6. Central Shenandoah Planning Region Local Action Plan Summary

Wildlife Action Plan and Local Summaries Overview

Wildlife Action Plan

Virginia is fortunate to contain a wide variety of natural resources and landscapes that provide Virginians with a range of benefits, services, and economic opportunities. Natural resource conservation in Virginia, as in most states, is implemented by government agencies, non-governmental organizations, private institutions, academic institutions, and private citizens. These groups work to enhance the quality of life within the Commonwealth by conserving Virginia's air, land, water, and wildlife. Adequate funding and human capital needed to manage and conserve these valuable resources are not always available. In 2005, Virginia's conservation community first came together to maximize the benefits of their actions and created the state's first Wildlife Action Plan (Action Plan). It was written to prioritize and focus conservation efforts to prevent species from declining to the point where they become threatened or endangered (DGIF 2005). The 2015 Action Plan is an update of the original Plan. The Action Plan must address eight specific elements mandated by Congress. They are:

> *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*
>
> *2. Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1); and*
>
> *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*
>
> *4. Descriptions of conservation actions determined to be necessary to conserve the identified species and habitats and priorities for implementing such actions; and*
>
> *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*
>
> *6. Descriptions of procedures to review the Plan-Strategy at intervals not to exceed ten years; and*
>
> *7. Plans for coordinating, to the extent feasible, the development, implementation, review, and revision of the Plan-Strategy 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.

8. Congress has affirmed through the Wildlife Conservation and Restoration Program (WCRP) and State Wildlife Grants (SWG), that broad public participation is an essential element of developing and implementing these Plans-Strategies, the projects that are carried out while these Plans-Strategies are developed, and the Species in Greatest Need of Conservation (SGCN) that Congress has indicated such programs and projects are intended to emphasize.

Each species included in the 2015 Action Plan (Species of Greatest Conservation Need or SGCN) has been evaluated and prioritized based upon two criteria: degree of imperilment and management opportunity.

To describe imperilment, SGCN are grouped into one of four Tiers: Critical (Tier I), Very High (Tier II), High (Tier III), and Moderate (Tier IV).

Tier I - *Critical Conservation Need. Species face an extremely high risk of extinction or extirpation. Populations of these species are at critically low levels, face immediate threat(s), and/ or occur within an extremely limited range. Intense and immediate management action is needed.*

Tier II - *Very High Conservation Need. Species have a high risk of extinction or extirpation. Populations of these species are at very low levels, face real threat(s), and/ or occur within a very limited distribution. Immediate management is needed for stabilization and recovery.*

Tier III - *High Conservation Need. Extinction or extirpation is possible. Populations of these species are in decline, have declined to low levels, and/ or are restricted in range. Management action is needed to stabilize or increase populations.*

Tier IV - *Moderate Conservation Need. The species may be rare in parts of its range, particularly on the periphery. Populations of these species have demonstrated a declining trend or a declining trend is suspected which, if continued, is likely to qualify this species for a higher tier in the foreseeable future. Long-term planning is necessary to stabilize or increase populations*.

While degree of imperilment is an important consideration, it is often insufficient to prioritize the use of limited human and financial resources. In order to identify and triage conservation opportunities, development of the updated Action Plan (2015) included assigning a Conservation Opportunity Ranking to each species identified within the Plan. Rankings were assigned with input from taxa or species experts (biologists) and other members of Virginia's conservation community. They also are based on conservation or management actions and research needs identified for the species within the 2005 Action Plan. In addition, a literature review was conducted to garner any new information available since the first version of the Action Plan. The three Conservation Opportunity Rankings are described as follows:

A – Managers have identified "on the ground" species or habitat management strategies expected to benefit the species; at least some of which can be implemented with existing resources and are expected to have a reasonable chance of improving the species' conservation status.

B – Managers have only identified research needs for the species or managers have only identified "on the ground" conservation actions that cannot be implemented due to lack of personnel, funding, or other circumstance.

C – Managers have failed to identify "on the ground" actions or research needs that could benefit this species or its habitat or all identified conservation opportunities for a species have been exhausted.

Over 880 SGCN are listed in the 2015 Action Plan and found in varying densities across the state (Figure 1). Of the Plan's SGCN, 23.4 percent are classified as Conservation Opportunity Ranking A; 7.1 percent are classified Conservation Opportunity Ranking B; and 69.5 percent are classified as Conservation Opportunity Ranking C. Additionally, of the 883 SGCN:

- Approximately 25% of the SGCN are already listed as threatened or endangered under the Federal or Virginia Endangered Species Act,
- Approximately 60% are aquatic,
- Approximately 70% are invertebrates, and
- All are impacted by the loss or degradation of their habitats.

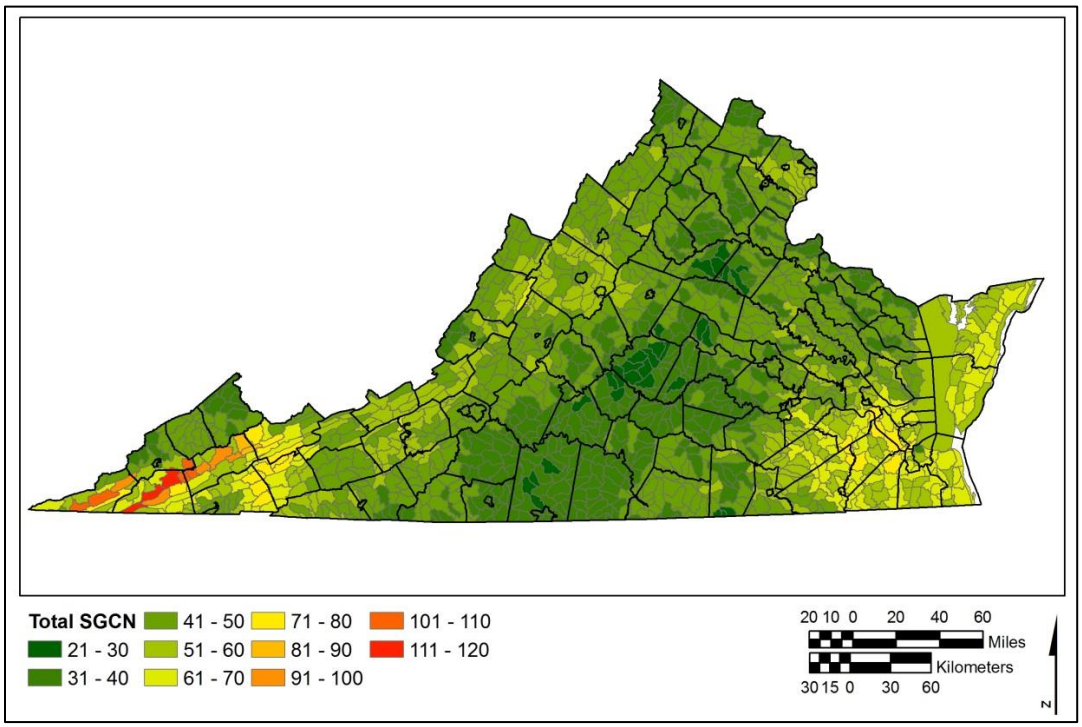

Figure 1. State Distribution of Species of Greatest Conservation Need by HUC12 Watersheds.

Wildlife Action Plan Implementation

Since its creation, the Wildlife Action Plan has helped Virginia acquire over $17 million in new conservation funding through the State Wildlife Grants Program. These resources have been used to implement significant research, advance species recovery efforts via captive propagation, and restore and conserve important wildlife habitats. Despite these successes, many conservation practitioners feel the original Wildlife Action Plan never reached its full potential. One common concern is that it failed to focus at the habitat level where the needs of many species could be addressed at once. Further, many partners indicated the original Action Plan did not provide sufficient details to help prioritize conservation needs and opportunities at a local scale, where many land use decisions are made, and conservation efforts are implemented. Lacking these local insights, it was often difficult for agencies, municipalities, organizations, academic institutions, and landowners to identify and focus on the highest priority wildlife conservation opportunities for their geographic area. To address this concern and make the Action Plan more user-friendly and relevant at a finer scale, this version (2015) of the Action Plan was developed to include locally-based summaries. These summaries identify species that are local priorities, habitats required to conserve those species, regional threats impacting species and habitats, and priority conservation actions that can be taken to address those threats. The goal of these summaries is to facilitate and benefit the work of local governments, conservation groups, landowners, and other members of the conservation community who wish to support wildlife conservation within their regions.

Local Action Plan Summaries

In creating the updated Action Plan, the Virginia Department of Game and Inland Fisheries (DGIF) adopted a model developed by the Virginia Department of Conservation and Recreation (DCR) for the Virginia Outdoors Plan. The Virginia Outdoors Plan describes recreational resource issues for 21 multi-county Recreational Planning Regions. Each Recreational Planning Region is roughly analogous to one of Virginia's 21 local Planning District Commissions (PDC). The PDCs are voluntary associations of local governments intended to foster intergovernmental cooperation by bringing together local officials, agency staff, the public, and partners to discuss common needs and develop solutions to regional issues. With its focus on local-scale actions, the Virginia Outdoors Plan has become an important tool for identifying and addressing local recreational issues. This DCR model was adapted and used in this Action Plan to address wildlife and habitat issues for the benefit of planning region residents. More broadly, the new Action Plan's Local Action Plan Summaries will create a framework that Virginia's diverse conservation community can use to identify issues and locations of mutual conservation interest, enhance collaborative opportunities, develop new conservation resources, and craft "win-win" situations that can be beneficial for both the people and wildlife of Virginia.

CENTRAL SHENANDOAH PLANNING REGION SUMMARY OVERVIEW

The Central Shenandoah Planning Region consists of 2,200,092 acres (3,438 square miles) and includes the counties of Augusta, Bath, Highland, Rockbridge, and Rockingham; cities of Buena Vista, Lexington, Harrisonburg, Staunton, and Waynesboro; and towns of Broadway, Bridgewater, Craigsville, Dayton, Elkton, Glasgow, Goshen, Grottoes, Monterey, Mt. Crawford, and Timberville. The human population in this planning region is estimated to be over 293,000 people, and most populations are projected to increase within the planning region by 2030 (Weldon Cooper Center 2012).

Less developed and more rural areas often provide a diversity of valuable wildlife habitats, which can be degraded or lost as human populations grow or energy and other extractive uses expand. This planning region contains a range of SGCN, including 28 SGCN that have 100 percent of their distribution within planning region. Many other SGCN such as mussels, amphipods, isopods, fish, bird, and mammal species depend on a variety habitats within the planning region, such as spruce fir forests, mixed hardwood and conifer forests, young forests, retired agricultural land, karst, non-tidal wetlands, and warm and cold water streams and riparian habitats (Figure 2).

In developing conservation actions for habitats and priority species within this planning region, a number of factors must be considered to determine how limited resources can be allocated to best effect. A project's likely impact and probability of success, the effectiveness of historic and ongoing conservation actions, as well as logistical, economic, and political factors will all influence the selection and prioritization of conservation actions. Virginia's Wildlife Action Plan advocates a proactive approach that focuses conservation resources to manage species before they become critically imperiled and to implement projects that can simultaneously benefit multiple species and human communities. These factors were considered during development of the conservation actions included in the following sections as well as in analyzing the existing threats facing SGCN and their habitats. Threats and conservation actions are organized based on the habitat types found within this planning region upon which priority SGCN depend.

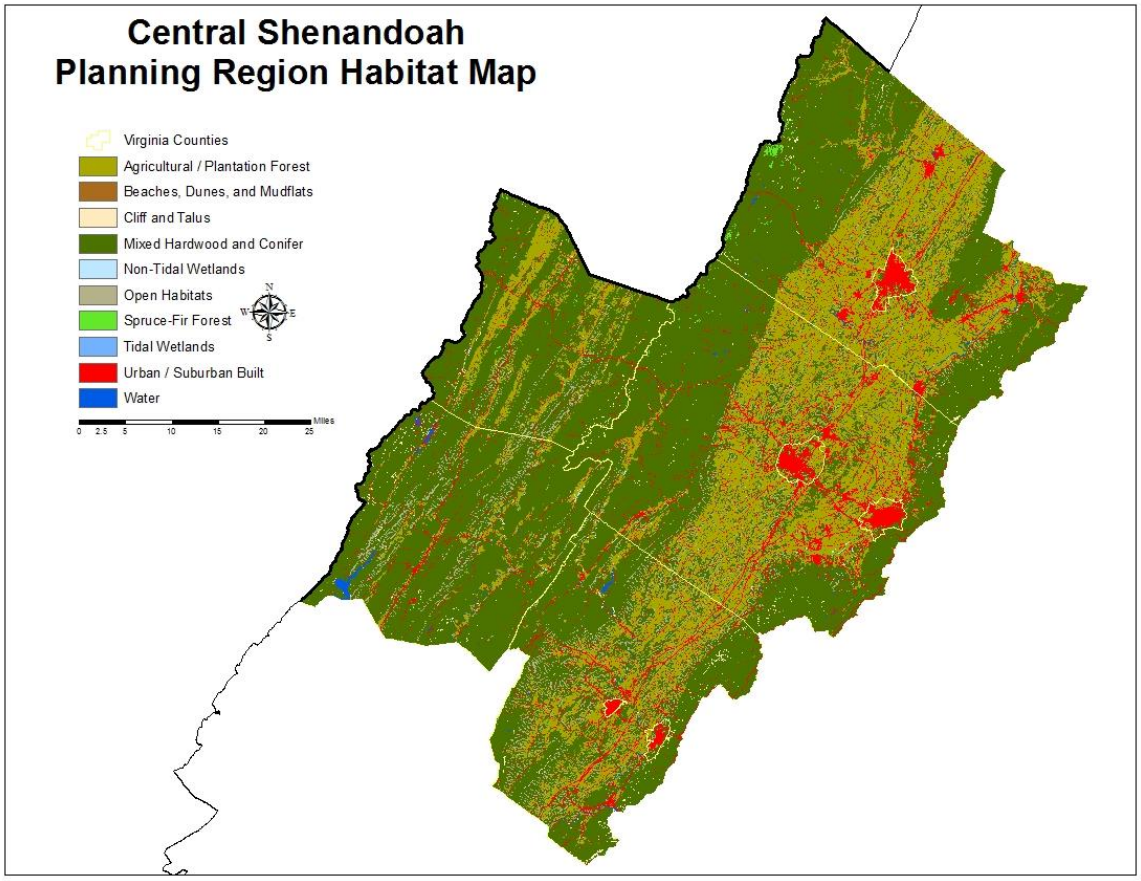

Figure 2. Central Shenandoah Planning Region Habitats (Anderson et al. 2013).

Priority Species of Greatest Conservation Need

Of Virginia's 883 SGCN, 120 are believed to either occur, or have recently occurred, within the Central Shenandoah Planning Region (Appendix A). Of these 121 species, ***97 SGCN are dependent upon habitats provided within the Central Shenandoah Planning Region (Table 2). These species constitute the priority SGCN for the region***. A summary of SGCN Tier and Conservation Opportunity Rankings is provided in Table 1, while Figure 3 demonstrates the density of the 96 priority species within this region.

Priority SGCNs within this Local Summary include species for which this planning region comprises a significant portion of its range in Virginia. To determine species priority, the authors implemented a 10 percent rule to identify locally important species. Under the 10 percent rule, an SGCN is included in a Local Summary if the planning region provides at least 10 percent of that species' range in Virginia. However, there are several other instances that warrant inclusion on a planning region's priority SGCN list. First, several SGCN occur statewide but in low numbers in each planning region and will never reach the 10 percent threshold in any single planning region. Species that fall in this category were manually added to priority SGCN lists where appropriate. Some species only occur in three or fewer planning regions. These SGCN are also included on priority lists for the planning regions in which they are found due to their rarity in the state and the importance of those few planning regions to their survival. For migrant species

that may only be in Virginia for a matter of days, these migratory habitats are considered critical for their long-term conservation. When these circumstances were identified, specific migratory species were manually added to local SGCN lists as well. Finally, where a species may have a particularly strong population in a relatively small portion of a planning region, the population may be determined to be significant enough to warrant inclusion on the local SGCN list. Again, when these circumstances were identified, species were manually added to the local priority SGCN list.

Table 1. Tier and Conservation Opportunity Ranking Distribution among Priority SGCN.

Tier and Conservation Opportunity Rank	Number of SGCN
Ia	8
Ib	5
Ic	10
IIa	3
IIb	2
IIc	23
IIIa	8
IIIb	1
IIIc	6
IVa	17
IVb	8
IVc	6

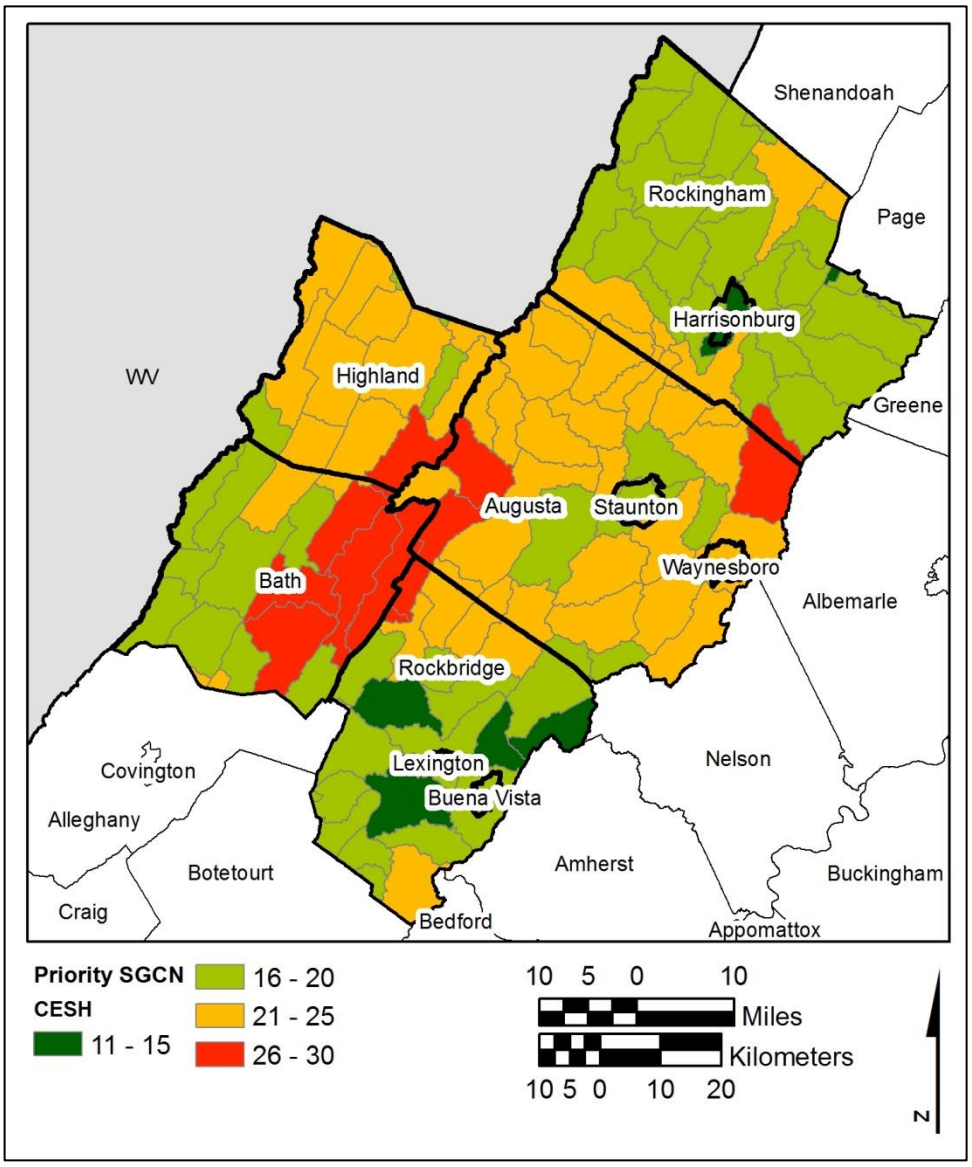

Figure 3. Priority SGCN Density in the Central Shenandoah Planning Region (HUC12 Watersheds).

Table 2. Priority Species of Greatest Conservation Need Distribution within the Central Shenandoah Planning Region.

Taxa	Conservation Status	Tier	Opportunity Ranking	Common Name	Scientific Name	Habitat
Amphibian		I	c	Cow Knob salamander	*Plethodon punctatus*	Site specific - mixed hardwood forests in rocky areas in high elevations
Amphibian	**SE**	II	a	Eastern tiger salamander	*Ambystoma tigrinum*	Site specific pine savanna
Amphibian		IV	a	Jefferson salamander	*Ambystoma jeffersonianum*	West of Shenandoah River - high elevation hardwood forests
Amphibian	**FS**	I	c	Peaks of Otter salamander	*Plethodon hubrichti*	Site specific - utilizing various forest, rhododendron thickets, and forested talus slopes with deep moist soils
Amphibian		III	c	Shenandoah Mountain salamander	*Plethodon virginia*	Site specific - deciduous hardwood forests on mountain slopes and ravines in western Rockingham County
Bird		III	c	Bank swallow	*Riparia riparia*	Habitat includes open and partly open situations, frequently near flowing water. Nests are in steep sand, dirt, or gravel banks, in burrows dug near the top of the bank, along the edge of inland water, or along the coast, or in gravel pits, road embankments, etc.
Bird		III	a	Barn owl	*Tyto alba*	Fields of dense grass. Open and partly open country (grassland, marsh, lightly grazed pasture, hayfields) in a wide variety of situations, often around human habitation.
Bird		III	b	Belted kingfisher	*Megaceryle alcyon*	Primarily along water, both freshwater and marine, including lakes, streams, wooded creeks and rivers, seacoasts, bays, estuaries, and mangroves. Perches in trees, on over hanging branches, posts and utility wires.
Bird		IV	a	Black-and-white warbler	*Mniotilta varia*	Habitat generalist with broad habitat tolerances
Bird		II	b	Black-billed cuckoo	*Coccyzus erythropthalmus*	Forest edge and open woodland, both deciduous and coniferous, with dense deciduous thickets
Bird		IV	a	Brown thrasher	*Toxostoma rufum*	Thickets and bushy areas in deciduous forest clearings and forest edge, shrubby areas and gardens; in migration and winter also in scrub
Bird		IV	b	Canada warbler	*Cardellina canadensis*	Breeding habitat includes moist thickets of woodland undergrowth (especially aspen-poplar), bogs, tall shrubbery along streams or near swamps, and deciduous second growth.
Bird		II	a	Cerulean warbler	*Setophaga cerulea*	A structurally mature hardwood forest in a mesic or wetter situation, with a closed canopy
Bird		IV	b	Chimney swift	*Chaetura pelagica*	Inhabits rural and urban environments having both an abundance of flying arthropods and suitable roosting/nesting sites.

Bird		IV	a	Dunlin	*Calidris alpina hudsonia*	Winter resident shorelines and estuaries
Bird		IV	a	Eastern kingbird	*Tyrannus tyrannus*	Forest edge, open situations with scattered trees and shrubs, cultivated lands with bushes and fencerows, and parks; in winter more closely associated with forest clearings and borders.
Bird		IV	a	Eastern meadowlark	*Sturnella magna*	Grasslands, savanna, open fields, pastures, cultivated lands, sometimes marshes.
Bird		IV	a	Eastern towhee	*Pipilo erythrophthalmus*	Inhabits forest and swamp edges, regenerating clearcuts, open-canopied forests, particularly those with a well-developed understory, reclaimed strip mines, mid-late successional fields, riparian thickets, overgrown fencerows, shrub/small-tree thickets, and other brushy habitats.
Bird		III	a	Eastern whip-poor-will	*Antrostomus vociferus*	Forest and open woodland, from lowland moist and deciduous forest to montane forest and pine-oak association
Bird		IV	b	Eastern wood-pewee	*Contopus virens*	Inhabits a wide variety of wooded upland and lowland habitats including deciduous, coniferous, or mixed forests
Bird		IV	a	Field sparrow	*Spizella pusilla*	Old fields, brushy hillsides, overgrown pastures, thorn scrub, deciduous forest edge, sparse second growth, fencerows.
Bird		I	a	Golden-winged warbler	*Vermivora chrysoptera*	Open shrubby habitat (ex. old fields and pastures) at mid to high elevations within broader forested matrix west of the Blue Ridge Mountains
Bird		IV	a	Grasshopper sparrow	*Ammodramus savannarum*	Grassland obligate
Bird		IV	a	Gray catbird	*Dumetella carolinensis*	Thickets, dense brushy and shrubby areas, undergrowth of forest edge, hedgerows, and gardens, dense second growth.
Bird		IV	b	Green heron	*Butorides virescens*	Swamps, mangroves, marshes, and margins of ponds, rivers, lakes, and lagoons
Bird		III	a	Kentucky warbler	*Geothlypis formosa*	Humid deciduous forest, dense second growth, swamps
Bird	**ST**	I	a	Loggerhead shrike	*Lanius ludovicianus*	Grasslands, orchards and open areas with scattered trees
Bird		III	a	Northern bobwhite quail	*Colinus virginianus*	Early successional habitats including croplands, grasslands, pastures, grass-brush rangelands, and open forests
Bird		IV	b	Northern Flicker	*Colaptes auratus*	Open forest, both deciduous and coniferous, open woodland, open situations with scattered trees and snags, riparian woodland, pine-oak association, parks
Bird		I	b	Northern saw-whet owl	*Aegolius acadicus*	Higher elevation coniferous woodlands in Blue Ridge and mountains west of Shenandoah River
Bird	**ST**	I	a	Peregrine falcon	*Falco peregrinus*	Human structures in the east and cliff sites in the west
Bird		III	c	Red crossbill	*Loxia curvirostra*	Spruce-fir or hemlock forests above 4000 feet

Bird		III	a	Ruffed grouse	*Bonasa umbellus*	Dense forest with some deciduous trees, in both wet and relatively dry situations from boreal forest (especially early seral stages dominated by aspen) and northern hardwood ecotone to eastern deciduous forest and oak-savanna woodland.
Bird		IV	b	Rusty blackbird	*Euphagus carolinus*	Wooded swamp and wooded wetland winter habitat
Bird		IV	b	Wood thrush	*Hylocichla mustelina*	Deciduous or mixed forests with a dense tree canopy and a fairly well-developed deciduous understory, especially where moist.
Bird		III	a	Yellow-billed cuckoo	*Coccyzus americanus*	Open woodland (especially where undergrowth is thick), parks, deciduous riparian woodland.
Bird		IV	a	Yellow-breasted chat	*Icteria virens*	Second growth, shrubby old pastures, thickets, bushy areas, scrub, woodland undergrowth, and fence rows, including low wet places near streams, pond edges, or swamps; thickets with few tall trees; early successional stages of forest regeneration; commonly in sites close to human habitation.
Crustacean		IV	c	Allegheny crayfish	*Orconectes obscurus*	Clean flowing streams with rocky substrates
Crustacean	**FS**	II	c	Bath County cave amphipod	*Stygobromus mundus*	Caves with clean abundant water flowing through the system
Crustacean		II	c	Blue crayfish	*Cambarus monongalensis*	Burrowing species that utilizes wooded hillsides with springs and seeps
Crustacean	**FS**	II	c	Burnsville Cove cave amphipod	*Stygobromus conradi*	Caves with clean abundant water flowing through the system
Crustacean	**FSST**	I	b	Madison Cave amphipod	*Stygobromus stegerorum*	Caves with clean abundant water flowing through the system
Crustacean	**FTST**	II	c	Madison Cave isopod	*Antrolana lira*	Caves with clean abundant water flowing through the system
Crustacean	**FS**	II	c	Morrison's cave amphipod	*Stygobromus morrisoni*	Caves with clean abundant water flowing through the system
Crustacean	**FS**	III	c	Natural Bridge cave isopod	*Caecidotea bowmani*	Caves with clean abundant water flowing through the system
Crustacean	**FS**	II	c	Rockbridge County cave amphipod	*Stygobromus baroodyi*	Caves with clean abundant water flowing through the system
Fish		IV	b	Allegheny pearl dace	*Margariscus margarita*	Pools of small creeks and rivers with sand or gravel substrate
Fish		IV	a	Brook trout	*Salvelinus fontinalis*	Clear, cool, well-oxygenated creeks, small to medium rivers, and lakes
Fish		III	a	Notched rainbow	*Villosa constricta*	Clean streams with stable banks and sand or gravel substrates
Fish	**FS**	I	b	Roughhead shiner	*Notropis semperasper*	Clear medium sized streams with moderate current
Fish		IV	c	Slimy sculpin	*Cottus cognatus*	Spring fed cold water streams

FW Mollusk		III	c	Blue Ridge springsnail	*Fontigens orolibas*	Springs and cave streams in the Potomac basin and along the Blue Ridge
FW Mollusk	**SE**	I	a	Brook floater	*Alasmidonta varicosa*	Clear flowing water with sand or gravel substrates
FW Mollusk		IV	a	Creeper	*Strophitus undulatus*	It is usually found in streams and rivers in a range of flow conditions (rarely in high-gradient streams of mountainous regions) but can tolerate lakes and ponds, particularly in outlets.
FW Mollusk	**FESE**	I	a	James spinymussel	*Pleurobema collina*	Clear flowing water with sand, gravel, or cobble substrates
FW Mollusk	**FSSE**	I	c	Rubble coil	*Helicodiscus lirellus*	Known from two rubble piles at the bases of two hills in Rockbridge county
FW Mollusk	**FSSE**	I	c	Shaggy coil	*Helicodiscus diadema*	Known from four locations and occupies leaf litter at the base of limestone/shale outcropings
FW Mollusk		IV	a	Triangle floater	*Alasmidonta undulata*	Clean streams with stable banks and sand or gravel substrates
FW Mollusk		I	b	Virginia pigtoe	*Lexingtonia subplana*	Site specific - cool clean headwater streams with sand and gravel substrates
FW Mollusk	**FSSE**	I	a	Virginia springsnail	*Fontigens morrisoni*	Site specific caves and springs in Bath and Highland counties
Insect	**FSST**	I	c	Appalachian grizzled skipper	*Pyrgus wyandot*	Dry open areas with shale soils, clear cuts, utility rights of way, and other areas with dwarf cinquefoil
Insect	**FS**	II	c	Avernus cave beetle	*Pseudanophthalmus avernus*	Caves with clean abundant water flowing through the system
Insect	**FS**	II	c	Crossroads Cave beetle	*Pseudanophthalmus intersectus*	Caves with clean abundant water flowing through the system
Insect	**FS**	II	c	Maureen's shale stream beetle	*Hydraena maureenae*	The known habitat is a shale bottom Appalachian stream. This species apparently prefers the margins of clear mountain streams, adults sometimes occur on submerged vegetation, but occur mostly among sand grains.
Insect	**FS**	II	c	Mud-dwelling cave beetle	*Pseudanophthalmus limicola*	Caves with clean abundant water flowing through the system
Insect	**FS**	II	c	Natural Bridge cave beetle	*Pseudanophthalmus pontis*	Caves with clean abundant water flowing through the system
Insect	**FS**	II	c	Persius duskywing	*Erynnis persius persius*	Pine barrens oak Savanna and other open sunny habitats
Insect	**FS**	I	c	Regal fritillary	*Speyeria idalia idalia*	Glades and prairie remnants
Insect		II	c	South Branch Valley cave beetle	*Pseudanophthalmus potomaca potomaca*	Caves with clean abundant water flowing through the system

Mammal		IV	c	Allegheny woodrat	*Neotoma magister*	Blue Ridge to the west - cliffs dry rocky slopes, talus, and exposed ridges
Mammal		IV	c	Appalachian cottontail	*Sylvilagus obscurus*	High elevation forested areas west of the Shenandoah River
Mammal		I	c	Eastern small-footed myotis	*Myotis leibii*	Hibernation occurs in solution and fissure caves and mine tunnels (including coal, iron, copper, and talc mines). Situations near the entrance where the air is relatively cold and dry seem to be preferred, though sometimes deeper locations are used. Roost sites often are deep in crevices, or under rocks on the cave floor. Forages over ponds and streams.
Mammal		IV	c	Eastern spotted skunk	*Spilogale putorius putorius*	Blue Ridge to the west - rock piles, rock slides and cliffs surrounded by forests
Mammal	**FESE**	I	b	Indiana bat	*Myotis sodalis*	West of Shenandoah River - winter site specific caves, summer forested areas containing trees with scaly or shaggy bark as well as dead trees
Mammal		IV	c	Long-tailed shrew	*Sorex dispar dispar*	West of Shenandoah talus slopes, rock slides and cliffs surrounded by forests
Mammal	**SE**	I	c	Snowshoe hare	*Lepus americanus virginianus*	Specific spruce/ fir sites in Highland county that provide sufficient cover.
Mammal	**SE**	II	c	Southern rock vole	*Microtus chrotorrhinus*	High elevation riparian areas
Mammal	**SE**	II	b	Southern water shrew	*Sorex palustris*	High elevation riparian areas in Bath and Highland counties
Mammal	**FESE**	II	a	Virginia big-eared bat	*Corynorhinus townsendii virginianus*	Caves typically in limestone karst regions dominated by mature hardwood forests of hickory, beech, maple, and hemlock. Prefers cool, well-ventilated caves for hibernation; roost sites are often near cave entrances or in places where there is considerable air movement.
Mammal	**FESE**	I	c	Virginia northern flying squirrel	*Glaucomys sabrinus fuscus*	Spruce -fir and mixed conifer-northern hardwood forests
Other Aquatic Invertebrate	**FS**	I	c	Rockbridge County cave planarian	*Sphalloplana virginiana*	Caves with clean abundant water flowing through the system
Other Terrestrial Invertebrate	**FS**	II	c	A cave pseudoscorpion	*Kleptochthonius anophthalmus*	Caves with clean abundant water flowing through the system

Other Terrestrial Invertebrate	**FS**	II	c	A cave spider	*Islandiana muma*	Caves with clean abundant water flowing through the system
Other Terrestrial Invertebrate	**FS**	II	c	A millipede	*Pseudotremia alecto*	No habitats have been identified for this species
Other Terrestrial Invertebrate	**FS**	II	c	Cave pseudoscorpion	*Apochthonius coecus*	Caves with clean abundant water flowing through the system
Other Terrestrial Invertebrate	**FS**	II	c	Cave pseudoscorpion	*Apochthonius holsingeri*	Caves with clean abundant water flowing through the system
Other Terrestrial Invertebrate	**FS**	II	c	Cave pseudoscorpion	*Chitrella superba*	Caves with clean abundant water flowing through the system
Other Terrestrial Invertebrate		III	c	Depressed glyph	*Glyphyalinia virginica*	No habitats have been identified for this terrestrial snail
Other Terrestrial Invertebrate	**FS**	II	c	South Branch Valley cave millipede	*Pseudotremia princeps*	Caves with clean abundant water flowing through the system
Other Terrestrial Invertebrate	**FS**	II	c	Talus coil	*Helicodiscus triodus*	No habitats have been identified for this species
Reptile		IV	a	Common ribbonsnake	*Thamnophis sauritus sauritus*	Permanent ponds, marshes, streams, and rivers, east of the Shenandoah river, with vegetated shorelines and amphibian and small fish populations
Reptile		II	c	Mountain earthsnake	*Virginia valeriae pulchra*	Forested portions of northwest Highland County
Reptile		I	a	Northern pinesnake	*Pituophis melanoleucus melanoleucus*	Dry open slopes with cover and soils suitable for burrowing
Reptile		IV	a	Queen snake	*Regina septemvittata*	Crayfish obligate clear streams with rock or sandy bottoms and vegetated shorelines
Reptile		III	a	Smooth greensnake	*Opheodrys vernalis*	Moist meadows or grassy areas at the edges of bogs or small streams
Reptile	**CC**	IV	a	Timber rattlesnake	*Crotalus horridus (timber)*	Barren
Reptile	**ST**	I	a	Wood turtle	*Glyptemys insculpta*	Clear streams with adjacent riparian forests and fields

** Federal Endangered (FE), State Endangered (SE), Federal Threatened (FT), State Threatened (ST), Federal Species of Concern (FS), Federal Candidate (FC), Federal Proposed (FP), and Species of Collection Concern (CC).

Conserved Lands in the Central Shenandoah Planning Region

Recognizing the importance of the local habitats to resident and migratory wildlife, state, federal, and private entities have made significant investments to conserve lands within this planning region. Conservation mechanisms range from national parks and national forests to state parks and state wildlife management areas to conservation easements. Significant conservation assets, in terms of size, include:

- George Washington and Jefferson National Forests,
- Shenandoah National Park,
- Blue Ridge Parkway,
- Skyline Drive,
- Goshen-Little North Mountain Wildlife Management Area,
- Highland Wildlife Management Area,
- T.M. Gathright Wildlife Management Area,
- Short Hills Wildlife Management Area,
- Lake Roberston Wildlife Management Area,
- Douthat State Park,
- Goshen State Natural Area Preserve,
- Deep Run Ponds Natural Area Preserve, and
- Warm Springs Mountain TNC Preserve.

These properties contain a diversity of open water, forest, agricultural, and wetland habitats (Figure 4). They have been conserved to provide a range of conservation, recreational, and economic benefits such as habitat protection and restoration, ecotourism, and fishing and hunting opportunities.

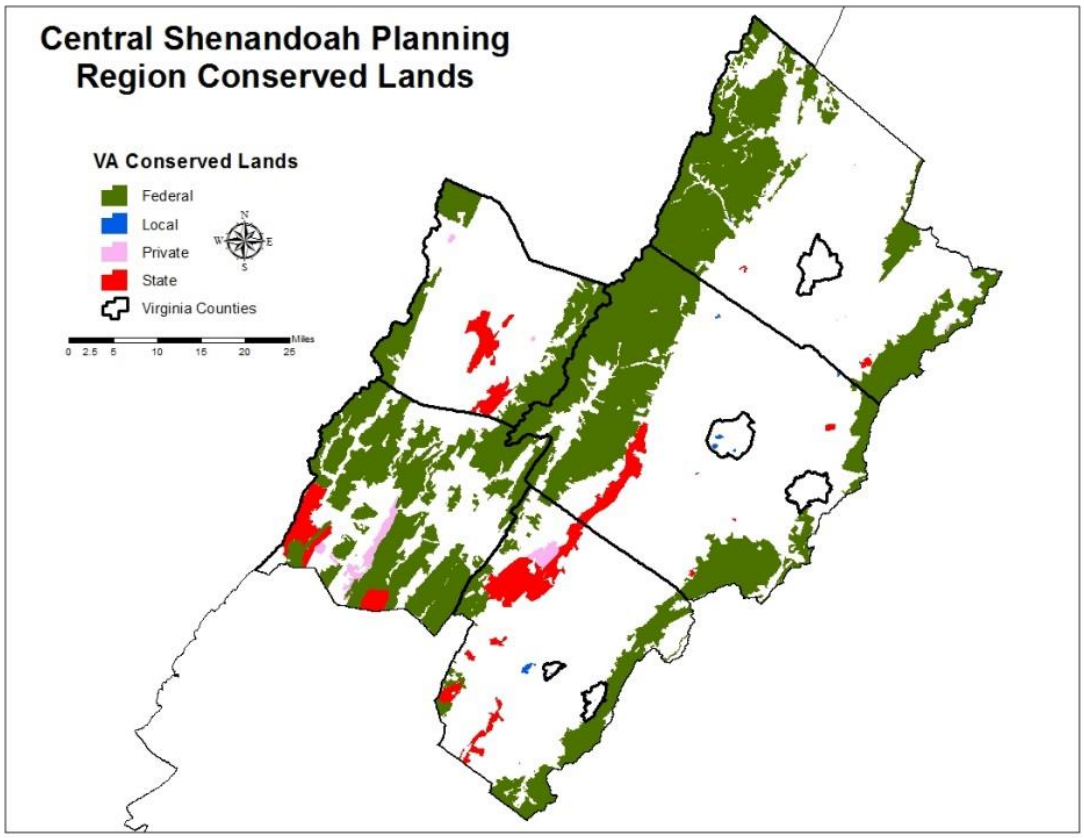

Figure 4. Conservation Lands in the Central Shenandoah Planning Region (DCR, Natural Heritage 2014).

These properties serve as an important component of wildlife conservation efforts on within Central Shenandoah Planning Region. Healthy and important habitats have been conserved within their boundaries; however, working to conserve other lands could be beneficial for many SGCN and habitats within the region. Although there may be concern over the economic and social impacts of putting more lands into conservation, many of these areas provide recreation and ecotourism benefits (DCR 2013; Carver and Caudill 2013). Through these mechanisms local economies could be bolstered; however, insufficient data exist to fully describe the specific benefits and drawbacks of these lands held in conservation within the planning region. To balance these interests, especially as conditions change, it will be critical for the conservation community to actively engage with local governments and stakeholders to ensure that conservation spending is beneficial for both wildlife and localities.

Climate Change Impacts in the Central Shenandoah Planning Region

Changes in temperature and precipitation will likely affect habitats and SCGN in the Central Shenandoah Planning Region. Based on scientific reports and research, it is clear that temperatures in the state will get warmer. The National Climate Assessment (NCA) is a national climate assessment that provides state level information. The NCA indicates Virginia's average temperature could increase by as much as 7°F by 2100 (Melilo et al. 2014). Earlier models used for Virginia's 2008

Climate Action Plan project that average temperatures will increase by 3.1°C (5.6°F) by the end of the century in Virginia (Governor's Commission on Climate Change 2008).

Temperature changes are likely to be even greater in at higher elevations than at lower elevations due to a range of factors such as snow albedo, water vapor changes and latent heat release, aerosols, among others (Pepin 2015; Staudinger et al. 2015). Projections also indicate a likely increase in summer high temperatures and longer growing seasons (Staudinger et al. 2015). These changes could affect depth of snow pack and earlier snow melt.

Increased temperatures may lead to heat stress for species, decreased water quality and dissolved oxygen content as well as changes to food availability (Boicourt and Johnson, 2011; Kane, 2013). Temperature increases may also be problematic for species at the edge of their ranges. For example, if species are at the more southern end of their range, they may not survive significant increases in temperature that are greater than they can withstand (Pyke et al., 2008). Warmer temperatures may also result in warmer waters, which could favor parasites and other pests in aquatic environments (Pyke, et al. 2008; Najjar et al. 2010; Kane 2013). Additionally, if temperatures and precipitation change such that season length is altered, fish and other species' reproductive cycles and other phenological processes may be affected. Ecological conditions may also be altered, including food supplies and sympatric animal behaviors (e.g., fish migrations and nest building).

Conservation Threats and Actions for Wildlife and Habitats in the Central Shenandoah Planning Region

The following sections on threats, conservation actions, and conservation priorities are subdivided based on habitat type. Key habitat conservation strategies, actions, threats, and other impacts are summarized in Table 3. In many cases, actions taken to protect or enhance habitat will positively affect many Central Shenandoah Planning Region priority SGCN and other species. Many of these activities are also expected to benefit landowners and communities.

Table 1. Summary of Conservation Strategies and Actions for the Central Shenandoah Planning Region.

Conservation Strategy	Conservation Action	Threats Addressed	Economic/ Human Benefits	Priority Areas
Protect karst habitats	1) Maintain vegetative cover within watersheds where subterranean species occur; 2) Establish vegetative buffers around springs and sinkholes; 3) Minimize nutrients and sediments flowing into the system; 4) Establish parks, greenways, or other conserved lands above karst systems; 5) Develop water conservation and use strategies to help minimize groundwater depletion; and 6) Better control fecal matter and sewage.	Increasing industrial/residential water consumption, sedimentation and pollutants, protection of cave entrances	Drinking water quality; sustainability of private landowner wells and residential water supply	Areas underlain by karst geology
Maintain and restore wetland habitats	1) Work with appropriate entities on wetlands permitting process to ensure adequate mitigation and restoration procedures are in place; 2) Establish or enhance vegetative buffer areas inland of existing wetlands; 3) Utilize relevant data (e.g., Virginia Department of Conservation and Recreation's wetlands catalog) to identify priority areas for conservation, acquisition, and restoration; and 4) Control invasive species.	Water quality degradation, habitat/ land use conversion, non-native and exotic invasive species	Flood control; filtration services; erosion and sediment control; supports recreational and commercial fisheries; ecotourism/ wildlife watching and fishing/ hunting opportunities	Watersheds with priority wetlands
Enhance, maintain, and restore aquatic and riparian habitats	1) Establish vegetated and/ or forested buffers along streams and sinkholes; 2) Reforest erodible pastures; 3) Exclude livestock from streams and areas around sinkholes; 4) Improve pasture and loafing lot management to prevent tainted runoff; 5) Implement conservation tillage; 6) Establish storage facilities for animal waste and runoff retention ponds;7) Prevent erosion after timber harvests; 8) Repair or replace failing septic systems and "straight pipes;" 9) Establish rain gardens;10) Sweep streets; 11) Stabilize dirt roads; 12) Reclaim abandoned mine lands;13) Work to prevent pet waste from entering the watershed; 14) Continue to identify impaired waters within the planning region; 15) Restore aquatic connections; 16) Monitor and address invasive species impacts; and 17) Adopt land use practices or policies through zoning or other means to help improve the health of aquatic systems.	Sedimentation, contaminants loading, water chemistry alteration, stream nutrient dynamics alteration, land use changes, water withdrawals, climate change, exotic and non-native invasive species	Address TMDL concerns by reducing amounts of sediment, nutrients, pesticides, and other pollutants that enter water ways; sustain sport fisheries and recreation opportunities; contribute to clean water supply	Blacks Run, Cooks Creek, Buffalo Creek, Cedar Creek, Colliers Creek, Christians Creek, South River, Hays Creek, Moffatts Creek, Walker Creek, Otts Creek, Holman's Creek, Jennings Branch, Middle River, Polecat Draft, Moffett Creek, Linville Creek, Long Glade Run, Mossy Creek, Naked Creek, Long Meadow Run, Turley Creek, Dry River, Mill Creek, Muddy Creek, Pleasant Run, Smith Creek

Maintain and restore forest habitat	1) Protect land through acquisition, easement, incentives, or other mechanisms; 2) Implement vegetative buffers around extractive practices and development; 3) Work with state and federal agencies to ensure implementation of appropriate best management practices; 4) Maintain forest health to help ensure forest viability; and 5) Monitor and control invasive species.	Land use change and conversion, invasive species, climate change	Flood control; water quality; ecotourism/ wildlife viewing/other outdoor recreation	Forest patches adjacent to already protected parcels
Maintain and restore open habitats	1) Restore native grasses, shrubs, and forbs; 2) Maintain existing open habitats with periodic disturbance (e.g., prescribed burning, mowing, disking, etc.); and 3) Conserve, via acquisition, easement, collaboration, or agreement, patches from 20 acres to 100 or more acres.	Land use changes, invasive species	Conservation of native pollinators; erosion control; sequestration of nutrients, pesticides, and other pollutants before they enter rivers or karst systems	Areas supporting SGCN that are not already protected

Protect Karst Habitats

The Central Shenandoah Planning Region contains cave/karst habitats that are relatively unique in Virginia. These features are created by complex interactions of water, bedrock, vegetation, and soils. Karst areas contain sinkholes, sinking and losing streams, caves, and large flow springs (DCR website 2015). Because cave entrances and karst habitats are sensitive systems, exact locations of karst habitats are not provided in this Action Plan; however, general areas that contain karst features are provided in Figure 5. Karst systems provide important habitats for the Bath County cave amphipod, Madison cave amphipod, crossroads cave beetle, Natural Bridge cave beetle, and a variety of other species. Other species such as the Indiana bat depend on karst habitat and are endangered throughout their range. Caves in the planning region provide crucial winter habitat for some bat species.

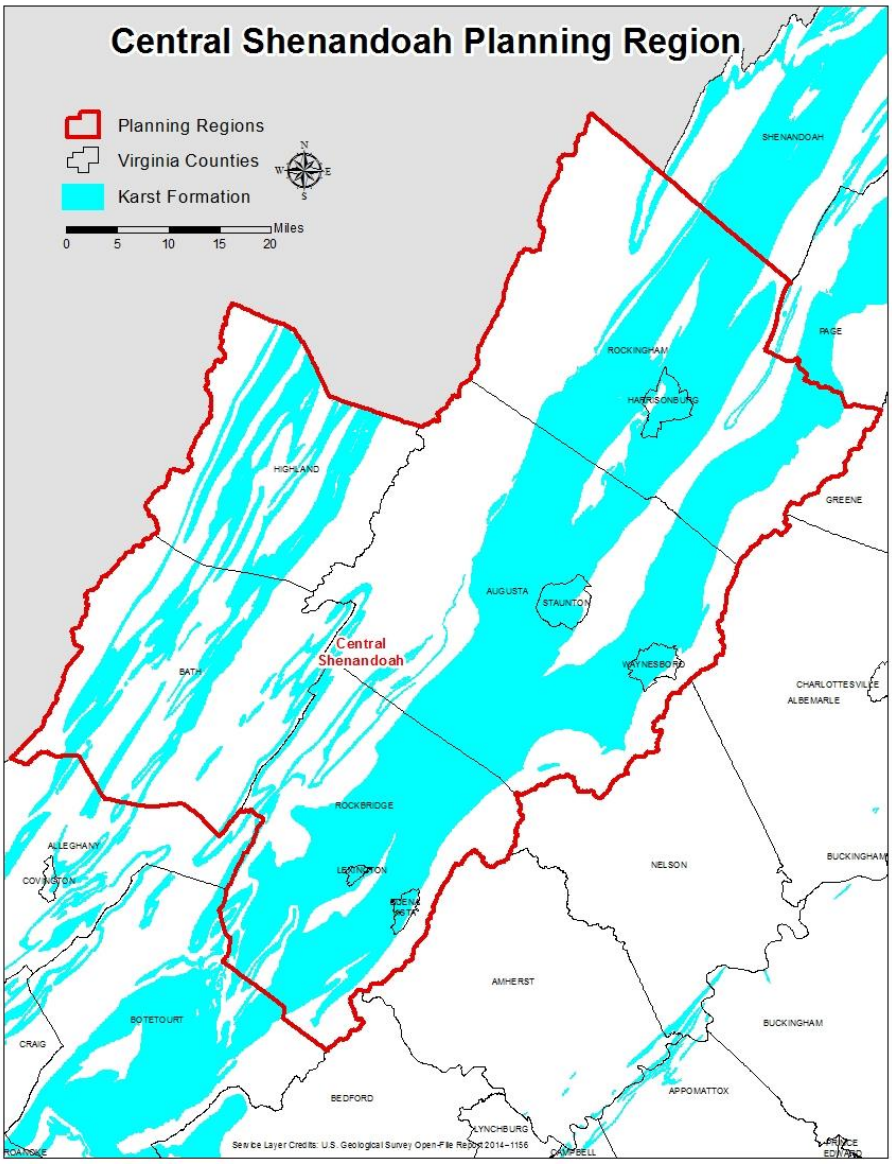

Figure 2. Karst Areas in the Central Shenandoah Planning Region (Geary and Doctor 2014).

Threats

Threats are primarily water-related for karst systems.

1. Water Quality Degradation: Water is the most critical element influencing the health of a karst system. The quality of water entering, and flowing through, Virginia's karst system is affected by a variety of issues. Nutrient pollution, especially from nitrogen and phosphorus, is a significant cause of water degradation as well as bacteria, fertilizer, and pesticides (DCR 2008). Nutrients often enter aquatic systems from lands without adequate best management practices (BMP), storm water runoff controls, or adequate waste treatment practices. Water quality degradation of karst systems also often occurs when sinkholes are used as disposal sites. Development and resulting pollutant-laden runoff also negatively affect water quality (DCR 2008).

2. Altered Hydrology: Development, which also likely plays a role in degraded water quality in the areas where karst occurs, can also result in altered hydrology which can affect water quantity and flows. The amount of water flowing through the system is also important. Withdrawals for human use have the potential to degrade subterranean habitats and change surface topography.

3. Climate Change: Changes to precipitation regimes that may cause more intense storm events could exacerbate already existing water quality problems. Higher amounts of precipitation in a short time frame could dramatically affect storm water runoff and nutrient run off from impervious surfaces.

Conservation Management Actions

The most efficient and cost effective means of conserving the integrity of karst and cave habitats is to preserve the quality and quantity of water flowing into these systems. To improve water quality, important management actions include: minimizing use of fertilizers and pesticides near karst sites, minimizing runoff and other pollutants around the areas, preventing disposal of residential or agricultural waste near these sites, and ensuring vegetative buffer areas where there are extractive or other intensive land uses (Veni et al. 2001). It is also important to prevent sewage from community or municipal sewer systems from contaminating ecologically sensitive groundwater systems in karst areas (B. Beaty, The Nature Conservancy, personal communication, 2015). Vegetative buffers around sinkholes and entrances work to maintain the quality of water flowing into karst systems and provide vegetative cover in areas underlain by karst geology. However, it is important to note that it can be difficult to identify surface areas above the subterranean system well enough to install appropriate buffer areas.

Additionally, working with residents and municipalities to develop water conservation strategies will be important to control water withdrawals in the area (Veni et al. 2001). Adopting land use practices or policies through zoning or other guidelines focused on karst systems may also help protect and improve the health of karst systems in sensitive areas. Establishing protected areas around these karst systems may also be valuable. Additionally, local government policies or ordinances could include overlay districts, karst feature buffers, geotechnical surveys when in area that could contain karst systems, and/ or performance standards for development (Belo 2003).

Climate-Smart Management Actions

Karst systems are vulnerable to stressors such as poor water quality and changes to water flow that may be exacerbated by climate change. When considering planting vegetative buffers, managers will need to understand how conditions may change in the area and work with appropriate vegetation. For example, if stream flow is expected to become flashier due to increased precipitation, or more frequent flooding is projected to occur, tree and shrub species that can tolerate flood conditions and inundation should be included in the selected plant species. Plants that are better able to withstand these conditions may be better suited to help mitigate the impacts of flooding and increased runoff. Minimizing impervious surface will be even more important under climate change as with increased storm intensity will result in even more stormwater runoff.

Maintain and Restore Wetland Habitats

A very small percentage of the Central Shenandoah Planning Region is considered wetland habitat. Non-tidal wetlands make up approximately 0.15 percent (3,360 acres) of the planning region (Anderson et al. 2013). In addition to providing habitat for a diversity of aquatic and terrestrial species, wetlands help maintain water quality and quantity within a watershed and provide recreational opportunities for hunters, anglers, and wildlife watchers. These wetlands provide valuable habitats for the rusty blackbird, green heron, common ribbon snake, and a variety of other species.

Threats

The health and quality of non-tidal wetlands are affected by a variety of issues, both natural and anthropogenic. As the quality of a wetland degrades, so does the value of that wetland to Virginia's wildlife.

1. Water Quality: Wetlands help filter nutrients and other pollutants from watersheds, but they are also sensitive to activities that impair water quality and overload the system (Hemond and Benoit 1986). When best management practices (BMP_ are not implemented upstream, runoff laden with nutrients, sediment, and other pollutants enter the system in concentrations that hinder the wetland's filtering capacity. Storm water runoff from urban and developed areas also contributes to water quality issues that degrade wetlands (Hemond and Benoit 1986). Nutrient pollution and sedimentation are important issues for non-tidal wetlands throughout the planning region.

2. Land Use Changes: One of the most significant threats to these non-tidal wetlands is conversion to other uses that result in a loss of wetland integrity and function. As more areas are developed for additional human uses, wetland areas will likely be lost.

3. Invasive Species: Invasive species often degrade quality of wetland habitat through damage or loss to wetland vegetation. Examples of invasive species affecting these non-tidal wetlands include Japanese stilt grass and exotic invertebrates.

4. Climate Change: As precipitation regimes change and temperatures likely increase, water availability may change, such as in summer months where droughts may become more frequent and water availability may decrease.

Conservation Management Actions

A number of actions can be taken to address threats affecting wetlands in the Central Shenandoah Planning Region. To address development and fill impacts, the federal government and the Commonwealth of Virginia has established an extensive wetlands permitting process to help landowners and developers avoid impacts to wetlands while pursuing their management objectives. The U.S. Army Corps of Engineers has authority to issue permits for impacts to non-tidal wetlands through the federal Clean Water Act, while DEQ has authority under Virginia's State Water Control Law. Permits are issued through a Joint Permit Application Process that can be initiated with DEQ (DEQ 2011). Mitigation to compensate for wetland loss is often required under these permits. However, wetlands restoration to reestablish or rebuild former wetland areas or restore functions to a degraded wetland also are voluntary conservation actions agencies and conservation partners can implement outside of required wetlands mitigation and are an important component to protecting wetlands (DEQ 2011). These types of conservation actions also help provide migration corridors for migratory birds that depend on wetlands for nesting, roosting, and foraging. Various programs implemented by the Natural Resources Conservation Service (NRCS) and other partners also provide guidance related to conserving wetlands, establishing oyster reefs, and implementing other actions.

Establishing or protecting vegetative buffers upland of wetlands is important to protect health of the existing wetlands as well as to provide a potential migration route as conditions change (Kane 2011). Protection of additional wetland areas through acquisition, easement, or agreement would allow for further conservation of this important habitat and associated SGCN. Working to limit invasive plants and animals and predators that might degrade the quality of these habitats will be important conservation actions.

Priority areas for wetlands protection and restoration within the Central Shenandoah Planning Region include those wetlands that allow for large wetland complexes to be protected, ensuring larger habitat patches remain available for wildlife. Areas identified by conservation partners, such as the Virginia Department of Conservation and Recreation (DCR), as outstanding opportunities for conservation should also be considered priorities for protection and conservation. An initial review of the Virginia Wetlands Catalog identifies priority wetlands for conservation and restoration (Weber and Bulluck 2014). Designation of these areas was based on several factors, including existing plant and animal diversity, presence of significant natural communities, presence of natural lands providing ecosystem services, presence of corridors and stream buffers, proximity to conserved lands, inclusion within or downstream of healthy watersheds, and location of drinking water sources (Figure 6) (Weber and Bulluck 2014). DCR also designates potential restoration sites, identified based on similar factors as conservation areas, but also including consideration of inclusion within degraded watersheds, proximity to impaired waters, location of existing wetland mitigation banks, presence of prior converted and farmed wetlands, and inclusion of stream reaches with lower aquatic biodiversity (Figure 7) (Weber and Bulluck 2014). The highest priority wetlands for conservation are primarily adjacent to Shenandoah National Park and George Washington National Forest. The highest priority areas for restoration appear primarily in the Shenandoah Valley.

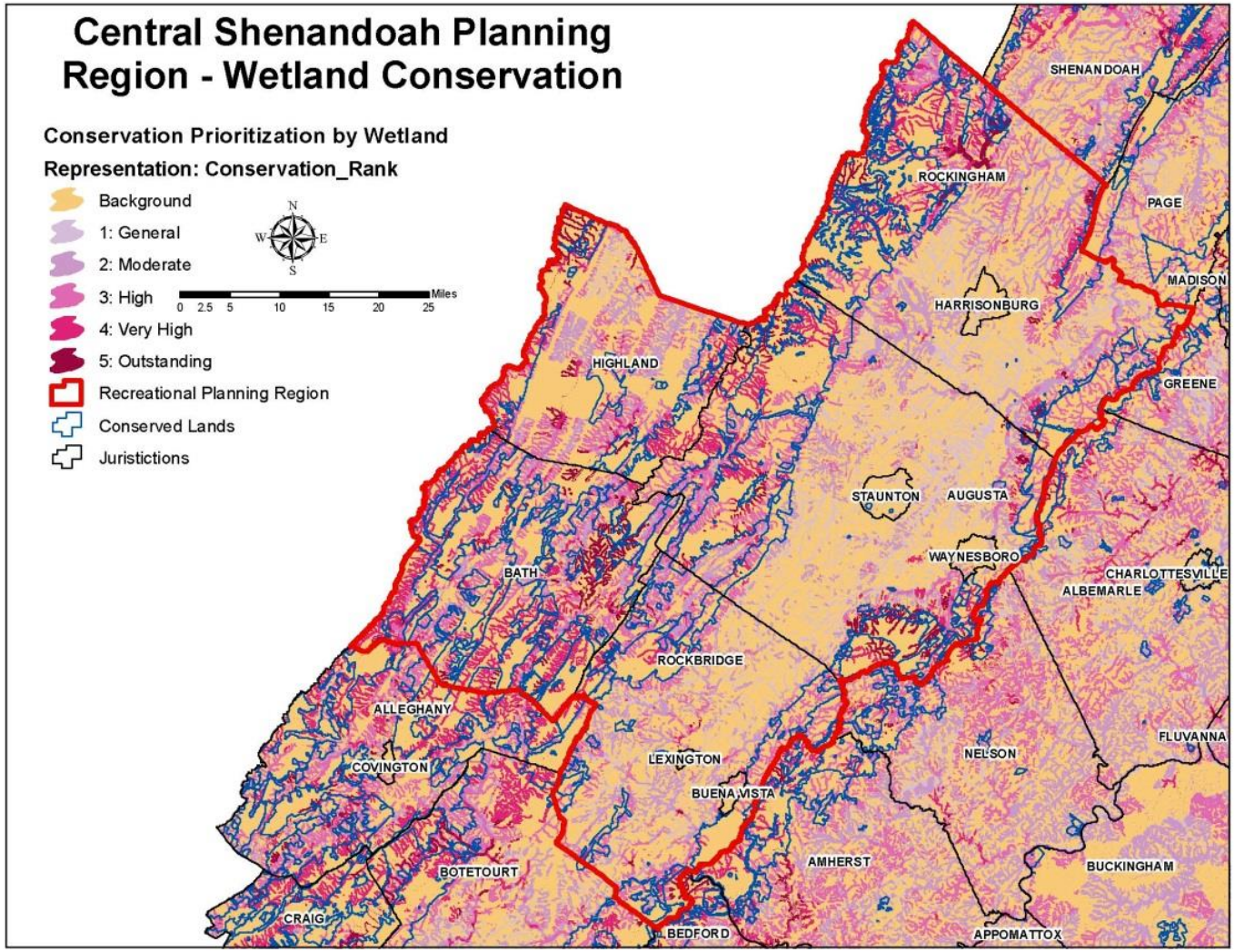

Figure 6. Wetland Conservation Priority Areas in Central Shenandoah Planning Region (Weber and Bulluck 2014).

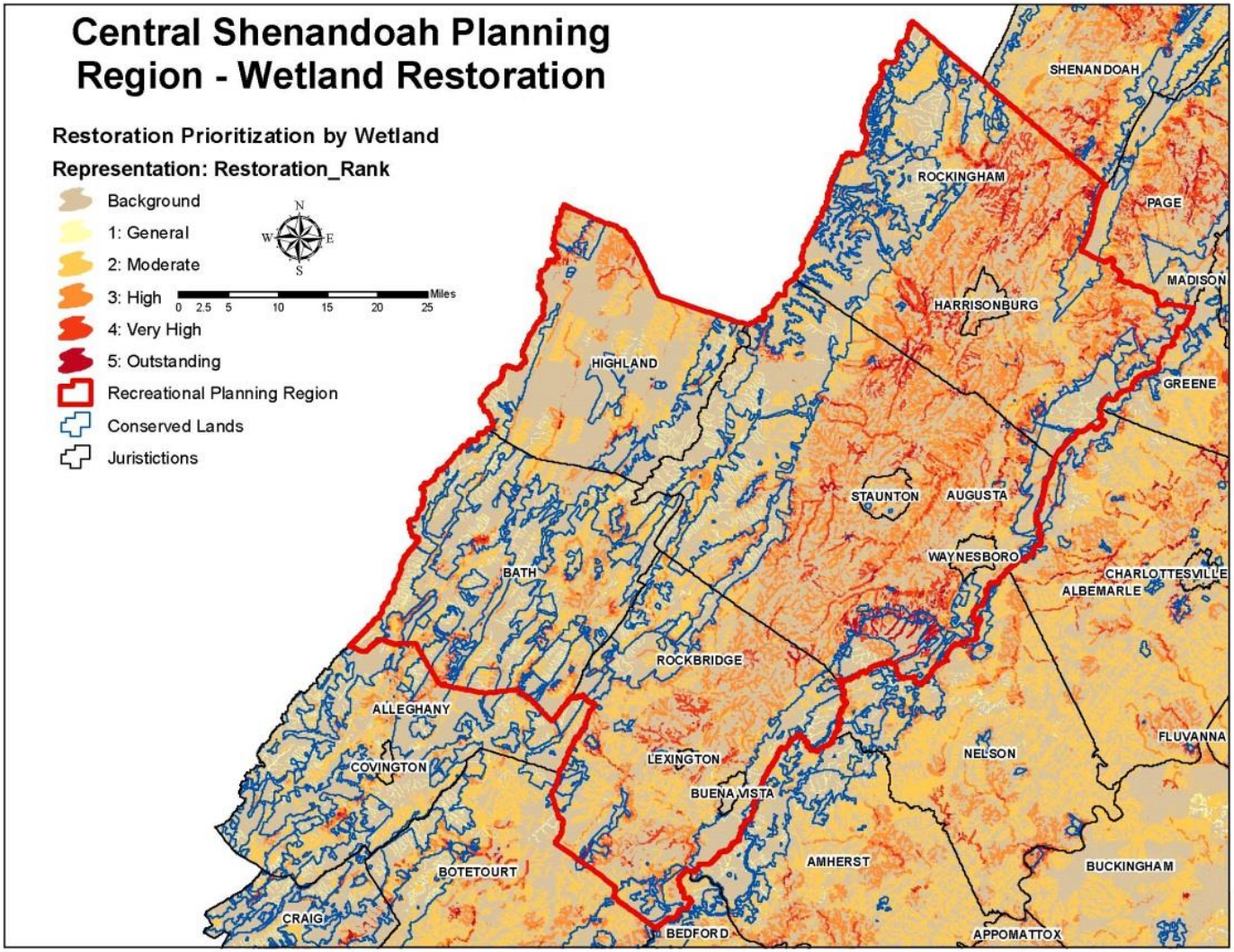

Figure 7. Priority Wetland Restoration Areas in Central Shenandoah Planning Region (Weber and Bulluck 2014).

Climate-Smart Management Actions

Additional wetlands climate-related conservation actions include: restoring and enhancing vegetation within the wetlands to support changing conditions (e.g., using vegetation species that can withstand a broader array of conditions such as more frequent inundation) and enhancement of wetlands by targeted restoration or acquisition in areas where impacts from climate change may be mitigated.

Enhance, Maintain, and Restore Aquatic and Riparian Habitats

Aquatic systems in the Central Shenandoah Planning Region include cold and warm water rivers, streams, and creeks. Much of the planning region is within the Shenandoah River watershed. Approximately 10,000 acres (0.46 percent) of the planning region are considered aquatic (Anderson et al. 2013). These systems provide important habitat for numerous species of wildlife, fish, and invertebrates. Priority SGCN that depend on these habitats include many mussels, snails, crayfish, and fish species, such as the Virginia pigtoe, slimy sculpin, roughhead shine, pearl dace, brook trout, brook floater, Blue Ridge springsnail, and James spinymussel.

Threats

Aquatic and riparian habitats within the Central Shenandoah Planning Region face multiple threats from water quality related issues to invasive species.

1. Water Quality Degradation: Pollution is the most significant threat to aquatic species and riparian habitats within the Central Shenandoah Planning Region. Polluting materials include fertilizers, eroded sediment, and human and animal waste flowing into the region's creeks and rivers from storm water runoff, failing septic systems, and agricultural practices that do not conform to standard best management practices (DEQ 2014). In many cases, watersheds have insufficient riparian buffers and vegetative areas to stop these materials from flowing into the creek or stream (ACJV 2005). Once present in aquatic systems, these materials may concentrate in sediment and bottom-dwelling organisms where they can result in reduced levels of dissolved oxygen and altered pH levels (Chesapeake Bay Foundation 2014). In addition to the impacts on aquatic life, many of these substances pose a risk to human health and local economies (Chesapeake Bay Foundation 2014).

2. Impervious Surface: Impervious surfaces (i.e., land covers that do not permit water to permeate the ground) give a useful measure of the environmental condition of an area. In a developed watershed there is often significant impervious surface cover; thus, a greater amount of surface water, often laden with pollutants, arrives into a stream at a faster rate than in less developed watersheds, increasing the likelihood of more frequent and severe flooding. Substantial amounts of impervious surface area can also lead to degradation of water quality, changes in hydrology, habitat structure, and aquatic biodiversity. Additionally, impervious surfaces often run along areas that directly interact with the stream or river through flooding, geomorphology, or material inputs. Although much of the Central Shenandoah Planning Region has a low percentage of impervious surface cover, there is a larger percentage of impervious surface cover around population centers (Figure 8).

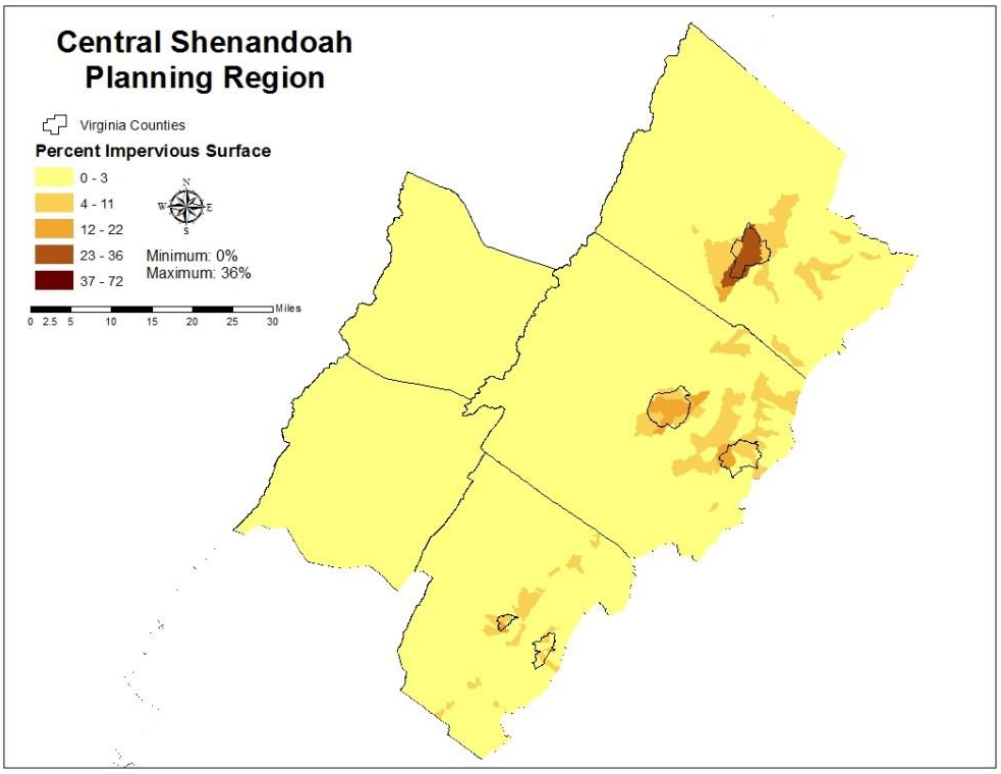

Figure 8. Impervious Surface Cover in Central Shenandoah Planning Region (SARP 2014).

3. Habitat Conversion and Alteration: Rivers are fragmented by dams, culverts, and other impediments that limit the connectivity of these aquatic habitats. This fragmentation can prevent aquatic species from accessing important aquatic habitats crucial to various life stages. Channelization, shoreline alteration, and extractive land use practices can alter aquatic habitats in terms of changes to hydrology, chemistry, and water temperature. These practices may also directly alter habitats through loss of vegetative riparian cover, filling of streams, or hardening of stream banks.

4. Invasive Species: Invasive species such as white perch threaten western warm water streams and rivers. Invasive species are less of a direct threat to fish within cold water systems, but invasive species cause significant impacts to the forests surrounding these systems. Defoliation by the emerald ash borer, gypsy moth, hemlock woody adelgid, and southern pine beetle can alter river and stream hydrology and temperature, especially important to cold water streams.

5. Stream pH: Fish species are sensitive to water pH, and pH can play a role in species richness. Waters flowing through non-karst areas in this planning region have experienced acid deposition over decades, making the waters more acidic and potentially harming or extirpating aquatic species, such as brook trout (Webb 2014).

6. Climate Change: Climate change will also affect both warm and cold water streams. Changes to precipitation regimes and air temperatures will result in changes to flow patterns, erosion rates, and water temperatures.

Conservation Management Actions

Water Quality Improvement Plans have been developed by the Virginia Department of Environmental Quality (DEQ) and various partners. Watersheds within the planning region that have Water Quality Improvement Plans include: Blacks Run and Cooks Creek (DCR 2006); Buffalo Creek, Cedar Creek, and Colliers Creek (DEQ 2014); Christians Creek and South River (DCR 2010a); Hays Creek, Moffatts Creek, Walker Creek, and Otts Creek (DCR 2010b); Holman's Creek (DCR 2008); Jennings Branch, Middle River, Polecat Draft, and Moffett Creek (DCR 2009); Linville Creek (DCR 2013); Long Glade Run, Mossy Creek, Naked Creek (DEQ/DCR 2009); Long Meadow Run and Turley Creek (Virginia Tech and UVA 2012); Dry River, Mill Creek, Muddy Creek, and Pleasant Run (MapTech 2001); and Smith Creek (Virginia Tech 2009) (Figure 9).

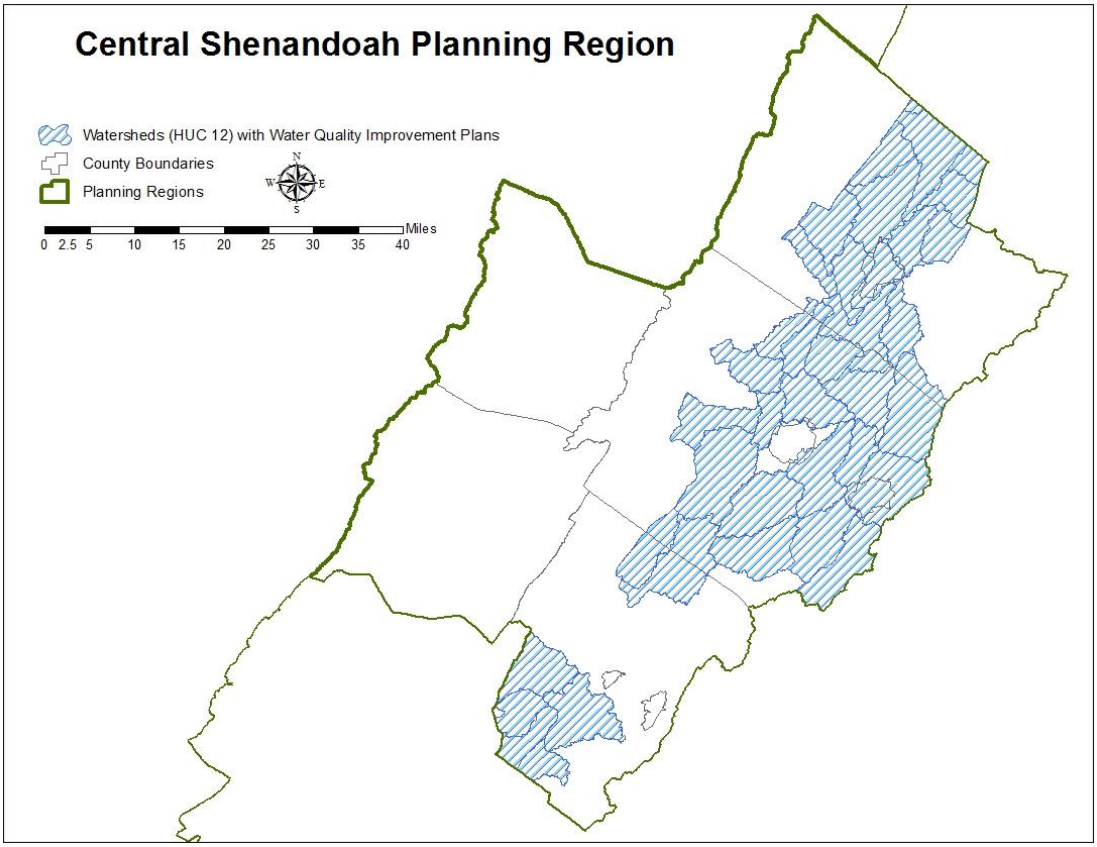

Figure 9. Watersheds with Water Quality Improvement Plans.

Each of these watersheds is designated as being impaired, and the primary actions needed to improve water quality within these watersheds include:

- Establishing vegetated and/ or forested buffers along streams and sinkholes;
- Reforesting erodible pastures;

- Excluding livestock from streams and areas around sinkholes;
- Improving pasture and loafing lot management to prevent tainted runoff;
- Implementing conservation tillage;
- Establishing storage facilities for animal waste and runoff retention ponds;
- Preventing erosion after timber harvests;
- Repairing or replacing failing septic systems and “straight pipes” that deposit human waste into streams;
- Establishing rain gardens;
- Sweeping streets;
- Stabilizing dirt roads;
- Reclamation of abandoned mine lands; and
- Working to prevent pet waste from entering the watershed.

Members of Virginia’s conservation community may consider working in other watersheds of local significance that may not have a Water Quality Improvement Plan. The Virginia Watershed Integrity Model identifies high value watersheds within the planning region for conservation based on their proximity to headwater streams, drinking water source protection, and biological integrity indices (Ciminelli and Scrivani 2007). These areas provide a starting point for identifying additional areas to focus conservation efforts (Figure 10).

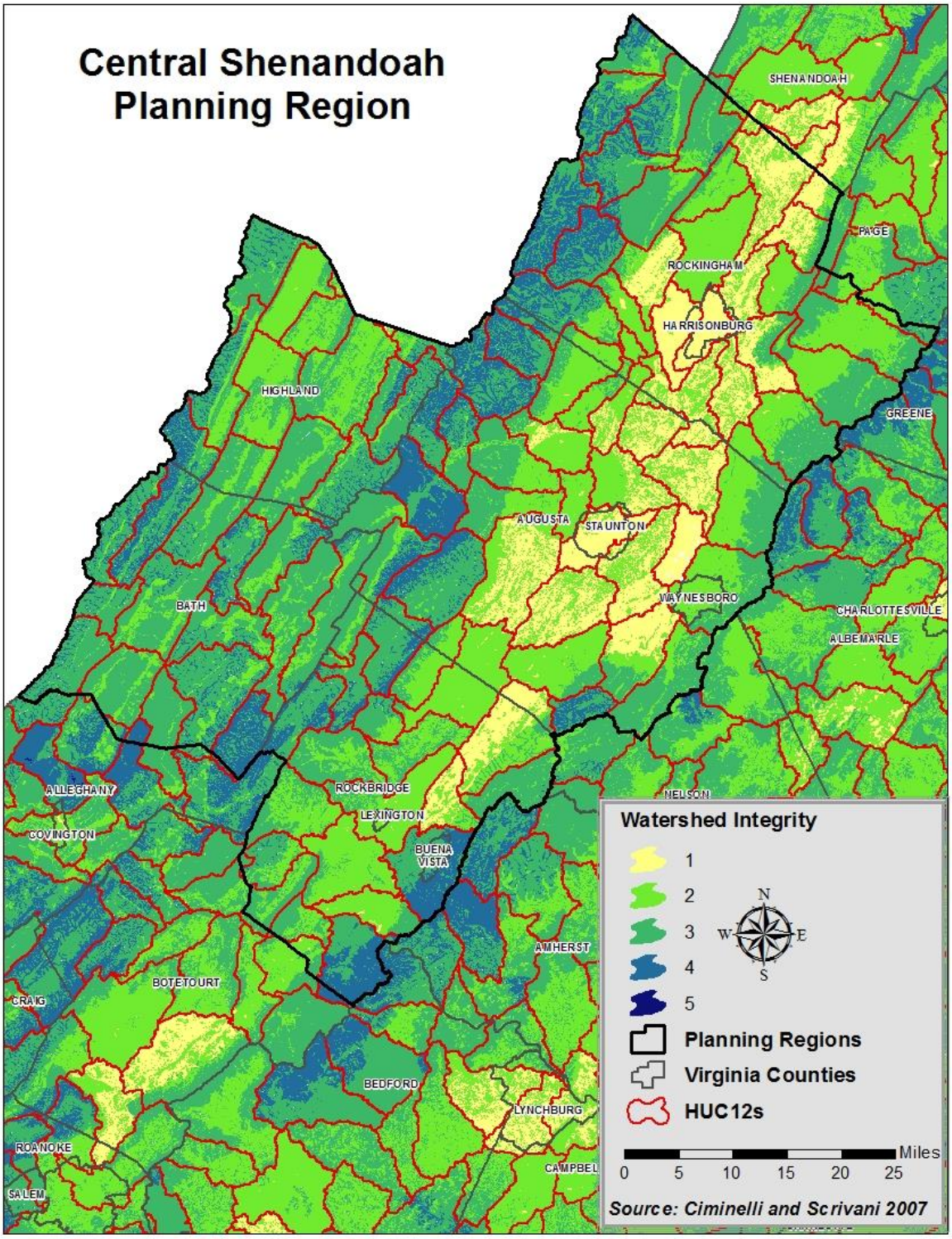

Figure 10. Watershed Integrity Model for Central Shenandoah Planning Region (Ciminelli and Scrivani 2007).

Several conservation actions common to most water quality and instream habitat enhancement plans can be implemented with little chance of ill consequence to wildlife or human communities downstream in these areas. Some of the most beneficial actions would include:

- Working with landowners to exclude livestock from streams;
- Reducing impervious surface by replacing with more porous materials or vegetation;
- Restoring or enhancing vegetated riparian buffers; and
- Working to enhance the health of upland forests and grassland habitats.

Additionally, many agencies help landowners in the Central Shenandoah Planning Region establish vegetative buffers along waterways flowing through their properties. The Virginia Department of Forestry (DOF), Virginia Department of Agriculture and Consumer Services (VDACS), and DCR have established BMPs for various land uses, which if implemented serve to minimize land use impacts upon adjacent and downstream waters. In addition, landowners are encouraged to work with DOF through the Forest Stewardship Program to utilize timber production BMPs, such as implementation of buffers and careful planning of roads and stream crossings, and agricultural producers are encouraged to work with VDACS and the local Soil and Water Conservation Districts to control erosion and limit runoff through the various available programs (DOF 2014; DCR 2014). NRCS provides landowners with other opportunities, including the Environmental Quality Incentives Program.

Additional actions to improve aquatic systems in the Central Shenandoah Planning Region include: restoring aquatic connections (i.e., removing culverts, dams, etc.), monitoring and addressing invasive species impacts, and working with the planning region to adopt use practices or policies through zoning or other guidelines (e.g., impervious surface limits) to help improve the health of aquatic systems within and downstream of regions that have significant impervious surface areas. Additionally, land acquisitions or easements that will help protect the land surrounding creeks should also be considered.

Climate-Smart Management Actions

When planting, restoring, or maintaining riparian buffers, managers should consider how conditions may change in the area and work with appropriate vegetation. For example, if stream flow is expected to become erratic due to increased precipitation or more frequent flooding as is projected to occur, native tree and shrub species that can tolerate flood conditions and inundation should be included in the selected plant species. Utilizing native species that may provide better erosion control (broader, deeper roots) than other species should be encouraged. Techniques and tools may be needed (e.g., fencing, biomats, etc.) to ensure success. Additionally, as stream temperatures will likely increase and hydrologic regimes may shift, it will be important to focus on maintaining and/ or improving stream connectivity to ensure aquatic organism can move to preferred habitats as these conditions change. Minimizing impervious surface will be even more important under climate change as increased storm intensity will likely result in increased levels of stormwater runoff. Improving stormwater control methods, to ensure they account for predicted changes in precipitation and flow, could help minimize the future impacts of storm water under climate change (Kane 2013).

Conserve and Manage Forest Habitats

Mixed hardwood and conifer forests make up almost two thirds of the Central Shenandoah Planning Region and are important for a broad range of species (Table 4). Within this forest type the majority of the trees are mature. Young forest habitat can be loosely defined as referring to areas dominated by

woody seedlings and saplings (Oehler et al. 2006). Previously, young forests were often referred to as an early successional habitat for eastern portions of North America. The young forest component (age class) in most of the forests within the Central Shenandoah Planning Region is lacking, which will impact the tree species present within these forests in the future. Lack of young forest habitat has detrimental effects on the wildlife species that depend on this forest stage for survival. Spruce-fir forests make up a small percentage of the forest types within this planning region, while the majority of the forested lands are made up of mixed hardwoods (oak and hickory) and conifers. These forests help protect water resources within the region and provide habitat for species such as the snowshoe hare, rock vole, mountain earthsnake, Virginia Northern flying squirrel, American woodcock, ruffed grouse, and American water shrew.

Table 4. Forest Acreage Totals in Central Shenandoah Planning Region (Anderson et al. 2013).

Forest Type	Acreage	Percent Planning Region
Spruce Fir	3,070.66	0.14%
Mixed Hardwood and Conifer	1,380,577.38	62.75%

Threats

Forests within this planning region face a range of threats.

1. Land Use Changes and Conversion: The largest threat to spruce fir and mixed hardwood and conifer forests within the Central Shenandoah Planning Region is fragmentation, mainly due to expanding residential and commercial development and resulting roads. In many cases, the losses can be complete and have profound impacts on local wildlife species composition, water quality, and outdoor recreational opportunities. If established BMPs are followed, impacts to waterways and adjoining properties can be prevented or mitigated such as through implementation of vegetative buffer areas (see below). Energy development (wind energy and the potential for natural gas) could also degrade habitat and affect species composition and water quality.

2. Lack of Young Forest Conditions: During recent decades, managers of federal and state-owned forests have managed properties for mature forest conditions. While mature forests provide habitat for a variety of species, the lack of young forest conditions in the western parts of Virginia have curtailed distribution of many species that rely upon open habitats. Forests with balanced age classes are critical for the health of the forest and the survival of forest dependent wildlife species.

3. Acid Rain: Although acid rain is less prevalent today than it once was, residual effects to the water and soil still remain and can affect forest health.

4. Invasive Species: Invasive plant species and pests are also a significant problem in this region. Of particular note are the hemlock wooly adelgid and the gypsy moth, which has a significant effect on the ecology of oak-hickory forests (DOF 2014).

5. Overabundance of Deer: Virginia's Draft 2015-2024 Deer Management Plan indicates the deer population in Rockingham County needs to be reduced in order to meet a variety of social and

ecological goals (DGIF 2015a). An overabundance of deer often hinders forest regeneration, impacts populations of sensitive native plants, and eliminates habitats for ground-nesting birds and other understory species. In many cases, deer overbrowse can facilitate colonization by invasive species such as privet or Japanese stilt grass. These invasive species are not palatable to deer, easily colonize these disturbed habitats, and provide few habitat benefits to native wildlife. Urban and suburban environments compound the issue as they often limit hunting opportunities that might otherwise help control deer numbers.

6. Climate Change: More intense storm events, higher temperatures, and the potential for droughts may exacerbate existing stressors as well as damage intact forests and result in more forest fires and an increase in incidence of pests.

Conservation Management Actions

Actions for conserving mixed hardwood and conifer forests (the majority of spruce fir forests are already under some form of conservation) in the Central Shenandoah Planning Region may include working to conserve, either through acquisition, easement, cooperative management, or incentives, intact forest patches capable of supporting a variety of Action Plan species. Land protection will help reduce conversion of forests to development. Additionally, working with landowners to ensure BMPs such as vegetative buffers are in place around agricultural operations or timber harvest areas will help prevent erosion and run off of sediments and nutrients into adjacent streams. Research demonstrates that vegetative riparian buffers can filter significant amounts of nutrient run off from timber operations and agricultural fields (DOF 2014). Some BMPs recommend a 50 foot buffer and allow some timber harvest within the buffers, while other BMPs encourage a 100 foot buffer with no harvest (DOF 2014; A. Ewing, Virginia Department of Game and Inland Fisheries, personal communication, 2015). BMPs also recommend building roads on areas with minimum slope and minimizing or avoiding stream crossings (DOF 2014). The *Hays, Moffatts, Walker, and Otts Creeks – A Plan to Reduce Bacteria in the Water* developed by DCR and stakeholders specifically highlights reforesting areas around eroding crop lands and pastures within Hays Creek, Moffatts Creek, Otts Creek, and Walker Creek watersheds to help decrease sediment run off as well as provide wildlife habitat (DCR 2010).

Several agencies, including DGIF, NRCS, DOF, USFWS and the USFS advocate that efforts be expanded to create young forest habitats on public lands. Managing forests via silvicultural practices and/or through the use of fire are the most economical options to create these desired conditions.

Working to maintain forest health (balance age classes and diversity of tree species) is also integral to ensuring forest habitat is available to be conserved and protected. DOF makes several key recommendations that relate to habitat health, including but not limited to using species within their native ranges, if feasible using a mix of tree species to help minimize susceptibility to pests, preventing unnecessary site disturbance, and protecting unusual (rare) forest habitats (DOF 2014). In terms of invasive species and pests, monitoring and control will be important to prevent its spread. Some of these forest habitats should be managed with thinning and prescribed burns to minimize outbreaks while also improving quality of wildlife habitats (Brooks and Lusk 2008; DOF 2014).

In terms of addressing deer and their impacts to forested habitats, hunting is the most expedient and efficient means of controlling their populations. DGIF staff and partners feel there are sufficient

numbers of hunters to affect a reduced population within this planning region. However, the efficiency of hunting is often limited by a lack of access to areas in need of herd reduction. DGIF currently works with various public and private landowners, property managers, and public officials to facilitate hunting opportunities within the planning region. These efforts will continue. The control of deer numbers is also hindered by a lack of a practical and efficient means to assess deer impacts to local habitats across the state, making it difficult to prioritize areas in need of population control. This issue is discussed several times within Virginia's current Deer Management Plan and will be similarly addressed in the revised 2015-2024 Deer Management Plan (DGIF 2015a). DGIF has initiated research to better understand deer impacts to local ecosystems.

Climate-Smart Management Actions

To best manage forests in the Central Shenandoah Planning Region as the climate changes, it will be imperative to understand how climate may affect potential future composition of forests in Virginia and how that may affect SCGN. Conservation and management efforts may need to focus on trees that can better withstand increased temperatures and drought, among other impacts. Providing forest habitat at elevation gradients for species migration also will be an important factor for enhancing resilience to climate change. Managers may wish to consult the U.S. Forest Service's tree atlas when planning management and conservation of these forests. Additionally, harvest guidelines may need to be revised, depending on projections for future tree composition. Invasive species monitoring and prevention will also become even more important to include in forest management as climate change may favor some tree pests, diseases, and invasive species.

In terms of considering how to best manage for birds, mammals, and other species that depend on these forests, managers will want to try to provide refugia for SGCN as habitat is lost as well as establishing corridors both north/ south and east/west between protected areas to assist with species movements as conditions change (King and Finch 2013). Some SGCN will not be able to migrate without contiguous forests, so some species may still be lost, but implementing conservation management actions and developing corridors can help provide can them the best chance at continued existence. It will also be important to work to maintain species diversity and continue to reduce existing stressors that will likely exacerbate impacts from climate change (McKelvey et al. 2013).

Maintain and Restore Open Habitats

Open habitats represent an assortment of habitat types that are botanically characterized by grasses, forbs, and shrubs. Trees may be present but they tend to be widely spaced and crowns do not form a canopy. DGIF biologists and partners have indicated several varieties of open habitats are important for Action Plan species. Open habitats are often comprised of post-agricultural lands, glades, and barrens and make up approximately 80,045 acres (3.6 percent) of the planning region (Anderson et al. 2013). These habitats are becoming rare in Virginia as agriculture and timber harvest practices change; however, they are important to a range of species that depend on these areas for nesting, feeding, protection, etc. Within this planning region, glades and barrens are the primary open habitat present. These areas provide habitat for the golden winged warbler, loggerhead shrike, and persius duskywing.

Threats

Changing land use patterns has played a large role in the loss of open forests habitats as has the alteration of natural disturbance regimes.

1. Land Use Changes: Dozens of open forest species have been affected by changing land use and agricultural practices that resulted in either degraded or destroyed open habitats. The most serious threats to remaining open habitats within the planning region involve either development (where habitats are converted for human use) or natural succession (where trees are allowed to dominate and the site eventually becomes forest).

2. Invasive Species: Invasive species are also problematic, especially tree of heaven, Japanese stilt grass, garlic mustard, and privet. These species can out-compete native open habitat species and take over the landscape. Some species such as tree of heaven can change the landscape from an open habitat to a more closed habitat relatively quickly due to its ability to spread and colonize areas rapidly (VISWG 2012). Japanese stilt grass also grows quickly and in mats that can crowd out native grasses. It also alters soil pH inhibiting growth of other native plants (VISWG 2012).

Conservation Management Actions

DGIF has recognized that the loss of open habitats, such as glades, savannas, and post-agricultural areas have caused significant declines in several Action Plan species, including the northern bobwhite, loggerhead shrike, field sparrows, eastern towhees, brown thrashers, prairie warblers, regal fritillary, and monarch butterflies. It is likely that the loss of these habitats has contributed to the declines in native pollinator species like bumblebees as well (Xerces Society 2011). To address this issue, Virginia has become a leader in the Northern Bobwhite Conservation Initiative (NBCI). DGIF contributes to this national effort by leading the Virginia Quail Recovery Initiative (QRI), which is a robust, state-based, multi-partner effort dedicated to conserving and restoring open habitats within Virginia. Both the NBCI and the QRI have determined that Augusta County offers some of the best opportunities for restoring open habitats that support a diversity of open habitat species (DGIF 2007).

Agriculture and forestry are large industries in Virginia, and landowners are important conservation partners. The QRI was created to find opportunities that help private landowners meet their economic goals while also contributing to the conservation and recovery of important wildlife and pollinator species. QRI efforts within this planning region focus on helping landowners manage retired agricultural lands and forested areas to benefit open habitat species, and DGIF provides information for landowners on its quail website (DGIF 2015b).

For landowners seeking to improve the habitat quality of pastures and field edges, the QRI generally recommends removing nonnative grasses and invasive species. In many instances, a sufficient seedbank of native species will exist in the soil to allow the restoration of native plant communities and replanting will likely not be required. Once a native plant community has been established, the QRI recommends managing these habitats either through burning, disking, or (least favorable) mowing. Additionally, within *Managing Pines for Profit and Wildlife* biologists describe landowner opportunities to create a commercially viable forest plot that also benefits open habitat species such as quail (Puckett et al. 2008). Recommendations are provided for site preparation, planting density, pre-commercial thinning, hardwood and grass suppression, commercial thinning, and post-thinning management.

Climate-Smart Management Actions

Changes in temperature and precipitation regimes could negatively affect open lands as temperatures increase and summers become drier and more drought prone. However, research demonstrates that many species that make up open habitats are already relatively drought tolerant, meaning that open lands may not be as affected by climate change as other habitats if they can maintain their diverse make up of vegetation species (Craine et al. 2012). It is important to note that if there is extended severe drought, open lands may succumb over time (Craine et al. 2012). To maintain diversity and help build resiliency in open lands within this planning region, it will be important to implement the management options above, especially focusing on removing non-natives and ensuring a diverse mix of vegetation species. Additionally, working to protect and preserve larger tracts of grasslands will help provide refugia for the species that depend on this habitat.

Effectiveness Measures Examples

As discussed within the Action Plan's Introduction (see Measuring the Effectiveness of Conservation Actions), it is increasingly important for the conservation community to demonstrate the effectiveness of conservation actions. Elected officials, budget authorities, private donors, and members of the public want to know that their investments in wildlife conservation are having the desired effects. During 2011, the Association of Fish and Wildlife Agencies developed and tested a series of effectiveness measures meant to support the Wildlife Action Plan implementation and the State Wildlife Grants program (AFWA 2011).

Virginia's 2015 Wildlife Action Plan describes a diversity of conservation actions that should help keep species from becoming endangered. The majority of these involve habitat protection, habitat restoration, controlling invasive species, or implementing efforts to keep pollutants from flowing into Virginia's waterways. Important data that can demonstrate the effectiveness of these conservation actions can include the following:

Conservation Action	Indicators of Effectiveness
Creation of Vegetative/ Forest Buffers along Streams or Wetlands	• Before/ after photos of project site; • Photos documenting changes as vegetation matures over multiple years; • Before/ after measurements of sedimentation immediately downstream of site; and • Changes in the number and diversity of species utilizing the site.
Control of Invasive Plants	• Before/ after photos of project site; • Photos documenting changes as restored vegetation matures over multiple years; and • Before/ after comparison of the number and diversity of species utilizing the site.
Remove Cattle from Streams	• Before/ after photos of project site; • Photos of alternative watering systems (if appropriate)

	• Photos documenting changes in shoreline as restored vegetation matures over multiple years; • Before/ after comparison of sediment and water chemistry immediately downstream of site; and • Before/ after comparison of the number and diversity of species utilizing the site.
Creating or Improving Open Habitats	• Before/after photos of project site; • Photos documenting changes to the site as the vegetation matures; and • Before/ after comparison of the number and diversity of species utilizing the site.

CONCLUSION

The development of the Virginia Wildlife Action Plan presented a unique opportunity for the Commonwealth—an opportunity not only to assess the condition and status of the state's wildlife and habitat resources, but to provide a shared vision and purpose in the management and conservation of this "common wealth." The true value of this initiative is this recognition of common interests and the enhancement of existing and fostering of new partnerships to address issues of mutual concern. The Action Plan's long-term success will depend on the implementation of the recommended actions by partners across the state and the effectiveness with which conservation partners collectively manage these natural resources.

This Local Action Plan Summary aims to prioritize species, habitats, and conservation actions within this planning region, so that partners working within this region can use limited resources to greatest effect. However, Virginia faces serious issues. Not addressing these problems would risk more species becoming threatened or endangered, the quality of our land and water would decline, and Virginians could lose important pieces of our natural heritage that contribute to our quality of life. However, there are significant conservation opportunities to benefit wildlife and people in the planning region. Our problems are not insurmountable, and most can be addressed with proven conservation management techniques.

Working to maintain and protect existing high quality habitat will be a priority before restoration; however, restoration is still an important action and necessary in many cases. Within Central Shenandoah Planning Region, priority conservation opportunities include:

- Protecting karst habitats.

- Protecting the quantity and quality of water.
- Maintaining existing vegetated wetlands and restoring vegetated wetland habitats where possible.
- Maintain and conserve patches of spruce fir and mixed hardwood conifer forests.
- Enhance and protect open habitats.

REFERENCES

Anderson, M.G. M. Clark, C.E. Ferree, A. Jospe, A. Olivero Sheldon and K.J. Weaver. 2013. Northeast Habitat Guides: A companion to the terrestrial and aquatic habitat maps. The Nature Conservancy, Eastern Conservation Science, Eastern Regional Office. Boston, MA. Available at http://easterndivision.s3.amazonaws.com/NortheastHabitatGuides.pdf.

Association of Fish and Wildlife Agencies (AFWA). 2011. Measuring the Effectiveness of State Wildlife Grants: Final Report. Washington, D.C. 40 p. Available at http://www.fishwildlife.org/files/Effectiveness-Measures-Report_2011.pdf

Atlantic Coast Joint Venture. 2005. North American Waterfowl Management Plan: Atlantic Coast Joint Venture Waterfowl Implementation Plan Revision. Available at http://www.acjv.org/wip/acjv_wip_main.pdf.

Belo, B. 2003. Natural Hazard Mitigation Planning For Karst Terrains in Virginia. Virginia Polytechnic Institute and State University. Available at http://scholar.lib.vt.edu/theses/available/etd-05222003-230312/unrestricted/etd.pdf.

Boicourt, K. and Z. Johnson (eds.). 2010. Comprehensive Strategy for Reducing Maryland's Vulnerability to Climate Change, Phase II: Building Societal, Economic, and Ecological Resilience. Report of the Maryland Commission on Climate Change, Adaptation and Response and Scientific and Technical Working Groups. University of Maryland Center for Environmental Science, Cambridge, Maryland and Maryland Department of Natural Resources, Annapolis, Maryland. Available at http://www.dnr.state.md.us/climatechange/climatechange_phase2_adaptation_strategy.pdf.

Brooks, M. and M. Lusk. 2008. Fire Management and Invasive Plants: a Handbook. United States Fish and Wildlife Service, Arlington Virginia, 27 pp. Available http://www.fws.gov/invasives/pdfs/USFWS_FireMgtAndInvasivesPlants_A_Handbook.pdf.

Carver, E. and J. Caudill. 2013. Banking on Nature: The Economic Benefits to Local Communities of National Wildlife Refuge Visitation. U.S. Fish and Wildlife Service.

Chesapeake Bay Foundation. 2014. State of the Bay Report. Annapolis, MD. Available at http://www.cbf.org/document.doc?id=2289.

Ciminelli, J. and J. Scrivani. 2007. Virginia Conservation Lands Needs Assessment Virginia Watershed Integrity Model. Virginia Department of Conservation and Recreation, Natural Heritage Program. Available at http://www.dcr.virginia.gov/natural_heritage/documents/WatershedIntegrityModel.pdf.

Craine, J.M., T.W. Ocheltree, J. B. Nippert, E.G. Towne, A.M. Skibbe, S.W. Kembel, and J.E. Fargione. 2013. Global diversity of drought tolerance and grassland climate-change resilience. Nature Climate Change: 3. 63–67.

Glick, P., J. Clough, and B. Nunley. 2008. Sea-Level Rise and Coastal Habitats in the Chesapeake Bay Region: Technical Report. National Wildlife Federation. Available at http://www.nwf.org/pdf/Reports/SeaLevelRiseandCoastalHabitats_ChesapeakeRegion.pdf.

Governor's Commission on Climate Change. 2008. A Final Report: Climate Action Plan. Available at http://www.sealevelrisevirginia.net/main_CCC_files/.

Hemond, H. F. and J. Benoit. 1986. Cumulative Impacts on Water Quality Functions of Wetlands. Environmental Management Vol. 12. No. 5, pp. 639-653.

Kane, A. 2013. Managing Coastal Watersheds to Address Climate Change: Vulnerability Assessment and Adaptation Options for the Middle Patuxent Subwatershed of the Chesapeake Bay. National Wildlife Federation. Available at http://www.nwf.org/pdf/Climate-Smart-Conservation/Middle%20Patuxent%20Subwatershed%20Vulnerability%20Assessment%20and%20Adaptation%20Report%20August%202013.pdf

King, D. and D. Finch. 2013. The Effects of Climate Change on Terrestrial Birds of North America. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. Available at http://www.fs.usda.gov/ccrc/topics/wildlife/birds.

McKelvey, K., R. Perry, and L. Mills. 2013. The Effects of Climate Change on Mammals. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. Available at http://www.fs.fed.us/ccrc/topics/wildlife/mammals/index.shtml.

MapTech, Inc. 2001. A Total Maximum Daily Load Implementation Plan for Fecal Coliform and Nitrate Reductions. Virginia Department of Conservation and Recreation. http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/nriverip.pdf

MapTech, Inc. 2014. Linville Creek Watershed Implementation Plan: A Plan to Reduce Bacteria and Sediment in the Linville Creek Watershed. Virginia Department of Environmental Quality. Available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/linvilepublic.pdf.

Melillo, J., T. Richmond, and G. Yohe (eds.). 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program.

Najjar, R., C. Pyke, M.B. Adams, D. Breitburg, C. Hershner, M. Kemp, R. Howarth, M. Mulholland, M. Paolisso, D. Secor, K. Sellner, D. Wardrop, and R. Wood. 2010. Potential climate-change impacts on the Chesapeake Bay. Estuarine, Coastal and Shelf Science 86: 1–20.

Oehler, J.D., D.F. Covell, S. Capel, and B. Long. 2006. Managing Grasslands, Shrublands, and Young Forest Habitats for Wildlife: A Guide for the Northeast. The Northeast Upland Habitat Technical Committee & Massachusetts Division of Fisheries & 9 of 9 Wildlife. 148pp. Available at http://www.wildlife.state.nh.us/Wildlife/Northeast_Hab_Mgt_Guide.htm.

Puckett, K.M., P. Keyser, J. Johnson, H. Haney, G. Gray, C. Godfrey, S. Warner, and S. Capel. 2008. Managing Pines for Profit and Wildlife. Wildlife Information Publication No. 98-1. Virginia Department of Game and Inland Fisheries. Available at http://www.dgif.virginia.gov/quail/managing-pines-smaller.pdf.

Pyke, C., R. Najjar, M.B. Adams, D. Breitburg, M. Kemp, C. Hershner, R. Howarth, M. Mulholland, M. Paolisso, D. Secor, K. Sellner, D. Wardrop, and R. Wood. 2008. Climate Change and the Chesapeake Bay:

State-of-the-Science Review and Recommendations. A Report from the Chesapeake Bay Program Science and Technical Advisory Committee. Annapolis, MD.

Southeast Aquatic Resources Partnership (SARP). 2014. Risk of Flow Alteration from Impervious Surface in Local Catchments of the SARP Region. This dataset was produced for the Southern Instream Flow Network with funding from the Gulf Coast Prairie and South Atlantic Landscape Conservation Cooperatives. Available at http://databasin.org/datasets/f49cb20b542b4e98b07cb98d1423f1fa.

Staudinger, M., T. L. Morelli, and A. M. Bryan. (eds.). 2015. Integrating Climate Change into Northeast and Midwest State Wildlife Action Plans. DOI Northeast Climate Science Center Report, Amherst, MA.

Veni, G., H. DuChene, N. Crawford, C. Groves, G. Huppert, E. Kastning, R. Olson, and B. Wheeler. 2001. Living with Karst: A Fragile Foundation. American Geological Institute. Available at http://www.americangeosciences.org/sites/default/files/karst.pdf.

Virginia Department of Conservation and Recreation and The Holman's Creek Citizens Watershed Committee (DCR). 2004. Holman's Creek Watershed Restoration Plan [Benthic and Fecal Bacteria TMDLs]. Available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/holmip.pdf.

Virginia Department of Conservation and Recreation (DCR). 2006. Water Quality Implementation Plan for Blacks Run and Cooks Creek – Fecal Coliform and Aquatic Life TMDLs. Available at http://www.deq.virginia.gov/portals/0/deq/water/tmdl/implementationplans/ccbrip.pdf

Virginia Department of Conservation and Recreation (DCR). 2008. Natural Heritage Resources Fact Sheet Karst Resources of the Shenandoah and Potomac River Basins. Available at http://www.dcr.virginia.gov/natural_heritage/documents/Shenandoah_Potomac2008.pdf.

Virginia Department of Conservation and Recreation. 2009. Water Quality Improvement Plan; Middle River, Moffett Creek, Jennings Branch, Polecat Draft – A Plan to Reduce Bacteria and Sediment in the Water. Available at http://www.deq.virginia.gov/portals/0/deq/water/tmdl/implementationplans/middlervrip.pdf.

Virginia Department of Conservation and Recreation (DCR). 2010a. Water Quality Improvement Plan South River and Christians Creek – A Plan to Reduce Bacteria, Sediment, and Phosphorous in the Water. Available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/southchristiansip.pdf.

Virginia Department of Conservation and Recreation (DCR). 2010b. Hays, Moffatts, Walker, and Otts Creeks – A Plan to Reduce Bacteria in the Water. Available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/haysip.pdf.

Virginia Department of Conservation and Recreation (DCR). 2013. Virginia Outdoors Plan. Available at http://www.dcr.virginia.gov/recreational_planning/vop.shtml.

Virginia Department of Conservation and Recreation (DCR). 2014. Program Year 2015 Virginia Agricultural Cost Share Program (VACS) BMP Manual. Virginia Soil and Water Conservation Board, Virginia Department of Conservation and Recreation. Available at http://dswcapps.dcr.virginia.gov/htdocs/agbmpman/csmanual.pdf

Virginia Department of Conservation and Recreation, Natural Heritage (DCR, Natural Heritage). 2014. Virginia Conservation Lands Database website. Available at http://www.dcr.virginia.gov/land_conservation/tools02a.shtml.

Virginia Department of Conservation and Recreation (DCR). 2015. Virginia Natural Heritage Karst Program Cave and Karst Protection website. Available at http://www.dcr.virginia.gov/natural_heritage/karsthome.shtml. Accessed 17 Marsh 2015.

Virginia Department of Conservation and Recreation and Virginia Department of Environmental Quality (DCR and DEQ). 2009. Water Quality Improvement Plan for Mossy Creek, Long Glade Run, and Naked Creek – A Plan to Reduce Bacteria and Sediment in the Creeks. Available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/mossybook.pdf.

Virginia Department of Environmental Quality (DEQ). 2011. Comprehensive Wetland Program Plan Commonwealth of Virginia. Submitted to U.S. Environmental Protection Agency. Available at http://water.epa.gov/type/wetlands/upload/virginia_wpp.pdf

Virginia Department of Environmental Quality (DEQ). 2014a. Virginia Water Quality Assessment 305(b)/303(d) Integrated Report 2014 to Congress and the EPA Administrator for the Period January 1, 2007 to December 31, 2012. Available at http://www.deq.virginia.gov/Programs/Water/WaterQualityInformationTMDLs/WaterQualityAssessments/2014305(b)303(d)IntegratedReport.aspx.

Virginia Department of Environmental Quality (DEQ). 2014b. Water Quality Improvement Plan for Buffalo, Colliers and Cedar Creeks. Available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/Buffalo_Public_Document.pdf.

Virginia Department of Forestry (DOF). 2014. Virginia Forest Stewardship Plan Appendix. Available at http://www.dof.virginia.gov/manage/stewardship/introduction.htm.

Virginia Department of Game and Inland Fisheries (DGIF). 2005. Virginia Comprehensive Wildlife Conservation Strategy. Available at http://www.bewildvirginia.org.

Virginia Department of Game and Inland Fisheries, Wildlife Division, Small Game Committee (DGIF). 2007. Northern Bobwhite Quail Action Plan for Virginia. Available at http://www.dgif.virginia.gov/wildlife/quail/action-plan/quail-action-plan.pdf.

Virginia Department of Game and Inland Fisheries (DGIF). 2015a. Virginia Deer Management Plan, 2015-2024. Virginia Department of Game and Inland Fisheries, Richmond, Virginia, USA. Available at http://www.dgif.virginia.gov/wildlife/deer/management-plan/draft/2015-2024-draft-virginia-deer-management-plan.pdf.

Virginia Department of Game and Inland Fisheries (DGIF). 2015b. The Bobwhite Quail in Virginia. Available at http://www.dgif.virginia.gov/quail.

Virginia Invasive Species Working Group (VISWG). 2012. Twelve Invasive Species of High Concern in Virginia. Virginia Department of Conservation and Recreation. Available at http://www.dcr.virginia.gov/natural_heritage/vaisc/documents/VISWG-Invasives-Brochure.pdf.

Virginia Tech Department of Biological Systems Engineering, and University of Virginia Institute for Environmental Negotiation (Virginia Tech and UVA). 2009. Smith Creek – A Plan to Reduce Bacteria and Sediment in Smith Creek. Available at http://www.deq.virginia.gov/Portals/0/DEQ/Water/TMDL/ImplementationPlans/smithip.pdf.

Virginia Tech Department of Biological Systems Engineering . 2012. *Turley Creek and Long Meadow Run TMDL* Implementation Plan. Virginia Department of Environmental Quality. Available at http://www.deq.virginia.gov/portals/0/DEQ/Water/TMDL/drftmdls/turleybc.pdf.

Weary, D.J., and Doctor, D.H., 2014, Karst in the United States: A digital map compilation and database: U.S. Geological Survey Open-File Report 2014–1156. Available at http://pubs.usgs.gov/of/2014/1156/.

Webb, R. 2014. The Shenandoah Watershed Study & The Virginia Trout Stream Sensitivity Study. University of Virginia. Available at http://people.virginia.edu/~swas/POST/assets/docs/SWAS_VTSSS_20140105.pdf.

Weber, J. T. and J. F. Bulluck 2014. Virginia Wetlands Catalog: An Inventory of Wetlands and Potential Wetlands with Prioritization Summaries for Conservation and Restoration Purposes by Parcel, Subwatershed, and Wetland Boundaries. Natural Heritage Technical Report 14-4. Virginia Department of Conservation and Recreation, Division of Natural Heritage. Richmond, Virginia 49 pp.

Weldon Cooper Center for Public Service (Weldon Cooper Center). 2012. Virginia Population Projections webpage. Demographic Research Group. University of Virginia. Available at http://www.coopercenter.org/demographics/virginia-population-projections. (Accessed 11 March 2015).

Wolter, F., S. Capel, D. Pashley, and S. Heath. 2008. Managing Land in the Piedmont of Virginia for the Benefit of Birds and Other Wildlife. American Bird Conservancy. Available at http://www.abcbirds.org/newsandreports/special_reports/PiedmontEnviroCouncil.pdf.

The Xerces Society. 2011. Attracting Native Pollinators – Protecting North America's Bees and Butterflies. Storey Publishing. 371 pp.

APPENDIX A. COMPLETE LIST OF SPECIES OF GREATEST CONSERVATION NEED IN CENTRAL SHENANDOAH PLANNING REGION

Complete SGCN list for the Central Shenandoah Planning Region (SGCN=120). Table includes federal and state statuses, Wildlife Action Plan Tier, and Conservation Opportunity Rankings. Species are listed in alphabetical order by taxa.

Taxa	Conservation Status	Tier	Opportunity Ranking	Common Name	Scientific Name
Amphibian		I	c	Cow Knob salamander	*Plethodon punctatus*
Amphibian		IV	a	Eastern mud salamander	*Pseudotriton montanus montanus*
Amphibian		IV	c	Eastern spadefoot	*Scaphiopus holbrookii*
Amphibian	**SE**	II	a	Eastern tiger salamander	*Ambystoma tigrinum*
Amphibian		IV	a	Jefferson salamander	*Ambystoma jeffersonianum*
Amphibian		II	a	Mole salamander	*Ambystoma talpoideum*
Amphibian	**FS**	I	c	Peaks of Otter salamander	*Plethodon hubrichti*
Amphibian		III	c	Shenandoah Mountain salamander	*Plethodon virginia*
Bird		II	a	American black duck	*Anas rubripes*
Bird		II	a	American woodcock	*Scolopax minor*
Bird		III	c	Bank swallow	*Riparia riparia*
Bird		III	a	Barn owl	*Tyto alba*
Bird		III	b	Belted kingfisher	*Megaceryle lcyon*
Bird		IV	a	Black-and-white warbler	*Mniotilta varia*
Bird		II	b	Black-billed cuckoo	*Coccyzus erythropthalmus*
Bird		IV	a	Brown thrasher	*Toxostoma rufum*
Bird		IV	b	Canada warbler	*Wilsonia canadensis*
Bird		II	a	Cerulean warbler	*Dendroica cerulea*
Bird		IV	b	Chimney swift	*Chaetura pelagica*
Bird		II	a	Common tern	*Sterna hirundo*
Bird		IV	a	Dunlin	*Calidris alpina hudsonia*
Bird		IV	a	Eastern kingbird	*Tyrannus tyrannus*
Bird		IV	a	Eastern meadowlark	*Sturnella magna*
Bird		IV	a	Eastern towhee	*Pipilo erythrophthalmus*
Bird		III	a	Eastern Whip-poor-will	*Caprimulgus vociferus*
Bird		IV	b	Eastern wood-pewee	*Contopus virens*
Bird		IV	a	Field sparrow	*Spizella pusilla*
Bird		III	a	Forster's tern	*Sterna forsteri*
Bird		I	a	Glossy ibis	*Plegadis falcinellus*
Bird		I	a	Golden-winged warbler	*Vermivora chrysoptera*

Bird		IV	a	Grasshopper sparrow	*Ammodramus savannarum*
Bird		IV	a	Gray catbird	*Dumetella carolinensis*
Bird		IV	a	Greater scaup	*Aythya marila*
Bird		IV	b	Green heron	*Butorides virescens*
Bird		III	a	Kentucky warbler	*Oporornis formosus*
Bird		III	b	Least bittern	*Ixobrychus exilis*
Bird	**ST**	I	a	Loggerhead shrike	*Lanius ludovicianus*
Bird		III	a	Northern bobwhite	*Colinus virginianus*
Bird		III	a	Northern harrier	*Circus cyaneus*
Bird		IV	c	Northern rough-winged swallow	*Stelgidopteryx serripennis*
Bird		I	b	Northern saw-whet owl	*Aegolius acadicus*
Bird	**ST**	I	a	Peregrine falcon	*Falco peregrinus*
Bird		III	c	Red crossbill (Type I)	*Loxia curvirostra*
Bird		III	a	Ruffed grouse	*Bonasa umbellus*
Bird		IV	b	Rusty blackbird	*Euphagus carolinus*
Bird		IV	b	Wood thrush	*Hylocichla mustelina*
Bird		III	a	Yellow-billed cuckoo	*Coccyzus americanus*
Bird		IV	a	Yellow-breasted chat	*Icteria virens*
Crustacean		IV	c	Allegheny crayfish	*Orconectes obscurus*
Crustacean	**FS**	II	c	Bath County cave amphipod	*Stygobromus mundus*
Crustacean		II	c	Blue crayfish	*Cambarus monongalensis*
Crustacean		IV	c	Eastern spotted skunk	*Spilogale putorius putorius*
Crustacean	**FESE**	II	a	Gray bat	*Myotis grisescens*
Crustacean	**FESE**	I	b	Indiana myotis	*Myotis sodalis*
Crustacean	**FSST**	I	b	Madison Cave amphipod	*Stygobromus stegerorum*
Crustacean	**FS**	II	c	Morrison's cave amphipod	*Stygobromus morrisoni*
Crustacean	**FS**	III	c	Natural Bridge cave isopod	*Caecidotea bowmani*
Crustacean	**FS**	II	c	Rockbridge County cave amphipod	*Stygobromus baroodyi*
Fish		IV	b	Allegheny pearl dace	*Margariscus margarita*
Fish		IV	c	American brook lamprey	*Lampetra appendix*
Fish		IV	a	Brook trout	*Salvelinus fontinalis*
Fish	**FSST**	II	b	Orangefin madtom	*Noturus gilberti*
Fish	**FS**	I	b	Roughhead shiner	*Notropis semperasper*
Fish		IV	c	Slimy sculpin	*Cottus cognatus*
FW Mollusk	**FSST**	I	a	Atlantic pigtoe	*Fusconaia masoni*
FW Mollusk		IV	c	Atlantic spike	*Elliptio producta*
FW Mollusk		III	c	Blue Ridge springsnail	*Fontigens orolibas*

FW Mollusk	**SE**	I	a	Brook floater	*Alasmidonta varicosa*
FW Mollusk		IV	c	Carolina lance mussel	*Elliptio angustata*
FW Mollusk		IV	a	Creeper	*Strophitus undulatus*
FW Mollusk	**ST**	II	a	Green Floater	*Lasmigona subviridis*
FW Mollusk	**FESE**	I	a	James spinymussel	*Pleurobema collina*
FW Mollusk		IV	b	Northern lance mussel	*Elliptio fisheriana*
FW Mollusk		III	a	Notched rainbow	*Villosa constricta*
FW Mollusk		IV	a	Triangle floater	*Alasmidonta undulata*
FW Mollusk		I	b	Virginia pigtoe	*Lexingtonia subplana*
FW Mollusk	**FSSE**	I	a	Virginia springsnail	*Fontigens morrisoni*
FW Mollusk	**FS**	II	a	Yellow lance	*Elliptio lanceolata*
Insect	**FSST**	I	c	Appalachian grizzled skipper	*Pyrgus wyandot*
Insect	**FS**	II	c	Avernus cave beetle	*Pseudanophthalmus avernus*
Insect	**FS**	II	c	Crossroads Cave beetle	*Pseudanophthalmus intersectus*
Insect	**FS**	II	c	Maureen's shale stream beetle	*Hydraena maureenae*
Insect	**FS**	II	c	Mud-dwelling cave beetle	*Pseudanophthalmus limicola*
Insect	**FS**	II	c	Natural Bridge cave beetle	*Pseudanophthalmus pontis*
Insect	**FS**	II	c	Persius duskywing	*Erynnis persius persius*
Insect	**FS**	I	c	Regal fritillary	*Speyeria idalia idalia*
Insect		II	c	South Branch Valley cave beetle	*Pseudanophthalmus potomaca potomaca*
Insect	**FS**	II	c	Tawny crescent	*Phyciodes batesii batesii*
Mammal		IV	c	Allegheny woodrat	*Neotoma magister*
Mammal		IV	c	Appalachian cottontail	*Sylvilagus obscurus*
Mammal		I	c	Eastern small-footed myotis	*Myotis leibii*
Mammal		IV	c	Long-tailed shrew	*Sorex dispar dispar*
Mammal	**SE**	I	c	Snowshoe hare	*Lepus americanus virginianus*
Mammal	**SE**	II	c	Southern rock vole	*Microtus chrotorrhinus*
Mammal	**SE**	II	b	Southern water shrew	*Sorex palustris*
Mammal	**FESE**	II	a	Virginia big-eared bat	*Corynorhinus townsendii virginianus*
Mammal	**FESE**	I	c	Virginia northern flying squirrel	*Glaucomys sabrinus fuscus*
Other Aquatic Invertebrates	**FS**	I	c	Rockbridge County cave planarian	*Sphalloplana virginiana*
Other Terrestrial Invertebrates	**FS**	II	c	A cave pseudoscorpion	*Kleptochthonius anophthalmus*

Other Terrestrial Invertebrates	**FS**	II	c	A cave spider	*Islandiana muma*
Other Terrestrial Invertebrates	**FS**	II	c	A millipede	*Pseudotremia alecto*
Other Terrestrial Invertebrates	**FS**	II	c	Cave pseudoscorpion	*Apochthonius coecus*
Other Terrestrial Invertebrates	**FS**	II	c	Cave pseudoscorpion	*Chitrella superba*
Other Terrestrial Invertebrates	**FS**	II	c	Cave pseudoscorpion	*Apochthonius holsingeri*
Other Terrestrial Invertebrates		III	c	Depressed glyph	*Glyphyalinia virginica*
Other Terrestrial Invertebrates	**FSSE**	I	c	Rubble coil	*Helicodiscus lirellus*
Other Terrestrial Invertebrates	**FSSE**	I	c	Shaggy coil	*Helicodiscus diadema*
Other Terrestrial Invertebrates	**FS**	II	c	South Branch Valley cave millipede	*Pseudotremia princeps*
Other Terrestrial Invertebrates	**FS**	II	c	Talus coil	*Helicodiscus triodus*
Other Terrestrial Invertebrates		III	c	Variable mantleslug	*Pallifera varia*
Reptile		IV	a	Common ribbonsnake	*Thamnophis sauritus sauritus*
Reptile		IV	c	Eastern hog-nosed snake	*Heterodon platirhinos*
Reptile		II	c	Mountain earthsnake	*Virginia valeriae pulchra*
Reptile		I	b	Northern pinesnake	*Pituophis melanoleucus melanoleucus*
Reptile		IV	a	Queen snake	*Regina septemvittata*
Reptile		IV	a	Scarletsnake	*Cemophora coccinea copei*
Reptile		III	c	Smooth greensnake	*Opheodrys vernalis*
Reptile		IV	c	Southeastern crowned snake	*Tantilla coronata*
Reptile	**CC**	III	a	Spotted turtle	*Clemmys guttata*
Reptile	**CC**	IV	a	Timber rattlesnake	*Crotalus horridus (timber)*
Reptile	**ST**	I	a	Wood turtle	*Glyptemys insculpta*

APPENDIX B. SGCN SPATIAL ANALYSIS METHODS

Analysis Units

The species data was analyzed within three spatial units for Virginia: county, planning region, and hydrologic unit (HUC12). The source spatial data for these units were provided by Virginia Department of Game and Inland Fisheries (DGIF). The analysis extent was constrained to that of the Virginia counties, so that portions of the planning region and HUC12 units falling outside of the county boundaries were eliminated from the analysis. Each of the 21 planning region units was assigned an alphabetic code (e.g. Accomack-Northampton = "ACNO"). Nottoway County does not fall within the jurisdiction of any Virginia planning region and was not included in any of our analyses.

Species Data

The source data for the species analysis consisted of three datasets, all of which were provided by DGIF: aquatic tier I-II plus species, terrestrial potential and confirmed species, and peer-reviewed HUC12 species. Within these datasets, individual species are identified by Biota of Virginia (BOVA) code.

Methods

Aquatic Species

The aquatic species are represented in the source dataset by linear stream segments, or reaches. For each BOVA code present, the total length was calculated for all assigned reaches within the analysis extent. The dataset was then divided by the three analysis units, and the total BOVA length was summarized again by county, planning region, and HUC12. The BOVA percent of total length was calculated by dividing the species length for the analysis unit by the total species length.

Terrestrial Species

The terrestrial species are represented in the source dataset by area. For each BOVA code present, the total area was calculated within the analysis extent. The dataset was then divided by the three analysis units, and the total BOVA area was summarized again by county, planning region, and HUC12. The BOVA percent of total area was calculated by dividing the species area for the analysis unit by the total species area in Virginia.

Peer-Reviewed HUC12 Species

The peer-reviewed species are represented in the source dataset by 6th order hydrologic units. For each BOVA code present, the total area was calculated within the analysis extent. The dataset was then divided by the county and planning region analysis units, and the total BOVA area was summarized by county, planning region, and HUC12. The BOVA percent of total area was calculated by dividing the species area for the analysis unit by the total species area.

Priority SGCN

For each planning region, priority species were identified as those SGCNs with a total planning region unit area or length ≥ 10% of the total SGCN area or length for Virginia. SGCN unit calculations were drawn from only one of the source datasets: if an SGCN was present in both the aquatic dataset and the HUC12 dataset, then the aquatic dataset took preference; and if an SGCN was present in the terrestrial dataset and the HUC12 dataset, then the terrestrial dataset took preference.