




TENNESSEE STATE WILDLIFE ACTION PLAN 2015

TENNESSEE WILDLIFE RESOURCES AGENCY

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The mission of the Tennessee Wildlife Resources Agency is to preserve, conserve, protect, and enhance the fish and wildlife of the state and their habitats for the use, benefit, and enjoyment of the citizens of Tennessee and its visitors. The Agency will foster the safe use of the state's waters through a program of law enforcement, education, and access.

In keeping with this mission, the Agency recognizes its long-standing partnership with sportsmen and the significant contributions that sportsmen have made and continue to make to benefit all fish and wildlife, including non-game species. In submitting this State Wildlife Action Plan, the Agency expresses its intent that implementation of this plan be conducted in a way to achieve the Agency's mission, while sustaining and promoting hunting and fishing in Tennessee.

The Nature Conservancy is the largest nonprofit conservation organization in the world and works collaboratively with individuals & communities, governments, nonprofits and companies across the globe. The mission of The Nature Conservancy is to conserve the lands and waters on which all life depends.

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EXECUTIVE SUMMARY

Since 2001, when Congress first funded the State and Tribal Wildlife Grants Program (SWG Program), states have been required to develop comprehensive plans to guide the conservation of nongame species. The SWG Program addresses important wildlife issues that have traditionally been underfunded, and it is now the nation's core program for preventing endangered species listings. To receive funds, each state and territory is required to develop a "Comprehensive Wildlife Conservation Strategy," popularly known as a State Wildlife Action Plan or SWAP. At a minimum, SWAPs must be updated every 10 years. This report represents the first revision of Tennessee's SWAP, originally issued in 2005. This revision has 7 chapters, outlined below, organized along the lines of the "8 Required Elements" that must be addressed in all SWAPs according to Congressional mandate.

The TN-SWAP was developed based upon two key assumptions: (1) that although the focus is conservation of nongame wildlife species, many nongame conservation strategies and actions are habitat based and therefore benefit a wide range of species, including those that are common or hunted recreationally, and (2) that the TN-SWAP serves to promote common understanding of problems facing species and habitats across the state to encourage and prioritize collective action among a wide range of conservation partners.

The Introduction provides a history of the SWG program and SWAPs and describes the guidance materials used during the Plan revision, including several Association of Fish and Wildlife Agencies (AFWA) publications.

Chapter 1 provides an overview of the state and describes the Tennessee Wildlife Resources Agency's (TWRA) approach in revising the Plan. It describes the revision timeline and the planning team structure, which included TWRA staff and leadership, The Nature Conservancy, and technical consultants. It summarizes planning areas of emphasis for the 2015 revision, which include updates to the GIS database since 2005, the addition of Conservation Opportunity Areas (COAs), and the more in-depth consideration of climate change vulnerabilities. It also describes the 2015 revision processes for engaging technical and conservation partners and soliciting public comment (#7 and #8 of the 8 Required Elements).

Chapter 2 illustrates how the 2005 SWAP has guided conservation in Tennessee over the past decade. It provides multiple examples of how SWG funding has supported habitat and species population restoration, has helped leverage the conservation expenditures of other organizations, and has supported research and monitoring for a wide variety of species and the status of emerging threats such as White-nose Syndrome in bats.

Chapter 3 focuses on the identification, distribution, and abundance of species of Greatest Conservation Need (GCN) as well as the identification of priority habitats for the conservation of those species (#1 and # 2 of the required 8 Elements). Since 2005, more than 300,000 species occurrence records have been added to Tennessee's SWAP GIS database and the prioritization scoring process has been updated to include information on state and federal listing status and the age of an occurrence observation in the field. Also for the first time, plants have been included in the GCN species assessment. With 568 plant species designated as "Tier 4" GCNs, Tennessee now has identified 1,499 total GCN species. The 2015 SWAP focuses on habitat prioritization using a process that includes the 2001 Southeast Gap Analysis Project landcover mapping and a revised methodology for mapping habitats and species that increases the resolution of the data and the flexibility of analyses possible at different spatial scales.

Chapter 4 describes problems that may adversely affect species and their habitats (#3 of the required 8 Required Elements). The planning team determined that the problems identified in the 2005 SWAP are still largely representative of current problems for GCN species and habitats, including for newly designated GCN species. The focus in this chapter is on (1) providing a crosswalk of the 2005 problems to the most recent standardized threats classification from the Conservation Measures Partnership and (2) providing in-depth treatment of the major sources of stress to terrestrial, aquatic, and subterranean species and habitats in Tennessee. Two additional problems were added during this process: recreational area development and renewable energy development. Where possible, a spatial assessment was used to help identify the location of problems relative to priority GCN habitats. In 2015, climate change vulnerabilities are evaluated as a major new source of stress. The National Wildlife Federation and The Nature Conservancy prepared a separate climate change vulnerability assessment for Tennessee in support of the 2015 revision, expanding on a SWAP update report on climate change issued by TWRA in 2009.

Chapter 5 focuses on conservation strategies and actions that can address identified problems (#4 of the 8 Required Elements). The SWAP planning team determined that the 2005 strategy hierarchy, including all the General and Specific Actions, remained applicable to GCN statewide conservation efforts, and this chapter focuses on a subset of the most important actions for addressing the major problems identified in Chapter 4. As recommended by AFWA, a new strategy for prioritizing conservation activities is the identification of Conservation Opportunity Areas (COAs). The planning team considered three major attributes in designing COAs: GCN habitat priority, the problems affecting the habitats, and on-the-ground opportunities to implement conservation actions. However, COAs are not intended to artificially constrain decisions about what strategic actions are needed and where they apply. To address climate change, the team also identified which goals and strategies of the National Fish, Wildlife, and Plants Conservation Adaptation Strategy best align with TWRA's mission and expertise. They then worked with the National Wildlife Federation to begin the process of identifying adaptation options for addressing anticipated problems highlighted in the "Climate Smart" Vulnerability Assessment.

Chapter 6 focuses on improving effectiveness monitoring in Tennessee (#5 of the 8 Required Elements). The plan outlines how metrics for SWAP-specific conservation actions have been cross-walked to the U.S. Fish and Wildlife Service's Wildlife/TRACS Reporting System hierarchy in preparation for the adoption of this system for tracking accomplishments in 2015. TRACS reporting units have also been assigned to each set of desired changes articulated for Tennessee's COAs. Another recommendation is to participate in collaborative efforts to improve monitoring capabilities at state and regional scales.

Chapter 7 addresses SWAP review procedures, coordination with both government and non-government partners, and processes for partner participation in the development and review of projects undertaken in accordance with the SWAP (# 6, 7, and 8 of the 8 Required Elements). Specifically, future SWAP reviews will be integrated with TWRA's cycles for strategic planning, operational planning, and annual planning. Partner engagement will be fostered through inclusion in SWAP-related planning cycles (such as those focusing on COAs), through expanded data-sharing, and through collaborative identification of emerging issues and lessons learned.

Highlights of appendices to this SWAP include:

- The revised 2015 list of GCN species
- A set of factsheets about each of Tennessee's 28 COAs, which include descriptions of habitats, issues, conservation and monitoring priorities, and partners as well as COA maps and detailed lists of GCN species occurrences within each COA.
- A factsheet on Climate Change and Potential Impacts to Wildlife in Tennessee
- Preliminary climate adaptation options for different sets of priority species and habitats

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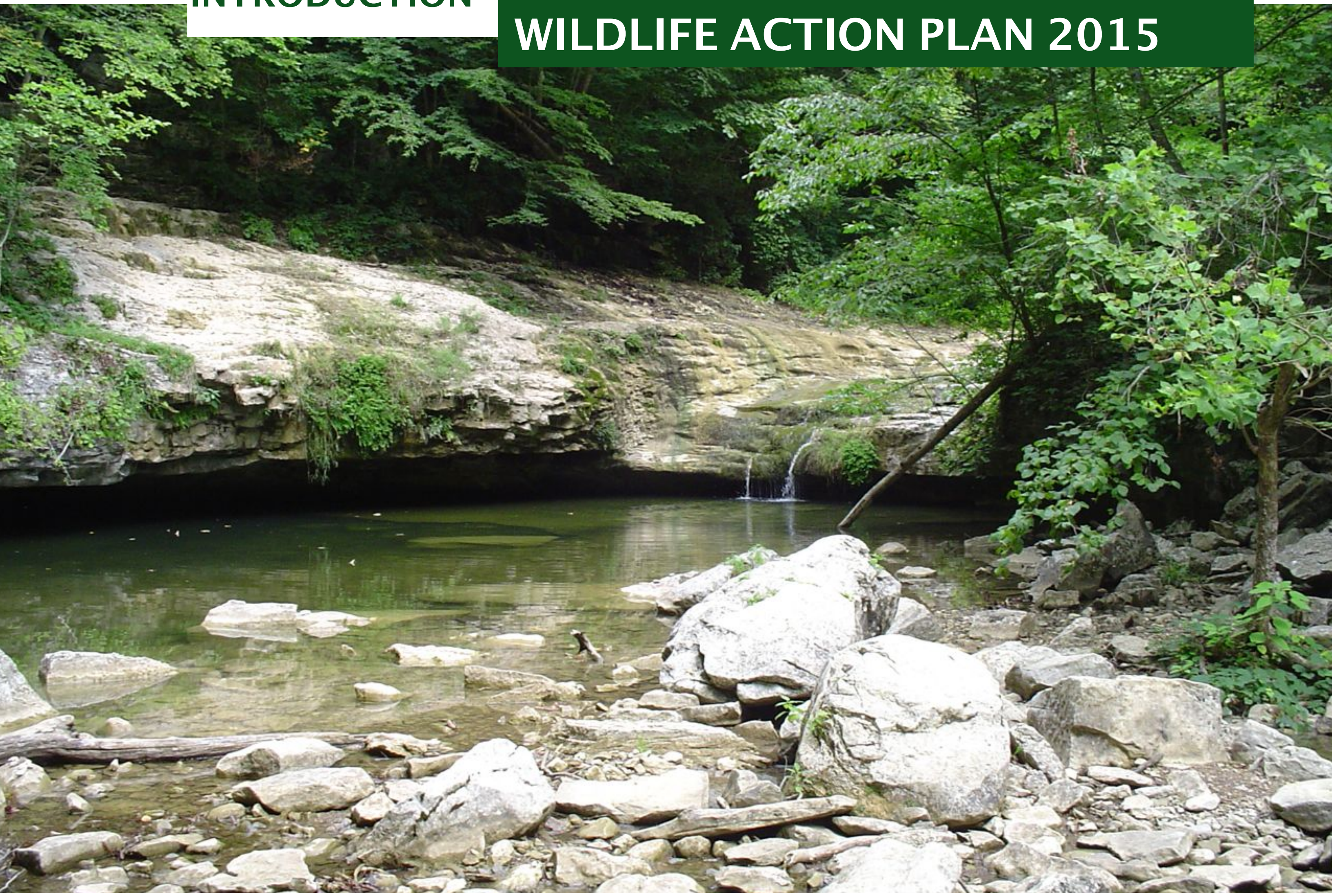
List of Acronyms

Acronyms	
AAFB	Arnold Air Force Base
AFWA	Association of Fish and Wildlife Agencies
AKN	Avian Knowledge Network
ATV	All Terrain Vehicle
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CCVI	Climate Change Vulnerability Index
CMP	Conservation Measures Partnership
COA	Conservation Opportunity Area
C-RAC	Cumberland River Aquatic Center
CRP	Conservation Reserve Program
CRT	Cumberland Region Tomorrow
DOD	U.S. Department of Defense
EPA	Environmental Protection Agency
GCN	Greatest Conservation Need
GIS	Geographic Information Systems
GSMNP	Great Smoky Mountains National Park
HR	Herbicide-resistant
HUC	Hydrologic Unit Code
HWA	Hemlock Woolly Adelgid
ILP	Interior Low Plateau
LCC	Landscape Conservation Cooperative
MAV	Mississippi Alluvial Valley
MSA	Metropolitan Statistical Area
MTSU	Middle Tennessee State University
NCWMA	North Cumberland Wildlife Management Area
NF	National Forest
NFWF	National Fish and Wildlife Foundation
NFWPCAS	National Fish, Wildlife and Plants Climate Adaptation Strategy
NGESOP	Nongame and Endangered Species Operational Plan
NHDPlus	National Hydrography Plus (a dataset)
NID	National Inventory of Dams
NLCD	National Landcover Database

NP	National Park
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NRRA	National River and Recreation Area
NWF	National Wildlife Federation
NWR	National Wildlife Refuge
OHV	Off Highway Vehicle
SF	State Forest
SHA	State Historic Area
SNA	State Natural Area
SP	State Park
SWAP	State Wildlife Action Plan
SWG	State Wildlife Grant
TADS	Tennessee Aquatic Database System
TCSI	Terrestrial Climate Stress Index
TDA	Tennessee Department of Agriculture
TDEC	Tennessee Department of Environment and Conservation
TDF	Tennessee Division of Forestry
TNBWG	Tennessee Bat Working Group
TNC	The Nature Conservancy
TVA	Tennessee Valley Authority
TWRA	Tennessee Wildlife Resources Agency
USACE	U.S. Army Corps of Engineers
USDA	US Department of Agriculture
USFS	USDA Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WMA	Wildlife Management Area
WNS	White-nose Syndrome

TENNESSEE STATE WILDLIFE ACTION PLAN 2015



I-1. From 2005 to 2015: Overview of the First SWAP Revision

TENNESSEE'S FIRST COMPREHENSIVE WILDLIFE CONSERVATION STRATEGY (now known as the State Wildlife Action Plan or SWAP) was completed in 2005. In developing the 2005 SWAP, the Tennessee Wildlife Resources Agency, in collaboration with The Nature Conservancy, invested in the development of an integrated relational database and Geographic Information Systems (GIS) tool to serve three main purposes: (1) consolidate numerous datasets on species occurrences and habitats managed by different agencies and organizations in the state; (2) link the species and habitat data to a GIS platform to facilitate conservation priority mapping statewide; and (3) promote common understanding of problems facing species and habitats across the state to encourage and prioritize collective action (TWRA 2005, pp. 28-29).

This 2015 update of the State Wildlife Action Plan is a comprehensive revision intended to build upon the original 2005 assessment methods, tools, and planning process addressing the Eight Required Elements (see I-2.2.). In the creation of this revision document, the emphasis is placed on highlighting where data and methods have been added, revised, and updated; how decisions on addressing priority problems and strategies have been made; and the rationale for decision-making throughout the process.

Key attributes of this 2015 comprehensive revision include the expansion of statewide mapping efforts to include priority problems affecting habitats, the identification of Conservation Opportunity Areas, integration of climate change vulnerability assessments, and the targeting of priority

Loggerhead Shrike - Derek Bakken

conservation actions with both government agency and non-governmental organization (NGO) partners.

I-2. Precedents and Requirements for State Wildlife Action Plans and Revisions

The development of State Wildlife Action Plans or SWAPs in every state and territory in 2005 was a historic milestone. All states completed plans following a similar, recommended format for the first time, which set the stage for better collaboration and decision-making on conservation priorities.

I-2.1. Mandating Legislation and Relationship to State Wildlife Grants

Congress funded the State & Tribal Wildlife Grants Program (commonly known as the State Wildlife Grant program or SWG) beginning in 2001. The focus of this program is to address important wildlife issues that have traditionally been underfunded and to "keep common species common." The SWG program is now the nation's core program for preventing endangered species listings. To receive funds, each state and

Photo credit previous page: Walls of Jericho - Josh Campbell, TWRA

Prescribed fire on Bark Camp Barrens WMA, Johnny Martin, Wildlife Technician - Josh Campbell, TWRA territory is required to develop a "Comprehensive Wildlife Conservation Strategy," popularly known as a State Wildlife Action Plan or SWAP.

These first-of-their-kind plans are helping state fish and wildlife agencies and their partners target and improve management for the full array of fish and wildlife under their jurisdiction.

Although the focus of the SWG program and SWAPs is conservation of nongame wildlife species, many nongame conservation strategies and actions are habitat based and therefore benefit a wide range of species, including those that are common or hunted recreationally. SWAPs are intended to serve as adaptive management plans to be updated at regular intervals, the maximum interval being a 10-year cycle. The Tennessee Wildlife Resources Agency published a 2009 SWAP update on potential climate change impacts on the state's

I-2.2. SWAPs Must Address 8 Key Elements

In its directive to states on the development of State Wildlife Action Plans, Congress identified eight required elements and directed that the strategies must identify and be focused on the "species in greatest need of conservation" as well as address the "full array of wildlife" and wildlife-related issues (TWRA 2005). The following summarizes the Eight Elements and the chapters of this revision document which address each element:

(1) Information on the distribution and abundance of species of wildlife, including low and declining populations as the state fish and wildlife agency deems appropriate, that are indicative of the diversity and health of the state's wildlife; [Ch 3]

(2) Descriptions of extent and condition of habitats and community types essential to conservation of species identified in (1); [Ch 3]

(3) Descriptions of problems which may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of these species and habitats; [Ch 4]

(4) Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions; [Ch 5]

(5) Proposed plans for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions; [Ch 6]

(6) Descriptions of procedures to review the plan at intervals not to exceed ten years; [Ch 7]

(7) Plans for coordinating the development, implementation, review, and revision of the plan with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats; [Ch 1,7]

(8) Processes for broad public participation in developing, revising, and implementing these plans, the projects that are carried out in accordance with these plans, and the designation of species in greatest need of conservation. [Ch 1, 7]

wildlife and habitats. This 2015 update plan constitutes Tennessee's first comprehensive revision of all Eight Elements from its 2005 SWAP.

I-2.3. Agency Guidance for Plan Revision and Implementation

Since the first round of State Wildlife Action Plans completed in 2005, the U.S. Fish and Wildlife Service, the Association of Fish and Wildlife Agencies, and conservation partners have developed voluntary guidance to help states revise and improve their plans. These flexible guidance documents focus on identifying best practices for meeting each of the Eight Elements and also assist states in determining their approach to addressing climate change vulnerabilities for species and their habitats:

- 2007 U.S. Fish and Wildlife Service-issued **Guidance on SWAP revisions**;
- 2009 AFWA **Voluntary Guidance for States to Incorporate Climate Change into State Wildlife Action Plans** and Other Management Plans;
- 2011 AFWA **Measuring the Effectiveness of State Wildlife Grants** report;
- 2012 Association of Fish & Wildlife Agencies (AFWA) **Best Practices for State Wildlife Action Plans**;
- 2012 National Fish, Wildlife and Plants Climate Adaptation Partnership's **national strategy**.

The 2015 revision team has utilized these guidance materials throughout the update development process.

I-2.4. Plan Revision Features and the 2012 Best Practice Guidance

The 2005 Tennessee State Wildlife Action Plan illustrates many of the features highlighted in AFWA's 2012 Best Practices Guidance document including the use of the NatureServe ranking methodology for assessing species conservation status; standardized habitat classifications, problem and strategy hierarchies; mapping of habitat priorities statewide; and using the input of many public and private partners in the plan's development. The 2015 update effort expands on those original approaches using the Best Practice Guidance, with a particular emphasis on the addition of plants as GCN species; updating habitat mapping to standardized units from nationwide datasets; selecting "Conservation Opportunity Areas" as strategic places to focus actions and partner engagement; alignment of program effectiveness measures to facilitate project reporting in the new U.S. Fish and Wildlife Service TRACs system; and the design of new stakeholder outreach tools including updating the Teaming With Wildlife coalition contact list, a new e-newsletter, and redesigning the Tennessee State Wildlife Action Plan website. For a list of specific Best Practices used by the 2015 revision team, please refer to Appendix A.

Mussel diversity in the Harpeth River - USFWS

CHAPTER 1

OVERVIEW OF TENNESSEE AND APPROACH TO THE STATE WILDLIFE ACTION PLAN

1.1. The State of Tennessee

WHEN IT COMES TO NATURAL RICHES, Tennessee is a state of superlatives. The geography of the state varies from the wetlands and bottomland hardwoods of the Mississippi River to the sheltered valleys and 6000-foot peaks of the Appalachians, where Southern Blue Ridge forests are considered one of the most biologically diverse temperate hardwood regions in the world (Stein et al. 2000). Tennessee is one of the most diverse inland states in the country, ranked by NatureServe as second in freshwater fish species diversity, fourth in amphibian diversity, and 13th overall compared with all other states (Stein 2002).

Tennessee's large expanses of limestone geology contribute to the development of thousands of cave systems, which are known to rank second in the U.S. for their number of obligate subterranean species (Niemiller and Zigler 2013). With 86 native crayfish found everywhere from caves and swamps to streams and lakes, it may top the list for crayfish diversity as well (Williams et al. 2014). Seven of the eight most ecologically rich rivers in the country are found in Tennessee (TWRA 2005), including the Duck River, recognized as **one of the most biodiverse waterways in the U.S.** (National Geographic 2010). Tennessee also has a rich floristic heritage: with 2,395 species, the state ranks 17th for its plant diversity (Stein and Gravuer 2008). The state's wide range of physiographic provinces and geology, temperate climate, and the fact that this region escaped the last glacial advance all contribute to the state's current species and habitat diversity. Six major terrestrial ecoregions are commonly recognized in Tennessee, from west to east (adapted from Bailey 1994; Keys et al. 1995):

Photo credit: Overlook Smoky Mountains - Ed Selby; Tennessee silhouette - Gograph.com

- Mississippi Alluvial Plain
- Upper Gulf Coastal Plain
- Interior Low Plateau
- Cumberland Plateau and Mountains
- Ridge and Valley
- Southern Blue Ridge

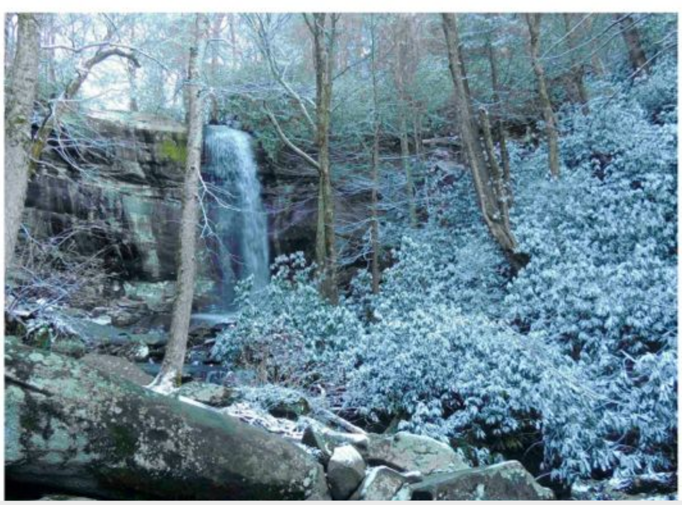
Tennessee also shares five major aquatic regions with neighboring states, defined by portions of five major river drainages:

- Mississippi River
- Tennessee River
- Cumberland River
- Barren River
- Conasauga River

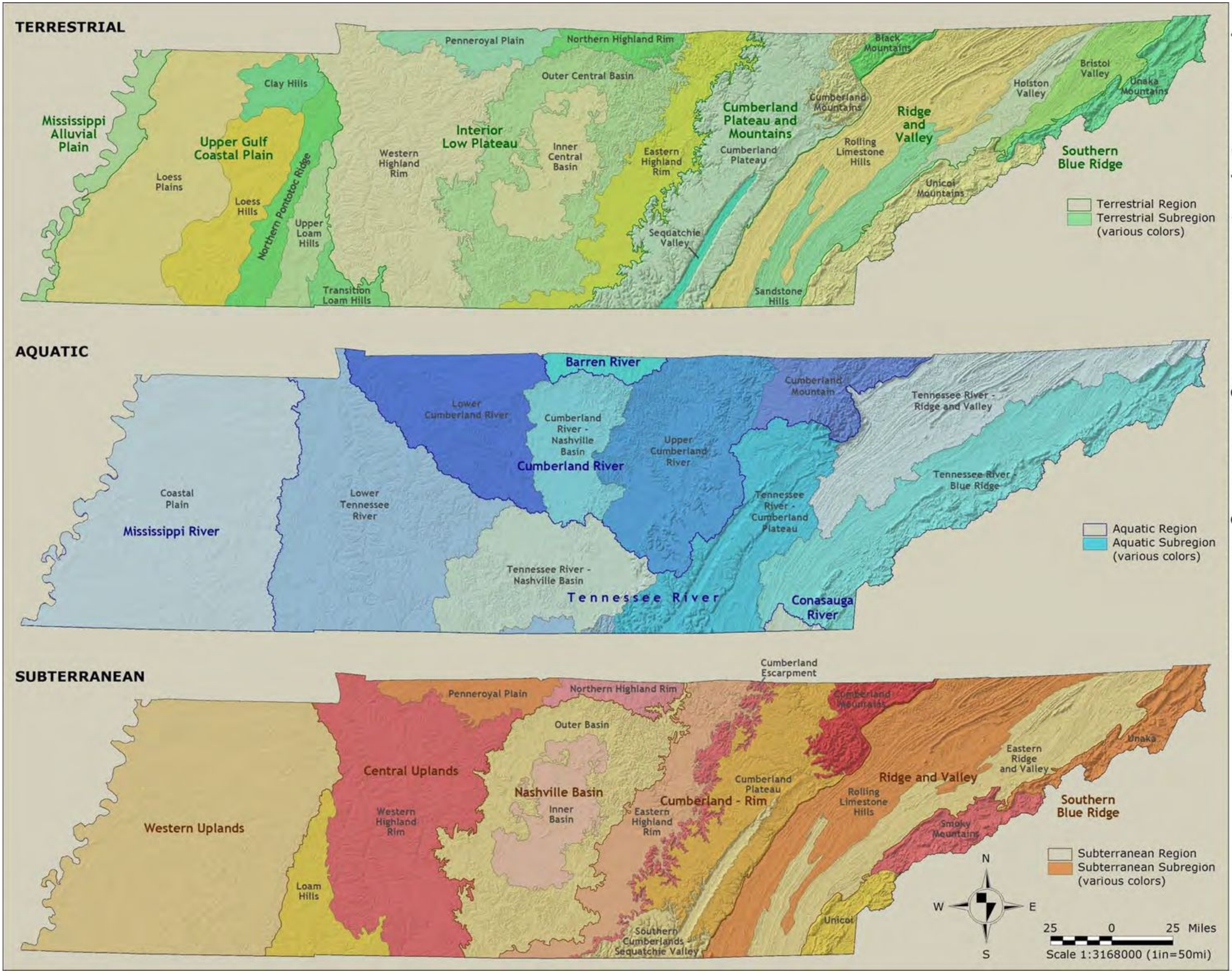
The subterranean landscapes of the state are also classified into regions and subregions in a fashion similar to terrestrial ecoregions, with more detail given to subsurface geological distinctions (TWRA 2005).

The State Wildlife Action Plan uses the classification of Tennessee's terrestrial, aquatic, and subterranean regions as the background for understanding the distribution of species of Greatest Conservation Need (GCN) and their habitats (Map 1). Chapter 1 of the 2005 TN-SWAP provides extensive detail of the dominant geology, vegetation, flora and fauna of each of these regions statewide (TWRA 2005).






Clockwise from upper left: Natchez Trace - Leigh Ann Fowler; Walls of Jericho amphitheater - Josh Campbell, TWRA; Sunset Rock on Lookout Mountain - Ron Jones; Rainbow Falls, Great Smoky Mountains National Park - Gregg Elliott, K Gregg Consulting



Map 1. Terrestrial, Aquatic, and Subterranean Regions and Subregions in Tennessee

1.2. Approach to the 2015 Plan Revision

1.2.1. Alignment with TWRA Strategic and Operational Planning

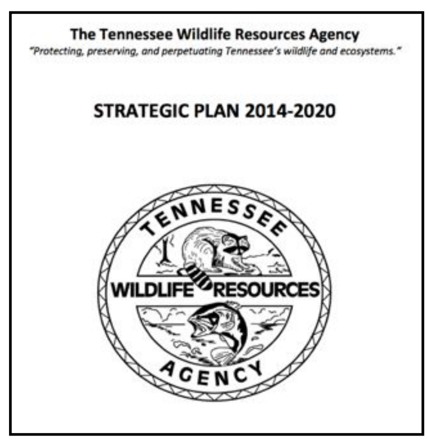
In 2005, Tennessee's planning team developed the first SWAP document in alignment with the guidance available from the U.S. Fish and Wildlife Service (USFWS) at the time. The next step after completing the SWAP was to develop a 2006-2012 Operational Plan (TWRA 2006) to align agency nongame species and habitat conservation activities with the Tennessee Wildlife Resource Agency's overall strategic planning approach. Many of the projects outlined in the 2006-2012 Operations Plan have been completed, and some are described in Chapter 2.

Tennessee's 2005 SWAP has guided wildlife conservation and the expenditure of State Wildlife Grants since 2005.

Highlights of Tennessee's first SWAP

- Identified 664 species of "Greatest Conservation Need" (GCN), representing birds, mammals, reptiles, amphibians, fish, mussels, crayfish, snails, and other invertebrates. These species inhabit all regions of Tennessee, including terrestrial, aquatic and subterranean habitats.
- Elevated knowledge of the state's biodiversity to an unprecedented level.
- Provided a solid scientific foundation for the state's future land conservation initiatives.
- Provided detailed information for federal agencies and Tennessee state agencies (e.g., Dept. of Transportation, Dept. of Environment and Conservation, etc.) to utilize in their own planning and operational activities.
- Provided detailed information for Tennessee counties and local communities to develop growth plans that consider the needs of Tennessee's fish and wildlife resources.

In 2014, TWRA completed its **2014-2020 Strategic Plan**, which provides an over-arching vision, broad-based goals, and strategies for achieving those goals in four main areas of operation: wildlife management, outdoor recreation, law enforcement, and information/education (TWRA 2014). To a significant degree, the operations of all four of these programs are essential to successfully managing Tennessee's GCN species. The planning approach of the 2005 SWAP, particularly the approach to using standardized habitat classification and species data, influenced the development of TWRA's 2014 Strategic Plan: for the first time, a habitat-based approach to defining priority management outcomes was used as the focus of the agency's Wildlife Resource Program.



For this reason, the 2015 SWAP Revision aligns with

TWRA's 2014-2020 Strategic Plan in the following ways:

- the plans use the same classification scheme for defining habitats;
- the plans focus on habitat conservation priorities to facilitate species management; and
- the plans are oriented toward achieving similar high-level outcomes.

The 2015 SWAP revision team worked intentionally with other divisions of TWRA to foster collaboration and identify shared conservation priorities using common understandings of habitats and problems affecting species and habitats statewide.

1.2.2. Revision Team Structure and Planning Objectives

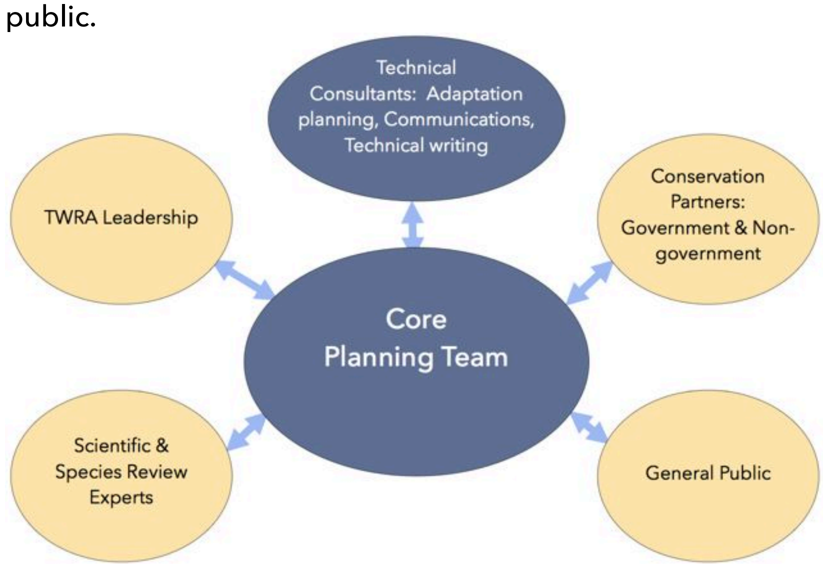
TWRA and The Nature Conservancy have made continuous investments in species monitoring data development and the SWAP relational database/GIS tool since the publication of the first SWAP in 2005. Chapter 2 of this report highlights many examples of on-the-ground conservation implementation as well as improvements to conservation data and planning methods. TWRA also completed an **internal revision of the 2005 SWAP** examining potential climate vulnerabilities of species and habitats statewide in 2009.

For the 2015 Comprehensive Review process, TWRA and TNC designed a team planning process (see Figure 1) focused on the following objectives:

1. Take advantage of core competencies within TWRA staff and meet capacity gaps with additional technical advisors (e.g., climate adaptation planning, communications, and technical writing);
2. Effectively engage all TWRA divisions and leadership at appropriate junctures in the planning process;
3. Achieve broad review of updated species list by technical experts;
4. Effectively engage government and non-government conservation partners to identify priorities for collaboration;
5. Develop the foundation for improved public communications, access and engagement with the State Wildlife Action Plan.

The core planning team designed a project approach to ensure comprehensive review of all Eight Elements from the 2005

Figure 1. **Conceptual diagram of the relationship between the core planning team, advisors, partners, and the general public.**



SWAP using the 2012 AFWA Best Practice Guidance recommendations wherever feasible. The overarching objectives of the 2015 revision process were to expand from the solid data assimilation and methodological approaches developed by the team in 2005, re-engage a diverse set of technical reviewers and collaborators, and apply the concept of Conservation Opportunity Areas as an additional strategic framework to inspire on-the-ground conservation delivery with a variety of partners.

1.2.3. Revision Process Timeline and Activities

The time schedule on the following page provides a summary of the major activities executed during the July 2013 through September 2015 comprehensive review period. Chapters 3 through 7 of this report provide detailed information regarding specific approaches, results, and outcomes of the revision process.

Clockwise: Wood Thrush - Cynthia Routledge; Green Salamander - Josh Campbell, TWRA; Redline Darter - Todd Stailey, Tennessee Aquarium; Mud Snake - Rob Colvin, TWRA

1.2.4. Summary of 2015 Planning Areas of Emphasis

The architecture of the 2005 SWAP database was designed to facilitate the incorporation of new and revised data over time. Since its initial development, various components of the database have been updated, revised, and expanded to support new planning and conservation mapping needs. One significant data development project led by Tennessee Department of Environment and Conservation Division of Natural Areas staff allowed for the addition of plant species to the SWAP database, along with their habitat preferences assigned to the same ecological systems as terrestrial animal GCN species.

Database improvements during the 2015 revision process also include the addition of thousands of species observation records, new standardized mapping units for terrestrial and aquatic priorities, updated landuse/landcover information, and the capacity to integrate spatial data on priority problems to understand the extent of potential impact to species and habitats across the state. The result is a comprehensive relational database management system and GIS platform for plant and animal species of greatest conservation need, their habitats, and the problems affecting them both.

SWAP Revision Time Schedule of Major Activities

July 1 – September 2013: Project Launch

- Notification to the Service of the formal revision process, including completed project management chart
- Core planning team defined. Species experts, Conservation Partners, and TWRA leadership groups identified and contacted
- Draft approach to public outreach completed
- Methods for assessing climate vulnerability reviewed

October 1 – December 2013: Species and Habitat Reviews

- Species and technical experts convened to review species of Greatest Conservation Need (GCN) list
- Core planning team assigns habitat preferences for GCN species added to list
- SWAP relational database updated with most currently available species observation data for all 2015 GCN species

January - March 2014: Problems and Action Reviews

- Core team review of 2005 hierarchy for problems affecting GCN species; selection of problems for 2015 mapping and focal strategies
- Core team review of 2005 priority actions to improve GCN species' habitat and status
- NatureServe Climate Change Vulnerability Index tool utilized to assess species vulnerability for a subset of GCNs across all faunal groups
- National Wildlife Federation engaged to assist with vulnerability summaries and ClimateSmart adaptation planning
- Communications program for general public and non-governmental organization partners developed

April – June 2014: Completion of Problem and Action Assessments, Draft Habitat Priority Maps

- Completion of selected GCN species Climate Change Vulnerability Index assessments
- Updated maps of habitat priorities statewide completed
- Core team begins consideration of Conservation Opportunity Area (COA) development and priority actions within COAs

July – September 2014: Development of Draft COAs and TWRA Leadership Engagement

- Draft Conservation Opportunity Areas assigned by core planning team
- Determination of high-level desired outcomes for COAs and assignment of draft primary conservation actions
- TWRA Leadership workshop held to gather feedback on process, COAs, and partnership recommendations

October - December 2014: ClimateSmart Team Workshop and Draft Revision Document Review

- Presentation to the **Organization of Fish and Wildlife Information Managers** on SWAP GIS habitat priorities
- NWF workshop on key climate vulnerabilities/determination of climate-smart strategy development approach
- Core team review of initial update document draft to approve format and primary content

January - July 2015: Conservation Partners Engagement and Strategy Alignment

- Refinement of draft COAs by core team
- Alignment of primary conservation actions with Wildlife TRACs framework
- ClimateSmart vulnerability report and strategy recommendations completed
- Incorporation of climate-smart strategy considerations into COA framework and conservation action selection
- Government agency and non-government organization partner workshops/comments incorporated into COAs
- SWAP presentation made before **Tennessee Geographic Information Council**

August 2015: Public Review of Draft Plan

- 2015 Update document available for TWRA Leadership comment
- 2015 Update document draft posted on website for public comment and publicized
- Public comments and additional Conservation Partners feedback collected

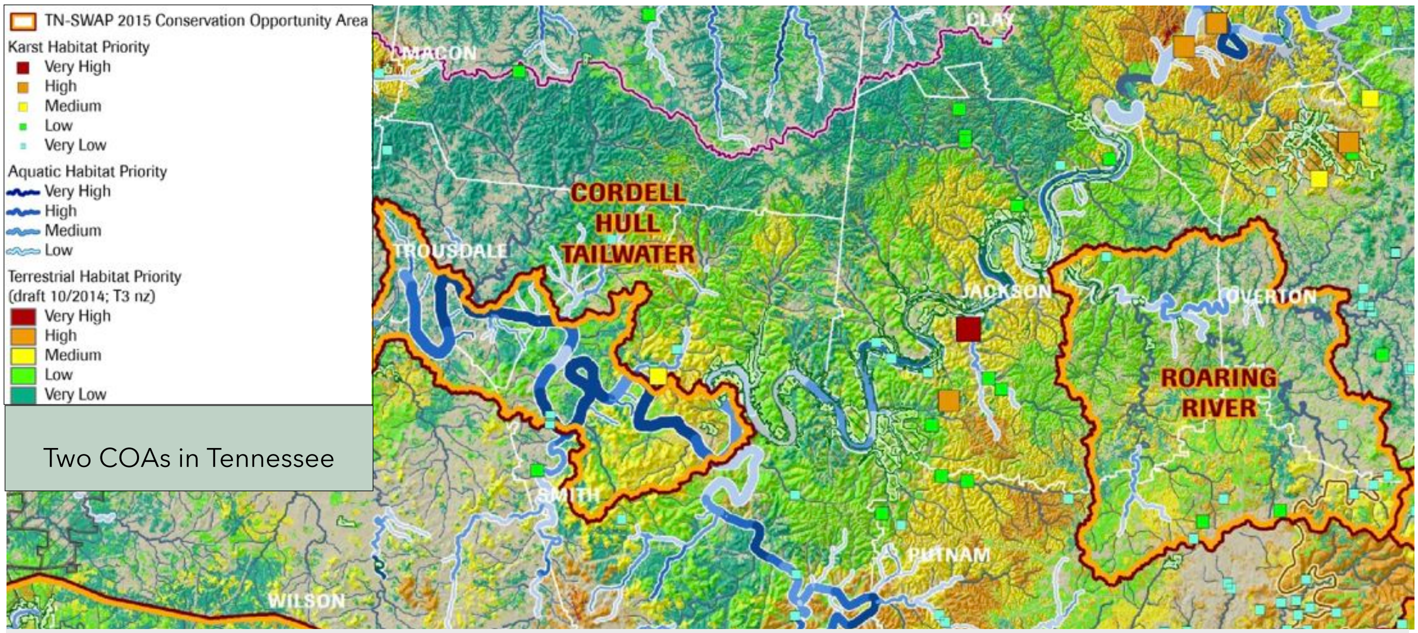
August – September 2015: Revision and Submission

- Response to public comments and completion of final 2015 Update report
- Submission of update report to USFWS for review prior to October 1

Conservation Opportunity Areas

One of the best practices for revising SWAPs is designation of Conservation Opportunity Areas, or COAs. Conservation Opportunity Areas are areas with the greatest opportunity for conserving, preserving, or restoring habitat critical to GCN species, and they will facilitate outreach and coordination with partners, extending the reach and effectiveness of state resource agencies.

Agricultural runoff - Lynn Betts, USDA NRCS

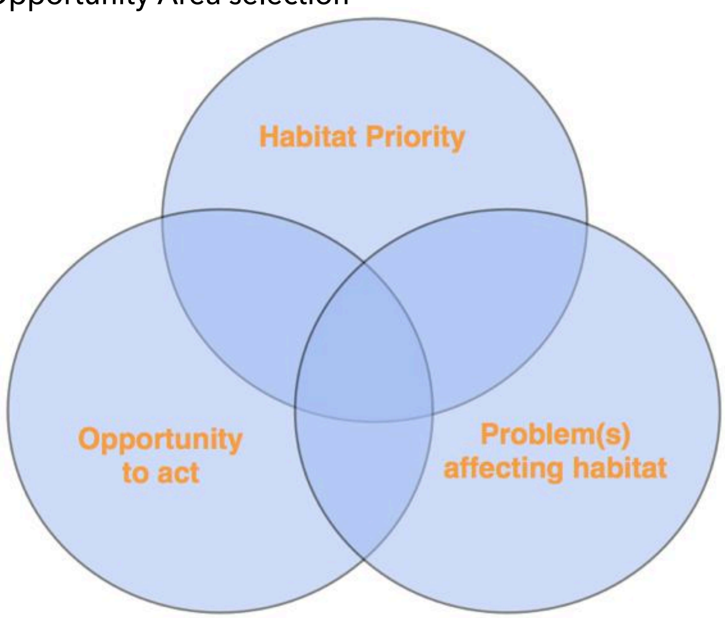


Two COAs in Tennessee

Example of a Conservation Opportunity Area

The identification of Conservation Opportunity Areas does not create nor presume to create new jurisdictional boundaries, regulatory authorities, or land use restrictions. COAs are intended to provide a framework for guiding voluntary and partnership-focused conservation action to address priority problems and achieve improved outcomes for species and habitats. Figure 2 depicts the general approach for the selection of Conservation Opportunity Areas. Chapter 5 gives more detail on the identification of COAs during the 2015 revision process.

Figure 2. Conceptual design of Conservation Opportunity Area selection



Climate Change

Nationwide there is growing recognition that without attending to the future impacts of climate change, it will become increasingly difficult to achieve the goals of protecting priority habitats and preventing wildlife and plant species from declining to the point of endangerment (National Fish, Wildlife, and Plants Climate Adaptation Partnership 2012). In particular, relying on historical conditions for factors such as average annual and seasonal temperatures, timing of streamflows, vegetation distribution, and species ranges will no longer be sufficient as a benchmark or goal for conservation decisions.

To meet this challenge and to follow the guidelines laid out by the Association of Fish & Wildlife Agencies in its report *Voluntary Guidance for States to Incorporate Climate Change into State Wildlife Action Plans,* TWRA contracted with the National Wildlife Federation - a leader in **Climate Smart conservation planning** - to prepare both a vulnerability assessment

Reelfoot Lake cypress swamp, dry during 2010 drought - Gregg Elliott, K. Gregg Consulting

summary for the state and guide the core planning team on selection of appropriate adaptation strategies.

The *Climate Change Vulnerability Assessment for Tennessee Wildlife and Habitats* (see Glick et al. 2015) provides an overview of current and projected climate change across the southeastern United States, including Tennessee, and summarizes recent efforts to assess the vulnerability of the state's wildlife species and habitats. The vulnerability assessment focuses on three main areas: species vulnerability, potential vegetation change, and landscape feature resiliency. Resources used to complete the assessment included NatureServe's Climate Change Vulnerability Index for species (Young et al. 2011), the Terrestrial Climate Stress Index for vegetation developed by the U.S. Forest Service (Joyce and Flather, personal communication, 2015), and The Nature Conservancy's resilient sites for terrestrial conservation in the Southeast U.S. (Anderson et al. 2014).

Measuring Progress

Wildlife TRACS is the tracking and reporting system for conservation and related actions funded by the U.S. Fish and Wildlife Service (USFWS) Wildlife and Sport Fish Restoration (WSFR) Program. Beginning in 2015, all State Wildlife Grant-funded projects must also be tracked and reported through this system. In developing the 2015 SWAP, TWRA decided to align the major conservation actions in the plan with the format of TRACS conservation reporting measures as an overarching classification method for tracking and reporting on effectiveness measures for conservation projects. This will improve the agency's results accounting, project monitoring, grant reporting, and ultimately the assessment of success in

Wildlife TRACS Project Action Levels with Indicators 8/20/14

Project Level	Action Level 1	Action Level 2	Action Level 3	Level 2 and Level 3 Output Measures	Description/Examples/Notes
Project Catagories	**Category**	**Strategy**	**Activity**	**Units**	
Administration and/or Conservation / Management and/or Recreation	Coordination and Administration	Coordination and Administration		Number	Coordination and administration necessary for effective agency operations and program/project management
			Agency administrative support	Number	Administration necessary for effective agency operations (e.g., acquisition of goods and services, human resources tasks)
			Program/project administrative support	Number	Administration necessary for effective program/project management (e.g., staff support and training, monitoring progress of grant proposal and reporting processes)
		Incentives	Incentives	Number	Development and delivery of economic incentives to private landowners to influence responsible stewardship of land/water and specific species
	Direct Management of Natural Resources				
		Create new habitat or natural processes		Acres	Creation of new habitat or natural processes for the benefit of fish and wildlife and recreational users
			Habitat conversion	Acres	Conversion of one type of habitat into another (e.g., creating bottomland forest from agricultural land, wetland creation) Note: Forest and wetland would be the appropriate broad habitat types to code for these two examples
			Public fishing lake construction	Acres	Construction of new public fishing lakes
			Waterfowl impoundment creation	Acres	Creation of shallow water impoundments for the primary benefit of waterfowl
				Structures	Removal of barriers to maintain aquatic species populations and restore ecological functions in streams (e.g., dam or dike removal, notching of dams)

Examples of TRACS Conservation Reporting Measures

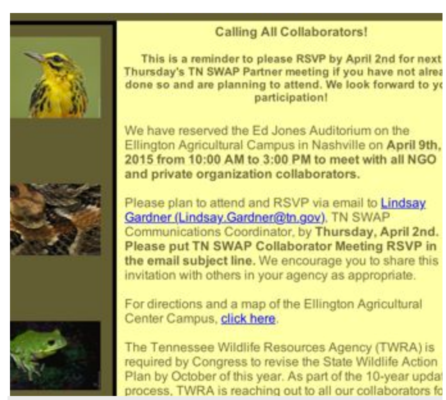
implementing State Wildlife Action Plan conservation strategies.

1.2.5. Conservation Partners Engagement

The Tennessee State Wildlife Action Plan is not intended solely for the Tennessee Wildlife Resources Agency, but rather for all stakeholders – large and small – within Tennessee who care about wildlife or make decisions affecting the state's land and water resources, including TWRA. As such, the agency recognizes the importance of partner and public involvement in the plan development process. Following best practices for state conservation programs (AFWA 2012), TWRA reached out to the biological research community to aid in reviewing and updating the GCN species list. Workshops were held and presentations made for conservation partners from other programs within TWRA itself, key state and federal agencies, academic and research institutes, nonprofit organizations, and interested citizen stakeholders.

1.2.6. Public Outreach and Communications: process, website, press release, e-newsletter

Early in the project planning phase, the core team recognized the need for improving the overall approach to engaging conservation partners and the general public. A communications expert was hired specifically to manage outreach. Techniques involved the overhaul of Tennessee's Teaming With Wildlife distribution list, development of quarterly electronic newsletter updates to partners, coordinated press releases sent out to statewide media, and the redesign of the Tennessee State Wildlife Action Plan website (**www.tnswap.com**). The SWAP webpage provided the capacity to receive, collect, and archive comments on the draft SWAP from any and all interested citizens during the official public review period. Comments were sorted according to category or topic, then considered and answered by the appropriate experts on the SWAP team. Appendix B provides an explanation of what actions, if any, were taken in response to comments raised during the review period.



Example of a quarterly e-newsletter sent to SWAP stakeholders.

CHAPTER 2

TENNESSEE STATE ACCOMPLISHMENTS UNDER THE 2005 SWAP

2.1. How the 2005 SWAP Guided Conservation Efforts

OVER THE PAST DECADE, the State Wildlife Action Plan has guided many agencies and organizations in conducting habitat and nongame species conservation throughout Tennessee. The State Wildlife Grant program (SWG) in particular has also influenced conservation investments across Tennessee. These grants were created by Congress to help keep species off of Threatened and Endangered (T&E) Species Lists, but to do so, they must be applied strategically; that is the role of the State Wildlife Action Plan. The 2005 SWAP identified 37 potential sources of stress affecting species of Greatest Conservation Need (GCN) and their habitats. Incompatible land use and development was identified as the primary problem facing the widest variety of species and habitats statewide (TWRA 2005). Alteration of streams and river habitats, degraded water quality, poor land management practices, natural fire suppression, and invasive exotic species were other priority problems linked to species and habitat declines in the 2005 SWAP.

To meet these challenges, SWG funding has supported habitat restoration, dam removal, and species reintroductions aimed at increasing populations of key GCN species. SWG funds have also helped to leverage the conservation expenditures of other organizations. Research and monitoring of a wide variety of species has resulted in vastly improved understanding of the distribution and needs of Tennessee's GCN species, which in turn results in improved management and conservation planning.

Photo credit: Early successional habitat, Bridgestone WMA, White Co. - Greg Wathen, TWRA

Research projects are also tracking the status of emerging threats such as White-nose Syndrome – a disease that is ravaging bat populations across the eastern U.S. – and the chytrid fungus and ranavirus, both of which threaten the state's diverse amphibians. Finally, the extensive spatial data upon which the SWAP is built, combined with strategic granting of SWG dollars, have informed local community planning aimed at promoting ecotourism and protecting local heritage and natural areas.

A major goal of State Wildlife Action Plans is to "keep common species common."

2.1.1. Restoring and Managing Habitat to Benefit Wildlife

The 2005 SWAP identified "Priority Terrestrial Restoration Portfolios" for the six ecoregions of Tennessee. Recommendations generally focused on bottomland hardwood forest restoration in western Tennessee, and dry oak forest and woodland restoration in eastern Tennessee. The SWAP also consistently recognized that the restoration of natural grassland systems would increase overall value to GCN species, since very few examples of natural grasslands remain (TWRA 2005, pp. 127, 131, 142). A recommended strategy was to address areas degraded by altered fire regimes through the application of prescribed fire management.

Bringing back oak savannah

At Catoosa Wildlife Management Area (WMA), a project to restore oak savannah and open woodland habitats has been ongoing since 1999. Canopy reduction plays a crucial role in the restoration process. To date, more than 3,100 acres of mixed pine forest has been cleared or thinned. Prescribed fire is applied regularly in the understory to promote native grasses such as big bluestem and wildflowers such as rattlesnake master and blazing star – species that thrive in more open conditions. The new growth provides abundant food in the form of seeds, sprouts, and legumes for birds, deer, and many other species. Native grasses benefit Bobwhite Quail, a GCN species whose populations have been in decline for decades, and the scrub-shrub habitat attracts songbirds such as Hooded Warblers, Common Yellowthroat, Yellow-breasted Chat, Eastern Towhee, Field Sparrow, and Red-headed Woodpeckers. This project has received support from at least 14 different agencies, organizations, and funders,

Top: Catoosa WMA 1 month post-burn in spring; Bottom: Catoosa 2.5 years post-burn - Clarence Coffey while also hosting a wide variety of researchers helping to catalog the response of wildlife and plants to the restoration (Woody 2011).

Aquatic restoration through small dam removal

The 2005 SWAP highlighted existing impoundments and dam construction as a priority source of stress affecting aquatic habitats throughout much of Tennessee. Since 2005, State Wildlife Grant (SWG) funds and other partnership efforts have focused on piloting small dam removals to improve stream habitat, water quality, and recreational opportunities.

Multiple government agencies and the nonprofit Harpeth River Watershed Association removed a **lowhead dam on the Harpeth River** near Franklin, TN in 2012 – the state's first – eliminating a recreational hazard while improving and increasing habitat for a wide diversity of native fish and mussels.

On September 19, 2014, the Tennessee Wildlife Resources Agency (TWRA) took down remnants of the **Brown's Mill dam** on the East Fork of the Stones River. This project resulted in 25 miles of improved free-flowing stream, providing habitat for scores of aquatic species, including three GCN species.


Removing Brown's Mill Dam, inset: dam before removal - Pandy English, TWRA

Benefits to species of greatest conservation need identified in the SWAP provide a rationale for large projects such as these. In addition to a SWG, the Brown's Mill dam removal was supported by funding from the **Tennessee Healthy Watershed Initiative**.

2.1.2. Controlling Destructive Invasive Species

Wild Hogs

Wild Pigs, also called Wild Hogs, wreak havoc in natural habitats and rural communities through habitat destruction – which occurs when they dig up the ground rooting for food – and directly through predation of native species. It is likely that Wild Hogs pose a significant threat to Tennessee's native amphibians and reptiles, many of which are GCN species (Jolley et al. 2010), as well as native plant communities, including some GCN plant species. TWRA conducts an ongoing statewide Wild Hog eradication program, using trapping equipment that was originally purchased with SWG funding. Tennessee is a leader among state


Trapped Wild Hogs - Scott Dykes, TWRA

agencies in developing its hog trapping methodology.

TWRA has taken a rare stance by closing Wild Hog hunting in favor of other methods of control, a decision made to reduce the likelihood of the spread of Wild Hog populations for recreational purposes.

2.1.3. Improving Decisions through Data Collection and Analysis

Two Strategic Plans issued subsequent to the 2005 SWAP identified the lack of information on (1) the status of nongame species populations, (2) their ecological limiting factors, and (3) needed management as priority issues. Since implementation of the 2005 State Wildlife Action Plan began, TWRA Wildlife Diversity staff have conducted surveys on 41 Wildlife Management Areas (WMAs), 1 refuge, 6 wetlands, and 6 state natural areas/state parks, as well as other key areas across the state.

These surveys have determined the presence, absence, and habitat preferences of GCN species and have produced over 68,000 observations of herpetofauna and mammals (both volant and non-volant), including 2,735 captures of GCN species. TWRA maintains all survey data, and these data have significantly increased occurrence records in the 2015 SWAP GIS relational database. Data collected through these and partner survey efforts are incorporated into management plans developed for WMAs and help to inform the development of habitat management or restoration projects to directly benefit GCN species. Additional monitoring projects have incorporated the ability to track species' response to management activities, such as the Golden-winged Warbler's response to habitat restoration at Hampton Creek Cove (see Golden-winged Warbler Case Study, Ch. 5).

New bat maternity colonies discovered

Bats are now widely recognized for their role in insect control, yet many species are declining or already rare. Tennessee has 16 insectivorous bat species, of which 9 are GCN species. TWRA initiated a migration study of the federally **endangered Indiana Bat** in 2009, which continues annually with the support of SWG and other federal funds. The project has resulted in the discovery of six previously unknown Indiana Bat maternity colonies in Tennessee and improved knowledge of cave habitat use by other bat species. Four of the colonies are in Wilson County, one in McNairy County, and another spans Benton and Henry counties.


Indiana Bats - Dustin Thames, TWRA

Maternity colonies were also discovered in other states, including a colony discovered in 2013 on Holly Springs National Forest in Mississippi, which represents the first Indiana Bat maternity colony ever discovered in that state. Understanding the range, roosting, and maternity needs of all GCN bat species is important for informing bat conservation, targeting habitat management, understanding the effects of weather on bat migration and stopover habitat needs, and tracking the progress and impacts of White-nose Syndrome.

Tracking the effects of a deadly disease

White-nose Syndrome (WNS), a devastating disease of bats caused by the *Pseudogymnoascus destructans* fungus, was first identified in Tennessee in 2010 and has begun to negatively impact many cave-hibernating bat species. The ecosystem role of bats in controlling insect pests is extremely valuable to society; therefore, TWRA will continue to partner with universities and NGOs to better understand and mitigate impacts of WNS in Tennessee. Since 2010, and as a result of WNS, TWRA has worked to improve bat monitoring protocols, which include use of acoustic call surveys in key areas and increased thermal imaging of Gray Bat maternity sites to better understand the impacts of WNS on bat populations. Acoustic data collection efforts have been expanded from summer months to winter months to determine bat activity levels during the coldest portions of the year – a key to understanding potential impacts of WNS.

2.1.4. Protecting Lands and Waters in Perpetuity

Priority bat caves in Tennessee

Priorities identified in the SWAP consistently guide land acquisition to protect sites critical to GCN species across Tennessee, in some cases with SWG funding leveraging additional sources of support. For example, since 2005 TWRA has purchased property surrounding two of the three largest bat caves in Tennessee: Bellamy Cave in Montgomery County (34 acres in 2007, and 5 acres added in 2013 with a State Wildlife Grant) and Pearson Cave in Hawkins County (102

Hibernating Gray Bats at Bellamy Cave - Josh Campbell, TWRA acres in 2009, and 46 acres added in 2013 with SWG funding).

Bellamy Cave is a top priority Gray Bat hibernaculum (overwintering site) whose population increased dramatically following protection through gating, from 91,000 in 2002 to over 381,000 in 2014. This increase occurred despite the discovery of WNS at the cave in 2012.

Pearson's Cave is an important Gray Bat hibernation and summer roosting site. The Gray Bat Recovery Plan identifies the acquisition of Pearson Cave as essential to prevent extinction of Gray Bats. Winter surveys at Pearson Cave have shown just how wintering populations may vary and move between caves. Surveys have indicated population sizes of over 365,000 (2002), over 147,000 (2013), and over 331,000 (2014). Populations have remained stable despite the discovery of WNS in 2012.

Golden-winged Warbler - Greg Levaty, USDA; Bog Turtle with tracking transmitter, showing characteristic yellow neck marking - Scott Dykes, TWRA

Cerulean Warbler - Ed Schneider

Specialized habitats for GCN species

Other acquisitions of land include 49 acres adjoining a conservation easement in Roane County (purchased with SWG funds in 2013), which provides critical habitat for Cerulean Warbler, Swainson's Warbler, Southeastern Shrew, Meadow Jumping Mouse, Woodland Jumping Mouse, Northern Pine Snake, and Tennessee Dace. Six acres purchased in Johnson County (with 2012 SWG funding, leveraging state wetland acquisition funds), expanded a southern cranberry bog preserve managed by The Nature Conservancy. This rare habitat type benefits several GCN species, including Golden-winged Warbler and Peregrine Falcon, Meadow Jumping Mouse, Southern Bog Lemming, and Bog Turtle. All of these acquisitions address threats to the species posed by development, incompatible forestry, and placement of new utility infrastructure.

2.1.5. Data-driven Planning

The 2005 SWAP recognized sprawl as the single greatest threat to Tennessee's remaining natural landscapes. To address this threat, it provided maps and data that could be used to identify critical watersheds for protection.

Improved agency planning and coordination

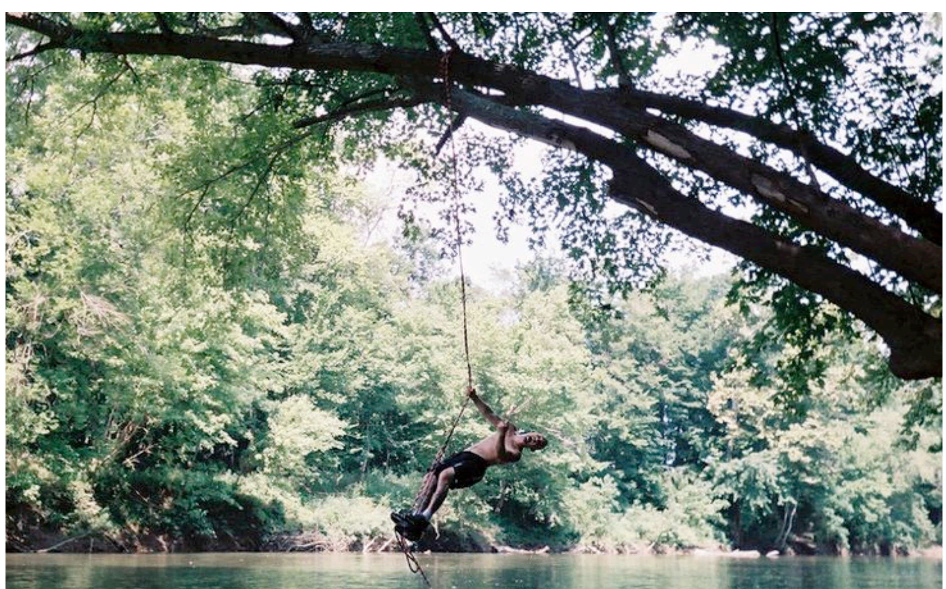
Beyond TWRA, organizations and agencies that protect or manage land in perpetuity, such as land trusts, Tennessee Department of Environment and Conservation, U.S. Fish and Wildlife Service, National Park Service, and the USDA Forest Service use the SWAP to identify and justify the protection of critical wildlife tracts. By working with TNC and TWRA GIS staff, species and their associated habitats can be identified for potential protection. Other agencies such as the USDA Natural Resources Conservation Service and Tennessee Division of Forestry can use the current and future Plans to identify watersheds and specific sites where improved land management will benefit GCN species and their habitats.

Community plans: protecting habitat and growing sustainably

Community planning is another arena that has benefited by incorporating data from Tennessee's SWAP. TWRA has supported local planning initiatives in several regions across the state:

✦With SWG funding, Cumberland Region Tomorrow (CRT) used the SWAP GIS database to create **"GIS Greenprint Tools"** for the Middle Tennessee Region; it has been used in the comprehensive planning process for four counties and two cities. The tools highlight critical lands for conservation to assist in strategic open space conservation and transportation planning in the 10-county CRT region (Elliott 2010).

✦The Tennessee Wildlife Federation developed a rural county planning document, also with SWG support, to better understand issues surrounding conservation planning in rural counties of the Southern Cumberlands (Elliott 2010).



Harpeth River at Pegram, TN in Cheatham County - Jason Nelms

✦Rural and scenic Cheatham County, located adjacent to the growing metropolis of Nashville, created a Sustainable Tourism Plan by assessing its natural and cultural resources to highlight, among other values, its ecotourism potential (Tennessee Regions' Roundtable Network 2013).

2.1.6. Saving Species through Reintroductions

Species reintroductions occur both as a means of preventing listing under the Endangered Species Act and to bring back populations of rare species where they have declined or disappeared. Stocking programs in Tennessee are part of a long-term program designed to restore reproducing populations of native species to Tennessee waters.

Alligator Snapping Turtle

With weights often in excess of 50 pounds, the Alligator Snapping Turtle is credited as being the **largest freshwater turtle in North America**. In contrast to Common Snapping Turtles, Alligator Snapping Turtles are listed in Tennessee as In Need of Management and are illegal to take. The restoration program for this largely aquatic species involves the release of live Alligator Snapping turtles, both adults and juveniles, focusing on the major river systems in west Tennessee that drain directly into the Mississippi River (the Hatchie, Obion, Forked Deer, and Wolf).

Alligator Snapping Turtle - James St. John

Alligator Gar

Alligator Gar are large apex predators that have been **extirpated from parts of their range** throughout the lower Mississippi River and tributaries, as well as rivers flowing into the northern Gulf of Mexico. In Tennessee, they are listed as species In Need of Management. With a reputation that has been rehabilitated from "trash fish" to "sport fish," they are also increasingly popular among sportsmen. Thus, the goal of Tennessee's Alligator Gar management plan is to restore populations by stocking Alligator Gar within their historic range in west Tennessee in cooperation with the U.S. Fish and Wildlife Service and to establish a sport fishery when population abundance and structure allows (Todd 2005). From 2006 through 2015, TWRA stocked 51,238 alligator gar fingerlings in various rivers and oxbows in west Tennessee, primarily the Hatchie River – a program that continues today. Gar were hatched at Private John Allen National Fish Hatchery (NFH), then reared at Humboldt and Springfield State Fish Hatcheries, the TWRA Cumberland River Aquatics Center (C-RAC), Warm Springs NFH, Natchitoches NFH, and Mammoth Spring NFH.

Freshwater mussels

Tennessee has tremendously rich aquatic fauna, particularly when it comes to freshwater mussels. Except for Alabama, the lakes, streams and rivers of **Tennessee once harbored the most diverse and abundant assemblage** of mussels known: 130 of 300 mussels species recorded in the country are or were known to occur here. However, mussels make up **almost half of the state's federally listed threatened and endangered species.** The current level of imperilment of Tennessee's mussel fauna adds greater importance to conservation efforts for species not yet designated in federal listings.

Mussels are important biological water filters for rivers, are used in research, and provide food for other wildlife. Their **shells are sought commercially** for nuclei used in the cultured pearl industry. The Tennessee Freshwater Mollusk Strategic Plan (Medlock et al. 2013) calls for the propagation and reintroduction of important mussel species into priority streams; this program has been augmented through SWG-funded equipment and facilities. An outstanding example is the C-RAC, a unique facility built with the partial support of SWG grants, the full dedication of TWRA staff, and partnerships with Tennessee Valley Authority (TVA) and the U.S. Army Corps of Engineers. The C-RAC focuses on propagation and reintroduction of aquatic species into the Cumberland River.

There are 11 rare mussel species housed at C-RAC, including the Tier 3 GCN species Pink Mucket, Orangefoot Pimpleback, Fanshell and Birdwing Pearly Mussel, along with 41 additional species that are not federally listed. Since the late 1990s, this facility has raised 18,000 endangered Pink Muckets from glochidia (the larval stage of mussels) as well as another 8,000 from 60 days old. It is also one of the few places in North America where a warm water discharge (from a nearby power plant) is used to help grow GCN species; the warm water provides an extended growing season, allowing greater growth of species prior to release time.

Left: Oyster Mussel traps fish host to deposit tiny young in fish gills to aid dispersal, Clinch River - Dave Herasimtschuk, Freshwaters Illustrated; Right: Wavy-rayed Lampmussel uses its lure to bring fish close, Clinch River - Jeffry Basinger, Freshwaters Illustrated



CHAPTER 3

SPECIES OF GREATEST CONSERVATION NEED AND PRIORITY HABITATS

3.1. Species Occurrence Records and the GCN Species List Review

A FUNDAMENTAL COMPONENT of developing conservation priorities is documenting current distributions of species and their habitats across the state, in particular, the designation of species of Greatest Conservation Need or "GCN species."

3.1.1. Updates to Species Occurrence Data in the SWAP Relational Database

During the creation of the first SWAP in 2005, the GIS relational database was designed to allow for continuous updates to species occurrence data gathered from a wide variety of data sources (TWRA 2005, p. 45). The Nature Conservancy has worked alongside the Tennessee Wildlife Resources Agency (TWRA) and other partners, including the Tennessee Department of Environment and Conservation (TDEC) Division of Natural Areas and the Tennessee Valley Authority (TVA) Heritage Program, to continually add to the datasets on known species distributions across the state.

Consistent data collection and assimilation work during the last decade has increased the number of species occurrence records available for use in the SWAP revision effort. Table 1 compares the differences in occurrence records available for planning in 2005 and 2015. In 2005, the database included approximately 25,000 aquatic, terrestrial and subterranean animal records, which has now been expanded to over 316,000 records. The records include an increase in the number of observations from cave

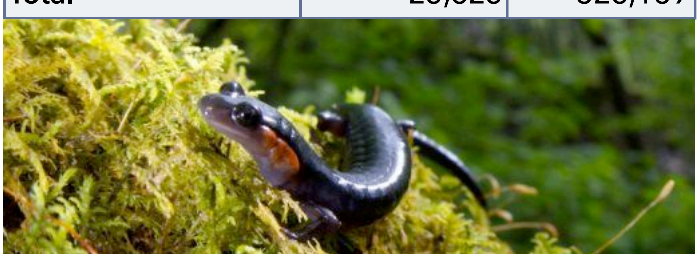
Photo credits: Conasauga Blue Burrower - Carl Williams, TWRA; Golden Eagle - Tony Hisgett; Gray Tree Frog - Dave Huth systems, with data from 300 more caves in 2015. An occurrence dataset of approximately 131,000 records for fish species known to be reproductive hosts for freshwater mussels was consolidated and added. Datasets of observational records for bird species have been improved, and the database now includes over 140,000 bird occurrences.

The increase in occurrence data for planning purposes in 2015 is attributable to three major opportunities: (1) better access to information housed in different data management systems, particularly **eBird** and TWRA's Aquatic Database System (TADS); (2) increase in occurrence records compiled in TDEC Division of Natural Areas and TVA Natural Heritage databases; and (3) increased levels of GCN species survey efforts and documentation conducted by TWRA and conservation partners. Table 2 provides a summary of the occurrence records now available for planning related to TWRA's improvements to data management and focused survey efforts, including over 2,700 records collected in the field by the nongame inventory program.

Finally, between 2005 and 2015, The Nature Conservancy worked with TDEC Natural Heritage program staff to add 568 plant species to the overall dataset. The addition of almost 10,000 plant species records increased the overall occurrence dataset available from 316,000 to approximately 326,000 records (Table 1). This collaborative effort allows for plant occurrence records to be utilized in a variety of ways including plant species-specific conservation planning, improved habitat distribution mapping of rare plant community types, and more comprehensive mapping of habitat priorities for plant and animal species combined. The availability of this data also provided the 2015 SWAP team with the option of identifying plants as GCNs if desired.

Table 1. **Comparison of species occurrence records available for planning in 2005 and in the 2015 revision process**

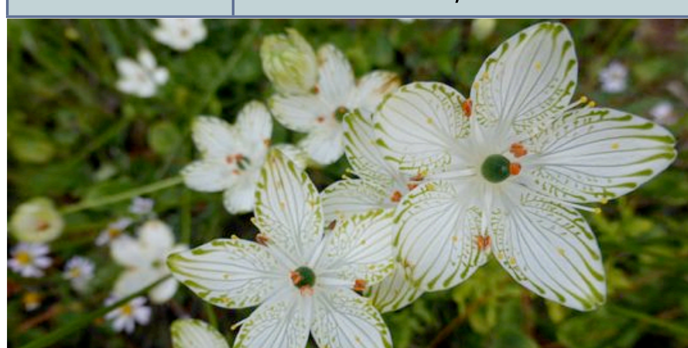
GCN group	2005	2015
Aquatic	5,268	149,224
Subterranean	961	7,000
Terrestrial	19,396	160,166
Plants	Not included	9,779
Total	25,625	326,169



Red-cheeked Salamander, endemic to Great Smoky Mountains National Park - Jeffrey Basinger, Freshwaters Illustrated

Table 2. **Summary of 2015 occurrence record availability from TWRA data management efforts and field surveys**

GCN group	Number of Occurrences (2015)
Aquatic	2,117
Subterranean	68
Terrestrial	16,566
Total	**18,751**



Large-leaved Grass-of-parnassus - "Eleanor"

3.1.2. Updates to the Species of Greatest Conservation Need List

The first major phase of the 2015 update focused on the review of the species of greatest conservation need (GCN) list. This process involved examining the 2005 GCN definition criteria; ensuring all species taxonomic names, conservation ranks, and legal designations are current; reviewing the full 2005 GCN species list by faunal group; and engagement with taxonomic field experts to ascertain that 2015 GCN selections align with current understandings of population status and the GCN definition criteria.

The core planning team determined that the overall GCN definition and selection rationale from 2005 was appropriate for the 2015 revision (TWRA 2005, p. 34). The three main elements include the species' global and state conservation status rankings, state and federal legal status designation, and additional rankings based on general population or habitat condition trends. Box 1 summarizes the definitions of global and state conservation ranks and Box 2 outlines the rationale for the selection of an individual species as a GCN in Tennessee.

Box 1. **TDEC Natural Heritage Program global and state ranking system for species**

Global Ranks:

G1 = critically imperiled globally; 5 or fewer occurrences worldwide imperiled globally

G2 = imperiled globally; 6 to 20 occurrences worldwide

G3 = very rare or restricted throughout range; 21 to 100 occurrences worldwide

G4 = apparently secure globally though locally rare sometimes; 100 to 1000 occurrences worldwide

G5 = demonstrably secure globally; over 1000 occurrences worldwide

G? = uncertain global rank

GH = historic global occurrence; possibly extinct

GNR = not ranked currently at global level

G#Q = questionable taxonomy

G#G# = mixed rank due to uncertainty

G#T# = rank of a subspecies or variety

State Ranks:

S1 = critically imperiled in state; 5 or fewer occurrences statewide

S2 = imperiled within state; 6 to 20 occurrences statewide

S3 = rare and uncommon in state; 21 to 100 occurrences statewide

S4 = apparently secure globally though locally rare sometimes; 100 to 1000 occurrences statewide

S5 = demonstrably widespread and secure in the state

S? = uncertain state rank

SH = historical occurrence in state

SNR = not ranked currently at state level

SP = potentially occurs in state

SR = reported to occur in state

SX = believed extirpated from state

S#S# = mixed rank due to uncertainty

(Note: additional global and state ranks are listed in this document, for more complete definitions please refer to the TN Division of Natural Areas' website at: **https://www.tn.gov/environment/section/natural-areas***)*

Beginning in October 2013 the planning team consulted taxonomic and field experts in mammals, birds, reptiles, amphibians, fish, mollusks, crustaceans, insects, and plants to finalize the updated 2015 GCN list. In November 2013, a species expert workshop was held to educate these experts about the 2015 update process and gather their feedback on GCN definition criteria, taxonomic accuracy, and choice of species for GCN designation. The planning team continued the consultation process through January 2014 to discuss the process with experts unable to attend the workshop and finalize choices.

Between 2005 and 2015, over 300,000 species occurrences were added to Tennessee's SWAP database, improving designation of GCN species and their priority habitats.

Box 2. Summary of rationales for selection and non-selection of GCN species

Rationale Categories for Selection as GCN Species

1. Globally rare, imperiled, or endangered species (G1-G3 NatureServe rank) or federal status category of LE (Listed Endangered), E/SA (Endangered by Similarity of Appearance), LT (Listed Threatened), T/SA (Threatened by Similarity of Appearance, PE (Proposed Endangered), PT (Proposed Threatened), or C (Candidate species); or state status category of E (Endangered), T (Threatened), or D (Deemed In Need of Management).
2. Special concern species due to declining trends, or otherwise vulnerable due to endemic, limited, disjunct, or peripheral status in region.
3. Special consideration wide-ranging species due to:
   a. **Partners in Flight** (PIF) score of 22 or higher
   b. National Shorebird Prioritization Score of 4 or higher
   c. National Wind Coordinating Collaborative category of 'High'
   d. Being a "keystone" species within a biodiversity "hotspot" or part of a globally significant aggregation of species
   e. Species is strongly dependent upon ecological processes often interrupted across the landscape.

Rationale Categories for Non-selection as GCN Species

1. Species occurs in the state but is not significantly imperiled, endangered, declining, or of special management concern.
2. Species range and/or habitat does not sufficiently occur in state to warrant target status.
3. Species is of uncertain taxonomic status.
4. Species is believed to be extinct range-wide.
5. Actively managed game species with sufficient number of viable populations in state.
6. Species is of historic significance but cannot currently be restored in the state.
7. Species distribution in habitats in state is either unknown or too uncertain to warrant target status.

Green Anole, example of a common, non-GCN species - Hunter Desportes

Plants as GCN species

Participants in the SWAP Species Experts Workshop held November 2013 to assist in updating the Species of Greatest Conservation Need List - Chris Simpson, TWRA

In consultation with scientific experts, the core planning team made the determination to grant 568 plant species GCN status in 2015. Plant species were not assigned GCN status during the 2005 planning effort. The decision to assign plants GCN status is consistent with the AFWA 2012 Best Practices Guidance, the recommendations of a NatureServe review of the role of plants in State Wildlife Action Plans (Stein and Gravuer 2008), as well as **the choice of 16 other states** which either selected plants as GCNs in 2005 or have added them since that time. States have chosen to add plants for a variety of reasons including a desire to help prevent federal listings of a greater spectrum of species, to collaborate with additional partners whose focus is on plant conservation, to garner additional funding for overall conservation efforts, and to help ensure that their SWAP is as comprehensive a conservation blueprint as possible for their states. (AFWA 2012).

GCN plant species clockwise from top left: Purple Milkweed - Katja Schulz; American Chestnut - Nicholas A. Tonelli; Clinton's Lily - Superior National Forest; Pink Lady's-slipper - Liz West

In addition, wild flora share many of the same management issues as wild fauna. Many of the same factors causing broad declines in the nation's wild animals – habitat destruction or alteration, spread of invasive alien species, emergence of lethal diseases, and increasingly, shifts in climate – all are taking a toll on the nation's plant life. Because many rare plants are highly localized, growing only in very specific soils or micro-climates, they are particularly susceptible to local habitat disturbances and direct damage to individuals and populations.

Of Tennessee's 2,395 plant species, 6.3% are at risk, making Tennessee the 19th-ranked state for plant species at risk. Without focused conservation attention to the growing plight of plant species, Tennessee could lose significant portions of its wild heritage and the ecological resilience that comes with that diversity (Stein and Gravuer 2008).

Tier Status

The Congressional mandate to states regarding the creation of State Wildlife Action Plans is to invest in conservation activities that assist in the prevention of future federal listings (e.g. Federally Endangered or Federally Threatened). Different state agencies also maintain separate jurisdictional authorities over species and habitat management. For these reasons, the 2005 SWAP designated "tiers" to track the legal status and jurisdictional authorities associated with all GCN species (TWRA 2005, p. 43). The 2015 core planning team decided to maintain the original tier designation system and add a fourth tier for plants. Box 3 summarizes the definitions of each tier designation.

Including the tier status in the SWAP relational database/GIS system allows planners to efficiently determine which species may be appropriate

Box 3. Summary of tier designations for GCN species

Tier 1: Species defined as wildlife under Tennessee Code Annotated 70-8-101, (i.e., amphibians, birds, fish, mammals, reptiles, crustaceans & mollusks), excluding federally listed and game species

Tier 2: All other fauna not defined as wildlife under Tennessee law (i.e., insects and other invertebrates)

Tier 3: Federally listed or game species which have alternative conservation funding

Tier 4: Plant species of Greatest Conservation Need

Examples of Tier 1-4 species, clockwise from top left: Tier 1: Mud Salamander - Chris Simpson, TWRA; Tier 2: Diana Fritillary - Pondhawk; Tier 3: Pallid Sturgeon (with children) - Scott Mensing, U.S. Army Corps of Engineers; Tier 4: Canada Anemone (*Anemone canadensis*) - Superior National Forest for different types of conservation project funding and which species are covered by various regulatory and management jurisdictions. TWRA does not have legal responsibility for rare plant species conservation, but wishes to track and incorporate the management needs of plants whenever feasible in ongoing conservation activities, particularly with respect to habitat protection and restoration for a broad suite of species.

The 2005 SWAP identified 664 aquatic, terrestrial, and subterranean GCN species in Tennessee. With the addition of plants as Tier 4 GCNs and the changes made to selections in other species groups, the number of GCNs for Tennessee in 2015 is now 1,499. Table 3 summarizes the changes made to the GCN list between 2005 and 2015. Appendix C provides the full updated list of 2015 GCN species including information on their state and global conservation ranking status, state and federal legal status, and tier designation.

Table 3. Comparison of GCN species designations between 2005 and 2015

	Number of GCN Species	
	2005	2015
Aquatic	246	276
Subterranean	185	411
Terrestrial	233	244
Plants	0	568
Total	664	1,499

GCN species clockwise from upper left: Aquatic: Chickamauga Crayfish - Carl Williams; Subterranean: Virginia Big-eared Bat - USFWS; Terrestrial: Red Squirrel - Giles Gonthier; Plant: Wood Lily - Jay Sturner

3.2. A Strategic Focus on Habitat Conservation

Habitat Prioritization Process Summary

In summary, the 2015 process for prioritizing habitats according to their importance for GCN species included the following steps:

1. **Terrestrial Habitat Mapping:** Utilize the most recent Southeast Gap Analysis Project's (SEGAP) landcover mapping (2001), which includes NatureServe's ecological system classification framework, to map habitat types for GCN species.
2. **Updates to mapping units:** Revise both terrestrial and aquatic mapping units to provide units of analysis that are more consistent statewide as well as smaller and more refined, allowing for even aggregation and disaggregation of data outputs when determining priorities, performing subsequent analyses on problems affecting habitats, and goal setting.
3. **Modeling and prioritizing habitat used by species:** As in 2005, this process combines 3 steps to develop overall habitat priority designations: identifying habitats preferred by each species, rating GCN species priority, and modeling actual habitat occupancy on the basis of species data records.
    - Assign habitat preferences for all terrestrial GCN species to NatureServe ecological systems (adding newly designated GCN species including GCN plants) on the basis of expert opinion. All terrestrial GCN plant and animal species now have habitat preference ratings for every natural ecological system in the GIS database.
    - Develop scores rating the priority of GCN species using data indicating how recently species were recorded in each location, combined with species rarity designations. Scores are designed to capture the species' rarity, likely persistence at or near a specific location, and the quality of the population when that information is available.
    - Use individual species occurrence observations as the beginning point for mapping habitat occupancy, then combine this with information that recognizes inherent differences in species' dispersal (movement) abilities to calculate a species habitat "footprint."
4. **Generating priority habitat maps**: Finally, combine the GCN prioritization scores with the species distribution footprints using the appropriate, updated mapping units and for terrestrial species, their habitat preference scores. Calculate ranks of low, medium, high, and very high priority habitats separately for each major type (terrestrial, aquatic, and subterranean) in each region of the state because some regions have higher concentrations of imperiled species. Compared to a single scoring standard, this method more fully captures all habitat priorities statewide.

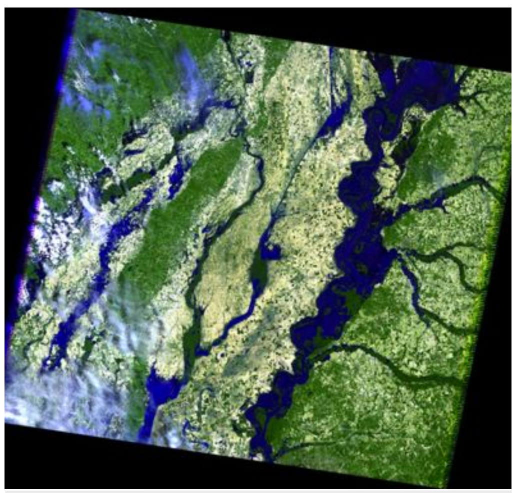
The following discussion gives a high level overview of the major improvements to spatial datasets and habitat prioritization scoring methodologies employed during the 2015 update. These changes, combined with the significant addition of species records to the database, have improved the resolution of the data and created the opportunity for more flexible applications of the outputs for use in a greater variety of subsequent analyses, decision-making contexts, and collaborations at different spatial scales. The Nature Conservancy (TNC) developed a companion GIS revision report to this 2015 SWAP to provide detailed information on all spatial data, methods, and formulas used to identify GCN species habitat priorities (Wisby and Palmer 2015).

Improvements to 2015 spatial datasets and prioritization methods have increased both resolution of the data and flexibility of analyses possible at different spatial scales.

3.2.1. Standardized Habitat Classification

The 2005 SWAP effort provided a major advance in statewide conservation planning through the intentional use of standardized habitat classification units and linking GCN species habitat preferences to those habitats. The emphasis on habitat classification and mapping improved the ability of conservation partners to make collaborative investments in habitat restoration and protection in all regions of the state. This success encouraged TWRA to adopt the same terrestrial habitat classification approach in the agency's 2014-2020 Strategic Plan (TWRA 2014).

In its 2014-2020 Strategic Plan, TWRA emphasizes the importance of a habitat-based approach to management, since habitat is the cornerstone of providing healthy populations of animals. "Provided that public and private lands and waters can provide ample quality habitat, species should be self-supporting if given the proper protection" (TWRA 2014). The Strategic Plan is now organized around broad habitat types generally corresponding to those used in the 2005 SWAP: Grassland, Forestland, Wetland, Karst, Streams and Rivers (TWRA 2014). The Strategic Plan also includes reservoir impoundments and urban areas as important wildlife management areas for fisheries and other habitat values.



Landsat 5 image, Flooding along the Mississippi (TN, AR, KY, MO) May 10, 2011

The 2015 SWAP update uses the same basic terrestrial habitat classification scheme developed in 2005. In the 2005 SWAP, the team used the Tennessee Gap Analysis Project's (SEGAP) landcover mapping, derived from 1990-1993 Landsat Thematic Mapper satellite imagery, as the base map of vegetation types and cross-walked the land cover classes to NatureServe's ecological systems (TWRA 2005, p. 61). The NatureServe ecological systems then served as the habitat types for terrestrial species. The 2015 update uses more recent 2001 SEGAP landcover mapping, which uses the NatureServe ecological systems as its classification framework. The NatureServe ecological systems are again used as the terrestrial habitat types.

The 2001 SEGAP land cover classification remains the most comprehensive map of vegetation cover by ecological systems for the state. Appendix D provides a summary of the SWAP habitat classification hierarchy, including information on the distribution of habitat types by ecoregion.

For freshwater systems, the planning team made no changes to the ecological drainage unit and stream classification system adopted in 2005 (Smith et al. 2002). The U.S. Fish and Wildlife Service's Appalachian Landscape Conservation Cooperative is developing an updated classification scheme for rivers and streams that was not yet available during the current planning horizon. In addition, a general physiographic scheme was used to classify karst systems (TWRA 2005, p. 8).

3.2.2. GCN Species Habitat Preferences

Following the selection of the habitat classification systems, the 2005 team used a process of expert-derived habitat preference assignments for terrestrial GCN species (TWRA 2005, p. 65). For every natural ecological system within each separate ecoregion, the planning team assigned a habitat preference rating for each species of "preferred," "suitable," "marginal," or "unsuitable."

The preference ratings are intended to categorize the relative utility of one ecological system type as habitat over another for each terrestrial species. For aquatic species, the occurrence record locations for GCNs were intersected in the SWAP GIS relational database with the freshwater classification designation of stream types, and these assignments were reviewed by the planning team (TWRA 2005, p. 65). No expert-derived preference assignments were made for subterranean species in 2005 due to lack of a consistent habitat classification for karst systems.

After completing the revision of the GCN species list, the 2015 planning team used the same process for assigning habitat preferences to all newly-designated terrestrial and freshwater GCNs. An interim project by TWRA, TNC, and Tennessee Department of Environment and Conservation (TDEC) Division of Natural Areas staff between 2005 and the 2015 comprehensive update process assigned karst preference ratings of trogloxene, troglophile, or troglobite (increasing degrees of dependence on cave environments) to all subterranean species based on their biological needs. These karst preference assignments were also maintained by the 2015 planning team.

The 2005 planning effort did not incorporate plant species, as no plants were designated GCN. However, during a project completed in 2009, TDEC Division of Natural Areas plant experts worked with TNC to make similar terrestrial habitat assignments for all plant species now included in the SWAP database. All terrestrial GCN plant and animal species now have habitat preference ratings for every natural ecological system in the 2001 SEGAP data. Appendix D provides an extensive summary of all 2015 GCN species and their habitat type preferences by ecoregion.

Top to bottom: Trogloxene: Northern Long-eared Bat - John Lamb; Troglophile: Cave Salamander - Dustin Thames; Troglobite: Tennessee Cave Salamander - Matthew Niemiller

In subsequent phases of priority habitat mapping in 2005 and 2015, aquatic habitat mapping did not use the preference assignments in the database. This choice was made due to the complexity of mapping the range of different aquatic system stream types in conjunction with the expert-derived preference assignments.

For use in the GIS mapping, the planning team assigned weights to terrestrial habitat preference ratings. In the 2005 model, these values were 10 points for preferred, 7 points for suitable and 3 points for marginal habitat designations. In the 2015 iteration, in order to emphasize the footprint of preferred habitats in the final mapping schemes, the ratings used are 10 points for preferred, 5 points for suitable, and 2 points for marginal habitats (Wisby and Palmer 2015). Finally, the 2015 model uses the karst preference ratings for each subterranean species as a scoring mechanism to capture the reliance of those species on karst habitats.

3.2.3. GCN Species Prioritization Scoring

In 2005 the planning team developed a prioritization scoring formula for GCN species using a combination of species rarity information and the presumed viability of a given species population (TWRA 2005, p. 80). The 2015 species prioritization scoring formula has been modified in two ways: (1) to reduce the complexity from the 2005 methods attempting to estimate population viability as a scoring component; and (2) to include federal and state legal listing status.

Specifically, as a substitute for a population viability rating estimate, the prioritization formula now uses a scaled point score associated with the date of last observation for every species occurrence (i.e., observation) record and the **NatureServe Element Occurrence Ranking score**, when available. In the scaled scoring system, occurrences with more recent observation dates are given more points, with the points tapering down for older records and records without dates receiving a nominal score of 20 out of 100 points. These two scoring elements represent the likelihood of a species' current persistence at or near the observation point and the quality of the population. The rarity portion of the species priority score, originally restricted to Global and State ranks (see Box 1, p. 26), has been amended to include federal and state legal listing status to account for potentially declining population trends triggering a legal status assignment (Tables 4 and 5). These trends may not be reflected in the Global or State rarity ranks alone (Wisby and Palmer 2015).

Species priority ratings of karst species and their occurrences are based only on NatureServe G-Ranks, when available, and on estimates of probable G-Rank designation for species not in the NatureServe database. These choices for

Top: Whooping Crane (G1 species) - Cynthia Routledge; Sedge Wren (G5 species) - Chris Sloan

Table 4. Federal species listing designations

Abbreviation	Designation	Explanation
LE	Listed Endangered	Taxon is threatened by extinction throughout all or a significant portion of its range
SAE	Endangered by Similarity of Appearance	Taxon is treated as an endangered species because it may not be easily distinguished from a listed species
LT	Listed Threatened	Taxon is likely to become an endangered species in the foreseeable future
SAT	Threatened by Similarity of Appearance	Taxon is treated as a threatened species because it may not be easily distinguished from a listed species
PE	Proposed Endangered	Taxon proposed for listing as endangered
PT	Proposed Threatened	Taxon proposed for listing as threatened
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
(status, XN)	Nonessential 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
PXN	Proposed nonessential experimental population	

*** Taxa listed as candidate species may be added to the list of Endangered and Threatened species, and as such, consideration should be given to them in environmental planning. Taxa listed as LE, LT, PE, and PT must be given consideration in environmental planning involving federal funds, lands, or permits, and should be given consideration in all non-federal activities.

Table 5. State species listing designations

Abbreviation	Designation	Explanation
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.

Table 5. State species listing designations, additional modifiers for plants

Abbreviation	Designation	Explanation
PE	Proposed Endangered	Any species or subspecies of plant nominated by the Scientific Advisory Committee to be added to the list of Tennessee's endangered species. After approval by the commissioner of the Dept. of Environment & Conservation and the concurrence of the commissioner of Agriculture, these plants will formally become State endangered.
PT	Proposed Threatened	Any species or subspecies of a plant nominated by the Scientific Advisory Committee to be added to the list of Tennessee threatened species. After a public hearing, these plants will formally become State threatened.
E-PT	Endangered-Proposed Threatened	Species which are currently on the state list of endangered plants, but are proposed by the Scientific Advisory Committee to be down- listed to threatened. After approval by the commissioner of the Dept. of Environment & Conservation and the concurrence of the commissioner of Agriculture, these plants will formally become State threatened.
E-PS	Endangered-Proposed Special Concern	Species which are currently on the state list of endangered plants, but are proposed by the Scientific Advisory Committee to be down- listed to special concern. After approval by the commissioner of the Dept. of Environment & Conservation and the concurrence of the commissioner of Agriculture, these plants will formally become State special concern.
T-PE	Threatened-Proposed Endangered	Species which are currently on the state list of threatened plants, but are proposed by the Scientific Advisory Committee to be listed on the state endangered list. After approval by the commissioner of the Dept. of Environment & Conservation and the concurrence of the commissioner of Agriculture, these plants will formally become State endangered.
T-PS	Threatened-Proposed Special Concern	Species which are currently on the state list of threatened plants, but are proposed by the Scientific Advisory Committee to be down- listed to special concern. After a public hearing, these plants will formally become State special concern.
P	Possibly Extirpated	Species or subspecies that have not been seen in Tennessee for the past 20 years. May no longer occur in Tennessee.
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.

karst species ratings were made because knowledge of karst biodiversity, while improving, still remains limited and many species have not been assessed for Global or State rarity ranking or State and Federal legal status.

3.2.4. 2015 Updates to Habitat Mapping Units

Terrestrial Habitats

The 2005 habitat mapping effort used products from the U.S. Census Topologically Integrated Geographic Encoding and Referencing (TIGER) database of roads to segment Tennessee's terrestrial landscape into roadless block sections. These roadless block areas were used as the smaller grain-sized land unit basis to assess priorities. For the 2015 update, the roadless block units have been replaced by uniform 100-acre hexagons statewide, subsequently grouped into 700-acre rosettes for terrestrial habitat prioritization. The full land area of Tennessee contains approximately 40,000 700-acre rosette clusters.

The 100-acre hexagon framework was also used to link cave sites (subterranean habitat) to the surrounding terrestrial landscapes in which they are located for further assessment (Table 6).

Woodland at Catoosa WMA - Clarence Coffey, TWRA (retired)

Roadless block areas vary in size and shape and have an inconsistent footprint on the landscape. The standardized, regular hexagon grain size approach is preferable for organizing prioritization assessments because it is consistent statewide and allows for even aggregation and disaggregation of data outputs when determining priorities. Also, the hexagon approach is not related to or dependent upon political or management jurisdictional boundaries, and instead can be used to examine data in a flexible manner within the context of these other boundaries when needed (Nhancale and Smith 2011).

Aquatic habitats

The 2005 version of the SWAP aquatic datasets used 12-digit hydrologic units (HUC12) as the units of analysis. Since its initial development, the aquatic component of the database has also been extensively revised and refined by TNC. The 2015 SWAP update uses this new hydrological modeling framework developed by TNC in a Microsoft Access platform using the National Hydrography Plus (NHDPlus v2) datasets from the U.S. Geological Survey and the U.S. Environmental Protection Agency (Table 6).

Built upon the 1:100,000-scale National Hydrography Dataset and 1:24,000-scale digital elevation models (DEM), NHDPlus v2 defines the catchment areas draining into each individual stream segment in a hydrologic

Estill Fork at Bear Hollow Mountain WMA, third order stream - Josh Campbell, TWRA network. The NHDPlus v2 dataset also defines the hydrologic upstream and downstream connections between individual stream segments, as well as providing a number of other relevant attributes, such as mean annual flow velocities and volumes. Dam locations and GIS attributions from the National Inventory of Dams (NID) dataset were also incorporated. Dams determined to be on the stream network were linked to their corresponding NHDPlus v2 stream segments for incorporation into the model. Normal storage values from NID data, as well as NHDPlus v2 flow volumes at linked stream segments, were used to estimate mean annual residence time of water behind dam impoundments.

The 2015 updates to the SWAP aquatic datasets provide several advantages in both the assessment of habitat priorities and the understanding of problems affecting these habitats. The grain size of the catchment areas around stream segments are much smaller and more refined than the HUC12 grain size, and the catchments and segments can be aggregated and disaggregated at different watershed spatial scales as needed. The catchment and stream segment connections also allow for assessments of land use and land cover conditions known to be related to stream health and overall habitat integrity. Finally, the upstream and downstream hydrologic connections provide a general means of understanding the linkages between upstream land and water uses on downstream sections of streams and rivers.

3.2.5. 2015 Updates to Species Distribution Footprints

The 2005 SWAP model used the individual species occurrence observation points as the basis for mapping the potential occupancy footprint of a species at a given location. For terrestrial species in 2005, occurrences inside one NatureServe "suitable habitat separation distance" (Box 4) were combined into one observation. For aquatic species, any occurrences of a

Table 6. Comparison of 2005 and 2015 mapping units

General Habitat Category	2005 Base Mapping Unit	2015 Base Mapping Unit
Terrestrial	TIGER-roadless blocks	100-acre hexagons, aggregated to 700-acre rosettes
Aquatic	12-digit Hydrologic Unit Code (HUC) watersheds	National Hydrography Dataset Plus, Version 2 catchments
Subterranean	Tiger-roadless blocks	100-acre hexagons, aggregated to 700-acre rosettes

Box 4. Separation Distance for Suitable Habitat

Distance (in kilometers) of intervening suitable habitat not known to be occupied that is great enough to effectively separate occurrences by limiting movement or dispersal of individuals between them. Suitable habitat is habitat capable of supporting reproduction or used regularly for feeding or other essential life history functions; a habitat in which you would expect to find the species (assuming appropriate season and conditions). For most animal species, the recommended minimum separation distance for intervening suitable habitat is 2 km (1.2 mi). This is to ensure that occurrences are not separated by unreasonably small distances, which would lead to the identification of unnecessarily fragmented populations as potential targets for conservation planning or action. Note: The separation distances for animals are currently under review and subject to revision. (Definition from NatureServe) species within a HUC12 watershed were combined to represent one observation. Subterranean species occurrences were linked to their known cave sites, and similar to aquatics, all occurrences were combined into one observation point for that species in that cave system (TWRA 2005).

The 2015 update also uses individual species occurrence observations as the beginning point for mapping occupancy. A few key modifications recognize the limitations inherent in using observations based on general field surveys designed primarily to document species presence only, without recording absence where a species might be expected to occur. In addition, the hexagon framework and NHDPlus v2 updated base mapping units allow for greater flexibility in examining potential species distributions than the roadless block and larger HUC12 watershed approach.

First, for terrestrial species, potential distribution footprints from every individual species observation point were modeled to the 700-acre rosettes using a formula which takes into consideration the age in years of the observation point and the distance of the point to each 700-acre rosette 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 (Wisby and Palmer 2015).

For aquatic species, the NHDPlus v2 stream segments were linked with each individual species observation. Then, stream segments upstream and downstream of the observation point within 2 times the NatureServe suitable habitat separation distance (Box 4) and with similar mean annual flow volumes to the flows at the observation point were identified to capture the potential distribution footprint of the species in a given collection of stream segments. The planning team considered NID dam locations to be barriers in the footprint development and these were not crossed when mapping potential species occurrence extents (Wisby and Palmer 2015).

Finally, for subterranean species, the 2015 model assigns all observation records to the cave system from which they are documented, duplicate occurrence records are removed, and one unique species/cave system observation developed. Using the 100-acre hexagon units of analysis, the planning team identified areas around all cave system entrances as habitat influencing subterranean species based on their distance to cave systems with documented GCN species.

"Douglas Dam - Tennessee 001," on the French Broad River - TVA Web Team, Wikimedia Commons

For species known to occupy dry zones in caves, a maximum distance of 2.5km was used, and for bats and karst species known to occupy cave streams and pools, a maximum distance of 5km was used. These distances were utilized to capture a general footprint of the organic recharge zone of each cave (2.5km or 1.5 mi) and to reflect the higher mobility and potential hydrologic recharge zone of bats and cave-stream dependent species, respectively (Wisby and Palmer 2015). Bat species are the only faunal group associated with cave systems for which the date of occurrence observation was considered in the scoring system for subterranean priorities (Wisby and Palmer 2015).

3.2.6. Mapping Terrestrial, Aquatic, and Subterranean Priority Habitats

The final steps in the generation of priority maps involved combining the GCN prioritization scores with the species distribution footprints using the appropriate mapping unit framework – hexagons for subterranean and terrestrial, NHDPlus v2 stream segments for aquatics (for detailed scoring formulas, see Wisby and Palmer 2015). This mapping process allows for each major habitat category (terrestrial, aquatic, and subterranean) to be assessed using its individual scoring and footprint methodology, but also to combine the assessments into different types of visual map and tabular outputs for interpretation.

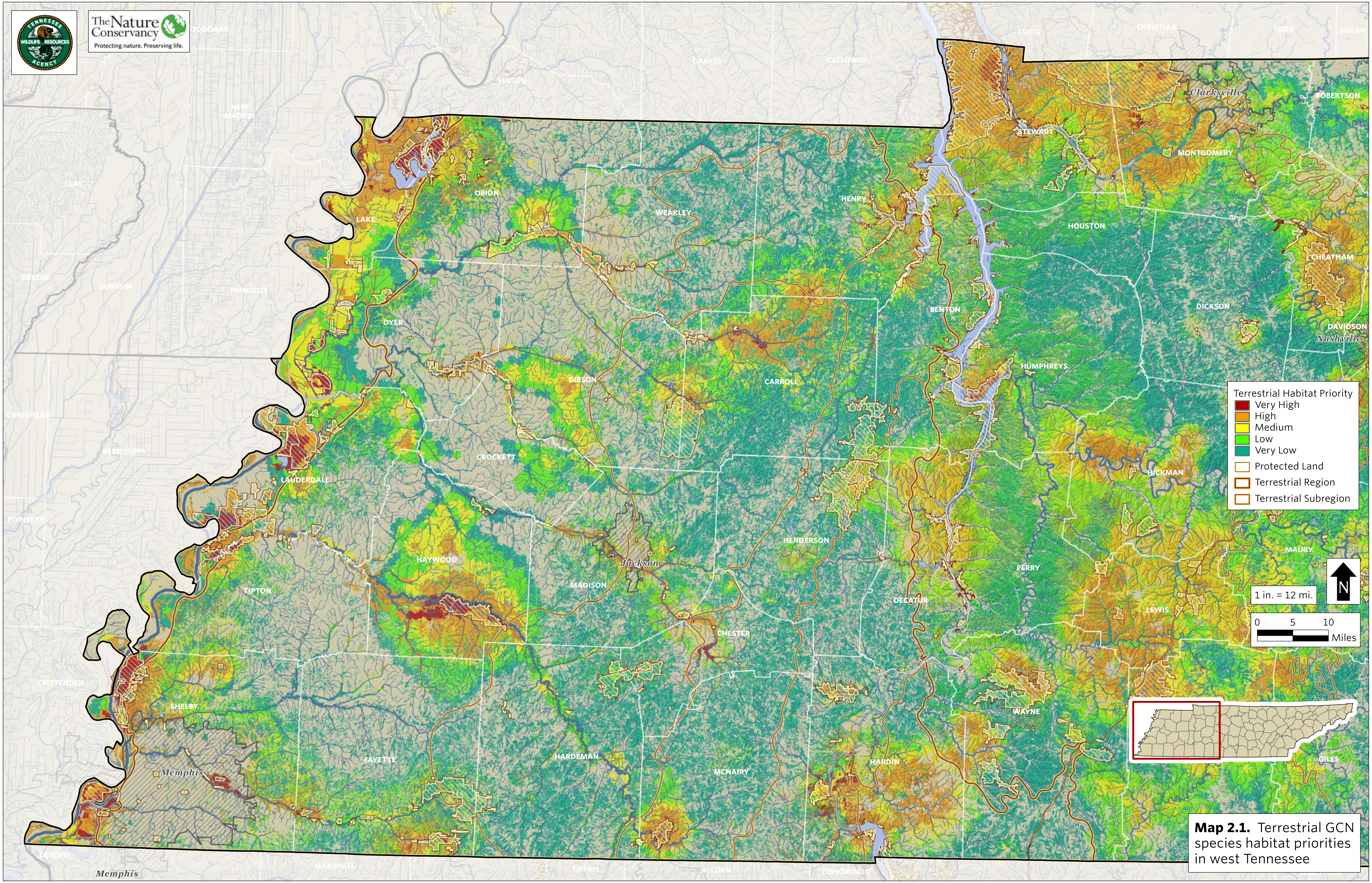
For terrestrial species, the planning team used the habitat preference scores for NatureServe ecological systems and the SEGAP landcover mapping of those systems in the final mapping process. They overlaid the SEGAP ecological system coverage with the 700-acre rosettes statewide, resulting in a GIS layer with roughly 400,000 ecological system class/rosette combinations. They then joined the terrestrial species distribution footprints (by 700-acre rosette) data table to the ecological system class/rosette table. Final priority scores for ecological systems (habitats) within each rosette were calculated by summing the GCN species prioritization, observation age and distance, and habitat preference scores for all species within the rosette (Wisby and Palmer 2015).

A similar calculation process was performed to generate aquatic habitat priority maps by summing the GCN prioritization, observation age, and distribution footprint of every species for each stream segment. The planning team identified cave system priorities based on the GCN species global rarity and karst affinity score, with scores for known bat caves and areas within a 2.5 km radius receiving an additional score component based on the age of the observation record (Wisby and Palmer 2015).

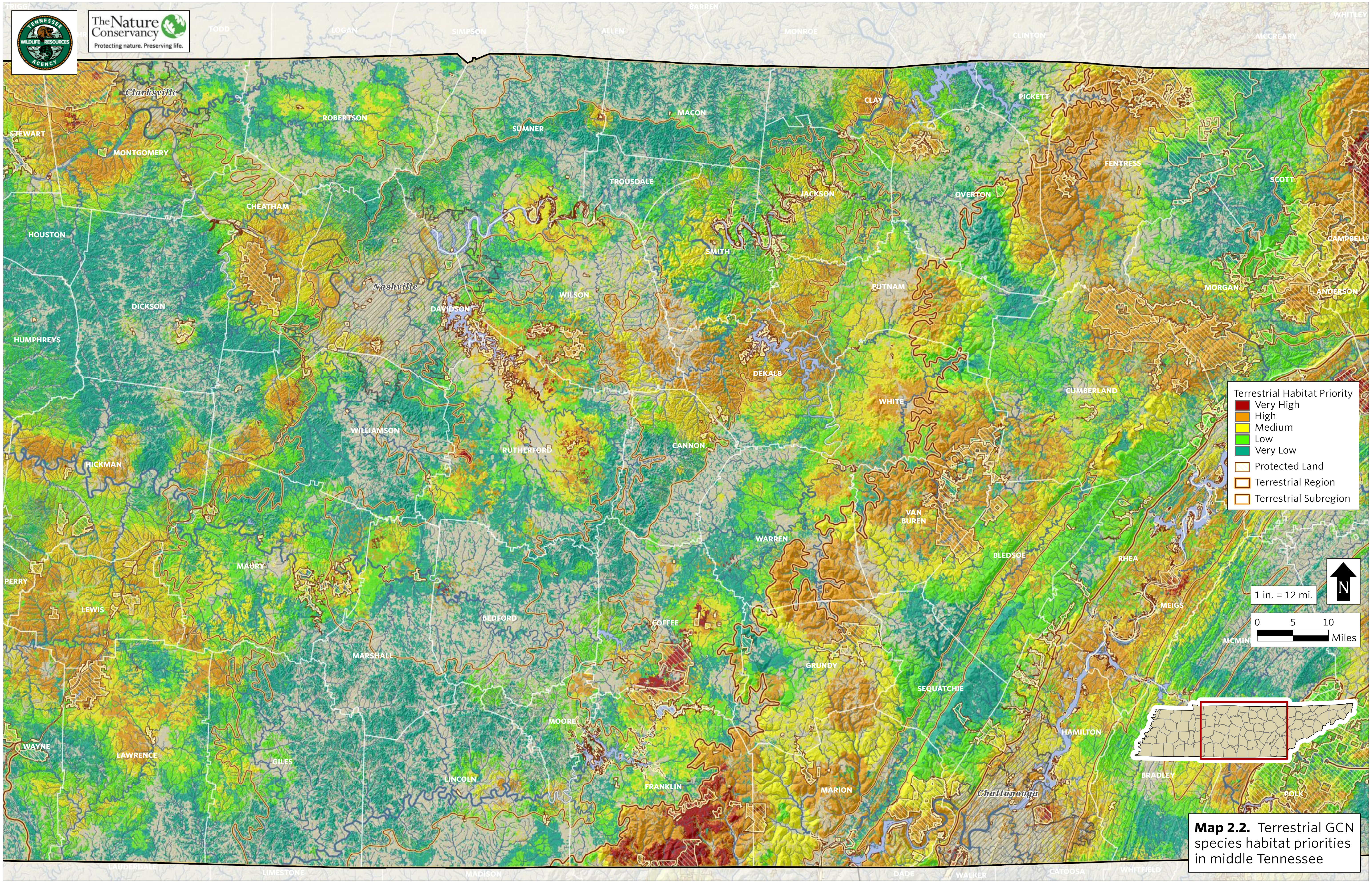
The 2005 plan used a scaled system categorizing the final habitat priority scores into low, medium, high, and very high for each major habitat, with the categorization performed independently for each terrestrial ecoregion, aquatic region, and subterranean region respectively (TWRA 2005, p. 83). Because some regions of the state have higher concentrations of imperiled species, a single scoring standard for mapping habitat priorities would not capture all habitat priorities statewide. The 2015 update uses a similar low, medium, high, and very high categorization for the priority scores. The mapping approach again is stratified by terrestrial ecoregion, aquatic region, and subterranean regions to capture representation of all GCN species and their priority habitats statewide.

3.2.7. 2015 Statewide Habitat Priority Maps

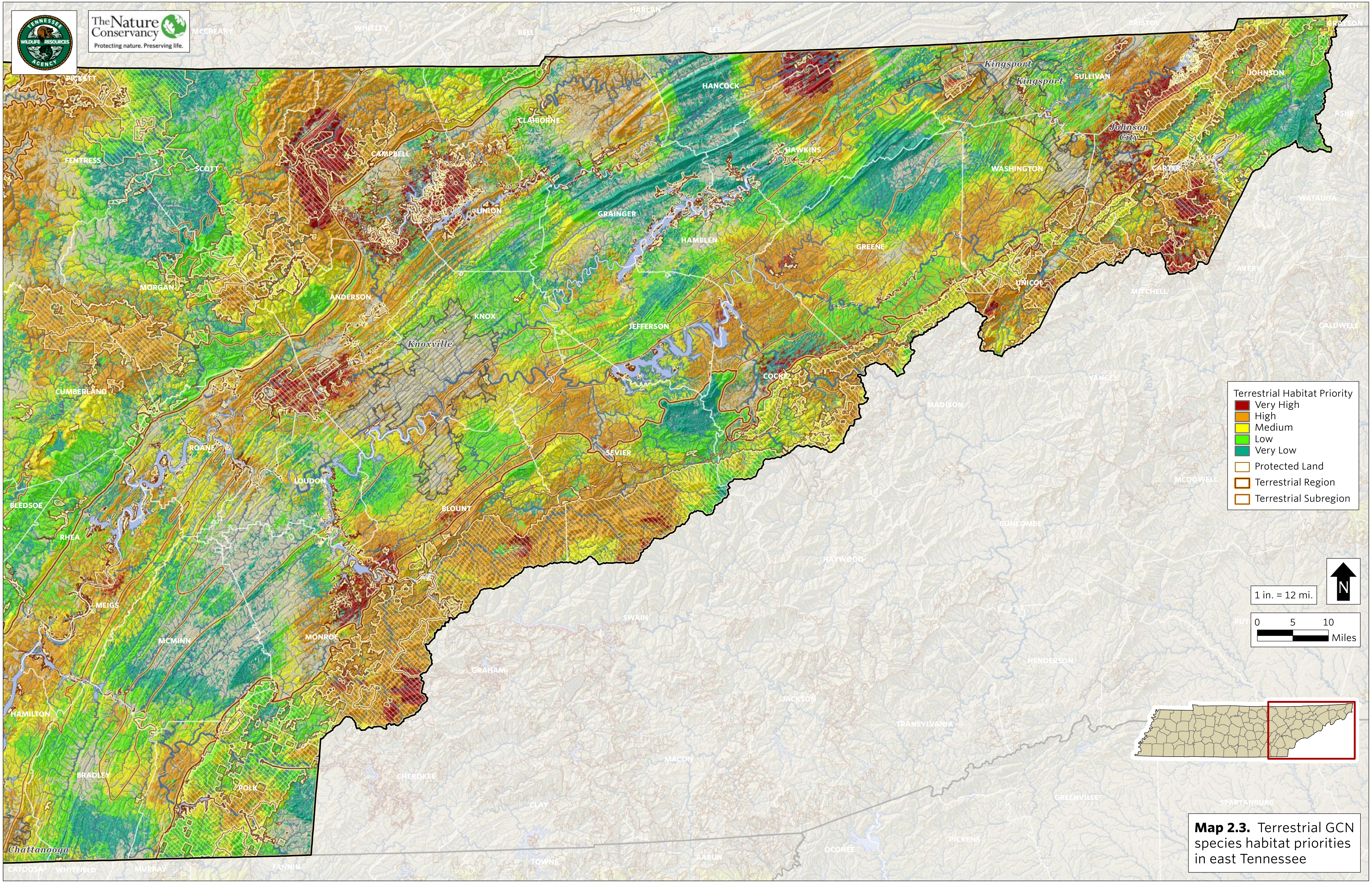
Maps of priority habitats for terrestrial, aquatic, and subterranean GCN species as well as all priority habitats combined follow.



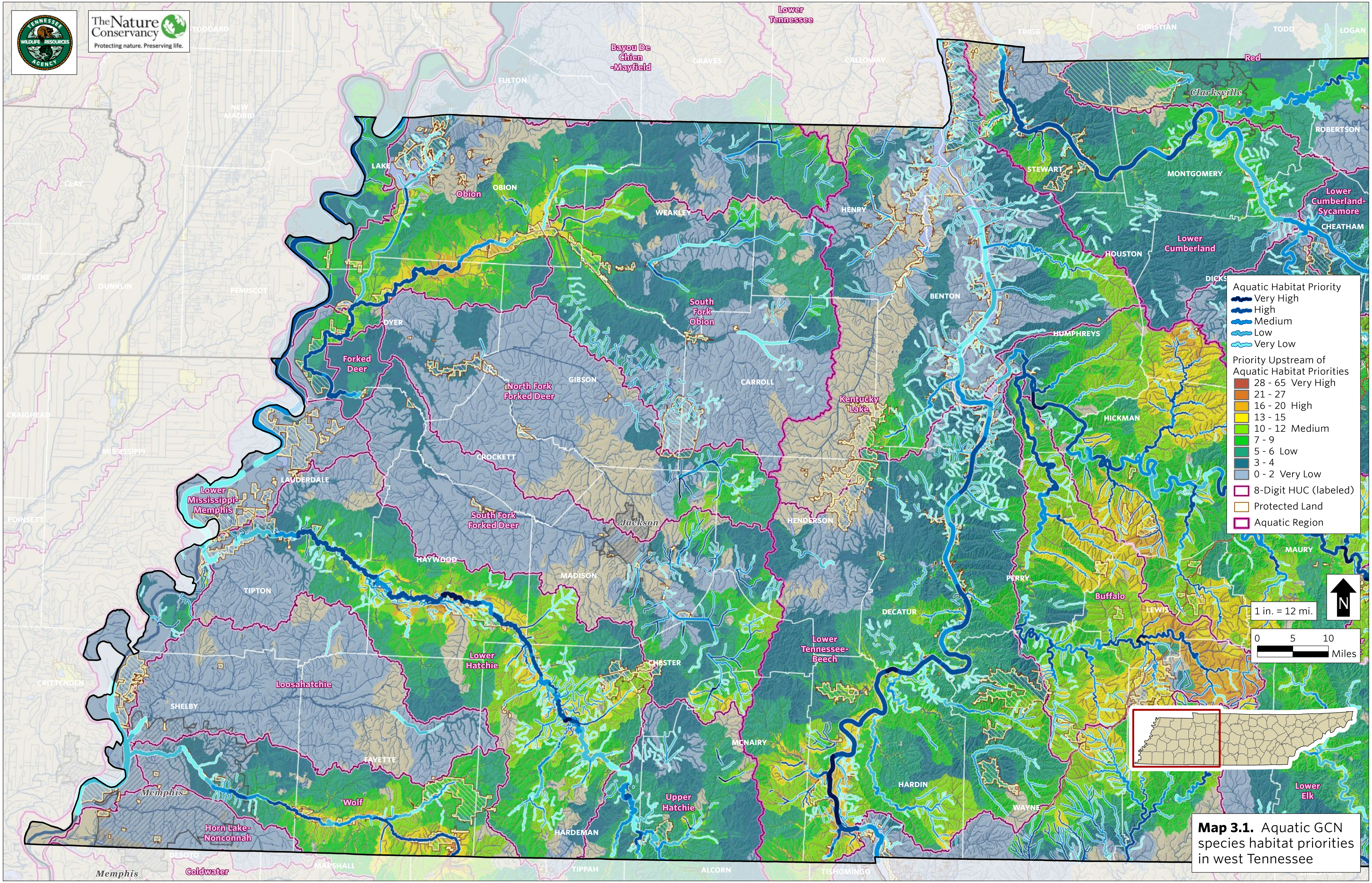
Map 2.1. Terrestrial GCN species habitat priorities in west Tennessee



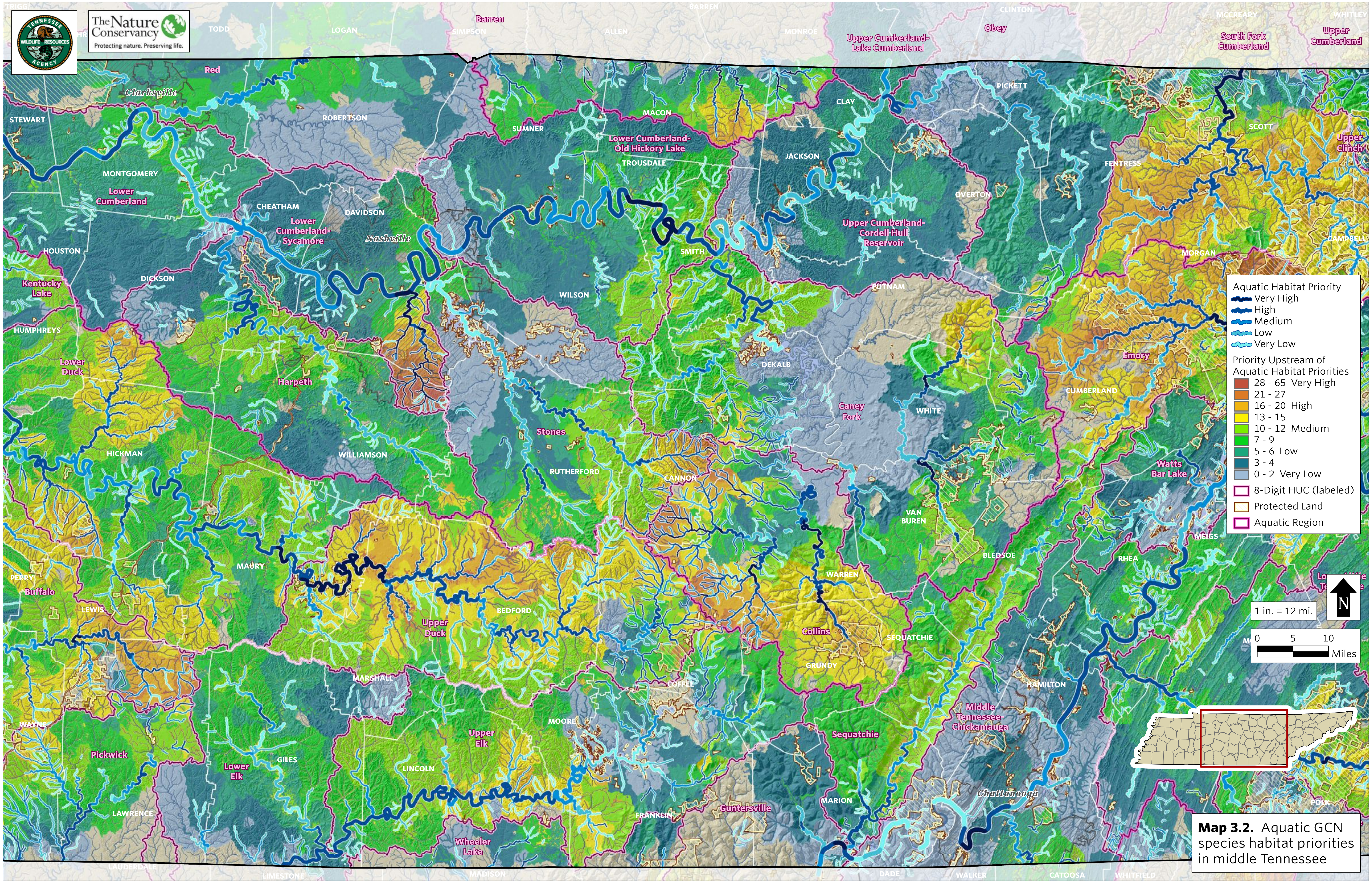
Map 2.2. Terrestrial GCN species habitat priorities in middle Tennessee



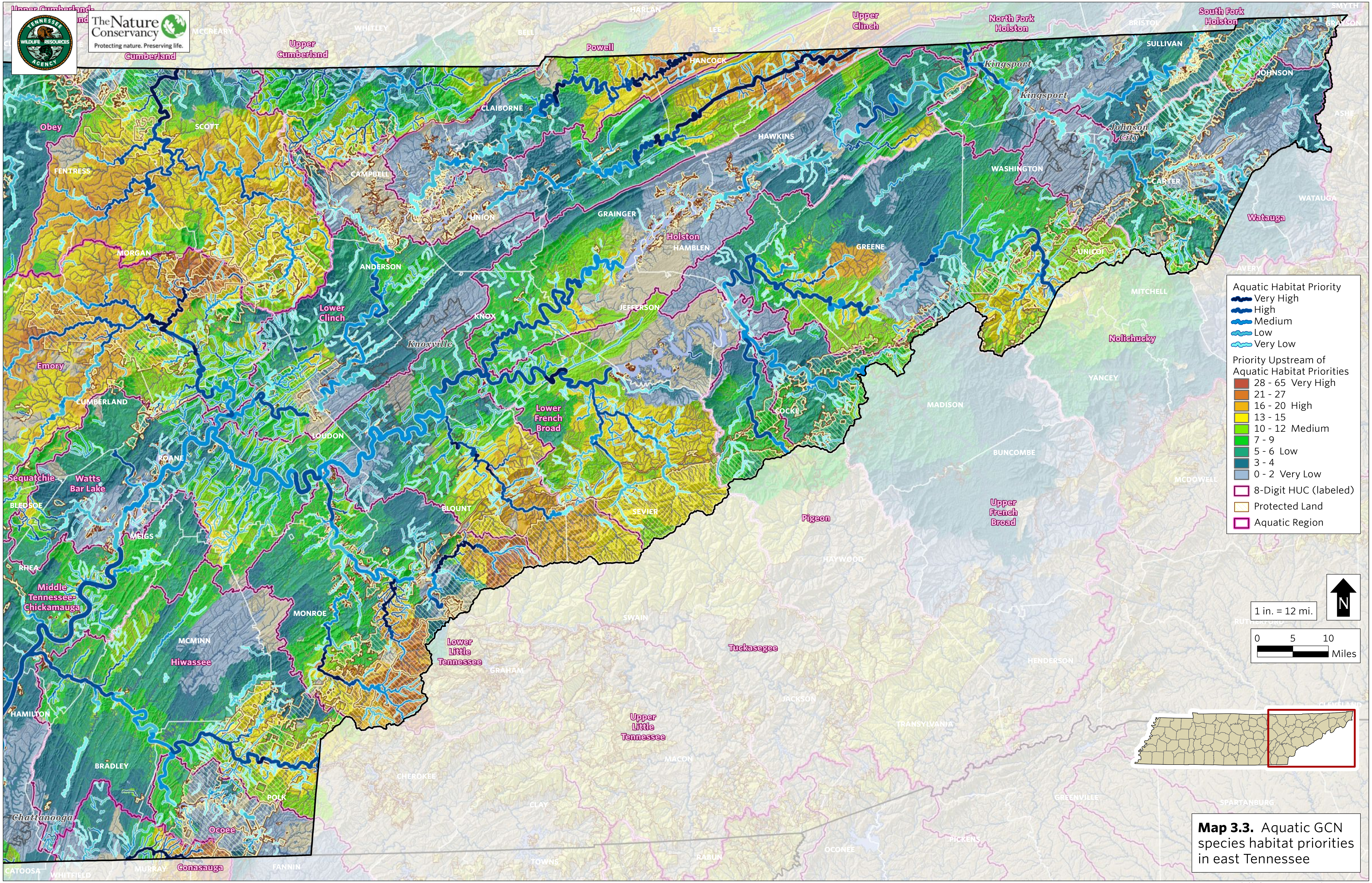
Map 2.3. Terrestrial GCN species habitat priorities in east Tennessee



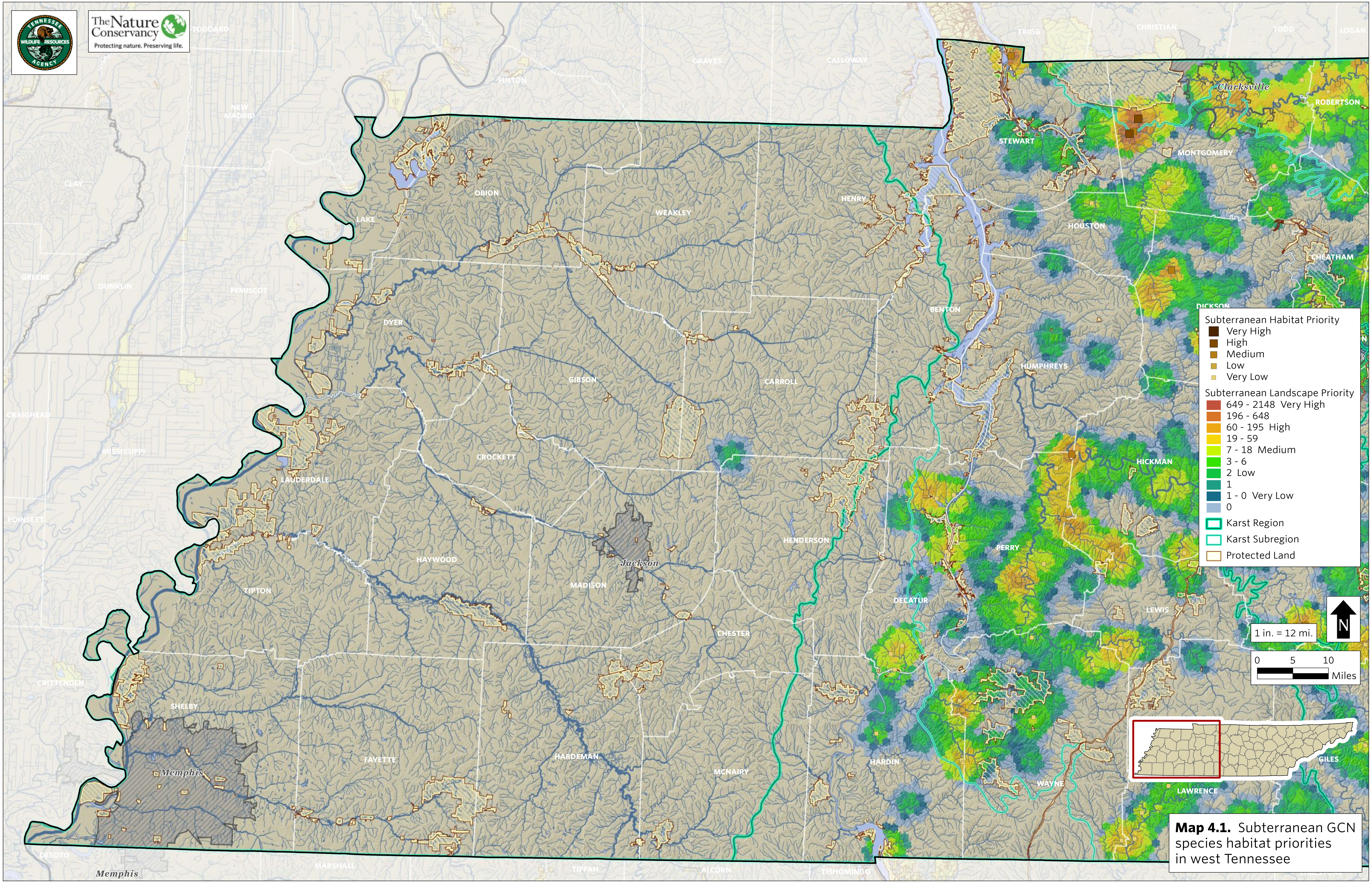
Map 3.1. Aquatic GCN species habitat priorities in west Tennessee



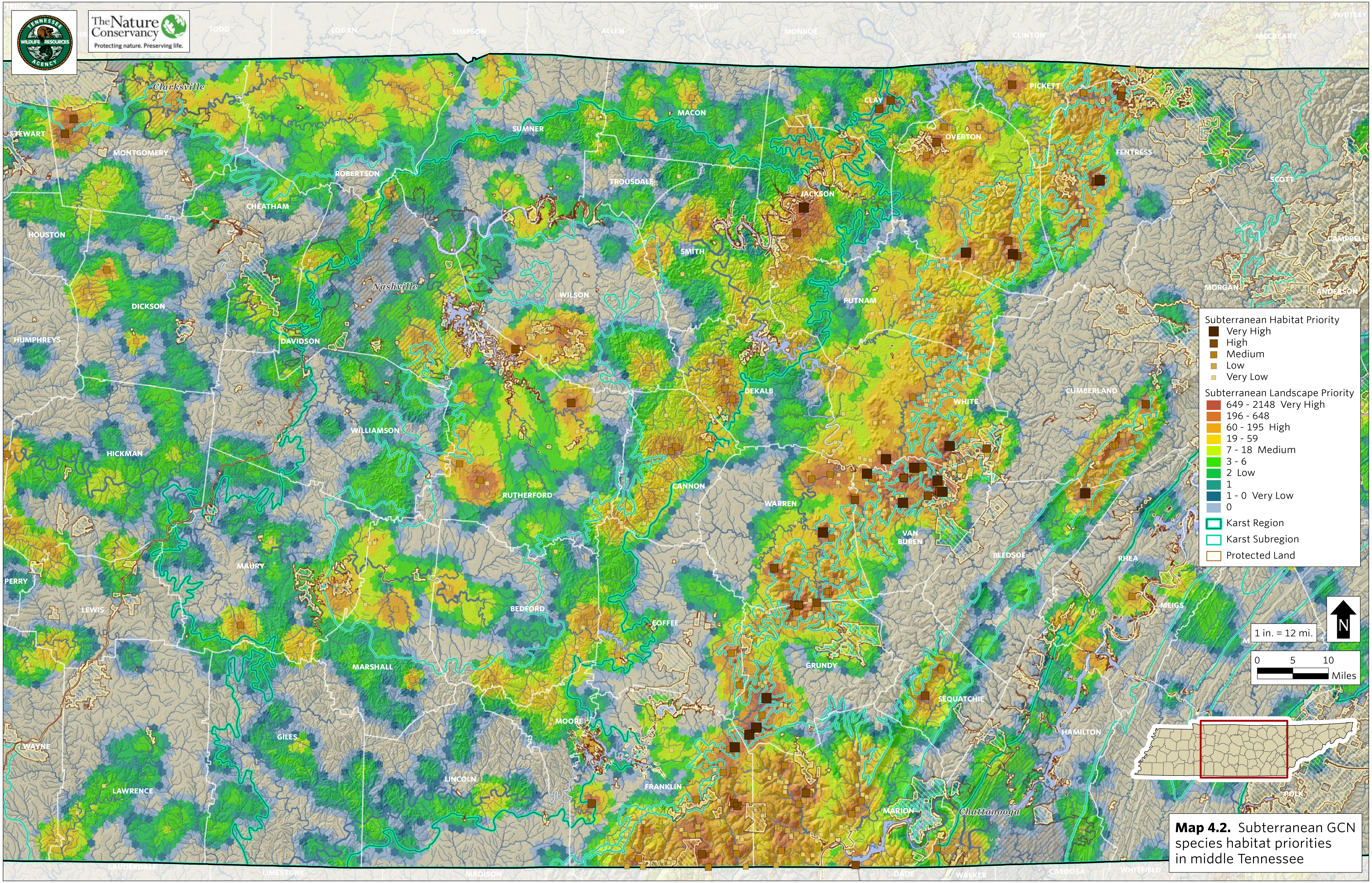
Map 3.2. Aquatic GCN species habitat priorities in middle Tennessee



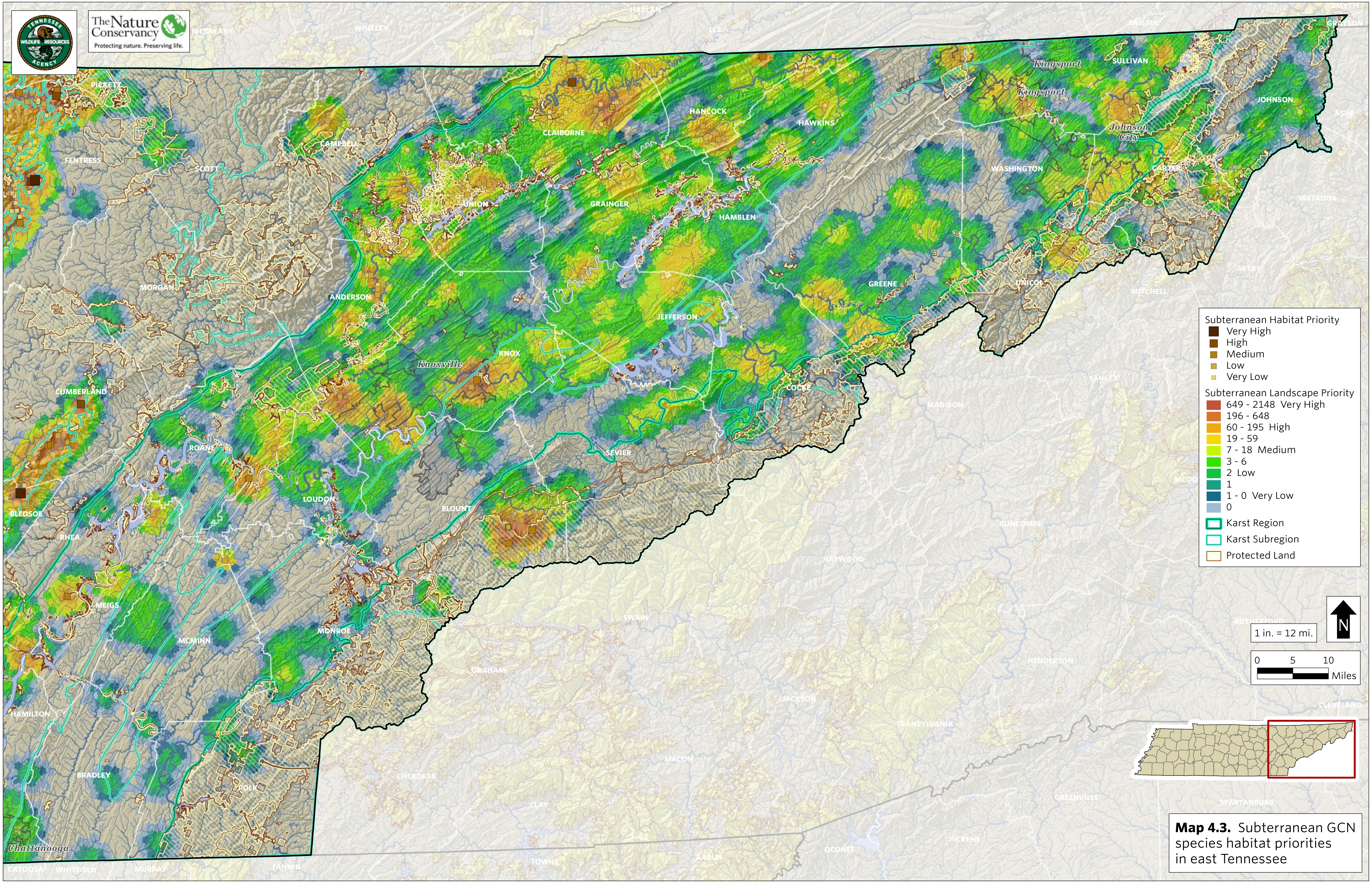
Map 3.3. Aquatic GCN species habitat priorities in east Tennessee



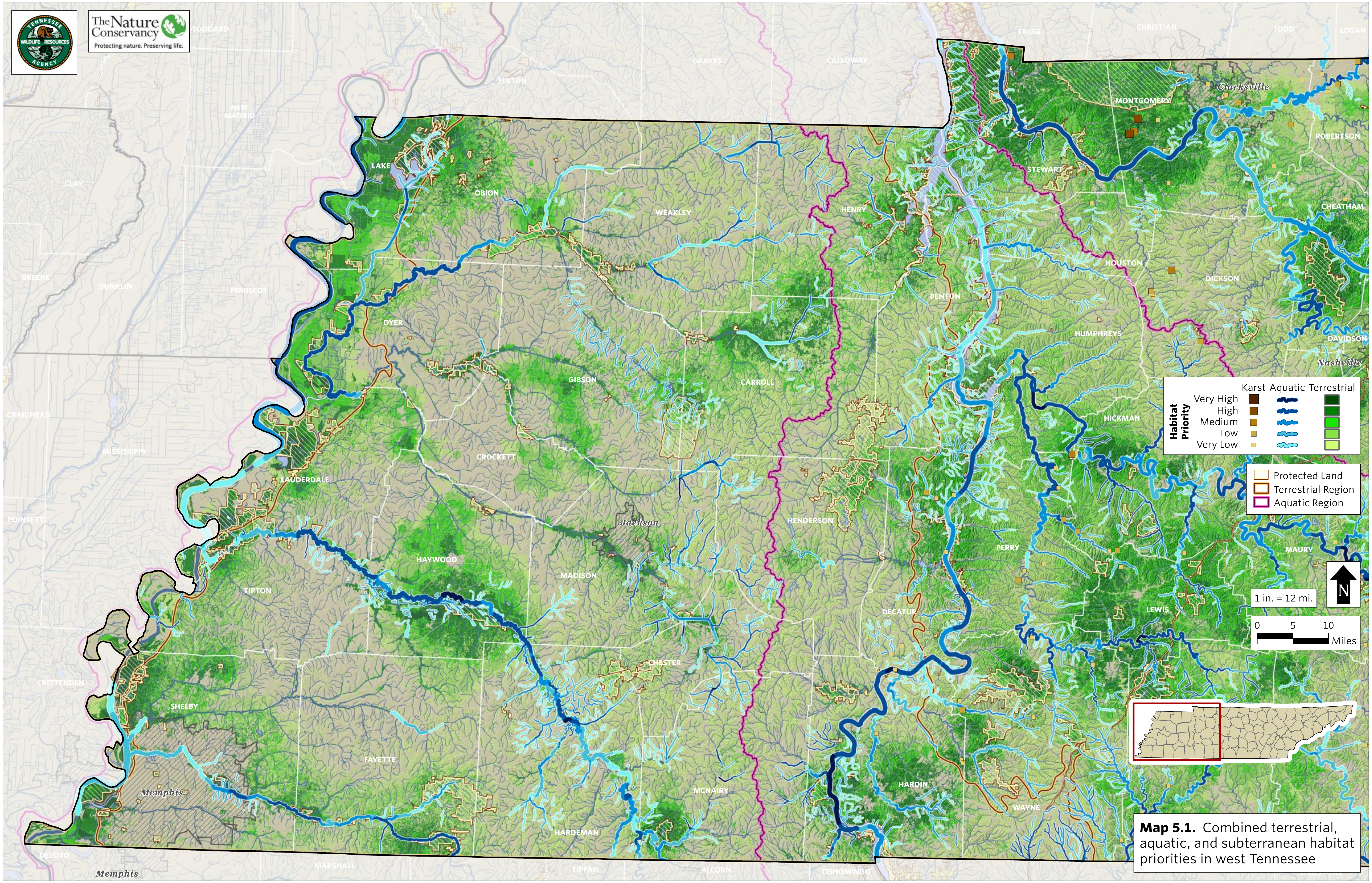
Map 4.1. Subterranean GCN species habitat priorities in west Tennessee



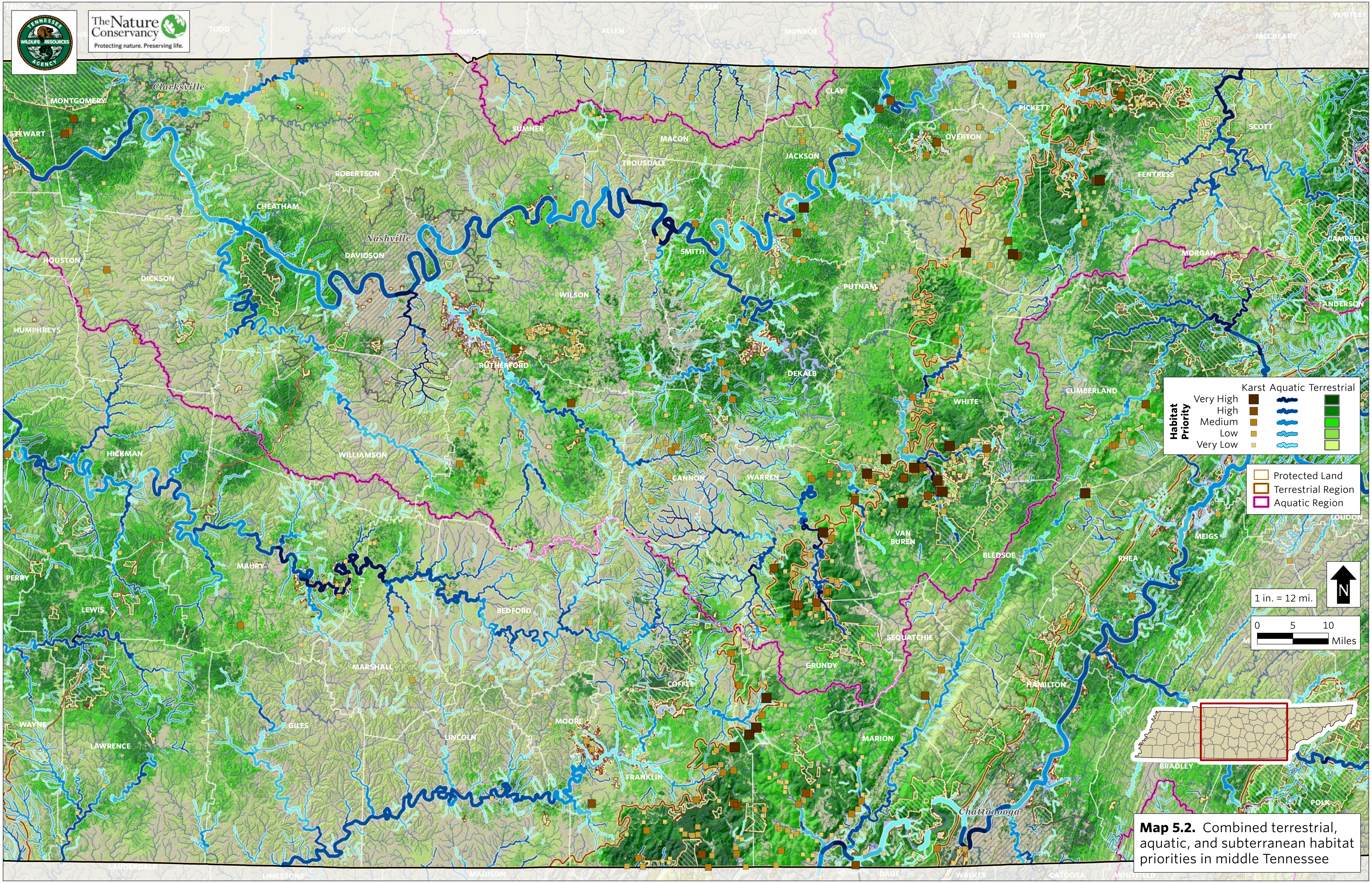
Map 4.2. Subterranean GCN species habitat priorities in middle Tennessee



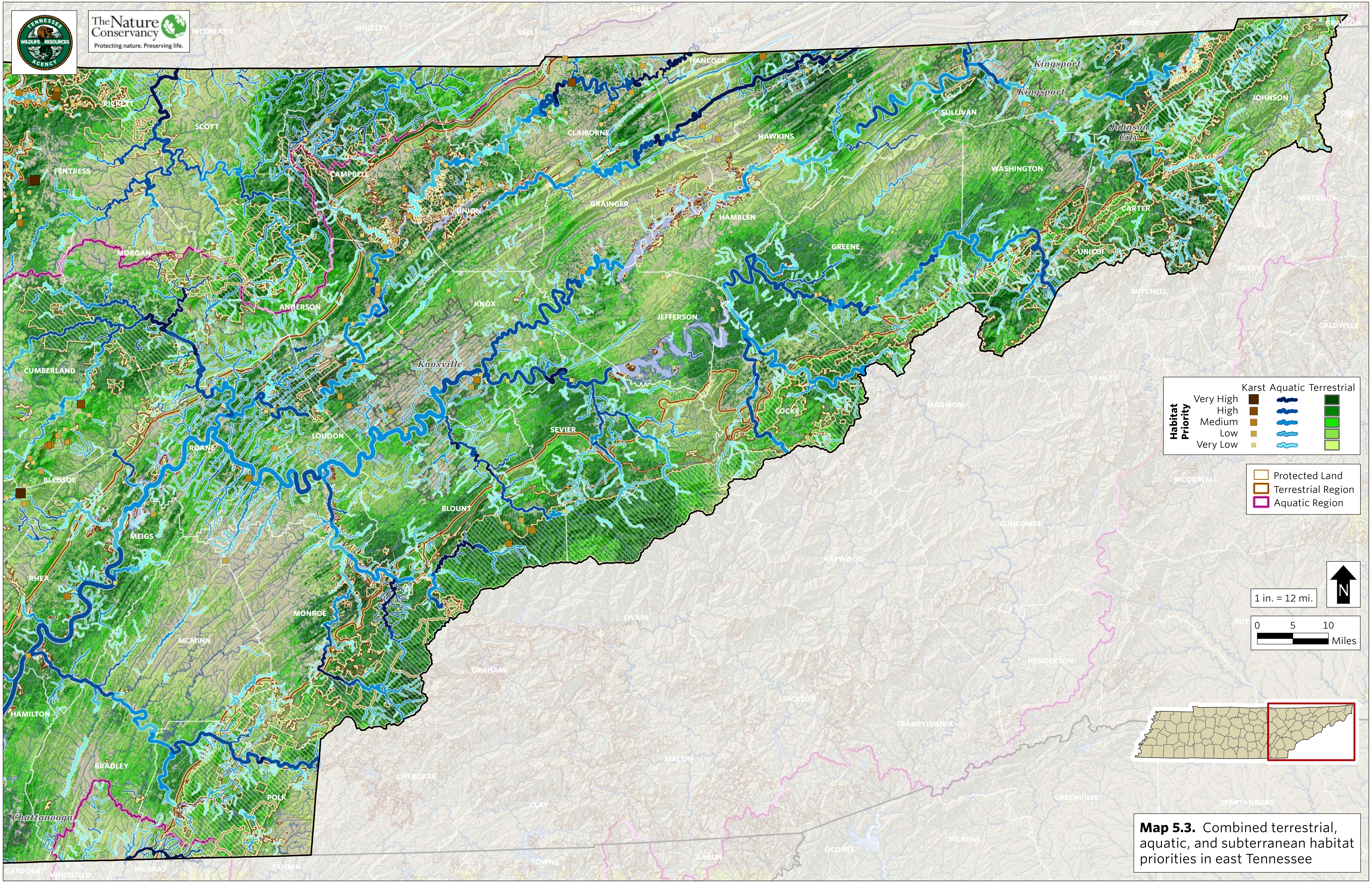
Map 4.3. Subterranean GCN species habitat priorities in east Tennessee



Map 5.1. Combined terrestrial, aquatic, and subterranean habitat priorities in west Tennessee



Map 5.2. Combined terrestrial, aquatic, and subterranean habitat priorities in middle Tennessee



Map 5.3. Combined terrestrial, aquatic, and subterranean habitat priorities in east Tennessee

3.2.8. Statewide Priority Habitat Summaries

Tables 7 through 12 summarize information on the priority terrestrial natural and semi-natural habitats by ecoregion. The data in these tables are ordered according to the average GCN species priority score for that habitat, with the scoring stratified down to the subregion scale. In certain instances, semi-natural habitats show higher priority scores than natural habitats in an ecoregion. This is due to the typically larger distribution footprint of species that can utilize semi-natural habitats (e.g. birds) and the fact that some natural habitats (e.g. cliffs or rockhouses) are very small in overall acreage, limiting the potential number of species that occupy them overall. In the Upper Gulf Coastal Plain and Mississippi River Alluvial Plain, bottomland and riparian forest habitats are most significant, and large acreages of upland forest types also occur in the Upper Gulf Coastal Plain. In the Interior Low Plateau (ILP), floodplain and riparian forests are again significant, as are both mesophytic and dry-mesic forests. The data for the ILP also demonstrate the significance of prairie, woodland/barren, and limestone glade habitats for a variety of rare GCN species. Prairie, woodland and limestone glade habitats can be smaller and more isolated in terms of their overall acreages in the ecoregion; however, they are home to many distinct plant and animal species.

Forest habitat types also rank highest in priority within the Cumberland Plateau and Mountains and the Ridge and Valley ecoregions, although the specific forest system type shifts according to the ecoregion. In the Southern Blue Ridge, the dominant forest system, Southern Appalachian oak forest, ranks highly, as does a variety of other systems distributed in cove and high elevation settings in the ecoregion.

Table 13 summarizes the number of stream miles of highly-ranked habitat within each aquatic subregion across Tennessee. While the total amounts of the Conasauga and Barren River subregion watersheds within Tennessee are small in comparison to others, a good percentage of their stream miles in the state are ranked as high priority GCN habitat. The Cumberland, Tennessee, and Coastal Plain-Mississippi aquatic regions have an average of approximately 15%, 12% and 6% of their total stream miles within the state of Tennessee ranked as medium, high, or very high priority habitat.

Fall in the Blue Ridge of Tennessee - Bill Showalter

Table 7. Summary of priority terrestrial habitats in the Mississippi River Alluvial Plain

Mississippi River Alluvial Plain terrestrial habitats	Average GCN species priority score for habitat, stratified down to subregion	Total acres of very high-, high-, and medium-ranked habitat
Natural habitats		
Mississippi River Bottomland Depression	70.0	97
Mississippi River Low Floodplain (Bottomland) Forest	50.4	115,288
Mississippi River Riparian Forest	46.3	27,846
Semi-natural habitats		
Old Field / Successional	32.6	6,378
Pasture	28.0	225
Cropland	15.8	117,227

Table 8. Summary of priority terrestrial habitats in the Upper Gulf Coastal Plain

Upper Gulf Coastal Plain terrestrial habitats	Average GCN species priority score for habitat, stratified down to subregion	Total acres of very high-, high-, and medium-ranked habitat
Natural habitats		
East Gulf Coastal Plain Large River Floodplain Forest	27.0	86,989
South-Central Interior Mesophytic Forest	25.8	1,308
East Gulf Coastal Plain Small Stream and River Floodplain Forest	23.5	224,138
South-Central Interior Small Stream and Riparian	23.4	5,086
East Gulf Coastal Plain Northern Loess Bluff Forest	17.5	20,764
East Gulf Coastal Plain Northern Mesic Hardwood Slope Forest	7.8	85,670
East Gulf Coastal Plain Interior Shortleaf Pine-Oak Forest	6.9	23,010
South-Central Interior / Upper Coastal Plain Flatwoods	5.2	5,017
East Gulf Coastal Plain Northern Dry Upland Hardwood Forest	4.3	55,639
East Gulf Coastal Plain Northern Loess Plain Oak-Hickory Upland	3.4	13,046
East Gulf Coastal Plain Limestone Forest	1.6	5
Semi-natural habitats		
Old Field / Successional	11.3	100,017
Pasture	9.1	149,288
Cropland	5.7	252,860

Table 9. Summary of priority terrestrial habitats in the Interior Low Plateau

Interior Low Plateau terrestrial habitats	Average GCN species priority score for habitat, stratified down to subregion	Total acres of very high-, high-, and medium-ranked habitat
Natural habitats		
South-Central Interior Large Floodplain	39.0	28,293
Eastern Highland Rim Prairie and Barrens	28.7	61,511
South-Central Interior Small Stream and Riparian	25.5	39,352
Nashville Basin Limestone Glade and Woodland	23.8	86,410
South-Central Interior Mesophytic Forest	21.5	943,809
Southern Appalachian Low-Elevation Pine Forest	17.3	3,354
Southern Interior Low Plateau Dry-Mesic Oak Forest	13.7	1,015,574
Central Interior Calcareous Cliff and Talus	3.8	280
Central Interior Acidic Cliff and Talus	2.2	12
Semi-natural habitats		
Old Field / Successional	11.6	101,453
Cropland	7.4	105,393
Pasture	6.5	293,987
Forest Plantation	1.3	4,749

Table 10. Summary of priority terrestrial habitats in the Cumberland Plateau and Mountains

Cumberland Plateau & Mountains terrestrial habitats	Average GCN species priority score for habitat, stratified down to subregion	Total acres of VH, H, & M ranked habitat
Natural habitats		
South-Central Interior Large Floodplain	36.5	573
Southern and Central Appalachian Cove Forest	33.5	58,967
Southern Appalachian Montane Pine Forest and Woodland	29.4	5,383
Allegheny-Cumberland Dry Oak Forest and Woodland	27.9	619,308
Southern Ridge and Valley / Cumberland Dry Calcareous Forest	27.6	627,596
South-Central Interior Mesophytic Forest	27.2	322,982
Appalachian (Hemlock)-Northern Hardwood Forest	25.7	119,785
South-Central Interior Small Stream and Riparian	23.4	21,038
Southern Appalachian Low-Elevation Pine Forest	21.4	92,045
Cumberland Acidic Cliff and Rockhouse	15.7	1,812
Cumberland Riverscour	8.8	161
Semi-natural habitats		
Old Field / Successional	9.5	50,761
Pasture	8.0	34,468
Cropland	7.3	5,999
Forest Plantation	1.7	1,835

Table 11. Summary of priority terrestrial habitats in the Ridge and Valley

Ridge and Valley terrestrial habitats	Average GCN species priority score for habitat, stratified down to subregion	Total acres of VH, H, & M ranked habitat
Natural habitats		
South-Central Interior Large Floodplain	47.5	9,197
Southern Appalachian Oak Forest	47.4	2,748
Southern and Central Appalachian Cove Forest	37.5	5,625
South-Central Interior Mesophytic Forest	31.4	282,972
South-Central Interior Small Stream and Riparian	31.1	53,871
Southern Ridge and Valley / Cumberland Dry Calcareous Forest	29.2	746,861
Southern Interior Calcareous Cliff	29.0	5
Southern Appalachian Montane Cliff and Talus	27.7	36
Appalachian (Hemlock)-Northern Hardwood Forest	27.0	12,586
Southern Appalachian Low-Elevation Pine Forest	26.8	118,418
Allegheny-Cumberland Dry Oak Forest and Woodland	25.0	212,067
Southern Appalachian Montane Pine Forest and Woodland	18.0	932
Cumberland Acidic Cliff and Rockhouse	7.1	91
Semi-natural habitats		
Old Field / Successional	16.4	156,524
Pasture	15.9	482,969
Cropland	15.5	49,416
Forest Plantation	0.4	64

Table 12. Summary of priority terrestrial habitats in the Southern Blue Ridge

Southern Blue Ridge terrestrial habitats	Average GCN species priority score for habitat, stratified down to subregion	Total acres of VH, H, & M ranked habitat
Natural habitat		
Southern Appalachian Northern Hardwood Forest	40.4	12,956
Central and Southern Appalachian Spruce-Fir Forest	39.9	5,775
Southern and Central Appalachian Cove Forest	34.4	124,142
Appalachian (Hemlock)-Northern Hardwood Forest	30.6	68,148
Southern Appalachian Oak Forest	30.4	719,556
Southern Appalachian Rocky Summit	26.0	165
South-Central Interior Small Stream and Riparian	25.0	14,012
Southern Appalachian Montane Pine Forest and Woodland	24.6	10,183
Southern Appalachian Low-Elevation Pine Forest	23.5	100,503
South-Central Interior Large Floodplain	20.5	444
Southern Appalachian Montane Cliff and Talus	18.2	340
Southern Appalachian Grass and Shrub Bald	9.5	462
Southern and Central Appalachian Bog and Fen*	2.6	12*
Semi-natural habitat		
Old Field / Successional	10.1	2,725
Pasture	5.9	687

*Acreage for Southern Central and Appalachian Bog and Fen habitat includes total across all ranks.

Table 13. Summary of priority aquatic habitats, summarized by aquatic subregion

Aquatic Subregion	Linear stream miles in subregion	Total stream miles of very high-, high-, and medium-ranked habitat	% of linear stream miles ranked very high, high, and medium
Barren River	588	111	19
Coastal Plain, Mississippi River	14,886	875	6
Conasauga River	234	63	27
Cumberland River, Cumberland Mountain	1,844	455	25
Cumberland River, Lower Cumberland	4,433	381	9
Cumberland River, Nashville Basin	2,397	253	11
Cumberland River, Upper Cumberland	5,205	720	14
Tennessee River, Blue Ridge	8,276	762	9
Tennessee River, Cumberland Plateau	4,491	499	11
Tennessee River, Lower Tennessee	11,045	1240	11
Tennessee River, Nashville Basin	4,679	671	14
Tennessee River, Ridge and Valley	6,808	1055	15

CHAPTER 4

PROBLEMS AFFECTING SPECIES AND HABITATS

4.1. Assessing Problems Affecting Species and Habitats

THE NEXT PHASE OF THE TN-SWAP REVISION EFFORT involved conducting a review and revision of the problems which may be adversely affecting species of Greatest Conservation Need (GCN) and their habitats in Tennessee. Although the problems differ across geography, flora, and faunal groups, all species designated as GCNs face one or more threats to their survival, including threats to habitat health and persistence and/or population stressors such as pollution and disease.

Certain issues, often related to human activities and management of lands and waters, pose threats to a range of habitat types and GCN species across the state. It is important to note, however, that in many cases people can make adjustments or implement "best practices" to mitigate or even eliminate the threats that these activities pose. In the past decade, conservation scientists and planners have become focused on understanding larger, or "landscape-scale" patterns of change to lands and waters as a means of evaluating challenges to habitat or population persistence. In addition, the negative impacts from climate change stressors increasingly are of concern to the short- and long-term health of GCN species and their habitats across the U.S. (NFWPCAP 2012).

Photo credit: Couchville Cedar Glades State Natural Area/prairie coneflower. Without proper management, grass and forb-dominated barrens often experience encroachment of woody species - Byron Jorjorian

4.1.1. Review and Update of Major Statewide Problems

Summary: 2015 process for identifying and prioritizing problems affecting GCN species and their habitats

1. Review and revise problems identified in 2005. The planning team determined 2005 SWAP problems are still representative of current problems for GCN species and habitats.
2. Categorize problems. Using the standardized Conservation Measures Partnership hierarchy, the team cross-walked 2005 problems to the most recent updated threats classification from 2015. Three additional problems were added: recreational area development , renewable energy development, and over-collection of plant species.
3. Prioritize threats. The team focused on the most consistently high-ranked problems from 2005 and, when possible for a particular problem, added a spatial assessment component to help identify the location of problem sources relative to priority GCN habitats. Problem rankings for individual species were not changed or updated from 2005.
4. Incorporate climate change as a major new source of stress. A separate climate change vulnerability assessment for Tennessee was prepared by the National Wildlife Federation and The Nature Conservancy, building on a SWAP update report on climate change issued by TWRA in 2009. The assessment examines data on species vulnerability, landscape resiliency, and potential vegetation change to gain a better understanding of the range of GCN vulnerabilities across the state.

The 2015 SWAP team used the Best Practices recommendations (AFWA 2012) to assist with the review of problems facing species and habitats (See Appendix A). In the 2005 planning effort, Tennessee followed a best practice, using a standardized process and hierarchy for identifying stresses and sources of stress aligned with broader categories defined by the Conservation Measures Partnership (CMP) (Salafsky et al. 2008). At the time, over 35 "sources" or problems, were identified and linked to 20 major ecological stress types, then the stress and source combinations linked to every GCN species and then evaluated for the scope, severity, timing, reversibility, and contribution to potential population declines in different regions of the state.

Both urban and rural development can have major impacts on the habitat of both terrestrial and aquatic species in Tennessee - Greg Wathen, TWRA

These evaluation assignments were captured in the SWAP database, then summarized to create cumulative ranking scores to identify the major problems facing GCN species distributed in the major terrestrial, aquatic, and subterranean regions of the state (see TWRA 2005, pp. 66-75). In 2005, TWRA lacked the planning time and resources to map the distribution of different problem sources, relying instead on an expert-derived estimate of the percentage of a species range that could potentially be affected by specific source-stress combinations. Therefore, the 2005 SWAP did not have the ability to spatially assess the intersection of problems with priority habitats to inform decision-making. Priority sources of stress were summarized in tabular format only and divided into terrestrial, aquatic, and subterranean regions.

The 2015 SWAP team reviewed the 2005 SWAP major stresses and potential sources of stress hierarchies and determined that they were still representative of current problems (Appendix E). The team also determined that the 2005 stresses to new GCNs identified as part of the update process remain the same, with the exception of plants, for which the 2005 stresses identified for fauna only do not completely apply.

Major statewide issues addressed in 2015 are urbanization; agricultural land management; forestry practices; water management; energy development; and transportation and utility corridors.

Three additional major problems were added during the 2015 revision process: potential issues with recreational area development, renewable energy sources, and over-collection of plant species. A crosswalk exercise was completed between the 2005 sources of stress hierarchy and the more recent CMP Open Standards threats classification (**Version 2, Beta – February 2015**).

A Tennessee gap - highway heading north into Tennessee - Bryan Alexander

Appendix E provides the summary of the crosswalk exercise and shows the addition of the new potential sources of stress for 2015.

In assessing problems for the 2015 revision, the planning team chose to focus on the major sources of stress across the state, using new spatial information and analyses to understand where major problem sources intersect with priority GCN habitats rather than conducting new species-by-species rankings. Examining problems in this fashion allowed the team to focus on the highest priority issues and the major landscape-scale drivers of change in Tennessee to better inform conservation investments and collaborations with conservation partners.

In reviewing the 2005 prioritization assessments for the terrestrial, subterranean, and aquatic regions, the 2015 planning team identified patterns in which sources of stress consistently emerged as top issues across all the regions, and grouped these sources by general category (for more details, see TWRA 2005, pp. 84-146). The team also documented which of these 2005 problems, and any emerging issues since 2005, warrant the greatest focus moving forward.

The most frequently documented potential sources of stress in 2005, summarized as major issues for 2015, include urbanization (its associated infrastructure and water uses); agricultural land management; forestry practices; water management; energy development; and transportation and utility corridors. These land and water use issues typically have a landscape-level footprint across one or more regions of Tennessee, and effectively managing for better habitat outcomes requires education and active engagement of the private sector and government agencies involved in land and water management, transportation, and compensatory mitigation decisions (AFWA 2012).

Fire suppression is a significant issue for multiple grassland, forest, and woodland habitat types statewide, and managing certain recreational activities remains a challenge for protecting species and habitats in specific locations. The collection of particular plant and animal species in different regions of the state must be monitored, and regulations enforced, to prevent overharvest and species population declines. Additional areas receiving increased emphasis for the 2015 update are problems associated with the ongoing spread of several disease pathogens and invasive exotic species, particularly those affecting cave dwelling bat species, reptiles, amphibians, and forest habitats. Airborne pollutants also remain a challenge, as acid rain and deposition of bioaccumulative toxic metals such as mercury damage both terrestrial and aquatic habitats, particularly in the eastern two-thirds of Tennessee.

Coal pile at Baldwin Plant in Anderson County; coal is a significant source of air pollution - Appalachian Voices

Pathogen infection: Snake fungal disease - Daniel Bryan - Cumberland University

Brown-headed Nuthatch, a species whose habitat is threatened by altered fire regimes - Allen Sparks

4.1.2. Climate Change Impacts Assessment

Like many SWAPs across the country, the 2005 version of Tennessee's plan did not explicitly address the potential impacts of climate change scenarios on GCN species and habitats. However, in 2009, TWRA published an update report for the SWAP entitled *Climate Change and Potential Impacts to Wildlife in Tennessee* (TWRA 2009). This report served as the first comprehensive review of the scientific literature on climate change at the time and the potential impacts on fish, wildlife, and habitats in Tennessee.

Topographical variation creates landscape diversity, which contributes to resilience. Southern Blue Ridge mountains - Greg Wathen, TWRA.

Understanding the synergies and linkages among multiple stresses affecting wildlife and plants, including climate change, is necessary for the development of successful conservation strategies. For the 2015 comprehensive update, TWRA built on the 2009 effort by contracting with the National Wildlife Federation to provide a Climate Change Vulnerability Assessment for Tennessee and to guide TWRA on the selection of appropriate adaptation strategies. (Glick et al. 2015).

Some amphibians may suffer disproportionately from climate change effects in TN. Southern Cricket Frog - Patrick Coin via Wikimedia

The primary emphasis of the assessment effort was to examine three major aspects of climate change impacts: species vulnerabilities, terrestrial and aquatic habitat changes, and landscape resiliency. Species vulnerability assessments using NatureServe's **Climate Change Vulnerability Index** (CCVI) (Young et al. 2011) were conducted by TWRA and academic experts for 189 GCN plant and animal species. Changes to terrestrial vegetation were identified using the U.S. Forest Service's Terrestrial Climate Stress Index (TCSI) methodology (Joyce et al. 2008). Data on landscape resiliency from The Nature Conservancy's *Resilient Sites for Terrestrial Conservation in the Southeast U.S.* (Anderson et al. 2014) were used in combination with the TCSI outputs and the SWAP terrestrial habitat priorities to gain a better understanding of the range of GCN habitat vulnerabilities across the state (Glick et al. 2015).

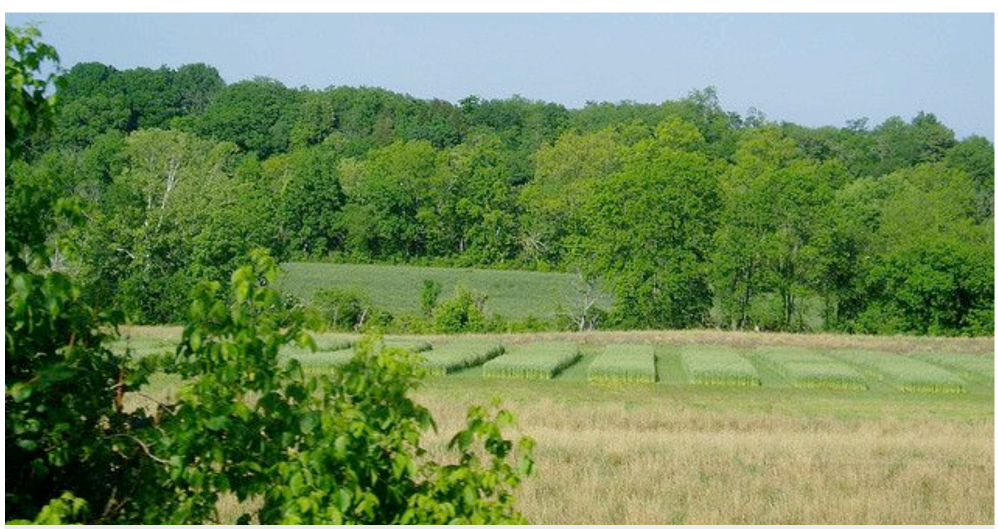
4.2. Updates to SWAP GIS and Database Information on Major Problems

In the decade since the 2005 SWAP was developed, through a variety of different project collaborations, TNC and TWRA have compiled a wide array of additional GIS data and spatial analyses to improve understanding of the major landscape-scale problems facing GCN species and habitats across the state. These efforts have focused on the aggregation and classification of state water quality and permit data managed by the Tennessee Department of Environment and Conservation (TDEC), the National Inventory of Dams, the USDA Cropland data coverage, urban growth boundary and population growth data from the State of Tennessee and University of Tennessee-Knoxville, and U.S. Office of Surface mining permitted lands. Field survey and planning efforts conducted by many partners to track the spread of pathogens, such as White-nose Syndrome in bats and Hemlock Woolly Adelgid in native hemlock forests, have also been used to map the current spatial extent of these problems.

Section 3.2.4. ***Updates to Habitat Mapping Units*** describes the basic unit of assessment for terrestrial, subterranean, and aquatic habitat priority maps (700-acre hexagon rosettes and NHDPlus v2 catchments, respectively). These same mapping units are used for assessments of potential problems. The GIS and relational database capacity makes it possible to look at the intersection of different types of land and water uses with the priority habitats identified for GCN species, and the mapping units allow for these data to be summarized at a variety of different spatial scales.

Understanding the current and potential spatial footprint of major land and water uses, as well as how these uses intersect with priority habitats, is critical to identifying habitat protection, restoration, and management needs and opportunities.

The maps and data summaries provided in this 2015 update document are intended to represent the scope and distribution of major potential problems including urbanization, agriculture, river and stream management, and non-renewable energy development. Also included are example distribution maps of White-nose



Farmland in Tennessee - Joel Kramer

Syndrome and the spread of Hemlock Woolly Adelgid. It is important to emphasize that these assessments are intended to direct attention to *potential* problems for habitats based on known issues with land and water management practices in general; they do not provide information on the presence or absence of best management practices in a given situation. The existence of actual problems always must be verified in the field with site specific knowledge and assessments.

For example, improving agricultural management practices in priority areas can improve outcomes for GCN freshwater species and overall water quality. These investments are being made by state and federal partners and private landowners across the state. The "potential" problem maps associated with agricultural land management do not contain information about where these actual on-the-ground practices are being used. Instead, these maps emphasize where best management practices may be targeted to achieve better outcomes for GCN species.

In addition, the data associated with permitted activities are not intended to substitute for the standard reviews and decision-making performed in a regulatory context by both state and federal agencies. Rather, these data should be complementary to those reviews, as it can provide both a local- and a landscape-scale context of the associated activities with respect to important GCN habitats. In addition, the 2015 mapping assessments do not include potential issues with renewable energy, transportation corridors, and utility/service line development, all of which have the potential for large spatial footprints in certain sections of the state. Data on these activities are becoming increasingly available, and examinations in the context of habitat priorities will be an important data update need in the near future. A more detailed methods explanation for the landscape analyses of major problems is available in The Nature Conservancy's publication *Database Development and Spatial Analyses in Support of Tennessee's State Wildlife Action Plan* (Wisby and Palmer 2015).


Powerlines - Artondra Hall

Compared to 2005, the data development effort for the 2015 update allows TWRA and its many partners to conduct a variety of more detailed problem assessments to serve specific project needs. Examples of efforts already in progress include partnerships for specific agricultural watersheds to identify where riparian buffer improvements can help improve aquatic GCN habitats (see Elk River case study). GIS scientists with the Southeast Aquatic Resources Partnership are using the information and other applications they are developing to create more refined tools for prioritizing which stream barriers to remove for improved stream network and habitat connectivity (Granstaff et al. 2015).

TENNESSEE CASE STUDY: Fair market conservation incentives for private landowners in the Elk River Watershed Conservation Opportunity Area

Guided by Tennessee's State Wildlife Action Plan (SWAP) data, the Tennessee Wildlife Resources Agency identified the Elk River watershed as a priority for improving water quality. The elimination of riparian habitat along the Elk River and tributaries over the years has degraded water quality, so TWRA joined forces with the Tennessee Valley Authority (TVA), the National Fish and Wildlife Foundation (NFWF), the Natural Resources Conservation Service (NRCS), The Nature Conservancy (TNC), and other partners to develop increased conservation incentives for private landowners in the Elk River COA. The goal of this targeted program is to create 26 miles of stream buffer that will contribute to improved water quality.

> Agency partnerships and science-based conservation are the hallmarks of a new conservation program effort taking shape in the Elk River watershed of Tennessee.

The USDA's existing Conservation Reserve Program (CRP) continuous signup practices can pay farmers for contract periods of 10 to 15 years by reimbursing approximately 90% of the costs of establishing riparian buffers as well as annual payments to offset income losses from retired cropland or marginal pastureland, plus a one-time Signing Incentive Payment. The program also cost-shares mid-contract management practices, such as prescribed fire or herbicide applications.

However, agricultural producers in the Elk River area have been reluctant to enroll in CRP because the high price of corn and other crops has made incentive payments far less attractive. University of Tennessee Extension performed an analysis of crop pricing to arrive at a competitive CRP payment in the region. The TVA, TWRA, and NFWF then supplied additional funding for several CRP buffer practices, managed by the Farm Services Agency and NRCS, to create the new Elk River incentive program. In addition to the normal payments listed, the new effort offers an additional one-time payment of $1500 per acre for herbaceous buffers and $1700 per acre for forest buffers to be established through planting trees, creation of grass filter strips, and cattle fencing to protect creeks combined with alternative sources of water for livestock.

Top to bottom: Prothonotary Warbler - Noel Pennington; Gray Bats - USFWS; Snuffbox Mussel - USFWS; Ashy Darter - Conservation Fisheries/next page: Runoff from a farm in Tennessee - Tim McCabe, USDA NRCS; Clint Borum, TWRA with farmer Rich Koker-Chris Wolkonowski, NRCS

The agencies recognize that the public needs to compensate landowners for providing public benefits such as clean water. For this reason, these incentives are far higher than standard CRP rates to cover the higher opportunity costs associated with land retirement in this region. They are currently seeking leaders in the farming community to set an example by signing up for the program.

The hope in restoring 26 miles of buffer in selected subwatersheds is to make measurable benefits for water quality and aquatic species. The subwatersheds chosen provide habitat for a diversity of species of Greatest Conservation Need: songbirds such as the Prothonotary Warbler (*Protonotaria citrea*) and Yellow-billed Cuckoo (*Coccyzus americanus*); Gray Bats (*Myotis grisescens*) that rely on riparian and stream habitats for foraging; and a variety of aquatic organisms. The aquatics include the endangered mussel species Cracking Pearlymussel (*Hemistena lata*), Cumberland Monkeyface (*Quadrula intermedia*), Dromedary Pearlymussel (*Dromus dromas*), and Snuffbox mussel (*Epioblasma triquetra*), to name just a few.

In a state known for its freshwater mussel diversity, NRCS and Soil Conservation District personnel and TWRA private lands biologists are working side-by-side to achieve conservation objectives that benefit local streams and their wildlife, as well as downstream communities that rely on clean water from the Elk River.

4.3. Major Statewide Land and Water Uses

This section describes land and water uses that have large footprints in Tennessee and can result in widespread detrimental impacts to species and habitats.

4.3.1. Urbanization

Residential, commercial and industrial development can lead to a host of impacts to habitats, wildlife, and plants. This is particularly true in locations across the state where cities or towns are growing in ways that consume more land and put more pressure on surface and ground water resources to provide drinking water and dilute wastewater (Thurman and Terry 2011). These negative effects can include:

- direct loss of habitat through land conversion to other uses or stream habitat destruction;
- habitat fragmentation;
- increased runoff as a result of increasing levels of impervious surface, leading to erosion and/or water quality issues;
- increased flooding;
- expanding transportation or service corridors that can fragment habitat or block the movement of smaller, less mobile species.

According to the National Wildlife Federation, for an estimated 85 percent of imperiled plant and animal species worldwide, habitat loss or degradation is the principal threat to their continued existence. Sixty percent of the rarest and most imperiled species in the U.S. occur in metropolitan areas, especially the 35 fastest growing large metro

Box 5. How habitat fragmentation caused by development is affecting Streamside Salamanders in middle Tennessee

The Streamside Salamander (*Ambystoma barbouri*) uses both terrestrial and aquatic habitats throughout the year. During breeding season, these salamanders migrate from upland forests to first and second order streams where they attach their eggs to the underside of large rocks. The larvae develop in these streams until metamorphosis occurs, at which time they migrate into the surrounding upland habitat.

The majority of Streamside Salamander populations are located in middle Tennessee, just outside the current footprint of major cities. Habitat alteration as a result of urbanization leading to fragmented habitats is the main threat to this species in Tennessee (Niemiller et al. 2006). These salamanders are typically not found in streams where the surrounding forests have been removed (Lannoo 2005), and populations are thought to have been lost as a result of development (Mitchell et al. 1999). Development of conservation plans to protect terrestrial habitat surrounding first and second order streams is critical for this species (Niemiller et al. 2006).

Streamside Salamander - Matthew Niemiller areas, which include both Memphis and Nashville. Though they comprise only 8 percent of the lower 48 states' land area, these metro areas are home to nearly one-third of the nation's declining species (Ewing et al. 2005).

Impacts to Terrestrial Habitats

Urbanizing land use patterns affect terrestrial species and habitats in a variety of ways. For example, urbanization can result in a shift in the types of species that live and thrive in a region, with non-native species often competing with or replacing native species. A review of 105 studies on the effects of urbanization found trends of increasing proportions of nonnative species toward urban cores in plants, birds, mammals, and insects. The effects of moderate urbanization (i.e. suburbs) varied significantly, with most studies indicating an increase in plant species richness, due in part to exotic species introductions, whereas most studies of invertebrates and non-avian vertebrates show decreasing species richness with increasingly intense urbanization (McKinney 2008).

Fragmentation

Terrestrial habitat fragmentation can affect the health and size of wildlife and plant populations by reducing the ability of organisms to migrate and/or disperse, which in turn can lead to inbreeding and loss of genetic diversity. Plants are intrinsically less mobile so may be more susceptible to habitat fragmentation and succession. Fragmentation can occur in a variety of settings across the state, including development in and around existing public lands. For example, development in the eastern mountains of Tennessee on steep mountainsides and ridge tops can damage viewsheds and decrease tree cover, which leads to erosion and habitat fragmentation. (Thurman and Terry 2011). Without greater attention to planning and proper management, the development of vacation and recreation sites can fragment significant conservation landscapes and public lands.

European Starlings, non-native species now widespread throughout North America in cities and countryside, displace and compete with many native bird species - Alden Chadwick

Land management patterns

An increased risk of land development can also be associated with forestland ownership. For example, on the Cumberland Plateau, much forestland held for decades by timber companies has been sold to institutional investors. These investor groups can be excellent land managers and conservation partners. However, depending on the income planning horizon and expectations, increased pressure may be placed on harvesting forest products and selling land assets for other types of development. Reduction of forestlands can also negatively impact water quality and quantity, the health and diversity of habitats, and other land values such as recreation, timber, and forest products. (Thurman and Terry 2011).

Parcelization

In addition, as development fans out into rural areas, a phenomenon known as parcelization can occur, in which larger landholdings are subdivided into smaller and smaller ownership units. Even in the absence of habitat fragmentation in terms of actual land use change, parcelization increases the difficulty of providing coordinated and coherent habitat management on a scale suitable for many wildlife and plant species. For example, when private lands with a history of conservation management using prescribed fire are subdivided, it will take far more effort and coordination among multiple landowners to conduct prescribed burns over the same acreage (EGCPJV 2014).

Unplanned development

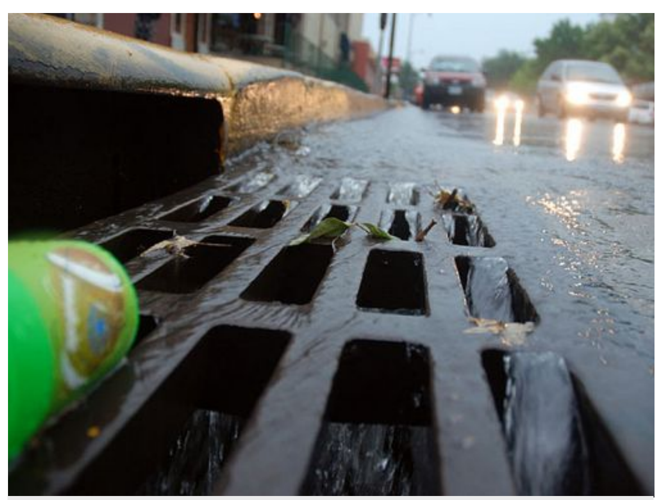
Unplanned development patterns also have a high cost to local communities, their economies, and cultural heritage. A 2011 report of the Tennessee Advisory Commission on Inter-governmental Relations concluded that if Tennessee continues to adhere to sprawling development patterns, nearly 800,000 additional acres of open land will be developed by 2025. While developed land in Tennessee increased by more than 12% from 1982 to 2007, the percentage of cropland decreased by more than 25%, putting Tennessee among the top 8 states nationwide for loss of prime farmland. Local governments, tax payers, and utility rate payers often subsidize the real cost of sprawl through expensive and inefficient infrastructure expansions (Thurman and Terry 2011).

Impacts to Aquatic Habitats

The complex relationship between land use and stream health means that several aspects of the land urbanization process contribute to declines in the state's water resources. Urban development can alter the stream flows, habitat quality, and water chemistry of streams in both direct and indirect ways (USGS 2015).

Urban development often results in direct alterations of streams, either to accommodate development of a specific site, improve site drainage, or access to a site. Direct stream alteration can degrade the physical habitat and contribute to downstream channel erosion, sedimentation, or lower stream flows. All of these changes reduce spawning, feeding, and living spaces of aquatic organisms (USGS 2015).

Faster and more frequent runoff from paved and built surfaces increases and destabilizes normal stream flow, which also alters streams and increases erosion. Rapid runoff carries surface pollutants directly to streams and reduces natural



Urban Drains carry pollutants; impervious road surfaces increase runoff and destabilize normal stream flow. - KOMU News water infiltration through the ground back to groundwater and aquifer recharge. Lowered aquifers may then contribute to lower stream flows, particularly in summer months (USGS 2015). Flooding can be exacerbated by both development in the floodplain and the failure to plan for stormwater management and adequate water infiltration to the ground. For example, a study of 21 stream sites in the Ridge and Valley ecoregion of Tennessee and Georgia revealed that more urbanized watersheds were characterized by increased proportions of fine sediments and pool areas, coupled with reduced variation in stream channel complexity. Urbanized watersheds exhibited declines in biotic integrity, species diversity, richness, and evenness (Smith 2009).

Sources of pollution from developed areas commonly include fertilizers, pesticides, animal waste, septic tanks, sewage, erosion from construction, vehicular fluids, and industrial and commercial site runoff. These sources contribute to an increase in concentrations of contaminants in streams including nitrogen, chloride, insecticides, and polycyclic aromatic hydrocarbons (PAHs). A USGS study found that aquatic invertebrate communities begin to degrade from the onset of urban development, which indicates that some species are highly sensitive to physical and chemical changes associated with urban development. (USGS 2015).

The Tennessee Water Quality Assessment Report (TDEC 2012/EPA 2015) provides a comprehensive summary of water quality assessments for the state's waters (See Table 14). Urban-related storm-water, wastewater, and construction activities are three of the top five sources of impairment to Tennessee streams.

Table 14. Top 5 causes and sources of stream impairment in Tennessee (TDEC 2012/EPA 2015)

Sources of Stream Impairment	Stream miles
CAUSES OF STREAM POLLUTION	
Pathogens (mainly E. Coli)	7364.5
Habitat Alterations	6785.9
Sediment	6187.6
Nutrients (includes phosphorus and nitrogen)	3380.2
Organic Enrichment/Oxygen Depletion	1823.3
SOURCES OF STREAM POLLUTION	
Agriculture (includes grazing in riparian zones and non-irrigated crop production)	8,780.1
Hydromodification (includes channelization, upstream impoundments, and dredging)	4349.6
Urban-related Runoff/Stormwater	2786.6
Municipal Discharges/Sewage	1560.2
Construction (includes site clearing for development and transportation corridors)	1003.1

Impacts to Karst Habitats

Karst landscapes are characterized by caves, sinkholes, underground streams, and other features formed by the slow dissolving, rather than mechanical eroding, of bedrock (Veni et al. 2001). With more than 10,000 documented, Tennessee has the greatest number of caves in the country equalling about 20% of all known U.S. caves (Wisby and Palmer 2015). Most Tennessee caves are associated with karst composed of limestone in the central and eastern regions of Tennessee. Karst areas present unique challenges because so many of the processes key to their formation and stewardship are located underground, invisible from the surface. For this reason, the complex hydrologies of karst aquifers and other critical processes require specialized monitoring and assessment (Veni et al. 2001).

Hubbard's Cave: Tennessee has more caves than any other state in the U.S. Much of middle and eastern Tennessee is underlain by karst. - Byron Jorjorian

Karst regions are rich in water and mineral resources, providing unique habitats and spectacular recreational opportunities. Problems associated with living on karst can threaten both people and natural resources. Problems for people include sinkhole collapse, sinkhole flooding, and easily polluted groundwater that rapidly moves contaminants to wells and springs. Problems to the unique biota associated with caves and aquatic habitats include sediment and pollutants that infiltrate from the surface, as well as alteration of drainage conditions and the aquifer itself (Veni et al. 2001).

A variety of best management practices (BMPs) exist to help reduce these types of potential impacts. BMPs rely on knowledge of the location of karst and aquifers, combined with practices designed largely to avoid impacts from contamination or hydrological alteration. BMPs for living and working in karst regions cover the following activities:

- development and road construction
- wells and groundwater mining
- septic and sewage systems
- agriculture and livestock production
- timber harvest

(Veni et al. 2001)

Sinkholes are subject to flooding in response to precipitation; flood duration depends on the rate of water inflow, outflow, and degree of hydrologic connection to groundwater. Insufficient delineation of sinkholes and incomplete knowledge of their characteristics can result in development patterns that exacerbate sinkhole flooding (Bradley and Hileman 2006). Since many of Tennessee's growing urban areas are located in karst regions, the understanding and mapping of these habitats is critical.

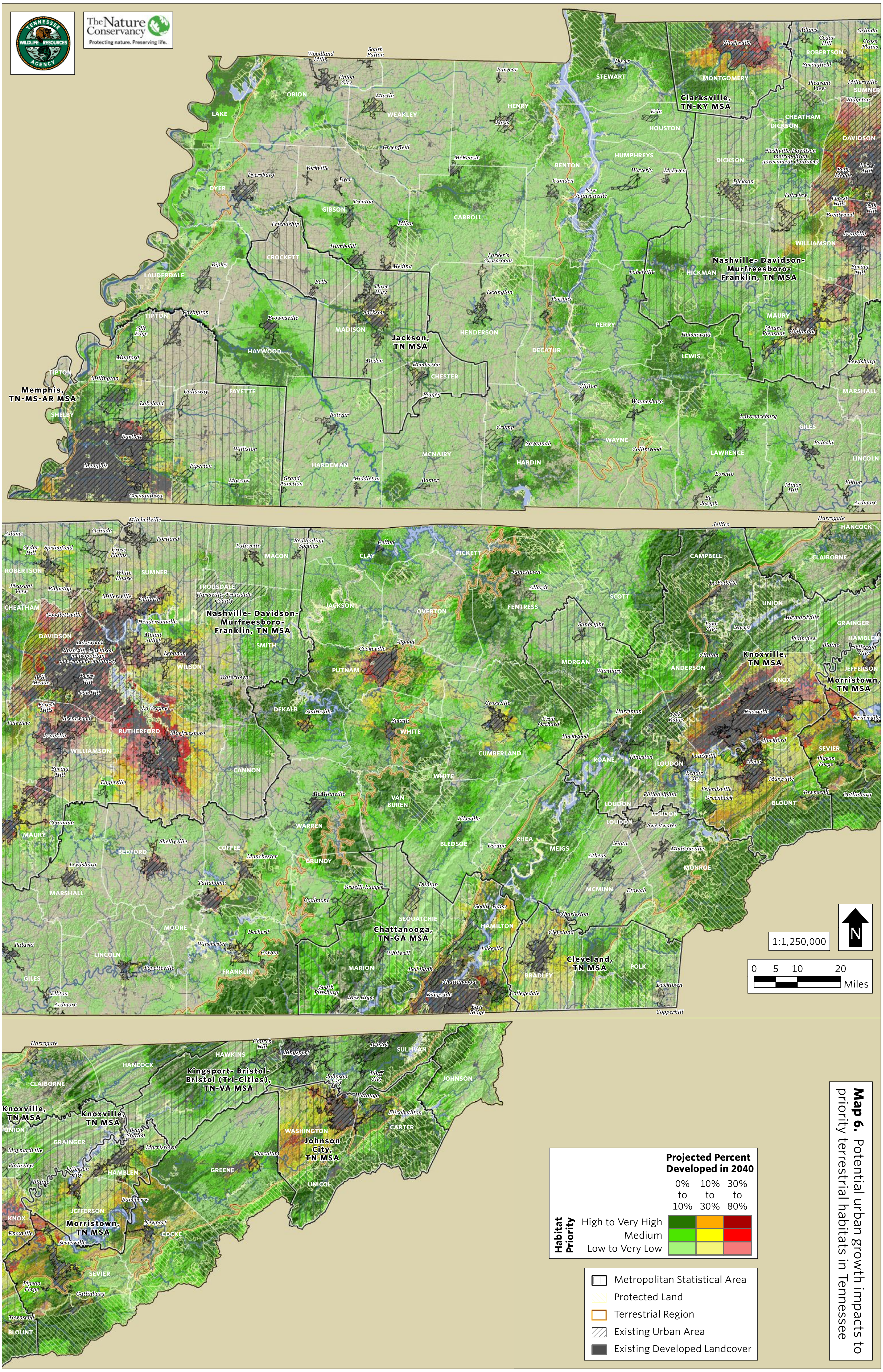
Mapping urbanization in Tennessee

While the population of Tennessee increased by 16.7% from 1990 to 2000, this rate subsequently declined. However, from 2000 to 2010, Tennessee's population still increased by 11.5% (US Census 2000 and 2010). The 2005 SWAP identified development-related issues as the most consistently high-ranked stressors to terrestrial, aquatic, and subterranean GCN species, and this assessment remains applicable in 2015.

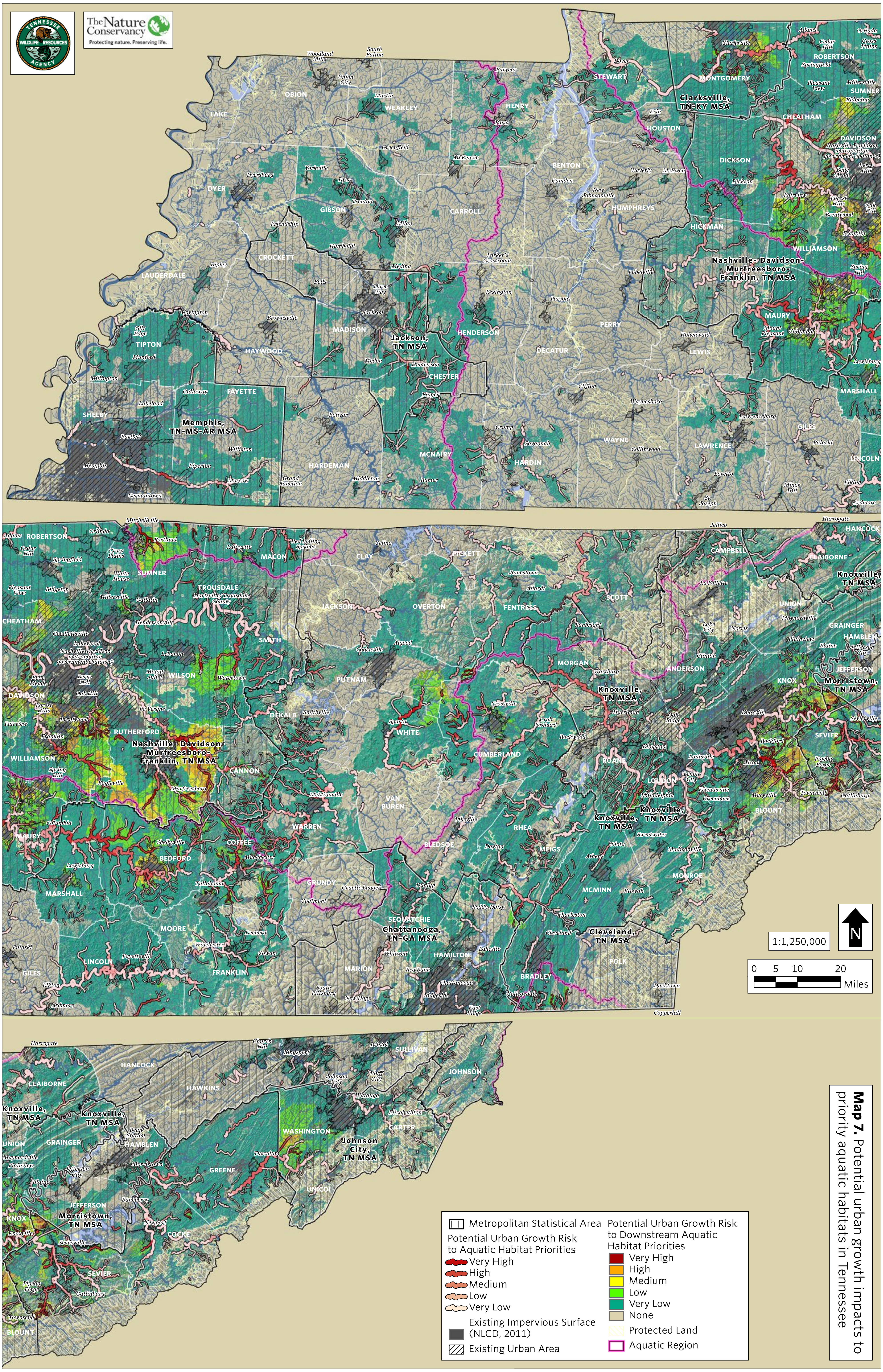
Nashville riverfront and skyline - Brad Montgomery

For the 2015 update, the SWAP team adopted a methodology developed by The Nature Conservancy (TNC) for examining the growth in urban land use footprints across Tennessee to accommodate our projected population through 2040 (Wisby and Palmer 2015). This methodology uses county-level population growth projections from the University of Tennessee's Center for Business and Economic Research; information on county and municipality urban growth and boundaries; and data on land features and proximity to infrastructure to determine which areas are likely to experience land conversion during the next 25 years.

The results show the specific locations across the state where GCN habitats and species may be at risk without proper planning for habitat protection (Maps 6 and 7). These maps, and the underlying species and habitat data, can help inform decision-making so that natural resource considerations can be made in advance. While the potential expansion footprint may not appear visually large in some places, such as far eastern Tennessee, urbanization can result in localized habitat fragmentation effects that can interrupt habitat connectivity at larger scales. Maps 6 and 7 also show the boundaries of Metropolitan Statistical Areas (MSAs) of Tennessee (Figure 3). The maps group the ten MSAs of Tennessee into a smaller subset of 5 combined areas. For planning collaborations with SWAP conservation partners, the data can be analyzed and presented for

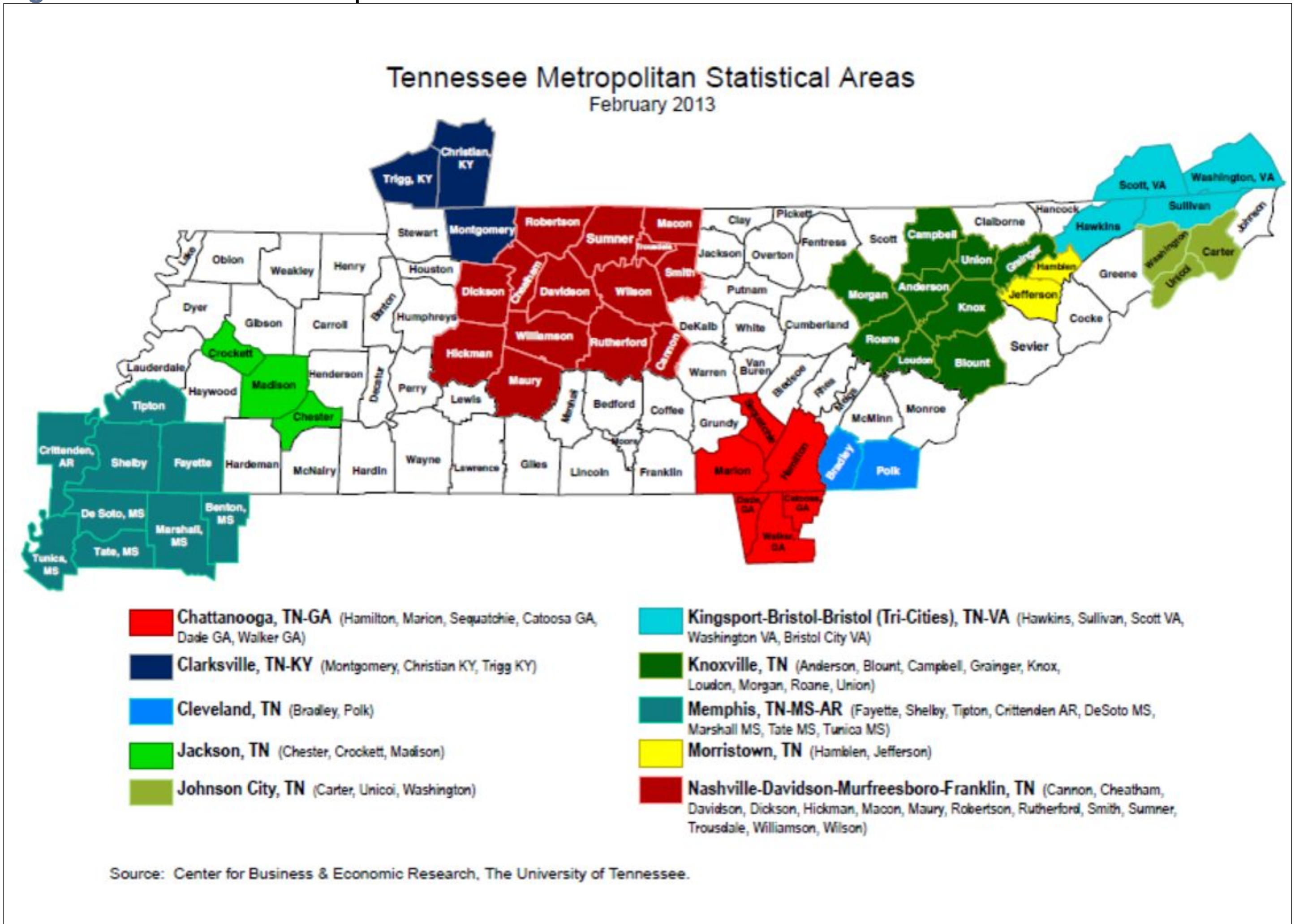


Map 6. Potential urban growth impacts to priority terrestrial habitats in Tennessee



Map 7. Potential urban growth impacts to priority aquatic habitats in Tennessee

Figure 3. Tennessee Metropolitan Statistical Areas



any specific MSA or combination of MSAs at the desired spatial scale.

4.3.2. Agriculture

Agricultural conversion and incompatible agricultural management practices can, in some cases, pose challenges to sustaining certain wildlife and plant species in Tennessee. However, it is important to note that not all agriculture poses a threat to wildlife and plants. In fact, certain forms of agricultural management can be beneficial for wildlife and plant conservation or can be managed to lessen negative impacts. Many such practices are promoted through incentive programs for landowners administered by the U.S. Department of Agriculture, Natural Resources Conservation Service, and the Tennessee Department of Agriculture.

Impacts to Terrestrial Habitats

Agricultural land use can pose a threat to terrestrial species when important grasslands or forests are converted to cropland or pasture, contributing to overall loss or fragmentation of habitat. Loss of riparian habitat impacts GCN bird species such as Prothonotary Warblers, Swainson's Warblers, and many others.

Wetland habitats provide important services such as water filtration and groundwater recharge, and they provide critical habitat to many species at various points in their life cycle as well. As with so many wetland areas of the United States, these highly localized habitats have been vastly reduced, often as a result of drainage and clearing for agriculture (USGS 1997). Tennessee lost 59% of its wetlands from the 1780's to the 1980's, according to estimates by the U.S. Fish and Wildlife Service (Dahl 1990).

Prothonotary Warbler, a species that depends on riparian and bottomland habitats. Cynthia Routledge

Contemporary estimates of Tennessee's wetland area range from 640,000 to 1,400,000 acres. Wetlands are ecologically and economically valuable to Tennessee, despite making up a relatively small percentage of the state. Bottomland forests are the state's most common type of wetland, located primarily in the flood plains of rivers in west Tennessee. Major causes of wetland loss or degradation in Tennessee include

- agricultural conversions,
- logging,
- reservoir construction,
- channelization,
- sedimentation,
- urbanization

(USGS 1997).

Beginning with the introduction of genetically modified herbicide-resistant (HR) crops, herbicide use increased in the U.S. by 527 million pounds from 1996 to 2011 (Benbrook 2012). These increases occurred in states such as Tennessee, where the HR crops soybeans, corn, or cotton are grown. The use of herbicides on HR crops increased 31% nationwide from 2007 to 2008, to a large degree due to the spread of weeds resistant to these same herbicides (Benbrook 2009).

Milkweed and many other flowering herbs and shrubs that serve as sources of seed and nectar for birds and other pollinators have suffered collateral damage from the widespread use of herbicides, with one study in 2012 showing a direct correlation between declining Monarch Butterfly numbers and increasing adoption of herbicide tolerant soybeans and corn (Monarch Joint Venture 2015). Also, studies by Purdue University have shown that herbicides making their way into streams have the potential to adversely affect GCN species such as Hellbenders by altering growth and development of larval stages (Solis et al. 2007).

Impacts to Aquatic Habitats

Incompatible agricultural management practices are the number one source of

Water flows off a farm in Tennessee following a storm.
- Tim McCabe, USDA NRCS

damage to streams across Tennessee (see Table 14). One reason for this ranking is that Tennessee's overall landscape remains largely in some form of agricultural use or forest type. Management practices that can contribute to stream health impairments include removal of streamside vegetation; grazing livestock along stream banks with unrestrained access to the stream; poor farm nutrient, waste, and herbicide management; channelizing and dredging streams; and creating impoundments on streams or withdrawing excess amounts of water.

Poor farm nutrient and waste management practices can contribute to pollution by Escherichia coli (E. coli) pathogens, and nitrogen and phosphorus inputs to streams and rivers. An excess of nutrients results in a problem known as eutrophication in streams, which lowers the dissolved oxygen in water available for freshwater animals, including insects.

Of all the effects associated with incompatible agricultural practices, excess sedimentation from farm fields and eroding stream banks may well be the single most deleterious for freshwater GCN species in Tennessee. According to a USGS study of 20 streams in Tennessee's Eastern Highland Rim ecoregion, nutrient concentrations, stream gradient, width, and substrate embeddedness (the degree to which fine particles surround coarse substrates) were all related to cropland density in a particular watershed. However, results suggest that fish communities respond primarily, and negatively, to the cumulative effects of sedimentation (Powell 2003). Channelization of streams and rivers to increase land

A channelized stream in west Tennessee, South Fork of the Forked Deer River - Rob Colvin, TWRA available for agricultural production is a major contributor to habitat impairments in western Tennessee.

Impacts to Karst Habitats

Tennessee is among a handful of states with the greatest number of springs (3000), most of which are associated with karst composed of limestone in middle and eastern Tennessee. Enhanced interactions between surface and groundwater processes occur in karst. The hydrological cycle begins with precipitation and surface water drainage into the aquifer, which can occur over the entire karst surface area. Caves are considered subsurface extensions of karst landscapes, with most caves forming at or just below the water table. Caves above the water table are tributaries to caves below the water table. Water percolating downward passes through caves, which serve as "natural pipes" and the water can often re-emerge at the surface as springs or seeps (Veni et al. 2001).

Water flows over steps into Arch Rock at Alum Cave in Great Smoky Mountains National Park - Patrick Mueller

In rural and agricultural areas, karst aquifers are subject to contamination from a number of sources. Chemical fertilizers, pesticides, herbicides, and elevated pathogen concentrations can be flushed through soils into aquifers beneath farmland, pastures, and feedlots. In addition to the impacts of sedimentation listed previously, sediments can affect the flow of groundwater through karst and may also carry contaminants, making programs to minimize soil loss critically important for many karst areas.

Another practice common in rural areas is dumping of refuse, construction materials, and dead livestock into sinkholes. "Common harmful products include bacteria from dead animals; used motor oil and antifreeze; and empty herbicide, solvent, and paint containers. These substances readily enter the aquifer and rapidly travel to nearby water wells and springs. Few people would throw a dead cow into a sinkhole if they realized that the water flowing over the carcass might be coming out of their kitchen faucet a few days later." (Veni et al. 2001).

Mapping agricultural land use and priority freshwater habitats

Improving agricultural management practices in priority areas can improve outcomes for freshwater species of greatest conservation need and overall water quality across Tennessee. To better understand the scope of the challenges and opportunities, for the 2015 update the SWAP team used an approach developed by TNC (Wisby and Palmer 2015) to examine where across the state important watersheds for freshwater species conservation intersect with different agricultural land uses that may contribute to habitat or water quality degradation, if not managed to prevent such problems (see Map 8). The results show specific locations across the state where GCN habitats and species may be at risk without the use of agricultural best management practices, including sound management of Combined Animal Feeding Operations (CAFOs). It is important to note that these maps do not take into consideration where best management practices may already be in place; therefore, they are not representative of actual site-specific habitat conditions.

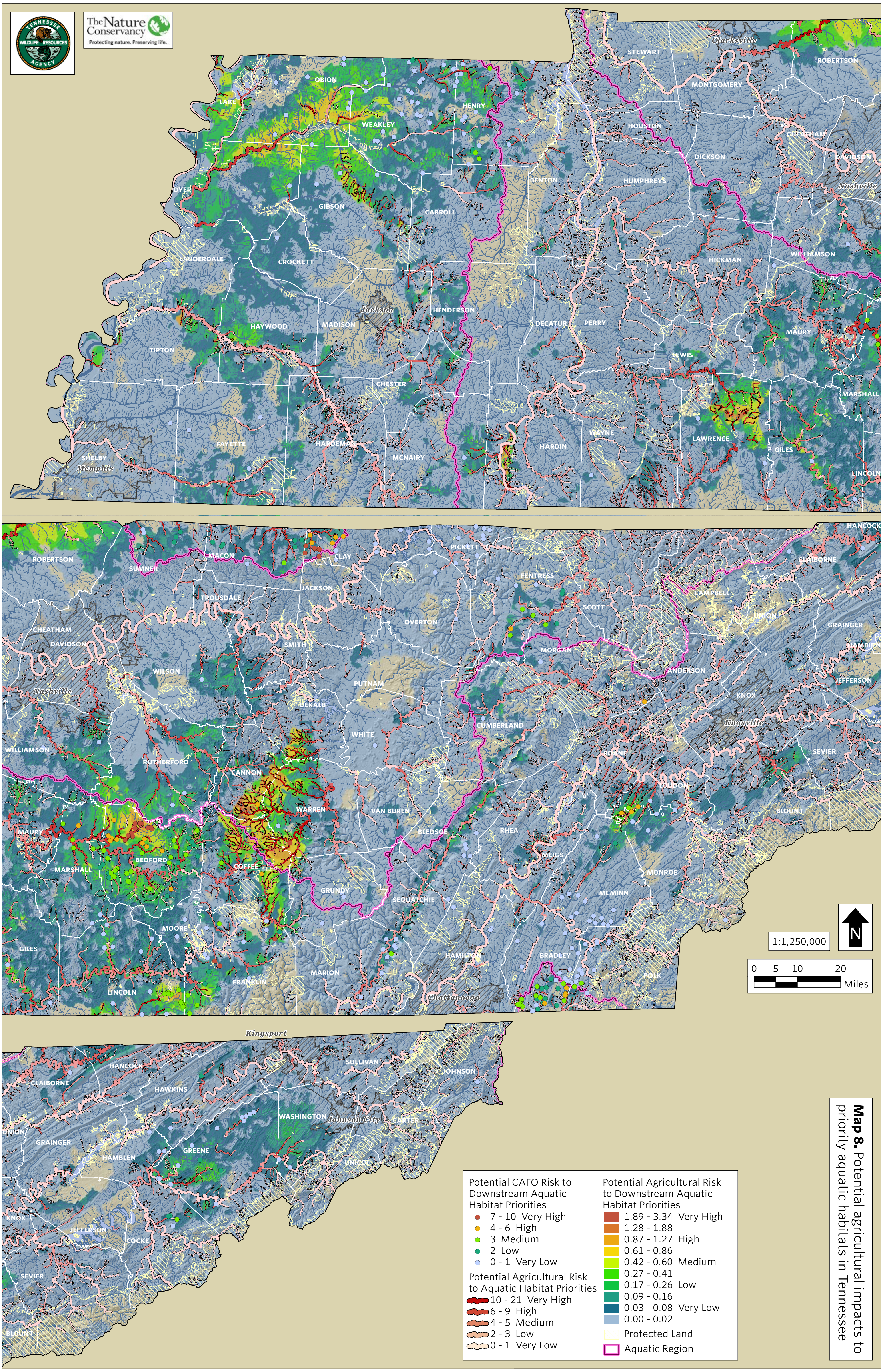
4.3.3. Forestry

The Tennessee Division of Forestry developed its first Forest Resource Assessment and Strategy, also called the Forest Action Plan, in 2010. Where possible, it complements other state plans including the 2005 SWAP. Both plans identify problems facing Tennessee forests in the form of incompatible forestry practices that decrease forest habitat extent, alter habitat structure, and contribute sediment and nutrients to streams. All of these problems can negatively impact GCN species populations. Changing forestland ownership and increased parcelization present additional challenges to coordinated management and protection activities in many regions of the state (TDF 2010).

In terms of specific management practices, the lack of vertical structure in forests (i.e. understory, mid-story, and canopy development) is a threat to wildlife because a hardwood forest with structure supports a far greater diversity of wildlife than one without. This lack of structure is the result of little or no natural disturbance or intermediate management action, such as burning or thinning, over the life of a forest (TDF 2010).

Across the southern Appalachians, early successional habitats have been declining over several decades due to farm abandonment, changes in farming practices, urban

Diverse forest structure: wildlife generally respond to diversity - Greg Wathen, TWRA



Map 8. Potential agricultural impacts to priority aquatic habitats in Tennessee

The Yellow-breasted Chat is a GCN species that depends on early successional habitat. - Chris Sloan

encroachment, and the suppression of natural disturbances such as fire, flooding, and beaver activity. Species like the Golden-winged Warbler that depend on these habitats have declined over time, and their habitat restoration has become a priority (USFSb 2015).

Other potentially incompatible practices include high grading, clearcutting, pine monoculture, and use of exotic plants. In addition, high density, even aged, short rotation pine stands provide few wildlife or native plant benefits (TDF 2010; D. Lincicome, personal communication, Sep. 4, 2015).

Large timber harvests implemented without attending to BMPs designed to protect water quality, snags, and ground cover can directly impact wildlife, native plant populations, and habitats. In recent years, clearcutting and harvesting of the largest, highest quality trees (known as high grading) has occurred on both public and private lands. Maintaining the structure and diversity of old growth forest habitats and their connectivity across the landscape is critical to conservation of many GCN plants and animals. Without proper planning with respect to landscape-level habitat requirements for multiple species, including those dependent on different types of habitat, high grading practices can be detrimental as they lessen diversity in forest structure.

Logging road in Tennessee: best management practices help to mitigate erosion, concentrated flows, and sedimentation. - Chris M. Morris

Other negative effects of certain types of forest management include the following:

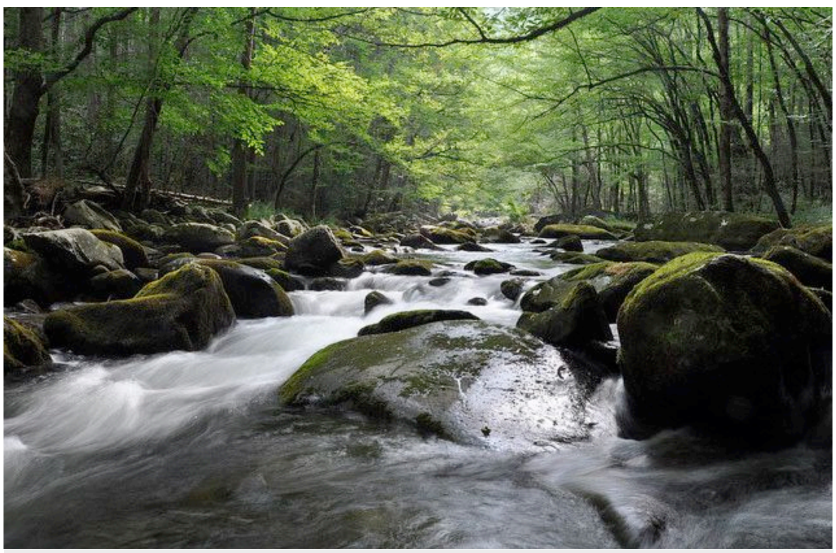
- Soil compaction and erosion;
- Impaired water quality from erosion, altered drainage patterns, and concentrated flows;
- Conditions that promote the establishment and spread of invasive species or insect pests (USFS 2015c).

Proper management of forest resources, including the promotion of landscape-level forest habitat health, helps protect a diversity of habitats for GCN species. It also promotes many other beneficial forest uses, such as protection of public drinking water supplies, recreation opportunities, and local forest-product related economic activities (TDF 2010).

4.3.4. Water Management

Tennessee's rivers and streams provide habitat for some of the greatest diversity of aquatic species in North America (Smith et al. 2002, Master et al. 1998). For the last century, government agencies and private businesses have developed the state's water resources to provide flood control, river navigation, electricity, drinking water, agricultural improvements, and recreation benefits to Tennesseans as well as residents of neighboring states. While transforming state and local economic opportunities, the construction of dams and other water infrastructure has also fundamentally changed Tennessee's rivers and tributaries from their original interconnected, free-flowing conditions. Currently the best estimate for number of dams in Tennessee is 1, 721 (E. Granstaff 2015, personal communication, Aug. 11).

The flow regime of a stream or river system and the connection of a river to its tributaries is a highly significant factor in determining both the structure and function of aquatic and riparian ecosystems. An ongoing USGS study on stream flow and ecology in the Tennessee river basin has identified specific aspects of streamflow that influence fish community health and abundance (USGS 2013).



Streamflow: one of the key factors that determine the species composition and health of a stream. - Greg Wathen, TWRA

Dam construction can alter flow by turning river systems into a series of large pool reservoirs. Flow alteration as a result of dams both large and small has significant impacts on aquatic species, fragmenting the river network, impeding the movement of resident and diadromous fish species, and eliminating or altering in-stream habitat. By preventing many species of fish and invertebrates from accessing river reaches upstream and downstream of the structures, dams essentially disconnect populations from large sections of their habitat. In addition, dams pose threats to native aquatic systems by changing several key characteristics of the streams that occur downstream of reservoirs: natural flow patterns, dissolved oxygen, temperature, nutrient loads, and water chemistry.

Water withdrawals are also a concern if the timing or amount of withdrawal is sufficient to alter basic flow patterns and affect ecological responses, posing a threat to aquatic wildlife and plants. Both channelization and upstream impoundments, which can affect flow patterns, are listed among the top ten sources of impairment to Tennessee river and stream health (TDEC 2012/EPA 2015) (See Table 14). In addition to reducing habitat for aquatic species, flow alteration can also affect water quality, water temperature, and water availability (USGS 2013).

Resource management challenges of large dams and reservoirs

Rivers below dams are commonly referred to as tailwaters or tailraces. Many hydropower and flood control dams, operated by the Tennessee Valley Authority (TVA) in the Tennessee River system and the U.S. Army Corps of Engineers (USACE) in the Cumberland River system, release cold water into the tailwaters. The cold water can degrade or reduce habitat for native fishes and mussels.

Likewise, some tailwaters are low in oxygen, especially by the end of the summer, because decaying organic matter in reservoirs uses up oxygen at the bottom of the reservoir, and the heavier, colder water does not mix with the surface. It is also these waters that are discharged from the dam. These are issues that TVA, USACE, TWRA, and the U.S. Fish and Wildlife Service (USFWS) have worked to address in recent decades, by creating flow regimes and improving downstream water quality to benefit at-risk and endangered species in key river reaches.

Since 1991, TVA has spent more than $60 million constructing capital projects to address the problem of low oxygen, installing a variety of equipment and technologies designed to increase dissolved oxygen concentrations below 16 dams. TVA also monitors key aspects of ecological health in the tailwater sections to achieve biological and recreation objectives (TVA 2015b).

In recognition of the importance of stream flows, TVA also changed their policy for operating the Tennessee River and reservoir system in May 2004. The policy now focuses on managing the flow of water through the system rather than storage. It specifies flow requirements for individual reservoirs, to prevent riverbeds below dams from drying out, and for the

Lake Sturgeon below Douglas Dam on the French Broad River. Once extirpated from the Tennessee River, in part due to hydroelectric dams, Lake Sturgeon are making a comeback due to TVA's Reservoir Releases Improvement program. - Bart Carter, TWRA system as a whole. (TVA 2015b). Their operations now maintain wetted habitat in 180 miles of river that previously were intermittently dry (Yarbrough 2013).

Similarly, the USACE has conducted watershed assessments in key watersheds where they operate. These are collaborative processes with state, federal, tribal, interstate, local government, and stakeholder organizations that produce watershed plans to balance needs for water supply, public safety (flood control), wildlife habitat, and aquatic diversity (USACE 2015).

In some cases, agencies recognize that cold tailwaters are inevitable and present an opportunity to provide a sport fishery. Because cold water released into the tailwaters below dams creates a new type of habitat, TWRA stocks trout to diversify the state's angling opportunities. TVA's monitoring program on the Elk River allows the agency to adjust the operation of Tims Ford Dam to protect the variety of life in the river, including a cold-water trout fishery, endangered species, and sport fish that require warm water (TVA 2015b).

Resource management challenges of small dams and stream barriers

Even small impoundments, which are constructed on smaller or headwater streams for various reasons, have the potential to adversely affect aquatic life. Such impoundments eliminate flowing stream habitat in the flooded pool zone, making habitat unsuitable for native stream species. These dams also may alter the physical, chemical, and biological components of downstream reaches. They create barriers that can result in isolated populations, and with no provision for minimum flows, they may result in insufficient flow downstream, particularly during summer months (Arnwine et al. 2006).


Even small dams create barriers and can alter the flow, chemistry, and biology of areas both up and downstream. - Chris Simpson, TWRA

All of these factors combined are a recipe for reduced biotic integrity, altered flows, and negative impacts on water quality downstream of the impoundment. Results from one study indicate that small impoundments affect the biological community for at least one-quarter mile downstream (Arnwine et al. 2006). As recognition of these impacts has grown, momentum has increased among a variety of constituents across the country to remove dams, particularly those that no longer serve their original purpose or that pose significant threats to public safety.

Negative impacts of stream and river channelization

Channelization of rivers and the use of levees and dikes to prevent flooding in former natural floodplains are two major contributing factors to the imperilment of many GCN fish species, particularly within the Mississippi River and its tributaries in western Tennessee. Straightening streams means removing the meanders that produce habitat structure in the form of pools and riffles, which are essential to a diversity of fish and other aquatic life. Channelization can also lead to greater erosion and sedimentation (TWRA and USFWS 2002).

Channelization and associated silt load in the Forked Deer River system in Madison County - TWRA staff

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Channelization has hurt the following species in west Tennessee:

- ***Alligator Snapping Turtle***
- ***Alligator Gar***
- ***Lesser Siren***
- ***Smallmouth Salamander***
- ***Piebald Madtom***
- ***Pink Mucket Mussel***
- ***Orangefoot Pimpleback Mussel***

Disconnecting streams from their floodplains through channelization, levees, or dike construction can cause the following problems (TWRA and USFWS 2002):

- ✦ loss of sediment;
- ✦ deposition outside of the streambed;
- ✦ decrease in groundwater recharge;
- ✦ elimination of spawning and nursery habitat for fish and amphibians.

4.3.5. Energy Development

Non-renewable energy development

Resource extraction for non-renewable energy sources includes mining for coal as well as drilling for oil and natural gas. These activities can involve significant impacts to natural habitats. Without proper advance planning, management, and mitigation, they can cause long-term and even irreversible damage.

Coal Mining

Coal mining activities, from site preparation to post-mining impacts, can introduce a spectrum of problems for GCN species and their habitats. A 2002 Clinch and Powell Valley Watershed Ecological Risk Assessment conducted by the EPA analyzed associations between land use and in-stream habitat and their effects on fish and mussels. Their findings show that coal mining activities can cause "unacceptable losses of valuable and rare native fish and mussels." (EPA 2002).

Forest loss can fragment habitat and severely affect interior forest-dwelling birds and other species. A current threat facing the region is that of mountaintop removal coal mining, which even with reclamation leaves landforms permanently altered (SELC 2015).

The Cumberland Plateau and Mountain region of Tennessee has experienced decades of long term environmental impacts from coal mining, including problems associated with contour mining, deep mining, cross-ridge mining, and re-mining of areas. Such activities destroy terrestrial habitats and permanently disrupt and degrade the hydrologic and ecologic function of surrounding forests, spring seeps, streams and riparian zones. These activities also disrupt and degrade the ecological function and connectivity of ridgeline habitat corridors.

Coal mining conducted prior to the passage of the 1977 Surface Mining Control and Reclamation Act (SMCRA), which required post-mining site repair activities to take place, left clear cuts, polluted rivers, and unstable slopes in their wake. Issues from older abandoned mines that were either never reclaimed or improperly reclaimed have degraded both water quality and aquatic wildlife diversity. (EPA 2014c).

Big South Fork acid mine drainage - NPS

For example, in the Big South Fork National River and Recreation Area, numerous abandoned coal mine sites are found throughout the park. These sites have become sources of contaminated water affecting the river and its tributaries (NPS 2014). The Office of Surface Mining, Reclamation and Enforcement's **Abandoned Mine Land Inventory System** lists 290 problem areas in their database for Tennessee.

An additional land management challenge in Tennessee comes from the "split estate" ownership status separating subsurface mineral rights from surface rights. Even in many cases where the state or federal government protects and manages the land surface, the mineral rights may be privately owned. According to the U.S. Bureau of Land Management, in these situations, "the mineral owner must show due regard for the interests of the surface estate owner and occupy only those portions of the surface that are reasonably necessary to develop the mineral estate." (BLM 2015). Maps 9 and 10 demonstrate where currently permitted coal mining activity intersects with priority GCN species habitats in Tennessee. Collaborative planning and management at site and regional scales may help reduce the potential for negative impacts.

Oil and Gas

Both public and private lands in the Northern Cumberland Mountains and Plateau region have experienced historic impacts from oil wells and are now facing new challenges from natural gas developments. Big South Fork National River and Recreation Area and Obed Wild and Scenic River have over 300 private oil and gas operations. "Many of the past and existing oil and gas operations in these NPS units are adversely impacting resources and values, human health and safety, and visitor use and experience; most are not in compliance with federal and state regulations." (NPS 2012).

Big South Fork acid mine runoff into a stream-National Park Service

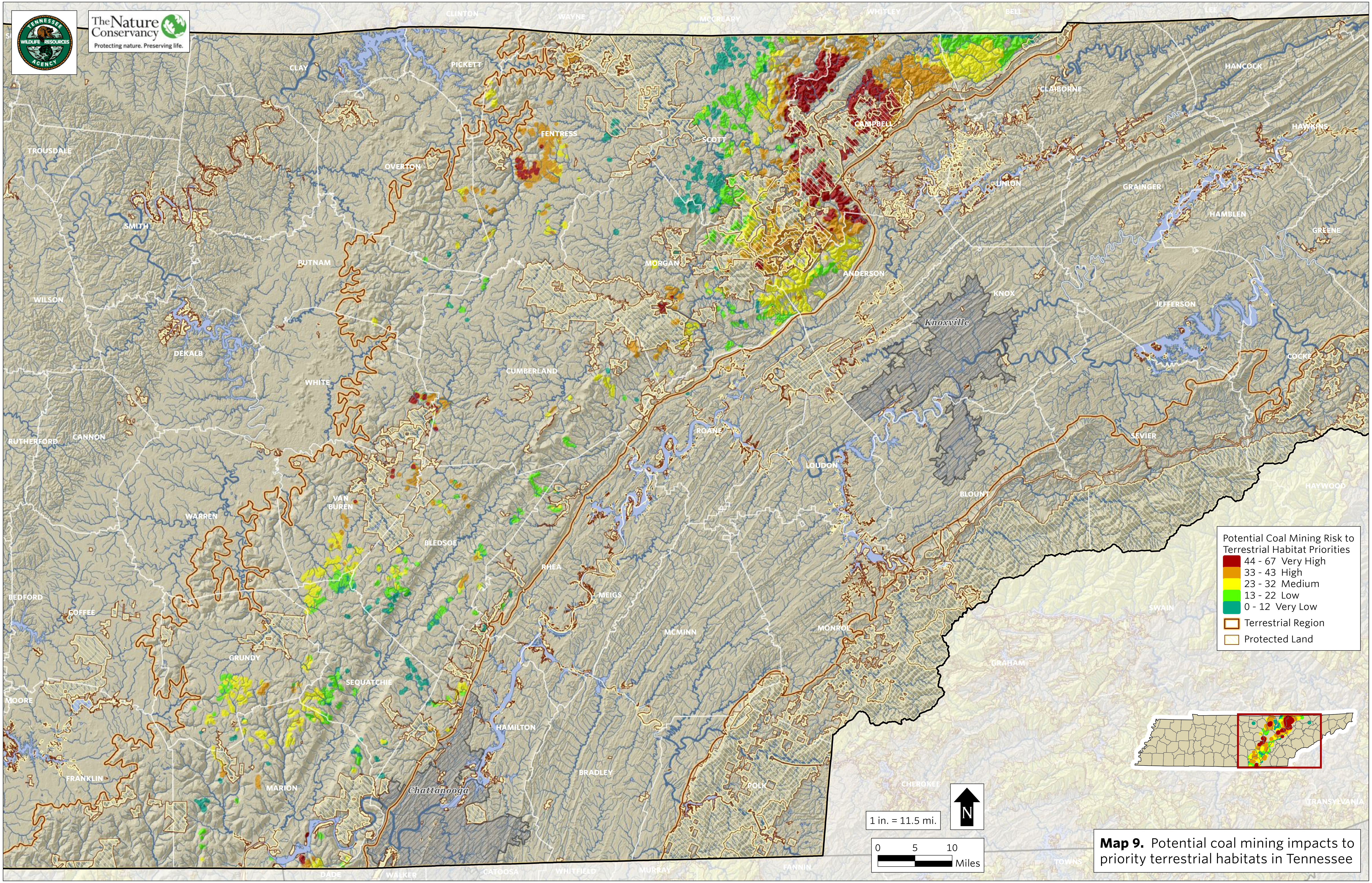
In 1994, 82 percent of Tennessee's total oil production, and 60 percent of its total gas production, came from counties within the watershed of the Big South Fork River. By 2006, 50% of Tennessee's total oil production and 99% of its gas production came from these same watershed counties (NPS 2012).

The National Park System's Oil and Gas Management Plan for these areas states that many of these operations are not in compliance with federal and state regulations. The plan is a strategy to help park managers ensure their park units are protected from current as well as potential future threats from new development. The plan provides park-specific guidance for oil and gas owners and operators who wish to establish new oil and gas extraction sites (NPS 2012).

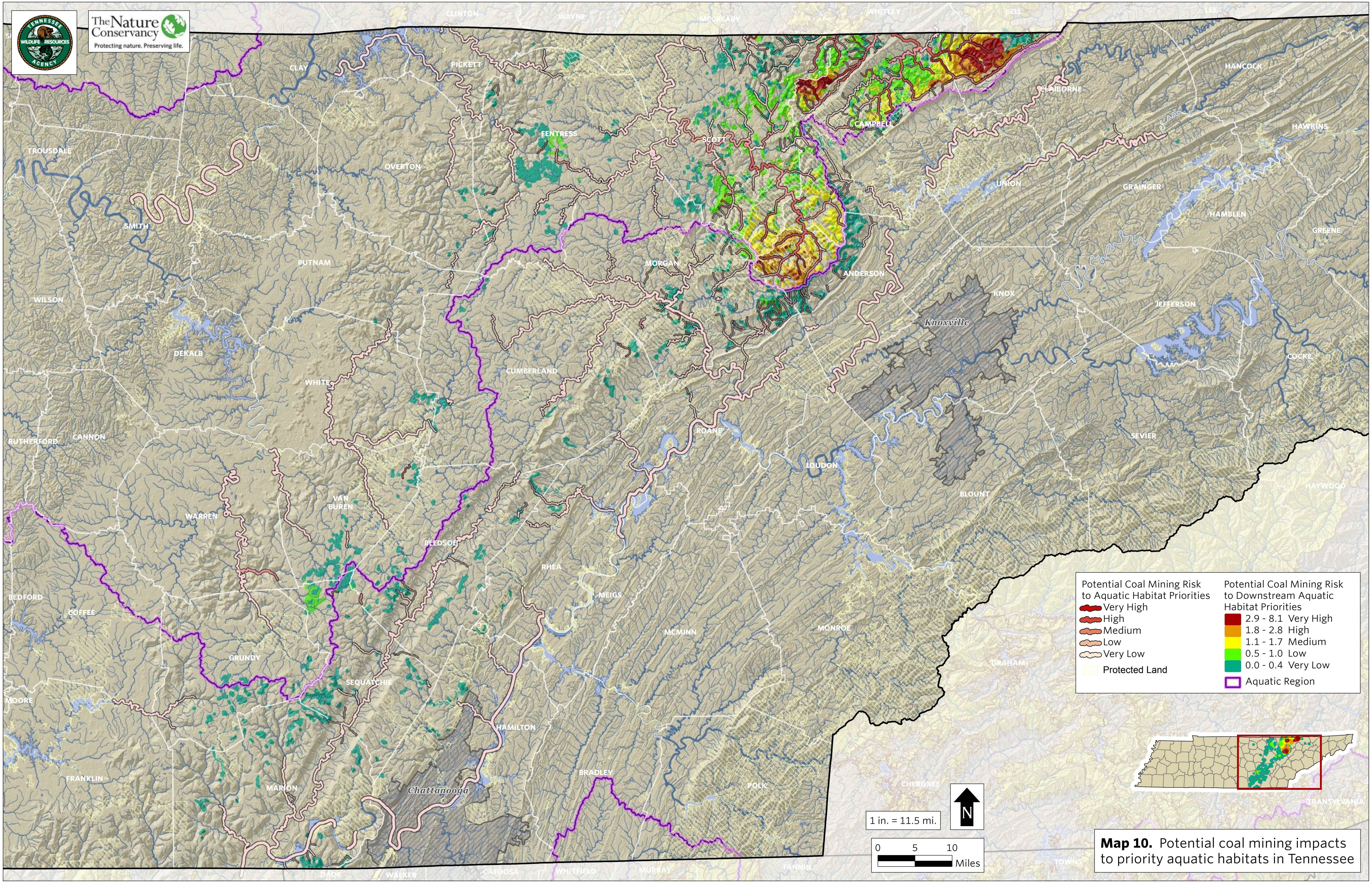
Different processes for extracting natural gas have raised concerns about potential negative impacts to both surface streams and groundwater affecting both freshwater species and overall water quality (Entrekin et al. 2011). In addition to the drilling process itself, the infrastructure development associated with production -- particularly new well pads, pipelines, and roads -- poses a major challenge to long term forest habitat integrity, both locally and across broader landscapes where production is increasing (Drohan et al. 2012, Fisher 2012). Tennessee has yet to experience the landscape-scale level of development similar to other states such as Pennsylvania; however, Tennessee does retain natural gas resources that are currently being developed and may be developed more in the future. Maps 11 and 12 demonstrate where permitted oil and natural gas activity intersects with priority GCN species habitats. As with potential coal mining impacts, use of these data in a collaborative planning framework may help reduce negative outcomes for species.

Renewable energy development

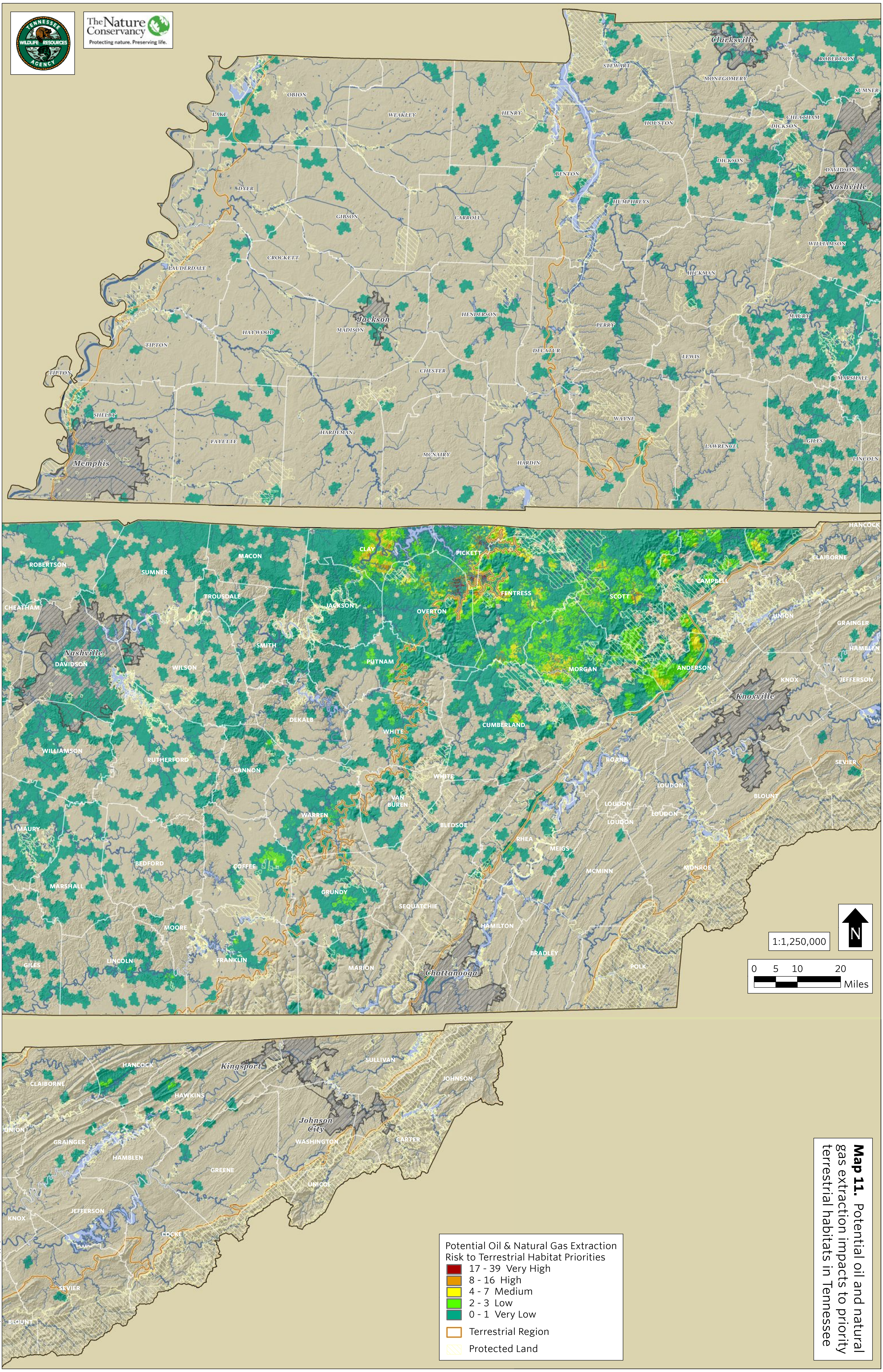
The development of renewable energy resources is receiving increased attention and study across the U.S. Renewable sources such as wind, solar, and biofuels/biomass, are currently being developed at smaller scales across Tennessee. Hydropower, also considered a renewable source, has been a significant



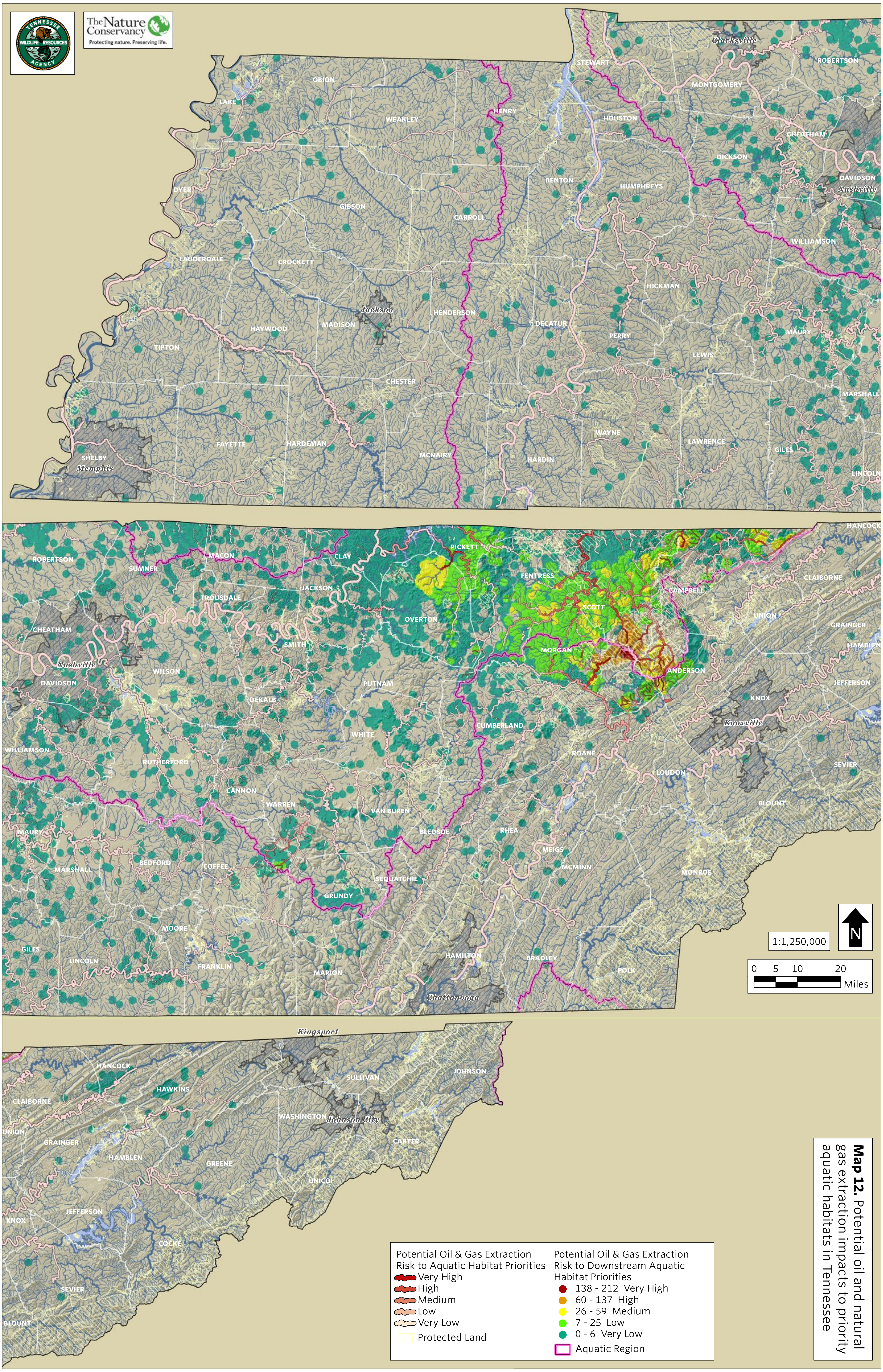
Map 9. Potential coal mining impacts to priority terrestrial habitats in Tennessee



Map 10. Potential coal mining impacts to priority aquatic habitats in Tennessee



Map 11. Potential oil and natural gas extraction impacts to priority terrestrial habitats in Tennessee



Map 12. Potential oil and natural gas extraction impacts to priority aquatic habitats in Tennessee

Switchgrass grown at the Power Plant Garden of the National Arboretum - USDA

provider of peak electrical power for many decades.

Each type of renewable source has its own potential conflicts with species and habitat conservation needs. Well-designed approaches for overall land uses need to consider the potential of the land for all human needs as well as for biodiversity protection, placing each use in its most suitable location. Primary considerations for all renewable energy development types include eliminating or reducing direct species impacts, habitat losses, and fragmentation of habitat across the landscape.

Bioenergy

Biofuels (liquid fuels) and biomass (solid fuels) are both forms of renewable energy derived from biological materials, such as plants, vegetable oils, forest products, or waste materials. A 2010 analysis of the implications of biofuels for land use and biodiversity points out that perennial bioenergy crops could be considered an appropriate component of conservation farming systems when their use is integrated with land use planning along with rotations that improve soil quality, reduce erosion, and minimize runoff of agricultural inputs (Dale et al. 2010). Several species of perennial warm season grasses, such as switchgrass (native to the North American prairie from the Gulf of Mexico to Canada) provide excellent wildlife habitat.

Continued crop breeding innovations will almost certainly expand the range of growing conditions for bioenergy feedstocks, making even more areas that are important habitats for wildlife suitable for agriculture. Also, while native warm season grasses do provide excellent habitat, the design of production fields for biofuels may not be structured to provide the spacing and pattern of habitat needed on the ground. Thus, the risk of conversion to cropland in such areas merits special attention, protection, and planning (Dale et al. 2010).

Within the last decade, more research and development projects have been directed toward understanding the potential of forest biomass to supply alternative energy sources. The U.S. Forest Service anticipates that woody biomass can help replace up to 30 percent of petroleum consumption by the year 2030 (USFS 2010). Harvesting of forest products

TVA windmills atop Buffalo Mountain-Michael Hodge is also seen as a positive mechanism for improving overall forest health while providing woody biomass for fuels (USDA 2014). Proper planning and utilization of these management practices in forests will be important for conserving terrestrial and freshwater habitats at both local and landscape scales

Wind

Improperly sited or operated wind turbines can directly affect native plant populations and wildlife, particularly birds and bats, especially during aerial migration at distinct geographic locations (Fiedler 2004, Nicholson et al. 2005). Negative effects can include direct mortality of animals, habitat loss, and habitat fragmentation. Birds and bats can be attracted to wind turbines by different lighting or operational features, and management attention to such features is warranted (Nicholson et al 2005). At present, wind production does not provide a significant portion of Tennessee's alternative energy portfolio. If facilities are to expand, considerations of cumulative impacts on population sizes and species ranges should be made (Fiedler 2004).

Hydropower

Finally, increasing the capacity of hydropower is believed to be a significant source of renewable energy across the U.S. (National Hydropower Association 2010). However, as previously discussed, dam construction and operations, including hydropower and other water management practices, have already significantly degraded natural river habitats in Tennessee. Alteration of existing dam structures to produce hydropower or the construction of new hydropower facilities must be considered in the context of these historic resource losses and with an eye to preventing further species and habitat declines (Grimm 2002).

4.3.6. Transportation and Service Corridors

Roads and other forms of transport, whether for people, utilities, energy, or goods, can directly impact habitats by damaging sensitive ecosystems, fragmenting habitat, and

Projected development to the year 2060 (shown in red) clearly shows linear branch development along roads in Tennessee-SLEUTH Projected Urban Growth dataset, GCPO LCC Conservation Planning Atlas

Perched culvert, impassable to small aquatic organisms. - Sam Beebe

creating barriers to movement of both species and the natural flow of water in wetlands and riverine habitats. Transportation routes are responsible for linear branch development, and the construction of highways and roads can cause rapid outgrowth from urban cores. For these reasons they are commonly considered in forecasting urban sprawl (Bhatta 2010).

Improperly designed road crossings such as bridges and culverts can fragment stream habitats, cause erosion, prevent the migration of species throughout a watershed, and impact local abundance and species richness of fishes in a stream. For example, one study in West Virginia found that in stream sections located above impassable culverts, fewer than half the number of species and less than half the total fish abundance occurred when compared with sections upstream of passable culverts (Nislow et al. 2011). This suggests that simple monitoring protocols to detect differences in local abundance and species richness could serve as indicators of problem barriers. Consideration of these problems can lead to better advance planning to avoid streams, improve engineering designs, and promote the use of less problematic materials (Warren and Pardew 1998, USDOT-FHA 2007). The USFWS, TWRA, and TDEC have begun looking at this issue in-depth, with the intention of working with state, county, and municipal departments during scheduled road maintenance to replace barriers with **passage-friendly culverts** and crossings across the Tennessee landscape.

Small fish, such as the Chucky Madtom, can be affected by lack of connectivity and dredging. - Conservation Fisheries, Inc.

In river environments, dredging for navigational channel maintenance is a key issue, particularly on the Tennessee and Cumberland River mainstems. Dredging destroys or degrades river bottom habitats and bottom-dwelling species; it also stirs up sediment, affecting downstream habitats. For these reasons, both the U.S. Fish and Wildlife Service and

TWRA have management oversight requirements relative to dredging, monitoring, and relocating species to protect them from channel dredging on a regular basis.

4.4. Habitat Management and Biological Resource Use Challenges

4.4.1. Fire suppression

Many of Tennessee's upland systems, as well as some types of wetlands, have been shaped and maintained by periodic fire – a process that was historically maintained to a large degree by Native Americans. Decades of fire suppression have degraded these systems and have changed the human perception of fire and its role on the landscape. Many species of wildlife depend on the plant communities that develop following a fire, in particular birds dependent upon grasslands and woodlands (EGCPJV 2014).

Prescribed burn at Catoosa Wildlife Management Area - Clarence Coffey, TWRA (retired)

In the Great Smoky Mountains National Park (GSMNP) fire suppression has occurred over the past 60 to 70 years; this is exacerbated by the construction of homes and cabins in the vicinity of the park. Lack of fire leads to fuel buildups in the form of heavy accumulations of dead wood and brush. Under drought conditions, this fuel can contribute to catastrophic wildfires that are bad for people, their property, and natural forest systems (NPS 2015d).

Prescribed fire (the controlled application of fire in selected habitat areas) is a management practice that can directly address the problem of altered fire regimes. Prescribed fire reduces the risk of wildfire and costs much less than wildfire. However, prescribed fire is not widely and publicly recognized, embraced, or supported as a beneficial practice. (EGCPJV 2014, TNPFC 2015). In Tennessee, restoration of oak and pine savannas and woodlands, native grasslands, and high-quality early successional habitat requires fire, although the application, timing, and intensity of fire needed differs depending on the natural system (Harper and Birckhead 2012).

Prescribed fire as a management practice is more practical and less controversial in some areas versus others. For example, at Arnold Air Force Base in the Barrens region of Tennessee's Eastern Highland Rim, prescribed fire has been incorporated into the management regime to benefit natural communities while also accomplishing a highly complex military mission. The prescribed fires are used to restore barrens habitat – Tennessee's prairie ecosystems – and to manage fuel loads in the Tennessee Army National Guard's weapons firing area as a means of preventing wildfire that interrupts training (DOD 2006).

4.4.2. Recreation

Tennessee's landscapes provide a wonderful array of recreational activities that contribute to the quality of life of both citizens and visitors, and which promote the state and local economies. Proper

ATV, All Terrain Vehicle-Jassen

management of recreational activities in many situations can be critical to promoting the protection of habitat and species, which in many cases are themselves one of the prime draws for visitors. A variety of recreational activities in natural area habitats can be detrimental, usually through the impacts of overuse.

One example is the growing concern that rock climbing, which has exploded in popularity in recent decades, could adversely affect the diversity of plant species that grow in specialized environments. The Obed River Gorge is a popular rock climbing destination, yet its vascular plants, bryophytes, and lichens make up one of the richest floras in the southeastern U.S. (Walker et al. 2009). Research on this topic indicated some impacts of foot traffic on vascular and non-vascular species, with a slight shift in lichen species composition on the cliff faces in response to climbing (Walker et al. 2009).

Another example is the importance of proper planning and management of horse riding trails. Studies have shown that damage to vegetation and stream water quality can occur when trails are not located properly, have maintenance issues, or are not properly followed by riders (Marion and Olive 2006). Good planning and maintenance can reduce potential damage and keep horse trails safe and enjoyable for the public.

The impacts of all-terrain vehicles (ATVs) and other recreational vehicles (RVs) can be significant in certain cases, but they are highly localized. TWRA allows restricted use on dedicated trails on some WMAs; however, the demand for trail access is growing. Without sufficient resources for signage and enforcement, this type of use in areas set aside for wildlife could pose a more significant threat. In addition, while most riders are responsible, as the number of riders coming from out-of-state is increasing, pressure on public and private lands will likely increase if greater density of use occurs.

Generally, people may not realize the extent to which ATVs and OHVs can damage the environment (TVA 2006). Mangled vegetation, destroyed wildlife habitats, severe soil erosion, and sedimentation of streams are the main impacts of ATVs and OHVs in sensitive or inappropriate areas, particularly when users blaze new trails; do not use designated stream crossings; or even ride within streambeds. The damage caused to wildlife and water quality by riding in streams has caused some states like Missouri and Georgia to outlaw the activity.

Eastern Box Turtle, a species that is sometimes taken from the wild as a pet. - Ezra Freelove

4.4.3. Overuse of Biological Resources

The collection of particular plant and animal species in different regions of the state must be monitored, and regulations enforced, to prevent overharvest and species population declines. Illegal poaching of desirable plants, particularly medicinal species, from both public and private lands is an issue in Tennessee.

According to the Tennessee Department of Environment and Conservation, ginseng is the number one poached plant (Lincicome 2015). This species has historically been used for medicine by Native Americans and is still valued for this purpose, particularly for use in Asian products. Goldenseal and orchids also are highly popular species.

The trade of ginseng and many other plant species is regulated under **CITES**, the Convention on International Trade in Endangered Species of Wild Fauna and Flora. TDEC administers a **licensing program** to regulate and monitor the harvest and export of American ginseng from Tennessee, and collection of ginseng on the Cherokee National Forest requires a permit from the U.S. Forest Service.

In some cases, such as the collection of turtles as pets, the problem is part of a web of interrelated issues. For example, as development fragments habitat, Box Turtles near urban areas increasingly encounter humans, domestic pets, and automobiles -- all of which can lead to direct mortality, impacts to overall health, and removal of reproductive individuals from wild populations (Andrews et al. 2013). This is significant, as loss of adults can cause declines in turtle populations regardless of reproductive rates (Bowen et al. 2004).

4.5. Pathogens and Invasive/Exotic Species

4.5.1. Pathogens

Novel pathogens are a continuing and growing problem in Tennessee as well as other parts of the U.S. Emerging infectious diseases pose a growing threat to wildlife, yet appropriate actions to manage outbreaks before, during, and after invasion are only in the beginning stages. Researchers active in this field have proposed definitions for recognizable stages of pathogen invasion and means for control or treatment appropriate to each stage. However, one of the best means of addressing

Pathogen infection: Little Brown Bat with White-nose Syndrome - Dustin Thames, TWRA

this threat will be prevention at the federal level, through quarantine and trade restrictions on common vectors for the introduction of new pathogens (Langwig et al. 2015).

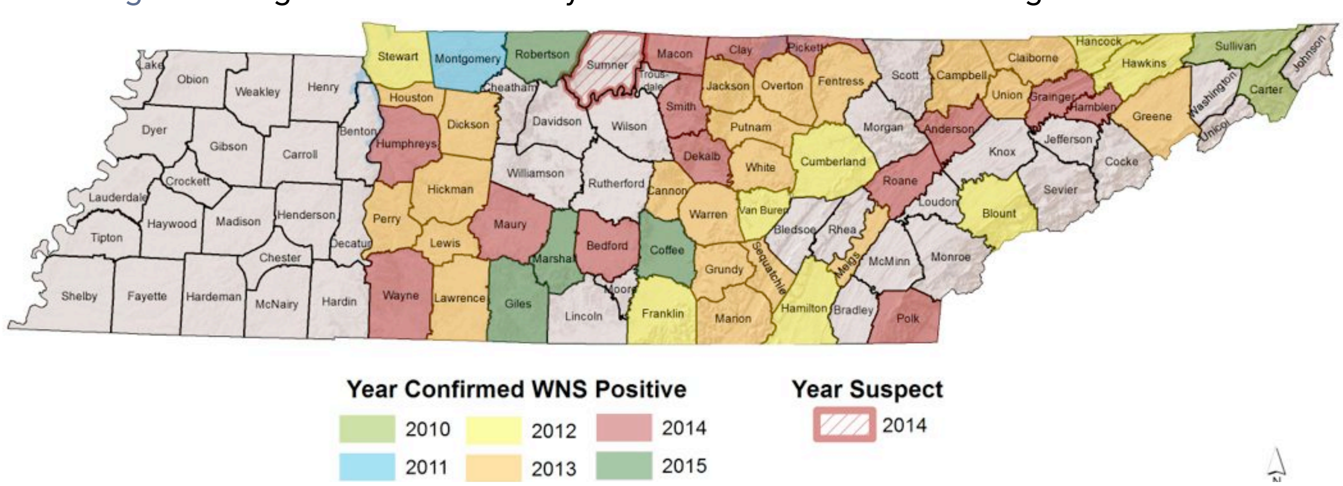
White-nose Syndrome

The challenge of White-nose Syndrome (WNS) in bats clearly illustrates how rapid, and devastating, pathogens can be. This disease had not even been considered a major problem in 2005, the date of first publication for State Wildlife Action Plans. WNS was first documented in New York in 2006-07 and has since spread across the eastern U.S. and Canada to more than 25 states and 5 Canadian provinces. TWRA confirmed the first case of WNS in Tennessee in February 2010.

Seven of the sixteen bat species that occur within Tennessee have been documented as having histologically confirmed cases. The syndrome is named for the characteristic white fungus (*Pseudogymnoascus destructans)* that causes white spots on the muzzle, ears, and wings of affected bats. Although it is not fully understood how WNS kills bats, the leading hypothesis is that infections arouse the bats during hibernation, causing them to exhaust their fat reserves prior to emergence in the spring. Essentially, they starve to death. Mortality rates differ among bat species (TNBWG 2014).

By 2014, WNS had killed more than 5.5 million bats in the U.S., and nothing has yet been effective in halting its spread. According to the Tennessee Bat Working Group, human transport of the fungus is probable, thus in 2009, the USFWS issued a cave advisory urging the closure of all caves and the implementation of a cave gear disinfection protocol to limit its spread between caves. In Tennessee, the National Park Service, The Nature Conservancy, Tennessee Wildlife Resources

Figure 4. **Progress of White-nose Syndrome in Tennessee 2010 through 2015**



Agency, Tennessee Valley Authority, Tennessee Department of Environment and Conservation, and the Tennessee Division of Forestry all had closed access to caves on their properties at the time (Lamb and Wyckoff 2010). Figure 4 shows the current distribution of WNS in Tennessee.

Chytrid Fungus

Another highly publicized threat is that of chytrid fungus (*Batrachochytrium dendrobatidis)* to amphibian species worldwide, including in Tennessee. Chytrid affects Hellbender salamanders (see Hellbender case study, Ch. 5). Both WNS and chytrid have caused mass mortality events and extinctions or extirpations in multiple species (Langwig et al. 2015).

Ranavirus

Ranaviruses are emerging pathogens of amphibians, reptiles, and fish, which have been associated with die-offs in the Americas, Europe, and Asia. With death rates often 90% or greater during an outbreak, as well as mounting evidence that some ranaviruses can be transmitted among all three of these vertebrate classes, these pathogens pose a substantial risk to Tennessee's biodiversity (Global Ranavirus Consortium, 2015).

Snake fungal disease causes swelling, crusty scabs, or open wounds in snakes - Danny Bryan, Cumberland University

Snake Fungal Disease

Another prime example of the pathogen threat is Snake Fungal Disease, an infection that has afflicted populations of snakes, primarily venomous species, from the northeast through the Midwest, and was recently discovered in Tennessee. This disease appears to be triggered by the fungus *Ophidiomyces ophiodiicola*, which is relatively new to science. At this time, it is not known whether this fungus has always been present in the environment, if it was introduced, or if perhaps it has recently mutated allowing it to cause more severe disease (NEPARC 2013). Researchers at University of Tennessee at Knoxville, Cumberland University, and Middle Tennessee State University have been working to document the spread of fungal infection in Timber rattlesnakes and other reptile species.

4.5.2. Invasive and Exotic Species

Invasive species, including both plants and animals, are a management concern across the state, along with the level of financial support and labor required to manage them. Invasive plants alter the composition, structure, and function of native ecosystems, while invasive animals can directly destroy habitat and reduce species populations through predation or competition. Intensive and extensive management is often required to prevent these undesirable ecosystem changes. Most invasive species are introduced non-natives (i.e. exotic), though not all.

Invasive and exotic plants

According to a survey and research conducted by the Tennessee Exotic Pest Plant Council, invasive plants cost the state of Tennessee at least $2.6 million annually. This figure only includes direct costs of control, mapping, and outreach. It does not include indirect costs associated with:

- ✦ Decreased agricultural yields;
- ✦ Lower property values;
- ✦ Diminished recreational opportunity; or
- ✦ Decreased diversity and wildlife habitat.

(TN-EPPC 2015).

While there are many invasive plant species in Tennessee, the following examples illustrate some of the current threats they pose:

✦*Lespedeza cuneata* and *Lespedeza bicolor* are particularly difficult to deal with when using fire as a management tool, as they are tolerant of fire and may even respond positively.

Lespedeza bicolor - Miya.m Wikimedia

These introduced species replace native vegetation, alter wildlife habitat, reduce diversity, and can limit restoration options because they can prevent grass growth and tree establishment. (USFS 2015a).

✦*Microstegium,* a grass species introduced from Asia, and *Ligustrum sinense*, or Chinese privet, are both insidious invasive species problems. Once established, they can be resource intensive to remove or control.

Tree of heaven, kudzu, and multiflora rose also are examples of species categorized as severe threats that spread easily into native plant communities, displacing native vegetation. Of growing concern are Callery pear trees invading natural habitats, particularly in Middle Tennessee. The seeds of the parent – the cultivated variety Bradford pear tree - are not sterile, and when distributed by birds and other wildlife revert back to the more aggressively growing Callery pear.

Invasive and exotic insects

A number of invasive insect pests threaten Tennessee forests annually. These include the following, all of which are introduced with the exception of pine beetles:

- ✦ Hemlock Woolly Adelgid
- ✦ Emerald Ash Borer
- ✦ Southern Pine Beetle
- ✦ Gypsy Moth
- ✦ Asian Longhorned Beetle

HWA infestation on hemlock-Nicholas A. Tonelli

Beetles that prey on HWA-Chris Simpson, TWRA

Figure 5. Hemlock Wooly Adelgid rate of spread

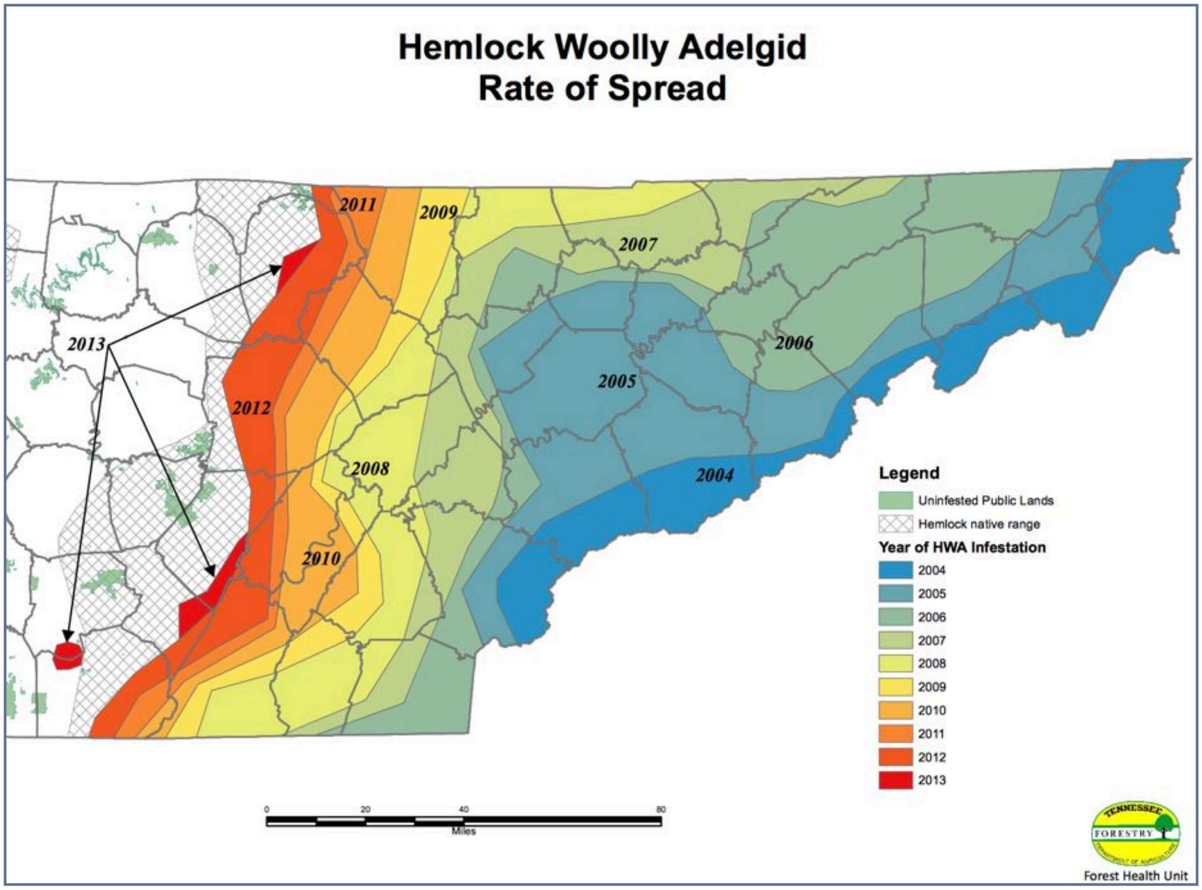
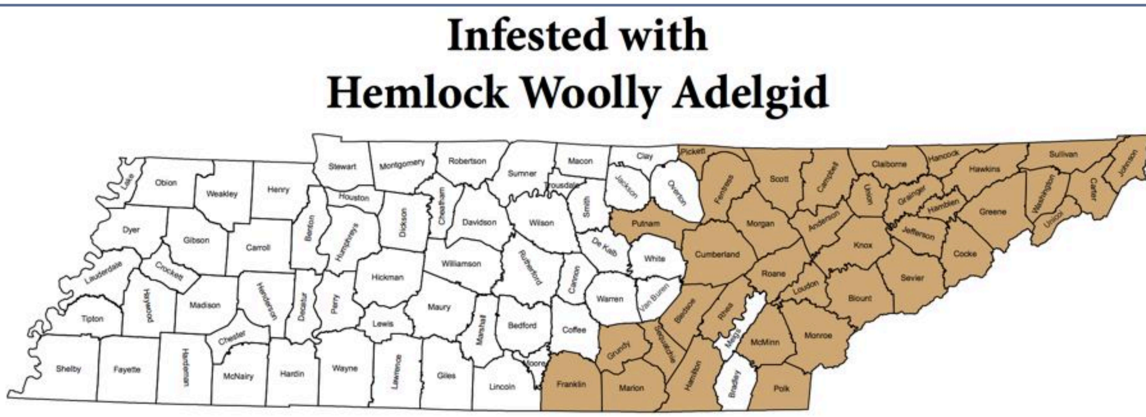


Figure 6. Tennessee Counties Infested with Hemlock Wooly Adelgid



Hemlock Woolly Adelgid infested counties

In Tennessee, 37 counties are known to be infested with HWA. They include **Anderson, Bledsoe, Blount, Campbell, Carter, Claiborne, Cocke, Cumberland, Fentress, Franklin, Grainger, Greene, Grundy, Hamblen, Hamilton, Hancock, Hawkins, Jefferson, Johnson, Knox, Loudon, Marion, McMinn, Monroe, Morgan, Pickett, Polk, Putnam, Rhea, Roane, Scott, Sequatchie, Sevier, Sullivan, Unicoi, Union, and Washington**.

Six states with HWA quarantines are Maine, Michigan, New Hampshire, Ohio, Vermont, Wisconsin and Canada. Entry requirements for hemlocks from infested or adjacent areas vary from state to state. A State Phytosanitary Certificate is required. The state summaries can be found at http://na.fs.fed.us/fhp/hwa/quarantines/quarantines.shtm or at the National Plant Board (NPB) laws and summaries site http://nationalplantboard.org/laws/.

Forest Health

February 10, 2015

http://protecttnforests.org/hemlock_wooly_adelgid.html

(TDF 2015)

The example of Hemlock Woolly Adelgid (HWA) serves to illustrate the issues surrounding invasive insects. Hemlocks are slow-growing, long-lived evergreens critical to the ecosystems in which they occur because they provide dense shade that helps to keep forest streams cool throughout the hot summer months. Since 2002, adelgids have been causing hemlock mortality, killing trees that are hundreds of years old in as little as three years. The HWA has caused extensive hemlock mortality in the Great Smoky Mountains National Park and the Cherokee National Forest. As of 2015, almost all counties in Tennessee with native hemlocks have these infestations (NPS 2015c) (See Figures 5 and 6).

While effective chemical treatments for these pests are available to individual landowners, they are cost prohibitive and impractical to address the problem on a landscape scale. Researchers and natural resource managers are working to find an effective mix of chemical and biological controls that can help protect some populations of hemlocks or slow down infestations (Wisby and Palmer 2015).

Invasive and exotic animals

Exotic animals pose similar problems to invasive plants and insects, and in addition they can directly impact native animal populations. Examples of current threats posed by exotic animals include:

✦Invasive crayfish are an issue in many areas of the state, as noted in the Tennessee Aquatic Nuisance Species (ANS) Management Plan (TANSTF 2008).

Crayfish burrow - Carl Williams, TWRA

Competition from both native crayfish (which are often transported across drainages in bait buckets and released into new areas of the state) and nonnative crayfish can displace or contribute to the decline of native species and overall diversity. Some species may hybridize with natives, and some also impact habitat through their burrowing

Surgeon Crayfish - Carl Williams, TWRA

The non-native Kentucky Crayfish is invading Surgeon Crayfish habitat and negatively affecting their populations. - Carl Williams, TWRA activities or destruction of aquatic vegetation.

✦Silver Carp, also noted in Tennessee's ANS Plan, may be a problem for big river GCN species. Wild populations were probably originally the result of escape from aquaculture facilities or shipments mixed with grass carp. Silver carp compete for food with native plankton-eating species including Paddlefish, Bigmouth Buffalo, Gizzard Shad, the larval fishes of many species, and freshwater mussels. The noise of boat motors induce Silver Carp to leap out of the water, creating the potential for human injury or fatality. Commercial fishermen have abandoned fishing sites on the Missouri River due to the high numbers of Asian carp in their nets (TANSTF 2008).

✦Although Mosquitofish are widely introduced as mosquito control agents, according to the Tennessee ANS Plan, critical reviews of the literature do not support the view that they are very effective in reducing either mosquito populations or mosquito borne diseases. Depending on what they choose to eat, Mosquitofish introductions can lead to algal blooms or even cause an increase in mosquitoes. Mosquitofish are extremely aggressive and can affect native fishes through direct competition and often attack, kill, or eat other fishes. In Tennessee, they pose a threat to imperiled Barren's Topminnow (*Fundulus julisia*) populations in the few springheads where this species occurs (TANSTF 2008).

Damage caused by Wild Hogs, Bush Farm, Jefferson County - Scott Dykes, TWRA

✦Wild Hogs cause extensive damage to crops, wildlife habitat, and plant populations; contribute to erosion and water pollution; and carry diseases harmful to livestock and other animals as well as humans. Wild Hogs are prolific reproducers and do massive damage to the land through feeding and wallowing. They are also omnivorous, and will eat just about anything they can find. Wild Hog depredation can cause turkeys, ground-nesting birds, amphibians, and reptiles to suffer population decreases (Cox 2014). Wild Hogs also root up acres of land, including native plant populations, which requires significant time and money to repair. The damage that Wild Hogs cause has become more common and widespread, as they have gone from being present in 15 counties in 1992 (~16%) to nearly 84% of Tennessee's 95 counties in 2015.

4.6. Air Pollution

4.6.1. Acid Rain

Acid precipitation is caused by air pollution, primarily nitrogen oxides and sulfur dioxide from the burning of fossil fuels for electricity production and, to a lesser degree, nitrogen oxides in automobile exhaust. These chemicals react in the atmosphere to form nitric and sulfuric acids, which fall to earth as both wet and dry deposition (EPA 2012).

Decades of research have made it clear that acid rain causes slower growth, injury, or death of forests by:

- damaging leaves
- limiting the nutrients available to plants
- exposing plants to toxic substances that are slowly released from the soil.

(EPA 2012, USFS 2013)

Acid rain has contributed to forest and soil degradation in many areas of the eastern U.S., particularly high elevation forests of the Appalachian Mountains that include areas such as the Great Smoky Mountains National Park (EPA 2012).

Red Salamander (left) and Mud Salamander (right): amphibian and aquatic species are especially sensitive to acid precipitation. - Chris Simpson, TWRA

Acid rain, coupled with other problems such as invasive exotic species, pathogens, and climate change, has decimated Tennessee's high elevation spruce-fir forest. These forests provide important habitat for several rare and endangered species, such as the Spruce-fir Moss Spider (Gunnarsson and Johnson 1989, TWRA 2005).

The effects of acid deposition in aquatic systems are no less severe. It causes a cascade of effects that harm or kill individual fish, reduce populations, extirpate fish species from a waterbody, and decrease biodiversity. In watersheds where soils do not have a buffering capacity, acid rain releases aluminum from the ground into lakes and streams, thus as acidity in a lake or stream increases, so does aluminum. Both increased acidity and aluminum are toxic to fish (EPA 2012).

According to TDEC, 41 miles of streams in Great Smoky Mountains National Park have very low pH (i.e. are very acidic). While all streams in the park are more acidic than they were 20 years ago, air quality is improving. Acidic streams are suspected to be the main cause for the decline of the native brook trout population in the park (NPS 2015a).

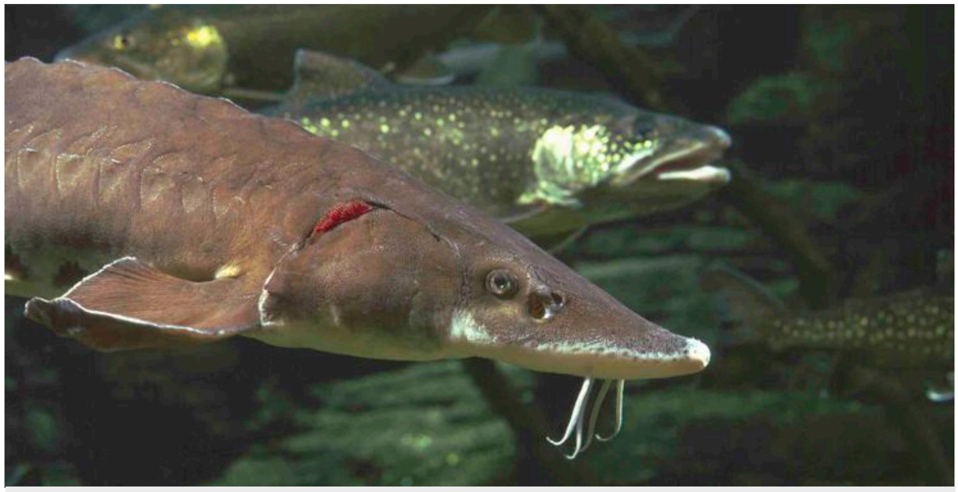
4.6.2. Ozone Pollution

Ground level ozone pollution (as opposed to the protective stratospheric layer) is a problem in GSMNP and other regions of the state, and it derives from sources similar to those that create acid rain. Ozone exposure levels on park ridge tops are up to twice as high as those in Knoxville and Atlanta. These levels are sufficient not

Auto exhaust contributes to ozone pollution - "biofriendly"

only to injure trees and plants, but also to threaten human health. Research has found that the following plants show signs of ozone damage in GSMNP: black cherry, milkweed, tuliptree, sassafras, winged sumac, blackberry, and cutleaf coneflower (NPS 2015b).

4.6.3. Mercury



Concentration of toxins through biomagnification is most likely to occur in large long-lived fish, such as Lake Sturgeon, which can affect fish development and pose a threat to people who consume them. - Todd Stailey, Tennessee Aquarium

Fish sampling surveys in the U.S. have shown widespread mercury contamination in streams, wetlands, reservoirs, and lakes, with 33 states -- including Tennessee -- having issued fish consumption advisories due to mercury contamination. Mercury is second only to PCBs as a pollutant impairing Tennessee ponds and lakes (TDEC 2012/EPA 2015). According to the USGS, the continental to global scale of mercury contamination is due to widespread air pollution (USGS 1997).

Levels of mercury measured in air and surface water are low. Nevertheless, they pose a threat because living organisms do not quickly excrete mercury, and it undergoes both bioaccumulation and biomagnification. Bioaccumulation is the process by which organisms (including humans) can take up contaminants more rapidly than their bodies can eliminate them, causing mercury levels in their bodies to accumulate over time. Biomagnification is the buildup of contaminants through the food chain.

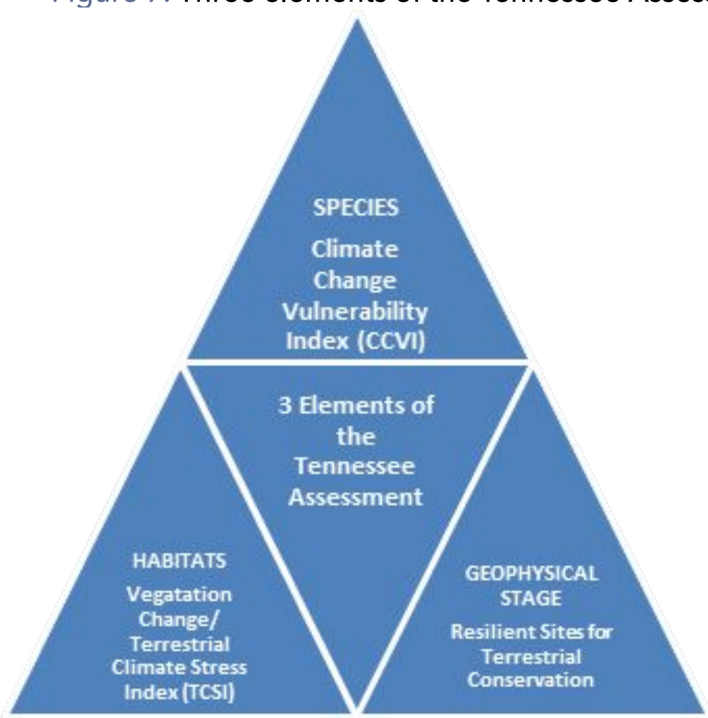
Coal-burning power plants are the largest human-caused source of mercury emissions to the air in the U.S., accounting for over 50 percent of domestically generated emissions; however, less than half of all mercury deposition within the country comes from U.S. sources (EPA 2014b).

4.7. Climate Change Vulnerabilities

The primary emphasis of Tennessee's updated climate vulnerability assessment was to use a multi-faceted approach and examine three major aspects of climate change impacts: species vulnerabilities, terrestrial and aquatic habitat changes, and landscape resiliency. Figure 7 summarizes these three major elements: assessment of *species* vulnerability using NatureServe's **Climate Change Vulnerability Index** (CCVI) (Young et al. 2011); assessment of terrestrial *habitat* vulnerability to climate stress including vegetation change; and evaluation of relative landscape resilience based on *geophysical settings* (Anderson et al 2014.) The focus on these elements together is intended to provide managers with a more comprehensive picture of climate change vulnerability by incorporating factors relevant to both species and habitats. The three-element approach is adapted from ideas piloted by the North Atlantic Landscape Conservation Cooperative for the Connecticut River watershed (NALCC 2014).

Details of the technical methods used in the assessment and results are provided in a 2015 SWAP companion report, *Climate Change Vulnerability Assessment for Tennessee Wildlife and Habitats* (Glick et al. 2015). The text and maps in the following sections are excerpted from this companion report to serve as a general overview of the results and application of the assessment work for informing further prioritization and strategy development during the 2015 SWAP update.

Figure 7. Three elements of the Tennessee Assessment



4.7.1. Species and Habitat Vulnerability Summaries

State fish and wildlife experts used NatureServe's **Climate Change Vulnerability Index** (CCVI) (Young et al. 2011) to assess a total of 189 GCN plant and animal species, including 15 mammals, 51 birds, 17 reptiles, 26 amphibians, 19 fish, 27 freshwater mussels, 8 crayfish, and 26 plants. Sixty-three percent (119) of the 189 species assessed scored as "Presumed Stable" or "Increase Likely," and 37% (70 species) were considered at least Moderately

Vulnerable (see Glick et al. 2015 for detailed species scores).

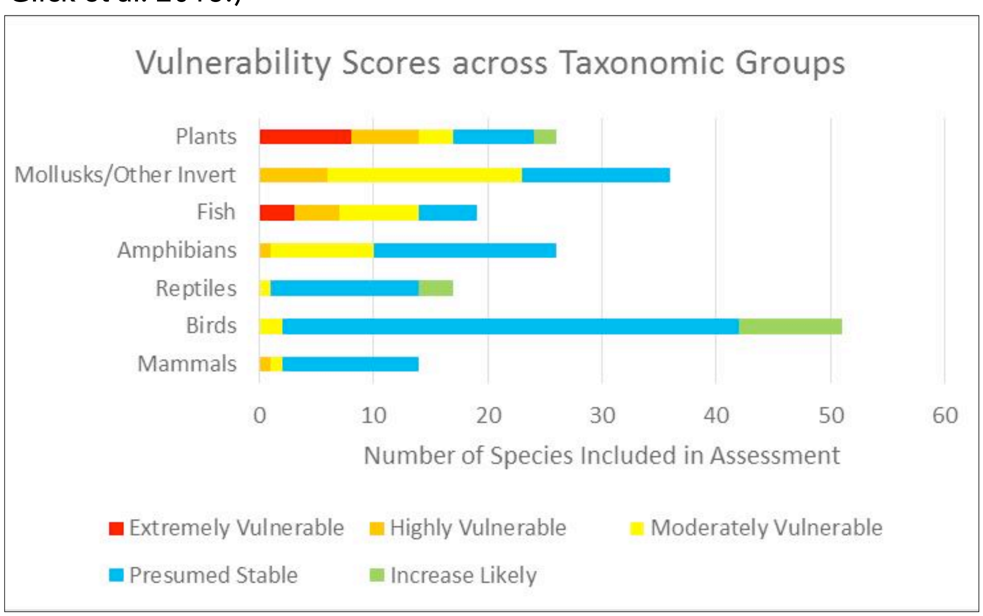
Mammals, birds, and reptiles comprise most of the species ranked as Presumed Stable or Increase Likely due, in part, to their mobility and other factors that enhance their adaptive capacity. Plants, fish, and mussels comprised the greatest number of species that ranked as Moderately, Highly, or Extremely Vulnerable for a variety of reasons, including the presence of natural and anthropogenic barriers to dispersal, restricted habitat range, and high levels of sensitivity to changes in temperature and moisture. Figure 8 provides a comparison of the CCVI vulnerability scores summarized across taxonomic groups. For more specific information on the scoring process and results, see Glick et al. 2015.

Brook Trout are coldwater species in Tennessee that may be impacted by warming waters. - Dave Herasimtschuk, Freshwaters Illustrated

Some of the most significant impacts of climate change on Tennessee's fish and wildlife species will be associated with potential changes to their habitats. Notable impacts include the following:

✦Changes in the composition of plant communities in both forest and grassland systems, particularly in the western portion of the state;
✦An increase in the frequency and severity of disturbances such as wildfires and outbreaks of already-problematic species such as Southern Pine Beetle (*Dendroctonus frontalis*) and Hemlock Wooly Adelgid (*Adelges tsugae*);
✦Shifts in the location and extent of suitable habitat for fish and other aquatic species due to higher water temperatures and altered water quality, with areas of coldwater habitat in mountain streams likely to decline and warmwater habitat projected to expand;
✦Changes in the timing and magnitude of streamflows and other hydrological conditions, including increased drying of ephemeral pools important

Figure 8. **Comparison of CCVI vulnerability scores across taxonomic groups. (For more specifics on the scoring process and results, see Glick et al. 2015.)**



to amphibians and other wildlife. Appendix F provides a summary factsheet of potential climate change impacts and strategies for Tennessee.

Given the complexities and uncertainties in climate projections and associated impacts, the general challenge for managers may be to consider how to transition Tennessee from its current mix of terrestrial habitats to a different mix without losing biodiversity (Joyce et al. 2008). The state's upland forest systems, for instance, support a great diversity of wildlife due in part to the variety of different habitats and niches found within a structurally diverse forest system (TWRA 2014). Managing for a diversity of habitat types, even if the composition of associated vegetation changes, may still support desired conditions for valued fish and wildlife.

With many of Tennessee's highly diverse aquatic species already considered at-risk for a variety of reasons, the additional threat from climate change is likely to exacerbate conservation concerns (TWRA 2009). Indeed, it is the combination of climate change and other stressors such as polluted runoff and barriers to stream connectivity that will have the greatest impact on aquatic habitats and the species that depend on them (Sun et al. 2013). An integrated approach to managing aquatic species and habitats that takes into account multiple stressors, including climate change, will be important to help the state meet its short- and long-term wildlife conservation goals.

Fish kill associated with drought in September 2012 on the Chickasaw National Wildlife Refuge - USFWS

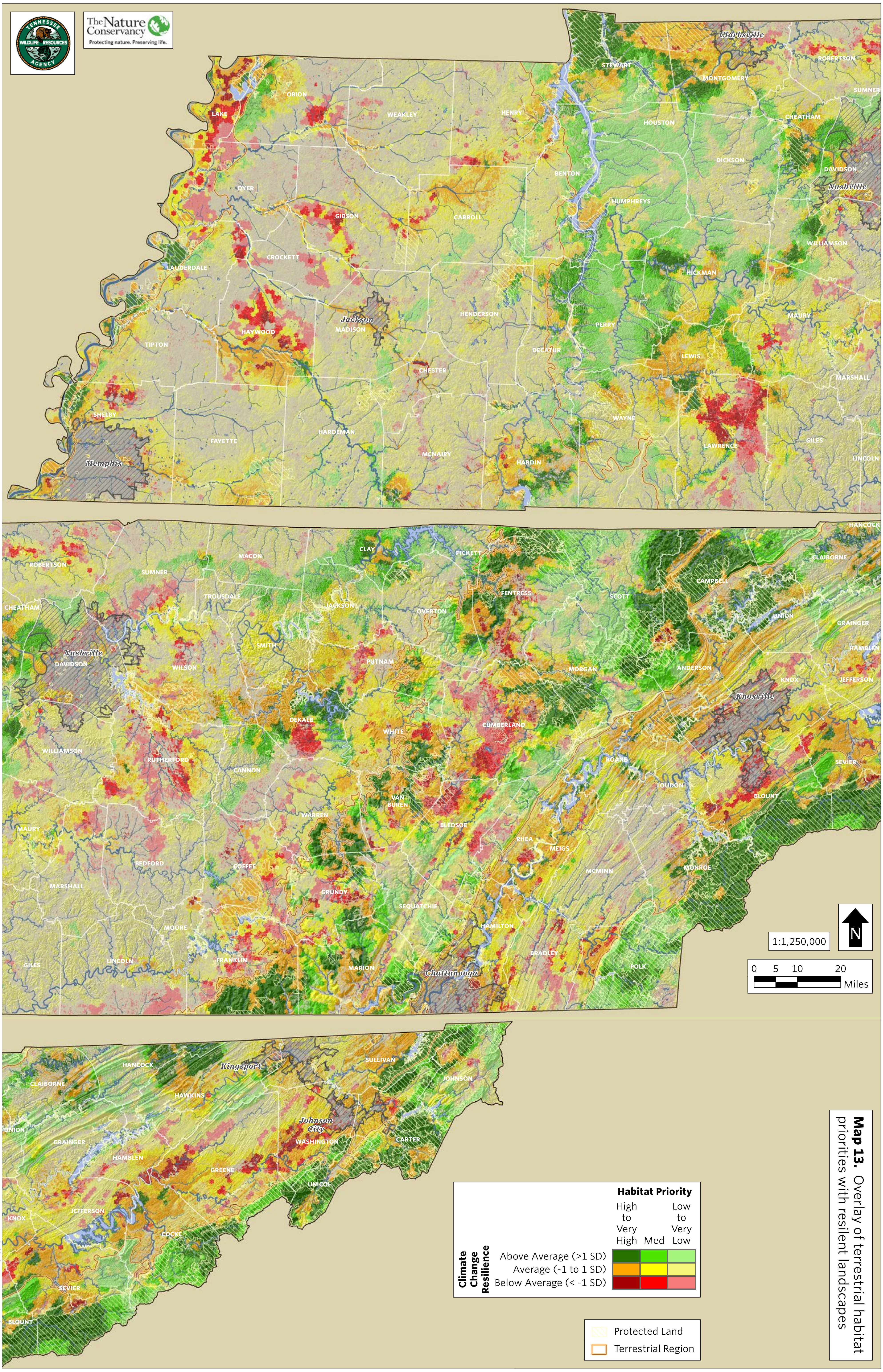
4.7.2. Spatial Vulnerability Assessment Maps

Tennessee's vulnerability assessment also includes a spatial analysis of climate change vulnerability across terrestrial habitats to help inform a landscape level understanding of potential issues across the state. The landscape vulnerability assessment draws from the approaches used by Joyce et al. (2008), Kershner and Mielbrecht (2012), and Anderson et al. (2014), with a focus on terrestrial habitat priorities updated by the 2015 SWAP (Glick et al. 2015). Several existing datasets and maps from these approaches are synthesized in the assessment, including:

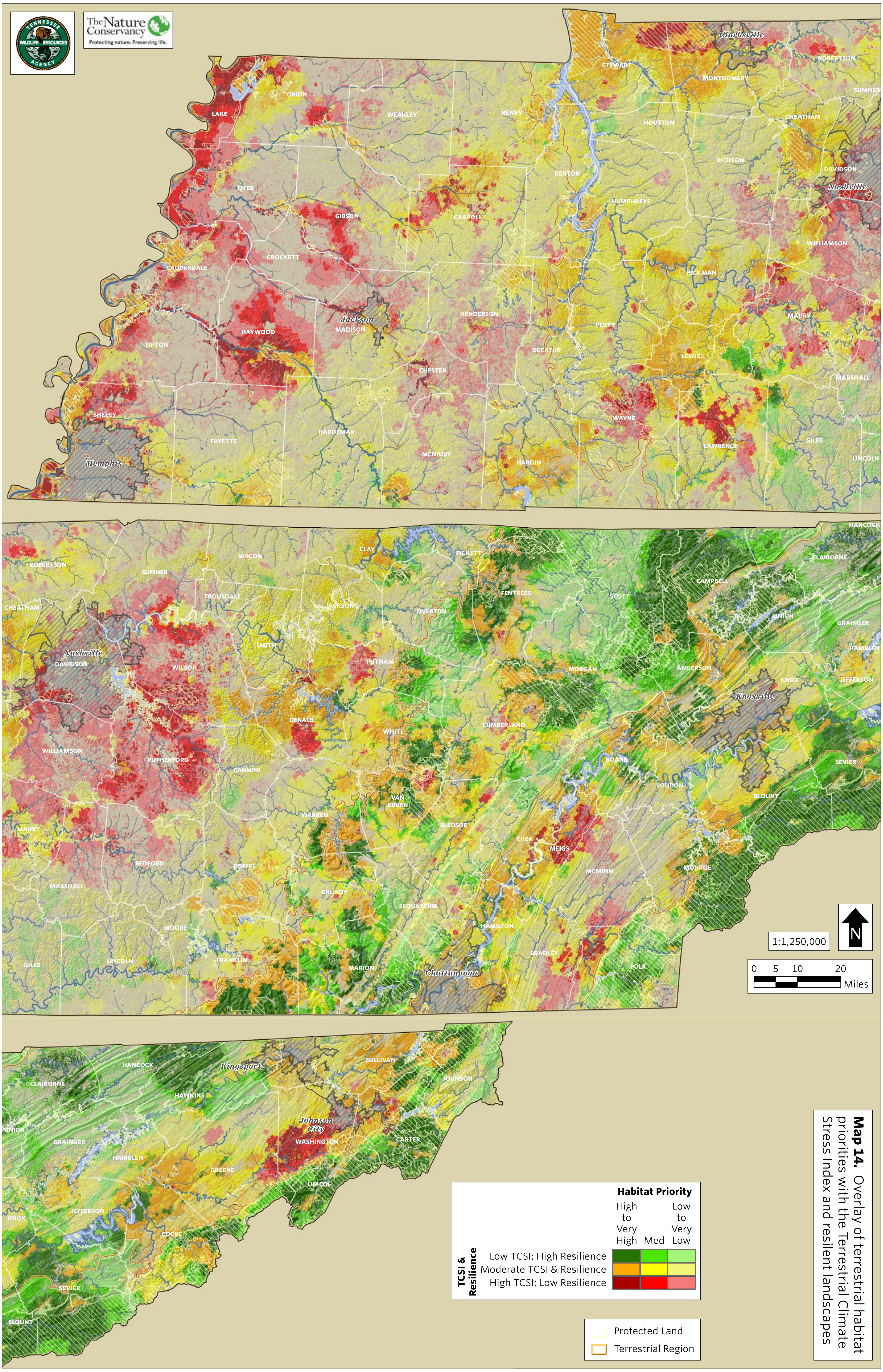
- Terrestrial GCN Habitat Priority areas in Tennessee;
- Potential vegetation change using a Terrestrial Climate Stress Index; and
- Resilient Sites for Terrestrial Conservation in Tennessee.

Two of the statewide vulnerability maps are provided below to illustrate the interplay between species, habitat, and resiliency in assessing climate vulnerability.

Map 13 shows an overlay of the landscape resilience to



Map 13. Overlay of terrestrial habitat priorities with resilient landscapes



Map 14. Overlay of terrestrial habitat priorities with the Terrestrial Climate Stress Index and resilient landscapes

climate change scores and the terrestrial habitat priority areas for Tennessee. Recall that both map inputs are stratified by ecoregion, meaning that sites within each ecoregion are compared only to other sites within the same ecoregion. Areas highlighted in darker green are high habitat priorities that coincide with relatively high landscape resiliency scores. Areas in yellow to light orange are high priority habitats within average locations of average landscape resiliency. Areas in darker red indicate places of high habitat priority but less than average resilience (i.e., higher potential climate change vulnerability). There are a number of areas across Tennessee that are identified as both high habitat priorities and resilient sites (the darkest green), which suggests that those particular resilient sites are likely to be important areas to maintain for biodiversity.

Map 14 combines information on the SWAP terrestrial habitat priorities with both landscape resilience and the terrestrial climate stress index (which incorporates potential vegetation change). Examining these data collectively makes it possible to identify those places of high habitat importance for terrestrial GCN species in 2015 that are in locations of comparatively low landscape resilience and facing higher climate stress, indicating overall vegetation types within those areas also may be changing.

Mississippi Alluvial Plain habitats may be vulnerable to climate change. - Rob Colvin, TWRA

In Map 14, the darker green areas are current (2015) high priority habitats for terrestrial species and are also showing higher degrees of overall resilience to potential climate stressors including vegetation change. The darker red areas are also current (2015) high priority habitats, but those which are showing greater vulnerability to climate change due to lower landscape resilience and higher potential for major vegetation changes.

While there is a fair amount of complexity in results across the state depending on the various factors considered, current habitat priority areas in certain regions -- such as the Mississippi Alluvial Plain, Upper East Gulf Coastal Plain, and the Nashville Basin subregion of the Interior Low Plateau -- appear especially vulnerable to climate change compared to other areas, such as the Cumberland

Plateau and Mountains and portions of the Southern Blue Ridge (Map 14). Management strategies for these areas will need to take into consideration the potential for dominant vegetation type changes as well as the lower capacity of the surrounding landscapes to provide niche refugia or connectivity to other areas with natural vegetation cover.

Forest of the Cumberland Plateau: relatively intact natural vegetation cover is one characteristic of these forests, which appear promising as habitat refugia. - Hunter Desportes

Places that are identified as resilient and face relatively low terrestrial climate stress, such as the forests of the Cumberland and Smoky Mountains, appear especially promising as habitat refugia. These eastern Tennessee landscapes have more complex topography and geology, more intact natural vegetation cover, and are less likely to experience major vegetation type shifts. Other areas, including the Western Highland Rim forests of the Interior Low Plateau in middle Tennessee and some higher elevation sections of the Southern Blue Ridge, are identified as resilient from a landscape feature perspective, but face higher terrestrial climate stress.

The Terrestrial Climate Stress Index (TCSI) rating identifies those areas more likely to undergo changes in terrestrial vegetation types. Also, the species CCVI results indicate that certain individual species may be vulnerable regardless of the potential for overall stability in their current surrounding landscapes. Therefore, management strategies for sites otherwise in resilient landscape settings will have to consider the potential trajectory of overall vegetation change as well as potential stresses on individual species of concern.

Climate change does not occur in a vacuum but rather acts synergistically with many other factors affecting Tennessee's GCN species. In some cases, climate change may not pose a major risk for a species, but that does not necessarily mean that the species is not otherwise imperiled. For example, a species assessed as Presumed Stable under the CCVI may still be impacted by other stressors unrelated to climate change, such as overharvest. Ultimately, managers will need to consider the broad context of conditions in which species and associated habitats exist, both now and in the future, in order to develop effective conservation strategies.

CHAPTER 5

CONSERVATION STRATEGIES AND ACTIONS

5.1. Defining Conservation Actions

THE 2015 SWAP PLANNING TEAM identified statewide conservation action priorities by reviewing the 2005 SWAP strategy hierarchy and the 2006-12 TWRA Nongame and Endangered Species Operational Plan (NGESOP), which was used by TWRA to begin implementation of the 2005 SWAP (TWRA 2006). The 2005 planning team used a standardized hierarchy to organize and define strategies, an approach now recognized as a Best Practice (AFWA 2012). The 2005 hierarchy was adapted from a format available at that time from the Conservation Measures Partnership and consisted of 2 broad categories, 6 major classes, 22 general actions and over 90 specific conservation actions. The Specific Conservation Actions were evaluated for their capacity to abate problems as determined through an expert-derived ranking process (see TWRA 2005, pp. 75-80).

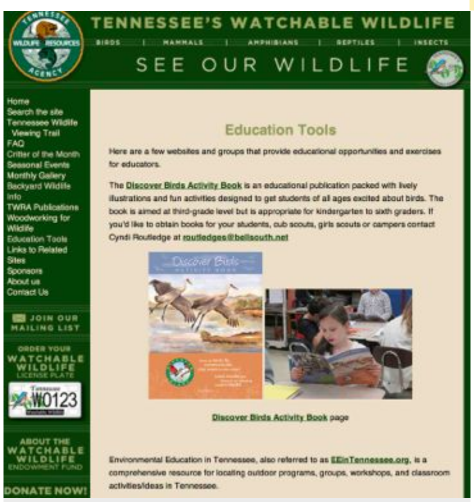
The 2005 strategy ranking information, compiled in the SWAP database, allowed for a general determination of which Specific Actions could be most appropriate to abate problems for terrestrial, aquatic, and subterranean species (see TWRA 2005, pp. 147-178). This ranking system alone, however, did not allow for the identification of geographically specific strategies, as major problems were not mapped during the 2005 effort. The 2006-12 NGESOP took the summary information on strategies in the 2005 SWAP and applied it to identify projects and outcomes for TWRA to achieve across the different ecoregions of the state, organized by the agency's administrative regions. A majority of these projects were successfully implemented during the last

Pogue Wilderness, Cumberland Plateau - Byron Jorjorian decade, and these experiences gave the 2015 planning team a foundation for understanding the relative applicability and success of various conservation actions in different places across the state.

The 2015 planning team determined that the 2005 strategy hierarchy, including all the General and Specific Actions, remains applicable to GCN statewide conservation efforts moving forward (Appendix G). The team chose to address General and Specific Actions that are most commonly implemented by TWRA in detail in the 2015 SWAP (see Table 15). Several other General Action categories -- particularly formal education and training, conservation finance, conservation enterprises, market forces, institutional improvements, and legislation -- can improve conditions for achieving conservation outcomes on the ground in meaningful ways. These types of enabling actions are successful most often in collaboration with a variety of partners and stakeholders, many times with these external partners in a leadership role. Therefore, the team determined that the specifics of when and how to execute these strategies is best addressed inde-pendently by partners or in collaboration with partners when appropriate. All SWAP partners and stakeholders

Summary: 2015 process for identifying and prioritizing conservation strategies and actions to benefit GCN species and habitats

1. Identify statewide conservation action priorities. Referring to the actions identified in both the 2005 SWAP and the 2006-2012 TWRA Nongame and Endangered Species Operational Plan, the SWAP planning team determined that the 2005 strategy hierarchy, including all the General and Specific Actions, remained applicable to GCN statewide conservation efforts.
2. Focus on a subset of the most important actions for addressing major problems identified in Chapter 4. In the 2015 SWAP, the team chose to elaborate in detail on 16 General Actions (in 5 Classes) that are most commonly implemented by TWRA and which address the major problems affecting species of Greatest Conservation Need and their habitats.
3. Define Conservation Opportunity Areas, a new approach in the 2015 update for focusing conservation efforts. The planning team considered three major attributes in designing COAs: GCN habitat priority, the problems affecting the habitats, and on-the-ground opportunities to implement conservation actions. The team stresses that COAs are not intended to artificially constrain decisions about what strategic actions are needed and where they apply.
4. Conduct vulnerability assessments and develop adaptation strategy approaches for GCN species and habitats in Tennessee. This is a new focus in the 2015 SWAP. The planning team identified which goals and strategies of the National Fish, Wildlife, and Plants Conservation Adaptation Strategy best align with TWRA's mission and expertise. The team worked with the National Wildlife Federation (NWF) to complete a "Climate-Smart" vulnerability assessment for Tennessee species and habitats and began the process of identifying the adaptation options for addressing key vulnerabilities.



TWRA's Watchable Wildlife website provides education tools and informas and promotes public engagement in wildlife conservation.

are encouraged to engage in these types of enabling strategies as best fits their organizational mission or individual expertise.

Table 15 provides a summary of the 16 General Actions (in 5 Classes) most commonly implemented by TWRA in a project leadership or funding role to achieve GCN species or habitat conservation outcomes since 2005. Under the General Actions listed in Table 15, the 2015 planning team also selected a total of 41 Specific Actions from the overall hierarchy as those most connected with TWRA's operational mission, capacity, and funding allocations for GCN management and assistance with federally-listed species recovery (Appendix H).

Table 15. Summary of conservation actions generally led and/or funded by TWRA in collaboration with partners to support GCN species and habitat conservation

Class	General Action
Habitat acquisition	Fee-title ownership Permanent protective easements
Information collection and dispersal	Communications and public relations Conservation planning Monitoring Research
Management and restoration of species and habitats	Compatible resource use Conservation area management Control/prevention of invasive exotic species and pathogens Habitat/Natural process restoration Species restoration
Capacity building	Alliances and partnerships
Law and policy	Compliance and enforcement Land use planning and zoning Policies and regulations Standards

The SWAP conservation actions, individually and collectively, will focus on addressing the major problems affecting species of conservation need and their habitats, as outlined in Chapter 4. These problems include addressing impacts from a wide variety of land and water uses; improving habitat quality and quantity; restoring species populations; and management to abate the negative effects of invasive species, pathogens, and climate change.

Successful conservation actions necessarily involve an emphasis on partnerships to achieve

- well-coordinated land and water management planning at a variety of spatial scales (i.e., regional, state, and local);
- effective environmental review and regulatory programs;
- expanded habitat acquisition and management;

- greater incentives for private landowner engagement in conservation;
- and education, research, and monitoring that fosters learning and improves our adaptive management capacity.

5.2. Conservation Opportunity Areas

Chapter 3 described the process for updating the SWAP terrestrial, aquatic, and subterranean habitat priorities. These habitat priorities are the most current geographic representation of the lands and waters across the state that are significant for protecting and restoring GCN species populations. Determining where and how to implement conservation actions involves many additional considerations including the problems affecting different places on the ground, the resources available to address the problems, and developing shared outcomes with conservation partners.

5.2.1. Designation Process for Conservation Opportunity Areas

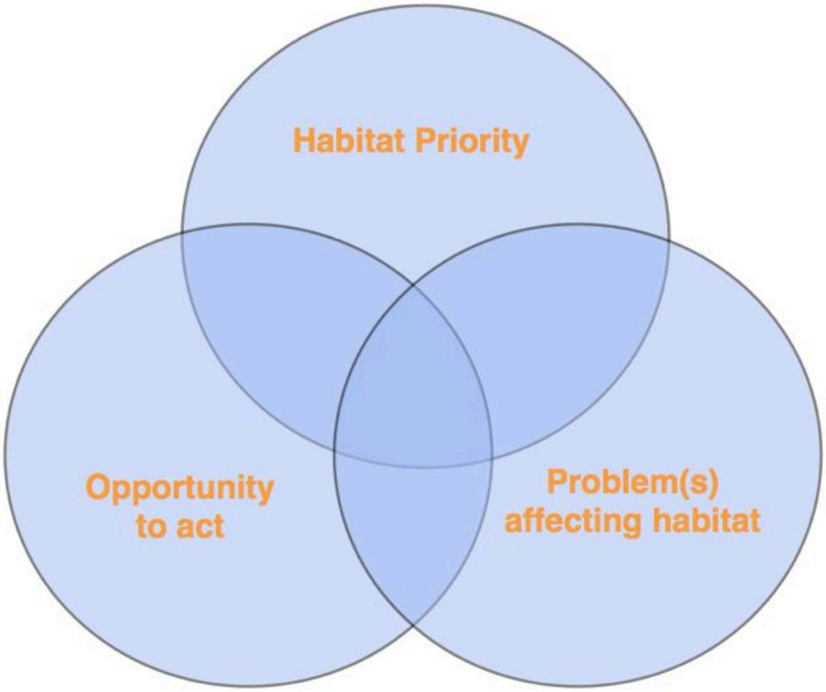
For the 2015 update, the designation of "Conservation Opportunity Areas" (COAs) is a new approach to help focus the conservation efforts, not only of TWRA, but also of a wide range of other agency and nongovernmental partners. The identification of COAs is a recommended best practice for SWAP updates (AFWA 2012).

Unlike the standard lexicon for classifying problems and conservation actions, COA designations vary from state to state and do not follow a specific method. Each state designates COAs in a manner consistent with its data availability, planning process, and priorities. While designing the COAs for Tennessee, the planning

"Spatially depict priority areas on the landscape that offer the best opportunities for GCN conservation and call them Conservation Opportunity Areas (COAs)." - AFWA Best Practices for SWAPs

Reelfoot Lake in west Tennessee, internationally recognized for its wildlife diversity, scenery, and recreational opportunities, is a designated Conservation Opportunity Area. - Rob Colvin, TWRA

Figure 9. Conceptual design of Conservation Opportunity Area selection



team considered three major attributes: GCN habitat priority, the problems affecting the habitats, and the on-the-ground opportunities to implement conservation actions (Figure 9). Several regional and statewide conservation planning efforts have been completed by other agencies since 2005. Many of these agencies collaborated with TWRA and used the 2005 habitat priorities to help inform their designations of significant conservation areas. In designing the COAs, the 2015 SWAP team referenced the following documents:

- Tennessee Heritage Conservation Trust Fund Act of 2005 analysis (TWRA, TDEC and TDA 2006);
- Tennessee Department of Environment and Conservation's **Tennessee 2020** plan (TDEC 2009);
- Tennessee Division of Forestry's **Tennessee Forest Resource Assessment & Strategy** (TDF 2010);
- **TWRA Strategic Plan 2014-2020** (TWRA 2014);
- West Tennessee Resources Conservation Plan (TWRA & USFWS 2004)

The COAs for Tennessee capture populations of GCN species and high quality habitats, and as appropriate, define the geographically relevant framework for achieving conservation outcomes. The COAs currently designed for Tennessee are large geographies, with the expectation that further prioritization and goal setting for specific habitat outcomes can be achieved within them through collaborations with partners on shared objectives.

The COA boundary designations do not carry any new legal, regulatory, or jurisdictional authorities, nor do they place any restrictions on land uses or activities occurring within these areas. COAs are intended to foster partnership collaborations, investments and voluntary actions to conserve habitat within a given region of the state. This general approach to COA development is consistent with other states such as Illinois, Missouri, and Pennsylvania.

Another important consideration is that COAs are not intended to be fixed, limiting geographic boundaries. As more projects are designed and executed with partners, changes to the COA designations may be useful to better represent new information or the footprint of a particular project opportunity. In addition, achieving habitat conservation objectives will require adequate consideration of all terrestrial, aquatic, and subterranean priorities regardless of whether they are physically located within a COA boundary at this time. Finally, other wide-ranging collaborations on issues such as maintaining forest health can potentially benefit many different geographies and COAs at once.

Table 16 summarizes the Tennessee COAs within their respective ecoregions, and Map 15 shows the locations of COAs in reference to statewide habitat priorities, while Maps 16-19 show the locations of COAs in relation to public lands and major cities (dividing the state into four sections west to east).

Appendix I provides summary information in the form of a stand-alone factsheet for each Conservation Opportunity Area across the state. This information includes a description of the area, lists of species and habitats, general desired conservation outcomes and associated monitoring strategies, as well as ongoing or proposed conservation partnerships.

5.2.2. Taking Action Outside of Conservation Opportunity Areas

The identification of Conservation Opportunity Areas helps define important geographies across the state where focused collaborations can improve outcomes for GCN species and habitats. However, not all populations of GCN species fall within COAs, and several types of significant conservation actions – such as land use planning, environmental reviews, and research – address issues that affect species and habitats across many different geographies.

COAs are not intended to artificially constrain decisions about what strategic actions are needed and where they apply.

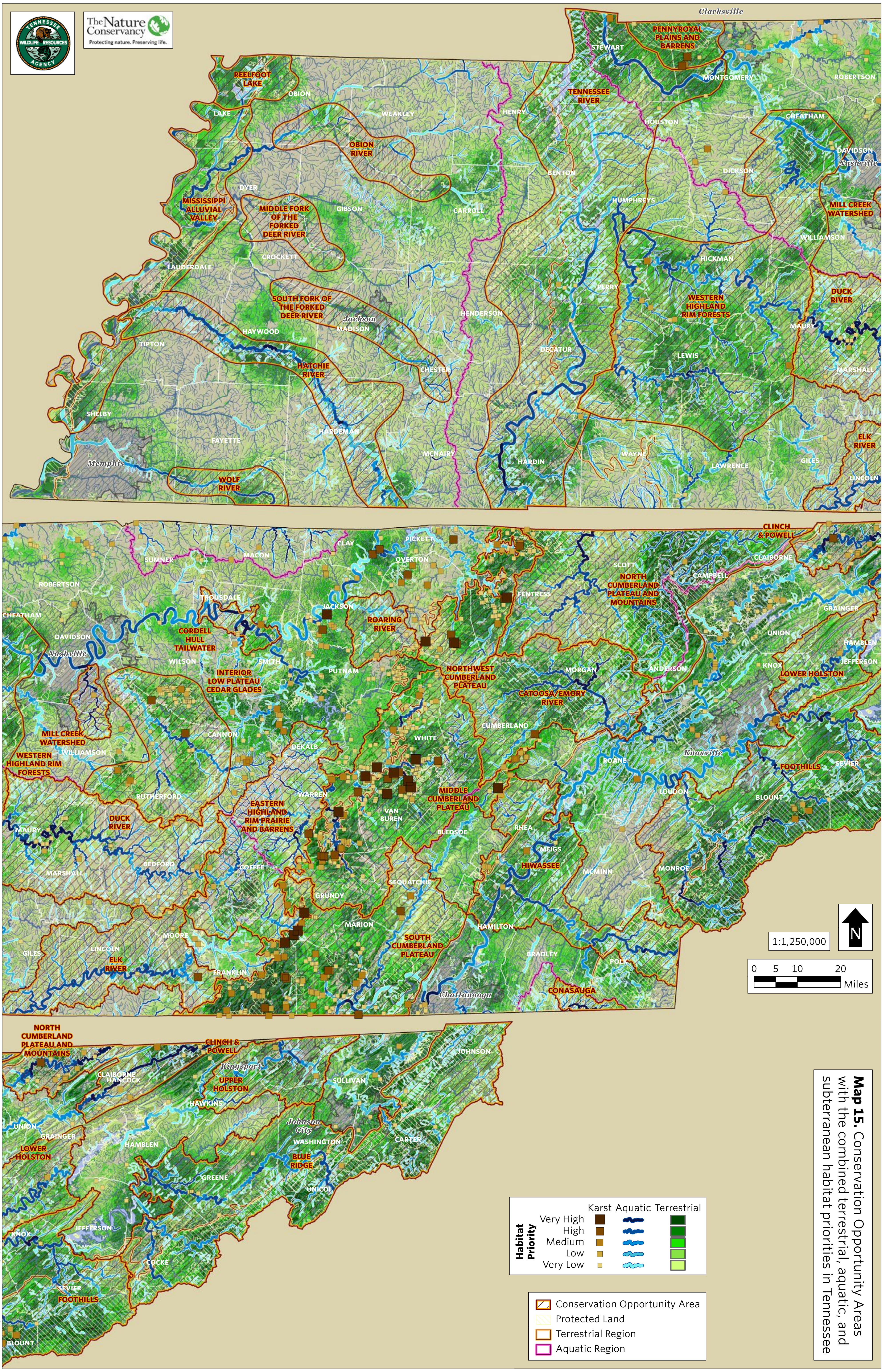
Other actions taken outside COA boundaries, such as stream barrier removals or using best practices for stormwater management, can show significant net benefits in both the local project area and for downstream aquatic habitats. Many of Tennessee's existing public lands contain one or more habitat types important for GCN species, and while most public lands are captured within COAs, some are not. As the assessment of potential climate vulnerabilities demonstrates, vegetation types may change over time, resulting in habitat type and distribution shifts from what are identified as priorities on the landscape today.

COAs, therefore, are not intended to artificially constrain decisions about what strategic actions are

Hellbender conservation takes place both within and outside of COAs - Joshua A. Miller

Table 16. Summary of Conservation Opportunity Areas and their location within terrestrial ecoregions and aquatic subregions

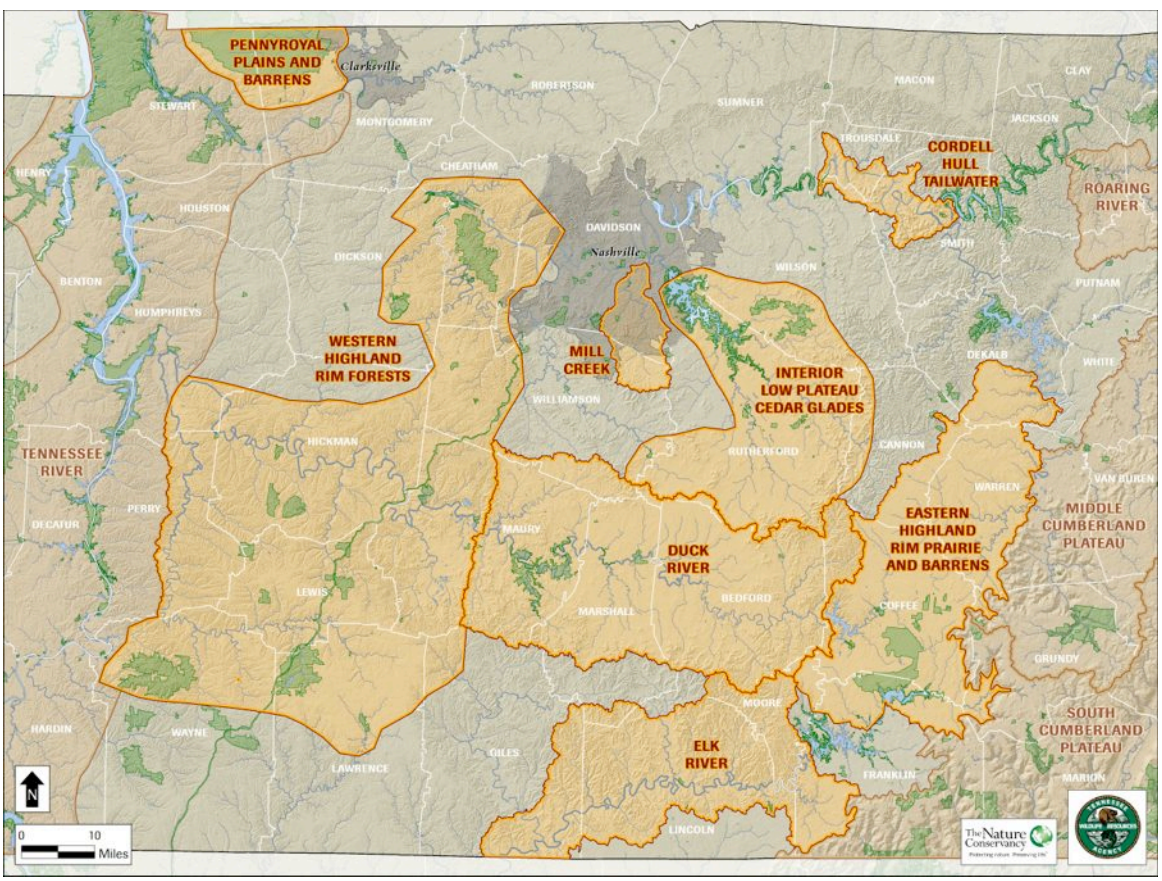
Conservation Opportunity Area	Terrestrial Ecoregion(s)	Aquatic Subregion(s)
Reelfoot Lake	Mississippi River Alluvial Plain	Mississippi
Mississippi Alluvial Valley	Mississippi River Alluvial Plain	Mississippi
Obion River	Upper Gulf Coastal Plain	Mississippi
Middle Fork of the Forked Deer River	Upper Gulf Coastal Plain	Mississippi
South Fork of the Forked Deer River	Upper Gulf Coastal Plain	Mississippi
Hatchie River	Upper Gulf Coastal Plain	Mississippi
Wolf River	Upper Gulf Coastal Plain	Mississippi
Tennessee River	Interior Low Plateau	Lower Tennessee, Lower Cumberland
Pennyroyal Plains and Barrens	Interior Low Plateau	Lower Cumberland
Western Highland Rim Forests	Interior Low Plateau	Lower Tennessee, Lower Cumberland
Mill Creek Watershed	Interior Low Plateau	Cumberland River-Nashville Basin
Interior Low Plateau Cedar Glades	Interior Low Plateau	Cumberland River-Nashville Basin; Upper Cumberland River
Duck River	Interior Low Plateau	Tennessee River-Nashville Basin
Elk River	Interior Low Plateau	Tennessee River-Nashville Basin
Eastern Highland Rim Prairie and Barrens	Interior Low Plateau	Tennessee River-Nashville Basin; Upper Cumberland River
Cordell Hull Tailwater	Interior Low Plateau	Upper Cumberland River
Roaring River	Interior Low Plateau	Upper Cumberland River
South Cumberland Plateau	Cumberland Plateau & Mountains	Tennessee River-Cumberland Plateau
Middle Cumberland Plateau	Cumberland Plateau & Mountains	Tennessee River-Cumberland Plateau; Upper Cumberland River
Northwest Cumberland Plateau	Cumberland Plateau & Mountains	Upper Cumberland River
Catoosa/Emory River	Cumberland Plateau & Mountains	Tennessee River-Cumberland Plateau
Hiwassee	Cumberland Plateau & Mountains, Ridge and Valley	Tennessee River-Blue Ridge; Tennessee River-Cumberland Plateau
Conasauga	Ridge & Valley, Southern Blue Ridge	Conasauga River
North Cumberland Plateau and Mountains	Cumberland Plateau & Mountains	Cumberland River-Cumberland Mountain; Upper Cumberland River
Clinch and Powell	Ridge & Valley	Tennessee River-Ridge & Valley
Upper Holston	Ridge & Valley	Tennessee River-Ridge & Valley
Lower Holston	Ridge & Valley	Tennessee River-Ridge & Valley
Blue Ridge	Southern Blue Ridge; Ridge & Valley	Tennessee River-Blue Ridge; Tennessee River-Ridge & Valley
Foothills	Southern Blue Ridge; Ridge & Valley	Tennessee River-Blue Ridge



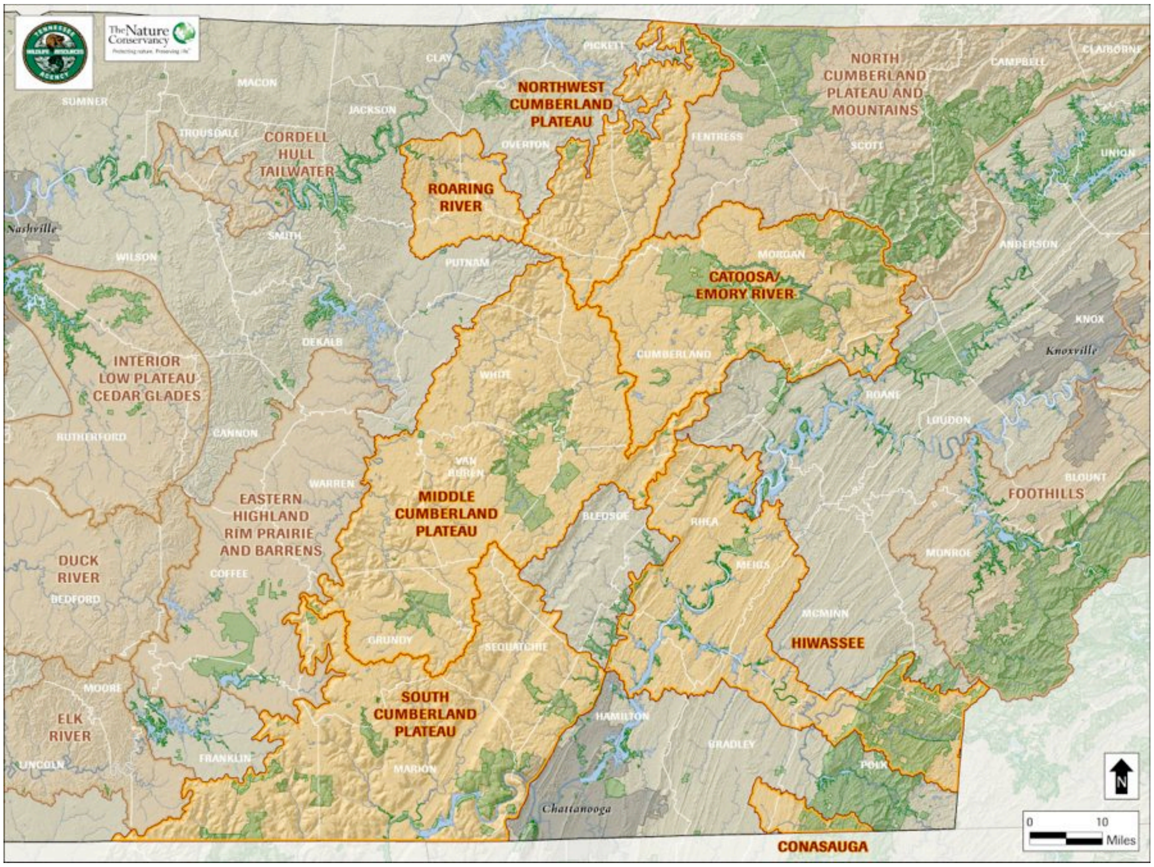
Map 15. Conservation Opportunity Areas with the combined terrestrial, aquatic, and subterranean habitat priorities in Tennessee

Map 16. West Tennessee COAs, Public Lands, and Major Cities

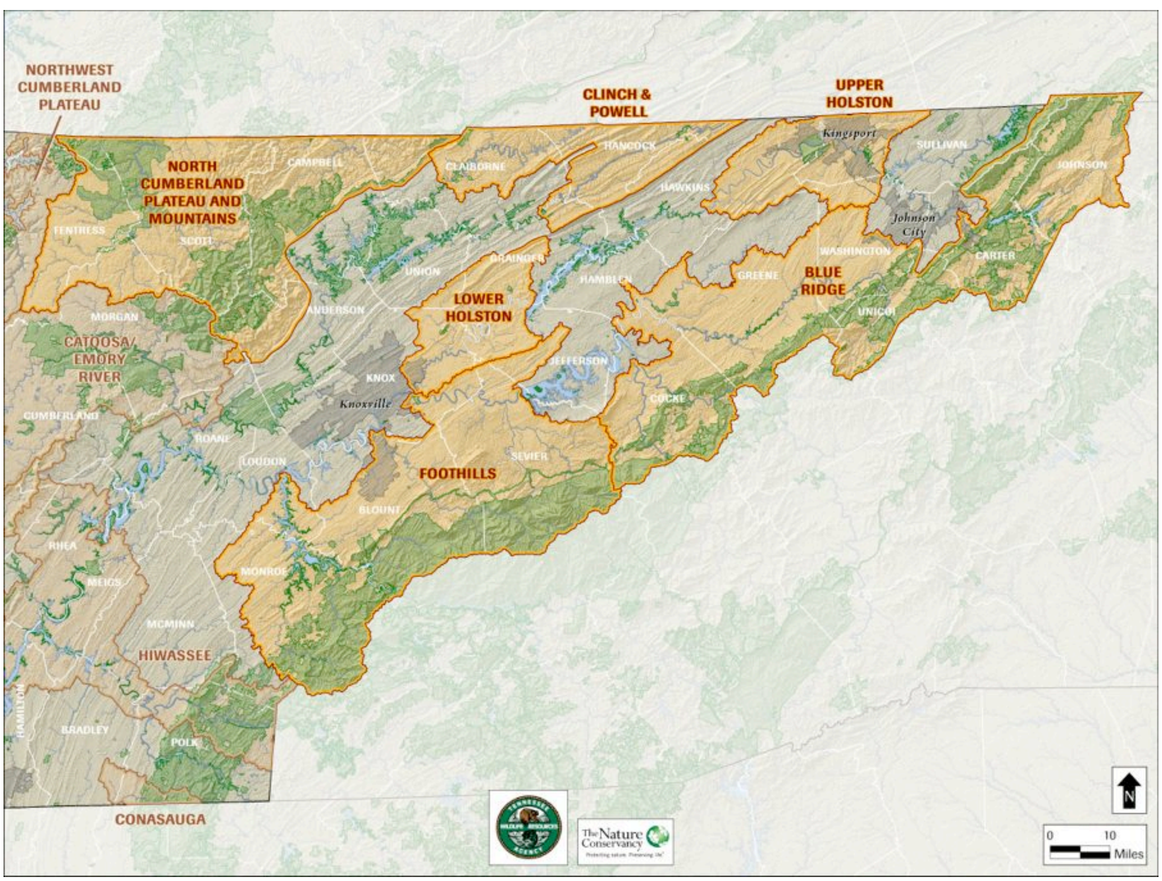
Map 17. Central Tennessee COAs, Public Lands, and Major Cities



Map 18. Cumberland Region COAs, Public Lands, and Major Cities



Map 19. East Tennessee COAs, Public Lands, and Major Cities



needed and where they apply. The information on GCN species, habitats, and major problems in the SWAP GIS database can be used in a variety of different decision-making contexts to help determine where a project or strategy may be of benefit in any location across Tennessee.

Accordingly, the 2015 SWAP update articulates those conservation actions that are recommended to be employed statewide to benefit GCN species and their habitats, irrespective of COA boundaries. The overview of strategies in the following section highlights examples of general and specific conservation actions, organized by the SWAP hierarchy, which can be employed to address the major issues affecting species and habitats – whether within or outside COA boundaries. These actions include efforts that could be best deployed at a statewide scale (e.g., policy or standards development) and others that must be tailored to habitat protection or restoration outcomes in specific locations (e.g., application of prescribed fire). The project examples demonstrate the importance of conservation activities for species and habitats both within and outside the current Conservation Opportunity Areas.

5.3. Overview of Priority Conservation Strategies in Tennessee

This section on priority conservation strategies is organized according to the Class level of the SWAP conservation strategy hierarchy (see Table 15 and Appendix H). The project examples are intended to illustrate the application of general and specific conservation actions both within and outside Conservation Opportunity Areas.

5.3.1. Habitat Acquisition

Habitat acquisition for conservation purposes continues to be a major need in Tennessee. Strategies for improving public and private funding for land acquisition statewide are important. A primary tenet guiding many, though not all, conservation acquisitions is to build upon and connect the existing public lands base. Conservation Opportunity Areas highlight geographies where this type of focus may be successful. Another major tenet is to help private land owners and local governments who are already engaged in conservation to retain their land ownership and manage their resource values through education, technical assistance, or financial support.

In many cases where limited or highly dispersed priority habitats remain, or where land use threats are high, acquisition may be the primary and most effective strategy for preventing further habitat destruction and achieving conservation goals. The cedar glades and barrens of middle Tennessee are a prime example of acquisition helping to protect both rare and highly dispersed habitats. Two successful examples of how the 2005 SWAP helped to guide acquisition strategies for conservation are provided in this chapter.

Landscape-scale habitat conservation

In June 2007, the state of Tennessee and the Nature Conservancy, teaming with the timber companies Conservation Forestry and Lyme Timber, completed the largest land protection deal in Tennessee since the creation of Great Smoky Mountains National Park. A total of $82 million in state funding, $13 million from TNC – with financial assistance from the Doris Duke Charitable Foundation and the Tucker Foundation – and $40.2 million from the two timber companies was combined to protect 127,854 acres on the Cumberland Plateau.

This purchase connects the forestlands in Scott, Campbell, Anderson, and Morgan counties with 66,000 acres of existing public lands, creating a protective corridor for wildlife as well as preserving a natural sanctuary for the public. Ranked as globally significant for its diversity of plant and animal species, the area harbors increasingly rare species of bats, salamanders, fish, and other creatures. Migratory songbirds rely on the forestlands of this region for habitat in spring and summer, and large, wide-ranging mammals such as elk and black bear are sheltered on the Plateau.

A sophisticated mix of fee title, conservation easements, and timber rights were combined to close the deal, in which innovative working forest conservation easements, crafted by the Tennessee Department of Environment and Conservation and The Nature

Sandy Gap, a part of the 127,854-acre Cumberland Plateau acquisition - David Engebretson

Conservancy, keep 42,075 acres open to the public for recreation and guide sustainable forest management.

Conservation on this scale ensures that:
✦working forestland is protected, sustaining forest-based jobs and the industry around them well into the future;
✦current and future generations will continue to enjoy access to the property for recreation;
✦ forests are well-managed, remaining healthy and intact, which will help maintain water quality in local communities that depend upon these watersheds and deter floods and erosion;
✦rare ecological lands are added to state ownership and protected for future generations.

Conservation in Developing Areas

In areas of rapid urban/ suburban development where land values are increasingly high, permanent conservation easements can provide an excellent alternative to fee title purchase. One such easement – purchased through private philanthropy in partnership with the Tennessee Parks and Greenways Foundation and $12,500 in federal funds through TWRA – occurred in 2013, permanently protecting 1,363 acres of mixed forest/grasslands on the Western Highland Rim in Williamson County.

Partnering with a landowner seeking to conserve property in the area, the easement conserves land near the headwaters of the Harpeth River, which is crucial to downstream habitat and aquatic biodiversity. It is also located adjacent to the Natchez Trace Parkway, with high connectivity to other protected lands. The SWAP GIS database model shows the habitat priority for this property is medium to high for terrestrial species. A survey of the property documented 22 species of reptiles and amphibians, including the Eastern Box Turtle. The tract also contains habitat for interior forest birds.

Conservation easement purchases such as this provide the following benefits:
✦Habitat for uncommon and rare species;
✦Public value in the form of scenic quality (in this case, viewable from the Natchez Trace Parkway);
✦High connectivity to other protected lands, which increases habitat functionality and security on a landscape scale;
✦Protection from encroaching suburban development.

5.3.2. Information Collection and Dispersal

The information collection and dispersal class of strategies includes the following types of General Conservation Actions: improved communications and public relations, conservation planning, monitoring, and research. Improved communications include a focus on raising awareness of stewardship issues on public lands, specific GCN conservation issues, and opportunities to partner in private lands conservation. TWRA also will continue and seek to expand engagements in joint planning efforts with a variety of partners.

This approach includes the use of new conservation planning data in the 2015 SWAP GIS model to help identify and implement a variety of projects. The agency will also continue to invest in monitoring GCN species, habitats, and particular problems that threaten them. Such monitoring can often best be accomplished through investments and collaborations with researchers. Teaching and engaging the public and volunteers in monitoring activities, sometimes called citizen science, also is growing in popularity and can be helpful to achieving a variety of monitoring objectives. Wildlife diversity staff also will take advantage of new collaborations (e.g. with Landscape Conservation Cooperatives) to improve capabilities for both monitoring and planning at landscape and regional scales.

Communications & Public Relations

Partnerships among agencies and other organizations are effective means of increasing public awareness about important stewardship issues where knowledge can translate into conservation results. Good examples of this in Tennessee include the public outreach campaign to "**Buy Firewood Where You Burn It**" and the related **Don't Move Firewood** website designed to help stop the spread of invasive insect pests, as well as **Protect TN Forests**, which has a broader focus on promoting knowledge of practices that benefit forest health.

Monitoring and Research

Since the 2005 SWAP, TWRA wildlife diversity biologists have spent a significant amount of time monitoring GCN species populations and their response to management activities, contributing to the

Clockwise from upper left: Electroshocking fish on East Fork of the Stones River - Pandy English; Banding a bat - Josh Campbell; Surveying Alligator Snapping Turtles - Rob Colvin; Live trapped woodrat on Kyles Ford WMA - Scott Dykes (photographers and those in photos all TWRA staff).

improvements in the GIS and relational database noted in Chapter 3. Citizen science refers to research collaborations between interested citizens and researchers to collect data about the natural world. Citizen science monitoring programs represent an opportunity to expand the agency's capacity for monitoring certain GCN species. The following are current examples of TWRA citizen science, which could be expanded or replicated for different species:

✦The Tennessee Amphibian Monitoring Program, a partnership between TWRA and Middle Tennessee State University, is a good example of citizen science that recruits and trains volunteers to collect data about GCN species of frogs and toads.
✦Another program trains volunteers to recognize and monitor the spread of the destructive Hemlock Woolly Adelgid, an introduced insect pest that kills native hemlocks in east Tennessee's highlands.
✦A number of citizen groups currently monitor bat houses; greater coordination and sharing of Tennessee bat research between scientists and these programs could benefit both researchers and volunteers.

Monitoring on a very large, or landscape, scale requires continuously updating information in a fast-changing world. The U.S. Fish and Wildlife Service Landscape Conservation Cooperatives, which have been organized since the first 2005 SWAP planning effort, provide a major opportunity for states to engage and assist with planning and monitoring at large spatial scales.

By applying the expanded datasets in Tennessee's GIS relational database, TWRA can improve its species and habitat management decisions. For example, data on lowhead dams being compiled in partnership with the Division of Natural Areas and information on riparian zone condition will be useful to Environmental Services when reviewing permit applications submitted to the Tennessee Dept. of Environment and Conservation.

TWRA also supports research by or in collaboration with partners from academia and other institutions. For example, TWRA has worked with researchers from Middle Tennessee State University, University of Tennessee, and the Nashville Zoo to conduct research focused on improving Hellbenders' resistance to both Chytrid fungus and Ranavirus.

TWRA is supporting research on chytrid fungus and ranavirus in Hellbenders, both of which are thought to be associated with missing digits on the salamanders, as with the hind foot shown here, which normally has five toes. - Sherri Reinsch, Nashville Zoo

5.3.3. Management and Restoration of Species and Habitats

Management and restoration of species and habitats includes a number of General Conservation Actions that form the core stewardship practices designed to maintain ecosystem health: compatible resource use on public and private lands, conservation area management, exotic species/ pathogen control, habitat and natural process restoration, and species restoration. This class of conservation strategies focuses on better direct resource management and planning on both public and private lands. Compatible resource use also can depend on effective environmental reviews which ensure that species and habitat needs are adequately considered and incorporated into land and water resource use decisions.

To achieve habitat improvements on public and private lands, it is necessary to make use of a variety of funding sources, especially state and federal incentive programs designed to assist landowners with practices that benefit habitat values as well as their own properties and operations.

Shelterwood cut with burning, an example of forestry management to benefit wildlife at North Cumberland WMA - Scott Dykes, TWRA

Habitat restoration can be thought of as two main types: (1) restoring natural processes, such as removal of barriers to restore stream flows or re-introduction of fire, and (2) restoring specific habitat types for species, such as forests, wetlands, and grasslands. Species restoration efforts become necessary in certain cases, such as with several fish and freshwater mussel species, when precipitous declines require direct population recovery strategies. In particular, restoration of habitats for federally-listed (Threatened or Endangered) species – as well as actions to address at-risk species that could result in precluding the need to list them under the ESA – can be supported through the USFWS Recovery and Partners for Fish & Wildlife programs.

Compatible Resource Use

The 2005 SWAP, the updated 2015 SWAP, and the Tennessee Division of Forestry's (TDF) 2010 **Forest Resource Assessment and Strategy** all agree that opportunities exist for collaboration among TWRA, TDF, and private landowners to improve forest management for the benefit of wildlife and plants. The following points, drawn directly from the Forest Assessment, summarize Best Management Practices (BMPs) needed to ensure healthy forests for Tennessee wildlife and plants:

✦Forest stewardship plans that address forest health, intermediate stand practices, aesthetics, and non-native invasives will assist landowners in achieving multiple management goals, including wildlife conservation.
✦Structure essential to a diverse fauna can be provided by applying intermediate treatments, such as burning or thinning, and by regeneration harvesting in groups or patches.
✦Modification of some forest practices has been identified as an opportunity to aid certain GCN species. For example, habitat fragmentation and nest predation caused by large clearcut areas may be mitigated by using smaller, irregularly shaped, soft-edged interspersed clearcuts.
✦Habitat fragmentation can also be reduced when stand placement is considered in the context of the surrounding forests. Maintaining the connectivity of hardwood stands provides travel corridors for wildlife, and greater interspersion of food and cover resources.
✦Restoration and protection of uncommon forest habitats is also key to supporting many GCN animals and plants. Uncommon forest habitats include savannas, cave openings, wetlands, rock outcrops, bogs, springs, seeps, glades, balds, and vernal pools. Maintaining contiguous, mature forests across the landscape is also critical for conserving many GCN species, and these habitat needs are important to consider as forest management plans are designed.

Private land management is critical to achieving positive, long-term conservation outcomes in Tennessee. More than 90 percent of Tennessee's land is privately owned, and the manner in which private lands are managed significantly affects public environmental benefits, including water quality, habitat quality, the costs of wildlife management, and the long-term sustainability of wildlife populations. In fact, TDF has identified priority watersheds for focused management and outreach to private landowners based on the following:
✦watershed > 50% forested;
✦privately owned;
✦threatened by development;
✦supplies at least one public water intake.

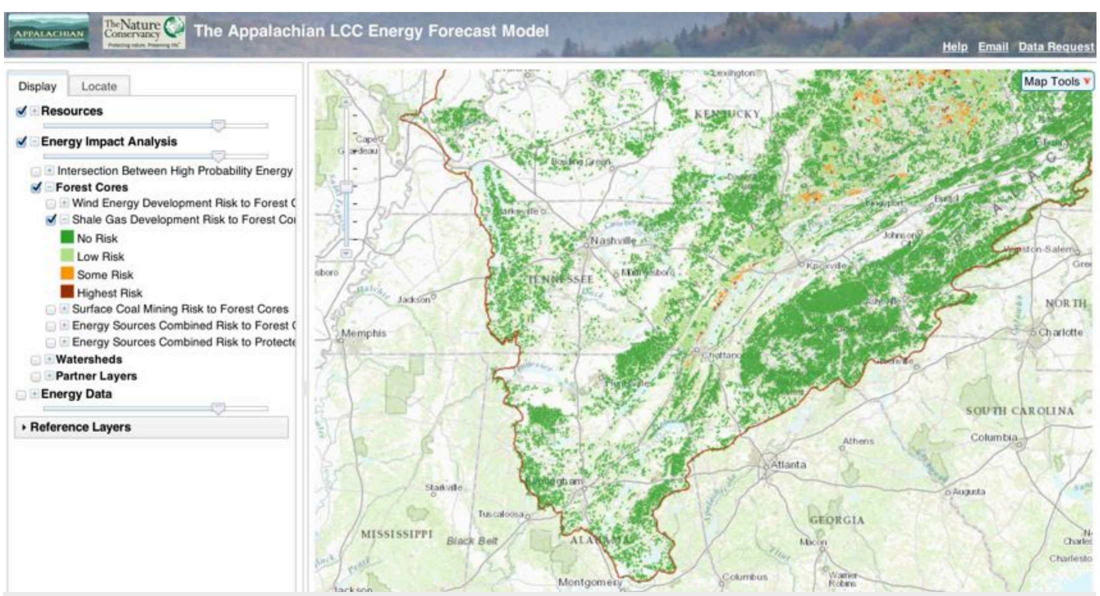
Since 2007, TWRA has cost-shared four Private Lands Biologist positions with the Natural Resources Conservation Service (NRCS), a very important partner in private lands management. TWRA staff will continue to partner with NRCS in outreach to private landowners, the identification

TWRA habitat biologist Wally Akins and a landowner discuss options for improving private property for wildlife. - Robin Mayberry, NRCS of priority conservation practices for key areas of the state, and the prioritization of incentive program applications based on pressing wildlife conservation needs.

Advance planning and effective environmental reviews to mitigate problems and protect sensitive resources is an important strategy for both public and private lands. For example, the National Park Service developed the Big South Fork National River and Recreation Area/Obed Wild and Scenic River Final Non-federal Oil and Gas Management Plan/ Environmental Impact Statement in 2012. This strategy helps park managers ensure their park units are protected from current as well as potential future issues from new development. The plan provides park-specific guidance for oil and gas owners and operators who wish to establish new oil and gas extraction sites (NPS 2012).

Another example of advance planning at a regional scale is an analysis developed by The Nature Conservancy with support from the Appalachian LCC to assist policy makers, land management agencies, and industry leaders in assessing the overlap between potential future energy development and biological and ecological resource values. Data from the study is hosted on the web-based **Appalachian LCC Energy Forecast Model**, which allows users to query various datasets to see where energy development may likely occur and intersect with important natural values to inform regional landscape planning decisions.

Another important approach to ensuring compatible resource use is the advance designation of sites and areas for which particular land or resource utilization would not advance habitat and species conservation goals. An example of this type of determination has been conducted for the North Cumberland Wildlife Management Area (NCWMA) and lands in its vicinity in the Cumberland Plateau and Mountains region. The NCWMA offers one of Tennessee's premier opportunities to protect, manage, conserve, and restore GCN species and their habitats, with special emphases on aquatic, riparian zone, and ridgeline hydrological and ecological



The Appalachian LCC Energy Forecast Model, showing potential risk of shale gas development relative to forest cores in Tennessee and surrounding states.

function. Over 150 wildlife and plant GCN species are dependent upon adequate protection of these habitat features and their ecological function in the landscape.

TWRA has determined that new contour, cross-ridge, or mountain top removal coal mining is wholly incompatible with agency management and restoration for the NCWMA. Re-mining to resolve outstanding water quality and slope stability problems from previous mining and deep-mining, when properly done, are not considered incompatible with TWRA management plans for the NCWMA. For a detailed list of GCN species potentially affected by incompatible mining in the NCWMA and surrounding vicinity defined in a current State of Tennessee Lands Unsuitable for Mining petition, please see Appendix C, Table 5.

Conservation Area Management

TWRA Wildlife Diversity staff strive to work effectively with other TWRA divisions, the Tennessee Department of Agriculture's Forestry Division, and Tennessee Dept. of Environment and Conservation on management issues within Wildlife Management Areas (WMAs). This is a frequent goal of conservation area management in the 2015 SWAP. Collaboration between agencies with different expertise and jurisdictional authorities helps achieve balance between a variety of management objectives and will help improve habitat zones for all GCN species. For example many rare plants occur in rare and/or small patch habitats that also may include GCN wildlife species.

Another example of improving conservation area management comes from the Obed River Gorge, a popular rock climbing destination. Potential impacts to native plant communities and cultural resources from climbers led the National Park Service to develop the Obed Wild and Scenic River Climbing Management Plan (NPS 2002) to manage and decrease impacts. A similar example is the **Rock Climbing Guidelines** developed by the Tennessee Division of Forestry in cooperation with its user group, the Southeastern Climbers Coalition, to manage the impacts of climbing in Prentice Cooper State Forest.

Proactive management to prevent damage by licensed motorized off-highway vehicles (OHVs) and non-licensed All Terrain Vehicles (ATVs) often consists of driver education. TWRA provides **guidance to riders** on where these different vehicles are allowed and not allowed on Wildlife Management Areas. An excellent example of an educational initiative to improve rider safety and help prevent damage to creeks and rivers is provided by the **Iowa ATV Safety Course**.

Control/Prevention of Invasive Exotic Species and Pathogens

When exotic or introduced species threaten GCN species and habitats, a hierarchy of approaches to prevention and control is needed. Over the long-term, the most cost-effective, but also potentially the most labor intensive and difficult approach is to monitor for new outbreaks or invasions.

Often control or even eradication of invasive species is possible before they become well established. After an exotic species has become established, a variety of control mechanisms is available, depending on the species, but eradication is unlikely. Monitoring is appropriate to determine the level of threat and the effectiveness of management actions.

Joe Elkins, TWRA using an injector to apply herbicide to undesirable tree species in Shady Valley bog habitat. - Scott Dykes, TWRA

Arnold Air Force Base in Coffee and Franklin Counties is a good example of integrated pest plant management. The base's invasive pest management strives to:

✦support the maintenance of biodiversity;

✦maintain the structure and function of ecologically significant plant communities;

✦restore a functioning mosaic of barrens habitats;

✦protect high priority sites where plant invasions threaten rare species habitats; and

✦develop monitoring protocols to track management effects, and to detect new pest plant occurrences.

Basal bark treatment of an invasive woody species - Arnold Air Force Base

The Hemlock Woolly Adelgid, *Adelges tsugae*, is an insect that has wreaked havoc on many hemlock forests in the eastern United States. A relatively new biological control, the predatory beetle species called *Laricobius nigrinus* eats Hemlock Woolly Adelgid (HWA). **Experiments are ongoing in the Great Smoky Mountains National Park** and other Tennessee forests to release these beetles and slow down HWA infestations in priority conservation areas. This effort demonstrates the importance of research efforts in determining the best possible responses so that potential unintended consequences from the introduction of biological controls are understood and minimized.

Timely management actions tailored to address a new pathogen's spread are needed to combat emerging infectious diseases of wildlife. Pathogen spread in populations of one or more GCN species may require focused conservation or research. The Eastern Hellbenders of Tennessee case study describes an example of this type of collaborative effort.

In recent years, TWRA has also seen evidence of the deleterious effects of pathogen infections on various reptile populations in middle and east Tennessee. Through participation in a multi-state State Wildlife Grant, TWRA has partnered with researchers from Cumberland University, Middle Tennessee State University, and University of Tennessee Department of Forestry, Wildlife and Fisheries Center for Wildlife Health to determine the presence of the snake fungal disease (*Ophidiomyces ophiodiicola*) in Timber Rattlesnake populations at Center Hill Lake, Cedars of Lebanon State Forest, and Flat Rock Cedar Glades and Barrens State Natural Area. Non-target species of reptiles are also sampled to determine if species other than rattlesnakes may be impacted.

Researchers have been performing telemetry to determine movement behavior and using special temperature-sensitive radio transmitters to record the body temperature of timber rattlesnakes throughout hibernation. These efforts, combined with observations of winter basking occurrences, allow researchers to gain valuable insights into the impacts of this devastating disease.

Habitat and Natural Process Restoration

Restoration of habitats and the natural processes that maintain their health is an important strategy for a large majority of GCN species. Within Conservation Opportunity Areas, restoration activities may be prioritized to improve or connect existing habitat areas. Important management techniques can include prescribed fire; removal of stream and river barriers; restoration and reconstruction of wetland and stream habitats; and reestablishment and management of native forest conditions. Map 20 provides an overview of where restoration from current semi-natural landcover conditions to the dominant forest type of the region can be most effective for expanding available habitat for GCN species (Wisby and Palmer 2015).

Prescribed fire is a management approach that provides measurable benefits to early successional and fire-adapted habitats in Tennessee, thereby benefiting many wildlife and

Rattlesnake with snake fungal infection - Daniel Bryan, Cumberland University

TENNESSEE CASE STUDY: The Eastern Hellbenders of Tennessee - A species indicative of good water quality provides a focus for conservation statewide

Perhaps no other species in Tennessee is more emblematic of the widespread, interacting, and complex mix of threats posed by society to healthy aquatic systems than the Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*). Picturesquely dubbed "The Last Dragons" in a 2014 film produced by Freshwaters Illustrated and the U.S. Forest Service, this giant salamander subspecies was once distributed throughout most streams in the eastern two-thirds of Tennessee.

With a fascinating life history – including a relatively long life (25 years or more), a fierce attachment to home territory, annual battles by males vying for mates, and males that guard their eggs and young – this species has become a flagship for what is extraordinary about Tennessee and southern Appalachian streams. Hellbenders have experienced precipitous population declines across much of the state in the past several decades, and their plight clearly illustrates an issue for which conservation efforts beyond the boundaries of Conservation Opportunity Areas must and will continue.

> "I did not know then (2001) that that individual would be the last Hellbender I would find in the Collins River." -- Dr. Brian Miller, herpetologist, Middle Tennessee State University

Top to bottom: Hellbender in typical habitat at night, Hiwassee River -Dave Herasimtschuk, Freshwaters Illustrated; Small hellbender indicative of a reproducing population, lower Little River - TWRA staff; The Hiwassee River: some of the best remaining Hellbender habitat in Tennessee - LookoutBelle/next page: Hellbender in Tellico River - Dave Herasimtschuk, Freshwaters Illustrated

The Hellbenders' descent into rarity

Dr. Brian Miller, a salamander expert who first came to Middle Tennessee State University in 1989 to study Hellbenders, has been observing the species' decline for more than 20 years. He began working with Hellbenders in the Collins and Buffalo Rivers where populations seemed relatively high. After a survey hiatus from 1995 to 2001, he returned to the Collins River to find only one Hellbender. "I did not know then that that individual would be the last Hellbender I would find in the Collins River," says Miller.

His assessment after searching numerous middle Tennessee rivers over subsequent years is that populations crashed over a 10-year span, going from low densities to almost non-existent. Miller notes, "In retrospect, I was probably working with an aged and dwindling population in the Collins River in the early 1990s, since I never found small Hellbenders back then."

This picture is complicated by one of the quintessential problems in ecology: a lack of historical information with which to compare current conditions. Miller estimates that the initial decline may have begun as early as the 1970s. However, the lack of data on the original size of Hellbender populations hinders any definitive assessment.

Unraveling Hellbender problems

Hellbenders require extremely good water quality. They need clear swift-flowing streams that keep crevices under streambed rocks open and available for Hellbender lairs. This species also breathes through its skin, making it dependent upon high levels of oxygen in the water. For these reasons, most stream modifications impact Hellbenders, including impoundments, channelization, siltation, acid mine drainage, and thermal pollution.

Increased levels of siltation from agriculture and other forms of runoff essentially bury Hellbender habitat. Silt may often carry with it herbicides and other chemicals, which some research has implicated as a potential contributor to Hellbender reproductive problems (Solis et al. 2007). Further complicating this picture is the fact that streams in Tennessee completely lack historical or current records on the chemical loads they carry. People who move or collect river stones for building often directly destroy Hellbender habitat. Finally, in the early 2000s there was also a question about whether Hellbenders were succumbing to diseases that have been spreading among amphibian populations on a global scale.

Responding to the unnerving decline that Miller had found in middle Tennessee's Hellbenders, in 2010 TWRA provided State Wildlife Grant (SWG) support to a collaborative group of researchers, including the University of Tennessee and the Nashville Zoo, to bring together salamander experts and develop a coordinated program of research aimed at improving Hellbender conservation. The program they developed aimed to achieve four goals:

1. Conduct field surveys of historic Hellbender locations to determine current distribution.
2. Determine the extent to which Hellbenders are susceptible to two widespread diseases affecting amphibians: chytrid fungus and ranavirus.
3. Develop an "e-DNA" (environmental DNA) protocol to allow sampling of Hellbender DNA from the water column to discern presence/absence and genetic differences among populations.

4. Develop techniques to study and boost wild Hellbender populations, including cryopreservation of sperm for captive breeding and development of crèche methods for rearing wild caught Hellbender young to increase their survival rate.

A complicated picture emerges

Research implemented by partners in this effort since 2010 has yielded the following:

- The Upper Tennessee Drainage has some of the best remaining Hellbender populations in the state, and the Middle Tennessee has remnant populations (the Duck and Buffalo watersheds), while the Cumberland Drainage populations are imperiled, with over 140 man hours of search effort yielding 0 Hellbenders. Moreover, moderate to high degrees of siltation were found in all the Cumberland waterways surveyed.
- Hellbenders can contract both chytrid fungus and ranavirus. In captivity, nearly all Hellbenders with ranavirus die when water temperature exceeds 68 degrees Fahrenheit (a common occurrence in streams during Tennessee summers).
- The Buffalo River in Middle Tennessee has a genetically unique strain of Hellbenders, which is different from those found in the Hiwassee and Ocoee Rivers of East Tennessee.
- Researchers successfully collected Hellbender sperm, using cryopreservation to "bank" their genes. Captive breeding of Hellbenders has been largely unsuccessful.
- Placing concrete Hellbender houses in streams has allowed fertilized eggs to be removed and hatched in captivity -- either for study or to improve survival of salamander larvae by growing them out for release back into the environment.

Bringing back Hellbenders: 2015 and beyond

The status of Hellbenders in Tennessee is inspiring concern and action: to understand where they are still found, what threatens them, and what conservation measures will be most effective.

People value rarity, and as Hellbender populations across the state have crashed, support and interest in their conservation has increased. Unfortunately, the level of effort required to assist rapidly declining wildlife populations is often quite high and quite complex.

TWRA and the U.S. Fish and Wildlife Service are supporting efforts aimed at further cataloguing Hellbender populations. In 2015, Dr. Miller at MTSU initiated (with TWRA SWG support) a population survey in the Little Buffalo River, the middle Tennessee stream with the best breeding densities of Hellbender according to a 2012 survey. Meanwhile, additional SWG funds are supporting researchers with the University of Tennessee Forestry, Wildlife, & Fisheries Department who are attempting to develop a means of inoculating Hellbenders against chytrid fungus to create disease-resistant populations in the wild.

The brightest part of the big picture is that steeper gradient rivers like the Hiwassee still have some of the best remaining Hellbender populations and could serve as potential sources for reintroduction efforts. However, if population crashes are associated with a decrease in water quality, then those issues must be remedied prior to any stocking efforts (see the Elk River case study). Dr. Miller sums it up by saying, "Some of these east Tennessee streams appear to have somewhat stable populations. Time will tell."

plant species. TWRA will promote the application of prescribed fire in the COAs where fire suppression has occurred, on both public and private lands.

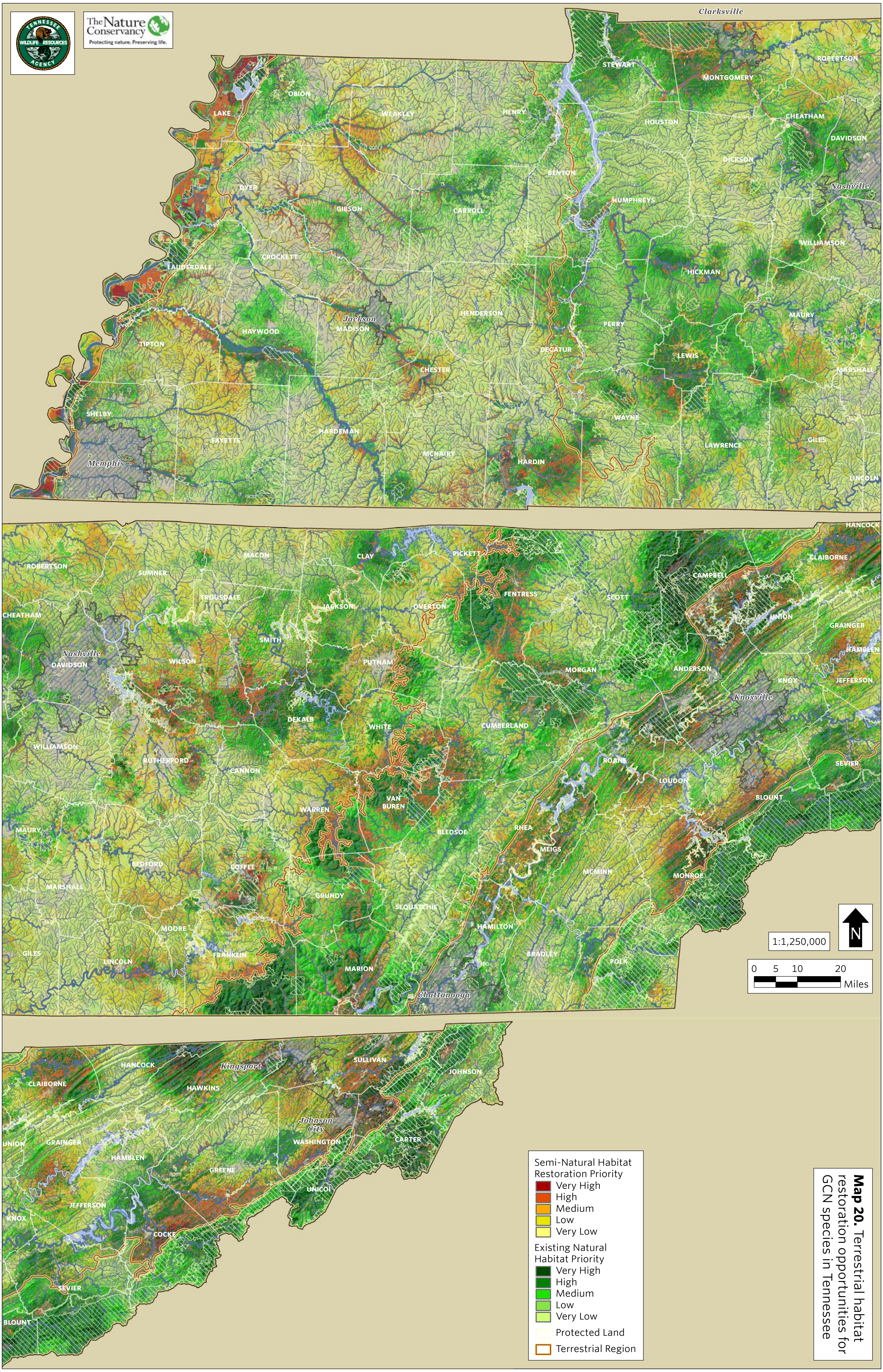
With support from the Tennessee Fire Council and the Tennessee Wildlife Federation, the Tennessee Prescribed Burning Act was signed into law May 10, 2012. This legislation provides liability protection for landowners who use prescribed fire appropriately, and it also authorizes the Tennessee Division of Forestry (TDF) to provide training programs to the public that teach basic fire ecology and the safe and appropriate use of prescribed fire.

The Golden-winged Warbler Case Study demonstrates how early successional habitat management is emerging as a priority for wildlife management in Tennessee. These habitats are by definition constantly changing, as plant colonization and regrowth occur subsequent to a disturbance. Disturbance may be natural, such as lightning-ignited fire and storm damage, or it may occur as a result of human management, such as a prescribed fire or tree harvesting. Early successional habitats are important for a variety of GCN species, such as Prairie Warbler and Spotted Skunk.

As discussed in Chapter 4, managing large dam infrastructure and reservoir releases to improve water quality and habitat conditions for GCN species is critical for conservation efforts in Tennessee. Another type of activity gaining positive momentum is the restoration of stream habitat connectivity and stream flow through small dam removals. Many small dams on streams and rivers no longer serve the purpose for which they were originally built, and many pose public safety hazards.

Since 2012, several dam removals have taken place in Tennessee, with one in the pipeline as of mid-2015. In 2012, a multi-agency and organization coalition removed a lowhead dam on the Harpeth River near Franklin, TN. This project is

Above: Catoosa Wildlife Management Area 1 month after a prescribed burn; below: two native early successional species post-burn. - Clarence Coffey, TWRA retired



Map 20. Terrestrial habitat restoration opportunities for GCN species in Tennessee

TENNESSEE CASE STUDY: Intensive management for early successional habitat, guided by the needs of Golden-winged Warbler in the N. Cherokee Conservation Opportunity Area

The birdwatchers and fishermen who visit Hampton Creek Cove State Natural Area in the Southern Appalachians may not realize the degree of collaboration and management that goes into maintaining this ecological gem. Hampton Creek Cove (HCC) is a popular birding destination owned by the Tennessee Department of Environment and Conservation (TDEC) and managed by the Southern Appalachian Highlands Conservancy (SAHC) land trust.

The creek itself supports one of the most productive native trout streams in East Tennessee, while the old field/early forest succession at lower mountain elevation provides excellent nesting habitat for Golden-winged Warblers, a declining neotropical migrant species. The National Audubon Society designated HCC an "Important Bird Area" in 2005, even though it falls at the edge of the species' breeding range. The HCC site supports the highest density of Golden-winged Warblers on the Roan Mountain Massif.

> Due to their marked dependence on early successional habitat, if an area can be maintained for Golden-winged Warblers, it will likely remain suitable for many more species who rely on that habitat type.

Like many warblers, the Golden-winged is suffering a range-wide decline due at least in part to loss of breeding habitat (Schubert 2013). In fall 2007, the Tennessee Wildlife Resources Agency (TWRA) decided to work with TDEC at this 693-acre Natural Area to enhance habitat for Golden-winged Warblers. The scientific literature supports the idea that these warblers can be considered a type of "indicator" species. Because of their marked dependence on early successional habitat, if an area can be maintained as preferred habitat for Golden-winged Warblers, it will likely remain suitable for many more species that rely on that habitat type.

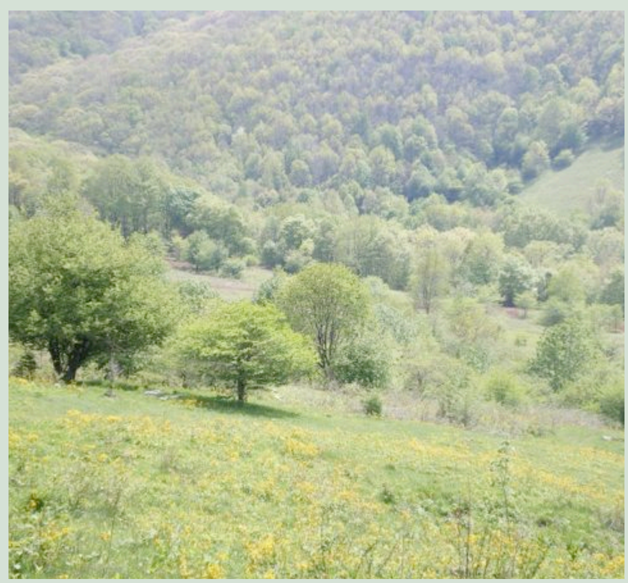
Hampton Creek Cove ranges from 3,000 to 4,800 feet at the higher elevations and is a mix of pasture, shrub-scrub, and mature timber. Golden-winged Warblers prefer scattered

Top to bottom: Forest habitat closing in without disturbance at HCC; Habitat opened up after bulldozing - both photos by Scott Dykes, TWRA; Golden-winged Warbler in the hand - Nora Schubert/next page left: Early successional habitat restoration begins; right: Green-up first spring after restoration - both photos by Scott Dykes, TWRA shrub habitat with an understory of forbs (wildflowers and other broad-leaved herbaceous plants) and grasses, where they hide their nests. As scrub habitat matures, in the absence of disturbance from fire or storms, the canopy closes in, eventually making the habitat unsuitable for these birds.

In natural cycles, rebirth follows death; the process is no different for habitat restoration. Early successional habitat restoration involved work from 2007 through 2009 to open up 45 acres of forest canopy using heavy equipment, herbicide, and native grass seeding to ensure quick ground cover for the next breeding season. The seed mix included Fowl Bluegrass (found in four Tennessee counties), Little Bluestem and Indian Grass.

To document management at HCC and to assess the effectiveness of their project, TWRA also funded biological surveys of HCC Golden-winged habitat. Field work is documenting the warblers' population and breeding activities post-restoration, including characteristics of the vegetation in preferred nest sites. Ideally, nest monitoring will assess nesting success in restored and natural habitat.

The results of the habitat work speak for themselves. In years prior to restoration, between 16 and 17 Golden-winged Warbler breeding territories were documented. In the first year after restoration work began, territories dropped to 11, but this result was expected due to the large-scale disturbance of the site. By the spring of 2010, the first year without on-the-ground work, surveys showed 21 occupied territories! The 2013 survey showed that early successional habitat restored by TWRA was occupied by relatively high densities of Golden-winged Warblers, with 17 territories overall (Schubert 2013). Future habitat restoration at the site is recommended, including a monitoring design that will measure GWWA population response to habitat modifications.



The immediate result of conservation work to restore early successional habitat can look like the results of a very bad storm, and that is precisely the point. In Tennessee, vegetation regrowth is quick and profuse.

Schubert, N. 2013. 2013 Golden-winged Warbler monitoring at Hampton Creek Cove State Natural Area, Tennessee. Report submitted to Tennessee Wildlife Resources Agency.

located outside of any COAs designated in the 2015 SWAP, but would still be a priority today for its benefits to GCN species and local community values. In September 2014, the Tennessee Wildlife Resources Agency (TWRA) took down remnants of the Brown's Mill dam on the East Fork of the Stones River, funded in part by a State Wildlife Grant. Also in 2014 an outdated dam on Richland Creek at McCabe Park in Nashville was removed. All of these projects eliminated recreational hazards while improving and increasing habitat for a wide diversity of native fish and mussels.

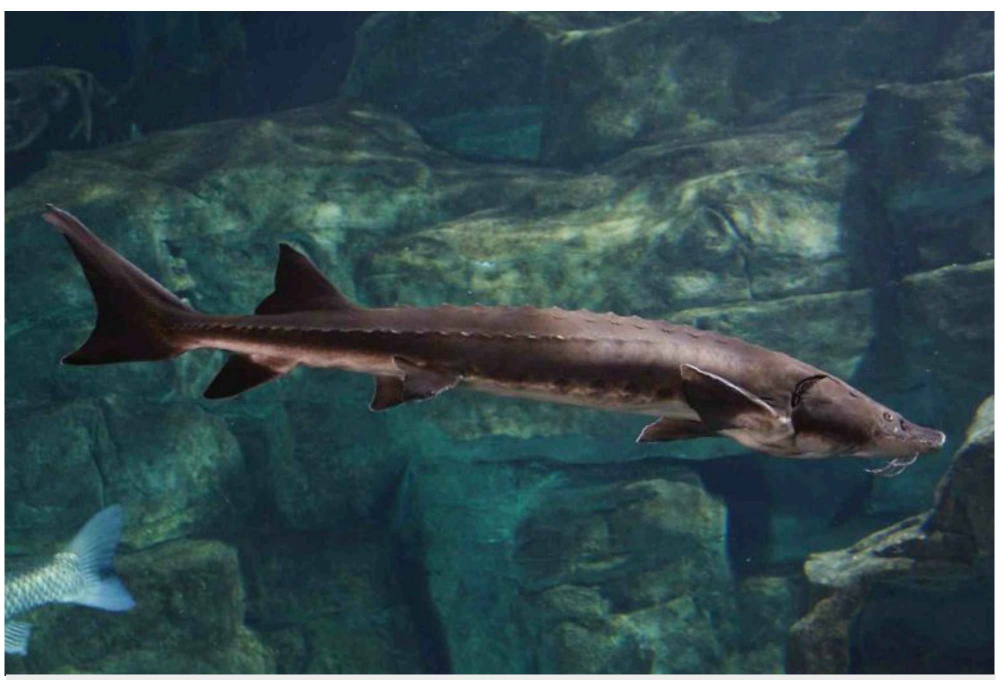
In collaboration with the Tennessee Dam Removal Partnership, TWRA has removed small dams and other river obstructions if they address the following criteria in a thorough planning effort designed to balance all resource values:

- The property owner is agreeable.
- Public safety can be improved.
- River ecology can be improved.
- Funding is available.
- There is support from the public, including but not limited to, local watershed associations and recreational users.
- The dam no longer serves its original or current purpose.

Species Restoration

TWRA and others have undertaken a number of species restoration projects in Tennessee to benefit animals and plants that are rare, declining, or locally extirpated (see Chapter 2). Species restorations occur primarily through one of two means: (1) propagation of plants/captive breeding and release of animals or (2) the transplanting of "seed stock" (both plants and animals). Restoration may occur to augment populations that are in trouble or to reintroduce species to sites where they have been extirpated. For example, a reintroduction and management program for Lake Sturgeon has restored this "fossil" species into several areas of both the Tennessee and Cumberland Rivers since 1998.

As with any complex program, many partners have played an essential role. In this case, the Tennessee Lake Sturgeon Reintroduction Working Group includes the U.S. Fish and Wildlife Service, TWRA, Tennessee Valley Authority, The Tennessee



Lake Sturgeon - Todd Stailey, Tennessee Aquarium

Aquarium, University of Tennessee, Tennessee Technological University, Tennessee Clean Water Network, World Wildlife Fund, and the U. S. Geological Survey (SLSWG 2014).

Lake Sturgeon are large, slow-growing fish that can live to be 150 years old. The cause of their decline was overfishing from the 1940s to 1961, when the last commercial catch took place. Since that time, the species has suffered from the effects of hydroelectric dams and water pollution. However, both the Clean Water Act (passed in 1972) and the Tennessee Valley Authority's Reservoir Release Improvement program contributed to improvements to habitat and prey species populations, making it feasible to consider reintroducing Lake Sturgeon.

Since 2000, more than 120,000 Lake Sturgeon juveniles have been released into both rivers. The program is considered a success by the following measures:

- all suitable habitat within management units is occupied;
- natural reproduction has been observed, with a level of recruitment sufficient to sustain the population;
- the population contains 20+ year classes of adults > 15 years old;
- some level of recreational harvest can be supported.

Although these outcomes have not yet been achieved, monitoring survey results and angler catches have indicated that Lake Sturgeon are persisting in Tennessee waters. These early successes indicate that the working group will be able to meet their long-term goal of Lake Sturgeon restoration.

5.3.4. Capacity Building

Capacity building is essential if governments and organizations are to meet the challenges faced by GCN species and habitats statewide. The problems, and often the solutions, are complex, requiring the intentional development of partnerships. Investments in designing and maintaining successful partnerships are significant conservation strategies that amplify the ability to deliver better on-the-ground outcomes in more places and for more species.

The **Tennessee Bat Working Group** (TNBWG) is an example of one such partnership. The group formed in the summer of 2004 to meet the need for cooperation in the coordination of bat conservation in Tennessee. The goal of the TNBWG is to conserve bats and their habitats in the southeastern United States through collaborative research, education, and management. The scope of the group's efforts is wide-ranging, including research, management, and information exchange concerning bats and their habitats anywhere they occur in the state, regardless of

An adult Rafinesque's Big-eared Bat in the hand. - Scott Dykes, TWRA ownership. Members of the TNBWG have played a pivotal role in addressing White-nose Syndrome through its collaborative monitoring, research, and public education efforts.

The Tennessee Dam Removal Partnership is a diverse group of individuals from many organizations across several states. There are currently 39 participants representing city, state, and federal entities as well as nongovernmental organizations (NGOs). These include TWRA, TDEC, the Southeast Aquatic Resources Partnership, universities, the U.S. Fish and Wildlife Service, the U.S. Army Corps of Engineers, environmental consultants, individual citizens and NGOs such as American Rivers, the Tennessee Clean Water Network, the Cumberland River Compact, and The Nature Conservancy. The group has held two dam removal workshops facilitated by American Rivers and has supported directly or indirectly the removal of three dams since its creation. Members of the group are actively documenting and mapping obstructions that impact stream health as well as developing prioritization tools to help plan for Tennessee's dam removals in the future.

Complex solutions to the challenges faced by GCN species often require the intentional development of partnerships.

Like the Tennessee Bat Working Group, which has been invaluable in the fight against White-nose Syndrome, the Tennessee Dam Removal Partnership is organized and poised to deal with dam removal issues and opportunities that will no doubt present themselves in the near future.

A dam under consideration for removal in 2015 - Chris Simpson, TWRA

The **Clinch-Powell Clean Rivers Initiative (CPCRI)** is a two state river coalition including government agencies, research scientists, conservation organizations, and industry leaders. This collaboration works to protect and restore water quality by executing and using high quality river monitoring and science in decision-making; educating key constituencies and raising public awareness; and investing in strategic conservation projects. Since 2007 the CPCRI has led a symposium and collaborative projects that have raised the national profile of these watersheds and elevated the significance of effective environmental management.

A critical feature of capacity building efforts is the willingness to invest substantial funding in support of collaborative efforts. Funding from both the public and private sectors, and the sharing of dedicated staff resources whenever possible, are the primary mechanisms which support successful partnerships. State and federal funding resources are regularly matched by private donations and grant funds raised by NGOs, and other private sector actors. Philanthropic foundations, individual businesses, and corporations often combine to make joint projects successful. Ongoing and future conservation are dependent upon effective relationships supported by intentional funding and commitment of staff.

5.3.5. Law and policy

Some of the problems that GCN species face are statewide in scope. The problems may be quite large, dispersed over vast areas, or accelerated by widespread economic needs and incentives. The major land and water use issues outlined in Chapter 4 – urbanization, agricultural land management, forestry practices, water management, energy development, and transportation and utility corridors – are contributors to these types of wide-ranging problems. Over-collection or illegal collection of several plant and animal species also can be a widespread problem in regions of the state. To address such challenges to GCN species and their habitats, the application of different federal, state, and local policies and regulations often is required. Much can be accomplished through advanced engagement, the identification of shared interests, and cooperative planning. Using these strategies, a variety of objectives may be achieved, including conservation of species and their habitats.

Land Use Planning and Zoning

By promoting and sharing information in the 2015 SWAP with local planning agencies, municipalities, nongovernmental organizations, and many other partners, TWRA will amplify the ability of those groups to effectively plan for the conservation of their community's natural wealth, which underpins quality of life. Information in the 2015 SWAP about priority GCN habitats, Conservation Opportunity Areas, and GCN species can improve planning and provide additional rationale for long-term comprehensive approaches designed to avoid urban sprawl.

Policies and Regulations

Information on GCN species and their priority habitats also can help better inform a variety of existing environmental policies. Similar to the specific partnerships discussed previously as Capacity Building examples, ensuring effective environmental policy and regulatory implementation requires a focus on active collaboration with both public and private sector partners. Protecting GCN species and habitats, in the context of many land and water resource use decisions, requires cooperation and commitment to incorporating available information on species and habitat needs during the process. Several of these types of strategic collaborations are outlined in more detail in Appendix G.

The application of compensatory mitigation approaches at different spatial scales is one area in particular where a variety of expertise and information can be utilized to achieve better outcomes. One example is the application of a "watershed approach" to compensatory mitigation under the 2008 rule issued under the Clean Water Act by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency (EPA) (see Case Study: Stones River Species of Greatest Conservation Need). The rule emphasizes the need to consider habitats of important species and the long-term sustainability of aquatic resources and their associated uplands.

Compliance and Enforcement

Regulations that limit or prohibit the take of wild animals or plants are written to protect the health of species populations. TWRA law enforcement officers investigate and apprehend violators for wildlife offenses ranging from the illegal sale of certain crayfish species as live bait to the illegal take and commercialization of Common Snapping Turtles. Without enforcement, such illegal activities would continue unabated and possibly increase.

Great Egret, a GCN species dependent on wetlands. - Cynthia Routledge

5.3.6. Develop Climate Adaptation Strategies

Preparing for and coping with current and future climate impacts is an emerging field known as climate change adaptation.

In 2012 a consortium of federal and state agency and tribal leaders released the National Fish, Wildlife, and Plants Climate Adaptation Strategy (NFWPCAS). The national strategy provides a framework of goals and strategies "designed to inspire and enable natural resource managers, elected officials, and other decision makers to take action over the next five to ten years to help our living resources adapt to climate change" (NFWPCAP 2012). The strategy is a complementary effort to a wide variety of ongoing science and conservation efforts across the country.

The NFWPCAS identifies the following seven over-arching national goals:

Goal 1: Conserve habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate.

Goal 2: Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, recreational, and commercial use in a changing climate.

Goal 3: Enhance capacity for effective management in a changing climate.

Goal 4: Support adaptive management in a changing climate through integrated observation and monitoring and use of decision support tools.

Goal 5: Increase knowledge and information on impacts and responses of fish, wildlife, and plants to a changing climate.

Goal 6: Increase awareness and motivate action to safeguard fish, wildlife, and plants in a changing climate.

Goal 7: Reduce non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate.

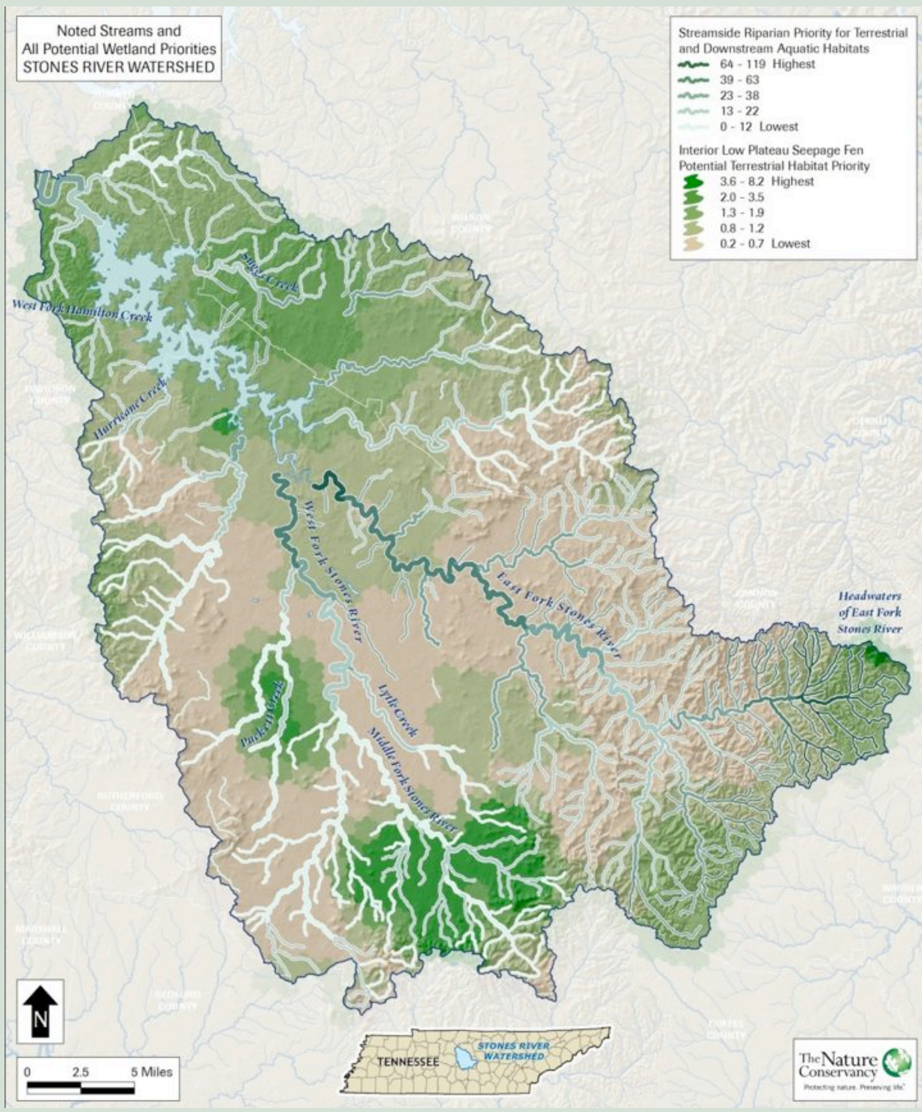
TENNESSEE CASE STUDY: Stones River Species of Greatest Conservation Need and their habitats inform the application of compensatory mitigation for wetlands and streams

From 2009-2011, The Nature Conservancy and the Environmental Law Institute, with support from the Doris Duke Charitable Foundation, worked with the U.S. Army Corps of Engineers, TDEC, EPA, TWRA, and other partners to demonstrate how data on GCN species and their habitats could be utilized as part of the watershed approach framework for wetland and stream mitigation decisions in Tennessee (**Palmer and Wisby 2011**).

The Stones River Watershed map shows the distribution of important stream habitats and potential wetland areas based on known GCN distributions and wetland habitat preferences. The results of this pilot effort demonstrate that proper application of the compensatory mitigation hierarchy within a watershed context can help achieve habitat conservation as well as promote the restoration and protection of other important resource values (Palmer and Wisby 2011). Using the information in the SWAP GIS database, similar watershed maps can now be produced for watersheds across Tennessee, at the preferred spatial scale of the planning effort.

> Application of this compensatory mitigation hierarchy within a watershed context can help achieve habitat conservation as well as promote the restoration and protection of other important resource values.

The Stones River is a significant watershed in Tennessee's history. It 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.



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. The Nature Conservancy 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.

The final report provides specific recommendations on how mitigation siting and techniques can be applied to achieve multiple resource benefits. These benefits include the following:

- Improving stream health currently degraded from excess sediment;
- Protecting and restoring species habitat;
- Connecting existing conservation lands in the watershed; and
- Maintaining and improving recreational, historic, and agricultural resources.

With respect to GCN species conservation, the Stones River watershed plan identifies several opportunities to avoid negative impacts and utilize restoration and preservation techniques to improve habitat conditions. These include the following:

- Floodplain sections of the East and West Forks of the Stones River provide significant habitat for rare plant and terrestrial animal species.
- The East Fork of the Stones contains the majority of remaining populations of fish, mussel, and crayfish native to the watershed.
- The upper headwaters of the East Fork provide extremely significant habitat for the Brawley's crayfish, a globally rare and State listed Endangered species.
- Isolated wetland habitats in the Puckett Creek subwatershed occupied by the Streamside Salamander, a State rare species, may be impacted by projected land conversion.
- The limestone glade habitats, including seep zones, are highly significant for many globally rare endemic plant species.

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 the associated benefits they provide.

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.

Top to bottom: Gray Bats - USFWS; Louisiana Waterthrush - Andy Reago & Chrissy McClarren; Stones River - Casey Fleser

The strategy calls upon government agencies and non-government partners to incorporate goals, strategies, and actions as appropriate into ongoing planning efforts, particularly State Wildlife Action Plans (NFWPCAP 2012).

As described in Chapter 4, TWRA and TNC worked with the National Wildlife Federation (NWF) to complete an updated vulnerability assessment for species and habitats in Tennessee and begin the process of identifying potential adaptation strategies (Glick et al. 2015). NWF is a national leader in connecting climate science and adaptation principles with on-the-ground management actions. The 2014 publication **Climate-Smart Conservation: Putting Adaptation Principles into Practice**, outlines a planning process that guides the development of many types of conservation actions to address climate change-related management concerns and provides case studies of strategy development and implementation (Stein et al. 2014).

Ephemeral wetlands at Hickory Flats WMA - Josh Campbell, TWRA

For the 2015 SWAP revision, the planning team focused on identifying which NFWPCAS goals and strategies best aligned with TWRA's mission and expertise, the key vulnerabilities facing Tennessee's native species and habitats, and what types of adaptation options might be most applicable for addressing key vulnerabilities.

While TWRA and its conservation partners in Tennessee have a role in achieving all seven national goals, three goals and their accompanying strategies were identified as particularly appropriate and connected to important conservation needs in Tennessee (Table 17).

Focus on key vulnerabilities and general adaptation actions

Effectively designing adaptation actions requires an emphasis on "key vulnerabilities," including an understanding or working hypothesis of the reasons a species or habitat is vulnerable (Stein et al. 2014). The companion report to this 2015 SWAP revision (Glick et al. 2015) provides a discussion of the key vulnerabilities facing Tennessee's species and habitats, which also are summarized in Table 18. The 2015 planning team also took the NWF General

Adaptation Strategy system and aligned it with the three main NFWPCAS national goals chosen as a method of "stepping down" elements of the national strategy into more specific adaptation options (see Table 19).

Identifying preliminary adaption options

Many of the conservation strategies and management actions previously discussed in this chapter are highly relevant for addressing climate change vulnerabilities. However, applying these actions as climate adaptation options requires considering their effectiveness given the potential impacts of climate change at local and landscape scales and in the context of other problems

Table 17. NFWPCAS goals and strategies emphasized in Tennessee's SWAP

Goal	Strategy
Goal 1: Conserve habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate.	***Strategy 1.1:*** Identify areas for an ecologically-connected network of terrestrial, freshwater, coastal, and marine conservation areas that are likely to be resilient to climate change and to support a broad range of fish, wildlife, and plants under changed conditions.
	Strategy 1.2: Secure appropriate conservation status on areas identified in Action 1.1.1 to complete an ecologically connected network of public and private conservation areas that will be resilient to climate change and support a broad range of species under changed conditions.
	Strategy 1.3: Restore habitat features where necessary and practicable to maintain ecosystem function and resiliency to climate change.
	Strategy 1.4: Conserve, restore, and as appropriate and practicable, establish new ecological connections among conservation areas to facilitate fish, wildlife, and plant migration, range shifts, and other transitions caused by climate change.
Goal 2: Manage species and habitats to protect ecosystem functions and provide sustainable cultural, subsistence, recreational, and commercial use in a changing climate.	***Strategy 2.1:*** Update current or develop new species, habitat, and land and water management plans, programs and practices to consider climate change and support adaptation.
	Strategy 2.2: Develop and apply species-specific management approaches to address critical climate change impacts where necessary.
	Strategy 2.3: Conserve genetic diversity by protecting diverse populations and genetic material across the full range of species occurrences.
Goal 7: Reduce non-climate stressors to help fish, wildlife, plants, and ecosystems adapt to a changing climate.	***Strategy 7.1:*** Slow and reverse habitat loss and fragmentation.
	Strategy 7.2: Slow, mitigate, and reverse where feasible ecosystem degradation from anthropogenic sources through land/ocean- use planning, water resource planning, pollution abatement, and the implementation of best management practices.
	Strategy 7.3: Use, evaluate, and as necessary, improve existing programs to prevent, control, & eradicate invasive species and manage pathogens.
	Strategy 7.4: Reduce destructive capture practices, over-harvesting and illegal trade to help increase fish, wildlife, and plant adaptation.

Table 18. Key Vulnerabilities of Tennessee Species and Habitats

Climate Change Drivers	Potential Impacts	Key Vulnerabilities
Changes in precipitation timing and duration	• Increased frequency, duration, and intensity of drought •Changes to seasonal timing, frequency, and magnitude of moderate and extreme flood events •Changes to habitat availability for different life history stages •Interactions with water quality conditions •Instream flow management response issues	•Low flow/extreme low flow and base flow alteration could result in reduced habitat quality and connectivity for aquatic species. •Increasingly extreme flood events could lead to habitat destabilization (especially in headwater/smaller order streams), affect spawning cues for some species, and interrupt the availability of feeding and nursery grounds. •Increases in stormwater runoff are likely to exacerbate the input of excess nutrients and toxicity loading and contribute to altered pH and dissolved oxygen levels. •Extreme droughts could alter habitat availability, including breeding habitat and food sources for birds, spawning habitat for mussels and fish, and vernal pools for amphibians.
Increasing temperatures	•Contributions to terrestrial habitat shifts •Relationship to pest and pathogen spread •Changes to freshwater and cave habitat suitability •Interactions with water quality conditions •Contributions to phenological mismatch	• Thermal habitat suitability is likely to be reduced for a number of aquatic species, especially Brook Trout, Hellbenders, and some mussel species. •Increased evaporation could cause drying of vernal pool habitats. •Higher temperatures in caves could harm certain cave fish and bat hibernacula. •Significant shifts in forest habitat types are projected, particularly at higher elevations and in the western portion of the state. •Negative impacts are expected among high-elevation habitat-dependent species such as Rock Vole and Carolina Northern Flying Squirrel. •Spread of pests and pathogens are likely to affect plant and animal species both directly and indirectly. •Phenological mismatch could lead to disruptions in species interactions and mutualisms (e.g., timing of insect emergence and other food sources for birds, fish, and other species).
Altered disturbances (e.g., fire, wind damage, ice storms)	•Contributions to terrestrial habitat shifts •Relationship to spread of invasive species •Damage to habitat	•Increasingly extreme events could have adverse effects on habitat quantity and quality, especially in forest communities. •Altered fire regimes could pose significant challenges for fire management practices.

affecting species and habitats (Stein et al. 2014).

The three elements of Tennessee's vulnerability assessment – priority species, potential vegetation/ habitat change, and landscape geophysical settings – as well as the landscape-level assessments of major problems statewide, allow TWRA and conservation partners to examine a variety of specific adaptation actions in different spatial contexts.

The SWAP planning team began this process of identifying preliminary adaptation options for a variety of species, habitats, and their key vulnerabilities. The following themes guided this effort (adapted from NWF 2014):

✦Identify circumstances where managing for habitat and species population changes, rather than persistence, may be appropriate.

✦Consider how conservation goals may need to change over time.

✦Link adaptation concepts to existing management actions.

Table 19. Alignment of NWF general adaptation strategies with three NFWPCAS goals of emphasis in the TN SWAP

NFWPCAS Goal	NWF ClimateSmart General Adaptation Strategy	NWF ClimateSmart General Adaptation Strategy Description
1	Protect Key Ecosystem Features	Focus management on structural characteristics, organisms, or areas that represent important "underpinnings" or "keystones" of the current or future system of interest. This may include protecting features such as the "geophysical settings" (Anderson et al. 2014).
	Ensure Connectivity	Protect, restore, and create landscape features that facilitate movement of organisms (and gene flow) among resource patches.
	Protect Refugia	Protect areas less affected by climate change as sources of "seed" for recovery or as destinations for climate-sensitive migrants.
	Restore Structure & Function	Rebuild, modify, or transform ecosystems that have been lost or compromised, in order to restore or establish desired structures and functions.
2	Support evolutionary potential	Protect a variety of species, populations, and ecosystems in multiple places to bet-hedge against losses from climate disturbances, and where possible manage these systems to assist positive evolutionary change.
	Relocate organisms	Engage in human-facilitated transplanting of organisms from one location to another in order to bypass a barrier.
7	Reduce non-climate stressors	Minimize localized human stressors that hinder the ability of species of ecosystems to withstand or adjust to climatic events.

Tennessee's exposure to climate change and landscape-scale impacts can be summarized in three broad categories: (1) changes in precipitation timing and duration; (2) warming temperatures; and (3) climate effects on the magnitude, severity, and return interval of

Smoky Mountains: The varied topography of mountainous terrain in east Tennessee has provided a home for many species over the millennium and is a critical region of habitat in the Southern Appalachians – Lee Coursey

disturbances (i.e. fire, wind damage, ice storms). These factors, both in isolation and combination, contribute to a variety of natural system vulnerabilities across the state (Table 18).

Appendix J summarizes preliminary adaptation options for different sets of priority species and habitats, all related to shifting precipitation and warming temperatures. These preliminary results focus on the following overarching conservation needs:

✦Maintain and improve hydrologic integrity of aquatic systems to support GCN species populations and habitats.

✦Maintain and improve suitable breeding habitat for migratory birds across their range in Tennessee in collaboration with regional partners.

✦Maintain and increase, as appropriate, the quality and abundance of amphibian breeding habitats.

✦Protect and maintain, where feasible, cold water stream habitat in support of eastern Brook Trout populations.

✦Conserve high elevation (>6000 ft) sites and monitor for potential forest type transition, managing for structure, function, and species migration changes as feasible.

✦Maintain stable populations of GCN species experiencing pathogen outbreaks through protection and management of diverse habitats, monitoring, and addressing the impacts of pathogens.

The planning team generated a variety of appropriate adaptation options designed to achieve these six overarching conservation needs. They are listed in Appendix J, grouped by both NFWPCAS goal (1, 2, or 7) and associated NWF general adaptation strategy. Next steps needed to refine these preliminary adaptation options are to apply them in goal- and outcome-setting exercises for the various species and habitat conservation targets, then evaluate which set of adaptation actions best address the conservation needs and also are feasible to implement (Stein et al. 2014).

Moving forward, TWRA, in collaboration with its conservation partners, will use the vulnerability assessment information and strategy development framework identified in the 2015 SWAP revision to generate additional adaptation options for priority species and habitats. This effort may include, but is not limited to, identification of new priority areas for acquisition and management; strategies for managing current high priority habitats as they transition to new vegetation states; new priorities for aquatic habitat restoration activities; and decisions regarding alternative management approaches to GCN species populations.

Frozen Head Mountain at Frozen Head Natural Area and State Park, TN - Michael Hodge

Northern Gray-cheeked Salamander, a GCN species - Chris Ogle, TWRA

CHAPTER 6

MONITORING FOR RESULTS AND ADAPTIVE MANAGEMENT

MONITORING OF SPECIES AND HABITATS IS IMPORTANT TO (1) gain a long-term understanding of trends in populations or ecosystem health, (2) provide greater understanding of species responses and needs relative to problems and changing environmental conditions, and (3) assess the results and effectiveness of conservation actions — the key to adaptive management. The first two purposes are collectively referred to as status monitoring, while the last is called effectiveness monitoring.

6.1. The Standards for Measuring Effectiveness of Actions

The 2005 SWAP provided a comprehensive summary of the species and habitat status monitoring conducted by TWRA, other government agencies, academic institutions, and volunteer organizations (see TWRA 2005, pp. 188-198). TWRA has long conducted status monitoring programs to assess and track various wildlife populations (see TWRA 2005, Appendix H "Sampling Protocols for Select Faunal Groups"), both for purposes of management and to identify problems. The results of individual conservation projects are likewise tracked, although often final assessments may consist of cataloguing actions successfully completed.

However, the Association of Fish and Wildlife Agencies in its 2011 *Measuring the Effectiveness of State Wildlife Grants* report notes that, "it has been much more difficult [for state agencies] to bring these two sets of data together to attribute changes in species or habitat status to the effects of any one action" (AFWA 2011). In Tennessee, much of the difficulty lies in ascertaining the status of resources at different spatial

Waterfall at Short Springs State Natural Area - Byron Jorjorian

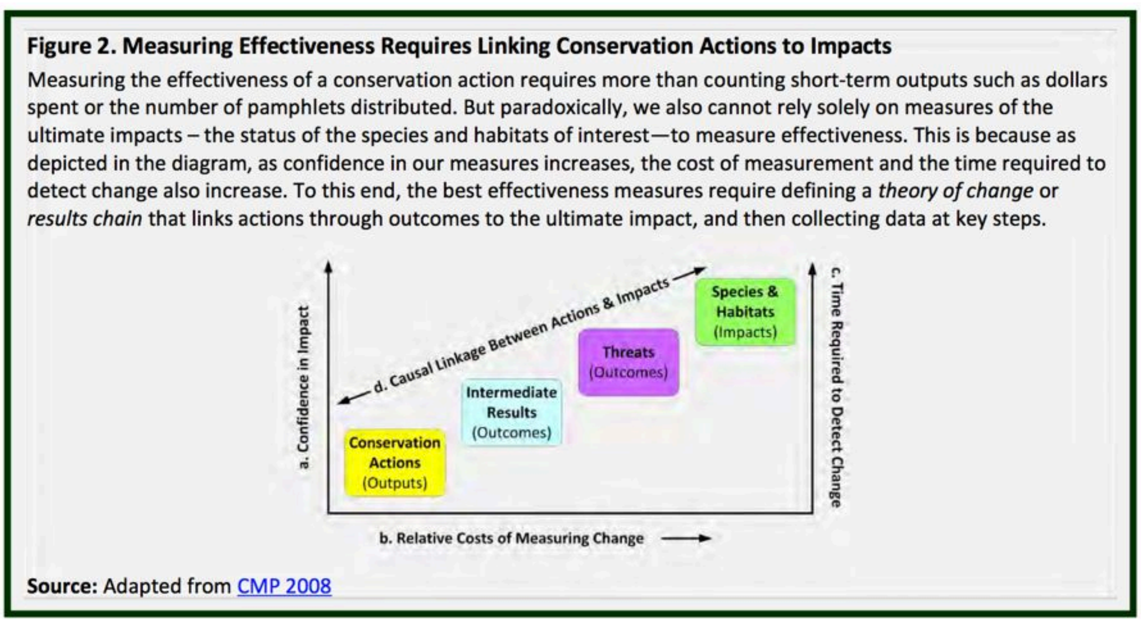
Summary: Monitoring and adaptive management goals in the 2015 SWAP

1. Focus on improving effectiveness monitoring in Tennessee. The 2005 SWAP provided an inventory of TWRA and partner status monitoring programs for species and habitats. The 2015 SWAP introduces effectiveness monitoring and outlines steps for integrating these approaches into existing agency programs and planning cycles.
2. Be explicit about metrics of conservation effectiveness. TWRA has developed a crosswalk of the TN-SWAP specific conservation actions to the U.S. Fish and Wildlife Service's Wildlife/TRACS Reporting System strategy hierarchy. TRACS reporting units have also been assigned for each set of desired changes articulated for the state's Conservation Opportunity Areas.
3. Develop an effectiveness measures framework. TWRA will incorporate status monitoring objectives and effectiveness measures into its existing planning cycles through triennial SWAP reviews and updates.
4. Begin using the Wildlife/TRACS Reporting System. TWRA plans to adopt the format of TRACS conservation measures, using TRACS as an overarching method for tracking and reporting on nongame wildlife monitoring and conservation projects in the state. TWRA will also assess current monitoring data and protocols to incorporate specific effectiveness monitoring approaches for key species and sites.
5. Maximize knowledge and conservation effectiveness through participation in shared monitoring databases.

scales and the connection between different types of conservation actions and results, particularly at landscape scales that necessarily must include at least some private lands. To assist states with making the connections between different types of monitoring, AFWA developed guidance on how to measure the effectiveness of conservation actions funded through the State Wildlife Grants (SWG), including recommendations for how to track and report that effectiveness. The importance of this tracking ultimately goes beyond a consideration of dollars and cents; it cuts to the heart of the stewardship enterprise by providing insight into the overall effectiveness of planning, management, and adaptation to benefit species and habitats.

The Effectiveness Measures report developed a framework for use by states and their partners in evaluating the effectiveness of

Figure 10. Measuring effectiveness requires linking conservation actions to impact



actions funded under State Wildlife Grants, as well as broader conservation strategies outlined in SWAPs (see Figure 10, taken from AFWA's 2011 Effectiveness Measures report). The report also provides comprehensive examples of connecting conservation actions to outcomes, including suggested objective statement formats and monitoring indicators for 11 generic conservation actions. All of these actions are identified in the 2015 TN-SWAP, and conservation partners are encouraged to use these examples as a resource to help design and implement successful conservation projects.

TWRA Wildlife Diversity Coordinator Chris Simpson (left) and TWRA Fisheries Program Manager Mark Thurman seining for GCN fish species in the Roaring River State Scenic River - Mime Barnes, TWRA

6.2. TWRA Adoption of Standardized Effectiveness Measures

The Effectiveness Measures report made several overarching recommendations to states. TWRA will be implementing the following recommendations:

1. Adopt the proposed effectiveness measures framework to improve accountability and project management of State Wildlife Grants.

TWRA has developed a crosswalk of the TN-SWAP specific conservation actions to the U.S. Fish and Wildlife Service's **Wildlife/TRACS Reporting System** Category (Level 1) and Strategy (Level 2) hierarchy (Appendix K). TRACS reporting units have also been assigned for each set of desired changes articulated for the state's Conservation Opportunity Areas (Appendix I).

2. Integrate the effectiveness measures framework into agencies' adaptive management, grant application, and reporting processes; this includes the use of these measures in reporting through the Wildlife/TRACS Reporting System.

TWRA will incorporate monitoring objectives and effectiveness measures into its existing planning cycles through triennial SWAP reviews and updates.

TWRA intends to incorporate status monitoring objectives and effectiveness measures into its existing planning cycle through triennial SWAP reviews and updates (see Table 20, Ch. 7). These reviews will provide an opportunity to assess conservation achievements in COAs; to prepare and analyze monitoring results; to make adaptive management decisions; and to identify emerging issues and appropriate responses. These reviews will then influence allocation of SWG funds and development of new partnerships. TWRA staff were trained in 2015 how to report these measures for SWG-funded projects in the Wildlife/TRACS Reporting System.

Development and implementation of an effectiveness measures framework will help TWRA and its conservation partners in the following ways:

✦Provide a means to evaluate conservation actions so that successful ones can be replicated and communicated while less successful ones are improved or abandoned;
✦Establish a standardized and accessible body of project performance data to help guide current and future wildlife managers;
✦Provide a cost-efficient mechanism for reporting to Congress, other policy makers, conservation partners, and taxpayers about the value of the SWG program and SWAPs (AFWA 2011).

TWRA Wildlife Diversity Coordinator Rob Colvin holding an Alligator Snapping Turtle - TWRA staff

6.3. Integrating Monitoring and Reporting with TRACS

Through report language in SWG appropriations, Congress has specifically instructed the U.S. Fish and Wildlife Service to work with states to adopt common mapping, data, and measurement standards to facilitate national evaluation and reporting. The Service developed the Wildlife/ TRACS Reporting System to track and report on the effectiveness of SWG-funded conservation actions and to make full use of the effectiveness measures developed by AFWA. TRACS will allow data to be collected and aggregated from state and national level databases.

TWRA plans to adopt the format of TRACS conservation measures as an overarching method for tracking and reporting on nongame wildlife monitoring and conservation projects in the state. This will improve the agency's results accounting, project monitoring, grant reporting,


TWRA Wildlife Diversity Coordinator Scott Dykes with a Golden Mouse - TWRA Staff

and determination of SWAP conservation strategies.

Another important goal is to generate spatial project 'footprints' in the TWRA GIS system to provide planners a better overview of their activities in a region.

According to AFWA (2012), TRACS will enhance overall SWAP effectiveness monitoring because it will accomplish the following:

✦Format data in a consistent manner, and encourage conservation partners to provide standardized information.
✦Incorporate the Effectiveness Measures approved by AFWA.
✦Demonstrate effectiveness in a format usable by the U.S. Congress and the Office of Management and Budget (OMB).
✦Provide industries that pay sporting excise taxes with information on the disposition of excise tax dollars and the return on investment of those tax dollars.
✦ Provide accountability and transparency while demonstrating the benefits of wildlife funding programs.

TWRA Wildlife Diversity Biologist Chris Ogle (left) and Wildlife Diversity Coordinator Josh Campbell place a monitoring band on a federally endangered Gray Bat. – Chris Simpson, TWRA

TWRA will begin this process by assessing its current monitoring data and protocols, including status monitoring performed by partners and used by the agency, to define specific effectiveness monitoring approaches for key species and sites where conservation work is planned or ongoing. For example the following programs could be adapted to incorporate effectiveness monitoring objectives:

TWRA Wildlife Manager Bill Smith with Northern Bobwhite - Chris Ogle

✦Shorebird and point count data can be aggregated to develop analyses of responses to habitat change (from restoration, management, climate change, etc.).
✦The use of drift fence monitoring of amphibians at breeding sites could be used to assess the species assemblages pre- and post-management or pre- and post-restoration, with a

particular focus on key projects, such as TWRA's early successional habitat initiative and Quail Focal Areas established in collaboration with the National Bobwhite Conservation Initiative.
✦The SWAP GIS database incorporates updates to land use data from the National Land Cover Database (NLCD) as it becomes available. The NLCD is the definitive Landsat-based, 30-meter resolution, land cover database for the U.S. Comparing land use from one update to the next would provide a comprehensive picture of changes in wildlife habitats at a state scale.

Long-term monitoring is essential to determine the success of species reintroduction efforts, such as reintroduction of the Pale Lilliput mussel into the Duck River in 2014. Crew left to Right: Todd Fobian, Alabama Aquatic Biodiversity Center (AABC); Andrew Henderson, TVA; Paul Johnson, AABC; Steve Ahlstedt (slightly in front), U.S. Geological Survey (retired); Jeff Powell, USFWS; Allen Pyburn, TWRA; Don Hubbs, TWRA; Michael Buntin, AABC; Stephanie Chance, USFWS - photo by Sally Palmer, TNC

6.4. Regional-scale Monitoring Collaborations

One example of how agencies can assess wildlife responses to management is through replicating project strategies and analyzing multiple sets of results over time. In addition, monitoring habitats and populations over a sufficient geographic area and

Steve Ahlstedt, USGS (retired) and Don Hubbs, TWRA preparing to place mussels into the Duck River - Sally Palmer, TNC

TWRA's Statewide Instream Flow Coordinator Pandy English holding two Northern Black Racers - Scott Dykes, TWRA timeframe can provide insight into how wildlife populations are changing or responding to change. Both of these objectives can be achieved when agencies (1) cooperate to leverage one another's work and knowledge by using monitoring standards that make data comparable, and (2) consolidate data in formats that promote collaborative use.

Jeremy Dennison, TWRA Wildlife Diversity Biologist, holding a Hellbender. - Rob Colvin, TWRA

Several examples of significant monitoring efforts and information sharing include the Tennessee River watershed Index of Biotic Integrity (IBI) work conducted by the Tennessee Valley Authority (TVA); the Great Smoky Mountains National Park All Taxa Biotic Inventory (ATBI); inventory and monitoring conducted by the U.S. Forest Service on federal forest lands; stream flow and biological monitoring managed by the U.S. Geological Survey; and multi-state freshwater mollusk recovery and monitoring activities with the U.S. Fish and Wildlife Service and academic institutions. These program activities, as well as those of many other partners, provide foundational habitat and species population status information that is instrumental to making sound management decisions over time. Solidifying relationships under Memoranda of Understanding or other types of network arrangements can be important mechanisms to ensure this type of critical partnership work is sustainable into the future.

Dustin Thames, TWRA Wildlife Diversity Biologist, attaching a radio transmitter to an Indiana Bat - Chris Simpson, TWRA

For wide-ranging species such as many birds, TWRA recognizes that regional, national, or flyway-wide databases will enhance each state's ability to manage and conserve these species across broad and biologically meaningful geographic areas. Specifically, the **Avian Knowledge Network** (AKN) is currently developed, supported, and used by many federal, state, and non-profit organizations and has proven to be extremely

TWRA Fisheries Program Manager Bart Carter holding a Paddlefish - Scott Dykes, TWRA/below: Carl Williams, TWRA Biologist, using mist net to monitor crayfish, which are released after collecting data. - Bart Carter, TWRA

effective in providing secure data storage capabilities and facilitating the application of monitoring standards to make datasets comparable across institutions and political boundaries. TWRA considers the exchange and integration of avian data into a permanent centralized data management system a priority action to be accomplished by 2020.

The AKN's Eastern Avian Data Center is an online node that could serve as Tennessee's data entry, storage, and retrieval website. In fact, the AKN already hosts some data from TWRA as well as agency partners. The benefit of this system is an online data interface that allows project or program leaders to easily enter and retrieve data. Another advantage is the community of users that can develop shared tools to analyze data for specific projects and also help to incorporate Tennessee data into larger scale analyses of phenomena such as migration patterns.

Since 2005, TWRA has also invested in the reorganization of its internal data management systems. The new database portals allow consolidation of a variety of project and monitoring data managed internally by TWRA. Compilation of these data ultimately will improve TWRA's ability to share information with other partners and participate in regional-scale monitoring efforts.

CHAPTER 7

TENNESSEE SWAP REVIEW AND REVISION

THE U.S. FISH AND WILDLIFE SERVICE (USFWS) REQUIRES REVIEW of State Wildlife Action Plans (SWAPs) at intervals of 10 years or less. The Association of Fish and Wildlife Agencies (AFWA) recommends that state resource agencies form a working group to assess SWAPs and SWAP implementation, identify best practices, and recommend improvements to SWAPs. In addition, AFWA recommends that SWAP reviews align with other relevant internal conservation planning efforts, for example in Tennessee, TWRA's Strategic Plan. Also, for taxa for which the state has limited authority, staff, or funding (such as insects and plants), agencies are encouraged to engage outside partners and seek additional funding to address these needs. TWRA proposes to engage in a three year review cycle which will provide the foundation for the next ten year comprehensive SWAP review in 2025.

7.1. Integrating Conservation Implementation, SWAP Review, and TWRA Planning Cycles

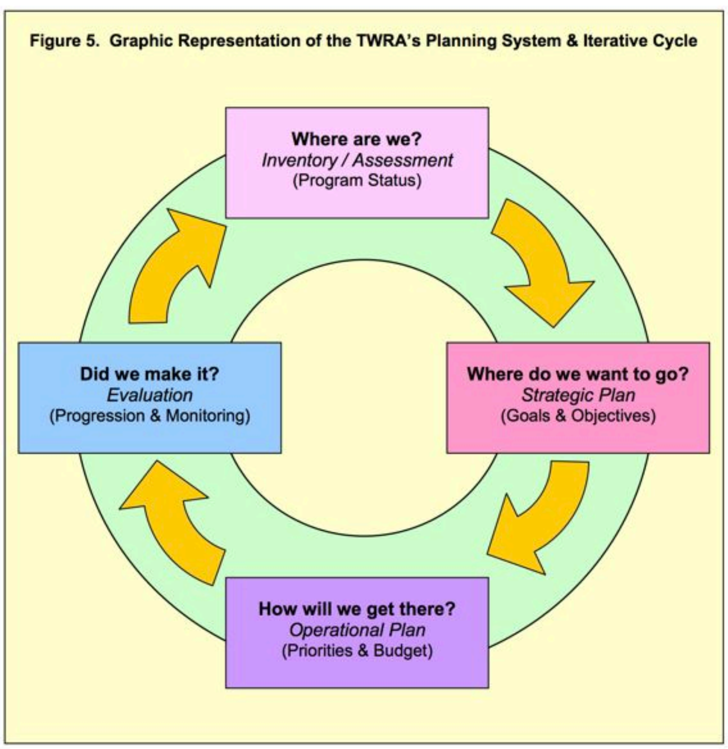
SWAP interim reviews and updates will be incorporated into the agency's comprehensive planning cycle (see Figure 11), by coordinating and sharing information across planning processes and departments within the agency. Table 20 shows the overlap and relationship of the various planning cycles over the SWAP's 10-year timeframe for implementation and revision. Coordination between the 2005 SWAP and TWRA's 2014-20 Strategic Plan has already resulted in a precedent: for the first time, TWRA adopted a habitat-based approach to define the priority management outcomes for its

Photo: Bald Cypress at Hatchie National Wildlife Refuge - Byron Jorjorian

Summary: The SWAP Review and Revision Process 2015-2025

1. Align SWAP reviews with the overall TWRA agency planning cycle. Specifically, integrate TWRA's cycles for SWAP planning with strategic planning, operational planning, and annual planning. The new SWAP planning schedule will include 3 triennial reviews to be rolled up into a draft SWAP update in year 10.
2. Improve partner engagement in SWAP implementation and planning. TWRA proposes to make the SWAP Planning Team as well as the Scientific and Technical Advisors into long-term standing committees. Teams will identify a subset of habitats for interim review (those likely to benefit from or require a shorter review period). Working groups that include conservation partners active in the COAs will review progress in a subset of COAs as part of each triennial SWAP review.
3. Improve and expand data sharing through shared databases and GIS information. TWRA will build upon relationships to reciprocally share and upgrade, on a regular basis, databases and GIS information with the most recent information collected by partners.
4. Identify emerging issues and lessons learned. Emerging issues will be addressed in the planning cycle described, documented with the USFWS, and summarized in subsequent revision documents. TWRA has identified several best practice approaches for improving SWAP implementation and future revisions.

Figure 11. **Graphic representation of the TWRA's planning system and iterative cycle**



Wildlife Resources Program.

Strategic Planning Cycle

TWRA's Strategic Planning cycle recurs at six-year intervals. The Strategic Plan sets forth legal responsibilities, policies, and program structure, and it identifies goals, objectives, problems, and strategies for each program. The SWAP helps inform the planning components for the next iteration of TWRA's strategic plan process, and both the Strategic Plan and SWAP help to guide annual budgetary and operational planning in subsequent years. In year three of the Strategic Planning cycle, a mid-term evaluation is conducted to determine program progress toward Strategic Plan goals. An end-of-cycle evaluation also occurs in year six.

Operational Planning Cycle

Operational Plans are site-specific plans that guide the management of discrete state-owned units, such as Wildlife Management Areas (WMAs). The primary management objectives for WMAs typically focus on game species management. The role of diversity staff in operational planning is primarily to ensure that the impacts to species of nongame/GCN animals, GCN plants, and significant natural communities are minimal, while promoting management strategies that improve GCN species habitat. Operational Plans are informed by both Strategic Plan Goals and SWAP priorities.

Annual Project Evaluation Cycle

Within 90 days of the fiscal year closing, every TWRA project is subjected to an annual evaluation according to established performance measures. Beginning in 2016, this process will include evaluation according to the Effectiveness Measures guidelines recommended by AFWA (see Chapter 6), and project performance data will be entered into the TRACS reporting system, while project spatial data will be entered into the SWAP GIS relational database as well. These evaluations will assess the effectiveness of SWG-funded and other projects, inform future SWAP priorities, and provide a measure of progress toward Strategic Plan goals.

By including partners in SWAP 3-year reviews, the agency is fostering the incorporation of SWAP priorities into the strategic planning efforts of other agencies and organizations.

SWAP Planning Cycle

The SWAP will be updated iteratively on a cycle of 3-year reviews and will focus on progress made in COAs; documentation of collaborative efforts and the work of partners in support of the SWAP; responses to emerging issues; and the incorporation of results from SWG and other project evaluations (to be assessed annually, with data loaded into TRACS). The results of three triennial reviews would then be rolled up into a draft SWAP update in year 10.

To accomplish interim SWAP progress reviews, TWRA proposes to make the SWAP Planning Team as well as the Scientific and Technical Advisors (drawn from many partner organizations and agencies) into long-term standing committees. The annual SWG project review

Partners from state and federal agencies participating in the 2015 SWAP revision. - Lindsay Gardner, Southeast Aquatic Resources Partnership process and the triennial SWAP reviews will inform TWRA's annual budget planning cycles, as well as the activities of other TWRA divisions. For example, the Environmental Services and Real Estate divisions rely on GCN species location data and habitat priorities when reviewing permit applications, developing grants, and targeting land acquisition.

Big South Fork National Recreation Area is encompassed within the North Cumberland Plateau and Mountains Conservation Opportunity Area. - Byron Jorjorian

Habitats selected for review will be identified by the SWAP Planning Team and Scientific/Technical Advisors as those likely to benefit from or require a shorter review period. COA reviews will be developed by working groups that include conservation partners active in the COAs. By including partners in SWAP 3-year reviews, the agency is fostering the incorporation of SWAP priorities into the strategic planning efforts of other agencies and organizations. Multiple partnerships will also promote leveraging of SWG and other conservation funds, while increasing the state's capacity to achieve priority conservation goals.

Shorter SWAP review cycles within the 10-year update period will also foster:

✦More timely and effective response to unforeseen emerging issues, such as changes related to climate, pathogens, or other stressors;
✦Greater continuity and flexibility in dealing with staff turnover and the potential for loss of institutional knowledge;
✦The development of annual objectives that can build toward achieving more long-term goals.

7.2. SWAP GIS Relational Database Updates

In addition to documenting project evaluation data annually, and to ensure that Tennessee's SWAP remains a "a living plan," TWRA will build upon relationships already established between the Agency and The Nature Conservancy, the Natural Heritage Inventory Program within the Tennessee Department of Environment and Conservation Division of Natural Areas, and the Tennessee Valley Authority to reciprocally share and upgrade, on a regular basis, databases with the most recent information each organization has collected. TWRA will also explore the possibility of expanding this partnership to other pertinent agencies, such as the Tennessee Division of Forestry, Tennessee Department of Transportation, U.S Department of Agriculture Natural Resources Conservation Service, the U.S. Fish and Wildlife Service, and other partners as appropriate. TWRA also will explore opportunities to share information on priorities and projects through different types of website interfaces for partners and the general public, with access and data protocols designed to protect sensitive information and ensure appropriate application of the data.

7.3. Emerging Issues

Inevitably, new issues will arise in between the 10-year comprehensive review cycles for State Wildlife Action Plans. SWAP Best Practices guidance indicates that these emerging issues can be addressed through "documented coordination with the U.S. Fish and Wildlife Service . . . as long as the issue is included in the next revision" (AFWA 2012).

Holiday Darter - Jeremy Monroe, Freshwaters Illustrated

The devastating onslaught of White-nose Syndrome (WNS) in bat populations across the eastern U.S., and its arrival and impacts in Tennessee since early 2010, illustrates the dynamic nature of wildlife conservation management and the need for effective responses to emerging issues. "Parasites and pathogens" were identified as a problem during the 2005 SWAP effort; however, WNS had not yet advanced and caused drastic population declines in cave-dwelling bats. In less than 10 years, however, even those bat species whose populations were stable prior to the onset of WNS have declined significantly. TWRA and its conservation partners have invested heavily in population monitoring, cave management, and disease abatement strategies for the past five years, and WNS is now identified within this 2015 update as an ongoing management challenge.

Eastern Meadowlark, like many grassland animals, a species of Greatest Conservation Need - Thomas Blevins

With time, emerging issues likely will include challenges associated with both temperature and precipi-tation shifts from a changing climate, and potential conflicts between resource uses and habitat needs. For example, more frequent and prolonged droughts may increase the demand for irrigated agriculture in Tennessee, which can result in more pressure on groundwater resources in the western part of the state and surface water streams in middle and east Tennessee. At the same time, these water resources provide public drinking water supplies, wastewater assimilation, recreation, and diverse species habitats.

Other examples of potential emerging issues in the future may involve consideration of the special habitat needs of insect pollinators. Pollinators play a crucial role in the health of overall ecosystems and maintenance of plant diversity in many habitat types (The Heinz Center 2013). Assessing the status of pollinators in Tennessee and their potential management needs could be considered emerging issues in future plan iterations.


Eastern Carpenter Bee - Bob Peterson

Addressing these types of challenges requires a commitment to collaboration among many agencies and stakeholders, particularly through advance planning and a willingness to share information in trans-parent decision-making processes. For the SWAP, emerging issues will be addressed on the planning cycle described, documented with the USFWS, and summarized in subsequent revision documents.

7.4. Lessons Learned from Tennessee's SWAP Review and Revision

The following is a list of ideas and potential next-step actions from Tennessee's SWAP planning team that could improve TWRA's processes in preparing for the next iteration of SWAP revision:

✦Organize all plans, monitoring reports, and other useful documents on a comprehensive internal server and staff-accessible drive to facilitate compiling pertinent information for the next revision.

✦Improve TWRA staff training in use and application of SWAP GIS data and TRACs.

✦Maintain regularly updated maps of conservation action and project locations.

✦Have staff or interns compile status survey data results by project, so that not only accomplishments but results of conservation management can be incorporated into SWG funding, project planning, and future SWAP goals.

✦Ensure that data entry protocols for projects are established and clear, and that all individuals conducting data entry work are trained in data quality control standards as appropriate.

✦Develop a culture of documenting conservation stories to share with partners and the public. For example, what are the interesting management activities (involving odd equipment, rare animals) that TWRA biologists and partners undertake, which the public does not know about or understand, and how can they be captured in photographs and stories? Organize and archive field photos, with credits, of TWRA and partners for use in a variety of media communications.

✦Communicate regularly and intentionally with agency partners, non-governmental organizations, and other stakeholders about ongoing work and to foster collaborative efforts and engagement in conservation efforts.

These types of specific activities, in conjunction with a more standardized review process aligned with TWRA's overall planning cycles, will help the agency more efficiently address the U.S. Fish and Wildlife Services's SWAP revision requirements over time, improve public awareness and engagement with species and habitat conservation in Tennessee, and ultimately increase the success of conservation efforts.

Green Anole next to a TWRA badge - Josh Campbell, TWRA

Table 20. TWRA Planning Cycles

	The Strategic Plan focuses on priority habitats identified in the SWAP; uses project evaluations and SWAP 3-year reviews to assess progress	Operational plans guide specific stewardship activities to achieve Strategic Plan goals; GCN species and habitat priorities are guided by the SWAP	Project evaluations inform TWRA management, COA projects and partnerships; are entered spatially in GIS relational database and reported into TRACS	Annual budgets are informed by past project priorities and results; they factor in SWG and partner funding proposals	SWAP triennial reviews/updates: include key partners, review of annual project evaluations, response to emerging issues, and development of new projects and funding partnerships as needed
Year	**Strategic Plan Cycle (2014 = year 1)**	**Operational Planning (WMA and other plans)**	**Annual Project Evaluations, (SWGs +)**	**Annual Budget Planning Cycle**	**State Wildlife Action Plan Cycle (2016 = year 1)**
2015		SWAP GCN species habitat priorities, objectives, and stewardship recommendations developed for incorporation into Operational Plans developed to achieve Strategic Plan goals on TWRA-owned lands		Data/results from previous year project evaluations informs budgeting	SWAP Update Approval; establish permanent planning & science advisory committees
2016			First annual review of projects under SWAP 2015, according to Effectiveness Measures guidelines; TRACS data entered	Data/results from previous year project evaluations informs budgeting	Establish working groups that include partner participation for a subset of high priority COAs
2017	3-year evaluation of agency program progress toward achieving Strategic Plan goals		Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	
2018			Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	1st triennial review: COA work groups assess conservation progress; evaluate TRACS project data; assess emerging issues/potential new partnerships; coordinate with Strategic Planning
2019	Next Strategic Plan Cycle begins; incorporates annual project reviews and SWAP review data		Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	
2020	End-of-cycle evaluation assesses achievement of Strategic Plan goals		Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	

	The Strategic Plan focuses on priority habitats identified in the SWAP; uses project evaluations and SWAP 3-year reviews to assess progress	Operational plans guide specific stewardship activities to achieve Strategic Plan goals; GCN species and habitat priorities are guided by the SWAP	Project evaluations inform TWRA management, COA projects and partnerships; are entered spatially in GIS relational database and reported into TRACS	Annual budgets are informed by past project priorities and results; they factor in SWG and partner funding proposals	SWAP triennial reviews/updates: include key partners, review of annual project evaluations, response to emerging issues, and development of new projects and funding partnerships as needed
Year	**Strategic Plan Cycle (2014 = year 1)**	**Operational Planning (WMA and other plans)**	**Annual Project Evaluations, (SWGs +)**	**Annual Budget Planning Cycle**	**State Wildlife Action Plan Cycle (2016 = year 1)**
2021	New Strategic Plan approved (2021-2027)		Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	2nd triennial review: COA work groups assess conservation progress; evaluate TRACS project data; assess emerging issues/potential new partnerships; coordinate with Strategic Planning
2022		SWAP GCN species habitat priorities, objectives, and stewardship recommendations developed for incorporation into Operational Plans developed to achieve Strategic Plan goals on TWRA-owned lands	Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	
2023			Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	
2024	3-year evaluation of agency program progress toward achieving Strategic Plan goals; coordinate with SWAP Update		Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	3rd triennial review: COA work groups assess conservation progress; evaluate TRACS project data; assess emerging issues/potential new partnerships; coordinate with Strategic Planning
2025			Annual review of projects/ effectiveness; TRACS data input	Data/results from previous year project evaluations informs budgeting	SWAP Update #2: incorporate 3 previous triennial SWAP reviews

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Glossary of Terms

acid deposition - also known as acid rain, is an environmental phenomenon caused by air pollutants, mainly nitrates (NOX) and sulfates (SOX) primarily from burning fossil fuels. Acid deposition is characterized by extremely high acidity which is particularly harmful to sensitive ecosystems.

aquatic ecological system - dynamic spatial assemblages of ecological communities (e.g. rivers, streams, and lakes) with similar geomorphological patterns tied together by ecological processes (e.g. hydrologic and nutrient regimes, access to floodplains) or environmental gradients (e.g. temperature, chemical and habitat volume), and form a cohesive, distinguishable unit on a hydrography map.

barrens - Tennessee's barrens ecosystems are typically mosaics of open canopy woodlands, or lacking trees altogether, with a dominance of perennial grasses and herbaceous species

bioaccumulation - the process by which organisms can take up contaminants more rapidly than their bodies can eliminate them.

biodiversity - the full range of natural variety and variability within and among living organisms, and the ecological and environmental complexes in which they occur. It encompasses multiple levels of organization, including genes, species, communities, and ecological systems or ecosystems.

bioenergy - a general term that encompasses both biofuel and biomass as sources of energy generation.

biofuels - biofuels, generally defined as liquid fuels derived from biological materials, can be made from plants, vegetable oils, forest products, or waste materials. The raw materials can be grown specifically for fuel purposes, or can be the residues or wastes of existing supply and consumption chains, such as agricultural residues or municipal garbage.

biomagnification - also known as bioamplification or biological magnification, is the sequence of processes in an ecosystem by which higher concentrations of a particular chemical, such as DDT or mercury, are reached in organisms higher up the food chain, generally through a series of prey-predator relationships.

biomass - solid organic materials produced in a renewable manner for energy generation. Two categories of biomass fuels, woody fuels and animal wastes, comprise the vast majority of available biomass fuels.

buffer - conservation buffers are small areas or strips of land in permanent vegetation, designed to slow water runoff, provide shelter and stabilize riparian or other habitat areas. Strategically placed buffer strips in the agricultural landscape can effectively mitigate the movement of sediment, nutrients, and pesticides within farm fields and from farm fields.

conservation action - any act taken to directly abate a stress or source of stress to a target species or habitat, or to prevent the future development of a stress upon a species or its habitat.

conservation goal - in conservation planning, the number and spatial distribution of on-the- ground occurrences of targeted species, natural communities, and ecological systems that are needed to adequately conserve the target in an ecoregion.

Conservation Opportunity Area - Priority areas for conservation, spatially depicted on the landscape, that offer the best opportunities and potential for conservation of species of greatest conservation need and their habitats.

dam - any structure that impounds water.

decline/declining - the historical or recent decrease of a conservation target through all or part of its range. Declining species exhibit significant, long-term decreases in habitat and/or numbers, are subject to a high degree of threat, or may have unique habitat or behavioral requirements that expose them to great risk.

diadromous - Fish that can live in and are migratory between fresh waters and salt waters.

disjunct - distributional range of a species or community which is found in an ecoregion a significant distance from its primary range in other disconnected ecoregions. Disjunct species have populations that are geographically isolated.

distribution pattern - the overall pattern of occurrence for a particular conservation target. In ecoregional planning, distribution patterns are often described in terms of the relative proportion of the target's natural range occurring within a given ecoregion (i.e. endemic, limited, disjunct, peripheral, and widespread).

dry bed retention dam - a dry detention basin temporarily detains and stores collected stormwater runoff for a period of time, releasing the stormwater slowly to reduce flooding and remove pollutants. It is referred to as "dry" because it dries out between rain events. Pollutants are removed by allowing particulates and solids to settle out from the water. Detention does not normally occur until the inflow rate exceeds the design outflow rate.

dry-mesic (forest) - Oak or oak-hickory forest type (typically), characterized by well-drained soils and episodic fire.

ecological systems - ecological systems are dynamic assemblages of native plant and/or animal communities that 1) occur together on the landscape or in the water, 2) are tied together by similar ecological processes (e.g., fire, hydrology), underlying environmental features (e.g., soils, geology), or environmental gradients (e.g., elevation).

ecoregion - a relatively large geographic unit of land and water defined by the climate, vegetation, geology, and other ecological and environmental patterns.

element occurrence (EO) - a term originating from methodology of the Natural Heritage Program network that refers to species, natural communities, or other entities (e.g. migratory bird stopovers, ecological systems) of biodiversity that serve as both conservation targets and as units for organizing and tracking information.

endemic - distributional range of a species or community which primarily or only occurs in one specific area

eutrophication - the process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. These typically promote excessive growth of algae. As the algae die and decompose, high levels of organic matter and the decomposing organisms deplete the water of available oxygen, causing the death of other organisms, such as fish. Eutrophication may be a natural, slow-aging process for a water body, but human activity can greatly speed up or amplify the process.

global rank - a numeric assessment of a biological element's relative imperilment and conservation status across its range of distribution ranging from G1 (critically imperiled) to G5 (secure). Assigned by the Natural Heritage Programs, global ranks for species and natural communities are determined primarily by the number of occurrences or total area of coverage (communities only), modified by other factors such as condition, historic trend in distribution or condition, vulnerability, and threats.

Greatest Conservation Need - a designation determined by each state's fish and wildlife agency, which identifies the species and their associated habitats that are most at risk, threatened, or deserving of conservation action for other reasons.

green infrastructure - a strategically planned and managed network of natural lands, working landscapes, and other open spaces that conserve ecosystem values and functions and provide associated benefits to human populations.

habitat fragmentation - occurs when large ecosystems are separated into smaller pieces, separating and isolating groups of species and habitats from one another, which impacts breeding patterns and may lead to inbreeding.

headwaters - the source area where a river or stream begins in a landscape.

hibernacula - (single hibernaculum) location where a creature seeks shelter over the winter, such as bats using a cave.

incompatible management practices - incompatible practices modify habitat composition, type, and/or ecological processes in a way that is not compatible with the needs of target wildlife or plant species.

instream flow - the natural variations of water levels in rivers and streams, critical to the maintenance of biodiversity and other values, such as recreation, in aquatic ecosystems.
invasive exotic species - nonindigenous species which have been introduced either intentionally or accidentally into areas outside their natural range and that have the capacity to outcompete native species either reproductively or for natural resources.

karst - landscape formed from the dissolution of soluble rocks including limestone, dolomite and gypsum. Karst is characterized by sinkholes, caves, and underground drainage systems.

keystone species - species with an important role in ecosystem function, such as top carnivores.

limited - distributional range of a species or natural community which occurs in the ecoregion and within a few other adjacent ecoregions.

mesophytic (forest) - a forest that generally receives a moderate amount of moisture.

natural communities - terrestrial plant communities of definite floristic composition, uniform habitat conditions, and uniform physiognomy. Natural communities are defined by the finest level of classification, the "plant association" level of the National Vegetation Classification. Like ecological systems, natural plant communities are characterized by both a biotic and abiotic component.

natural process - processes in nature that play a vital role in ecosystem function by causing change or disturbance on a cyclical basis, such as flooding, fire, or plant succession. Habitat restoration can sometimes be achieved by incorporating natural processes into conservation designs.

occurrence - a spatially referenced location of a species or a location of a natural plant community or ecological system. Many occurrences are tracked by the various Natural Heritage Programs and are known as Element Occurrences. Occurrences may also be more loosely defined locations delineated through the definition/mapping or other spatial data or through the identification of areas by experts.

parcelization - generally refers to the division of ownerships that result in smaller holdings of land which, in turn, results in constrained management options and potentially adverse effects on ecosystem health and wildlife habitat. Parcelization is caused by subdividing large tracts into smaller forest tracts, ranchettes for residential use, or sale of large tracts to buyers who further subdivide the land.

prescribed fire - fire that is purposely lit under controlled conditions and guided by a burn plan to improve ecological health, reduce fuel loads that contribute to catastrophic fire, or achieve desired habitat conditions.

propagation - the breeding of plants or animals for reintroduction into suitable habitats as supplementation of existing populations or as a means of restoring locally extirpated populations.

problem - the combined concept of ecological stresses to a target and the sources of that stress to the target.

refugia - (single refugium) areas in which a population of organisms can survive through a period of unfavorable conditions.

rockhouse - a rockhouse is an area that typically has been eroded away by a stream under a large rock or bluff line. Common on the Cumberland Plateau, they are typically found in sandstone where the old stream meandered next to a rock bluff. .

sinkhole - a cavity in the ground, especially in limestone bedrock, caused by water erosion and providing a route for surface water to disappear underground.

source (of stress) - an extraneous factor, either human (i.e. activities, policies, land uses) or biological (e.g. non-native species), that infringes upon a conservation target in a way that results in stress.

species richness - the number of different species represented in an ecological community, landscape or region.

stress - something which impairs or degrades the size, condition, or landscape context of a conservation target, resulting in reduced viability.

split estate - in split estate situations, the surface rights and subsurface rights (such as the rights to develop minerals) for a piece of land are owned by different parties.

sprawl - low-density decentralized development at the fringes of a central city. It is characterized by a spreading out of development over a wide area with little or no connectivity to the contiguously developed area.

stream connectivity - streams, from headwaters to large rivers, provide pathways for the transport of a wide range of materials, energy and aquatic life. This transport moves upstream and downstream, between surface and groundwater, between channel and floodplain and in time, i.e. seasonal flooding or scouring.

stocking - relative to fish or other aquatic organisms, the practice of raising organisms in a hatchery and releasing them into appropriate lake, stream, or other aquatic habitat.

substrate embeddedness - the degree to which fine sediments surround coarse substrates on the surface of a streambed is referred to as embeddedness.

succession - the process of change in the species structure of an ecological community over time. Generally resulting in increasing structural complexity over time until a community becomes relatively stable or self-perpetuating in the absence of disturbance.

tailwater - waters located immediately downstream from a hydraulic structure, most often a dam.

target - Specific components of biodiversity which serve as the focus of conservation, including the development and prioritization of conservation strategies. Conservation targets consist of ecological systems, natural communities, and species.

translocation - the capture, transport, and release or introduction of species, habitats or other ecological material from one location to another.

troglobite - an animal that cannot survive outside its cave environment.

troglophile - an animal able to live its entire life in a cave, but usually maintain some of their senses such as partial pigmentation and are usually only partially blind.

trogloxene - an animal that uses caves for shelter but does not complete its life cycle in them, for example bats.

umbrella species - a species or group of species, such as forest interior dwelling birds, whose habitat needs overlap those of other animals and plants.

viable/viability - the ability of a species to persist for many generations, or a natural community or ecological system to persist over some time period. An assessment of viability will often focus on the minimum area and number of occurrences and presence of natural processes necessary for persistence.

viewshed - the geographical area that is visible from a location. It includes all surrounding points that are in line-of-sight with that location and excludes points that are beyond the horizon or obstructed by terrain and other features (e.g., buildings, trees).

volant - able to fly or glide.

widespread - distributional range of a species or natural community which is typically found in the ecoregion, but common in many others also; the bulk of distribution may be elsewhere however.

vulnerability - the inability to withstand the effects of a hostile environment, generally measured by degree of exposure to hostile elements or change, inherent sensitivity to that exposure, and adaptive capacity to accommodate change.

Credits clockwise from top left: Lamprey on a Striped Shiner - Jeremy Monroe, Fisheries Illustrated; Streamside Salamander - Matthew Niemiller; Western Sandpiper - Chris Sloan; Bog Turtle - Jeffrey Basinger, Fisheries Illustrated; Upland Burrowing Crayfish - Carl Williams, TWRA; Little Brown Bats - Chris Ogle, TWRA