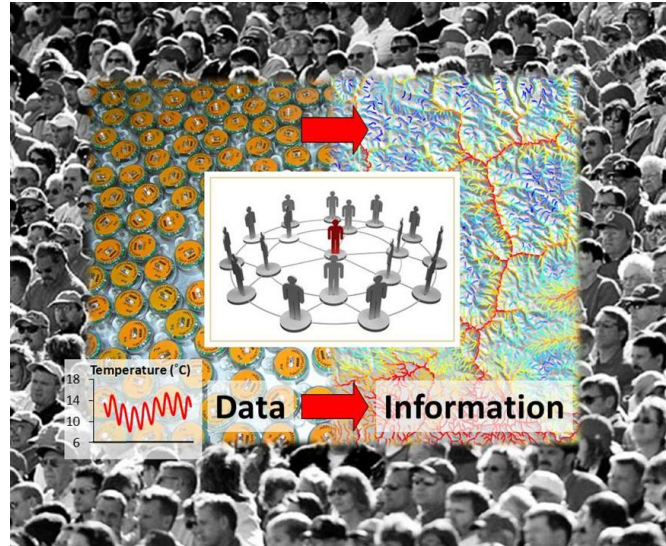


Climate-Aquatics Blog #40: Crowd-sourcing a BIG DATA regional stream temperature model for high-resolution climate vulnerability assessments



Everyone has some skin in the game...

Hi Everyone,

So last time we described the potential that BIG DATA holds, this time we'll demonstrate its power. Recall that ridiculously large NorWeST stream temperature database compiled from data collected by hundreds of biologists and hydrologists from dozens of agencies over the last two decades across the Northwest U.S. ([blog #25](#))? That same database that contains some 45,000,000 hourly temperature recordings at more than 15,000 unique stream sites and would require some \$10,000,000 to replicate if we were to collect it from scratch. Yes that one (graphic 1).

Well, a small tribe of us temperature aficionados have been working diligently on NorWeST the last few years to surmount the technical challenges associated with organizing that much data, feeding it through the spatial statistical stream network models to extract unbiased parameter estimates (blog #'s [27](#), [28](#), and [29](#)), and using those estimates and the model's enhanced predictive abilities to generate accurate stream temperature climate scenario maps. And I'm happy to say that the day has finally come wherein most of those challenges are now behind us and we're in the process of developing and distributing a regionally consistent set of stream temperature scenarios. Similar to earlier pilot work that involved application of the spatial models to smaller temperature databases ([blog #7](#)), the model predictions are very accurate ($r^2 \sim 0.90$; RMSE $\sim 1.0^\circ\text{C}$) and provide the fundamental underpinnings for "smart maps" based on hundreds or thousands of observations (graphic 2; [blog #26](#)). Different from the earlier pilot work, however, these smart maps can now be generated at scales large enough to be relevant for conservation planning, and the maps are easily accessible and usable as geospatial data (i.e., ArcGIS shapefiles) distributed through a NorWeST website (graphic 3). We still have a lot of work to do over the next year to complete the stream temperature scenarios across the region (graphic 4), but at project completion, an accurate, consistent datum will exist to facilitate

applies-to-apples comparisons and strategic climate vulnerability assessments across a 5 state region & more than 300,000 stream kilometers.

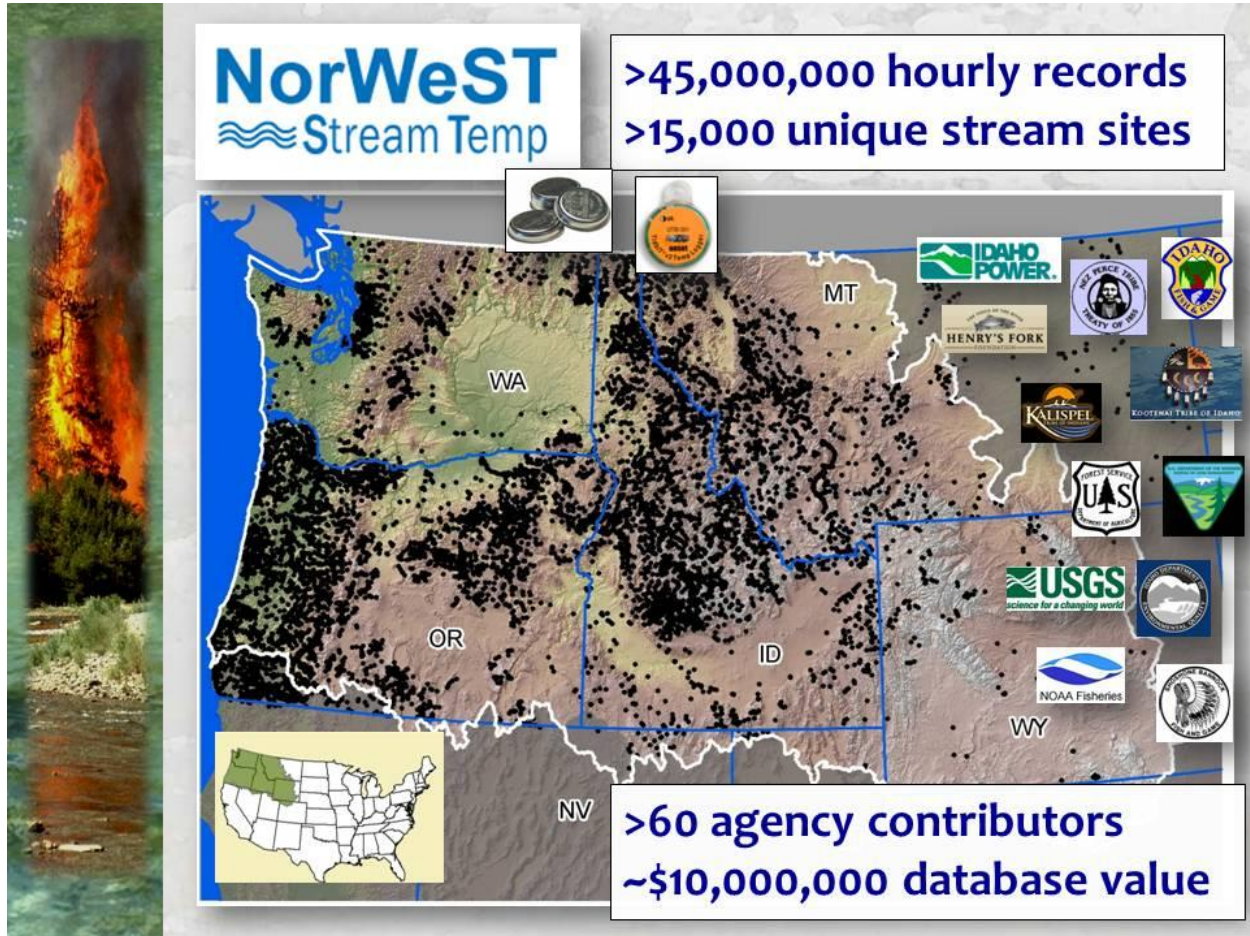
By filling a significant need, the NorWeST project outputs are also serving as a catalyst for a variety of related research and monitoring projects that are being developed in parallel, and which will ultimately compose an integrated system that sums to something larger than the individual pieces (graphic 6; I like to think of it as a “stream intranet” but that’s the subject of a future blog post). As illustration of the potential synergies, one project is co-registering a massive fish survey database compiled earlier by Wenger & colleagues ([blog #33](#)) with NorWeST historical temperature scenarios to develop regionally consistent thermal niche definitions (graphic 7). With stream temperature criteria based on these niches, it is then trivial to accurately map the distribution of thermally suitable habitats for historic conditions and to play “what-if” games with future scenarios (graphic 8). Moreover, subtraction of the historic thermal habitat map from a future map immediately highlights habitats that are most vulnerable to loss as the climate warms & thermal thresholds are exceeded for a species (graphic 9). It becomes similarly straightforward to identify key historical fish survey sites for resurveys that could describe the rate at which fish distributions are shifting as we discussed last time ([blog #39](#)). And we could also map where thermal constraints on upstream invasions would be ameliorated with future warming, or predict where and how long thermally isolated headwater populations may persist (graphic 10).

So a scientifically sound, accurate and consistent means of mapping stream temperature scenarios, therefore, could go a long way toward providing a basis for strategic prioritization of efforts to conserve and restore habitats, populations, and aquatic biodiversity threatened by climate change this century (graphic 11). There will be many places and populations that, despite our best intentions & significant investments, we simply won’t be able to maintain in desired historical states. There will be other places and populations where what we do will make a big difference in effecting the outcome. We want to spend as much of our time and limited resources in the latter areas rather than the former.

But even with better information to inform conservation decisions, the choices we face in the next few decades will often be difficult and at times painful. So perhaps the most significant thing about NorWeST—beyond the useful data summaries and model outputs, analytical advances it has spurred, and sexy geospatial maps—is that it’s a crowd-sourced approach to doing science that could significantly enhance natural resource stewardship (graphic 12). Crowd-sourcing lets us leverage massive amounts of useful information from existing datasets at relatively low cost, which is always useful, but especially so during times of shrinking budgets. And because NorWeST is built from the collective efforts of hundreds of people that have worked for more than 60 natural resource agencies across the region during the past 20 years, literally everyone has some skin in the game here & is engaged in the process. And it’s going to be regional & local communities of managers, researchers, decision makers, anglers, and the like that will ultimately have to come together in future years as the decisions are made about where, and what, work is done to conserve the species and fisheries that we care about.

Until next time, best regards,
Dan

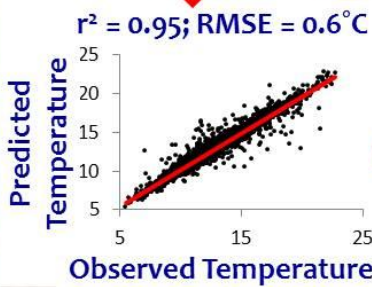
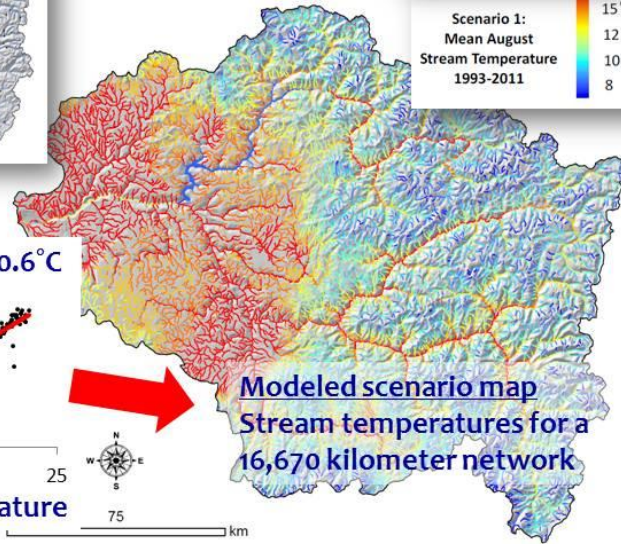
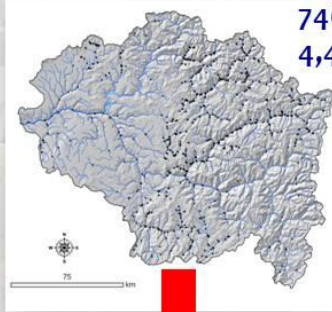
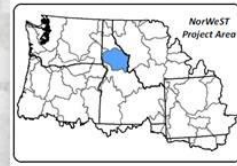
For more details regarding NorWeST, visit the project website (<http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html>) or see this recent article in the Great Northern Landscape Conservation Cooperative newsletter (<http://greatnorthernlcc.org/features/streamtemp-database>).



NorWeST Example - Clearwater River Basin

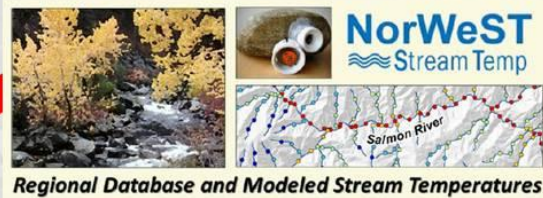
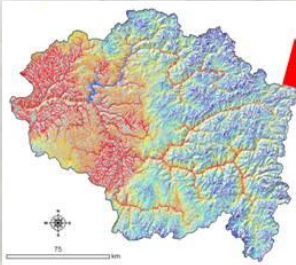
Observed data

746 stream sites
4,487 August periods
over a 19 year period

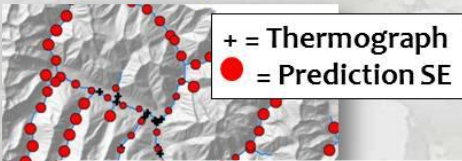


NorWeST Website Distributes Scenarios & Other Temperature Products as GIS Layers

1) GIS shapefiles of stream temperature scenarios



2) GIS shapefiles of stream temperature model prediction precision



3) Temperature data summaries



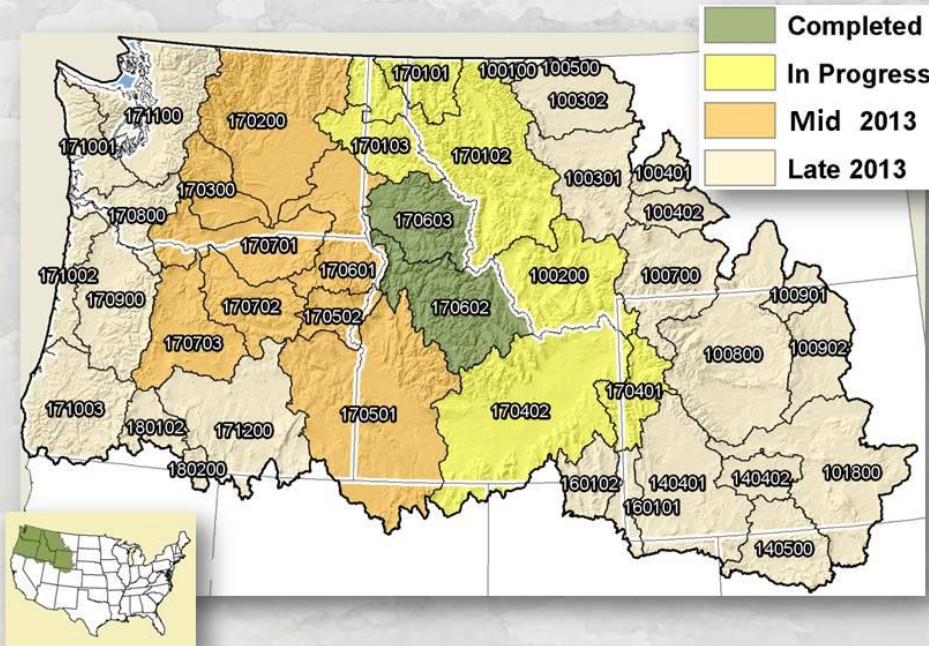
Google "NorWeST" or go here...

<http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.shtml>

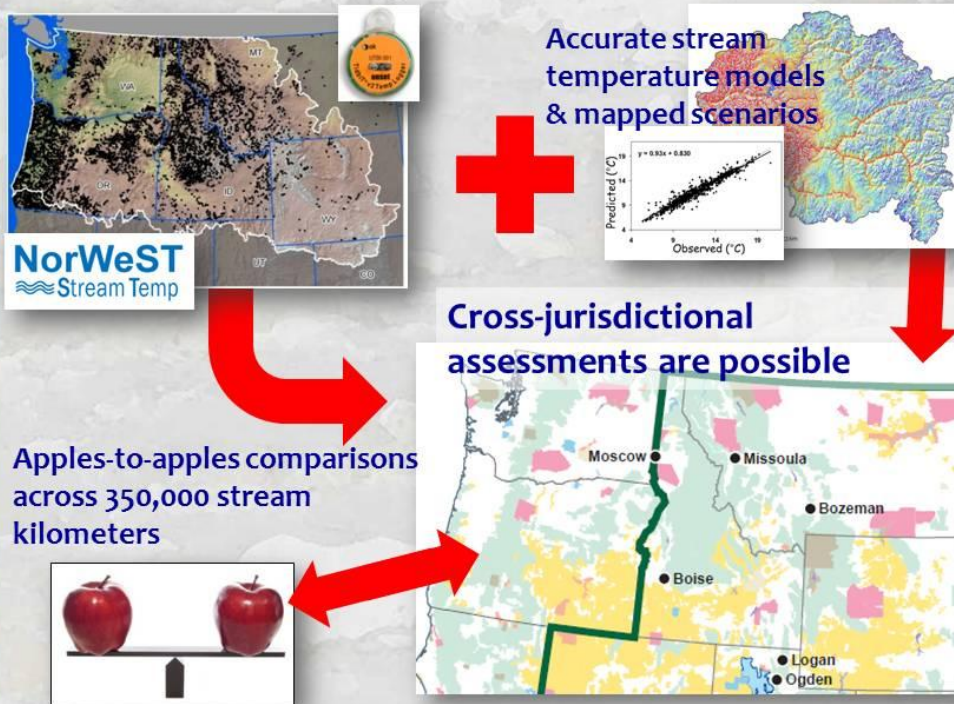




NorWeST Schedule



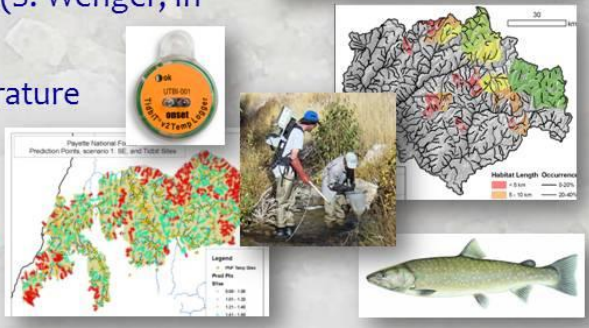
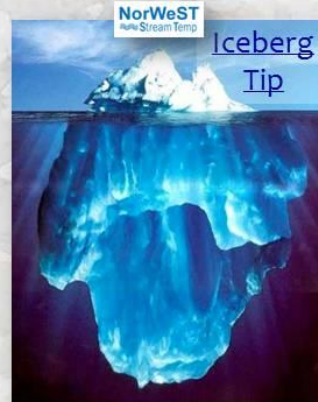
Regional Temperature Model Enables Strategic Assessments



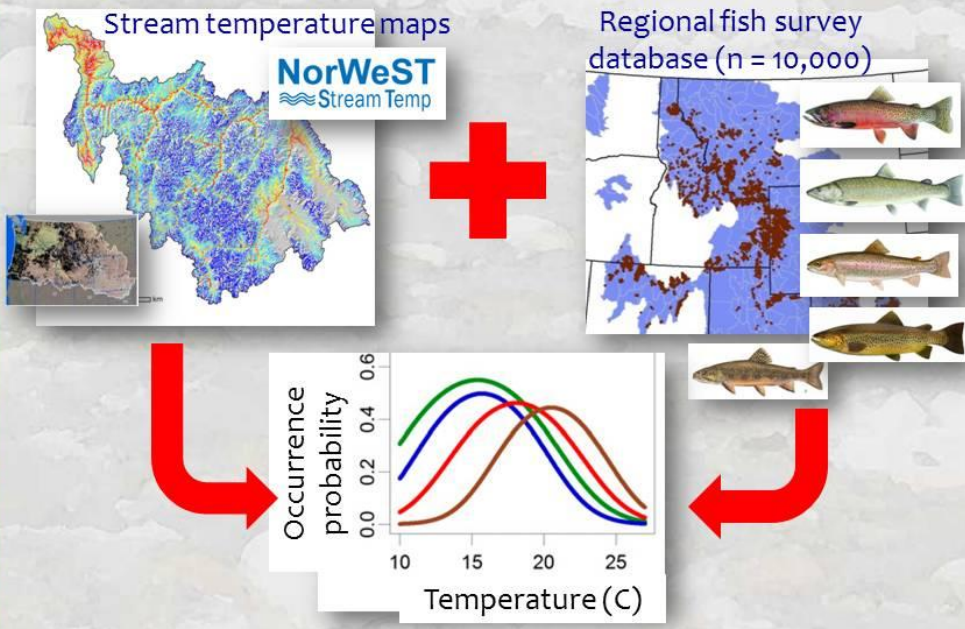


NorWeST Catalyzes Related Projects

- Regional bull trout climate vulnerability assessment (J. Dunham, In Prep.)
- Cutthroat & bull trout climate decision support tools (Peterson et al. 2013)
- Landscape-scale bull trout monitoring protocol (Isaak et al. 2009)
- Consistent thermal niche definitions & more accurate bioclimatic models for trout & nongame fishes (S. Wenger, In Prep.)
- Efficient stream temperature monitoring designs



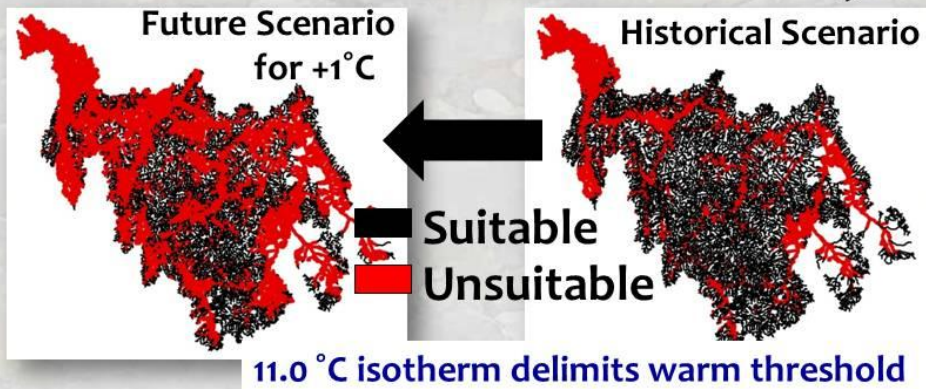
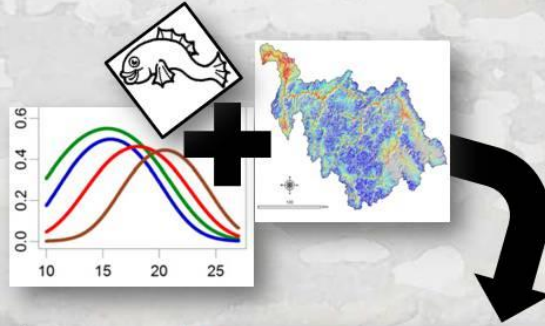
Regionally Consistent Temperature Maps Mean Regionally Consistent Thermal Niche Descriptions



Wenger et al. 2011a. *PNAS* 108:14175-14180
Wenger et al. 2011b. *CJFAS* 68:988-1008; Wenger et al., *In Preparation*



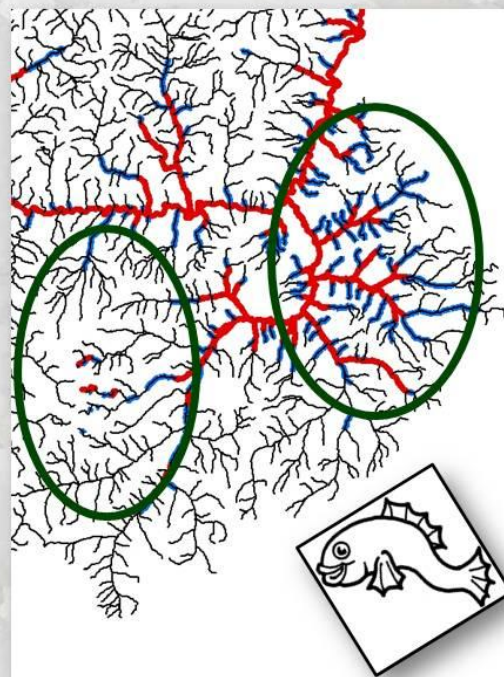
Thermal Niches Can Then be Consistently Mapped to Real-World Coordinates for Climate Assessments



Maps of Differences Between Historic & Future Scenarios Show Vulnerable Habitat Locations

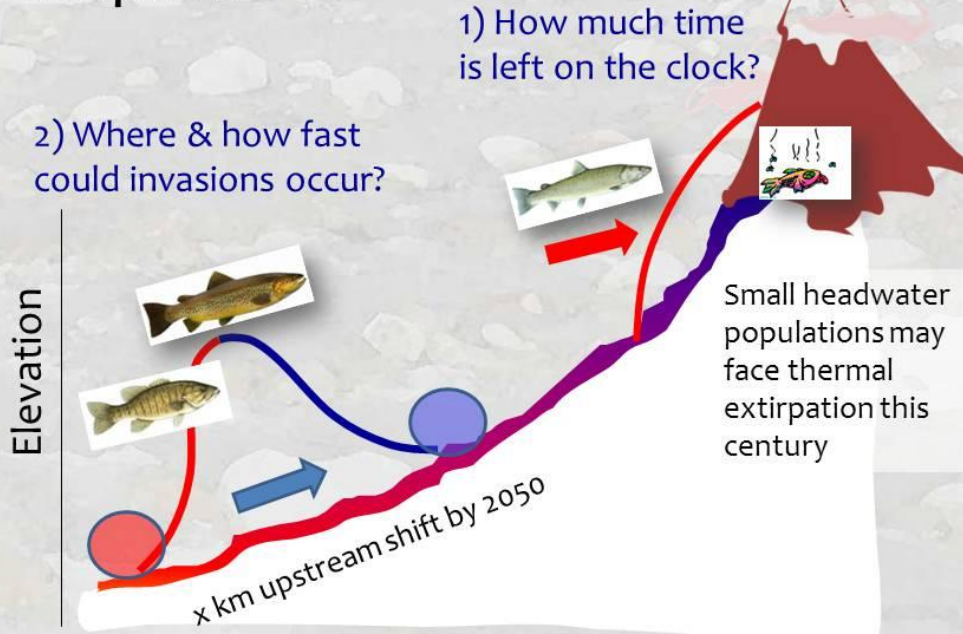
Blue reaches indicate where an 11.0°C stream isotherm moves if streams warm by +1°C.

Local variation in habitat losses arises from differences in climate velocity caused by the interaction between stream slope and temperature lapse rate ([Blog #36](#))





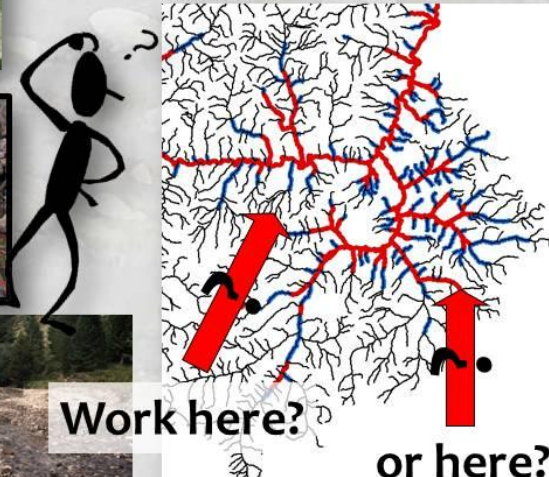
Accurate Stream Temperature Scenarios Also Provide Precise Information Regarding Species Invasions & Headwater Populations at Risk of Extirpation



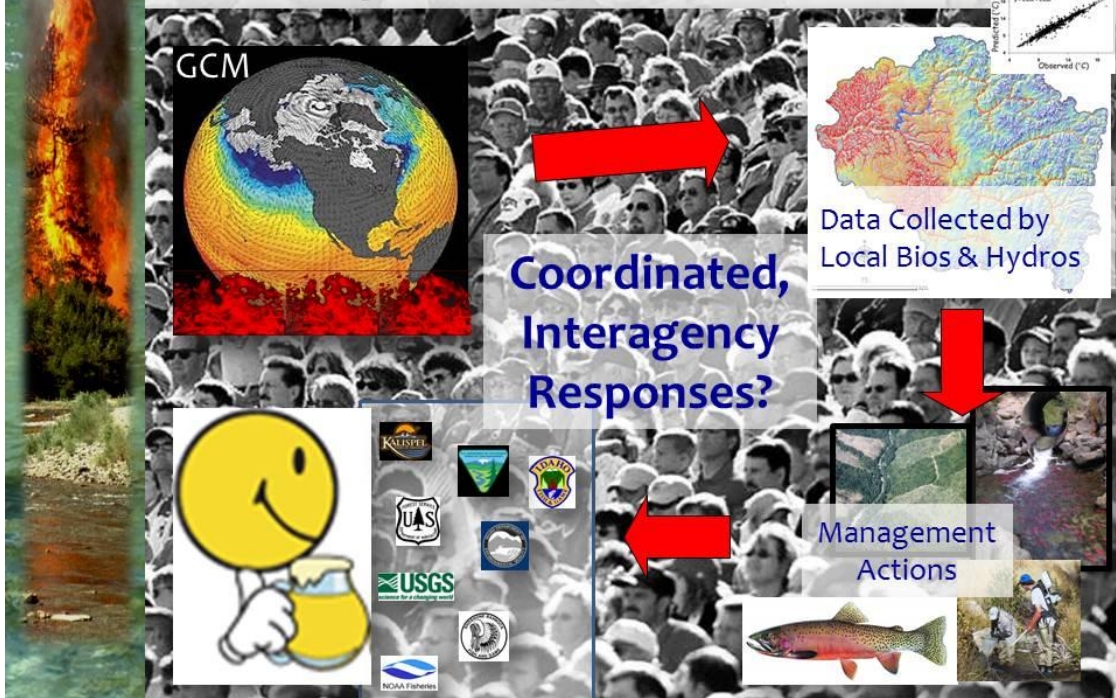
Strategic Prioritization of Restoration Actions is Possible



- Maintaining/restoring flow...
- Maintaining/restoring riparian...
- Restoring channel form/function...
- Prescribed burns limit wildfire risks...
- Non-native species control...
- Improve/impede fish passage...



NorWeST is a Crowd-Sourced Model Developed from Everyone's Data



NorWeST is possible through the efforts of folks working for these 60+ resource agencies & ...

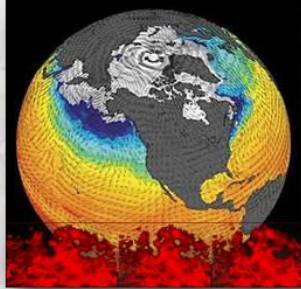


a great funding source

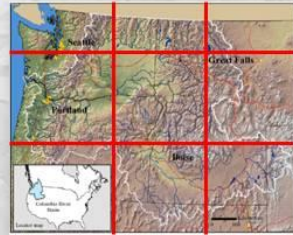


How Does Global Climate Change Affect my Local Stream?

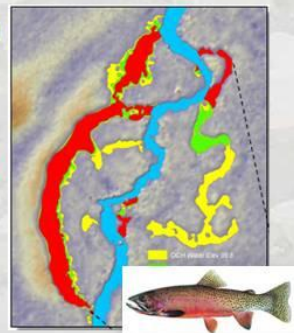
Global climate model



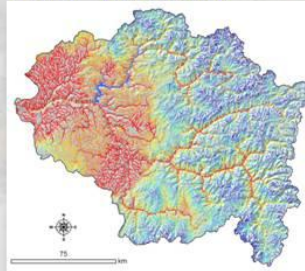
Regional climate model



Stream reach

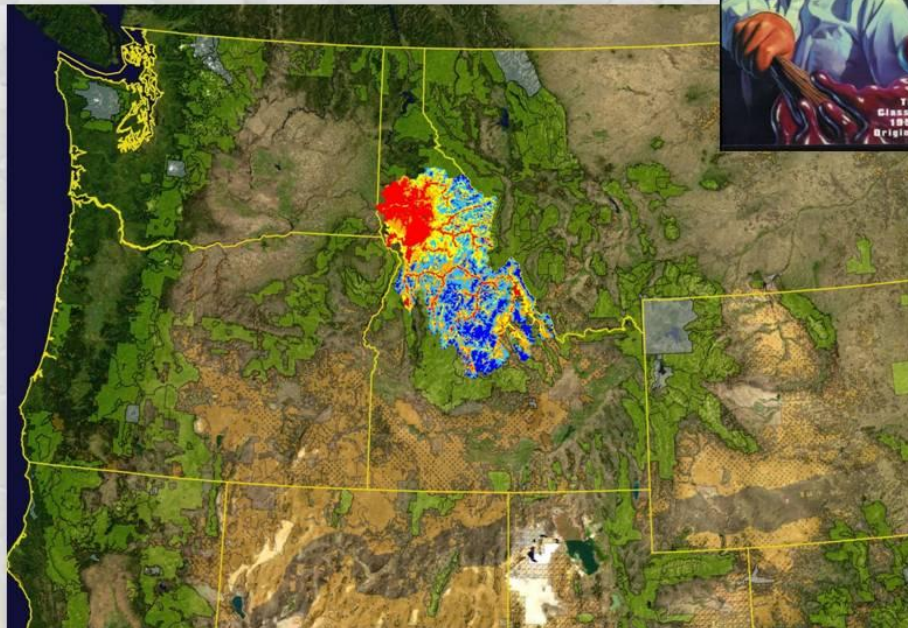


River network



NorWeST Blob Growing...

8,888 summers of data swallowed so far...



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 4,853 (& 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 these 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 Overviews

Blog #1: [Climate-aquatics workshop science presentations available online](#)

Blog #2: [A new climate-aquatics synthesis report](#)

Climate-Aquatics Thermal Module

Blog #3: [Underwater epoxy technique for full-year stream temperature monitoring](#)

Blog #4: [A GoogleMap tool for interagency coordination of regional stream temperature monitoring](#)

Blog #5: [Massive air & stream sensor networks for ecologically relevant climate downscaling](#)

Blog #6: [Thoughts on monitoring air temperatures in complex, forested terrain](#)

Blog #7: [Downscaling of climate change effects on river network temperatures using inter-agency temperature databases with new spatial statistical stream network models](#)

Blog #8: [Thoughts on monitoring designs for temperature sensor networks across river and stream basins](#)

Blog #9: [Assessing climate sensitivity of aquatic habitats by direct measurement of stream & air temperatures](#)

Blog #10: [Long-term monitoring shows climate change effects on river & stream temperatures](#)

Blog #11: [Long-term monitoring shows climate change effects on lake temperatures](#)

- Blog #12: [Climate trends & climate cycles & weather weirdness](#)
- Blog #13: [Tools for visualizing local historical climate trends](#)
- Blog #14: [Leveraging short-term stream temperature records to describe long-term trends](#)
- Blog #15: [Wildfire & riparian vegetation change as the wildcards in climate warming of streams](#)
- Blog #23: [New studies describe historic & future rates of warming in Northwest US streams](#)
- Blog #24: [NoRRTN: An inexpensive regional river temperature monitoring network](#)
- Blog #25: [NorWeST: A massive regional stream temperature database](#)
- Blog #26: [Mapping thermal heterogeneity & climate in riverine environments](#)

Climate-Aquatics Hydrology Module

- Blog #16: [Shrinking snowpacks across the western US associated with climate change](#)
- Blog #17: [Advances in stream flow runoff and changing flood risks across the western US](#)
- Blog #18: [Climate change & observed trends toward lower summer flows in the northwest US](#)
- Blog #19: [Groundwater mediation of stream flow responses to climate change](#)
- Blog #20: [GIS tools for mapping flow responses of western U.S. streams to climate change](#)
- Blog #21: [More discharge data to address more hydroclimate questions](#)
- Blog #22: [Climate change effects on sediment delivery to stream channels](#)

Climate-Aquatics Cool Stuff Module

- Blog #27: [Part 1, Spatial statistical models for stream networks: context & conceptual foundations](#)
- Blog #28: [Part 2, Spatial statistical models for stream networks: applications and inference](#)
- Blog #29: [Part 3, Spatial statistical models for stream networks: freeware tools for model implementation](#)

Climate-Aquatics Biology Module

- Blog #30: [Recording and mapping Earth's stream biodiversity from genetic samples of critters](#)
- Blog #31: [Global trends in species shifts caused by climate change](#)
- Blog #32: [Empirical evidence of fish phenology shifts related to climate change](#)
- Blog #33: [Part 1, Fish distribution shifts from climate change: Predicted patterns](#)
- Blog #34: [Part 2, Fish distribution shifts from climate change: Empirical evidence for range contractions](#)
- Blog #35: [Part 3, Fish distribution shifts from climate change: Empirical evidence for range expansions](#)
- Blog #36: [The "velocity" of climate change in rivers & streams](#)
- Blog #37: [Part 1, Monitoring to detect climate effects on fish distributions: Sampling design and length of time](#)
- Blog #38: [Part 2, Monitoring to detect climate effects on fish distributions: Resurveys of historical stream transects](#)
- Blog #39: [Part 3, Monitoring to detect climate effects on fish distributions: BIG DATA regional resurveys](#)

Future topics...

Climate-Aquatics Management Module