Greater Greenbrier Conservation Focus Area (Draft) Plan

Contents

Acronyms

AFWA	Association of Fish and Wildlife Agencies
CFA	Conservation Focus Area
NNIS	Non-Native Invasive Species
SGCN	Species of Greatest Conservation Need
SWAP	State Wildlife Action Plan
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WVCA	West Virginia Conservation Agency
WVDNR	West Virginia Division of Natural Resources

Abstract

The West Virginia State Wildlife Action Plan provides a broad framework for conservation across the state. Conservation Focus Areas are specific regions where SGCN are concentrated, addressable threats are identified, and where opportunities exist for focused actions. Priority SGCN are targeted because of their association with other SGCN, the potential conservation benefit, and the availability of willing partners. Priority Action areas are regions where Priority SGCN and their habitats occur, threats are identified, and where opportunities exist for habitat restoration or protection. Managing and protecting SGCN and vulnerable habitats is a priority. Effective conservation requires collaboration with land management agencies, conservation partners, and stakeholders. The participation of an informed public is essential for successful and enduring outcomes. This plan initiates conservation efforts that secure and safeguard wildlife resources. However, enduring protection demands the adoption of a conservation ethic by the people who live, work, and recreate in the Greater Greenbrier CFA.

Suggested Citation

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Introduction - *Features of the WV Wildlife Action Plan*

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 WV State Wildlife Action Plan (SWAP) was therefore developed to also function as a blueprint for conservation that other natural resource agencies, local governments, non-governmental organizations, and the general public can use and apply (WVDNR 2015).

The SWAP provides a broad framework for conservation across West Virginia however Species of Greatest Conservation Need (SGCN) are distributed across the state often in concentrations that include multiple taxa. These concentrations may be exposed to multiple, and often similar, stresses which also occur 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. The WVDNR analyzed SGCN locations, threats to SGCN, evaluated conservation opportunities, and defined 21 CFAs across the state (Figure1.).

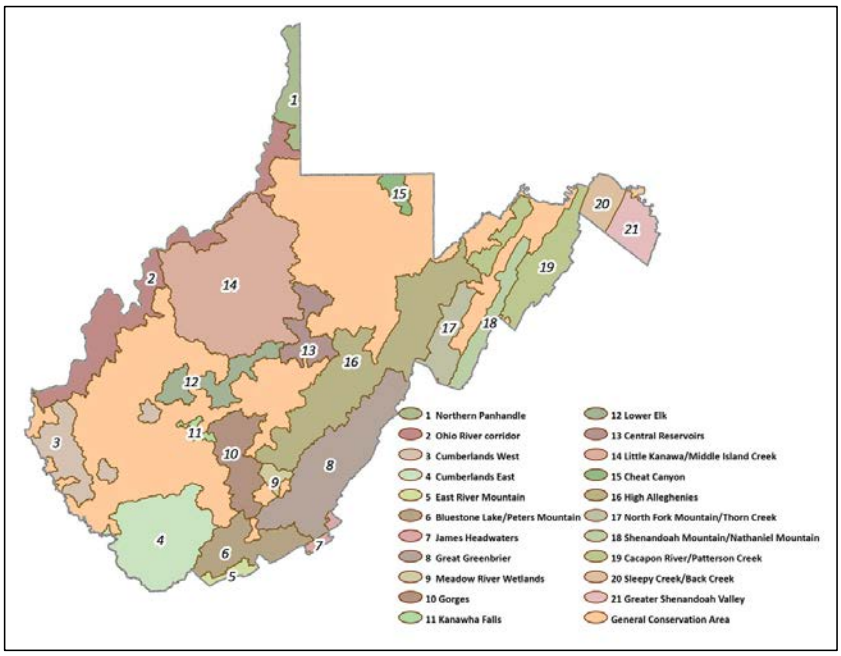

Figure 1. Conservation Focus Areas in West Virginia.

Conservation Focus Area plans target priority species with specific actions at a local level. Public lands provide abundant conservation opportunities, however many SGCNs and their habitats occur on private property. Therefore conservation and restoration actions must occur through collaboration with land owners, partner agencies, stakeholder groups, and nongovernmental conservation organizations. Conservation Focus Area plans identify priority

species from each taxa group, important habitats, key stresses, and recommend actions that will effectively secure or protect the most species and their habitats.

Success may be measured by the amount of protected or restored habitat, by stable or increasing populations, or by acquiring a more complete understanding of species and threats in order 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 Focus Area planning will engage local partners and stakeholders at a scale where intensive investigation collaboration can increase resources (funding, capacity) available for conservation action

Partners and stakeholders can use this plan to secure funding to implement solutions and protect key areas. Habitat protection, restoration, and the promotion of best management practices (BMP) should reduce key environmental threats and address concerns related to climate change and environmental integrity. Public involvement is essential to identifying critical resources to protect (e.g., high-priority forested lands), potential sites to restore (e.g., severely eroding streambanks), and opportunities to expand habitat resources.

Habitats

Terrestrial

Nineteen terrestrial habitats were classified and mapped in the SWAP. These include 16 natural or semi-natural habitats that are derived from NatureServe's Ecological Systems (Comer et al. 2003, Gawler 2008) and three anthropogenic habitats that represent map classes of the National Land Cover Database (Homer et al. 2004) (Appendix A).

Aquatic

Eighteen aquatic habitat types were classified and mapped for the SWAP. 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 effect 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 this model (Appendix B).

Subterranean

Caves and manmade subterranean habitats occur in most counties of the state. Biologically important limestone caves are concentrated in areas with extensive limestone bedrock at or near the surface in the Allegheny Mountains and Ridge and Valley Ecoregions. Caves in the Allegheny Mountains Ecoregion associated with Greenbrier Limestone account for a large proportion of caves in the state (Davies 1958); the largest concentration of these caves is in the Greenbrier Valley. Caves in the Ridge and Valley Ecoregion are associated with several limestone formations, including the Conococheague, Elbrook, Tonoloway, the Helderburg Group, and others (WVASS 2014).

Caves are important habitat for wildlife, including bats that move in and out, as well as a diverse group of vertebrate and invertebrate animals that have evolved specialized adaptations to permanent underground living. Common traits exhibited by permanent cave dwellers (troglobites) include blindness (or complete loss of eyes) and reduced pigmentation. West Virginia SGCN that depend on cave habitats include eight bats, a fish, two salamanders, a crayfish, and 91 cave invertebrates.

Other SGCN that often use caves (e.g., Allegheny Woodrat), but they are not solely dependent on caves for their survival. Manmade subterranean habitats may be used by mobile animals such as bats, but lack the less mobile, more specialized life forms that evolved in isolated natural cave systems. For planning purposes subterranean habitats are collectively elevated to a habitat class and include caves, sinkholes, karst areas, mine portals, and tunnels.

Priority Species and Action Areas

In order to maximize effectiveness of conservation actions, priority Species of Greatest Conservation Need from each taxon (and priority habitats) in the CFA were identified whose populations can be significantly increased and/or protected. The list is not exhaustive but instead represents species for which the CFA is of particular importance (e.g. a species with a limited distribution) as well as SGCN that will serve as "umbrella" species (i.e., actions directed at these species will benefit many others).

Six hundred and sixty one animal (661) SGCN and 482 plant SGCN are identified in the SWAP. The animal SGCN taxa are organized into species groups according to habitat use or species associations (Appendix C). Effectiveness and efficiency are paramount in targeting actions in CFAs and specifically addressing every SGCN is not feasible. Therefore priority SGCN are selected that represent the best opportunity for successful conservation and also represent the needs of a broader set of co-occurring SGCN within the CFA.

Criteria for selecting priority SGCN include identifying 1) those species whose populations can be most significantly increased or protected by feasible actions, 2) the most important and addressable stresses affecting these species, 3) the most feasible actions that address the identified stresses, 4) those species for which the CFA is critical for its survival, and 5) those species that represent a conservation "umbrella" for co-occurring species (within a species group) and even across taxa .

Subterranean fauna is diverse and unique to the point that a single species cannot represent species groups in the manner that aquatic and terrestrial species can. CFA planning elevates subterranean habitats to a third habitat classification along with terrestrial and aquatic species classes. Priorities are assigned specifically to facultative cave species (e.g., bats, Allegheny woodrats) while diverse or endemic cave species groups are better addressed by identifying specific cave/subterranean habitats.

Priority action areas are regions within the CFA where priority SGCN or their habitats occur, threats are identified, and where perceived opportunities exist for habitat restoration or protection. In addition, priority areas may be identified because they represent the source or cause of an environmental threat. These areas were defined internally and are subject change with input from partners and stakeholders. While the defined areas represent the proposed scope of work, conservation practices outside the defined areas are still encouraged.

Stresses (Threats) to SGCN and Habitats

WVDNR staff developed a stress assessment for the West Virginia SWAP using 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 stresses affecting terrestrial SGCN and habitats and 21 major stresses that affect aquatic SGCN and habitats (Salafsky et al 2008)(Appendix D).

Stresses exerted on SGCN populations and habitats from a number of sources can reduce species populations either directly, by disease, or indirectly, by affecting the quality or quantity of available habitat. In considering how stresses are affecting SGCN habitats, scale is an important parameter. Some stresses are local, some are regional, and some occur statewide. The scale at which the stress is impacting habitats must be considered when developing potential actions to reduce the effects of the stress. CFA plans identify and address specific threats at a local scale.

Climate Change

Climate change is the ultimate causative agent for many terrestrial and aquatic stresses. Even within taxonomic and habitat groupings, species will respond to climate change differently based on individual sensitivities to temperature, moisture, seasonal triggers, and other climate-related effects. Management decisions must consider feasible projects with a high likelihood of success versus projects addressing more vulnerable species but with uncertain viability in the context of a changing climate.

Successfully countering climate change effects requires a comprehensive approach. Strategies must include 1) reducing the sensitivity of species and ecosystems by minimizing other critical stressors, 2) reducing exposure to climate change impacts, and 3) increasing adaptive capacity to respond to those impacts. The objective is to remove the critical direct threats and allow SGCN and their habitats the full opportunity to respond or adapt to changes. Conservation actions must address SGCN populations, habitat integrity, and ecosystem processes. This includes conserving or preserving *intact* and *functional* habitats, maintaining and restoring connectivity between habitats, and protecting or restoring aquatic resources (AFWA 2012, Byers and Norris, 2011).

This approach reflects a true conservation ethic. It requires a strong outreach component designed to broadcast the concept and recruit partners. Climate change is a dynamic process that demands constant attention. Monitoring SGCN populations and evaluating conservation actions will allow the WVNDR and partners to adjust to changing conditions.

Conservation Actions

Key SGCN species from each taxon were selected based on their strong association with other SGCNs (resulting in an umbrella effect), the opportunity for significant conservation benefit, and the availability of key stakeholders or willing partners. The actions were selected based on available opportunities and the greatest likelihood for broad conservation success.

Conservation actions vary according to the species and the specific stresses. Actions can manifest themselves in many forms. Direct action may involve directly protecting or restoring habitats or even restoring populations. A lack of information on the status of a species or understanding of a threat may indicate a need for baseline inventory, research, or data acquisition. 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 possible that a number of actions are required depending on the identified stress and the opportunities available. Ideally, actions are designed to address the source of the stress (AFWA 2012).

Effectiveness Measures

The key to adaptive management involves effectively assessing action outcomes. Effectiveness measures indicate progress to date and whether the expected results are being realized (e.g. increased populations, increased habitat acreage, improved water quality, etc.). Furthermore, accountability and transparency to funding sources, partners, and the public are essential for program success. As discussed in the SWAP, the WVDNR will use relevant metrics to evaluate, track, and report the results of conservation actions.

Conservation actions should be designed with enough specificity that performance can be measured but broadly enough to benefit multiple species and also engage partners. 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.

The Association of Fish and Wildlife Agencies' State Fish and Wildlife Grant Effectiveness Measures Working Group developed a systematic methodology, Tracking and Reporting Actions for the Conservation of Species (TRACS), to measure, evaluate, and report conservation action implementation (AFWA 2011). Pursuant to AFWA's recommendations, the WVDNR will use selected measures to report and track project effectiveness as part of the agency's annual State Wildlife Grant reporting.

Outreach Strategy

Conservation Focus Areas advance the concepts and guidance provided by the State Wildlife Action Plan. Many actions occur on private lands and private landowners possess local knowledge, skills, resources, and familiarity with the land that complements and often exceeds that of the WVDNR. At times, the biological knowledge, skills, and conservation resources of DNR, can add to that of the landowner. Therefore it is important to identify and engage with the land owners, the local conservation community, key stakeholders, and potential participants in order to affect change on both private and public lands.

Partnerships

For the purposes of this plan, conservation partners are agencies and organizations whose missions align with CFA objectives and whose primary responsibilities are to implement conservation and restoration projects on public or private lands. The SWAP identified several land management and conservation agencies, influential non-governmental organizations (NGOs), and citizen groups that either have an obvious role in or will be affected by actions recommended in the plan. The WVDNR will collaborate with these partners to implement recommended practices in CFA priority action areas. In some cases these willing partners may assume a lead role in implementing the CFA plans.

Agency partners with large scale responsibility include the West Virginia Department of Environmental Protection, The Nature Conservancy, land trusts, the Natural Resource Conservation Service, the U.S. Forest Service, and the National Park Service. The WVDNR will engage with these partners in regular face-to-face meetings and planning workshops during CFA planning, implementation, and monitoring phases. With an established "constituency"

(e.g., program participants, friends groups, etc.), conservation partners also represent a direct outreach connection to willing landowners and key stakeholders.

Public Involvement, Outreach, and Education

For the purposes of this plan, stakeholders are groups or individuals that either can affect or will be affected by conservation actions. Stakeholders generally own land, live, recreate, or work within a CFA. They possess knowledge of local ecological, social, and economic issues which must be integrated into CFA planning. Their involvement is needed to ensure the proposed conservation actions are feasible and socially acceptable.

Stakeholders include, but are not limited to, private landowners, local governments, non-governmental organizations, businesses, and public land managers. They may also be constituents of conservation partner agencies and can be reached through those relationships. An active outreach and education campaign will generate public support and seek involvement with, as yet unidentified, affected parties.

Effective outreach and education efforts must create awareness and interest in CFA goals, the need for conservation actions, and solicit approval, if not support, for conservation efforts. Outreach actions will target landowners and residents within priority action areas, owners of large tracts of land, businesses, local government officials, county representatives, community groups, public land managers, and local NGOs.

The WVDNR will connect with communities and deliver its message via direct mailings, public open houses, press releases, radio broadcasts, social media, WVDNR website, and presentations to local government and community organizations. Stakeholder contact information will be entered in a database and used for future outreach efforts.

Greater Greenbrier Conservation Focus Area

The Greater Greenbrier CFA encompasses the Greenbrier River watershed from the joining of the East and West Forks at Durbin downstream to the confluence with the New River. In the Allegheny Mountains Ecoregion, it includes a globally significant karst landscape surrounded by ridges and valleys of shale and sandstone. More caves occur in this watershed than anywhere else in West Virginia, with sinkhole and cave densities reaching an average of seven per square mile (18 per square kilometer) in the Big Levels region.

Davis Spring, with an average volume of 110 cubic feet per second (cfs), is the largest spring in the state, and Friars Hole, with 44 miles of mapped passage, is the sixth largest cave in the United States. Allegheny Mountain, whose crest forms the border with Virginia, defines the eastern boundary of the landscape, with a series of parallel shale and sandstone ridges running west to the karst region. In the karst region, most surface drainage is limited due to numerous sinking streams.

The Greenbrier River and its major tributaries to its east are the main surface streams. The Greenbrier River is the longest undammed river in the Central Appalachians. Elevations are generally moderate but rise to over 4000 feet at higher summits. The Greenbrier Valley is in a rain shadow and has lower precipitation than most portions of West Virginia.

The karst region was originally forested by deciduous forests, which have been largely displaced by farmland with scattered woodlots and towns such as Lewisburg. The shale and sandstone ridges remain largely forested, especially on public land, with small farms and communities in some valley areas. Portions east of the Greenbrier River originally supported the most extensive White Pine (*Pinus strobus*) forests south of northern Pennsylvania, but most of the White Pine area converted to mixed oak and oak-pine forests after the original forest was logged and burned.

Some of the most extensive intact forest blocks (primarily Dry-Mesic Oak) in the Central Appalachians Ecoregion occur in this eastern portion, where the largest landowner is the Monongahela National Forest. Most private forestland exists as small to medium-sized, non-industrial holdings. A few large, corporate-owned tracts exist in the vicinity of White Sulphur Springs. Residential development is expanding around Lewisburg and second home development is expanding along the Greenbrier River and locally elsewhere.

Wildlife

The Greenbrier Valley is recognized as a globally significant center of cave endemism and is one of the six most endemic-rich karst regions in North America. Well over one thousand caves are known, with nine caves supporting single cave endemics and 41 SGCN cave invertebrates overall. Organ Cave supports more known cave invertebrate species endemic to a single cave than any other cave in the state. Caves in the CFA also support important rare bat populations, and the world's entire populations of the the Greenbrier Cave Crayfish (*Cambarus nerterius*) , West Virginia Spring Salamander (*Gyrinophilus subterraneus*), and other cave restricted invertebrates.

A substantial statewide portion of several stream habitats occur in this CFA, including about 40% of all moderate gradient, cold headwater streams. Surface streams support significant rare mussel populations including the largest known population of the Green Floater (*Lasmigona subviridis*) in West Virginia (and is also the largest segment of the Ohio Basin metapopulation); the regionally endemic New River Crayfish (*Cambarus chasmodactylus*); Eastern Hellbender (*Cryptobranchus alleganiensis*); and eight of the ten fish species recognized as endemic to the New River Basin. One of two known global populations of a newly discovered crayfish, the Meadow River Mudbug (*Cambarus pauleyi)*, also occurs here. The federally listed shrub Virginia Spiraea (*Spiraea virginiana*) also occurs in riparian areas.

Dry Oak-Pine and Dry-Mesic Oak Forests in the CFA's eastern valleys and ridges and embedded Shale Barren patches support one of the largest and most diverse assemblages of the regionally endemic shale barren flora, including the federally listed Shale Barren Rockcress (*Arabis serotina*) and globally rare Nodding Wild Onion (*Allium oxyphilum*), a critically imperiled Appalachian population of Grizzled Skipper (*Pyrgus wyandot*, which may survive in West Virginia only here), and globally significant populations of Box Huckleberry (*Gaylussacia brachycera*) and Swordleaf Phlox (*Phlox buckleyi*).

A considerable portion of the state's Calcareous Cliffs and Talus and Dry Calcareous Forests, Woodlands, and Glades habitats occur here, supporting three new species of locally endemic land snails, globally imperiled Tall Larkspur (*Delphinium exaltatum*), and other rare plants. The significant mix of forest interior, forest successional, and grassland habitats support 51 SGCN birds.

Intact forest blocks support many forest interior breeding birds, including Broad-winged Hawk (*Buteo platypterus*), Wood Thrush (*Hylocichla mustelina*), Cerulean Warbler (*Setophaga cerulea*), Worm-eating Warbler (*Helmitheros vermivorum*) , and Eastern Whip-poor-will (*Antrostomus vociferous*), plus Timber Rattlesnake (*Crotalus horridus*), and the federally listed orchid, Small Whorled Pogonia (*Isotria medeoloides*).

Early successional forest habitats support the highest densities of remaining Golden-winged Warbler and are critical to the species' continued presence in West Virginia. Grasslands associated with karst topography are among the most extensive in West Virginia and important in the state for the Loggerhead Shrike (*Lanius ludovicianus*), as well as Eastern Meadowlark (*Sturnella magna*), and Grasshopper (*Ammodramus savannarum*), Vesper (*Pooecetes gramineus*) and Henslow's sparrows (*Ammodramus henslowii*).

Conservation Objective for the Greater Greenbrier Conservation Focus Area

The Greater Greenbrier Conservation Focus Area Plan is an extension of the State Wildlife Action Plan. While it is driven by local issues, the overarching goals remain the same. These include

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

The WVDNR will develop relationships with conservation partners and key stakeholders to support and promote natural resource stewardship and guide efforts that protect, restore, enhance, and otherwise benefit natural communities and processes. Only through collaboration with agency partners, non-governmental organizations, and the public can threats to Species of Greatest Conservation Need, key habitats, and unique communities be addressed.

Opportunities

Strategies for implementing conservation actions in this CFA rely on developing relationships with willing partners and willing land owners. Publicly owned property in this CFA presents abundant opportunities for on-the-ground ecosystem protection and management activities in primarily forested habitat. State and federal agencies manage 265,219 acres which comprise approximately 27.7% of the total area in the CFA. The Monongahela National Forest is the largest public land manager in the CFA (Figure 2.).

State owned lands are managed by the WV Division of Forestry (WVDOF) and the WVDNR. The WVDOF manages Calvin Price, Greenbrier, and Seneca State Forests. The WVDNR manages the Greenbrier River Trail, Droop Mountain Battlefield, Cass Scenic Railroad, Beartown, and Watoga State Parks; and Moncove Lake State Park and WMA.

The WVDNR and the U.S. Forest Service work together under a memorandum of agreement to cooperatively develop and implement Forest Service and WVDNR management plans. WVNDR planning staff participates in the national forest management plan development process and field personnel (wildlife managers) are stationed in the national forest to support forest plan implementation and to advance WVDNR objectives. Similarly, WVDNR and

WVDOF cooperate to implement wildlife habitat restoration and improvement on state forest lands. As a section of the WVDNR, State Parks are managed as natural areas.

The relationship with the U.S. Forest Service and the state land management agencies is based on mutual interest and the fact that the land is in public ownership. It facilitates successful broad scale conservation and protection actions for a variety of species and habitats. The relationship is much different with conservation agencies that do not own land or private property owners who may or may not be interested in conservation or protection.

Privately owned land presents conservation opportunities that require different implementation strategies. Private property generally has a primary purpose other than wildlife conservation. Land owners, particularly those whose land contains SGCN or critical habitats, are potential stakeholders. A number of conservation service agencies and land trusts are charged with actions on private property and each organization has its own "constituency" (e.g., farmers, hunting clubs, forest land owners, cave owners, etc.).

The WVDNR must develop relationships with agencies and groups such the Natural Resource Conservation Service, the West Virginia Conservation Agency, and land trusts so they may advance SWAP objectives to their constituents. WVDNR staff can provide technical and possibly financial support but the agencies and non-governmental organizations will lead conservation, restoration, or protection action implementation on private lands.

Seven thousand six hundred and eighty--three (7,683) acres of private property are held in conservation easements in the CFA reflecting that some property owners value conservation and land protection. Like public land, private properties with conservation easements can serve as "anchors" for additional conservation actions. That is, conservation practices, whether direct management or acquiring additional easements, can potentially originate within or adjacent to easement lands and extend or increase the conservation benefit on the landscape (Figure 2.).

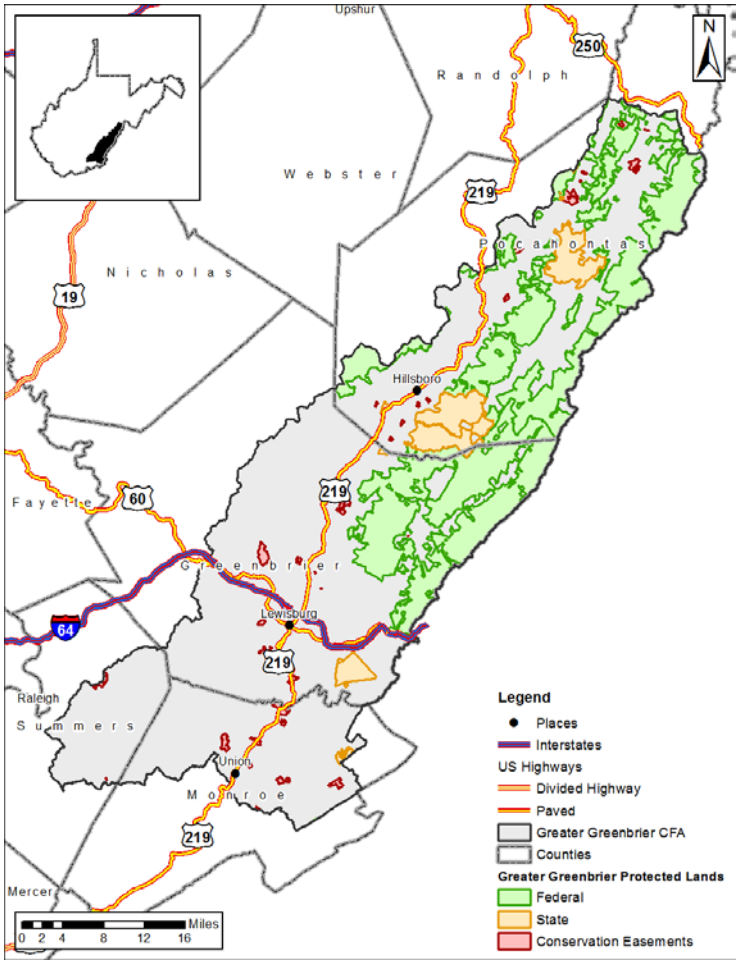

Figure 2. Properties in public ownership and under conservation easement in the Greater Greenbrier Conservation Focus Area.

Effective conservation on public lands may be measured in terms of acres of land protected or management plans that incorporate actions to benefit SGCN. The time frame for implementation may vary according agency schedules so short term effectiveness may be difficult to measure.

Success on private lands depends on the actions and the lead organization. Service agencies operate through contracts with landowners. The number of properties contracted and the resulting number of acres affected through conservation practices are measures of effectiveness. If habitat restoration is a goal, the presence of a viable SGCN population ultimately indicates the level of success.

Greater Greenbrier Conservation Focus Area - Proposed Scope of Work

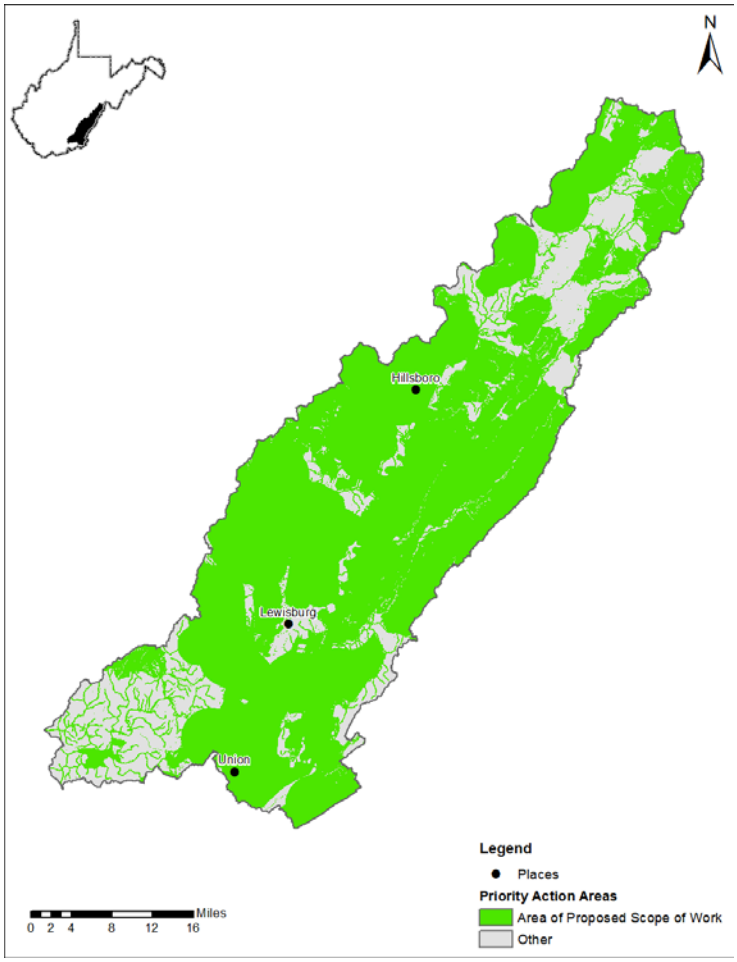

Figure 3. Area of proposed work in the Greater Greenbrier Conservation Focus Area.

The Greenbrier CFA is diverse in the number of SGCN, habitats, threats, and presents a number of opportunities to implement protection, restoration, and at least conservation practices. WVDNR staff identified regions in the CFA where successful conservation is likely to occur. The area of proposed work is an estimate based on known SGCN occurrences, SGCN habitats, and what are perceived to be threats and opportunities for conservation (Figure 3.). This scope of work is subject to change with input from partners and stakeholders.

Terrestrial Resources in the Greater Greenbrier Conservation Focus Area

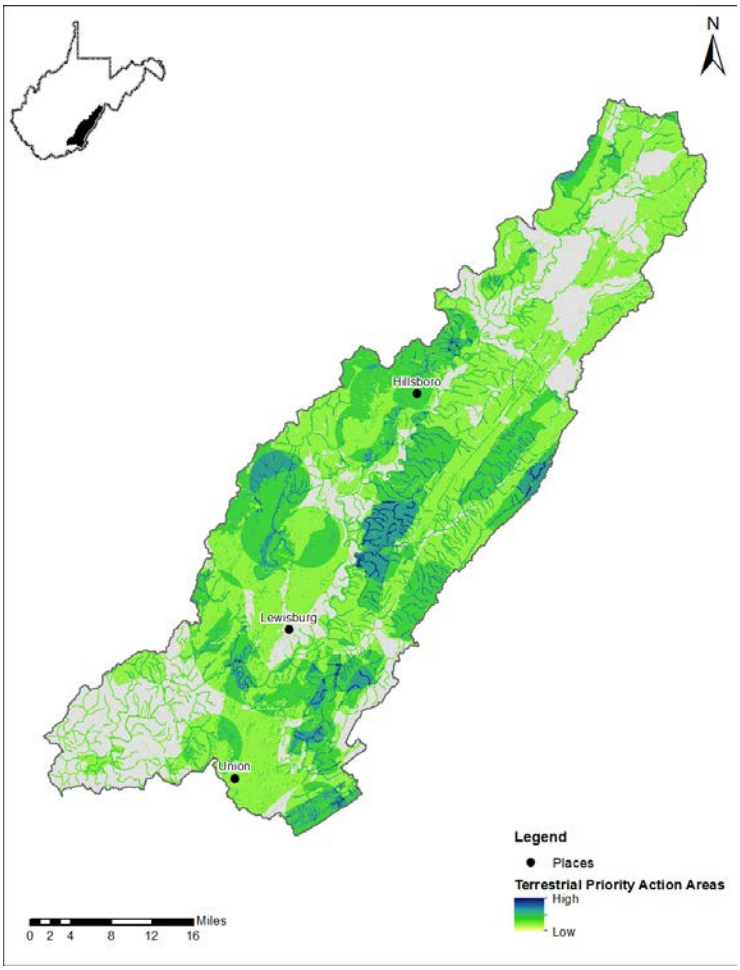

Figure 4. Terrestrial Priority Action Areas in the Greater Greenbrier CFA.

WVDNR staff identified priority SGCN representing seven taxa (Table 1.) and in terrestrial habitats in the Greater Greenbrier CFA. The presence of priority SGCN, their habitats, perceived threats, and apparent opportunities for protection and conservation informed the development of priority action areas to guide partners and stakeholders (Figure 4.) Figure 4 represents proposed priority action areas. These areas may be subject to change in response to information from local partners and stakeholders.

Table 1. Greater Greenbrier Conservation Focus Area Terrestrial Priority Species.

Taxon	Common Name	Scientific Name	Priority SGCN	Species Group
Amphibian	Cheat Mountain Salamander	*Plethodon nettingi*	1	Terrestrial Salamanders
Bird	Cerulean Warbler	*Setophaga cerulea*	1	Forest Interior Species
Bird	Loggerhead Shrike	*Lanius ludovicianus*	1	Early Succesional, Grassland Species
Bird	Golden-winged Warbler	*Vermivora chrysoptera*	1	Early Succesional Species
Lepidoptera	Grizzled Skipper	*Pyrgus wyandot*	1	Shale Barrens/ Eastern Oak-Pine Species
Lepidoptera	Northern Metalmark	*Calephilis borealis*	1	Shale Barrens/ Eastern Oak-Pine Species
Lepidoptera	Dusky Azure	*Celastrina nigra*	1	Mixed Mesophytic/Oak with Openings Species
Mammal	Allegheny Woodrat	*Neotoma magister*	1	Talus/Boulder Field Species
Mammal	Eastern small-footed bat	*Myotis leibii*	1	Talus/Boulder Field Species, Bats
Plant	American Barberry	*Berberis canadensis*	1	Plant
Plant	Swordleaf Phlox	*Phlox buckleyi*	*1*	Plant
Plant	Tall Larkspur	*Delphinium exaltatum*	*1*	Plant
Reptile	Timber Rattlesnake	*Crotalus horridus*	*1*	Terrestrial Snakes
Snail	Greenbrier Tigersnail	*Anguispira stihleri*	1	Snails Associated with Limestone Cliff along Greenbrier River
Snail	Club Supercoil	*Paravitrea bellona*	1	Undetermined

Priority SGCN may be present in more than one habitat type (terrestrial, aquatic, subterranean) depending on the suite of resources required by their life history. These are not the only species of concern in the CFA but as "umbrella species" they can serve as indicators of success. They were selected based on their association with co-occurring SGCN, identified and addressable threats, and conservation opportunities that occur in the CFA. For some SGCN, the CFA may actually serve as a "stronghold" for that species and thus merit priority consideration (Table 1.).

Table 2. Stresses Affecting Priority Terrestrial SGCN in the Greater Greenbrier Conservation Focus Area.

Taxon	Common Name	Scientific Name	Terestrial Stresses
Amphibian	Cheat Mtn Salamander	*Plethodon nettingi*	Climate change and timber harvesting.
Bird	Cerulean Warbler	*Setophaga cerulea*	Inadequate habitat: even -aged forest with degraded/absent understory
Bird	Loggerhead Shrike	*Lanius ludovicianus*	Land use: clean farming practices
Bird	Golden-winged Warbler	*Vermivora chrysoptera*	Population sinks: agricultural margins that also favor Blue-winged Warbler
Lepidoptera	Grizzled Skipper	*Pyrgus wyandot*	Shale barren succession to more closed canopy and gypsy moth spraying
Lepidoptera	Northern Metalmark	*Calephelis borealis*	Loss of larval host to forest succession
Lepidoptera	Dusky Azure	*Celastrina nigra*	Excessive deer browsing on larval host and nectar plants
Mammal	Allegheny Woodrat	*Neotoma magister*	Habitat loss, degradation and fragmentation due to development.
Mammal	Eastern small-footed bat	*Myotis leibii*	Habitat loss, degradation and fragmentation due to development.
Plant	American Barberry	*Berberis canadensi*	Residential development
Plant	Swordleaf Phlox	*Phlox buckleyi*	Harvesting trees and other woody vegetation for timber, fiber, or fuel, unknown population status
Plant	Tall Larkspur	*Delphinium exaltatum*	Residential development
Reptile	Timber Rattlesnake	*Crotalus horridus*	Changes in habitat through development and direct persecutionof species.
Snail	Greenbrier Tigersnail	*Anguispira stihleri*	Species is associated with limestone cliffs/talus in a small area of Greenbrier County. These areas could be threatened by housing development overlooking the Greenbrier River. Forest managment practices affect moisture conditions and the resulting drying of habitat needs to be considered.
Snail	Club Supercoil	*Paravitrea bellona*	Drying out of habitat due to timbering or other disturbance.

Terrestrial Threat Summary

1) *Climate change* potentially affects high elevation SGCN especially those in the red spruce habitat type.
2) *Forest management* practices (or lack thereof) affect forest interior taxa and habitats.
3) *Agricultural practices* affect grassland taxa and habitats.
4) *Pesticide application* (gypsy moth spraying) affects forest interior SGCN.
5) *Problematic native species* (white-tailed deer) impact understory vegetation and thus habitat for several taxa.
6) *Direct persecution* (hunting, killing) is impacting predatory SGCN (timber rattlesnakes).
7) *Residential development* degrades or eliminates habitats for many taxa.

Table 3. Conservations Actions Affecting Terrestrial SGCN in the Greater Greenbrier Conservation Focus Area.

Taxon	Common Name	Scientific Name	Terrestrial Conservation Actions
Amphibian	Cheat Mtn Salamander	*Plethodon nettingi*	Develop forest management plans and conservation easements on properies with species. Ensure landowners maintain intact stands of high elevation forest. Work with USFS to ensure stand integrity.
Bird	Cerulean Warbler	*Setophaga cerulea*	Implement Cerulean Warbler management guidelines on public and private lands where possible.
Bird	Loggerhead Shrike	*Lanius ludovicianus*	Implement Loggershead Shrike Conservation Action Plan. Work with partners on landowner outreach.
Bird	Golden-winged Warbler	*Vermivora chrysoptera*	Encourage large forest landowners to implement Golden-winged Warbler management guidelines.
Lepidoptera	Grizzled Skipper	*Pyrgus wyandot*	Implement timber stand improvement and prescibed fire to open up forest canopy. Modify gypsy moth control actions to minimze non-target mortality.
Lepidoptera	Northern Metalmark	*Calephelis borealis*	Develop forest management plans that include forest thinning and cut back borders at selected sites to encourage herbaceous growth
Lepidoptera	Dusky Azure	*Celastrina nigra*	Reduce deer density; Increase antlerless harvest in selected areas
Mammal	Allegheny Woodrat	*Neotoma magister*	Identify and work toward long-term protection/conservation of cliff/talus/cave habitats and maintain connectivity between sites so they function as metapopulations.
Mammal	Eastern small-footed bat	*Myotis leibii*	Identify and work toward long-term protection/conservation of cliff/talus/cave habitats and maintain connectivity between sites so they function as metapopulations.
Plant	American Barberry	*Berberis canadensi*	Collaborate with others to enhance landowner incentives and funding for participating in land conservation. (Discourage development on limestone cliff top habitat.)
Plant	Swordleaf Phlox	*Phlox buckleyi*	Survey and assess threats
Plant	Tall Larkspur	*Delphinium exaltatum*	Conservation easements and landowner incentives for participating in land conservation. (Discourage development on limestone cliff habitat.)
Reptile	Timber Rattlesnake	*Crotalus horridus*	Educate public of importance of rattlesnakes in the environment, locate dens, and rookeries.
Snail	Greenbrier Tigersnail	*Anguispira stihleri*	Limit development near talus and cliff habitats. Develop forest management plans that conserve habitat.
Snail	Club Supercoil	*Paravitrea bellona*	Limit timber harvest and other disturbance in areas with pockets of deep, moist leaf litter (e.g., ravines) within the range of this species.

Conservation actions are not intended to benefit just priority species. Actions to conserve or otherwise benefit priority SGCN should also benefit associated SGCN (including species across taxa groups). Priority SGCN should serve as indicators of effectiveness at least for that taxon and possibly for several species/taxa groups associated with the respective habitats.

Terrestrial Priorities in this CFA include restoration activities, protection actions, and developing educational media (Table 4.). Restoration activities generally involve implementing habitat management practices that improve,

increase or create habitat for SGCN. Protection actions should focus on protecting parcels of intact and/or vulnerable habitat. This can occur through cooperative agreements with public agencies or by purchasing parcels outright or acquiring conservation easements. The education component involves creating awareness among land owners and land managers of vulnerable habitats and SGCN and how to avoid impacting them.

Table 4. Summary of Conservation Actions for Terrestrial Resources in the Greater Greenbrier Conservation Focus Area

Activity	Goal	Actions	Effectiveness Measures
1. Restoration	Increase habitat for forest interior songbirds (e.g., Cerulean warbler, Wood Thrush, etc.).	Partner with resource agencies, the forest management community, and large forest landowners to implement management plans that benefit SGCN species (Olcott et al 2006, Wood et al 2013).	1) number of participating landowners implementing plans 2) acres of habitat created 3) before and after comparison of breeding pairs in treated areas
2. Restoration	Increase habitat for grassland songbirds (e.g., Loggerhead Shrike)	Partner with conservation agencies and large agricultural landowners to implement Loggerhead Shrike Management Plan.	1)number of participating landowners implementing plans 2) acres of habitat created 3) before and after comparison of breeding pairs in treated areas
3. Restoration	Increase early successional habitat for songbirds (Golden-winged Warbler)	Partner with conservation agencies and agricultural landowners to implement Golden-winged Warbler Management Plan (Bakermans et al 2013).	1)number of participating landowners implementing plans 2)acres of habitat created 3) before and after comparison of breeding pairs in treated areas
4. Restoration	Develop and expand forest understory vegetation layers (structural diversity).	Partner with WVDNR Game Management and large hunting clubs to decrease deer density in order to restore forest understory vegetation.	1)deer density assessment 2)deer density objective lowered (according to deer management plan) 3)antlerless harvest increased 4)before and after comparison of understory vegetation structure and diversity

Table 4. (cont'd) Summary of Conservation Actions for Terrestrial Resources in the Greater Greenbrier Conservation Focus Area.

Activity	Goal	Actions	Effectiveness Measures
5. Restoration	Reduce/manage invasive plant species in sensitive habitats.	Implement the WV Invasive Species Strategic Plan (Bailey 2014).	1) identify areas for treatment 2) treat invasive plant populations 3) re-treat and monitor as needed until area is free of invasive plants 4) before and after comparison of invasive plant coverage 5) estimated abundance and diversity of native vegetation
6. Protection	Protect or conserve large blocks of intact or unique habitat types (e.g. grassland, forest land, cliff/talus habitat, karst, etc.) for priority SGCN.	Partner with conservation agencies, land trusts, farm boards, landowners to identify properties and either purchase or facilitate conservation easements on properties containing large blocks of intact forest, important or unique habitat types (e.g., cliff/talus habitat, karst, etc.).	1) evidence of agreements with land trust partners 2) number of landowner contacts 3) number of easements purchased 4) acres of habitat under easement that have management and monitoring plans
7. Education	Educate landowners, especially homeowner associations, about living with vulnerable Species of Greatest Conservation Need (e.g., Timber Rattlesnake, ground nesting birds, etc.).	Develop educational programs and material to inform landowners and especially homeowner associations about living with SGCN such as the Timber Rattlesnake.	1) educational material produced 2) number of land owner contacts 3) number of workshops held
8. Education	Develop educational programs and material to inform landowners of the importance of karst topography and special considerations when living on karst.	Partner with conservation agencies, land trusts, farm boards, landowners to identify properties and either purchase or facilitate conservation easements on properties containing large blocks of intact forest, important or unique habitat types (e.g., cliff/talus habitat, karst, etc.).	1) educational material produced 2) number of land owner contacts 3) number of workshops held

Aquatic and Riparian Resources in the Greater Greenbrier Conservation Focus Area

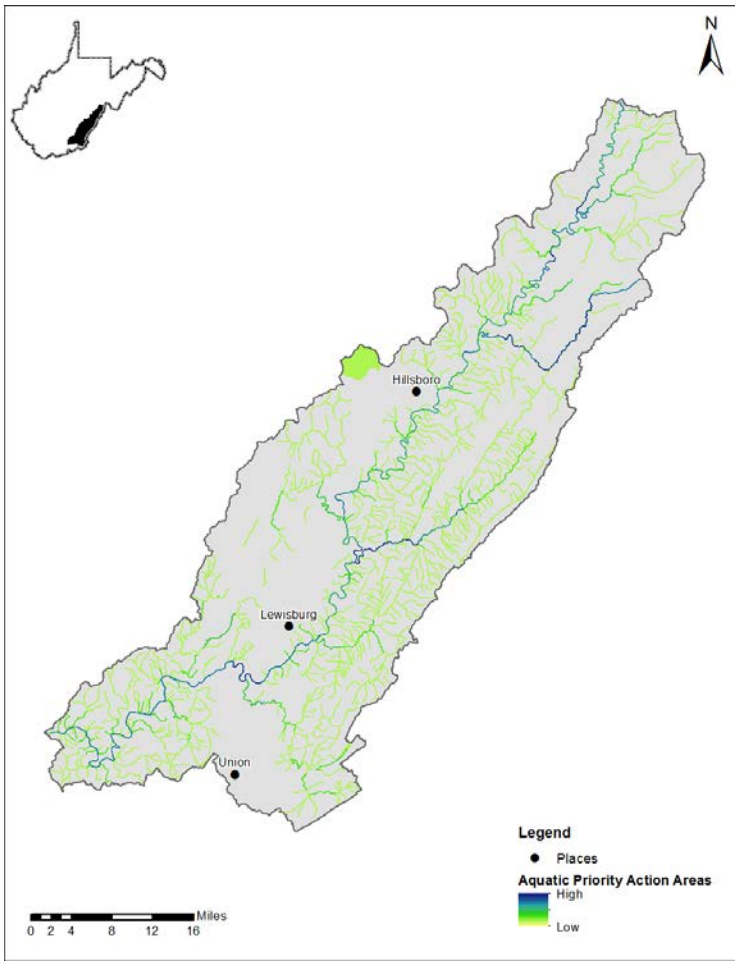

Figure 5. Aquatic and Riparian Priority Action Areas in the Greater Greenbrier Conservation Focus Area.

The Greater Greenbrier CFA encompasses much of the lower Greenbrier River watershed. The region contains a mosaic of forested and agricultural land. Impacts to aquatic and riparian resources result from land use and disturbance not just in the riparian zone and floodplain but also higher in the watershed (Figure 5.).

With almost 75% of the aquatic and riparian resources in private ownership, private landowners have the greatest opportunity to directly affect this resource. The WVDNR intends to create awareness of the stresses to the resource and encourage landowners and conservation partners to implement conservation practices on their property.

Table 5. Greater Greenbrier Conservation Focus Area Priority Aquatic and Riparian Species.

Taxon	Common Name	Scientific Name	Priority SGCN	Species Group
Amphibian	Eastern Hellbender	*Cryptobranchus alleganiensis*	1	Aquatic Salamanders
Crayfish	Meadow River Mudbug	*Cambarus pauleyi*	1	Terrestrial Crayfish
Crayfish	Greenbrier River Crayfish	*Cambarus smilax*	1	Aquatic Crayfish
Fish	Candy Darter	*Etheostoma osburni*	1	New River Species
Fish	Kanawha Minnow	*Phenacobius teretulus*	1	New River Species
Fish	Tonguetied Minnow	*Exoglossum laurae*	1	New River Species
Mussel	Green Floater	*Lasmigona subviridis*	1	New River and Potomac River Species
Mussel	Elktoe	*Alasmidonta marginata*	1	Potomac River Basin Species
Mussel	Wavy-rayed lampmussel	*Lampsilis fasciola*	1	Ohio River Basin Large River Species Ohio River Small Stream Species
Odonata	Maine Snaketail	*Ophiogompus mainensis*	1	High Elevation Streams and Rivers Species
Odonata	Riffle Snaketail	*Ohiogomphus carolus*	1	High Elevation Streams and Rivers Species
Odonata	Mustached Clubtail	*Gomphus adelphus*	1	High Elevation Streams and Rivers Species
Reptile	Eastern Hog-nosed Snake	*Heterodon platirhinos*	1	Terrestrial Snakes
Reptile	Eastern Ribbonsnake	*Thamnophis sauritus*	1	Terrestrial Snakes
Tiger Beetle	Appalachian Tiger Beetle	*Cicindella ancocisconensis*	1	Tiger Beetles

Table 6. Stresses Affecting Priority Aquatic and Riparian SGCN in the Greater Greenbrier Conservation Focus Area.

Taxon	Common Name	Scientific Name	Aquatic and Riparian Stresses
Amphibian	Eastern Hellbender	*Cryptobranchus alleganiensis*	Sedimentation and thermal changes in habitat, direct persecution by fishermen.
Crayfish	Meadow River Mudbug	*Cambarus pauleyi*	Draining of wetlands/wet areas
Crayfish	Greenbrier River Crayfish	*Cambarus smilax, C. chasmodactylus*	Agricultural run off (nutrient inputs) in Greenbrier River
Fish	Candy Darter	*Etheostoma osburni*	Non-point source pollution (agricultural, forestry related)
Fish	Kanawha Minnow	*Phenacobius teretulus*	Non-point source pollution (agricultural, forestry related)
Fish	Tonguetied Minnow	*Exoglossum laurae*	Non-point source pollution (agricultural, forestry related)
Mussel	Green Floater	*Lasmigona subviridis*	Livestock in stream trampling mussels and habitat. Direct nutrient input.
Mussel	Elktoe	*Alasmidonta marginata*	Lack of riparian habitat,decreased stream shading, increased summer stream temperatures. Vulnerable to drought. Increased runoff of non-point source effluent (sediment and nutrients).
Mussel	Wavy-rayed lampmussel	*Lampsilis faciola*	An increase in algal blooms in the mainstem Greenbrier River indicate potential excess nutrient inputs.
Odonata	Maine Snaketail	*Ophiogompus mainensis*	Agricultural effluent (nutrient and sediment)
Odonata	Riffle Snaketail	*Ohiogomphus carolus*	Agricultural effluent (nutrient and sediment)
Odonata	Mustached Clubtail	*Gomphus adelphus*	Agricultural effluent (nutrient and sediment)
Reptile	Eastern Hog-nosed Snake	*Heterodon platirhinos*	Degraded riparian habitat due to development. Direct persecution.
Reptile	Eastern Ribbonsnake	*Thamnophis sauritus*	Degraded riparian habitat due to development. Direct persecution.
Tiger Beetle	Appalachian Tiger Beetle	*Cicindella ancocisconensis*	Degradation or complete loss of habitat (sandy shores along rivers and islands).

Aquatic and Riparian Threat Summary

1) *Sediment and nutrient inputs* affect aquatic and riparian habitat and taxa.
2) *Altered riparian vegetation* affects water temperatures, degrades shoreline and floodplain habitat, and fragments aquatic and riparian connectivity.
3) *Draining or altering* wetlands (lentic habitats) impacts several SGCN taxa.
4) SGCN are *persecuted* or otherwise *killed* by recreational or agricultural activities.

Table 7. Conservation Actions Affecting Aquatic and Riparian SGCN in the Greater Greenbrier Conservation Focus Area.

Taxon	Common Name	Scientific Name	Aquatic and Riparian Conservation Actions
Amphibian	Eastern Hellbender	*Cryptobranchus alleganiensis*	Promote Best Management Practices for land (housing) development, agriculture and timber harvest. Restore and protect riparian buffers.
Crayfish	Meadow River Mudbug	*Cambarus pauleyi*	Assess status and distribution. Encourage private landowners, the Division of Highways, and State Parks to restore and maintain habitat.
Crayfish	Greenbrier River Crayfish	*Cambarus smilax, C. chasmodactylus*	Promote agricultural best management practices including stream fencing to restore and maintain water quality.
Fish	Candy Darter	*Etheostoma osburni*	Watershed partnerships and landowner incentives
Fish	Kanawha Minnow	*Phenacobius teretulus*	Watershed partnerships and landowner incentives
Fish	Tonguetied Minnow	*Exoglossum laurae*	Watershed partnerships and landowner incentives
Mussel	Green Floater	*Lasmigona subviridis*	Augment Green Floater mussel populations through propagation/reintroduction projects to maintain and expand populations.
Mussel	Elktoe	*Alasmidonta marginata*	Work with partners to provide better sediment and erosion protection and reduce effluent runoff from agriculture and other contributors.
Mussel	Wavy-rayed lampmussel	*Lampsilis faciola*	Actively work with landowners to provide stream bank fencing, stream restoration, and development of riparian buffers primarily on tributary streams.
Odonata	Maine Snaketail	*Ophiogompus mainensis*	Partner with USDA-FS, watershed groups, and NRCS to reduce agricultural runoff into Greenbrier River and tributaries.
Odonata	Riffle Snaketail	*Ohiogomphus carolus*	Partner with USDA-FS, watershed groups, and NRCS to reduce agricultural runoff into Greenbrier River and tributaries.
Odonata	Mustached Clubtail	*Gomphus adelphus*	Partner with USDA-FS, watershed groups, and NRCS to reduce agricultural runoff into Greenbrier River and tributaries.
Reptile	Eastern Hog-nosed Snake	*Heterodon platirhinos*	Promote development of pond and vernal pools to enhance food source for species, practice minimal impact development practices, keep intact forest tracts.
Reptile	Eastern Ribbonsnake	*Thamnophis sauritus*	Protect and restore riparian corridors. Educate public on minimizing habitat changes when developing areas (Best Management Practices).
Tiger Beetle	Appalachian Tiger Beetle	*Cicindella ancocisconensis*	Maintain or restore natural stream channels and minimize channelization and rip-rapping.

Table 8. Summary of Conservation Actions for Aquatic and Riparian Resources in the Greater Greenbrier Conservation Focus Area.

Activity	Goal	Actions	Effectiveness Measures
9. Baseline Inventory	Assess population status for Meadow River Mudbug	Survey for Meadow River Mudbug. Describe the population size, the distribution, and habitat. Identify threats and determine required conservation actions.	1)population status and distribution is defined 2) threats to the population are identified 3) conservation actions are determined 4) management plan is developed 5) management plan is implemented
10. Restoration	Improve water quality (restore temperature regime, reduce sediment loads, and nutrients).	Partner with resource agencies (NRCS, WVCA, WVDEP, WVDOH) to reduce priority stressors on farm land, forest land, road design, and in residential developments.	1) agreements with resource agencies and WV Division of Highways to implement conservation practices 2) identify priority locations where reducing key stressors most likely to benefit target species and habitats, and determine the management actions necessary for success at those locations 3) acreage/stream miles of identified priority locations where desired management actions implemented 4) before and after comparison of stream chemistry (when appropriate) 5) before and after comparison of species diversity 6) before and after comparison of invasive species presence 7) barriers to aquatic life passage are removed
11. Restoration	Create or improve functional riparian habitat. Improve connectivity.	Partner with resource agencies, watershed associations, and land owners on bank stabilization, tree planting, and stream fencing projects	1) agreements with resources agencies and NGOs 2) identify priority locations where reducing key stressors most likely to benefit target species and habitats, and determine the management actions necessary for success at those locations 3) acreage/stream miles of identified priority locations where desired management actions implemented number of landowners participating in conservation projects 4) before and after comparison of floristic diversity and structure at project sites 5) before and after comparison of faunal diversity at project sites 6) before and after comparison of sediment loads below project sites

Table 8. (cont'd) Summary of Conservation Actions for Aquatic and Riparian Resources in the Greater Greenbrier Conservation Focus Area.

Activity	Goal	Actions	Effectiveness Measures
12. Restoration	Increase Green Floater mussel populations.	Partner with state and federal hatcheries to propagate and reintroduce Green Floater mussels.	1) before and after population assessment at reintroduction sites 2) implement long term population monitoring plan 3) evidence of reproduction
13. Protection	Protect large blocks of intact riparian and floodplain habitats.	Partner with resource agencies, land trusts, farm boards, and landowners to purchase land outright or to facilitate conservation easements on properties with intact riparian and floodplain habitats.	1) evidence of agreements with land trust partners to cooperate to conserve identified priority lands 2) acreage of easements acquired which effectively protect priority lands 3) acres of habitat under easement that have SGCN conservation based management and monitoring plans
14. Education	Increase landowners' expertise about the importance of water quality for people and SGCN.	Develop outreach and education material designed to create awareness about water quality.	1) conservation partners (watershed association) are enlisted 2) workshops and open houses to present best management practices 3) educational material (brochures, booklets, posters) developed
15. Planning	Develop watershed protection plans that promote SGCN conservation..	Develop watershed protection plans that target impaired locations and implement best management practices.	1) conservation partners (watershed association) are enlisted 2) watershed management and monitoring plan is developed that incorporates SWAP objectives 3) evidence that the management plan is being implemented 4) evidence that the management plan is reducing stresses or achieving conservation benefit

Conservation priorities for aquatic and riparian habitats include conducting baseline inventories, streambank restoration , riparian protection actions, developing a wise stewardship message, and engaging with partners and stakeholders to develop conservation plans (Table 8.).

The Meadow River Mudbug (*Camabrus pauleyi*) is a wetland crayfish endemic to the Greater Greenbrier CFA. In order to develop informed management decisions, a comprehensive baseline assessment is needed. This inventory will identify occupied and unoccupied habitat and locations where restoration or protection actions can potentially occur.

Historic land uses have altered or degraded the aquatic and riparian resources. Restoration activities should involve implementing best management practices (agricultural, forestry, road design, etc.), streambank stabilization, and restoring or creating appropriate riparian vegetation buffers. Restoration actions must improve the water and riparian vegetation quality and, ideally, restore connectivity between suitable habitats. With improved habitat conditions, reintroduction of Green Floater mussels and possibly Eastern Hellbenders to historic range can then be considered.

Aquatic and riparian habitats and SGCN can best be protected by developing management agreements for land under public ownership, purchasing valuable lands outright, or acquiring conservation easements on large parcels containing intact habitat or habitat that can be restored. Conservation benefit can be extended when habitat adjoining protected lands also comes under protective management. Protection and restoration actions can also link blocks of intact functional habitat.

Local awareness and wise land stewardship especially on private lands are essential for conservation actions to effectively improve conditions in the CFA. Conservation agencies such as the WVDEP, WVCA, NRCS, and stakeholder groups such as the Greenbrier Watershed Association actively promote water quality, responsible stewardship, and environmental awareness. The WVDNR seeks to partner with these groups and initiate or contribute (financial and technical support) to ongoing watershed education and improvement plans. Engagement with agencies and stakeholder groups already active in the CFA ensures an effective and locally appropriate conservation message.

Subterranean Resources in the Greater Greenbrier Conservation Focus Area

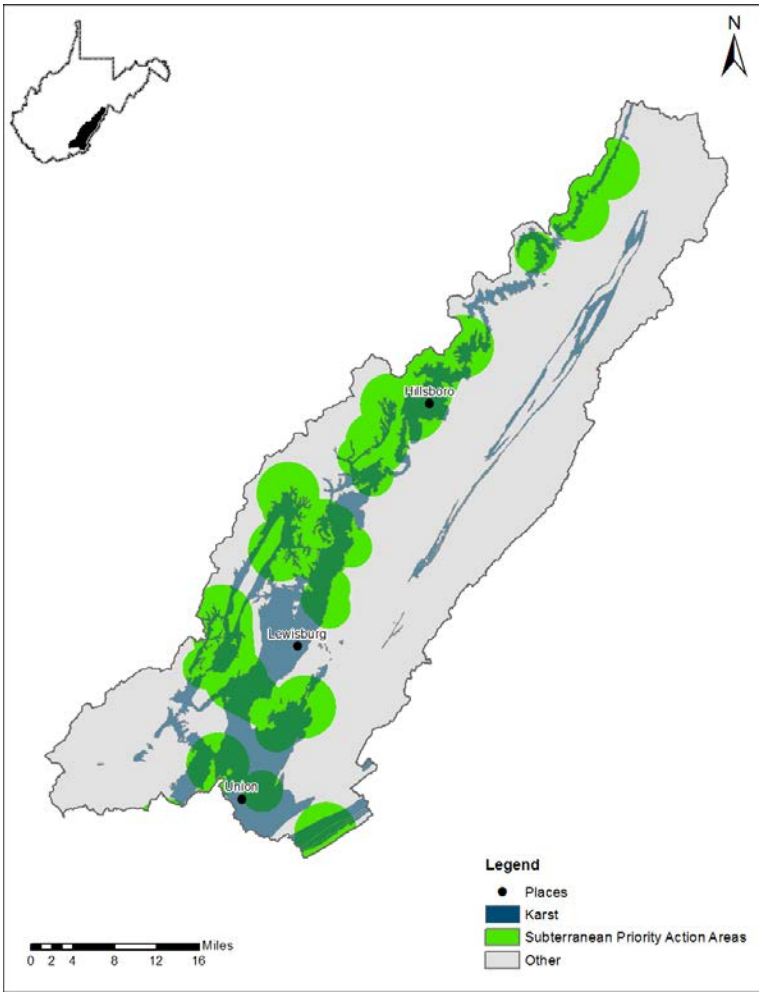

Figure 4. Subterranean Priority Action Areas in the Greater Greenbrier Conservation Focus Area.

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Subterranean priority action areas in the Greenbrier CFA occur primarily in areas with limestone/karst topography. Caves, sinkholes, and springs are common features that support SGCN. Areas of influence may extend beyond the limestone/karst geology (Figure 4.). SGCN may be directly affected by human activities or indirectly through impacts to the habitat. Much of this habitat occurs on private property and provides opportunities to develop relationships with landowners, the recreational caving community, resource agencies, and land trusts in order to protect or restore subterranean features and SGCN.

Table 9. Greater Greenbrier Conservation Focus Area Priority Subterranean Species

Taxon	Common Name	Scientific Name	Priority SGCN	Species Group
Amphibian	West Virginia Spring Salamander	*Gyrinophilus subterraneus*	*1*	Aquatic Salamanders
Cave Invertebrate	9 caves with single cave endemic species		1	Terrestrial Cave Invertebrates
Cave Invertebrate	8 caves with rank weighted score of 25 or more		1	Terrestrial Cave Invertebrates
Cave Invertebrate	5 caves with rank weighted score of 20 to 24		1	Terrestrial Cave Invertebrates
Crayfish	Greenbrier Cave Crayfish	*Cambarus nerterius*	1	Aquatic Crayfish
Mammal	Cave bats impacted by WNS	Cave hibernating bats		Bats
Mammal	Allegheny Woodrat	*Neotoma magister*	*1*	Talus/Boulder Field Species
Mammal	Eastern small-footed bat	*Myotis leibii*	*1*	Bats/Talus/Boulder Field Species
Snail	Greenbrier Cavesnail	*Fontigens turritella*	*1*	Snails in Other Groups (caves/aquatic)

Table 10. Stresses Affecting Subterranean SGCN in the Greater Greenbrier Conservation Focus Area.

Taxon	Common Name	Scientific Name	Subterranean Stresses
Amphibian	West Virginia Spring Salamander	*Gyrinophilus subterraneus*	Changes in surface land use and groundwater inputs.
Cave Invertebrate	Several species	9 caves with endemic species	Assess potential impacts from degraded water quality, recreational use, and alteration of cave entrances.
Cave Invertebrate	Several species	8 caves with weighted score of $\geq$ 25	Assess potential impacts from degraded water quality, recreational use, and alteration of cave entrances.
Cave Invertebrate	Several species	5 caves with weighted score 20-24	Assess potential impacts from degraded water quality, recreational use, and alteration of cave entrances.
Crayfish	Greenbrier Cave Crayfish	*Cambarus nerterius*	Pollution (effluent) from agriculture and residential development
Mammal	Cave bats impacted by WNS	Cave bats severely impacted by WNS	Disturbance in hibernacula.
Mammal	Allegheny Woodrat	*Neotoma magister*	Habitat loss, degradation, and fragmentation due to development.
Mammal	Eastern small-footed bat	*Myotis leibii*	Habitat loss, degradation, and fragmentation due to development.
Snail	Greenbrier Cavesnail	*Fontigens turritella*	Degraded water quality in the two caves where this species occurs.

Subterranean Threat Summary

1) *Residential and agricultural activities* contribute *nutrients and sediment* to groundwater in karst regions and cave systems which impact aquatic subterranean SGCN.
2) Cave dwelling species are *persecuted or otherwise disturbed* during vulnerable periods of their life history.
3) Areas of influence surrounding cave/karst systems are *developed* or otherwise *fragmented* which degrades cave habitat and potentially *alters connectivity*.

Table 11. Conservation Actions Affecting Subterranean SGCN in the Greater Greenbrier Conservation Focus Area.

Taxon	Common Name	Scientific Name	Subterranean Conservation Actions
Amphibian	West Virginia Spring Salamander	*Gyrinophilus subterraneus*	Minimize changes to drainage patterns and sediment loads. Develop Best Mangement Practices and present to land developers.
Cave Invertebrate	Several species	9 caves with endemic species	Seek information from cavers and caving organizations, landowners, etc. Visit caves to assess impacts to recreational use. Develop cave owner registry and cave management plans
Cave Invertebrate	Several species	8 caves with weighted score of ≥ 25	Develop educational material (programs and booklets) to inform landowners of the importance of karst topography and special considerations when living on karst.
Cave Invertebrate	Several species	5 caves with weighted score 20-24	Seek information from cavers and caving organizations, landowners, etc. Visit caves to assess impacts to recreational use. Develop cave owner registry and cave management plans
Crayfish	Greenbrier Cave Crayfish	*Cambarus nerterius*	Complete status and distribution assessment. Work with landowners to maintain water quality (stream fencing, sinkhole clean-up).
Mammal	Cave bats impacted by WNS	Cave bats severely impacted by WNS	Work with land owners to minimize human traffic in significant bat caves fall through spring. Develop cave owner registry and cave management plans
Mammal	Allegheny Woodrat	*Neotoma magister*	Identify and work toward long-term protection/conservation of cliff/talus/cave habitats and maintain connectivity between sites so they can function as metapopulations.
Mammal	Eastern small-footed bat	*Myotis leibii*	Identify and work toward long-term protection/conservation of cliff/talus/cave habitats and maintain connectivity between sites so they can function as metapopulations.
Snail	Greenbrier Cavesnail	*Fontigens turritella*	Develop and implement watershed plans for the drainages that feed these caves to maintain water quality.

Table 12. Summary of Conservation Actions for Subterranean Resources in the Greater Greenbrier Conservation Focus Area.

Activity	Goal	Actions	Effectiveness Measures
16. Baseline Inventory	Establish a registry of most important cave & karst areas and property owners, develop a database of endemic cave species, an assess threats to subterranean species and habitats.	Identify cave owners and develop a database of cave owners and the endemic species their caves contain.	1) Identify key cave and karst landscape properties. 2) develop a database of property owners and the endemic species their caves/karst landscapes contain.
17. Restoration	Improve degraded water quality entering cave systems.	Identify areas of influence (e.g., watersheds) around cave systems, the potential stresses, and partner with conservation agencies, landowners, and land trusts to develop protective buffers.	1) conservation partners (caving community, landowners, resource agencies) are actively engaged in implementing conservation actions 2) cave management and monitoring plans are developed for priority caves that incorporate SWAP objectives 3) evidence that management plans are being implemented 5) priority lands are identified protected through conservation easements (with management plans).
18. Restoration	Improve water quality within caves and remove physical trash from caves.	Partner with landowners, conservation agencies, and the caving community to remove trash from caves and sinkholes.	1)number of priority caves with a meaningful reduction of physical trash.
19. Education	Inform cave owners, the caving community, and the public about cave fauna, conservation, and ecology.	Develop and distribute educational material on caves, cave fauna, and cave conservation, and recreational caving ethics to priority landowners and the caving community.	1) conservation partners (cave owners caving organizations) are enlisted 2) conservation workshops 3) educational material developed

Table 12 (cont'd) Summary of Conservation Actions for Subterranean Resources in the Greater Greenbrier Conservation Focus Area.

Activity	Goal	Actions	Effectiveness Measures
20. Education	Inform land owners and the public about living on karst geology.	Develop educational programs and material to inform landowners of the importance of karst topography and special considerations when living on karst.	1) workshops for landowners land developers, and county planning commissions 2) educational material developed 3) community adopts best management practices for building/living in karst areas
21. Planning	Develop management plans for priority caves containing SGCN. Plans should address recreational activities and watershed protection as needed.	Partner with the recreational caving community to reduce cave visits during critical times of the year and to caves containing single-cave endemic species.	1) agreements/partnerships with caving organizations and land owners to regulate visits at critical caves. 2) before and after comparison of select SGCN where agreements and partnerships created. 3) before and after comparison of trash/indicators of human impacts where agreements and partnerships created.

Specific priority actions for subterranean resources include developing a registry of cave ownership, cave species inventories, identifying (land) areas of influence around caves, and threats to cave fauna and habitat. Restoration actions include trash clean ups, addressing causes of degraded water quality, and constructing cave gates, when needed. Educational activities should include developing workshops or educational material literature about cave fauna, responsible caving practices, and wise use practices for living and working in a karst landscape.

Karst geology supports productive forestland, grassland, farmland, and associated land uses. Caves in the Greenbrier Valley are also popular with the recreational caving community. The WVDNR must collaborate with landowners, caving groups, and conservation partners to develop cave conservation plans that effectively protect vulnerable subterranean resources and still accommodate land uses and human activities as much as possible (Table 12.).

Vulnerable Habitats

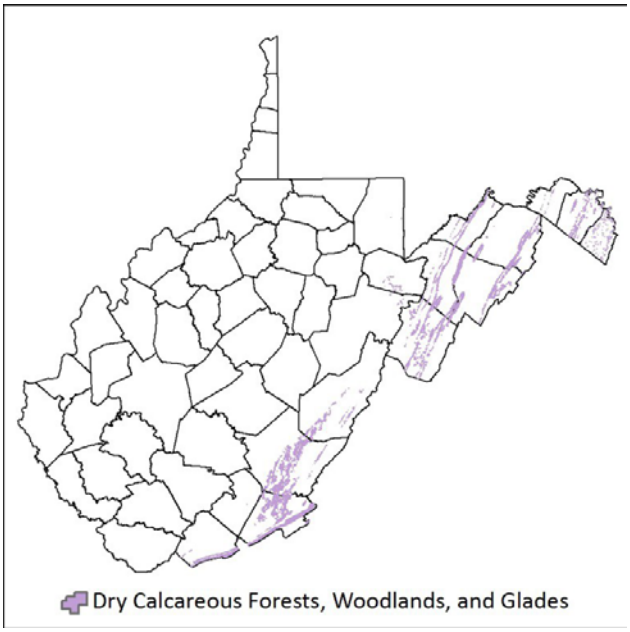

Figure 5. Dry Calcareous Forests, Woodlands and Glades in West Virginia.

Dry Calcareous Forests, Woodlands, and Glades habitat occurs to large extent in the Ridge and Valley province along the Potomac River. Very few representative locations occur in the Greenbrier Valley of the Allegheny Mountains province (Figure 5.). The limestone geology supports productive farm land and forest land and consequently much of this habitat in the Greenbrier Valley has been cleared for farming and timber production. In areas where the habitat is recovering, non-native and invasive plants degrade the representative habitats. Very few examples of this habitat occur on public or protected lands in this CFA.

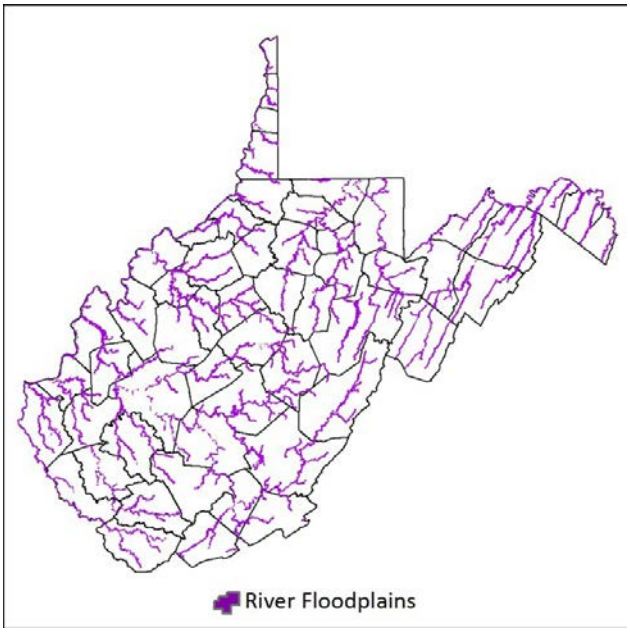

Figure 6. River Floodplains in West Virginia.

River floodplains occur throughout the state generally along rivers at lower elevations (Figure 6.). The habitat is represented by a disproportionately high number of vegetation community types relative to other habitats. River floodplains are frequently modified or otherwise developed for human activities. Timber harvesting and conversion to grazing land threatens the habitat in the Greater Greenbrier CFA. Non-native invasive vegetation further degrades impacted areas following disturbance activities. Intact functioning floodplain communities represent intact functioning riparian habitat and are thus a priority in this CFA.

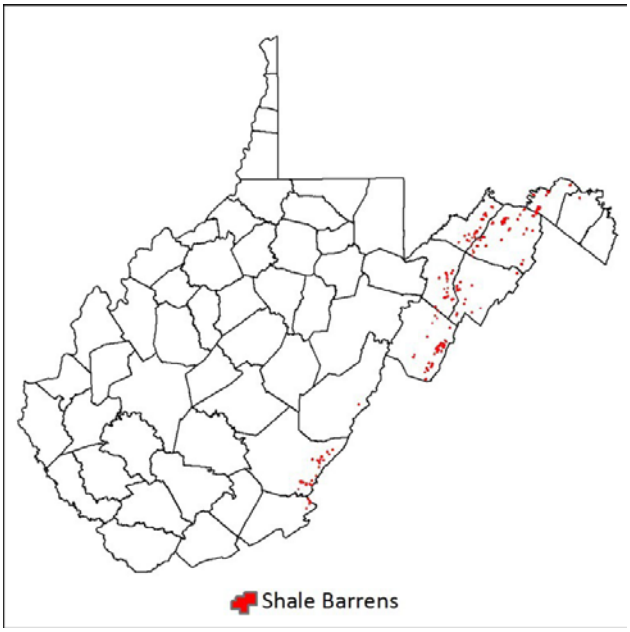

Figure 7. Shale barren habitats in West Virginia.

In West Virginia, shale barren habitats are restricted to the Ridge and Valley Ecoregion and the Greenbrier Valley in the Allegheny Mountain Ecoregion (Figure 7.). Shale barren habitats generally occur as small woodland patches on steep southerly facing slopes primarily on acidic shale substrate. The habitat contains diverse plant assemblages including some plant species considered to be "shale barren endemic" plants.

The unique shale barren vegetation supports an equally unique Lepidopteran SGCN including the Grizzled Skipper (*Pyrgus wyandot*). Shale barren habitats are vulnerable because they are typically embedded within woodlands that are subject to pesticide application for gypsy moth. The habitat is further degraded when human activities such as grazing, timber management, and road construction introduce non-native invasive plants (Table 13.).

Table 13. Vulnerable Habitats in the Greater Greenbrier Conservation Focus Area

	Habitat Type	Habitat Stresses	Conservation Actions
Terrestrial Habitats	Dry Calcareous Forests, Woodlands, and Glades	Residential and agricultural development	Acquire conservation easments on private lands. Engage with public agencies to preserve blocks of intact habitat.
Terrestrial Habitats	River Floodplains	Timber harvest	Acquire conservation easments on private lands. Engage with public agencies to preserve blocks of intact habitat.
Terrestrial Habitats	Shale Barrens	Non-native invasive species (weeds)	Establish and implement West Virginia Invasive Species Plan

Table 14. Summary of Conservation Actions for Vulnerable Habitats in the Greater Greenbrier Conservation Focus Area

Activity	Goal	Actions	Effectiveness Measures
23. Protection	Protect large intact blocks of 1) dry calcareous forest, woodland, glade habitat. 2) intact riparian and floodplain habitat.	Partner with conservation agencies, land trusts, farm boards, landowners to identify properties and either purchase or facilitate conservation easements on properties containing large blocks of intact forest, important or unique habitat types (e.g., cliff/talus habitat, karst, etc.).	1) priority habitat locations identified for protection. 2) acreage of private lands acquired through purchase or easement that have management and monitoring plans. 3) acreage of compatibly designated public lands that have complementary management and monitoring plans.
24. Restoration	Reduce/manage invasive plant species in shale barren habitats.	Implement the WV Invasive Species Strategic Plan (Bailey 2014).	1) identify priority areas for treatment 2) treat invasive plant populations 3) re-treat and monitor until invasive plants do not functionally degrade habitat/SGCN populations. 4) before and after comparison of invasive plant coverage 5) estimated abundance and diversity of native vegetation

Priority actions for vulnerable habitats include identifying areas of intact habitat on public and private lands and pursuing means of protecting or preserving them. On private land, conservation easements can effectively protect sensitive areas. Easements must include management plans that guide responsible land uses. Public land agencies can incorporate management strategies into their operational plans that secure sensitive areas, minimize disturbance, and maintain ecological integrity.

Managing vulnerable habitats on both public and private land must include plans that address NNIS which degrade habitat integrity and reduce their capacity to support SGCN fauna. Management plans must include treatment and monitoring strategies (Table 14.).

Greater Greenbrier Conservation Focus Area Outreach Plan

Outreach Goals

1. Increase community awareness of the SWAP and the Conservation Focus Area.
2. Promote a sense of stewardship and inspire the community to take action.
3. Encourage support for conservation actions from the public and local government.
4. Seek public comments on WVDNR goals for the Conservation Focus Area. How feasible are the WVDNR goals? How acceptable are the actions?
5. Seek potential partners who will implement actions on their property and/or carry the conservation message to their neighbors.
6. Increase human capacity and resources needed to implement conservation actions and monitoring

Target Audiences

1. State and federal government natural resource agencies (Table 15.).
2. Large forest land owners, and other key private land owners, hunt clubs, homeowners associations, public land managers, and residents in the priority action areas.
3. Civic groups (e.g., 4-H, Master Gardners, Rotary, etc.) and other non-governmental organizations including land trusts, watershed associations, and agricultural organizations (Table 15.).
4. Local governments including County Commissions and County Planning Commissions (Table 15.).
5. Citizens and organizations willing to advocate for implementing SWAP conservation actions in the CFA.

Activities Designed to Reach the Target Audience

Print Media

- News releases in local papers – Submit articles to the Pocahontas Times and the West Virginia Daily News and Greenbrier Valley Ranger.
- Letters to the Editor – Submit letters to the editor to announce upcoming events in the CFA.
- Direct mailings – Use digital courthouse to identify landowners in priority action areas and send direct mailings/flyers/invitations to open house events.

Electronic Media

- Public Service Announcements
- Radio Interviews (NPR, Chris Lawrence, Allegheny Mountain Radio, etc.)
- DNR Website - Post fact sheets (wildlife, wild vegetation, habitat improvement BMP's, etc.)
- DNR Facebook page – Post CFA event announcements, post CFA plans for review, BMP materials, SGCN wildlife facts, etc.

Visual Media

- Displays – State fair, county fairs, local festivals, etc.
- Posters - Use at DNR events, county fairs, etc.
- Fact sheets - Offer species fact sheets and habitat BMP information available on the agency website.

Personal Contacts

- Workshops - Invite potential partners (contacted through bulk mailings) and stakeholders to discuss issues and concerns and develop priorities.
- Presentations - Offer to speak to citizen groups and local governments, planning commissions, etc.
- Meetings - Meet with conservation agencies (USFS, NRCS, etc.) to incorporate CFA objectives into their plans.
- Open Houses – Host open house events within the CFA for the general public. Have staff specialists and agency partners present to discuss conservation opportunities.
- Personal Engagement - Target corporate and private owners of large and other key tracts of habitat to discuss conservation actions.

Other

- Partnerships – Join or start local working groups with partners and stakeholders to develop projects, raise funds, and implement actions. Partner agencies have constituents with mutual interests. These are the people we need to reach.
- Cooperative Agreements – Develop agreements with partner agencies to implement actions on private lands (e.g., NRCS/WVDNR shared biologist positions).
- Local governments – Engage with city and county governments (e.g., planning commissions). Seek their approval and support and allay their concerns of "big government" actions.

Message

- WVNDR goals are to restore, conserve, and protect SGCN populations and habitat.

- WVDNR wants to encourage residents, landowners, and land managers to implement conservation actions on their property.
- Best Management Practices can benefit landowners, businesses, and wildlife.
- Wildlife conservation can be complementary to and often enhance land use, land ownership, or business.

Implementation

- Initiate contact with partners and stakeholders who are likely project leaders.
- Elicit support from partners to advance our message to their constituents.
- Host outreach activities for the general public.

Outreach Evaluation (Indicators of Effectiveness)

- Record attendance at public events (meetings, workshops, presentation, etc.)
- Record the number of news articles and press releases.
- Record the number of inquiries regarding the SWAP
- Record the number of participants registered by partner agencies.
- Record and evaluate the comments received from the public.

Table 15. Potential Partners and Stakeholder Groups in the Greater Greenbrier CFA.

USDA Natural Resource Conservation Service	WV Beekeepers Association
USDA Animal Plant Health Inspection Service	The Nature Conservancy
USDA Forest Service	Greenbrier River Watershed Association
USFWS Partners Program	Pocahontas Nature Club
US Army Corps of Engineers	WV Speleological Survey
Greenbank National Radio Observatory	WV Cave Conservancy
White Sulphur Springs Fish Hatchery	WV Association For Cave Studies
WV Division of Highways	Monroe County Cavers
WV Conservation Agency	Consulting foresters
WV Department of Environmental Protection	Forest Land Group
WV Division of Forestry	Plum Creek Timber Company
WVU Extension Service	Planning commissions
WV Department of Agriculture	County government
WV State Parks (incl. Greenbrier River Trail)	Chamber of Commerce
Land trusts	Farmland Protection Board
Watershed Associations	Hunting clubs (assist from Game Management)
Appalachian Mountain Joint Venture	The Greenbrier Sportsmans Club
National Wild Turkey Federation	The Greenbrier

Discussion

The WVDNR must develop working relationships with land management agencies, identify conservation partners, and connect with local stakeholders. Sustainable conservation, especially on private property, depends on participation from the public that lives, works, and recreates in the CFA. This plan is

intended to inform and guide partners and stakeholders in decision making and implementing conservation practices. Conversely, participating conservation partners and stakeholders must contribute their local knowledge and expertise to ensure this plan is feasible and effective.

This plan proposes specific actions to benefit priority SGCN and vulnerable habitats. Recommendations are based on perceived threats to SGCNs and opportunities for successful conservation. Although the plan proposes specific conservation actions for priority SGCN in broad habitat categories (terrestrial, aquatic/riparian, subterranean), the benefits are not necessarily exclusive. Protecting large blocks of habitat, restoring habitat, and improving water quality benefit the entire wildlife resource.

Conservation Activities

Protection – Management plans on public lands and conservation easements on private lands (with management plans) secure and maintain habitat conditions for perpetuity. Preserving large blocks of functional intact forest and riparian habitat maintains connectivity, ensures species resiliency, safeguards vulnerable resources, and expands secured lands. Land management agencies can incorporate protective actions into their overarching management plans. Land trusts and local farmland protection boards are active the Greater Greenbrier CFA and in position to acquire easements..

Restoration – Management activities that create, improve, connect, maintain, or otherwise benefit SGCN and habitats. Examples of management activities include cerulean warbler habitat management guidelines, stream fencing, and invasive species control. Restoration activities also include captive propagation and species re-introductions. Restoration (management) plans should be incorporated with conservation easements to accommodate multiple uses (e.g. farming and timber harvesting) without impacting SGCN. Restoration actions improve degraded habitat conditions, create habitat where habitat has been lost, and improve opportunities for SGCN populations to expand.

Baseline Inventory – Research, surveys, status assessments, and other information that informs management decisions.

Education – Outreach activities including workshops and presentations that inform and educate the general public, local government, and other stakeholder groups. Outreach material includes literature, social media, and web based information.

Planning – Incorporating green infrastructure, best management practices, management area designations (on public land), and source water protection in agricultural, transportation, watershed, local government, and public land planning. Conservation principles are integrated in all land use and infrastructure plan development.

Conclusion

This plan is intended to guide conservation actions in the Greater Greenbrier Conservation Focus Area. It is a living document that can be modified as new issues develop and with input from resource specialists and local residents. Public involvement is an essential element of this plan. The WVDNR seeks to

collaborate with local residents, recreationists, and resource experts, instill a sense of stewardship, and inspire them to restore, protect, and expand the wildlife resources in the Greenbrier Valley. The desired outcome is secure wildlife populations and intact habitats.

When confronted by an array of opportunities, the WVDNR will make protection of existing high quality habitats a priority. Restoration activities in the form of management action remains an important and, for many species and habitats, a essential tool. Collaboration with local residents and the development of a conservation ethic within the community is essential for enduring protection of wildlife resources in the Greenbrier Valley.

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Still need references for LOSH plans

Appendix A. Terrestrial Habitats in the West Virginia State Wildlife Action Plan

Acidic Rock Outcrops, Cliffs, and Talus	Montane Red Oak Forests
Agriculture	Northern Hardwood Forests
Anthropogenic Shrubland & Grassland	Pine-Oak Rocky Woodlands
Calcareous Cliffs and Talus	Anthropogenic habitats
Caves and Karst	Red Spruce Forests
Developed	River Floodplains
Dry Calcareous Forests, Woodlands, and Glades	Shale Barrens
Dry Oak (-Pine) Forests	Sinkhole and Depression Ponds
Dry-Mesic Oak Forests	Small Lentic Water Bodies
Heath-Grass Barrens	Small Stream Riparian Habitats
High Allegheny Wetlands	Unresolved
Mixed Mesophytic Forests	

Appendix B. Aquatic Habitat Classes in the West Virginia State Wildlife Action Plan.

Headwater Creek,Low Gradient,Cold	Medium River,Moderate Gradient,Cold
Headwater Creek,Low Gradient,Cool	Medium River,Moderate Gradient,Cool
Headwater Creek,Low Gradient, Warm	Medium River,Moderate Gradient,Warm
Headwater Creek,Moderate Gradient,Cold	Medium River,High Gradient,Cold
Headwater Creek,Moderate Gradient,Cool	Medium River,High Gradient,Cool
Headwater Creek,Moderate Gradient,Warm	Medium River,High Gradient,Warm
Headwater Creek,High Gradient,Cold	Large River,Low Gradient,Cold
Headwater Creek,High Gradient,Cool	Large River,Low Gradient,Cool
Headwater Creek,High Gradient,Warm	Large River,Low Gradient,Warm
Small River,Low Gradient,Cold	Large River,Moderate Gradient,Cold
Small River,Low Gradient,Cool	Large River,Moderate Gradient,Cool
Small River,Low Gradient, Warm	Large River,Moderate Gradient,Warm
Small River,Moderate Gradient,Cold	Large River,High Gradient,Cold
Small River,Moderate Gradient,Cool	Large River,High Gradient,Cool
Small River,Moderate Gradient,Warm	Large River,High Gradient,Warm
Small River,High Gradient,Cold	Lentic,Low Gradient,Cold
Small River,High Gradient,Cool	Lentic,Low Gradient,Cool
Small River,High Gradient,Warm	Lentic,Low Gradient,Warm
Medium River,Low Gradient,Cold	Embayment,Low Gradient,Cold
Medium River,Low Gradient,Cool	Embayment,Low Gradient,Cool
Medium River, Low Gradient,Warm	Embayment,Low Gradient,Warm

Appendix C. Species Group Associations

Taxon	Species Groups
Amphibians	Frogs and Toads
	Aquatic Salamaders
	Terrestrial Salamanders
Birds	Aerial Insectivores
	Early Successional Species
	Forest Edge and Riparian Species
	Forest Interior Species
	Grasslands Species
	High Elevation Forests and Wetlands Species
	Owls
	Raptors and Vultures
	Waterbirds, Waterfowl and Shorebirds
Cave Invertebrates	Aquatic Cave Invertebrates
	Terrestrial Cave Invertebrates
Crayfish	Aquatic Crayfish
	Terrestrial Crayfish
Fish	Ohio River Basin Large River Species
	Ridge and Valley High Volume Spring Obligate Species
	James River Basin Species
	New River Species
	Potomac River Basin Species
	Potomac River Basin Large River Species
	Ohio River Basin Small Stream Species
	Migratory Predator Species
	Headwater Stream Predator Species
Lepidoptera	Shale Barrens/ Eastern Oak-Pine Species
	Appalachian Wetlands/Red Spruce Species
	Heathlands Species
	Northern Hardwood Forest Species
	Southern Coalfields Species
	Wet Meadows/Edges Species
	Mixed Mesophytic/Oak with Openings Species
	Other Species
Mammals	Bats
	Talus/Boulder Field Species
	Red Spruce/Northern Hardwood Forest Species
	Grassland/Meadow/Shrubland Species
	Other Species
Mussels	Ohio River Basin Large River Species
	Ohio River Basin Small Stream Species
	Potomac River Basin Species
	James River Basin Species
	New River and Potomac River Species

Appendix C. Species Group Associations (continued)

Taxon	Species Groups
Odonates	High Elevation Wetlands Species
	High Elevation Streams and Rivers Species
	Western/Eastern Streams and Rivers Species
	Forested Seeps and Streamlets Species
	Well Vegetated or Marshy Ponds Species
	Fishless Ponds Species
	Ponds Species
Reptiles	Terrestrial Skinks
	Terrestrial Turtles
	Terrestrial/Aquatic Turtles
	Aquatic Turtles
	Terrestrial Snakes
Snails	Snails found in Forest Habitats
	Snails of Dry Open Habitats
	Snails of Open Wetland habitats
	Snails Associated with Limestone Cliff along Greenbrier River
	Snails Associated with Cliffs along Tribs of Bluestone River
	Other Terrestrial Snails
	Snails in Other Groups (caves/aquatic)
Tiger Beetles	All Tiger Beetles

Appendix D. Major Stresses Affecting SGCN and Habitats in the Greater Greenbrier CFA.

Significant Terrestrial Stresses	Significant Aquatic Stresses
Invasive Non-native/Alien Species/Diseases	Industrial and Military Effluents
Roads and Railroads	Storms and Flooding
Utility and Service Lines	Invasive Non-native/Alien Species/Diseases
Housing and Urban Area	Roads and Railroads
Recreational Activities	Domestic and Urban Waste Water
Mining and Quarrying	Dams and Water Management/Use
Problematic Native Species/Diseases	Agricultural and Forestry Effluents
Logging and Wood Harvesting	Droughts
Collecting Terrestrial Animals	Mining and Quarrying
Commercial and Industrial Areas	Utility and Service Lines
Agricultural and Forestry Effluents	Recreational Activities
Livestock Farming and Ranching	Logging and Wood Harvesting
Oil and Gas Drilling	Other Ecosystem Modifications
Tourism and Recreational Areas	Collecting Aquatic Resources
Fire and Fire suppression	Shipping Lanes
Renewable Energy	Livestock Farming and Ranching
Annual and Perennial Non-timber crops	Temperature Extremes
Dams and Water Management/Use	Tourism and Recreational Areas
Other Ecosystem Modifications	Air-Bourne Pollutants
Industrial and Military Effluents	Problematic Native Species/Diseases
Habitat Shifting or Alteration	