

Idaho Applications of the NorWeST Stream Temperature Database, Model, & Climate Scenarios

Dan Isaak, Seth Wenger¹, Erin Peterson², Jay Ver Hoef³ Charlie Luce, Steve Hostetler⁴, Jason Dunham⁴, Jeff Kershner⁴, Brett Roper, Dave Nagel, Dona Horan, Gwynne Chandler, Sharon Parkes, Sherry Wollrab, Colete Breshares, Neal Bernklau

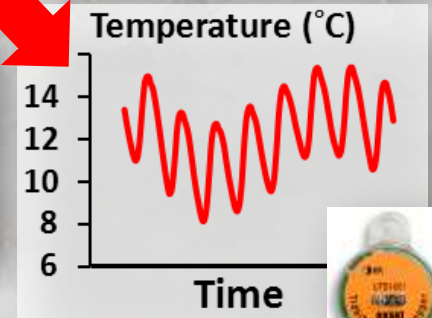
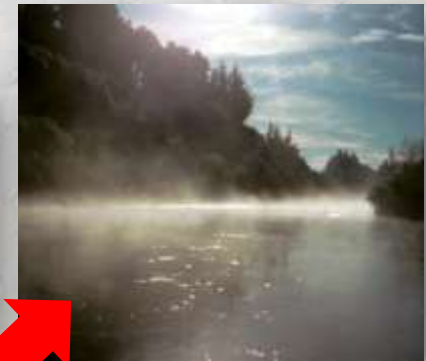
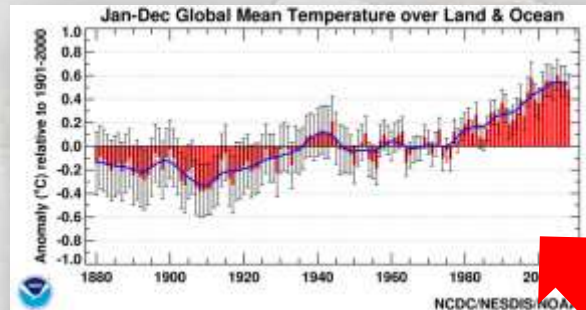
U.S. Forest Service

¹Trout Unlimited

²CSIRO

³NOAA

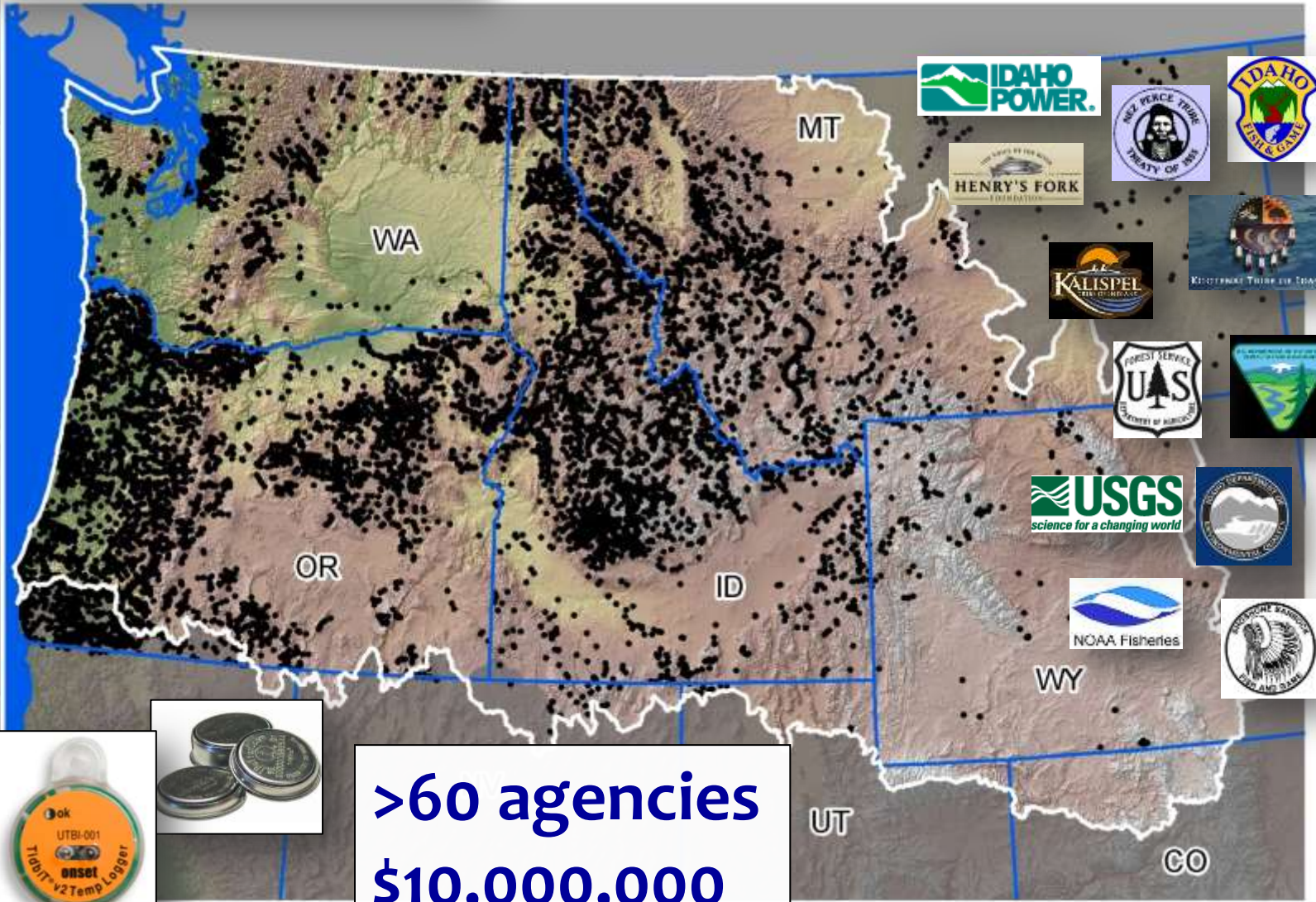
⁴USGS



NorWeST

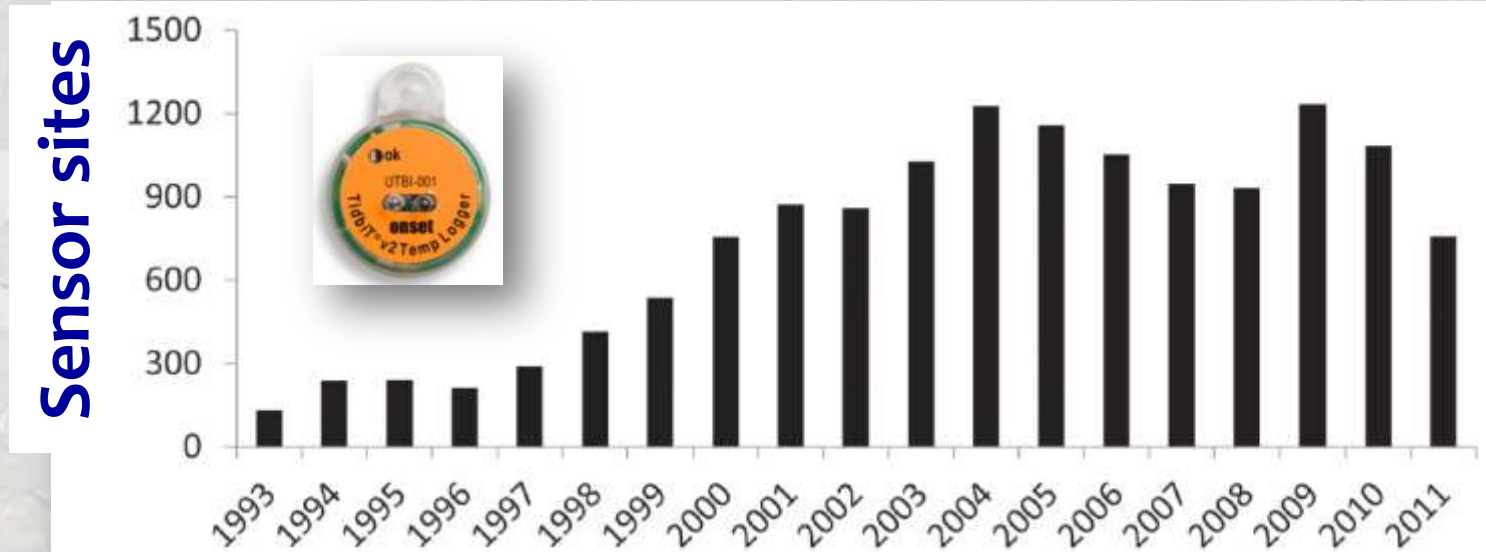
Stream Temp

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

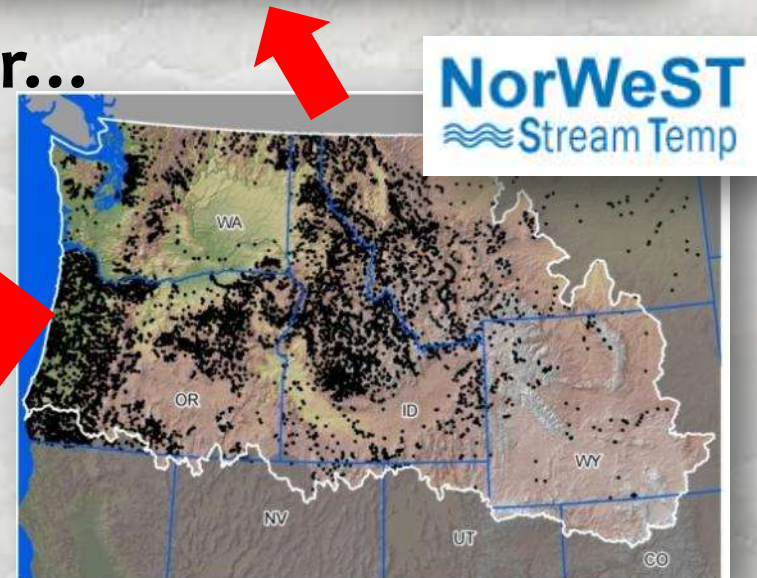
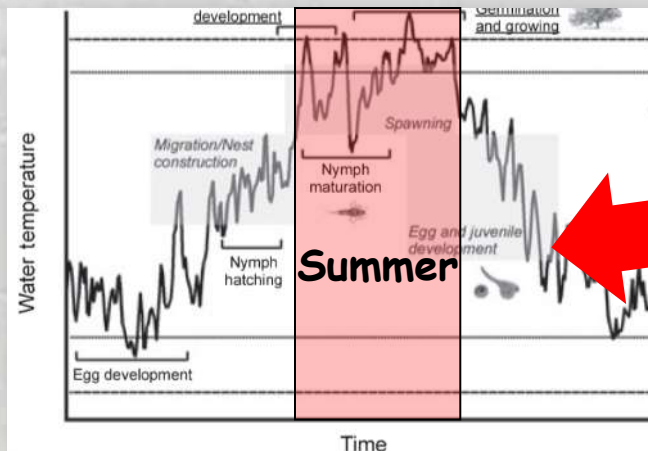


>60 agencies
\$10,000,000

How Do We Monitor? Many sites, but...

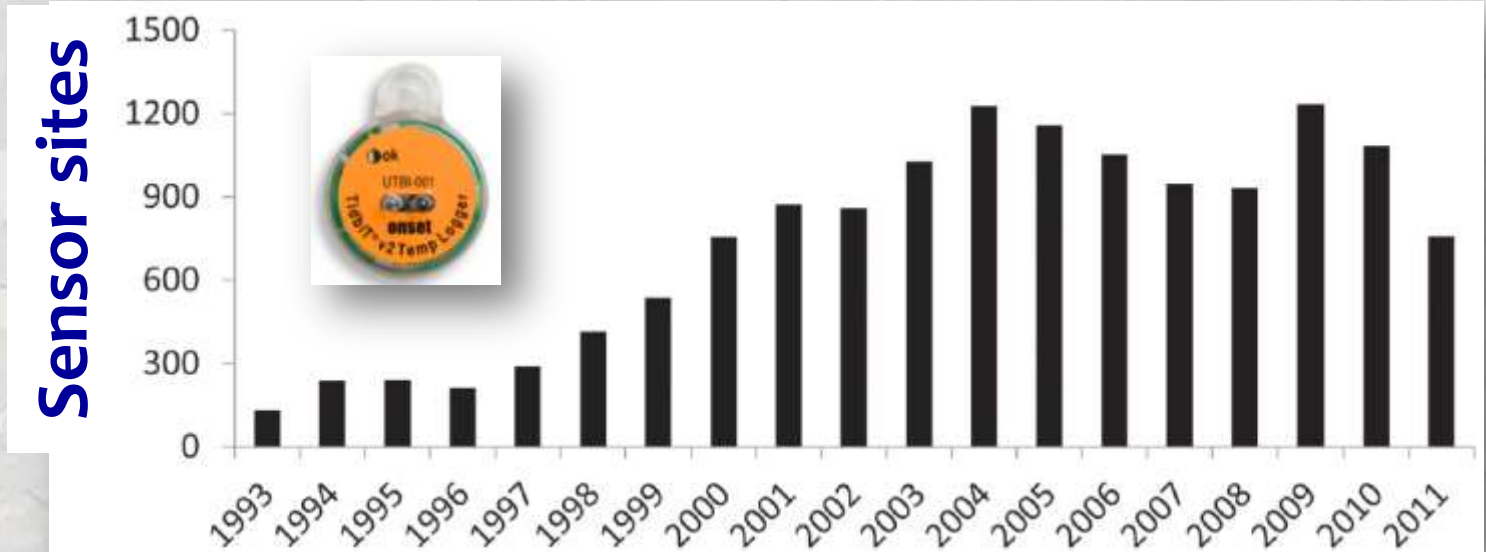


usually only in the summer...

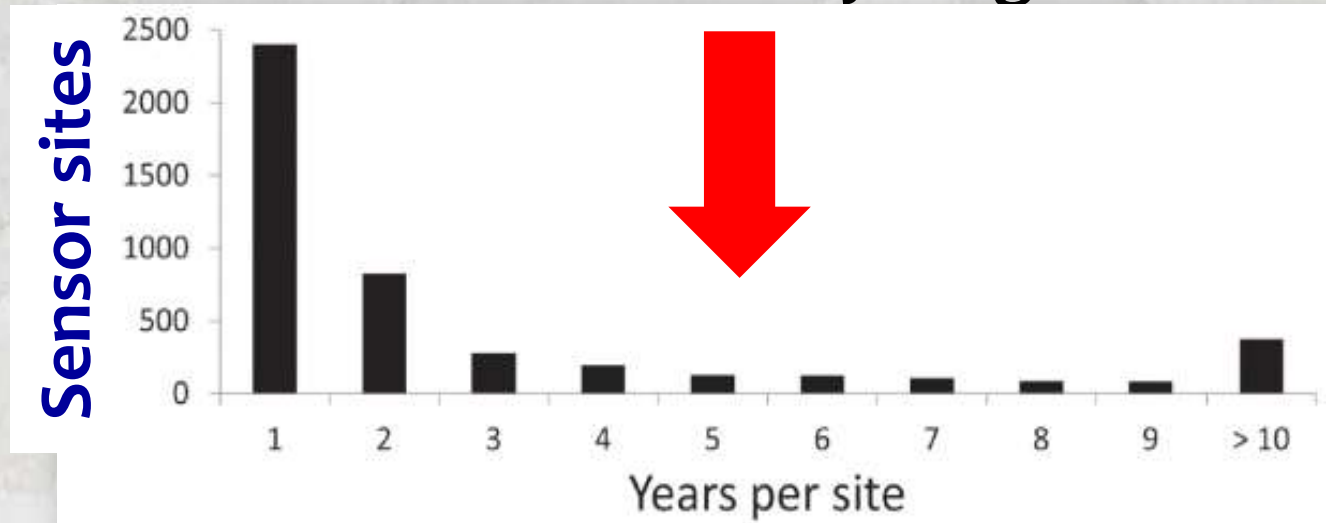


Isaak et al. 2013. [A simple protocol using underwater epoxy to install annual temperature monitoring sites in rivers and streams.](#) USFS General Technical Report, 314.

How Do We Monitor? Many sites, but...



& not for very long

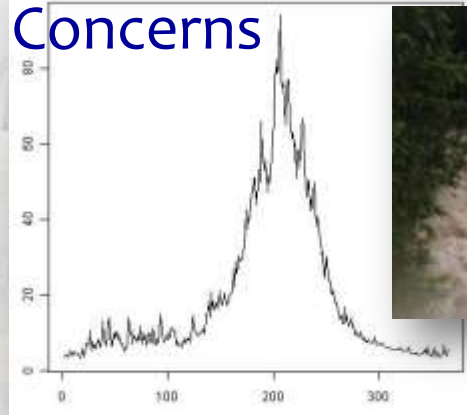


More Longterm, Annual Monitoring Needed

Inexpensive, reliable “epoxy protocol”

Annual Flooding

Concerns



Underwater epoxy cement



\$130 = 5 years of data

Data retrieved
from underwater



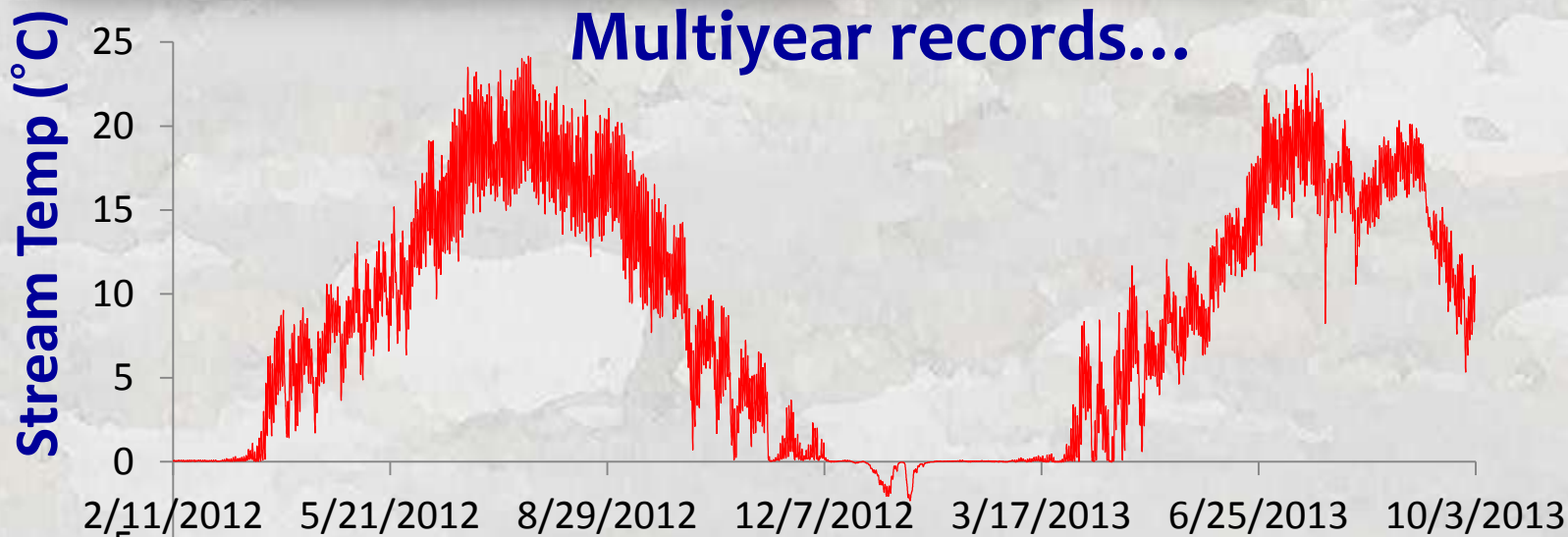
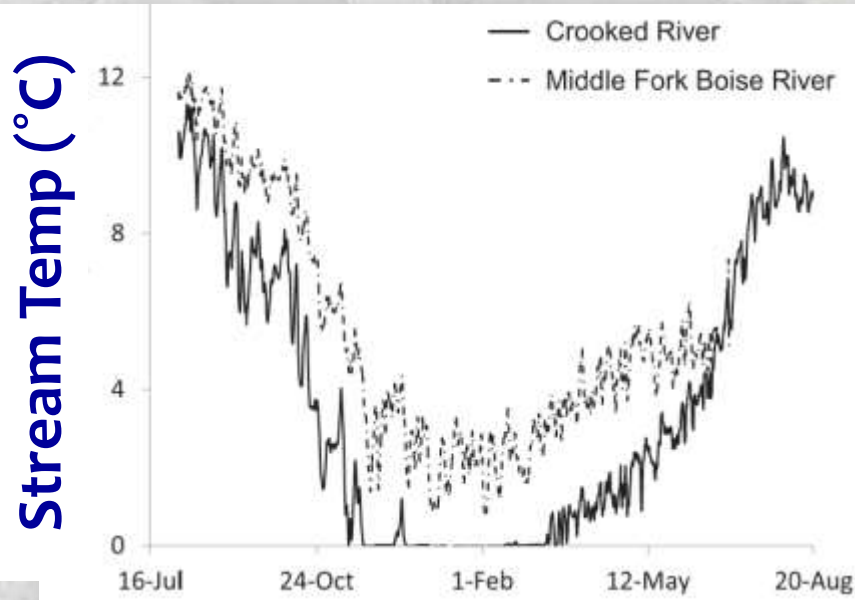
Sensors glued to large
boulders & bridges



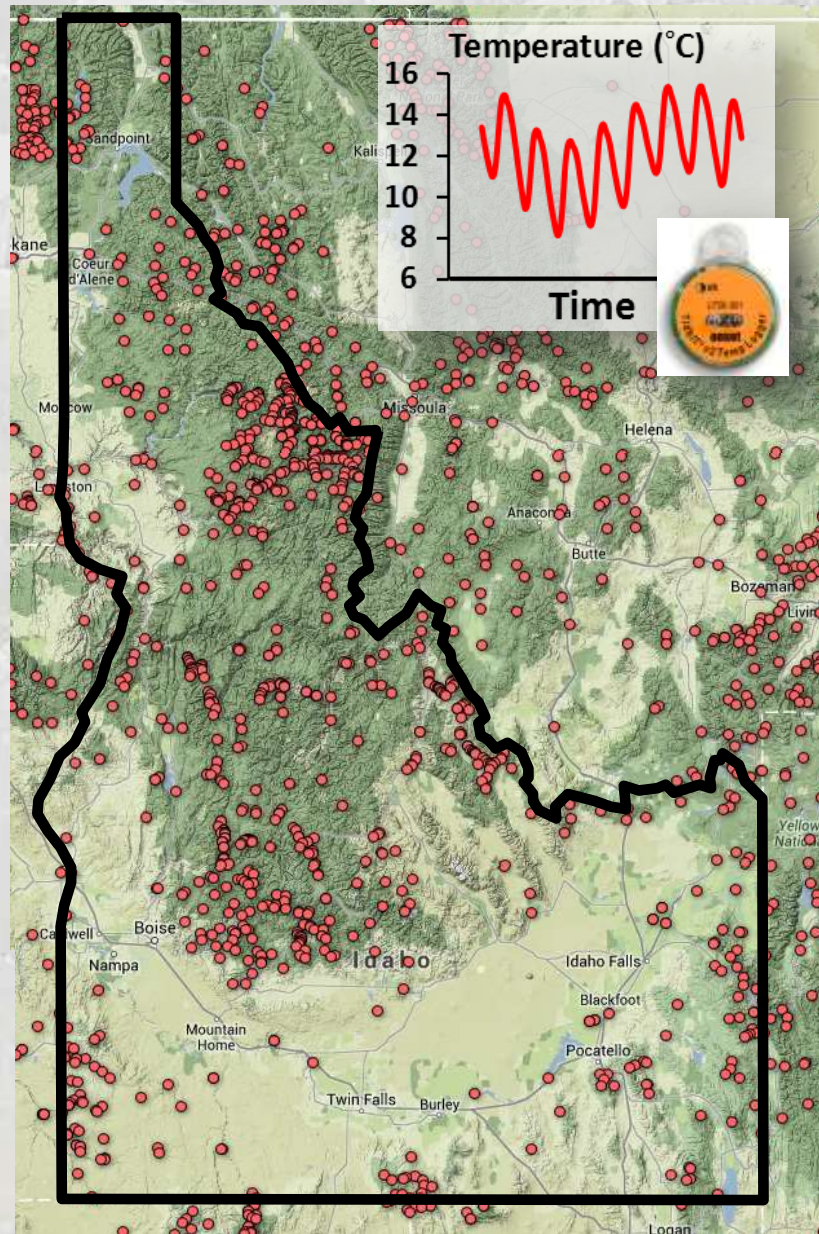
Isaak et al. 2013. USFS Report;
Isaak & Horan 2011. *NAJFM* 31:134-137

It's a Win-Win

More data, more hunting!



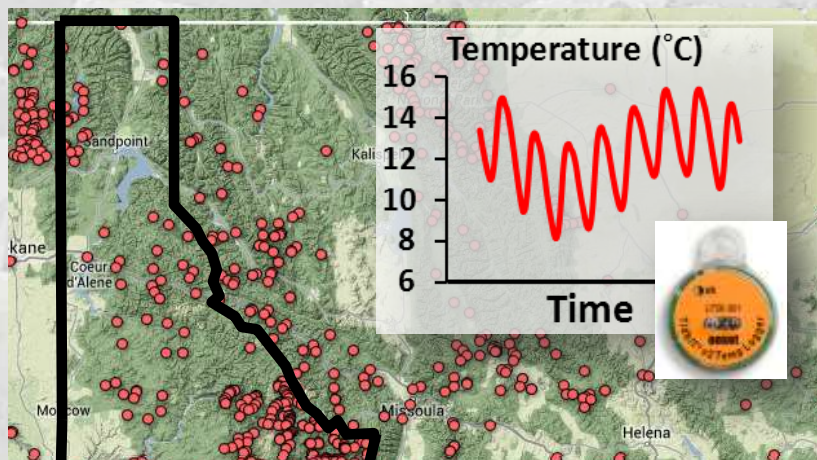
Current Annual Temp Monitoring Sites



- >500 annual sites currently
- GAPS in our coverage?



Current Annual Temp Monitoring Sites



- >500 annual sites currently
- GAPS in our coverage?

GoogleMap Tool for Current Annual Monitoring sites at “**Stream Temperature Monitoring and Modeling**” website



Save to My Maps

Montana Annual Stream Temperature Points available
http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml

Stream Temperature Points available by Agency:

2/22/2011
62 views - Public
Created on Feb 2 - Updated 13 hours ago
By
Rate this map - Write a comment

- **Adair Creek**
Thermograph Location: Adair Creek Contact: Clint Muhfeld - cmuhfeld@usgs.gov (406-866-7926)
USGS, NOROCK
- **Agassiz Creek**
Thermograph Location: Agassiz Creek Contact: Clint Muhfeld - cmuhfeld@usgs.gov (406-866-7926)
USGS, NOROCK
- **Alkokala Creek**
Thermograph Location: Alkokala Creek Contact: Clint Muhfeld - cmuhfeld@usgs.gov (406-866-7926)
USGS, NOROCK

Cottonwood-Clyde Park- Creek
Updated 2 days ago

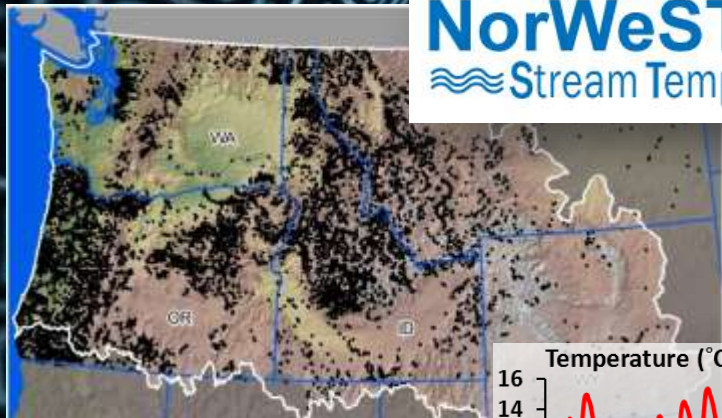
Thermograph Location: Cottonwood-Clyde Park- Creek
Contact: Robert Al-Chokhachy - ral-chokhachy@usgs.gov (406-994-7842)
USGS, NOROCK

Directions Search nearby more

1 of 2 nearby results Next >

Query Individual Sites

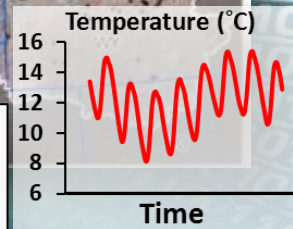
What About All That Summer Data?



NorWeST
Stream Temp



**~45,000,000
hourly records**



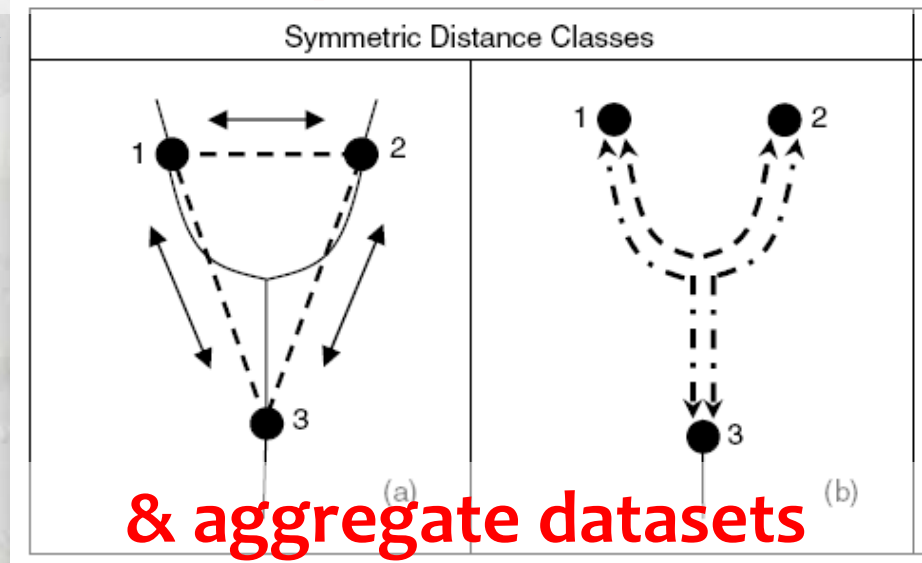
BIG DATA = BIG INFORMATION?

BIG DATA are often Autocorrelated

Spatial Statistical Network Models



Valid interpolation on networks

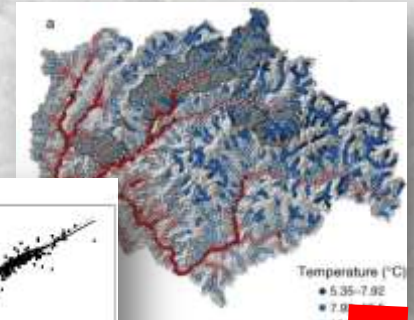
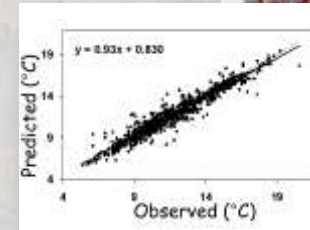
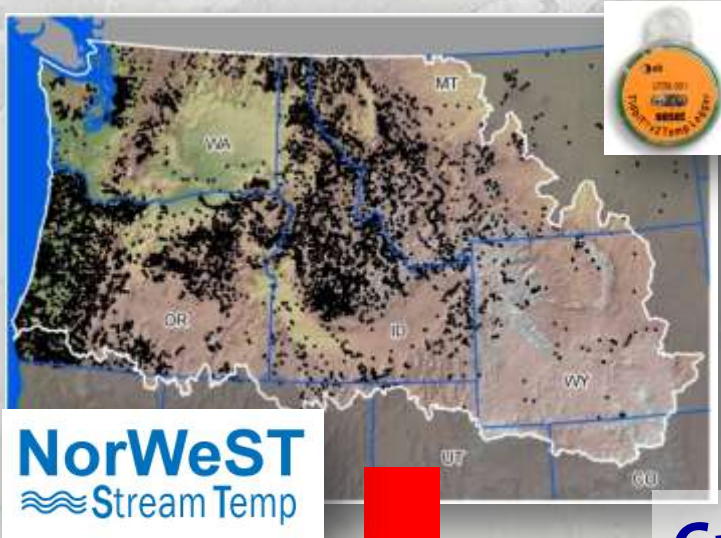


Advantages:

- flexible & valid autocovariance structures that accommodate network topology & non-independence among observations
- improved predictive ability & parameter estimates relative to non-spatial models

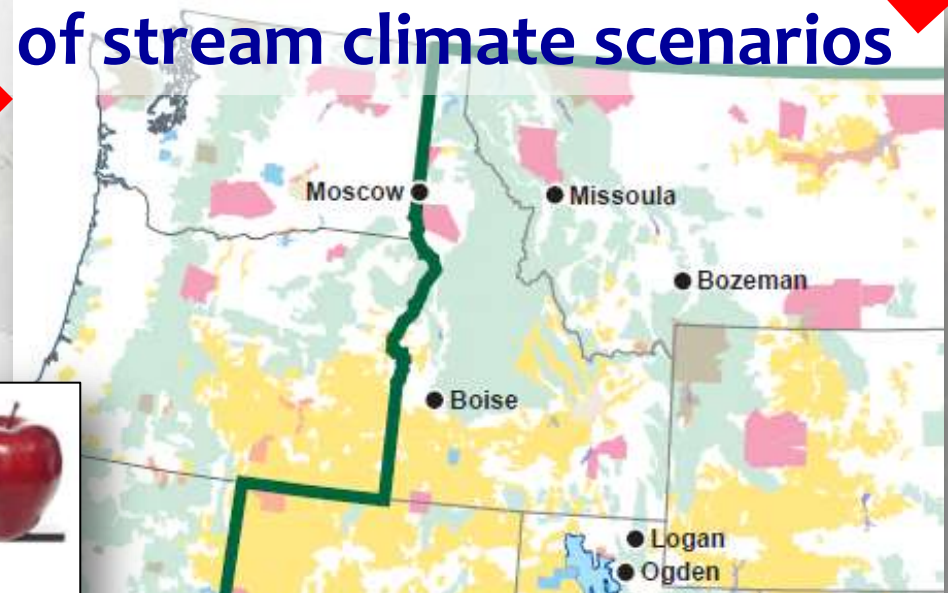
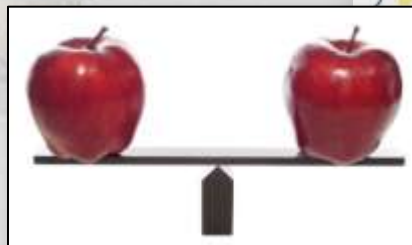
Regional Temperature Model

Accurate stream temp model

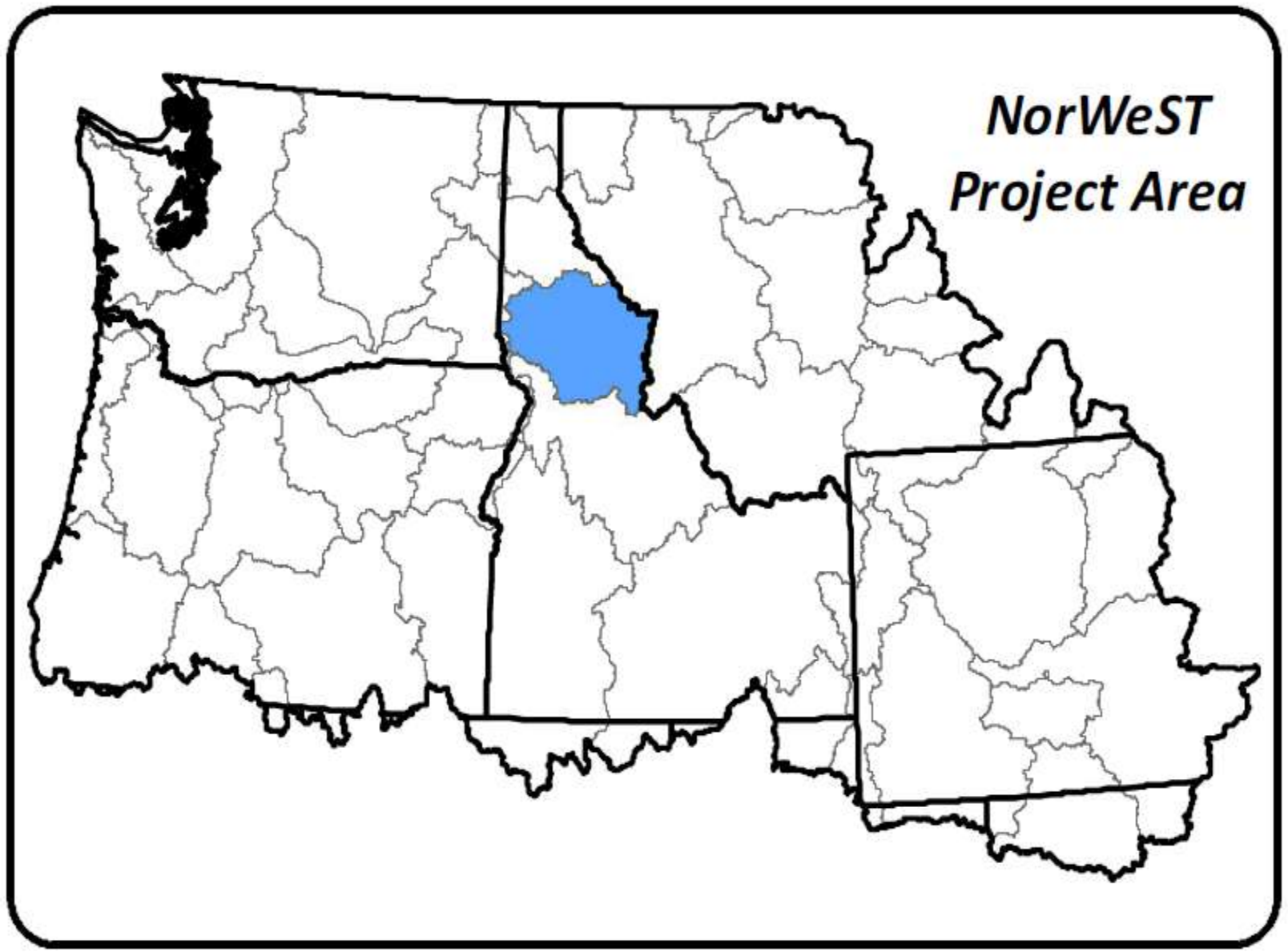


Cross-jurisdictional “maps” of stream climate scenarios

Consistent datum for strategic planning across 600,000 stream kilometers



Example: Clearwater River Basin

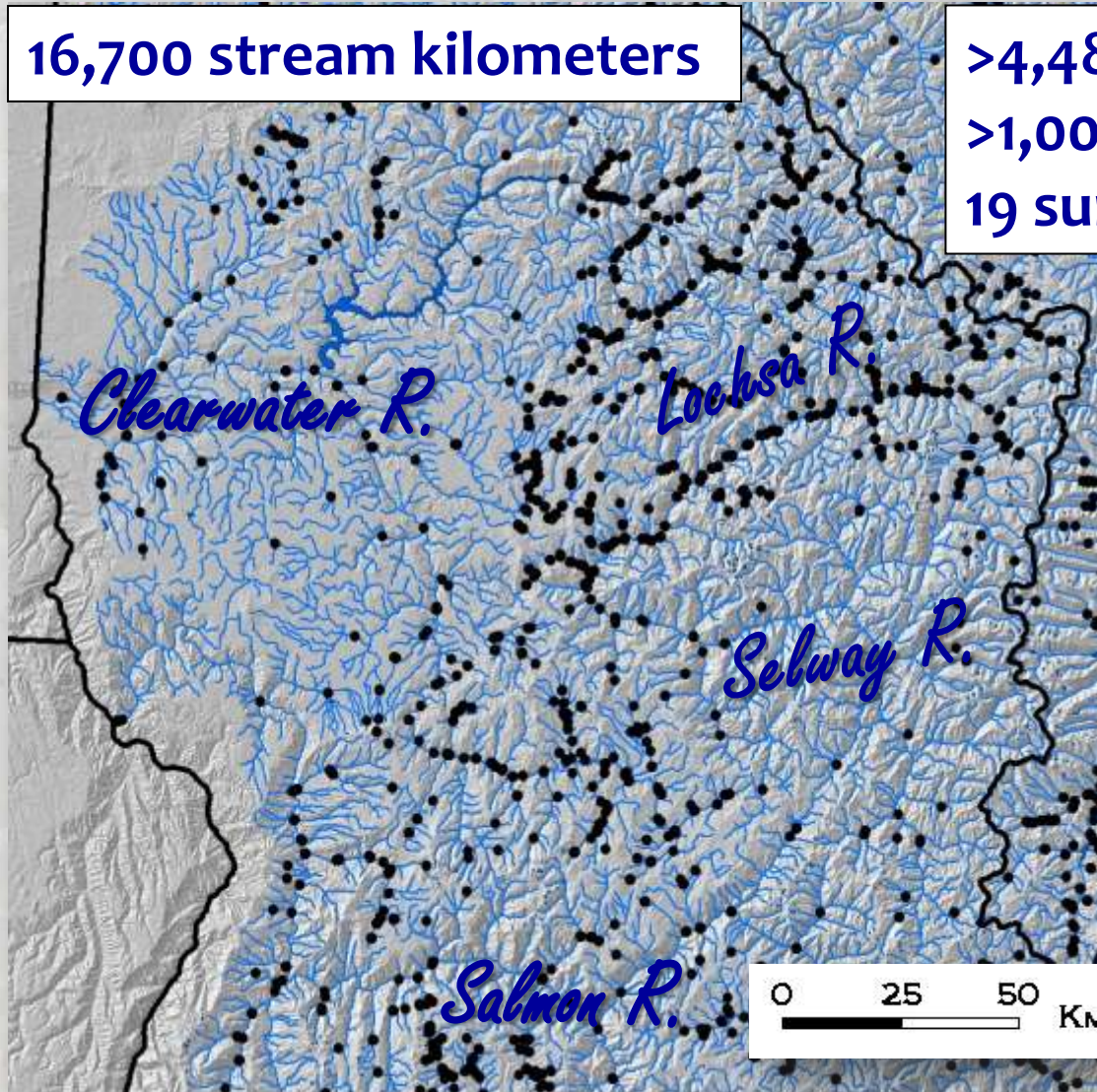


Example: Clearwater River Basin

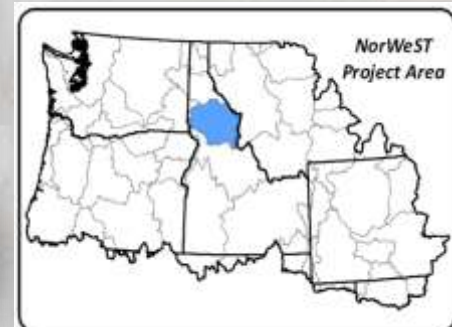
Data extracted from NorWeST

16,700 stream kilometers

>4,487 August means
>1,000 stream sites
19 summers (1993-2011)

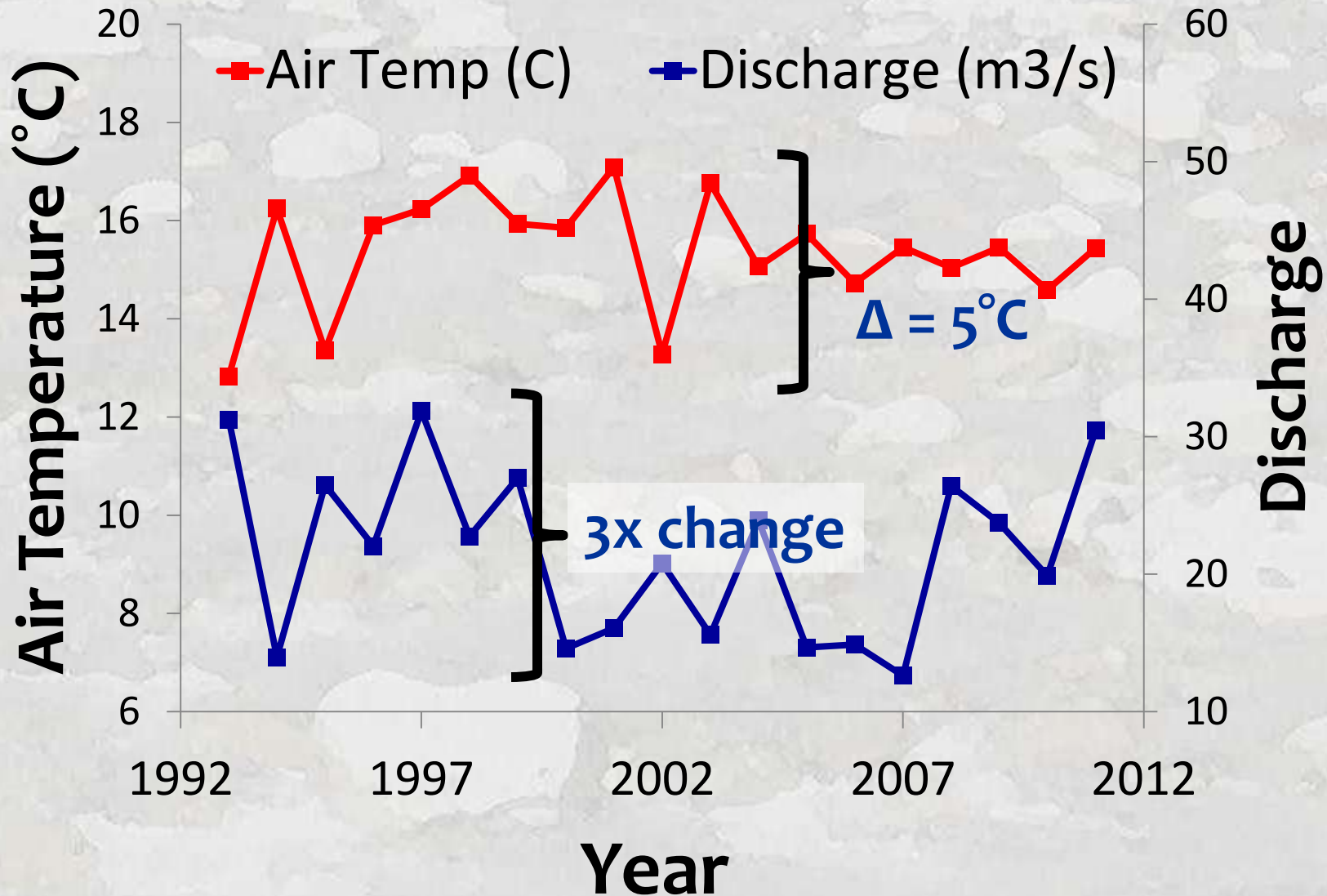


•Temperature site



Climatic Variability in Historical Record

Extreme years include mid-21st-Century “averages”



Clearwater River Temp Model

n = 4,487

Covariate Predictors

1. Elevation (m)
2. Canopy (%)
3. Stream slope (%)
4. Ave Precipitation (mm)
5. Latitude (km)
6. Lakes upstream (%)
7. Baseflow Index
8. Watershed size (km²)

9. Discharge (m³/s)

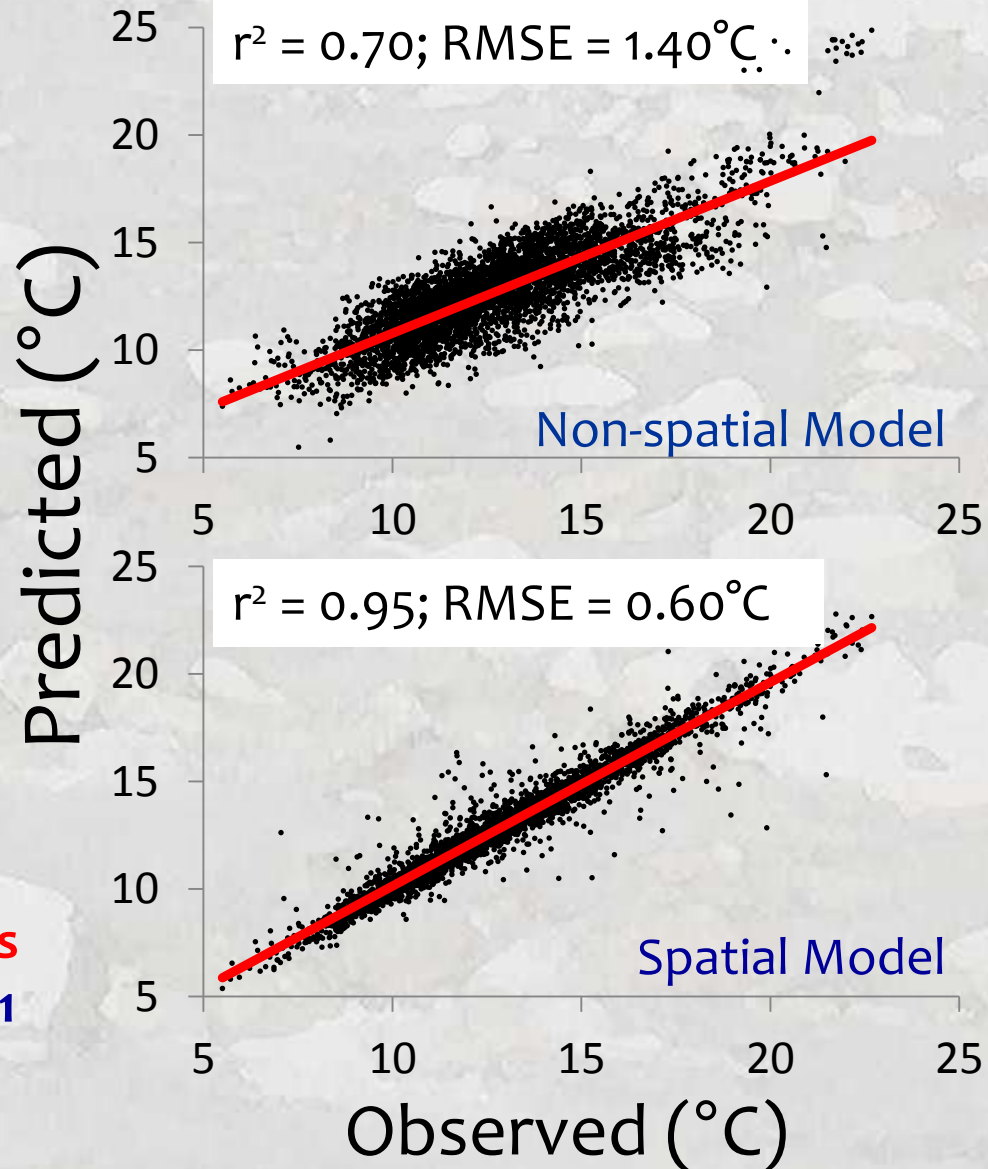
USGS gage data

10. Air Temperature (°C)

RegCM3 NCEP reanalysis

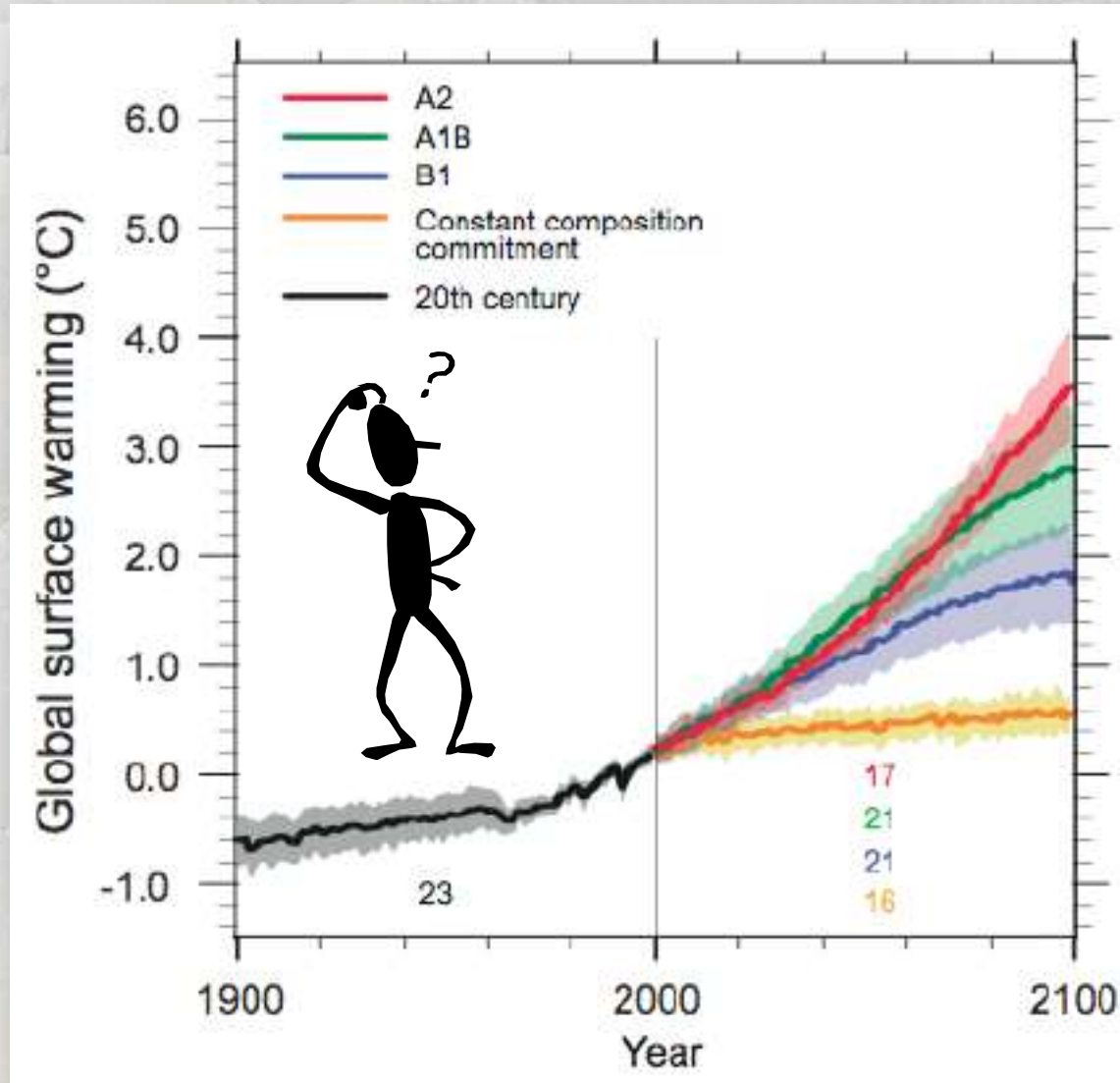
Hostetler et al. 2011

Mean August Temperature



Models Enable Climate Scenario Maps

Many possibilities exist...



Adjust...

- Air
- Discharge
- %Canopy

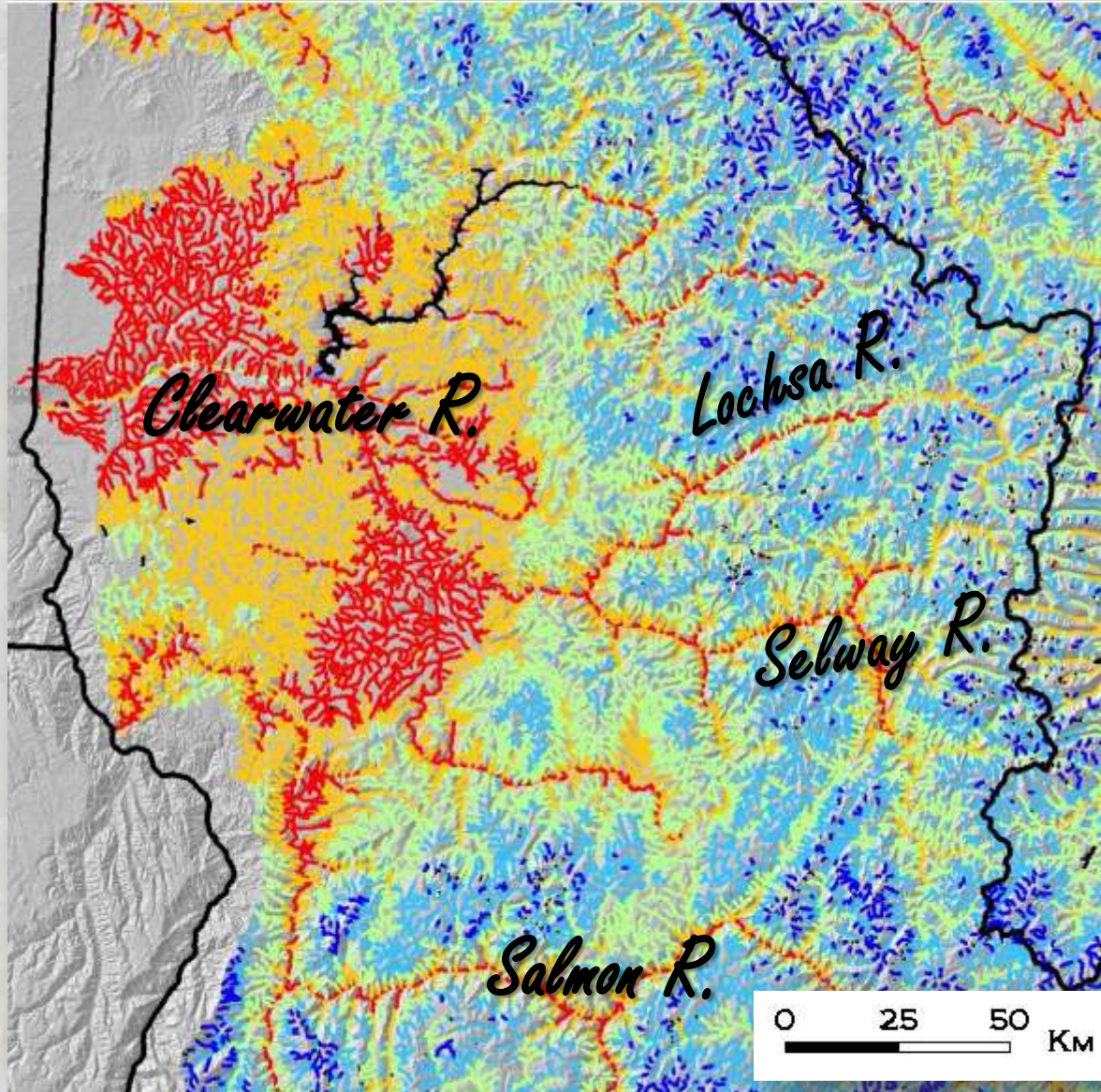
... values to
create scenarios

NorWeST Scenario Descriptions

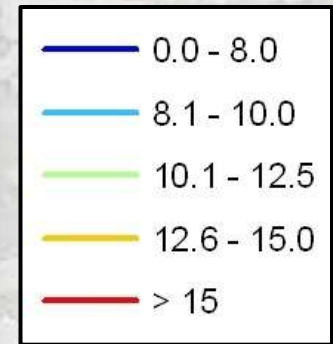
Scenario	Description
S1_93_11	Historical scenario representing 19 year average August mean stream temperatures for 1993-2011
S2_02_11	Historical scenario representing 10 year average August mean stream temperatures for 2002-2011
S3_1993	Historical scenario representing August mean stream temperatures for 1993
S4_1994	Historical scenario representing August mean stream temperatures for 1994
Etc...	
S22...S32	Futures: 1) A1B scenarios for 2040s and 2080s; 2) “scenario free (e.g., +1°C, +2C, etc.)

Clearwater Stream Temperature Scenario

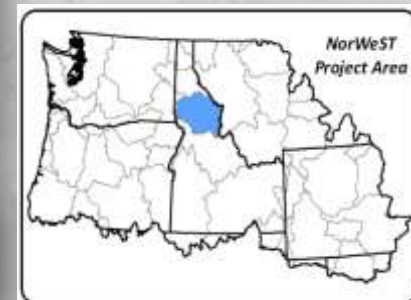
Historic (1993-2011 Average August)



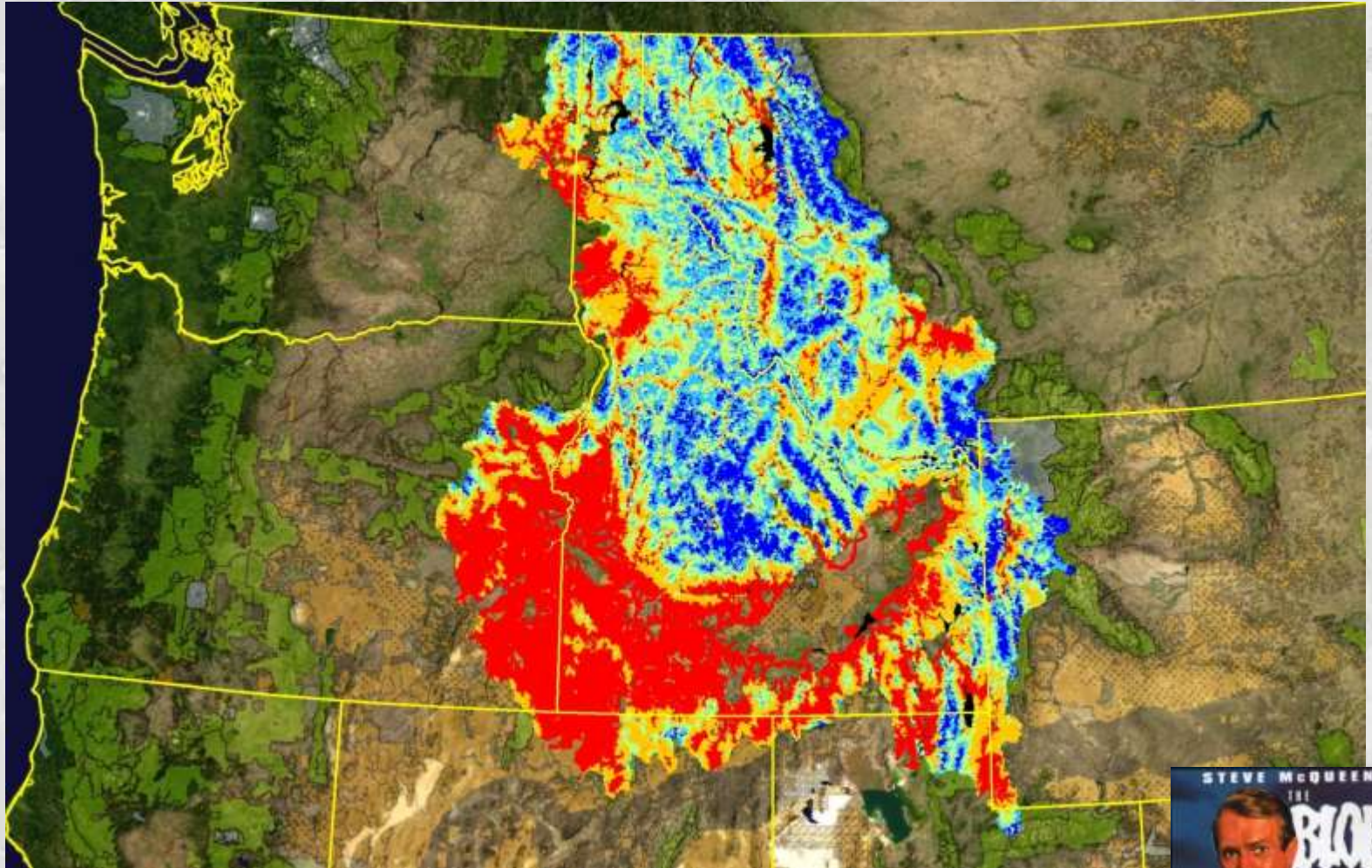
Temperature (°C)



**1 kilometer
resolution**



Stream Thermalscape so Far...

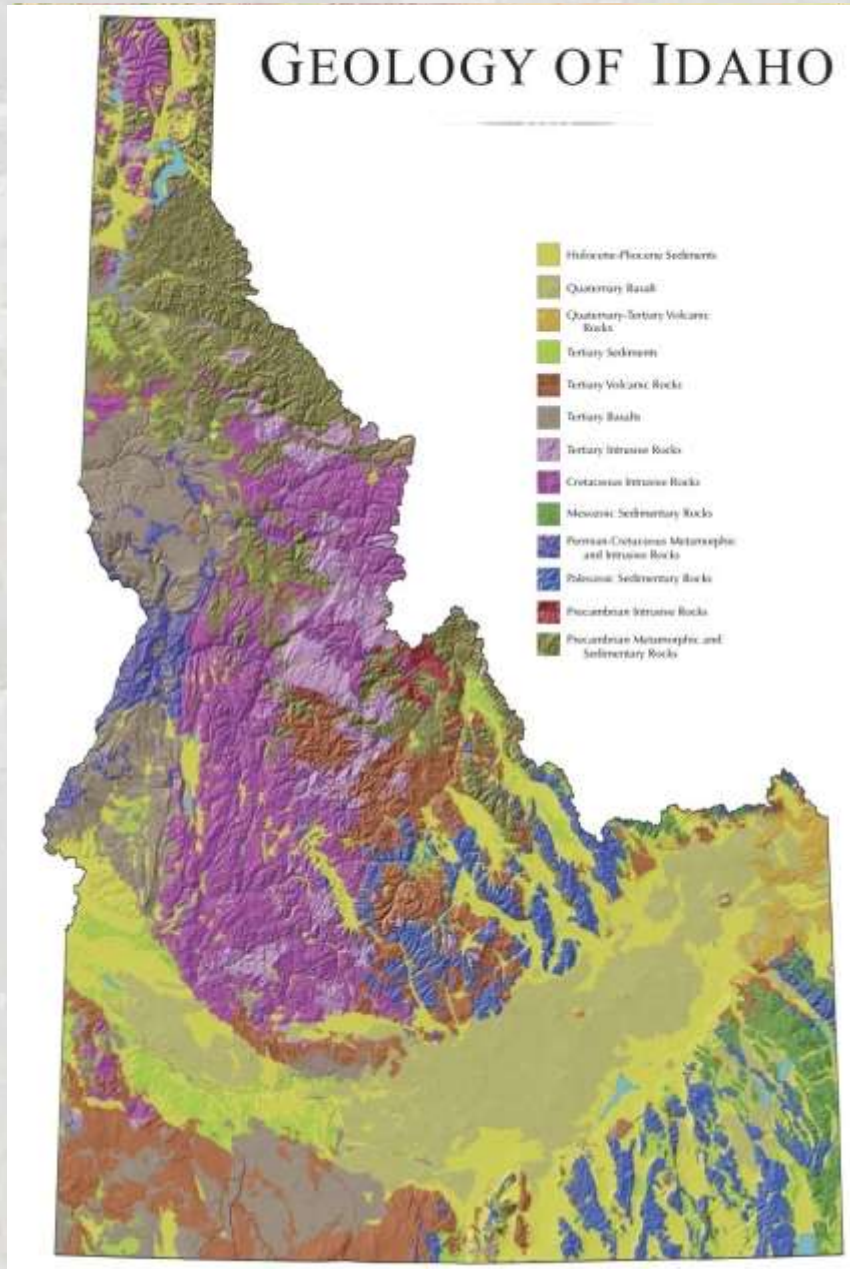


The BLOB... it just keeps growing...

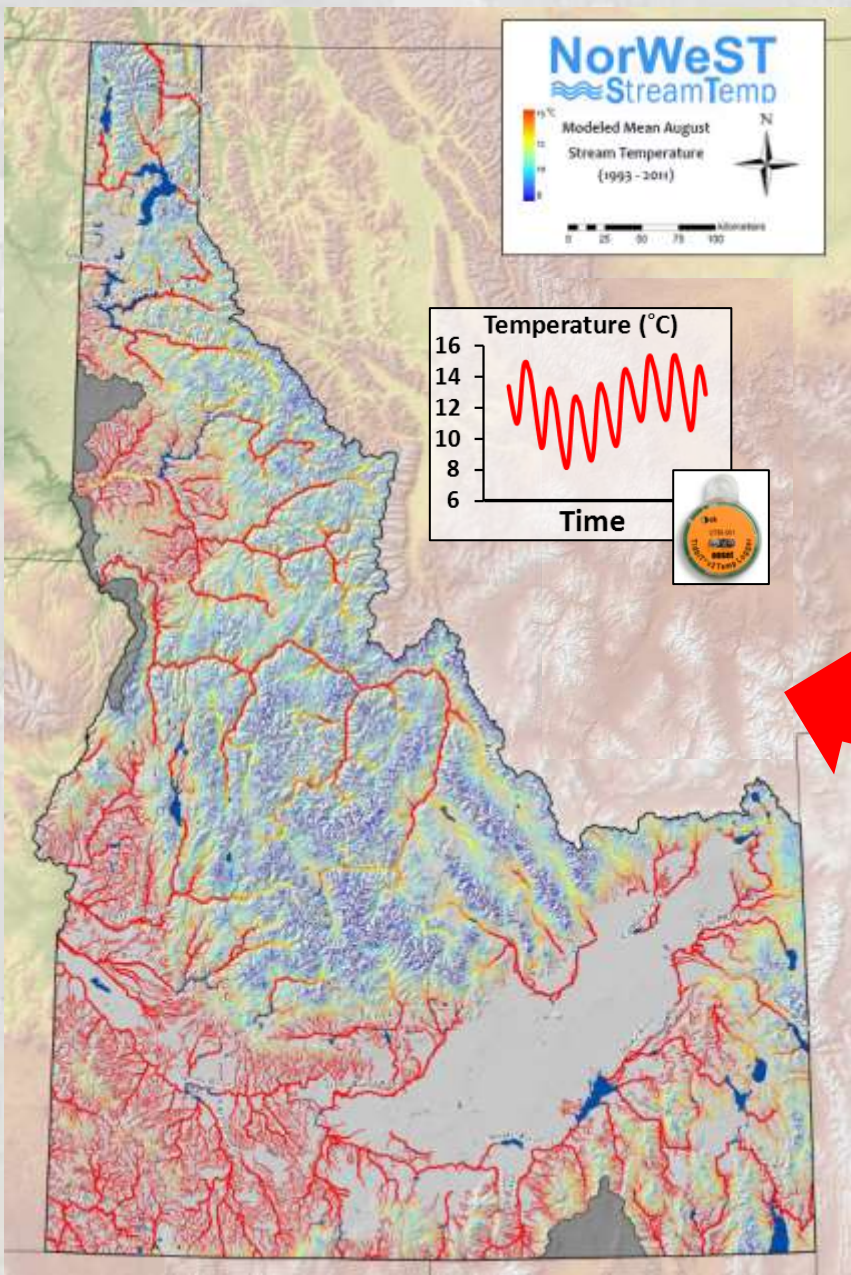
- 234,000 stream kilometers of thermal ooze
- 20,072 summers of data swallowed



We have State Geologic Maps...



Why not Stream Thermalscape Maps?



Built From...

- 4,888 stream sites
- 12,755 summers of data
- Dozens of contributing individuals
- all agencies



BLOB Space, but BLOB time too...

Where
will the
Coldwater
Refuges
Exist?



2080's A1B

Here
they
are

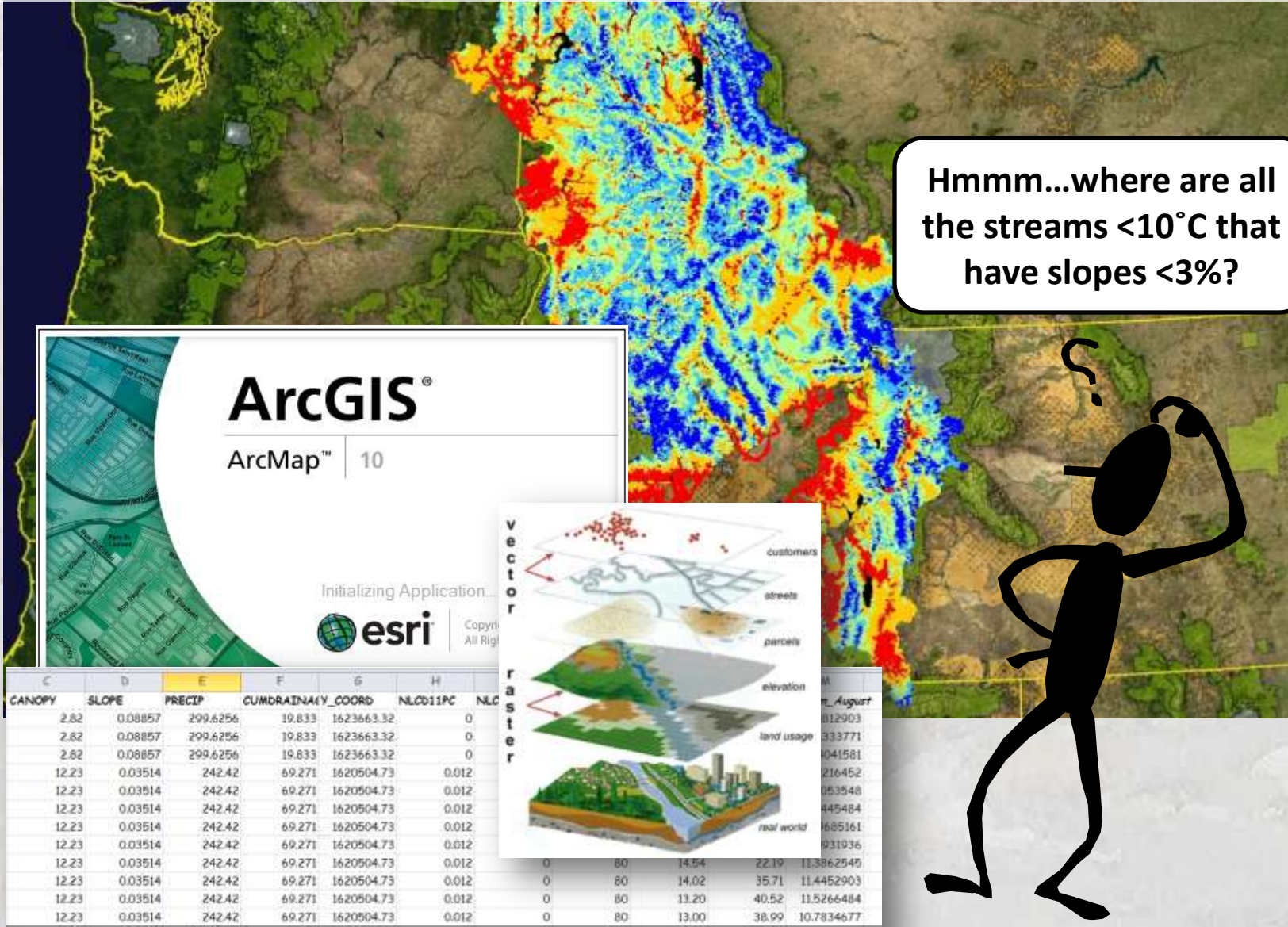
The BLOB... it just keeps growing...

- 234,000 stream kilometers of thermal ooze
- 20,072 summers of data swallowed



The BLOB is User-Friendly

ArcGIS spatial temperature database is easily queried



Hmmm...where are all the streams <math><10^{\circ}\text{C}</math> that have slopes <math><3\%</math>?



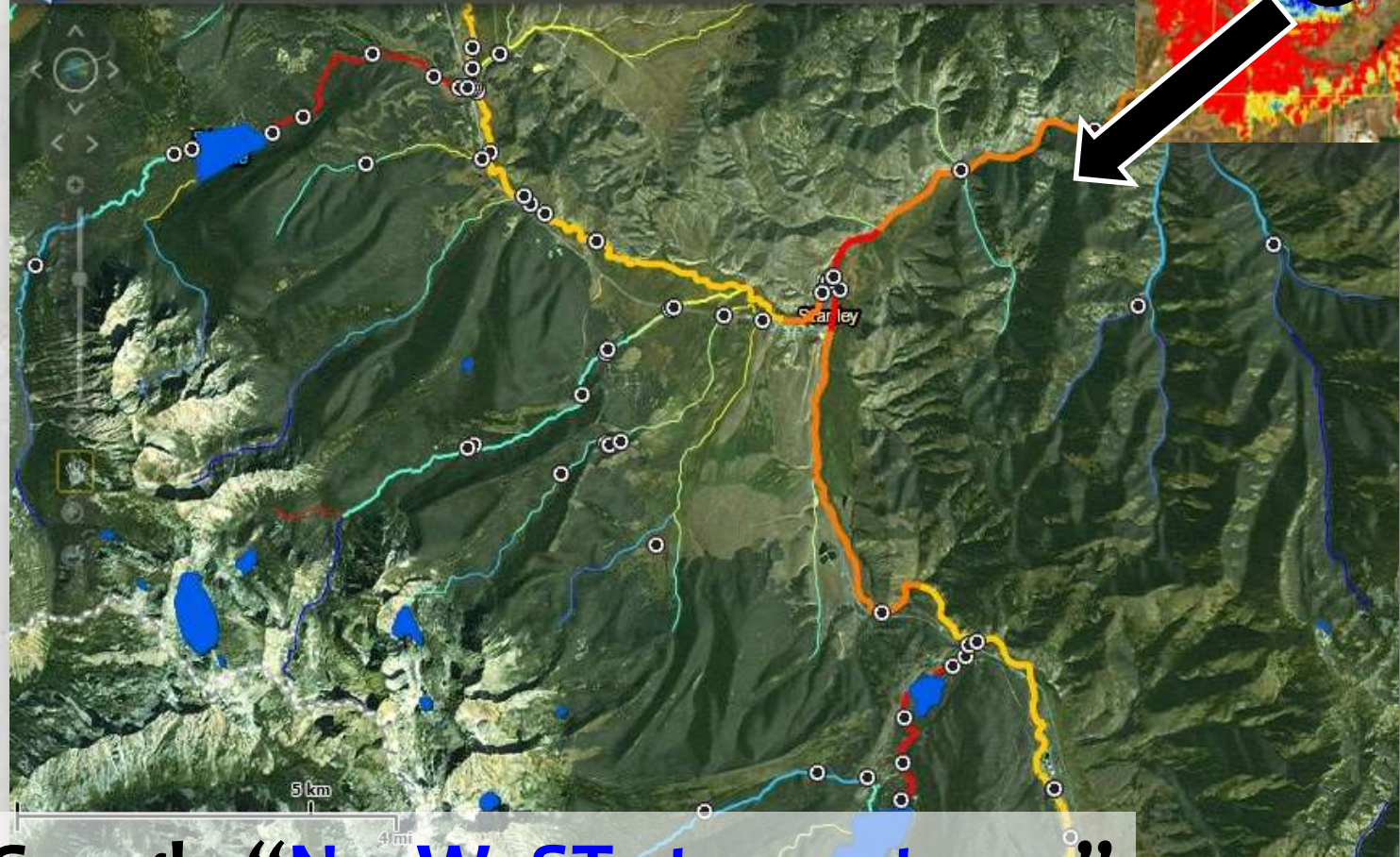
Websurf the BLOB

★ Dynamic Online Map Viewer

NorWeST Predicted Stream Temperat... x The New York Times - Breaking News... x Google Finance: Stock market qu
https://www.sciencebase.gov/flexviewer/salmonriver/

RMRS Boise FSweb Ho... The New York Times - ... Google Finance: Stock ... Bing Dan Isaak - Google Sc...

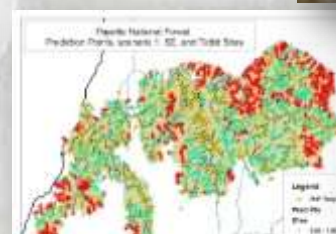
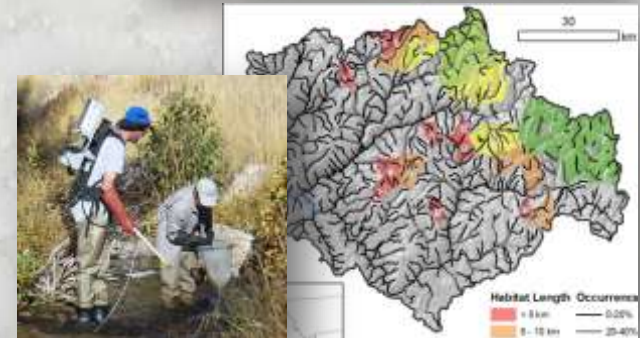
NorWeST Predicted Stream Temperatures for the Salmon River



Google “NorWeST stream temp”

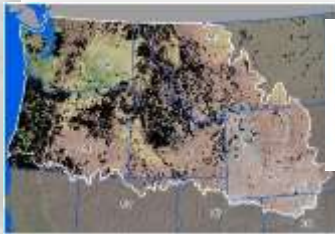
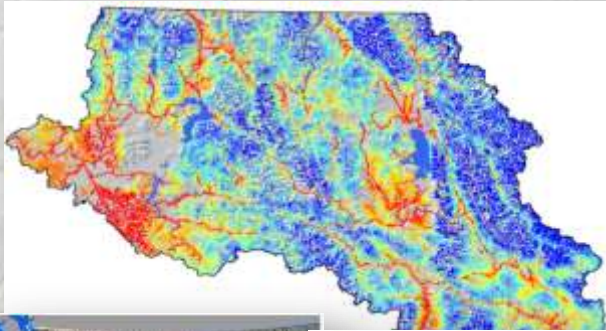
Good Stream Temperature Information Creates Synergies...

- Interagency monitoring coordination
- New stream temperature research enabled
- Improve understanding thermal ecology of aquatic species
- Precise bioclimatic models & vulnerability assessments
- **Regionally consistent thermal criteria using BIG FISH data**



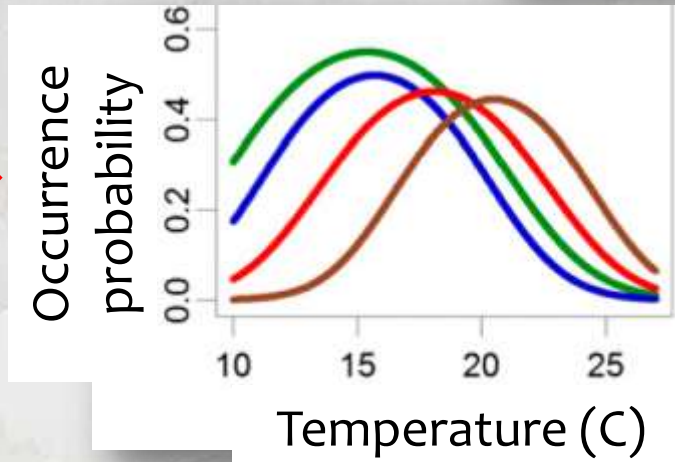
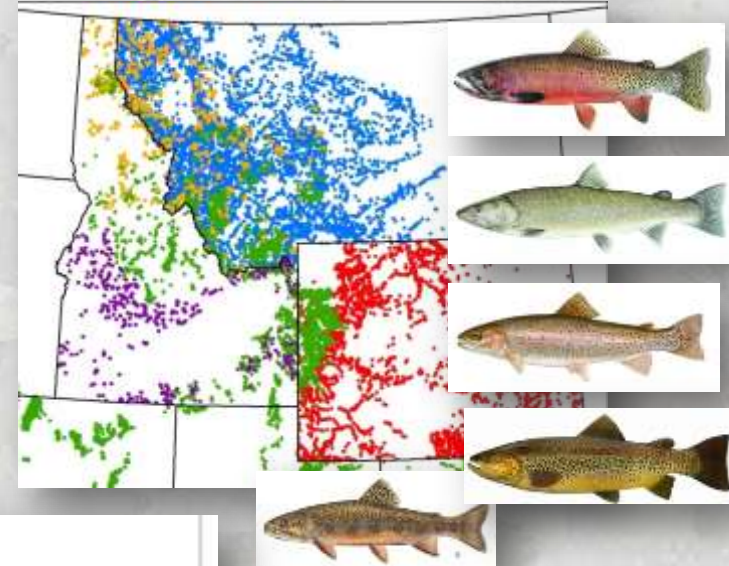
Regionally Consistent Thermal Criteria

Stream temperature maps



NorWeST
Stream Temp

Regional fish survey
databases (n ~ 20,000)

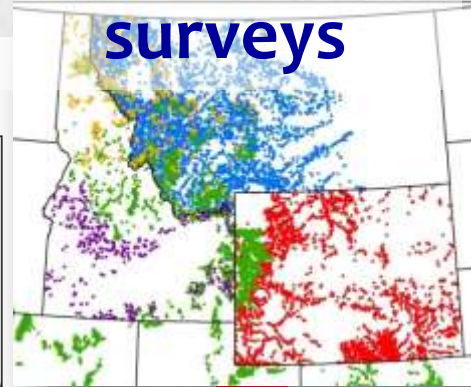


Wenger et al. 2011a. *PNAS* **108**:14175-14180

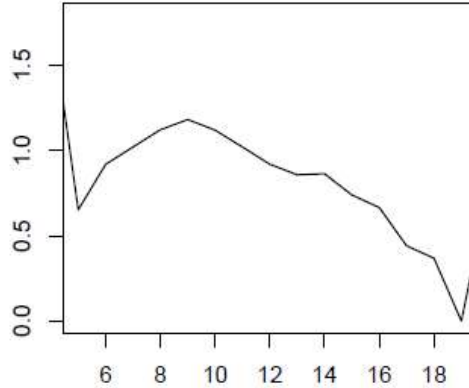
Wenger et al. 2011b. *CJFAS* **68**:988-1008; Wenger et al., *In Preparation*

Preliminary Results...

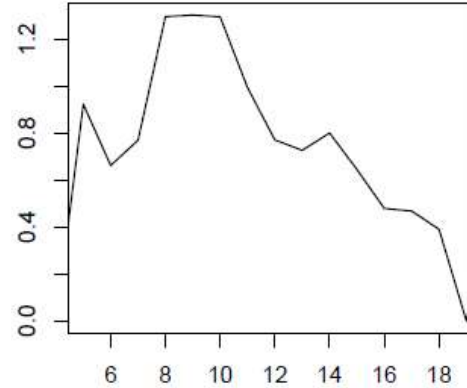
~20,000 fish surveys



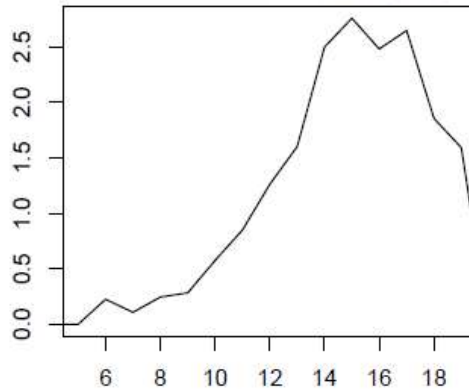
Cutthroat 



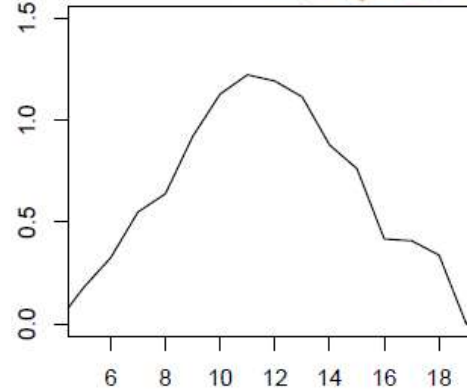
Bull 



Rainbow 



Brook 

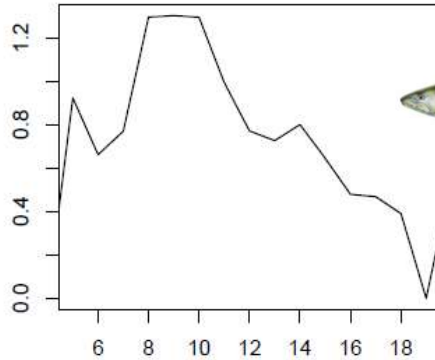


NorWeST Stream Temperature (S1)

Thermal Niche Nuances...

All Bull Trout

Frequency

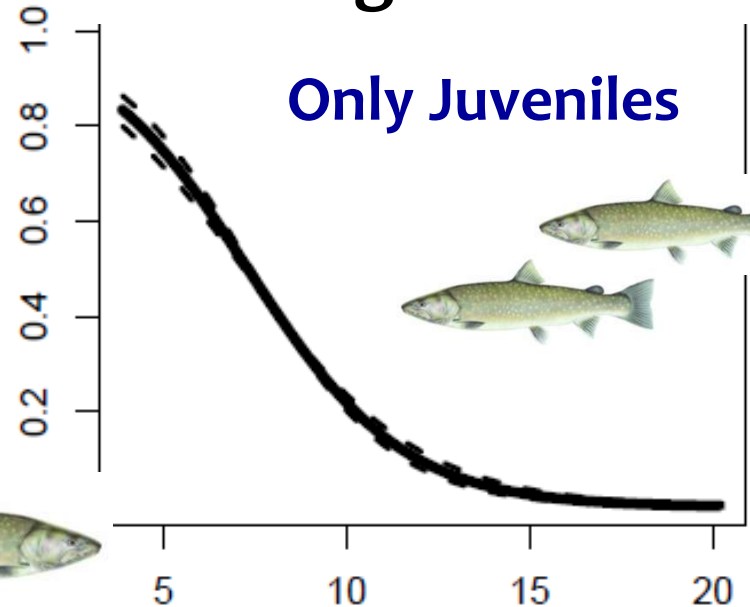


NorWeST
Temperature



Life Stage Varies...

Frequency



Only Juveniles

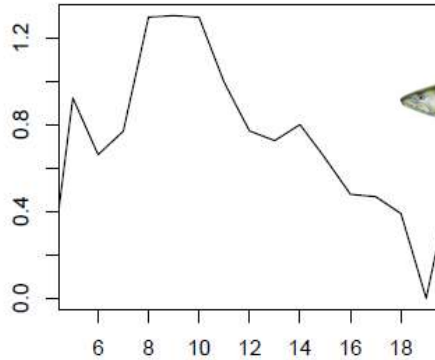
NorWeST
Temperature



Thermal Niche Nuances...

All Bull Trout

Frequency

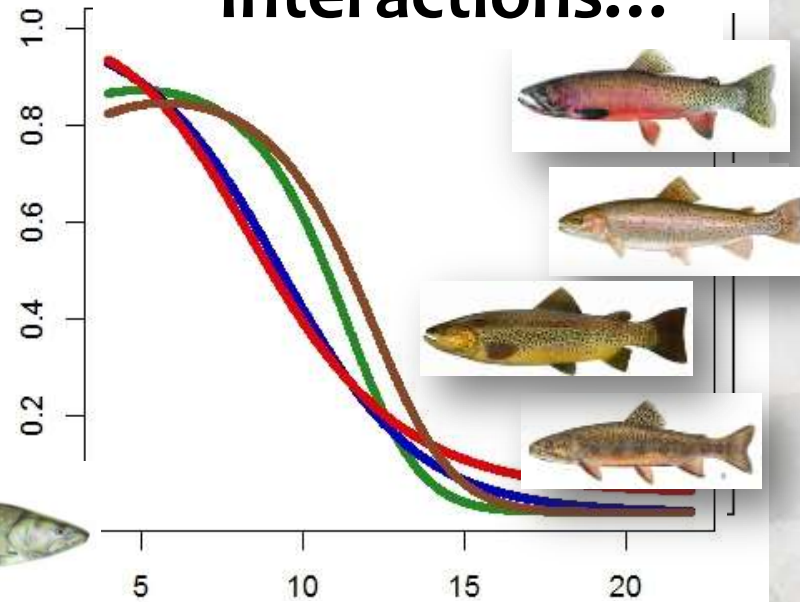


NorWeST
Temperature



Competitive Interactions...

Frequency



NorWeST
Temperature

Thermal Criteria For Any Stream Critter

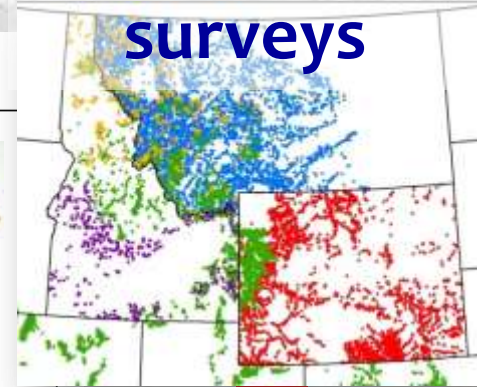
Just need georeferenced biological survey data



Too warm... Too cold... Just right

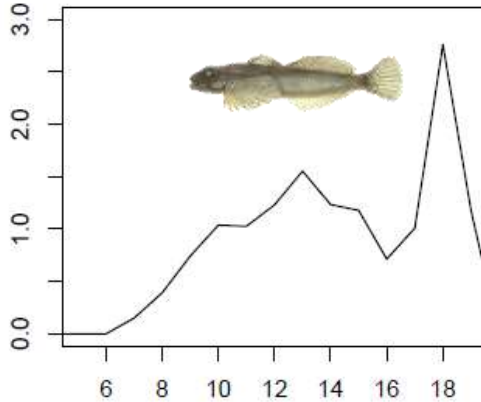
Preliminary Results...

~20,000 fish surveys

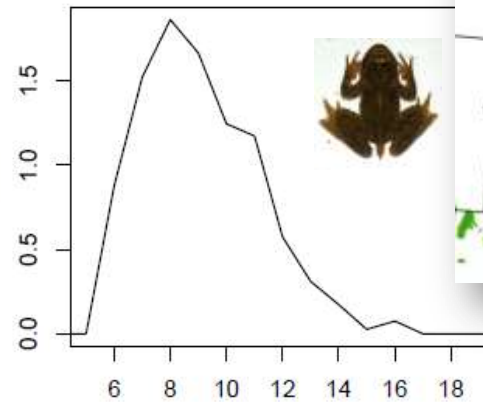


Frequency of Occurrence

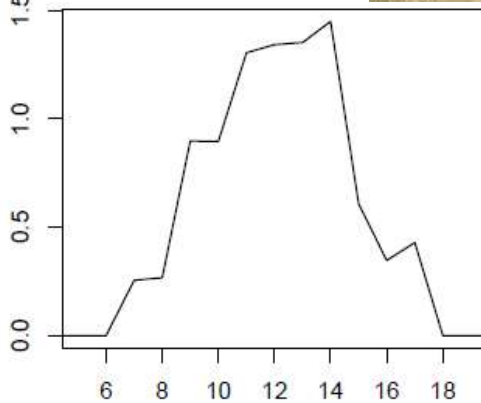
Sculpin spp.



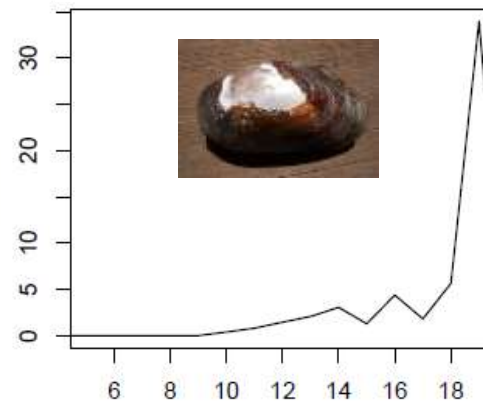
Tailed frog



Spotted frog



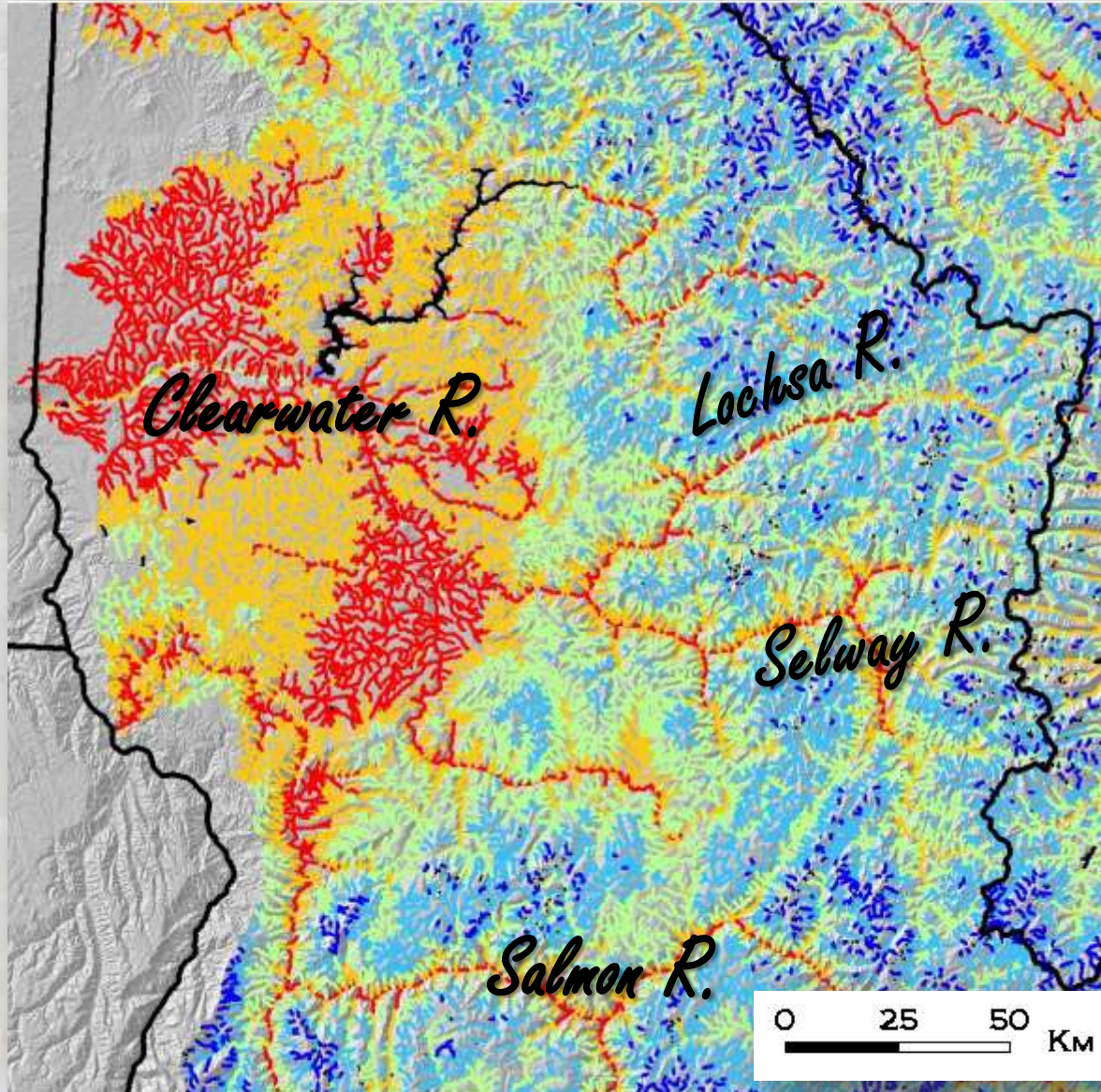
Pearlshell mussell



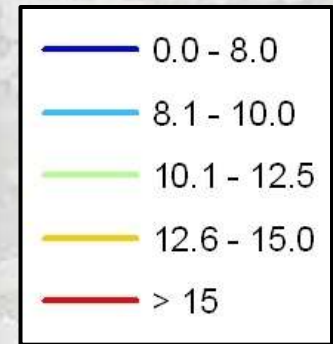
NorWeST Stream Temperature (S1)

Clearwater Stream Temperature Scenario

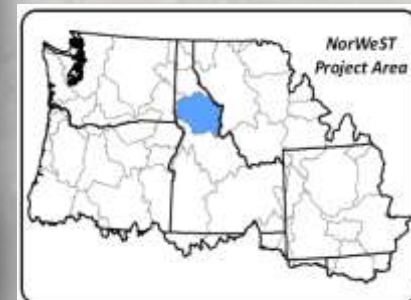
Historic (1993-2011 Average August)



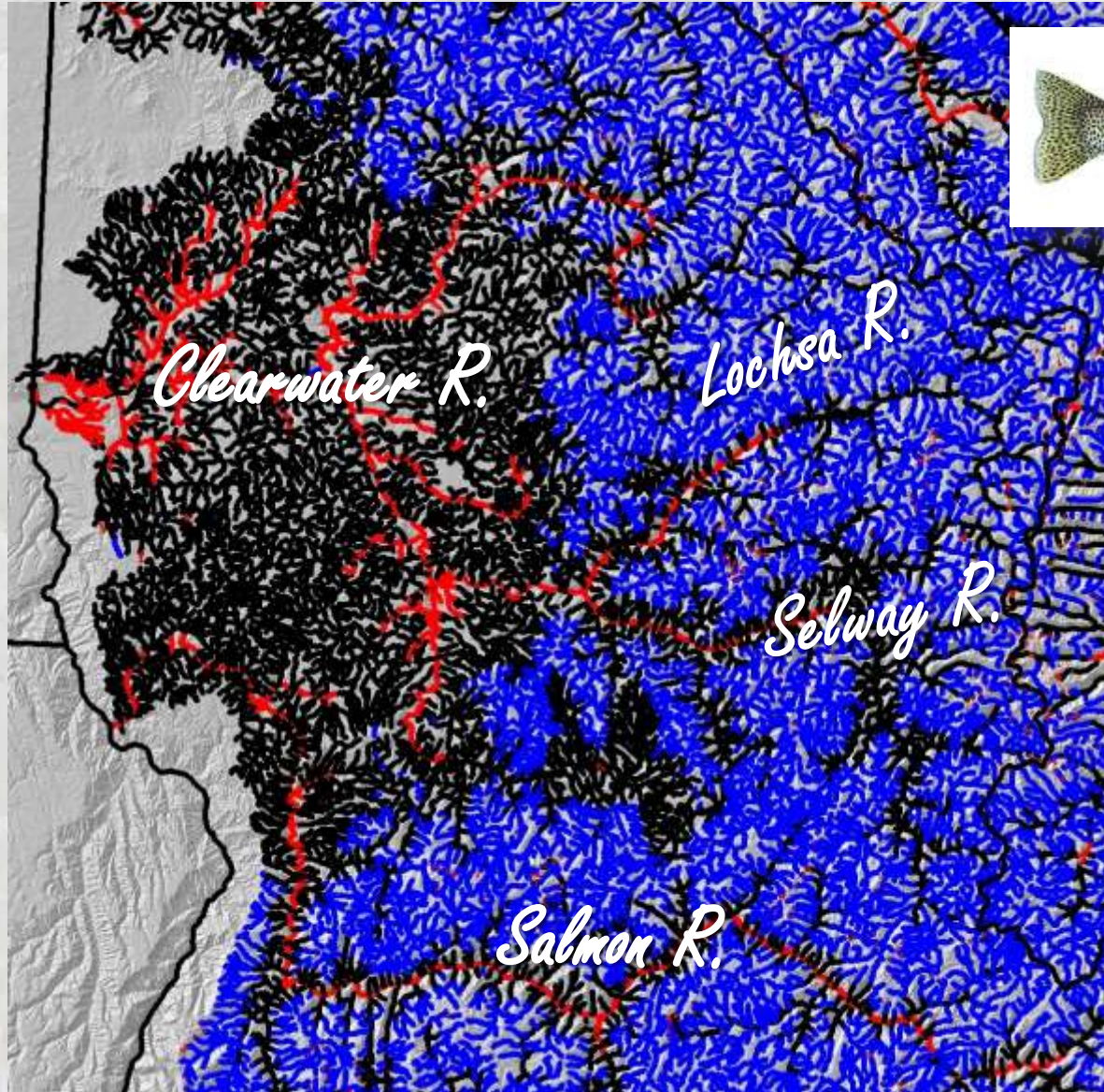
Temperature (°C)






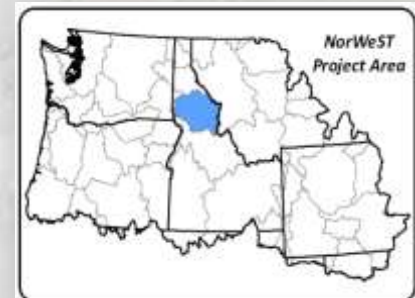
**1 kilometer
resolution**



Climate Effects on Cutthroat Thermal Habitat Historic (1993-2011 Average August)

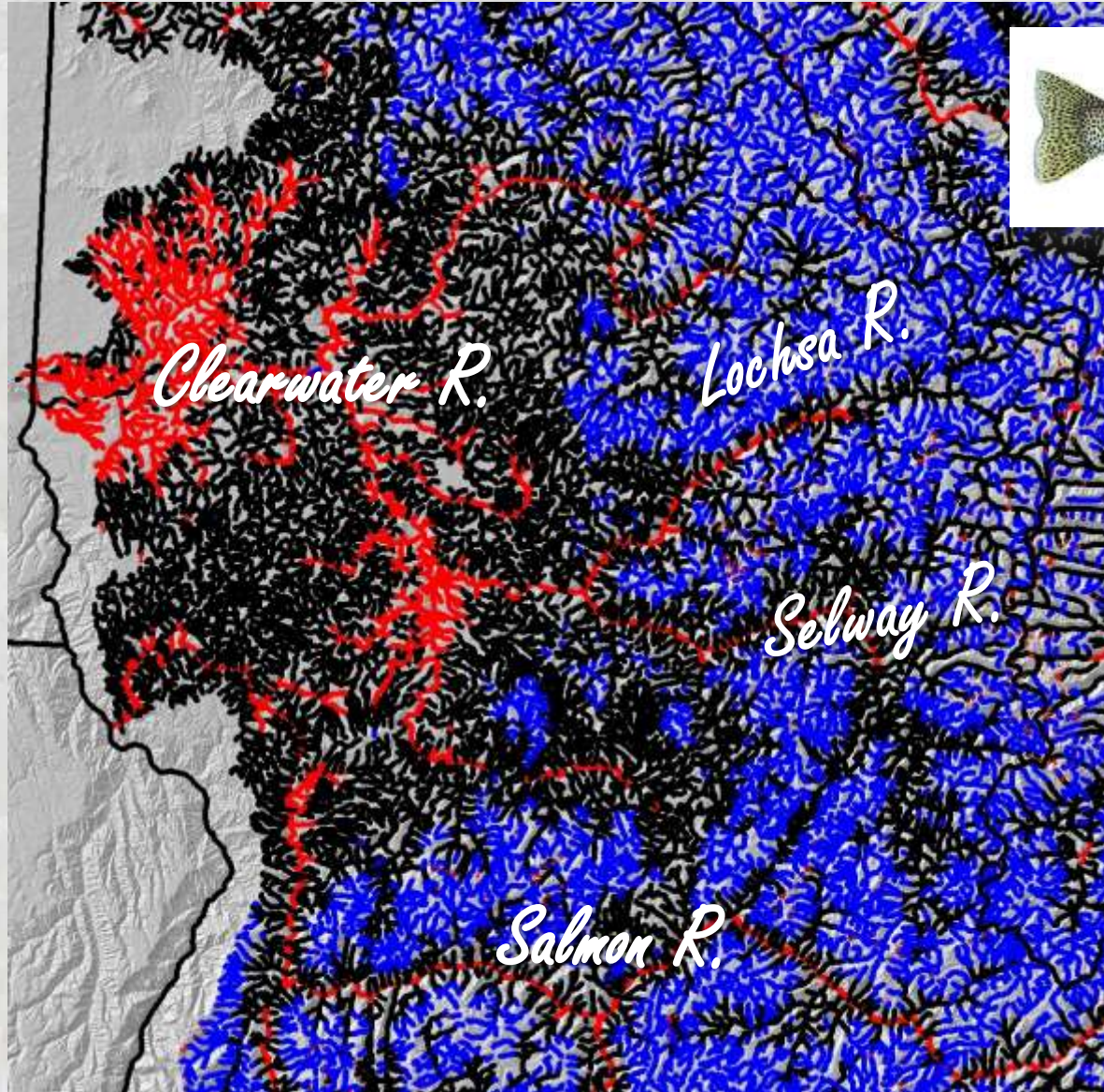





-  Suitable
 -  Too Hot
 -  Too Cold
- <17.0°C & >11.0 °C

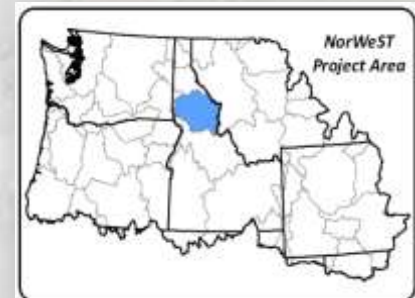


Climate Effects on Cutthroat Thermal Habitat

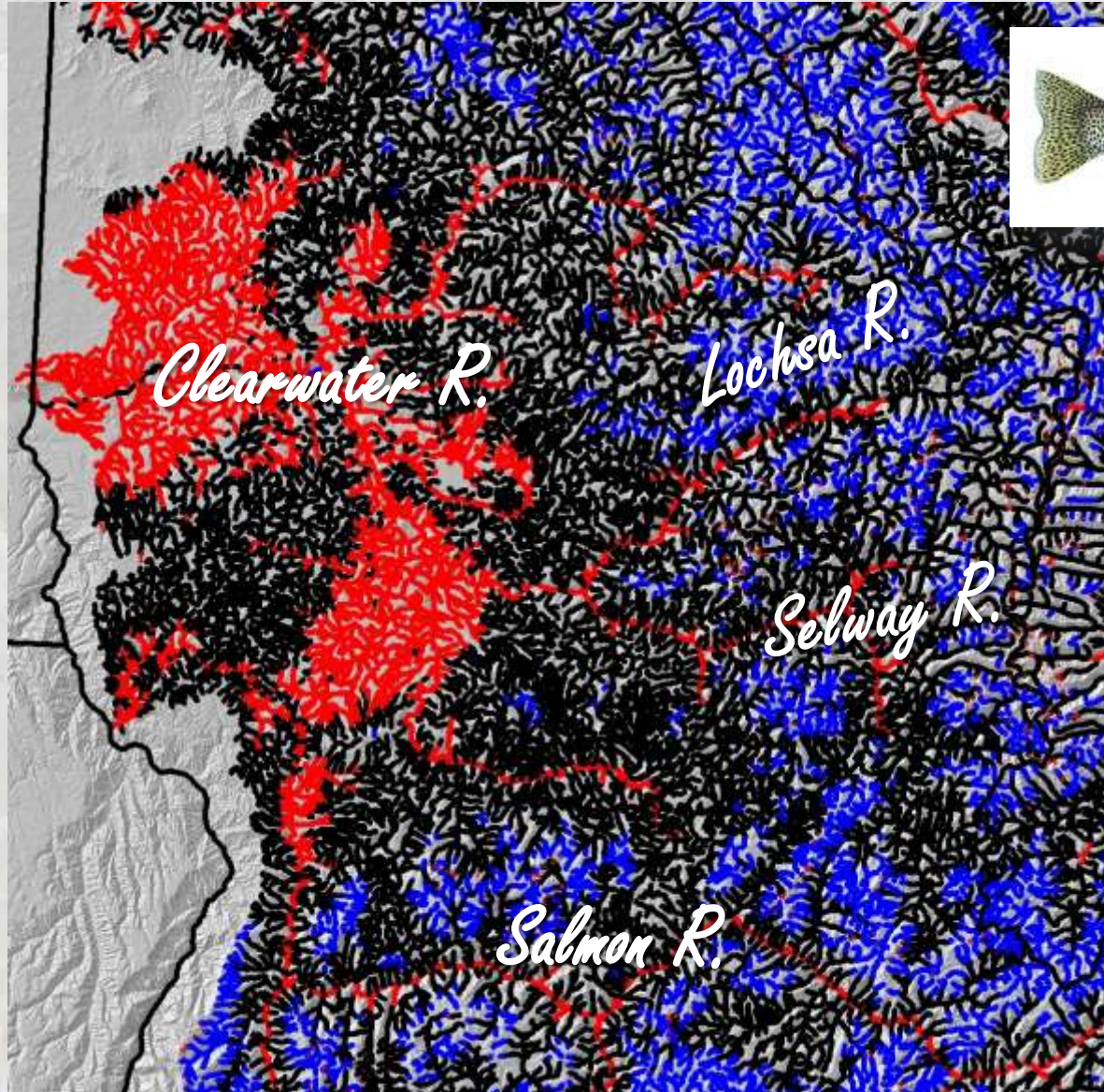
+1.54°C Stream Temp (A1B 2040s)



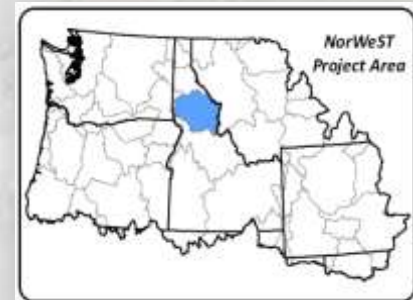
-  Suitable
 -  Too Hot
 -  Too Cold
- <17.0°C & >11.0 °C



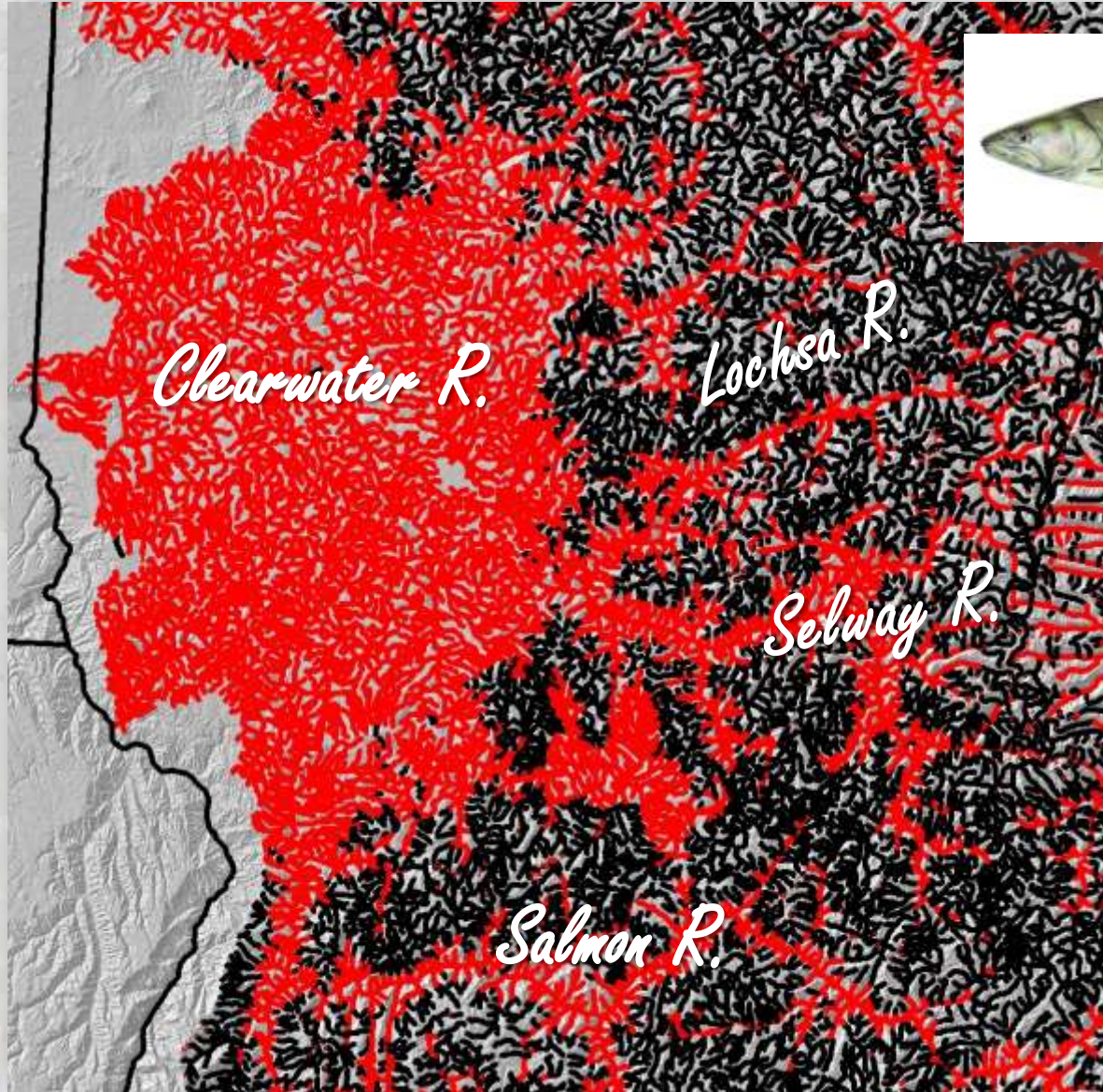
Climate Effects on Cutthroat Thermal Habitat +2.86°C Stream Temp (A1B 2080s)



- Suitable
 - Too Hot
 - Too Cold
- <17.0°C & >11.0°C



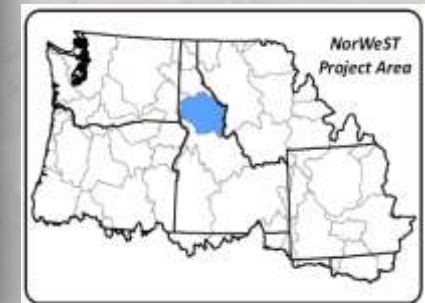
Climate Effects on Bull Trout Thermal Habitat Historic (1993-2011 Average August)



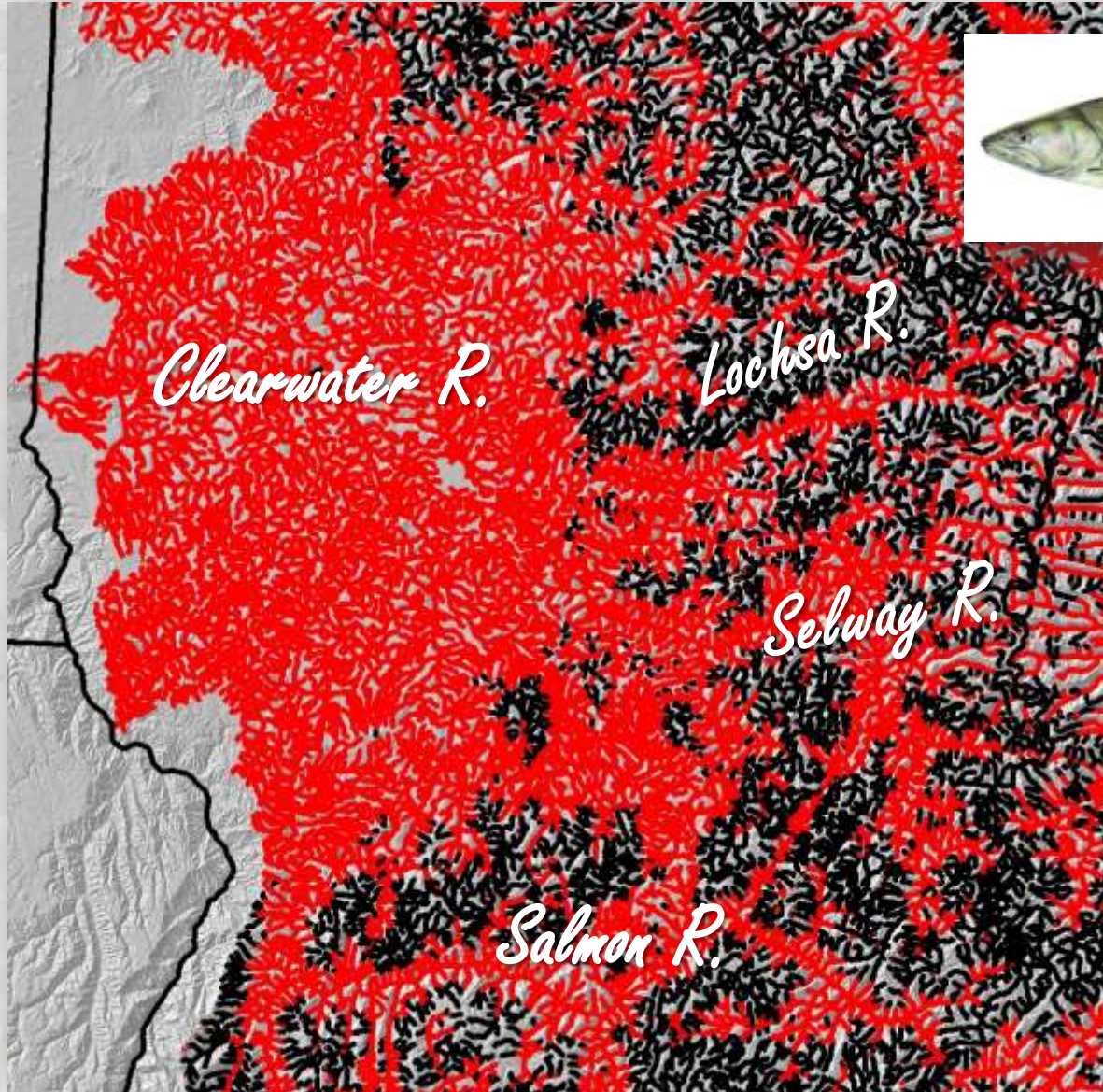
■ Suitable

■ Unsuitable

< 11.0°C

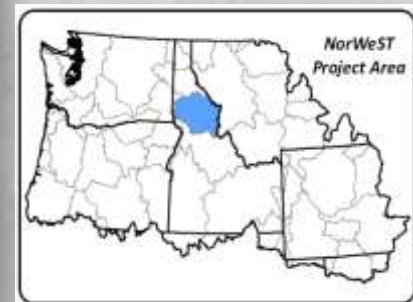


Climate Effects on Bull Trout Thermal Habitat +1.54°C Stream Temp (A1B 2040s)

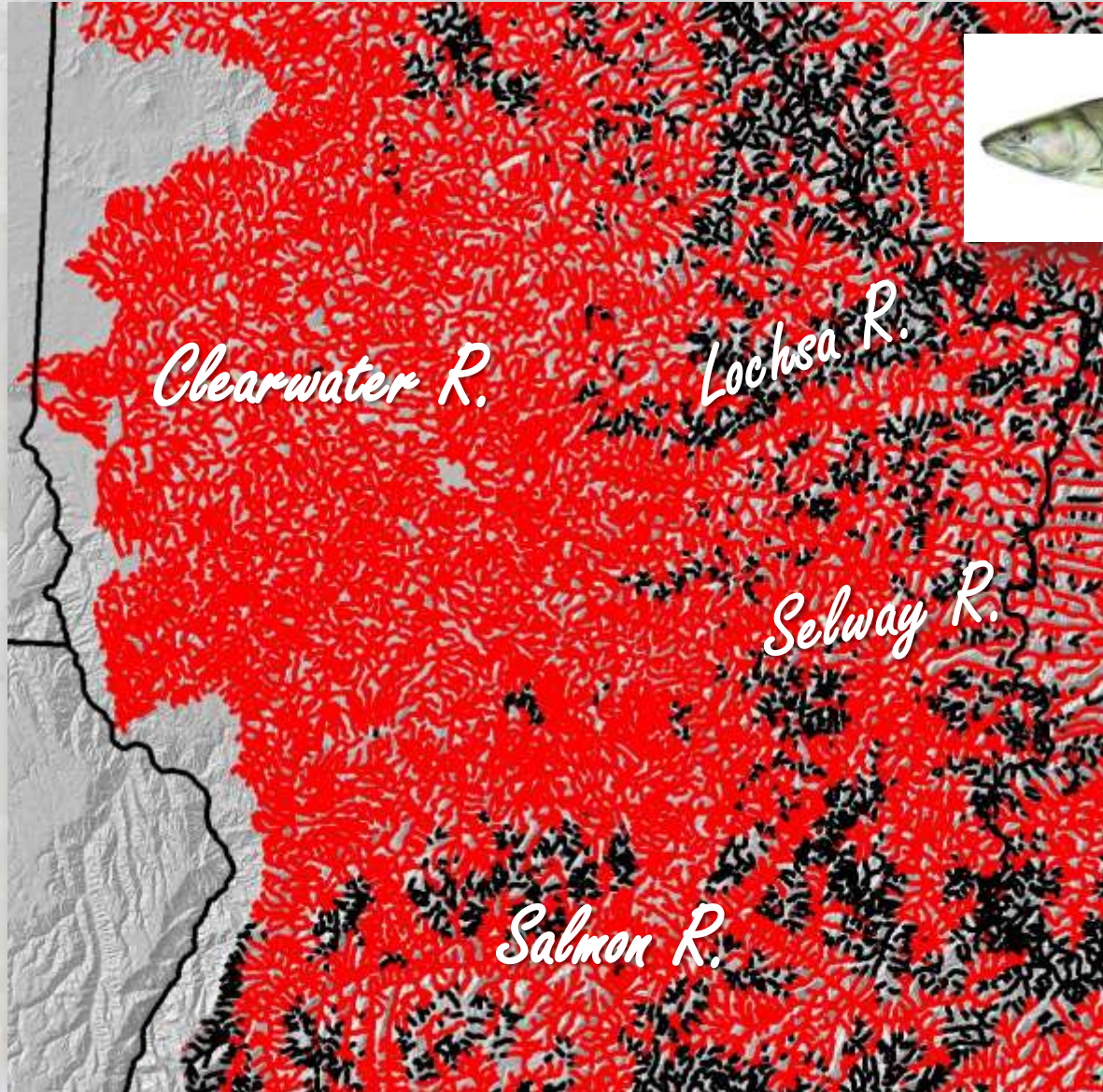


- Suitable
- Unsuitable

< 11.0°C

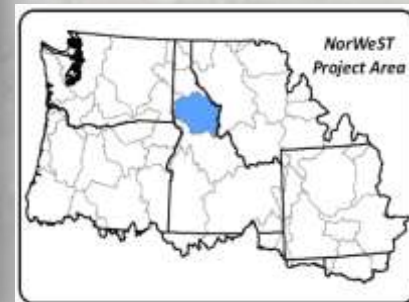


Climate Effects on Bull Trout Thermal Habitat +2.86°C Stream Temp (A1B 2080s)



■ Suitable
■ Unsuitable

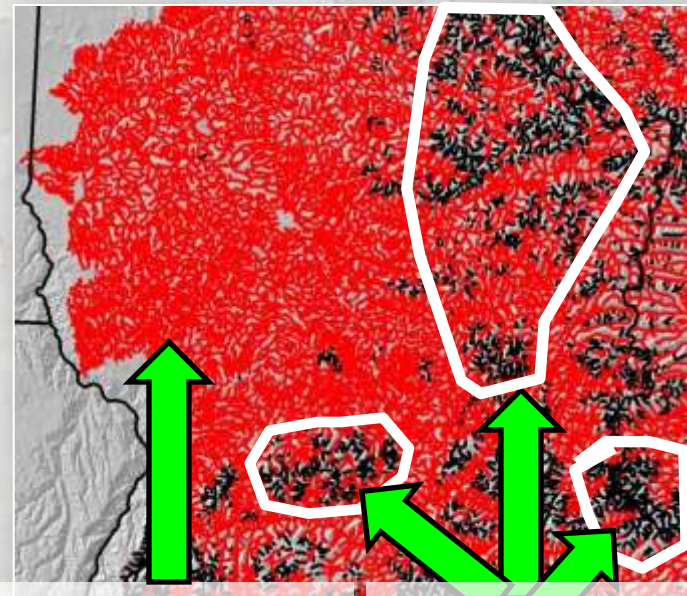
< 11.0°C



Climate-Smart Prioritization of Habitat Restoration

Lots of things we can do...

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

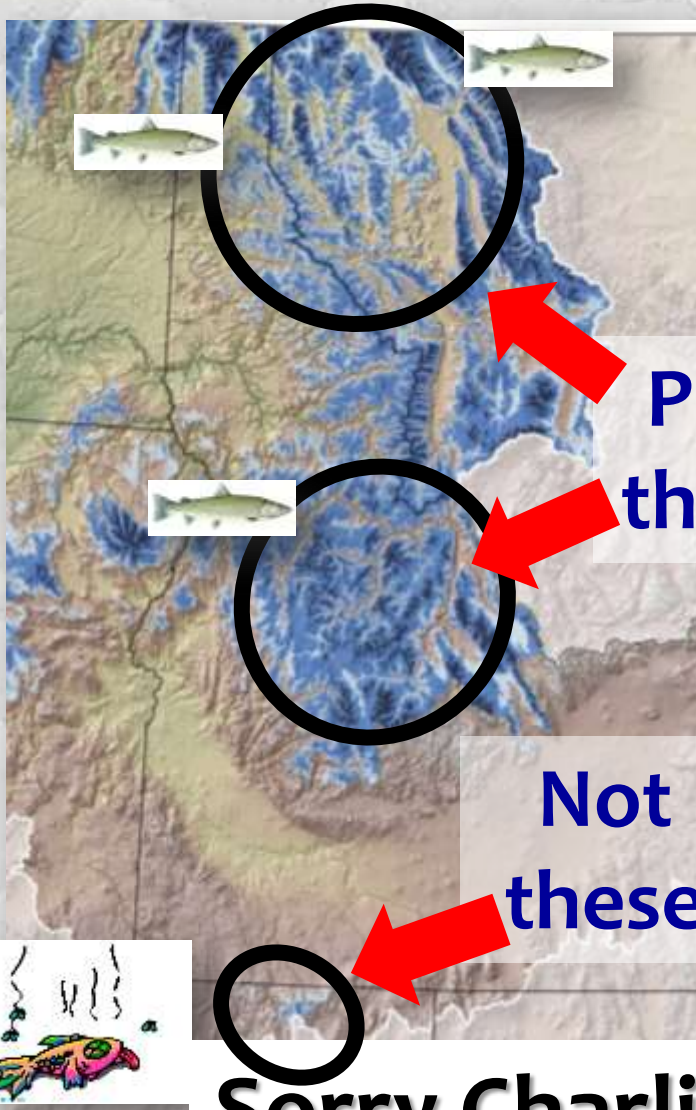


Low
Priority

High
Priority

Good Information for Strategic Decision Making Will be Critical

The 21st-Century will Be a Transitional One



Pick these

Not these

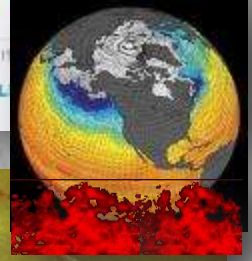
Sorry Charlie

2012: HOTTEST YEAR ON RECORD

Average Annual Temperature in Contiguous U.S.



*Source: Climate Central, compiled from NOAA's National Climatic Data Center and Applied Climate Information System. Based on observed temperatures through December 15, 2012 and an estimate of the normal distribution of temperatures for the last 21 days of December based on data from the previous 17 years. (See methodology)

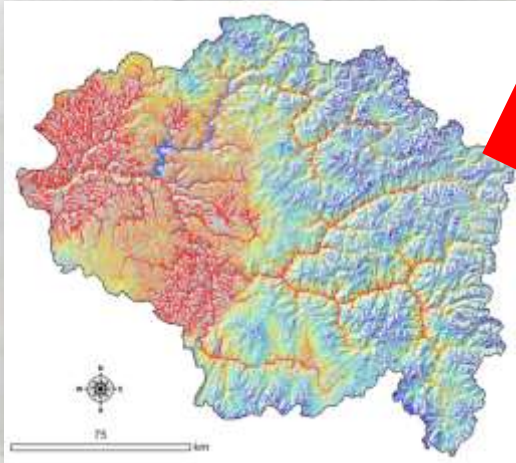


Crowd-Sourced Science Build Consensus & Strengthens Social Networks

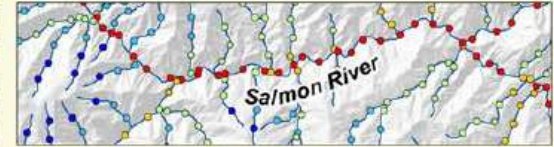


Website Distributes BLOB Scenarios & Temperature Data as GIS Layers

1) GIS shapefiles of stream temperature scenarios

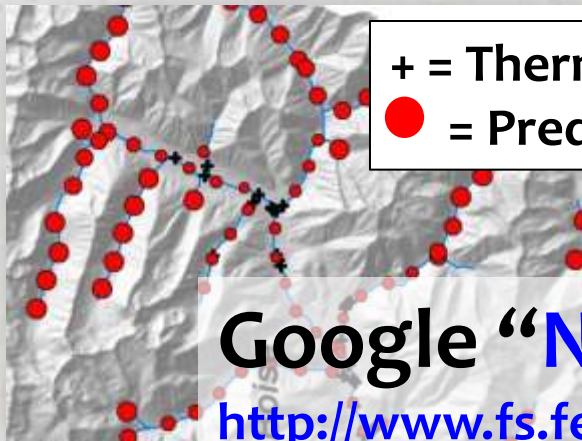


NorWeST
Stream Temp



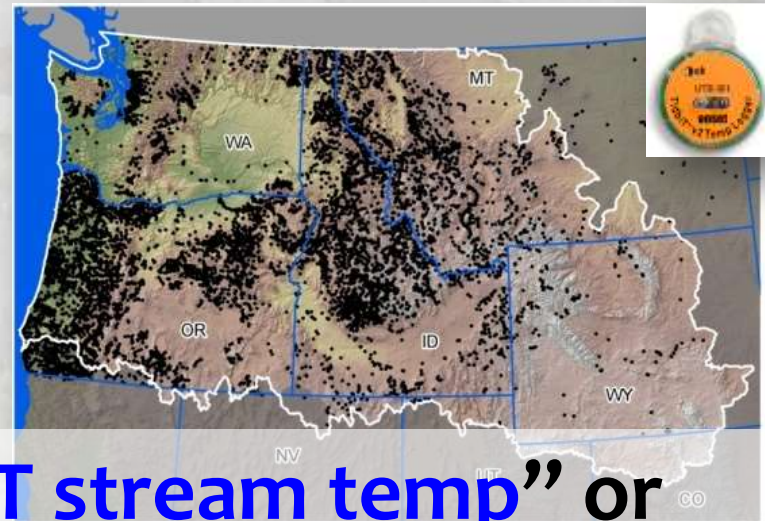
Regional Database and Modeled Stream Temperatures

2) GIS shapefiles of stream temperature model prediction precision



+ = Thermograph
● = Prediction SE

3) Temperature data summaries



Google **"NorWeST stream temp"** or

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

Final Mid-Columbia Stream Temperature Database

- 2,760 stream sites
- 9,521 summers of data
- 60,099 stream kilometers

