Climate-Aquatics Blog #15: Riparian Vegetation Change as an Underappreciated Unknown

Hi Everyone,
This week we're back to wrap up the thermal module with the last post before transitioning into the hydrology module. This last topic on temperature pertains to how climate related alteration of riparian vegetation may exacerbate, at least on some streams, general warming trends associated with air temperature increases and flow alterations (blogs #7 & #10). Because heat budgets in streams are typically dominated by incoming solar radiation (graphic 1), shading from riparian vegetation plays an important role in buffering stream temperatures on small to medium sized streams. In the western U.S., where wildfires are a natural part of many landscapes, aquatic communities have evolved to persist through these periodic disturbances, and may even benefit from their long-term effects on habitat diversity. As the climate has warmed in recent decades, however, the frequency & extent of wildfires have increased (graphic 2) and concerns have arisen that wildfire regimes could move beyond historical conditions.

In the context of a changing climate, therefore, understanding how wildfires affect stream thermal regimes is going to be more important than ever. Because although climate forcing from trends in air temp & precipitation/flow appear to play the largest roles in stream temperature increases when all factors are considered across broad river networks (blog #7), wildfires can have strong local effects that occur rapidly & may persist for decades. As such, I wanted to highlight one of the better studies out there on the topic by Jason Dunham & co-authors (graphic 3). This study uses a space-for-time substitution design to examine the subject in detail & demonstrates the wide range of possible outcomes, from strong local temperature increases to relatively minor effects, it all depends on the severity of the fire…and what happens after the fire. In the steep topography of central Idaho where this study was conducted, wildfires made streams more susceptible subsequent debris flow torrents that scoured the channels of alluvium & further decreased shading—making these streams especially sensitive to warming.

The other thing that's supposed to happen after the fire is that the riparian vegetation re-grows to its former state to once again shade the stream. Or at least that's been the working paradigm for many decades. Climate change is changing this assumption, however, because just like any other species affected by a shifting climate, plant species have to shift their distributions to track suitable habitat conditions. The attached study by Allen et al. provides a global overview of the large regional "events" that are becoming more common each decade as large areas of forest & shrub-lands die-off from extreme temperatures and droughts (graphic 4).

Since many western streams are currently shaded by conifers that were established > 50 years ago, it's not hard to imagine that in some areas the set of environmental conditions necessary for young trees to re-grow at a site may no longer be present & trees could eventually be replaced by shrubs or grasses that are more drought tolerant (& provide less shade). I don't want to go too far with this, but conversion of vegetative type is a here-to-fore underappreciated aspect of how climate change may cause warming in forested streams. At the very least, it's something that warrants more study & it should be possible to develop bioclimatic models for riparian vegetation communities, similar to those for fish or other organisms, to predict which riparian areas are more sensitive to future changes.

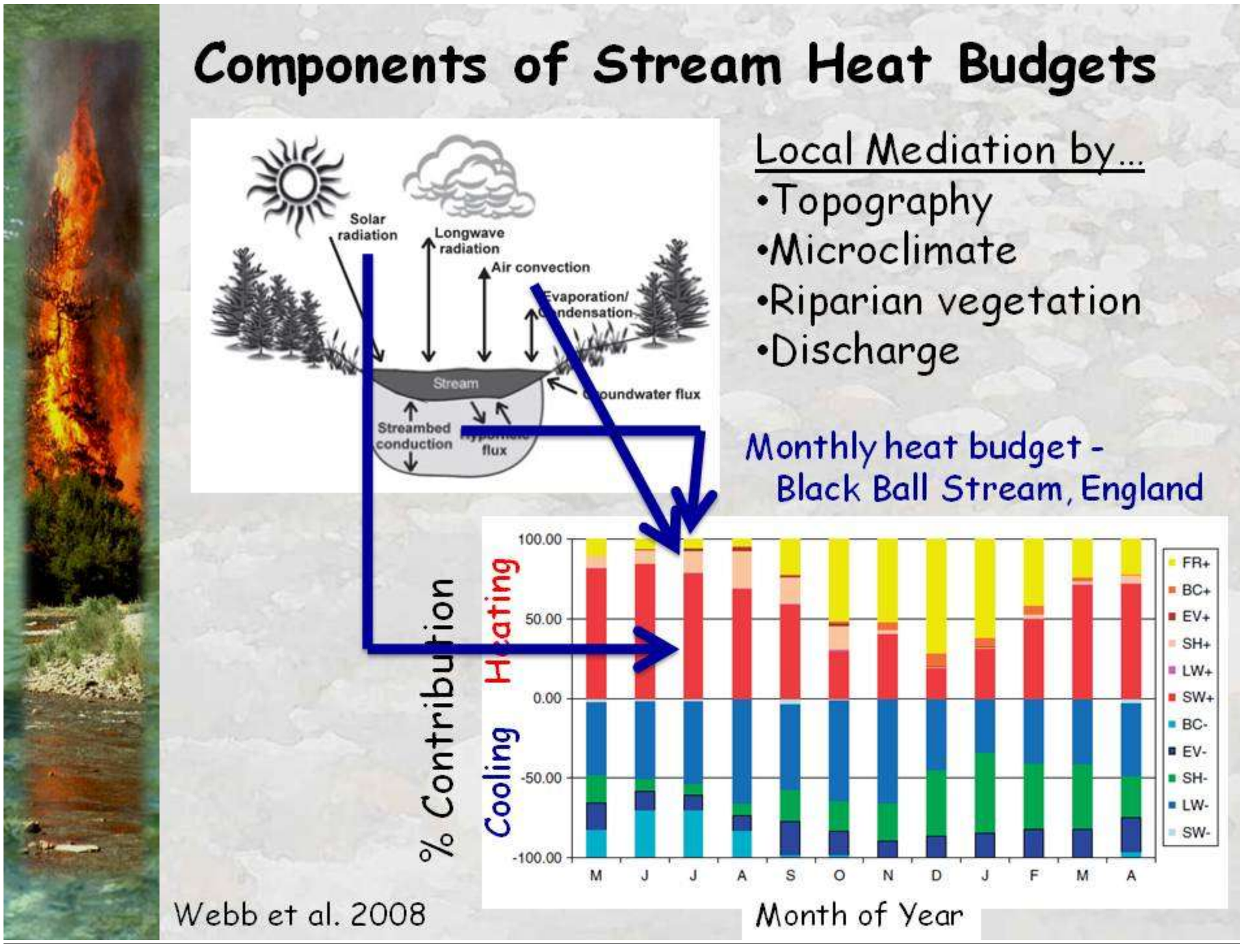
So that's it for the **climate-aquatics thermal module**. The summary points for stream temperatures & climate are:

1) steam temperatures—they are a changing (blogs #7, #10, #14);
2) warming patterns are regionally & globally coherent at decadal time-scales (blogs #10 & #14), but may be obscured over shorter timescales by climate cycles (blog #12). Landscape- & stream-level factors like glaciers, wildfires, etc. may exacerbate/buffer rates of warming in some streams (blogs #10 & #15);
3) long-term (i.e., > 30 years) stream temperature monitoring records are relatively rare (blogs #10 & #14), but short-term monitoring records at 1,000's of different stream sites are common in many areas when databases from multiple agencies are integrated & viewed in composite (blogs #4 and #7);
4) inexpensive digital temperature sensors (blog #6) and convenient means of establishing permanent monitoring sites (blogs #3 & #6) now make full year temperature monitoring routine. Monitoring networks are being deployed across many landscapes by numerous agencies (blogs #5, #6, #8, #9) with the end result that massive regional networks are rapidly evolving (blog #4);
5) new spatial tools are available to help visualize monitoring sites so that coordination among agencies is increased and redundancy of efforts decreased (blogs #4 & #13);
6) new analytical techniques are available that can extract valuable information from existing temperature databases regarding spatial patterns and temporal trends in stream temperatures associated with climate (blogs #7, #8, #9, #14).

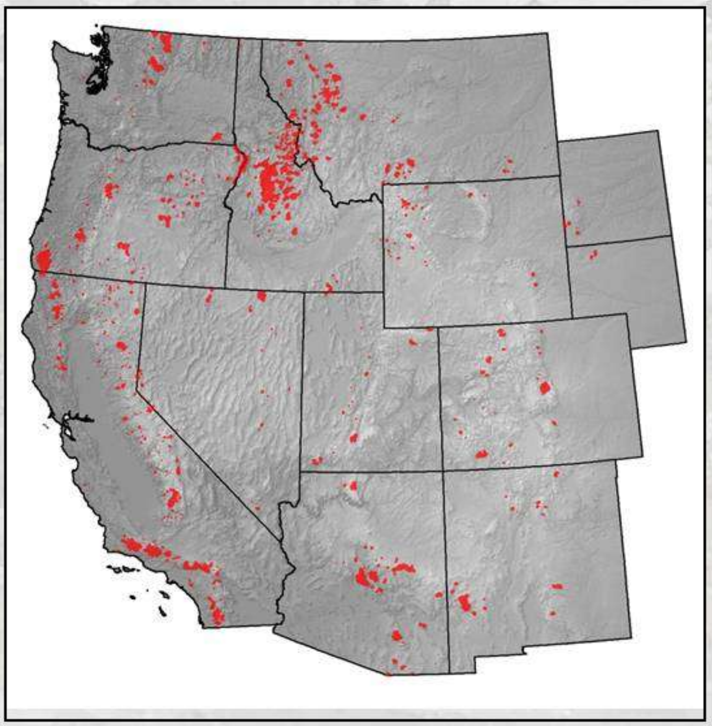
In short, we're rapidly learning a lot about thermal regimes in rivers and streams and in the next 2 – 5 years will have literally mountains of data and the capacity to accurately predict this critical attribute for a variety of climate scenarios across large areas & river networks. That will give us one of the fundamental building blocks necessary to understand how climate change is affecting aquatic ecosystems. Just as importantly, however, it will also yield a powerful set of tools for better predicting & understanding patterns in fish distribution & abundance that are ultimately of broader interest across a suite of management applications.

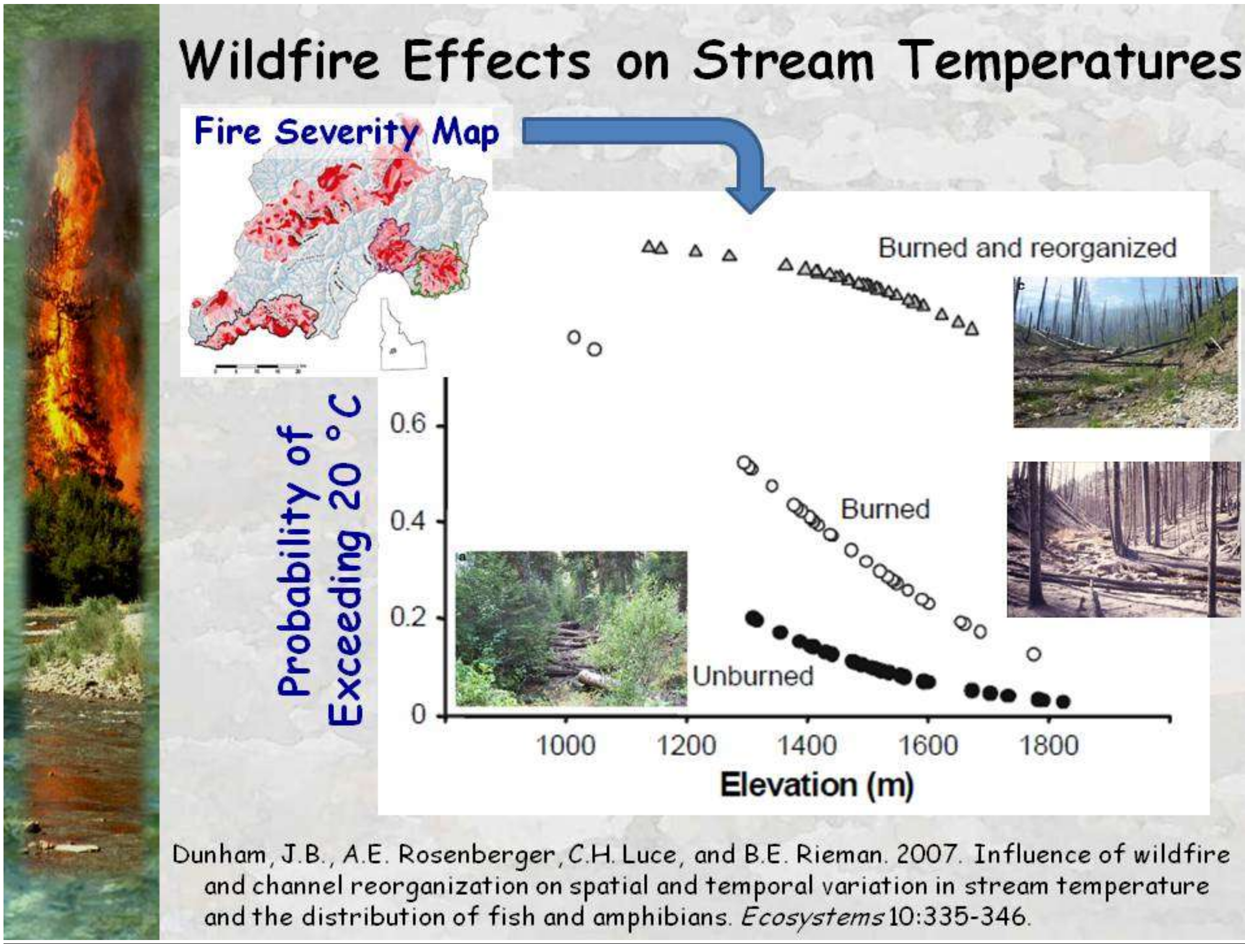
Until next time, best regards,

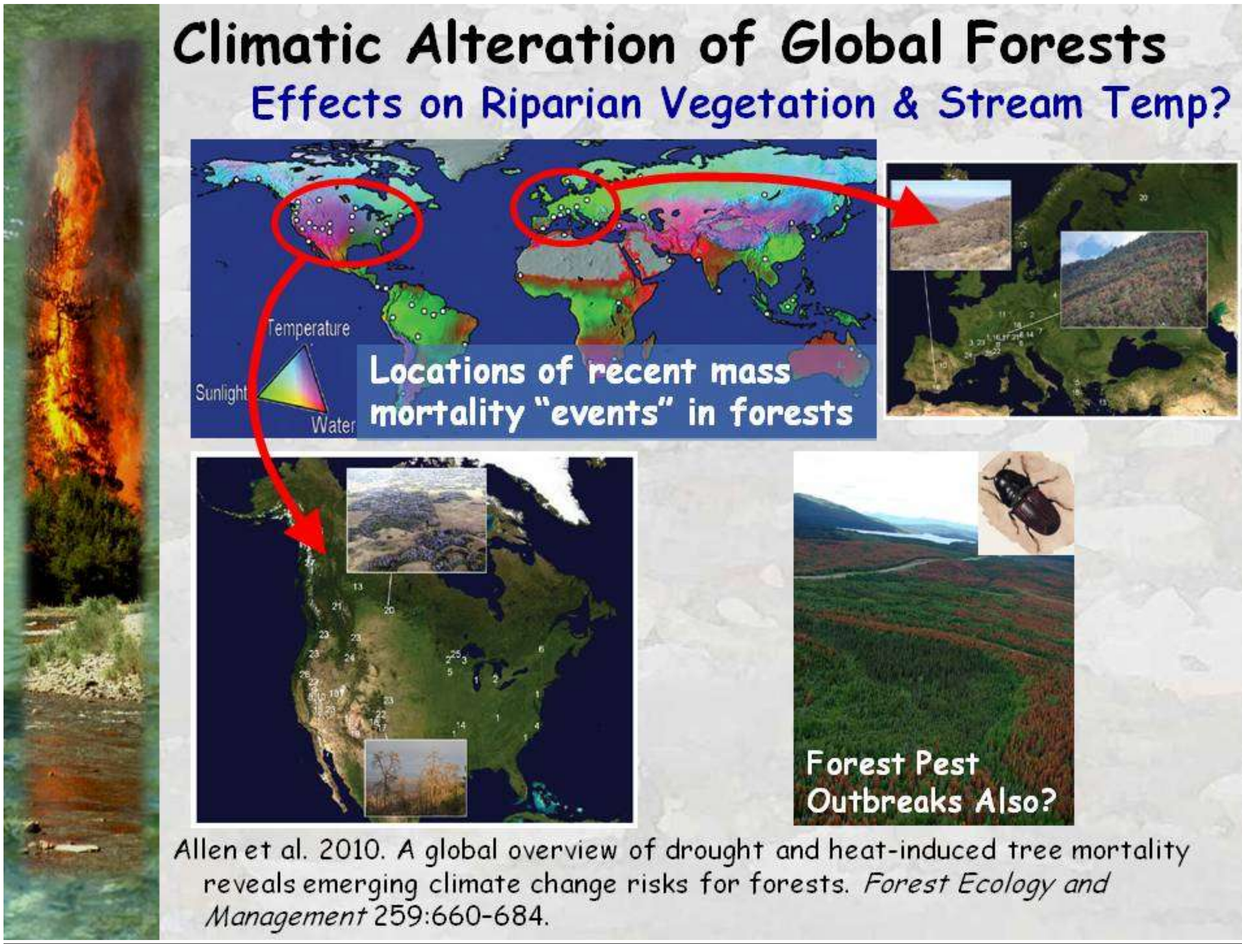
Dan


Components of Stream Heat Budgets
Solar radiation
Longwave radiation
Air convection
Evaporation/ Condensation
Stream
Groundwater flux
Streambed conduction
flux
Local Mediation by…
•Topography
•Microclimate
•Riparian vegetation
•Discharge
Monthly heat budget - Black Ball Stream, England
% Contribution
Heating
Cooling
100.00
50.00
0.00
-50.00
-100.00
M J J A S O N D J F M A
FR+
BC+
EV+
SH+
LW+
SW+
BC-
EV-
SH-
LW-
SW-
Month of Year
Webb et al. 2008

Distribution of Wildfires Across the Western U.S. From 2001-2006




Wildfire Effects on Stream Temperatures
Fire Severity Map
Burned and reorganized
Burned
Unburned
Probability of Exceeding 20 °C
0.6
0.4
0.2
0
1000
1200
1400
1600
1800
Elevation (m)
Dunham, J.B., A.E. Rosenberger, C.H. Luce, and B.E. Rieman. 2007. Influence of wildfire and channel reorganization on spatial and temporal variation in stream temperature and the distribution of fish and amphibians. *Ecosystems* 10:335-346.



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 Google Map 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: Accurate downscaling of climate change effects on river network temperatures through use of inter-agency temperature databases and application of new spatial statistical stream 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 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

Future topics…
Climate-Aquatics Hydrology Module
Climate-Aquatics Biology Module
Climate-Aquatics Management Module

How to join the group discussion: After clicking on the link, you should be able to see the discussion thread text, but to post comments & read those of others you'll first have to join the Climate-Aquatics Group (you'll only have to do this the first time). To join, follow these steps: 1) on the right side of the page, click on "Join this group" 2) Create your account information with Google user name & password, 3) Add your "nickname", 4) Pick one of the four available options for how you'll read this group (I'd advise against the bottom one that sends a new email every time a comment is added to a discussion thread), 5) Select "Join this group" at the bottom of the page, and 6) Click on the discussion topic hyperlink and you should now be able to post comments to the discussion thread.

The intent of the discussion group is to provide a means for the 1,900 (& growing) field biologists, hydrologists, 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 this 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 future 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 passionate 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.