Progress on the NorWeST Stream Temperature Climate Scenarios

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

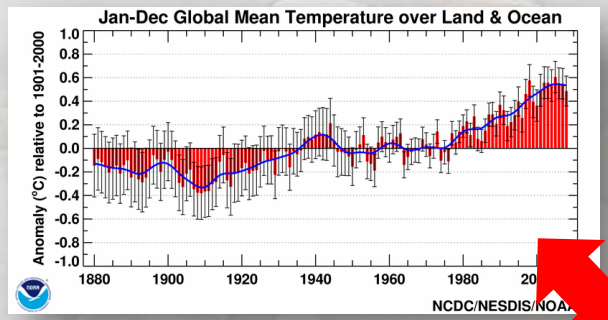
U.S. Forest Service

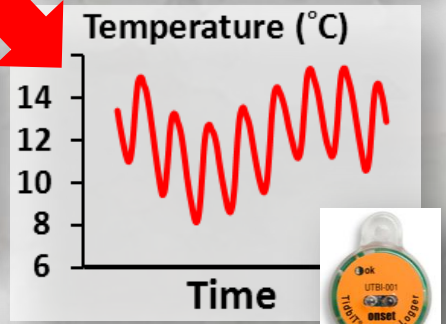
[1]Trout Unlimited

[2]CSIRO

[3]NOAA

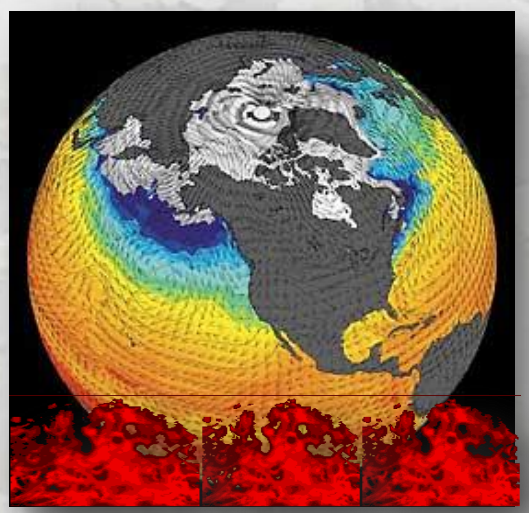
[4]USGS



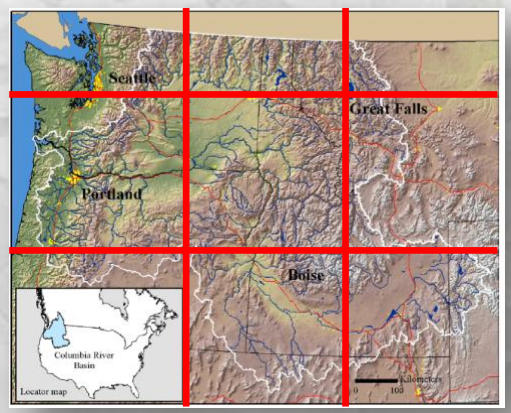


How Will Global Climate Change Affect Streams & Rivers Locally?

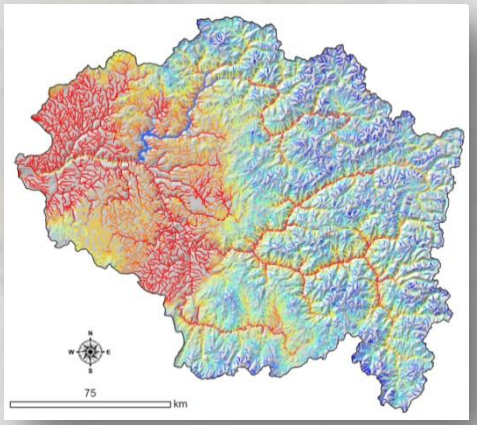
Global climate



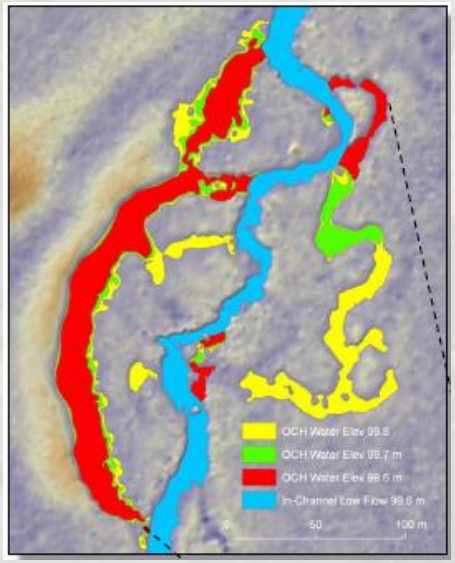
Regional climate



River network temperatures



Stream reach



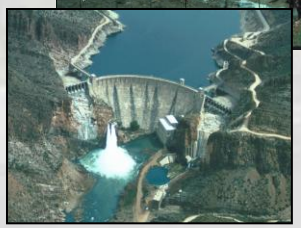
There's A Lot on the Line…

Climate Boogeyman

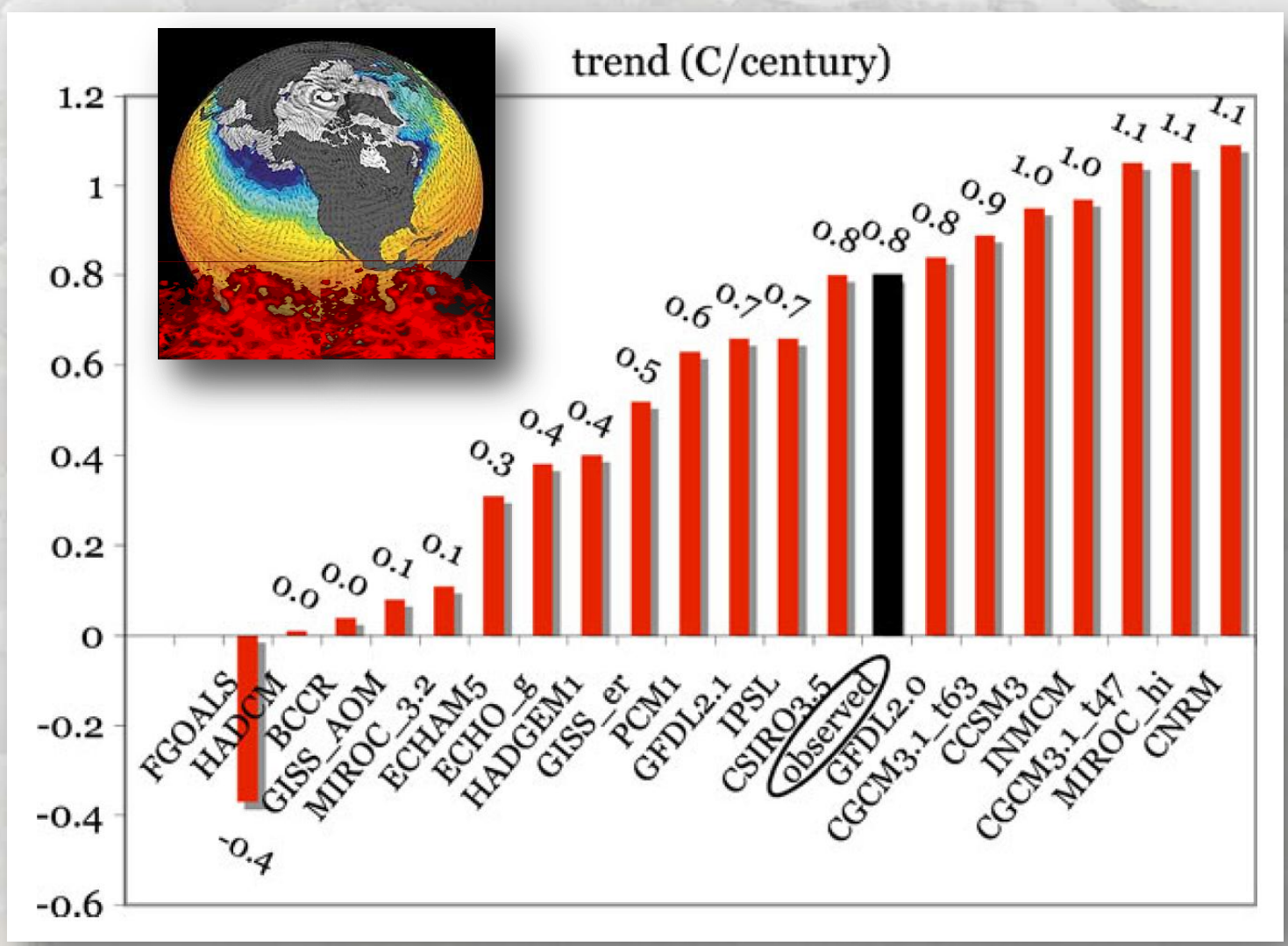
Recreational Fisheries

$4 Billion on Fish & Wildlife Recovery Efforts in PNW Since 1980 (ISAB/ISRP 2007)

ESA Listed Species

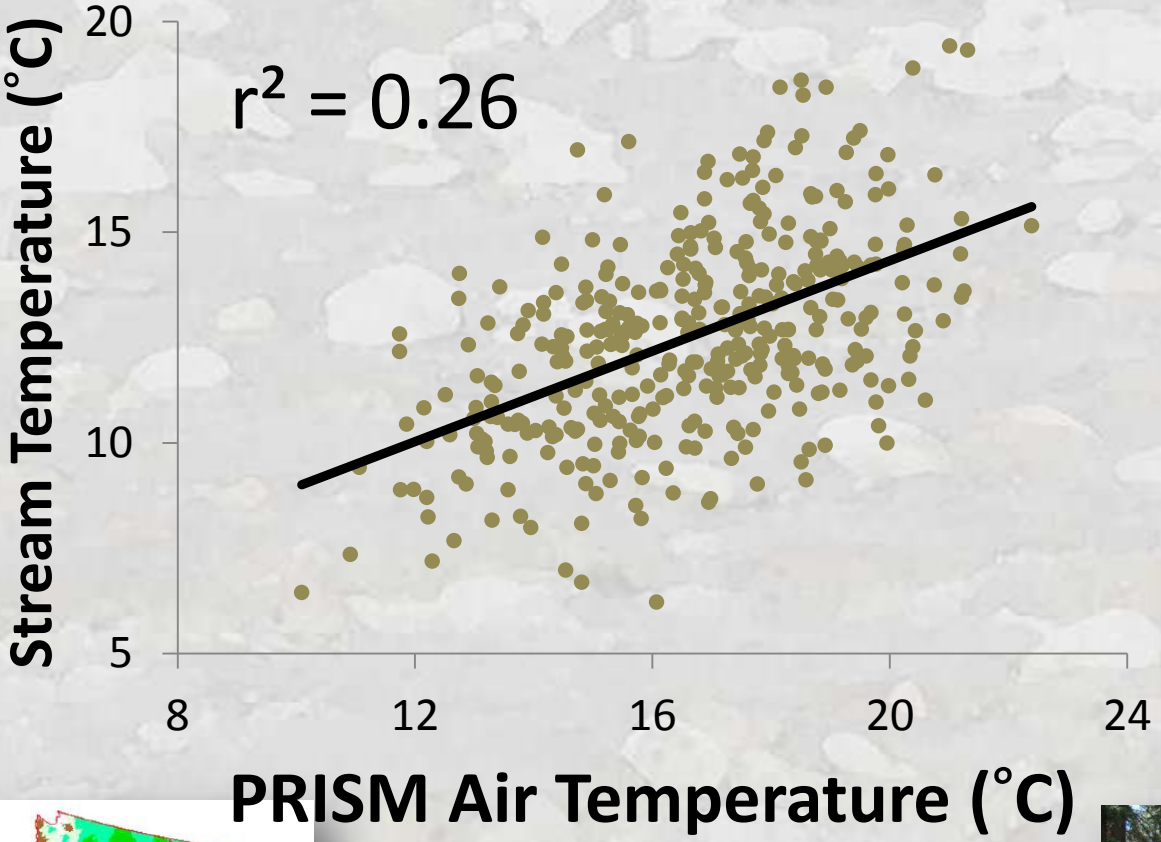


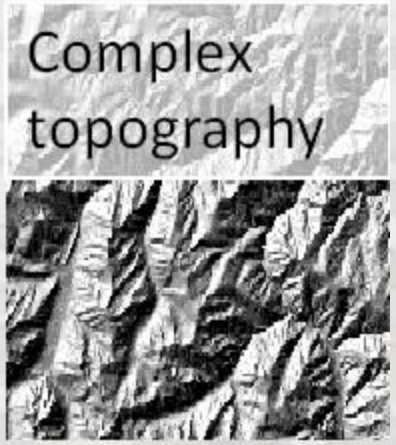
Many GCMs for Air Temperature & Precipitation Exist…

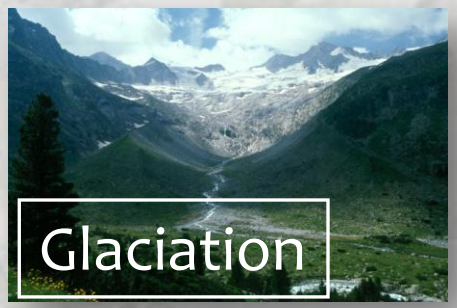


Mote & Salathe 2010

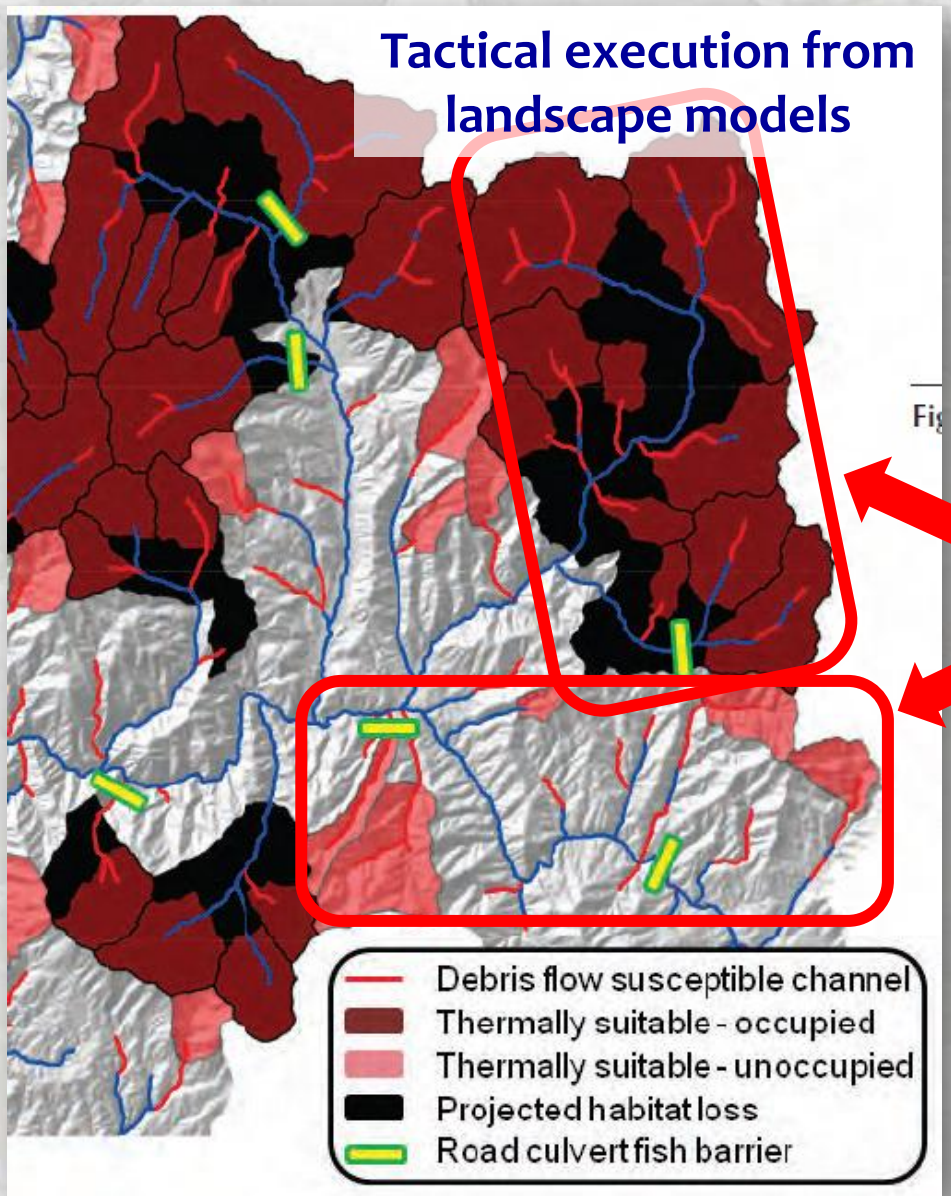
Air Temp ≠ Stream Temp

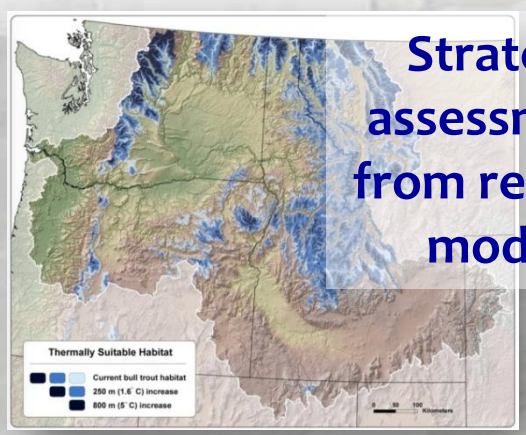






Accurate Local Information Needed to Empower Local Decision Makers





I'm going to invest here...

...instead of here

Lots of Stream Temp Data Out There…

Stealth Sensor Network

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

NOAA Fisheries

USGS science for a changing world

IDAHO FISH & GAME

EPA

IDAHO POWER.

KALISPEL TRIBE OF INDIANS

U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR

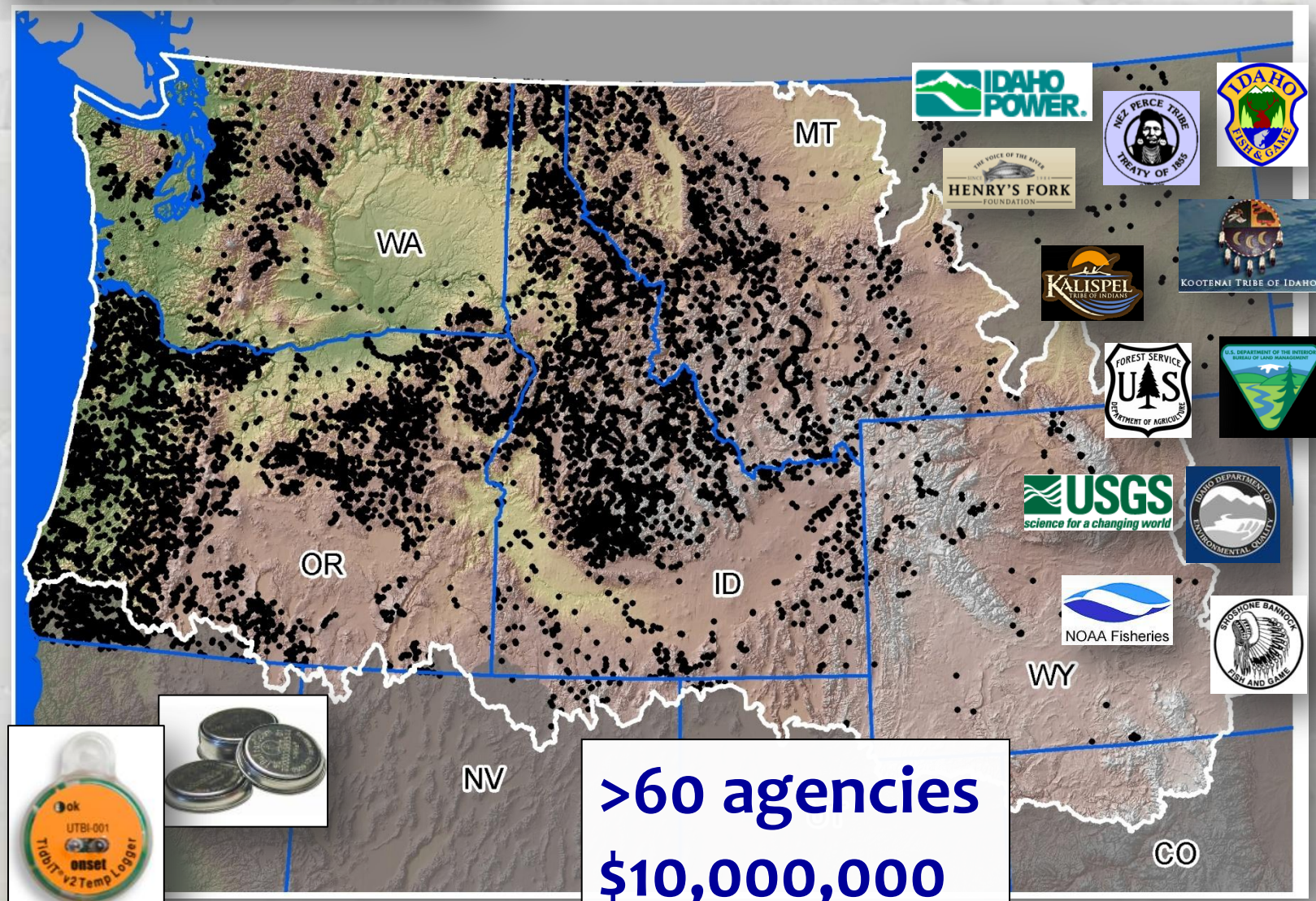
Washington Department of FISH and WILDLIFE

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

University of Idaho

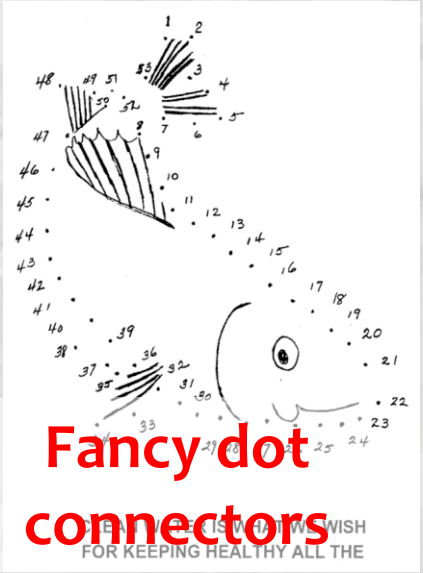
NorWeST Stream Temp

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



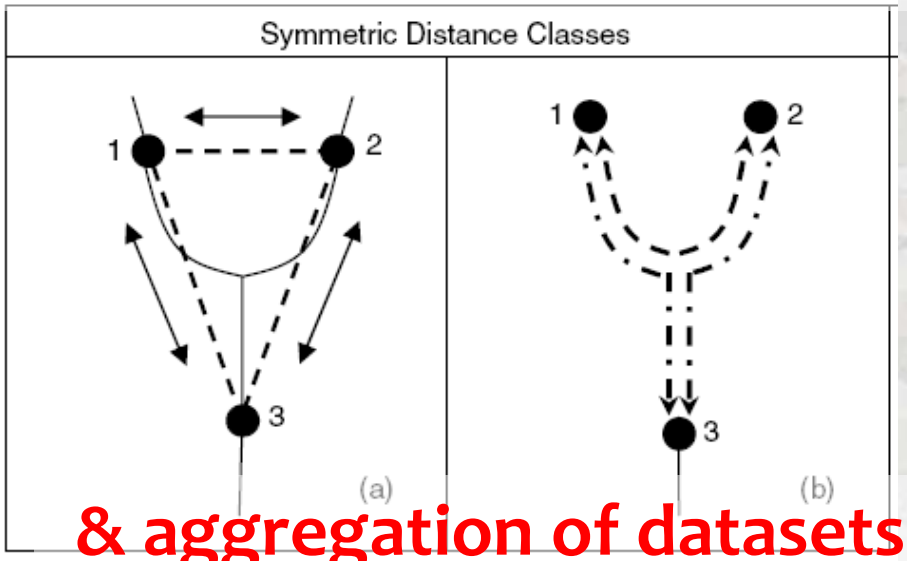
>60 agencies
$10,000,000

Spatial Statistical Network Models for Climate Downscaling



Fancy dot connectors

Valid interpolation on networks



& aggregation of datasets

Advantages:

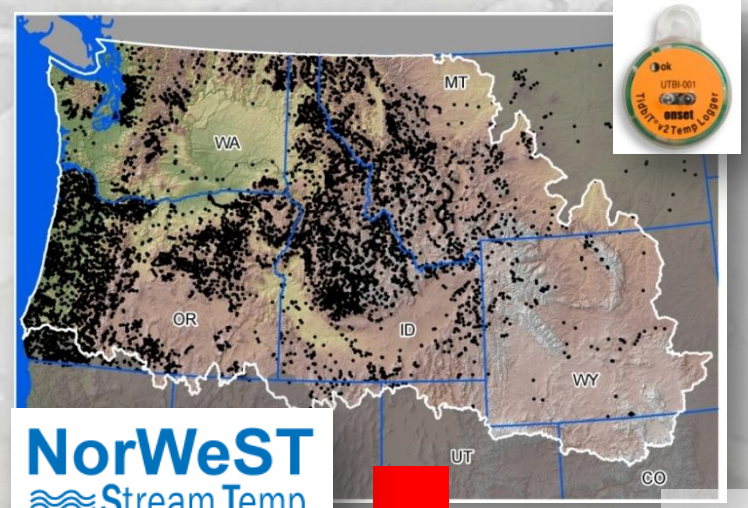
-flexible & valid covariance structures by accommodating network topology

-weighting by stream size

-improved predictive ability & parameter estimates relative to non spatial models

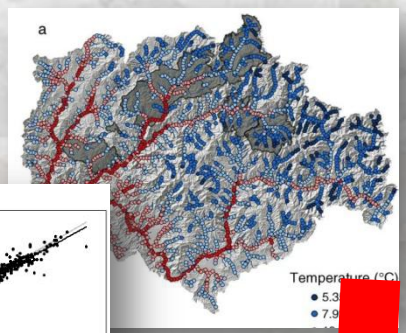
Ver Hoef et al. 2006; Peterson & Ver Hoef 2010; Ver Hoef & Peterson 2010

Regional Temperature Model

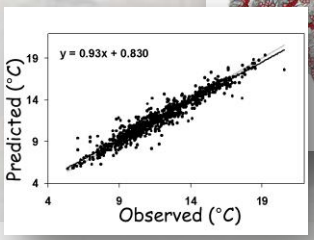


NorWeST Stream Temp

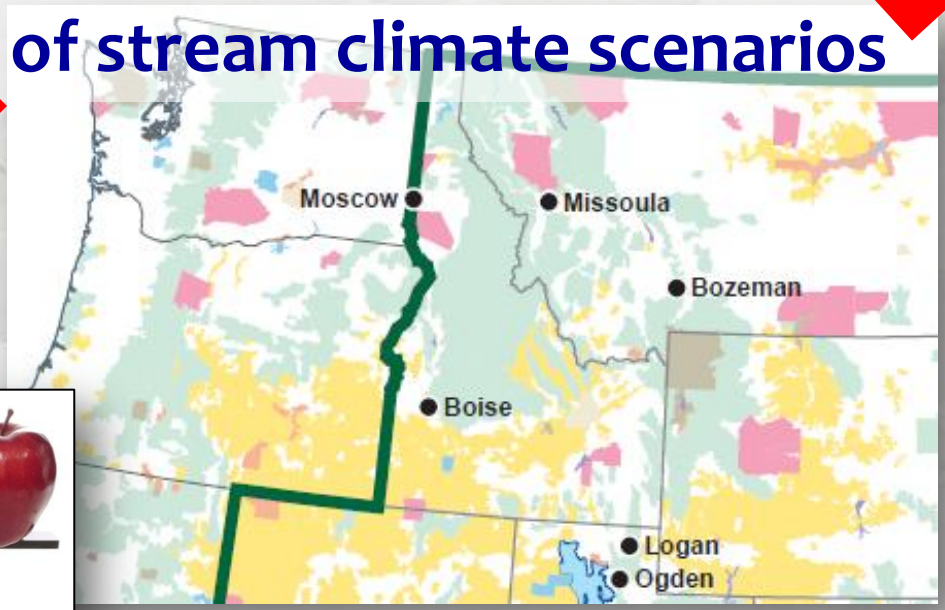
Accurate stream temp model



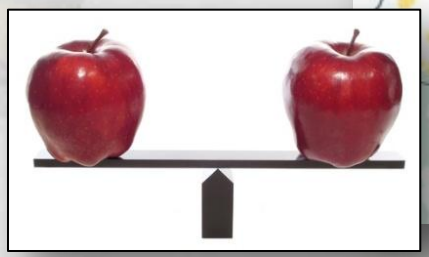
+



Cross-jurisdictional "maps" of stream climate scenarios

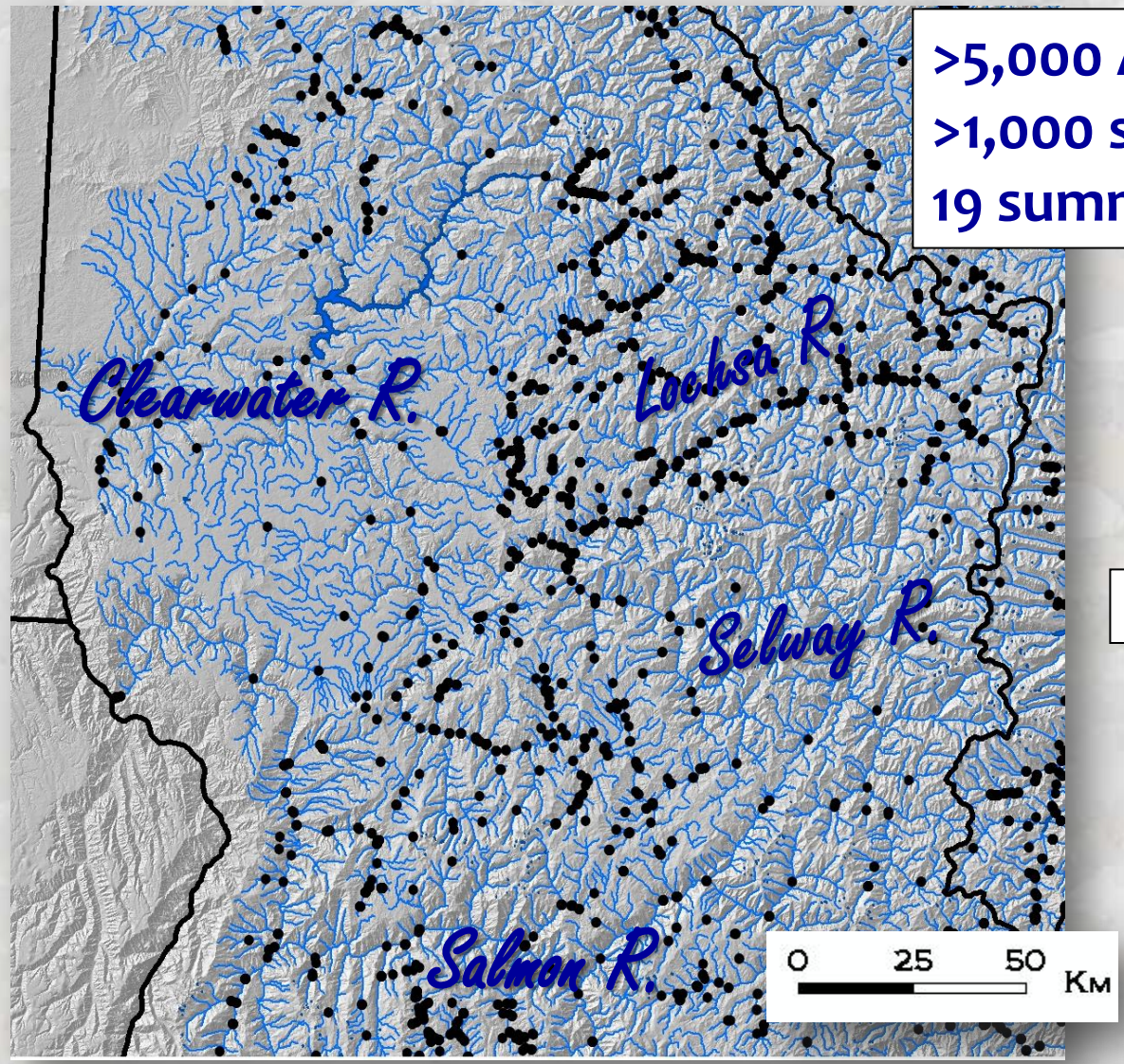


Consistent datum for strategic assessments across 400,000 stream kilometers



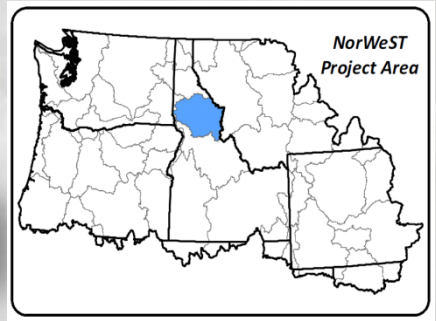
Example: Clearwater River Basin

Data extracted from NorWeST



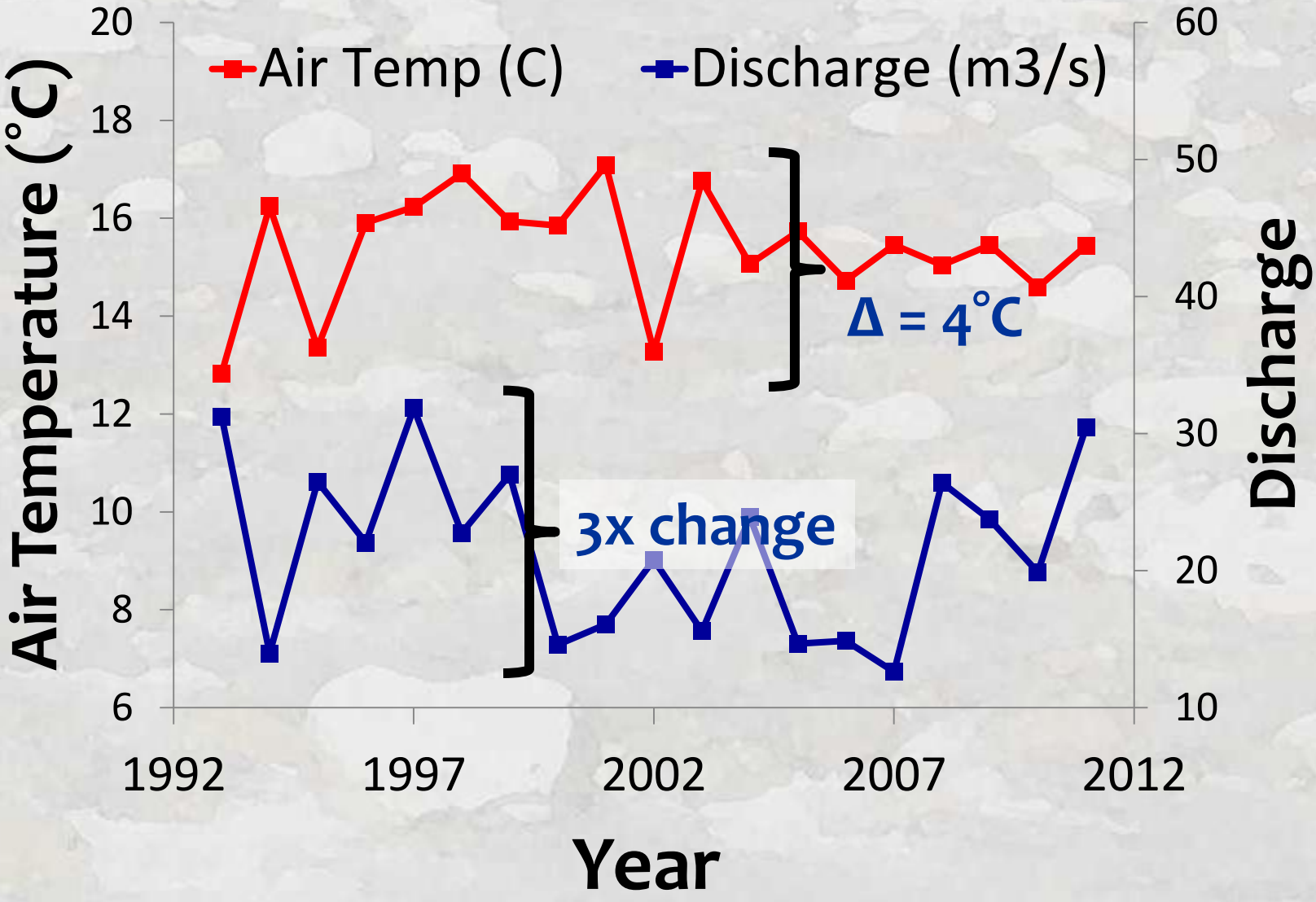
>5,000 August means
>1,000 stream sites
19 summers (1993-2011)

•Temperature site



Climatic Variability in Historical Record

Extreme years include mid-21st-Century "averages"



Clearwater River Temp Model

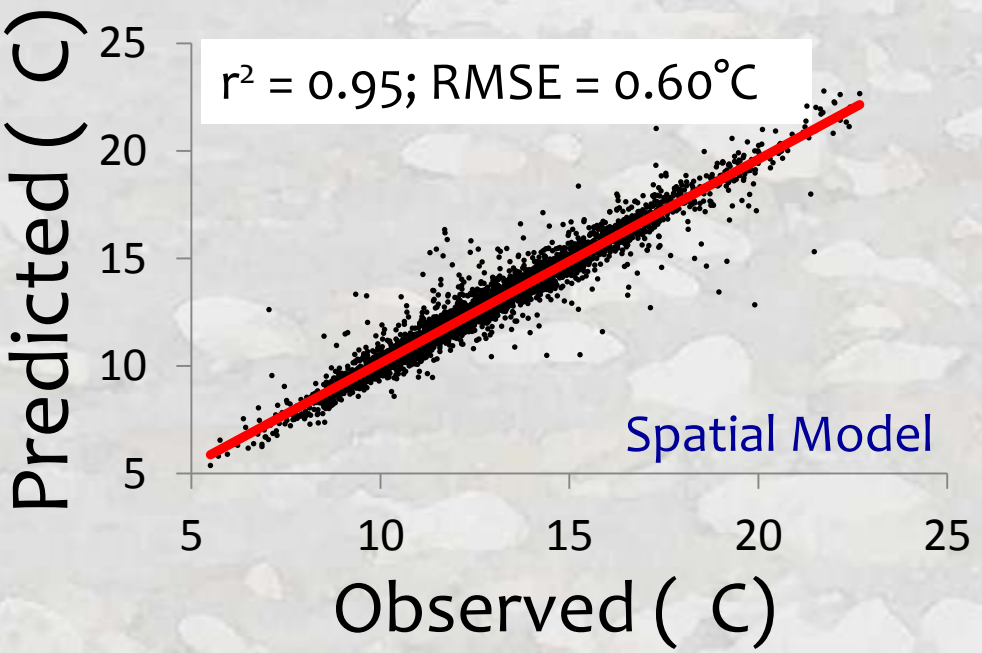
n = 4,487

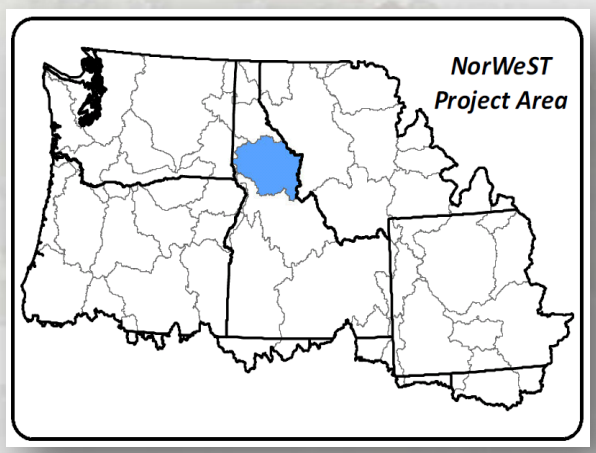
Covariate Predictors

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

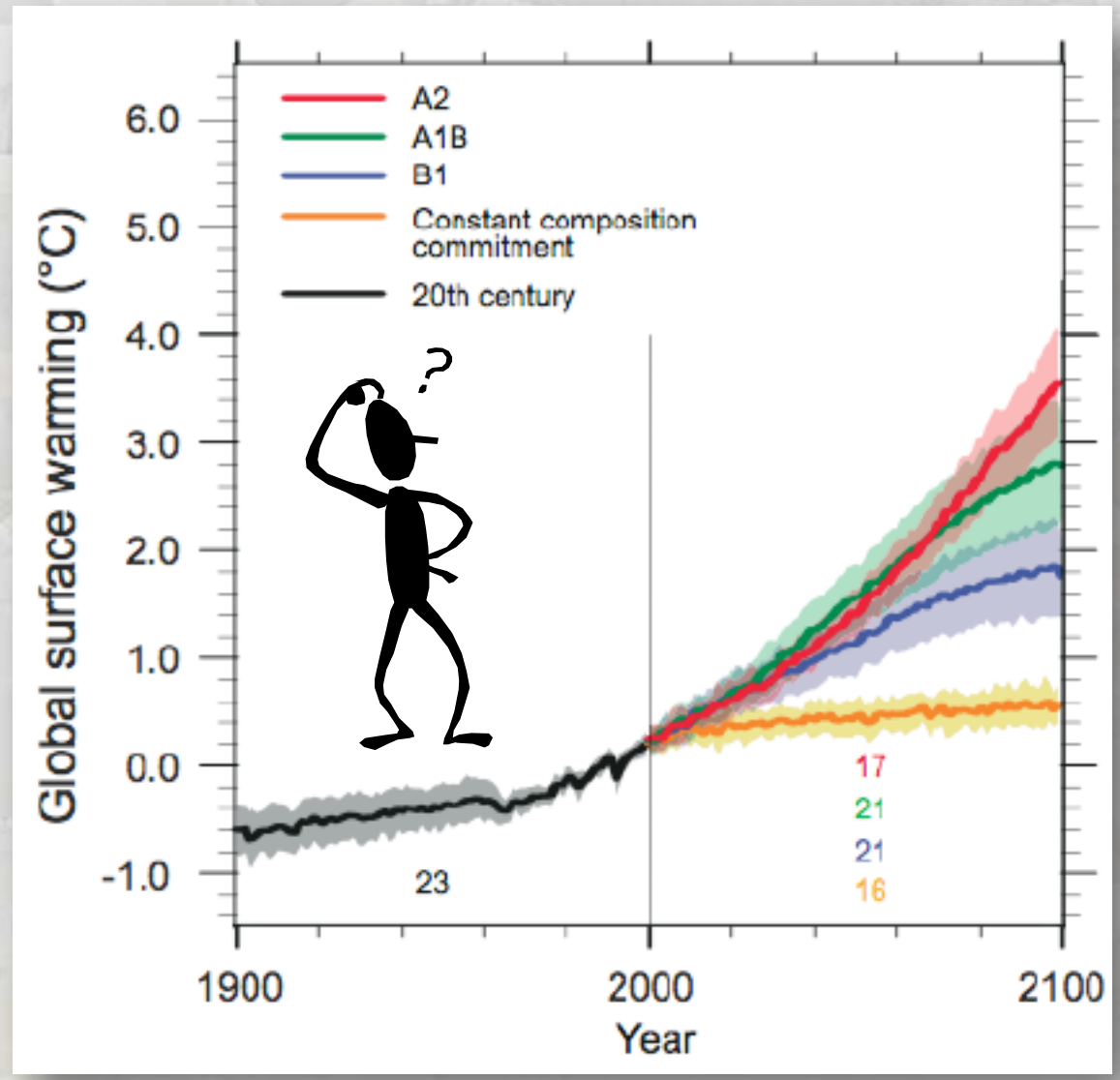
Mean August Temperature





Models Enable Climate Scenario Maps

Many possibilities exist…



Adjust…

- **Air**
- **Discharge**
- **%Canopy**

…values to create scenarios

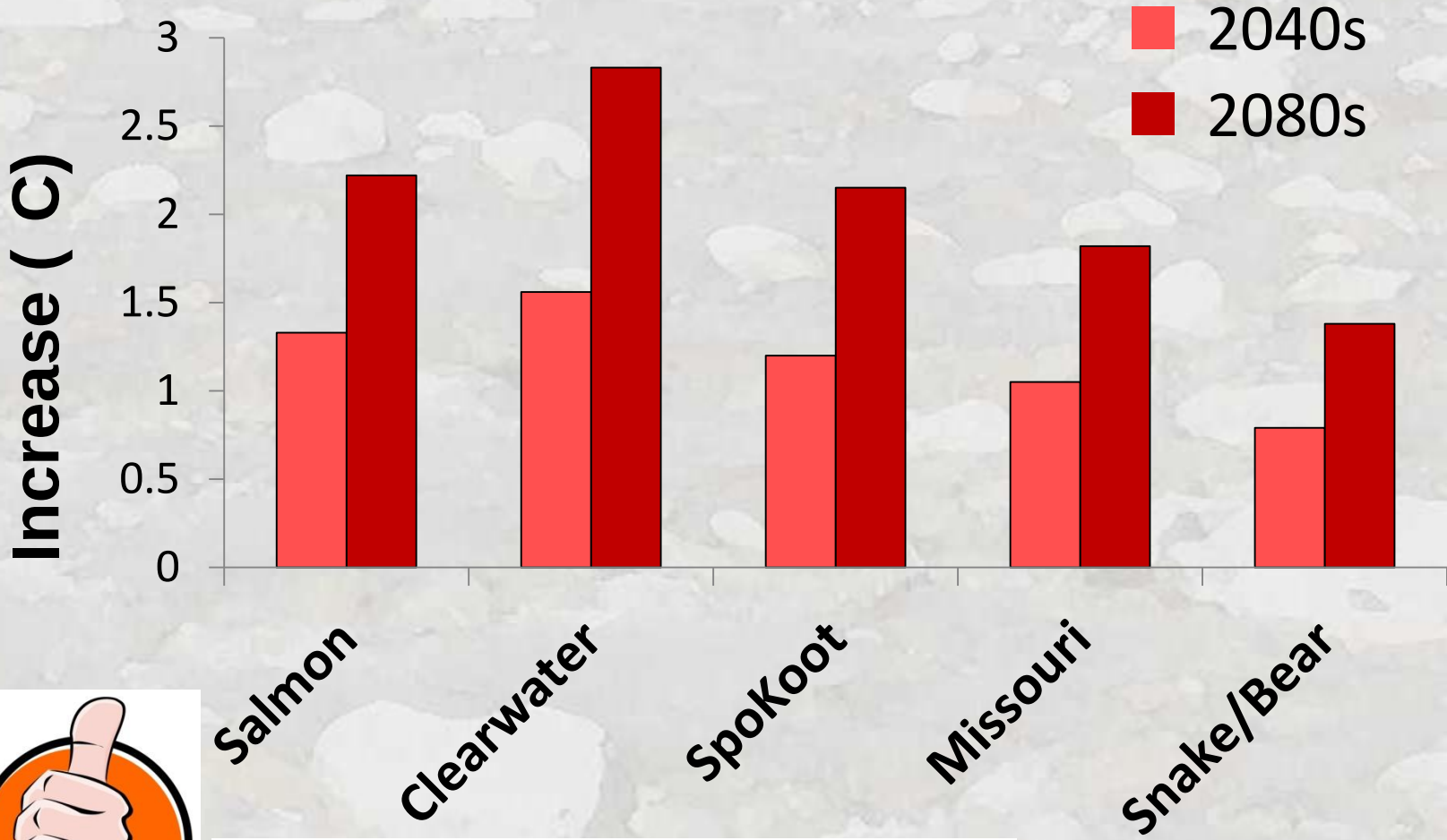
NorWeST Scenario Descriptions

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…	
S21_2011	Historical scenario representing August mean stream temperatures for 2011
S22+…	Futures: 1) IPCC scenarios for 2040s and 2080s; 2) "scenario free (e.g., +1˚C, +2C, etc.)

Future Stream Temperature Increases

Scenario: A1B ensemble averages from CIG (delta-hybrid)

Baseline: 1980s (1970-1999) period

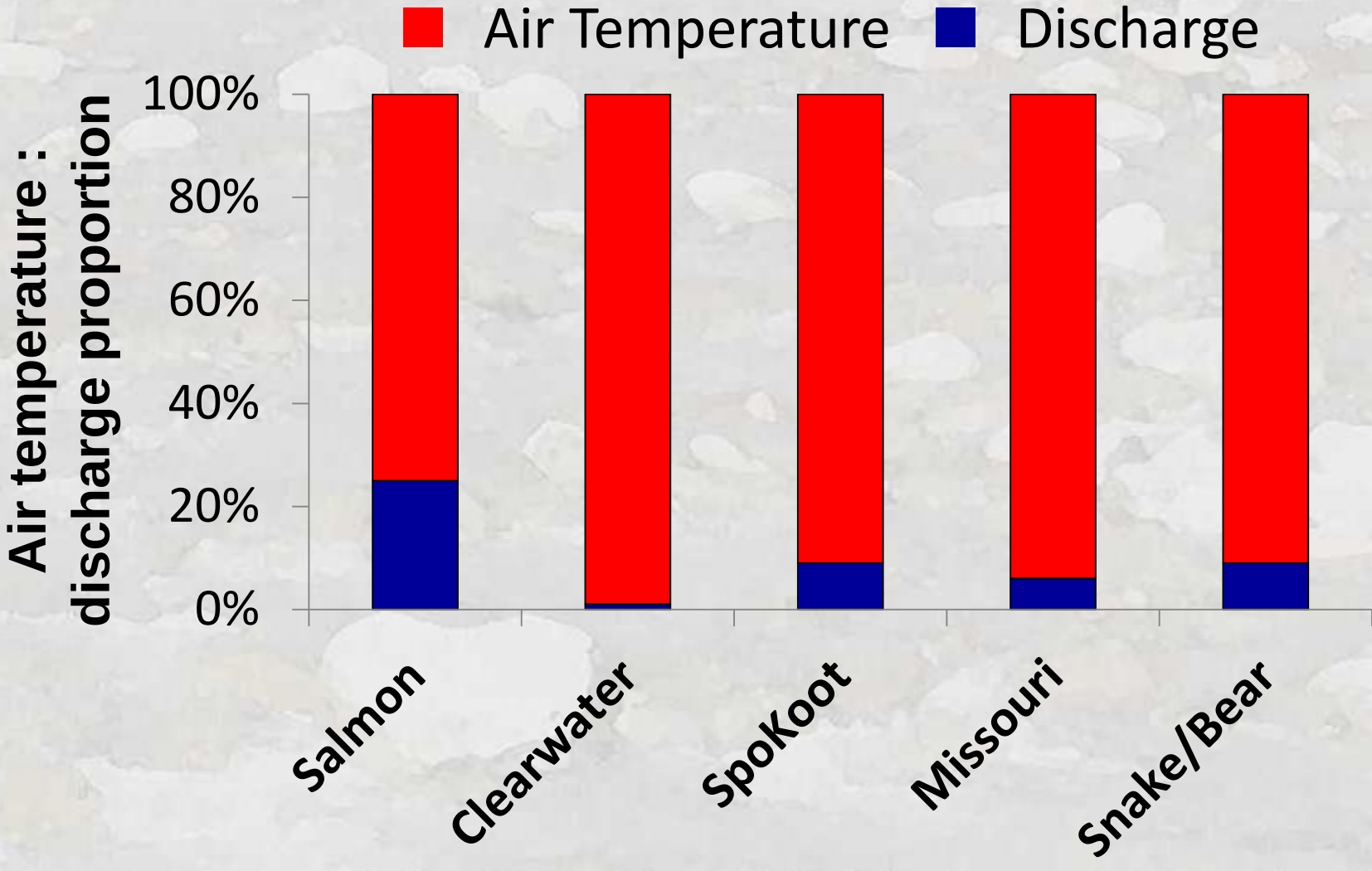


Rule of thumb: streams warm ~50% as fast as air temps increase

What Causes Future Stream Increases?

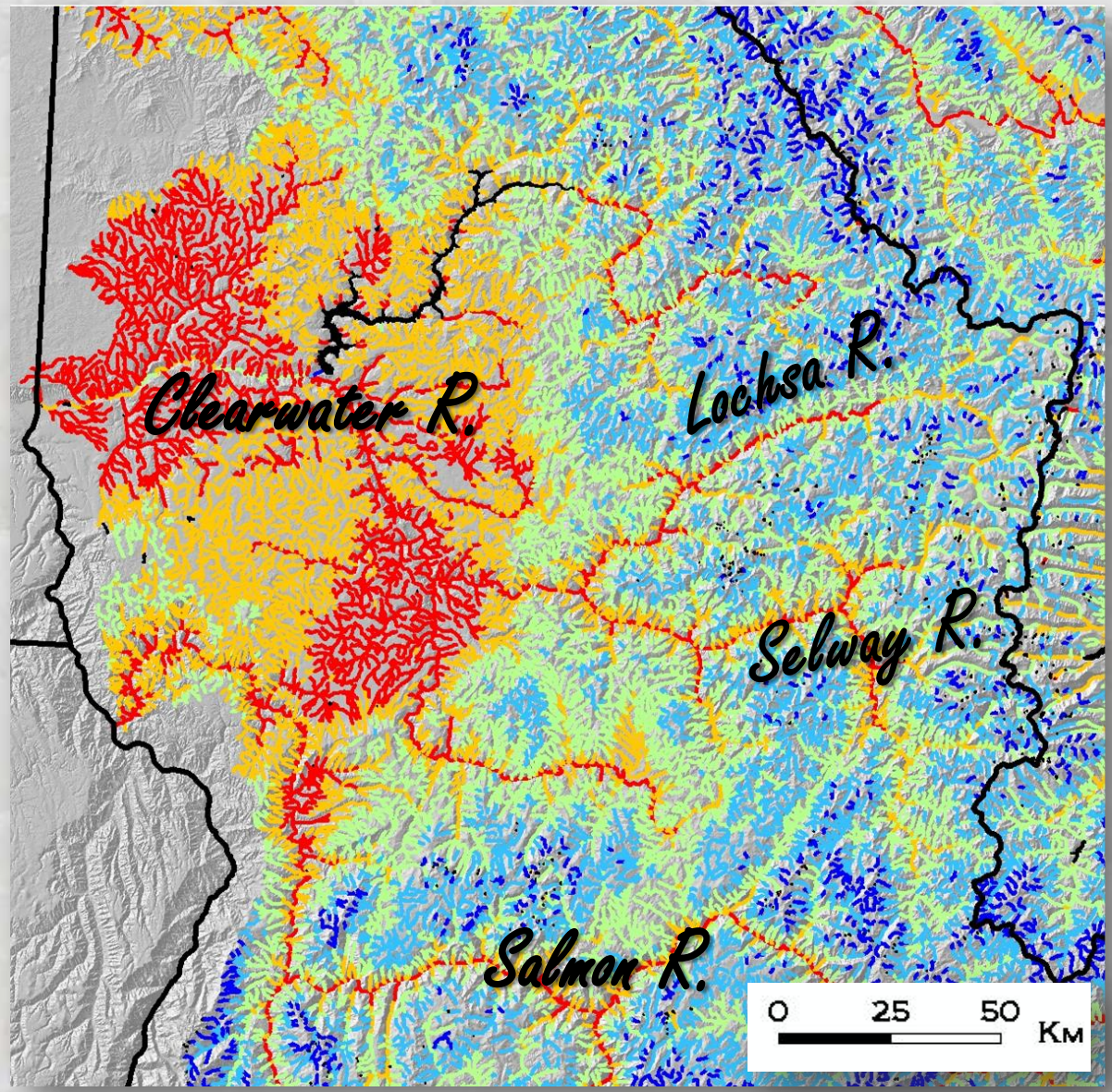
Scenario: A1B ensemble averages from CIG (2040s)

Baseline: 1980s (1970-1999) period



Clearwater Stream Temperature Scenario

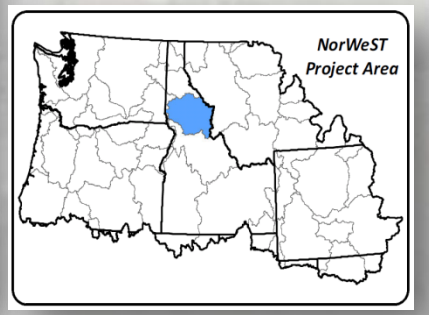
Historic (1993-2011 Average August)



Temperature (C)

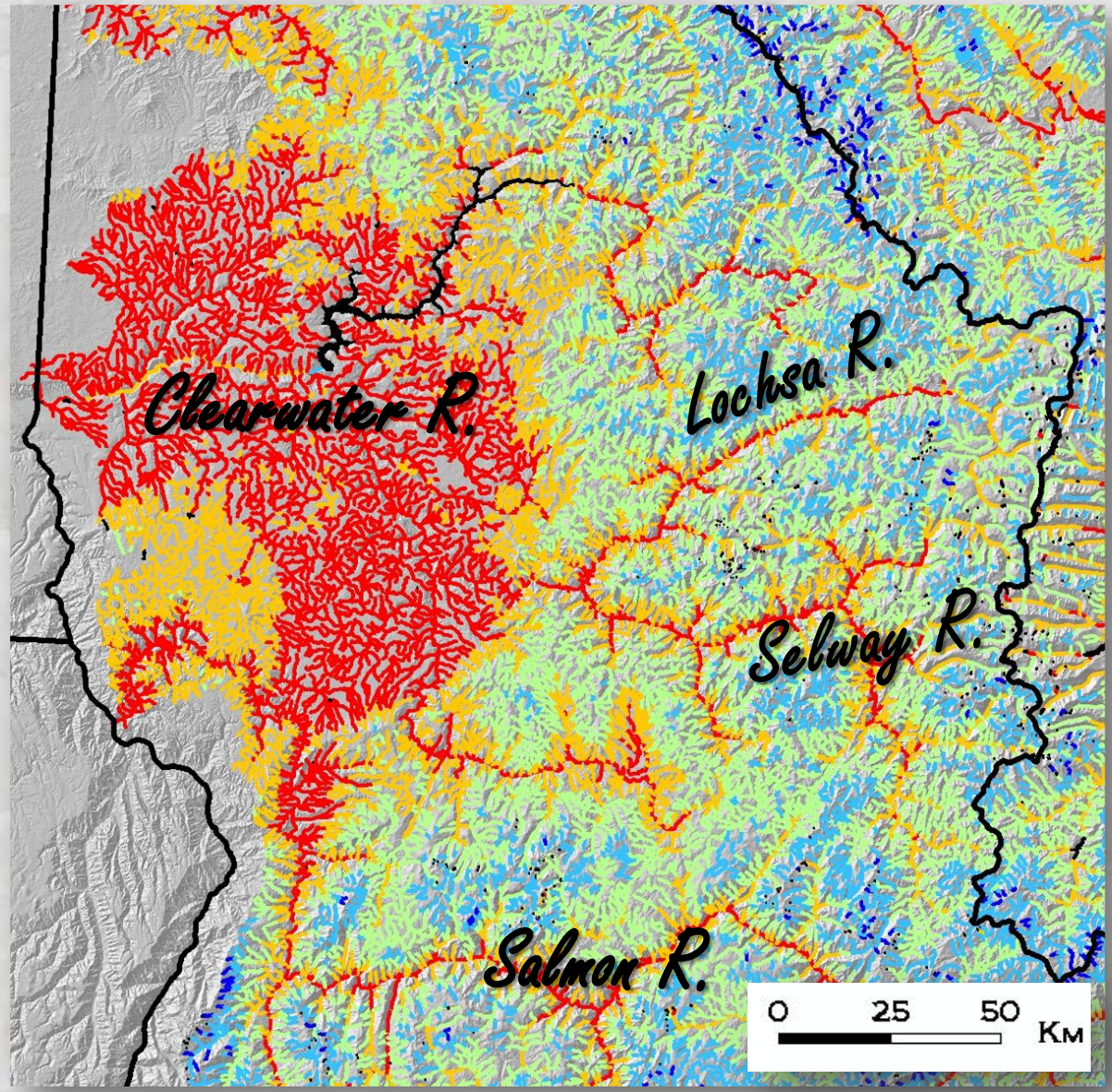
- 0.0 - 8.0
- 8.1 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15

1 kilometer resolution



Clearwater Stream Temperature Scenario

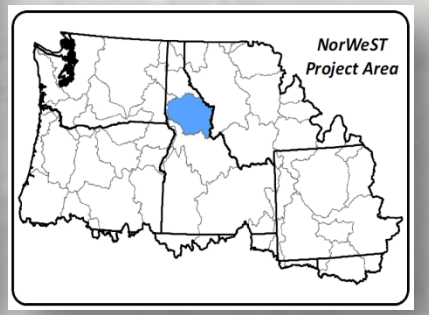
+1.00°C Stream Temp



Temperature (C)

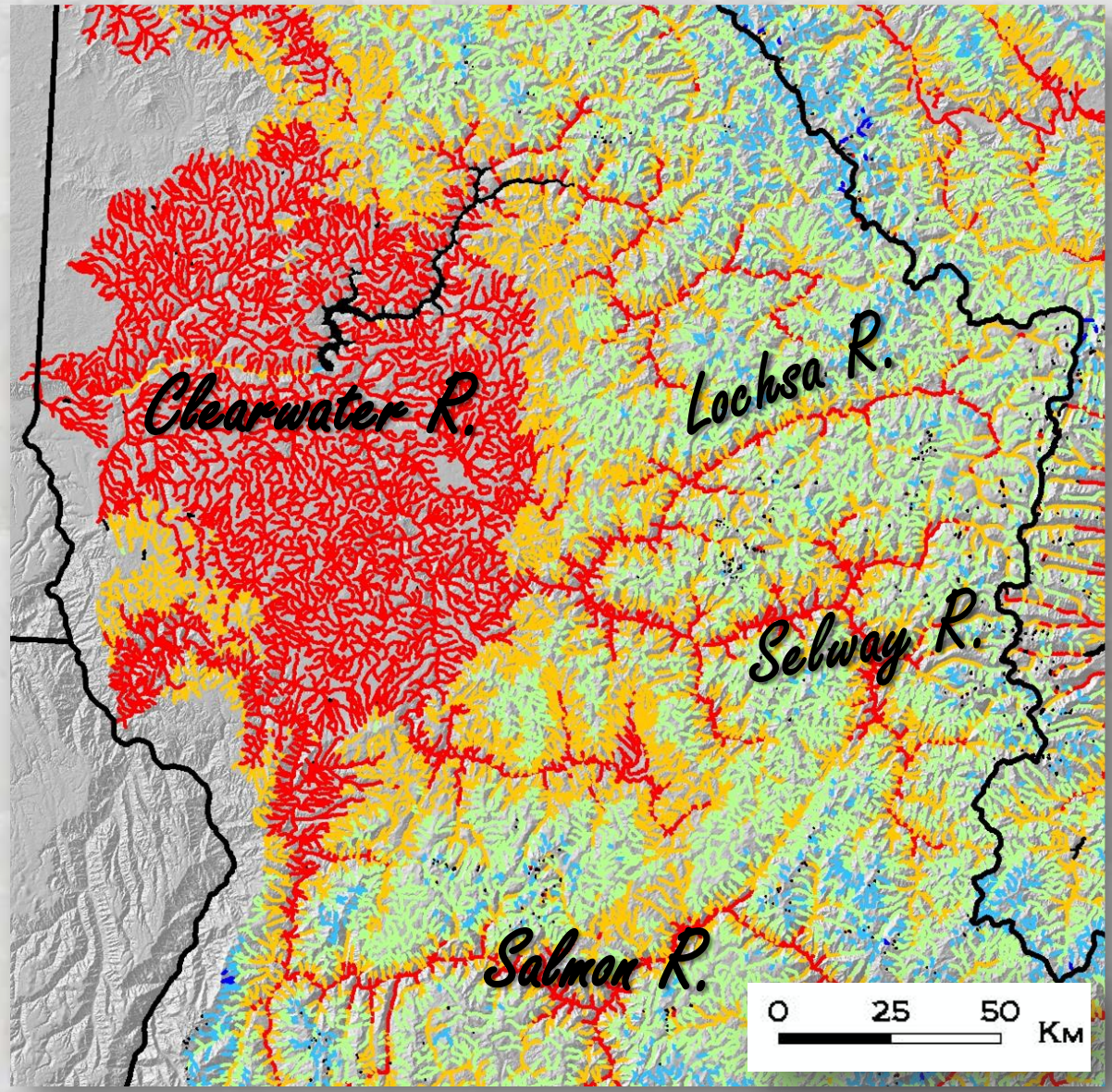
- 0.0 - 8.0
- 8.1 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15

1 kilometer resolution



Clearwater Stream Temperature Scenario

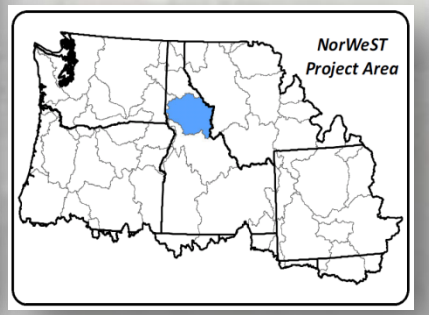
+2.00˚C Stream Temp



Temperature (C)

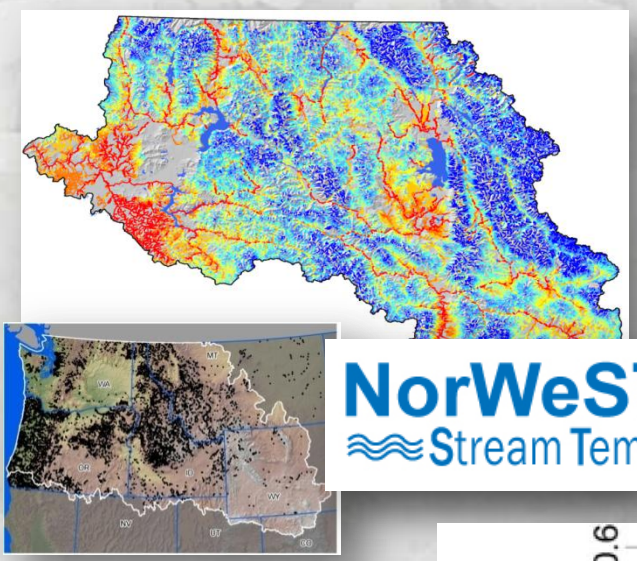
- 0.0 - 8.0
- 8.1 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15

1 kilometer resolution



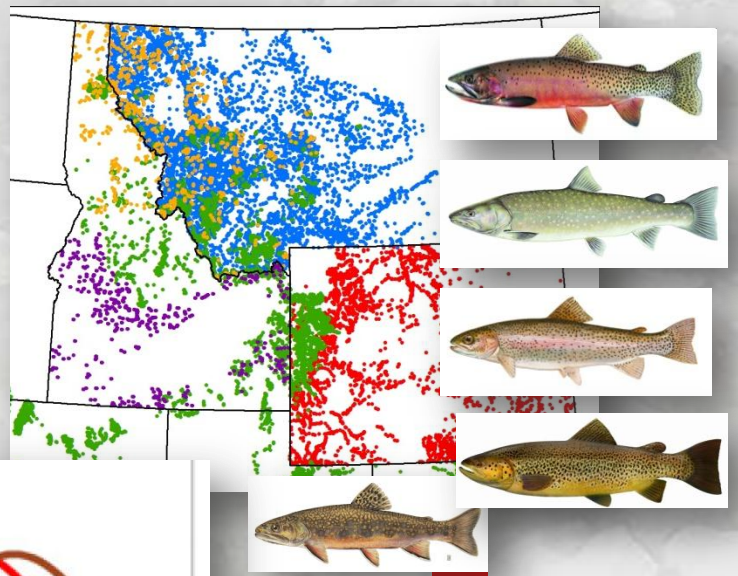
Develop Regionally Consistent Thermal Niche Definitions

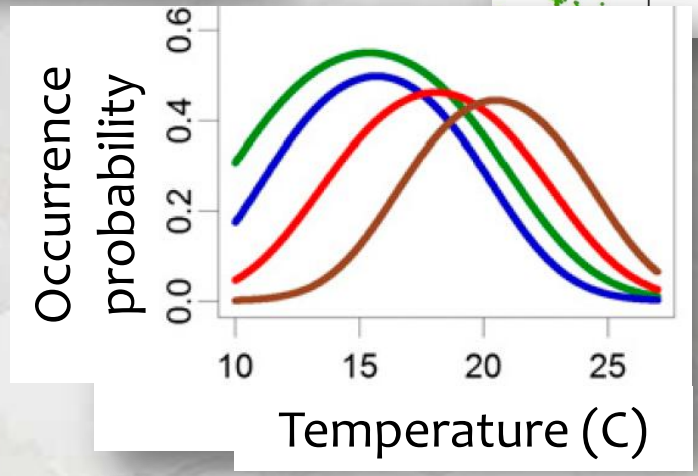
Stream temperature maps



NorWeST Stream Temp

Regional fish survey databases (n ~ 30,000)



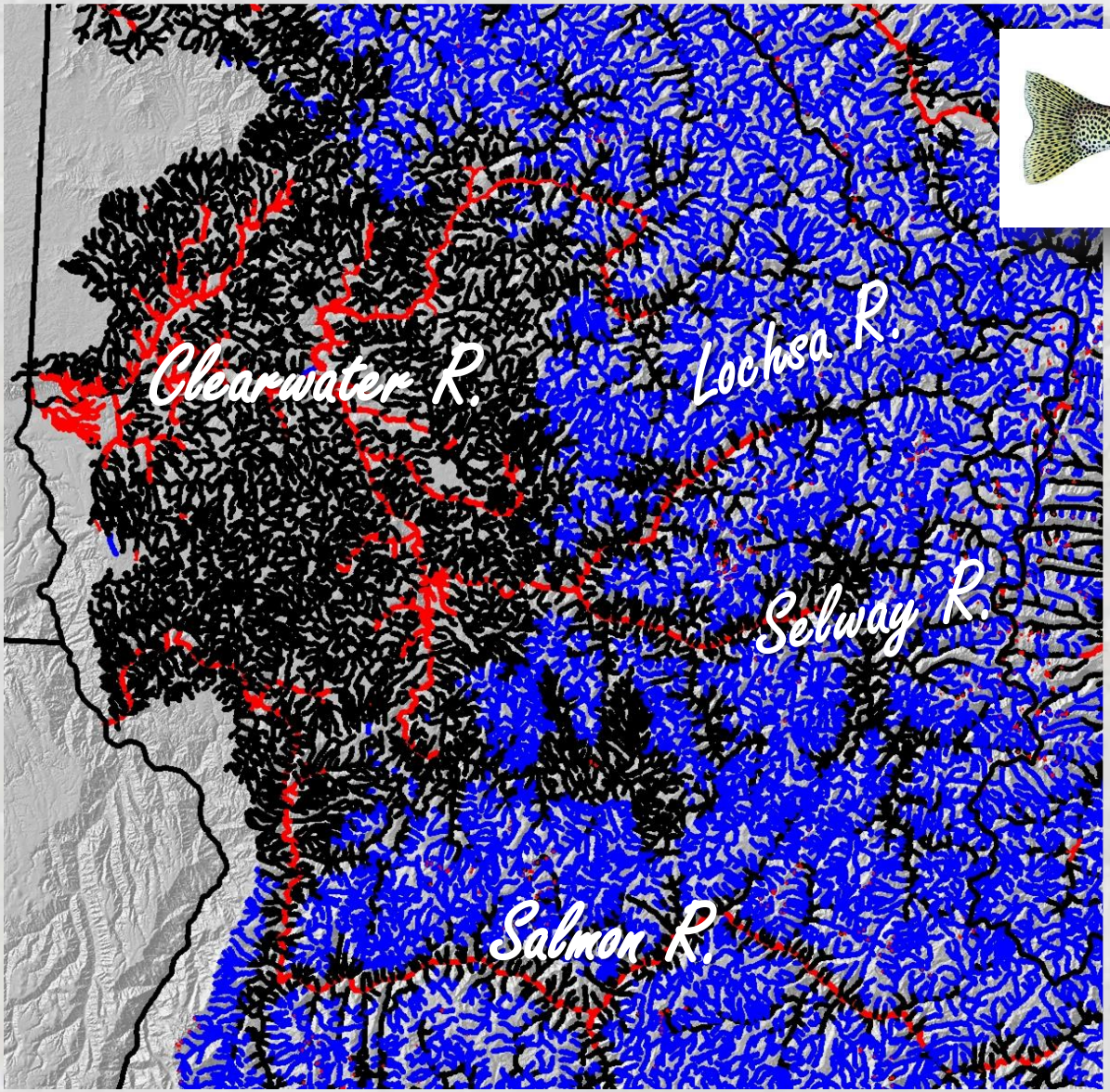


Wenger et al. 2011a. *PNAS* **108**:14175-14180

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

Climate Effects on Cutthroat Thermal Habitat

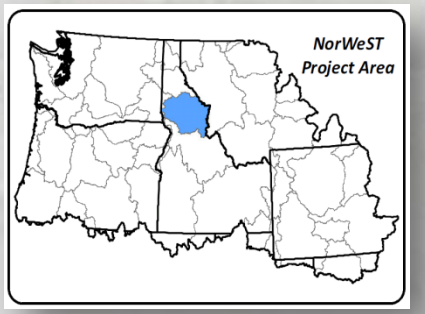
Historic (1993-2011 Average August)



Suitable

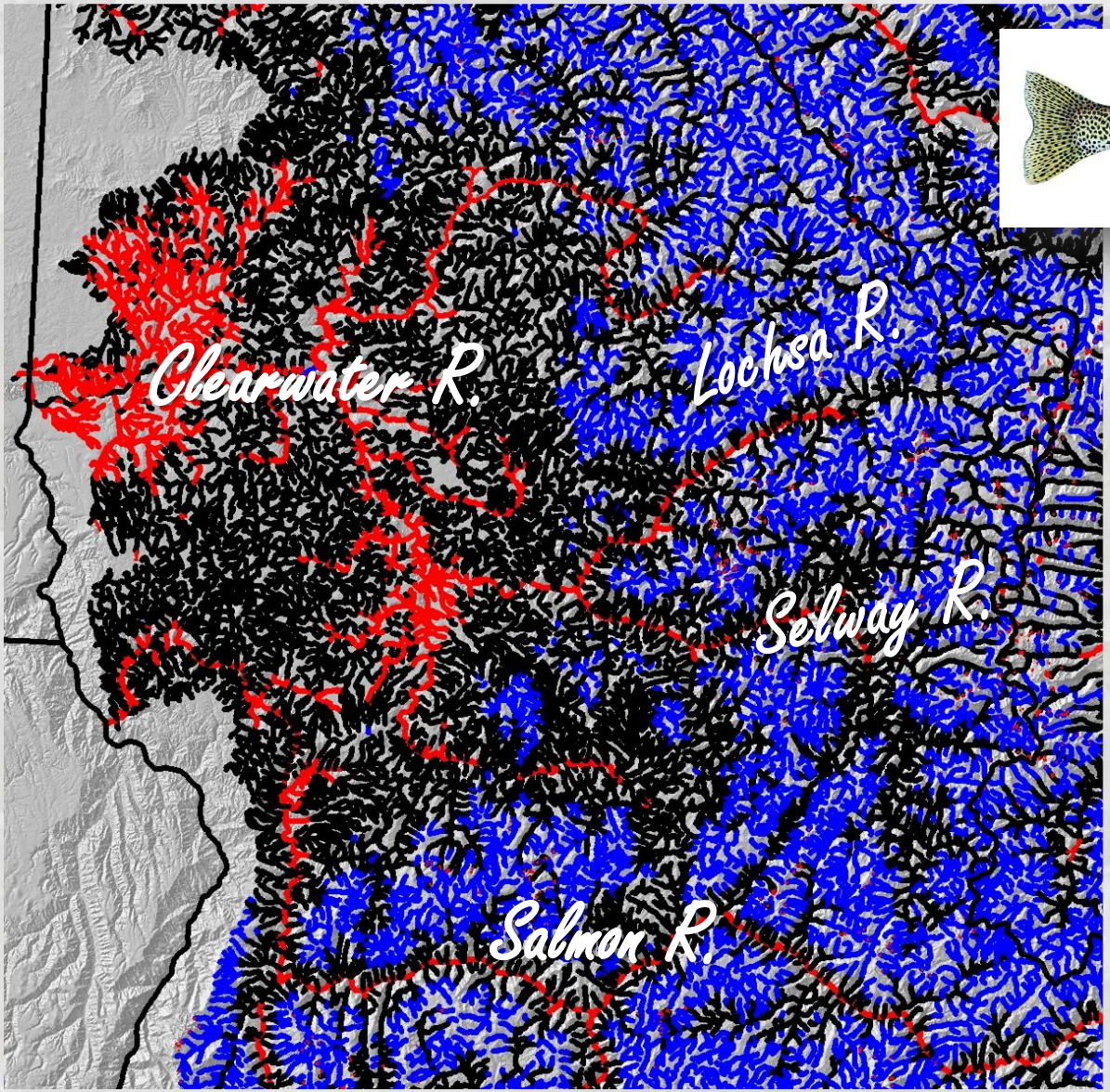
Too Hot

Too Cold



Climate Effects on Cutthroat Thermal Habitat

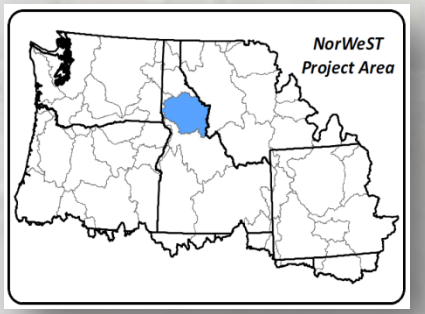
+1.00°C Stream Temp (~2040s)



Suitable

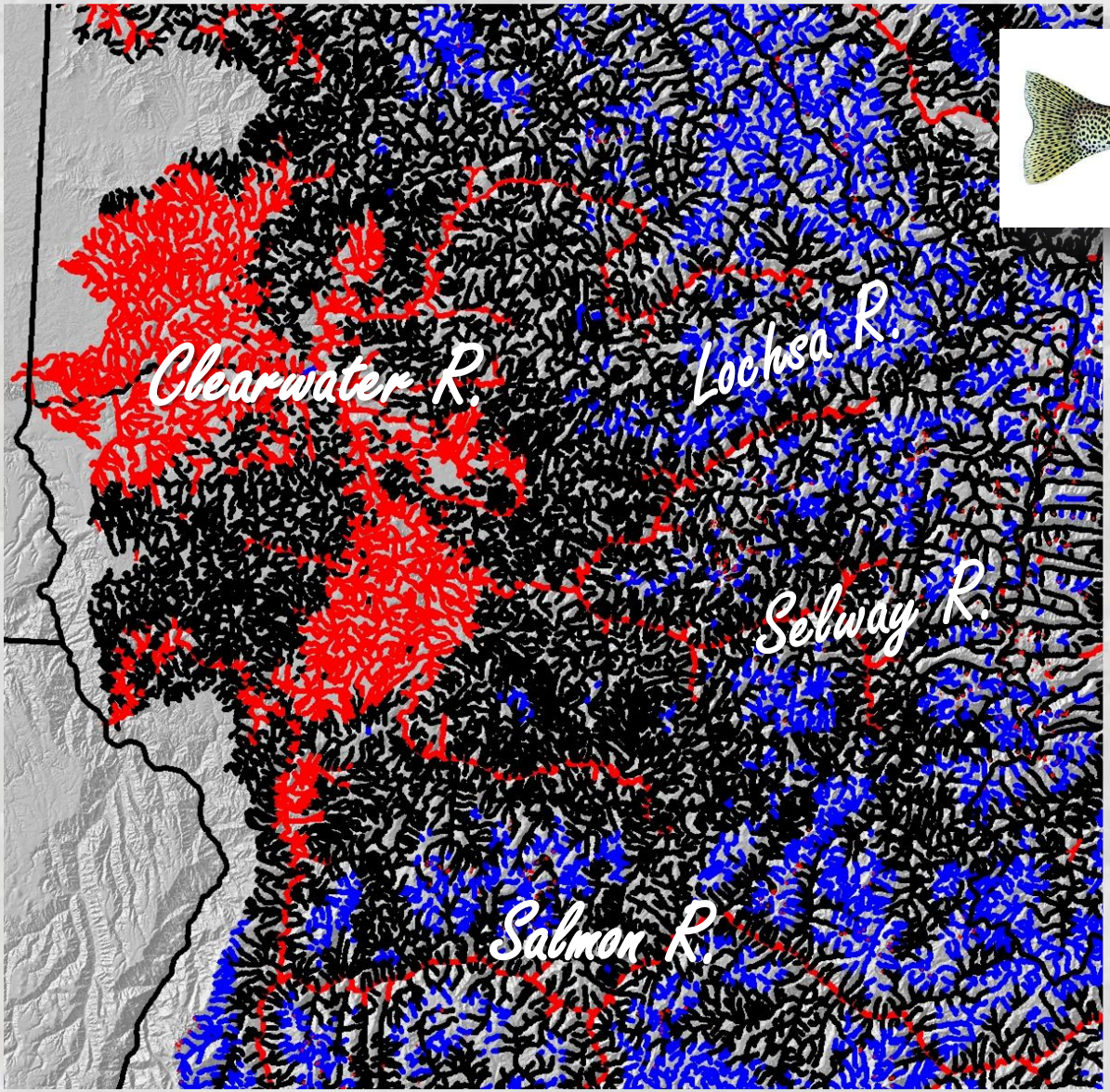
Too Hot

Too Cold



Climate Effects on Cutthroat Thermal Habitat

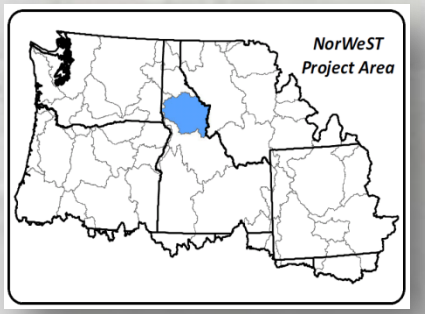
+2.00˚C Stream Temp (~2080s)



Suitable

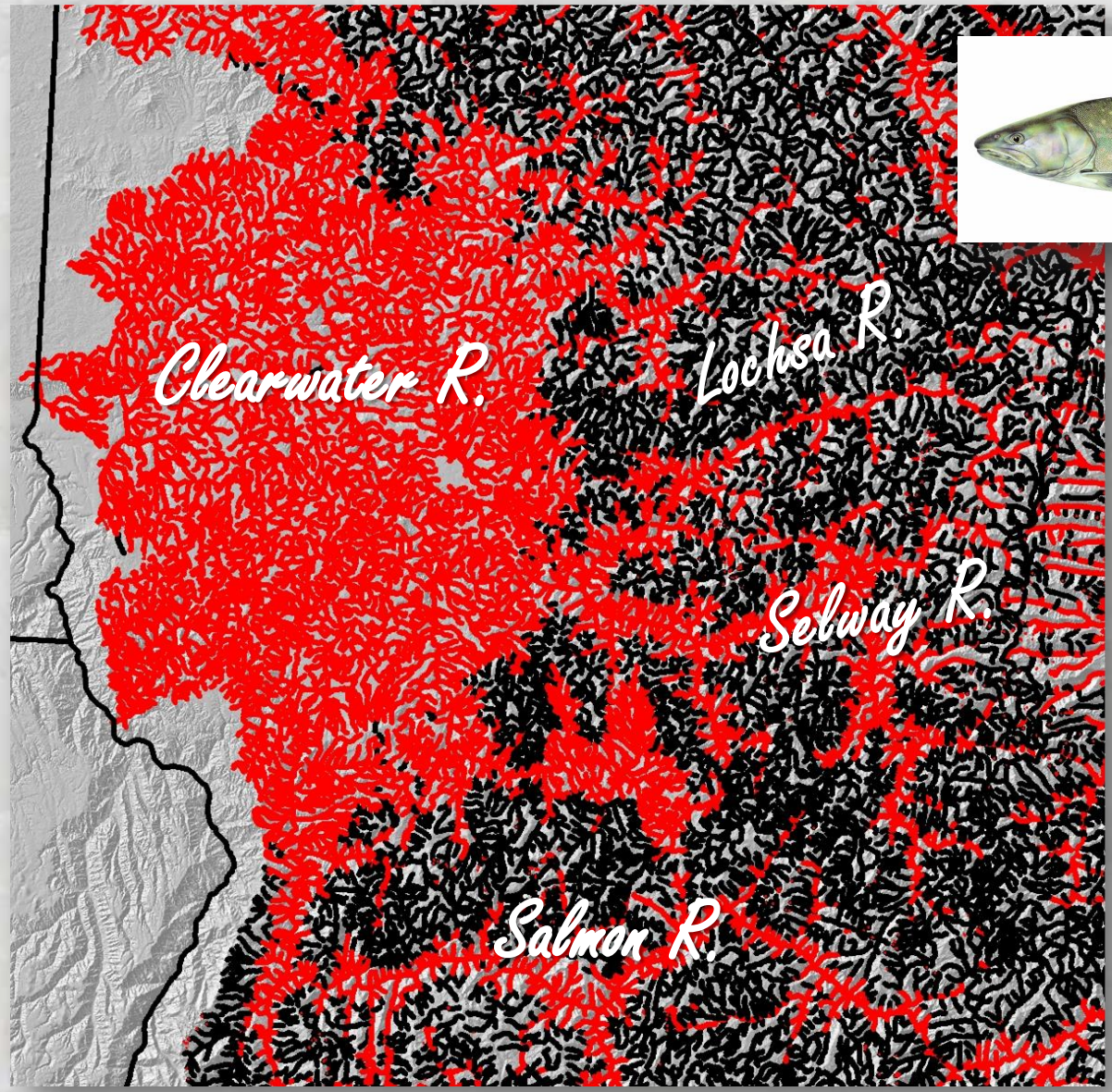
Too Hot

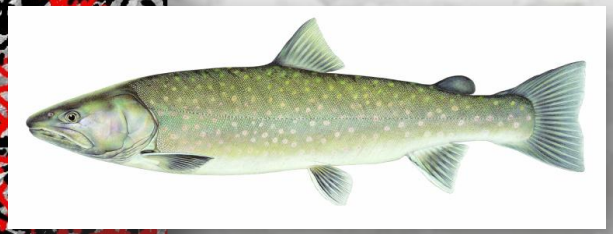
Too Cold



Climate Effects on Bull Trout Thermal Habitat

Historic (1993-2011 Average August)

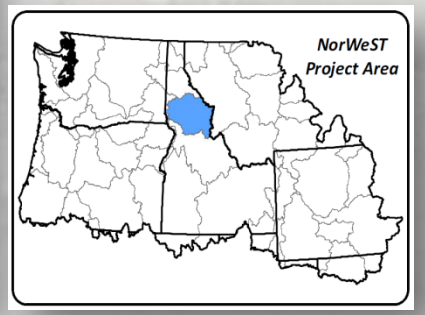




11.0°C Isotherm

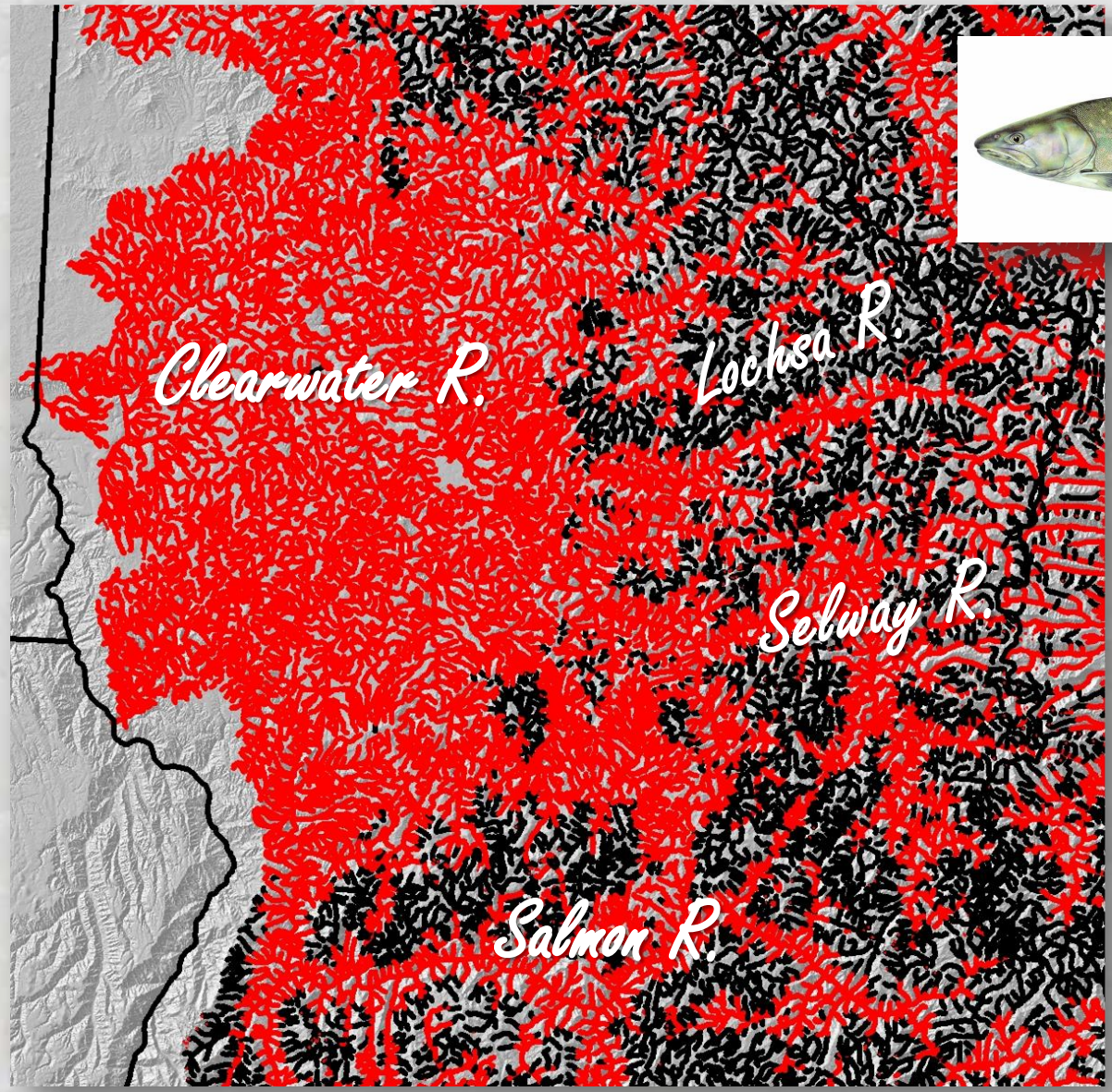
Suitable

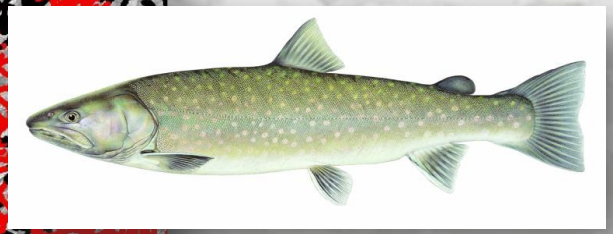
Unsuitable



Climate Effects on Bull Trout Thermal Habitat

+1.00˚C Stream Temp (~2040s)

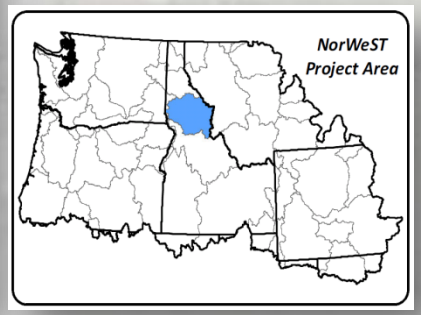




11.0˚C Isotherm

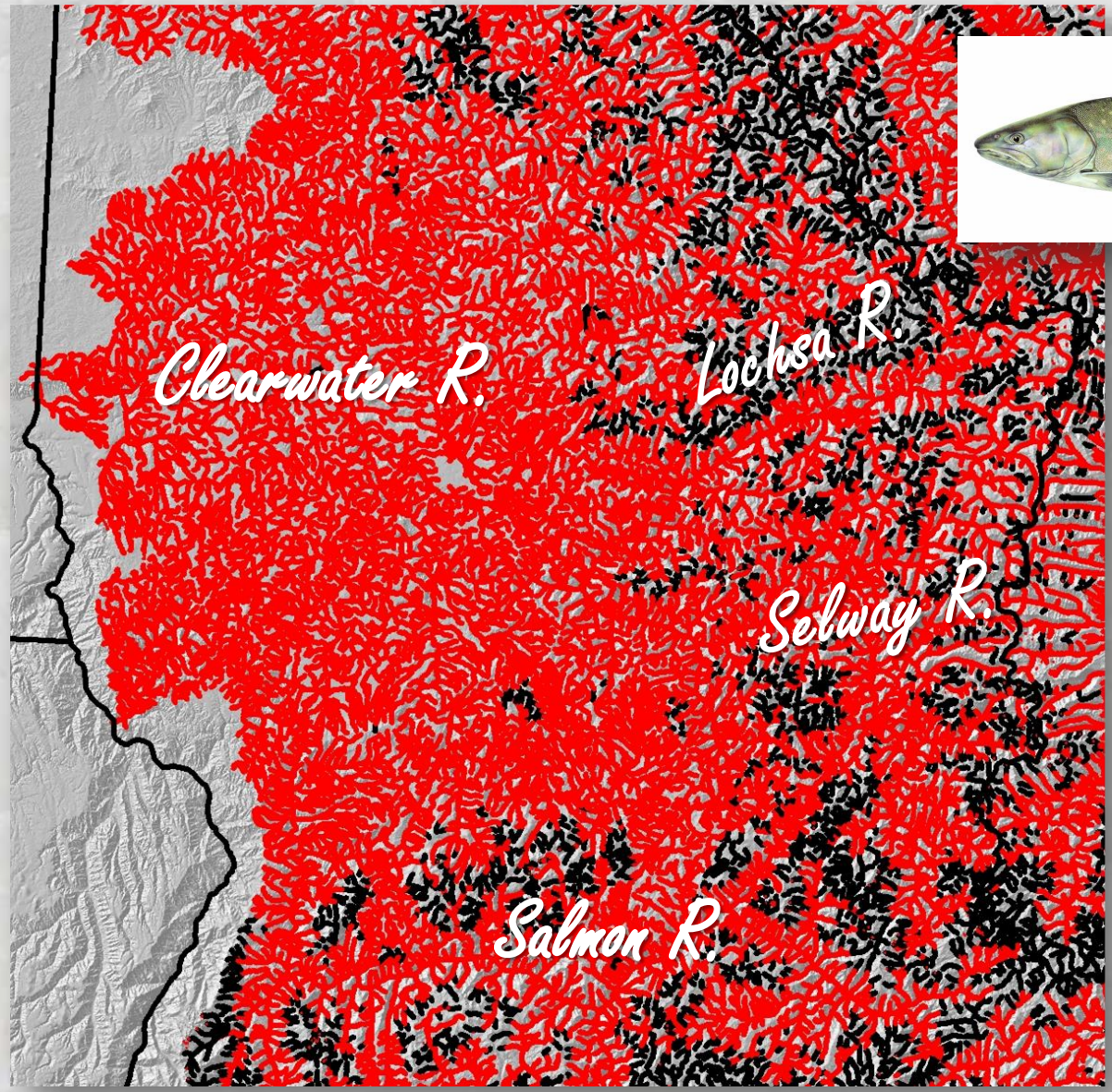
Suitable

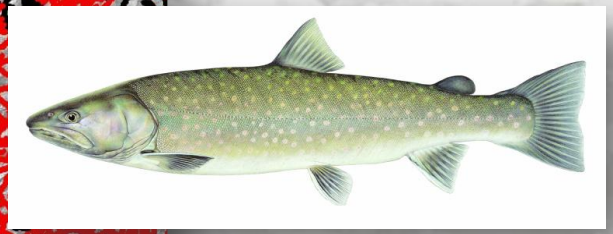
Unsuitable



Climate Effects on Bull Trout Thermal Habitat

+2.00˚C Stream Temp (~2080s)

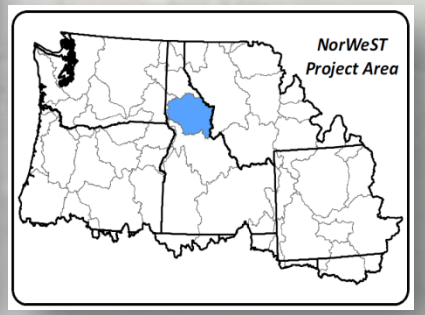




11.0˚C Isotherm

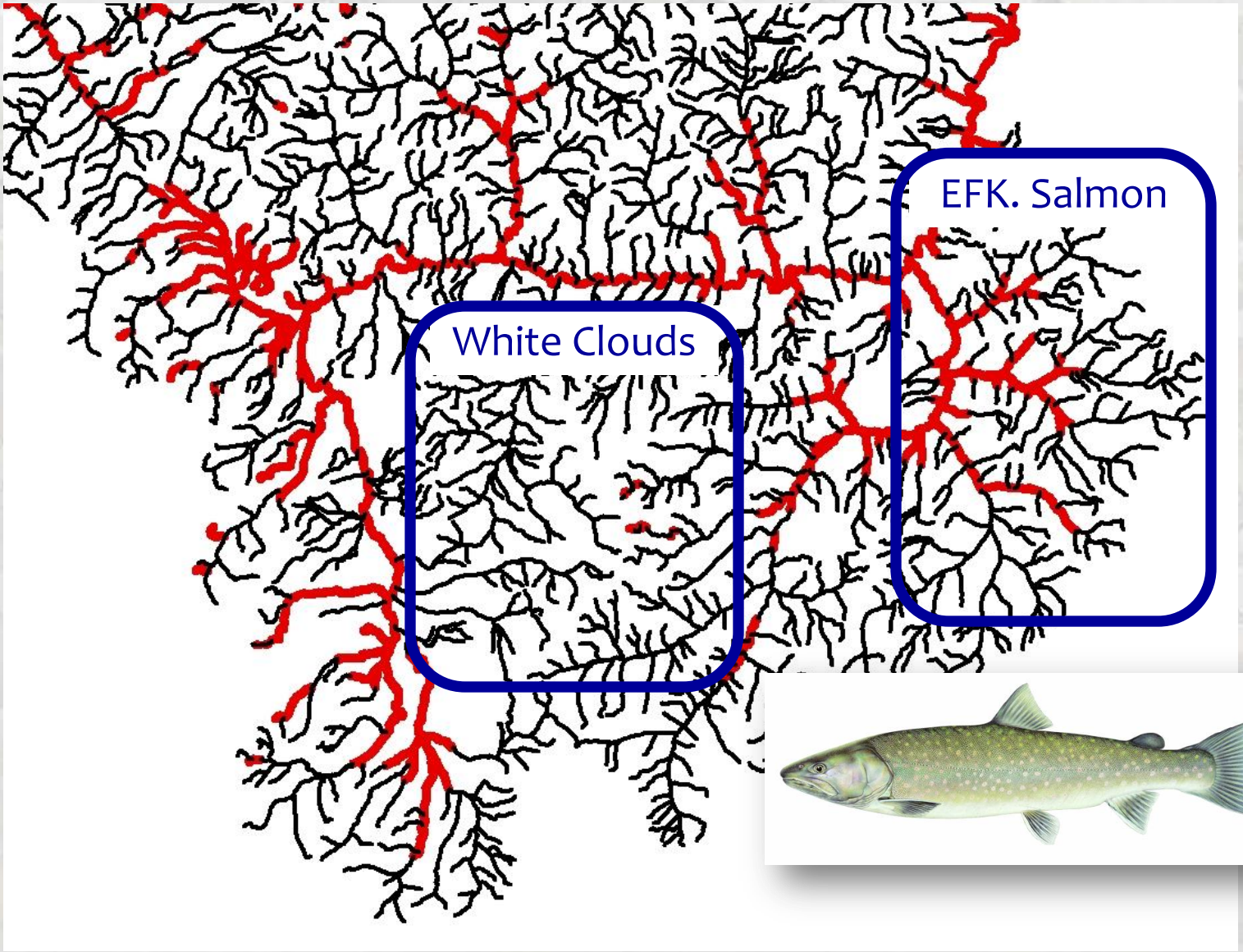
Suitable

Unsuitable



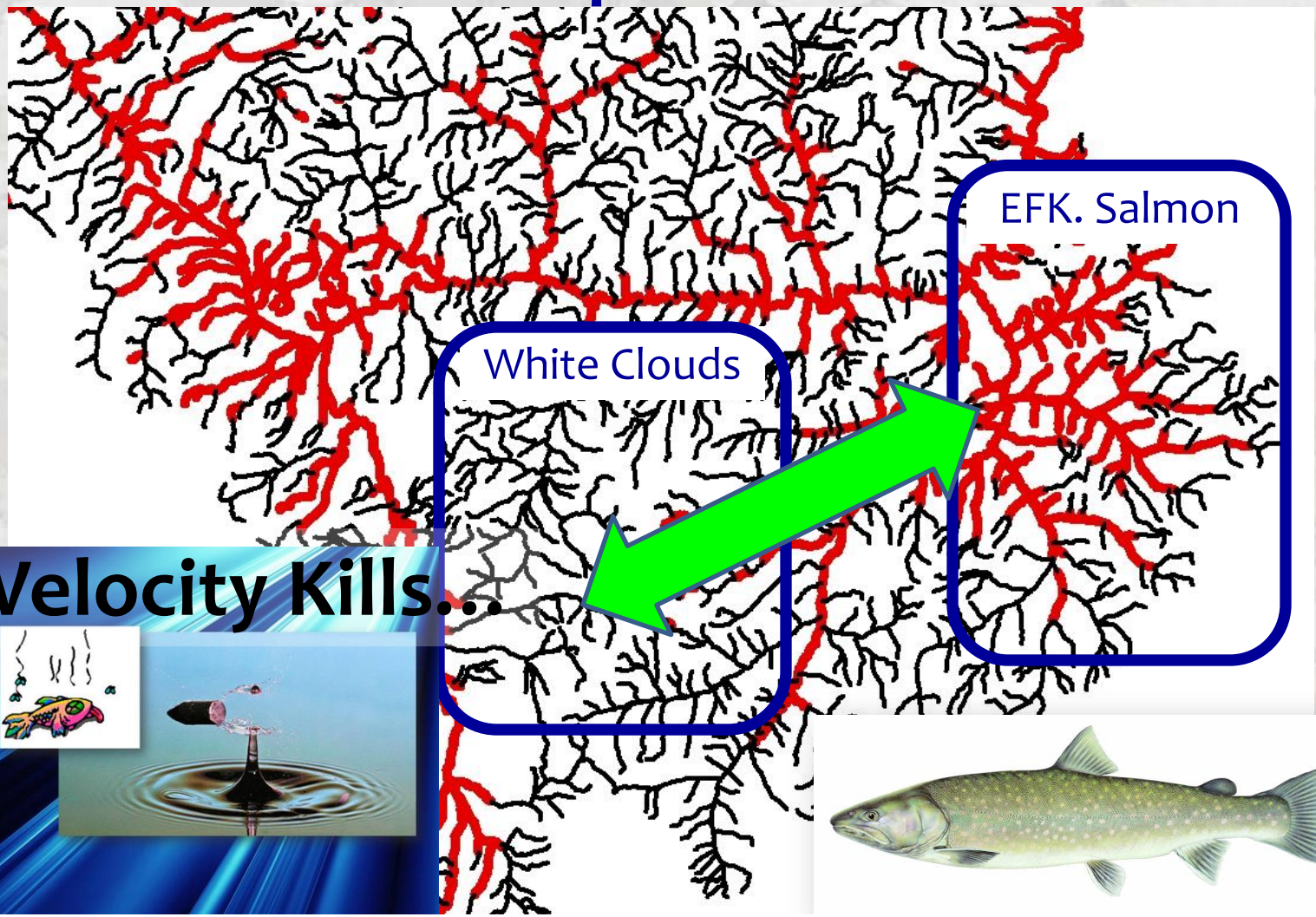
Spatial Variation in Habitat Loss

Historical scenario



Spatial Variation in Habitat Loss

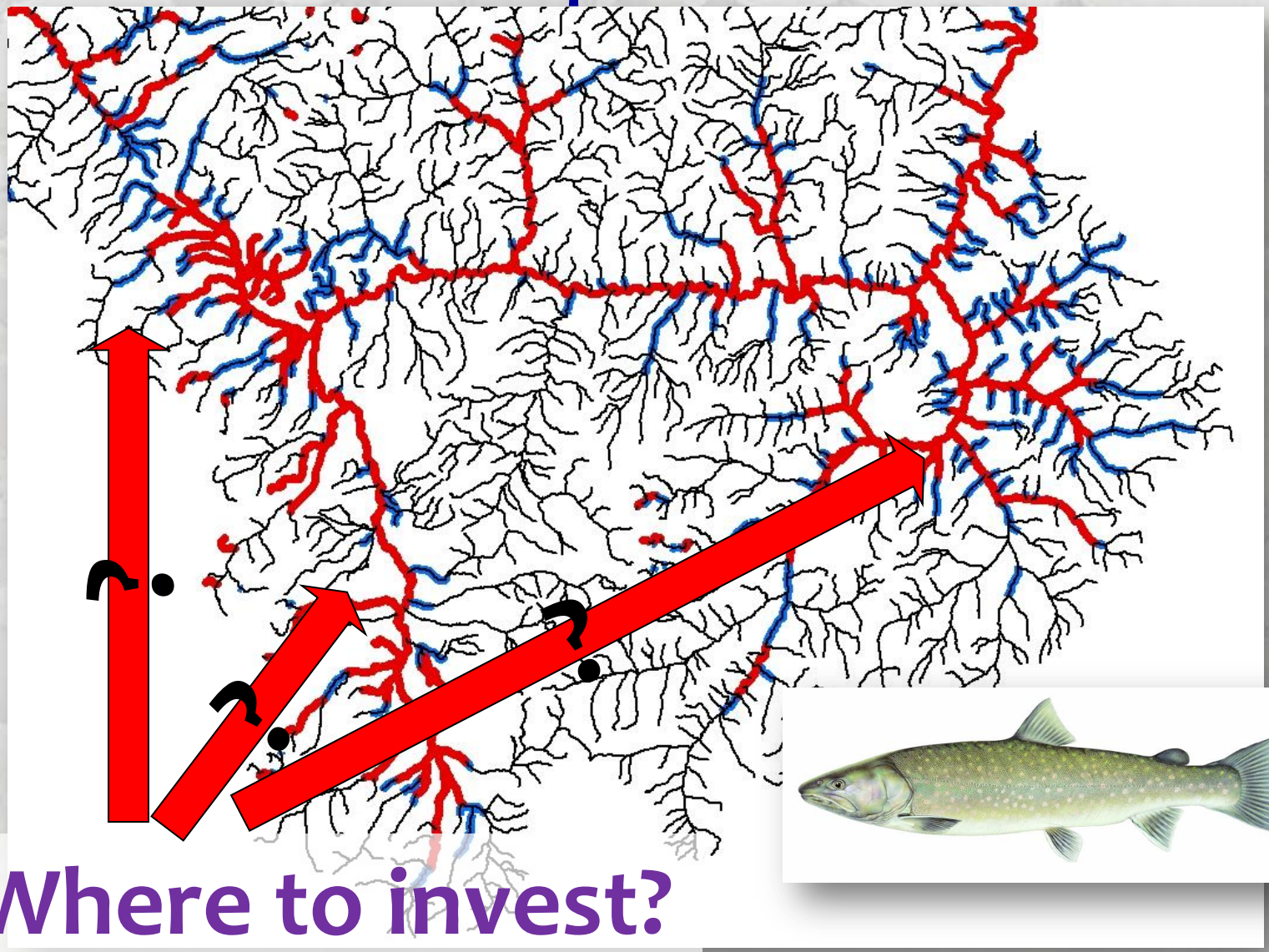
+1°C stream temperature scenario



Isaak & Rieman. 2013. Stream isotherm shifts from climate change and implications for distributions of ectothermic organisms. *Global Change Biology* 19:742-751.

Difference Map Shows Vulnerable Habitats

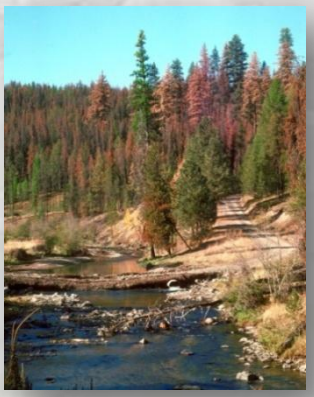
+1°C stream temperature scenario

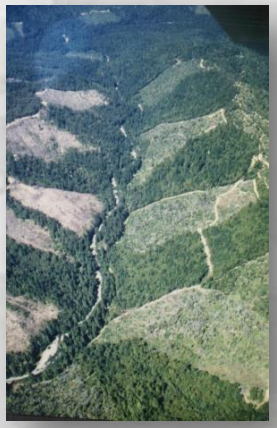


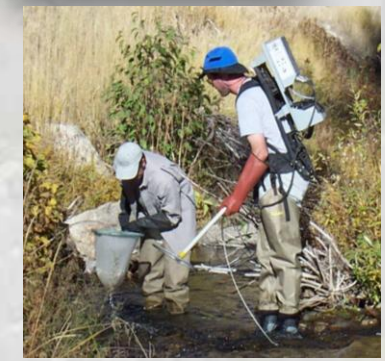
Where to invest?

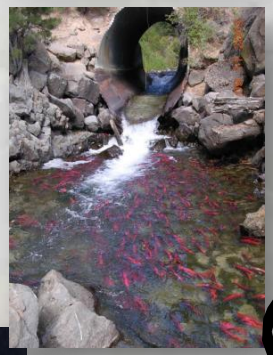
Climate-Smart Strategic Prioritization of Restoration

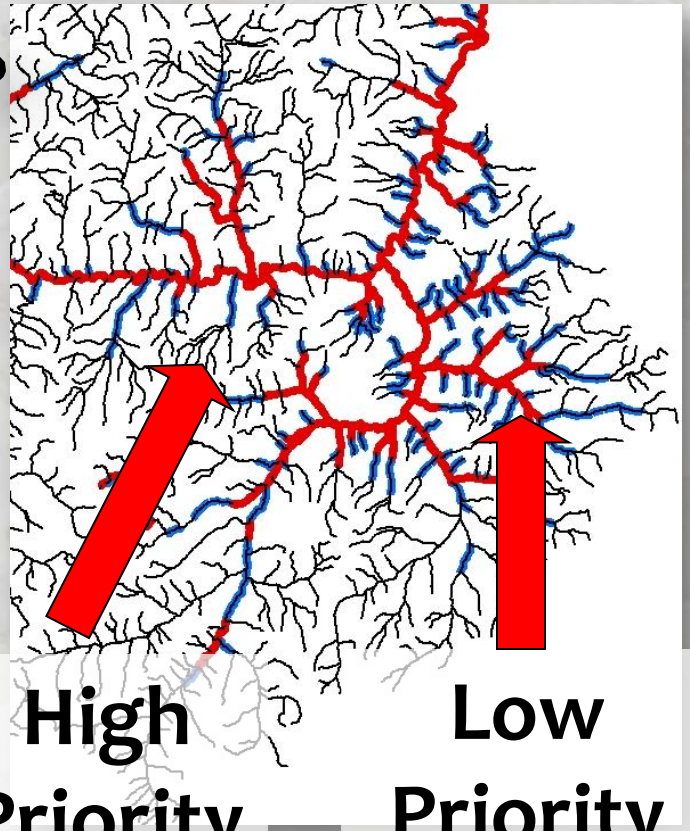
- Maintaining/restoring flow…
- Maintaining/restoring riparian…
- Restoring channel form/function…
- Prescribed burns limit wildfire risks…
- Non-native species control…
- Improve/impede fish passage…



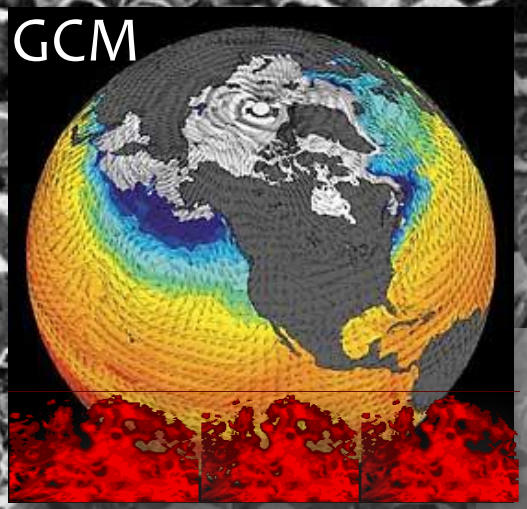


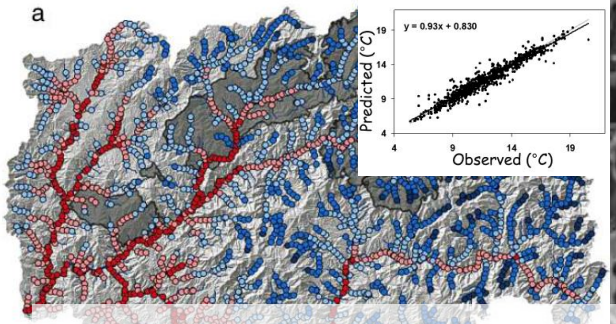






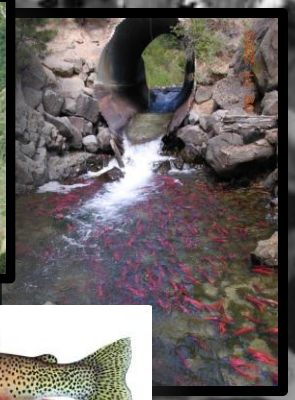
NorWeST is "Crowd-Sourced" so Everyone's Skin is in the Game





Data Collected by Local Bios & Hydros

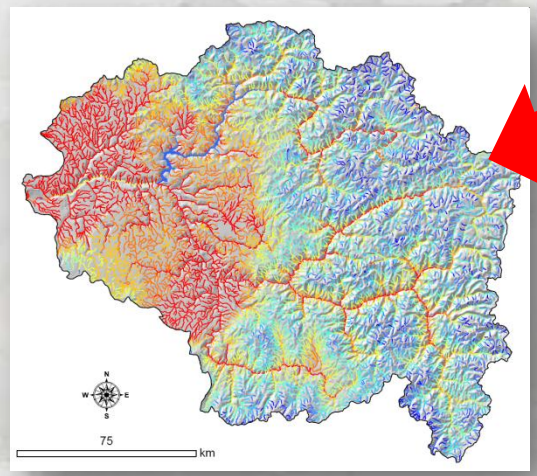
Coordinated Management Responses?



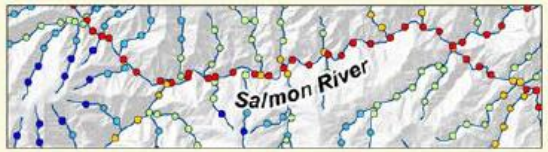
Management Decisions

Website Distributes Scenarios & Temperature Data as GIS Layers

1) GIS shapefiles of stream temperature scenarios

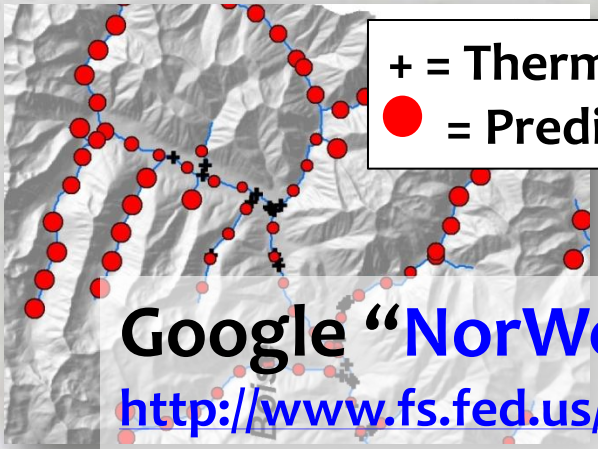


NorWeST Stream Temp

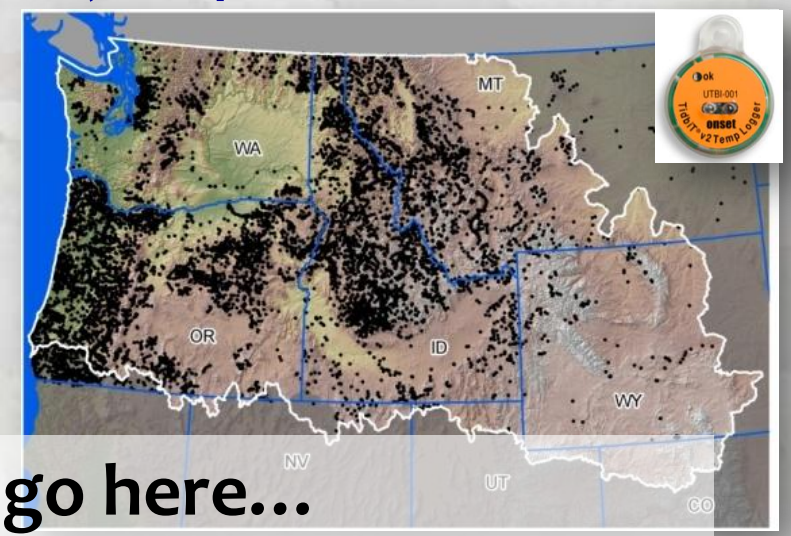


Regional Database and Modeled Stream Temperatures

2) GIS shapefiles of stream temperature model prediction precision



3) Temperature data summaries

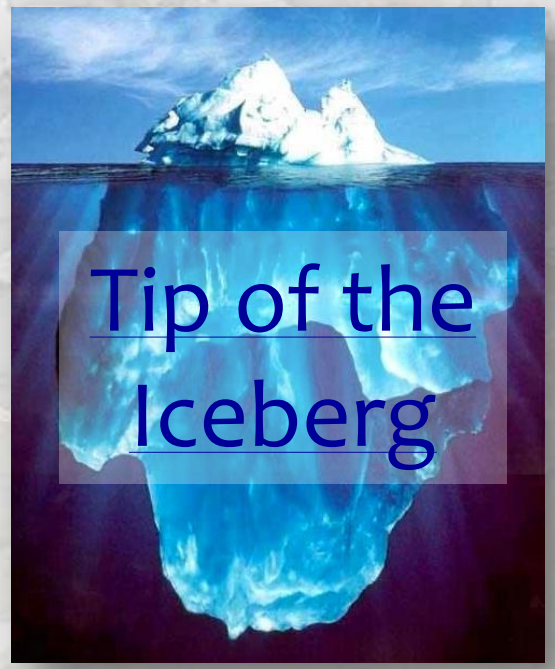


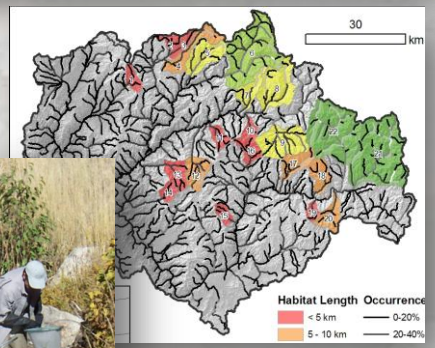
Google "NorWeST" or go here…

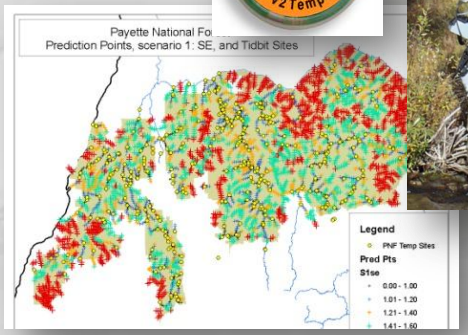
http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.shtml

NorWeST Facilitating Related Projects

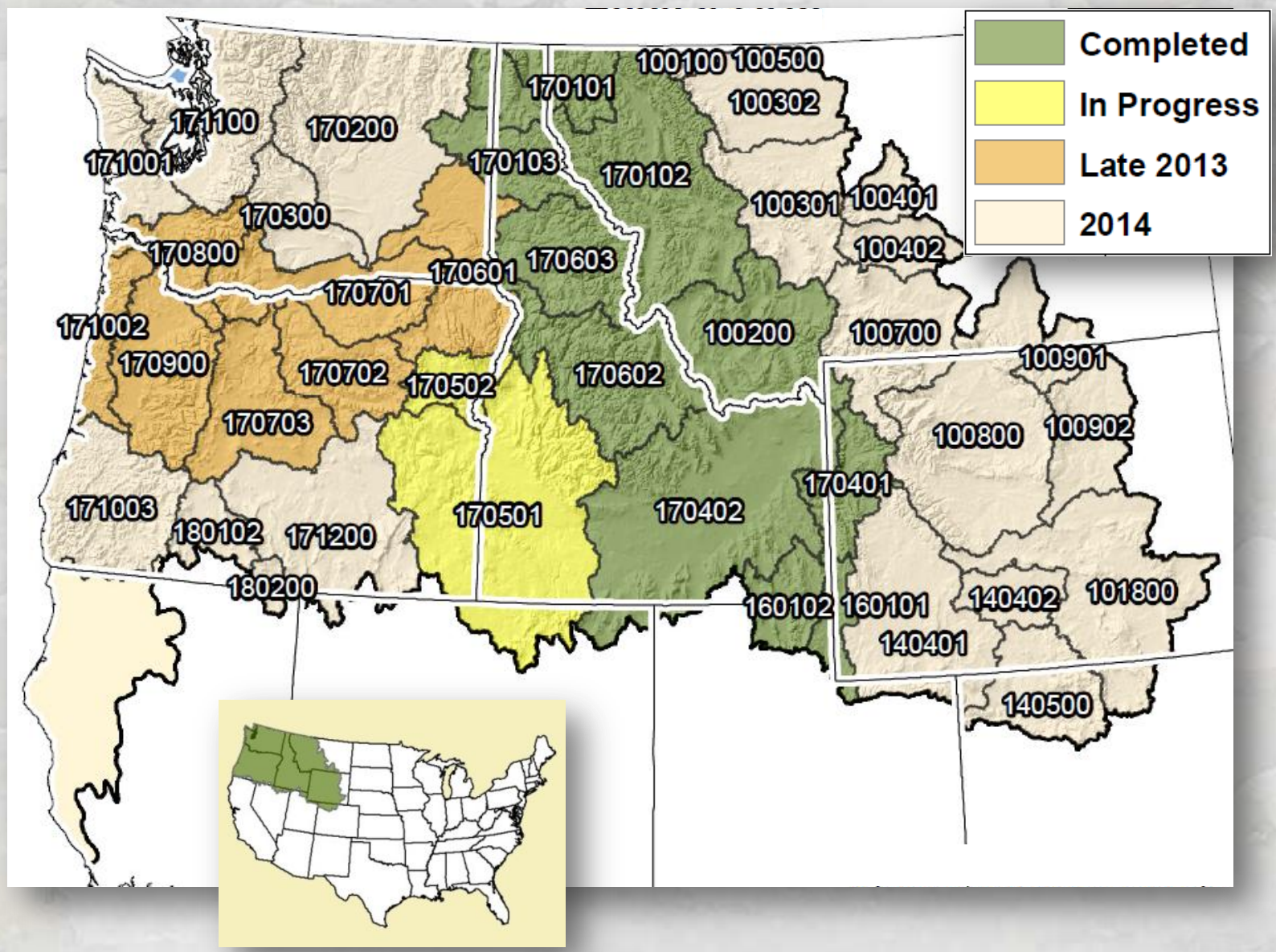
- Regional bull trout climate vulnerability assessment (J. Dunham)
- Cutthroat & bull trout climate decision support tools (Peterson et al., 2013)
- Landscape-scale bull trout monitoring protocol (Isaak et al. 2009)
- Consistent thermal niche definitions & more accurate bioclimatic models for trout & nongame fishes (S. Wenger, In Prep.)
- Efficient stream temperature monitoring designs





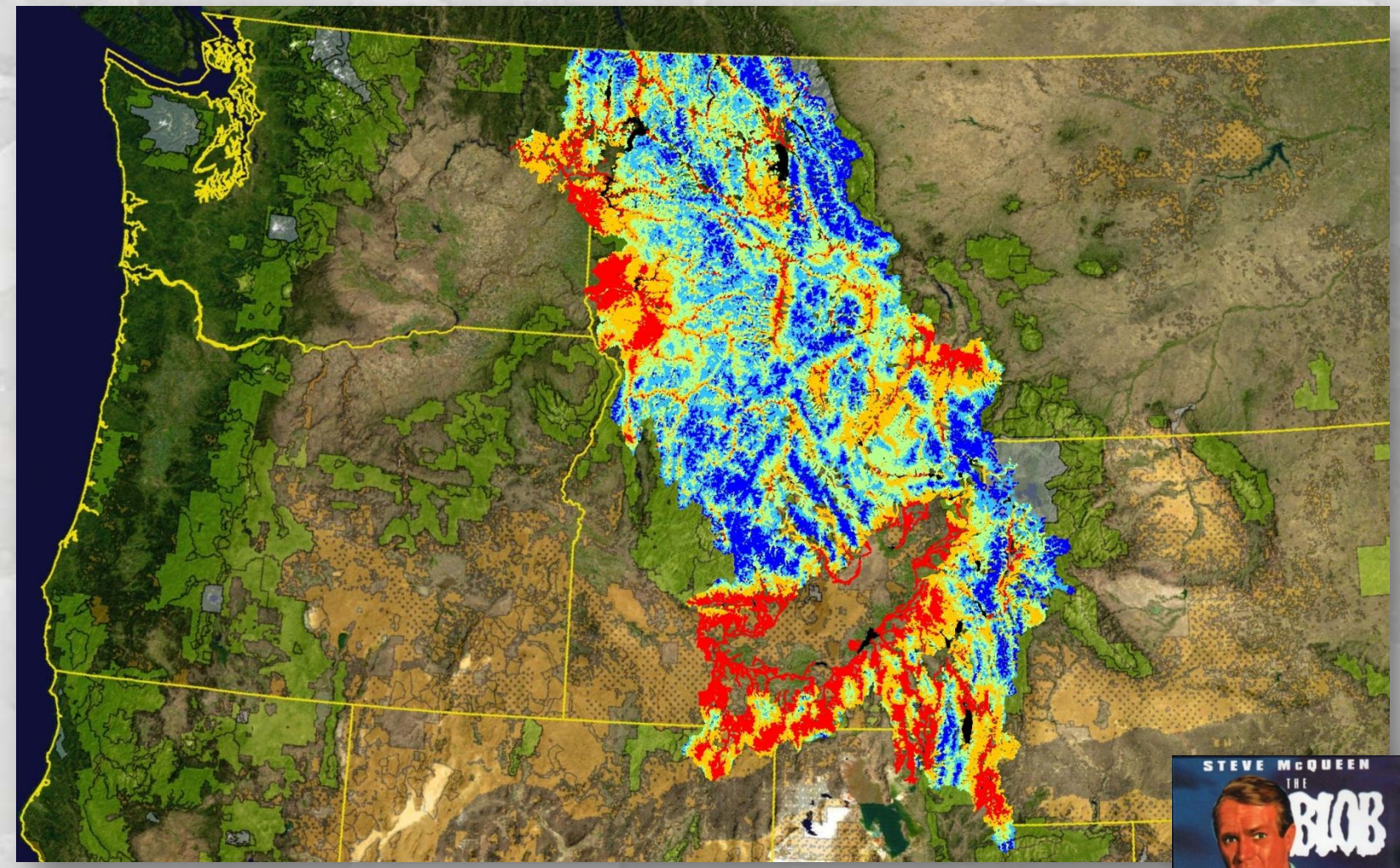


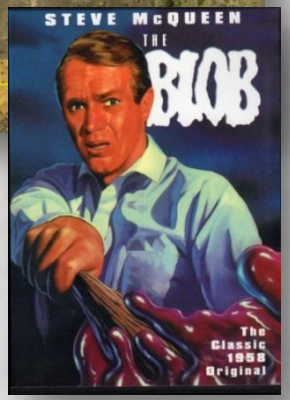
NorWeST Status & Schedule



A Special Thanks to These 60+ Partner Agencies…

Stream Thermalscape so far…





The BLOB… it just keeps growing…

- 171,000 stream kilometers of thermal ooze
- 16,688 summers of data swallowed