Proceedings from the Symposium: Eastern Brook Trout Management: Can Brook Trout Hold On or Expand into the Future?

From the 148th Annual Meeting of the American Fisheries Society – Communicating the Science of Fisheries Conservation to Diverse Audiences. Atlantic City, New Jersey
August 20, 2018

Sponsor: Eastern Brook Trout Joint Venture & AFS Fish Habitat Section

Symposium Description:
This symposium will share the recent population and habitat patch data for Eastern Brook Trout across the eastern range spanning from Maine to Ohio to Georgia, as well as the latest research regarding brook trout population dynamics, genetics, life history expression, habitat preference, and response to harvest regulation. The symposium will share habitat and population success stories as well as ongoing challenges with non-native species competition, water quality degradation, habitat impacts and climate change. A panel discussion will conclude this full day symposium with state, federal and NGO perspectives on can the brook trout hold on and expand across its native eastern U.S. range into the future.

Organizer: Steve Perry, Coordinator, Eastern Brook Trout Joint Venture
Moderator: Nathaniel Gillespie, USDA Forest Service Fisheries Staff, and President, EBTJV Steering Committee

Panel members: Sheryl Bryan: USDA Forest Service, National Forests of North Carolina
Lisa Barno, New Jersey Department of Environmental Protection, Division of Fish and Wildlife
David Kazyak, US Geological Survey, Leetown Science Center
Matt Kulp, The National Park Service, Great Smoky Mountains National Park

Panel Discussion Summary: For the opening 20 minute panel discussion, after introductions from the panelists and 50+ participants, each of the four panelists were asked to name one theme they would like the symposium participants to think about over the course of the day. The panelists provided the following themes for consideration:

- Obstacles to Brook Trout population restoration
- Genetics – how we can best use this growing body of information
- Resiliency – the ways to provide resiliency to brook trout populations
- Recreational use – increased recreation on our public lands and its growing impacts

During the afternoon discussion, the panelists were asked the following questions for discussion. The questions and answers are provided below:

In your state or area of management, do you see brook trout declining, holding on, or expanding over the next 20 years, and why?

- It is the professional opinion of those panel participants that Eastern brook trout will see some slight declines in certain states, but generally are poised hold on in the future, given that current and continued and future restoration and conservation actions (including aquatic connectivity, acid mine drainage and acid deposition remediation, species translocation, etc.) occur. Continued and future restoration and conservation actions will have to address the threats of increasing water temperatures and changes in precipitation patterns from a changing climate, current and legacy habitat degradation, and stresses and competition from non-native species.

- In the southern Appalachians, Eastern brook trout are in more of a holding on pattern. Populations above 3,000 feet elevation are likely to improve and those below 3,000 feet likely to be increasingly stressed.
- Acid deposition and acid neutralizing capacity (ANC) depletion has been severe in places but is improving, particularly in the mid-Atlantic and Southern Appalachians. Yet many of these watersheds retain very low ANC and will take centuries to recover on their own. In the Northeast, some watersheds have recovered on their own as the Clean Air Act has reduced sulphate deposition.
- Some losses of brook trout are to be expected from climate change in the future - particularly those smaller, fragmented patches that currently have marginal summer water temperatures.
- Additional populations are expected to be found or identified as state population surveys continue. Pennsylvania, Maine, New Hampshire, New York, Maryland and North Carolina have identified Eastern brook trout populations previously unidentified in recent years. These are mostly small first order stream habitats but also include sea-run brook trout populations.
- The panel recognized the high level of knowledge gained over the past 14 years since the inception of the Eastern Brook Trout Joint Venture in terms of available and potential brook trout habitat, brook trout biology and successful techniques to protect, enhance and restore brook trout habitat and brook trout populations. In Maine, MDGIF has been systematically surveying previously unsurveyed remote ponds and have documented 87 ‘new’ pond-dwelling brook trout populations since 2012.
- Outside of water temperature requirements, the Eastern brook trout is in fact a very tough and highly adaptable fish. The fact that New Jersey still harbors a number of wild, self-sustaining populations given the heavy alteration of the landscape over the past 300 years is testament to the ability of the Eastern brook trout to persevere into the future.
- The panel also recognized the large and dedicated group, in part represented by those attending the symposium, who are dedicated to protecting and restoring this beloved fish across its eastern range. This group has the tools to make good decisions and this bodes well for the Eastern brook trout’s future.

Given what we have heard today, how do you recommend that we as members of the EBTJV prioritize our work in terms of both research and management actions?

- The panel recommended continuing to identify restoration opportunities to return Eastern brook trout to historic habitats with high likelihood of success.
- The panel recommended publicize the restoration work that has been accomplished as the public is generally supportive.
- There is a need for states to begin becoming familiar with the techniques and process of removing non-native species from individual stream reaches and reintroducing brook trout. States have good information from the EBTJV patch data and increasingly from genetics analyses.
- Genetics information can be used to help assist states in deciding which populations can serve as source populations for brook trout and which populations may benefit from genetic rescue via supplementation of the population, or need increased habitat to build patch size and genetic variability.
- Genetic information can also be used to assist states with stocking decisions, such as where and how to supplement recreational fisheries, reduce harvest, or where risks associated with hatchery supplementation are too high on wild populations. The EBTJV and its many partners have strategically focused on aquatic connectivity projects, including culverts and to a smaller extent small dams, over the past decade. This works needs to continue but also be complimented with more reintroduction or expansion of brook trout populations after mitigating competing non-native species, and to be informed by potential risks from non-native species (such as largemouth bass, pike and muskellunge in Maine for example) if connectivity is restored.

What are your recommendations about stocking and best practices?

- The USGS Leetown Science Center is developing a national brook trout hatchery database which will help inform genetics information related to future stocking.
- In 2018, New Jersey created a "Brook Trout Conservation Zone." The zone encompasses the northwest section of the state where almost all wild, self-sustaining Eastern brook trout populations occur. The stocking of brook trout is not allowed within the zone and all brook trout caught must be released. Many other states avoid stocking hatchery brook trout on top of wild brook trout populations.
- Maine has created two wild strains (Sourdnadunk – spawned from wild adults, and Kennebago – maintained in the hatchery system) for hatchery reproduction and stocking in some waters with high fishing pressure. North Carolina does not stock hatchery brook trout currently.

Given the rapid expansion of genetics analyses over the past decade, what do you see as the best use of the various genetics methodologies for managers?

- Identify genetically robust populations for use in restoration/translocation
- Use genetic metrics as a monitoring tool (Ar, Ne, etc.)
- Elucidate adaptive potential of various populations
- One of the emerging threats to brook trout that has gained increased attention in research is the loss of genetic fitness over time for the many small, isolated populations of Eastern brook trout. It's generally accepted that low genetic diversity in a given population makes the population less resilient to environmental stresses and more likely to go locally extinct.
- There is a focus on protecting current existing populations, particularly in a state such as New Jersey where the amount of current development may limit the ability to cost-effectively improve habitat and watershed health.

We see that brook trout populations are generally small, less than 2 miles in length, across most of the Eastern range south of Maine and parts of New York, Vermont and New Hampshire. What have we learned about effective population size for long-term persistence?

- Vice a versa, given the low effective sizes of southeastern pops (<20), this raises questions about their ability to persist despite these low effective sizes? We have more to learn about effective population size and long-term persistence of Eastern brook trout.
- Aquatic connectivity to expand patch size is an objective of the EBTJV, and there is growing focus on removing small dams to promote future increases in effective population size as well as to improve water temperatures, reconnect and recreate brook trout habitat and mitigate future climate change impacts.
- Managers in some states must balance reconnecting headwater brook trout populations with larger downstream habitats when trying to increase patch size for Eastern brook trout with possible impacts from competing trout species (brown and rainbow trout). See recent study in PA link

It seems like the EBTJV members have a clear understanding of the water quality and aquatic habitat needs of brook trout. Do we understand the science of how brook trout interact with competing species? What are the panel's best management practices recommendations for dealing with competing species that currently impact brook trout?

- This discussion needs to expand beyond salmonids to include largemouth and smallmouth bass, northern pike and muskellunge in New York and New England. These species have extirpated brook trout from large numbers of lakes, ponds, reservoirs and larger rivers.
- In the south, rainbow trout will extirpate brook trout, except in extreme headwater reaches.

- YY supermales may be a tool to consider for eliminating competing species. They are currently experimenting with this technique in Idaho.

We've heard lots of presentations today on climate change impacts or the threat of impact to brook trout. What are the panel's recommendations for brook trout surviving in a warming climate?

- Preserve all the forested habitat you can.
- Use modeling and monitoring to identify the best potential habitat with the coldest water and prioritize these catchments for brook trout restoration.
- Develop modeling or remote sensing methods to more accurately identify high groundwater input areas/
- Expand effective population size of individual brook trout populations through expansion of patch size or techniques that promote larger fish within a population to adopt greater migratory life histories and encourage gene flow through neighboring populations

Watershed health plays a huge role in providing quality brook trout habitat. What kind of land management recommendations or partnerships could the panel provide beyond riparian protection to reduce stresses such as development, water withdrawals, and large-scale tree mortality associated with climate change?

- Long term riparian buffer easements (>30 years).
- Better agreement on acceptable buffer widths and the level of disturbance or activities that are acceptable within these riparian buffers.
- The use of watershed liming to expand potential habitat in area that are acidified or recently have recovered from acid deposition. Watershed liming is being considered as a way to retain sugar maple stands and to improve the biological productivity of a watershed.
- Large scale watershed coalitions can solicit large federal appropriations for habitat protection and species restoration and engage in innovative funding support for watershed-scale, multi-year projects.

What do you consider the greatest knowledge gap associated with Brook Trout conservation?

- There is more research needed on how to effectively restore Eastern Brook Trout populations to waters where they have vanished or currently survive at low numbers/densities. This research includes why certain brook trout populations remain sympatric (co-existing) with brown and rainbow trout, and why other populations vanish over a certain time period when overlapping with non-native trout species. This research might be complimented and informed by the various research ongoing Out West on how to remove brook trout that outcompete native cutthroat populations, including identification of the habitat attributes that correlate with brook trout success and dominance over native cutthroat populations.

Symposium Abstracts:

1. Estimating Brook Trout Potential versus Occupied Habitat on the Nantahala and Pisgah National Forests, North Carolina

Sheryl Bryan, U.S. Forest Service, Jacob M. Rash, North Carolina Wildlife Resources Commission and Mark Endries, U.S. Fish and Wildlife Service

Abstract Text: This project estimated Brook Trout potential versus occupied habitat in western North Carolina, specifically on the Nantahala and Pisgah National Forests, based on existing distributional data

and several habitat models. While the primary use of this analysis was to evaluate potential effects of forest plan revision on the future of brook trout on the Forests, it has also proven useful in the identification and prioritization of restoration efforts. To accomplish this effort, existing distributional data was gathered, including EBTJV catchments, USGS hydrography, and over two decades of trout distribution data collected by the NCWRC and U.S. Forest Service. To this end, over 10,000 data points were used to estimate miles of habitat occupied by brook, brown, and rainbow Trout. Using the USFWS MaxEnt estimation of potential Brook Trout habitat in western North Carolina, it was also possible to estimate key metrics such as percent occupied habitat and potential range loss (and contributing factors such as the presence of Brown and Rainbow Trout). This project accentuates EBTJV catchment-level data by validating existing assumptions around range occupancy (and loss), and provides a detailed look at this issue at a scale appropriate for land management agencies to achieve success.

Key points:

- There are within 6,250 miles of estimated potential brook trout habitat on the North Carolina National Forests.
- Of the 2,462 miles of occupied by trout, there are 722 miles of brook trout populations existing (522 miles brook trout only/ 200 miles of brook and brown/rainbow trout). Brown and rainbow trout exclusively occupy 1,740 miles of coldwater habitat.
- The biggest manageable threat to brook trout is sedimentation and reduction of spawning gravel.
- Brook trout are highly valued culturally and recreationally in the southern Appalachians.

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2. Identifying Brook Trout Conservation Opportunity Areas Using the EBTJV Patch Layer

Lucas Nathan[1], Amy Welsh[2] and Jason C. Vokoun[1], (1)University of Connecticut, (2)West Virginia University

Abstract Text: Contemporary Brook Trout *Salvelinus fontinalis* populations are often found in patchy networks due to anthropogenic fragmentation. Although separated by unsuitable habitat, headwater streams are often connected via gene flow through mainstem habitat over distances of 5-15 river km. The Eastern Brook Trout Joint Venture (EBTJV), a region wide collaborative group, have delineated habitat patches that likely represent genetic meta-populations based on historical stream survey data and physical barriers. The objectives of this research were to evaluate genetic structuring at the patch level and to develop a decision support tool to identify conservation opportunities based on the EBTJV patch layer. We collected genetic samples from 49 of the EBTJV patches in Connecticut and modeled genetic diversity as a function of patch- and stream-level riverscape variables. Patch area was the best predictor of population-level genetic diversity, indicating management practices should target patch expansion to improve long term population viability. Based on these findings, we developed a user friendly ArcMap toolbox to aid in the identification of conservation opportunity areas across the region. The tool allows resource managers to specify a suite of habitat quality and distance based parameters to target specific areas for protection or restoration actions.

Other Key points:

- Genetic differentiation of brook trout within a brook trout patch does exist, particularly up and downstream of dams.
- Distance within a connected patch does affect gene flow, although more validation is needed.
- Managers should target the expansion of brook trout patches to increase brook trout genetic variability and long-term resilience.

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3. Genetic Characteristics of Wild Brook Trout Populations in North Carolina and Their Implications for Management

David C. Kazyak[1], Jacob M. Rash[2] and Barbara A. Lubinski[1], (1)U.S. Geological Survey, (2)North Carolina Wildlife Resources Commission

Abstract Text: Since 2010, the U.S. Geological Survey Leetown Science Center has been working with the North Carolina Wildlife Resources Commission using contemporary molecular techniques to provide a genetic characterization of the State's Brook Trout populations. As a result, we have genotyped 8,609 Brook Trout representing 433 collections from across North Carolina at 12 microsatellite loci. The majority of these collections appeared to represent single populations, with low to moderate allelic diversity relative to Brook Trout populations endemic to higher latitudes. Effective population sizes varied widely among populations, but were often very small and indicative of populations at risk of losing diversity through genetic drift. Remarkably high levels of genetic differentiation existed among populations which indicates that little, if any, gene flow occurred among most populations. These results suggest that the fundamental unit of management for Brook Trout in North Carolina should be the population. Despite extensive stocking across the state, the majority of wild populations show limited evidence of introgression by hatchery strains of northern origin. Based on our genetic baseline, management and restoration strategies are being developed for wild Brook Trout populations in North Carolina. A case study demonstrating the utility of genetic data for management purposes will be presented.

Other Key points:

- Median patch size for brook trout is North Carolina is very small: 345 hectares or less than 1 mile in length.
- 77% of 400 populations sampled have an effective breeding population of less than 50 fish.
- In general, introgression with hatchery brook trout has been very low.
- Genetic analyses can be used to identify suitable source stocks from brook trout reintroduction, translocation and genetic rescue efforts by states and federal agencies.

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4. Thermal Sensitivity and Resiliency Among Brook Trout in Headwater Stream Along the Laurel Hill

David G. Argent and William G. Kimmel, California University of Pennsylvania

Abstract Text: The effects of climate change on aquatic biota, particularly those inhabiting coldwater ecosystems, is of increasing concern. Headwater streams harboring populations of Eastern Brook Trout (Salvelinus fontinalis) and sensitive macroinvertebrate taxa may be the most severely threatened by rising global temperatures. To evaluate the extent of this threat, it is important to understand how such streams respond to changes in ambient air temperature as measured by thermal sensitivity (r), and to what extent those changes impact their resident ichthyofauna. Since 2011, we have monitored paired air and in-stream temperature data loggers on six headwater streams draining the slopes of Laurel Ridge in southwestern Pennsylvania. Daily maxima and r values were compared seasonally among streams. In addition, fish were sampled from 100-m reaches in each stream to characterize resident populations and to determine the impact that thermal sensitivity may have on early developmental stages. Data suggest that some streams are more thermally stable than others even during periods of increasing air temperature. Among those exhibiting elevated r values, resident fish populations may experience a wide range of temporal fry emergence patterns. Protection of riparian cover and groundwater inputs will be critical in maintaining the thermal resilience of these headwater streams.

Other key points:

- This region has experienced acid deposition, resource extraction, water withdrawals and climate change.
- Brook trout populations have experienced an 85% decline over the study period, suggesting increased temperatures associated with climate change is the driving factor.

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5. Forecasting the Effects of Climate Change on Suitable Thermal Habitat for Trout in Northern Georgia

Jenna Haag[1], Nathan Nibbelink[1] and Cecil Jennings[2], (1)University of Georgia, (2)U.S. Geological Survey

Abstract Text: Georgia is the southern terminus of trout distribution in the US. As trout are a coldwater species, climate change may affect persistence in the state thus impacting recreational opportunities and natural communities. We used stream water temperature data from 76 sites distributed throughout 38 counties in Georgia (where trout are native, naturalized, and/or stocked) and linear regression in a model selection framework to predict stream temperature based on air temperature and watershed geomorphology. Air temperature alone was most often selected as the top model. We then used air temperature estimates from global model outputs based on three emissions scenarios to forecast stream temperature through 2050. All three forecasts showed a reduction of available thermal habitat for trout. Model forecasts predicted a decline in available habitat of 26% to 67% for brook trout and a 31% to 69% for brown and rainbow Trout. Suitable thermal habitat for all three species will be increasingly restricted to higher elevations during summer, where refuge from lethal temperatures is available. Our results will inform a revision of Georgia's trout management plan, and thus can be used by fisheries managers to allocate limited resources to areas where trout are most likely to persist in the future.

Other key points:

- A 2-day 22.2 C^{o} thermal threshold was used to model brook trout occupancy.
- August is the most difficult month for brook trout in terms of daily maximum stream temperature.

Impacts of Historic Barriers on Wild Brook Trout (Salvelinus fontinalis) in Central New Hampshire

Tyson Morrill, Dr. Brigid O'Donnell and Dr. Amy Villamagna, Plymouth State University

Abstract Text: Populations of wild Brook Trout (*Salvelinus fontinalis*) continue to decline across their historic range, making relatively healthy populations and intact habitats within northern New England important for conservation. The Beebe River watershed, located in central New Hampshire, is home to relatively intact populations of wild Brook Trout, despite physical and thermal barriers historically affecting five tributaries to the mainstem river. These historic barriers include culverts and a powerline with decreased or nonexistent riparian cover. We hypothesize that these barriers have led to measurable impacts on trout population demographics and individual movement across this watershed. To assess the influence of these barriers, depletion backpack electrofishing was used to collect two years of data prior to restoration in three tributaries of the Beebe River, including data on population abundance, demographics, and several metrics of movement supplemented by detailed habitat and thermal analysis. This project is a unique opportunity to document and assess the spatial and temporal impacts of road crossings on wild Brook Trout populations prior to watershed-level restoration to better understand the impacts of historic barriers and the outcomes of habitat restoration on Brook Trout populations.

Other key points:

- Impassable culverts have affected brook trout demographics and population.
- The lack of large wood across this region is a common cause of simplified, suboptimal aquatic habitat.
- In July, when water temperatures are in the suitable range, brook trout do not move.

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6. Restoring Brook Trout and Appalachian River Networks in a Changing Climate

J. Todd Petty and Eric Merriam, West Virginia University

Abstract Text: River restoration seeks to recover aquatic ecosystem functions lost from historic impacts. However, restoration actions must also consider the potential complicating effects of climate change. We will present the results from two studies of brook trout restoration in the Appalachian region. First, we will describe a process for identifying watershed restoration priorities within the context of expected impacts from climate change. This process can be used to direct resources towards restoration actions that have the greatest potential for producing benefits to brook trout populations under threat from climate change. Second, we will present results from a long-term assessment of restoration actions in the upper Shavers Fork, WV designed to recover brook trout populations and build resilience to future impacts from climate change. Our results indicate that targeted watershed scale restoration actions can be used to re-establish connectivity among resilient tributary populations and larger, productive main stem rivers that may be vulnerable to future warming. The synthesis of these two studies together is used to propose a path for conserving brook trout and cold-water ecosystems in the face of climate change.

Other key points:

- Restoration inertia, in the case of the perfect project being the enemy of the good, can be an obstacle to stakeholders and agencies taking important steps to restore brook trout.
- Reconnection of cold tributaries to warmer, more productive main stem rivers, results in increased brook trout growth and benefits population resiliency.
- Climate change impacts will be spatially complicated, but the high elevation plateau containing a large stream network like Shavers Fork represents a smart investment for climate change adaptation.

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7. Effects of Winter Stream Habitat Conditions on Larval brook trout (*Salvelinus fontinalis*) Physical Condition at Swim up in Northern Michigan Streams

Eric Miltz-Miller and Jill Leonard, Northern Michigan University

Abstract Text: Several species of stream salmonid fishes dwell in winter stream conditions from spawning through their early larval stages, yet relatively little is known about the effect of winter variability on these fish. Three northern Michigan streams were selected based on winter conditions: No ice (stable unfrozen), dynamic/intermittent ice formation, or constant ice throughout the winter (stable frozen). Streams had two study sites, each with two artificial redds, two incubation boxes, and two natural redds. Wild brook trout (*Salvelinus fontinalis*) were field spawned and the resulting embryos stocked into artificial redds/boxes in the stream from which the parent fish originated. Larvae were collected at swim up and evaluated for stage/morphology. Our results showed that streams with lower average winter temperatures (dynamic and stable frozen) resulted in longer intra-gravel periods and larvae swam up at a less developed stage compared to stable open streams where winter temperatures were higher. These results are important since all the streams in the study are currently managed as a single population, yet

considerable variability in larval characteristics was generated by small-scale winter habitat variability. Further, these results allow us to consider effects on brook trout of predicted climate changes in small streams based on winter conditions.

Other key points:

- Swim-up of larval brook trout is related to water temperature and/or stability of stream reach over winter months.

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8. Contribution of Public Lands to Current and Future Brook Trout Habitat in the Northeastern United States

Keith H. Nislow, USDA Forest Service, Benjamin Letcher, U.S. Geological Survey and Jason A. Coombs, University of Massachusetts Amherst

Abstract Text: Private lands comprise the majority of the northeast US, but lands under public ownership contribute to major conservation goals. This contribution may become even more important under a changing regional climate, but substantial variation in the type and distribution public lands necessitates spatially-explicit analyses linked to robust ecological models. Using a regionally-validated high-resolution occupancy model in combination with jurisdictional map layers, we assessed the role of public lands in providing habitat for native brook trout under current and predicted future warming scenarios in the northeastern US. We found that at the broadest scale (entire region) while comprising only 17% of total land area, public lands currently provide over one-third of the high quality (>90% probability of occupancy) brook trout habitat, with this relative contribution increasing under +2 and +6 degrees C climate warming scenarios. However, both current and predicted future contributions varied considerably across the region (by state and major watershed) as well as between jurisdictions (federal, state, and municipal) and specific agencies. Results indicate both the importance of public lands to current and future conservation goals, and the need to work within a complex landscape of ownership to develop context-appropriate strategies and communication products.

Other key points:

- While 17% of all Eastern brook trout patches are located on public lands, but 34% of high quality Eastern brook trout habitat is located on public lands.
- Outside of Maine, this percentage is much higher.

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9. Population Structure and Hatchery Introgression of Brook Trout in Maine

Bradley Erdman[1], Merry Gallagher[2], Wesley Wright[1] and Michael Kinnison[1], (1)University of Maine, (2)Maine Department of Inland Fisheries and Wildlife

Abstract Text: Lacustrine populations of brook trout (*Salvelinus fontinalis*) are an economically and culturally important sportfishery in Maine. Hatchery supplementation has occurred in many of these wild populations since the 1800's. Early on, hatchery broodstock were derived from geographically distant sources, with a shift toward Maine-derived broodstocks in the 1990's. Management emphasis is now increasingly focused on preserving wild trout populations that represent Maine's genetic heritage. However, the effects of historical stocking on this genetic heritage remain largely unknown. In this study, we assayed non-stocked, historically-stocked, currently-stocked, and hatchery-sourced populations at 13 microsatellite loci to characterize natural patterns of brook trout genetic diversity and potential genetic legacy effects of stocking. We found distinct genetic profiles associated with major drainage basins and a significant isolation by distance pattern, representing a substantive revision of our understanding of brook

trout population structure in the state. We also found evidence that hatchery introgression was modest or absent in most historically, but no-longer, stocked populations. We hypothesize this outcome reflects a combination of genetic resistance and resilience to introgression, mediated by natural selection against hatchery genotypes and by ongoing gene flow within intact drainage networks.

Other key points:

- Maine has 21,136 stream miles occupied by brook trout and 1,503 pond or lake populations of brook trout.
- The "State Heritage Fish Law" adopted in 2005 identifies all ponds and lakes that contain Eastern brook trout and arctic char that have never been stocked or have not been stocked in the past 25 years. This research supports the law's assertion that hatchery introgression is likely minimal if stocking occurred more than 25 years ago.
- Heritage waters identified by this law are not allowed to be fished with live bait to reduce the likelihood of non-native fish introductions of baitfish in order to protect these brook trout and char populations.

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10. Native Brook Trout Reintroduction in West Virginia: Translocation and Propagation Utilizing WVU's Reymann Memorial Farm in Brook Trout Population Reestablishment

Clayton Raines, West Virginia Department of Natural Resources and Brandon Keplinger, West Virginia Division of Natural Resources

Abstract Text: Brook Trout (*Salvelinus fontinalis;* BKT) is West Virginia's only native trout species and a valuable sport fish. Poor agricultural practices, urbanization, introduction of exotic species, and climate change have resulted in substantial declines in Brook Trout populations throughout the Mid-Atlantic region. Thus, reintroduction efforts were evaluated for the potential repatriation of historic BKT streams. Edwards Run WMA (Hampshire County, WV) was selected as a viable reintroduction site due to its habitat availability and quality, water temperature, and its proximity to a suitable donor stream. 50 BKT, of 3 year-classes, were translocated to Edwards Run in Mid-September 2014 prior to spawning. Surveys conducted from 2014-2017 indicated successful reproduction, as well as recruitment of adults, has occurred during subsequent survey years. Overall, both translocation and captive propagation have emerged as viable options for reintroduction of BKT to West Virginia steams. However, concerns remained about the removal of substantial numbers of reproductively fit adults from a donor stream, as well as methodology for selection of donor and repatriation candidates. Further investigations into viability of captive hatchery BKT propagation, habitat selection criteria, and threats to larval recruitment are currently in evaluation and updated information will be provided at the meeting.

Other key points:

- This partnership between WVDNR and WVU included raising fish in an onsite aquaculture facility from a donor wild brook trout population located less than a mile away. 50 YOY fish (4") were stocked in Edwards Run in spring 2018.
- Because local donor streams have very low numbers of adults, WVDNR will be collecting 5 adults each from 4 individual streams within the watershed and will be splicing males and females of the populations, with the hope that splicing will impart genetic diversity and preserve rare alleles while salvaging the cultural significance, adapted traits, and spawning compatibility of the region's disconnected populations.

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11. Recovery of Native Brook Trout Populations Following the Eradication of Nonnative Rainbow Trout in Southern Appalachian Mountains Streams

Matt Kulp[1], Yoichiro Kanno[2] and Stephen Moore[1], (1) National Park Service, (2) Colorado State University

Abstract Text: Nonnative Rainbow Trout have displaced native Brook Trout in many southern Appalachian Mountains streams. We monitored the population recovery of Brook Trout following Rainbow Trout eradication at 10 sites in seven allopatric Rainbow Trout streams located in Great Smoky Mountains National Park. Rainbow Trout were successfully eradicated by electrofishing or Fintrol and Brook Trout were reintroduced at low densities (39–156 fish/km) from streams located within the park. Within 2 years after reintroduction, the density and biomass of adult Brook Trout recovered to levels comparable to the prerestoration density and biomass of Rainbow Trout. Spawning in the first autumn after reintroduction was assumed by the presence of young-of-the-year fish in seven out of nine sites surveyed the following summer. Brook Trout density and biomass 3–5 years after restoration did not significantly differ from those in natural allopatric populations within the park in young-of-the-year (YOY) fish but were significantly lower in adults. Individual body size of adult and YOY fish were density dependent after restoration, indicating that Brook Trout populations had recovered to a point that habitat saturation triggered intraspecific competition. We conclude that Rainbow Trout removal is a viable management technique to restore Brook Trout populations in the park.

Other key points:

- Brook trout restoration can be successful if there is a sufficient barrier, sufficient effort and proper technique.
- Don’t underestimate the need for public awareness and support.
