using the model builder for ArcGIS 10.1.
- Includes a number of Python scripts. Knowledge of Python scripting is not necessary to run the model, however, it will help to know Python when updating or customizing the model. The methodology details scripts used in the model.

Use of Terms

Please note that shapefiles, rasters and other data files are in *italics*.

CAPITAL letters represent GIS tools. Geoprocesses with multiple rows for a single input are separated from the rest of the process by a **thick** border around related cells.

Setting Map Parameters

Setting map parameters helps standardize data environments. Standardizing parameters ensures that all data can be calculated, transformed and transferred easily, quickly and consistently. Setting parameters means the projection, raster cell size and data extent require definition. This is a simple, but very important, process that must be completed for every dataset, both raster and vector, utilized in this model.

Before setting parameters, create a file geodatabase for your model. This maintains data in a single, organized location.

For this tutorial, *GI Network.gdb* is the geodatabase's name. Save all data within this geodatabase. It will be the workspace for this project and all outputs will be stored there.

Standardize projection, cell size and extent for all data in your model. This prevents inconsistencies between datasets.

There may be a more accurate projection, cell size or extent for your locality than those suggested in this model. Recommendations in this methodology come from map parameters for the Arkansas 2006 Land Use Land Cover imagery and other data downloaded from the state's GeoStor online repository.

From this point on, the methodology assumes users reproject all data to conform to these parameters.

Map Parameters

Spatial Reference	NAD83_UTM_zone_15N
Linear Unit	Meter
Angular Unit	Degree (0.0174532925199433)
False_easting	500000
False_northing	0
Central_meridian	-93
Scale_factor	0.9996
Latitude_of_origin	0
Datum	D_North_America_1983
Cell Size	28.5 meters x 28.5 meters

Obtaining Data

In order to run the model, you will need to obtain the datasets listed below. The model will ask you to give the directory location for each of these datasets. It may be a good idea to import each of them into *GI Network.gdb*. There may be additional datasets that you also wish to incorporate into your project. This will require editing the model to meet your needs.

Dataset: AGRIC_DBO_STATSGO_SOILS_polygon
Download Location: Arkansas GeoStor
Description: USDA STATSGO level soil data.

Dataset: CULTU_DBO_TRANSP_FEATURES_GNIS_USGS_point
Download Location: Arkansas GeoStor
Description: Transportation point features. Contains bridges and other crossings.

Dataset: National Elevation Datasets
Download Location: NRCS Geospatial Data Gateway
Processing Notes: This data comes in multiple raster image files that will vary depending upon the size of your study area. Mosaic all files for the study area into a single raster called *Elev_Mosaic*.
Description: Digital elevation models.

Dataset: IMAGE_DBO_LANDCOVER_30M_CAST_1993
Download Location: Arkansas GeoStor
Description: Gap Analysis Program data that categorizes 38 different types of land cover.

Dataset: IMAGE_DBO_LULC_FALL_CAST2006
Download Location: Arkansas GeoStor
Description: Land use and land cover data.

Dataset: National Land Cover Dataset
Download Location: NRCS Geospatial Data Gateway
Processing Notes: Mosaic all files for the study area into a single raster called *NLCD_Mosaic*.
Description: Land cover data.

Dataset: STRUC_DBO_SITUS_ADDRESS_PT_point
Download Location: Arkansas GeoStor
Description: Address points that show the location of structures. This dataset covers most of, but not all, the state of Arkansas.

Dataset: Study Area
Download Location: Varies
Processing Notes: User-defined area. Study area could include a county or regional boundary, or even a watershed.
Description: This will be the project boundary.

Dataset: TRANSP_DBO_ROADS_ALL_AHTD_line
Download Location: Arkansas GeoStor
Description: Transportation data in line format. It includes roads, highways and railways.

Dataset: WATER_DBO_NHD_HIGH_RES_WATERBODY_USGS_polygon
Download Location: Arkansas GeoStor
Description: High resolution data for waterbodies in Arkansas.

Dataset: WATER_DBO_STREAM_ORDER_ADEQ_line
Download Location: Arkansas GeoStor
Description: Streams in Arkansas with their stream order noted in the attributes.

Defining a Study Area

Green infrastructure assets do not stop at jurisdictional boundaries. A green infrastructure network model must be able to assess values of resources that cross boundaries. While only a sliver of a hub or core may exist within your jurisdiction, it may be an integral connection to a larger, high-value network in a neighboring state, county, planning district or watershed. To accommodate this, make the study area larger than the current planning area (jurisdictional boundary). We suggest you extend it by at least ten kilometers (6.2 miles), but the feel free to expand the size based upon the preferences of your locality.

Buffer

Input Features	*jurisdictional_boundary*
Output Features	*study_area*
Distance, Linear Unit	10 kilometers
Side Type	FULL
End Type	ROUND
Dissolve Type	None

All data collected for the model should be within this boundary. To obtain some data, you may have to contact neighboring jurisdictions that fall within the study area boundary. Arkansas's Geostor houses most data for the model. To reduce data processing times and file sizes, consider clipping vector data and extracting raster data by mask to this boundary.

Please note that all models created for these processes include the CLIP or EXTRACT BY MASK to the *study area* function as necessary.

Identifying Cores

The first step in creating a green infrastructure network is identifying the core habitat areas. These include forests, wetlands, streams, lakes and grasslands. The model identifies cores in GIS with land cover imagery data. The methodology identifies intact, interior habitat areas.

Identify Appropriate Land Cover

1. Identify land cover data for the study area with EXTRACT BY MASK.
Input raster, IMAGE_DBO_LULC_FALL_CAST2006
Input raster or feature mask data, *study_area*
Output raster, *LULC*

2. Identify forest type land cover with RECLASSIFY.
Input raster, *LULC*
Reclass field, Value
Reclassification

Old Values	New Values
11 – 49, 52 – 99, 102 – 210, No Data	0
50 – 51, 100 – 101 (represent Forest Cover)	1

Output raster, *Forest_LULC*

Define Interior Forest Areas

1. Identify paved and unpaved roads in the *study_area* with CLIP.
Input features, *TRANSP_DBO_ROADS_ALL_AHTD_line*
Clip Features, *study_area*
Output Feature Class, *roads*

2. Convert the polyline shapefile to raster format with POLYLINE TO RASTER.
Input Features, *roads*
Value field, *ROAD_TYPE*
Output Raster Dataset, *roads_grid*
Cell assignment type, MAXIMUM_LENGTH
Priority field, NONE
Cellsize, 28.5000000006032

3. RECLASSIFY *roads_grid* to identify paved and unpaved roads. The table below shows the descriptions for the old values. If values for *TRANSP_DBO_ROADS_ALL_AHTD_line* differs in your *study_area*, use a "1" for road values that are unpaved and a "0" for paved roads.
Input raster, *roads_grid*
Reclass field, Value10

Old Values	New Values
1, 4 , 7 – 11, NoData	0
2 – 3, 5 -6	1

Output raster, *not_paved*

Value	ROAD_TYPE
1	City_Street_Paved
2	City_Street_Unpaved
3	County_Road_Unpaved
4	County_Road_Paved
5	County_Road_Graded_Drained
6	County_Road_Unimproved
7	Miscellaneous_Roads
8	State_Highway_HTB
9	State_Highway_LTB
10	US_Highway_HTB
11	Interstate_Highway

Table 1 - Old Values for TRANSP_DBO_ROADS_ALL_AHTD_line.

4. Combine *Forest_LULC* and *not_paved* rasters using the RASTER CALCULATOR.
Map Algebra expression, "*Forest_LULC* + *not_paved*"
Output raster, *forest_suit*

5. RECLASSIFY again to switch values of zero and one.
Input raster, *forest_suit*
Reclass field, Value

Old Values	New Values
1, 2	NoData
NoData, 0	1

Output raster, *not_forest*

6. Calculate the EUCLIDEAN DISTANCE of *forest_suitReclass*.
Input raster or feature source data, *not_forest*
Output distance raster, *forest_Euclid_dist*
Maximum distance, NULL
Output cell size, 28.5000000006032
Output direction raster, NULL

7. RECLASSIFY *forest_Euclid_dist* to identify a 100 meter buffer between forests and paved roads. This identifies interior forest.
Input raster, forest_Euclid_dist
Reclass field, Value

Old Values	New Values
0 – 100, NoData	NoData
100.00001 - 100000000	1

Output raster, forest_100mInt

Identify Forest Cores

1. Use REGION GROUP to identify contiguous interior forests.

Input raster, *forests_100mInt*
Output raster, *forests*
Number of neighbors to use, EIGHT
Zone grouping method, WITHIN
Add link to field to output, checked
Excluded value, NULL

2. Utilize EXTRACT BY ATTRIBUTES to identify cores of at least 14250 pixels in size. 14250 pixels of 28.5 meters squared is approximately 100.35 acres. This is the minimum size for cores throughout scientific literature.

Input raster, *forests*
Where clause, COUNT >= 14250
Output raster, *forests_by_cores*

3. RECLASSIFY all values to equal 1.

Input raster, *forests_by_cores*
Reclass field, VALUE

Old Values	New Values
1 – 100000000	1
NoData	0

Output raster, *forest_cores*

Aquatic Cores

Identify Waterbody Cores

1. Identify waterbodies within the study area with CLIP.

Input features, *WATER_DBO_NHD_HIGH_RES_WATERBODY_USGS_polygon*
Clip features, *study_area*
Output Feature Class, *waterbodies*

2. Identify only named waterbodies using SELECT.

Input Features, *waterbodies*
Output Feature Class, *waterbodies_named*
Expression, "GNIS_NAME" <> ' '

3. Convert POLYGON TO RASTER.

Input Features, *waterbodies*
Value field, GNIS_NAME
Output Raster Dataset, *waterbody_grid*
Cell assignment type, MAXIMUM_AREA
Priority field, NONE
Cellsize, 28.5000000006032

4. Simplify *waterbody* values with RECLASSIFY.

Input raster, *waterbody_grid*
Reclass field, GNIS_NAME

Old Values	New Values
1 - 999999999	1
NoData	NoData

Output raster, *Lakes*

5. Calculate the EUCLIDEAN DISTANCE for *Lakes*.

Input raster or feature datasource, *Lakes*
Output distance raster, *lakes_Euclid_dist*
Maximum distance, NULL
Output cell size, 28.5000000006032
Output direction raster, NULL

6. RECLASSIFY *lakes_Euclid_dist* to determine buffer.

Input raster, *lakes_Euclid_dist*
Reclass field, Value

Old Values	New Values
0 – 100	1
100.001 – 9999999999	0
NoData	NoData

Output raster, *lakes_buff*

Identify Stream Cores

1. Identify streams within the *study_area* using CLIP.

Input Features, *WATER_DBO_STREAM_ORDER_ADEQ_line*
Clip Features, *study_area*
Output Feature Class, *stream_order*

2. Convert stream_order to raster using POLYLINE TO RASTER.

Input Features, *stream_order*
Value field, SO
Output Raster Dataset, *stream_order_grid*
Cell assignment type, MAXIMUM LENGTH
Priority field, SO
Cellsize, 28.5000000006032

3. RECLASSIFY *stream_order_grid* to determine second order and higher streams.
Input raster, *stream_order_grid*
Reclass field, Value

Old Values	New Values
0, 1, NoData	NoData
2 – 9	2 – 9

Output raster, *stream_order2up*

4. Calculate EUCLIDEAN DISTANCE for *stream_order2up*
Input raster or feature source data, *stream_order2up*
Output distance raster, *stream_Euclid_dist*
Maximum distance, NULL
Output cell size, 28.5000000006032
Output direction raster, NULL

5. RECLASSIFY *stream_Euclid_dist* to determine buffer.
Input raster, *stream_Euclid_dist*
Reclass field, Value

Old Values	New Values
0 – 100	1
100.001 – 9999999999	0
NoData	NoData

Output raster, *stream_buff*

Combine Aquatic Cores Types Into a Single Raster

1. Combine all aquatic core types using RASTER CALCULATOR.
Map Algebra expression, "lakes_buff" + "stream_buff"
Output raster, *Aqua_Cores_math*

2. RECLASSIFY the combined rasters to have only values of zero and one.
Input raster, *Aqua_Cores_math*
Reclass field, Value

Old Values	New Values
1 – 999999	1
0, NoData	0

Output raster, *Aquatic_Cores*

Grassland and Wetland Cores

Identify Cores from NLCD Data

1. Identify NLCD features within the study area using EXTRACT BY MASK.
Input raster, *NLCD_Mosaic*
Input raster or feature mask data, *study_area*
Output raster, *NLCD*

NOTE: Download NLCD data from the USDA NRCS Geospatial Data Gateway. There will likely be multiple rasters for your study area. For the model (and likely in your implementation), datasets covering the study area were combined using MOSAIC. The name of the resulting raster is *NLCD_Mosaic*.

2. Identify appropriate land cover with RECLASSIFY.
Input raster, *NLCD*
Reclass field, Value

Old Values	New Values
0 – 51, 53 – 70, 72 – 89, 91 – 94, 96 – 999999	0
52, 71, 90, 95	1
NoData	0

Output raster, GrasslandWetland_NLCD

NOTE: Selected NLCD values are 52 – Shrub/Scrub; 71 – Grassland/Herbaceous; 90 – Woody Wetlands; 95 – Emergent Herbaceous Wetlands. For more information please see the NLCD 2006 Product Legend available from the USGS Multi-Resolution Land Characteristics Consortium (MRLC) here: http://www.mrlc.gov/nlcd06_leg.php.

Identify Grassland Cores From LULC Data.

1. RECLASSIFY LULC to identify grassland cores.
Input raster, *LULC*
Reclass field, Value

Old Values	New Values
209 – 210	1
0 – 208, 211 – 999999, NoData	0

Output raster, LULC_grasses

NOTE: Values 209 and 210 represent cool and warm season grasses. Metadata for CAST's LULC dataset can be found here: http://www.geostor.arkansas.gov/metadata/IMAGE.DBO.LULC_FALL_CAST2006.xml

Combine Wetland and Grassland Cores Into a Single Raster

1. Combine all aquatic core types using RASTER CALCULATOR.
Map Algebra expression, "SwampMarsh_gridReclass" + "GrasslandWetland_NLCD" + "LULC_grasses"
Output raster, *GrasslandWetland_math*

2. RECLASSIFY the combined rasters to have only values of zero and one.
Input raster, *GrasslandWetland_math*
Reclass field, Value

Old Values	New Values
1 – 999999	1
0, NoData	0

Output raster, GrasslandWetland_Cores

Combine All Cores Into a Single Raster

1. Use RASTER CALCULATOR to combine all core types into a single core.
Map Algebra expression, "forest_cores" + "Aquatic_Cores" + "GrasslandWetland_Cores"
Output raster, *Cores_math*

2. RECLASSIFY *Cores_math* to include NoData and 1 values only.
Input Raster, *Cores_math*

Old Values	New Values
1 – 999999	1
0, NoData	0

Output raster, *Cores*

Indian grass on Callie's Prairie, Lake Fayetteville by Joe Neal.

ASSESSING FRAGMENTATION OF CORES

Create a Fragmentation Raster

Identify Building Locations From Address Points

1. CLIP address points to the *study_area*.
Input Features, *STRUC_DBO_SITUS_ADDRESS_PT_Point*
Clip Features, *study_area*
Output Feature Class, *AddressPts*

2. Convert data from POINT TO RASTER.
Input Features, *AddressPts*
Value Field, ID
Output Raster Dataset, *AddressPts_grid*
Cell assignment type, MOST_FREQUENT
Priority field, NONE
Cellsize, 28.5000000006032

3. RECLASSIFY to make all values equal to one.
Input Raster, *AddressPts_grid*

Old Values	New Values
1 – 999999	1
NoData	0

Output raster, *Addresses*

Reclassify LULC and Transportation Data To Combine Fragmenting Features

1. RECLASSIFY *LULC*.
Input Raster, *LULC*

Old Values	New Values
11 – 14, 30, 31	1
0 – 10, 15 – 29, 32 – 9999999, NoData	0

Output raster, LULC_UrbanBarren

NOTE: These values represent urban areas (11 – 14) and barren land (30, 31). For more information on LULC values please see: http://www.geostor.arkansas.gov/metadata/IMAGE.DBO.LULC_FALL_CAST2006.xml

2. RECLASSIFY *roads_grid*.
Input Raster, *roads_grid*

Old Values	New Values
1, 4, 7 - 11	1
2, 3, 5, 6, NoData	0

Output raster, *paved*

NOTE: Values equal to one represent paved roads. Please see the table above in Define Interior Forest Areas, Step 3, for a complete list of road type values.

3. Combine Fragmenting Features with RASTER CALCULATOR.
Map Algebra Expression, "LULC_UrbanBarren" + "Addresses" + "paved"
Output raster, *Fragmentation_math*

4. RECLASSIFY *Fragmentation_math*.
Input Raster, *Fragmentation_math*

Old Values	New Values
1 - 999999999	1
0, NoData	NoData

Output raster, *Fragmentation_math2*

5. Measure EUCLIDEAN DISTANCE of *Fragmentation_math2*.
Input raster or feature source data, *Fragmentation_math2*
Output distance raster, *FragMath2_Euclid_dist*
Maximum distance, NULL
Output cell size, 28.5000000006032
Output direction raster, NULL

6. Determine a buffer around fragmenting features with RECLASSIFY.
Input Raster, *FragMath2_Euclid_dist*

Old Values	New Values
100 - 999999999	1
0 - 100, NoData	NoData

Output raster, *Frag_100mInt*

7. Clip fragmenting features to study area with EXTRACT BY MASK.
Input raster, *Frag_100mInt*
Input raster or feature mask data, *study_area*
Output raster, *Frag_100mIntStudyArea*

8. Remove fragmentation from cores with RASTER CALCULATOR.
Map Algebra expression, "Cores"-"Frag_100mIntStudyArea"
Output raster, *Cores_woFrag*

9. Identify contiguous cores with REGION GROUP.
Input raster, *Cores_woFrag*
Output raster, *Cores_RgGrp*
Number of neighbors to use, FOUR
Zone grouping method, WITHIN

10. Identify cores larger than 100 acres.
Input raster, *Cores_RgGrp*
Where clause, "Count" >= 14250
Output raster, *Cores_gt100acres*

NOTE: 100 acres is roughly 406,125 square meters. Each pixel is 28.5000000006032 square meters. A region group of 14250 pixels is slightly more than 100 acres.

Blue Ash Tree

Ranking Cores

The core ranking methodology described in this section was adapted from the Urban Forest Conservation Assessment for Fayetteville Arkansas.

Create Raster Attribute Table and Identifying Field

These preliminary processing steps prepare the cores for assessment and ranking.

1. BUILD RASTER ATTRIBUTE TALE.
Input Raster, *Cores_gt100acres*

2. ADD FIELD to create unique identity for each core.
Input Table, *Cores_gt100acres*
Field Name, CoreID
Field Type, LONG
Field Is Nullable, Checked.
Note: all other parameters are NULL.

3. CALCULATE FIELD.
Input Table, *Cores_RgGr*
Field Name, CoreID
Expression, [VALUE]
Expression Type, VB

4. Convert core RASTER TO POLYGON.
Input raster, *Cores_gt100acres*
Field, CoreID
Output polygon features, *Cores_Poly*

5. DISSOLVE
Input Features, *Cores_Poly*
Output Feature Class, *Cores_Poly_Dissolve*
Dissolve_Field, grid_code
Create multipart features, checked.

NOTE: All other inputs are NULL.

Landscape Geometry

The size and shape of a core matters when ranking cores. A core is more valuable for wildlife when it is larger in size and more circular in shape because it provides more interior habitat.

Area

1. Calculate landscape geometry of cores with the ZONAL GEOMETRY tool.
Input raster or feature zone data, *Cores_RgGr*
Zone field, CoreID
Output table, *ZGeoArea*
Geometry type, AREA
Processing cell size, 28.5000000006032

2. Convert the results to integer for continued processing with INT.
Input raster or constant value, *ZGeoArea*
Output raster, *ZGeoArea_Int*

3. RASTER TO POLYGON.
Input raster, *ZGeoArea_Int*
Field, VALUE
Output polygon features, *ZGeoArea_Poly*

4. SPATIAL JOIN to Cores.
Target Features, *Cores_Poly_Dissolve*
Join Features, *ZGeoArea_Poly*
Output Feature Class, *Cores_SpJnZGArea*
Join Operation, JOIN_ONE_TO_ONE
Keep All Target Features, Checked
Field Map of Join Features
CoreID, merge rule First
Area, merge rule Maximum
Match Option, INTERSECT

Perimeter

1. ZONAL GEOMETRY
Input raster or feature zone data, *Cores_gt100acres*
Zone field, CoreID
Output raster, *ZGeoPerim*
Geometry type, PERIMETER
Output cell size, 28.5000000006032

2. Convert the results to integer for continued processing with INT.
Input raster or constant value, *ZGeoPerim*
Output raster, *ZGeoPerim_Int*

3. RASTER TO POLYGON.
Input raster, *ZGeoPerim_Int*
Field, VALUE
Output polygon features, *ZGeoPerim_Poly*

4. SPATIAL JOIN to Cores.
Target Features, *Cores_SpJnZGArea*
Join Features, *ZGeoPerim_Poly*
Output Feature Class, *Cores_SpJnZGPerim*
Join Operation, JOIN_ONE_TO_ONE
Keep All Target Features, Checked
Field Map of Join Features
Perimeter, merge rule Maximum
All other merge rule first
Match Option, INTERSECT

Thickness

Calculating thickness for raster zones requires significant amounts of memory. GIC created a script in order to reduce this load and prevent memory failures. The script accomplishes the following:

- CONVERTS *cores_gt20ac* to a polygon.
- ADD Field, "ThickID" to help with processing. SPLITS cores based upon ThickID.
- CONVERT POLYGON TO RASTER for each core based on ThickID.
- Calculates ZONAL GEOMETRY Thickness for each core raster.
- Combines all thickness calculated rasters back into a single raster with CELL STATISTICS.
- Converts that raster to an INTEGER. CONVERT RASTER TO POLYGON for the combined integer raster. The raster containing each core's thickness value is ready for spatial joining with the model output.

1. Use THICKNESS PROCESSOR custom script. Below is the script text.

```
#Import arcpy and set environments, relative pathways.

print "Running script..."
import sys, os
print 'sys.argv[0] =', sys.argv[0]
pathname = os.path.dirname(sys.argv[0])
print 'path =', pathname
print 'full path =', os.path.abspath(pathname)
import arcpy
from arcpy import env
from arcpy.sa import *
pathname = os.path.dirname(sys.argv[0])
env.workspace = pathname
env.overwriteOutput = True
env.extent = "MAXOF"

corespoly = arcpy.GetParameterAsText(0)

#Convert Raster to Polygon.
arcpy.RasterToPolygon_conversion(corespoly, "Cores_gt20ac_poly",
"NO_SIMPLIFY", "CoreID")
print "Cores converted from Raster to polygon."

fc = pathname + "\Cores_gt20ac_poly"

#Add field "CoreID" and update with string "Core" plus grid_code
value.
arcpy.AddField_management(fc, "ThickID", "TEXT")
delimNode = arcpy.AddFieldDelimiters(fc, "ThickID")
delimCodeID = arcpy.AddFieldDelimiters(fc, "grid_code")
cursor = arcpy.da.UpdateCursor(fc, ["ThickID","grid_code"])
for row in cursor:
   row[0] = "Thick" + str(row[1])
   cursor.updateRow(row)
del cursor

#Split based on ThickID.
arcpy.Copy_management("Cores_gt20ac_poly", "Cores_gt20ac_poly_
copy")
print "Cores copied for processing."
arcpy.Split_analysis("Cores_gt20ac_poly", "Cores_gt20ac_poly_copy",
"ThickID", pathname)
print "Cores have been split by core ID."

#Create list of split cores.
listCores = arcpy.ListFeatureClasses("Thick*")
print "Cores found: " + str(listCores)

#Convert split cores to raster.
for core in listCores:
   outraster = arcpy.CreateUniqueName(pathname + "\Thick")
   arcpy.PolygonToRaster_conversion(core, "ThickID", outraster, "", "",
"28.5000000006032")
   print "Core converted to raster."

#For each core raster, calculate Thickness with Zonal Geometry.
listCoreRast = arcpy.ListRasters("Thick*")
print "Cores found in raster format: " + str(listCoreRast)
for core in listCoreRast:
   thicknesscalc = arcpy.sa.ZonalGeometry(core, "Value",
"THICKNESS", "28.5000000006032")
   thicknesscalc.save()
   print "Thickness calculated for a core."

#Combine cores back together with Cell Statistics.
listZonThick = arcpy.ListRasters("ZonalGe_Th*")
print "Cores with thickness analyzed: " + str(listZonThick)
CombThick = arcpy.sa.CellStatistics([listZonThick], "MAXIMUM",
"DATA")
print "Core zonal thickness analysis combined into single raster."

#Convert output to integer.
Comb_ThickInt = arcpy.sa.Int(CombThick)
print "Thickness raster converted to integer."

#Convert output to polygon.
outfeat = pathname + "\ThickPoly"
output = arcpy.RasterToPolygon_conversion(Comb_ThickInt, outfeat,
"NO_SIMPLIFY")
print "Thickness converted to polygon."

arcpy.SetParameterAsText(1, output)

#Clean up intermediate data.
print "Cleaning up intermediate data."
for core in listCores:
   arcpy.Delete_management(core)
   print "Deleted " + str(core)

for raster in listCoreRast:
   arcpy.Delete_management(raster)
   print "Deleted " + str(raster)

for raster in listZonThick:
   arcpy.Delete_management(raster)
   print "Deleted " + str(raster)

arcpy.Delete_management(fc)
arcpy.Delete_management(pathname + "\Cores_gt20ac_poly_copy")

print "Script complete."
```

2. SPATIAL JOIN to Cores.
Target Features, *Cores_SpJnZGPerim*
Join Features, *ZGeoThick_Poly*
Output Feature Class, *Cores_SpJnZGThick*
Join Operation, JOIN_ONE_TO_ONE
Keep All Target Features, Checked
Field Map of Join Features
    Thickness, merge rule Maximum
    All other merge rule first
Match Option, INTERSECT

Topographic Diversity In Cores

Variation in elevation acts as a surrogate for biodiversity since vertical stratification leads to a higher diversity of biological communities. This analysis obtained the National Elevation Dataset data at ten meter resolution from the USDA's Natural Resources Conservation Service Geospatial Data Gateway. Thirty meter resolution and LiDAR data are also available for some parts of the state. They will work the same in isolated analysis. However, when comparing multiple studies, use the same resolution for all data. Data will come in multiple different files. MOSAIC files in advance of running the model. Export Mosaic data to the GI Network.gdb. The Mosaic's name in the model is *Elev_Mosaic*.

1. ZONAL STATISTICS
Input raster or feature zone data, *Cores_gt100acres*
Zone field, CoreID
Input value raster, *Elev_Mosaic*
Output raster, *ElevSTD*
Geometry type, STD
Ignore NoData in calculations, checked

2. Convert the results to integer for continued processing with INT.
Input raster or constant value, *ElevSTD*
Output raster, *ElevSTD_Int*

3. RASTER TO POLYGON.
Input raster, *ElevSTD_Int*
Field, VALUE
Output polygon features, *ElevSTD_Poly*

4. SPATIAL JOIN to Cores.
Target Features, *Cores_SpJnZGThick*
Join Features, *ElevSTD_Poly*
Output Feature Class, *Cores_SpJnElevSTD*
Join Operation, JOIN_ONE_TO_ONE
Keep All Target Features, Checked
Field Map of Join Features
    ElevSTD, merge rule Maximum
    All other merge rule first
Match Option, INTERSECT

Grassland and Wetland Area In Cores

Grasslands and wetlands are unique habitat types that house a variety of different species and provide a number of ecosystem services. Their presence in cores acts as a surrogate for biodiversity.

1. ZONAL STATISTICS
Input raster or feature zone data, *Cores_gt100acres*
Zone field, CoreID
Input value raster, *GrasslandWetland_Cores*
Output raster, *GrassWetLandSum*
Geometry type, SUM

2. Convert the results to integer for continued processing with INT.
Input raster or constant value, *GrasslandWetlandSum*
Output raster, *GrasslandWetlandSum_Int*

3. RASTER TO POLYGON.
Input raster, *GrasslandWetlandSum_Int*
Field, VALUE
Output polygon features, *GrassWetSumInt_Poly*

4. SPATIAL JOIN to Cores.
Target Features, *Cores_SpJnElevSTD*
Join Features, *GrassWetSumInt_Poly*
Output Feature Class, *Cores_SpJnWetGrass*
Join Operation, JOIN_ONE_TO_ONE
Keep All Target Features, Checked
Field Map of Join Features
    GrassWet, merge rule Maximum
    All other merge rule first
Match Option, INTERSECT

Water Willow and Clearwing Moth, Buffalo National River by Joe Neal.

Aquatic Area In Cores

1. ZONAL STATISTICS
Input raster or feature zone data, *Cores_gt100acres*
Zone field, CoreID
Input value raster, *Aquatic_Cores*
Output raster, *AquaticSum*
Geometry type, SUM

2. Convert the results to integer for continued processing with INT.
Input raster or constant value, *AquaticSum*
Output raster, *AquaticSum_Int*

3. RASTER TO POLYGON.
Input raster, *AquaticSum_Int*
Field, VALUE
Output polygon features, *AquaticSum_Poly*

4. SPATIAL JOIN to Cores.
Target Features, *Cores_SpJnWetGrass*
Join Features, *AquaticSum_Poly*
Output Feature Class, *Cores_SpJnAquaSum*
Join Operation, JOIN_ONE_TO_ONE
Keep All Target Features, Checked
Field Map of Join Features
AquaArea, merge rule Maximum
All other merge rule first
Match Option, INTERSECT

Buffalo National River Near Ponca by Joe Neal.

GAP Analysis Diversity In Cores

The GAP analysis depicts 38 land cover categories. These include a variety of forest, grassland and shrubland types, as well as urban, agricultural, water and bare lands. The GAP analysis acts as a surrogate for biodiversity in cores by showing those cores with more habitat variety.

1. EXTRACT BY MASK to the study area.
Input raster, *IMAGE_DBO_LANDCOVER_30M_CAST_1993*
Input raster or feature mask data, *study_area*
Output raster, *GAP*

2. Remove inappropriate land cover types using RE-CLASSIFY.
Input Raster, *GAP*

Old Values	New Values
1 – 52	Old Values
55 – 70, NoData	NoData

Output raster, *GAP_Habitat*

3. RESAMPLE to ensure that the raster cell size is 28.5000000006032 square meters.
Input Raster, *GAP_Habitat*
Output Raster Dataset, *GAPHab_resized*
Output Cell Size, X = 28.5000000006032, Y = 28.5000000006032
Resampling Technique, NEAREST

4. Determine habitat diversity in cores with ZONAL STATISTICS.
Input raster or feature zone data, *Cores_gt100acres*
Zone field, CoreID
Input value raster, *GAPHab_resized*
Output raster, *GAPVar*
Statistics type, VARIETY
Ignore NoData in calculations, Checked

5. Convert RASTER TO POLYGON.
Input raster, *GAPVar*
Field, VALUE
Output polygon features, *GAPVar_Poly*

6. SPATIAL JOIN.
Target Features, *Cores_SpJnAquaSum*
Join Features, *GAPVar_Poly*
Output Feature Class, *Cores_SpJnGAPVar*
Join Operation, JOIN_ONE_TO_ONE

Keep All Target Features, Checked
Field Map of Join Features
GAPVar, merge rule Maximum
All other merge rule first
Match Option, INTERSECT

Soil Diversity In Cores

Determining soil diversity in cores acts as a surrogate for plant and ecological community diversity. The more soil types, the greater potential for diversity in plant species and animals that rely on those plants.

1. Remove water from soil dataset SELECT LAYER BY ATTRIBUTE.
Layer Name or Table View, *AGRIC_DBO_STATSGO_SOILS_polygon*
Selection type, NEW_SELECTION
Expression, "MLRA" = 'Water'

2. SELECT LAYER BY ATTRIBUTE to switch selection and remove water.
Layer Name or Table View, *AGRIC_DBO_STATSGO_SOILS_polygon*
Selection type, SWITCH_SELECTION

NOTE: Leave the expression field blank.

3. CLIP to study area.
Input Features, *AGRIC_DBO_STATSGO_SOILS_polygon*
Clip features, *study_area*
Output Feature Class, *soils*

4. POLYGON TO RASTER
Input Features, *soils*
Value field, MUID
Output Raster Dataset, *soils_grid*
Cell assignment type, MAXIMUM_COMBINED_AREA
Priority field, NONE
Cellsize, 28.5000000006032

5. Determine diversity of soils in cores with ZONAL STATISTICS.
Input raster or feature zone data, *Cores_gt100acres*
Zone field, CoreID
Input value raster, *soils_grid*
Output raster, *SoilsVar*
Statistics type, VARIETY
Ignore NoData in calculations, checked.

6. RASTER TO POLYGON
Input raster, *SoilsVar*
Field, VALUE
Output polygon features, *SoilsVar_poly*

7. SPATIAL JOIN
Target Features, *Cores_SpJnGAPVar*
Join Features, *SoilsVar_poly*
Output Feature Class, *Cores_SpJnSoilsVar*
Join Operation, JOIN_ONE_TO_ONE
Keep All Target Features, checked
Field Map of Join Features
SoilsVar merge rule maximum
All other merge rule first
Match Option, INTERSECT

Ranking Cores

This model has so far identified large core areas. It has also calculated a wide variety of statistics for associated landscape features. Ranking cores based upon the calculated statistics allows for prioritization of the best cores.

1. DELETE FIELD to remove unnecessary fields.
Input Table, *Cores_SpJnSoilsVar*
Drop Field, Join_Count
Drop Field, TARGET_FID

2. ADD FIELD to calculate core scores.
Input Table, *Cores_SpJnSoilsVar*
Field Name, Score
Field Type, LONG
Field Is Nullable, Checked.
Field Alias, Core Score

NOTE: all other parameters are NULL.

Central Arkansas Transit

3. Use CALCULATE FIELD to insert a Python script that replaces NULL values with 0.

NOTE: To complete this operation manually, select all NULL values for each field in *Cores_SpJnSoilsVar* and replacing them with 0 using the field calculator in ArcMap. The script simply automates this process. The script has also been included separately in *GI Network.gdb*.

Input Table, *Cores_SpJnSoilsVar*
Field Name, Score
Expression, !Score!
Expression Type, PYTHON
Code Block

```
#Import arcpy and set environments, feature class, relative pathways.
import sys, os
print 'sys.argv[0] =', sys.argv[0]
pathname = os.path.dirname(sys.argv[0])
print 'path =', pathname
print 'full path =', os.path.abspath(pathname)
import arcpy
pathname = os.path.dirname(sys.argv[0])
fc = pathname + "Cores_SpJnSoilsVar"

#Update ElevSTD to replace NULL with 0.
delimElev = arcpy.AddFieldDelimiters(fc, "ElevSTD")
cursor = arcpy.da.UpdateCursor(fc, "ElevSTD", delimElev + ' IS
NULL')
for row in cursor:
   row[0] = 0
   cursor.updateRow(row)
del cursor

#Update GrassWet to replace NULL with 0.
delimGrassWet = arcpy.AddFieldDelimiters(fc, "GrassWet")
cursor2 = arcpy.da.UpdateCursor(fc, "GrassWet", delimGrassWet + ' IS
NULL')
for row in cursor2:
   row[0] = 0
   cursor2.updateRow(row)
del cursor2

#Update AquaArea to replace NULL with 0.
delimAquaArea = arcpy.AddFieldDelimiters(fc, "AquaArea")
cursor3 = arcpy.da.UpdateCursor(fc, "AquaArea", delimAquaArea + '
IS NULL')
for row in cursor3:
   row[0] = 0
   cursor3.updateRow(row)
del cursor3

#Update GAPVar to replace NULL with 0.
delimGAPVar = arcpy.AddFieldDelimiters(fc, "GAPVar")
cursor4 = arcpy.da.UpdateCursor(fc, "GAPVar", delimGAPVar + ' IS
NULL')
for row in cursor4:
   row[0] = 0
   cursor4.updateRow(row)
del cursor4

#Update SoilsVar to replace NULL with 0.
delimSoilsVar = arcpy.AddFieldDelimiters(fc, "SoilsVar")
cursor5 = arcpy.da.UpdateCursor(fc, "SoilsVar", delimSoilsVar + ' IS
NULL')
for row in cursor5:
   row[0] = 0
   cursor5.updateRow(row)
del cursor5
```

4. Calculate SUMMARY STATISTICS.
Input Table, *Cores_SpJnSoilsVar*
Output Table, *Cores_AllAttrSumStats*
Statistics Field, Statistic Type
Area, MAX
Thickness, MAX
ElevSTD, MAX
GrassWet, MAX
GAPVar, MAX
SoilsVar, MAX

5. Prepare for score analysis with GET FIELD VALUE.

NOTE: This process is iterated for each statistics field (see step 4 above). This is a process required when using Model Builder. If you are undergoing this process without Model Builder, simply note the max value for each field in the above step and use it in the calculations described in Step 6. The use of * below indicates that it will change for each statistics field calculated in Step 4.

Input Table, *Cores_AllAttrSumStats*
Field, MAX_*
Data Type, String
Null Value, 0
Output names, Value*

NOTE: After finding the field value for each field, every output is a precondition of Step 6 below.

6. CALCULATE FIELD to determine core scores.
Input Table, *Cores_SpJnSoilsVar*
Field Name, Score
Expression, (([Area]/%ValueArea%)*5) + (([Thickness]/%ValueThick%)*5) + (([ElevSTD]/%ValueElev%)*5) + (([GrassWet]/%ValueGrassWet%)*5) + (([AquaArea]/%ValueAqua%)*5) + (([GAPVar]/%ValueGAP%)*5) + (([SoilsVar]/%ValueSoil%)*5)
Expression Type, VB

NOTE: The Expression in this step determines which quintile the core falls in for each attribute assessed. The quintiles are added together to give the core an overall score. This means that as the study area size changes, the importance of each core will change. A smaller area will increase the value of cores that would be valued less at a larger scale. This scalability of the model can aid decision makers who work at multiple scales. To do so, rerun the model for each study area.

7. ADD FIELD.
Input Table, *Cores_SpJnSoilsVar*
Field Name, Rank
Field Type, LONG
Field Is Nullable, Checked.

NOTE: all other parameters are NULL.

8. Use SUMMARY STATISTICS to find Score field's maximum value.
Input Table, *Cores_SpJnSoilsVar*
Output Table, *Cores_ScoreSum*
Statistics Field, Score
Statistic Type, MAX

9. GET FIELD VALUE.
Input Table, *Cores_ScoreSum*
Field, MAX_Score
Data Type, String
Null Value, 0

NOTE: After finding the field value for the Score field, the output becomes a precondition of Step 10 below.

10. CALCULATE FIELD.
Input Table, *Cores_SpJnSoilsVar*
Field Name, RANK
Expression, ([Score]/%ValueScore%)*5
Expression Type, VB

11. RENAME.
Input Data Element
Output data element, *GI_Cores*

Congratulations, you have now identified, assessed and ranked cores within your study area. Now we will move on assessing connectivity between the cores in the green infrastructure network.

Image provided by the City of Springdale.

IDENTIFYING IMPEDANCES

Identify impedances by assigning values to each pixel in a raster dataset. These values represent the cost of travel across each individual pixel based upon the landscape features that make up that pixel. A single travel cost raster will be created that will combine the costs of all other assessed impedances.

Determine Travel Cost Value For Riparian Forests

Forested streams act as corridors for wildlife travel. The following steps will assign a travel cost to these 'natural highways'.

1. RECLASSIFY
Input raster, *stream_order_grid*

Old Values	New Values
0 – 9	1
NoData	NoDat

Output raster, imp_strm_notstrm

2. Calculate EUCLIDEAN DISTANCE
Input raster or feature source data, imp_strm_notstrm
Output distance raster, ipm_strm_euclidist
Maximum distance, NULL
Output cell size, 28.5000000006032
Output direction raster, NULL

3. RECLASSIFY to determine 30 meter buffer.
Input raster, imp_strm_euclidist
Reclass field, Value

Old Values	New Values
0 – 30	1
30.0001 – 999999, NoData	NoData

Output raster, imp_strm_30mbuff

4. Use PLUS to include forested areas.
Input raster or constant value 1, imp_strm_30mbuff
Input raster or constant value 2, Forest_LULC
Output raster, imp_strm_forest

5. RECLASSIFY to define travel cost for riparian forests.
Input raster, imp_strm_forest
Reclass field, Value

Old Values	New Values
1, NoData	0
2	-25

Output raster, imp_rip_forest

Determine Travel Cost Value For Interior Forests

1. RECLASSIFY interior forest to reflect travel cost.
Input raster, *forest_100mInt*
Reclass field, Value

Old Values	New Values
1	-13
NoData	0

Output raster, imp_int_forest

Determine Travel Cost Value For Cores

1. Convert cores from POLYGON TO RASTER based on core rank to determine travel cost value.
Input Features, *GI_Cores*
Value field, Rank
Output Raster Dataset, *imp_cores*
Cell assignment type, CELL_CENTER
Priority field, NONE
Cellsize, 28.5000000006032

Determine Travel Cost Value For Urban Areas

1. RECLASSIFY LULC data to determine high intensity urban areas.
Input raster, *LULC*
Reclass field, Value

Old Values	New Values
11, 31 – 210, NoData	NoData
13	1

Output raster, *imp_LULC_urbhigh*

2. Calculate EUCLIDEAN DISTANCE for high intensity urban areas.
Input raster or feature source data, imp_LULC_urbhigh
Output distance raster, imp_urbhigh_euclidist
Maximum distance, NULL
Output cell size, 28.5000000006032
Output direction raster, NULL

3. Assign travel cost values for high intensity urban areas based on proximity.
Input raster, imp_urbhigh_euclidist
Reclass field, Value

Old Values	New Values
0 – 28.5	2000
28.500001 – 40.25	950
40.25 – 57	518
57.00001 – 63.7	212
63.700001 – 91.44	134
91.440001 – 999999, NoData	0

Output raster, imp_urbhigh

NOTE: *Linking Arkansas Communities* provided values used in this geoprocess. This model converted values to meters.

4. RECLASSIFY *LULC* data to determine low intensity urban areas.
Input raster, LULC
Reclass field, Value

Old Values	New Values
13, 31 – 210, NoData	NoData
11	1

Output raster, imp_LULC_urblow

5. Calculate EUCLIDEAN DISTANCE for high intensity urban areas.
Input raster or feature source data, imp_LULC_urblow
Output distance raster, imp_urblow_euclidist
Maximum distance, NULL
Output cell size, 28.5000000006032
Output direction raster, NULL

6. Assign travel cost values for high intensity urban areas based on proximity.
Input raster, imp_urblow_euclidist
Reclass field, Value

Old Values	New Values
0 – 28.5	1000
28.500001 – 40.25	450
40.25 – 57	234
57.00001 – 63.7	81
63.700001 – 91.44	42
91.440001 – 999999, NoData	0

Output raster, *imp_urblow*

NOTE: Values come from the *Linking Arkansas Communities* case study. This model converted values to meters.

7. Combine urban high and low intensity travel costs using CELL STATISTICS.
Input rasters or constant values,
imp_urbhigh
imp_urblow
Output raster, *imp_urban*
Overlay statistic, MAXIMUM
Ignore NoData in calculations, Checked

Determine Travel Cost Value for LULC Data

1. RECLASSIFY *LULC* data to reflect travel costs.
Input raster, LULC
Reclass field, Value

Old Values	New Values
11, 13	5000
31, 41, 51, 208, 209, 210	150
100	50
201	250
NoData	0

Output raster, *imp_LULC*

NOTE: Metadata for CAST's LULC dataset that explain the values above can be found here: http://www.geostor.arkansas.gov/metadata/IMAGE.DBO.LULC_FALL_CAST2006.xml

Determine Travel Cost Value For Roads and Bridges

1. Identify bridges within the study area using CLIP.
Input Features, *CULTU_DBO_TRANSP_FEATURES_GNIS_USGS_point*
Clip Features, *study_area*
Output Feature Class, *bridge*

2. BUFFER bridges by 45.75 meters (about 150 feet).
Input Features, *bridge*
Output Feature Class, *bridge_buff*
Distance, Linear unit, 45.75 Meters
Side Type, FULL
End Type, ROUND
Dissolve Type, NONE

3. Convert POLYGON TO RASTER.
Input Features, *bridge_buff*
Value field, OBJECTID_1
Output Raster Dataset, *bridge_grid*
Cell assignment type, CELL_CENTER
Priority field, NONE
Cellsize, 28.5000000006032

4. Determine bridge travel cost value with RECLASSIFY.
Input raster, *bridge_grid*
Reclass field, Value

Old Values	New Values
0 – 9999999999999	300
NoData	0

Output raster, *imp_bridge*

5. Determine road travel cost values with RECLASSIFY.
Input raster, *roads_grid*
Reclass field, Value

Old Values	New Values
1 – 3, 5 – 7, NoData	0
8, 10, 11	5000
9	1000
4	500

Output raster, *imp_road*

NOTE: Old Values for roads are in Table 1, under Identifying Cores, Forest Cores, Define Interior Forest, step 3.

6. Combine travel cost rasters for roads and bridges with PLUS.
Input raster or constant value 1, *imp_bridge*
Input raster or constant value 2, *imp_road*
Output raster, *imp_rd_bridge*

7. RECLASSIFY to remove non-bridge costs from bridge areas.
Input raster, *imp_rd_bridge*
Reclass field, Value

Old Values	New Values
300, 1300, 5300	300
0, NoData	0
500, 1000, 5000	Old Values

Output raster, imp_road_bridge

Determine Travel Costs From Slope

1. Determine SLOPE.
Input raster, *Elev_Mosaic*
Output raster, *Slope*
Output measurement, PERCENT_RISE
Z factor, 1

2. Add travel costs based on slope with RECLASSIFY.
Input raster, *Slope*
Reclass field, Value

Old Values	New Values
0 – 8, NoData	0
9 – 15	2
26 – 9999	10

Output raster, *imp_slope*

Combine All Travel Cost Rasters Into a Single Impedance Raster

1. Add travel cost rasters together with CELL STATISTICS.
Input rasters or constant values, *imp_LULC, imp_rip_forest, imp_urban, imp_road_bridge, imp_int_forest, imp_slope, imp_cores*
Output raster, *imp_combined*
Overlay statistic, SUM
Ignore NoData in calculations, checked

2. Ensure that no negative values remain with ABS. This is necessary for determining corridors.
Input raster or constant value, *imp_combined*
Output raster, *imp_all_math*

3. EXTRACT BY MASK to ensure all costs are within the study area.
Input raster, *imp_all_math*
Input raster or feature mask data, *study_area*
Output raster, *imp_all*

Developing Corridors

Identify Highest Ranking Cores To Serve As Network Nodes

1. SELECT highest ranking cores.
Input Features, *GI_Cores*
Output Feature Class, *GI_Cores_R4_R5*
Expression, "Rank" = 4 OR "Rank" = 5

2. ADD FIELD with Node ID as a string. This will enable further processing.
Input Table, *GI_Cores_R4_R5*
Field Name, NodeID
Field Type, TEXT
Field Is Nullable, Checked.

NOTE: all other parameters are NULL.

3. CALCULATE FIELD with a Python script to automate the addition of a unique NodeID to each identified Node.
Input Table, *GI_Cores_R4_R5*
Field Name, NodeID
Expression, !NodeID!
Expression Type, PYTHON_9.3
Code Block

```
#Import arcpy and set environments, feature class, relative pathways.
import sys, os
print 'sys.argv[0] =', sys.argv[0]
pathname = os.path.dirname(sys.argv[0])
print 'path =', pathname
print 'full path =', os.path.abspath(pathname)
import arcpy
pathname = os.path.dirname(sys.argv[0])
fc = pathname + "GI_Cores_R4_R5"

#Update NodeID with letter A plus CoreID.
delimNode = arcpy.AddFieldDelimiters(fc, "NodeID")
delimCodeID = arcpy.AddFieldDelimiters(fc, "CoreID")
cursor = arcpy.da.UpdateCursor(fc, ["NodeID", "CoreID"])
for row in cursor:
   row[0] = "Node" + str(row[1])
   cursor.updateRow(row)
del cursor
```

4. COPY nodes to allow for processing in the next step.
Input Data, *GI_Cores_R4_R5*
Data type, NULL
Output data element, *GI_Cores_R4_R5ProcessCopy*

5. Separate nodes into individual shapefiles with SPLIT.
Input Features, *GI_Cores_R4_R5*
Split Features, *GI_Cores_R4_R5ProcessCopy*
Split Field, NodeID
Target Workspace, *GI Network.gdb*

Create Corridors

This model automates corridor creation with a Python script. The script is separate from the Model Builder in the *GI Network.gdb*. After the GI AR Model finishes running, run the script called Corridor Analysis. The script completes the following operations:

- Finds all nodes created by the GI AR Model.
- Determines the COST DISTANCE for each node.
- Determines COST BACKLINK for each node.
- Executes a COST PATH from each node to every other node.
- Adds all cost paths into a single raster using RASTER CALCULATOR.
- Converts the RASTER TO POLYGON.
- BUFFER the shapefile by 300 meters. Final output is a shapefile called *CoPaPoly_Buff*
- Uses RECLASSIFY to identify natural land cover from *LULC*. Values 10, 42, 200 and 208 become 0. Values 50, 101, 209 and 210 become 1. The script names the output raster *LULCNat*.
- Converts *LULCNat* RASTER TO POLYGON called *LULCNatural_poly*.
- INTERSECTs *CoPaPoly_Buff* with *LULCNatural_poly*. The output is a shapefile called *Wldlf_Corr*.
- DISSOLVE *Wldlf_Corr* to simplify data. The final corridor output for the model is *Wildlife_Corridors*.

The script that completes this operation is:

```
#Import arcpy and set environments, relative pathways.
print "Running script..."
import sys, os
print 'sys.argv[0] =', sys.argv[0]
pathname = os.path.dirname(sys.argv[0])
print 'path =', pathname
print 'full path =', os.path.abspath(pathname)
import arcpy
from arcpy import env
from arcpy.sa import *
pathname = os.path.dirname(sys.argv[0])
env.workspace = pathname + "\GI Network.gdb"
env.overwriteOutput = True
env.extent = "study_area"
if arcpy.CheckExtension("spatial") == "Available":
   print "Spatial Analyst is available."
   arcpy.CheckOutExtension("spatial")
   print "Spatial Analyst is checked out."

#Variables for script.
bklink = arcpy.CreateUniqueName("backlink")

#Reduce imp_all_math to study area using extract by mask.
cost = arcpy.sa.ExtractByMask("imp_all_math", "study_area")
cost.save("imp_all")
print "Cost distance raster reduced to study area to avoid unnecessary
calculations."

#List nodes in workspace for geoprocessing.
listNodes = arcpy.ListFeatureClasses("Node*")
print "Nodes found: " + str(listNodes)

#Execute CostDistance for listNodes.
for node in listNodes:
   outCostDist = arcpy.sa.CostDistance(node, cost)
   outCostDist.save()
   print "A Node's cost distance has been calculated."
listCostDist = arcpy.ListRasters("CostD*")
print "Node Cost Distance rasters created: " + str(listCostDist)

#Execute BackLink for listNodes.
for node in listNodes:
   outBkLnk = arcpy.sa.CostBackLink(node, "imp_all")
   outBkLnk.save()
   print "A Node's cost backlink has been calculated."
listBkLnk = arcpy.ListRasters("CostB*")
print "Node Cost Back Link rasters created: " + str(listBkLnk)

#Execute Cost Path to for listCostDist and listBkLnk.
for costdist in listCostDist:
   for costbk in listBkLnk:
      for node in listNodes:
         coreCoPa = arcpy.sa.CostPath(node, costdist, costbk, "EACH_
ZONE", "CoreID")
         coreCoPa.save()
         print "A Cost Path has been created."
listCoPa = arcpy.ListRasters("CostPat*")
print "Cost Paths created: " + str(listCoPa)

#Add Cost Paths together using raster calculator.
SingleCoPa = arcpy.sa.CellStatistics(listCoPa, "SUM", "")
SingleCoPa.save("Combined_CoPa")
print "Cost Paths have been combined."

#Convert Cost Path raster into shapefile.
CoPaPo = arcpy.RasterToPolygon_conversion("Combined_CoPa",
"CoPaPoly")
print "Combine Cost Paths have been converted to a polygon."

#Buffer Cost Path shapefile by 300meters.
arcpy.Buffer_analysis("CoPaPoly", "CoPaPoly_Buff", "300 METERS",
"FULL", "")
print "Combined Cost Path polygon has been buffered by 300 meters."

#Reclassify LULC to identify natural land cover.
lulc = arcpy.sa.Reclassify("LULC", "Value", RemapRan
ge([[10,42,0],[50,101,1],[200,208,0],[209,210,1]]), "NODATA")
lulc.save("LULCNat")
print "Reclassified LULC data to identify natural land cover."

#Convert LULC natural land cover to polygon.
arcpy.RasterToPolygon_conversion("LULCNat", "LULCNatural_poly",
"NO_SIMPLIFY", "Value")
print "Converted LULC to polygon."

#Intersect buffered cost paths with LULC natural land cover to identify
potential wildlife corridors.
arcpy.Intersect_analysis(["CoPaPoly_Buff", "LULCNatural_poly"],
"Wldlf_Corr")
print "Intersected buffered cost paths with natural land cover to identify
wildlife corridors."

#Dissolve Wildlife Corridors to simplify data.
arcpy.Dissolve_management("Wldlf_Corr", "Wildlife_Corridors")
print "Dissolved wildlife corridors to simplify data."

arcpy.CheckInExtension("spatial")
print "Spatial Analyst has been checked in."
print "Script complete."
```

Summary of Model Outputs

This model creates two main outputs for use in land use planning in accordance with the methods suggested throughout this guide.

Cores

The first is the shapefile *GI_Cores*. This file represents all large, intact habitat blocks identified by the model. It also has ranked them according to a number of different factors. Cores are the basic building block of a green infrastructure network.

Corridors

The corridors created in the model are in the shapefile *Wildlife_Corridors*. These corridors act as linkages between the highest value cores. Cores require connection in order for plants and animals to move between them. The corridors show the least cost path, as determined by the model, between each core.

Image provided by the City of Springdale.

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