Action Plan for the Kanawha Falls Conservation Focus Area

November, 2023

Table of Contents

List of Tables

List of Maps

List of Acronyms Used

ACEP- Agricultural Conservation Easement Program
AMJV- Appalachian Mountain Joint Venture
BMPs- Best Management Practices
B-Rank- Biodiversity Rank
CFA- Conservation Focus Area
CCV- Cave Conservancy of the Virginias
CCVI- Climate Change Vulnerability Index
CERW- Cerulean Winged Warbler
CREP- Conservation Reserve Enhancement Program
CRP- Conservation Reserve Program
CSP- Conservation Stewardship Program
EQIP- Environmental Quality Improvement Program
ESH- Early-Successional Habitat
FERC- Federal Energy Regulatory Commission
FSA- Farm Service Agency
G Rank- Global Rank
GWWA- Golden-winged Warbler
HUC- Hydrologic Unit Code
KCEMGA- Kanawha County Extension Master Gardeners' Association
KVMN- Kanawha Valley Master Naturalists
NRCS- Natural Resources Conservation Service
NWTF- National Wild Turkey Foundation
RC&D- Resource Conservation and Development Council
RGS- Roughed Grouse Society
SGCN- Species of Greatest Conservation Need
S Rank- State Rank
SWAP- State Wildlife Action Plan
TNC- The Nature Conservancy
TU- Trout Unlimited
USDA- United States Department of Agriculture
USFWS- United States Fish and Wildlife Service
WVDHHR- Department of Health and Human Resources
WVDNR- West Virginia Division of Natural Resources
WMA- Wildlife Management Area
WVDEP- West Virginia Department of Environmental Protection
WVDOF- West Virginia Division of Forestry
WVDOH- West Virginia Division of Highways
WVU- West Virginia University

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 and other non-profit conservation organizations working in the area to develop the Action Plan for the Kanawha Falls 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 habitats, aquatic, floodplain and riparian. It also identifies 50 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 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.

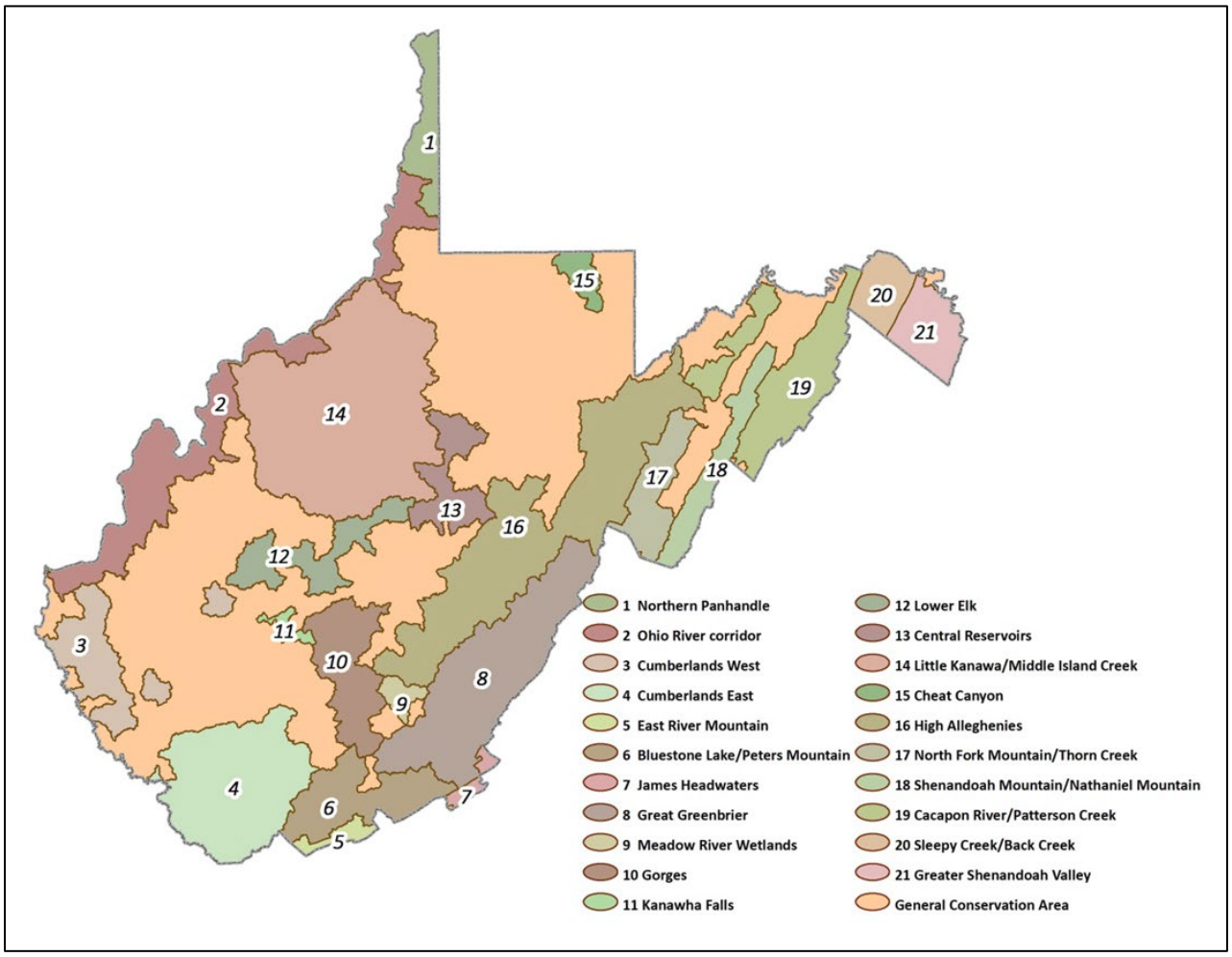
Conservation actions vary according to the species and the specific stresses; actions can take many forms. A lack of information on the status of a species or understanding of a threat may indicate a need for actions such as baseline inventory, research, or data acquisition. Direct action may involve 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.



Climate Change and Resilience

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

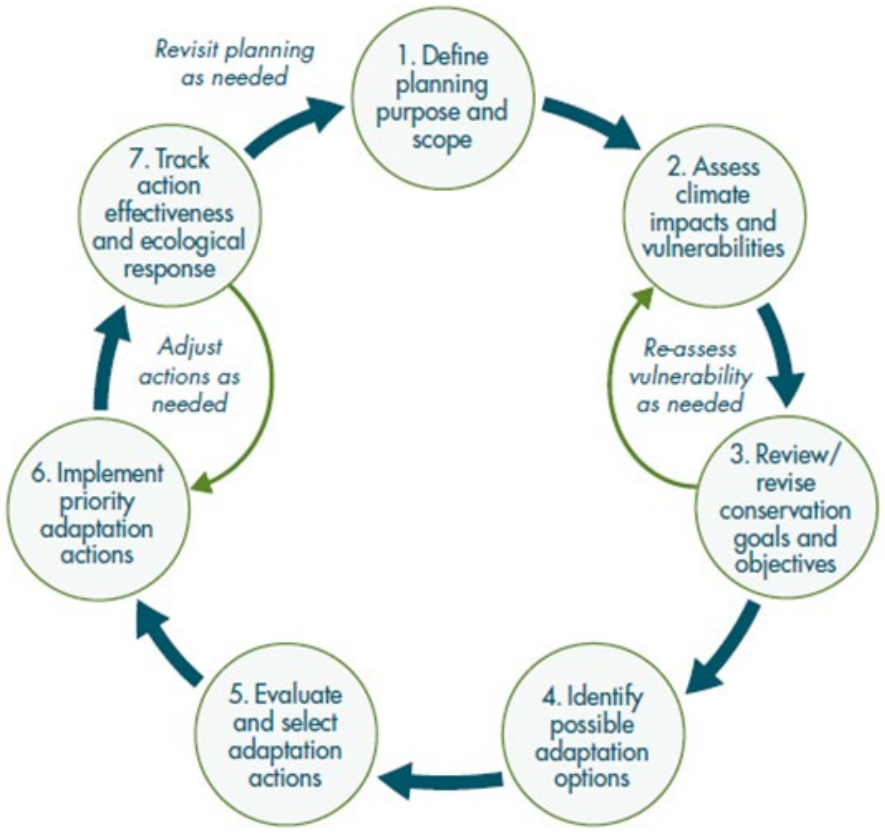
others. The SWAP suggests that efficient approaches to maintaining broad suites of species include maintaining functioning ecological systems, landscapes that are resilient to the effects of climate change and ecological connectivity within and between landscapes. Rather than a species-specific approach, 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, and aquatic, floodplain and riparian 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 for greater impact, connecting conservation actions for climate resilience and outlines next steps in plan implementation.

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

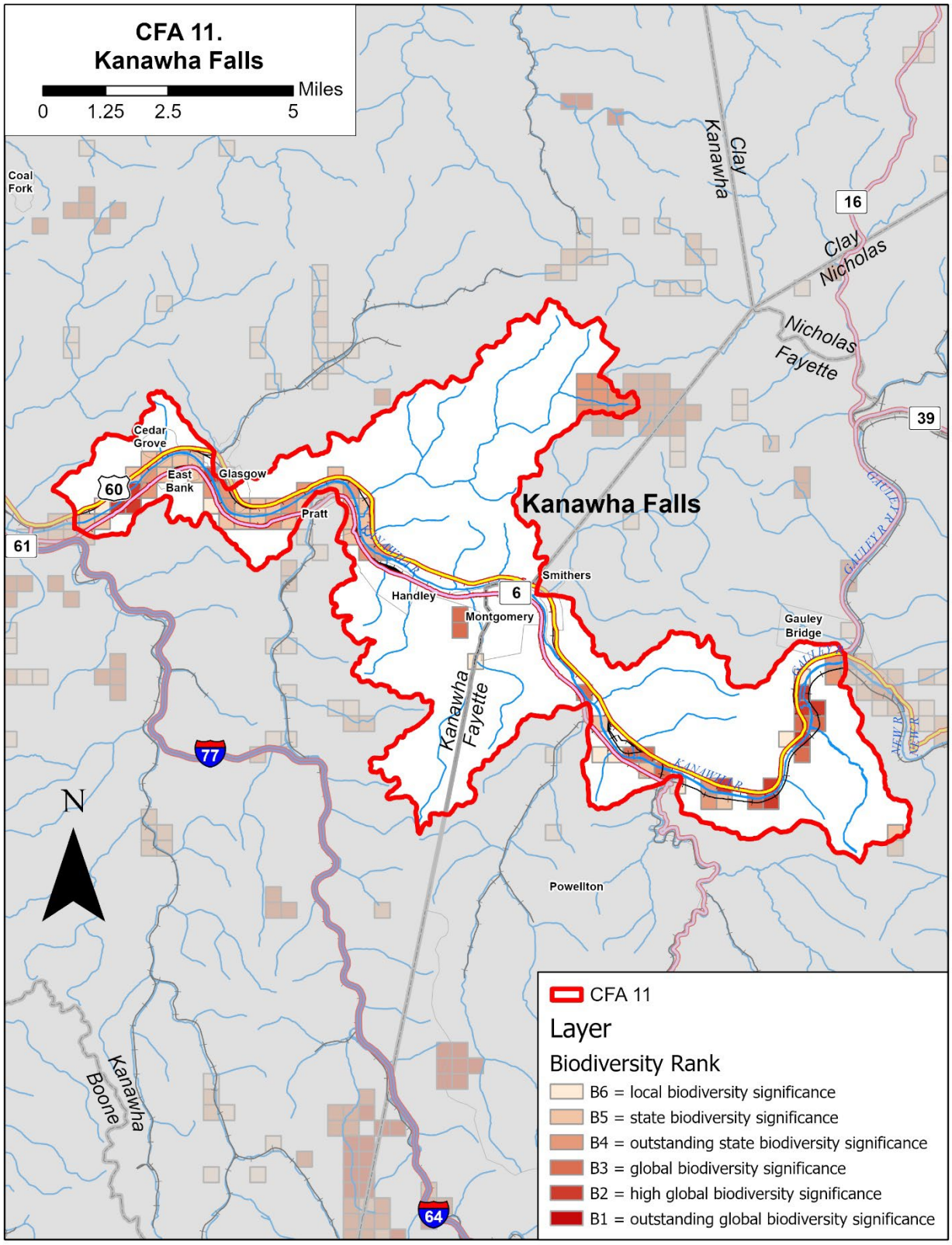
Kanawha Falls Conservation Focus Area

Overview

Map 2 provides an overview of the Kanawha Falls CFA. On the east, upstream side of the CFA, Kanawha Falls is a natural and historic barrier for aquatic organisms. This unique and critically important habitat feature provides a refuge and population source for many species that have been extirpated from lower reaches of the Kanawha River. The river reach in this CFA is the last section of any great river in West Virginia that remains un-impounded. Although flow is still regulated by dams upstream on the Gauley and New Rivers, this reach maintains its flowing riffle, pool and run complex of habitats. Much of the uplands in this small CFA in the Cumberland Mountains Ecoregion consist of mostly forested steep slopes. Extensive residential and commercial development is concentrated along the narrow floodplain of the Kanawha River. The river is also paralleled by US Route 60 and a railroad.

The map also shows known occurrences of SGCN and rare plant communities within 500- square meter areas and the biodiversity rank (including global, state, or local significance) of those occurrences, as generated by WVDNR in 2017. The map illustrates many known SGCN occurrences along the Kanawha River. With no sizable public lands in this CFA, most SGCN and rare plant communities occur on private land, so WVDNR and other partners need to work with private landowners to restore and protect biodiversity.

Map 2. Overview



Habitats

The Kanawha Falls CFA includes a variety of terrestrial, aquatic and subterranean habitat types.

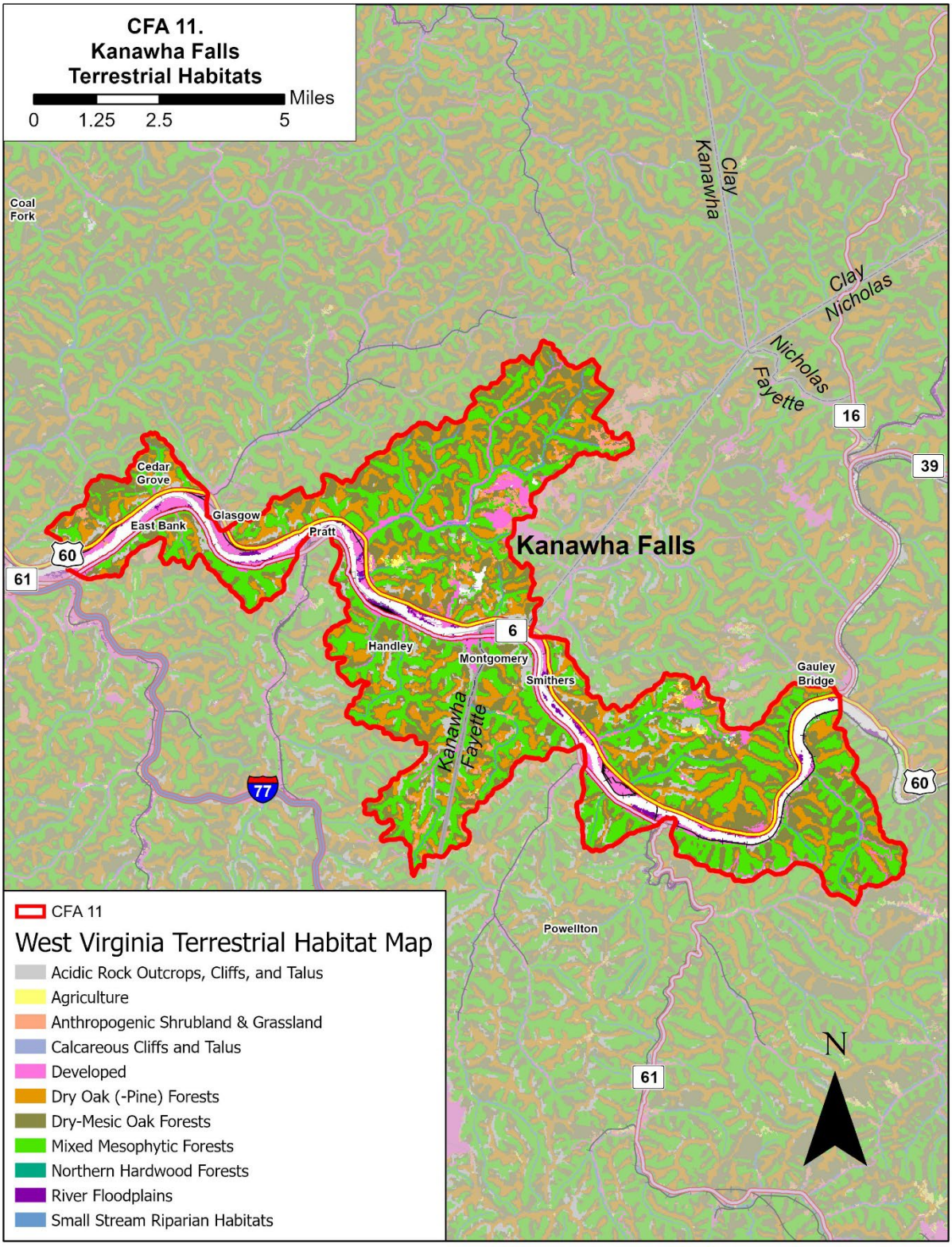
Terrestrial Habitats

Ten of the habitat types described in the SWAP are present in this CFA and range in abundance from covering nearly one third of the total area in the case of Mixed Mesophytic Forests, to covering as little as 0.01% of the total area in the case of Northern Hardwood Forests. 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	1,792	4.57%	2.00%
Agriculture	144	0.37%	0.01%
Anthropogenic Shrubland & Grassland	741	1.89%	0.47%
Developed	3,953	10.07%	0.35%
Dry Oak (-Pine) Forests	7,143	18.20%	0.29%
Dry-Mesic Oak Forests	10,882	27.73%	0.22%
Mixed Mesophytic Forests	11,381	29.00%	0.39%
River Floodplains	401	1.02%	0.33%
Small Stream Riparian Habitats	651	1.66%	0.13%
Unresolved	2,156	5.49%	1.85%
Totals	39,247	100.00%	

Map 3. Terrestrial Habitats



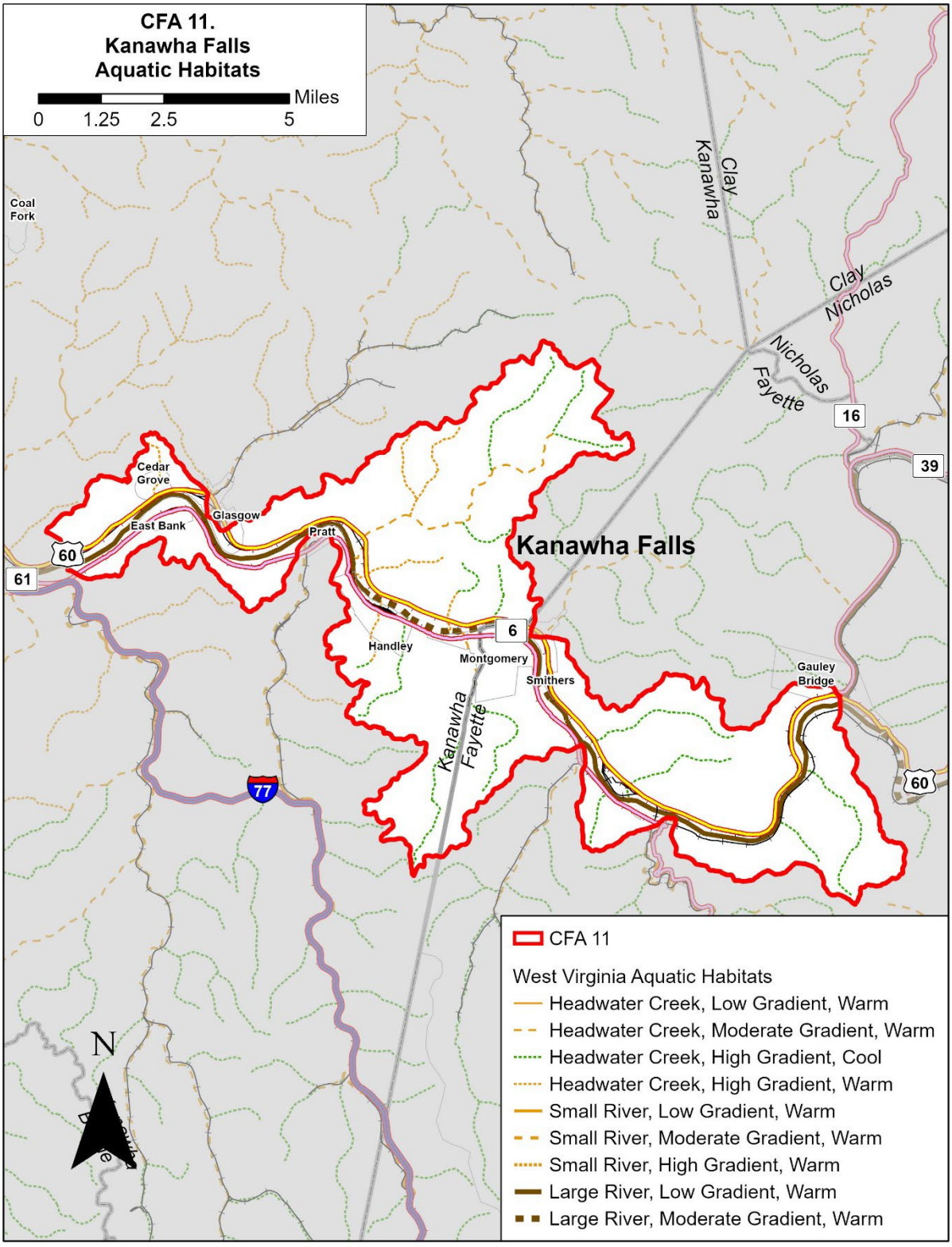
Aquatic Habitats

Nine of the aquatic habitat types described in the SWAP are present within the Kanawha Falls CFA, the most abundant of which are cool, moderate gradient headwater creeks, which comprise 30 miles of stream within the CFA. Aquatic habitats are described in Chapter 3 of the 2015 SWAP.

Table 2. Aquatic Habitat Summary

Habitat Type	Miles in CFA	% of CFA Area	% of WV Total for Type
Headwater Creek, Low Gradient, Warm	0	0.57%	0.08%
Headwater Creek, Moderate Gradient, Warm	9	12.25%	0.24%
Headwater Creek, High Gradient, Cool	30	40.57%	0.49%
Headwater Creek, High Gradient, Warm	9	12.08%	1.19%
Small River, Low Gradient, Warm	0	0.13%	0.02%
Small River, Moderate Gradient, Warm	3	4.57%	0.63%
Small River, High Gradient, Warm	0	0.08%	0.38%
Large River, Low Gradient, Warm	18	24.62%	3.18%
Large River, Moderate Gradient, Warm	4	5.13%	3.51%
Totals	75	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 Kanawha Falls CFA.

Table 3. Species Summary by Taxa

Taxa	# SGCN
Amphibian	5
Birds	9
Butterflies and Moths	3
Fish	9
Mammals	3
Mussels	39
Plants	6
Reptiles	6
Snails	2
Total	**82**

The falls, a barrier to passage, provides a natural break point for fish and mussel species diversity between the mainstem Kanawha River downstream and the New River drainage upstream. Thirty-seven SGCN mussels occur below the falls, including four federally endangered species. One of these, the Northern Riffleshell (*Epioblasma rangiana*), became extirpated but was subsequently reintroduced here in 2014. Along with the New River in the Gorge just upstream, this provides the last stronghold for the Purple Wartyback mussel in West Virginia and represents the highest diversity mussel bed in the state. There is a highly diverse fish fauna here. Seventy-three fish species are documented in this CFA including 10 SGCN.

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

Distinctive Stresses

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

- The Glenn Ferris Hydropower facility has the potential to change flow patterns across established mussel beds.
- Spill from tanker truck wrecks or train derailments could be disastrous.

In addition to this list of potential stresses, this Action Plan will list current stresses affecting priority SGCN in each major habitat type.

Conservation Actions

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

- Protecting the un-impounded condition of this reach is of utmost priority.
- This reach has the potential to provide broodstock for restoration of mussel species throughout the state. Due to the lack of the exotic zebra mussels this area is also important for restoration of big river mussel species such as the on-going Northern Riffleshell restoration project.
- Develop a hazardous spill prevention and response protocol that addresses biological and ecological concerns.

This Action Plan will also list conservation actions to address the current 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:

- CSX Corporation
- Federal Energy Regulatory Commission (FERC)
- Glenn Ferris Hydropower operator
- National Transportation Safety Board
- U.S Fish and Wildlife Service
- WV Division of Forestry
- Morris Creek Watershed Association
- Paint Creek Watershed Association

The Morris Creek and Paint Creek Watershed Associations promote the restoration of watersheds that are not included in the CFA, but which contribute to the waters of the Kanawha Falls CFA, and may also be valuable partners in conservation efforts here.

These partners are important stakeholders in the conservation of rare plant and animal species in this CFA. Some have an established “constituency” and can also provide direct outreach to landowners and other 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.

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 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
Birds	Antrostomus vociferus	Eastern Whip-poor-will	S3B	G5
Birds	Chaetura pelagica	Chimney Swift	S3B	G5
Birds	Geothlypis formosa	Kentucky Warbler	S3B	G5
Birds	Helmitheros vermivorum	Worm-eating Warbler	S3B	G5
Birds	Hylocichla mustelina	Wood Thrush	S3B	G5
Birds	Limnothlypis swainsonii	Swainson's Warbler	S3B	G4
Birds	Megaceryle alcyon	Belted Kingfisher	S3B	G5
Birds	Parkesia motacilla	Louisiana Waterthrush	S3B	G5
Birds	Setophaga cerulea	Cerulean Warbler	S2B	G4
Birds	Vermivora cyanoptera	Blue-winged Warbler	S3B	G5
Butterflies and Moths	Pieris virginiensis	West Virginia White	S3	G2
Fish	Ammocrypta pellucida	Eastern Sand Darter	S3	G3
Fish	Anguilla rostrata	American Eel	S2	G4
Fish	Moxostoma carinatum	River Redhorse	S3	G4
Fish	Notropis ariommus	Popeye Shiner	S2	G3
Fish	Notropis blennius	River Shiner	S2	G5
Fish	Noturus stigmosus	Northern Madtom	S1	G3
Mussels	Cyprogenia stegaria	Fanshell	S1	G1Q
Mussels	Elliptio crassidens	Elephant-ear	S2	G5
Mussels	Epioblasma rangiana	Northern Riffleshell	S1	G2T2
Mussels	Lampsilis abrupta	Pink Mucket	S1	G2
Mussels	Lasmigona subviridis	Green Floater	S2	G3
Mussels	Obovaria subrotunda	Round Hickorynut	S3	G4
Mussels	Plethobasus cyphyus	Sheepnose	S2	G3
Mussels	Simpsonaias ambigua	Salamander Mussel	S2	G3
Reptiles	Graptemys geographica	Northern Map Turtle	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.

Forest and Woodland Habitats

Mixed Mesophytic, Dry-Mesic Oak, and Dry Oak (Pine) Forests compose the majority of the Forest and woodland habitat types found in the CFA. The dry forest types are threatened by invasive species, mesophication (gradual moistening) and lack of fire, while overbrowsing by deer reduces regeneration of oak and other palatable understory species. Maps 5 and 6 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 rare Acid Rock Outcrops, Cliff and Talus habitats. 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 may provide core habitat for priority 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. Large, intact forest blocks support forest interior breeding birds, including Wood Thrush, Cerulean Warbler and Worm-eating Warbler. Several rare plant species are associated with Dry Oak-Pine Forests, but additional surveying will be required to ascertain their status and location.

Acidic rock outcrops, cliffs and talus can be found throughout the CFA, with heavy groupings of the habitat occurring around Cedar Grove and Montgomery. These habitats are threatened by nonnative invasive plants, woody encroachment, quarrying and other development. Those in smaller forest patches may be more vulnerable to stresses. 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. These rare habitats require careful management within the forested landscapes.

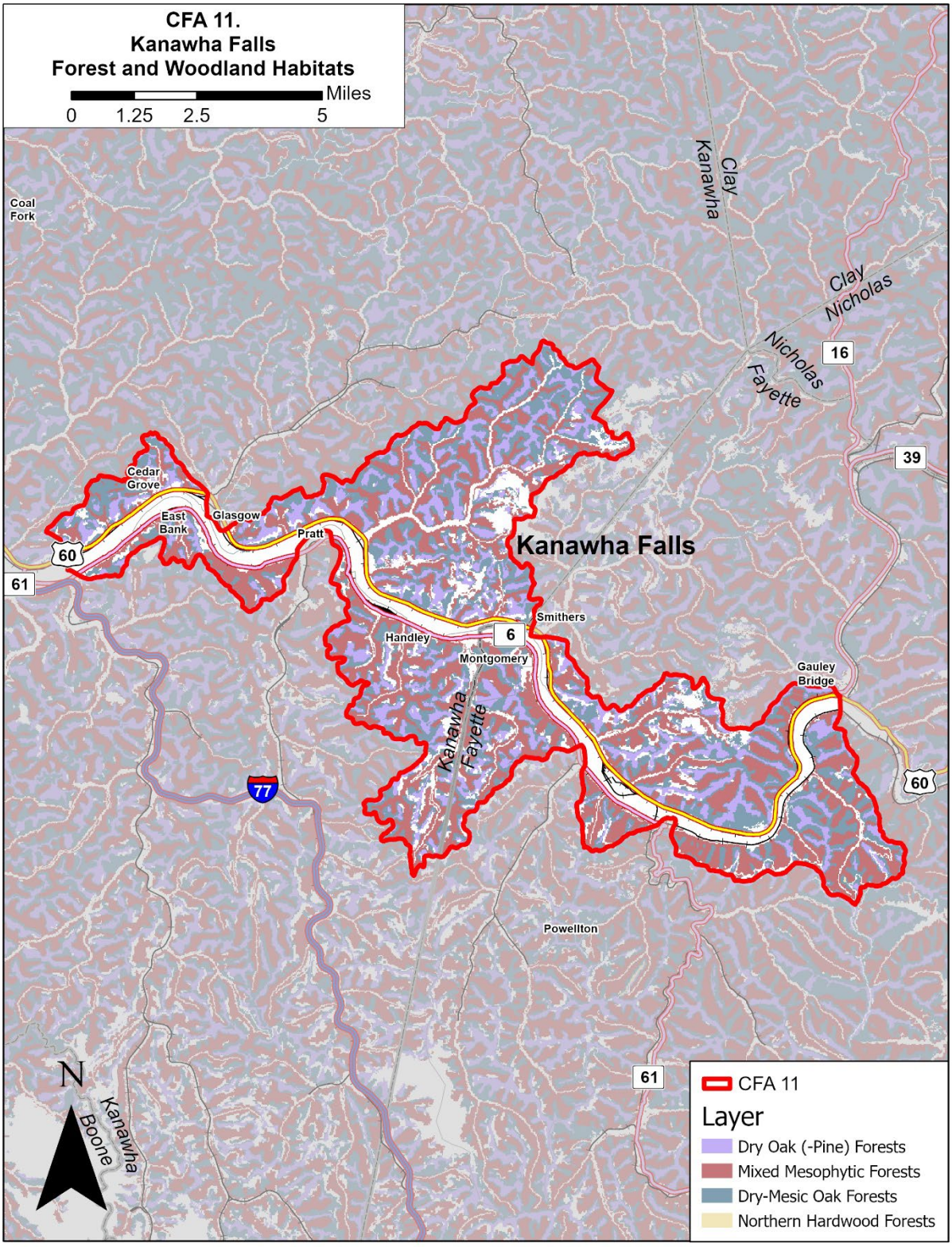
Priority Species

Table 5 lists priority species in the CFA associated with forest and woodland habitats.

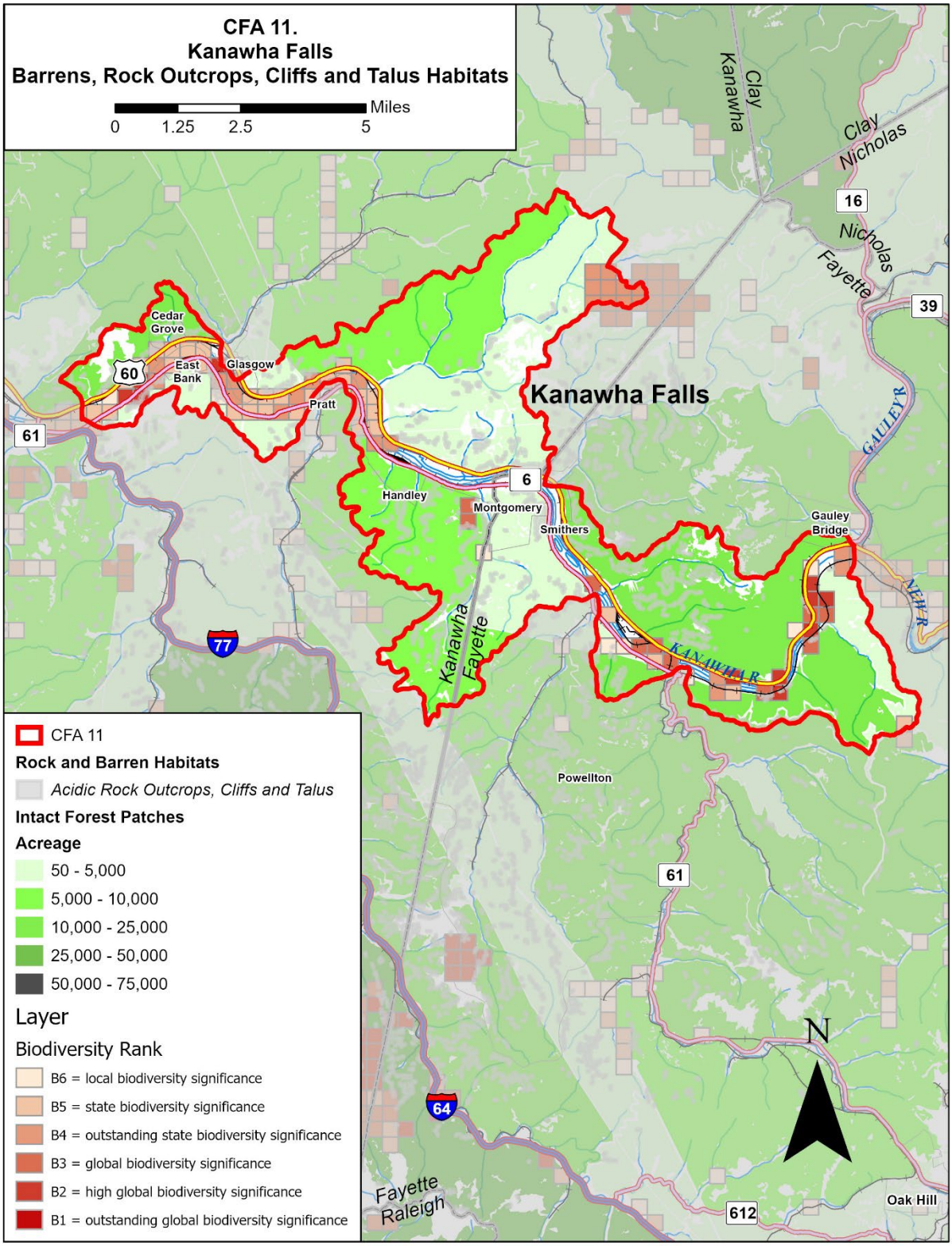
Table 5. Priority Species in Forest and Woodland Habitats.

Taxa	Scientific Name	Common Name
Birds	Antrostomus vociferus	Eastern Whip-poor-will
Birds	Geothlypis formosa	Kentucky Warbler
Birds	Helmitheros vermivorum	Worm-eating Warbler
Birds	Hylocichla mustelina	Wood Thrush
Birds	Limnothlypis swainsonii	Swainson's Warbler
Birds	Setophaga cerulea	Cerulean Warbler
Birds	Vermivora cyanoptera	Blue-winged Warbler
Butterflies and Moths	Pieris virginiensis	West Virginia White

Map 5. Forest and Woodland Habitats



Map 6. Intact Forest Patches, Rock Outcrop, Cliff & Talus Habitats



Habitat Stresses and Conservation Actions

Table 6 lists stresses impacting species in forest and woodland habitats, and conservation actions landowners and partners can take to address those stresses.

Table 6. Stresses and Actions in Forest and Woodland Habitats:

Habitat Stress	Conservation Action
Deforestation, forest fragmentation, poor forest structure, climate change	Maintain and protect contiguous forest cover, structural and spatial complexity
Deforestation and disturbance of rare habitats and hydrological features	Maintain and protect forest cover and hydrology, especially around seeps, streams, rock outcrops, cliffs and talus, and other rare habitat features
Invasive weeds: forest fragmentation, climate change	Maintain forest cover and control invasive weeds, 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 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
Incompatible utility corridor management	Improve vegetation management practices in utility corridors
Road collision/mortality (Eastern Whip-poor-will)	Install highway signage in high density areas

In addition to the general stresses listed above, the West Virginia White is also threatened by the expansion of invasive Garlic Mustard, which outcompetes the butterflies host plant.

Maintaining a diverse population of forest birds requires dynamic forest landscapes with mosaics of age classes and structure. Efforts to manage and restore both early successional and interior forest habitat are needed for priority SGCN. Early successional forest habitat forest restoration can target managed timberlands, small patches of forest and along forest edges. Existing young forests can be enhanced outside of large blocks of interior forest.

Climate Change and Habitat Resilience

The Central Appalachian Forest Ecosystem Vulnerability Assessment (Butler et al., 2015) described 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, although species such as red spruce may persist in cool, wet microclimates. 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 at greater risk from 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. Drought and 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 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.

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 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. Protection of 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.

Ecosystems that are limited by geological features, including rock outcrops, cliffs and talus habitats, 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 non-native invasive plants. Maintaining intact forest ecosystems around these rare habitats, and controlling invasive species, may help maintain resilience to a changing climate.

Table 7 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 7. Climate Stresses and Resilience Actions in Forest and Woodland Habitats

Climate Stresses	**Habitat Resilience Actions**
• 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	• 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 plant species and remove existing invasive species • 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 8. Implementation Plan for Forest and Woodland Habitats

Action	Partners	Effectiveness Measures
Forest Habitat, Reserve and Corridor Protection: • Conservation Easements • Land Acquisition • Natural Area designation	• County Farmland Protection Boards • OHCF, TCF, TNC, WVLT • WVDOF Forest Legacy • WVDNR	• Acres of habitat protected for priority species • Abundance and diversity of priority species and habitats
Forest Habitat, Reserve and Corridor Protection: • Land use planning	• County Planning Commissions	• Acres of habitat protected through land use planning in forested areas
Forest Planning and Management • Land Use Plans • Forest Management Plans • Forest Carbon Programs • Cost-Share Programs • Sustainable Forestry Certification Programs • USDA NRCS Climate Smart Forestry Activities	• AFF • AFTS, FSC, SFI • Consulting Foresters • Forest Carbon Programs • Planning Commissions • Public Land Managers • USDA NRCS • WVDOF	• Acres of habitat protected for priority species • Abundance and diversity of priority species and habitats
Create or maintain early-successional habitat (ESH) to benefit wildlife species through forest management on appropriate sites. GWWA guidelines for large forest patches with > 70% forest cover: • 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)	• Consulting Foresters • NWTF and RGS Public Land Managers • USDA NRCS • WVDOF WVU Extension	• Acres of habitat restored for priority species • Before and after comparison: abundance and diversity of priority species

Improve or maintain interior forest habitat to benefit wildlife species through forest management activities on appropriate sites CERW guidelines for large forest patches with > 70% forest cover: 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.	• Consulting Foresters • Public Land Managers • USDA NRCS • WVDOF • WVU Extension	• Acres of habitat restored for priority species • Before and after comparison: abundance and diversity of priority species
Maintain forested buffers and minimize impact on fragile Acid Rock Outcrop, Cliffs and Talus habitat	• Consulting Foresters • Public Land Managers • Quarries and developers	• Acres of habitat protected for priority species • Before and after comparison: abundance, diversity and distribution of priority species
Manage deer population where abundant	• Private landowners • Public Land Managers • WVDNR	• Change in deer population or forest structure • Acres of habitat restored for priority species • Before and after comparison: abundance and diversity of priority species
Manage forests at landscape scale for diversity of native species and age classes, structural and spatial complexity appropriate for the forest type	• AMJV • Consulting Foresters • Forest Certification Programs: AFTS, FSC, SFI • NWTF and RGS • Public Land Managers • USDA NRCS • WVDOF • WVU Extension	• Acres of habitat restored for priority species • 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)	• Landowners, partners and utility companies	• Acres of habitat restored for priority species • Before and after comparison: abundance and diversity of priority species
Monitor and control invasive weeds, promptly revegetate disturbed sites	• KCEMGA & KVMN • Public Land Managers • USDA NRCS • WVCA and GVCD • WVDOF • WVDOH	• Acres of habitat protected or restored for priority species • Before and after comparison: abundance and diversity of priority species
Public & Landowner Outreach and Demonstration	• KCEMGA & KVMN • Public Land Managers • USDA NRCS • WVDEP, WVCA and Conservation Districts • WVDNR • WVDNR, WVDOF • WVU Extension	• # Landowners engaged • # Landowners implementing actions
Restore native forest vegetation on adjacent degraded lands through planting and silviculture	• Consulting Foresters • Public Land Managers • USDA NRCS • WVDOF • WVU Extension	• Acres of habitat restored for priority species • 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, and opportunities for forest carbon sequestration, hunting, wildlife viewing, tourism, and recreation.

Aquatic, Floodplain and Riparian Habitats

A diversity of aquatic habitats in the CFA range from warm, low-gradient headwater streams such as Falls Creek, to warm, moderate gradient, large sized rivers such as the Kanawha 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

Tables 9 and 10 list priority species in aquatic, floodplain and riparian habitats in the CFA.

Table 9. Priority Species in Aquatic Habitats

Taxa	Scientific Name	Common Name
Fish	Ammocrypta pellucida	Eastern Sand Darter
Fish	Anguilla rostrata	American Eel
Fish	Moxostoma carinatum	River Redhorse
Fish	Notropis ariommus	Popeye Shiner
Fish	Notropis blennius	River Shiner
Fish	Noturus stigmosus	Northern Madtom
Mussels	Cyprogenia stegaria	Fanshell
Mussels	Elliptio crassidens	Elephant-ear
Mussels	Epioblasma rangiana	Northern Riffleshell
Mussels	Lampsilis abrupta	Pink Mucket
Mussels	Lasmigona subviridis	Green Floater
Mussels	Obovaria subrotunda	Round Hickorynut
Mussels	Plethobasus cyphyus	Sheepnose
Mussels	Simpsonaias ambigua	Salamander Mussel

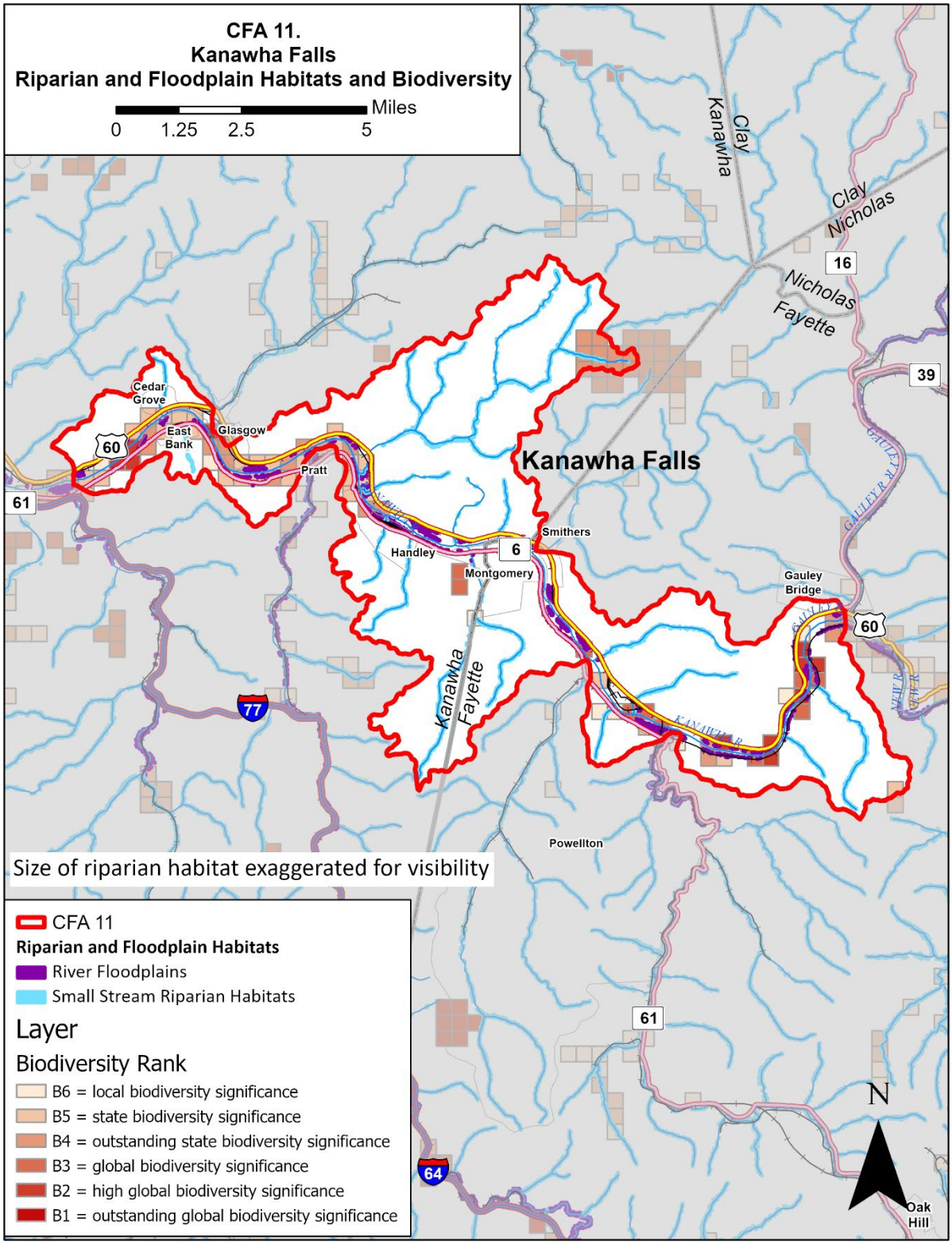
Table 10. Priority Species in Riparian and Floodplain Habitats

Taxa	Scientific Name	Common Name
Birds	Geothlypis formosa	Kentucky Warbler
Birds	Limnothlypis swainsonii	Swainson's Warbler
Birds	Megaceryle alcyon	Belted Kingfisher
Birds	Parkesia motacilla	Louisiana Waterthrush
Reptiles	Graptemys geographica	Northern Map Turtle

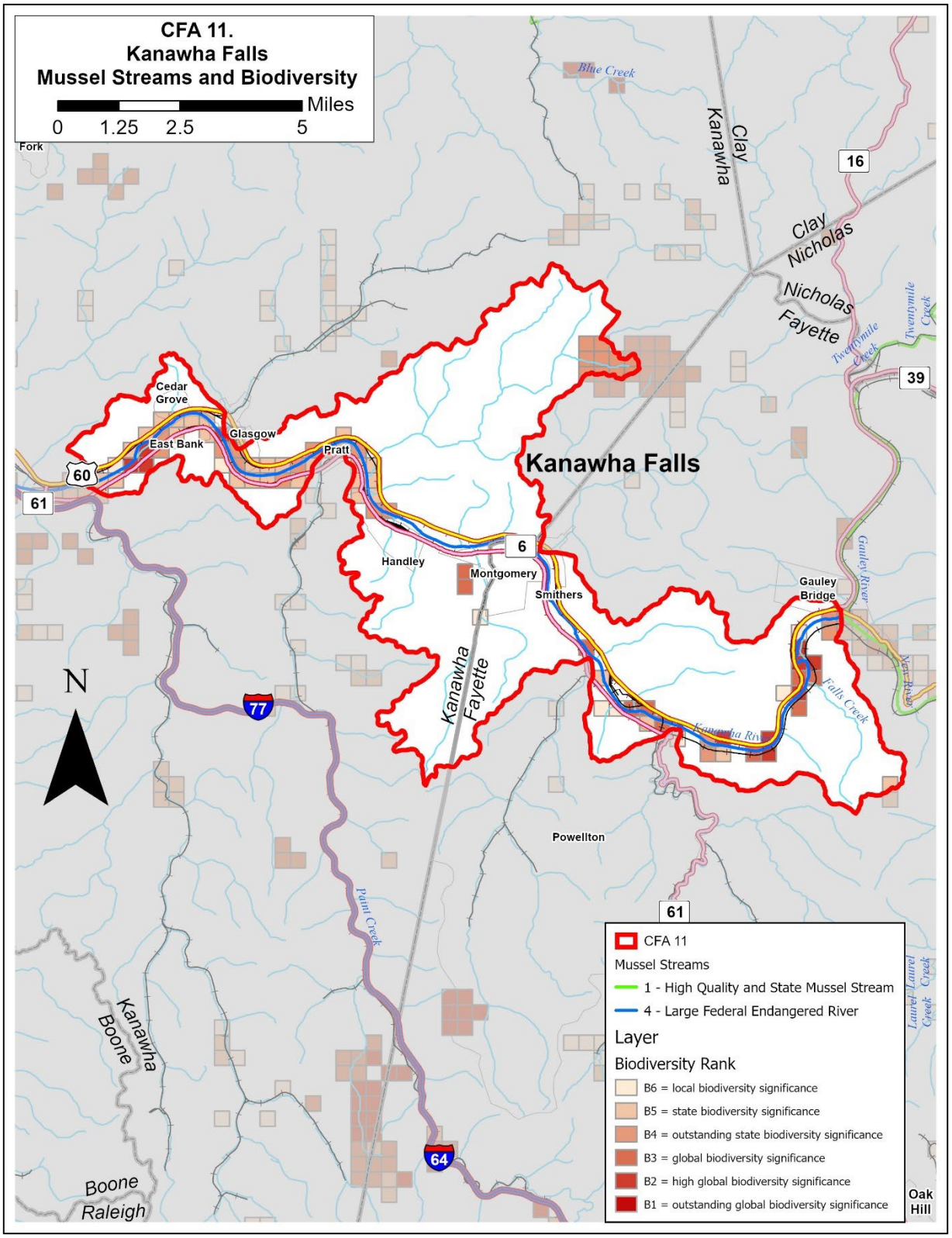
Map 7 illustrates riparian and floodplain habitats and biodiversity. These areas provide core habitat and movement corridors for many of the priority species listed above and are priority habitats. The B-Rank occurrences indicate that numerous SGCN and rare communities occupy stream, floodplain and riparian habitats. Floodplain habitat within this CFA lies along the Kanawha River, which flows from the west side of the CFA to the east. Riparian habitat is present along various streams which feed into the Kanawha River. Riparian and floodplain habitats in this CFA are bound by and impacted by developed lands, which cover almost 4,000 acres and are concentrated along U.S. Route 60.

Map 8 illustrates mussel streams in this CFA. The Kanawha River in this CFA is designated as a large river that supports federally listed, endangered mussel species. These include the Fanshell, Northern Riffleshell, Pink Mucket and Sheepnose mussels.

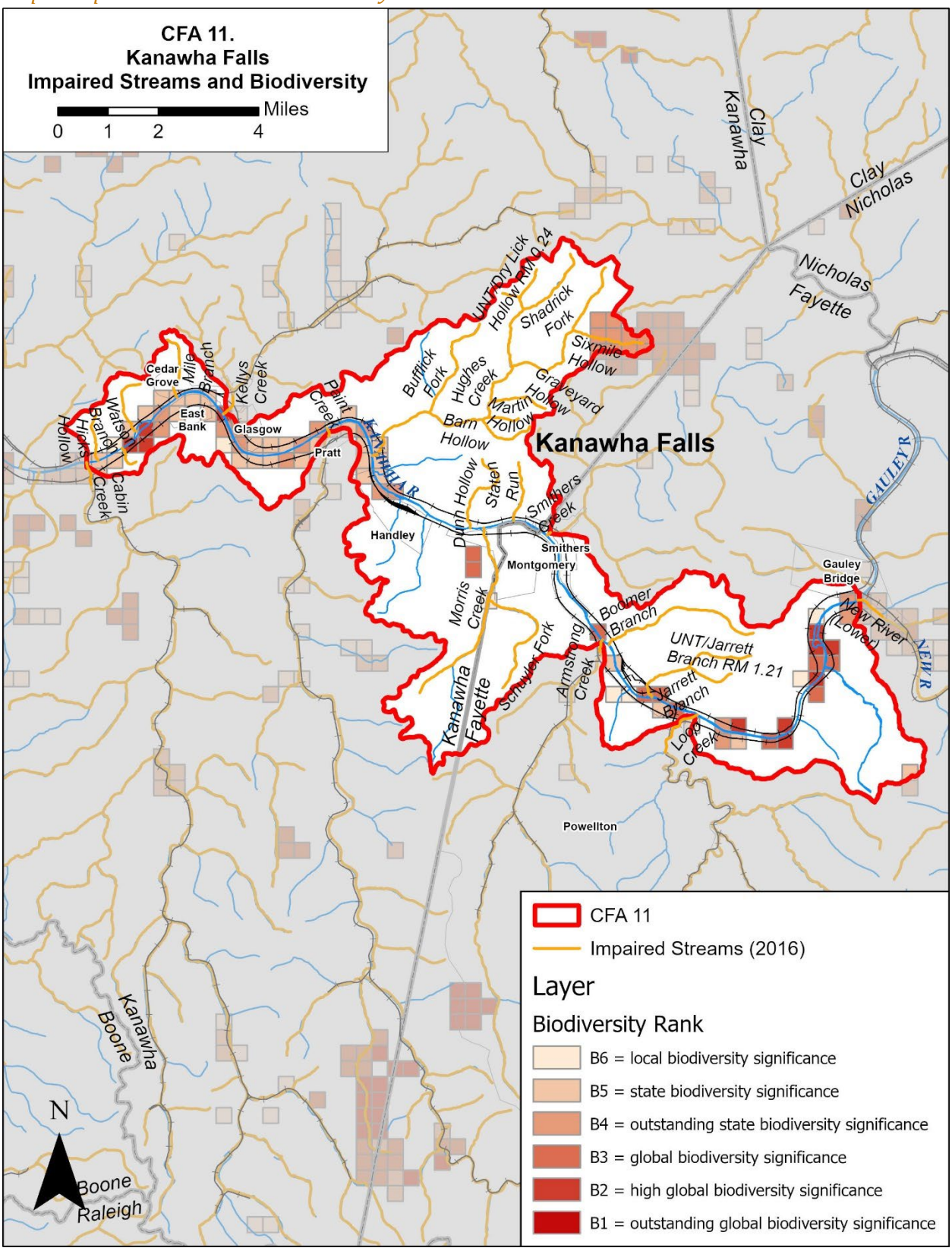
Map 7. Riparian and Floodplain Habitats



Map 8. Mussel Streams and Biodiversity



Map 9. Impaired Streams and Biodiversity



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 stream passage barriers limiting the movement of American Eels and loss of host fish impacting the development of juvenile Elephant-ear and Round Hickorynut mussels.

Map 9 shows stream impairments, along with biodiversity. Numerous streams within the CFA are impaired by various causes, many of which cause impairments to aquatic biota (WVDEP, 2016). Jarrett Branch is one of the most heavily impaired streams with at least five known causes of impairment including: aluminum, iron, manganese and pH (WVDEP, 2016). A table listing all impaired streams and their causes can be found in Appendix 3. Many of these impaired streams host clusters 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 11. Habitat Stresses and Conservation Actions for Aquatic, Floodplain and Riparian Habitat

Habitat Stress	**Conservation Action**
Potential for impounded river conditions upstream of Glenn Ferris Hydropower Facility	Maintain unimpounded river conditions for established mussel beds
Potential for hazardous spills into aquatic ecosystems from trains and tanker trucks	Develop hazard spill prevention and response protocol to protect aquatic ecosystems and priority species
Lack of protected floodplain, wetland and riparian habitat, including sandy beaches, shoals and islands	Habitat protection through land use planning, conservation easements and other programs and activities
Water quality degradation (organic and chemical pollutants, acid deposition, sedimentation, run-off, dredging)	Pollution control, improved sewage treatment, storm water management, sediment load reductions, plant and protect riparian buffers
Riparian habitat disturbance and deforestation, road crossings, altered hydrology, increased runoff and stream temperatures, climate change	Landowner outreach; Plant, fence, maintain forested riparian corridors; Minimize disturbance
River channelization, stream bank erosion, disconnection of river and floodplain hydrology and habitats	Restore and protect floodplain, riparian, stream bank, channel, island, shoal and sandbar habitats and functions
Invasive plants	Treating of cattail and other invasive plants
In-stream habitat impacts to mussels from stream restoration activities	Protect and avoid disturbance to mussel beds. Survey and salvage mussels before restoration activities.

Habitat Stress	Conservation Action
Loss of host-fish interaction (mussels)	Manage host fish species, explore inoculation of host fish
Aquatic passage barriers	Modify or remove barriers; install eel ladders
Disturbance of nesting beaches for turtles by recreation and boat wakes, and predation by mesopredators attracted by trash	Protect, clean up trash, reduce boat wakes and minimize disturbance on nesting beaches

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.

Table 12 provides 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 12. Climate Stresses and Resilience Actions in Aquatic, Floodplain and Riparian Habitat

Climate Stresses	Resilience Actions
• 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	• 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 13. Implementation Plan for Aquatic, Floodplain and Riparian Habitats

Action	Partners	Effectiveness Measures
Habitat Protection: • Conservation Easements • Land Acquisition	• County Farmland Protection Boards • The Nature Conservancy • USDA NRCS • WV Land Trust	• Acres of aquatic and riparian habitat protected for priority species • Abundance and diversity of priority species and habitats

Action	Partners	Effectiveness Measures
Habitat Protection • Cost Share and Incentive Programs	• USDA FSA	• Acres of aquatic and riparian habitat protected for priority species • Abundance and diversity of priority species and habitats
Habitat Protection: • Land Use Planning • Floodplain Management • Hazardous spill prevention and response plan	• County Planning Commissions/Departments • CSX Corportation • WVDEP • WVDNR • WVDOH	• Acres or miles of habitat protected through land use planning, hazard spill prevention and response planning, floodplain and stormwater regulations
Habitat Protection: • Maintain unimpounded conditions at Glenn Ferris Hydropower Facility	• FERC • Hydropower Facility Operator • WVDNR	• Acres or miles of habitat protected through maintenance of flow
In-stream and riparian habitat restoration	• Morris Creek & Paint Creek Watershed Associations • Public Land Managers • Trout Unlimited • USACE • USDA FSA & NRCS • USFWS Partners for Fish and Wildlife	• 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	• Morris Creek & Paint Creek Watershed Associations • Trout Unlimited • USDA FSA & NRCS • USFWS Partners for Fish and Wildlife • WVDEP and WVCA • WVDOF	• 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
Remove or improve aquatic passage barriers	• Trout Unlimited • USDA NRCS • USFWS Partners for Fish and Wildlife • WVDOH • WVRC	• # barriers improved or removed • # miles stream opened • Before and after comparison: abundance and diversity of priority species

Action	Partners	Effectiveness Measures
Improved wastewater and stormwater treatment	• County governments • WVDEP • WVDHHR	• # 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
Identify and treat sources of water pollution in streams and wetlands	• Morris Creek & Paint Creek Watershed Associations • USDA FSA & NRCS • WV Rivers Coalition • WVDEP and WVCA	• Change in water quality measurements • Before and after comparison: abundance and diversity of priority species
Clean up trash, reduce boat wakes and minimize disturbance on nesting beaches	• Community and volunteer groups • Morris Creek & Paint Creek Watershed Associations • Local governments • WVDEP • WVDNR	• Acres or linear feet protected or restored • Before and after comparison: abundance and diversity of priority species
Manage host fish species, explore inoculation of host fish	• USFWS • WVDNR	• Before and after comparison: abundance and diversity of priority species
Avoid disturbance of mussel beds, consider habitat needs in construction plans, survey and salvage before construction activities	• USACE • USFWS • WVDEP • WVDNR	• Before and after comparison: abundance and diversity of priority species
Monitor and carefully treat invasive plants around streams and wetlands	• KCEMGA & KVMN • USDA FSA & NRCS • USFWS Partners for Fish and Wildlife • WVDOH	• Acres treated • Treatment success rate • Before and after comparison: abundance and diversity of priority species
Public & Landowner Outreach and Demonstration	• KCEMGA & KVMN • Morris Creek & Paint Creek Watershed Associations • Public Land Managers • USDA NRCS, USFWS • WVDEP, WVCA and Conservation Districts • WVDNR, WVDOF • WVU Extension	• # Landowners engaged • # Landowners implementing actions

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.

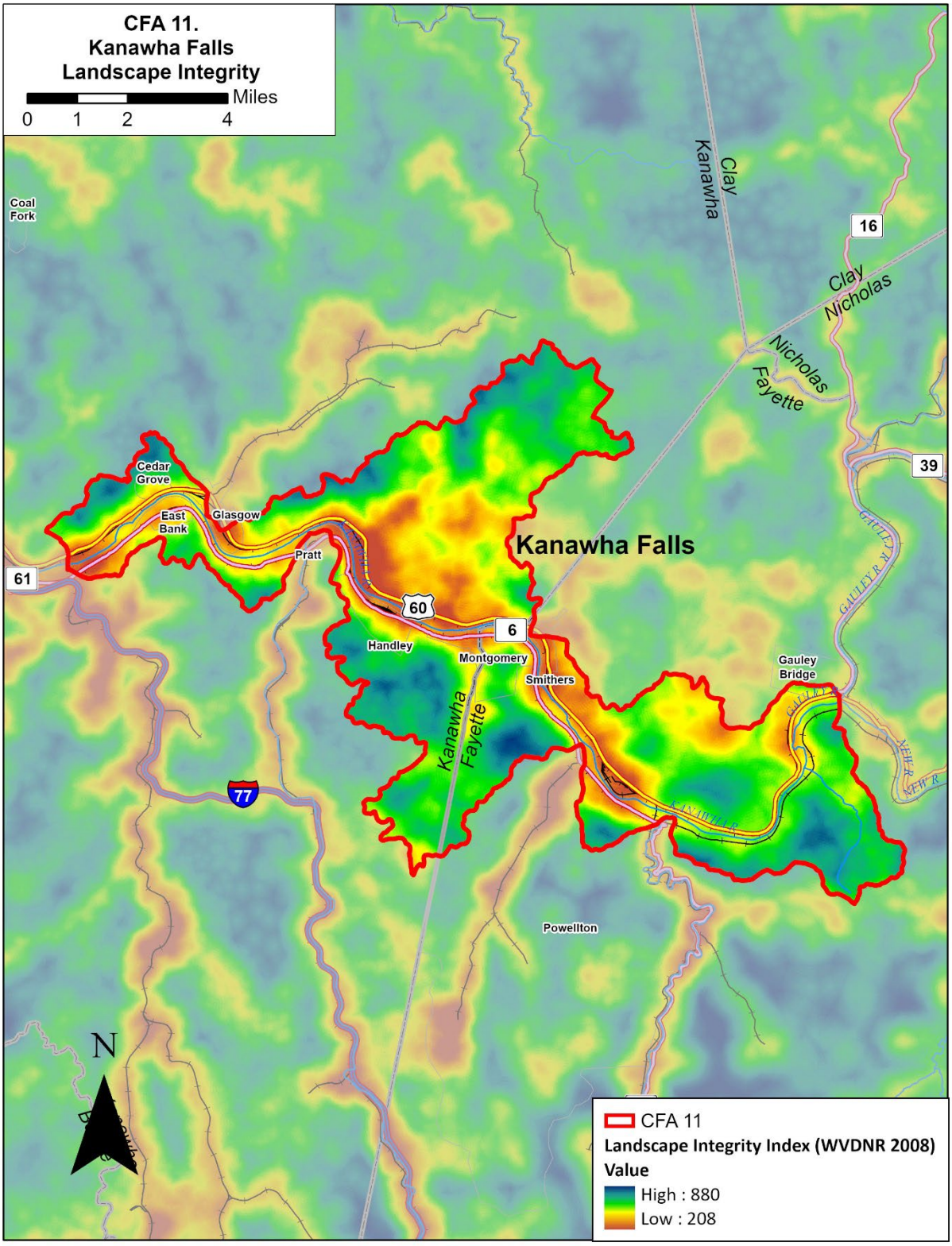
Landscape Resilience and Connectivity

The conservation and resilience actions described previously in this 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 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 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).

Maintaining or restoring wildlife populations in a 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 1,000 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. Map 10 illustrates areas of high landscape integrity in the CFA. Landscape integrity is seen 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. There are also landscapes of high integrity in private ownership adjacent to public lands. These areas are important for species movement in response to climate change and are priorities for protection of wildlife habitat.

Map 10. 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 diversity that offer a range of habitat types and microclimates for species and ecosystems to adapt to climate change. Resilient sites also have high landscape integrity, enabling species to move locally in response to climate change and natural processes like fire and floods to continue unimpeded. These are core areas for species movement and adaptation at a local level. They then modeled the flow of species across the landscape over time in response to climate change and 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.

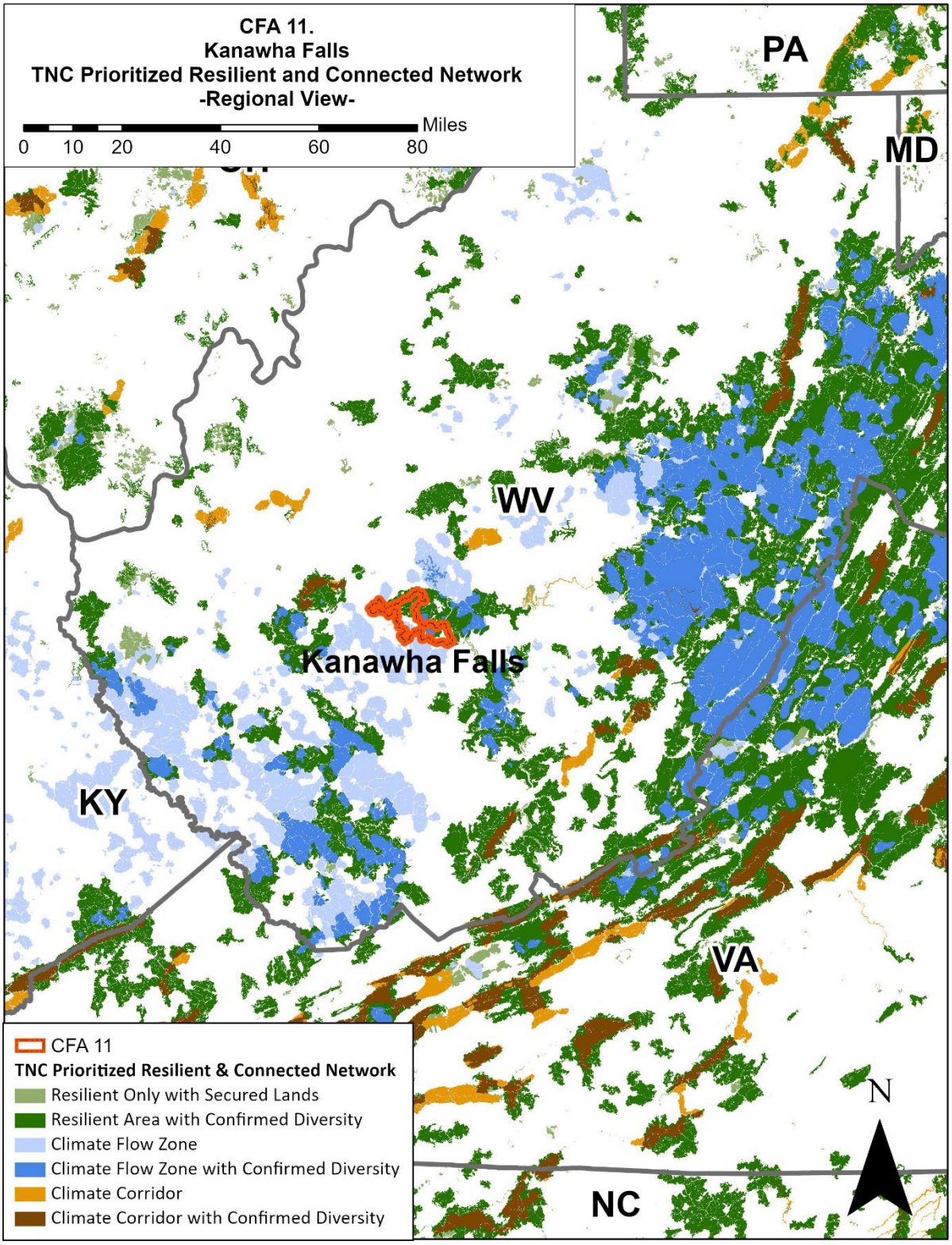
Next, the team developed models that integrated landscape resilience, connectivity and the flow of species across the landscape. They selected a connected network of sites that represents the full suite of geophysical settings, includes known records of biological diversity and has the configuration and connections necessary to support the continued movement of species in response to change conditions. Within this network they identified the 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:

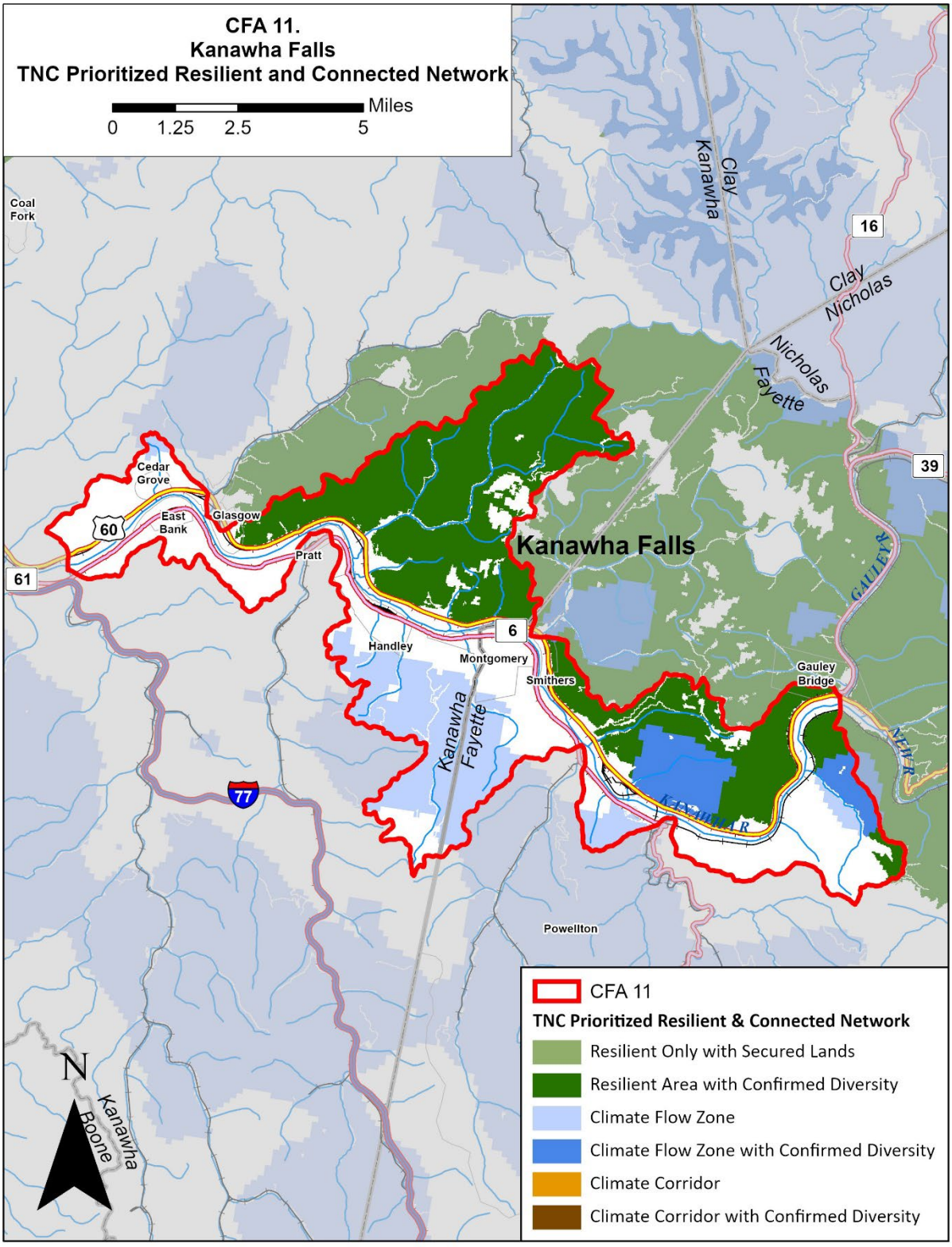
- Resilient area: a place buffered from climate change because it contains diverse, complex, connected landscapes with many micro-climates that create options for species adapting to climate change
- Climate corridor: a narrow conduit of natural cover in which the movement of plants and animals becomes 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 11 is a regional map of priority resilient and connected landscapes. It illustrates that the Kanawha Falls CFA is part of a mid-point of resilient landscapes connecting a patchwork of climate flow zones in the west of the state to a large hub of resilient and connected landscapes in the east. These are connected to narrower climate corridors leading both north into Maryland and Pennsylvania and south into Virginia.

Map 11. Priority Resilient and Connected Network – Regional View



Map 12. Priority Resilient and Connected Network – Detailed View



Map 12 provides a detailed view of the resilient, connected landscapes in the Kanawha Falls CFA. Resilient lands with patches of climate flow zones can be found north of U.S. Route 60, while a large patch of climate flow zone is present to the south. These priority resilient and connected landscapes contain the CFA's large forest patches and high integrity areas and most of the CFA's rock outcrop, cliff and talus habitats.

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.

Table 14 summarizes conservation actions for climate resilience to address stresses from climate change at a landscape level.

Table 14. Climate Stresses and Actions for Landscape Resilience and Connectivity

Climate Stresses	Habitat Resilience Actions
• 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	• 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 • Natural area designation

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 15. Implementation Plan for Landscape Resilience and Connectivity

Action	Partners /Programs	Effectiveness Measures
Protection of Resilient, Connected Landscapes • Conservation Easements • Land Acquisition	• County Farmland Protection Boards • The Nature Conservancy • USDA NRCS • WVDNR • WV Land Trust	• 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 • Land use planning	• County Planning Commissions	• Acres of habitat protected through land use planning in resilient, connected landscapes
Forest Planning and Management • Land Use Plans • Forest Management Plans • Forest Carbon Programs • Cost-Share Programs • Sustainable Forestry Certification Programs • USDA NRCS Climate Smart Forestry Activities	• AFF • AFTS, FSC, SFI • Consulting Foresters • Forest Carbon Programs • Planning Commissions • Public Land Managers • USDA NRCS • WVDOF	• Acres of habitat protected for priority species • Abundance and diversity of priority species and habitats
Protection of Resilient, Connected Landscapes • Conservation and Management	• Partner Organizations • Private Landowners • US Forest Service • WV DNR	• 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, acidic rock outcrops, cliffs and talus, aquatic, riparian and floodplain 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 within each major habitat type.

- Large, intact forest patches, including interior forest and early successional forest habitat
- Small areas of unique, geologically derived habitat including:
    - Acidic rock outcrops, cliffs and talus
- The Kanawha River, floodplain and small stream riparian habitats

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 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. Maintaining and 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 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 climate connectors and flow zones, stakeholders are encouraged to restore and protect the connections between these areas in order to maintain an interwoven fabric of natural systems for wildlife within this CFA 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, and
- 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 Kanawha Falls CFA

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFWS at Risk
Amphibians	Aneides aeneus	Green Salamander	S3	G3G4	—	
Amphibians	Desmognathus kanawha	Black-bellied Salamander	S3	G5		
Amphibians	Plethodon wehrlei	Wehrle's Salamander	S4	G4		
Amphibians	Pseudotriton montanus diastictus	Midland Mud Salamander	S1	G5T5		
Amphibians	Scaphiopus holbrookii	Eastern Spadefoot	S1	G5		
Birds	Antrostomus vociferus	Eastern Whip-poor-will	S3B	G5		At Risk Conserv
Birds	Chaetura pelagica	Chimney Swift	S3B	G5		
Birds	Geothlypis formosa	Kentucky Warbler	S3B	G5	R	
Birds	Helmitheros vermivorum	Worm-eating Warbler	S3B	G5	R	
Birds	Hylocichla mustelina	Wood Thrush	S3B	G5	R	At Risk Conserv
Birds	Limnothlypis swainsonii	Swainson's Warbler	S3B	G4		
Birds	Parkesia motacilla	Louisiana Waterthrush	S3B	G5		
Birds	Setophaga cerulea	Cerulean Warbler	S2B	G4		At Risk Conserv
Birds	Sturnella magna	Eastern Meadowlark	S3B, S2N	G5	R	
Birds	Vermivora cyanoptera	Blue-winged Warbler	S3B	G5		
Butterflies and Moths	Cyllopsis gemma	Gemmed Satyr	S3	G4G5		
Butterflies and Moths	Euchloe olympia	Olympia Marble	S2S3	G4G5		
Butterflies and Moths	Pieris virginiensis	West Virginia White	S3	G3?		
Fish	Anguilla rostrata	American Eel	S2	G4	R	
Fish	Ichthyomyzon bdellium	Ohio Lamprey	S2S3	G3G4		

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFWS at Risk
Fish	Ictiobus niger	Black Buffalo	S2	G5		
Fish	Moxostoma carinatum	River Redhorse	S3	G4		
Fish	Notropis blennius	River Shiner	S2	G5		
Fish	Noturus stigmosus	Northern Madtom	S1	G3		
Fish	Percina copelandi	Channel Darter	S2S3	G4		
Fish	Percina sciera	Dusky Darter	S3	G5		
Fish	Pimephales vigilax	Bullhead Minnow	S2	G5		
Mammals	Myotis sodalis	Indiana Bat	S1	G2	E	
Mammals	Neotoma magister	Allegheny Woodrat	S3	G3G4		
Mammals	Synaptomys cooperi	Southern Bog Lemming	S3	G5		
Mussels	Actinonaias ligamentina	Mucket	S3	G5		
Mussels	Alasmidonta marginata	Elktoe	S1	G4	—	
Mussels	Amblema plicata	Threeridge	S3	G5		
Mussels	Cambarunio iris	Rainbow	S2	G5Q		
Mussels	Cumberlandia monodonta	Spectaclecase	S1	G3	E	
Mussels	Cyclonaias tuberculata	Purple Wartyback	S1	G5		
Mussels	Cyprogenia stegaria	Fanshell	S1	G1Q	E	
Mussels	Ellipsaria lineolata	Butterfly	S2	G4		
Mussels	Elliptio crassidens	Elephant-ear	S2	G5		
Mussels	Eurynia dilatata	Spike	S3	G5		
Mussels	Epioblasma rangiana	Northern Riffleshell	S1	G2T2	E	
Mussels	Fusconaia flava	Wabash Pigtoe	S1	G5		
Mussels	Fusconaia subrotunda	Long-solid	S3	G3		At Risk Conserv
Mussels	Lampsilis abrupta	Pink Mucket	S1	G2	E	
Mussels	Lampsilis cardium	Plain Pocketbook	S3	G5		
Mussels	Lampsilis fasciola	Wavy-rayed Lampmussel	S3	G5		
Mussels	Lampsilis ovata	Pocketbook	S3	G5		
Mussels	Lasmigona complanata	White Heelsplitter	S3	G5		

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFWS at Risk
Mussels	Lasmigona costata	Fluted-shell	S3	G5		
Mussels	Lasmigona subviridis	Green Floater	S2	G3	—	At Risk Conserv
Mussels	Potamilus fragilis	Fragile Papershell	S3	G5		
Mussels	Ligumia recta	Black Sandshell	S3	G5	—	
Mussels	Megalonaias nervosa	Washboard	S2	G5		
Mussels	Obliquaria reflexa	Threehorn Wartyback	S3	G5		
Mussels	Obovaria olivaria	Hickorynut	S1	G4		
Mussels	Obovaria subrotunda	Round Hickorynut	S3	G4		
Mussels	Plethobasus cyphyus	Sheepnose	S2	G3	E	
Mussels	Pleurobema cordatum	Ohio Pigtoe	S2	G4		
Mussels	Pleurobema sintoxia	Round Pigtoe	S2	G4G5		
Mussels	Ptychobranchus fasciolaris	Kidneyshell	S3	G4G5		
Mussels	Pyganodon grandis	Giant Floater	S3	G5		
Mussels	Quadrula quadrula	Mapleleaf	S3	G5		
Mussels	Simpsonaias ambigua	Salamander Mussel	S2	G3		
Mussels	Strophitus undulatus	Squawfoot	S3	G5		
Mussels	Theliderma metanevra	Monkeyface	S2	G4		
Mussels	Toxolasma parvus	Lilliput	S2	G5		
Mussels	Tritogonia verrucosa	Pistolgrip	S3	G4G5		
Mussels	Truncilla truncata	Deertoe	S2	G5		
Mussels	Utterbackia imbecillis	Paper Pondshell	S2	G5		
Plants	Arundinaria gigantea ssp. gigantea	Giant Cane	S2	G5T5?		
Plants	Heteranthera reniformis	Kidneyleaf Mud-plantain	S1	G5		
Plants	Parnassia grandifolia	Largeleaf Grass-of-parnassus	S1	G3		
Plants	Scutellaria saxatilis	Rock Skullcap	S2	G3		
Plants	Sida hermaphrodita	Virginia Mallow	S3	G3		
Plants	Thalictrum clavatum	Mountain Meadowrue	S2	G4		
Plants	Viola septentrionalis	Northern Blue Violet	S2	G5		

Taxa	Scientific Name	Common Name	S Rank	G Rank	Federal Status	USFWS at Risk
Reptiles	Carphophis amoenus	Wormsnake	S3	G5		
Reptiles	Crotalus horridus	Timber Rattlesnake	S3	G4		
Reptiles	Graptemys geographica	Northern Map Turtle	S1	G5		
Reptiles	Opheodrys aestivus	Rough Greensnake	S2	G5		
Reptiles	Regina septemvittata	Queen Snake	S4	G5		
Reptiles	Terrapene carolina carolina	Eastern Box Turtle	S5	G5T5	R	
Snails	Stenotrema macgregori	Fraudulent Slitmouth	S2	GNR		
Snails	Ventridens collisella	Sculptured Dome	S3	G4G5		

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.

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

Appendix 2. Priority SGCN, Known Stresses and Actions

Forests and Woodlands		
Common Name	**Local Stress**	**Action**
Eastern Whip-poor-will	• Road/collision mortality. • Incompatible forest structure. • Possible declines in high quality prey	• Identify high density areas and install highway signage. • Manage forests for interior gaps and edges. • Long-term monitoring of insect populations
Kentucky Warbler	• Deer overherbivory. • Incompatible forest structure	• Reduce deer population. • Manage forests for structural and spatial complexity
Worm-eating Warbler	• Deer overherbivory. • Incompatible forest structure. Residential development	• Reduce deer population. • Manage forests for structural and spatial complexity
Wood Thrush	• Deer overherbivory. • Incompatible forest structure. • Residential development	• Reduce deer population. • Manage forests for structural and spatial complexity
Swainson's Warbler	• Riparian habitat loss and degradation	• Research to assess productivity and survival in novel breeding habitat dominated by invasive species. Protect floodplain forests with suitable habitat
Cerulean Warbler	• Poor forest structure	• Manage forests to create suitable habitat as per CERW guidelines
Blue-winged Warbler	• Insufficient habitat. • Residential development	• Reduce clean farming practices. • Create early successional habitat
West Virginia White	• Expansion of invasive garlic mustard	• Pull garlic mustard. • Education for landowners about garlic mustard

Floodplain, Riparian and Wetland Habitats		
Common Name	**Local Stress**	**Action**
Kentucky Warbler	• Deer overherbivory. • • Incompatible forest structure	• Reduce deer population. Manage forests for structural and spatial complexity
Swainson's Warbler	• Riparian habitat loss and degradation	• Research to assess productivity and survival in novel breeding habitat dominated by invasive species. Protect floodplain forests with suitable habitat
Louisiana Waterthrush	• Loss of riparian forests. • Stream degradation. • Acid deposition. • Residential development	• Improve water quality. Conserve riparian and upland stream valley forests. Conservation easements
Northern Map Turtle	• River channelization. • Sedimentation. • Recreation. • Artificial increase in mesocarnivores	• Identify important nesting beaches. • Reduce human recreation on sandy beaches. • Trash clean-up to reduce mesopredators from nesting beaches. • Reduce boat wakes near nesting beaches to reduce erosion. • Stream bank stabilization and reduction of run-off to improve water quality. • Protection of habitat upstream of known populations

Aquatic Habitats		
Common Name	**Local Stress**	**Action**
Eastern Sand Darter	• Increased sedimentation. • River channelization. • Point & nonpoint-source pollution	• Create and/or preserve island, shoal and sandbar habitats
American Eel	• Stream passage barriers	• Install Eel Ladders
River Redhorse	• River channelization. • Disconnection of river and floodplain	• Create and/or preserve island, shoal and sandbar habitats
Popeye Shiner	• Increased sedimentation. • River channelization. • Point & nonpoint-source pollution	• Riparian restoration
River Shiner	• Increased sedimentation. • River channelization. • Point & nonpoint-source pollution	• Create and/or preserve island, shoal and sandbar habitats
Northern Madtom	• Increased sedimentation. • River channelization. • Point & nonpoint-source pollution	• Riparian restoration
Fanshell	• Loss of Host Fish interaction	• Manage host fish species within the watershed. • Potential innoculated release
Elephant-ear	• Habitat loss. • Loss of host fish	• Conservation of known beds. • Manage host fish species
Northern Riffleshell	• Sedimentation and hydrology changes	• Erosion protection
Pink Mucket	• Hydroelectric dam. • Water quality	• Sediment control and water quality improvement
Green Floater	• Hydroelectric dam. • Water quality	• Sediment control and water quality improvement
Round Hickorynut	• Loss of host fish interaction	• Manage host fish species. • Potential innoculated release
Sheepnose	• Sedimentation and in-stream work	• Erosion controls

Salamander Mussel	• Sedimentation. • Hydraulic changes. • Water quality	• Sediment control. • Water withdrawal conservation. • Unconventional Oil & Gas BMP's
Agricultural and Developed Habitats		
Common Name	**Local Stress**	**Action**
Chimney Swift	• Chimney capping. • Turnover of older structures	• Landowner outreach and education. • Protect known significant migration roosts. • Uncap chimneys. Install swift towers

Appendix 3. Impaired Streams

Reach Code	AUID	Common Name	Impairments
05050006000078	WVK-73_01	ArmstrongCreek	Bio, Aluminum, Selenium
05050006000626	WVK-66-B.6_00	BarnHollow	Bio, Iron, Selenium
05050006000257	WVK-74_00	BoomerBranch	Bio, Aluminum
05050006000235	WVK-66-B_00	BufflickFork	Bio
05050006000020	WVK-61_01	CabinCreek	Bio, Fecal_Coli, Iron, Selenium
05050006000527	WVK-66-C-2_00	DryLickHollow	Iron
05050006000238	WVK-69_00	DunnHollow	Iron, Selenium
05050006000604	WVK-66-B.7_00	GraveyardHollow	Iron, Selenium
05050006000729	WVK-61.5_00	HicksHollow	Bio, Ph, Aluminum, Iron
05050006000108	WVK-66_03	HughesCreek	Iron, Selenium
05050006000108	WVK-66_02	HughesCreek	Bio, Iron, Selenium
05050006000106	WVK-66_01	HughesCreek	Bio, Selenium
05050006000258	WVK-75_02	JarrettBranch	Bio, Manganese
05050006000258	WVK-75_01	JarrettBranch	Bio, Ph, Aluminum, Iron, Manganese
05050006000109	WVK-64_01	KellysCreek	Bio, Fecal_Coli, Iron
05050006000086	WVK-76_01.1	LoopCreek	Bio
05050006000231	WVK-66-B.5_00	MartinHollow	Bio, Iron
05050006000224	WVK-63_00	MileBranch	Bio, Fecal_Coli, Aluminum, Iron
05050006000162	WVK-70_01_02	MorrisCreek	Bio, Ph, Iron
05050006001701	WVK-70_03	MorrisCreek	Ph, Iron
05050004000638	WVKN-lo_00	NewRiver(Lower)	Fecal_Coli
05050006000036	WVK-65_01	PaintCreek	Bio
05050006000302	WVK-70-A_00	SchuylerFork	Ph, Aluminum
05050006000233	WVK-66-C_00	ShadrickFork	Iron
05050006000232	WVK-66-D_00	SixmileHollow	Iron, Selenium
05050006000240	WVK-72_01	SmithersCreek	Bio, Aluminum
05050006000239	WVK-71_00	StatenRun	Bio, Iron
05050006000526	WVK-66-C-2-A_00	UNT/DryLickHollowRM0.24	Iron
05050006000876	WVK-75-A_00	UNT/JarrettBranchRM1.21	Ph, Aluminum, Manganese
05050006000728	WVK-61.7_00	UNT/KanawhaRiverRM75.75	Ph
05050006000683	WVK-62_02	WatsonBranch	Ph, Aluminum
05050006000695	WVK-62_01	WatsonBranch	Ph, Aluminum, Iron

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
American Forest Foundation (AFF) https://www.forestfoundation.org/ https://www.familyforestcarbon.org/	• 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)
Consulting Foresters https://wvforestry.com/forestry-consultants/	• 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
County Farmland Protection Boards http://wvfp.org/	• 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

Partner	Role/Assistance Provided
CSX https://www.csx.com/	• CSX is a leading supplier of rail-based freight transportation in North America. • Operates and maintains more than 2,000 miles of track in WV • CSX has a three-pronged approach to sustainability, which includes reducing the environmental footprint of operations, engaging openly on sustainability issues, and supporting sustainable developments.
Federal Energy Regulatory Commission (FERC) https://www.ferc.gov/	• Regulates Hydropower licensing, including construction of new projects, continuance of existing projects and oversight of ongoing project operations including dam safety inspections and environmental monitoring.
Forest Certification Programs: • American Tree Farm System (ATFS) https://www.treefarmsystem.org/ • Sustainable Forestry Initiative (SFI) https://www.forests.org/ https://www.wvfa.org/sfi/ • Forest Stewardship Council (FSC) https://fsc.org/en	• Resources, assistance and certification for sustainable forest management on public and private lands
Kanawha County Extension Master Gardeners Association (KCEMGA) https://extension.wvu.edu/kanawha/master-gardeners	• The West Virginia University Extension Master Gardener Program is a volunteer educational program meeting the horticultural needs of everyday West Virginians. The program trains volunteers, utilizing their expertise to teach others more about plants, their culture, their importance to the environment and to our quality of life. • Master Gardener volunteers provide technical assistance to their local county Extension office in order that consumer horticultural activities and programs can be more effectively and efficiently delivered to more people.
Kanawha County Master Naturalists (KCMN) https://www.facebook.com/KanawhaValleyMasterNaturalists/ http://www.mnofwv.org/	• The mission of the West Virginia Master Naturalist Program is to train interested people in the fundamentals of natural history, nature interpretation and teaching, and to instill in them an appreciation of the importance of responsible environmental stewardship. The program will also provide 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.

Partner	Role/Assistance Provided
Kanawha County Department of Planning and Development https://kanawha.us/planning-development/	• The Planning and Development Department oversees and enforces land use ordinances in the unincorporated areas of Kanawha County. Currently the ordinances in effect in Kanawha County include flood plain regulations, subdivision regulations, public nuisances and property maintenance, adult only establishments, salvage yards, and video lottery.
Master Naturalists Program http://mnofwv.org/	• 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
Morris Creek Watershed Association https://morriscreekwatershed.org/ https://www.facebook.com/MorrisCreekWatershed/	• The MCWA is made up of citizens from the local area joining together in an effort to protect and improve the Morris Creek watershed for the benefit of all citizens.
National Wild Turkey Federation (NWTF) https://www.nwtf.org/	• 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
Outdoor Heritage Conservation Fund (OHCF) https://commerce.wv.gov/boards-commissions/outdoor-heritage-conservation-fund/	• 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.
Paint Creek Watershed Association https://www.facebook.com/PaintCreekWatershedAssociationInc https://paintcreekwatershedassociation.wordpress.com/	• An association of volunteers working to reduce pollution and restore the Paint Creek Watershed

Partner	Role/Assistance Provided
Ruffed Grouse Society/American Woodcock Society (RGS) https://ruffedgrousesociety.org/#	• 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 impacts. https://ruffedgrousesociety.org/the-ruffed-grouse-society-model-of-working-forests/
The Conservation Fund (TCF) https://www.conservationfund.org/where-we-work/west-virginia	• 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.
The Nature Conservancy (TNC) https://www.nature.org/en-us/about-us/where-we-work/united-states/west-virginia/	• 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
Trout Unlimited (TU) • http://www.wvtu.org/ • http://www.tu.org/	• 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
US Army Corps of Engineers (USACE): Great Lakes and Ohio River Division https://www.lrd.usace.army.mil/ • Environmental Stewardship https://www.lrd.usace.army.mil/Missions/Environmental/ • Flood Risk Management: https://www.lrd.usace.army.mil/Missions/Civil-Works/Flood-Risk-Management/	• The Great Lakes and Ohio River Division civil works missions provide navigation, flood risk management, environmental, emergency response, recreation, hydropower, water supply and regulatory permits. • Through Environmental Stewardship, ACOE works to restore degraded ecosystem structure, function and dynamic processes to a more natural condition through large-scale ecosystem restoration projects • Flood risk management includes operation of dams, reservoirs and levees along the Ohio River and its tributaries

Partner	Role/Assistance Provided
USDA Farm Service Agency (FSA) https://www.fsa.usda.gov/state-offices/West-Virginia/programs/index • Conservation Reserve Program (CRP) • Conservation Reserve Enhancement Program (CREP) • State Acres for Wildlife Enhancement (SAFE) • Farmable Wetlands Program (FWP) • Grasslands Reserve Program (GRP)	• 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
USDA Natural Resources Conservation Service (NRCS): https://www.nrcs.usda.gov/wps/portal/nrcs/main/wv/programs/financial/ • Environmental Quality Incentive Program (EQIP) • Conservation Stewardship Program (CSP) • Agricultural Management and Assistance Program (AMA) • Agricultural Conservation Easement Program (ACEP) • Climate-Smart Forestry Mitigation Activities	• 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. • Climate-Smart Agriculture and Forestry Mitigation Activities may deliver quantifiable reductions in greenhouse gas emissions and/or increases in carbon sequestration. Many offer co-benefits that help operations build climate change resilience while addressing other natural resource concerns such as soil health, water quality, pollinator and wildlife habitat, and air quality.

Partner	Role/Assistance Provided
US Fish and Wildlife Service (USFWS) Partners for Fish and Wildlife Program https://www.fws.gov/northeast/ecologicalservices/partners.html	• 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
WV Conservation Agency (WVCA) and Conservation Districts http://www.wvca.us/ • Ag Enhancement Program (AgEP) • Non-Point Source Program • Stream Partners Program	• 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.

Partner	Role/Assistance Provided
WV Department of Environmental Protection (WVDEP) • 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 • Spill Prevention Response Plan Guidance for Above Ground Storage Tanks https://dep.wv.gov/WWE/ee/tanks/abovegroundstoragetanks/Pages/SpillPreventionResponsePlanRequirements.aspx	• 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 • Provides spill prevention response plan guidance for above ground storage tanks
WV Department of Health and Human Resources (WVDHHR) • On-Site Sewage Program https://www.wvdhhr.org/phs/sewage/index.asp	• 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.
WV Division of Forestry (WVDOF) http://www.wvforestry.com/	• 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

Partner	Role/Assistance Provided
WV Division of Natural Resources (WVDNR) http://www.wvdnr.gov/wildlife/wdpintro.shtm	• 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
West Virginia Land Trust (WVLT) https://www.wvlandtrust.org/	• 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.
West Virginia University Extension Service (WVU Extension): • Forestry https://extension.wvu.edu/natural-resources/forestry • Wildlife https://extension.wvu.edu/natural-resources/wildlife	• 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.

Watershed Based Plan for Morris Creek, Implementation of the Upper Kanawha TMDL 2013. Available at: https://dep.wv.gov/WWE/Programs/nonptsource/WBP/Documents/WP/MorrisCreekWBP.pdf
Long Range Plans for the Capitol and Sothern Conservation Districts. Summarize natural resources conditions and 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
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
National Wild Turkey Foundation- Landowner's Toolbox https://www.nwtf.org/conservation/category/landowners
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. http://gwwa.org/resources/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
Fighting Invasive Plants in West Virginia http://www.wvnps.org/FightingInvasives.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 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
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