

The NorWeST Stream Temperature Database, Model & Climate Scenarios for the American West

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 Bresheares, Neal Bernklau

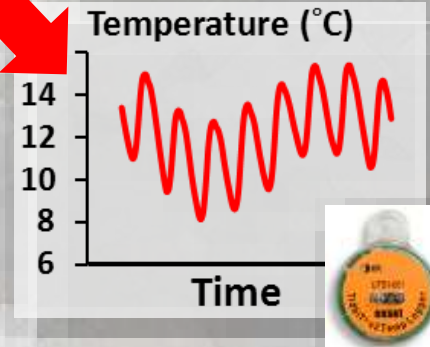
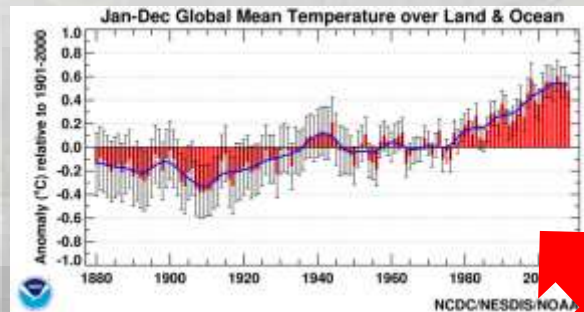
U.S. Forest Service

¹Trout Unlimited

²CSIRO

³NOAA

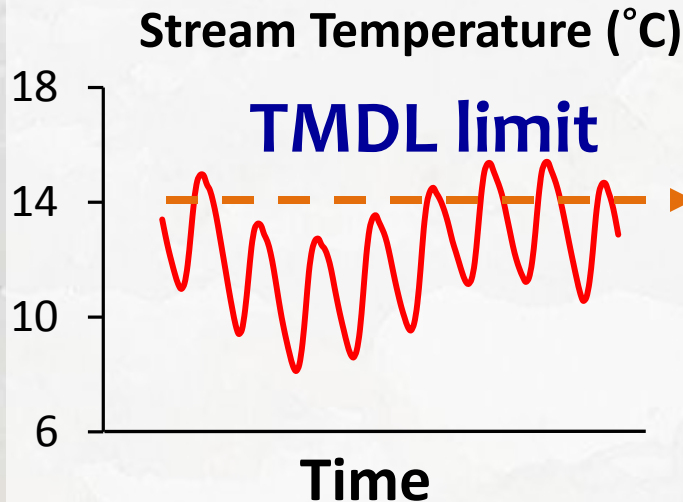
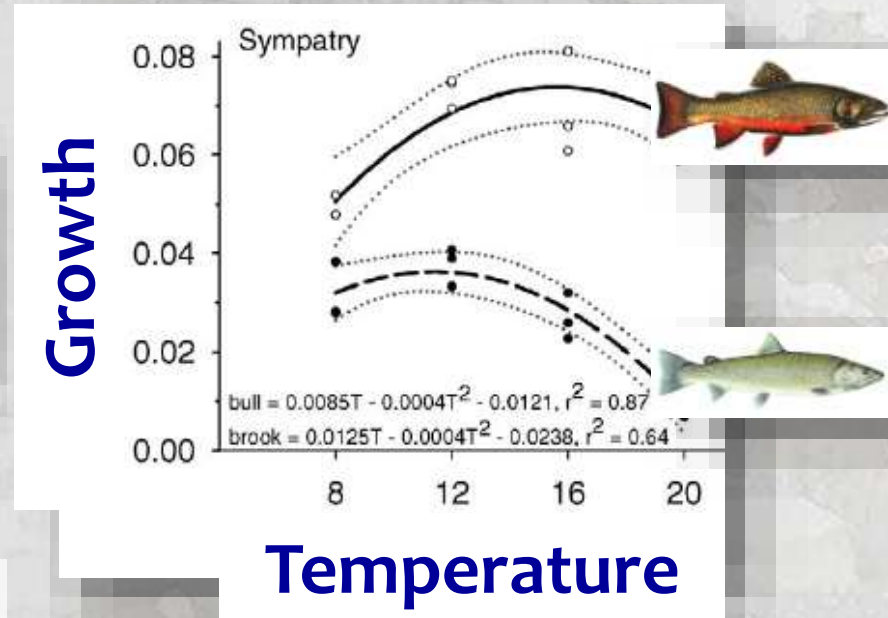
⁴USGS



Funding agencies:



Temperature is Destiny for Cold-Blooded Stream Critters

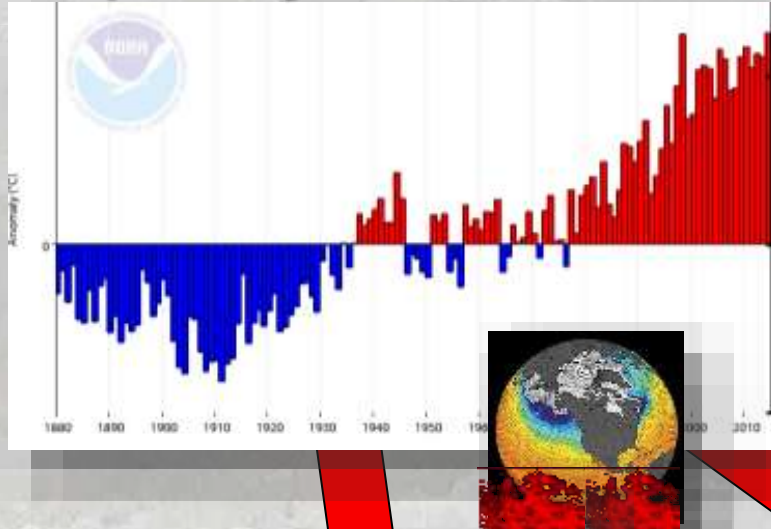


Too Hot!



Concerns about Climate Change

2014 & 2015 Set New Records



Tribal & Recreational Fisheries



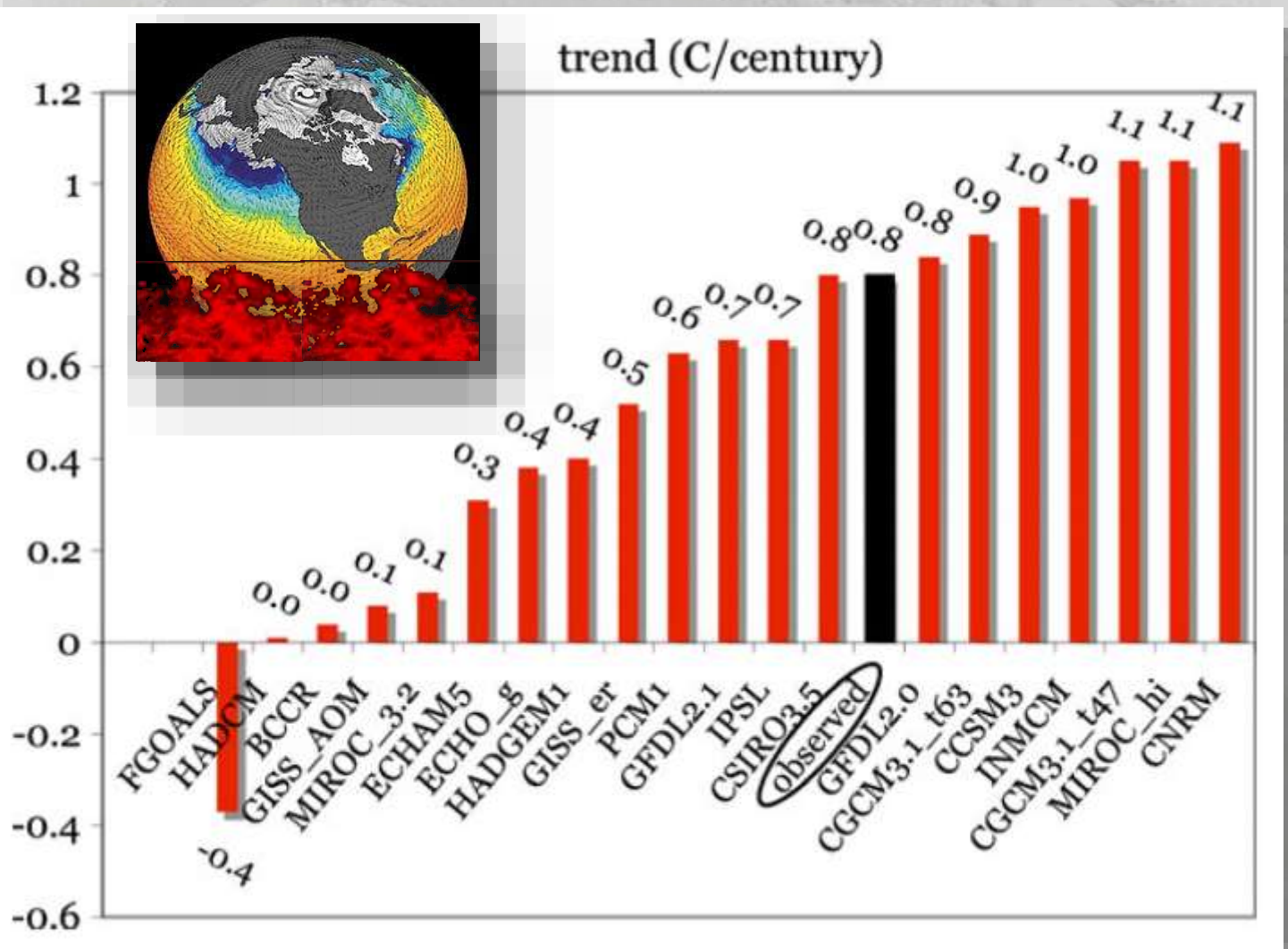
Land Use & Water Development



ESA Listed Species

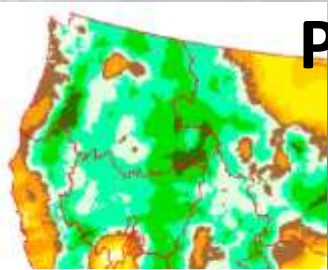
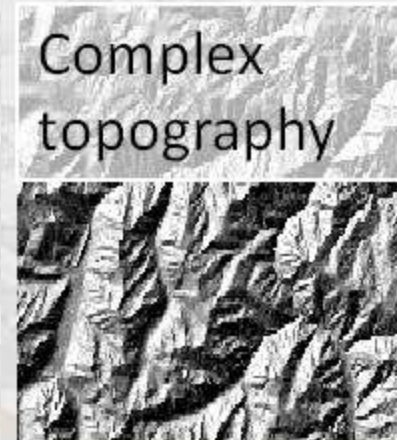
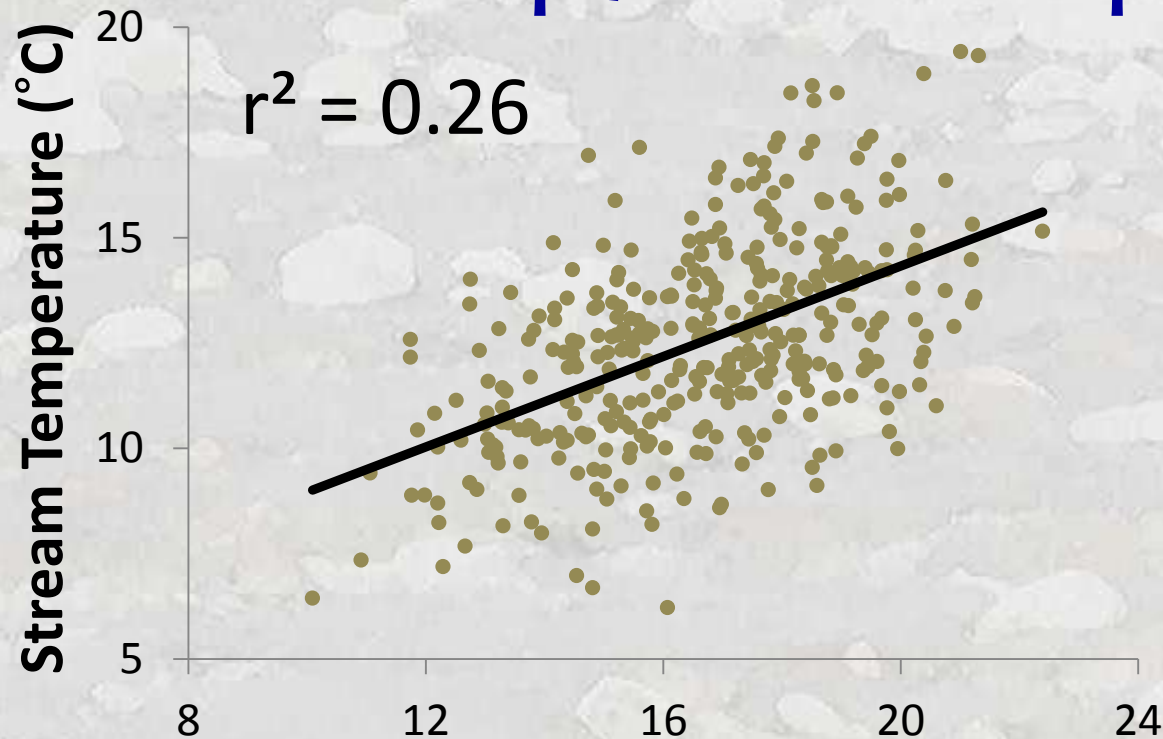


Many Climate Models & Scenarios for Air Temperature & Precipitation...



...but None for Stream Temperature

Air Temp $\neq$ Stream Temp



Groundwater buffering



Riparian differences

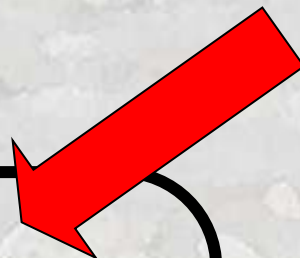
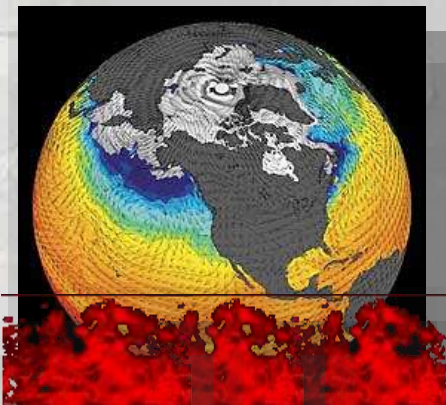
Need: High Resolution Stream Scenarios to Provide Management-Relevant Information

Global climate models

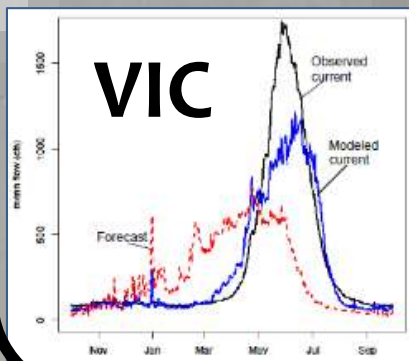
Resolution: 1000s of kilometers

Regional patterns

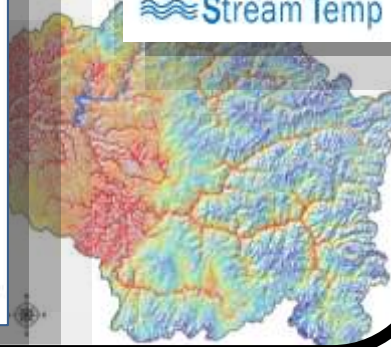
Resolution: 10s kilometers



River network
temperature & flow



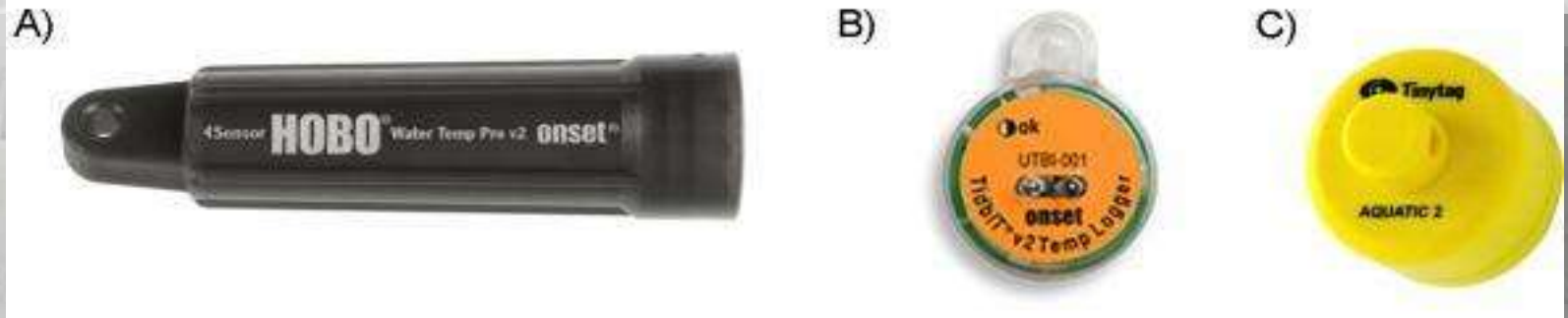
NorWeST
Stream Temp



Stream
reach



Miniature Temperature Sensors Made Data Collection Easy 20 Years Ago...



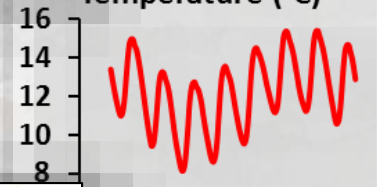
Sensor model	Accuracy	Battery life & memory	Cost
Hobo Pro v2	$\pm 0.2^{\circ}\text{C}$	6 years	\$123
Tidbit v2	$\pm 0.2^{\circ}\text{C}$	5 years	\$133
iButton	$\pm 0.5^{\circ}\text{C}$	1 year	\$20 – 40
Tinytag Aquatic 2	$\pm 0.5^{\circ}\text{C}$	1 year	\$170

& Lots of Temperature Were Collected...



NorWeST
Stream Temp

Temperature (°C)



Time



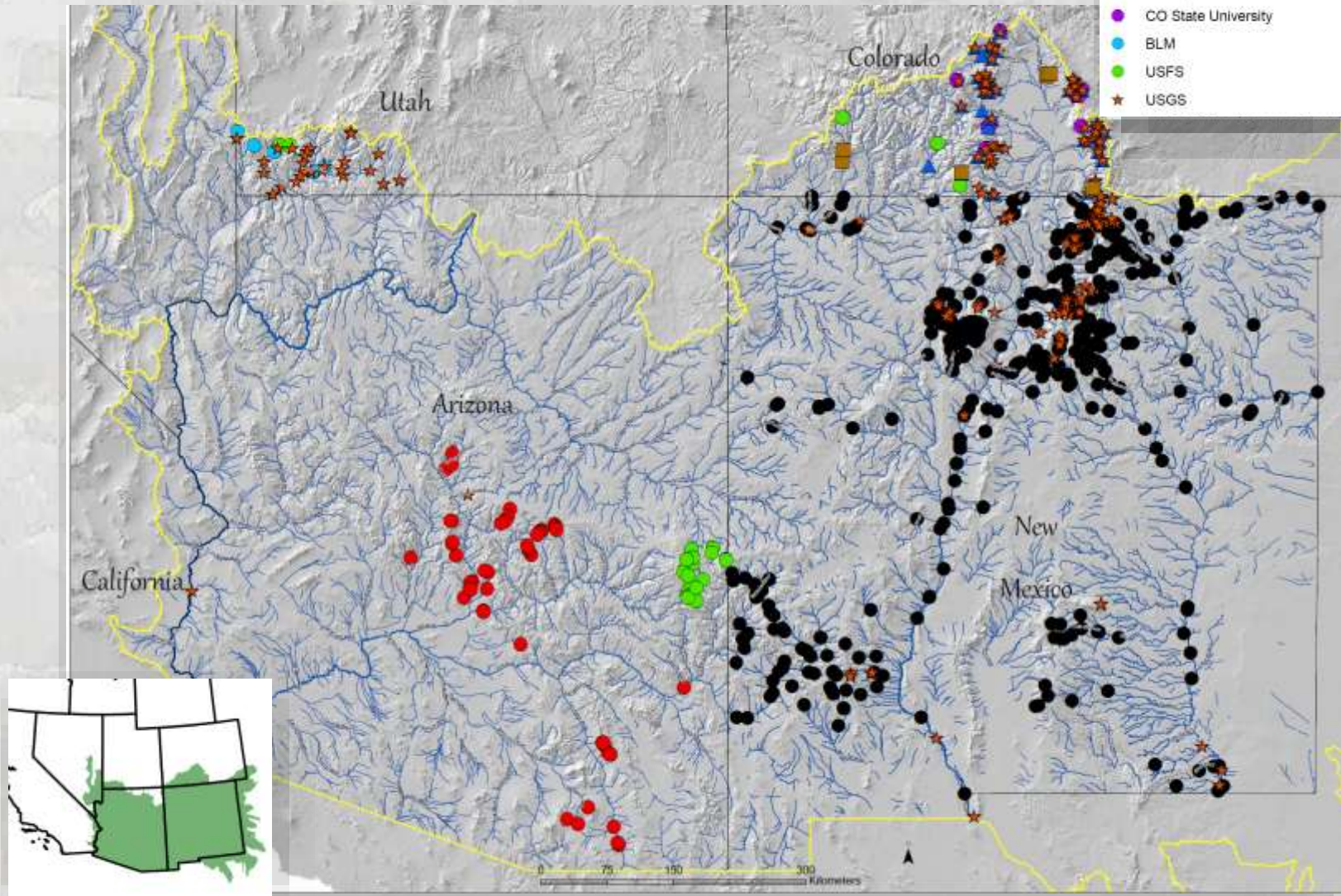
>100 agencies

>200,000,000 hourly records
>20,000 unique stream sites

Current Status of Southwest's Datasets

- 920 sites with temperature data
- 8 contributing agencies

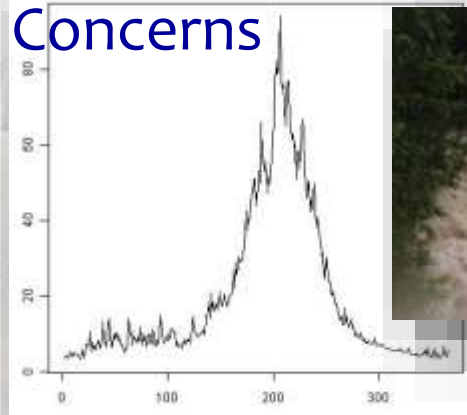
Data Contributor	
●	AZ Game & Fish
●	NM Environment Dept
■	CO Parks & Wildlife
▲	CO Dept Public Health & Envir
●	CO State University
●	BLM
●	USFS
★	USGS



Collect New Data to Fill Gaps

Epoxy sensors onto boulders & bridges

Annual Flooding
Concerns



Underwater epoxy cement



\$130 = 5 years of data

Data retrieved
from underwater



Sensors glued to large
boulders & bridges

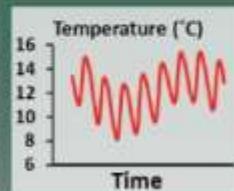


Isaak et al. 2013. USFS Report;
Isaak & Horan 2011. **NAJFM** 31:134-137

Collect New Data to Fill Gaps

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



United States Department of Agriculture / Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-314
September 2013



EPA/600/R-13/170F | September 2014 | www.epa.gov

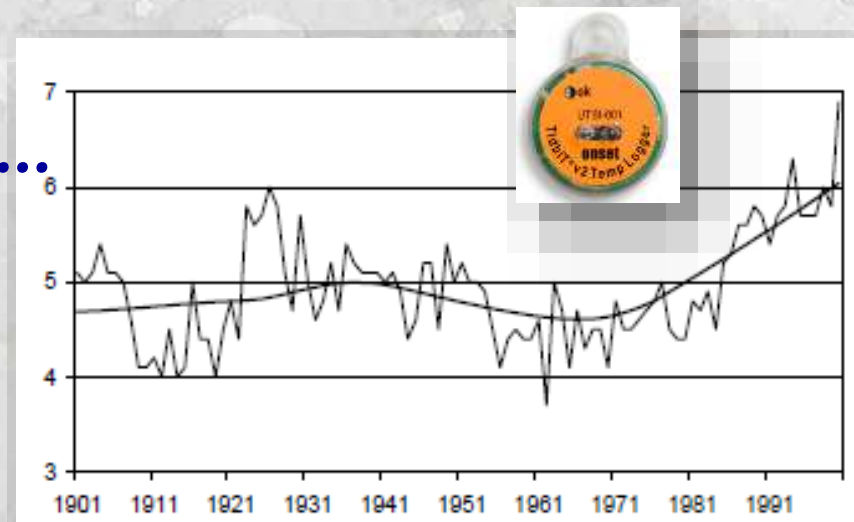
Best Practices for Continuous Monitoring of Temperature and Flow in Wadeable Streams



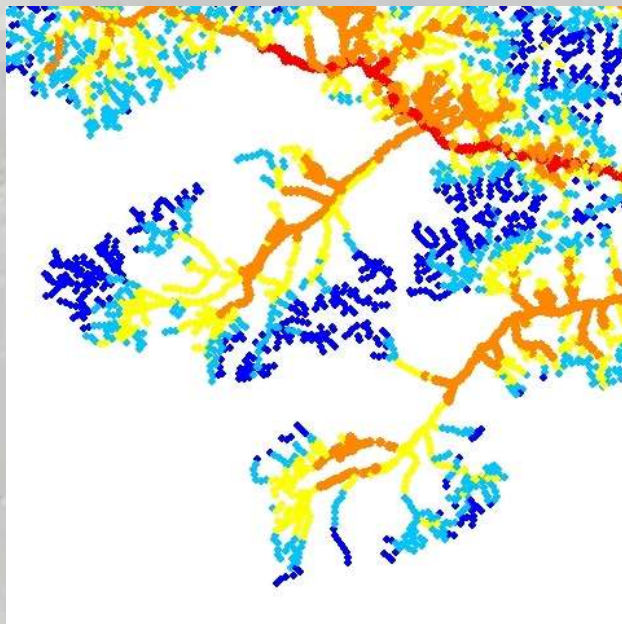
How Long Should Temperatures be Monitored?

Long-term records are rare...

So some sites should be monitored indefinitely



Webb and Nobilus 2007

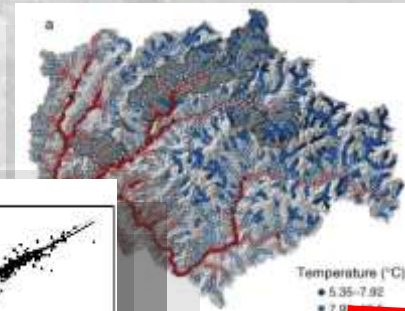
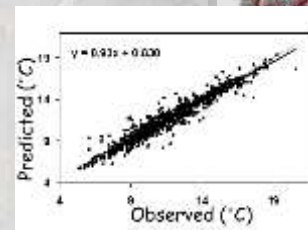
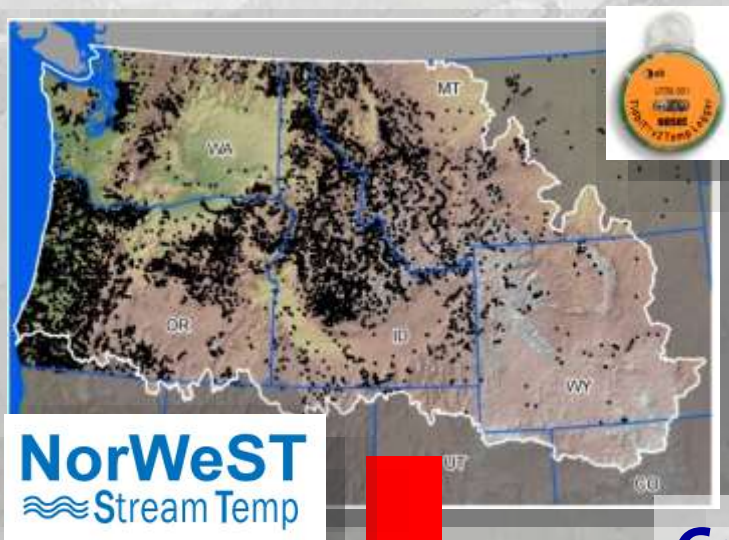


... but spatial variation among sites contains most “information” about thermal regimes

So some sites could be monitored for short periods (1 – 3 years) & sensors rotated to new sites

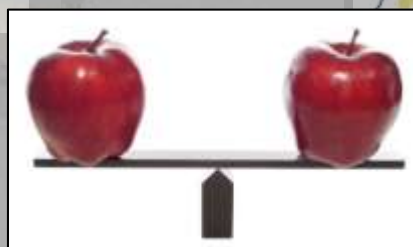
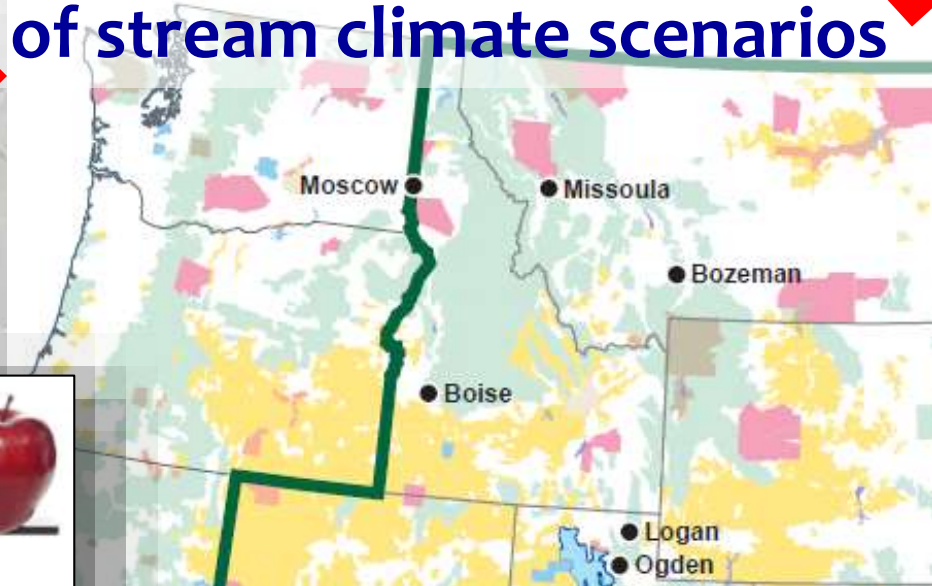
Develop Accurate Temperature Model

Accurate stream temp
model



Cross-jurisdiction “maps”
of stream climate scenarios

Consistent datum for
strategic planning
across all streams

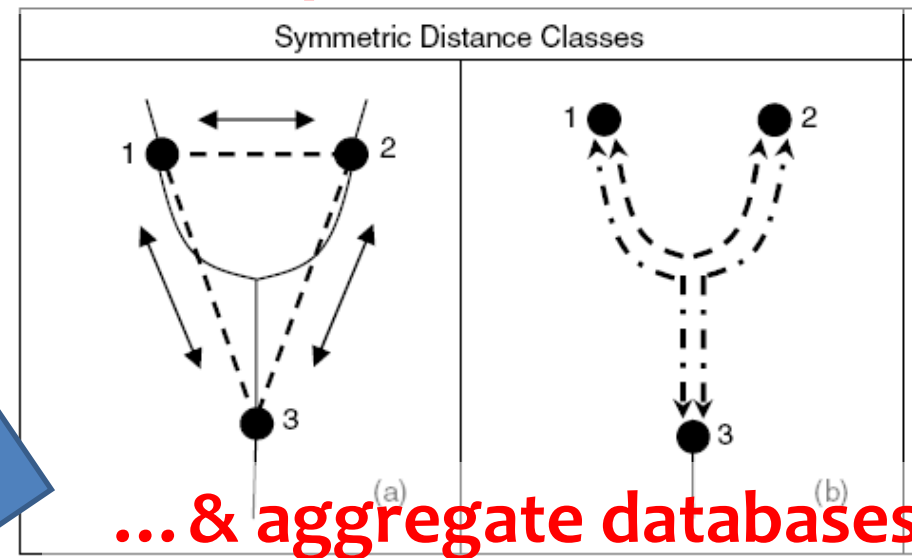


“Found” Data are often Autocorrelated

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

Apply Data Mining Techniques

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. Glacier (%)

10. Discharge (m³/s)

USGS gage data

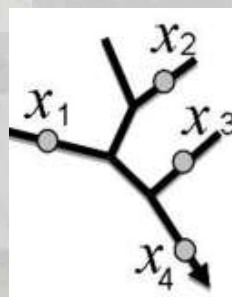
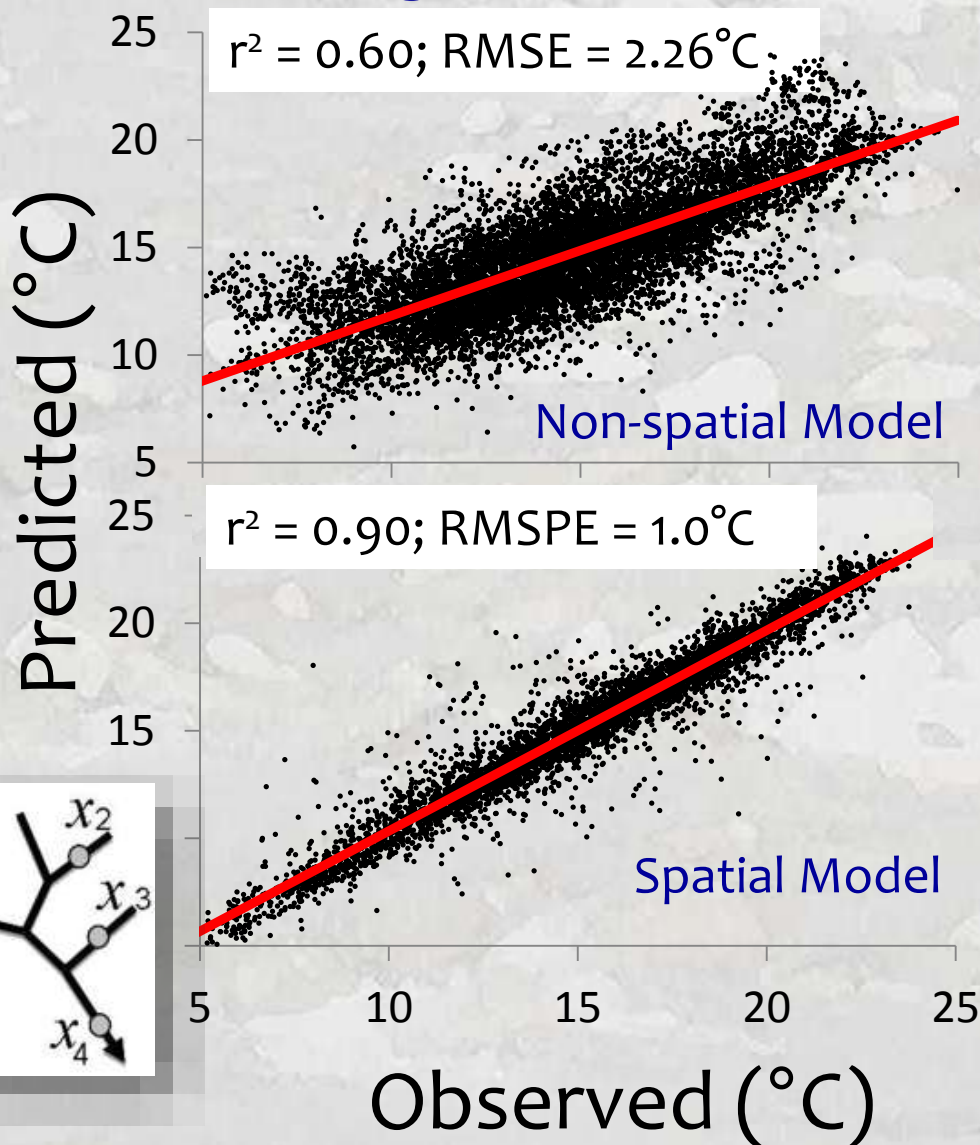
11. Air Temperature (°C)

RegCM3 NCEP reanalysis

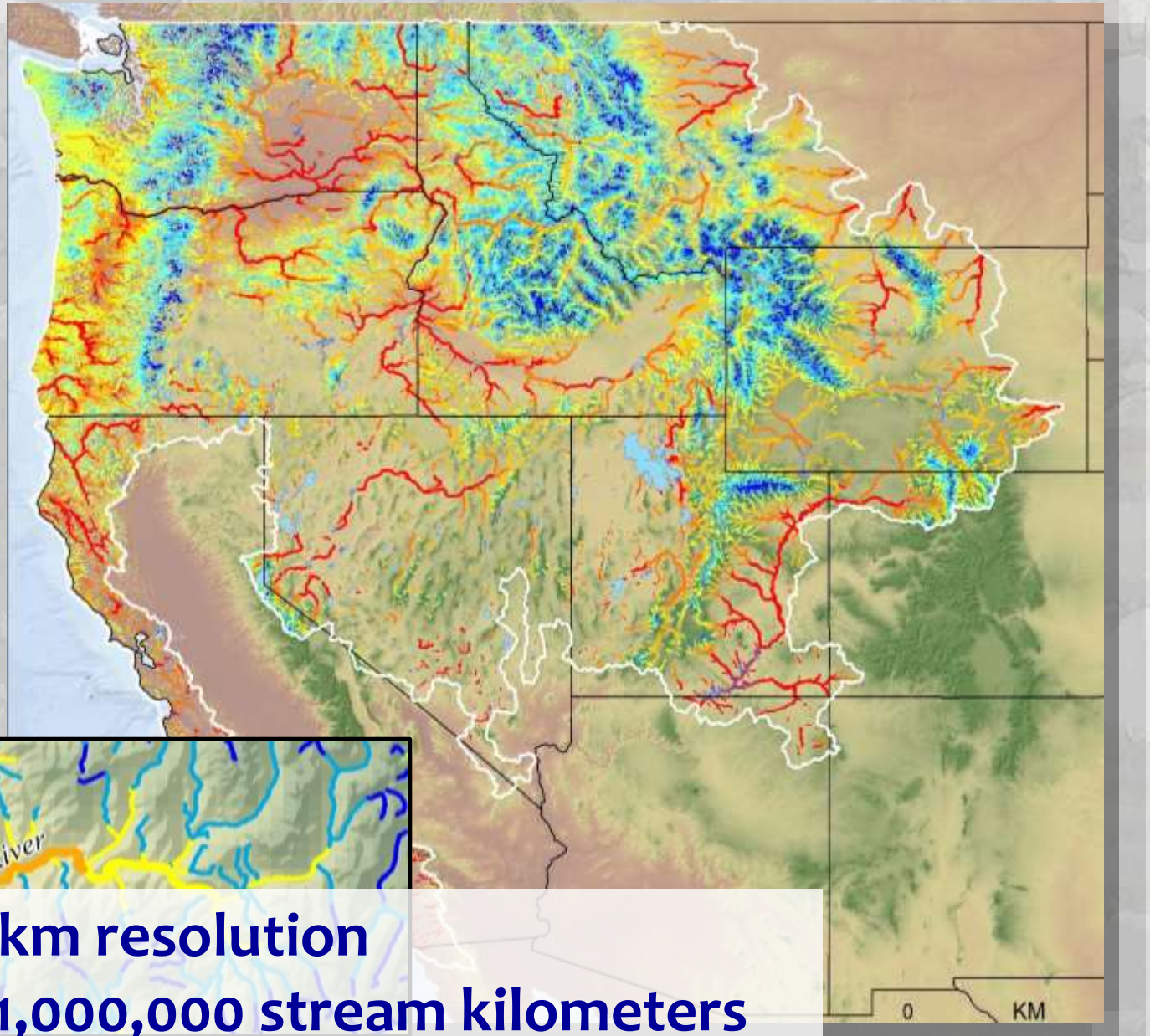
Hostetler et al. 2011

Ecological Applications
20:1350-1370.

Mean August Temperature

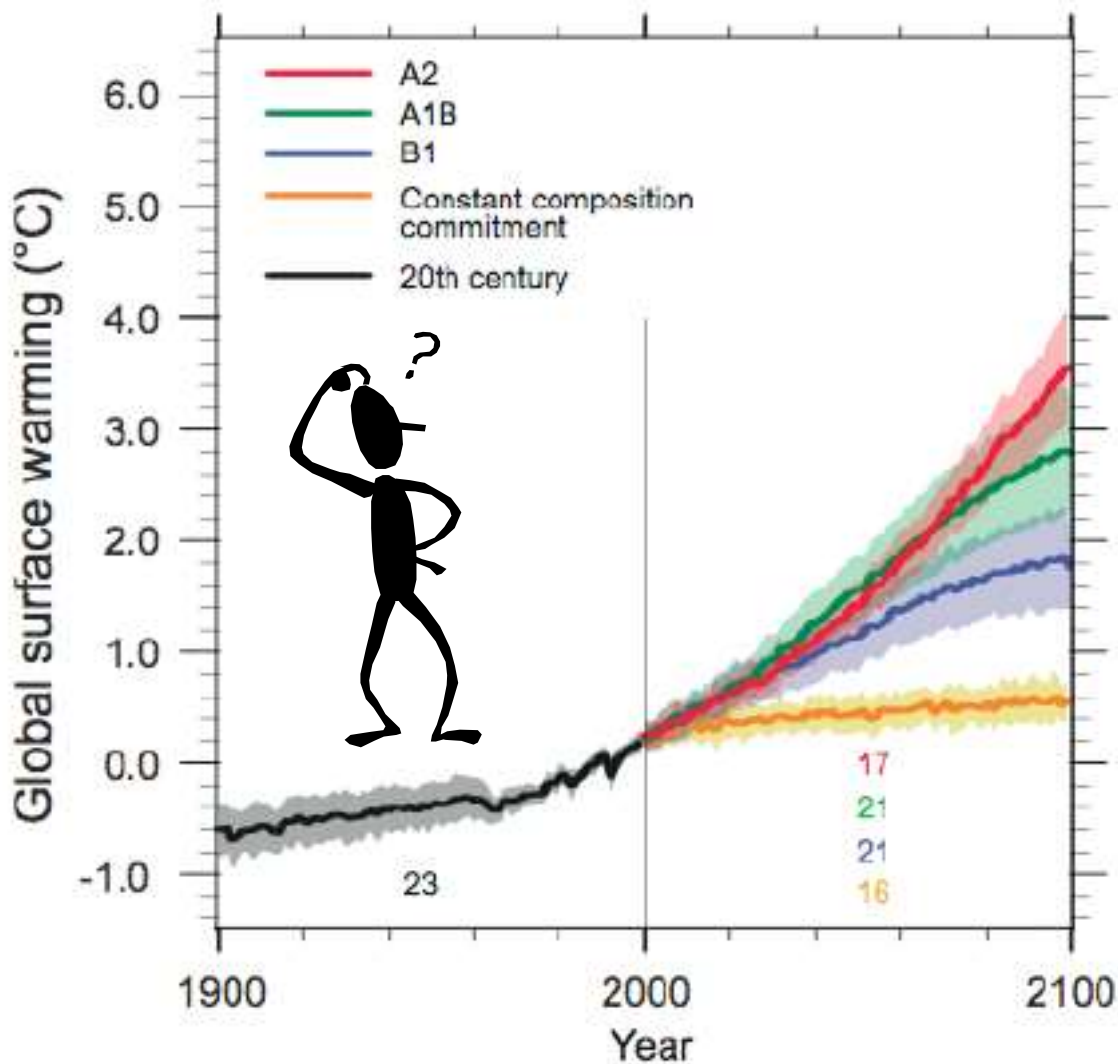


Stream ThermalScale so Far...



Climate Scenario Development

Many possibilities exist...



Adjust...

- Air
- Discharge
- %Canopy

... values to
create scenarios

30 NorWeST Climate Scenarios

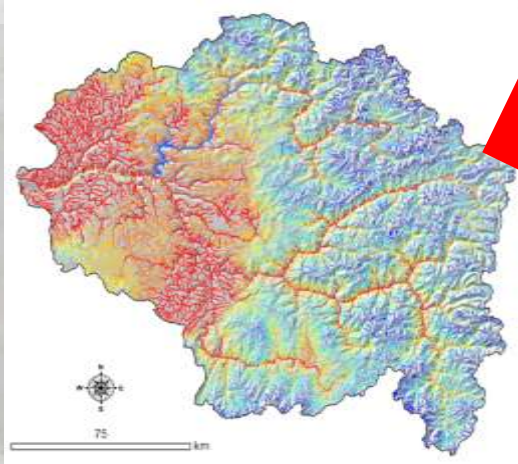


Scenario	Description
S1_93_11	Historical scenario representing 19 year average August mean stream temperatures for 1993-2011
S2_02_11	Historical scenario representing 10 year average August mean stream temperatures for 2002-2011
S3_1993	Historical scenario representing August mean stream temperatures for 1993
S4_1994	Historical scenario representing August mean stream temperatures for 1994
Etc...	
S23-33	10 Future scenarios...

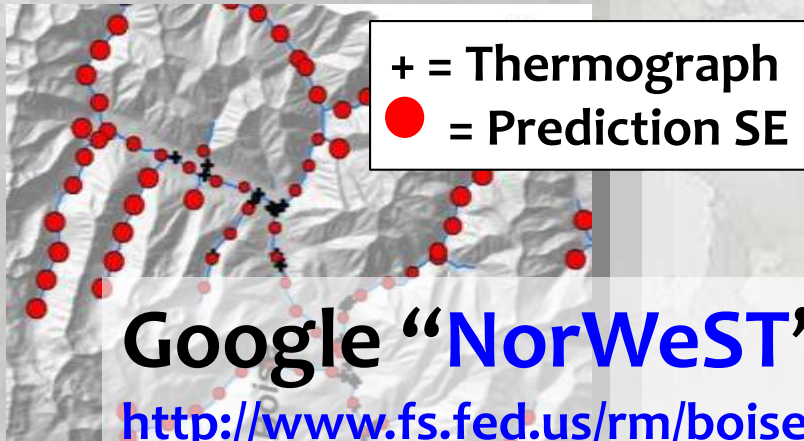
***Extensive metadata on website**

Website Distributes Scenarios & Data in User-Friendly Formats

1) GIS shapefiles of stream temperature scenarios



2) GIS shapefiles of stream temperature model prediction precision



NorWeST
Stream Temp



Regional Database and Modeled Stream Temperatures

3) Temperature data summaries

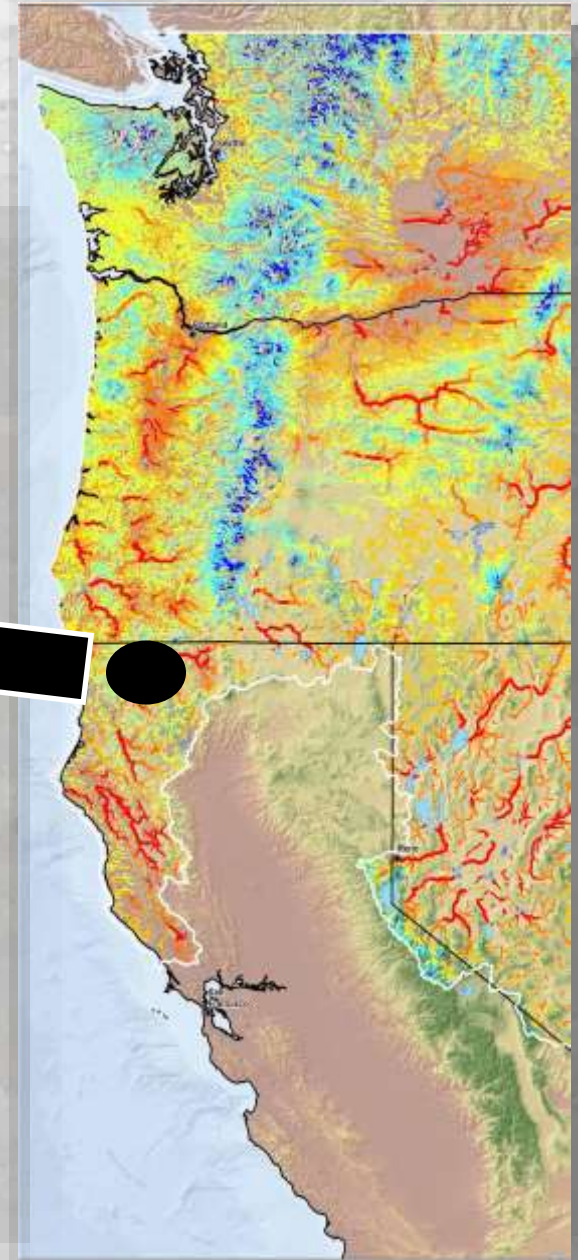
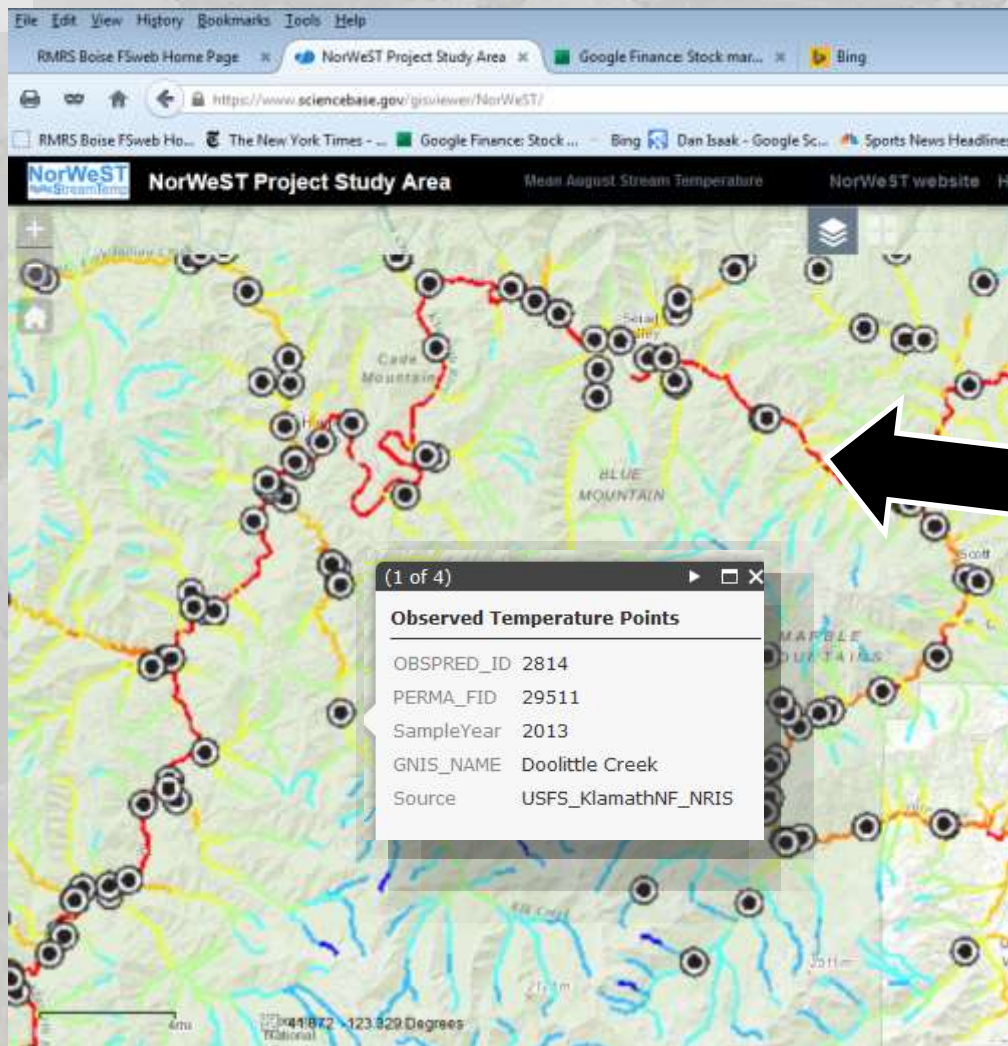


Google “**NorWeST**” or go here...

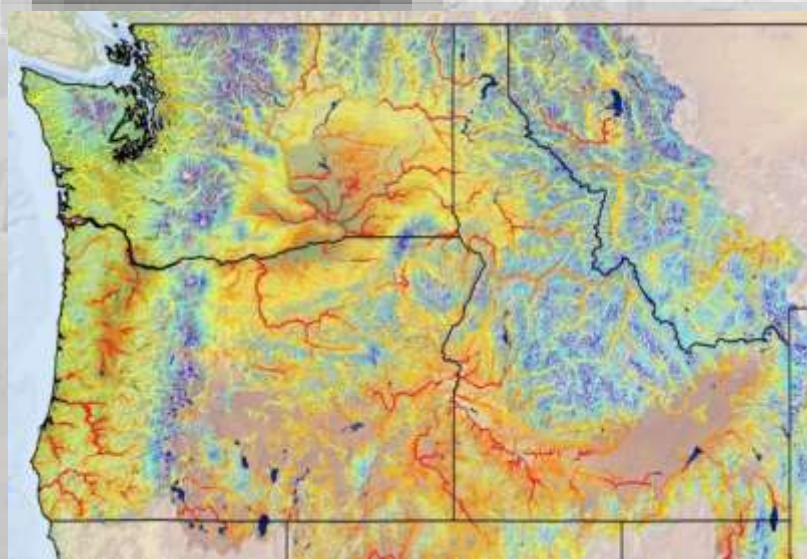
<http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.shtml>

Websurf from your Desktop

★ Dynamic Online Map Viewer



Temperature Applications



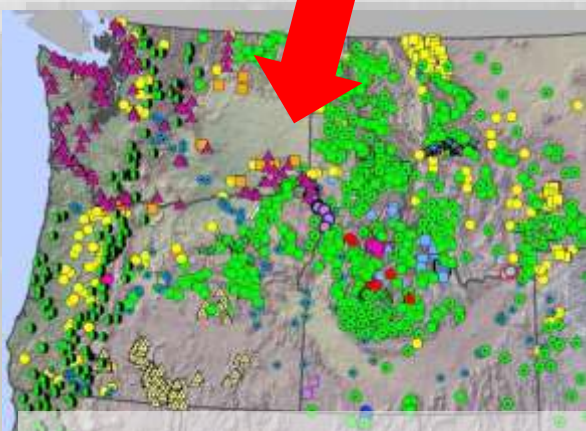
Regulatory temperature standards



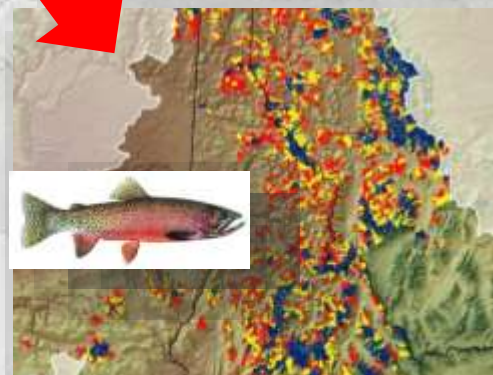
Too Hot!

Too cold!

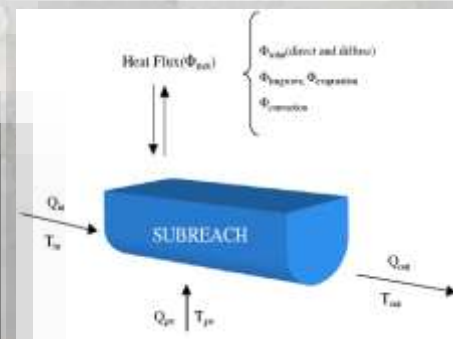
Data access accelerates temperature research



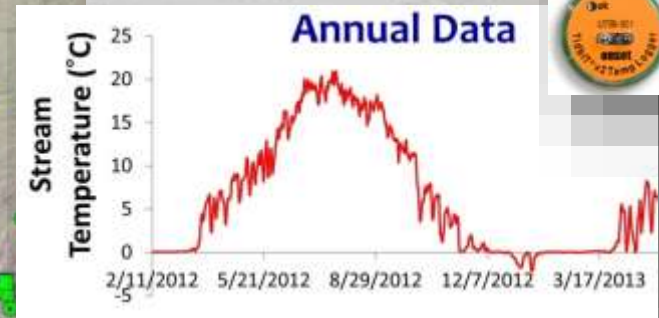
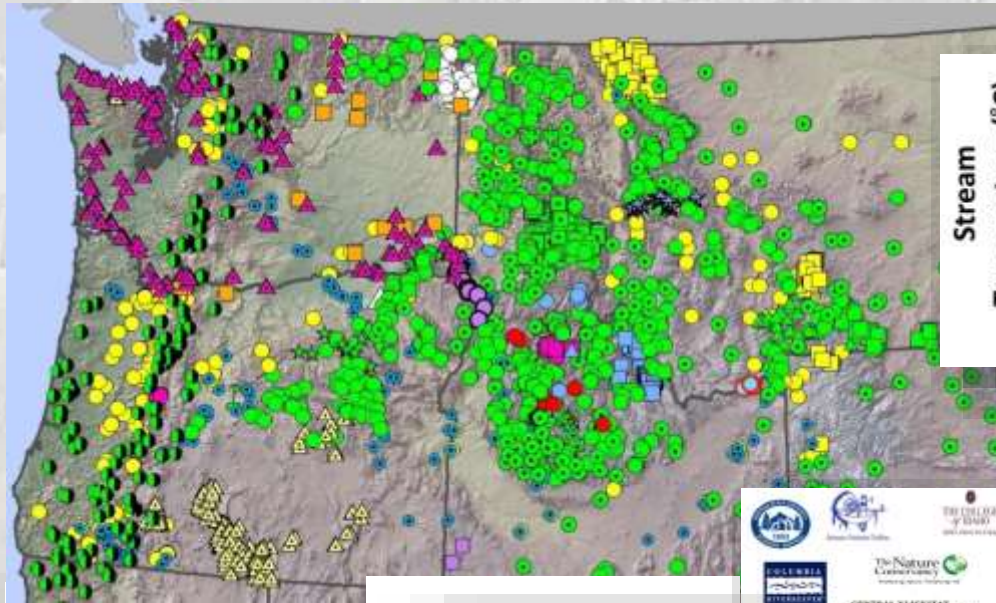
Coordinated
Interagency monitoring



Species distribution models &
climate assessments



Efficient Inter-Agency Coordination



A vertical strip of a photograph showing a large fire burning in a wooded area. The fire is intense, with bright orange and yellow flames reaching upwards. In the foreground, there is a body of water, possibly a river or lake, with a rocky shoreline. The background shows a dense forest of trees. The entire strip is set against a blue, textured background.

