Eco-logical: Integrating Green Infrastructure and Regional Transportation Planning

Thomas Jefferson Planning District Commission

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Executive Summary

It has long been the assumption that the development of the infrastructure that facilitates community life and societal function may have to come at the cost of the ecosystems they traverse. Over the decades since the National Environmental Policy Act (NEPA) and other environmental laws were passed, highway departments have become accustom to navigating environmental regulations, checking off the lists of requirements, paying for mitigation of impacts, and generally doing what is necessary to move a road project forward. However, as with many industries, the transportation sector is beginning to recognize that incorporating environmental considerations into its business functions can actually strengthen its core competencies in developing infrastructure.

In response to the 2002 Executive Order 13274 *Environmental Stewardship and Transportation Infrastructure Project Reviews*, the Federal Highway Administration, in partnership with several other federal infrastructure and environmental agencies, developed an ecosystems approach to infrastructure development. This approach, called Eco-logical, relies on enhanced cooperation between transportation and environmental agencies to more effectively link transportation system planning with natural and cultural resource concerns and mitigation of unavoidable impacts more effectively (Bush, 2002). The Eco-logical approach is grounded in three defining principles. These include:

1. *Integrated planning between natural resource and transportation agencies*
2. *Mitigation options that enhance the Regional Ecological Framework (REF)*
3. *Performance measures that balance predictability and adaptive management*

The Eco-logical approach advises taking a systems view of the ecosystems in which transportation networks operate to better understand how mitigation of transportation-caused impacts can serve the long-term health and vitality of ecosystems. The approach recommends stepping back from the project-by-project routine to identify the region's greatest conservation needs, and applying mitigation funds to those needs first. The Eco-logical approach was born out of the apparent net-failure of the traditional project-specific, onsite, in-kind compensatory mitigation, which, after 30 years of administration, has proven not to reproduce the ecosystem services that were taken by transportation project impacts (National Research Council, 2001). Eco-logical endorses integrated planning to identify a region's highest conservation priorities and management of mitigation funds to fulfill those needs, allowing the limited funding made available through the compensatory mitigation program to achieve the maximum ecological restoration potential. This long-term, programmatic approach to mitigation benefits partnering agencies by proactively avoiding and minimizing conflict between transportation projects and green infrastructure, taking the guesswork out of where mitigation money could most productively be spent, and by advancing conservation priorities of multiple environmental agencies.

After completing the *Green Infrastructure Study* for the region in 2009, the Thomas Jefferson Planning District Commission (TJPDC) developed a project applying green infrastructure and eco-logical principles to its long range transportation planning program to facilitate more environmentally sensitive infrastructure development in the region. The goals of the project were to develop tools that would allow transportation planners and decision makers to incorporate here-to-for absent environmental information into the planning and early design phases of project development, and to identify the region's highest conservation priorities to be used as mitigation sites for transportation impacts. The TJPDC will make the "ecological blueprint" and associated conservation priorities available to other conservation and/or mitigation interested entities in the region to facilitate coordination at the regional scale for ecological restoration and protection. The TJPDC's Eco-logical project produced the following deliverables:

1. ***An integrated regional map for bringing long range transportation planning information together with regional environmental information to inform transportation planners, decision makers, and the public about the potential environmental risk associated with specific roadway construction projects.***
2. ***Least Environmental Cost Analyses that demonstrate how spatial analysis tools can be used to plan roadway alignments and alternatives that avoid and minimize environmental impacts to the maximum extent practicable.***
3. ***Methodologies and results for prioritizing mitigation sites for use inside and outside of the compensatory mitigation program to strategically restore and enhance the health of region's ecosystems.***

Guided by an advisory committee of local planners and environmental managers, each project deliverable was designed with reproducibility in mind for use by small Metropolitan Planning Organizations, other transportation planning agencies, planning districts, and natural resource managers. The TJPDC hopes that these products will assist the evolution of more environmentally sensitive transportation infrastructure, while giving rise to a regional conservation infrastructure that enhances cooperation across boundaries in the effort to conserve and restore ecosystems at the landscape scale.

1 Introduction & Background

The Federal Highway Administration's (FHWA) Eco-logical approach advises transportation and environmental resource agencies to form partnerships and integrate agency plans to promote more environmentally sensitive development of transportation infrastructure. In response, the Thomas Jefferson Planning District Commission (TJPDC), with funding from the FHWA, developed a project that brought transportation planners and environmental professionals together to begin a discussion on how environmental considerations could be introduced into the transportation planning process. As the regional government and lead long range transportation planning institution for the region, the TJPDC has long voiced its commitment to sustainability through local planning. The decision support tools that are the products of the Eco-logical project enable the TJPDC to apply the principles of sustainability to its transportation program. These tools bring to the transportation planning process an ecosystem approach to infrastructure development that is more informed, transparent, and holistic than has been practiced previously. These tools were developed with reproducibility in mind, to serve as a model for other small Metropolitan Planning Organizations (MPOs) and planning districts wishing to integrate transportation and environmental planning processes.

The Thomas Jefferson Planning District

The Thomas Jefferson Planning District (TJPD), as depicted in Figure 1, is located in the approximate geographic center of the Commonwealth of Virginia, and encompasses 2,155 square miles across six localities. The Planning District is made up of the counties of Albemarle, Fluvanna, Greene, Louisa and Nelson, the City of Charlottesville and the incorporated towns of Columbia, Scottsville, Louisa, Mineral and Stanardsville. The region has experienced a higher than average growth rate over the past two decades, growing 18% from 2000 to 2010. Route 29 connects areas south of the Planning District to areas to its north, while Interstate 64 and Route 250 connect the east to the west. A network of other primary and secondary routes facilitate transportation throughout the region.

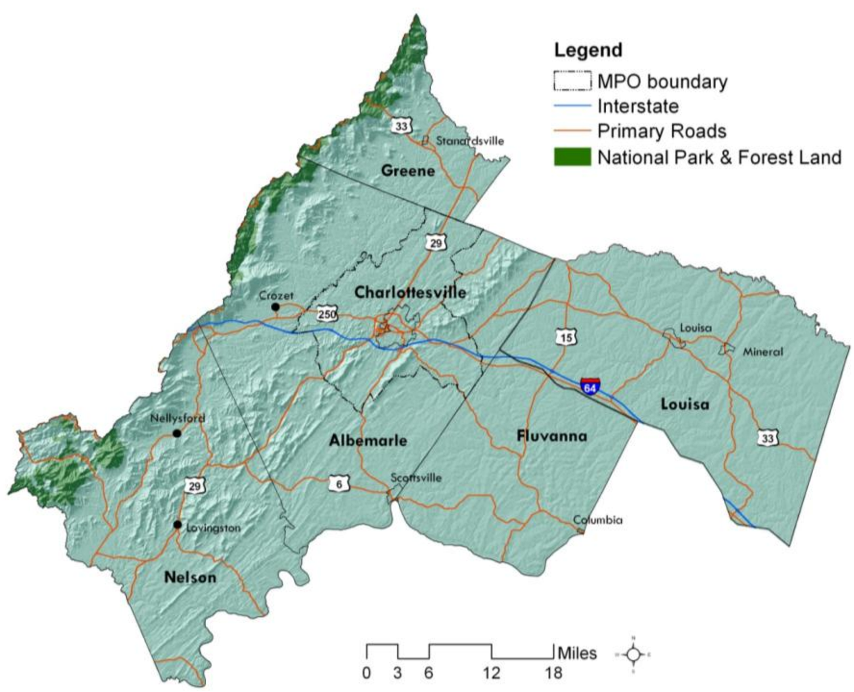


FIGURE 1. THE THOMAS JEFFERSON PLANNING DISTRICT

The District is situated in the Southern Appalachian Piedmont ecoregion, which provides a topographic transition between the coastal plain and the Blue Ridge Mountains. Elevations range from more than 2,500 feet above sea level in the mountains to roughly 200 feet at Columbia on the James River. More scarce are areas of relatively flat land, which are found in larger river valleys and floodplains.

Water resources in the Planning District are characterized by six major rivers that drain the land. They include the Tye, Rockfish, Hardware, Rivanna, Anna, and Rapidan Rivers. Generally, the region's headwaters originate in the mountains and flow to the James River, which provides major drainage and flow east to the Chesapeake Bay. The Rapidan and Anna Rivers drain into the Rappahannock and York Rivers respectively, which also reach the Bay.

The natural landscape of the ecoregion is characterized by oak-hickory forest. However, much of the region's forests are secondary growth, as the Piedmont was largely grassland at the time of the early settlements (Department of Conservation and Recreation, 2010). According to the latest update to the National Land Cover Dataset (2001), the region's land cover is composed of approximately 72% "natural" vegetation, consisting of deciduous, evergreen, or mixed forest, shrubland, upland herbaceous, and woody or emergent herbaceous wetlands. The Shenandoah National Park and George Washington National Forest protect habitats in the mountainous western edge of the region. The TJPD is home to a number of threatened or endangered species, including birds such as the Loggerhead Shrike, river mussels like the James Spinymussel, Pink Swamp, a flowering herbaceous wetland plant, and many others.

Long Range Plans

In the planning phase of transportation infrastructure development, Planning District Commissions and Metropolitan Planning Organizations (MPO) adopt regional Long Range Transportation Plans that prioritized transportation projects for implementation based on a number of considerations. Long Range Transportation Planning within the Thomas Jefferson Planning District occurs within two distinct geographic areas. There is a district-wide plan called the Rural Long Range Transportation Plan (RLRP), which is currently administered throughout the region by VDOT and their consultants, Parsons Transportation. The RLRP is structured as a comprehensive list of potential projects in the rural area of the planning district, and is not tied to potential funding. The RLRP was approved December 2nd, 2010.

Within the MPO's boundaries, the Long Range Transportation Plan is known as UnJAM 2035 and was approved May 27th, 2009. Unlike the RLRP, the MPO's Long Range Transportation Plan is a federally required document that must be approved by the Federal Highway Administration (FHWA). Furthermore, UnJAM 2035 is fiscally-constrained, meaning that the costs of all projects listed in the plan must be equal to or less than the estimated amount of funding anticipated for projects in the MPO over the next twenty years. FHWA also requires that any transportation project receiving federal funding must consider specific planning factors. Currently, there are eight planning factors defined in the United States Code 23 USC 134 (h).

THE EIGHT PLANNING FACTORS

1. *Support the economic vitality of the metropolitan area, especially by enabling global competitiveness, productivity and efficiency.*
2. *Increase the safety of the transportation system for motorized and non-motorized users.*
3. *Increase the security of the transportation system for motorized and non-motorized users.*
4. *Increase the accessibility and mobility of people and for freight.*

5. *Protect and enhance the environment, promote energy conservation, improve the quality of life, and promote consistency between transportation improvements and state and local planned growth and economic development patterns.*
6. *Enhance the integration and connectivity of the transportation system, across and between modes, for people and freight.*
7. *Promote efficient system management and operation.*
8. *Emphasize the preservation of the existing transportation system.*

These eight planning factors are outlined in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). Signed into law in August 2005, SAFETEA-LU authorized highway, highway safety, transit and other surface transportation programs. It builds on the initiatives established in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and the Transportation Equity Act for the 21st Century of 1998 (TEA-21). A new transportation bill is anticipated to replace SAFETEA-LU in September 2011.

Another long-range plan that affects the region's transportation system is the VTRANS 2035 plan, the statewide long range transportation plan. This plan considers transportation planning from an inter-regional perspective, focusing on major roads that connect various communities throughout the state. This plan is not as locally detailed as the RLRP and UnJAM 2035, but projects in VTRANS 2035 will affect roadways in the region. VTRANS 2035 is currently in process.

Presently, environmental impacts are minimally considered in the planning phase of infrastructure development. The environmental implications of a project are typically not reviewed until it reaches the design phase. Leaving environmental review until the design phase precludes the opportunity to use the potential environmental impact as a parameter for prioritizing projects in Long Range Transportation Plans. The Eco-logic project offers a tool that will change this dynamic to allow estimations of environmental impact to be considered along with the host of other criteria used to prioritize transportation projects for implementation. This tool will assist the region in meeting the planning requirements of the FHWA. It will also introduce new information into the plan phase of transportation administration in the region. Having this information in the plan phase can assist planners and project managers in scheduling and budgeting appropriately for the anticipated level of environmental review and mitigation that may be necessary for a given project.

Environmental Review & Mitigation

The National Environmental Policy Act (NEPA) environmental review process that takes place in the design phase of transportation project development is well established, although it continues to evolve. The NEPA process is intended to assist public officials in understanding the environmental consequences of proposed actions and alternatives to allow them to make fully informed decisions that balance engineering and transportation needs with those of the human environment (Federal Register, 1978). NEPA established the "avoid, minimize, mitigate" sequence of prioritizing the preference for avoiding environmental impacts, minimizing impacts when avoidance is not possible, and mitigating impacts that must occur. This approach is echoed in many state environmental review policies. The NEPA process requires the review of 25 individual parameters in order to assess the environmental consequences of a proposed action, in addition to the development of project alternatives. It is required of any "major federal action" (defined in 40 CFR 1508) and any project receiving federal funding.

While the NEPA process covers a broad range of potential impacts to the social, economic, and natural environment, the TJPDC's Eco-logical project focuses solely on the natural environment. Social and economic interests are very important to the work of the TJPDC, including its transportation program. However, they were not included in this project since the scope of work was focused on applying the FHWA's defining principles of the Eco-logical approach, which mainly pertain to the natural environment. The TJPDC Eco-logical project offers a tool that would help facilitate roadway design that avoids and minimizes impacts to the natural environment to the extent possible.

According to NEPA, when opportunities for avoidance and minimization have been exhausted, permitted impacts to environmental resources must be mitigated. Mitigation for impacts to resources regulated under Section 404 of the CWA is common in Virginia. These resources are referred to as the "waters of the United States" and included streams and wetlands, in addition to other navigable waters (CFR, 2010). While water resources are most often the focus of mitigation in Virginia, mitigation to the natural environment may also be required by other regulations applicable under NEPA. Examples include threatened and endangered species habitat, public parks, visual and cultural resources, and others.

The compensatory mitigation program, administered by the U.S. Army Corp of Engineers with oversight from the Environmental Protection Agency, has evolved from requiring on-site mitigation of impacts to encouraging the use of "banking," or buying credits from a large stream or wetland restoration or construction project using dollars generated by permitted impacts under the regulatory program (National Research Council, 2001). The theory behind banking is that it allows for the implementation of larger, more contiguous mitigation projects, which are thought to be more effective in restoring ecosystem functions than smaller, fragmented and dispersed mitigation measures (Federal Register, 2008). The Eco-logical approach takes this idea a step further and advises cooperating agencies to establish a Regional Ecological Framework (REF) to use as the basis for mitigation projects (Brown, 2006).

The TJPDC Eco-logical project establishes a REF as the basis of a regional conservation infrastructure network, and develops and implements a methodology for using the REF to strategically prioritize water resource mitigation projects to achieve the highest conservation value for the dollars available. Since mitigation funding is usually generated from impacts to water resources, the methodologies applied here pertain only to water resources. However, the REF can also be used as the basis for other types of required mitigation.

Opportunities for Partnership

Beyond the aforementioned benefits, we believe that Eco-logical has a broader appeal beyond the boundaries of the transportation planning process. The REF and mitigation priorities could potentially to be used by any organization or agency that sees the value in partnering in a coordinated effort to protect and restore the resources making up the REF. This may included community development and recreation planners at the locality level, private sector developers and industries whose activities fall under Section 404 regulation, state environmental resource agencies, regional water authorities, land trusts, other conservation easement holders, Soil and Water Conservation Districts, corporate sponsors, environmental non-profits, and others. The TJPDC also encourage the use of the transportation regulatory program and the Eco-logical project deliverables to assist in meeting the goals and requirements of other environmental regulations, such as Total Maximum Daily Loads, Municipal Separate Storm Sewer Systems, the Endangered Species Act, and state stormwater regulations.

The following report illustrates how the Eco-logical approach can be applied to plan phase transportation planning, and to prioritizing mitigation projects. It will describe the development of each decision support tool, how it will be used, by whom, and for what purpose. We hope that it conveys how a planning district can manage its transportation programs more sustainably by blending the plans, information, and interests of multiple environmental and transportation entities at the earliest stages of infrastructure development to advance the highest priority ecological and infrastructure goals of the region.

2 Objectives

The goal of the Eco-logical project is to make tools and information available to planners and decision makers that will enable the development of infrastructure in a fashion that is more sensitive to environmental context at the landscape scale. The following objectives were crafted to meet this goal:

1. *Create a tool that can be used by local elected officials, planners, and transportation professionals to incorporate regional environmental information into the planning phase of infrastructure development.*
2. *Create a tool for transportation planners that can be used to identify the least environmentally damaging path through a corridor for new road way alignments. Incorporate flexibility into the tool to develop alternative alignments based on user defined constraints and the values assigned to them.*
3. *Develop and implement a methodology that small MPOs and planning districts, other transportation planning organizations, in-lieu-fee program administrators, and others with an interest in environmental mitigation can use to prioritize streams for either protection or restoration.*
4. *Identify and prioritize wetland mitigation sites within the region using a methodology developed by the Virginia Department of Conservation and Recreation (DCR) for this purpose that is accessible for use by small MPOs, planning districts, and others with an interest in wetlands restoration, enhancement, and protection.*

3 Regional Ecological Framework

What	Inventory of resources of regional significance that form the ecological framework.
Why	Establish an ecological blueprint that can inform future planning of all types.
How	➢ *Collect available natural resources data from diverse sources* ➢ *In consultation with experts and stakeholders, apply valuations to data that indicate biodiversity, rarity, quality, etc. of existing resources* ➢ *Aggregate data to show regional distribution of value within the ecological framework*

Establishment of a Regional Ecological Framework (REF) is the first step in creating each of the decision support tools and methodologies describe above. The REF is an inventory of significant natural resources in the TJPD that are important to the regions ecological health. In creating the REF, plans and data of state and federal resource agencies and wildlife organizations were consulted to ascertain the locations, distribution, relative importance and other attributes of the resources. The inventory brings together conservation priorities of multiple agencies and builds a visual network of the most ecologically important areas in the region by depicting where priorities overlap.

In the TJPDCs 2009 Green Infrastructure Study, cornerstone data layers that represent the regions green infrastructure were pieced together to identify "Areas of Environmental Opportunity." Creation of the REF builds upon the Green Infrastructure Study by identifying "keystones" within the green infrastructure network, which represent high ecological value due to the presence or combination of rare, diverse, pristine, or otherwise unique resource qualities or occurrences. The REF also inventories the collection of resources that support the keystone sites, representing them with a numerical scale that indicates their relative importance in the REF. The keystone sites are simply those geographic areas that score the highest on the scale.

The REF is a starting point for multiple entities, working with different missions in the region, to form a universal understanding of the region's natural resources. It provides information that can be used by many for different purposes, but allows each organization to work from a common ecological blueprint. The REF enables agencies to fulfill individual missions, while maintaining the ability to partner with others in a coordinated effort to more effectively manage the regions green infrastructure. For resource agencies and conservation organizations, the REF prioritizes those land areas that are most worthy of protection. For transportation institutions, it allows the estimation of potential environmental impacts, and if impacts must occur, it identifies areas where mitigation dollars would best be invested to enhance the natural capitol of the region.

Methodology

CHOOSING THE INPUT DATASET

The REF was created using spatial data in a Geographic Information System (GIS). The TJPDC, with help from the advisory committee, identified available GIS data that is representative of ecological significance on a regional scale. The search included consulting the state natural resources agencies, the Department of Conservation and Recreation (DCR), and the Department of Game and Inland Fisheries (DGIF) for inventories of natural resources of significance, and for previous work done to prioritize importance among these inventories. Among other things, these agencies are tasked with documenting the location and ecological status of rare plant and animal species and natural communities. Each maintains several different spatial datasets of data collected by professional scientists to inventory these resources. The United States Geological Survey (USGS) and the United States Fish and Wildlife Service (USFWS) were also consulted for inventories of streams and wetlands in the region. Finally, the Audubon Society's Important Bird Areas data was used as an indication of high quality habitat. All GIS data available for the region that inventories natural resources was considered for use in this analysis, with the exception of point data, which would need significant extra processing to extrapolate to a larger geographic area. Table 1 lists each dataset that was used in creating the REF, and Figures 3 - 11 illustrate each.

Creation of an REF need not be limited to the datasets used in this study. The ones used here happen to be the data that is available in the TJPD that characterize the critical ecological resources. However, different regions may have additional datasets that represent ecological integrity and would be appropriate to includes in the analysis. Such data may include water quality monitoring data, citizen monitoring data of environmental quality indicators, or other assessment of natural resource quality and/or occurrence. However, caution should be taken in using data that is available for one part of a region, but not others. Using such data with this methodology will skew the REF to indicate higher ecological integrity where additional datasets are used, unless multipliers are added to each dataset in that geographic area to accommodate the extra data (reducing the weight of each dataset so as to not outway the data used in the rest of the region). This does not apply if a the resource *only* exists in a certain part of the region, as cold water streams do in the TJPD, for example.

Finally, the region on which the REF is based does not have to be within planning district boundaries. Although it suits the purposes of this Eco-logical project, a REF could usefully be formed on watershed, locality, ecoregion, state, multi-state, or other agency district boundaries, depending on the goals and objectives of the partners involved.

TABLE 1. REF INPUT DATASETS.

Dataset	Description	Agency Maintaining Data
Tiered Species Habitat	This dataset highlights wildlife habitat conservation opportunities in Virginia. While all areas with the potential to support tiered species are important, areas that may support multiple species represent areas of greater conservation impact. This data shows the number of Tier 1, 2, or listed species with mapped potential or confirmed essential habitat across VA. It is a combination of mapped habitat from 149 terrestrial species and 98 aquatic species.	Department of Game and Inland Fisheries (DGIF)
Threatened & Endangered Species Waters	T&E Waters identifies streams and rivers than contain documented occurrences of federal or state listed threatened or endangered species and their associated habitat. Each reach contains descriptive fields including stream name, upstream and downstream boundaries, status (federal/state) and length.	DGIF
Species Observations	This shapefile contains species observations data derived from ten different sources, including: the Virginia Breeding Bird Atlas Project; Cold Water Stream Survey; WMA Bird Surveys; Rare Bird Sitings; Mid-winter bald eagle survey; Bald Eagle Nest Database; VDGIF Scientific Collections, TE, and Salvage permit data; Colonial Waterbird Locations; and Colonial Waterbirds 2003.	DGIF
Virginia Natural Landscape Assessment (VaNLA): Cores and Corridors	VaNLA is a landscape-scale geospatial analysis for identifying, prioritizing, and linking natural lands in Virginia. VaNLA data is derived from satellite imagery, and identifies large patches of natural land with at least one hundred acres of interior cover. These large patches are known as Cores, and begin one hundred meters from patch edges. All ecological cores with the highest ecological integrity (i.e. classified as C1, outstanding, or C2, Very high) are connected by landscape corridors and nodes to create a statewide network of natural lands. These corridors were developed by creating a model that represented impedances to wildlife movement through the landscape and then selected the easiest routes between each high priority ecological core and its neighboring cohorts.	Virginia Department of Conservation & Recreation (DCR)
Priority Conservation Sites	The PCS is made up of Natural Heritage Conservation Sites, Stream Conservation Units, and General Locations. Conservation sites are a tool for representing key areas of the landscape worthy of protection and stewardship action because of the natural heritage resources and habitat they support. Stream Conservation Units identify stream reaches that contain aquatic natural heritage resources, including upstream and downstream buffer and tributaries associated with these reaches. Conservation sites and stream conservation units are ranked here to coincide with DCR's Biodiversity Conservation Need ranking of them. B1being "critical" and B5 being "moderate."	DCR
Important Bird Areas	This dataset identifies areas that are vital to birds and other biodiversity. There are currently 20 IBAs in VA.	National Audubon Society
National Wetlands Inventory	NWI provides current geospatially referenced information on the status, extent, characteristics, and functions of wetland, riparian, deepwater, and related aquatic habitats in priority areas to promote the understanding and conservation of these resources.	US Fish and Wildlife Service
VCLNA Watershed Integrity Model	The Virginia Watershed Integrity Model was developed to show the relative value of land as it contributes to watershed or water quality integrity. The input parameters focused on identifying important terrestrial features that contribute to water resources, and, therefore watershed integrity. The model uses a variety of datasets including: slope, wetland, streams, forest fragmentation, land use, public source water protection areas, ecological cores/forested areas, a terrestrial index, and an aquatic index.	DCR

Dataset	Description	Agency Maintaining Data
National Hydrography Dataset: 1:100,000 streams	The National Hydrography Dataset is a comprehensive set of digital spatial data that contains information about surface water features. Within NHD, surface water features are combined to form "reaches." Reaches form the framework for linking water-related data to the NHD surface water drainage network, and enables the analysis and display of water-related data in upstream and downstream order.	US Geologic Survey (USGS)
Cold Water Stream Survey	CWSS is a trout stream survey containing biological and physiochemical data about each classified stream reach or specific collection location. The class scale indicates trout habitat quality.	DGIF

RANKING DATASET ATTRIBUTES

Table 2 shows the attributes used and scores assigned to each dataset. The advisory committee considered the attributes of each dataset, and assigned a score to the relevant attribute of each, on a scale of one to ten. The score reflects the relative importance of the occurrence of any certain resource found in a dataset relative to other resources used in the analysis. For example, DCR VaNLA Cores with an attribute of "1," according to DCR, represent habitat cores of the highest integrity. In this analysis, the committee assigned these cores a score of ten to represent the highest importance in the REF. Likewise, the occurrence of all streams included in the 1:100,000 National Hydrography Dataset were assigned a score of three to reflect the relatively less importance of any *individual* stream to the integrity of the REF, since there are so very many streams in the region. However, Cold Water Streams were scored differently to reflect their unique occurrence in the region. These streams were assigned a higher score than other streams in the region. The Audubon Important Bird Areas received a lower score than other habitat data because it is known that the resolution of this dataset is lower than the other habitat data used in the analysis.

Finally, since the audience of potential users is broad, and represents many interests, it is important to document decisions that lead to the rankings of individual datasets. Documentation facilitates transparency, and helps to ensure the proper use of the output data. Metadata (information about the output data representing the REF) should direct data users to documentation on the process by which the data was created. A new field was added to the attribute table of each dataset used in the REF analysis, and the score assigned to the relevant attribute was added to the new field.

TABLE 2. ATTRIBUTE SCORES USED TO FORM THE REF.

Dataset	Attribute	Rank	Comments
DGIF Tiered Species Habitat (terrestrial and aquatic)	2	10	Variety
	1	8	
DGIF Threatened & Endangered Species Waters	Tier I	10	Lines buffered 100'. Where both Tiers are present, pixel rank = 10.
	Tier II	8	
DGIF Species Observations - Diversity, # of Species Present	1	4	
	2	6	
	3	8	
	4	10	
DCR Virginia Natural Landscape Assessment (VaNLA)			
Habitat Cores	1	10	
	2	8	
Habitat Corridors		2	
Cores 3 - 5 that intersect corridors	3	6	
	4	4	
	5	2	
DCR Priority Conservation Sites	B1	N/A	Conservation Sites and Stream Conservation units are ranked here to coincide with DCR's Biodiversity Conservation Need ranking of them. B1 being "critical", and B5 being "moderate".
	B2	9	
	B3	8	
	B4	7	
	B5	6	
	General Location	4	
Audubon Important Bird Areas		4	
USFWS National Wetlands Inventory	wetlands	8	
	200' buffer	6	
DCR VCLNA Watershed Integrity Model	5	N/A	
	4	8	
	3	6	
	2	4	
	1	2	
NHD 1:100,000 streams			
1st order	50' buffer	3	Where buffers intersect, keep larger buffer.
2nd order	75' buffer	3	
3rd order and above	100' buffer	3	
DGIF Cold Water Stream Survey - Classes I - IV - 100' buffer	Class I	7	Where 1:100,000 streams intersect with cold water streams, cold water stream ranks prevail
	Class II	6	
	Class III	5	
	Class IV	4	

SPATIAL ANALYSIS

With the datasets' attributes scored appropriately, they can now be brought together to create a map of the spatial distribution of important environmental resources across the region. ArcGIS's Spatial Analyst allows the user to perform a number of analyses by overlaying grids and analyzing the values in geographically corresponding pixels. After converting all input datasets to raster format (grid), we used the Spatial Analyst to overlay all of the scored datasets. The Spatial Analyst analyzed the input datasets, assessing geographic concurrence, adding attribute scores where they overlap, and finally, creating an output map containing the cumulative value of all scored areas. Areas in the output map with higher scores represent areas with more important, and/or more variety of the resources used as the inputs.

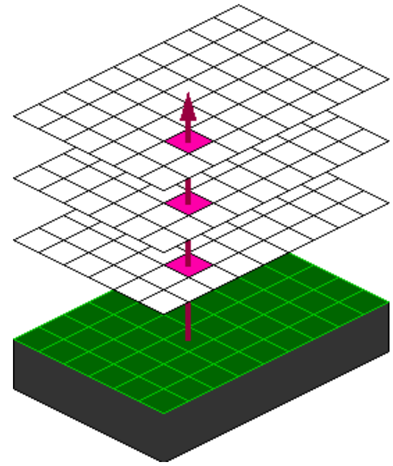


FIGURE 2. DEPICTION OF HOW THE SPATIAL ANALYST ANALYZES RASTER DATA.

SPATIAL ANALYSIS

First, all datasets must be converted to raster file type (ArcGIS Toolbox, Conversion Tools). The conversion turns each dataset into a grid format with pixels of equal size. This analysis used a 30 meter pixel resolution. Each pixel contains the attribute score assigned to its shapefile entry. Finally, each input raster must be merged with a raster of the region that is coded with a value of zero.

To combine the values from the individual datasets, select Cell Statistics from the Spatial Analyst menu. Use each of the scored datasets as an input raster, and choose "Sum" as the overlay statistic. An aggregated output dataset will be generated.

DATASET IMAGES

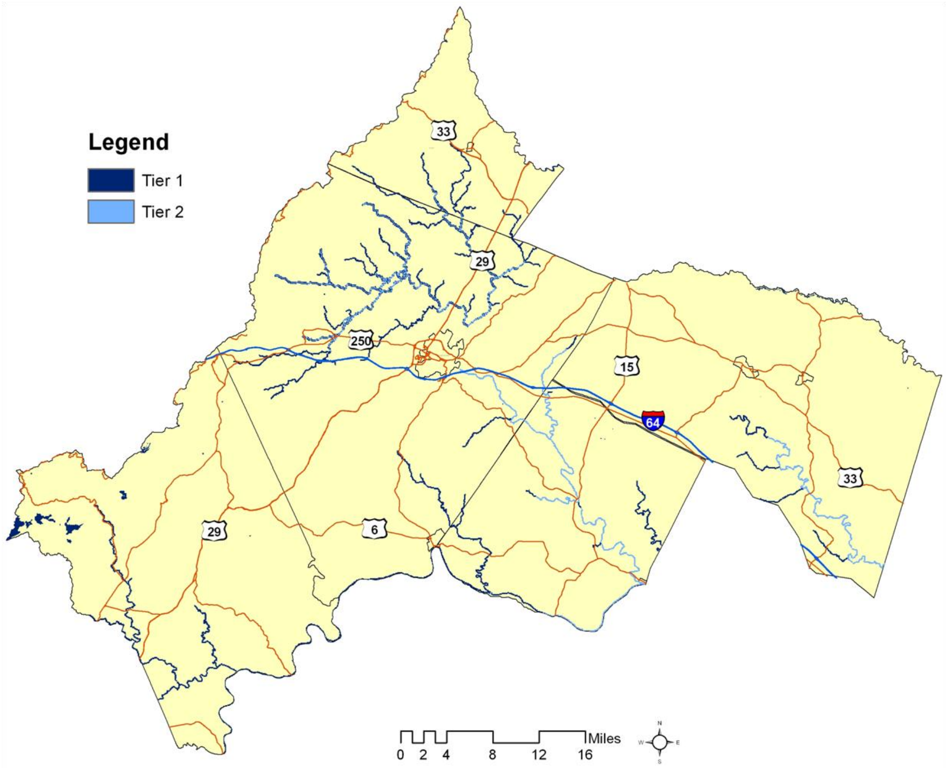


FIGURE 3. DGIF TIERED SPECIES HABITAT

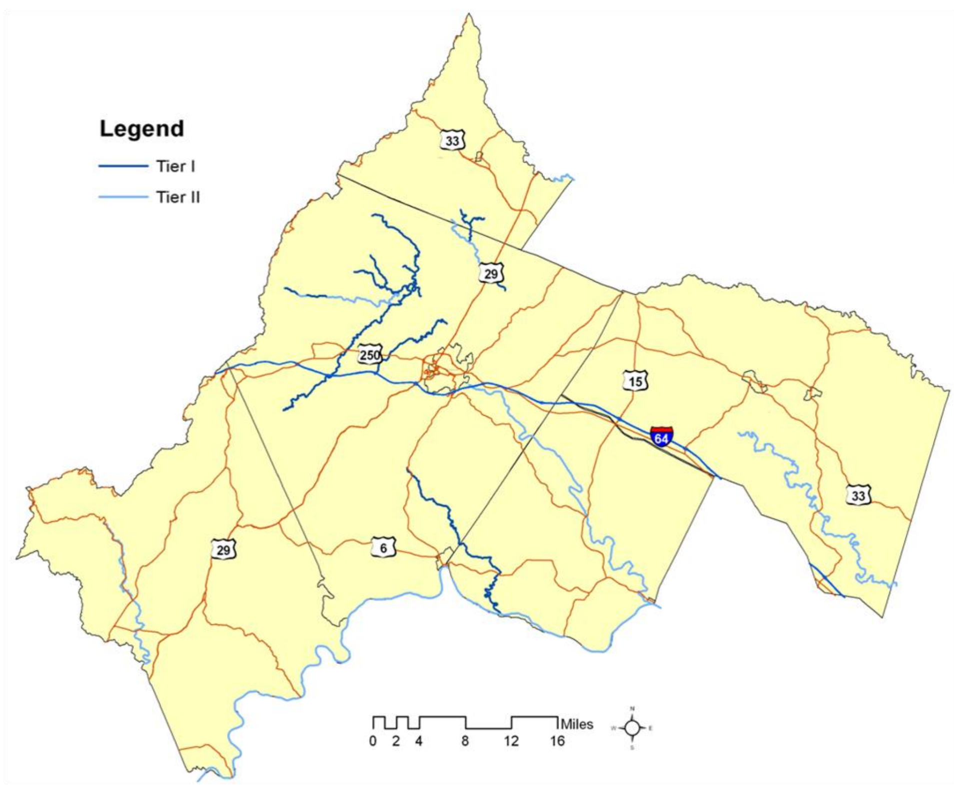


FIGURE 4. DGIF THREATENED AND ENDANGERED SPECIES WATERS

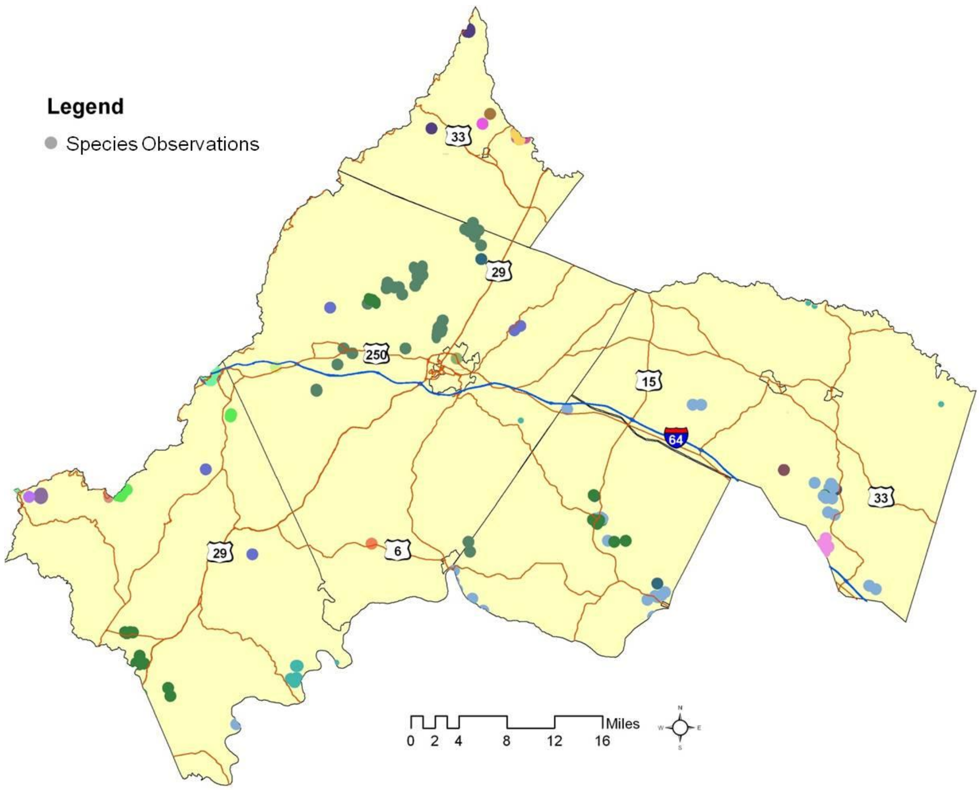


FIGURE 5. DGIF SPECIES OBSERVATION

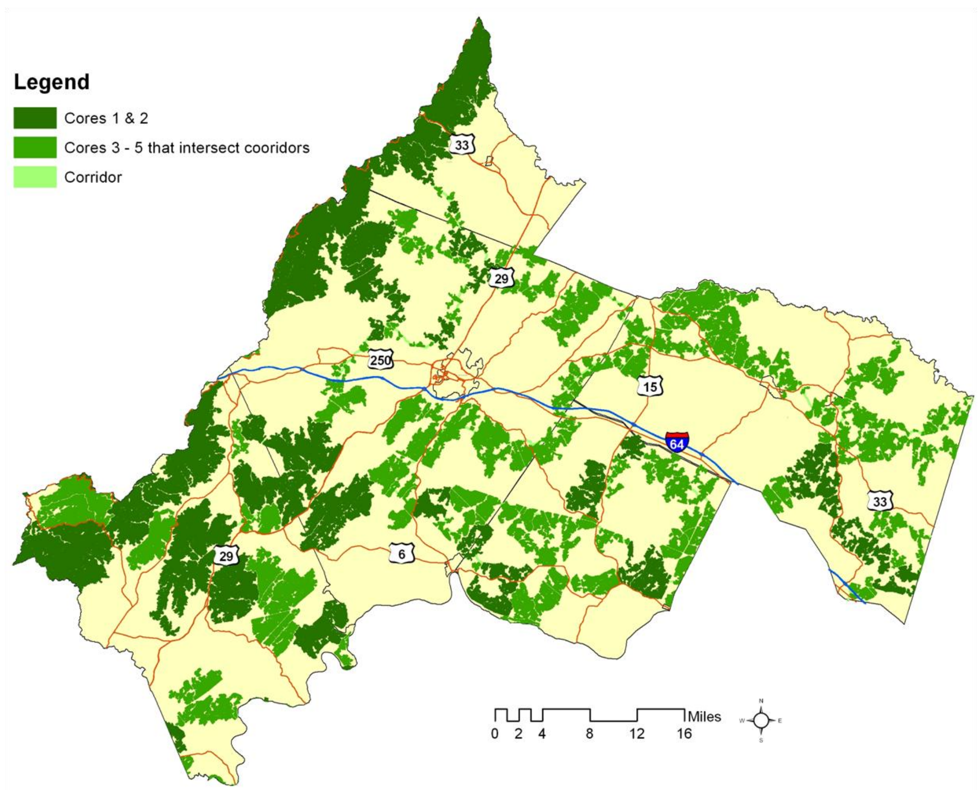


FIGURE 6. DCR VIRGINIA NATURAL LANDSCAPE ASSESSMENT

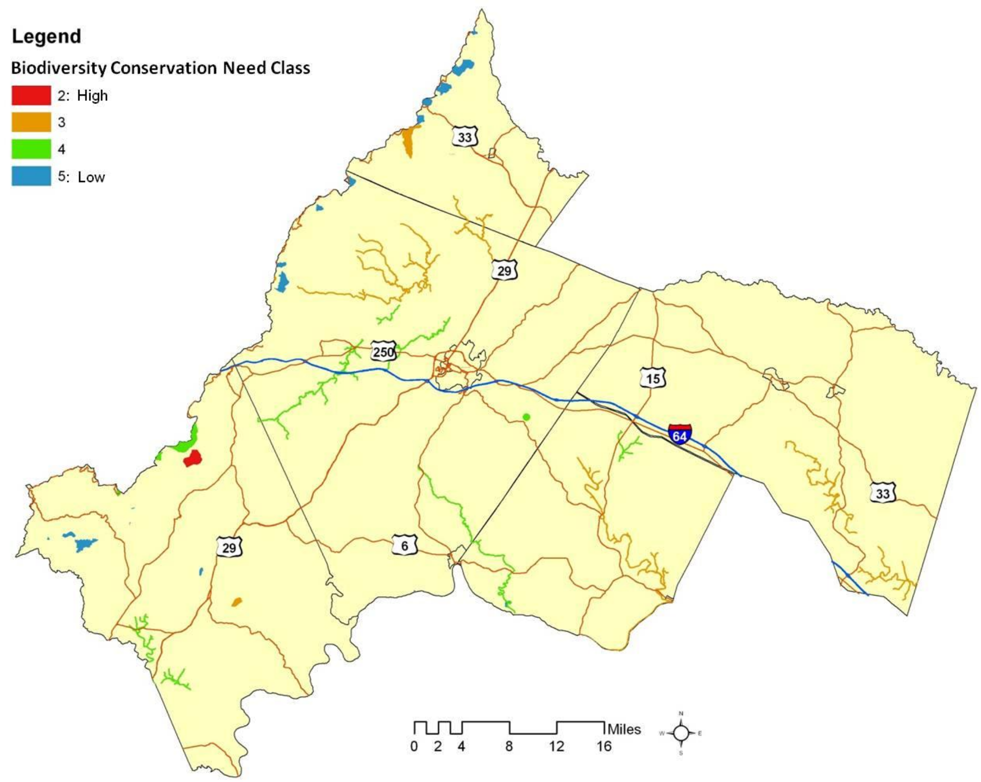


FIGURE 7. DCR PRIORITY CONSERVATION AREAS

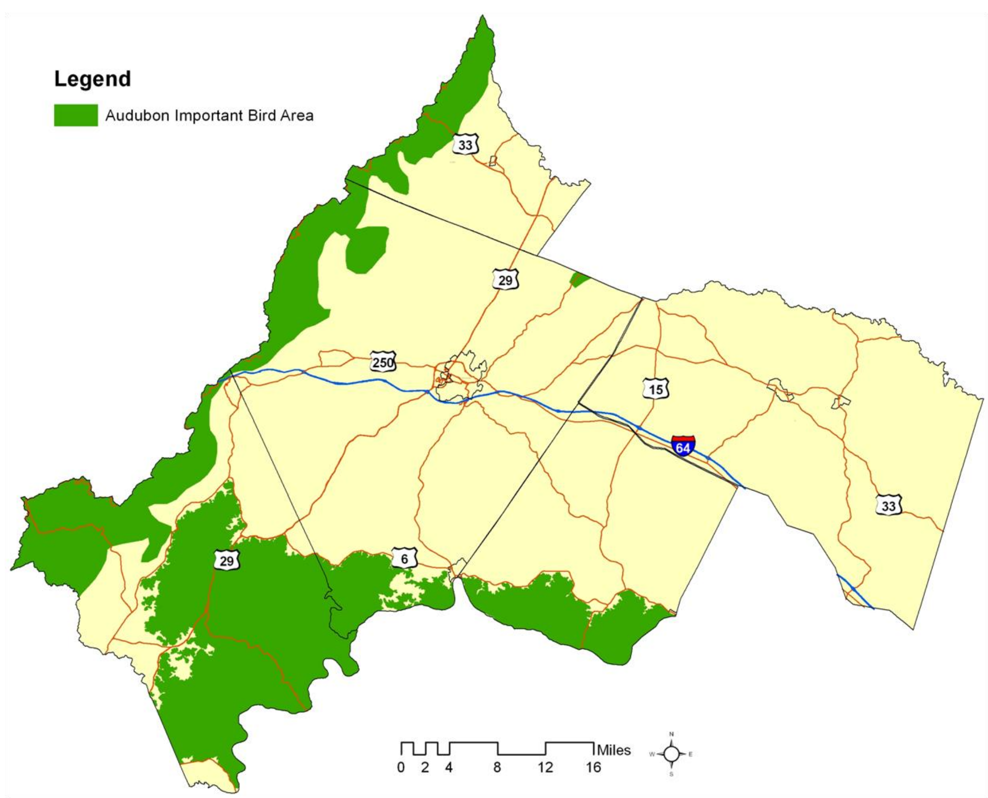


FIGURE 8. AUDUBON IMPORTANT BIRD AREAS

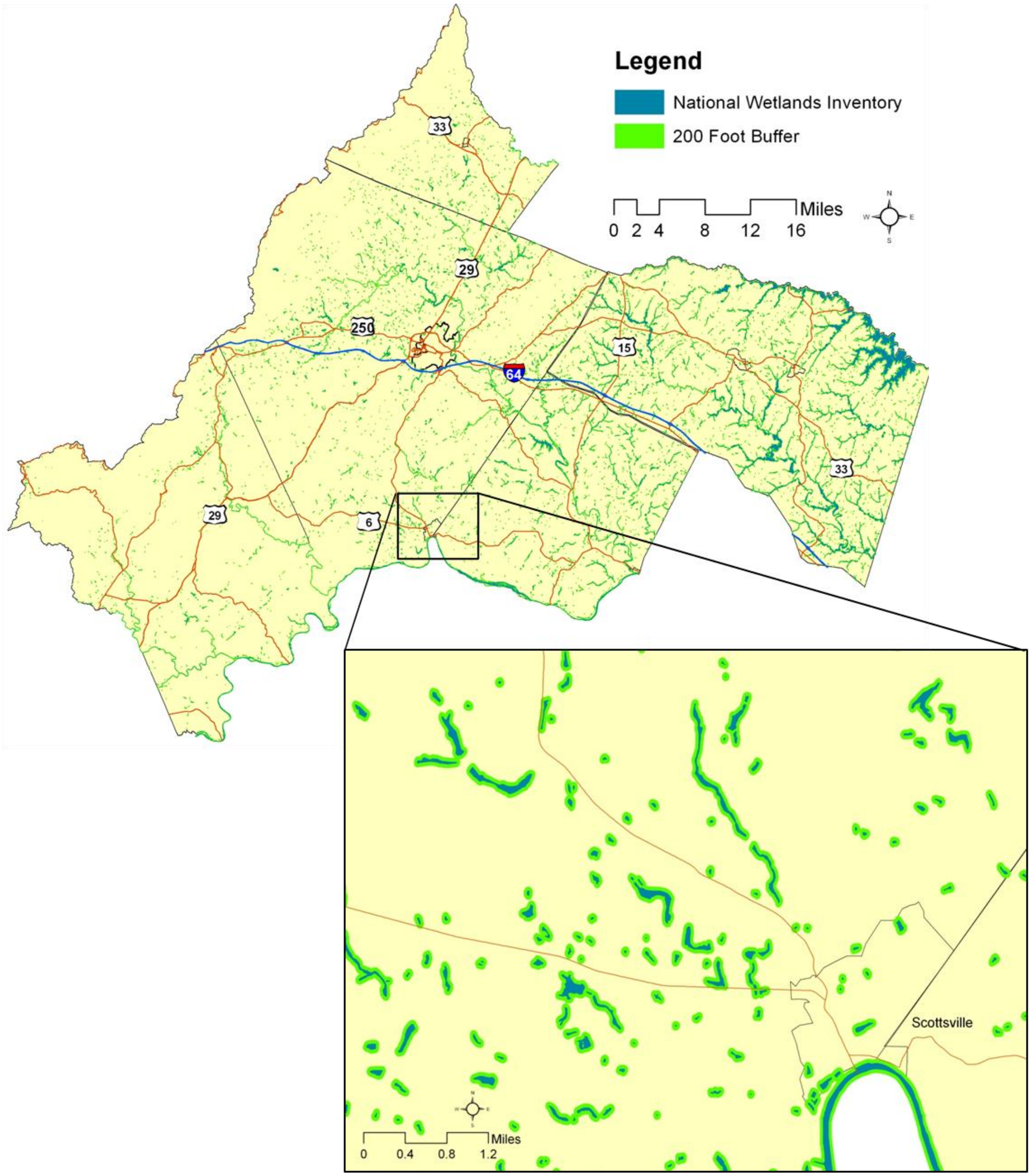


FIGURE 9. NATIONAL WETLANDS INVENTORY

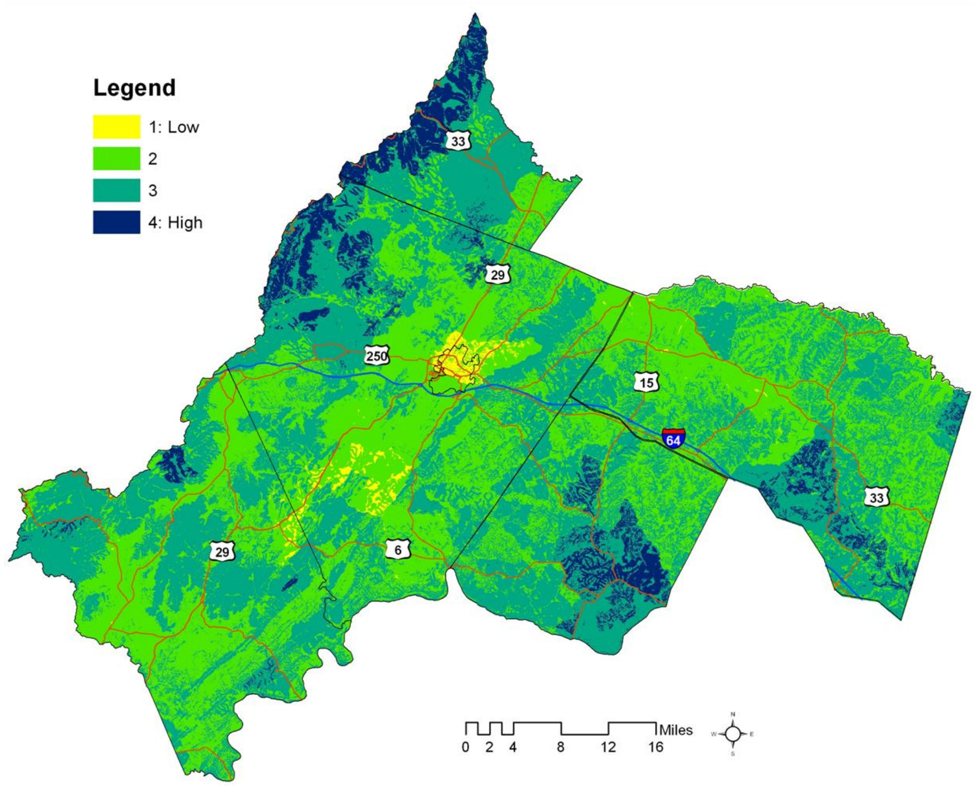


FIGURE 10. DEPARTMENT OF CONSERVATION AND RECREATION - WATERSHED INTEGRITY ASSESSMENT

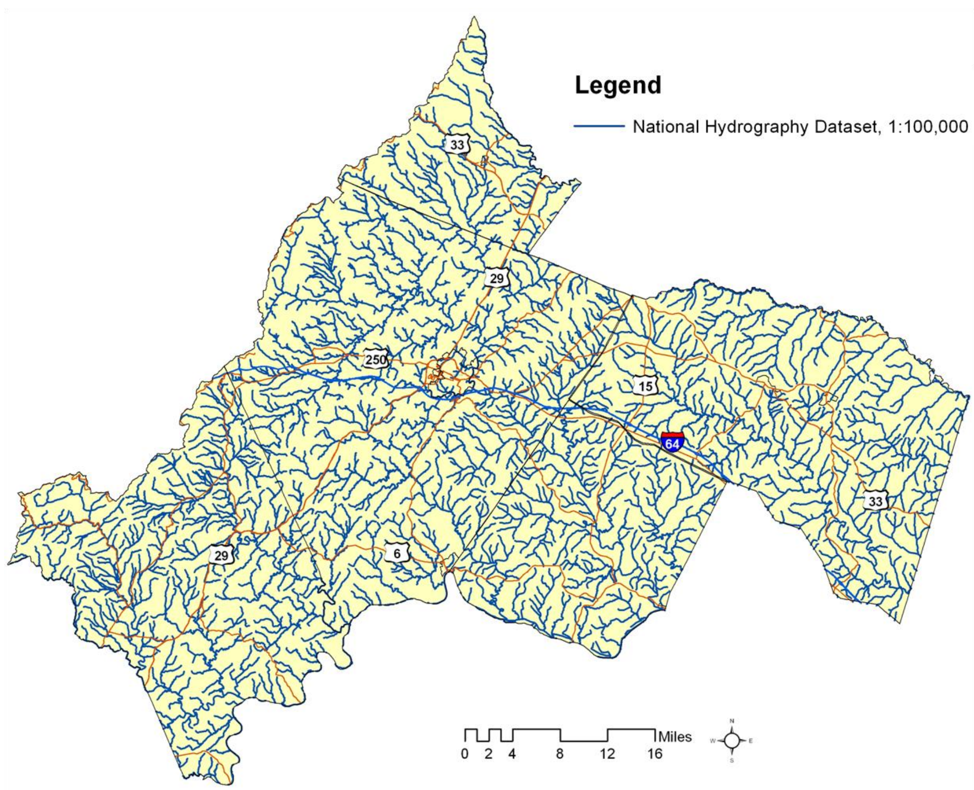


FIGURE 11. NATIONAL HYDROGRAPHY DATASET, 1:100,000 FEET

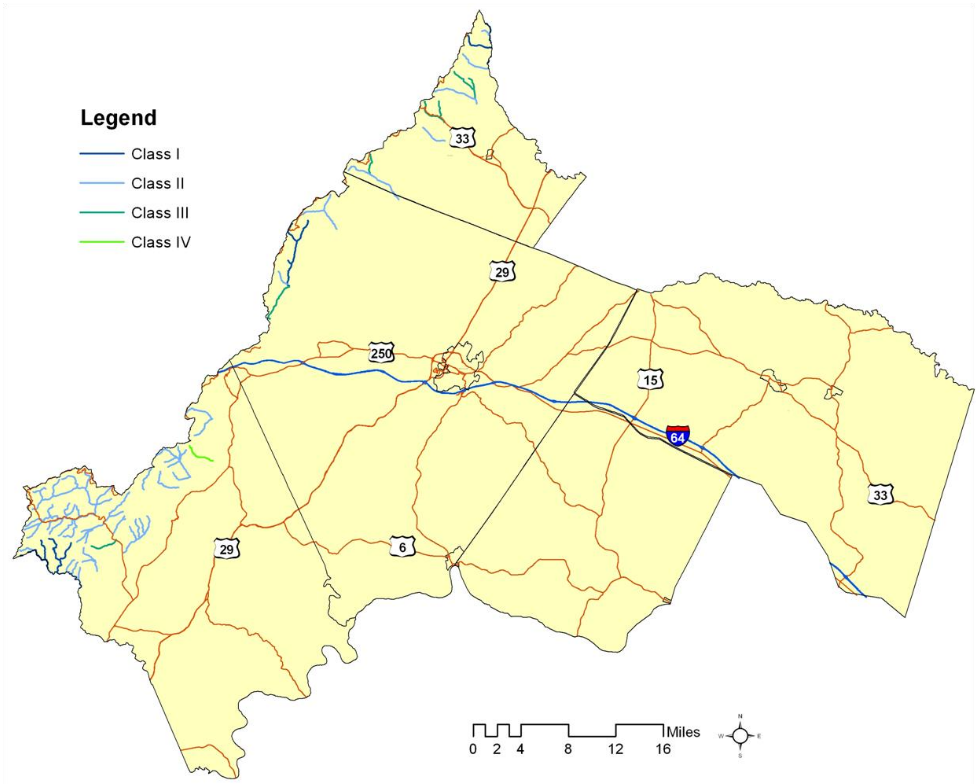


FIGURE 12. DEPARTMENT OF GAME AND INLAND FISHERIES - COLD WATER STREAM SURVEY

Results

Figure 13 is the output map of the spatial analysis, which represents the TJPD REF. The legend provides a color scale to represent the summed scores across the region. Light areas represent low scores where there are relatively disperse, or degraded environmental resources. Increasingly darker greens represent increasing density or integrity of resources, and dark green represents high scores where resources in relatively more pristine condition, high density, or rarity, exist. This map is a visual tool that allows users to identify the spatial distribution and concentration of resources across the region. To precisely ascertain which resources are present at any given location, the user would need this map, and each of the input datasets in a working GIS map document.

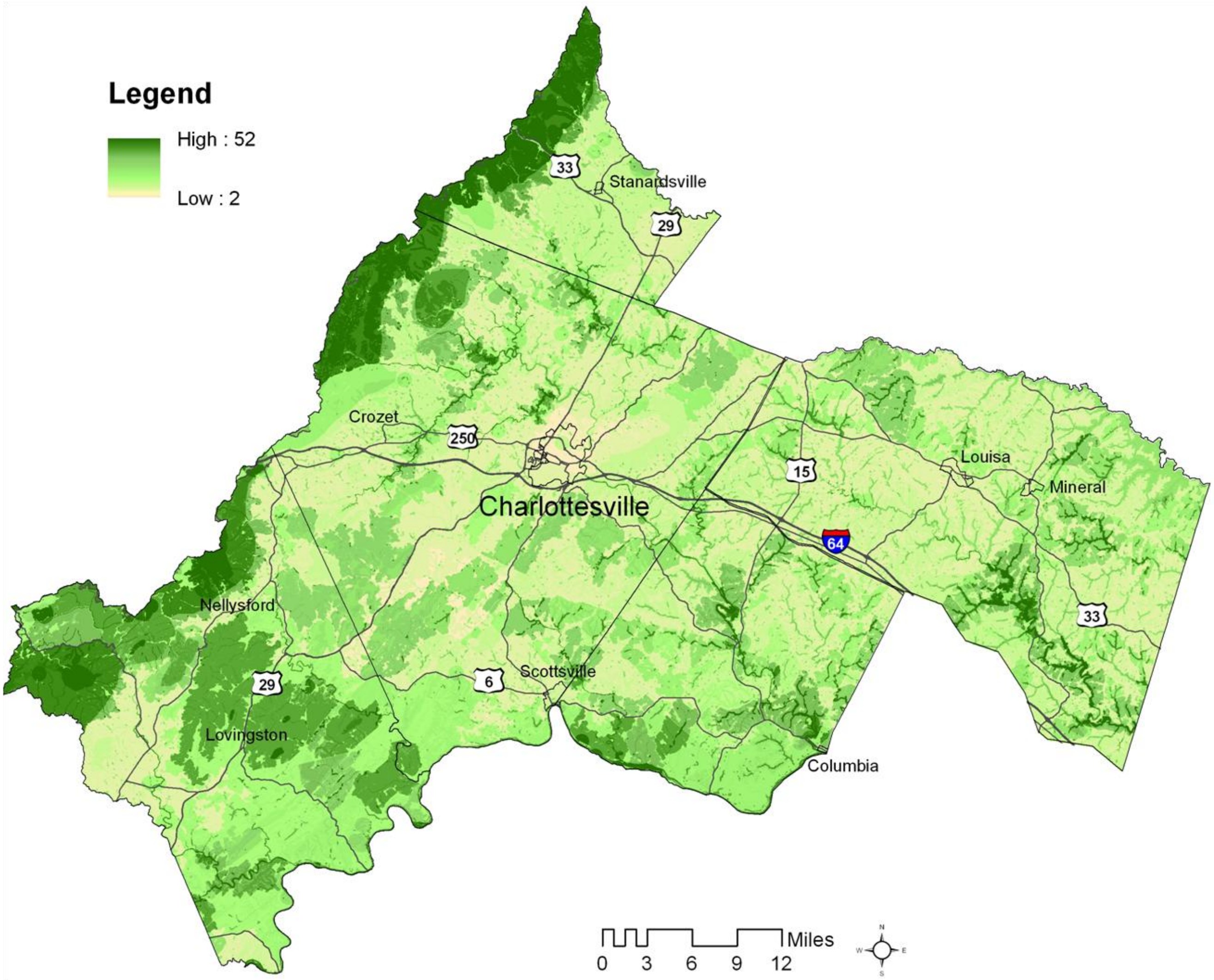
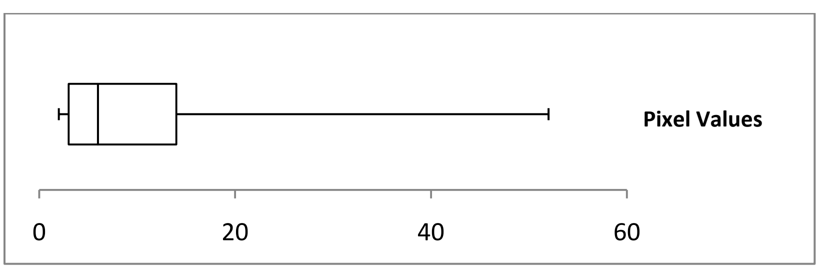


FIGURE 13. TJPD REGIONAL ECOLOGICAL FRAMEWORK

Figure 14 shows the distribution of pixel scores across the region. Fifty percent of all pixel values are below the median value of 6. The pixel values that make up the REF are highly skewed toward the lower limit, and pixels values in the upper quartile cover a wide range of scores. Thus, pixel areas approaching the upper limit are of special interest, since they are relatively scarce.



Percentile	Pixel Value
Lower Limit	2
25th	3
50th	6
75th	14
Upper Limit	52

FIGURE 14. PIXEL DISTRIBUTION BOX PLOT

Limitations

GIS analyses are always temporally constrained. This analysis is limited to the most recent datasets available for the region, which may become outdated at different rates. The REF map should be updated on a regular schedule to remain current and relevant. To determine the best schedule for updating the map, determine how often the input datasets are updated by their respective agencies and organizations. Update the inventory map as often as the input dataset that is updated the most often. Additionally, the analysis is limited to the 30 meter resolution. There is risk that smaller resources are excluded from the framework because of the resolution. Additionally, the quality of the framework is only as good as the data collected by the various agencies and organizations that create and maintain the input datasets. As with any GIS analysis, users should be prepared to accept a marginal amount of error. The committee attempted to address the differences in data quality in the attribute scoring process.

Finally, the REF map should only be used as a landscape scale conceptual planning tool that *indicates*, but does not confirm the presence or absence of sensitive environmental resources. The input datasets document occurrences of resources that have been assessed. However, data collection is often limited by financial resources, thus limiting the scale at which data can be collected. For this reason, documentation of resource occurrences may be incomplete. For any project specific environmental review, a thorough field review must be preformed to make up for knowledge gaps that may be present in the input datasets.

Uses

As previously discussed, the REF can be used by different organizations to progress toward the shared goal of environmental stewardship. Localities could use the REF as a guide for natural resource protection. Adding it to their comprehensive plans would lay the groundwork for possible use of the REF in a host of planning and community development tools that could afford some level of protection to higher scoring areas of the REF, as individual localities see fit. It could also be used by localities, state and federal agencies for recreation planning. Important parts of the REF could be protected as outdoor recreational resources and connected with greenways that can also serve as wildlife corridors. This would enhance both the REF and the quality of life for citizens. Finally, localities may want to explore the monetary value of services associated with the green infrastructure making up the REF. Quantifying potential economic burdens that would accompany reductions in green infrastructure, and cost avoidances and potential revenue associated with increasing green infrastructure would assist local decision makers in appreciating the full value inherent in the REF.

The REF could also be used by the many organizations whose mission it is to promote land protection via conservation easements, or other means. These may include land trusts, the Virginia Outdoors Foundation, conservation nonprofit groups, watershed organizations, state resource agencies, and again, local governments. These groups could use the REF to strategically target those high scoring areas of the REF for conservation easements, fee simple purchase, purchase of development rights, or other action that would protect those resource rich areas. Finally, the REF can be used by transportation planning organizations to estimate the environmental impact of proposed projects, identify options for avoidance and minimization, and identify the best places to use mitigation dollars. Section 4 will describe how transportation planning organizations can use the REF.

Review

The REF inventories the region's most critical natural resources, assigning them value in a transparent manner by including stakeholders and experts in the process. It uses ArcGIS's Spatial Analyst tools to identify concentrations of these important resources, which can be a powerful planning tool. The REF can be used to inform all types of planning. Environmental applications might include watershed or green infrastructure planning, while planning for the built environment can take many forms. Examples include transportation, utilities, commercial and residential building construction. Planners, decision makers, regulators, and business leaders from each of these sectors has an opportunity to use the REF to minimize its impact on valuable green infrastructure.

4 Application to Transportation Infrastructure Development

What	Development of decision support tools to assist public officials, decision makers, planners, administrators and the public in reducing conflicts between the built environment and ecosystems.
Why	Ecosystem services provided by green infrastructure are becoming increasingly valued as they become scarcer. Cost avoidance and revenue in some cases are compelling reasons to maintain and enhance regional green infrastructure.
How	➢ *Integrate infrastructure and natural resources plans* ➢ *Allow the Regional Ecological Framework to inform project alternatives* ➢ *Strategically identify mitigation projects that provide the maximum ecological benefit for the dollars spent*

The REF contains important information for managing viable ecosystems in the TJPD. Just as the roadway network enables productivity by moving people and goods from place to place, so too does the REF promote ecological productivity by enabling the movement of flora and fauna to and from food, water, shelter, and diverse genetic resources that are required for the persistence of healthy populations. To continue this analogy, no center of human activity (development ranging from home to work to shopping and so on) is cut off from the transportation network. The further a facility is removed from the network, the less useful it becomes. Less useful to less people too, are neighborhoods containing many dead ends and cul-de-sacs, which are often designed to strictly limit access and movement. The same principles apply to the REF and the connectivity it provides for habitats. The further removed from the framework a habitat is situated, the more isolated, and therefore, the less useful it is for facilitating the movement of flora and fauna. Barriers and disturbances associated with the development serve to isolate patches of habitat, and limit mobility in the same way as dead-end roads. And in the same way that increased distance from the transportation network decreases human productivity, habitat fragmentation diminishes ecological productivity.

How then, can transportation planners and decision makers use the REF to reduce habitat fragmentation caused by future roadway development, and how will this ease the environmental review process, in addition to easing stress on regional ecological health? The decision support tools described below provide answers to these questions.

4.1 Integrated Regional Map

What	A tool that summarizes potential environmental impacts of projects recommended in long range transportation plans.
Why	So that transportation and natural resources decision makers can collaborate at the plan development stage on strategies to reduce impacts to each other's systems. And at the plan implementation stage, to inform planners and project managers of the estimated environmental impact of any given project, to allow appropriate time and funding for the expect extent of the environmental review process.
How	➢ *Overlay transportation projects on the Regional Ecological Framework map.* ➢ *Use ArcGIS tools to summarize the cumulative value of pixels beneath each recommended project footprint.* ➢ *Normalize by area and compare projects.*

Paramount to the Eco-logical approach is information sharing between agencies for the purpose of identifying conflicts in future plans at a stage early enough to do something about them. When conflicts are identified in the conceptual planning phase, leaders have ample time to modify scopes or otherwise address conflicts within the context of their normal planning processes. Example applications may include conflicts in recreation or resource protection planning with locality designated growth areas, utility expansion plans, or long-term transportation plans. The Integrated Regional Map is tool that applies information from the REF to long-range transportation plans, in order to identify and assess the magnitude of conflicts between local, state, and federally important natural resources. While this tool works well for the transportation sector of infrastructure development, it would easily transfer to other sectors, such as housing and utilities development.

For large infrastructure projects, the ever looming threat of being held up in the environmental review process is a concern for managers whose performance is judged by the degree that their projects adhere to a schedule and budget. Even small maintenance projects can be delayed for months. For transportation professionals, this can be frustrating. To address the concerns that come with the environmental review, transportation professionals would be best served by finding ways to make the process easier and more predictable.

The Regional Integrated Map is a decision support tool that seeks to create the kind of awareness of the environmental review process that is needed at the plan level of infrastructure development. This geographic analysis synthesizes information from the REF and the region's three long range transportation plans to evaluate the transportation project recommendations based on the cumulative impact each is expected to have on the resources making up the REF. Integrating this information is powerful both in long-range plan development, and for shorter-term prioritizing of plan recommendations.

Having this information available during the *development* of long-range plans can assist plan approving authorities in shaping recommendations that will avoid and minimize impacts to environmentally sensitive areas identified in the REF. Information provided by the Integrated Regional Map can also facilitate collaboration and even negotiation with natural resource agencies by identifying and planning mitigation strategies for anticipated impacts to occur over the long-term. With some level of agreement and commitment to long-term regional strategies, partnerships between infrastructure and natural resource agencies are likely to strengthen. As long-term transportation recommendations become present day, design phase projects, agencies would be working from common expectations of the environmental review process that creates some predictability of the process, at least, and facilitates a level of streamlining, at best. As projects are built, and mitigation strategies are implemented, transportation agencies would be contributing to natural resource agencies' priority conservation projects that may have otherwise not been possible.

In shorter-term planning, the integration of the REF with long-range plans creates a heretofore lacking level of transparency of the environmental review process that allows decision makers to analyze the more fundamental question of the worthiness of a project, given the total commitment of resources in cost, time, and ecosystem services for its implementation. In the conventional infrastructure development process, the impact of the environmental review process on these factors is largely unknown in the planning phase, and is only fully accounted for well into the design phase, and sometimes not until project completion; far too late to fully assess the value of a given project, given the extra costs.

At the project level, the Integrated Regional Map can assist project managers in the development of an accurate timeline and budget to fit the level of environmental impact that a project is expected to have. The intensity of the impact has the potential to affected staff or consultant time in completing the NEPA analysis, which directly affects a project's bottom line and timeline. The Integrated Regional Map will provide a new sense of awareness about what may result from a project's in-depth review, thereby providing the ability to plan for it accordingly. The map enables its users to anticipate hidden costs and delays inherent in the review process, which should alleviate some of the frustration it causes.

Finally, it must be fully recognized that the Regional Integrated Map in no way can supplant the on-site environmental review of any transportation project in the design phase. It is only a plan level tool to bring more environmental information to the table, allowing for more predictability and transparency in anticipating and planning for the outcome of the full design phase environmental review.

Methodology

The Integrated Regional Map requires little extra processing to create after the REF map is completed. To create the Integrated Regional Map, we started by reviewing the recommendations in the region's three long-range transportation plans, Virginia's Long-Range Multimodal Transportation Plan (VTRANS 2035), the United Jefferson Area Mobility Plan 2035 (UnJAM 2035), and the Rural Long-Range Transportation Plan (RLRP). Each plan includes a project list of improvements to be made to the transportation network. The combination of projects from these three plans represents all potential infrastructure projects anticipated to be implemented in the Thomas Jefferson Planning District over the next twenty years.

VTRANS 2035

VTRANS 2035 is the long range transportation plan for the Commonwealth of Virginia that assesses the needs of all corridors of statewide significance, regional networks, and urban systems. The plan is an update to VTRANS 2025, and is being developed through the Office of the Secretary of Transportation, with the assistance of the Virginia Department of Aviation, the Virginia Department of Motor Vehicles, the Virginia Department of Rail and Public Transportation, the Virginia Port Authority, the Virginia Department of Transportation and representative regional transportation agencies.

From this planning process, a vision of Virginia's future transportation system will be established and the transportation priorities that facilitate achieving this vision will be identified. These transportation priorities take two forms, construction priorities and policy priorities. Construction priorities are projects that will physically change the current transportation network. The policy priorities have resulted in new transportation goals for the state, including the enhancement of transit options and the increase in bicycle and pedestrian facilities.

UnJAM 2035

The UnJAM 2035 is the long range transportation plan for the Charlottesville-Albemarle Metropolitan Planning Organization (MPO). The Charlottesville-Albemarle MPO includes the City of Charlottesville and the urban area of Albemarle County. UnJAM 2035 outlines the future vision for the transportation system within the MPO and provides a list of project recommendations to help achieve this transportation vision.

UnJAM 2035 was developed by the staff of the Charlottesville-Albemarle MPO, with assistance from the Virginia Department of Transportation, elected officials and staff from the City of Charlottesville and Albemarle County, the CHART Citizen Advisory Committee, and members of the public.

RLRP

The RLRP was prepared by the Virginia Department of Transportation and the TJPDC to assess all potential transportation improvements at a regional level. Though this plan is produced as a statewide initiative it is focused at the regional level, therefore the RLRP used for ecological is specific to the Thomas Jefferson Planning District. The project list created by the RLRP is intended to be a list of all potential transportation projects in the rural part of the region.

VDOT developed the RLRP in conjunction with Parsons Transportation, a consultant company. The plan document and project were crafted by these agencies, with assistance from planning staff in Albemarle, Fluvanna, Green, County, Nelson Counties and planning staff from the Thomas Jefferson Planning District. The RLRP also includes a public input process.

DETERMINE LIKELIHOOD OF IMPACT

VTRANS 2035, UnJAM 2035, and the RLRP were reviewed in order to extract only those recommended projects that have the potential to cause a physical environmental impact to jurisdictional areas, based on their descriptions in long-range plans. Jurisdictional areas are those that are regulated by environmental laws, and include resources such as:

- *streams*
- *wetlands*
- *sinkholes, seeps, and springs*
- *threatened or endangered species habitat*
- *land protected for conservation*
- *cultural resources*

Recommendations such as adding signage, modifications to traffic signals, or policy changes would likely not cause an impact to a jurisdictional area. A new bypass, road widening, or bridge work however, could potentially incur impacts. Put more simply, projects causing significant ground disturbance, or those near water are most likely to cause an impact. Projects from VTRANS 2035, UnJAM35, and the RLRP meeting these criteria are listed in Tables 3, 4, and 5.

The project location shapes (line or point) for each of the projects in Tables 3, 4, and 5 were exported from their respective GIS shapefiles that accompany each of the three transportation plans. The exported project locations were added to two new common shapefiles, one for line segments and one for points (as lines and points cannot be added to the same shapefile). Each project was buffered 50 feet to represent the approximate right-of-way width of an average primary route in Virginia. The two shapefiles were overlaid with the REF to see where conflicts may exist, as seen in Figure 15.

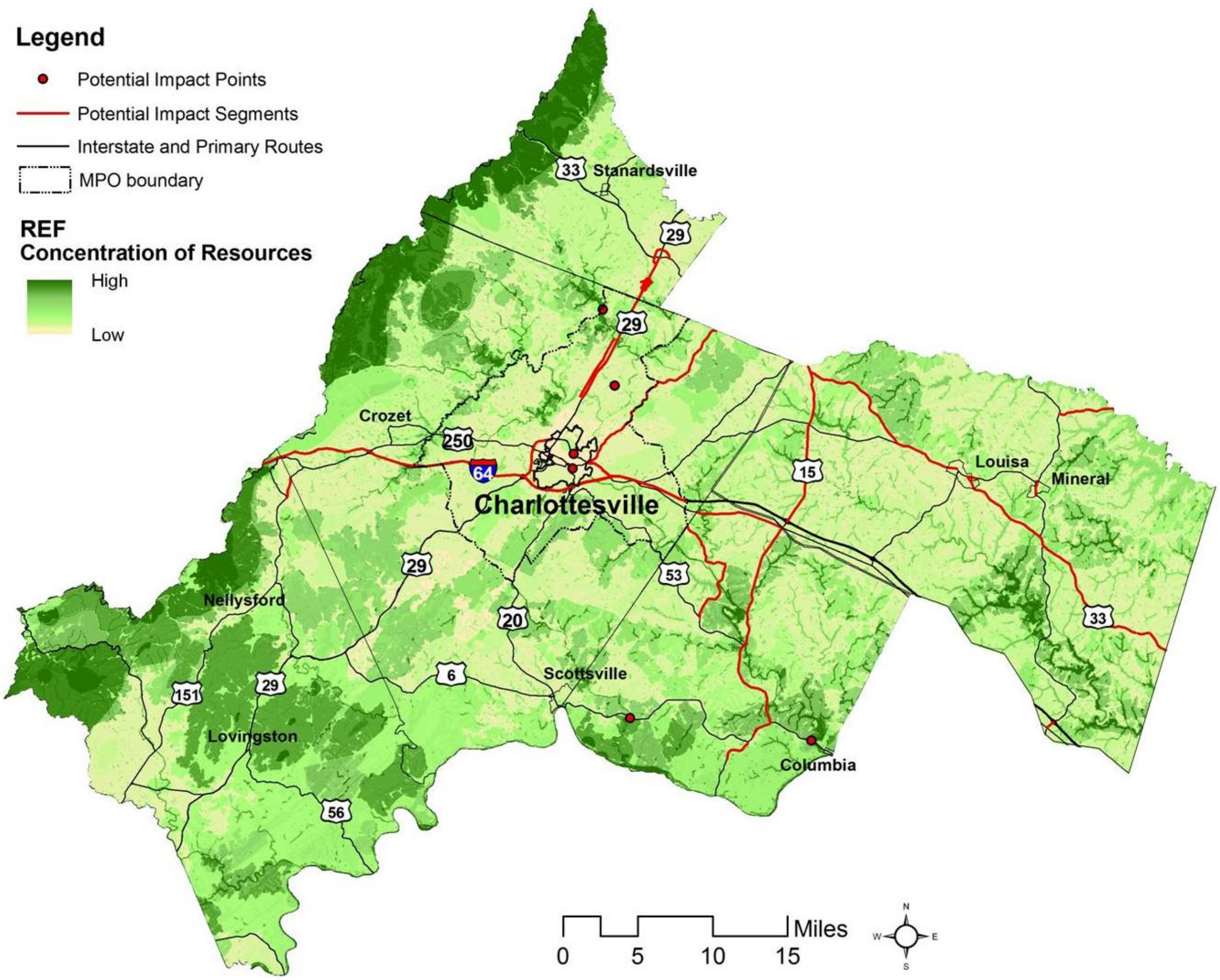


FIGURE 15. OVERLAY OF REF AND SELECTED TRANSPORTATION PROJECTS.

TABLE 3. EXTRACT OF VTRANS 2035: PROJECTS THAT MAY IMPACT JURISDICTIONAL RESOURCES

Jurisdiction	ID*	Planning Document	Project Location	Planned Improvement	Estimated Costs	REF Conflict Score	Intersects Upper Quartile of REF
Albemarle	1	VTRANS	Route 20 (Stony Point Road) from route 250 to route 649.	Widen road to 4 lanes.	$ 37,599,000	3.1	No
	2	VTRANS	Route 29 (Monocan Trail) from I-64 to Route 250 Underpass	Widen road to 6 lanes	$ 26,830,000	4.4	No
	3	VTRANS	Route 29 (Monocan Trail) from Route 250 underpass to WCL Charlottesville.	Widen road to 8 lanes.	$ 20,585,000	3.4	No
	4	VTRANS	Route 250 (Richmond Road) from ECL Charlottesville to I-64.	Widen to 8 lanes	$ 54,176,000	Defer to ID 27	No
	5	VTRANS	Route 29 (Seminole Trail) Route 643 to Route 649	Widen to 8 Lanes.	$ 58,856,000	Defer to ID 26	Yes
Albemarle - Charlottesville	6	VTRANS	I-64 from Route 29 to Route 616	Widen to 6 lanes.	$ 307,036,000	5.1	Yes
Albemarle - Greene	7	VTRANS	Route 29 (Seminole Trail) from Route 649 to Route 33.	Widen road to 8 lanes.	$ 199,864,000	9.8	Yes
Albemarle - Nelson - Augusta	8	VTRANS	I-64 from ECL Waynesboro to Route 250.	Widen to 6 lanes.	$ 223,748,000	18.3; Defer to IDs 32 & 56	Yes
Albemarle - Orange	9	VTRANS	Route 20 (Stony Point Road) from Route 649 to Route 33 west.	Widen to 2 lanes	$ 76,327,000	6.1	No
Fluvanna	10	VTRANS	Route 15 (James Madison Highway) from Route 695 to Route 652.	Widen Road to 2 lanes.	$ 15,235,000	6.4	No
	11	VTRANS	Route 15 (James Madison Highway) from Route 702 to Route 250.	Widen to 4 lanes.	$ 132,556,000	7.8; Segment from Route 702 to VA 6, defer to ID 35	Yes
Louisa	12	VTRANS	Route 15 (James Madison Highway) from I-64 to Route 617.	Widen to 6 lanes.	$ 47,049,000	Defer to ID 51	No
	13	VTRANS	Route 15 (James Madison Highway) from 617 to Orange CL.	Widen to 4 lanes.	$ 65,967,000	4.8	Yes
	14	VTRANS	Route 33 (Louisa Road - South Spotswood Trail) from route 15 to WCL Louisa	Widen to 2 lanes.	$ 92,324,000	6.4; Segment from Route 613 to WCL Louisa, defer to ID 47	No
	15	VTRANS	Route 33 (West Main Street) from WCL Louisa to Route T-669.	Widen to 3 lanes.	$ 8,110,000	3.9	No
	16	VTRANS	Route 33 (West Main Street) from Routes 22 & 33 to ECL Louisa	Widen to 3 lanes.	$ 9,603,000	2.9	No
	17	VTRANS	Route 33 (Jefferson Highway) from ECL Louisa to Route 655	Widen to 2 lanes.	$ 118,955,000	5.2	Yes
	18	VTRANS	Route 208 (Zachary Taylor Highway) from Route 522 to Spotsylvania CL.	Widen to 2 lanes	$ 27,575,000	5.8	Yes
	19	VTRANS	Route 522 (Sandy Hook Road) from Route 250 to Route I-64.	Widen to 4 lanes.	$ 5,918,000	4.5	No
	20	VTRANS	Route 522 (Pendelton Road) from SCL Mineral to Route 22/208	Widen to 4 lanes.	$ 7,841,000	4.2	No
Nelson	21	VTRANS	Route 151 (Rockfish Valley Highway) from Route 6 to Albemarle CL	Widen to 2 lanes.	$ 54,177,000	5.0	No

TABLE 4. EXTRACT OF UNJAM35: PROJECTS THAT MAY IMPACT JURISDICTIONAL RESOURCES

Jurisdiction	ID*	Planning Document	Project Location	Planned Improvement	Estimated Costs	REF Conflict Score	Intersects Upper Quartile of REF
City of Charlottesville	22	CLRP	Rte. 20 Bridge Replacement	Belmont bridge replacement: Improve safety	$ 9,195,000	2.6	No
	23	CLRP	Meadow Creek Parkway Phase I (City)	City portion of MCP; southern terminus beginning on 250 Bypass, northern terminus at NCL; includes parkland; County matching City's Design: Alternate Route, Increase Connectivity	$ 10,474,329	4.7	No
	24	CLRP	Route 250 Bypass Interchange at McIntire Park	Construct grade-seperated interchange: Alternate Route, Increase Connectivity	$ 29,645,000	9.0	No
	25	CLRP	Sunset - Fontaine Connector	Connector road from Sunset Ave to Fontaine Ave to include sidewalks, bike lanes and Railroad Crossing (under / overpass): Alternate Route, Increase Connectivity	$ 16,006,000	5.2	Yes
Albemarle	26	CLRP	Route 29 (from South Fork Rivanna River to Airport Road)	Complete widening from 4-6 lanes: Improve Safety	$ 25,725,000	4.9	Yes
	27	CLRP	Pantops Master Plan US 250 Corridor Improvements	Improve US 250 East corridor as recommended in the Pantops Master Plan (pedestrian crossings, widening to no more than six lanes and parallel road: Add Capacity, improve safety	$ 41,824,000	3.7	No
	29	CLRP	Route 641, Frays Mills Road over Marsh Run	Replace Bridge: Improve safety	$ 1,340,000	21.8	Yes
	30	CLRP	Route 649, Proffit Road over NS RR	Replace Bridge: Improve safety	$ 3,719,000	5.1	No
	31	CLRP	Berkmar Drive Extended (Town Center Road)	Extend existing roadway from northern terminus of Hilton Heights Road to Rivanna North Fork, including a bridge over the South Fork of the Rivanna River: Alternate Route, Increase Connectivity	$ 21,835,000	5.3	Yes

TABLE 5. EXTRACT OF RLRP: PROJECTS THAT MAY IMPACT JURISDICTIONAL RESOURCES

Jurisdiction	ID*	Planning Document	Project Location	Planned Improvement	Estimated Costs	REF Conflict Score	Intersects Upper Quartile of REF
Albemarle	32	RLRP	I-64 from Nelson County Line to US 250	Local Priority. Long-term widen to six lanes to increase capacity and/or accommodate travel demand on alternative corridor modes.	n/a	5.4	No
	33	RLRP	I-64 from US 250 to Charlottesville MPO	Long-term: Widen to 6 lanes.	n/a	5.3	Yes
Fluvanna	34	RLRP	US 6 Over Hardware River	Short-term replace bridge.	n/a	23.0	Yes
	35	RLRP	US 15 from VA 702 to VA 6 East	Local Priority. Long-term reconstruct road to address geometric deficiencies (including full-width lanes and shoulders). Seek to reserve rights-of-way (through setbacks) in order to allow for potential widening to four lanes with a median.	n/a	8.1	No
	36	RLRP	VA 600 from US 53 to VA 618 to VA 616 (Lake Monticello Road)	Local Priority. Long Term Widen to four lanes.	n/a	5.6	Yes
	37	RLRP	VA 616 from VA 600 to Albemarle County Line	Local Priority. Long Term Widen to four lanes.	n/a	5.6	Yes
	38	RLRP	VA 250 from Albemarle County Line to Louisa County Line	Local Priority. Long Term Widen to four lanes with median.	n/a	6.3	Yes
	39	RLRP	US 6 Over Rivanna River	Short-term replace bridge.	n/a	44.8	Yes
Greene	40	RLRP	US 29 from Albemarle County Line to US 33	Long-term widen to six lanes with median, remove traffic signals, and upgrade to provide alternative forms of access, including interchanges.	n/a	5.7	No
	41	RLRP	New Developer Road (Eastside, US 29 bypass near VA 607) from US 29 to US 29	Long-term construct new roadway.	n/a	6.1	No
	42	RLRP	New Developer Road (Westside, US 29 bypass near VA 607) from US 29 to US 29	Long-term construct new roadway.	n/a	4.8	No
	43	RLRP	New Developer Road (Westside) from US 29 to VA 607	Long-term construct new roadway.	n/a	4.9	No
	44	RLRP	New Developer Road (Eastside) from US 29 to VA 607	Long-term construct new roadway.	n/a	7.9	No
	45	RLRP	New Developer Road (Westside, US 29 bypass near US 33) from US 29 to US 29	Long-term construct new roadway.	n/a	4.4	No
	46	RLRP	New Developer Road from US 29 to US 33	Long-term construct new roadway.	n/a	5.1	No
Louisa	47	RLRP	US 33 from VA 613 (Oakland Road) to Western City Limit Louisa	Long-term reconstruct road to address geometric deficiencies (including full-width lanes and shoulders).	n/a	4.3	No
	48	RLRP	VA 208 from US 522 to Spotsylvania County Line	Long-term widen to four lanes with median.	n/a	Defer to ID 18	Yes
	49	RLRP	US 522 (Sandy Hook Road) from US 250 to I-64	Long-term widen to four lanes with median.	n/a	Defer to ID 19	No
	50	RLRP	US 33 from VA 655 to Hanover County Line	Long-term widen to four lanes with median.	n/a	5.1	No
	51	RLRP	US 15 from I-64 to Sommerfield Drive (0.96 miles south of VA 617/East Green Springs Road)	Seek to reserve rights-of-way (through setbacks) from I-64 to Sommerfield Drive in order to allow for potential widening of this section of the corridor to four lanes with a median.	n/a	4.6	No
Town of Louisa	53	RLRP	22/33 (E Main St) at VA 208 (Courthouse Square)	Long-term remove street parking and reconfigure eastbound and westbound lanes to provide additional capacity.	n/a	40.0	
Town of Louisa	54	RLRP	VA 208 from Southern City Limit Louisa to US 33	Long-term construct new bypass route.	n/a	107.0	
Town of Louisa	52	RLRP	US 22 from US 33 East to Eastern City Limit Louisa	Long-term widen to four lanes.	n/a	4.0	No
Town of Louisa	53	RLRP	US 33 (Jefferson Highway) from US 22 to Eastern City Limit Louisa	Long-term widen road to increase capacity and/or accommodate travel demand on alternative corridors or modes.	n/a	Defer to ID 16	
Town of Mineral	54	RLRP	US 522 from US 22/522 to VA 618	Long-term construct new bypass route.	n/a	3.3	No
Town of Mineral	55	RLRP	US 522 from VA 618 to Northern City Limit Mineral	Long-term construct new bypass route.	n/a	4.0	No
Nelson	56	RLRP	I-64 from Augusta County Line to Albemarle County Line	Long-term widen road to six lanes to increase capacity and accommodate existing and future travel demand.	n/a	12.6	Yes
(Town of Lovingston)	60	RLRP	VA 56 Extension	Mid-term study extension of Rt 56 to Rt 29 to create safer intersection.	n/a	83.0	83.0

* IDs identify projects in shapefile attribute table.

ZONAL STATISTICS

The new polygons created by the buffers served as the "zones" for use in calculating zonal statistics. The zonal statistics tool found in the Spatial Analyst extension of ArcGIS, uses the entries in a polygon shapefile (or raster, but a shapefile was used here) as a zone, and calculates statistics (sum, mean, median, count, etc) based on values from a separate raster file that fall (geographically) within the zone defined by the polygon file. In other words, it uses the values in the raster that fall within the polygons, to calculate statistics. In this analysis, the value raster is the REF. Recall that the REF dataset is an aggregate of all of the ranked environmental resources used as inputs. The zonal statistic tool creates a new table of calculated statistics, which can then be added to the shapefile attribute table on which the zone was based (the original road projects selection from the previous step).

The relevant statistic is this case is the "sum." The sum value for each polygon, or project, represents the total sum of values found in the pixels of the REF raster that correspond geographically to the project polygon. In effect, the sum represents the cumulative REF conflict that can be expected from a project, with higher sums indicating greater environmental integrity, and thus potential for greater impacts. Not coincidentally, the datasets making up the REF cover many of the regulated resources that require analysis in the environmental review process. The sum score for each project was normalized by project footprint area (area of the buffer) to facilitate comparison of natural resource conflicts between projects. The normalized impact score for the subset of projects reviewed are found in Tables 3, 4, and 5.

In addition to the normalized potential impact across the entire project footprint, we also assessed each project for the potential to impact keystone areas within the REF (areas representing the upper quartile values). Any project that intersected an area of the REF map containing 75th percentile pixel values, at any point along the project, was considered to potentially impact keystone areas. Tables 3, 4, and 5 contain a column that simply disclose which projects intersect these areas, and which do not. This piece of additional information supplements the Integrated Regional Map analysis, providing additional perspective for planners, decision makers, and project managers.

SPATIAL ANALYSIS

Perform zonal statics using the buffered line and buffered point shapefiles, separately. Create a new field in the original common projects shapefiles, and title them "Impact." Copy the cells in the "sum" column from the zonal statistics tables. In an edit session, paste the cells into the Impact columns, making sure the row order corresponds to the zonal statistics table from which they were copied (so that the impact score corresponds with the correct project shape).

Normalizing project impact score by land area: Add a new field to the buffered line and point shapefiles. In the new field, calculate the geometry of the shapes. Use the field calculator to divide the sum column by the area column. Multiply out the decimals.

Results

The Integrated Regional Map is a thematic map created using the normalized potential impact score discussed above. These scores are listed in Table 3, 4, and 5. The map is symbolized using the Natural Breaks classification method to create five classes of relative impact. The map provides a visual tool that boils down the anticipated environmental impacts associated with each project. A tool as simple as this can provide essential information at a glance, and send a powerful message to planners and decision makers about which projects require more careful consideration. Figure 16 shows the Integrated Regional Map.

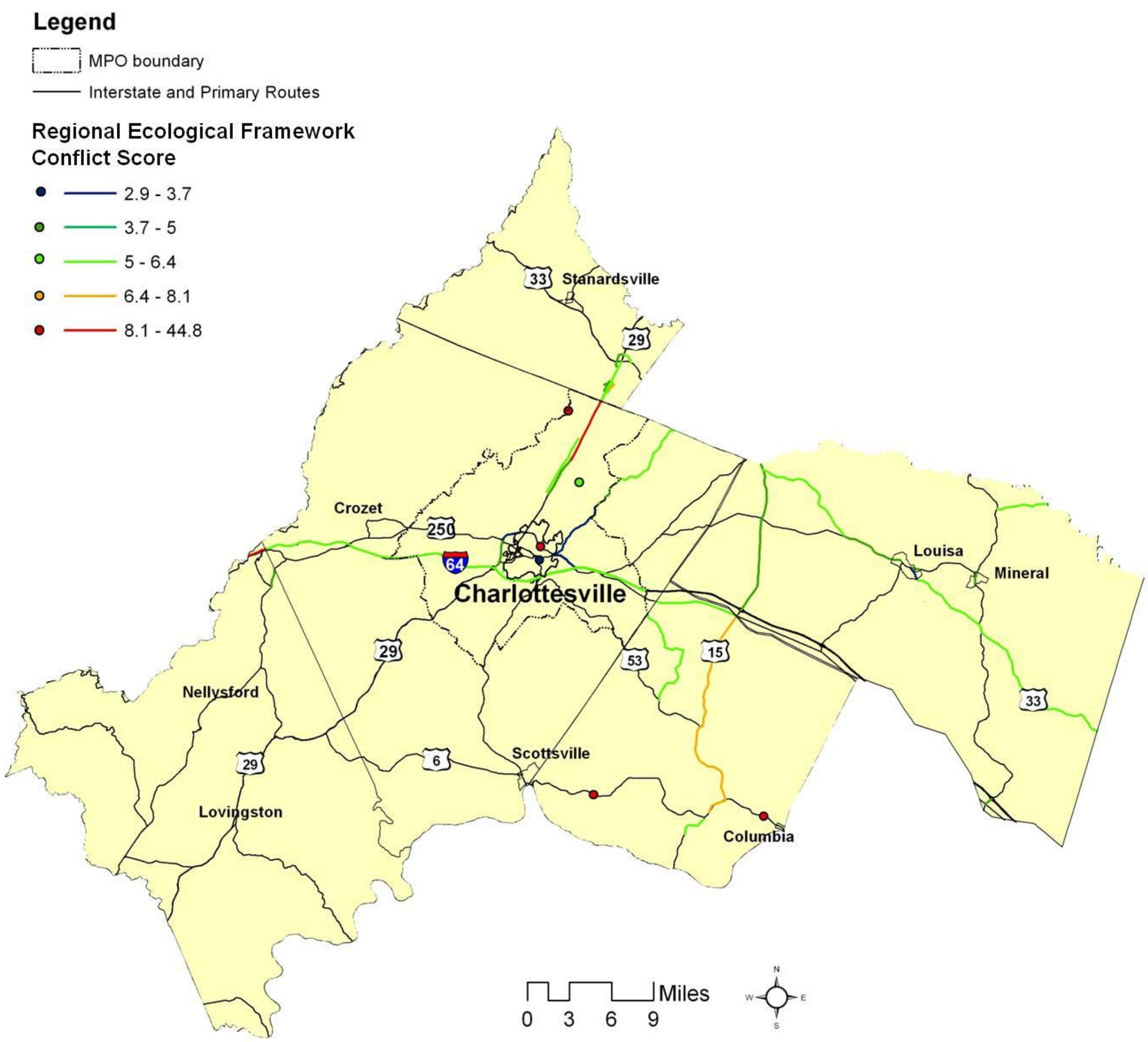


FIGURE 16. INTEGRATED REGIONAL MAP

Limitations

The limitations of the Regional Integrated Map include the same limitations as the REF, since the REF was used in its making, and thus, there is minor risk that a project's impact may be over or underestimated. For example, it is generally accepted that the NWI, even though it is the best data available, unintentionally excludes some wetlands in the data creation process (Spruce, *et. al.,* 1996), so it is possible that the Integrated Regional Map fails to account for impacts to some small jurisdictional areas.

Additionally, project locations indicated by points in the long range plan shapefiles that are buffered by 50 feet result in a buffer diameter of 100 feet. This creates a situation where only one cell is considered in the calculation of statistics for these projects. For most point projects, this is adequate for estimating impacts. However, if the user knows of specific projects represented by points in long range plan shapefiles that will extend well beyond the currently established right-of-way, a larger buffer should be used. Similarly, if a project represented by a line segment is expected to extend well beyond the current right-of-way boundary, the buffer for that project should be extended. Expansion of the buffer should be in 100 foot (or 30 meter) increments to accommodate the 30 meter resolution of the REF raster.

Finally, it should be noted is that the Integrated Regional Map conforms to a definition of "impact" that is specific to the CWA Section 404 regulations, and endangered species requirements of infrastructure development. Some communities may want to expand the definition to cover other impacts, such as the carbon footprint, or watershed impact of infrastructure projects, which, to date, have been unregulated. This would require amendments to the methodology, or could be undertaken in a separate analysis.

Uses

The Integrated Regional Map is intended to be incorporated into Long Range Transportation Plans to provide a comprehensive reference tool that estimates the plans' affect on the region's green infrastructure, and alerts planners and decision makers to the presence of important natural resources in the vicinity of transportation project recommendations. It may be used by public officials and agency leaders to inform further study of projects that are anticipated to cause major impacts to regionally important natural resources. Decision makers representing natural resources and transportation infrastructure may also use it to negotiate modifications to long-term plans in order to reduce conflicts. This tool is also meant to be used by transportation administrators and project managers to more fully inform them of the temporal and fiscal implications of the environmental review process that can be expected from individual projects, allowing them to plan accordingly. This information will improve the certainty and predictability that is often lacking in the environmental review process, but again, it is not a substitution of the on-site review and NEPA analysis in the design phase of project implementation.

4.2 Least Environmental Cost Analyses

What	When planning alignments for new roads, identify alignments that are least damaging to the Regional Ecological Framework.
Why	In order to identify alternative during NEPA process that most effectively avoid and minimize critical environmental resources.
How	➢ *Use ArcGIS tools to analyze the Regional Ecological Framework map and other constraining data between the points to be connected* ➢ *Use ArcGIS tools to delineating the path of least impact*

We also believe it is possible to use the REF to plan roadway alignments to follow the least environmentally damaging path. Roadways are designed with the intent of connecting point A to point B. With a start and endpoint in mind, the design then must consider site constraints such as existing development, topography, site distance, public safety issues, utilities, and others. Usually, environmental resources are not at the top of the list of constraints to consider in designing a roadway alignment. Assessing environmental impacts of various alternatives to compare to one another is difficult while a project is in the planning phases, since the exact alignment is still loosely defined. Additionally, different alternatives may impact different environmental resources, leaving the proposing agency to make judgments on which are most important. Assessing alternatives often involves a desktop analysis of the presence or absence of regulated resources in the project vicinity, which relies on data that may or may not be comprehensive enough to provide a reliable indication of the presence of jurisdictional areas. These kinds of complications add to the difficulty of a comparative assessment of natural resource conflicts between alternatives.

In the NEPA process, alternative alignments are developed that meet the constraints of a project, and the one with the least environmental impact is usually chosen for implementation. While this is an improvement over pre-NEPA roadway design strategy, there may yet be ways for transportation infrastructure design to be more proactively sensitive to increasingly scarce, and therefore increasingly valued regional green infrastructure.

The Least Environmental Cost tool uses the REF as a “value” raster in a corridor analysis with the goal of charting a roadway alignment that represents the least environmentally damaging path through a corridor. This analysis demonstrates how the ArcGIS Spatial Analyst’s Cost Weighted Distance and Shortest Path tools allow navigation from point A to point B, avoiding and minimizing “costs” to environmental resources along its path. In this analysis, the REF was the only value raster used. However, a number of other data could be use in such an analysis. Transportation planners can identify GIS data that represents roadway design constraints, such as building footprint, land cover, slope data, utilities, etc. and use them in conjunction with the REF to identify the best roadway alignment to suit the corridor. This relatively simple desktop exercise allows the development of roadway alignments that avoid and minimize impacts to resources to the maximum extent practicable, and allows the development of alternatives to analyze in the NEPA process.

Methodology

Often times when a new roadway is necessary, it is to connect two existing points, or to extend a road to a point of interest. In the Least Cost analysis, these are referred to as the "source" and the "destination," and can be represented by line, point, or polygon shapefiles. The Berkmar Drive Extended project from UnJam35 was used as an example for this project. This proposed construction project would extend existing Berkmar Drive approximately four miles north of the current Berkmar Drive in Albemarle County. The project is needed to diversify local traffic options and create a parallel roadway network to Route 29 in order to relieve congestion in that corridor.

In this example, road segments were used as the source and destination, since the new road needed to connect these two segments, but the location of the intersection along each segment was inconsequential. Quail Run and Louis and Clarke Drive, combined, served as the source segment, and Hilton Heights Road served as the destination segment.

In addition to a source and a destination, the tool needs a "cost" raster. The REF served as the cost raster for this analysis, with higher valued pixels representing a higher cost through which the road would pass. The tool navigates the least costly path from the source to the destination. The steps described below produced the least environmental cost roadway alignment for the Berkmar Drive extension.

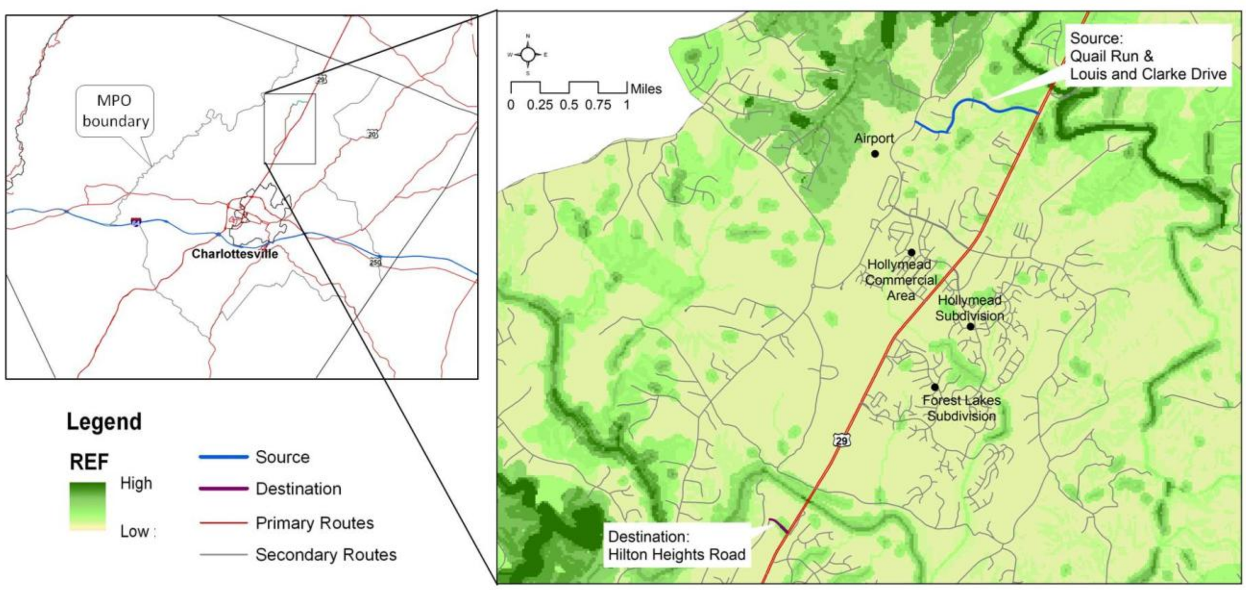


FIGURE 17. BERKMAR DRIVE VICINITY MAP, COST RASTER, SOURCE, AND DESTINATION SEGMENTS

COST WEIGHTED DISTANCE AND DIRECTION

First, the source and the destination segments were extracted from the Road Centerline shapefile (Virginia Geographic Information Network) into their own respective shapefiles. Then the source segment was used in the Spatial Analyst's Cost Weighted Distance tool to create an output raster in which each pixel is assigned a value representing the *least* accumulative cost of travel from that cell back to the source. For each pixel in the raster, the tool calculates this value by analyzing the values of adjacent and diagonal cells in the cost raster (the REF), choosing the neighboring pixel with the lowest value (least cost), and then calculating the accumulative least-cost of travel from each pixel back to the source. The later step is calculated as the sum of costs to move from cell to cell on the path to the source. The path to the source always passes through the least costly neighboring cells. The resulting output raster is the Cost Weighted Distance raster.

At the same time the Cost Weighted Distance raster is bring produced, the tool can also calculate a Cost Weighted Direction output raster, if directed by the user, which is also needed for this analysis. To create the Cost Weighted Direction raster, the tool assigns a number between one and eight to each of the cardinal and intermediate directions. It then codes the cells of an output raster with the number corresponding to the direction of travel taken from each pixel on the least-cost path to the source (Spatial Analyst derives this information from the Cost Weighted Distance raster).

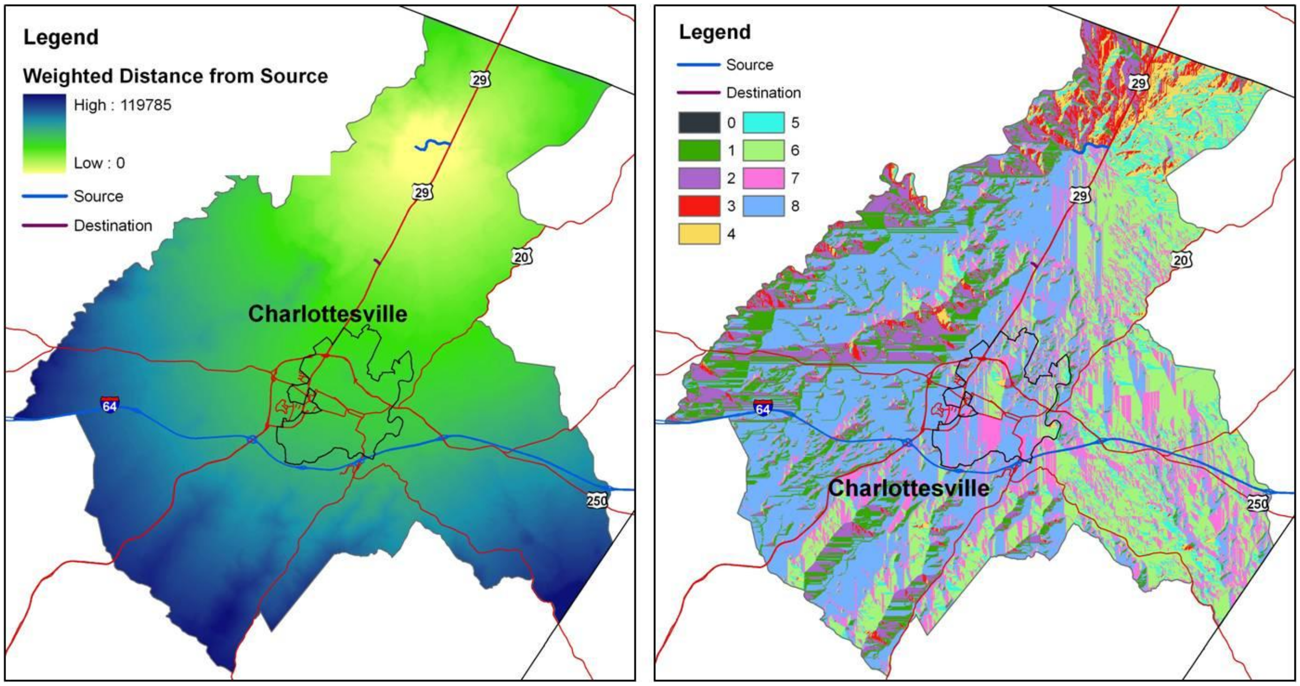


FIGURE 18. COST WEIGHTED DISTANCE AND DIRECTION RASTERS.

SHORTEST PATH

Finally, the Cost Weighted Distance and Direction rasters were used in the Spatial Analyst's Shortest Path function to identify the least-cost, shortest path through the corridor from the source to the destination. To direct the Spatial Analyst to analyze these rasters to find the best single path to the destination the settings for the tool should be entered using the destination file as the "path to" option, and the "best single" option as the path type. The resulting line represents the single least environmentally damaging, shortest path from the road segment at one end of the Berkmar Drive Extended project, to the road segment at the other end.

SPATIAL ANALYSIS

Tip: If problems occur while executing the Least Environmental Cost Analysis, confirm that the Spatial Analyst extent (under options) is set to "Union of Inputs" and not "Intersection of Inputs."

Adding additional constraints to this analysis would provide a more pragmatic basis for a roadway alignment design. The user has the option to add infinite combinations of constraints that can inform the best possible roadway alignment, balancing avoidance of environmental resources with other design requirements. When adding datasets as constraints, score the pertinent attributes appropriately to convey the importance of avoiding those features. For example, slope may be divided into classes, and slopes that absolutely must be avoided should be scored very high, to divert the path to lower cost cells. Easily buildable slopes should be scored from zero and increase as suitability for construction decreases. These additional datasets should be added to the REF raster using the raster calculator, or Spatial Analyst's Cell Statistics tool.

Results

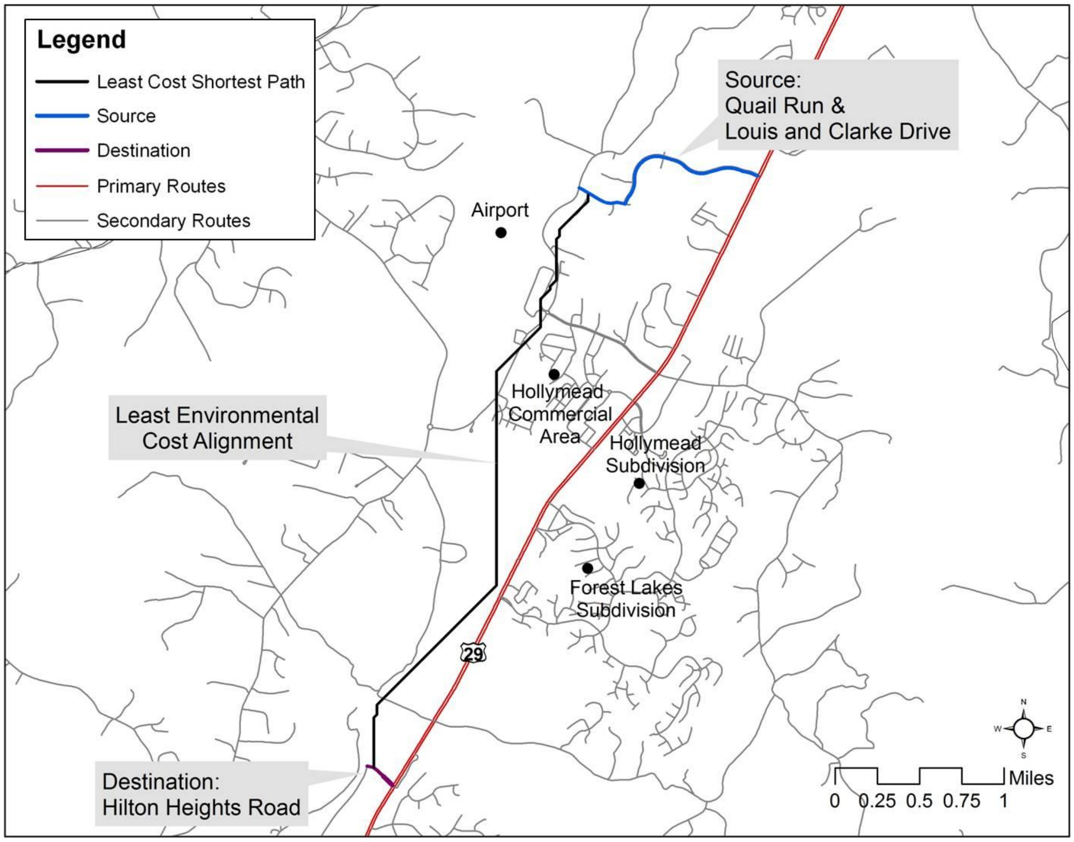


FIGURE 19. LEAST COST SHORTEST PATH

Limitations

Limitations associated with this tool are the same as for the REF. Additionally, the line representing the least environmental cost alignment may neglect roadway standards, such as turn radius, right-of-way width, etc., and should only be used as a guide for designing an alignment. Finally, the shortest path identified will not avoid any features, environmental resources or otherwise, that are not included in the cost raster. Thus, the effectiveness of this tool is directly related to the user's familiarity with the proposed corridor.

Uses

The Least Environmental Cost tool is intended to be used by transportation planners responsible for establishing roadway alignments when projects are in the plan phase development. This integration of environmental information into the planning process allows the consideration of environmental impacts at the project alternative selection level, and more effectively achieves the intent of the NEPA process. For transportation administrators, these alignments will minimize the environmental review process and potential mitigation burden, and improve the public perception of the transportation program, leading to a shorter and less costly review process.

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4.3 Prioritizing Mitigation Sites

What	Strategically identify mitigation sites that enhance the Regional Ecological Framework.
Why	To ensure that the maximum ecological benefit is achieved per mitigation dollar spent.
How	➢ *Use ArcGIS tools to assess the suitability of resources to serve as mitigation sites based on geographic concurrence among the Regional Ecological Framework and other indicators of ecological health, physical characteristics, risk of degradation, and probability of success.*

The National Research Council's 2001 evaluation of the compensatory mitigation program concluded that, despite progress over the previous 20 years, "the goal of no-net-loss for wetlands is not being met for wetland functions by the mitigation program." The program evaluation recommends that mitigation dollars be spent on the purchase of credits from a mitigation bank, or an in-lieu fee program over the option of permittee-responsible mitigation because of the large-scale benefits they can provide by pooling funds from multiple impacts. Stream and wetland mitigation banks and in-lieu fee programs, in Virginia's case, the Virginia Aquatic Resources Trust Fund, have the ability to use their purview over comparatively large-scale mitigation efforts to add value and robustness to the REF. The stream and wetland mitigation sites identified here provide options for siting the mitigation banks of the future, provide project options for the Trust Fund in the Middle James watershed, and provide a blue print for environmental groups, local, state and federal governments, conservation easement holders, and other conservation interested parties to work from.

The methodology used to prioritize stream and wetland mitigation sites builds on the work of The Nature Conservancy, the Department of Conservation and Recreation, and others who have identified areas in the region that are of high conservation value, and applies factors that indicate risk, value to water quality, and contribution to strengthening of the REF. While the Eco-logical approach allows us to identify and prioritize mitigation sites based on a number of factors, it applies a nonprescriptive approach to the specific measures that accomplish the mitigation. This approach leaves the project development level of detail to professionals "on the ground" to determine the site-specific strategies that will produce the best possible outcome. Mitigation may include protection, restoration, or enhancement of environmental resources, but a combination of these strategies is most likely for any given site or project.

It is important to recognize what the Eco-logical approach to prioritizing mitigation sites does well, and what it does not attempt to do. A useful analogy to clarify how the Eco-logical approach is applied here is the application of patient health care. There are two ends on a spectrum of how people use health care.

On one end, the perfect patient goes to her annual physical for routine check-ups. If there is any sign of an ailment at one of these visits, it is likely that it's been caught before it gets serious, and is therefore isolated, easily and inexpensively treated. At this end of the spectrum, people adhere to wellness programs that keep them healthy, and receive "whole patient care," that recognizes the interdependence of health between the body's systems. On the other end of the spectrum, patients do not go to the doctor routinely, and make poor lifestyle choices, such as poor diet, not exercising, and substance abuse. They allow ailments to get serious, and may require emergency room visits to treat effectively. By then such ailments have had time to grow, weakening the patient, and affecting other systems in the body. Allowing this to happen makes treating the ailment much more difficult, and much more expensive. Additionally, the patient may never make a full recovery, and continued poor lifestyle choices accelerate relapses of the ailment.

Eco-logical approaches environmental mitigation from the wellness end of the spectrum. This holistic, preventative medicine point of view, attempts to efficiently maintain regional ecological health by spending the fewest financial resources to maintain and enhance health, instead of waiting until resources become degraded to apply funding to restore them, which always costs more than the proactive approach (Gabanski, 2009). The analyses used to identify mitigation sites here are likely to exclude many "bleeding wounds" (highly degraded resources) because their restoration is less likely to contribute to the REF in the most cost efficient, or cohesive way.

The Eco-logical approach therefore, diverges from the current strategy of federal and state regulations of the CWA, which simply focuses on the restoration of "impaired" waters (those that do not meet water quality standards). Instead it seeks to identify areas of the region that have retained one or more desirable ecological traits, but could be enhanced to provide more fully functioning ecological services to the region. Like preventative medicine, this strategy is thought to provide greater value to the region at a significantly reduced cost to that of restoring highly degraded resources. The Eco-logical approach seeks to circumvent the "pennywise, pound foolish" pitfall to which water resources are currently subjected. It is also aligned with the EPA's new Healthy Watersheds Initiative, which emphasizes the advantages of a holistic approach to regional ecological integrity, including (Gabanski, 2009):

- *Cost avoidance:*
  - *From reduced property damage/loss associated with natural disaster and extreme weather resilience*
  - *Drinking water treatment costs*
  - *For restoration of highly impaired waters*
  - *For infrastructure to treat the larger volume of stormwater discharged from degraded areas of the regional landscape, and associated long-term maintenance*
- *More and higher quality recreational opportunity for citizens*
- *Habitat quality and connectivity*
- *Quality of life reputation*

SCALE

The Eco-logical approach works at the landscape scale from the perspective of the REF. It is removed from any one resource type, or individual stream, species, or site. Instead it looks at the combination of occurrences of these resources, proactively targeting concentrations of ecological resources for protection, while identifying areas of lesser ecological integrity within the framework whose restoration would strategically add to the strength of the system. Because the strategy for prioritization works from a pre-established framework of ecologically functionality, the results often preclude highly impaired water resources that don't presently exhibit a minimum contribution to the bigger picture of regional ecological health. However, as with a patient in a state of emergency, if a community is aware of a stream section that is actively degrading, diversion of mitigation funds from the REF may be justified. If a "bleeding wound" scenario exists and discrete measures would "stem the bleeding," preventing degradation from spreading to the landscape scale, mitigation funds should be used to prevent degradation of additional otherwise healthy resources. This scenario, however, is the exception to the rule for the Eco-logical approach.

Methodology

In response to the guidance provided by the advisory committee for this project, mitigation priorities were divided into three categories:

- *Stream protection priorities*
- *Stream restoration priorities*
- *Wetland mitigation priorities (indiscriminant strategy)*

Separate, but similar methodologies were used to prioritize mitigation sites appropriately in these categories. As with the REF methodology, the methodologies again employ ArcGIS tools to score attributes of various data that indicate suitability for mitigation. These map data were overlaid in ArcGIS to identify concentrations of suitable conditions for mitigation. Areas with the most indicators of suitability were considered high priority mitigation sites in one of these categories. Refer to Appendix A for a flow chart illustrating the order of analyses used in identifying mitigation priorities. Each step is described below.

STREAM MITIGATION PRIORITIES

The TJPDC is composed of an urban area in the City of Charlottesville and surrounding parts of Albemarle County, and mostly rural surrounding areas in Greene, Nelson, Louisa, Fluvanna, and the outlying area of Albemarle Counties. Since urbanization correlates fairly linearly with stream health conditions (RRBC, 2009), the urban part of the planning district, delineated by the MPO boundary, underwent a modified analysis to identify stream mitigation priorities. Since these streams exist in very different environmental conditions, the prioritization model was modified by allocating higher scores to specific attributes within the MPO boundary so that urban streams would also immerge as priorities in the analysis results, even though the analysis is intentionally biased toward prioritizing less degraded resources. The modification allows the comparison of urban resources to each other by removing the influence of the relatively higher quality (less disturbed) resources located in less urban areas. This allows urban priorities, as a class of their own, to be integrated with the priorities from the rest of the region. The results of the MPO analysis were merged with those of the greater region in a final step, as depicted in Appendix A. The MPO boundary was added to the input data maps and results maps to distinguish the analysis boundary.

The following section describes the datasets used to assess the suitability of streams for mitigation. The process for identifying mitigation priorities need not be limited to the suitability parameters used here.

Data availability varies by region, and additional datasets should be considered, to the degree that they contribute to prioritization. Datasets should inform such issues as risk of resource degradation, expectation of long-term conservation success, degree of integration with and enhancement of the REF, research supported spatial indicators that contribute or detract from watershed health, or water quality, and previous work that assesses the quality of natural resources in the region.

Spatial Analysis

In a process similar to that used to create the REF, the pertinent attributes of input datasets were scored, and processed using the ArcGIS Spatial Analyst extension. The advisory committee again offered guidance on the attribute classes and scores assigned to each attribute. The Spatial Analyst analyzed the input datasets, assessing geographic concurrence and adding attribute scores where they overlap. As previously discussed, separate analyses were conducted for stream protection and stream restoration priorities; each of these were divided again between the urban area (MPO boundary) and the rest of the region.

Appendix A contains the scoring matrices and functions by which the datasets were processed using the Spatial Analyst raster calculator, and they are further explained below. The sites were prioritized using a combination of “sum” and “true, false” operations, creating a numeric scale on which the highest scoring stream segments became the top priorities. Notice that many of the same datasets are used in each analysis, with some datasets maintaining the same scoring in each analysis, while others flip scores as appropriate to indicate suitability for protection versus restoration. The “urban” matrices contain slightly modified scores to indicate relative importance, or rarity of certain resources or conditions in the urban landscape. Unless indicated in the descriptions below, assume that the same dataset scoring was used for the protection and restoration analyses, and was constant between the MPO and the rest of the region. The urban and region stream priority results were merged in a final step to produce a common protection priorities map, and a common restoration priorities map, as depicted in Appendix A. The following datasets were used to prioritize stream mitigation sites:

- *Regional Ecological Framework*
- *Locality Growth Areas*
- *The Nature Conservancy Priorities*
- *Land Cover*
- *Impairment Status*
- *Protected Status*
- *National Hydrography Dataset, 1:24,000*

IDENTIFYING STREAM MITIGATION PRIORITIES

INPUT DATASET: **REGIONAL ECOLOGICAL FRAMEWORK**

To reflect the Ecological approach of maintaining and enhancing the region's most valuable green infrastructure, higher scoring areas of the REF were targeted for both stream protection and restoration. Higher scores in the REF indicate a minimum level of ecological function, suggesting that a stream restoration project in that area has a reasonable guarantee of success, and will contribute to the robustness of the REF. Pixel values making up the REF map were grouped into three classes using the Natural Breaks classification type. Since the distribution of values in the REF differ between the urbanized area and the rest of the region, this input dataset used different classifications for the MPO and region analysis, as described in Table 6. To prepare this dataset for analysis, classes were assigned a score from zero to three. REF values below the median (6) we assigned a score of zero, indicating no preference to those areas. Areas above the median were assigned increasing priority with increasing REF value class.

TABLE 6. REF CLASSIFICATION DIFFERENCE.

REF Value Classes		Score
Region	MPO	
0 - 6	0 - 6	0
7 - 12	7 - 12	1
13 - 19	13 - 22	2
20 - 52	23 - 52	3

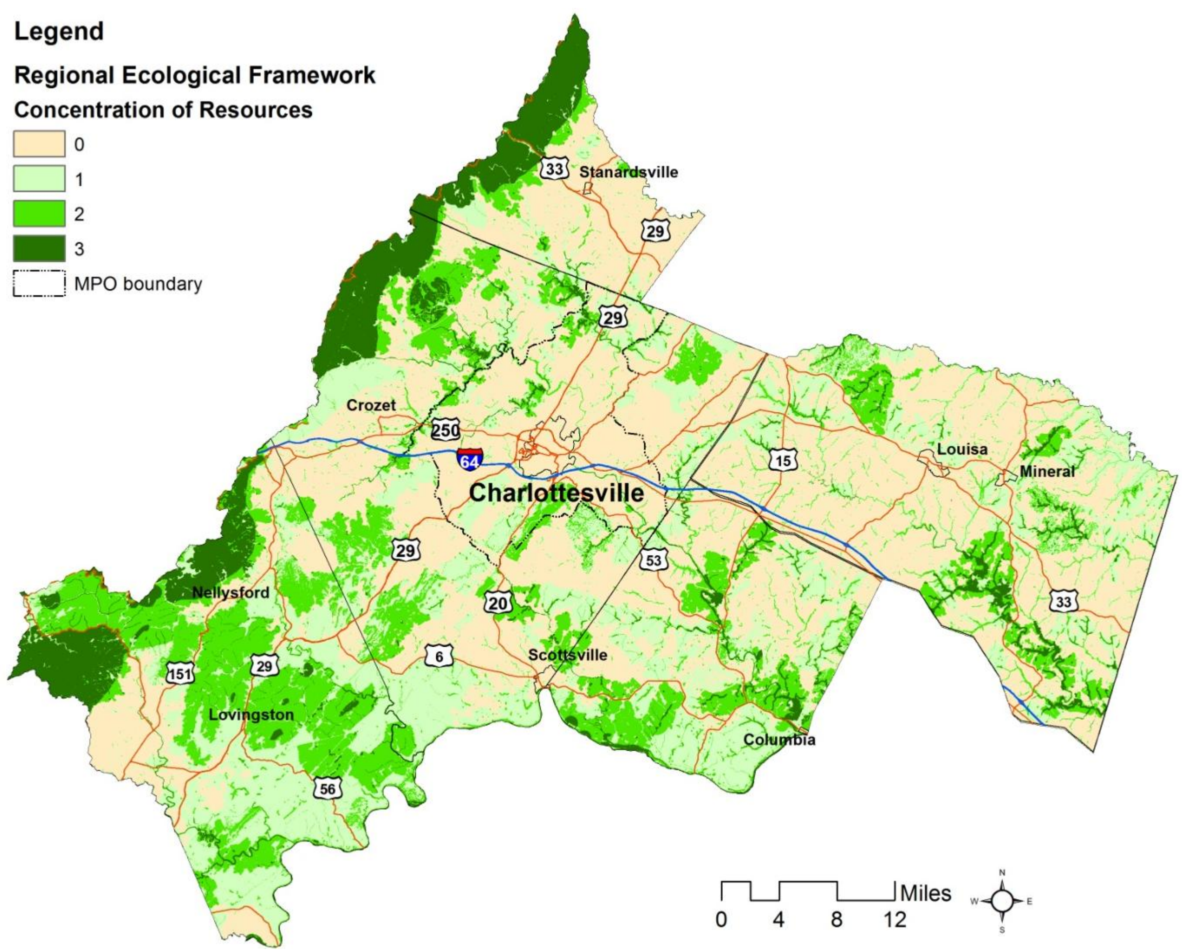

FIGURE 20. REGIONAL ECOLOGICAL FRAMEWORK - CLASSIFIED

IDENTIFYING STREAM MITIGATION PRIORITIES

INPUT DATASET: **GROWTH AREAS**

Designated Growth Areas in the individual counties are assumed to possess streams that have yet to be affected by high levels of impervious surface, but are at greater risk than other streams for such in the near term. For that reason, streams within growth areas received elevated priority for protection across the entire region. To prepare this dataset for analysis, areas outside of growth areas were assigned a value of zero, and areas within designated growth areas were assigned a value of one.

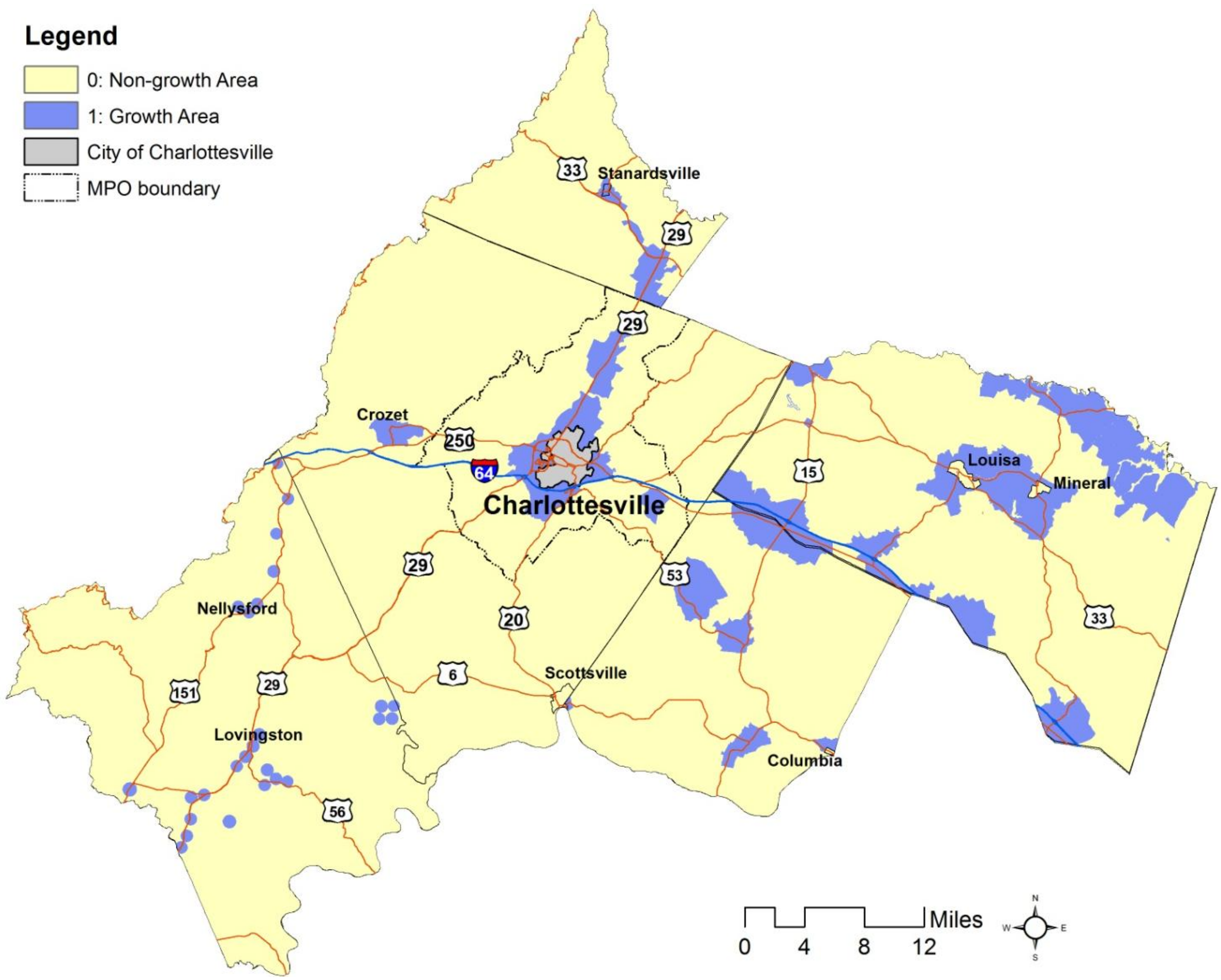

FIGURE 21. GROWTH AREAS

IDENTIFYING STREAM MITIGATION PRIORITIES

INPUT DATASET: **THE NATURE CONSERVANCY PRIORITIES**

The Nature Conservancy has undertaken significant efforts in Virginia to create a portfolio of priority conservation areas that aim to conserve biodiversity at the ecoregional level, of which there are five in the state. The process of assessing resource for the portfolio received expert review and input. The priorities seek to protect intact, healthy representations of each ecoregion, and restore degraded connections between them. The TNC uses these priorities in the administration of the Virginia Aquatic Resources Trust Fund. These priorities were elevated for both protection and restoration across the entire region. To prepare this dataset for analysis, Nature Conservancy priorities were assigned a score of one, and all other areas were assigned a score of zero.

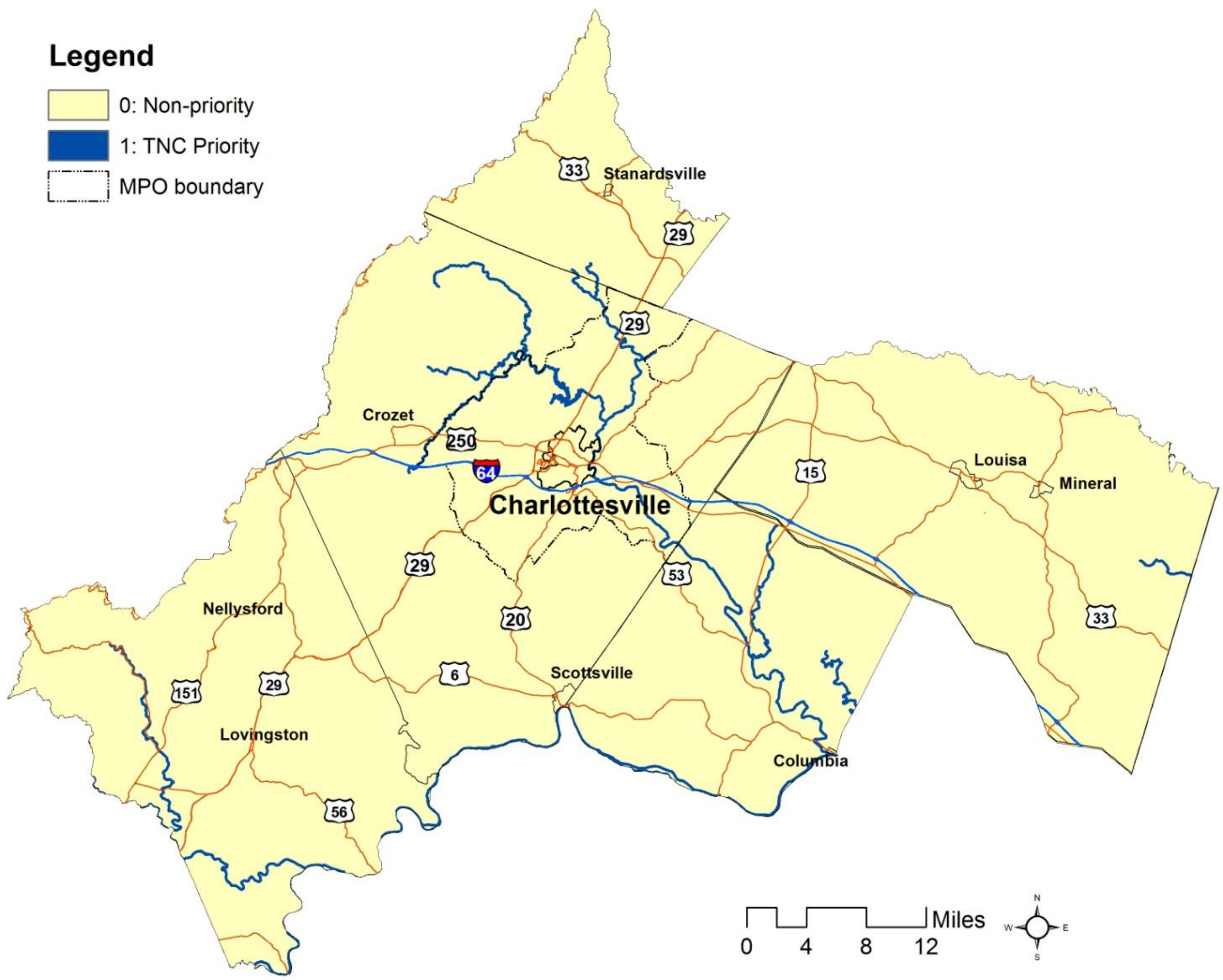

FIGURE 22. THE NATURE CONSERVANCY PRIORITIES

IDENTIFYING STREAM MITIGATION PRIORITIES

INPUT DATASET: **LAND COVER**

The United States Geological Survey's National Land Cover Dataset (NLCD) was used to analyze land cover in Louisa and Nelson Counties, while the Rivanna River Basin Commission land cover dataset was used for Greene, Albemarle, and Fluvanna Counties, and the City of Charlottesville. Land cover affects the water quality and stability of streams, and land cover directly adjacent to a stream has the most influence at any point.

Streams surrounded by natural land cover were targeted for protection in this analysis. In the NLCD, this included deciduous, evergreen, and mixed forest, dwarf shrub, and wetlands. In the RRBC dataset, "natural" was defined as deciduous or evergreen forest, or pine plantation. Inside the MPO boundary, natural land cover was assigned a score of two, since it is relatively rarer than in the rest of the region. In the rest of the region, natural land cover was assigned a score of one. Land cover of any other type, in both the MPO and the region, was assigned a score of zero in the stream protection analyses.

Streams surrounded by unnatural land cover were targeted for restoration. In both the MPO and the rest of the region, natural land cover was assigned a score of zero, while developed areas were assigned a score of two. All other land cover types, such as barren land, orchards, golf courses, pasture, and crop fields, were assigned a score of one.

FIGURE 23. NON-IMPAIRED SEGMENTS

Identifying Stream Mitigation Priorities

INPUT DATASET: **IMPAIRED AND NON-IMPAIRED WATERS**

The Eco-logical approach also aims to use mitigation funding to achieve goals of other environmental laws and regulations (Kirsten Holder, Volpe National Transportation Systems Center, personal communication, December 2, 2010). Virginia updates the state's 303(d) list of impaired waters every two years. While it is known that this is a course assessment of stream health in the region, it is the best data available for the entire planning district. Only impaired streams were considered as restoration priorities, and only non-impaired streams were considered as protection priorities. To prepare this parameter for spatial analysis, the streams in the National Hydrography Dataset served as non-impaired waters. Impaired waters were removed from the NHD, and the non-impaired waters were assigned a score of one to use in the protection analyses. For the restoration analysis, impaired waters received a score of one, and all other waters received a score of zero. While each of the previous datasets were summed using the Spatial Analyst raster calculator, these datasets served as multipliers so that non-impaired waters would be eliminated from the restoration priority results, and impaired waters would be eliminated from the protection priority results.

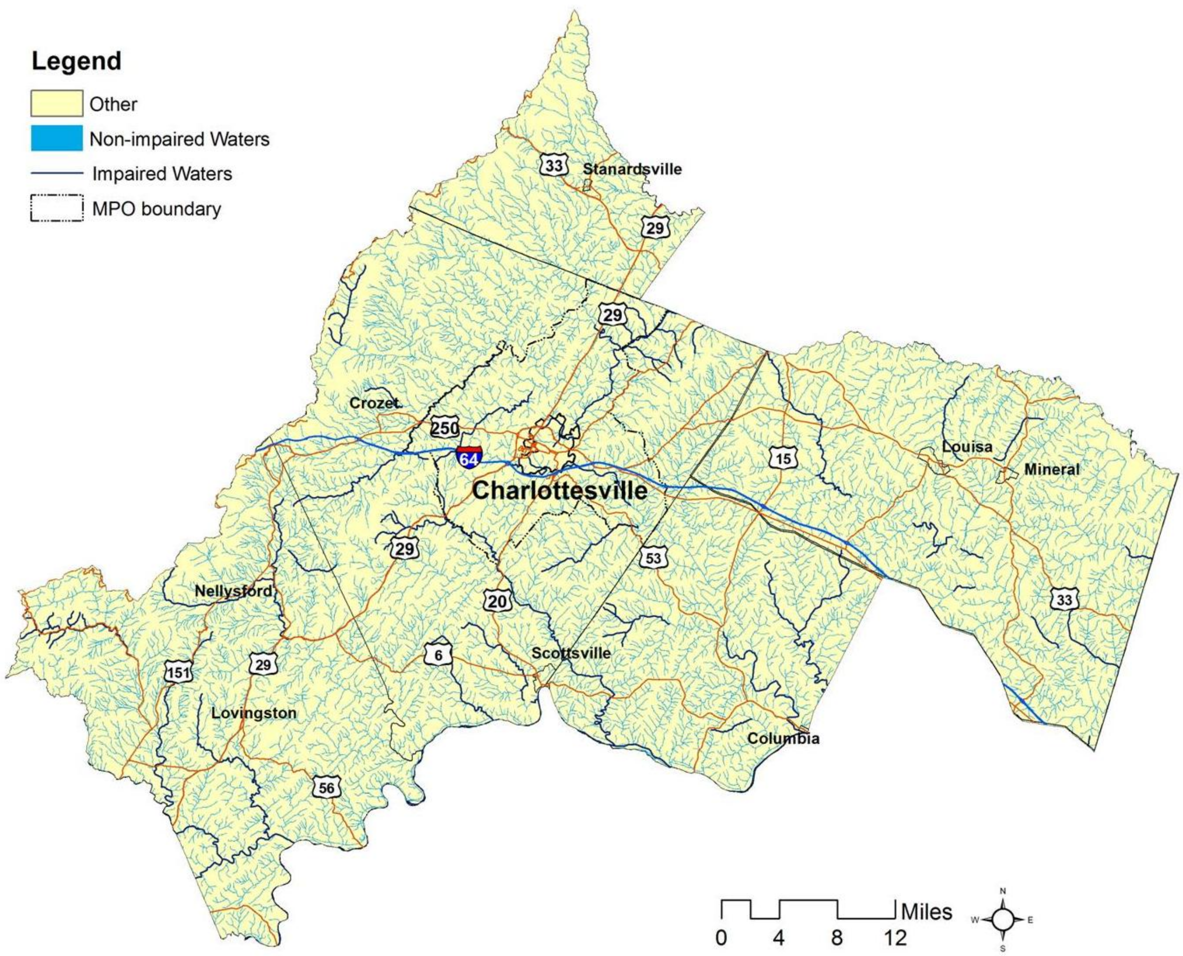

FIGURE 24. IMPAIRED AND NON-IMPAIRED STREAMS

IDENTIFYING STREAM MITIGATION PRIORITIES

INPUT DATASET: **PROTECTION STATUS**

Habitat connectivity is one of the cornerstones of conservation biology (Strasburg, 2006) because flora and fauna need corridors of habitat to move from place to place for food, water, shelter, and genetic diversity. Land set aside for conservation provide hubs of habitat, and are most productive when connected to one another with habitat corridors. Streams are one kind of habitat corridor. The Eco-logical approach aims to achieve the most ecological restoration with the available funding, which includes habitat restoration and enhancement. To build more connectivity into the REF, the closer a stream is located to other protected land, the higher priority it is for both protection and restoration. However, currently protected land was eliminated from consideration, since those resources already possess a level of protection that should ensure their productivity.

To prepare this dataset for analysis, a dataset of protected land across the region was processed using the Euclidean Distance tool of the ArcGIS toolbox. The tool assigned four buffers around the protected land at geometric intervals from zero feet to one mile. Streams further than one mile from a protected site were assumed to offer no connectivity benefits. The intervals are listed in Figure 24. The advisory committee recommended further refining the closest class to protected land, since land adjacent to other protected land is of the highest interest. This was accomplished by manually adding another class (0 – 206 feet), which represented the first quarter of the first geometric interval. Scores were then assigned to the intervals, as seen in Figure 25. The closer the interval was to the protected land, higher was its score. The protected land dataset was scored with a zero, and used as a multiplier to eliminate streams passing through protected land as either restoration or protection priorities.

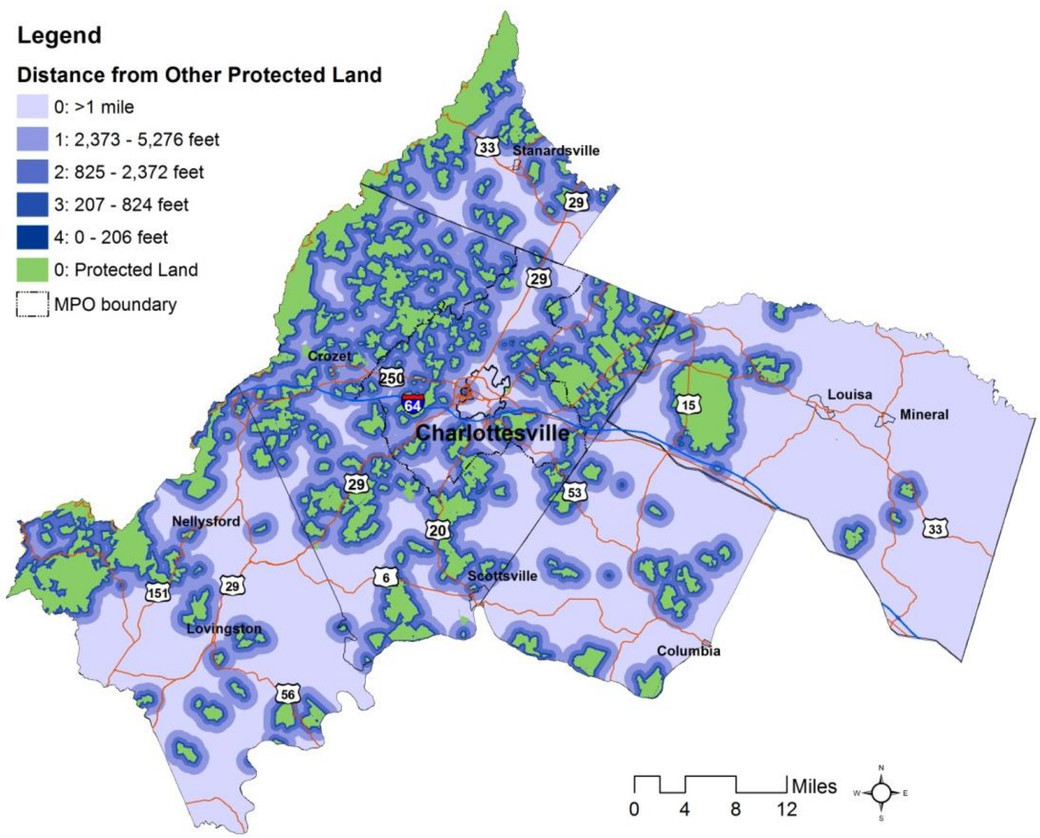

FIGURE 25. PROXIMITY TO OTHER PROTECTED LAND

IDENTIFYING STREAM MITIGATION PRIORITIES

INPUT DATASET: **NATIONAL HYDROGRAPHY DATASET, 1:24,000**

The preceding datasets assign scores to land area in most cases, but the mitigation priorities analyses focuses exclusively on streams. The NHD was used to confine results to streams only. To prepare the NHD for analysis, it was buffered by 100 feet, creating polygon layer that would convert to raster file more easily than would a line file. Area inside the buffer was assigned a score of one, and area outside the buffer was assigned a score of zero. This dataset was used as a multiplier to eliminate area outside of the buffer from the results.

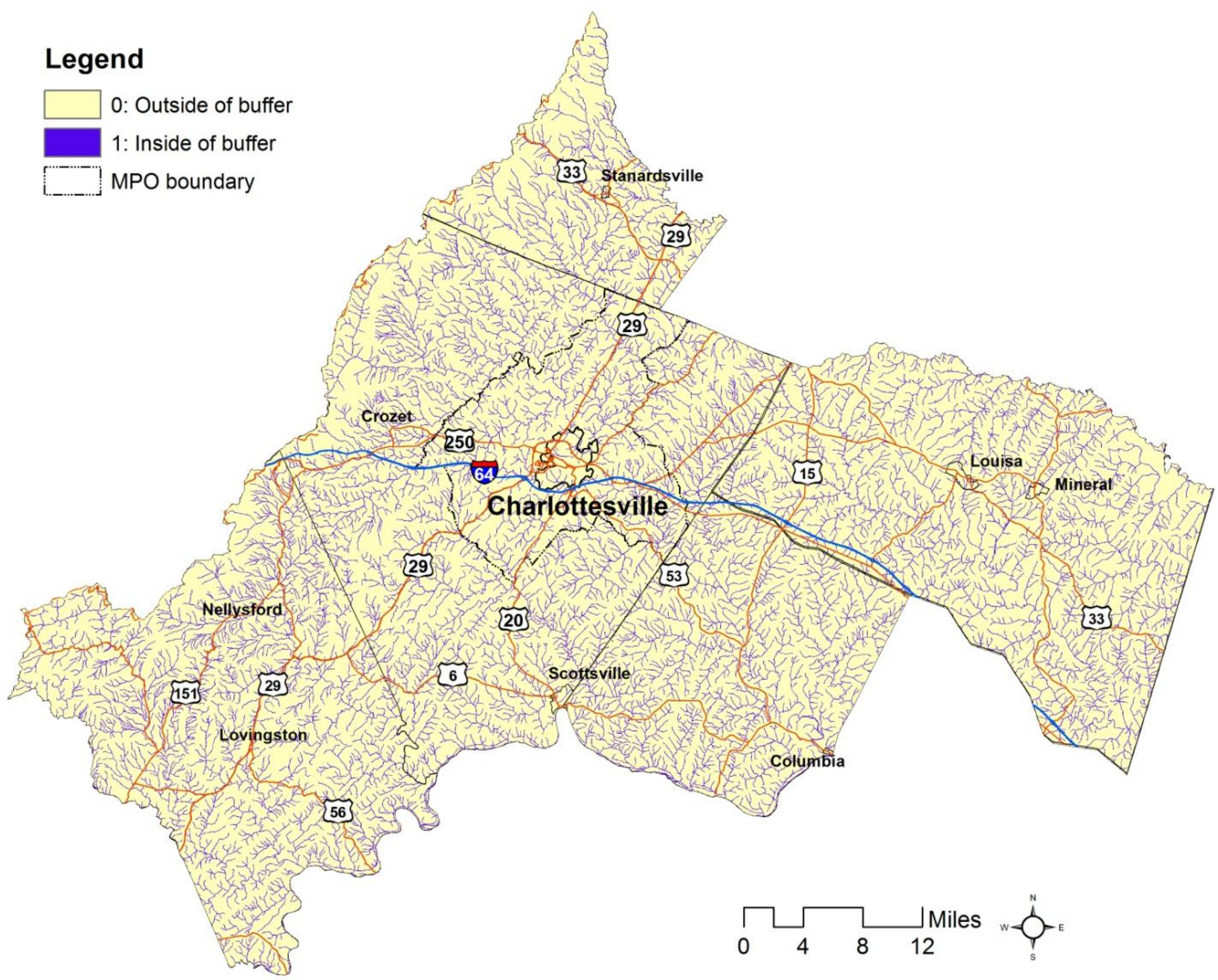

FIGURE 26. NHD 100-FOOT STREAM BUFFER

AGGREGATED OUTPUT DATA

The analyses described above and in Appendix A were implemented using a 30 meter resolution format, resulting in output datasets that contain a relatively high amount of variability over short distances. In order to aggregate output scores over larger distances, the scores contained in the output rasters were summarized by stream reach using the zonal statistics tool in the ArcToolbox.

The tool calculated several statistics, which were provided in an output database table. The pertinent statistic for use here is the Mean, which averages the scores in the raster cells that fall within each "zone" (stream reach code buffer). The mean statistic normalizes for area (number of raster cells) so that stream reaches are not prioritized just because they are longer in length than others, thereby containing more raster cells to contribute to the score, as the "sum" statistic would allow. The output zonal statistic tables was then joined to the original NHD shapefile using the reach code as the common field. Summarizing the priority output rasters by stream reach creates modified NHD shapefiles of aggregated priorities that are easy to symbolize and interpret.

The two resulting modified NHD shapefiles were divided into five classes using the Natural Breaks classification type. The classes were numbered from one to five, five being the highest priority, and one being the lowest. The actual stream reach mean scores on which these classes are based can be found in Appendix B.

ZONAL STATISTICS

The NHD reach codes served as the "zone," and the stream mitigation priorities output rasters served as the "value rasters." To prepare the NHD for use with the zonal statistics tool, each stream reach shape was buffered by 200 feet (with flat ends) to ensure that the value raster "cell centers" that contain prioritization scores would be captured in the calculations. Any extra raster cells captured in the calculation because of the extra area added to the zones by the buffer are of no consequence, since the cells in the output rasters that are not associated with prioritization, have a value of zero.

TIP: To preserve table joins, export the map data to a new feature class.

Wetlands Mitigation Priorities

The TJPDC used a methodology developed by DCR to prioritize wetland mitigation sites. DCR's *Methodology for Developing a Parcel-based Wetland Restoration, Mitigation, and Conservation Catalog: A Virginia Pilot* can be accessed by contacting the DCR Natural Heritage Division. This methodology identifies wetland mitigation sites at the parcel-scale resolution using indicators of the level of wetland ecosystem services and biodiversity protection potential. The methodology identifies parcels that are currently wetlands, and are thus appropriate for protection and/or enhancement. It also identifies sites that are appropriate for restoration, such as parcels that were historically wetlands and those that possess features that would allow them to become successful wetlands with little extra help. A modified methodology for the urban area of the region was not needed for prioritizing wetland restoration sites, as the DCR methodology includes a step to account for and exclude areas of concentrated impervious surfaces.

The wetland mitigation methodology is similar to the stream mitigation methodology in that it scores GIS data attributes and overlays the data so that scores can be summed and concentrations identified. As with the stream mitigation methodology, the wetland priority analysis is not prescriptive in approach, and does not readily distinguish between suitability for protection versus restoration. Users of the data will have the flexibility to determine which mitigation strategies are most appropriate for each priority when groundtruthing the results.

The DCR methodology differs from the TJPDC streams methodology in that it uses feature data, instead of raster data, allowing the wetland restoration priorities to be identified by a parcel ID number and Hydrologic Unit Code (HUC). To align the priorities by parcel ID and HUC, the ArcToolbox Union tool was used to overlay the datasets, instead of the Spatial Analyst's raster calculator. Although the mechanics of data processing differ between the methodologies, the two approaches were developed using essentially the same concept. Appendix A presents the dataset scores used in the DCR methodology, and they are discussed below.

You will notice from the Wetland Mitigation Parameters chart in Appendix A that the input datasets to the wetland mitigation sites analysis are grouped into three categories: wetland source datasets, priority source datasets, and priority identifiers. Wetland source datasets are those that predict the occurrence of wetlands. Higher confidence is assigned to geographic areas where a greater number of these features occur in the same place, indicating that the area was once, is currently, or would make a successful wetland. Priority source datasets are those that were used to prioritize parcels on which wetland predictors were found. This category represents a range of features that would benefit from the establishment of a wetland in a certain area to provided needed ecosystem services, such as habitat restoration, enhancement, or connectivity, water quality improvement, protection of rare or ecologically important resources, etc. Priority identifiers simply provide a way of identifying the geographic areas that emerge as priorities. This is mainly for ease of communication or administration.

To perform the analysis that identified the wetland mitigation priorities, the wetland source datasets, priority source datasets, and priority identifiers were overlaid in ArcGIS. All parcels that did not contain at least one feature in any of wetland source datasets were eliminated from consideration as mitigation sites. Among those remaining, those that exhibit the most concurrence among wetland indicators and priority source features become the highest priority wetland mitigation sites. The following data was considered in prioritizing parcels as wetland mitigation sites:

Wetland Source Datasets

- *National Wetlands Inventory*
- *National Hydrography Dataset, 1:24,000*
- *100 Year Floodplains*
- *Hydric Soils*

Priority Source Datasets

- *Farmed Wetlands*
- *Regional Internet Bank Information Tracking System*
- *Impaired Waters*
- *DCR Priority Conservation Sites*
- *Virginia Natural Landscape Assessment*

IDENTIFYING WETLAND MITIGATION PRIORITIES

WETLAND SOURCE DATASET: **NATIONAL WETLAND INVENTORY (NWI)**

The NWI catalogs wetlands occurrences and attributes, and is the most comprehensive wetlands data available in the region. Thus, it is one of the best wetland occurrence indicators. However, because it is digitized from aerial photographs, the dataset excludes more obscure wetlands, those that may have been dry at the time of year the imagery was procured, or disturbed wetlands that may be missing one or more conventional wetland indicators. Along with each of the other wetland source datasets, the NWI entries were assigned a score of one.

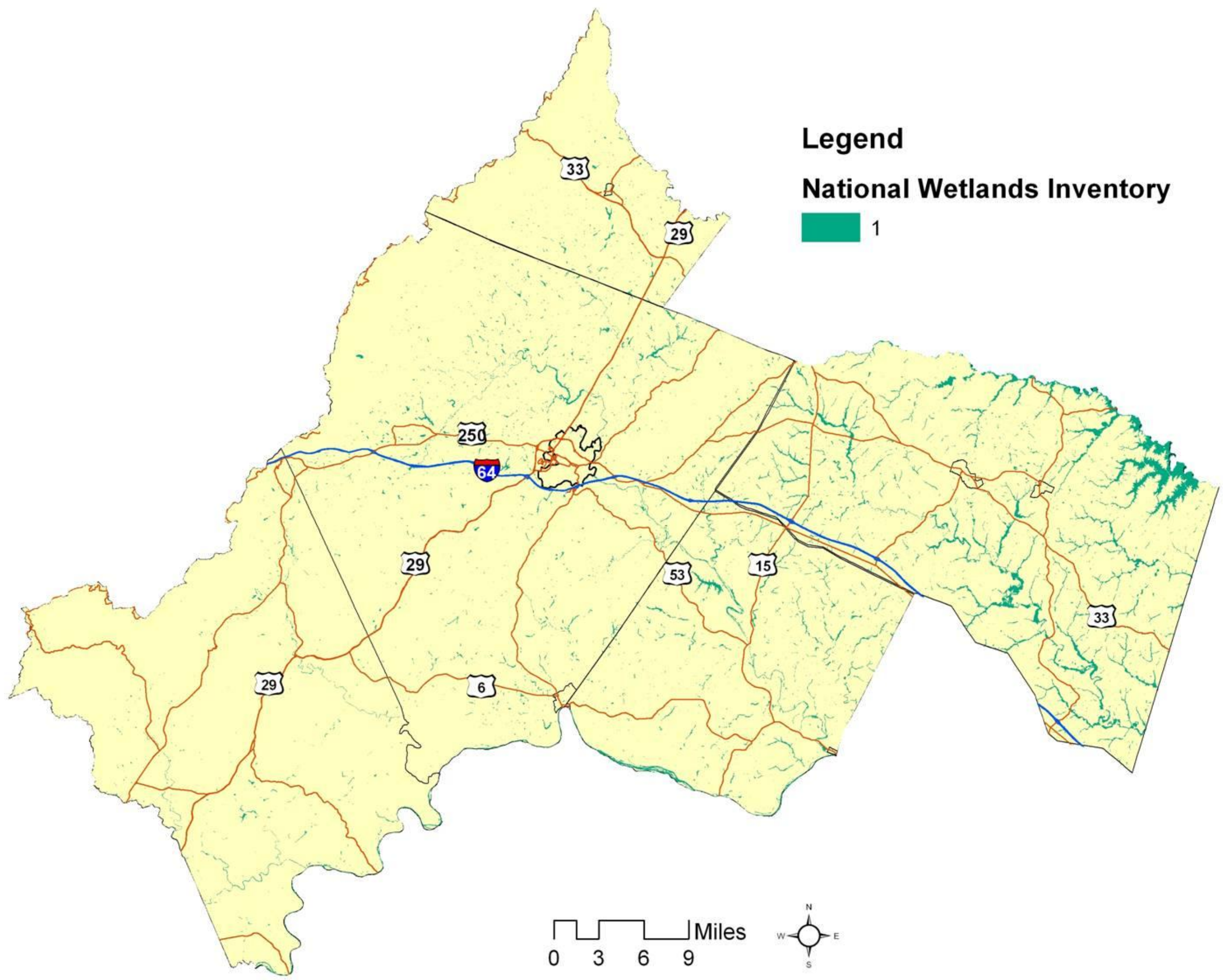

FIGURE 27. NATIONAL WETLANDS INVENTORY

IDENTIFYING WETLAND MITIGATION PRIORITIES

WETLAND SOURCE DATASET: **NATIONAL HYDROGRAPHY DATASET, 1:24,000**

The remainder of the wetland source datasets was used in the analysis to append the NWI. Each is a predictor of the presence of wetlands, and each provides ecosystem services consistent with those offered by wetlands. Streams are natural arteries that convey surface runoff and base flows. They are saturated for some or all of the year. Since streams drain land area to a low point, they are an obvious place for water to collect. Given the right conditions, wetland would easily form around streams, and offer them protection from pollutants and high volume/velocity surface runoff. Along with each of the other wetland source datasets, the NHD dataset entries were assigned scores of one.

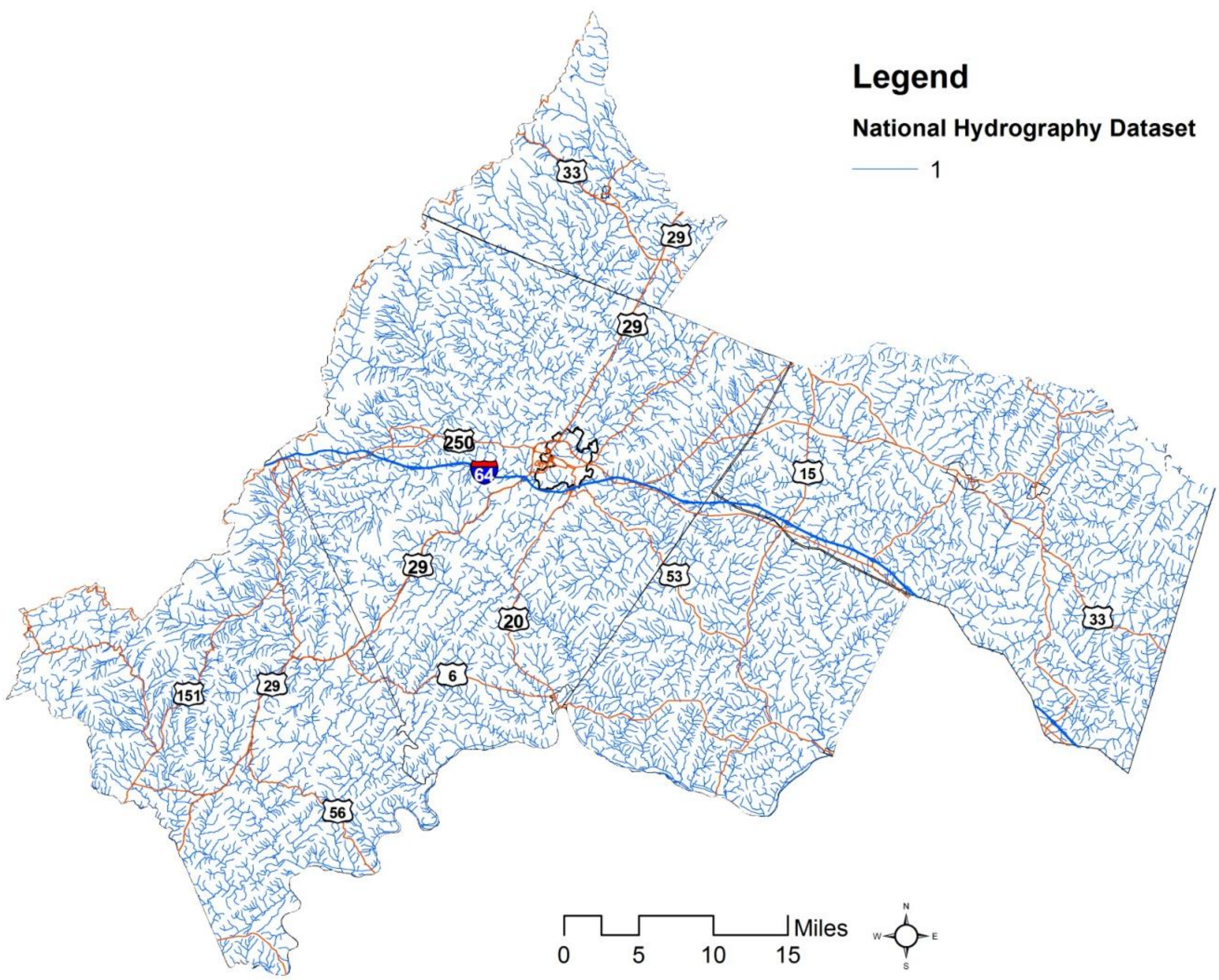

FIGURE 28. NATIONAL HYDROGRAPHY DATASET, 1:24,000

Identifying Wetland Mitigation Priorities

WETLAND SOURCE DATASET: **100 YEAR FLOODPLAINS**

Floodplains are another predictor of the presence of wetlands for reasons similar to streams. They are well adapted to wet conditions, also becoming saturated regularly. They absorb and convey flood water, protecting upland life and property from dangerous conditions. Obligate and facultative flora is drawn to floodplains, as is wildlife, which needs water to live. Again, given the right conditions, wetlands would thrive in floodplains, and enhance the ecosystem services they provide. The Federal Emergency Management Agency's 100 year floodplains dataset was used to represent floodplains in the region. To prepare the dataset for analysis, floodplains were assigned a score of one.

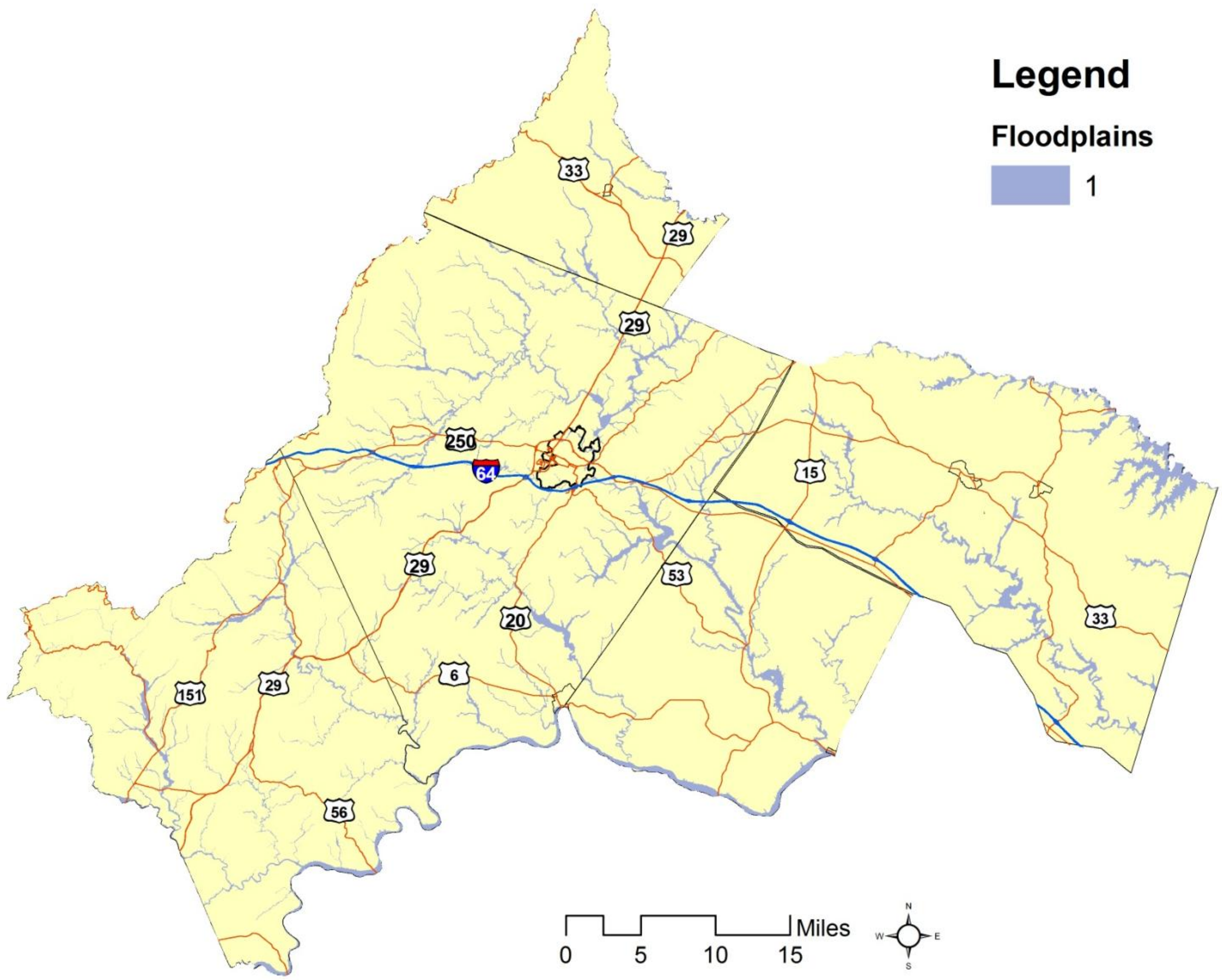

FIGURE 29. 100-YEAR FLOODPLAINS

IDENTIFYING WETLAND MITIGATION PRIORITIES

WETLAND SOURCE DATASET: **HYDRIC SOILS**

Hydric soil is another dataset used in the analysis to append the NWI. It is a wetland indicator that suggests the land is saturated the majority of the time. Hydric conditions are identified by examining the soils for signs of graying or mottling. This is the unique appearance of a lack of color in the soil after iron and other compounds have leach out of the matrix. These compounds become mobile and leach away because of the anoxic conditions caused by water logging in hydric soils. A soil that holds water well is a good indicator that it would make a successful wetland. The hydric soils dataset was extracted from the United States Natural Resource Conservation Service's Soil Survey Geographic Database, which contains data on all soil types. Although this is the best soil data available for the region, the variability across the region reflects the fact that it was collected over a number of years by different soil scientists. Along with each of the other wetland source datasets, hydric soils were assigned a score of one.

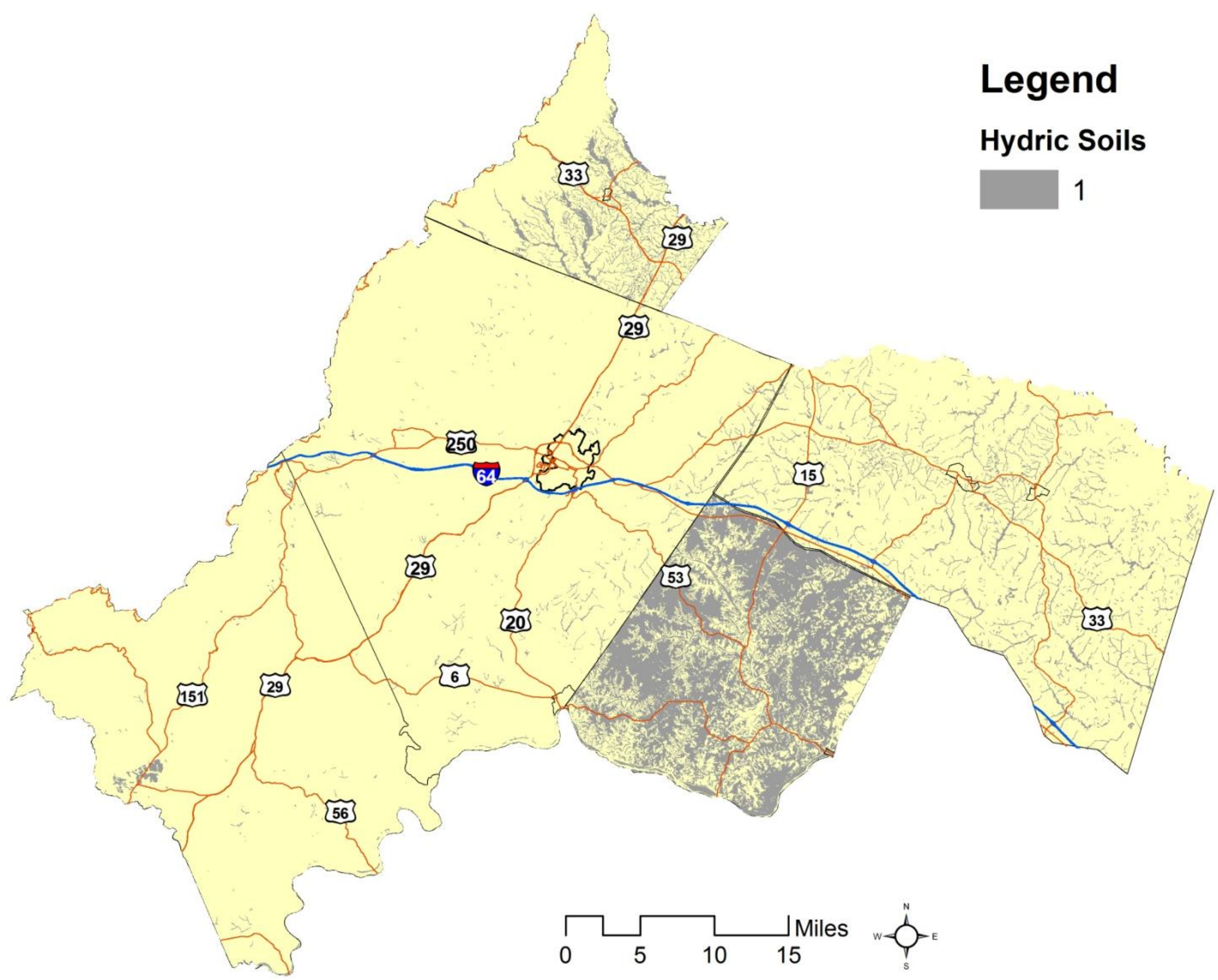

FIGURE 30. HYDRIC SOILS

IDENTIFYING WETLAND MITIGATION PRIORITIES

PRIORITY SOURCE DATASET: **FARMED WETLANDS**

The NWI classifies wetlands by type. One type of classification is farmed wetlands. These wetland features were extracted from the NWI and given extra weight in the analysis because they represent opportunities to restore areas that are known to have once been wetlands, indicating a high probability that their restoration would be successful. Additionally, areas that evolved as wetlands fill a landscape niche. Restoring these areas would allow them provide ecosystem services where they are needed, and would contribute significantly to the REF. To prepare the farmed wetland dataset for analysis, these features were assigned a score of three.

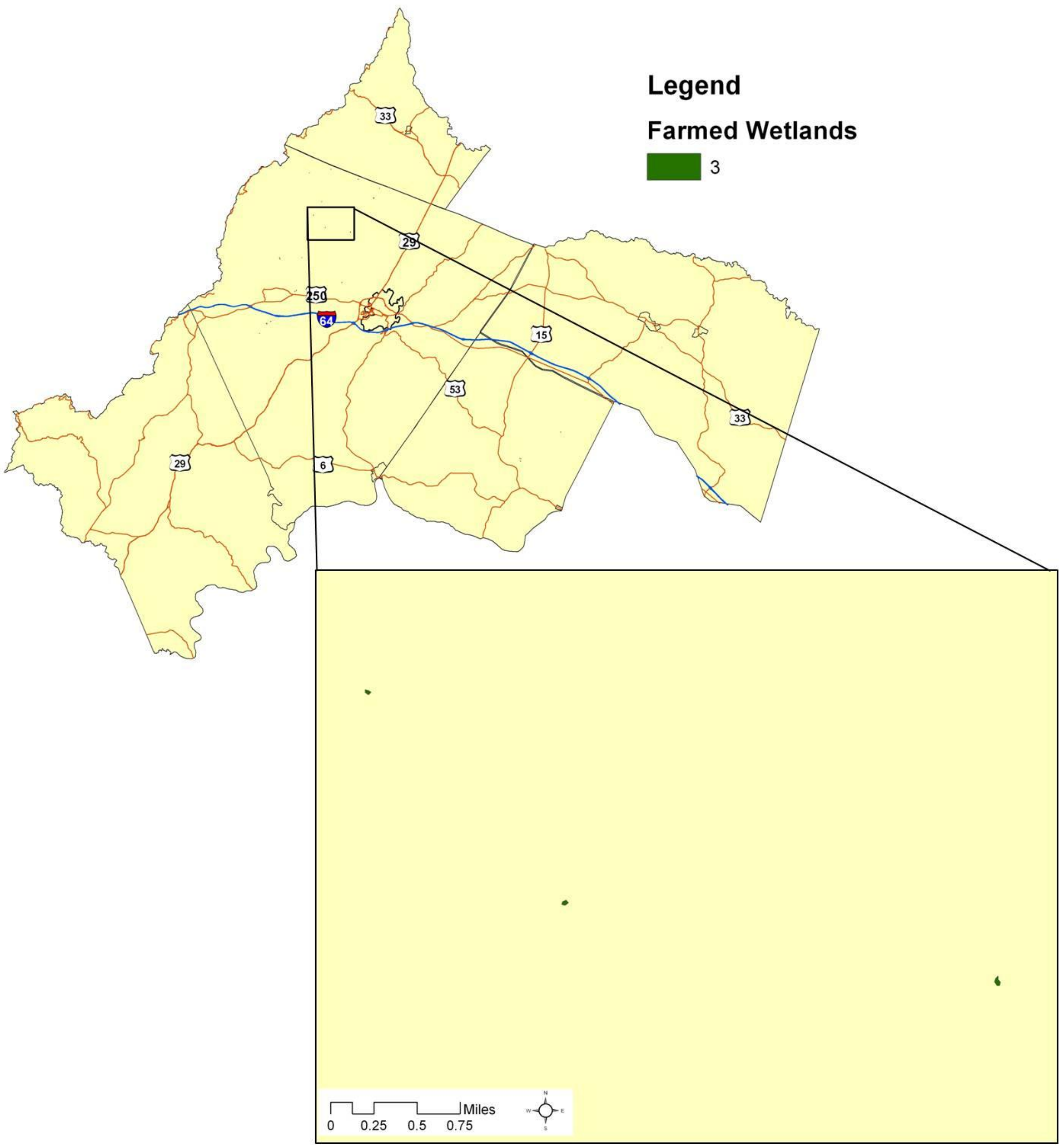

FIGURE 31. FARMED WETLANDS

IDENTIFYING WETLAND MITIGATION PRIORITIES

PRIORITY SOURCE DATASET: **REGIONAL INTERNET BANK INFORMATION TRACKING SYSTEM (RIBITS)**

RIBITS is a database containing the locations of all mitigation banks permitted by the Army Corps of Engineers. Restoring wetlands adjacent to previous or active restoration projects increases the size of habitat, connectivity, flood abatement, pollution control and other ecosystem service that restoration projects can provide. There are only two ACE permitted restoration sites in the TJPDC. To prepare these sites for analysis, they each received a score of three.

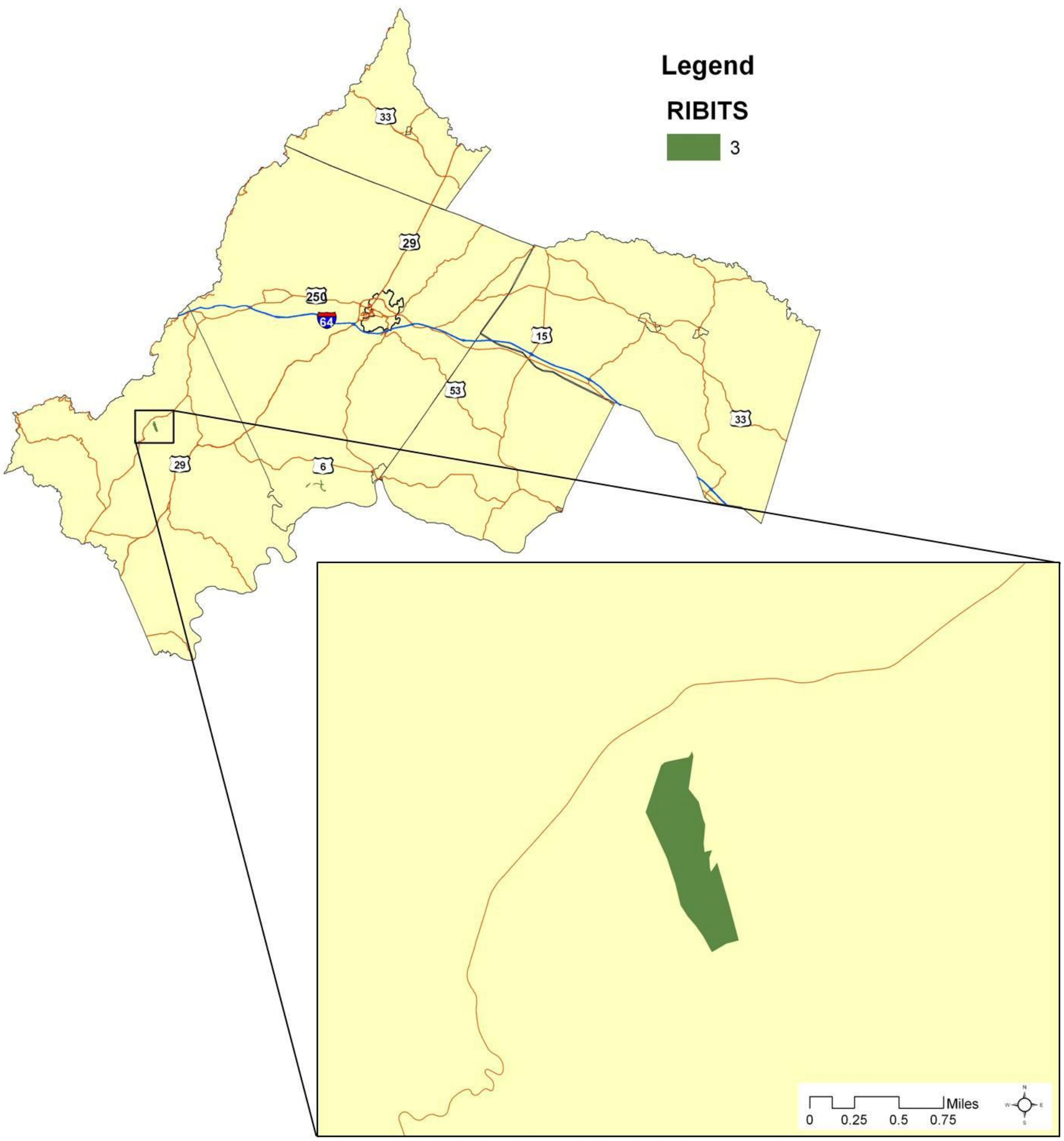

FIGURE 32. REGIONAL INTERNET BANK INFORMATION TRACKING SYSTEM (RIBITS)

IDENTIFYING WETLAND MITIGATION PRIORITIES

PRIORITY SOURCE DATASET: **IMPAIRED WATERS**

The Eco-logical approach also aims to use mitigation funding to achieve goals of other environmental regulations (Kirsten Holder, Volpe National Transportation Systems Center, personal communication, December 2, 2010). Restoring, enhancing, or constructing wetlands adjacent to impaired streams would help to restore the stream, as well, assisting states in restoring impaired waters that are required to be list under section 303(d) of the Clean Water Act. To prepare this dataset for analysis, impaired streams were assigned a score of three.

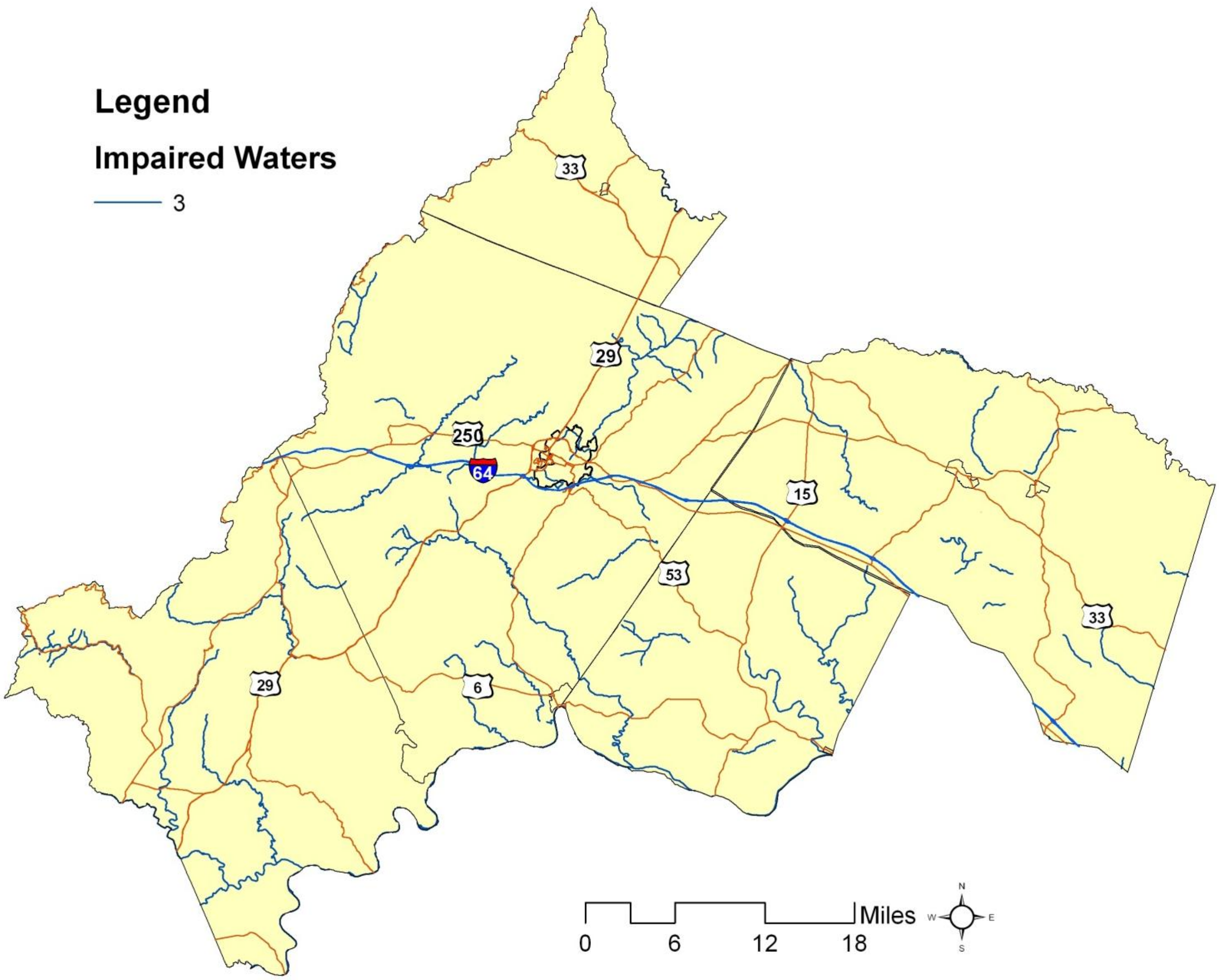

FIGURE 33. 303(D) IMPAIRED WATERS

IDENTIFYING WETLAND MITIGATION PRIORITIES

PRIORITY SOURCE DATASET: **PRIORITY CONSERVATION SITES**

Collected and maintained by the Virginia Department of Conservation and Recreation, this data map locations of priority conservation sites that seek to protect biodiversity. A collection of publicly and privately owned sites, they are ranked by conservation need based on threat to degradation posed by poor land use planning and/or development. The wetland mitigation analysis sought to protect these sites, as they are important to the REF. The higher the priority a site was according to the data, the more suitable a wetland restoration site it was in this analysis. Table 7 lists the score assigned to each Biodiversity Conservation Need Class (BCN).

TABLE 7. BCN SCORES

BCN	Score
B2	4
B3	3
B4	2
B5	1

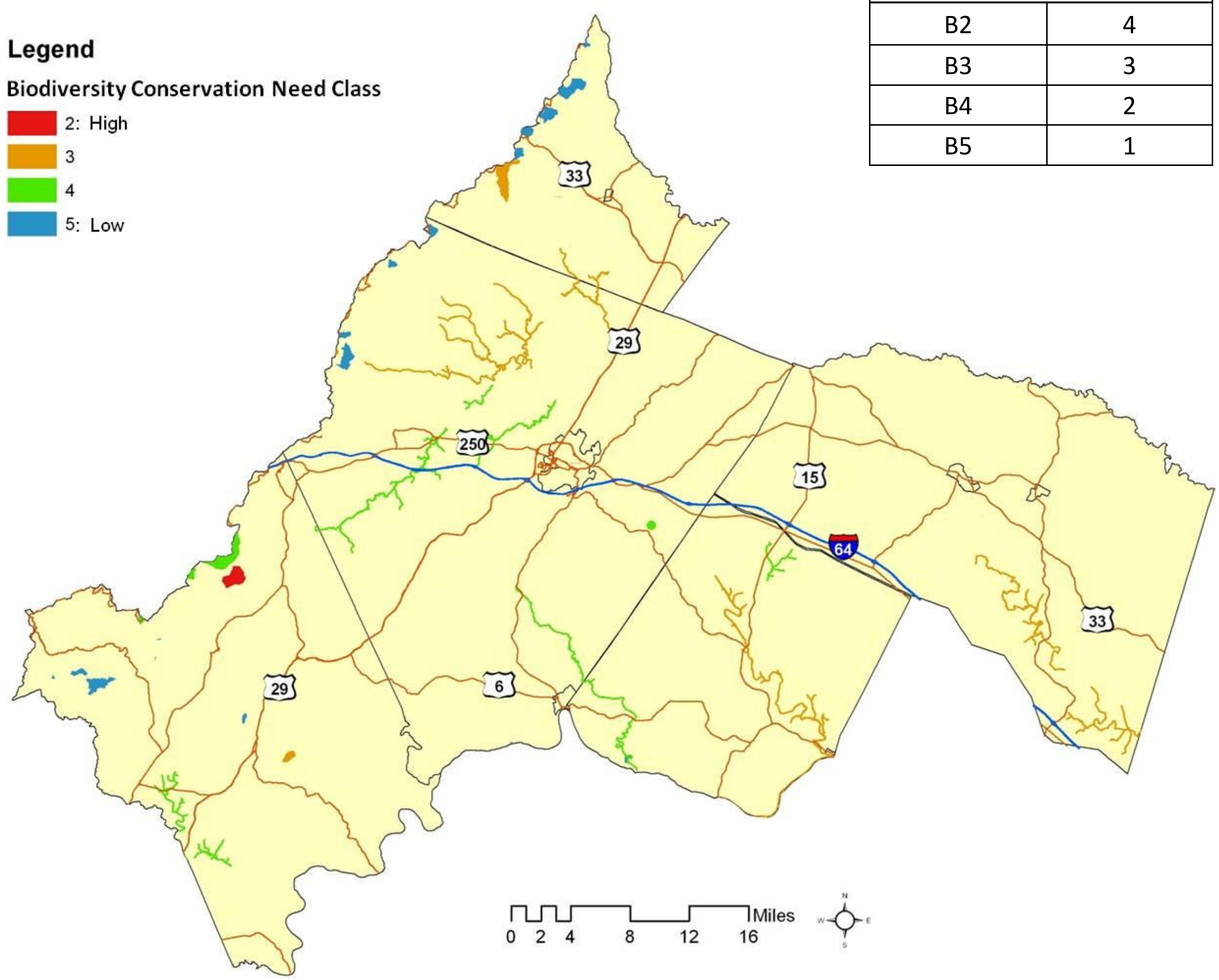

FIGURE 34. PRIORITY CONSERVATION SITES

IDENTIFYING WETLAND MITIGATION PRIORITIES

PRIORITY SOURCE DATASET: **VIRGINIA NATURAL LANDSCAPE ASSESSMENT (VANLA)**

The Virginia Department of Conservation and Recreation Natural Heritage Program maintains the VaNLA. The dataset maps habitat cores, or large tracts of habitat, and corridors, linear stretches of habitat that are not of sufficient size or quality to be considered cores, but serve to connect cores to one another. The cores are classified from high (1) to low (5) quality based a number of factors. The wetland mitigation analysis sought to protect these habitats, as they are important to the REF. The higher the quality of the core according to this dataset, the more suitable a wetland restoration site it was in this analysis. Corridors also received elevated priority in the analysis because of the vital connectivity services they provide. Table 8 lists the score assigned to each core classification and corridors.

TABLE 8. VANLA SCORES

Habitat Rank	Score
1	5
2	4
3	3
4	2
5	1
Corridors	1

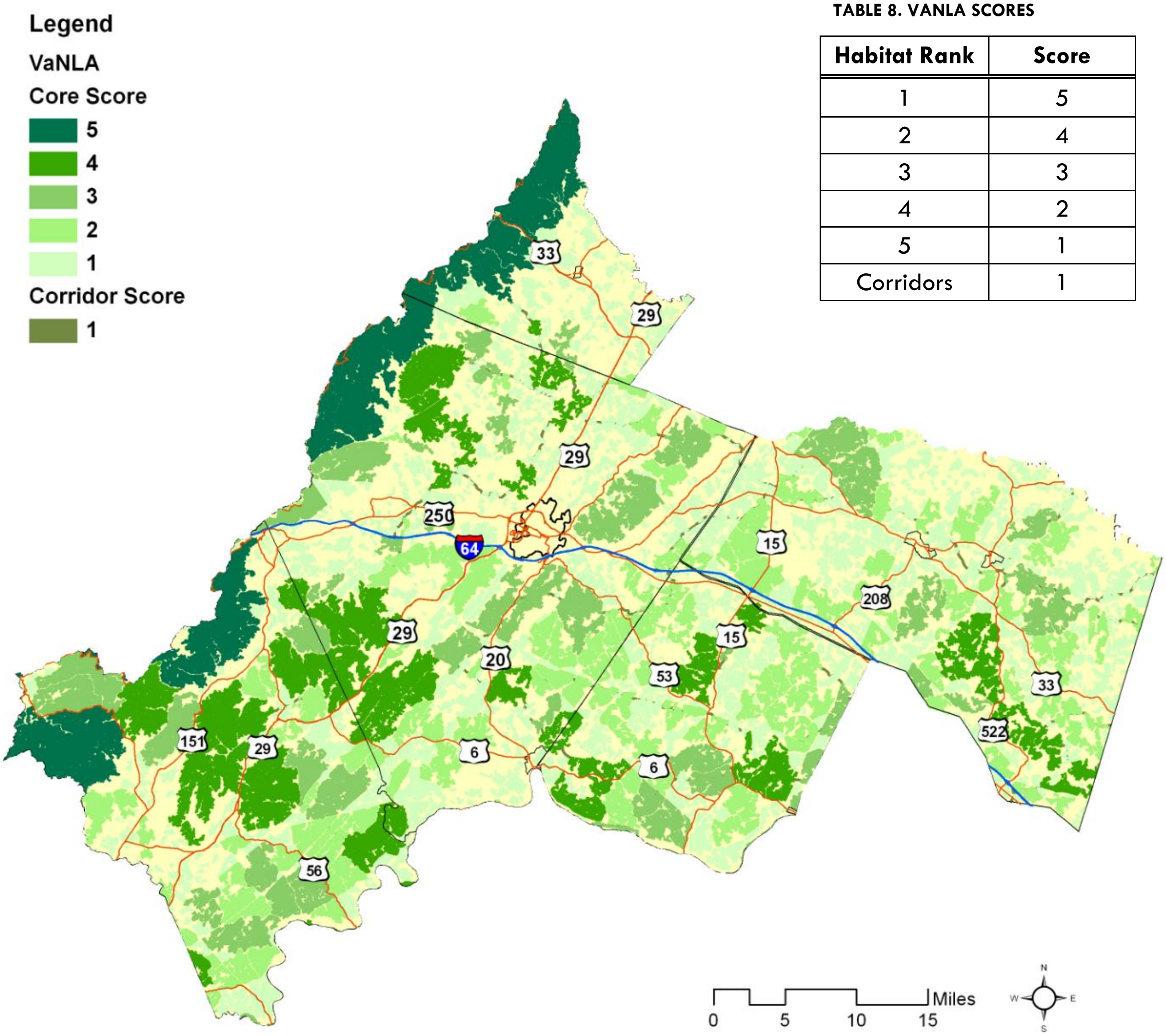

FIGURE 35. VANLA HABITAT CORES AND CORRIDORS

IDENTIFYING WETLAND MITIGATION PRIORITIES

PRIORITY IDENTIFIER: **PARCELS**

Locality parcel identification numbers were used to identify priority wetland mitigation sites. They did not receive a value for use in prioritizing sites.

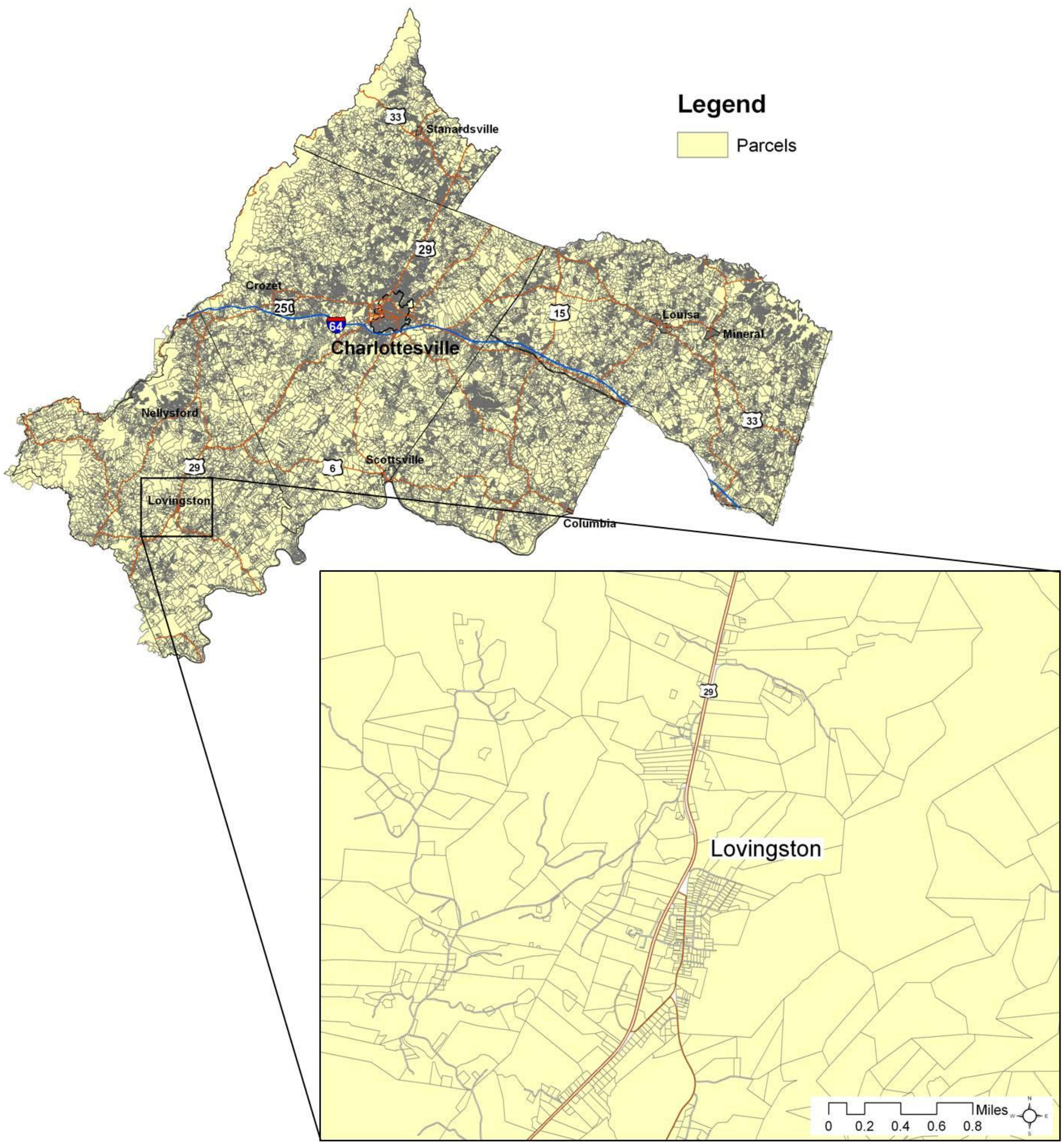

FIGURE 36 . PARCELS

IDENTIFYING WETLAND MITIGATION PRIORITIES

PRIORITY IDENTIFIER: **HYDROLOGIC UNIT**

The USGS maintains a watershed cataloging system that divides watershed into hydrologic units and identifies them with codes. Regional scale hydrologic units are large, and nest within them successively smaller hydrologic units. Data exists from the regional scale (two digits) to the cataloging scale (eight digits), and is available in a twelve digit scale for some areas. The smaller the unit, the more digits its code contains (USGS, 2011). Mitigation projects are required by law to occur within the same eight-digit hydrologic unit in which the impact occurred. These units are pictured in Figure 37. They did not receive a value for use in prioritizing sites, but were included for ease of identifying the geographic area to which a mitigation priority could apply.

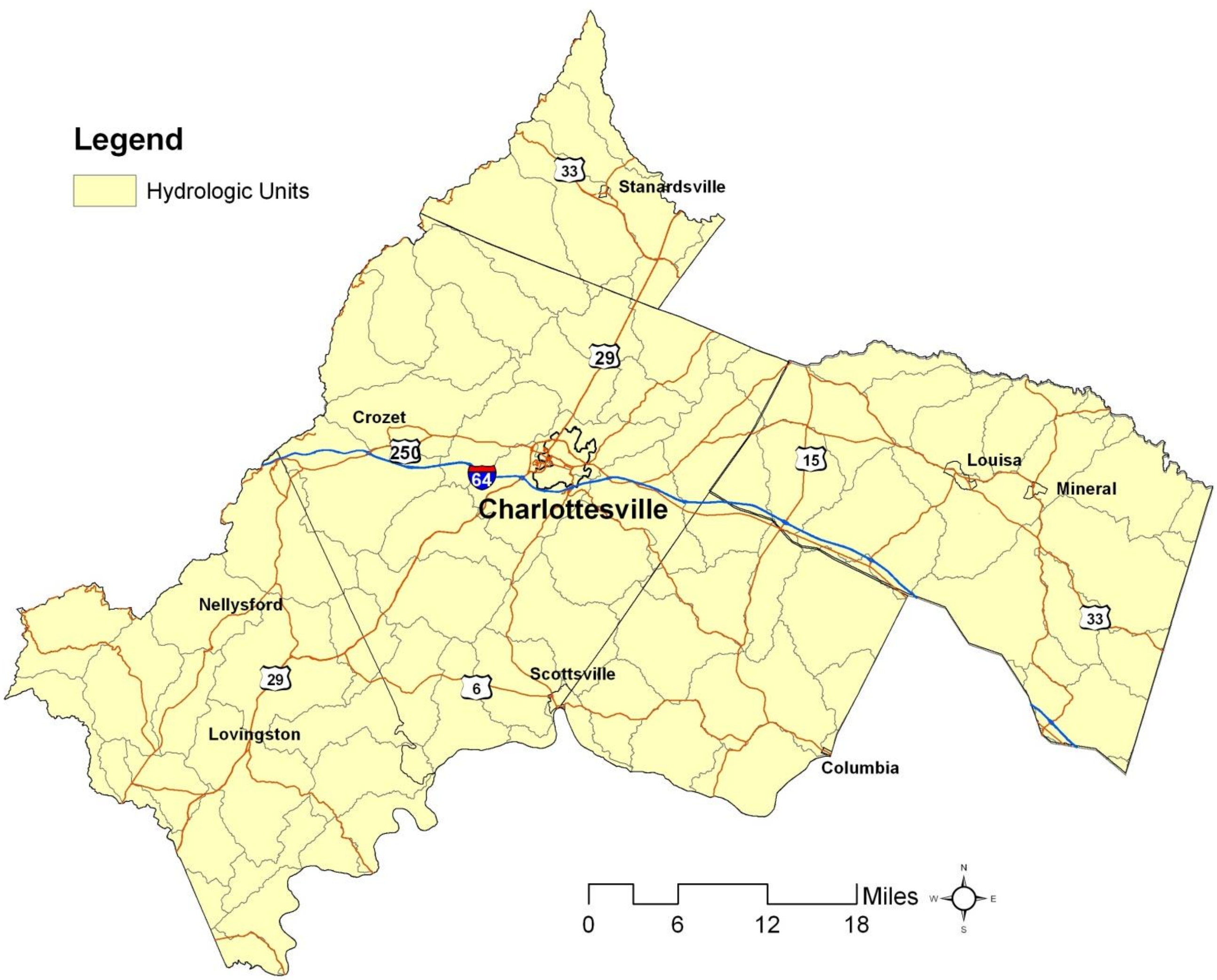

FIGURE 37. HYDROLOGIC UNIT

SPATIAL ANALYSIS

A union overlay was performed to combine all of the above datasets into one shapefile. The union formed a new shape and attribute table entry for every place that any two or more of the data inputs overlapped. The union also associated a parcel ID and hydrologic unit code with every entry in the attribute table of the new shapefile, which is how the wetland mitigation priorities are ultimately identified. From the attribute table of the union shapefile, all parcels containing one or more wetland source feature were extracted to a new dataset (many parcels did not overlap any wetland source layers). In the attribute table of the new dataset, a new field was created and calculated to be the sum of wetland source dataset scores, using the field calculator. This step summed the scores of geographically coordinated, wetland predicting entries in the attribute table to indicate the level of confidence that an area is, or would make a successful wetland. Another field was then added to the attribute table and was calculated to be the sum of priority source datasets. This step summed the scores of geographically coordinated entries in the attribute table that predict habitat quality, restoration need, ability to build on previous restorations, and areas that are expected to be easily restored. A final field was added to the table and titled "Composite Prioritization." It was calculated to be the sum of the Wetland Source Sum and Priority Source Sum fields.

SUMMARY STATISTICS

Summary statistics were conducted on the Parcel ID field of the union attribute table. This step selects the highest scoring combination of data inputs within each parcel, and assigns that score to the parcel, establishing a priority weight for each parcel. The numeric scale of weights ranged from 1 to 14, with the highest scores representing the highest priorities for mitigation. The scores were reclassified into five priority classes (1 – 5) using the Natural Breaks classification type. Parcels in class 1 are low priorities for wetland mitigation, and those in class 5 are the highest priorities. The "null" class represents parcel that did not contain any wetland sources and can be considered to have a priority weight of zero, meaning they are not priorities. For further detail on how this analysis was performed, refer to the DCR methodology (see References).

SUMMARY STATISTICS

Tool settings: Select "first" for the hydrologic unit code, and "maximum" for all other fields in the table.

The output summary statistics table was joined to the original parcels shapefile using the Parcel ID field as the common field. This coded the parcel shapefile with the priority weight scores.

Results

The mitigation priorities are identified in three output datasets. Stream reach and parcel data are considered high resolution at the landscape scale. Both the National Hydrography Dataset (NHD) and parcel data were classified into five classes using the Natural Breaks classification method. Refer to Appendix B for the scoring ranges on which the classes are based.

TABLE 9. MITIGATION PRIORITIES OUTPUTS

Deliverable	Dataset Outputs
I. Stream Mitigation Priorities	
a) Protection Priorities	Modified NHD shapefile
b) Restoration Priorities	Modified NHD shapefile
II. Wetland Mitigation Priorities	Modified Parcels shapefile

STREAM MITIGATION PRIORITIES

STRATEGY: **PROTECTION**

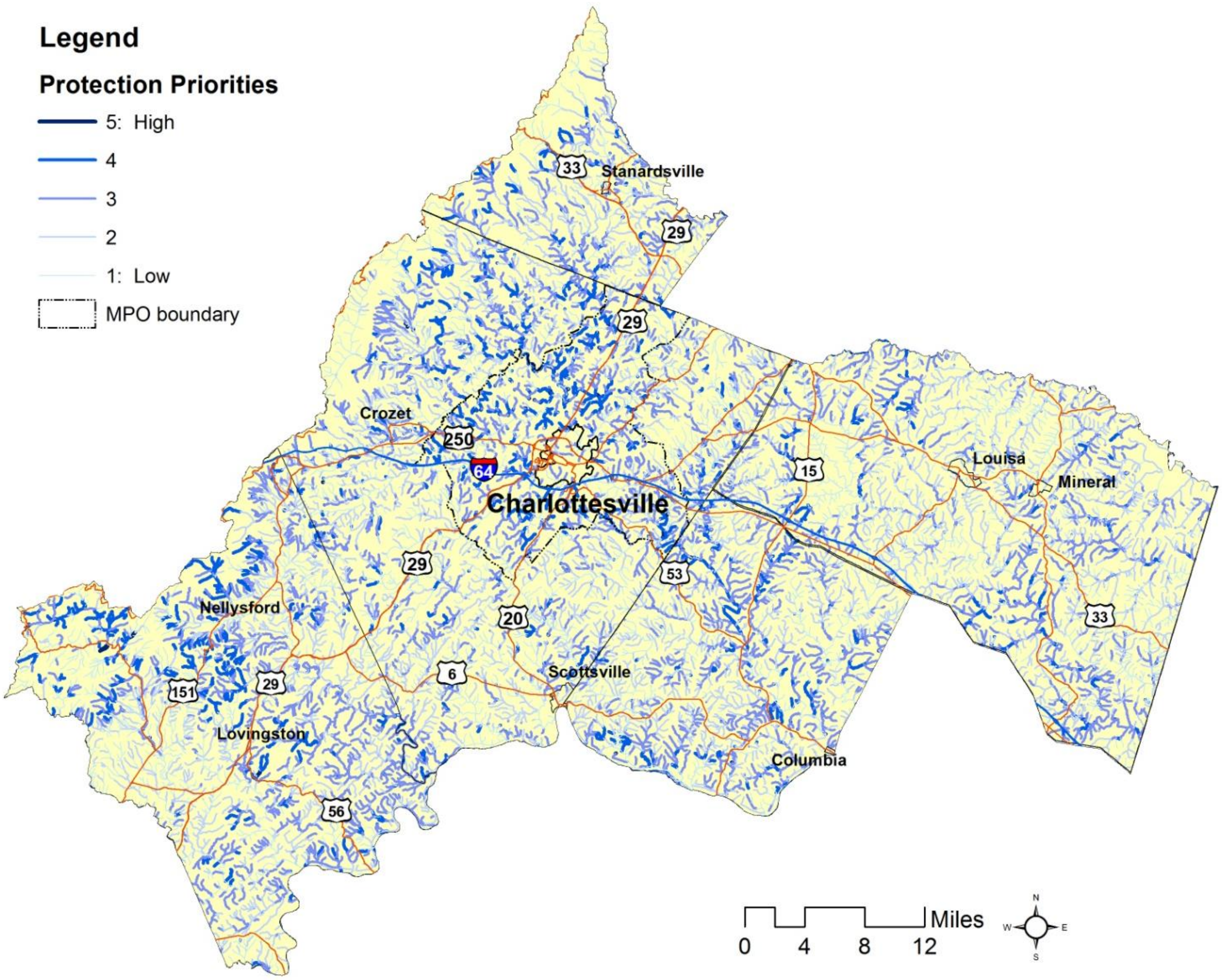

FIGURE 38. STREAM PROTECTION PRIORITIES BY STREAM REACH (NHD)

STREAM MITIGATION PRIORITIES

STRATEGY: **PROTECTION**

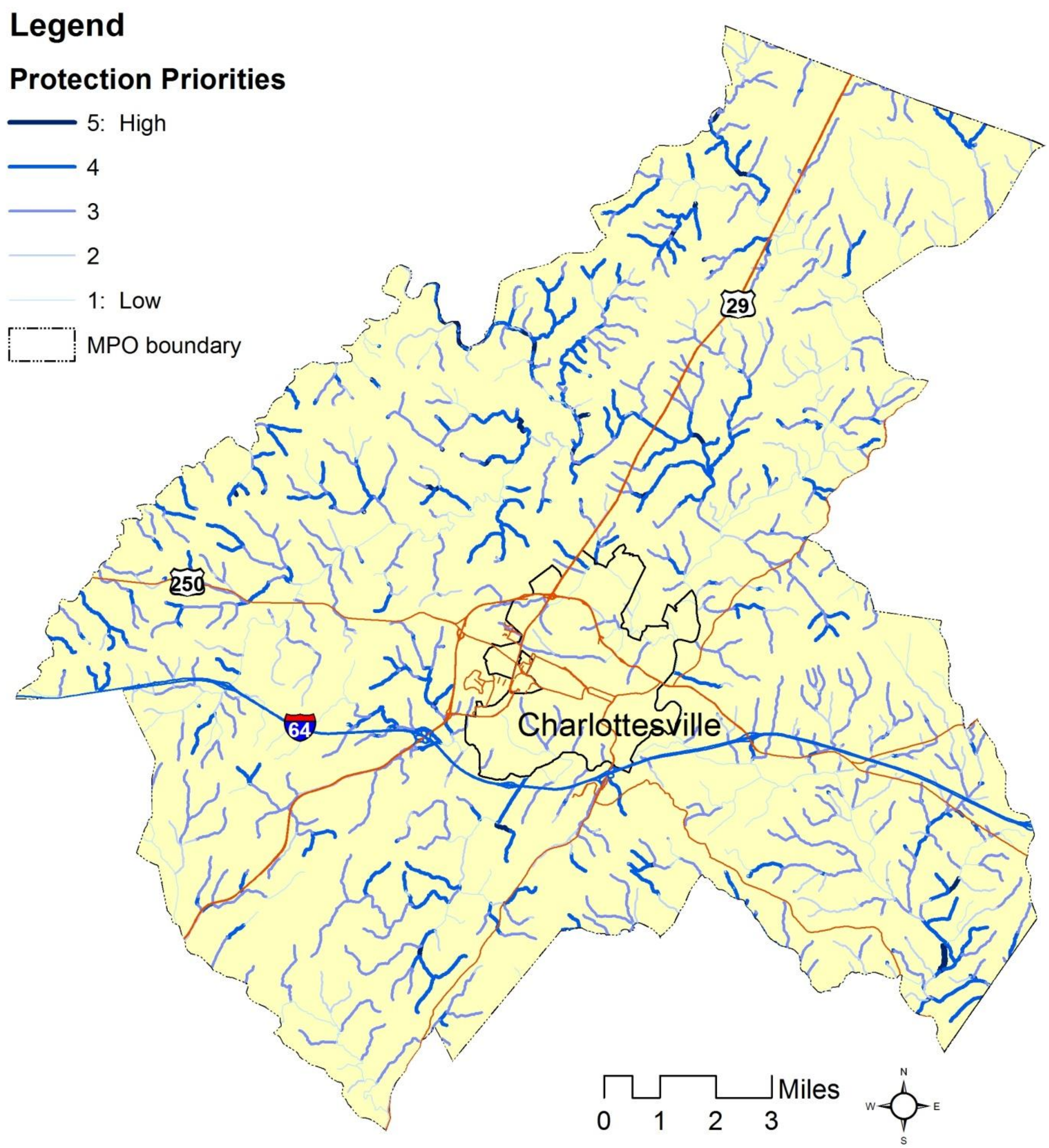

FIGURE 39. MPO EXTRACT OF PROTECTION PRIORITIES BY STREAM REACH (NHD)

STREAM MITIGATION PRIORITIES

STRATEGY: **RESTORATION**

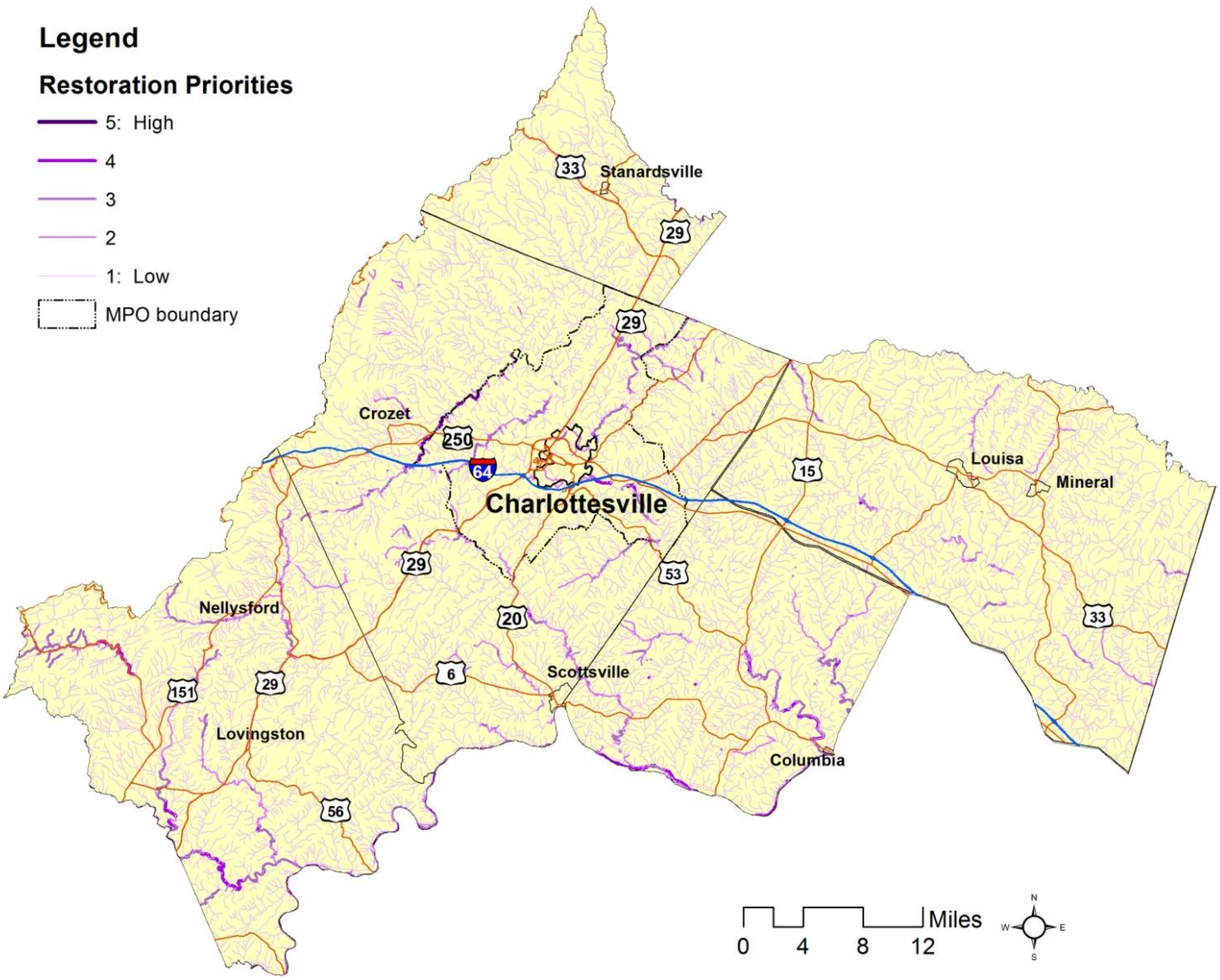

FIGURE 40. STREAM RESTORATION PRIORITIES BY STREAM REACH (NHD)

STREAM MITIGATION PRIORITIES

STRATEGY: **RESTORATION**

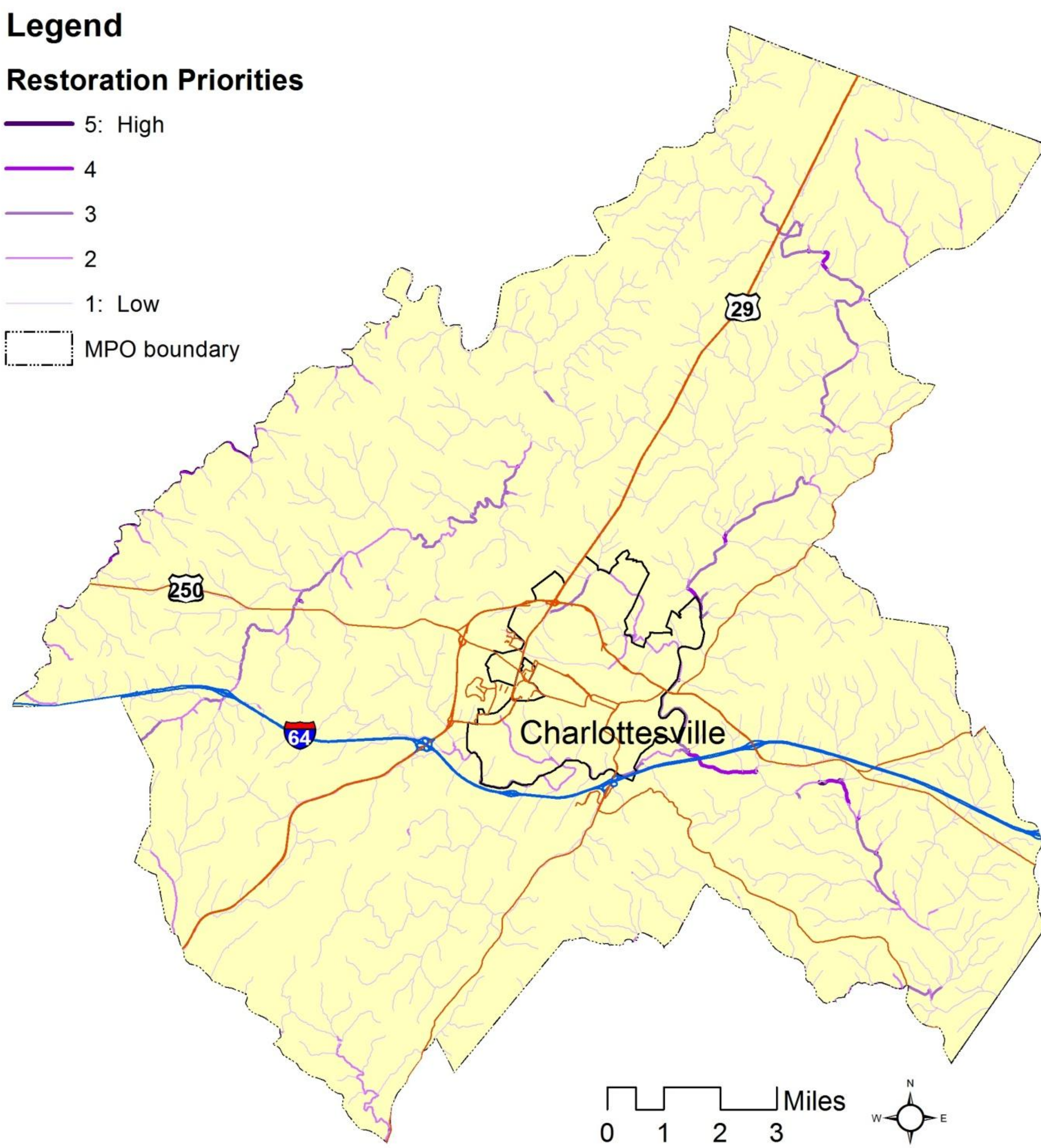

FIGURE 41. MPO EXTRACT OF RESTORATION PRIORITIES BY STREAM REACH (NHD)

WETLAND MITIGATION PRIORITIES

STRATEGY: **PROTECTION, RESTORATION, ENHANCEMENT**

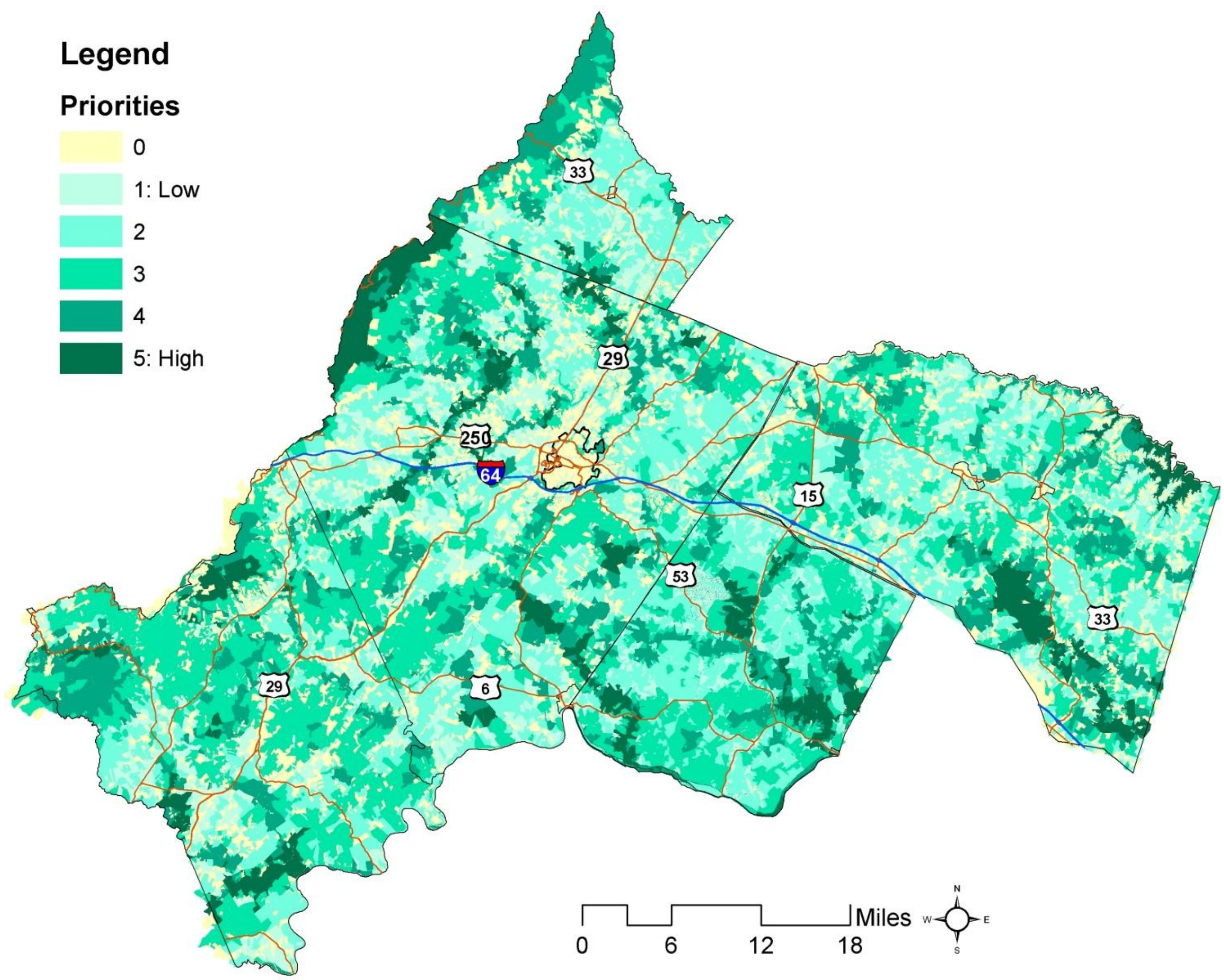

FIGURE 42. WETLAND MITIGATION PRIORITIES BY PARCEL

ALL MITIGATION PRIORITIES

HIGHEST PRIORITIES: **STREAM & WETLAND MITIGATION**

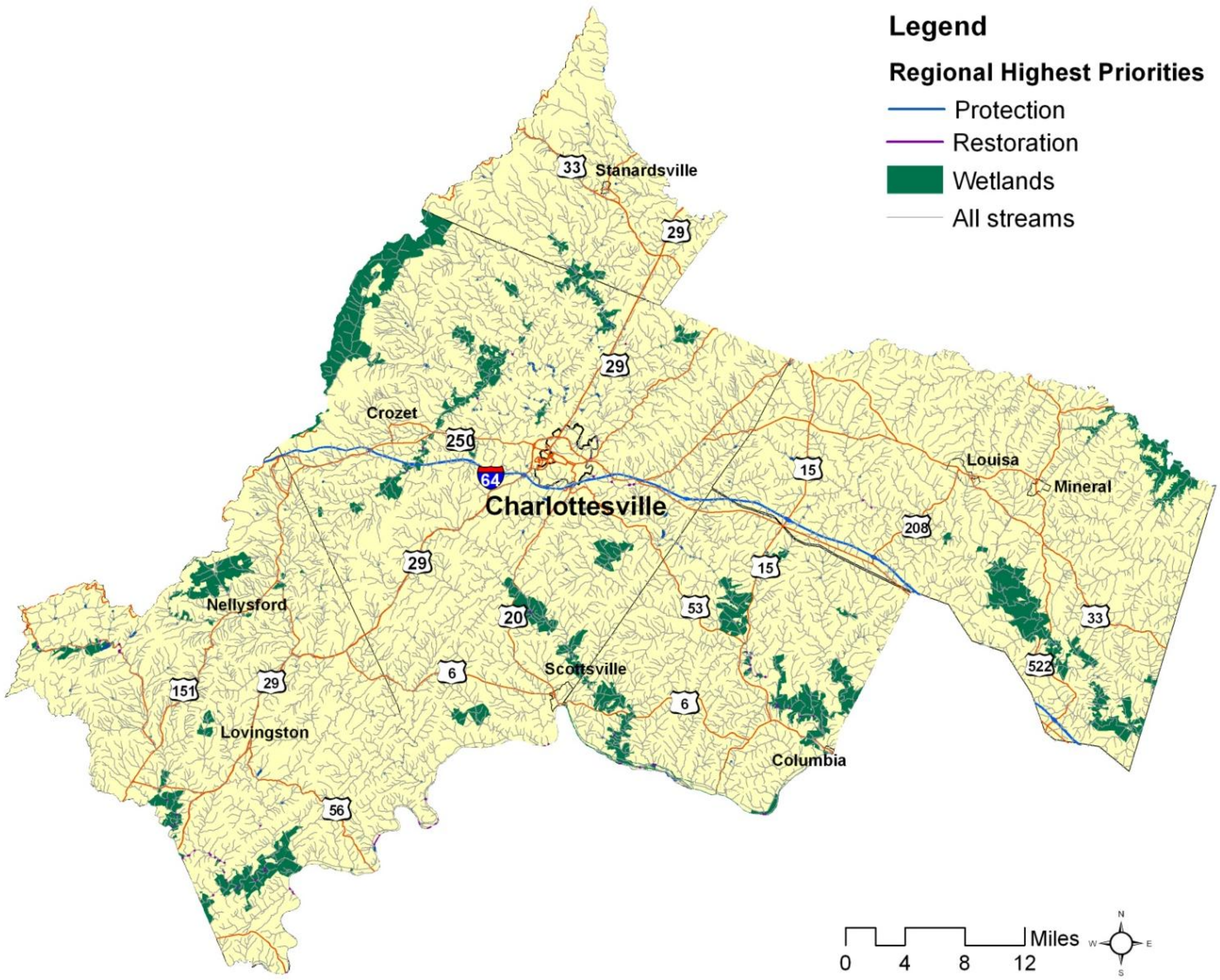

FIGURE 43. TOP REGIONAL PRIORITIES

Limitation

The identification of mitigation priorities is limited by the degree of comprehensiveness, accuracy and resolution of the input datasets. The analyses are also limited by the accuracy of the assumptions inherent to the model.

Uses

The mitigation priorities identified here provide opportunities for partnership across political and economic boundaries. They are not intended to be exclusive to the transportation mitigation process. They are available to all, including but not limited to:

- *The Virginia Department of Transportation when impacts from road projects must be mitigated*
- *In-lieu fee programs*
- *Private sector entities whose environmental impacts must be mitigated*
- *Conservation organizations undertaking mitigation initiatives*
- *Developers who need offsite stormwater draw down credit, to the extent allowed by law*
- *Entities generating credits for the Chesapeake Bay Nutrient Credit Exchange Program*

Review

The above tools are meant to assist public officials, decision makers, planners, and administrators in assessing the implications of infrastructure development on regional natural resources. Increasingly, leaders need to be concerned with the impact of erratic climatic conditions and natural hazards on the built environment, and recognize the tempering affect that green infrastructure can provide against these conditions. Thus, it's in everyone's best interest to protect, restore, and enhance the REF.

The Integrated Regional Map provides the opportunity at the long range plan development stage for leaders to be proactive about reducing conflicts between transportation infrastructure development and natural resource protection. It also provides valuable information to planners and project managers who can more adequately budget time and funding for the estimated amount of environmental impact expected from a given project.

The Least Environmental Cost Analysis provides new information on which to bases project alternative in the environmental review process and better meets the intent of NEPA. The user has the option to add infinite combinations of constraints that can inform the best possible roadway alignment, balancing avoidance and minimization of environmental impacts with other design standards.

Finally, strategic identification of mitigation sites is necessary in order to ensure optimal ecological mitigation with the limited amount of funding available for such projects. Here we developed methodologies for prioritizing these sites, and plan to share the results with a broad audience to accelerate the protection, restoration, and enhancement of the REF.

5 Performance Measures

What	Track the progress of the TJPDC and other transportation and conservation entities operating in the region on incorporating Eco-logical concepts into their programs and processes.
Why	To assess the effectiveness of the Eco-logical approach and inform future administration of programs using the approach.
How	➢ *Develop indicators of integration of approach into programs and processes* ➢ *Assess ecological health often enough to inform adaptive management of the Eco-logical approach*

In the future, the TJPDC's transportation program will be evaluated on the extent to which it has incorporated Eco-logical concepts into its products and service, and uses the tools developed for this project to guide the planning process. Evaluations of performance are import in validating the value of the Eco-logical approach, and for informing the path forward to achieve the most efficient and effective management of infrastructure and environmental resources. Assessments of progress should take place at the plan level for infrastructure and the environment. Accordingly, the following performance measures will indicate the progress made on the integration of green infrastructure with regional transportation planning:

Long-Range Transportation Plan

- *Adoption of a long-range regional transportation plan that includes the Regional Integrated Map and describes how it is intended to be used. It should also contain reference to the Least Environmental Cost Analysis as a tool that is available to assist in developing alternatives that are sensitive to the REF.*
- *Recommendations made in the plan indicating how the mitigation priorities identified by this project will be considered for implementation when impacts occur.*
- *Funding allocated in successive updates to the long range transportation plan to allow for an update to the GIS products developed by this project to incorporate the latest versions of the data inputs. Current data is vital to the tools' effectiveness and relevance.*
- *Citizen involvement and education on the Eco-logical approach through public participation associated with the long-range planning process. The number of attendees at public workshops and website traffic will indicate the amount of exposure the approach is getting with members of the public.*

Comprehensive Plans

- *TJPDC member governments' comprehensive plans include the REF as a framework for natural resource protection, and consider the REF when making changes in land use and zoning policies.*
- *Transportation chapters of comprehensive plans reference the Eco-logical approach, transportation tools and mitigation priorities made available by this project.*
- *Incorporation of green infrastructure principles into comprehensive plans as a starting point for progress toward using them in the local permitting process.*
- *Member governments prioritize keystone areas of the REF for siting future parks and/or conservations areas.*

Conservation

- *Progress made toward protecting keystone areas of the REF and implementation of high priority mitigation sites identified by this project.*
- *New partnerships emerge between the TJPDC, conservation groups, in-lieu fee programs, future mitigation banks, and natural resource agencies to coordinate conservation and restoration efforts so that the limited resources available are allocated to projects that will do the most good for regional ecological health.*
- *Development of a central database to track completed projects so that the transportation and environmental communities can track progress on conserving their "common ecological blueprint."*
- *Regular assessments of the region's ecological health are made to inform adaptive management strategies as the Eco-logical approach continues to evolve.*
- *Mitigation priorities identified by this project are considered for use in meeting emerging regulatory requirements for water quality programs at the local level, to the extent applicable, when off-site pollution reductions are desired or required, and stream and wetland mitigation projects can fulfill that need.*

Review

Evaluation of how Eco-logical concepts affect infrastructure development and the REF are essential to validating their effectiveness. The development of measurable indicators of progress is the first step in the information gathering process that will eventually yield data on which to assess the Eco-logical approach. These assessments will illustrate the strengths and weaknesses of the approach, from which guidance can be developed on how to proceed with future planning efforts. This adaptive management approach is necessary as interactions between the built and natural environment, economies, values, and the natural world continue to evolve.

6 Conclusion

The tools developed for this project aim to increase the effectiveness, efficiency, and predictability of the environmental review and compensatory mitigation processes that are needed to advance transportation infrastructure projects under the existing regulatory framework. Their use will assist planners and decision makers in developing environmentally sensitive roadway networks by introducing environmental considerations into the plan phase of infrastructure development, where they have the opportunity to inform project priorities, budgets, and schedules. The Least Environmental Cost Analysis suggests that environmental information used in early stages of the design phase may also assist in streamlining the environmental review process by identifying alignment alternatives that will avoid and minimize impacts to resources to the maximum extent practicable.

The TJPDC wishes to also extend the goals of improved effectiveness, efficiency, and predictability to the greater environmental community by sharing the tools developed for this project with parties both inside and outside of the compensatory mitigation process. The principles of Eco-logical seek to stretch the effectiveness of the limited resources available to advance conservation goals by developing a conservation infrastructure in the form of the REF, and a road map, in the form of mitigation priorities. This infrastructure will allow partners to concentrate their resources where they will collectively have the most impact in preserving and restoring the ecosystem services that we rely on for a prosperous future. To allow this to happen, future partners will need to learn to work across boundaries more often, and take advantage of the cooperative opportunities to achieve more as a community than any could hope to achieve on their own.

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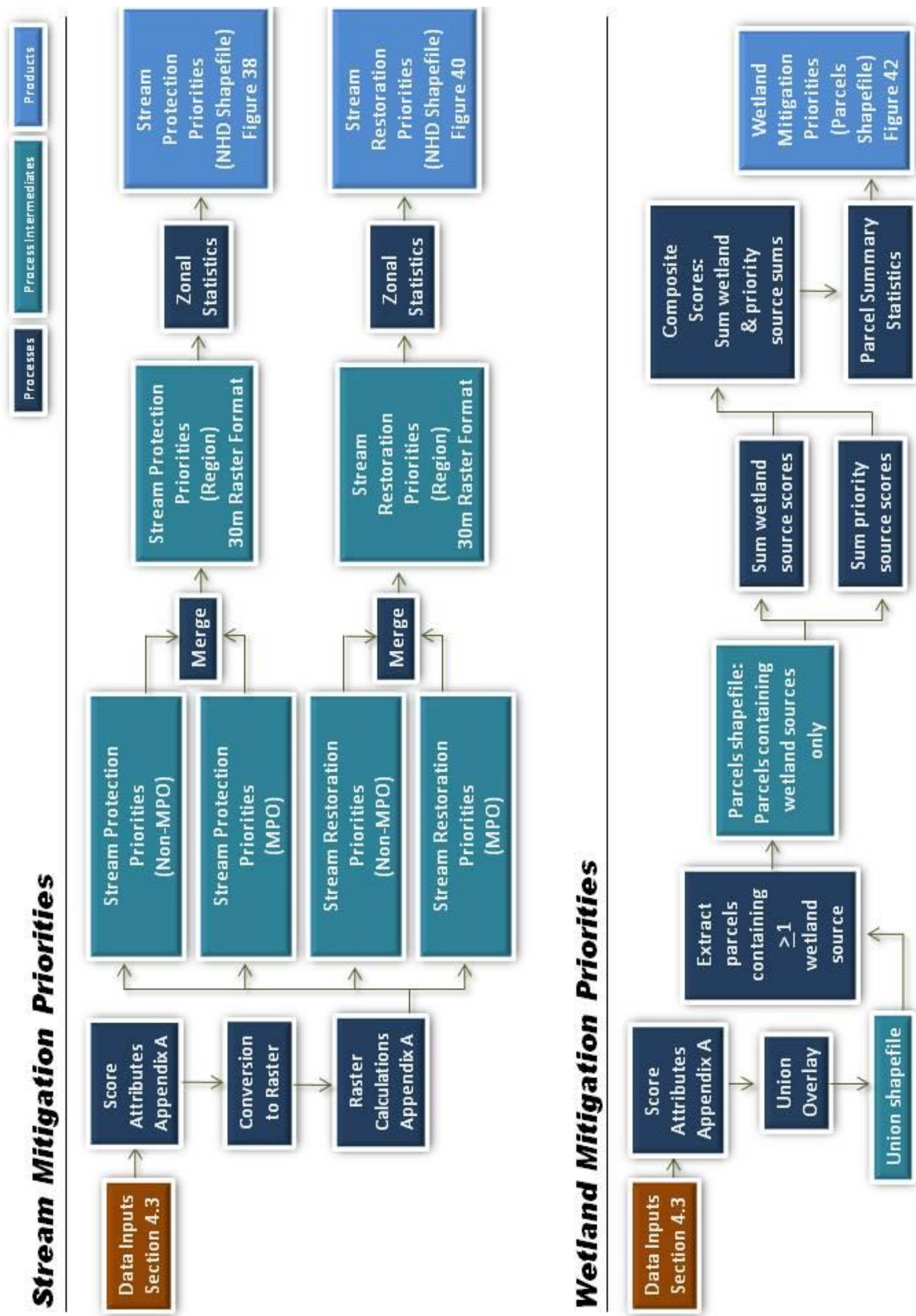
Appendix A

Mitigation Priorities Methodologies



Stream Mitigation Priorities Parameters

STREAM PROTECTION SUITABILITY PARAMETERS - OUTSIDE OF THE MPO

Criteria	Options	Score	Operation	Comments
REF Score	0 - 6	0	SUM	Classification: Natural Breaks
	7 - 12	1		
	13 - 19	2		
	20 - 52	3		
TNC Priority	TRUE	1		
	FALSE	0		
Within Growth Area	TRUE	1		
	FALSE	0		
Land Cover	Natural	1		Natural land cover: NLCD: Deciduous, evergreen, mixed, dwarf shrub, wetlands; RRBC map: Deciduous, evergreen, pine plantation
	Other	0		
Proximity to other protected land, within 1 mile (feet)	0 - 206	4		Classification: Geometric Interval; 0-206 class added manually (1/4 of 824)
	207 - 824	3		
	825 – 2,372	2		
	2,373 – 5,276	1		
303(d) Impaired Segments	TRUE	Eliminate (0)	MULTIPLY	
	FALSE	Sum of Scores (1)		
Streams - 100 foot buffer	TRUE	Sum of Scores (1)		Used to eliminate non-stream areas of the map only.
	FALSE	Eliminate (0)		
Protected Land	TRUE	Eliminate (0)		
	FALSE	Sum of Scores (1)		

STREAM PROTECTION SUITABILITY PARAMETERS - INSIDE THE MPO

Criteria	Options	Score	Operation	Comments
REF Score	0 - 6	0	SUM	Classification: Natural Breaks
	7 - 12	1		
	13 - 22	2		
	23 - 52	3		
TNC Priority	TRUE	1		
	FALSE	0		
Within Growth Area	TRUE	2		
	FALSE	0		
Land Cover	Natural	2		Natural land cover: RRBC map: Deciduous, evergreen, pine plantation
	Other	0		
Proximity to other protected land, within 1 mile (feet)	0 - 206	4		Classification: Geometric Interval; 0-206 class added manually (1/4 of 824)
	207 - 824	3		
	825 - 2372	2		
	2373 - 5276	1		
303(d) Impaired Segments	TRUE	Eliminate (0)	MULTIPLY	
	FALSE	Sum of Scores (1)		
Streams - 100 foot buffer	TRUE	Sum of Scores (1)		Used to eliminate non-stream areas of the map only.
	FALSE	Eliminate (0)		
Protected Land	TRUE	Eliminate (0)		
	FALSE	Sum of Scores (1)		

STREAM RESTORATION SUITABILITY PARAMETERS - OUTSIDE OF THE MPO

Criteria	Options	Score	Operation	Comments
REF Score	0 - 6	0	SUM	Classification: Natural Breaks
	7 - 12	1		
	13 - 19	2		
	20 - 52	3		
TNC Priority	TRUE	1		
	FALSE	0		
Land Cover	Other than	1		Development: NLCD: High, medium, low density and open space. RRBC: Impervious; Natural: same as above
	Developed	2		
	Natural	0		
Proximity to other protected land, within 1 mile (feet)	0 - 206	4		Classification: Geometric Interval; 0-206 class added manually (1/4 of 824)
	207 - 824	3		
	825 – 2,372	2		
	2,373 – 5,276	1		
303(d) Impaired Segments	TRUE	Sum of Scores (1)	MULTIPLY	
	FALSE	Eliminate (0)		
Streams - 100 foot buffer	TRUE	Sum of Scores (1)		Used to eliminate non-stream areas of the map only.
	FALSE	Eliminate (0)		
Protected Land	TRUE	Eliminate (0)		
	FALSE	Sum of Scores (1)		

STREAM RESTORATION SUITABILITY PARAMETERS - INSIDE THE MPO

Criteria	Options	Score	Operation	Comments
REF Score	0 - 6	0	SUM	Classification: Natural Breaks
	7 - 12	1		
	13 - 22	2		
	23 - 52	3		
TNC Priority	TRUE	1		
	FALSE	0		
Land Cover	Other than natural	1		Natural Land Cover: RRBC map = Deciduous, evergreen forest, pine plantation
	Impervious	2		
	Natural	0		
Proximity to other protected land, within 1 mile (feet)	0 - 206	4		Classification: Geometric Interval; 0-206 class added manually (1/4 of 824)
	207 - 824	3		
	825 – 2,372	2		
	2,373 –	1		
303(d) Impaired Segments	TRUE	Sum of Scores (1)	MULTIPLY	
	FALSE	Eliminate (0)		
Streams - 100 foot buffer	TRUE	Sum of Scores (1)		Used to eliminate non-stream areas of the map only.
	FALSE	Eliminate (0)		
Protected Land	TRUE	Eliminate (0)		
	FALSE	Sum of Scores (1)		

WETLANDS MITIGATION PARAMETERS

Datasets	Attribute	Score
Wetland Source Datasets		
National Wetlands Inventory	Presence	1
National Hyrography Dataset 1:24,000 scale		1
100 Year Floodplains		1
Hydric Soils		1
Priority Source Datasets		
Farmed Wetlands	Presence	3
Regional Internet Bank Information Tracking System		3
Impaired Waters (303d)		3
DCR Priority Conservation Sites	B2	4
	B3	3
	B4	2
	B5	1
VaNLA Cores & Corridors	1	5
	2	4
	3	3
	4	2
	5	1
	Corridors	1
Priority Identifier		
Parcel ID number		
Subwatershed HUC		

Appendix B

Priority Class Categories

Stream Protection Priorities

Score Range	Priority Class	Priority
0.0 – 0.45	1	Low
0.45 – 1.13	2	
1.13 – 1.88	3	Medium
1.88 – 3.26	4	
3.26 – 8.0	5	High

Stream Restoration Priorities

Score Range	Priority Class	Priority
0.0 – 0.45	1	Low
0.46 – 1.38	2	
1.38 – 2.57	3	Medium
2.57 – 4.50	4	
4.50 – 8.00	5	High

Wetland Restoration Priorities

Score Range	Priority Class	Priority
1 – 2	1	Low
3 – 4	2	
5 – 6	3	Medium
7 – 9	4	
10 - 14	5	High