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Tennessee's Comprehensive Wildlife Conservation Strategy

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Tennessee's Comprehensive Wildlife Conservation Strategy

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This document was produced as a collaborative effort between the Tennessee Wildlife Resources Agency & The Nature Conservancy – TN Chapter:

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 Comprehensive Wildlife Conservation Strategy, 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 a nonprofit organization with the mission to preserve plants, animals, and natural communities that represent the diversity of life on earth by protecting the lands and waters they need to survive.

Executive Summary

State fish and wildlife agencies are the backbone of our nation's wildlife resource management and conservation programs. However, effective conservation and management programs depend on a firm partnership between states and Congress to provide adequate funding. For decades, dedicated and consistent funding has been provided to states from funds accumulated through the Federal Aid in Wildlife Restoration Act (Pittman-Robertson), the Federal Aid in Sport Fisheries Restoration Act (Dingell-Johnson), and the Aquatic Resources Trust Fund (Wallop-Breaux). Utilizing these funding sources, states have demonstrated the ability to institute successful wildlife conservation and management programs ensuring the sustainable use of game species and often benefiting nongame wildlife species as well. There exists, however, a recognized gap in both state and federal funding dedicated to conservation and management programs targeting nongame species of wildlife across the nation.

The need has never been greater for adequate dedicated funding to support the conservation, planning, and restoration of nongame wildlife species not covered under traditional funding sources. The number of federally listed species has doubled in the last decade. There are currently over 1,000 animal species now listed on the Federal Endangered and Threatened species list. Clearly, it is critical that states adopt proactive conservation programs that provide cost-effective solutions and avoid costly crisis-driven measures undertaken when faced with the imminent loss of wildlife species.

Congress began to provide the first substantial funding for state nongame wildlife conservation in fiscal year 2001 with the Wildlife Conservation and Restoration Program (WCRP) and has maintained that funding through the State Wildlife Grants Program (SWG). To date, Tennessee has received annually an average of $ 1,200,365 dollars from these programs. States and territories that utilized this new funding accepted the responsibility to develop a Comprehensive Wildlife Conservation Strategy (CWCS). Congress has provided the States and Territories with a list of 8 required elements that the U.S. Fish and Wildlife Service (FWS) must use as criteria to evaluate whether a state's CWCS meets the letter and spirit of the law. This Tennessee CWCS is submitted to satisfy these responsibilities.

The Tennessee Wildlife Resources Agency (TWRA) has been coordinating this planning effort in compliance with its legal mandate to protect and conserve the State's natural resources, including all wildlife species. Work to develop Tennessee's CWCS began in early 2003. Near the end of 2003, TWRA contracted with TNC for the services of its state conservation planning manager to establish and lead a core planning team. Ultimately, the core planning team was responsible for leading the overall planning process and final decision making for the CWCS. However, the strategy's development has been, and its implementation must be, a collective endeavor of Tennessee's conservation partners.

A Steering Committee composed of representatives of various agencies, organizations, and land management groups provided project oversight. Advisory teams addressed specific components of the conservation strategy; these teams included TWRA staff and representatives of other agencies and organizations. Input from the Steering Committee, representatives of other conservation organizations, consulting biologists, academic researchers, and the public was used in the development of the conservation strategy. Educational materials were developed to inform the public about the project's goals and milestones; these materials were posted on a website developed specifically for this project and distributed at public meetings.

The primary goal of this planning process was to develop a CWCS that adequately addressed the 8 elements required by Congress, and in the process, provide a workable conservation tool for agencies, organizations, industries, and academics across the state to apply sound science in the conservation of nongame wildlife species. To that end, the foundation of Tennessee's CWCS is an integrated geographic information system (GIS) model based on the best available wildlife distribution data and comprehensive habitat classification systems and maps.

The key components of the GIS are:

- A comprehensive database of selected Greatest Conservation Need (GCN) species that is spatially relevant – mapped to the individual species occurrence level.
- A terrestrial habitat hierarchy based on the Natureserve ecological systems that can be mapped to various spatial scales (i.e. statewide, eco-regionally, locally).
- Aquatic habitats based on Freshwater Initiative aquatic system classifications that can be mapped to various spatial scales (i.e. statewide, aquatic drainage, hydrologic unit (HUC).
- Subterranean habitats based on known cave locations and surrounding terrestrial habitat units.
- A database of species - habitat preferences (Preferred, Suitable, Marginal, Unsuitable) evaluated for individual GCN species.
- A stress/source-of-stress hierarchy based on TNC's 5-S system of conservation planning. Stress/source-of-stress combinations are evaluated for individual GCN species.
- A hierarchy of terrestrial, aquatic, and subterranean conservation actions. Conservation actions are evaluated for each stress/source of stress combination.

These key components are linked, via the GIS, to create a fully relational database that is spatially relevant at a wide array of landscape scales. Ultimately, the GIS portion of this CWCS provides Tennessee with an unprecedented conservation planning tool. Never before have conservation planners in Tennessee had the ability to simultaneously analyze this level of data at a variety of landscape scales. Some of the potential uses of the GIS presented in this document include: ecoregional maps that prioritize habitat units based on known species occurrences and the data associated with those occurrences, ecoregional reforestation scenarios, prioritized sources of stress linked to GCN species, prioritized conservation actions for terrestrial, aquatic, and subterranean habitats, and prioritized inventory/research needs for GCN species.

Finally, it should be emphasized that this CWCS and associated GIS are a work in progress and should continue to evolve during implementation and in future iterations of the CWCS planning process. It should also be noted that this document was developed and presented on a strategic planning level. This CWCS document and the associated GIS can be used by conservation planners as a powerful planning tool. The implementation of activities identified in this CWCS require further consideration of operational details, evaluation in conjunction with other existing conservation plans, setting of explicit ecoregional goals and objectives, etc. The completion of this first edition of Tennessee's CWCS is just the beginning.

Acknowledgements

The following individuals are acknowledged for their assistance and contributions to various components of this Comprehensive Wildlife Conservation Strategy. Special thanks are due to conservation partners in other agencies and organizations that volunteered their time and services for this planning process. In addition, many thanks are offered to the Tennessee Division of Natural Heritage and the Chicago Field Museum of Natural History for sharing database information about various fauna in the state.

All contributors to this effort are listed according to their participation in various teams as leaders, expert advisors, steering committee members, or for assisting with some portion of the planning process. Apologies are offered in advance for omission of anyone who played a role in the development of this project.

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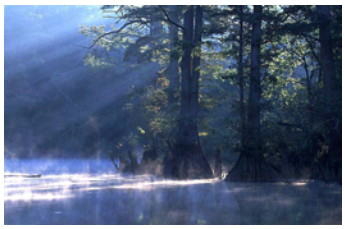
INTRODUCTION

The Comprehensive Wildlife Conservation Strategy



In 1973, an evaluation of the organization and operation of the Tennessee Game and Fish Commission was concluded and the final report issued (Kimball 1973). One of the many conclusions (#7) of the report states "Too little emphasis is being placed on small game and nongame species". It further recommended the implementation of nongame projects within the Game and Fish Commission [*currently known as the Tennessee Wildlife Resources Agency (TWRA)*].

In 1974, The Nongame and Endangered or Threatened Wildlife Species Conservation Act was passed and signed into law (Tennessee Code Annotated 70-8-101). Under the Act four primary declarations were made (T. C. A. 70-8-102):

1. It is the policy of this state to manage certain nongame wildlife to ensure their perpetuation as members of ecosystems for scientific purposes and human enjoyment;
2. Species or subspecies of wildlife indigenous to this state which may be found to be endangered or threatened within the state should be accorded protection in order to maintain and, to the extent possible, enhance their numbers;
3. The state should assist in the protection of species or subspecies of wildlife which are deemed to be endangered or threatened elsewhere by prohibiting the taking, possession, transportation, exploration, processing, sale or offer for sale or shipment within this state of species or subspecies of wildlife listed on the United States' List of Endangered Wildlife as set forth herein unless such actions will assist in preserving or propagating the species or subspecies; and
4. Adequate funding should be made available to the agency annually by appropriations from the general fund or from other sources for management of nongame and endangered species.

To meet these declarations, in 1974, the Nongame Task Force was formed. Comprised with members from state and federal agencies, state universities and conservation organizations, this committee developed the first Nongame and Endangered Species Program Plan. It was during this period the first Nongame Biologist position was created and funded. In the early years of the program, organizational structure varied. In the late1970s, the Nongame program settled into the structure it would maintain until the turn of the new millennium.

The basic organizational structure of the Nongame and Endangered Species Program (NGESP) consisted of a statewide coordinator and one regional nongame coordinator per TWRA administrative region. Program activities included providing technical assistance and management planning with public and private landowners. Personnel monitored rare wildlife (i.e. Bald Eagle nest counts), conducted bird inventories (i.e. point-counts), fish and mussel surveys, developed rare species lists (i.e. Endangered, Threatened and Deemed in Need of Management), developed Wildlife Viewing Areas, inspected wildlife rehabilitator and wildlife education facilities, and reviewed and issued scientific collectors & falconry permits. Program objectives were also forwarded through partnerships with other organizations. Administration and coordination with academic institutions, governmental agencies and non-governmental organizations conducting research, species inventories and

habitat or populations surveys provided the program with additional data.

The NGESP receives federal funds through the Endangered Species Act allocated by the U. S. Fish and Wildlife. This funding, though consistent annually, varies in amounts. Funding for other activities of the NGESP has been dependent on state legislative appropriations, federal funds and state wildlife funds. TWRA Wildlife funds have been necessary to maintain the NGESP throughout its existence. Without a substantial increase in funding the nongame program could not intensively plan or expand activities.

In 2000, Congress passed the Wildlife Conservation and Restoration Act (WCRP) appropriating $50 million nationwide. In succeeding years the TWRA has received additional federal nongame funding under the State Wildlife Grants Program (SWG). Under WCRP and SWG funding, the state was required to develop this Comprehensive Wildlife Conservation Strategy (CWCS).

Congress identified eight required elements to be addressed in each state's Comprehensive Wildlife Conservation Strategy. Congress also directed that the strategies must identify and be focused on the "species in greatest need of conservation," yet address the "full array of wildlife" and wildlife-related issues. The eight elements are:

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; and,

Element 2 – Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1); and,

Element 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; and,

Element 4 – Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions; and,

Element 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; and,

Element 6 – Descriptions of procedures to review the strategy at intervals not to exceed ten years; and,

Element 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.

Element 8 – Congress also affirmed through this legislation that broad public participation is an essential element of developing and implementing these plans, the projects that are carried out while these plans are developed, and the Species in Greatest Need of Conservation that Congress has indicated such programs and projects are intended to emphasize.

With the influx of new federal money and with the mandate to plan, the NGESP expanded activities. Four regional planning biologists were hired with the sole responsibility of developing a CWCS to direct the NGESP for the next 10 years. Also, through a partnership with The Nature Conservancy, additional planning expertise and funding was realized.

This CWCS presents the results of the most intensive planning effort undertaken by the

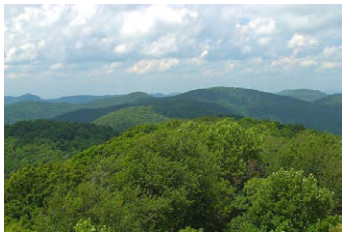
TWRA. Never before has the status of over 1000 species been reviewed. Never before has such a comprehensive GIS based database been developed. Never before has the TWRA had the ability to geographically analyze nongame species data at this scale. Never before has such a comprehensive look at issues and opportunities affecting nongame wildlife been conducted.

This CWCS meets the required elements identified in the State Wildlife Grants legislation and much more. Although this plan is submitted as a paper document, the real results are much more substantial. The network of partners created in this process will continue to produce benefits as plan implementation begins. The GIS database and model will continue to be expanded and updated. As management tools they will give direction in applying conservation actions and answer those "what if" questions we could only suppose before.

Through this CWCS, the management of rare species has taken a major step forward in Tennessee. With increased federal funding, on the ground benefits can be recognized.

CHAPTER 1

Overview of the State



Tennessee is recognized by scientists as one of North America's most biologically rich states. The state is made up of a diverse range of habitats from mountain ranges to winding rivers to extensive cave networks to majestic bottomland hardwood forests – a landscape as varied as the plants and animals that call Tennessee home.

According to the Tennessee Department of Environment and Conservation's Natural Heritage Division, the state boasts:

- Seven of the eight most ecologically rich rivers in North America.
- More than 325 fish species, ranking Tennessee first among all states in freshwater fish diversity.
- More than 300 species of birds, 89 mammals, 70 amphibians, and 61 reptiles.
- More than 2,300 varieties of plants.

National & Regional Context

The name, Tennessee, is derived from the Cherokee village of Tanasi, meaning "place of gathering". In 1796, Tennessee was the first territory admitted as a state under the federal Constitution. Before statehood, it was known as the Territory South of the River Ohio.

Tennessee is located between 35° 00′ to 36° 30′ north latitudes and 81° 45′ to 90° 15′ west longitudes. It covers an area of approximately 120,200 square kilometers or 23 million acres. Tennessee's topography is among the most diverse in the United States ranging from mountains in the east to wide swampy river bottoms in the west, with rolling hill country, deep gorges and other features in between. From the Mississippi River to Clingman's Dome in the Great Smoky Mountains National Park, the elevation ranges from 253 ft. (77 m) to 6,642 ft. (2,025 m).

Tennessee has a humid, mesothermal climate. The state is in a path of warm moist air currents from the Gulf of Mexico and cold relatively dry currents from Canada. Normally there are four distinct seasons of about equal length. Spring typically includes periods of cool temperatures interrupted by warmer periods. Precipitation occurs as scattered showers and a few general rains. Due to the influx of air from the Gulf of Mexico, summers are warm and humid. Thundershowers are the main form of precipitation. Fall weather includes mild temperatures, low humidity and light to moderate precipitation. Winters are moderately cold and may have moderate to heavy amounts of precipitation. The mean annual temperature ranges from about 62°F (17°C) near Memphis to below 44°F (7°C) atop the highest peaks in the Smoky Mountains. Most of the state receives an annual rainfall of approximately 45 inches (114 cm) to 55 inches (140 cm). However, higher elevations of the Blue Ridge Mountains in the eastern part of the state receive almost 76 inches (193 cm) of rainfall each year (Nicholson 1997)

Human Population and Land Use

Like many parts of the world, Tennessee has been strongly shaped by the history of human settlement. For many generations, this area was the hunting grounds for Native American parties. Tribes as distant as the Iroquois of the Great Lakes and the Choctaws from the Gulf Coast came to the state. Later, the Cherokee near the eastern mountains and the Chickasaw near the Mississippi River formed villages and began using the land. Early European settlement brought dramatic change to the landscape, which greatly increased with time. Human population and land use has exhibited a much more dramatic change in the last 100 years and will likely continue its

proliferation as we move into the 21st Century and beyond.

Pre-historic Native American Settlement

By 1000 A.D. many tribes had settled into small indigenous communities. These settlements had great impacts on the native landscape. Much of the grassland and forestland burning that was done by Native Americans was beneficial to many natural plant and animal communities. Frequent burning in eastern North America has been attributed to creating habitat suitable for American bison (Nicholson 1997). On the other hand, though necessary, the settlement of small villages and the conversion of native land to agricultural land impacted the landscape by degrading or destroying native habitat, which in turn greatly affected many natural plant and animal communities.

European Settlement

The earliest European settlers that came to the region were primarily land seekers of Scots-Irish descent. The first permanent settlement was made in 1769 in the Watauga River valley of East Tennessee. The Watauga Association, the first attempt at government in Tennessee was formed in 1772. Jonesboro, the oldest town in the state was founded in 1779. In 1775, the Transylvania Company bought a large region of land from the Cherokee. The famous Wilderness Road was soon created and became the main route from Virginia to the new settlements. Settlement continued westward with the establishment of Fort Nashboro in Middle Tennessee, along the Cumberland River in 1779. Communities were soon established in rich farmlands further west, while some regions in the east remained relatively unsettled until the mid to late part of the 19th century (Manning 1999).

By the early 1800's, landscape patterns were already being altered drastically by the masses of European settlers in the state. Settlement of small villages and towns, conversion of native land to agricultural land, and building of houses and railroads all led to the destruction of native habitat, which in turn had great impacts on plants and animals.

From the late 1800's to the 1900's, a social and economic transition began to take place as the state shifted from being a rural agricultural society to a modern industrial economy. Despite this change, there still is a tremendous amount of agricultural production taking place in Tennessee. According to the U.S. Department of Agriculture, in 1999 there were 11,900 farms in Tennessee, each having an average of 134 acres. In 2004 there were 11,600 farms in Tennessee, each having an average of 133 acres in agricultural production. This is a net loss of 51,800 acres of agricultural land in just 6 years, and much of this loss is from semi-natural habitats being converted to non-natural residential and commercial areas.

Large-scale forest clearing was also taking place in the late 1800's/early 1900's. This practice coupled with the agricultural economy of the time created large amounts of early successional habitats in Tennessee. However, changes in farming practices and forest maturation in the last 50 years have resulted in loss of many early successional habitats that are beneficial to species.

Beginning in the 1940's, the impounding of rivers and tributaries in the Tennessee and Cumberland Drainages began to take place. During this period, the Tennessee Valley Authority was formed to oversee many dam construction and rural improvement projects, as part of President Roosevelt's New Deal Policy. These impoundments destroyed much native habitat and disrupted the natural flow regimes of many of the state's river systems.

Also during this time, the non-native grass, tall fescue, was introduced into the United States, and has resulted in the widespread conversion of native grass pastures and old fields to this exotic grass, which provides inferior wildlife habitat. In Tennessee, it is estimated that 2.5 to 3 million acres have been converted to tall fescue. While useful for pasture, the introduction of this grass has had a tremendous effect on the Tennessee landscape.

Introductions of other invasive exotic species and pathogens have also been deleterious to Tennessee's natural systems. Since the early 1900's, the effects of Chestnut Blight on the American chestnut tree have seriously altered the composition of forests in the state. By some estimates, this tree comprised at least 40 - 45% of the total canopy cover of pre-blight forests in some portions of the state (Vandermast 2002). Loss of this single species has greatly altered the dynamics of forest systems and wildlife in Tennessee (Schlarbaum et al. 1997).

During the 1950's and 1960's channelization of major tributaries of the Mississippi River in Western Tennessee began to take place. This had enormous effects on the natural flow regime of the rivers, and many bottomland hardwood forests were cleared during this time. Some counties in the western portion of the state have lost as much as 90% of their bottomland hardwoods forests since the 1950's (*source* TWRA GIS analysis).

American Chestnut*

*(*photo credit:* Southern Appalachian Historical Society)

In recent decades, other human activities have also had great influence on the state's habitats. According to a 2002 (305b report) document written by the Tennessee Department of Environment & Conservation, there are many other stresses that are known to affect wildlife. Some of these are municipal discharge, urban runoff, sedimentation, and coal mining operations.

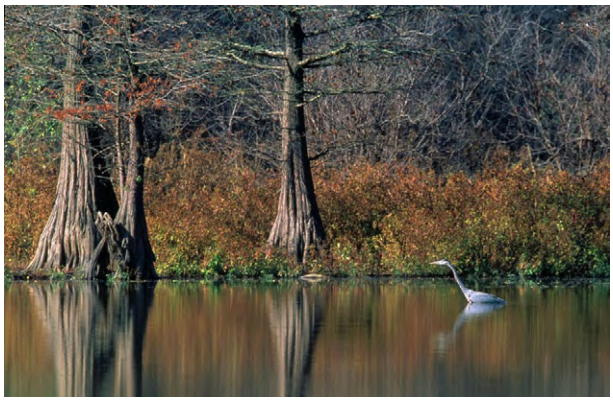
Land Use Today

The population of Tennessee (2000 census) is 5,689,283, a 16.7% increase since the 1990 census. The largest city in the state is Memphis. Other major metropolitan areas include Nashville, Knoxville, Chattanooga, and the Tri-Cities area of Bristol, Kingsport, and Johnson City.

Although Tennessee is now primarily industrial, with most of its people residing in urban areas, many Tennesseans still derive their livelihood from the land. The state's leading crops are cotton, soybeans, and tobacco; cattle, dairy products, and hogs are also principal farm commodities (Natural Resource Conservation Service, 2005). Tennessee's leading mineral, in dollar value, is stone; zinc ranks second and Tennessee leads the nation in the production of zinc. Industry is being continually diversified; the state's leading manufactures are chemicals and related products, foods, electrical machinery, primary metals, automobiles, textiles and apparel, and stone, clay, and glass items. As well, aluminum production has been important since World War I (www.Tennesseeanytime.org).

Long-term development of the state will be heavily driven by growth in population and the labor force. Immigration from other nations and even other states is continually trending upward in Tennessee, as with many other states. The U.S. Census Bureau reports that from 1900-2000 the population in Tennessee

has grown from 2 million to 5.7 million people. The Tennessee Advisory Commission on Intergovernmental Relations estimates that from 2000 - 2025 Tennessee's population will increase from 5.7 million to 7.6 million people and approximately 1/3 of this growth occurring in the 13 county Nashville Metropolitan Statistical Area. This sharp upward turn in population growth could be economically beneficial to the state, but will pose great challenges when it comes to conserving and protecting species of Greatest Conservation Need.



Terrestrial, Aquatic, and Subterranean Regions of the State

Tennessee's terrestrial, aquatic, and subterranean habitats are unlike any other in the United States. A broad assemblage of terrestrial and aquatic habitats can be found throughout the entire state, while a collection of subterranean habitats are found throughout the eastern two-thirds of the state. Consequently, the fauna found within these habitats are some of the most biodiverse in the nation (Stein et al. 2000) (see Map 1).

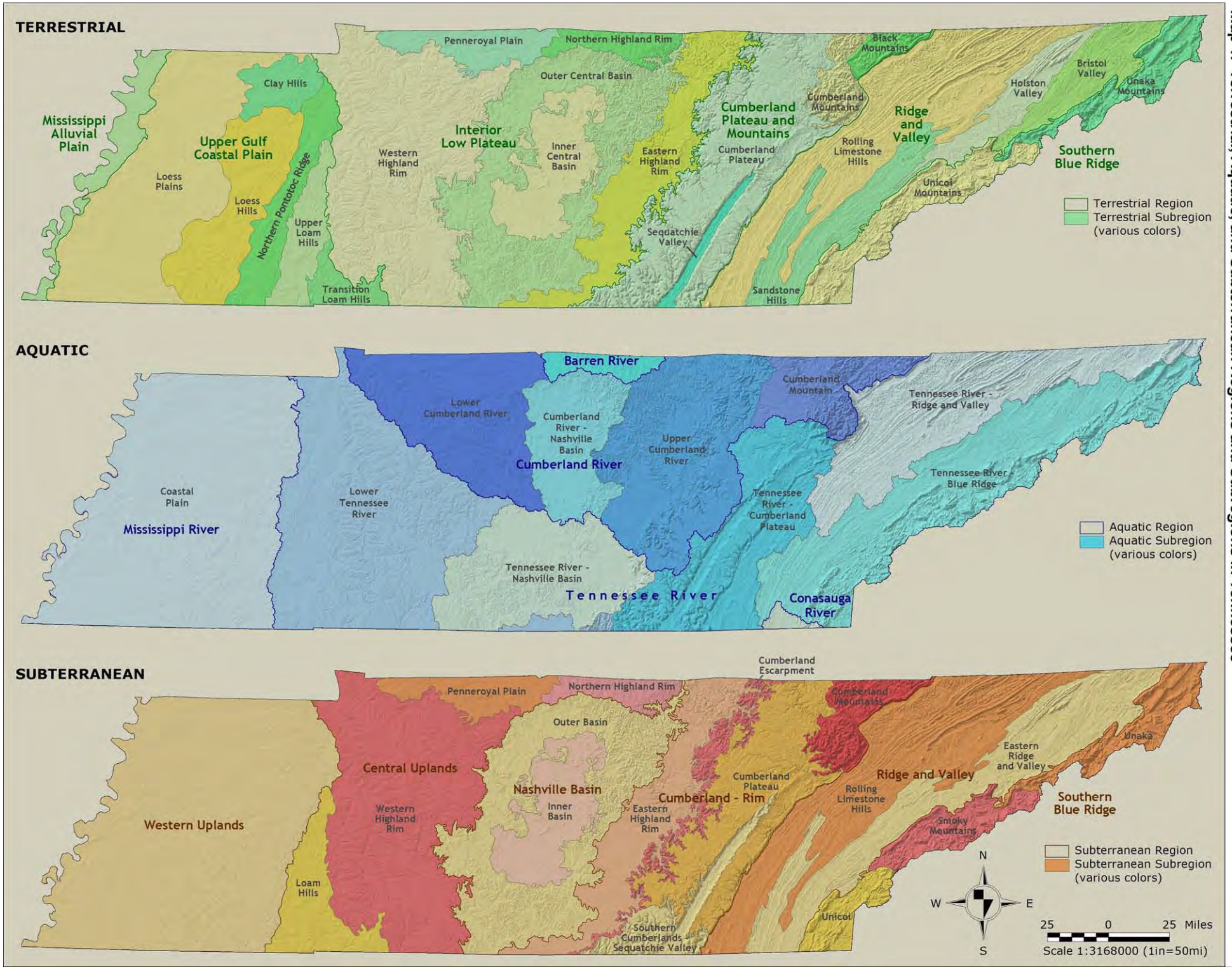
Terrestrial Ecological Regions

Six major terrestrial ecological regions occur across Tennessee. From west to east, these regions include: the Mississippi Alluvial Plain, the Upper Gulf Coastal Plain, the Interior Low Plateau, the Cumberland Plateau & Mountains, the Ridge & Valley, and the Southern Blue Ridge. The names and boundaries of these regions were adapted from an early scheme developed by the U.S. Forest Service and further modified by The Nature Conservancy (Bailey 1994; Keys et al. 1995). Descriptions of these regions are presented in the following sections.

(Mississippi Alluvial Plain)

Tennessee's western boundary is formed by the Mississippi River. Alongside the main body of this river lies a floodplain known as the Mississippi Alluvial Plain or the MAP. Over the millennia, lateral migrations of the river have created numerous oxbow lakes, meander scars, and natural levees. Much of the area periodically floods although artificial levees have been constructed to reduce this. In Tennessee, the MAP consists primarily of alluvial (i.e. river deposited) soils. To the east, the floodplain is bound by the loess (i.e. wind blown silt) soils of the Chickasaw Bluffs. The Chickasaw Bluffs rise about 100 feet (30 meters) above the MAP. Much of the floodplain lies over a portion of the New Madrid Fault, which created the great earthquake of 1811-1812 that shook the entire eastern U.S., and formed the 33,000-acre Reelfoot Lake in the northwest corner of Tennessee (Nuttli 1973).

The MAP is known for its bottomland hardwood swamps. Swamp forests occur in areas with standing water present most of the year, typically in the oxbow lakes. Other types of wetlands are also frequently a prominent landscape feature. Bald cypress and water tupelo are usually the dominant trees in permanently flooded areas. Areas flooded during the winter and early spring support a diverse forest dominated by red maple, sweetgum, water hickory, and many species of mesophyllic oaks. Cane often occurs in the understory of the seasonally flooded forest. Dominant trees on the highest, rarely flooded sites include American beech, American elm, sweetgum, a variety of oaks, and shagbark hickory. Forested wetlands including permanently flooded cypress and tupelo, periodically flooded bottomland hardwoods, and periodically flooded streamside (riparian) forests are common in the MAP and West Tennessee.



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

(Upper Gulf Coastal Plain)
The Upper Gulf Coastal Plain is located between the Chickasaw Bluffs on the west and the Tennessee River on the east. This area's undulating terrain gradually increases in elevation moving eastward. The UGCP is comprised of six distinct subregions: the Loess Plain, the Loess Hills, the Clay Hills, the Northern Pontotoc Ridge, the Upper Loam Hills, and the Transition Loam Hills.

In the Loess Plain and Loess Hills, rivers and creeks have created broad floodplains with many of the same wetland features and vegetation as in the MAP. Other subregions are made up of upland hardwood forest with the predominant trees being oaks and hickories. Southern red oak is dominant on drier upland sites and white oak, often in association with tulip poplar and sweetgum, is dominant on more mesic sites. Hickories are common throughout the area. There are also many maples, beeches, and birches. Small populations of eastern red cedars, tulip poplars and yellow pines can be found along with dogwoods and redbuds. Shortleaf pine occurs on sandy upland soils of the uplands. The average elevation for the region is approximately 492 feet (150 meters) with some hills near the Tennessee River reaching over 705 feet (215 meters).

(Interior Low Plateau)
The Interior Low Plateau is composed of two primary areas, the Central Basin and the Highland Rim, which are further divided into six distinct subregions. The Central Basin is an elliptically shaped depression measuring about 120 miles (193 kilometers) long by 60 miles (97 kilometers) wide covering an area of 8,600 square miles (22,274 square kilometers) (Miller 1974). It is oriented nearly north/south and encircled by the Highland Rim. The Central Basin lies in the heart of Middle Tennessee. There are two parts, the Inner and the Outer Basin. The Outer Basin is made up of knobs, narrow ridges and dissected landscape. The Inner Basin is flat with some gently rolling hills dominated by eastern red cedars and hardwoods interspersed with openings of exposed limestone that underlies one of Tennessee's most unique ecosystems, the Cedar Glades. The average elevation of the Inner Basin is 590 feet (180 meters). The Outer basin has an average elevation of 754 feet (230 meters), with a few hills in the southern portion reaching elevations of approximately 1,250 feet (380 meters). The Central Basin was created as resistant siliceous (containing silica) limestone was breached and soluble limestone was removed. Poor surface drainage, shallow soils, and other karst features such as caves, sinkholes, and underground drainages are common in the Inner Basin. The Outer Basin has much greater relief with rolling hills and narrow ridges. It has deeper phosphoric soils that prior to settlement supported significantly diverse hardwood forests.

The Outer and Inner Basins support forest communities containing mixed mesophytic species such as tulip poplar, beech, northern red oak, yellowwood, shagbark hickory, sugar maple, Kentucky coffeetree, pawpaw, bladdernut, spicebush, and flowering dogwood in the ravines, lower terraces and north facing slopes. Dry ridges are often remnants of the Highland Rim and support acid loving species like sourwood, blackgum, blueberry species, oaks and hickories. Dryer limestone sites and south facing slopes of the Outer Basin resemble Inner Basin forests comprised of eastern red cedar mixed with hardwoods and pure stands of eastern red cedar.

The Highland Rim encircles the Central Basin, and stretches from the Tennessee River in the

west to the Cumberland Plateau in the east. The Highland Rim is broken into 4 distinct subregions: the Eastern Highland Rim, the Western Highland Rim, the Northern Highland Rim, and the Pennyroyal Plain. Collectively, these subregions represent remnants of an ancient massive dome that eroded. The Highland Rim today is characterized as an upland area heavily dissected by river and creek valleys. In general, the Highland Rim's elevation approaches 1000 feet (300 meters), being somewhat higher in the Eastern Highland Rim section than in the more expansive Western Highland Rim. The Pennyroyal Plain and Northern Highland Rim sections extend southward from Kentucky into northern Middle Tennessee. Underlain with limestone, the Highland Rim entails extensive area of karst topography and cave development, especially on the eastern and northern sections.

The Highland Rim is covered with rich oak/hickory/poplar forests with many woodland streams. Species of these forests include white, black, and chinkapin oaks, tulip poplar, beech, hickory and sugar maple. Swamp forests including pin, overcup, willow, water and swamp chestnut oaks, red maple, sweet gum and black gum occur on poorly drained soils. Extensive nearly flat areas occur in a karst plain in the northern edge of the Pennyroyal Plain and in an area known as the "Barrens" in the Eastern Highland Rim. The vegetation of these Barrens is floristically similar to mid-western prairies that were dominated by big bluestem, little bluestem, Indian grass, switchgrass, and many forbs (Carman 2001).

(Cumberland Plateau & Mountains)

The Cumberland Plateau & Mountains region is separated from the Interior Low Plateau by an irregular escarpment. The region cuts diagonally across Tennessee a length of about 140 miles (225 kilometers) and on average is about 40 miles (64 kilometers) wide. The CP&M stretches from northern Alabama to West Virginia, and represents a western extension of the Southern Appalachian Mountain chain.

The southern portion of this region in Alabama and Tennessee is the "true" plateau section with gently rolling uplands averaging 1500 (457 meters) to 1800 feet (549 meters) in elevation. Along both sides of the plateau are deep gorges known as "gulfs," the deeper being where the Tennessee River cuts through the Plateau near Chattanooga. Lookout Mountain, Raccoon Mountain, Signal Mountain, and Walden's Ridge are all fingers of the Plateau. Short Mountain and Caldwell Mountains are erosional remnants separated from the Plateau proper by several miles.

The northern portion of the region in Tennessee is where the Cumberland Mountains terminate. The topography of this section is quite complex with a lesser mountainous region known as the Black Mountains protruding from Kentucky and Virginia. The entire area is characterized by rugged terrain and elevations ranging up to 3,500 feet (1075 meters) on Cross Mountain. Within the Cumberland Mountains, mixed mesophytic forest occupies most of the slopes, with species composition varying with topography and microclimate. Hemlock is usually confined to ravines, and rhododendrons and mountain laurel often occur in the understory. Dry slopes and ridges often contain oak/pine communities. The oak is usually chestnut oak. Shortleaf, Virginia and sometimes pitch pine stands occur over the shallow, sandy soils over sandstone.

The Cumberland Plateau envelops the Cumberland Mountains section to the west and southwest and proceeds southward to

Alabama. One of the most unique features of the plateau is the Sequatchie Valley. On the southern reaches of the Plateau, the Sequatchie Valley separates Walden's Ridge from the plateau. This feature is 1000 feet (305 meters) deep, five miles (8 kilometers) wide and approximately 120 miles (193 kilometers) long. At the northern end is the Crab Orchard Mountains created by an anticlinal fault system that eroded away along the rest of its length creating the valley.

Surface rock strata in the plateau have produced varied soils and a wide variety of forest types. The Plateau forests differ widely from the hemlock/basswood/buckeye/ tulip poplar forest found in the cool gorges to the oak/hickory/Virginia pine associations found on dry sandy ridges. Out of the gorges but directly below the bluff lines occur almost pure stands of chestnut oaks. Directly above the bluff lines Virginia pine stands dominate the dry rocky soil. The forest on top of the

Plateau varies from the tulip poplar/white oak/and red oak associations of the moister, richer hollows, to the post oak/scarlet oak and hickory stands of the dryer, sandy uplands.

(Ridge & Valley)
Between the uplands of the Cumberlands and the Blue Ridge Mountains lies the Ridge & Valley. This province extends from the Coastal Plain of Alabama to southwest Virginia. The Ridge & Valley is creased by several parallel ridges running northeast-southwest. These ridges divide the region into 4 recognized subregions: the rolling limestone hills, the sandstone hills, the Holston Valley, and the Bristol Valley.

The R&V was formed concurrently with the Cumberland Plateau & Mountains, as a shallow inland sea which gradually filled with deltaic sediments of marine life. However, unlike the CP&M, the R&V contains less impervious sandstone. As a result, the limestone valleys eroded more rapidly into the current system of narrow ridges and broad river valleys. The ridges are higher at the north end with Clinch Mountain 2,624 feet (800m) and Bays Mountain 3,100 feet (945m). The valley floors slope gently to the southwest from an average elevation of about 980 feet (300 meters) in the north to about 750 feet (230 meters) in the south.

Forests are dominated by oak-hickory-pine forest types with some mesic northern hardwoods. Mixed-mesophytic communities similar to the nearby Cumberland Mountains also occur on the northern slopes and in the ravines of the Ridge & Valley. Scattered patches of prairie remnants, barrens, and glades also dot the region. These areas have similar floristic components as other natural grasslands in the state (Martin 1989; DeSelm 1984).

(Southern Blue Ridge)
The eastern-most portion of Tennessee is characterized by the southern reaches of the Appalachian mountain chain that runs in a northeast-southwest direction. This area is often referred to as the "Blue Ridge" region.

The Southern Blue Ridge Mountains between Tennessee and North Carolina form the highest peaks in the eastern United States at over 6,600 feet elevation (2,025 meters). The SBR is characterized by a steep topography that is heavily forested. Valleys tend to be narrow and found only along large creeks and rivers. This geologically complex area is comprised of several mountain ranges: the Iron, Holston, Stone, Unaka, Bald, Great Smoky, and Unicoi mountains. Along the western edge of the SBR region are a series of outlying mountains, generally lower in elevation than those along the North Carolina border: English, Chilhowee, Starr, and Bean Mountains. Also, the SBR contains several isolated limestone valleys at low elevations. The most notable of these are Shady Valley, Bumpass Cove, Wear Cove, Cades Cove, and Tuckaleechee Cove. Overall, the SBR is comprised of two distinct subregions: the Unaka Mountains and the Unicoi Mountains. Some physiographers carve out the Great Smoky Mountains as a third central region.

These Southern Blue Ridge Mountains were created during the Appalachian orogeny. The Blue Ridge is part of the oldest land mass in Eastern North America, which has not been affected by marine submersion or continental glaciation (Miller 1974). These mountains are composed of ocean sediment laid down millions of years ago that thrust upward as the huge tectonic plates supporting Africa collided with the North American plate. Land was forced up and over, folding and buckling to form the Smoky Mountains, Chilhowee Mountains, Unicoi Mountain and the Nantahala ranges. These mountains have undergone continuous erosion over the last 180 million years. Rainfall in the region is 40 - 100 inches (102 - 254 cm) per year.

A multitude of forest types occur in the SBR. Lowlands support cove hardwood forests composed of tulip poplar/sugar maple/yellow buckeye/and silverbells. Oak/chestnut forests once dominated this forest community until the chestnut blight virtually eliminated the American chestnut. Hemlock forests are found at slightly higher elevations. In

association with the hemlock, hydrangea, blackberry, and doghobble can be found in the understory. Northern hardwood forests with yellow birch, beech, and servicberry are usually found above 3000 feet. South-facing slopes support oak/pine forests. Dryer acidic soils support Virginia pine/pitch pine/ doghobble/trailing arbutus and mountain laurel. Above 5,500 feet are the "Canadian-like" spruce/fir forests which occur due to the cooler, moister weather. Along this alpine zone, Fraser fir, a Southern Appalachian endemic, and red spruce tower over a mossy forest floor where bluets, trilliums, clintonia, and a host of other herbaceous flowers grow. As well, treeless areas called "balds" are frequently encountered along these ridges. In some places, heath balds occur, with azaleas and rhododendron. Others are grassy balds with approximately 35 different species of grass growing on them. These high elevations have a short summer season.

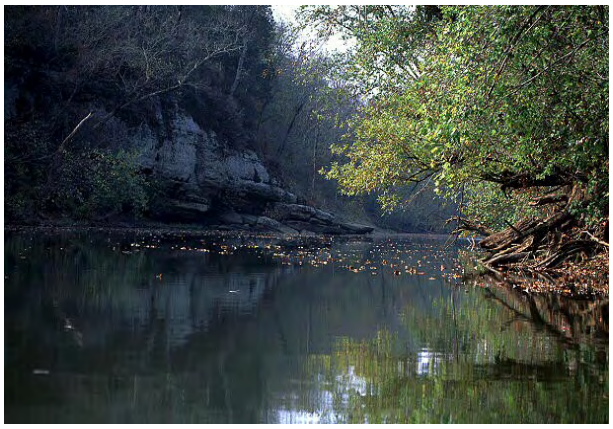
Aquatic Regions

Five aquatic regions drain the state of Tennessee. From west to east, these regions include: the Mississippi River, the Tennessee River, the Cumberland River, the Barren River, and the Conasauga River. These river drainages constitute a wide variety of aquatic habitats and collectively compose some of the most biologically important freshwater ecosystems in the country (Smith et al. 2002; Stein et al. 2000; Master et al. 1998). The boundaries of these regions are based on the Natural Resource Conservation Service's (NRCS) watershed mapping system of 12-digit hydrologic units. Likewise, subregions

were taken from Ecological Drainage Units developed by The Nature Conservancy's Freshwater Initiative (Smith et al. 2002). Descriptions of each aquatic region are presented in the following sections.

(Mississippi River)
The Mississippi River drainage lies in the western quarter of Tennessee in the Mississippi Alluvial Plain and the Upper Gulf Coastal Plain terrestrial ecoregions. The major rivers draining this area include the Forked Deer, Hatchie, Loosahatchie, Obion, and Wolf systems, all of which drain into the Mississippi River. In its natural state, the Mississippi River was ever meandering and shifting channels creating many oxbow lakes and swamps. Its waters are constantly turbid, colored by the heavy silt load it carries from eroded mid-western farmlands.

The natural character of the river was altered by levees, wing dams, and dredging. It can no longer seasonally flood its natural floodplain on a regular basis, therefore limiting access to and rejuvenating marginal swampland. This has had tremendous impacts on the ecology of some fish species, as well as destroying many of the natural gravel bars in the river's main channel. Still, the river is home to several large river fishes found nowhere else in Tennessee (Etnier and Starnes, 1993). The MAP and Upper Gulf Coastal Plain contain Tennessee's richest agricultural lands. Consequently, aquatic habitats within these areas have suffered greatly because of forest clearing, channelization, and excessive pesticide runoff. The resulting habitats consist of straight ditches with silt bottoms and very little, if any, natural cover for aquatic life. Although, the remaining bottomland and floodplain along the Hatchie River harbor some of the best hardwoods and wildlife habitat found anywhere in the state of Tennessee.



(The Tennessee River)
The Tennessee River drains a major portion of the state. Beech River, Big Sandy River and several smaller streams all of which are tributaries of the Tennessee River drain a sizable part of the Upper Gulf Coastal Plain. In Middle Tennessee, the Tennessee River receives the drainage from the Western and Eastern Highland Rim regions, including the Duck, Buffalo, and Elk River systems.

The Tennessee River is formed in East Tennessee from the confluence of the French Broad and Holston rivers. The French Broad and its tributaries, all drain from the Southern Blue Ridge ecoregion in North Carolina. These waters are characterized by small headwater streams with a high gradient, numerous riffles and falls over bedrock, and boulder substrates interspersed with pool areas composed of gravel, sand and bedrock. Many of the smaller streams are near pristine though acid rain has undoubtedly had some effect and natural acidification from Anakeesta shales is seen in some parts of the Blue Ridge. While it may lack the diversity of the Ridge and Valley, a distinct fish fauna exists in the associated bodies of water.

After receiving the French Broad and the Holston rivers, the Tennessee River then flows in a southwesterly direction into Alabama, turns back into Tennessee and flows north into Kentucky where it empties into the Ohio River. The Pleistocene era (last 2 million years) brought lower sea levels because of water retention from the earth's glaciers. This in turn cut deep huge gorges forming the Tennessee River systems unusual configuration.

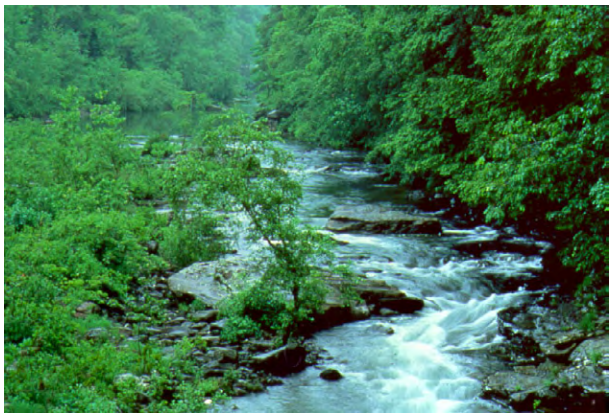
The Tennessee and its tributaries drain virtually the entire Ridge and Valley ecoregion

in Tennessee with the exception of the Watauga River, which flows down from the Blue Ridge ecoregion. All of the major tributaries in the Ridge and Valley except the upper portions of the Emory and Little rivers (the lower sections of the Emory and Little rivers are impounded) contain large dams constructed by the Tennessee Valley Authority (TVA) from the 1930's to the 1970's (Etnier et al. 1979). Only these sections of rivers along with the Powell and the upper Clinch have escaped the direct effects of impoundments (Etnier and Starnes 1993). The Ridge and Valley offers great habitat diversity and has a very diverse fish and mussel assemblage. Of all the rivers within this ecoregion, the upper Clinch remains the least altered and supports the greatest diversity of aquatic communities in North America (Stein et al. 2000; Master et al. 1998).

Further downstream along the main channel of the Tennessee River, the natural characteristics have been completely altered by impoundments. These impoundments generally maintain downstream flow, especially in the Kentucky Lake impoundment. The natural spring flooding that once occurred has now been greatly reduced because of the dams. Several species are known to be extirpated from the river because of these man-made impoundments diverting away from their natural state (Etnier et al. 1979). However, these impoundments allow reservoir fisheries and boating opportunities.

(Cumberland River)
During the 1950's through the 1970's, the main channel of the Cumberland was impounded over much of its entire length…from Barkley Dam in Kentucky to Cumberland Falls in its headwaters. Thus, its riverine qualities have largely been destroyed and its pre-impoundment fauna is incompletely known. The Red River tributary has suffered immensely in some areas form siltation due to agricultural practices.

The northern half of the Central Basin is drained by tributaries to the Cumberland



River, such as the lower Harpeth, Stones and lower Caney Fork systems. The southern half of the Central Basin drains to the lower Tennessee River by the Duck and Elk Rivers. The Eastern Highland Rim streams that drain to the Cumberland include the Caney Fork, Roaring, Wolf and Obey rivers. The impoundment on the upper Caney Fork (Center Hill Reservoir) dramatically altered the natural characteristics of the river and turned most of the lower reach into a cold river that can no longer support a rich aquatic fauna.

Much of the Cumberland Plateau in Tennessee, which tilts slightly to the west, is drained in that direction by tributaries to the Cumberland River, including the Big South Fork, Wolf and Obey systems and Caney Fork River (Etnier and Starnes 1993).

Cumberland aquatic regions contain the highest number of fish, mussel and crayfish species, and the highest number of endemic freshwater fauna in North America, with 231 species of fish [67 endemic], 125 species of mussels [20 endemic] and 65 species of crayfish [40 endemic] (Smith et al. 2002). The Duck River alone contains more fish species than are found in all of Europe (Stein et al. 2000).

(Barren River)
North of the Central Basin, in Clay, Macon, and Sumner counties, draining the northward sloping portion of the Eastern Highland Rim, is the Barren River system. This region of Tennessee contains a number of creeks (Drakes Creek, Line Creek, Long Creek, Long

Fork Creek, Puncheon Creek, Salt Lick Creek, Sulphur Fork Creek, Trammel Creek, and White Oak Creek) that form the headwaters of the Barren River, which is in Kentucky. The Barren River is a tributary of the Green River, which flows into the Ohio River system. While containing typical Highland Rim habitats (chert, gravel, etc.) this drainage association is quite atypical and remote from the Tennessee and Cumberland River systems, resulting in a considerable degree of faunal distinctness and adding several species to Tennessee's fish fauna (Etnier and Starnes 1993).

(Conasauga River)
A very small portion of southeast Tennessee (Bradley and Polk counties) is drained by streams which empty the Conasauga River. The Conasauga loops into the state from Georgia and is a tributary of the Mobile River. This region overlaps with the Southern Blue Ridge and Ridge & Valley ecoregions. The headwaters of the Conasauga in the mountainous Southern Blue Ridge region remain in forested cover and have good water quality. However, portions of this watershed run through the agricultural Ridge & Valley region. Recent declines in the molluscan fauna have led to research indicating chronic and acute toxicity of river sediments from a number of specific herbicides (Sharpe et al. 2003). Shifts to livestock and row crop land use have also resulted in greater water nutrient levels. Despite these problems, the river supports a diverse fish fauna composed of many Mobile Basin endemics, and is in fact the last stronghold of several of these fishes (Etnier and Starnes 1993).

Subterranean Regions
Tennessee's subterranean regions extend from the Tennessee River in the western part of the state to the Southern Blue Ridge Mountains in the east. Overall, the state is thought to have more caves than any other state in the country (>9,000). The regions, as defined by this plan, mainly follow the terrestrial physiographic provinces. Upon initial inspection, caves appear to be scattered throughout the state. However, a closer look reveals patterns of distribution and clustering of known caves within a smaller distinct karst landscape. Therefore, it is necessary to point out more specific subregions to better capture the diversity and differences of the state's subterranean systems and fauna.

Subregions are outlined more from the point of view of related caves and their geologic associations rather than strictly upon fauna. This is due to the fact that a majority of rare troglobitic species are endemic to a very small area; a single cave or caves in a particular county. Other faunal groups, particularly aquatic species, can be found across sub-regions and regions presumably moving through subterranean watersheds that are not well understood at this time. Unfortunately, there is a tremendous lack of information regarding the movement of water into and through Tennessee's underground systems. Yet, this factor should be seriously considered as problems are analyzed and strategies developed for potential protection of sites.

(Western Uplands)
The Western Uplands subterranean region occurs west of the Tennessee River. This region possesses shallow sandstone caves and also contains limestone caves mainly along the western portion of the Tennessee River. Most of the rest of the region is devoid of karst terrain sufficient for the formation of caves.

(Central Uplands)
This region consists of the area west and north of the Nashville Basin and is essentially considered to comprise the Western Highland Rim terrestrial physiographic subregion. In actuality, there are four sub-regions outlined in the Central Uplands: the Loam Hills, the Western Highland Rim, the Penneroyal Plain, and the Northern Highland Rim. While caves dot the landscape in this region, they are more densely clustered in the Penneroyal Plain.

(Nashville Basin)
Located in the mid-section of the state, this region is divided into two distinct sub-regions: the Outer Basin and the Inner Basin. It is in this region where the state's complex geology truly affects cave development and caves are found clustered along physiographic breaks. This is particularly notable along the eastern border of the Outer Basin where the Eastern Highland Rim rises. Caves are also clustered along the northeast border of the two sub-regions. In the Inner Basin, caves tend to be more interconnected with "sinkholes" and other intricate karst features.

(Cumberland-Rim)
The majority of Tennessee's caves are found in this region. The caves tend to be developed along the western escarpment of the Cumberland Plateau, thus blurring the terrestrial line between the Eastern Highland Rim and the Cumberland Plateau. For this reason, these two regions have been combined. Five sub-regions have been defined in the Cumberland-Rim; the Eastern Highland Rim, the Cumberland Escarpment, the Cumberland Plateau, the Cumberland Mountains, and the South Cumberland-Sequatchie Valley.

Caves are extremely dense in the Cumberland Escarpment sub-region and represent the highest species diversity in the state. Cave entrances are nearly absent from the Cumberland Plateau and the Cumberland Mountains due to a sandstone cap that precludes the necessary solution for development. As the sandstone-capped plateau gives way to the Sequatchie Valley and the many wide coves of the South Cumberlands, caves become numerous again. The karst development in this area extends south into Alabama and shares similar fauna.

(Ridge & Valley)
The Ridge and Valley region is the geologic transition between the Cumberland Plateau and the Southern Blue Ridge Mountains. It is separated into two sub-regions; the Rolling Limestone Hills and the Eastern Ridge and Valley. Caves are developed along valley breaks and mainly concentrated in the northern portion of the region.

(Southern Blue Ridge)
The Southern Blue Ridge Mountains of east Tennessee are not as conducive to cave development due to a change in geology from limestone to harder, less soluble rock at the higher altitudes. Most of the caves are located in cove bottoms, which are limestone and dolomite. The Southern Blue Ridge is divided into three sub-regions; the Unaka Mountains, Great Smoky Mountains, and the Unicoi Mountains.

Tennessee's Wildlife
Tennessee is well known for biodiversity. In fact, Tennessee is thought to have the most diverse vertebrate fauna of any inland state. As mentioned previously, Tennessee encompasses portions of six terrestrial ecoregions and has five independent river drainages. The high degree of biodiversity found in Tennessee is strongly influenced by this equally diverse habitat. From the Mississippi Alluvial Plain in the west to the Southern Blue Ridge in the east, the terrestrial and aquatic habitat changes dramatically. While there are animals that have statewide distribution, each ecoregion has unique fauna.

In State of the States, (Natureserve, 2002) the states were ranked for the following faunal groups: vascular plants, all native vertebrate species, and native species in the following invertebrate groups: freshwater mussels; freshwater snails; crayfishes; large branchiopods; butterflies and skippers;

underwing moths; tiger beetles; and dragon flies and damselflies. Tennessee was ranked 13th for overall diversity with 3,772 species. The richness of the Tennessee fish and amphibian fauna was ranked second and fourth nationally for fish and amphibians, respectively. Tennessee was ranked 10th for species at risk with a value of 10.3%. For endemism, Tennessee was ranked 15th with 49 endemic species. If this diversity is considered on a area-adjusted basis, then Tennessee is likely one of the most biodiverse states in the country. Furthermore, inclusions of subterranean invertebrate fauna not factored into the NatureServe study would certainly increase Tennessee's ranking. New discoveries of subterranean fauna are being made each year. A recent survey of cave invertebrates in the state revealed 48 new species to science within 117 caves.

In a list compiled by Bob Hatcher of TWRA (2000), it was estimated that there had been 32 probable wildlife extirpations or extinctions in Tennessee. At present, TWRA lists 92 species deemed In Need of Management (INOM), 47 as threatened, 92 as endangered, and 33 as extirpated or extinct. It has been estimated that 85% of the species listed as threatened, endangered or In Need of Management in Tennessee are aquatic.

Fishes

In Tennessee's Rare Vertebrates (1980), Starnes and Etnier stated: "Tennessee has the richest freshwater fauna in the United States. The combination of many independent drainages, physiographic regions, and habitat types coupled with the relative geological stability of the region since Permian times (2000 million years ago) has provided a great diversity of habitats and ample time for species to radiate into these habitats." According to the Natural Heritage Program, the result is approximately 325 species of native fishes within the states boundaries, a fish fauna well in excess of that possessed by any other state.

Etnier and Starnes (1993) estimated that there were between 302 and 319 native and introduced species of fish in Tennessee. Warren and Burr (1994) listed 257 native species, 40 of which were considered imperiled. According to NatureServe, Tennessee was ranked second nationally for number of fish species (NatureServe 2002).

Despite uncertainty as to the actual number of fish in the state, it is clear that many are in jeopardy. Tennessee has the largest number of at-risk freshwater fish species in the United States (Master et al. 1998). There are 20 fish species state-listed as endangered, 17 as threatened and 40 species considered INOM. There are 85 fish species of Greatest Conservation Need (GCN) in the Tennessee CWCS.

Mollusks

Tennessee has the most diverse Mollusk fauna of any inland state (Neves et al. 1997). Bogan and Parmalee (1983) list 460 species and forms of mollusks in Tennessee. Eighteen mussel species have become extinct. This is by far the largest number of extinctions for any of the faunal groups in this chapter. Dams, pollution and exotic species have taken a great toll on our state's mollusk fauna. There are 39 species of freshwater mussels listed as endangered and two listed as threatened. There are two species of aquatic snails that are federally and/or state-listed in Tennessee. There are 77 mussel species of GCN and 30 aquatic snail species of GCN in the CWCS.

It seems that land snails have only recently shown up on the conservation radar. This is surprising with the number of land snails that occur in Tennessee. The actual status of this whole group is difficult to determine. The majority of the research on this group has dealt with taxonomy. There is only one species of land snail, the Painted Disc (*Anguispira picta*), that is federally listed as threatened and state listed as endangered. There are 87 land snail species of GCN in the Tennessee CWCS.

Crustaceans

Tennessee has the most diverse crayfish fauna in the United States (TWRA Strategic Plan 2000). There are 77 species and subspecies of crayfish found in Tennessee. It is likely that this number will increase as new species are being described annually.

In recent years, loss of aquatic habitat, pollution, and introductions of exotic species has created management concern among biologists. In 1995, the Division of Natural Heritage listed 12 species with impaired conservation status. In 1996, the American Fisheries Society, Endangered Species Committee, assigned a conservation status to all crayfishes of the United States and Canada. Tennessee has 10 species that are considered Endangered, 2 Threatened, and 2 of Special Concern. These listings represent species known to have very small distributions and live in areas of moderate to heavy human impact. However, little or no monitoring of these populations has been implemented. There is paucity of data concerning crayfish in Tennessee. However, when one considers the status of fishes and mollusks in the state, it is likely that many crayfish species are imperiled. There are 28 crayfish species of GCN in the Tennessee CWCS.

Mammals

Although numerous museum specimens and literature records exist, there is overall a paucity of information concerning the distribution and status of many mammals in Tennessee. Tennessee has 14 species of bats and sampling takes place across the state each year, but only recently (in 2004 the Tennessee Bat Working Group was formed) have efforts been made to pull together all of this work so that population characteristics might be better understood. Based on expert opinion, there are 72 native mammal species representing 8 orders in Tennessee. Eight species have been introduced. In the southeastern U.S., Tennessee ranks 6th for mammal diversity. Five mammal species have been extirpated. Three mammal species are federal and state listed as endangered: the Carolina northern flying squirrel, gray bat and Indiana bat. There are 29 mammal species of GCN in the Tennessee CWCS.

Amphibians and Reptiles

In terms of amphibian fauna, Tennessee is the fourth most diverse state in the country. Tennessee rates 8th nationally for at risk amphibian species. In the introduction to this chapter the unique fauna of each ecoregion was mentioned. This uniqueness is exemplified with the amphibians, particularly the salamanders. There are nine salamander species and one frog species deemed INOM by the TWRA; the hellbender, the streamside, seepage, black mountain dusky, pygmy, junaluska, four-toed, Weller's and Wherle's salamanders, and the barking tree frog. Only one species of salamander, the Tennessee cave salamander is state-listed as threatened. There are 24 amphibian species of GCN in the Tennessee CWCS.

The global decline of amphibian populations has received considerable scientific (Azous and Richter 1995; Wake 1991; Booth 1991; Blaustein and Wake 1990) and public attention, but the public is generally unaware

that reptile populations are at least equally at risk (Gibbons et al. 2000). Like the mammals, there is paucity in the information describing the distribution and status of reptile species in Tennessee. The coal skink, alligator snapping turtle, Mississippi green water snake and the eastern slender glass lizard are considered INOM by the TWRA. There are two snake species state listed as threatened, the northern pine snake and the western pigmy rattlesnake. There is one turtle species state-listed as threatened, the bog turtle. There are 17 reptile species of GCN in the Tennessee CWCS.

Birds

For some Tennesseans birding is a passion. There are 175 species of birds that regularly breed in Tennessee. In large part, the study of birds in Tennessee has been conducted by amateur birders. Since 1915, the Tennessee Ornithological Society (TOS), a non-governmental organization composed of volunteer bird enthusiasts, has played a major role in monitoring bird populations across the state. This effort coupled with research conducted by state agencies and universities has provided a wealth of information on the distribution and status of Tennessee birds.

Tennessee ranks 41st nationally for bird diversity, but the state ranks relatively high for at risk species with an estimated 2.2% of bird species considered at risk (Natureserve 2000). There are 4 bird species state listed as endangered, 4 listed as threatened and 21 species considered INOM by the TWRA. Five species have been extirpated; the swallow-tailed kite, greater prairie chicken, whooping crane, red cockaded woodpecker and the ivory-billed woodpecker. The Carolina parakeet and the passenger pigeon are extinct. There are 81 bird species of GCN in the Tennessee CWCS.

Public Lands in Tennessee

There are currently 118 state wildlife management areas and refuges, 15 state forests, 54 state parks, 7 national wildlife refuges, 2 national fish hatcheries, 3 national historic trails, 2 national river and recreation areas, 2 national battlefields, 3 national parks, 2 national parkways, 3 major military installations, 1 major national laboratory, and 2 national forests/recreation areas in the state of Tennessee (see Map 2). In total, there are approximately 2,146,000 acres of public lands in the state. Roughly 63% of public lands are under federal ownership, with the remainder in state, county, or municipal ownership.

State Wildlife Management Areas & Refuges

The Tennessee Wildlife Resources Agency manages 118 state wildlife management areas and state refuges. They are quite different, ranging from bottomland hardwoods and wetlands in the west to mountainous terrain in the eastern part of the state. Tennessee's Wildlife Management Areas offer small to large tracts of land with many good opportunities for recreational sportsmen such as hunting/fishing, bird watching, hiking and even camping in designated areas.

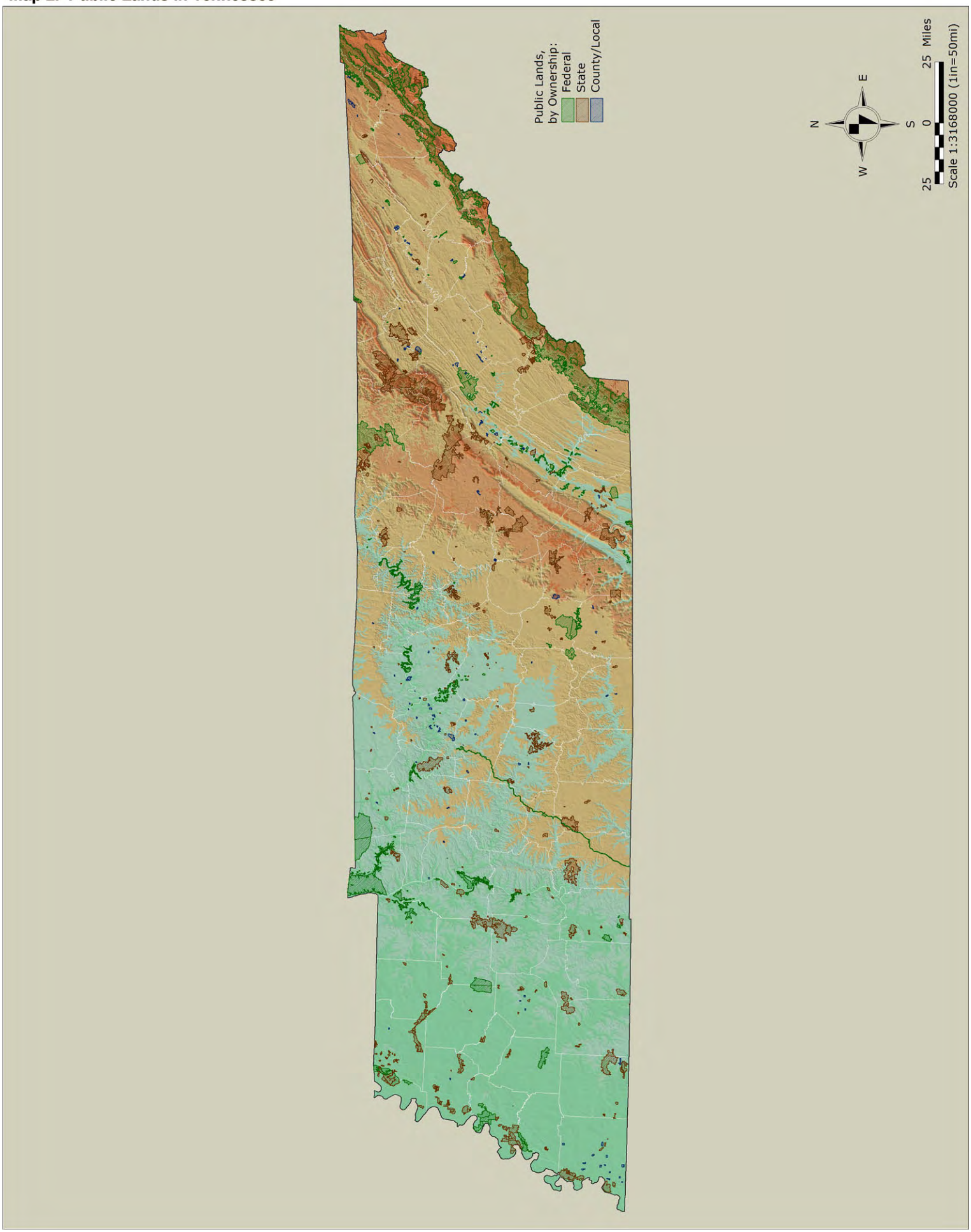
State Forests

The Tennessee Division of Forestry owns 15 state forests totaling 162,371 acres. They are quite varied, ranging from mountain coves to cedar glades to bottomlands along the Mississippi. Tennessee's state forests are undeveloped and offer large tracts of land for hunting, hiking and bird watching. Tennessee State Forests have been certified by the Forest Stewardship Council, an internationally recognized third-party group of experts, as having a sustainable strategy of management for many benefits.

State Parks/State Natural Areas

Tennessee currently has 54 State Parks in all areas of the state from which to enjoy a wide variety of recreational activities. The purpose of these parks often differs. Some commemorate historical places or are located in urban areas, while others are meant to protect pristine wilderness areas. Several of the state's parks are managed as recreational resorts with activities such as golf, tennis, swimming, and horseback riding. However, many are co-designated as State Natural Areas and do not allow development. Other state natural areas are designated solely for

Map 2. Public Lands in Tennessee



the protection of natural resources. In total, there are 66 state natural areas in the state.

National Wildlife Refuges

The U.S. Fish and Wildlife Service manages 7 National Wildlife Refuges in the state. Most of the refuges are in West Tennessee (6) and 1 refuge is in Middle Tennessee. Habitats are quite varied ranging from bottomland hardwoods and wetlands to more upland xeric type habitats. Bird watching and hiking are allowed year round with hunting and fishing being allowed during specified times of the year.

National Fish Hatcheries

The U.S. Fish and Wildlife Service own and operate 2 National Fish Hatcheries in the state of Tennessee. The 2 hatcheries are located in middle and east Tennessee and are used for propagation and relocation of fish and mussel species into appropriate areas of the state.

National Parks and Historic Trails

The National Park Service manages 3 National Parks and 3 Historic Trails in the state of Tennessee. The 3 National Parks provide recreational opportunities such as camping, hiking, picnicking, fishing, and horseback riding. The 3 Historic Trails allow camping, hiking, and sightseeing.

National Rivers/Recreation Areas

The National Park Service manages 1 national river and recreation area, 1 national wild and scenic river, and 2 national battlefields in the state of Tennessee. The national river and recreation area and the wild and scenic river provide camping, hiking, rafting, horseback riding, and some hunting and fishing opportunities. The national battlefields provide sightseeing and educational opportunities.

National Parkways

The National Park Service manages 2 national parkways in the state of Tennessee. The parkways provide hiking, biking, horseback riding, and even some camping opportunities.

Military Installations

The United States military owns and/or manages 5 military installations in the state of Tennessee. Several of these installations provide hiking, sightseeing, and hunting/fishing opportunities at designated times in designated locations.

National Laboratory

The Department of Energy along with UT Battelle manages the Oak Ride National Laboratory in Tennessee. This is a science and technology laboratory that offers tours of the lab and facility with good sightseeing opportunities offered by staff biologist. Hunting/fishing opportunities are restricted but allowed at designated times and locations.

National Forest and Recreation Areas

The United States Forest Service manages 2 national forests, Cherokee National Forest and Land Between the Lakes, in the state of Tennessee. These national forests and recreation areas provide hiking, camping, sightseeing, boating, biking, and hunting/fishing opportunities.

Tribally Owned Lands

Currently, there are no reservations or other major landholdings owned by Native American tribes in the state of Tennessee.

CHAPTER 2

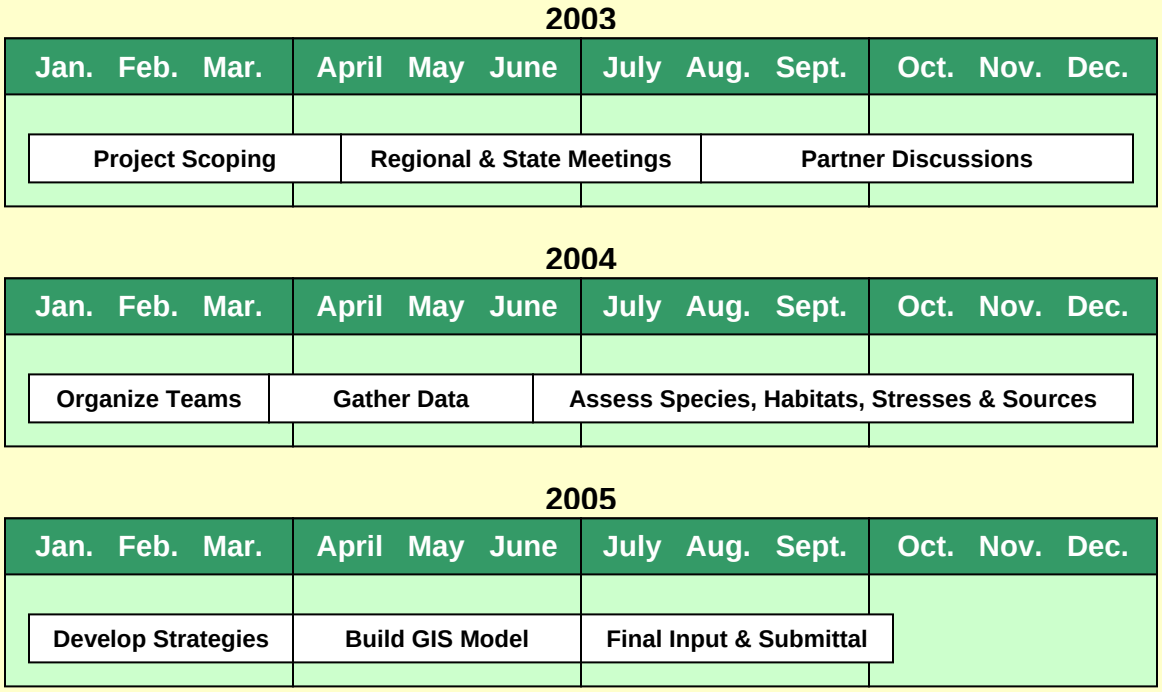
Approach to Developing the CWCS

Development of a CWCS is a dynamic process requiring numerous hours of data collection, scientific inquiry, collaboration, outreach, and many other tasks. Much of the information contained in this strategy has emerged from previous years of work by other biologists and planners across many organizations. Still, much of the data contained in this plan is new or has never before been gathered at a statewide scale. The CWCS planning process is intended to be an iterative, long-term endeavor. With increased time and effort, the process will hopefully continue to yield more conservation knowledge for the future benefit of wildlife.

Overview of the Project Timeline

Work to develop Tennessee's CWCS began in early 2003 (see Figure 1). After receipt of the planning grant from the U.S. Fish & Wildlife Service (USFWS), the Tennessee Wildlife Resources Agency (TWRA) commenced scoping of the project to assess requirements, staff, resources, and other needs. In the second and third quarters of the year, the agency participated in several regional and state meetings to discuss establishment of planning standards for the Southeast Region and other issues. During this time, the TWRA decided it was imperative to expand the planning capacity of its nongame program. In the latter portion of the year, the agency began discussions with The Nature Conservancy (TNC) and other conservation partners to gather additional input on how to manage the planning process. Near the end of 2003, a decision was made to contract with TNC for the services of its

Figure 1. CWCS Project Timeline



conservation planner to establish and lead a core planning team.

By the first quarter of 2004, four regional conservation planners were hired by the TWRA to serve on the core planning team. Also, the agency employed a Geographic Information Systems (GIS) specialist to work with mapping and data management. As well, TNC committed the full-time services of its GIS scientist to develop the overall conservation model, and the part-time services of a cave biologist to focus on subterranean issues. Also, an advisory team was assembled from additional TWRA, TNC, & other state agency staff to help with planning activities. As part of the advisory team, a field biologist was hired for each of TWRA's four regions to conduct surveys and other assessments. Additionally, a steering committee composed of major conservation partners (i.e. federal/state agencies and other non-governmental organizations) was formed to provide oversight to the planning process.

For the remainder of 2004, the core planning team gathered data, contacted scientific experts, selected focal species, evaluated habitat needs, and analyzed problems affecting wildlife. The advisory team provided technical input, contacted experts, and assisted with developing monitoring protocols. The steering committee also met during the second and third quarters of(the year to review major products that were developed and provide guidance for subsequent phases of planning.

At the beginning of 2005, the core planning team began development of conservation actions for the strategy. These actions were placed in a hierarchy and evaluated for their effectiveness in abating various stresses upon focal species. By spring 2005, development of a GIS model to assist with overall data management and priority setting commenced. In mid-year, input was gathered from TWRA regional staff and other conservation partners to assess overall results of the model. Public input was gathered from a website posting of conservation products and an online questionnaire. As well, public meetings were conducted to solicit comments on the planning process and results. The draft document was also developed during this period and submitted for internal review to the steering committee. Recommendations from the steering committee, other partners, and from the general public for improvement were incorporated into the final document.

Organizational Structure

(Core Planning Team)

The core planning team was responsible for leading the overall planning process and final scientific decision making for the CWCS. Most members met generally on a bi-weekly basis from 2004 through early 2005 and worked full-time on assigned duties for the project. The team conducted the majority of tasks associated with data collection, biological evaluations, selection of focal species, analysis of stresses and sources, evaluation of conservation actions, and compilation of the final CWCS document.

Core Planning Team Members:
Chris Bullington (TNC) – Project Coordinator
Richard Kirk (TWRA) – Agency Lead
Andrea English (TWRA) – Biologist/Planner
Mark Fagg (TWRA) – Biologist/Planner
Heather Garland (TNC) – Cave Biologist
Chris Hunter (TWRA) – Biologist/Planner
Kirk Miles (TWRA) – Biologist/Planner
David Rudisail (TWRA) – Data Manager
Joey Wisby (TNC) – GIS Scientist

(Advisory Team)

The advisory team was assembled to provide additional biological and technical expertise to the core planning team. Members came from other TWRA and TNC staff and from the TN Division of Natural Heritage (TDNH). Team members were able to work part-time on the CWCS project and contributed on an as-needed basis. On average, the advisory team was called upon bi-monthly to provide planning assistance from 2004 through early 2005. However, some members contributed more frequently. Overall, the advisory team provided planning assistance by: helping develop the list of focal species, contacting

scientific experts, dealing with administrative tasks, promoting the CWCS to the public and partners, determining habitat preferences, analyzing stresses, and devising conservation actions.

Advisory Team Members:
Bruce Anderson (TWRA) – Regional Biologist
Jim Hamlington (TWRA) – Regional Biologist
Pete Wyatt (TWRA) – Regional Biologist
Mike Roedel (TWRA) – State Ornithologist
Polly Rooker (TWRA) – Nongame Biologist
Scott Dykes (TWRA) – Field Biologist
Chris Simpson (TWRA) – Field Biologist
Mark Thurman (TWRA) – Field Biologist
Brandon Wear (TWRA) – Field Biologist
David Withers (TDNH) – State Zoologist
Gabby Call (TNC) – Government Relations
Gina Hancock (TNC) – Project Management

(Steering Committee)
The steering committee was composed of representatives from various federal and state agencies, non-governmental organizations, and other groups. Committee members were selected by the TWRA from a diverse array of major conservation partners and stakeholders. To keep the size of the steering committee to a reasonable number, participants were chosen from agencies and organizations based on several criteria: a) management of large land holdings, b) political advocacy ability for conservation, and/or c) other management or conservation expertise in the state. Representation at meetings often rotated among one or more individuals within an agency or organization. However, participation by most groups was consistent throughout the planning process.

The primary role of the steering committee was to provide guidance and critical feedback to the core planning team. As well, steering committee members served as liaisons of the CWCS to their respective organizations and to other parts of the conservation community. Four committee meetings were conducted on approximately a quarterly basis from the second quarter of 2004 through the middle of 2005. Ultimately, the steering committee was asked to give implicit approval of the CWCS document before submittal to the USFWS National Advisory Acceptance Team.

Federal Agency Participants:
National Park Service
Terri Hogan – Ecologist, Stones River NB
Natural Resource Conservation Service
James Ford – State Conservationist
Febe Ortiz – Deputy State Conservationist
U.S. Fish & Wildlife Service –
E. J. Williams – Assistant Regional Director, Migratory Birds, SE Region
Doug Winford – Assistant Supervisor, Ecological Services Office, Cookeville
U.S. Forest Service
Susan Shaw – Cherokee National Forest, Timber, Wildlife, & Fisheries Staff Officer
Laura Lewis – Cherokee National Forest, Forest Wildlife Biologist
State Agency Participants:
TN Dept. of Environment & Conservation
Jim Fyke – Commissioner
Rob Sherrill – Special Asst. to Commissioner
Charlie Tate – State Parks, Director of Natural & Cultural Resource Management
TN Division of Forestry
Steve Scott – State Forester
David Todd – State Forest Systems Unit Leader
TN Wildlife Resources Agency
Gary Myers – Executive Director
Greg Wathen – Special Asst. to Director
Richard Kirk – Nongame Program & Endangered Species Coordinator
Non-governmental Organization Participants:
TN Ornithological Society
Dr. Charles Nicholson
Tennessee Wildlife Federation
Mike Butler – Executive Director
The Nature Conservancy
Scott Davis – State Director
World Wildlife Fund
Wendy Smith – Director, Southeast Rivers & Streams Program

Coordination with Conservation Partners
As part of the CWCS planning process, considerable effort was made to connect with other conservation partners not included on the steering committee, and to further connect with those groups that were represented. A

variety of outreach methods was used, including: CWCS sponsored meetings, group presentations and individual consultations. The following sections summarize the most important contact activities made and the agencies and organizations that participated:

(CWCS Sponsored Meetings)
The CWCS planning team sponsored a number of meetings during 2004 and 2005 as part of outreach efforts to various conservation partners. In June 2004, TWRA representatives on the CWCS steering committee and other planning team members conducted a meeting with the Lower Mississippi Valley (LMV) Joint Venture Program. The purpose of the meeting was to discuss integration of the LMV conservation model with the current CWCS planning effort. The group convened a second meeting in February 2005. An early draft of the CWCS model for West Tennessee was unveiled during this meeting. Plans were made to continue discussions in the future. Attendees at these meetings included staff from: Ducks Unlimited, LMV Joint Venture Program, Quail Unlimited, TNC, TWRA, USFWS, and the TN Department of Environment & Conservation.

In June 2005, the planning team invited an additional group of conservation partners and stakeholders to participate in the fourth steering committee meeting. The purpose of this meeting was to unveil results of identified priority habitat areas for CWCS focal species, and to build consensus on the need for coordinating conservation actions. Invited partners included: TN Department of Transportation, TN Division of Natural Heritage, and the Joint Venture Program coordinators for each of the four Bird Conservation Regions found in Tennessee (Lower Mississippi Valley, East Gulf Coastal Plain, Central Hardwoods, and Appalachian).

Finally, in July and August 2005, a series of meetings was held with local conservation partners and other stakeholders in each of the four TWRA administrative regions across the state in Crossville, Jackson, Knoxville, and Nashville. The purpose of these regional meetings was to present and discuss the full results of the CWCS conservation model. Partners were asked to provide input on the model results and the various courses of action developed for the strategy. Twenty-four conservation partners and other groups participated in these meetings statewide as follows:
Federal Agencies – National Park Service, Natural Resource Conservation Service, Tennessee Valley Authority, U.S. Forest Service, and U.S. Fish & Wildlife Service
State Agencies – (TDEC) TN Division of Natural Heritage, (TDEC) TN State Parks
Non-governmental Organizations – Alliance for the Cumberlands, Conservation Fisheries, Inc., Land Trust for Tennessee, League of Women Voters, Lookout Mountain Land Trust, North Chickamauga Creek Land Conservancy, Tennessee Aquarium, Tennessee Citizens for Wilderness Planning, Tennessee Ornithological Society, Tennessee Parks & Greenways, The Nature Conservancy, West Tennessee Basin Authority, World Wildlife Fund
Universities – University of Memphis, University of Tennessee - Knoxville

(Group Presentations)
A number of group presentations about the CWCS were given at meetings hosted by academic groups and other conservation organizations. The purpose of these presentations was to inform partners about opportunities for input to the planning process, provide general information about current planning results, and gather technical feedback. Thirteen presentations were given during 2004 and 2005 to the following groups: Big South Fork National River & Recreation Area Task Force, Cumberland-Harpeth Chapter of the Audubon Society, Oak Ridge National Laboratory staff, TN Bat Working Group, TN Cave Survey Annual Meeting, TN Herpetological Society Annual Meeting, TN Ornithological Society Fall Meeting plus chapter meetings, TN Rare Fish Meeting, TN Rare Mollusk Committee Annual Meeting, TNC Landscape Managers Meeting, TWRA Law Enforcement Area Nongame Coordinators Meeting, TWRA Wildlife

Management Area Managers Meeting, and TN Chapter of the Wildlife Society Annual Meeting.

(Individual Consultations)
Throughout the CWCS planning process, individual consultations were arranged with members of various federal and state agencies, non-governmental organizations, academic institutions, and other groups. In particular, much effort was made to consult scientists, researchers, and other experts knowledgeable of specific fauna, natural systems, or with expertise in GIS or landscape analysis. The following experts were contacted to provide input or data at various times during the development of the strategy:

Faunal Experts:
Birds
Charles Baxter (Coordinator, Lower Mississippi Valley Joint Venture)
Dr. David Buehler (Univ. of TN)
Dr. Jane Fitzgerald (Coordinator, Central Hardwoods Joint Venture)
Bivalves
Steve Ahlstedt (U.S. Geol. Society – *retired*)
Don Hubbs (TWRA)
Crustaceans
Rick Bivens (TWRA)
Carl Williams (TWRA)
Fish
Dr. Tom Blanchard (Univ. of TN – Martin)
Bart Carter (TWRA)
Dr. David Etnier (Univ. of TN – *retired*)
Pat Rakes (Conservation Fisheries, Inc.)
Charlie Saylor (TVA)
John R. Shute (Conservation Fisheries, Inc.)
Gastropods
Dr. Ron Caldwell (Lincoln Memorial Univ.)
Jeff Garner (AL Div. of Wildlife & Fisheries)
Dr. Paul Johnson (Tennessee Aquarium)
Herps
Dr. Brian Butterfield (Freed-Hardeman Univ.)
Ray Jordan (TN Technological Univ.)
Dr. Brian Miller (Middle TN State Univ.)
Dr. Floyd Scott (Austin Peay State Univ.)
Insects
Dr. Tom Barr (Univ. of Kentucky – *retired*)
Dr. Steven Murphree (Belmont Univ.)
Rita Venable (N. American Butterfly Assoc.)
Mammals
Hill Henry (TVA)
Dr. Michael Kennedy (Univ. of Memphis)
Dr. Lisa Muller (Univ. of TN)
Other Invertebrates
Dr. Jerry Lewis (private consultant)

Natural Systems Experts:
Aquatic Systems
Ryan Smith (TNC)
Subterranean Systems
Dr. Tom Barr (Univ. of Kentucky – *retired*)
Joe Douglas (TN Cave Survey)
John Hoffelt (TN Cave Survey)
Gerald Moni (TN Cave Survey)
Lynn Roebuck (TN Cave Survey)
Thany Mann (TN Cave Survey)
Terrestrial Systems
Geoff Call (USFWS)
Rob Evans (NatureServe – *former staff*)
Roger McCoy (TDNH)

GIS / Landscape Analysis Experts:
Jeanette Jones (TWRA) – TN GAP
Sue Lanier (TWRA) – TN Aquatic Database
Alexa McKerrow (SE Gap Analysis Program)
Dr. Virginia Dale (Oak Ridge National Lab)

Coordination with Other States
Tennessee adjoins portions of eight other states (Alabama, Arkansas, Georgia, Kentucky, Mississippi, Missouri, North Carolina, and Virginia). Due to its unique geographic boundary, six distinct ecoregions cut across Tennessee (*see later section on selection of species of greatest conservation need*). These ecoregions are shared by a number of border states within and beyond

the southeast region. In order to fulfill the mandate for an ecoregion-based approach to the CWCS, the planning team sought opportunities for coordination with as many states as possible that shared ecoregional interests with Tennessee.

Collaboration with other states was a difficult task, given the number of parties involved and the limited timeframe of the planning process. In anticipation of this dilemma, the executive committee of the Southeast Association of Fish and Wildlife Agencies (SEAFWA) designated that each member state send delegates to participate in a special ad hoc committee over the course of the planning process. Ultimately, the SEAFWA ad hoc committee was composed of CWCS coordinators plus additional team members from each member state, the USFWS Region 4 federal aid coordinator and other staff, CWCS planners from the U.S. Virgin Islands, and a representative from the International Association of Fish & Wildlife Agencies (IAFWA). Overall, the ad hoc committee was tasked with maintaining dialogue about progress on each state's CWCS, building partnerships, and making decisions on planning issues of mutual interest.

Furthermore, other opportunities for cross-border collaboration were arranged by the USFWS, the IAFWA, and by individual states. In addition to sponsoring conference calls and hosting meetings for the SEAFWA ad hoc committee, the USFWS Region 4 office conducted informational meetings and discussion sessions as part of other regular meetings for the region. Also, the IAFWA sponsored national meetings for CWCS planners to gather and share information. The North Carolina CWCS planning team hosted a 'Neighbor States' meeting to discuss ideas and opportunities for mutual planning among five other states (VA, TN, GA, SC, and AL)

The Tennessee CWCS planning team consulted other strategy coordinators at several key junctions during the planning process. The most important coordination activities that the planning team participated in from 2003 to 2005 are listed in order chronologically as follows:

April 2003 – USFWS sponsored CWCS information meeting in GA
July 2003 – Southeast 'Neighbor States' Meeting (NC)
September 2003 – SEAFWA ad hoc committee organizational meeting in GA
March 2004 – SEAFWA ad hoc committee conference call
April 2004 - USFWS Region 4 Nongame and Endangered Species Meeting in TN
July 2004 – SEAFWA ad hoc committee regional meeting in GA
August 2004 – IAFWA sponsored "One Year Out Meeting" in NE
January 2005 – SEAFWA ad hoc committee regional meeting in SC

Public Outreach & Input

In order to cultivate broad acceptance for implementation of the CWCS, the planning team conducted a number of outreach activities to solicit input from the general public. These activities consisted of public meetings, presentations, media outreach, and development of an informational website and questionnaire. Discussion of each of these efforts is provided in the following sections:

(Public Meetings)

During July and August 2005, a series of public meetings was conducted across the state in each of the four TWRA administrative regions in the cities of Crossville, Jackson, Knoxville, and Nashville. In these meetings, the public was invited to view a presentation on the results of the CWCS conservation model and provide feedback. As well, participants were informed about potential options for implementing the strategy at the regional and local level, and asked to fill out a formal response survey. All meetings were conducted mid-week outside of normal business hours in the early evening. Notices of dates, times, and locations were sent in advance to local newspapers and other media outlets, and listed on the CWCS website. Overall, approximately 50 private citizens participated in these meetings.

(Public Presentations)
Members of the core and advisory teams also gave a number of public presentations during 2004 and 2005 to promote awareness of the CWCS planning process. Sometimes these presentations were given at the request of specific groups on more general topics. At other times, the CWCS process was the primary topic. Information about the planning effort was provided during each of the following events:

- Cumberland Harpeth Audubon Society Chapter Meeting – Feb. 2005 (attendance 25 app.)
- Catoosa Savannah Field Days – Nov. 2004 & Feb. 2005 (attendance 80 app.)
- Ijams Nature Center – Oct. & Nov. 2004 (attendance 300 app.)
- Hiwassee Wildlife Refuge Annual Crane Day – Feb. 2005 (attendance 200 app.)
- TN Ornithological Society Fall Meeting & Chattanooga, Memphis, & Nashville Chapter Meetings – Oct., Dec. 2004; Jan., Feb. 2005 (attendance 185 app.)

(Media Outreach)
The planning team also submitted articles, press releases, and conducted interviews with various media organizations to raise awareness of the CWCS process. The media included magazines, newspapers, and television with circulations and viewerships both within and outside the state. The following media outlets produced information about the CWCS during 2004 and 2005:

- Knoxville News Sentinel interview & article (December 6, 2004 & July 18, 2005)
- Maryville – The Daily Times (July 19, 2005)
- Memphis Commercial Appeal article (July 19, 2005)
- Sevierville – The Mountain Press (July 10, 2005)
- TN Wildlife Magazine article Nov./Dec. issue 2004
- TN Wildside Television Show (two segments filmed March 8, 2005 and May 3, 2005 to be aired at a future date)
- TNC TN Chapter Fieldnotes (August 2005)

(Website & Questionnaire)
In November 2004, the TWRA established an informational website and online questionnaire about the CWCS planning process. The site was linked to the main TWRA website on the state of Tennessee's government homepage at www.state.tn.us/twra/nongmain.html. A variety of information was posted on the website including: a presentation about the history of wildlife management in Tennessee, the 8 required elements of the CWCS, the project timeline, the list of species of greatest conservation need, regional maps, habitats, stresses & sources of stress affecting fauna, conservation actions, and links to the IAFWA and the Teaming With Wildlife (TWW) websites. Notices of public meetings and other opportunities for input to the planning process were also provided on the website. The final CWCS document was posted online in mid-September 2005.

In addition, the website contained an online questionnaire to gauge public opinion of the CWCS process and planning products. The questionnaire also allowed open comments on specific topics. To promote awareness of the website and questionnaire, the TWRA mailed approximately 8,500 informational cards to the top "10" wildlife license agents across the state and the remaining top "3" agents in each county. By the end of August 2005, a total of approximately 80 users submitted comments online through the website.

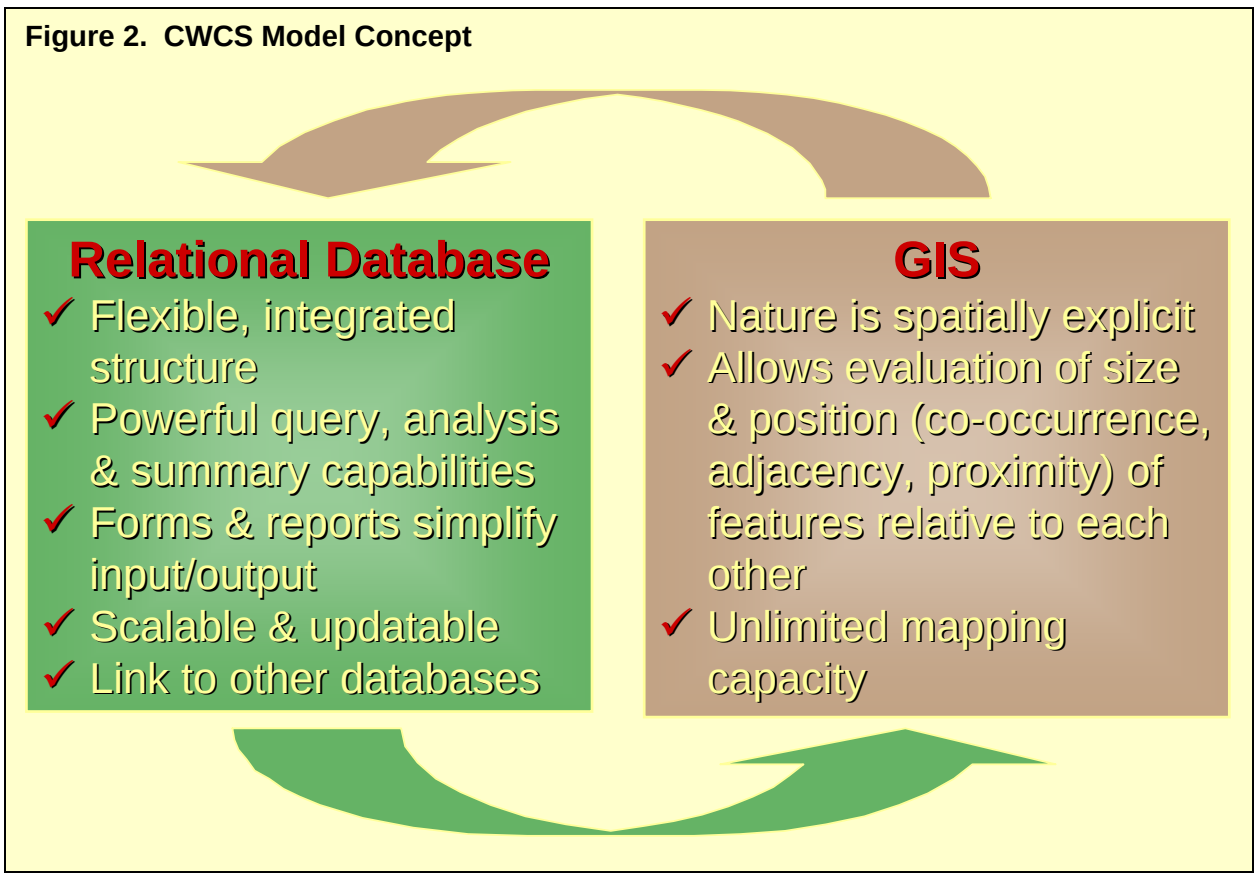
Objectives of the Planning Process and Development of the GIS Model
Currently, there are many management needs for wildlife in Tennessee that are unfulfilled. Federal/state agencies and other private conservation organizations have worked relentlessly for many years to improve the status of wildlife in the state. Yet, each year the list of management needs seems to grow. Furthermore, the full scope of these needs has never been quantified at a statewide scale. As such, three primary objectives were established to guide the CWCS project. The first objective is to consolidate the numerous

repositories of biological information used by different agencies and organizations into a comprehensive relational database for wildlife in the state. The second objective is to create a spatially explicit computer model that integrates the relational database with GIS to assist with determining conservation priorities. Finally, the third objective is to promote widespread usage of the CWCS model in order to establish a larger conservation network and maximize the benefits of any conservation actions taken.

The CWCS computer model was built on an ESRI and ERDAS GIS platform and integrated with Microsoft's Access database. The core of the model consists of seven datasets representing over 171,000 records. As well, habitat units were developed from existing GIS coverages of terrestrial, aquatic, and subterranean environments. Terrestrial habitat units were derived from an existing land use / land cover map developed by the Tennessee GAP project (Whitehead et al. 2000). Aquatic units were developed from aquatic system types developed from TNC's Freshwater Initiative (Smith et al. 2002). Subterranean units were plotted from mapped locations in TNC's Cave Database.

Overall, the computer model should substantially enhance the ability of the TWRA and other groups to manage information, set priorities, and improve biological decision making (see Figure 2). However, as with any model, results are only as good as the information that is fed into the formulas. The utility of this model depends heavily upon close partnerships with field biologists, computer scientists, and other professionals to continually add data and refine assumptions. Maintenance of this human infrastructure is equally important to the computer network. With care, the power and flexibility in this approach will hopefully provide a long-term solution to quantifying the growing list of needs for wildlife across the state.

Figure 2. CWCS Model Concept



Overview of the Planning Process

Tennessee's CWCS planning process is based on a combination of ecoregional & site conservation planning methodologies developed by TNC and wildlife planning principles from the TWRA. Guidelines for TNC methodologies are published, and the documents can be found on the Conservancy's scientific website at www.conserveonline.org (Groves et al. 2000; The Nature Conservancy 2001). Although the planning process was modified to reflect the eight CWCS elements mandated by Congress, the general process has remained consistent with TNC's planning approach. The starting point of the planning process is to assemble members of the various teams and committees that will develop and evaluate planning products. Once the organizational structure is in place, the process follows a series of discrete steps as listed below:

1. Select animals that represent the species of greatest conservation need within all major environments (terrestrial, aquatic, & subterranean) for each region of the state.
2. Gather occurrence data and set numeric goals for conservation of each selected species by population within relevant regions and subregions.
3. Determine natural systems that constitute the full spectrum of habitats required by selected species within each environment across the state.
4. Assess the current viability of individual species populations based on their relative size, condition, and landscape context.
5. Analyze past, current, and future stresses and sources of stress affecting populations of selected species.
6. Evaluate the most critical conservation actions needed to fulfill goals for the long-term protection of selected species and habitats.
7. Determine conservation priorities for each region of the state based on priority habitat areas, imperilment, and opportunities for conservation action.
8. Develop monitoring protocols to measure the relative success of conservation actions in fulfilling goals, to set thresholds for adaptive management, and to help determine an appropriate timetable for review/revision of the strategy.

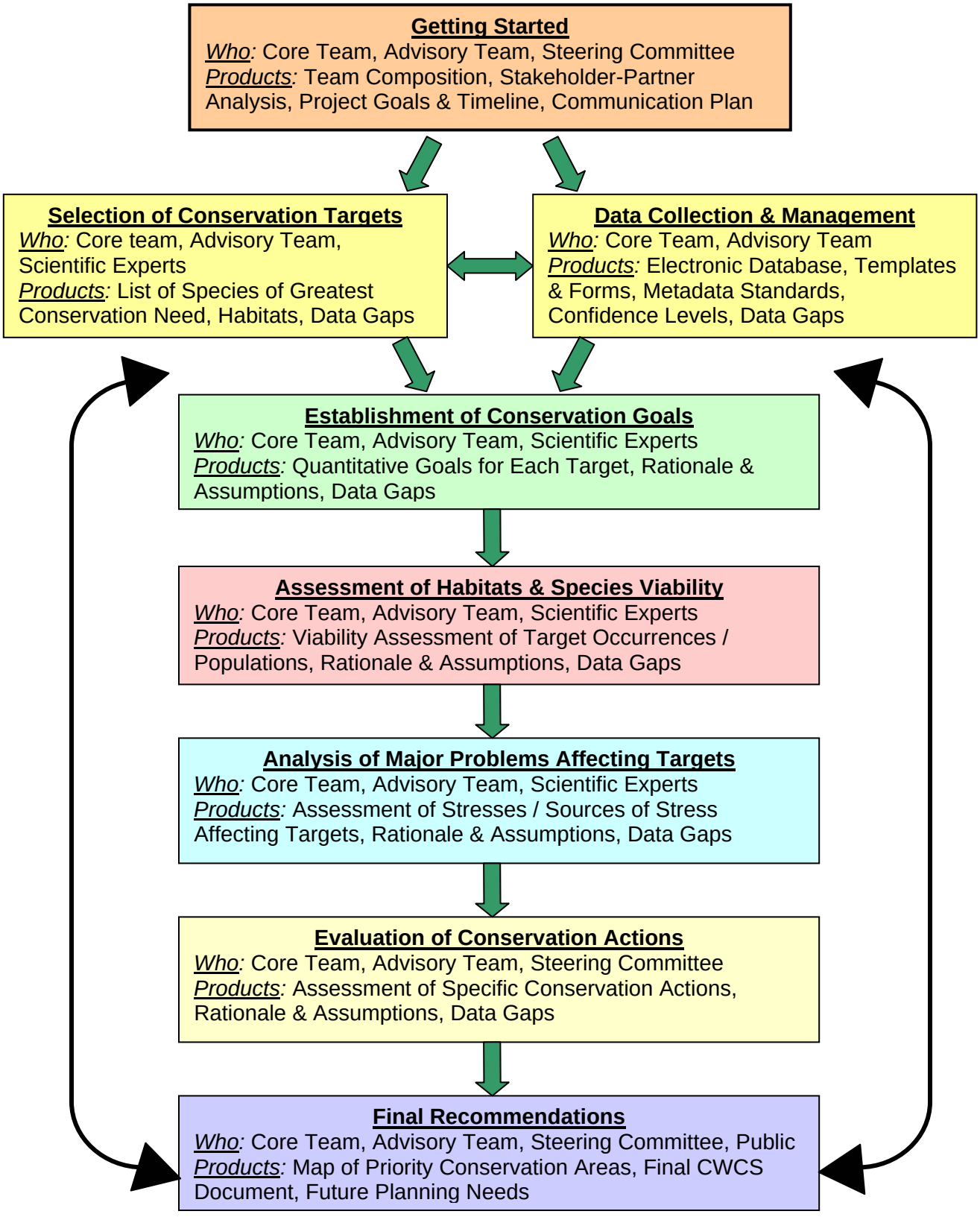
These steps are intended to be conducted in a linear succession. However, the process is often very dynamic with certain steps flowing out of sequence in response to available data. As well, each step is designed to be iterative and modifiable as new information is discovered and appropriate input is gathered from experts, managers, stakeholders, and the general public (see Figure 3). Further details of each of these planning steps are provided in the subsequent sections of this chapter.

Selection of Species of Greatest Conservation Need

At the heart of the CWCS planning effort is the selection of species of greatest conservation need (GCN). The main purpose of selecting focal species in planning is to provide focus and context to the development of specific conservation actions. In metaphorical terms, species and their occurrences are the units of 'currency' that drive the economics of the planning process. However, not all planning approaches are based equally on the notion of species as conservation targets. Some methodologies are centered on the selection of natural systems or "keystone" species that serve as surrogates for overall biological richness and diversity. Often, the number and types of targets chosen in a planning process are dictated by constraints on time, expertise, and/or technology. Notwithstanding such constraints, and given the objective of Congress to prevent further declines in GCN species nationwide, the decision was made by the core planning team to adopt a species-centric approach in developing Tennessee's CWCS.

Prior to discussion of species selection, additional information on several key ecological concepts is required in order to clarify some of the basic concepts and assumptions used in the planning process. Additional important terms and concepts used in this document are defined in the *Glossary*

Figure 3. CWCS Planning Process



at the end of the text. Also, refer to the *Literature Cited* section for other reading materials.

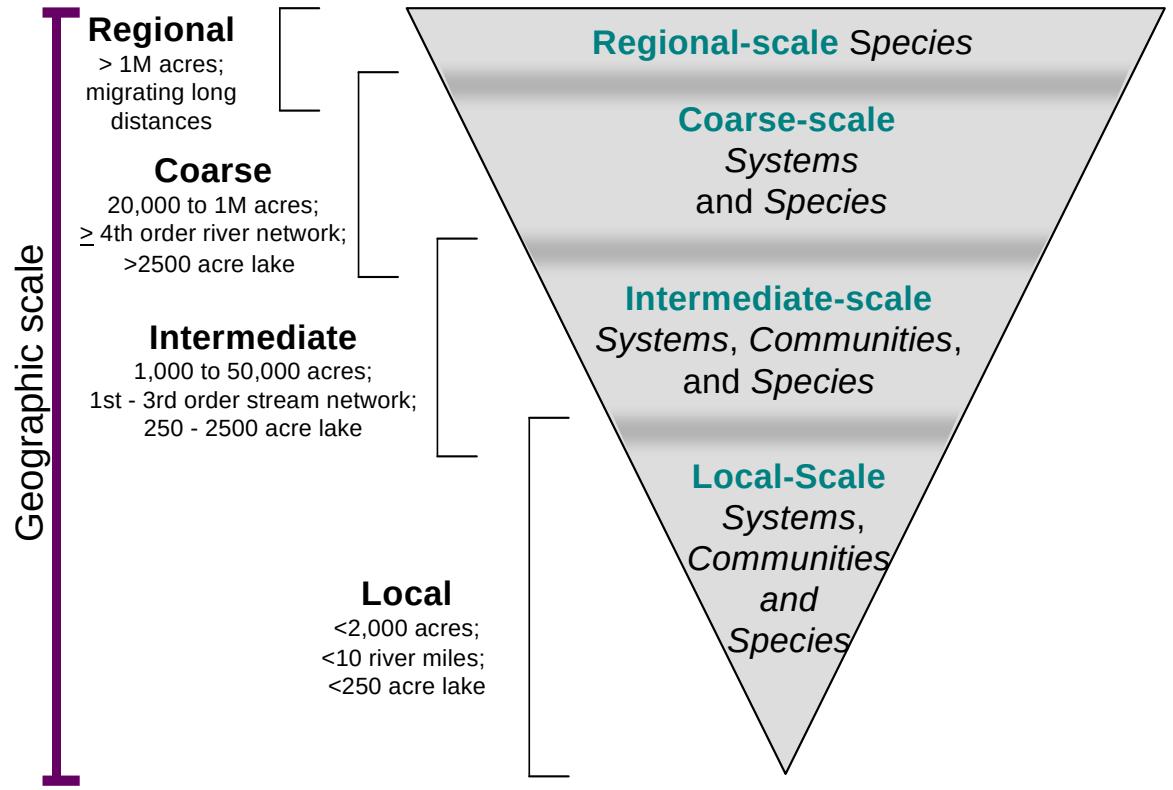
Biological Scales and Patterns

Elements of biodiversity from species to natural systems may occur across the landscape at varying degrees ranging from only a few square feet to millions of acres. As such, the different levels of biological organization can be arranged by spatial scale and pattern. For this plan, there are four geographic scales at which species and natural systems occur: regional, coarse, intermediate, and local (see Figure 4). Each spatial scale has a corresponding range which characterizes its area (e.g. acreage, stream order, river miles, or cave miles).

In addition, terrestrial natural systems occur as different patterns across the landscape: matrix, large patch, small patch, and linear. Matrix systems are typically dominant on the landscape and form the 'fabric' of vegetation at a variety of scales from local to regional (e.g. East Gulf Coastal Plain Northern Loess Plain Oak-Hickory Upland). Large patch systems are less dominant, but still constitute major portions of vegetative cover primarily from local to coarse scales (e.g. East Gulf Coastal Plain Northern Mesic Hardwood Forest). Small patch systems occupy a much smaller area at local to intermediate scales. Often, they form a patchwork within matrix and large patch systems and can be quite small (e.g. Central Interior Highlands Calcareous Glade and Barrens). Linear systems can occur at a variety of spatial scales from local to regional, but do not occupy much space due to their long and narrow pattern of occurrence (e.g. East Gulf Coastal Plain Large River Floodplain Forest).

Most landscapes are composed of a mosaic

Figure 4. Conservation Targets at Multiple Spatial Scales – (Poiani and Richter 1999)



of natural systems with multiple patterns and scales. Consideration of these elements is an important component of species selection, goal setting, and other analysis for the planning process. Overall, it is essential to capture the full array of biological scales and patterns represented by the species and natural systems of a particular region.

Biological Distribution

As well, the distribution of a species or natural system is an important consideration for species selection. There are five distributional categories used in this plan: endemic, limited, disjunct, peripheral, and widespread. Endemic means that the species or system type occurs primarily within a single ecological region (i.e. ecoregion). Limited distribution denotes that the range of occurrences is limited to only two or three ecoregions. Disjunct refers to a species or system whose main distribution is within an area unconnected to and far removed from the primary ecoregion of occurrence. Peripheral signifies that the species distribution is located within an ecoregion along the edge of its primary range. Widespread means that the animal or system is distributed across multiple ecoregions, typically more than three.

Distribution is often confused with the concepts of biological scale and pattern. For example, a particular animal species may have a widespread distribution over much of the United States, but the scale of habitat utilization for an individual occurrence may be local and the pattern small patch. Vice versa, a species with an endemic distribution in one particular ecoregion may have a coarse habitat utilization scale and a pattern that is large patch. Given the potential combinations, it is important to consider the interplay of biological scale, pattern, and distribution when selecting a full complement of conservation targets.

Compilation of Draft List of GCN Species

The first major data gathering step of the CWCS is to derive a draft list of potential GCN species from available literature (see Box 1). For the CWCS, only animals were considered

Box 1. Primary Data Sources Used to Compile Draft List of GCN Species

TN Reference Lists & Publications:

A Guide to the Rare Animals of Tennessee (TN Division of Natural Heritage 2004)
Database List of Terrestrial Snails in Tennessee (Chicago Field Museum of Natural History 2004)
Database List of Subterranean Fauna in Tennessee (Culver Database 2004)
Tennessee's Rare Wildlife Volumes I & II (Alsop et al. 1983; Bogan & Parmalee 1983)
USGS Lists of Dragonflies, Damselflies, Mayflies, Moths, & Stoneflies of Tennessee (www.npwrs.usgs.gov)

National & Regional Publications:

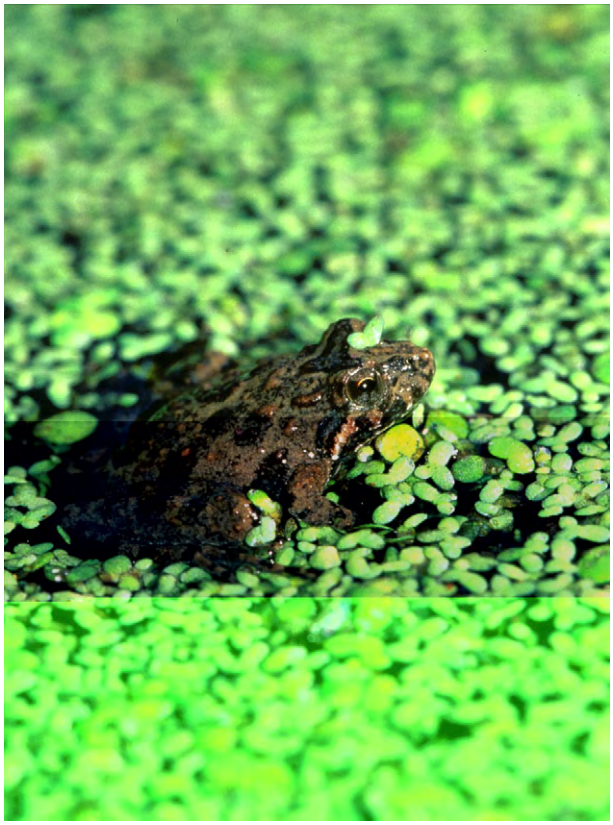
Birds of Conservation Concern (USFWS 2002)
Central Hardwoods Joint Venture Concept Plan (Fitzgerald et al. 2003)
Conservation Status of the Freshwater Mussels of the United States and Canada (Williams et al. 1993)
Crayfishes of the Lower TN-Cumberland Ecosystem… (Butler 2002)
Fishes of North America, Endangered, Threatened, or of Special Concern (William et al. 1989)
Freshwater Biodiversity Conservation Assessment of the Southeastern U.S. (Smith et al. 2002)
Imperiled Fishes of the Cumberland Ecoregion… (Butler 2000a)
Imperiled Fishes of the Southern Appalachian Ecosystem… (Butler 2002b)
Partners in Flight - Conservation of the Land Birds of the United States (Pashley et al. 2000)
Partners in Flight - North American Land Bird Conservation Plan (Rich et al. 2004)
TNC's Ecoregional Plans (The Nature Conservancy 2000, 2001b, 2003, 2004, and 2005.)
TWRA West Tennessee Resource Conservation Plan (TWRA 2004)
United States Shorebird Conservation Plan (Brown et al. 2001)
Waterbird Conservation for the Americas (Kushlan et al. 2002)

as conservation targets. Due to congressional guidelines, plants were not formally eligible for selection in this iteration of planning. However, the planning process does address plants and other natural system components within the context of wildlife habitats. Information was compiled from a number of published and unpublished data sources of known rare, threatened, endangered, or declining animal species in need of management in Tennessee. These sources were composed of: 1) database lists of fauna in the state maintained by the TDNH, 2) other federal, state, and private database lists, 3) journal publications, and 4) national and regional assessments of fauna conducted by government agencies, non-governmental organizations, and other groups working collaboratively. Not all fauna were selected from these sources. Some references listed species not found in the state, while others contained redundant or dated information that conflicted with other sources. To complete the draft species list, additional nominations were solicited from scientific experts across the state.

Candidate GCN species were drawn from all faunal groups known to occur in Tennessee. When warranted, species were listed at a sub-specific level to better reflect conservation needs. At other times, some sub-species were lumped into complexes due to taxonomic confusion among experts. In such instances, it was deemed that each of the relevant sub-species of the complex were in need of listing. Furthermore, scientific names listed in this document follow the nomenclature maintained on NatureServe's Explorer Database (see www.natureserve.org/explorer). Common names are also provided for reference. Relevant synonyms for both scientific and common names are given for each taxon, including sub-specific epithets. In total, 1,005 species and lesser taxa comprised the draft list of potential GCN animals in Tennessee (see Appendix A).

Process for Selecting Final GCN Species

In order to select final GCN species for the CWCS, the core planning team evaluated the



rarity, legal status, distribution, and population trends of each animal on the draft target list. To assess rarity, the team adopted the global and state ranking system developed by NatureServe and the Natural Heritage Program network (see Box 2). Each species was categorized with a specific rationale for acceptance or rejection as a final GCN species (see Box 3 & Appendix A).

In general, fauna with global ranks (i.e. G-ranks) of G1 to G3 or their mixed rank equivalents were automatically selected as focal species. State ranks (i.e. S-ranks) were used primarily as supplemental information in instances where the G-rank was ambivalent or when other information was needed to gauge the rarity of a species at a more local level. For wide-ranging birds species that typically have high G-ranks (i.e. G3 – G5), other measurements of rarity were evaluated, such as Partners in Flight (PIF) Physiographic Region Breeding Scores, National Shorebird Prioritization Scores (NSPS), and National Waterbird Conservation Concern (NWCC) categories. Birds with PIF scores of 22 or

higher were automatically selected as focal species. Similarly, shorebirds with a priortization score of 4 or higher, and waterbirds with a concern category of 'high' were routinely selected.

As well, the legal status of each species was reviewed in an effort to further assess issues of conservation need. Fauna formally listed under the federal "Endangered Species Act of 1973" as endangered (LE), threatened (LT), proposed endangered (PE) or proposed threatened (PT), or candidates for listing (C) were automatically selected as GCN species. Similarly, species listed under the "Tennessee Nongame and Endangered or Threatened Wildlife Species Conservation Act of 1974" as endangered (E), threatened (T), or deemed in need of management (D) were selected as GCN species, as long as their status wasn't nullified by other selection criteria. It should be clarified that insects and a few other invertebrate groups are not covered under the aforementioned statute in Tennessee.

Other determinants for selection of GCN species involved analysis of distribution and declining trends. Special consideration was given to fauna that were : a) endemic to the state or to a particular ecological region of the state, b) vulnerable to extirpation in the state or a region due to their disjunct or peripheral distribution, and/or c) exhibiting declining trends either rangewide or within specific regions or subregions of the state. Reasons for exclusion of a species from the target list were primarily due to: low imperilment ratings, non-presence in the state, or a general lack of information.

Furthermore, GCN species were not selected automatically at a statewide level. Rather, fauna were selected on a regional basis as focal species for either terrestrial, aquatic, or subterranean environments (*please refer to the regional maps detailed in Chapter 1*.) Though some fauna can be classified in more than one environmental regime (e.g. turtles or salamanders as aquatic & terrestrial, etc.) species were restricted to only one primary environment for this plan. Species were

Box 2. Natural Heritage Program Global and State Ranking System for Species

Global Ranks:

- G1 = critically imperiled globally; 5 or fewer occurrences worldwide
- 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 Heritage's website at: www.state.tn.us/environment/nh/)

Box 3. Summary of Rationales for Selection & Non-selection of GCN Species:

Rationale Categories for Selection as GCN Species:

1) Rare, imperiled, or endangered species (G1 - G3) or federal status category of LE, E/SA, LT, T/SA, PE, PT, or C; or state status category of E, T, or D.
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) PIF score of 22 or higher, (b) NSPS of 4 or higher, (c) NWCC category of 'High', (d) being a "keystone" species within a unique biodiversity "hotspot", or part of 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 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 rangewide.
5) Actively managed game species with sufficient number of viable populations in state.
6) Species is of historic significance but can not currently be restored in the state.
7) Species distribution in habitats in state is either unknown or too uncertain to warrant target status.

evaluated for target status across all regions of the state, but were selected as GCN species only for regions where they are significantly rare, imperiled, or declining. Similarly, distribution within a region was often a key factor in species selection.

Finally, effort was made to analyze the commonality of GCN species selected by adjoining states (see Appendix B). However, very little dialogue was had with other states in choosing species. As such, selection or non-selection of a species by another state did not necessarily influence the selection of fauna in Tennessee.

Summary of Final GCN Species

With the conclusion of the selection process, 664 species were chosen as the final species of greatest conservation need in Tennessee (see Table 1, Appendix A, & Box 4). These species represent all major vertebrate and invertebrate faunal groups known within the state. Roughly 28% of all vertebrate taxa in the state were selected as final GCN species. The percentage of invertebrates selected is more difficult to estimate, as the total diversity of many major invertebrate groups is unknown in Tennessee. However, approximately 41% of all known crustacean and mollusk taxa in the state were selected. In proportional terms, invertebrates compose just over 64% of all selected GCN fauna.

Further breakdown of individual faunal groups shows that on average invertebrates comprise a much larger percentage of GCN species per total number of known members in the state compared to vertebrates. Approximately 58% of all mussels statewide were selected as GCN species. Crustaceans are next with roughly 51%, followed by snails at around 32%. Again, insects and other miscellaneous invertebrates can not be accurately counted due to vague estimates of total diversity. For vertebrate groups, mammals are the highest with approximately 38% of all species known from the state on the list. Remaining vertebrate groups have between 27 – 30% of their members listed as final GCN species.

When major environments are considered, there were 238 terrestrial, 247 aquatic, and 179 subterranean final GCN species. Proportionately, invertebrates comprise a much higher percentage of the aquatic and subterranean GCN taxa, approximately 63% and 98% respectively. Vertebrates make up almost 60% of terrestrial GCN fauna.

The majority of final selected GCN species have low G-ranks, which indicate high risk (see Table 2 & Appendix A). Approximately 61% of all selected fauna have G-ranks or equivalent ranks between G1 and G3. Thirty-two percent are between G3 and G5, with less than 2% in invertebrates (85%) outpace vertebrates (33%) with the majority of their species having G-ranks from G1 – G3. Some of this difference can be accounted for in the fact that many invertebrate species have relatively poor inventory information and may be more common than their G-ranks actually indicate. Nevertheless, many invertebrate species are indeed quite rare, so no presumptions should be made about rarity until further scientific evidence warrants a change in rank.

The selection of GCN species by global rank also correlates strongly with the percentages of total known species selected in each faunal group statewide. Snails (91%), other inverts (90%), insects (89%), mussels (75%), and crustaceans (69%) have G-ranks between G1

Table 1. GCN Species by Major Environment

Major Faunal Group	Total # of Animals Known From TN	Total # of Species Selected as Draft Targets	# Species Selected as Final Targets *(Aquatic)*	# Species Selected as Final Targets *(Subterranean)*	# Species Selected as Final Targets *(Terrestrial)*
Vertebrates:	*846*	*373*	*90*	*4*	*142*
Amphibians	70	30	3	3	18
Birds	301	169	--	--	81
Fish	325	114	84	1	--
Mammals	89	43	0	0	29
Reptiles	61	17	3	0	14
Invertebrates:	*> 881*	*632*	*157*	*175*	*96*
Crustaceans*	101	67	24	28	0
Insects	> 209**	209	26	88	6
Mussels	132	127	77	--	--
Snails	374	164	30	3	87
Other Misc. Invertebrates	> 65***	65	0	56	3
Total	**> 1,727**	**1,005**	**247**	**179**	**238**

Total # of Final GCN Species = 664

(*note: Crustaceans on the draft target list include amphipods, copepods, crayfish, isopods, and shrimp.)

(**note: The total # of insect species in Tennessee is unknown. However, the state is believed to have a diverse insect fauna numbering in the thousands. This # represents the minimum included on the draft target list.)

(***note: The total number of species found in miscellaneous invertebrate faunal groups in Tennessee is unknown, but probably are in the thousands. These groups include arachnids, flatworms, millipedes, roundworms, and tardigrades. This # represents the minimum included on the draft target list.)

and G3. With the exception of fish (68%), all other vertebrates have relatively lower percentages of members with G-ranks from G1 – G3: amphibians (33%), mammals (21%), reptiles (12%), and birds (5%). Overall, analysis of G-ranks suggests that aquatic and subterranean faunal groups are in general more rare and/or more imperiled across the state.

Analysis of state ranks shows that most final GCN species are also rare at the local level in Tennessee (see Table 3 & Appendix A). Overall, 83% of all selected fauna have S-ranks between S1 and S3. Approximately 11% of these species are between S3 and S5, and 6% are listed either as state historic/extinct or with some other mixed state rank. Again, proportionately invertebrates (89%) outpace vertebrates (72%) in regard to total number of species between S1 & S3. However, most faunal groups have over 70% of their GCN species with S-ranks within the this range. Insects and other miscellaneous invertebrates lead all faunal groups with 95% having S-ranks equal to or lower than S3, followed by crustaceans (90%), snails (85%), and mussels (81%). For vertebrates, fish are second overall with approximately 94% of all species with S-ranks between S1 & S3. Next are amphibians (71%), mammals (66%), and reptiles (59%). Birds were the lowest group with only 56% within the range.

It should be noted that both global and state ranks are subject to revision as new occurrences of species are found both within and beyond the state. The CWCS project will seek to track and reconcile information on occurrences periodically with NatureServe, the TN Division of Natural Heritage, and other conservation partners with database information. Likewise, considerable efforts have already been made to delineate and

Table 2. GCN Species by Global Rank

	*Global Rank**											
Major Faunal Group	*G1*	*G1 to G2*	*G2*	*G2 to G3*	*G3*	*G3 to G4*	*G4*	*G4 to G5*	*G5*	*G? or GNR*	*GH*	**Total**
Vertebrates:												
Amphibians	2	0	1	2	3	4	4	0	8	0	0	**24**
Birds	1	0	1	0	2	0	12	1	64	0	0	**81**
Fish	16	4	15	5	18	5	10	5	6	1	0	**85**
Mammals	1	0	2	0	3	3	3	0	17	0	0	**29**
Reptiles	0	0	0	1	1	1	2	0	12	0	0	**17**
Invertebrates:												
Crustaceans	13	8	5	4	6	3	8	0	5	0	0	**52**
Insects	46	22	16	9	14	6	0	0	3	4	0	**120**
Mussels	32	4	8	3	11	3	6	1	6	0	3	**77**
Snails	30	10	35	15	19	3	5	2	0	0	1	**120**
Other Misc. Invertebrates	12	32	2	3	4	4	0	0	0	2	0	**59**
Total	**153**	**80**	**85**	**42**	**81**	**32**	**50**	**9**	**121**	**7**	**4**	**664**

(*note: For reporting purposes, species with mixed global ranks are tallied in equivalent score categories, e.g. a species ranked G1– G3 is tallied under the G2 column, G1–G4 is equivalent to G2–G3, etc. Similarly, G-ranks with "?" or "Q" or with sub-specific "T-ranks" attached to a numeric rank are tallied to the G-ranks numeric equivalent, e.g. G2? = G2 or G2T2 = G2. For the exact G-ranks of all species, see Appendix A).

Table 3. GCN Species by State Rank

Major Faunal Group	State Rank* S1	S1 to S2	S2	S2 to S3	S3	S3 to S4	S4	S4 to S5	S5	SX to SH	Other S-rank	Total
Vertebrates:												
Amphibians	5	0	6	1	5	1	3	0	2	0	1	**24**
Birds	14	0	13	2	16	3	18	1	4	2	8	**81**
Fish	34	5	22	6	13	2	0	0	0	2	1	**85**
Mammals	3	0	8	1	7	0	6	1	0	0	3	**29**
Reptiles	2	0	1	4	3	0	4	0	1	0	2	**17**
Invertebrates:												
Crustaceans	27	4	5	4	7	1	2	0	0	1	1	**52**
Insects	57	23	23	4	7	2	0	0	0	1	3	**120**
Mussels	36	4	11	6	5	2	3	1	2	6	1	**77**
Snails	29	6	24	13	30	5	4	1	1	1	6	**120**
Other Misc. Invertebrates	29	20	3	1	3	0	0	0	0	0	3	**59**
Total	**236**	**62**	**116**	**42**	**96**	**16**	**40**	**4**	**10**	**13**	**29**	**664**

(*note: For reporting purposes, species with mixed state ranks are tallied in equivalent score categories, e.g. a species ranked S1– S3 is tallied under the S2 column, S1–S4 is equivalent to S2–S3, etc. Similarly, S-ranks with "?" or "Q" attached to a numeric rank are tallied to the S-ranks numeric equivalent, e.g. S2? = S2. For birds, mixed ranks for breeding "B" and nonbreeding "N" status were listed according to the appropriate "B" rank., e.g. S1BS4N = S1. For convenience, birds that only occur in the state in a nonbreeding status were listed under the listed S-rank for nonbreeding, e.g. S3N = S3. All other S-ranks are totaled under the "Other S-rank" column. For the exact S-ranks of all species, see Appendix A)

track numbers of occurrences for all species selected for the CWCS.

Analysis was also conducted on the number of GCN species with a federal or state legal status (see Table 4 and Appendix A). Overall, 39% of all GCN species have at least one legal status category. When considering federal status only, approximately 11% of focal species are listed as LE, LT, or C. Similarly, 27% of selected fauna have a state status of E, T, or D. Roughly an equal percentage of vertebrate and invertebrate species are federally listed at 12% and 11% respectively. However, approximately 55% of vertebrates have state legal status compared to only 12% of invertebrates. When environmental regimes are considered, aquatic species constitute the majority of federally and state listed species, led by mussels and fish. Terrestrial GCN species are next, with mammals, reptiles, and birds. Relatively few subterranean species have any federal or state status.

Analysis of distribution patterns across major environments reflects disparity in the numbers of final GCN species that are rare, imperiled, or declining in various regions across the state (see Table 5 & Appendix A). Aquatically, the majority of final GCN species (63%) are found in the Tennessee River drainage. The Cumberland River drainage is second (37%), followed by the Conasauga River drainage (17%), the Mississippi River drainage (11%), and the Barren River drainage (4%). It should be noted that most focal species occur in more than one river system. By area, the

Table 4. GCN Species by Federal and State Legal Status

Major Faunal Group	*Federal and State Legal Status*										
	*Federally Listed Species**						*State Listed Species***				**Overall Total**
	LE	*LT*	*PE*	*PT*	*C*	*Total*	*E*	*T*	*D*	*Total*	
Vertebrates:											
Amphibians	0	0	0	0	0	0	0	1	10	11	**11**
Birds	1	2	0	0	0	3	4	4	16	24	**27**
Fish	9	7	0	0	4	20	20	17	32	69	**89**
Mammals	4	0	0	0	0	4	3	0	16	19	**23**
Reptiles	0	1	0	0	0	1	0	3	4	7	**8**
Invertebrates:											
Crustaceans	1	0	0	0	0	1	9	2	1	12	**13**
Insects	1	0	0	0	2	3	0	0	0	0	**3**
Mussels	35	2	0	0	4	41	34	2	0	36	**77**
Snails	2	1	0	0	0	3	3	0	0	3	**6**
Other Misc. Invertebrates	1	0	0	0	0	1	0	0	0	0	**1**
Total	**54**	**13**	**0**	**0**	**10**	**77**	**73**	**29**	**79**	**181**	**259**

(*note: Federal status categories used in the CWCS are as follows: listed endangered (LE), listed threatened (LT), proposed endangered (PE), proposed threatened (PT), and candidate species for listing (C). Species with categories such as partial status (PS) or experimental populations (XN) were not included in these tabulations. The category of threatened by similarity of appearance (T/SA) was listed under the LT category.)

(**note: State status categories used in the CWCS are as follows: endangered (E), threatened (T), and deemed in need of management (D).)

Tennessee River drainage is the largest in the state, followed by the Cumberland, Mississippi, Barren, and Conasauga drainages. On a distribution per area basis, the Conasauga and Barren Rivers have a disproportionate share of aquatic GCN species given the relatively small size of each watershed. Similarly, the Cumberland River and Tennessee River have a relatively high share of species even after adjusting for the large size of their watersheds. The Mississippi River drainage has the fewest number of aquatic GCN species per unit area.

For subterranean fauna, the largest percentage of GCN species (64%) are found in the Cumberland-Rim region. The Ridge & Valley karst region is next (20%), followed by the Nashville Basin (16%), the Central Uplands (11%), and the Southern Blue Ridge (6%). The Western Uplands is largely devoid of karst terrain and has no occurrences of final GCN subterranean species. Again, many of these faunal targets occur in more than one region.

Calculation of total area for each subterranean region is less meaningful than for aquatic regions. Total distribution of GCN species in a particular subterranean region is more likely determined by the amount of karst terrain. Underground karst availability is currently unknown across the state. Nevertheless, when total numbers of caves are considered by region, the Cumberland-Rim area has the highest number of known caves, followed by

Table 5. GCN Species Distribution by Region

Major Faunal Group	*Regions**																
	Aquatic					*Subterranean*						*Terrestrial*					
	MS	CU	BR	CO	TN	WU	CU	NB	CR	RV	SB	MP	UG	IP	CP	RV	SB
Vertebrates:																	
Amphibians	0	2	0	0	3	0	0	1	2	1	0	4	4	6	7	3	10
Birds	--	--	--	--	--	--	--	--	--	--	--	51	35	41	33	35	37
Fish	12	27	7	15	41	0	1	1	1	0	0	--	--	--	--	--	--
Mammals	0	0	0	0	0	0	0	0	0	0	0	6	10	12	18	17	27
Reptiles	3	2	0	0	3	0	0	0	0	0	0	6	11	9	7	7	8
Invertebrates:																	
Crustaceans	1	7	2	2	14	0	4	0	13	10	5	0	0	0	0	0	0
Insects	1	8	1	3	19	0	11	16	55	16	3	2	2	1	3	2	2
Mussels	10	38	0	20	51	--	--	--	--	--	--	--	--	--	--	--	--
Snails	0	8	0	2	26	0	1	0	1	1	0	2	0	12	33	18	46
Other Misc. Invertebrates	0	0	0	0	0	0	2	10	42	8	2	0	0	0	0	0	3
Total	**27**	**92**	**10**	**42**	**157**	**0**	**19**	**28**	**114**	**36**	**10**	**71**	**62**	**81**	**101**	**82**	**133**

(*note: This table summarizes the number of target GCN species in each faunal group by regions within each major environment. Aquatic regions are: (MS) = Mississippi River Drainage, (CU) = Cumberland River Drainage, (BR) = Barren River Drainage, (CO) = Conasauga River Drainage, and (TN) = Tennessee River Drainage. Subterranean Regions are: (WU) = Western Uplands, (CU) = Central Uplands, (NB) = Nashville Basin, (CR) = Cumberland-Rim, (RV) = Ridge & Valley, and (SB) = Southern Blue Ridge. Terrestrial Regions are: (MP) = Mississippi Alluvial Plain, (UG) = Upper Gulf Coastal Plain, (IP) = Interior Low Plateau, (CP) = Cumberland Plateau & Mountains, (RV) = Ridge & Valley, (SB) = Southern Blue Ridge.

the Ridge & Valley, the Nashville Basin, the Central Uplands, the Southern Blue Ridge, and finally the Western Uplands. Overall, the relative distribution per total known caves for each region matches the order of the total distribution figures.

Terrestrial GCN fauna are more evenly distributed across the state. The Southern Blue Ridge has the highest percentage of focal species (55%) occurring in the region, followed by the Cumberland Plateau & Mountains (42%), the Ridge & Valley and the Interior Low Plateau (34%), the Mississippi Alluvial Plain (30%), and the Upper Gulf Coastal Plain (26%). Like aquatic and subterranean species, many terrestrial fauna occur in multiple regions and a number are found in every terrestrial region. When adjusted for size, the Mississippi Alluvial Plain has the highest proportion of GCN species per unit area. The Southern Blue Ridge is next, followed by the Cumberland Plateau & Mountains, the Ridge & Valley, the Upper Gulf Coastal Plain, and the Interior Low Plateau.

Regional distribution is often dictated by rangewide distribution patterns of species (see Table 6 & Appendix A). Some animals are inherently endemic or limited to few regions, whereas others are widespread across many regions. Likewise some fauna are disjunct or occur only peripherally within certain areas. Analysis of distribution categories across regions shows high levels of endemic and limited distribution for aquatic

Table 6. GCN Species Distribution Category by Region

Distribution Category	*Regions**																	
	Aquatic					*Subterranean*						*Terrestrial*						
	MS	CU	BR	CO	TN	WU	CU	NB	CR	RV	SB	MP	UG	IP	CP	RV	SB	
Endemic	3	20	8	30	76	0	14	10	85	26	7	0	0	3	10	4	37	
Limited	2	35	1	8	41	0	3	16	24	9	3	0	0	7	22	13	20	
Peripheral	4	1	0	3	2	0	0	0	1	1	0	5	4	2	1	0	2	
Disjunct	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	
Widespread	16	36	1	1	38	0	2	2	4	0	0	66	58	68	68	65	74	
Total	**27**	**92**	**10**	**42**	**157**	**0**	**19**	**28**	**114**	**36**	**10**	**71**	**62**	**81**	**101**	**82**	**133**	

(*note: This table summarizes the number of target GCN species in each distribution category by regions within each major environment. Aquatic regions are: (MS) = Mississippi River Drainage, (CU) = Cumberland River Drainage, (BR) = Barren River Drainage, (CO) = Conasauga River Drainage, and (TN) = Tennessee River Drainage. Subterranean Regions are: (WU) = Western Uplands, (CU) = Central Uplands, (NB) = Nashville Basin, (CR) = Cumberland-Rim, (RV) = Ridge & Valley, and (SB) = Southern Blue Ridge. Terrestrial Regions are: (MP) = Mississippi Alluvial Plain, (UG) = Upper Gulf Coastal Plain, (IP) = Interior Low Plateau, (CP) = Cumberland Plateau & Mountains, (RV) = Ridge & Valley, (SB) = Southern Blue Ridge.

and subterranean species. Such high rates of endemism are anticipated due to the highly restricted nature of aquatic and subterranean environments. Particularly, the severe conditions needed to support life in caves have resulted in extremely high levels of endemism. Many subterranean fauna are known from only one or two cave locations within the entire state. Terrestrial regions overall have lower levels of endemic and limited GCN species, with the exception of the Southern Blue Ridge and to some degree the Cumberland Plateau & Mountains. Again, higher levels of endemism are expected in these regions due to the rugged terrain and abundance of highly restricted 'niche' habitats. Analysis of distribution was also conducted by faunal group for GCN species (see Table 7 & Appendix A).

On average, invertebrate groups are much more likely to be endemic to a region than vertebrates. Almost 65% of all invertebrates are endemic, as compared to only 22% of vertebrates. The highest rates of endemism (83%) are found in the other miscellaneous invertebrate species category, which primarily includes subterranean taxa. Crustaceans are next (79%), followed by insects (73%), snails (53%), and mussels (36%). Vertebrate endemism is led by fish (60%), amphibians (38%), and mammals (10%). Birds and reptiles have no endemic GCN species.

Most vertebrates (64%) are widespread in distribution. Birds lead all faunal groups in this category due to their highly mobile nature and broader habitat availability. Relatively few invertebrates, less than 10% on average, have a widespread distribution. Mussels compose the only invertebrate faunal group with a significant number of species with a widespread distribution (36%), followed by insects (8%) and snails (4%). Crustaceans are the only faunal group with no widespread species.

Overall, fewer than 5% of all final GCN species selected have a peripheral distribution and less than 1% are disjunct within any region. No discernible trends are present amoung faunal groups with these distributions. Fish, mussels, amphibians, mammals, reptiles, snails, and insects each

Table 7. GCN Species by Distribution Category

Major Faunal Group	*Distribution Category**															
	Aquatic					*Subterranean*					*Terrestrial*					
	E	L	P	D	W	E	L	P	D	W	E	L	P	D	W	**Total**
Vertebrates:																
Amphibians	1	1	0	0	1	2	1	0	0	0	6	3	3	0	6	**24**
Birds	--	--	--	--	--	--	--	--	--	--	0	0	0	0	81	**81**
Fish	51	14	6	0	13	0	1	0	0	0	--	--	--	--	--	**85**
Mammals	0	0	0	0	0	0	0	0	0	0	3	0	1	0	25	**29**
Reptiles	0	0	0	0	3	0	0	0	0	0	0	0	1	0	13	**17**
Invertebrates:																
Crustaceans	21	3	0	0	0	20	6	2	0	0	0	0	0	0	0	**52**
Insects	14	10	0	0	2	72	13	0	0	3	1	0	1	0	4	**120**
Mussels	28	15	4	2	28	--	--	--	--	--	--	--	--	--	--	**77**
Snails	21	8	0	0	1	2	1	0	0	0	41	37	4	1	4	**120**
Other Misc. Invertebrates	0	0	0	0	0	46	9	0	0	1	3	0	0	0	0	**59**
Total	**136**	**51**	**10**	**2**	**48**	**142**	**31**	**2**	**0**	**4**	**54**	**40**	**10**	**1**	**133**	**664**

(*note: This table summarizes the rangewide distribution assignments of (E)ndemic, (L)imited, (P)eripheral, (D)isjunct, & (W)idespread for target GCN species by major faunal group across each of the 3 major environmental regimes in the state. It is acknowledged that some species utilize more than one environmental regime (i.e. aquatic, subterranean, or terrestrial). For purposes of this analysis, species were restricted to only one primary environment.

have at least one member that is peripheral or disjunct.

Declining trends were also considered during selection of GCN species (see Table 8 and Appendix A). Information was gathered from NatureServe's Explorer database, scientific experts, and other data sources for both short and long-term population trends. In general, species with global ranks of G4 – G5, with no federal or state status, and without another rarity score of sufficient rank were evaluated for declining trends before being rejected. Overall, 101 final GCN species were selected due to declining rangewide populations.

Establishment of Tier Groups

The primary purpose of the CWCS is to conserve and restore viable populations of GCN species in appropriate habitats nationwide. Another key function is to prevent future additions to the federal endangered species list, and to avert overall declines in GCN fauna. Many GCN fauna are eligible for other types of conservation funding, such as federal Section 6 money or state proceeds from hunting and fishing licenses. CWCS funding is intended primarily for species without other significanct financial resources. However, guidelines on the CWCS allow selection of federally listed species and game species as conservation targets. Nonetheless, such fauna were to be selected more for their importance in developing a complete strategy than for their individual biological needs.

To better distinguish the status of various fauna in the CWCS, species were segregated into one of three tier categories. Tier 1

Table 8. GCN Species With Declining Trends by Major Environment				
Major Faunal Group	# Declining Species Selected as Final Targets *(Aquatic)*	# Declining Species Selected as Final Targets *(Subterranean)*	# Declining Species Selected as Final Targets *(Terrestrial)*	***Total***
Vertebrates:				
Amphibians	0	0	8	**8**
Birds	--	--	21	**21**
Fish	6	0	--	**6**
Mammals	0	0	7	**7**
Reptiles	2	0	7	**9**
Invertebrates:				
Crustaceans	9	4	0	**13**
Insects	1	8	0	**9**
Mussels	14	--	--	**14**
Snails	2	0	8	**10**
Other Misc. Invertebrates	0	4	0	**4**
Total	**34**	**16**	**51**	**101**

consists of 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 includes all other fauna not defined as wildlife under Tennessee law (i.e. insects and other invertebrates). Currently, these fauna are not covered under any other legal statutes in the state and no state agency has responsibility for their management. Tier 3 consists of federally-listed species or game species that have alternative funding sources. Tier 3 species are excluded from Tier 1 and Tier 2 fauna (see Table 9, Box 4, & Appendix A).

Tier 1 fauna will serve as the primary focus of priority setting for this iteration of the CWCS. However, planning information will be compiled and analyzed also for Tier 2 and Tier 3 species in this strategy. Map results for these tiers are presented in the next chapter to provide context. Future iterations of the CWCS may focus in greater detail on Tier 2 and Tier 3 fauna, if CWCS guidelines change or as more information is gathered.

Species Populations and Goal Setting

With the development of the final species list, research was conducted to assemble a complete inventory of occurrence information for GCN fauna. Subsequently, effort was made to discern populations and to set long-term conservation goals.

Delineation of Species Populations

The methods used to delineate populations of terrestrial, aquatic, and subterranean fauna for the CWCS are based on simplified ecological concepts. These concepts are mainly predicated on the notion that species congregations are dictated by distance factors that limit dispersal, foraging and breeding ability within various units of habitat. In actuality, populations are determined by more complex sets of ecological factors such as: habitat structure, behavioral patterns, disease, environmental calamity, and other random events (TNC and ABI 1999). Complete representations of these factors are nearly impossible in current conservation models. Still, the delineation of preliminary populations is integral to the CWCS model.

Table 9. GCN Species by Target Tier Category

Major Faunal Group	# Species Selected as Final Targets *(Aquatic)* Tier 1	Tier 2	Tier 3	# Species Selected as Final Targets *(Subterranean)* Tier 1	Tier 2	Tier 3	# Species Selected as Final Targets *(Terrestrial)* Tier 1	Tier 2	Tier 3	***Total***
Vertebrates:										
Amphibians	3	0	0	3	0	0	18	0	0	**24**
Birds	--	--	--	--	--	--	74	0	7	**81**
Fish	67	0	17	1	0	0	--	--	--	**85**
Mammals	0	0	0	0	0	0	22	0	7	**29**
Reptiles	3	0	0	0	0	0	13	0	1	**17**
Invertebrates:										
Crustaceans	23	0	1	28	0	0	0	0	0	**52**
Insects	0	26	0	0	88	0	0	5	1	**120**
Mussels	40	0	37	--	--	--	--	--	--	**77**
Snails	28	0	2	3	0	0	86	0	1	**120**
Other Misc. Invertebrates	0	0	0	0	56	0	0	2	1	**59**
Total	**164**	**26**	**57**	**35**	**144**	**0**	**213**	**7**	**18**	**664**

Information about species occurrences was gathered from a number of databases, from scientific experts, and from published literature. Existing database records were collected from the following sources: TN Division of Natural Heritage Rare Species Database (Biotics), TN Amphibian and Reptile Database (TAROD), TN Aquatics Database (TADS), Chicago Field Museum of Natural History Terrestrial Snail Database, TN Breeding Bird Atlas Database, TWRA-Parmalee Mussel Database, and TNC Cave Fauna Database. Each of these databases was joined into a single directory and shapefile locations of each record were created in GIS. As well, several scientific experts maintained private stores of biological data which were also integrated into the master database. Furthermore, the CWCS planning team researched additional locations of species from literature sources. When locations were found, coordinates were logged using GIS and added to the database. Despite these efforts, a number of species are still without mapped locations. Work to find occurrences of GCN species is continuing.

Over 171,000 individual records are contained in the new combined database. However, only about 151,000 records are mappable. Many of these represent multiple observations of the same occurrence. To eliminate duplicates, effort was made to reconcile records and develop precise counts of the total number of occurrences for each final GCN species. For terrestrial species, a 100 meter buffer was established around the database location of each occurrence using GIS. Overlapping buffers of the same species were joined into occurrence groups. Any degree of overlap was deemed sufficient for records to be combined. These combined occurrence groups represent the best approximation of the total number of unique occurrences that exist for a species in the state (~22,000).

Afterward, individual buffer distances were used to delineate adjacent occurrence groups into terrestrial populations. The population buffer distances were derived from species habitat separation distances set by NatureServe biologists. These distances can

Box 4. List of GCN Species

TIER 1 FAUNA
Terrestrial (Vertebrates)

Amphibians

Acris gryllus (Southern Cricket Frog)
Ambystoma barbouri (Streamside Salamander)
Aneides aeneus (Green Salamander)
Desmognathus aeneus (Seepage Salamander)
Desmognathus wrighti (Pigmy Salamander)
Hemidactylium scutatum (Four-toed Salam.)
Hyla gratiosa (Barking Treefrog)
Hyla versicolor (Gray Treefrog)
Plethodon aureolus (Tellico Salamander)
Plethodon jordani (Red-cheeked Salamander)
Plethodon richmondi (Ravine Salamander)
Plethodon wehrlei (Wehrle's Salamander)
Plethodon welleri (Weller's Salamander)
Plethodon yonahlossee (Yonahlossee Salam.)
Pseudacris brachyphona (Mtn. Chorus Frog)
Pseudotriton montanus (Mud Salamander)
Rana areolata (Crawfish Frog)
Rana capito (Gopher Frog)

Birds

Accipiter striatus (Sharp-shinned Hawk)
Aegolius acadicus (Northern Saw-whet Owl)
Aimophila aestivalis (Bachman's Sparrow)
Ammodramus henslowii (Henslow's Sparrow)
Ammodramus savannarum (Grass. Sparrow)
Anhinga anhinga (Anhinga)
Aquila chrysaetos (Golden Eagle)
Ardea alba (Great Egret)
Asio flammeus (Short-eared Owl)
Bartramia longicauda (Upland Sandpiper)
Botaurus lentiginosus (American Bittern)
Calidris canutus (Red Knot)
Calidris himantopus (Stilt Sandpiper)
Calidris mauri (Western Sandpiper)
Caprimulgus carolinensis (Chuck-will's-widow)
Caprimulgus vociferus (Whip-poor-will)
Certhia americana (Brown Creeper)
Charadrius wilsonia (Wilson's Plover)
Chondestes grammacus (Lark Sparrow)
Circus cyaneus (Northern Harrier)
Cistothorus platensis (Sedge Wren)
Coccyzus americanus (Yellow-billed Cuckoo)
Contopus cooperi (Olive-sided Flycatcher)
Contopus virens (Eastern Wood-pewee)
Corvus corax (Common Raven)
Dendroica caerulescens (B.t. Blue Warbler)
Dendroica cerulea (Cerulean Warbler)
Dendroica discolor (Prairie Warbler)
Dendroica dominica (Yellow-throated Warbler)
Dendroica virens (B.t. Green Warbler)
Egretta caerulea (Little Blue Heron)
Elanoides forficatus (Swallow-tailed Kite)
Empidonax alnorum (Alder Flycatcher)
Empidonax minimus (Least Flycatcher)
Empidonax virescens (Acadian Flycatcher)
Helmitheros vermivorus (Worm-eating Warbler)
Hylocichla mustelina (Wood Thrush)
Icterus spurius (Orchard Oriole)
Ictinia mississippiensis (Mississippi Kite)
Ixobrychus exilis (Least Bittern)
Lanius ludovicianus (Loggerhead Shrike)
Limnothlypis swainsonii (Swainson's Warbler)
Limosa fedoa (Marbled Godwit)
Limosa haemastica (Hudsonian Godwit)
Melanerpes erythrocephalus (R.h. Woodpecker)
Numenius phaeopus (Whimbrel)
Oporornis formosus (Kentucky Warbler)
Parula americana (Northern Parula)
Passerculus sandwichensis (Sav. Sparrow)
Passerina ciris (Painted Bunting)
Pluvialis dominica (American Golden Plover)
Poecile atricapillus (Black-capped Chickadee)
Pooecetes gramineus (Vesper Sparrow)
Protonotaria citrea (Prothonotary Warbler)
Rallus elegans (King Rail)
Regulus satrapa (Golden-crowned Kinglet)
Riparia riparia (Bank Swallow)
Seiurus motacilla (Louisiana Waterthrush)
Sitta canadensis (Red-breasted Nuthatch)
Sitta pusilla (Brown-headed Nuthatch)
Sphyrapicus varius (Yellow-bellied Sapsucker)
Spiza americana (Dickcissel)
Thryomanes bewickii (Bewick's Wren)
Troglodytes troglodytes (Winter Wren)
Tryngites subruficollis (Buff-breast. Sandpiper)
Tympanuchus cupido (Greater Prairie-chicken)
Tyrannus forficatus (Scissor-tailed Flycatcher)
Tyto alba (Barn Owl)
Vermivora chrysoptera (Gold.-winged Warbler)
Vermivora pinus (Blue-winged Warbler)
Vireo bellii (Bell's Vireo)
Vireo flavifrons (Yellow-throated Vireo)
Vireo griseus (White-eyed Vireo)
Wilsonia citrina (Hooded Warbler)

Box 4. List of GCN Species (cont'd.)

TIER 1 FAUNA
Terrestrial (Vertebrates)

Mammals

Condylura cristata (Star-nosed Mole)
Corynorhinus rafinesquii (Raf. Big-eared Bat)
Martes pennanti (Fisher)
Microtus chrotorrhinus carolinensis (Southern Rock Vole)
Mustela nivalis (Least Weasel)
Myotis austroriparius (Southeastern Bat)
Myotis leibii (Eastern Small-footed Bat)
Napaeozapus insignis (Wood. Jumping Mouse)
Neotoma floridana haematoreia (Southern Appalachian Woodrat)
Neotoma floridana illinoensis (Eastern Woodrat)
Neotoma magister (Allegheny Woodrat)
Ochrotomys nuttalli (Golden Mouse)
Parascalops breweri (Hairy-tailed Mole)
Sorex cinereus (Common Shrew)
Sorex dispar (Long-tailed Shrew)
Sorex fumeus (Smoky Shrew)
Sorex hoyi (Pygmy Shrew)
Sorex longirostris (Southeastern Shrew)
Sorex palustris (Water Shrew)
Spilogale putorius (Eastern Spotted Skunk)
Synaptomys cooperi (Southern Bog Lemming)
Zapus hudsonius (Meadow Jumping Mouse)

Reptiles

Anolis carolinensis (Green Anole)
Crotalus horridus (Timber Rattlesnake)
Eumeces anthracinus (Coal Skink)
Glyptemys muhlenbergii (Bog Turtle)
Heterodon platirhinos (E. Hognosed Snake)
Masticophis flagellum (Coachwhip)
Nerodia cyclopion (Green Water Snake)
Nerodia erythrogaster flavigaster (Yellowbelly Water Snake)
Ophisaurus attenuatus longicaudus (Eastern Slender Glass Lizard)
Pituophis melanoleucus melanoleucus (Northern Pine Snake)
Sistrurus miliarius streckeri (Western Pigmy Rattlesnake)
Terrapene carolina (Eastern Box Turtle)
Virginia striatula (Rough Earth Snake)

Terrestrial (Invertebrates)

Snails

Anguispira alabama (Alabama Tigersnail)
Anguispira cumberlandiana (Cumb. Tigersnail)
Anguispira knoxensis (Rustic Tigersnail)
Anguispira kochi (Banded Tigershell)
Daedalochila auriformis (Rockpile Liptooth)
Discus bryanti (Sawtooth Disc)
Discus clappi (Channelled Disc)
Euchemotrema fraternum montanum (a pillsnail)
Fumonelix archeri (Ocoee Covert)
Fumonelix christyi (Glossy Covert)
Fumonelix jonesiana (Big-tooth Covert)
Fumonelix orestes (Engraved Covert)
Fumonelix wetherbyi (Clifty Covert)
Fumonelix wheatleyi (Cinnamon Covert)
Fumonelix wheatleyi clingmanicus (Clingman Covert)
Glyphyalinia junaluskana (Dark Glyph)
Glyphyalinia ocoae (Blue-gray Glyph)
Glyphyalinia pentadelphia (Pink Glyph)
Glyphyalinia rimula (Tongued Glyph)
Glyphyalinia vanattai (Honey Glyph)
Haplotrema kendeighi (Blue-footed Lancetooth)
Helicodiscus aldrichianus (Burrowing Coil)
Helicodiscus enneodon (Bluff Coil)
Helicodiscus fimbriatus (Fringed Coil)
Helicodiscus hexodon (Toothy Coil)
Inflectarius downieanus (Dwarf Globelet)
Inflectarius ferrissi (Smokey Mountain Covert)
Inflectarius kalmianus (Brown Globelet)
Inflectarius smithi (Alabama Shagreen)
Inflectarius subpalliatus (Velvet Covert)
Megapallifera wetherbyi (Blotchy Mantleslug)
Mesodon altivagus (Wandering Globe)
Mesodon andrewsae (Balsam Globe)
Mesodon sanus (Squat Globelet)
Mesomphix andrewsae (Mountain Button)
Mesomphix rugeli (Wrinkled Button)
Mesomphix subplanus (Flat Button)
Paravitrea alethia (Goddess Supercoil)
Paravitrea andrewsae (High Mtn. Supercoil)
Paravitrea bellona (Club Supercoil)
Paravitrea blarina (Shrew Supercoil)
Paravitrea calcicola (Pearl Supercoil)

Box 4. List of GCN Species (cont'd.)

TIER 1 FAUNA
Terrestrial (Invertebrates)

Snails (Cont'd.)

Paravitrea clappi (Mirey Ridge Supercoil)
Paravitrea lamellidens (Lamellate Supercoil)
Paravitrea lapilla (Gem Supercoil)
Paravitrea metallacta (Caney Fork Supercoil)
Paravitrea petrophila (Cherokee Supercoil)
Paravitrea placentula (Glossy Supercoil)
Paravitrea reesei (Round Supercoil)
Paravitrea subtilis (Slender Supercoil)
Paravitrea tantilla (Teasing Supercoil)
Paravitrea ternaria (Sculpted Supercoil)
Paravitrea tridens (White-foot Supercoil)
Paravitrea umbilicaris (Open Supercoil)
Paravitrea variabilis (Variable Supercoil)
Paravitrea varidens (Roan Supercoil)
Patera clarki (Dwarf Proud Globe)
Philomycus sellatus (Alabama Mantleslug)
Philomycus virginicus (Virginia Mantleslug)
Pilsbryna aurea (Ornate Bud)
Pilsbryna castanea (Prominent Bud)
Stenotrema altispira (Highland Slitmouth)
Stenotrema angellum (Kentucky Slitmouth)
Stenotrema calvescens (Chatt.Slitmouth)
Stenotrema cohuttense (Cohutta Slitmouth)
Stenotrema depilatum (Great Smoky Slitmouth)
Stenotrema edgarianum (Sequatchie Slitmouth)
Stenotrema exodon (Alabama Slitmouth)
Stenotrema magnafumosum (App. Slitmouth)
Stenotrema pilula (Pygmy Slitmouth)
Stenotrema waldense (Doaks Creek Slitmouth)
Striatura exigua (Ribbed Striate)
Succinea greerii (Dryland Ambersnail)
Triodopsis anteridon (Carter Three-tooth)
Triodopsis claibornensis (Claib. Three-tooth)
Ventridens coelaxis (Bidentate Dome)
Ventridens decussatus (Crossed Dome)
Ventridens eutropis (Carinate Dome)
Ventridens lasmodon (Hollow Dome)
Ventridens percallosus (Tennessee Dome)
Vertigo clappi (Cupped Vertigo)
Vertigo parvula (Smallmouth Vertigo)
Vertigo teskeyae (Swamp Vertigo)
Webbhelix multilineata (Striped Whitelip)
Xolotrema obstrictum (Sharp Wedge)
Zonitoides lateumbilicatus (Striate Gloss)

Aquatic (Vertebrates)

Amphibians

Cryptobranchus alleganiensis (Hellbender)
Desmognathus welteri (Black Mtn. Salamander)
Eurycea junaluska (Junaluska Salamander)

Fish

Acipenser fulvescens (Lake Sturgeon)
Ammocrypta beani (Naked Sand Darter)
Ammocrypta clara (Western Sand Darter)
Ammocrypta vivax (Scaly Sand Darter)
Carpiodes velifer (Highfin Carpsucker)
Clinostomus funduloides ssp. 1 (Smoky Dace)
Crystallaria asprella (Crystal Darter)
Cycleptus elongatus (Blue sucker)
Ericymba buccata (Silverjaw Minnow)
Erimystax dissimilis (Streamline Chub)
Erimystax insignis (Blotched Chub)
Etheostoma acuticeps (Sharphead Darter)
Etheostoma aquali (Coppercheek Darter)
Etheostoma baileyi (Emerald Darter)
Etheostoma barbouri (Teardrop Darter)
Etheostoma barrenense (Splendid Darter)
Etheostoma bellum (Orangefin Darter)
Etheostoma blennioides gutselli (Tuckasegee Darter)
Etheostoma blennius sequatchiense (Sequatchie Blenny Darter)
Etheostoma brevirostrum (Holiday Darter)
Etheostoma cervus (Chickasaw Darter)
Etheostoma cinereum (Ashy Darter)
Etheostoma corona (Crown Darter)
Etheostoma denoncourti (Golden Darter)
Etheostoma ditrema (Coldwater Darter)
Etheostoma forbesi (Barrens Darter)
Etheostoma maculatum (Spotted Darter)
Etheostoma microlepidum (Finescale Darter)
Etheostoma neopterum (Lollypop Darter)
Etheostoma olivaceum (Sooty Darter Darter)
Etheostoma pseudovulatum (Egg-mimic Darter)
Etheostoma pyrrhogaster (Firebelly Darter)
Etheostoma rupestre (Rock Darter)
Etheostoma sagitta (Arrow Darter)
Etheostoma striatulum (Striated Darter)
Etheostoma susanae (Cumb. Johnny Darter)

Box 4. List of GCN Species (cont'd.)

TIER 1 FAUNA
Aquatic (Vertebrates)

Fish (Cont'd.)

Etheostoma tippecanoe (Tippecanoe Darter)
Etheostoma trisella (Trispot Darter)
Etheostoma vulneratum (Wounded Darter)
Fundulus chrysotus (Golden Topminnow)
Fundulus julisia (Barrens Topminnow)
Hemitremia flammea (Flame Chub)
Hybopsis lineapunctata (Lined Chub)
Ichthyomyzon gagei (Southern Brook Lamprey)
Lepisosteus spatula (Alligator Gar)
Macrhybopsis gelida (Sturgeon Chub)
Macrhybopsis meeki (Sicklefin Chub)
Notropis asperifrons (Burrhead Shiner)
Notropis chrosomus (Rainbow Shiner)
Notropis rubellus rubellus (Rosyface Shiner)
Notropis rupestris (Bedrock Shiner)
Noturus munitus (Frecklebelly Madtom)
Noturus sp. 3 (Saddled Madtom)
Noturus sp. 4 (Chucky Madtom)
Noturus stigmosus (Northern Madtom)
Percina aurantiaca (Tangerine Darter)
Percina burtoni (Blotchside Logperch)
Percina macrocephala (Longhead Darter)
Percina phoxocephala (Slenderhead Darter)
Percina sp. 3 (Muscadine Darter)
Percina sp. 9 (Upland Bridled Darter)
Percina squamata (Olive Darter)
Percina stictogaster (Frecklebelly Darter)
Phenacobius catostomus (Riffle Minnow)
Phoxinus saylori (Laurel Dace)
Phoxinus tennesseensis (Tennessee Dace)
Thoburnia atripinnis (Blackfin Sucker)

Reptiles

Apalone mutica (Smooth Softshell Turtle)
Apalone spinifera (Spiny Softshell Turtle)
Macrochelys temminckii (Alligator Snapping Turtle)

Aquatic (Invertebrates)

Crustaceans

Barbicambarus cornutus (Bottlebrush Crayfish)
Cambarus angularis (Angled Crayfish)
Cambarus bouchardi (Big South Fork Crayfish)
Cambarus brachydactylus (Shortfing. Crayfish)
Cambarus conasaugaensis (a crayfish)
Cambarus crinipes (Bouchards's Crayfish)
Cambarus cymatilis (Con. Blue Burr. Crayfish)
Cambarus deweesae (Valley Flame Crayfish)
Cambarus extraneus (Chickamauga Crayfish)
Cambarus hiwasseensis (a crayfish)
Cambarus manningi (a crayfish)
Cambarus obeyensis (Obey River Crayfish)
Cambarus pristinus (Caney Fork Crayfish)
Cambarus sp. 1 (Emory River Crayfish)
Cambarus williami (Stones River Crayfish)
Fallicambarus hortoni (Hatchie Burr. Crayfish)
Orconectes alabamensis (Stateline Crayfish)
Orconectes barrenensis (a crayfish)
Orconectes burri (Blood River Crayfish)
Orconectes cooperi (Flintbriar Crayfish)
Orconectes forceps (Surgeon Crayfish)
Orconectes pagei (Big Sandy Crayfish)
Orconectes wrighti (Hardin County Crayfish)

Mussels

Actinonaias pectorosa (Pheasantshell)
Alasmidonta marginata (Elktoe)
Alasmidonta viridis (Slippershell Mussel)
Cumberlandia monodonta (Spectaclecase)
Elliptio arca (Alabama Spike)
Elliptio arctata (Delicate Spike)
Epioblasma triquetra (Snuffbox)
Fusconaia barnesiana (Tennessee Pigtoe)
Fusconaia subrotunda (Longsolid)
Lampsilis straminea claibornensis (Southern Fatmucket)
Lasmigona complanata complanata (White Heelsplitter)
Lasmigona holstonia (Tennessee Heelsplitter)
Lasmigona subviridis (Green Floater)
Lexingtonia dolabelloides (Slab. Pearlymussel)
Ligumia recta (Black Sandshell)
Medionidus conradicus (Cumb. Moccasinshell)
Obovaria jacksoniana (Southern Hickorynut)
Obovaria olivaria (Hickorynut)
Obovaria subrotunda (Round Hickorynut)
Plethobasus cyphyus (Sheepnose)

Box 4. List of GCN Species (cont'd.)

TIER 1 FAUNA
Aquatic (Invertebrates)

Mussels (Cont'd.)

Pleurobema coccineum (Round Pigtoe)
Pleurobema cordatum (Ohio Pigtoe)
Pleurobema hanleyianum (Georgia Pigtoe)
Pleurobema johannis (Alabama Pigtoe)
Pleurobema oviforme (Tennessee Clubshell)
Pleurobema rubellum (Warrior Pigtoe)
Pleurobema rubrum (Pyramid Pigtoe)
Pleurobema troschelianum (Alabama Clubshell)
Ptychobranchus subtentum (Fluted Kidneyshell)
Quadrula cylindrica cylindrica (Rabbitsfoot)
Strophitus connasaugaensis (AL Creekmussel)
Strophitus undulatus (Squawfoot)
Toxolasma lividus (Purple Lilliput)
Uniomerus declivis (Tapered Pondhorn)
Villosa fabalis (Rayed Bean)
Villosa lienosa (Little Spectaclecase)
Villosa nebulosa (Alabama Rainbow)
Villosa taeniata (Painted Creekshell)
Villosa vanuxemensis umbrans (Coosa Creekshell)
Villosa vibex (Southern Rainbow)

Snails

Elimia acuta (Acute Elimia)
Elimia arachnoidea (Spider Elimia)
Elimia aterina (Coal Elimia)
Elimia interrupta (Knotty Elimia)
Elimia porrecta (Nymph Elimia)
Elimia striatula (File Elimia)
Elimia strigosa (Brook Elimia)
Elimia teres (Elegant Elimia)
Elimia troostiana (Mossy Elimia)
Io fluvialis (Spiny Riversnail)
Leptoxis crassa (Boulder Snail)
Leptoxis umbilicata (Umbilicate Rocksnail)
Leptoxis virgata (Smooth Mudalia)
Lithasia armigera (Armored Rocksnail)
Lithasia duttoniana (Helmet Rocksnail)
Lithasia geniculata fuliginosa (Geniculate River Snail)
Lithasia geniculata pinguis (Small Geniculate River Snail)
Lithasia jayana (Rugose Rocksnail)
Lithasia lima (Warty Rocksnail)
Lithasia salebrosa (Muddy Rocksnail)
Pleurocera corpulenta (Corpulent Hornsnail)
Pleurocera curta (Shortspire Hornsnail)
Pleurocera trochiformis (Sulcate Hornsnail)
Pleurocera walkeri (Telescope Hornsnail)
Somatogyrus aureus (Golden Pebblesnail)
Somatogyrus parvulus (Sparrow Pebblesnail)
Somatogyrus sp. 2 (Hiwassee Pebblesnail)
Somatogyrus tennesseensis (Op. Pebblesnail)

Subterranean (Vertebrates)

Amphibians

Gyrinophilus palleucus (TN Cave Salamander)
Gyrinophilus palleucus gulolineatus (Berry Cave Salamander)
Gyrinophilus palleucus necturoides (Big Mouth Cave Salamander)

Fish

Typhlichthys subterraneus (Southern Cavefish)

Subterranean (Invertebrates)

Crustaceans

Amergoniscus nicholasi (an isopod)
Amergoniscus paynei (an isopod)
Bactrurus angulus (Cu. Gap Cave Amphipod)
Caecidotea circulus (an isopod)
Caecidotea incurva (Incurved Cave Isopod)
Caecidotea nickajackensis (Nick. Cave Isopod)
Caecidotea nortoni (an isopod)
Caecidotea recurvata (SW VA Cave Isopod)
Caecidotea scyphus (an isopod)
Caecidotea stygia (an isopod)
Cambarus hamulatus (Nickajack Cave Crayfish)
Diacyclops sp. (Indiana Groundwater Copepod)
Diacyclops yeatmani (Yeatman's Gr. Copepod)
Donnaldsoncythere tuberosa (a shrimp)
Ligidium elrodii hancockensis (an isopod)
Miktoniscus barri (an isopod)

Box 4. List of GCN Species (cont'd.)

TIER 1 FAUNA
Subterranean (Invertebrates)

Crustaceans (cont'd.)

Orconectes australis (Blind Crayfish)
Orconectes incomptus (TN Cave Crayfish)
Orconectes pellucidus (Eyeless Crayfish)
Stygobromus barryi (a cave obligate amphipod)
Stygobromus dicksoni (an amphipod)
Stygobromus fecundus (an amphipod)
Stygobromus finleyi (Finley's Cave Amphipod)
Stygobromus nortoni (Norton's Cave Amphipod)
Stygobromus sp. (an amphipod)
Stygobromus sp. 22 (S. River Cave Amphipod)
Stygobromus sparsus (an amphipod)
Stygobromus vitreus (an amphipod)

Snails

Carychium stygium (Cave Thorn)
Helicodiscus hadenoecus (Cave Disc Snail)
Helicodiscus notius specus (a cave snail)

TIER 2 FAUNA
Terrestrial (Invertebrates)

Insects

Amblyscirtes linda (Linda's Roadside Skipper)
Callophrys irus (Frosted Elfin)
Cicindela ancocisconensis (a tiger beetle)
Semiothisa fraserata (Fraser Fir Geo. Moth)
Speyeria diana (Diana Fritillary)

Tardigrades

Calohypsibius schusteri (Schuster's Tardigrade)
Hypsibius roanensis (Roan Tardigrade)

Aquatic (Invertebrates)

Insects

Agarodes stannardi (Stannard's Ag. Caddisfly)
Allocapnia brooksi (Sevier Snowfly)
Allocapnia cunninghami (Karst Snowfly)
Allocapnia fumosa (Smokies Snowfly)
Allocapnia perplexa (Perplexing Snowfly)
Amphinemura mockfordi (Tennessee Forestfly)
Ceratopsyche etnieri (Buffalo Springs Caddisfly)
Cheumatopsyche helma (Helma's N. Caddisfly)
Glyphopsyche sequatchie (Seq. Caddisfly)
Gomphus consanguis (Cherokee Cl. Dragonfly)
Gomphus sandrius (TN Clubtail Dragonfly)
Gomphus septima (Septima's Clubtail)
Habrophlebiodes celeteria (a mayfly)
Hydroperla rickeri (Tennessee Springfly)
Macromia margarita (Mountain River Cruiser)
Megaleuctra williamsae (Williams' R. Stonefly)
Oconoperla innubila (a stonefly)
Ophiogomphus acuminatus (TNSnaketail)
Ophiogomphus alleghaniensis (Al. Snaketail)
Ophiogomphus edmundo (Edmund's Snaketail)
Ophiogomphus howei (Howe's Dragonfly)
Paraleptophlebia kirchneri (a mayfly)
Perlesta etnieri (a stonefly)
Plauditus grandis (a mayfly)
Stenonema sinclairi (a mayfly)
Zapada chila (a stonefly)

Subterranean (Invertebrates)

Arachnids

Appaleptoneta sp. (a cave leptonetid spider)
Appaleptoneta sp. 1 (a cave leptonetid spider)
Callioplus pantoplus (an amaurobiid spider)
Chitrella archeri (a pseudoscorpion)
Hesperochernes mirabilis (SE Pseudoscorpion)
Kleptochthonius affinis (a pseudoscorpion)
Kleptochthonius barri (a pseudoscorpion)
Kleptochthonius charon (a pseudoscorpion)
Kleptochthonius daemonius (a pseudoscorpion)
Kleptochthonius infernalis (a pseudoscorpion)
Kleptochthonius magnus (a pseudoscorpion)
Kleptochthonius myopius (a pseudoscorpion)

Box 4. List of GCN Species (cont'd.)

TIER 2 FAUNA
Subterranean (Invertebrates)

Arachnids (cont'd.)

Kleptochthonius pluto (a pseudoscorpion)
Kleptochthonius rex (a pseudoscorpion)
Kleptochthonius sp. (a pseudoscorpion)
Kleptochthonius stygius (a pseudoscorpion)
Kleptochthonius tantalus (a pseudoscorpion)
Liocranoides sp. (a two-clawed spider)
Nesticus barrowsi (a spider)
Nesticus dilutus (Grassy Creek Cave Spider)
Nesticus furtivus (Crystal Caverns Cave Spider)
Nesticus paynei (a spider)
Nesticus stygius (a spider)
Nesticus tennesseensis (a spider)
Nesticus valentinei (Valentine's Cave Spider)
Phalangodes appalachius (App. Harvestman)
Poecilophysis weyerensis (a cave mite)
Theromaster sp. 1 (a harvestman)
Tyrannochthonius fiskei (a pseudoscorpion)
Tyrannochthonius steevesi (a pseudoscorpion)

Flatworms

Sphalloplana buchanani (a planarian)
Sphalloplana chandleri (Chandler's Planarian)
Sphalloplana consimilis (Powell Vall. Planarian)
Sphalloplana sp. (a flatworm)
Sphalloplana sp. 2 (Rumbling Falls Flatworm)

Insects

Aloconota diversiseta (a rove beetle)
Anillinus sp. (Flag Trail Cave Beetle)
Arrhopalites sp. (a springtail)
Atheta lucifuga (Light Shunning Rove Beetle)
Batriasymmodes jeanneli (a beetle)
Batriasymmodes quisnamus (a beetle)
Batrisodes barri (a beetle)
Batrisodes clypeospecus (a beetle)
Batrisodes ferulifer (a beetle)
Batrisodes gemmoides (a beetle)
Batrisodes gemmus (a beetle)
Batrisodes pannosus (a beetle)
Batrisodes valentinei (a beetle)
Darlingtonea kentuckensis (a ground beetle)
Folsomia sp. 2 nr. macrochaeta (a springtail)
Hadenoecus opilionides (a cricket)
Hypogastrura sp. 1 (a viatica group springtail)
Litocampa sp. 5 (Rumbling Falls Cave Dipluran)
Litocampa sp. TN #6 (Buf. Cove Cave Dipluran)
Litocampa sp. TN #7 (Mill Holl. Cave Dipluran)
Litocampa sp. TN #8 (Mtn. Eye Cave Dipluran)
Neanura sp. 1 (Swamp River Cave Neanura)
Nelsonites walteri (a beetle)
Onychiurus sp. 2 (S. River Cave Onychiurus)
Pseudanophthalmus acherontis (E.C. Beetle)
Pseudanophthalmus bendermani (B. C. Beetle)
Pseudanophthalmus catherinae (C. C. Beetle)
Pseudanophthalmus ciliaris ciliaris (a beetle)
Pseudanophthalmus ciliaris colemanensis (Coleman Cave Beetle)
Pseudanophthalmus cumberlandus (a beetle)
Pseudanophthalmus digitus (a beetle)
Pseudanophthalmus engelhardti (E. C. Beetle)
Pseudanophthalmus farrelli (a beetle)
Pseudanophthalmus fowlerae (F. C. Beetle)
Pseudanophthalmus fulleri (a beetle)
Pseudanophthalmus hesperus (a beetle)
Pseudanophthalmus humeralis (a beetle)
Pseudanophthalmus inquisitor (S. C. Beetle)
Pseudanophthalmus insularis (BS. C.Beetle)
Pseudanophthalmus jonesi (G. C. C. Beetle)
Pseudanophthalmus loganensis (a beetle)
Pseudanophthalmus longiceps (L.H. C. Beetle)
Pseudanophthalmus macradei (a beetle)
Pseudanophthalmus nickajackensis (N. Beetle)
Pseudanophthalmus nortoni (N. Cave Beetle)
Pseudanophthalmus occidentalis (W. C. Beetle)
Pseudanophthalmus pallidus (P. C. Beetle)
Pseudanophthalmus paradoxus (R. C. Beetle)
Pseudanophthalmus paulus (N. C Beetle)
Pseudanophthalmus paynei (Payne's C. Beetle)
Pseudanophthalmus productus (a beetle)
Pseudanophthalmus pusillus (Tiny Cave Beetle)
Pseudanophthalmus rotundatus (a beetle)
Pseudanophthalmus scutilus (N. M. C. Beetle)
Pseudanophthalmus sidus (Mer. Cave Beetle)
Pseudanophthalmus simplex (S. Cave Beetle)
Pseudanophthalmus sp. TN #27 (Rf. C. Beetle)
Pseudanophthalmus sp. TN #28? (a beetle)
Pseudanophthalmus sp. TN #29 (a beetle)
Pseudanophthalmus sp. TN #30 (A. C. Beetle)
Pseudanophthalmus templetoni (a beetle)
Pseudanophthalmus tennesseensis (a beetle)
Pseudanophthalmus tiresias (IGP Cave Beetle)

Box 4. List of GCN Species (cont'd.)

TIER 2 FAUNA
Subterranean (Invertebrates)

Insects (cont'd.)

Pseudanophthalmus tullahoma (D. Riv. Beetle)
Pseudanophthalmus unionis (U. C. C. Beetle)
Pseudanophthalmus valentinei (a beetle)
Pseudanophthalmus vanburensis (a beetle)
Pseudanophthalmus ventus (Blow. C. Beetle)
Pseudanophthalmus wallacei (W. C. Beetle)
Pseudosinella aera (a cave obligate springtail)
Pseudosinella christianseni (C. Cave Springtail)
Pseudosinella hirsuta (Hirsute Cave Springtail)
Pseudosinella orba (a cave obligate springtail)
Pseudosinella sp. 5 (S. R. Cave Pseudosinella)
Pseudosinella sp. 6 (a cave obligate springtail)
Pseudosinella sp. 7 nr. nata (a springtail)
Pseudosinella spinosa (Sp. Cave Springtail)
Ptomaphagus barri (a beetle)
Ptomaphagus chromolithus (a beetle)
Ptomaphagus fecundus (a beetle)
Ptomaphagus hubrichti (a beetle)
Sinella basidens (a springtail)
Trechus cumberlandus (Cumb. Ground Beetle)
Trechus tennesseensis tauricus (a carabid beetle)
Trechus tennesseensis tennesseensis (a carabid beetle)
Trechus tuckaleechee (a carabid beetle)
Triacanthella copelandi (C. Cave Springtail)
Tychobythinus strinatii (a beetle)

Millipedes

Chaetaspis mollis (a millipede)
Chaetaspis sp. 1 (Thunder Run Cave Millipede)
Pseudotremia acheron (a millipede)
Pseudotremia cercops (a millipede)
Pseudotremia deprehendor (a millipede)
Pseudotremia lethe (a millipede)
Pseudotremia lictor (a millipede)
Pseudotremia rhadamanthus (a millipede)
Pseudotremia sp.TN #4 (W.Cave Millipede)
Pseudotremia sp. TN #5 (M. Cave Millipede)
Pseudotremia sp. TN #6 (R.Cave Millipede)
Pseudotremia sp. TN #7 (G. Cave Millipede)
Pseudotremia valga (a millipede)
Scoterpes copei (a millipede)
Scoterpes ventus (E. TN Cave Millipede)
Tetracion jonesi (a millipede)
Tetracion tennesseensis (a millipede)

Roundworms

Cambarincola alienus (a roundworm)
Cambarincola leptadenus (a roundworm)
Cambarincola marthae (a roundworm)
Trichodrilus allegheniensis (a roundworm)

TIER 3 FAUNA
Terrestrial (Vertebrates)

Birds

Charadrius alexandrinus (Snowy Plover)
Charadrius melodus melodus (Piping Plover)
Falco peregrinus (Peregrine Falcon)
Grus americana (Whooping Crane)
Haliaeetus leucocephalus (Bald Eagle)
Scolopax minor (American Woodcock)
Sterna antillarum athalassos (Interior Least Tern)

Mammals

Corynorhinus townsendii virginianus (Virginia Big-eared Bat)
Glaucomys sabrinus coloratus (Carolina Northern Flying Squirrel)
Lepus americanus (Snowshoe Hare)
Myotis grisescens (Gray Bat)
Myotis sodalis (Indiana Bat)
Sylvilagus transitionalis (Appalachian Cottontail)
Tamiasciurus hudsonicus (Red Squirrel)

Reptiles

Nerodia erythrogaster neglecta (Copperbelly Water Snake)

Box 4. List of GCN Species (cont'd.)

TIER 3 FAUNA
Terrestrial (Invertebrates)

Arachnids

Microhexura montivaga (Spruce-Fir Moss Spider)

Insects

Nicrophorus americanus (American Burying Beetle)

Snails

Anguispira picta (Painted Disc)

Aquatic (Vertebrates)

Fish

Cyprinella caerulea (Blue Shiner)
Cyprinella monacha (Spotfin Chub)
Erimystax cahni (Slender Chub)
Etheostoma boschungi (Slackwater Darter)
Etheostoma doration sp. (Jewel Darter)
Etheostoma percnurum (Duskytail Darter)
Etheostoma wapiti (Boulder Darter)
Notropis albizonatus (Palezone Shiner)
Noturus baileyi (Smoky Madtom)
Noturus flavipinnis (Yellowfin Madtom)
Noturus stanauli (Pygmy Madtom)
Percina antesella (Amber Darter)
Percina jenkinsi (Conasauga Logperch)
Percina tanasi (Snail Darter)
Phoxinus cumberlandensis (Mtn. Black. Dace)
Polyodon spathula (Paddlefish)
Scaphirhynchus albus (Pallid Sturgeon)

Aquatic (Invertebrates)

Crustaceans

Orconectes shoupi (Nashville Crayfish)

Mussels

Alasmidonta atropurpurea (Cumberland Elktoe)
Alasmidonta raveneliana (Appalachian Elktoe)
Cyprogenia stegaria (East. Pearlymussel)
Dromus dromas (Dromedary Pearlymussel)
Epioblasma brevidens (Cum. Combshell)
Epioblasma capsaeformis (Oyster Mussel)
Epioblasma florentina walkeri (Tan Riffleshell)
Epioblasma obliquata obliquata (Purple Cat's Paw Pearly Mussel)
Epioblasma othcaloogensis (So. Acornshell)
Fusconaia cuneolus (Fine-rayed Pigtoe)
Fusconaia edgariana (Shiny Pigtoe)
Hemistena lata (Cracking Pearlymussel)
Lampsilis abrupta (Pink Mucket)
Lampsilis altilis (Fine-lined Pocketbook)
Lampsilis virescens (Alabama Lampmussel)
Lemiox rimosus (Birdwing Pearly Mussel)
Leptodea leptodon (Scaleshell)
Medionidus acutissimus (AL Moccasinshell)
Medionidus parvulus (Coosa Moccasinshell)
Obovaria retusa (Ring Pink)
Pegias fabula (Little-wing Pearlymussel)
Plethobasus cicatricosus (White Wartyback)
Plethobasus cooperianus (O.foot Pimpleback)
Pleurobema clava (Clubshell)
Pleurobema decisum (Southern Clubshell)
Pleurobema georgianum (Southern Pigtoe)
Pleurobema gibberum (Cumberland Pigtoe)
Pleurobema perovatum (Ovate Clubshell)
Pleurobema plenum (Rough Pigtoe)
Ptychobranchus greeni (Triangular Kidneyshell)
Quadrula cylindrica strigillata (Rough Rabbitsfoot Pearlymussel)
Quadrula fragosa (Winged Mapleleaf)
Quadrula intermedia (Cumberland Monkeyface)
Quadrula sparsa (Appalachian Monkeyface)
Toxolasma cylindrellus (Pale Lilliput)
Villosa perpurpurea (Purple Bean)
Villosa trabalis (Cumberland Bean)

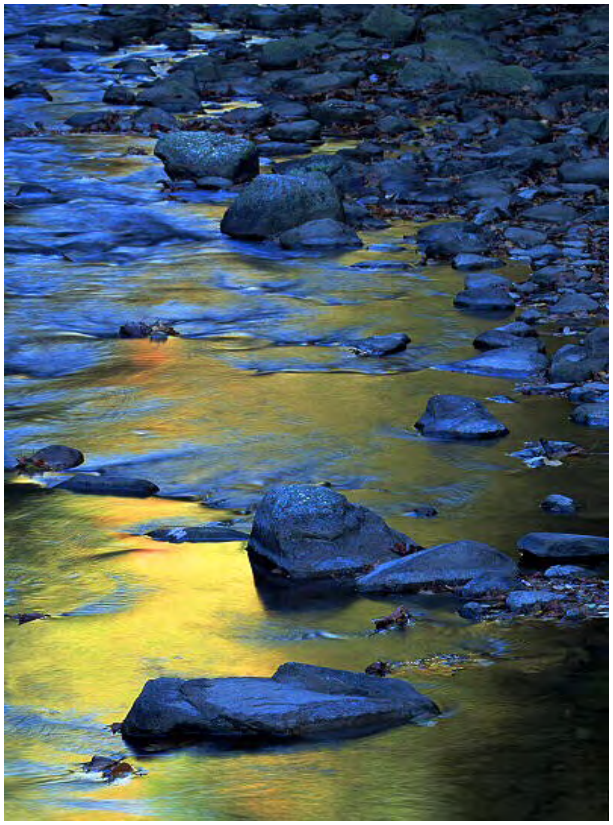
Snails

Leptoxis crassa anthonyi (Anthony's River Snail)
Marstonia ogmorhaphe (Royal Springsnail)

be found online on the NatureServe Explorer database. Each buffer represents a scientific estimate of the maximum distance a given species may travel for local breeding and foraging purposes within suitable and unsuitable habitats, assuming no physical barriers to movement are present. Overall, the buffer distances provide theoretical estimates of the spatial requirements needed by a population of a given species. Though these estimates can be somewhat arbitrary, they constitute the only available source of data currently to segregate populations of GCN fauna.

For aquatic fauna, occurrences were segregated into specific sub-watershed units. To delineate these watersheds, NRCS 12-digit hydrologic unit codes (HUCs) were mapped in GIS. For purposes of this planning effort, aquatic occurrences located in the same HUC-12 watershed unit were considered as part of the same occurrence group and population. This decision was made primarily due to the difficulty of intersecting mapped dot occurrences with stream features represented by lines in GIS. As well, many streams are not mapped adequately in order to delineate occurrences or populations at a finer level. However, work is continuing to resolve aquatic populations to the level of stream order.

Subterranean species were treated similarly to aquatic fauna. First, a GIS map of known cave locations was derived. Individual cave entrances were then reconciled into cave systems which served as the units of subterranean populations. Next, database occurrences of subterranean fauna were linked by cave name to the GIS coverage. Any occurrence record of a species found within the same cave system was considered part of a single occurrence group and population. Admittedly, this approach to establishing subterranean populations is overly simplistic, given the size and complexity of many caves in the state. However, the limited data available for caves did not leave much other recourse. Creation of the GIS coverage of cave locations with corresponding subterranean fauna was a



major milestone in conservation planning for Tennessee. Regardless, much more work remains to be done in delineating cave systems and resolving units of habitat for purposes of defining populations.

The total number of currently known populations for all final GCN species in the state was calculated by region (see Table 10 & Appendix C). Approximately 11,000 populations were delineated for the CWCS. Again, these are cursory estimates for planning purposes. The actual number of populations of GCN species may be higher or lower in a given region. New locations of species are discovered each year with scientific surveys. The number of populations of a species is not static in nature, as occurrences appear and disappear over time for a variety of reasons. Furthermore, no scientific assertions are inferred about the number of individuals comprising populations of a particular species. Regardless, the numbers of populations listed in this plan represent the best approximation of GCN fauna in the state.

Table 10. Populations of GCN Species by Region

Major Faunal Group	*Regions*																
	Aquatic					*Subterranean*						*Terrestrial*					
	MS	CU	BR	CO	TN	WU	CU	NB	CR	RV	SB	MP	UG	IP	CP	RV	SB
Vertebrates:																	
Amphibians	0	24	0	0	118	0	0	5	8	6	0	3	47	32	60	9	105
Birds	--	--	--	--	--	--	--	--	--	--	--	193	1150	2467	775	908	289
Fish	77	153	25	19	790	0	13	9	19	0	0	--	--	--	--	--	--
Mammals	0	0	0	0	0	0	0	0	0	0	0	5	70	160	139	114	326
Reptiles	4	3	0	0	63	0	0	0	0	0	0	3	63	86	36	19	38
Invertebrates:																	
Crustaceans	1	15	0	1	49	0	7	5	62	25	4	0	0	0	0	0	0
Insects	2	7	1	3	87	0	23	79									
Mussels	18	275	0	26	1214	--	--	--	--	--	--	--	--	--	--	--	--
Snails	0	21	0	0	185	0	1	2	3	1	0	8	0	27	56	20	127
Other Misc. Invertebrates	0	0	0	0	0	0	3	22	95	23	3	0	0	0	0	0	4
Total	**102**	**498**	**26**	**49**	**2506**	**0**	**47**	**122**	**286**	**81**	**7**	**212**	**1330**	**2772**	**1066**	**1070**	**893**

(*note: This table summarizes the number of populations for each faunal group by regions within each major environment. Aquatic regions are: (MS) = Mississippi River Drainage, (CU) = Cumberland River Drainage, (BR) = Barren River Drainage, (CO) = Conasauga River Drainage, and (TN) = Tennessee River Drainage. Subterranean Regions are: (WU) = Western Uplands, (CU) = Central Uplands, (NB) = Nashville Basin, (CR) = Cumberland-Rim, (RV) = Ridge & Valley, and (SB) = Southern Blue Ridge. Terrestrial Regions are: (MP) = Mississippi Alluvial Plain, (UG) = Upper Gulf Coastal Plain, (IP) = Interior Low Plateau, (CP) = Cumberland Plateau & Mountains, (RV) = Ridge & Valley, (SB) = Southern Blue Ridge.

Goal Setting Process

With the assignment of population numbers in each region, the core planning team undertook the process of goal setting. The purpose of setting conservation goals is twofold. First, it permits GCN species to be selected as targets at a subregional level by analyzing whether historic distribution ever occurred. If so, a numeric goal was established for the species in the subregion. If not, a goal of "0" was set for the species in the subregion. In such instances that a zero goal was set, no explicit action will be taken to conserve the animal within that particular area. The rationale of this approach is that it focuses actions toward those subregions which contain relevant populations of fauna in need of conservation.

The second purpose of goal setting is to establish long-term objectives for the number of viable populations of GCN species that need to be maintained within each subregion. The core planning team set goals as estimates of how many populations are necessary to sustain the species for at least a hundred years. Establishing long-term conservation goals is a subjective process. Nevertheless, rather than just conserving all known populations of GCN species, setting numeric goals provides a benchmark for measuring success of various conservation actions in protecting and restoring faunal elements. Furthermore, goal setting provides a makeshift numeric standard for determining whether a sufficient number of populations are represented within priority conservation areas.

The process of setting goals is an inexact exercise because scientists often lack information on historic population sizes, distributions, and other pertinent information about species viability. To expedite the process, default goals were established based on the rangewide distribution of each GCN species within a particular region (see Box 5). In general, all fauna with endemic and limited distributions were assigned higher overall goals within a region due to the fact that their populations are concentrated within a more restricted area. Conversely, fauna that are widespread were assigned lower overall goals within a region due to their populations being spread over a much wider area. Similarly, peripheral and disjunct species have the main portion of their range within other regions and are thus less dependent on the conservation of many populations within regions in Tennessee.

In setting conservation goals, the core planning team first evaluated the number of calculated populations of GCN species within each subregion. Next, default goals for the region were assessed in relation to the total calculated number of subregional populations. Adjustments were then made to increase or decrease the default goal number based on perceived population trends and any other relevant scientific factors across the region. Afterward, the adjusted regional goal was stratified accordingly into relevant subregions (see Appendix C). Consensus was needed by each member of the core planning team before any species goal was finalized. These goals will be re-evaluated periodically as scientists learn more about the distribution of GCN species and their biological needs.

Ultimately, the objective of goal setting should be to establish precise standards for viability and determine the exact number of viable populations needed in a region to sustain a particular species long-term. Other planning efforts, such as Partners in Flight, have attempted to set more accurate goals based on such viability criteria (e.g. numbers of breeding bird pairs that may be supported by a particular habitat). Given time limitations, it was beyond the capacity of this planning effort to set comparable conservation goals for all GCN species. Future iterations of the CWCS will strive to integrate and further refine goals for fauna in partnership with other planning efforts. Potential concepts for refinement include setting customized population goals by a combination of habitat availability, spatial requirements for species, physical barriers, and habitat restoration potential.

Box 5. Default Population Goals per Region Based on Distribution Category

Endemic	= 15	viable populations
Limited	= 10	" "
Disjunct	= 5	" "
Peripheral	= 5	" "
Widespread	= 5	" "

Assessment of Population Viability

To complete analysis of conservation goals, the core planning team assessed the viability of each population of final GCN species. Viability may be defined as the capacity of a species to persist over many generations. The overall viability of an individual species population is often measured by its size, condition, and the surrounding landscape context (The Nature Conservancy 1998).

Size primarily refers to the number of individuals present within a population. However, opinions of how to gauge population size can vary considerably. Depending on the species, some experts measure size by: the total number of individuals, minimum or maximum numbers of individuals, age/gender demographics, or the number of reproducing individuals, etc. Typically, very little scientific information exists about optimal population sizes for most species. Likewise, not much database information is available for the number of individuals found in specific populations in Tennessee.

For purposes of the CWCS model, the size of a given population was based on the total number of unique occurrences (i.e. occurrence groups) found within a population.

While the number of individuals in each occurrence is still unknown, it is presumed that populations with larger numbers of documented occurrences are likely to have relatively larger numbers of individuals than populations with fewer occurrences. Again, this method is predicated on the notion that the total number of occurrences likely correlates to the total number of individuals within a population. However, currently there is no scientific evidence to warrant such speculation. Populations with more occurrence records may be a result of greater intensity of survey effort rather than larger numbers of individuals. Nevertheless, until more evidence becomes available, the core planning team made the decision to proceed with ranking the size of species populations in relative terms to the number of occurrences for each population.

Condition refers to the health or vitality of individuals in a population. Opinion on what constitutes positive health or vitality for a species varies by expert. Factors often used to estimate condition include: presence or absence of disease, fecundity and mortality rates, population persistence, etc. Again, very little scientific information exists about optimal population conditions for most species.

In the CWCS model, condition was limited to two factors. The first factor is based on the persistence or stability of the population. Persistence was measured in several ways: 1) by the date of last observation for each occurrence record, 2) by the duration between first and last observations of the occurrence record, and 3) by the total frequency of observations of each occurrence. In general, a species occurrence whose last observation date is more than 20 years old was considered to be potentially nonviable and received a lower viability score. This date cutoff was adopted from NatureServe's standards on managing records for current and historic occurrences of species. The second factor used to assess condition was based on assigned element occurrence ranks by experts within the Biotics database maintained by the TN Division of Natural Heritage. Element occurrence ranks are based on a grading scale that essentially ranges from A to D, with A being the highest rank. Overall, relatively few GCN species populations had occurrences with Heritage element ranks.

Landscape context denotes whether a broader range of factors necessary for the maintenance of habitat are present for a species population. Such factors include the presence or absence of wide scale ecological processes and natural disturbances (e.g. fire, flooding, wind, drought, ice, and insect cycles); as well as the individual aspects of size, quality, location, and connectivity that constitute various habitat units. Measurements of landscape context dominate much of the field of ecology. Scientists are just now beginning to unravel many of the complexities of how species interact with habitat. As such, relatively little documented information on landscape context exists for many species.

In general, time and data constraints limited the amount of analysis of landscape context for this iteration of the CWCS model. Only terrestrial species were evaluated for this category of viability due to a lack of spatial information for aquatic and subterranean habitats. Furthermore, only simplified concepts of habitat size, quality, and location could be considered. To conduct the analysis, terrestrial species occurrences were overlaid onto habitat maps and their population buffers intersected with individual units of habitat in GIS. Numeric scores were assigned based on the distance of each occurrence location from the center of the habitat unit. As well, scores were given based on the degree of preference of the species for the particular habitat type. In general, more points were assigned for landscape context the closer a species occurrence was to a particular habitat unit of higher preference.

In summary, the viability assessment process developed for the CWCS is not intended to provide an absolute indication of population viability. Rather, the assessment is meant

only to give a relative measure of potential viability based on the best interpretation of scientific information that is currently available. Cumulative scores for viability were assigned to each population based on the adjusted point coefficients for size, condition, and landscape context (see Box 6 & Appendix C). Assignment of viability scores provided another means of prioritizing species populations and habitats in the CWCS model. However, much more data collection and computer modeling are needed before any steadfast assertions of viability can be provided in future iterations of planning.

Box 6. General Population Viability Formula for CWCS Model

Viability = (S)ize x (C)ondition x (L)andscape Context

(S) = relative number of occurrence records per population

(C) = persistence of population as measured by observation dates x TN Heritage Program element occurrence ranks

(L) = distance of species occurrence records from habitats of varying preferences

Analysis of Habitats for GCN Species

As a key element of the CWCS, the core planning team evaluated habitats for each final GCN species. This evaluation consisted of three primary tasks: 1) establishment of an overall habitat hierarchy for terrestrial, aquatic, and subterranean environments, 2) mapping of discrete units of major habitat types, and 3) assignment of habitat preference values for each species. Further details of these tasks are provided in the following sections.

Development of the Habitat Hierarchy

Construction of an overall habitat hierarchy was necessary to describe and categorize appropriate levels of all habitat types utilized by GCN species in the state. The hierarchy consists of five levels of habitat classification (see Appendix D).

The first three levels of the hierarchy are divided sequentially into habitat category, habitat class, and habitat alliance. The highest level, habitat category, is composed of the three major environments recognized in the state: terrestrial, aquatic, and subterranean. The next level, habitat class, separates the three habitat categories into natural, semi-natural and non-natural components. Third, habitat alliance consists of further descriptive breakdowns that repeat at the class level. Terrestrial habitat alliances consist of forestland, grassland/woodland, and wetland habitats. As well, developed land is included as a non-natural terrestrial alliance. Aquatic alliances are divided into riverine and lacustrine habitats. Subterranean habitat classifications are not well developed currently, and are simply split into karst and artificial karst habitats at the alliance level.

The fourth level of the hierarchy, called habitat group, is composed of further alliance–level divisions. Natural terrestrial habitat groups are divided into upland deciduous, coniferous, and mixed forest types, forested rock outcrop, prairie/barrens, glade/barrens, bald/summit grasslands, riparian wetlands, and isolated wetlands. Semi-natural terrestrial groups are: forest plantations, urban/suburban managed forest, old field/successional grasslands, pasture, cropland, urban/suburban managed grasslands, excavated land, and various converted wetlands. Non-natural groups consist of edifices & other man-made structures and impervious landscapes. Aquatic natural and semi-natural habitat groups are divided into large, medium, and small rivers, creeks & headwater streams, lakes, channelized rivers & streams, and reservoirs. Subterranean habitat groups consist of caves/sinkholes, and various types of deep excavated lands such as mines, rock quarries, pits, and tunnels.

The fifth level of the hierarchy consists of natural ecological systems that describe habitats at fairly discrete levels. For terrestrial systems, the decision was made to adopt the

ecological system framework created by NatureServe as part of the U.S. National Vegetation Classification (Grossman et al. 1998; Anderson et al. 1998). Information on this classification system as well as individual system types can be found on NatureServe's website on the internet. The greatest benefit of using this classification is that it provides a standardized means of categorizing habitats at a national level. Additionally, the Southeast Regional GAP effort is currently utilizing NatureServe's ecological system framework to create a detailed vegetation map of the region due in 2006 (McKerrow et al. 2003).

Terrestrial ecological systems were developed in accordance to distribution within specific ecoregions in North America. Each of the systems found in Tennessee occurs in one or more regions of the state, but none are ubiquitous across all regions. In total, 56 terrestrial ecological systems occur in Tennessee. There are 27 forested systems, 15 grassland/woodland systems, and 14 wetland system types (see Appendix D). As well, ecological systems are classified by biological patterns of occurrence (i.e. matrix, large patch, small patch, and linear). Overall, there are 7 matrix, 18 large patch, 26 small patch, and 5 linear ecological systems.

Aquatic natural ecological systems were taken from a classification developed by TNC's Freshwater Initiative[1] (Smith et al. 2002). This classification was developed as part of a larger assessment of 3 major river basins in the southeastern United States: the Mississippi Embayment, the Mobile Bay, and the Tennessee-Cumberland Basin. A majority

of the watersheds in Tennessee (~97%) are included in these three large basins. Only the Barren River drainage was excluded in the Freshwater Initiative's study area. Regardless of this omission, the classification was the best source of aquatic habitat information in the state. Adoption of this scheme allowed for a consistent vernacular of habitat types across multiple regions. Given the benefits, the core planning team decided to proceed with this classification scheme and later develop supplemental systems for the Barren River.

Aquatic systems constitute rivers, streams, and lakes with similar geomorphological patterns tied together by ecological processes (e.g. hydrologic and nutrient regimes, access to floodplains, etc.) or environmental gradients (e.g. physical and chemical regimes, etc.). Aquatic systems are segregated based on regions and subregions of occurrence by size class, elevation, geology, gradient, origin, and connectivity; and form a distinguishable unit on a hydrography map. In general, there are

[1] *For more information about TNC's Freshwater Initiative check the worldwide web at:*

http://nature.org/initiatives/freshwater/ or

http://www.freshwaters.org

Also, TNC's report for the Southeast Freshwater Initiative project can be viewed or downloaded along with GIS and other data at:

http://gis.tnc.org/community/projects/fwi/southeastfront.html

8 large river, 11 medium river, 20 small river, and 90 creek/headwater aquatic system types in Tennessee. These include 3 supplemental creek/headwater aquatic systems developed for the Barren River drainage (see Appendix D).

Due to the unique character of freshwater conditions across watersheds, aquatic systems should be considered as distinct system types within individual subregions. Therefore, actual numbers of aquatic system types are likely to be much higher in reality. It should be noted that lacustrine systems were lumped under larger river systems in the Freshwater Initiative classification system in Tennessee. As such, lacustrine systems were added as a generic system type. In general, Tennessee has few natural lakes. Virtually all of them occur in the western portion of the state.

Currently, no broad classification scheme exists for subterranean ecological systems. Attempts to research and develop a reasonable structure were unsuccessful. The core planning team consulted a number of scientific experts on potential classification schemes. However, no consensus could be reached on drafting a preliminary group of systems within the available timeframe. As such, the decision was made to treat all natural subterranean systems as a single system type. In actuality, the conditions found within karst environments very likely represent a number of diverse habitat types. Nevertheless, for purposes of the CWCS, subterranean environments are represented by a single system type. However, like aquatic systems, caves found within individual subregions should at least be considered as unique ecological systems until a future classification scheme is developed.

Mapping of Major Habitat Types

A major component of the CWCS model is the delineation and mapping of individual units of major habitat types across the state. The primary objective of mapping habitat units is to help identify discrete areas that accommodate large numbers of GCN species. As such, the decision was made to map to the finest level of habitat in the hierarchy, natural ecological systems. It was not possible to map some systems due to their scale of occurrence. Regardless, an effort was made to map as many natural ecological systems as possible for terrestrial, aquatic, and subterranean environments. When feasible, semi-natural and non-natural habitats were mapped also.

(Terrestrial Habitat Mapping)

For terrestrial habitats, the decision was made to utilize a landcover map developed by the Tennessee GAP project at TWRA (Whitehead et al. 2000). The GAP coverage was created from Landsat Thematic Mapper satellite imagery dating from 1990 – 1993, and from various other ancillary datasets such as: the National Wetlands Inventory (NWI) data, National High Altitude Photography (NHAP) transparencies, and from video transects flown in 1995. Overall, the GAP map depicts 30 land cover classes, 18 of which represent various forest and woodland classes composing approximately 52% of the state. Remaining cover types are represented by open water, various anthropogenic cover classes, and uncategorized features such as cloud cover. Despite the age of the map imagery, the GAP land cover classification is the most comprehensive map of vegetative cover available for the state. In the future, it is hoped that an updated land cover map will become available.

To map terrestrial habitats for the CWCS, land cover types identified in the GAP project were “cross walked” in GIS to NatureServe’s ecological systems and to other semi-natural

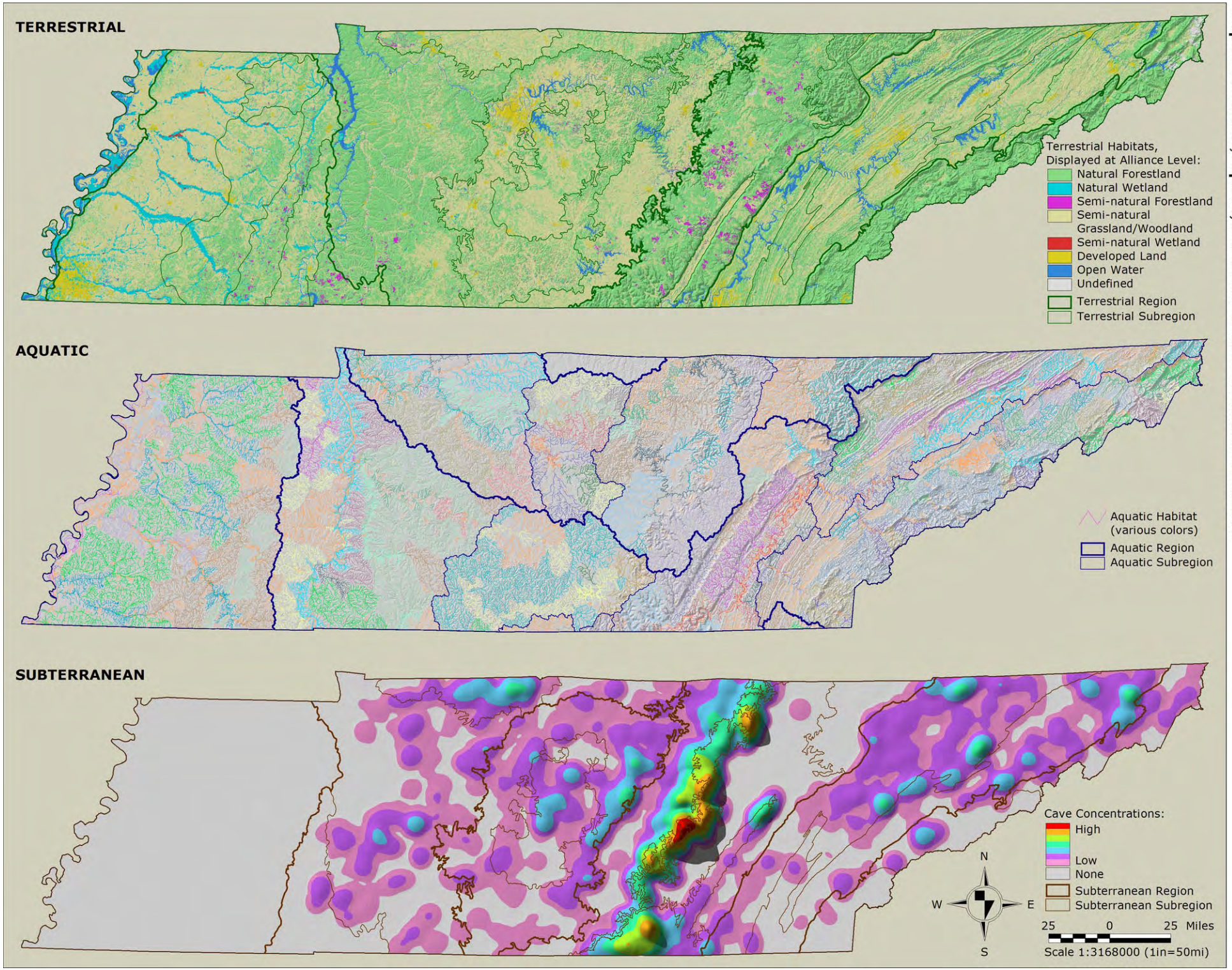
and non-natural habitat types. Given that the GAP forest cover types were developed from Alliance level vegetation identified in the U.S. National Vegetation Classification, the vegetation crosswalk to ecological systems was fairly straightforward.

The "cross walking" process involved analyzing database acreage and percentage breakdowns of GAP cover classes by subregion and linking each class to appropriate ecological systems as an "Equivalent", a "Taxonomic Subset", or a "Spatial Subset" of the cover class. Equivalent linkages indicated that the ecological system was the best representative of the GAP cover class in a particular subregion. Likewise, equivalent ecological systems replaced the GAP cover class in the new terrestrial habitat map. Taxonomic subsets indicated that a particular ecological system partially composed a GAP cover class at a matrix or large patch level. However, these systems could not be accurately split in the GAP coverage. Similarly, spatial subsets indicated that a particular ecological system made up part of a GAP cover class at a small patch level. Small patch ecological systems could not be accurately resolved at an appropriate scale from the GAP coverage. Work continues to try to map natural systems currently linked as either taxonomic or spatial subsets.

At least one equivalent ecological system was identified for each GAP cover class in a subregion. In many instances, there were other taxonomic subsets or spatial subsets that were also linked to the cover class. As well, an equivalent ecological system in one subregion may have been assigned as a taxonomic subset or spatial subset in another subregion, depending on its pattern of occurrence. Despite the inability to distinguish taxonomic and spatial subsets in the new terrestrial habitat map, equivalent habitat units have a corresponding database link which indicates other underlying ecological systems that compose some portion of the habitat unit. Overall, 17 of the 56 terrestrial ecological systems were identified as equivalents of

various GAP cover classes and mapped (see Map 3). As well, 8 systems wee identified as taxonomic subsets, and 31 as spatial subsets (see Appendix D).

Furthermore, in order to identify specific units of habitat, roads were overlaid on top of the terrestrial systems map. The road coverage was taken from the U.S. Census Bureau's 2003 'Tiger' Data. Roads contained in this coverage essentially constitute primary and secondary thoroughfares maintained by state and county governments. Overall, these roads outline a network of 'roadless' blocks. These blocks are polygon areas of various sizes formed by the intersections of assorted roads. The term 'roadless' should be applied loosely as many of the block areas actually contain lesser byways and drivable trails that may or may not connect to a maintained road. Taken alone, mapped areas of natural systems often extend for protracted distances that are too large to be useful for conservation planning. As such, it is important to delineate more specific habitat units by virtue of the 'roadless' block network.



Map 3. Terrestrial, Aquatic, and Subterranean Habitats in Tennessee

In the GIS model, natural systems entirely or partially contained within a 'roadless' block were divided into discrete block units. A given block may contain a multitude of natural systems. The individual areas of the natural systems within a particular block constitute polygons of various shapes and sizes. These individual polygons are what formulate the terrestrial habitat units used in the conservation model. Certainly, the number of habit units defined at this scale is in constant flux, given changes in land cover and the construction of new roads. Efforts to continue refinement and mapping of terrestrial ecological systems into habitat units are ongoing.

(Aquatic Habitat Mapping)
Mapping of aquatic ecological systems was already completed by the Freshwater Initiative. Aquatic system classification and delineation involved five steps:

1. Determining physiochemical habitat variables that define environmental gradients and influence species distributions (i.e. stream size, gradient, elevation, downstream connectivity, and bedrock & other surficial geology).
2. Acquiring and developing GIS data layers of these habitat variables or other data layers that can be used for modeling.
3. Determining classes for these variables that correspond to ecologically meaningful breaks in environmental gradients and attributing each stream reach with a value for the variables.
4. Classifying the types of systems by identifying all distinct combinations of physiochemical attributes.
5. Mapping aquatic systems by assigning system types to stream reaches at the small watershed scale.

Stream size class was used as the initial variable to distinguish lotic system types. As previously mentioned, these size classes were composed of creek/headwaters, small rivers, medium rivers, and large rivers. Again, lentic systems were nested within various larger river systems. As a note, springs, seeps, cave flows, and wetlands are not included in the aquatic system classification, but are covered within various terrestrial and subterranean system types. Individual aquatic systems were mapped in GIS using the Environmental Protection Agency's Reach File 3 hydrography data (see Map 3). In the future, aquatic systems will be mapped at more detailed stream reach levels.

(Subterranean Habitat Mapping)
Mapping of subterranean systems was undertaken on a much more limited basis. Currently, no comprehensive coverage exists that depicts the actual underground extent of all karst features throughout the state. As such, sources of information about subterranean habitat locations were drawn from TNC's Cave Database. Over the years, this database has compiled the latitude/longitude locations of approximately 6,500 cave entrances from a variety of surveys, scientific forays, publications, and miscellaneous reports from biologists. While cave entrances taken alone are insufficient indicators of karst habitat, clusters of cave entrances start to reveal patterns of karst development. Nevertheless, for purposes of the CWCS, subterranean habitats were limited to just cave locations that contained GCN species. Due to the sensitive nature of subterranean environments and the rarity of the species they contain, no solitary maps of cave locations are provided in this report. However, a map of the general locations of karst areas is provided in terms of areas with high cave concentrations (see Map 3).

In the future, more precise methods may be used to delineate subterranean habitats. Potential methods include development of karst hydrology and geology maps, stream dye tracing, and/or usage of buffers around cave entrances to represent karst recharge zones and forage areas used by fauna.

<u>Assignment of Habitat Preference</u>
With the finalization of the habitat hierarchy and natural system mapping, the core planning team assessed the habitat preferences of each final GCN species.

Different habitat types inherently provide varying levels of benefit to a given species. Many fauna are strongly tied to specific habitat types which determine their distribution and overall vitality. As such, assignment of habitat preference was an integral part of the viability portion of the CWCS model. Methods for assigning preference varied for terrestrial, aquatic, and subterranean species.

(Terrestrial Habitat Preferences)
For terrestrial fauna, a database form was created using Microsoft Access that listed each level of the habitat hierarchy. Available scientific information about habitats for GCN fauna was researched and added to the database. Using the scientific literature as a guide, habitats from the class to group level of the hierarchy were assessed on a "Yes" or "No" basis for each GCN species. The database form was designed so that selection of "No" at higher habitat levels would limit choices at lower levels in the hierarchy. For natural ecological systems, a preference rating of "Preferred", "Suitable", "Marginal", or "Unsuitable" was assigned for appropriate systems within relevant regions of occurrence for the species (see Appendix D).

A rating of "Preferred" indicated that a species either utilized the habitat exclusively or would make a conscious decision to occupy the habitat over other habitats if given a choice. An assignment of "Suitable" implied that the habitat was appropriate in a general context and could supply all the needs of a species within relevant time periods. "Marginal" habitat ratings meant that only some of the needs of a species could be provided by the system or that a species could subsist in the habitat in a diminished state. Finally, a designation of "Unsuitable" indicated that the habitat could not fulfill any survival needs of the species.

It should be noted that assignment of habitat preferences was made only to categorize the relative utility of one habitat type over another for a species. Preference ratings were not assigned based on the improved or degraded quality of a particular unit of habitat. Assessment of individual habitat quality will be addressed in future iterations of the CWCS as part of the landscape context measurement of viability.

(Aquatic Habitat Preference)
For aquatic fauna, habitat preferences were assigned on a more formulaic basis due to the large number of aquatic systems. Like the terrestrial analysis, a database form was developed with the aquatic system hierarchy. Similarly, published scientific information about general habitat requirements of aquatic species was incorporated into the database. However, for the aquatic analysis, GIS was employed to assist with determining habitat preference.

During the process, occurrences of each aquatic species were overlaid onto a map of aquatic systems distributed across various HUC-12 watersheds. Tallies were then generated for each aquatic system based on the number of times it was deemed to be the closest system to a species occurrence within a given watershed. Habitat preferences were subsequently selected by the computer for aquatic systems based on the overall tallies. To maintain a dimension of human oversight, the core planning team reviewed each of the computer-assigned habitat preference rankings and made adjustments in accordance to published habitat information for each GCN species (see Appendix D).

In general, aquatic systems were selected as "Preferred" when at least half of the HUC-12 watersheds of occurrence for the system were indicated as being the closest system to the species. Similarly, aquatic systems with a lower ratio were assigned as "Suitable", as long as the system was in agreement with literature descriptions of habitat for the species. A "Marginal" preference was assigned to an aquatic habitat when occurrences of a species occurred within a given watershed, but the system was never determined to be the closest one to the occurrence. Again, the aquatic system had to be of an appropriate nature to be selected. Finally, "Unsuitable" assignments were made

only for aquatic systems that were determined to be inappropriate in regard to published literature descriptions of habitat for the species. Aquatic systems that were in line with literature descriptions of habitat, but with no species occurrences in their respective watersheds, were left as unknown. Future inventories may eventually show these systems to have some species preference. If so, subsequent iterations of the CWCS will document the preference of the habitat accordingly in the master database.

(Subterranean Habitat Preferences)
No individual preference assignments were made for subterranean habitats, due to the inability of the planning team to segregate karst systems into discrete types. The current list of subterranean GCN species is composed essentially of obligate cave fauna. Therefore, all karst habitats are likely "Preferred" by the species that inhabit them. However, until more scientific research is done and a detailed habitat classification is developed no exact preference ratings can be determined. As such, all subterranean GCN species were scored conservatively as "Suitable" in the CWCS model. Likewise, the core planning team believed there was insufficient evidence to assign ratings of "Marginal" or "Unsuitable" for cave species.

Assessment of Problems Affecting GCN Species

As a major element of the CWCS, the core planning team conducted an assessment of major problems affecting GCN species in Tennessee. To begin, the team researched various conservation planning tools that had previously been used for analyzing problems. A decision was made to adopt the stress – source of stress methodology utilized in TNC's *5-S* system of conservation planning (The Nature Conservancy 2001).

The *5-S* approach is predicated on determining the exact stresses that negatively affect a species, in addition to distinguishing the sources that generate each stress. Not all sources are equivalent in regard to the types of stress they may inflict upon an animal. The unique combinations of stress and sources of stress formulate the primary 'problems' potentially affecting GCN species.

As a starting point of the analysis, an existing list of major stress categories known to affect fauna was adapted (see Table 11). Five major stress categories containing 20 specific stress types were identified. Overall, these categories and types represent a complete assortment of stresses potentially affecting all GCN species in the state.

Next, a catalog of potential sources of stress was developed for terrestrial, aquatic, and subterranean GCN species in Tennessee. Approximately 50 anthropogenic and natural activities were identified as possible sources of stress to fauna in the state. Upon further review, these activities were lumped into 37 general source categories (see Table 12). Descriptions of each of these categories were developed to avoid confusion among some related activities (see Table 13). Sources were then linked to individual stress categories (see Table 14). These linkages were made in order to determine the precise ways in which sources may affect species.

With development of the stress – source linkages, a database was created with each species and a list of evaluating criteria (see Table 15). Also, information on known problems affecting fauna or their habitats was researched and entered into the database. Using the literature as a guide, the core planning team selected relevant stress – source groupings believed to be currently affecting each GCN species. For some animals, no published information was available. In such instances, team members either used their own professional experiences as a guide or consulted other scientific experts for input. After the selection of stress – source combinations, the team then assigned values to the various evaluators.

First, regions of occurrence were selected for each problem thought to be affecting a species. Next, team members entered the

Table 11. Major Stresses Affecting GCN Species by Category and Type

Stress Category	Stress Type
Altered Structure of Habitat	1. Destruction of Habitat 2. Altered Arrangement of Habitat (vertical & horizontal) 3. Altered Distribution or Abundance of Patch/Seral Stages of Habitat
Altered Physical Environment of Habitat	1. Altered Energy Regime (food source, organic matter, UV radiation) 2. Altered Hydrologic Regimes (surface water level, discharge, frequency, groundwater) 3. Altered Sediment Regime (air & water borne) 4. Altered Fire Regime (frequency, intensity, seasonality) 5. Altered Micro-climate Regime (air/water/soil temperature, precipitation, wind, light)
Altered Chemical Environment of Habitat	1. Altered Water Quality (toxins, nutrient loading, pH, salinity, dissolved oxygen) 2. Altered Soil Quality (toxins, nutrient loading, ion exchange, dissolved oxygen, redox potential) 3. Altered Air Quality (toxins)
Altered Connectivity of Habitat	1. Isolation From Habitats and Resources Needed for Life Cycle Completion (migration, dispersal, recolonization, foraging, mating) 2. Isolation Resulting in Reduced Opportunity for Range Adjustment in Response to Changing Environmental Conditions
Altered Biological Composition & Interaction of Species	1. Altered Species Distribution (density, richness, evenness) 2. Altered Population Demographics (age structure, size class, sex ratios, genetic diversity) 3. Altered Reproduction (hybridization/sterilization) 4. Altered Availability of Food Source 5. Altered Competition for Resources 6. Altered Mutualistic / Symbiotic Relationships 7. Altered Behavior

Table 12. Potential Sources of Stress Affecting GCN Species & Habitats in Tennessee

Source of Stress	Terrestrial	Aquatic	Subterranean
Acid Rain	Yes	Yes	No
Agricultural Conversion	Yes	Yes	Yes
Channelization of Rivers / Streams	Yes	Yes	Yes
Commercial Collection of Species	Yes	Yes	Yes
Commercial / Industrial Development	Yes	Yes	Yes
Construction of Dams / Impoundments	Yes	Yes	Yes
Construction of Ditches / Dikes / Drainage / Diversion Systems	Yes	Yes	Yes
Construction of Roads / Railroads / Utilities	Yes	Yes	Yes
Excessive Competition / Predation by Native Species	Yes	Yes	Yes
Excessive Groundwater Withdrawal	No	Yes	Yes
Excessive Surfacewater Withdrawal	Yes	Yes	Yes
Fire Suppression	Yes	No	No
Forest Type Conversion	Yes	Yes	Yes
Illegal Dumping	Yes	Yes	Yes
Illegal Hunting/Fishing/Collection/Killing	Yes	Yes	Yes
Incompatible Animal Production Practices	Yes	Yes	Yes
Incompatible Forestry Practices	Yes	Yes	Yes
Incompatible Grazing / Pasture Management Practices	Yes	Yes	Yes
Incompatible Mining Practices	Yes	Yes	Yes
Incompatible Row Crop Agricultural Practices	Yes	Yes	Yes
Incompatible Species Management Practices	Yes	Yes	Yes
Industrial Discharge	Yes	Yes	Yes
Invasive Exotic Species	Yes	Yes	Yes
Landfill Construction / Operation	Yes	Yes	Yes
Low-level Ozone Air Pollution	Yes	No	No
Military Maneuvers	Yes	Yes	Yes
Municipal Wastewater Treatment / Stormwater Runoff	Yes	Yes	Yes
Oil or Natural Gas Drilling	Yes	Yes	Yes
Operation of Dams / Reservoirs	Yes	Yes	Yes
Operation of Drainage / Diversion Systems	Yes	Yes	Yes
Parasites / Pathogens	Yes	Yes	Yes
Primary Residential Development	Yes	Yes	Yes
Recreational Use of Habitats (Non-vehicular)	Yes	Yes	Yes
Recreational Vehicles	Yes	Yes	Yes
Residential Sewage / Septic Systems	Yes	Yes	Yes
Secondary Home / Resort Development	Yes	Yes	Yes
Shoreline Stabilization	Yes	Yes	Yes

Table 13. Descriptions of Potential Sources of Stress to GCN Species	
Source of Stress Category	**Description**
Acid Rain	Destruction or degradation of terrestrial & aquatic habitat from precipitation in the low pH range (acid). Acid rain results from emissions of various pollutants by powerplants, factories, automobiles, and other sources.
Agricultural Conversion	Removal of the natural vegetation of an area for agricultural purposes such as: pasture, row crops, feed lots, outbuildings, etc.
Channelization of Rivers / Streams	Alteration of the natural course of a river or stream by removing rock, dirt, gravel, and other sediments from shorelines and bottoms. Such alteration is done primarily for navigation and flood control purposes.
Commercial Collection of Species	Increased mortality due to legal taking or killing of species for commercial purposes such as: pet trade, live bait, mussel collection for pearl industry, fur trade, smelt production, etc.
Commercial / Industrial Development	Destruction or degradation of habitats in an area due to construction and other activities related to the development of commercial or industrial buildings.
Construction of Dams / Impoundments	Disruption and degradation of the natural flow of a river or stream due to construction of dams or impoundments. Also includes destruction of terrestrial habitats due to removal and inundation of vegetation along shorelines.
Construction of Ditches / Dikes Drainage / Diversion Systems	Disruption and degradation of the natural hydrologic patterns of wetlands, rivers, and streams due to construction of various water diversionary or containment structures.
Construction of Roads / Railroads / Utilities	Destruction or degradation of habitats in an area due to construction of roads, railroads, or utilities. The linear makeup of these corridors often fragment terrestrial habitats.
Excessive Competition / Predation by Native Species	Increased mortality of animals resulting from either excessive take by predators or by the inability to compete with other species for food and resources.
Excessive Groundwater Withdrawal	Removal of groundwater resources essential to maintenance of hydrologic levels that support aquatic and subterranean species. Withdrawal is primarily from wells drilled for home water supply, irrigation, and other agricultural uses.

Table 13. Descriptions of Potential Sources of Stress to GCN Species (cont'd.)	
Source of Stress Category	**Description**
Excessive Surfacewater Withdrawal	Removal of surfacewater resources needed to maintain hydrologic levels for aquatic and subterranean species.
Fire Suppression	Degradation of fire-dependent natural systems due to either human suppression of fire or the conditions needed to support combustion.
Forest Type Conversion	Any anthropogenic action that results in significant change in forest composition or type.
Illegal Dumping	Increased mortality or degradation of habitats due to illegal disposal of waste products containing pollutants harmful to animals.
Illegal Hunting/Fishing/Collection/Killing	Increased mortality of animals due to illegal acts of hunting, fishing, commercial collection, killing, vandalism, or other activities.
Incompatible Animal Production Practices	Degradation of soil & water quality via improper management of animal waste or chemical applications required during the rearing of livestock or other farm animals raised in concentrated conditions.
Incompatible Forestry Practices	Modification of the forest composition or type of an area related to silvicultural (in)activities not compatible with species or habitat.
Incompatible Grazing / Pasture Management Practices	Degradation of soil & water quality and habitat structure of an area due to excessive grazing or to Inappropriate exclusion of cattle from stream and forest resources. Also, includes degradation caused by overapplication of fertilizers or other chemicals during pasture management practices.
Incompatible Mining Practices	Destruction or degradation of soil & water quality and habitat structure of an area due to inappropriate removal of soil and minerals or disposal of overburden or waste materials during various mining activities. May also affect subterranean habitats.
Incompatible Row Crop Agriculture Practices	Degradation of soil - water quality or habitat structure related to row crop production and maintenance not compatible with species needs. Often due to erosion from plowing/tilling or chemical applications of herbicides/pesticides.

Table 13. Descriptions of Potential Sources of Stress to GCN Species (cont'd.)	
Source of Stress Category	**Description**
Incompatible Species Management Practices	Increased mortality or degradation of habitats resulting from the application of management practices that conflict with the ecological needs of a particular species.
Industrial Discharge	Increased mortality or degradation of habitats resulting from legal or illegal releases of toxins or contaminants into the environment by various industries.
Invasive Exotic Species	Increased mortality or habitat degradation caused by excessive competition from invasive exotic species.
Landfill Construction / Operation	Destruction or degradation of habitats due to construction and maintenance of county or municipal landfill operations. Also, includes habitat degradation and increased mortality caused by releases of toxins and other contaminants into the environment.
Low-level Ozone Air Pollution	Destruction or degradation of natural vegetation from the accumulation of toxic ozone in the lower atmosphere, usually in higher elevation regions of the state. Ozone results from emissions of various pollutants by powerplants, factories, automobiles, and other sources.
Military Maneuvers	Increased mortality of species or destruction / degradation of habitats due to the use of heavy vehicles or explosives on the landscape during military exercises.
Municipal Wastewater Treatment / Stormwater Runoff	Degradation of water quality resulting from ineffective treatment of municipal wastewater released into rivers and streams. Also, includes ineffective capture and treatment of stormwater runoff which is often contaminated by various pollutants.
Oil or Natural Gas Drilling	Degradation of soil and water quality due to release or spillage of oil, brine, and other chemicals during drilling for oil or natural gas deposits. May also affect subterranean habitats.
Operation of Dams / Reservoirs	Degradation of water quality and aquatic habitat availability due to disruption of natural hydrologic regimes of rivers and streams by dams or reservoirs. Also, includes destruction / degradation of terrestrial habitats due to periodic raising or lower of water levels.

Table 13. Descriptions of Potential Sources of Stress to GCN Species (cont'd.)	
Source of Stress Category	**Description**
Operation of Drainage / Diversion Systems	Degradation of water quality and habitat availability due to disruption of natural hydrologic regimes of rivers, streams, & wetlands by the operation of drainage ditches, dikes, and other water diversionary & containment structures.
Parasites / Pathogens	Increased mortality of species due to high levels of parasites or disease-causing pathogens.
Primary Residential Development	Destruction or degradation of habitats due to construction activities associated with the building of primary residences.
Recreational Use of Habitats (Non-vehicular)	Destruction and degradation of habitats and increased mortality of species due to excessive levels of recreational activities or inappropriate usage of habitats for recreation.
Recreational Vehicles	Destruction and degradation of habitats and increased mortality of species due to excessive levels of recreational vehicle traffic or inappropriate usage of habitats for recreational vehicles.
Residential Sewage / Septic Systems	Degradation of water quality resulting from ineffective treatment of residential sewage by septic systems. Often caused by older, defective sewage systems or by poorly-sited septic tanks.
Secondary Home / Resort Development	Destruction or degradation of habitats due to construction activities associated with the building of secondary/vacation homes and resort developments.
Shoreline Stabilization	Degradation of water quality and destruction of habitats along shorelines during stabilization activities that cover stream banks with rock or other erosion-control structures (e.g. rip rap).

Table 14. Potential Stress and Source of Stress Linkages to GCN Species

Source of Stress Category	Stress Category				
	Altered Phys. Structure	Altered Phys. Env.	Altered Chem. Env.	Altered Conn.	Altered Bio. Comp./Int. of Species
Acid Rain	Yes	No	Yes	No	No
Agricultural Conversion	Yes	Yes	No	Yes	No
Channelization of Rivers / Streams	Yes	Yes	No	Yes	No
Commercial Collection of Species	No	No	No	No	Yes
Commercial / Industrial Development	Yes	Yes	No	Yes	Yes
Construction of Dams / Impoundments	Yes	Yes	No	Yes	No
Construction of Ditches / Dikes Drainage / Diversion Systems	Yes	Yes	No	Yes	No
Construction of Roads / Railroads / Utilities	Yes	Yes	No	Yes	No
Excessive Competition / Predation by Native Species	Yes	Yes	No	No	Yes
Excessive Groundwater Withdrawal	No	Yes	No	Yes	No
Excessive Surfacewater Withdrawal	No	Yes	No	Yes	No
Fire Suppression	Yes	Yes	No	No	No
Forestry Conversion	Yes	Yes	No	Yes	No
Illegal Dumping	No	No	Yes	No	No
Illegal Hunting/Fishing/Collection/Killing	No	No	No	No	Yes
Incompatible Animal Prod. Practices	No	Yes	Yes	No	No
Incompatible Forestry Practices	Yes	Yes	Yes	Yes	No
Incompatible Grazing / Pasture Management Practices	Yes	Yes	Yes	No	No
Incompatible Mining Practices	Yes	Yes	Yes	No	No
Incomp. Row Crop Ag. Practices	Yes	Yes	Yes	No	No
Incomp. Species Mgmt. Practices	Yes	No	Yes	No	Yes
Industrial Discharge	No	No	Yes	No	Yes
Invasive Exotic Species	Yes	Yes	No	No	Yes
Landfill Construction / Operation	Yes	Yes	Yes	No	No
Low-level Ozone Air Pollution	Yes	No	Yes	No	No
Military Maneuvers	Yes	Yes	Yes	No	Yes
Municipal Wastewater Treatment / Stormwater Runoff	No	Yes	Yes	No	No
Oil or Natural Gas Drilling	Yes	Yes	Yes	No	No
Operation of Dams / Reservoirs	Yes	Yes	No	Yes	No
Operation of Drainage / Div. Systems	Yes	Yes	No	Yes	No
Parasites / Pathogens	Yes	Yes	Yes	No	Yes
Primary Residential Development	Yes	Yes	No	Yes	Yes
Recreational Use of Habitats (Non-vehicular)	Yes	Yes	Yes	No	Yes
Recreational Vehicles	Yes	Yes	Yes	No	Yes
Residential Sewage / Septic Systems	No	No	Yes	No	No
Secondary Home / Resort Development	Yes	Yes	No	Yes	Yes
Shoreline Stabilization	Yes	Yes	No	No	No

Table 15. Evaluators Used to Assess Stress & Source of Stress Linkages				
Scope	**Severity**	**Timing**	**Reversibility**	**Contribution**
Estimated % of Populations Affected in a Region(s)	*Degree / Intensity of Effect on a Species*	*Starting Point of Effect on a Species*	*Relative Ease of Reversibility of Stress and Source*	*Degree of Contribution to Other Stresses and Sources*
0 – 25% 26 – 50% 51 – 75% 76 – 100%	Low Medium High Very High	Historic-Cont. Current Next 1 – 5 Yrs. Next 6 – 10 Yrs.	None Low Medium High	Low Medium High Very High

scope (i.e. estimated %) of populations potentially affected by the stress-source either in each region or across all regions. Estimates of scope were developed subjectively based on numbers of species populations that could potentially encounter the stress – source.

Afterward, the severity level of each stress – source combination was also entered as "Low", "Medium", "High", or "Very High". Severity is defined as a measure of the overall degree or intensity of effect on a species (e.g. altering the behavior of a species might constitute a low severity rating; whereas, mortality might indicate a high severity rating). Also, timing was considered in terms of the starting point of the stress on the animal. Generally, starting points were listed as being "Historic-Continuing", "Current", or in the future either in the "Next 1 – 5 Years", or "Next 6 – 10 Years".

Furthermore, the reversibility or ease of abatement of each problem was evaluated in terms of feasibility costs. Problems that have extremely high remediation costs (i.e. are cost prohibitive in terms of benefit) or have no immediate restoration benefits had reversibility ratings of "None". Sources of stress that could be somewhat abated but at a relatively high cost were listed as "Low". "Medium" and "High" reversibility ratings were given to problems that could be abated for either a moderate or low cost. It should be noted that cost was defined as both capital and staff resources.

Finally, the relative contribution of each problem to facilitating the establishment of other problems was evaluated. For this analysis, the contribution rating was based on the capacity to generate other sources of stress, not additional stresses from the same source. For example, construction of a new road within a particular region may generate additional sources of stress such as residential development or commercial / industrial development. Contribution is often difficult to assess. As such, ratings of "Low", "Medium", "High", or "Very High" were assigned by the planning team based on subjective opinion. In general, if a problem could contribute 1 or fewer additional sources of stress, a rating of "Low" was assigned, "Medium was for 1 to 2 sources, "High" for 2 to 3, and "Very High" for 3 or more.

During the evaluation process, the list of problems affecting species was narrowed to a select number of sources of stress. In total, 34 final sources of stress were selected based on documented and believed instances of stress upon fauna. Numbers of GCN species linked to these selected sources of stress are presented in Chapter 3. To assess the overall "imperilment" level for each species, the individual ratings for scope,

severity, timing, reversibility, and contribution were assigned a relative point value and tallied for each stress – source tandem. Afterward, a combined score for all problems was generated for each GCN species based on the cumulative points assigned to each evaluative category in each region (see Appendix E).

Development of Conservation Actions

With completion of the assessment of problems affecting GCN species, the core planning team began reviewing conservation actions. The review process was focused on three tasks: 1) development of a hierarchy outlining various levels of action, 2) linkage of specific actions to sources of stress, and 3) evaluation of the overall effectiveness of each specific action in abating problems. Further details of each of these processes are provided in the following sections.

Conservation Action Hierarchy

One of the major challenges of conservation planning is developing strategies that are directed at an appropriate level. Often, the inability to formulate focused actions stems from an inconsistent use of terminology in describing the action at suitable scales for implementation. As such, the core planning team developed a hierarchy of conservation actions to standardize descriptions across various strategic levels.

To begin, the planning team modified a proposed taxonomy of conservation actions drafted by a multi-organizational working group known as the Conservation Measures Partnership (CMP). The CMP taxonomy divided actions into 6 broad categories and 29 classes. However, only a few examples of specific action types were provided below the class level. The Tennessee CWCS hierarchy followed much of the same organization but expanded the CMP taxonomic scheme into 2 broad categories, 6 classes, and 22 general actions (see Table 16). In addition, 90 specific actions were identified and described accordingly under each general action (see Appendix F).

The development of specific actions was undertaken with the assistance of various conservation partners and members of the steering committee. Research was conducted to discern actions previously identified in other planning efforts. Ideas were adapted from a variety of sources including: TWRA Strategic Plan, TNC ecoregional plans & conservation area plans, TVA Reservoir Operations Study, World Wildlife Fund Tennessee – Cumberland Drainage plan, Cherokee National Forest unit plans, USFWS National Wildlife Refuge plans, and Southeastern Bat Diversity Network plan. Many of the actions described in these references were very similar. As well, the descriptions were often either too general or too detailed. In such cases, the actions were modified to fit the CWCS hierarchy.

After the literature review, analysis was conducted to determine if the "arsenal" of conservation actions was sufficient to address all the identified problems affecting GCN species. Additional strategies were developed to complement the current pool of actions and to address several sources of stress without any discernible abatement opportunities. While the list of 90 specific actions is thorough, it is by no means exhaustive. Strategy development is an ongoing process in conservation planning. Hopefully, future iterations of the CWCS will continue to develop conservation actions at more refined levels to protect GCN species.

Linking Specific Actions to Sources of Stress

After the development of the conservation action hierarchy, an Access Database was created to link each of the 90 specific actions to relevant problems. From the database menu, the core planning team selected individual stress – source groups that could be abated by a specific action. First, the presumed abatement level of an action upon a particular stress – source combination was entered as either "Low", "Medium", or "High". An entry of "Low" indicated that the action either had some limited capacity to remedy the source of stress in a general context or it

Table 16. Hierarchy of Conservation Actions to General Action Level			
Category	**Class**	**General Action**	**General Action Description**
Conservation Science, Stewardship, & Protection	Habitat Acquisition	Fee-title Ownership	Acquire fee-title ownership of critical units of aquatic, subterranean, & terrestrial habitats.
		Permanent Protective Easements	Acquire permanent protective easements on critical units of aquatic, subterranean, & terrestrial habitats.
	Information Collection & Dispersal	Communications & Public Relations	Develop communications & public relations programs that benefit target species and habitats.
		Conservation Planning	Conduct planning to establish conservation objectives and actions that benefit target species and habitats at state or regional scales.
		Formal Education, Training, Outdoor Education, & Recreation	Support formal education, training, outdoor education, and/or recreation programs that benefit target species and habitats.
		Monitoring	Develop programs to monitor environmental quality of habitats and/or biological monitoring of species populations.
		Research	Facilitate research programs that benefit target species and habitats.
	Management & Restoration of Species and Habitats	Compatible Resource Use	Encourage compatible resource uses on public and private lands that contain target species and habitats.
		Conservation Area Management	Implement management practices that benefit target species and habitats on public and private conservation areas.
		Control/Prevention Of Invasive Exotic Species & Pathogens	Implement management practices that control or prevent occurrences of invasive exotic species & pathogens on critical units of aquatic, subterranean, and terrestrial habitats.
		Habitat/Natural Processes Restoration	Restore critical units of aquatic, subterranean, and terrestrial habitats and/or natural processes that benefit target species.

Table 16. Hierarchy of Conservation Actions to General Action Level (cont'd.)			
Category	**Class**	**General Action**	**General Action Description**
Conservation Science, Stewardship, & Protection	Management & Restoration of Species and Habitats	Species Restoration	Restore populations of target species on critical units of aquatic, subterranean, and terrestrial habitats.
Conservation Financial, Legal, and Political Development	Capacity Building	Alliances & Partnerships	Develop strategic alliances and/or formal partnerships among public & private institutions that benefit target species and habitats.
		Conservation Finance	Develop new sources of conservation funding to increase capacity of federal/state agencies, non-governmental organizations and, other institutions to benefit target species and habitats.
		Institutional Improvement	Increase internal capacity of public/private institutions to benefit target species and habitats.
	Commercial Incentives	Conservation Enterprises	Develop commercial enterprises that provide financial incentives for private individuals, industries, and/or small businesses to benefit target species and habitats.
		Market Forces	Develop marketing strategies to improve patterns of production and consumption of goods and services for the benefit of target species and habitats.
	Law & Policy	Compliance & Enforcement	Improve compliance & enforcement programs that benefit target species and habitats.
		Land-use Planning & Zoning	Develop land-use planning & zoning ordinances that benefit target species and habitats.
		Legislation	Enact legislation to benefit target species and habitats.
		Policies & Regulations	Improve policies & regulations that benefit target species and habitats.
		Standards	Improve environmental standards that benefit target species and habitats.

was restricted on a regional basis. A "Medium" ranking meant that the action had moderate capacity to abate the problem in most regions; whereas, a "High" rank denoted the action as being fully capable of abating the source of stress in all regions. If the action was determined to have only nominal ability to affect a particular problem, then no linkage was made. In such cases, the abatement column was left blank in the database.

Next, faunal groups were evaluated for their individual capacity to benefit from the abatement effects of a specific action upon each stress – source combination. Not all fauna necessarily gain in equal increments from the implementation of an action against a source of stress. As such, all faunal groups were listed in a checkbox table beside each stress – source combination in the database. The default presumption was that all fauna could benefit equally from a given strategy. However, if a particular faunal group was deemed to be potentially unaffected, then the check was deleted in the database form. In some cases, all faunal groups within a particular environment (i.e. aquatic, subterranean, or terrestrial fauna) may have been unchecked. It should be noted that the ability to indicate which individual species might be unaffected by an action was beyond the capacity of this planning effort. As such, if the majority of species within a given faunal group could conceivably improve from the conservation action, then the faunal group linkage was retained.

Evaluation of Specific Actions

To further assess the effectiveness of specific conservation actions in abating problems, five evaluative criteria were incorporated into the database (see Table 17). These criteria include: 1) the scope of species populations affected by the action, 2) the relative benefit of the action, 3) the feasibility of the action, 4) an estimate of the required duration or timing of the action, and 5) the approximate cost range.

The ranking process for each evaluator was completed on a subjective basis by the core planning team. For scope, estimates were made as to the percentage of populations of all species that may benefit in any degree from the specific action. If the range was 0 – 25%, then an entry of "Low" was made, and so forth on a quarterly percentage basis through the ranks of "Medium", "High", and "Very High". It should be noted that species are linked to actions indirectly in the database via the source – stress combinations that are linked to actions. As such, the number of species affected by an action could have been calculated from the database itself. However, estimates of scope were still individually provided by the planners in order to account for potential variations among populations and regions.

Table 17. Evaluators Used to Assess Specific Conservation Actions

Scope	Benefit	Feasibility	Duration / Timing	Cost
Estimated % of Populations Affected by Action	*Amount of Positive Abatement to Problem*	*Ease of Implementing Action*	*Amount of Time / Reps. Required for Action to Have Significant Benefit*	*Direct and Indirect Cost of Implementing Action*
0 – 25% 26 – 50% 51 – 75% 76 – 100%	Low Medium High Very High	Low Medium High Very High	Single Event (< 1 yr.) Ongoing (1 – 5 yrs.) Ongoing (6 – 10 yrs.) Ongoing (> 10 yrs.)	< $10,000 $10 K – $100 K $100 K - $1 M > $1,000,000

The overall benefit of each specific action was also approximated based on the amount of positive abatement to problems that might be provided. Again, a general rating system of "Low", "Medium", "High", and "Very High" was used.

A "Low" rating indicates that the conservation action has low capacity to abate the effects of major stress – source combinations for species; or, has low capacity to restore species within a region; and/or, provides low leverage for the successful implementation of other conservation actions. A "Medium" rating means the conservation action moderately abates the effects of the major stresses & sources on species; or, can partially restore species into suitable habitats within a region; and/or, provides some leverage for the successful implementation of other actions. A "High" rating denotes the conservation action mostly abates the effects of the major stresses and sources of stress on species; or, can mostly restore species into suitable habitats within a region; and/or, provide major leverage for the successful implementation of other conservation actions. Finally, a "Very High" rating indicates the conservation action fully abates the effects of the major stresses and sources; or, can fully restore species into suitable habitats within a region; and/or, provides critical leverage for the successful implementation of other conservation actions.

Estimates of the feasibility of implementing a specific action were also made. Like the evaluation of benefit, a general rating system of "Low", "Medium", "High", and "Very High" was employed. Feasibility was assessed based on several factors: 1) complexity, 2) current funding potential, and 3) availability of a lead agency or organization.

A "Low" rating infers the complexity of implementing the conservation action is high; sources of required funding are either unidentified or can not be secured within a reasonable amount of time; and, a lead agency or organization is either unknown or unavailable to direct implementation of the action. Similarly, a "Medium" rating indicates that the complexity of implementation is moderate; required funding is unsecure but potentially obtainable within a reasonable amount of time; and, a lead agency or organization is possibly available and willing to direct implementation of the action. For a "High" rating, the conservation action is considered highly feasible due to the low to moderate complexity of implementing the action; required funding may be unsecure but is easily obtainable; and, a lead agency or organization is available and willing to direct implementation of the action. Finally, a "Very High" rating indicates the conservation action is very highly feasible due to the low complexity of implementing the action; required funding is already secure; and, a lead agency or organization is already committed to direct implementation.

Another important evaluator is the duration or timing of the specific action. This category is based on considerations of the amount of time or repetition required for an action to reach 'critical mass' before having significant benefit for any species. To measure the duration / timing of actions, estimates were made as to whether a given action would need to be implemented as: 1) a single event or a series of related events within a year or less, 2) a single event that will require repetition over a 1 to 5 year interval or an ongoing series of related events that will require 1 to 5 years to fully implement, 3) a single event that will require repetition over a 5 to 10 year interval or an ongoing series of related events that will require 5 to 10 years to fully implement, or 4) a single event that will require repetition over an interval of more than 10 years or an ongoing series of related events that will require more than 10 years to fully implement.

Finally, the core planning team also evaluated the approximate cost range needed to implement each specific action. Cost estimates for a conservation action should include all direct and indirect costs such as cash outlays, personnel/staffing, and extraneous expenses related to project setup. In addition, costs that recur over the required

time period for implementation of the conservation action should be factored into the overall cost estimate. To evaluate cost, projections of the total expense required to setup and implement an action within its listed duration were made. Ratings were assigned based on 4 cost ranges: a) actions costing less than $10,000, b) actions costing between $10,000 and $100,000, c) actions costing between $100,000 and $1,000,000, and d) actions costing over $1,000,000.

After the analysis of evaluators, relative point values were assigned to the selected ratings made within each evaluative category for every conservation action. Scores were tallied for each specific action to get a combined evaluator rating. Abatement ratings assigned to each stress – source combination were then factored against the total evaluator points to produce a modified 'action' score for each problem. In general, stress – source groups with abatement ranks of "High" received the full point values of the combined evaluators. Stress – source combinations rated "Medium" or "Low" received fewer points. Afterward, the modified 'action' scores were tallied to get an overall 'conservation action' score (see Appendix F). In general, scores are higher for actions which abate more problems at higher levels. Similarly, greater yields are expected from specific actions that have higher overall 'conservation action' scores.

In addition to these evaluators, key constituents required to implement a specific action were identified. For simplicity, six general categories of constituents were derived as follows: 1) government agencies (i.e. federal & state), 2) non-governmental organizations, 3) private corporations / industries, 4) private individuals / landowners, 5) general public, and 6) universities or other research institutions. Though considerations of stakeholders are important to implementing actions, the number of key constituent groups listed was not factored as part of the scoring scheme. Nevertheless, some attention should be given to the number and diversity of constituent groups before deciding to implement a particular set of conservation actions.

Establishment of Conservation Priorities

After the analysis of specific actions, effort was made to establish a protocol for determining the highest conservation priorities in each region of the state for terrestrial, aquatic, and subterranean GCN species. To begin, the GIS-database model was used to assess priorities based on 4 general criteria: 1) important habitat areas for species in each region of the state, 2) potential forest habitat restoration scenarios for each region of the state, 3) imperilment ratings, and 4) the relative opportunities presented by various conservation actions. As well, previous planning efforts were analyzed to assess priority habitats and conservation issues that were already identified.

To determine priority habitat areas for GCN species using the CWCS computer model, rarity and viability scores were combined into an overall priority score and plotted by each occurrence on a GIS map. Priority scores for all species were applied to respective habitats for terrestrial, aquatic, and subterranean environments. The highest scoring habitat areas of GCN species were subsequently generated for each region based on clusters of the rarest and most viable species occurrences within various habitat units (see Box 7).

Imperilment was assessed in a similar fashion. The combined "stress" scores from each evaluative category were linked to species occurrences in GIS to generate a relative estimate of regional susceptibility to

Box 7. GCN Species Prioritization Scoring Formula

Prioritization Score = (R)arity x (V)iability

(R) = Global Rank + State Rank

(V) = Size x Condition x Land. Context

various sources of stress. However, it should be emphasized that no explicit mapping of sources of stress was conducted for this project. In the future, more work will need to be done to develop GIS coverages that indicate specific areas posing problems to GCN species.

For conservation actions, the combined 'action' scores were also linked to individual occurrences for all species via the database connection to problems. Analysis was then conducted to determine habitats containing clusters of species occurrences with high 'action' scores (i.e. actions that can be easily implemented). Such clusters potentially represent areas of high conservation opportunity. However, given the lack of detailed mapping for problems, these areas should be viewed in a more general context as just potential areas of high opportunity.

Overall, a comprehensive conservation strategy should synthesize concepts of priority habitat areas, imperilment, and opportunity in selecting a portfolio of priority areas to work. By one theory, conservation priorities should be based on identifying specific units of functional habitats that contain the largest assemblages of the rarest, most imperiled GCN species that have the highest potential to benefit from conservation actions. However, discerning actual combinations of these measures in a conservation model is an extremely difficult process. What often works in the theoretical construct of a database or GIS coverage may not be effective in reality. In the future, this concept may be combined with other types of conservation planning. In particular, habitat-based approaches employed by the bird joint venture programs have been successful.

For now, conservation priorities are determined in a more straightforward manner for this iteration of this CWCS. High-scoring GCN species concentrations form the primary criteria for prioritization. As described, priority habitat areas are delineated independently for terrestrial, aquatic, and subterranean regions based on species prioritization scores overlaid onto habitats. Areas with the highest values should correspond to combinations of species that are either more rare or are found within more functional habitat units. These areas likely represent the best places to begin working in a given region and should formulate the initial portfolio of areas for conservation. Extra consideration should be given to overlaps between terrestrial, aquatic, and subterranean portfolio areas. However, analysis to properly combine these areas based on ecological complementarity was beyond the scope of this study. Likewise, it should be understood that these portfolio areas are subject to revision with increased biological information.

The next level of prioritization is based on regional assessments of relative imperilment and conservation opportunity. In general, regions that have high imperilment and high conservation opportunity should receive additional consideration for their portfolio areas. Given that stresses and sources are not mapped, no presumptions of portfolio priorities should be made for imperilment and opportunity below the regional level. However, it is hoped that additional consideration can be given by planners based on expert knowledge of an area outside this prioritization process.

In conclusion, overall conservation priorities for each region are presented in the form of priority habitat area maps with supporting summary data compiled for each region. Maps, tables, and further discussion of these areas are presented in *Chapter 3*.

CHAPTER 3

Conservation Priorities for the CWCS

For this iteration of the CWCS, conservation priorities were developed using the GIS – database model described previously in *Chapter 2*. Data queries were performed independently for terrestrial, aquatic, and subterranean environments. Regional assessments were conducted to determine priority habitat types, priority habitat concentrations of GCN species, potential forest restoration areas, and key sources of stress for GCN species. In conducting these assessments, all regions were evaluated individually. This rationale is based on the fact that subtle variations in habitats across regions influence species in different ways. Likewise, problems affecting species in each region are often idiosyncratic due to disparities in land use and socio-economic conditions that exist. Intrinsic differences among regions must be weighed individually before developing specific actions at any scale. These assessments can be conducted for all species tiers. However, to simplify comparisons, only Tier 1 species were considered as part of the regional assessments discussed here.

Based on results at the regional level, priority conservation actions were derived for the state. These actions are based on analysis of problems affecting species in priority Tier 1 conservation and restoration areas. Both regional and statewide scales were considered during the development of conservation actions. Such analysis allows actions that transcend regional issues to be put in a larger context for decision making. Likewise, many specific actions need further comparison of sites and species across regions and at different spatial scales in order to proceed. The primary focus of the statewide assessment is to identify potential suites of actions capable of working in tandem across multiple regions. Overall, priorities are evaluated in 6 separate categories, as follows:

1. terrestrial habitat types are prioritized at the regional level by the number, rarity, and habitat preference of GCN species;
2. current units of terrestrial, aquatic, and subterranean habitats are rated as “Very High”, “High”, “Medium”, and “Low” focus (i.e. portfolio) areas at the regional level based on species prioritization scores;
3. areas for possible restoration of important terrestrial habitats are presented according to the potential benefits to GCN species at the regional level;
4. sources of stress are prioritized according to the combined effects upon terrestrial, aquatic, and subterranean GCN species of different levels of rarity at the regional level;
5. priority conservation actions are presented according to their capacity to abate problems for species at a statewide level.
6. priority areas identified in previous conservation planning efforts are compared with the CWCS current priority habitat areas.

Assessment of Priority Habitat Types

The first prioritization category is based on analysis of the terrestrial habitat preferences of GCN species with different levels of rarity. In general, the habitat needs of wildlife may be stated in terms of an individual species’ predilection to occupying a particular habitat for any number of uses. Again, to express this relationship, habitats were rated as being “Preferred”, “Suitable”, “Marginal”, or “Unsuitable” for each GCN species.

The preference values of every species found within a particular habitat were scored cumulatively. Then, the individual rarity

scores of all species in each habitat were factored against preference scores. The collective preference and rarity scores of all fauna were added into an overall terrestrial habitat score. This score reflects the relative condition of terrestrial habitats in regard to theoretical maximum numbers of species that may occupy the habitat. Aquatic habitats were not evaluated in this context due to the lack of information about possible usage of aquatic systems by species currently absent from the habitat. Likewise, subterranean fauna were not evaluated due to limitations in delineating unique cave habitat types.

Assessment of Priority Conservation Areas
The second type of prioritization is centered on identification of clusters of habitat units that currently support mixed assemblages of GCN species. For terrestrial environments, these habitat units consist of a variety of mapped ecological system types within roadless blocks in each region. For aquatic environments, these clusters are depicted as priority watershed units (i.e. NRCS 12-digit HUCs). For subterranean environments, habitat units are presented as mapped terrestrial systems that overlay cave occurrences.

Clusters of habitat units in all environments were categorized into four portfolio classes of "Very High", "High", "Medium", and "Low" based on the collective GCN species prioritization scores based on rarity and viability (see Maps 4 – 15). These portfolios capture the highest rated occurrences of species in the state, and represent a relative "snapshot" of current biological conditions. Portfolio levels are subject to modification as new information is collected or as conditions change for species and habitats across the landscape. Conservation efforts for a particular species in a region may require working in all four portfolio levels at a regional or statewide scale to reach established conservation goals.

Assessment of Priority Restoration Areas
The third prioritization category conveys restoration scenarios for terrestrial habitats within each region. Natural habitats in many regions of the state have undergone substantial modification from anthropogenic activities since the early days of European settlement. As such, a potential reforestation scenario is presented for each region based on the increase in prioritization scores of GCN species derived from the hypothetical replacement of relevant semi-natural habitats with the dominant forest type found within the majority of subregions.

Four portfolio levels of priority restoration areas from each scenario are presented for each region (see Maps 16 – 19). These portfolios are rated as "Very High", "High", "Medium", and "Low" areas that may potentially benefit from the particular restoration scenario. These portfolios are also shown relative to semi-natural habitat areas that may be negatively affected by the restoration, as well as current areas of natural habitats. It is likely that many areas on the ground may not ecologically support the forest system from the restoration scenario, but could benefit from other types of restoration. Overall, much more ecological analysis will be required before specific areas for actual restoration are recommended. Furthermore, aquatic and subterranean habitat restoration scenarios are not presented, as the level of analysis is beyond the current scope of this project.

Assessment of Priority Problems
The fourth prioritization category concerns the overall severity of problems affecting GCN species. To assess problems, a stress – rarity scoring system was developed that weighs the individual stress rating of each problem by the combined rarity scores of all species affected by the problem in a region. This score helps to prioritize sources of stress in relation to their ability to affect the largest number of rare GCN species. Again, it should be emphasized that no analysis was conducted to measure problems at the local level for this iteration of the CWCS. Therefore, any problems linked to particular species are based only on their potential effects. However, the total number of rare species linked to a source of stress with the

combined stress rating still provides a good indication of the overall imperilment risk that a problem may generate across the landscape.

Assessment of Priority Conservation Actions

The fifth type of prioritization focuses on identifying specific conservation actions that can be utilized to address problems across the state. To begin, actions were divided into two scale categories: regional and statewide. The primary difference between these categories is that regional actions are best initiated at a regional or local scale; whereas, statewide actions require centralized planning and coordination. To measure the abatement potential of either scale, a combined effectiveness score was produced for each action based on individual ratings for cost, benefit, feasibility, duration/timing, and scope. This combined effectiveness score was then weighed against the individual abatement ability of the action for each threat to produce a final action score. For both regional and state-scale actions, the top two conservation strategies to abate sources of stress at a statewide level are presented according to their combined action scores. Complete rankings of conservation actions for each source of stress were also done (see Appendix F).

As a second measure, conservation actions were also prioritized based on the total number and rarity of GCN species indirectly linked to each action in the database via sources of stress. To measure this relationship, overall stress abatement scores were developed for each action based on the sum of final action scores for problems and rarity scores for species. The stress abatement score measures the ability of a given action to abate problems of varying severity for species of assorted rarity across the state.

Assessment of Previous Planning Efforts

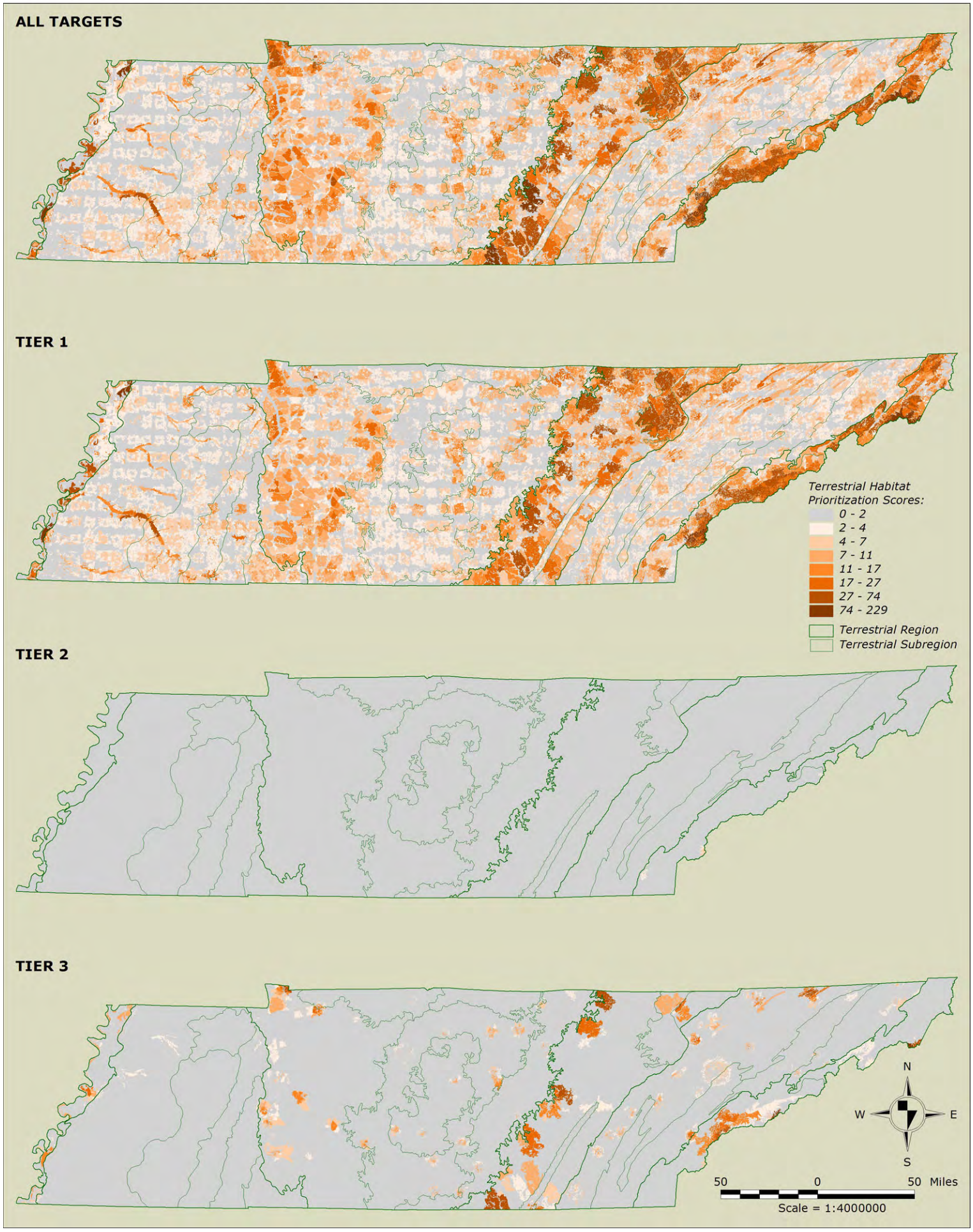
In addition to the GIS model, results from previous planning efforts were analyzed for similarities to the CWCS. In total, eight other plans were assessed. These plans included TWRA's West Tennessee Wildlife Resources Conservation Plan, Central Hardwoods Joint Venture Concept Plan, 5 TNC ecoregional plans (i.e. Mississippi River Alluvial Plain, Upper East Gulf Coastal Plain, Interior Low Plateau, Cumberlands and Southern Ridge & Valley, and Southern Blue Ridge), and results from TNC's Freshwater Initiative. Identified areas for conservation in each plan were overlaid individually with a composite map of terrestrial, aquatic, and subterranean portfolio areas for the CWCS. Priority areas included in these other plans should also be considered for inclusion in any decision making process. Overall, the combination of these planning efforts strengthens the scientific foundation for the conservation of all species in Tennessee.

Summary of Prioritization Assessments

Overall, each of the prioritization categories presented in this chapter should be weighed both individually and collectively. It is intended that natural resource managers will weigh the merits of each category and develop their own criteria for consideration of priorities before making critical decisions to take action. Likewise, decisions to enact conservation strategies in a particular order or scope are subjective. Rather than focusing on the notion of a single "right" course of action, this iteration of the CWCS is centered on presenting multiple courses of actions that are efficient and complementary.

Furthermore, it is hoped that a more detailed list of recommended actions will be developed in the future with input from a broad committee of natural resource managers and other experts. Successful implementation of all the actions outlined in this document will undoubtedly require input from a diverse array of conservation partners. New strategic alliances will be needed to garner the necessary resources to conserve GCN species. Similarly, the amount of cooperation required for the CWCS will likely extend beyond state boundaries. However, in the short-term, actions may be implemented individually by the TWRA at smaller scales as resources and opportunities permit.

Map 4. Current Statewide Priority Terrestrial Habitat Areas for GCN Species by Tier Level



Current Terrestrial Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
V HIGH	54-108	16-35	15-47	20-65	17-29	78-229
HIGH	28-54	13-16	12-15	15-20	12-17	25-78
MED	16-28	10-13	10-12	11-15	10-12	13-25
LOW	8-16	8-10	8-10	8-11	8-10	8-13

Public Land
Interstate Highway
Urban Area
Subregion Boundary

N
W E
S

10 0 10 Miles
Scale 1:760,320 or 1 Inch = 12 Miles

LAKE
OBION
WEAKLEY
HENRY
STEWART
Clarksville
MONTGOMERY
CHEATHAM
HOUSTON
DICKSON
DYER
GIBSON
CARROLL
BENTON
HUMPHREYS
LAUDERDALE
CROCKETT
Jackson
MADISON
HENDERSON
DECATUR
PERRY
HICKMAN
MAURY
HAYWOOD
TIPTON
CHESTER
LEWIS
FAYETTE
HARDEMAN
MCNAIRY
HARDIN
WAYNE
SHELBY
Memphis

Map 5. West Tennessee Current Priority Terrestrial Habitat Areas for Tier 1 GCN Species

AREA OF DETAIL

Public Land
Interstate Highway
Urban Area
Subregion Boundary

Current Terrestrial Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
V HIGH	54-108	16-35	15-47	20-65	17-29	78-229
HIGH	28-54	13-16	12-15	15-20	12-17	25-78
MED	16-28	10-13	10-12	11-15	10-12	13-25
LOW	8-16	8-10	8-10	8-11	8-10	8-13

N
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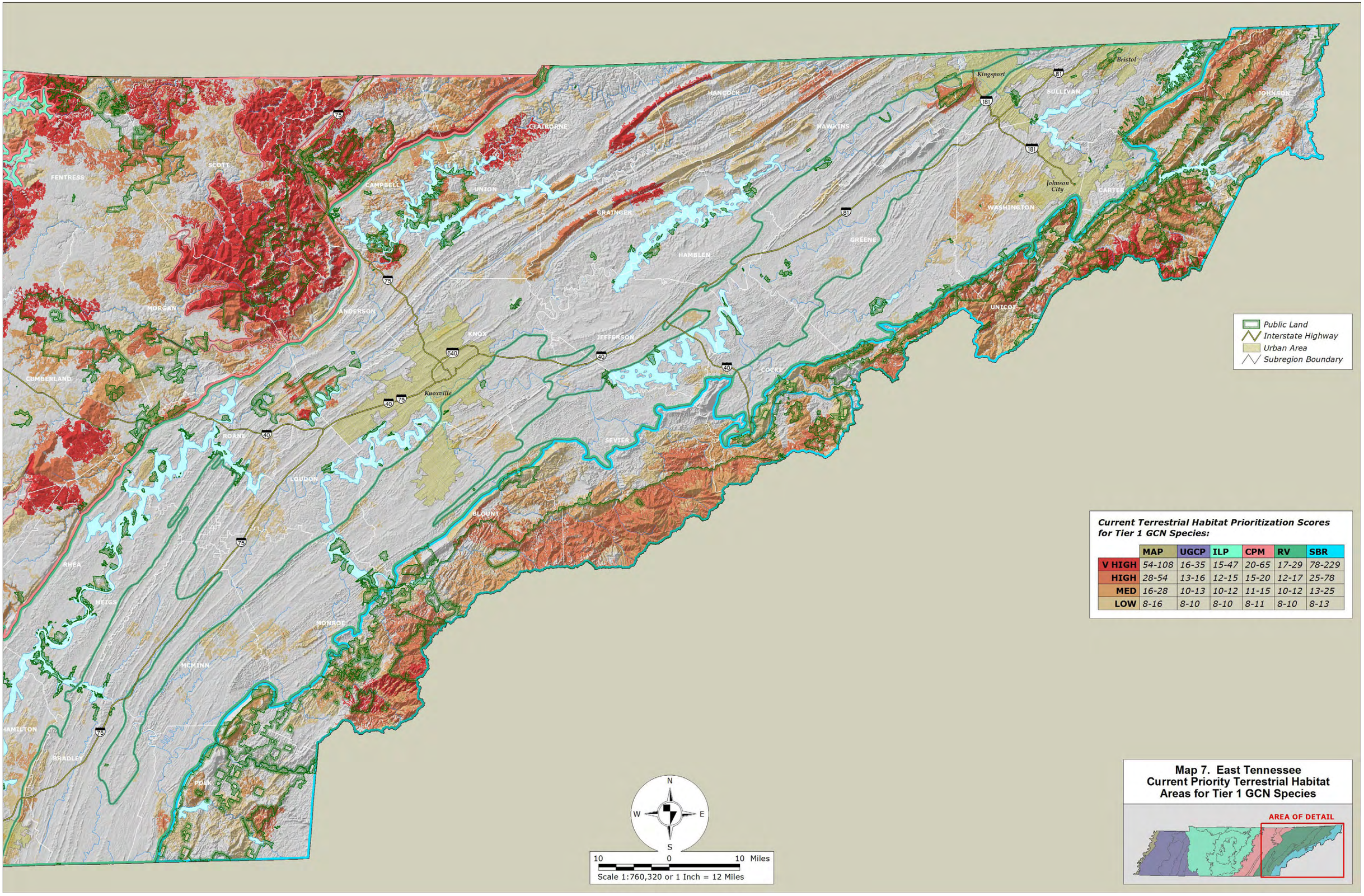
10 0 10 Miles
Scale 1:760,320 or 1 Inch = 12 Miles

Map 6. Middle Tennessee Current Priority Terrestrial Habitat Areas for Tier 1 GCN Species

AREA OF DETAIL

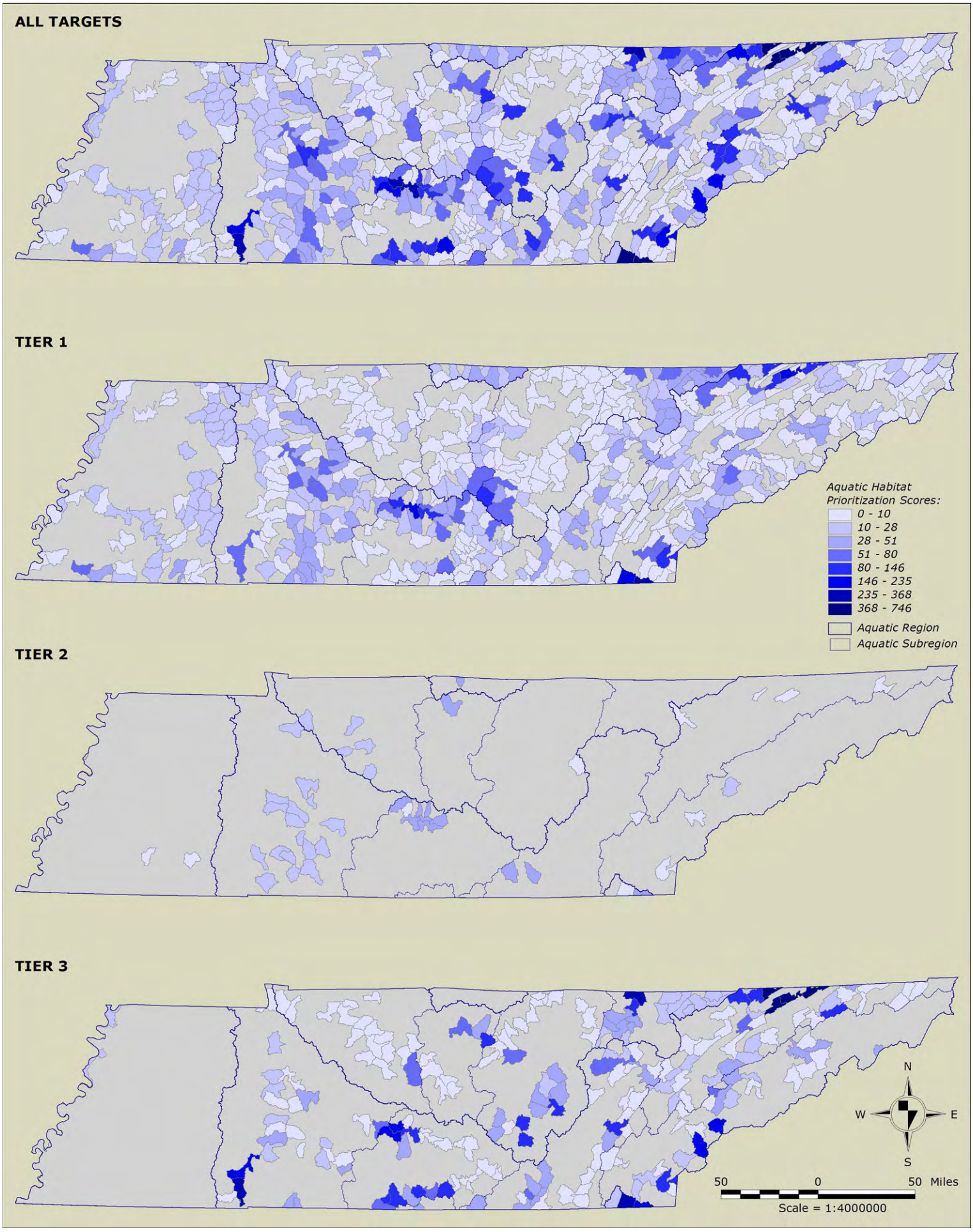


Current Terrestrial Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
V HIGH	*54-108*	*16-35*	*15-47*	*20-65*	*17-29*	*78-229*
HIGH	*28-54*	*13-16*	*12-15*	*15-20*	*12-17*	*25-78*
MED	*16-28*	*10-13*	*10-12*	*11-15*	*10-12*	*13-25*
LOW	*8-16*	*8-10*	*8-10*	*8-11*	*8-10*	*8-13*

Map 7. East Tennessee Current Priority Terrestrial Habitat Areas for Tier 1 GCN Species

Map 8. Current Statewide Priority Aquatic Habitat Areas for GCN Species by Tier Level



Current Aquatic Habitat Prioritization Scores for Tier 1 GCN Species:

	MS R	TN R	CU R	BA R	CO R
V HIGH	*36-59*	*82-193*	*45-103*	*39-51*	*183-244*
HIGH	*19-36*	*40-82*	*22-45*	*19-39*	-
MED	*4-19*	*16-40*	*8-22*	*4-19*	-
LOW	*1-4*	*1-16*	*1-8*	*1-4*	*1*

Public Land
Interstate Highway
Urban Area
Subregion Boundary

N
W E
S

10 0 10 Miles
Scale 1:760,320 or 1 Inch = 12 Miles

LAKE
OBION
WEAKLEY
HENRY
STEWART
Clarksville
MONTGOMERY
CHEATHAM
HOUSTON
DICKSON
DYER
GIBSON
CARROLL
BENTON
HUMPHREYS
LAUDERDALE
CROCKETT
Jackson
MADISON
HENDERSON
DECATUR
PERRY
HICKMAN
MAURY
HAYWOOD
TIPTON
CHESTER
LEWIS
SHELBY
Memphis
FAYETTE
HARDEMAN
MCNAIRY
HARDIN
WAYNE

Map 9. West Tennessee Current Priority Aquatic Habitat Areas for Tier 1 GCN Species

AREA OF DETAIL

Public Land
Interstate Highway
Urban Area
Subregion Boundary

Current Aquatic Habitat Prioritization Scores for Tier 1 GCN Species:

	MS R	TN R	CU R	BA R	CO R
V HIGH	36-59	82-193	45-103	39-51	183-244
HIGH	19-36	40-82	22-45	19-39	-
MED	4-19	16-40	8-22	4-19	-
LOW	1-4	1-16	1-8	1-4	1

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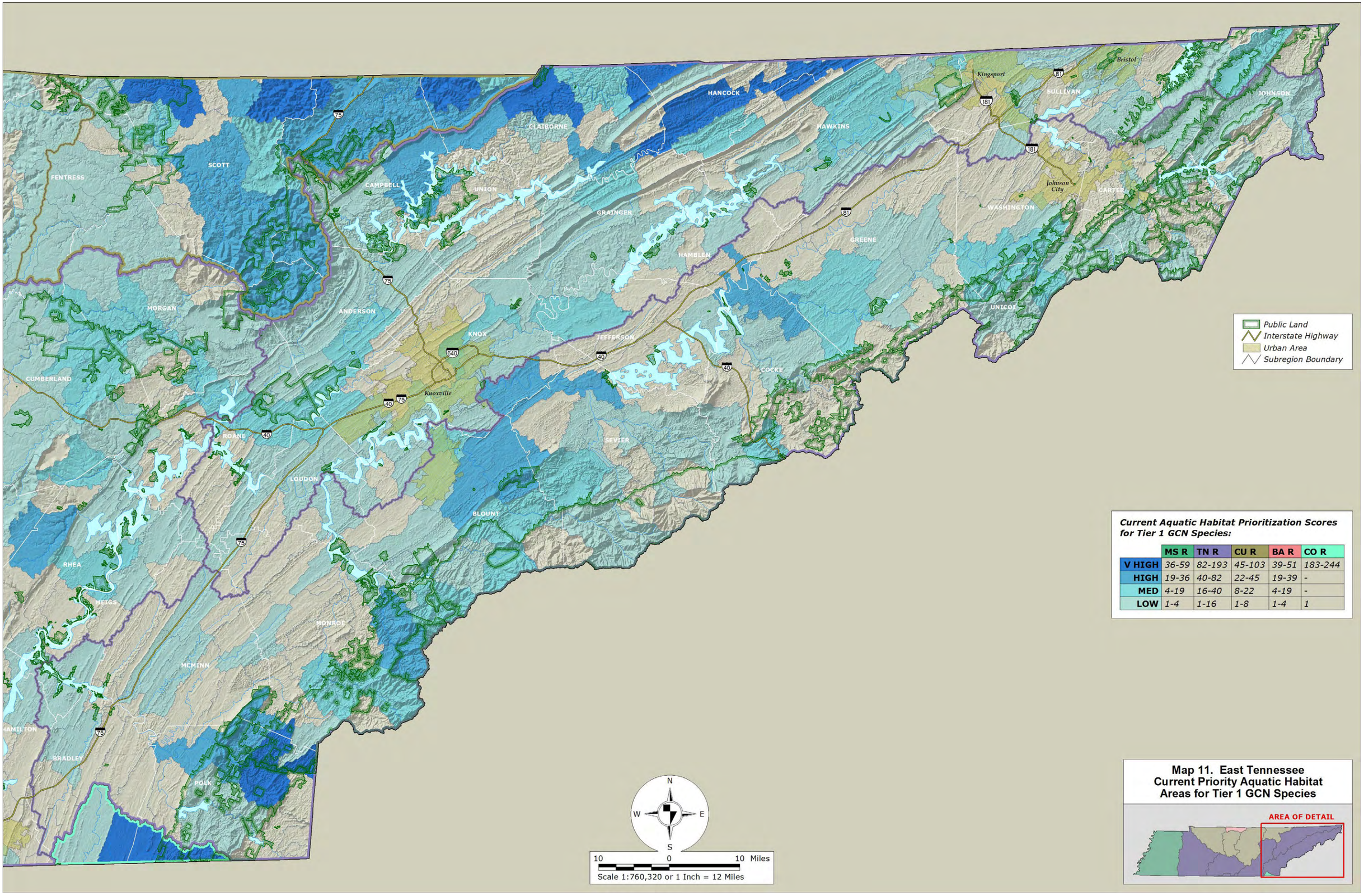
10 0 10 Miles
Scale 1:760,320 or 1 Inch = 12 Miles

Map 10. Middle Tennessee Current Priority Aquatic Habitat Areas for Tier 1 GCN Species

AREA OF DETAIL

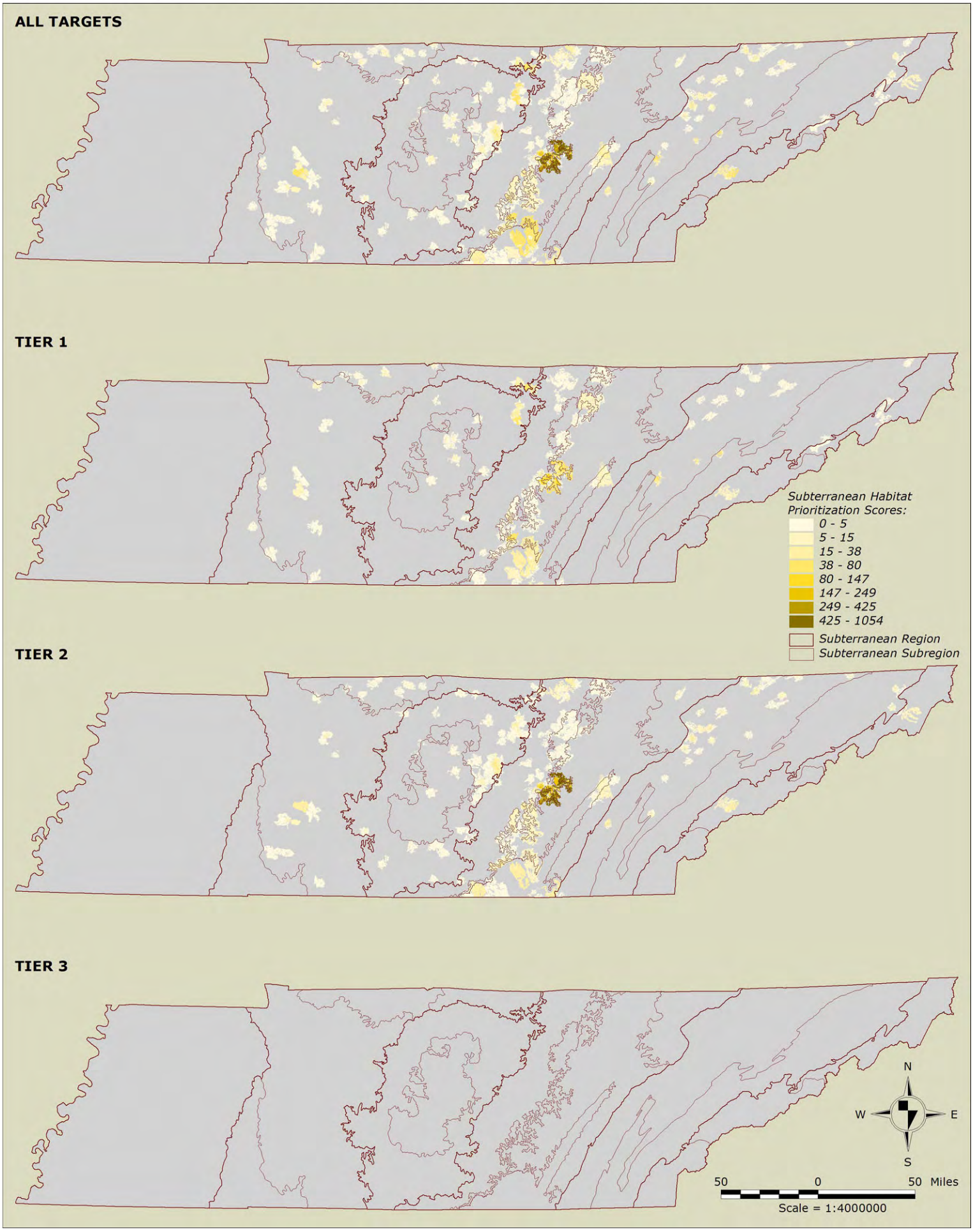


Current Aquatic Habitat Prioritization Scores for Tier 1 GCN Species:

	MS R	TN R	CU R	BA R	CO R
V HIGH	*36-59*	*82-193*	*45-103*	*39-51*	*183-244*
HIGH	*19-36*	*40-82*	*22-45*	*19-39*	-
MED	*4-19*	*16-40*	*8-22*	*4-19*	-
LOW	*1-4*	*1-16*	*1-8*	*1-4*	*1*

Map 11. East Tennessee Current Priority Aquatic Habitat Areas for Tier 1 GCN Species

Map 12. Current Statewide Priority Subterranean Habitat Areas for GCN Species by Tier Level



Current Subterranean Habitat Prioritization Scores for Tier 1 GCN Species, by Cave System:

	W Up	C Up	NB	CR	RV	SBR	Map Pts.
V HIGH	-	36	35-66	91	32-64	14	80
HIGH	-	10-14	6-8	31-39	4-5	-	40
MED	-	5-7	5	6-19	2-3	-	20
LOW	-	1-3	1-2	0-4	0-1	5	10

Current Cave System Prioritization Scores for Tier 1 GCN Species, Mapped to Terrestrial Habitats:

Map Pts.
125-165
84-124
43-83
1-42

Public Land
Interstate Highway
Urban Area
Subregion Boundary

N
W E
S

10 0 10 Miles
Scale 1:760,320 or 1 Inch = 12 Miles

LAKE
OBION
WEAKLEY
HENRY
STEWART
Clarksville
MONTGOMERY
CHEATHAM
DYER
GIBSON
CARROLL
BENTON
HOUSTON
HUMPHREYS
DICKSON
LAUDERDALE
CROCKETT
Jackson
MADISON
HENDERSON
DECATUR
PERRY
HICKMAN
MAURY
HAYWOOD
TIPTON
CHESTER
LEWIS
SHELBY
Memphis
FAYETTE
HARDEMAN
MCNAIRY
HARDIN
WAYNE

Map 13. West Tennessee Current Priority Subterranean Habitat Areas for Tier 1 GCN Species

AREA OF DETAIL

Public Land
Interstate Highway
Urban Area
Subregion Boundary

Current Subterranean Habitat Prioritization Scores for Tier 1 GCN Species, by Cave System:

	W Up	C Up	NB	CR	RV	SBR	Map Pts.
V HIGH	-	36	35-66	91	32-64	14	80
HIGH	-	10-14	6-8	31-39	4-5	-	40
MED	-	5-7	5	6-19	2-3	-	20
LOW	-	1-3	1-2	0-4	0-1	5	10

Current Cave System Prioritization Scores for Tier 1 GCN Species, Mapped to Terrestrial Habitats:

Map Pts.
125-165
84-124
43-83
1-42

N
W E
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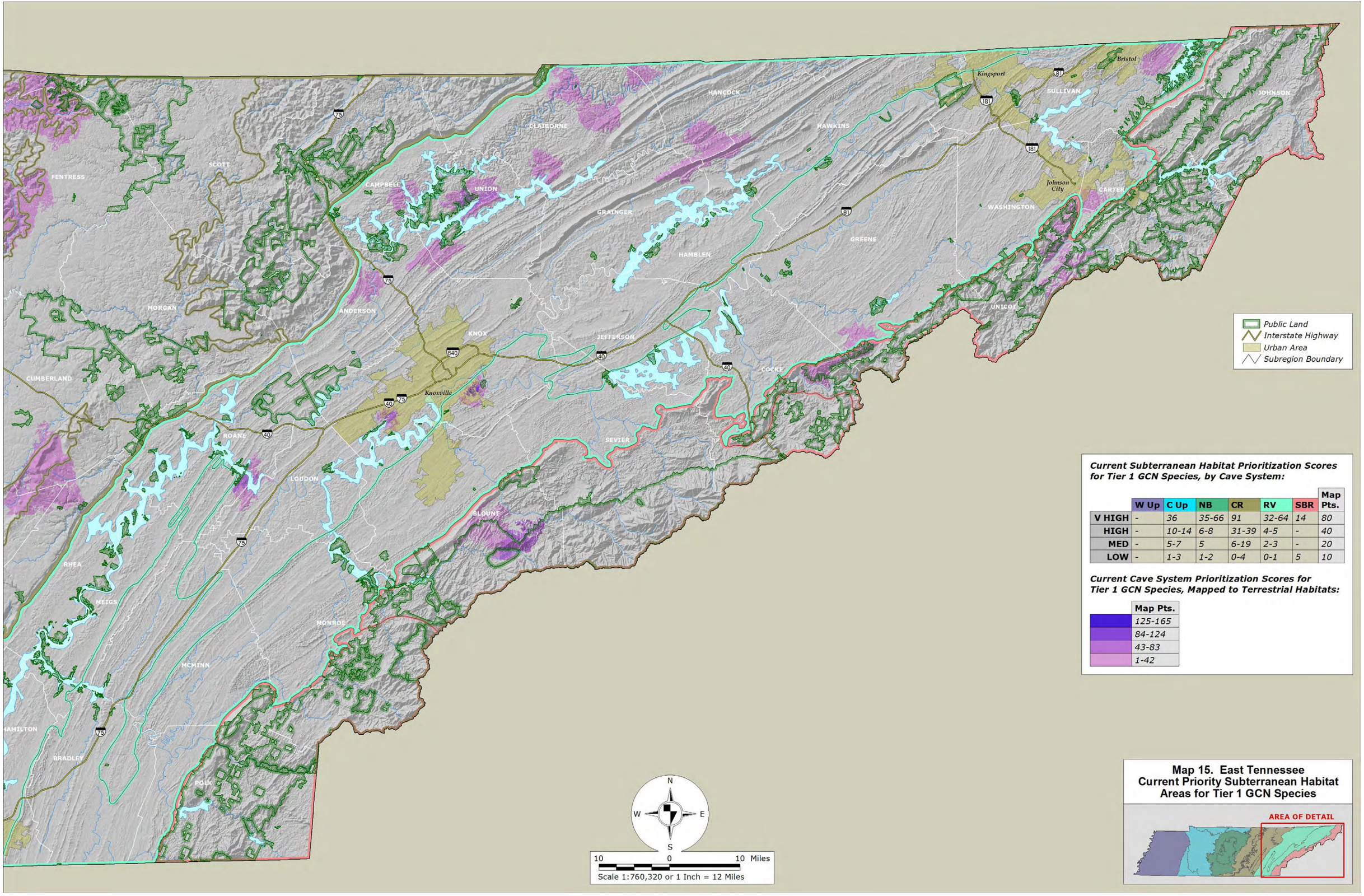
10 0 10 Miles
Scale 1:760,320 or 1 Inch = 12 Miles

Map 14. Middle Tennessee Current Priority Subterranean Habitat Areas for Tier 1 GCN Species

AREA OF DETAIL



Current Subterranean Habitat Prioritization Scores for Tier 1 GCN Species, by Cave System:

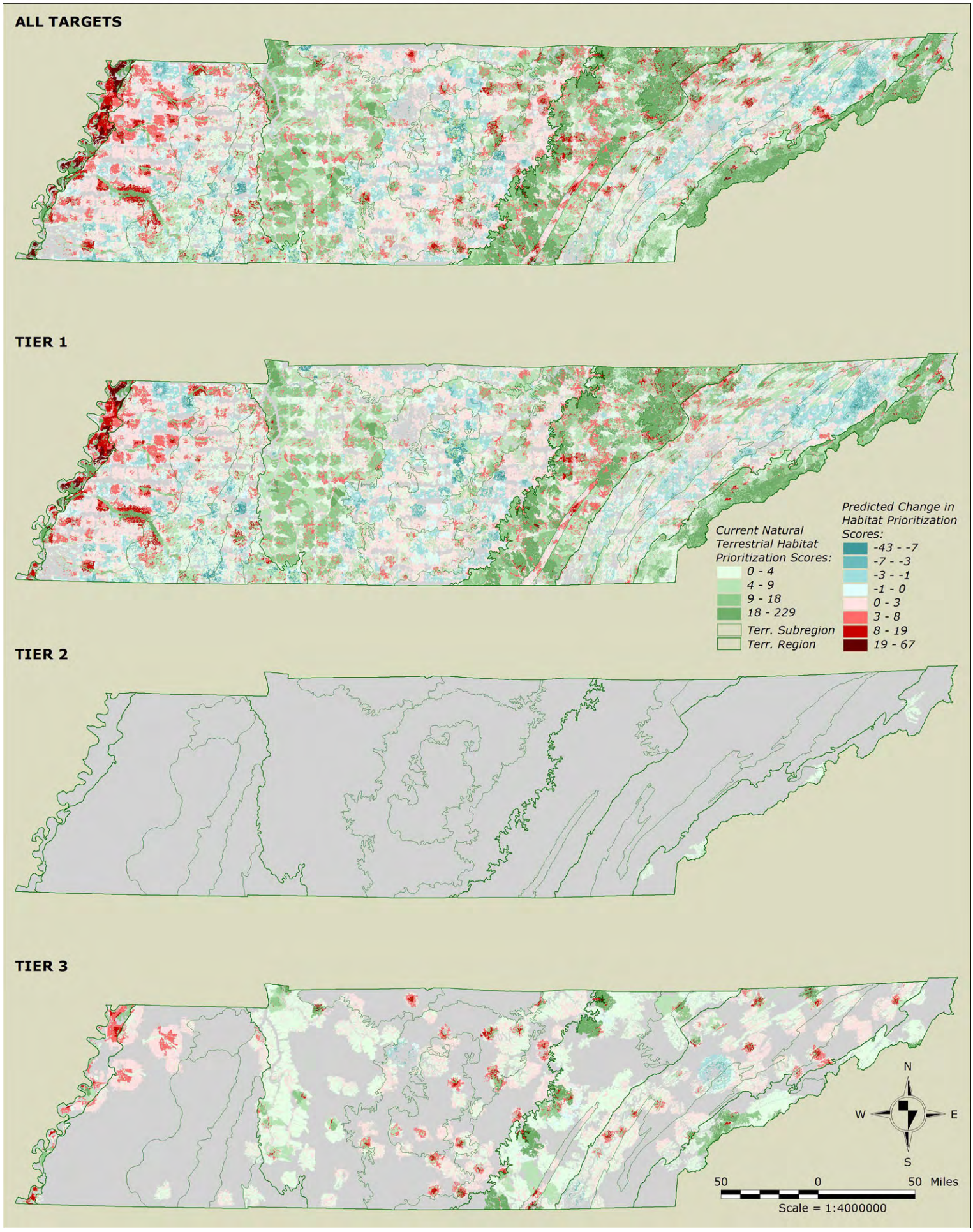
	W Up	C Up	NB	CR	RV	SBR	Map Pts.
V HIGH	-	36	35-66	91	32-64	14	80
HIGH	-	10-14	6-8	31-39	4-5	-	40
MED	-	5-7	5	6-19	2-3	-	20
LOW	-	1-3	1-2	0-4	0-1	5	10

Current Cave System Prioritization Scores for Tier 1 GCN Species, Mapped to Terrestrial Habitats:

Map Pts.
125-165
84-124
43-83
1-42

Map 15. East Tennessee Current Priority Subterranean Habitat Areas for Tier 1 GCN Species

Map 16. Priority Areas for Restoration to Dominant Subregional Forest Type for GCN Species by Tier Level



Predicted Change in Semi-natural Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
+ V HIGH	30-48	13-20	7-12	12-22	10-19	47-67
+ HIGH	19-29	9-12	5-6	10-11	7-9	12-29
+ MED	12-18	6-8	4	7-9	5-6	6-11
+ LOW	3-11	1-5	1-3	2-6	1-4	1-5

	ALL REGIONS
- LOW	-1 - -3
- MED	-4 - -7
- HIGH	-8 - -13
- V HIGH	-14 - -43

Current Natural Terrestrial Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
V HIGH	54-108	16-35	15-47	20-65	17-29	78-229
HIGH	28-54	13-16	12-15	15-20	12-17	25-78
MED	16-28	10-13	10-12	11-15	10-12	13-25
LOW	8-16	8-10	8-10	8-11	8-10	8-13

Public Land
Interstate Highway
Urban Area
Subregion Boundary

N
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S

10 0 10 Miles
Scale 1:760,320 or 1 Inch = 12 Miles

LAKE
OBION
WEAKLEY
HENRY
STEWART
Clarksville
MONTGOMERY
CHEATHAM
DYER
GIBSON
CARROLL
BENTON
HUMPHREYS
DICKSON
HOUSTON
CROCKETT
LAUDERDALE
Jackson
HENDERSON
DECATUR
PERRY
HICKMAN
MAURY
LEWIS
TIPTON
HAYWOOD
MADISON
CHESTER
WAYNE
SHELBY
Memphis
FAYETTE
HARDEMAN
MCNAIRY
HARDIN

Map 17. West Tennessee Priority Areas for Restoration to Dominant Subregional Forest Type for Tier 1 GCN Species

AREA OF DETAIL

Public Land
Interstate Highway
Urban Area
Subregion Boundary

Predicted Change in Semi-natural Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
+ V HIGH	30-48	13-20	7-12	12-22	10-19	47-67
+ HIGH	19-29	9-12	5-6	10-11	7-9	12-29
+ MED	12-18	6-8	4	7-9	5-6	6-11
+ LOW	3-11	1-5	1-3	2-6	1-4	1-5

	ALL REGIONS
- LOW	-1 - -3
- MED	-4 - -7
- HIGH	-8 - -13
- V HIGH	-14 - -43

Current Natural Terrestrial Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
V HIGH	54-108	16-35	15-47	20-65	17-29	78-229
HIGH	28-54	13-16	12-15	15-20	12-17	25-78
MED	16-28	10-13	10-12	11-15	10-12	13-25
LOW	8-16	8-10	8-10	8-11	8-10	8-13

N
W E
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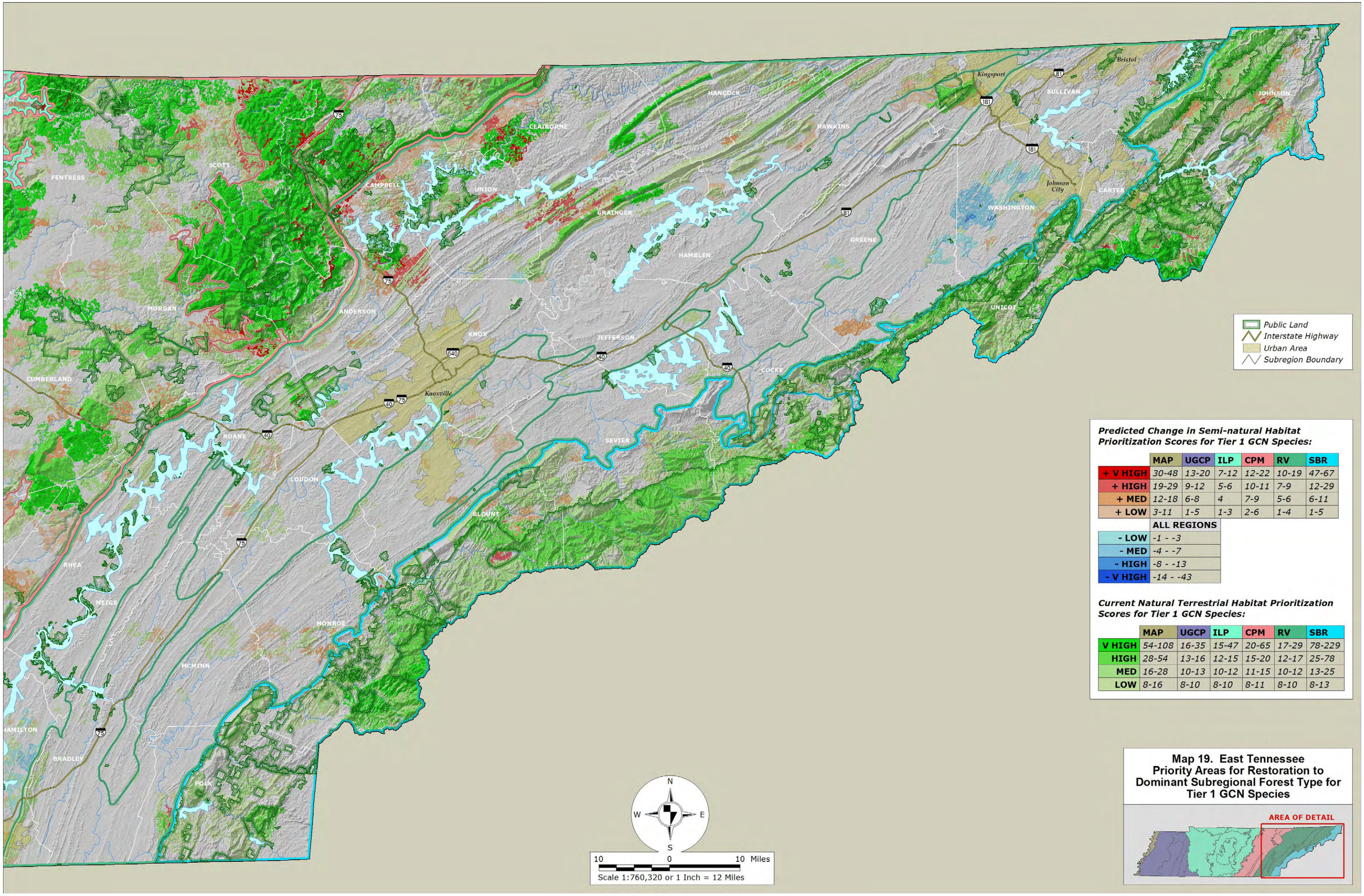
10 0 10 Miles
Scale 1:760,320 or 1 Inch = 12 Miles

Map 18. Middle Tennessee Priority Areas for Restoration to Dominant Subregional Forest Type for Tier 1 GCN Species

AREA OF DETAIL



Predicted Change in Semi-natural Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
+ V HIGH	30-48	13-20	7-12	12-22	10-19	47-67
+ HIGH	19-29	9-12	5-6	10-11	7-9	12-29
+ MED	12-18	6-8	4	7-9	5-6	6-11
+ LOW	3-11	1-5	1-3	2-6	1-4	1-5

	ALL REGIONS
- LOW	-1 - -3
- MED	-4 - -7
- HIGH	-8 - -13
- V HIGH	-14 - -43

Current Natural Terrestrial Habitat Prioritization Scores for Tier 1 GCN Species:

	MAP	UGCP	ILP	CPM	RV	SBR
V HIGH	54-108	16-35	15-47	20-65	17-29	78-229
HIGH	28-54	13-16	12-15	15-20	12-17	25-78
MED	16-28	10-13	10-12	11-15	10-12	13-25
LOW	8-16	8-10	8-10	8-11	8-10	8-13

Map 19. East Tennessee Priority Areas for Restoration to Dominant Subregional Forest Type for Tier 1 GCN Species

Conservation Priorities in Terrestrial Regions

As previously stated, the state of Tennessee is bisected by 6 terrestrial regions representing a broad variety of ecological system types in the southeastern United States (see Map 1 in *Chapter 1*). These regions include: the Mississippi Alluvial Plain, the Upper Gulf Coastal Plain, the Interior Low Plateau, the Cumberland Plateau & Mountains, the Ridge & Valley, and the Southern Blue Ridge. Terrestrial regional priorities are presented in geographic order from west to east as follows:

Mississippi Alluvial Plain (MAP)

The MAP covers approximately 2% of the total land area of Tennessee. The region encompasses a long, narrow corridor of land within the Mississippi River floodplain in the extreme western portion of the state. Descriptively, the landscape consists mostly of a network of forested wetland habitats interspersed with agricultural lands of various sorts. According to analysis conducted by TWRA's GIS laboratory, much of the natural forest systems of the region in Tennessee have been lost or significantly altered. Such findings have also been documented by the Lower Mississippi Valley Joint Venture (see www.lmvjv.org). Overall, the region is considered to be a globally important "flyway" for shorebirds and neo-tropical migratory bird species (Rich et al. 2004).

At present, habitats in the MAP consist of 2 natural systems, 10 semi-natural systems, and 1 non-natural system type. GCN fauna utilize these habitat types to varying degrees (see Table 18 and Appendix D). On average, about 70% of GCN species in the MAP depend upon the two natural systems. Similarly, a large portion of GCN fauna in the region (~50%) also make use of semi-natural grassland and wetland habitat types to some degree. Other semi-natural habitats are

Table 18. Priority Terrestrial Habitat Types by Tier 1 GCN Species in the MAP

Habitat Type	# of Species	Sum of Rarity – Preference Scores*	Average Rarity – Pref. Score**
Natural			
Lower MS River Bottomland Depression	49	375.50	7.66
Lower MS River Bottomland & Floodplain Forest	51	372.70	7.31
Semi-natural			
Converted Wetland (Palustrine)	38	213.10	5.61
Old Field/Successional Grassland	35	199.60	5.70
Converted Wetland (Riverine)	37	197.80	5.35
Converted Wetland (Lacustrine)	36	196.20	5.45
Pasture	34	157.80	4.64
Urban / Suburban Managed Grassland	35	143.60	4.10
Excavated Land	24	92.20	3.84
Cropland	22	75.70	3.44
Urban / Suburban Managed Forestland	20	54.20	2.71
Forest Plantation	13	39.60	3.05
Non-natural			
Edifices / Other Man-made Structures	4	26.50	6.63

(*note: Rarity–preference scores are composed of the cumulative point values assigned to the global and state ranks multiplied by the preference ratings of habitats for each GCN species)

(** The average rarity–preference score = sum of rarity–preference scores divided by # of species in the habitat.)

exploited in lesser increments by GCN fauna, along with non-natural habitats. When rarity and preference scores are taken into consideration, again the rarest of GCN fauna are found to be utilizing the two natural wetland system types.

With the GIS model, mappable units of terrestrial ecological systems were segregated into 4 portfolios of priority habitat areas (see Map 5). In the MAP, only one natural system is mappable (Lower Mississippi River Bottomland & Floodplain Forest). Again, these portfolios represent combinations of habitats and Tier 1 species occurrences of varying degrees of rarity and viability (see Table 19 & Appendix G).

Portfolio 1 contains the highest rated assortment of GCN species at 29, with an average prioritization score per habitat type of 98.53. This portfolio constitutes 25,994 acres of essentially natural terrestrial habitat. A site example for portfolio 1 is Reelfoot Lake, which contains a number of bird, herp, and other GCN species. Portfolio 2 has 31 GCN species and the next highest prioritization score of 38.54. This portfolio is the largest of all with 39,124 acres of natural wetland habitat. Portfolio 3 has the highest and most diverse number of GCN fauna at 40 species. However, the prioritization scores for these species are considerably lower at 22.08. Likewise, this portfolio constitutes 27,248 acres of natural and semi-natural habitats. Portfolio 4 also has a high number of GCN species at 38, but again, the average prioritization score is relatively low at 9.80. Similarly, this portfolio is made up of a more diverse collection of natural and semi-natural habitats totaling 27,062 acres. Much of the disparity among average GCN species prioritization scores in the MAP comes from the low number of habitats found in the first three portfolios, which increases the average score per habitat significantly. Collectively, all four portfolios constitute 103,282 acres of priority lands for conservation. Approximately 64,920 acres or 54% of these portfolio areas are publicly owned.

Given the loss of natural systems, habitat

Table 19. Priority Terrestrial Conservation Portfolios in the MAP

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	29	31	40	38
# of Tier 1 Vertebrates:	*28*	*30*	*40*	*38*
Amphibians	*1*	*0*	*2*	*1*
Birds	*22*	*29*	*33*	*34*
Mammals	*3*	*0*	*3*	*1*
Reptiles	*2*	*1*	*2*	*2*
# of Tier 1 Invertebrates:	*1*	*1*	*0*	*0*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*1*	*1*	*0*	*0*
Average Species Prioritization Score per Habitat Type	98.53	38.54	22.08	9.80
# of Mapped Habitat Types:	1	1	2	4
Natural	*1*	*1*	*1*	*1*
Semi-natural	*0*	*0*	*1*	*3*
Non-natural	*0*	*0*	*0*	*0*
Total Acreage of all Portfolio Units	25,994	39,124	27,248	27,062

restoration is a key activity in the MAP. Connectivity between habitat units of various portfolios should be a primary consideration when selecting priority areas to begin working. Natural wetland types such as bottomland depressions and floodplain forests are presumably the most beneficial systems to restore, due to the high species prioritization scores associated with existing habitat units.

Priority areas for potential restoration were calculated based on the overall benefit of converting semi-natural habitat types within the MAP to Lower Mississippi River Bottomland and Floodplain Forest (see Map 17 & Table 20). According to GIS analysis, restoration portfolio 1 (15,972 acres) would benefit 27 species with an average increase in prioritization scores of 40.49. The second portfolio (61,870 acres) would benefit 32 GCN species with an average increase in prioritization scores of 26.48. The third and fourth restoration portfolios (77,769 & 32,257 acres) would benefit 33 and 29 GCN species respectively with an average increase of 17.28 and 11.45.

Total acreage of all four restoration portfolios is 187,868 acres. Semi-natural areas not benefiting from conversion of this forest type constitute less than 280 acres in the MAP. Again, these areas may benefit from other types of restoration. Overall, the acreage values in the portfolios represent only hypothetical restoration scenarios. They are not meant to infer an actual amount of needed restoration in a region. However, benefit and acreage figures for the scenario do convey a general sense of where gains can be made for GCN species in the MAP.

Another consideration in the selection of a portfolio of places to begin work is relative imperilment. A list of the highest rated

Table 20. Priority Terrestrial Restoration Portfolios in the MAP

Restoration Scenario – *Conversion of semi-natural habitats to Lower Mississippi River Bottomland and Floodplain Forest*

Species & Habitat Categories	Restoration Portfolio 1 (Very High)	Restoration Portfolio 2 (High)	Restoration Portfolio 3 (Medium)	Restoration Portfolio 4 (Low)
# of Tier 1 Species to Benefit	27	32	33	29
# of Tier 1 Vertebrates:	*26*	*32*	*33*	*29*
Amphibians	*1*	*1*	*2*	*1*
Birds	*22*	*26*	*27*	*25*
Mammals	*2*	*3*	*3*	*1*
Reptiles	*1*	*2*	*1*	*2*
# of Tier 1 Invertebrates:	*1*	*0*	*0*	*0*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*1*	*0*	*0*	*0*
Average Increase in Species Prioritization Score	40.49	26.48	17.28	11.45
# of Restoration Units in Portfolio	28	79	132	144
Total Acreage of all Restoration Portfolio Units	15,972	61,870	77,769	32,257

Table 21. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the MAP

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Incompatible Row Crop Agricultural Practices	36	228.56	6.35
Primary Residential Development	34	226.08	6.65
Commercial / Industrial Development	33	213.05	6.46
Agricultural Conversion	34	209.55	6.16
Construction of Ditches / Dikes / Drainage / Diversion Systems	25	176.33	7.05
Incompatible Grazing / Pasture Management Practices	17	107.11	6.30
Incompatible Forestry Practices	22	86.02	3.91
Industrial Discharge	6	47.20	7.87
Construction of Roads / Railroads / Utilities	10	44.06	4.41
Incompatible Species Management Practices	12	35.86	2.99
Operation of Drainage / Diversion Systems	9	31.39	3.49
Municipal Wastewater Treatment / Stormwater Runoff	5	37.56	5.51
Excessive Competition / Predation by Native Species	7	18.27	2.61
Recreational Use of Habitats (Non-vehicular)	3	18.17	6.06
Illegal Hunting/Fishing/Collection/ Killing	6	11.80	1.97
Channelization of Rivers / Streams	1	7.31	7.31

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

sources of stress linked to GCN species was compiled for the MAP (see Table 21). Overall, 16 sources of stress were selected for target species in the region. These sources were rated according to the sum of the calculated stress – rarity scores for each faunal element linked to a source of stress. Again, these scores reflect the overall severity of the stress in relation to the rarity of species affected by the stress.

Top sources of stress identified by the planning team in the region are related mainly to incompatible agricultural practices and conversion of forest land and wetlands for agricultural purposes. Urban development and related infrastructure improvements are another identified source of stress on targets. Much of the development is due to the region's proximity to Memphis, a major metropolitan area, located in the southwest corner of the region in Tennessee. However, other areas of the MAP are relatively remote and undeveloped. A third category of sources of stress is related to water management activities for navigation and flood control The

Mississippi River is a major transportation corridor. For decades attempts have been made to "tame" the river via a series of dikes, levees, and other water control structures. In addition, lesser sources of stress include: incompatible forestry practices, recreational use, poaching, and other activities that cause disturbance to habitats and species.

Upper Gulf Coastal Plain (UGCP)

The UGCP covers approximately 23% of the total land area of Tennessee. The region covers much of the western portion of the state between the Mississippi River floodplain and the uplands of the Tennessee River, where it bisects the state. In general, the Tennessee River is considered to be the dividing line between West and Middle Tennessee. Like the MAP, much of the UGCP consists of fertile loess soils well-suited for farming. Similarly, GIS analysis by TWRA has revealed that a sizable amount of the western portion of the UGCP has been converted for agricultural use. Lowland areas in this part of the region consist primarily of natural wetland habitats interspersed with a variety of other semi-natural habitat types. The landscape in western portions of the region is "hilly" and generally less productive for agriculture. Subregions in this part of the UGCP contain a mixture of natural upland forest habitats mixed with upland semi-natural habitat types such as pasture. Despite the large presence of agriculture, the UGCP supports some of the best remaining examples of bottomland hardwood forests in the Southeast (The Nature Conservancy 2004). Overall, there is great potential for restoration of the region.

Currently, habitats for GCN species in the UGCP consist of 17 natural systems, 10 semi-natural systems, and 1 non-natural system type (see Table 22 & Appendix D). Slightly more than half the species in the region (~55%) depend on one or more of the natural wetland system types of the region. Remaining species depend on a variety of upland forest types or one of the several prairie – barren – glade complexes. Similarly, almost half of the rare species in the region

depend on semi-natural grassland types, such as old fields and pastures. Other natural, semi-natural, and non-natural habitats are also utilized in varying degrees by fauna. When rarity and habitat preference are taken into consideration, again major natural wetland systems contain the rarest species in the region, followed by various prairie / barren systems. Old field / successional grassland systems also score fairly high for rare species in the UGCP.

Analysis of GCN species prioritization scores for current mappable units of terrestrial ecological systems was also conducted for the UGCP (see Map 5, Table 23, & Appendix G). Portfolio 1 contains the highest rated faunal assortment with 36 GCN species, and an average prioritization score per habitat type of 19.55. As well, this portfolio captures 77,297 acres of primarily natural wetland and mesic upland forest habitats. A site example for portfolio 1 is the Hatchie River, which contains key bottomland forest habitats supporting several birds, herps, mammals, and other GCN species. Portfolio 2 has 39 species and the next highest prioritization score of 14.47. This portfolio contains a similar complement of natural habitats, but contains more pasture lands for a total of 71,611 acres. Portfolio 3 has 42 species but a lower prioritization score of 11.86. This portfolio incorporates additional

Table 22. Priority Terrestrial Habitat Types by Tier 1 GCN Species in the UGCP

Habitat Type	# of Species	Sum of Rarity – Preference Scores*	Average Rarity – Pref. Score**
Natural			
East Gulf Coastal Plain (EGCP) Large River Floodplain Forest	36	277.20	7.70
EGCP Small Stream & River Floodplain Forest	35	248.70	7.11
EGCP Jackson Plain Prairie & Barrens	30	248.10	8.27
EGCP Black Belt Calcareous Prairie & Woodland	30	248.10	8.27
South-Central Interior (SCI) Small Stream & Riparian	35	229.10	6.55
EGCP Northern Seepage Swamp	31	204.30	6.59
SCI / Upper Coastal Plain Wet Flatwoods	34	201.30	5.92
EGCP Northern Mesic Hardwood Forest	31	176.80	5.70
SCI Mesophytic Forest	31	172.60	5.57
Central Interior Highlands (CIH) Dry Acidic Glade and Barrens	23	166.20	7.23
SCI / Upper Coastal Plain Flatwoods	34	159.80	4.70
EGCP Limestone Forest	30	159.60	5.32
CIH Calcareous Glade and Barrens	22	156.80	7.13
EGCP Northern Loess Bluff Forest	30	154.70	5.16
EGCP Interior Shortleaf Pine-Oak Forest	29	131.70	4.54
EGCP Northern Loess Plain Oak-Hickory Upland	30	120.60	4.02
EGCP Northern Dry Upland Hardwood Forest	30	112.60	3.75
Semi-natural			
Old Field/Successional Grassland	32	218.70	6.83
Urban / Suburban Managed Grassland	30	131.30	4.38
Pasture	29	130.50	4.50
Converted Wetland (Palustrine)	21	127.90	6.09
Converted Wetland (Riverine)	20	112.60	5.63
Converted Wetland (Lacustrine)	19	111.00	5.84
Excavated Land	24	91.30	3.80
Urban / Suburban Managed Forestland	26	69.30	2.67
Forest Plantation	17	62.70	3.69
Cropland	16	53.00	3.31
Non-natural			
Edifices / Other Man-made Structures	6	34.90	5.82

(*note: Rarity–preference scores are composed of the cumulative point values assigned to the global and state ranks multiplied by the preference ratings of habitats for each GCN species)

(** The average rarity–preference score = sum of rarity–preference scores divided by # of species in the habitat.)

Table 23. Priority Terrestrial Conservation Portfolios in the UGCP				
Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	36	39	42	47
# of Tier 1 Vertebrates:	*36*	*39*	*42*	*47*
Amphibians *Birds* *Mammals* *Reptiles*	*2* *25* *4* *5*	*1* *27* *6* *5*	*3* *28* *6* *5*	*4* *28* *6* *9*
# of Tier 1 Invertebrates:	*0*	*0*	*0*	*0*
Crustaceans *Snails*	*0* *0*	*0* *0*	*0* *0*	*0* *0*
Average Species Prioritization Score per Habitat Type	19.55	14.47	11.86	8.84
# of Mapped Habitat Types:	4	5	7	11
Natural *Semi-natural* *Non-natural*	*3* *1* *0*	*4* *1* *0*	*5* *2* *0*	*6* *5* *0*
Total Acreage of all Portfolio Units	77,297	71,611	69,281	195,714

dry upland forest types for a total of 69,281 acres. Portfolio 4 has the largest number of GCN species at 49 but the lowest average prioritization score per habitat type at 8.84. Overall, this portfolio captures a more diverse assortment of natural and semi-natural habitat types totaling 195,714 acres. Together, all four portfolios constitute 413,903 acres of priority lands in need of additional conservation work. Approximately 46,893 acres or 11% of these portfolio areas are publicly owned.

Priority areas for potential restoration in the UGCP were calculated based on the overall benefit of converting semi-natural habitat types to East Gulf Coastal Plain Large River Floodplain Forest (see Map 17 & Table 24). Upland sub-regions of the UGCP that contain lesser amounts of this habitat type were excluded from the GIS model. With the analysis, restoration portfolio 1 containing 40,046 acres would benefit 27 species with an average increase in GCN species prioritization scores of 15.09. The second portfolio consisting of 101,402 acres would benefit 30 species with an average increase in prioritization scores of 10.43. The third and fourth restoration portfolios at 169,156 and 146,256 acres would benefit 27 and 28 GCN species respectively with an average increase of 7.52 and 4.56. Total acreage of all four portfolios is 456,860 acres. Semi-natural areas not benefiting from restoration of this forest type constitute approximately 57,139 acres in the UGCP. Again, these areas may gain from other types of restoration. Upland areas in the region would likely benefit from restoration of East Gulf Coastal Plain Interior Shortleaf Pine-Oak Forest and/or other forest types.

A list of the highest rated sources of stress linked to GCN species of different rarity was also compiled for the UGCP (see Table 25). Overall, 16 sources of stress were identified by the planning team as likely causing significant effects to GCN species or habitats in the region. In western portions of the UGCP, many problems are similar to the MAP

Table 24. Priority Terrestrial Restoration Portfolios in the UGCP

Restoration Scenario – *Conversion of semi-natural habitats to Lower Mississippi River Bottomland and Floodplain Forest*

Species & Habitat Categories	Restoration Portfolio 1 (Very High)	Restoration Portfolio 2 (High)	Restoration Portfolio 3 (Medium)	Restoration Portfolio 4 (Low)
# of Tier 1 Species to Benefit	27	30	27	28
# of Tier 1 Vertebrates:	*27*	*30*	*27*	*28*
Amphibians	*2*	*3*	*2*	*3*
Birds	*16*	*15*	*15*	*13*
Mammals	*5*	*7*	*6*	*7*
Reptiles	*4*	*5*	*4*	*5*
# of Tier 1 Invertebrates:	*0*	*0*	*0*	*0*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*0*	*0*	*0*	*0*
Average Increase in Species Prioritization Score	15.09	10.43	7.42	4.56
# of Restoration Units in Portfolio	205	508	824	573
Total Acreage of all Restoration Portfolio Units	40,046	101,402	169,156	146,256

both in scope and origin. Urban development, historic agricultural conversion, and wide-scale agricultural use of land for row crop production and pasture constitute the primary sources of stress. The region is generally rural compared to other parts of the state. However, some urban areas in the region are rapidly growing, especially Memphis and Jackson.

Declines in agriculture in recent years have contributed to the sale of farmland for commercial, industrial, and residential development. Nevertheless, the region remains a key agricultural region in the state producing cotton, soybeans, and beef cattle. The effects on terrestrial habitats from agriculture are primarily due to the extent of historic habitat conversion that took place (Herrington & Schulstad 1982). However, current row crop and grazing / pasture management practices were linked as having significant effects on GCN species by the planning team. These effects are related primarily to plowing, mowing, and other activities that maintain semi-natural habitat.

Despite its absence from the list, channelization has long been a source of stress to terrestrial bottomland hardwood systems. Many streams in the UGCP region are suffering from excessive sedimentation from channelization, which clogs waterways and creates flooding beyond the boundaries of riparian zones. As a result, bottomland hardwoods and adjoining upland forests of the region are declining due to inundation by water and sediment (The Nature Conservancy *unpublished report* 2003b). Relatively few forested floodplains have not been affected to

Table 25. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the UGCP

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Commercial / Industrial Development	35	258.94	7.40
Primary Residential Development	35	258.47	7.39
Agricultural Conversion	35	195.88	5.60
Incompatible Row Crop Agricultural Practices	32	180.16	5.63
Incompatible Grazing / Pasture Management Practices	21	126.56	6.03
Incompatible Forestry Practices	26	102.42	3.94
Construction of Ditches / Dikes / Drainage / Diversion Systems	12	79.78	6.65
Construction of Roads / Railroads / Utilities	12	59.72	4.98
Fire Suppression	10	58.95	5.90
Excessive Competition / Predation by Native Species	7	26.50	3.79
Forestry Conversion	4	22.56	5.64
Municipal Wastewater Treatment / Stormwater Runoff	4	21.56	5.39
Illegal Hunting/Fishing/Collection/ Killing	10	21.08	2.11
Industrial Discharge	4	18.00	4.50
Incompatible Species Management Practices	2	3.80	1.90
Recreational Use of Habitats (Non-vehicular)	1	1.88	1.88

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

some degree by efforts to channelize rivers and streams in the UGCP.

In the more upland eastern sections of the UGCP, sources of stress are related more to forest use and related species management practices. In particular, fire suppression has likely led to declines in the matrix pine – oak forest type which is thought to have dominated much of the region in the past (NatureServe *unpublished data* 2003). Conversion of forests to other land use types combined with disruptions in forest composition have also led to other stresses such as excessive competition by native species. An example of this source of stress includes cow bird parasitism (Robinson et al. 1992). Lesser sources of stress in the UGCP include contamination from municipal stormwater runoff and industrial discharges that release various pollutants into wetland habitats, illegal collection or killing of animals, and incompatible recreational use of habitats.

Interior Low Plateau (ILP)

The ILP is the largest terrestrial region in Tennessee, covering approximately 37.3% of the state's landmass. The boundaries of this region stretch from the Tennessee River to the edge of the Cumberland Plateau

escarpment. In general, the region encompasses most of what is referred to as the Middle Tennessee area. The terrain consists mainly of rolling hills, except in the "Highland Rim" and "Pennyroyal Plain" sub-regions, which comprise a relatively flat low plateau region that encircles the lower "Central Basin" sub-regions. In general, the landscape is composed of a mosaic of forests and agricultural lands. The soils of the ILP are not as conducive as the western portion of the state to row crop agriculture. However, the underlying limestone geology supports bountiful pasturage for the region's many cattle and horse farms. Overall, the "patchiness" of the forests in the region is a result of clearing but is also due to large swaths of natural grassland – savanna conditions that historically occurred in the region. At one time, fragments of the Tallgrass Prairie Ecosystem occurred across several sections of the ILP to such extent that allowed bison to roam the region (The Nature Conservancy 2005). As well, the central portion of the region is known for its "Cedar Glades", which are shallow soil areas that are relatively treeless. These glades support extremely high levels of rare, endemic plant species found nowhere else in the world (TN Division of Natural Heritage 2004). Overall, fire has played a large role in determination and maintenance of many of the forest, woodland, and grassland habitats of the ILP.

Today, habitats for GCN species in the ILP consist of 16 natural systems, 10 semi-natural systems, and 1 non-natural system type (see Table 26 & Appendix D). Analysis of current habitat preferences by rare species shows that both the region's mesic forests and xeric grassland – woodland systems are important habitats. Just over half (52%) of GCN species are associated with the rich, mesic forests in the region. These mixed-mesophytic forest types are present mainly in the many hollows and swales created from the undulating landscape. Likewise, riparian and isolated wetland types are often interspersed with these mesic forest types. Prairie – barren systems are also extremely important habitats in the ILP. Approximately

43% of GCN species utilize grassland habitats to some degree. However, only relict stands of natural grassland systems remain today.

Analysis of current habitat units for GCN fauna in the region revealed a multitude of priority habitat areas (see Map 6, Table 27, & Appendix G). Again, these areas are divided into four portfolios of mixed habitat types. Portfolio 1 contains the highest rated faunal assortment with 45 GCN species, and an average species prioritization score per habitat type of 17.92. As well, this portfolio captures 263,695 acres of primarily natural xeric and mesic upland forest habitats and riparian wetlands. A site example for portfolio 1 includes Land Between the Lakes, which contains neo-tropical birds, amphibians, mammals, and other GCN species. Portfolio 2 has 51 species and the next highest prioritization score of 14.05. Like the first portfolio, this portfolio contains a similar mix of natural habitats, but contains more pasture lands for a total of 199,929 acres. Portfolio 3 also has 51 taxa but a lower average species prioritization score of 11.60. This portfolio incorporates small portions of additional semi-natural habitats but otherwise has a

Table 26. Priority Terrestrial Habitat Types by Tier 1 GCN Species in the ILP

Habitat Type	# of Species	Sum of Rarity – Preference Scores*	Average Rarity – Pref. Score**
Natural			
South-Central Interior Mesophytic Forest	42	356.20	8.48
Eastern Highland Rim Prairie & Barrens	36	349.20	9.70
Western Highland Rim Prairie & Barrens	35	331.50	9.47
Pennyroyal Karst Plain Prairie & Barrens	34	307.80	9.05
South-Central Interior Small Stream & Riparian	32	265.40	8.29
Southern Interior Low Plateau Dry Oak Forest	41	259.00	6.32
Central Interior Highlands Calcareous Glade and Barrens	29	233.60	8.06
Central Interior Highlands Dry Acidic Glade and Barrens	28	233.20	8.33
South-Central Interior Large Floodplain	32	229.60	7.18
Central Interior Highlands & Appalachian Sinkhole & Depression Pond	32	219.40	6.86
Nashville Basin Limestone Glade	28	215.80	7.71
Western Highland Rim Seepage Fen	25	151.80	6.07
Southern Appalachian Low Mountain Pine Forest	28	122.70	4.38
Central Interior Calcareous Cliff & Talus	10	121.20	12.12
Central Interior Acidic Cliff & Talus	6	50.40	8.40
Southern Interior Sinkhole Wall	3	29.00	9.67
Semi-natural			
Old Field/Successional Grassland	36	267.70	7.44
Pasture	32	173.50	5.42
Urban / Suburban Managed Grassland	32	156.70	4.90
Converted Wetland (Palustrine)	18	124.00	6.89
Converted Wetland (Riverine)	13	109.70	8.44
Converted Wetland (Lacustrine)	13	109.70	8.44
Excavated Land	24	92.90	3.87
Urban / Suburban Managed Forestland	25	83.20	3.33
Cropland	18	61.80	3.43
Forest Plantation	15	49.00	3.27
Non-natural			
Edifices / Other Man-made Structures	4	24.50	6.13

(*note: Rarity–preference scores are composed of the cumulative point values assigned to the global and state ranks multiplied by the preference ratings of habitats for each GCN species)

(** The average rarity–preference score = sum of rarity–preference scores divided by # of species in the habitat.)

Table 27. Priority Terrestrial Conservation Portfolios in the ILP				
Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	45	51	51	55
# of Tier 1 Vertebrates:	*45*	*49*	*49*	*52*
Amphibians	*2*	*1*	*2*	*2*
Birds	*34*	*35*	*34*	*36*
Mammals	*5*	*8*	*7*	*9*
Reptiles	*4*	*5*	*6*	*5*
# of Tier 1 Invertebrates:	*0*	*2*	*2*	*3*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*0*	*2*	*2*	*3*
Average Species Prioritization Score per Habitat Type	17.92	14.05	11.60	8.83
# of Mapped Habitat Types:	5	5	7	6
Natural	*4*	*4*	*4*	*4*
Semi-natural	*1*	*1*	*3*	*2*
Non-natural	*0*	*0*	*0*	*0*
Total Acreage of all Portfolio Units	263,695	199,929	386,013	1,060,174

similar complement of natural systems totaling 386,013 acres. Portfolio 4 has the largest number of GCN species at 55 but the lowest average prioritization score per habitat type at 8.83. Again, this portfolio captures a similar assortment of natural and semi-natural habitat types to the other three portfolios totaling 1,060,074 acres. All four portfolios constitute 1,909,811 acres of priority lands. Approximately 177,019 acres or 9% of these portfolio areas are publicly owned.

Overall, each of the portfolios has a similar mix of natural and semi-natural systems. However, the portfolios vary considerably by the amount of included pasture lands. Combined, approximately 265,420 acres of pasture are captured in all four portfolios. It is important to realize that many of the lands currently mapped as pasture were likely part of the natural grassland – savanna habitat mosaic described previously. Current satellite land classification methods can not easily resolve differences between some natural and semi-natural habitat components. As such, it should not be overly construed that pasture is biologically important as a specific habitat type. A more realistic assessment is that pasture lands provide vestigial benefits to GCN species that once were provided by higher quality natural grasslands. However, in general terms, the open conditions provided by pasture are clearly benefiting some species. Overall, pastures should be considered as potentially important grassland restoration areas.

Priority areas for potential restoration in the ILP were calculated based on the overall benefit of converting semi-natural habitats to Southern Interior Low Plateau Dry Oak Forest, which is the dominant forest system of the region. Again, four restoration portfolios were developed to highlight important areas for reforestation of this forest type (see Map 18 & Table 28). With the analysis, restoration portfolio 1 containing 24,783 acres would benefit 22 species with an average increase in prioritization scores of 10.12. The second portfolio consisting of 66,995 acres would

Table 28. Priority Terrestrial Restoration Portfolios in the ILP

Restoration Scenario – *Conversion of semi-natural habitats to Southern Interior Low Plateau Dry Oak Forest*

Species & Habitat Categories	Restoration Portfolio 1 (Very High)	Restoration Portfolio 2 (High)	Restoration Portfolio 3 (Medium)	Restoration Portfolio 4 (Low)
# of Tier 1 Species to Benefit	22	22	22	21
# of Tier 1 Vertebrates:	*22*	*22*	*22*	*21*
Amphibians	*1*	*2*	*1*	*1*
Birds	*13*	*12*	*12*	*12*
Mammals	*4*	*4*	*4*	*4*
Reptiles	*4*	*4*	*5*	*4*
# of Tier 1 Invertebrates:	*0*	*0*	*0*	*0*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*0*	*0*	*0*	*0*
Average Increase in Species Prioritization Score	10.12	6.33	4.48	3.17
# of Restoration Units in Portfolio	122	464	374	441
Total Acreage of all Restoration Portfolio Units	24,783	66,995	79,194	109,432

benefit 22 species with an average increase in prioritization scores of 6.33. The third and fourth restoration portfolios at 79,194 and 109,432 acres would benefit 22 and 21 GCN species respectively with an average increase of 4.48 and 3.17. Total acreage of all four portfolios is 280,494 acres. Semi-natural areas not benefiting from restoration of this forest type constitute approximately 138,379 acres in the ILP. The ratio of benefiting to non-benefiting habitat acreage suggests that restoration of Southern Interior Low Plateau Dry Oak Forest does not provide the highest returns as a restoration scenario. Instead, restoration of natural grassland system types may provide additional benefit for the region. However, no analysis was conducted to establish comparative numbers of other restoration scenarios. Much more research needs to be done in the ILP.

An assessment of the highest rated sources of stress linked to GCN species of different rarity was also conducted for the ILP (see Table 29). A total of 16 sources of stress were identified as potentially contributing significant effects to GCN species or habitats in the region. Much like the UGCP, urban development, conversion of natural habitat types to agricultural use, and incompatible agricultural and forestry practices are believed to be the chief sources of potential stress. According to the U.S. Census Bureau's 2000 Census, the Middle Tennessee area is one of the fastest growing regions of the state. Much of the population growth is centered on the metropolitan area of Nashville. Urban sprawl in the Nashville area is rapidly consuming both natural and semi-natural habitats. As suburban communities spread further from the city's center, rural

Table 29. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the ILP

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Primary Residential Development	55	480.28	8.73
Agricultural Conversion	52	389.04	7.48
Commercial / Industrial Development	47	385.50	8.20
Incompatible Forestry Practices	43	254.30	5.91
Incompatible Row Crop Agricultural Practices	29	194.53	6.71
Incompatible Grazing / Pasture Management Practices	26	192.19	7.39
Construction of Roads / Railroads / Utilities	16	86.03	5.38
Fire Suppression	11	70.33	6.39
Forestry Conversion	19	53.95	2.84
Municipal Wastewater Treatment / Stormwater Runoff	4	23.97	5.99
Excessive Competition / Predation by Native Species	7	15.11	2.16
Illegal Hunting/Fishing/Collection/ Killing	7	14.52	2.07
Industrial Discharge	2	13.25	6.63
Parasites / Pathogens	1	9.84	9.84
Recreational Use of Habitats (Non-vehicular)	1	1.88	1.88
Incompatible Species Management Practices	1	1.69	1.69

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

areas on the periphery have undergone further subdivision of land. Farms and forests alike are being developed in the wake of unchecked growth. Another primary source of stress contributing to the demise of grassland systems in the region is fire suppression. Much of the suppression of fire is due to the close proximity of remaining grassland systems to urban areas. Likewise, urban health issues combined with property protection make reintroduction of fire a difficult undertaking. Also, in the Western Highland Rim sub-region, native hardwood forests have been converted to pine plantations (Wear and Greis 2003). Other less significant sources of stress in the ILP include: municipal wastewater treatment / stormwater runoff management and industrial discharge affecting wetlands, and various species related problems such as excessive competition by native species, poaching, disease, recreational use, and incompatible species management practices.

Cumberland Plateau & Mountains (CP&M)

The CP&M region composes approximately 13.5% of the state. The region consists of an uplifted area of high plateau and low mountains that separate the Interior Low Plateau from the Ridge & Valley region of East Tennessee. Due to the higher elevations and rough terrain, the CP&M was

one of the last regions to be settled in the state. Early pioneers typically skirted the area in favor of more productive farm lands further west. The region is still relatively unpopulated today. Overall, the landscape is mostly forested except in flatter portions of the Cumberland Plateau and the Sequatchie Valley, where some forests have been cleared for pasture. Relatively little row crop agriculture is present due to the generally poor soils. Vast tracts of forestland still cover much of the Cumberland Mountains, the eastern and western escarpments of the plateau, and select portions of the northern, central, and southern Cumberland Plateau proper. Overall, the mix of rugged mountains and deep gorges provide an assortment of rich, cove forest habitats. Historically, many of the forests grew extremely large trees that were prized for lumber.

At present, habitats in the CP&M consist of 17 natural systems, 10 semi-natural systems, and 1 non-natural system type. Again, rare fauna utilize these habitat types to varying degrees (see Table 30 & Appendix D). The majority of GCN species (72%) depend upon one or more of the natural forest habitats. Analysis of rarity and preference among fauna shows that mesic mixed hardwood and conifer forests support the bulk of GCN species in the region, followed by drier hardwood forests, pine forests, and then riparian wetland forests. Other natural habitats utilized to lesser degrees in the region include various glades & barrens, isolated wetlands, cliffs, and river scour prairies. Rare fauna in the region (~32%) also make use of several semi-natural grassland habitats. Despite the dominance of forests in the region, fire did play a significant role in the region in creating barrens and other open areas important to grassland species (The Nature Conservancy 2003). Like other regions of the state, very few intact examples of natural grassland habitats exist. Other semi-natural and non-natural habitats also support fauna at different levels in the CP&M.

Analysis of GCN species prioritization scores for current mappable units of terrestrial ecological systems was also conducted for the

CP&M (see Map 7, Table 31, & Appendix G). Portfolio 1 contains the highest rated faunal assortment with 61 GCN species, and an average prioritization score per habitat type of 26.30. As well, this portfolio captures 797,347 acres of mixed xeric and mesic upland forest habitats. A site specific example of portfolio 1 is the Sundquist Wildlife Management Area, which contains GCN neo-tropical migratory birds, amphibians, mammals, & snails. Portfolio 2 has 46 species and the next highest prioritization score of 18.10. This portfolio contains an identical mix of natural forest habitats, but captures less overall area at 304,450 acres. Portfolio 3 has 58 fauna but a lower GCN species prioritization score of 13.27. Habitats in portfolio 3 are also similar to the previous portfolios, except for the inclusion of a riparian wetland forest type and a xeric pine forest habitat. Portfolio 3 contains a total of 353,587 acres. Finally, portfolio 4 has 60 GCN species but the lowest average prioritization score per habitat type at 8.89. Once more, this portfolio contains a similar array of natural forest habitats, but also includes small amounts of floodplain forest and pasture. Portfolio 4 is comprised of 525,166 acres of habitat. Together, all four portfolios constitute 1,980,550 acres of priority lands in need of additional conservation work. Approximately 310,285 acres or 16% of these portfolio areas are publicly owned.

Priority areas for potential restoration in the CP&M were calculated based on the overall

Table 30. Priority Terrestrial Habitat Types by Tier 1 GCN Species in the CP&M

Habitat Type	# of Species	Sum of Rarity – Preference Scores*	Average Rarity – Pref. Score**
Natural			
South-Central Interior Mesophytic Forest	73	803.50	11.01
Appalachian Hemlock-Hardwood Forest	73	803.10	11.00
Southern and Central Appalachian Cove Forest	73	793.90	10.88
Allegheny-Cumberland Sandstone Box Canyon and Rockhouse	39	591.80	15.17
Allegheny-Cumberland Dry Oak Forest and Woodland	72	576.00	8.00
Southern Appalachian Low Mountain Pine Forest	55	300.70	5.47
Southern Appalachian Montane Pine Forest and Woodland	53	273.30	5.16
South-Central Interior Small Stream & Riparian	28	223.30	7.98
South-Central Interior Large Floodplain	27	187.00	6.93
Southern Appalachian Montane Cliff & Talus	14	180.60	12.90
Central Interior Highlands Calcareous Glade and Barrens	22	166.70	7.58
Cumberland Sandstone Glade & Barrens	20	156.00	7.80
Central Interior Highlands & Appalachian Sinkhole & Depression Pond	24	134.80	5.62
Cumberland Seepage Forest	21	106.10	5.05
Cumberland Acid Cliff	7	65.40	9.34
Appalachian Shale Barrens	13	49.10	3.78
Cumberland Riverscour	8	36.40	4.55
Semi-natural			
Old Field/Successional Grassland	33	250.40	7.59
Pasture	28	135.50	4.83
Urban / Suburban Managed Grassland	30	125.50	4.18
Excavated Land	24	80.60	3.36
Urban / Suburban Managed Forestland	26	67.70	2.60
Forest Plantation	16	51.00	3.19
Converted Wetland (Palustrine)	12	48.80	4.07
Cropland	12	43.50	3.63
Converted Wetland (Riverine)	10	40.70	4.07
Converted Wetland (Lacustrine)	10	40.70	4.07
Non-natural			
Edifices / Other Man-made Structures	5	28.50	5.70

(*note: Rarity–preference scores are composed of the cumulative point values assigned to the global and state ranks multiplied by the preference ratings of habitats for each GCN species)

(** The average rarity–preference score = sum of rarity–preference scores divided by # of species in the habitat.)

Table 31. Priority Terrestrial Conservation Portfolios in the CP&M				
Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	61	46	58	60
# of Tier 1 Vertebrates:	*42*	*37*	*43*	*49*
Amphibians	*4*	*4*	*5*	*6*
Birds	*21*	*20*	*22*	*26*
Mammals	*12*	*9*	*11*	*12*
Reptiles	*5*	*4*	*5*	*5*
# of Tier 1 Invertebrates:	*19*	*9*	*15*	*11*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*19*	*9*	*15*	*11*
Average Species Prioritization Score per Habitat Type	26.30	18.10	13.27	8.89
# of Mapped Habitat Types:	3	3	5	7
Natural	*3*	*3*	*5*	*6*
Semi-natural	*0*	*0*	*0*	*1*
Non-natural	*0*	*0*	*0*	*0*
Total Acreage of all Portfolio Units	797,347	304,450	353,587	525,166

benefit of converting semi-natural habitat types to Allegheny-Cumberland Dry Oak Forest and Woodland (see Map 19 & Table 32). This matrix forest type already covers much of the region. In general, less forest restoration work is needed in the CP&M relative to other regions. Nevertheless, GIS analysis was conducted to determine areas where species may benefit from re-establishment of the matrix forest type. As such, restoration portfolio 1 containing 20,323 acres would benefit 37 fauna with an average increase in GCN species prioritization scores of 13.80. The second portfolio consisting of 31,242 acres would benefit 32 species with an average increase in prioritization score of 11.13. The third and fourth restoration portfolios at 79,287 and 77,508 acres would benefit 38 and 29 GCN species respectively with an average increase of 8.77 and 5.87.

Total acreage of all four portfolios is 208,360 acres. No semi-natural areas were identified as being negatively affected by restoration of this forest type. However, other restoration scenarios may ultimately prove to be more beneficial. As previously stated, the relatively high amounts of natural forest habitat in the region do not suggest that restoration is a high priority, even though significant acreages were identified in each of the portfolios. Alternatively, restoration of historic natural grassland habitats in parts of the CP&M may pose a more biologically valuable scenario. Much of the glade and barrens habitats have declined greatly in recent years due to disruptions in fire and other natural processes. However, the historic grasslands of the region likely never approached the scale of those in other regions.

Again, in order to prioritize the relative imperilment of fauna, a list of the highest rated sources of stress linked to GCN species of different rarity was compiled for the CP&M (see Table 33). Overall, 18 sources of stress were identified as likely causing significant effects to GCN species or habitats in the region. Given the preponderance of forest habitats and the large number of fauna that

Table 32. Priority Terrestrial Restoration Portfolios in the CP&M

Restoration Scenario – *Conversion of semi-natural habitats to Allegheny-Cumberland Dry Oak Forest and Woodland*

Species & Habitat Categories	Restoration Portfolio 1 (Very High)	Restoration Portfolio 2 (High)	Restoration Portfolio 3 (Medium)	Restoration Portfolio 4 (Low)
# of Tier 1 Species to Benefit	37	32	38	29
# of Tier 1 Vertebrates:	*32*	*31*	*33*	*28*
Amphibians	*2*	*4*	*4*	*2*
Birds	*18*	*17*	*17*	*16*
Mammals	*8*	*7*	*9*	*6*
Reptiles	*4*	*3*	*3*	*4*
# of Tier 1 Invertebrates:	*5*	*1*	*5*	*1*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*5*	*1*	*5*	*1*
Average Increase in Species Prioritization Score	13.80	11.13	8.77	5.87
# of Restoration Units in Portfolio	160	226	649	401
Total Acreage of all Restoration Portfolio Units	20,323	31,242	79,287	77,508

depend on them, incompatible forestry practices were documented as a potential source of stress. Forestry has long been a part of the history and economy of the CP&M. Forest companies have owned large tracts of land for many years. Some of the stresses associated with forest practices on terrestrial GCN species come from issues of timing and mismatching of harvest methods within key habitats. Similarly, in recent decades, some areas of the Cumberland Plateau have been converted to forest plantations of loblolly pine (Wear & Greis 2003; Evans et al. 2002). As well, even though most of the CP&M is rural, development pressures are starting to afflict the large forest blocks of the region. Some areas have become increasingly popular as retirement havens. Cities such as Crossville are rapidly growing due to an increase in retirees and from the resort industry. Commercial and industrial development, roads, utilities, and other infrastructure related growth is also occurring as the region's population increases. One of the biggest threats to the region is the increase in land prices stemming from development. Declines in the forest industry have led some large, private forest owners to break up their landholdings and sell them as smaller parcels. Ironically, decreases in forestry in the region may lead to more severe problems for forest habitats via development.

Another important problem linked by the planning team to terrestrial species in the region comes from activities associated with mining and drilling operations. Coal mining has been an important industry in the region since the late 1800's (Jones 1996). In recent decades, strip mining has become the

Table 33. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the CP&M

Source of Stress	# of Species	Sum of Stress - Rarity Scores*	Average Stress - Rarity Score**
Incompatible Forestry Practices	70	522.52	7.47
Primary Residential Development	59	521.41	8.84
Commercial / Industrial Development	43	362.22	8.42
Agricultural Conversion	47	327.38	6.97
Forestry Conversion	52	215.42	4.14
Incompatible Mining Practices	29	186.63	6.44
Incompatible Grazing / Pasture Management Practices	22	144.61	6.57
Incompatible Row Crop Agricultural Practices	17	97.38	5.73
Construction of Roads / Railroads / Utilities	17	83.69	4.92
Fire Suppression	10	60.52	6.05
Incompatible Species Management Practices	4	22.59	5.65
Secondary Home / Resort Development	1	18.86	18.86
Excessive Competition / Predation by Native Species	6	15.39	2.57
Illegal Hunting/Fishing/Collection/ Killing	6	11.47	1.91
Construction of Ditches / Dikes / Drainage / Diversion Systems	3	10.78	3.59
Parasites / Pathogens	1	9.84	9.84
Oil or Natural Gas Drilling	1	6.00	6.00
Recreational Use of Habitats (Non-vehicular)	1	1.88	1.88

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

preferred method of coal extraction. Less destructive means of removing soil and rock overburden in priority areas of terrestrial habitats remains a key challenge. Similarly, construction of roads and other infrastructure necessary for access to coal mines and oil/natural gas wells can be very damaging to terrestrial habitats.

Other key problems affecting habitats in the CP&M include: destruction of forests from outbreaks of southern pine beetle, parasites / pathogens, construction of drainage systems for wetlands, illegal collection of species, and recreational use of habitats.

Ridge & Valley (R&V)

The R&V comprises approximately 18.3% of the total area of the state. The region is composed of a series of parallel ridges and valleys situated between the Cumberland Plateau and the Appalachian mountains to the east. The terrain is rugged due to the steep ridges, but flat, valley bottomlands also are prevalent in places. Overall, the landscape consists of a mix of forests and agricultural

lands. With few exceptions, forests are mainly relegated to ridges in the region. River floodplains in the valleys were cleared for agriculture by Native Americans long before the arrival of Europeans (Bonnicker 2000; Martin 1989). Alluvial soils along river floodplains are well-suited for row crop agriculture. With the arrival of white settlers, forest clearing continued in the valleys and on some of the steep ridges. Today, pastures cover much of the region. Historically, natural grassland complexes also occurred at various scales throughout the region. The R&V is somewhat of a crossroads region. It contains elements of habitats from both of the adjoining mountainous regions. However, it also has qualities that liken it to other regions such as the Interior Low Plateau. Despite these affinities it is a very unique region of the state.

Today, habitats for GCN species in the region consist of 19 natural systems, 10 semi-natural systems, and 1 non-natural system type (see Table 34 & Appendix D). Analysis of current habitat preferences by rare species shows many similarities to the CP&M. Again, approximately 72% of GCN species are associated with natural forest habitats. By rarity and preference scores for species, the rich mixed-mesophytic forests of the region comprise the most important habitat types. These forests are present mainly in protected cove environments on north and northeast-facing slopes of ridges. They are also present in limited pockets of the valleys. Likewise, drier forest types of both hardwoods and pine also provide important habitat to GCN species. Unlike their mesic forest counterparts, xeric forests are more abundant in the region, but are still limited mainly to ridges. In addition, prairie – barren systems also comprise valuable habitats in the R&V. However, like the ILP, only relict stands of natural grassland systems remain. Approximately 40% of GCN species utilize grassland habitats to some degree. Semi-natural grasslands such as old field / successional areas, pasture, and others help fill this important "niche" for fauna. Other vital habitats include riparian forests, cliffs, bogs & fens, cliffs, and shale barrens.

Again, analysis of current mapped habitat units based species prioritization scores revealed a number of critical portfolio areas for conservation work (see Map 7, Table 35, & Appendix G). Portfolio 1 contains the highest rated faunal assortment with 32 GCN species, and an average prioritization score per habitat type of 21.14. As well, this portfolio captures 39,727 acres of primarily natural xeric and mesic upland forest. A site-specific example of portfolio 1 is the Oak Ridge Reservation, which again hosts several GCN neo-tropical birds, herps, and mammal populations. Portfolio 2 has 43 species and the next highest prioritization score of 14.14. Like the first portfolio, this portfolio has a more expansive mix of natural forest types, including pine. The portfolio also captures some pasture lands for a total of 60,946 acres. Portfolio 3 has 46 species and a lower prioritization score of 11.49. This portfolio contains an almost identical complement of habitats, but has subtantially more pasture. Total amount of habitat is 94,031 acres. Portfolio 4 has the largest number of GCN species at 53 but the lowest average prioritization score per habitat type at 8.60. Again, this portfolio has a similar habitat composition as the other three portfolios, but

Table 34. Priority Terrestrial Habitat Types by Tier 1 GCN Species in the R&V

Habitat Type	# of Species	Sum of Rarity – Preference Scores*	Average Rarity – Pref. Score**
Natural			
South-Central Interior Mesophytic Forest	60	644.00	10.73
Appalachian Hemlock-Hardwood Forest	59	615.40	10.43
Southern and Central Appalachian Cove Forest	60	615.20	10.25
Southern and Central App. Oak Forest	59	526.00	8.92
Allegheny-Cumberland Dry Oak Forest and Woodland	59	472.40	8.01
Southern Ridge & Valley Patch Prairie	33	292.60	8.87
Southern App. Low Mountain Pine Forest	46	258.90	5.63
Southern Appalachian Montane Pine Forest and Woodland	44	243.80	5.54
South-Central Interior Small Stream & Riparian	29	211.00	7.28
Southern Interior Calcareous Cliff	13	205.10	15.78
South-Central Interior Large Floodplain	28	157.70	5.63
Central Interior Highlands Calcareous Glade and Barrens	21	149.30	7.11
Ridge & Valley Calcareous Valley Bottom Glade and Woodland	21	143.30	6.82
Southern Interior Sinkhole Wall	10	134.70	13.47
Central Interior Highlands & Appalachian Sinkhole & Depression Pond	24	134.50	5.60
Southern and Central App. Bog and Fen	20	117.80	5.89
Southern App. Montane Cliff & Talus	9	88.20	9.80
Cumberland Acid Cliff	5	54.60	10.92
Appalachian Shale Barrens	10	43.90	4.39
Semi-natural			
Old Field/Successional Grassland	33	241.30	7.31
Pasture	28	140.20	5.01
Urban / Suburban Managed Grassland	30	132.90	4.43
Urban / Suburban Managed Forestland	28	89.70	3.20
Excavated Land	23	71.00	3.09
Forest Plantation	17	63.70	3.75
Converted Wetland (Palustrine)	11	53.40	4.85
Converted Wetland (Riverine)	10	51.60	5.16
Converted Wetland (Lacustrine)	10	51.60	5.16
Cropland	12	41.20	3.43
Non-natural			
Edifices / Other Man-made Structures	5	28.50	5.70

(*note: Rarity–preference scores are composed of the cumulative point values assigned to the global and state ranks multiplied by the preference ratings of habitats for each GCN species)

(** The average rarity–preference score = sum of rarity–preference scores divided by # of species in the habitat.)

Table 35. Priority Terrestrial Conservation Portfolios in the R&V				
Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	32	43	46	53
# of Tier 1 Vertebrates:	*32*	*40*	*42*	*44*
Amphibians	*1*	*2*	*2*	*2*
Birds	*21*	*26*	*26*	*28*
Mammals	*7*	*9*	*11*	*10*
Reptiles	*3*	*3*	*3*	*4*
# of Tier 1 Invertebrates:	*0*	*3*	*4*	*9*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*0*	*3*	*4*	*9*
Average Species Prioritization Score per Habitat Type	21.14	14.14	11.49	8.60
# of Mapped Habitat Types:	3	7	7	10
Natural	*3*	*6*	*6*	*8*
Semi-natural	*0*	*1*	*1*	*2*
Non-natural	*0*	*0*	*0*	*0*
Total Acreage of all Portfolio Units	39,727	60,946	94,031	344,835

also includes riparian wetland forest and old field / successional habitats, for a combined total of 344,836 acres. Together, all four portfolios constitute 539,540 acres of priority lands. Approximately 60,104 acres or 11% of these portfolio areas are publicly owned.

Priority areas for potential restoration in the R&V were calculated based on the overall benefit of converting semi-natural habitats to Southern and Central Appalachian Oak Forest, and Allegheny-Cumberland Dry Oak Forest and Woodland, which are both key natural forest systems in the region. However, they do not co-occur in all regions. As such, the restoration assessment was divided between these two dominant forest types within relevant regions. Again, four restoration portfolios were developed to highlight important areas for reforestation of both forest types (see Map 19 & Table 36). With the analysis, restoration portfolio 1 containing 6,386 acres would benefit 27 species with an average increase in prioritization scores of 14.56. The second portfolio consisting of 26,115 acres would benefit 29 species with an average increase in prioritization scores of 8.96. The third and fourth restoration portfolios with 37,608 and 88,295 acres would benefit 31 GCN species in each portfolio with an average increase of 7.32 and 3.25. Total acreage of all four portfolios is 158,404 acres. Semi-natural areas not benefiting from restoration of either of these forest types constitute approximately 53,376 acres in the R&V. Like the ILP, the ratio of benefiting and non-benefiting habitat acreage suggests that restoration of Southern and Central Appalachian Oak Forest and Allegheny-Cumberland Dry Oak Forest and Woodland may not provide the highest benefit as a restoration scenario. It is likely that restoration of more mesic forest types or natural grassland systems may provide more habitat gains for species in the region. However, no analysis was conducted to establish comparative numbers of other restoration scenarios. Additional work is needed to develop appropriate scenarios in the Ridge & Valley.

Table 36. Priority Terrestrial Restoration Portfolios in the R&V

Restoration Scenario – *Conversion of semi-natural habitats to Southern and Central Appalachian Oak Forest and Allegheny-Cumberland Dry Oak Forest and Woodland*

Species & Habitat Categories	Restoration Portfolio 1 (Very High)	Restoration Portfolio 2 (High)	Restoration Portfolio 3 (Medium)	Restoration Portfolio 4 (Low)
# of Tier 1 Species to Benefit	27	29	31	31
# of Tier 1 Vertebrates:	*27*	*28*	*29*	*28*
Amphibians	*1*	*1*	*2*	*1*
Birds	*16*	*18*	*17*	*17*
Mammals	*7*	*7*	*7*	*8*
Reptiles	*3*	*2*	*3*	*2*
# of Tier 1 Invertebrates:	*0*	*1*	*2*	*3*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*0*	*1*	*2*	*3*
Average Increase in Species Prioritization Score	14.56	8.96	7.32	3.25
# of Restoration Units in Portfolio	59	178	249	395
Total Acreage of all Restoration Portfolio Units	6,386	26,115	37,608	88,295

As for every other region, an assessment of the highest rated sources of stress linked to GCN species of different rarity was also conducted for the R&V (see Table 37). A total of 18 sources of stress were identified as potentially contributing significant effects to GCN species or habitats in the region. Again, activities related to urban development are rated as the top problems in the region. Much of the R&V is rapidly developing, as the third, fourth, and fifth largest metropolitan areas in the state (i.e. Knoxville, Chattanooga, and the Tri-Cities region of Bristol, Kingsport, & Johnson City) are all located in this region. The proximity of these cities to the mountains and the relatively low cost of living have made them desirable locations for retirees and others seeking recreational opportunity and urban convenience. Likewise, Knoxville has become a major scientific research center in the country due to the nearby Oak Ridge National Laboratory. As such, urban sprawl is rapidly converting habitats throughout much of the region. Another important component of urban development pertains to the construction of roads, utilities, and other transportation corridors. The series of parallel ridges that define the area also have an isolating effect on communities. In recent years, more cross-ridge road construction has either occurred or been proposed.

Habitats in the R&V are also under pressure from other land use issues. Incompatible forestry practices and agricultural conversion are stressing remaining stands of forest in some areas (The Nature Conservancy 2003). Overall, large tracts of high-quality forest habitat are rare in the region. Similarly, incompatible grazing/pasture management

Table 37. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the R&V

Source of Stress	# of Species	Sum of Stress - Rarity Scores*	Average Stress - Rarity Score**
Primary Residential Development	58	589.70	10.17
Commercial / Industrial Development	43	394.80	9.18
Incompatible Forestry Practices	52	378.14	7.27
Agricultural Conversion	52	374.20	7.20
Incompatible Grazing / Pasture Management Practices	24	163.13	6.80
Incompatible Row Crop Agricultural Practices	24	137.08	5.71
Construction of Roads / Railroads / Utilities	15	75.72	5.05
Fire Suppression	10	52.20	5.22
Excessive Competition / Predation by Native Species	9	29.22	3.25
Incompatible Mining Practices	7	28.22	4.03
Construction of Ditches / Dikes / Drainage / Diversion Systems	4	20.88	5.22
Incompatible Species Management Practices	3	14.86	4.95
Forestry Conversion	2	12.72	6.36
Illegal Hunting/Fishing/Collection/ Killing	6	11.47	1.91
Parasites / Pathogens	1	9.84	9.84
Industrial Discharge	1	8.50	8.50
Municipal Wastewater Treatment / Stormwater Runoff	1	7.97	7.97
Recreational Use of Habitats (Non-vehicular)	1	1.88	1.88

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

practices were noted by the planning team as affecting the ability of semi-natural grasslands to provide habitat for GCN species. Row crop production practices and fire suppression were also highlighted as influencing the quality of open habitats.

Other potential sources of stress in the region include: excessive species competition from southern pine beetle, incompatible mining practices from coal and gravel, destruction of wetland habitats from construction of drainage and other water diversionary systems, incompatible species management practices, forest conversion to loblolly pine plantations, illegal collection of species, disease, contamination of wetlands from industrial discharge and municipal wastewater treatment, and incompatible recreational use of habitats. Overall, the R&V has a wide variety of problems affecting GCN species.

Southern Blue Ridge (SBR)

The SBR region composes approximately 5.9% of the state. The region consists of the Unaka and Unicoi sections of the Appalachian

Mountains, which form the eastern boundary of Tennessee. Again, the highest peaks in the eastern United States are found in the SBR. Due to the high elevations and rugged terrain, the SBR was seen by early pioneers as more of a barrier to settlement than a place to live. Nevertheless, a hardy group of settlers did stay in the region. After nearly 200 years of European settlement, much of the region was purchased by the federal government in the early part of the 20th century (e.g. Cherokee National Forest and Great Smoky Mountains National Park). As such, the region is relatively unpopulated today compared to other regions.

Overall, the landscape is mostly forested except in some small valleys where land was cleared by settlers for agriculture. Relatively little row cropping is present due to the poor soils and steep topography. Most cleared land is in pasture in lower elevations. However, forests were historically cleared on some higher elevation areas to rotate cattle for summer pasturage. Today, vast tracts of forestland cover the majority of the SBR in Tennessee, but are usually contained within the national park or national forest boundary. Smaller tracts of private lands do occur as inholdings, but most private lands lie along the perimeter of the region in lower elevation foothills. Small to medium-sized towns are typical of the region. Overall, the forests of the SBR are considered by many to be one of the most biologically diverse temperate hardwood regions in the world (Stein et al. 2000).

At present, habitats in the SBR consist of 19 natural systems, 10 semi-natural systems, and 1 non-natural system type. Again, rare fauna utilize these habitat types to varying degrees (see Table 38 & Appendix D). The majority of GCN species (79%) depend upon one or more of the natural forest habitats in the region. Much like the CP&M region, analysis of rarity and preference among fauna shows that mesic mixed hardwood and conifer forests support the bulk of GCN species in the region, followed by drier hardwood forests, pine forests, and then riparian wetland forests. Other natural habitats utilized to lesser degrees in the region include various isolated wetlands (e.g. bogs, fens, seeps), montane cliff & talus slopes, calcareous and acidic cliffs, grass & shrub balds, mafic glades & barrens, shale barrens, and rocky summits. Rare fauna in the region (21%) also make use of several semi-natural grassland habitats, such as old field / successional areas and pasture. Despite the dominance of forests in the region, fire does play a role in the region in creating barrens and maintaining other open areas important to grassland species. Again, very few extant examples of natural grassland habitats exist except in some of the high elevation grassy balds. Other semi-natural and non-natural habitats also support fauna at different levels in the SBR.

Analysis of species prioritization scores for current mappable units of terrestrial ecological systems was also conducted for the SBR (see Map 19, Table 39, & Appendix G). Portfolio 1 contains the highest rated faunal assortment with 69 GCN species, and an average prioritization score per habitat type of 116.87. As well, this portfolio captures 48,152 acres of mesic to xeric upland hardwood forest habitats. A site-specific example of portfolio 1 is Roan Mountain, which has several GCN species such as amphibians, snails, and neotropical migratory birds. Portfolio 2 has 95 species and the next highest prioritization score of 36.63. This portfolio contains an identical complement of

Table 38. Priority Terrestrial Habitat Types by Tier 1 GCN Species in the SBR

Habitat Type	# of Species	Sum of Rarity – Preference Scores*	Average Rarity – Pref. Score**
Natural			
Southern and Central App. Cove Forest	105	1,476.30	14.06
Central and Southern Appalachian Northern Hardwood Forest	105	1,476.10	14.06
Appalachian Hemlock-Hardwood Forest	104	1,464.00	14.08
Southern and Central App. Oak Forest	105	1,265.40	12.05
Central and Southern Appalachian Spruce-Fir Forest	42	641.60	15.28
Southern App. Low Mountain Pine Forest	84	498.10	5.93
Southern Appalachian Montane Pine Forest and Woodland	82	493.20	6.01
South-Central Interior Small Stream & Riparian	34	378.40	11.13
Southern and Central App. Bog and Fen	27	272.20	10.08
Southern Appalachian Seepage Wetland	28	238.30	8.51
South-Central Interior Large Floodplain	30	235.20	7.84
Southern App. Montane Cliff & Talus	13	152.60	11.74
Southern Interior Sinkhole Wall	10	145.60	14.56
North-Central Appalachian Acidic Cliff and Talus	13	141.10	10.85
Southern Interior Calcareous Cliff	8	98.70	12.34
Southern Appalachian Grass and Shrub Bald	7	87.60	12.51
Southern and Central Appalachian Mafic Glade and Barrens	12	82.00	6.83
Appalachian Shale Barrens	9	34.00	3.78
Southern Appalachian Rocky Summit	3	26.60	8.87
Semi-natural			
Old Field/Successional Grassland	28	195.20	6.97
Pasture	25	107.40	4.30
Urban / Suburban Managed Grassland	24	86.90	3.62
Urban / Suburban Managed Forestland	27	67.40	2.50
Excavated Land	19	51.10	2.69
Converted Wetland (Palustrine)	12	50.40	4.20
Forest Plantation	15	45.50	3.03
Cropland	11	40.20	3.65
Converted Wetland (Riverine)	9	37.20	4.13
Converted Wetland (Lacustrine)	9	37.20	4.13
Non-natural			
Edifices / Other Man-made Structures	5	28.50	5.70

(*note: Rarity–preference scores are composed of the cumulative point values assigned to the global and state ranks multiplied by the preference ratings of habitats for each GCN species)

(** The average rarity–preference score = sum of rarity–preference scores divided by # of species in the habitat.)

Table 39. Priority Terrestrial Conservation Portfolios in the SBR				
Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	69	95	102	99
# of Tier 1 Vertebrates:	*47*	*59*	*64*	*64*
Amphibians	*7*	*9*	*8*	*9*
Birds	*26*	*29*	*33*	*35*
Mammals	*13*	*16*	*17*	*14*
Reptiles	*1*	*5*	*6*	*6*
# of Tier 1 Invertebrates:	*22*	*36*	*38*	*35*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*22*	*36*	*38*	*35*
Average Species Prioritization Score per Habitat Type	116.87	36.63	18.09	10.04
# of Mapped Habitat Types:	3	5	8	9
Natural	*3*	*5*	*7*	*8*
Semi-natural	*0*	*0*	*1*	*1*
Non-natural	*0*	*0*	*0*	*0*
Total Acreage of all Portfolio Units	48,152	323,150	333,466	243,259

natural forest habitats, but also captures higher elevation spruce-fir and montane pine forests within an overall area at 323,150 acres. Portfolio 3 has 102 species but a lower prioritization score of 18.09. Habitats in portfolio 3 are also similar to the previous portfolios, except for the inclusion of lower elevation pine forest habitats and pasture. Portfolio 3 contains a total of 333,466 acres. Finally, portfolio 4 has 99 GCN species but the lowest average prioritization score per habitat type at 10.04. Once more, this portfolio contains a similar array of natural forest habitats, but also includes small amounts of riparian forest and pasture. Portfolio 4 is comprised of243,259 acres of habitat. Together, all four portfolios constitute 948,027 acres of priority lands in need of additional conservation work. Approximately 613,340 acres or 65% of these portfolio areas are publicly owned.

Priority areas for potential restoration in the SBR were calculated based on the overall benefit of converting semi-natural habitat types to Southern and Central Appalachian Oak Forest (see Map 19 & Table 40). This matrix forest type already covers much of the region. As in the CP&M, little forest restoration work is needed in the SBR relative to other regions. Nevertheless, GIS analysis was conducted to determine areas where species may benefit from re-establishment of this matrix forest type. As such, restoration portfolio 1 containing 193 acres would benefit 21 species with an average increase in prioritization scores of 57.10. The second portfolio consisting of 4,474 acres would benefit 46 species with an average increase in prioritization scores of 16.70. The third and fourth restoration portfolios at 22,819 and 8,482 acres would benefit 46 and 23 GCN species respectively with an average increase of 8.99 and 2.96. Total acreage of all four portfolios is 35,968 acres. Semi-natural areas not benefiting from restoration of this forest type constitute approximately 1,053 acres in the SBR. In general, the ratio of benefiting and non-benefiting habitat acreage verses the total amount of natural habitats suggests that

Table 40. Priority Terrestrial Restoration Portfolios in the SBR

Restoration Scenario – *Conversion of semi-natural habitats to Southern and Central Appalachian Oak Forest*

Species & Habitat Categories	Restoration Portfolio 1 (Very High)	Restoration Portfolio 2 (High)	Restoration Portfolio 3 (Medium)	Restoration Portfolio 4 (Low)
# of Tier 1 Species to Benefit	21	46	46	23
# of Tier 1 Vertebrates:	*15*	*41*	*44*	*23*
Amphibians	*1*	*4*	*6*	*2*
Birds	*14*	*23*	*23*	*18*
Mammals	*0*	*12*	*10*	*1*
Reptiles	*0*	*2*	*5*	*2*
# of Tier 1 Invertebrates:	*6*	*5*	*2*	*0*
Crustaceans	*0*	*0*	*0*	*0*
Snails	*6*	*5*	*2*	*0*
Average Increase in Species Prioritization Score	57.10	16.70	8.99	2.96
# of Restoration Units in Portfolio	2	41	245	67
Total Acreage of all Restoration Portfolio Units	193	4,474	22,819	8,482

restoration of Southern and Central Appalachian Oak Forest may not provide the highest benefit as a restoration scenario. It is possible that restoration of more mesic forest types or natural grassland systems may provide more habitat gains for species in the region. Again, no analysis was conducted to establish comparative numbers of other restoration scenarios.

Finally, an assessment of the highest rated sources of stress linked to GCN species of different rarity was also conducted for the SBR (see Table 41). By analysis of stress and rarity scores, a total of 19 sources of stress were prioritized by their potential for contributing significant effects to GCN species or habitats in the region. Again, given the dependence of fauna on forests of the region, forest-related stresses, such as from Incompatible forestry practices, may pose the biggest risk to terrestrial species. However, much of the region is under strict management by the U.S. Forest Service. Private lands in the SBR may be relatively more susceptible to incompatible forestry practices. Another potential problem in the region is acid rain. Coupled with other problems such as invasive exotic species, low-level ozone accumulation, pathogens, and potentially climate change, acid rain has decimated the high elevation spruce-fir forest (Gunnarsson and Johnson 1989). The decline of this forest type has also had residual effects on composition of other forest habitat types (Grant 1999). As well, the north-south orientation of the mountains in the SBR are conducive to the transmittal of several parasites/pathogens (Schlarbaum 1997). Several other parasites/pathogens

Table 41. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the SBR

Source of Stress	# of Species	Sum of Stress - Rarity Scores*	Average Stress - Rarity Score**
Incompatible Forestry Practices	95	904.31	9.52
Acid Rain	25	313.69	12.55
Primary Residential Development	28	301.21	7.93
Commercial / Industrial Development	33	253.47	7.68
Invasive Exotic Species	28	179.91	6.43
Agricultural Conversion	26	126.41	4.86
Incompatible Grazing / Pasture Management Practices	16	107.11	6.69
Incompatible Row Crop Agricultural Practices	16	102.31	6.40
Construction of Roads / Railroads / Utilities	16	79.00	4.94
Fire Suppression	8	51.33	6.42
Secondary Home / Resort Development	11	43.80	3.98
Construction of Ditches / Dikes / Drainage / Diversion Systems	4	42.81	10.70
Illegal Hunting/Fishing/Collection/ Killing	8	28.97	3.62
Excessive Competition / Predation by Native Species	7	27.34	3.91
Parasites / Pathogens	2	20.16	10.08
Incompatible Species Management Practices	3	14.86	4.95
Recreational Use of Habitats (Non-vehicular)	2	4.53	2.27
Residential Sewage / Septic Systems	1	4.25	4.25
Municipal Wastewater Treatment / Stormwater Runoff	1	3.98	3.98

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

(e.g. hemlock adelgid, gypsy moth, beech canker, etc.) have been documented from the region and are poised to inflict major changes in forest structure if unchecked.

Though the SBR is generally less populated than other regions in the state, small towns and cities have been growing rapidly in recent years. Families and retirees alike have flocked to the area due to the scenic attraction of the mountains and the abundance of outdoor recreational opportunities. Likewise, commercial / industrial development, along with construction of roads & utility corridors, has followed in the wake of residential development. Construction of secondary homes and resorts has also been a key source of stress, especially near the boundaries of federal landholdings. Agricultural conversion within the SBR has not been as extensive as other regions in the state. However, valleys, coves, and other

high elevation flat lands have been strongly influenced by conversion to pasture land and limited row crops. In particular, many of the high elevation bog systems have been ditched and drained for agricultural purposes over the past 50 years or so.

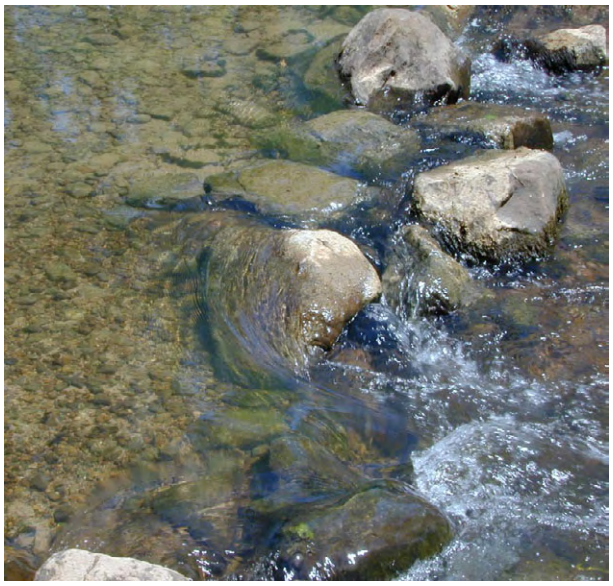
Other key sources of stress noted by the planning team in the region include: In residential sewage from septic systems, municipal wastewater treatment/stormwater runoff, illegal hunting/fishing/collection/killing of species, incompatible species management practices, and incompatible recreational use of habitats.

Conservation Priorities in Aquatic Regions

As previously discussed, portions of five major river drainages are found in Tennessee (see Map 1 in *Chapter 1*). These drainages compose the following aquatic regions: the Mississippi River, the Tennessee River, the Cumberland River, the Barren River, and the Conasauga River. Again, these river drainages constitute a wide variety of aquatic habitats and collectively compose some of the most biologically important freshwater ecosystems in the country (Smith et al. 2002; Stein et al. 2000; Master et al. 1998). Analysis of preference of aquatic habitats by GCN species was conducted for the CWCS. However, the number and complexity of mapping these systems makes priority setting by aquatic habitat difficult. As such, aquatic regional priorities are presented according to portfolios of biologically important watersheds as delineated by NRCS 12-digit HUCs. Likewise, restoration priorities are not presented for aquatic regions due to the number and difficulty of delineating specific aquatic systems. Primary sources of stress affecting aquatic GCN species are provided at the regional level. Aquatic regional priorities are presented in geographic order from west to east as follows:

<u>Mississippi River Drainage (MSR)</u>

The MSR drains approximately 19.9% of the land mass of Tennessee. The region lies entirely in the western portion of the state and encompasses all of the Mississippi River



Alluvial Plain and portions of the Upper Gulf Coastal Plain terrestrial regions. Major tributaries in the MSR include the Forked Deer, Hatchie, Loosahatchie, Obion, and Wolf river systems.

Analysis of species prioritization scores was conducted for watersheds in the MSR (see Map 9 & Table 42). Portfolio 1 contains the highest rated assortment of fauna with 4 GCN species and an average prioritization score per watershed of 54.42. Again, Reelfoot Lake is a prime site-specific example of a portfolio 1 aquatic area, containing several GCN fish, amphibians, and reptiles. This portfolio captures 2 HUC-12 watersheds comprising 68,335 acres. Portfolio 2 has the next highest rating with 12 species and a prioritization score of 24.76. This second portfolio contains 9 watersheds covering 281,965 acres. Portfolio 3 has the highest number of species at 14, but the average prioritization score per HUC is lower at 14.79. This portfolio contains 39 watersheds of approximately 928,608 acres. Finally, portfolio 4 has 11 GCN species and the lowest prioritization score of 2.13. As well, this portfolio captures 19 HUCs totaling 581,060 acres.

Primary sources of stress potentially affecting GCN species or habitats in the MSR were ranked according to overall stress ratings and rarity scores for species (see Table 43).

Table 42. Priority Aquatic Conservation Portfolios in the MSR

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	4	12	14	11
# of Tier 1 Vertebrates:	*2*	*7*	*10*	*9*
Amphibians	*0*	*0*	*0*	*0*
Fish	*2*	*7*	*8*	*8*
Reptiles	*0*	*0*	*2*	*1*
# of Tier 1 Invertebrates:	*2*	*5*	*4*	*2*
Crustaceans	*1*	*0*	*0*	*0*
Mussels	*1*	*5*	*4*	*2*
Snails	*0*	*0*	*0*	*0*
Average Species Prioritization Score per HUC-12 Watershed	54.42	24.76	14.79	2.13
Total # of HUC-12 Watersheds	2	9	39	19
Total Acreage of HUC-12 Watersheds	68,335	281,965	928,608	581,060

Table 43. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the MSR

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Channelization of Rivers / Streams	20	292.94	14.65
Incompatible Row Crop Agricultural Practices	23	262.16	11.36
Industrial Discharge	10	139.98	13.99
Municipal Wastewater Treatment / Stormwater Runoff	9	68.72	7.64
Incompatible Grazing / Pasture Management Practices	10	63.28	6.33
Incompatible Forestry Practices	1	60.00	60.00
Construction of Ditches / Dikes / Drainage / Diversion Systems	2	39.78	19.89
Construction of Dams / Impoundments	3	22.81	7.60
Residential Sewage / Septic Systems	1	13.36	13.36
Illegal Hunting/Fishing/Collection/ Killing	2	10.25	5.13
Invasive Exotic Species	2	6.00	3.00
Excessive Surfacewater Withdrawal	1	3.44	3.44

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

Channelization of streams was the highest rated problem in the region. Likewise, incompatible agricultural practices from row cropping and grazing of cattle also rated high. Particular problems caused by agriculture come from sediment in streams, chemicals, and nutrient loading. Similarly, industrial discharge of chemicals or other effluent may also have a negative effect upon fauna. Other water quality stresses come from forestry practices and residential sewage from septic systems. Excessive surfacewater withdrawal may impinge on water quality by lowering the dilution capacity of streams.

As well, the region's streams have been affected from construction of ditches, dikes, drainage, and other water diversionary systems that disrupt natural flow regimes. Small impoundments in the region also impede water flow and permanently inundate aquatic resources. Also, illegal hunting/fishing/collection/killing was implicated by the planning team as a problem for some GCN fauna. Exemptions of some areas via special acts for collection of amphibians and reptiles may also pose risks to GCN fauna. Finally, invasive exotic species pose a potentially large risk to aquatic fauna in the region. Several examples of exotic fish, mussels, and plants have already been documented as aquatic pests in the MSR (Smith et al. 2002). Many more could be on the way, given that the Mississippi River is a major transportation corridor.

Tennessee River Drainage (TNR)

The TNR is the largest aquatic region in the state draining approximately 53.4% of the state's landmass. Headwaters of the region lie in North Carolina, Tennessee, and Virginia in the Southern Blue Ridge Mountains. Other headwater streams originate in the Cumberland Plateau and Mountains in Tennessee, the Interior Low Plateau, and the Upper Gulf Coastal Plain. Major tributaries of the TNR include the Big Sandy, Clinch, Duck, Elk, French Broad, Hiwassee, Holston, Little Tennessee, and Sequatchie rivers.

Again, analysis of species prioritization scores was conducted for the TNR (see Map 10 & Table 44). Portfolio 1 contains the highest rated assortment of fauna with 45 GCN

Table 44. Priority Aquatic Conservation Portfolios in the TNR

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	45	56	64	60
# of Tier 1 Vertebrates:	*17*	*26*	*32*	*25*
Amphibians	*2*	*1*	*3*	*3*
Fish	*15*	*23*	*26*	*20*
Reptiles	*0*	*2*	*3*	*2*
# of Tier 1 Invertebrates:	*28*	*30*	*32*	*35*
Crustaceans	*1*	*3*	*6*	*6*
Mussels	*18*	*19*	*19*	*22*
Snails	*9*	*8*	*7*	*7*
Average Species Prioritization Score per HUC-12 Watershed	142.31	54.48	26.85	6.42
Total # of HUC-12 Watersheds	8	39	76	169
Total Acreage of HUC-12 Watersheds	221,565	1,234,582	2,272,193	4,761,783

Table 45. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the TNR

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Incompatible Grazing / Pasture Management Practices	116	2,332.31	20.28
Construction of Dams / Impoundments	73	1,325.23	18.15
Incompatible Mining Practices	55	898.47	16.34
Incompatible Row Crop Agricultural Practices	61	878.78	14.41
Incompatible Forestry Practices	46	784.89	17.44
Municipal Wastewater Treatment / Stormwater Runoff	40	617.20	16.24
Residential Sewage / Septic Systems	26	515.64	19.83
Industrial Discharge	23	417.41	18.97
Operation of Dams / Reservoirs	19	307.58	17.09
Primary Residential Development	7	112.19	16.03
Forestry Conversion	5	90.48	18.10
Construction of Roads / Railroads / Utilities	3	53.75	17.92
Invasive Exotic Species	10	47.74	4.78
Construction of Ditches / Dikes / Drainage / Diversion Systems	1	32.50	32.50
Commercial / Industrial Development	1	32.50	32.50
Animal Production Practices	2	23.94	11.97
Oil or Natural Gas Drilling	3	22.50	7.50
Channelization of Rivers / Streams	3	15.84	5.28
Excessive Surfacewater Withdrawal	3	15.81	5.27
Illegal Hunting/Fishing/Collection/ Killing	3	11.00	3.67
Commercial Collection of Species	1	8.00	8.00
Agricultural Conversion	1	5.25	5.25

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

species and an average prioritization score per watershed of 142.31. This portfolio captures 8 HUC-12 watersheds comprising 221,565 acres. A site-specific example for portfolio 1 is the Duck River, which hosts numerous species of fish and mussel GCN species. Portfolio 2 has the next highest prioritization score with 56 species and an average score of 54.48. This second portfolio contains 39 watersheds covering 1,234,582 acres. Portfolio 3 has the highest number of species at 64, but the average prioritization score per HUC is lower at 26.85. This portfolio contains 76 watersheds of approximately 2,272,193 acres. Finally, portfolio 4 has 60 GCN species and the lowest prioritization score of 6.42. As well, this portfolio captures 169 HUCs totaling 4,761,783 acres.

Twenty-two priority sources of stress were linked to GCN species in the TNR (see Table 45). By stress – rarity rankings, agriculture again rates high in the region as a potential

source of stress to aquatic fauna via incompatible grazing / pasture management practices and incompatible row crop practices. Construction of dams and impoundments is also rated as a very high source of stress in the region (World Wildlife Fund 1999). Most of the major tributaries of the TNR have one or more hydroelectric dams that were constructed primarily by the Tennessee Valley Authority (TVA) in the early to mid-part of the 20th century. The type of construction of these dams and their operation plays a large role in maintenance of aquatic habitats. Likewise, use of the reservoirs for navigation has created opportunities for spread of invasive exotic species. Coordination of aquatic resource planning with TVA is a crucial endeavor for maintaining GCN species.

Other sources of stress noted by the planning team for the region again come from activities that directly affect water quality via sediment, pollutants, or nutrient loading: incompatible mining practices, incompatible forestry practices, municipal wastewater treatment / stormwater runoff, residential sewage / septic systems, industrial discharge, forest conversion, animal production practices (e.g. concentrated feedlots for cattle and chicken farms), oil or natural gas drilling, and agricultural conversion. Urban areas are also contributing to water quality issues via primary residential development, construction of roads & utilities, and commercial / industrial development. Several of the largest cities in the state are located in the TNR. Lesser problems in the region include channelization, excessive surfacewater withdrawal, and commercial collection.

Cumberland River Drainage (CUR)

The CUR is the second largest aquatic region in Tennessee composing 25.4% of the state's total land area. Headwaters are located in the Cumberland Plateau & Mountains region of Tennessee and Kentucky. The CUR drains much of the Interior Low Plateau in these two states. Major tributaries of the region include the Big South Fork, Caney Fork, Harpeth, Obey, Red, and Stones rivers.

Four portfolios of priority watersheds were also developed for the CUR (see Map 10 & Table 46). Portfolio 1 contains 15 GCN fauna

Table 46. Priority Aquatic Conservation Portfolios in the CUR

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	15	21	24	40
# of Tier 1 Vertebrates:	*11*	*14*	*11*	*16*
Amphibians	*0*	*1*	*1*	*2*
Fish	*11*	*13*	*9*	*13*
Reptiles	*0*	*0*	*1*	*1*
# of Tier 1 Invertebrates:	*4*	*7*	*13*	*24*
Crustaceans	*1*	*2*	*0*	*3*
Mussels	*1*	*4*	*12*	*17*
Snails	*2*	*1*	*1*	*4*
Average Species Prioritization Score per HUC-12 Watershed	68.96	31.90	14.68	2.79
Total # of HUC-12 Watersheds	11	21	18	69
Total Acreage of HUC-12 Watersheds	342,808	524,552	568,387	1,874,708

and has the highest average species prioritization score per watershed of 68.96. This portfolio captures 11 HUC-12 watersheds comprising 342,808 acres. A site-specific example for portfolio 1 is the Big South Fork watershed, which has a number of GCN fish, mussels, salamanders, and aquatic snails. Portfolio 2 has the next highest rating with a prioritization score of 31.90 and 21 GCN species. This second portfolio contains 21 watersheds covering 524,552 acres. Portfolio 3 captures 24 species and has an average prioritization score of 14.68. This portfolio contains 18 watersheds of approximately 568,387 acres. Finally, portfolio 4 has the highest number of GCN species at 40, but has the lowest prioritization score of 2.79. As well, this portfolio captures 69 HUCs totaling 1,874,708 acres.

As with other aquatic regions, primary sources of stress potentially affecting GCN species or habitats in the CUR were ranked according to overall stress ratings and rarity scores for species (see Table 47). Twenty problems were linked to species in the region. Again, incompatible grazing / pasture management practices top the list. GIS analysis of land cover in the CUR drainage shows that much of the region's forest has been cleared, and

Table 47. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the CUR

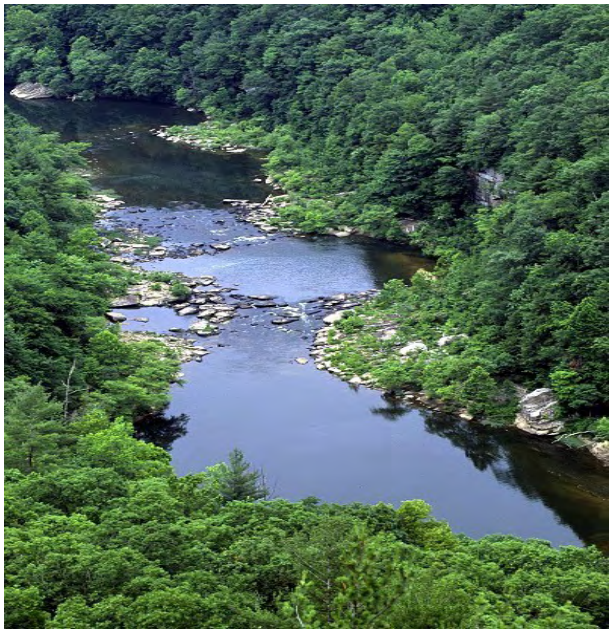
Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Incompatible Grazing / Pasture Management Practices	62	849.78	13.71
Construction of Dams / Impoundments	49	696.30	14.21
Incompatible Mining Practices	53	629.69	12.11
Incompatible Row Crop Agricultural Practices	34	360.25	10.56
Incompatible Forestry Practices	25	350.03	14.00
Municipal Wastewater Treatment / Stormwater Runoff	27	342.81	12.70
Residential Sewage / Septic Systems	13	184.94	14.23
Industrial Discharge	15	183.44	13.10
Operation of Dams / Reservoirs	13	170.63	13.13
Oil or Natural Gas Drilling	12	104.72	8.73
Excessive Surfacewater Withdrawal	6	96.31	16.05
Excessive Groundwater Withdrawal	1	26.25	26.25
Invasive Exotic Species	7	22.38	3.20
Channelization of Rivers / Streams	4	19.84	4.96
Illegal Hunting/Fishing/Collection/ Killing	1	9.00	9.00
Commercial Collection of Species	1	8.00	8.00
Primary Residential Development	1	6.00	6.00
Agricultural Conversion	1	5.25	5.25
Construction of Roads / Railroads / Utilities	1	3.75	3.75
Recreational Use of Habitats (Non-vehicular)	1	1.88	1.88

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

much of the land converted to pasture for cattle. In general, many of the problems associated with grazing come from stream bank erosion by cattle (Platts and Nelson 1985). Row crop agriculture was also linked as contributing to some stresses in the region. Like the TNR, the Cumberland River and many of its tributaries have hydroelectric dams, which were constructed by the U.S. Army Corps of Engineers in the mid 1900's. The connected system of reservoirs on the Cumberland River is heavily used for navigation and recreation, which has contributed to the spread of invasive exotic species. Coordination with USACE on the management and operation of these dams is a crucial endeavor.

Another major source of stress affecting water quality in the CUR comes from incompatible mining practices, primarily from coal mining (Nichols and Bulow 1973). Much of the damage to the region has come from historic mining and from abandoned mines that are leaching acidic water into streams. Another problem from mining comes from the improper disposal of overburden during strip mining. Oil or natural gas drilling often occurs in close proximity to coal mining in the CUR and may also contribute to water quality problems from oil spills, brine, and drilling sediment.



Other sources of stress linked by the planning team include: incompatible forestry practices (i.e. poor streamside buffer management), municipal wastewater treatment / stormwater runoff (e.g. the Nashville metropolitan area), residential sewage / septic systems, industrial discharge, channelization, agricultural conversion, and construction of transportation and utilities corridors. As well, excessive surface and groundwater withdrawal has been noted in the region as affecting some GCN fauna. Finally, illegal fishing/collection/killing of species and recreational use of habitats may also cause stress to a few animals in the region.

Barren River Drainage (BAR)

The BAR comprises 1% of the total land area of Tennessee. The region barely dips into the state from Kentucky in the Interior Low Plateau terrestrial region. The entire drainage in Tennessee consists of headwater streams. Major streams in the region include Drakes Creek, Line Creek, Long Creek, Long Fork Creek, Puncheon Creek, Salt Lick Creek, Sulphur Fork Creek, Trammel Creek, and White Oak Creek. Despite the small size of this region in the state, the headwaters of the Barren River are considered to be a major center of diversity for darter fish species (Etnier and Starnes 1993).

Priority watersheds in the BAR are also divided into four portfolios based on species prioritization scores (see Map 14 & Table 48). Portfolio 1 has 4 fish with an average species prioritization score per HUC-12 watershed of 50.02. This portfolio captures 7 watersheds comprising 72,121 acres. Portfolio 2 has the next highest species prioritization score at 39.13 and 3 fish species. This second portfolio contains 3 watersheds covering 31,370 acres. Portfolio 3 captures 5 fish species and has an average prioritization score of 14.29. This portfolio contains 12 watersheds of approximately 99,076 acres. Finally, portfolio 4 contains 3 fish with an average species prioritization score of 4.15. The portfolio contains 3 HUC-12 watersheds of approximately 34,164 acres.

Table 48. Priority Aquatic Conservation Portfolios in the BAR				
Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	4	3	5	3
# of Tier 1 Vertebrates:	*4*	*3*	*5*	*3*
Amphibians	*0*	*0*	*0*	*0*
Fish	*4*	*3*	*5*	*3*
Reptiles	*0*	*0*	*0*	*0*
# of Tier 1 Invertebrates:	*0*	*0*	*0*	*0*
Crustaceans	*0*	*0*	*0*	*0*
Mussels	*0*	*0*	*0*	*0*
Snails	*0*	*0*	*0*	*0*
Average Species Prioritization Score per HUC-12 Watershed	50.02	39.13	14.29	4.15
Total # of HUC-12 Watersheds	7	3	12	3
Total Acreage of HUC-12 Watersheds	72,121	31,370	99,076	34,164

Five primary sources of stress linked to GCN species in the BAR were rated based on overall stress – rarity scores (see Table 49). The low number of identified problems in this region is attributed to the size of the drainage, the limited number of aquatic system types, and fewer GCN species of only a single faunal group. Sources of stress in the region are all related to water quality issues. Again, the category of incompatible grazing / pasture management practices is rated as the highest problem.

Incompatible forestry practices are also rated high. In general, the forests of the BAR have been historically cleared for agriculture and from logging. Other problems potentially affecting GCN species are related to housing development, residential septic systems, and municipal wastewater treatment /

Table 49. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the BAR			
Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Incompatible Grazing / Pasture Management Practices	10	100.31	10.03
Primary Residential Development	5	56.06	11.21
Incompatible Forestry Practices	5	40.88	8.18
Residential Sewage / Septic Systems	2	15.94	7.97
Municipal Wastewater Treatment / Stormwater Runoff	1	5.63	5.63

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

stormwater runoff. Overall, cities and towns in the BAR are rapidly growing as "bedroom" communities of Nashville. Likewise, private landholdings are being subdivided at ever-increasing rates for housing developments and mini-farms. Relatively little urban or rural planning has been done in the region's counties, and few zoning regulations exist.

Conasauga River Drainage (COR)

Approximately a 10 river mile stretch of the Conasauga River reaches into the far southeastern corner of Tennessee. The COR is the smallest drainage in the state comprising only 0.3% of the state's landmass. The river has a few headwater streams in the Southern Blue Ridge and Ridge & Valley in Tennessee. However, most of the drainage emanates from headwaters further south in Georgia.

Due to the limited number of HUC-12 watersheds, priorities for the COR were divided into two portfolios only (see Table 50). Each portfolio was still rated as Very High, High, Medium, or Low based on average species prioritization scores per watershed. Analysis of actual ratings of the two portfolios revealed that one was in the "Very High" range and the other in the "Low" range of scores. Portfolio 1 contains 23 GCN species with an average prioritization score per watershed of 213.49. Only 2 HUC-12 watersheds are captured by the portfolio with a total area of 45,434 acres. Again, no portfolio 2 or 3 category exists. Portfolio 4 captures only 2 species with an average species prioritization score of 1.18. As well, only 1 HUC is contained in this portfolio comprising 36,728 acres.

Seven primary sources of stress are linked to GCN species within the COR (see Table 51). Again, the small area of this drainage in the state somewhat limits the number of potential sources of stress. Given the proximity of the region in the Ridge & Valley, agricultural effects from incompatible grazing / pasture management practices and incompatible row crop practices again head the list of aquatic problems. Overall, the COR is a very rural region of the state and much of the area is being farmed. Another highly rated source of stress by the planning team is incompatible

Table 50. Priority Aquatic Conservation Portfolios in the COR

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	23	0	0	2
# of Tier 1 Vertebrates:	*11*	*0*	*0*	*0*
Amphibians	*0*	*0*	*0*	*0*
Fish	*11*	*0*	*0*	*0*
Reptiles	*0*	*0*	*0*	*0*
# of Tier 1 Invertebrates:	*12*	*0*	*0*	*2*
Crustaceans	*0*	*0*	*0*	*1*
Mussels	*12*	*0*	*0*	*1*
Snails	*0*	*0*	*0*	*0*
Average Species Prioritization Score per HUC-12 Watershed	213.49	0	0	1.18
Total # of HUC-12 Watersheds	2	0	0	1
Total Acreage of HUC-12 Watersheds	45,434	0	0	36,728

Table 51. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the COR

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Incompatible Grazing / Pasture Management Practices	33	729.61	22.11
Incompatible Row Crop Agricultural Practices	20	576.09	28.81
Incompatible Forestry Practices	24	489.30	20.39
Residential Sewage / Septic Systems	16	341.48	21.34
Primary Residential Development	1	65.00	65.00
Landfill Construction / Operation	1	39.38	39.38
Invasive Exotic Species	1	28.00	28.00

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

forestry practices. A portion of the headwaters of the COR are located in the mountains of the Southern Blue Ridge. Much of this area is a mix of private and federal forest land.

As well, residential sewage is also implicated as a problem affecting species. Though the region is currently rural, development pressures are increasing in portions of some watersheds. Other identified sources of stress involve issues with landfill construction & operation, and invasive exotic species.

Conservation Priorities in Subterranean Regions

For purposes of this study, Tennessee was divided into 6 broad subterranean regions representing every portion of the state (see Map 1 in *Chapter 1*). These regions include: the Western Uplands, the Central Uplands, the Nashville Basin, the Cumberland-Rim, the Ridge & Valley, and the Southern Blue Ridge. As previously described, these regions were derived with the input of several experts across the state. However, these regions are not recognized on a wide basis, and do not represent a consensus of opinion of all karst geographers. The primary purpose of these regions is to stratify biologically important cave systems so that priorities may be more easily established. Though all subterranean regions have some karst topography, the Western Uplands is more or less devoid of important cave systems. As such, it was excluded from this report.

Again, due to the sensitive nature of subterranean fauna, locations of cave entrances are not provided in this report. Priority areas for cave conservation are depicted by mapped units of terrestrial habitats segregated within roadless blocks. Portfolios of priority cave areas are also shown as clusters of terrestrial habitats that capture entrances to cave systems. No assertions are made in this report about the underground extent of cave systems in relation to these depicted terrestrial regions. Also, only a limited number of subterranean fauna (35) are classified as Tier 1. Most cave-dwelling species in the state (135) are Tier 2. Subterranean regional priorities for Tier 1 species are presented in geographic order from west to east as follows:

Central Uplands Subterranean Region (CUP)

The CUP region comprises approximately 20.2% of the total land area of Tennessee. This region comprises much of the western upland subregions of the Upper Gulf Coastal Plain and the Western and Northern Highland

Table 52. Priority Subterranean Conservation Portfolios in the CUP

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	1	4	1	4
# of Tier 1 Vertebrates:	*0*	*1*	*1*	*1*
Amphibians	*0*	*0*	*0*	*0*
Fish	*0*	*1*	*1*	*1*
Mammals	*0*	*0*	*0*	*0*
Reptiles	*0*	*0*	*0*	*0*
# of Tier 1 Invertebrates:	*1*	*3*	*0*	*3*
Crustaceans	*1*	*2*	*0*	*3*
Snails	*0*	*1*	*0*	*0*
Average Species Prioritization Score per Cave System	35.88	9.98	5.91	1.24
# of Cave Systems per Portfolio	1	4	2	11

Rim and Pennyroyal Karst Plain subregions of the Interior Low Plateau. Most caves in the CUP form down in "hollows" along creeks.

Analysis of priority subterranean areas was conducted for the CUP (see Map 13 & Table 52). Portfolio 1 rates the highest, but contains only a single GCN species with an average prioritization score per cave system of 35.88. Only 1 cave system is captured in this portfolio. Portfolio 2 comprises 4 species with an average prioritization score of 9.98 across 4 cave systems. Portfolio 3 has just one species and a lower prioritization score of 5.91. This portfolio captures 2 cave systems. Finally, portfolio 4 contains 4 species with an average prioritization score of only 1.25 scattered across 11 cave systems.

Six sources of stress were documented as potentially affecting subterranean fauna within the CUP (see Table 53). These problems

Table 53. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the CUP

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Primary Residential Development	4	77.75	19.44
Residential Sewage / Septic Systems	5	72.19	14.44
Incompatible Grazing / Pasture Management Practices	5	56.25	11.25
Construction of Roads / Railroads / Utilities	1	36.75	36.75
Incompatible Forestry Practices	2	31.88	15.94
Excessive Groundwater Withdrawal	1	6.00	6.00

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

include: primary residential development, residential sewage / septic systems, incompatible grazing / pasture management practices, construction of roads / railroads / utilities, incompatible forestry practices, and excessive groundwater withdrawal. Overall, these problems vary by location in the CUP.

Nashville Basin Subterranean Region (NAB)

The NAB region comprises approximately 14.4% of the total land area of Tennessee. This region essentially underlies the outer and inner Central Basin subregions of the Interior Low Plateau. Caves in the "hilly" outer basin tend to form in ravines along creeks, much like the CUP. However, caves in the inner basin are essentially "sinkhole" caves.

Analysis of key subterranean portfolio areas for the NAB reveals several priority areas (see Map 14 & Table 54). Portfolio 1 captures two GCN species with an average prioritization score per cave of 40.03. This portfolio has 4 cave systems. Portfolios 2 and 3 contain only a single species each, with an average prioritization score per cave of 7.13 and 5.16 respectively. Portfolio 2 is composed of 4 caves; whereas, portfolio 3 contains 2 caves. Finally, portfolio 4 captures 2 GCN species for the lowest average prioritization score of 1.50.

Four cave systems are found within this portfolio.

Analysis of sources of stress shows that seven problems are potentially affecting fauna in the NAB (see Table 55). Problems in the region include: residential sewage / septic systems, primary residential development, construction of roads / railroads/ utilities, incompatible grazing practices, incompatible forestry practices, excessive groundwater withdrawal, and municipal wastewater treatment / stormwater runoff. As a whole, karst resources in the NAB are being pressured by rampant urban development. As well, the extensive underground network of the predominantly "sinkhole" caves are much

Table 54. Priority Subterranean Conservation Portfolios in the NAB

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	2	1	1	2
# of Tier 1 Vertebrates:	*1*	*1*	*1*	*1*
Amphibians	*0*	*0*	*0*	*0*
Fish	*1*	*1*	*1*	*1*
Mammals	*0*	*0*	*0*	*0*
Reptiles	*0*	*0*	*0*	*0*
# of Tier 1 Invertebrates:	*1*	*0*	*0*	*1*
Crustaceans	*1*	*0*	*0*	*0*
Snails	*0*	*0*	*0*	*1*
Average Species Prioritization Score per Cave System	40.03	7.13	5.16	1.50
# of Cave Systems per Portfolio	4	4	2	4

Table 55. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the NAB

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Residential Sewage / Septic Systems	3	45.94	15.31
Primary Residential Development	2	45.25	22.63
Construction of Roads / Railroads / Utilities	1	36.75	36.75
Incompatible Grazing / Pasture Management Practices	3	30.00	10.00
Incompatible Forestry Practices	1	26.25	26.25
Excessive Groundwater Withdrawal	1	6.00	6.00
Municipal Wastewater Treatment / Stormwater Runoff	1	5.63	5.63

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

more susceptible to contamination and depletion of groundwater resources than other cave types. As well, tree loss in the NAB from historic agricultural conversion and logging has left cave species vulnerable.

Cumberland-Rim Subterranean Region (CRM)

The CRM makes up approximately 19.2% of the total land area of Tennessee. This region captures the Eastern Highland Rim subregion of the Interior Low Plateau and the entirety of the Cumberland Plateau & Mountains. Most caves in this region lie along the eastern escarpment of the Cumberland Plateau. This area is thought to be one of the most dense karst regions in the country (Moss 1998). Subsequently, more caves are found in this region than any other area in the state. Most caves in the CRM are formed along the edge of hillsides at the bottom of deep ravines.

Priority subterranean areas in the CRM capture more caves and more Tier 1 species than in other regions (see Map 14 & Table 56). Portfolio 1 captures 4 GCN fauna with an average species prioritization score of 22.67. This portfolio contains only 2 cave systems. Portfolio 2 has 7 species with an average prioritization score of 21.22 spread across 5 caves. Portfolio 3 has 4 species with a significantly lower prioritization score average of 7.60. However, this portfolio captures 19 caves. Finally, portfolio 4 has 7 species with an average prioritization score of less than one. However, this average is scattered across 36 cave systems.

Nine priority sources of stress have been linked to species in the CRM (see Table 57). These problems include: incompatible forestry practices, incompatible grazing / pasture management practices, municipal wastewater treatment / stormwater runoff, residential sewage / septic systems, non-vehicular recreational use of habitats, excessive groundwater withdrawal, secondary home / resort development, primary residential development, and forestry conversion.

The CRM composes two distinct areas, each with its own unique set of problems. Forestry takes place mainly in the Cumberland Plateau portion of the region; whereas, the Eastern Highland Rim portion is mostly agricultural. Recent years have seen an increase in secondary and primary home development in the bluffs overlooking the rim. Unfortunately, this is where the majority of caves are clustered. Being at the top of the watershed, water is also a scarce resource in the region.

Table 56. Priority Subterranean Conservation Portfolios in the CRM

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	4	7	4	7
# of Tier 1 Vertebrates:	*1*	*2*	*1*	*1*
Amphibians	*0*	*1*	*0*	*0*
Fish	*1*	*1*	*1*	*1*
Mammals	*0*	*0*	*0*	*0*
Reptiles	*0*	*0*	*0*	*0*
# of Tier 1 Invertebrates:	*3*	*5*	*3*	*6*
Crustaceans	*3*	*5*	*2*	*5*
Snails	*0*	*0*	*1*	*1*
Average Species Prioritization Score per Cave System	22.67	21.22	7.60	0.91
# of Cave Systems per Portfolio	2	5	19	36

Table 57. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the CRM

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Incompatible Forestry Practices	13	257.19	19.78
Incompatible Grazing / Pasture Management Practices	10	237.89	23.79
Residential Sewage / Septic Systems	12	208.59	17.38
Municipal Wastewater Treatment / Stormwater Runoff	3	30.23	10.08
Recreational Use of Habitats (Non-vehicular)	1	29.75	29.75
Excessive Groundwater Withdrawal	1	6.00	6.00
Secondary Home / Resort Development	1	5.91	5.91
Primary Residential Development	1	2.95	2.95
Forestry Conversion	1	2.81	2.81

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

Ridge & Valley Subterranean Region (R&V)

The R&V is another important karst region comprising almost 18.3% of the state. The regions corresponds exactly to the confines of the Ridge & Valley terrestrial region. Most caves in the area tend to form along hillsides near streams and rivers, although "sinkhole" type caves are also found.

Analysis of subterranean areas in the R&V reveals several priority areas (see Map 15 and Table 58). Portfolio 1 has 2 GCN fauna with an average species prioritization score of 38.56 for 4 cave systems. Portfolio 2 has the highest number of fauna at 5, but an average prioritization score of only 2.82 for 5 caves. Likewise, portfolio 3 captures 3 species with a prioritization score of 2.81 for 5 caves. Finally, portfolio 4 captures only 2 species with the lowest prioritization score of 0.22 scattered across 11 cave systems.

More problems were linked to subterranean fauna in the R&V than in any other region (see Table 59). Ten sources of stress are documented as follows: residential sewage / septic systems, incompatible grazing / pasture management practices, municipal wastewater treatment / stormwater runoff, incompatible forestry practices, primary residential development, incompatible mining practices, recreational use of habitats, construction of roads / railroads / utility corridors, excessive groundwater withdrawal, and commercial / industrial development. Overall, the R&V is affected by multiple categories of stress which may have a compounding affect.

Table 58. Priority Subterranean Conservation Portfolios in the R&V

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	2	5	3	2
# of Tier 1 Vertebrates:	*1*	*0*	*0*	*0*
Amphibians	*1*	*0*	*0*	*0*
Fish	*0*	*0*	*0*	*0*
Mammals	*0*	*0*	*0*	*0*
Reptiles	*0*	*0*	*0*	*0*
# of Tier 1 Invertebrates:	*1*	*5*	*3*	*2*
Crustaceans	*1*	*4*	*3*	*2*
Snails	*0*	*1*	*0*	*0*
Average Species Prioritization Score per Cave System	38.56	2.82	2.81	0.22
# of Cave Systems per Portfolio	4	5	5	11

Table 59. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the R&V

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Residential Sewage / Septic Systems	11	220.47	20.04
Incompatible Grazing / Pasture Management Practices	8	151.41	18.93
Municipal Wastewater Treatment / Stormwater Runoff	5	91.17	18.23
Incompatible Forestry Practices	4	67.19	16.80
Primary Residential Development	3	59.19	19.73
Incompatible Mining Practices	1	32.00	32.00
Recreational Use of Habitats (Non-vehicular)	2	39.50	19.75
Construction of Roads / Railroads / Utilities	2	30.75	15.19
Excessive Groundwater Withdrawal	2	30.75	15.19
Commercial / Industrial Development	1	19.25	19.25

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

Southern Blue Ridge Subterranean Region (SBR)

The SBR corresponds to the same boundaries as the SBR terrestrial region. The area comprises approximately 5.9% of the land mass of Tennessee. Overall, this region has the fewest number of known caves among the 5 regions discussed in this report. Most of the caves in the region form in limestone coves and are often “sinkholes”.

Several priority subterranean areas are present in the SBR (see Map 15 and Table 60). However, given the relatively low number of caves in the region containing Tier 1 species, portfolios were limited to 2 categories only, “Very High” and “Low”. The margin of difference between these two categories is relatively small. Portfolio 1 captures only 3 GCN fauna with an average species prioritization score of 4.65. However, only one cave is found in portfolio 1. Again, portfolios 2 and 3 are not statistically relevant. Portfolio 4 contains only 1 species within a single cave with a prioritization score of 5.25. Portfolio 1 is still ranked higher based on total points.

Major problems affecting fauna in the SBR include: recreational use of habitats, residential sewage / septic systems, incompatible forestry, and incompatible grazing / pasture management practices (see Table 61).

Table 60. Priority Subterranean Conservation Portfolios in the SBR

Species & Habitat Categories	Portfolio 1 (Very High)	Portfolio 2 (High)	Portfolio 3 (Medium)	Portfolio 4 (Low)
Total # of Tier 1 Species	3	0	0	1
# of Tier 1 Vertebrates:	*0*	*0*	*0*	*0*
Amphibians	*0*	*0*	*0*	*0*
Fish	*0*	*0*	*0*	*0*
Mammals	*0*	*0*	*0*	*0*
Reptiles	*0*	*0*	*0*	*0*
# of Tier 1 Invertebrates:	*3*	*0*	*0*	*1*
Crustaceans	*3*	*0*	*0*	*1*
Snails	*0*	*0*	*0*	*0*
Average Species Prioritization Score per Cave System	4.65	0	0	5.25*
# of Cave Systems per Portfolio	1	0	0	1

(*note: The average species prioritization score is higher in portfolio 4 due to a statistical anomaly of having only 1 target species. The sum of the species prioritization scores in portfolio 1 is much higher.

Table 61. Prioritized Sources of Stress Linked to Tier 1 GCN Species in the SBR

Source of Stress	# of Species	Sum of Stress – Rarity Scores*	Average Stress – Rarity Score**
Recreational Use of Habitats (Non-vehicular)	2	66.50	33.25
Residential Sewage / Septic Systems	2	58.13	29.06
Incompatible Forestry Practices	2	52.00	52.00
Incompatible Grazing / Pasture Management Practices	1	18.75	18.75

(*note: Stress rarity scores are composed of the cumulative point values assigned for each of the stress – source of stress evaluators factored by the rarity score of each of the GCN species affected by the source of stress.)

(** The average stress rarity score = sum of stress rarity score / # of species affected by source of stress.)

Priorities for Conservation Action

Recommendations for conservation action are based on the regional analyses conducted for tier 1 fauna. Priorities for action are presented in two assessments. For the first assessment, the top two regional and state-scale actions to abate terrestrial, aquatic, and subterranean sources of stress are provided according to action score ratings (see Tables 62 - 64). Again, these scores convey the relative ability of an action to abate a given source of stress. Furthermore, some regional and statewide actions are "universal" in the sense that they are linked to almost every problem. In total, 11 of 49 specific statewide actions and 9 of 42 regional actions are considered to be "universal". In determining regional and statewide actions for each problem, selections were limited to "non-universal" actions. The top two "universal" actions for abating problems regionally and statewide are presented in a separate category listed as "All Sources of Stress" at the beginning of the first assessment. As well, some problems may have only one regional or statewide action that is "non-universal". In such instances, only one action is listed.

For the second assessment, regional and state-scale actions are ranked individually by stress abatement scores for each major environment (see Tables 65 - 67). Again, these scores measure the overall capacity of an action to abate relevant sources of stress in relation to the rarity of tier 1 species. As in the first assessment, those actions deemed to be "universal" are prioritized independently from "non-universal" actions. Prioritization of actions in this manner provides a categorical "top to bottom" look at the most beneficial actions. Not all actions are relevant in certain environmental regimes. As such, they may be omitted or may still be listed but may vary by order and score. Finally, in cases where scores were of equal rank or where certain actions were deemed improper, a subjective ordering was made based on analysis of statewide trends for all tiers of GCN species.

Table 62. Priority Terrestrial Conservation Actions by Source of Stress

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
"All Sources of Stress"	S1) Evaluate standards for review of state & federally-listed GCN species.	97	51
	S2) Propose legislation to create dedicated funding for conservation.	80	45
	R1) Conduct scientific surveys for lesser known GCN species.	19	36
	R2) Solicit private donations to fund conservation work.	63	33
Acid Rain	S1) Encourage state/federal agencies to increase standards for air pollution.	93	40
	S2) Develop strategic alliances with EPA, TDEC, and other agencies.	57	30
	R1) Participate in the review of county urban growth management plans.	76	24

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 62. Priority Terrestrial Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Agricultural Conversion	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Acquire priority tracts of habitat for GCN species.	1	40
Channelization of Rivers / Streams	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Propose legislation to expand gov't.-funded incentive programs.	87	44
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Restore in-stream flows to channelized streams.	44	40
Commercial / Industrial Development	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48
Construction of Ditches / Dikes / Drainage / Diversion Systems	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Propose legislation to expand gov't.-funded incentive programs.	87	44
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Restore degraded/converted wetland systems.	43	44

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 62. Priority Terrestrial Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Construction of Roads / Railroads / Utilities	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Evaluate standards for conducting environmental review of projects.	87	39
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48
Excessive Competition / Predation by Native Species	S1) Provide funding for rehabilitation of GCN species.	50	30
	S2) Develop statewide burn crew to reintroduce fire to priority habitats.	59	16
	R1) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	40
	R2) Restore pastures, fields, and other agricultural lands.	46	40
Fire Suppression	S1) Modify "greenbelt" program to fund landowners for maintaining ecosystem services.	84	33
	S2) Develop statewide burn crew to reintroduce fire to priority habitats.	59	32
	R1) Reintroduce prescribed fire to priority habitats.	41	40
	R2) Develop formal management agreements with landowners.	27	40
Forestry Conversion	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	40
	R2) Acquire priority tracts of habitat for GCN species.	2	40

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 62. Priority Terrestrial Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Illegal Hunting/Fishing/ Collection/Killing	S1) Propose legislation to strengthen laws for poaching/killing of fauna.	82	52
	S2) Enact more stringent policies for issuance of scientific collector permits.	88	48
	R1) Establish/adjust wildlife sanctuaries to protect priority populations or habitats.	32	36
	R2) Re-introduce extirpated/historic populations of GCN species.	48	18
Incompatible Forestry Practices	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	40
	R2) Develop formal management agreements with landowners.	27	40
Incompatible Grazing / Pasture Management Practices	S1) Propose legislation to expand gov't.-funded incentive programs.	87	44
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Develop formal management agreements with landowners.	27	40
Incompatible Mining Practices	S1) Propose legislation to designate priority habitats as unsuitable for mining.	86	40
	S2) Encourage Office of Surface Mining to designate priority habitats as lands unsuitable for mining.	91	40
	R1) Reclaim abandoned coal mines within priority habitats.	42	40
	R2) Participate in environmental review procedures for mining/drilling projects.	30	33

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 62. Priority Terrestrial Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Incompatible Row Crop Agricultural Practices	S1) Propose legislation to expand gov't.-funded incentive programs.	87	44
	S2) Develop strategic alliance with Farm Bureau, NRCS, FSA, & others.	52	33
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Restore pastures, fields, and other agricultural lands.	46	40
Incompatible Species Management Practices	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	36
	S2) Propose legislation to expand gov't.-funded incentive programs.	87	33
	R1) Encourage USACE & TVA to review operations of dams/structures.	90	60
	R2) Restore degraded / converted wetland systems.	43	44
Industrial Discharge	S1) Evaluate standards for conducting environmental review of projects.	97	39
	S2) Develop network of trained aquatic biologists to assist TDEC's monitoring.	72	36
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Increase compliance monitoring of ARAP and other permits.	73	40
Invasive Exotic Species	S1) Propose legislation to restrict import of invasive exotic species to TN.	81	48
	S2) Develop strategic alliance with USACE, TVA, water boards, & others.	53	36
	R1) Conduct rapid assessments of priority habitats for invasive exotics.	36	44
	R2) Implement integrated pest mgmt. practices in priority habitats.	37	36

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 62. Priority Terrestrial Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Municipal Wastewater Treatment / Stormwater Runoff	S1) Evaluate standards for conducting environmental review of projects.	97	39
	S2) Develop network of trained aquatic biologists to assist TDEC's monitoring.	72	36
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48
Oil or Natural Gas Drilling	S1) Modify "greenbelt" program to fund landowners for maintaining ecosystem services.	84	33
	S2) Develop strategic alliance with regulatory agencies, TN Oil & Gas Association, & others.	56	30
	R1) Participate in the review of county urban growth management plans.	76	36
	R2) Participate in environmental review procedures for projects mining/drilling projects.	30	33
Operation of Drainage / Diversion Systems	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Develop state standards for in-stream flows for GCN species.	92	44
	R1) Encourage USACE & TVA to review operations of dams/structures.	90	60
	R2) Participate in environmental review procedures for construction projects.	29	56
Parasites / Pathogens	R1) Develop/implement ecosystem-based management plans for conservation areas in the state.	33	30
	R2) Re-introduce extirpated /historic populations of species.	48	18

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 62. Priority Terrestrial Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Primary Residential Development	S1) Evaluate standards for conducting environmental review of projects.	97	39
	S2) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	R1) Participate in the review of county urban growth management plans.	76	48
	R2) Develop strategic alliance with TDOT, planners, developers, & others.	54	40
Recreational Use of Habitats (Non-vehicular)	S1) Propose legislation to strengthen laws for poaching/killing of fauna.	82	39
	S2) Provide non-game funding to TWRA wildlife officers to assist with monitoring compliance of state laws.	75	30
	R1) Participate in the review of county urban growth management plans.	76	36
	R2) Develop recreation management plans for public lands.	34	32
Residential Sewage / Septic Systems	S1) Evaluate standards for conducting environmental review of projects.	97	39
	S2) Develop more stringent standards for environmental permitting.	96	33
	R1) Participate in the review of county urban growth management plans.	76	48
	R2) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	30
Secondary Home / Resort Development	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Evaluate standards for conducting environmental review of projects.	97	39
	R1) Participate in the review of county urban growth management plans.	76	48
	R2) Develop strategic alliance with TDOT, planners, developers, & others.	54	40

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 63. Priority Aquatic Conservation Actions by Source of Stress

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
"All Sources of Stress"	S1) Evaluate standards for review of state & federally-listed GCN species.	97	51
	S2) Propose legislation to create dedicated funding for conservation.	80	45
	R1) Conduct scientific surveys for lesser known GCN species.	19	36
	R2) Solicit private donations to fund conservation work.	63	33
Agricultural Conversion	S1) Propose legislation to expand gov't.-funded incentive programs	87	44
	S2) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Restore pastures, fields, and other agricultural lands.	46	40
Channelization of Rivers / Streams	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Propose legislation to expand gov't.-funded incentive programs.	87	44
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Restore in-stream flows to channelized streams.	44	40
Commercial / Industrial Development	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 63. Priority Aquatic Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Commercial Collection of Species	S1) Enact more stringent policies for issuance of collection permits.	88	64
	S2) Work with state/federal agencies to enforce compliance with stipulations on collection permits.	74	44
	R1) Establish/adjust wildlife sanctuaries to protect priority populations or habitats.	32	36
	R2) Re-introduce historic/extirpated populations of GCN species.	48	27
Construction of Dams / Impoundments	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Develop state standards for in-stream flows for GCN species.	92	44
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48
Construction of Ditches / Dikes / Drainage / Diversion Systems	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Propose legislation to expand gov't.-funded incentive programs.	87	44
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Restore degraded/converted wetland systems.	43	44
Construction of Roads / Railroads / Utilities	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Evaluate standards for conducting environmental review of projects.	95	39
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 63. Priority Aquatic Conservation Actions by Source of Stress (cont'd.)			
Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Excessive Groundwater Withdrawal	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Develop more stringent standards for environmental permitting.	96	33
	R1) Participate in environmental review procedures for construction projects.	29	42
	R2) Participate in the review of county urban growth management plans.	76	36
Excessive Surfacewater Withdrawal	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Develop state standards for in-stream flows for GCN species.	92	44
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Develop strategic alliance with TDOT, planners, developers, & others.	54	40
Forestry Conversion	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	40
	R2) Acquire priority tracts of habitat for GCN species.	1	40
Illegal Hunting/Fishing/ Collection/Killing	S1) Propose legislation to strengthen laws for poaching/killing of fauna.	82	52
	S2) Enact more stringent policies for issuance of scientific collector permits.	88	48
	R1) Establish/adjust wildlife sanctuaries to protect priority populations or habitats.	32	36
	R2) Re-introduce extirpated/historic populations of GCN species.	48	18

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 63. Priority Aquatic Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Incompatible Animal Production Practices	S1) Propose legislation to expand gov't.-funded incentive programs.	87	44
	S2) Evaluate standards for conducting environmental review of projects.	95	39
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Participate in the review of county urban growth management plans.	76	36
Incompatible Forestry Practices	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	40
	R2) Develop formal management agreements with landowners.	27	40
Incompatible Grazing / Pasture Management Practices	S1) Propose legislation to expand gov't.-funded incentive programs.	87	44
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Develop formal management agreements with landowners.	27	40
Incompatible Mining Practices	S1) Propose legislation to designate priority habitats as unsuit. for mining.	86	40
	S2) Encourage Office of Surface Mining to designate priority habitats as lands unsuitable for mining.	91	40
	R1) Reclaim abandoned coal mines within priority habitats.	42	40
	R2) Participate in environmental review procedures for mining/drilling projects.	30	33

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 63. Priority Aquatic Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Incompatible Row Crop Agricultural Practices	S1) Propose legislation to expand gov't.-funded incentive programs.	87	44
	S2) Develop strategic alliance with Farm Bureau, NRCS, FSA, & others.	52	33
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Restore pastures, fields, and other agricultural lands.	46	40
Industrial Discharge	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Develop network of trained aquatic biologists to assist TDEC's monitoring.	72	36
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Increase compliance monitoring of ARAP and other permits.	73	40
Invasive Exotic Species	S1) Propose legislation to restrict import of invasive exotic species to TN.	81	48
	S2) Develop strategic alliance with USACE, TVA, water boards, & others.	53	36
	R1) Conduct rapid assessments of priority habitats for invasive exotics.	36	44
	R2) Implement integrated pest mgmt. practices in priority habitats.	37	36
Landfill Construction / Operation	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Provide funding/assistance for state property ownership base mapping project.	78	33
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 63. Priority Aquatic Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Municipal Wastewater Treatment / Stormwater Runoff	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Develop network of trained aquatic biologists to assist TDEC's monitoring.	72	36
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48
Oil or Natural Gas Drilling	S1) Modify "greenbelt" program to fund landowners for maintaining ecosystem services.	84	33
	S2) Develop strategic alliance with regulatory agencies, TN Oil & Gas Association, & others.	56	30
	R1) Participate in the review of county urban growth management plans.	76	36
	R2) Participate in environmental review procedures for projects mining/drilling projects.	30	33
Operation of Drainage / Diversion Systems	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Develop state standards for in-stream flows for GCN species.	92	44
	R1) Encourage USACE & TVA to review operations of dams/structures.	90	60
	R2) Participate in environmental review procedures for construction projects.	29	56
Primary Residential Development	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Participate in the review of county urban growth management plans.	76	48
	R2) Develop strategic alliance with TDOT, planners, developers, & others.	54	40

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 63. Priority Aquatic Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Recreational Use of Habitats (Non-vehicular)	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Propose legislation to strengthen laws for poaching/killing of fauna.	82	39
	R1) Participate in the review of county urban growth management plans.	76	36
	R2) Develop recreation management plans for public lands.	34	32
Residential Sewage / Septic Systems	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Develop more stringent standards for environmental permitting.	96	33
	R1) Participate in the review of county urban growth management plans.	76	48
	R2) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	30

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 64. Priority Subterranean Conservation Actions by Source of Stress

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
"All Sources of Stress"	S1) Evaluate standards for review of state & federally-listed GCN species.	97	51
	S2) Propose legislation to create dedicated funding for conservation.	80	45
	R1) Conduct scientific surveys for lesser known GCN species.	19	36
	R2) Solicit private donations to fund conservation work.	63	33
Commercial / Industrial Development	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48
Construction of Roads / Railroads / Utilities	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Evaluate standards for conducting environmental review of projects.	95	39
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48
Excessive Competition / Predation by Native Species	S1) Establish a propagation facility to increase populations of GCN species.	51	30
	S2) Provide funding for rehabilitation of GCN species.	50	27
	R1) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	40
	R2) Restore pastures, fields, and other agricultural lands.	46	40

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 64. Priority Subterranean Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Excessive Groundwater Withdrawal	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Develop more stringent standards for environmental permitting.	96	33
	R1) Participate in environmental review procedures for construction projects.	29	42
	R2) Participate in the review of county urban growth management plans.	76	36
Forestry Conversion	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	40
	R2) Acquire priority tracts of habitat for GCN species.	1	40
Incompatible Forestry Practices	S1) Coordinate planning for land acquisition among agencies & NGOs.	2	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	40
	R2) Develop formal management agreements with landowners.	27	40
Incompatible Grazing / Pasture Management Practices	S1) Propose legislation to expand gov't.-funded incentive programs.	87	44
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	2	39
	R1) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	40
	R2) Develop formal management agreements with landowners.	27	40

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 64. Priority Subterranean Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Incompatible Mining Practices	S1) Propose legislation to designate priority habitats as unsuitable for mining.	86	40
	S2) Encourage Office of Surface Mining to designate priority habitats as lands unsuitable for mining.	91	40
	R1) Reclaim abandoned coal mines within priority habitats.	42	40
	R2) Participate in environmental review procedures for mining/drilling projects.	30	33
Municipal Wastewater Treatment / Stormwater Runoff	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Develop network of trained aquatic biologists to assist TDEC's monitoring.	72	36
	R1) Participate in environmental review procedures for construction projects.	29	56
	R2) Participate in the review of county urban growth management plans.	76	48
Primary Residential Development	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Coordinate planning for easement acquisition among agencies & NGOs.	4	39
	R1) Participate in the review of county urban growth management plans.	76	48
	R2) Acquire priority tracts of habitat for GCN species.	1	40
Recreational Use of Habitats (Non-vehicular)	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Propose legislation to strengthen laws for poaching/killing of fauna.	82	39
	R1) Participate in the review of county urban growth management plans.	76	36
	R2) Install exclusionary devices to limit access to priority units of habitat.	28	34

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 64. Priority Subterranean Conservation Actions by Source of Stress (cont'd.)

Source of Stress	Specific Action Description	Specific Action Reference Code*	Relative Action Score (0 – 100)
Residential Sewage / Septic Systems	S1) Evaluate standards for conducting environmental review of projects.	95	39
	S2) Develop more stringent standards for environmental permitting.	96	33
	R1) Participate in the review of county urban growth management plans.	76	48
	R2) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	30
Secondary Home / Resort Development	S1) Develop strategic alliance with USACE, TVA, water boards, & others.	53	48
	S2) Evaluate standards for conducting environmental review of projects.	95	39
	R1) Participate in the review of county urban growth management plans.	76	48
	R2) Develop strategic alliance with TDOT, planners, developers, & others.	54	40

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 65. Priority Terrestrial Conservation Actions by Stress Abatement Score			
Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide (Universal)	1) Evaluate standards for review of state & federally-listed GCN species.	97	6,496
	2) Propose legislation to create dedicated funding for conservation.	80	5,732
	3) Develop faunal and/or habitat working groups of academics & other expert biologists.	58	5,350
	4) Develop central database to reconcile & maintain information for GCN species.	10	4,586
	5) Incorporate network of volunteers to use as "in-kind" services match on federal grants.	64	4,586
	6) Expand network of volunteers to conduct monitoring of GCN species and habitats.	17	3,821
	7) Increase staffing and funding of agencies responsible for managing GCN species.	65	3,439
	8) Increase staffing and funding of NGOs that assist with conservation of GCN species.	66	3,349
	9) Develop school curricula to emphasize issues affecting GCN species and habitats.	14	3,057
	10) Form partnerships in other states/countries to to manage wide-ranging species and habitats.	61	3,057
	11) Propose legislation to support a national/regional initiative for aquatic resource protection.	85	2,755
Statewide	1) Coordinate planning for land acquisition among agencies & NGOs.	2	4,533
	2) Coordinate planning for easement acquisition among agencies & NGOs.	4	4,533
	3) Provide funding/assistance for state property ownership base mapping project.	78	3,920
	4) Modify "greenbelt" program to fund landowners for maintaining ecosystem services.	84	3,847
	5) Develop GIS-remote sensing program to detect land cover changes in habitat for GCN species.	18	3,773
	6) Develop multi-media public outreach campaign to promote issues for GCN species.	7	3,514
	7) Propose legislation to strengthen laws for poaching/killing of fauna.	82	3,055
	8) Propose legislation to expand government-funded incentive programs.	87	2,958
(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)			

Table 65. Priority Terrestrial Cons. Actions by Stress Abatement Score (cont'd.)			
Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide	9) Establish a private land acquisition fund to purchase or leverage land deals in the state.	62	2,645
	10) Develop multi-media public outreach campaign to promote gov't.-funded incentive programs.	5	2,468
	11) Develop strategic alliance with USACE, TVA, water boards, & others.	53	1,889
	12) Create ecotourism-based local economies for depressed areas in or near priority habitats.	69	1,776
	13) Develop strategic alliance with Farm Bureau, NRCS, FSA, & others.	52	1,157
	14) Develop more stringent standards for environmental permitting.	96	1,144
	15) Provide non-game funding to TWRA wildlife officers to assist with monitoring compliance of state laws.	75	1,132
	16) Incorporate information about management of GCN species & habitats into forestry training programs.	12	986
	17) Encourage adoption of more stringent forestry practices on public lands with priority habitats.	31	903
	18) Develop strategic alliances with EPA, TDEC, & other agencies.	57	833
	19) Develop network of trained aquatic biologists to assist TDEC's monitoring.	72	667
	20) Evaluate standards for conducting environmental review of projects.	95	533
	21) Develop strategic alliance with regulatory agencies, TN Oil & Gas Association, & others.	56	229
	22) Develop state standards for in-stream flows for GCN species.	92	213
	23) Develop statewide burn crew to reintroduce fire to priority habitats.	59	128
	24) Encourage state/federal agencies to increase standards for air pollution.	93	127
	25) Establish a propagation facility to increase populations of GCN species.	51	91
	26) Propose legislation to restrict import of invasive exotic species to TN.	81	86

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 65. Priority Terrestrial Cons. Actions by Stress Abatement Score (cont'd.)			
Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide	27) Propose legislation to designate priority habitats as unsuitable for mining.	86	86
	28) Encourage Office of Surface Mining to designate priority habitats as lands unsuitable for mining.	91	86
	29) Provide funding for rehabilitation of GCN species.	50	82
	30) Develop a multi-media public outreach campaign to promote awareness of invasive exotic species.	6	54
	31) Organize a TN Exotic Pest Animal Council to coordinate information and management of invasive exotic animal species.	38	49
	32) Enact more stringent policies for issuance of collection permits.	88	48
	33) Establish a central GIS database to track severe category invasive exotic species.	10	43
	34) Propose legislation to increase penalties for illegal trade in wildlife.	83	40
	35) Work with state/federal agencies to enforce compliance with stipulations on collection permits.	74	33
	36) Utilize ex-situ conservation methods to preserve GCN species.	49	29
	37) Develop outdoor education and recreation programs to educate public about destructive recreation for GCN species.	11	10
Regional (Universal)	1) Conduct scientific surveys for lesser known GCN species.	19	4,586
	2) Solicit private donations to fund conservation work.	63	4,203
	3) Participate in regional conservation planning activities sponsored by state/federal agencies.	8	3,821
	4) Participate in regional conservation planning activities sponsored by NGOs or other groups.	9	3,821
	5) Deliver formal presentations to promote issues affecting GCN species or habitats.	15	3,821
	6) Conduct research on life history and ecological needs of GCN species to determine viability.	20	3,821
	7) Conduct research on problems affecting GCN species and habitats.	22	3,821

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 65. Priority Terrestrial Cons. Actions by Stress Abatement Score (cont'd.)

Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Regional (Universal)	8) Develop strategic alliances with state/federal agencies, NGOs, & others to focus on improvement of a regional landscape.	60	3,821
	9) Create opportunities for cost-shared positions among state/federal agencies, NGOs, & others.	67	3,057
Regional	1) Participate in the review of county urban growth Management plans.	76	5,024
	2) Acquire priority tracts of habitat for GCN species.	1	4,343
	3) Acquire conservation easements on priority tracts of habitat for GCN species.	3	3,474
	4) Participate in environmental review procedures for construction projects.	29	3,223
	5) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	2,996
	6) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	2,689
	7) Develop formal management agreements with landowners.	27	2,577
	8) Establish/adjust wildlife sanctuaries to protect critical populations or habitats.	32	2,036
	9) Develop/implement ecosystem-based management plans for conservation areas in the state.	33	2,033
	10) Develop strategic alliance with TDOT, planners, developers, & others.	54	2,014
	11) Restore pastures, fields, and other agricultural lands.	46	1,572
	12) Develop forest banking systems for forest habitats at high risk of destruction/degradation.	68	1,525
	13) Encourage county/municipal governments to adopt zoning ordinances that restrict development near priority units of habitat.	77	1,442
	14) Restore degraded/converted forest systems.	45	1,195
	15) Restore degraded/converted wetland systems.	43	1,095
	16) Develop strategic alliance with TDF, TFA, USFS, & others.	55	1,089
	17) Develop more stringent forestry BMPs based on differences in regional landforms.	94	914

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 65. Priority Terrestrial Cons. Actions by Stress Abatement Score (cont'd.)			
Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Regional	18) Encourage municipal/county governments to offer incentives for "green" construction.	70	905
	19) Increase compliance monitoring of ARAP and other permits.	73	741
	20) Restore in-stream flows to channelized streams.	44	694
	21) Conduct research to map subterranean systems & watersheds.	23	651
	22) Reintroduce prescribed fire to priority habitats.	41	182
	23) Conduct rapid assessments of priority habitats for invasive exotics.	36	145
	24) Develop recreation management plans for public lands.	34	127
	25) Implement integrated pest management practices in priority habitats.	37	119
	26) Re-introduce historic/extirpated populations of GCN species.	48	118
	27) Develop a monitoring program to measure bioaccumulation of contaminants in species.	16	101
	28) Remove physical barriers that disrupt habitat/ population connectivity for GCN species.	47	92
	29) Reclaim abandoned coal mines within priority habitats.	42	86
	30) Participate in environmental review procedures for mining/drilling projects.	30	73
	31) Encourage USACE & TVA to review operation of dams/structures.	90	62
	32) Encourage programs that advocate usage of native plants in horticulture, erosion control, and wildlife plantings.	40	38
	33) Install exclusionary devices to limit access to priority units of habitats.	28	26
(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)			

Table 66. Priority Aquatic Conservation Actions by Stress Abatement Score

Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide (Universal)	1) Evaluate standards for review of state & federally-listed GCN species.	97	8,261
	2) Propose legislation to create dedicated funding for conservation.	80	7,289
	3) Develop faunal and/or habitat working groups of academics & other expert biologists.	58	6,803
	4) Develop central database to reconcile & maintain information for GCN species.	10	5,831
	5) Incorporate network of volunteers to use as "in-kind" services match on federal grants.	64	5,831
	6) Expand network of volunteers to conduct monitoring of GCN species and habitats.	17	4,859
	7) Increase staffing and funding of agencies responsible for managing GCN species.	65	4,374
	8) Increase staffing and funding of NGOs that assist with conservation of GCN species.	66	4,374
	9) Propose legislation to create a national/regional aquatic conservation initiative.	85	4,374
	10) Form partnerships in other states/countries to to manage wide-ranging species and habitats.	61	3,888
	11) Develop school curricula to emphasize issues affecting GCN species and habitats.	14	3,888
Statewide	1) Modify "greenbelt" program to fund landowners for maintaining ecosystem services.	84	5,102
	2) Provide funding/assistance for state property ownership base mapping project.	78	5,099
	3) Propose legislation to expand government-funded incentive programs.	87	4,596
	4) Coordinate planning for land acquisition among agencies & NGOs.	2	4,426
	5) Coordinate planning for easement acquisition among agencies & NGOs.	4	4,426
	6) Propose legislation to strengthen laws for poaching/killing of fauna.	82	3,783
	7) Develop network of trained aquatic biologists to assist TDEC's monitoring.	17	3,585
	8) Develop multi-media public outreach campaign to promote issues for GCN species.	7	3,536

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 66. Priority Aquatic Conservation Actions by Stress Abatement Score (cont'd.)

Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide	9) Develop GIS-remote sensing program to detect land cover changes in habitat for GCN species.	18	3,412
	10) Develop multi-media public outreach campaign to promote gov't.-funded incentive programs.	5	2,910
	11) Evaluate standards for conducting environmental review of projects.	95	2,810
	12) Provide non-game funding to TWRA wildlife officers to assist with monitoring compliance of state laws.	75	2,668
	13) Create ecotourism-based local economies for depressed areas in or near priority habitats.	69	2,410
	14) Establish a private land acquisition fund to purchase or leverage land deals in the state.	62	2,257
	15) Develop strategic alliance with Farm Bureau, NRCS, FSA, & others.	52	2,130
	16) Develop strategic alliance with USACE, TVA, water boards, & others.	53	1,891
	17) Develop more stringent standards for environmental permitting.	96	1,889
	18) Develop state standards for in-stream flows for GCN species.	92	1,307
	19) Incorporate information about management of GCN species & habitats into forestry training programs.	12	654
	20) Develop strategic alliances with EPA, TDEC, & other agencies.	57	619
	21) Propose legislation to designate priority habitats as unsuitable for mining.	86	611
	22) Encourage Office of Surface Mining to designate priority habitats as lands unsuitable for mining.	91	611
	23) Encourage adoption of more stringent forestry practices on public lands with priority habitats.	31	599
	24) Develop strategic alliance with regulatory agencies, TN Oil & Gas Association, & others.	56	535
	25) Enact more stringent policies for issuance of collection permits.	88	80
	26) Propose legislation to restrict import of invasive exotic species to TN.	81	50

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 66. Priority Aquatic Conservation Actions by Stress Abatement Score (cont'd.)			
Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide	27) Establish a propagation facility to increase populations of GCN species.	51	49
	28) Propose legislation to prevent/rescind passage of private legislative acts that negatively affect GCN species.	79	45
	29) Provide funding for rehabilitation of GCN species.	50	44
	30) Work with state/federal agencies to enforce compliance with stipulations on collection permits.	74	43
	31) Develop a multi-media public outreach campaign to promote awareness of invasive exotic species.	6	31
	32) Organize a TN Exotic Pest Animal Council to coordinate information and management of invasive exotic animal species.	38	28
	33) Establish a central GIS database to track severe category invasive exotic species.	39	25
	34) Utilize ex-situ conservation methods to preserve GCN species.	49	24
	35) Propose legislation to increase penalties for illegal trade in wildlife.	83	19
	36) Develop outdoor education and recreation programs to educate public about destructive recreation for GCN species.	11	1
Regional (Universal)	1) Conduct scientific surveys for lesser known GCN species.	19	5,831
	2) Solicit private donations to fund conservation work.	63	5,345
	3) Participate in regional conservation planning activities sponsored by state/federal agencies.	8	4,859
	4) Participate in regional conservation planning activities sponsored by NGOs or other groups.	9	4,859
	5) Deliver formal presentations to promote issues affecting GCN species or habitats.	15	4,859
	6) Conduct research on life history and ecological needs of GCN species to determine viability.	20	4,859
	7) Conduct research on problems affecting GCN species and habitats.	22	4,859
(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)			

Table 66. Priority Aquatic Conservation Actions by Stress Abatement Score (cont'd.)

Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Regional (Universal)	8) Develop strategic alliances with state/federal agencies, NGOs, & others to focus on improvement of a regional landscape.	60	4,859
	9) Create opportunities for cost-shared positions among state/federal agencies, NGOs, & others.	67	3,888
Regional	1) Participate in the review of county urban growth Management plans.	76	6,343
	2) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	4,178
	3) Increase compliance monitoring of ARAP and other permits.	73	3,984
	4) Develop formal management agreements with landowners.	27	3,846
	5) Conduct research to map subterranean systems & watersheds.	23	3,655
	6) Acquire priority tracts of habitat for GCN species.	1	3,626
	7) Participate in environmental review procedures for construction projects.	29	3,349
	8) Develop/implement ecosystem-based management plans for conservation areas in the state.	33	3,203
	9) Acquire conservation easements on priority tracts of habitat for GCN species.	3	2,901
	10) Restore in-stream flows to channelized streams.	44	2,705
	11) Restore degraded/converted wetland systems.	43	2,539
	12) Restore pastures, fields, and other agricultural lands.	46	2,501
	13) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	2,366
	14) Establish/adjust wildlife sanctuaries to protect priority populations or habitats.	32	2,294
	15) Encourage county/municipal governments to adopt zoning ordinances that restrict development near priority units of habitat.	77	1,476
	16) Develop a monitoring program to measure bioaccumulation of contaminants in species.	16	1,280
	17) Develop strategic alliance with TDOT, planners, developers, & others.	54	1,269

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 66. Priority Aquatic Conservation Actions by Stress Abatement Score (cont'd.)			
Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Regional	18) Restore degraded/converted forest systems.	45	747
	19) Develop more stringent forestry BMPs based on differences in regional landforms.	94	654
	20) Develop forest banking systems for forest habitats at high risk of destruction/degradation.	68	617
	21) Develop strategic alliance with TDF, TFA, USFS, & others.	55	617
	22) Encourage municipal/county governments to offer incentives for "green" construction.	70	614
	23) Reclaim abandoned coal mines within critical habitats.	42	611
	24) Participate in environmental review procedures for mining/drilling projects.	30	546
	25) Encourage USACE & TVA to review operation of dams/structures.	90	287
	26) Remove physical barriers that disrupt habitat/ population connectivity for GCN species.	47	183
	27) Re-introduce historic/extirpated populations of GCN species.	48	70
	28) Conduct rapid assessments of priority habitats for invasive exotics.	36	46
	29) Develop recreation management plans for public lands.	34	38
	30) Implement integrated pest management practices in critical habitats.	37	38
	31) Install exclusionary devices to limit access to critical units of habitats.	28	31
	32) Encourage programs that advocate usage of native plants in horticulture, erosion control, and wildlife plantings.	40	22
	33) Reintroduce prescribed fire to priority habitats.	41	21

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 67. Priority Subterranean Conservation Actions by Stress Abatement Score			
Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide (Universal)	1) Evaluate standards for review of state & federally-listed GCN species.	97	1,119
	2) Propose legislation to create dedicated funding for conservation.	80	987
	3) Develop faunal and/or habitat working groups of academics & other expert biologists.	58	921
	4) Develop central database to reconcile & maintain information for GCN species.	10	790
	5) Incorporate network of volunteers to use as "in-kind" services match on federal grants.	64	790
	6) Expand network of volunteers to conduct monitoring of GCN species and habitats.	17	658
	7) Increase staffing and funding of agencies responsible for managing GCN species.	65	593
	8) Increase staffing and funding of NGOs that assist with conservation of GCN species.	66	593
	9) Propose legislation to create a national/regional aquatic conservation initiative.	85	551
	10) Form partnerships in other states/countries to to manage wide-ranging species and habitats.	61	527
	11) Develop school curricula to emphasize issues affecting GCN species and habitats.	14	527
Statewide	1) Provide funding/assistance for state property ownership base mapping project.	78	673
	2) Modify "greenbelt" program to fund landowners for maintaining ecosystem services.	84	639
	3) Coordinate planning for land acquisition among agencies & NGOs.	2	556
	4) Coordinate planning for easement acquisition among agencies & NGOs.	4	556
	5) Develop GIS-remote sensing program to detect land cover changes in habitat for GCN species.	18	548
	6) Develop network of trained aquatic biologists to assist TDEC's monitoring.	72	512
	7) Propose legislation to expand government-funded incentive programs.	87	492
	8) Develop multi-media public outreach campaign to promote issues for GCN species.	7	456
(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)			

Table 67. Priority Subterranean Cons. Actions by Stress Abatement Score (cont'd.)

Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide	9) Evaluate standards for conducting environmental review of projects.	95	432
	10) Propose legislation to strengthen laws for poaching/killing of fauna.	82	421
	11) Develop more stringent standards for environmental permitting.	96	355
	12) Create ecotourism-based local economies for depressed areas in or near critical habitats.	69	332
	13) Develop multi-media public outreach campaign to promote gov't.-funded incentive programs.	5	319
	14) Establish a private land acquisition fund to purchase or leverage land deals in the state.	62	305
	15) Provide non-game funding to TWRA wildlife officers to assist with monitoring compliance of state laws.	75	254
	16) Develop strategic alliance with USACE, TVA, water boards, & others.	53	222
	17) Develop strategic alliance with Farm Bureau, NRCS, FSA, & others.	52	167
	18) Incorporate information about management of GCN species & habitats into forestry training programs.	12	157
	19) Encourage adoption of more stringent forestry practices on public lands with priority habitats.	31	144
	20) Develop strategic alliances with EPA, TDEC, & other agencies.	57	82
	21) Develop outdoor education and recreation programs to educate public about destructive recreation for GCN species.	11	45
	22) Develop strategic alliance with regulatory agencies, TN Oil & Gas Association, & others.	56	41
	23) Develop state standards for in-stream flows for GCN species.	92	36
	24) Propose legislation to designate priority habitats as unsuitable for mining.	86	13
	25) Encourage Office of Surface Mining to designate priority habitats as lands unsuitable for mining.	91	13

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 67. Priority Subterranean Cons. Actions by Stress Abatement Score (cont'd.)			
Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Statewide	27) Establish a propagation facility to increase populations of GCN species.	51	6
	28) Provide funding for rehabilitation of GCN species.	50	5
	29) Develop statewide burn crew to reintroduce fire to priority habitats.	59	3
Regional (Universal)	1) Conduct scientific surveys for lesser known GCN species.	19	790
	2) Solicit private donations to fund conservation work.	63	724
	3) Participate in regional conservation planning activities sponsored by state/federal agencies.	8	658
	4) Participate in regional conservation planning activities sponsored by NGOs or other groups.	9	658
	5) Deliver formal presentations to promote issues affecting GCN species or habitats.	15	658
	6) Conduct research on life history and ecological needs of GCN species to determine viability.	20	658
	7) Conduct research on problems affecting GCN species and habitats.	22	658
	8) Develop strategic alliances with state/federal agencies, NGOs, & others to focus on improvement of a regional landscape.	60	658
	9) Create opportunities for cost-shared positions among state/federal agencies, NGOs, & others.	67	527
Regional	1) Participate in the review of county urban growth Management plans.	76	915
	2) Conduct research to map subterranean systems & watersheds.	23	585
	3) Increase compliance monitoring of ARAP and other permits.	73	569
	4) Acquire priority tracts of habitat for GCN species.	1	494
	5) Utilize government-funded incentive programs for landowners to improve/protect water quality.	24	447
	6) Develop formal management agreements with landowners.	27	440
	7) Develop strategic alliance with TDOT, planners, developers, & others.	54	430

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Table 67. Priority Subterranean Cons. Actions by Stress Abatement Score (cont'd.)

Scale of Action	Specific Action Description	Specific Action Reference Code*	Stress Abatement Score
Regional	8) Develop/implement ecosystem-based management plans for conservation areas in the state.	33	404
	9) Acquire conservation easements on priority tracts of habitat for GCN species.	3	395
	10) Utilize government-funded incentive programs for landowners to restore/manage forests.	25	343
	11) Encourage county/municipal governments to adopt zoning ordinances that restrict development near priority units of habitat.	77	290
	12) Participate in environmental review procedures for construction projects.	29	243
	13) Establish/adjust wildlife sanctuaries to protect priority populations or habitats.	32	217
	14) Develop strategic alliance with TDF, TFA, USFS, & others.	55	207
	15) Restore pastures, fields, and other agricultural lands.	46	205
	16) Encourage municipal/county governments to offer incentives for "green" construction.	70	194
	17) Restore degraded/converted forest systems.	45	181
	18) Develop forest banking systems for forest habitats at high risk of destruction/degradation.	68	175
	19) Restore degraded/converted wetland systems.	43	160
	20) Develop more stringent forestry BMPs based on differences in regional landforms.	94	157
	21) Restore in-stream flows to channelized streams.	44	148
	22) Develop a monitoring program to measure bioaccumulation of contaminants in species.	16	135
	23) Develop recreation management plans for public lands.	34	68
	24) Install exclusionary devices to limit access to priority units of habitats.	28	48
	25) Reclaim abandoned coal mines within priority habitats.	42	13
	26) Participate in environmental review procedures for mining/drilling projects.	30	11
	27) Re-introduce historic/extirpated populations of GCN species.	48	6
	28) Reintroduce prescribed fire to priority habitats.	41	4

(*note: Full descriptions of each specific action can be viewed in Appendix F by referencing this code.)

Priorities from Other Planning Efforts in Tennessee

In addition to priorities presented for the CWCS, results from eight other conservation plans previously conducted in Tennessee were analyzed for comparison. To conduct this analysis, maps of the priority conservation areas highlighted in other plans were overlaid onto a composite map of the terrestrial, aquatic, and subterranean habitat portfolios from the CWCS (see Maps 20 - 24).

Areas of commonality on each map generally represent agreement among plans about the conservation value of a particular area. Areas of non-overlap should not be construed as indicating disagreements among plans. The objectives and methods used by each planning effort sometimes varied greatly. In depth comparisons of priorities presented by each plan are beyond the scope of this project. As such, it is recommended that results from all of the other planning efforts be used as a supplement to the information in the CWCS. Further work is needed to integrate the planning results generated through each of these plans. General details about the goals and methods of these conservation efforts are presented in the following sections:

<u>TWRA - West Tennessee Wildlife Resources Conservation Plan</u>

The West Tennessee Wildlife Resources Conservation Plan was a collaborative effort of the TWRA and the U. S. Fish & Wildlife Service. The goal was to develop a landscape-level, biologically driven, land planning mechanism focused on issues of mutual concern and benefit among habitats for the wildlife and fish resources in western Tennessee. This initiative involved both landscape level planning and a multiple species focus to encompass the broad spectrum of issues and priorities affecting biodiversity for the region. Completed in 2002, the plan has served as a tool for both federal and state agencies. With the overall purpose of developing a landscape level, multi-species habitat plan, a number of primary objectives were included in this initiative:

- To assist the USFWS in the development of their Comprehensive Conservation Plans (CCP) for the Reelfoot Complex (Reelfoot NWR, Lake Isom NWR, Chickasaw NWR, Lower Hatchie NWR, and Hatchie NWR).

- To identify land management priorities on public lands administered by the TWRA and the USFWS, as related in national and regional habitat protection plans such as the North American Waterfowl Management Plan, Partners in Flight bird conservation plans, U. S. Shorebird Plan, Southeastern Quail Study Group habitat plan, and other species habitat plans that might be developed.

- To establish a framework of cooperation between the TWRA, the USFWS, and other interested land management agencies in addressing and meeting species habitat objectives in a coordinated manner to accomplish landscape priorities for species conservation.

- Develop maps that delineate and quantify “current” and “desired” habitat objectives on a landscape level for the West Tennessee landscape. Develop “current” and “desired” population level or status for the various wildlife resources in the West Tennessee landscape.

- Identify and quantify recreational opportunities on public and private lands and/or waters.

- Identify critical habitats, if any, essential for the viability of threatened, endangered, or rare species. Identify areas of high priority for acquisition, protection, or enhancement based on habitat requirements or public recreational needs.

- Develop criterion for "stepping down" focus area-wide habitat objectives to federal, state, and private land units.

The planning process for the *West Tennessee Wildlife Resources Conservation Plan* included the formation of a Core Planning Group and 9 Resource Working Groups The Core Planning Group was responsible for guiding the planning process and providing oversight throughout the development of the plan. The Resource Working groups were established as follows: Waterfowl; Shorebirds; Songbirds; Farm Game; Big Game; Mammal Species of Concern; Reptiles/amphibians; Aquatic Resources; and Public Use. The Resource Working Groups were each comprised of approximately 5-9 individuals who had expertise in that area, or had management responsibility for the respective resource group. The groups gathered information on species, critical habitats, and opportunities, and developed management strategies for West Tennessee. These groups developed Focus Area-Wide Goals and Objectives, which were then translated into a series of map overlays which would rank areas of specific interest and provide a simple means for inter-relating the various types of resource information included in each map. In addition, each Working Group developed a text describing goals, objectives, and strategies for implementing the desired goals and objectives.

Bird Habitat Joint Ventures

The TWRA has been an active participant in bird habitat joint ventures since the early 1990's. The agency's earliest involvement in joint venture planning was with the Lower Mississippi Valley Joint Venture (LMVJV), established in 1991. The LMVJV is a self-directed, non-regulatory conservation partnership that exists for the purpose of implementing the goals and objectives of national/international bird conservation plans within the LMV region. Comprised of federal, state, and non-governmental organizations, the LMVJV was one of the original waterfowl joint ventures established as a result of the *North American Waterfowl Management Plan*. Though its original focus was on waterfowl habitat conservation, its mission soon expanded to include other bird groups, including shorebirds, migratory landbirds, and waterbirds. This "all bird" focus has resulted in the development of bird habitat planning tools and decision support models which are utilized to guide landscape level project design and the achievement of bird conservation objectives.

The LMVJV comprises portions of 8 states, and 2 bird conservation regions (BCRs), the Mississippi Alluvial Valley and West Gulf Coastal Plain. In Tennessee, the LMVJV's primary focus is in the Mississippi Alluvial Valley, which makes up approximately 650,000 acres in the far western portion of the state. Planning activities have included the development of explicit step down plans for waterfowl, shorebirds, and forest interior land birds. Additional information on the Lower Mississippi Valley Joint Venture can be found at www.lmvjv.org.

The Central Hardwoods Joint Venture (CHJV) partnership was initiated in 2000, to implement all-bird conservation in the 9-state region known as the Central Hardwoods Bird Conservation Region. In Tennessee, the Central Hardwoods BCR covers the Interior Low Plateau terrestrial ecoregion. Similar to the LMVJV, the Central Hardwoods is developing GIS-based planning tools and decision support models to guide and inform bird conservation planning in support of national and international bird plans under the auspices of the North American Bird Conservation Initiative (NABCI): *North American Waterfowl Management Plan*, *United States Shorebird Conservation Plan*, *Partners in Flight North American Landbird Conservation Plan*, N*orth American Waterbird Conservation Plan*, and N*orthern Bobwhite Conservation Initiative*.

As a primary part of its initial planning efforts, the CHJV developed a strategic plan (http://www.abcbirds.org/nabci/chjv_plan.htm) articulating the partnership's conservation objectives, and establishing goals and

objectives in three primary program areas: biological foundation, conservation design, and conservation delivery. Also included in the strategic plan is the delineation of focus areas for priority bird species in the following habitat suites: forest interior species, grasslands, and wetlands. These initial habitat focus areas will be further refined and delineated as more sophisticated planning tools and GIS decision support models become available. The Central Hardwoods JV was granted official joint venture designation by the USFWS in 2004.

TWRA is involved in two additional and more recent bird conservation partnerships, which are envisioned to become joint ventures of their own. The first is the East Gulf Coastal Plain Joint Venture (EGJV), which covers the East Gulf Coastal Plain BCR, which generally corresponds with the Upper Gulf Coastal Plain terrestrial ecoregion of the Tennessee CWCS. The EGJV is just initiating its partnership activities, and has developed a draft concept plan that will be submitted to the USFWS soliciting official joint venture status. The second developing partnership is the Appalachian Mountains Bird Conservation Initiative (AMBCI), which covers bird conservation planning and activities within the Appalachian Mountains BCR. This BCR roughly corresponds to the Cumberland Plateau, Ridge and Valley, and Southern Blue Ridge terrestrial ecoregions of the Tennessee CWCS. Similar to the EGJV, the AMBCI has developed a draft concept plan. However, it has not been determined at this time what a joint venture of the AMBCI will look like, or whether a joint venture partnership will be established for this BCR.

As the EGJV and AMBCI partnerships continue to develop and strengthen into functional entities, bird conservation planning activities for these regions will be initiated under the auspices of the national and international bird plans of NABCI. These plans will be further stepped down to discrete project sites within each state of the partnership. As these step down plans are developed they will be incorporated into the Tennessee CWCS for those species that are identified as GCN species. For the Tennessee portion of the EGJV, this step down process has already begun, and is articulated in the Landbird section of the West Tennessee Wildlife Resources Conservation Plan.

TNC Ecoregional Plans and the Freshwater Initiative

Almost a decade ago, TNC embarked on an ambitious mission to develop detailed conservation plans for every ecoregion in the United States. Five distinct ecoregions overlap the state of Tennessee. Plans for each of these areas of the state were developed independently between 1997 and 2002.

Overall, the identification of conservation areas for an ecoregional plan is a dynamic process. The Nature Conservancy's method depends on a series of planning steps and assumptions that are iterative. Plans are meant to be revisited every few years to assess new information. Likewise, input from a wide-variety of scientific experts is crucial. Priorities are established through the following steps:

- Selecting targets for species, natural plant communities, and ecological systems as the focus of planning efforts;
- Gathering ecoregional, system, species and communities data from a range of sources;
- Setting numeric goals for conservation of each species and community type;
- Assessing the viability of individual species populations and community occurrences;
- Evaluating the landscape context of the ecoregion; and
- Identifying a portfolio of key conservation areas.

The Conservancy has published specific guidelines for developing and taking action to conserve ecoregional portfolios (Groves et al. 2000). Although the ecoregional planning process has been refined over the past

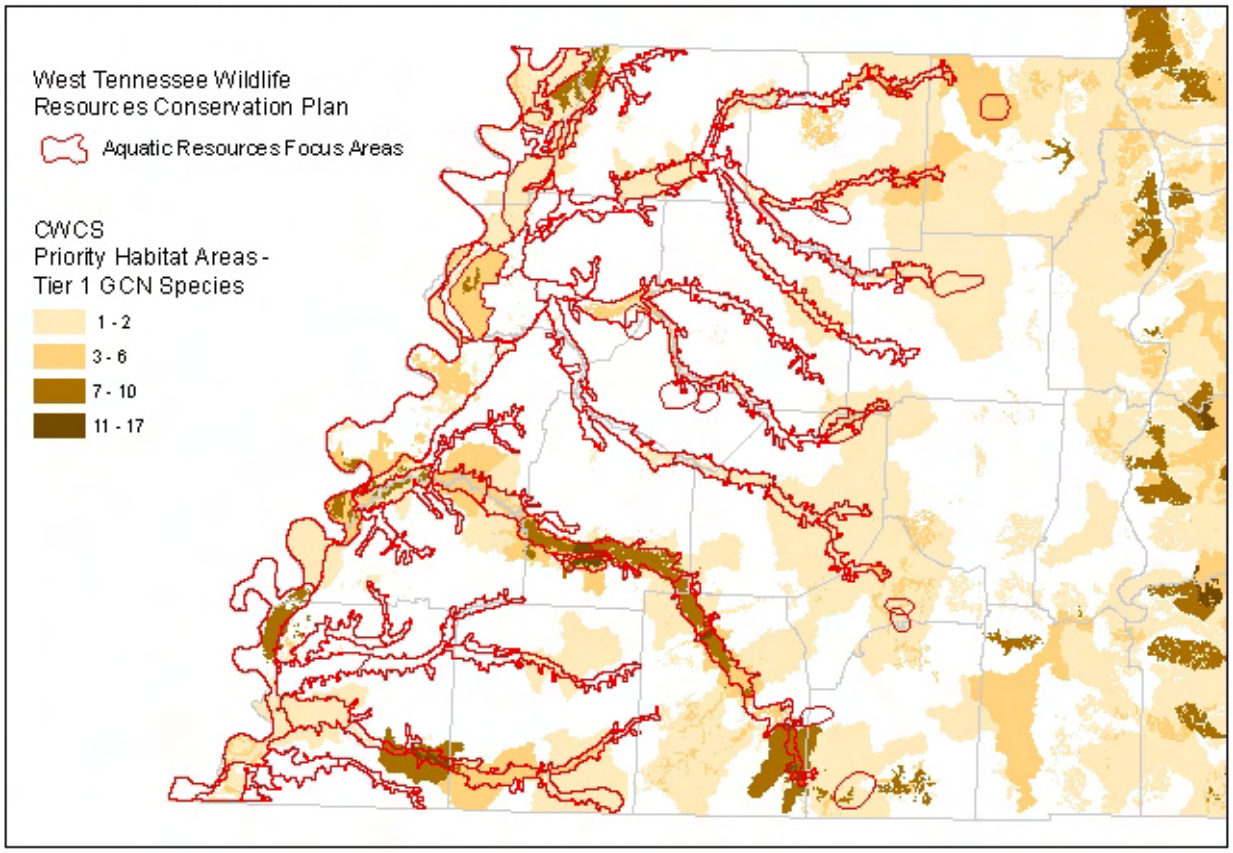
several years, the general principals have remained consistent.

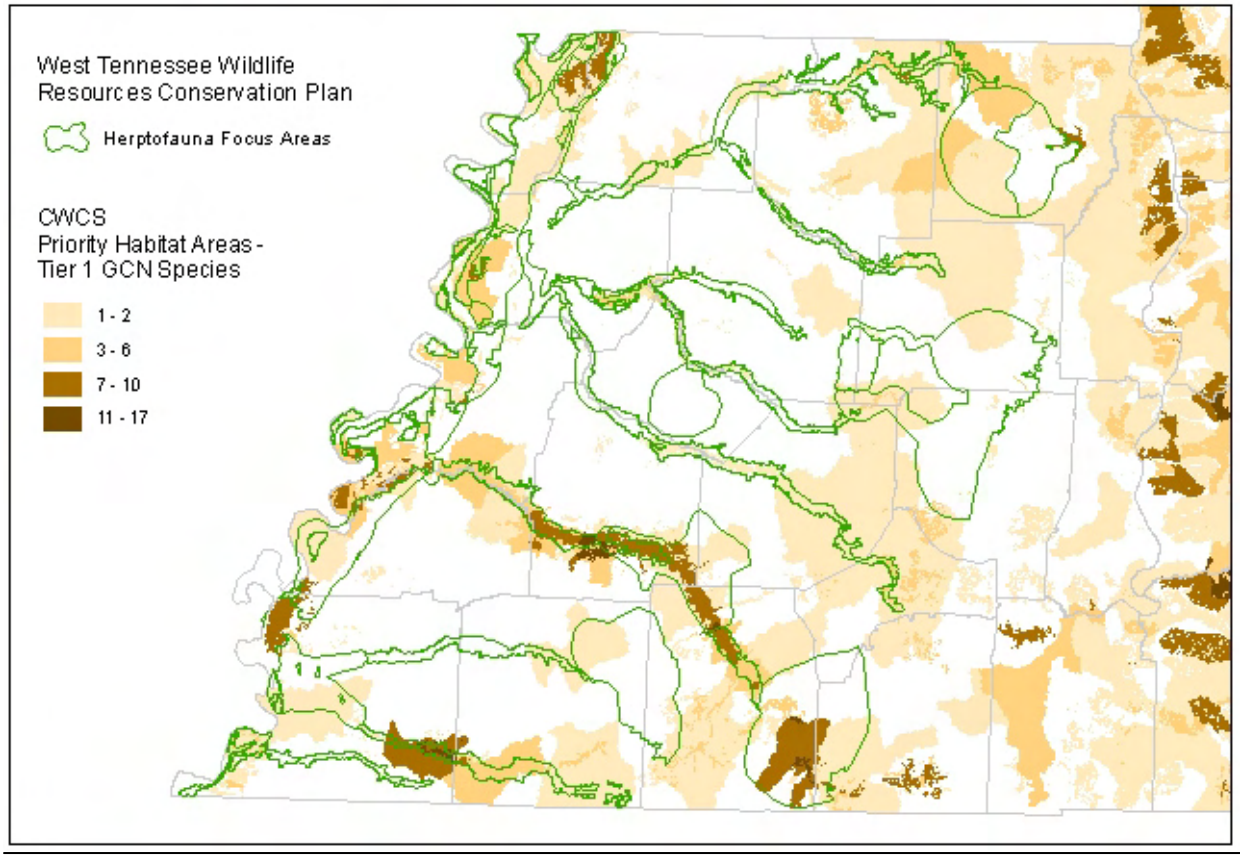
In 1998, the Conservancy also embarked on another far-reaching project known as the Freshwater Initiative. Similar to ecoregional planning, this initiative focused solely on aquatic resources within several large river basins in the southeastern United States: the Mississippi Embayment, the Mobile Bay Basin, and the Tennessee-Cumberland River Basin.

The goal of the project was to identify highest priority areas within each of these large watersheds and identify a suite of conservation actions to be implemented by TNC and its partners. In developing this work, the planning team for the Freshwater Initiative developed a scheme for delineating aquatic systems. These systems were used as the finest scale of aquatic habitats for the CWCS.

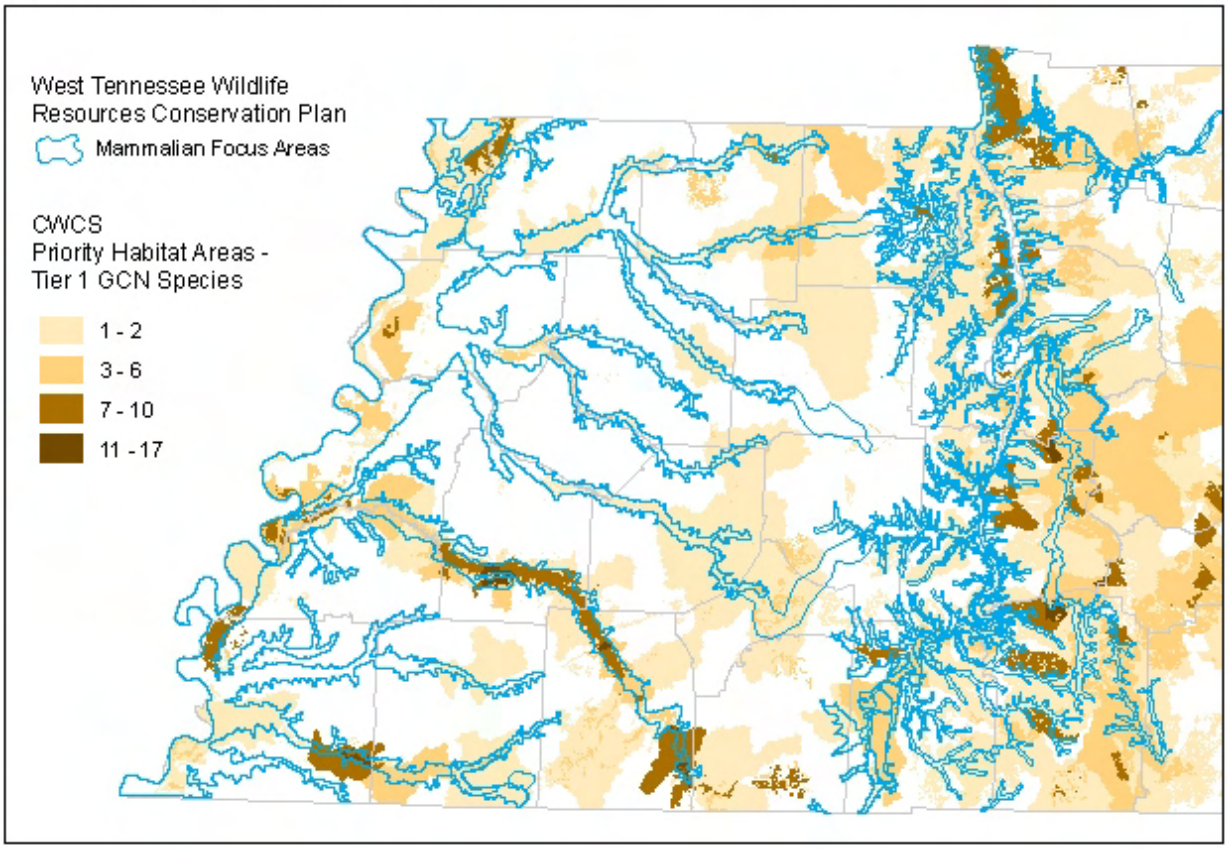
Products from this effort were presented in a single report. *(note: Links to the Freshwater Initiative website to download the final report were provided in Chapter 2.)* Results were also incorporated into the aquatic portfolios of several ecoregional plans. Overall, TNC has produced an integrated map of conservation areas from ecoregional planning and the Freshwater Initiative for the state of Tennessee.

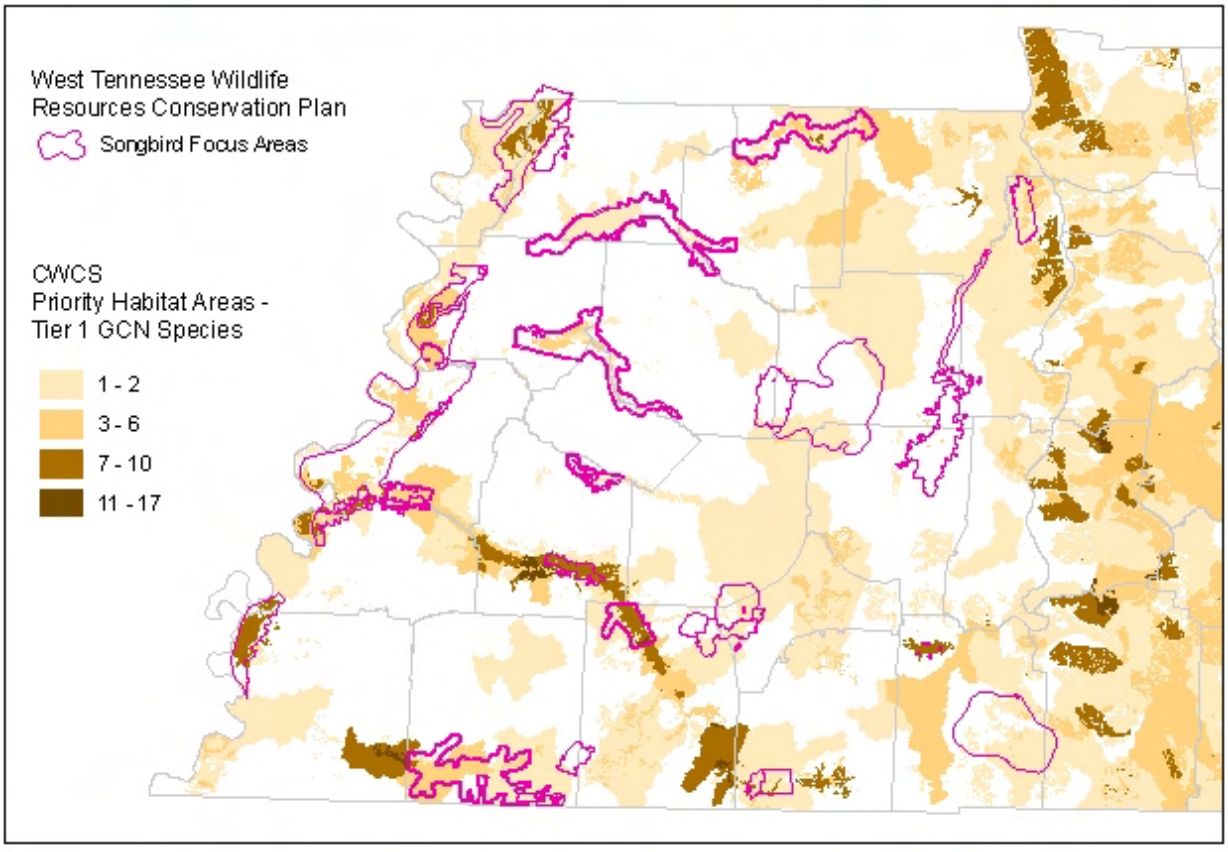
Map 20. Combined Current CWCS Priority Habitat Areas for Tier 1 GCN Species in Relation to TWRA's West Tennessee Resource Conservation Plan - Aquatic Resources, Amphibians & Reptiles



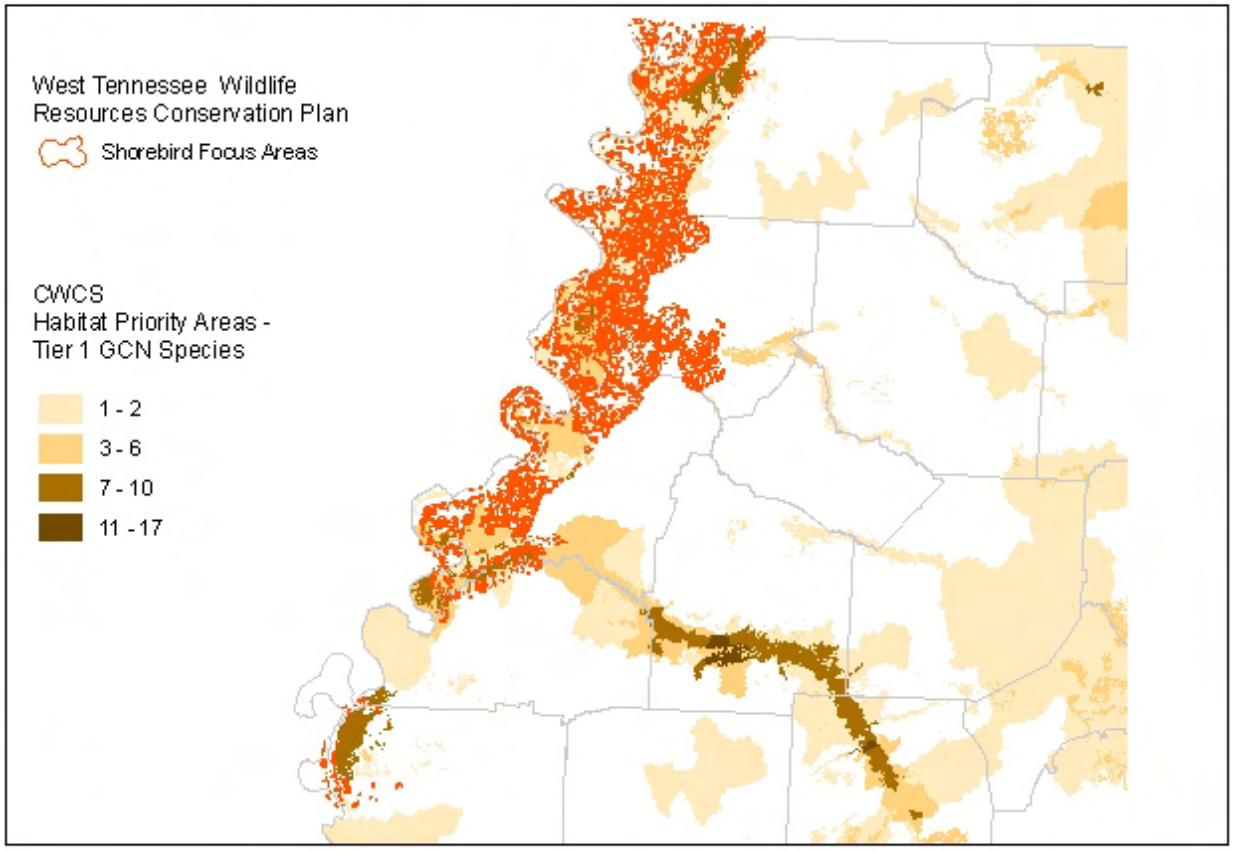


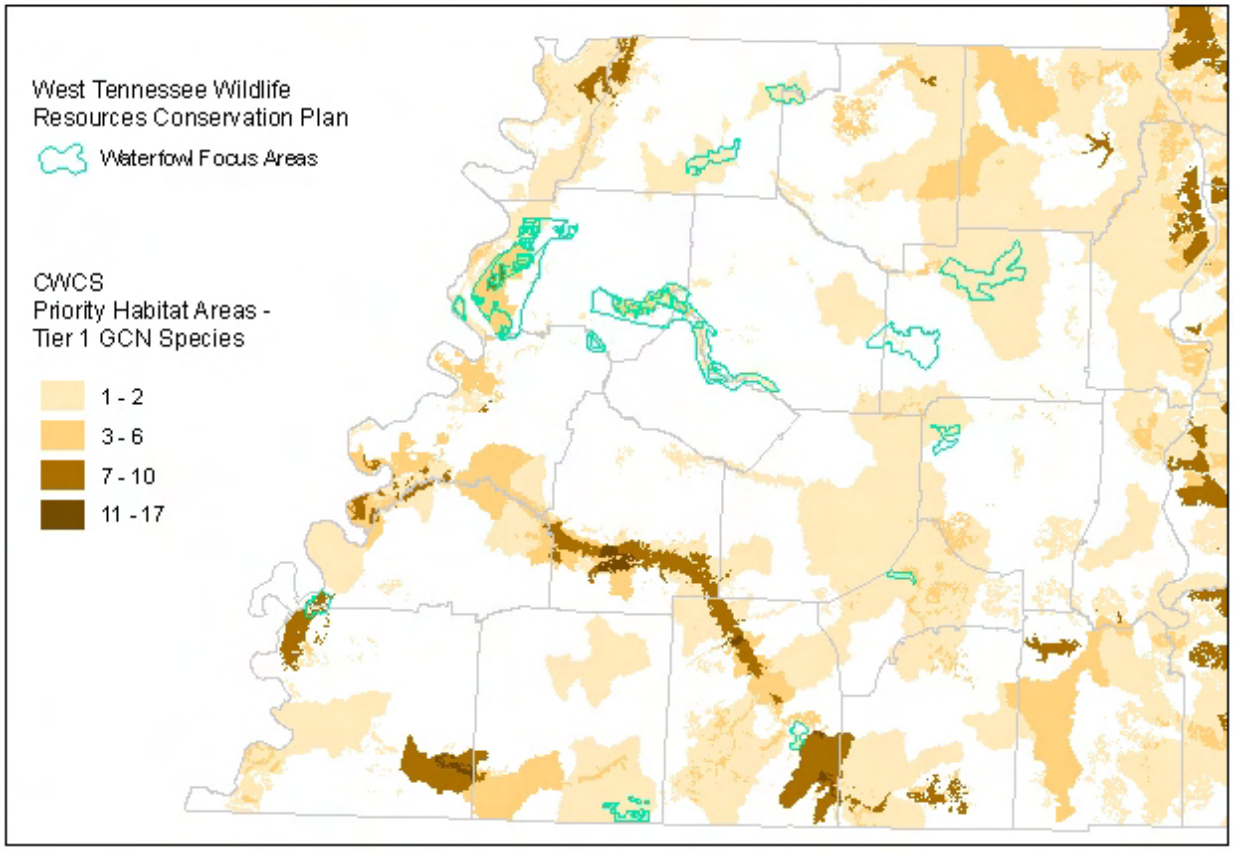
Map 21. Combined Current CWCS Priority Habitat Areas for Tier 1 GCN Species in Relation to TWRA's West Tennessee Resource Conservation Plan - Mammals & Migratory Land Birds



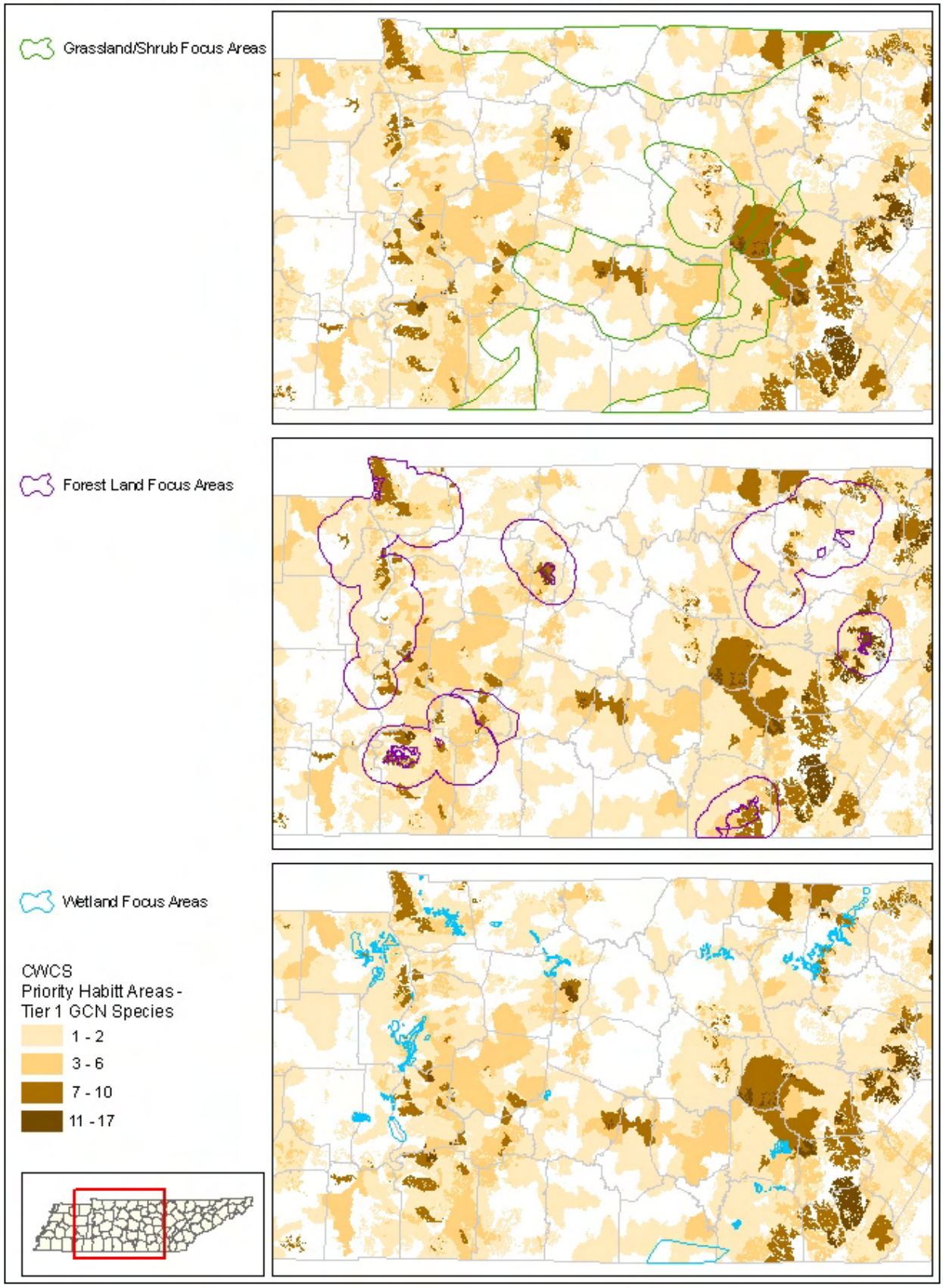


Map 22. Combined Current CWCS Priority Habitat Areas for Tier 1 GCN Species in Relation to TWRA's West Tennessee Resource Conservation Plan - Shorebirds & Waterfowl





Map 23. Combined Current CWCS Priority Habitat Areas for Tier 1 GCN Species in Relation to Central Hardwoods Joint Venture Primary Focus Areas



Map 24. Combined Current CWCS Priority Habitat Areas for Tier 1 GCN Species in Relation to The Nature Conservancy's Ecoregional Planning and Freshwater Initiative Conservation Areas

CHAPTER 4

Monitoring, Management, Research, & Review Plans

To ensure the long-term success of the CWCS, significant effort must be made to monitor the effectiveness of conservation actions after implementation. All steps taken to manage GCN fauna must be able to adapt in response to changing conditions on the ground. Furthermore, thresholds for decision making must be set to determine when actions have either achieved their desired effects or have proven unsuccessful in conserving fauna. Likewise, data gaps in research must be filled in order to establish better parameters for decision making. Finally, the CWCS must be periodically reviewed to assess progress, to refine strategies, and to re-examine priorities as new data is gathered.

Monitoring Plans

At its most basic level, monitoring must be able to determine change in the status of a target species' habitats or populations at a specified scale over time. To adequately monitor either habitats or populations, strict protocols must be established for observation and data collection. These protocols should set parameters that regulate the quality and type of information that can be used to determine the status or condition of a target. Ultimately, the process of setting monitoring protocols depends upon several factors: data quality, spatial scale, sampling effort, and duration. In turn, each of these factors is influenced by the stated objective of the monitoring effort.

Costs associated with monitoring are another factor to consider when designing and implementing a monitoring program. Intensive monitoring of the 664 GCN species identified in this strategy, at a statewide scale, would be an enormous task even if the appropriate funding were available. Further, monitoring all 412 Tier 1 species to which the TWRA holds jurisdictional responsibility is unrealistic due to associated costs. Resolution of this issue can only be achieved by establishing well-defined monitoring objectives. These objectives should determine the scale, intensity of effort and qualitative level of data collected for a select set of priority species and/or habitat units. Along with clearly defined monitoring objectives, there must be a long-term commitment to data management and data analysis. Without this commitment, monitoring cannot be expected to identify the trends needed to determine the status of selected GCN species or their habitats.

Once objectives are derived, monitoring can provide either detailed or general information about a wide array of biological factors that affect GCN species. Intensive study of a population can yield estimates of absolute abundance, age class, mortality/fecundity, survivorship, habitat condition/structure, etc. Conversely, monitoring can provide more streamlined sets of information such as the presence/absence of species and relative abundance. Both complex and simple monitoring schemes can reflect trends in parameter values and infer target status over time.

A primary goal of Tennessee's CWCS is to keep species from declining to the point of requiring protection under the federal Endangered Species Act. Depending on the status of a species and the current level of its problems, species-level management (e.g. propagation, re-introduction, or increased legal protection at the state level) may be required to sustain or recover a given faunal target. Regardless, habitat conservation, enhancement, and/or management are much more efficient options to employ to affect a

species' status. As such, habitat monitoring is crucial to determining the success of conservation and recovery projects.

Habitat Monitoring for the CWCS

Again, to successfully monitor habitat, consideration must be given to objectives, data quality/consistency, geographic & temporal scale, and costs (Schoonmaker and Luscombe 2005). With these factors in mind, the primary goals of habitat monitoring should be:

1. To assess the quality and quantity of habitat at local, regional, statewide, and national scales;
2. To assess the spatial arrangement of habitat at various scales over time; and,
3. To cooperate and partner with other organizations and agencies during the process in order to increase effectiveness, broaden applications and decrease costs.

An ideal methodology to achieve the first two goals in habitat monitoring may be found in land use / land cover analysis, remote sensing data, and other GIS modeling applications. Land use / land cover data provides the flexibility to monitor habitat at multiple spatial and temporal scales. However, some limitations do exist in regard to resolution, spectrum, and the level of habitat classification that can be achieved.

As previously mentioned, NatureServe's ecological systems compose the land cover / habitat classification system employed in the GIS model complementing this strategy. There were several reasons for selecting this system. First, it provides a standardized means of describing and comparing habitats at the ecoregional level. Second, the ecological system classification scheme provides a framework for updates. Finally, efforts are underway to develop a seamless land use / land cover map for the southeast that will more easily facilitate collaboration across state boundaries in shared ecoregions.

With future use of remote sensing and a standardized classification system, changes in land cover over time can be identified and quantified. Gains or losses in habitat can be measured and incorporated into the current CWCS GIS model. As well, more sophisticated spatial analyses can be conducted to identify and quantify important habitat corridors or core habitat blocks.

Southeast Regional GAP is developing several products based on the National Land Cover Dataset (NLCD) and NatureServe's Ecological Systems. Completion of the southeast mapping zones is projected for 2006 (McKerrow et al. 2004). Once completed, the new land use / land cover data will be employed in the CWCS model. A general schedule of re-mapping needs should be developed and coordinated with the Southeast Regional GAP program for the state. Understandably, re-mapping the southeast is a complex process and Tennessee is just one of many states with needs. However, comparing land use at five to ten year intervals would provide a high degree of monitoring of wildlife habitats at a state scale (also suggested by Schoonmaker and Luscombe 2005). This frequent analysis could also be used in considering the results of other forest/habitat analysis efforts.

Other Habitat Assessment Programs

A number of other habitat assessment and monitoring programs conducted by agencies, organizations, and academic institutions have either recently been conducted or are ongoing across portions of Tennessee. Despite the fact that these programs have their own sets of objectives, scales and methodologies, coordination at a basic level should produce some residual benefits to CWCS efforts. Knowing which monitoring and assessment programs are being conducted and understanding their respective objectives will hopefully minimize any unnecessary duplication of labor. Many of these programs delve deeply into assessment of underlying causes of habitat change. Due to a number of reasons, not all of these programs may explicitly integrate or mesh with each other. They can, however, at a minimum provide supplemental information to habitat monitoring

conducted for the CWCS. Descriptions of ongoing assessment programs and other monitoring studies are provided as follows:

- The Southern Forest Resource Assessment (SFRA) was completed in 2003. The USFS, USFWS, USEPA, TVA and some state forestry departments and fish and wildlife agencies worked cooperatively in evaluating the status and future conditions of southern forests (Wear and Greis, 2003). Issues considered included rapid urbanization, increasing timber demand, increasing numbers of satellite chip mills, forest pests, water quality and changing air quality. This assessment was based on NLCD land cover standards and Forest Inventory Analysis data. Periodic land use / land cover analysis at the regional level could help track and predict forest conditions.

- The Tennessee Division of Forestry evaluated the SFRA relative to forest resources in Tennessee. Specific areas on which the Tennessee Forestry Commission offered recommendations included: urbanization, forest fragmentation, forest health, timber resources and water quality (Tennessee Forestry Commission 2004).

- Forest Health Monitoring Program is a USFS program designed to determine the status, changes, and trends in indicators of forest condition on an annual basis. The FHM program uses data from ground plots and surveys, aerial surveys, and other biotic and abiotic data sources and develops analytical approaches to address forest health issues that affect the sustainability of forest ecosystems. FHM covers all forested lands through a partnership involving USFS, State Foresters, and other state and federal agencies and academic groups (U.S. Dept. of Agriculture Forest Service 2003).

- A 2003 report by the USFS / Southern Research Station evaluated forest fragmentation at the national scale (Wear and Greis 2003). Fragmentation greatly affects habitat suitability, wildlife movements, and invasion of exotic plant species. Again, periodic land use / land cover analysis at the regional level could track fragmentation.

- Riiters et al. (2002) reports on the fragmentation of continental U. S. forests. The report conducts a multiple-scale analysis of forest fragmentation and finds most forests are in a fragmented landscape. State-level implications may be inferred from the report.

- *Forests on the Edge*, a report by the USFS (Stein et al. 2004), evaluated the impact of housing development on private forestlands. This assessment ranked the Lower Cumberland watershed as 6th in the nation in terms of increased housing density by the year 2030.

- NRCS conducts an annual Natural Resources Inventory (NRI) (Natural Resources Conservation Service, 2004). The NRI is a land use survey statistically designed to measure the status, conditions, and trends of the natural resources on non-federal lands. Full implementation of the annual NRI approach is expected in 2005. Future products from the survey should allow evaluations of conservation programs implemented by the NRCS. Water quality, water use conservation, soil erosion, soil quality and carbon sequestration benefits will be identified. Additional goals of the NRI include regional level evaluations of land use, air quality and wildlife habitat.

- Climate change is expected to affect forest composition, water quality and wildlife in Tennessee by the year 2100 (U.S. Environmental Protection Agency 1999). Monitoring of land use / land cover and biological communities is imperative to document any potential effects from climate change.

- Other pertinent Southeast GAP efforts include partnering with the USFWS to refine habitat models of priority bird species to southeastern habitats. Impervious surface and closed canopy estimations are also being developed (McKerrow et al. 2004). Both estimations have implications for water quality assessment.

- The Tennessee Division of Water Pollution Control assesses the status of water quality in Tennessee and has recently issued the 2004 305b Report. In this assessment watersheds are sampled on a 5-year rotation. Based on biological and chemical sampling of streams and habitat descriptions, streams are evaluated into 5 use categories (Category 1 and 2 supporting, Category 3 not assessed, Category 4 water impaired with Total Maximum Daily Load assessment not required, and Category 5 monitored water found not to meet its designated use).

- The USFWS sponsored bird joint ventures have developed or are developing GIS coverages of various habitat layers for bird conservation. The Lower Mississippi Valley Joint Venture (LMVJV) and the Central Hardwoods Joint Venture (CHJV) are working collaboratively on forest bird habitat models for the Central Hardwoods Bird Conservation Region. The LMVJV has developed decision support models for forest interior birds for the LMV Bird Conservation Region. The CHJV is looking at developing wetland data layers. The East Gulf Coastal Plain JV and Appalachian JV partnerships are just getting started with bird conservation planning and GIS capabilities.

- State and regional-level mapping using satellite and other imagery is ongoing in several agencies. There is an opportunity to acquire 1 meter resolution digital aerial imagery for the state through partnerships with the TN Division of Forestry and the TN Department of Transportation.

Species Monitoring

The TWRA along with other agencies and partners are currently engaged in various monitoring/surveys at different levels of data complexity. Details of ongoing species inventories and monitoring efforts are provided by faunal group, participation of agencies / organizations, and geographic & temporal scale (see Table 68). Due to the high costs associated with species monitoring, identifying and integrating the CWCS with other monitoring efforts is imperative. As such, attempts will first be made to incorporate species monitoring into existing efforts before establishing additional monitoring programs. Supplemental monitoring will be initiated only after current capacity is assessed. However, the TWRA and its partners are committed to fulfilling additional species monitoring as is deemed necessary.

In considering the design of a monitoring program, the relationship between objectives and cost should be a primary concern. Expenses can rise dramatically as objectives increase in complexity and scale. Conversely, objectives can decrease to the point of being ineffectual if funding is insufficient. In order to determine objectives for a monitoring project, a number of questions must be asked:

1. What is to be monitored? Is it an individual species, population, community, or faunal group?
2. What is the question to be answered and what needs to be measured? Is it the presence or absence of the species, its relative abundance, or the response to management?
3. What level of data quality will answer the question? Is it descriptive qualitative data such as an index or a quantitative estimate of the population's size or is it something in between?
4. At what geographic scale does the question need answering? Is it locally important to know the answer? Regionally? Statewide? How many samples are needed?

Table 68. Ongoing Monitoring and Survey Efforts for Species in Tennessee			
Species / Faunal Group	Agency / Organization*	Geographic Scale (*Local, Regional, Statewide*)	Temporal Scale (*Periodic, Annual*)
Sportfish Surveys	TWRA	Statewide	Annual
Fish Surveys	TWRA TVA TNARI CFI	Statewide Regional Local Local	Annual Annual Annual Periodic
Fish IBI Surveys	TWRA TDEC TVA	Regional Regional Regional	Annual Annual Annual
Fish Tissue Analysis	TWRA TDEC	Regional Statewide	Annual Annual
Lake Sturgeon Reintroduction / Evaluation	TWRA TVA UTK TNARI	Regional Regional Regional Regional	Annual Annual Annual Annual
Barrens Topminnow	TWRA USFWS USGS TTU	Local Local Local Local	Annual Annual Annual Annual
Pigeon River Fish Community Restoration	TWRA UTK TDEC USGS TVA ORNL	Local Local Local Local Local Local	Annual Annual Annual Annual Annual Annual
Freshwater Mussel Surveys	TWRA NPS TVA USGS USFWS USACE	Statewide Local Local Local Local Local	Annual Periodic Periodic Periodic Periodic Periodic
Mussel Tissue Analysis	TWRA TDEC	Local Local	Periodic Periodic

Table 68. Ongoing Survey and Monitoring Efforts for Species in Tennessee (cont'd.)			
Species / Faunal Group	Agency / Organization*	Geographic Scale (*Local, Regional, Statewide*)	Temporal Scale (*Periodic, Annual*)
Crayfish Surveys	TWRA TDEC DLU	Regional Statewide Local	Annual Annual Periodic
Aquatic Insects	TWRA TDEC	Statewide Statewide	Annual Annual
Terrestrial Snails	TWRA USFS	Regional Regional	Periodic Periodic
Aquatic Snails	TWRA TNARI	Regional Regional	Periodic Periodic
Frogs and Toads - TN Amphibian Monitoring Program (TAMP)	TWRA Volunteers AEDC TDEC	Statewide Statewide Local Local	Annual Annual Annual Annual
Turtles	TWRA TNARI MTSU	Statewide Local Local	Annual Annual Periodic
Bog Turtle	TWRA TNC Knoxville Zoo	Local Local Local	Annual Annual Annual
International Shorebird Survey	TWRA TOS TVA USFWS	Statewide Statewide Statewide Statewide	Annual Annual Annual Annual
PIF Point Counts	TWRA TOS Volunteers USFWS	Statewide Statewide Statewide Statewide	Annual Annual Annual Annual
Breeding Bird Survey	TWRA TOS USGS Volunteers	Statewide Statewide Statewide Statewide	Annual Annual Annual Annual

Table 68. Ongoing Survey and Monitoring Efforts for Species in Tennessee (cont'd.)			
Species / Faunal Group	Agency / Organization*	Geographic Scale (*Local, Regional, Statewide*)	Temporal Scale (*Periodic, Annual*)
Christmas Bird Counts	TOS USFWS	Statewide Statewide	Annual Annual
Monitoring Avian Productivity (MAPS)	Warner Park Grassmere Wildlife Park USFS TNARI NPS	Local Local Local Local Local	Annual Annual Annual Annual Annual
Cerulean Warbler	TWRA UTK	Statewide Local	Annual Annual
Golden-wing Warbler	TWRA UTK	Statewide Local	Annual Annual
Bewick's Wren	TWRA UK	Local Local	Annual Annual
Saw-whet Owl Count	USFS	Local	Annual
Yellowbellied Sapsucker Count	USFS	Local	Annual
Mid-winter Eagle Counts	TWRA TDEC USACE USFWS	Statewide Regional Regional Regional	Annual Annual Annual Annual
Eagle Nest Surveys	TWRA USFWS USACE	Statewide Statewide Statewide	Annual Annual Annual
Peregrine Falcon Survey	TOS	Local	Annual

Table 68. Ongoing Survey and Monitoring Efforts for Species in Tennessee (cont'd.)			
Species / Faunal Group	Agency / Organization*	Geographic Scale (*Local, Regional, Statewide*)	Temporal Scale (*Periodic, Annual*)
Migration Monitoring	TOS	Statewide	Annual
Spring Bird Counts	TOS	Statewide	Annual
Bird Banding Stations	TOS TWRA	Local Regional	Annual Annual
All Taxa Inventory	DL NPS TDEC	Local Local Statewide	Periodic Periodic Periodic

(*note: Agency / organization acronyms are as follows: AEDC – Arnold Engineering Development Center; CFI – Conservation Fisheries, Inc.; DL – Discover Life; DLU – David Lipscomb University; MTSU – Middle Tennessee State University;; NPS – National Park Service; ORNL – Oak Ridge National Laboratory; TDEC – Tennessee Department of Environment & Conservation; TNARI – Tennessee Aquatic Resources Institute; TNC – The Nature Conservancy; TOS – Tennessee Ornithological Society; TTU – Tennessee Technological University; TVA – Tennessee Valley Authority; TWRA – Tennessee Wildlife Resources Agency; UK – University of Kentucky; USACE – U.S. Army Corps of Engineers; USFS – U.S. Forest Service; USFWS – U.S. Fish & Wildlife Service; USGS – U.S. Geological Survey; UTK – University of Tennessee-Knoxville)

5. What is the frequency and duration of the monitoring project? Is it a one-time assessment, or does it require seasonal samples for multiple years?

Considerations of these types of issues have received some attention in the literature. The standards derived by Morrison et al. (1998) deal primarily with concepts and applications of determining the wildlife/habitat relationship. There are numerous references detailing sample design (Cochran 1977; Thompson 1992). However, statistically defensible sampling over large areas can be labor and equipment intensive, thus cost prohibitive. Heyer et al. (1994) discusses, in general terms, the application and costs associated with amphibian sampling methods and data quality.

Another recurring question involves species detectability. Detection is a complex issue. There are numerous methods for estimating detectability, mark-recapture (Pollock 1991), removal models for fish or salamanders (Pollock 2002), distance methods (Buckland et al. 1993), repeated presence-absence data (Royal and Nichols 2003), and others. Again, the primary issue is balancing costs with geographic coverage and level of data collection.

Species monitoring, again, must be based on management objectives, which then defines the scale and level of data quality. One avenue to approach monitoring is through an adaptive tiered approach. For example, initial monitoring steps might consist of collecting qualitative and/or descriptive data about a faunal group utilizing a volunteer labor force to offset costs of the large geographic coverage. Excellent examples of this methodology, in place now, include the Tennessee Amphibian Monitoring Program, the numerous bird

surveys contributed to by members of the Tennessee Ornithological Society and other volunteers, and the Save Our Streams Program of the Isaac Walton League. Data collected at this level could be used to determine short-term trends derived from the qualitative data.

An intermediate level of monitoring might consist of presence/absence surveys of certain fauna (e.g. fish) or an index of biological integrity surveys. The level of labor increases at this scale, but so does the level of data quality. However, trained volunteers could still be a labor resource. Again, using fish as an example, catch per unit effort could yield sufficient information about relative abundance that trends could be inferred.

The most intensive level of monitoring would target species populations and answer questions about their viability status. This level of review is labor intensive, costly, and only necessary for the highest priority species. Specific fauna to undergo such monitoring will need to be identified.

Important to the tiered approach are mechanisms or thresholds which, when met, dictate the next level of monitoring. These thresholds must be defined in terms of the collected data (i.e. the level of the data collected meets the level of data required for the threshold). A monitoring program that is expending effort on various species or faunal groups at various intensities and time-schedules must be coordinated to maintain efficiency and direction. Coordination would insure that objectives, labor, data quality and geographic coverage needs are met. Key resources for guidance on designing adaptive and coordinated monitoring include:

1. Measure of Success, Designing, Managing and Monitoring Conservation and Development Projects (Margoluis and Salafsky 1998)
2. Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans (Atkinson et al. 2004)
3. Guidance for Designing an Integrated Monitoring Program (National Park Service 2005)

Examples of current and planned coordinated species monitoring efforts are provided in the following sections.

(Coordinated Avian Monitoring Efforts in Tennessee)

The need for coordinated bird monitoring has received national attention in the last few years. To that end, Tennessee is currently assessing its bird monitoring efforts. The TWRA is working to develop a guide to Tennessee's Important Bird Areas (IBA). These areas are the most important sites for the conservation of birds within the state. The National Audubon Society in conjunction with BirdLife International has developed the IBA process. Sites are nominated by managers, invested parties, or other interested individuals. Nominations are reviewed by a panel of bird professionals to determine merit for inclusion within the program. Documentation is to be made available through the agency web site. The Tennessee IBA project is scheduled to be completed December 31, 2005.

The IBA guide will help to determine the prioritization of an area for monitoring. The areas that support the birds of highest Partners in Flight priority ranking will be addressed first for monitoring issues. Monitoring programs will vary based on what is determined to be best for the specific avifauna within a particular area.

(TN Coordinated Bird Monitoring Plan)

Current and ongoing avian monitoring programs are also being evaluated through the Tennessee Coordinated Bird Monitoring Plan (CBM). The TWRA is working to develop a plan to address the effectiveness of monitoring programs within the state as well as the gaps, needs, and redundancies among various monitoring programs. Tennessee's CBM is part of a nationwide effort by the North American Bird Conservation Initiative (NABCI) and others to

coordinate bird monitoring at the regional, national, and continental levels. The NABCI programs along with existing CBM plans in other states (Nevada and Idaho), have been used as a model in creating the CBM plan for Tennessee. Findings will be brought into the Tennessee CWCS and implemented as part of the strategy wherever feasible. The CBM plan is scheduled to be completed by September 30, 2005.

Tennessee's state-specific monitoring efforts for birds contribute to regional, national, and even international bird conservation efforts. The TWRA will continue to integrate the recommendations of NABCI reports, which address monitoring at different scales, during implementation: U.S. Shorebird Conservation Plan (Brown et al. 2001), North American Waterbird Conservation Plan (Kushlan et al. 2002), North American Waterfowl Management Plan (NAWMP Committee 2003), and PIF North American Land Bird Conservation Plan (Rich et al. 2004)

Specific avian monitoring actions in the state shall include:

- Continue to develop the Tennessee CBM plan, adhering to recommendations put forth in reports of the national and regional entities of NABCI (e.g. Partners in Flight regional and state plans, Southeastern Migratory Bird Conservation Initiative, North American Waterbird Conservation Plan) and the Continental Bird Monitoring Workgroup of IAFWA to strengthen coordinating bird monitoring efforts.

- Evaluate statewide monitoring protocols for standard point counts and Breeding Bird Survey (estimation of detectability) through the SEPIF monitoring working group. Continue monitoring at established points where warranted by the CMB (see below).

- Continue to improve collection and quality of supporting habitat data for standard point counts.

- Expand current bird monitoring across the state to improve specific information for birds not adequately sampled under existing protocol (e.g. Breeding Bird Survey). Specifically single species surveys are indicated for species of highest concern where numbers of that species are of a low enough density within a survey area that multi species surveys are not effective at determining a species status therein. Species such as King Rail, Yellow-bellied Sapsucker, Loggerhead Shrike, Bewick's Wren, Cerulean Warbler, Golden-winged Warbler, Bachman's Sparrow, Henslow's Sparrow, and Lark Sparrow meet these criteria in most situations within the state.

- Continue to establish shorebird and waterbird monitoring efforts along lakes, large rivers, and wetlands; expand monitoring of secretive marshbirds along lake, and marsh habitats using established protocol. Shorebird Surveys are to be carried out at sites that may support the species during migration. These sites were identified by the Tennessee Valley Authority (TVA) biologists and others in a recent cooperative exercise between TVA, TWRA, USFWS, USACE, TOS, and private individuals. Shorebird surveys will follow the WSHRN protocol with data regularly provided to the WSHRN database for analysis. Marsh bird Surveys will be carried out in areas that meet the IBA standards for these birds. Marsh habitats are one of the least understood habitats within the state and warrant further study.

- Continue monitoring for recovering species such as bald eagles and peregrine falcons in their key habitats.

(Developing Other Coordinated Monitoring Programs)
Currently, no other coordinated monitoring programs exist across the state at the intermediate and upper tier levels previously described. One notable exception to this

statement is the Tennessee Amphibian Monitoring Program, which does operate statewide with the assistance of multiple organizations and volunteers. Establishing other coordinated monitoring programs for species will require development of a network of participants committed to working together. In-state coordination should logically fall to the state agency. However, multi-state regional coordination will likely require federal guidance.

Overall, more effort is needed to develop the rationales and protocols required to build coordinated monitoring programs for other species. Additional publications to reference in developing possible approaches include:

1. Measuring and Monitoring Biological Diversity, Standard methods for Amphibians (Heyer et al. 1994).
2. Southeast Amphibian Inventory and Monitoring Protocol (Partners in Amphibian and Reptile Conservation, in development)
3. Amphibian Research and Monitoring Initiative (U.S. Geological Survey 2000)
4. Southeast Amphibian Monitoring initiative (U.S. Geological Survey 2000b)
5. Monitoring Amphibians in Great Smoky Mountains National Park (Dodd 2003)
6. Measuring and Monitoring Biological Diversity, Standard Methods for Mammals (Wilson et al. 1996)
7. Multiple Species Inventory and Monitoring Guide (U.S. Dept. of Agriculture Forest Service Draft 2004)
8. Large Scale Wildlife Monitoring Studies: Statistical Methods for Design and Analysis (Pollock 2002).
9. Program for Regional and International Shorebird Monitoring (PRISM)
10. The North American Raptor Monitoring Strategy (U.S. Geological Survey *in development*)
11. Handbook of field methods for monitoring land birds (U.S. Department of Agriculture Forest Service 1993)
12. Overview of national bird population monitoring programs and databases (U.S. Department of Agriculture Forest Service website)
13. The Partners in Flight Land bird Monitoring Strategy & Monitoring workshop. (1988)
14. Waterbird Conservation for the Americas (Kushlan et al. 2002)

Current Habitat Management

In Tennessee, numerous federal and state agencies and non-governmental organizations manage holdings of land and water or conduct conservation activities on a broad scale. The size and scale of management of these holdings varies from large tracts composing tens or hundreds of thousands of acres to smaller units of less than a hundred acres. Likewise, the types of management by these agencies and organizations may vary considerably from intensive uses to little or no activity. Joint agency management of some public lands often occurs. For example, it is not uncommon for the TWRA to manage other federal, state, and private landholdings. In addition, many public lands often are designated for multiple uses; therefore, management may vary by parcel or by season. State and federally managed lands and waters include the following:

1. U. S. Forest Service
   - Cherokee National Forest (North)
   - Cherokee National Forest (South)
   - Land Between the Lakes
2. National Park Service
   - Great Smoky Mountains National Park
   - Big South Fork National River & Recreation Area
   - Cumberland Gap National Historic Park
   - Natchez Trace Parkway
   - Numerous National Battlefields and Monuments
   - Obed Wild & Scenic River
3. U. S. Fish and Wildlife Service
   - Chickasaw National Wildlife Refuge (NWR)
   - Cross Creeks NWR
   - Hatchie & Lower Hatchie NWR
   - Lake Isom NWR
   - Reelfoot NWR

Tennessee NWR
4. Tennessee Valley Authority
   Tennessee River Reservoir System
   TN River Tributary Reservoir System
   Numerous reservoir associated lands
5. U.S. Army Corp of Engineers
   Cumberland River Reservoir System
   Cumberland River Tributary Reservoir System
   Reservoir associated lands
   Mississippi River
6. Department of Defense / Contractors
   Fort Campbell Army Base
   Holston Army Ammunition Plant
   Milan Arsenal
   Spencer Range
   Arnold Engineering Development Center
7. Department of Energy Oak Ridge National Laboratory lands.
8. State managed lands include:
   Tennessee Wildlife Resources Agency
      118 Wildlife Management Areas
      15 State Lakes
   Tennessee Department of Environment and Conservation
      54 State Parks
      66 State Natural Areas
   Tennessee Department of Agriculture
      15 State Forests
9. The Nature Conservancy of Tennessee
      21 Preserves

Research Needs

An extensive review of distribution and life history data for GCN species was conducted in preparing the CWCS. This effort was successful in compiling over 11,000 non-avian geo-referenced occurrence records of species distribution. An additional 80,000 records from the Breeding Bird Atlas were also utilized. Occurrence records with their supporting database information formulate much of the foundation of this strategy.

Furthermore, many areas of Tennessee have had very little survey effort, while others have been more thoroughly inventoried. Some areas have historic survey information, but little current data. Likewise, survey effort also varies greatly by faunal group and by environmental regime. Nevertheless, numbers of occurrences do not always indicate sufficient information for evaluating fauna. For example, the Breeding Bird Atlas data is by far the most comprehensive distributional data for any species group in the state but was geographically generalized to the hexaquad (1/6 of a USGS 1:24,000 quadrangle), greatly limiting its effectiveness in evaluating habitat usage by birds. Conversely, subterranean systems have had the least amount of inventory work (fewer than 350 of over 8,000 caves), but likely yield some of the highest rarity and endemism among fauna per unit area in the state.

With additional federal funding in the 1980's, TWRA was able to expand survey efforts for aquatic species and communities statewide. This effort provided a lot of geo-referenced occurrence information for many aquatic species. In general, this in-house aquatic data along with outside sources provided good statewide data coverage for aquatic species for the development of the CWCS. Expansion of stream crews would further increase our level of knowledge. Similar expansions of funding for terrestrial and subterranean species would likely go far in overcoming deficiencies in survey data.

Likewise, when database occurrence records were subjected to viability analysis, it became apparent that there were many other research needs. In general, very little information exists about the biological requirements of many GCN species. Most database records lack viability information about population size, condition, and landscape context of habitat. Again, such data gaps are often due to a lack of spatial, temporal, and life history information.

An emphasis on species occurrence and viability surveys should be a primary objective for the TWRA to begin satisfying basic research needs. Generating new data and compiling other data from outside sources will be an ongoing process. Also, the GIS model will be useful in determining where research is needed. Species represented with low viability scores, and portions of the state with

little representative survey data may be focal areas of future effort. Additionally, effort may be focused on TWRA Wildlife Management Areas and other suitable lands held in public trust (i.e. state parks, natural areas, etc.) and suitable private lands (such as lands identified as Important Bird Areas).

Research projects, whether focused on inventory or life history studies, have the same issues of target specificity, scale, and costs as monitoring projects. Likewise, much benefit may be gained from a coordinated hierarchical approach. Utilization of a volunteer workforce and prioritization of species based on differential data quality can help offset scope and geographic scale. The possible expansion of programs like TAMP and the development of new volunteer-oriented programs needs evaluation. Adding low cost equipment (e.g. GPS) to volunteer programs could increase the level of data geo-referencing and increase data utilization. In the future, more intensive surveys will be conducted for some fauna using a standardized protocol for each species group (see Appendix H). Data collected will include species occurrence and number, geo-referenced location, habitat description, the unit of effort expended, viability information, and prevailing environmental conditions. Projects targeting single species or populations would be more costly, and require additional planning to define specific questions to be researched. Likewise, the number of measurable parameters and geographic scale may be lower depending on the number of species or populations to be studied.

Research needs are highly dependent on: 1) the status of the species and/or habitat, 2) level of knowledge about the species and/or habitat, 3) and the avenue of approach in delivery of conservation actions. Additionally, research needs build upon previous research, and often require a stepwise approach. For instance, in order to propagate and re-introduce a species, genetic research may be required to determine the best source populations. Then, natural history studies may be required to determine reproductive strategies. Next, propagation techniques may need to be developed to mimic reproductive habitat and conditions to facilitate reproduction. Finally, rearing experiments are possibly required in order to maximize health and condition of the animals at the time of release. Parallel to this research, potential release sites often have to be evaluated to determine priorities or in some instances, habitat restoration may need to occur.

For some species, this stepwise approach to research may require more intermediate steps than for other species. These steps would be determined by conservation actions and the base knowledge about the species, habitat, or management technique. Given these issues, possible areas of research for GCN species and habitats have been identified to further establish the extent and types of information needed to fully implement the CWCS (see Table 69).

Evaluating Progress of the CWCS

To progress toward a desired outcome for a conservation plan, several key tenets must be achieved. The strategy must: 1) establish clearly defined objectives, 2) delineate methods to accomplish identified tasks, 3) state expected benefits, and 4) determine measures of success that reflect project goals (Margoluis and Salafsky 1998). Overall, strategy assessment must answer an important question: Do determined activities lead to realization of a plan's objectives? Ultimately, answering this important question requires periodic assessment of the project. Project monitoring and evaluation is an iterative process that provides managers with the information to maintain or modify actions which insure success.

The CWCS has identified, based on a set of standard criteria, species of "greatest conservation need". It also identified regions of the state where concern for the species exists. In the process, species occurrence data was compiled into a central GIS database. Habitat was evaluated to the level of species preference. A GIS model was

Table 69. Identified Areas of Research for the CWCS		
Category	Subject	General Research Topics
Habitat Assessment	Environmental Contaminants	1) Toxicity assays for aquatic species (fish, (mollusks, crustaceans, amphibians) 2) Bioaccumulation of pesticides and metabolites in terrestrial and aquatic species 3) Affects of degraded water quality on aquatic communities
	Remote Sensing	1) Detection of point/non-point sources of pollution 2) Development of new techniques 3) Assessment of habitat quantity/quality.
Management Issues	Wildlife / Habitat Relationships	1) Evaluation of minimum stream flows for maintaining aquatic diversity 2) Assessment of water levels/reservoir management on shorebirds 3) Identification of factors limiting habitat, causes, and potential management 4) Development of management rationales to address source/sink areas for breeding birds 5) Studies of seasonal use of habitat 6) Evaluation of habitat restoration techniques 7) Assessment of exotic species effects
	Species Based Management	1) Development of propagation and rearing techniques 2) Potential use of indicator/focal species
	Information Management & Analysis	1) Development of faunal group distribution databases 2) Development of central data repositories 3) Development of data delivery/data access systems 4) Development of data analysis tools
	Modeling	1) Development of population viability models 2) Development of population and/or community assessment models 3) Development of habitat assessment models

Table 69. Identified Areas of Research for the CWCS (cont'd.)		
Category	Subject	General Research Topics
Management Issues (cont'd.)	Genetics	1) Evaluation of genetic isolation/outbreeding 2) Evaluation of species hybridization 3) Identification of genetically suitable source populations 4) Genetic banking / library 5) Taxonomic verification of species
	Inventory / Monitoring	1) Species distribution surveys 2) Development of survey/sampling/ monitoring methods and protocols 3) Development of indices to assess terrestrial & subterranean communities 4) Species status assessments 5) Pre & post habitat management evaluations
Ecological Information	Natural & Life History Studies	1) Species home range, movement, and migration studies 2) Productivity studies for avifauna or other faunal groups 3) Evaluation of predator – prey relationships 4) Occurrence or prevalence of disease

developed to identify areas of GCN species concentrations and occurrence data was evaluated. Potential stresses and sources of stress were identified for habitats and species and potential conservation actions were identified to address the sources of stress. This CWCS provides resource managers with the information and tools needed to direct conservation activities for years to come.

TWRA's Comprehensive Planning System

Realizing that future wildlife management must be based on an understanding of TWRA's long-rang capabilities, changing social and environmental conditions, and the best possible appraisal of expectations for the future, the Agency developed its own adaptive comprehensive planning system (TWRA 2000).

This planning system involves four distinct phases. These phases are:

1. Inventory / Assessment – Where are we?
2. Strategic Plan – Where do we want to go?
3. Operational Plan – How will we get there?
4. Evaluation – Did we make it?

These steps intergrade into a continuous cycle of management planning (see Figure 5). TWRA's Strategic Planning cycle is updated on six-year intervals. It is intended to guide the Agency and sets forth legal responsibilities, policies, program structure, and identifies goals, objectives, problems and strategies for each program. Under the current TWRA Strategic plan, nongame and endangered species are addressed in separate programs plans. In each plan, the current and projected status of both programs are detailed, program goals, objectives, ranked problems, and strategies are set forth. The CWCS will be invaluable in determining these planning components for the next iteration of the TWRA's strategic planning and

in annual budgetary and operational planning in subsequent years.

The TWRA is currently developing the next iteration of the Strategic Plan (2006-2012). Because of the comprehensive nature of the CWCS, portions of the CWCS will be incorporated both directly and indirectly, into the plan. The identification of species of "greatest conservation need" and the GIS model will provide information as to the current status of the combined programs. In the TWRA Strategic Plan, problems and strategies were identified as in the CWCS and ranked as to importance and benefit. Due to the differing processes used, however, some compilation will be required in final ranking of problems and strategies.

Within 90 days of the fiscal year closing, every TWRA project is subjected to an annual evaluation as to performance measures and accomplishments toward reaching Strategic Plan goals. This evaluation provides a project status report and listing of activities and accomplishments for the year. Project managers can assess a year's work toward meeting project objectives.

In year 3 of the planning cycle, a mid-term evaluation is conducted in order to determine program progress toward Strategic Plan goals. This evaluation identifies efforts and accomplishments during the first half of the planning cycle. It is this mid-term evaluation that provides managers a cumulative look at project accomplishments in order to assess program progress.

An end-of-cycle evaluation also occurs. This evaluation looks at accomplishments for the entire planning cycle and allows the manager to assess program progress to stated goals for the entire planning period. It is this evaluation that feeds information into the next planning cycle.

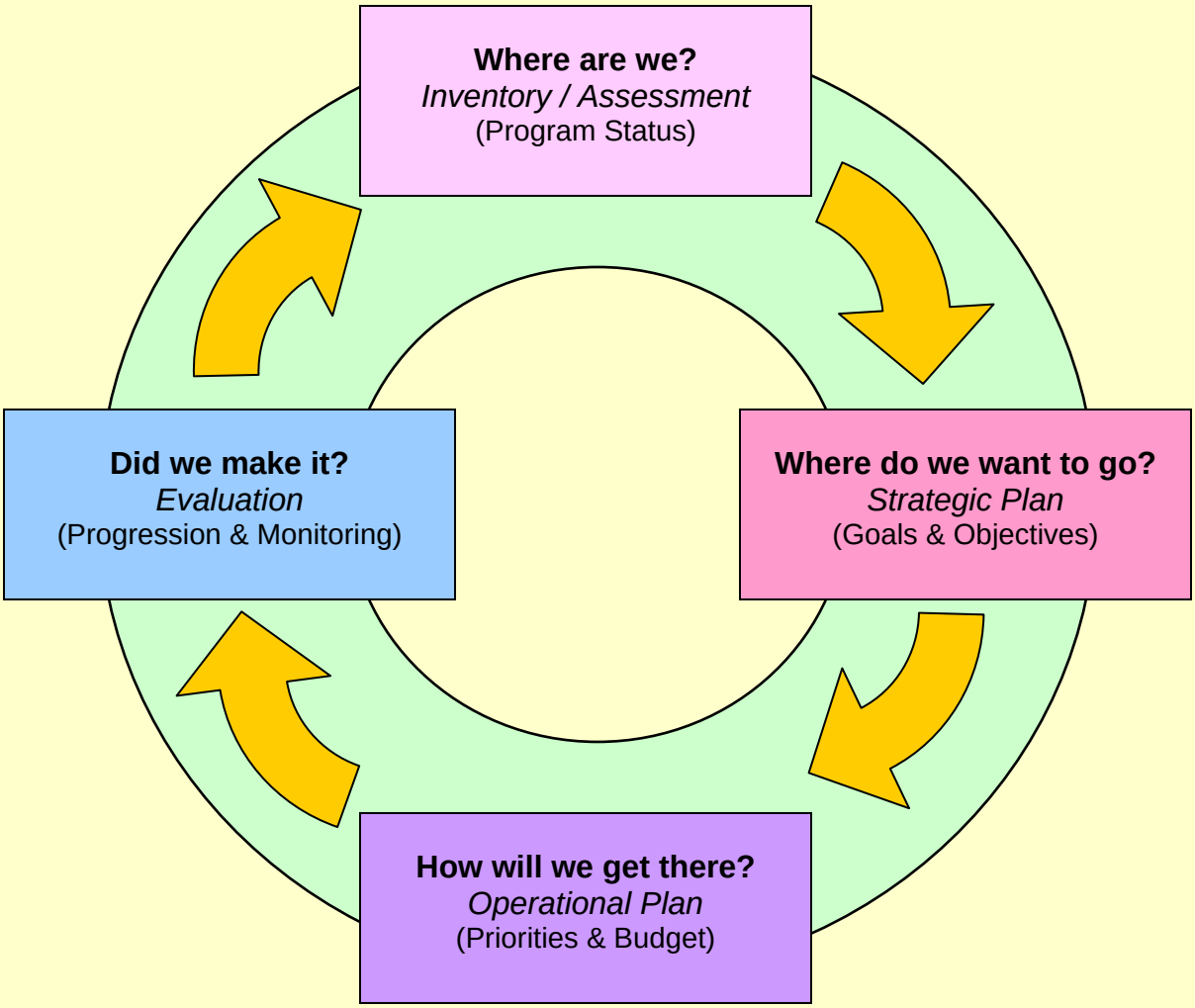
Review of the CWCS Planning Cycle

By guideline, the CWCS planning cycle must be no more than every 10 years. This time period, in fact, may be the best planning interval for completing a CWCS planning cycle. The constant search for species occurrence data (in-house and outside data sources) will provide annual updates to the GIS model. The TWRA is committed to GIS model refinements to insure that model applications continue to be reasonable, logical and have broad application. This process will feed TWRA's own comprehensive planning cycle. The agency's in-house planning period will provide annual, 3-year, and 6-year evaluations of the program. A new TWRA Strategic Plan in year 6 will serve to adjust program/project objectives.

In more specific terms for the CWCS, review of the list of species of "greatest conservation need" will, in all practicality, be performed more frequently than every 10 years. As new occurrence data is added, the GCN species prioritization scores will obviously change. As new data are plugged in, some species may be removed from the list and others added. Similarly, new information about species population viability, problems, and implementation of conservation actions will very likely emerge on an annual basis and need to be incorporated into the database. However, the timeframe for entering this data and re-running the GIS model must be flexible enough to allow the TWRA and its conservation partners sufficient time to interpret results and respond accordingly. Otherwise, the planning process becomes perpetual and no action is taken due to the constant influx of new information.

Allowing a planning CWCS cycle to default to the maximum time period provides an opportunity for standardizing some of the processes involved. Inventory protocols and monitoring efforts can be integrated and coordinated across the state and across state boundaries within the planning cycle. Inventory and monitoring trend data analysis can begin to provide new insight on species distribution and habitat relationships. Habitat or species restoration efforts, which may not yield noticeable benefits in the short term, may be producing initial results. New versions

Figure 5. Graphic Representation of the TWRA's Planning System & Iterative Cycle



of land use / land cover can be produced and implemented into the model. With newer habitat data, initial analysis of habitat gain or loss and spatial arrangements can begin.

The TWRA is committed to the CWCS becoming a dynamic, flexible and useful document and model. Continued coordination with partners, either through the steering committee or a less formal arrangement is imperative. Only through a cooperative arrangement can this data meet the needs of not only TWRA, but all partners. It is the goal of the agency's nongame program that the CWCS and GIS model be available for all partners. It is hoped that the CWCS may be equally incorporated into the strategic planning efforts of other agencies and organizations. Through development of a cooperative working environment, validity and usefulness of the plan and model will develop and increase. Participation of partners in future iterations of the plan would be guaranteed. This version of the CWCS is only the beginning. Continued support and effort can make this process more dynamic, flexible and informative. Furthermore, continued refinement will lead to more efficient use of State Wildlife Grant monies, which will bring progress in attaining the stated goal of preventing species decline.

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Glossary of Terms

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.

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.

Coarse-filter/fine-filter approach – a working hypothesis that assumes that conservation of multiple, viable examples of all coarse-filter targets (communities and ecological systems) will also conserve the majority of species (fine-filter targets).

Coarse scale approach – the first step in the portfolio assembly process where all coarse-scale targets (i.e. ecological systems or matrix plant communities which occur across a large spatial scale) are represented or "captured" in the ecoregion (including those that are feasibly restorable).

Complementarity – the principle of selecting action sites that complement or are "most different" from sites that are already conserved.

Conservation area – an area selected for inclusion in the conservation portfolio for an ecoregion, which is defined by the presence of conservation targets and their cumulative habitat/spatial requirements. Conservation areas are the focus of conservation action, and are the locus for measuring conservation success.

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.

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.

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).

Ecological drainage unit (EDU) – groups of watersheds (8-digit U.S. Geological Survey Hydrologic Units) within aquatic ecoregions with similar patterns of zoogeographic sources and constraints, physiography, drainage density, hydrologic characteristics and connectivity.

Ecological land unit (ELU) – derived units of land using spatial data sets such as digital elevation models, surficial geology, and hydrography. ELUs are defined from combinations of several of these environmental variables. In ecoregional planning, ELUs are useful tools for predicting locations of natural communities or ecological systems, when such information is lacking, and for capturing ecological variation based upon environmental factors.

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 ecoregion.

Feasibility – a principle used in ecoregional planning to select Action Sites by evaluating the staff capacity of the Conservancy and other partners to abate threats, the probability of success, and the financial costs of implementation.

Fine-filter approach – to ensure that the coarse-fine filter strategy adequately captures all viable, native species and ecological communities, ecoregional planning teams also target species that cannot be reliable conserved through the coarse-filter approach and may require individual attention through the fine-filter approach. Wide-ranging, very rare, extremely localized, narrowly endemic, or keystone species are all likely to need fine-filter strategies.

Fine-filter/coarse-filter approach – (see Coarse-filter/fine-filter approach)

Functional site – small conservation areas which maintain targets and their supporting ecological processes within their natural ranges of variability. A functional site will conserve a small number of ecological systems, natural communities, or species at one or two scales below the regional scale; and targets tend to be relatively few, often sharing similar ecological processes.

Functional landscape – conservation areas which capture a large number of ecological systems, natural communities, and species at all scales below regional. Functional landscapes are similar to functional sites in that they both maintain targets and their supporting ecological

process within their natural ranges of variability. However, functional landscapes differ often by the scale of ecological systems/natural communities captured (e.g. matrix communities).

Functionality – refers to a principle during the portfolio assembly process where all sites in the conservation portfolio are ensured as being functional or feasibly restorable to a functional condition. Such areas maintain the size, condition, and landscape context within the natural range of variability of the perspective conservation targets.

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.

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.

Irreplaceable – refers to the single most outstanding example of a target species, natural community, or ecological system; or a population that is critical to a species remaining extant and not going extinct.

Large patch – a ecological system or natural plant community that forms large areas of interrupted cover. Individual occurrences of this community patch type typically range in size from 50 to 2,000 hectares (app. 50 to 500 acres). Large-patch communities are associated with environmental conditions that are more specific than those of matrix communities, and are less common or less extensive in the landscape. Like matrix communities, large-patch communities are also influenced by large-scale processes, but these tend to be modified by specific site features that influence the community.

Leverage – the principle of selecting action sites by evaluating if conservation at a site will influence conservation elsewhere, if the site provides an opportunity to test a strategy, or if staff or a mechanism exists to help export conservation experience from one site to others.

Limited – distributional range of a species or natural community which occurs in the ecoregion and within a few other adjacent ecoregions.

Matrix – an ecological system or natural plant community that forms extensive and contiguous cover over a broad range. Matrix communities occur on the most extensive landforms and typically have wide ecological tolerances. They may be characterized by a complex mosaic of successional stages resulting from characteristic disturbance processes. Individual occurrences range in size from 2,000 to 500,000 hectares (app. 5,000 to over 1.2 million acres). Matrix community types are often influenced by large-scale processes (e.g. climate patterns, fire) and are important habitat for wide-ranging or large area-dependent fauna, such as large herbivores or birds.

Metadata – documents the content, source, reliability, and other characteristics of data. Metadata are particularly important in the iterative ecoregional planning process because this

documentation will expedite the review of existing tabular and geospatial data sets when an ecoregional plan is revisited and will minimize the likelihood of "lost" data.

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. Even though natural communities are classed based upon dominant vegetation, they are also used as inclusive conservation units that include all component species (plant and animal) and the ecological processes that support them.

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.

Peripheral – distributional range of a species or community which rarely occurs in the ecoregion and is more common in other nearby ecoregions.

Population – a collection of occurrences of a species within reasonable proximity for breeding or interaction. Populations were delimited by NatureServe's element occurrence separation buffer distances.

Portfolio – the suite of conservation areas within an ecoregion selected to represent and conserve the conservation targets and their genetic and ecological variation.

Problem – the combined concept of ecological stresses to a target and the sources of that stress to the target.

Representation – a principle of reserve selection and design referring to the capture of the full spectrum of biological and environmental variation within a network of reserves or conservation areas (sites), including all genotypes, species, communities, ecosystems, habitats, and landscapes.

Site – (see Conservation area)

Small patch community – an ecological system or natural plant community that forms small, discrete areas of vegetative cover. Individual occurrences of this community type typically range in size from 1 to 50 hectares (or approximately 2 to 125 acres). Small-patch communities occur in very specific ecological settings, such as on specialized landform types or in unusual microhabitats. The specialized conditions of small patch communities, however, are often dependent on the maintenance of ecological processes in the surrounding matrix and large-patch communities. In many ecoregions, small-patch communities contain a disproportionately large percentage of the total flora, and also support a specific and restricted set of associated fauna (e.g. invertebrates or herpetofauna) dependent on specialized conditions.

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.

Stress – something which impairs or degrades the size, condition, or landscape context of a conservation target, resulting in reduced viability.

Subregion (i.e. stratification unit) – a hierarchical division of an ecoregion into nested, progressively smaller geographic units. Spatial stratification is used to represent each conservation target across its range of variation (in internal composition and landscape setting) within the ecoregion, to ensure long-term viability of the type by buffering against degradation in one portion of its range, and to allow for possible geographic variation.

Target – Specific components of biodiversity used to design ecoregional portfolios and develop and prioritize conservation strategies. Conservation targets consist of ecological systems, natural communities, and species.

Urgency – a qualitative measure referring to the immediacy of severe threats – taking into account how severe the threat is and how likely it is to destroy or seriously degrade the targets.

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 necessary for persistence.

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.