# Linking Conservation Priorities to Wetland and Stream Mitigation Decisions

A watershed planning approach for the Stones River, Tennessee

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# Acknowledgements

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# Executive Summary

In 2008 the U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) issued a new rule establishing the "watershed approach" as the primary framework for approving and siting compensatory mitigation projects. The rule requires the Corps to identify and use "appropriate" watershed plans to inform Section 404 permit decisions when such plans are available. The watershed approach, as articulated in the 2008 rule, does not require that a watershed plan be developed; however, a watershed approach must still be used to inform decisions in absence of a plan. A watershed approach is defined as "an analytical process for making compensatory mitigation decisions that support the sustainability or improvement of aquatic resources in a watershed. It involves consideration of watershed needs, and how locations and types of compensatory mitigation projects address those needs" (332.2).

The rule also outlines the considerations and information needs that must inform the watershed approach. It emphasizes the importance of identifying sites that support the long-term sustainability of aquatic resources. In addition, it states that the watershed approach should consider "habitat requirements of important species [and] habitat loss and conversion trends…" (332.3(c)(2)).

The Nature Conservancy (TNC) and the Environmental Law Institute (ELI) received funding from the Doris Duke Charitable Foundation in early 2009 to undertake a pilot watershed approach project in Tennessee that meets the definition of a watershed plan outlined in 2008 compensatory mitigation rule. ELI and TNC saw the project as an opportunity to apply our collective policy and science expertise to the compensatory mitigation program, and to do so in partnership with the Corps, EPA, and other key partners.

The overarching goal of this pilot effort was to demonstrate how species of conservation need and their habitats, particularly as identified in the Tennessee State Wildlife Action Plan (SWAP), can be utilized as part of a watershed approach to develop a conservation framework for wetland and stream mitigation decisions.

TNC staff worked with the Nashville District Corps of Engineers regulatory branch and the Tennessee Department of Environment and Conservation (TDEC) to select an appropriate watershed at the 8-digit HUC (hydrologic unit code) scale to serve as Tennessee's pilot watershed. The Stones River watershed in middle Tennessee was identified due to the significance of its remaining native plant and animal habitats, historic and current resource impacts and land conversion rates, and future land development trends.

The project approach was designed to provide watershed-scale analyses that the Corps and TDEC can use in making individual permit decisions regarding compensatory mitigation. The plan outlines a conservation framework for executing mitigation decisions by identifying spatially explicit wetland and stream restoration, enhancement, and preservation priorities. The spatial relationship between these priorities and other resource values such as water quality concerns, recreational opportunities, historic and agricultural resources, is also addressed.

Our hope is that the priorities identified through this analysis will be valuable to guiding other regulatory and non-regulatory decision making. TNC is continuing its efforts with the Nashville District Corps, TDEC, and other key partners to interpret the results of this plan, and share datasets and other information, which can be utilized during their decision-making processes.

This watershed plan demonstrates the application of several different nationally available spatial datasets in conjunction with data typically available in State Wildlife Action Plans and Natural Heritage datasets. These national datasets include the National Wetland Inventory, the National Hydrography Dataset Plus, and GAP land cover classifications. The application of these datasets collectively for the Stones River watershed plan represents a major step forward in the integration of conservation data within stream and wetland mitigation reviews in Tennessee. Field verifications were outside the scope of this plan and are necessary to fully evaluate the appropriateness of specific sites in the mitigation context.

The results of this pilot effort for Tennessee demonstrate that a watershed approach to compensatory mitigation can help achieve habitat conservation needs identified in the Tennessee State Wildlife Action Plan as well as promote the restoration and protection of other important resource values. The Stones River is a significant watershed in Tennessee's history; contains large expanses of prime farmland; provides drinking water for over 250,000 people and annual recreational opportunities for millions; and provides important habitats for globally rare plant and animal species. Land development patterns and future trends suggest that resource impacts requiring mitigation in the watershed are likely to continue. Applying this conservation framework to mitigation decisions in the future may make significant contributions to the long-term sustainability of aquatic resources in the Stones River watershed and all the benefits they provide.

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# Chapter 1: Introduction

## The Watershed Approach to Compensatory Mitigation

The objective of the Clean Water Act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's Waters" (EPA 2008). Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into waters of the United States, including wetlands. The 404 program is guided by the goal of "no overall net loss" of aquatic resources, both in acres and functions. Before a permit for any activity can be issued, the activity must undergo a review that seeks to avoid any impacts to aquatic resources.

If these impacts cannot be avoided, then the project must seek to minimize adverse impacts. Finally, if adverse impacts are unavoidable, compensatory mitigation to offset the impacts is required (EPA 2008). The U.S. Army Corps of Engineers or the approved state authority determines the type and method of compensatory mitigation required, which may include restoration, creation, enhancement, or preservation.

Traditionally, evaluations of potential impacts have been conducted on a project-specific basis, which has limited the overall effectiveness of mitigation efforts to compensate for wetland losses (ELI 2004, NRC 2001). In their 2001 review of compensatory mitigation nationwide, the National Resource Council recommended the modification of spatial and temporal boundaries so that "site selection for wetland conservation and mitigation" can be "conducted on a watershed scale." (ELI 2004, NRC 2001).

In March 2008, the U.S. Army Corps of Engineers (Corps) and the U.S. Environmental Protection Agency (EPA) issued a final rule formalizing a new approach to the federal wetland compensatory mitigation program. Drawing on recommendations from the 2001 National Research Council report, the rule required the Corps to utilize a "watershed approach" for approving and siting compensatory mitigation projects. This approach requires the utilization of existing appropriate plans or other information that is available to guide decision-making in a watershed context. The watershed approach represents a sea-change in the federal regulatory program's approach to compensatory mitigation, moving from a long-standing preference for on-site, in-kind compensation to a more flexible approach for approving and siting mitigation projects that relies upon a science-based analysis of watershed needs.

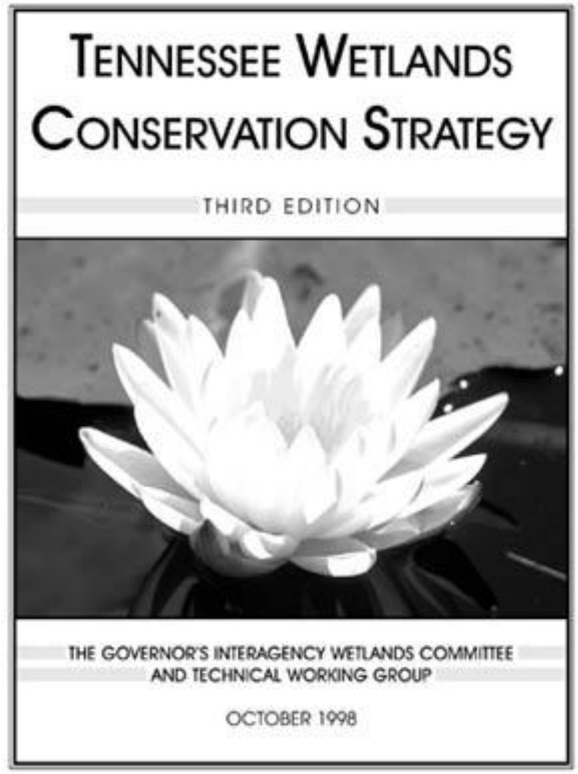
*The ultimate goal of a watershed approach is to maintain and improve the quality and quantity of aquatic resources within watersheds through strategic selection of compensatory mitigation sites.*

§332.3, Compensatory Mitigation for the Losses of Aquatic Resources, Final Rule
U.S. Department of the Army and
U.S. Environmental Protection Agency
2008

## Compensatory mitigation in Tennessee

The Clean Water Act also delegates authority to the states to review projects that require federal 404 permits to verify that the project will not violate state water quality standards. These verifications are known as "401" Water Quality Certifications after Section 401 of the Clean Water Act. The Tennessee Department of Environment and Conservation's Division of Water Pollution Control is responsible for administering the State's delegated federal authorities as well as additional State authorities articulated in the Tennessee Water Quality Control Act of 1977 (TWQCA) (TDEC 2004). The purpose of the TWQCA is to abate existing pollution, prevent future pollution, and plan for future use of water resources, and the Act outlines the authority to grant permits for "activities and discharges" to waters of the State (TDEC 2004).

*It shall be the goal of the State of Tennessee to provide the maximum practicable wetlands benefits to Tennessee and her citizens by conserving, enhancing, and restoring the acreage, quality, and biological diversity of Tennessee's wetlands.*




The rules promulgated under the TWQCA require that permit applicants consider avoidance and mitigation. Activities that result in lost resource value to waters of the state in one location must provide sufficient mitigation to result in "no overall net loss of resource value" (ELI 2007). Neither the Section 401 Water Quality Certification nor the Tennessee state Aquatic Resource Alteration Permit (ARAP) may be issued unless the avoidance, minimization, and/or mitigation requirements are fulfilled. Wetland resource values in Tennessee are protected by the same water quality standards and designated uses for surface waters (ELI 2007).

Tennessee has an established Interagency Review Team (IRT). The IRT is a team of state and federal agencies that is chaired by the Corps and includes the Tennessee Department of Environment and Conservation, Tennessee Wildlife Resources Agency, Tennessee Valley Authority, U.S. Fish and Wildlife Service, and the U.S. Department of Agriculture Natural Resources Conservation Service. The IRT is charged with overseeing the establishment and management of mitigation banks and in-lieu fee programs statewide. In 2000, Tennessee adopted revised rules requiring that state permits for stream alterations (ARAPs) also not result in a net loss of water resource value. Through their respective authorities, the Corps and TDEC both require compensatory mitigation for permitted stream and riparian wetland impacts (TDEC 2004, ELI 2007). Permit applicants have the option to meet mitigation requirements by paying into an in-lieu fee program – the Tennessee Stream Mitigation Program – which is operated by the non-profit Tennessee Wildlife Resource Foundation. This program invests the funds in mitigation activities to accomplish the state and federal no-net-loss goals.

The Tennessee Wetlands Conservation Strategy was first published in 1994. The purpose of the original strategy document and subsequent revisions is to provide a "blueprint" for guiding decisions, actions, and research to better "understand and conserve Tennessee's wetland resources" (TDEC 1998). Characterizing the State's wetland resources, measuring wetland gains and losses more accurately, and conserving resource values - including through better execution of mitigation programs - are major objectives of the strategy.

The Tennessee Wetland Acquisition Act, first passed in 1986, authorized the Tennessee Wildlife Resources Agency (TWRA) to purchase wetlands from willing sellers for permanent preservation and restoration (TWRA 2005). The wetland acquisition program helps conserve a variety of resource values (see examples from Kusler 2006). Wetlands acquired by TWRA are evaluated according to a number of resource criteria including, but not limited to, size, quality, value to wildlife, value to endangered species, opportunities for public use, diversity, and other considerations such as the degree of threat from surrounding or future land uses (TWRA 2005).

### Examples of Wetland Values (*from* Kusler 2006)

Flood storage and conveyance

Erosion control

Sediment load reduction in reservoirs and streams

Water pollution prevention and treatment

Crop and timber production

Groundwater recharge & discharge

Habitat for fish, mammals, reptiles, amphibians, and birds

Habitat for endangered and threatened species

Scenic beauty

Recreational opportunities

Historical, archaeological, and heritage values

Educational and research opportunities

Atmospheric gas exchange potentially important to moderation of climate change impacts

## Tennessee's Wildlife Action Plan as a mitigation planning framework

This project focused on applying Tennessee's Comprehensive Wildlife Conservation Strategy (State Wildlife Action Plan) as a framework for the watershed approach to advance mitigation planning. Currently, State Wildlife Action Plans nationwide play a very limited role in directing compensatory mitigation expenditures, despite the fact that utilizing these plans could have potentially significant conservation outcomes while also promoting the restoration of other important stream and wetland values (ELI 2003).

State Wildlife Action Plans include information on the distribution and abundance of "Species of Greatest Conservation Need," the spatial extent and distribution of their habitats, and descriptions of problems affecting these species and their habitats. Utilizing the information in these plans can help decision-making with respect to avoiding and minimizing impacts to sensitive habitats, as well as guiding restoration activities in a manner that assists with habitat conservation and recovery goals. Historically, mitigation decisions have been made without such a framework, and studies have found that this project-by-project approach has not resulted in cumulative habitat or other functional gains over time. The data available in State Wildlife Action Plans allows a more thorough understanding of key habitat features necessary for the maintenance of significant species populations found within a given landscape context.

One of the primary goals of the State Wildlife Action Plans is to develop conservation strategies that can help protect wildlife in a proactive manner and lessen the need for future federal listings. Several states developed detailed information on species and their habitat distributions within their respective jurisdictions. In Tennessee, the data utilized in the State Wildlife Action Plan, completed in 2005, included existing species distribution records, habitat preferences for every species covered by the plan, and satellite-based land use/land cover data linked to NatureServe ecological systems to map habitat distributions statewide.

The methodology developed in Tennessee — linking species to their habitats and mapping habitat distributions — was well suited for experimenting with State Wildlife Action Plan (SWAP) data and how it can be used to inform mitigation decisions. Although the emphasis of the 2005 SWAP was on animal species deemed of greatest conservation without Federal listing designation, the State of Tennessee also compiled the same information on Federally listed threatened and endangered animal species. In the years following the completion of the first SWAP, The Nature Conservancy worked with the Tennessee Natural Heritage Program to compile information on State and Federal rare, threatened and endangered plant species, linking these plants to the same ecological system classification completed for animals.

Previous techincal reviews of mitigation outcomes in Tennessee, particularly with regards to wildlife values, have shown limited success in achieving wildlife benefits. These results have been attributed to problems with siting, intensive surrounding land uses, and lack of understanding of habitat requirements (Morgan and Roberts 1999). Difficulties quantifying the relationships between

biodiversity and other important freshwater resource values complicate objective setting and management decisions for streams and wetlands. This complexity requires that resource managers collaborate to apply existing information and guide mitigation efforts towards achieving better biodiversity outcomes for freshwater systems (Dudgeon 2010). Ideally, decisions regarding impacts to biodiversity will be made in a landscape context to ensure land use activities, in total, minimize the loss of significant habitats and connect existing protected areas (ELI 2003).

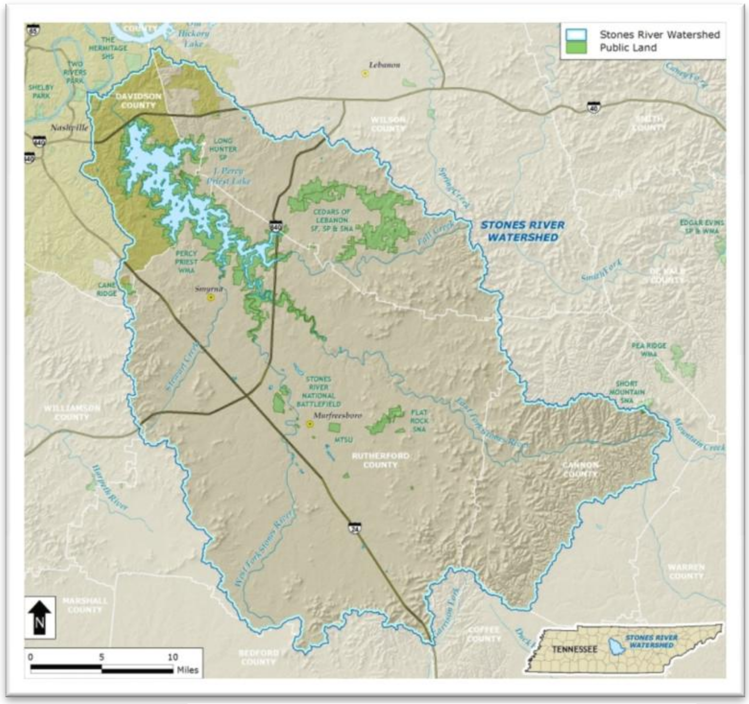


Figure 1. The Stones River watershed.

## Overview of the Stones River watershed planning effort

In December 2009, TNC worked with partners at the Corps Nashville District and the Tennessee Department of Environment and Conservation-Division of Water Pollution Control to help understand which watersheds in Tennessee would most benefit from the piloting of a "watershed approach to mitigation." Together, TNC and the Corps looked at a number of variables, including state and federal permit activity, the State Wildlife Action Plan, state data on rare plant distributions, the National Wetland Inventory, the Tennessee 303d Water Quality List, 2001 land use/land-cover data, and hydric soils maps. Following this review, we selected the Stones River watershed in Tennessee, southeast of Nashville, as our test area to pilot a new watershed approach planning framework.

The Stones River watershed (Figure 1) is located in one of the fastest urbanizing landscapes in the state, yet still retains globally rare and significant terrestrial and aquatic resources. These include the Ashy darter, streamside salamander and limestone glade plant communities, as well as 30 other endemic plant communities. Applying the watershed approach to mitigation decisions in the Stones during the next decade will lead to improvements in the functioning of the watershed and in water quality, and will promote the conservation of rare species and habitats and other important social values in the local communities.

TNC, ELI, and the Nashville District of the Corps kicked off the pilot study for the Stones River watershed with a one-day workshop for key partners in April 2010. The Corps played a strong leadership role in planning and carrying out the meeting. The agency sent out the invitation on behalf of TNC, ELI and itself and offered welcoming remarks to participants. Thirty participants attended the workshop to learn about the project and to provide input on sources of information (e.g. plans and data) that would support the watershed analysis. Workshop participants included members of the IRT, relevant state agencies and local governments not represented on the IRT, and relevant NGOs and academic institutions (for a list of participants, see Appendix 1).

After the April 2010 kick-off meeting, TNC began working one-on-one with several of the workshop participants and other local or technical stakeholders that were identified by the group as key contributors. During the summer and fall of 2010 and spring of 2011, TNC held meetings with the citizen-led Stones River Watershed Association, county and municipal storm water program leaders, staff of local government parks and greenways programs, private engineers who have led local planning and restoration projects, and academics involved in the development of Tennessee's wetlands classifications and field guide materials (see Appendix 1).

Meeting with these local stakeholders informed our understanding of which constituencies are directly and indirectly involved with mitigation issues and expanded our appreciation for the different needs a watershed plan could address. The kick-off workshop and stakeholder interviews helped build a strong foundation for a comprehensive planning framework that demonstrates how species and their habitat requirements can be considered along with other stream and wetland values as compensatory mitigation decisions are made. The members of the Tennessee IRT played an important technical advisory role throughout the project.

In addition to state and local stakeholder engagement, TNC staff participated in a new "Mitigation Learning Network" during the entire course of the project. The network enabled access to important literature and opportunities for dialogue with, NGO, state, and federal experts to understand the strengths and limitations of various planning approaches nationwide. Network participation allowed our implementation plan for the Stones to be tailored to the local level and at the same time be relevant to the national conversation about improving mitigation outcomes.

## Project Objectives

The Stones River watershed planning effort was guided by three primary objectives:

(1) Develop a watershed plan for the Stones River Watershed that priorities for wetland and stream restoration and preservation;

(2) Articulate a framework for the watershed approach that supports sustainable and ecologically effective mitigation; and

(3) Align mitigation priorities with local planning and biodiversity conservation goals.

To achieve these project objectives, TNC focused on several key planning elements:

- Improving the understanding of both the significance and spatial distribution of biodiversity targets in the watershed;
- Connecting information on biodiversity priorities to other existing watershed goals (e.g., water quality); and
- Identifying the most appropriate mitigation techniques and spatial arrangement of implementation to achieve sustainable ecological benefits.

The project objectives and planning efforts were designed to provide the type of data and guidance the Corps and TDEC could utilize to improve decisions regarding avoidance, minimization, and on-site and off-site mitigation, including the use of banks and in-lieu fee programs. Stakeholders on the Interagency Review Team expressed a strong desire to have the habitat requirements of species of greatest conservation need incorporated more directly into permit review and mitigation decisions. The plan was designed to provide this conservation framework and watershed context for considering individual permit impacts. These types of general frameworks for achieving management objectives tend to have fewer complications when implemented compared to those that follow stringent prescriptions in advance (White and Shabman 1995).

The 2008 federal compensatory mitigation rule outlines specific watershed approach considerations, and defines a watershed plan as "a plan developed by federal, tribal, state, and/or local government agencies or appropriate non-governmental organizations, in consultation with relevant stakeholders, for the specific goal of aquatic resource restoration, establishment, enhancement, and preservation. A watershed plan addresses aquatic resource conditions in the watershed, multiple stakeholder interests, and land uses" (332.2). These considerations, and the definition of a watershed plan, guided the acquisition of necessary datasets and other information, as well as the direction of all data analyses performed in support of the plan's development. Chapters 2 and 3 of this report provide descriptions of the Stones River watershed according to the planning considerations. Chapters 4 through 7 describe how this information was utilized to develop a conservation framework for executing future mitigation decisions.

## Watershed Approach Considerations

- Habitat requirements of important species
- The protection and maintenance of terrestrial resources
- Habitat loss or conversion trends
- Sources of watershed impairment
- Current and projected development trends
- The requirements of other regulatory and non-regulatory programs that affect the watershed
- Locational factors

§332.3, Compensatory Mitigation for the Losses of Aquatic Resources, Final Rule

# Chapter 2: Resource values of the Stones River Watershed

## Physiographic Setting

The Stones River watershed is located in the Central Basin physiographic region of Tennessee, a region dominated by limestone geology in the geographic center of the State (Figure 2). The Central Basin is divided into two primary subregions, the Outer and Inner Central Basin. The majority of the 921 square mile Stones River watershed falls within the Inner Central Basin, with the upper headwaters of the system emerging from the Outer Central Basin. The Outer Central Basin, which falls within 500 to 1200 feet of elevation, is characterized by more hilly and rolling terrain and slightly higher slopes and elevations.

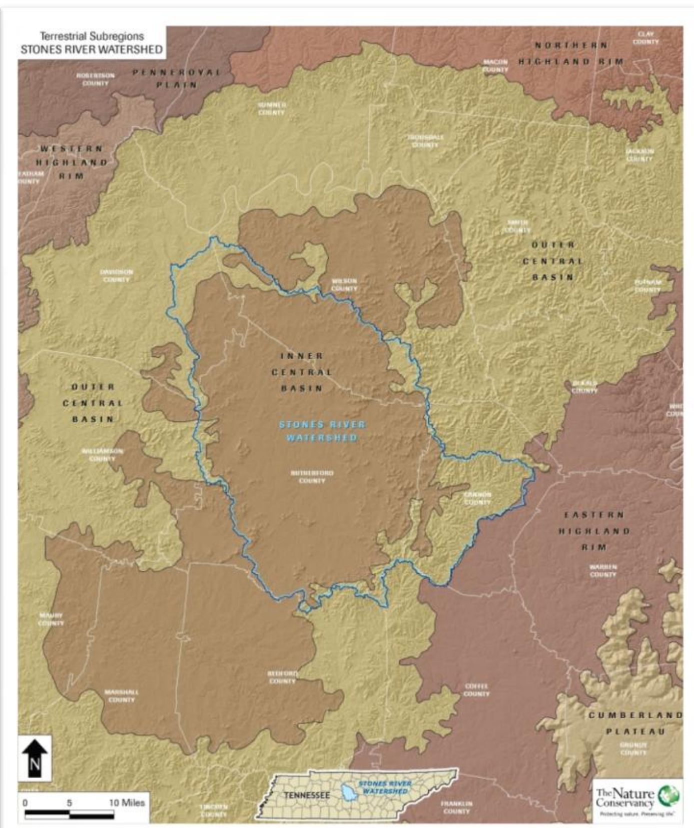



Figure 2. The physiographic subregions of Middle Tennessee.

In the Inner Central Basin (500-900 feet elevation), exposed outcrops of Ordivician-aged limestone bedrock are common, soils tend to be thinner, and sinkholes are prevalent (Wolfe et. al 1997, Arnwine and Denton 2001).

This limestone-dominated landscape, also referred to as a "karst" landscape, results in very complex relationships between surface and ground water ecosystems. The surface-ground water connections are constantly evolving in karst systems as diffuse flows through small bedrock openings change to conduit-flows through dissolved channels within the limestone, sending surface water to underground channels which emerge once again at surface spring discharges (Martin and White 2008). Over longer periods of time, as more surface flow is diverted underground, stream channels may become less visible on the land surface and are replaced by sinkhole features which funnel run-off directly to conduits into aquifers below (Wolfe et al. 1997, Martin and White 2008).

The Outer Central Basin region tends to have larger conduits that the Inner Central Basin due to the greater topographic relief. However, the Inner Central Basin contains very productive aquifers with zones of strong conduit flow and large cave systems have developed in some areas, including the Snail Shell Cave system located within the Stones River Watershed (Wolfe et al. 1997). Figure 3 shows a cross-section of the Inner Central Basin's hydrogeology. This figure demonstrates the interconnections of surface and ground water systems and the important flow interchanges between the two.

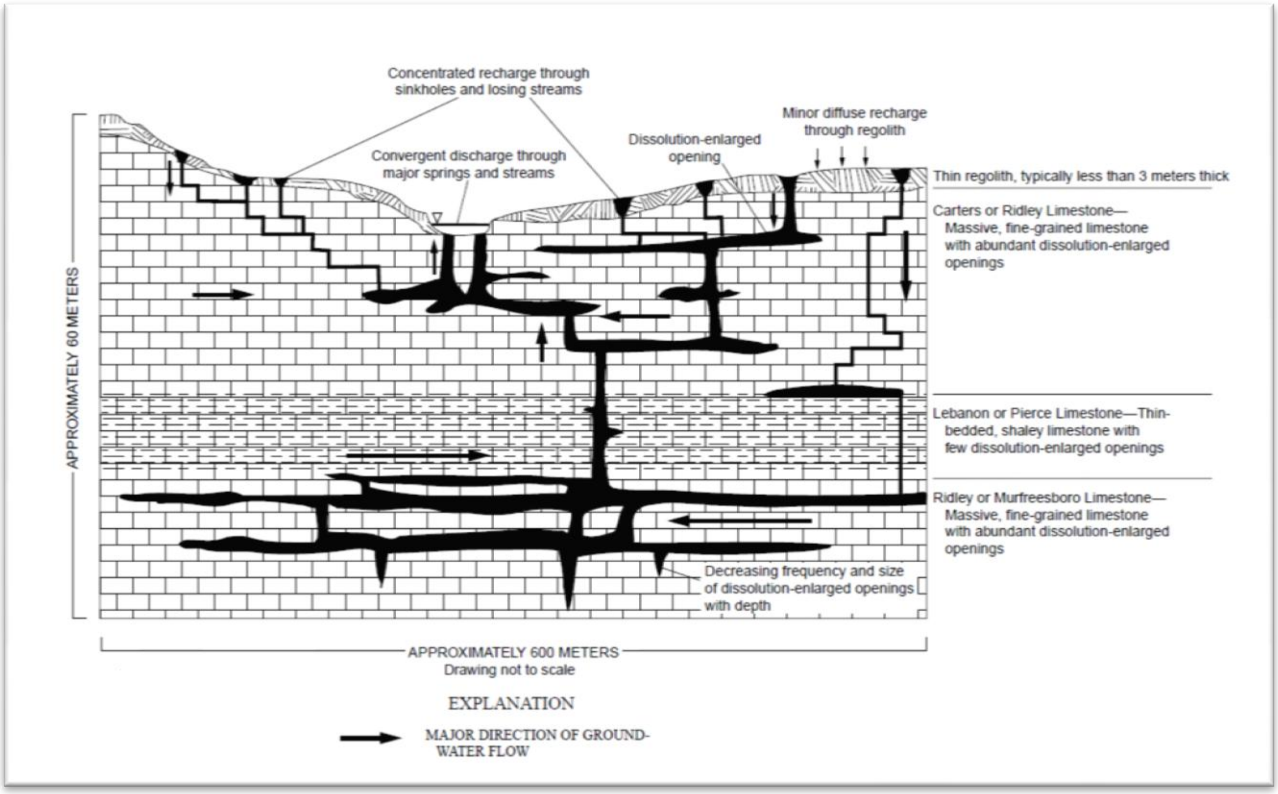



Figure 3. Generalized hydrogeologic section of the Inner Central Basin of Tennessee. From Wolfe, et al. 1997.

## Freshwater and Wetland Resources

The karst hydrogeology of the Outer and Inner Central Basin results in a diverse and complex spatial distribution of stream and wetland resources within the Stones River Watershed. The physical features of stream and wetland habitats are also strongly influenced by the dynamic processes of karst systems. The Stones River is a tributary to the Cumberland River system and is characterized by three major branches: the East Fork, West Fork, and Middle Fork. The Middle Fork of the Stones River flows into the West Fork before the West and East Forks merge downstream. The main forks of the Stones are small, low gradient rivers which meander through the limestone-dominated landscape . There are over 1000 miles of small river and streams in the watershed, all of which have a variety of habitat features including limestone bedrock and rubble, silty substrates, and gravel riffles. The headwater streams emerging from the Outer Central Basins are slightly higher in gradient and have less exposed bedrock and more consistent gravel coverage within the streambeds (TDEC 2000, Arnwine et al. 2005, Smith et al. 2002, Buckner et al. 2002).

The small headwater streams originating along the Outer Central Basin in the Stones watershed have a slightly higher sinuosity and are fed by springs. Streams in the Inner Central Basin are also spring-fed, however, stream flows are highly seasonal in nature, with dry isolated pools and surface flow loss to subterranean streams coming during the low flow periods of August through October. The fauna which utilize these stream habitats are adapted to these conditions, which are also very nutrient rich due to the parent bedrock (Arnwine et al. 2005).

The Tennessee Department of Environment and Conservation's Division of Water Pollution Control (TDEC-WPC) is responsible for overseeing the application of an antidegradation policy into water permit decision-making. As part of this policy, TDEC-WPC identifies "Exceptional Tennessee Waters" which meet the characteristics outlined in state rules. These general characteristics include good water quality, important ecological values, valuable recreational uses, and outstanding scenery (TDEC 2011). Table 1 provides a listing of the Exceptional Tennessee Waters identified in the Stones River watershed. The basis for inclusion for most of these streams is a significant ecological feature.

Table 1. Exceptional Tennessee Waters located within the Stones River watershed. Tennessee Department of Environment and Conservation, Division of Water Pollution Control (WPC), 2011.

| Waterbody | County | Description | Basis for Inclusion |
|---|---|---|---|
| Parchcorn Hollow Branch | Cannon | From East Fork Stones River to headwaters. | State endangered Brawley's Fork Crayfish. |
| Rockhouse Branch | Cannon | From East Fork Stones River to confluence with intermittent tributary. | State endangered Brawley's Fork Crayfish. |
| East Fork Stones River | Cannon | From Hwy 64 to headwaters. | State endangered Brawley's Fork Crayfish |
| Rush Creek | Cannon | From East Fork Stones River to headwaters. | State endangered Brawley's Fork Crayfish |
| East Fork Stones River Unnamed Tributary | Cannon | Headwater tributary from East Fork Stones River to origin. | Breeding population of state endangered Brawley's Fork Crayfish confirmed on 4-12-11. Breeding poulation of Short Mountain Crayfish which has global and state vulnerable status also confirmed 4-12-11. Candidate headwater reference stream. |
| West Fork Stones River | Rutherford | From Panther Creek to headwaters. | Exceptional biological diversity. WPC ecoregion reference stream for 71i. |
| East Fork Stones River | Rutherford | From Cripple Creek to unnamed tributary near Halls HIll. | State threatened Water Stitchwort. |
| West Fork Stones River | Rutherford | From Sinking Creek to Lytle Creek. | State threatened Water Stitchwort. |
| West Fork Stones River Unnamed Tributary | Rutherford | From West Fork Stones River to Origin | State threatened Yellow Sunnybell |
| West Fork Stones River Unnamed Tributary | Rutherford | From West Fork Stones River to origin. | State threatened Yellow Sunnybell, Sunnybell Cedar Glade State Natural Area. |
| Hurricane Creek | Davidson | From Stones River to Holloway Branch. | State threatened Yellow Sunnybell. |
| Suggs Creek | Davidson | From Stones River to Vivret Creek | State threatened Yellow Sunnybell. |
| West Fork Hamilton Creek | Davidson | From Stones River (J. Percy Priest Reservoir) to Bell Road. | State threatened Yellow Sunnybell |

Riparian and stream areas provide significant habitat for terrestrial plants and wildlife as well. Many species either travel through or spend portions of their life cycles in riparian corridor habitats. The regions between riparian and upland zones are dynamic and often contain small habitat patches which support a diverse array of plants and terrestrial animal species (Smith et al. 2008, Fischer 2001, FISRWG 1998).

In addition to stream and river resources, the Stones watershed includes a freshwater reservoir constructed by the Corps. J. Percy Priest dam was completed on the Stones River in 1967 at a downstream location near the confluence of the Stones with the Cumberland River. The reservoir pool covers approximately 14,200 acres, has 213 miles of shoreline, and is 42 miles long at summer pool levels. (USACE 2007). Percy Priest was authorized by Congress primarily for recreation purposes – the first authorization of this kind in the nation - with flood control and hydropower production as additional purposes. Since its completion, the reservoir has also grown into a significant source of municipal water supplies for some of the fastest growing communities in the State. Finally, a number of freshwater ponds are located throughout the watershed, which are largely artificial impoundments created for agricultural purposes (TDEC 2000).

The National Wetland Inventory (NWI), produced by the U.S. Fish and Wildlife Service, was completed for the Stones River watershed in the mid-1990s. In addition to mapping the riverine, lake, and pond resources in the watershed, the NWI identifies two primary wetland types in the watershed: freshwater emergent and freshwater forested/shrub wetlands. The forested/shrub wetlands are dominated by broadleaf deciduous vegetation, and both types are noted to have the full range of hydrologic regimes (temporarily, seasonally, semi-permanent, and permanent) associated with them at different locations in the watershed. Figure 4 shows the distribution of NWI-mapped wetlands in the watershed, as well as the spatial extent of hydric soils as mapped by the U.S. Department of Agriculture Natural Resources Conservation Service Soil Survey Geographic Database (SSURGO).

Many of the wetlands mapped in the Stones River watershed by the NWI tend to appear isolated and disconnected from one another, and do not necessarily correspond to mapped areas of hydric soils. Experts familiar with the wetlands in the Central Basin of Tennessee confirmed that both the NWI and SSURGO maps tend to underestimate the spatial extent and context of wetland habitats observed in the field (Morgan, personal communication 2010). Most of the wetland habitats common to this physiographic region are less than one acre in size, and hydric soils generally are not mapped at sizes less than five acres. NWI also underestimates the number and extent of headwater slope wetlands, even though these are the most common in number if not overall acreage (Morgan, personal communication 2010). Recent surveys of the Stones River National Battlefield Park documented fifteen wetlands (depression, slope, and riverine) in the field where the NWI previously identified only four. The primary function performed by these wetlands was breeding habitat for amphibians (Roberts and Morgan 2006).

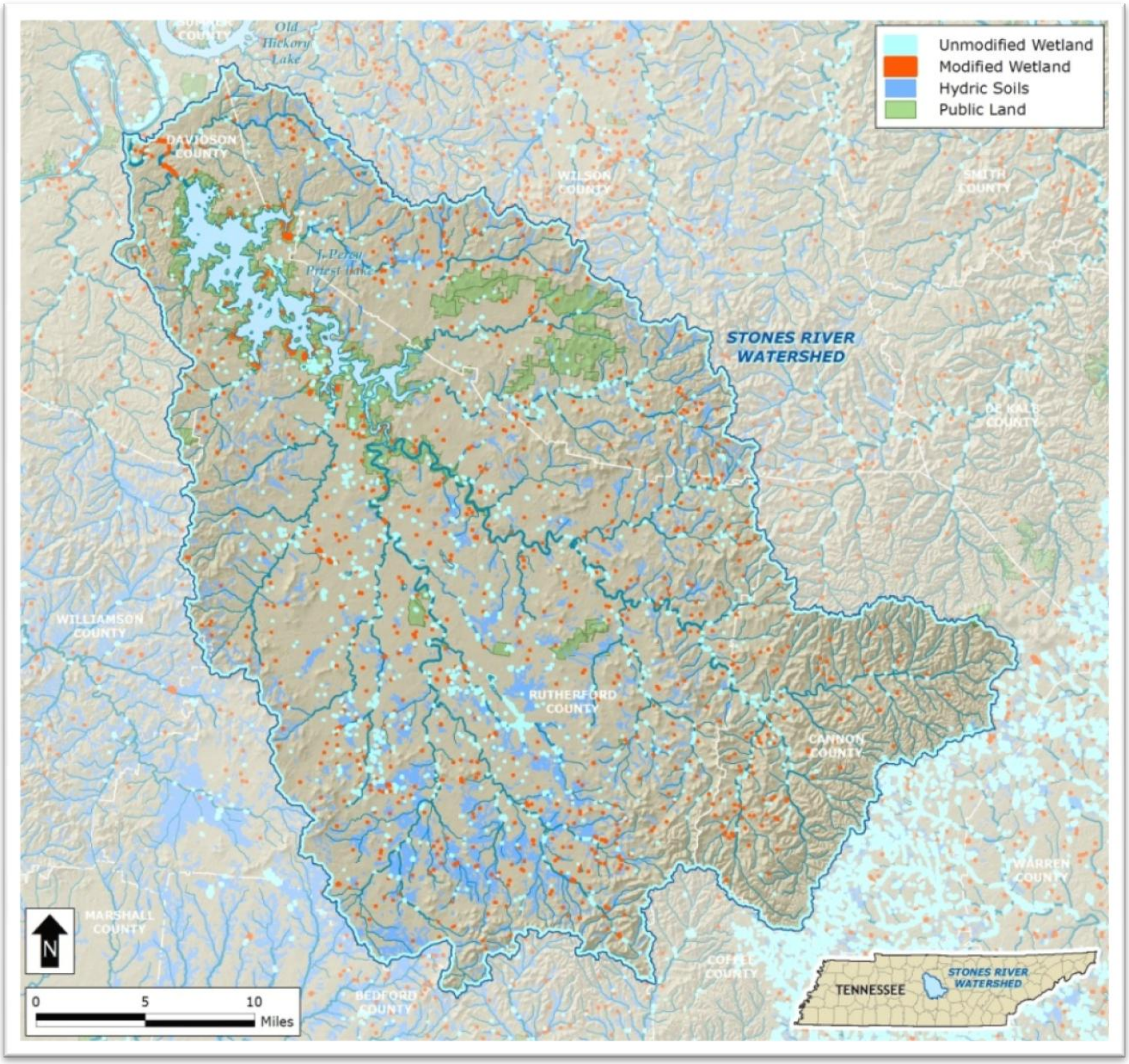



Figure 4. Distribution of NWI mapped wetlands, SSURGO hydric soils, and public lands in the Stones River watershed.

## Terrestrial and subterranean resources

The Central Basin in Tennessee, a sub-section of the Interior Low Plateau ecoregion, was originally dominated by forest systems, but also contained extensive prairies and oak savannas (Rollins 1997, TNC 2001). Today's hardwood forests are primary dominated by oak, hickory, maple, and ash species. Eastern red cedar (*Juniperus virginiana*) is a common evergreen species in the understory of forests and at the perimeter of rock outcrops and fields dominated by broomsedge (*Andropogon virginicus*). Small patch community types including calcareous seeps, sinkhole swamps, and limestone "glades" are interspersed throughout the landscape (TNC 2001). In the last two hundred years, the Central Basin, including the area incorporated by the Stones River watershed, has been largely converted to agricultural land use, although some areas of contiguous forest remain (TNC 2001, Arnwine and Denton 2001).

The Central Basin contains the highest concentration of limestone glade habitats east of the Mississippi River (Quarterman et al. 1993, Baskin and Baskin 1986). Glades are considered "edaphic climax" communities, and they support a variety of rare and endemic plant species (Quarterman 1989, Norton 2010). The open characteristics of these habitats also support a distinct set of amphibian and reptile species (Arnwine and Denton 2001). The karst features of the Central Basin result in a diverse array of subterranean habitats, both "dry" caves and aquatic systems. This abundance of cave habitats, with their relatively stable environmental conditions over evolutionary time, has also spawned a high degree of narrow endemism; many cave species are known from only one system (TNC 2001).

A Cedar Glade in the Stones River watershed.
Photo by Byron Jorjorian

# Conservation Priorities

## Regional scale conservation plans

The Middle and Eastern sections of Tennessee are known internationally for their highly significant karst resources. Karst ecosystems worldwide support highly diverse floras and faunas and tend to have high numbers of endemic species. The study of the subterranean biodiversity of karst systems has only just become an area of research interest in recent decades (Martin and White 2008).

During the last decade, The Nature Conservancy, in collaboration with many state, federal, and private partners, has led the development of Ecoregional Conservation Plans across the United States. These plans were designed to develop "portfolios" of conservation sites built from known distributions of significant plant, animal, and natural communities within a given ecoregion. The portfolios assist The Nature Conservancy and our partners direct resources towards those locations most important for achieving the long-term conservation of native plant and animal resources (TNC 1996).

Two planning efforts have been completed for the ecoregions in which the Stones River watershed is located. The Interior Low Plateau Ecoregional Plan identified native plants, plant communities, terrestrial and aquatic animals (vertebrates and invertebrates) for conservation emphasis, and set goals for achieving conservation objectives. For species known to be endemic to the ecoregion, a goal of ten secure occurrences was set for their conservation, and those species with very limited distributions outside the ecoregion, a goal of seven secure occurrences was set (TNC 2001).

A second planning effort focused specifically on aquatic species and community types in the Southeastern United States, and included the Tennessee and Cumberland River systems. This effort did a more thorough assessment of existing data on aquatic species and their habitats using "ecological drainage units" as the basis for setting conservation goals. (Smith et al. 2002).

Collectively these plans covered 67 vascular plant species, three non-vascular plants, 174 plant communities, three amphibians, two birds, three mammals, 2 reptiles, 52 fish, 47 crustaceans, 162 insects, 68 mollusks, and 120 aquatic systems. Many of the crustaceans and insects are subterranean species with very limited distributions. Portfolio sites for terrestrial, aquatic, and subterranean species and systems were all identified within the Stones River watershed and included multiple cedar glade and cave and the East Fork of the Stones River.

## Tennessee State Wildlife Action Plan

The Tennessee Comprehensive Wildlife Conservation Strategy (also known as the State Wildlife Action Plan, or "SWAP") was completed in 2005. The Nature Conservancy worked closely with the Tennessee Wildlife Resources Agency to assist in the completion of the SWAP. In selecting the terrestrial, aquatic, and subterranean animal species for inclusion in the SWAP, planning teams utilized the data from previous ecoregional planning efforts and other landscape-scale plans such as those developed by the Joint Ventures for bird conservation (TWRA 2005)

To support this planning effort, a GIS and relational database management system (RDBMS)-based system was developed to manage the large amounts of data on Species of Greatest Conservation Need (SGCN), their habitats, and problems affecting these species and habitats.

At the time of its initial development, the SWAP database included over 28,000 raw SGCN element occurrence records, compiled from TN Division of Natural Heritage (TN-DNH) and a number of other governmental and academic datasets. Terrestrial, aquatic, and subterranean habitats were classified and mapped, and preferences of faunal species for various types of habitats, including wetlands, were evaluated. The database utilized scoring indexes of species rarity, occurrence viability, habitat preference, and spatial proximity to allow the spatially explicit identification and prioritization of habitats critical for the conservation of SGCN fauna throughout the state.

The emphasis of the 2005 SWAP was on animal species deemed of greatest conservation without Federal listing designation. However, Tennessee also compiled information on Federally listed threatened and endangered species and included it in the RDBMS. In addition, The Nature Conservancy and the Tennessee Natural Heritage Program have worked to compile data on State and Federal rare, threatened and endangered plant species, linking these plants to the same ecological system classification completed for animals. Appendix 2 provides a list of all the plant and animal species of conservation interest known to occur in the Stones River watershed now contained within the RDBMS system.

## Existing conservation lands

The Stones River watershed does not have an extensive network of protected conservation lands. In the last three decades efforts by federal, state and local authorities and non-profit organizations have increased conservation land acreage, improved land management, and expanded opportunities for public education and recreation.

The largest contiguous acreage of public lands consists of the Cedars of Lebanon State Forest and Cedars of Lebanon State Park in the northeastern sector of the watershed (Figure 4). This land was first purchased in 1935 under the Federal Resettlement Administration (TDEC 2011). Together these constitute approximately 10,400 acres of land protected for native oak-hickory-cedar forest, glades, barrens, and karst conservation purposes as well as public education and recreation.

The largest contiguous acreage of public lands surrounds the perimeter of Percy Priest reservoir. Within these 19,460 acres are a number of State Natural Areas including Elsie Quarterman Cedar glade and Fate Sanders Barrens, managed for their cedar glade resources (USACE 2007). Long Hunter State Park, managed by TDEC, and Percy Priest Wildlife Management Area, managed by TWRA, are also located within the perimeter lands.

Stones River National Battlefield and Barfield Crescent Park are also located in the watershed in the city of Murfreesboro, and both have active natural resource management programs. Barfield Crescent Park contains a 330 acre "Wilderness Area" protecting the forest and karst resources on the property and educating the public about the areas native plants and animals, karst features, and freshwater resources (Murfreesboro Parks and Recreation 2009).

Other conservation lands purchased for cedar glade protection by The Nature Conservancy and the State of Tennessee include Sunnybell, Overbridge, Stones River, Gattinger's, Manus Road, and Flat Rock. Flat Rock Cedar glades and barrens preserve is the largest of these at almost 850 acres.

## Recreational, historic, and agricultural resources

Most of the lands set aside for conservation purposes in the Stones River watershed also provide many recreational opportunities. The Percy Priest area provides hunting, fishing, swimming, camping, and hiking. Four commercial marinas are located on the reservoir that provide boating access, and the Corps estimates that 6 to 7 million people visit each year, with an economic benefit averaging $62 million (USACE 2007).

Metro Nashville, Rutherford County, and the cities of Murfreesboro, Smyrna and LaVergne in Rutherford County all have active local parks and greenway programs associated with the Stones River and its tributaries (USACE 2007, RCRPC 2011). These programs are actively developing passive recreation opportunities along river and stream corridors, including acquiring riparian and floodplain zones, and improving natural resource management in these areas. The municipalities within Rutherford County have a stated goal of integrating their greenways into a consolidated system to help achieve a goal of protecting and enhancing a network of parks, stream and tree corridors (RCRPC 2011). Metro Nashville has also identified the need to connect opens spaces within its jurisdiction to the Percy Priest area and others further to the southeast (Metro and LTTN 2011).

The Murfreesboro Parks and Recreation Department and partner non-profits such as the Friends of the Greenway and Stones River Watershed Association (SRWA) are also promoting the development of a "blueway" system for the Stones, incorporating more canoe and kayak access points in the watershed (RCRPC 2011, SRWA 2010). Several sections of the East, Middle and West Fork Stones and tributaries such as Cripple Creek and Overall Creek are popular canoeing locations (TDEC 2000). Non-profits such as SRWA and the Discovery Center at Murfree Spring and the Murfreesboro Parks and Recreation Department have very popular local natural resource education programs for children and adults. The Middle Tennessee State University Center for Environmental Education cooperates with many schools to provide grant and technical support for environmental education programs in the watershed.

The Stones River watershed was one of the first areas of middle Tennessee settled after the Revolutionary War, as many land grants were given to veterans of the war in payment for their service. The river itself is named not for the abundance of limestone, but for one of the original "Long Hunters" who first explored the region, Uriah Stone. Settlers of English, French, German, and Scotch-Irish descent moved into the region from the 1770s through 1790s. This period marked the transition of the landscape from what was previous a vast shared hunting grounds of primarily the Cherokee and Chickasaw to permanent settlements of European immigrants who cut large acreages of timber and began converting lands to agricultural production (Drake et al. 2009, Masters and Puryear 2011).

The Stones River near Murfreesboro was the site of one of the most significant victories for the Union Army during the Civil War. Following the major defeat at Fredricksburg, VA in mid-December 1862, Union troops led by General William S. Rosecrans left their camps in Nashville and moved south to engage Confederate troops led by General Braxton Bragg camped outside Murfreesboro. From December 26, 1862 until the Confederate troops withdrew on January 3, 1863, the battle claimed 24,000 casualties including more than 3,000 dead. The victory at Stones River gave the Union control of the rich agricultural lands of Middle Tennessee set the stage for the subsequent Union marches deeper south into Georgia, Alabama, Mississippi and Louisiana (NPS 2011). The Stones River National Battlefield, managed by the National Park

Service, covers approximately 790 acres along the banks of the West Fork of the Stones. The National Park Service manages the cultural, historical, and natural resources of the park and provides interpretive guidance and education to the general public. The park averages around 200,000 visitors per year (NPS 2011).

Approximately 242 square miles of the Rutherford County portions of the Stones River watershed are classified as prime farmland even today (RCRPC 2011). Twenty-five operations are recognized as Century Farms by the State of Tennessee, having been in continuous operation by the same family for at least 100 years (RCRPC 2011). Livestock and hay production are the primary activities, although crops such as soybeans, cotton, and corn are grown as well. In recent years, more farms are active in local direct-to-consumer markets. These include Community Supported Agriculture (CSA) programs, farmers markets, and value-added production such dairy product development and direct sales (Bruch and Holland 2007). Rutherford and Wilson Counties both rank in the top 5 counties with the number of farm operations selling directly to individual consumers (Bruch and Holland 2007).

River clean up, kayak day, plant restoration, and stream science education events led by the City of Murfreesboro, Friends of the Greenway, Stones River Watershed Association, and Middle Tennessee State University.
Photo credits: City of Murfreesboro

# Chapter 3: Current Resource Conditions & Future Trends

The karst landscape of the Stones River watershed results in a complex system of surface and ground water relationships, which expose both resources to similar impacts from land use activities, stream withdrawals and discharges, and groundwater withdrawals and discharges. Agricultural activities, urban land cover, land development practices, landfills, on-site sewage disposal, municipal water and sewage systems, and chemical discharges all have the potential to negatively impact surface and ground water in a karst system (Martin and White 2008, Wolfe et al. 1997). All of these land and water use activities have historic and current footprints in the Stones River watershed, and future trends suggest that the conversion to more urban uses will continue (Buckner et al. 2002, RCRPC 2011).

## The influence of historic land and water use

As previously discussed, the majority of the land cover in the Stones River watershed – and the Central Basin of Tennessee in general – began to be converted to agricultural uses over 200 years ago. Within the last 30 years, the land use has changed rapidly in the central and northwestern portions of the watershed as the cities of LaVergne, Smyrna, and Murfreesboro and adjacent unincorporated areas of Rutherford County have grown and transitioned to suburban communities in the greater Nashville Metropolitan Area (Quillen 2010, RCRPC 2011). In the evolutionary time context of natural systems, these land use conversions have been relatively recent and have influenced our understanding of historic, or "baseline" conditions, for stream, wetland, and biodiversity health (Stein et al. 2010, Humphries and Winemiller 2009, Harding et al 1998).

"Reference" system conditions for restoration targets can be difficult to establish because of historical land and water resource use patterns. In the case of aquatic species diversity, historical agricultural land use within the watershed has been a better predictor of current diversity patterns than more recent land use (Harding et al. 1998). Present distributions of aquatic species up and down river and stream corridors are influenced both by current and the historical locations of barriers such as low-head dams (Humphries and Winemiller 2009, Smith et al. 2008). The Stones River has a 200 year history of mill dams and other similar structures through the watershed. Loss of species and reduced viability of populations influences food web dynamics, and can influence other biological, chemical and physical properties of freshwater systems (Humphries and Winemiller 2009).

When available, data on historic conditions can help inform decisions on restoration opportunities in highly modified landscapes with analyses are focused on revealing landscape-scale processes over time (Stein et al. 2010). A systematic assessment of historical land and water use trends for the Stones River watershed was outside the scope of this current project. However, when possible information on historic land and water use has been used to increase our understanding of what we observe to be the current conditions of stream, wetland, and biodiversity resources.

# Stream and Wetland Resources

## River and stream conditions

The West, Middle, and East Fork of the Stones River and their smaller stream tributaries have been impacted by a variety of land and water uses including reservoir construction, agriculture, urban development, water withdrawals and discharges, floodplain topsoil harvesting and gravel dredging (Buckner et al. 2002, TDEC 2000). An analysis of river and stream hydrology using the National Hydrography Plus dataset shows that approximately 42% of the original riverine habitat in Stones watershed was impounded with the construction of J. Percy Priest Reservoir. By comparison, only about 4% of the original smaller stream habitats were converted at that time. Approximately 40 river miles of larger riparian floodplain habitat remain in the West, Middle and East Forks of the Stones River watershed today. Table 2 summarizes the 2001 Southeastern GAP land cover types found within the typical Federal Emergency Management Agency's (FEMA) land feature categories. The native "South Central Interior Large Floodplain" system has the lowest aerial coverage than any other type in the Stones River watershed.

Table 2. A summary of the land cover types found in the Stones River watershed, including acreages within specific FEMA land feature categories. The data is sorted by the highest land cover type acreage within the entire watershed.

| Land Cover Type | Acreage within typical land feature categories | | | |
|---|---|---|---|---|
| | **Entire Watershed** | **Floodway** | **100-Yr Floodplain** | **500-Yr Floodplain** |
| Pasture | 217144 | 23824 | 171021 | 22299 |
| Southern Interior Low Plateau Dry-Mesic Oak Forest | 95155 | 18559 | 72261 | 4334 |
| Nashville Basin Limestone Glade and Woodland | 72024 | 4435 | 62952 | 4637 |
| Developed Open Space | 57874 | 11288 | 36184 | 10402 |
| Old Field / Successional | 37805 | 4792 | 30544 | 2469 |
| Cropland | 37661 | 2942 | 32222 | 2496 |
| Low Intensity Developed | 24249 | 3425 | 14530 | 6294 |
| Excavated Land (Strip Mine / Road Cut / Rock Quarry / Gravel Pit) | 12695 | 369 | 12072 | 253 |
| South-Central Interior Small Stream and Riparian | 8170 | 1673 | 6440 | 58 |
| Medium Intensity Developed | 5843 | 530 | 3217 | 2097 |
| High Intensity Developed | 3587 | 182 | 2278 | 1127 |
| South-Central Interior Mesophytic Forest | 2376 | 448 | 1833 | 94 |
| Forest Plantation | 1487 | 53 | 1387 | 47 |
| South-Central Interior Large Floodplain | 750 | 521 | 226 | 3 |
| **TOTALS** | **576,819** | **73,041** | **447,168** | **56,610** |

Table 3. The Southeast GAP land cover types within the Stones River watershed, summarized by major types including agriculture, natural vegetation, developed lands, and other land uses.

| Land Cover Type | Entire Watershed | Floodway | 100-Yr Floodplain | 500-Yr Floodplain |
|---|---|---|---|---|
| **Agricultural or Successional** | | | | |
| Pasture | 217144 | 23824 | 171021 | 22299 |
| Cropland | 37661 | 2942 | 32222 | 2496 |
| Old Field / Successional | 37805 | 4792 | 30544 | 2469 |
| Total acreage within land feature category | 292609 | 31557 | 233787 | 27264 |
| Percent of total acreage within land feature category | 51% | 43% | 52% | 48% |
| | | | | |
| **Natural Vegetation** | | | | |
| Southern Interior Low Plateau Dry-Mesic Oak Forest | 95155 | 18559 | 72261 | 4334 |
| Nashville Basin Limestone Glade and Woodland | 72024 | 4435 | 62952 | 4637 |
| South-Central Interior Small Stream and Riparian | 8170 | 1673 | 6440 | 58 |
| South-Central Interior Mesophytic Forest | 2376 | 448 | 1833 | 94 |
| South-Central Interior Large Floodplain | 750 | 521 | 226 | 3 |
| Total acreage within land feature category | 178475 | 25636 | 143713 | 9126 |
| Percent of total acreage within land feature category | 31% | 35% | 32% | 16% |
| | | | | |
| **Developed Lands** | | | | |
| Developed Open Space | 57874 | 11288 | 36184 | 10402 |
| Low Intensity Developed | 24249 | 3425 | 14530 | 6294 |
| Medium Intensity Developed | 5843 | 530 | 3217 | 2097 |
| High Intensity Developed | 3587 | 182 | 2278 | 1127 |
| Total acreage within land feature category | 91554 | 15425 | 56209 | 19920 |
| Percent of total acreage within land feature category | 16% | 21% | 13% | 35% |
| | | | | |
| **Other Land Uses** | | | | |
| Excavated Land (Strip Mine /Rock Quarry / Gravel Pit) | 12695 | 369 | 12072 | 253 |
| Forest Plantation | 1487 | 53 | 1387 | 47 |
| Total acreage within land feature category | 14182 | 422 | 13459 | 300 |
| Percent of total acreage within land feature category | 2% | 1% | 3% | 1% |

Agriculture, old fields, and natural vegetation remain the dominant land cover types in the Stones River watershed and floodplains (Table 3). Because of the predominance of agriculture in the landscape, management practices have a high probability of affecting stream and wetland resources. The pattern of developed lands in relationship to floodway and floodplains in the watershed shows that development is changing the characteristics of these watershed features.

Most of the developed lands in the watershed fall in the less intensive "developed open space" cover type. However, 4-5% of the 100 and 500-year floodplains remaining since reservoir construction have already been converted to high intensity development, as has approximately one percent of floodways. Low and medium intensity development has occurred in 26% of all floodways, 32% of 100-year floodplains, and 42% 500-year floodplains.

The Tennessee Department of Environment and Conservation Division of Water Pollution Control (TDEC-WPC) is responsible for setting water quality standards for the State's water bodies. Setting these standards involves the selection of ecoregion reference streams to serve as monitoring and water quality target baselines. Locating appropriate reference stream conditions in the Inner Central Basin is especially challenging, given the long history of agricultural land uses (Arnwine et al. 2003). In fact, the some of the reference streams identified for the Inner Central Basin have observable impacts from agriculture. As urbanization impacts continue to grow, the reference streams chosen represent the best water quality and instream habitat characteristics of Inner Central Basin streams observable at this time (Arnwine et al. 2003).

The water quality standards developed from research on reference streams guide TDEC-WPC's monitoring and assessment programs, which include the development of individual watershed reports and the 303d list of impaired waters (TDEC 2000, TDEC 2010). Tables 4 and 5 summarize information from the 2010 303d report. Almost thirty percent of stream miles in the Stones River watershed do not meet state water quality standards for one or more cause. The primary causes of non-attainment are from sedimentation and alteration of streamside vegetation. The sources of these problems include land development, discharges from municipal storm water systems, and grazing practices.

Table 4. Summary of water quality standard attainment in the Stones River watershed (adapted from TDEC 2010).

| Water Quality Standard Attainment | Number of stream miles | Percent of total stream miles |
|---|---|---|
| Fully Supporting | 577 | 47% |
| Not Supporting | 340 | 28% |
| Not Assessed | 236 | 19% |
| Insufficient Information | 75 | 6% |
| **TOTALS** | 1228 | 100% |

Table 5. Causes and sources of water quality impairments in the Stones River watershed (adapted from TDEC 2010).

| Cause of standard non-attainment | Primary Sources | Number of stream miles |
|---|---|---|
| Sedimentation/Siltation | Discharges from Municipal Separate Storm Sewer Systems (MS4s), Land Development or re-development, Grazing in riparian or shoreline zones, and Channelization | 133 |
| Alteration in stream-side or littoral vegetative covers | Grazing in Riparian or Shoreline zones, Land Development or re-development, Discharges from Municipal Separate Storm Sewer Systems (MS4s), and Channelization | 91 |
| Nutrient/Eutrophication Biological Indicators | Grazing in Riparian or Shoreline zones, Industrial Point Source Discharge, and Sanitary Sewer Overflows (Collection System Failures) | 39 |
| Nitrate/Nitrite (Nitrite + Nitrate as N) | Discharges from Municipal Separate Storm Sewer Systems (MS4s) and Municipal Point Source Discharges | 22 |
| Oxygen, Dissolved | Grazing in Riparian or Shoreline Zones, Unrestricted Cattle Access, and Upstream Agricultural Impoundments | 13 |
| Physical substrate habitat alterations | Channelization, Land Development or re-development, new construction of Highways, Roads, Bridges, & Infrastructure | 11 |
| Phosphorus (Total) | Discharges from Municipal Separate Storm Sewer Systems (MS4s) and Municipal Point Source Discharges | 10 |
| Sulfide-Hydrogen Sulfide | Upstream Agricultural Impoundments | 7 |
| Odor threshold number | Upstream Agricultural Impoundments | 7 |
| Low flow alterations | Upstream Agricultural Impoundments | 7 |

Since 2002, TDEC-WPC has developed several Total Maximum Daily Load (TMDL) protocols for pollutants in the Stones River watershed. These include TMDLs for siltation and habitat alterations, E. coli, and low dissolved oxygen and nutrients for all listed streams in the watershed. A TMDL for fecal coliform has also been developed for three tributary streams.

The TMDLs set limits for the amount of a given pollutant that can enter a stream and make recommendations for management practices which can abate pollutant loads and restore streams to water quality standard attainment (TDEC 2002, TDEC 2004, TDEC 2006, and TDEC 2008).

## Wetland conditions

Tennessee retains a large land area of wetlands and floodplains in the western section of the state; however, approximately 59% of the historic extent of wetland habitats is estimated to have been lost since late 1700s (Dahl 1990). Agricultural conversion, including wetland drainage and stream channelization, accounts for the majority of historic losses. This conversion rate to agriculture is thought to have declined, with urban conversion and impacts to wetlands on the rise. No comprehensive datasets exist in Tennessee which allow a thorough evaluation of historic wetland losses or current conversion trends (TDEC 1998).

Local scale data of historic wetland distributions in the Stones River watershed is not readily available. However, the National Wetland Inventory (NWI) classification system does provide "modifier" labels which indicate whether or not a particular wetland is in a more natural state or has been impacted by one or more management activities. A review of the NWI data shows over 100 types of wetlands – modified and unmodified – in the Stones River watershed (for a list of these types, see Appendix 3). For this planning effort, TNC used the National Hydrography Plus dataset to organize these many types of wetlands into those which may or may not be connected hydrologically to a small stream or larger river segment (see Chapter 4 for methodological details). Table 6 summarizes the acreage of each wetland ecological system type within each NWI modifier category.

All of the wetlands mapped by NWI and classified into general ecological system types show very high levels of modification. Over eighty percent of small stream riparian wetlands, and over ninety percent of large floodplain wetlands, have been modified by impoundments or excavation activities. Sixty –one percent of isolated wetlands have been modified, primarily by excavation activities (Table 6). As previously discussed, the NWI mapping underestimates the actual extent and locations of wetlands in the Stones River watershed. The acreages listed in Table 6 should be considered estimates of total modified and unmodified wetland types.

Table 6. Wetland ecological system types developed using the National Hydrography Plus dataset, with reference to the Southeast GAP ecological systems, listed by acreage in each NWI modifier category.

| Wetland ecological system | NWI Modifier | Total NWI acreage | Percent of total acreage |
|---|---|---|---|
| Isolated | none | 994 | 38 |
| Isolated | Diked / Impounded | 374 | 14 |
| Isolated | Excavated | 1188 | 46 |
| Isolated | Partially Drained / Ditched | 29 | 1 |
| TOTALS | | 2585 | 100 |
| | | | |
| Large Floodplain | none | 508 | 6 |
| Large Floodplain | Diked / Impounded | 8586 | 94 |
| Large Floodplain | Excavated | 2 | 0 |
| TOTALS | | 9096 | 100 |
| | | | |
| Small Stream Riparian | none | 1453 | 19 |
| Small Stream Riparian | Diked / Impounded | 6096 | 80 |
| Small Stream Riparian | Excavated | 69 | 1 |
| | | | |
| TOTALS | | 7618 | 100 |

## Plant and animal species populations

The analyses of plant and animal species of conservation need and their habitats described in Chapters 4 and 5 provide more detailed information on the current distributions in the watershed. This section describes the condition and distribution of species populations in the watershed.

The construction of Percy Priest Reservoir impounded sections of riverine habitat previously occupied by riffle-dependent freshwater mussels. Table 7 provides a summary of the number of occurrences of these mussel species in the Stones River, including the occurrences known from locations now within the reservoir pool. All known occurrences of seven mussel species were impacted by the reservoir, and 20-30% of the occurrences of five other species were also affected. Riffle-dependent fish and other riverine species also lost habitat, but we did not have the historic distribution records to perform a similar analysis. At present, many native fish species adapted to reservoir pool habitats comprise an active sports fishery on Percy Priest Reservoir today. These species include bluegill, catfish, crappie, and black bass (USACE 2007).

TNC conducted a spatial analysis of aquatic species distributions in the watershed in comparison to the water quality status of streams as measured by TDEC-WPC. This analysis showed that the majority of aquatic species are located in stream segments identified as “fully supporting” designated uses. This review suggests that fish, crayfish, mussel, and snail species are occupying less disturbed or impacted stream segments in the watershed.

The Southern Interior Low Plateau Dry-Mesic Oak Forest and Nashville Basin Limestone Glade and Woodland systems remain predominant natural vegetation types. However, the condition of these habitats throughout the watershed is not thoroughly documented. Limestone glades, in particular, are at risk for degradation by being used as illegal dumping sites and marginal pasture lands (Rollins 1997). Many glade habitats were also flooded by the Percy Priest impoundment, and expanding urbanization threatens these systems as well (Quarterman 1989). Several of the endemic glade plants have multiple occurrences watershed, but in many cases these multiple occurrences represent the concentration of habitats within the Inner Central Basin of Tennessee which are globally rare (Appendix 2).

Table 7. Current and historic freshwater mussel species in the Stones River watershed.

| Scientific Name | Common Name | Federal Status | Number of occurrences | Number of occurrences impounded |
|---|---|---|---|---|
| Villosa taeniata | Painted Creekshell | | 10 | 2 |
| Villosa lienosa | Little Spectaclecase | | 2 | 2 |
| Simpsonaias ambigua | Salamander Mussel | | 4 | 1 |
| Epioblasma florentina walkeri | Tan Riffleshell | LE | 3 | 1 |
| Medionidus conradicus | Cumberland Moccasinshell | | 3 | 1 |
| Pegias fabula | Littlewing Pearlymussel | LE | 3 | 1 |
| Cumberlandia monodonta | Spectaclecase | C | 1 | 1 |
| Ellipsaria lineolata | Butterfly | | 1 | 1 |
| Ligumia recta | Black Sandshell | | 1 | 1 |
| Pleurobema cordatum | Ohio Pigtoe | | 1 | 1 |
| Pleurobema sintoxia | Round Pigtoe | | 1 | 1 |
| Truncilla donaciformis | Fawnsfoot | | 1 | 1 |

## Future Land Use Trends

Portions of four county jurisdictions fall within the Stones River watershed (see Figures 1 and 2). The majority of the watershed land cover within Metro Nashville-Davidson County is now in urban land use, while those portions within Wilson and Cannon counties are primarily agricultural and low-density residential. The rapid changes in land use during the last 30 years have occurred primarily in Rutherford County, from the northwestern end of the county towards the southeast along the Interstate 24 corridor.

Rutherford County has experienced an over 300% growth in population since 1970 and is now the second most populated county in Middle Tennessee (RCRPC 2011). During some periods in the last two decades, land in the Middle Tennessee areas including Rutherford County was being converted at a rate of 60 acres per day (RCRPC 2011). From 2002 to 2007, according to the U.S. Census Bureau the overall acreage in farms dropped 22% and the number of farms dropped 27% to 1525 total farms with an average farm size of approximately 108 acres (RCRPC 2011).

The land conversion trajectory to accommodate population growth has proceeded from the downstream reaches of the Stones around Percy Priest and continued upstream along the West, Middle, and East Forks and their tributaries – especially those of the West and Middle Forks. During the timeframe of this planning effort for the watershed, the Rutherford County Regional Planning Commission was developing a comprehensive land use plan to guide zoning and land development regulations through the year 2035.

Figure 5 is a draft map of a newly proposed land use zoning framework for the county. As of the completion of this watershed plan, Rutherford County government was in the review phase of the framework and regulations associated with each zoning category. While not yet officially adopted, this map demonstrates the county's desire to support low (yellow) and medium (orange) density residential growth to the county boundaries (see Figure 5). The draft zoning regulations indicate that low density residential will allow one house per acre, while medium density residential will allow one house per 15,000 feet. TNC performed additional analyses of population growth and land conversion trajectories for the entire Stones River watershed. The results and their interpretation in the context of stream and wetland mitigation decisions are provided in Chapter 6.

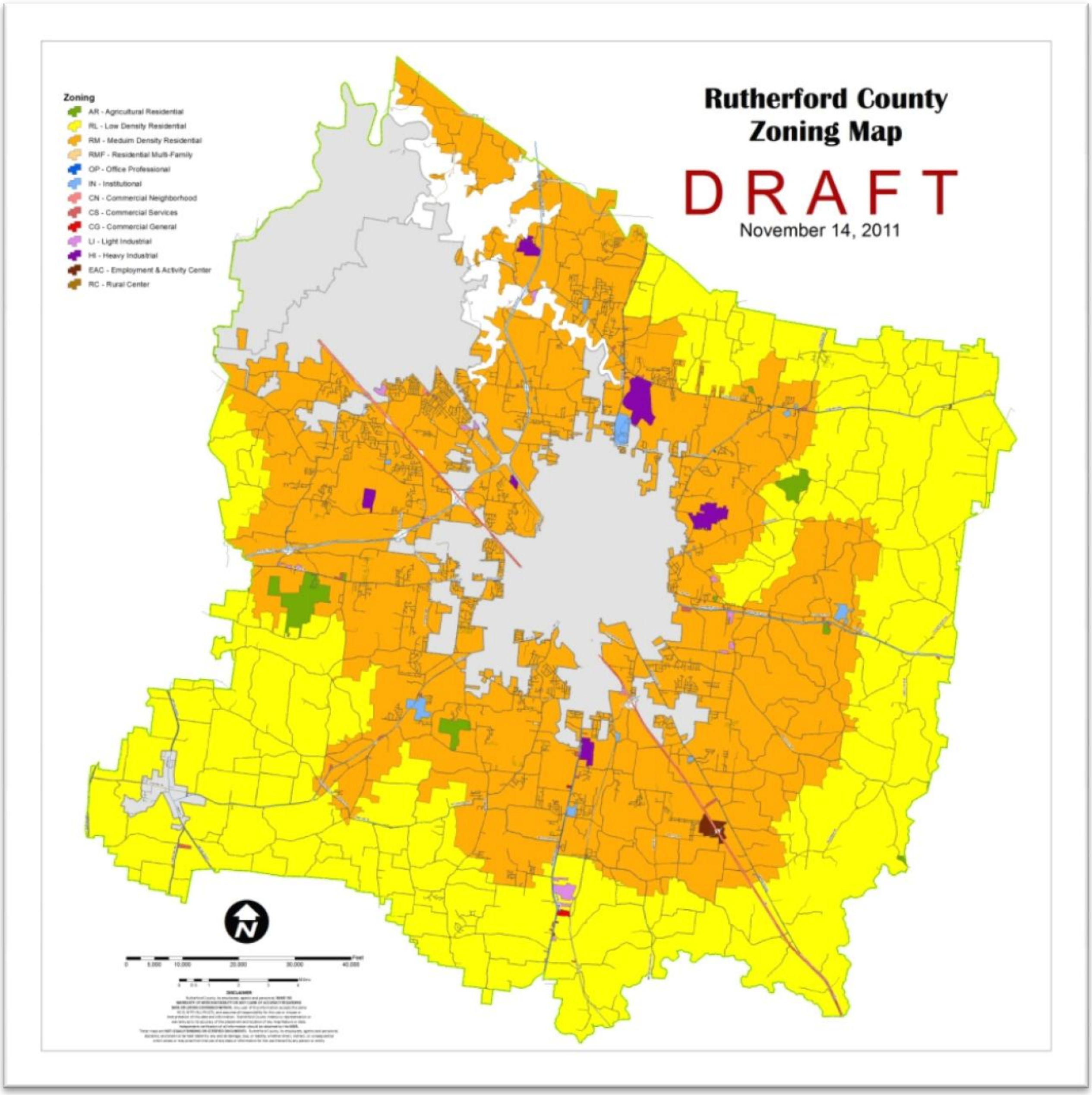



Figure 5. Draft zoning map for Rutherford County, Tennessee as of November 2011. Low density residential is depicted in yellow; medium density residential is depicted in orange. The zoning categories displayed have not been formally adopted by Rutherford County government and are subject to change. Source: Rutherford County Regional Planning Commission.

# Chapter 4: Identifying Watershed Priorities

In conducting the data analysis for the planning effort, TNC focused on the following primary tasks:

- Improving the understanding of both the significance and spatial distribution of biodiversity targets in the watershed;
- Connecting information on biodiversity priorities to other existing watershed goals; and
- Identifying the most appropriate mitigation techniques and spatial arrangement of implementation to achieve sustainable ecological benefits.

Our analyses specifically emphasize the use of conservation data as a frame for identifying watershed restoration needs and guiding avoidance, minimization and mitigation decisions. While the project focused solely on using Geospatial Information Systems (GIS) data from the outset, efforts were made to connect this data to expected field observations when on-the-ground assessments are performed in the future by permit applicants and others.

The limitations of existing spatial data on wetlands and hydric soils led us away from wetland "functional" assessments and instead towards producing spatially explicit information on the relative conservation value of different terrestrial and riverine habitats in the watershed. We then were able to compare these priorities to future population growth and land conversion trends as well as other watershed priorities such as restoring the water quality of impaired streams, preventing future impairments, and expanding conservation and community recreation lands.

The next sections outline how TNC further developed the original GIS and database management system first constructed during the 2005 State Wildlife Action Plan effort to conduct these analyses. Key pieces of this work include following:

- Selecting the appropriate spatial units to assess terrestrial and aquatic habitats;
- Assessing the relative biodiversity value of the planning units;
- Determining the appropriate relationships between land cover data, NWI locations, stream networks
- Determining the upstream/downstream connectivity of stream reaches and the relationship to upland features
- Establishing an understanding of current & potential future conditions
- Identifying opportunities to combine multiple watershed objectives

This planning approach allowed us to clearly identify areas of conservation focus; to understand the relationship between species of conservation need, their current distribution, and potential future impacts; and to suggest specific areas within the watershed where avoidance, minimization, and mitigation decisions can contribute to sustaining multiple resource values over time.

## GIS and relational database analysis methods

The architecture of the 2005 State Wildlife Action Plan GIS and relational database management system (RDBMS)-based was designed to facilitate the incorporation of new and revised data over time. Since its initial development in partnership with TWRA, TNC has maintained, updated, revised, and expanded various components of the database to support new functionality. Species of Greatest Conservation Need (SGCN) element occurrence records in the SWAP database have undergone a number of revisions and expansions, as new records were collected and new datasets became available. Currently, the database includes roughly 54,000 occurrences of SGCN fauna, as well as 11,000 occurrences of rare plants in the state from the Tennessee Division of Natural Heritage (TN-DNH).

As a precursor to subsequent habitat prioritization analyses, a relative conservation priority score is calculated for each animal and plant species based on its rarity and legal status (RL). The components of this score are global rarity/imperilment, as defined by NatureServe G-Rank; rarity/imperilment rating within Tennessee (NatureServe S-Rank); federal listing status under the Endangered Species Act (F-Status), if applicable; and Tennessee listing status (TN-Status), if applicable. A relative index of viability (V) is also calculated for each occurrence, based on date of last observation and, where available, NatureServe EO-Rank. Rather than a true population viability analysis rating, in the strict biological science sense, the viability rating in this case is a relative measure of confidence that the species currently persists on the landscape at the location evidenced by the occurrence record.

## Terrestrial Habitat Prioritization

As part of the initial 2005 SWAP effort, a database of preferences of SGCN fauna for habitats occurring in the state, as defined by NatureServe's Ecological System classification, was developed and populated. Since that time, plant biologists at DNH have worked to incorporate the habitat preferences of state tracked plant species into the database. Currently, the dataset includes roughly 8,800 records of preferred, suitable, or marginal habitat preference designations between terrestrial species and ecological system classes, including approximately 2,700 preference assignments for wetland habitat classes. For incorporation into the mathematical prioritization models, preferences were assigned weighting values, with 10 points for preferred, 5 points for suitable, and 2 points for marginal habitats.

The next step of the analysis was to generate a GIS coverage of over 270,000 100-acre hexagons covering the state of Tennessee. This coverage would allow a consistent spatial unit to further examine terrestrial priorities. However, the large number of records proved both impractical for use in analyses and more spatially specific than the underlying input data support. The hexagons were therefore aggregated into clusters, with a single hexagon in the center surrounded by six adjacent hexagons. The resulting 700-acre rosettes, of which there are approximately 40,000 covering the state, are the units of analysis in the current model.

Rosettes surrounding terrestrial occurrences were assessed based the occurrence viability score, as well as distance to the occurrence, as a percentage of 4 times the NatureServe suitable habitat separation distance of the species, with maximum distance/viability score combinations selected for each species/rosette pair. The result is a potential species distribution footprint around known occurrence locations.

The 2001 Southeast GAP (SE-GAP) ecological system coverage was used for mapping terrestrial habitats. Based on classification of Landsat imagery, this coverage is able to identify matrix- and large-scale habitat classes, but the 30-meter resolution of the source Landsat data makes identification of small-patch and linear habitats difficult. For incorporation into the terrestrial analysis, the ecological system coverage was overlaid with the rosettes, resulting in a layer with roughly 400,000 ecological system class/rosette combinations. This layer was then mated to the occurrence-based species/rosette table, and habitat/species combinations scored based on species imperilment scores (RL), species viability/distance (VD), and habitat preference (P) within each rosette. This table has roughly 3,000,000 records of unique species/habitat/rosette combinations. Priority scores of habitats within each rosette were then calculated by summing the corresponding RLVDP scores for all species within the rosette.

## Aquatic Habitat Prioritization

The aquatic component of the SWAP database has also been extensively revised and refined in the time since initial development in 2005. To support evaluation and analysis of the potential implications of upstream activities and conditions to downstream aquatic fauna, an Access-based hydrologic modeling framework was developed utilizing National Hydrography Plus (NHDPlus) datasets. Built upon the 1:100K National Hydrography Dataset (NHD) and 24K digital elevation models (DEM), NHDPlus defines the hydrologic upstream/downstream connections between individual stream segments, the catchment areas draining into them, and a number of other hydrologically relevant attributes, such as mean annual flow velocities and volumes. The data were compiled for the entire Tennessee and Cumberland River basins, as well as the portions of the Barren and Conasauga Rivers within the state of Tennessee. The data underwent significant editing to correct topological network errors inherent in the raw NHDPlus data. Catchments were reconciled with 12-digit hydrologic unit codes (HUC) from the Water Boundary Dataset (WBD). Dam locations and attribution from the National Inventory of Dams (NID) dataset were incorporated. Finally, the cleaned network connections, incremental mean annual flow volume and velocity attributes, and dam storage data were used to create an Access database of hydrologic upstream/downstream relationships between stream segments. This dataset allows the characterization and analysis of watersheds upstream of each segment in the stream network, weighted by the mean annual travel time and percent flow contribution of the individual catchments within that watershed.

The hydrologic relationship data were used to model potential instream habitat footprints from the occurrence data. Occurrences were snapped to their nearest NHDPlus stream segment, and grouped to remove duplicates, with the maximum occurrence viability score (V) selected. Stream segments upstream and downstream of those with known species occurrences were evaluated and scored, based on species rarity/legal status score (RL); occurrence viability score (V); flow distance, as a percentage of the NatureServe suitable habitat separation distance for the species (D); and percent deviation of mean annual flow volume from that of the reference stream segment of documented occurrence (Q). Dams were considered barriers to faunal movement, and so were not crossed in assessing potential occurrence extent. The resulting table contains approximately 120,000 species/stream segment combinations.

Similar to the terrestrial habitat analysis, the RLVDQ scores for all corresponding species records were totaled to give the overall habitat priority of each stream segment. The amount of habitat represented by each stream segment, as a function of segment length as a percentage of the NatureServe suitable habitat separation distance for the species, was also calculated and used to weight the RLVDQ scores of each species/segment combination. Areas upstream of aquatic habitats were prioritized based on proximity, as a function of instream water travel time, and relative flow contribution to the downstream habitat segments prioritized by analysis of the species records.

## Assessing wetland priorities

### Wetland mapping approach

The limitations of existing GIS data on the location, condition, and types of wetlands, both existing historical, are well documented, and present challenges both within the Stones River watershed and throughout the state of Tennessee (USACE 2010, Morgan 2010, Roberts and Morgan 2006, TDEC 1998,). From the outset of our planning effort, technical experts on the Tennessee IRT and others who have worked on wetland issues for the State and the Corps shared their knowledge on the limitations of the NWI and hydric soils spatial data in capturing potential wetlands across the landscape.

National Wetlands Inventory (NWI) data in the Stones River watershed were completed in different phases, the first prior to 1993 and the second between 1993 and 1998 (TDEC 1998). These data have not been updated to reflect recent changes in land use and associated impacts to wetlands. Soils data (SSURGO) were also developed decades ago, and at the county level, resulting in very different classifications and hydric soil designations from county to county. As a result, it is not possible to explicitly map wetlands, or even potential wetlands, with useful accuracy.

We used the guidance of the technical stakeholders to design an analysis technique which would help overcome the gaps in the currently available NWI and hydric soil designations. To work around these limitations in mapped wetlands data, the analyses were conducted to prioritize areas based on *potential* wetland conservation value, essentially answering the question, "If a wetland is identified at a particular location, what would be its relative priority within the landscape?" Structuring the analysis in this fashion allowed us to develop a more complete portfolio of upland, stream, and wetland sites throughout the watershed based our analyses on known species occurrence records and their habitat preferences.

This analysis approach was particularly important in a karst watershed like the Stones River, where previous field studies have documented the under-representation of wetlands by the NWI and hydric soils spatial data (Roberts and Morgan 2006). Seasonal and temporal seeps, springs, and sinkhole wetlands are common and provide significant amphibian and rare plant habitat. The shallow soils of the area do not always fit the established criteria, and seasonal shifts in vegetation make field verification difficult when limited observations are made (USACE 2010). Limestone glade habitats, in particular, difficult to characterize because they have patterns of wetland and non-wetland features interspersed across microtopographic features (Norton 2010, USACE 2010).

A recent floristic study of limestone glades in Kentucky and middle Tennessee performed a wetland delineation assessment of the Limestone Seep Glade community type recognized by NatureServe using the Corps manual and appropriate regional supplements (Norton 2010). This seasonally wet community type met the soil, hydrology, and vegetation characteristics for wetland determination. Approximately 100 species were documented in this community type, 16 of which are endemic to glades. Leafy prairie clover (*Dalea foliosa)*, a federally listed endangered species, is one of several endemics which are restricted to seep habitats within glades. In addition to this community type, the study revealed that approximately 20% of documented plant taxa in limestone glades are obligate or facultative wetland species. Many glade plant species, including endemic species, do not have wetland code assignments and may in fact have hydrophytic characteristics (Norton 2010).

## Mapping species habitat preferences

The relative priority for potential wetland habitats in the landscape was assessed for terrestrial species using the species/rosette footprints, data on preferences of the species for wetland ecological systems contained in the relational database, and an assessment of potential wetland ecological system occurrence in the landscape. The Stones River Watershed is located within the Interior Low Plateau ecoregion, and is associated with three potential wetland ecological systems: Interior Low Plateau Seepage Fen, South-Central Interior Small Stream and Riparian, and South-Central Interior Large Floodplain. The Interior Low Plateau Seepage Fen is an isolated, small-patch wetland class not affiliated with the riparian zone, and so potential habitat priority was assessed and mapped to the terrestrial rosettes. For each rosette, the species assessments from the terrestrial model, rating species by imperilment (RL), viability (V), and relative distance from known occurrence (D), were also scored by their preference for the Interior Low Plateau Seepage Fen ecological system, and the resulting RLVDP scores totaled for each rosette to give overall potential habitat priority for terrestrial species.

South-Central Interior Small Stream and Riparian and South-Central Interior Large Floodplains are linear riparian wetland classes in the 2001 SE-GAP that are differentiated from each other in the frequency and duration of inundation and subsequent lateral floodplain extent. Because of their tight association with hydrologic regimes, potential priority for these systems was assessed and mapped using the aquatic stream segment units of analysis. Both riparian systems were mapped in the 2001 SE-GAP ecological system dataset, but are believed to be underrepresented in the coverage. Based on overlaying the SE-GAP coverage with the catchments associated with aquatic stream segments, and connecting the relative amount of each class mapped in GAP with flow volumes of the stream segments, an arbitrary but reasonable cutoff flow value of 270 cfs was selected to differentiate between the small stream and large floodplain classes.

To spatially associate the terrestrial rosettes with the aquatic stream segments, the 2 layers were overlaid, and proportional stream segment lengths within intersecting rosettes were calculated. This allowed the species/rosette assessments (RLVD scores) from the terrestrial model to be linked to the aquatic stream segments. Similar to the assessment of Interior Low Plateau Seepage Fens, habitat preference scores for the appropriate riparian ecological system were also calculated. Species in riparian areas with flow less than 270 cfs were assessed for their South-Central Interior Small Stream and Riparian habitat preference, while species in streams with flows greater than 270 cfs were scored by their preference for South-Central Interior Large Floodplain. As with the seepage fen analysis, resulting RLVDP scores for individual species were totaled for each stream segment to give overall potential riparian habitat priority for terrestrial species.

Intact and functional stream-side riparian buffers are very important to the health and condition of adjacent and downstream habitats (Jones et al. 1999). The aquatic model was therefore used to assess the relative priority of stream-sides by proximity, as a function of instream water travel time, and relative flow contribution, to prioritized instream aquatic habitats. These stream-side aquatic priorities were then added to the terrestrial riparian priorities, to give overall priority scores for riparian areas.

# Chapter 5: Conservation Framework of Watershed Priorities

This chapter presents the map products generated from the spatial analysis of watershed priorities outlined in Chapter 4. These map products demonstrate the relative significance of terrestrial and aquatic habitats, and their relationships to isolated, small stream, and large floodplain wetlands which may occur throughout the watershed. Our results provide a more complete picture of the connectivity between significant upland and stream habitats, upstream-downstream relationships, and the distribution of these terrestrial and aquatic habitats across the Stones River watershed.

Figures 6 and 7 display the priority upland habit regions for all terrestrial plant and animal species based on known distributions and habitat preferences. Figure 8 displays the terrestrial plant and animal habitat priorities for isolated wetlands and the small stream & large floodplain wetlands combined into one "riparian" descriptor for map display purposes. Figure 9 shows the same information as Figure 8, but also displays the locations of limestone glade plant species known to have strong affiliations to wet seep habitats, as well as the Stones River bladderpod (*Lesqurella stonensis),* an endemic floodplain species.

Figures 10, 11 and 12 provide overviews of priority instream habitats and their associated catchment areas. Figure 10 shows the priority stream reaches in the watershed and displays important upland catchment areas. Figure 11 provides this same information and displays the aquatic animal species occurrences behind the prioritization scheme. Figure 12 shows the analysis of stream side zones prioritized by their relationship to significant instream habitat reaches.

Figures 13 and 14 combine the terrestrial and aquatic riparian results into one prioritization scheme. Figure 13 shows both the terrestrial and aquatic results at the same time, while Figure 14 displays the results of combining both sets of priorities in the GIS analysis. Figure 15 displays all the potential wetland habitat priorities together: the combined terrestrial and aquatic riparian priorities with the isolated seepage fen habitats terrestrial priorities.

Several patterns with respect to the distribution of terrestrial and aquatic priorities are visible in Figures 1 through 15:

- Upland terrestrial habitat priorities co-occur with wetland priorities in some sections of the watershed but not others. Notable exceptions include limestone glades in the south central and western regions. Also, some known occurrences of plants found in glade seep habitats do not correspond with projected distributions of isolated wetlands at the scale of these maps.

- Differences in the spatial arrangement of priorities for terrestrial and aquatic species exist in the watershed.

- Isolated wetlands in the vicinity of tributaries to the West Fork of the Stones may provide significant habitat for streamside salamander (*Ambystoma barbouri*).

- Riparian zones in the lower East Fork Stones are significant for a number of plant species, particularly the Stones River bladderpod (*Lesqurella stonensis).*

- The areas surrounding Percy Priest Reservoir have a higher priority for terrestrial plants and animals than for aquatic species.

- Segments of the West Fork Stones and tributaries, and most stream miles of the East Fork Stones are important habitats for aquatic animal species, particularly fish and mussels.

- The headwaters of the East Fork Stones are highly significant habitat for the globally rare Brawleys Fork Crayfish (*Cambarus williami*).

- The headwater streams of the East Fork Stones and their catchment zones are also important due to their connectivity and contribution to the instream flows of other significant stream reaches further downstream.

- The headwater zones of the West, Middle, and East Fork in general provide important isolated and riparian wetland habitats for terrestrial and aquatic species.

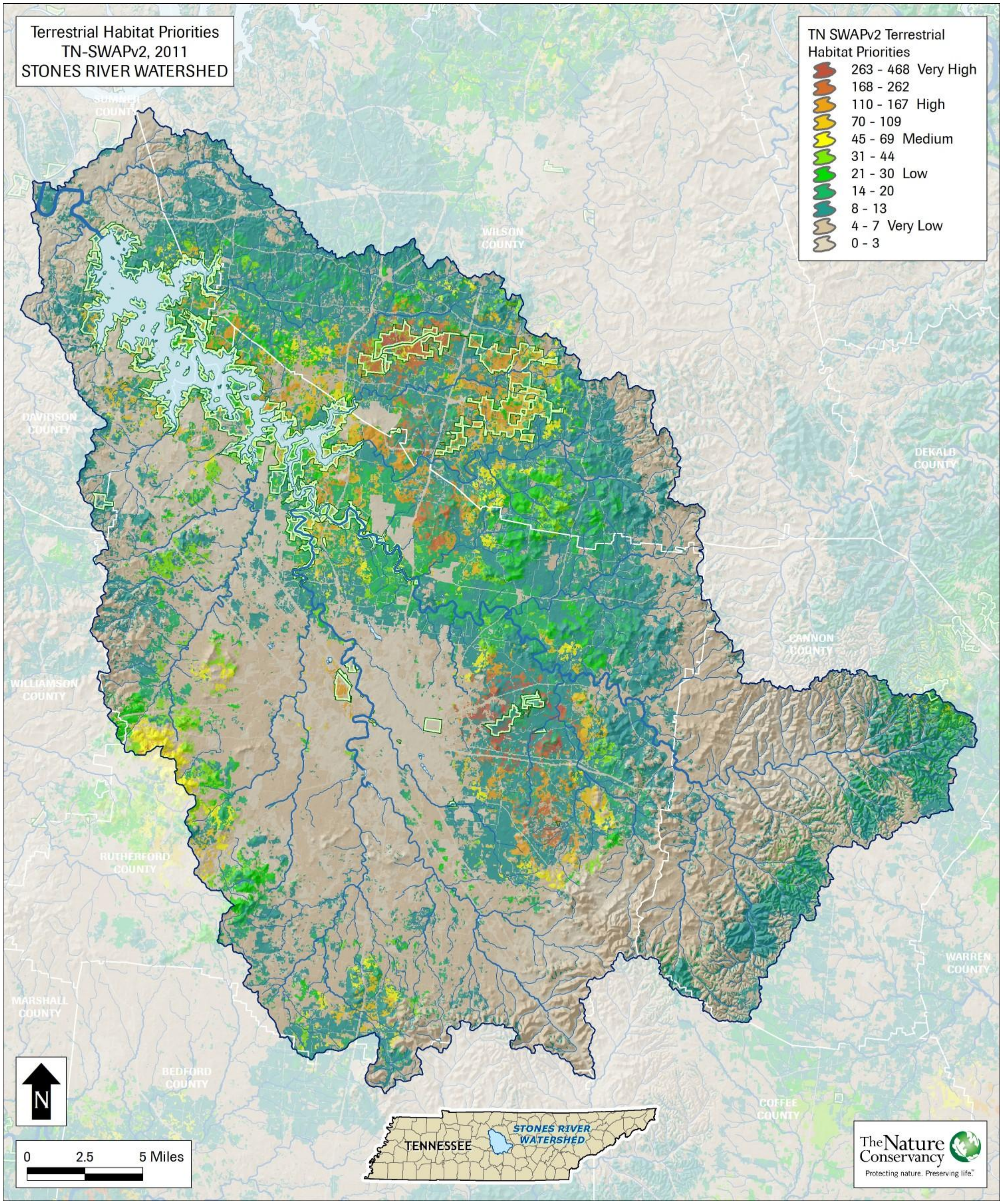



Figure 6. Location of priority habitats for terrestrial species in the Stones River watershed.

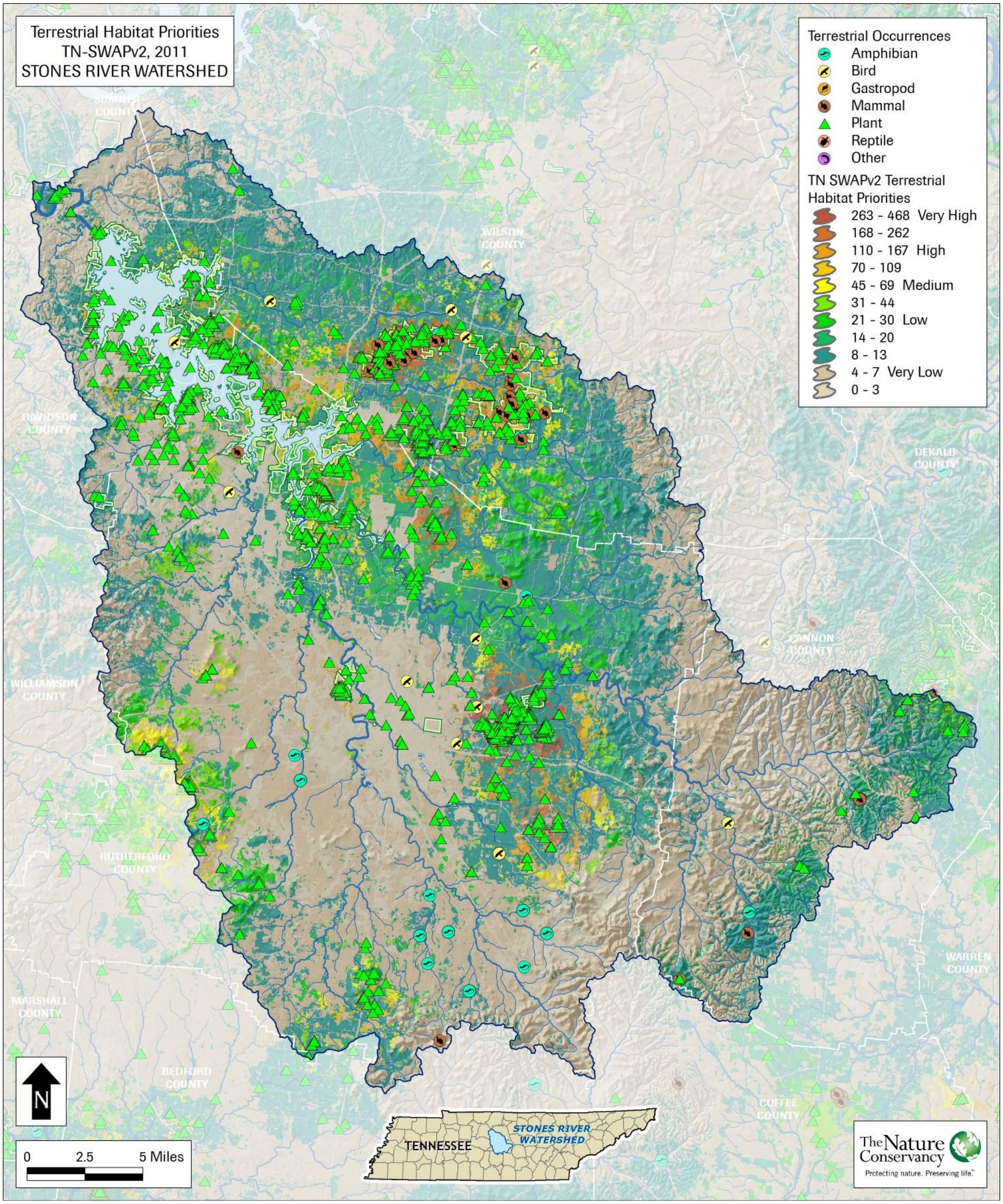



Figure 7. Location of priority habitats for terrestrial species in the Stones River watershed, with individual plant and animal occurrence records displayed.

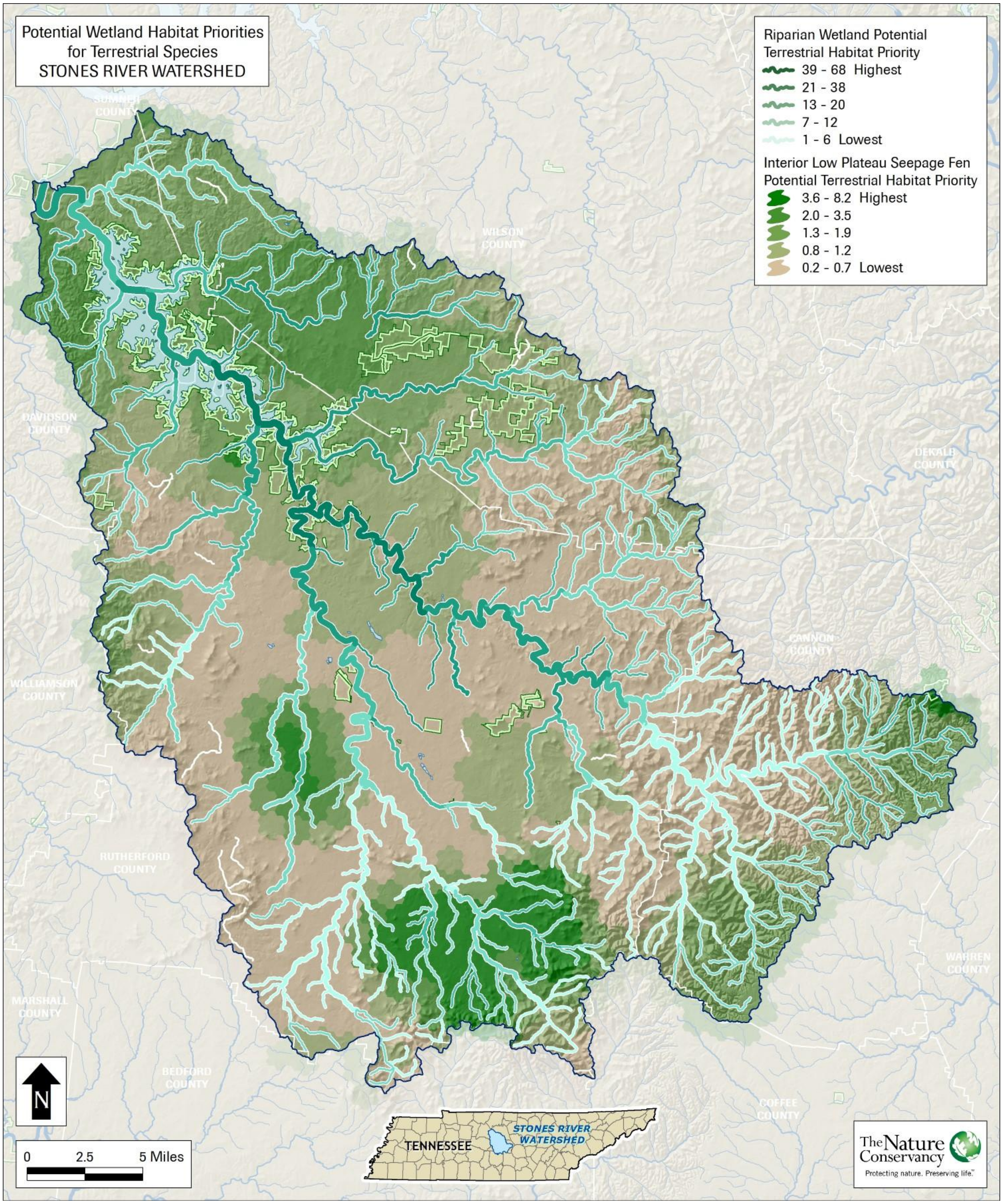



Figure 8. Potential riparian and isolated wetland habitats for all terrestrial species of conservation need.

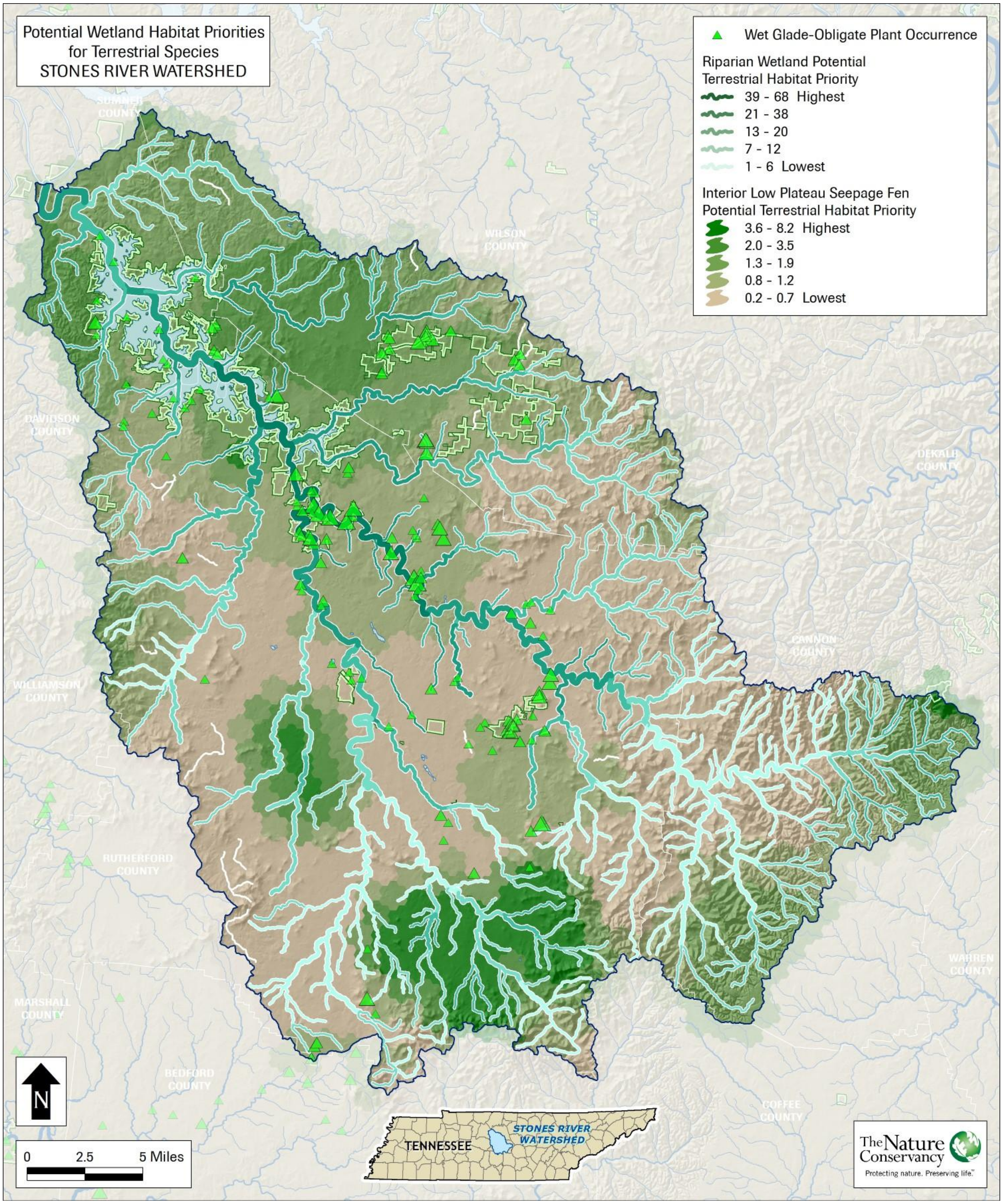



Figure 9. Potential riparian and isolated wetland habitats for all terrestrial species of conservation need. Occurrence records for wet glade habitat affiliated plant species displayed.

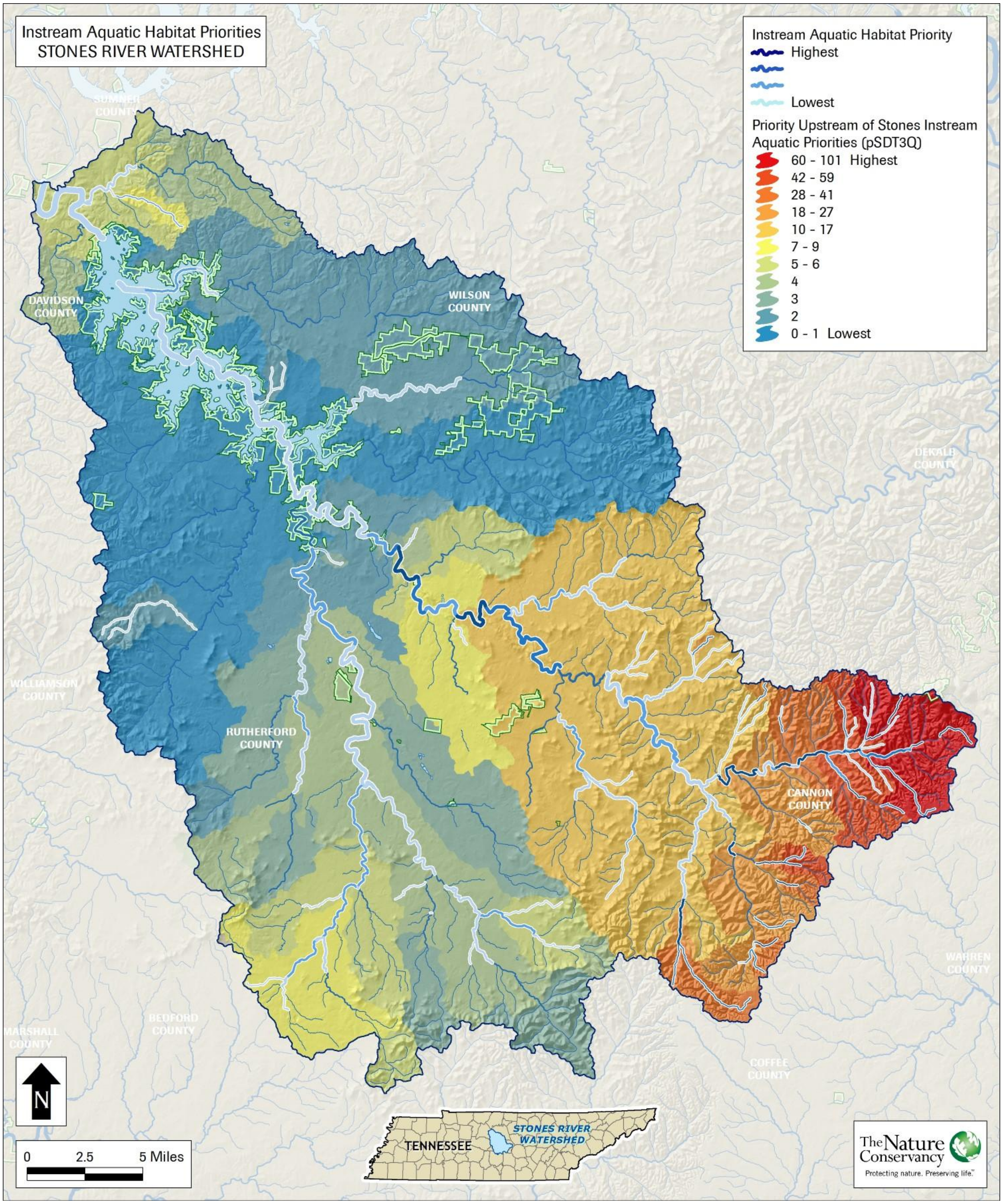



Figure 10. Instream aquatic habitat priorities and significant upstream catchment areas.

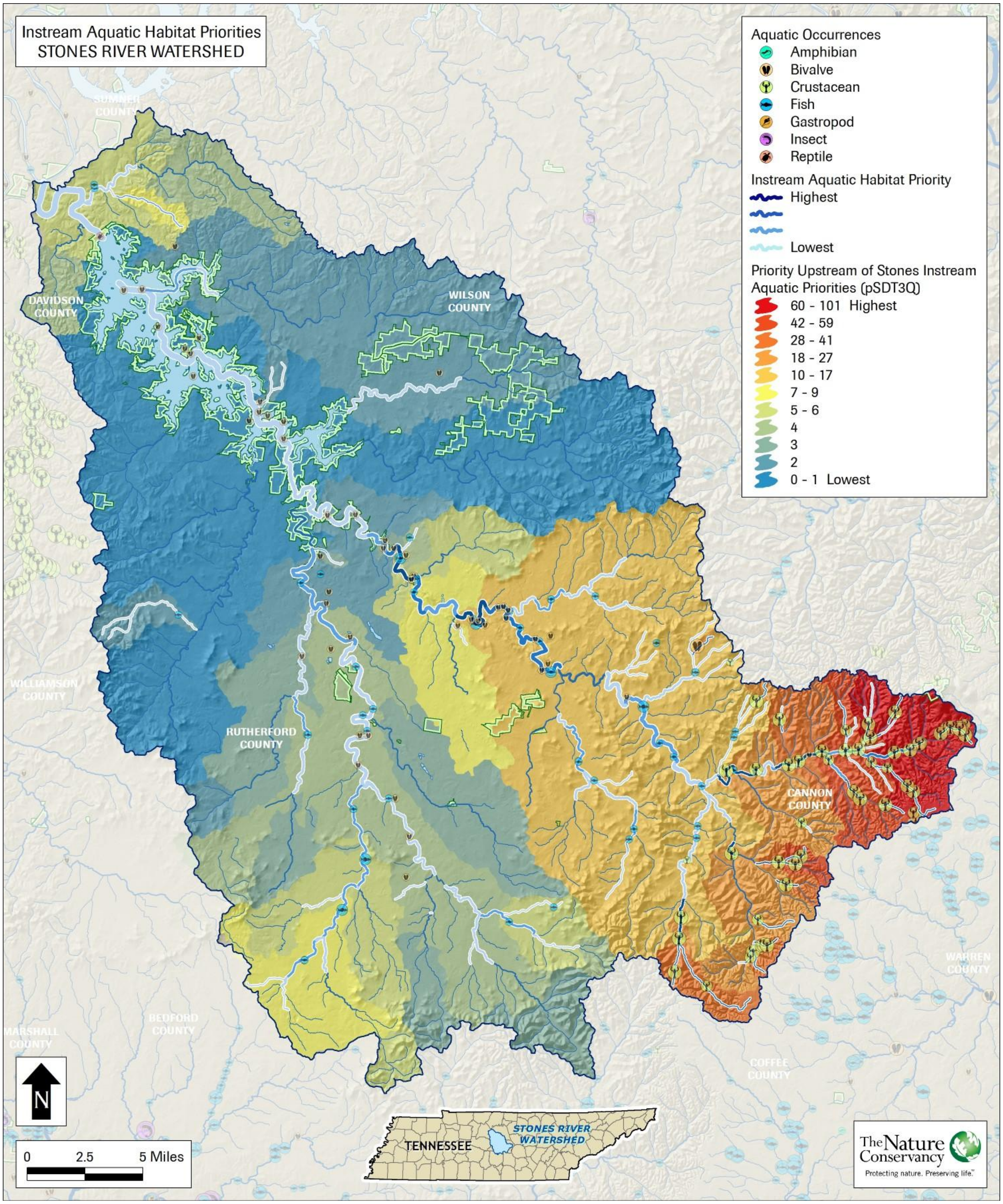



Figure 11. Instream aquatic habitat priorities and significant upstream catchment areas, with individual animal occurrence records displayed.

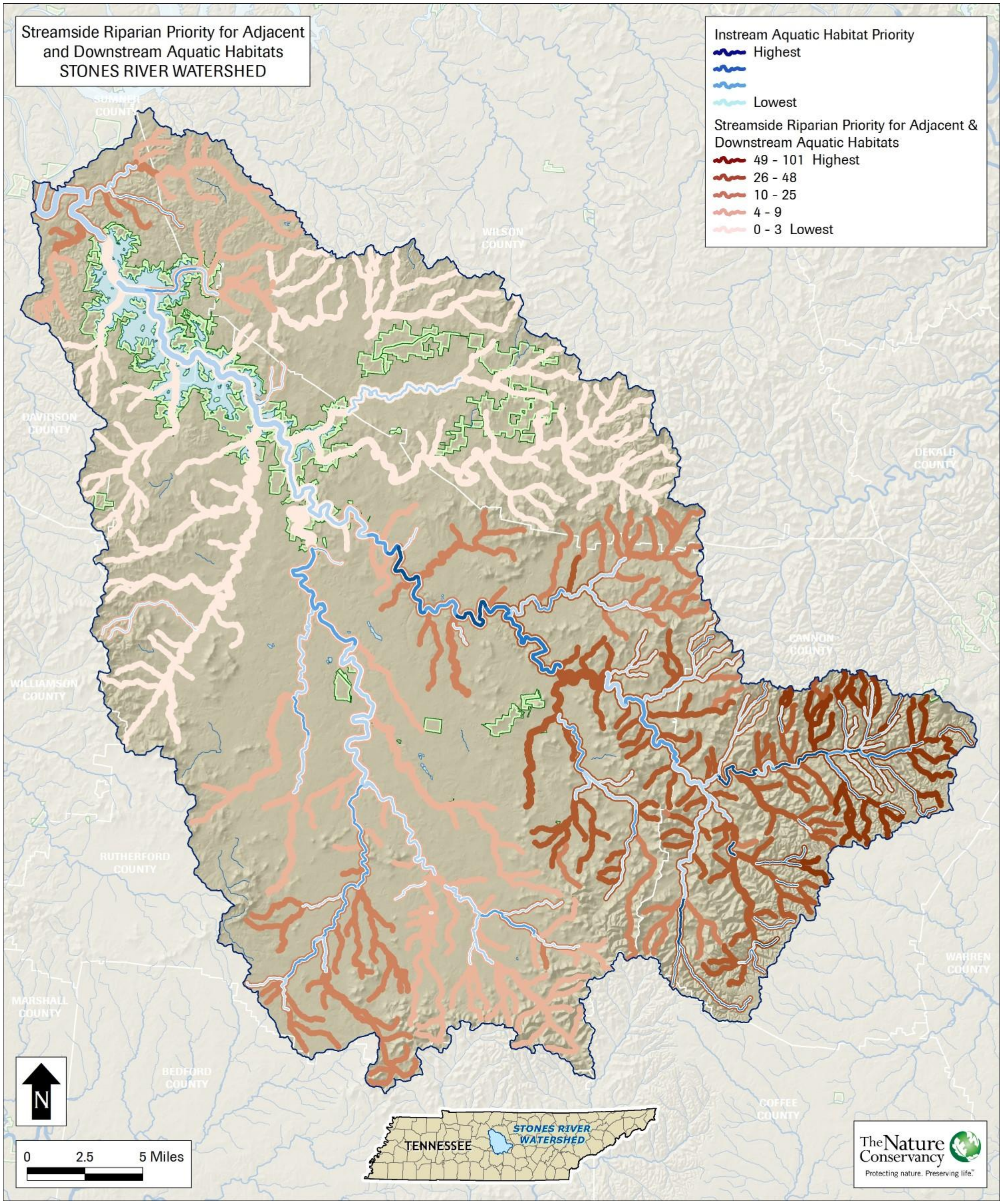



Figure 12. Stream side zone relative priority as a function of proximity, flow contribution, and travel time in relationship to significant instream habitats

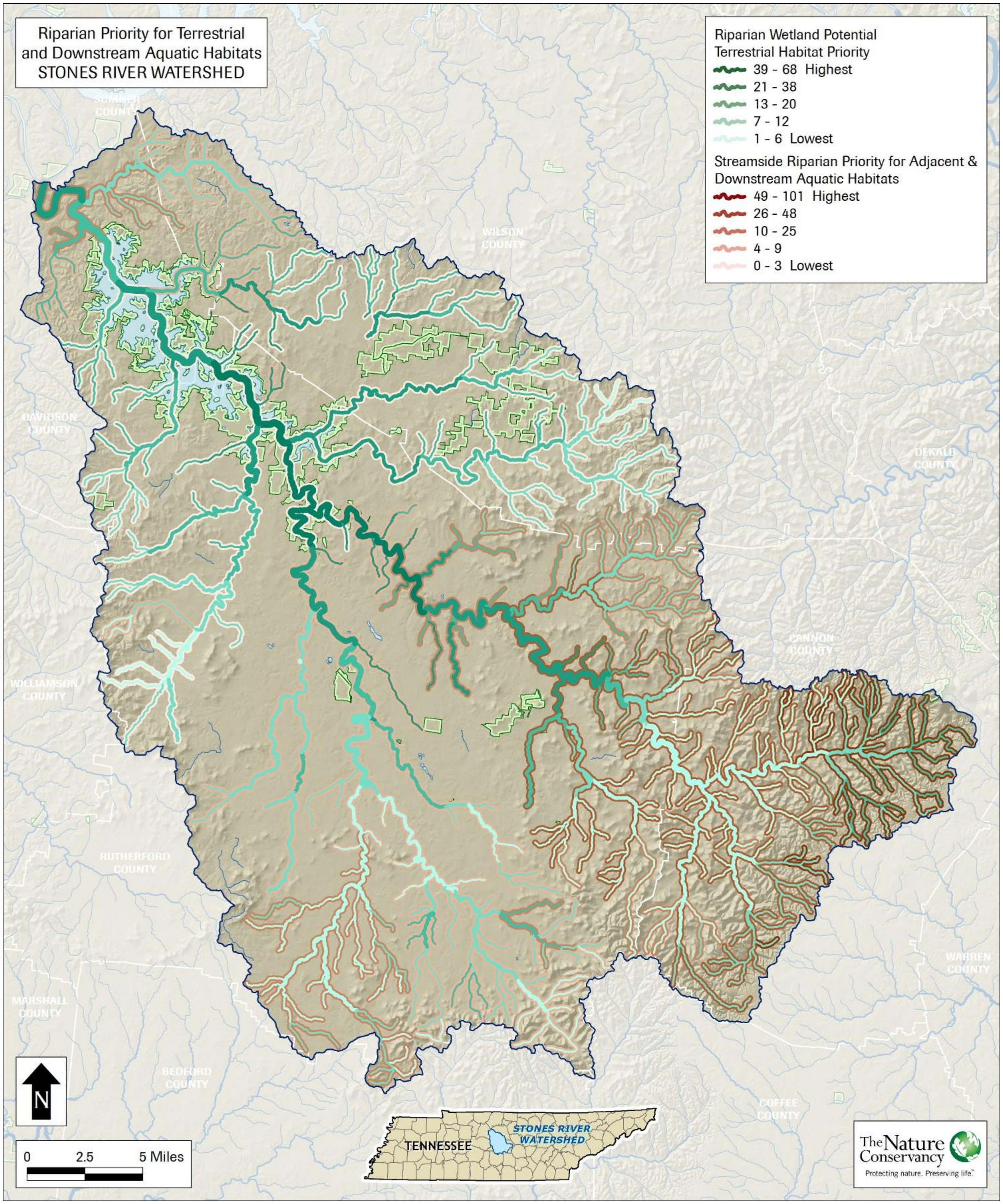



Figure 13. Stream side aquatic priorities overlain with terrestrial riparian priorities. An intermediate map showing both aquatic and terrestrial priorities simultaneously.

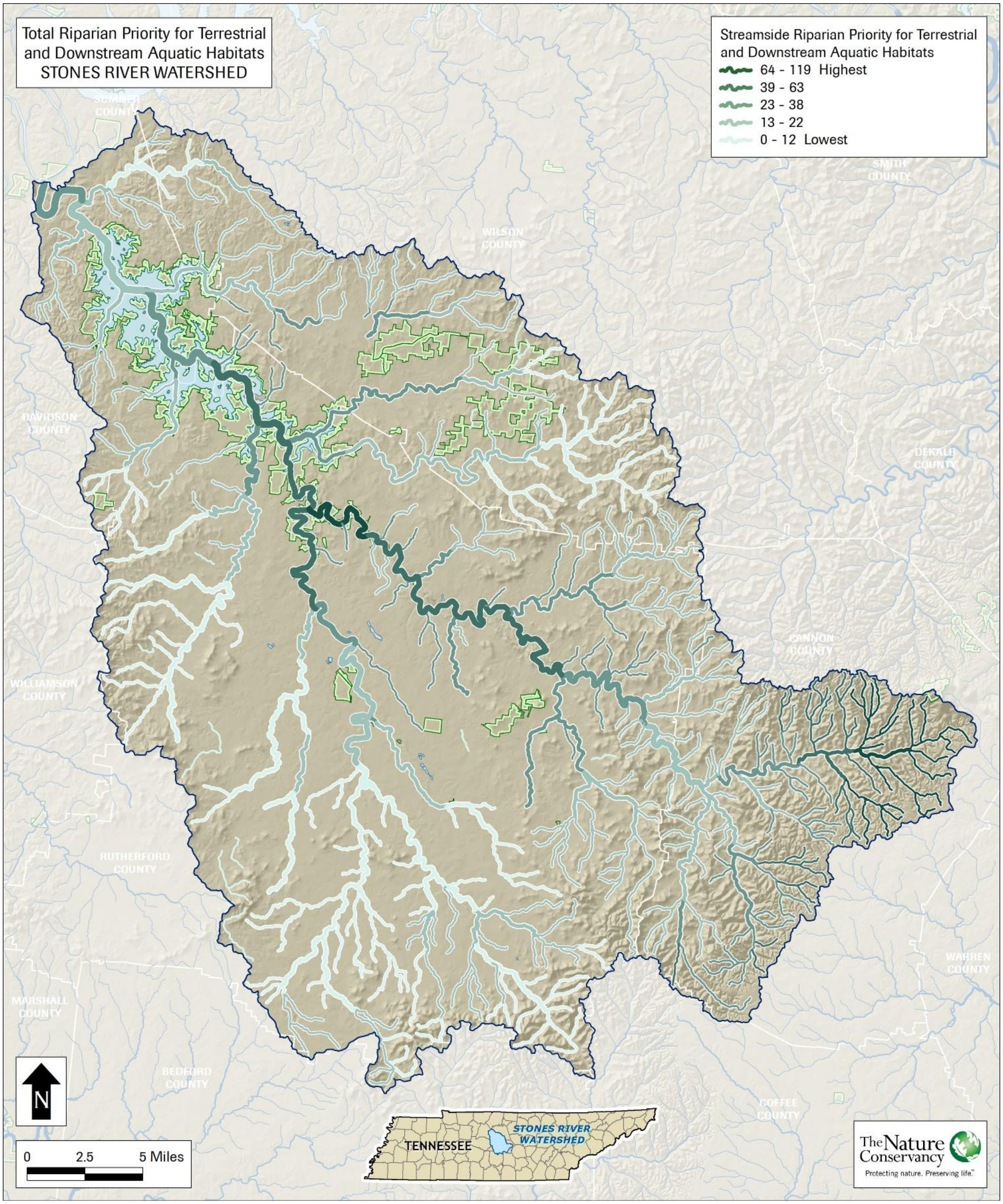



Figure 14. Stream side aquatic priorities, combined with terrestrial riparian priorities in GIS, to give and overall priority score for potential riparian wetlands.

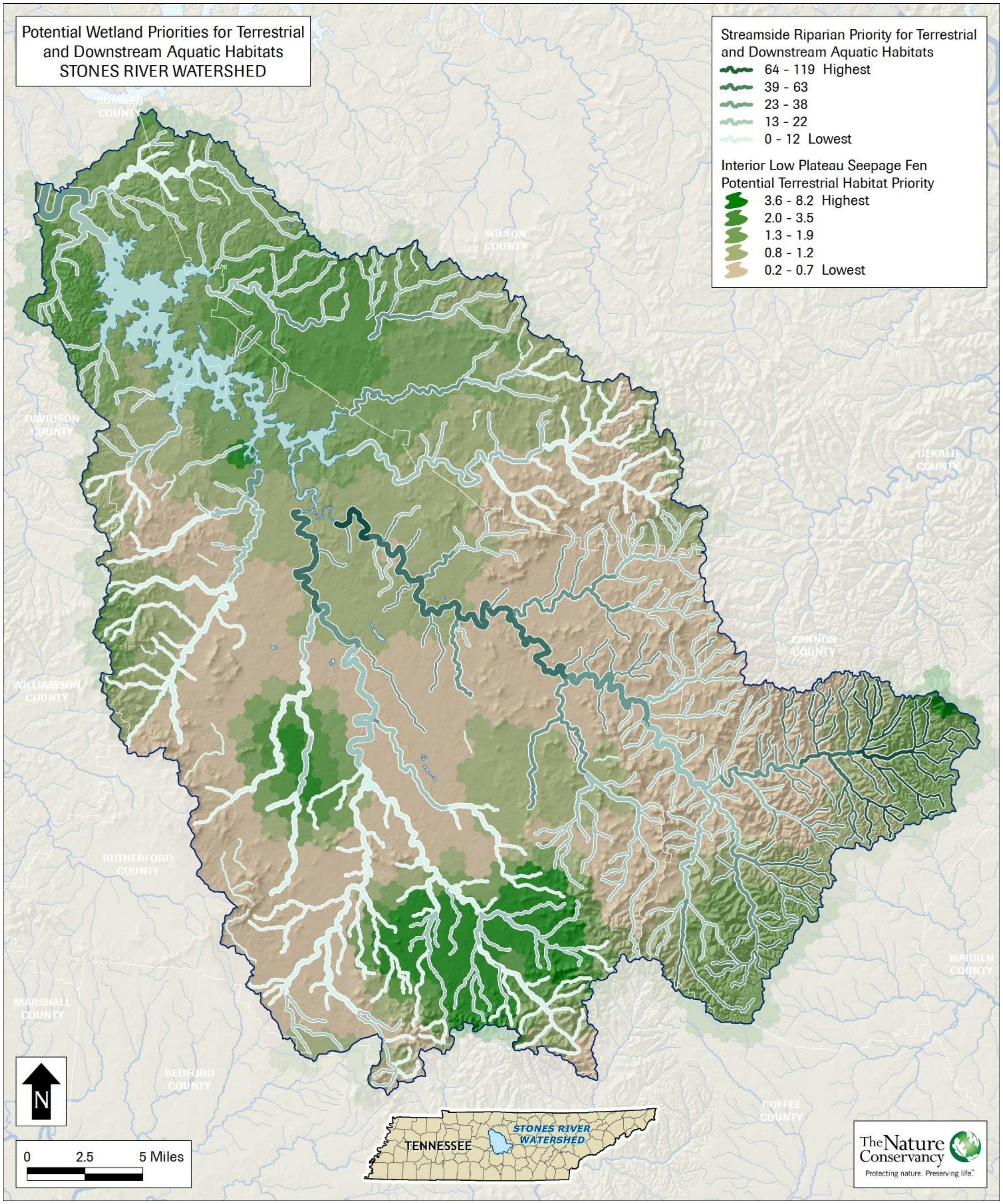



Figure 15. Relative conservation priority of all potential riparian and isolated wetland habitats for terrestrial and aquatic species.

# Chapter 6: Linking mitigation decisions to watershed priorities

In addition to conservation priorities for plant and animal species, Chapter 2 outlined several other resource values in the Stones River watershed, including water quality for a variety of uses designated by the State of Tennessee. Chapter 3 discussed the current condition of these resource values, particularly water quality and wetland conditions. In this chapter, we compare the wetland conservation priorities described in Chapter 5 to the NWI's wetland data. This comparison shows the distribution of NWI intact and modified wetlands across the wetland priority areas mapped throughout the watershed. We also discuss the spatial co-occurrence between the conservation priorities and areas of water quality concern, both of which may benefit from better informed wetland and stream avoidance, minimization, and mitigation decisions. Opportunities to consider additional values while selecting mitigation sites in conjunction with the conservation framework are outlined in Chapter 7.

## Comparing NWI data to conservation priorities

Figure 16 shows the distribution of both intact and modified NWI isolated wetlands compared to the wetland habitat priority areas described in Chapter 5 (Figure 15). Figure 17 shows the distribution of intact and modified NWI riparian wetlands in comparison to the same habitat priorities. Note that most of the NWI modified isolated wetlands shown in Figure 16 are small farm ponds scattered throughout the watershed. Together, Figures 16 and 17 give perspective on the distribution of intact and modified NWI types known on the landscape relative to wetland habitat priorities for both terrestrial and aquatic species. This data can help inform individual permit decisions regarding avoidance and minimization based on habitat significance, as well as guide wetland restoration efforts to sites which may contribute to improved species habitat conditions when mitigation is necessary.

The limited distribution of wetlands currently in the NWI for the Stones River watershed, and the methods used in this study to estimate potential wetland habitat significance, mean that any final determination on wetland presence or species habitat utilization must be made in the field. Nevertheless, our analyses can be used to help target field verifications to sections of the watershed more likely to contain wetland resources which are providing significant habitat for plant and animals species, both terrestrial and aquatic.

For example, if a field assessment identifies a site as currently degraded but restorable, the location of that site within our priority map indicates potential restored value to species of conservation need. Alternately, if the site visit identifies a functional, intact wetland, its location on the priority map indicates a relative conservation value to inform avoidance and minimization decisions. This information is also helpful when impacts requiring mitigation occur in other sections of the watershed by demonstrating where preservation may help improve habitat conservation outcomes.

## Priority riparian habitats and water quality impairments

Over 200 stream miles in the Stones River watershed are listed as impaired due to sedimentation and alteration of streamside vegetation (Chapter 3, Table 5). Figure 18 shows the relationship between priority wetland habitat areas and stream segments impaired from these two sources. The highest priority stream segments, particularly for aquatic animals, do not co-occur with these impaired segments. However, several are of low to moderate priority or flow into larger stream segments of higher conservation priority. Therefore, restoration investments in these reaches may reduce sediment loads and contribute to some species habitat recovery over time.

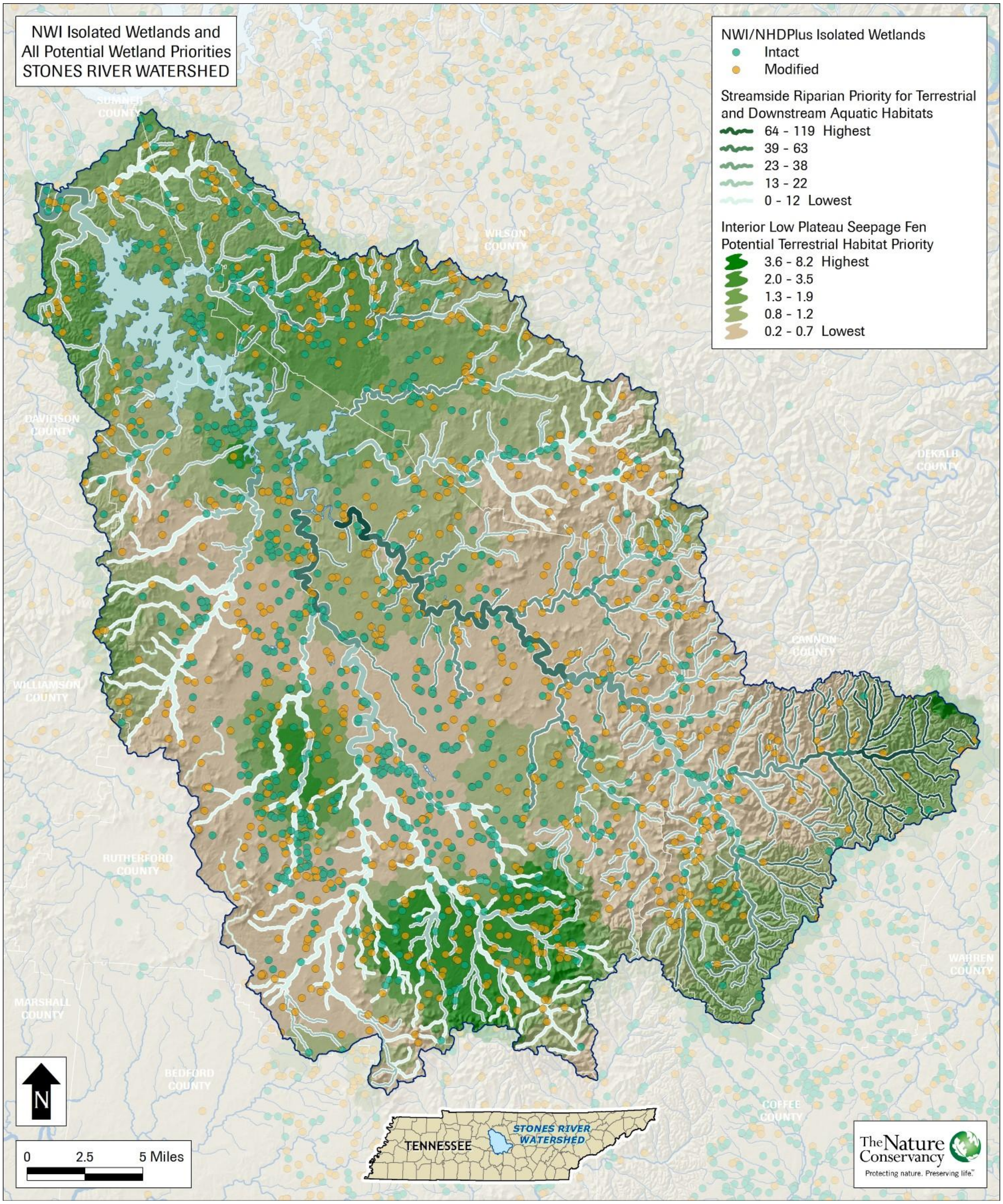



Figure 16. NWI intact and modified isolated wetland distributions compared to wetland habitat priorities.

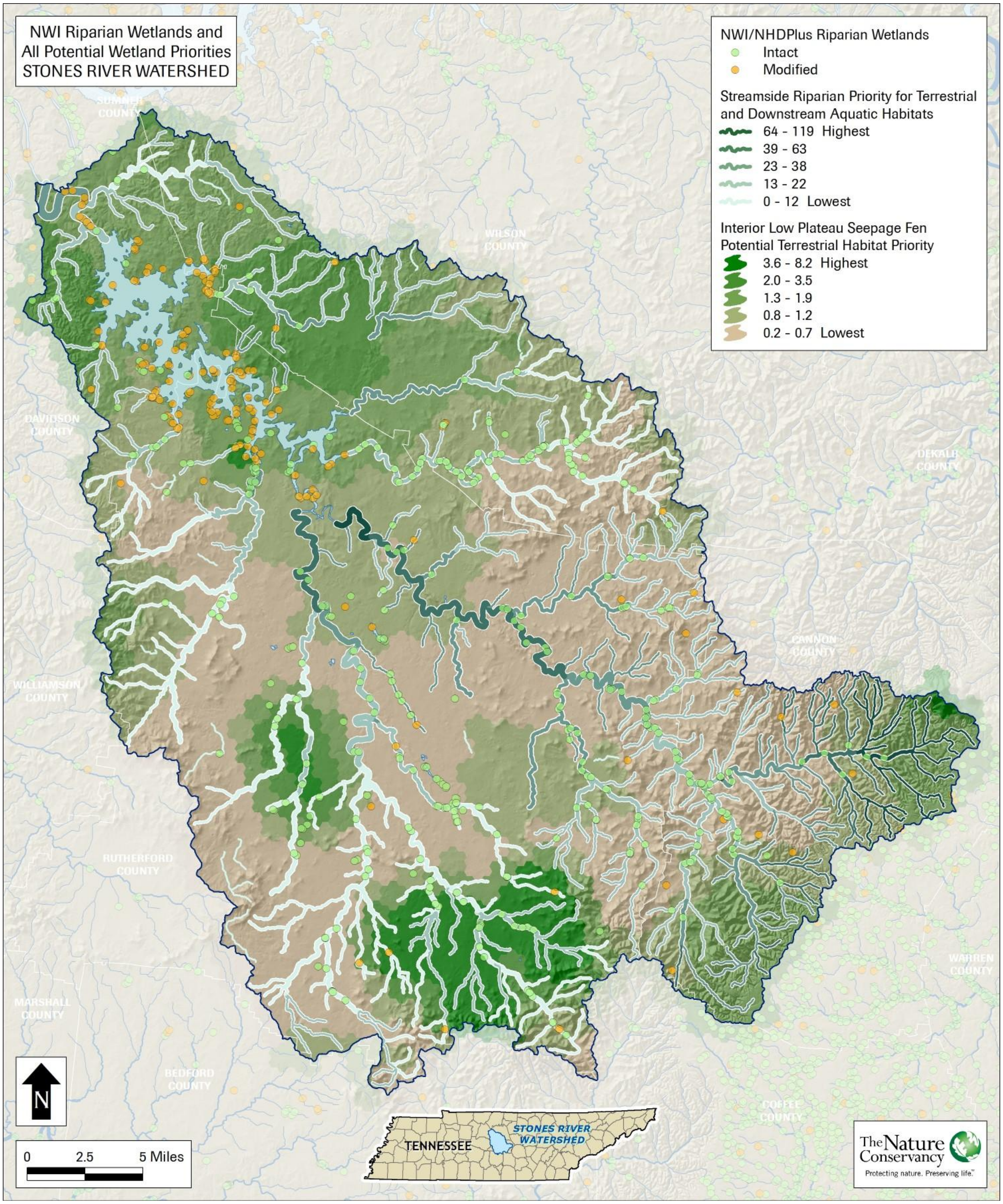



Figure 17. NWI intact and modified riparian wetland distributions compared to wetland habitat priorities.

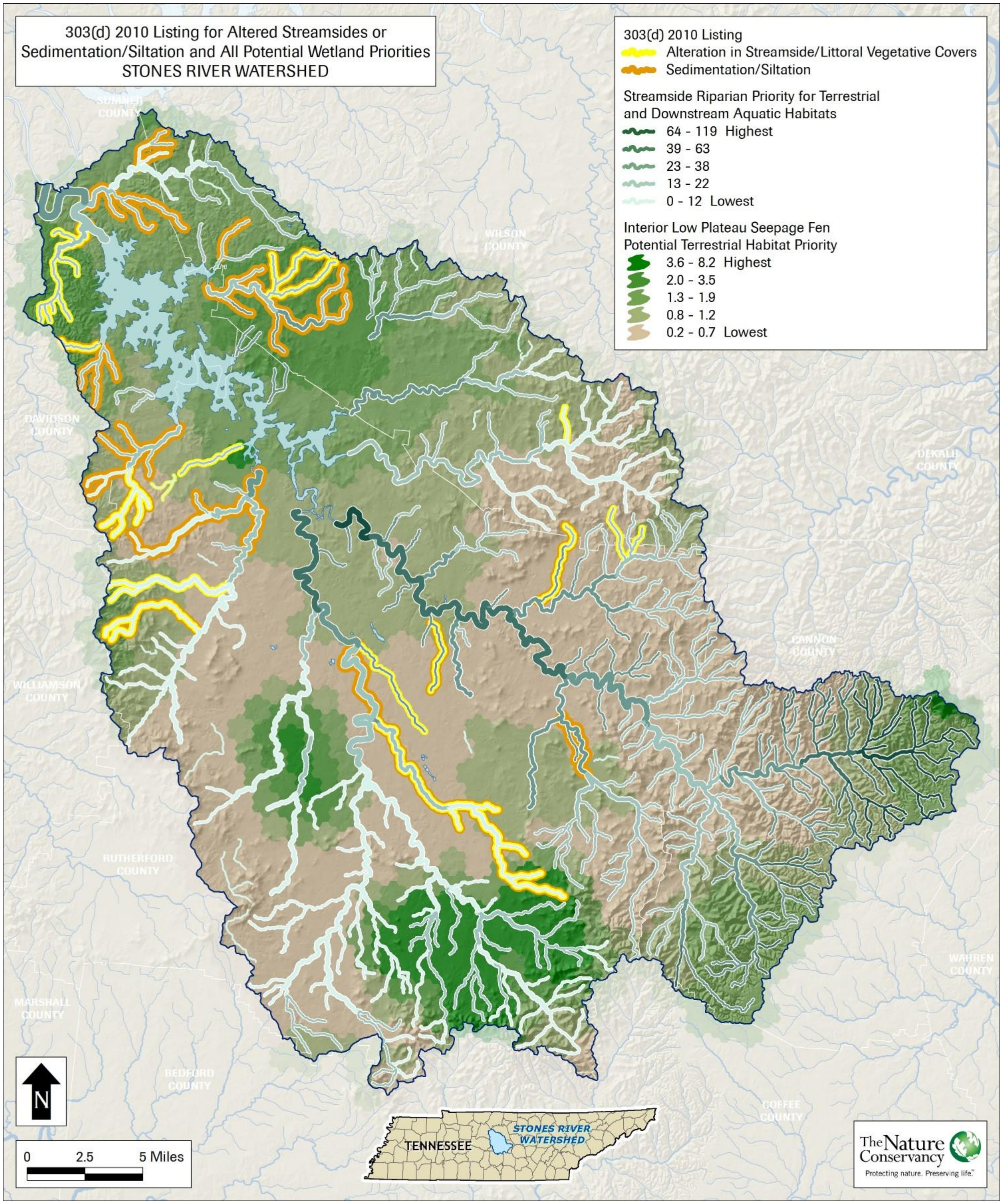



Figure 18. Streams listed impaired by TDEC in 2010 for sedimentation and stream side vegetation alteration compared to wetland habitat priorities.

## Local water quality improvement efforts

With the support of state and federal agency technical and financial assistance, municipal and county governments, local non-profits and academic institutions have undertaken a number of stream restoration projects in the last decade. Examples of these projects include a restoration plan for the Lytle Creek tributary, improved pasture management along Cripple Creek and Wades Branch, and surveys along Sinking Creek (SRWA 2004, EPA 2007(a), EPA 2007(b), City of Murfreesboro 2008). All of the municipal and county governments, with the exception of Cannon County which does not meet the federal requirements, have very active Municipal Stormwater (MS4) programs that map and monitor local streams, engage in restoration projects, and educate the public.

In recent years, the Stones River Watershed Association worked with TDEC to complete an advance BMP plan for Puckett Creek, a tributary to the West Fork just west of Murfreesboro (SRWA 2008). Puckett Creek is not currently impaired, but is located in section of the watershed experiencing development. The study confirmed that water quality and habitat conditions in the watershed are good, and made several recommendations on best management practices to employ as more of the watershed develops over time. These include protecting existing stream buffers, restoring stream buffers in some locations, and restoring small wetland features (SRWA 2008). Keeping streams off the list of the State's impaired waters in advance reduces the regulatory burden for local governments and permit applicants. Puckett Creek is also located within a priority area for riparian and isolated wetlands providing habitat for the streamside salamander (Figures 16 and 17).

Maintaining the water quality of Percy Priest Reservoir is a concern not just of the Corps, but for all municipalities in the watershed (USACE 2007). LaVergne, Smyrna, Mufreesboro, and many unincorporated portions of Rutherford County withdraw public drinking water at tributary locations where the reservoir pool begins. The municipalities also discharge their treated wastewater in similar locations which eventually flow into Percy Priest.

Because Percy Priest is at the downstream reaches of the Stones, it receives the run-off from all land uses and discharges upstream.
Investments in priority riparian habitats upstream of the reservoir benefit not only species of conservation need but drinking water sources and recreational fisheries in Percy Priest. The City of Woodbury, located in Cannon County, withdraws its water from the East Fork of the Stones River. Therefore, efforts to avoid, minimize, and mitigate stream impacts in the upper East Fork and its headwaters may help conserve significant aquatic habitats and improve public drinking water supplies.

# Chapter 7: Mitigation techniques and site selection

## Future land development trajectories

The recent history of land development in the watershed and future trends were discussed in Chapters 2 and 3. Understanding the trajectory of land development, in this case the conversion of agriculture to residential and commercial development, provides important landscape context for mitigation decisions. Wetland restoration projects executed to meet mitigation requirements can fail to meet no-net-loss goals in the long-term when the surrounding land areas experience intensive land use. This is the case in agricultural dominated landscapes, but particularly prevalent in urbanizing situations (Roni et al. 2008, Morgan and Roberts 1999).

In the past three years, The Nature Conservancy developed GIS analyses to improve our understanding of population growth and land development patterns over the next few decades in Tennessee. The Tennessee Advisory Commission on Intergovernmental Relations (TACIR) and The University of Tennessee Center for Business and Economic Research (CBER) produce and publish population growth projections for Tennessee's 389 municipalities and unincorporated portions of counties at 5-year intervals. Separately, as part of their growth management plans required by the Tennessee Growth Policy Act of 1998, counties in Tennessee mapped future urban growth areas around existing municipalities, as well as planned growth areas within unincorporated portions of counties.

TNC constructed a statewide development suitability model, based on land cover type, topographic slope, FEMA flood ratings, land protection status, and accessibility to roads and existing urban centers. This model was then used to spatially allocate TACIR/CBER's projected population changes within the planned growth areas. The result is a spatially explicit projection of future population growth and distribution, at 5-year time steps, out to the year 2030. Population densities were then calculated from the projections and, using a formula published by the EPA, converted to estimates of percent total impervious area (%TIA). %TIA projections for the year 2030 were then subtracted from those for the year 2000 to give estimates of total projected change in %TIA.

We applied this analysis to develop a map of the projected land cover change in relationship to population growth expected in the Stones River watershed (Figure 19). This map shows the differences in projected land use change in each county jurisdiction of the watershed. The southeastern section of Wilson County and the central and western sections of Cannon County are not expected to gain significant population according to TACIR and CBER reports. By contrast, all areas within Rutherford and Metro Nashville-Davidson counties show some degree of change, with the highest percentages associated with existing municipalities and transportation corridors. Increased land development, including necessary transportation improvements, typically involves impacts to stream and wetland resources which are reviewed and permitted by TDEC and the Corps. Figure 19 shows areas of the Stones River watershed where increased permit activity may be anticipated, as well as areas where lower degrees of land use change may occur. Both pieces of information are useful in avoidance and minimization analyses, as well as in choosing mitigation sites likely to be more sustainable in the future.

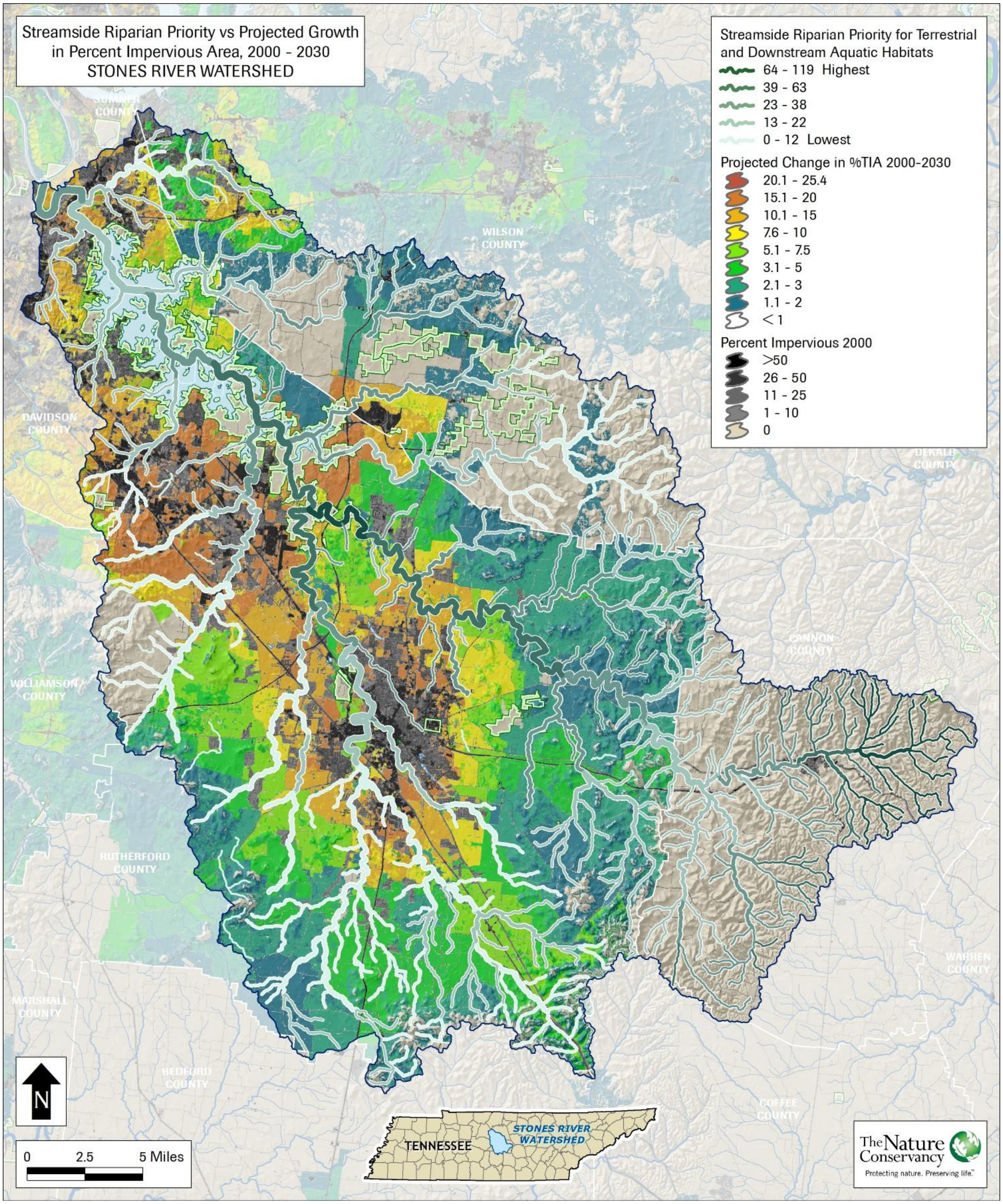



Figure 19. Projected change in total percent impervious area from 2000-2030 compared with riparian wetland priorities for plant and animal species.

# Siting mitigation to achieve multiple resource benefits

## Sediment reduction TMDL goals

The most prevalent sources of stream impairment in the Stones River watershed are sedimentation and stream side alteration (see Chapter 3, Table 5). In 2002 TDEC published TMDL goals for siltation and habitat alteration in those streams listed as impaired in 1998. Reduction of sediment from wet weather point and nonpoint sediment sources is the focus of this TMDL. The TMDL was designed to achieve full support of fish and aquatic life designated uses. Achieving restoration of this designated use is protective of all other use classifications (TDEC 2002). Appendix 4 provides the list of specific waterbodies targeted for sediment load reductions and streams requiring improvements to dissolved oxygen status and nutrient loads. Several of the recent and ongoing water quality projects outlined in Chapter 6 are helping achieve the sediment TMDL objectives as well as others, particularly low dissolved oxygen and nutrients (TDEC 2008).

## Sensitive species habitat protection and restoration

The current condition of stream and wetland resources, and projections of future land use change, have serious implications for the remaining viable populations of plant and animal species of conservation need. A majority of the historic large river floodplain habitat has been converted to reservoir pool conditions. While many terrestrial species and native sports fish utilize the impounded habitats, other native fish and mussel species are restricted to the remaining stream and river section of the West, Middle and East Forks. Most of the larger river floodplain segments important for plants and freshwater animal species are located in the high potential land conversion areas (see Figure 19). Our GIS analyses highlight the following habitat protection and restoration needs in particular (see Figure 20):

- The remaining unimpounded segments of the East and West Fork provide significant floodplain habitat for rare plant and terrestrial animal species. Avoiding and minimizing further impacts to these reaches may be a preferred management alternative.

- Sections of the West Fork and East Fork Stones are significant for native fish and mussel species. Minimizing additional impacts and targeting stream and associated wetland restoration in these areas may improve habitat conditions for these species.

- The East Fork of the Stones contains the majority of remaining populations of fish, mussel, and crayfish native to the watershed. Avoiding and minimizing development impacts in lower reaches of the East Fork and restoring sections in upper reaches with lower land conversion percentages could provide important habitat benefits for these species.

- The upper headwaters of the East Fork provide extremely significant habitat for the Brawley's crayfish, a globally rare and State listed Endangered species (see Figures 11 and 20). Brawley's crayfish is restricted to these areas of the upper East Fork. Avoiding and minimizing impacts in these areas may be a preferred management alternative.

- Isolated wetland habitats in the Puckett Creek subwatershed occupied by the streamside salamander, a State rare species, may be impacted by projected land conversion. Minimizing impacts and implementing the best management practices identified in the Puckett Creek BMP plan (SRWA 2008) may be beneficial for this species. Habitat restoration and protection in headwater sections of the Middle and West Fork may also benefit populations of the streamside salamander as well as rare plants and other terrestrial and aquatic species.

- The limestone glade habitats, including seep zones, are highly significant for many globally rare endemic plant species. Once disturbed by development activities, these habitats and populations are difficult to restore. Avoiding impacts and implementing protection measures may be a preferred management alternative (see Figures 9 and 20).

## Connecting existing conservation lands

The majority of the Stones River watershed landscape is outside existing areas set aside for conservation purposes. Therefore, building off existing conservation lands only will not meet all resource management needs. Some opportunities may exist in the northeastern regions around Percy Priest Reservoir, east towards Cedars of Lebanon State Forest and Park (see Chapter 5, Figure 15). Other existing conservation lands tend to be isolated in the watershed, and expanding outwards from these areas is constrained by other surrounding land uses. Opportunities do exist for more protection of glade habitats found throughout the watershed, and conservation efforts in the south central portions around Flat Rock State Natural Area continue. The Stones River National Battlefield is primarily surrounded by intensive residential and commercial development, but is connected to the greenway system along the West Fork.

## Maintaining and improving recreational, historic and agricultural resources

Rather than focus solely on traditional conservation lands, local investments in expanding parks, greenways, blueways, and promoting sustainable local agricultural markets may provide the best opportunities to achieve a network of management areas which can help improve habitat for sensitive species, protect and restore water quality, and provide recreational, cultural, and economic benefits to local communities. Appendix 5 contains examples of open space and greenway development that exist and are expanding near Percy Priest and small tributary creeks, in addition to sections of the West, Middle, and East Fork Stones. Locating mitigation projects and utilizing site appropriate techniques have the opportunity to greatly benefit these local resource management and recreation goals.

Local governments acknowledge the importance of agriculture to the heritage and economy of the region, and that expanding residential and commercial development can encroach upon those values (RCRPC 2011). Local farmers markets and direct to consumer sales have already increased opportunities for value-added income in recent years (Bruch and Holland 2007). In the next decade, municipal and county governments may take steps to help maintain agricultural areas through a combination of land use regulations and infrastructure planning decisions (RCRPC 2011). These activities may help keep more prime farm land in productive agriculture in the future. Restoration opportunities for stream and wetland resources that will be sustainable in the future may be available these agricultural settings.

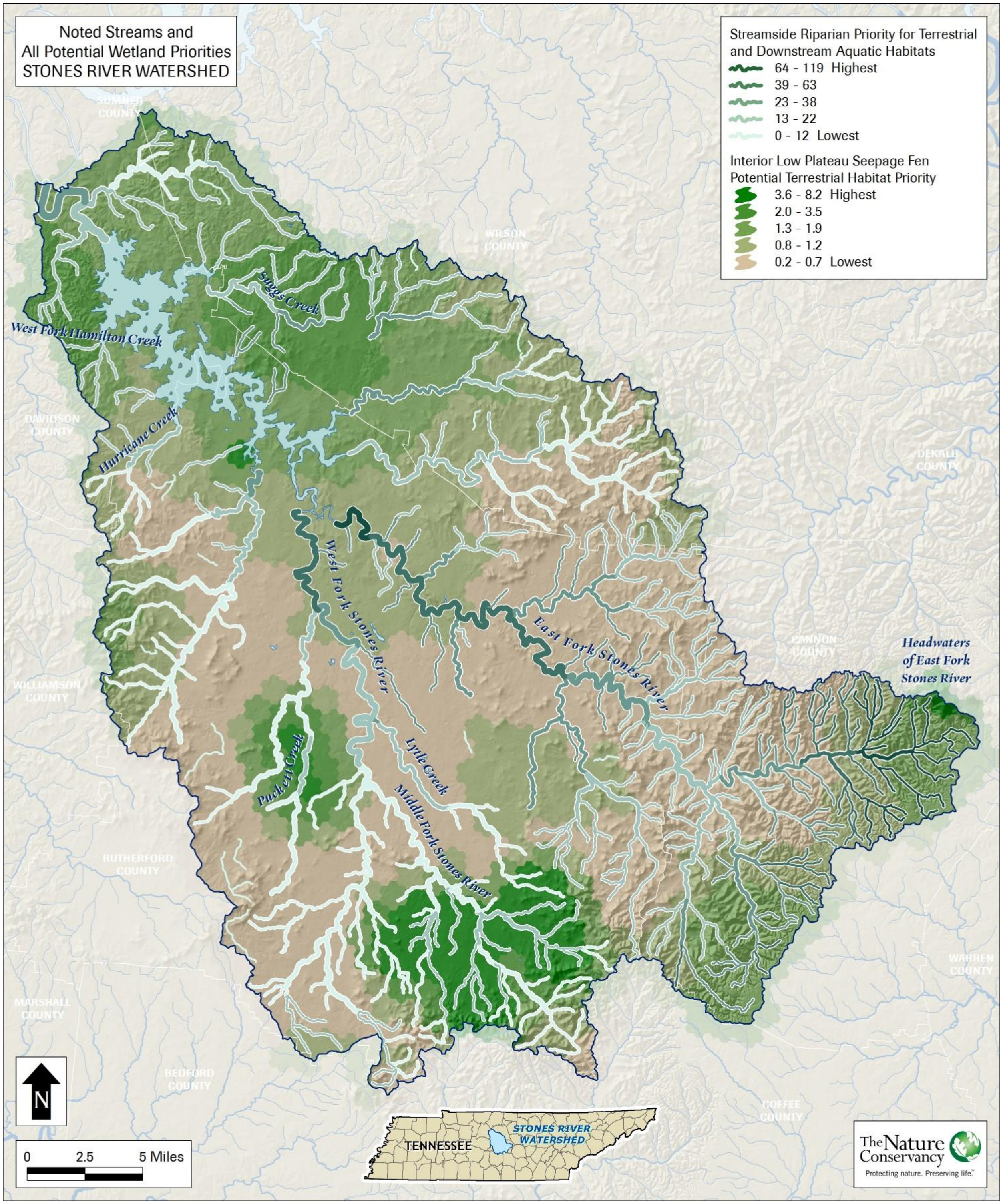



Figure 20. Overall wetland habitat priorities, with important stream and river reaches identified.

# Recommended mitigation techniques

## Overview of approved methods

Federal regulations outline allowable forms of compensatory mitigation for wetland impacts. These include restoration, creation, enhancement, and preservation. The 2008 regulations state that restoration "should generally be the first option considered because the likelihood of success is greater…" (332.3(a)(2)). In Tennessee, TDEC and the Corps have demonstrated this preference for restoration over other forms of compensation, but enhancement, preservation and creation have been allowed (TDEC 2004, TWRA 2005, Morgan and Roberts 1999). Compensatory mitigation for stream impacts is guided by a classification system which includes replacement, restoration, enhancement II, enhancement I, and preservation categories for determining credit ratios (TDEC 2004). Replacement, the removal of artificial structures and re-creation of a natural stream channel, and preservation are applied less often than restoration and enhancement.

This study did not review whether wetland creation or stream replacement might be an appropriate technique in the watershed due to the regulatory agencies' preference for restoration, as well as data which suggests past creation projects may not successfully achieve resource management goals (Morgan and Roberts 1999). Previous sections in this chapter discussed avoidance and minimization, and locations where restoration or preservation may help achieve various resource goals. Here we discuss more specific applications of approved restoration, enhancement, and preservation techniques.

## Restoration & enhancement techniques

The State of Tennessee recognizes four general types of stream mitigation treatments: riparian buffer restoration (re-establishment), hydrologic buffering and pollutant removal, bank stabilization, and livestock exclusion (TDEC 2004). The Clean Water Act and 2008 rule also grant the Corps the authority to require riparian buffers as part of mitigation requirements (Fischer 2001). These treatments fall within the types of mitigation most often used in Tennessee: Restoration, Enhancement II, and Enhancement I. Mitigation is also specifically directed to impaired waters on the 303(d) list or waters determined to be impaired based on standard field survey protocols (TDEC 2004).

The statewide in-lieu fee stream mitigation program (TSMP) focuses on natural channel design and corresponding re-establishment of native vegetation as the primary restoration technique. These restoration projects may also include in-stream structures for improving habitat diversity. TSMP implements streambank stabilization and in-stream habitat structures as approved Enhancement II techniques. Livestock exclusion and riparian vegetation restoration are approved Enhancement I treatments. Most activities conducted by TSMP are restoration projects, with a smaller proportion of enhancement activities (TSMP 2009).

Wetland restoration projects in Tennessee typically involve the re-establishment of hydrologic conditions of wetland soils, often altered by ditching and draining for agricultural purposes (TDEC 1998). Native wetland vegetation is then re-established by planting and natural regeneration. TDEC and the Corps require monitoring of all stream and wetland mitigation projects, regardless of the techniques employed (TDEC 1998).

These stream and wetland mitigation techniques can help improve resource conditions in the Stones River watershed, especially when applied in the proper landscape context. The following is a summary of key locations where specific restoration and enhancement practices may be of benefit (see Figure 20):

- Riparian buffer re-establishment, hydrologic buffering and pollutant removal, and bank stabilization in mid- to lower downstream sections of the West and East Fork Stones.
- Natural channel restoration with instream structures, livestock exclusion, bank stabilization and riparian buffer re-establishment, particularly along tributaries to the East Fork Stones as

well as some tributaries to the West Fork (see Figures 18 and 20).

- Riparian buffer re-establishment, bank stabilization, and livestock exclusion along the main stem of the East Fork Stones.
- Localized bank stabilization and riparian buffer improvements in the upper headwaters of the East Fork.
- Restoration of modified isolated wetlands in small tributaries and headwater sections of the Middle and West Fork.
- Riparian buffer re-establishment, hydrologic buffering and pollutant removal, and bank stabilization for tributaries of the West Fork impacted by urban land uses (e.g. Lytle Creek).
- Natural channel restoration with instream structures, riparian buffer re-establishment, hydrologic buffering and pollutant removal, and bank stabilization in streams which flow directly into Percy Priest Reservoir (see Figures 18 and 20).

## Preservation techniques

Tennessee's mitigation guidance states that preservation may serve as compensatory mitigation only when associated with a replacement or restoration project (TDEC 2004). High quality resources must be at imminent risk to development, or be associated with endangered species dependent on the habitat in question, in order to qualify for preservation credits. Preservation is also approved under the 2008 rule according to similar criteria. The criteria are that the resources to be preserved must provide important physical, chemical, or biological functions; the resources contribute significantly to the ecological sustainability of the watershed; they are under threat of destruction or adverse modifications; and the site will be permanently protected through an appropriate real estate or other legal instrument (332.3(h)). While not a preferred mitigation technique in most settings, preservation activities may be appropriate for some situations in the Stones River watershed (see Figure 20):

- Puckett Creek, Lytle Creek, and sections of the Middle and West Fork Stones in the vicinity of Murfreesboro.
- The East Fork of the Stones and its tributaries, from its confluence with the West Fork upstream to the northeastern sector the city of Murfreesboro.
- Preservation of limestone glade habitats to the east and south of Murfreesboro, and northeast of Smyrna & LaVergne in the vicinity of Percy Priest Reservoir (see also Figure 7).
- The upper headwaters of the East Fork Stones associated with Brawley's crayfish occurrences, which are susceptible to impacts from gravel harvesting.
- All stream segments identified as Exceptional Tennessee waters for outstanding biological diversity or presence of rare species in Davidson and Rutherford County (see also Table 1).

Finally, while restoration of riparian buffers provides important water quality and habitat benefits, research on native freshwater species has demonstrated that intact forest cover within whole watershed catchments is critical (Harding et. al 1998). Watershed management goals designed to limit impervious surface land use to 5-10% and utilize riparian buffers for biological resource protection may not in fact be protective. In areas where urbanization is replacing agricultural land use, the previous effects of agriculture on instream biota can mask those of increasing urbanization (Cuffney et al. 2010). This type of land use conversion is precisely the scenario in many sections of the Stones River watershed. Therefore, consideration should be given to preservation activities which can contribute to increased forest cover within priority catchment areas, and not focus solely on traditional buffer widths of 25-100 feet dependent on stream size.

## Current mitigation delivery options

The Corps allows permittees to meet their compensatory mitigation requirements through several different mechanisms. The 2008 rule established a preference for compensation to be carried out based on the following hierarchy: mitigation bank credits from a bank approved using a watershed approach, in-lieu fee program credits from a program with sites selected using a watershed approach (currently TSMP is the only approved in-lieu fee program in the state), permittee-responsible mitigation with the sites selected using a watershed approach (on-site or off-site), permittee-responsible mitigation on-site and in-kind, or permittee-responsible mitigation off-site and/or out of kind (332.3(b)). The Tennessee Department of Transportation, the permit applicant with the largest need for mitigation statewide, has developed an internal program for achieving its mitigation requirements. TDOT attempts to perform on-site mitigation where practicable and then off-site mitigation on TDOT-owned properties, approved mitigation banks, or the TSMP program (TDOT 2007).

The TSMP program implements stream mitigation statewide. Figure 21 shows the distribution of approved wetland banks and their service areas in Tennessee. No mitigation banks are located within the Stones watershed at this time. As a result, impacts are generally addressed through credit purchases from banks whose service areas include the Stones River watershed, payment to TSMP, or through permittee-responsible mitigation. On-site mitigation has been utilized by local governments during the development of parks and recreation facilities.

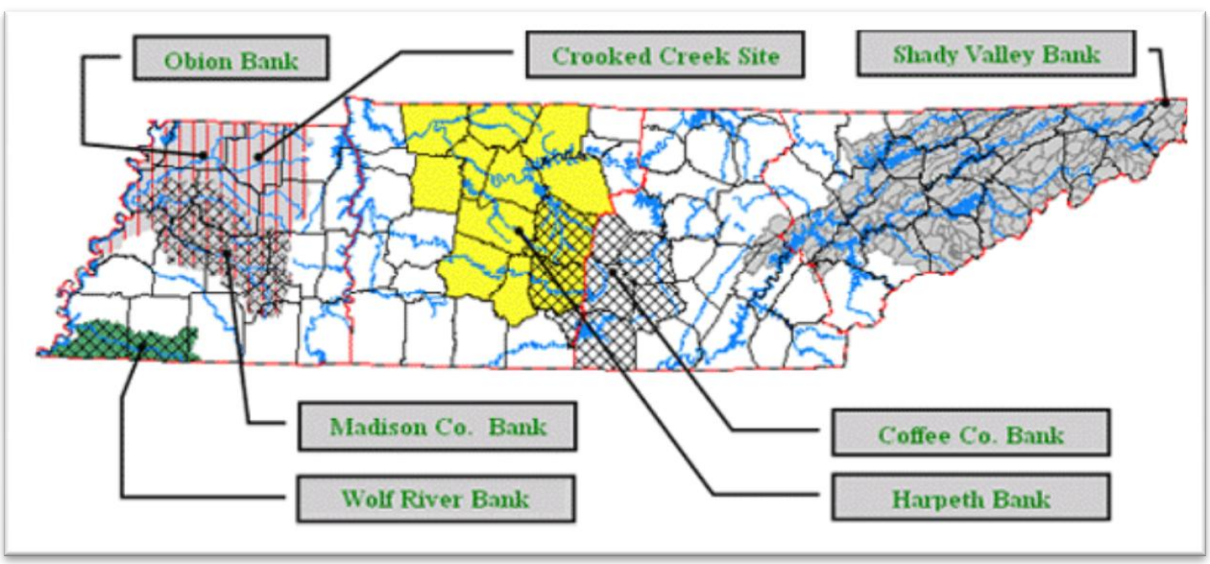



Figure 21. Wetland mitigation banks and their corresponding service areas in Tennessee. Source: TDEC 1998.

## Limitations of GIS analyses

Our project utilized landscape-scale GIS assessments to develop recommendations on avoidance, minimization, and compensatory mitigation decisions. Application of the mitigation hierarchy, and final application of any mitigation technique, must be supported with data collected from standardized field surveys of potential sites.

The map products and general recommendations in this report describe how and where stream and wetland mitigation decisions can contribute to conserving habitat for species of conservation need, as well as promote the restoration and improvement of other important resource values. This report also describes the constraints of existing NWI and hydric soil spatial data. The analyses performed attempted to document locations of potential wetlands on the landscape having high conservation value. These maps can guide future field surveys for wetland delineations as well as inform the necessary field-based verifications using the Tennessee Rapid Assessment Methodology associated with all permit applications and decisions (TDEC 2007).

This project also did not address issues related to feasibility or opportunity with respect to specific locations. The lack of existing wetland banks in the Stones River watershed and the use of in-lieu-fee options means that mitigation for impacts to the Stones River watershed is occurring outside of the watershed. Further efforts must be directed at determining the opportunity and feasibility of meeting more compensatory mitigation requirements within the watershed.

# Chapter 8: Conclusion

The 2008 federal rule sets new expectations regarding the role of compensatory mitigation in achieving aquatic resource protection and restoration goals nationwide. The approach considerations outlined in the rule address several resource values, including the habitat requirements of important species. This plan provides a conservation framework for implementing mitigation decisions by identifying habitat priorities for wetland and stream restoration and preservation. We also describe how these locations intersect with other watershed needs such as water quality improvements, public recreation opportunities, and preservation of historic and agricultural values. Using the priorities identified in this plan to guide compensatory mitigation decisions will help meet the habitat conservation objectives identified in Tennessee's State Wildlife Action Plan as well as address needs associated with other resource values in the Stones River watershed.

The plan was designed to help inform individual permit decisions by providing a watershed context for assessing the potential impacts of proposed activities, and executing avoidance, minimization, and mitigation determinations. Field verification remains critical for establishing site characteristics and informing all permit decisions.

The data and methods developed for the Stones River plan mark a major advancement in the application of conservation data to stream and wetland mitigation decision-making in Tennessee. Previously, conservation data was available to decision-makers either as individual species locations or habitat patches, neither of which was related to known wetland occurrences in the National Wetland Inventory. We have used a variety of different datasets to make these connections more explicit, and to improve our collective understanding of the significance and spatial distribution of plant and animal species habitats throughout the watershed.

We also demonstrate the application of several different nationally available spatial datasets in conjunction with data typically available in State Wildlife Action Plans and Natural Heritage datasets. These include the National Wetland Inventory (NWI), the National Hydrography Dataset Plus, and GAP land cover information. A key accomplishment of the Stones River pilot effort was the creation of a new methodology for translating the habitat mapping procedures developed for the 2005 Tennessee SWAP into a framework that explicitly addresses the spatial relationship between known preferred habitats with small and large riparian wetlands and isolated wetlands within the Stone watershed. In addition, we utilized the National Hydrography Dataset Plus to explicitly connect small upland watershed catchments to downstream habitats with known occurrences of priority species.

The 2008 compensatory mitigation rule encourages the engagement of many stakeholders in carrying out the watershed approach to improve the likelihood that compensation decisions contribute to meeting watershed needs. During our Stones River planning effort, we learned from a variety of stakeholders about their varying levels of understanding and interest in compensatory mitigation decisions. Also, we learned about the challenges of meeting multiple resource goals (e.g. water quality and habitat conservation) and regulatory objectives (e.g. municipal storm water requirements) within a watershed undergoing rapid land use changes. State and federal authorities provide planning and regulatory oversight for compensatory mitigation, but local governments, non-profit organizations, academic institutions, businesses, and individual citizens all have the capacity to make or influence decisions which protect or improve stream and wetland resources.

Watersheds are dynamic ecosystems, and the values provided by stream and wetland habitats change through time. Understanding the types of habitat, their landscape context and connectivity helps identify those values in the present, but natural ecological processes along with human activities on the landscape mean that these will likely change (Kusler 2006). The Stones River watershed has experienced rapid land and water use changes over the last 200 years, and especially in the last 4 decades.

Future projections indicate that the watershed will continue to experience population growth and land conversion from agriculture to residential and commercial development with associated transportation, drinking water, and wastewater infrastructure. Decisions regarding how and where these changes occur have important implications for the conservation of globally rare species and habitats, as well as the character of local communities, their economies, and their quality of life.

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# Appendices

Appendix 1. Project launch workshop agenda and list of stakeholders

Appendix 2. List of all plant and animal species of conservation interest known to occur in the Stones River watershed.

Appendix 3. National Wetland Inventory (NWI) wetland types in the Stones River watershed.

Appendix 4. Total Maximum Daily Loads (TMDLs) for sedimentation, low dissolved oxygen, and nutrients in the Stones River watershed.

Appendix 5. Examples of Open Space and Greenway plans in the Stones River watershed.

# Appendix 1. Project launch workshop agenda and list of stakeholders

**U.S. Army Corps of Engineers, Nashville District**
**Tennessee Department of Environment and Conservation**
**The Nature Conservancy**
**Environmental Law Institute**

Watershed Approach Workshop
April 28, 2010
Tennessee Wildlife Resources Agency
Commission Room
Nashville, TN

**Project goals:**
- Develop a watershed plan for the Stones River Watershed that identifies and prioritizes locations for wetland and stream restoration and preservation;
- Articulate a framework for the watershed approach that supports sustainable and ecologically effective mitigation; and
- Align mitigation priorities with local conservation goals.

**Workshop goals:**
- Seek input on the watershed functions participants feel are of concern (i.e., wildlife habitat, flooding, water quality) in the Stones River Watershed.
- Solicit participant input on sources of information (plans, data) in Tennessee that can support a watershed approach pilot project in the Stones River Watershed.

| | |
|---|---|
| 8:30 am | Convene |
| 9:00 – 9:15 | Welcome<br>Kathleen Kuná, U.S. Army Corps of Engineers<br>Mike Lee, Tennessee Department of Environment and Conservation<br>Sally Palmer, The Nature Conservancy |
| 9:15 – 9:45 | Introductions & Workshop Goals<br>Jessica Wilkinson, Environmental Law Institute |
| 9:45 – 10:00 | The Watershed Approach: Background<br>Jessica Wilkinson, Environmental Law Institute |
| 10:00 – 10:15 | Questions & Discussion |
| 10:15 – 10:30 | BREAK |

| | |
|---|---|
| 10:30 – 11:00 | Implementation Challenges & Project Outcomes<br>Kathleen Kuná, U.S. Army Corps of Engineers<br>Mike Lee, Tennessee Department of Environment and Conservation |
| 11:00 – 11:20 | Overview of the Stones River Watershed Pilot Project<br>Sally Palmer, The Nature Conservancy |
| 11:20 – 11:40 | Functional Goals for Watershed Planning<br>Sally Palmer, The Nature Conservancy |
| 11:40 – 12:00 | Questions & Discussion |
| 12:00 – 1:00 | LUNCH (provided) |
| 1:00 – 2:00 | Facilitated Input: Available Plans and Data<br>Seek input on the watershed functions participants feel are of concern (i.e., wildlife habitat, flooding, water quality) in the Stones River Watershed. |
| 2:00 – 2:15 | Break |
| 2:15 – 3:15 | Facilitated Input:<br>Solicit participant input on sources of information (plans, data) in Tennessee that can support a watershed approach pilot project in the Stones River Watershed. |
| 3:15 – 4:00 | Wrap-Up and Next Steps<br>Sally Palmer, The Nature Conservancy<br>Kathleen Kuná, U.S. Army Corps of Engineers |
| 4:00 pm | ADJOURN |

List of April 2010 Workshop Participants & Affiliations

| | | |
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List of additional stakeholders interviewed during the planning effort (2010-11)

Greg Upham, City of Smyrna, Stormwater Program Manager
Todd Sullivan, Rutherford County, Stormwater Coordinator
Robert Hailey, City of Murfreesboro, Stormwater Program Manager
Katie Kline, City of LaVergne, Project Engineer, Stormwater program
Randle Branch, Stones River Watershed Association
Beth Chesson, Civil & Environmental Consultants, Inc. (personal interview re: Puckett Creek BMP plan)
Lanny Goodwin, City of Murfreesboro, Director of Parks and Recreation
Angela Jackson, City of Murfreesboro, Assistant Director of Parks and Recreation

## Appendix 2. List of all plant and animal species of conservation interest known to occur in the Stones River watershed

The Tennessee Division of Natural Heritage is responsible for the maintenance of information on the global and state rarity ranks, and the Federal and State legal status, assigned to plant and animal species. The definitions of these ranks and status codes follow and were taken from information on the Tennessee Division of Natural Heritage website at http://www.tn.gov/environment/na/pdf/Status&Ranks.pdf.

Global Rarity Rank: The global or world-wide rank of a species, which is a non-legal rank indicating the rarity and vulnerability of a species.

**G1:** Extremely rare and critically imperiled in the world with five or fewer occurrences, or very few remaining individuals, or because of some special condition where the species is particularly vulnerable to extinction.
**G2:** Very rare and imperiled within the world, six to twenty occurrences, or few remaining individuals, or because of some factor(s) making it vulnerable to extinction.
**G3:** Rare and uncommon in its range or found locally in a restricted range, generally from 21-100 occurrences.
**G4:** Widespread, abundant, and apparently secure globally, but with cause for long-term concern.
**G5:** Demonstrably widespread and secure globally.

**_Q:** Questionable taxonomy
**_T#:** Subspecific taxon rank
**_?:** Unranked at this time or rank uncertain
**G#G#:** Denotes a “range rank” because the rarity of the species is uncertain (e.g. G2G3).

State Rarity Rank: The state rank of a species in Tennessee. Like the G-rank this is a non-legal rank indicating the rarity and vulnerability of a species at the state level.

**S1:** Extremely rare and critically imperiled in the state with five or fewer. occurrences, or very few remaining individuals, or because of some special condition where the species is particularly vulnerable to extinction.
**S2:** Very rare and imperiled within the state, six to twenty occurrences, or few remaining individuals, or because of some factor(s) making it vulnerable to extinction.
**S3:** Rare and uncommon in the state, from 21-100 occurrences.
**S4:** Widespread, abundant, and apparently secure within the state, but with cause for long-term concern.
**S5:** Demonstrably widespread and secure in the state.
**SH:** Of historical occurrence in Tennessee, e.g. formally part of the established biota, with the expectation that it may be rediscovered.
**SX:** Believed to be extirpated from the state.
**S#S#:** Denotes a “range rank” because the rarity of the species is uncertain (e.g. S1S3).
**_N:** Occurs in Tennessee in a non-breeding status (mostly applies to vertebrates).
**_B:** Breeds in Tennessee.

Federal Status: The federal listing under the U.S. Endangered Species Act.

**LE, Listed Endangered:** Taxon is threatened by extinction throughout all or a significant portion of its range.
**LT, Listed Threatened:** Taxon is likely to become an endangered species in the foreseeable future.
**C, Candidate species:** Taxon for which the USFWS has sufficient information to support proposals to list the species as threatened or endangered, and for which the Service anticipates a listing proposal.
**(PS) Partial Status** (based on taxonomy): Taxon which is listed in part of its range, but for which Tennessee subspecies are not included in the Federal designation.
**(XN) Non-essential experimental population in portion of range:** Taxon which has been introduced or re-introduced in an area from which it has been extirpated, and for which certain provisions of the Act may not apply.

State Status: The legal listing in Tennessee.

**E, Endangered:** Any species or subspecies whose prospects of survival or recruitment within the state are in jeopardy or are likely to become so within the foreseeable future.
**T, Threatened:** Any species or subspecies that is likely to become an endangered species within the foreseeable future.
**D, Deemed in Need of Management:** Any species or subspecies of nongame wildlife which the executive director of the TWRA believes should be investigated in order to develop information relating to populations, distribution, habitat needs, limiting factors, and other biological and ecological data to determine management measures necessary for their continued ability to sustain themselves successfully. This category is analogous to “Special Concern.”
**S, Special Concern** Any species or subspecies of plant that is uncommon in Tennessee, or has unique or highly specific habitat requirements or scientific value and therefore requires careful monitoring of its status.
**C, Commercially Exploited** Due to large numbers being taken from the wild and propagation or cultivation insufficient to meet market demand. These plants are of long-term conservation concern, but the Division of Natural Heritage does not recommend they be included in the normal environmental review process.

List of terrestrial animal and plant species known to occur in the Stones River watershed.

| Taxa | Scientific Name | Common Name | Global Rarity Rank | State Rarity Rank | Federal Status | State Status |
|---|---|---|---|---|---|---|
| Amphibian | Aneides aeneus | Green Salamander | G3G4 | S3S4 | | |
| Amphibian | Ambystoma barbouri | Streamside Salamander | G4 | S2 | | D |
| Amphibian | Pseudotriton montanus | Mud Salamander | G5 | S5 | | |
| Bird | Botaurus lentiginosus | American Bittern | G4 | S1 | | |
| Bird | Dendroica cerulea | Cerulean Warbler | G4 | S3B | | D |
| Bird | Falco peregrinus | Peregrine Falcon | G4 | S1B | | E |
| Bird | Lanius ludovicianus | Loggerhead Shrike | G4 | S1B, S2N | | D |
| Bird | Accipiter striatus | Sharp-shinned Hawk | G5 | S3B, S4N | | D |
| Bird | Ammodramus savannarum | Grasshopper Sparrow | G5 | S4 | (PS) | |
| Bird | Aquila chrysaetos | Golden Eagle | G5 | S1 | | T |
| Bird | Ardea alba | Great Egret | G5 | S2B, S3N | | D |
| Bird | Caprimulgus carolinensis | Chuck-will's-widow | G5 | S3S4 | | |
| Bird | Caprimulgus vociferus | Whip-poor-will | G5 | S3S4 | | |
| Bird | Chondestes grammacus | Lark Sparrow | G5 | S1B | | T |
| Bird | Coccyzus americanus | Yellow-billed Cuckoo | G5 | S4S5 | (PS) | |
| Bird | Contopus virens | Eastern Wood-pewee | G5 | S5 | | |
| Bird | Dendroica discolor | Prairie Warbler | G5 | S3S4 | | |
| Bird | Dendroica dominica | Yellow-throated Warbler | G5 | S4 | | |
| Bird | Egretta caerulea | Little Blue Heron | G5 | S2B, S3N | | D |
| Bird | Empidonax virescens | Acadian Flycatcher | G5 | S5 | | |
| Bird | Haliaeetus leucocephalus | Bald Eagle | G5 | S3 | | D |
| Bird | Helmitheros vermivorus | Worm-eating Warbler | G5 | S4 | | |
| Bird | Hylocichla mustelina | Wood Thrush | G5 | S4 | | |
| Bird | Icterus spurius | Orchard Oriole | G5 | S4 | | |
| Bird | Melanerpes erythrocephalus | Red-headed Woodpecker | G5 | S4 | | |
| Bird | Oporornis formosus | Kentucky Warbler | G5 | S4 | | |
| Bird | Parula americana | Northern Parula | G5 | S5 | | |
| Bird | Protonotaria citrea | Prothonotary Warbler | G5 | S4 | | |
| Bird | Scolopax minor | American Woodcock | G5 | S4B | | |
| Bird | Seiurus motacilla | Louisiana Waterthrush | G5 | S4 | | |
| Bird | Spiza americana | Dickcissel | G5 | S4 | | |
| Bird | Thryomanes bewickii | Bewick's Wren | G5 | S1 | | E |
| Bird | Tyto alba | Barn Owl | G5 | S3 | | D |
| Bird | Vermivora pinus | Blue-winged Warbler | G5 | S4 | | |
| Bird | Vireo flavifrons | Yellow-throated Vireo | G5 | S4 | | |
| Bird | Vireo griseus | White-eyed Vireo | G5 | S4 | | |
| Bird | Wilsonia citrina | Hooded Warbler | G5 | S4 | | |
| Mammal | Myotis grisescens | Gray Bat | G3 | S2 | LE | E |
| Mammal | Neotoma magister | Allegheny Woodrat | G3G4 | S3 | | D |
| Mammal | Sorex hoyi | American Pygmy Shrew | G5 | S2 | | |
| Mammal | Sorex longirostris | Southeastern Shrew | G5 | S4 | | D |
| Mammal | Zapus hudsonius | Meadow Jumping Mouse | G5 | S4 | | D |

| | Scientific Name | Common Name | Global Rarity Rank | State Rarity Rank | Federal Status | State Status |
|---|---|---|---|---|---|---|
| Plant | Astragalus bibullatus | Pyne's Ground Plum | G1 | S1 | LE | E |
| Plant | Lesquerella stonensis | Stones River Bladderpod | G1 | S1 | | E |
| Plant | Trifolium calcaricum | Running Glade Clover | G1 | S1 | | E |
| Plant | Arabis perstellata | Braun's Rockcress | G2 | S1 | LE | E |
| Plant | Echinacea tennesseensis | Tennessee Coneflower | G2 | S2 | LE | E |
| Plant | Neviusia alabamensis | Alabama Snow-wreath | G2 | S2 | | T |
| Plant | Dalea foliosa | Leafy Prairie-clover | G2G3 | S2S3 | LE | E |
| Plant | Lejeunea sharpii | Sharp's Lejeunea | G2G3 | S1S2 | | E |
| Plant | Cololejeunea ornata | Ornate Cololejeunea | G2G4 | S1 | | T |
| Plant | Astragalus tennesseensis | Tennessee Milk Vetch | G3 | S3 | | S |
| Plant | Echinacea simulata | Wavy-leaf Purple Coneflower | G3 | S2 | | T |
| Plant | Elymus svensonii | Svenson's Wild-rye | G3 | S2 | | E |
| Plant | Lesquerella densipila | Duck River Bladderpod | G3 | S3 | | T |
| Plant | Parnassia grandifolia | Large-leaved Grass-of-parnassus | G3 | S3 | | S |
| Plant | Stellaria fontinalis | Water Stitchwort | G3 | S3 | | T |
| Plant | Talinum calcaricum | Limestone Fameflower | G3 | S3 | | S |
| Plant | Solidago gattingeri | Gattinger's Goldenrod | G3?Q | S1 | | E |
| Plant | Eleocharis wolfii | Wolf Spike-rush | G3G4 | S1 | | E |
| Plant | Panax quinquefolius | American Ginseng | G3G4 | S3S4 | | S-CE |
| Plant | Silphium pinnatifidum | Southern Prairie-dock | G3Q | S2 | | T |
| Plant | Ammoselinum popei | Pope's Sand-parsley | G4 | S2 | | T |
| Plant | Carex davisii | Davis' Sedge | G4 | S1 | | S |
| Plant | Echinacea pallida | Pale-purple Coneflower | G4 | S1 | | T |
| Plant | Eleocharis compressa | Flat-stemmed Spike-rush | G4 | S1 | | S |
| Plant | Eleocharis equisetoides | Horse-tail Spike-rush | G4 | S1 | | E |
| Plant | Hydrastis canadensis | Goldenseal | G4 | S3 | | S-CE |
| Plant | Juglans cinerea | Butternut | G4 | S3 | | T |
| Plant | Perideridia americana | Thicket Parsley | G4 | S2 | | E |
| Plant | Polygala boykinii | Boykin's Milkwort | G4 | S2 | | T |
| Plant | Schoenolirion croceum | Yellow Sunnybell | G4 | S3 | | T |
| Plant | Allium burdickii | Narrow-leaved Wild Leek | G4G5 | S1S2 | | T-CE |
| Plant | Arnoglossum plantagineum | Fen Indian-plantain | G4G5 | S2 | | T |
| Plant | Gentiana puberulenta | Downy Gentian | G4G5 | S1 | | E |
| Plant | Caulophyllum giganteum | Giant Blue Cohosh | G4G5Q | S1 | | T |
| Plant | Onosmodium molle ssp. subsetosum | Smooth False Gromwell | G4G5T4? | S1 | | E |
| Plant | Xyris laxifolia var. iridifolia | Wide-leaved Yellow-eyed Grass | G4G5T4T5 | S2 | | T |
| Plant | Leavenworthia exigua var. exigua | Glade-cress | G4T3 | S3 | | S |
| Plant | Acmella oppositifolia | Creeping Spotflower | G5 | S3 | | S |
| Plant | Allium stellatum | Glade Onion | G5 | S1 | | E |
| Plant | Anemone caroliniana | Carolina Anemone | G5 | S1S2 | | E |
| Plant | Arabis glabra | Tower-mustard | G5 | S1 | | S |
| Plant | Arabis hirsuta | Western Hairy Rockcress | G5 | S1 | | T |
| Plant | Arabis shortii | Short's Rockcress | G5 | S1S2 | | S |
| Plant | Cypripedium acaule | Pink Lady's-slipper | G5 | S4 | | S-CE |
| Plant | Dalea candida | White Prairie-clover | G5 | S2 | | S |

| Taxa | Scientific Name | Common Name | Global Rarity Rank | State Rarity Rank | Federal Status | State Status |
|---|---|---|---|---|---|---|
| Plant | Dalea purpurea | Purple Prairie-clover | G5 | S1 | | E |
| Plant | Erysimum capitatum | Western Wallflower | G5 | S1S2 | | E |
| Plant | Evolvulus nuttallianus | Evolvulus | G5 | S3 | | S |
| Plant | Fimbristylis puberula | Hairy Fimbristylis | G5 | S1S2 | | T |
| Plant | Gaylussacia dumosa | Dwarf Huckleberry | G5 | S3 | | T |
| Plant | Helianthus occidentalis | Naked-stem Sunflower | G5 | S2 | | S |
| Plant | Isoetes melanopoda | Blackfoot Quillwort | G5 | S1S2 | | E |
| Plant | Liatris cylindracea | Slender Blazing-star | G5 | S2 | | T |
| Plant | Lilium canadense | Canada Lily | G5 | S3 | | T |
| Plant | Lycopodiella alopecuroides | Foxtail Clubmoss | G5 | S2 | | T |
| Plant | Mirabilis albida | Pale Umbrella-wort | G5 | S2 | | T |
| Plant | Oenothera macrocarpa | Missouri Primrose | G5 | S2 | | T |
| Plant | Ribes missouriense | Missouri Gooseberry | G5 | S2 | | S |
| Plant | Rosa virginiana | Virginia Rose | G5 | SH | | S |
| Plant | Sagittaria platyphylla | Ovate-leaved Arrowhead | G5 | S2S3 | | S |
| Plant | Scleria verticillata | Low Nutrush | G5 | S2 | | S |
| Plant | Sporobolus heterolepis | Northern Dropseed | G5 | S1 | | S |
| Plant | Veronica catenata | Sessile Water-speedwell | G5 | S1 | | E |
| Plant | Zanthoxylum americanum | Northern Prickly-ash | G5 | S2 | | S |
| Plant | Carex oxylepis var. pubescens | Hairy Sharp-scaled Sedge | G5?T3 | S1 | | S |
| Plant | Phlox bifida ssp. stellaria | Glade Cleft Phlox | G5?T3 | S3 | | T |
| Plant | Amsonia tabernaemontana var. gattingeri | Limestone Blue Star | G5T3Q | S3 | | S |
| Plant | Phlox pilosa ssp. ozarkana | Ozark Downy Phlox | G5T4? | S1S2 | | S |
| Plant | Ranunculus aquatilis var. diffusus | White Water-buttercup | G5T5 | S1 | | E |
| Reptile | Terrapene carolina | Eastern Box Turtle | G5 | S4 | | |

List of aquatic species known to occur in the Stones River watershed.

| Taxa | Scientific Name | Common Name | Global Rarity Rank | State Rarity Rank | Federal Status | State Status |
|---|---|---|---|---|---|---|
| Bivalve | Epioblasma brevidens | Cumberlandian Combshell | G1 | S1 | LE | E |
| Bivalve | Pegias fabula | Littlewing Pearlymussel | G1 | S1 | LE | E |
| Bivalve | Pleurobema gibberum | Cumberland Pigtoe | G1 | S1 | LE | E |
| Bivalve | Epioblasma florentina walkeri | Tan Riffleshell | G1T1 | S1 | LE | E |
| Bivalve | Toxolasma lividum | Purple Lilliput | G2 | S1S2 | | |
| Bivalve | Villosa umbrans | Coosa Creekshell | G2 | S2 | | |
| Bivalve | Pleurobema oviforme | Tennessee Clubshell | G2G3 | S2S3 | | |
| Bivalve | Pleurobema rubrum | Pyramid Pigtoe | G2G3 | S1S2 | | |
| Bivalve | Cumberlandia monodonta | Spectaclecase | G3 | S2S3 | C | |
| Bivalve | Pleurobema cordatum | Ohio Pigtoe | G3 | S3 | | |
| Bivalve | Simpsonaias ambigua | Salamander Mussel | G3 | S1 | | |
| Bivalve | Medionidus conradicus | Cumberland Moccasinshell | G3G4 | S3 | | |
| Bivalve | Villosa taeniata | Painted Creekshell | G3G4 | S3S4 | | |
| Bivalve | Quadrula cylindrica cylindrica | Rabbitsfoot | G3G4T3 | S3 | | |
| Bivalve | Ellipsaria lineolata | Butterfly | G4 | S4 | | |
| Bivalve | Lampsilis fasciola | Wavy-rayed Lampmussel | G4 | S4 | | |
| Bivalve | Obovaria subrotunda | Round Hickorynut | G4 | S2S3 | | |
| Bivalve | Pleurobema sintoxia | Round Pigtoe | G4 | S4 | | |
| Bivalve | Alasmidonta viridis | Slippershell Mussel | G4G5 | S3S4 | | |
| Bivalve | Fusconaia flava | Wabash Pigtoe | G5 | S4S5 | | |
| Bivalve | Lampsilis ovata | Pocketbook | G5 | S5 | | |
| Bivalve | Lasmigona costata | Fluted-shell | G5 | S5 | | |
| Bivalve | Ligumia recta | Black Sandshell | G5 | S5 | | |
| Bivalve | Pyganodon grandis | Giant Floater | G5 | S5 | | |
| Bivalve | Truncilla donaciformis | Fawnsfoot | G5 | S5 | | |
| Bivalve | Villosa lienosa | Little Spectaclecase | G5 | S4S5 | | |
| Crustacean | Cambarus clivosus | Short Mountain Crayfish | G2 | S2 | | |
| Crustacean | Cambarus williami | Brawleys Fork Crayfish | G2 | S2 | | E |
| Crustacean | Cambarus friaufi | Hairy Crayfish | G4 | S3 | | |
| Fish | Erimonax monachus | Spotfin Chub | G2 | S2 | LT, XN | T |
| Fish | Notropis rupestris | Bedrock Shiner | G2 | S2 | | D |
| Fish | Etheostoma cinereum | Ashy Darter | G2G3 | S2S3 | | T |
| Fish | Etheostoma microlepidum | Smallscale Darter | G2G3 | S2 | | D |
| Fish | Etheostoma tippecanoe | Tippecanoe Darter | G3G4 | S1S2 | | D |
| Fish | Erimystax dissimilis | Streamline Chub | G4 | S3S4 | | |
| Fish | Erimystax insignis | Blotched Chub | G4 | S3S4 | | |
| Fish | Etheostoma luteovinctum | Redband Darter | G4 | S4 | | D |
| Fish | Etheostoma squamiceps | Spottail Darter | G4G5 | S2S3 | | |
| Fish | Etheostoma rufilineatum | Redline Darter | G5 | S5 | | |
| Fish | Notropis rubellus | Rosyface Shiner | G5 | S2 | | D |
| Fish | Percina phoxocephala | Slenderhead Darter | G5 | S3 | | D |
| Fish | Moxostoma lacerum | Harelip Sucker | GX | SX | | D |
| Gastropod | Leptoxis umbilicata | Umbilicate Rocksnail | G1Q | S1 | | |
| Reptile | Macrochelys temminckii | Alligator Snapping Turtle | G3G4 | S2S3 | | D |

# Appendix 3. National Wetland Inventory (NWI) wetland types in the Stones River watershed.

The table below summarizes all the NWI wetland types mapped within the Stones River watershed by code and type. Also included is a habitat type label (isolated, small stream riparian, or large floodplain riparian). The habitat types were assigned in our analyses based on hydrologic connectivity, or lack thereof, to stream segments mapped by the National Hydrography Dataset Plus (NHD Plus). Distinctions between small stream riparian and large floodplain riparian habitats were determined by using a 270 cubic feet per second mean annual flow volume cut off. For more details on the methods utilized for the habitat assignment, see Chapter 4.

Most NWI types fall within only one of the habitat type categories, however a few (e.g. PAB6/UBHh) might fall into both an isolated and riparian type depending on the proximity of a given wetland location to a NHD Plus stream segment in the GIS. Finally, the table lists both modified and non-modified (intact) NWI wetlands.

| NWI Code | NWI Wetland Type | Habitat type |
|---|---|---|
| L1AB6/UBHh | Lake | Small Stream Riparian |
| L1UBH | Lake | Isolated |
| L1UBHh | Lake | Isolated |
| L2USCh | Lake | Isolated |
| PAB/UBF | Freshwater Pond | Isolated |
| PAB/UBFh | Freshwater Pond | Isolated |
| PAB/UBFx | Freshwater Pond | Isolated |
| PAB6/UBFh | Freshwater Pond | Isolated |
| PAB6/UBFx | Freshwater Pond | Isolated |
| PAB6/UBH | Freshwater Pond | Isolated |
| PAB6/UBHh | Freshwater Pond | Isolated |
| PAB6/UBHh | Freshwater Pond | Small Stream Riparian |
| PAB6/UBHx | Freshwater Pond | Isolated |
| PAB6F | Freshwater Pond | Isolated |
| PAB6Fh | Freshwater Pond | Isolated |
| PAB6Fx | Freshwater Pond | Isolated |
| PAB6H | Freshwater Pond | Isolated |
| PAB6Hh | Freshwater Pond | Isolated |
| PAB6Hx | Freshwater Pond | Isolated |
| PEM/AB6Fx | Freshwater Emergent Wetland | Small Stream Riparian |
| PEM/UBCx | Freshwater Emergent Wetland | Isolated |
| PEM/UBFh | Freshwater Emergent Wetland | Isolated |
| PEM/USC | Freshwater Emergent Wetland | Small Stream Riparian |
| PEM1/FO1C | Freshwater Emergent Wetland | Isolated |
| PEM1/SS1Ch | Freshwater Emergent Wetland | Small Stream Riparian |
| PEM1/UBF | Freshwater Emergent Wetland | Small Stream Riparian |

| NWI Code | NWI Wetland Type | Habitat type |
|---|---|---|
| PEM1/UBFh | Freshwater Emergent Wetland | Isolated |
| PEM1/UBFx | Freshwater Emergent Wetland | Small Stream Riparian |
| PEM1/UBHh | Freshwater Emergent Wetland | Isolated |
| PEM1/UBHx | Freshwater Emergent Wetland | Isolated |
| PEM1/USA | Freshwater Emergent Wetland | Isolated |
| PEM1/USC | Freshwater Emergent Wetland | Isolated |
| PEM1/USCh | Freshwater Emergent Wetland | Isolated |
| PEM1A | Freshwater Emergent Wetland | Isolated |
| PEM1Ad | Freshwater Emergent Wetland | Isolated |
| PEM1Ah | Freshwater Emergent Wetland | Isolated |
| PEM1Ax | Freshwater Emergent Wetland | Isolated |
| PEM1C | Freshwater Emergent Wetland | Isolated |
| PEM1Cd | Freshwater Emergent Wetland | Isolated |
| PEM1Ch | Freshwater Emergent Wetland | Isolated |
| PEM1Cx | Freshwater Emergent Wetland | Small Stream Riparian |
| PEM1F | Freshwater Emergent Wetland | Isolated |
| PEM1Fh | Freshwater Emergent Wetland | Small Stream Riparian |
| PEM1Fx | Freshwater Emergent Wetland | Isolated |
| PEMFx | Freshwater Emergent Wetland | Isolated |
| PFO1/EM1Ad | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/EM1Ah | Freshwater Forested/Shrub Wetland | Large Floodplain |
| PFO1/EM1C | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/EM1Cd | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/EM1Ch | Freshwater Forested/Shrub Wetland | Large Floodplain |
| PFO1/EM1F | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PFO1/EMA | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/SS1A | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/SS1C | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/SS1Cd | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/SS1Ch | Freshwater Forested/Shrub Wetland | Large Floodplain |
| PFO1/UBC | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/UBF | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/UBFh | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PFO1/UBH | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1/USA | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PFO1/USC | Freshwater Forested/Shrub Wetland | Large Floodplain |
| PFO1A | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PFO1Ad | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1Ah | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1C | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1Ch | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PFO1F | Freshwater Forested/Shrub Wetland | Isolated |
| PFO1Fh | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PFO1G | Freshwater Forested/Shrub Wetland | Isolated |
| PFOF | Freshwater Forested/Shrub Wetland | Isolated |
| PSS/EMAh | Freshwater Forested/Shrub Wetland | Large Floodplain |
| PSS1/EM1A | Freshwater Forested/Shrub Wetland | Isolated |

| NWI Code | NWI Wetland Type | Habitat type |
|---|---|---|
| PSS1/EM1Ah | Freshwater Forested/Shrub Wetland | Large Floodplain |
| PSS1/EM1C | Freshwater Forested/Shrub Wetland | Isolated |
| PSS1/EM1Ch | Freshwater Forested/Shrub Wetland | Large Floodplain |
| PSS1/EM1F | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PSS1/USA | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PSS1A | Freshwater Forested/Shrub Wetland | Isolated |
| PSS1C | Freshwater Forested/Shrub Wetland | Isolated |
| PSS1Ch | Freshwater Forested/Shrub Wetland | Small Stream Riparian |
| PUBCx | Freshwater Pond | Isolated |
| PUBF | Freshwater Pond | Isolated |
| PUBFh | Freshwater Pond | Small Stream Riparian |
| PUBFx | Freshwater Pond | Isolated |
| PUBH | Freshwater Pond | Small Stream Riparian |
| PUBHh | Freshwater Pond | Isolated |
| PUBHx | Freshwater Pond | Small Stream Riparian |
| PUSA | Other | Isolated |
| PUSAh | Other | Isolated |
| PUSAx | Freshwater Pond | Isolated |
| PUSC | Other | Small Stream Riparian |
| PUSCh | Freshwater Pond | Isolated |
| PUSCx | Other | Small Stream Riparian |
| R2UBH | Riverine | Large Floodplain |
| R2USA | Riverine | Small Stream Riparian |
| R2USC | Riverine | Isolated |
| R4SBA | Riverine | Small Stream Riparian |
| R4SBC | Riverine | Small Stream Riparian |
| R4USC | Riverine | Small Stream Riparian |

# Appendix 4. Total Maximum Daily Loads (TMDLs) for sedimentation, low dissolved oxygen, and nutrients in the Stones River watershed.

Sediment TMDLs for Stones River subwatersheds based on 1998 303(d) listed impaired streams for excess sedimentation. Table from TDEC 2002.

| Subwatershed | Waterbody ID | 1998 303(d) List Waterbody | Level IV Ecoregion | Target Load [lbs/acre/yr] | TMDL (Required Load Reduction*) [%] |
|---|---|---|---|---|---|
| 0308 | TN05130203001 | McCrory Creek | 71h | 660 | 37.7 |
| 0304 | TN05130203010 | Stewart Creek; Olive Br.; Rock Spring Br. | 71i | 220 | 50.1 |
| 0301 | TN05130203003T | Finch Branch | 71i | 220 | 41.2 |
| 0205 | TN05130203015 | Armstrong Branch | 71i | 220 | 25.1 |
| 0204 | TN05130203022 | Lytle Creek | 71i | 220 | 37.2 |
| 0107 | TN05130203023 | Wades Branch | 71i | 220 | 46.7 |
| 0105 | TN05130203023 | Bear Branch; Dry Branch | 71i | 220 | 57.3 |
| 0104 | TN05130203025 | Cripple Creek; McElroy Creek | 71i | 220 | 39.8 |
| 0101 | TN05130203026 | East Fork Stones River (upper); Cavender Br. | 71h | 660 | 9.7 |
| 0103 | TN05130203026 | McKnight Branch | 71i | 220 | 61.8 |
| 0106 | TN05130203029 | Jarman Branch | 71i | 220 | 48.0 |
| 0302 | TN05130203032 | Fall Creek; Cedar Branch; Williams Branch | 71i | 220 | 46.5 |
| 0307 | TN05130203035 | Stoners Creek; Unnamed Tributary | 71h | 660 | 45.0 |
| 0301a | TN05130203036.78 | Hurricane Creek | 71i | 220 | 41.2 |

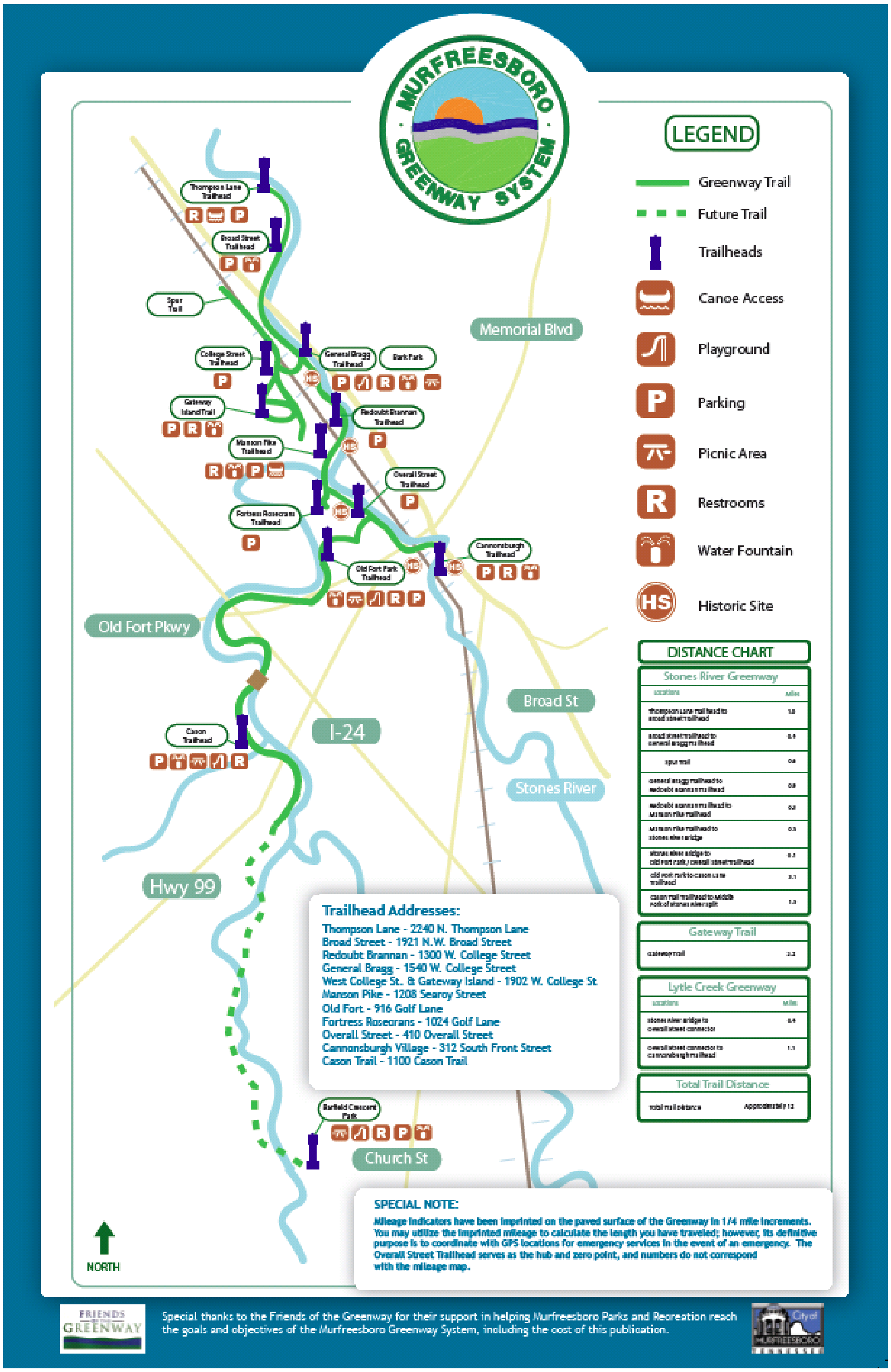
* Required reduction in existing average annual sediment load to achieve target average annual sediment load.

TMDLs for low dissolved oxygen and nutrients in the Stones River watershed based on 2006 303(d) listed impairments. Table from TDEC 2008.

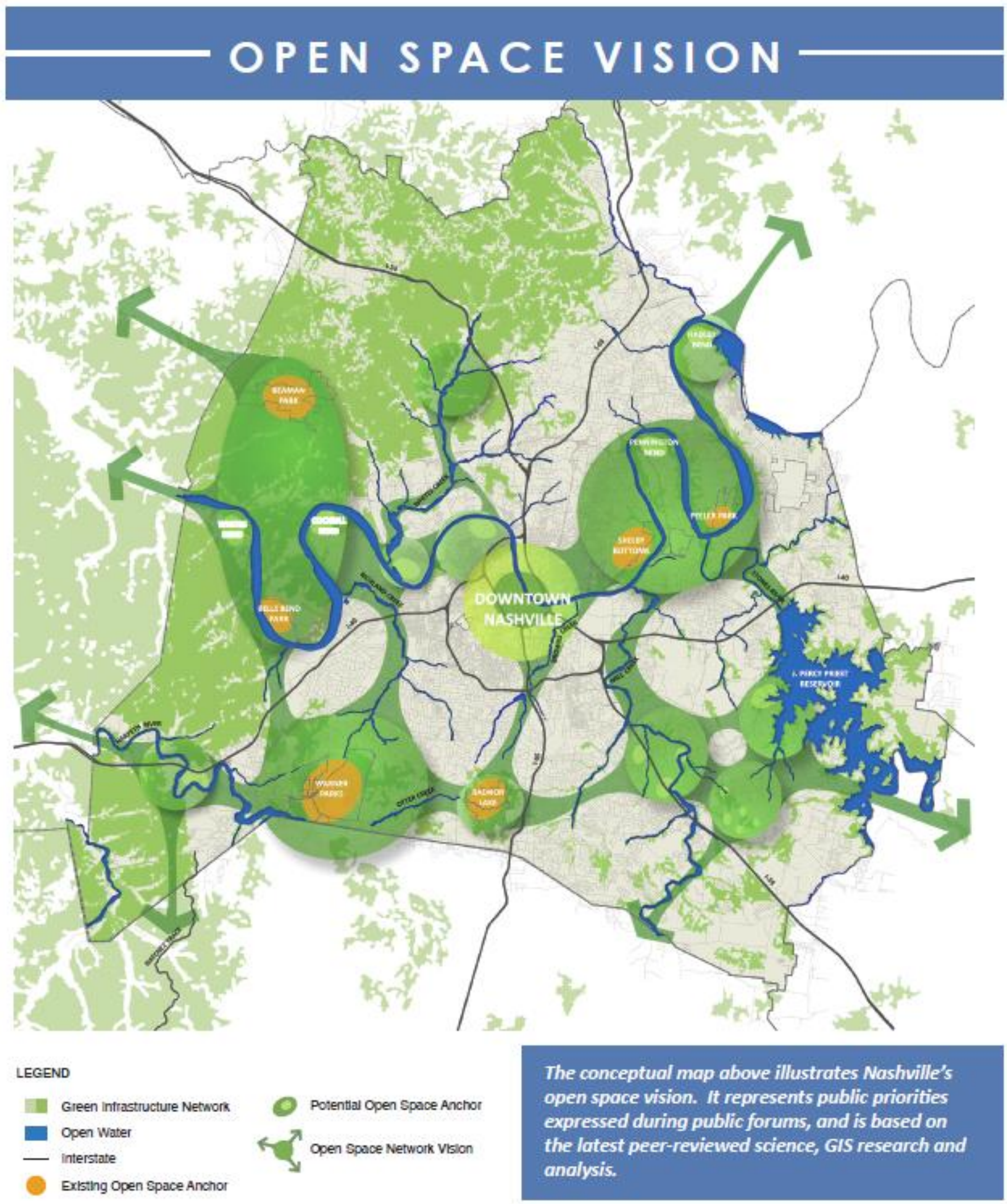
| HUC-12 Subwatershed (05130203__) or Drainage Area | Impaired Waterbody | Waterbody ID | TMDL | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Total Nitrogen | | Total Phosphorus | | $CBOD_5$ | |
| | | | [lbs/yr] | [lbs/day] [a] | [lbs/yr] | [lbs/day] [a] | [lbs/yr] | [lbs/day] [a] |
| 0106 | Jarman Branch | TN05130203029-0100 | 112,695 | $2.157 \times 10^1 * Q$ | 22,655 | $1.008 \times 10^1 * Q$ | 224,597 | $4.046 \times 10^1 * Q$ |
| | Unnamed Tributary to Bradley Creek | TN05130203029-0200 | | | | | | |
| | Unnamed Tributary to Bradley Creek | TN05130203029-0300 | | | | | | |
| 0201 | West Fork Stones River | TN05130203018-7000 | 169,007 | $2.200 \times 10^1 * Q$ | 34,899 | $1.045 \times 10^1 * Q$ | 336,300 | $4.046 \times 10^1 * Q$ |
| McCrory Ck. DA | McCrory Creek | TN05130203001-0100 | 25,354 | $1.243 \times 10^1 * Q$ | 2,090 | $2.116 \times 10^0 * Q$ | NA [b] | NA [b] |
| | | TN05130203001-0150 | | | | | | |
| Hurricane Ck. DA | W. Branch Hurricane Ck. | TN05130203036-0200 | 41,786 | $2.038 \times 10^1 * Q$ | 7,760 | $9.031 \times 10^0 * Q$ | 83,642 | $4.046 \times 10^1 * Q$ |
| | Hurricane Creek | TN05130203036-1000 | | | | | | |
| Bear Branch DA | Bear Branch | TN05130203023-0310 | 8,019 | $2.243 \times 10^1 * Q$ | 1,699 | $1.082 \times 10^1 * Q$ | NA [b] | NA [b] |
| Unnamed Trib. to Lytle Ck. DA [c] | Unnamed Tributary to Lytle Creek | TN05130203022-0100 | 534 | $2.243 \times 10^1 * Q$ | 113 | $1.082 \times 10^1 * Q$ | 1,061 | $4.046 \times 10^1 * Q$ |

Notes:
a. Q = Stream flow at pour point of subwatershed or drainage area [$ft^3$/sec].
b. NA = Not applicable (low dissolved oxygen not listed as a cause for waterbody impairment or no low diurnal dissolved oxygen measurements).
c. Drainage area for Unnamed Tributary to Lytle Creek estimated at 120 acres.

## Appendix 5. Examples of Open Space and Greenway plans in the Stones River watershed.




Source: City of Murfreesboro and Friends of the Greenway.




Source: Metro Nashville-Davidson County government and the Land Trust for Tennessee.