Brook Trout Outcome

Management Strategy

2015–2025, v.2

Dustin Wichterman, Potomac Headwaters Project Coordinator with Trout Unlimited, fishes for brook trout in Pendleton County, W.Va., on Oct. 2, 2012. (Photo by Steve Droter/Chesapeake Bay Program)

I. Introduction

Brook trout symbolize healthy waters because they rely on clean, cold stream habitat and are sensitive to rising stream temperatures, thereby serving as an aquatic version of a "canary in a coal mine". Brook trout are also highly prized by recreational anglers and have been designated as the state fish in New York, Pennsylvania, Virginia and West Virginia. They are an essential component of the headwater stream ecosystem, an important part of the watershed's natural heritage and a valuable recreational resource. Land trusts in West Virginia, New York and Virginia have found that the possibility of restoring Brook trout to local streams can act as a motivator for private landowners to take conservation actions, whether it is installing a fence that will exclude livestock from a waterway or putting their land under a conservation easement. The decline of brook trout serves as a warning about the health of local waterways and the lands draining to them. More than a century of declining brook trout populations has led to lost economic revenue and recreational fishing opportunities in the Bay's headwaters.

II. Goal, Outcome and Baseline

This management strategy identifies approaches for achieving the following goal and outcome:

Vital Habitats Goal

Restore, enhance and protect a network of land and water habitats to support fish and wildlife, and to afford other public benefits, including water quality, recreational uses and scenic value across the watershed.

Brook Trout Outcome

Restore and sustain naturally reproducing brook trout populations in Chesapeake Bay headwater streams, with an eight percent increase in occupied habitat by 2025.

Priority Brook Trout Conservation Strategies

- Protect highly functional Wild Brook Trout Only patches from detrimental changes in land use and water use practices.
- Connect habitats that have a high likelihood of sustaining stable wild brook trout populations.
- Improve access to brook trout spawning and seasonally important habitats (e.g., coldwater refugia, wintering areas).
- Improve brook trout habitats that have been impacted by poor land and water use practices.
- Mitigate factors that degrade water quality.
- Enhance or restore natural hydrologic regimes.
- Prevent and mitigate the spread of invasives/exotic species into patches containing wild Brook Trout only.
- Re-introduce wild brook trout into catchments where the species has been extirpated or an increase in genetic fitness of the population is needed.

Baseline and Current Condition

The wild brook trout populations in the Chesapeake Bay watershed have been significantly reduced over the last 150 years and continue to face ongoing and future threats from land use changes, invasive species, loss of genetic integrity, climate change, and a myriad of other anthropogenic impacts (Hudy et al. 2008). In this region of the country, most wild brook trout are relegated to headwater streams in watersheds where human disturbance is minimal and forest cover is still prevalent

A 2005 assessment of brook trout status in 1,443 subwatersheds (sixth-level hydrologic unit) located in the Chesapeake Bay watershed, resulted in 16 percent being classified as Intact (brook trout are present in more than 50 percent of the streams); 38 percent were classified as Reduced (brook trout are present in 50 percent of the streams or fewer); 20 percent were classified as Extirpated (brook trout no longer exist in the streams); and 27 percent were not classified because either the historical presence of brook trout is not known or the species was never known to occur in these subwatersheds (Hudy et al. 2008) (Figure 1).

Additionally, an approach was developed that assists with prioritizing subwatersheds with the greatest potential for successful brook trout protection, enhancement or restoration actions (Hanson et al. 2014) based on how intact they are and how intact neighboring watersheds are. In the Chesapeake Bay watershed, there are 103 Intact subwatersheds and 43 Reduced subwatersheds that are assigned high priority scores (0.79 or more) (Appendix Table I). These should serve as a cross-outcome focus for anti-degradation and maintenance (Healthy Watersheds Management Strategy)

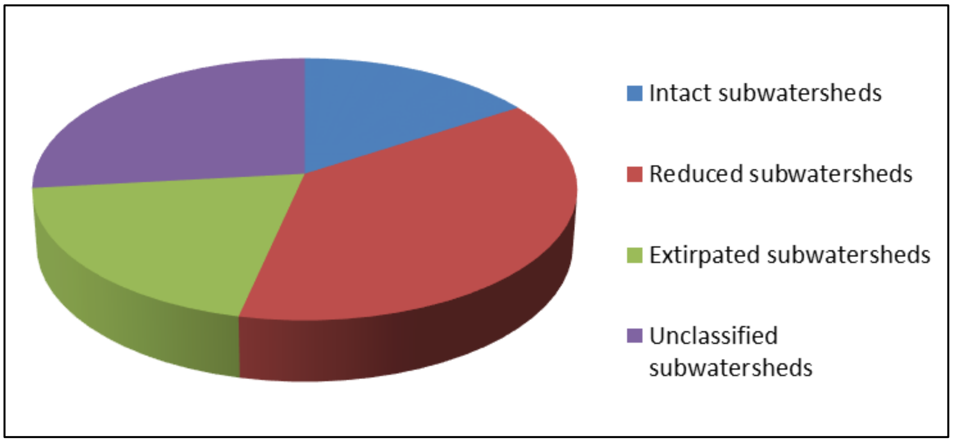


Figure 1. Brook trout classification of subwatersheds located in the Chesapeake Bay watershed.

In 2015, a finer scale assessment of brook trout populations in the Chesapeake Bay watershed was completed by the Eastern Brook Trout Joint Venture in an effort to provide natural resource managers with better tools for detecting population changes and setting conservation priorities (EBTJV 2016). This assessment entailed determining wild brook trout occupancy at the catchment scale, which was then used to identify brook trout patches and classify them as being Wild Brook Trout Only, Wild Brook Trout with Brown Trout present, Wild Brook Trout with Rainbow Trout present or Wild Brook Trout with Rainbow Trout and Brown Trout present (Hudy et al. 2013a).

A “patch” is defined as a group of contiguous catchments occupied by wild brook trout. Patches are not connected physically (i.e., they are separated by a dam, unoccupied warm water habitat, downstream invasive species, etc.) and are generally assumed to be genetically isolated. Patches with only brook trout present are known as allopatric and those with Brown and/or Rainbow Trout present are known as sympatric. A GIS-based algorithm was created to extrapolate the point stream survey data to the catchment scale (Coombs and Nislow 2015). The output of the algorithm is a GIS shapefile containing polygons that are classified based on the allopatric/sympatric codes noted above. This 2015 assessment indicated there are 1,713 Wild brook trout patches in the Chesapeake Bay watershed, with a combined area of 33,250 square kilometers (Table 1). There are 990 Wild Brook Trout Only (allometric) patches and the area of these patches is 13,500 square kilometers (Table 2).

A Boosted Regression Tree (BRT) model has been developed that uses widely available landscape variables to predict the presence of brook trout in catchments located in the Chesapeake Bay watershed (Martin et al. 2012). One of the model outputs is baseline information on the optimal potential condition of a catchment, which is presented as a natural habitat quality index (HQI). The HQI is defined as the maximum probability of brook trout presence under a zero-stress situation; essentially, the highest attainable condition in the catchment. Preliminary results from the Chesapeake Bay Brook Trout pilot model indicate that 54 percent of the catchments within the Chesapeake Bay watershed have an HQI greater than or equal to 0.50 (Appendix Table II).

Baseline

This management strategy is focused on conserving "Wild Brook Trout Only" patches and therefore is using the current area of occupancy (13,500 square kilometers) as the baseline for measuring progress toward achieving the Brook Trout outcome. To be successful, the total amount of "Wild Brook Trout Only" patch area needs to reach 14,622 square kilometers (an 8 percent increase) by 2025 (Table 3).

III. Participating Partners

The following partners have pledged to help implement this strategy:

Team Lead: Vital Habitats Goal Team

Opportunities for Cross-Goal Team Collaboration:

- Fisheries Goal Team
- Water Quality Goal Team
- Healthy Watersheds Goal Team

Participating Signatories:

- Maryland
- New York
- Pennsylvania
- Virginia
- West Virginia

Other Participating Partners:

- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- National Park Service
- USDA Forest Service
- USDA Natural Resource Conservation Service
- Trout Unlimited
- Eastern Brook Trout Joint Venture

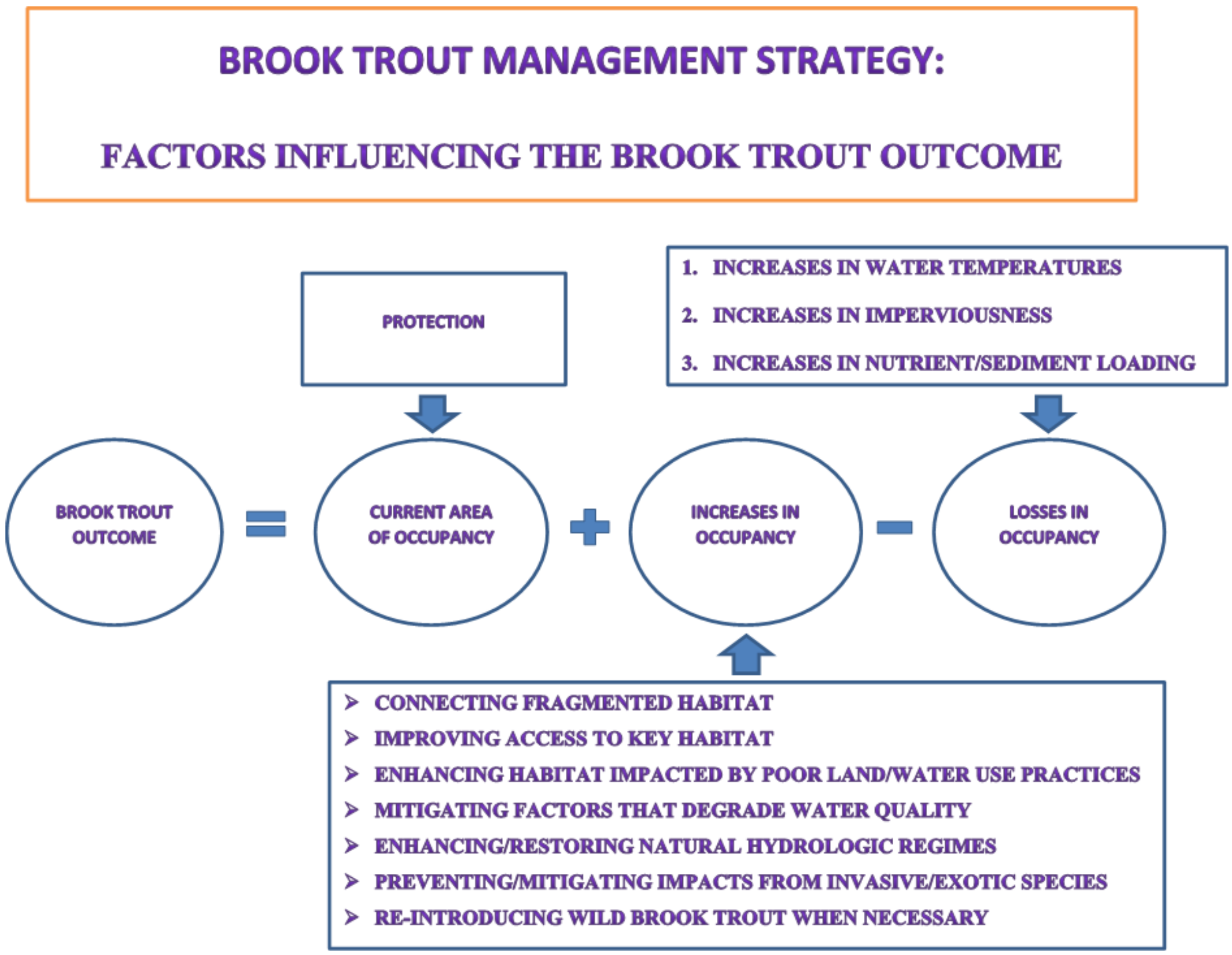
Local Engagement

Communicating the community/watershed wide benefits of brook trout from a recreational and economic perspective is important for engaging the general public and local decision makers. As one of the many species that inhabit headwater streams, protecting brook trout also safeguards additional fish habitat and downstream waters. Adopting certain brook trout habitat protection practices, like streamside and agricultural tree plantings, can provide co-benefits to other priorities like water quality and stream health.

IV. Factors Influencing Success

A variety of activities, both on the land and in the water, will influence the ability to meet the Brook

Trout outcome. Land development, roads, culverts, and unconventional oil and gas drilling all result in three root causes of decreased brook trout occupancy in streams: increased water temperature, increased imperviousness, and increased nutrient/sediment loading. Well pads and access roads associated with shale gas drilling, for example, lead to loss of tree canopy and increased sediment shown to affect stream quality and temperatures.



An output of Martin et al. (2012) BRT modeling approach is a list of the predictor variables used in the model, ordered and scored by their relative importance. The relative importance values are based on the number of times a variable is selected for splitting, weighted by the squared improvement to the model as a result of each split, and averaged over all trees. The relative influence score is scaled so that the sum of the scores for all variables is 100, where higher numbers indicate higher influence. Martin et al. (2012) used ten predictor variables in the Chesapeake Bay Brook Trout BRT Model (Table 4). The most influential predictor, which accounted for almost 43 percent of the total influence in the model, was predicted mean July water temperature. The three predictor variables that were identified as anthropogenic stressors (network mean imperviousness, network percent agriculture, and network percent mined, non-active) accounted for approximately 34 percent of the total influence.

In addition to compiling data on brook trout populations over a 17 state region, Hudy et al. (2005) interviewed regional fisheries managers and asked them to rank perturbations and threats to all subwatersheds that historically supported wild brook trout populations. Perturbations and threats were separated into three categories of severity: (1) eliminates Brook Trout life cycle component; (2) reduces brook trout populations; and (3) potentially impacts Brook Trout populations. Across the entire study region (eastern U.S), the top five perturbations listed as category 1 or 2 severity for streams were high water temperature, agriculture, riparian condition, the presence of one or more non-native fish species, and urbanization. While their relative influence has not been quantified at a watershed or landscape scale, changes in water quality, modification of hydrologic regime, altered stream flows, and fish passage barriers are other factors affecting the viability of wild brook trout populations (EBTJV 2005).

The restoration of potential brook trout habitat and the protection of existing brook trout habitat by partners will be imperative to reaching the outcome goal. As it stands, the Chesapeake Bay Watershed must gain 1,080 square kilometers of allopatric brook trout habitat by 2025, not including any potential, concurrent loss of existing habitat. As stream temperatures increase, areas of potential habitat will decrease. The understanding of and coordinated use of Brook Trout Habitat Decision Support Tools by conservation managers will facilitate more targeted habitat restoration and protection efforts.

The ability of states, NGOs, and federal partners to accurately monitor brook trout occupancy and habitat will affect the Bay Program's ability to measure true outcome progress. Increased and consistent funding coupled with the advancement of enhanced methods (e.g., eDNA) will be essential to successful monitoring efforts. Having a coordinated reporting process to document restoration actions and Brook Trout occupancy is necessary to ensure that outcome progress is measured reliable and consistently through time.

V. Current Efforts

Maryland Department of Natural Resources

The Department of Natural Resources Fisheries Service is responsible for managing commercial and recreational fishing. Fishery Management Plans (FMPs) are developed to outline agreed upon management goals, objectives, strategies, and actions. Freshwater, estuarine and migratory fish stocks are managed for sustainable fisheries, to enhance and restore fish or shellfish species in decline, to promote ethical fishing practices, and to ensure public involvement in the fishery management process. The mission of the Fisheries Service is to: develop a management framework for the conservation and equitable use of fishery resources; manage fisheries in balance with the ecosystem for present and future generations; monitor and assess the status and trends of fisheries resources; and provide high quality, diverse and accessible fishing opportunities. The statewide Brook Trout Fisheries Management Plan was developed in 2006 by the Fisheries Services' Inland Fisheries Division, with a goal to "to restore and maintain healthy Brook Trout populations in Maryland's freshwater streams and provide long-term social and economic benefits from a recreational fishery."

Maryland is unique among the other Bay states in that its geographic area is relatively small and so the existing and potential Brook Trout habitat is much reduced. Because of this Maryland has the ability to census all known, historic, and/or suspected brook trout populations and habitat. Additionally the geography of Maryland is such that the habitat available to brook trout is highly diverse statewide and representative of the range wide northern and southern conditions. Maryland Inland Fisheries is currently conducting a statewide census, from 2014 to 2018, that will sample all historic/current/suspected brook trout populations and additional habitats that modeling or physical proximity suggest may be suitable candidates for brook trout reintroduction. High priority for restoration in Maryland is in the mountainous western portion of the state where mitigating legacy mining impacts has the greatest potential for population re-establishment. As part of the 2014 *Watershed Agreement* and EBTJV led partnership, Maryland Inland Fisheries Division and its sister DNR agency, the Maryland Biological Stream Survey through their sentinel site surveys, will be able to provide substantial annual sampling effort and genetic data collection as part of already planned sampling, helping to meet the monitoring needs of the strategy without having to duplicate/create new sampling efforts.

New York State Department of Environmental Conservation

The mission of the New York State Department of Environmental Conservation is "to conserve, improve and protect New York's natural resources and environment and to prevent, abate and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being." The New York State Department of Environmental Conservation, Division of Fish, Wildlife and Marine Resources, Bureau of Fisheries delivers a diverse program and annually conducts a wide array of activities to conserve and enhance New York State's abundant and diverse populations of freshwater fishes while providing the public with quality recreational angling opportunities.

Pennsylvania Fish and Boat Commission

The mission of the Pennsylvania Fish and Boat Commission (PFBC) is to protect, conserve, and enhance the Commonwealth’s aquatic resources and provide fishing and boating opportunities. Within the PFBC, the Division of Fisheries Management, Bureau of Fisheries, oversees PFBC efforts in the management of Pennsylvania fisheries. A key strategy for the PFBC is “provide high quality resource management and protection to reduce the impacts of current and increasing threats to aquatic resources.”

Virginia Department of Game and Inland Fisheries

The mission of the Virginia Department of Game and Inland Fisheries (VDGIF) is to manage Virginia's wildlife and inland fish to maintain optimum populations of all species to serve the needs of the Commonwealth; provide opportunity for all to enjoy wildlife, inland fish, boating and related outdoor recreation and to work diligently to safeguard the rights of the people to hunt, fish and harvest game as provided for in the Constitution of Virginia; promote safety for persons and property in connection with boating, hunting and fishing; and provide educational outreach programs and materials that foster an awareness of and appreciation for Virginia's fish and wildlife resources, their habitats, and hunting, fishing and boating opportunities.

VDGIF monitors brook trout distribution in all areas of the Virginia portion of the Chesapeake Bay watershed except sub-watersheds within the Shenandoah National Park. The National Park Service monitors those brook trout habitats. VDGIF maintains a Coldwater Stream Database that classifies individual brook trout streams and documents spatial distribution of brook trout. Through VDGIF’s monitoring program and database, changes in brook trout distribution and population health can be documented and measured. Currently, VDGIF has sufficient resources to monitor Brook Trout populations in Virginia. The National Park Service has a monitoring program in place that has the same capabilities. The VDGIF is adding Brook Trout to the list of species of "Greatest Conservation Need" in the Virginia Wildlife Action Plan and is partnering with Trout Unlimited to restore Brook Trout to streams in the Shenandoah River Watershed.

West Virginia Division of Natural Resources

It is the statutory mission of the West Virginia Division of Natural Resources (WV DNR) to provide and administer a long-range comprehensive program for the exploration, conservation, development, protection, enjoyment and use of the natural resources of the State of West Virginia. The WV DNR's Wildlife Resources Section (WRS) is responsible for the management of the state's wildlife resources for the use and enjoyment of its citizens. The primary objective of the section is to maintain and perpetuate fish and wildlife at levels compatible with the available habitat, while providing maximum opportunities for recreation, research and education. The WV State Wildlife Action Plan now includes the Brook Trout on the list of Species of Greatest Conservation Need. Partnerships with West Virginia University, Trout Unlimited and the US Forest Service (Monongahela and George Washington/Jefferson National Forests) have become vital in meeting short- and long-term management objectives.

U.S. Fish and Wildlife Service

The mission of U.S. Fish and Wildlife Service (FWS) is to work with others to conserve, protect, and enhance fish, wildlife and plants and their habitats for the continuing benefit of the American people. The FWS Northeast Region Fisheries Program is designed to support the conservation and management of aquatic species by maintaining, restoring, and recovering populations of species of conservation and management concern to self-sustaining levels; and, conservation and management of aquatic ecosystems by maintaining and restoring the ecological composition, structure and function of natural and modified aquatic ecosystems to ensure the long-term sustainability of populations of species of conservation and management concern.

U.S. Geological Survey

USGS is providing decision-relevant science related to restoring and sustaining naturally reproducing brook trout populations and their habitat. USGS studies are focusing on better understanding several factors that affect brook trout populations including: (1) role of groundwater in sustaining stream temperatures, (2) effects of climate and land change on elevated stream temperature and altered hydrology, (3) competition of invasive species on brook trout populations, and (4) effects of unconventional oil and gas development on brook trout populations and habitat." USGS research provides data that contribute to brook trout management and the refinement of Brook Trout Decision Support Tools.

National Park Service

The fundamental purpose of the National Park Service (NPS) "is to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The NPS covers more than 84 million acres and is comprised of 401 sites. These include 125 historical parks or sites, 78 national monuments, 59 national parks, 25 battlefields or military parks, 18 preserves, 18 recreation areas, 10 seashores, four parkways, four lakeshores and two reserves. Additionally, the

National Park Service maintains active research programs that cover climate change, habitat stressors, and habitat restoration methods, providing data that contribute to Brook Trout management and the refinement of Brook Trout Decision Support Tools.

USDA Forest Service

The mission of the Forest Service is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations. The Forest Service is a multi-faceted agency that protects and manages 154 national forests and grasslands in 44 states and Puerto Rico and is the world's largest forestry research organization.

The Forest Service maintains active research programs that cover climate change, habitat stressors and habitat restoration methods, providing data that contribute to brook trout management and the refinement of Brook Trout Decision Support Tools. Forest Service experts provide technical and financial help to state and local government agencies, businesses, private landowners to help protect and manage non-federal forest and associated range and watershed lands. They develop partnerships with many public and private agencies to augment their work planting trees, improving trails, providing education on conservation and fire prevention, and improve conditions in wildland/urban interfaces and rural areas. Their team also promotes sustainable forest management and biodiversity conservation internationally.

USDA Natural Resource Conservation Service

The mission of the USDA Natural Resource Conservation Service (NRCS) is to improve the health of our Nation's natural resources while sustaining and enhancing the productivity of American agriculture. They achieve this by providing voluntary assistance through strong partnerships with private landowners, managers, and communities to protect, restore, and enhance the lands and waters upon which people and the environment depend. NRCS is "Helping People Help the Land" by ensuring productive lands in harmony with a healthy environment is their priority. The NRSC staffs state offices in the five Chesapeake Bay states (MD, NY, PA, VA and WV).

Trout Unlimited

Trout Unlimited (TU) is a non-profit organization dedicated to the conservation of North America's coldwater fisheries and their watersheds—places where trout and salmon thrive. Within the Chesapeake Bay watershed, TU has over 70 local chapters and five state councils, representing over 16,000 members, and a staff of 15 that work in the watershed's headwaters protecting, reconnecting and restoring brook trout habitat.

At all levels of government, TU advocates for native trout conservation. In addition to this advocacy, TU's role in this strategy will be as an on-the-ground implementer of the priority conservation actions, specifically those related to the reconnection and restoration of Brook Trout habitat including the Home Rivers Initiative program in Virginia.

In the Gunpowder River Basin in Maryland, where 25% of the total Maryland brook trout population are found, TU and partner organizations have distributed an informational brochure to all landowners in the watershed, deployed temperature loggers, surveyed and tagged brook trout in several tributaries, and is working with the North Atlantic Aquatic Community Collaborative to identify culverts and stream crossings for restoration work. TU has also developed the Eastern Brook Trout Conservation Portfolio

Analysis to provide Decision Support Tools for managers and practitioners (Fesenmyer et al. 2017).

Eastern Brook Trout Joint Venture

The Eastern Brook Trout Joint Venture (EBTJV) is a diverse group of partners, including state fish and wildlife agencies, federal resource agencies, Indian tribes, regional and local governments, businesses, conservation organizations, academic institutions, scientific societies, and private citizens working to conserve wild brook trout resources across their native range in the eastern portion of the U.S. The EBTJV facilitates collaboration among the conservation community by completing landscape-level scientific assessments on the status of wild brook trout, along with identifying the major threats they face, and using the results of these assessments to establish key priorities that serve as the framework for the coordination of strategic conservation actions.

VI. Gaps

It is imperative to know which streams are occupied by brook trout, potential threats to high quality brook trout streams, and which areas are best suited for restoration. A better understanding of climate change, population genetics, functional genomics, and spatially explicit linkages between brook trout populations and stressors is needed to inform conservation decisions and Decision Support Tools. Given climate change projections, identifying groundwater influence and coldwater refugia on the landscape will be an important long-term strategy. In those areas with suitable cold water, repopulating with wild Brook Trout may give a good bang for the buck in terms of restoring extirpated catchments and providing climate change resiliency. Incorporating springs and groundwater influences into Decision Support Tool would be beneficial to make sure limited resources are going towards removing barriers that create connectivity to thermal refugia. In general, Decision Support Tool refinement, coordination, and training for practitioners is necessary to meet the outcome goal.

Limited funding for habitat restoration and conservation programs significantly diminishes progress on achieving the outcome. Inadequate funding of monitoring programs and insufficient support for a coordinated, centralized reporting system is a barrier to accurately documenting changes in brook trout occupancy, especially improvements related to restoration activities. It will become more important to use the Decision Support Tools and monitoring information efficiently, including the development of tools and technologies necessary to better understand which best management practices (BMPs) are most effective in conservation and restoring wild Brook Trout populations.

VII. Management Approaches

The partnership will work together to carry out the following actions and strategies to achieve the Brook Trout outcome. These approaches seek to address the factors affecting our ability to meet the goal and the gaps identified above.

Identify and Communicate Priority Focal Areas for Brook Trout Conservation

In order to assist with strategic decision-making on where to focus Brook Trout conservation actions, the Wild Brook Trout Only patches in the Chesapeake Bay watershed have been sorted into three priority levels. Wild Brook Trout Only patches that occur in and around current brook trout strongholds, which are defined as being located in subwatersheds with a priority score ≥0.79, have been assigned priority Level 1 since these subwatersheds offer the best potential for sustaining wild Brook Trout populations and capitalizing on increased habitat connectivity (Hanson et al. 2014). Priority Level 1 Wild Brook Trout Only patches occurs in 146 subwatersheds; 77 of these subwatersheds are located in Pennsylvania, 65 are in Virginia, three are in West Virginia and one is in Maryland (Table 5 and Appendix Table III).

Wild Brook Trout Only patches that occur in subwatersheds having priority scores < 0.79, but have ≥60% of their catchments with an HQI ≥0.50, have been given a Level 2 priority because they possess habitat that exhibits good potential for attaining favorable conditions when stressors are lessened. Priority Level 2 Wild Brook Trout Only patches occur in 238 subwatersheds; 152 of these subwatersheds are in Pennsylvania, 44 are in New York, 22 are in Virginia, 14 are in Maryland, and six are in West Virginia (Table 5 and Appendix Table IV). Streams in these areas may have lost their ability to support Brook Trout due to logging, farming and loss of riparian cover. Restoration techniques exist to mitigate such land use impacts and bring Brook Trout back to these areas of reduced habitat value.

Wild Brook Trout Only patches that occur in subwatersheds having priority scores < 0.79 and have <60% of their catchments with an HQI ≥0.50 have been given a Level 3 priority. Priority Level 3 Wild Brook Trout Only patches occur in 216 subwatersheds; 82 of these subwatersheds are in Pennsylvania, 68 are in New York, 32 are in Virginia, 21 are in West Virginia, and 13 are in Maryland (Table 5 and Appendix Table V). While prioritizing Wild Brook Trout Only patches this way is helpful in guiding strategic decision-making to achieve the outcome goal, additional potential priority focal areas can be identified using other criteria based on site-specific information.

The specific locations of Wild Brook Trout Only patches can be viewed at the Spatial Hydro-Ecological Decision System (SHEDS) website, which features an interactive GIS map capable of displaying data layers (Brook Trout status and habitat patches) and tools (riparian prioritization, drainage area calculator) developed and endorsed by the EBTJV.

The communication of brook trout habitat stressors, conservation needs, and priority conservation areas with local decision makers is critical to outcome progress. The development of information fact-sheets and educational tools by Action Team partners will help relay this information.

Consider Climate Change and Emerging Stressors in Determining Restoration Priorities

Regardless of a Wild Brook Trout Only patch's priority level, added considerations need to be given to those locations where brook trout have a lower vulnerability to the effects of climate change because their populations are less likely to disappear under various climate change scenarios (Trumbo et al. 2014). While the data layer does not cover the entire Chesapeake Bay watershed, the Brook Trout Integrated Spatial Data and Tools website has a GIS data layer (Brook Trout Patch Vulnerability) that identifies Wild Brook Trout patches with low exposure (predicted change in water temperature per unit increase in air temperature) and sensitivity (predicted frequency, magnitude and duration of water temperature averaged over a range of temperatures). Groundwater exchange may also mitigate stream thermal sensitivity to air temperature change (Snyder et al. 2016) and spatial models are needed to predict the role of groundwater for brook trout spawning, feeding and refugia across stream networks.

Stressors such as acid mine drainage and unconventional oil and gas development, and trout population genetics should also be considered when identifying suitable brook trout habitat conservation and restoration areas.

Refine and Apply Decision Support Tools

In addition to the SHEDS website noted above, there are several other Decision Support Tools available that will assist the conservation community in refining their efforts to conserve Chesapeake Bay Brook Trout resources at the local level.

Trout Unlimited Eastern Brook Trout Conservation Portfolio: The Conservation Portfolio uses the 3-R framework (Representation, Resiliency, and Redundancy) to evaluate each brook trout population patch for its resiliency to disturbances, likelihood of demographic persistence, and representation of genetic, life history, and geographic diversity. The Range-wide habitat integrity and future security assessment uses broad-scale GIS information to characterize the general habitat condition and vulnerability of EBT patches. The Chesapeake Bay focal area analysis adds regional data sources to provide additional resolution on habitat condition and threats within Chesapeake Bay watershed.

Chesapeake Bay Fish Passage Prioritization: This web-mapping platform is designed to be a screening-level tool that can be used to help investigate potential fish passage projects in the context of many ecological factors (Martin and Apse 2013). However, results do not incorporate important social, economic or feasibility factors and are not intended to be a replacement for site-specific knowledge nor a prescription for on-the-ground action. This platform includes a Brook Trout-specific scenario, though this scenario is limited to dams on small streams (those draining <100 km^2). Users of this tool can view results in the context of other relevant data including project data and various base maps, query results, download tabular data, search for a dam interactively or by name, annotate a map and print or save a map. (Fish Passage Management Strategy)

Riparian Restoration for Climate Change Resilience Tool: This tool enables users to dynamically locate areas (within the selected region) in the riparian zone that would benefit most from increased shading produced by planting of trees. The tool operates on a 200 meter stream buffer (100 on each side), and requires the user to specify values for maximum percent canopy cover and minimum solar gain percentile. The user can additionally choose to include minimum elevation (meters) and maximum percent impervious surface values in the analysis.

Additional Decision Support Tools can be found on the EB TJV website Resources section. With the advent of multiple Decision Support Tools, it is important that conservation managers know how to use them. The Brook Trout Action team plans to hold workshops and webinars to educate partners on the use of these tools.

Continue and Expand Brook Trout Monitoring Efforts

The ability of states, NGOs, and federal partners to monitor the extent and occupancy of brook trout habitat will affect the Bay Program's ability to measure true outcome progress. Consistent funding coupled with the advancement of enhanced monitoring methods (e.g. eDNA monitoring) will be important to monitoring efforts. The Brook Trout Action Team will help coordinate new information into partner monitoring programs and assist in identifying funding opportunities to sustain such programs. The creation and use of an official occupancy reporting process amongst Action Team partners will help ensure that outcome progress is measured reliably and consistently through time.

VIII. Monitoring Progress

Monitoring the Status of Wild Brook Trout Only Patches

The state agency partners identified in Section V routinely conduct statewide census and monitoring efforts. Those data will be used in conjunction with other partner data to update the progress toward the outcome goal. These efforts are driven by the individual partner needs, programs, and budgets and are not all on the same timeline for data collection, review and reporting. It is anticipated the next update on progress toward the Brook Trout outcome will be in 2020.

In addition, an ad hoc sampling program has been developed to subsample the existing number of Wild Brook Trout Only patches to determine changes in status (Hudy et al. 2013b). This approach designates “sentinel sample” patches that are sampled every year while others are sampled every five years. Sentinel samples are intended to capture year-to-year and fast changes while the once every five year samples will capture long-term trends. Number of patches, number of patches with increasing size/connectivity (i.e., additional downstream/upstream catchments occupied by wild brook trout only), number of patches decreasing in size (loss of occupancy of downstream/upstream catchments), average patch size, and genetic diversity contained within these patches (defined as heterozygosity and allelic diversity) will be used to determine the status of Wild Brook Trout Only patches. This approach was funded for one year but has continued in some areas.

IX. Assessing Progress

To achieve the brook trout outcome, there is a need to increase the amount of wild brook trout only occupied patch area by 1,083 km^2. This equates to expanding occupancy by 108 km^2 per year over a ten year period. The Brook Trout Action Team will adopt the Eastern Brook Trout Joint Venture’s 3-5-year range-wide assessment to measure outcome progress. To assess interim progress, pertinent jurisdictions will annually report the amount of habitat (km^2) occupied by wild brook trout only that was added to (through conservation actions) or removed from (due to loss in

Lessons Learned

Cross-partnership Collaboration

As resources become scarcer, we recommend adding an emphasized cross-GIT collaboration effort to our management approach. Our new Workplan will include collaboration with specific CBP outcomes (e.g., Forest Buffer, Fish Passage, Healthy Watersheds) to address specific environmental stressors identified as influencing factors in the brook trout management strategy and potentially tie their progress to progress made on some of our environmental stressor related actions and to guide conservation and restoration opportunities that would yield many cross-outcome benefits.

Restoration Partnership Expansion

The new work plan will emphasize on expanding our partnership with on-ground restoration groups to keep up with the need for outcome progress.

Partner Organization Decision Support Tool Communications

The new work plan will include specific actions meant to communicate decision support tool use to practitioners including informational workshops, and an emphasis on expanding our communications with federal, state, and local decision-makers on brook trout issues.

occupiable habitat) the baseline figure using a standardized occupancy reporting protocol. These annual gains will be combined with the outputs of the monitoring protocol (i.e., sentinel sampling sites) to determine overall progress. Then, after every five year period, when all monitoring sites have been sampled at least once and assuming adequate continued funding for monitoring/evaluation, a status report will be developed that summarizes the gains and/or losses of area occupied by wild brook trout only over that time period and contains recommendations for making adjustments to maintain progress toward the outcome (i.e. managing adaptively). Such adjustments will likely take the form of interim geographic targets identified by the pilot model and articulated in biennial workplans.

Table 1. The number and area of all wild brook trout patches (allopatric and sympatric) in the Chesapeake Bay watershed.

State	Number of Wild Brook Trout Patches	Wild Brook Trout Patch Area (km²)
Maryland	110	1,017
New York	359	5,684
Pennsylvania	925	18,914
Virginia	240	6,042
West Virginia	79	1,598
Totals	**1,713**	**33,254**

Table 2. The number and area of patches classified as wild brook trout only (allopatric) in the Chesapeake Bay watershed.

State	Number of Patches Classified as Wild Brook Trout Only	Wild Brook Trout Only Patch Area (km²)
Maryland	75	604
New York	201	2,498
Pennsylvania	430	4,754
Virginia	213	4,651
West Virginia	71	1,032
Totals	**925**	**13,495**

Table 3. Additional area needed to increase the amount of wild brook trout only (allopatric) patches by 8% during the next 10 years.

State	2014 Area (km²) of Wild Brook Trout Only Patches	Area (km²) Needed to Achieve an 8% Increase	Projected 2025 Area (km²) of Wild Brook Trout Only Patches
Maryland	604	48	652
New York	2,498	200	2,698
Pennsylvania	4,754	380	5,134
Virginia	4,651	372	5,023
West Virginia	1,032	83	1,115
Totals	13,539	1,083	14,622

Table 4. Relative influence of all predictor variables used in the Chesapeake Bay Brook Trout BRT Model.

Predictor Variable Description	Predictor Variable Code	Relative Influence
Predicted mean July water temperature	mnjuly	42.7
Network mean imperviousness	IMP06C	21.6
Network percent agriculture	Ag_pc	9.7
Catchment slope of flowline	SLOPE_fix	7.5
Catchment mean annual precipitation	Precip	6.6
Nework percent grassland (log transformed)	Log_Grass_pc	2.6
Catchment mean soil pH	SoilpH	2.5
Network percent acidic bedrock geology	Acid_geol_pc	2.5
Network percent mined, non-active (log transformed)	Log_past_minepc	2.3
Network percent wetlands (log transformed)	Log_Wet_pc	2.1

Table 5. The distribution of HUC 12s containing wild brook trout only (allopatric) patches sorted by priority level and state.

State	Number of Priority Level 1 HUC 12s	Number of Priority Level 2 HUC 12s	Number of Priority Level 3 HUC 12s	Totals
Maryland	1	14	13	**28**
New York	0	44	68	**112**
Pennsylvania	77	152	82	**311**
Virginia	65	22	32	**119**
West Virginia	3	6	21	**30**
Totals	**146**	**238**	**216**	**600**

X. Adaptively Managing

The partnership will use the following approaches to ensure adaptive management: The Brook Trout Action Team will meet annually to track progress toward the goal of an 8% increase in brook trout habitat, as well as share progress and discuss any new challenges or opportunities. The Action Team will use this time to review performance assessment information and adjust Management Strategies where appropriate. As new issues are identified, the Action Team will work with conservation partners to develop strategies to overcome barriers to restoration, as well as identify trends, priority areas, and research needs.

XI. Biennial Workplan

Biennial workplans for each management strategy will be revised every two years. It will include the following information:

- Each key action
- Timeline for the action

- Expected outcome
- Partners responsible for each action
- Estimated resources

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