

STREAM ISOTHERM SHIFTS FROM CLIMATE CHANGE

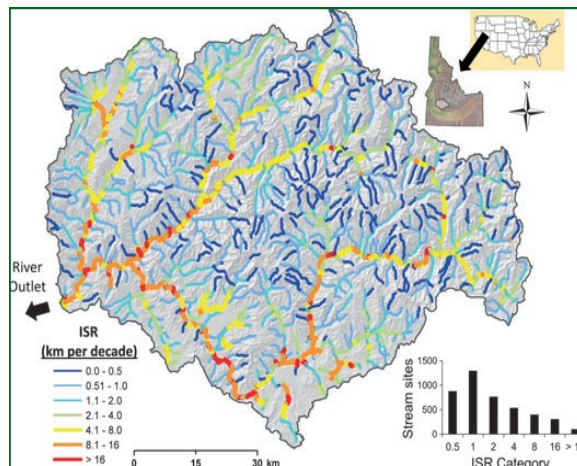
BACKGROUND

Stream ecosystems are especially vulnerable to climate warming because most aquatic organisms are ectothermic and live in dendritic networks that are easily fragmented. Many bioclimatic models predict significant range contractions in stream biotas, but subsequent biological assessments have rarely been done to determine the accuracy of these predictions. Assessments are difficult because model predictions are either untestable or so imprecise that definitive answers may not be obtained within timespans relevant for effective conservation.

RESEARCH

Research Activity: RMRS researchers developed equations for calculating isotherm shift rates (ISRs) in streams that can be used to represent historic or future warming scenarios and be calibrated to individual streams using local measurements of stream temperature and slope. They have provided a set of reference equations and formulas for application to most streams. Variability analysis suggests that short-term variation associated with inter-annual stream temperature changes will mask long-term isotherm shifts for several decades in most locations, so extended biological monitoring efforts are required to document anticipated distribution shifts. Resampling of historical sites could yield estimates of biological responses in the short term and should be prioritized to validate bioclimatic models and develop a better understanding about the effects of temperature increases on stream biotas.

Management Implications: The ISR framework is a useful tool for making better predictions at scales relevant to conservation efforts and can help focus research and monitoring efforts to resolve uncertainties associated with climate change. Implementing the ISR framework on a stream or river requires only easily obtained measurements of temperature and slope and yields several valuable applications. Important commercial, recreational, and subsistence fisheries may be especially vulnerable to thermal disruptions this century because stream isotherms shift more rapidly in flatter streams (which typically include the largest rivers within a region or river network).



Climate velocity map for the Boise River network in central Idaho. Isotherm shift rates (ISR) were calculated assuming a long-term warming rate of $0.2^{\circ}\text{C}/\text{decade}$ and stream lapse rate of $0.4^{\circ}\text{C}/100\text{ m}$. The histogram summarizes the number of stream segments within each ISR category.

KEY FINDINGS

- The velocity of climate change is the rate at which isotherms shift across the landscape.
- Calculations indicate that isotherms shift upstream at $0.13\text{--}1.3\text{ km}/\text{decade}$ in steep streams ($2\text{--}10\%$ slope) and $1.3\text{--}25\text{ km}/\text{decade}$ in flat streams ($0.1\text{--}1\%$ slope).
- The equations predict isotherms shifted $1.5\text{--}43\text{ km}$ in many streams during the 20th century as air temperatures increased by 0.6°C and would shift another $5\text{--}143\text{ km}$ in the first half of the 21st century if projections of a 2°C air temperature increase occur.
- Species distributions are already shifting to cooler areas (higher elevations and poleward) in response to climate change.

MORE INFORMATION

- www.fs.usda.gov/treesearch/pubs/42640

The Climate-Aquatics Blog (www.fs.usda.gov/rm/boise/AWAE/projects/stream_temp/stream_temperature_climate_aquatics_blog.html) provides links to resources on topics relating to aquatic ecosystems and climate change. For more information, please contact **Dan Isaak**, USFS Research Fishery Biologist, disaak@fs.fed.us or (208)373-4385.