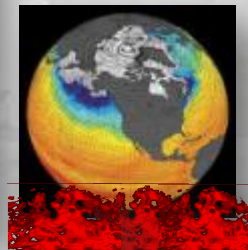
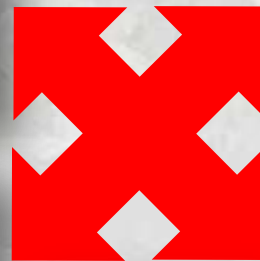
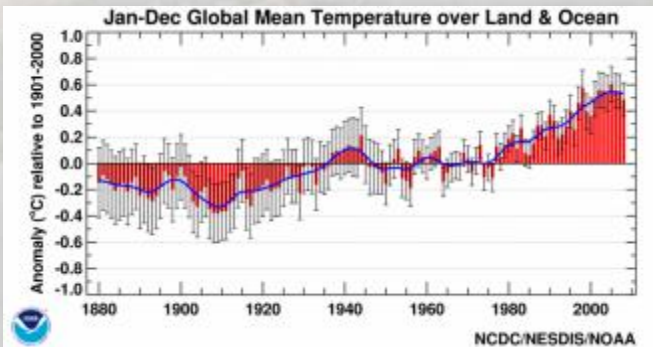


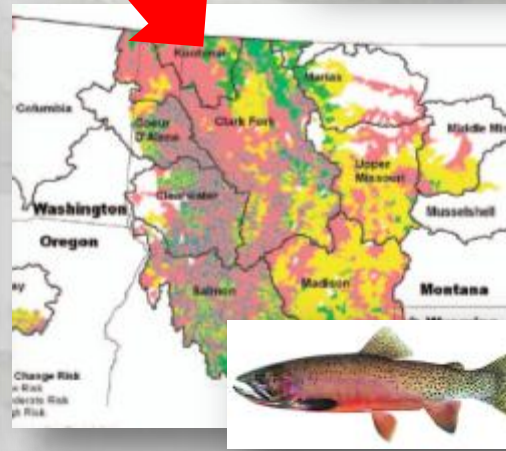
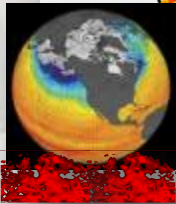
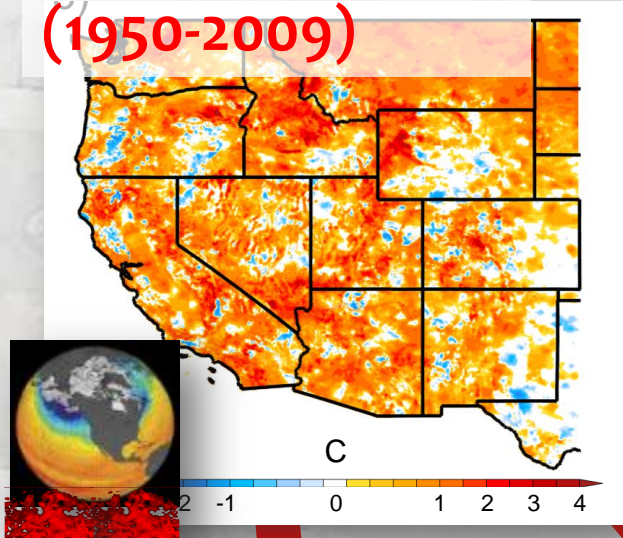
# Crowd-Sourcing, Digital Media, & Building Social Networks for Landscape Conservation of Native Trouts in the Climate Change Era

Dan Isaak, US Forest Service  
Rocky Mountain Research Station  
[disaak@fs.fed.us](mailto:disaak@fs.fed.us); 208-373-4385



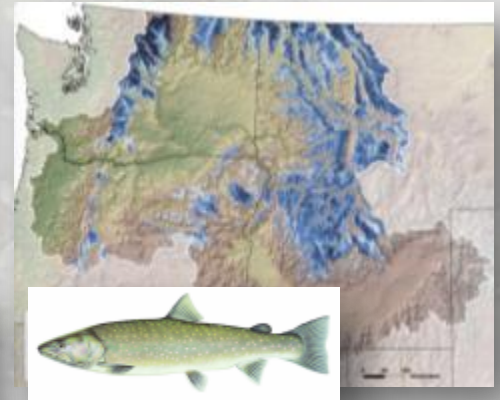
# If You're a Coldwater Fish, The Future Ain't so Pretty...

## Air Temp trends (1950-2009)



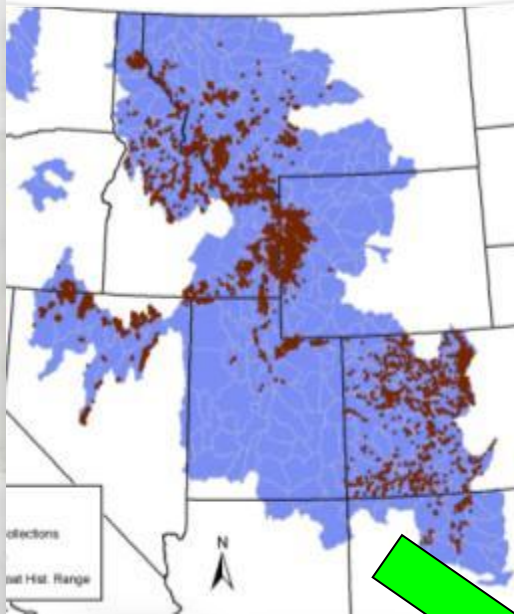
## Many Studies...

- Meisner 1988, 1990
- Eaton & Schaller 1996
- Keleher & Rahel 1996
- 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

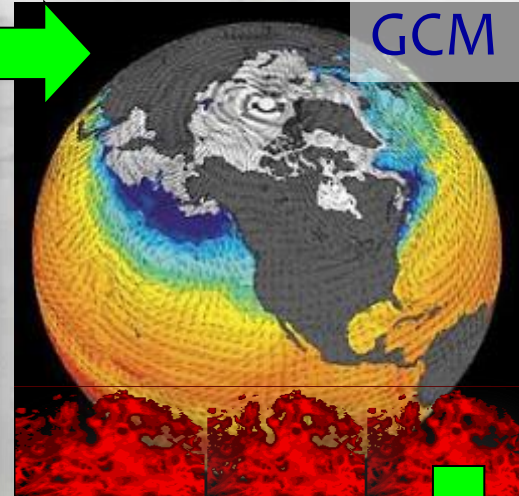
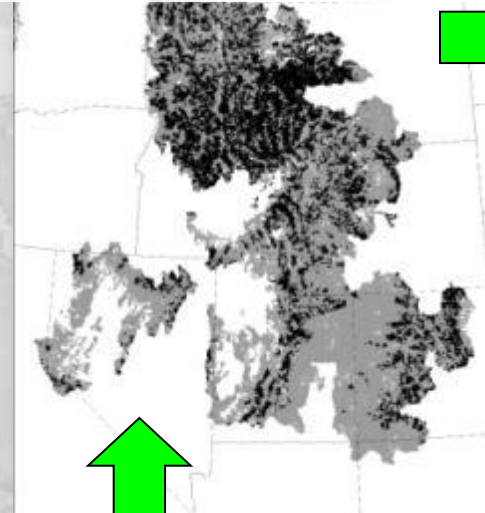


# Rocky Mountain Trout Climate Assessment

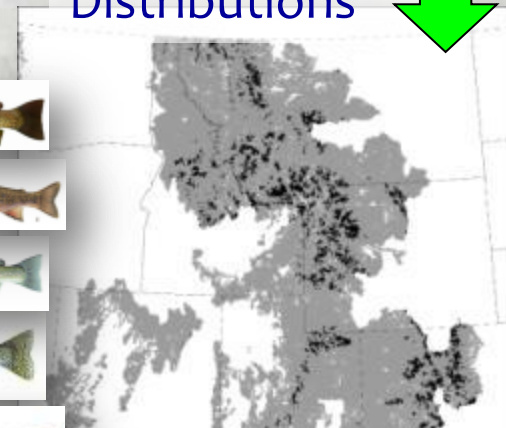
Fish survey database  
~10,000 sites



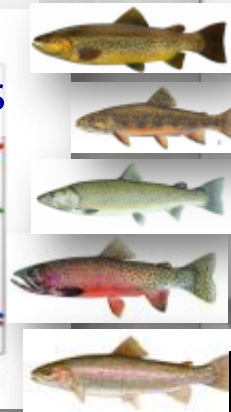
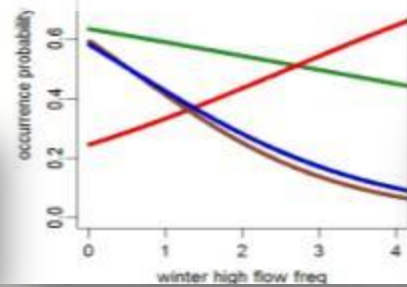
Historic Distributions



Future A1B  
Distributions



Species-Specific  
Habitat  
Response Curves

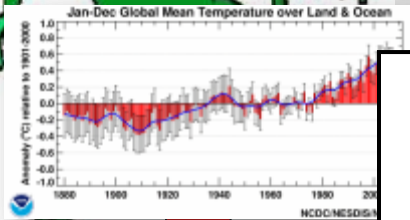
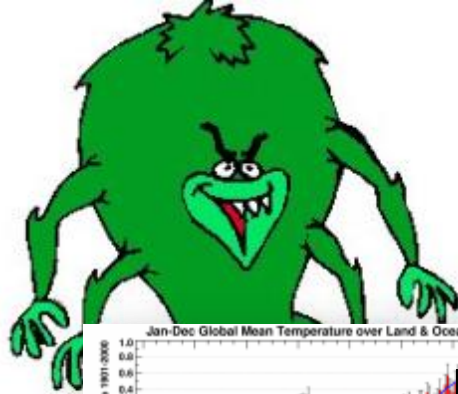


Wenger et al. 2011. *PNAS* 108:14175-14180

**~50% reduction by  
2080 under A1B**

# There's A Lot on the Line...

## Climate Boogeyman



## Recreational/Commercial Fisheries

Low Flows Prompt Fishing Closure On Upper Beaverhead River And Reduced Limits On Clark Canyon Reservoir

Wednesday, September 29, 2004  
Fishing

High Water  
Temperature In Grande  
Ronde Kills 239 Adult  
Spring Chinook



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

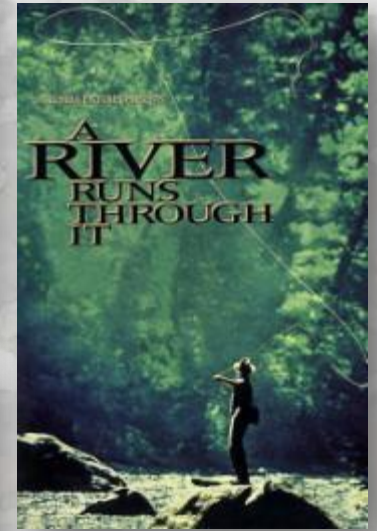
## Land Use & Water Development



**ESA Listed Species**

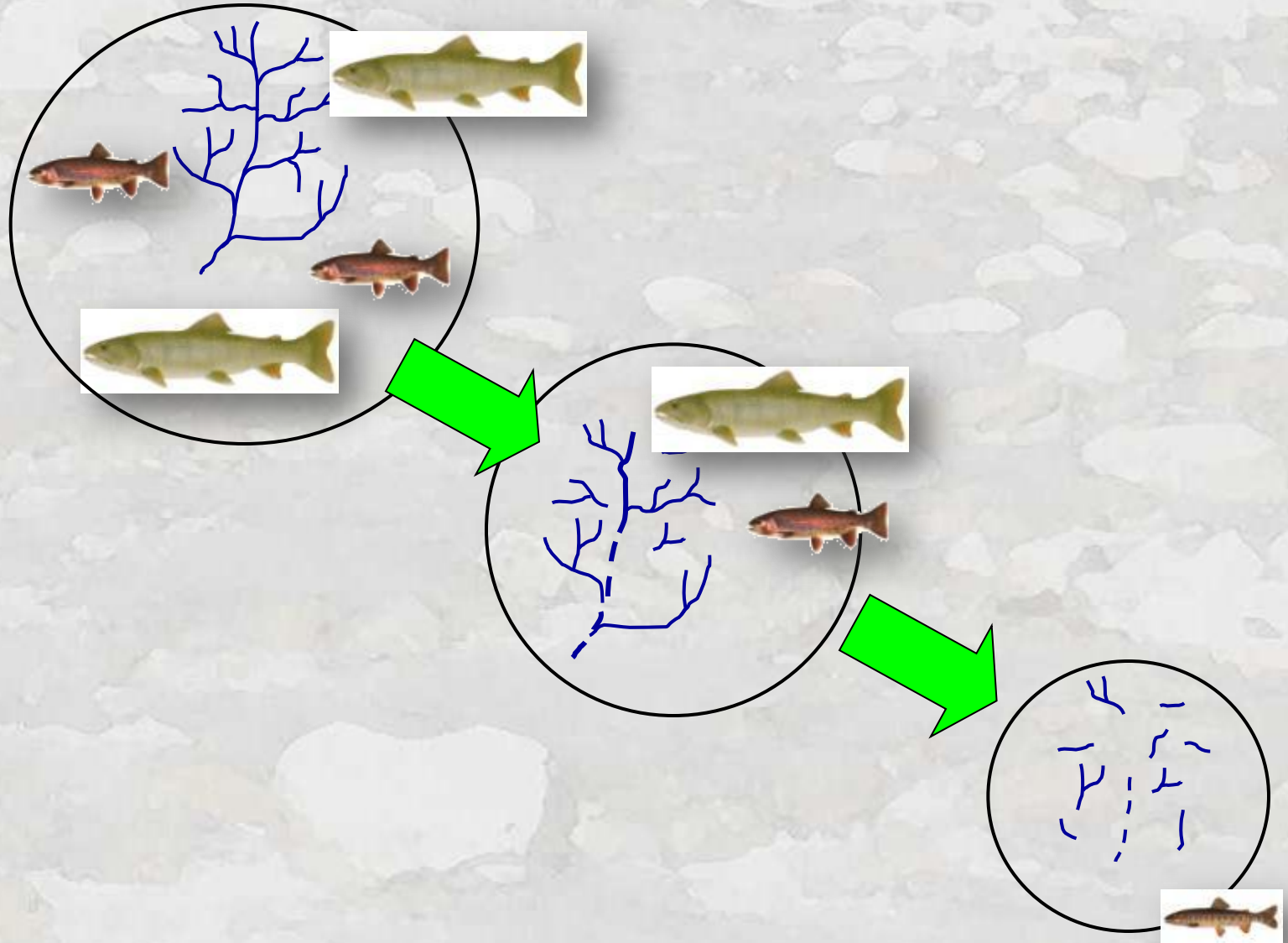


# People Love These Fish & Landscapes



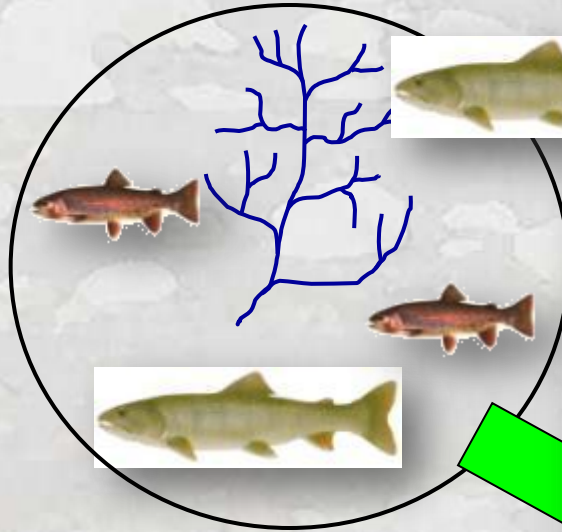
# We'll Have to Make Difficult Choices

## Not all Populations Can be Saved



# We'll Have to Make Difficult Choices

## Not all Populations Can be Saved



**Sorry  
Charlie**

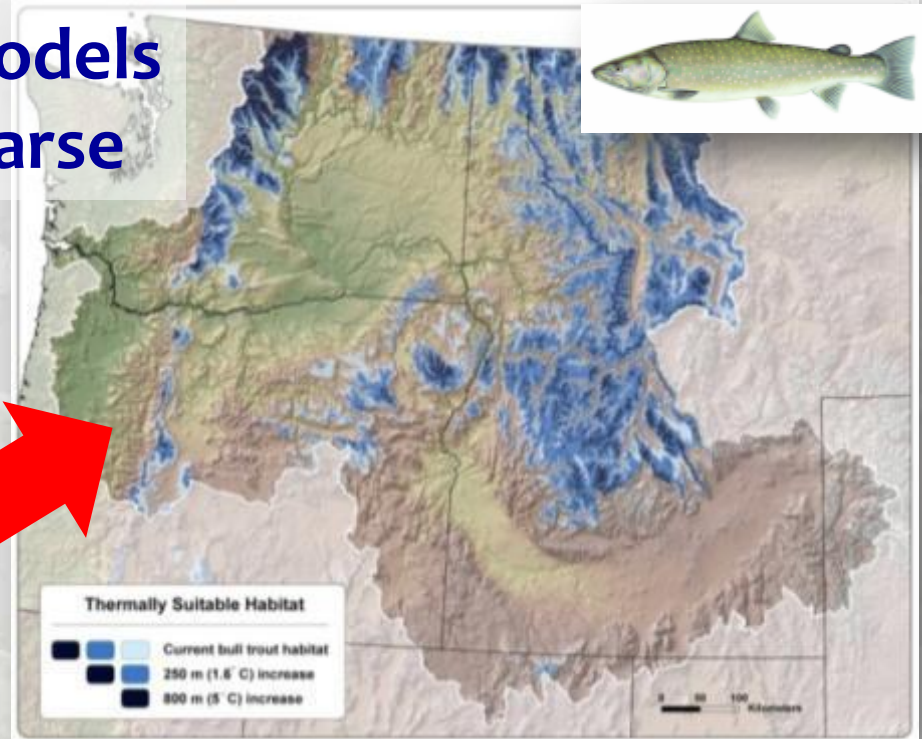
**Thresholds Beyond  
Which Populations  
Become "Walking Dead"**



# Precise Information Needed to Empower Local Decision Makers

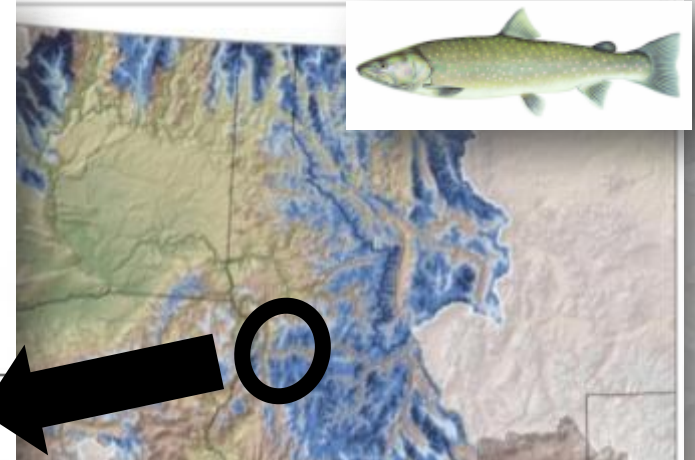
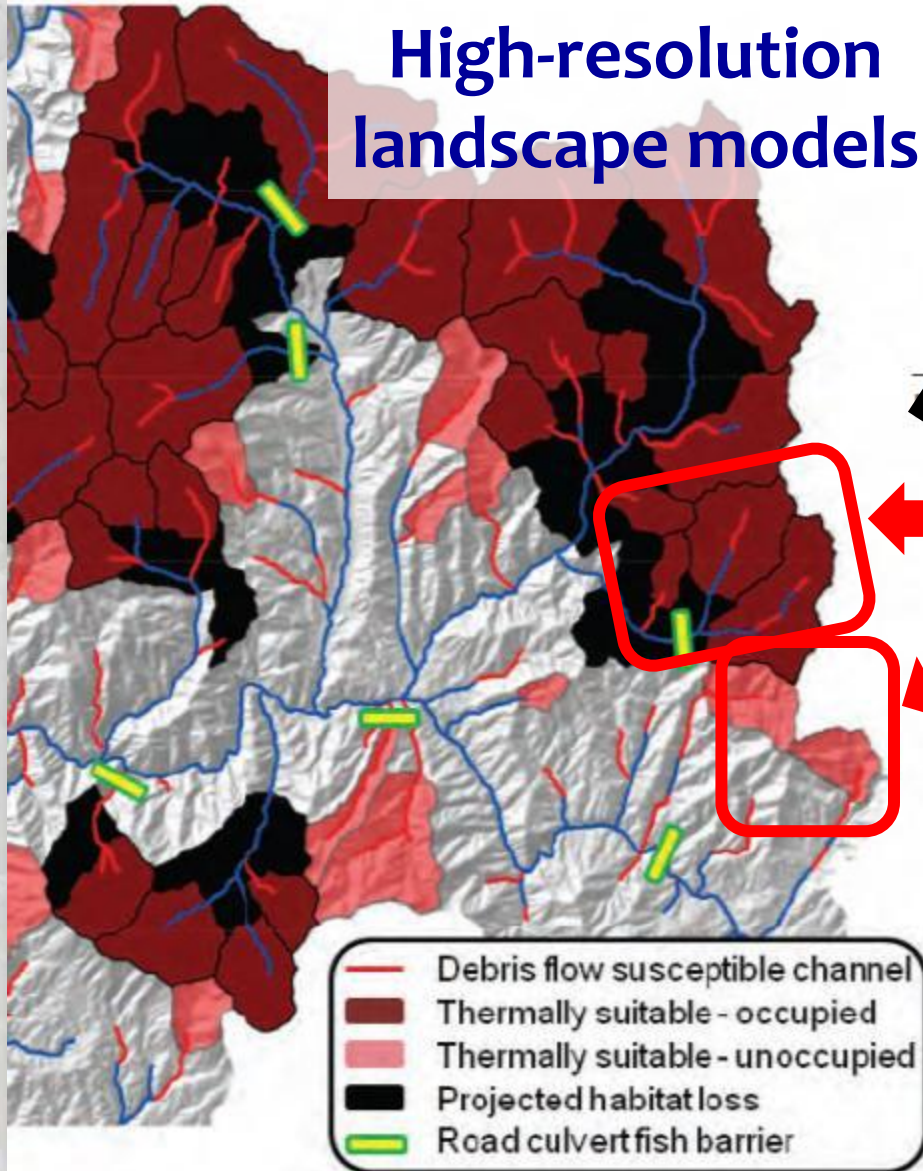
Regional models  
are too coarse

Not Good Enough for  
Zombie Detection





# Precise Information Needed to Empower Local Decision Makers



I'm going to invest here...

... instead of here



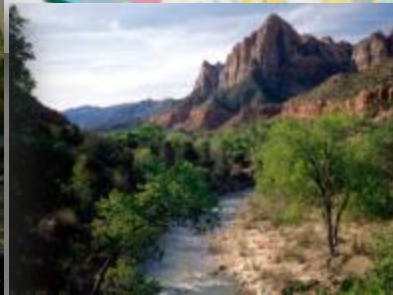
# Information Needed Across Broad Areas, Multiple Agencies & Remote Locations



**>1,000,000  
kilometers of  
stream**



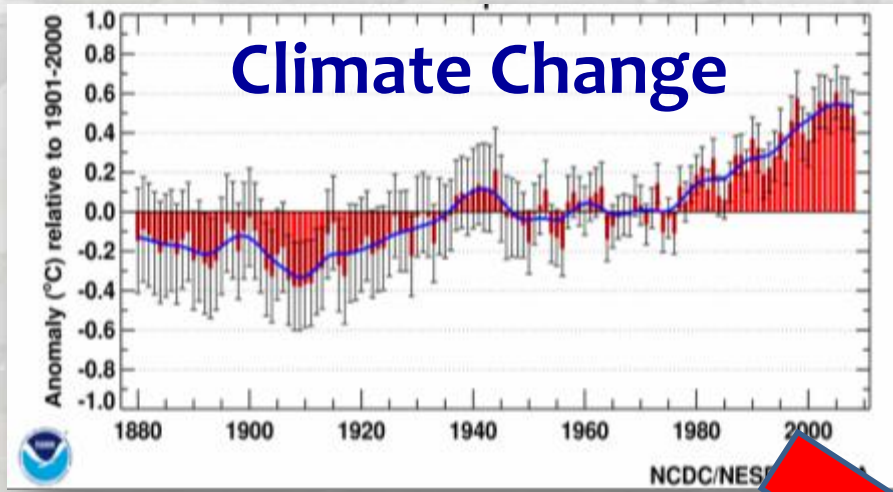
- 193 Million Acres (10% of US)
- 155 National Forests



Diverse streams

Remote landscapes

# More Pressure, Fewer Resources



Urbanization & Population Growth



Shrinking Budgets

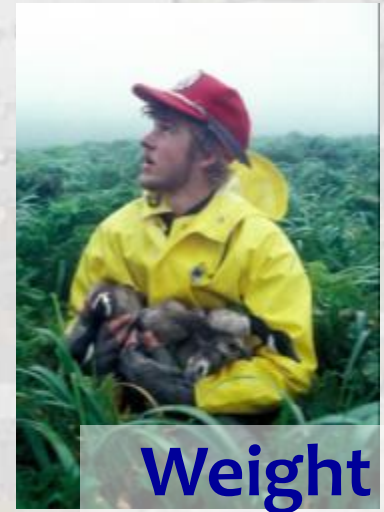


Need to do more with less

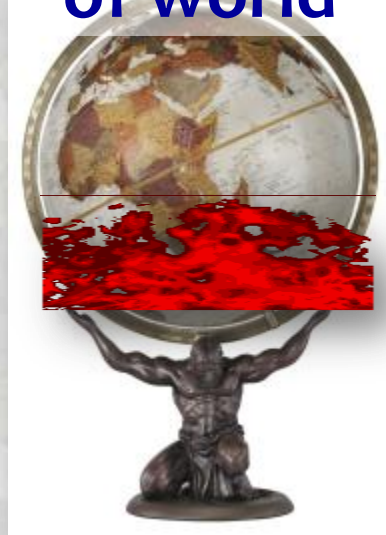


# Climate Boogeyman

Onus?



Weight of world



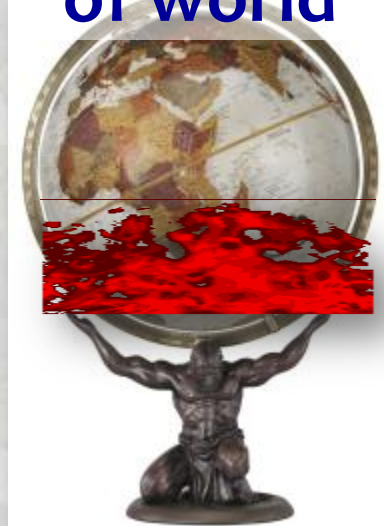
# Climate Boogeyman



## Analytical Capacity

- Remote sensing/GIS
- Georeferenced, corporate databases
- Computational capacity
- Spatial models

## Weight of world



## Interagency Collaboration



All agencies under pressure to “do something”...

# Geospatial Technologies & Spatial Analyses Translate Science to “Real-World” Coordinates

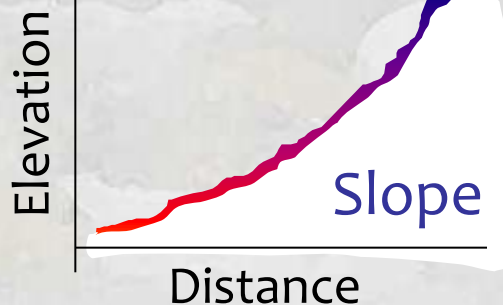
Remote Sensing



Visualization



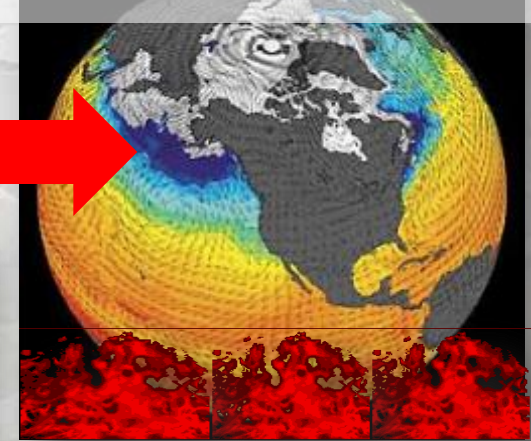
Nationally Consistent Hydrology  
Databases (USGS NHD+)



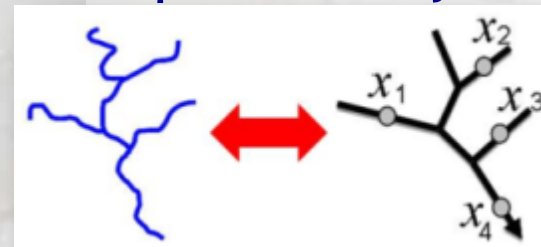
GIS /  
Computing  
Capacity



Climate, weather,  
GCM data online

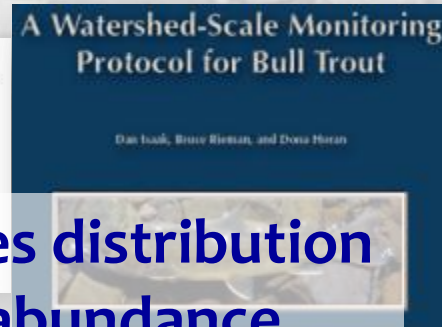


Spatial analyses

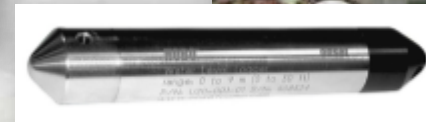


# Local Measurements Provide Model Calibration

## Standard Protocols, Inexpensive Sensors/Bioassays



Stream discharge

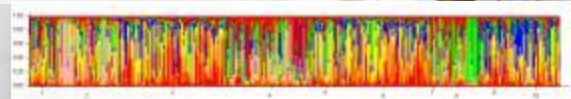


Species distribution & abundance

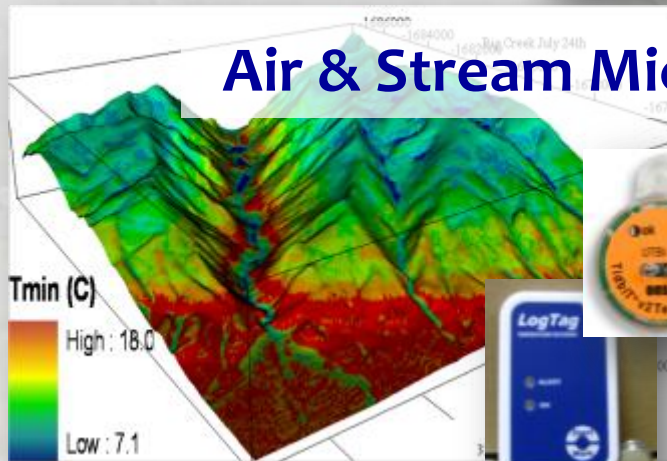


Tissue Samples & DNA barcoding

Sample	TIME	TEMP	DATE
1/1	1/2	1/3	1/4
1/5	1/6	1/7	1/8
1/9	1/10	1/11	1/12
1/13	1/14	1/15	1/16
1/17	1/18	1/19	1/20



Air & Stream Microclimates



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



Short communication

Design and evaluation of an inexpensive radiation shield for monitoring surface air temperatures

Zachary A. Holden<sup>a,+</sup>, Anna E. Klene<sup>b</sup>, Robert F. Keefe<sup>c</sup>, Gretchen G. Moisen<sup>d</sup>

# Huge Potential Synergies Between Researchers, Managers, & the Public

## Huge Land Base



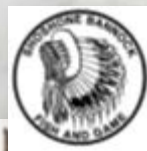
## “Boots-on-the-Ground”



USFS has ~600 fish bios/hydros.  
(That's an aquatics army!)



Managers collecting mountains of useful data



Researchers can develop information & connect people

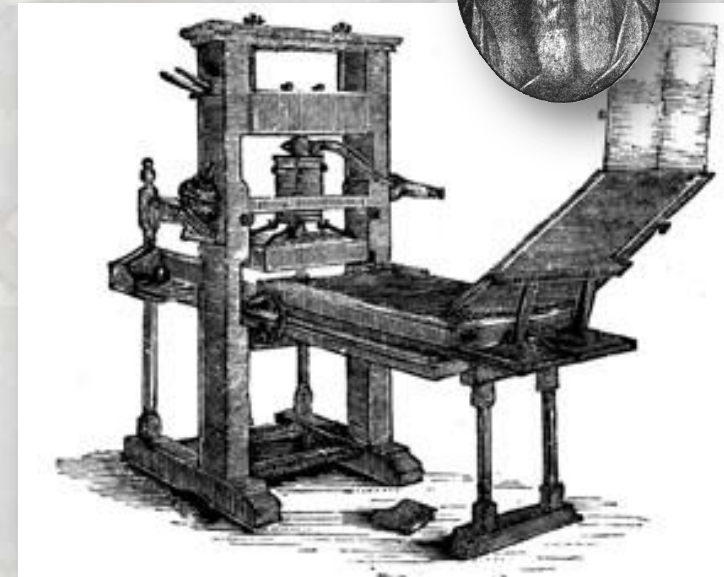




# Information Development & Dissemination Has Been Revolutionized



Top-Down Control Has Evolved to Open Networks



Access to “Free” & Ubiquitous Information is a Game Changer



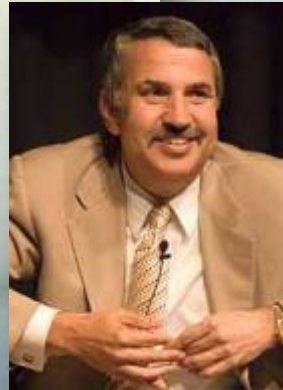
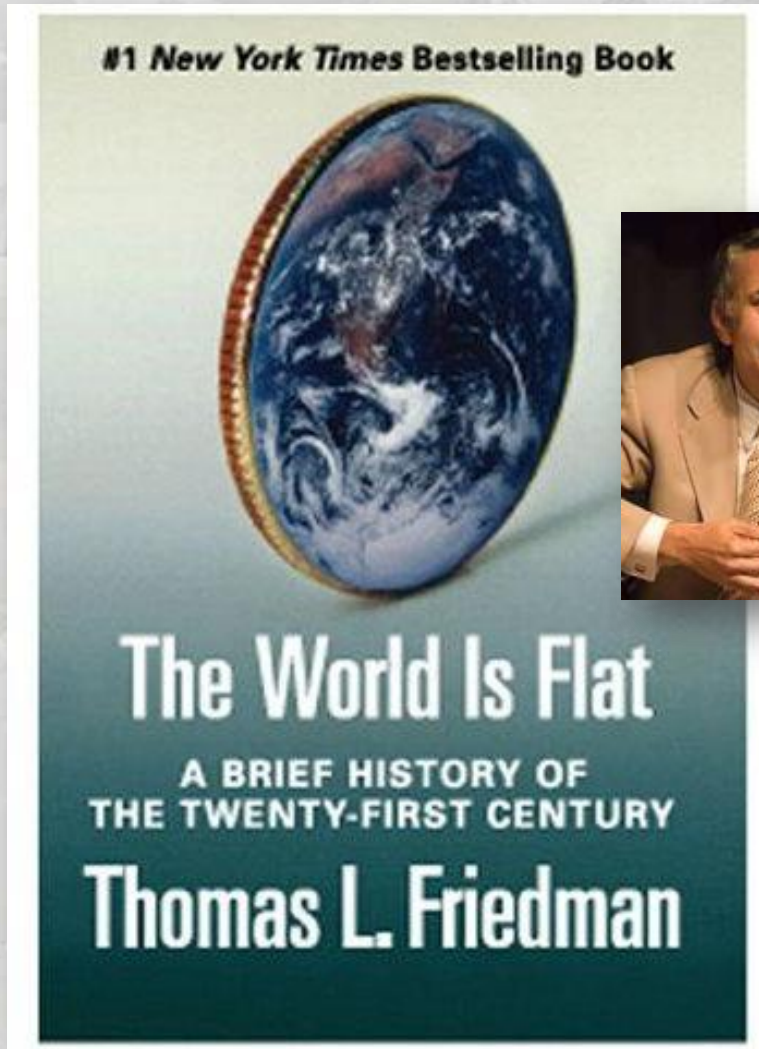
# Proliferation of Digital Media Types

Low- or no-cost to use



If you can think it, you can create it...

# Good Ideas & Tools Can Spread Rapidly

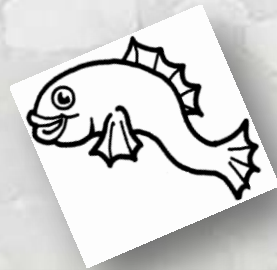


What-else explains  
twenty-something  
billionaires?

A digital meritocracy with low barriers to entry & the playing field is more level

# Examples: Climate-Aquatics Blog

- Digest & transfer latest/greatest science rapidly
- Facilitate global discussion & community building
- Blog mailing list grows from <500 to >5,500 in 2.5 years



Google groups Discussion site

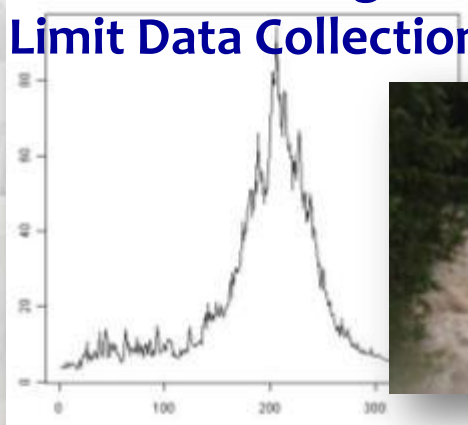


Map shows locations where blog website was accessed in last month

Google “Climate-Aquatics Blog”

# Distributing New Temperature Monitoring Protocol

Annual Flooding Concerns  
Limit Data Collection



Solution: Glue sensors to large boulders & permanent cement structures



\$130 = 5 years of data

Isaak & Horan 2011. NAJFM 31:134-137

## Stream Temperature Modeling and Monitoring



Website Distributes Information

Thermal regimes are important to aquatic ecosystems because they strongly dictate species distributions, growth, and abundance. Inexpensive digital temperature loggers, geographic information systems (GIS), remote sensing technologies, and new spatial analyses are facilitating the development of temperature models and monitoring networks applicable at broad spatial scales. This web site provides a mapping tool to help those in the western US organize temperature monitoring efforts, describes techniques for measuring stream temperatures, and describes several statistical models for predicting stream temperatures and thermally suitable fish habitats from temperature data. The web site also provides links to other stream temperature resources such as publications, videos, and presentations on topics relating to thermal regimes in streams.

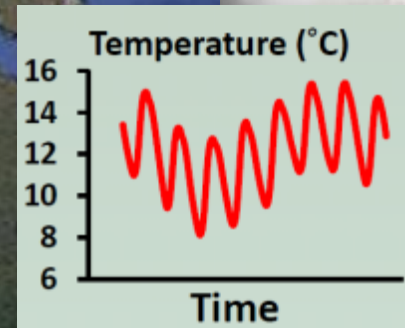
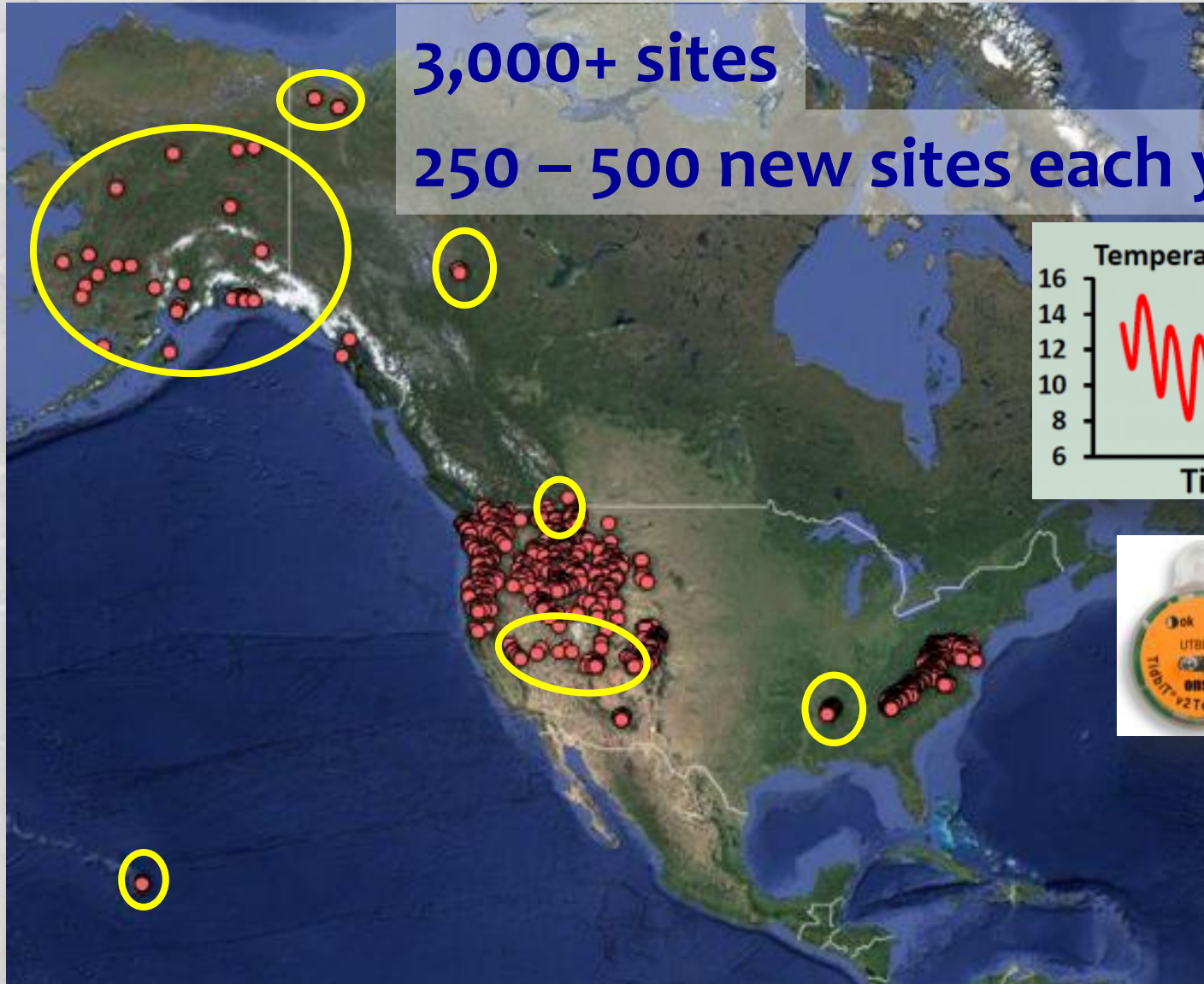
Google “Stream temperature Forest Service”



Training Video & Manual

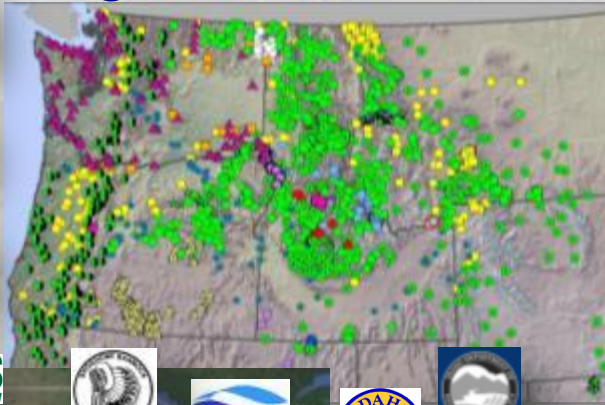


# Rapid Protocol Adoption & Emergence of Annual Temperature Monitoring Network



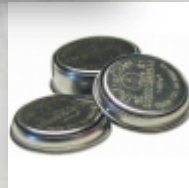
# GoogleMap Tool Shows Monitoring Locations Across Agencies to Coordinate Efforts

## Regional Sensor Network



## Site Information

- Stream name
- Data steward contact information
- Agency
- Site Initiation Date



## Query Individual Sites

**Montana Annual Stream Temperature Points available**  
[http://www.fs.fed.us/m/boise/AWAE/projects/stream\\_temperature.shtml](http://www.fs.fed.us/m/boise/AWAE/projects/stream_temperature.shtml)

Stream Temperature Points available by Agency

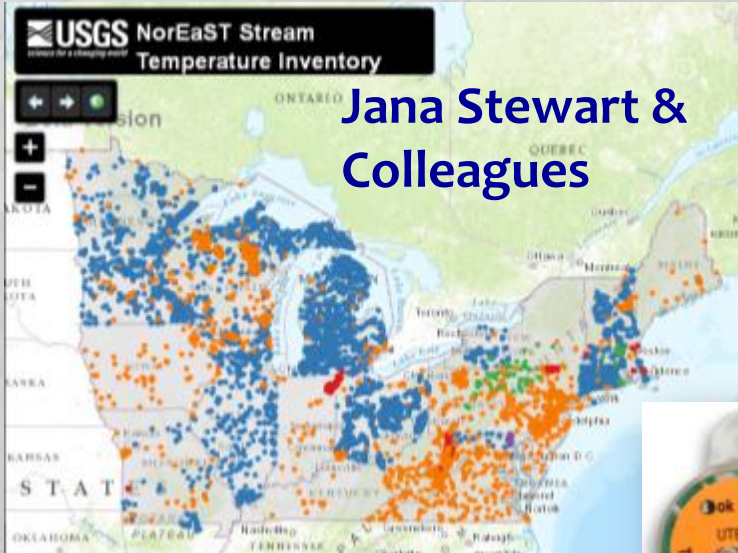
2002/2011  
52 views - Public  
Created on Feb 2 - Updated 13 hours ago  
By  
Rate this map - Write a comment

- **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
- **Akokala Creek**  
Thermograph Location: Akokala 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 ▸

# Crowd-Sourced Temperature Databases

Regional projects developing massive databases



Free  
millions!



NorWeST  
Stream Temp



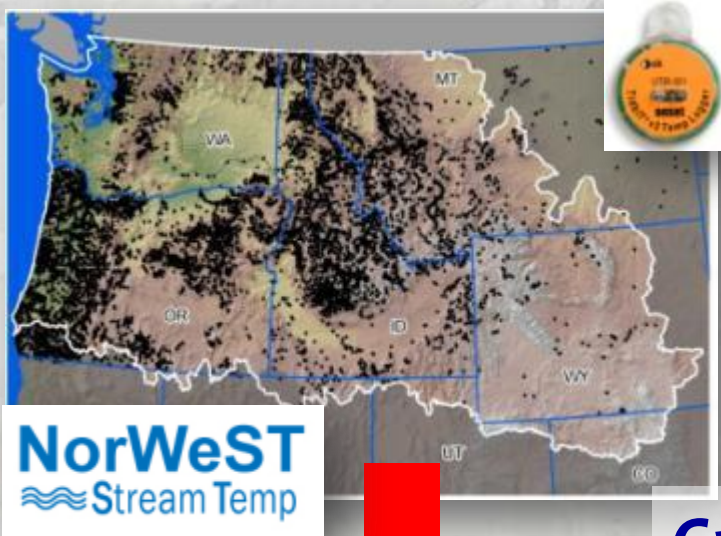
Small teams  
linked through  
virtual networks  
organize data



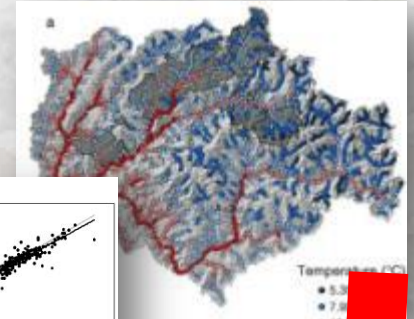
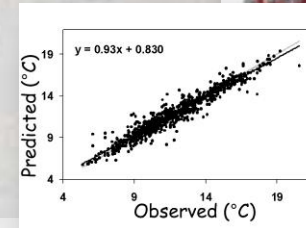
>60 agencies  
>45,000,000 hourly records  
>15,000 unique sites



# Regional Stream Temp Model

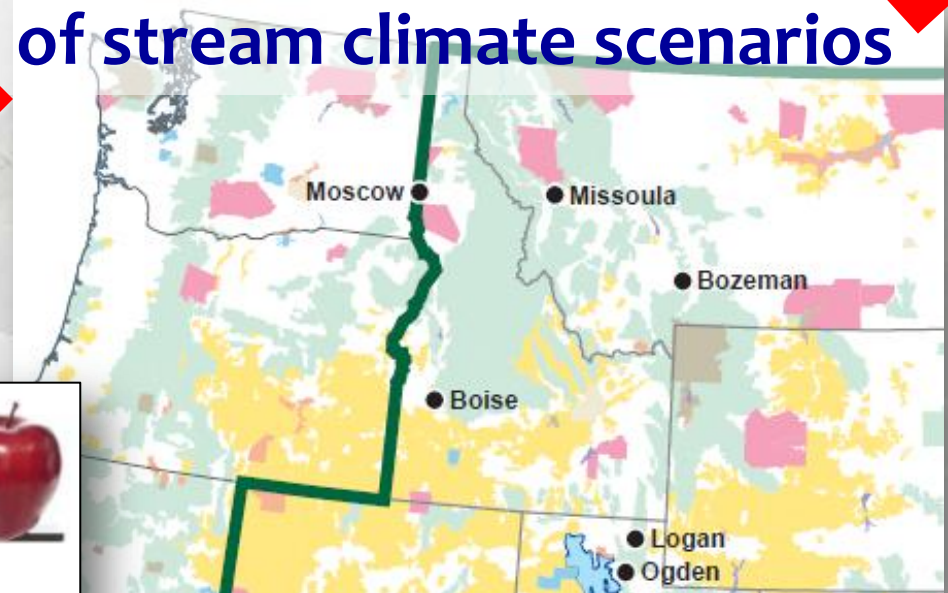
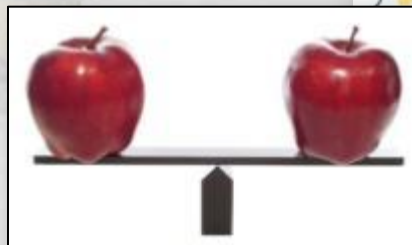


Accurate stream temp model



Cross-jurisdictional “maps” of stream climate scenarios

Consistent datum for strategic assessments across 400,000 stream kilometers



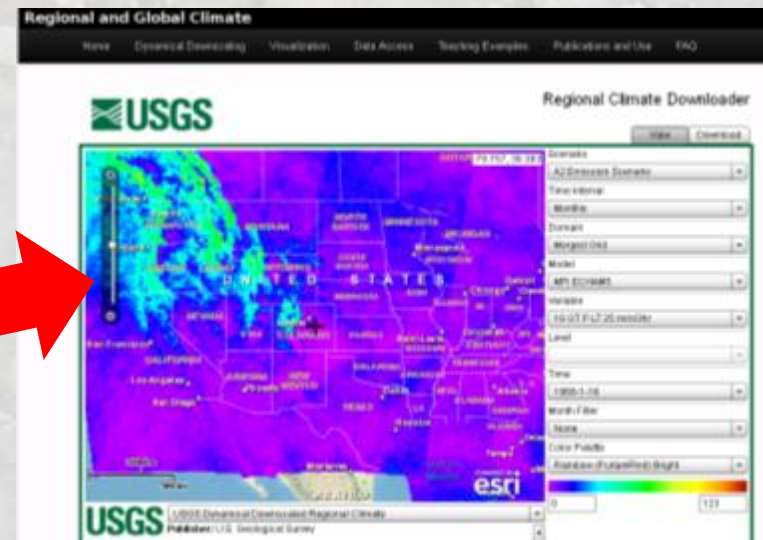
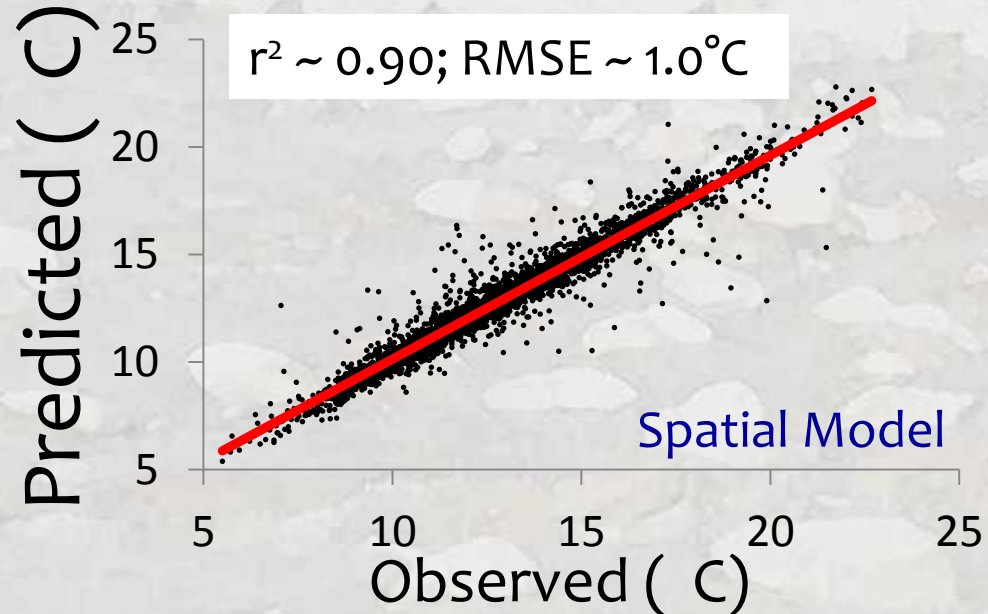
# NorWeST Model Predictors are from National GeoSpatial Layers (NHD+, NLCD, etc.)

## Spatial Predictors

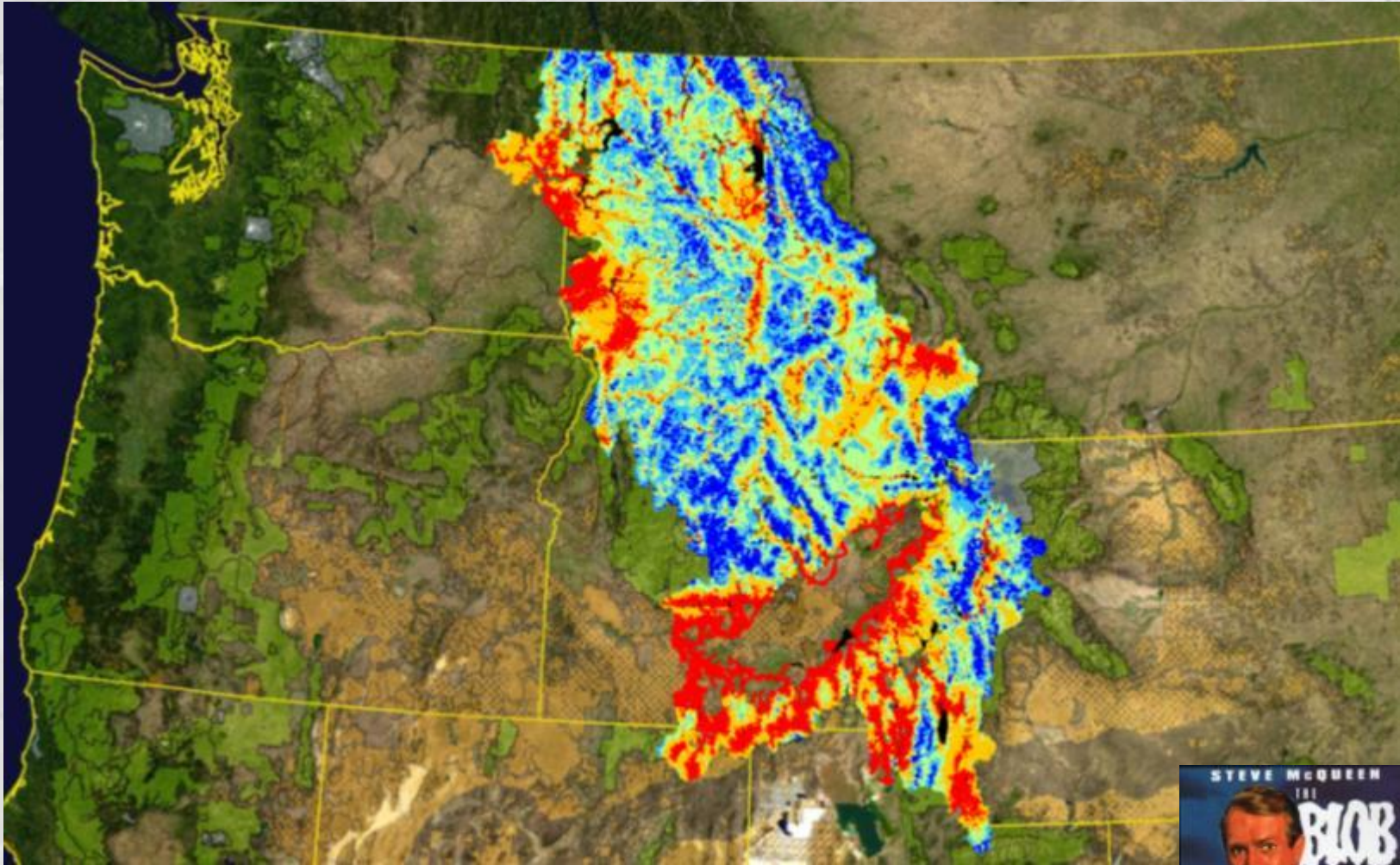
1. Elevation (m)
2. Canopy (%)
3. Stream slope (%)
4. Ave Precipitation (mm)
5. Latitude (km)
6. Lakes upstream (%)
7. Baseflow Index
8. Watershed size (km<sup>2</sup>)

## Climate Predictors

9. Discharge (m<sup>3</sup>/s)  
**USGS gage data**
10. Air Temperature (°C)  
**RegCM<sub>3</sub> NCEP reanalysis**  
**Hostetler et al. 2011**



# Stream Thermalscape so far...

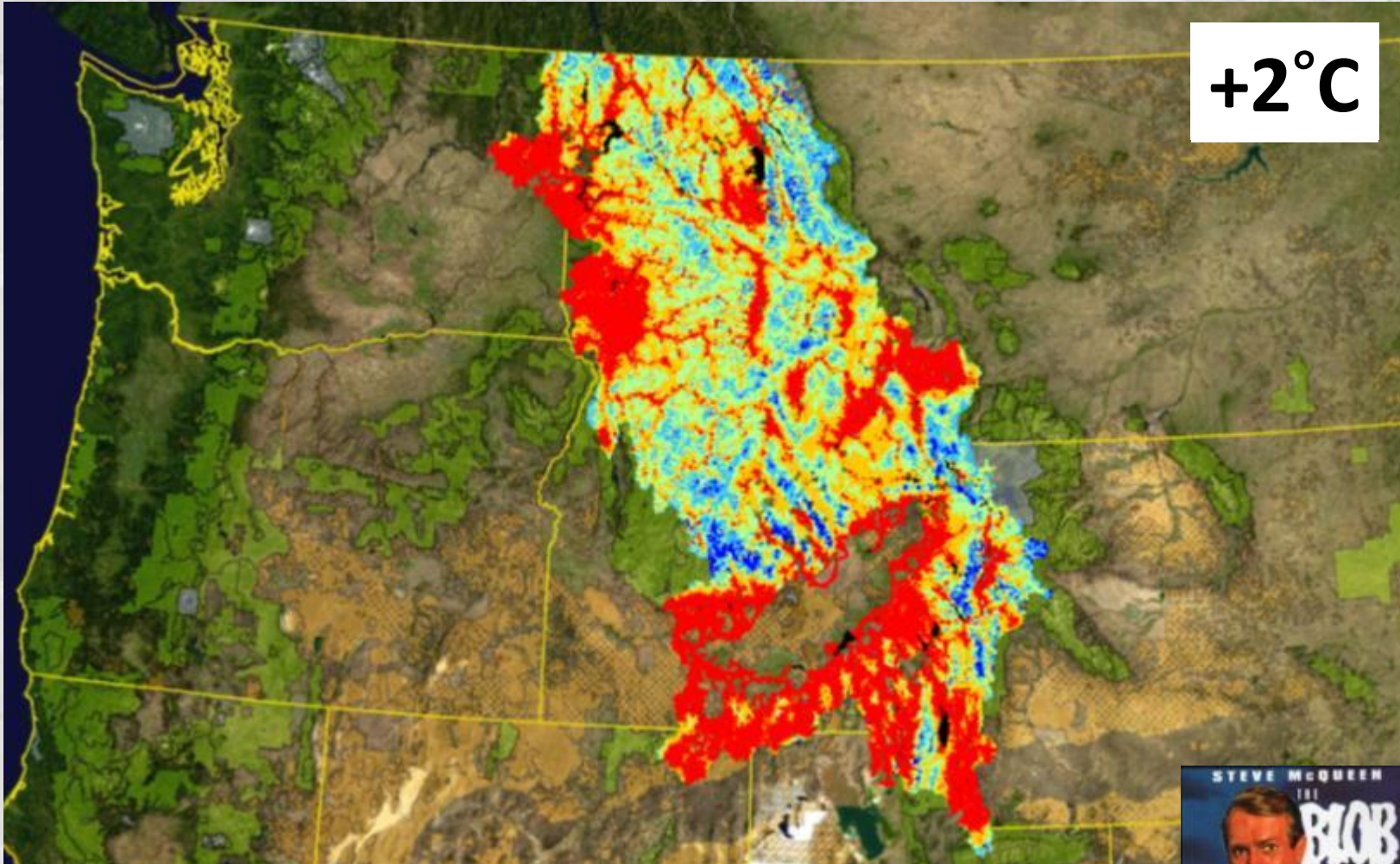


**The BLOB... it just keeps growing...**

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



# Stream Thermalscape so far...

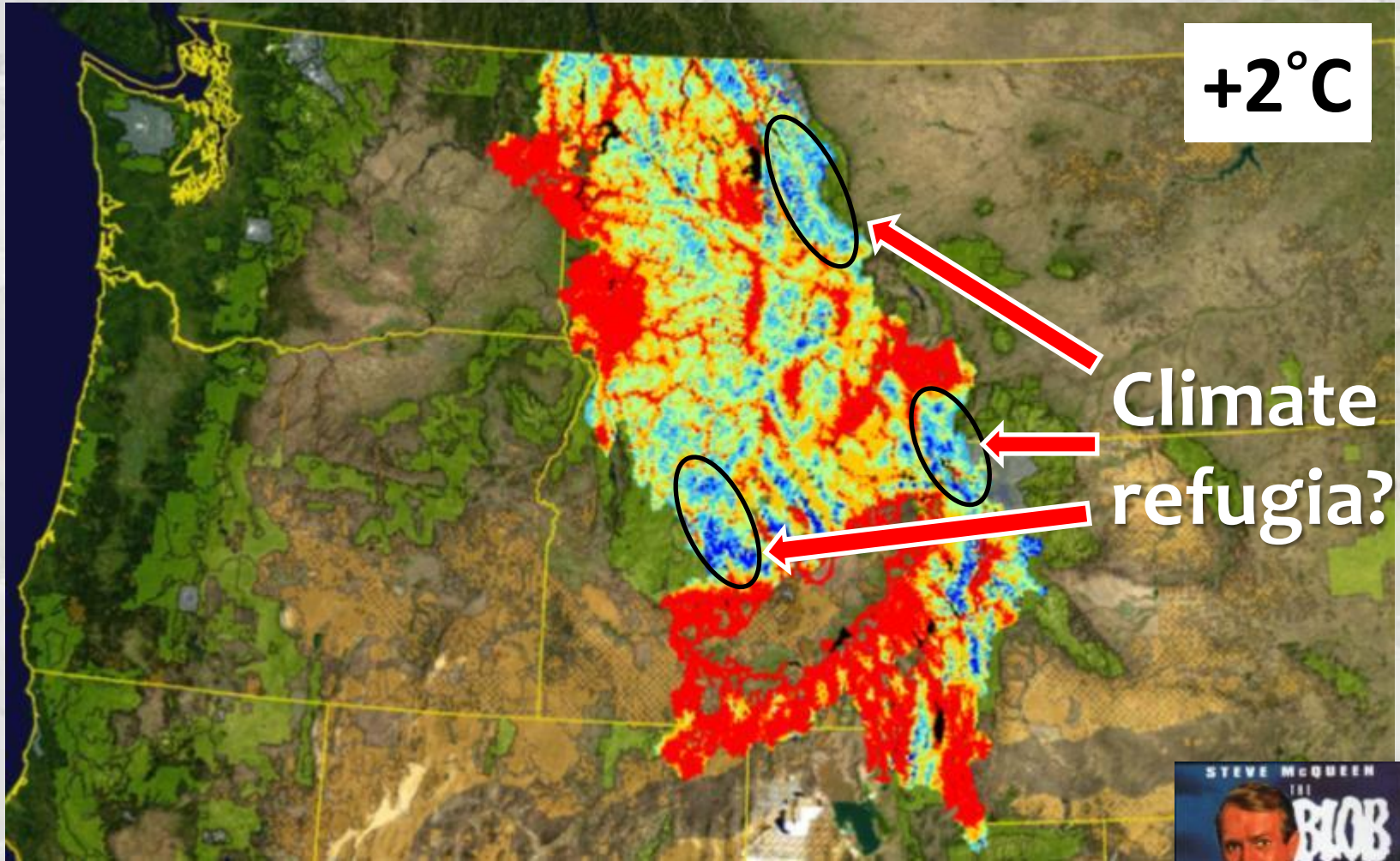


**The BLOB... it just keeps growing...**

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# Stream Thermalscape so far...



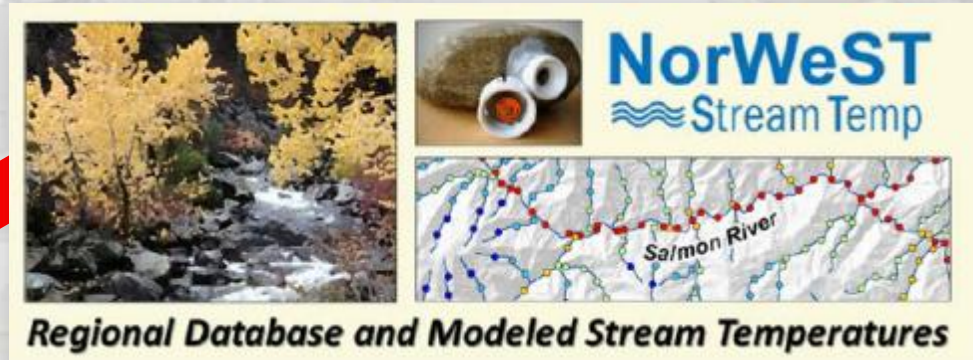
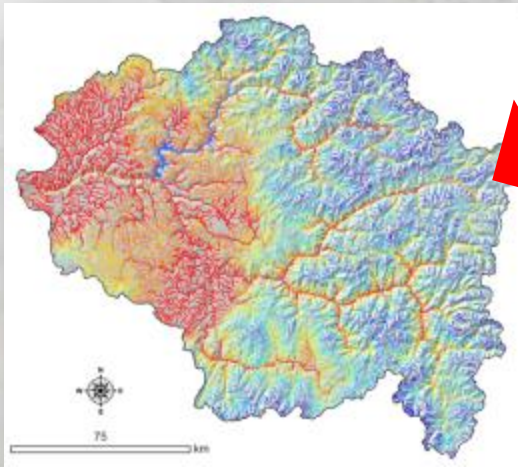
**The BLOB... it just keeps growing...**

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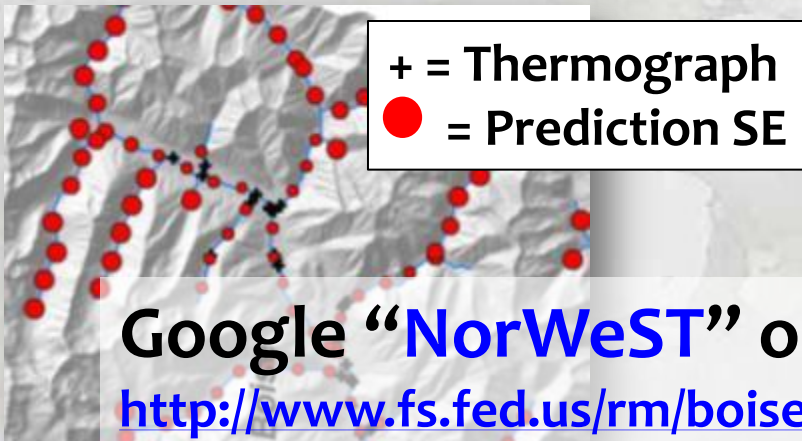


# Website Provides Easy Data Access

1) GIS shapefiles of stream temperature scenarios



2) GIS shapefiles of stream temperature model prediction precision



3) Temperature data summaries

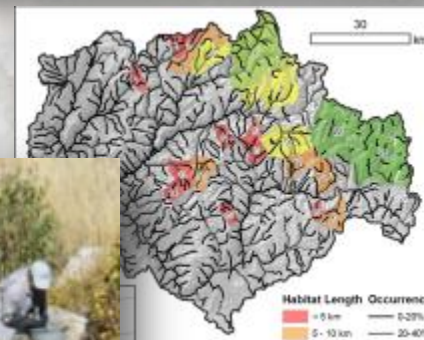


Google **NorWeST** or go here...

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

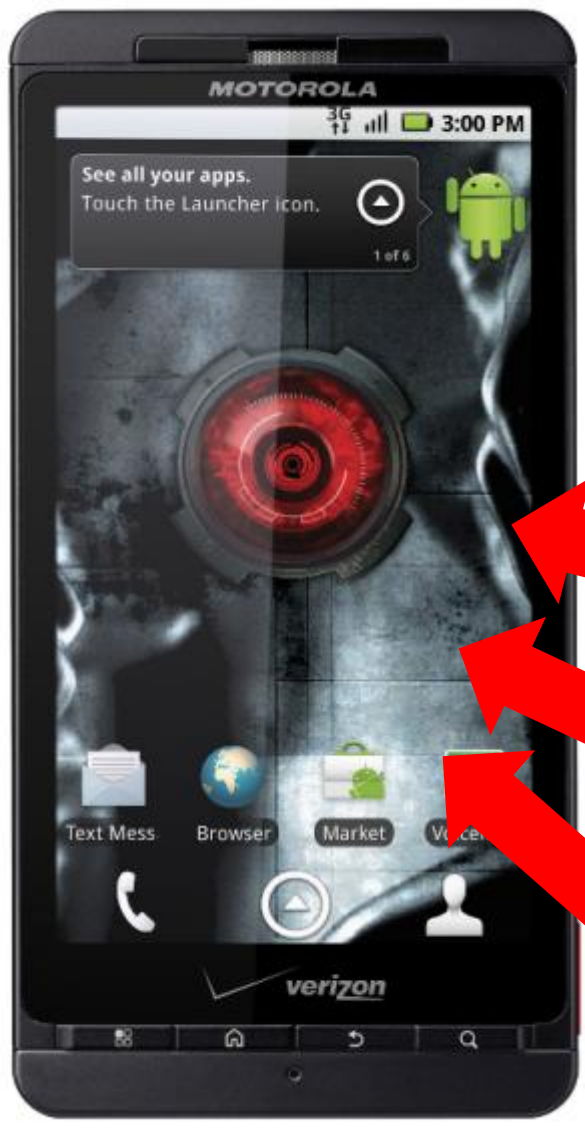
# NorWeST Facilitating Related Projects

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

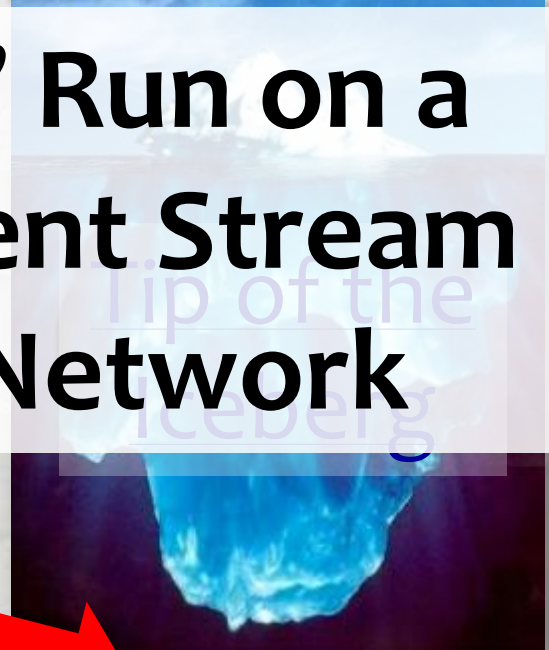


# NorWeST Facilitating Related Projects

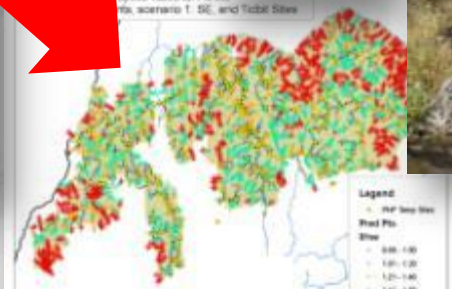
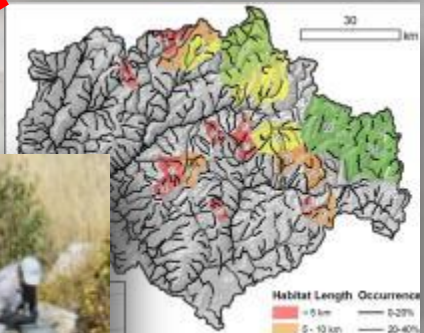
“Apps” Run on a  
Consistent Stream  
Data Network



ate vulnerability  
- USGS  
climate decision  
et al. 2015 - IWS)  
out mon  
09)



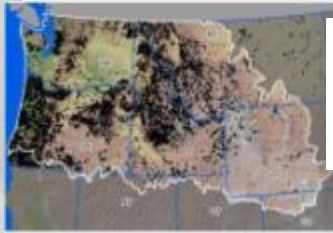
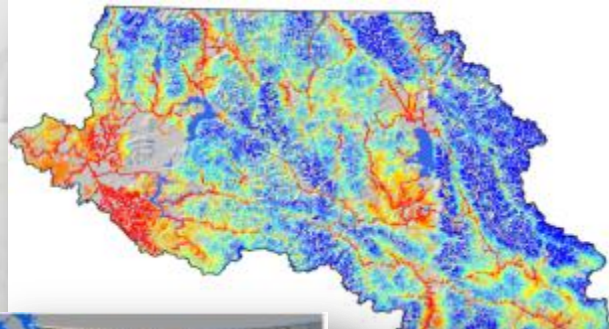
Definitions &  
ic mod  
(S. Wenger - TU)





# BIG fish DATA for Regionally Consistent Thermal Habitat Definitions

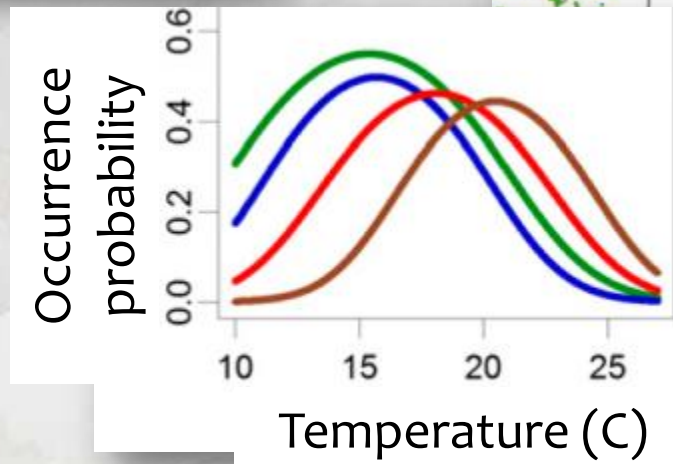
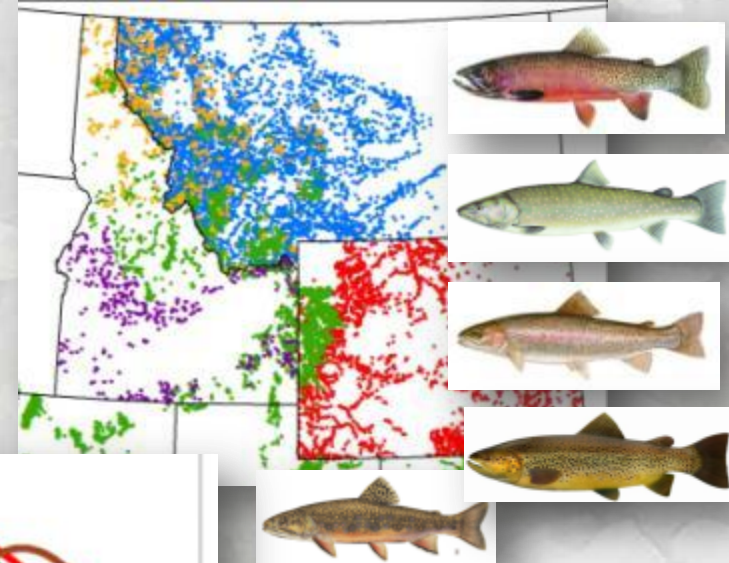
Stream temperature maps



**NorWeST**  
Stream Temp



Regional fish survey databases (n ~ 30,000)

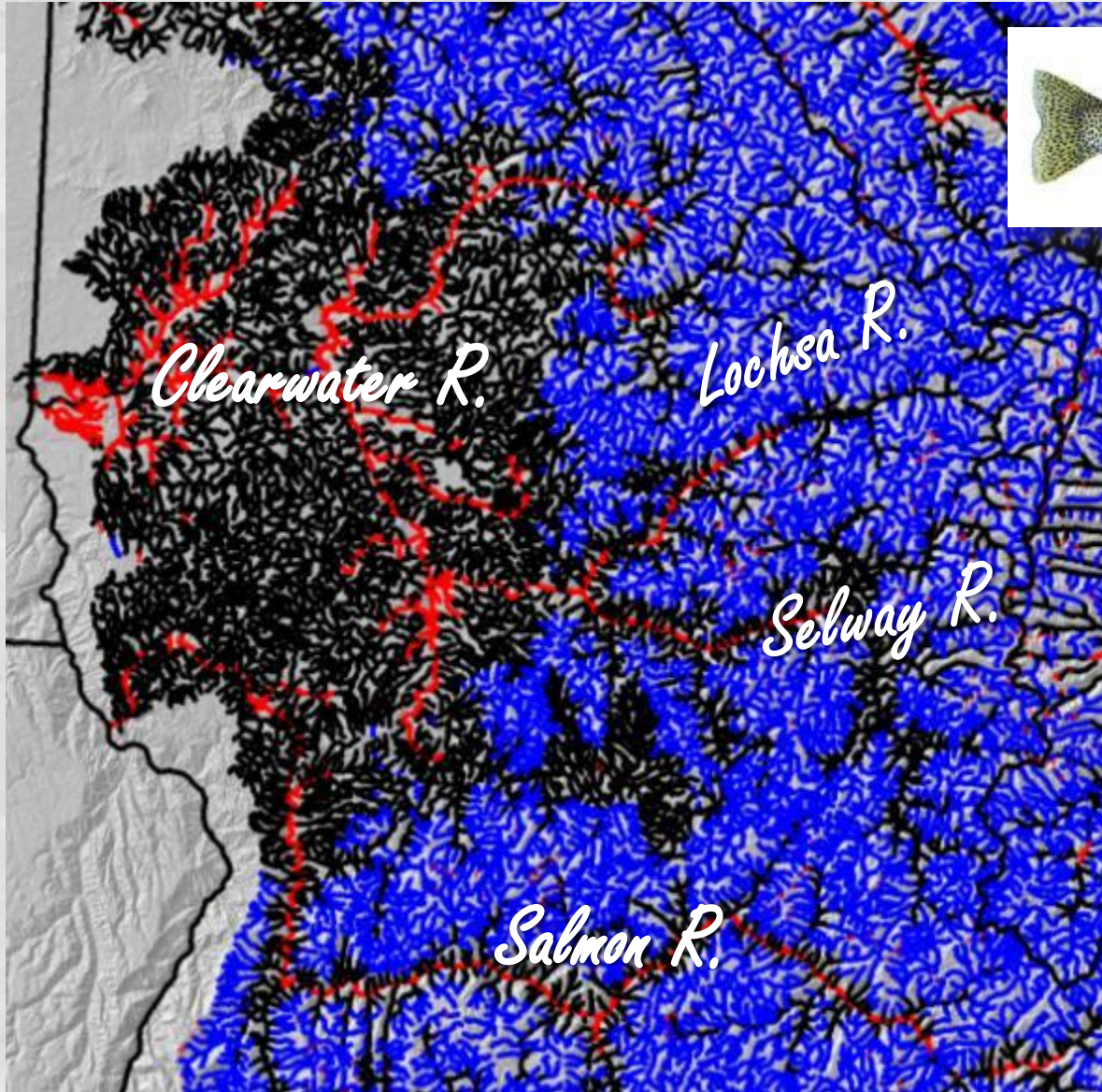





Wenger et al. 2011a. *PNAS* **108**:14175-14180

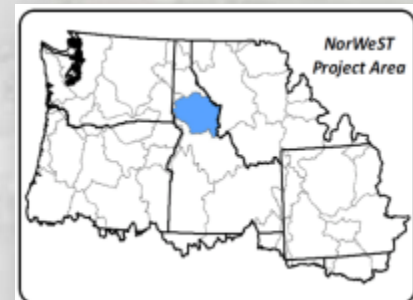
Wenger et al. 2011b. *CJFAS* **68**:988-1008; Wenger et al., *In Preparation*

# Risk Varies by Species & Landscape Position

## Historic (1993-2011 Average August)

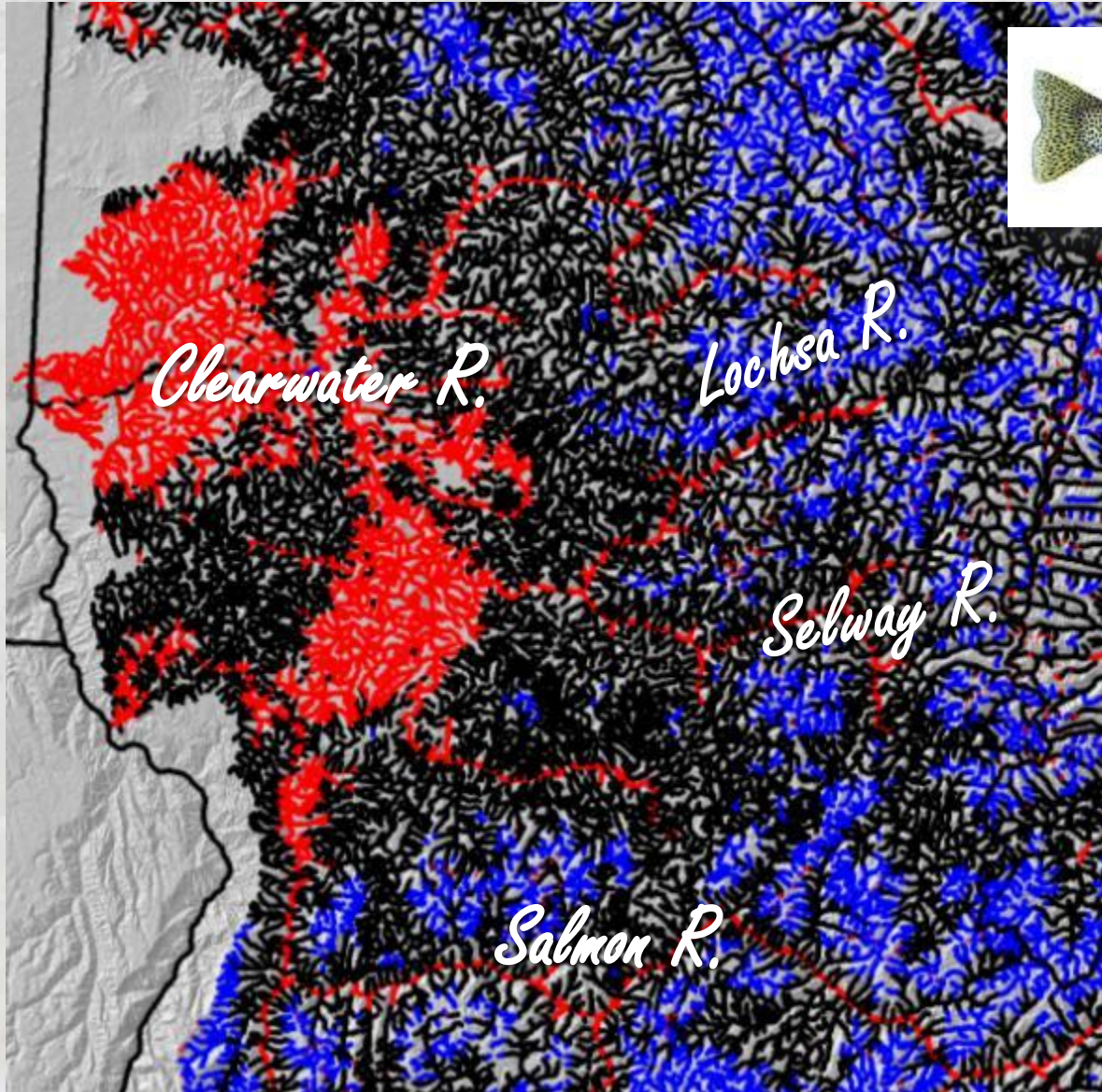




-  Suitable
-  Too Hot
-  Too Cold

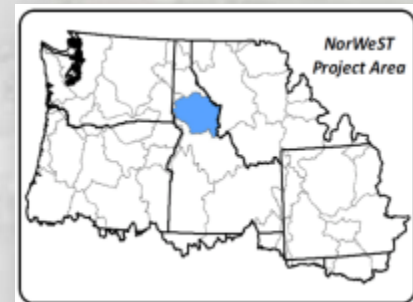


# Risk Varies by Species & Landscape Position

## +2.00°C Stream Temp (~2080s)

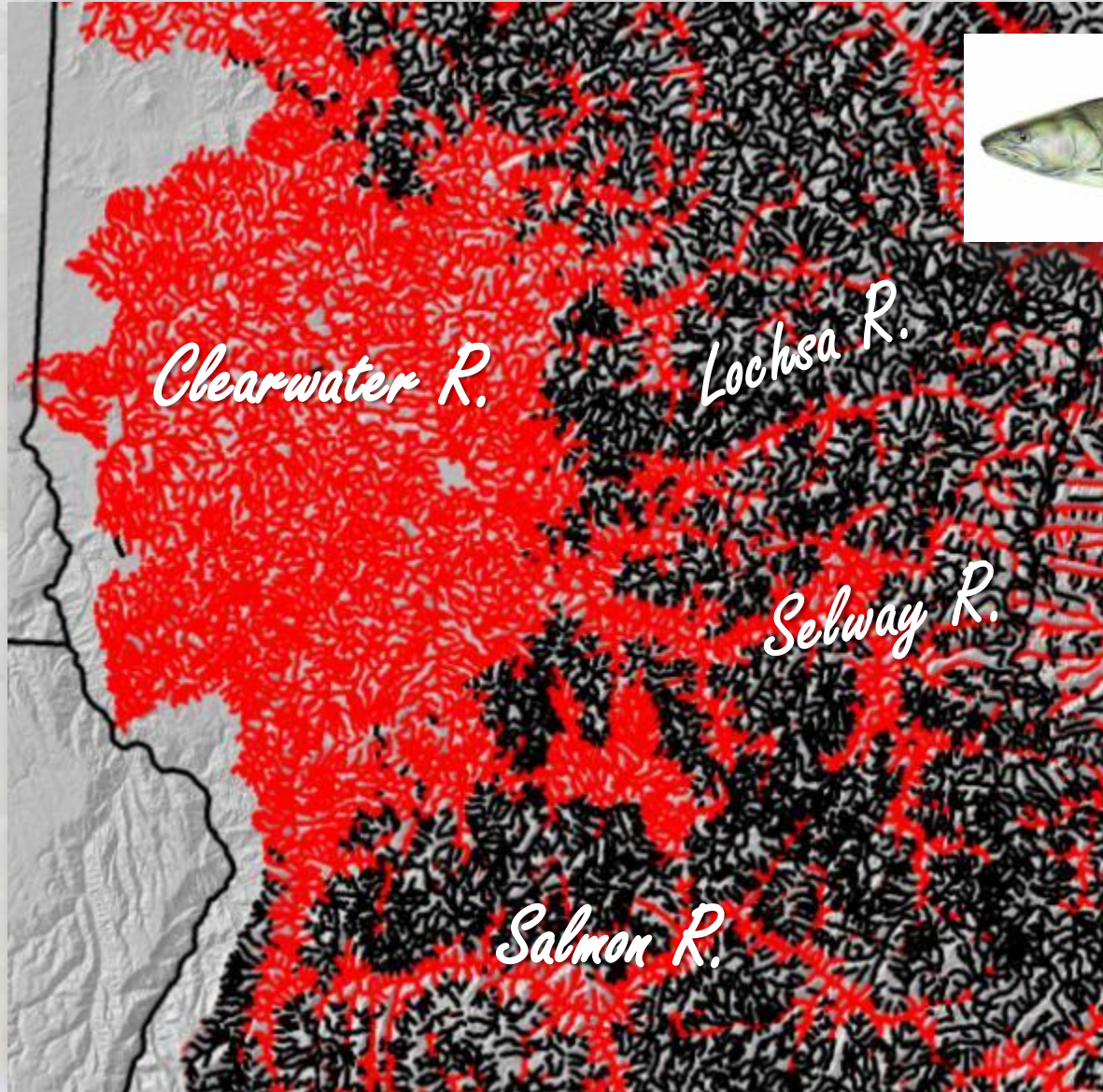


-  Suitable
-  Too Hot
-  Too Cold



# Risk Varies by Species & Landscape Position

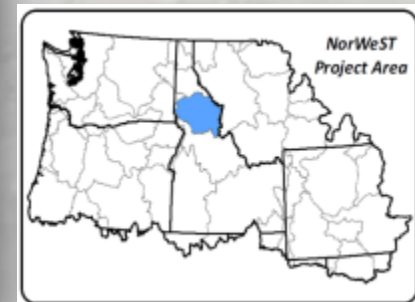
## Historic (1993-2011 Average August)



11.0°C Isotherm

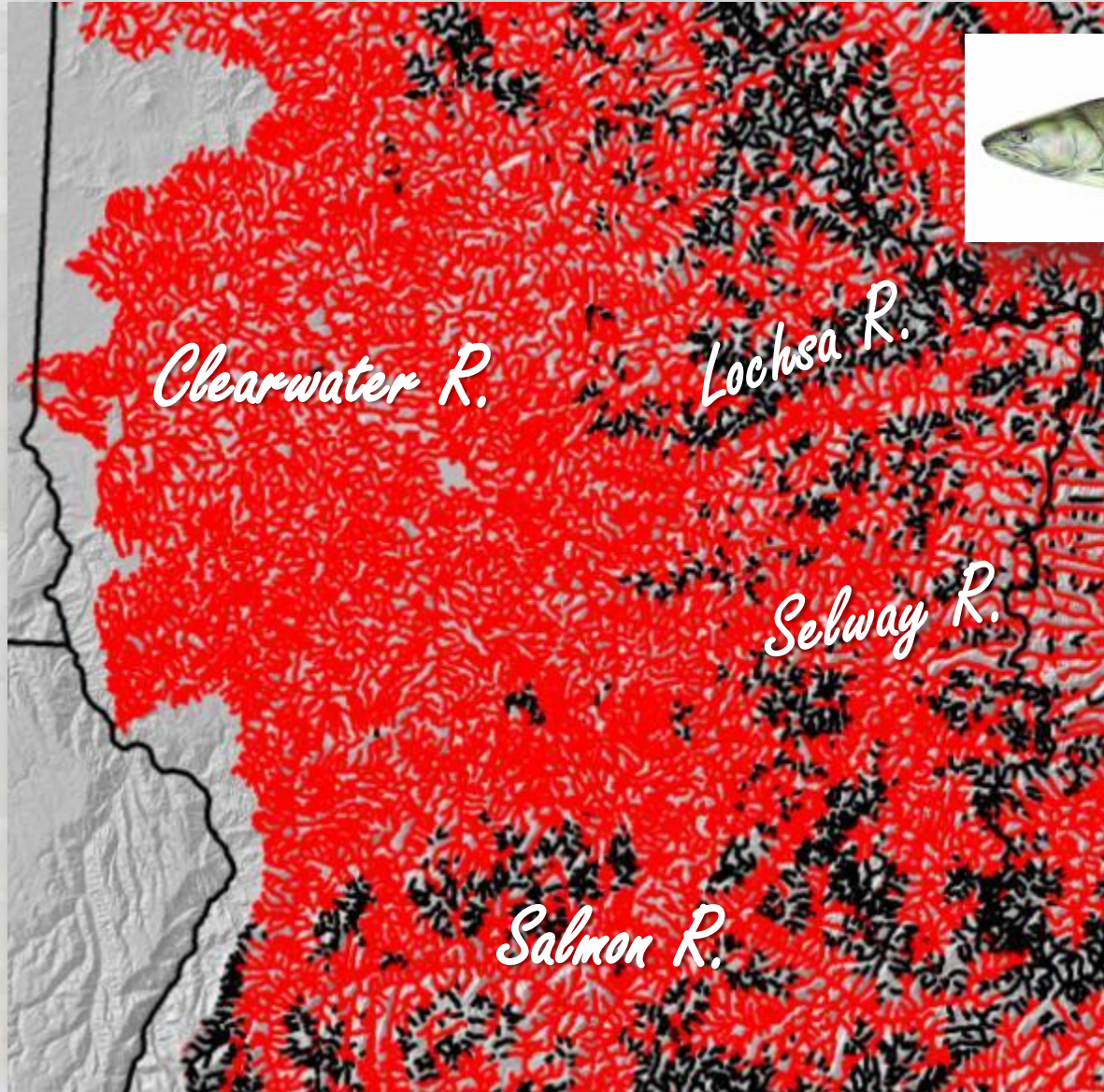
■ Suitable

■ Unsuitable



# Risk Varies by Species & Landscape Position

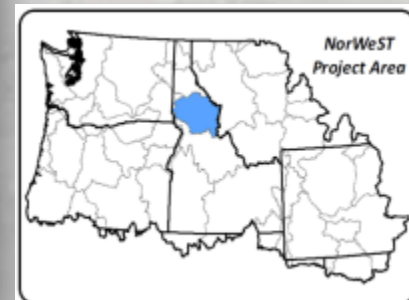
## +2.00°C Stream Temp (~2080s)



11.0°C Isotherm

■ Suitable

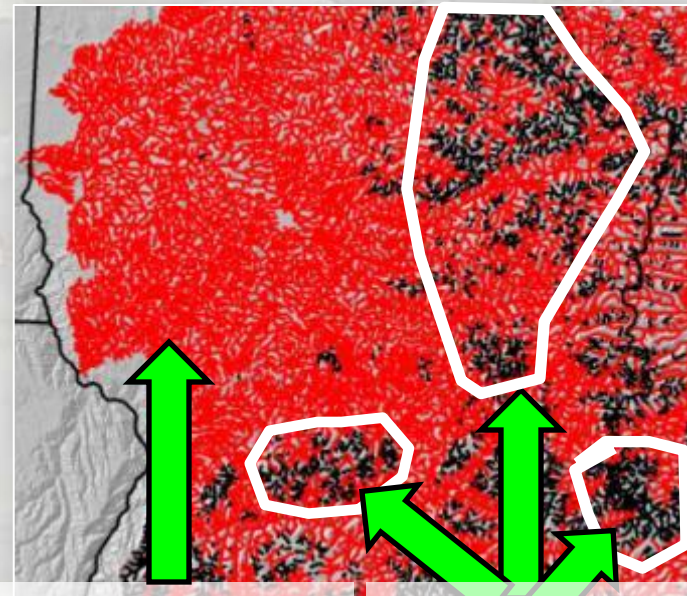
■ Unsuitable



# Climate-Smart Strategic Prioritization of 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...

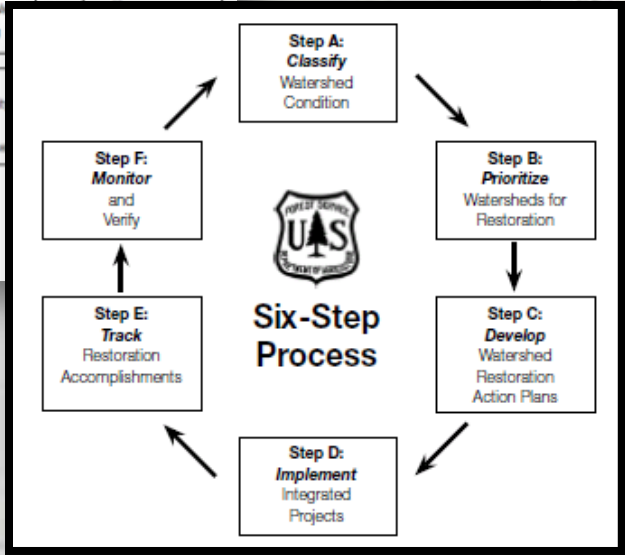
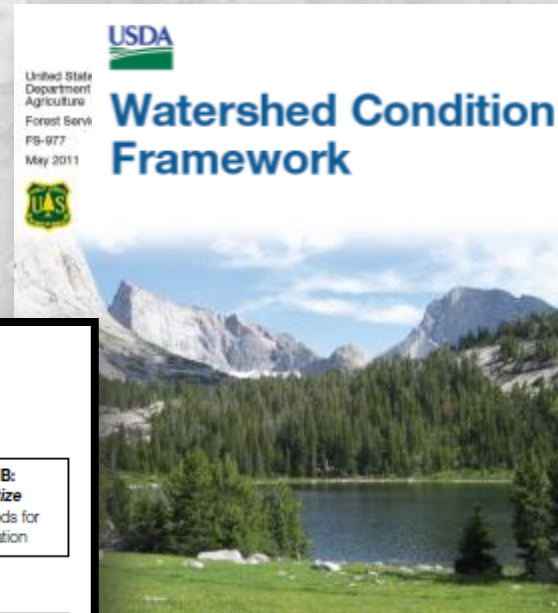
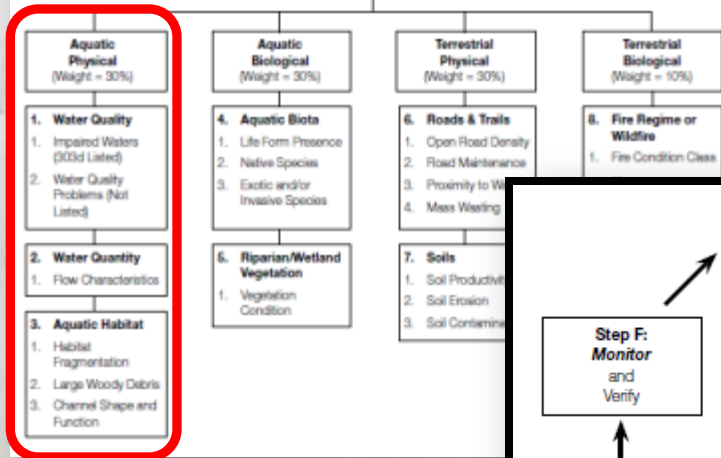


Low  
Priority

High  
Priority

# Integration with Land-management Planning is Beginning...

## Watershed Condition Indicators



Forest Plan Revisions

 United States Department of Agriculture  
 Forest Service  
 Northern Region  
 March 2007

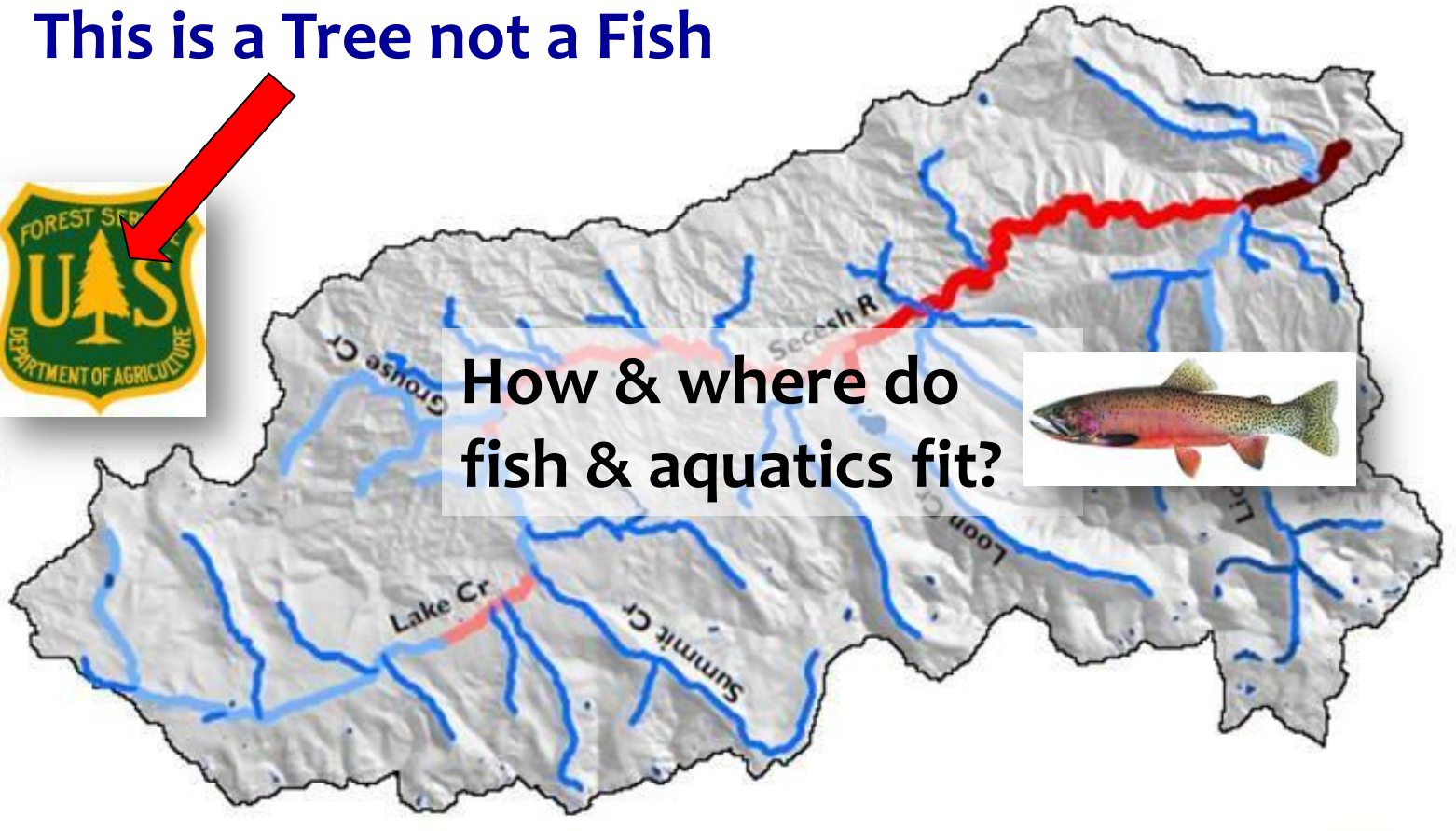
Proposed  
**Land Management Plan**  
**Clearwater National Forest**

# Continuous Maps of Aquatic Resource Priority Areas Could Facilitate Integrated Landscape Management

**This is a Tree not a Fish**

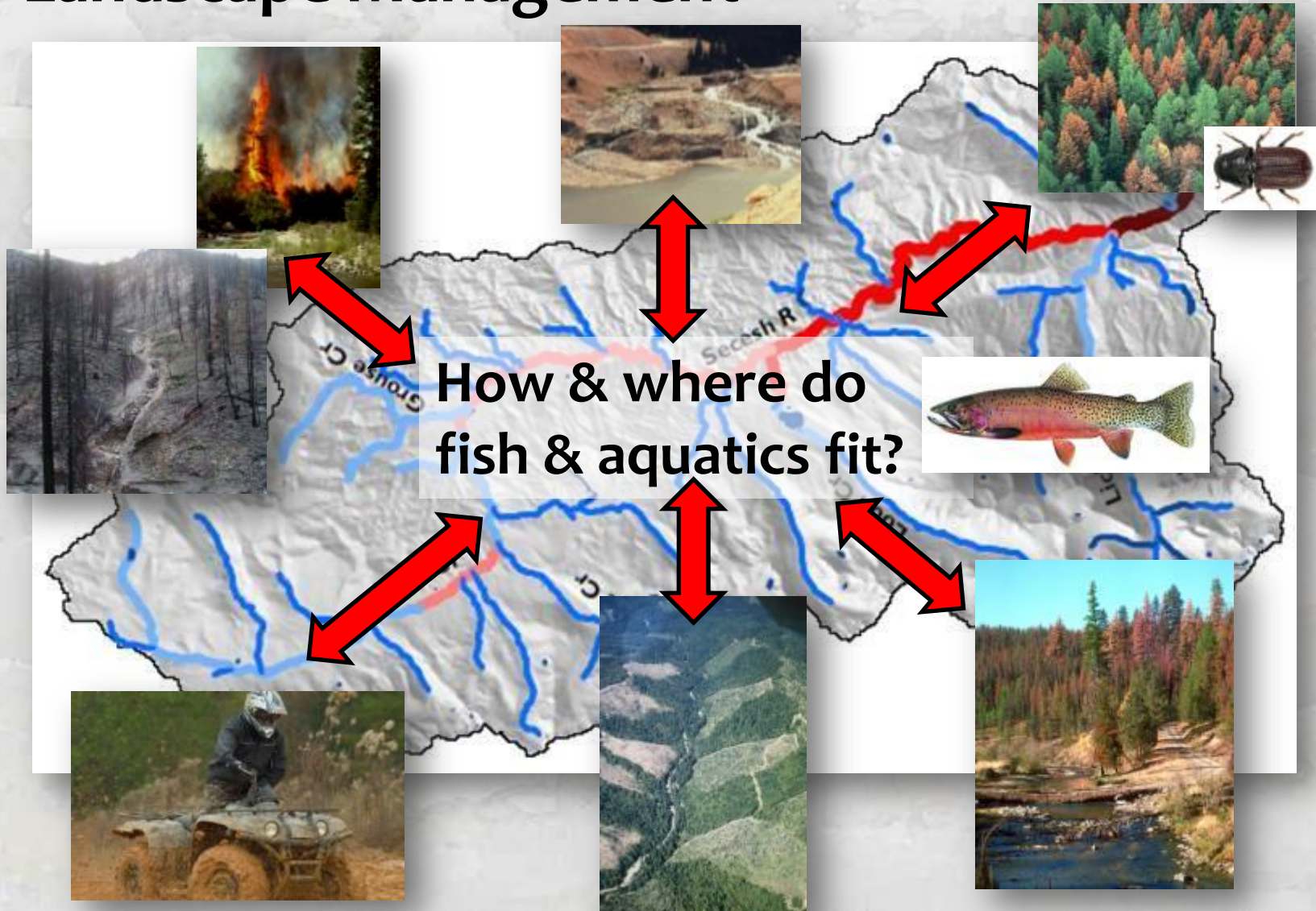


**How & where do fish & aquatics fit?**

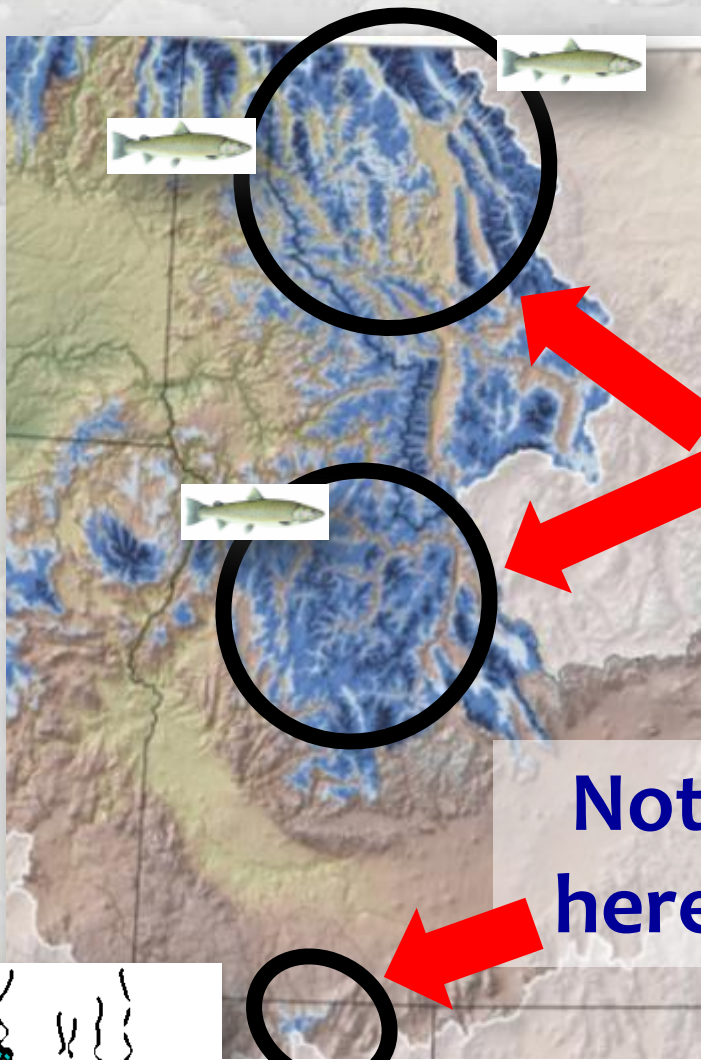




# Continuous Maps of Aquatic Resource Priority Areas Could Facilitate Integrated Landscape Management



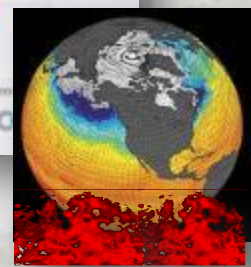
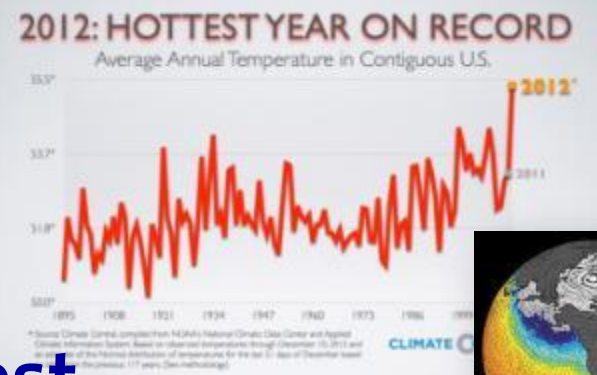
# Good Information, Shared Broadly, Should Enable Good Community Decision Making



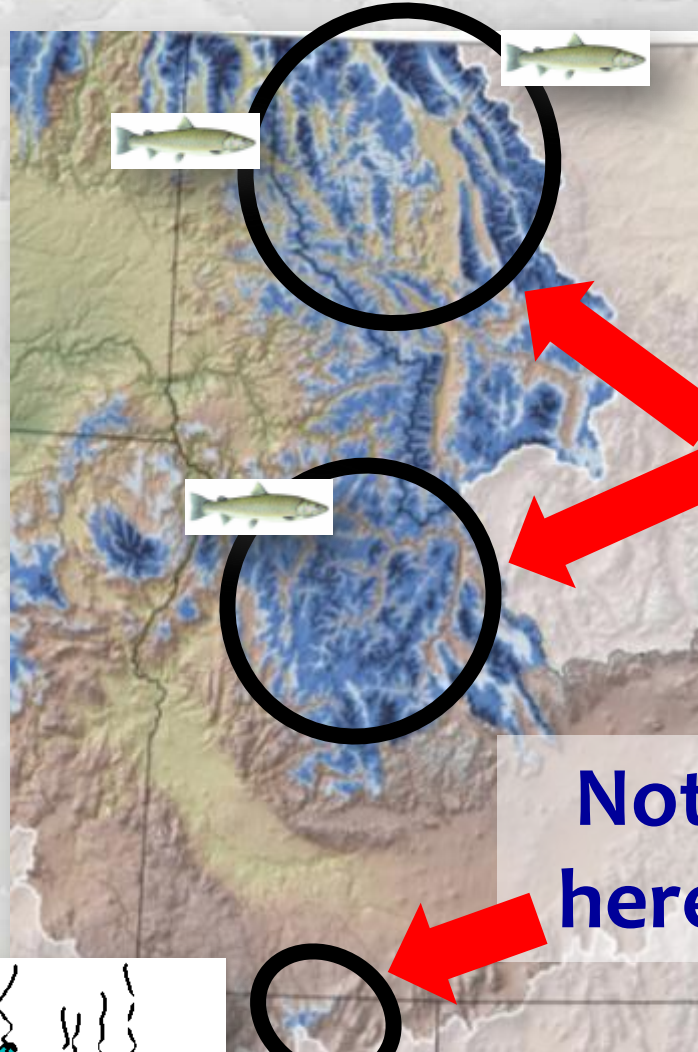
Invest Here

Not here

Sorry Charlie



# Developing Good Scientific Information is the Easy Part, butt...



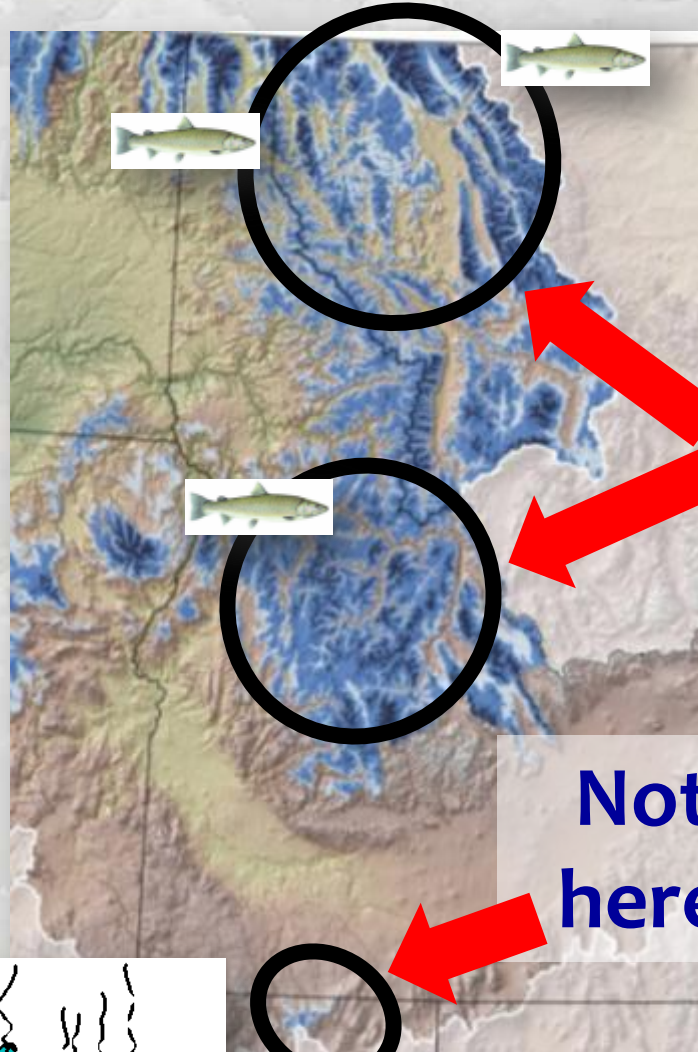
**Invest Here**

**Not here**

**Sorry Charlie**



# Developing Good Scientific Information is the Easy Part, butt...



**Invest Here**

**Not here**

**Sorry Charlie**

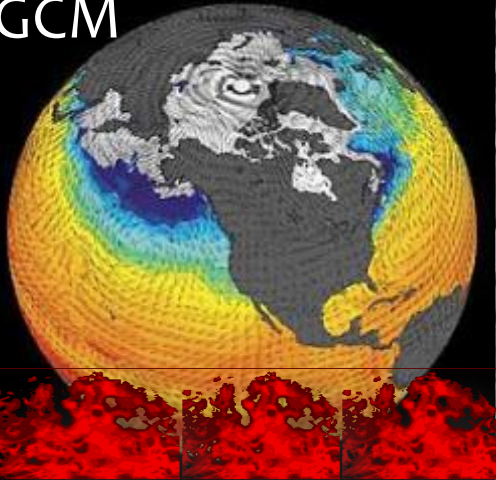


**... we're not dealing with rational creatures here**



# Building Consensus is Critical “Crowd-Sourcing” is an Important Tool

GCM



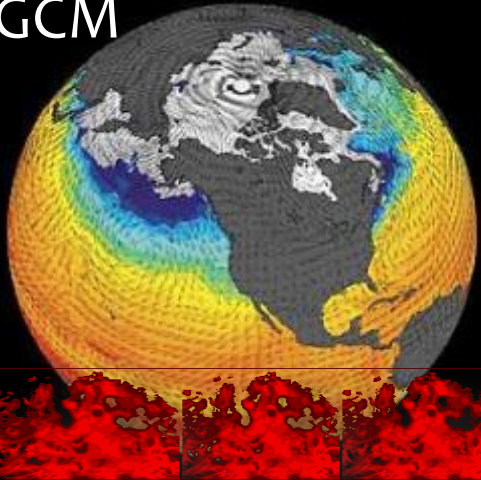
Management  
Decisions



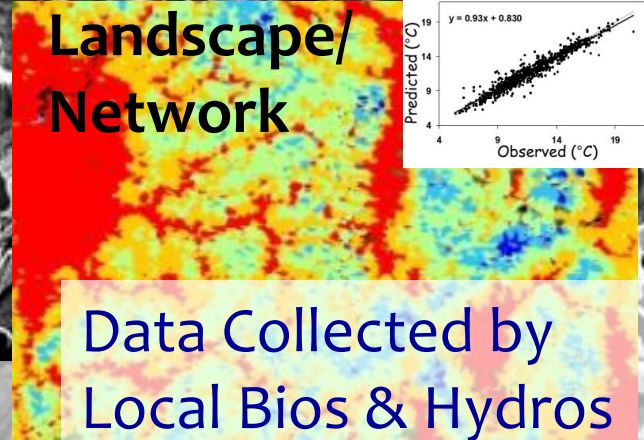
# Building Consensus is Critical

## “Crowd-Sourcing” is an Important Tool

GCM



Landscape/  
Network

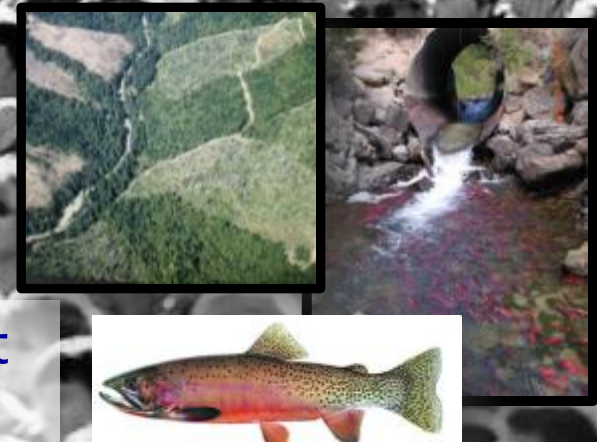


Coordinated  
Management  
Responses?

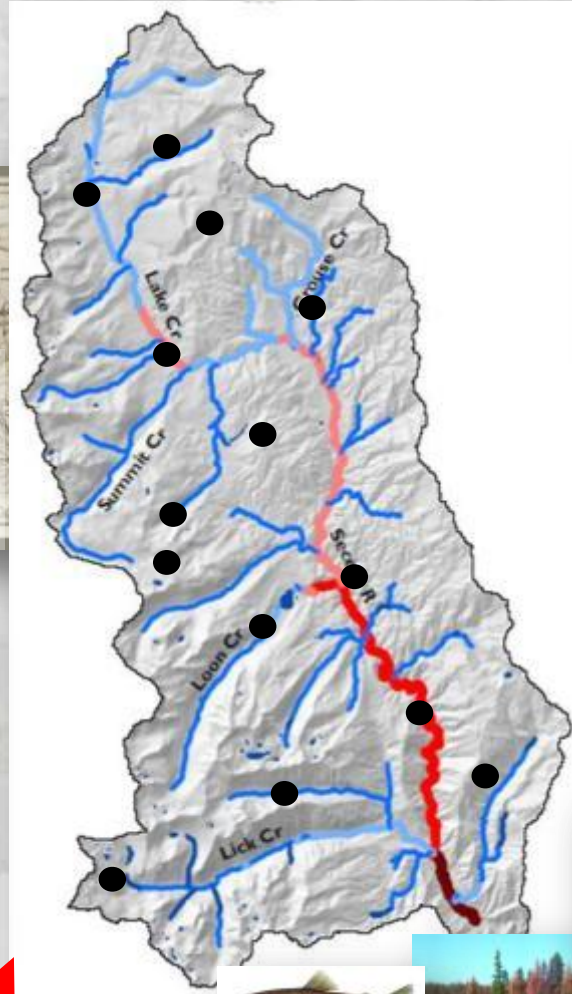
Data Collected by  
Local Bios & Hydros



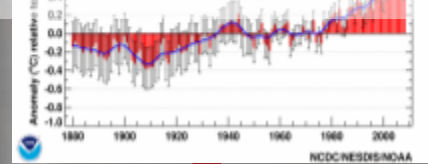
Management  
Decisions



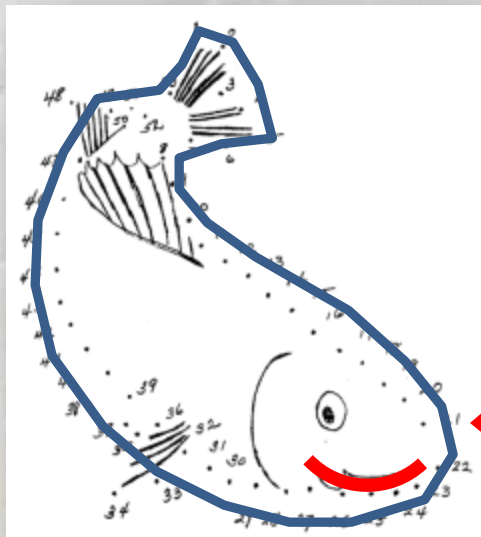
# Connect the Dots <sup>^</sup> to Map the Future & the People & the Agencies



## Climate Change

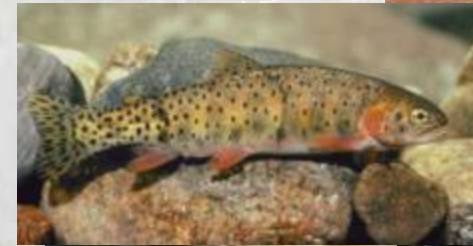
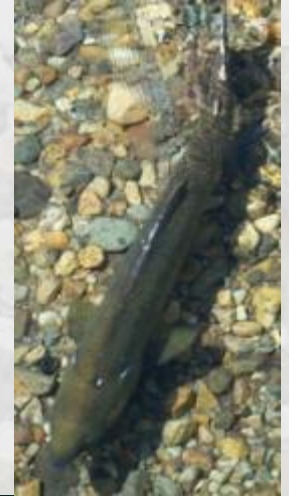
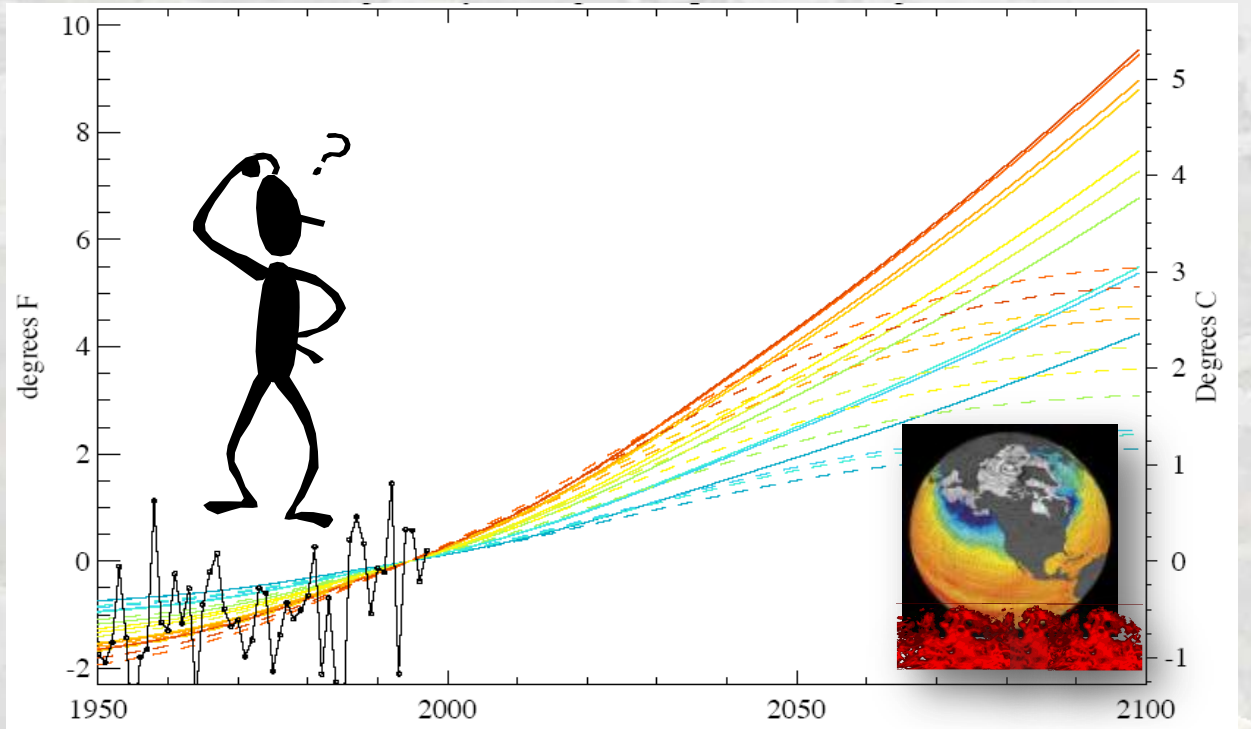


## Urbanization & Population Growth



## Land & Species Management

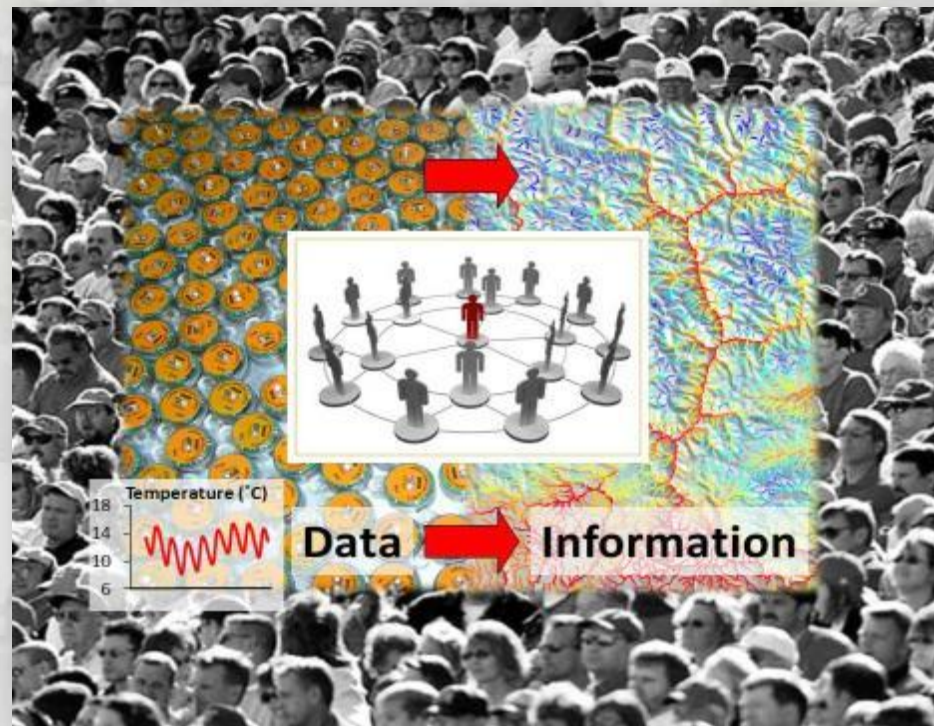
# The Sooner (& Smarter) We Act, The Bigger the Long-term Impact...







*stream*



# Crowd-Sourcing, Digital Media, & Building Social Networks for Landscape Conservation of Native Trouts in the Climate Change Era

Dan Isaak, US Forest Service  
Rocky Mountain Research Station  
[disaak@fs.fed.us](mailto:disaak@fs.fed.us); 208-373-4385

