



Fisheries: Responding to Drought and Water Challenges



A synopsis of presentations from the Jan. 11, 2017, Webinar on
Fisheries: Responding to Drought and Water Challenges



Fisheries—Responding to Drought and Water Challenges

Coldwater Fisheries and Climate Adaptation Case Studies in the Western and Eastern United States

In January 2017, the U.S. Forest Service's **Office of Sustainability and Climate** hosted a webinar that explored the impact of a changing climate—particularly warming temperatures, flooding, and drought events—on coldwater fisheries. Scientists highlighted the impacts of such extremes on various fish species, and shared conservation tools and models. Resource managers, in turn, described how they applied these products on the ground as adaptation case studies to enhance coldwater fish populations in both the western and eastern United States.

This fact sheet provides a synopsis of the various tools, models, and case studies presented during the webinar.

Higher Water Temperatures

Water temperature is an important factor in determining the health, abundance, and persistence of coldwater fishes, including, but not limited to, salmon and trout species. As stream temperatures approach and surpass their thermal tolerances, and oxygen levels decline, these species experience increased physiological stress, slower growth rates, and higher susceptibility to environmental toxins, parasites and pathogens, and predators and competitors (Glick 2005).

Researchers have found that a 3 degree Fahrenheit rise in average August air temperatures could adversely impact 20 percent of salmonids found in the Columbia River Basin and coastal watersheds of Washington and Oregon (Glick 2005), with similar impacts on native salmonids in the eastern US.

Drought Impacts

During drought years with atypically low stream

and river flows, coldwater fish species are affected by a reduction in water quantity and quality, often accompanied by warmer temperatures. If fish are forced to take refuge in decreasing and/or isolated pools of water, they become easier targets for their prey, such as osprey and heron. Furthermore, isolated and stagnant pools of water lack the amount of oxygen required to maintain healthy fish populations.

It can take many years for fish populations to recover from a single drought year, and up to a decade or more if repeated drought persists (Telegram 2016; Matthews and Matthews 2003).

Flooding Impacts

The timing of flooding is an important factor in determining effects on fish populations that have recently spawned or for fry that have recently emerged. For example, winter floods can adversely affect the eggs of brown trout and brook trout; however they can be advantageous to spring spawning species such as rainbow trout (Warren et al. 2009). Conversely, late spring floods can scour the eggs or kill newly fry spring spawners (Seegrist and Gard 1972).

Flooding may benefit streams by increasing sediment transport, creating gravel bars, recruiting large wood to the channel, and promoting riffle and pool formation (Williams et al. 2015).

It is important to note that flooding may have little impact to river systems that are in a natural state and connected to floodplains and riparian habitats, as opposed to those that have been channelized or fragmented by dams, roads, or diversions (Poff 2002).



Effects and Adaptations in the Western United States

Bull trout (*Salvelinus confluentus*)—listed as threatened under the Endangered Species Act—and cutthroat trout (*Oncorhynchus clarkia*) are both coldwater fish species that rarely occur where stream temperatures are warmer than 15 degrees Celsius (60 degrees Fahrenheit). Climate scenarios project increasing temperatures and decreasing summer flows will result in habitat fragmentation and a declines in the suitable habitat available for these trout species (Rieman et al. 2007; Isaak et al. 2015).

As temperatures warm and flows decrease, species with warmer thermal niches gradually encroach upstream as their distributions shift to take advantage of newly suitable habitats. Where a species like rainbow trout (*Oncorhynchus mykiss*) shifts into contact with the closely related cutthroat trout, the two sometimes interbreed and form hybrid zones in portions of stream networks (Young et al. 2016).

Although warmer and drier landscapes suggest long-term declines in iconic coldwater species, each species consists of numerous individual populations, some that occupy habitats that will be resistant to changes. To identify those refuge habitats, Forest Service scientists at the Rocky Mountain Research Station developed accurate predictive models and detailed digital maps that show which stream habitats are most likely to support continued population persistence in the future (Isaak et al. 2015).

While bull trout habitat is predicted to shrink in anticipated climate scenarios, models indicate there are many locations where these coldwater species can persist in abundance (see Figure 1). The same is true for cutthroat trout populations.

Western Adaptation Tools

Strategies and tactics to improve habitat and population resilience of fish species include maintaining and restoring flow; restoring channel

form and function; controlling non-native species; and improving fish passage.

The [Climate Shield Coldwater Refuge Streams for Native Trout](#) website hosts decision-making tools for coldwater streams within the western U.S. for conservation and planning purposes.

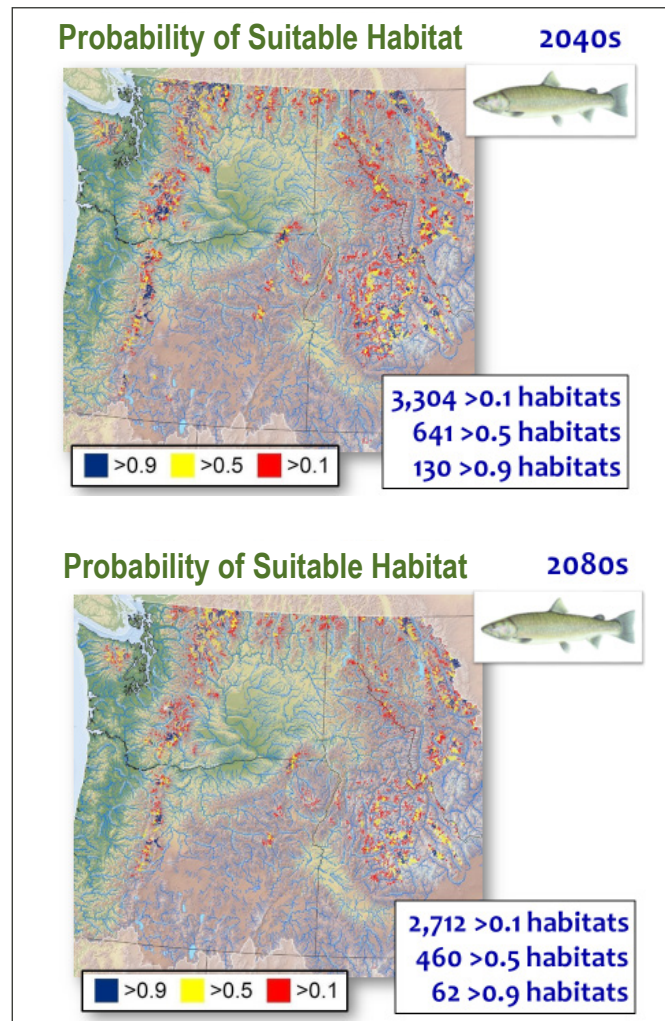


Figure 1 - Climate Shield models display climate refugia for bull trout. (Click on the maps for more information.)

Because of limited resources, restoration strategies need to be strategic and coordinated across agencies to achieve the most effective outcomes. Toward that end, the [NorWeST Stream Temperature Database](#) was developed from data contributed by more than 100 agencies and natural resource groups. It contains data from over 23,000 stream temperature sites across the western U.S., including 101 national forests.



These data help managers and researchers improve monitoring networks in drought-stressed streams, conduct new research, and develop conservation plans.

For example, the **NorWeST** database was used to create high-resolution stream temperature scenarios—instrumental to the Climate Shield project—by highlighting where cold streams would persist under various climate and drought scenarios.

Western Adaptation Examples (Lolo National Forest, MT)

Lolo Watershed Vulnerability to Climate Change

This assessment had three goals:

- » Understand the magnitude of potential climatic change on the Lolo National Forest.
- » Conceptualize the relative vulnerability of forest resources that may be affected.
- » Help managers prioritize actions for improving or maintaining resilience.

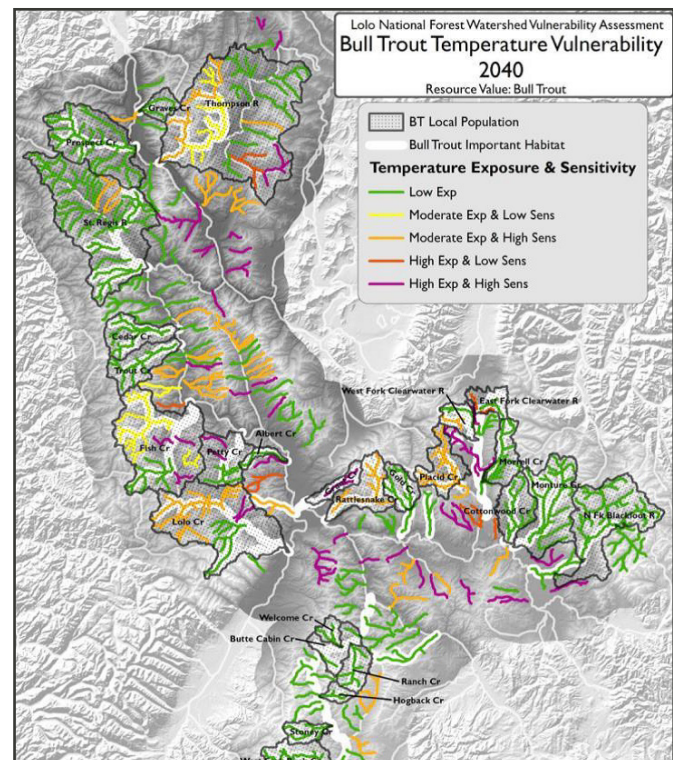
Aquatic species (e.g., bull trout and pearlshell mussel), water supply, and infrastructure (recreation sites, trails, Forest Service roads) were the three primary resource areas in the [Watershed Climate Change Vulnerability Assessment](#).

Researchers analyzed the exposure and sensitivity of bull trout to various factors, including temperature and flow predictions for 2040, then modeled vulnerability indices shown in Figure 2. These maps have helped managers emphasize certain priority restoration areas (yellow) and conservation areas (green).



Lolo National Forest

Figure 2 - The estimated vulnerability of bull trout to projected temperature changes by 2040. (Click on map for Watershed Vulnerability Assessment Supplementary Materials.)



Bull Trout Restoration in the Scapegoat Wilderness

Researchers and managers used maps of current bull trout distribution, along with potential bull trout restoration areas, to locate sustainable but unoccupied areas in wildernesses. The Scapegoat Wilderness in the upper north fork of the Blackfoot River provides a unique opportunity for bull trout restoration based on its suitability indicated by various models and scenarios. There are nearly 80 miles of suitable bull trout habitat projected to persist in 2040 in this area.

Cedar Creek Habitat Restoration and Road Relocation

Trout Unlimited partnered with the U.S. Forest Service to implement a large-scale channel relocation project along the Middle Clark Fork bull trout area. The project relocated roads and re-established the flood plain as a climate change adaptation strategy. This will improve transportation infrastructure resilience and aquatic habitat in response to projected increases in rain-on-snow events, as well as increased scour.



A road relocation (top) and wood jam installation (below) are components of the Cedar Creek climate change adaptation strategy.



Using eDNA Sampling to Detect Bull Trout

The collection of DNA released by species in the water is known as environmental DNA (eDNA)/ sampling. Researchers at the U.S. Forest Service's **National Genomics Center for Wildlife and Fish Conservation** have pioneered this method,

Researchers can rapidly, reliably, and inexpensively screen for the presence of aquatic species through eDNA water sampling. [Learn more here.](#)



including the development of the first reliable eDNA assay for salmonid fish species, and the first one that is able to distinguish bull trout from other species (Carim et al. 2016).

On the Lolo NF, researchers compared occupancy data for bull trout species using two techniques: electrofishing and eDNA. Results showed that eDNA detected the same information as electrofishing.

The benefits eDNA data collection include greater efficiencies in collecting samples, fewer impacts to fish, and greater safety for researchers collecting the data. The eDNA technique is reliable and has numerous applications for conservation planning.

Effects and Adaptations in the Eastern United States

Forest Service scientists have been working with cooperators on a [long-term study](#) to assess the mechanisms underlying stream flow and temperature effects on a wild brook trout (*Salvelinus fontinalis*) population in western Massachusetts.

Trout within a 1,500-meter stream were individually tagged and genotyped four times a year. These data were used along with continuous flow and temperature data to develop statistical models.

Over the 15-year study, and consistent with regional trends, stream temperatures and winter stream flows increased. During the same time period, brook trout abundance declined, while individual body size increased.

Reduced abundance appears to be the result of the direct effect of high summer water temperatures on juvenile survival, which is particularly low during summers that are both warm and dry. In contrast, increases in body size (opposite to predictions based on thermal optima) appear to be an indirect effect of these climate-driven decreases in abundance reducing intraspecific competition and increasing individual growth rates, and not a direct effect of changes in stream flow and temperature.



Approaches for Adapting to Drought and Water Extremes in the Eastern U.S.

Consider Changes in the Frequency and Magnitude of Extreme Events and Incorporate Multiple Dimensions of Risk and Resilience

Given forecasted increases in the frequency and magnitude of floods, drought, and heatwaves, climate scientists are considering the impacts of these extreme events on riparian and aquatic ecosystems in the East.

For example, a recent study mapped and dated landslides pre- and post-Hurricane Irene to estimate sediment and wood yields. Results suggest extreme events such as the hurricane are currently playing a larger role in determining river sediment and wood regimes, and may come to dominate these regimes given forecasted increases in storm magnitude and frequency.



Landslide following Hurricane Irene

Human responses (e.g., dams, diversions, dredging) to the perceived and actual risks of these hydrologic extremes may even override the direct effects of the extreme events themselves.

Recognizing these multiple dimensions, Forest Service researchers working with cooperators at the **Department of Interior Northeast Climate Science Center** are looking broadly at management strategies that increase resilience of ecosystems and human infrastructure from the headwaters to the coasts. One study examines the capacity for gains and losses of green infrastructure—via changes in soil permeability, channel and bed roughness, flow path length, and floodplain storage—to moderate hydrograph extremes and provide mutual benefits to people and natural

habitats. (Green infrastructure is an approach to water management that uses the natural environment—sometimes with engineered systems—to provide clean water, habitat for wildlife, and other ecosystem services)

Provide Data Platforms and Decision Support Tools

As in the West, Forest Service researchers and cooperators in the eastern U.S. have used crowd-sourced data on environmental conditions and wild trout populations to inform and support climate adaptation.

An example is the [Spatial Hydro-Ecological Decision System \(EcoSHEDS\)](#), a web application that links hydro-ecological datasets, models, and decision support systems. It provides tools for gaining insight, improving decision making, and supporting better management of hydro-ecological resources. For example, users can plot histograms and compare scenarios based on various water temperature increases. These tools have helped to identify climate-resilient habitats for native coldwater species.

The EcoSHEDS tool can also help managers conduct prioritization within habitat patches. It can be used in combination with the riparian planting tool model and others based on data.

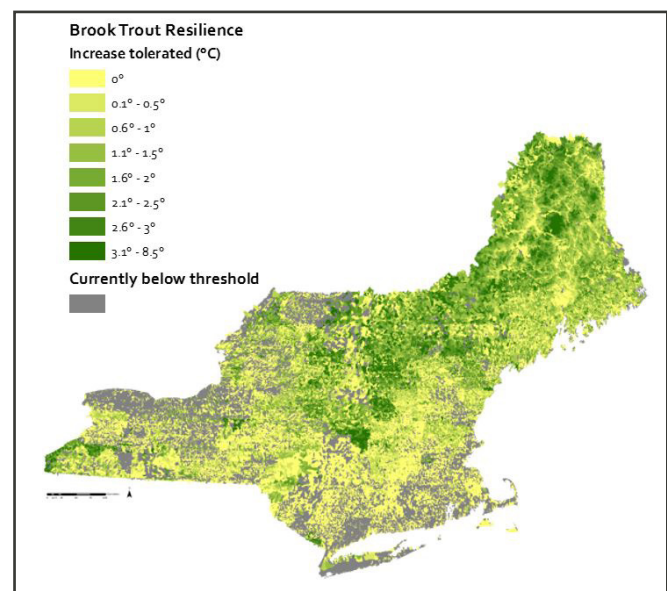


Figure 3 - An EcoSHEDS model displays brook trout tolerance to increases in temperature.

Eastern Adaptation Tools

Eastern Brook Trout Subwatershed Analysis

Conducted by the [Eastern Brook Trout Joint Venture](#), the *Eastern Brook Trout Subwatershed Analysis (2006)* is based on the presence and absence of eastern brook trout, determined by a GIS analysis of threats.

Three broad groups of stressors affecting this species include climate change, land use and habitat impacts, and non-native fish. In 2015, the Joint Venture completed a fine scale catchment level assessment that looked at 5-15 catchments per subwatershed. They classified catchments by presence at stream reach of brook, brown, and rainbow trout. This study will be one of many to improve the ability to monitor species status and the impact of conservation and management actions.

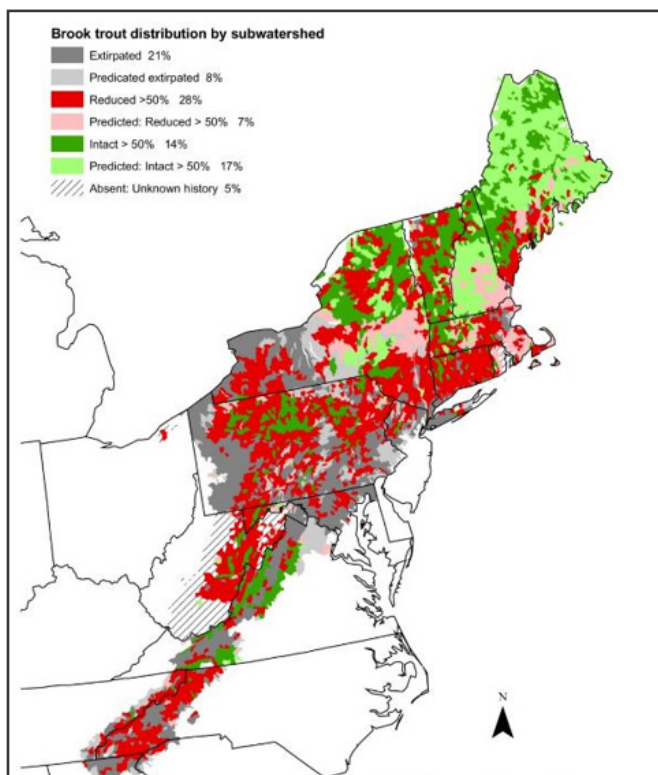


Figure 4 - Example of an analysis of brook trout distribution.

Brook Trout Catchments Analysis

A catchments analysis was conducted to highlight distribution of brook trout from Pennsylvania south. The results show 11 percent of 125,000 catchments are occupied by brook trout. This

finding indicates that this iconic species has been extirpated from 89 percent of their historic catchments. This analysis will help managers make place based investments on suitable habitats for brook trout in a particular catchment.

Eastern Adaptation Examples

Monongahela National Forest

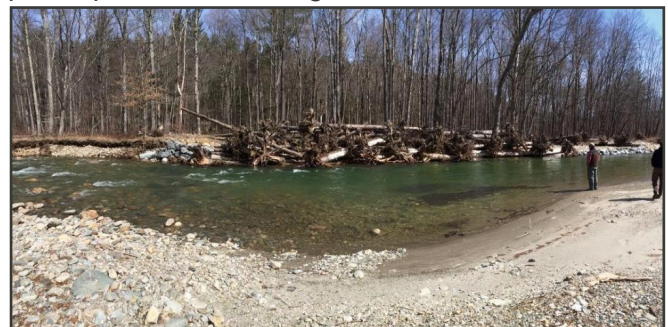
A watershed project on the national forest, in collaboration with *Trout Unlimited*, intends to improve water quality and aquatic habitat. In 2016, three aquatic organism passage culverts were built and up to five are planned for 2017. In early 2017, 22 miles of roads were decommissioned. Eighteen miles of stream habitat have been improved with the addition of large wood to the channel. These adaptation strategies will accommodate for higher peak flows in the future while also allowing trout and other fish species to persist.



A new aquatic organism passage culvert on the Monongahela NF

Green Mountain National Forest

The [West Branch Restoration Project](#) focused on flood recovery and aquatic habitat improvement. Project accomplishments include restoring fish habitat, channel sinuosity, and flood resilience on public/private land along three miles of the river.



Adaptation projects on the West Branch increase resilience and habitat complexity.

Total project costs (including Forest Service and partner contribution) were \$770,000. Partners include *White River Partnership, Vermont Agency of Transportation, Trout Unlimited, Natural Resources Conservation Service, U.S. Fish and Wildlife Service,* and *Wing Farm*. These adaptation strategies will accommodate for higher peak flows in the future while also allowing trout and other fish species to persist.

Conclusion

Drought, warm water temperatures, and increased flooding pose adverse effects to coldwater fisheries populations. However, there are tools and strategies that can help managers make investments at reliable locations to allow many coldwater species to thrive well into the future.



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This fact sheet was written by Karen Dante-Wood, Nat Gillespie, Dan Isaak, Keith Nislow, Dan Shively, Scott Spaulding, Mike Young, Cindi West and Rob Harper. Any errors or omissions remain the responsibility of the authors.

A recording of the ***Fisheries-Responding to Drought and Water Challenges*** webinar is available at <http://www.forestrywebinars.net/webinars/fisheries-responding-to-drought-and-water-challenges>.

