

Action Plan for the Greater Greenbrier Conservation Focus Area



October 4, 2021

Table of Contents

Executive Summary	1
Introduction to the State Wildlife Action Plan & Conservation Focus Areas.....	2
Species of Greatest Conservation Need, Habitats and Stresses	2
Conservation Actions	2
Conservation Focus Areas and Action Plans	3
Climate Change and Resilience	4
Monitoring and Adaptive Management	5
Organization of this Action Plan	6
How to use this plan	7
Greater Greenbrier Conservation Focus Area.....	8
Overview	8
Habitats.....	10
Terrestrial Habitats	10
Aquatic Habitats	12
Species of Greatest Conservation Need	14
Distinctive Stresses	16
Conservation Actions.....	16
Potential Partners.....	17
Protected Lands.....	17
Action Plan for the Conservation Focus Area	20
Conservation Goals.....	20
Priority Species.....	20
Forest and Woodland Habitats	27
Priority Species	27
Rare Plant Communities.....	29
Habitat Stresses and Conservation Actions.....	34
Climate Change and Habitat Resilience	35
Implementation Plan	38
Human Benefits	41

Barrens, Rock Outcrops, Cliffs and Talus Habitats..... 42

 Priority Species 42

 Rare Plant Communities..... 43

 Habitat Stresses and Conservation Actions..... 44

 Climate Change and Habitat Resilience 46

 Implementation Plan 46

 Human Benefits 48

Aquatic, Floodplain and Riparian Habitats..... 49

 Priority Species 49

 Rare Plant Communities..... 54

 Habitat Stresses and Conservation Actions..... 55

 Implementation Plan 60

 Human Benefits 62

Subterranean Habitats..... 63

 Karst and Cave Habitats 63

 Priority Species 63

 Habitat Stresses and Conservation Actions..... 64

 Climate Change and Habitat Resilience 68

 Implementation Plan 68

 Human Benefits 70

Agricultural and Developed Habitats..... 71

 Priority Species 71

 Habitat Stresses and Conservation Actions..... 73

 Climate Change and Habitat Resilience 74

 Implementation Plan 75

 Human Benefits 77

Landscape Resilience and Connectivity 78

 Implementation Plan 83

Conclusion..... 85

 Habitat Conservation Priorities 85

 Integration of Conservation Actions 85

 Connecting Conservation Actions for Climate Resilience 86

 Next Steps in Implementation..... 86

References	87
Appendix 1. SGCN in the Greater Greenbrier CFA	89
Appendix 2. Priority SGCN, Known Stresses and Actions	105
Appendix 3. Habitats on Public Lands	125
Appendix 4. Partners and Assistance Provided.....	131
Appendix 5. Resources.....	141

List of Tables

Table 1. Terrestrial Habitat Summary.....	10
Table 2. Aquatic Habitat Summary	12
Table 3. Species Summary by Taxa.....	14
Table 4. Priority Species in the CFA	21
Table 5. Priority Species in Forest and Woodland Habitats.....	27
Table 6. Rare Plant Communities in Forest and Woodland Habitats.	29
Table 7. Stresses and Actions in Forest and Woodland Habitats:.....	34
Table 8. Climate Stresses and Resilience Actions in Forest and Woodland Habitats.....	38
Table 9. Implementation Plan for Forest and Woodland Habitats	38
Table 10. Priority Species in Barrens, Rock Outcrops, Cliffs and Talus Habitats.....	42
Table 11. Rare Plant Communities in Barrens, Rock Outcrops, Cliffs and Talus Habitats	43
Table 12. Habitat Stresses and Conservation Actions in Barrens, Rock Outcrops, Cliffs and Talus Habitats .44	
Table 13. Climate Stresses and Resilience Actions in Barrens, Rock Outcrop, Cliffs and Talus Habitats	46
Table 14. Implementation Plan for Barrens, Rock Outcrop, Cliffs and Talus Habitats	46
Table 15. Priority Aquatic Species	49
Table 17. Priority Species in High Allegheny Wetlands	51
Table 18. Rare Plant Communities in Aquatic, Floodplain and Riparian Habitats.....	54
Table 19. Habitat Stresses and Conservation Actions for Aquatic, Floodplain and Riparian Habitat	56
Table 20. Climate Stresses and Resilience Actions in Aquatic, Floodplain and Riparian Habitat.....	60
Table 21. Implementation Plan for Aquatic, Floodplain and Riparian Habitats.....	60
Table 22. Priority Species in Subterranean Habitats	63
Table 23. Habitat Stresses and Conservation Actions in Subterranean Habitats.....	64
Table 23. Climate Stresses and Resilience Actions in Karst and Cave Habitats	68
Table 24. Implementation Plan for Subterranean Habitats.....	69
Table 25. Priority Species in Agricultural and Developed Habitats	71
Table 26. Habitat Stresses and Conservation Actions in Agricultural & Developed Habitats:.....	73
Table 27. Climate Stresses and Resilience Actions for Agricultural and Developed Habitats	75
Table 28. Implementation Plan for Agricultural and Developed Habitats.....	75
Table 29. Climate Stresses and Actions for Landscape Resilience and Connectivity	83
Table 30. Implementation Plan for Landscape Resilience and Connectivity	84

List of Maps

Map 1. Conservation Focus Areas in West Virginia.....	4
Map 2. Overview	9
Map 3. Terrestrial Habitats	11
Map 4. Aquatic Habitats	13
Map 5. Protected Lands and Biodiversity	19
Map 6. Forest and Woodland Habitats.....	32
Map 7. Intact Forest Patches and Biodiversity.....	33
Map 8. Barrens, Rock Outcrop, Cliffs & Talus Habitats and Biodiversity.....	45
Map 9. Riparian and Floodplain Habitats, and Biodiversity.....	52
Map 10. Mussel Streams, Wetlands and Biodiversity	53
Map 11. Impaired Streams and Biodiversity.....	58
Map 12. Karst Areas and Biodiversity.....	66
Map 13. Karst and Cave Features.....	67
Map 14. Developed & Agricultural Lands and Biodiversity	72
Map 15. Landscape Integrity.....	79
Map 16. Priority Resilient and Connected Network: Regional View	81
Map 17. Priority Resilient and Connected Network – Detailed View.....	82

List of Acronyms Used

ACEP- Agricultural Conservation Easement Program	RGS- Roughed Grouse Society
AFF- American Forest Foundation	SFI- Sustainable Forestry Initiative
AMJV- Appalachian Mountain Joint Venture	SGCN- Species of Greatest Conservation Need
ATFS- American Tree Farm System	S Rank- State Rank
BMPs- Best Management Practices	SWAP- State Wildlife Action Plan
B-Rank- Biodiversity Rank	TCF- The Conservation Fund
CFA- Conservation Focus Area	TNC- The Nature Conservancy
CCV- Cave Conservancy of the Virginias	TU- Trout Unlimited
CCVI- Climate Change Vulnerability Index	USDA- United States Department of Agriculture
CERW- Cerulean Winged Warbler	USFWS- United States Fish and Wildlife Service
CREP- Conservation Reserve Enhancement Program	WMA- Wildlife Management Area
CRP- Conservation Reserve Program	WVACS- West Virginia Association for Cave Studies
CSP- Conservation Stewardship Program	WVASS- West Virginia Speleological Survey
EQIP- Environmental Quality Improvement Program	WVCA- West Virginia Conservation Agency
FSA- Farm Service Agency	WVCC- West Virginia Cave Conservancy
FSC- Forest Stewardship Council	WVDA- West Virginia Department of Agriculture
G Rank- Global Rank	WVDHHR- West Virginia Department of Health and Human Resources
GVCD- Greenbrier Valley Conservation District	WVDNR- West Virginia Division of Natural Resources
GWWA- Golden-winged Warbler	WVDEP- West Virginia Department of Environmental Protection
HUC- Hydrologic Unit Code	WVDOF- West Virginia Division of Forestry
NRCS- Natural Resources Conservation Service	WVDOH- West Virginia Division of Highways
NSS- National Speleological Society	WVLT- West Virginia Last Trust
NWTF- National Wild Turkey Foundation	WVU- West Virginia University
OHCF- Outdoor Heritage Conservation Fund	

Executive Summary

In 2015 the West Virginia Division of Natural Resources (WVDNR) completed the first revision to the State Wildlife Action Plan (SWAP) with the input of numerous stakeholders from across the state, including public agencies and land managers, researchers, local and regional conservation organizations, volunteer groups, private landowners and members of the public. The 2015 SWAP identified 21 Conservation Focus Areas (CFAs), each with a distinctive set of Species of Greatest Conservation Need (SGCN), wildlife habitats, stresses that can adversely affect those species and conservation opportunities to address those stresses. In 2018 the WVDNR and The Nature Conservancy (TNC) began convening a working group of local stakeholders including public agencies and land managers, watershed groups, cave interest groups and other non-profit conservation organizations working in the area to develop the Action Plan for the Meadow River Wetlands CFA. The plan addresses the eight essential elements required in the SWAP. It provides an overview of the landscape and major habitat types within this CFA, including forest and woodland habitats, rock outcrop, cliffs and talus and shale barren habitats, aquatic, floodplain and riparian habitats, karst and cave habitats, and developed and agricultural habitats. It also identifies 341 plant and animal SGCN that are priorities for conservation within this CFA based on factors such as their abundance, distribution, population trends and opportunities for conservation. For each major habitat type the plan lists the priority species, stresses and voluntary actions that can be taken by private landowners, public land managers and partner organizations for the conservation of wildlife species and their habitats. Climate stresses impacting each major habitat type and potential actions to boost their resilience are also listed. An implementation plan for each major habitat type lists partners and programs available to assist with each of the actions as well as metrics for monitoring conservation success. There is also a summary of other human benefits that may be generated by the proposed conservation actions in each major habitat type. The plan also describes a regional network of resilient and connected landscapes within which wildlife species can adapt and shift to a changing climate, identifies high integrity as well as resilient and connected landscapes within the CFA and provides an implementation plan for landscape resilience and connectivity. The plan concludes with a summary of the priority habitats for conservation, describes the importance of combining conservation actions for greater impact and connecting them across the landscape for climate resilience and outlines next steps in plan implementation.

Local stakeholders can use this plan to identify priority species, the habitats and stresses within the CFA, as well as partners who can assist with planning, implementation and monitoring of conservation actions to conserve wildlife and enable climate adaptation. The information in this plan can also be used to inform conservation projects being planned by partners and provide justification for grant applications and other proposals seeking to conserve priority species and habitats. Local stakeholders can also work with relevant agencies to develop strategies to avoid, minimize and mitigate impacts to priority species, their habitats and the resilient and connected landscapes within the CFA.

Conserving wildlife species and their habitat within the CFA will rely upon the voluntary actions of local landowners, public agencies and partner organizations, with support from the WVDNR. WVDNR will convene a working group of local stakeholders on a regular basis to provide guidance, assistance and support; implement and monitor conservation actions; facilitate stakeholder collaboration; and update the plan every 10 years or sooner if needed.

Introduction to the State Wildlife Action Plan & Conservation Focus Areas

The West Virginia Division of Natural Resources (WVDNR) manages the state's wildlife resources as part of the public trust. A goal of the WVDNR is to support and promote a sense of ownership in the conservation community and the public for the unique habitats and wildlife resources in West Virginia. The 2015 WV State Wildlife Action Plan (SWAP) was therefore developed to function as a blueprint for conservation for use by other natural resource agencies, local governments, non-governmental organizations and the general public (WVDNR 2015). The SWAP is intended to have a ten-year timeframe and will be updated by 2025.

Species of Greatest Conservation Need, Habitats and Stresses

The 2015 SWAP identified 681 wildlife Species of Greatest Conservation Need (SGCN) across the state. Because plants are a fundamental element of habitat for wildlife SGCN, a list of SGCN plants was also developed, including 482 plant species.

The SWAP classified and mapped 19 terrestrial habitats across the state. These include 16 natural or semi-natural habitats that are derived from NatureServe's Ecological Systems (Comer et al., 2003, Gawler 2008) and 3 anthropogenic habitats that represent map classes of the National Land Cover Database (Homer et al., 2004). In addition, the SWAP classifies and maps 18 aquatic habitat types. These are GIS-derived types based on a simplification for West Virginia of the Northeast Aquatic Habitat Classification System (Anderson et al., 2013). Stream size is considered the most influential variable on determining biological assemblages at the reach scale and is divided into four primary classes: headwaters and creeks, small rivers, medium rivers and large rivers. Stream slope, or gradient, affects aquatic communities at the reach scale due to its influence on stream bed morphology, water velocity and sediment dynamics. Three relative classes (low, moderate, high) of gradient are used to define West Virginia's streams. Water temperature in streams is a key physiological characteristic determining where different stream organisms may persist. Temperature affects seasonal migrations, growth rates, body condition and fecundity of biota. Three temperature classes (cold, cool, warm) based on continuously recorded data and modeled environmental variables were used to determine biological constraints on stream communities in the model. The characteristics, distribution, trends and threats associated with each of the terrestrial and aquatic habitats are described in the 2015 SWAP.

For those SGCN listed in the SWAP as priority species and their associated habitats, WVDNR staff developed a statewide stress assessment using the classification system of the International Union for Conservation of Nature. Terrestrial stresses were addressed at the habitat level within ecoregions. Aquatic stresses were addressed at the HUC 8 watershed level within ecoregions. The resulting analysis identified 21 major statewide stresses affecting terrestrial SGCN and habitats and 21 major stresses that affect aquatic SGCN and habitats. Stresses exerted on SGCN populations and habitats can reduce species populations either directly, by causes such as disease, or indirectly, by affecting the quality or quantity of available habitat.

Conservation Actions

The purpose of stress assessment and prioritization in the 2015 SWAP is to identify statewide conservation actions that can reduce stress on SGCN populations and their habitats. Most stresses are the result of the lawful activities of people, corporations and public agencies. Rather than seeking a regulatory approach to

restrict lawful activities, the intent of the SWAP is to promote collaboration with landowners, corporations and other partner organizations and agencies to reduce stresses on wildlife species and their habitats.

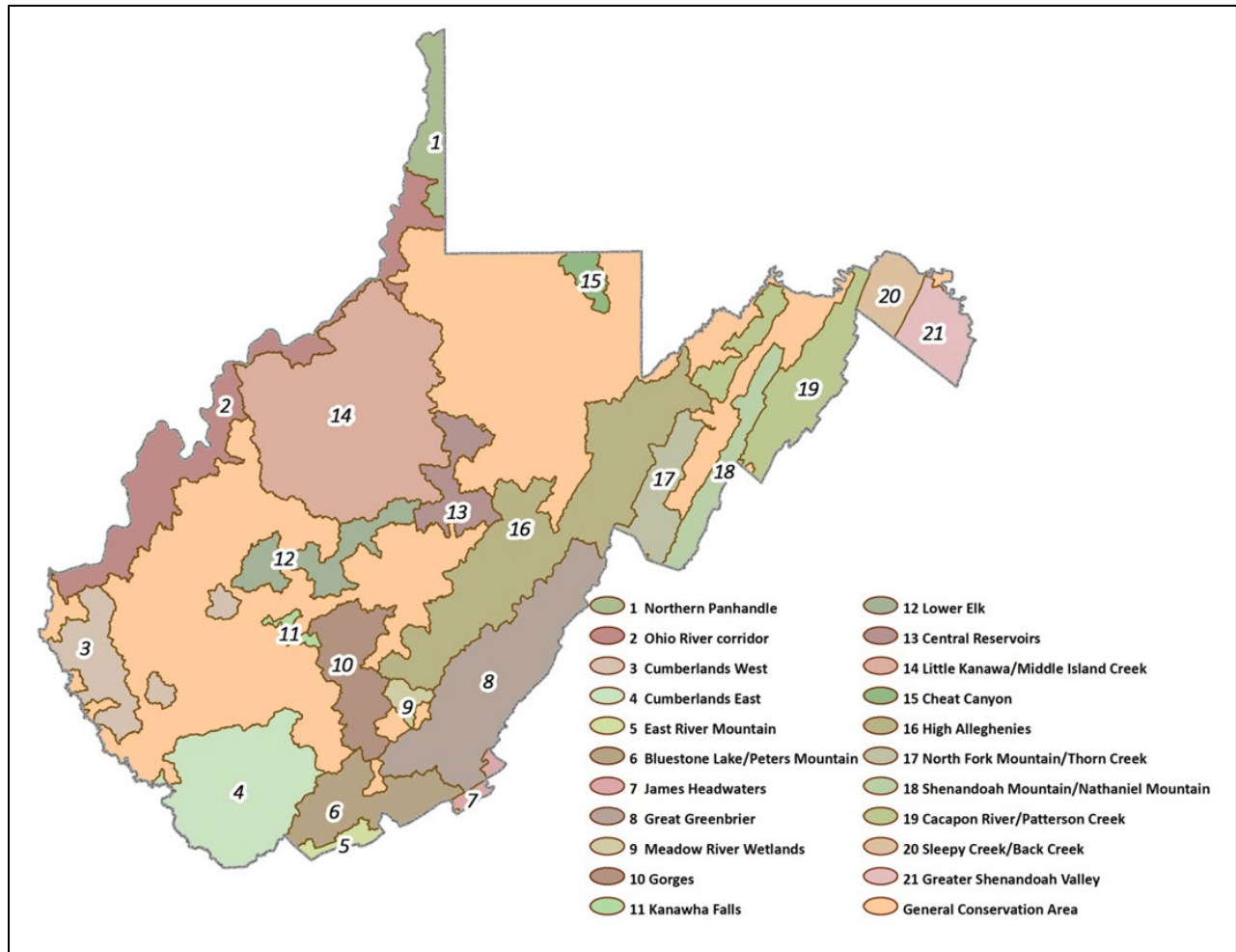
Conservation actions vary according to the species and the specific stresses; actions can take many forms. A lack of information on the status of a species or understanding of a threat may indicate a need for actions such as baseline inventory, research, or data acquisition. Direct action may involve directly protecting or restoring habitats or even restoring populations. Conservation easements are a form of habitat protection that preserves habitat in its current state or can include land management plans that benefit wildlife. It is likely that a suite of actions is required depending on the identified stress and the opportunities available. Ideally, actions are designed to address the source of the stress (AFWA 2011). Conservation actions must also address habitat integrity and ecosystem processes. This includes conserving or preserving intact and functional habitats, protecting or restoring aquatic resources and maintaining and restoring connectivity between habitats (AFWA 2012, Byers and Norris, 2011).

Conservation Focus Areas and Action Plans

The SWAP provides a broad framework for conservation across West Virginia. However, wildlife species are concentrated in different parts of the state and exposed to multiple stresses at state, regional and local scales. Conservation Focus Areas (CFAs) are specific regions in the state where SGCNs are concentrated, addressable threats are identified and where feasible opportunities exist for focused actions that will achieve success. In completing the 2015 SWAP, WVDNR defined 21 CFAs across the state based on these factors. Map 1 on the following page illustrates the CFAs in West Virginia.

In addition to conservation actions at the statewide level, the 2015 SWAP envisioned that planning at the CFA level would be necessary to fully implement successful conservation and to further define conservation actions and measurable outcomes for most SWAP-based activities. The SWAP also notes that investing conservation resources in the CFAs could increase the potential for collaboration with partners and landowners, as well as the efficiency and effectiveness of conservation on the ground. CFA Action Plans have been developed to identify priority SGCN from each taxa group in each major habitat type, key stresses in those habitats and actions that will effectively secure or protect priority species and their habitats within the CFA. The Plans also identify public lands that can provide opportunities for conservation in collaboration with public land managers. Because many SGCN and their habitats occur on private property within CFAs, conservation actions will require collaboration with private landowners, as well as partner organizations and stakeholder groups. Many local partners have relations with landowners as well as the expertise, capacity, resources and funding to plan and implement the actions listed in CFA Action Plans. CFA planning engages local partners and stakeholders at a scale where collaboration can increase resources (funding, capacity) available for conservation action. WVDNR has engaged a working group of local partners in developing each CFA Action Plan and intends to facilitate, guide and support partner efforts in planning, implementation and evaluation of conservation actions to implement the plans.

Map 1. Conservation Focus Areas in West Virginia.



The 2015 SWAP lists climate change as a substantial threat to wildlife and plant populations, noting several recent studies. For example, an assessment of the relative vulnerability to climate change of 185 animal and plant species in West Virginia (Byers and Norris, 2011) identified natural and anthropogenic barriers to movement and dispersal, and physiological thermal and hydrological niches occupied by some species as risk factors correlated with vulnerability to climate change. Over half of the species assessed were determined to be vulnerable to climate change. Both this study and the SWAP identify climate change as a stressor particularly for cool and coldwater fish, mollusks, plants, terrestrial salamanders and many species associated with wetlands and high elevation ecosystems. The SWAP lists habitat shifts and alterations as statewide stresses for terrestrial SGCNs and it lists increasing frequency and severity of droughts, storms and flooding and temperature extremes as statewide stresses for aquatic SGCN and habitats. The SWAP notes that even within taxonomic and habitat groupings, species may respond differently to climate change based on their sensitivity to factors such as temperature, moisture and seasonal triggers. Because climate change acts in tandem with other stresses on wildlife and habitat, the SWAP suggests that actions to address those other stresses could decrease their vulnerability to climate change. Varying conditions among CFAs means actions to address climate impacts should be tailored to each CFA, emphasizing restoration and expansion of vulnerable habitat types in some areas, or reducing habitat fragmentation in

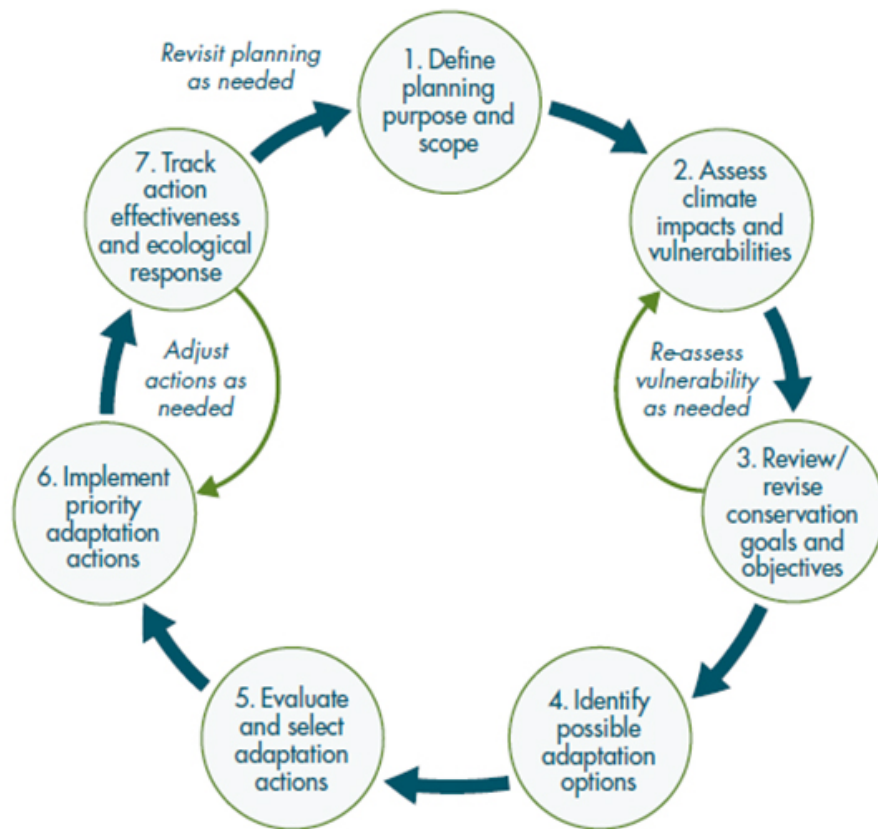
others. The SWAP suggests that efficient approaches to maintaining broad suites of species include maintaining functioning ecological systems, landscapes that are resilient to the effects of climate change and ecological connectivity within and between landscapes. Rather than a species-specific approach, the SWAP therefore seeks to address climate change broadly through additional vulnerability assessments for select species, statewide actions to reduce additional stresses on SGCNs and their habitats, and more geographically focused actions in Conservation Focus Areas (CFAs). CFAs are an appropriate scale to promote climate resilience by identifying local actions to relieve stresses on SGCN, restore or expand vulnerable habitats, and maintain ecosystems process, landscape resilience and habitat connectivity.

Monitoring and Adaptive Management

Monitoring of SGCNs and their habitat is essential to establish better baseline data about species distribution, abundance and population trends. The SWAP calls for monitoring of species and habitat trends across the state, along with more-intensive monitoring within CFAs through collaboration with local partners to gain more area-specific data and to address local threats with targeted conservation actions.

Beyond monitoring SGCNs and their habitat, successful wildlife conservation in CFAs will require monitoring the effectiveness of conservation actions and adapting those actions accordingly. The SWAP envisions monitoring the results of conservation actions at the CFA level, and that CFA-level plans should incorporate measurement and monitoring protocols integrated with conservation actions themselves. Effectiveness measures indicate progress to date and whether the expected results are being realized. Conservation actions should be designed with enough specificity that project impacts and performance can be measured but broadly enough to benefit multiple species and engage partners. Success may be measured by the amount of protected or restored habitat, by stability or increase in populations, or by the acquisition of the information required to make informed conservation decisions. Another measure of success is the amount of “buy-in” or participation by conservation partners in the public and private sectors. Conservation partners, especially those operating through grant funding or those following conservation agency protocols, may already have metrics for accomplishment/success that are used for their own reporting requirements. Furthermore, accountability and transparency to funding sources, partners and the public are essential for program success.

Adaptive management also requires monitoring of climate change impacts on species and their habitats, as well as the success of conservation actions. In common terms, climate adaptation may be thought of as preparing for, coping with, or adjusting to climatic changes and their associated impacts (Stein et al., 2014). Frameworks such as the Climate Smart Conservation Cycle illustrated below (from Stein et al., 2014) can be used to plan, implement and monitor conservation actions to enable wildlife to adapt to a changing climate. Planning conservation actions to implement this plan should consider climate impacts to species and habitats, WVDNR’s ongoing vulnerability assessments and field surveys to further document population trends, distribution and abundance of priority species and the options to build the resilience of each major habitat type listed in this Action Plan. Information on site conditions and project plans provided by partners and landowners should also be considered. This will require careful coordination among WVDNR and local stakeholders.



Climate-Smart Conservation Cycle
 A General Framework for Adaptation Planning and Implementation
 Stein et. al, 2014

Organization of this Action Plan

This CFA Action Plan will begin by introducing the CFA, including an overview of the landscape, terrestrial and aquatic habitats, species of greatest conservation need, distinctive stresses and broad conservation actions, potential partners and lands protected by public ownership or conservation easements. The plan then reviews the conservation goals and lists priority species identified by WVDNR specialists based on factors such as their abundance, population trends and opportunities for conservation within the CFA. The plan is then divided by major habitat type, including forest and woodland habitats, rock outcrops, cliffs and talus and shale barren habitats, aquatic, floodplain and riparian habitats, karst and cave habitats, and developed and agricultural habitats. For each major habitat type the plan lists priority species, stresses effecting those species and actions to alleviate those stresses. The plan also identifies climate stresses impacting each major habitat type and lists potential actions to boost their resilience. The plan provides a roadmap for implementation and monitoring of conservation actions for each major habitat type and brief statements about other human benefits that may be generated by the proposed actions. The plan also describes a regional network of resilient and connected landscapes spanning multiple habitat types that enable wildlife species to adapt and shift to a changing climate and provides an implementation plan for landscape resilience and connectivity. The conclusion provides a summary of the priority habitats for conservation, describes the importance of integrating conservation

How to use this plan

Implementation of this Action Plan will rely upon voluntary actions by local stakeholders including landowners, public agencies and partner organizations, and collaboration between them to conserve wildlife species and their habitat. The role of WVDNR in implementing this plan is to provide local stakeholders with information, guidance, assistance and support to develop, implement and monitor conservation actions and facilitate stakeholder collaboration.

Local stakeholders can use this plan for many purposes, including the following:

- Identify priority wildlife species, rare plant communities and their habitats and the resilient and connected landscapes that can enable species to shift in response to changing conditions.
- Work with relevant agencies to develop strategies to avoid, minimize and mitigate for impacts to priority species, their habitats and the resilient and connected landscapes.
- Identify stresses on priority species in specific habitats, conservation actions that can alleviate those stresses, monitoring protocols to evaluate success, and partners who can provide assistance.
- Understand climate impacts on wildlife habitat and actions to boost habitat resilience.
- Plan and implement conservation actions to boost habitat resilience and enable wildlife to adapt to climate change.
- Design and implement monitoring protocol to evaluate the success of conservation actions.
- Inform and provide rationale for activities being proposed in grant or permit applications.
- Integrate priority species, habitat and climate resilience into other local project plans.

The information provided in this Action Plan is constantly evolving. Local stakeholders are encouraged to seek additional information and assistance from WVDNR to:

- Confirm whether specific priority wildlife species and habitats are present at specific sites
- Understand species and habitat vulnerability to climate change
- Further define or confirm stresses on wildlife species and habitats
- Tailor proposed wildlife conservation actions to alleviate stresses
- Consider adaptation options to boost habitat resilience to climate change
- Develop effective strategies to monitor and evaluate project success

Greater Greenbrier Conservation Focus Area

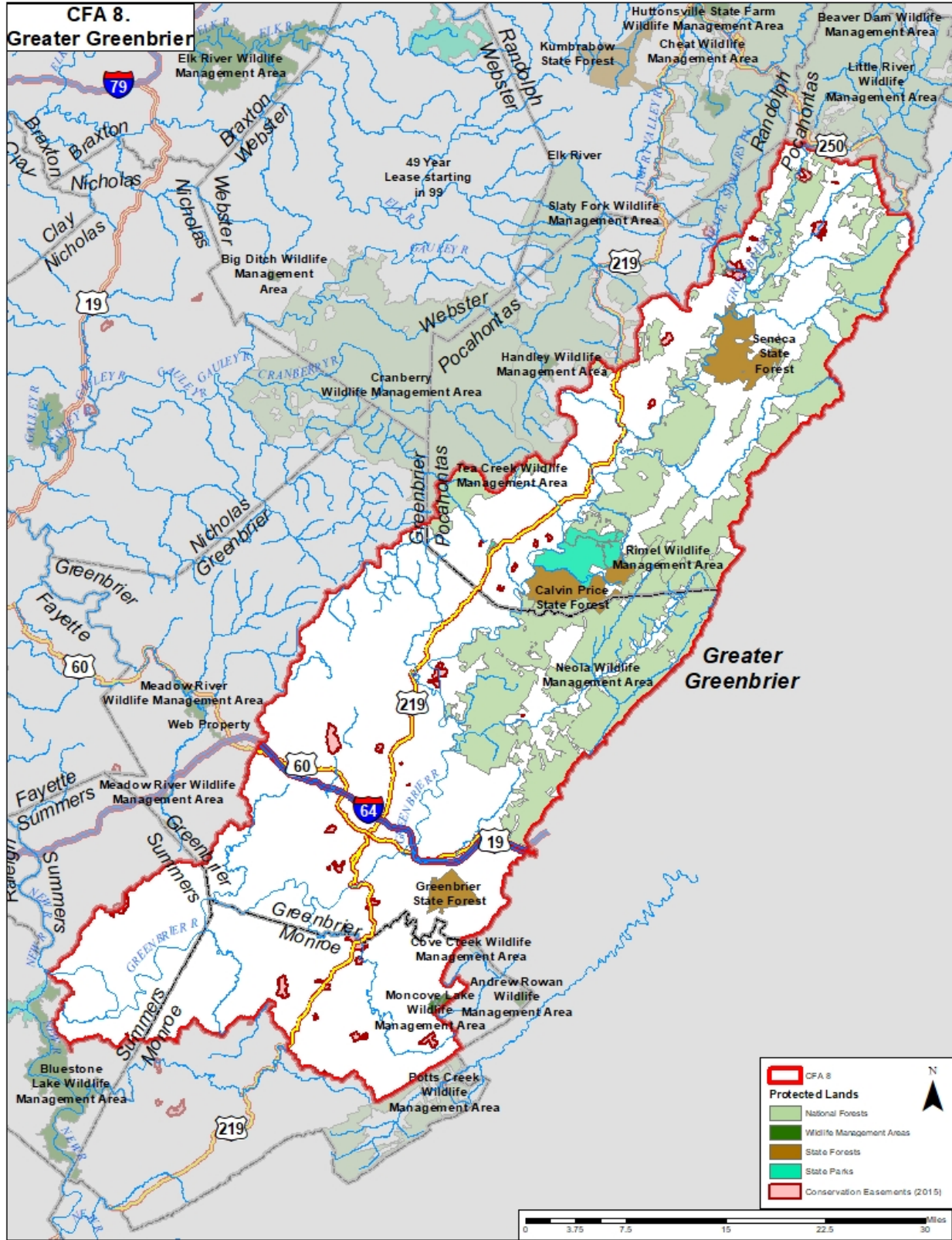
Overview

The Greater Greenbrier Conservation Focus Area (CFA) encompasses the Greenbrier River Watershed from the joining of the East and West forks at Durbin downstream to the Greenbrier River's confluence with the New River. Entirely in the Allegheny Mountains ecoregion, this CFA includes a globally significant karst landscape surrounded by ridges and valleys of shale and sandstone. More caves occur here than anywhere else in West Virginia, with sinkhole and cave densities reaching an average of seven per square mile (18 per square kilometer) in the Big Levels area, a karst plateau of hills and sinkholes near Lewisburg. Davis Spring, with an average volume of 110 cubic feet per second, is the largest spring in the state. Friars Hole, with 44 miles of mapped passage, is the sixth largest cave in the United States. Allegheny Mountain, whose crest forms the border with Virginia, defines the eastern boundary of the landscape, with a series of parallel shale and sandstone ridges running west to the karst region. In the karst region, most surface drainage is limited due to numerous sinking streams.

The Greenbrier River and its major tributaries to its east are the main surface waterways. The Greenbrier River is the longest undammed river in the Central Appalachians. Elevations are generally moderate but rise to over 4,000 feet at higher summits. The Greenbrier Valley is in a rain shadow and has lower precipitation than most portions of West Virginia. The karst region was originally forested by deciduous forests, which have been largely displaced by farmland with scattered woodlots and towns such as Lewisburg. The shale and sandstone ridges remain largely forested, especially on public land, with small farms and communities in some valley areas.

Areas east of the Greenbrier River originally supported the most extensive Eastern white pine forests south of northern Pennsylvania, but most of the White Pine region converted to mixed oak and oak-pine forests after the original forest was logged and burned. Some of the most extensive intact forest blocks (primarily Dry-Mesic Oak) in the Central Appalachians Ecoregion occur in this eastern portion, where the largest landowner is the Monongahela National Forest. Most privately owned forestland exists as small to medium-sized, non-industrial properties. A few large, corporate-owned forested tracts exist in the vicinity of White Sulphur Springs. Residential development is expanding around Lewisburg and second home development is expanding locally along the Greenbrier River and elsewhere.

Map 2. Overview



Habitats

Greater Greenbrier CFA includes a variety of terrestrial, aquatic and subterranean habitat types.

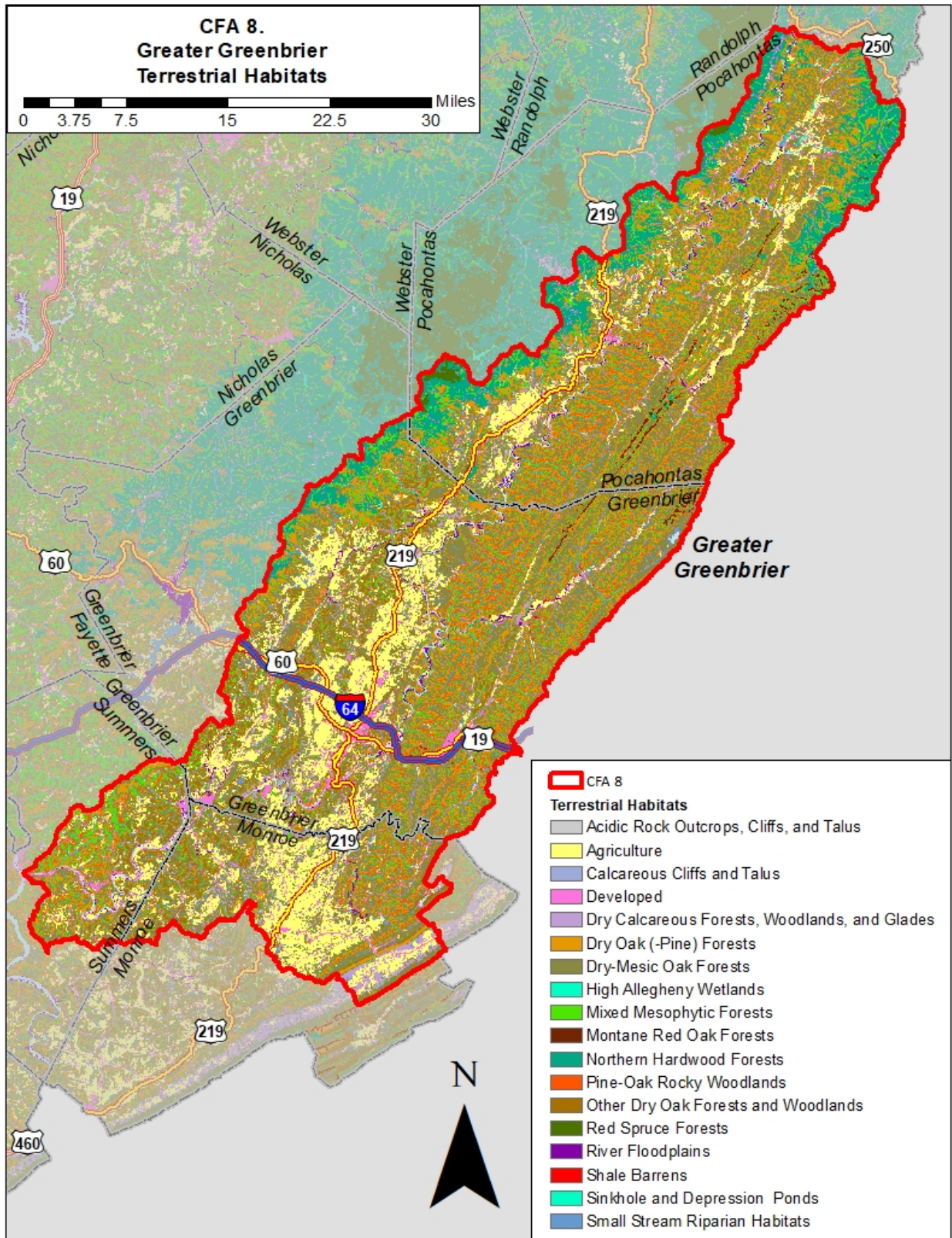
Terrestrial Habitats

Seventeen of the habitat types described in the SWAP are present in this CFA. These include over a quarter of the state's Dry Calcareous Forests, Woodlands and Glades, and Pine-Oak Rocky Woodlands. Shale barrens represent a tiny portion of the terrestrial habitats in this CFA yet represent roughly 18% of the state's total shale barren habitat. Terrestrial habitats are described in Chapter 3 of the 2015 SWAP.

Table 1. Terrestrial Habitat Summary

Habitat	Acres in CFA	% of CFA Area	% of WV Total for Type
Acidic Rock Outcrops, Cliffs and Talus	4,179	0.43%	4.65%
Agriculture	135,883	13.97%	9.47%
Calcareous Cliffs and Talus	935	0.10%	10.15%
Developed	50,268	5.17%	4.41%
Dry Calcareous Forests, Woodlands and Glades	19,911	2.05%	27.84%
Dry Oak (-Pine) Forests	186,630	19.18%	7.55%
Dry-Mesic Oak Forests	344,933	35.45%	6.91%
High Allegheny Wetlands	1,051	0.11%	5.02%
Mixed Mesophytic Forests	59,242	6.09%	2.01%
Montane Red Oak Forests	4,490	0.46%	21.24%
Northern Hardwood Forests	63,991	6.58%	6.43%
Pine-Oak Rocky Woodlands	21,290	2.19%	27.87%
Red Spruce Forests	3,636	0.37%	2.04%
River Floodplains	7,597	0.78%	6.32%
Shale Barrens	333	0.03%	18.57%
Sinkhole and Depression Ponds	11	0.00%	7.29%
Small Stream Riparian Habitats	29,855	3.07%	6.04%
Unresolved	38,736	3.98%	33.18%
Totals	972,971	100.00%	

Map 3. Terrestrial Habitats



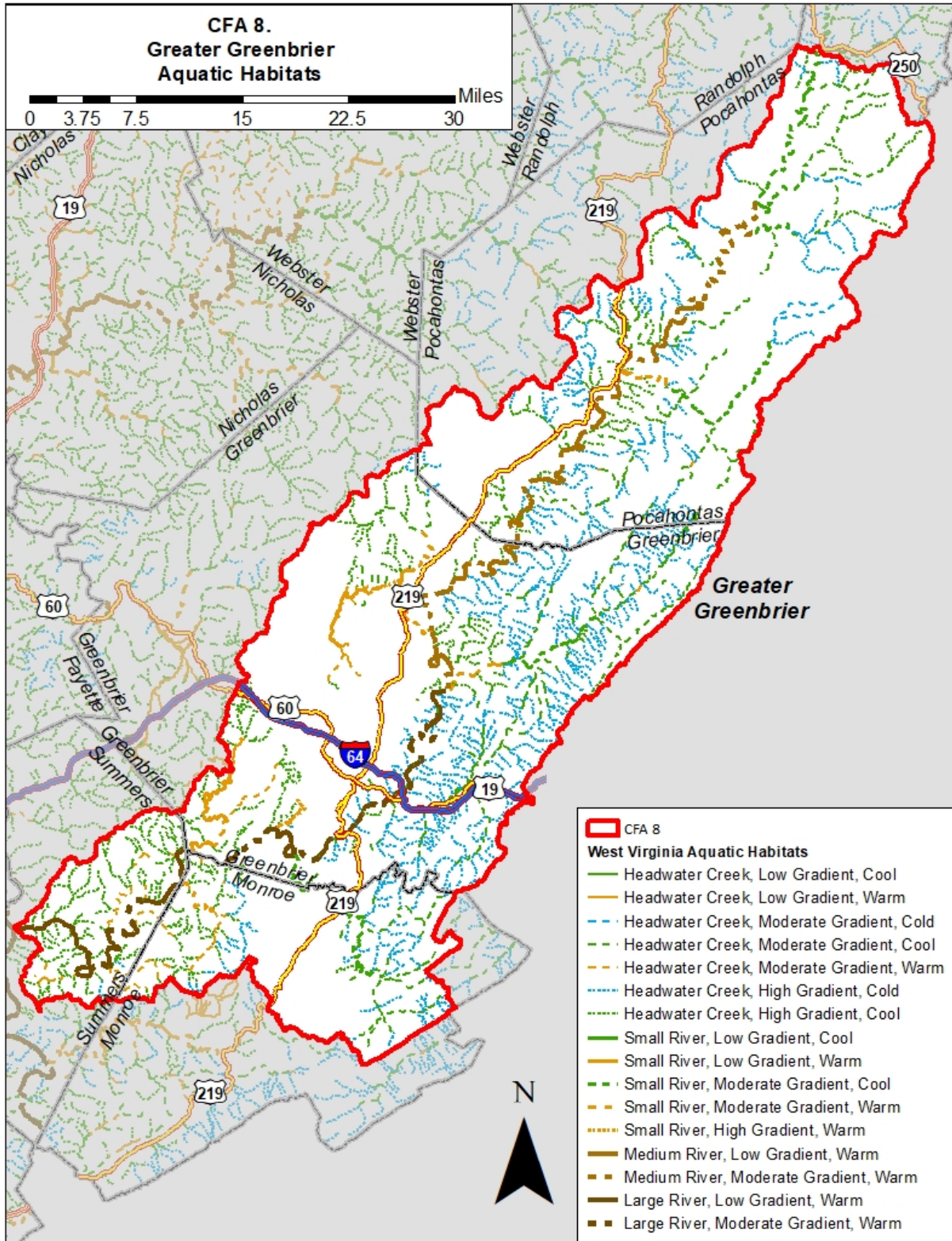
Aquatic Habitats

Sixteen of the aquatic habitat types described in the SWAP are present within the Greater Greenbrier CFA, including nearly 40% of the state’s cold, moderate gradient headwater creek habitat.

Table 2. Aquatic Habitat Summary

Habitat Type	Miles in CFA	% of CFA Area	% of WV Total for Type
Headwater Creek, Low Gradient, Cool	1	0.09%	9.76%
Headwater Creek, Low Gradient, Warm	16	1.03%	2.84%
Headwater Creek, Moderate Gradient, Cold	21	1.36%	39.80%
Headwater Creek, Moderate Gradient, Cool	274	17.73%	12.47%
Headwater Creek, Moderate Gradient, Warm	47	3.05%	1.21%
Headwater Creek, High Gradient, Cold	548	35.50%	18.68%
Headwater Creek, High Gradient, Cool	361	23.38%	5.76%
Small River, Low Gradient, Cool	3	0.18%	7.45%
Small River, Low Gradient, Warm	22	1.45%	4.86%
Small River, Moderate Gradient, Cool	76	4.91%	16.26%
Small River, Moderate Gradient, Warm	36	2.30%	6.54%
Small River, High Gradient, Warm	4	0.25%	24.22%
Medium River, Low Gradient, Warm	31	2.04%	6.63%
Medium River, Moderate Gradient, Warm	41	2.68%	11.91%
Large River, Low Gradient, Warm	41	2.66%	7.06%
Large River, Moderate Gradient, Warm	22	1.40%	19.70%
Totals	1,543	100.00%	

Map 4. Aquatic Habitats



Species of Greatest Conservation Need

Table 3 lists the number of SGCN in each taxa listed in the SWAP for the Greater Greenbrier CFA.

Table 3. Species Summary by Taxa

Taxa	# SGCN
Amphibians	11
Birds	45
Butterflies and Moths	22
Cave Invertebrates	49
Crayfish	4
Dragonflies and Damselflies	35
Fish	8
Mammals	18
Mussels	8
Plants	143
Reptiles	14
Snails	22
Tiger Beetles	2
Totals	381

The Greenbrier Valley is recognized as a globally significant center of cave endemism and is one of the six most endemic-rich karst regions in North America. Well over 1,000 caves are known, with 9 caves supporting single cave endemics and 49 Species of Greatest Conservation Need (SGCN) cave invertebrates overall. Organ Cave supports more known cave invertebrate species endemic to a single cave than any other cave in the state. Caves here also support important rare bat populations. The presumed extinct Buckeye Creek Cave Sculpin was known only from one cave system in this CFA. A substantial statewide portion of several stream habitats occur in this CFA, including about 40% of all moderate gradient, cold headwater streams. Surface streams support significant rare populations including:

- The largest known population of the Green Floater (mussel) in West Virginia
- The regionally endemic New River Crayfish
- Eastern Hellbender
- Eight of the ten fish species recognized as endemic to the New River Basin
- One of two known globally rare populations of a newly discovered crayfish in the *Cambarus dubius* group (Upland Burrowing Crayfish)
- The federally listed Virginia Spiraea and Candy Darter occur in riparian areas of this CFA

Dry Oak-Pine and Dry-Mesic Oak Forests in the CFA's eastern valleys and ridges and embedded Shale Barren patches support one of the largest and most diverse assemblages of regionally endemic shale

barren flora including:

- Shale Barren Rockcress (listed as endangered under the Endangered Species Act)
- Globally rare Nodding Wild Onion
- A critically imperiled Appalachian population of Grizzled Skipper (probably the only known population in West Virginia)
- Globally significant populations of Box Huckleberry
- Swordleaf Phlox

A considerable portion of the state's Calcareous Cliffs and Talus and Dry Calcareous Forests, Woodlands and Glades occur here supporting the following:

- Three new species of locally endemic land snails
- Canby's Mountain-lover (globally imperiled)
- Tall Larkspur
- Other rare plants

The mix of forest interior, early-successional and grassland habitats support 45 SGCN birds. Intact forest blocks support many forest interior breeding birds and some reptiles including:

- Broad-winged Hawk
- Wood Thrush
- Eastern Whip-poor-will
- Small Whorled Pogonia (listed as threatened under the federal Endangered Species Act)
- Cerulean Warbler
- Worm-eating Warbler
- Timber Rattlesnake

Early-successional forest habitats in this CFA support the highest densities of remaining Golden-winged Warbler and are critical to the species' continued presence in West Virginia. Grasslands and old fields associated with karst topography are among the most extensive in West Virginia and especially important in the state for:

- Loggerhead Shrike
- Eastern Meadowlark
- Grasshopper Sparrow
- Bobolink
- Field Sparrow

This Action Plan will list the priority SGCN in each major habitat type in the CFA.

Distinctive Stresses

The 2015 SWAP identifies several general stresses affecting SGCN and habitat in this CFA:

Cave and karst habitats are particularly threatened by:

1. Sinkhole dumping
2. Run-off from agriculture and residential development
3. Quarrying

Aquatic and riparian habitats are particularly threatened by:

1. Residential and second home development which fragments riparian forests and habitats.
2. Agriculture practices which introduce sediment and nutrients into the Greenbrier River.
3. Nutrient loading in streams is the apparent source for algal blooms in the Greenbrier River.

Upland terrestrial habitats are threatened by:

1. Residential and second home development is fragmenting intact forest habitats near public lands.

In addition to this list of general stresses, this Action Plan will list more specific local stresses affecting priority SGCN in each major habitat type.

Conservation Actions

To address these stresses, the 2015 SWAP recommended these main types of actions in the CFA, listed below.

Karst Conservation – Actively work with landowners and caving groups to encourage sinkhole clean-up, sinkhole and sinking stream fencing, and to reduce other impacts to cave systems.

Land Protection - Secure conservation lands, through ownership or easement, to protect significant terrestrial and subterranean habitats.

Riparian Restoration - Actively work with landowners to provide stream bank fencing, stream restoration and development of riparian buffers - primarily on tributaries of the Greenbrier River.

Terrestrial Habitat Management Actions - Provide assistance and incentives to landowners to maintain grassland, shrubland and early forest successional habitats for birds.

Species Restoration - Augment Green Floater mussel populations through propagation and reintroduction projects to maintain and expand populations.

Climate Smart Conservation

1. Develop cooperative agreements with public landowners to maintain large, intact forest blocks thus protecting many other special habitats.

2. Implement a comprehensive plan to enhance climate change resiliency through reducing other stressors (such as invasive species), identifying, maintaining and creating key habitat cores and corridors and protecting areas of high landscape complexity and integrity.

This Action Plan will also list more specific conservation actions to address the stresses affecting priority SGCN in each major habitat type.

Potential Partners

The 2015 SWAP lists many potential partners for landowners and others interested in wildlife conservation in the CFA, including:

- WV Division of Forestry
- WV Department of Environmental Protection
- West Virginia Cave Conservancy
- Monongahela National Forest
- Greenbrier River Watershed Association
- Natural Resources Conservation Service
- USFWS Partners Program
- West Virginia Land Trust
- New River Conservancy
- The Nature Conservancy
- County farmland protection boards
- National Wild Turkey Federation
- Appalachian Mountains Joint Venture

With an established “constituency”, many conservation partners can provide direct outreach to landowners and key stakeholders interested in wildlife conservation. The WVDNR will engage with these and other partners in regular face-to-face meetings and planning workshops during CFA planning, planning and implementation of conservation actions, and monitoring effectiveness. In many cases partners may assume a lead role in implementing the conservation actions. Appendix 4 lists the types of programming and assistance each partner provides to landowners. Specific partners are also listed along with conservation actions supported through their programs in the implementation plan for each habitat type.

Protected Lands

Public lands that may provide significant opportunities for wildlife conservation include:

- Monongahela National Forest
- Calvin Price, Greenbrier and Seneca State Forests
- Greenbrier River Trail
- WVDNR Wildlife Management Areas
- Droop Mountain Battlefield
- Cass Scenic Railroad, Beartown and Watoga State Parks
- Moncove Lake State Park and WMA

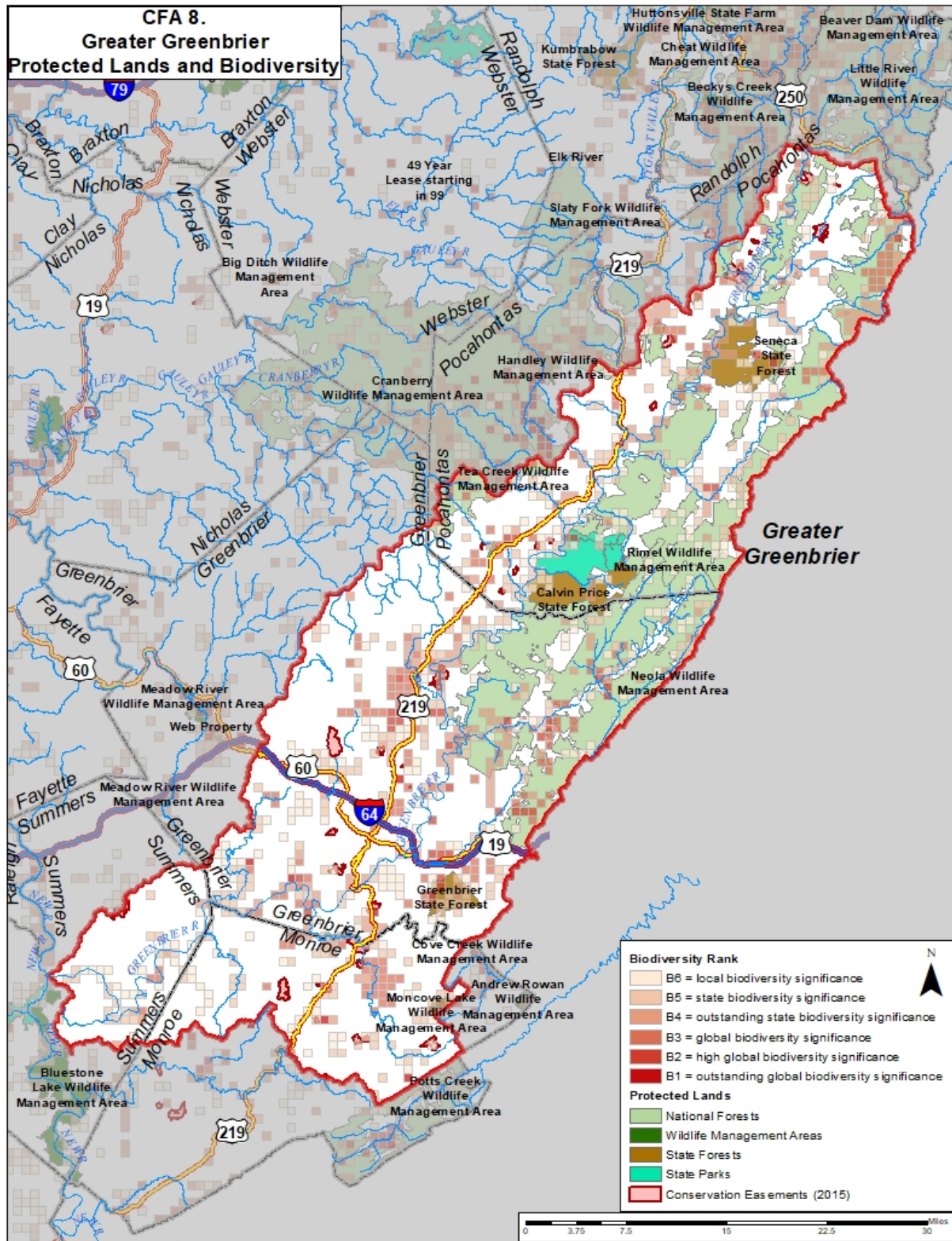
These public lands provide important wildlife habitat and are managed for conservation or other compatible goals. Appendix 3 lists habitat types occurring in each of the public lands within this CFA. WVDNR will work with public land managers to identify opportunities to plan and implement conservation actions that address stresses in these habitats and support priority SGCN. On state lands, this can include protection of important ecosystems, habitats, SGCN populations or plant communities

through designation as State Natural Areas. City and county-owned public lands may also be managed to benefit wildlife and habitat.

In addition, land trusts including West Virginia Land Trust, the Grasslands Reserve Program and Wetlands Reserve Program, as well as The Nature Conservancy, the Monroe, Pocahontas and Greenbrier County Farmland Protection Boards and the West Virginia Agricultural Land Protection Authority hold conservation easements that may protect important wildlife habitat and provide additional wildlife conservation opportunities.

Map 5 shows the location of public lands and conservation easements in the CFA, based on data provided in 2015 by The Conservation Fund (TCF), USGS Gap Analysis Program (GAP), The Nature Conservancy (TNC) and the National Conservation Easement Database (NCED). It also shows known occurrences of SGCNs and rare plant communities over a 1-kilometer grid and the biodiversity rank (including global, state, or local significance) of those occurrences, as generated by WVDNR in 2017. This map illustrates that many SGCN and rare plant communities occur on public lands and conservation easements in the CFA and there may be opportunities for WVDNR, public agencies and landowners to protect them there. Many SGCN and rare plant communities also occur on private land outside of public lands and conservation easements. This indicates how important it is for WVDNR and other partners to work with landowners to restore and protect biodiversity on private lands. Appendix 4 lists partners and programs that provide assistance to private landowners in wildlife conservation.

Map 5. Protected Lands and Biodiversity



Action Plan for the Conservation Focus Area

Conservation Goals

This CFA Action Plan is an extension of the State Wildlife Action Plan. While it is driven by local issues, the overarching goals remain the same. These include:

1. Halt the decline of at-risk species and thus avoid the need for federal listing as threatened or endangered
2. Assist with the recovery of federally listed species
3. Keep the common species common
4. Conserve the full array of habitat types and biological diversity in the state

The WVDNR will collaborate with agency partners, non-governmental organizations and the public to address threats to Species of Greatest Conservation Need, key habitats and unique communities.

Priority Species

Effectiveness and efficiency are paramount in targeting actions in CFAs and specifically addressing every SGCN present in the CFA is not feasible. From the list of SGCNs documented in the CFA as provided in the SWAP, WVDNR biologists selected priority species for conservation action that represent the best opportunity for successful conservation based on:

- their conservation status and known trends globally, across the state and in the CFA;
- the degree of dependence of each species on habitats within the CFA;
- the degree to which conservation activities to protect targeted species will also benefit a suite of other species occupying the same habitat or niche;
- conservation opportunities and likelihood of conservation success in the CFA;
- and other factors.

Table 4 lists SGCNs that were selected as priorities within the CFA based on the above criteria.

Additional field surveying and information is needed to document and monitor the distribution, abundance and population trends of these priority species in the habitats where they occur, and to assess their vulnerability to climate change. This work is ongoing.

Table 4. Priority Species in the CFA

Taxa	Scientific Name	Common Name	S Rank	G Rank
Amphibian	<i>Cryptobranchus alleganiensis</i>	Eastern Hellbender	S2	G3G4
Amphibian	<i>Eurycea lucifuga</i>	Cave Salamander	S3	G5
Amphibian	<i>Pseudacris feriarum</i>	Upland Chorus Frog	S3	G5
Bird	<i>Aegolius acadicus</i>	Northern Saw-whet Owl	S2B,S2N	G5
Bird	<i>Ammodramus savannarum</i>	Grasshopper Sparrow	S3B	G5
Bird	<i>Antrastomus vociferus</i>	Eastern Whip-poor-will	S3B	G5
Bird	<i>Aquila chrysaetos</i>	Golden Eagle	S3N	G5
Bird	<i>Bonasa umbellus</i>	Ruffed Grouse	S3B,S3N	G5
Bird	<i>Buteo platypterus</i>	Broad-winged Hawk	S3B	G5
Bird	<i>Chaetura pelagica</i>	Chimney Swift	S3B	G5
Bird	<i>Coccyzus erythrophthalmus</i>	Black-billed Cuckoo	S2B	G5
Bird	<i>Dolichonyx oryzivorus</i>	Bobolink	S3B	G5
Bird	<i>Falco sparverius</i>	American Kestrel	S3B	G5
Bird	<i>Helmitheros vermivorum</i>	Worm-eating Warbler	S3B	G5
Bird	<i>Hylocichla mustelina</i>	Wood Thrush	S3B	G5
Bird	<i>Lanius ludovicianus</i>	Loggerhead Shrike	S1B,S1N	G4
Bird	<i>Parkesia motacilla</i>	Louisiana Waterthrush	S3B	G5
Bird	<i>Scolopax minor</i>	American Woodcock	S3B	G5
Bird	<i>Setophaga cerulea</i>	Cerulean Warbler	S2B	G4
Bird	<i>Setophaga discolor</i>	Prairie Warbler	S3B	G5
Bird	<i>Spizella pusilla</i>	Field Sparrow	S3B, S3N	G5
Bird	<i>Sturnella magna</i>	Eastern Meadowlark	S3B, S2N	G5
Bird	<i>Tyto alba</i>	Barn Owl	S2B,S2N	G5
Bird	<i>Vermivora chrysoptera</i>	Golden-winged Warbler	S1B	G4
Cave Invertebrate	<i>Arrhopalites commorus</i>	A Collembola	S1	G2G4
Cave Invertebrate	<i>Arrhopalites pavo</i>	A Cave Springtail	S1S2	G1G2
Cave Invertebrate	<i>Arrhopalites sacer</i>	A Collembola	S1	G1G2

Taxa	Scientific Name	Common Name	S Rank	G Rank
Cave Invertebrate	<i>Chitrella regina</i>	Royal Syarinid Pseudoscorpion	S1	G1G2
Cave Invertebrate	<i>Crangonyx</i> sp. 2	An Amphipod	S2	G2
Cave Invertebrate	<i>Gyrinophilus Subterraneus</i>	WV Spring Salamander		
Cave Invertebrate	<i>Haplotaxis brinkhursti</i>	An Oligochaete	S1	G1
Cave Invertebrate	<i>Kleptochthonius henroti</i>	Greenbrier Valley Cave Pseudoscorpion	S1	G3G4
Cave Invertebrate	<i>Kleptochthonius hetricki</i>	Organ Cave Pseudoscorpion	S1	G1
Cave Invertebrate	<i>Kleptochthonius orpheus</i>	Orpheus Cave Pseudoscorpion	S1	G1
Cave Invertebrate	<i>Kleptochthonius proserpinae</i>	Proserpina Cave Pseudoscorpion	S1	G1
Cave Invertebrate	<i>Onychiurus janus</i>	A Cave Springtail	S1	G2G3
Cave Invertebrate	<i>Pseudosinella gisini gisini</i>	A Cave Springtail	S3	G3G4T3
Cave Invertebrate	<i>Pseudosinella orba</i>	A Cave Springtail	S1	G3G4
Cave Invertebrate	<i>Pseudosinella</i> sp. 8	A Springtail	S2	G2
Cave Invertebrate	<i>Sinella agna</i>	A Springtail	S3	G3G4
Cave Invertebrate	<i>Stygobromus emarginatus</i>	Greenbrier Cave Amphipod	S3	G3G4
Cave Invertebrate	<i>Stygobromus nanus</i>	Pocahontas Cave Amphipod	S1	G1G2
Cave Invertebrate	<i>Stygobromus parvus</i>	Minute Cave Amphipod	S1	G2G3
Cave Invertebrate	<i>Stygobromus pollostus</i>	An Amphipod	S1	G2G3
Cave Invertebrate	<i>Stygobromus redactus</i>	An Amphipod	S1	G1
Cave Invertebrate	<i>Stygobromus spinatus</i>	Spring Cave Amphipod	S2	G2G3
Cave Invertebrate	<i>Stylodrilus beattiei</i>	A Cave Lumbriculid Worm	S1	G2G3
Cave Invertebrate	<i>Trichodrilus culveri</i>	An Oligochaete	S1	G2G3
Crayfish	<i>Cambarus chasmodactylus</i>	New River Crayfish	S3	G4
Crayfish	<i>Cambarus pauleyi</i> (previously <i>Dubius</i> B)	Meadow River Mudbug	S2	GNR
Crayfish	<i>Cambarus nerterius</i>	An Underground Crayfish	S1?	G2
Crayfish	<i>Cambarus smilax</i>	Greenbrier River Crayfish	S2	GNR
Fish	<i>Ameiurus nebulosus</i>	Brown Bullhead	S2	G5

Taxa	Scientific Name	Common Name	S Rank	G Rank
Fish	<i>Cottus kanawhae</i>	Kanawha Sculpin	S2	G4
Fish	<i>Etheostoma osburni</i>	Candy Darter	S1	G3
Fish	<i>Exoglossum laurae</i>	Tonguetied Minnow	S2	G4
Fish	<i>Lythrurus ardens</i>	Rosefin Shiner	S1	G5
Fish	<i>Notropis scabriceps</i>	New River Shiner	S2	G4
Fish	<i>Percina gymnocephala</i>	Appalachia Darter	S2	G4
Fish	<i>Phenacobius teretulus</i>	Kanawha Minnow	S1	G3G4
Fish	<i>Salvelinus fontinalis</i>	Brook Trout	S5	G5
Gastropoda	<i>Anguispira stihleri</i>	Anguispira stihleri	S1	GNR
Gastropoda	<i>Fontigens tartarea</i>	Organ Cavesnail	S2	GNR
Gastropoda	<i>Fontigens turritella</i>	Greenbrier Cavesnail	S1	GNR
Gastropoda	<i>Gastrocopta holzingeri</i>	Lambda Snaggletooth	S2	G5
Gastropoda	<i>Helicodiscus villosus</i>	Helicodiscus villosus	S1	GNR
Gastropoda	<i>Mesomphix luisant</i>	Mesomphix luisant	S1	G1
Gastropoda	<i>Paravitrea bellona</i>	Club Supercoil	S1	G1
Gastropoda	<i>Triodopsis picea</i>	Spruce Knob Threetooth	S3	G3
Gastropoda	<i>Vallonia perspectiva</i>	Thin-lip Vallonia	S3	G4G5
Lepidoptera	<i>Prygus (centaurae) wyandot</i>	Appalachian Grizzled Skipper	S1	G1G2Q
Lepidoptera	<i>Speyeria diana</i>	Diana Fritillary	S2S3	G3G4
Mammal	<i>Myotis leibii</i>	Eastern Small-footed Bat	S1	G3
Mammal	<i>Myotis lucifugus</i>	Little Brown Myotis	S2*	G3
Mammals	<i>Myotis septentrionalis</i>	Northern Long-eared Bat	S2*	G2
Mammals	<i>Myotis sodalis</i>	Indiana Bat	S1	G2
Mammal	<i>Perimyotis subflavus</i>	Tricolored Bat	S2*	G3
Mammal	<i>Spilogale putorius</i>	Eastern Spotted Skunk	S1	G5
Mammal	<i>Sylvilagus obscurus</i>	Appalachian Cottontail	S2	G4
Mussel	<i>Alasmidonta marginata</i>	Elktoe	S1	G4
Mussel	<i>Lasmigona subviridis</i>	Green Floater	S2	G3

Taxa	Scientific Name	Common Name	S Rank	G Rank
Odonata	<i>Gomphus fraternus</i>	Midland Clubtail	S2	G5
Odonata	<i>Gomphus lineatifrons</i>	Splendid Clubtail	S2	G4
Odonata	<i>Gomphus quadricolor</i>	Rapids Clubtail	S3	G3G4
Odonata	<i>Gomphus viridifrons</i>	Green-faced Clubtail	S3	G3G4
Odonata	<i>Nehalennia gracilis</i>	Sphagnum Sprite	S1	G5
Odonata	<i>Ophiogomphus carolus</i>	Riffle Snaketail	S2	G5
Other Invertebrate	<i>Utaperla gaspesiana</i>	Gaspe Sallfly	S1	G3
Plant	<i>Allium oxyphilum</i>	Nodding Wild Onion	S2	G2Q
Plant	<i>Arabis serotina</i>	Shalebarren Rockcress	S2	G2
Plant	<i>Baptisia australis</i> var. <i>australis</i>	False Blue Indigo	S3	G5T3T4
Plant	<i>Berberis canadensis</i>	American Barberry	S1	G3
Plant	<i>Calopogon tuberosus</i> var. <i>tuberosus</i>	Tuberous Grass-pink	S1	G5T5
Plant	<i>Carex albolutescens</i>	Greenish-white Sedge	S1	G5
Plant	<i>Carex roanensis</i>	Roan Mountain Sedge	S2	G3
Plant	<i>Carex styloflexa</i>	Bent Sedge	S1	G4G5
Plant	<i>Carex trichocarpa</i>	Hairy-fruit Sedge	S1	G4
Plant	<i>Clematis occidentalis</i> var. <i>occidentalis</i>	Purple Virgin's Bower	S2	G5T5
Plant	<i>Cypripedium reginae</i>	Showy Lady's-slipper	S1	G4
Plant	<i>Decodon verticillatus</i>	Swamp-loosestrife	S1	G5
Plant	<i>Delphinium exaltatum</i>	Tall Larkspur	S2	G3
Plant	<i>Eleocharis engelmannii</i>	Engelmann's Spikerush	S1	G4G5Q
Plant	<i>Eriogonum allenii</i>	Shalebarren Wild Buckwheat	S2	G4
Plant	<i>Goodyera repens</i>	Dwarf Rattlesnake-plantain	S1S2	G5
Plant	<i>Gymnocarpium dryopteris</i>	Northern Oak Fern	S1	G5
Plant	<i>Helianthus laevigatus</i>	Smooth Sunflower	S2	G4
Plant	<i>Huperzia porophila</i>	Rock Clubmoss	S1	G4
Plant	<i>Hypericum mitchellianum</i>	Blue Ridge St. John's-wort	S1	G3

Taxa	Scientific Name	Common Name	S Rank	G Rank
Plant	<i>Isotria medeoloides</i>	Small Whorled Pogonia	S1	G2
Plant	<i>Liatrix turgida</i>	Turgid Gayfeather	S2	G3
Plant	<i>Lupinus perennis</i> ssp. <i>perennis</i>	Wild Lupine, Sundial Lupine	S1	G5T4?
Plant	<i>Packera antennariifolia</i>	Shalebarren Ragwort	S3	G4
Plant	<i>Parnassia asarifolia</i>	Kidneyleaf Grass-of- parnassus	S2	G4
Plant	<i>Pedicularis lanceolata</i>	Swamp Lousewort	S2	G5
Plant	<i>Phlox buckleyi</i>	Swordleaf Phlox, Shale Barren Phlox	S2	G2
Plant	<i>Platanthera psycodes</i>	Lesser Purple Fringed Orchid	S1	G5
Plant	<i>Platanthera shriveri</i>	Shriver's Frilly Orchid	S1	G1?
Plant	<i>Potamogeton tennesseensis</i>	Tennessee Pondweed	S2	G2
Plant	<i>Quercus prinoides</i>	Dwarf Chinquapin Oak	S1	G5
Plant	<i>Ranunculus pensylvanicus</i>	Bristly Crowfoot	S1	G5
Plant	<i>Ribes triste</i>	Swamp Red Currant	S1	G5
Plant	<i>Rosa blanda</i> var. <i>blanda</i>	Smooth Rose	S2	G5T5
Plant	<i>Scutellaria saxatilis</i>	Rock Skullcap	S2	G3
Plant	<i>Silphium compositum</i> var. <i>reniforme</i>	Rosinweed	S1	G5T3T5
Plant	<i>Spiraea virginiana</i>	Virginia Spiraea	S1	G2
Plant	<i>Spiranthes lucida</i>	Shining Ladies'-tresses	S1S2	G5
Plant	<i>Stachys eplingii</i>	Epling's Hedge-nettle	S1	G1G2
Plant	<i>Tortula ammonsiana</i>	Ammons' Twist Moss	S1	G1
Plant	<i>Trichomanes boschianum</i>	Appalachian Bristle Fern	S1	G4
Plant	<i>Trifolium reflexum</i>	Buffalo Clover	S1	G3G4
Plant	<i>Viburnum lentago</i>	Nannyberry	S1S2	G5
Plant	<i>Vitis rupestris</i>	Sand Grape	S2	G3
Plant	<i>Vittaria appalachiana</i>	Appalachian Shoestring Fern	S1	G4
Reptile	<i>Crotalus horridus</i>	Timber Rattlesnake	S3	G4

Taxa	Scientific Name	Common Name	S Rank	G Rank
Reptile	<i>Opheodrys vernalis</i>	Smooth Greensnake	S5	G5
Reptile	<i>Plestiodon anthracinus anthracinus</i>	Northern Coal Skink	S2	G5T5
Reptile	<i>Virginia valeriae pulchra</i>	Mountain Earthsnake	S2	G5T3T4

S Rank (State Rank) and G Rank (Global Rank) Conservation Status: 1= Critically Imperiled, 2 = Imperiled, 3 = Vulnerable, 4 = Apparently Secure, 5 = Secure, NR = Not Ranked, T = Subspecies or Varieties, B = Breeding, N = Non-breeding, S#S# or G#G# indicates range of uncertainty of conservation status.

Forest and Woodland Habitats

Dry-Mesic Oak Forests cover 35% of the CFA and represent the largest proportion of forest habitat types, followed by Dry Oak-Pine Forests covering slightly less than 20% of the CFA. Both of these forest types can be found throughout the CFA but are primarily concentrated in the northeastern section of the CFA following along the Middle Mountain ridgeline and up into the Seneca State Forest area. Montane Red Oak Forests, Dry Calcareous Forests, Woodlands and Glades, and Pine-Oak Rocky Woodlands occupy much smaller proportions of the CFA but represent over 20% of those habitat types in the state. The dry forest types are frequently threatened by invasive species, mesophication (gradual moistening) and lack of fire, while overbrowsing by deer reduces regeneration of oak and other palatable understory species. Smaller proportions of forested areas are composed of Red Spruce and Northern Hardwood Forests and can be found primarily along the northwestern boundary of the CFA. Maps 6 and 7 display forest habitat types and intact forest patches (based on the Appalachian and Mid-Atlantic Forest Patch Dataset compiled by The Nature Conservancy in 2011) with biodiversity within the CFA. The diversity of forest types across elevational gradients provides great opportunities for their conservation within larger forest patches and requires careful management tied to specific site conditions and forest stand characteristics. Intact forest patches provide core habitat for a significant proportion of SGCN and rare communities, as well as a matrix of forest habitat types and large corridors within which forest species may shift and adapt to climate change.

Priority Species

The table below lists priority species in the CFA associated with forest and woodland habitats.

Table 5. Priority Species in Forest and Woodland Habitats.

Taxa	Scientific Name	Common Name
Bird	<i>Aegolius acadicus</i>	Northern Saw-whet Owl
Bird	<i>Antrostomus vociferus</i>	Eastern Whip-poor-will
Bird	<i>Aquila chrysaetos</i>	Golden Eagle
Bird	<i>Bonasa umbellus</i>	Ruffed Grouse
Bird	<i>Buteo platypterus</i>	Broad-winged Hawk
Bird	<i>Coccyzus erythrophthalmus</i>	Black-billed Cuckoo
Bird	<i>Helmitheros vermivorum</i>	Worm-eating Warbler
Bird	<i>Hylocichla mustelina</i>	Wood Thrush
Bird	<i>Setophaga cerulea</i>	Cerulean Warbler
Bird	<i>Setophaga discolor</i>	Prairie Warbler
Bird	<i>Vermivora chrysoptera</i>	Golden-winged Warbler
Gastropoda	<i>Anguispira stihleri</i>	Greenbrier tigersnail

Taxa	Scientific Name	Common Name
Gastropoda	<i>Gastrocopta holzingeri</i>	Lambda Snaggletooth
Gastropoda	<i>Paravitrea bellona</i>	Club Supercoil
Gastropoda	<i>Triodopsis picea</i>	Spruce Knob Threetooth
Gastropoda	<i>Vallonia perspectiva</i>	Thin-lip Vallonia
Lepidoptera	<i>Speyeria diana</i>	Diana Fritillary
Mammal	<i>Myotis leibii</i>	Eastern Small-footed Bat
Mammal	<i>Myotis lucifugus</i>	Little Brown Bat
Mammal	<i>Myotis septentrionalis</i>	Northern Long-eared Bat
Mammal	<i>Myotis sodalis</i>	Indiana Bat
Mammal	<i>Perimyotis subflavus</i>	Tricolored Bat
Mammal	<i>Spilogale putorius</i>	Eastern Spotted Skunk
Mammal	<i>Sylvilagus obscurus</i>	Appalachian Cottontail
Plant	<i>Allium oxyphilum</i>	Nodding Wild Onion
Plant	<i>Arabis serotina</i>	Shalebarren Rockcress
Plant	<i>Berberis canadensis</i>	American Barberry
Plant	<i>Carex roanensis</i>	Roan Mountain Sedge
Plant	<i>Clematis occidentalis</i> var. <i>occidentalis</i>	Purple Virgin's Bower
Plant	<i>Delphinium exaltatum</i>	Tall Larkspur
Plant	<i>Goodyera repens</i>	Dwarf Rattlesnake-plantain
Plant	<i>Gymnocarpium dryopteris</i>	Northern Oak Fern
Plant	<i>Isotria medeoloides</i>	Small Whorled Pogonia
Plant	<i>Lupinus perennis</i> ssp. <i>perennis</i>	Wild Lupine, Sundial Lupine
Plant	<i>Phlox buckleyi</i>	Swordleaf Phlox, Shale Barren Phlox
Plant	<i>Platanthera shriveri</i>	Shriver's Frilly Orchid
Plant	<i>Scutellaria saxatilis</i>	Rock Skullcap
Plant	<i>Trifolium reflexum</i>	Buffalo Clover
Reptile	<i>Crotalus horridus</i>	Timber Rattlesnake
Reptile	<i>Plestiodon anthracinus anthracinus</i>	Northern Coal Skink

Taxa	Scientific Name	Common Name
Reptile	Virginia valeriae pulchra	Mountain Earthsnake

Large, intact forest blocks support many forest interior breeding birds, including Broad-winged Hawk, Cerulean Warbler (CERW), Wood Thrush and Worm-eating Warbler. Early-successional forest habitats support Black-billed Cuckoo, Golden-winged Warbler (GWWA) and Prairie Warbler. Several rare plant species are associated with Pine-Oak Rocky Woodlands and Dry Oak-Pine Forests, but additional surveying will be required to ascertain their status and location.

Rare Plant Communities

The following rare plant communities are found in Forest and Woodland habitats in this CFA. Note that over half of the state’s Greenbrier Valley Hemlock – White Pine Forests are located here. These communities are vulnerable to disturbance by logging and grazing activities, and to the spread of Hemlock Woolly Adelgid and nonnative invasive plants. Disturbance should be avoided and nonnative invasive plant infestations should be treated.

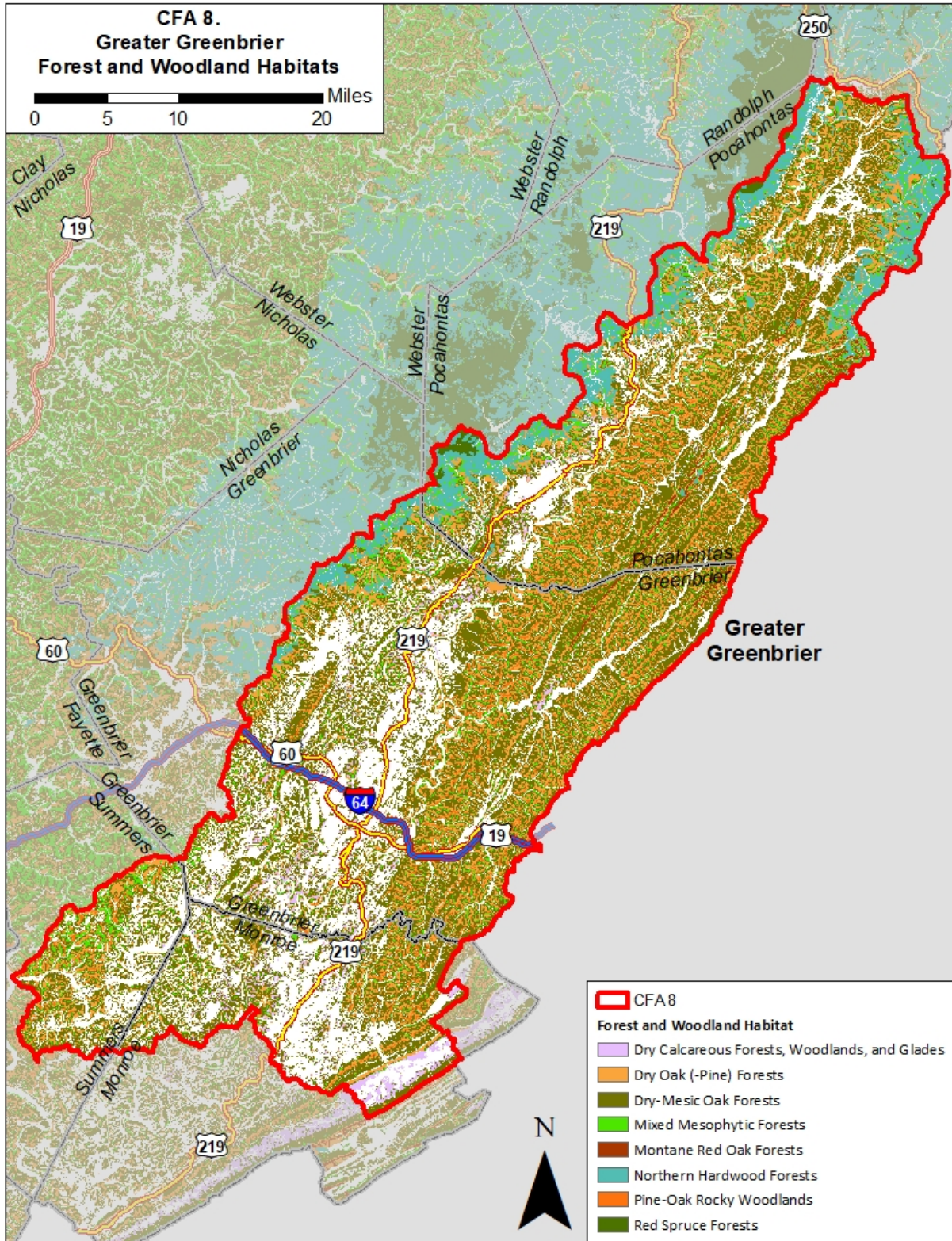
Table 6. Rare Plant Communities in Forest and Woodland Habitats.

Habitat	Common Name	Relative Abundance	G Rank	S Rank
Dry Calcareous Forests, Woodlands and Glades	Ridge and Valley Calcareous Red Oak - Sugar Maple Forest	6.25%	G4	S3
Dry Calcareous Forests, Woodlands and Glades	Calcareous Prairie	14.29%	G1G2	S1
Dry Calcareous Forests, Woodlands and Glades	Calcareous Shale Prairie Woodland	30.77%	G2	S1
Dry Oak (-Pine) Forests	Chestnut Oak (- Hemlock) / Catawba Rosebay Forest	7.14%	G4	S2
Dry Oak (-Pine) Forests	White Pine - Oak / Heath Forest	33.33%	G4	S4
Dry Oak (-Pine) Forests	Eastern Ridges Acidic Oak - Hickory / Heath Forest	35.71%	G4	S3
Dry-Mesic Oak Forests	Allegheny Montane Red Oak Forest	11.76%	G4?	S2S3

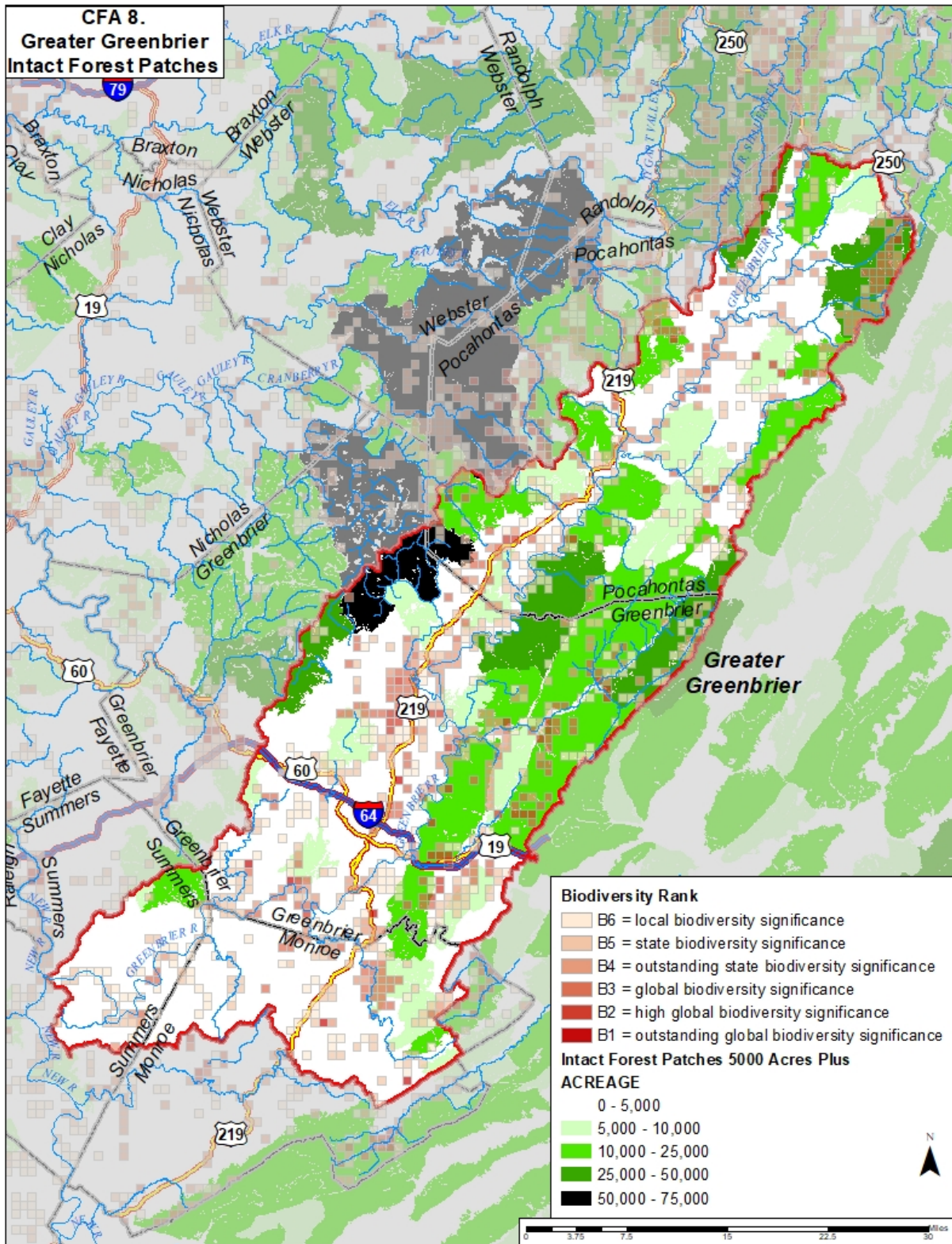
Habitat	Common Name	Relative Abundance	G Rank	S Rank
Dry-Mesic Oak Forests	Eastern Ridges Rich Oak - Hickory Forest	41.67%	G3G4	S3
Dry-Mesic Oak Forests	Eastern Ridges Oak - Hickory / Graminoid Forest	4.76%	G3G4	S3
Mixed Mesophytic Forests	Rich Hemlock - Hardwood Forest	8.70%	G4	S2
Mixed Mesophytic Forests	Greenbrier Valley Hemlock - White Pine Forest	81.82%	G4?	S2
Mixed Mesophytic Forests	Cumberland/Allegheny Mixed Mesophytic Forest	1.07%	G4?	S4
Montane Red Oak Forests	Eastern Ridges Montane Red Oak Forest	20.51%	G3G4	S3
Northern Hardwood Forests	Typical Northern Hardwoods Forest	3.13%	G4	S4
Northern Hardwood Forests	Allegheny Montane Red Oak Forest	11.76%	G4?	S2S3
Northern Hardwood Forests	Southern Appalachian Northern Hardwoods Forest	37.50%	G3	S1
Northern Hardwood Forests	Allegheny Mountains Hemlock - Hardwood Forest	8.33%	G4?	S3
Pine - Oak Rocky Woodlands	Ridge and Valley Pitch Pine - Table Mountain Pine Woodland	2.44%	G4	S3
Red Spruce Forests	Red Spruce – Hemlock – Beech Forest	3.51%	G3	S3
Red Spruce Forests	Red Spruce – Yellow Birch Forest	3.33%	G2	S2
Red Spruce Forests	Red Spruce / Great Laurel Forest	7.14%	G2G3	S2

S Rank (State Rank) and G Rank (Global Rank) Conservation Status: 1= Critically Imperiled, 2 = Imperiled, 3 = Vulnerable, 4 = Apparently Secure, 5 = Secure, NR = Not Ranked, T = Subspecies or Varieties, B = Breeding, N = Non-breeding, S## or G## indicates range of uncertainty of conservation status.

Map 6. Forest and Woodland Habitats



Map 7. Intact Forest Patches and Biodiversity



Habitat Stresses and Conservation Actions

Table 7 lists stresses impacting species in forest and woodland habitats, and conservation actions landowners and partners can take to address those stresses.

Table 7. Stresses and Actions in Forest and Woodland Habitats:

Habitat Stress	Conservation Action
Deforestation, forest fragmentation, poor forest structure and climate change (microhabitats)	Maintain and protect contiguous forest cover, structural complexity and habitat diversity
Deforestation, forest fragmentation, climate change and disturbance of rare habitats and hydrological features	Maintain and protect forest cover and hydrology, especially around seeps, streams, bogs, cliffs, talus, rocky substrates and other rare habitat features
Deforestation & forest fragmentation on ridgetops, lack of mast trees for Allegheny Woodrat	Keep ridgetops forested and promote mast producing trees
Development, deforestation, poor habitat quality & water quality degradation around caves	Promote and protect contiguous, diverse forest habitat and natural hydrology around caves
Invasive plants: forest fragmentation, climate change	Maintain forest cover and control invasive plants, especially around rare habitat features
Early-successional habitat: poor forest structure, forest maturation, fire suppression	Use forest management and prescribed fire to promote early-successional habitat across 15-20% of forested landscapes and structural complexity, including gaps with healthy native grasses, forbs, vegetative cover and snags
Mature forest: deforestation, fragmentation, poor forest structure	Protect mature forest and promote structural complexity: old growth, small openings with well-developed understories, snags and decaying logs
Deer browse impacting forest structure	Manage local deer populations where abundant
Loss of basking/ gestation/ denning habitat for timber rattlesnake	Use forest management to create canopy gaps; reduce canopy over known gestation and basking sites; develop basking structures; avoid impact to dens

Habitat Stress	Conservation Action
Climate change (microclimate), acid rain, soil contamination impacting gastropods	Protect cedar habitat, talus and limestone outcrops for calcium enrichment and detritus; protect wooded river bluffs and ravines
Suspect loss of nectar resources for Lepidoptera	Alter roadside mowing regimes, install pollinator habitat using cost share programs
Fragmentation of core forests from energy and other development	Develop state-level guidance on siting and construction of energy infrastructure to avoid fragmentation of core forests
Incompatible utility corridor management	Improve vegetation management practices in utility corridors
Fire suppression, forest maturation	Controlled burns and forest practices that maintain appropriate cover and winter browse for Appalachian Cottontail.
Logging around rare plants: Altered light regime and introduction of invasive weeds	Avoid & minimize logging impacts; monitor and treat invasive weeds to prevent their spread
Woody encroachment around rare plants	Survey, timber management and prescribed burning to create openings
Aerial application of pesticides (targeting caterpillars - food source for Black-billed Cuckoo)	Reduce aerial application of pesticides
Forest pests and pathogens including Hemlock Woolly Adelgid, Emerald Ash Borer	Monitoring and treatment of target tree species in select priority areas

In addition to the habitat-linked stresses listed above, direct stresses to priority species include road collision mortality for Black-billed Cuckoos, harassment, collection and deliberate killing of Timber Rattlesnakes, and Tricolored Bat mortality caused by wind turbines. Several rare plant species require additional field surveys to determine their distribution and threats.

Maintaining a diverse population of forest birds requires dynamic forest landscapes with mosaics of age classes, structural and spatial complexity. Efforts to manage and restore both early-successional and late-successional, interior forest habitats are needed for priority SGCN.

Climate Change and Habitat Resilience

The Central Appalachian Forest Ecosystem Vulnerability Assessment (Butler et al., 2015) describes many potential impacts of climate change on forests in the region. Likely impacts include increased

temperatures (especially during the summer and fall), a decrease in winter snowpack, longer growing seasons, increased precipitation during spring and even greater decreases in precipitation during summer and fall, more frequent heavy precipitation events and increasing frequency and severity of storms. These impacts will likely lead to changing soil moisture patterns, increased risk of wildfire, increased damage from pests and pathogens, and increased extent and abundance of invasive plants. Habitat for northern species is likely to decline. Tree seedlings will likely be more vulnerable to climate change impacts than mature trees. Forest ecosystems lacking a diversity of species, age classes and genotypes may be more susceptible to climate change than those with greater diversity. Forest species in fragmented landscapes will have less opportunity to migrate across the landscape in response to changing conditions. Ecological communities tied to specific hydrological conditions or geologic features may also be unable to migrate. Urban areas and impervious cover can exacerbate the effects of increasing temperatures and heavier precipitation. However, ecosystems within areas of high landscape complexity, including a diversity of topography and microhabitats, may be more able to persist and adapt in response to climate change.

The 2015 assessment also described likely impacts to specific forest types. Dry-Mesic Oak Forests support a large number of tree species over a diversity of terrain and many of the tree species are tolerant of drought and fire, providing some resilience to climate change. However, drought may increase susceptibility to forest pests and pathogens, and drought as well as disturbances from stronger storms may enable the spread of nonnative invasive plants. Intense fires or droughts, combined with other stressors, could increase mortality of some species.

Dry Oak-Pine Forests and Pine-Oak Rocky Woodlands are adapted to heat, drought and fire, and may benefit from climate change. However, droughts may increase susceptibility to forest pests and pathogens, and enable nonnative invasive plants to outcompete native herbs and shrubs, providing additional fuel for fires and increasing fire intensity. Forest pests, pathogens and invasive plants need to be carefully managed to build resilience to climate change.

Dry Calcareous Forests, Woodlands and Glades are adapted to heat, drought and wildfire, but may be impacted by increased fire intensity, correlated with increases in invasive plant species. Management of invasive plants will be critical for the long-term resilience of the ecosystem. Dependence on unique soils may impede the ecosystem's ability to shift across the landscape.

Mixed Mesophytic Forests may be vulnerable to increasing disturbance by wildfire, drought and invasion by nonnative plants. These ecosystems may decline in some areas, while sheltered sites in areas of complex topography may provide some refuge from climate change. Drought may increase the susceptibility of these forests to hemlock woolly adelgid, forest tent caterpillar, beech bark disease and other insect pests and diseases. Invasive plants may outcompete native species as conditions change and drought may increase the risk of wildfire, to which these forests are not well adapted.

The small areas of red spruce and northern hardwood forests may be particularly impacted by climate change. Increased heat and moisture stress in summer and fall may interact with acid deposition as well as increases in insect pests and pathogens, storm disturbance and wildfires to stress these forests,

reducing species diversity and coverage. Cool, moist sites within areas of complex topography may provide some refuge and buffer the effects of climate change.

Some changes in forest composition and structure are likely to occur over time as these different forest types adapt and adjust in response to changes in climate. Conservation actions to reduce existing stresses on forests will aid in building their resilience. Protecting large forest blocks in areas with complex topography and maintaining natural cover linkages between them, may further enable their adaptation and shifting distribution across the landscape.

Table 8 provides a summary of climate stresses on forest habitats and actions which could boost their resilience (Swanston et al., 2016). While climate stresses are listed separately, forest and woodland habitats are often impacted by multiple climate stresses occurring simultaneously and actions to boost habitat resilience are intended to address multiple climate stresses. Many of these actions resemble previously listed conservation actions to reduce stress on priority species, meaning that they could have positive outcomes for priority species as well as habitat resilience. WVDNR, land managers, landowners and partners can select the actions best suited to their specific site conditions, management goals and objectives, from the list below or other sources.

Table 8. Climate Stresses and Resilience Actions in Forest and Woodland Habitats

Climate Stresses	Habitat Resilience Actions
<ul style="list-style-type: none"> • Increased spring and summer temperatures • Increased risk of drought and wildfire • Increased frequency and severity of storms • Increased competition from nonnative invasive species, pests and pathogens 	<ul style="list-style-type: none"> • Restore or maintain fire in fire-adapted ecosystems • Manage deer populations to promote regeneration • Promptly revegetate sites after disturbance, prevent the introduction and establishment of invasive plants and remove existing invasive plants • Promote diversity of native species and age classes through planting and silviculture • Protect habitat refugia for rare plant communities and forest types dependent on unique soils, such as calcareous forests, woodlands and glades • Protect forest reserves in areas of high biological diversity or priority species • Reduce forest fragmentation • Maintain or restore large patches and corridors of forest habitat • Restore native forest vegetation on degraded lands within and adjacent to forested areas

Implementation Plan

WVDNR will work with interested partners and landowners to plan, implement and measure the effectiveness of conservation actions to benefit priority species in forest and woodland habitats.

Table 9. Implementation Plan for Forest and Woodland Habitats

Action	Partners	Effectiveness Measures
Forest Habitat, Reserve and Corridor Protection: <ul style="list-style-type: none"> • Conservation Easements • Land Acquisition • Natural Area designation 	<ul style="list-style-type: none"> • County Farmland Protection Boards • OHCF, TCF, TNC, WVLT • WVDOF Forest Legacy • WVDNR 	<ul style="list-style-type: none"> • Acres of habitat protected • Abundance and diversity of priority species and habitats
Forest Habitat, Reserve and Corridor Protection: <ul style="list-style-type: none"> • Land use planning 	<ul style="list-style-type: none"> • County Planning Commissions 	<ul style="list-style-type: none"> • Acres of habitat protected through land use planning in forested areas

Action	Partners	Effectiveness Measures
<p>Forest Habitat, Reserve and Corridor Protection:</p> <ul style="list-style-type: none"> • Incentive Programs • Forest Carbon projects 	<ul style="list-style-type: none"> • USDA NRCS • Consulting Foresters • AFTS, FSC, SFI • AFF, TNC 	<ul style="list-style-type: none"> • Acres of habitat protected • Abundance and diversity of priority species and habitats
<p>Manage forests at landscape scale for diversity of native species and age classes, structural and spatial complexity appropriate for the forest type</p>	<ul style="list-style-type: none"> • AMJV • Consulting Foresters • Forest Certification Programs: AFTS, FSC, SFI • NWTF and RGS • USDA NRCS • WVDOF • WVU Extension • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat restored for priority species • Before and after comparison: abundance and diversity of priority species
<p>Restore native forest vegetation on adjacent degraded lands through planting and silviculture</p>	<ul style="list-style-type: none"> • Consulting Foresters • WVDOF • WVU Extension • USDA NRCS • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance, diversity and distribution of priority species
<p>Create or maintain early-successional habitat (ESH) to benefit wildlife species through forest management on appropriate sites.</p> <p>GWWA guidelines for large forest patches with > 70% forest cover:</p> <ul style="list-style-type: none"> • Maintain ESH on 15-20% of forest at any one time, as part of shifting mosaic • ESH should include irregular, interspersed clumps of shrubs and/or saplings, grasses and forbs, and widely spaced overstory trees (10-30% canopy cover or 20-40 ft² residual basal area) 	<ul style="list-style-type: none"> • Consulting Foresters • NWTF and RGS • USDA NRCS • WVDOF • WVU Extension • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance and diversity of priority species

Action	Partners	Effectiveness Measures
<p>Improve or maintain interior forest habitat to benefit wildlife species through forest management activities on appropriate sites</p> <p>CERW guidelines for large forest patches with > 70% forest cover:</p> <ul style="list-style-type: none"> • Provide heterogenous stand structure and species diversity with 40-90 ft² residual basal area of well-spaced, large diameter trees (favor white oak, hickory, sugar maple) with canopy gaps and well-developed understory vegetation. Mesic north- and east-facing slopes optimal. 	<ul style="list-style-type: none"> • Consulting Foresters • WVU Extension • USDA NRCS WVDOF • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance and diversity of priority species
<p>Forest management to prevent woody encroachment or avoid disturbance of rare plants, create forest canopy gaps and vegetative cover</p>	<ul style="list-style-type: none"> • WVU Extension • USDA NRCS • WVDOF • Consulting Foresters • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance, diversity and distribution of priority species
<p>Monitor and control invasive plants, promptly revegetate disturbed sites</p>	<ul style="list-style-type: none"> • WVDOF • WVCA and GVCD • USDA NRCS • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat protected or restored • Before and after comparison: abundance and diversity of priority species
<p>Monitor and treat pests and pathogens targeting specific trees and plant communities in priority sites, including ash and hemlock</p>	<ul style="list-style-type: none"> • Public Land Managers • WVDA, WVDOF, WVDNR 	<ul style="list-style-type: none"> • Acres of habitat maintained for priority species • Before and after comparison: abundance, diversity and distribution of priority species

Action	Partners	Effectiveness Measures
Reduce aerial application of pesticides	<ul style="list-style-type: none"> • Landowners/Orchards 	<ul style="list-style-type: none"> • Change in pesticide use • Acres of habitat restored • Before and after comparison: abundance and diversity of priority species
Manage deer population where abundant	<ul style="list-style-type: none"> • WVDNR (hunting licenses) • Private landowners • Public Land Managers 	<ul style="list-style-type: none"> • Change in deer population or forest structure • Acres of habitat restored • Before and after comparison: abundance and diversity of priority species
Manage utility corridors to reduce wildlife impacts (implement BMPs promoted by the Wildlife Habitat Council, NRCS and other organizations)	<ul style="list-style-type: none"> • Landowners, partners and utility companies 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance and diversity of priority species
Provide guidance on timber rattlesnake den avoidance	<ul style="list-style-type: none"> • WVU Extension • Public land managers 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance, diversity and distribution of priority species
Controlled burning by public agencies in fire adapted ecosystems	<ul style="list-style-type: none"> • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance, diversity and distribution of priority species

Human Benefits

Actions to restore and protect forest and woodland habitat may provide human health and economic benefits for local residents and communities. These benefits include protection of water ways, water quality and drinking water sources, reduced flood damages, long-term timber production, forest carbon sequestration opportunities and hunting, wildlife viewing, tourism and recreational opportunities.

Barrens, Rock Outcrops, Cliffs and Talus Habitats

Acidic rock outcrops, cliffs and talus occur within the CFA area primarily following along the Greenbrier River, which runs through the middle of the CFA, while shale barrens are present in the eastern portion near Anthony and Howard Creek, and the White Sulfur Springs area. Calcareous cliffs and talus, as well as heath barrens can also be found covering small areas dotted throughout the CFA. These habitats are threatened by nonnative invasive plants, woody encroachment, quarrying and other development. A map illustrating the location of these rare habitat types is on the following page. There are numerous occurrences of rare species in these habitats.

Priority Species

The table below lists priority species in the CFA associated with Barrens, Rock Outcrops, Cliffs and Talus Habitats.

Table 10. Priority Species in Barrens, Rock Outcrops, Cliffs and Talus Habitats

Taxa	Scientific Name	Common Name	Primary Habitat
Amphibian	<i>Eurycea lucifuga</i>	Cave Salamander	Calcareous Cliffs and Talus
Gastropoda	<i>Anguispira stihleri</i>	Greenbrier Tigersnail	Calcareous Cliffs and Talus
Gastropoda	<i>Helicodiscus villosus</i>	<i>Helicodiscus villosus</i>	Calcareous Cliffs and Talus
Gastropoda	<i>Mesomphix luisant</i>	<i>Mesomphix luisant</i>	Calcareous Cliffs and Talus
Gastropoda	<i>Vallonia perspectiva</i>	Thin-lip Vallonia	Calcareous Cliffs and Talus
Lepidoptera	<i>Prygus (centaurae) wyandot</i>	Appalachian Grizzled Skipper	Shale Barrens
Mammal	<i>Myotis leibii</i>	Eastern Small-footed Bat	Acidic Rock Outcrops, Cliffs and Talus & Calcareous Cliffs and Talus
Mammal	<i>Spilogale putorius</i>	Eastern Spotted Skunk	Acidic Rock Outcrops, Cliffs and Talus
Plant	<i>Allium oxyphilum</i>	Nodding Wild Onion	Shale Barrens
Plant	<i>Arabis serotina</i>	Shalebarren Rockcress	Shale Barrens
Plant	<i>Eriogonum allenii</i>	Shalebarren Wild Buckwheat	Shale Barrens
Plant	<i>Helianthus laevigatus</i>	Smooth Sunflower	Shale Barrens
Plant	<i>Huperzia porophila</i>	Rock Clubmoss	Acidic Rock Outcrops, Cliffs and Talus
Plant	<i>Liatris turgida</i>	Turgid Gayfeather	Shale Barrens
Plant	<i>Packera antennariifolia</i>	Shalebarren Ragwort	Shale Barrens
Plant	<i>Quercus prinoides</i>	Dwarf Chinquapin Oak	Shale Barrens

Taxa	Scientific Name	Common Name	Primary Habitat
Plant	<i>Silphium compositum</i> var. <i>reniforme</i>	Rosinweed	Shale Barrens
Plant	<i>Tortula ammonsiana</i>	Ammons' Twist Moss	Acidic Rock Outcrops, Cliffs and Talus
Plant	<i>Trichomanes intricatum</i>	Weft Fern	Acidic Rock Outcrops, Cliffs and Talus
Plant	<i>Vittaria appalachiana</i>	Appalachian Shoestring Fern	Acidic Rock Outcrops, Cliffs and Talus
Reptile	<i>Crotalus horridus</i>	Timber Rattlesnake	Heath-Grass Barrens & Shale Barrens
Reptile	<i>Plestiodon anthracinus</i>	Northern Coal Skink	Shale Barrens

Protected rocky outcrops, cliffs and talus, and barrens support many unique species, including the Cave Salamander, Appalachian Shoestring Fern, Eastern Small-footed Bat and Timber Rattlesnake. While the majority of rocky habitat species have evolved adaptations to disturbance events; climate change and the increasing occurrence of disturbances could lead to further endangerment of rare species.

Rare Plant Communities

These habitats are home to several rare plant communities, some of which only occur within this CFA, while others represent a significant percentage of the state's occurrences.

Table 11. Rare Plant Communities in Barrens, Rock Outcrops, Cliffs and Talus Habitats

Habitat	Common Name	Relative Abundance	G Rank	S Rank
Acidic Rock Outcrops, Cliffs and Talus	Sweet Birch - Chestnut Oak Rocky Woodland	12.50%	G4	S3
Acidic Rock Outcrops, Cliffs and Talus	Western Plateaus Dry Sandstone Cliff	6.67%	G4Q	S2
Calcareous Cliffs and Talus	Greenbrier Limestone Boulderfield Forest	100.00%	G3G4	S1
Shale Barrens	Calcareous Shale Prairie Woodland	30.77%	G2	S1
Shale Barrens	Classic Central Appalachian Shale Barren	61.70%	G3G4	S3

S Rank (State Rank) and G Rank (Global Rank) Conservation Status: 1= Critically Imperiled, 2 = Imperiled, 3 = Vulnerable, 4 = Apparently Secure, 5 = Secure, NR = Not Ranked, T = Subspecies or Varieties, B = Breeding, N = Non-breeding, S#S# or G#G# indicates range of uncertainty of conservation status.

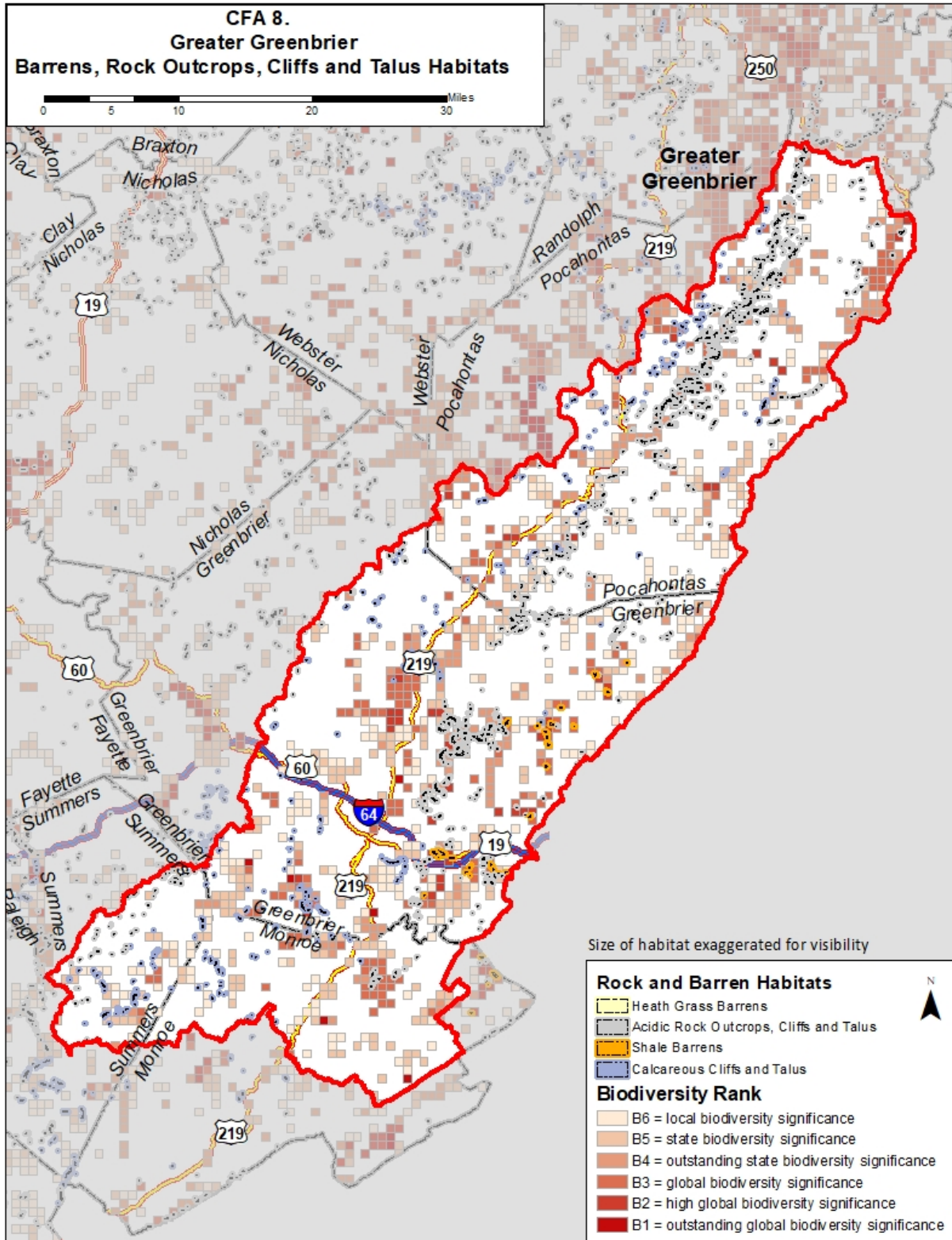
Habitat Stresses and Conservation Actions

The following stresses to these sensitive habitats may be addressed through the actions below.

Table 12. Habitat Stresses and Conservation Actions in Barrens, Rock Outcrops, Cliffs and Talus Habitats

Habitat Stress	Conservation Action
Deforestation, climate change	Maintain dense forest to protect talus slope microhabitat for Eastern Small-footed Bat
Fire Suppression/ Lack of disturbance in forest succession	Use forest management and fire to increase vegetative cover and early-successional habitat, retain snags and windblown trees for Eastern Spotted Skunk
Climate change (microclimate), acid rain, soil contamination (gastropods)	Protect cedar habitat, talus slopes/limestone outcrops for calcium enrichment and detritus
Woody encroachment, habitat degradation	Prescribed fire and timber harvests to provide additional habitat; removal of woody vegetation along roads to release larval host and nectar plants for early spring Lepidoptera species
Loss of basking/ gestation/ denning habitat for timber rattlesnake	Use forest management to create canopy gaps, reduce canopy over known gestation and basking sites, develop basking structures and avoid dens

Map 8. Barrens, Rock Outcrop, Cliffs & Talus Habitats and Biodiversity



Climate Change and Habitat Resilience

As described in The Central Appalachians Forest Ecosystem Vulnerability Assessment (Butler et al., 2015), ecosystems that are limited by geological features may be restricted from shifting across the landscape in response to climate change. These habitat types are dependent on underlying geology, so their ability to shift across the landscape in response to climate change is very limited. While they are usually adapted to extreme conditions, they may be vulnerable to increased disturbance from drought, fire and storms and from invasion by nonnative invasive plants. Maintaining intact forest ecosystems around these rare habitats and controlling invasive species may help maintain resilience to a changing climate.

Table 13. Climate Stresses and Resilience Actions in Barrens, Rock Outcrop, Cliffs and Talus Habitats

Climate Stresses	Habitat Resilience Actions
<ul style="list-style-type: none"> • Increased risk of drought and wildfire • Increased frequency and severity of storms • Increased competition from nonnative invasive species 	<ul style="list-style-type: none"> • Promptly revegetate sites after disturbance, prevent the introduction and establishment of invasive plant species, and remove existing invasive species • Protect rare habitats and refugia for rare plant communities • Maintain intact, resilient forest habitat in surrounding areas

Implementation Plan

WVDNR will work with interested partners and landowners to plan, implement and measure the effectiveness of conservation actions to benefit priority species in shale barrens, acid rock outcrops, and calcareous cliffs and talus.

Table 14. Implementation Plan for Barrens, Rock Outcrop, Cliffs and Talus Habitats

Action	Partners	Effectiveness Measures
Habitat Protection: <ul style="list-style-type: none"> • Conservation Easements • Land Acquisition • Natural Area designation 	<ul style="list-style-type: none"> • County Farmland Protection Boards • OHCF, TCF, TNC, WVLT • WVDOF Forest Legacy • WVDNR 	<ul style="list-style-type: none"> • Acres of habitat protected for priority species • Abundance and diversity of priority species and habitats

Action	Partners	Effectiveness Measures
Habitat Protection: <ul style="list-style-type: none"> Land use planning 	<ul style="list-style-type: none"> County Planning Commissions 	<ul style="list-style-type: none"> Acres of habitat protected through land use planning for development around cliffs, steep slopes and fragile soils
Habitat Protection <ul style="list-style-type: none"> Incentive Programs 	<ul style="list-style-type: none"> USDA NRCS CSP 	<ul style="list-style-type: none"> Acres of habitat protected for priority species Abundance and diversity of priority species and habitats
Re-vegetate sites after disturbance, prevent the introduction and establishment of invasive plant species, and remove existing invasive species	<ul style="list-style-type: none"> WVDOF WVCA and GVCD NRCS CSP Public Land Managers 	<ul style="list-style-type: none"> Acres of habitat restored for priority species Before and after comparison: abundance, diversity and distribution of priority species
Create and maintain openings in forest canopy	<ul style="list-style-type: none"> WVU Extension USDA NRCS WVDOF Consulting Foresters 	<ul style="list-style-type: none"> Acres of habitat restored for priority species Before and after comparison: abundance, diversity and distribution of priority species
Controlled burning by public agencies	<ul style="list-style-type: none"> Public Land Managers 	<ul style="list-style-type: none"> Acres of habitat restored for priority species Before and after comparison: abundance, diversity and distribution of priority species
Manage recreation on sensitive sites	<ul style="list-style-type: none"> Public Land Managers 	<ul style="list-style-type: none"> Acres of habitat restored for priority species Before and after comparison: abundance, diversity and distribution of priority species

Action	Partners	Effectiveness Measures
Minimize impact on fragile habitat	<ul style="list-style-type: none"> • Quarries and developers • WVDEP • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat protected for priority species • Before and after comparison: abundance, diversity and distribution of priority species

Human Benefits

Actions to restore rock outcrop, cliffs and talus, and shale barren habitat may provide human health and economic benefits for local residents and communities, including hunting, wildlife viewing, tourism and recreational opportunities.

Aquatic, Floodplain and Riparian Habitats

A diversity of aquatic habitats in the CFA range from cool, low-gradient headwater streams to warm, moderate gradient, large sized rivers such as the Greenbrier River. A map of aquatic habitat types is included in the introduction to the CFA. These streams and river habitats are tightly connected with their adjacent floodplains, wetlands and riparian habitats. Many plant and animal species rely on aquatic habitats such as streams, rivers and wetlands, as well as their adjacent terrestrial habitats, especially riparian areas and forests. The loss of natural floodplain habitats and riparian corridors often impacts water quality and adjacent aquatic habitat. Improving wildlife habitat in streams and rivers often requires conservation actions to improve adjacent floodplain and riparian habitats. Therefore aquatic, floodplain, wetland and riparian habitats will be addressed together.

Priority Species

Table 15 lists priority species in the CFA that occur aquatic, riparian and floodplain and wetland habitats. This CFA contains more than half of this state's occurrences of several species of Odonata including the Green-faced Clubtail and the Riffle Snaketail. Wetlands provide habitat critical for many threatened or endangered plants and animals. The Hairy-fruit Sedge for example is a plant species, critically imperiled in the state of WV, that relies on High Allegheny Wetlands habitats as well as aquatic habitats associated with floodplains. Like other aquatic environments, ponds and wetland habitats are influenced by land use practices in adjacent lands and waters.

Table 15. Priority Aquatic Species

Taxa	Scientific Name	Common Name
Amphibian	<i>Cryptobranchus alleganiensis</i>	Eastern Hellbender
Fish	<i>Percina gymnocephala</i>	Appalachia Darter
Fish	<i>Ameiurus nebulosus</i>	Brown Bullhead
Fish	<i>Etheostoma osburni</i>	Candy Darter
Fish	<i>Phenacobius teretulus</i>	Kanawha Minnow
Fish	<i>Cottus kanawhae</i>	Kanawha Sculpin
Fish	<i>Notropis scabriceps</i>	New River Shiner
Fish	<i>Lythrurus ardens</i>	Rosefin Shiner
Fish	<i>Exoglossum laurae</i>	Tonguetied Minnow
Fish	<i>Salvelinus fontinalis</i>	Brook Trout
Mussel	<i>Alasmidonta marginata</i>	Elktoe
Mussel	<i>Lasmigona subviridis</i>	Green Floater
Odonata	<i>Gomphus viridifrons</i>	Green-faced Clubtail
Odonata	<i>Gomphus fraternus</i>	Midland Clubtail
Odonata	<i>Gomphus quadricolor</i>	Rapids Clubtail
Odonata	<i>Ophiogomphus carolus</i>	Riffle Snaketail
Odonata	<i>Gomphus lineatifrons</i>	Splendid Clubtail
Other Invertebrate	<i>Utaperla gaspesiana</i>	Gaspe Sallfly

Table 16. Priority Riparian and Floodplain Species

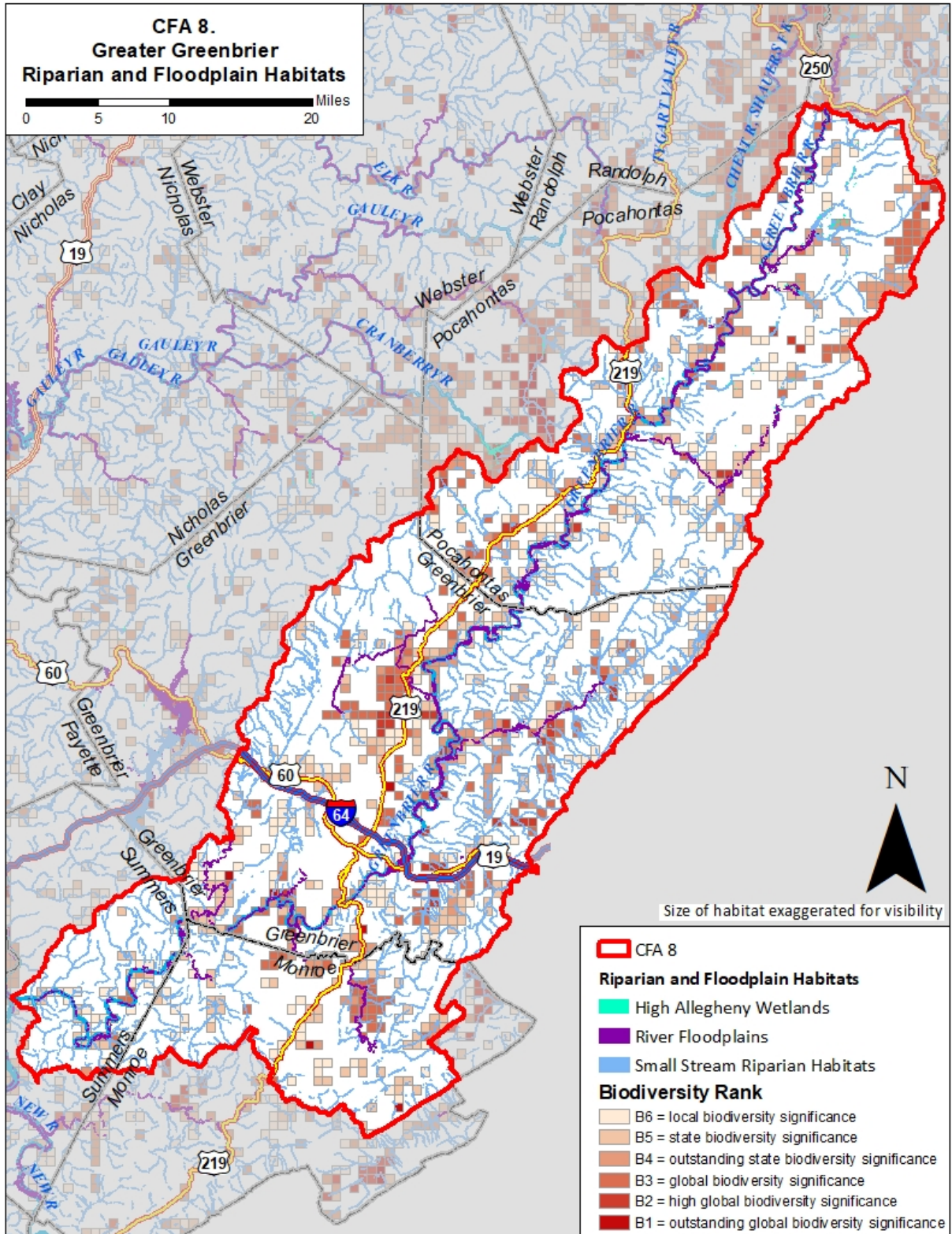
Taxa	Scientific Name	Common Name
Bird	<i>Parkesia motacilla</i>	Louisiana Waterthrush
Crayfish	<i>Cambarus chasmodactylus</i>	New River Crayfish
Crayfish	<i>Cambarus pauleyi</i> (previously <i>Dubius</i> B)	Meadow River Mudbug
Crayfish	<i>Cambarus smilax</i>	Greenbrier River Crayfish
Lepidoptera	<i>Speyeria diana</i>	Diana Fritillary
Mammal	<i>Perimyotis subflavus</i>	Tricolored Bat
Plant	<i>Baptisia australis</i> var. <i>australis</i>	False Blue Indigo
Plant	<i>Carex albolutescens</i>	Greenish-white Sedge
Plant	<i>Carex styloflexa</i>	Bent Sedge
Plant	<i>Carex trichocarpa</i>	Hairy-fruit Sedge
Plant	<i>Decodon verticillatus</i>	Swamp-loosestrife
Plant	<i>Eleocharis engelmannii</i>	Engelmann's Spikerush
Plant	<i>Parnassia asarifolia</i>	Kidneyleaf Grass-of-parnassus
Plant	<i>Pedicularis lanceolata</i>	Swamp Lousewort
Plant	<i>Platanthera psycodes</i>	Lesser Purple Fringed Orchid
Plant	<i>Potamogeton tennesseensis</i>	Tennessee Pondweed
Plant	<i>Ranunculus pensylvanicus</i>	Bristly Crowfoot
Plant	<i>Rosa blanda</i> var. <i>blanda</i>	Smooth Rose
Plant	<i>Spiraea virginiana</i>	Virginia Spiraea
Plant	<i>Spiranthes lucida</i>	Shining Ladies'-tresses
Plant	<i>Stachys eplingii</i>	Epling's Hedge-nettle
Plant	<i>Viburnum lentago</i>	Nannyberry
Plant	<i>Vitis rupestris</i>	Sand Grape
Reptile	<i>Opheodrys vernalis</i>	Smooth Greensnake

Table 17. Priority Species in High Allegheny Wetlands

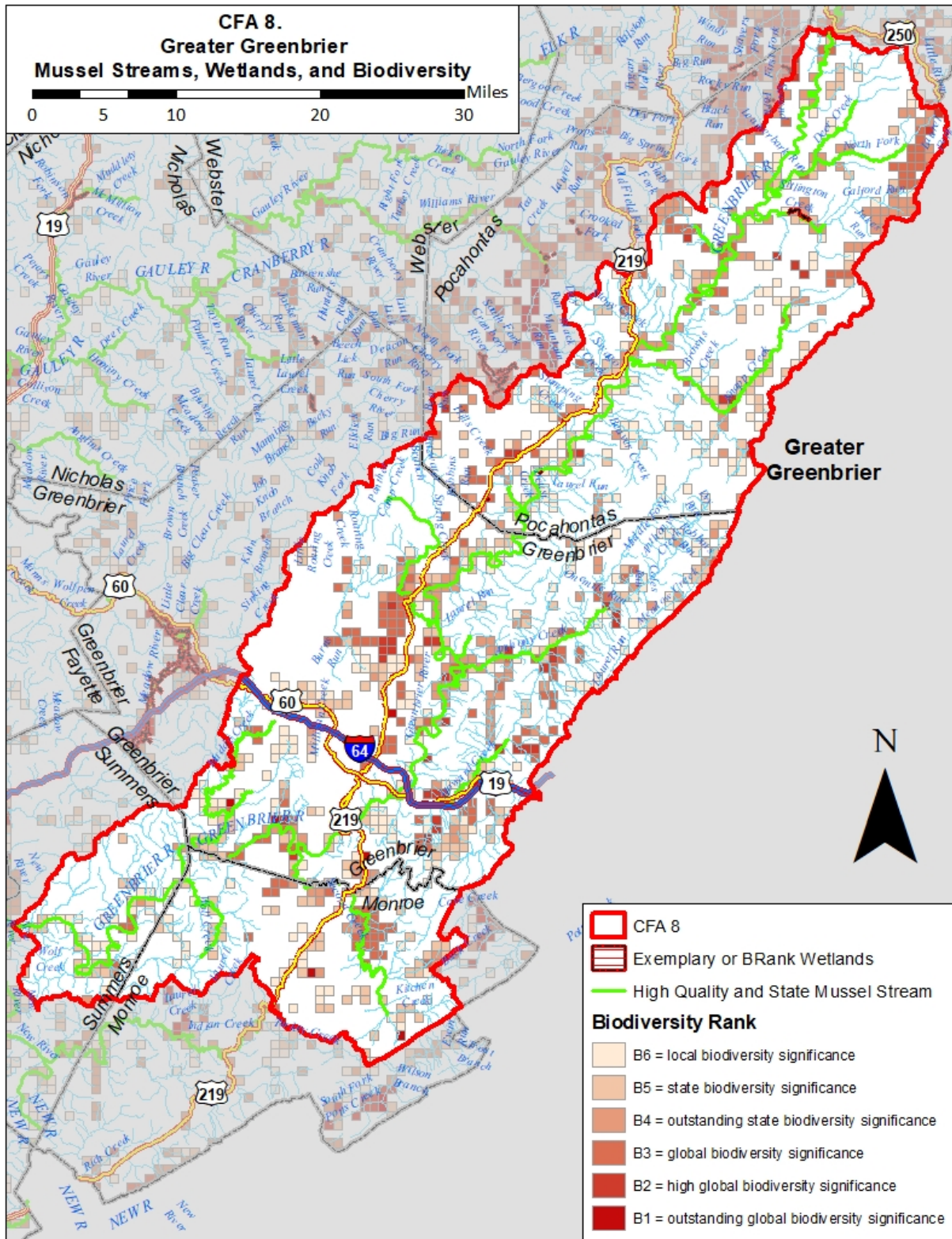
Taxa	Scientific Name	Common Name
Odonata	<i>Nehalennia gracilis</i>	Sphagnum Sprite
Plant	<i>Calopogon tuberosus</i> var. <i>tuberosus</i>	Tuberous Grass-pink
Plant	<i>Parnassia asarifolia</i>	Kidneyleaf Grass-of-parnassus
Plant	<i>Pedicularis lanceolata</i>	Swamp Lousewort
Plant	<i>Potamogeton tennesseensis</i>	Tennessee Pondweed
Plant	<i>Ribes triste</i>	Swamp Red Currant

Map 9 illustrates riparian and floodplain habitats along with biodiversity, and Map 10 illustrates mussel streams (mapped by WVDNR in 2018), exemplary wetlands (as assembled by WVDNR in 2015) and biodiversity. These areas provide core habitat and movement corridors for many of the priority species and rare plant communities listed above and are priority habitats. The Biodiversity Rank occurrences indicate that numerous SGCN and rare communities occupy stream, floodplain and riparian habitats. A few sinkhole and depression ponds are visible in the southern end of the CFA. River floodplain habitats occur along the Greenbrier River and major tributaries, with small stream riparian habitats occurring along numerous smaller streams. There are sinkholes and depression ponds near the southeastern edge of the CFA and High Allegheny Wetland habitats in the high mountains. There is a large, exemplary wetland along Sitlington Creek and several smaller ones elsewhere. The Greenbrier River, Knapp Creek, Anthony Creek, Spring Creek, Howard Creek, Muddy Creek, Second Creek and Wolf Creek are designated State Mussel Streams.

Map 9. Riparian and Floodplain Habitats, and Biodiversity



Map 10. Mussel Streams, Wetlands and Biodiversity



Rare Plant Communities

The following rare plant communities may be found in aquatic, floodplain and riparian habitats in this CFA. Note that there are a large number of rare plant communities within the CFA that are ranked imperiled or critically imperiled within West Virginia. These plant communities are vulnerable to disturbance and the spread of nonnative invasive plants. Disturbance should be avoided and nonnative invasive plant infestations should be treated.

Table 18. Rare Plant Communities in Aquatic, Floodplain and Riparian Habitats.

Habitat	Common Name	Relative Abundance	G Rank	S Rank
High Allegheny Wetlands	Red Maple - Black Gum / Peatmoss Swamp	6.67%	GNR	S2
High Allegheny Wetlands	Cranberry - Beakrush Peatland	8.82%	G2	S1
High Allegheny Wetlands	Goldenrod Wet Meadow	3.17%	GNR	S3
High Allegheny Wetlands	Red Spruce / Heath Peat Woodland	2.63%	G2G3	S1
High Allegheny Wetlands	American Bur-Reed Marsh	2.44%	G3?	S2
High Allegheny Wetlands	Woolgrass Wet Meadow	2.22%	GNR	S3
River Floodplains	Virginia Pine Riverscour Woodland	10.53%	GNR	S1
River Floodplains	Hairy-fruit Sedge Floodplain Prairie	14.29%	G4?	S1
River Floodplains	Hemlock Floodplain Forest	17.24%	GNR	S2
River Floodplains	Big Bluestem - Blue Wild Indigo Riverscour Prairie	23.08%	G3	S1
River Floodplains	Ohio River Silver Maple Floodplain Forest	0.85%	G4?	S2
River Floodplains	Sycamore - Buckeye Floodplain Forest	6.45%	GNR	S2
River Floodplains	Mountain Valley Oak Swamp	18.18%	G3G4	S1
River Floodplains	Lizard's Tail Backwater Slough	5.56%	G3	S2
River Floodplains	Red Maple - Black Gum / Peatmoss Swamp	6.67%	GNR	S2
River Floodplains	Switchgrass - Big Bluestem Riverscour Prairie	4.76%	G2G3	S2
River Floodplains	Goldenrod Wet Meadow	3.17%	GNR	S3
River Floodplains	Buttonbush Shrub Swamp	3.13%	G4	S3
River Floodplains	American Bur-Reed Marsh	2.44%	G3?	S2
River Floodplains	Woolgrass Wet Meadow	2.22%	GNR	S3

Habitat	Common Name	Relative Abundance	G Rank	S Rank
River Floodplains	Water-Willow Riverbed	6.25%	G4G5	S3
Small Stream Riparian Habitats	Mountain Valley Oak Swamp	18.18%	G3G4	S1
Small Stream Riparian Habitats	Hemlock Floodplain Forest	17.24%	GNR	S2
Small Stream Riparian Habitats	Sycamore - Buckeye Floodplain Forest	6.45%	GNR	S2
Small Stream Riparian Habitats	Water-Willow Riverbed	6.25%	G4G5	S3
Small Stream Riparian Habitats	Lizard's Tail Backwater Slough	5.56%	G3	S2
Small Stream Riparian Habitats	Red Maple - White Oak Forest Seep	4.17%	G2	S2
Small Stream Riparian Habitats	Goldenrod Wet Meadow	3.17%	GNR	S3
Small Stream Riparian Habitats	Buttonbush Shrub Swamp	3.13%	G4	S3
Small Stream Riparian Habitats	American Bur-Reed Marsh	2.44%	G3?	S2
Small Stream Riparian Habitats	Woolgrass Wet Meadow	2.22%	GNR	S3
Small Stream Riparian Habitats	Ohio River Silver Maple Floodplain Forest	0.85%	G4?	S2
Small Stream Riparian Habitats	Red Maple - Black Gum / Peatmoss Swamp	6.67%	GNR	S2

S Rank (State Rank) and G Rank (Global Rank) Conservation Status: 1 = Critically Imperiled, 2 = Imperiled, 3 = Vulnerable, 4 = Apparently Secure, 5 = Secure, NR = Not Ranked, T = Subspecies or Varieties, B = Breeding, N = Non-breeding, S#S# or G#G# indicates range of uncertainty of conservation status.

Habitat Stresses and Conservation Actions

Protecting and restoring streamside riparian buffers is an important conservation action that improves water quality as well as both in-stream and riparian habitat for priority bird, fish, mussel, dragonfly/damselfly and plant species. Direct stresses to priority species include hybridization from live bait releases that effect the Appalachia Darter, Brown Bullhead and Candy Darter. Eastern Hellbenders are directly impacted by illegal collections, harassment, rock piling and killing by anglers. These threats can be prevented by enforcing closed seasons, avoiding use of live bait, education of anglers, investigation and law enforcement targeting harassment and killing of Eastern Hellbenders, and increased surveying at known sites.

Map 11 shows stream impairments, along with biodiversity. There are numerous streams impaired by fecal/bacteria (WVDEP, 2014), including Deer Creek and Buffalo Run, Galford Run and Shock Run, Knapp Creek, Douthat Creek and Brown's Creek, Swago Creek, Beaver Creek, Spring Creek, Meadow Creek, Little Creek, Whites Draft, Sinking Creek, Hughart Creek, Milligan Creek, Monroe Draft, Second Creek,

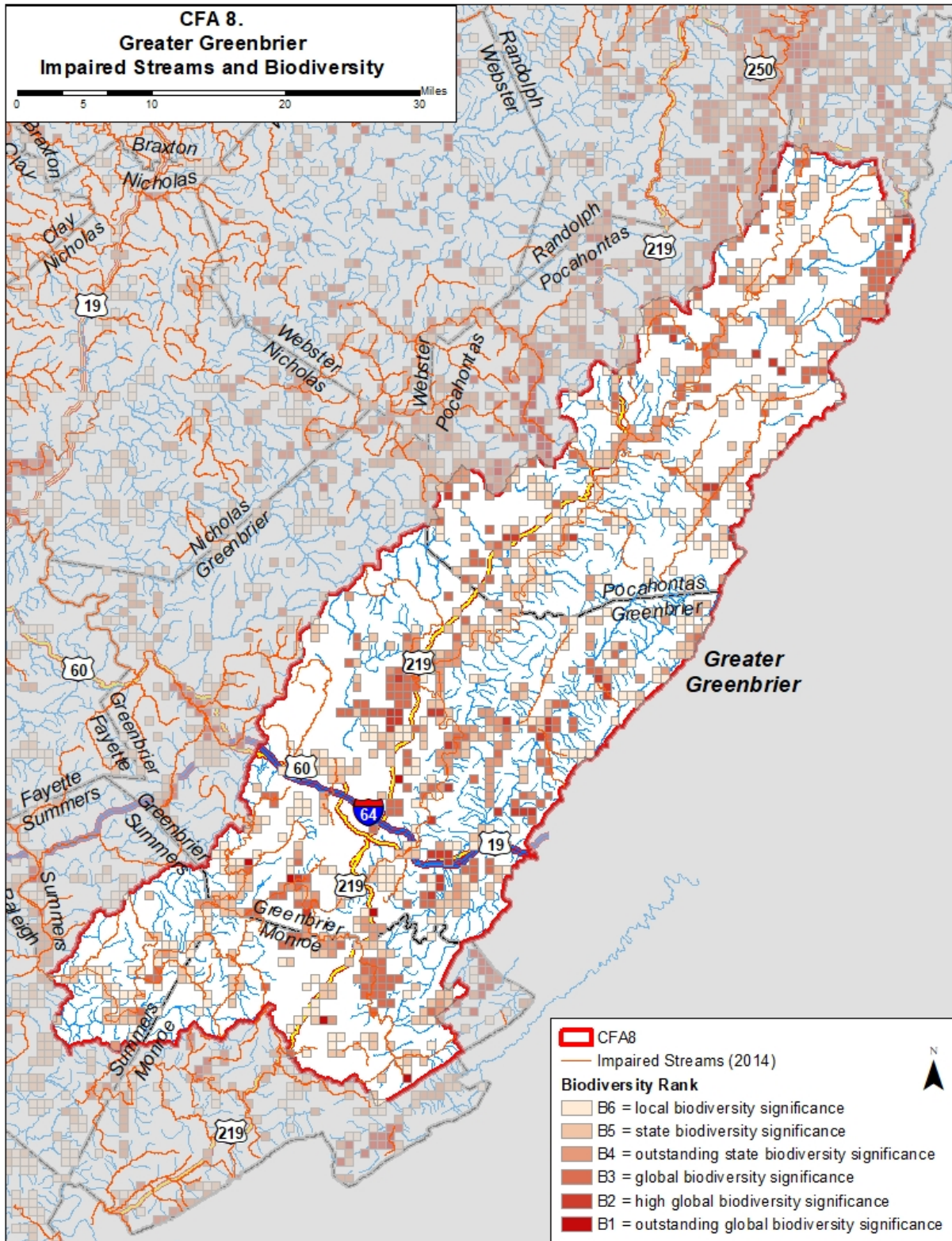
Kitchen Creek, Back Creek, Burnside Branch, Broad Run, Wolf Creek, Laurel Creek, Kelly Creek, Hungard Creek and Big Creek (WVDEP, 2014). Many of these impaired streams nonetheless host concentrations of biodiversity and provide habitat for mussels and other priority species. Improving water quality in these impaired streams is an important conservation action, especially where priority SGCN are present.

Table 19. Habitat Stresses and Conservation Actions for Aquatic, Floodplain and Riparian Habitat

Habitat Stress	Conservation Action
Lack of protected floodplain, wetland and riparian habitat	Habitat protection through land use planning, conservation easements and other programs and activities
Water quality degradation (organic and chemical pollutants, sedimentation, run-off, dredging)	Identify and treat sources of pollution: improved sewage treatment, storm water management, agricultural nutrient load reductions, sediment load reductions
Riparian habitat disturbance and deforestation, road crossings, altered hydrology, increased runoff and stream temperatures, climate change	Landowner outreach Plant, fence, maintain forested riparian corridors install pollinator habitat Minimize disturbance
Invasive plants	Treating of cattail and other invasive plants; replace with native plants
Deforestation, disturbance and runoff from agriculture, oil/gas development, mining	Increased coordination with WVDNR, maintain forested riparian corridors, minimize disturbance, control invasive plants and runoff
Riparian habitat disturbance, trampling rare plants	Landowner outreach; plant, fence, maintain forested riparian corridors; minimize disturbance
In-stream habitat impacts to mussels from stream restoration activities	Consider habitat needs in restoration plans; survey and salvage before restoration activities
Aquatic passage barriers	Identify, modify or remove barriers
Degradation of wetlands	Maintain high elevation wetland integrity

Habitat Stress	Conservation Action
Habitat degradation and fragmentation, isolated populations, climate change	Protect isolated populations and refugia; Stream restoration

Map 11. Impaired Streams and Biodiversity



Climate Change and Habitat Resilience

As noted in the Central Appalachians Forest Ecosystem Vulnerability Assessment (Butler et al., 2015), riparian forests are vulnerable to climate change stressors including increased flood frequency and severity and resulting erosion and sedimentation. Impervious cover may exacerbate these impacts. Drought may stress plants and increase their susceptibility to forest pests and pathogens. Warming temperatures and increased disturbances may enable nonnative invasive plant species to outcompete native species. Although riparian forests are adapted to some level of disturbance and variable conditions, habitat alterations and invasive species may limit the ability of riparian forests to adapt to climate change. Restoring and maintaining the health, acreage and connectivity of native riparian forests along streams and rivers will build their resilience to climate change.

The Assessment also describes how instream habitats and associated plant and animal species may be stressed by climate change-related increases in temperature, droughts, flood frequency and severity, and resulting erosion and sedimentation. Low flow events may also become more frequent and severe. Warming surface waters is likely to result in water quality degradation and eutrophication. Many aquatic species and life stages are adapted to specific timing and ranges of flow and temperature, as well as water quality variables. Climate change may impact different species and life stages in different ways. Cold water habitats and aquatic communities may be at particular risk. Areas within a watershed may be more or less sensitive to increases in air temperature, depending on local factors such as watershed characteristics, position within the watershed, upstream land uses, groundwater contributions, forest cover and shading.

Restoring and maintaining the health, size and connectivity of native riparian forests along streams and rivers can provide riparian habitat, shade and cooling, organic matter, structure and debris, protect stream banks and in-stream habitat during high flows and maintain water quality. Stabilizing eroding stream banks using natural channel design techniques and reconnecting streams with their floodplains can restore fluvial processes and floodplain habitats. Cleaning and enlarging culverts and stream crossings to accommodate increased peak flows and aquatic organism passage can reduce flood damage to infrastructure and habitat and allow aquatic organisms to reach additional habitat as they adapt to changing conditions.

Below is a summary of climate stresses on aquatic, floodplain and riparian habitat, and actions to boost their resilience (Swanston et al., 2016). While climate stresses are listed separately, aquatic, floodplain and riparian habitats are often impacted by multiple climate stresses occurring simultaneously and actions to boost habitat resilience are intended to address multiple climate stresses. Many of these actions reiterate previously listed conservation actions to reduce stress on priority species and could have positive outcomes for priority species as well as habitat resilience. WVDNR, land managers, landowners and partners can select the actions best suited to their specific site conditions, management goals and objectives, from the list below or other sources.

Table 20. Climate Stresses and Resilience Actions in Aquatic, Floodplain and Riparian Habitat

Climate Stresses	Habitat Resilience Actions
<ul style="list-style-type: none"> • Increased flood frequency and severity, erosion and sedimentation • Increased surface water temperatures, low-flow events and water quality degradation • Increased risk of drought and wildfire • Increased competition from nonnative invasive species, pests and pathogens 	<ul style="list-style-type: none"> • Restore and maintain the health, diversity and connectivity of riparian forests • Stabilize eroding streambanks and reconnect stream hydrology to floodplains • Clean and enlarge culverts and stream crossings to accommodate peak flows and aquatic organism passage • Minimize disturbance to riparian forests, promptly revegetate after disturbance, prevent the introduction and establishment of invasive plant species and remove existing invasive species • Protect refugia for cold water habitat

Implementation Plan

WVDNR will work with interested partners and landowners to plan, implement and measure the effectiveness of conservation actions to benefit priority species in aquatic, floodplain and riparian habitats.

Table 21. Implementation Plan for Aquatic, Floodplain and Riparian Habitats

Action	Partners	Effectiveness Measures
<p>Habitat Protection:</p> <ul style="list-style-type: none"> • Conservation Easements • Land Acquisition • Natural Area designation 	<ul style="list-style-type: none"> • County Farmland Protection Boards • OHCF, TCF, TNC, WVLT • WVDEP ILF • WVDNR • USDA Natural Resource Conservation Service ACEP 	<ul style="list-style-type: none"> • Acres of aquatic and riparian habitat protected for priority species • Abundance and diversity of priority species and habitats
<p>Habitat Protection</p> <ul style="list-style-type: none"> • Incentive Programs 	<ul style="list-style-type: none"> • USDA FSA 	<ul style="list-style-type: none"> • Acres of aquatic and riparian habitat protected for priority species • Abundance and diversity of priority species and habitats

Action	Partners	Effectiveness Measures
Habitat Protection: <ul style="list-style-type: none"> • Land Use Planning 	<ul style="list-style-type: none"> • County Planning Commissions 	<ul style="list-style-type: none"> • Acres of habitat protected through land use planning, floodplain and stormwater regulations
In-stream and riparian habitat restoration	<ul style="list-style-type: none"> • Trout Unlimited • USDA NRCS • USDA FSA CREP • USFWS Partners for Fish and Wildlife Restoration • Public Land Managers 	<ul style="list-style-type: none"> • Acres or linear feet of in-stream and riparian habitat restored for priority species • Before and after comparison: abundance and diversity of priority species
Planting and fencing stream buffer zones	<ul style="list-style-type: none"> • Trout Unlimited • USDA NRCS • USDA FSA CREP • USFWS Partners for Fish and Wildlife • WVDEP and WVCA • WVDOF 	<ul style="list-style-type: none"> • Acres or linear feet of stream buffer zones planted and fenced to protect priority species • Before and after comparison: abundance and diversity of priority species
Identify and remove or enlarge aquatic passage barriers, increase aquatic connectivity	<ul style="list-style-type: none"> • Trout Unlimited • USFWS Partners for Fish and Wildlife • WVDOH 	<ul style="list-style-type: none"> • # barriers enlarged or removed • # miles stream opened • Before and after comparison: abundance and diversity of priority species
Identify and treat sources of water pollution: Improved wastewater and stormwater treatment	<ul style="list-style-type: none"> • County governments • Municipalities • Trout Unlimited • WVDEP • WVDHHR • WV Rivers Coalition 	<ul style="list-style-type: none"> • # wastewater and stormwater systems installed or improved • Change in fecal, sediment and other water quality measurements • Before and after comparison: abundance & distribution of priority species

Action	Partners	Effectiveness Measures
Improve water quality in streams and wetlands	<ul style="list-style-type: none"> • USDA FSA & NRCS • WVDEP and WVCA 	<ul style="list-style-type: none"> • Change in water quality measurements • Before and after comparison: abundance and diversity of priority species
Treat cattail and other invasive plants in streams and wetlands	<ul style="list-style-type: none"> • USDA FSA & NRCS • USFWS Partners for Fish and Wildlife 	<ul style="list-style-type: none"> • Acres treated • Treatment success rate • Before and after comparison: abundance and diversity of priority species

Human Benefits

Actions to restore and protect aquatic, floodplain and riparian habitat may have numerous health and economic benefits for local residents and communities, including absorption and reduction of pollution in water ways and drinking water sources, absorption and reduction of flood waters and reduced flood damages, soil conservation and improved agricultural productivity, and improved hunting, fishing and recreational opportunities.

Subterranean Habitats

Karst and Cave Habitats

Areas with karst geology and subterranean caves provide unique habitats that may be influenced by human activities, surface land use, and surface and underground hydrology in the surrounding landscape. Caves provide important habitat for bats that move in and out, as well as a diverse group of vertebrate and invertebrate animals that have evolved specialized adaptations to permanent underground living. Common traits exhibited by permanent cave dwellers (troglobites) include blindness (or complete loss of eyes) and reduced pigmentation. The Greater Greenbrier CFA is a globally significant karst landscape with more caves occurring here than anywhere else in West Virginia. Sinkhole and cave densities reach an average of seven per square mile (18 per square kilometer) in the Big Levels region. Davis Spring, with an average volume of 110 cubic feet per second, is the largest spring in the state. Friars Hole, with 44 miles of mapped passage, is the sixth largest cave in the United States. The next map (based on maps from the WV Geologic and Economic Survey in 1998) illustrates a large band of karst geology running NE-SW along the northern side of the CFA, and a smaller band along the southern side. The karst areas overlap numerous occurrences of rare species. Surface drainage in these areas is limited due to numerous sinking streams. The map on the subsequent page illustrates multiple biologically significant caves that host rare bat or endemic cave species, or exceptional biological diversity, with 3-mile buffers offset randomly. It also illustrates numerous karst features with 3-kilometer random offset buffers, and karst feature density. This data was provided by the West Virginia Speleological Survey, with offset buffers developed by WVDNR. Buffers around karst features and biologically significant caves are concentrated in the northeast portion of the CFA, along US Highway 219 and the Greenbrier-Monroe county line and occupy at least half of the CFA. These areas require careful management to minimize disturbance on priority species.

Priority Species

Caves in this CFA host the following priority species, all of which are rare and dependent on specific cave habitats for their survival. Of special significance, this CFA hosts all of the state's Greenbrier Valley Cave Pseudoscorpion, Organ Cave Pseudoscorpion, and Orpheus Cave Pseudoscorpion, the world's only known population of West Virginia Spring Salamander, and over 50% of the state's Greenbrier Cave Amphipod and Pocahontas Cave Amphipod.

Table 22. Priority Species in Subterranean Habitats

Taxa	Scientific Name	Common Name
Amphibian	<i>Gyrinophilus subterraneus</i>	West Virginia Spring Salamander
Cave Invertebrate	<i>Arrhopalites commorus</i>	A Collembola
Cave Invertebrate	<i>Arrhopalites pavo</i>	A Cave Springtail
Cave Invertebrate	<i>Arrhopalites sacer</i>	A Collembola
Cave Invertebrate	<i>Chitrella regina</i>	Royal Syarinid Pseudoscorpion
Cave Invertebrate	<i>Crangonyx</i> sp. 2	An Amphipod
Cave Invertebrate	<i>Gyrinophilus subterraneus</i>	WV Spring Salamander
Cave Invertebrate	<i>Haplotaxis brinkhursti</i>	An Oligochaete
Cave Invertebrate	<i>Kleptochthonius henroti</i>	Greenbrier Valley Cave Pseudoscorpion

Taxa	Scientific Name	Common Name
Cave Invertebrate	Kleptochthonius hetricki	Organ Cave Pseudoscorpion
Cave Invertebrate	Kleptochthonius orpheus	Orpheus Cave Pseudoscorpion
Cave Invertebrate	Kleptochthonius proserpinae	Proserpina Cave Pseudoscorpion
Cave Invertebrate	Onychiurus janus	A Cave Springtail
Cave Invertebrate	Pseudosinella gisini gisini	A Cave Springtail
Cave Invertebrate	Pseudosinella orba	A Cave Springtail
Cave Invertebrate	Pseudosinella sp. 8	A Springtail
Cave Invertebrate	Sinella agna	A Springtail
Cave Invertebrate	Stygobromus emarginatus	Greenbrier Cave Amphipod
Cave Invertebrate	Stygobromus nanus	Pocahontas Cave Amphipod
Cave Invertebrate	Stygobromus parvus	Minute Cave Amphipod
Cave Invertebrate	Stygobromus pollostus	An Amphipod
Cave Invertebrate	Stygobromus redactus	An Amphipod
Cave Invertebrate	Stygobromus spinatus	Spring Cave Amphipod
Cave Invertebrate	Stylodrilus beattiei	A Cave Lumbriculid Worm
Cave Invertebrate	Trichodrilus culveri	An Oligochaete
Crayfish	Cambarus nerterius	An Underground Crayfish
Mammal	Myotis leibii	Eastern Small-footed Bat
Mammal	Myotis lucifugus	Little Brown Myotis
Mammals	Myotis septentrionalis	Northern Long-eared Bat
Mammal	Myotis sodalis	Indiana Bat
Mammal	Perimyotis subflavus	Tricolored Bat
Snails	Fontigens tartarea	Organ Cavesnail
Snails	Fontigens turritella	Greenbrier Cavesnail

Habitat Stresses and Conservation Actions

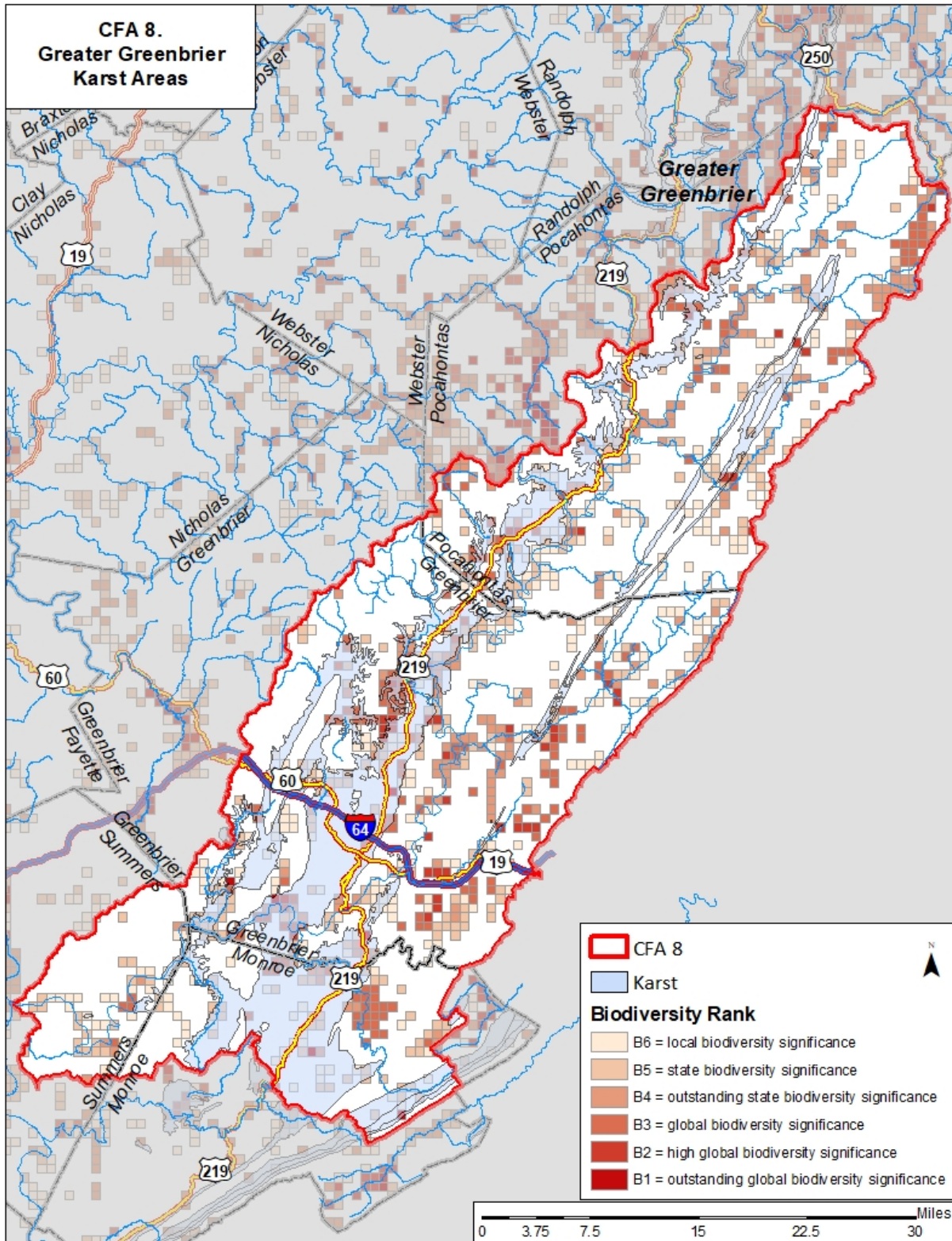
Caves and subterranean habitats, particularly in porous karst geology, are impacted by changes to water quality and land use in adjacent areas. The following table lists stresses affecting wildlife in caves and subterranean habitats, and conservation actions landowners and partners can take to address them.

Table 23. Habitat Stresses and Conservation Actions in Subterranean Habitats

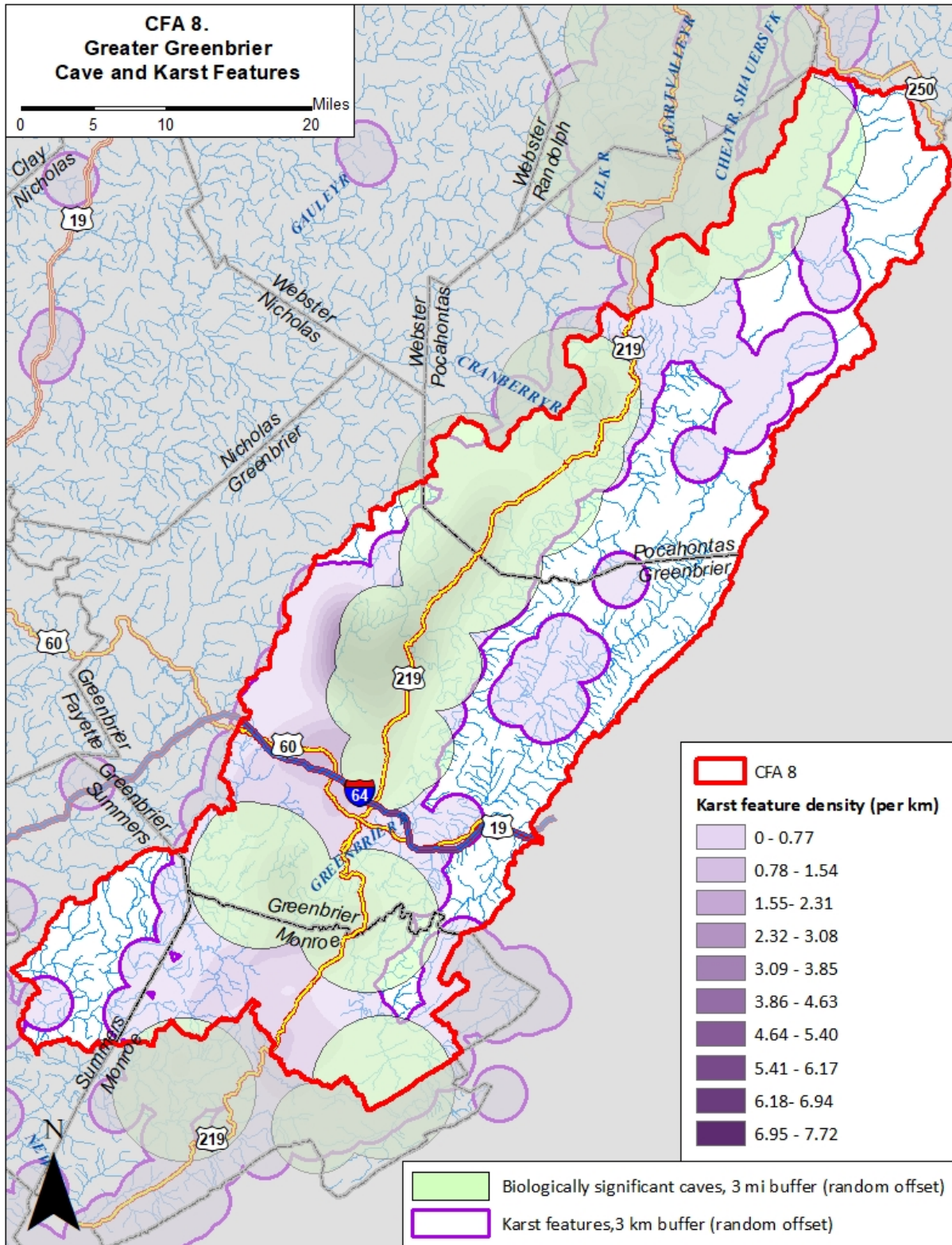
Habitat Stress	Conservation Action
Water quality degradation due to stormwater runoff, inadequate wastewater treatment, animal waste, sinkhole dumping	Identify sinkholes and other important karst features. Provide educational materials to landowners, planners, partner agencies. Mapping of passage and surface influences. Conduct sinkhole clean ups, fencing and signage. Improve wastewater treatment. Restore and maintain riparian buffers and livestock exclusion fencing.

Habitat Stress	Conservation Action
Cave disturbance, passage alteration, excessive visitation	Conserve cave locations with known hibernacula, continue cave visitation restrictions during winter hibernation, cave fencing and signage
Agriculture and deforestation around caves, climate change (caves need to be cool, humid)	Maintain forest cover and hydrology around caves

Map 12. Karst Areas and Biodiversity



Map 13. Karst and Cave Features



Climate Change and Habitat Resilience

The Central Appalachians Forest Ecosystem Vulnerability Assessment (Butler et al., 2015), noted that ecosystems that are limited by geological or hydrological features, such as cave and karst habitats, may be restricted from shifting across the landscape in response to climate change. However, caves that are connected more closely with groundwater inputs than surface water may be buffered by the impacts of climate change, and caves and karst areas may be buffered from increasing surface temperatures. But caves and karst areas may be vulnerable to groundwater extraction during droughts as well as changes in surface water flow regimes, nutrient inputs and contaminants carried by floods. Restoring and maintaining water quality and natural flow regimes in areas upstream and above caves and karst may boost the resilience of cave ecosystems. Some cave dwelling species also rely on adjacent forest, riparian and aquatic habitats. Maintaining the resilience of adjacent ecosystems could further buffer cave species from the impacts of climate change.

Below is a summary of climate stresses on cave and karst habitats, and actions to boost their resilience. Although climate stresses are listed separately, subterranean habitats are often impacted by multiple climate stresses occurring simultaneously and actions to boost habitat resilience are intended to address multiple climate stresses. Some of these actions repeat previously listed conservation actions to reduce stress on priority species and could benefit priority species while also boosting habitat resilience. WVDNR, partners and landowners can collaborate to select the habitat resilience actions best suited to site conditions, conservation goals and land management objectives.

Table 23. Climate Stresses and Resilience Actions in Karst and Cave Habitats

Climate Stress:	Habitat Resilience Action:
<ul style="list-style-type: none"> • Increased flood frequency and severity, nutrient inputs and contaminants • Increased surface water temperatures, low-flow events and ground water withdrawals • Impacts to adjacent forest, riparian and aquatic habitat 	<ul style="list-style-type: none"> • Restore and protect surface water quality and hydrology • Limit impervious cover • Maintain ground water quality and quantity • Maintain resilient forests, riparian and aquatic habitat around karst and cave ecosystems

Implementation Plan

WVDNR will work with landowners and the following partners and programs to implement and measure the impact of conservation actions around caves and karst habitat.

Table 24. Implementation Plan for Subterranean Habitats

Action	Partners	Effectiveness Measures
Land protection around caves and karst habitat: <ul style="list-style-type: none"> • Conservation Easements • Land Acquisition • Natural Area designation 	<ul style="list-style-type: none"> • County Farmland Protection Boards • OHCF, TCF, TNC, WVLT • USDA NRCS ACEP • WVDNR 	<ul style="list-style-type: none"> • Acres of habitat protected around caves and karst habitat • Abundance and diversity of priority species and habitats
Land protection around caves and karst habitat <ul style="list-style-type: none"> • Incentive Programs 	<ul style="list-style-type: none"> • USDA FSA 	<ul style="list-style-type: none"> • Acres of habitat protected • Abundance and diversity of priority species and habitats
Land use planning around caves and karst habitat	<ul style="list-style-type: none"> • County Planning Commissions 	<ul style="list-style-type: none"> • Acres of cave, karst and buffer habitat protected for public health and safety through land use planning ordinances
Stream buffer fencing and riparian plantings around caves and karst	<ul style="list-style-type: none"> • Trout Unlimited • USDA FSA & NRCS • USFWS Partners for Fish and Wildlife Restoration • WVDOF, WVDEP and WVCA 	<ul style="list-style-type: none"> • Acres or linear feet of stream buffer zones planted and fenced • Before and after comparison: abundance and diversity of priority species
Land management around caves and karst	<ul style="list-style-type: none"> • USDA FSA & NRCS • Trout Unlimited • USFWS Partners for Fish and Wildlife • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat managed • Before and after comparison: abundance and diversity of priority species
Identification of critical karst features and landowner outreach, sinkhole cleanups, cave research, mapping and protection	<ul style="list-style-type: none"> • CCV • NSS and grottos • WVACS • WVASS • WVCC 	<ul style="list-style-type: none"> • # of cave/karst resources protected or restored • # landowners participating in cave/karst protection and restoration activities

Action	Partners	Effectiveness Measures
Improved wastewater treatment around caves and karst habitat	<ul style="list-style-type: none"> • WVDEP • WVDHHR 	<ul style="list-style-type: none"> • # systems installed or improved • Change in fecal and other water quality Before and after comparison: abundance and diversity of priority species

Human Benefits

Actions to restore and protect subterranean habitat may benefit human health and economies in surrounding communities, mainly through the protection of water quality and drinking water sources.

Agricultural and Developed Habitats

Agricultural areas are most heavily concentrated in the central southern section of this CFA along US Highway 219, while developed areas are most heavily concentrated around Lewisburg and White Sulfur Springs. Many species rely on agricultural lands, especially pastures and woody vegetation in fallow areas, abandoned fields, field borders, wetlands and riparian corridors. Some species even depend on habitats in residential and urban areas. Map 14 shows the locations of agricultural and developed habitats and highlights biodiversity occurrences in and around these areas. Grassland birds in particular rely on agricultural areas in this CFA. Many of those agricultural areas coincide with fertile soils in karst landscapes, where agricultural activities may also impact water quality and subterranean habitats. Maintaining pastures, fallow fields, woody vegetation, wetlands and riparian corridors is a priority for SGCNs in agricultural habitats.

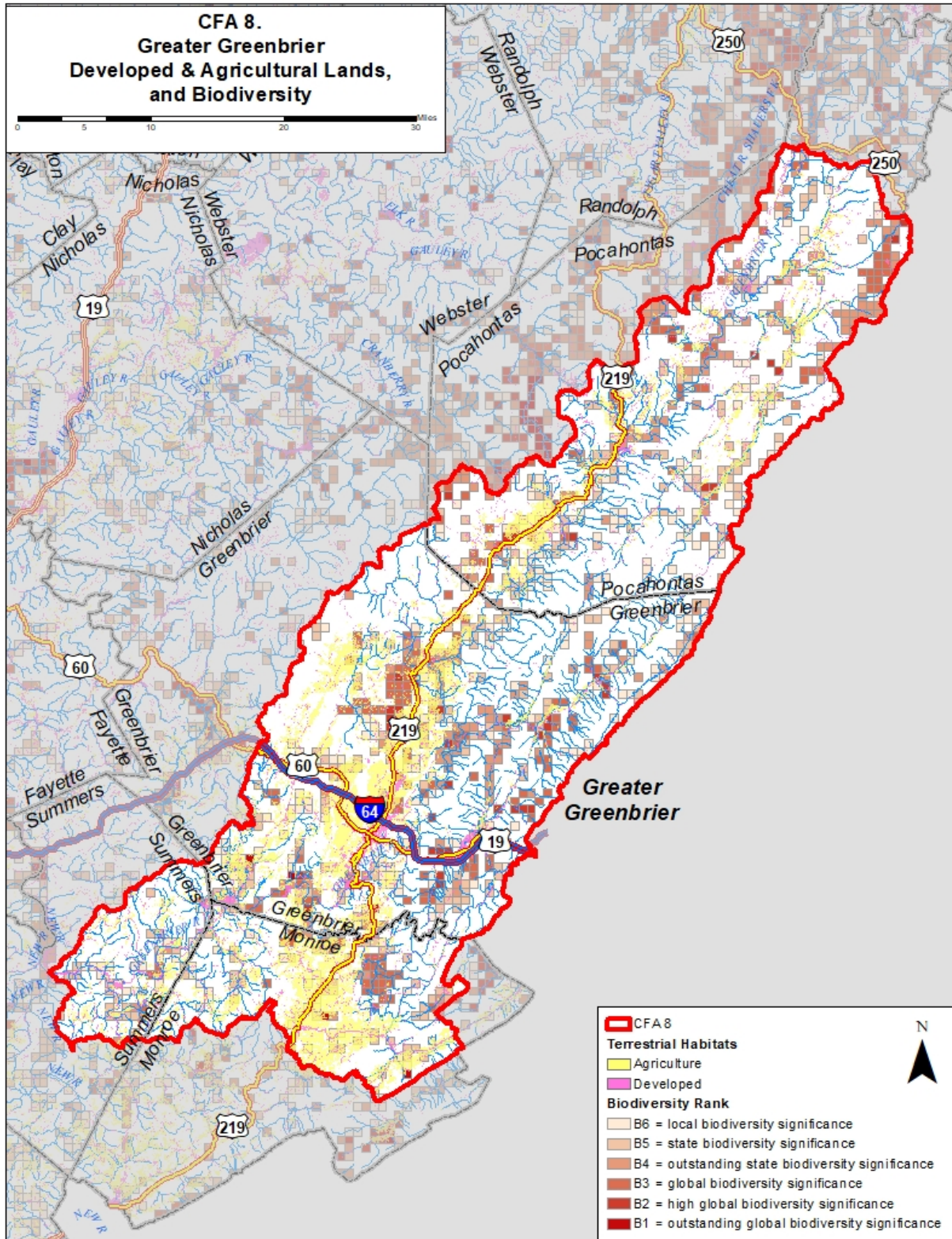
Priority Species

Agricultural lands including pastures and hayfields, along with adjacent areas of natural vegetation in and around adjacent forests and woodlots, hedgerows, fallow areas, ponds, wetlands and streams provide valuable habitat for several priority grassland bird species in the CFA. Table 25 provides a list of priority SGCN associated with agricultural habitats in the CFA. Developed areas also provide important habitat, most notably for the Chimney Swift.

Table 25. Priority Species in Agricultural and Developed Habitats

Taxa	Scientific Name	Common Name
Amphibian	<i>Pseudacris feriarum</i>	Upland Chorus Frog
Bird	<i>Ammodramus savannarum</i>	Grasshopper Sparrow
Bird	<i>Chaetura pelagica</i>	Chimney Swift
Bird	<i>Dolichonyx oryzivorus</i>	Bobolink
Bird	<i>Falco sparverius</i>	American Kestrel
Bird	<i>Lanius ludovicianus</i>	Loggerhead Shrike
Bird	<i>Scolopax minor</i>	American Woodcock
Bird	<i>Tyto alba</i>	Barn Owl
Bird	<i>Spizella pusilla</i>	Field Sparrow
Bird	<i>Sturnella magna</i>	Eastern Meadowlark
Lepidoptera	<i>Speyeria diana</i>	Diana Fritillary
Reptile	<i>Opheodrys vernalis</i>	Smooth Greensnake
Reptile	<i>Virginia valeriae pulchra</i>	Mountain Earthsnake

Map 14. Developed & Agricultural Lands and Biodiversity



Habitat Stresses and Conservation Actions

The conversion of farmland for residential and commercial development reduces valuable habitat for wildlife, especially grassland birds. In addition, modern farming practices have resulted in the intensification of mechanized farming practices and the expansion of areas cleared for crop agriculture. Consequently, much natural vegetation providing wildlife habitat in grasslands, wetlands, fallow areas, riparian corridors, hedgerows and forest edges has been cleared. The timing of agricultural practices also impacts some priority species. For example, incompatible timing and interval of haying can drastically reduce breeding productivity of ground-nesting birds such as the Eastern Meadowlark. Many SGCNs also rely on habitat created by utility corridors, where the cutting of vegetation or herbicide treatment can have direct impacts on native birds and their nests. Rodenticides used to kill pests may also harm Barn Owls and other birds of prey. Table 26 lists stresses to wildlife habitat in agricultural areas and conservation actions to address them.

Table 26. Habitat Stresses and Conservation Actions in Agricultural & Developed Habitats:

Habitat Stress	Conservation Action
Conversion to crop agriculture and clean farming practices: loss of grassland, woody vegetation, pollinator habitat, bird breeding and roosting sites	Retain or plant shrubs, hedgerows and hawthorns in pastures, pollinator habitat and grasslands
Wetland loss and degradation in agricultural areas	Protection, restoration and fencing of wetlands
Loss of early-successional habitat in and around agricultural land, overgrazing	Retain early-successional habitat with healthy grasses and forbs, monitor grazing impacts and prevent overgrazing
Chimney capping	Uncap chimneys, install towers for chimney swifts, retain hollow snags and logs
Barn owl poisoning from rodenticides	Outreach to landowners to reduce rodenticides
Insufficient American kestrel and barn owl nest microhabitat	Install and monitor nest boxes
Non-native invasive species	Monitoring and careful treatment, replace with native plantings
Overgrazing and nutrient loading on pastures	Install stream fencing and alternative watering systems, rotational grazing with interior fencing and other ways to avoid overgrazing. Develop nutrient management plans
Water quality degradation around caves and sinkholes	Control livestock access, protect water quality, riparian buffers and natural vegetation around caves and sinkholes

Climate Change and Habitat Resilience

According to Adaptation Resources for Agriculture (Janowiak et al., 2016), agriculture will likely be impacted by many of the same climate changes that affect forest and freshwater habitats. Likely changes include increasing temperatures, longer growing seasons, increasing number of hot days and nights, and changing precipitation patterns. Impacts include increases in the risk of damage to soil, crops and infrastructure from extreme storm and precipitation events, flood damage, soil moisture stress and drought, competition from weeds and invasive plants, crop damage from insects and pathogens, and livestock parasites and pathogens. Butler et al. (2015) also noted that impervious surfaces in developed areas can exacerbate many of these impacts.

Many wildlife species associated with agricultural and developed lands rely on grassland and pasture, fallow fields, floodplain and riparian corridors, streams, wetlands and areas of natural vegetation around field and forest edges. In agricultural settings, these areas may already be degraded and sensitive to disturbance. As we have seen in previous sections of this plan, these areas may also be susceptible to impacts from climate change. Riparian forests may be vulnerable to climate change stressors including increased flood frequency and severity and resulting erosion and sedimentation in streams. Drought may stress streams and aquatic life, as well as plants, and increase their susceptibility to pests and pathogens. Warming temperatures and increased storm disturbances may enable nonnative invasive plant species to outcompete native species.

Janowiak et al. (2016) list numerous strategies to boost the resilience of agriculture to climate change, including maintaining soil health and water quality, reducing competition from weeds and invasive species, creating pollinator habitat, adapting farm infrastructure such as stream crossings to higher peak flows, adapting farm practices or shifting agricultural land use to match changing conditions. Managing farms as part of a larger landscape by maintaining, restoring and connecting natural habitats such as streams, wetlands, riparian areas and forest edges can boost the resilience of farms by buffering hydrological impacts while providing habitat and corridors wildlife to persist and adapt to climate change. In developed areas, limiting and buffering impervious surfaces, and using constructed wetlands and other green infrastructure can also reduce the hydrological impacts of climate change.

Table 27 provides a summary of climate stresses on wildlife habitat in agricultural and developed areas, and actions to boost their resilience. Climate stresses are listed separately, but agricultural habitats are often impacted by multiple climate stresses occurring simultaneously. Therefore, actions to boost habitat resilience are intended to address multiple climate stresses. These actions reinforce conservation actions to reduce stress on priority species in agricultural and developed habitats. WVDNR, partners and landowners can collaborate to select the habitat resilience actions best suited to site conditions, conservation goals and land management objectives.

Table 27. Climate Stresses and Resilience Actions for Agricultural and Developed Habitats

Climate Stress:	Habitat Resilience Action:
<ul style="list-style-type: none"> • Increased flood frequency and severity, erosion and sedimentation • Increased surface water temperatures, low-flow events and water quality degradation • Increased risk of drought and wildfire • Increased competition from nonnative invasive species, pests and pathogens 	<ul style="list-style-type: none"> • Maintain soil health and water quality • Reduce competition from weeds and invasive species • Create pollinator habitat • Maintain, restore and connect aquatic, riparian and forest habitats to buffer against hydrological impacts • Adapt farm practices, infrastructure and land uses to changing conditions • Reduce and buffer impervious surfaces and use green infrastructure to absorb runoff and mitigate hydrological impacts

Implementation Plan

WVDNR will seek to engage the following partners and programs in implementing and measuring the effectiveness of conservation actions in agricultural habitats.

Table 28. Implementation Plan for Agricultural and Developed Habitats.

Action	Partners	Effectiveness Measures
Habitat Protection: <ul style="list-style-type: none"> • Conservation Easements • Land Acquisition 	<ul style="list-style-type: none"> • County Farmland Protection Boards • OHCF, TCF, TNC, WVLT • USDA NRCS • WVDNR 	<ul style="list-style-type: none"> • Acres of habitat protected for priority species • Abundance and diversity of priority species and habitats
Habitat Protection <ul style="list-style-type: none"> • Incentive Programs 	<ul style="list-style-type: none"> • USDA FSA • WVCA and GVCD 	<ul style="list-style-type: none"> • Acres of habitat protected for priority species • Abundance and diversity of priority species and habitats
Reduce clearing of native vegetation such as hawthorns in pastures; retain or plant hedgerows and areas with native plants	<ul style="list-style-type: none"> • USDA FSA & NRCS • WVCA and GVCD • USFWS Partners for Fish and Wildlife Program 	<ul style="list-style-type: none"> • Acres or linear feet of native vegetation planted and protected • Change in abundance, diversity and distribution of priority species and habitats

Action	Partners	Effectiveness Measures
Create and maintain pollinator habitat and nectar resources, including diverse native and non-invasive flowering forbs, shrubs, trees, larval host plants and undisturbed nesting and overwintering areas along field edges, woodlots, water bodies, roads, on fallow fields and other appropriate sites.	<ul style="list-style-type: none"> • Consulting Foresters • USDA NRCS • USFWS Partners for Wildlife Program • WVDOH • Public Land Managers 	<ul style="list-style-type: none"> • Acres or linear feet of pollinator habitat created or maintained • Change in abundance, diversity and distribution of priority species and habitats
Maintain or restore aquatic, riparian and forest habitat as well as species and structural diversity in natural areas in and around farmland and enhance connections between them	<ul style="list-style-type: none"> • Trout Unlimited • USDA FSA & NRCS • WVCA and GVCD • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat restored • Abundance & distribution of priority species and habitats
Create early-successional habitat	<ul style="list-style-type: none"> • USDA NRCS • WVCA and GVCD • Public Land Managers 	<ul style="list-style-type: none"> • Acres of habitat created • Change in abundance, diversity and distribution of priority species and habitats
Prevent conversion of grasslands to croplands	<ul style="list-style-type: none"> • USDA FSA 	<ul style="list-style-type: none"> • Acres of grasslands planted and protected • Change in abundance, diversity and distribution of priority species and habitats
Manage utility corridors to reduce wildlife impacts (implement BMPs promoted by the Wildlife Habitat Council, NRCS and other organizations)	<ul style="list-style-type: none"> • Landowners, partners and utility companies 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance and diversity of priority species
Adjust timing and interval of hay harvest	<ul style="list-style-type: none"> • USDA FSA • WVCA and GVCD 	<ul style="list-style-type: none"> • Acres of hayfields under adjusted harvest schedule • Change in abundance, diversity and distribution of priority species and habitats

Action	Partners	Effectiveness Measures
Monitoring and careful treatment of nonnative invasive species, replace with native plantings	<ul style="list-style-type: none"> • USDA FSA & NRCS • WVCA and GVCD • WVU Extension 	<ul style="list-style-type: none"> • Acres of habitat maintained or restored • Before and after comparison: abundance and diversity of priority species
Install fencing and watering systems, rotational grazing or other ways to avoid overgrazing and nutrient loading	<ul style="list-style-type: none"> • USDA FSA & NRCS • USFWS Partners for Wildlife Program • WVCA and GVCD • WVU Extension 	<ul style="list-style-type: none"> • Acres of habitat restored • Before and after comparison: abundance and diversity of priority species
Control livestock access, protect water quality, riparian buffers and natural vegetation around caves and sinkholes	<ul style="list-style-type: none"> • USDA FSA & NRCS • USFWS Partners for Wildlife Program • WVCA and GVCD • WVU Extension 	<ul style="list-style-type: none"> • Acres of habitat maintained or restored • Before and after comparison: abundance and diversity of priority species
Adapt farm practices, infrastructure and land uses to changing conditions	<ul style="list-style-type: none"> • USDA FSA & NRCS • Public Land Managers 	<ul style="list-style-type: none"> • # practices or acres adapted • Change in abundance, diversity and distribution of priority species
Outreach to landowners to reduce rodenticides for barn owls	<ul style="list-style-type: none"> • WVU Extension • Landowners and volunteer groups 	<ul style="list-style-type: none"> • # of landowners engaged • Reduction in use of rodenticides • Change in abundance, diversity and distribution of priority species
Landowner outreach, uncapping chimneys, install swift towers	<ul style="list-style-type: none"> • WVU Extension • Landowners and volunteer groups 	<ul style="list-style-type: none"> • # chimneys uncapped • # swift towers installed • Change in abundance, diversity and distribution of chimney swifts

Human Benefits

Actions to restore and protect wildlife habitat within agricultural areas and developed lands may provide benefits including erosion control and improved water quality, improved hunting, fishing and recreational opportunities, and conservation of native pollinators for crop production.

Landscape Resilience and Connectivity

For the Greater Greenbrier CFA, the SWAP included the following conservation action:

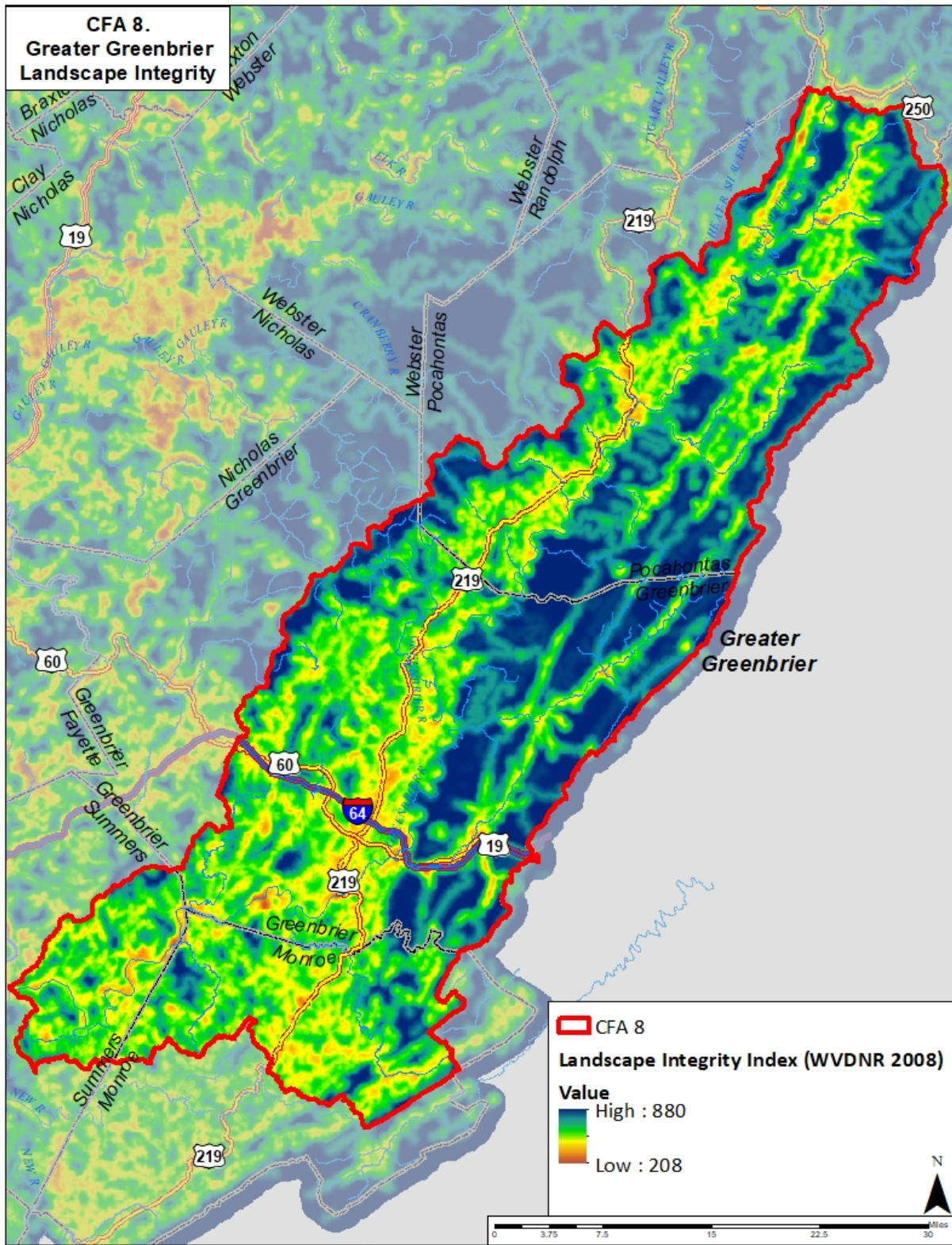
- “Implement a comprehensive plan to enhance climate change resiliency through reducing other stressors, identifying, maintaining and creating key habitat cores and corridors, and protecting areas of high landscape complexity and integrity”.

The conservation and resilience actions described previously in this action plan aim to reduce stressors on priority species in each major habitat type and enhance the resilience of those habitats to climate change. Some of those actions include protecting refugia, core areas of intact habitats and habitat corridors. Habitat cores are patches of high-quality habitat for priority species surrounded by areas with a different community structure, and they serve as nodes in a connected ecological network (Harrison and Odell, 2016; USDA Natural Resources Conservation Service, 2004). Habitat cores identified for protection in this CFA include large forest blocks, wetlands, habitats limited to specific soil types and geology such as shale barrens, cliffs and talus, biologically significant caves and their buffer zones, and core aquatic habitat such as mussel streams. Important habitat corridors identified for protection include connected forest patches, intact river floodplains and small stream riparian forests. Protecting corridors of terrestrial and aquatic habitat connected to habitat patches and larger core areas may allow for species movement and enhance the flow of genetic material in response to climate change (Butler et al., 2015; Anderson et al., 2016a).

Wildlife conservation in changing climate may require conservation actions at a landscape level, across habitat types and beyond individual habitat cores and corridors. Anderson (2016b) summarized a wealth of current research demonstrating how the increasing frequency and severity of storms, floods, droughts and fires may cause species to respond by shifting location or behavior within their existing habitat, evolving to adapt to new conditions, or shifting their distributions across the landscape. Evidence has been documented for over 1000 species currently shifting one of four ways: locally toward suitable microclimate, upslope to higher elevations, downslope towards moist riparian areas and northward toward cooler latitudes. However, landscape fragmentation has been shown to slow movement in response to climate change. Enabling wildlife to shift and adapt to climate change will require the conservation of a network of unfragmented landscapes within which species can shift their range to more suitable local microclimates or upslope, downslope or northward.

In 2008 the WVDNR developed a model of landscape integrity to identify unfragmented landscapes. The map on the subsequent page illustrates areas of high landscape integrity in the CFA. Landscape integrity is estimated to increase with distance from roads, powerlines, development and other features that fragment the landscape. These high integrity landscapes tend to correspond to larger forest patches and most lie within public lands including the Monongahela National Forest, State Forests and Wildlife Management Areas protecting large forest patches along the eastern and central portions of the CFA. The lands along Allegheny Mountain, along the east edge of the CFA form a particularly important migratory pathway, the southern end of which is mostly in private ownership. High integrity landscapes in public and private ownership, especially those along migratory pathways, are conservation priorities in this CFA.

Map 15. Landscape Integrity



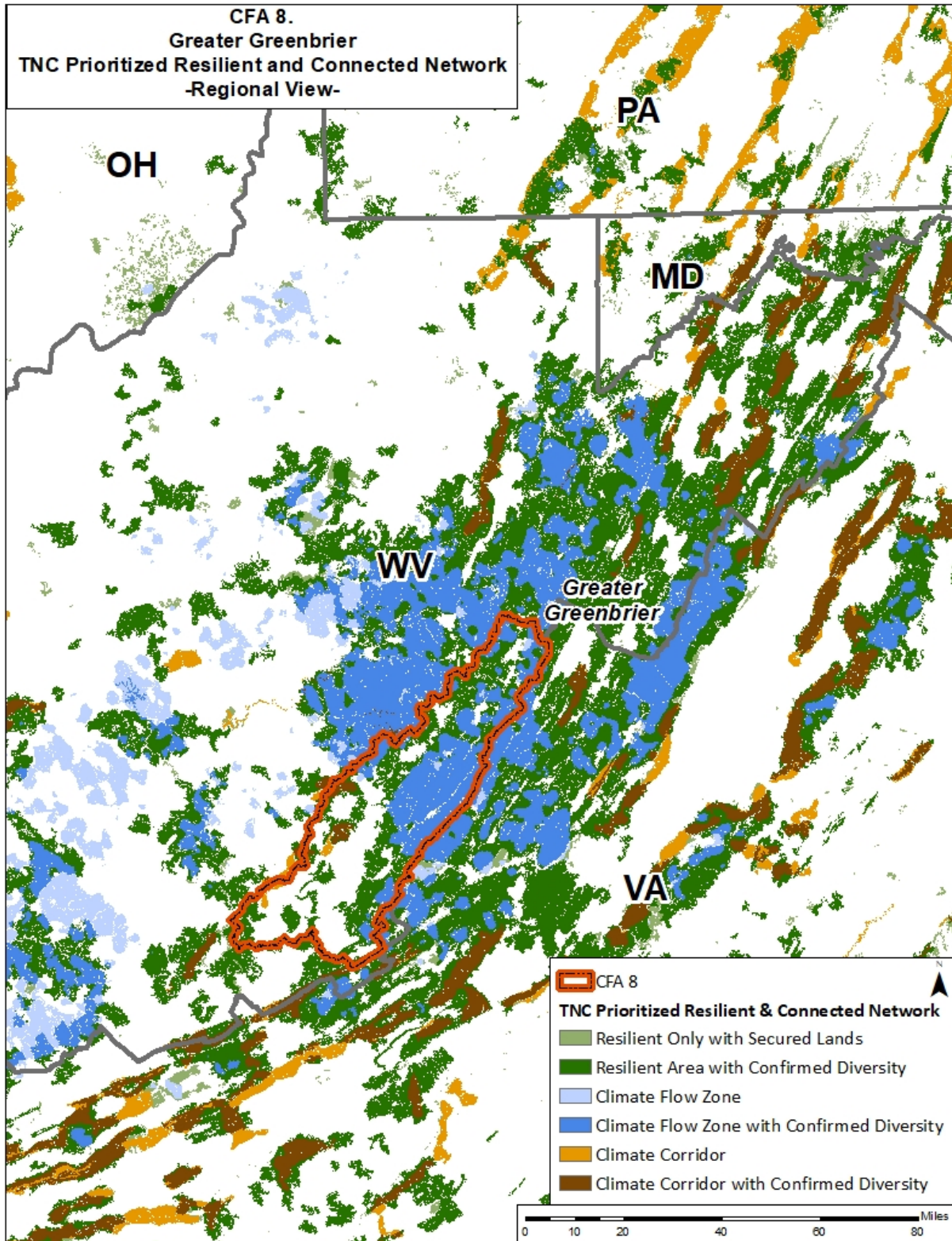
Building on the concept of landscape integrity, The Nature Conservancy (TNC) led a team of 60 scientists to identify areas representing all geophysical settings, with varied microclimates and natural cover, that were most likely to sustain native plants and animals and natural processes into the future and be resilient to climate change. The team identified resilient sites as those with topographic and elevation diversity that offer a range of habitat types and microclimates for species and ecosystems to adapt to climate change, along with high landscape integrity or local connectedness where species could move locally and disperse in response to climate change, and where natural processes like fire and floods could continue unimpeded. These are core areas for species movement and adaptation at a local level. They then modeled the movement or flow of species across the landscape over time in response to climate change, as constrained by natural and human-caused barriers. This led to the identification of corridors of constrained movement and flow zones of dispersed movement. These are corridors and core areas for species movement and adaptation at a landscape level. Lastly the team developed models that integrated landscape resilience, connectivity and the flow of species and populations across the landscape to identify a connected network of sites that represents the full suite of geophysical settings, includes known records of biological diversity and has the configuration and connections necessary to support the continued movement of species in response to change conditions. To identify the subset of places most essential for sustaining biodiversity in a changing climate and aligned to the natural flow patterns across the region, the team then identified the most resilient and diverse lands representing all of the region's geophysical settings, recorded occurrences of biological diversity, resilient lands already secured through public ownership or conservation easements, and the riparian corridors and other landscape linkages with the most concentrated movement of species. This prioritized network covers 23% of the land in the Eastern United States.

This work is documented in Resilient Sites for Terrestrial Conservation in Eastern North America (Anderson et al., 2016a) and Resilient and Connected Landscapes for Terrestrial Conservation (Anderson et al., 2016b). The studies produced a series of maps (see <http://maps.tnc.org/resilientland/>) that identified the following areas:

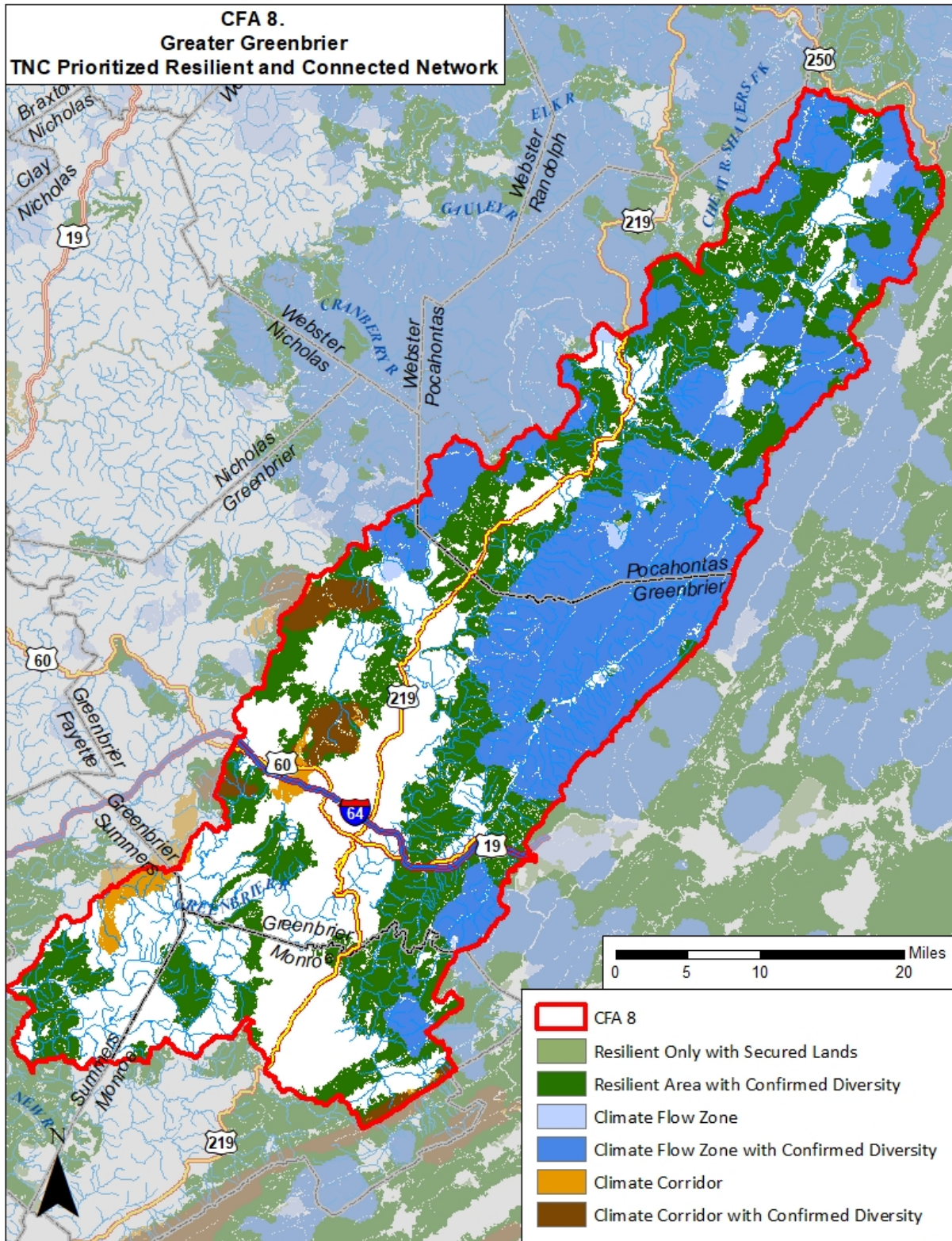
- Resilient area: a place buffered from climate change because it contains diverse, complex, connected landscapes with many micro-climates that create options for species adapting to climate change
- Climate corridor: a narrow conduit of natural cover in which the movement of plants and animals becomes concentrated, often along a stream corridor or ridgeline
- Climate flow zone: areas with high levels of plant and animal movement that is less concentrated than in a corridor, such as an intact forest patches and areas of high integrity

Map 16 illustrates that the resilient, connected landscapes in the northern and eastern portions the CFA form part of a hub of large forest blocks, resilient landscapes and flow zones that link the narrower climate corridors both north into Maryland and Pennsylvania and south into Virginia. The resilient, connected landscapes in this CFA are critical to the species adapting to climate change within the larger network across the Eastern United States.

Map 16. Priority Resilient and Connected Network: Regional View



Map 17. Priority Resilient and Connected Network – Detailed View



Map 17 provides a detailed view of the resilient, connected landscapes in the Greater Greenbrier CFA. On the eastern half of the CFA there is a network of climate flow zones and resilient areas stretching from Monroe County in the south, up through Greenbrier County and into Pocahontas County, following the eastern border of the state. This is an important migratory pathway. There are also several more isolated patches of resilient land and narrower climate corridors in the CFA. These priority resilient and connected landscapes contain the CFA’s large forest patches and high integrity areas, an important migratory corridor, several biologically significant caves and buffer areas, and most of the CFA’s rock outcrop, cliff and talus, shale barren habitats and known biodiversity.

Protecting and maintaining these areas of high landscape integrity and the resilient areas, climate corridors and climate flow zones within the region’s priority resilient and connected network is critical in order to enable priority SGCN and their habitat to adapt to climate change and persist in this CFA. These areas are priorities for conservation action within the CFA.

The table below summarizes conservation actions for climate resilience to address stresses from climate change at a landscape level.

Table 29. Climate Stresses and Actions for Landscape Resilience and Connectivity

Climate Stress	Conservation Action
<ul style="list-style-type: none"> • Changing conditions exacerbating existing stresses on species and habitat • Species responding to climate change by shifting locally as well as across the landscape • Landscape fragmentation that prevents or constrains species movement 	<ul style="list-style-type: none"> • Protect and maintain a connected network of resilient landscapes, flow zones and climate corridors across the landscape for species to adapt and shift locally and regionally in response to climate change

Implementation Plan

The resilient and connected landscapes in this CFA provide critical links to the larger network of resilient and connected landscapes in West Virginia, Maryland, Virginia, the Central Appalachians and Eastern North America. They provide a blueprint of habitat cores and corridors where conservation actions to restore, maintain and protect natural habitat and remove barriers to movement will be crucial to enabling priority species and habitats to shift and adapt to climate change at both local and regional scales. The following implementation plan lists specific actions to protect, maintain and restore the network of resilient, connected lands within the CFA.

Table 30. Implementation Plan for Landscape Resilience and Connectivity

Action	Partners	Effectiveness Measures
Protection of Resilient, Connected Landscapes and migratory corridors <ul style="list-style-type: none"> • Conservation Easements • Land Acquisition 	<ul style="list-style-type: none"> • County Farmland Protection Boards • OHCF, TCF, TNC, WVLT • USDA NRCS • WVDNR 	<ul style="list-style-type: none"> • Acres of habitat protected for priority species in resilient landscapes and climate corridors • Abundance & distribution of priority species and habitats
Protection of Resilient, Connected Landscapes <ul style="list-style-type: none"> • Land use planning 	<ul style="list-style-type: none"> • County Planning Commissions 	<ul style="list-style-type: none"> • Acres of habitat protected through land use planning in resilient, connected landscapes
Protection of Resilient, Connected Landscapes <ul style="list-style-type: none"> • Incentive Programs • Forest Carbon projects • Forest Certification Programs 	<ul style="list-style-type: none"> • USDA FSA & NRCS • Consulting Foresters • AFF, TNC • ATFS, FSC, SFI 	<ul style="list-style-type: none"> • Acres of habitat protected for priority species in resilient landscapes and climate corridors • Abundance & distribution of priority species and habitats
Protection of Resilient, Connected Landscapes <ul style="list-style-type: none"> • Conservation and Management 	<ul style="list-style-type: none"> • AFF, AMJV, NWTF, RGS, TNC • Forest Certification Programs: ATFS, FSC, SFI • WVDNR • WVDOF • Private Landowners • Public Land Managers • Partner Organizations 	<ul style="list-style-type: none"> • Acres of habitat protected, restored and maintained in resilient landscapes and climate corridors • Abundance & distribution of priority species and habitats

Conclusion

Habitat Conservation Priorities

This action plan lists priority species and rare plant communities targeted for conservation action on public and private land and within each major habitat type. The major habitat types include forests and woodlands, barrens, cliffs and talus, caves and karst, aquatic, riparian, floodplain, developed and agricultural habitats. For each major habitat type the plan identifies stresses that affect priority species, conservation actions to reduce those stresses, climate stresses on those habitats, actions to boost resilience, partners that can assist with conservation actions to implement the plan and the human benefits of conservation.

Below is a list of the priority habitats identified by this Action Plan for conservation action.

- Large, intact forest patches, including interior forest habitat
- Early-successional forest habitat
- Small areas of unique, geologically derived habitat including:
 - Acidic rock outcrops, cliffs and talus
 - Calcareous cliffs and talus
 - Shale and heath grass barrens
- The state's largest karst areas, caves and their watersheds
- Buffer areas surrounding biologically significant caves
- Special aquatic habitats, such as mussel streams and wetlands
- Small stream riparian and river floodplain habitats
- Riparian corridors, wetlands, grasslands and fallow fields, field borders and other areas of natural and woody vegetation within and around agricultural lands
- High integrity, resilient and connected landscapes and migratory corridors.

These priority habitats include habitat cores and corridors that are critical for maintaining wildlife populations in this CFA. To protect priority SGCN and enable them to adapt to changing conditions within these priority habitats, landowners and partner organizations are encouraged to plan and implement conservation actions to alleviate stresses on priority species and boost habitat resilience, and carefully monitor the results using an adaptive management framework such as the Climate Smart Conservation Cycle included in the introduction. Stakeholders are also encouraged to coordinate with relevant agencies to develop strategies to avoid, minimize and mitigate for impacts to these priority habitats.

Integration of Conservation Actions

Integration of conservation actions within the above priority habitats, such as projects to improve mussel stream habitat by improving wastewater treatment, enlarging stream crossings and planting riparian stream buffers may benefit multiple plant communities and wildlife species. Coordinating actions across multiple habitats, such as protecting large patches of diverse forest habitats that also include rare shale barrens, rock outcrops or cliff and talus habitats, or improving water quality and

planting riparian corridors in karst landscapes or cave watersheds, may benefit additional species. Private landowners, public land managers and conservation partners are encouraged to focus resources across priority habitats to maximize benefits to multiple species.

Connecting Conservation Actions for Climate Resilience

As we have seen, conservation actions to relieve stresses on priority species and efforts to boost the resilience of wildlife habitat are essential for enabling climate adaptation. Protecting areas of high landscape integrity as well as the regional network of resilient lands, climate corridors and flow zones is also critical for enabling wildlife species to adapt to changing conditions and shift across the landscape.

Furthermore, creating local networks of connected habitat cores and corridors will enhance their resilience and connectivity, and the ability of wildlife species to adapt to changing conditions within this CFA. Connected local networks of headwater streams and larger rivers, their riparian corridors, floodplains and wetlands enhances the stability of these habitats and enables fish, reptiles, birds and other priority wildlife species that depend on those habitats to move across the landscape as conditions change. Maintaining connections between patches of diverse forest habitat and with rare shale barrens, rock outcrops, cliff and talus, karst or cave habitat buffers enhances the resilience of these habitats and enables forest species to move to optimal sites as conditions change. Conservation of aquatic, riparian and floodplain corridors along with areas of native vegetation in and around agricultural areas, small forest patches and larger blocks of forest habitat can create a local network of resilient, connected lands that merges into the larger regional network. Beyond undertaking conservation actions in the priority habitats listed above and protecting the regional network of resilient and connected lands, stakeholders are encouraged to restore and protect the connections between these areas in order to maintain an interwoven fabric of natural systems for native plants and animals to thrive long into the future.

Next Steps in Implementation

WVDNR engaged a working group of partner organizations and public land managers in developing this Action Plan and will seek to remain engaged by convening semi-annual meetings with the working group to collaborate on actions including the following:

- Planning, implementing and evaluating ongoing field surveys of priority species to document and monitor their abundance, distribution, population trends, vulnerability and range shifts
- Planning, implementing, monitoring and evaluating the results of the conservation actions
- Engaging and supporting private landowners in this work.

WVDNR may lead some of these efforts but will most often play the role of supporting efforts by the many partners active in this CFA with ongoing projects, established programs and connections with landowners. In the case of public lands, WVDNR will also seek to incorporate conservation actions targeting priority species, habitats and priority areas for conservation action into agency planning processes and support those actions. WVDNR will also work with state agencies and other authorities to promote avoidance, minimization and mitigation for development impacts to priority habitats and other priority areas for conservation action.

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Appendix 1. SGCN in the Greater Greenbrier CFA

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Amphibians	<i>Ambystoma jeffersonianum</i>	Jefferson Salamander	S2	G4			
Amphibians	<i>Aneides aeneus</i>	Green Salamander	S3	G3		S	
Amphibians	<i>Cryptobranchus alleganiensis</i>	Eastern Hellbender	S2	G3		S	
Amphibians	<i>Desmognathus quadramaculatus</i>	Black-bellied Salamander	S3	G5			
Amphibians	<i>Eurycea lucifuga</i>	Cave Salamander	S3	G5			
Amphibians	<i>Gyrinophilus subterraneus</i>	West Virginia Spring Salamander	S1	G1			
Amphibians	<i>Lithobates pipiens</i> (R. <i>pipiens</i>)	Northern Leopard Frog	S1	G5			
Amphibians	<i>Plethodon nettingi</i>	Cheat Mountain Salamander	S2	G2	T		
Amphibians	<i>Plethodon wehrlei</i>	Wehrle's Salamander	S4	G4			
Amphibians	<i>Pseudacris feriarum</i>	Upland Chorus Frog	S3	G5			
Amphibians	<i>Pseudotriton ruber ruber</i>	Northern Red Salamander	S3	G5			
Birds	<i>Aegolius acadicus</i>	Northern Saw-whet Owl	S2B,S2N	G5			
Birds	<i>Ammodramus henslowii</i>	Henslow's Sparrow	S1B	G4		S	
Birds	<i>Ammodramus savannarum</i>	Grasshopper Sparrow	S3B	G5	R		
Birds	<i>Antrostomus carolinensis</i>	Chuck-will's-widow	S1B	G5			
Birds	<i>Antrostomus vociferus</i>	Eastern Whip-poor-will	S3B	G5			At Risk-Conserv
Birds	<i>Aquila chrysaetos</i>	Golden Eagle	S3N	G5			
Birds	<i>Bonasa umbellus</i>	Ruffed Grouse	S3B,S3N	G5	R		
Birds	<i>Buteo platypterus</i>	Broad-winged Hawk	S3B	G5			
Birds	<i>Butorides virescens</i>	Green Heron	S3B				
Birds	<i>Cardellina canadensis</i>	Canada Warbler	S3B	G5			
Birds	<i>Carduelis pinus</i>	Pine Siskin	S2B,S4N	G5			
Birds	<i>Catharus fuscescens</i>	Veery	S3B	G5			

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Birds	<i>Chaetura pelagica</i>	Chimney Swift	S3B	G5			
Birds	<i>Circus cyaneus</i>	Northern Harrier	S1B,S3N	G5			
Birds	<i>Coccyzus erythrophthalmus</i>	Black-billed Cuckoo	S2B	G5			
Birds	<i>Colinus virginianus</i>	Northern Bobwhite	S1B, S1N	G5			
Birds	<i>Dolichonyx oryzivorus</i>	Bobolink	S3B	G5	R		
Birds	<i>Eremophila alpestris</i>	Horned Lark	S2B,S3N	G5			
Birds	<i>Falco peregrinus</i>	Peregrine Falcon	S2B,S2N	G4		S	
Birds	<i>Falco sparverius</i>	American Kestrel	S3B	G5			
Birds	<i>Geothlypis formosa</i>	Kentucky Warbler	S3B	G5	R		
Birds	<i>Haliaeetus leucocephalus</i>	Bald Eagle	S3B,S3N	G5		S	
Birds	<i>Helmitheros vermivorum</i>	Worm-eating Warbler	S3B	G5	R		
Birds	<i>Hylocichla mustelina</i>	Wood Thrush	S3B	G5	R		At Risk-Conserv
Birds	<i>Icteria virens</i>	Yellow-breasted Chat	S3B	G5			
Birds	<i>Lanius ludovicianus</i>	Loggerhead Shrike	S1B,S1N	G3			
Birds	<i>Lanius ludovicianus migrans</i>	Migrant Loggerhead Shrike	S1B,S1N	T3		S	
Birds	<i>Lophodytes cucullatus</i>	Hooded Merganser	S1B,S4N	G5			
Birds	<i>Loxia curvirostra</i>	Red Crossbill	S2B,S2N	G5			
Birds	<i>Parkesia motacilla</i>	Louisiana Waterthrush	S3B	G5			
Birds	<i>Petrochelidon pyrrhonota</i>	Cliff Swallow	S3B	G5			
Birds	<i>Piranga rubra</i>	Summer Tanager	S3B	G5			
Birds	<i>Podilymbus podiceps</i>	Pied-billed Grebe	S2B,S4N	G5			
Birds	<i>Poocetes gramineus</i>	Vesper Sparrow	S2B, S2N	G5		S	
Birds	<i>Riparia riparia</i>	Bank Swallow	S2B	G5	R		
Birds	<i>Scolopax minor</i>	American Woodcock	S3B	G5	R		
Birds	<i>Seiurus noveboracensis</i>	Northern Waterthrush	S2B	G5			
Birds	<i>Setophaga cerulea</i>	Cerulean Warbler	S2B	G4		S	At Risk-Conserv

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Birds	<i>Setophaga discolor</i>	Prairie Warbler	S3B	G5	R	S	
Birds	<i>Spiza americana</i>	Dickcissel	S1B	G5			
Birds	<i>Spizella pusilla</i>	Field Sparrow	S3B, S3N	G5	R		
Birds	<i>Sturnella magna</i>	Eastern Meadowlark	S3B, S2N	G5	R		
Birds	<i>Tyto alba</i>	Barn Owl	S2B,S2N	G5			
Birds	<i>Vermivora chrysoptera</i>	Golden-winged Warbler	S1B	G4		S	At Risk- Conserv
Birds	<i>Vermivora cyanoptera</i>	Blue-winged Warbler	S3B	G5			
Butterflies & Moths	<i>Boloria selene myrina</i>	Silver-bordered Fritillary	S3	T5			
Butterflies & Moths	<i>Calephelis borealis</i>	Northern Metalmark	S2	G3		S	
Butterflies & Moths	<i>Catocala dulciola</i>	Sweet Underwing	SU	G3			
Butterflies & Moths	<i>Celastrina nigra</i>	Dusky Azure	S3	G4			
Butterflies & Moths	<i>Erora laeta</i>	Early Hairstreak	S2	GU		S	
Butterflies & Moths	<i>Erynnis martialis</i>	Mottled Duskywing	S3	G3			
Butterflies & Moths	<i>Euchlaena milnei</i>	Milne's Euchlaena Moth	S2	G3		S	
Butterflies & Moths	<i>Euphyes bimacula</i>	Two-spotted Skipper	S1	G4			
Butterflies & Moths	<i>Glaucopsyche l. lygdamus</i>	Silvery Blue	S4	T3			
Butterflies & Moths	<i>Hadena ectypa</i>	Starry Champion Moth	S1	G3		S	
Butterflies & Moths	<i>Hesperia metea</i>	Cobweb Skipper	S2S3	G4		S	
Butterflies & Moths	<i>Papilio appalachiensis</i>	Appalachian Tiger Swallowtail	SNR	G4			
Butterflies & Moths	<i>Parrhasius m-album</i>	White-m Hairstreak	S2	G5			
Butterflies & Moths	<i>Phyciodes cocyta diminutor</i>	Summer Crescent	SNR	GNR			
Butterflies & Moths	<i>Pieris virginiensis</i>	West Virginia White	S3	G3		S	
Butterflies & Moths	<i>Polygonia faunus smythi</i>	Smyth's Green Comma	S1	T3		S	
Butterflies & Moths	<i>Polygonia progne</i>	Gray Comma	S3	G4			
Butterflies & Moths	<i>Pyrgus (centaureae) wyandot</i>	Grizzled Skipper	S1	G1		S	At Risk- Science
Butterflies & Moths	<i>Satyrium edwardsii</i>	Edwards' Hairstreak	S2	G4			

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Butterflies & Moths	<i>Speyeria atlantis</i>	Atlantis Fritillary	S3	G5			
Butterflies & Moths	<i>Speyeria diana</i>	Diana Fritillary	S2S3	G3		S	
Butterflies & Moths	<i>Speyeria idalia</i>	Regal Fritillary	SH	G3			
Cave Invertebrates	<i>Anthrobia coylei</i>	Spider	S2	GNR			
Cave Invertebrates	<i>Arrhopalites commorus</i>	A Collembola	S1	G3			
Cave Invertebrates	<i>Arrhopalites pavo</i>	A Cave Springtail	S1S2	G1		S	
Cave Invertebrates	<i>Arrhopalites sacer</i>	A Collembola	S1	G1			
Cave Invertebrates	<i>Bathyphantes weyeri</i>	A Cave Spider	S3	G4			
Cave Invertebrates	<i>Caecidotea holsingeri</i>	Greenbrier Valley Cave Isopod	S3	G5		S	
Cave Invertebrates	<i>Chitrella regina</i>	Royal Syarinid Pseudoscorpion	S1	G1			
Cave Invertebrates	<i>Crangonyx sp. 2</i>	An Amphipod	S2	G2			
Cave Invertebrates	<i>Gammarus minus tenuipes</i>	An Amphipod	S2	GNR			
Cave Invertebrates	<i>Haplotaxis brinkhursti</i>	An Oligochaete	S1	G1			
Cave Invertebrates	<i>Horologion speokites</i>	Arbuckle Cave Ground Beetle	SH	GH			
Cave Invertebrates	<i>Kleptochthonius henroti</i>	Greenbrier Valley Cave Pseudoscorpion	S1	G3			
Cave Invertebrates	<i>Kleptochthonius hetricki</i>	Organ Cave Pseudoscorpion	S1	G1			
Cave Invertebrates	<i>Kleptochthonius orpheus</i>	Orpheus Cave Pseudoscorpion	S1	G1			
Cave Invertebrates	<i>Kleptochthonius proserpinae</i>	Proserpina Cave Pseudoscorpion	S1	G1			
Cave Invertebrates	<i>Litocampa fieldingi</i>	Diplura	S2	G3			
Cave Invertebrates	<i>Litocampa sp. 1</i>	Diplura	S1	G1			
Cave Invertebrates	<i>Macrocotyla hoffmasteri</i>	Hoffmaster's Cave Flatworm	S2	G3			
Cave Invertebrates	<i>Onychiurus janus</i>	A Cave Springtail	S1	G2			
Cave Invertebrates	<i>Phanetta subterranea</i>	A Spider	S3	G5			
Cave Invertebrates	<i>Poecilophysis extraneostella</i>	A Cave Mite	S2	G2			

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Cave Invertebrates	<i>Poecilophysis weyerensis</i>	A Cave Mite	S1	G3			
Cave Invertebrates	<i>Porrhomma cavernicola</i>	Appalachian Cave Spider	S2	G5			
Cave Invertebrates	<i>Pseudanopthalmus fuscus</i>	A Cave Beetle	S2	G4		S	
Cave Invertebrates	<i>Pseudanopthalmus grandis elevatus</i>	A Cave Beetle	S1	G2			
Cave Invertebrates	<i>Pseudanopthalmus grandis grandis</i>	A Cave Beetle	S3	G3			
Cave Invertebrates	<i>Pseudanopthalmus henroti</i>	A Cave Beetle	S2	GNR			
Cave Invertebrates	<i>Pseudanopthalmus higinbothami</i>	A Cave Beetle	S2	G3			
Cave Invertebrates	<i>Pseudanopthalmus hypertrichosis</i>	A Cave Beetle	S3	G5		S	
Cave Invertebrates	<i>Pseudanopthalmus lallemanti</i>	Lallemant's Cave Beetle	S1	G1			
Cave Invertebrates	<i>Pseudanopthalmus sp. 3</i>	A Beetle	S1	G1			
Cave Invertebrates	<i>Pseudosinella gisini gisini</i>	A Cave Springtail	S3	G3		S	
Cave Invertebrates	<i>Pseudosinella orba</i>	A Cave Springtail	S1	G3			
Cave Invertebrates	<i>Pseudosinella sp. 8</i>	A Springtail	S2	G2			
Cave Invertebrates	<i>Pseudotremia fulgida</i>	Greenbrier Valley Cave Millipede	S3	G4			
Cave Invertebrates	<i>Pseudotremia sp. 1</i>	General Davis Cave Millipede	S1	G1			
Cave Invertebrates	<i>Rhagidia varia</i>	A Cave Mite	S3	G5			
Cave Invertebrates	<i>Sinella agna</i>	A Springtail	S3	G2		S	
Cave Invertebrates	<i>Sinella hoffmani</i>	Hoffman's Springtail	S3	G5			
Cave Invertebrates	<i>Stygobromus emarginatus</i>	Greenbrier Cave Amphipod	S3	G3		S	
Cave Invertebrates	<i>Stygobromus nanus</i>	Pocahontas Cave Amphipod	S1	G1		S	
Cave Invertebrates	<i>Stygobromus parvus</i>	Minute Cave Amphipod	S1	G2		S	
Cave Invertebrates	<i>Stygobromus pollostus</i>	An Amphipod	S1	G2			
Cave Invertebrates	<i>Stygobromus redactus</i>	An Amphipod	S1	G1			
Cave Invertebrates	<i>Stygobromus spinatus</i>	Spring Cave Amphipod	S2	G2			

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Cave Invertebrates	<i>Stylodrilus beattiei</i>	A Cave Lumbriculid Worm	S1	G2			
Cave Invertebrates	<i>Trichodrilus culveri</i>	An Oligochaete	S1	G2			
Cave Invertebrates	<i>Zygonopus packardi</i>	Packard's Blind Cave Millipede	S2	G4			
Cave Invertebrates	<i>Zygonopus weyeri</i>	Grand Caverns Blind Cave Millipede	S2	G3		S	
Crayfish	<i>Cambarus chasmodactylus</i>	New River Crayfish	S3	G4			
Crayfish	<i>Cambarus nerterius</i>	An Underground Crayfish	S1?	G2		S	
Crayfish	<i>Cambarus pauleyi</i>	Meadow River Mudbug	S2	GNR			
Crayfish	<i>Cambarus smilax</i>	Greenbrier River Crayfish	S2	GNR		S	
Dragonflies/Damselflies	<i>Aeshna tuberculifera</i>	Black-tipped Darner	S3	G4			
Dragonflies/Damselflies	<i>Anax longipes</i>	Comet Darner	S3	G5			
Dragonflies/Damselflies	<i>Celithemis fasciata</i>	Banded Pennant	S3	G5			
Dragonflies/Damselflies	<i>Cordulegaster obliqua</i>	Arrowhead Spiketail	S2	G4			
Dragonflies/Damselflies	<i>Cordulia shurtleffi</i>	American Emerald	S4	G5			
Dragonflies/Damselflies	<i>Enallagma annexum</i>	Northern Bluet	S3	G5			
Dragonflies/Damselflies	<i>Enallagma antennatum</i>	Rainbow Bluet	S1S2	G5			
Dragonflies/Damselflies	<i>Enallagma vernale</i>	Vernal Bluet	S1	G4			
Dragonflies/Damselflies	<i>Enallagma vesperum</i>	Vesper Bluet	S3	G5			
Dragonflies/Damselflies	<i>Epiaeschna heros</i>	Swamp Darner	S3	G5			
Dragonflies/Damselflies	<i>Gomphus adelphus</i>	Mustached Clubtail	S1	G4			
Dragonflies/Damselflies	<i>Gomphus descriptus</i>	Harpoon Clubtail	S2S3	G4			
Dragonflies/Damselflies	<i>Gomphus fraternus</i>	Midland Clubtail	S2	G5			
Dragonflies/Damselflies	<i>Gomphus lineatifrons</i>	Splendid Clubtail	S2	G4			
Dragonflies/Damselflies	<i>Gomphus quadricolor</i>	Rapids Clubtail	S3	G3		S	
Dragonflies/Damselflies	<i>Gomphus rogersi</i>	Sable Clubtail	S1	G4			
Dragonflies/Damselflies	<i>Gomphus vastus</i>	Cobra Clubtail	S2	G5			
Dragonflies/Damselflies	<i>Gomphus viridifrons</i>	Green-faced Clubtail	S3	G3		S	

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Dragonflies/Damselflies	<i>Helocordulia uhleri</i>	Uhler's Sundragon	S2S3	G5			
Dragonflies/Damselflies	<i>Ladona deplanata</i>	Blue Corporal	S3	G5			
Dragonflies/Damselflies	<i>Lanthus parvulus</i>	Northern Pygmy Clubtail	S3	G4			
Dragonflies/Damselflies	<i>Lestes disjunctus</i>	Northern Spreadwing	S3	G5			
Dragonflies/Damselflies	<i>Lestes forcipatus</i>	Sweetflag Spreadwing	S3	G5			
Dragonflies/Damselflies	<i>Lestes inaequalis</i>	Elegant Spreadwing	S3	G5			
Dragonflies/Damselflies	<i>Macromia alleghaniensis</i>	Allegheny River Cruiser	S2S3	G4			
Dragonflies/Damselflies	<i>Macromia illinoensis</i>	Illinois River Cruiser	S3	G5			
Dragonflies/Damselflies	<i>Nehalennia gracilis</i>	Sphagnum Sprite	S1	G5			
Dragonflies/Damselflies	<i>Neurocordulia yamaskanensis</i>	Stygian Shadowdragon	S3	G5			
Dragonflies/Damselflies	<i>Ophiogomphus carolus</i>	Riffle Snaketail	S2	G5			
Dragonflies/Damselflies	<i>Ophiogomphus mainensis fastigiatus</i>	Maine Snaketail	S3	G4			
Dragonflies/Damselflies	<i>Ophiogomphus rupinsulensis</i>	Rusty Snaketail	S2	G5			
Dragonflies/Damselflies	<i>Somatochlora linearis</i>	Mocha Emerald	S3	G5			
Dragonflies/Damselflies	<i>Stylurus scudderi</i>	Zebra Clubtail	SH	G4			
Dragonflies/Damselflies	<i>Tachopteryx thoreyi</i>	Gray Petaltail	S3	G4			
Dragonflies/Damselflies	<i>Tramea carolina</i>	Carolina Saddlebags	S3	G5			
Fish	<i>Ameiurus nebulosus</i>	Brown Bullhead	S2	G5			
Fish	<i>Cottus kanawhae</i>	Kanawha Sculpin	S2	G4			
Fish	<i>Etheostoma osburni</i>	Candy Darter	S1	G3	E	S	
Fish	<i>Exoglossum laurae</i>	Tonguetied Minnow	S2	G4		S	
Fish	<i>Lythrurus ardens</i>	Rosefin Shiner	S1	G5			
Fish	<i>Notropis scabriceps</i>	New River Shiner	S2	G4		S	
Fish	<i>Percina gymnocephala</i>	Appalachia Darter	S2	G4		S	
Fish	<i>Phenacobius teretulus</i>	Kanawha Minnow	S1	G3		S	
Mammals	<i>Erethizon dorsatum</i>	Porcupine	S3	G5			
Mammals	<i>Glaucomys sabrinus fuscus</i>	WV Northern Flying Squirrel	S2	G2		S	

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Mammals	<i>Lasionycteris noctivagans</i>	Silver-haired Bat	S2	G5			
Mammals	<i>Lasiurus borealis</i>	Eastern Red Bat	S4	G5			
Mammals	<i>Microtus chrotorrhinus carolinensis</i>	Southern Rock Vole	S2	G3		S	
Mammals	<i>Myotis leibii</i>	Eastern Small-footed Bat	S1	G3		S	
Mammals	<i>Myotis lucifugus</i>	Little Brown Myotis	S2*	G3	R	S	
Mammals	<i>Myotis septentrionalis</i>	Northern Long-eared Bat	S2*	G2	T		
Mammals	<i>Myotis sodalis</i>	Indiana Bat	S1	G2	E		
Mammals	<i>Neotoma magister</i>	Allegheny Woodrat	S3	G3		S	
Mammals	<i>Perimyotis subflavus</i>	Tricolored Bat	S2*	G3		S	
Mammals	<i>Reithrodontomys humulis</i>	Eastern Harvest Mouse	SH	G5			
Mammals	<i>Sorex dispar</i>	Long-tailed Shrew	S2S3	G4		S	
Mammals	<i>Sorex hoyi winnemana</i>	Southern Pygmy Shrew	S2S3	G4			
Mammals	<i>Sorex palustris punctulatus</i>	Southern Water Shrew	S1	G3		S	
Mammals	<i>Spilogale putorius</i>	Eastern Spotted Skunk	S1	G5		S	
Mammals	<i>Sylvilagus obscurus</i>	Appalachian Cottontail	S2	G4		S	
Mammals	<i>Synaptomys cooperi</i>	Southern Bog Lemming	S3	G5		S	
Mammals	<i>Zapus hudsonius</i>	Meadow Jumping Mouse	S3	G5			
Mussels	<i>Actinonaias ligamentina</i>	Mucket	S3	G5			
Mussels	<i>Alasmidonta marginata</i>	Elktoe	S1	G4		S	
Mussels	<i>Cyclonaias tuberculata</i>	Purple Wartyback	S1	G5			
Mussels	<i>Elliptio dilatata</i>	Spike	S3	G5			
Mussels	<i>Lampsilis cardium</i>	Plain Pocketbook	S3	G5			
Mussels	<i>Lampsilis fasciola</i>	Wavy-rayed Lampmussel	S3	G5			
Mussels	<i>Lasmigona subviridis</i>	Green Floater	S2	G3		S	At Risk-Conserv
Mussels	<i>Tritogonia verrucosa</i>	Pistolgrip	S3	G4			
Other Invertebrates	<i>Allocapnia frumi</i>	A Stonefly	S2	G2			At Risk-Science

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Other Invertebrates	<i>Utaperla gaspesiana</i>	A Stonefly	S1	G3			At Risk- Science
Plants	<i>Aconitum reclinatum</i>	White Monkshood	S3	G3			
Plants	<i>Ageratina aromatica</i> var. <i>aromatica</i>	Small White Snakeroot	S1	T5			
Plants	<i>Allium oxyphilum</i>	Nodding Wild Onion	S2	G2		S	
Plants	<i>Amelanchier bartramiana</i>	Oblong-fruit Serviceberry	S2	G5		S	
Plants	<i>Anemone quinquefolia</i> var. <i>minima</i>	Dwarf Anemone	S2	T3			
Plants	<i>Arabis hirsuta</i> ssp. <i>pycnocarpa</i>	Hairy Rockcress	S2	T5			
Plants	<i>Arabis serotina</i>	Shalebarren Rockcress	S2	G2	E		
Plants	<i>Arundinaria gigantea</i> ssp. <i>gigantea</i>	Giant Cane	S2	T5			
Plants	<i>Baptisia australis</i> var. <i>australis</i>	False Blue Indigo	S3	T3		S	
Plants	<i>Berberis canadensis</i>	American Barberry	S1	G3			
Plants	<i>Bouteloua curtipendula</i> var. <i>curtipendula</i>	Sideoats Grama	S3	T5			
Plants	<i>Calopogon tuberosus</i> var. <i>tuberosus</i>	Tuberous Grass-pink	S1	T5			
Plants	<i>Calystegia spithamea</i> ssp. <i>purshiana</i>	Shale Bindweed	S3	T4			
Plants	<i>Carex aggregata</i>	Glomerate Sedge	S2	G5			
Plants	<i>Carex albolutescens</i>	Greenish-white Sedge	S1	G5			
Plants	<i>Carex bromoides</i> ssp. <i>bromoides</i>	Brome-like Sedge	S3	T5			
Plants	<i>Carex eburnea</i>	Bristleleaf Sedge	S3	G5			
Plants	<i>Carex emoryi</i>	Emory's Sedge	S2	G5			
Plants	<i>Carex hirtifolia</i>	Pubescent Sedge	S3	G5			
Plants	<i>Carex lacustris</i>	Lake Sedge	S2	G5			
Plants	<i>Carex laxiculmis</i> var. <i>copulata</i>	Spreading Sedge	S2	T4			
Plants	<i>Carex normalis</i>	Greater Straw Sedge	S3	G5			

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Plants	<i>Carex pedunculata</i>	Longstalk Sedge	S2	G5			
Plants	<i>Carex pellita</i>	Woolly Sedge	S2	G5			
Plants	<i>Carex planispicata</i>	Flat-spiked Sedge	S2	G4			
Plants	<i>Carex roanensis</i>	Roan Mountain Sedge	S2	G3		S	
Plants	<i>Carex styloflexa</i>	Bent Sedge	S1	G4			
Plants	<i>Carex trichocarpa</i>	Hairy-fruit Sedge	S1	G4			
Plants	<i>Clematis albicoma</i>	White-hair Leatherflower	S3	G4			
Plants	<i>Clematis occidentalis</i> var. <i>occidentalis</i>	Purple Virgin's Bower	S2	T5		S	
Plants	<i>Coeloglossum viride</i> var. <i>virescens</i>	Long-bracted Green Orchid, Satyr Orchid	S1	T5			
Plants	<i>Coreopsis pubescens</i>	Star Tickseed	S2	G5			
Plants	<i>Cuscuta indecora</i> var. <i>neuropetala</i>	Dodder	S1	T5			
Plants	<i>Cuscuta rostrata</i>	Beaked Dodder	S2	G4			
Plants	<i>Cymophyllus fraserianus</i>	Fraser's Sedge	S3	G4			
Plants	<i>Cypripedium reginae</i>	Showy Lady's-slipper	S1	G4		S	
Plants	<i>Decodon verticillatus</i>	Swamp-loosestrife	S1	G5			
Plants	<i>Delphinium exaltatum</i>	Tall Larkspur	S2	G3		S	
Plants	<i>Desmodium pauciflorum</i>	Few-flower Tick-trefoil	S1	G5			
Plants	<i>Dichanthelium acuminatum</i> ssp. <i>columbianum</i>	District Of Columbia Panicgrass	S1	T5			
Plants	<i>Drosera rotundifolia</i> var. <i>rotundifolia</i>	Roundleaf Sundew	S3	T5			
Plants	<i>Eleocharis compressa</i>	Flat-stem Spikerush	S2	G4			
Plants	<i>Eleocharis engelmannii</i>	Engelmann's Spikerush	S1	G4			
Plants	<i>Eleocharis palustris</i>	Marsh Spikerush	S3	G5			
Plants	<i>Eriogonum allenii</i>	Shalebarren Wild Buckwheat	S2	G4		S	
Plants	<i>Eupatorium pilosum</i>	Rough Boneset	S2	G5			

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Plants	<i>Euphorbia purpurea</i>	Glade Spurge	S2	G3		S	
Plants	<i>Gaylussacia brachycera</i>	Box Huckleberry	S2	G3		S	
Plants	<i>Geum rivale</i>	Purple Avens	S1	G5			
Plants	<i>Glyceria grandis</i> var. <i>grandis</i>	American Mannagrass	S2	T5			
Plants	<i>Glyceria laxa</i>	Mannagrass	S2S3	G5			
Plants	<i>Goodyera repens</i>	Dwarf Rattlesnake-plantain	S1S2	G5			
Plants	<i>Gymnocarpium appalachianum</i>	Appalachian Oak Fern	S2	G3		S	
Plants	<i>Gymnocarpium dryopteris</i>	Northern Oak Fern	S1	G5			
Plants	<i>Hasteola suaveolens</i>	False Indian-plantain	S3	G4		S	
Plants	<i>Helianthus laevigatus</i>	Smooth Sunflower	S2	G4			
Plants	<i>Helianthus occidentalis</i> ssp. <i>occidentalis</i>	Western Sunflower	S2	T5			
Plants	<i>Heuchera alba</i>	White Alumroot	S2	G2		S	
Plants	<i>Heuchera americana</i> var. <i>hispida</i>	Rough Alumroot, Rough Heuchera	S2	T3			
Plants	<i>Hibiscus laevis</i>	Halberd-leaf Rosemallow	S2	G5			
Plants	<i>Huperzia porophila</i>	Rock Clubmoss	S1	G4			
Plants	<i>Hypericum mitchellianum</i>	Blue Ridge St. John's-wort	S1	G3		S	
Plants	<i>Ilex collina</i>	Hill Holly	S2	G3		S	
Plants	<i>Isotria medeoloides</i>	Small Whorled Pogonia	S1	G2	T		
Plants	<i>Juglans cinerea</i>	Butternut	S3	G4		S	
Plants	<i>Juncus articulatus</i>	Jointleaf Rush	S2	G5			
Plants	<i>Lemna valdiviana</i>	Pale Duckweed	S3	G5			
Plants	<i>Leucothoe recurva</i>	Red-twig Doghobble	S1	G4			
Plants	<i>Liparis loeselii</i>	Yellow Wide-lip Orchid	S3	G5			
Plants	<i>Listera cordata</i> var. <i>cordata</i>	Heartleaf Twayblade	S2	T5		S	
Plants	<i>Listera smallii</i>	Kidneyleaf Twayblade	S2	G4			
Plants	<i>Lonicera canadensis</i>	Fly Honeysuckle	S2	G5			

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Plants	<i>Lupinus perennis</i> ssp. <i>perennis</i>	Wild Lupine, Sundial Lupine	S1	T4			
Plants	<i>Lygodium palmatum</i>	American Climbing Fern	S3	G4			
Plants	<i>Maianthemum stellatum</i>	Starflower False Solomon's-seal	S2	G5			
Plants	<i>Malaxis bayardii</i>	Bayard Long's Adder's Mouth	SH	G1			
Plants	<i>Marshallia grandiflora</i>	Monongahela Barbara's-buttons	S2	G2		S	
Plants	<i>Matteuccia struthiopteris</i>	Ostrich Fern	S2	G5			
Plants	<i>Nuttallanthus canadensis</i>	Old-field Toadflax	S2	G5			
Plants	<i>Oenothera argillicola</i>	Shalebarren Evening-primrose	S3	G3			
Plants	<i>Packera antennariifolia</i>	Shalebarren Ragwort	S3	G4			
Plants	<i>Packera paupercula</i>	Balsam Ragwort	S2	G5			
Plants	<i>Panicum flexile</i>	Wiry Panicgrass	S1	G5			
Plants	<i>Parnassia asarifolia</i>	Kidneyleaf Grass-of-parnassus	S2	G4			
Plants	<i>Paxistima canbyi</i>	Canby's Mountain-lover	S2	G2		S	
Plants	<i>Pedicularis lanceolata</i>	Swamp Lousewort	S2	G5		S	
Plants	<i>Pellaea glabella</i> ssp. <i>glabella</i>	Smooth Cliffbrake	S2	T5			
Plants	<i>Phlox buckleyi</i>	Swordleaf Phlox, Shale Barren Phlox	S2	G2		S	
Plants	<i>Pieris floribunda</i>	Mountain Fetterbush	S3	G4			
Plants	<i>Piptatherum racemosum</i>	Black-seed Mountain Ricegrass	S2	G5			
Plants	<i>Platanthera ciliaris</i>	Yellow-fringe Orchid	S3	G5			
Plants	<i>Platanthera peramoena</i>	Pride-of-the-peak	S3	G5			
Plants	<i>Platanthera psycodes</i>	Lesser Purple Fringed Orchid	S1	G5			
Plants	<i>Platanthera shriveri</i>	Shriver's Frilly Orchid	S1	G1		S	
Plants	<i>Potamogeton tennesseensis</i>	Tennessee Pondweed	S2	G2		S	At Risk-Science

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Plants	<i>Prunus alleghaniensis</i> var. <i>alleghaniensis</i>	Allegheny Plum	S3	T4			
Plants	<i>Pycnanthemum muticum</i>	Clustered Mountainmint	S1	G5			
Plants	<i>Quercus prinoides</i>	Dwarf Chinquapin Oak	S1	G5			
Plants	<i>Ranunculus pensylvanicus</i>	Bristly Crowfoot	S1	G5		S	
Plants	<i>Rhododendron viscosum</i>	Swamp Azalea	S1	G5			
Plants	<i>Ribes lacustre</i>	Bristly Black Currant	S2	G5		S	
Plants	<i>Ribes triste</i>	Swamp Red Currant	S1	G5			
Plants	<i>Rosa blanda</i> var. <i>blanda</i>	Smooth Rose	S2	T5		S	
Plants	<i>Sagittaria calycina</i> var. <i>calycina</i>	Long-lobe Arrowhead	S2	T5			
Plants	<i>Samolus valerandi</i> ssp. <i>parviflorus</i>	Seaside Brookweed	S2	T5			
Plants	<i>Saxifraga michauxii</i>	Cliff Saxifrage	S1	G4		S	
Plants	<i>Schizachne purpurascens</i>	False Melicgrass	S1	G5			
Plants	<i>Scirpus atrocinctus</i>	Blackgirdle Bulrush	S3	G5			
Plants	<i>Scirpus microcarpus</i>	Red-tinge Bulrush	S3	G5			
Plants	<i>Scleria triglomerata</i>	Whip Nutrush	S2	G5			
Plants	<i>Scutellaria saxatilis</i>	Rock Skullcap	S2	G3		S	
Plants	<i>Silphium compositum</i> var. <i>reniforme</i>	Rosinweed	S1	T4			
Plants	<i>Solidago arguta</i> var. <i>harrisii</i>	Shalebarren Goldenrod	S3	T4			
Plants	<i>Spiraea virginiana</i>	Virginia Spiraea	S1	G2	T		
Plants	<i>Spiranthes lucida</i>	Shining Ladies'-tresses	S1S2	G5			
Plants	<i>Spiranthes ovalis</i> var. <i>erostellata</i>	Oval Ladies' Tresses	S1	T4			
Plants	<i>Stachys eplingii</i>	Epling's Hedge-nettle	S1	G5			
Plants	<i>Stachys tenuifolia</i>	Smooth Hedge-nettle	S3	G5			
Plants	<i>Symphyotrichum laeve</i> var. <i>concinnum</i>	Smooth Blue American-aster	S2	T4			
Plants	<i>Taenidia montana</i>	Mountain-pimpernel	S3	G3		S	

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Plants	<i>Taxus canadensis</i>	Canada Yew	S2S3	G5		S	
Plants	<i>Thuja occidentalis</i>	Northern White-cedar	S2	G5			
Plants	<i>Tortula ammonsiana</i>	Ammons' Twist Moss	S1	G1		S	
Plants	<i>Toxicodendron vernix</i>	Poison-sumac	S2	G5			
Plants	<i>Triadenum tubulosum</i>	Lesser Marsh-st. John's-wort	S1	G4			
Plants	<i>Trichomanes boschianum</i>	Appalachian Bristle Fern	S1	G4		S	
Plants	<i>Trichophorum planifolium</i>	Bashful Bulrush	S1	G4			
Plants	<i>Trifolium reflexum</i>	Buffalo Clover	S1	G3			
Plants	<i>Trifolium stoloniferum</i>	Running Buffalo Clover	S3	G3	E		
Plants	<i>Trifolium virginicum</i>	Kate's Mountain Clover	S3	G3		S	
Plants	<i>Vaccinium macrocarpon</i>	Large Cranberry	S3	G4			
Plants	<i>Vaccinium oxycoccos</i>	Small Cranberry	S3	G5			
Plants	<i>Viburnum lentago</i>	Nannyberry	S1S2	G5			
Plants	<i>Viburnum rafinesquianum</i>	Downy Arrow-wood	S2	G5			
Plants	<i>Viola blanda</i> var. <i>palustriformis</i>	Violet	SH	T4			
Plants	<i>Viola septentrionalis</i>	Northern Blue Violet	S2	G5			
Plants	<i>Vitis rupestris</i>	Sand Grape	S2	G3		S	
Plants	<i>Vittaria appalachiana</i>	Appalachian Shoestring Fern	S1	G4			
Plants	<i>Woodsia appalachiana</i>	Allegheny Cliff Fern	S2	G4			
Plants	<i>Woodsia ilvensis</i>	Rusty Cliff Fern	S2	G5			
Plants	<i>Woodwardia areolata</i>	Netted Chainfern	S2	G5		S	
Plants	<i>Zannichellia palustris</i>	Horned Pondweed	S1	G5			
Plants	<i>Zigadenus leimanthoides</i>	Pine Barren Deathcamas	S2	G4			
Reptiles	<i>Agkistrodon contortrix mokasen</i>	Northern Copperhead	S5	T5			
Reptiles	<i>Apalone spinifera spinifera</i>	Eastern Spiny Softshell	S4	G5			
Reptiles	<i>Carphophis amoenus</i>	Wormsnake	S3	G5			
Reptiles	<i>Coluber constrictor constrictor</i>	Northern Black Racer	SNR	T5			
Reptiles	<i>Crotalus horridus</i>	Timber Rattlesnake	S3	G4		S	

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Reptiles	Heterodon platirhinos	Eastern Hog-nosed Snake	S2	G5	R		
Reptiles	Liochlorophis vernalis	Smooth Greensnake	S5	G5			
Reptiles	Opheodrys aestivus	Rough Greensnake	S2	G5			
Reptiles	Pituophis melanoleucus melanoleucus	Northern Pinesnake	SH	G4			
Reptiles	Plestiodon anthracinus anthracinus	Northern Coal Skink	S2	G5			
Reptiles	Regina septemvittata	Queen Snake	S4	G5			
Reptiles	Terrapene carolina carolina	Eastern Box Turtle	S5	T5	R		
Reptiles	Thamnophis sauritus	Eastern Ribbonsnake	S2	G5			
Reptiles	Virginia valeriae pulchra	Mountain Earthsnake	S2	G3		S	
Snails	Anguispira stihleri	Stihler's Tigersnail	S1				
Snails	Carychium nannodes	File Thorn	S3				
Snails	Fontigens tartarea	Organ Cavesnail	S2			S	
Snails	Fontigens turritella	Greenbrier Cavesnail	S1				
Snails	Gastrocopta holzingeri	Lambda Snaggletooth	S2				
Snails	Glyphyalinia cumberlandiana	Hill Glyph	S3				
Snails	Helicodiscus villosus		S1				
Snails	Hendersonia occulta	Cherrystone Drop	S3				
Snails	Mesodon mitchellianus	Sealed Globelet	S3				
Snails	Mesomphix luisant		S1				
Snails	Paravitrea bellona	Club Supercoil	S1				
Snails	Paravitrea reesei	Round Supercoil	S2				
Snails	Stenotrema barbatum	Bristled Slitmouth	S3				
Snails	Striatura ferrea	Black Striate	S3				
Snails	Triodopsis picea	Spruce Knob Threetooth	S3				
Snails	Triodopsis tennesseensis	Budded Threetooth	S3				
Snails	Triodopsis vulgata	Dished Threetooth	S2				

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFS Region 9	USFWS at Risk
Snails	<i>Vallonia excentrica</i>	Iroquois Vallonia	S3				
Snails	<i>Vallonia perspectiva</i>	Thin-lip Vallonia	S3				
Snails	<i>Vallonia pulchella</i>	Lovely Vallonia	S3				
Snails	<i>Ventridens arcellus</i>	Golden Dome	S3				
Snails	<i>Vertigo tridentata</i>	Honey Vertigo	S3				
Tiger Beetles	<i>Cicindela ancocisconensis</i>	Appalachian Tiger Beetle	S3	G3		S	
Tiger Beetles	<i>Cicindela splendida</i>	A Tiger Beetle	S1	G5			

S Rank (State Rank) and G Rank (Global Rank) Conservation Status: 1= Critically Imperiled, 2 = Imperiled, 3 = Vulnerable, 4 = Apparently Secure, 5 = Secure, NR = Not Ranked, T = Subspecies or Varieties, B = Breeding, N = Non-breeding, S#S# or G#G# indicates range of uncertainty of conservation status.

Federal Status: R = Rare, T= Threatened, E = Endangered.

USFS Region 9 Sensitive Species: S = Sensitive.

USFWS Priority At Risk (2021): Conserv = need management attention, Science = need more research.

Appendix 2. Priority SGCN, Known Stresses and Actions

Forests and Woodlands		
Common Name	Local Stress	Action
Black-billed Cuckoo	<ul style="list-style-type: none"> • Forest maturation. • Degradation of riparian habitats. • Clean farming practices. • Reduced caterpillar abundance. 	<ul style="list-style-type: none"> • Create early-successional habitat. • Reduce aerial application of pesticides. • Manage farms for wildlife.
Broad-winged Hawk	<ul style="list-style-type: none"> • Habitat loss from energy and other development. • Unsuitable forest structure. 	<ul style="list-style-type: none"> • Manage mature forests for gaps while retaining mature trees. • Develop state-level guidance on siting and construction of energy infrastructure to avoid fragmentation of core forests.
Cerulean Warbler	<ul style="list-style-type: none"> • Forest fragmentation and loss from development. • Incompatible forest structure. 	<ul style="list-style-type: none"> • Implement management guidelines at suitable locations on public lands. • Implement guidelines on private lands via CERW/farm bill programs.
Eastern Whip-poor-will	<ul style="list-style-type: none"> • Forest maturation. • Understory habitat degradation from fire suppression. • Deer overabundance. 	<ul style="list-style-type: none"> • Timber management for canopy openings. • Implement prescribed burning in fire adapted systems. • Reduce deer abundance.
Golden Eagle	<ul style="list-style-type: none"> • Habitat loss from energy and other development. 	<ul style="list-style-type: none"> • Develop state-level guidance on siting and construction of energy infrastructure to avoid fragmentation of core forests.

Forests and Woodlands		
Common Name	Local Stress	Action
Golden-winged Warbler	<ul style="list-style-type: none"> • Forest maturation. • Incompatible forest structure. • Habitat loss on wintering grounds 	<ul style="list-style-type: none"> • Implement management guidelines at suitable locations on public lands. • Implement guidelines on private lands via GWWA/farm bill programs.
Northern Saw-whet Owl	<ul style="list-style-type: none"> • Hemlock mortality from Hemlock Woolly Adelgid. • Timber harvesting in critical habitat. 	<ul style="list-style-type: none"> • Treat mature hemlock stands. • Consider timber avoidance measures as needed.
Prairie Warbler	<ul style="list-style-type: none"> • Residential and industrial development. • Forest maturation. • Incompatible utility corridor management. 	<ul style="list-style-type: none"> • Improve vegetation management practices in utility corridors. • Consider needs of priority species when managing forests. • Increase amount of early-successional habitat.
Ruffed Grouse	<ul style="list-style-type: none"> • Forest fragmentation. • Forest maturation. • Incompatible forest structure. 	<ul style="list-style-type: none"> • Create early-successional habitat through forest management within core forests.
Wood Thrush	<ul style="list-style-type: none"> • Forest fragmentation and loss. • Incompatible forest structure. • Deer overabundance. 	<ul style="list-style-type: none"> • Maintain and improve core forests with scattered openings and well-developed understories. • Reduce local deer populations.
Worm-eating Warbler	<ul style="list-style-type: none"> • Forest fragmentation and loss. • Incompatible forest structure. • Deer overabundance. • Fire suppression. 	<ul style="list-style-type: none"> • Maintain and improve core forests with scattered openings and well-developed understories. • Increase use of fire in adapted systems. • Reduce local deer populations.
Club Supercoil	<ul style="list-style-type: none"> • Climate change. (microclimate) • Acid deposition. 	<ul style="list-style-type: none"> • Buffer wooded river bluffs and ravines.

Forests and Woodlands		
Common Name	Local Stress	Action
Greenbrier tigersnail	<ul style="list-style-type: none"> • Acid deposition. • Soil contamination 	<ul style="list-style-type: none"> • Protect/buffer cedar glade habitat and limestone outcrops for calcium enrichment and detritus. • Educate public on presence of this unique species. • Avoid development near known habitat.
Lambda Snaggletooth	<ul style="list-style-type: none"> • Climate change. (microclimate) • Acid deposition. • Soil contamination 	<ul style="list-style-type: none"> • Protect cedar and talus bluffs for calcium enrichment and detritus.
Spruce Knob Threetooth	<ul style="list-style-type: none"> • Climate change. (microclimate) • Acid deposition. • Forest disturbance 	<ul style="list-style-type: none"> • Prevent high elevation forest fragments (maintain contiguous sections) and retain rocky substrates within forest.
Thin-lip Vallonia	<ul style="list-style-type: none"> • Climate change. (microclimate) • Acid deposition. • Soil contamination 	<ul style="list-style-type: none"> • Protect cedar habitat, talus slopes/limestone outcrops for calcium enrichment and detritus.
Diana Fritillary	<ul style="list-style-type: none"> • Suspect loss of nectar resources 	<ul style="list-style-type: none"> • Alter roadside mowing regimes to promote nectar plants.
Appalachian Cottontail	<ul style="list-style-type: none"> • Climate change. • Habitat fragmentation, conversion of shrublands for agriculture and development. • Forest maturation/loss of dense understory • Lack of fire to restore understory and shrub habitat 	<ul style="list-style-type: none"> • Forest practices that allow for winter browse vegetation of Vaccinium and Photinia spp. (among others). • Implement forest practices that provide/promote shrub and spruce cover. • Institute prescribed fire program to restore understory and shrub vegetation.

Forests and Woodlands		
Common Name	Local Stress	Action
Eastern Small-footed Bat	<ul style="list-style-type: none"> • Deforestation • Climate change. (microclimate) 	<ul style="list-style-type: none"> • Protect rock outcroppings and talus fields. • Maintain forest cover in these rare habitat types to retain microclimate.
Eastern Spotted Skunk	<ul style="list-style-type: none"> • Fire Suppression/Lack of disturbance in forest succession 	<ul style="list-style-type: none"> • Use forest management and fire to increase vegetative cover and early-successional habitat. • Protect potentially occupied sites. • Leave snags and wind-blown trees to allow for den sites.
Indiana Bat	<ul style="list-style-type: none"> • Deforestation, agriculture, industry 	<ul style="list-style-type: none"> • Maintain forest cover • USFWS requires management actions within 10 miles of "Priority 1/2" Indiana Bat caves.
Northern Long-eared Bat	<ul style="list-style-type: none"> • Development, agriculture. • Lack of complexity in forest stand (i.e. snags/early-successional trees). 	<ul style="list-style-type: none"> • This species needs mature forest habitat arguably more than any other bat. • Continue to protect any hibernacula, benefiting all bats. • Maintain large intact forest blocks.
Tricolored Bat	<ul style="list-style-type: none"> • Deforestation • Human disturbance during hibernation 	<ul style="list-style-type: none"> • Protect caves with known hibernacula including Snedegar's Cave • Research summer habits. • Protect all occupied habitat from human intrusion.

Forests and Woodlands		
Common Name	Local Stress	Action
Mountain Earthsnake	<ul style="list-style-type: none"> • Loss of early-successional habitat • Fire suppression • Livestock overgrazing 	<ul style="list-style-type: none"> • Manage for early-successional habitat. • Create forest openings. • Institute prescribed fire regime to maintain healthy grasses and forbs in openings. • Monitor grazing impacts, habitat and cover.
Northern Coal Skink	<ul style="list-style-type: none"> • Poorly understood habitat and life history 	<ul style="list-style-type: none"> • Conduct surveys to determine distribution, habitat, life history requirements.
Timber Rattlesnake	<ul style="list-style-type: none"> • Loss of basking/ gestation/ denning habitat 	<ul style="list-style-type: none"> • Create forest openings. • Reduce canopy over known gestation and basking sites. • Develop basking structures to mitigate impacts to habitat. • Develop den avoidance guidance.
Nodding Wild Onion	<ul style="list-style-type: none"> • Restricted geographic Distribution (WV endemic) 	<ul style="list-style-type: none"> • Monitor populations. • Survey edges of range.
Northern Oak Fern	<ul style="list-style-type: none"> • Taxonomic questions • Unknown status 	<ul style="list-style-type: none"> • Identify non-hybrid populations. • Survey occurrences to determine distribution and threats.
Purple Virgin's Bower	<ul style="list-style-type: none"> • Unknown status in WV 	<ul style="list-style-type: none"> • Conduct field surveys to assess distribution and threats.
Roan Mountain Sedge	<ul style="list-style-type: none"> • Altered light regime, • Invasive plants introduced through logging 	<ul style="list-style-type: none"> • Avoid disturbing habitat.
Rock Skullcap	<ul style="list-style-type: none"> • Forest management activities 	<ul style="list-style-type: none"> • Investigate response to management (silvicultural treatments).

Forests and Woodlands		
Common Name	Local Stress	Action
Shalebarren Rockcress	<ul style="list-style-type: none"> • Woody encroachment • Invasive plants 	<ul style="list-style-type: none"> • Investigate use of prescribed fire to maintain barren habitat. • Control or manage invasive plants.
Shriver's Frilly Orchid	<ul style="list-style-type: none"> • Forest management activities 	<ul style="list-style-type: none"> • Avoid disturbing habitat.
Small Whorled Pogonia	<ul style="list-style-type: none"> • Timber harvesting • Road construction 	<ul style="list-style-type: none"> • Conduct field surveys to better assess distribution and threats. • Avoid impacting known populations.
Swordleaf Phlox, Shale Barren Phlox	<ul style="list-style-type: none"> • Woody encroachment 	<ul style="list-style-type: none"> • Survey for additional occurrences. • Research habitat ecology. • Research prescribed burning and silvicultural treatments to promote the species.
Tall Larkspur	<ul style="list-style-type: none"> • Logging • Grazing • Invasive plants • Subdivision and development 	<ul style="list-style-type: none"> • Protect habitat from disturbance through conservation easement or direct purchase.
Wild Lupine, Sundial Lupine	<ul style="list-style-type: none"> • Unknown status in WV 	<ul style="list-style-type: none"> • Relocate historical occurrences. • Conduct field surveys to better assess distribution and threats.

Rock Outcrop, Cliff, Talus and Barren Habitats		
Common Name	Local Stress	Action
Eastern Small-footed Bat	<ul style="list-style-type: none"> • Deforestation • Climate change. (microclimate) 	<ul style="list-style-type: none"> • Maintain intact forest canopy to protect talus slope microhabitat. • Dense forested conditions will help maintain talus slope microhabitat.

Rock Outcrop, Cliff, Talus and Barren Habitats		
Common Name	Local Stress	Action
Eastern Spotted Skunk	<ul style="list-style-type: none"> • Fire Suppression/Lack of disturbance in forest succession 	<ul style="list-style-type: none"> • Use forest management and fire to increase vegetative cover and early-successional habitat. • Create or retain snags and windfall trees to allow for den sites.
Cave Salamander	<ul style="list-style-type: none"> • Climate change. (microclimate) • Vandalism 	<ul style="list-style-type: none"> • Conserve habitat around cave entrances. • Install cave gates.
Anguispira stihleri	<ul style="list-style-type: none"> • Climate change. (microclimate) • Acid deposition. 	<ul style="list-style-type: none"> • Protect/buffer cedar glade habitat and limestone outcrops for calcium enrichment and detritus.
Greenbrier tigersnail	<ul style="list-style-type: none"> • Acid deposition. (affecting soil chemistry) 	<ul style="list-style-type: none"> • Educate public on presence of this unique species. • Manage or protect the cedar glades adjacent to the limestone habitats.
Helicodiscus villosus	<ul style="list-style-type: none"> • Climate change. (microclimate) • Acid deposition. 	<ul style="list-style-type: none"> • Protect/buffer limestone outcrops/talus slopes for calcium enrichment and detritus.
Mesomphix luisant	<ul style="list-style-type: none"> • Forest disturbance • Climate change. (microclimate) • Acid deposition. 	<ul style="list-style-type: none"> • Prevent forest fragments (maintain contiguous sections) and buffer forested limestone cliffs.
Thin-lip Vallonia	<ul style="list-style-type: none"> • Climate change. (microclimate) • Acid deposition. • Soil contamination. 	<ul style="list-style-type: none"> • Protect cedar habitat, talus slopes/limestone outcrops for calcium enrichment and detritus.
Appalachian Grizzled Skipper	<ul style="list-style-type: none"> • Afforestation (forest succession). • Habitat degradation. 	<ul style="list-style-type: none"> • Thinning and timber harvest to provide additional habitat. • Removal of woody vegetation along current FS roads to release larval host and nectar plants (early spring species).

Rock Outcrop, Cliff, Talus and Barren Habitats		
Common Name	Local Stress	Action
Northern Coal Skink	<ul style="list-style-type: none"> Poorly understood habitat and life history. 	<ul style="list-style-type: none"> Conduct surveys to determine distribution, habitat, life history requirements.
Timber Rattlesnake	<ul style="list-style-type: none"> Loss of basking/ gestation/ denning habitat. 	<ul style="list-style-type: none"> Use forest management to create canopy gaps. Reduce canopy over known gestation and basking sites. Develop basking structures to mitigate impacts to habitat. Develop den avoidance guidance for WV projects.
Ammons' Twist Moss	<ul style="list-style-type: none"> Unknown status. 	<ul style="list-style-type: none"> Monitor known occurrence. Survey new habitats.
Weft Fern	<ul style="list-style-type: none"> Appalachian Bristle Fern is Incorrect taxonomy. 	<ul style="list-style-type: none"> Revise USFS Sensitive Species List Revise signage at Hills Creek to reflect correct taxonomy.
Appalachian Shoestring Fern	<ul style="list-style-type: none"> Unknown status. 	<ul style="list-style-type: none"> Monitor known occurrence.
Dwarf Chinquapin Oak	<ul style="list-style-type: none"> Extremely small population (single tree). Deer herbivory. 	<ul style="list-style-type: none"> Protect (fence) single tree. Conduct surveys to locate additional individual and populations.
Nodding Wild Onion	<ul style="list-style-type: none"> Restricted geographic range (WV endemic). 	<ul style="list-style-type: none"> Monitor known populations. Survey edges of range.
Rock Clubmoss	<ul style="list-style-type: none"> Limited distribution. 	<ul style="list-style-type: none"> Conduct surveys to locate additional populations and threats.
Rosinweed	<ul style="list-style-type: none"> Unknown status. 	<ul style="list-style-type: none"> Conduct surveys to locate additional populations and threats.

Rock Outcrop, Cliff, Talus and Barren Habitats		
Common Name	Local Stress	Action
Shalebarren Ragwort	<ul style="list-style-type: none"> • Woody encroachment. • Invasive plant encroachment. 	<ul style="list-style-type: none"> • Investigate role of prescribed fire to maintain barren habitat. • Control or manage invasive plants.
Shalebarren Rockcress	<ul style="list-style-type: none"> • Woody encroachment. • Invasive plant encroachment. 	<ul style="list-style-type: none"> • Investigate role of prescribed fire to maintain barren habitat. • Control or manage invasive plants.
Shalebarren Wild Buckwheat	<ul style="list-style-type: none"> • Woody encroachment. • Invasive plant encroachment. 	<ul style="list-style-type: none"> • Investigate role of prescribed fire to maintain barren habitat. • Control or manage invasive plants.
Smooth Sunflower	<ul style="list-style-type: none"> • Unknown status. 	<ul style="list-style-type: none"> • Conduct surveys to locate additional populations and threats.
Turgid Gayfeather	<ul style="list-style-type: none"> • Unknown status. 	<ul style="list-style-type: none"> • Conduct surveys to locate additional populations and threats.

Cave and Karst Habitats		
Common Name	Local Stress	Action
WV Spring Salamander	<ul style="list-style-type: none"> • Impacts to water quality from upstream agriculture and industry • Increased flooding and runoff • Disturbance by recreational cavers 	<ul style="list-style-type: none"> • Restore and protect upstream riparian buffers and install livestock exclusion fences • Install gates and fences to limit cave access
A Cave Lumbricid Worm	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups. • Install fencing and signage. • Mapping of passage and surface influences.

Cave and Karst Habitats		
Common Name	Local Stress	Action
A Cave Springtail	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups. • Install fencing and signage. • Mapping of passage and surface influences.
A Collembola	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups. • Install fencing and signage. • Mapping of passage and surface influences.
A Springtail	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups • Install fencing and signage. • Mapping of passage and surface influences.
An Amphipod	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups. • Install fencing and signage. • Mapping of passage and surface influences.

Cave and Karst Habitats		
Common Name	Local Stress	Action
An Oligochaete	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups • Install fencing and signage. • Mapping of passage and surface influences.
Greenbrier Cave Amphipod	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping • Cave passage alteration • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups. • Install fencing and signage. • Mapping of passage and surface influences.
Greenbrier Valley Cave Pseudoscorpion	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups • Install fencing and signage. • Mapping of passage and surface influences.
Minute Cave Amphipod	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups. • Install fencing and signage. • Mapping of passage and surface influences.

Cave and Karst Habitats		
Common Name	Local Stress	Action
Organ Cave Pseudoscorpion	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups. • Install fencing and signage. • Mapping of passage and surface influences.
Orpheus Cave Pseudoscorpion	<ul style="list-style-type: none"> • Stormwater entering cave systems • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups. • Install fencing and signage. • Mapping of passage and surface influences.
Pocahontas Cave Amphipod	<ul style="list-style-type: none"> • Stormwater entering cave systems • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups • Install fencing and signage. • Mapping of passage and surface influences.
Proserpina Cave Pseudoscorpion	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups • Install fencing and signage. • Mapping of passage and surface influences.

Cave and Karst Habitats		
Common Name	Local Stress	Action
Royal Syarinid Pseudoscorpion	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups • Install fencing and signage. • Mapping of passage and surface influences.
Spring Cave Amphipod	<ul style="list-style-type: none"> • Stormwater entering cave systems. • Degraded water quality. • Sinkhole dumping. • Cave passage alteration. • Human disturbance (excessive visitation). 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Conduct sinkhole clean ups • Install fencing and signage. • Mapping of passage and surface influences.
An Underground Crayfish	<ul style="list-style-type: none"> • Water quality degradation including sediment, nutrient and chemical inputs, sinkhole dumping, septic system failure and thermal changes caused by deforestation, agriculture and development around caves 	<ul style="list-style-type: none"> • Provide educational materials to landowners, planners, partner agencies. • Sinkhole cleanups, stormwater and wastewater treatment, septic system maintenance and repairs, riparian buffer zones • Land use planning and land protection around caves and karst to maintain forest cover around caves and karst

Cave and Karst Habitats		
Common Name	Local Stress	Action
Bats: Indiana Bat, Little Brown Bat, Northern Long-eared Bat, Eastern Small-footed Bat and Tri-colored bat	<ul style="list-style-type: none"> Deforestation, agriculture, industry, cave disturbance 	<ul style="list-style-type: none"> Protect hibernacula Protect and maintain forest cover Follow Forestry BMPs developed by White-Nose Syndrome Response team. Reduce nonpoint source pollution. Restore riparian corridors. Research summer habits. Protect all occupied habitat from human intrusion. USFWS requires management actions within 10 miles of "Priority 1/2" Indiana Bat caves.
Organ and Greenbrier Cave Snails	<ul style="list-style-type: none"> Water quality degradation including sediment, nutrient and chemical inputs, sinkhole dumping, septic system failure and thermal changes caused by deforestation, agriculture and development around caves 	<ul style="list-style-type: none"> Provide educational materials to landowners, planners, partner agencies. Sinkhole cleanups, stormwater and wastewater treatment, septic system maintenance and repairs, riparian buffer zones Land use planning and land protection around caves and karst to maintain forest cover around caves and karst

Agricultural and Developed Habitats		
Common Name	Local Stress	Action
Loggerhead Shrike	<ul style="list-style-type: none"> Loss of grasslands to development or succession/farmland abandonment. Clean farming practices. 	<ul style="list-style-type: none"> Work with private landowners and NRCS to create and maintain scattered shrubs in pastures, and hedgerows. Increase grazing intensity at active sites.

Agricultural and Developed Habitats		
Common Name	Local Stress	Action
Chimney Swift	<ul style="list-style-type: none"> • Decline in suitable nest sites and migration roosts. • Possible decline in aerial insects. 	<ul style="list-style-type: none"> • Educate residents to reduce chimney capping. • Mitigate loss of nest and roost sites through constructing dedicated towers. • Retain large hollow snags
Diana Fritillary	<ul style="list-style-type: none"> • Loss of nectar resources. 	<ul style="list-style-type: none"> • Alter roadside mowing regimes to promote nectar plants.
Mountain Earthsnake	<ul style="list-style-type: none"> • Loss of early-successional habitat. • Fire suppression. • Livestock overgrazing. 	<ul style="list-style-type: none"> • Manage for early-successional habitat & forest openings. • Institute prescribed fire regime to maintain healthy grasses and forbs in openings. • Monitor grazing impacts, habitat and cover.
Smooth Greensnake	<ul style="list-style-type: none"> • Loss of early-successional habitat. • Fire suppression. • Livestock overgrazing. 	<ul style="list-style-type: none"> • Manage for early-successional habitat & forest openings. • Institute prescribed fire regime to maintain healthy grasses and forbs in openings. • Monitor grazing impacts, habitat and cover.

Stream and River Habitats		
Common Name	Local Stress	Action
Brook Trout	<ul style="list-style-type: none"> • Increased water temperature. • Passage impediments. • Increased sediment. 	<ul style="list-style-type: none"> • Restore and protect riparian buffers. • Develop BMPs for activities in riparian habitats.
Candy Darter	<ul style="list-style-type: none"> • Increased water temperatures. 	<ul style="list-style-type: none"> • Implement BMP's to restore/protect riparian habitat.

Stream and River Habitats		
Common Name	Local Stress	Action
Kanawha Minnow	<ul style="list-style-type: none"> Increased water temperatures. 	<ul style="list-style-type: none"> Implement BMP's to restore/protect riparian habitat.
Kanawha Sculpin	<ul style="list-style-type: none"> Increased water temperatures. Increased sedimentation. 	<ul style="list-style-type: none"> Implement BMP's to restore/protect riparian habitat.
New River Shiner	<ul style="list-style-type: none"> Increased water temperatures 	<ul style="list-style-type: none"> Implement BMP's to restore/protect riparian habitat.
Rosefin Shiner	<ul style="list-style-type: none"> Increased water temperatures. Increased sedimentation. 	<ul style="list-style-type: none"> Implement BMP's to restore/protect riparian habitat.
Tonguetied Minnow	<ul style="list-style-type: none"> Increased water temperatures. 	<ul style="list-style-type: none"> Implement BMP's to restore/protect riparian habitat.
Elktoe	<ul style="list-style-type: none"> Climate change. (microclimate). Habitat degradation and fragmentation. 	<ul style="list-style-type: none"> Restore instream habitat. Augment population through a propagation and stocking program.
Green Floater	<ul style="list-style-type: none"> Livestock access. Degraded riparian habitat. 	<ul style="list-style-type: none"> Stream and riparian restoration. Install fencing along riparian corridors.
Green-faced Clubtail	<ul style="list-style-type: none"> Degraded water quality. (organic and chemical pollutants, Increased sedimentation, dredging). 	<ul style="list-style-type: none"> Pollution control. Upgrade sewage infrastructure. Improve sedimentation control (construction, recreation, timber harvest).
Midland Clubtail	<ul style="list-style-type: none"> Organic and chemical pollutants. Increased sedimentation. Dredging. 	<ul style="list-style-type: none"> Pollution control. Upgrade sewage infrastructure. Implement sediment control BMP's.
Rapids Clubtail	<ul style="list-style-type: none"> Organic and chemical pollutants. Increased sedimentation. Dredging. 	<ul style="list-style-type: none"> Pollution control. Upgrade sewage infrastructure Improve sedimentation control (construction, recreation, timber harvest).

Stream and River Habitats		
Common Name	Local Stress	Action
Riffle Snaketail	<ul style="list-style-type: none"> • Organic and chemical pollutants. • Increased sedimentation. • Dredging. 	<ul style="list-style-type: none"> • Pollution control. • Upgrade sewage infrastructure • Improve sedimentation control (construction, recreation, timber harvest).
Splendid Clubtail	<ul style="list-style-type: none"> • Organic and chemical pollutants. • Increased sedimentation. • Dredging. 	<ul style="list-style-type: none"> • Pollution control. • Upgrade sewage infrastructure • Improve sedimentation control (construction, recreation, timber harvest).
Gaspe Sallfly	<ul style="list-style-type: none"> • Mining in surrounding landscape. • Oil and gas development. • Deforestation. • Frequent high-water events. • Climate change. (microclimate). 	<ul style="list-style-type: none"> • Restore riparian buffers to prevent potential contaminant runoff and retain canopy cover near rivers.

High Allegheny Wetland Habitats		
Common Name	Local Stress	Action
Sphagnum Sprite	<ul style="list-style-type: none"> • Degraded wetland habitat. 	<ul style="list-style-type: none"> • Maintain high elevation wetland integrity.
Kidneyleaf Grass-of-parnassus	<ul style="list-style-type: none"> • Unknown status and threats on private land. 	<ul style="list-style-type: none"> • Survey for additional occurrences. • Inform landowners of occurrences.
Swamp Lousewort	<ul style="list-style-type: none"> • Unknown status and threats on private land. 	<ul style="list-style-type: none"> • Survey for additional occurrences. • Inform landowners of occurrences.
Swamp Red Currant	<ul style="list-style-type: none"> • Unknown status and threats on private land. 	<ul style="list-style-type: none"> • Survey for additional occurrences. • Inform landowners of occurrences.
Tennessee Pondweed	<ul style="list-style-type: none"> • Unknown status and threats on private land. 	<ul style="list-style-type: none"> • Survey for additional occurrences. • Inform landowners of occurrences.
Tuberous Grass-pink	<ul style="list-style-type: none"> • Unknown status and threats on private land. 	<ul style="list-style-type: none"> • Survey for additional occurrences. • Inform landowners of occurrences.

Floodplain and Riparian Habitats		
Common Name	Local Stress	Action
Louisiana Waterthrush	<ul style="list-style-type: none"> Forest and riparian habitat degradation from agricultural activities and development. 	<ul style="list-style-type: none"> Restore and protect riparian buffers. Reduce agricultural and forestry runoff.
Greenbrier River Crayfish	<ul style="list-style-type: none"> Habitat disturbance, limited range, competition from nonnative crayfish (bait) 	<ul style="list-style-type: none"> Protect habitat Restore and protect riparian buffers. Prevent introduction of nonnative crayfish
New River Crayfish	<ul style="list-style-type: none"> Isolated populations, habitat disturbance from development, siltation, competition from nonnative crayfish (bait) 	<ul style="list-style-type: none"> Protect habitat Restore and protect riparian buffers. Prevent introduction of nonnative crayfish
Meadow River Mudbug	<ul style="list-style-type: none"> Agricultural practices. Oil and gas development. 	<ul style="list-style-type: none"> Limit encroachment of agriculture and runoff into adjacent forested watersheds. Increase coordination with WVDNR on oil & gas pipeline projects. Preserve rare habitat type of bottomland oak forests.
Diana Fritillary	<ul style="list-style-type: none"> Suspect loss of nectar resources. 	<ul style="list-style-type: none"> Alter roadside mowing regimes.
Tricolored Bat	<ul style="list-style-type: none"> Deforestation. 	<ul style="list-style-type: none"> Research summer habitats. Protect all occupied habitat from human intrusion.
Bent Sedge	<ul style="list-style-type: none"> Clearing and development. Altered hydrology. 	<ul style="list-style-type: none"> Maintain oak swamp habitat. Inform land managers.

Floodplain and Riparian Habitats		
Common Name	Local Stress	Action
Bristly Crowfoot	<ul style="list-style-type: none"> Unknown status and threats on private land. 	<ul style="list-style-type: none"> Survey occurrences to determine distribution and threats. Inform landowners.
Engelmann's Spikerush	<ul style="list-style-type: none"> Stream disturbance. Road crossings. Trampling. 	<ul style="list-style-type: none"> Inform landowners and partners Avoid disturbance.
Epling's Hedge-nettle	<ul style="list-style-type: none"> Woody vegetation encroachment. Mowing and Grazing 	<ul style="list-style-type: none"> Monitor populations and consider treatments to delay succession. Fence wet meadow habitat and avoid grazing. Mow infrequently to maintain native plants.
False Blue Indigo	<ul style="list-style-type: none"> Altered hydrology (due to climate change). 	<ul style="list-style-type: none"> Monitor populations and river scour habitat.
Greenish-white Sedge	<ul style="list-style-type: none"> Unknown status and threats on private land. 	<ul style="list-style-type: none"> Survey occurrences to determine distribution and threats. Inform landowners.
Hairy-fruit Sedge	<ul style="list-style-type: none"> Altered hydrology (due to climate change). 	<ul style="list-style-type: none"> Monitor populations and river scour habitat.
Kidneyleaf Grass-of-parnassus	<ul style="list-style-type: none"> Unknown status and threats. 	<ul style="list-style-type: none"> Survey occurrences to determine distribution and threats.
Lesser Purple Fringed Orchid	<ul style="list-style-type: none"> Unknown status and threats. 	<ul style="list-style-type: none"> Survey occurrences to determine distribution and threats.
Nannyberry	<ul style="list-style-type: none"> Clearing and development. Altered hydrology. 	<ul style="list-style-type: none"> Maintain oak swamp habitat. Inform land managers.
Sand Grape	<ul style="list-style-type: none"> Stream disturbance. Road crossings Trampling 	<ul style="list-style-type: none"> Inform landowners and partners. Avoid disturbance.

Floodplain and Riparian Habitats		
Common Name	Local Stress	Action
Shining Ladies'-tresses	<ul style="list-style-type: none"> • Stream disturbance. • Road crossings. • Trampling. 	<ul style="list-style-type: none"> • Inform landowners and partners. • Avoid disturbance.
Smooth Rose	<ul style="list-style-type: none"> • Unknown status and threats. 	<ul style="list-style-type: none"> • Survey occurrences to determine distribution and threats.
Swamp Lousewort	<ul style="list-style-type: none"> • Unknown status and threats. 	<ul style="list-style-type: none"> • Survey occurrences to determine distribution and threats.
Swamp-loosestrife	<ul style="list-style-type: none"> • Unknown status and threats. 	<ul style="list-style-type: none"> • Survey occurrences to determine distribution and threats.
Tennessee Pondweed	<ul style="list-style-type: none"> • Increased siltation. • Altered hydrology. 	<ul style="list-style-type: none"> • Investigate sources of stress (silt, degraded water quality, hydrology) and address as required.
Virginia Spiraea	<ul style="list-style-type: none"> • Altered hydrology in dam-controlled streams. 	<ul style="list-style-type: none"> • Work with USACOE to restore natural flow regime.
Mountain Earthsnake	<ul style="list-style-type: none"> • Loss of early-successional habitat. • Fire suppression. • Livestock overgrazing. 	<ul style="list-style-type: none"> • Manage for early-successional habitat & forest openings. • Institute prescribed fire regime to maintain healthy grasses and forbs in openings. • Monitor grazing impacts, habitat, and cover.
Smooth Greensnake	<ul style="list-style-type: none"> • Loss of early-successional habitat. • Fire suppression. • Livestock overgrazing. 	<ul style="list-style-type: none"> • Manage for early-successional habitat & forest openings. • Institute prescribed fire regime to maintain healthy grasses and forbs in openings. • Monitor grazing impacts, habitat and cover.

Appendix 3. Habitats on Public Lands

Public Land	Terrestrial Habitat	Aquatic Habitat
Cranberry Wildlife Management Area	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Northern Hardwood Forests • Red Spruce Forests • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • High Allegheny Wetlands • Small Stream Riparian Habitats • Developed 	<ul style="list-style-type: none"> • Headwater Creek, Hi Gradient, Cold
Little River Wildlife Management Area	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Montane Red Oak Forests • Northern Hardwood Forests • Pine-Oak Rocky Woodlands • Red Spruce Forests • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Calcareous Cliffs and Talus • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • High Allegheny Wetlands • Open Water • River Floodplains • Small Stream Riparian Habitats • Agricultural and Developed 	<ul style="list-style-type: none"> • Headwater Creek, Moderate Gradient, Cool • Headwater Creek, High Gradient, Cold • Headwater Creek, High Gradient, Cool • Small River, Moderate Gradient, Cool • Medium River, Moderate Gradient, Warm

Public Land	Terrestrial Habitat	Aquatic Habitat
Neola Wildlife Management Area	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Calcareous Forests, Woodlands and Glades • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Montane Red Oak Forests • Northern Hardwood Forests • Other Dry Oak Forests and Woodlands • Pine-Oak Rocky Woodlands • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Calcareous Cliffs and Talus • Shale Barrens • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • High Allegheny Wetlands • Open Water • River Floodplains • Small Stream Riparian Habitats • Agricultural and Developed 	<ul style="list-style-type: none"> • Headwater Creek, Low Gradient, Warm • Headwater Creek, Moderate Gradient, Cool • Headwater Creek, High Gradient, Cold • Headwater Creek, High Gradient, Cool • Small River, Moderate Gradient, Cool • Small River, Moderate Gradient, Warm • Medium River, Moderate Gradient, Warm
Rimel Wildlife Management Area	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Calcareous Forests, Woodlands and Glades • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Montane Red Oak Forests • Northern Hardwood Forests • Other Dry Oak Forests and Woodlands • Pine-Oak Rocky Woodlands • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Calcareous Cliffs and Talus 	<ul style="list-style-type: none"> • Headwater Creek, Low Gradient, Warm • Headwater Creek, Moderate Gradient, Cold • Headwater Creek, Moderate Gradient, Cool • Headwater Creek, High Gradient, Cold • Headwater Creek, High Gradient, Cool • Small River, Moderate Gradient, Cool • Small River, Moderate Gradient, Warm • Medium River, Low Gradient, Warm

Public Land	Terrestrial Habitat	Aquatic Habitat
	<ul style="list-style-type: none"> • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • High Allegheny Wetlands • Open Water • River Floodplains • Small Stream Riparian Habitats • Agricultural and Developed 	<ul style="list-style-type: none"> • Medium River, Moderate Gradient, Warm
Tea Creek Wildlife Management Area	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Northern Hardwood Forests • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Calcareous Cliffs and Talus • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • Small Stream Riparian Habitats • Agricultural and Developed 	<ul style="list-style-type: none"> • Headwater Creek, Low Gradient, Warm • Headwater Creek, High Gradient, Cold • Headwater Creek, High Gradient, Cool
Moncove Lake Wildlife Management Area	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Other Dry Oak Forests and Woodlands • Pine-Oak Rocky Woodlands • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • Small Stream Riparian Habitats • Developed 	<ul style="list-style-type: none"> • Headwater Creek, Moderate Gradient, Cool • Headwater Creek, High Gradient, Cold

Public Land	Terrestrial Habitat	Aquatic Habitat
Calvin price State Forest	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Montane Red Oak Forests • Northern Hardwood Forests • Pine-Oak Rocky Woodlands • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • River Floodplains • Small Stream Riparian Habitats • Agricultural and Developed 	<ul style="list-style-type: none"> • Headwater Creek, Low Gradient, Cool • Headwater Creek, Low Gradient, Warm • Headwater Creek, Moderate Gradient, Cold • Headwater Creek, Moderate Gradient, cool • Headwater Creek, Moderate Gradient, warm • Headwater Creek, high Gradient, Cold • Headwater Creek, high Gradient, Cool • Headwater Creek, high Gradient, Warm • Small River, Low Gradient, Cool • Small River, Low Gradient, Warm • Small River Moderate Gradient, Cool • Small River, Moderate Gradient, Warm • Small River, High Gradient, Cool • Small River, High Gradient, Warm • Small River, High Gradient, Cool • Small River, High Gradient, Warm • Medium River, Low Gradient, Warm • Medium River, Moderate Gradient, Warm • Medium River, High Gradient, Warm • Large River, Low Gradient, Warm • Large River, Moderate Gradient, Warm

Public Land	Terrestrial Habitat	Aquatic Habitat
Greenbrier State Forest	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Pine-Oak Rocky Woodlands • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • Small Stream Riparian Habitats • Agricultural and Developed 	<ul style="list-style-type: none"> • Headwater Creek, Moderate Gradient, cool • Headwater Creek, high Gradient, Cold
Seneca State Forest	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Montane Red Oak Forests • Northern Hardwood Forests • Pine-Oak Rocky Woodlands • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • Open Water • River Floodplains • Agricultural and Developed 	<ul style="list-style-type: none"> • Headwater Creek, moderate Gradient, Cool • Medium River, Moderate Gradient, Warm
Droop Mountain Battlefield State Park	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Calcareous Forests, Woodlands and Glades • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Developed 	<ul style="list-style-type: none"> • N/A
Beartown State Park	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Northern Hardwood Forests • Developed 	<ul style="list-style-type: none"> • N/A

Public Land	Terrestrial Habitat	Aquatic Habitat
Moncove Lake State Park	<ul style="list-style-type: none"> • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • Open Water • Small Stream Riparian Habitats • Developed 	<ul style="list-style-type: none"> • Headwater Creek, Moderate Gradient, Cool
Watoga State Park	<ul style="list-style-type: none"> • Forest and Woodland <ul style="list-style-type: none"> • Dry-Mesic Oak Forests • Dry Oak (-Pine) Forests • Mixed Mesophytic Forests • Northern Hardwood Forests • Pine-Oak Rocky Woodlands • Rock Outcrops, Cliffs and Talus, and Shale Barrens <ul style="list-style-type: none"> • Acidic Rock Outcrops, Cliffs and Talus • Aquatic, Floodplain and Riparian <ul style="list-style-type: none"> • River Floodplains • Small Stream Riparian Habitats • Agricultural and Developed 	<ul style="list-style-type: none"> • Headwater Creek, Low Gradient, Warm • Headwater Creek, Moderate Gradient, Cool • Headwater Creek, High Gradient, Cold • Headwater Creek, High Gradient, Cool • Medium River, Low Gradient, Warm • Medium River, Moderate Gradient, Warm

Cave and Karst Features in Public Lands

Public Land	Karst Feature Count	Area Type
Beartown State Park	3	State Park
Droop Mountain Battlefield State Park	1	State Park
Greenbrier State Forest	1	State Forest
Seneca State Forest	1	State Forest
Monongahela National Forest	7	National Forest

Appendix 4. Partners and Assistance Provided

The table below lists partners and assistance provided to landowners for wildlife conservation actions in the CFA.

Partner	Role/Assistance Provided
<p>Appalachian Mountains Joint Venture (AMJV)</p> <p>https://amjv.org/</p>	<ul style="list-style-type: none"> The Appalachian Mountains Joint Venture (AMJV) is a regional partnership of state and federal agencies, conservation organizations, and universities who work to restore and sustain viable populations of native birds and their habitats in the Appalachian Mountains. AMJV works with partners to provide private landowners with guidance and opportunities to improve habitat for birds and other wildlife.
<p>American Forest Foundation (AFF)</p> <p>https://www.forestfoundation.org/</p> <p>https://www.familyforestcarbon.org/</p>	<ul style="list-style-type: none"> The American Forest Foundation's mission is to deliver meaningful conservation impact through the empowerment of family forest landowners. The American Tree Farm System (ATFS) recognizes landowners for their good stewardship and adhering to the ATFS Standards of Sustainability while meeting their own goals and objectives for their land. The Family Forest Carbon Program focuses on two specific practices: Growing Mature Forests (encouraging Forest Management Plans) and Enhancing the Future Forest (control of competing vegetation to improve regeneration before or after a regeneration harvest)
<p>Cave Conservancy of the Virginias (CCV)</p> <p>https://caveconservancyofvirginia.org/</p>	<ul style="list-style-type: none"> Promoting conservation, management, knowledge and acquisition of caves and karst resources in Virginia and West Virginia Contributes to educational, research and environmental protection projects Funds a variety of cave and karst education, outreach, research, cleanup and acquisition projects. Provides research scholarships and stipends for graduate and undergraduate students Supports <i>Project Underground</i> environmental education program to promote a better understand of caves and karst lands.

Partner	Role/Assistance Provided
<p>Consulting Foresters</p> <p>https://wvforestry.com/forestry-consultants/</p>	<ul style="list-style-type: none"> • Developing Forest Stewardship Plans • Promoting Forestry BMPs • Designing forest management practices to achieve landowner goals and ecological objectives • Assisting landowners with developing forest carbon projects aimed at achieving verifiable carbon sequestration through improved forest management practices
<p>County Farmland Protection Boards</p> <p>http://wvfp.org/</p>	<ul style="list-style-type: none"> • County Farmland Protection Boards and West Virginia Agricultural Land Protection Authority are authorized through WV Department of Agriculture, under the Voluntary Farmland Protection Act, to • Assist in sustaining the farming community • Provide sources of agricultural products within the state for citizens of the state • Control the urban expansion which is consuming the agricultural land, topsoil and woodland of the state • Curb the spread of urban blight and deterioration • Protect agricultural land and woodland as open-space land • Enhance tourism • Protect worthwhile community values, institutions & landscapes which are inseparably associated with traditional farming
<p>Forest Certification Programs:</p> <ul style="list-style-type: none"> • American Tree Farm System (ATFS) https://www.treefarmssystem.org/ • Sustainable Forestry Initiative (SFI) https://www.forests.org/ https://www.wvfa.org/sfi/ • Forest Stewardship Council (FSC) https://fsc.org/en 	<ul style="list-style-type: none"> • Resources, assistance and certification for sustainable forest management on public and private lands

Partner	Role/Assistance Provided
<p>Master Naturalists Program</p> <p>http://mnofwv.org/</p>	<ul style="list-style-type: none"> • Training interested people in the fundamentals of natural history, nature interpretation and teaching. • Instilling an appreciation of the importance of responsible environmental stewardship. • Providing a corps of highly qualified volunteers to assist government agencies, schools and non-government organizations with research, outdoor recreation development, and environmental education and protection
<p>National Speleological Society (NSS)</p> <p>https://caves.org/</p>	<ul style="list-style-type: none"> • Promotes safe and responsible caving practices, effective cave and karst management, speleology, and conservation. • Members work together in NSS grottos (i.e, chapters), regions, surveys, and sections to develop ideas and pursue projects in the areas of speleology, as well as cave conservation, management, preservation, restoration, exploration, surveying, rescue, equipment, techniques, and education.
<p>National Wild Turkey Federation (NWTf)</p> <p>https://www.nwtf.org/</p>	<ul style="list-style-type: none"> • Provides information to landowners on hunting and habitat management for wild turkey and other wildlife • Partners with state and federal agencies on hunting access and habitat management for wild turkey and other wildlife species
<p>Outdoor Heritage Conservation Fund (OHCF)</p> <p>https://commerce.wv.gov/boards-commissions/outdoor-heritage-conservation-fund/</p>	<ul style="list-style-type: none"> • The Outdoor Heritage Conservation Fund (OHCF) protects lands that host West Virginia’s wild and wonderful natural resources. The OHCF’s land-protection projects can include important wildlife habitats, working forests and farmlands, as well as hunting, fishing, and outdoor recreational areas. The OHCF is working to protect the best of our natural resources for all West Virginians.

Partner	Role/Assistance Provided
<p>Ruffed Grouse Society/American Woodcock Society (RGS)</p> <p>https://ruffedgrousesociety.org/#</p>	<ul style="list-style-type: none"> • Creates healthy forest habitat for the benefit of ruffed grouse, American woodcock and other forest wildlife • Works with landowners and government agencies to develop critical habitat using scientific management practices • RGS works with the forest product industry, including landowners, foresters, loggers, and forest product manufacturers, to scale up capacity building, investment and conservation benefits from working forests to the landscape scale. <p>https://ruffedgrousesociety.org/the-ruffed-grouse-society-model-of-working-forests/</p>
<p>The Conservation Fund (TCF)</p> <p>https://www.conservationfund.org/where-we-work/west-virginia</p>	<ul style="list-style-type: none"> • Works with public, private and nonprofit partners to protect America’s legacy of land and water resources through land acquisition, sustainable community and economic development, and leadership training, emphasizing the integration of economic and environmental goals.
<p>The Nature Conservancy (TNC)</p> <p>https://www.nature.org/en-us/about-us/where-we-work/united-states/west-virginia/</p>	<ul style="list-style-type: none"> • Assist public land managers with land protection, management and restoration to maintain landscape resilience and connectivity • Assist private landowners with land protection and improved management, including conservation easements and forest carbon projects • Manages a network of nature preserves and conservation easements for conservation and recreation
<p>Trout Unlimited (TU)</p> <ul style="list-style-type: none"> • http://www.wvtu.org/ • http://www.tu.org/ 	<ul style="list-style-type: none"> • Plans and implements restoration projects with landowners and in coordination with USFWS Partners program and USDA Natural Resource Conservation Service and Forest Service and other partners • Projects focus on riparian corridor and in-stream habitat restoration, invasive weed treatment and aquatic passage barrier removal/replacement to benefit brook trout and other wildlife species

Partner	Role/Assistance Provided
<p>USDA Farm Service Agency (FSA)</p> <p>https://www.fsa.usda.gov/state-offices/West-Virginia/programs/index</p> <ul style="list-style-type: none"> • Conservation Reserve Program (CRP) • Conservation Reserve Enhancement Program (CREP) • State Acres for Wildlife Enhancement (SAFE) • Farmable Wetlands Program (FWP) • Grasslands Reserve Program (GRP) 	<ul style="list-style-type: none"> • CRP provides rental payments to agricultural producers participating voluntarily to safeguard environmentally sensitive land, conserve water quality, control soil erosion and enhance wildlife habitat, including floodplain wetlands. • CREP provides extra incentives and payments to eligible producers to reduce soil erosion and pollution, improve water quality and enhance terrestrial and aquatic wildlife habitat through practices such as riparian buffers and wetland restoration • The State Acres for Wildlife Enhancement (SAFE) Initiative provides farmers and landowners with assistance to establish wetlands, grasses and trees to enhance important wildlife populations by creating critical habitat and food sources, while protecting soil and water health. • The Farmable Wetlands Program (FWP) provides farmers and ranchers annual rental payments in return for restoration wetlands and wetland buffers zones. • The Grassland Reserve Program (GRP) provides farmers a rental payment to voluntarily prevent grazing and pasture land from being converted into cropland or urban development.

Partner	Role/Assistance Provided
<p>USDA Natural Resources Conservation Service (NRCS):</p> <p>https://www.nrcs.usda.gov/wps/portal/nrcs/main/wv/programs/financial/</p> <p>Environmental Quality Incentive Program (EQIP)</p> <ul style="list-style-type: none"> • Conservation Stewardship Program (CSP) • Agricultural Management and Assistance Program (AMA) • Agricultural Conservation Easement Program (ACEP) 	<ul style="list-style-type: none"> • EQIP provides cost-share to forest and agricultural landowners targeting for activities such as forestry and grazing BMPs, reduction of nutrient, sediment and pesticide pollution, stream restoration and wildlife habitat enhancement, including stream buffers • Working Lands for Wildlife is a partnership between NRCS and USFWS to work with agricultural producers and forest land managers on habitat conservation for seven at-risk species, including Golden-winged Warbler • The RCPP-EQIP Cerulean Warbler Initiative is designed to enhance Cerulean Warbler habitat and increase their populations • The RCPP-EQIP WV Aquatic Passage-Working Farms project is a partnership between NRCS, TU and USFWS designed to improve fish and aquatic wildlife habitat, reduce infrastructure risk and increase flood resiliency. CSP provides payments to farm and forest landowners for actively managing, maintaining and expanding conservation activities to enhance natural resources and improve their business operations. Priority resource concerns for funding include terrestrial habitat for wildlife and invertebrates. • AMA provides technical and financial assistance to agricultural producers on a voluntary basis to address issues such as water management, water quality and erosion control by incorporating conservation into their farming operations. • ACEP is a voluntary program providing technical and financial assistance to landowners for both agricultural land easements and wetland reserve easements to protect farmland and wetland habitat.

Partner	Role/Assistance Provided
<p>US Fish and Wildlife Service (USFWS)</p> <p>Partners for Fish and Wildlife Program</p> <p>https://www.fws.gov/northeast/ecologicalservices/partners.html</p>	<ul style="list-style-type: none"> • Provides technical and financial assistance to private landowners for restoration and enhancement of fish and wildlife habitat for the benefit of Federal Trust species (Migratory Birds, Threatened and Endangered and At-Risk Species) • Efforts focus on controlling nonnative invasive plants, managing livestock access to forests, wetland restoration, riparian buffer planting and fencing, in-stream habitat improvement, aquatic passage barrier removal and creating pollinator habitat • Works in coordination with the USDA Natural Resources Conservation Service farm bill programs, Trout Unlimited and other partners
<p>West Virginia Association for Cave Studies (WVACS)</p> <p>https://www.wvacs.org/</p>	<ul style="list-style-type: none"> • Contributes to cave surveys and research • Hosts cave scientists and graduate students pursuing cave research at field stations in Greenbrier County
<p>West Virginia Cave Conservancy</p> <p>https://wvcc.net/</p>	<ul style="list-style-type: none"> • Manages caves to protect sensitive cave resources and environments • Educates and provides expertise to landowners, developers, local governments and the public on the value of cave and karst resources • Organizes cave and karst conservation projects including sinkhole cleanups and livestock barrier fences. • Preserves access to significant caves through ownership and management agreements • Sponsor research and survey projects on WVCC caves

Partner	Role/Assistance Provided
<p>WV Conservation Agency (WVCA) and Greenbrier Valley Conservation District (GVCD)</p> <p>http://www.wvca.us</p> <ul style="list-style-type: none"> • Ag Enhancement Program (AgEP) • Non-Point Source Program • Stream Partners Program 	<ul style="list-style-type: none"> • The Ag Enhancement Program (AgEP), administered by Conservation Districts and the WVCA, offers technical and financial assistance to implement conservation best management practices for the reduction of nutrients and sediment entering waterways and increasing farm profitability and sustainability. Practices may include invasive species management and exclusion fencing to protect streams, wetlands and other environmentally sensitive areas. • Through Conservation Districts, the statewide Non-Point Source Program uses federal Clean Water Act, Section programs to reduce nonpoint source pollution related to agriculture, construction and urban stormwater management. • Through the Stream Partners Program, WVDNR, WVCA, WVDOF and WVDEP provide grants up to \$5,000 to citizens' groups who want to improve, restore, protect, study or celebrate the state's rivers and streams.
<p>WV Department of Environmental Protection (WVDEP)</p> <ul style="list-style-type: none"> • Nonpoint Source Program https://dep.wv.gov/WWE/Programs/nonptsource/Pages/home.aspx • Watershed Based Plans https://dep.wv.gov/WWE/Programs/nonptsource/WBP/Pages/WBP.aspx • Save Our Streams Program https://dep.wv.gov/WWE/getinvolved/sos/Pages/default.aspx • Rehabilitation Environmental Action Plan (REAP) https://dep.wv.gov/environmental-advocate/reap/Pages/default.aspx • WVDEP Youth Environmental Program (YEP) https://dep.wv.gov/environmental-advocate/yep/Pages/default.aspx 	<ul style="list-style-type: none"> • Supports partners and citizen-based watershed organizations in restoring impaired watersheds • Provides assistance in proper installation and maintenance of Best Management Practices • Provides funding for projects by watershed groups and partners to improve water quality in watersheds listed as impaired, including the Greenbrier River and many tributaries • Practices include wastewater treatment, agricultural BMPs, rain gardens for stormwater runoff, streambank restoration and community outreach • Save our Streams provides training for volunteers to monitor local wadable streams and rivers • REAP provides communities with technical, financial and resource assistance in cleanup efforts. • YEP organizes youth and volunteer groups for hands-on conservation projects

Partner	Role/Assistance Provided
<p>WV Department of Health and Human Resources (WVDHHR)</p> <ul style="list-style-type: none"> On-Site Sewage Program <p>https://www.wvdhhr.org/phs/sewage/index.asp</p>	<ul style="list-style-type: none"> Provides rule interpretation and technical assistance on conventional and non-conventional on-site sewage systems, including information on septic systems, installers, permits, fees and loan programs.
<p>WV Division of Forestry (WVDOF)</p> <p>http://www.wvforestry.com/</p>	<ul style="list-style-type: none"> Oversees the Managed Timberland Program to provide tax incentives for landowners who manage their forest land sustainably according to a management plan Oversee timber sales and Best Management Practices Provides training workshops for loggers on safety and Best Management Practices Maintains list of consulting foresters who can help landowners with Forest Stewardship Plans to enhance wildlife habitat Protection of large private forest tracts through Forest Legacy Program
<p>WV Division of Natural Resources (WVDNR)</p> <p>http://www.wvdnr.gov/wildlife/wdpintro.shtm</p>	<ul style="list-style-type: none"> Identification of SGCN and rare communities Education, outreach and teaching resources Field guides, Landscaping and Management guidelines Fish and game management Habitat restoration assistance Natural Areas Program
<p>West Virginia Land Trust (WVLT)</p> <p>https://www.wvlandtrust.org/</p>	<ul style="list-style-type: none"> WVLT's mission is to protect land with significant conservation values through the use of conservation easements and real estate acquisitions, and by working with a statewide network of partners to build a passionate land conservation movement in the state.

Partner	Role/Assistance Provided
<p>West Virginia Scenic Trails Association (WVSTA)</p> <p>https://www.wvscenictrails.org/</p>	<ul style="list-style-type: none"> • Serves the outdoor community by building and maintaining the Allegheny Trail and other trails in partnership and cooperation with landowners, managers, and others. • Maintains, preserves, protects, and promotes this challenging and scenic foot trail (that will exceed 300 miles) running southward from the Mason-Dixon Line through WV and VA to the Appalachian Trail. • Furthers the conservation of wild pristine lands and wildlife and protect areas of natural beauty and historic interest through stewardship
<p>West Virginia University Extension Service (WVU Extension):</p> <ul style="list-style-type: none"> • Forestry <p>https://extension.wvu.edu/natural-resources/forestry</p> <ul style="list-style-type: none"> • Wildlife <p>https://extension.wvu.edu/natural-resources/wildlife</p>	<ul style="list-style-type: none"> • Landowner technical assistance and information on financial assistance for forest and wildlife management • Training workshops and conferences on forestry Best Management Practices and safety practices

Appendix 5. Resources

The following resources may provide additional information to landowners and partners seeking to manage habitat for priority SGCN in this CFA.

Greenbrier River Watershed- Watershed Based Plans for Anthony Creek, Beaver Creek, Knapp Creek, Milligan Creek, Muddy Creek, Second Creek and Spring Creek. Available at:

<https://dep.wv.gov/WWE/Programs/nonptsource/WBP/Pages/WBP.aspx>

Long Range Plan for the Greenbrier Valley Conservation District

Summarizes natural resources conditions and ranks resource concerns that could be addressed through NRCS technical and financial assistance. Available at:

<https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/wv/programs/financial/eqip/?cid=nrcseprd1167606>

Living on Karst- A Reference Guide for Landowners in Limestone Regions

http://www.livingonkarst.org/living_on_karst.htm

Guidelines for Cave and Karst Protection- IUCN

<https://www.iucn.org/content/guidelines-cave-and-karst-protection-0>

A Guide to Responsible Caving, by the National Speleological Society

https://caves.org/brochure/Guide_to_Resp_Caving_2016.pdf

National Wild Turkey Foundation- Landowner's Toolbox

https://www.nwtf.org/conservation/category/landownershttps://caves.org/brochure/Guide_to_Responsible_Caving_2016.pdf-tool-box

Cerulean Warbler Management Guidelines for Enhancing Breeding Habitat in Appalachian Hardwood Forests

http://amjv.org/wp-content/uploads/2018/06/cerulean_guide_1-pg_layout.pdf

Best Management Practices for Golden-winged Warbler Habitats in the Appalachian Region: A Guide for Land Managers and Landowners.

https://www.allaboutbirds.org/bbimages/clo/pdf/GWWA-APPLRegionalGuide_130808_lo-res.pdf

Wildlife Habitat Council Integrated Vegetation Management Project Guidance for Infrastructure Corridors: <https://www.wildlifehc.org/wp-content/uploads/2015/11/WHC-Integrated-Vegetation-Management-Project-Guidance.pdf>

West Virginia Pollinator Handbook – A Field Office Technical Guide Reference to management of pollinators and their habitats. Developed by WV NRCS Ecological Sciences in conjunction with WV Division of Natural Resources and the Xerces Society for Invertebrate Conservation.

<http://xerces.org/sites/default/files/publications/12-049.pdf>

Brochures about Aquatic Invasive Species, Forest Pests and Pathogens, and Invasive Plant Species

<https://www.nrcs.usda.gov/wps/portal/nrcs/main/wv/technical/ecoscience/invasive/>

West Virginia Invasive Species Strategic Plan and Voluntary Guidelines, 2014

https://eos.ucs.uri.edu/seagrant_Linked_Documents/mdu/2014-09_RO_Anderson_M_INV-3b.pdf

Fighting Invasive Plants in West Virginia

<http://www.wvnps.org/FightingInvasives.pdf>

American Forest Foundation: Woodland owners planning tool for forest management

<https://mylandplan.org/>

The Nature Conservancy Resilient Land Mapping Tool and Documents:

<http://maps.tnc.org/resilientland/>

USDA Forest Service, Northern Research Station's Climate Change Atlas: documentation of current and possible future distribution of 134 tree species and 147 bird species in the Eastern United States

<https://www.fs.fed.us/nrs/atlas/>

Rudnick, D.A. et al. 2012. The Role of Landscape Connectivity in Planning and Implementing Conservation and Restoration Priorities. Ecological Society of America.

<https://applcc.org/cooperative/our-organization/rudnick-et-al.-2012-the-role-of-landscape-connectivity-in-planning-and-implementing-conservation-and-restoration-priorities>

Adaptation Workbook: A climate change tool for land management and conservation, created by the Northern Institute of Applied Climate Science:

<https://adaptationworkbook.org/>

U.S. Climate Resilience Toolkit, a website designed to help people find and use tools, information and subject matter expertise to build climate resilience. The Toolkit offers information from all across the U.S. federal government in one easy-to-use location.

<https://toolkit.climate.gov/tool/climate-smart-conservation-putting-adaptation-principles-practice>

Forest Adaptation Resources: climate change tools and approaches for land managers, 2nd edition, 2016, published by the USDA Forest Service, Northern Research Station

<https://www.nrs.fs.fed.us/pubs/52760>

Adaptation Resources for Agriculture: Responding to Climate Variability and Change in the Midwest and Northeast. U.S. Department of Agriculture.

<https://www.climatehubs.usda.gov/sites/default/files/AdaptationResourcesForAgriculture.pdf>