AASHTO

Environmental Planning GIS Tools

Integrating Transportation and Resource Conservation

Partners:

U.S. Environmental Protection Agency Region 6

Maryland Department of Natural Resources

The Conservation Fund

Guidance Document

Maryland State Highway Administration

Texas Department of Transportation

DISCLAIMER

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Executive Summary

As the United States continually strives to prosper in a global economy, we recognize that efficient transportation infrastructure and services are key components of a sustainable future and that healthy and well-functioning ecosystems play a vital role in attaining the economic and societal goals that positively affect our quality of life. Combining the use of geographic information systems (GIS) technologies with physical science provides an opportunity for transportation agencies to realize project-development efficiencies and economies while contributing to the conservation and stewardship of essential ecological resources and services.

This Environmental Planning GIS Tools (EPGT) Guidebook offers transportation industry members:

- Information about adoptable concepts and tools to advance the use of GIS and environmental data in the development of transportation and support infrastructure;
- Shared knowledge and experience regarding the benefits of enhanced GIS technology and integrated decision making;
- Important assessment considerations and requirements for implementing GIS tools; and
- Links to valuable GIS data, tools, and other initiatives to help develop a program that best fits the objectives and resources of each agency.

Background

The American Association of State Highway and Transportation Officials (AASHTO), Technology Implementation Group (TIG) program seeks to identify innovative transportation technologies and accelerate their adoption by agencies nationwide. TIG selected the EPGT initiative as an innovative technology to share with other states. The EPGT Team is led by the Maryland State Highway Administration and the Texas Department of Transportation and includes representatives from the Maryland Department of Natural Resources; The Conservation Fund; and the United States Environmental Protection Agency, Region 6.

EPGT provides a scalable project-development enhancement that uses spatial technology merged with ecological science to analyze environmental assets and assign values to ecological resources and services. By effectively using existing and emerging environmental data assets and technology, transportation officials, planners, and designers can better incorporate these values into infrastructure needs by working with members of the public in an integrated decision-making process. This “ecosystem approach” recognizes the interrelationship between healthy ecosystems and sustainable communities and economies that rely on efficient transportation and investments.

Since 1995, the United States Department of Transportation and partner federal agencies have been actively promoting the advantages of implementing an "ecosystem approach" for decision making to state and local transportation and environmental resource agencies. The 2006 influential publication, "Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects," brought this effort to the forefront of the transportation industry. Since then, transportation agencies nationwide have developed and implemented new procedures, policies, and tools for more effectively integrating ecological resource values into the transportation project-development process.

Derived Transportation Project-Development Benefits

Transportation agencies that have implemented innovative EPGT have experienced numerous benefits, including:

- Improved interagency project-development procedures;
- Enhanced opportunities to support partner agencies with shared mission goals;
- Improved project-development efficiency and effectiveness and accelerated project delivery;
- Better adaptation to changing regulatory demands, especially those related to mitigation;
- Increased credibility and improved working relationships with resource agencies and the public;
- Defensible project decisions;
- Scalable solutions; and
- Ease of integration with existing data.

Derived Public Benefits

The general public also benefits by agency use of EPGT through:

- Reduced public expenditure for infrastructure planning due to process efficiencies;
- More effective public involvement in decision making through a more transparent evaluation and selection process supported by objective data analysis and science;
- Improved "ecosystem services" and human health through strategic conservation of natural resources (regulating climate, filtering pollutants, cleaning the air, etc.) within the development of public infrastructure;

- Better quality of life resulting from the identification of natural areas and their incorporation into project development that can conserve open space and potentially provide recreation benefits to a community;
- Potentially increased property values for homes adjacent to protected conservation areas; and
- Opportunities for expanded environmental education and stewardship.

Derived Natural and Human Environment Benefits

The derived benefits to the natural and human environment include:

- Improved understanding of ecological resources and value;
- Early identification and consideration of significant ecological resources in project development to maximize impact avoidance and minimization;
- Increased opportunity to integrate consideration of ecological resources into public and private decision making;
- Expanded prospects for implementing multi-value stewardship actions that generate benefits for the natural and human environments;
- Strategic planning and efficient use of funds for conservation of ecologically important resources and unique habitats;
- Potential targeted restoration of degraded resources and gaps within larger ecosystems through an ecosystem mitigation approach; and
- In developing public infrastructure, reduction of forest fragmentation that can reduce health risks and manage the expansion of disease vectors in nature.

I. Introduction

A. Why Environmental Planning GIS Tools?

The use of Environmental Planning Geographic Information System Tools (EPGT) facilitates the improved planning and design of transportation projects through an expanded consideration of ecological, socioeconomic, and cultural features and values. Using geographic information system (GIS) technologies, these tools highlight the importance of an integrated, multi-scale planning process to facilitate the development of transportation infrastructure within the context of interconnected networks of ecologically important lands.

With EPGT, state departments of transportation (DOTs) can identify and develop optimal paths to address transportation improvement needs and environmental mitigation and stewardship responsibilities. Innovative GIS technology allows DOTs to integrate transportation planning and design with environmental stewardship and mitigation in a cost-effective and efficient manner that is science-based and supportive of multi-value cooperative efforts between governmental and non-governmental agencies and the greater public.

Geographic information system(s)

GIS technologies allow users to view, understand, question, interpret, and visualize data about our world in order to reveal relationships, patterns, and trends. It integrates hardware, software, and data for capturing, managing, analyzing, and displaying multiple forms of geographically referenced information. GIS is a tool that can help manage, analyze, and model data from our environment to improve decisions that affect the conservation of our natural resources and diversity.

B. Federal Policies and Initiatives

The need for stronger consideration and effective planning linkages between efforts to meet our transportation needs and our recognized role as stewards of our natural, social, and cultural environment has been recognized as far back as the 1970s, when the National Environmental Policy Act (NEPA) and a suite of environmental resource protection laws were enacted. While these early efforts helped reduce damage to resources affected by societal progress, a gap remained in the effectiveness of efforts to meet our growth demands and the conservation of valued environmental resources at a more holistic level. More recently and at an increasing pace, federal environmental policies and initiatives are promoting an integrated ecosystem approach to infrastructure planning and environmental conservation, bringing ideas such as stewardship and sustainability to the forefront of transportation concerns.

A major impetus for the promotion of integrating project development with ecosystem concerns occurred in December 1995. Recognizing the increasing need for a common framework to carry out their environmental stewardship responsibilities more effectively and efficiently, the United States Department of Transportation (U.S. DOT) entered into a Memorandum of Understanding (MOU) with the Council on Environmental Quality (CEQ) and 11 other federal agencies to cooperatively foster an interagency "ecosystem approach" to federal actions and mandates (Council on Environmental

Quality, 1995). The goal of this "ecosystem approach" is to restore and sustain the health, productivity, and biological diversity of ecosystems and overall quality of life through a natural resource management approach fully integrated with social and economic goals. In carrying out this policy and these interagency relationships, the signatory agencies will emphasize:

- Consideration of all relevant and identifiable short- and long-term ecological and economic consequences;
- Improved coordination among federal partners and communication with the general public;
- Development of partnerships between federal agencies and state, local, tribal, and foreign partners;
- Carrying out federal responsibilities more efficiently and cost effectively;
- Basing decision making on the best available science;
- Improving information and data management; and
- Implementing adaptive management principles as new information becomes available.

Executive Order (EO) 13274, "Environmental Stewardship and Transportation Infrastructure Project Reviews," signed September 18, 2002, further promoted the "ecosystem approach" to transportation decision making among the U.S. DOT and its federal agency partners. EO 13274 charged agencies to implement appropriate actions that advance environmental stewardship through protection and enhancement of the natural and human environment in the planning, development, operation, and maintenance of transportation facilities and services.

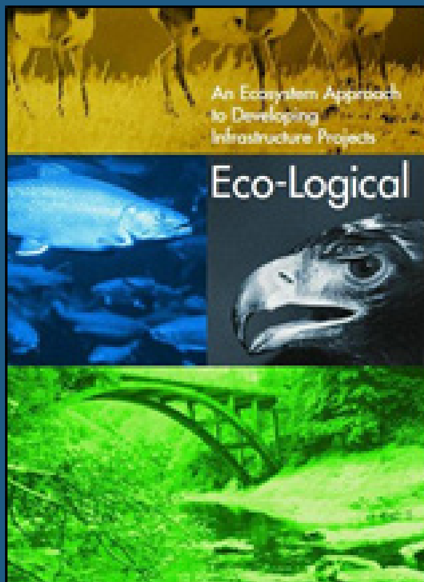
On August 26, 2004, Executive Order 13352, "Facilitation of Cooperative Conservation," reinforced the "ecosystem approach" to transportation decision making by ensuring that US DOT partner agencies in the Departments of the Interior, Agriculture, Commerce, and Defense and the U.S. Environmental Protection Agency (EPA) implement laws relating to the environment and natural resources in a manner that promotes cooperative conservation. This EO emphasizes appropriate inclusion of local participation in federal decision making, in accordance with respective agency missions, policies, and regulations.

In fulfilling the commitments of the 1995 MOU and to further promote the principles of these Executive Orders, eight federal agencies collectively developed "Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects (FHWA, April 2006)." This report articulates a vision for federal resource and partner agencies to improve the efficiency and effectiveness of decision making and environmental regulatory compliance. The goals promoted by improved interagency cooperation through the Eco-Logical principles include:

Ecosystem Approach

A conceptual method for sustaining or restoring ecological systems and their functions and values. It is goal driven and based on a collaboratively developed vision of desired future conditions that integrates ecological, economic, and social factors. It is applied within a geographic framework defined primarily by ecological boundaries.

Eco-logical: An Ecosystem Approach to Developing Infrastructure Projects, USDOT, 2006



- Safer, improved infrastructure;
- Improved watershed and ecosystem health;
- Increased connectivity and conservation;
- Efficient project development; and
- Increased transparency.

At the heart of this process is the endorsement of integrated resource assessment, analysis, and management across agencies and disciplines — an ecosystem approach — and the application of those efforts to infrastructure decision making. An ecosystem approach is a process for the comprehensive management of land, water, and biotic and abiotic resources that equitably promotes conservation and sustainable use. The approach continues the shift of the federal government's traditional focus from individual agency jurisdiction to the interactions of multiple agencies within larger ecosystems. It seeks ways to increase collaboration with state, tribal, and local governments and to involve other landowners, stakeholders, interested organizations, and the public.

The Strategic Highway Research Program (SHRP) was authorized by Congress in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) of 2005. The objective of the SHRP, administered by the Transportation Research Board (TRB) of The National Academy of Sciences, is to address the safety, reliability, capacity, and sustainability of our nation's highway infrastructure. The second phase of the SHRP (SHRP-2) is actively supporting research that looks at opportunities to advance the "ecosystem approach" promoted by Eco-Logical through long-range planning, corridor planning, and the programming phases of transportation delivery. To date, two projects have been completed in this research area: Integration of Conservation, Highway Planning and Environmental Permitting Using an Outcome-Based Ecosystem Approach; and Development of an Ecological Assessment Process for Enhancement to Highway Capacity. These projects recommended a nine-step Integrated Ecological Framework to guide the conduct of an ecological approach to transportation project development. The program is now embarking on research to develop an integrated, geospatial, ecological, web-based screening tool for early transportation planning.

The Moving Ahead for Progress in the 21st Century Act (MAP-21) was signed into law by President Barack Obama on July 6, 2012. This act is the first long-term highway authorization enacted since 2005. MAP-21 creates a streamlined and performance-based surface transportation program and builds on established highway, transit, bicycle, and pedestrian programs and policies. Environmental stewardship is included as part of the overarching goals for the program, which aims to enhance the performance of the transportation system while protecting and enhancing the natural environment. One especially relevant area of environmental stewardship applicable to the use of EPGT is that of mitigation, where federal funding of mitigation can include contributions to statewide and regional environmental protection plans and programs to conserve, restore, enhance, and create natural habitats.

MAP-21 also encourages the acceleration of project delivery through the planning and environmental review process and promotes innovation, such as EPGT, to meet this objective.

The tools highlighted in this report were developed in accordance with the principles of Eco-Logical and promote the consideration of a broad range of ecosystem values in planning and developing transportation improvements. They also mesh with the ongoing process and technology ideas being developed through the SHRP-2 program and the policies of MAP-21 to meet our collective stewardship responsibilities and make sustainability between our natural environment and transportation demands a reality.

II. AASHTO TIG Initiative

A. TIG Vision and Mission

The American Association of State Highway and Transportation Officials (AASHTO), Technology Implementation Group (TIG) annually searches for innovative and outstanding advancements in technology (including process "technologies") within the transportation industry to share with professionals. TIG's goal is to improve the nation's transportation system by shortening the learning curve for other agencies and accelerating the adoption of these technologies nationwide. Each year, TIG reviews applications of highly valuable but largely underutilized technology and provides funding and marketing support with the hope that the selected technology will provide a process/program improvement within the transportation industry.

Each "focus technology" selected by TIG is typically developed through rigorous research and "real world" applications, international technology tours, or simply through practices that have not been widely shared. Lead States Teams involved with the focus technology are formed with the charge of championing the consideration and application of the technology to other AASHTO members. The Lead States Team comprises a consortium of transportation or industry professionals with focus-technology experience and/or a commitment to supporting the technology with the financial support of AASHTO. A list of TIG focus-technologies initiatives can be found at tig.transportation.org (see Appendix).

B. EPGT Lead States Team and Selected Technologies

AASHTO TIG selected the Maryland State Highway Administration (MD SHA) and the Texas Department of Transportation (TX DOT) to jointly market similar focus technologies collectively known as "Environmental Planning GIS Tools" (EPGT). The MD SHA and TX DOT, supported by the Maryland Department of Natural Resources (MD DNR); the U.S. Environmental Protection Agency (EPA) Region 6; and The Conservation Fund constitute the designated EPGT Lead States Team. The EPGT technologies are summarized below.

1. Maryland SHA Green Infrastructure Approach and Assessment

The MD SHA Green Infrastructure (GI) Approach, using science-based GI assessment of ecological resources, provides innovative consideration of environmental features in developing transportation and infrastructure projects. The MD DNR originally developed a statewide GI assessment of important ecological lands to identify and prioritize areas in Maryland for conservation and restoration. The MD SHA further refined and integrated this technology as a consideration in its transportation project-development process. The resultant GI Approach incorporates an "ecosystem approach" concept to project development that aims to achieve sustainable transportation infrastructure and protection of critical ecosystem features and services. The approach can also complement strategic conservation and environmental protection objectives of agency partners who strive to protect Maryland's valued natural resources.

2. Texas DOT Geographic Information System Tools

In Texas, a suite of EPGT is used to support the development of transportation and infrastructure projects statewide. A multi-agency team comprising federal, state, and local resource interests created the Texas Ecological Assessment Protocol (TEAP), a GIS model used to assess and identify ecologically important resources across the diverse landscape of Texas. This tool allowed the rapid identification and assessment of potential environmental impacts on valued ecological lands related to large-scale infrastructure projects across the state. Building on the success of that effort, TX DOT and EPA Region 6 developed their Geographic Information System Screening Tool (GISST). GISST is a desktop application that integrates TEAP data and is used as an early planning tool that targets ecologically important areas for avoidance, identifies minimization and compensatory mitigation opportunities, and assists with National Environmental Policy Act (NEPA) planning and analysis in the development of proposed transportation initiatives. A

EPGT Team:

Lead States

- Maryland State Highway Administration (MD SHA)
- Texas Department of Transportation (TX DOT)

Partner Agencies

- Maryland Department of Natural Resources (MD DNR)
- U.S. Environmental Protection Agency, Region 6 (EPA)
- The Conservation Fund

third component of EPGT used in Texas is NEPAssist. This tool is a web-based screening application that draws environmental data from regional EPA GIS databases to allow planners to identify potential environmental issues early in project development.

III. State of the Practice: Maryland SHA Green Infrastructure Approach & Assessment

A. What is Green Infrastructure?

Green infrastructure (GI) is a network of natural areas that helps protect, conserve, and restore naturally functioning ecosystems. This expanse of forests, wetlands, streams, and other ecological features filters our air and water resources, enables the production of forestry and agricultural crops, protects against storm and flood damage, provides habitat for valued wildlife, and contributes to our quality of life through recreation opportunities and scenic beauty.

GI provides a diversity of ecological, cultural, and socioeconomic functions and benefits. Maintaining natural processes, conserving unique habitat, supporting biodiversity, providing cleaner air, and reducing nutrient and sediment pollution are just a few of the ecological benefits of GI. These benefits are essential to the sustainability of the human and natural environments.

GI can also positively influence human health by providing an environment that can help reduce health risks and manage the expansion of disease vectors in nature. Expanded natural areas (forests, water features, parks, trails, etc.) within our communities provide opportunities for solace and relaxation in a natural setting, while at the same time accommodating more active exercise pursuits. Humans need a balance of these experiences to further health and contentment. Use of natural green areas for passive and active recreation can help lower stress and reduce risks for conditions such as obesity, diabetes, and heart disease. Research has also shown that conservation efforts can positively affect the abundance and distribution of disease vectors in nature. For example, fragmentation of forest areas produces increased edge habitat that can promote the growth and expansion of disease-carrying ticks associated with Lyme disease and other fever-related illnesses.

In addition, GI supports working lands (e.g., farms), decreases the need for extensive public works (e.g., stormwater management), increases property values, and supports a high quality of life by attracting businesses and people.

Green Infrastructure

"Strategically planned and managed networks of natural lands, working landscapes and other open spaces that conserve ecosystem functions, and provide associated benefits to human populations."

Green Infrastructure: Linking Landscapes and Communities, Benedict and McMahon, 2006

B. Green Infrastructure Assessment

GI conceptually comprises interior, high-quality blocks of naturally functioning ecosystems, or cores, within slightly fragmented aggregations of core areas that consist of forest and wetland habitat, or hubs. Linear habitats that allow movement of animals, seeds, water, etc., between hubs and core areas are called corridors (Exhibit 1).

Linking large contiguous blocks of ecologically significant natural areas with natural corridors creates an interconnecting network of natural lands across the landscape. Conservation of such connections can help offset the functional losses caused by fragmentation resulting from human development (Maryland Department of Natural Resources, 2003).

Hubs and cores are important ecological patches that are critical for maintaining species diversity and abundance. They may typically contain sensitive plant or animal species, large blocks of contiguous interior forest, and significant floodplain or wetland resources. Corridors are linear features that typically follow prominent landscape features, such as ridgelines, streams, or forest strands that serve as connections between hub areas. Corridors provide a pathway for plant and animal species movement and propagation between key habitat areas.

Another important GI network concept is the identification of gaps; missing areas or breaks in the GI network that are considered conceptual areas for restoration and conservation. Removing gaps through restoration of impaired habitats contributes to the overall value, effectiveness, and sustainability of the entire GI network. Improving connectivity by reducing or removing gaps can expand access to and increase the extent of interior habitat, reduce excess edge habitat by smoothing GI edges along hubs and corridors, and improve species mobility within the network along complete corridors. Using GIS, MD DNR mapped the state's ecological network by pulling together existing information such as land-use cover maps, satellite and aerial imagery, and environmental and biological databases. Identification of the GI network in Maryland (Exhibit 2) combined the principles of landscape ecology and conservation biology with robust GIS analysis of detailed statewide resource data. The resultant GI assessment provides a consistent and scientifically derived approach for evaluating priority land conservation and restoration needs in the state. Results of the GI assessment were also envisioned as complementing local, state, and interstate land planning (Conn, 2009).

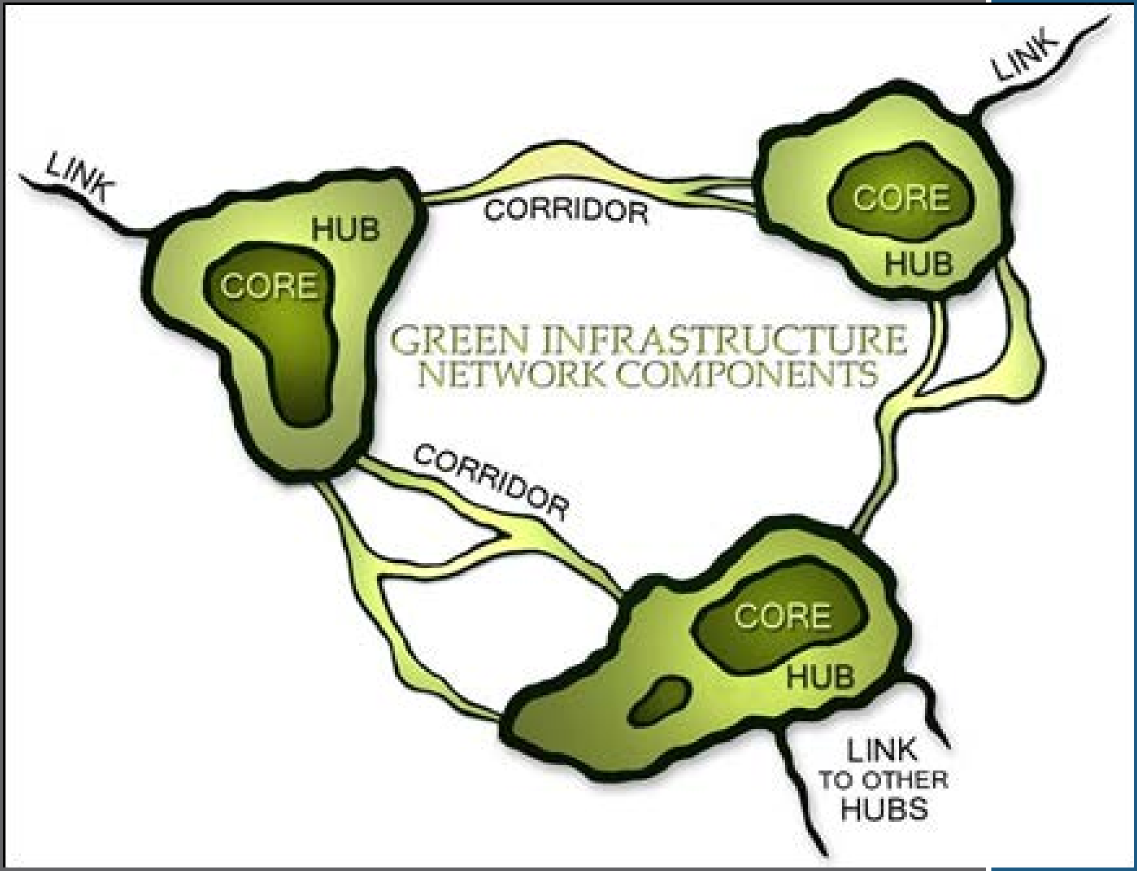
Each identified hub/core area was evaluated at an approximate 0.3-acre grid scale; provided a ranking based on its relative ecological value; and

Green Infrastructure Assessment

The scientific methods used to identify and characterize the green infrastructure of a given geography as part of a Green Infrastructure Approach. The methods involve:

1. identification of the most important natural lands and resources based on the application of ecological principles, typically facilitated using geographic information system (GIS) technology;
2. identification of connective land through a system of corridors and linkages; and
3. characterization and verification of the presence and ecological value of these lands and resources.

Exhibit 1 - *Green Infrastructure System*



(Source: Weber & Allen, 2010)

examined for its level of protection, status of management, and risk of development (Maryland Department of Natural Resources, 2003).

The ecological value of a given grid scale was based on a combination of local ecological attributes and landscape attributes representative of the location of the grid scale within the GI network.

Ecological attributes evaluated included:

- occurrence of rare plants or animals;
- vegetative land cover;
- length and quality of streams;
- number and area of wetlands;
- soils characteristics; and
- proximity to urban development.

The level of protection analysis considered:

- acres of surrounding lands permanently conserved;
- pending land sales;
- existing zoning;
- potential changes to existing zoning;
- availability of public water and sewer infrastructure; and
- distance to new construction.

Exhibit 2 - *Maryland State Green Infrastructure Network*

(Source: Maryland Department of Natural Resources, 2003)

Composite ranking compared lands in the GI network for relative conservation value, feasibility for protection, and urgent need for quick acquisition to secure protection (The Conservation Fund, 2004). Areas of fewer than 100 contiguous acres, developed lands, and major roads were excluded from the total land identified as GI. In total, more than two million acres of GI (38 percent of the state's land area) were identified and mapped throughout Maryland in 2000 (Conn, 2009). These two million acres of statewide GI include approximately 63 percent of the total state forest land; 87 percent of the state's remaining unmodified wetlands; 88 percent of lands supporting state rare, threatened, and endangered species; and 90 percent of high-quality, forest-interior-dwelling-bird-species' habitat in the state (Maryland Department of Natural Resources, 2003).

GI assessments can also be used as a long-range strategic land-planning tool. By identifying ecologically significant areas, non-compatible land uses can be guided to the least ecologically disruptive places, and conservation of significant core areas, hubs, and corridors can be targeted. In Maryland, the use of GI assessments in land-use planning aids state and county agencies in achieving restoration and conservation goals established for federal and state Chesapeake Bay restoration programs.

C. The MD SHA Green Infrastructure Approach

The GI Approach, as refined and adopted by the MD SHA, emphasizes the importance of integrating the planning and development of transportation infrastructure with the consideration of the connections between ecologically important resources, developed and undeveloped areas, and valued components of our communities (Exhibit 3). The approach uses the results of a GI assessment to assist in planning for transportation improvements that support the concept of sustainability and the role of MD SHA as a steward of the environment.

MD SHA utilizes existing statewide GI data (or more detailed localized GI assessment data, when it is available) and associated information during the scoping phase to provide a full understanding of the environmental setting within which a proposed transportation project would occur. This information allows for the early and comprehensive identification of valued environmental features on which pertinent environmental concerns can be focused and helps define the underlying purpose and need of the transportation project.

Ideally, appropriate GI data at either a statewide or county level is available to assist in the transportation alternatives identification. For the majority of transportation projects, this process is employed. For more complex projects, for which additional analysis is appropriate, MD SHA may perform a more detailed GI assessment to better understand the valued ecological resources of the project area and to better inform the development of project alternatives. The objective at this phase is to identify available and practicable alternatives that minimize GI impacts in consideration of other natural, social, and community resources.

Once the project alternatives have been developed, SHA integrates consideration of GI impacts with typical alternatives analysis performed through the NEPA process. Avoidance and minimization of GI hubs, core areas, and corridors is a primary effort, as is the evaluation of potential impact on transportation alternatives that cross or parallel "gaps" in the GI network. (Gaps are breaks in the connective GI network and are often notable areas for restoration/conservation opportunities.) For more complex projects, the alternatives analysis process may be iterative, as multiple alternative options are developed and assessed against potential GI and other resource impacts. Of primary importance is the minimization of impact on identified high ecological score resources and priority conservation areas.

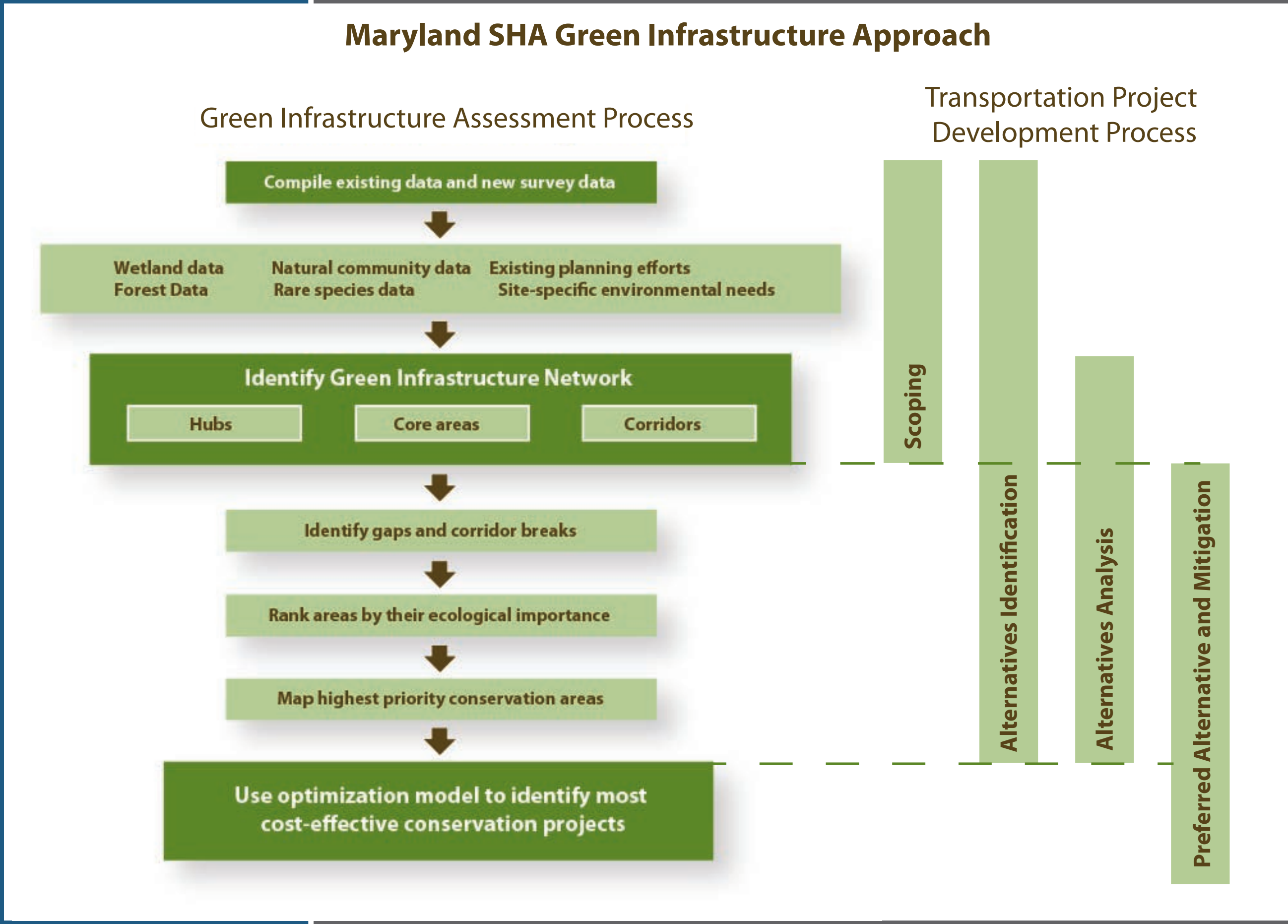
The final step in the MD SHA GI Approach is to identify a preferred alternative and conceptual mitigation that meets the project purpose and need and reflects a balance between effective public investment and environmental

MD SHA Green Infrastructure Approach

The Green Infrastructure Approach is a planning method used by the Maryland State Highway Administration, in partnership with other federal, state and local resource agencies, that integrates the transportation project development process with the identification, analysis and consideration of green infrastructure ecological features and values.

Encompassing the aims of the ecosystem approach concept, the method promotes the value of green infrastructure through a systematic and strategic approach to environmental protection and mitigation at multiple scales while addressing transportation needs throughout the state.

Exhibit 3 - *Maryland SHA Green Infrastructure Approach*



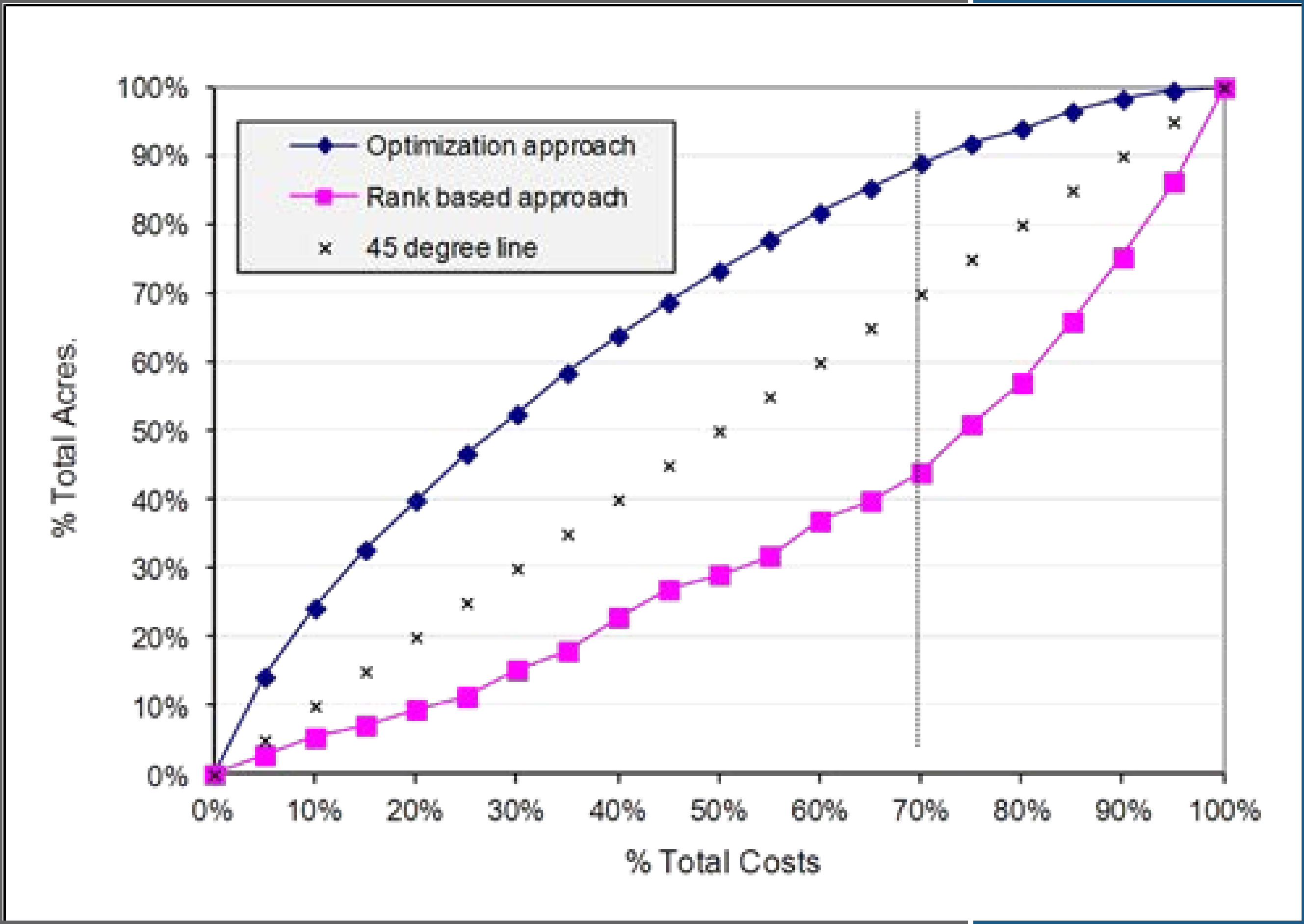
(Green infrastructure planning process derived from Allen, Weber & Hollen, 2010)

impact by considering a full range of environmental concerns (including GI). For compensatory and voluntary mitigation, the GI Approach can facilitate the identification of priority locations for potential mitigation at a watershed or landscape scale — the strategy that regulatory agencies are increasingly employing instead of a traditional site-specific strategy. The MD SHA is also working to employ an optimization tool that provides an objective mechanism for selecting a suite of voluntary stewardship or compensatory mitigation actions (conservation, restoration, enhancement) that considers environmental value and cost.

Unlike a traditional rank-based implementation approach, which is focused on a single parameter (either quality or cost), the optimization approach seeks to identify a suite of actions that considers both variables and ensures that "best-buys" are not passed over (Exhibit 4).

The primary benefit of the cost-optimization tool is its use in identifying a set of ecologically beneficial projects that can move forward, given a specified budget, and that can be justified through a science-based, economic rationale. Additionally, the model can account for constraints (e.g., limited budget) or goals (e.g., land preservation objectives) of agencies in meeting

Exhibit 4 - *Optimization Model Selection Comparison*



their mission challenges. As shown in Exhibit 4, using an optimization approach for conservation action selection can result in more acres acquired than a rank-based approach under a typical scenario in which an agency has only 70 percent of the funds needed to implement all of the actions.

Additionally, use of the optimization model, coupled with engagement in local priorities, can help achieve community "buy-in" on the allocation and use of public funds.

D. Case Study – U.S. 301 Waldorf Area Transportation Improvements Project

The MD SHA adopted an environmental stewardship goal of creating a net benefit to the environment as part of the agency's U.S. 301 Waldorf Area Transportation Improvements Project (U.S. 301 Waldorf project). This goal focused on leaving the environment in better shape than it was before the project was implemented, by going "above and beyond" compensatory mitigation in addressing environmental issues within the project study area. The agency recognized that use of its GI Approach was a necessary commitment to providing transportation improvements in an area of expanding community development among high- quality natural resources.

Sample Core Area Criteria

U.S. 301 Waldorf Area Transportation Improvements Project GI Assessment

Core Forest: Blocks of forest containing at least 250 acres of mature interior (at least 100 meters from the nearest edge) deciduous or mixed forest. Criteria were derived from habitat requirements of forest interior-breeding-birds.

Core Wetlands: Relatively unimpaired wetlands with adjacent forest or water. These included large blocks (at least 250 acres) of interior broadleaf forest along natural perennial streams, large blocks of mature interior swamp or floodplain forest with standing water, unpolluted wetlands (at least seasonally flooded) and vernal pools with at least 215 meters of surrounding forest, and unimpaired and well-buffered marsh of at least 12 acres. Criteria were derived from habitat requirements of several species of birds, amphibians, and reptiles.

Core Streams: Stable perennial streams with continuous riparian vegetation that are not impounded or channelized.

Core Aquatic Areas: Forests and wetlands adjacent to streams. Criteria derived from habitat requirements of native fish and mussels.

The U.S. 301 Waldorf project study area is surrounded by four significant Maryland watersheds: Piscataway Creek, Mattawoman Creek, Port Tobacco Creek, and Zekiah Swamp. Recognizing the importance of landscape and watershed contexts, the MD SHA embarked on the development of a study-area-specific GI assessment to help achieve the established stewardship goal and to refine the consideration of transportation alternatives. The scale used to analyze ecological values for the U.S. 301 Waldorf project was much finer than the scale used for the overall statewide GI assessment — 0.3-acre grid cell size for the statewide GI assessment versus 0.009-acre grid cell size for the U.S. 301 Waldorf Project GI assessment.

MD SHA also provided funding for the U.S. 301 Waldorf project Natural Resources Working Group (NWRG), a contingent of natural resource professionals including The Conservation Fund, MD DNR, and the U.S. Fish and Wildlife Service (USFWS). Through a collaborative effort, this group conducted field reconnaissance and data collection on wetlands, streams, forest cover, and rare species and habitat within the study area and used that information to supplement the existing GI data layers. Core areas, hubs, and corridors were identified, evaluated, and given an ecological rank based on a set of factors at multiple scales (Exhibit 5.).

Candidate natural environmental stewardship opportunities were evaluated against a set of factors that considered:

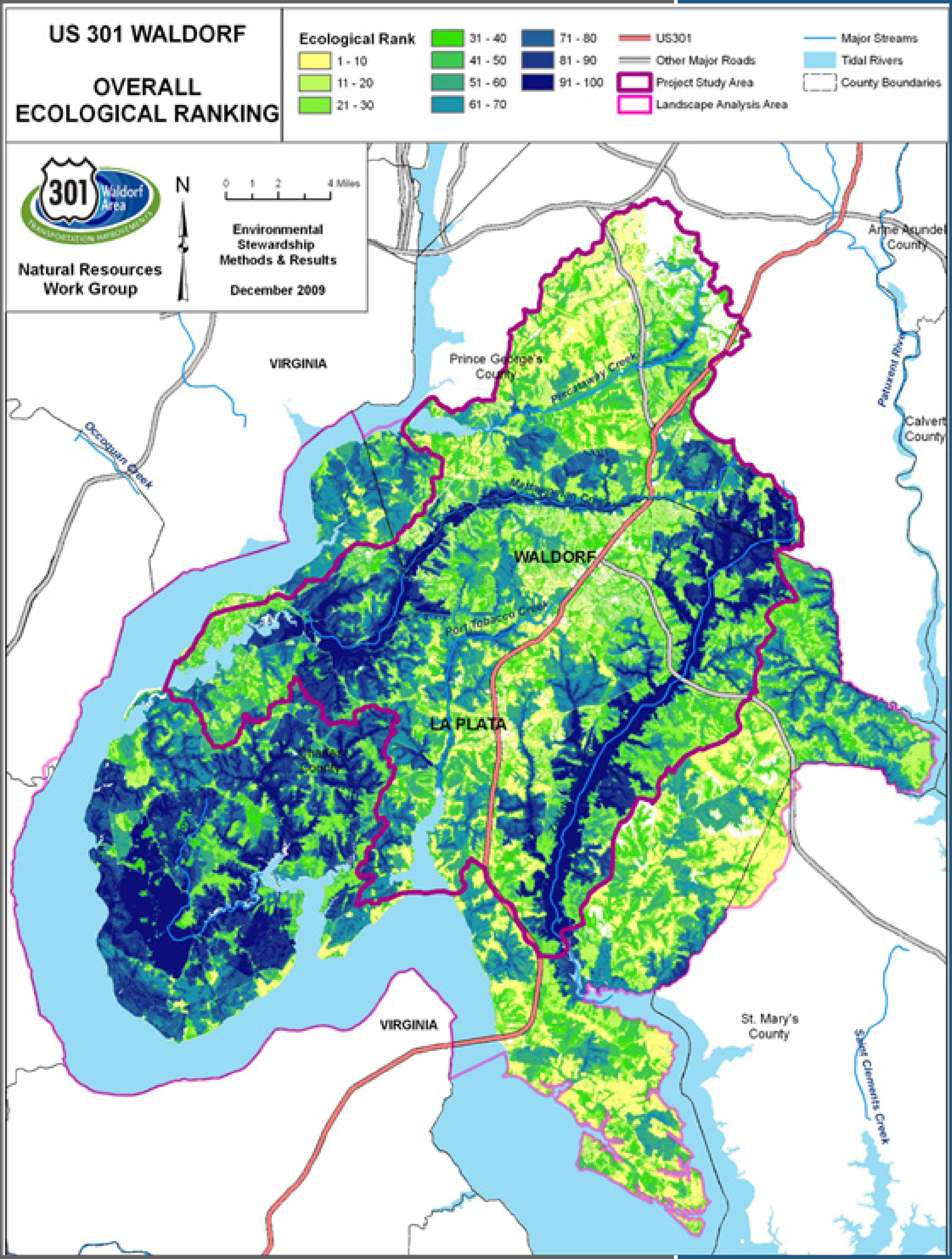
- Rare species' presence, viability, and habitat extent;
- Aquatic biological condition and importance;
- Forest maturity and extent;
- Wetland and stream condition and extent;
- Distance from roads and development;
- Proximity to other core areas or hubs;
- Connectivity potential and importance in overall network; and
- Type of neighboring land use.

(Allen, Weber and Hoellen, 2010)

The results of the GI assessment identified high-priority conservation target areas. Within these conservation focus areas, individual stewardship opportunities were identified based on GI area, ecological score, and proximity to existing protected land.

Field assessments of stewardship-opportunity parcels were then completed and an overall field score derived for each parcel considering high-quality forests, wetlands, streams and the presence of rare species. These natural resource stewardship opportunities were envisioned as addressing (through either conservation or restoration activities) compensatory mitigation

Exhibit 5 - *U.S. 301 Waldorf Area Transportation Improvements Project – GI Ecological Rankings*



requirements of regulatory agencies and meeting environmental stewardship objectives above and beyond required mitigation (MD SHA, 2009).

As a companion forum to the NRWG, a Community Resource Work Group (CRWG) was formed as part of the project's environmental stewardship initiative. The CRWG was tasked with identifying and analyzing opportunities to further the quality and protection of important civic, cultural, and neighborhood resources within the project study area. This community aspect was added to complement the natural resources GI assessment due to contrasting transportation alternative contexts involving suburbanized and commercial lands (highway upgrade alternatives) and undeveloped, valued natural areas (highway bypass alternatives).

Community-focused environmental stewardship opportunities identified by the CRWG included improvements to protect important local historic resources, aesthetics, and landscaping programs; extension of pedestrian and bicycle connections; expanded recreation facilities and educational programs; and urban stormwater management retrofits. Integration of these community approaches with natural resource protection in the Mattawoman Creek watershed, supplemented by the project's GI assessment, was a consistent theme expressed by governmental resource agencies and residents of the Waldorf area.

Candidate community environmental stewardship opportunities were evaluated against a set of factors that included:

- Community priorities;
- Public support;
- Regional benefits;
- Economic-development linkages;
- Resource consumption;
- Public safety and health;
- Support for persons with special needs;
- Management complexity;
- Construction impacts; and
- Cost-share opportunities.


Mattawoman Creek

Candidate natural and community resource environmental stewardship opportunities were then envisioned as being assigned a benefit score (considering resource value) and feasibility considerations (including cost of implementation).

Using the optimization model, an environmental stewardship package would be identified for each project alternative that would provide the greatest environmental benefit within given constraints. Ultimately, the objective was to develop an environmental stewardship package for each project alternative under consideration, which provided that voluntary stewardship actions be carried out by MD SHA. The actions would be provided "above and beyond" the compensatory mitigation required by law, in an effort to achieve the project goal of "leaving the environment in better shape than it was in before the project was implemented."

The detailed information and analysis of environmental stewardship projects compiled for the U.S. 301 Waldorf project were also envisioned as being shared with state, county, and local partners for additional consideration in complementary planning and conservation efforts. The process and effective partnerships formed during development of the U.S. 301 Waldorf project have continued to have positive impacts on working relationships within and among the MD SHA and partner agencies.

The planned agency and public engagement efforts that helped guide the overall GI assessment and the identification of candidate priority environmental stewardship actions were key to the GI Approach used for the U.S. 301 Waldorf project. Throughout project development, the MD SHA worked with an interagency team of federal, state, and local partners to construct the overall project-development approach, evaluate the alternatives, and implement the methods for minimizing and mitigating project impacts. This interagency group also helped guide the project-specific GI assessment and was instrumental in advocating that additional water resource and aquatic ecological criteria be integrated into the assessment. Both the NRWG and the CRWG held meetings with state and county agencies, the general public, and non-governmental interests to identify stewardship preferences (conservation, restoration, management) and specific priority candidate stewardship actions related to the protection or improvement of the identified GI network.

E. Challenges

Most of the challenges of using the GI Approach are associated with the upfront work needed to develop the GIS data and analysis tools. Having well-established working relationships with land planning and resource agencies is of utmost importance in implementing the GI assessment tools. Data is needed from many sources, including existing GIS databases and other secondary sources. Once data is obtained, identification of critical GI hubs and core areas is necessary and requires input from multiple agencies. Because it is also necessary to have a consortium of professionals willing to cooperate and share information to achieve a common goal, it is imperative that good relations be established among local, state, and federal agencies.

As with any technology, funding can be a challenge. Funding may be needed to acquire GIS technologies, pay for secondary data collection, or provide user training. The process of determining data collection needs; identifying critical core areas, hubs, and corridors; and prioritizing land for conservation and restoration can be time consuming. An established GIS database with crucial data layers (wetlands, floodplains, sensitive species, roads, etc.) and an established working relationship with agency partners can significantly reduce the time and cost needed for the initial development and implementation of GI assessment tools and GI Approach policies.

F. Next Steps


Mattawoman Creek

MD SHA is increasingly integrating its GI Approach and GI assessment information into transportation planning and project-development activities. For major projects, the GI network is considered an important ecological component evaluated as part of the typical suite of environmental resource considerations in complying with NEPA and other environmental resource laws and regulations. GI information is typically derived from the statewide GI network or from individual county GI information. The consideration of the GI network is often included as part of a project's purpose and need. Planners assess impacts on hubs, corridors, and gaps for preliminary and final project alternatives and seek to avoid and minimize impacts. Direct and indirect impacts on GI are assessed and the sustainability of the network is considered as part of the assessment of cumulative effects. GI networks are also used to target potential mitigation opportunities that could provide the greatest overall ecological value. When appropriate, project-specific GI development and analysis could be created at finer levels than the statewide or county GI assessment to support project development.

The consideration of GI networks is an expanding policy that is being implemented statewide in strategic land and conservation planning. The development of individual county GI assessments, based on the statewide assessment, is increasing and those assessments are routinely being used in multi-scale evaluations. Using defined GI networks and priority conservation areas, planners can support land use development and management decisions that seek to conserve and improve vital ecological connections. In so doing, those planners can also help enhance ecological health and provide a sustainable quality of life within communities. Ultimately, GI assessment and optimization tools can be used to evaluate the benefits and costs associated with conservation of those environmental resources and GI elements that the public identifies as worthy of preservation. Use of GI networks and ecological information derived through assessments is being integrated with statewide efforts to meet the environmental restoration goals of the federal Chesapeake Bay Program, which is encompassed in Maryland's GreenPrint Program (http://www.greenprint.maryland.gov/faq.asp).

IV. State of the Practice: Texas DOT GISST, TEAP & NEPAssist

A. Technology Description

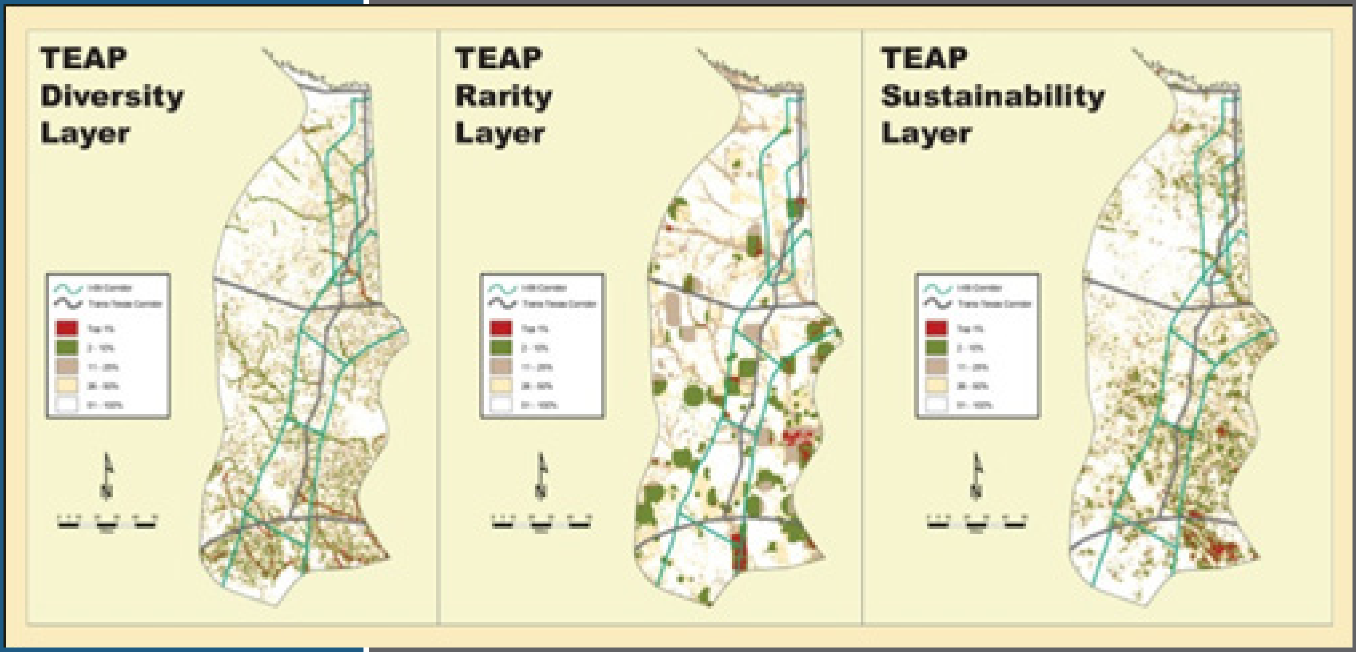
1. Texas Ecological Assessment Protocol (TEAP)

The Texas Ecological Assessment Protocol (TEAP) is a rapid-assessment screening tool used to identify ecologically important areas throughout the state of Texas. TEAP was developed through the efforts of the Texas Environmental Resource Stewards (TERS) Steering Committee, a group of federal- and state-agency representatives tasked with increasing interagency collaboration on joint transportation-related priorities. TEAP was created as a tool to meet the TERS' established goals of identifying ecologically important areas within Texas, identifying potential mitigation and conservation areas, and streamlining the regulatory process (Osowski et al., November 2005) (see Appendix).

TEAP evaluates three ecological criteria: diversity (habitats and landscapes), rarity (threatened and endangered species), and sustainability (based on stressors/human impacts) by analyzing existing statewide GIS data (Exhibit 6). The results of TEAP's analysis are provided for 18 delineated ecoregions within the state of Texas. Most of the identified ecoregions contained minimally impacted areas used as reference conditions to provide a basis for comparison to impacted areas (Osowski et al., November 2005).

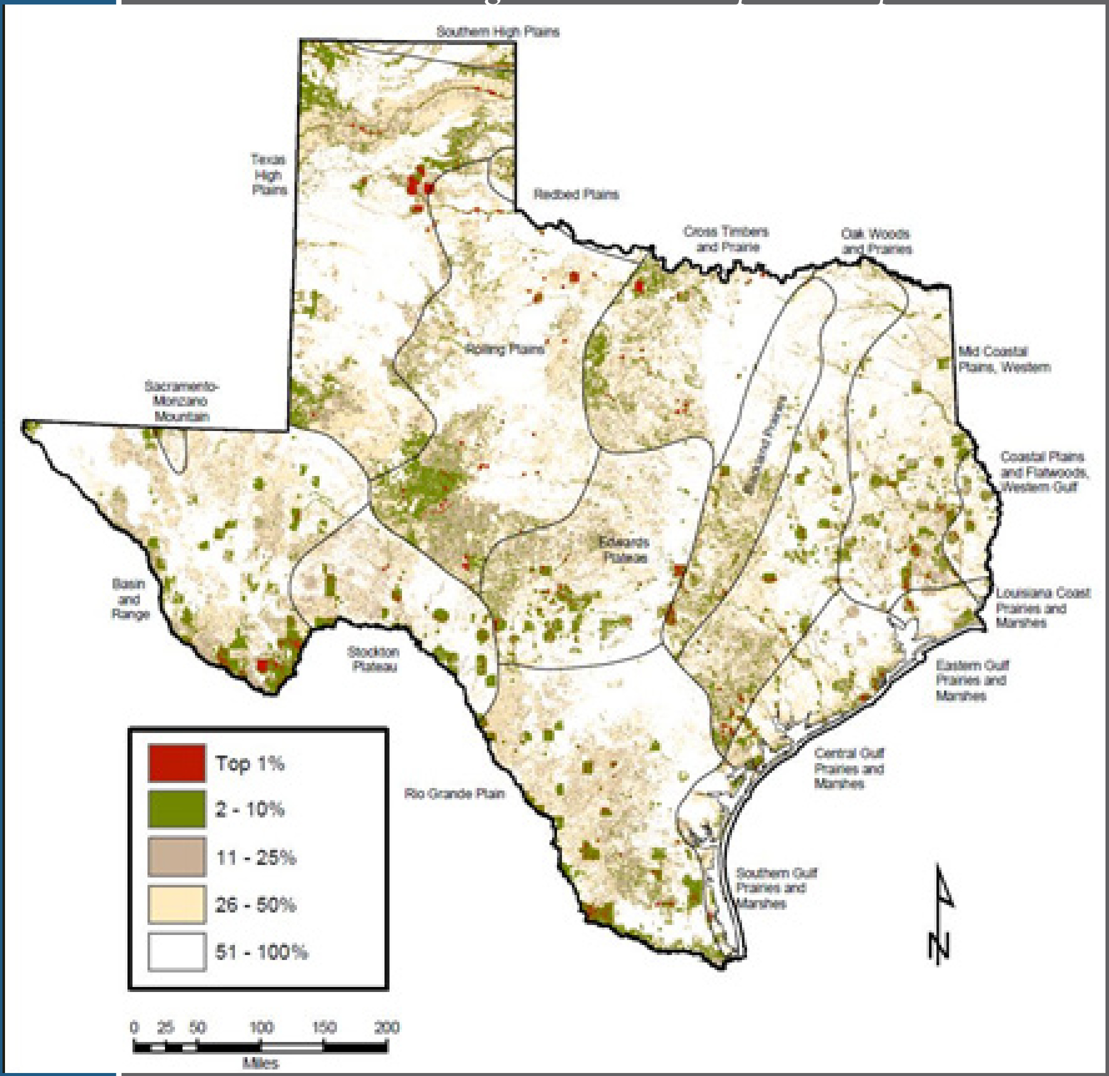
The three criteria layers (rarity, diversity, and sustainability) are combined into one composite map highlighting ecologically important areas in each ecoregion (Exhibit 7). This information can be used to target and prioritize ecosystem mitigation, assist with conservation planning, narrow the scope of analysis, and identify areas to avoid during the alternatives development stage.

Exhibit 6 - *TEAP Criteria Layers*



(Source: Maryland State Highway Administration, 2011)

Exhibit 7 - *Texas Ecoregions TEAP Composite Map*



(Source: Osowski et. al., November 2005)

2. Geographic Information System Screening Tool (GISST)

EPA Region 6 and TX DOT developed the Geographic Information System Screening Tool (GISST) as a GIS-based screening-level application used to identify and assess a variety of individual and cumulative environmental resources within a defined area. Like most GIS-based tools, GISST has spatial data mapping functions. Its real value, however, is in its analytical capabilities as it uses a mathematical algorithm and "natural weighting" on multiple environmental resource and stressor criteria to identify environmental concerns and evaluate environmental vulnerability (Osowski et al., March 2005) (see Appendix). These criteria can be placed into broad categories such as water quality, ecological resources, socioeconomic resources, toxicity, air quality, etc.

GISST is unique in the way it analyzes the data and creates a scoring structure that allows the user to prioritize criteria and ultimately compare impacts. The scoring structure imposed on the data is based on a scale of one to five, where "one" indicates less vulnerability/concern and "five" indicates high vulnerability/concern. Some criteria, such as rare species, cannot be represented by a scale and instead are represented as a score of either "one" (absent) or "five" (present). The individual criterion scores can be applied to geographic base units as a function of area, vulnerability, and impact (Exhibit 8). The GISST can also be used at any level or scale, from census block to watershed. The end product is a GISST report created by the user, which enables the comparison of alternatives based on the results. Either an individual criterion or the sum of several criteria can be used to identify the most suitable alternative and help determine where additional field studies may be necessary. The GISST scoring structure is a systematic yet simplified way to rapidly assess and prioritize environmental impacts associated with an action.

Exhibit 8 - *GISST: Degree of Vulnerability and Degree of Impact Criterion for Wetlands*

% of Area	Score
< 20%	1
20-29%	2
30-39%	3
40-49%	4
> 50%	5

Source: U.S. EPA Region 6 GISST User's Manual, 2005

In addition to identifying ”red flags” for direct impacts, GISST is capable of assessing cumulative impacts, as well. The summation of criteria can be used to measure potential cumulative impacts over a period of time.

3. NEPAssist

Developed by EPA, NEPAssist is a ready-to-use web-based application that draws environmental inventory data from existing EPA GIS databases. NEPAssist is a standardized, data-driven tool that uses consistent federal, state, and local data sets. The technology associated with the tool is unique in that it is web-based and automates the collection of environmental information, which creates a user-friendly application (Osowski, 2007) (see Appendix).

NEPAssist allows the user to rapidly assess an area by highlighting environmental resources and potential environmental concerns. The environmental features are resources inherent in the NEPA process, including socioeconomic resources, air quality, wetlands/waterways, hazardous waste, farmland, etc. The results of the analysis are shown as “yes or no” responses to the question of whether resources are present within the digitized area. This attribute, which allows the user to determine whether impacts will occur within a particular area, creates an opportunity for transportation alignments to be adjusted to avoid or minimize impacts.

NEPAssist is best used as a high-level environmental feature screening tool, and while its analytical capabilities are not as comprehensive as GISST by design, the two tools can be used in conjunction.

B. Application

The GISST, TEAP, and NEPAssist tools are similar in that they act as high-level environmental feature screening tools. The tools have been applied to the NEPA process (scoping, alternatives development, etc.), to streamline the authorization of large-scale projects and assist with regulatory compliance (assessment of avoidance, minimization, and mitigation solutions). The difference lies within the applied technology. For example, GISST goes beyond mapping features and, through the use of algorithms, imposes a scoring structure on the data. Therefore, the GISST tool can be used in the NEPA process to compare alternatives. GISST also allows users not only to identify potential individual effects, but also to consider cumulative effects of an action by assessing resources at the landscape, regional, and watershed levels over a period of time.

As the name implies, NEPAssist facilitates NEPA reviews by enabling users to quickly identify environmental concerns early in the planning stage. Because NEPAssist can identify environmental impacts within a digitized area, users have the ability to understand potential impacts and adjust project alternatives to avoid or minimize impacts.

TEAP is set up to identify specific ecologically important resources and can be used in combination with GISST as a composite data layer. Like the other tools, TEAP can be used in the NEPA planning process to identify high-priority, ecologically significant areas. By using the TEAP tool in the NEPA phase, decision makers can adjust the alternatives as needed to avoid and/or minimize impacts on these areas. If impacts are unavoidable, TEAP allows the user to identify areas that may be best suited for mitigation.

GISST, which was created by the EPA, requires a transfer of the technology through formal agreement. Therefore, the users of GISST are typically DOTs and state and federal resource agencies. Because TEAP is typically used as a data layer in conjunction with GISST, users of this technology are similar to users of GISST and include state and federal transportation and resource agencies. Although web-based, NEPAssist requires EPA's permission for the tool's use. However, once permission is granted and a user ID and password are established, NEPAssist can be used by anyone with internet access. A training session is typically offered by EPA to assist users in their exploration of the tool's navigation and analysis features.

C. Case Study – I-69 Trans-Texas Corridor Study

The I-69 Trans-Texas Corridor Study comprised 15 separate "sections of independent utility" along I-69, from Texarkana to the Texas-Mexico border. In an effort to streamline a seemingly overwhelming coordination and environmental review process, TX DOT and the Federal Highway Administration (FHWA), Texas Division, recognized the project as a pilot environmental streamlining opportunity. As a tool to aid in this effort, GISST was made available for use on the I-69 Trans-Texas Corridor Tier 1 NEPA Study through a partnership agreement between EPA Region 6, TX DOT, and FHWA Texas Division. The expectation was that, through the use of such technology, the NEPA process would be greatly streamlined and more cost effective, and more environmentally sound decisions would be made (see Appendix).

GISST was used early in the planning stage of the I-69 Trans-Texas Corridor Study to facilitate corridor identification, evaluation, and selection. The environmental data used in the corridor analysis relied primarily on existing GIS and GISST data, as well as supplemental data that was reviewed and approved by TX DOT and EPA. TEAP data was also included in the available data sets. Due to the large study area, a minimal amount of new data from field collection was made available and applied to the existing GIS database. Through the use of an alignment optimization technology, avoidance constraints were modeled with GISST while the corridors were being developed. Examples of avoidance constraints included managed lands, wetlands, high-population-density areas, and sites listed in the National Register of Historic Places.

Twenty-one GISST criteria were used and supplemented with additional secondary source data and aerial mapping to evaluate the preliminary I-69 Trans-Texas Corridor (National Academy of Sciences, Transportation Research Board, 2010). The GISST criteria included stream diversity, total maximum daily load (TMDL), wildlife habitat, percentage of minority population, ecologically significant streams, and TEAP criteria (rarity, sustainability, and diversity). For each criterion, scores were developed ranging from "one" (signifying absence or low vulnerability/concern) to "five" (signifying presence or high vulnerability/concern).

A GIS-based application was used to estimate the area coverage of each GISST criterion as a percentage of the total corridor area, and scores were developed for each 0.62-mile square grid cell within the study area. The scores were used as "red flag" indicators to assess the potential for impacting or avoiding important environmental features and served as the basis for comparing corridors. For example, in an area that had a low percentage of higher GISST agricultural land scores (4 or 5, indicating high concern), the assessment conclusion would be that the corridor would have less potential to affect agricultural lands (Exhibit 9).

Ultimately, the use of GISST and TEAP data sets was seen as beneficial to the project team and stakeholders because the NEPA process was greatly streamlined, and more environmentally sound decisions could be made. The use of these tools was seen as an innovative way to reduce a seemingly overwhelming NEPA study and narrow the level of analysis during the subsequent Tier 2 NEPA stage.

D. Challenges

The challenges associated with utilization of the tools can be seen in the application of those tools, the use of secondary data, and the process of achieving acceptance by partner agencies and stakeholders.

GISST, NEPAssist, and TEAP are screening-level tools that may require field reconnaissance and additional studies to verify the information or provide additional resource details. These EPGTs are not intended to take the place of traditional impact assessments or field investigation. Users should have a solid understanding of the NEPA process before they use the tools.

While the use of existing GIS data can provide time and cost savings, it is important that any supplemental and secondary data be reviewed and

Exhibit 9 - *I-69 Trans-Texas Corridor GISST and TEAP Criteria and Scores*

GISST Criteria	GISST Scores
1. Stream density	1, 2, 3, 4, and 5
2. TMDL (as outlined in CWA, Section 303 [d])	1 or 5
3. Floodplain	1, 2, 3, 4, and 5
4. Ozone nonattainment	1, 3, and 5b
5. Hazardous waste	1, 2, 3, 4, and 5
6. Managed lands	1 or 5
7. Agricultural lands	1, 2, 3, 4, and 5
8. Wetlands	1, 2, 3, 4, and 5
9. Wildlife habitat	1, 2, 3, 4, and 5
10. Federal threatened and endangered species	1 or 5
11. State threatened and endangered species	1 or 5
12. Percentage minority population	1, 2, 3, 4, and 5
13. Percentage economically stressed population	1, 2, 3, 4, and 5
14. Population density	1, 2, 3, 4, and 5
15. Ecologically significant streams	1 or 5
16. Summary score (Criteria 1-15)	1, 2, 3, 4, and 5
17. TEAP sustainability	1, 2, 3, 4, and 5
18. TEAP diversity	1, 2, 3, 4, and 5
19. TEAP rarity	1, 2, 3, 4, and 5
20. TEAP composite	1, 2, 3, 4, and 5
21. Summary score (Criteria 1-8, 12-14, and 17-20)	1, 2, 3, 4, and 5

Source: National Academy of Sciences, Transportation Research Board, 2010

refined. Issues can arise when there is a heavy reliance on "available" data that may not be up-to-date. Inaccuracies can result from mixing data with different coverage accuracy, precision, and scale (e.g., data sets at a county-wide vs. census-block geography).

Specific to GISST and NEPAssist, the potential to create an overwhelming amount of data in a short period of time presents a challenge to the use of those tools. A process that would typically take weeks of field data collection might take only a few hours with these tools but could produce an unwieldy amount of data (depending on the number of criteria used and the alternatives developed). This potential may significantly increase staff workload, at least initially.

Another challenge with the use of GIS-based tools is the need to create partnerships among agencies and stakeholders so the tools can be accepted. GISST and NEPAssist rely heavily on existing databases provided by EPA, but local data may not be readily available. Creating partnerships with state and local resource agencies to gain access to and acceptance of the data is of utmost importance. It is also important to gain the stakeholders' consensus on the criteria used for each application, to create a more open and transparent process.

E. Next Steps

EPA released NEPAssist on a national level in April 2012, and can be found at http://www.epa.gov/compliance/nepa/nepassist-mapping.html. NEPAssist was selected as one of five tools to be investigated nationwide through an initiative developed by CEQ to modernize and reinvigorate federal agency implementation of NEPA through innovation, public participation, and transparency. Versions of NEPAssist have also been deployed in other countries, mainly in Central America, to support their national environmental protection programs.

The TEAP tool has now been expanded as a regional asset (REAP) and evaluates ecologically important areas throughout the EPA Region 6 states of Arkansas, Louisiana, New Mexico, Oklahoma, and Texas.

A 2011 Transportation Research Board (TRB) workshop brought together several transportation and environmental agencies that are using similar EPGT programs. This workshop has led to the development of a proposal to investigate ways in which different EPGTs could be integrated across multiple platforms. In addition, EPA would like to develop new web-applications to provide NEPAssist, GISST, and other related EPGTs for use on mobile devices.

V. Adoption Benefits

Adoption of EPGT can help provide a range of benefits for DOTs, partner agencies, and the greater public. Beyond enhanced consideration of ecological resources and values, the use of EPGT in the transportation program and project processes can strengthen interagency relationships, improve public perception through increased agency credibility and transparency, and--perhaps most importantly--help agencies and the public realize optimal use of project-development and mitigation funds.

A. DOT and Partner Agency Derived Benefits

1. Data-Driven Decision Support

Fundamentally, the use of EPGT provides DOTs with high-quality information and analyses to support transportation decision making. With the expanding availability of spatial ecological data, primarily qualitative analyses of ecological concepts and value can now be efficiently integrated with quantitative metrics to improve the overall information available for decision makers. Integrating qualitative and quantitative analyses using EPGT enables DOTs and partner agencies to invest more time in optimizing decisions and investments while expending less time resolving differences of opinion about the relative quality or value of resources and associated impacts.

2. Multi-Agency, Multi-System Concerns

An ecosystem approach to transportation project planning and development recognizes that all components of the ecosystem (function, structure, and composition) are interrelated and must be considered in the context of resource conservation and mitigation decision making (National Academy of Sciences, Transportation Research Board, March 2011). Unlike the traditional site-specific focus of individual agency jurisdiction, this approach involves a broader vision in its consideration of impacts and benefits for a full range of interconnected environmental components (i.e., a watershed or local ecoregion perspective). Using this expanded approach, DOTs and partner agencies can more easily develop strategies that not only balance transportation needs and stewardship responsibilities, but also more easily address the varied environmental and regulatory missions of resource agencies.

3. Scalable Application

EPGT also support decision making at various geographic scales. For instance, Maryland has developed a GI assessment for the entire state to support statewide and regional conservation policy and management decisions. At a more local scale, Maryland used the GI Approach with a detailed GI assessment to support the design and mitigation strategies for the U.S. 301 Waldorf project. While the basic GI network design was the same for both the local and state levels, the resource information detail and complexity of ecological analyses was commensurate with the level of understanding needed to inform the particular decision maker. The scale, or level of detail, at which ecological values were analyzed for the Maryland Statewide GI assessment was 0.3 acre (i.e., a "coarse scale" evaluation) (Maryland Department of Natural Resources, 2003). For the U.S. 301 Waldorf project, the GI assessment scale involving two counties was 0.009 acre (i.e., a "fine scale" evaluation) (Maryland State Highway Administration, 2009). EPGTs for conducting a GI assessment are flexible and can be tailored to include additional emphasis on priority resource issues. For the U.S. 301 Waldorf project, the GI assessment used additional detailed criteria (especially as related to water resources and aquatic ecology) that were vitally important to the study area. Those criteria were not used in the statewide assessment. The Texas EPGT are also adaptable to various scales of investigation and provide pertinent information at the more appropriate scale, based on the extent of the inquiry.

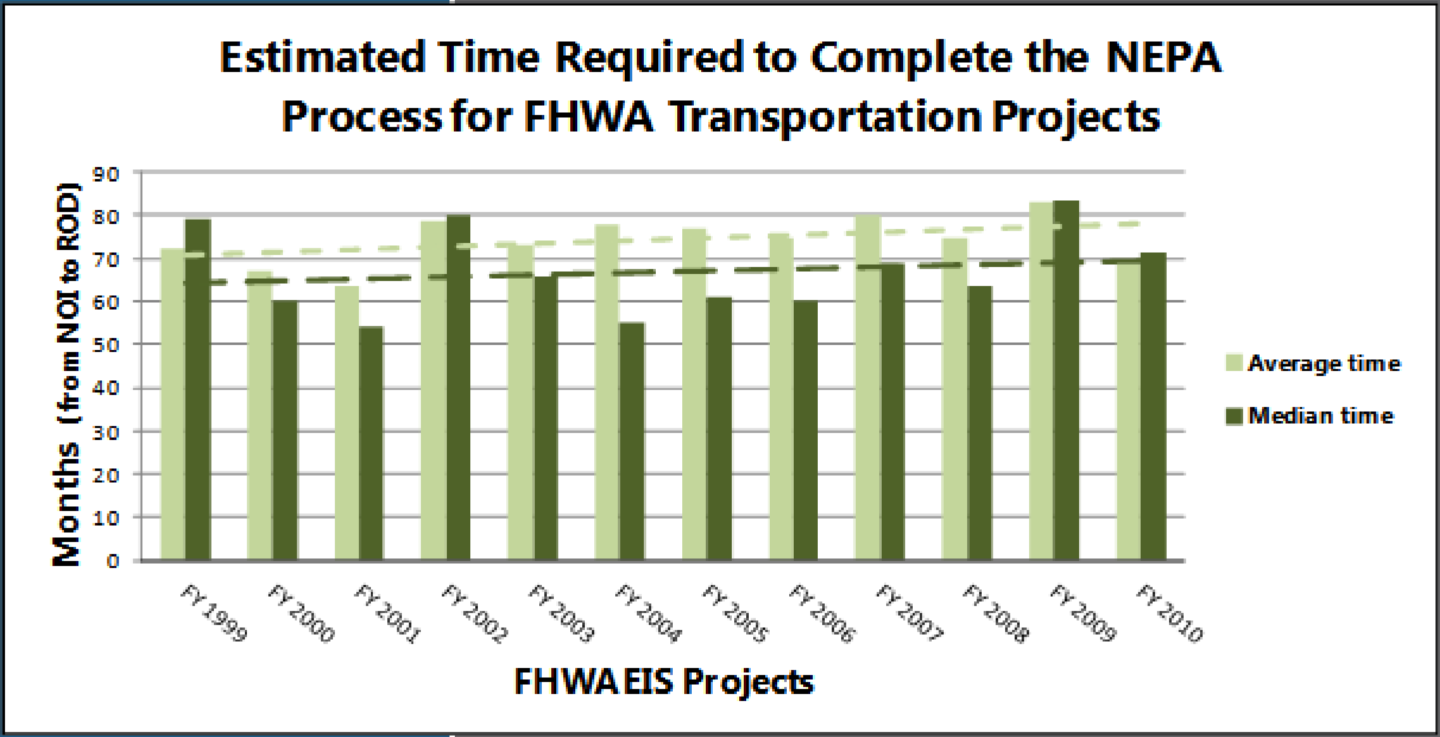
4. Strengthen Working Relationships

Effective interagency coordination, communication, and collaboration are critical to leveraging the resources of all agencies involved in developing and implementing an ecosystem approach using EPGT. As an initial step, DOT environmental personnel can identify common missions, interests, and expertise among federal and state agencies typically involved in the development of transportation projects. Key considerations among agencies are common regulatory roles and shared interests or activities in resource conservation and management. Forging effective partnerships can also provide expanded opportunities to share information and develop mutually derived data that meets the scientific scrutiny of resource agencies.

5. Improve Project Efficiency and Effectiveness

Despite efforts to streamline project development, the time required to complete FHWA EIS projects (Exhibit 10) continues to trend toward longer timeframes (Federal Highway Administration, 2011). Among the top five reasons noted by FHWA regions for EIS project delays were project complexity and time required for resource agency reviews (Federal Highway Administration, 2000). While the use of EPGT requires some initial upfront investment, improved project efficiency and effectiveness can result from an enhanced information basis and collaborative efforts with resource partners during project development and decision making, thereby reducing

Exhibit 10 - *NEPA Compliance Trends*



(Source: FHWA, 2011)

resource-agency review times and reactive DOT analysis to address concerns after EIS publication. At the NEPA scoping stage, project information is typically generic, and resource agencies cannot provide specific comments relative to the project and potential impacts. Using the data derived from implementation of EPGT, early coordination with resource agencies can be more detailed and provide a forum for more specific agency comment on relevant resource issues and concerns.

Improved efficiency from the use of EPGT can be derived mainly from the maximized use of GIS data and analysis to support decision-making and thorough collaborative engagement throughout the NEPA process. In addition, many EPGTs are ready to use at multiple resource scales or project complexities and provide a means to rapidly identify important environmental features that can significantly streamline a typically time- and resource-intensive process.

From an effectiveness perspective, another benefit of EPGT and associated partner relationships is the potential to address shared priorities in resource protection and conservation. Early discussion of potential impacts and permitting can help ensure alignment of DOT priorities and policies with resource-agency stewardship responsibilities and identify joint mitigation approaches. This collaboration can help reduce the time and money spent on achieving compensatory mitigation and perhaps provide the opportunity to implement environmental enhancement above and beyond those required by law.

6. Responsive to Emerging Regulatory Environment

When making mitigation decisions, interagency teams can seek to select an approach that not only complies with regulatory requirements, but also yields the greatest benefit for the ecosystem while remaining economically fitting, given the estimate of impacts from the proposed improvement (Federal Highway Administration, 2006). Furthermore, the ecosystem approach concept considers resources across the jurisdictional boundaries of any one agency in an attempt to achieve the greatest positive result for the environment. The use of EPGT supports this multi-agency and multi-resource strategy for identifying mitigation and conservation opportunities. This approach is being promoted by regulatory agencies, including the EPA and U.S. Army Corps of Engineers (USACE), through efforts such as the Watershed Resources Registry, a GIS suitability analysis tool that helps agencies identify watershed needs and determine where those needs are best addressed. That information is then integrated into regulatory actions and planning activities (http://watershedresourcesregistry.com) (see Appendix).

7. Enhance Impact Assessment

A 2003 survey of environmental stakeholders (including historic preservation and environmental organizations) found that 70 percent of respondents noted that undue time is frequently added to environmental reviews because state DOTs generally do not consider environmental and historic resource impacts early enough in the project-development process (U.S. General Accounting Office, 2003). Using EPGT, DOTs can respond to that concern through improved early identification of resource "red-flags" and can more efficiently communicate and document those findings with the environmental stakeholders and the public.

Additionally, tools such as GISST, TEAP, and GI Assessment can provide a method for early assessment of ecological responses and effects on ecosystem services related to proposed transportation improvements, beyond mere resource identification. Advanced application of EPGT can assist agencies in addressing resource quality impacts, such as cumulative effects on water quality from increased impervious coverage and other projected development in a watershed.

8. Support Emerging Federal Initiatives

EPGT can help DOTs integrate emerging methods and strategies for improving NEPA compliance and resource conservation work with partner agencies. Examples are provided below:

Linking Planning and NEPA

"Linking Planning and NEPA" represents an approach that helps create a collaborative and integrated transportation decision-making process. It is the term used when agencies include environmental considerations in transportation planning, such as long-range or corridor planning, and carry activities or decisions into the NEPA process. The overall goal is to create a seamless decision-making process that minimizes duplication of effort, promotes environmental stewardship, and reduces delay from planning through project implementation. Learn more at: http://environment.fhwa.dot.gov/integ/index.asp (see Appendix).

Green Highways Partnership

The Green Highways Partnership serves as a voluntary public-private collaborative that advances environmental stewardship in transportation planning, design, construction, operations, and maintenance while balancing economic and social objectives. The initiative's efforts center on three focus groups — Watershed-Based Stormwater Management, Recycle and Beneficial Reuse, and Conservation and Ecosystem Protection — associated with the planning, design, and construction of our nation's streets, roads, and highways. The Conservation and Ecosystem Protection group coordinates and promotes the development of Regional Ecosystem Frameworks and Strategic Transportation and Conservation Plans, using GI assessments and ecosystem approaches, to support integrated natural resource conservation and transportation network development. Learn more at: http://www.greenhighwayspartnership.org/ (see Appendix).

U.S. Fish and Wildlife Service/U.S. Geological Survey Strategic Habitat Conservation Program

The Strategic Habitat Conservation Program is an adaptive resource-management framework for making management decisions about where and how to deliver conservation efficiently to achieve specific biological outcomes. The framework involves biological planning, conservation design and delivery, monitoring and adaptive management, and research to plan for strategic habitat conservation in the face of a wide range of landscape-scale resource threats such as development, invasive species, and water scarcity. Learn more at: http://www.fws.gov/science/shc/.

Other emerging issues at the federal and state levels for which EPGT can be a significant asset to DOTs and others include stormwater management using natural approaches, design and retrofit for sustainable communities, and natural disaster vulnerability planning and recovery for infrastructure.

9. Improved Credibility

A survey of state and metropolitan transportation agencies noted that improvement in public perception of an agency and improved relations with other resource agencies were perceived benefits of using an ecosystem approach to transportation planning (U.S. General Accounting Office, 2004). As evidence, participants in the Integrated Transportation and Ecological Enhancements for Montana (ITEEM) Process, which was based on an ecosystem approach following the Eco-Logical model, noted that relationships among the interagency group not only improved, but were also essential to the success of the effort (Hardy et al., 2007). Identification of common personal and professional interests, shared field opportunities, and using a facilitation process with collective goals, outcomes, responsibilities, and accountability contributed to "team building." Finally, recognition of and respect for individual agency missions and values was vital to developing a collaborative environment where participants were willing to seek and promote "balance" in decision making.

From a technology perspective, the level of trust related to application of EPGT is high and generally increases when one or more agencies participate in EPGT development and maintenance. Since data and analyses are typically peer-reviewed to strengthen acceptance, the tools contribute to improved trust and communication among project partners and stakeholders.

B. Public Benefits

1. Community Assets/Economic Development Advantages

At the community level, benefits of employing EPGT are derived from transportation development that reduces natural resource impacts and integrates strategic conservation. This result provides the opportunity to conserve or improve "ecosystem services" value to the community. Ecosystem services — such as cleaning the air, filtering pollutants from surface and ground waters, storing and cycling nutrients, conserving and generating soils, regulating climate, sequestering carbon, protecting against storm and flood damage, and maintaining local and regional hydrological systems — are provided by existing expanses of forests, wetlands, and other natural lands (Costanza et al., 1997). These lands also provide directly marketable goods (such as lumber), fish and wildlife and recreation opportunities, and other indirect benefits such as visual and scenic qualities. All of these services are valuable to the sustainability of communities from quality-of-life and economic perspectives (Exhibit 11). When valuable lands are ineffectively used to support human development, the cost of the services those lands provide are typically not accounted for. Such services would either be lost or replaced at a later time and would require substantially higher expenditures.

In addition to its use in ecological services, EPGT can provide a diversity of social and economic benefits when it is employed in land-use planning. Tools can be used to outline an ecological blueprint so that GI and the built environment can be planned in synergy. As previously mentioned, the benefits of planning for GI include providing a sense of space for communities, increasing property values, lowering the risk of disease (e.g., Lyme disease), supporting natural stormwater management, increasing recreational opportunities, and providing living classrooms for education.

Additionally, ecological lands such as parks, forests, and water features are attractive to residents and business. Homes adjacent to recreation areas and parks may increase in value by as much as 22 percent; while nearby recreation areas and parkland provide a 15-20 percent increase in value. Similar increases are found for homes near permanently protected forest areas (Center for Green Infrastructure Design, 2011). Residents throughout the U.S. are increasingly recognizing the inherent value of conservation in their support of public land conservation programs, despite troublesome economic conditions (Exhibit 12).

Exhibit 11 - *Estimated Ecosystem Service Values of Common Landforms*

Land Cover/Type	Estimated Value/Acre/Year (2006 $)
Forest	$ 1,114 (Breunig, 2003) $ 1,318 (Costanza et al, 1997) $ 443 - $ 2,175 (Wilson et al, 2004) $ 12,033 (upland forest) (Weber, 2007) $ 52,765 (riparian forest) (Weber, 2007)
Freshwater Wetland	$ 17,497 (Breunig, 2003) $ 20,103 (Costanza et al, 1997) $ 1,981 - $ 25,213 (Wilson et al, 2004) $ 43,685 (Weber, 2007)
Saltwater Wetland	$ 14,245 (Breunig, 2003) $ 11,293 - $ 13,010 (Wilson et al, 2004)
Tidal Marsh	$ 13, 583 (Costanza et al, 1997) $ 28,146 (Weber, 2007)
Coastal Marsh	$ 31,044 (Costanza et al, 1997) $4,000 - $28,000 (Mitsch and Gosselink, 1993)

Exhibit 12 - *National Land Conservation Ballot Measure Trends*

Measure	2006	2007	2008	2009	2010
Approved Ballot Measures	104	64	63	25	30
Number of States	23	14	24	13	20
Approval Rate	80%	65%	71%	62%	84%
Total Estimated Conservation Funding	$6.4 billion	$2.0 billion	$7.3 billion	$600 million	$2.0 billion

Source: The Trust for Public Land, LandVote Series

2. Stewardship and Enhancement of Environmental Quality

Use of EPGT within an ecosystem approach creates the opportunity to provide multi-objective benefits, which help achieve a sustainable balance between societal needs and conservation of valued natural resources. From a mitigation perspective, the use of EPGT also allows the integrated development of strategic conservation plans that can help pre-identify opportunities for mitigation or conservation on a watershed or region basis and avoid reactionary efforts typically narrowly focused at a project or site perspective. Multi-agency development of conservation plans also provides an opportunity for the pooling of financial resources to capitalize on short-term opportunities or meaningful prospects that may be quickly disappearing or becoming too expensive as development affects areas of ecological importance.

From a community perspective, EPGT can be a valuable asset in promoting environmental education and stewardship efforts to care for locally important resources. Web-based mapping and resource information, when developed in concert with partner resource agencies, can provide residents a wealth of information and increased recognition of the importance of ecosystem components of their community. The value of ecosystem services provided by local parks, streams, buffer areas, wetlands, and forest areas can be delivered through school curriculum, recreation guides, and presentations to civic and community organizations and can be supported by GIS maps, attribute data, and analysis.

3. Positive Influence on Human Health

Implementation of EPGTs, such the GI Assessment tool, can positively influence human health by supporting a natural and community environment that fosters reduced health risks and manages the expansion of disease vectors in nature. Expanded natural areas (e.g., forests, water features, parks, trails) within communities provide opportunities for solace and relaxation in a natural setting, while at the same time accommodating more active exercise pursuits. Humans need a balance of both experiences (active and passive) to further health and contentment. Use of natural green areas for passive and active recreation can help reduce stress and lower risks for conditions such as obesity, diabetes, and heart disease. Research has also shown that conservation efforts can positively affect the abundance and distribution of disease vectors in nature. For example, fragmentation of forest areas can produce excess edge habitat that can promote the growth and expansion of disease-carrying ticks associated with Lyme disease and various fever-related illnesses.

4. Transparent Decision Making and Increased Credibility

Use of an ecosystem approach concept incorporating EPGT inherently requires a concerted public outreach component to establish community resource priorities and objectives. In addition to traditional community engagement, public stakeholders, including local governments and collaborative-minded non-governmental organizations, should be involved throughout the process for the approach to be most effective. These stakeholders may assist DOTs and partner agencies in determining priorities and objectives and can have local knowledge, data, and expertise of high value. Use of EPGT also allows decisions to be based on objective data and accepted science, which improves DOT credibility, and can help manage the influence of participants' important, but often emotional, subjective principles.

5. Efficient Regulatory Environment

An ecosystem approach concept that takes advantage of EPGT provides a framework for efficient solutions and saves time and public money while maximizing environmental benefits.

While DOTs benefit from more efficient project development and streamlined NEPA compliance, the public benefits from:

- Reduced public expenditure on evaluation of routine issues and more focused work on resolution of key environmental issues of importance and value to the community;
- The ability to leverage other funding sources and expenditures from partners to achieve a greater return on conservation and mitigation investments;
- Faster completion of needed transportation improvements and value obtained from reduction in personal and business time delays, safety hazards, and vehicle damage maintenance from congested, poorly designed, and under-maintained roadways; and
- Maximized conservation of natural areas and the direct and intrinsic values provided by local ecosystems.

VI. Key Adoption Considerations and Requirements

DOTs need to evaluate a few key considerations before adopting and implementing EPGT (Exhibit 13). These key elements should be considered throughout the agency's organizational structure, including at leadership, management, and staff levels. As noted, a coordinated effort among multiple organizational levels is likely necessary to successfully evaluate the need and feasibility of adopting EPGT, and for ultimately implementing these tools and the processes that support their continued effectiveness.

Exhibit 13 - *Key EPGT Adoption Considerations and DOT Organizational Roles*

Measure	***Leadership***	***Management***	***Staff***
Process and Policy Considerations	P	P	S
Leadership Support and Acceptance	P	P	S
Development of Partnerships	P	P	S
Leveraging Available Resources and Cost Considerations	S	P	S
Data Management Plans and Considerations	S	S	P
P = primary role/responsibility, S=support role/responsibility			

A. Process and Policy Considerations

Before adoption of the EPGT, it is important to consider the need and desire for such technology. Process and policy considerations are typical factors that drive the need for better and more integrated technology. A well-defined organizational objective that explains why EPGTs are being considered and describes the specific policy or process needs or desires that are being pursued is vital. An objective that has been properly vetted and documented will provide a DOT with a foundation upon which to develop comparative criteria for determining the most appropriate tools and support policies.

Adoption and development of these tools support federal policy initiatives including FHWA's Vital Few Goal of environmental streamlining and stewardship (http://www.environment.fhwa.dot.gov/strmlng/es4vitalfew.asp); the CEQ 2003 recommendations on ways to modernize NEPA; and EO 13274 "Environmental Stewardship and Transportation Infrastructure Project Reviews" among others. The adoption of EPGT can aid in promoting environmental stewardship while concurrently streamlining the environmental review process under NEPA and other environmental regulations. Local and state policies and initiatives can also be driving factors and should be considered. Smart land-use planning, resource conservation, and environmental restoration are also needed to support the use of EPGT.

B. Leadership Support and Acceptance

Gaining leadership support from DOTs and partner agencies is critical to the success of collaboration. Aside from time and funding support, incorporation of EPGT and associated collaborative approaches to decision making should be part of agencies' policies that support their overall mission. Benefits of the tools, including cost and time savings, are well documented and should be shared with leadership in an effort to promote the need for such tools.

Recognition and respect for individual agency mission, values, and objectives is a critical foundation for establishing an effective, collaborative relationship and for gaining acceptance of DOTs' and partner agencies' use of EPGT in the project-development process. DOTs should defer to the expertise of resource agencies on ecological science and environmental resource values; partner agencies should defer to the expertise of DOTs on transportation planning and design engineering.

C. Developing Partnerships

A vitally important action that an organization can take to adopt and implement EPGT efficiently is to develop partnerships with local, state, and national planning, environmental, and transportation agencies to gain an understanding of the tools and data that are readily available. The application of EPGT has greatly broadened in recent years; there are numerous examples around the country of federal and state agencies, often working with local agencies and non-governmental interests, collaboratively implementing EPGT. Agencies looking to develop or expand existing GIS technology should first determine existing resources that can be built upon. Data recommendations and decisions regarding use should come from a formalized collaborative effort; roles and responsibilities should be documented; and dispute resolution procedures should be developed so that issues can be efficiently elevated to upper management.

Developing formal agreements with agencies for technology transfers and support, such as funding and training, can help establish the framework for implementing the EPGT. For example, through an interagency agreement with EPA Region 6, TX DOT was able to use GISST for the I-69 Trans-Texas corridor. Two key components of this interagency agreement were provisions for technical assistance and training on the use of GISST.

For Maryland's US 301 Waldorf project, a consortium of industry professionals (MD DNR, The Conservation Fund, and the USFWS) collaborated on a Natural Resources Working Group (NRWG) structure. By combining expertise on EPGT with regional ecological science, the NRWG completed a detailed GI assessment that identified and evaluated environmental stewardship needs and opportunities. Results of this critically accepted work, including field-data collection, GI network mapping, and stewardship opportunity summaries were shared and are now being used by other agencies, including EPA, USACE, and county planning and environmental agencies.

In addition to partnerships between local, state, and federal transportation and environmental agencies, partnerships with non-profit and educational institutions should be considered. Those partners can often provide research funding and technical assistance or training opportunities and may have existing data that is readily available.

D. Leveraging Available Technology Resources and Cost Considerations

Leveraging available resources is imperative to the successful implementation of EPGT. In developing partnerships with agencies and major stakeholders early in the adoption stage, users can determine the type and extent of available resources, including existing tools and data, so that initial time and cost commitments are greatly reduced.

Each partner, whether a resource agency or a DOT, should be willing to support its own involvement and contribute to collaborative efforts that benefit the agency. Partners should agree to share data and information from a cost-neutral perspective and contribute to priority GIS data development and analysis when it benefits the agency. When the participation of partner agencies is funded by DOTs, partner agencies should provide sufficient levels of involvement and expertise in concert with priority expectations of the DOT. Partner agencies should also be willing to provide and receive internal training on a cost-neutral basis (see Appendix for a list of potential training opportunities).

Many of the EPGTs are available for immediate use, although access may require interagency agreements and upfront costs. If existing GIS software and data exist, the initial cost and time expended on the tools can be minimized and typically recovered within the first years of use through the streamlining of the NEPA process and regulatory reviews. NEPAssist is now available nationwide through the EPA (http://www.epa.gov/oecaerth/nepa/nepassist-mapping.html). GISST is available through an interagency agreement and technology transfer from EPA Region 6 to the FHWA and state DOTs. The GIS analysis tools behind the Texas TEAP and MD GI assessment tools are transferable to other states, which would need to develop comparable data and landscape ecology criteria to identify and evaluate priority resource areas. The FHWA maintains a comprehensive list of GIS tools at http://gis.fhwa.dot.gov/statepracs.asp (see Appendix).

Advanced GIS software and hardware are not prerequisites for use of the EPGT. However, consideration of additional funding to increase the availability of GIS technology to a wider group of users and improve their basic skills in the system may be advantageous (see Appendix for a list of potential funding opportunities).

E. Data-Management Plans and Considerations

With the increased use of GIS in transportation planning in recent decades, an abundance of data and information exists. The key to adopting EPGT is to capitalize on the systems and data already available. This effort not only reduces redundancy in data collection and maintenance but also saves money and time. Many agencies offer downloadable GIS data layers that are easy to access and modify. Field reconnaissance may be necessary to bridge gaps in existing spatial data.

1. Data Refinement

Once the data is in place, data refinement must be considered in adopting EPGT. The tools are only as good as the quantity and quality of the data sets that support them. The environment is ever changing, and developing a strategy for collecting new data, field-verifying data, and refining existing data is essential to getting the most from these decision-making tools. With the use of EPGT, there can be a heavy reliance on "available" data that may not be up-to-date. In addition, inaccuracies can result from mixing data with different coverage accuracy, precision, and scale (e.g., countywide vs. watershed). Another important consideration is user acceptance of the scientific base and methodologies to accurately depict ecological values. Solutions to these identified data challenges include developing a solid base of existing data through established databases, existing GIS data layers, and field assessments before the tools are implemented; developing a strategy with agency partners and stakeholders for periodically updating data sets and refining existing data to ensure better quality and accuracy; and gaining consensus among agency partners and major stakeholders on the type and scale of data used to alleviate the potential for later disagreement and controversy.

2. Data-Management Plan

A data-management plan to ensure that data is accurate and up-to-date is another important consideration when adopting these tools. The availability of data at expanded geographies and for new resource variables is constantly increasing, but without a framework for organization, inefficiencies and errors are likely to occur. It is highly recommended that agency partners and major stakeholders make a commitment to develop GIS-compatible integration, accepted data resources and management controls, and data.

VII. Key Adoption Considerations Checklist

Before a DOT implements EPGT and works collaboratively with partner resource agencies, it should examine the following key considerations to ensure that these basic components have been vetted and included in an adoption plan.

A. Acceptance

- Leadership support from DOTs and partner agencies is critical to the success of collaboration. Aside from time and funding support, incorporation of EPGT and associated collaborative approaches to decision making should be part of agency policies that support the overall mission.
- Recognition of and respect for individual agency mission, values, and objectives is a critical foundation for an effective, collaborative relationship.
- DOTs should defer to the expertise of resource agencies on ecological science and environmental resource values.
- Partner agencies should defer to the expertise of DOTs on transportation planning and design engineering.

B. Costs

- Each partner (i.e., resource agencies, DOTs) should be willing to support its own involvement and contribute to collaborative efforts that benefit the agency.
- Where the participation of partner agencies is funded by DOTs, partner agencies should provide a sufficient level of involvement and expertise in concert with priority expectations of the DOT.
- Partners should agree to share data from a cost-neutral perspective, but may include common external restrictions.
- Partners should contribute to priority GIS data development/analysis when it is of benefit to the agency.
- Advanced GIS software and hardware is not a prerequisite to use of EPGT. However, consideration of additional funding to increase the availability of and basic skills in GIS technology to a wider group of users may be advantageous.
- DOTs should investigate opportunities within their own states or with other partners to use available GIS data and/or tools.
- Potential funding opportunities:

  FHWA Eco-Logical Grant:
  http://environment.fhwa.dot.gov/ecological/eco_entry.asp

  FHWA Transportation, Community and System Preservation Program:
  http://www.fhwa.dot.gov/tcsp/index.html

  FHWA Surface Transportation Environment and Planning Cooperative Research Program (STEP): http://www.fhwa.dot.gov/hep/step/

C. Training

- Partner agencies should be willing to provide and receive internal training on a cost-neutral basis.
- Informal opportunities for training, especially field views of resources and infrastructure, should be maximized for the exchange of knowledge and team building.
- Potential training sources:

  FHWA GIS in Transportation: http://gis.fhwa.dot.gov/training.asp

  The Conservation Fund, Conservation Leadership Network:
  http://www.conservationfund.org/our-conservation-strategy/major-programs/conservation-leadership-network/

  USFWS National Conservation Training Center:
  http://nctc.fws.gov/

D. Procedural Modifications

- Implementation of EPGT may require changes in DOT project-development procedures.
- DOTs and partner agencies should identify and establish agreements related to data maintenance and housing roles and responsibilities.
- Data sharing and use agreements, both internally and externally, will likely need to be addressed for each partner agency to ensure effective collaboration.
- The collaborative effort for establishing EPGT and accompanying decision-making processes must be formalized, with documented roles and responsibilities.

Dispute-resolution procedures should be developed to provide efficient elevation of issues to upper management.

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
CEQ	Council on Environmental Quality
CRWG	Community Resource Working Group
DOT	Department of Transportation (state)
EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
FHWA	Federal Highway Administration
GI	Green Infrastructure
GIS	Geographic Information System(s)
GISST	Geographic Information System Screening Tool
LST	Lead States Team
MAP-21	Moving Ahead for Progress in the 21st Century Act
MD DNR	Maryland Department of Natural Resources
MD SHA	Maryland State Highway Administration
MOU	Memorandum of Understanding
NEPA	National Environmental Policy Act
NRWG	Natural Resource Working Group
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users
SHRP-2	Strategic Highway Research Program 2
TEAP	Texas Ecological Assessment Protocol
TERS	Texas Environmental Resource Stewards
TIG	Technology Implementation Group
TMDL	Total Maximum Daily Load
TX DOT	Texas Department of Transportation
USACE	U.S. Army Corps of Engineers
US DOT	U.S. Department of Transportation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

Glossary

AASHTO: The American Association of State Highway and Transportation Officials advocates transportation-related policies and provides technical services to support states in their efforts to move people and goods efficiently and safely.

Core: A green infrastructure area consisting of interior, high-quality blocks of naturally functioning ecosystems.

Corridor: A green infrastructure area consisting of linear habitat that allows movement of animals, seeds, water, etc., and links hubs and core areas.

Ecoregion: A relatively homogeneous ecological area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.

Ecosystem Approach: A conceptual method for sustaining or restoring ecological systems and their functions and values. It is goal driven and based on a collaboratively developed vision of desired future conditions that integrates ecological, economic, and social factors. It is applied within a geographic framework defined primarily by ecological boundaries.

Environmental Planning: The process of facilitating decision-making to carry out development and/or use of resources, with due consideration given to natural environmental, social, political, economic, and governance factors and the resultant implications.

Environmental Stewardship: The responsibility for environmental quality shared by all individuals, companies, communities, and government organizations whose actions affect the environment, reflected as both a value and a practice. Positive stewardship behavior demonstrates acceptance of this responsibility through the continuous improvement of environmental performance to achieve measurable results and sustainable outcomes (EPA 2005).

Sustainable environmental stewardship includes those concepts, strategies, tools, practices, and approaches that lead to environmental improvement that is sustainable over time; considers long-term, short-term, and more immediate effects; and contributes positively (even if indirectly) to the social and economic condition. (Ed Pinero, White Office of the Federal Environmental Executive, 2005).

Executive Order: A declaration by a U.S. President that has the force of law, usually based on existing statutory powers, and requiring no action by the Congress or state legislature. Executive orders are generally used to direct federal agencies and officials in the execution of congressionally established laws or policies.

Gaps: As part of a green infrastructure network, gaps are generally areas that do not have natural vegetative cover. Gap areas could include agricultural or croplands, barren or mining areas, lawn areas, or other portions of the landscape devoted to human development (roads, buildings, etc.). Gaps in a green infrastructure network weaken the integrity of hubs and corridors, increase negative edge habitat effects, hinder wildlife movement, and increase opportunities for invasive species to become established.

Geographic Information System: A system that integrates hardware, software, and data for capturing, managing, analyzing, and displaying multiple forms of geographically referenced information.

Green infrastructure: Strategically planned and managed networks of natural lands, working landscapes, and other open spaces that conserve ecosystem functions and provide associated benefits to human populations.

Green Infrastructure Approach: A planning method used by the Maryland State Highway Administration, in partnership with other federal, state, and local resource agencies that integrate the transportation project-development process with the identification, analysis, and consideration of green infrastructure ecological features and values. Encompassing the aims of the ecosystem approach concept, the method promotes the value of green infrastructure through a systematic and strategic approach to environmental protection and mitigation at multiple scales while addressing transportation needs throughout the state.

Green Infrastructure Assessment: The scientific methods used to identify and characterize the green infrastructure of a given geography as part of a Green Infrastructure Approach process. The methods involve: (1) identification of the most important natural lands and resources based on the application of ecological principles, typically facilitated by using geographic information system (GIS) technology; (2) identification of connective land through a system of corridors and linkages; and (3) characterization and verification of the presence and ecological value of these lands and resources.

Hub: A green infrastructure area of slightly fragmented blocks of core areas consisting of forest and wetland habitat (250 acres or greater).

NEPA: The National Environmental Policy Act is a federal law requiring Federal agencies to: (1) assess the environmental impacts of major Federal actions (such as issuing permits, allocating Federal funds, or implementing construction projects on Federal lands); (2) consider those effects before making decisions on major actions; and (3) disclose the environmental impacts and reasons for Federal decisions to the public.

Sustainability: Meeting the needs of the present generation without compromising the ability of future generations to meet their own needs (United Nations Brundtland Commission, 1987).

A set of environmental, economic, and social conditions in which all of society has the capacity and opportunity to maintain and improve its quality of life indefinitely without degrading the quantity, quality, or availability of natural, economic, and social resources (American Society of Civil Engineers, 2010).

Watershed: A basin-like landform defined by highpoints and ridgelines that descend into lower elevations and stream valleys. Watersheds contain a common set of streams and rivers that all drain into a single larger body of water, such as a larger river, a lake, or an ocean.

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APPENDIX

Informational Websites

AASHTO TIG: Environmental Planning GIS Tools

http://tig.transportation.org/Pages/EnvironmentalPlanningGISToolsfor-TransportationPlanning.aspx

As the Lead States Team homepage for this TIG effort, this site includes presentations and other promotional materials that highlight the application and benefits of using EPGT to integrate transportation planning and resource conservation.

EPA Green Infrastructure Program

http://water.epa.gov/infrastructure/greeninfrastructure

Although the information presented here is more directly focused on stormwater management, low- impact development, and other ecosystem services, many of the tools, case studies, and research and funding opportunities are directly applicable to resource conservation efforts that use a green infrastructure approach.

FHWA GIS in Transportation

http://gis.fhwa.dot.gov

This online compendium offers the latest in GIS applications, research, and educational opportunities related to the transportation industry. Links are also provided to sources of GIS data, software vendors, GIS-related organizations, and GIS initiatives of other federal agencies. Of particular note are links to GIS applications used by state DOTs that address environmental compliance, resource conservation, and NEPA compliance effectiveness.

FHWA Sustainable Highways

http://www.sustainablehighways.org/

This on-line rating system allows DOTs to evaluate the "sustainability" of a proposed highway project by considering ecological impact along with access and mobility effectiveness, energy reduction, safety improvements, and lifecycle costs.

Green Highways Partnership

http://www.greenhighwayspartnership.org

The Green Highways Partnership is a public-private collaborative initiative to promote environmental stewardship in transportation planning, design, construction, and operations while balancing economic and social objectives. Focus areas of the partnership include watershed-based stormwater management for streets and highways, recycling and beneficial reuse of roadway construction materials, and the integration of conservation and ecosystem protection with transportation planning and project development.

Green Infrastructure Resources

http://www.greeninfrastructureresources.com

This site is focused on providing information and resources promoting sustainability through application of green infrastructure principles. The site provides breaking news on issues of concern and links to a wide variety of resources regarding GI economics, grants and funding, plans, technical manuals, and related organizations.

Maryland GreenPrint

http://www.greenprint.maryland.gov/

Maryland GreenPrint is the foremost web-enabled map tool showing the relative ecological importance of every parcel of land in the state. By identifying valued ecological conservation targets using detailed environmental data and addressing multiple objectives, GreenPrint is being used for making land- conservation decisions and building a broader and better-informed public consensus for sustainable growth and land-preservation decisions into the future.

Maryland Green Infrastructure

http://www.dnr.state.md.us/greenways/gi/gi.html

This site provides statewide information on Maryland's green infrastructure efforts, including educational materials, statewide assessments, GI data, and on-line mapping tools.

Watershed Resources Registry

http://watershedresourcesregistry.com

The Watershed Resources Registry (WRR), a Green Highways Partnership project, is a GIS-based targeting tool that analyzes watersheds and identifies the best opportunities for the protection of high-quality resources, the restoration of impaired resources, and the improvement of stormwater management. The WRR is intended to integrate the Clean Water Act (CWA) authorities by facilitating implementation of CWA Sections 319, 401, 402, 404 and multiple state programs. Beginning with four watersheds in Southern Maryland associated with the U.S. 301 Waldorf Area Transportation Improvements Project, the tool now includes coverage for the entire state of Maryland.

Informational Documents

Case Study: I-69 Trans-Texas Corridor Study, Using GISST, TEAP, Quantm, SAM, and ProjectSolve Technologies

http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2_CS_C01_Texas.pdf

This TRB report offers an independent evaluation and endorsement of the GISST and related GIS tools and offers lessons learned and barriers overcome to implement the technologies.

Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects

http://environment.fhwa.dot.gov/ecological/eco_entry.asp

Eco-Logical articulates a vision for an infrastructure development process that endorses ecosystem-based mitigation through the integration of plans and data across agency and disciplinary boundaries.

GISST User's Manual

Contact EPA Region 6, Sharon Osowski, Phone 214-665-7506

The GISST tool provides a screening of environmental vulnerability and impact through evaluation of more than 100 environmental resource and stressor criteria. This technical document provides background on the development principles and components of the GISST tool and documents case study applications of the tool for transportation planning projects in Texas.

Green Infrastructure: Smart Conservation for the 21st Century

http://www.sprawlwatch.org/greeninfrastructure.pdf

This foundational paper takes readers from the origins and history of GI concept to its implementation and benefits today - demonstrating how green infrastructure plans can allow for future growth and the protection of significant natural resources.

Green Infrastructure Design and Benefit-Cost Optimization in Transportation Planning-Maximizing Conservation and Restoration Opportunities in Four Southern Maryland Watersheds

http://www.conservationfund.org/a-sustainable-chesapeake-better-models-for-conservation/

Chapter 3 of this document reviews the green infrastructure approach used by the Maryland State Highway Administration for the U.S. 301 Waldorf Area Transportation Improvements Project. This approach used integrated transportation planning with natural and community resource conservation with the goal of providing a net benefit to the environment, while helping meet the mobility challenges of this rapidly growing area.

Green Infrastructure & GreenPrint: Defining and Preserving our Natural Legacy

http://dnr.maryland.gov/naturalresource/winter2009/green.pdf

This summary article reviews the basis of Maryland's green infrastructure program and describes how its GreenPrint initiative is using this information to set priorities and approve investments in meeting sustainability challenges of growth management, ecosystem protection, climate change, and Chesapeake Bay restoration.

Maryland's Green Infrastructure Assessment: A Comprehensive Strategy for Land Conservation and Restoration

http://www.dnr.state.md.us/greenways/gi/gidoc/gidoc.html

This report details the technical methodology and field evaluation methods of the state's GI framework.

Texas Environmental Resource Stewards: Texas Ecological Assessment Protocol (TEAP) Results Pilot Project

http://nepis.epa.gov/ - document # 906C05001

Emerging from a state and federal partnership with the goal of common ecosystem management and regulatory efficiency, the Texas Ecological Assessment Protocol analyzes broad-scale ecosystem criteria to identify high-value resources throughout the state. This report focuses on the development of the data and methods used to evaluate diversity, rarity, and sustainability of ecological regions throughout the state.