Heritage Conservancy

Growing with Green Infrastructure

Preserving Our Natural and Historic Heritage

Celebrating 50 Years of Preservation

HERITAGE CONSERVANCY

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Heritage Conservancy is a full service conservation organization with over 50 years of professional experience. Our mission of "Preserving Our Natural and Historic Heritage" is achieved by working with national, regional and local partners to plan and implement sustainable initiatives for land conservation, historic preservation, natural resource protection and land stewardship.

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Growing with Green Infrastructure

"Yet it is evident that in our daily lives nature must be thought of not as a luxury to be made available if possible, but as part of our inherent indispensable biological need."

Frederick Law Olmstead
Frederick Law Olmstead (1822-1903) a Biography by J.E. Todd, 1982

Introduction

From the ancient aqueducts of the Roman Empire to the soaring Golden Gate Bridge of modern times, man has responded to the needs and desires of society by creating, adapting and reshaping the infrastructure of his world.

Infrastructure, defined as "the substructure or underlying foundation, especially the basic installations and facilities on which the continuance and growth of a community depends," reflects the social priorities of diverse cultures around the world.

In the United States, a burgeoning population concentrated in major metropolitan areas necessitated the installation and refinement of basic utility systems over the last three centuries. Economic growth and continental expansion fueled the rapid development of complex communication, transportation and energy networks extending nationwide.

Basic human services originally satisfied by individuals or small groups were eventually centralized within larger governmental and economic systems. For example, clergymen in Revolutionary times not only provided spiritual leadership but also delivered the mail. Today's complex society now relies upon a network of communication services including the mass media, the Internet, and the U.S. Postal Service.

Technological advancements and societal shifts have shaped other forms of infrastructure. Outhouses on individual properties have been replaced by septic systems or regional sewage collection and treatment facilities. Dirt roads once used by wagons in the wilderness are now major highways. Table #1 summarizes in a broad manner the growth issues within American society that prompted a variety of infrastructure improvements from which we benefit today.

Table #1
Advances in the History of American Infrastructure

Era	Growth Issue	Infrastructure Solution
Mid-Late 1800's	Public Health and Welfare Communication Industrialization Energy Transportation	Sanitation, Hospitals, Parks, Schools Telegraph Planned Communities, Company Towns Coal, Oil, Gas, Electricity Canals, Railways
Early 1900's	Automobiles Food Production (Dust Bowl) Communication	Roads Crop Rotation, Agricultural Practices Radio, Telephone
Mid 1900's	Energy Nuisances Pollution Transportation Mass Communication	Hydro & Nuclear Power Community Zoning and Planning Air/Water/Sewage Treatment Interstate System, Airports Television
Late 1900's	Garbage Traffic Congestion Flooding Information Management	Recycling Mass Transit, Alternative Transportation Stormwater Management, Detention Computers/Internet
2000+	Sprawl, Globalization Sustainability	Sound Land Use, Smart Growth Green Infrastructure

The forces of the Industrial Revolution responsible for many of these infrastructure solutions also created new spheres of influence and unprecedented concentrations of wealth. Fortunately, leaders in a variety of fields not only invested in the technological advances that enabled infrastructure to evolve but also used their public stature and/or the financial proceeds from their success to support philanthropic efforts to address the social consequences of such advancement. Influential figures included President Theodore Roosevelt, who guided the construction of the Panama Canal and fostered the development of our National Park System, and Andrew Carnegie, a leader in the steel industry and a patron of higher education and scientific research programs.

As the 20th Century unfolded, the adverse effects of many infrastructure systems on the environment became apparent. In her ground-breaking book, *Silent Spring*, Rachel Carson spotlighted the dangers of chemicals in our world, prompting the reversal of some previously accepted practices and stimulating the development of innovative solutions to other environmental impacts. The banning of the pesticide DDT, the enactment of auto emission control standards and the establishment of recycling programs reflected an increasing awareness of the stresses being placed on the environment by society. This awareness was matched by a growing interest and participation in land and water conservation efforts to protect important natural resources.

"What a country chooses to save is what a country chooses to say about itself."

Mollie Beatty
Director, U.S. Fish and Wildlife Service
1993-1996

At the same time, the scientific community was discovering that environmental issues were crossing geopolitical boundaries at the local, state, national, and international level. Acid rain was a problem for both the United States and Canada, since industrial pollutants carried by prevailing winds did not recognize national borders, and the deforestation of South American rain forests had implications for global warming. The rapid pace at which land and natural resources were being consumed by an exploding world population inevitably raised the question of whether there was indeed a finite limit to the environment's capacity to support human life.

Sustainability and Green Infrastructure

In 1983, the United Nations' World Commission on Environment and Development brought together representatives of 21 countries, including the United States, to discuss sustainable development—how to promote economic development throughout the world without adversely impacting the environment and depleting natural resources needed by future generations. The Commission stressed that sustainable development could "only be pursued *if population size and growth are in harmony with the changing productive potential of the ecosystem*"—the ecosystem being the collection of living organisms and the physical environment upon which they depend for survival.

However, the development of land for agricultural, residential, commercial, industrial and institutional uses and the associated man-made infrastructure needed to support these uses has reduced, fragmented and degraded nature's ecosystems.

In *Who Sprawls Most? How Growth Patterns Differ Across the U.S.*, the Brookings Institution reported on dramatic levels of urban sprawl across the United States. The study revealed a nationwide rise in land development of 47% compared to an increase in the U.S. population of only 17% over a 15-year period, from 1982 through 1997. These imbalances are evident in the Philadelphia Region as documented by the Delaware Valley Regional Planning Commission in its publication, *Destination 2030: The Year 2030 Plan for the Delaware Valley*. A comparison of population and land use statistics from 1930 to 1970 reveals that the amount of land developed in the Philadelphia region over this 40-year period increased **twice** as fast as the total population. From 1970 to 2000, the rate of land development was nearly **nine** times the rate of population growth.

The impact of such growth has decreased nature's ability to respond to both short-term changes, such as sporadic flooding and drought, and long-term environmental trends, such as the spread of invasive species and global warming. Because changes in land use happen gradually, the resulting fragmentation of natural systems may not be immediately obvious.

Man and nature, both in constant motion, are often at odds. The infrastructure improvements that facilitate the movement of people, goods and information have created an ever-growing network of barriers to our natural systems. In conflict with the natural landscape, these barriers foster a patchwork distribution of land uses and isolate open space areas. Man-made infrastructure has also impeded natural processes that involve the migration of animals, the flow and filtration of water and the parachuting of seeds and spores upon the wind. The social consequences of this spatial fragmentation include a decline in the productivity of the environment to support human activities and the alienation of man from nature. The signs are there, even though we may not fully appreciate their implication:

- The Canada geese that now make their home in the detention pond at a new shopping center.
- A mom's insistence on driving her son to the

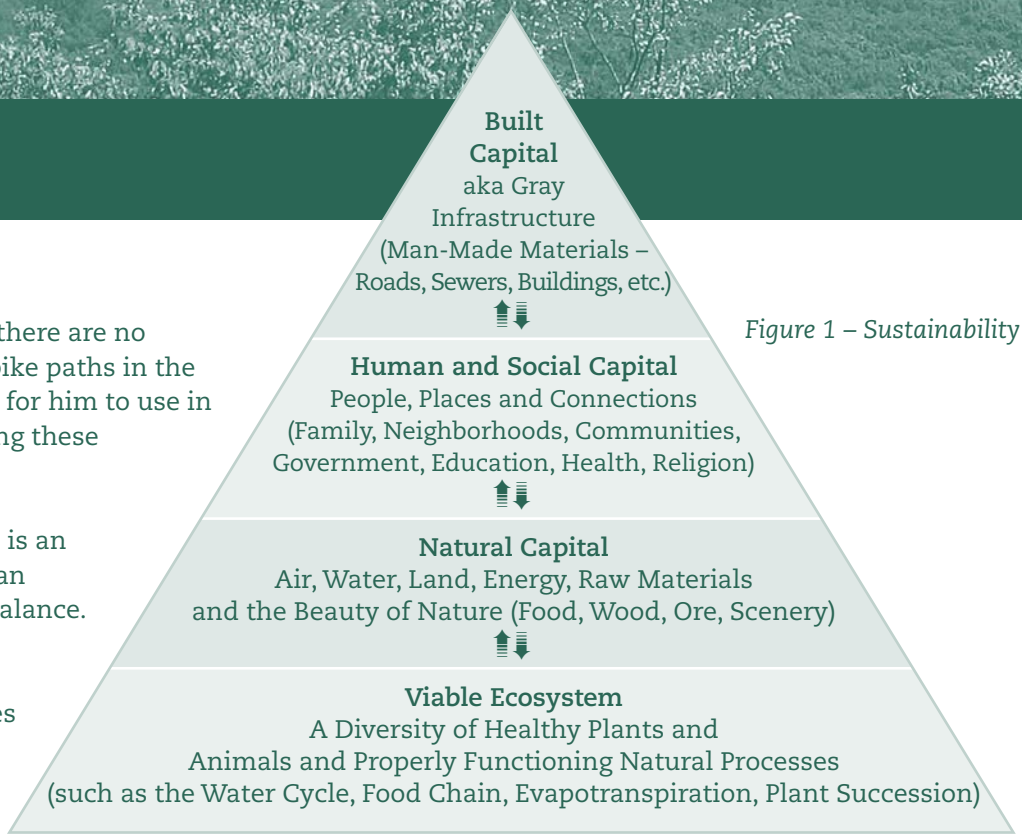

Figure 1 – Sustainability Pyramid

park because there are no sidewalks or bike paths in the neighborhood for him to use in safely accessing these facilities.

Fortunately, there is an alternative that can provide a better balance.

A Sustainability Pyramid illustrates how a viable ecosystem serves as the foundation for our society by providing the natural resources we need to support our human systems and man-made surroundings. A variety of natural processes interact to create a healthy environment, allowing us to harvest the food we eat and obtain the raw materials to build our communities. (See Figure 1).

The sustainability concept recognizes the need for mankind to tap into environmental resources in order to improve the quality of life, but it encourages us to do so in a manner that enhances, not destroys, the natural processes we rely on for our very existence.

The President's Council on Sustainable Development initiated efforts to apply the concept of sustainable development in the United States and identified "Green Infrastructure" as one of several key strategies for achieving sustainability in its May 1999 report, *Towards a Sustainable America—Advancing Prosperity, Opportunity and a Healthy Environment for the 21st Century*. Green infrastructure is defined as:

"Our Nation's natural life support system—an interconnected network of protected land and water 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."

"How long can we go on and safely pretend that the environment is not the economy, is not health, is not the prerequisite to development, is not recreation?"

Charles Caccia
Member of Parliament, House of Commons, 1996

What constitutes Green Infrastructure?

Green infrastructure consists of several components that work together to maintain a network of natural processes. These elements range in size and shape depending upon the type and the scale of the resource being protected. The rarity or ecological importance of the natural features within each component determines the level of conservation required to protect these resources, while the sensitivity of the environment to human activity determines how much interaction between man and nature is appropriate.

HUBS: Act as an "anchor" for a variety of natural processes and "provide an origin or destination for wildlife." Hubs include:

Less Human Interaction

Reserves: Lands that protect significant ecological sites, including wildlife areas typically in their pristine state, such as the John Heinz National Wildlife Refuge.

Managed Native Landscapes: Large publicly owned lands, such as the Allegheny National Forest, managed for resource extraction as well as natural and recreational values.

Working Lands: Private working lands, including farmland, forests, and ranch lands.

Parks and Open Space Areas: Landscapes at the national, state, regional, county, municipal and private level that may protect natural resources and/or provide recreational opportunities. Examples include public parks, natural areas, playgrounds, and golf courses.

Recycled Lands: Natural resources that were previously damaged by intense public or private use and that have since been restored or reclaimed. Mined lands, landfills or brownfields that have been improved in total or in part to provide an environmental function are examples of recycled lands.

More Human Interaction

LINKS: Interconnect the hubs, facilitating the flow of ecological processes. Links include:

Less Human Interaction

Conservation Corridors: Linear areas, such as river and stream corridors that serve primarily as biological conduits for wildlife and may provide recreational opportunities. Greenways and riparian buffer areas are examples of conservation corridors.

Greenbelts: Protected natural lands or working landscapes that serve as a framework for development while also preserving native ecosystems and/or farms or ranchlands. They often act as partitions within a community—a form of visual and physical relief in the landscape—separating adjacent land uses and buffering the impacts of these uses. Farmland preservation areas are considered greenbelts.

Landscape Linkages: Open spaces that connect wildlife reserves, parks, managed and working lands and provide sufficient space for native plants and animals to flourish. In addition to protecting the local ecology, these linkages may contain cultural elements, such as historic resources, provide recreational opportunities and preserve scenic views that enhance the quality of life in a community or region. Landscape linkages include urban streetscapes and recreational trail corridors.

More Human Interaction

PENNSYLVANIA'S ONCE-BOUNDLESS FORESTS ARE NOW DIVIDED INTO MORE THAN 377,000 FRAGMENTS, 91% OF WHICH ARE SMALLER THAN 25 ACRES.

Creating a Green Infrastructure System

The procedure for establishing a green infrastructure system starts with a thorough understanding of two important aspects of a community:

- **The ecological forces at work in the area.** An analysis of the natural resources of an area should be made to determine the role that each landscape feature plays in supporting ecological processes. An assessment of their variety, distribution and current condition will reveal which aspects of the landscape are at risk and how damage to these resources might adversely impact the sustainability of the region. To the greatest extent possible, the scientific principle should be used to perform this analysis to substantiate the findings and conclusions.
- **The social fabric of the community and its relationship to the surrounding region.** Demographic information, historical research and economic data should be used to identify development patterns and trends, determine how these factors have shaped the community, and what their future effects might be, if any. An organized public participation process should encourage a variety of individuals to work together to develop a vision for the future development of the community.

More than half of Pennsylvania's forests lie within 100 yards of fields, roads or some other non-wooded cover.

With this knowledge, the goals and objectives of the green infrastructure system can be determined and prioritized. These objectives should highlight:

- the specific ecological and social benefits that can be derived from the various green infrastructure components (such as clean air and water or improved physical fitness), and
- the land conservation and development policies that can be used to implement the system.

The interconnection of hubs and links is critical in providing landscape continuity for ecological functions, the passage and dispersal of wildlife, and the healthy interaction of man and nature. (See Figure 2). In making these connections, obstacles that act as a barrier to movement may be discovered. Efforts to eliminate or minimize the impact of these barriers are an important part of the interconnection process.

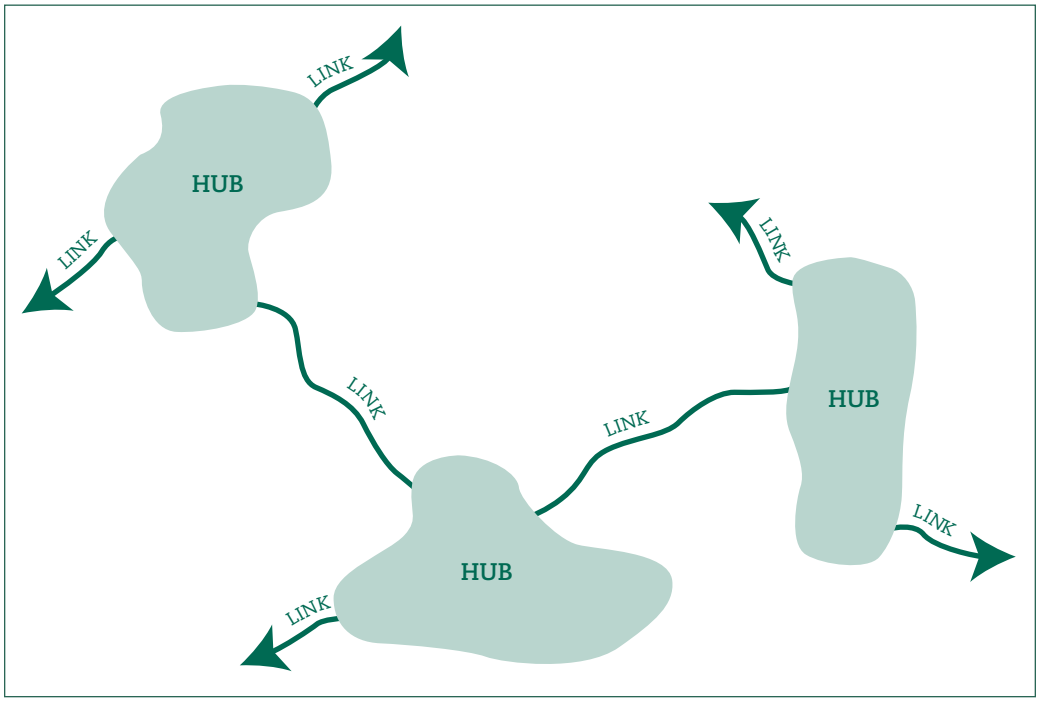

Figure 2– Conceptual Green Infrastructure System

How does a Green Infrastructure System work?

The concept of green infrastructure is relatively new. Even though many municipalities already possess some hubs and links, communities across the country are just beginning to apply green infrastructure principles to tie these components together to form an integrated network of sustainable resources.

The following six-step process clearly defines how a community can develop and implement a green infrastructure system:

1 – Develop an Approach
2 – Inventory Community Resources
3 – Envision the Future
4 – Find the Hubs and Links
5 – Create the Plan
6 – Build the System

To more fully illustrate the process, the following hypothetical example tracks a fictitious community, Hope Township, and describes how its citizens combined their human resources and current land use planning tools to create a vibrant, workable green infrastructure system.

Background:

The talk was lively as a number of residents in Hope Township, population 11,703 and growing, gathered at the municipal building to attend the monthly planning commission meeting. Tonight's agenda included a presentation on the topic of green infrastructure, and curious neighbors wanted to know more about the commission's ideas for incorporating green infrastructure into a new long-term land use plan for the township.

The physical layout of the municipality merely hinted at the challenges and opportunities the community faced. The township consisted of a densely populated village center (with traditional residential, commercial and institutional uses) surrounded by agricultural lands that extended to the base of a forested hill.

The township's population and economic vitality had diminished years ago when a local paint factory, a key employer, closed. However the economy was being re-stimulated by younger residents who had previously left the area to strike out on their own, but were now returning to raise families and care for aging parents. Economic recovery was evident, with the recent construction of a continuing care facility, a second elementary school, a new hospital wing and the scattering of residential developments outside the village.

The controversial Route 10 widening project, stalled for many years due to state budget constraints, was now rumored to be back on the drafting table, and land speculators were already tempting older farmers to "sell out" even though the specific highway improvements were not yet finalized.

Residents and business owners alike felt that the village was the cultural and economic center of the community and that future development along Route 10 might adversely impact its character. Residents were also worried that new development would worsen flooding, threaten water supplies, alter the farming community, and destroy scenic views of the nearby hillside.

The audience at the planning commission meeting was anxious to hear how a new long-term land use plan would help address existing concerns and accommodate future changes in the community. Could a green infrastructure strategy help resolve existing problems and manage change within various areas of the township?

Step 1 – Develop an Approach

The planning commission chairman stated that a study committee had been created for the sole purpose of recommending a new plan for the township based upon the green infrastructure concept. The composition of the committee reflected the wide range of community interests. In addition to two members from the planning

commission, the committee included the county extension agent, community development director and other township leaders who represented local farmers, downtown businesses and residential neighborhoods. A biologist, community planner, landscape architect, township engineer and the township solicitor were retained to provide technical expertise throughout the planning process.

The county extension agent and community development director explained how the concept of green infrastructure could be used as the framework for the township's long-term land use plan. In essence, the committee would work with the consultants to identify the unique natural processes and cultural features in the township and then suggest a land use plan to protect and maintain these elements as part of a green infrastructure system that would enhance the quality of life. The decision-making process would involve a series of investigations and discussions based upon an understanding of ecology and a desire to strike a balance between protecting natural resources and supporting economic development.

Everyone understood that change was inevitable and that preventing further development of any kind was not only unrealistic but also undesirable. However, the participants in the planning process would have to learn more about the natural processes at work in the environment in order to make wise choices about the future growth of their community.

Step 2 – Inventory Community Resources

The committee recruited students majoring in land use planning from the nearby community college to prepare geographic information system maps showing a variety of existing features such as the township's topography, geology, soils, water resources, vegetation, zoning districts, land uses, wildlife habitat, public parks and farmland. The drawings enabled the study committee to visualize these features.

The biologist explained how plants and animals coexist in various combinations in the environment based upon the physical characteristics of the landscape. The amount of space that different plants and animals need to live and breed varies with the species, depending upon migration and settlement patterns. Some species are "generalists" and adapt to a range of landscape conditions while others are "specialists," requiring a habitat composed of very specific elements. Variations in the size, shape and type of wildlife areas contribute to the diversity of flora and fauna. Large patches of vegetation in the landscape support more wildlife than smaller ones, and certain plants and animals make their home in the interior of a patch while other species prefer the edge. Wildlife movement occurs when favorable habitat areas are physically connected or are in close proximity.

The study committee identified five basic landscape types in the township—the forested hills, cultivated farmlands, wetlands, creek/stream corridors and disturbed urban areas. (See Figure 3). Each landscape type not only created different habitats for wildlife but also different resources for man's use. For example, the forested hillside provided critical habitat for rare wildlife and supported timber harvesting. The wetlands provided a nesting ground for special amphibian populations and filtered stormwater to keep ground water supplies clean. Cultivated lands provided a source of food and acted as a visual transition between the village's urban environment and the forested hillside.

Even though some committee members had lived in the township for years, many of them were pleasantly surprised by what they learned from the inventory. So far, the green infrastructure planning process had been a valuable educational experience.

Step 3 – Envision the Future

The community development director suggested that the study committee establish some overriding principles to guide the establishment of a green infrastructure system. Several meetings were held to discuss those aspects of Hope Township that made it a desirable place to live and that were vital to its long-term stability and success. The committee members talked about their dreams for Hope Township and tried to visualize what the township could become. At the conclusion of this brainstorming process, they identified four green infrastructure principles that would both enhance the environment and support community values:

1. **Preserve critical resources** within each landscape type to protect natural and cultural features that shape the character of the community.
2. **Maintain important ecological processes** that are required for long-term sustainability.
3. **Reclaim lands** that have been adversely affected by human activity.
4. **Create connections** to allow for the movement of wildlife and provide opportunities for people to interact with nature.

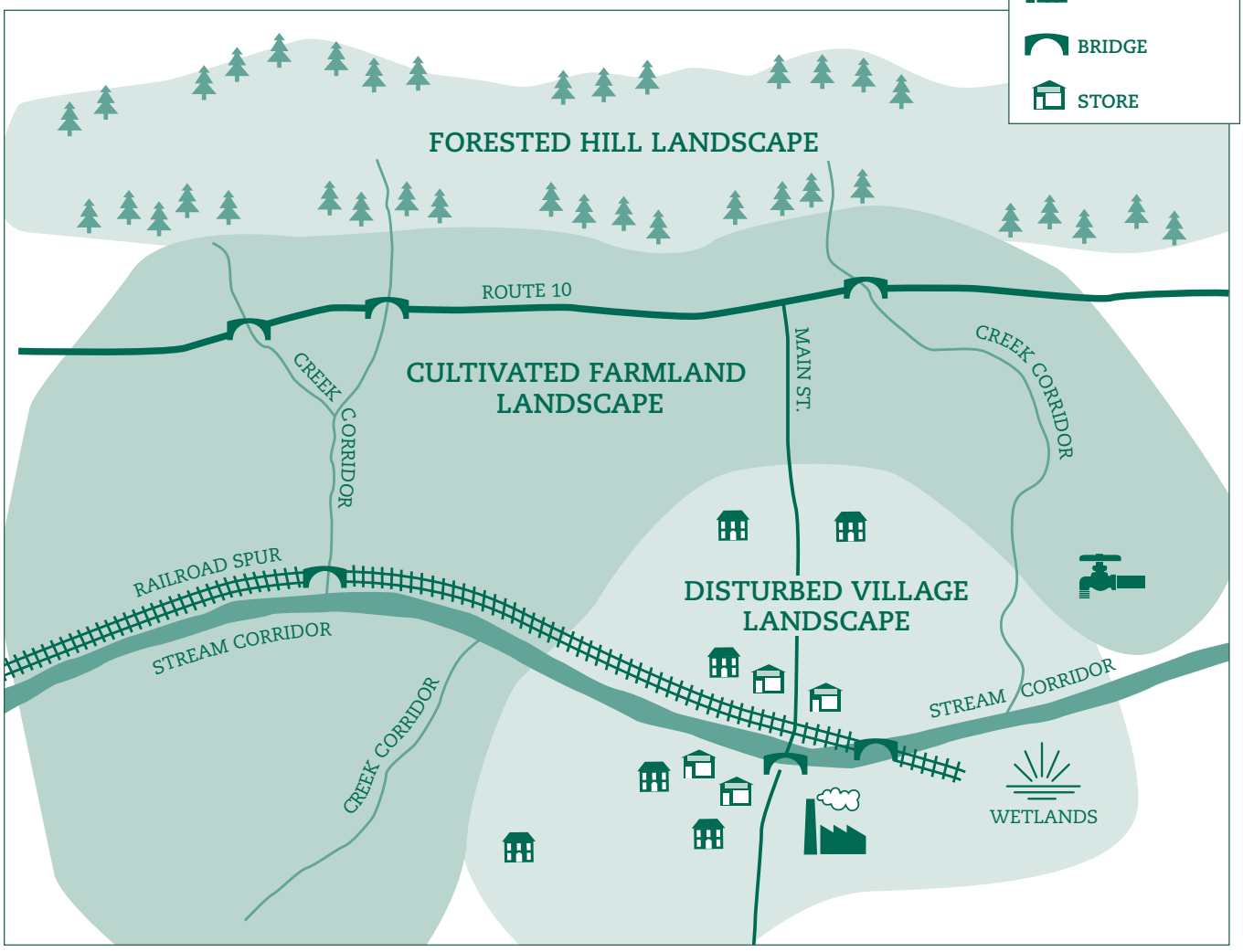

Figure 3 – Landscape Types – Hope Township

Step 4 – Find the Hubs, Links and Barriers

The committee identified the elements or hubs within each landscape type that contributed to the rich environmental and social fabric of the community and determined ways to interconnect the various hubs. (See Figure 4).

Forested Hill Landscape:

State Game Lands Hub:
The biologist and landscape architect explained that the state game preserve on the hill not only provided a large forested habitat for a variety of plants and animals but was also a scenic backdrop for the community.

Unique and Endangered Species Hubs:
Representatives of the Audubon Society and a local sportsman's club identified two unprotected sites near the State Game Lands that contained unique or endangered species. The study committee agreed that these two sites should be protected.

Cultivated Farmland Landscape:

Prime Agricultural Soils Hub:
Farming was and always should be an integral part of the community. The most productive soils were identified for farmland use and protection.

Clean Water Hub:
The township engineer noted that the community's future depended upon a clean water supply that came from three wells located along the border with a neighboring municipality to the east. The wells were located in a specific geological area of the township that could provide additional well water as the population grew. Collaboration with the adjacent municipality was needed to protect the existing water supply from possible contamination.

Disturbed Urban Landscape:

Wetland Hub:
There was a large wetland in the township on the old paint factory property. The redevelopment of this brownfield site presented an opportunity to restore the wetland and integrate this natural feature into the village community.

Park and School Hubs:
The junior high school and two elementary schools provided public spaces in the township for residents to socialize and enjoy the outdoors. Three small community parks were also identified as important green spaces accessible to residents.

With the green infrastructure hubs identified, the committee next considered how to *link* the hubs in order to connect ecological processes and facilitate the interaction of residents with nearby natural areas.

Rail Line Link:
Raw materials and finished products were once transported to and from the paint factory via a railroad spur that went through the village and included a bridge across the stream. The spur connected to the abandoned railroad right-of-way that had recently been purchase by the County for future use as a recreational trail. The committee agreed that converting the spur to a rail-trail needed to be considered, in light of the potential for this route to link the township with natural and recreational areas elsewhere in the region.

Aquatic Link:
The creeks and the stream could be used to link a number of green infrastructure components, since these watercourses crossed through each of the landscapes and came near several of the hubs.

Pedestrian Link:
Streetscapes could be used to link parks and schools to each other and to the natural areas of the community, enhancing access to these sites and providing additional recreational opportunities for improving the health and well-being of residents.

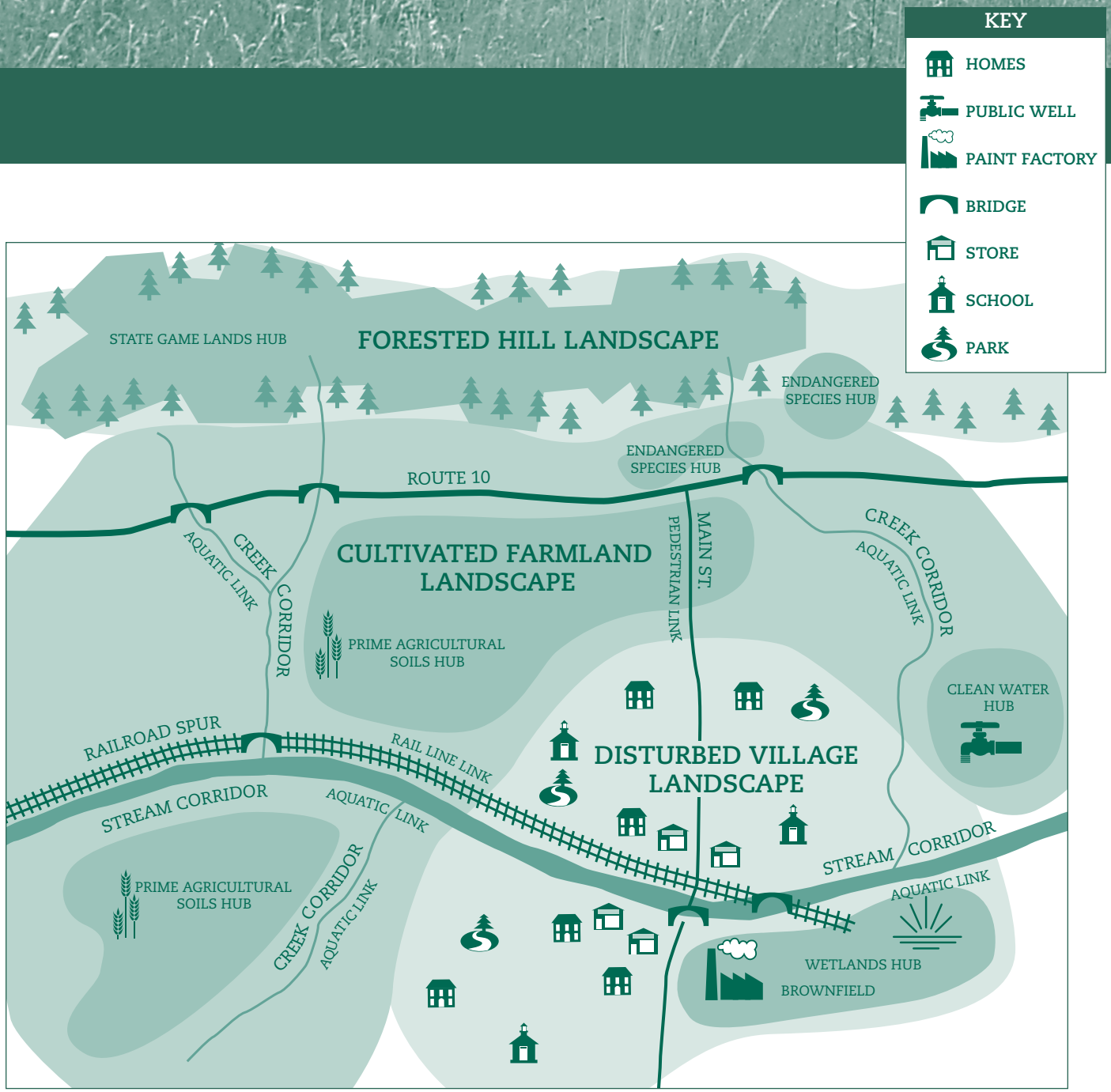

Figure 4 – Hubs and Links – Hope Township

Step 5 – Create the Plan

The hubs and links were added to the collection of drawings prepared by the community college students for the study committee. With each layer of information, a pattern in the distribution of natural and cultural resources began to take shape. The committee could now see how the railroad spur and watercourses could connect the different hubs and landscape types within the community and link the township's green infrastructure system to other municipalities in the county.

The study committee worked in small groups to develop specific recommendations for building the green infrastructure system in accordance with the agreed upon goals. Each group presented a preliminary list of ideas for critique and coordination. The committee refined these ideas into a coherent action plan and a map of the green infrastructure system. (See Figure 5).

The results were compiled into a draft report that included a proposed timetable and cost estimate for completing the recommendations along with a

list of funding options for review by the planning commission. The study committee and planning commission jointly presented the final report at a public meeting before the township's Board of Supervisors, who subsequently adopted the green infrastructure plan and agreed to budget funds each year for implementing the plan recommendations.

Step 6 – Build the System

The township formed an environmental advisory council made up of members of the study committee to continue working with the Board of Supervisors to implement the recommendations in the green infrastructure plan. Over the next ten years, Hope Township was able to use a number of land planning techniques to achieve several goals with assistance from a variety of partners:

Green Infrastructure Investments and Accomplishments:

1. Protected both properties containing unique and endangered species. Acquired one tract using grant funds from the state and a donation from a local sportsman's club. Partnered with a land trust to obtain a conservation easement on the other tract.
2. Amended the zoning ordinance to allow for the transfer of development rights from prime agricultural lands to the residential zone surrounding the village in order to preserve the existing agricultural greenbelt and concentrate population growth near existing businesses to stimulate the economy. Added provisions governing the construction of clustered residential homes to encourage natural resource preservation while minimizing the future expense of constructing and maintaining the public water, sanitary sewer and road network associated with new development.
3. Worked with the neighboring municipality to develop a wellhead protection plan to identify the area around the well where contaminants could travel above or below ground to reach the township water supply. Amended the existing ordinances to include provisions for protecting the well.
4. Monitored and assessed the quality of the creeks and stream with volunteer assistance from the high school science club. Developed a watershed management plan that recommended solutions to the existing storm drainage, flooding and water pollution problems. Completed a storm sewer upgrade project and revised the stormwater management ordinance to require that detention basins be planted with native vegetation to filter runoff. Obtained conservation easements to restore eroded creek banks with assistance from the land trust and garden club.
5. Worked with the paint factory owner to remediate the environmental hazards at this brownfield and adaptively redevelop the property for new businesses, using a combination of low-interest loans and grant funding from the state. Accepted dedication of the wetlands and began habitat restoration work.
6. Installed sidewalks and street trees using community development block grant funds to improve pedestrian access and reduce air/heat pollution. Encouraged residents to participate in the garden club's program to attract wildlife to backyard settings.
7. Collaborated with the land trust to acquire land and conservation easements along a creek, thereby connecting an existing park and school with the railroad spur and creek/stream corridors.
8. Teamed up with the county to prepare a master plan for a rail-trail along the railroad spur right-of-way and coordinate construction efforts. Selectively cleared vegetation from the overgrown right-of-way, paved the trail with help from the boy scouts and public works department and installed benches, trash receptacles and signage. Repaired the railroad bridge, providing a pedestrian link to the redeveloped paint factory site.

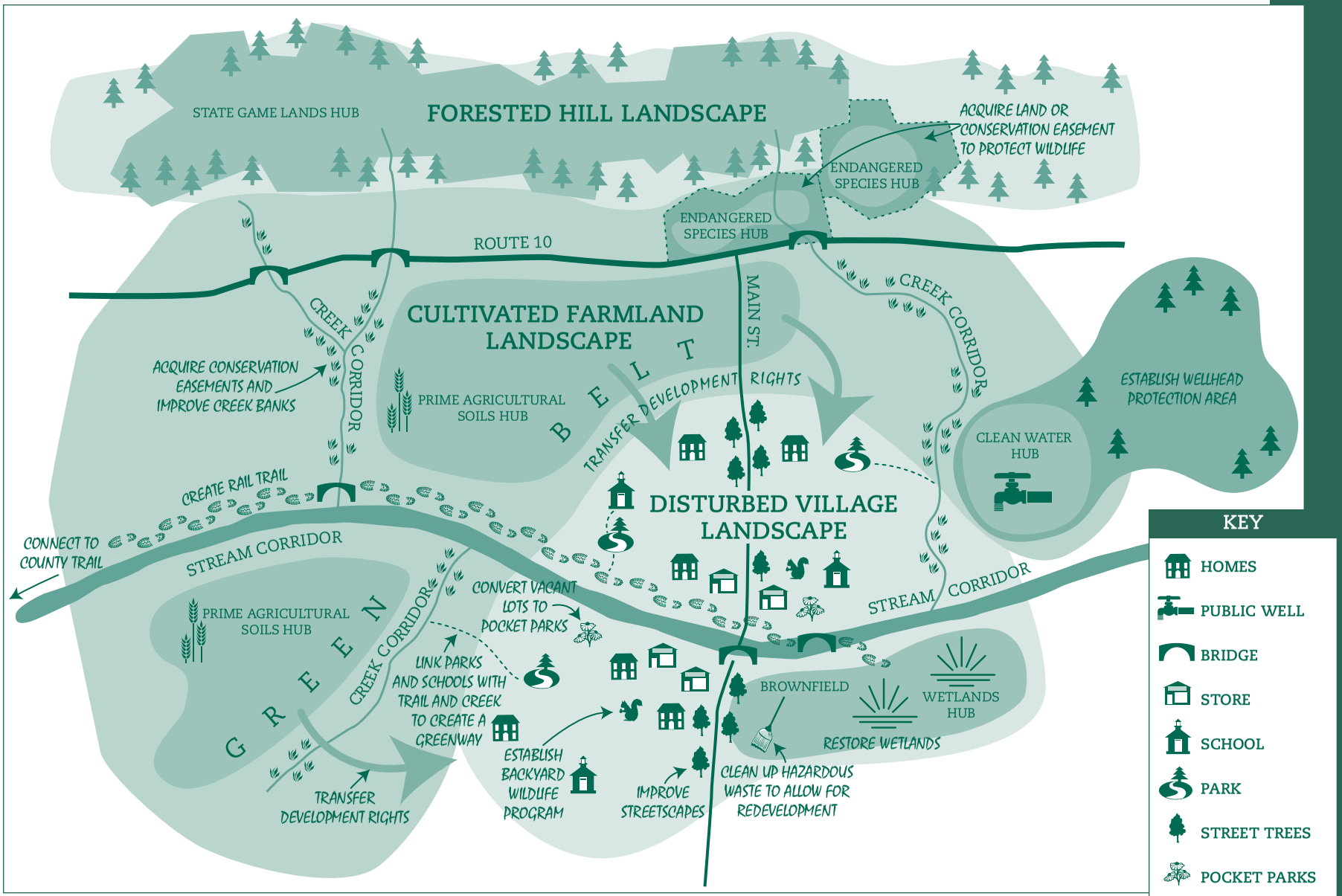

Figure 5 – Green Infrastructure Plan – Hope Township

Conclusion

The example of Hope Township reinforces several important techniques that, when implemented properly, contribute to a successful green infrastructure plan:

A. **Use a comprehensive approach to planning.** The goal of a green infrastructure system is to establish a framework for coordinating conservation efforts. Keep an open mind about what should be included in the green infrastructure system.

B. **Plan ahead.** It easier and often more cost effective to protect the environment before land development occurs than to restore natural processes after they are impaired.

C. **Learn as much as you can.** There is often no single source for information about the natural ecology of your area or the latest land planning techniques. Get the professional expertise you need to make sure the green infrastructure plan is based upon accepted scientific knowledge and sound land use practices. (See References).

D. **Encourage public participation.** Identify potential partners and include a variety of stakeholders in the planning and implementation process.

E. **Promote biodiversity.** Create variation in the landscape by protecting natural resources that differ in size and type. Find a way to link these resources. Think beyond municipal boundaries to connect with environmental features in the surrounding region.

F. **Incorporate the human element.** Green infrastructure is not intended to isolate people from nature by creating a separate network of open spaces just for wildlife. Its purpose is to weave nature back into the community in a way that facilitates various levels of human interaction with the environment based upon the resiliency of the natural resources being protected.

G. **Make the tough choice.** Building a green infrastructure system is an investment in your future. Promote the hidden value of green infrastructure and commit the time and money to bring the plan to fruition.

As civilization progresses, so does our understanding of the environment and our appreciation of its contribution to the quality of life. Great strides have already been made to protect precious natural resources. Take the next step in the conservation process by using green infrastructure to care for the natural processes that sustain us all.

Green Infrastructure...Let natural systems work for you...

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Acknowledgements

Heritage Conservancy is a non-profit organization dedicated to preserving our natural and historic heritage. We are grateful to Representative Charles T. McIlhinney, Jr., the Commonwealth of Pennsylvania, Department of Community and Economic Development and the William Penn Foundation whose support made this publication possible.

CELEBRATING 50 YEARS OF PRESERVATION

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