Climate-Aquatics Blog #24: NoRRTN: An Inexpensive Regional River Temperature Monitoring Network

How $50,000 = 1,000 years of river temperature measurements (& informs us about 20,000 years)

Hi Everyone,
Time to put my money where my mouth is after that last blog post regarding the need for more long-term, full year temperature monitoring of unregulated rivers and streams. So this week I want to introduce NoRRTN to demonstrate just how easy & inexpensive it is to set up a temperature monitoring network with modern sensor technology these days. NoRRTN stands for Northern Rockies River Temperature Network & is a project we started a few years ago that involved instrumenting most of the large rivers across the northern Rockies with full year temperature sensors (graphics 1 and 2). Not that there isn't some temperature data from these rivers already, but it often consists of only a few summers measured sporadically here and there or monitoring occurs in association with dams, reservoirs, and urban environments that alter stream thermal regimes to some degree and therefore don't constitute the best climate sentinel sites (see blog #23). A lack of temperature data from larger rivers is a significant problem since these systems often constitute important recreational fisheries and migratory corridors for salmon and other species that move long distances. Moreover, when it comes to climate impacts this century, these rivers are often already the warmest within a region, and are where the rubber hits the road in terms of having high profile resources at risk and strong public scrutiny. We need to be preparing for that scrutiny by getting good thermal inventory data now as a step towards developing the capacity to accurately model river thermal regimes associated with climate change scenarios so that it's possible to see ahead of the next bend in the river and manage accordingly.

The first step in that process is simply getting more and better temperature data from rivers and streams. We've developed our preferred technique for monitoring full year temperatures that uses underwater epoxy to glue sensors to large boulders or bridge pilings (graphics 3, 4, and 5; blog #3; YouTube video demonstration @ http://www.youtube.com/watch?v=vaYaycwfmXs&feature=youtu.be), but it ultimately doesn't matter how it gets done, as long as it gets done. The next step is choosing where it gets done, and identifying the data gap on larger rivers across the Northern Rockies was done simply by studying the locations of existing temperature monitoring sites using a GoogleMap tool we developed last year (blog #4). This tool provides a unified spatial index to most of the sites we're aware of in the northwest U.S. where full year temperature monitoring is occurring & is intended to provide a means of coordinating monitoring efforts among the dozens of resource agencies that are doing so. All the NoRRTN sites have been added to the GoogleMap tool, & if you go to the website (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml), you'll notice they're just the tip of the iceberg because there are now almost 3,000 sites with full year monitoring efforts underway. In some cases, these sites are part of centralized monitoring programs like USFS PIBO/AREMP, USGS NWIS, or BOR HydroMet, but in many cases, they are from individual biologists & hydrologists on national forests or with fish and game agencies doing it on their own and committed to monitoring streams in their backyard. Most of the sites on the GoogleMap were set up in just the last few years, so monitoring efforts are rapidly expanding (still a ways to go though with hundreds of thousands of stream kilometers out there). So far, we've been developing and beta-testing the GoogleMap tool with a primary focus on streams in the northwest U.S. but are slowly expanding its geographic scope (& are happy to do so) as people share with us their monitoring site coordinates from other parts of the country. We still have some revising of the sites shown currently on the GoogleMap to make it as accurate as possible before this next field season, but will have a comprehensive set of site revisions up by May/June.

Regarding the logistics & costs associated with NoRRTN. Basically, two technicians drove around and did the installations over the span of a few months in the summer of 2010 and the fall of 2011. We tried to get 2-3 replicates in most of the region's rivers that didn't already have temperature monitoring underway. When the road trips were done, we'd established 250 new sites on 80 rivers across Idaho, Montana, and Wyoming. Those 250 sensors cost $30,000 ($120/unit), then throw in some salary, per diem, & vehicle costs on top of that, and you get to $50,000. We'll no doubt lose some of those sensors to floods and vandalism in subsequent years, but data recorded at the remaining sites will tell us a lot about thermal regimes in the region's rivers and how these regimes are influenced by climate.

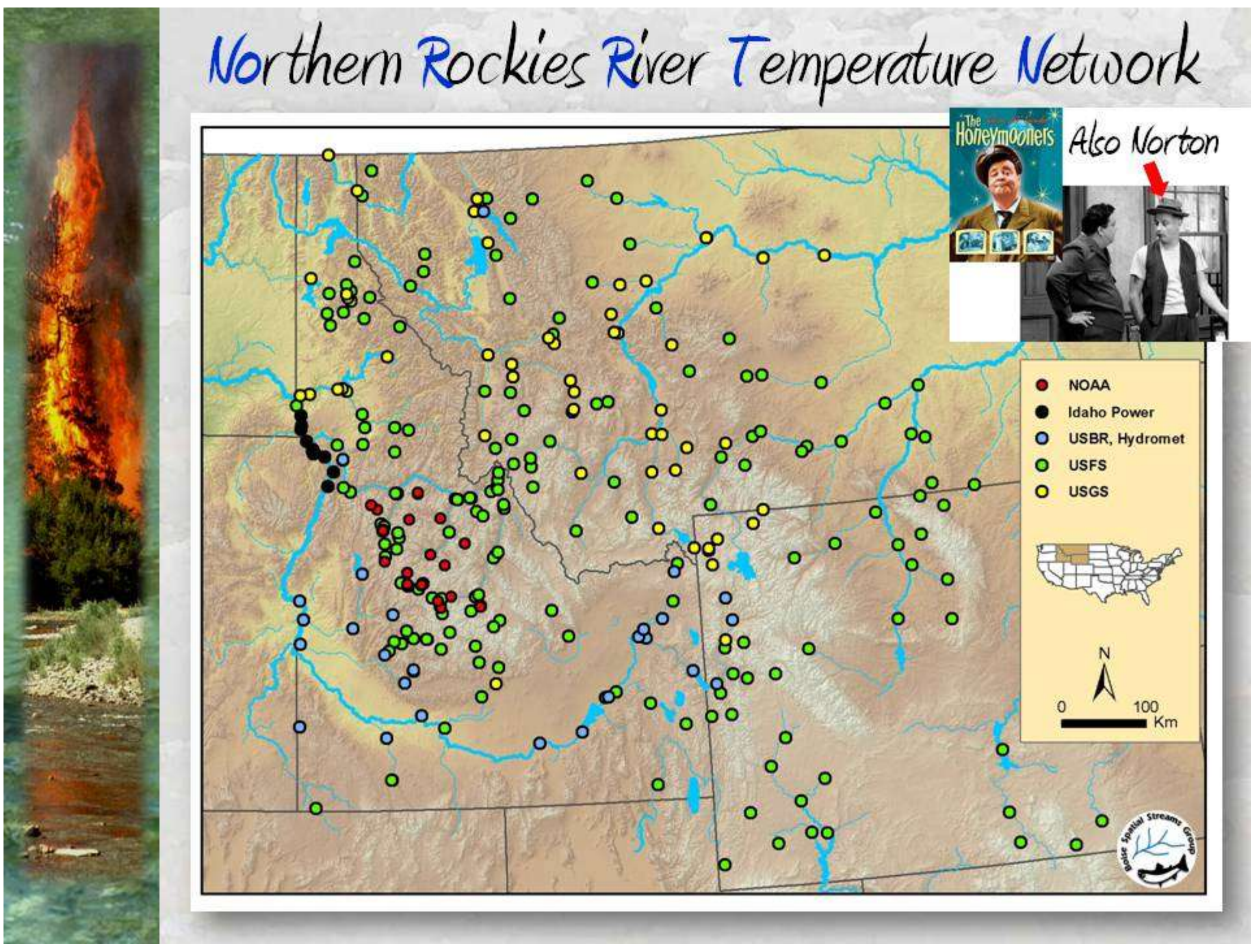
Validation work for the underwater epoxy protocol based on a large scale field test initiated in 2010 suggests first year retention rates are 85% in channels with slopes < 3% that are typical of large rivers (graphic 6; Horan 2012.pdf document attached to this email). Moreover, once a sensor installation weathers that first year's snowmelt flood, subsequent retention rates should be even higher. Each sensor has a service life of 5 years (battery life and memory capacity), so assuming 200 of our sensors stay where we put them that gets us to 1,000 years of direct temperature measurements. Those data can be leveraged using modeling techniques like those described in previous blogs to develop link functions with air temperature and stream discharge records from nearby climate stations to reconstruct historic thermal regimes (#7, #14, #23) or make projections about the future (#23). Since 50 year historical air temperature and discharge monitoring records are common in many places, it's often easy to go back that far with historical river temperature reconstructions, and since many climate models project similar warming trajectories for the first half of this century, it's not too hard to project that far into the future. Using previously published techniques, therefore, with those 5 years of empirical temperature measurements could conceivably provide inference about 100 years of thermal conditions at a river site. 200 sensors x 100 years gets us to 20,000 years, so not too bad for that initial investment of $50k.

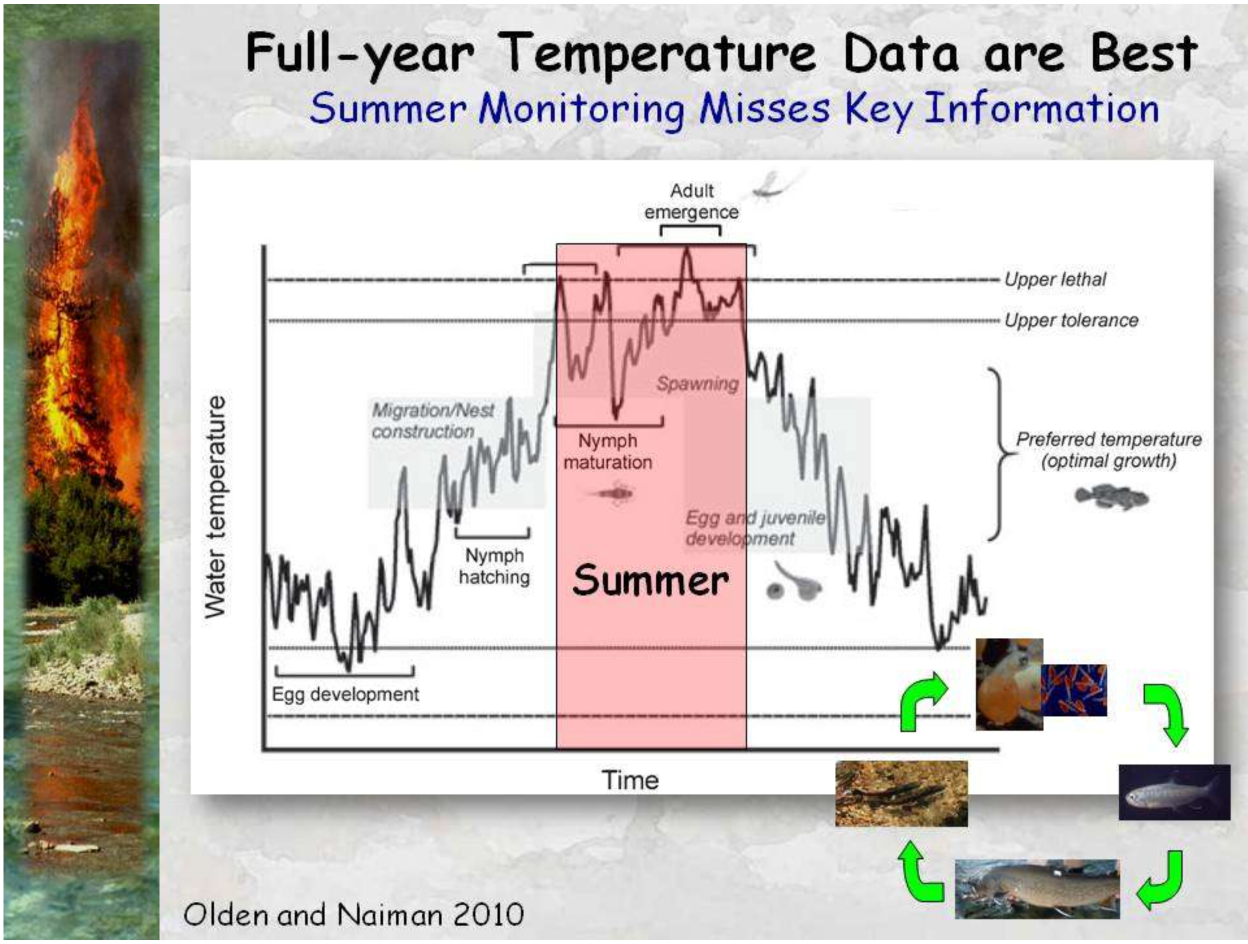
Models will be important to use with monitoring data because they are the only means we have of looking around that next river bend in time to navigate the right line in the present. However, models are also imperfect representations of the real world & so in some places at least, it's going to be important to commit to monitoring indefinitely for the foreseeable future. For example, most of the best evidence we have regarding how stream discharge regimes are changing in response to climate forcing comes from 50 rather than 5 years of monitoring (blogs #17, #18, #21). Moreover, monitoring & watching the same place the same way for a long time helps catch the unexpected events that may be especially illuminating with regards to revealing important mechanisms and may also develop a deeper sense of appreciation in the watcher.

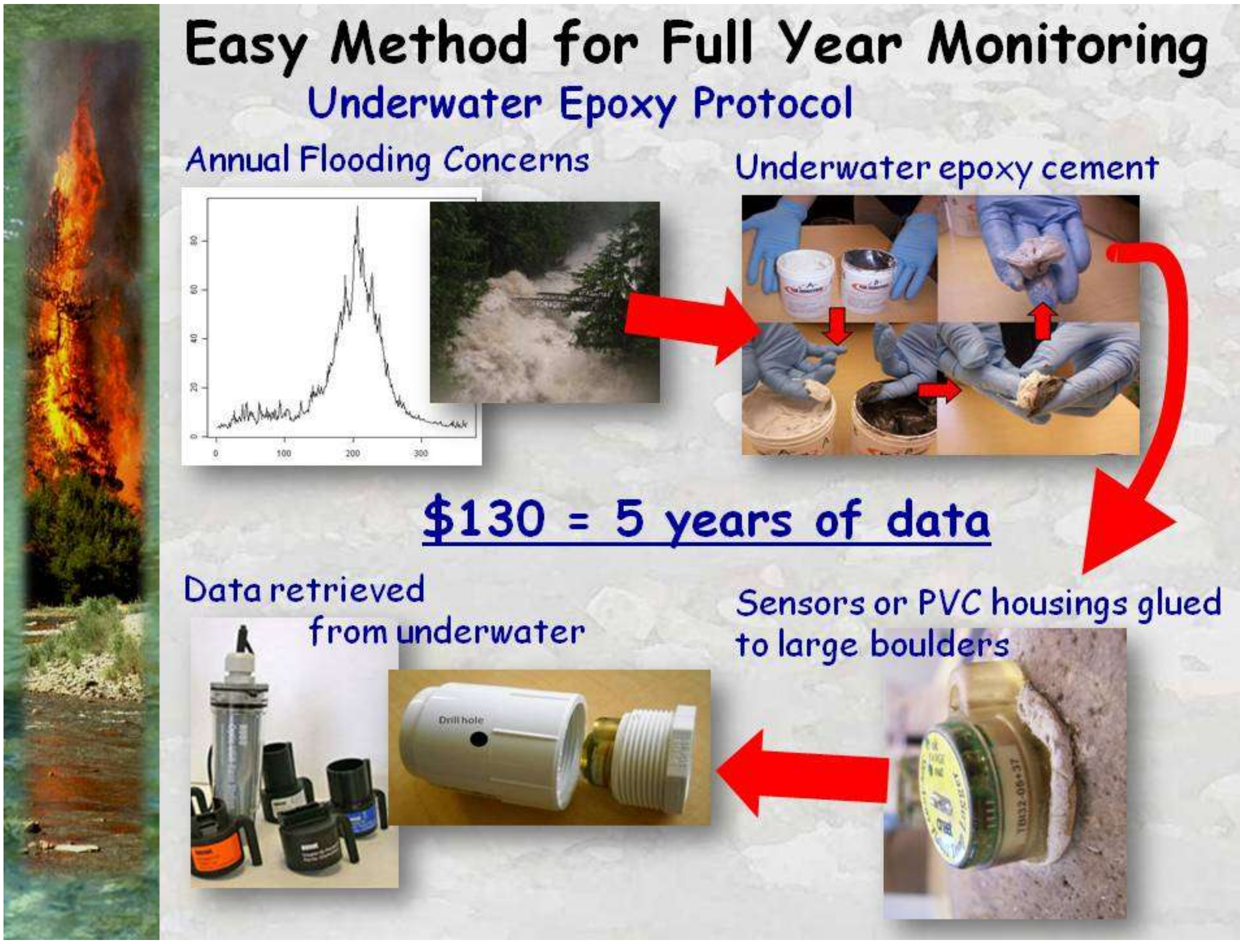
For me, traveling around the region to install temperature sensors in rivers has instilled a sense of awe in these ancient and dynamic systems and the beautiful landscapes they are parts of (graphics 7 – 24). Today's rivers have been here doing their thing for 10,000's – 100,000's of years and will be doing their thing for that long into the future, but at present are changing more rapidly than they ever have. My hope is that we'll be able to maintain the NoRRTN network over the next few decades of my career to better document some of these changes, and that similar temperature monitoring efforts might be initiated in rivers and streams everywhere. The better we can describe how things are changing, the easier it will be to discern underlying processes and to manage more effectively through this transitional century. None of us will be here to know exactly what rivers and streams are like a century from now when the climate change story can be told more precisely in retrospect, but our data can help future stewards of aquatic resources understand where we started and the path that was travelled.

Until next time, best regards,

Dan




Full-year Temperature Data are Best
Summer Monitoring Misses Key Information
Adult emergence
Upper lethal
Upper tolerance
Spawning
Migration/Nest construction
Nymph maturation
Preferred temperature (optimal growth)
Water temperature
Egg and juvenile development
Nymph hatching
Summer
Egg development
Time
Olden and Naiman 2010



Easy Method for Full Year Monitoring
Underwater Epoxy Protocol
Annual Flooding Concerns
Underwater epoxy cement
$130 = 5 years of data
Data retrieved
from underwater
Drill hole
Sensors or PVC housings glued
to large boulders


Big Boulders & Small Sensors
Are Our Friends…
UTBI-001
onset
TidbiT v2 Temp Logger
…while a bridge piling or two will also do.

Relevant Publications

Field test and validation work …

An Evaluation of Underwater Epoxies to Permanently Install Temperature Sensors in Mountain Streams

Daniel J. Isaak* and Dona L. Horan
U.S. Forest Service, Rocky Mountain Research Station, Boise Aquatic Sciences Laboratory, 322 East Front Street, Suite 401, Boise, Idaho 83702, USA

North Amer. J. Fish. Manage. 31:134-137

"How-to" protocol…

Air, Water, and Aquatic Environments
RMRS Science Program

A Simple Method Using Underwater Epoxy to Permanently Install Temperature Sensors in Mountain Streams

(Version 3.12; updated 2/02/2012)

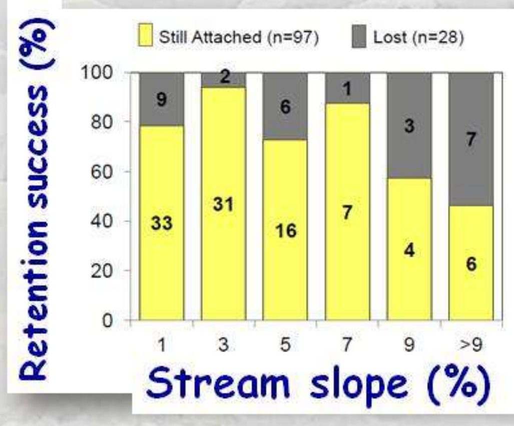
Dan Isaak (disaak@fs.fed.us), Dona Horan (dhoran@fs.fed.us), and Sherry Wollrab (sherrywollrab@fs.fed.us)

Available for Download at…

http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml

Google "Stream Temperature Forest Service"

Epoxy Sensor Retention Rates



Sensors installed in 2010;
<u>then checked one year later</u>

78% (97/125) retained across all stream slopes

85% (64/75) retained in stream slopes ≤3%

"How-to" installation video…

http://www.youtube.com/watch?v=vaYaycwfmXs&feature=youtu.be

Lower Snake River, Idaho

Upper Snake River, Idaho

Big Hole River, Montana

Boulder River, Montana

Green River, Wyoming

Encampment River, Wyoming


Saint Maries River, Idaho
Selway River, Idaho

Stillwater River, Montana

Little Bighorn River, Montana

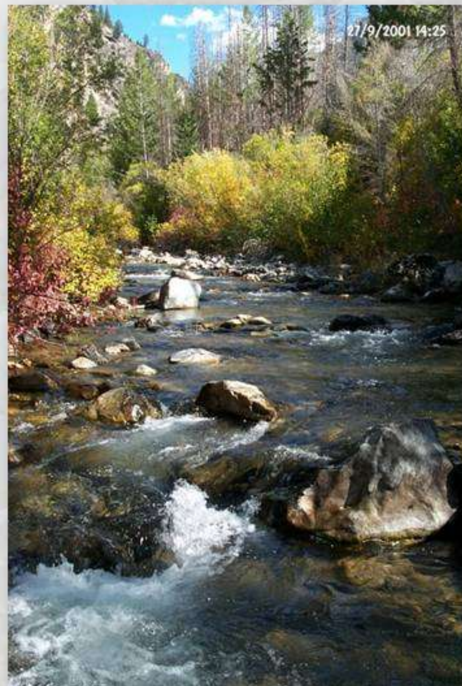
Tongue River, Wyoming

Hoback River, Wyoming

Big Wood River, Idaho

Big Lost River, Idaho

St. Joe River, Idaho

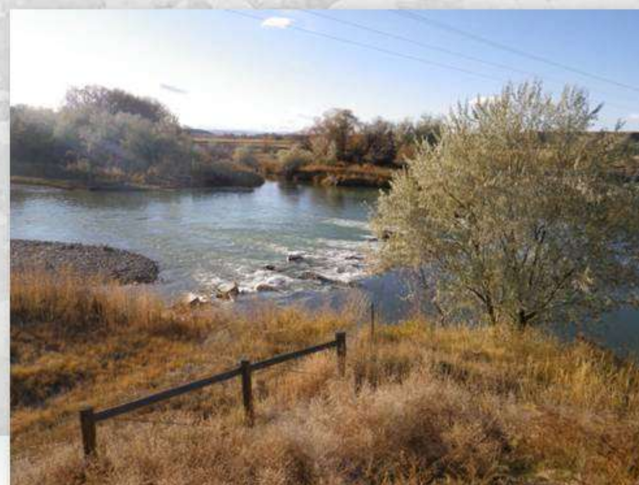


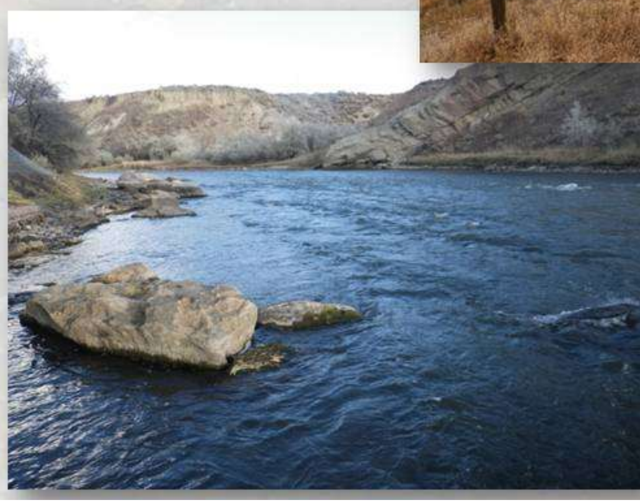
Loon Creek, Idaho

Thompson River, Montana

Yaak River, Montana

No Wood River, Wyoming





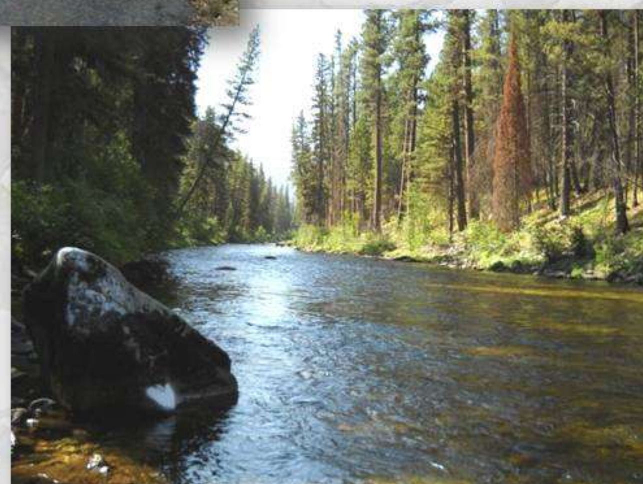
Shoshone River, Wyoming

Middle Fork Boise River, Idaho

Middle Fork Salmon River, Idaho


Rock Creek, Montana
Yellowstone River, Montana

Bear Valley Creek, Idaho



Johnson Creek, Idaho

North Platte River, Wyoming

Wind River, Wyoming

South Fork Salmon River, Idaho

Salmon River, Idaho


Ruby River, Montana
East Fork Bitterroot River, Montana

Tensleep River, Wyoming

Blackfoot River, Idaho

Welcome to the Climate-Aquatics Blog. For those new to the blog, previous posts with embedded graphics can be seen by clicking on the hyperlinks at the bottom or by navigating to the blog archive webpage on our Forest Service site at: (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temp/stream_temperature_climate_aquatics_blog.html). To discuss these topics with other interested parties, a Google discussion group has also been established and instructions for joining the group are also on the webpage. The intent of the Climate-Aquatics Blog and associated discussion group is to provide a means for the 3,824 (& growing) field biologists, hydrologists, anglers, students, managers, and researchers currently on this mailing list across North America, Europe, and Asia to more broadly and rapidly discuss topical issues associated with aquatic ecosystems and climate change.

Messages periodically posted to the blog will highlight new peer-reviewed research and science tools that may be useful in addressing this global phenomenon. Admittedly, many of the ideas for postings have their roots in studies I and my colleagues have been a part of in the Rocky Mountain region, but attempts will be made to present topics & tools in ways that highlight their broader, global relevance. Moreover, I acknowledge that the studies, tools, and techniques highlighted in future missives are by no means the only, or perhaps even the best, science products in existence on particular topics, so the hope is that this discussion group engages others doing, or interested in, similar work and that healthy debates & information exchanges will occur to facilitate the rapid dissemination of knowledge among those most concerned about climate change and its effects on aquatic ecosystems.

If you know of others interested in climate change and aquatic ecosystems, please forward this message and their names can be added to the mailing list for notification regarding additional science products on this topic. If you do not want to be contacted regarding future such notifications, please reply to that effect and you will be removed from this mailing list.

Previous Posts

Climate-Aquatics Management Module
Climate-Aquatics Cool Stuff Module