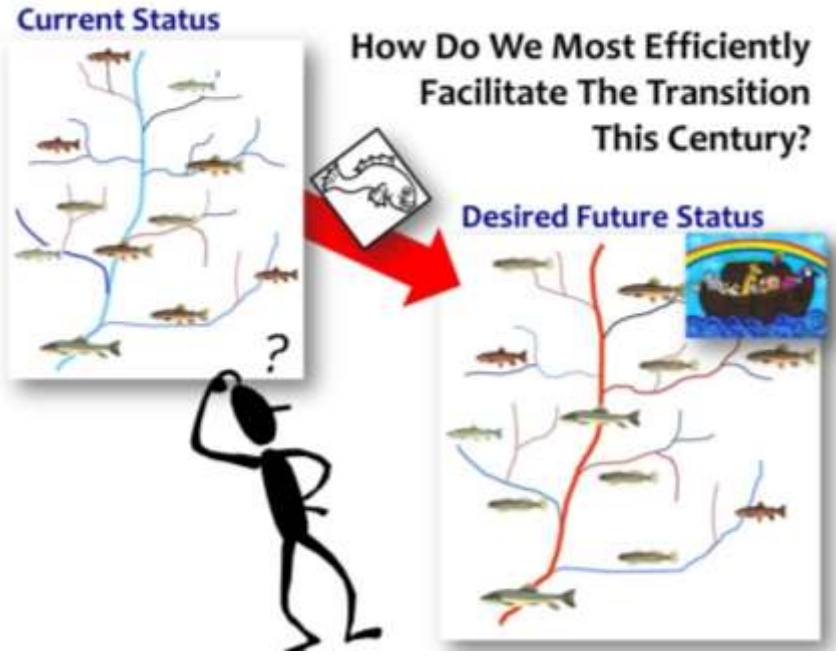
Climate-Aquatics Blog #54:
Part 1, Managing with climate change: Goal setting & decision support tools for climate-smart prioritization



Time to get a plan Stan…

Hi Everyone,
So I'm sometimes asked if I'm not totally bummed by all the bad things climate change is doing to streams & fish? My response is that it's too early to bum out, there's too much we don't know & need to learn; and far too much uncertainty about how much warmer the Earth will be 50 or 100 years from now. Moreover, initial indications suggest fish responses to climate change, although ongoing, are relatively gradual and often take decades to manifest (blog #'s 32, 37, 42). That being the case, we have time over the next decade or so to develop the monitoring systems, databases, tools, and adaptive management plans that will provide the information needed for coping efficiently with changes this century. If we take advantage of this time, that information and the decisions we make could have a big impact on the fishes swimming in rivers and streams 100 years from now and the fisheries resources that future generations have to enjoy. So there's no time to bum, we've got far too much work to do as we attempt to secure those legacies.

As in any significant endeavor, clearly articulating goals and objectives is a key step. Without those specifics, it's impossible to create a roadmap for success, getting there is painfully inefficient, and we won't even know when we've arrived! Specific goals & objectives, of course, will vary among agencies and in different geographies, but I think most can be framed by 2 basic choices (graphic 1). Choice A means coexisting with climate change and going with the flow so to speak. Here, we basically acknowledge that things, including biological communities, are going to change and we're not going to stop the change. If this option is chosen, we then have sub-choices about whether to passively accept changes or whether we actively intervene to influence the trajectory that the biological community is on. Choice B means resisting climate change in an effort to preserve and protect things we hold dear like important fisheries or native

biodiversity. Here, we're going to actively intervene and do our best to impede change. Making this choice at times is a fundamental responsibility we have as stewards of the natural world but it's also a lot trickier than choice A & may also involve real pain. First, we risk being run over by the climate freight train as it moves through if we commit limited resources to the wrong places & fritter those resources away. Second, resisting change in some places means they become higher priority and that's likely to mean diverting resources away from some "lost cause" areas & populations that people care about. That will stir considerable debate, but not prioritizing effectively may mean we spread our efforts so thinly that they don't make a difference in the long run. In effect, trying to save it all risks losing it all (graphics 2 & 3).

The crux of the matter then is when & where A and B are chosen on real-world landscapes, and whether those choices can be implemented coherently within a broader strategic framework. A key requirement in this regard is visualizing the status of the stream resources we're concerned about so that "what-if" games and the consequences of our choices can be explored before commitments are made. Until recently, that sort of visualization in the stream world was a big challenge, but a quiet revolution has occurred over the last decade. A wealth of new information sources have become available from remote sensing, development of nationally consistent hydrology layers, accumulation of BIG DATA databases, and new stream geospatial analyses techniques (graphics 4 – 7; blog #'s 27, 28, 29). In fact, it's to the point that information overload is now sometimes a problem & tools are needed to filter the signal from the noise (graphic 8).

Enter Peterson and colleagues, who explore the use of Bayesian belief networks to develop spatially explicit climate decision support tools for stream fish (study hyperlinked here: http://www.treesearch.fs.fed.us/pubs/43351; graphic 9). The authors tools addressed two common problems; 1) the spatial prioritization of management actions and resources among populations, and 2) the benefits of removing/installing a fish barrier in a stream (graphics 10 & 11). The latter might be considered a tactical action to help ensure population persistence in the former prioritization scheme. For both problems, the data for parameterizing the belief networks were derived from regionally consistent geospatial data sources and high-resolution stream climate scenarios (graphic 12; blog #'s 20 & 40), which allowed results to be mapped onto stream networks. A key point made by Peterson & colleagues in the paper is that rigorously working through the steps of developing the belief network tools (e.g., problem identification goal setting, clearly articulating logic, identifying uncertainties, etc) is at least as important as the final answers the models provide (more details on one of the decision support tools is here: http://www.fs.fed.us/rm/boise/AWAE/workshops/CADS/Peterson/BayesianNetworkModelBullTroutBoiseRiver.html)

The impetus for developing those decision support tools was a river basin climate planning workshop we hosted 3 years ago in Boise. Climate change was coming onto everyone's radar at the time, and the workshop was designed to step through some real-world examples wherein participants had to make explicit choices about prioritizing resources to conserve a sensitive fish species in a specific river basin. During the workshop, everyone was given a laptop with the same sets of geospatial data, climate scenarios, fish distribution information, and decision support tools…and everyone was forced to make choices. Having access to the information didn't result in a wholesale reorganization of people's thinking about where, or how, to prioritize (graphic 13), but it did create a stronger consensus to focus efforts in a subset of areas rather than

spreading them out. Most importantly, the decision tools & consistent sets of accurate geospatial data facilitated effective communication among people and stimulated open, involved, and productive debates as people grappled with the information & maps showing the potential effects of climate change on fish populations (more details on the workshop are available here: http://www.fs.fed.us/rm/boise/AWAE/workshops/climate_aquatics_decision_support.shtml)

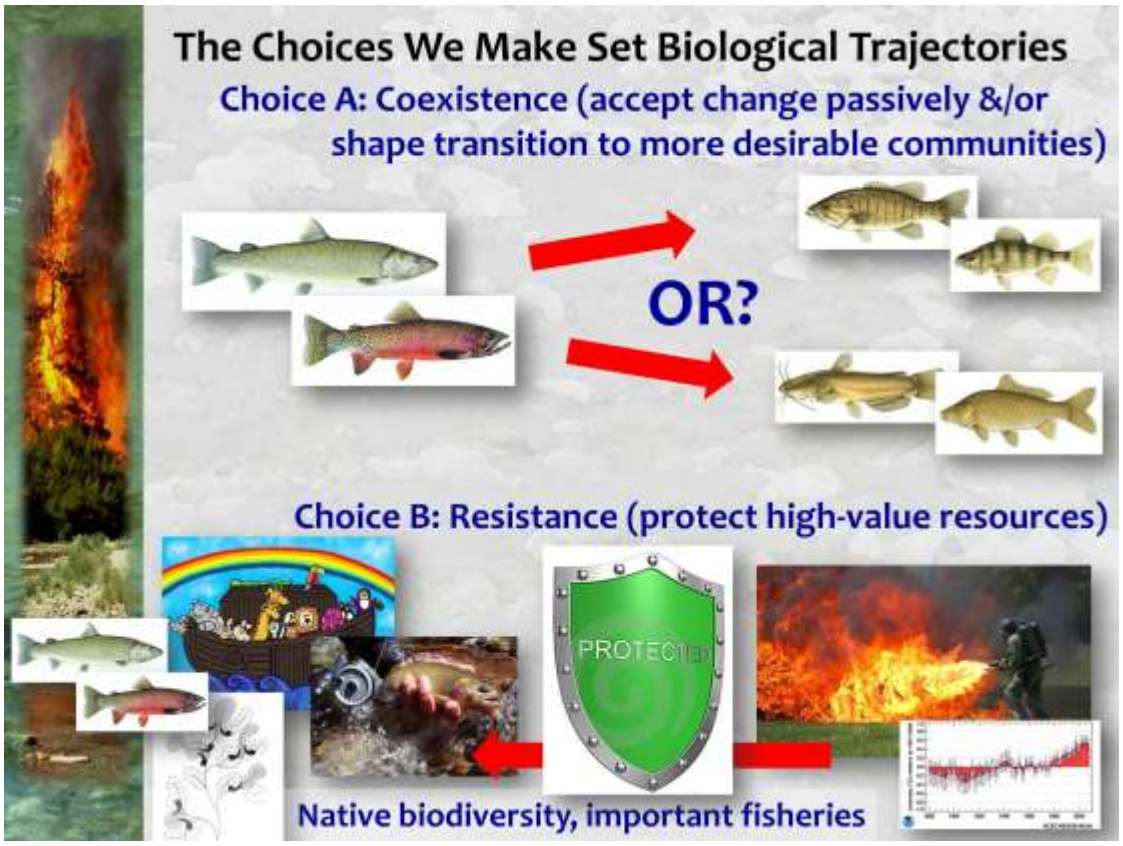
The overwhelmingly positive responses we received from the workshop encouraged us to push towards developing high-resolution stream temperature and flow scenarios regionally—a process that's still ongoing in the northwest US as the NorWeST team organizes and works through the huge volume of temperature data that exists here (blog #'s 25 & 40). Those responses also provided the impetus for starting this blog. Because it seemed we'd only scratched the surface of something really powerful and really necessary during those 2 workshop days. That's proven to be the case as the original blog mailing list has grown from some 400 people that participated in the workshop to >6,000 currently. During that same time, the global aquatics community has produced a huge amount of new information about climate effects on streams, which has significantly reduced many key uncertainties.

So let's not bum out or freak out, there's time to figure it all out. Subsequent blogs in this climate-aquatics management module will address specific actions that can be taken to improve the resilience of habitats and fish populations to climate change. But those are just the means to an end, and the first step is defining where we want that end to be. By methodically working through the process of goal setting and information creation, we're not only building a solid foundation for decision making, but we're also strengthening the social networks within/among agencies and within/among concerned publics. Addressing the challenges posed by climate change is our generation's great challenge, and opportunity. Our collective response to that challenge as we begin this journey is already creating many synergies that are making us a more effective force to do good for more fish in more places. We can't do anything more than that.

Until next time, best regards,

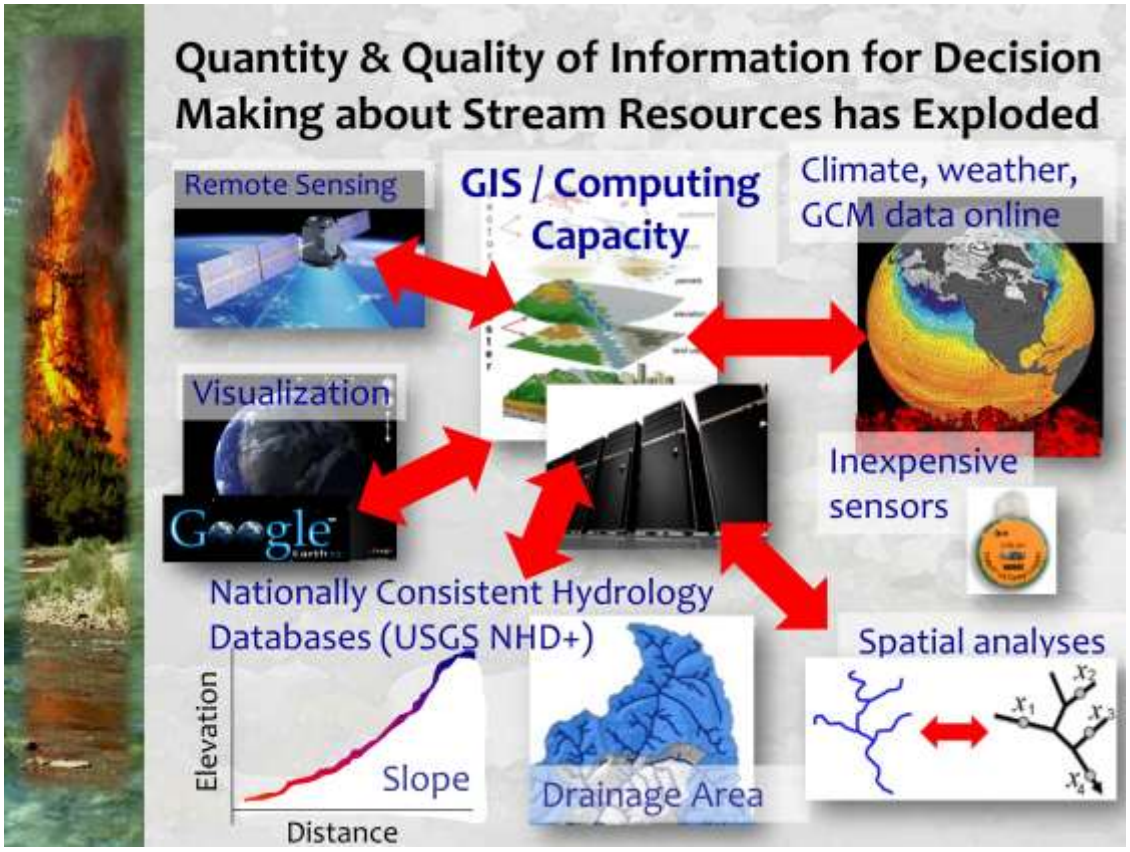
Dan

 Now Tweeting at Dan Isaak@DanIsaak 

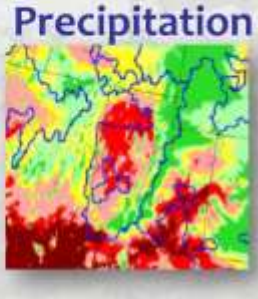

The Choices We Make Set Biological Trajectories
Choice A: Coexistence (accept change passively &/or shape transition to more desirable communities)
OR?
Choice B: Resistance (protect high-value resources)
PROTECTION
Native biodiversity, important fisheries


We Can't Do Everything Everywhere
Needs Far Exceed Conservation Resources
Ecological process/function
Evolutionary legacies
Economic benefits
Maintenance
Restoration
Control
So what are our Goals?
A. Dispersion of Activity
B. Concentration of Activity
Time 1
Time 2
Time 1
Time 2
?
What is "Optimal" Management?


Many Stream Things Can be Done,
... But Where to do Them?
•Maintaining/restoring flow...
•Maintaining/restoring riparian...
•Restoring channel form/function...
•Prescribed burns limit wildfire risks...
•Non-native species control...
•Improve/impede fish passage...
Low Priority?
High Priority?


Quantity & Quality of Information for Decision Making about Stream Resources has Exploded
Remote Sensing
GIS / Computing Capacity
Climate, weather, GCM data online
Visualization
Google
Inexpensive sensors
Nationally Consistent Hydrology Databases (USGS NHD+)
Elevation
Slope
Distance
Drainage Area
Spatial analyses

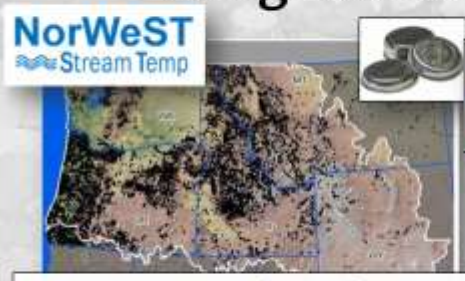
100's of Stream Reach Habitat Descriptors Are Already Calculated & Available from National Geospatial Databases

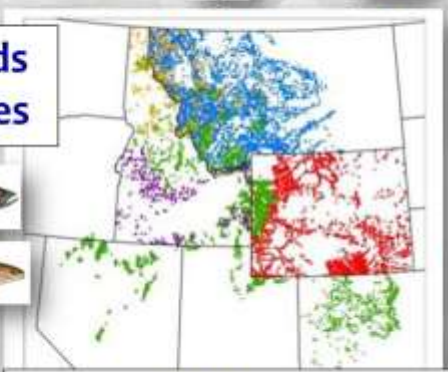


Cooter et al. 2010. A nationally consistent NHDPlus framework for identifying interstate waters: Implications for integrated assessments and interjurisdictional TMDLs. *Environmental Management* **46**:510-524.

Wang et al. 2011. A Hierarchical Spatial Framework and Database for the National River Fish Habitat Condition Assessment. *Fisheries* **36**:436-449.

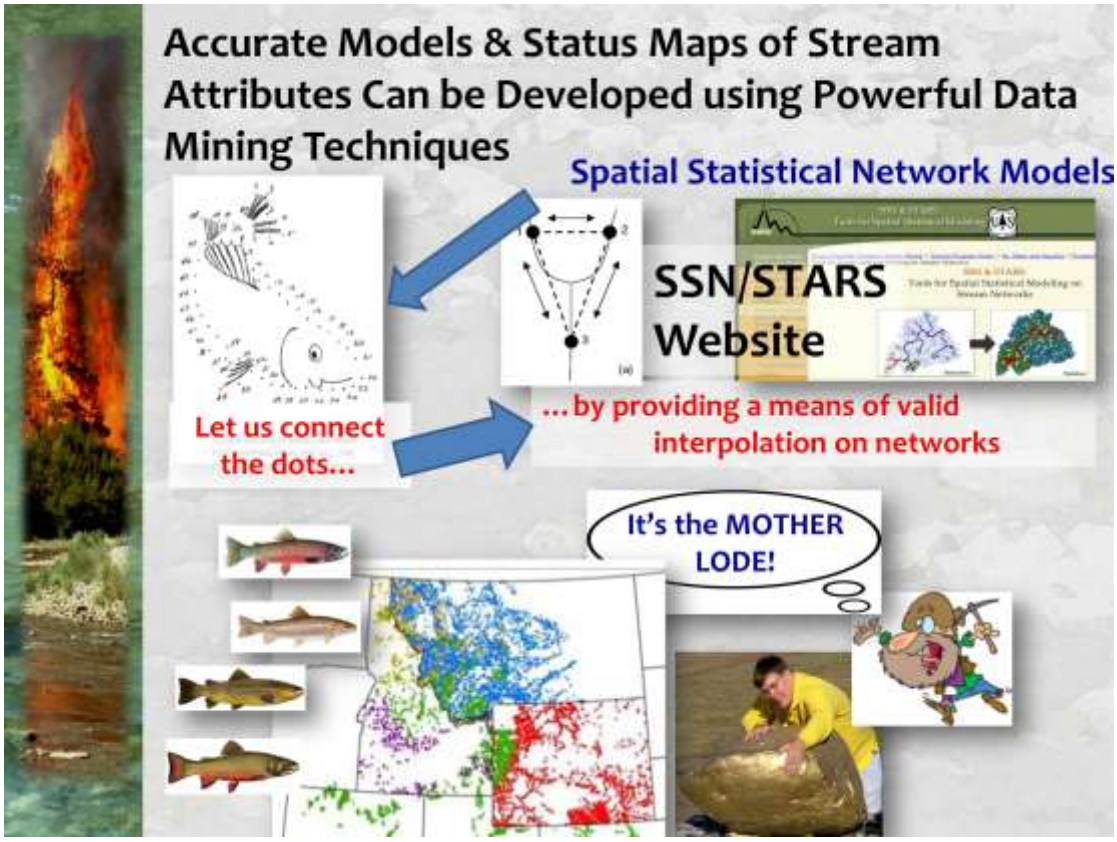
BIG DATA Often Exists for the Things we Care About & Manage

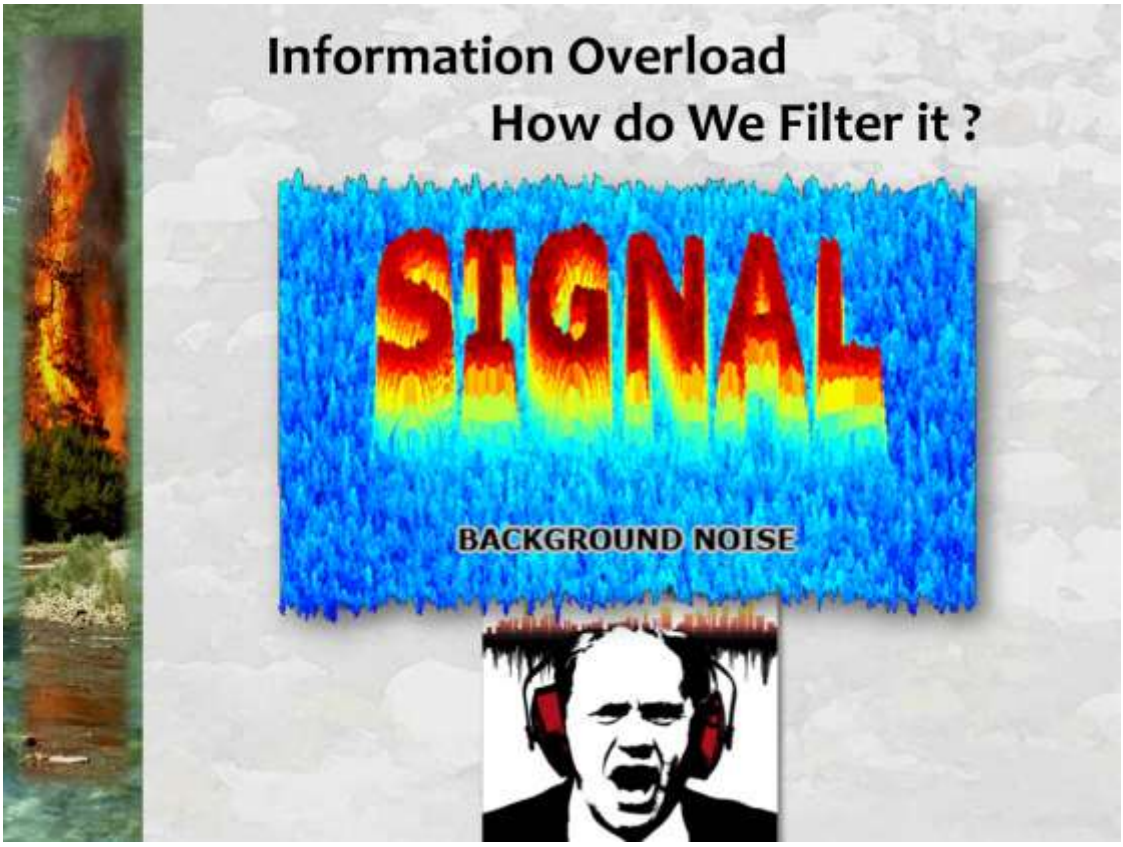




>45,000,000 hourly records
>15,000 unique stream sites

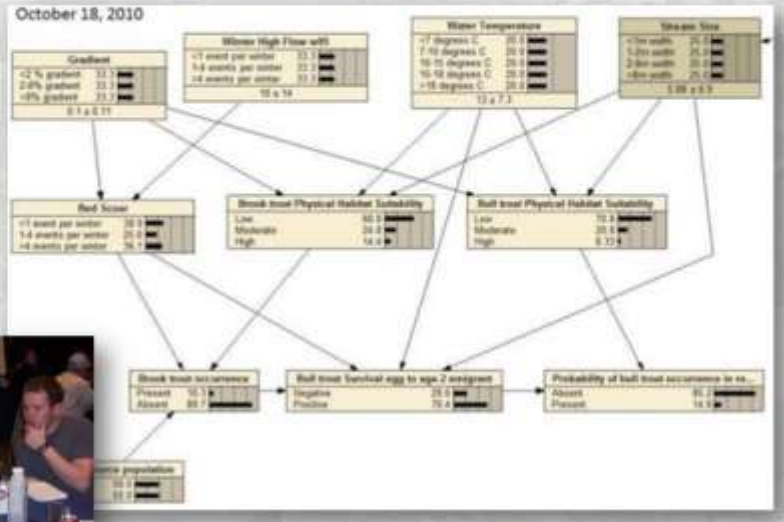
20,000 fish surveys


Accurate Models & Status Maps of Stream Attributes Can be Developed using Powerful Data Mining Techniques
Spatial Statistical Network Models
SSN/STARS Website
Let us connect the dots…
…by providing a means of valid interpolation on networks
It's the MOTHER LODE!


Information Overload
How do We Filter it ?
SIGNAL
BACKGROUND NOISE

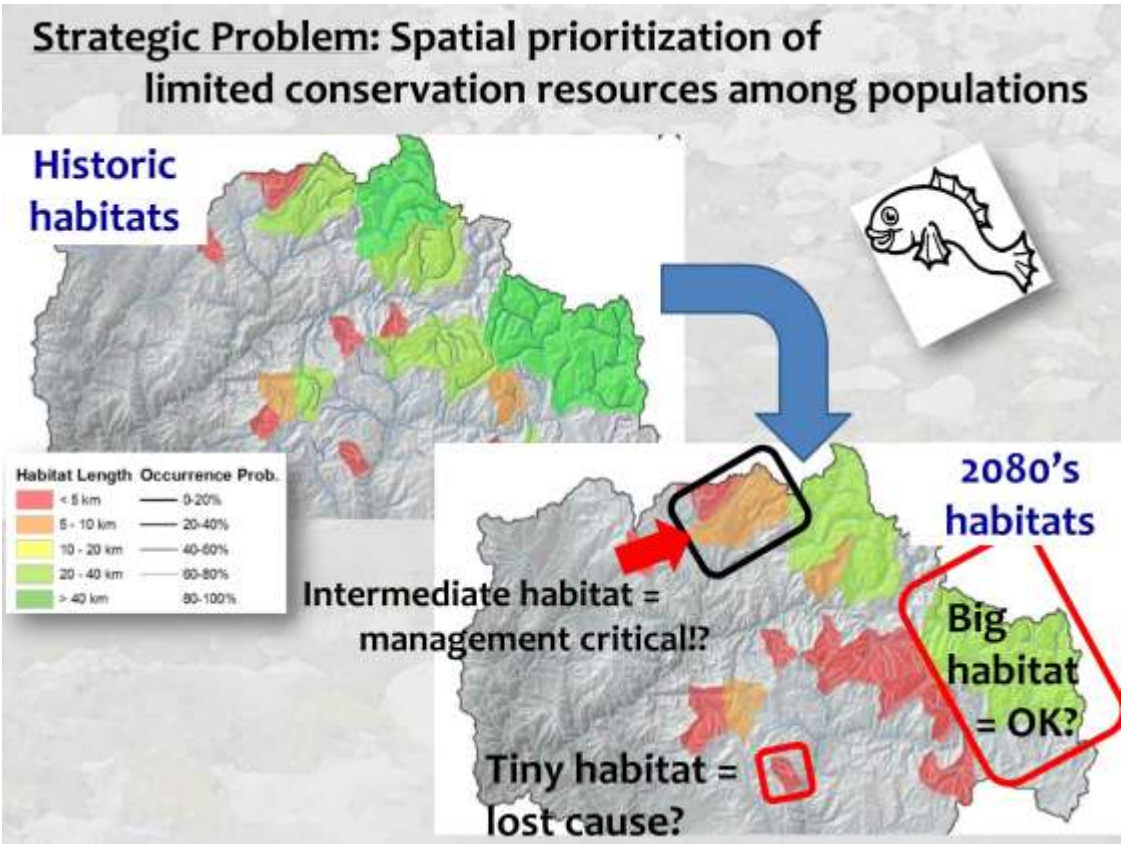
Decision Support Tools Integrate Information from Multiple Sources

Structured Process & Transparent Logic



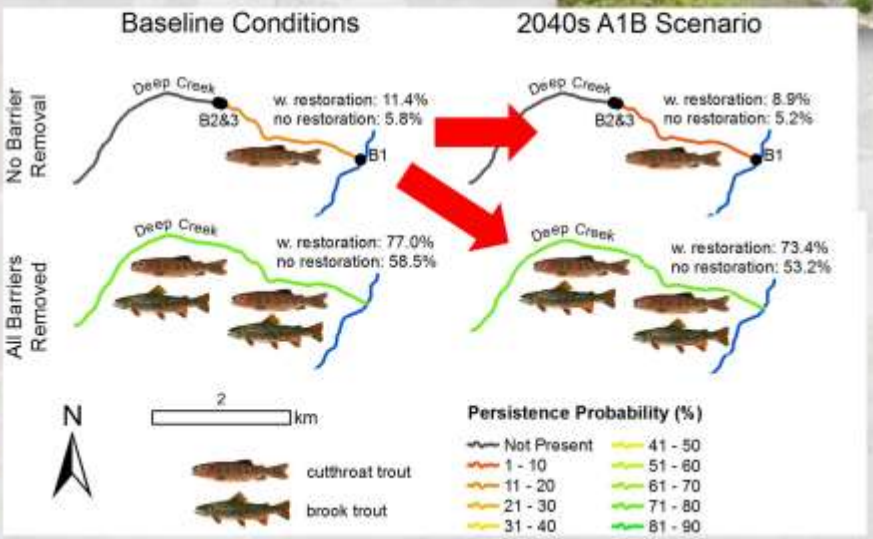
Peterson et al. 2013. Linking climate change and fish conservation efforts using spatially explicit decision support tools. *Fisheries* **38**:112-127.

Strategic Problem: Spatial prioritization of limited conservation resources among populations

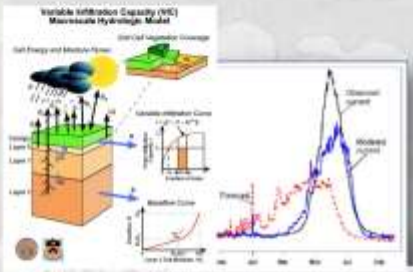


Tactical Problem: Fish barrier installation/removal

Does it help or hurt 50 years from now?



Availability of High-Resolution Stream Climate Scenarios as GIS data Enables Consistent Application of Decision Support Tools among River Basins

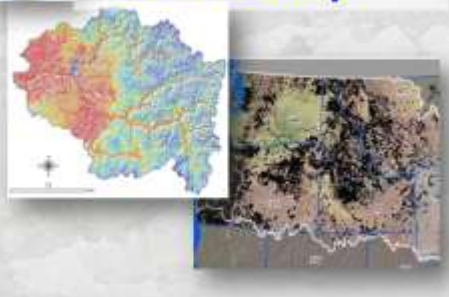


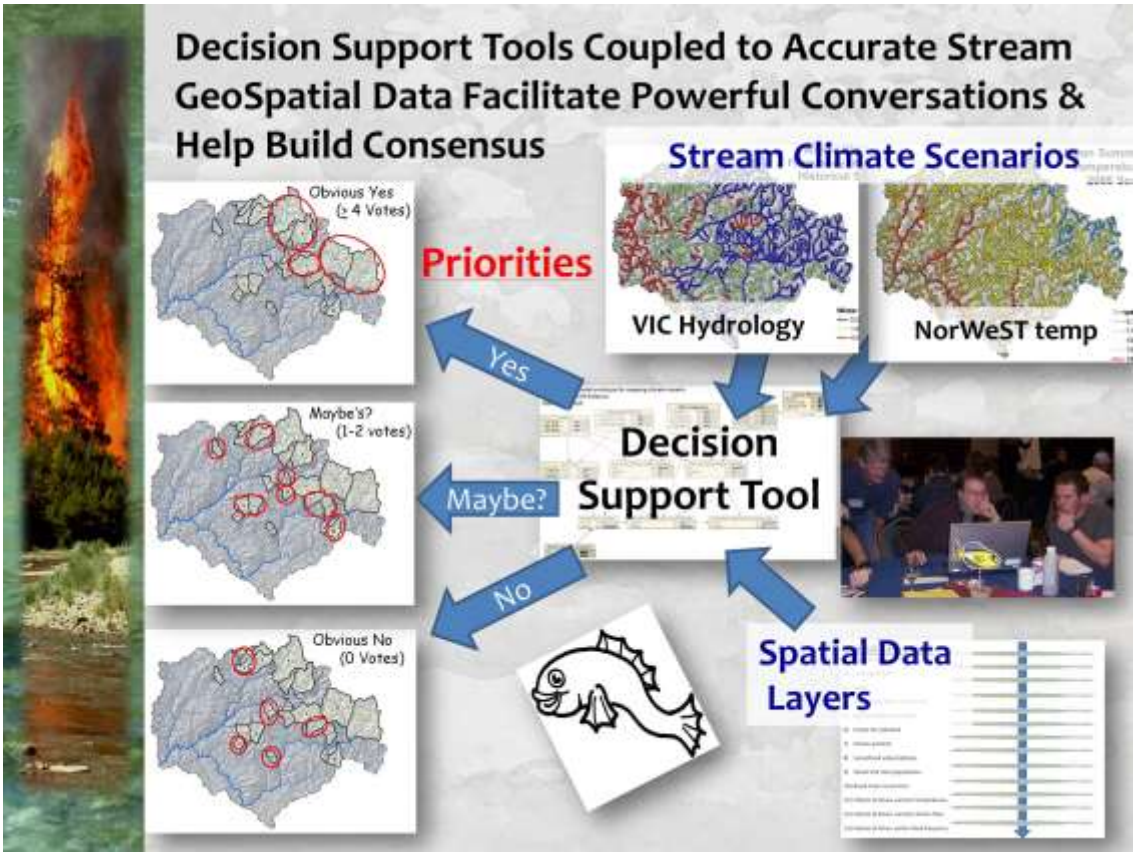
Google "Stream flow Metrics"

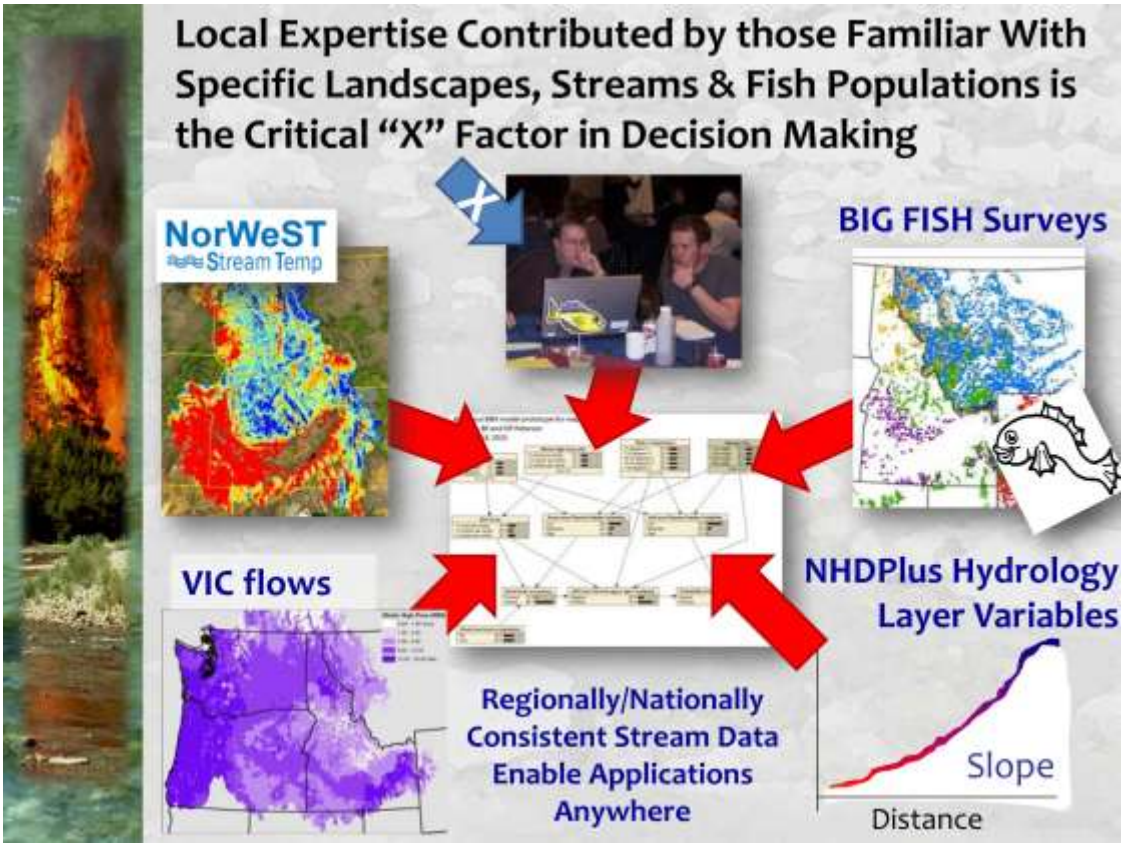
VIC Streamflow Scenarios

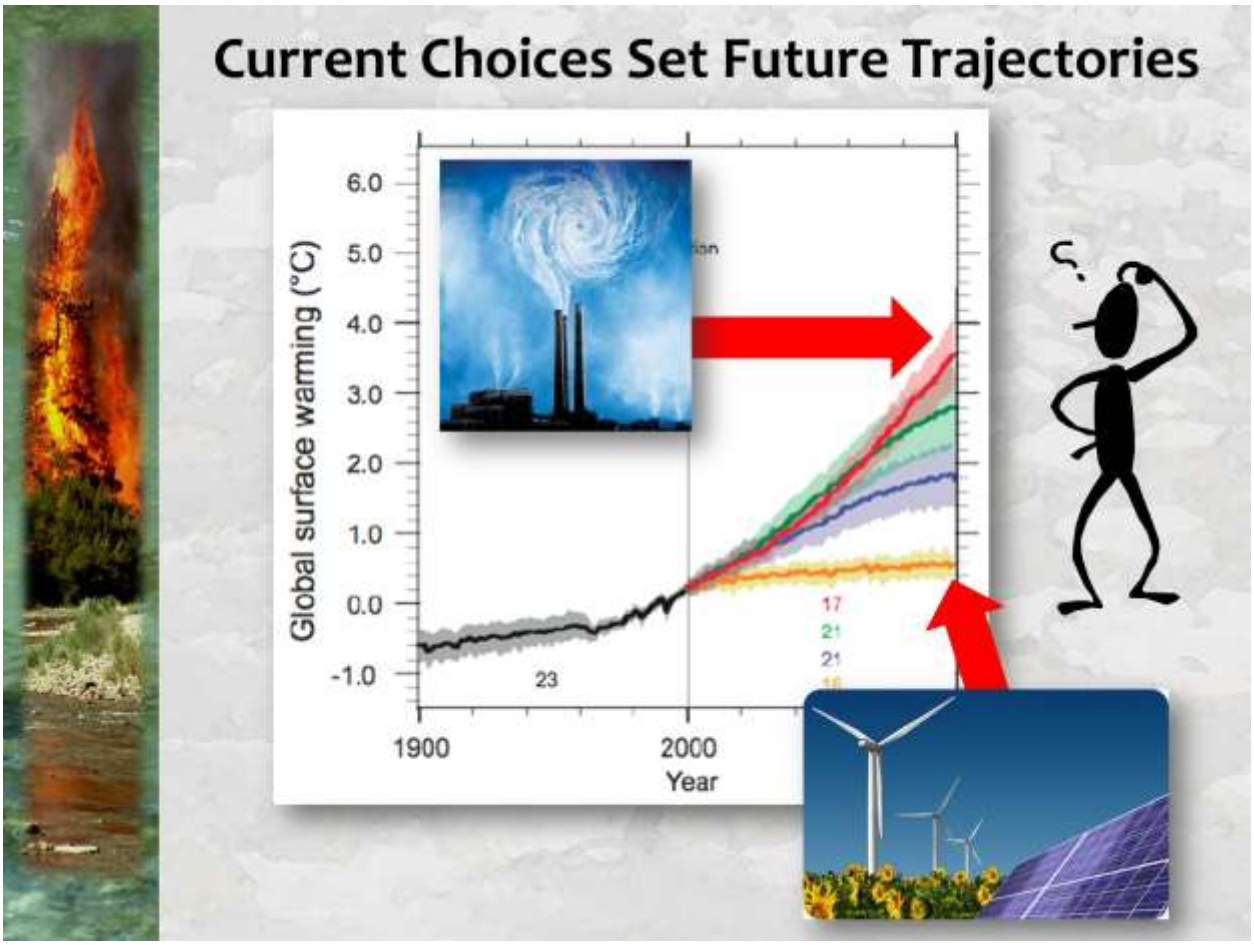
Regional Database and Modeled Stream Temperatures

Google "NorWeST stream temp"




Decision Support Tools Coupled to Accurate Stream GeoSpatial Data Facilitate Powerful Conversations & Help Build Consensus
Stream Climate Scenarios
Obvious Yes (≥ 4 Votes)
Priorities
VIC Hydrology
NorWeST temp
Yes
Maybe's? (1-2 votes)
Decision Support Tool
Maybe?
No
Obvious No (0 Votes)
Spatial Data Layers


Local Expertise Contributed by those Familiar With Specific Landscapes, Streams & Fish Populations is the Critical "X" Factor in Decision Making
X
NorWeST
Stream Temp
BIG FISH Surveys
VIC flows
NHDPlus Hydrology Layer Variables
Regionally/Nationally Consistent Stream Data Enable Applications Anywhere
Slope
Distance



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 here: (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temp/stream_temperature_climate_aquatics_blog.html). The intent of the Climate-Aquatics Blog is to provide a means for the 6,551 (& growing) field biologists, hydrologists, anglers, students, managers, and researchers currently on this mailing list across North America, South 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 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 my colleagues & I have been conducting in the Rocky Mountain region, but attempts will be made to present topics & tools in ways that highlight their broader, global relevance. 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 occur to facilitate the rapid dissemination of knowledge among those concerned about climate change and its effects on aquatic ecosystems.

If you know others interested in climate change and aquatic ecosystems, please forward this message to them. If you do not want to be contacted again in the future, please reply to that effect and you will be de-blogged.

Previous Blogs…

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
Blog #40: Crowd-sourcing a BIG DATA regional stream temperature model

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
Blog #41: Part 1, Mechanisms of change in fish populations: Patterns in common trend monitoring data
Blog #42: BREAKING ALERT! New study confirms broad-scale fish distribution shifts associated with climate change
Blog #43: Part 2, Mechanisms of change in fish populations: Floods and streambed scour during incubation & emergence
Blog #44: Part 3, Mechanisms of change in fish populations: Lower summer flows & drought effects on growth & survival
Blog #45: Part 4, Mechanisms of change in fish populations: Temperature effects on growth & survival
Blog #46: Part 5, Mechanisms of change in fish populations: Exceedance of thermal thresholds
Blog #47: Part 6, Mechanisms of change in fish populations: Interacting effects of flow and temperature
Blog #48: Part 7, Mechanisms of change in fish populations: Changing food resources
Blog #49: Part 8, Mechanisms of change in fish populations: Non-native species invasions
Blog #50: Part 9, Mechanisms of change in fish populations: Evolutionary responses
Blog #51: Part 10, Mechanisms of change in fish populations: Extinction
Blog #52: Review & Key Knowable Unknowns
Blog #53: DNA Barcoding & Fish Biodiversity Mapping

Climate-Aquatics Management Module
Blog #54: Part 1, Managing with climate change: Goal setting & decision support tools for climate-smart prioritization

Future topics…
Climate-Aquatics End Game