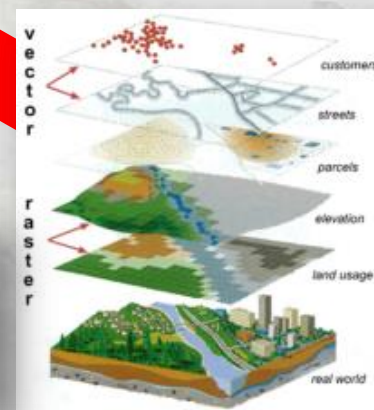
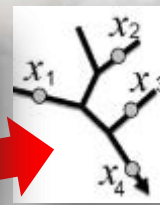
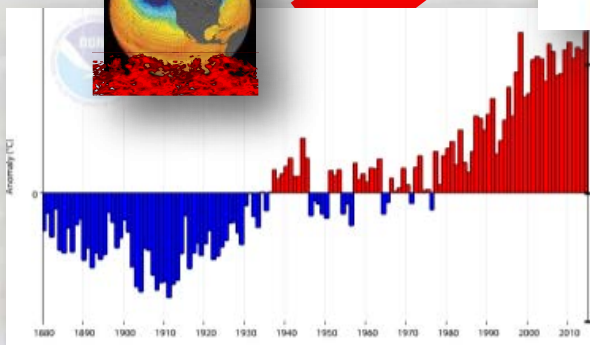
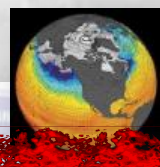


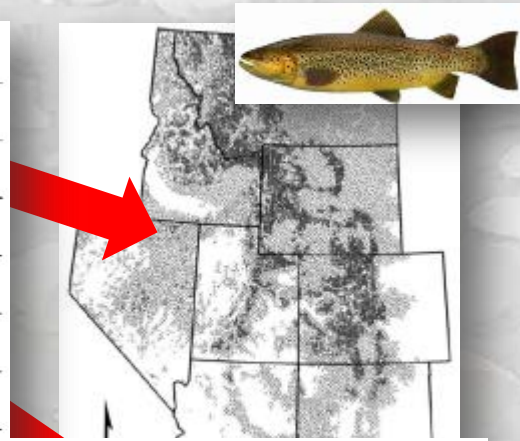
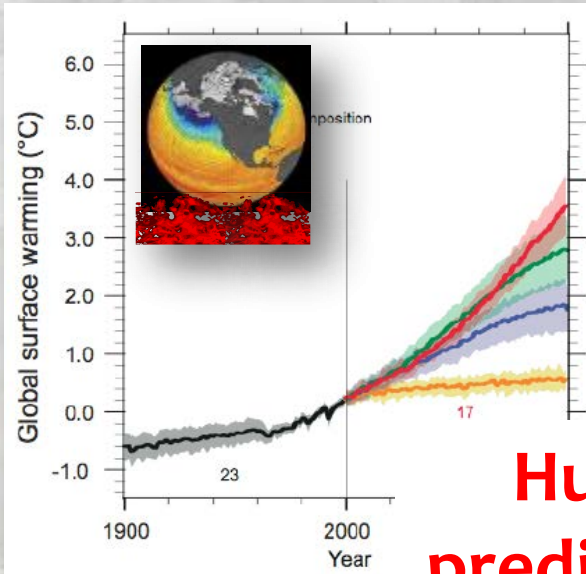
Cutting Climate Change Down to Size Through Crowd sourcing, Collaborations, Better Monitoring and Models

Dan Isaak

US Forest Service Research

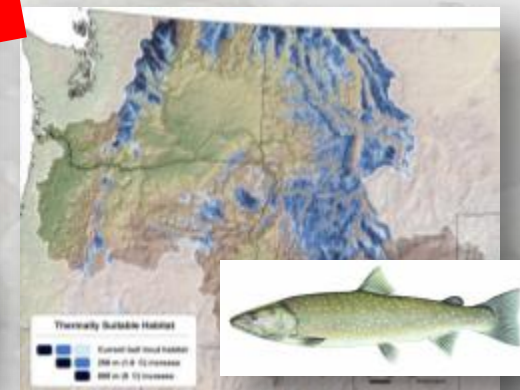
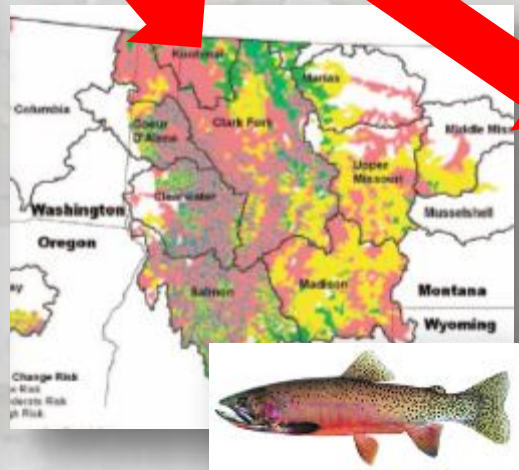


Common Perception: Cold-Water Fish World is Ending...

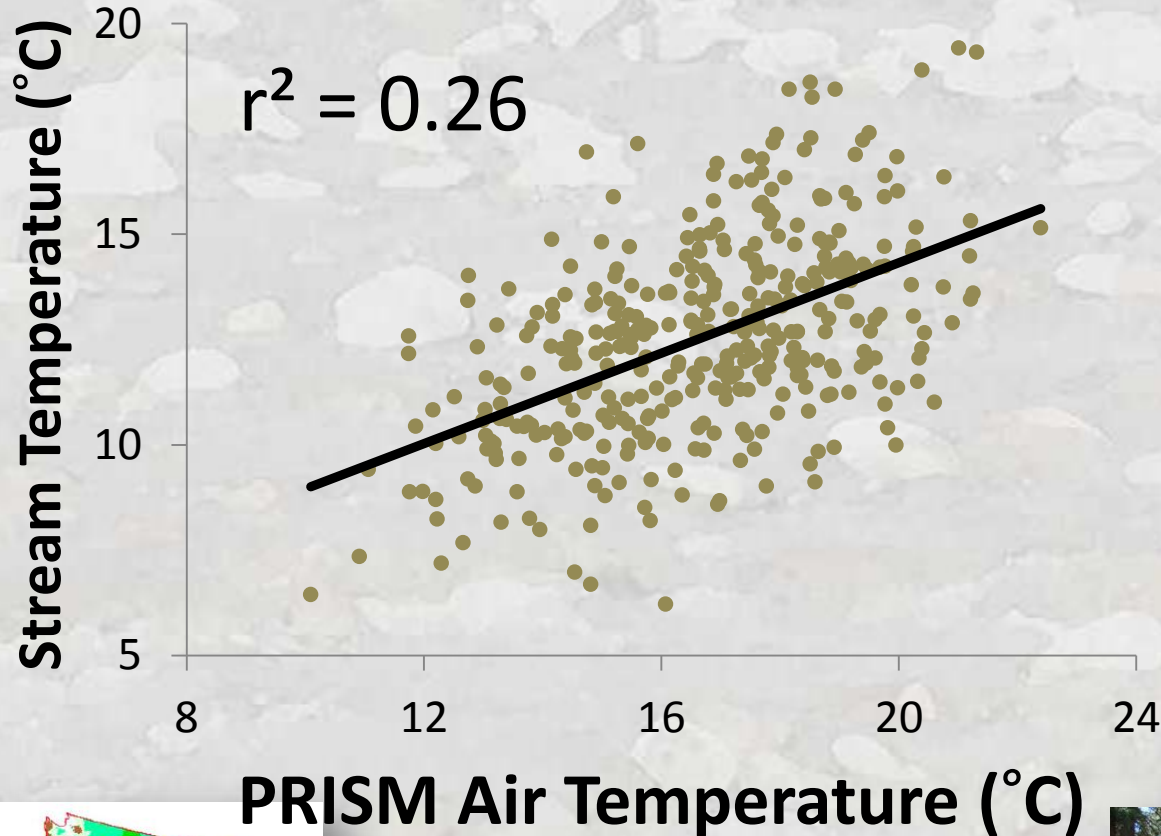


**Huge declines
predicted: 50%-100%**

- Meisner 1988
- Keleher & Rahel 1996
- Eaton & Schaller 1996
- Reusch et al. 2012
- Rahel et al. 1996
- Mohseni et al. 2003
- Flebbe et al. 2006
- Rieman et al. 2007
- Kennedy et al. 2008
- Williams et al. 2009
- Wenger et al. 2011
- Almodovar et al. 2011
- Etc.



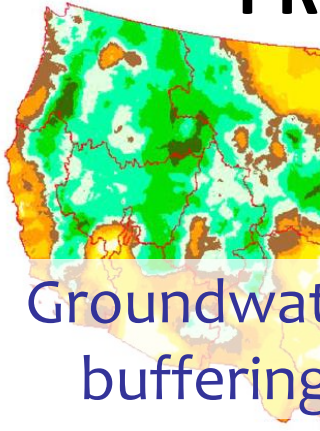
Air Temp \neq Stream Temp



Complex topography



Glaciation



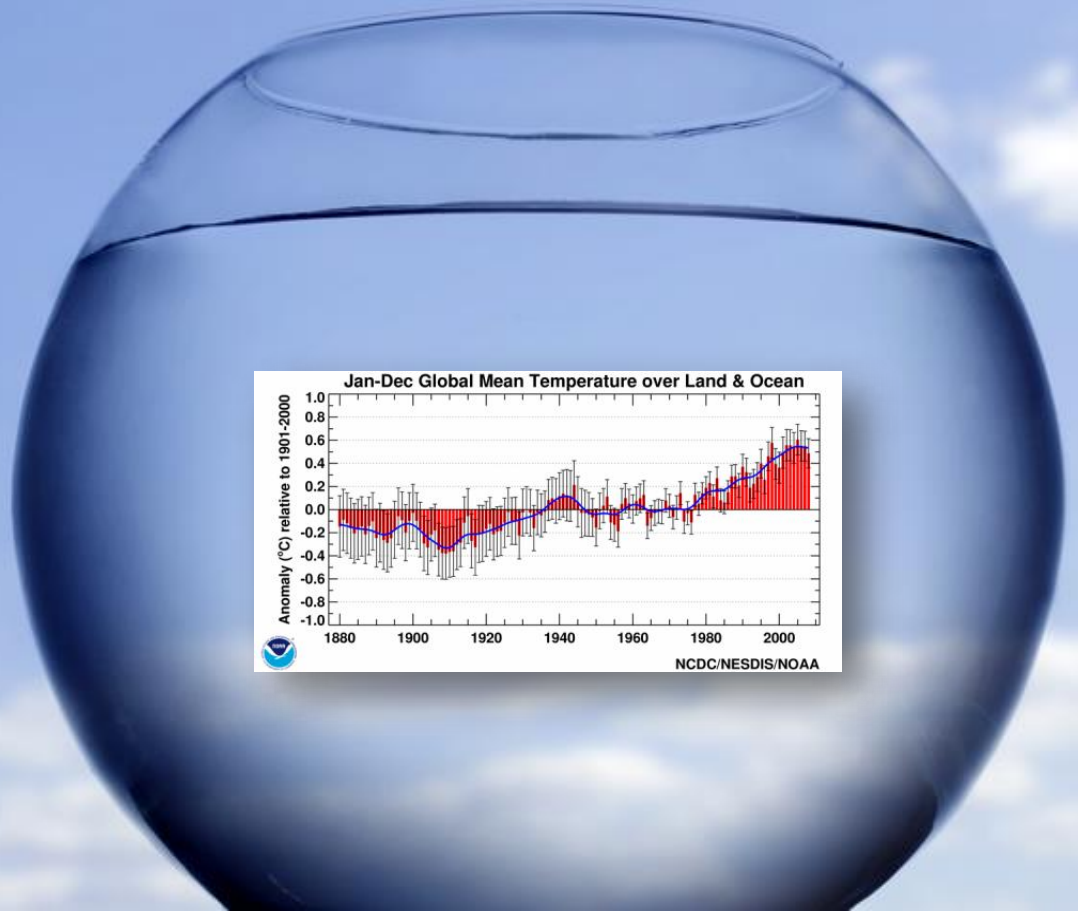
Groundwater buffering



Riparian differences



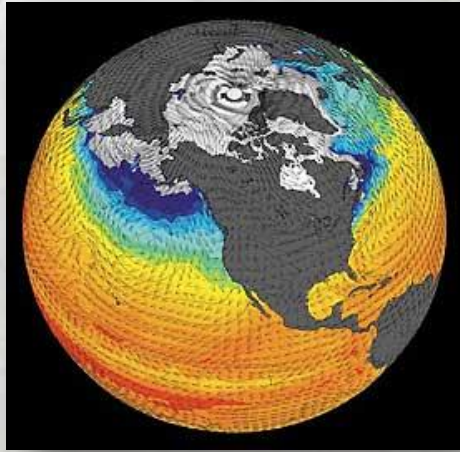
Taking Climate Into the Water Where Fish Live



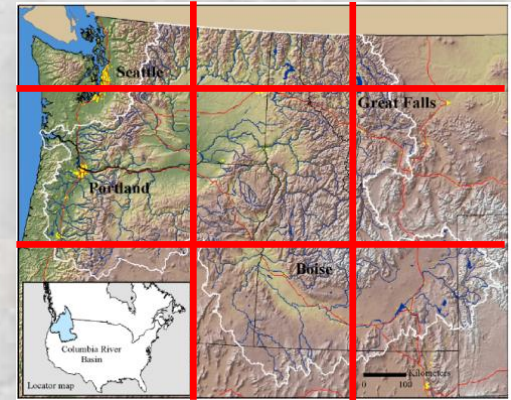
Taking Climate Into the Water

Where Fish Live

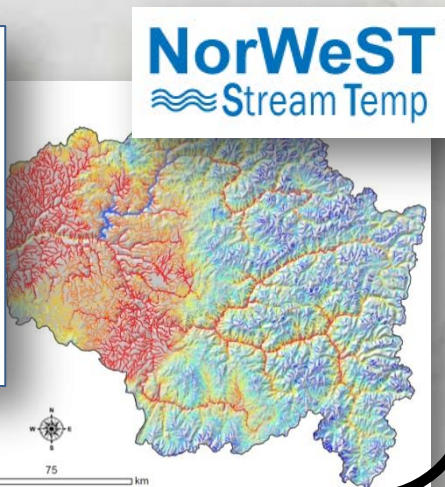
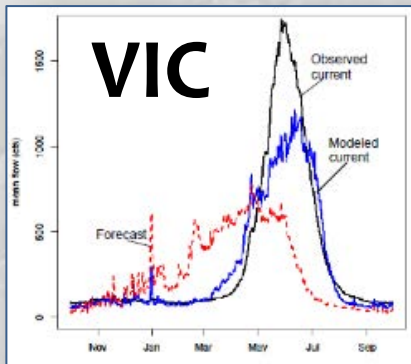
Climate model (air temp & precip)



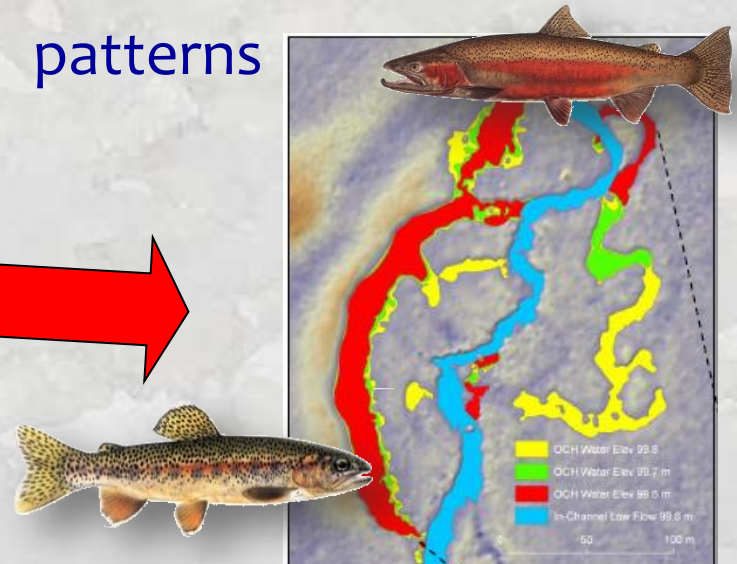
Regional patterns



Stream temperatures & flow

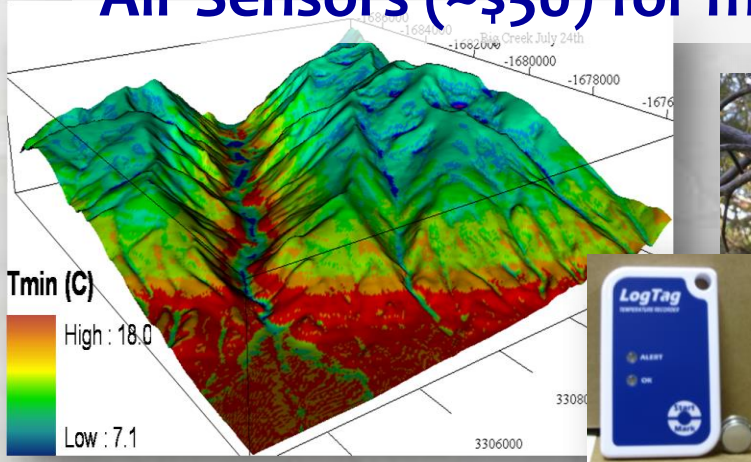


Stream reach patterns



Better Information Flows From Better Monitoring, Databases & Models...

Air Sensors (~\$50) for microclimate models



Stream discharge



\$299 sensor

Stream Temperature

A Simple Protocol Using Underwater Epoxy to Install Annual Temperature Monitoring Sites in Rivers and Streams

Daniel J. Isaak
Dona L. Horan
Sherry P. Wollrab



\$130 = 5 Years of Data

Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams



Standard Protocols

Better Biological Databases Needed

Who All Lives Here?



Mollusks



Amphibians



Non-game fish



Aquatic eDNA Revolution Will Change That

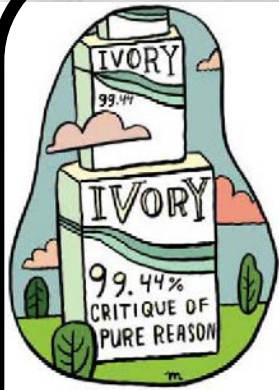
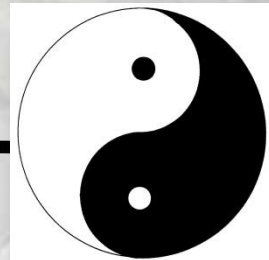


A "Virtuous Cycle" of Information

Many stakeholders



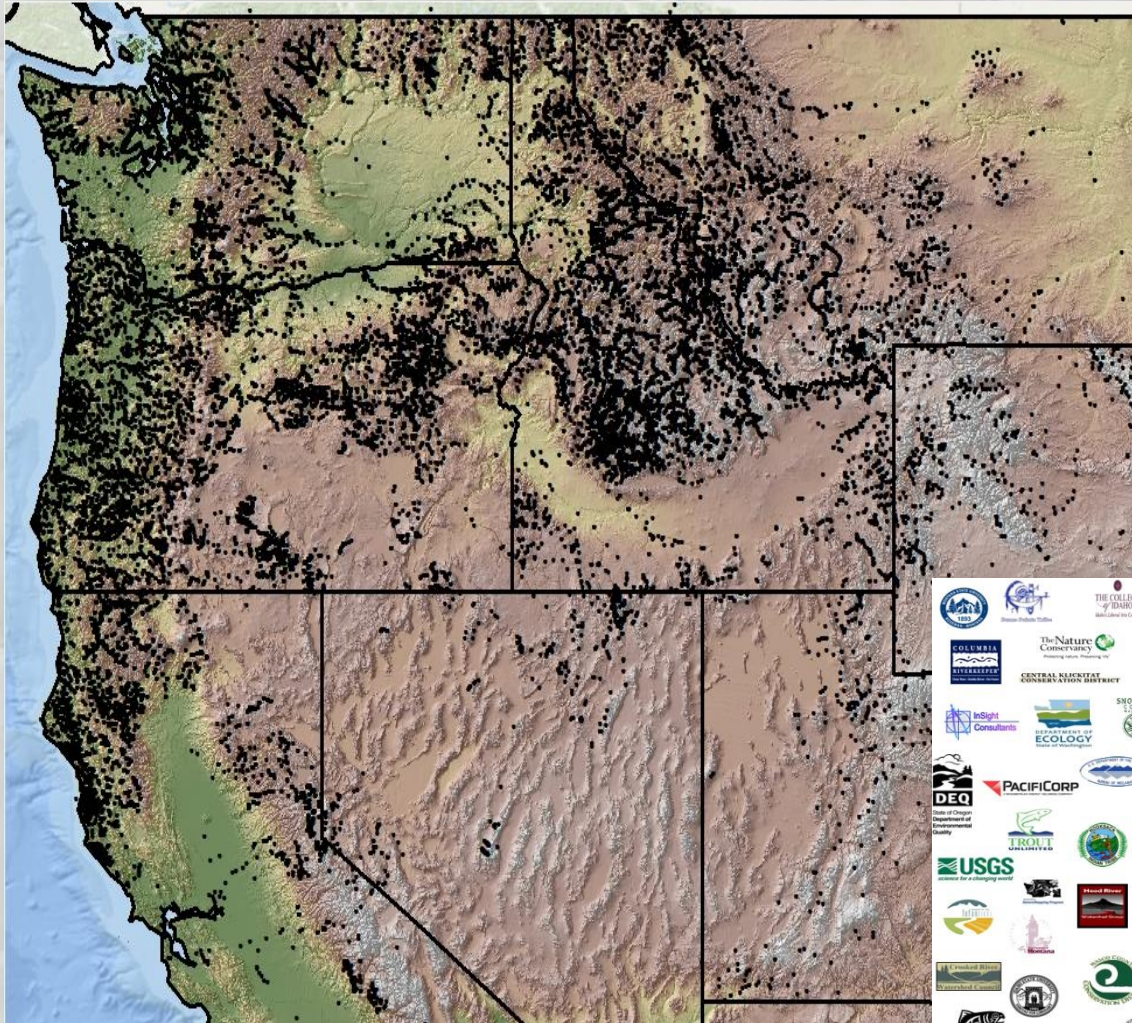
"Boots-on-the-Ground"



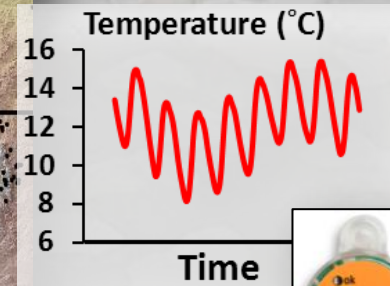
Research develops/maintains open-access databases

Mountains of data

A Western Example with Temperature Data



NorWeST
Stream Temp

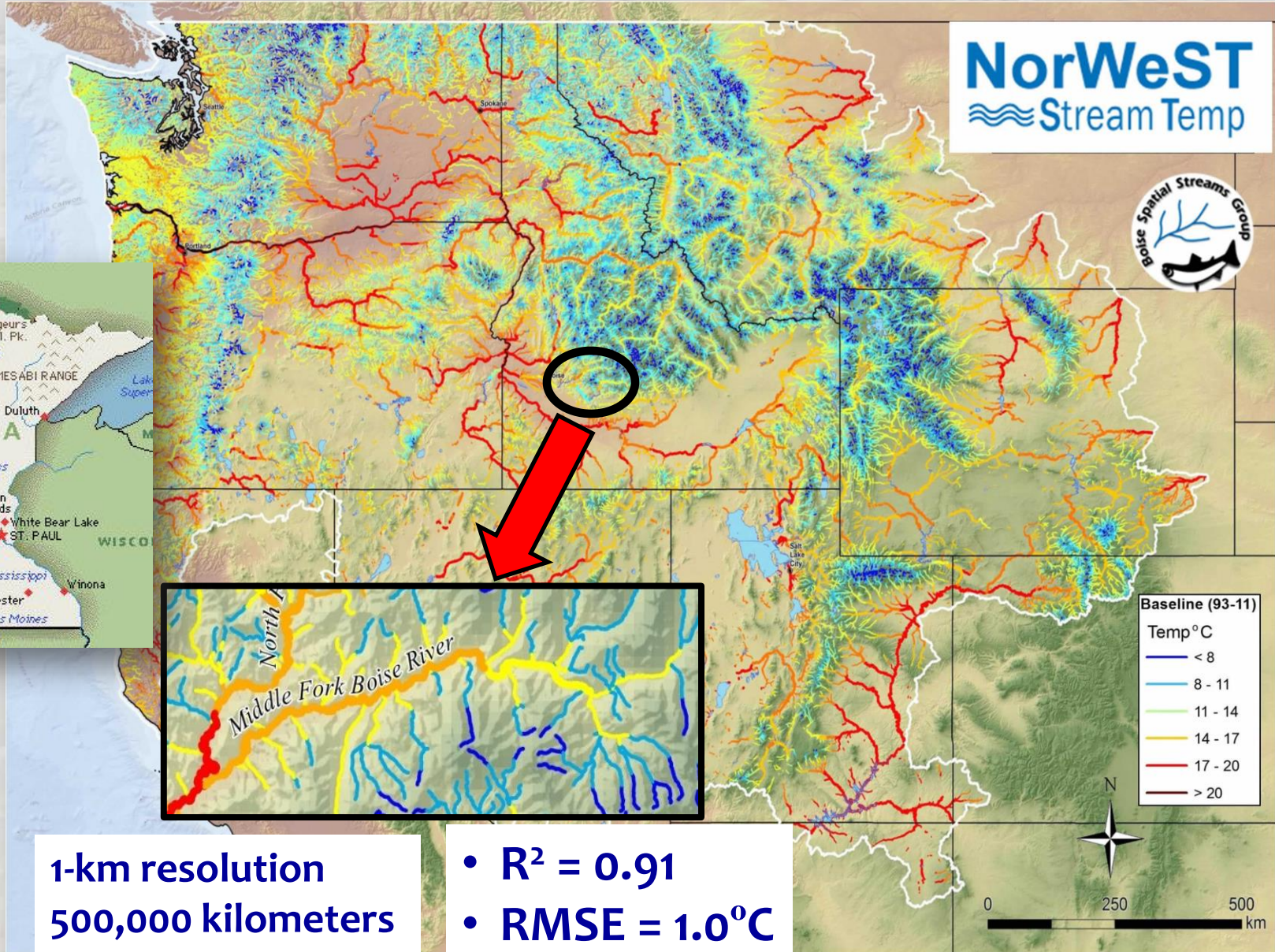


>150,000,000 hourly records
>20,000 unique stream sites



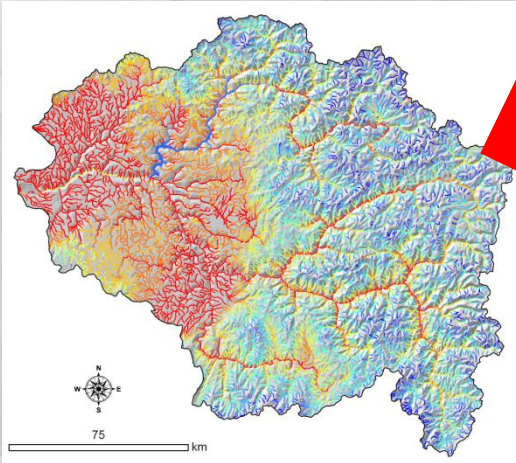
>100 agencies

High-Resolution Stream Scenarios

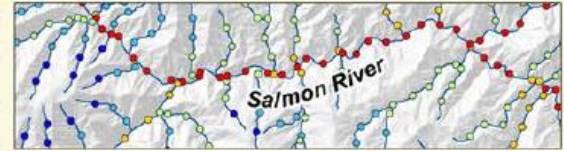


Website: Distributes Information in Useful Digital Formats (ArcGIS & .pdfs & Excel)

1) GIS shapefiles of stream temperature scenarios

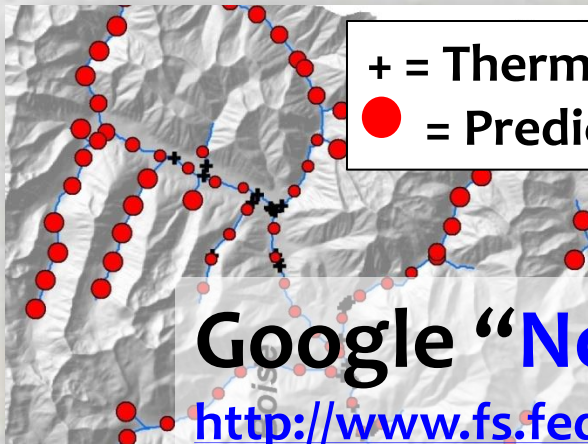


NorWeST
Stream Temp



Regional Database and Modeled Stream Temperatures

2) GIS shapefiles of stream temperature model prediction precision



+ = Thermograph
● = Prediction SE

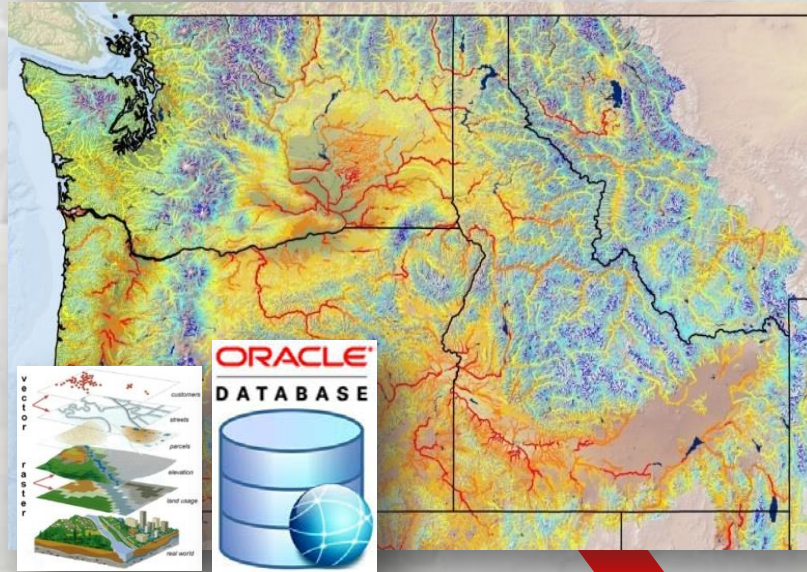
3) Temperature data summaries



Google **"NorWeST"** or go here...

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

Temperature Applications

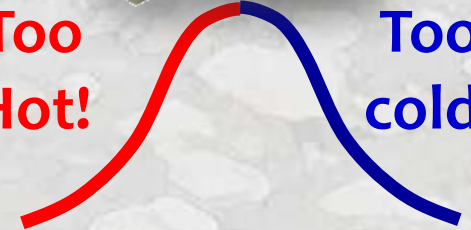


Regulatory temperature standards

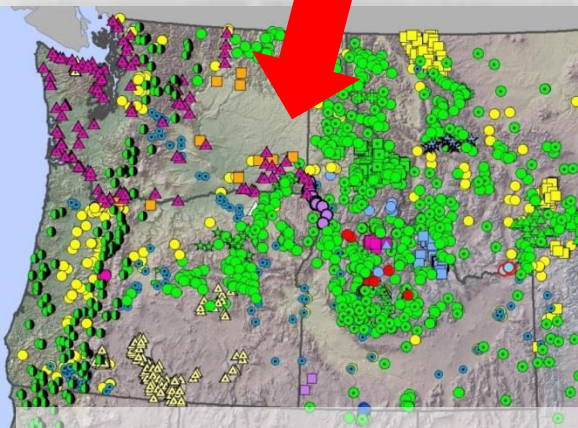


Too Hot!

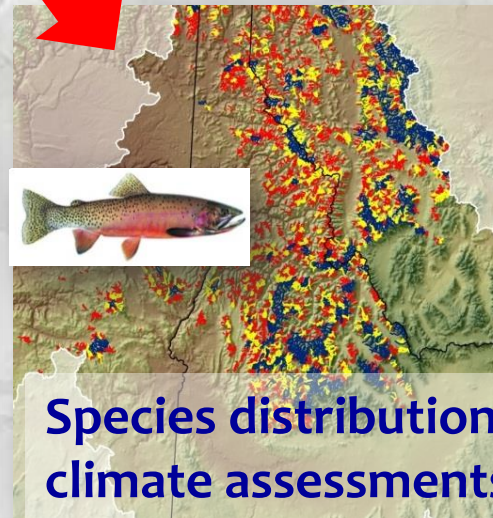
Too cold!



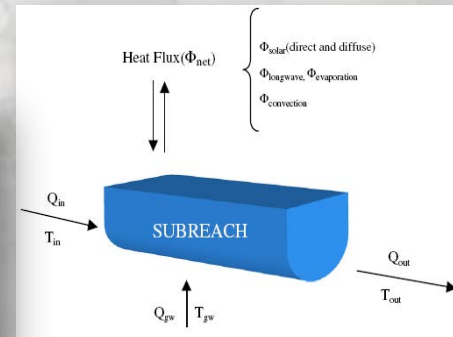
Data access accelerates temperature research



Coordinated Interagency monitoring



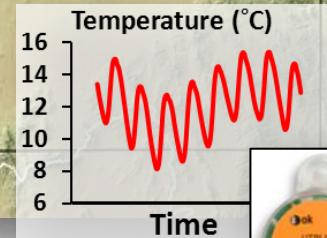
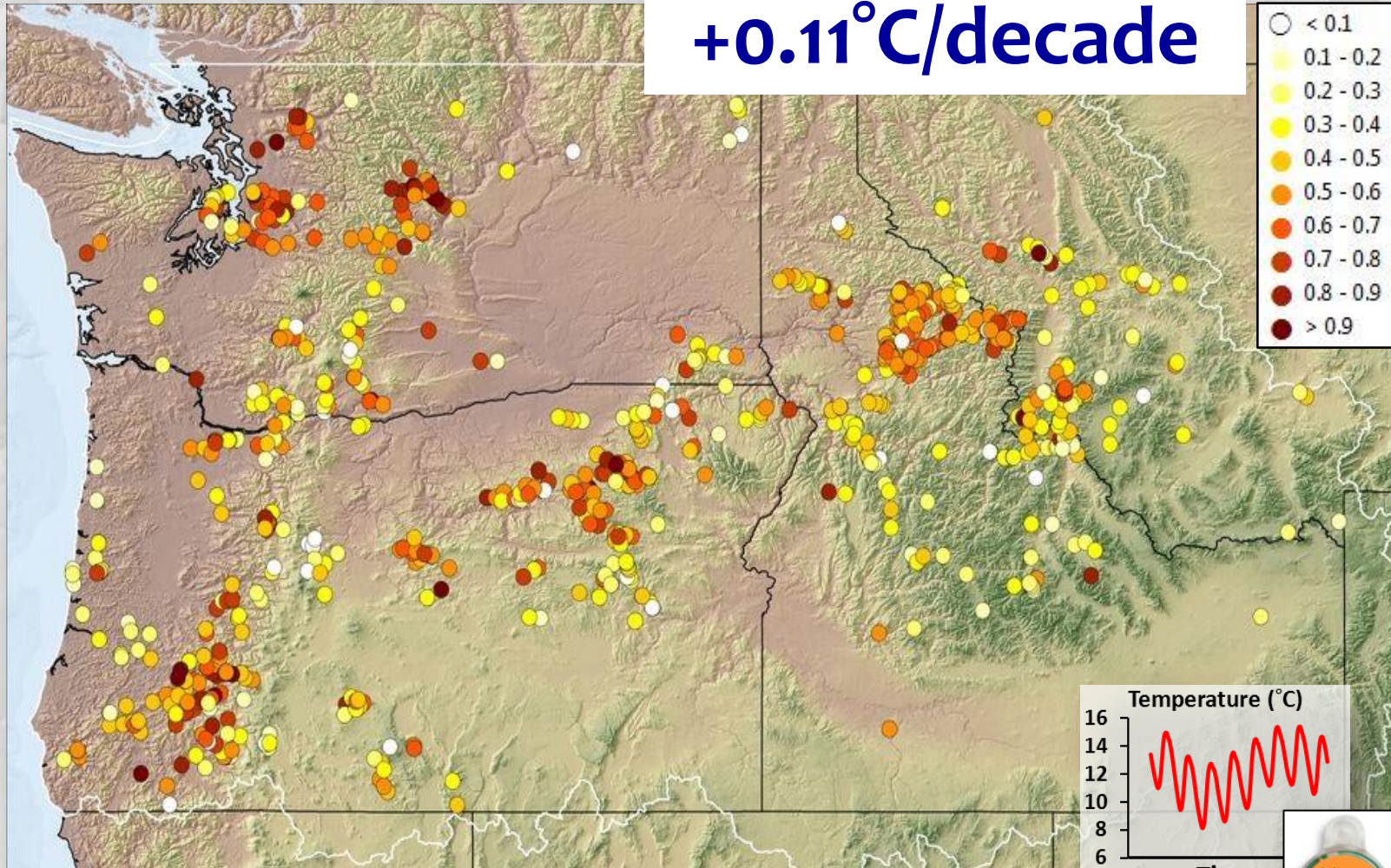
Species distribution models & climate assessments



Database Query: Stream Warming Rates?

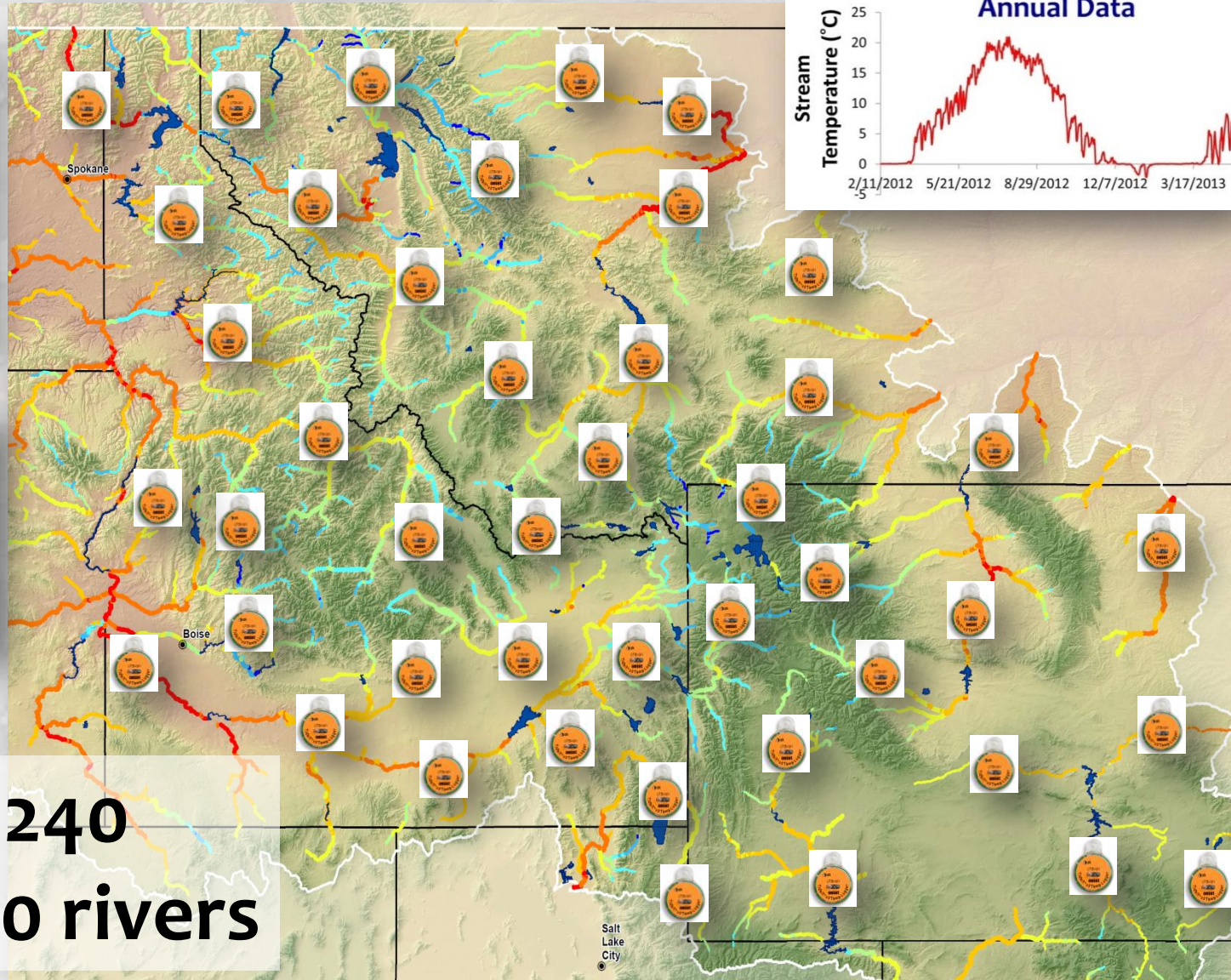
923 sites in NorWeST database with >10 year records

+0.11°C/decade



Database Query: Monitoring Gaps?

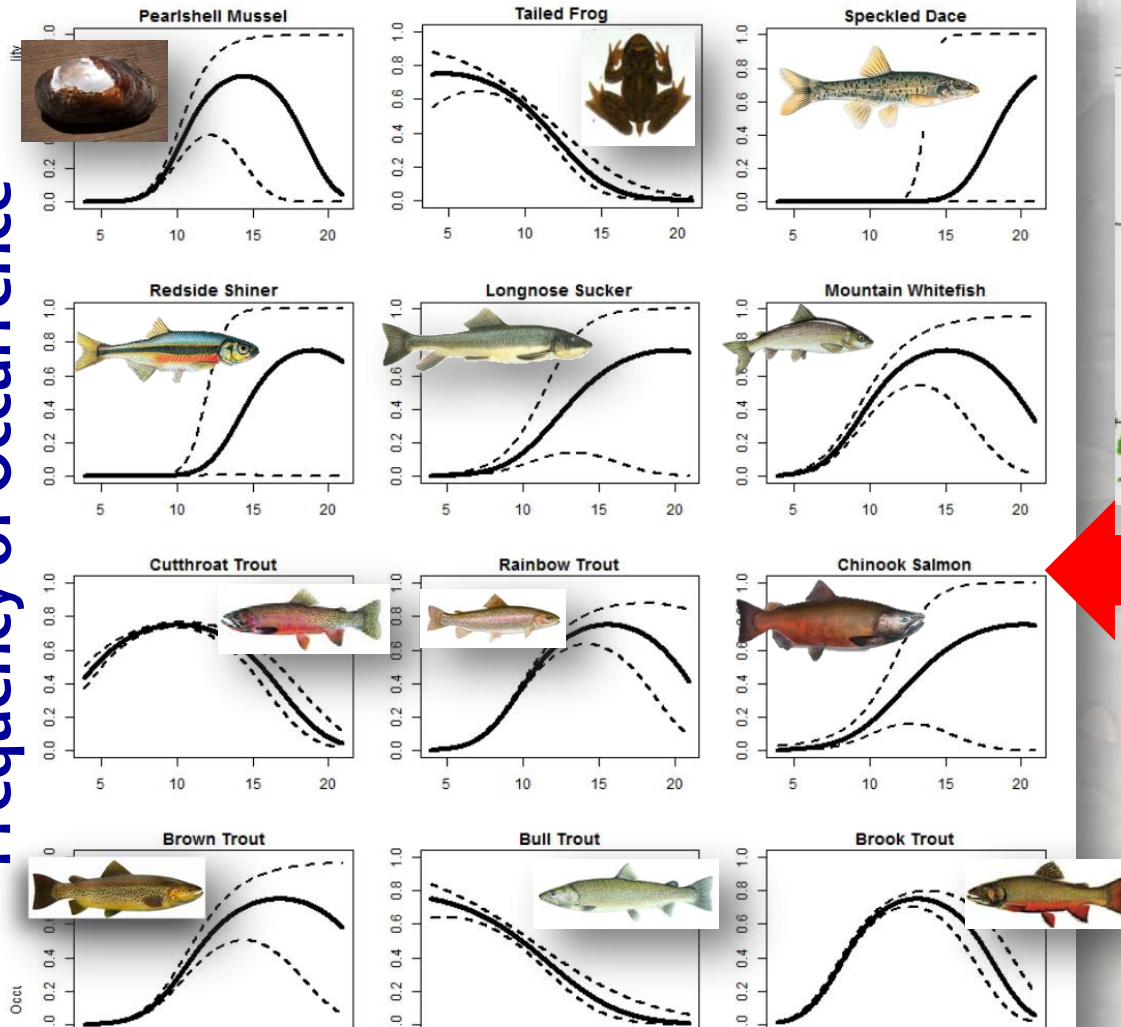
Large rivers lacked temperature data



NoRRTN: 240
sites on 80 rivers

Thermal Criteria For Dozens of Species

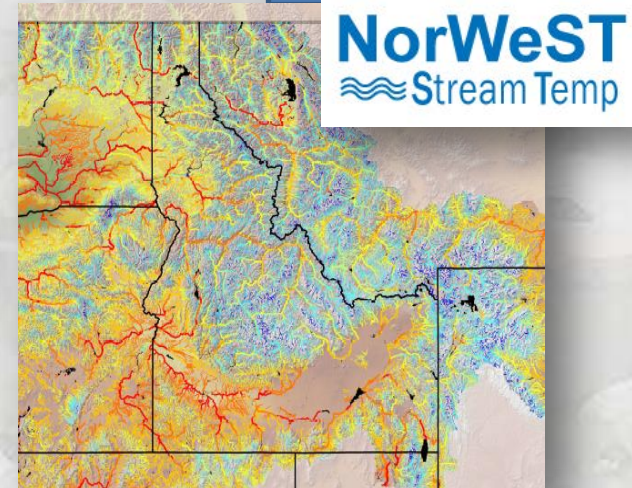
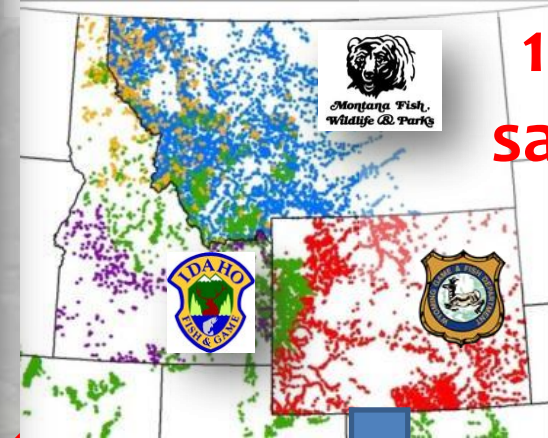
Frequency of Occurrence



NorWeST Stream Temperature (S1)

BIG FISH Databases

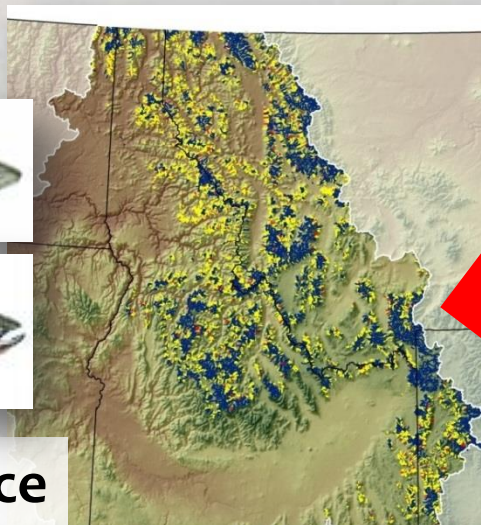
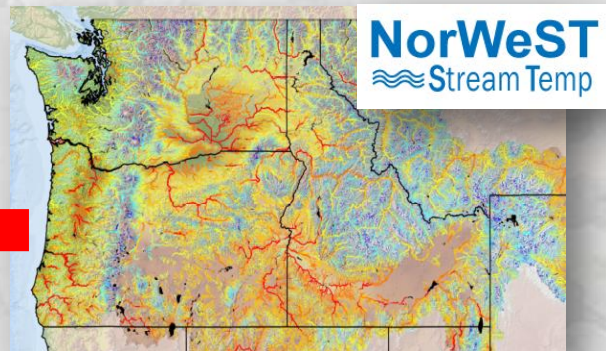
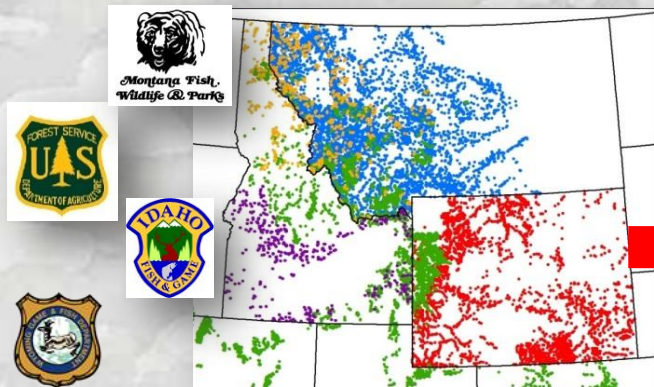
13,000
sample
sites



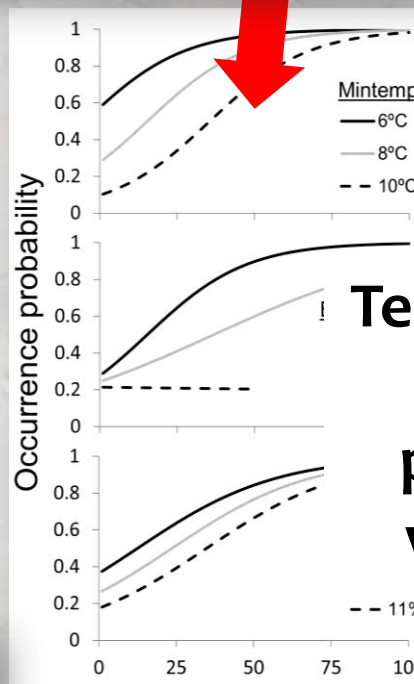
Wenger et al. *In Review*. Description of realized thermal niches from massive biological & temperature databases. *EcoSphere*

Precise Species Distribution Models to Highlight Climate Refugia

BIG FISH DATA



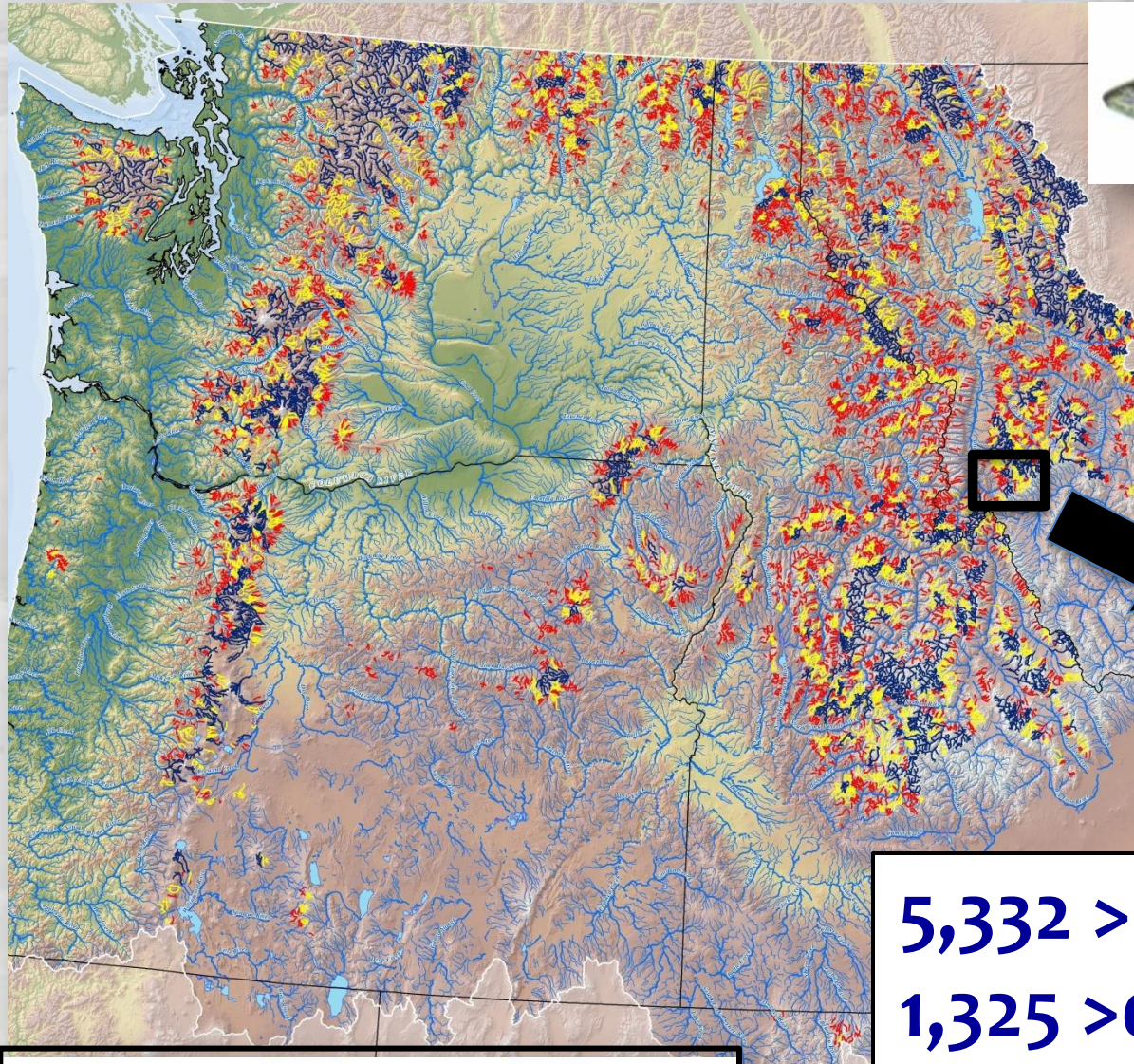
Occurrence probability maps



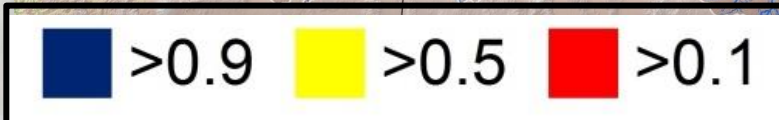
Temperature & other predictor variables

Isaak et al. 2015. The cold-water climate shield: Delineating refugia for preserving native trout through the 21st Century. *Global Change Biology* 21: 2540-2553

Bull Trout Occurrence Probability Map 1980s



Precise local
information



5,332 >0.1 habitats
1,325 >0.5 habitats
348 >0.9 habitats



Bull Trout Occurrence Probability Map 2080s

North Cascades



Flathead


Walla Walla

Metolius

Upper
Salmon

**Worst
case
scenario!**

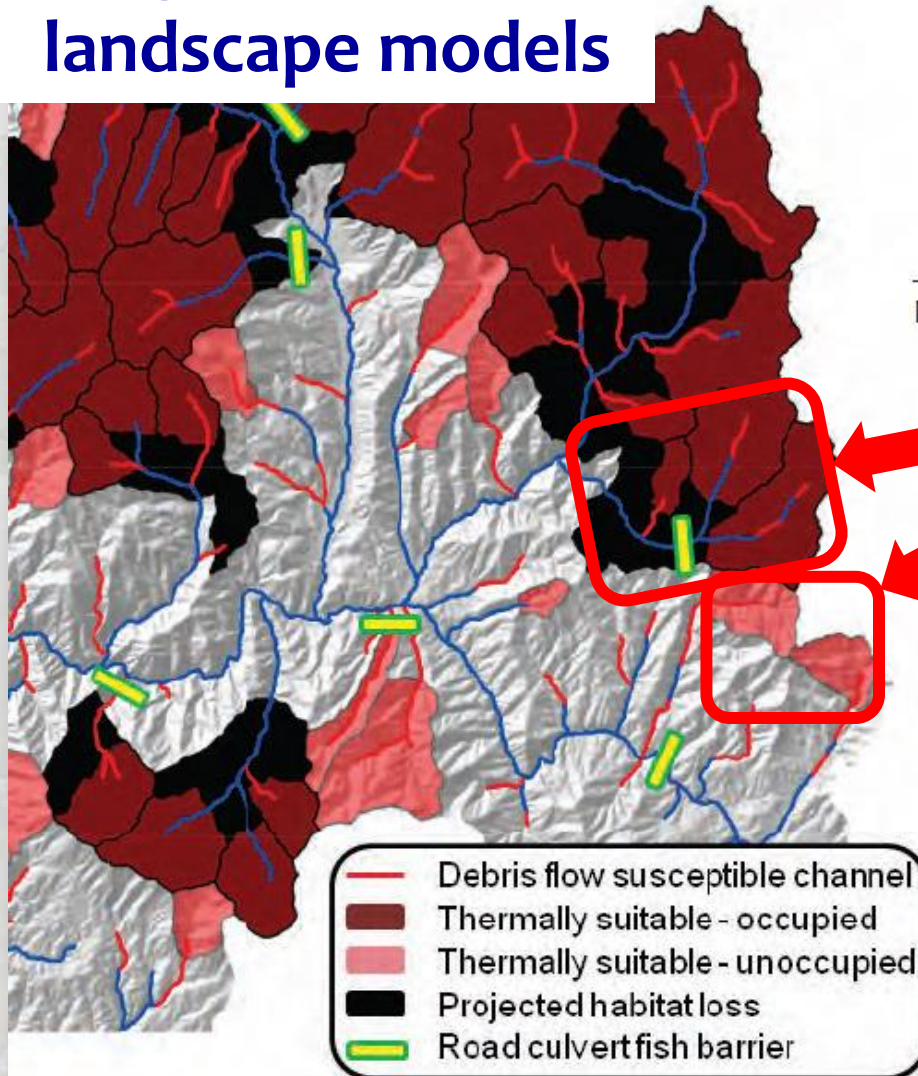


 >0.1

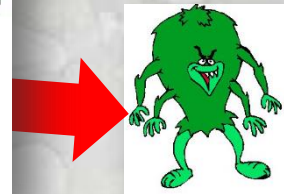
2,712 >0.1 habitats
460 >0.5 habitats
62 >0.9 habitats

Precise Climate Information Empowers Local Decision Makers

High-resolution
landscape models



Climate
boogeyman
less scary

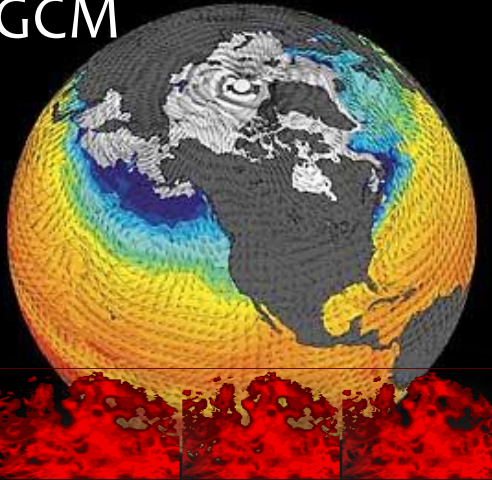


I'm going to invest here...
... instead of here

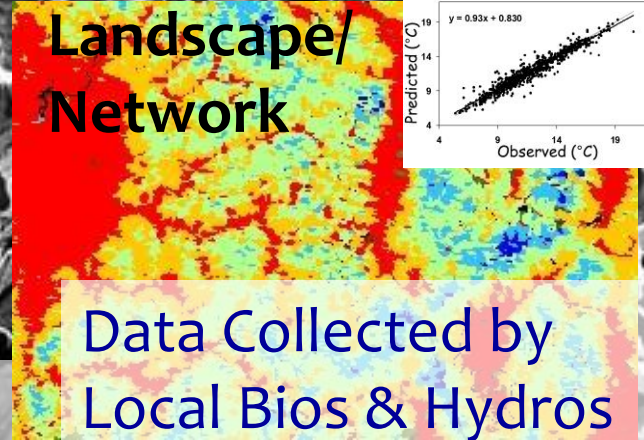


Crowd-Sourcing is a Powerful Tool for Better Science & Broader Engagement

GCM



Landscape/
Network

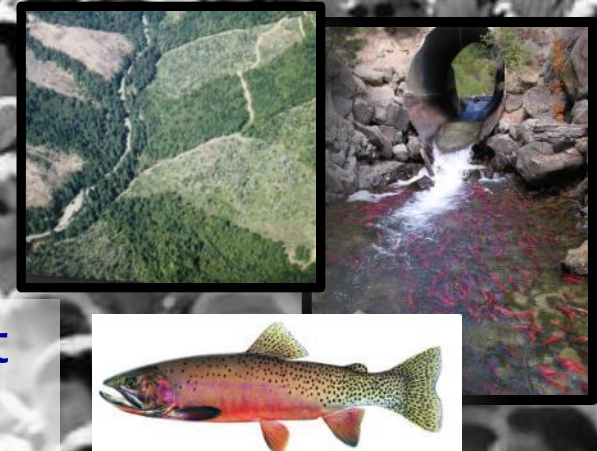


Coordinated
Management
Responses

Data Collected by
Local Bios & Hydros



Management
Decisions



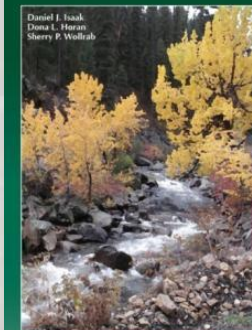
Additional Resources...

Websites (Google Search On...)

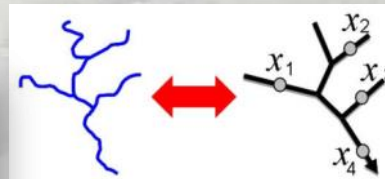
- 1) **SSN/STARS** – statistical modeling of data on networks
- 2) **NorWeST** – regional stream temperature database & climate scenarios
- 3) **Forest Service Stream Temperature**

Publications & protocols...

A Simple Protocol Using Underwater Epoxy to Install Annual Temperature Monitoring Sites in Rivers and Streams



Software...



Data...

