

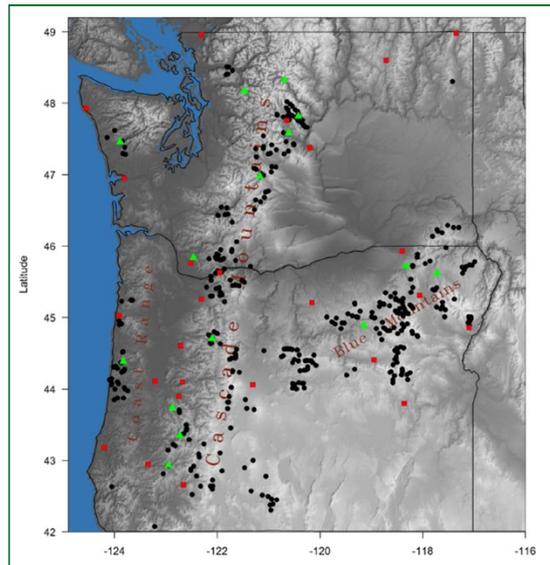
## DIFFERENTIAL SENSITIVITY OF STREAM TEMPERATURES TO CLIMATE VARIABILITY

### BACKGROUND

Estimating the thermal response of streams to a warming climate is important for prioritizing fish conservation efforts. While many estimates of air temperature responses to climate change exist, the sensitivity of streams to warming temperatures is less well understood. Previous research has focused on establishing a correlation between sub-annual scale temperature variations in air and stream temperatures driven by annual cycles in solar angle; however, this is an indirect and imprecise proxy to explain changes in stream energy balance driven by climate change.

### RESEARCH

RMRS researchers analyzed summer stream temperature records from forested streams in the Pacific Northwest for interannual correlations to air temperature and standardized annual streamflow departures. Differential sensitivity of streams to climate forcing (i.e., the hypothesis that some streams warm more than others) was then incorporated into NorWeST stream temperature models by scaling future stream temperature increases relative to the average historical stream temperatures.



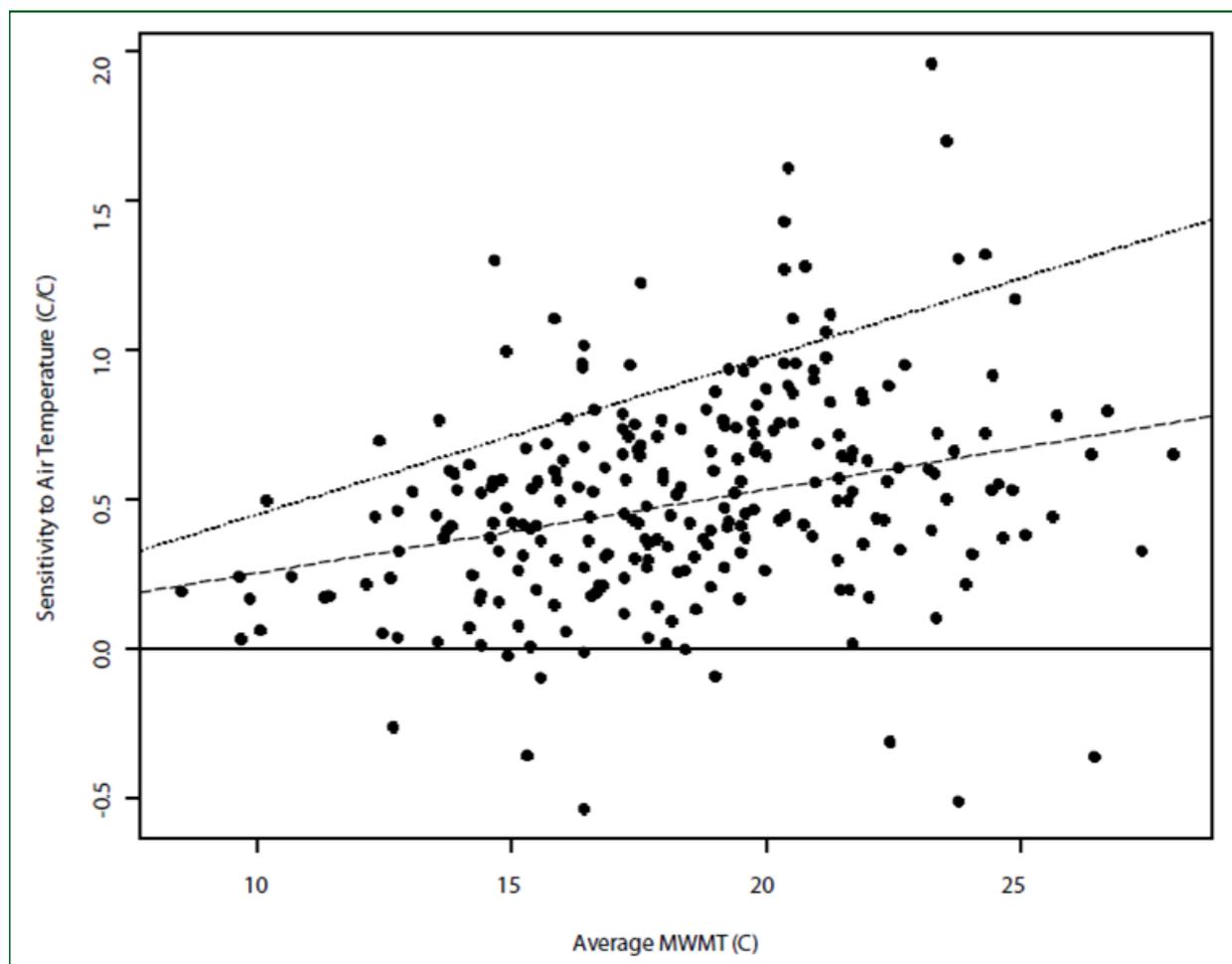
Map of stream temperature (black), air temperature (red), and streamflow (green) stations distributed across National Forests in Oregon and Washington.

### KEY FINDINGS

- Climate change is warming aquatic ecosystems and some of the most sensitive cold-adapted species are already experiencing thermal habitat losses and fragmentation.
- In general, colder streams are less sensitive to fluctuations in air temperature than warmer streams.
- Warm streams had greater variance in sensitivity than cold streams.
- Interannual scale sensitivity estimates may vary from subannual scales estimates.
- Incorporating differential sensitivities into [NorWeST](#) stream temperature models created future scenarios in which the coldest streams warmed 40-60% less than warmer streams.



# DIFFERENTIAL SENSITIVITY OF STREAM TEMPERATURES TO CLIMATE VARIABILITY



Sensitivity of stream temperatures to air temperature anomalies plotted against the station maximum weekly maximum temperature (MWMT). The dashed line represents the median regression with a slope of  $0.028^{\circ}\text{C}/^{\circ}\text{C}^2$ , and the dotted line represents the 90th percentile regression, with a slope of  $0.053^{\circ}\text{C}/^{\circ}\text{C}^2$ .

## MANAGEMENT IMPLICATIONS

A significant pattern emerged where cold streams were consistently less sensitive to variations in air temperature (see above), while warmer streams show greater variability in sensitivity. These findings suggest that approximations of sensitivity for a stream could be obtained from direct measurements of summer stream temperature. A pattern where cold streams are less sensitive to direct temperature increases could have important implications for aquatic species conservation strategies, especially for cold water-dependent species such as bull trout (*Salvelinus confluentus*). While complex uncertainties still remain regarding secondary climate change effects, such as riparian disturbances (e.g., fire or debris flows), earlier snowmelt and decreased summer flows, or decreased groundwater recharge, understanding the threats to the persistence of sensitive cold-water species will help to prioritize limited management resources for conserving and protecting native stream biota.

### CITATION

- Luce, C.H., B.P. Staab, M.G. Kramer, S.J. Wenger, D.J. Isaak, and C. McConnell. 2014. Sensitivity of summer stream temperatures to climate variability in the Pacific Northwest. *Water Resources Research* 50: 1-16.

### MORE INFORMATION

This article can be accessed online at: [www.onlinelibrary.wiley.com/doi/10.1002/2013WR014329/abstract](http://www.onlinelibrary.wiley.com/doi/10.1002/2013WR014329/abstract). For additional information please contact **Charlie Luce**, USFS Research Hydrologist, [cluce@fs.fed.us](mailto:cluce@fs.fed.us) OR **Dan Isaak**, USFS Research Fishery Biologist, [disaak@fs.fed.us](mailto:disaak@fs.fed.us).

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