

Climate-Aquatics Blog Post #9: Direct Measurement of Stream and Air Temperatures to Assess Climate Sensitivity of Small, Fragmented Trout Habitats

Hi Everyone,

As a follow up to the last blog post regarding monitoring designs for river networks to make predictive temperature models, this week we have a guest blog from Bradley Trumbo, a recently completed MS student at James Madison University, who worked with Mark Hudy of the USFS Fish and Aquatic Ecology Unit. In their work, a temperature monitoring network was developed wherein the placement of sensors was motivated primarily by biological concerns rather than physical gradients as was discussed in Blog #8 (and no, the two monitoring designs aren't mutually exclusive). Their key insights regarding the relative sensitivities of populations to climate change are predicated on the assumption that short-term stream temperature responses to climate forcing serve as useful surrogates for long-term responses. In the absence of long-term monitoring records, their approach provides an elegant way of generating useful information at specific locations. It also minimizes the need for complex modeling efforts in situations where the goal is simply a basic ranking of relative risk among a series of discrete entities. So, without further adieu, here's Bradly's post...

Why Model Something When you Can Measure It?

Predicting coldwater fisheries distributions under various climate scenarios is of interest to many fisheries managers and researchers. Larger scale models often assume a constant relationship of $+1^{\circ}\text{C}$ air temperature = $+0.8^{\circ}\text{C}$ water temperature, and base stream temperature predictions on elevation and latitude. These models have been useful in highlighting the potential large scale threat to salmonid habitat; however, they may not be accurate at the local habitat scale. Errors (Type I or Type II) associated with models using secondary data (air temperatures from PRISM 2007 and assumed predicted water temperature response relative to predicted air temperature) makes predictions of the persistence of individual trout populations under various climate change scenarios problematic.

Since many of the wild trout habitats throughout the US are becoming highly fragmented, an approach to trout habitat temperature modeling in these instances may be to directly measure temperatures with inexpensive sensors placed in the habitat units of interest. This approach would provide high accuracy and account for the varying sensitivity of streams to air temperature fluctuations driven by local landscape characteristics such as canopy cover, groundwater inputs, aspect, and solar insolation. Pairing air sensors with each stream sensors would also enable assessments of the stability of air/water temperature relationships.

Beginning in 2009, we implemented a population based temperature monitoring network for wild brook trout habitat throughout the state of Virginia. Paired air and water temperatures were directly measured at 100 sites in watersheds containing reproducing populations of brook trout in Virginia during the critical summer period (July 1 to September 30) in both 2009 and 2010. The data were used to developed a classification system using sensitivity (change in the daily maximum water temperature from a 1°C increase in the daily maximum air temperature) and vulnerability metrics (frequency; duration; and magnitude of daily maximum water temperatures $> 21^{\circ}\text{C}$) that classified brook trout populations into four categories: High Sensitivity-High Vulnerability (HSHV); High Sensitivity-Low Vulnerability (HSLV); Low Sensitivity-High Vulnerability (LSHV); and Low Sensitivity- Low Vulnerability (LSLV). Paired air and water

temperature relationships were highly variable among sites and were a useful metric for classifying the sensitivity and exposure of individual brook trout populations to various climate change scenarios. The median ratio of stream sensitivity to air temperature (0.38°C: 1.0C) in this study was lower than the ratio (0.80°C: 1.0C) often used in previous regional models that predicted declines of brook trout in Virginia. Several GIS generated metrics (sample area; % riparian canopy; solar insolation; % groundwater; elevation; % watershed in forest cover) were useful for predicting (accuracy approximately 75%) sensitivity and vulnerability values. Directly measuring paired air and water temperature relationships at the population scale can reduce the error of large scale models and may allow for resources to be more wisely invested for successful conservation and restoration efforts.

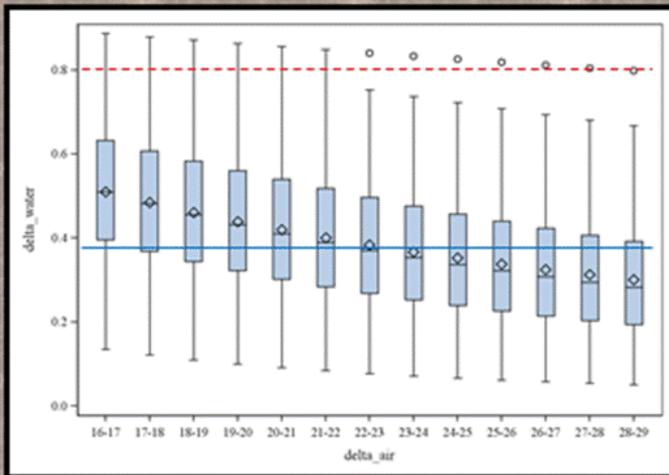
In 2010, our population based temperature monitoring approach was successfully expanded to other sites across the brook trout range in Maryland, West Virginia, North Carolina, South Carolina, Tennessee, and Georgia. At present, 275 sites among 2329 individual brook trout habitat patches are being monitored.

The following citation provides more details regarding results of the Virginia brook trout-climate change project:

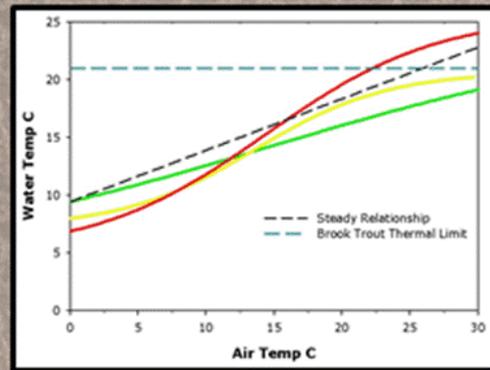
Trumbo, B., M. Hudy, E. P. Smith, D. Kim, B. A. Wiggins, K. H. Nislow, and C. A. Dolloff. 2010. Sensitivity and vulnerability of brook trout populations to climate change. Pages 62-68 *in* R. F. Carline and C. LoSapio, editors. *Wild Trout X: Conserving Wild Trout*. Wild Trout Symposium, West Yellowstone, Montana.

http://www.fs.fed.us/biology/resources/pubs/feu/trumbo-wild-trout_etal_2010.pdf

Stream air/water temp relationships vary among habitats



Box plots of the response of daily maximum water temperatures to a 1°C increase in daily maximum air temperature (by one degree bins from 16 to 28°C) from 77 patches of brook trout habitat during July 1 through September 30, 2009.



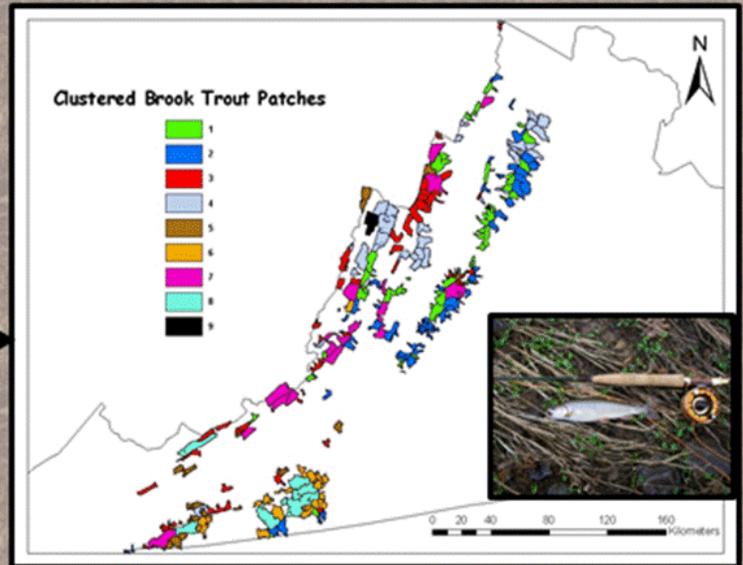
← Previous large scale models have often assume a 0.8°C water temp change to every 1°C air temp change (red line). Air/water temp direct measurement provided 0.38°C median water temp change (blue line)

Localized Habitat Modeling

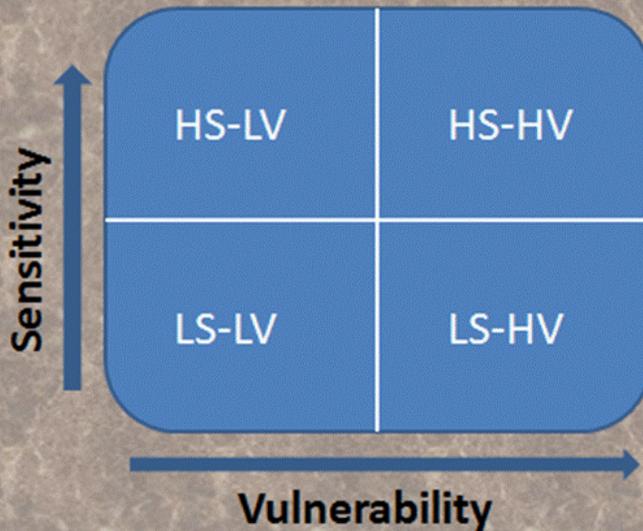


Example regional scale model would assume all trout habitat in Virginia has an equal air/water temp relationship

Local habitat scale models fragmented habitats individually



Virginia Habitat Classification



Classification system useful for prioritizing habitat conservation efforts and our model can predict LSLV habitats with 74% accuracy.

High Sensitivity-High Vulnerability (HSHV); High Sensitivity-Low Vulnerability (HSLV); Low Sensitivity-High Vulnerability (LSHV); Low Sensitivity-Low Vulnerability (LSLV).

LSLV habitats are likely to have a more stable stream temperature with air temperature fluctuations and may be the best candidates for conservation efforts

Virginia Habitat Classification

