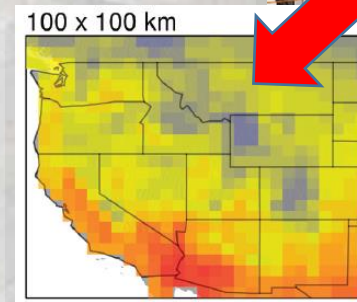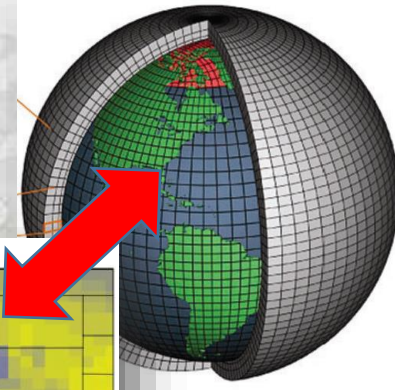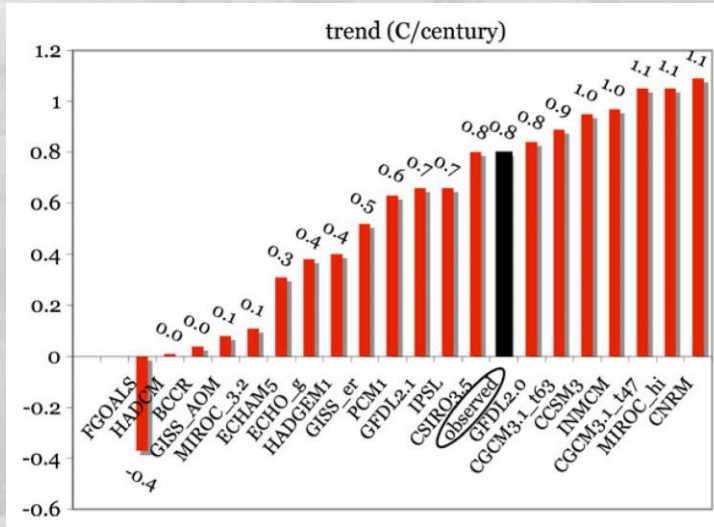# A Cacophony of Terrestrial Climate Science
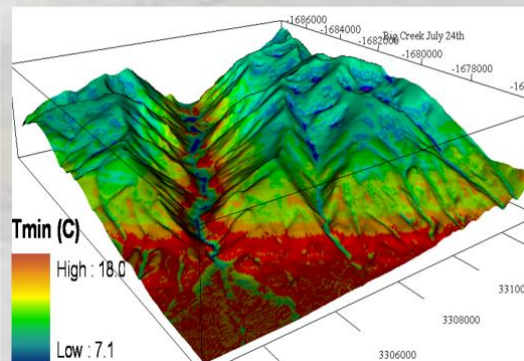
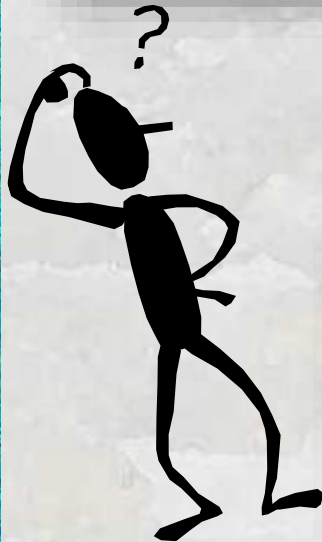**Dozens of GCMs & ensemble forecasting**

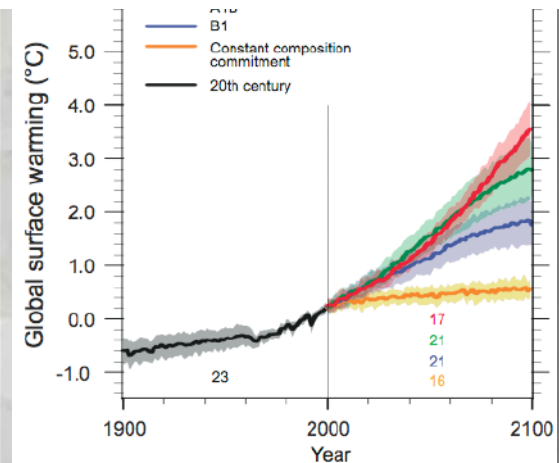**Statistical & dynamic downscaling**
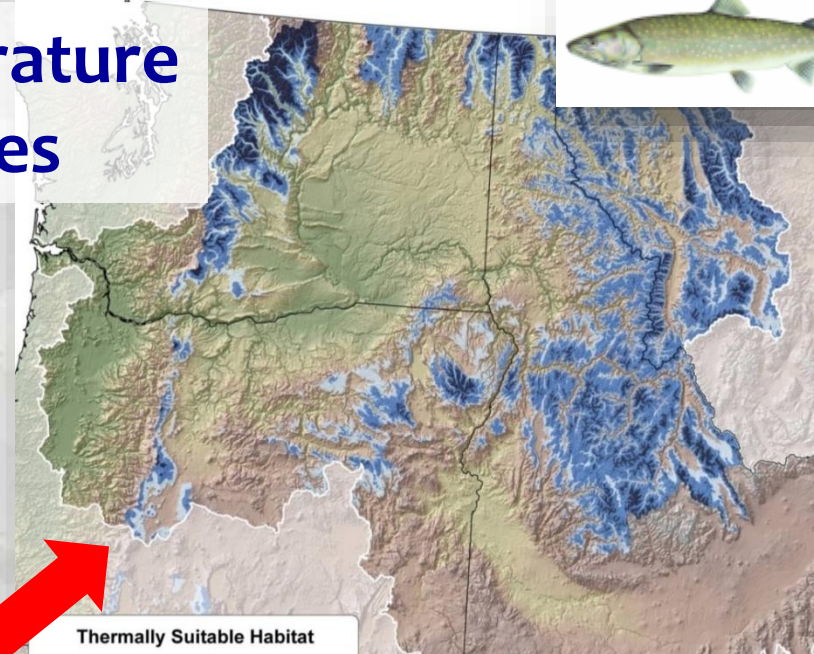
CMIP3 & CMIP5

Topoclimate models

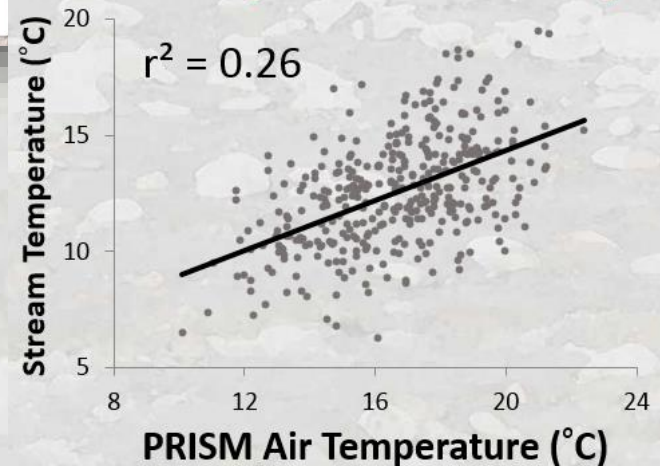**Scenario trajectories (A1B, B2, RCP 6.0, etc…)**

Stream Temperature Climate Scenarios (circa ~2010)

Elevation & Air Temperature as Coarse Surrogates

- 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

Thermally Suitable Habitat

		Current bull trout habitat
		250 m (1.6° C) increase
		800 m (5° C) increase

Air Temp ≠ Stream Temp

$r^2 = 0.26$

Stream Temperature (°C) vs PRISM Air Temperature (°C)

Stream Temperature Climate Scenarios (circa ~2010)

High-resolution landscape models
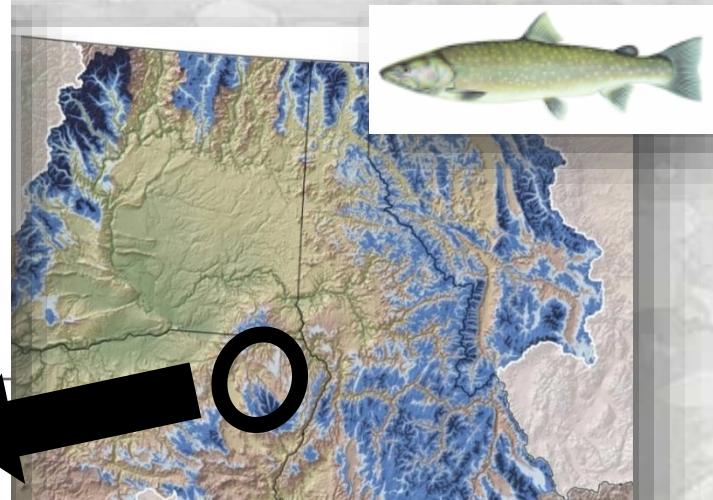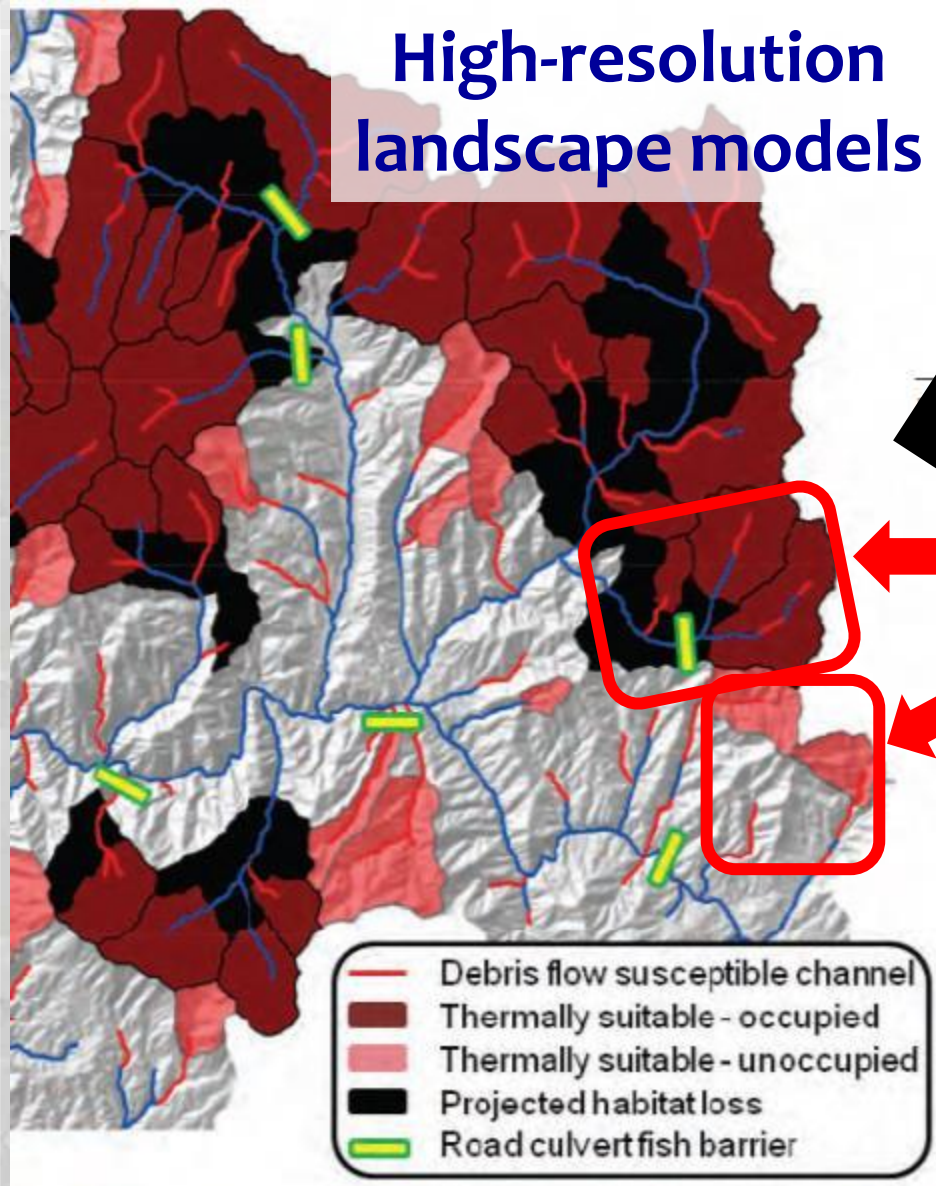
I'm going to invest here...

...instead of here

Debris flow susceptible channel
Thermally suitable - occupied
Thermally suitable - unoccupied
Projected habitat loss
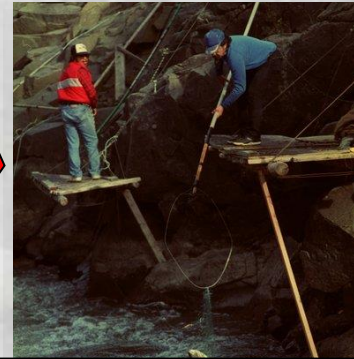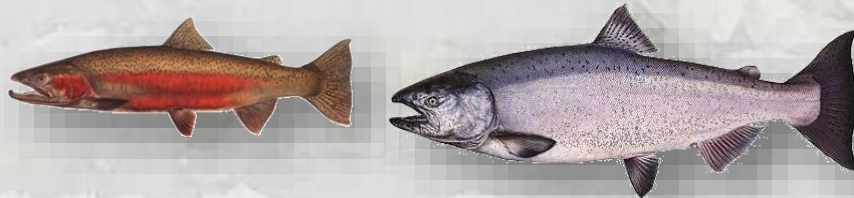Road culvert fish barrier

There's a Lot on the Fish Line…

Climate Boogeyman
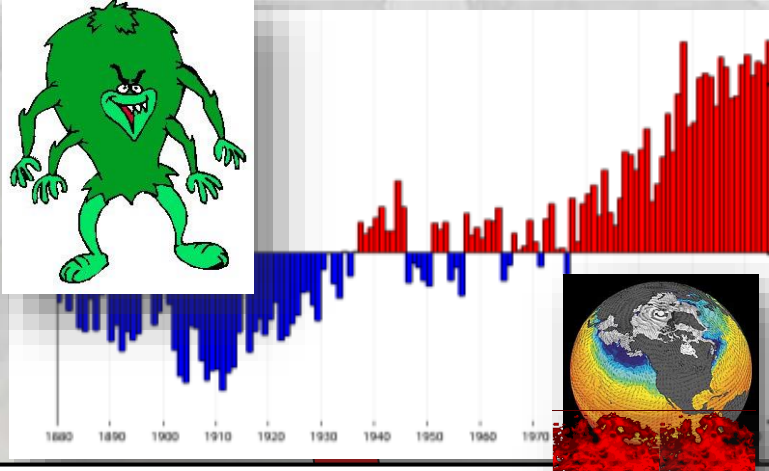
Tribal & Recreational Fisheries

$20-30 Billion on Salmon Recovery Efforts in PNW Since 1980

Land Use & Water Development

ESA Listed Species

We were Swimming in Un-usable Data
Not Accessible = Didn't Exist

Temperature (°C)

Time

HOBO Water Temp Pro v2 onset

>100 agencies

State   **Federal**
Tribal   **Private**
Municipal **County**

THE NORWEST STREAM TEMPERATURE PROJECT:

HOW CROWD-SOURCING & SOCIAL NETWORKING FORGED A USER-COMMUNITY TO PROTECT AQUATIC BIODIVERSITY IN THE AMERICAN WEST

Dan Isaak, Seth Wenger[1], Erin Peterson[2], Jay Ver Hoef[3] Charlie Luce, Steve Hostetler[4], Jason Dunham[4], Jeff Kershner[4], Brett Roper, Dave Nagel, Dona Horan, Gwynne Chandler, Sharon Parkes, Sherry Wollrab
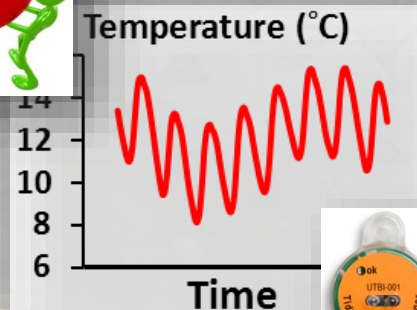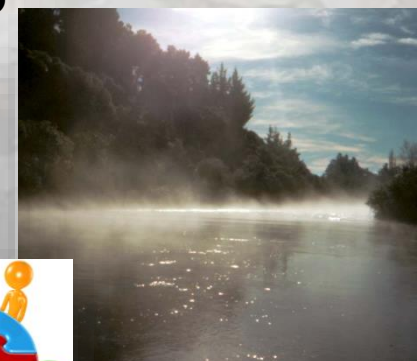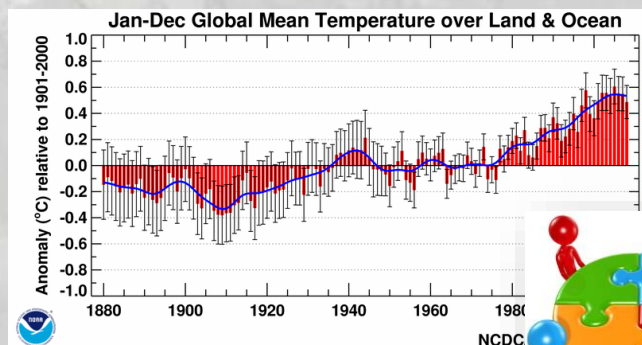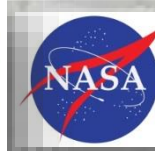
U.S. Forest Service
[1]Trout Unlimited
[2]CSIRO
[3]NOAA
[4]USGS

Funding agencies:

A Database: 5 Years Later…

NorWeST Stream Temp

Temperature (°C)

Time
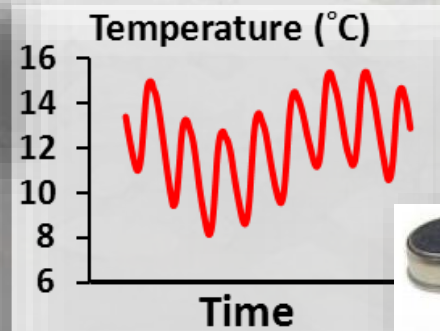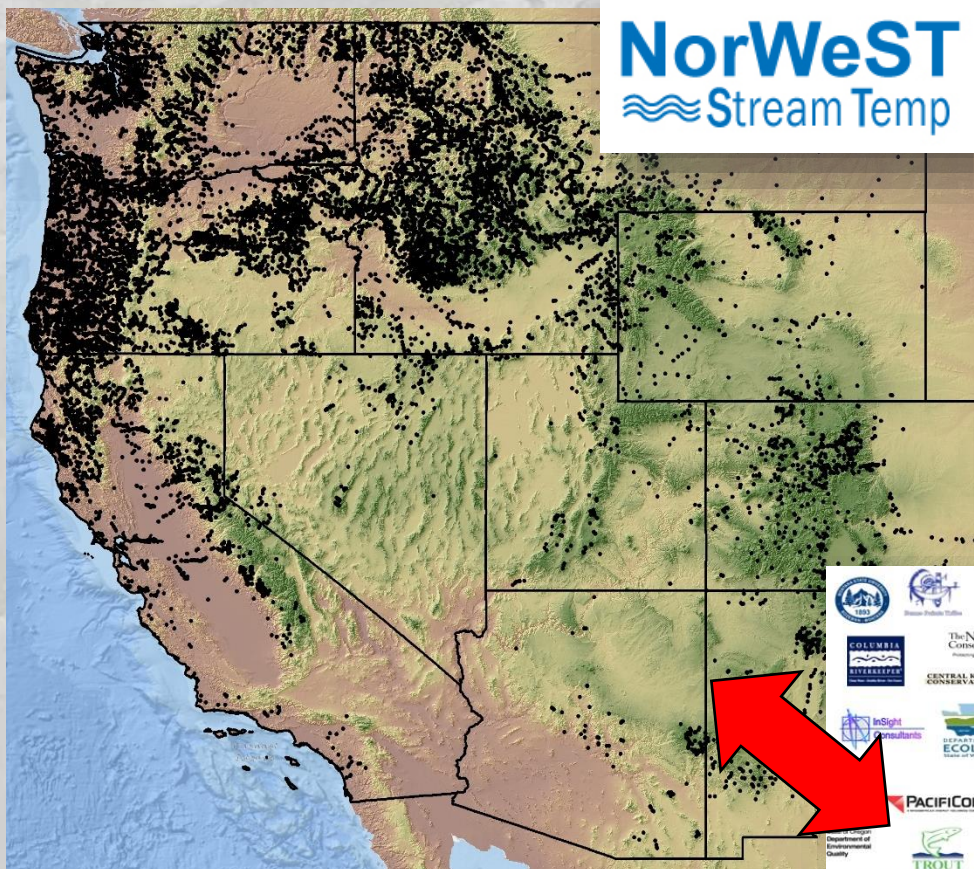
>100 agencies

>200,000,000 hourly records
>20,000 unique stream sites
>$10,000,000 value

Scenarios Created Using Geostatistical Model & Covariates

Covariate Predictors

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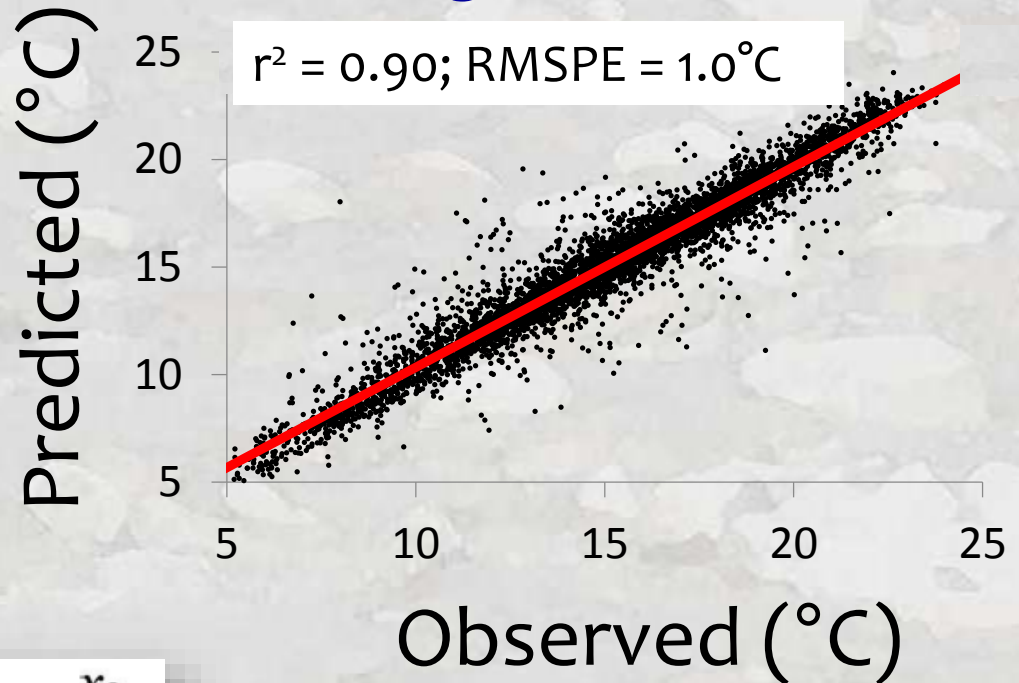8. Watershed size (km²)
9. Glacier (%)

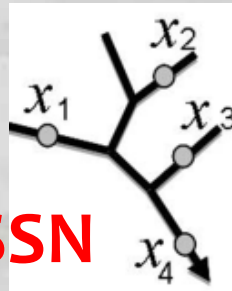10. Discharge (m³/s)
    USGS gage data
11. Air Temperature (°C)
    RegCM3 NCEP reanalysis
      Hostetler et al. 2011

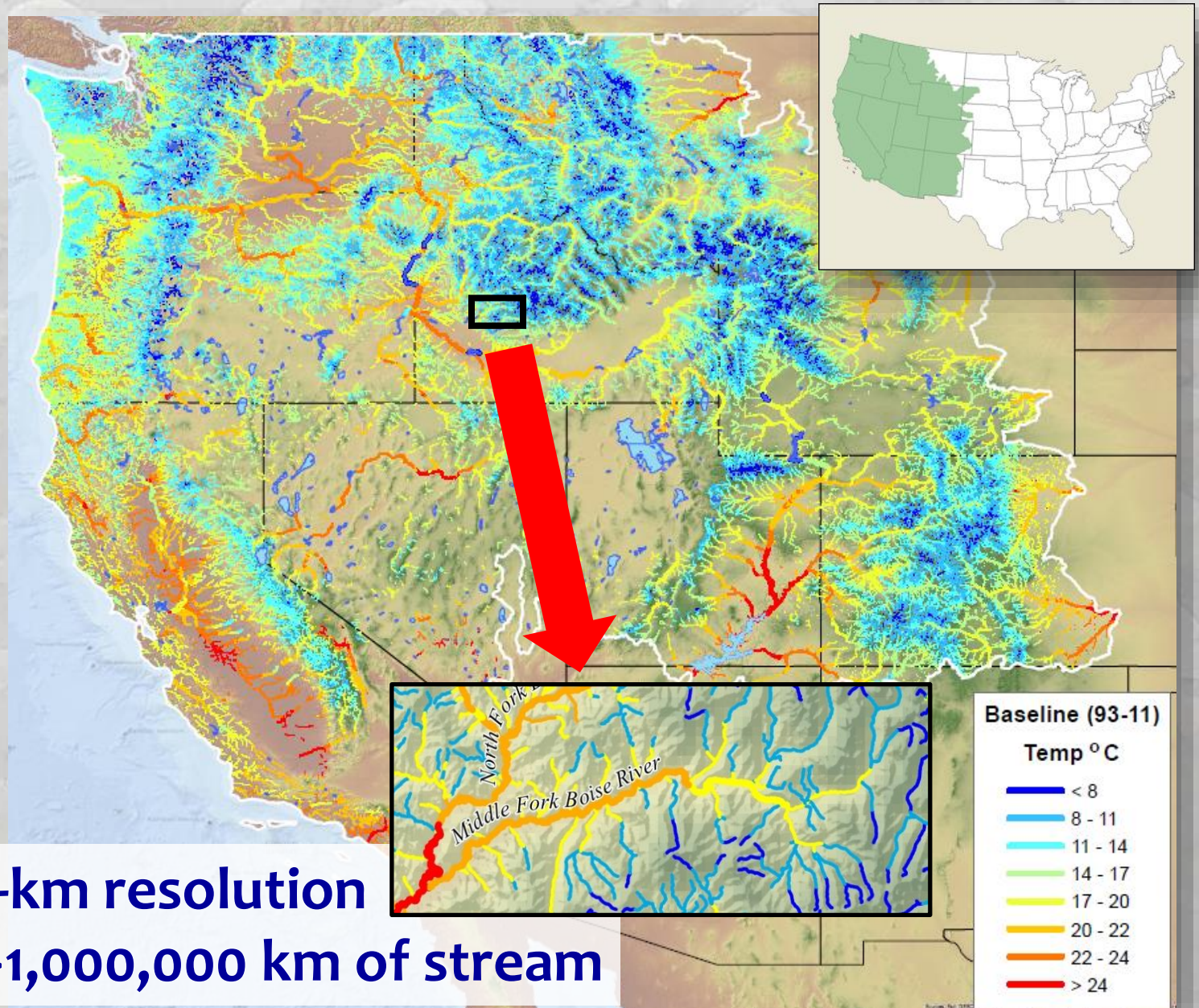Isaak et al. 2010.
Ecological Applications
20:1350-1370.

SSN

Mean August Temperature

r² = 0.90; RMSPE = 1.0°C

Predicted (°C)

Observed (°C)

~Topoclimate model

Consistent Scenarios for all Rivers & Streams

Baseline (93-11) Temp °C

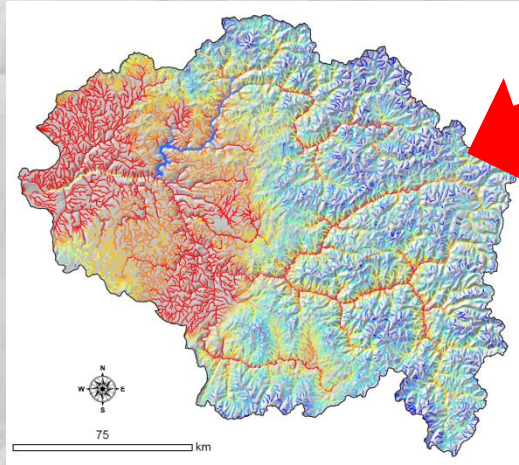|	
▬	< 8
▬	8 - 11
▬	11 - 14
▬	14 - 17
▬	17 - 20
▬	20 - 22
▬	22 - 24
▬	> 24

1-km resolution
>1,000,000 km of stream

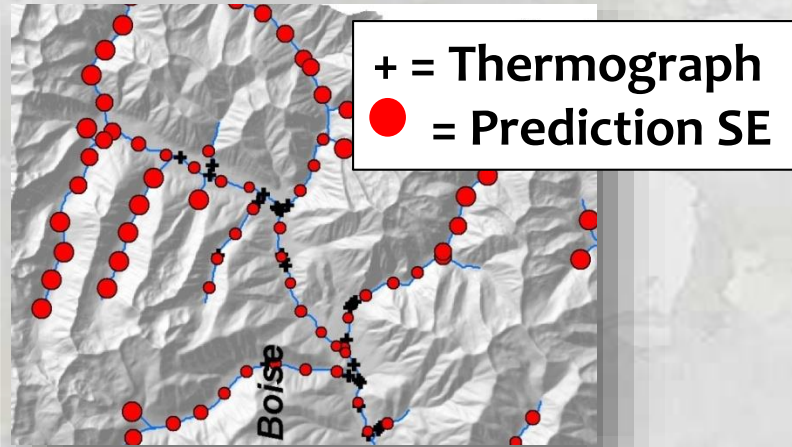# Information Delivered Through Custom Website in User-Friendly Digital Formats

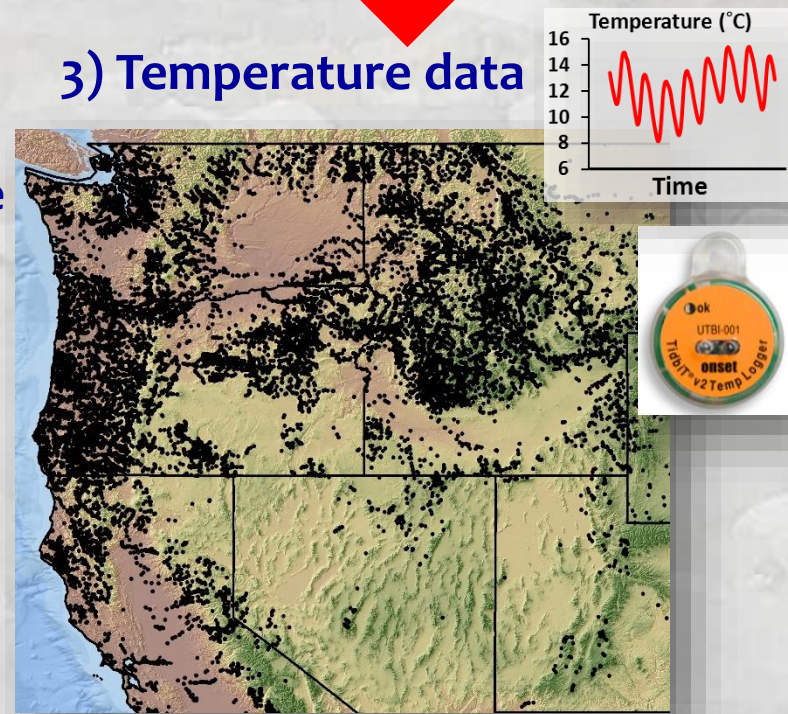**1) GIS shapefiles of stream temperature scenarios**

NorWeST ≈ Stream Temp

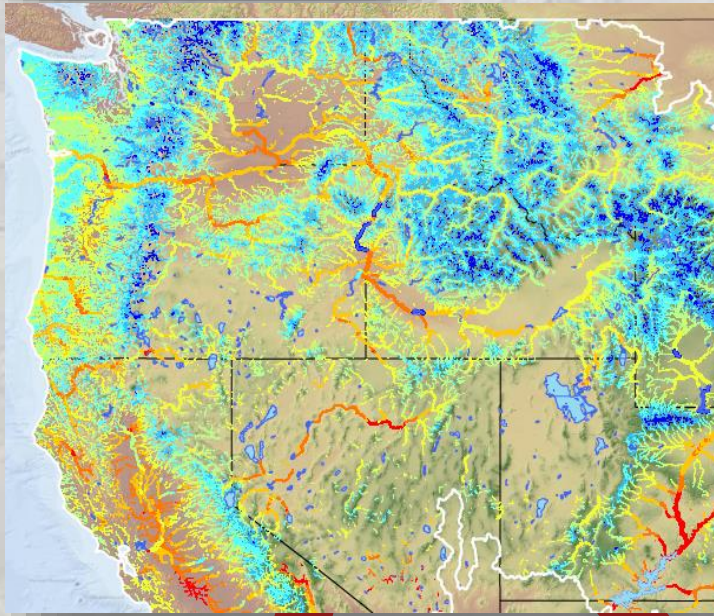**Regional Database and Modeled Stream Temperatures**

Salmon River

3) Temperature data

Temperature (°C)

Time

2) GIS shapefiles of stream temperature model prediction precision

+ = Thermograph

● = Prediction SE
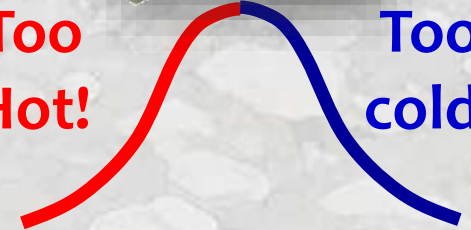
Boise

Temperature Applications
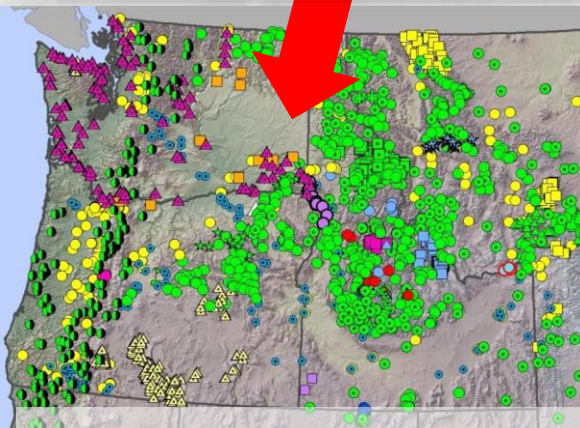
NorWeST Stream Temp

Regulatory temperature standards

Too Hot!   Too cold!

Data access accelerates temperature research

Heat Flux(Φ_{net})
Φ_{solar}(direct and diffuse)
$\Phi_{longwave}$, $\Phi_{evaporation}$
$\Phi_{convection}$

Q_{in}
T_{in}
SUBREACH
Q_{out}
T_{out}
Q_{gw} T_{gw}

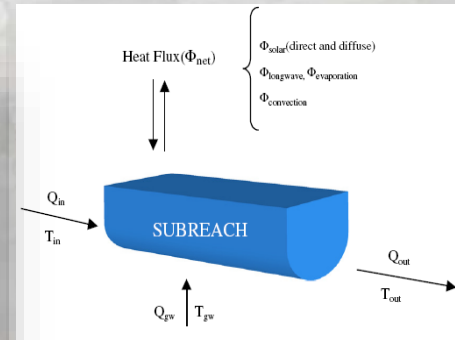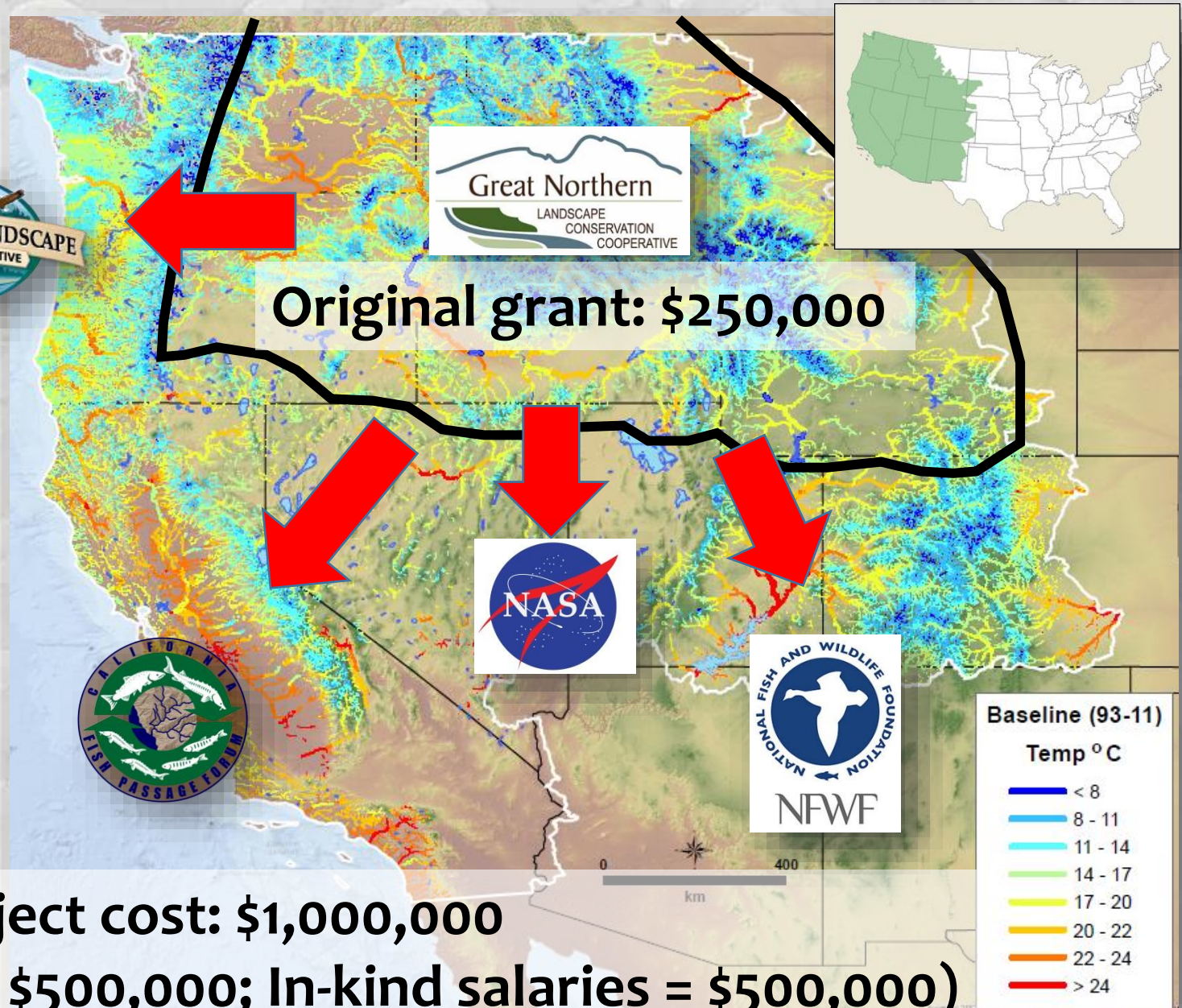**Coordinated Interagency monitoring**
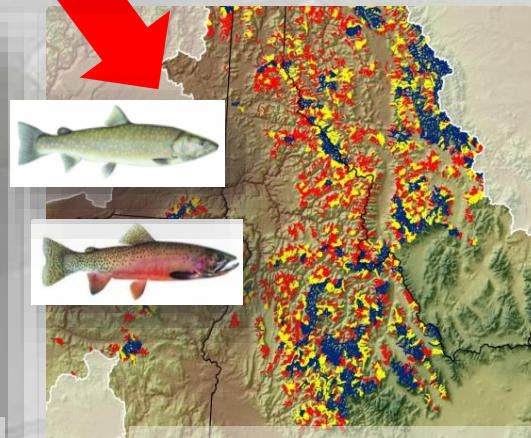
Species distribution models & Climate Adaptation Partnerships (D. Peterson)

Low Cost & Organic Growth

Original grant: $250,000

Total project cost: $1,000,000
(Grants = $500,000; In-kind salaries = $500,000)

Baseline (93-11)
Temp °C

- < 8
- 8 - 11
- 11 - 14
- 14 - 17
- 17 - 20
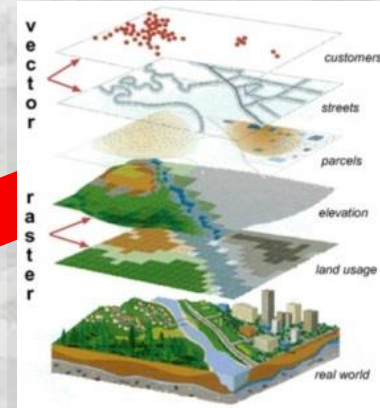- 20 - 22
- 22 - 24
- > 24

Secret Weapon: A Database team

& Good Customer Service!

Secret Weapon II: Team Science Approach

Managers

GIS analysts

Scientists

Database experts

Ecological Modelers
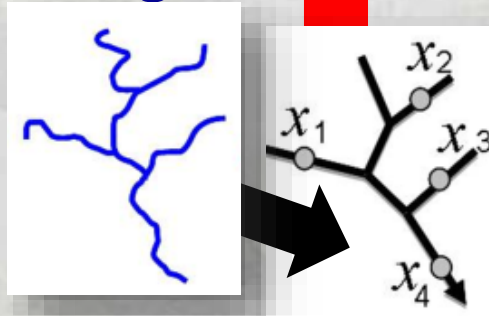
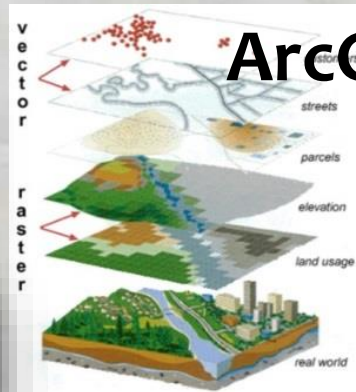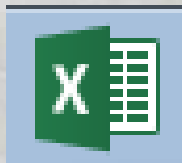# Secret Weapon III: Digital Media for Rapid & Pervasive Information Dissemination

1) Attractive & functional website

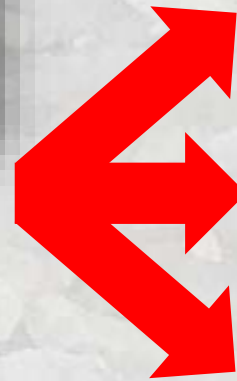**3) Social media, blogs, email chat...**
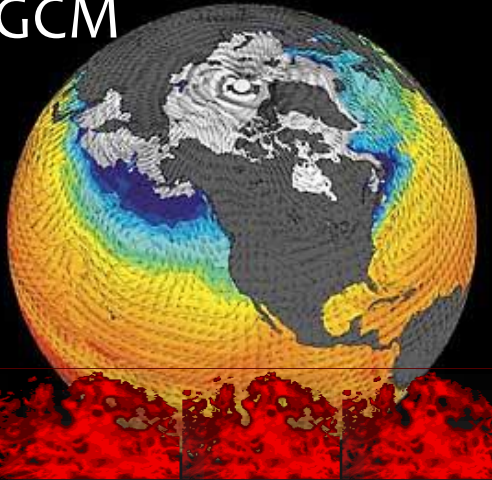
+

2) User-friendly data formats

ArcGIS

PDF Adobe

EMAIL

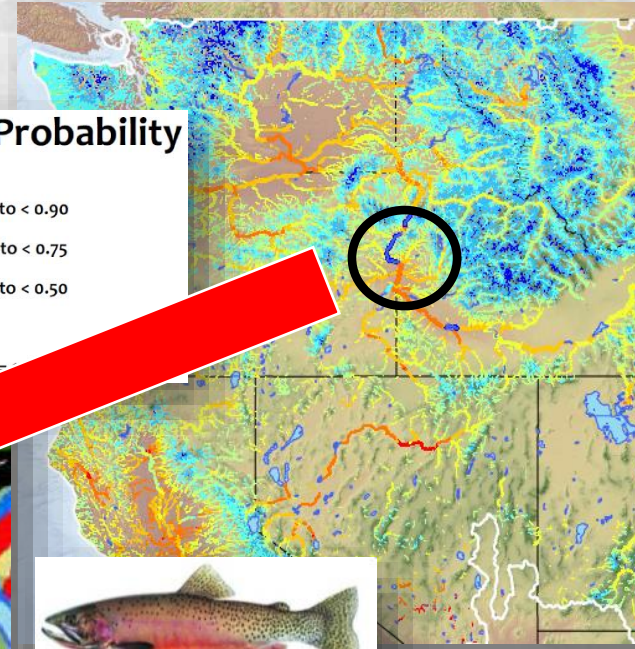twitter

Crowd-Sourcing Science Builds Stronger Social & Conservation Networks...
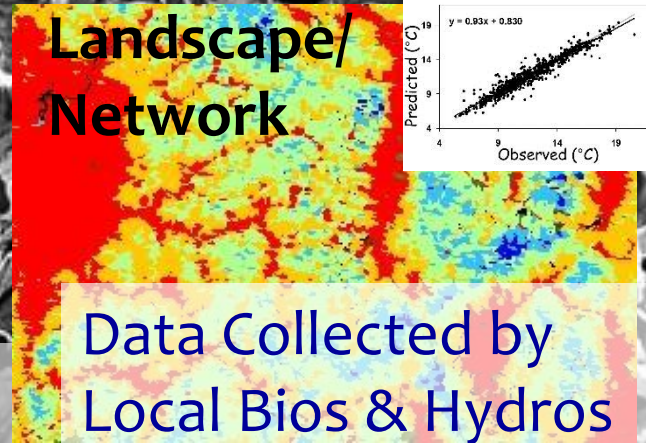
High-quality Spatial Information Empowers Local Decision Makers…

Cold-water Refuge streams

Occupancy Probability
- > 0.90
- > 0.75 to < 0.90
- > 0.50 to < 0.75
- > 0.25 to < 0.50
- < 0.25
- Slope –

Isaak et al. 2015. The cold-water climate shield. *GCB* **21:**2540-2553.

Isaak et al. 2016. Slow climate velocities of mountain streams. *PNAS* **113:**4374-4379.

High-quality Spatial Information Empowers Local Decision Makers...

Cold-water Refuge streams

Highest priority conservation investment!

More Efficient Conservation =
More Cool Critters in the Longrun…