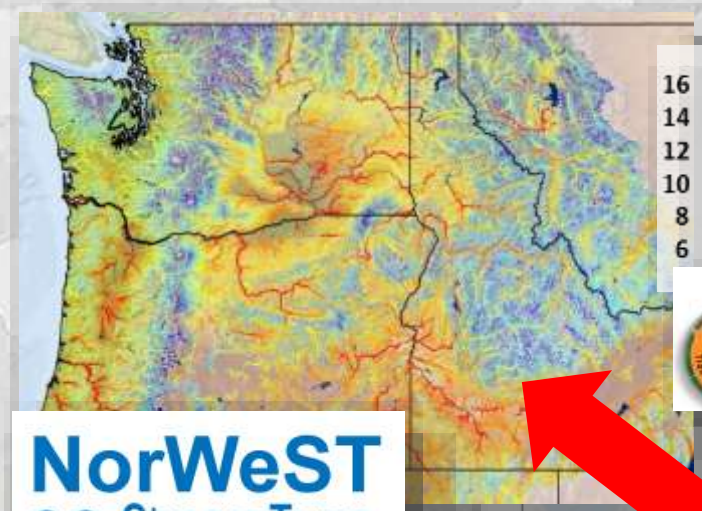
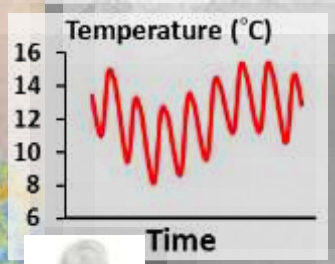
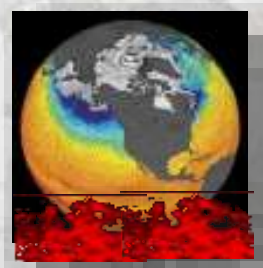
Recent Rapid Evolution of Stream Science in the Rockies

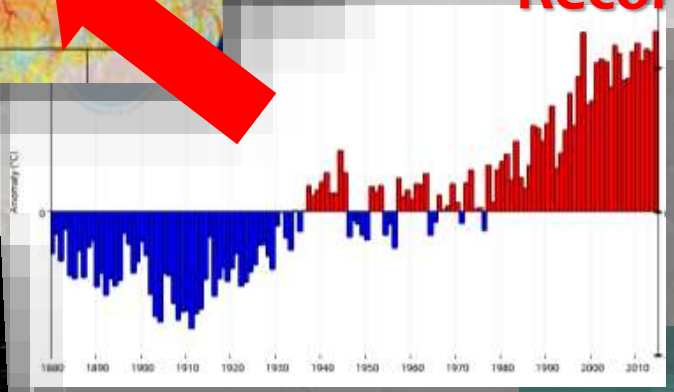


NorWeST
Stream Temp





2015 Set New Record

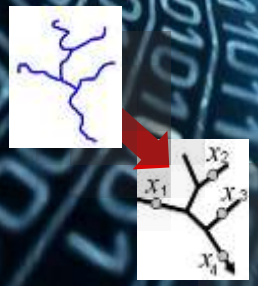


Strategically Consistent Information Across Broad Areas for Planning

Lands Administered by USFS

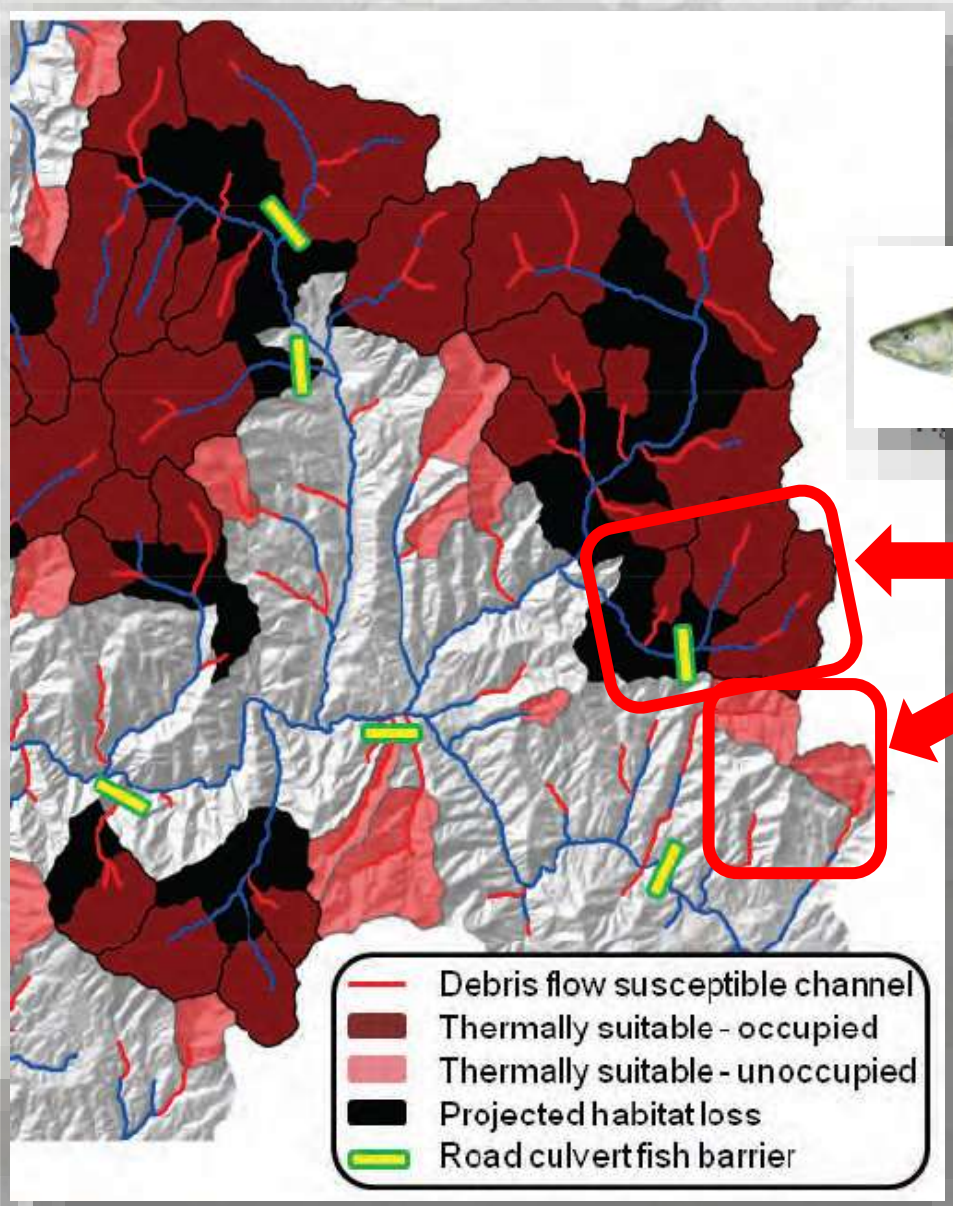
193 Million Acres
(10% of US)
155 National Forests
1,00,000 stream km

Diverse streams



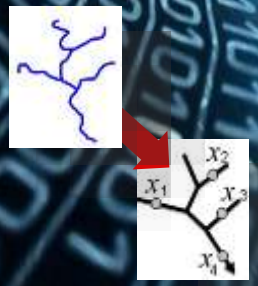
Remote landscapes

Tactically Precise Information for Local Decisions & Project Implementation



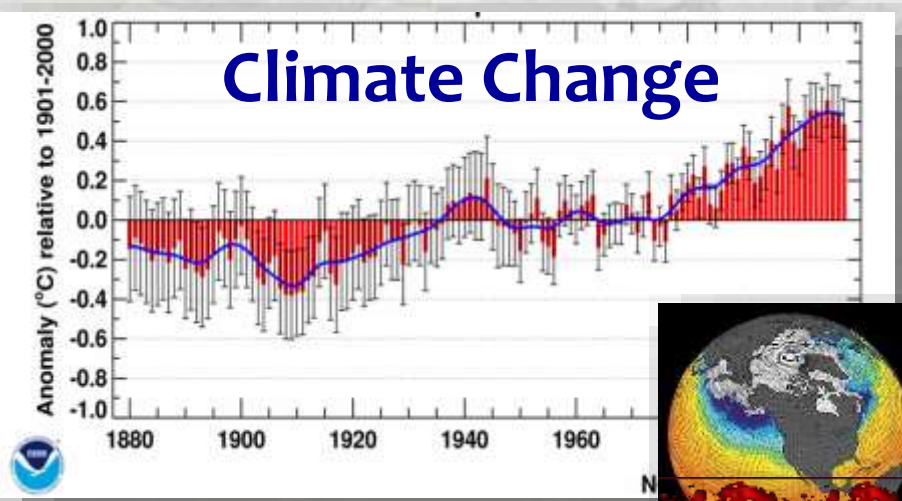
I'm going to invest here…

…instead of here



More Pressure, Fewer Resources

Climate Change



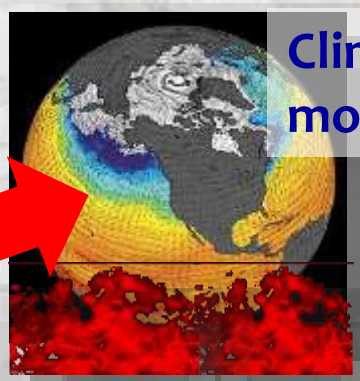
Urbanization & Population Growth

Shrinking Budgets

Need to do more with less

Technology Is a Force Multiplier

Remote Sensing



Climate models

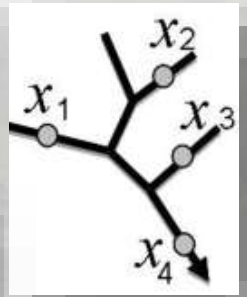
Visualization

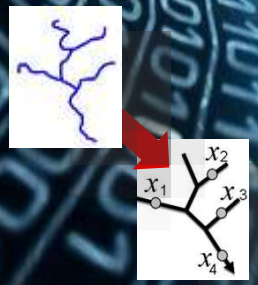
Miniature sensors

Nationally Geospatial Frameworks

DEMs

Spatial analyses

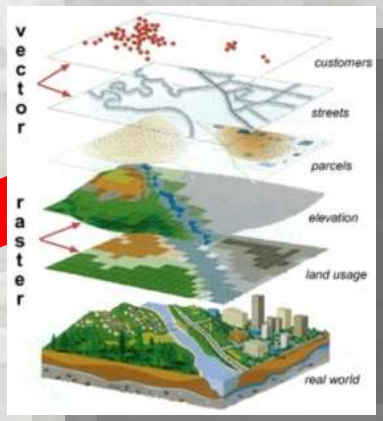




Specialized Science-Data Teams Required

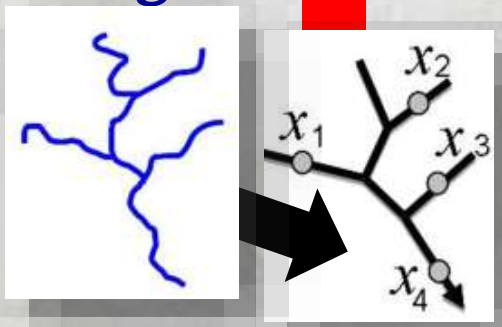
Managers

GIS analysts

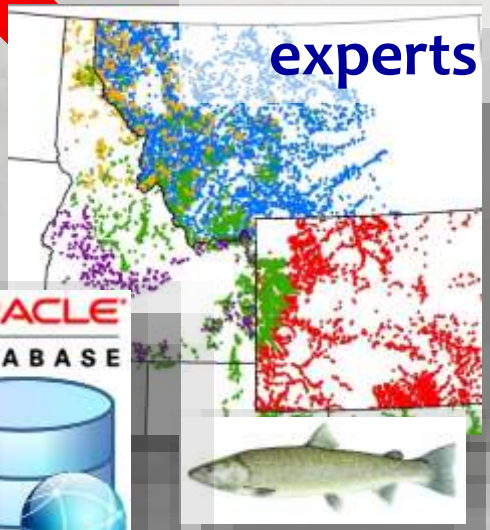


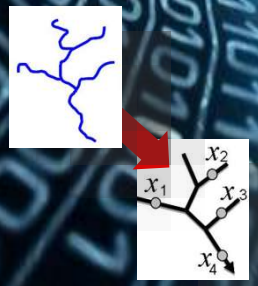
Scientists

Ecological Modelers



Database experts





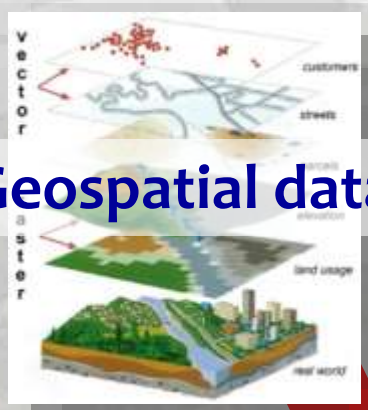
Technology Is a Force Multiplier

Information Dissemination & Adoption

Email chat & BLOGs

Workshops

Publication



Geospatial data

Webpages

Digitalmedia

Forest Plans

USDA United States Department of Agriculture

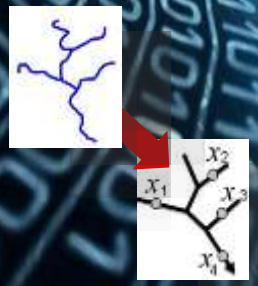
Forest Service

Northern Region

March 2007

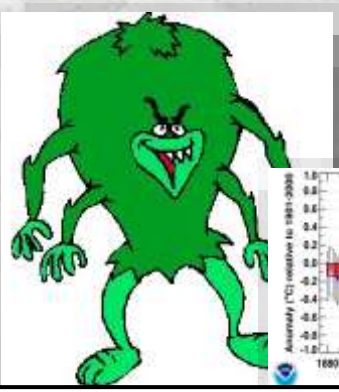
Land Management Plan

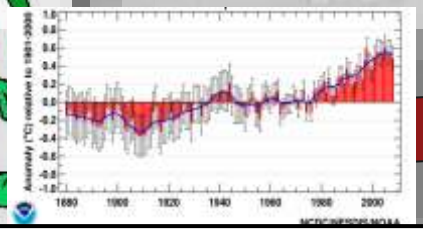
Clearwater National Forest



Climate = A Catalyst for Innovation

Climate Boogeyman





Recreational 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

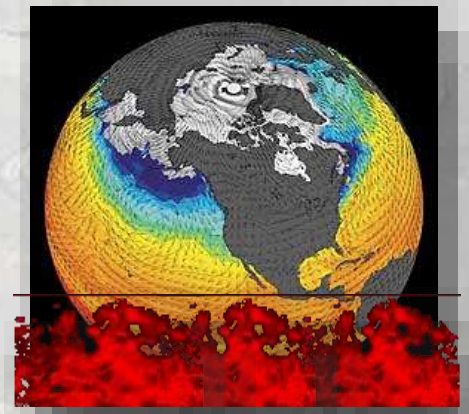
$4 Billion on Fish & Wildlife Recovery Efforts in PNW Since 1980 (ISAB/ISRP 2007)

ESA Listed Species

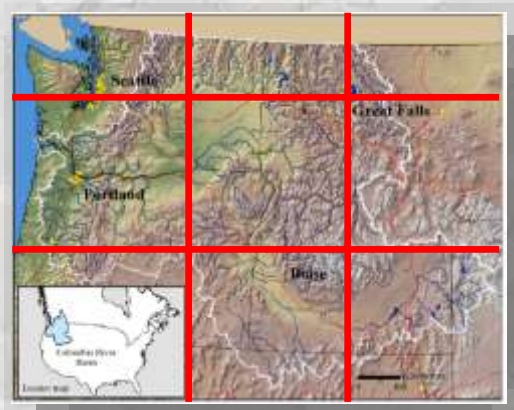
Land Use & Water Development

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

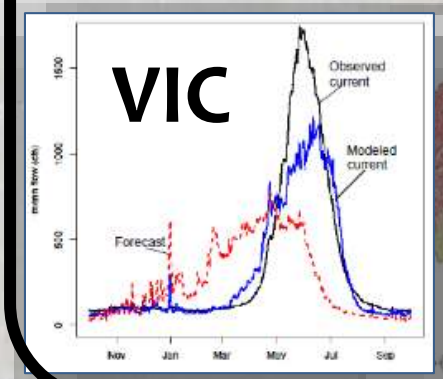
Global climate models
Resolution: 1000s of kilometers

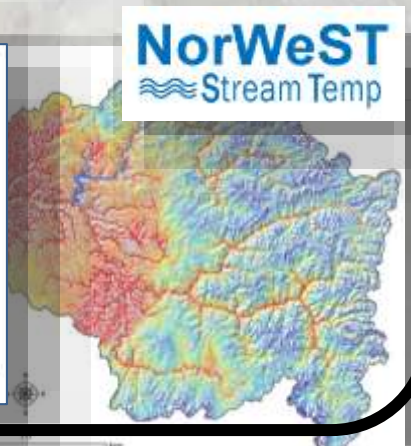


Regional patterns
Resolution: 10s kilometers

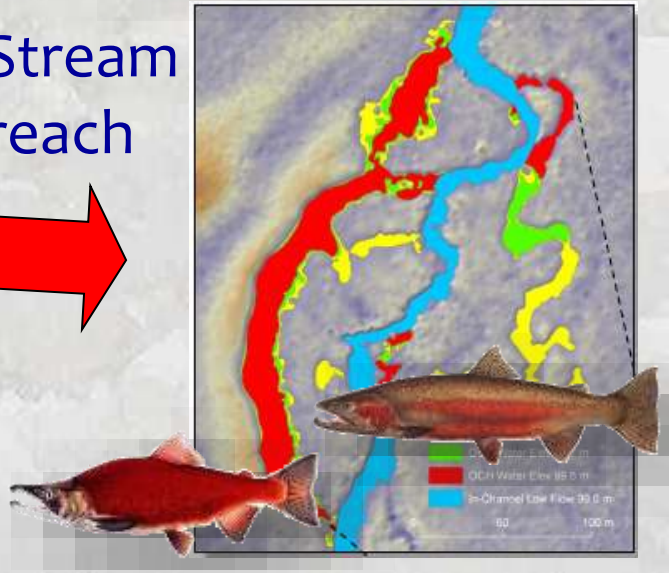


River network
temperature & flow



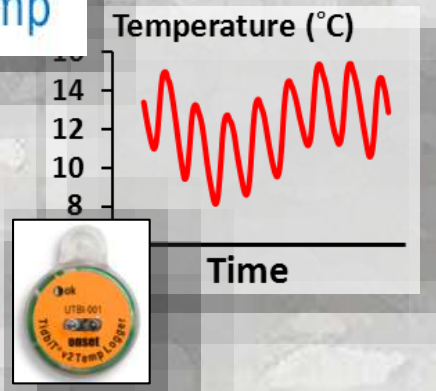


Stream reach



Step 1: Forge Disparate Data Into a Database

NorWeST Stream Temp



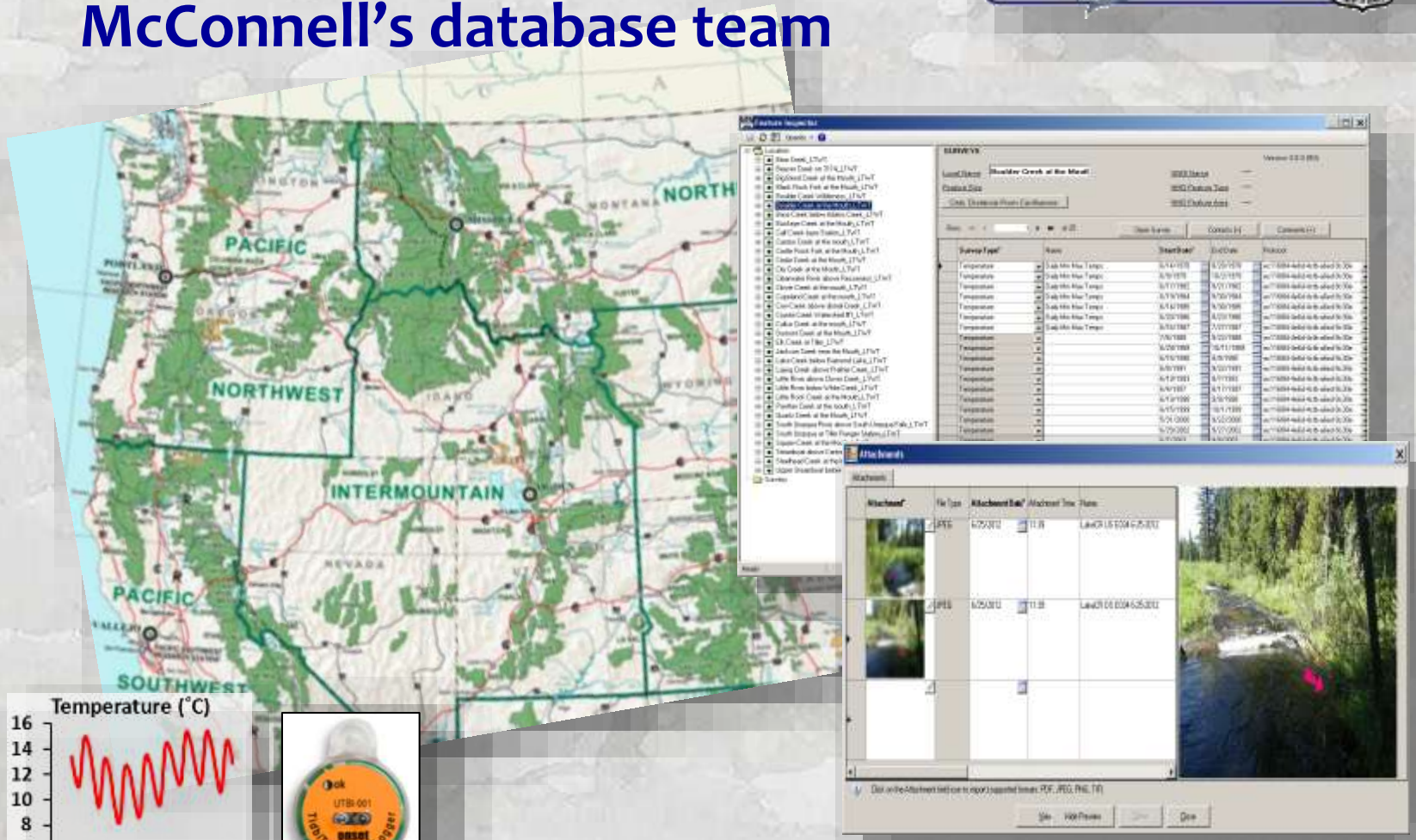
>100 agencies

>200,000,000 hourly records

>20,000 unique stream sites

Data Pulled/Uploaded From/To Aquatic Surveys Module in NRM

Close coordination with Callie McConnell's database team

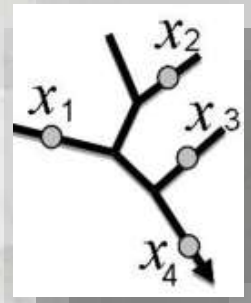


Step 2: Apply Data Mining Techniques

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 (km^2)
9. Glacier (%)

10. Discharge (m^3/s)
    USGS gage data
11. Air Temperature (˚C)
    RegCM3 NCEP reanalysis
    Hostetler et al. 2011



Ecological Applications **20**:1350-1370.

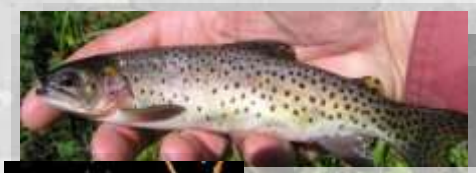
Mean August Temperature

Step 3: Map Interpolated Stream Scenarios

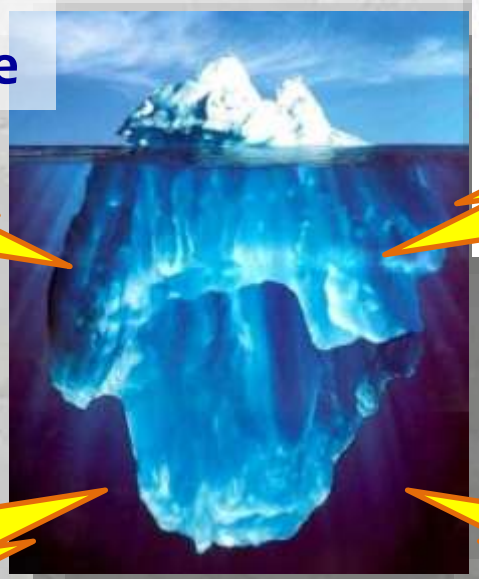
1-km resolution

>1,000,000 stream kilometers

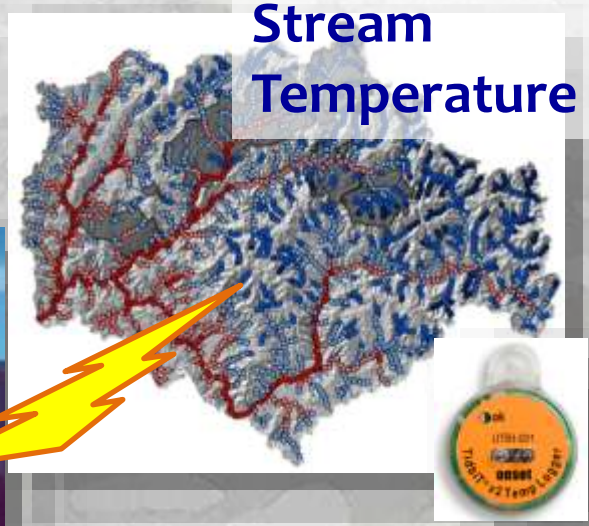
Same Possible for Many Things…



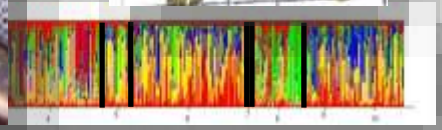
Distribution & abundance



Stream Temperature



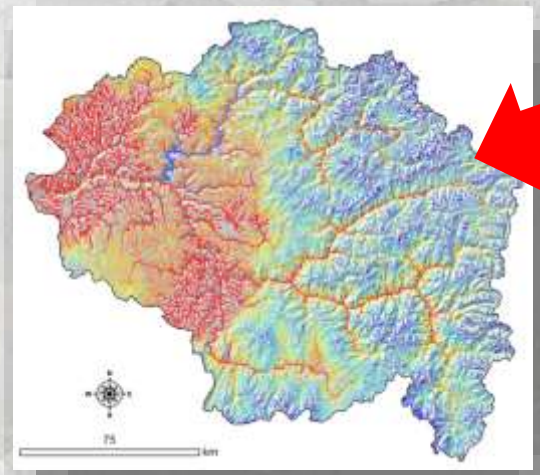
Genetic Attributes



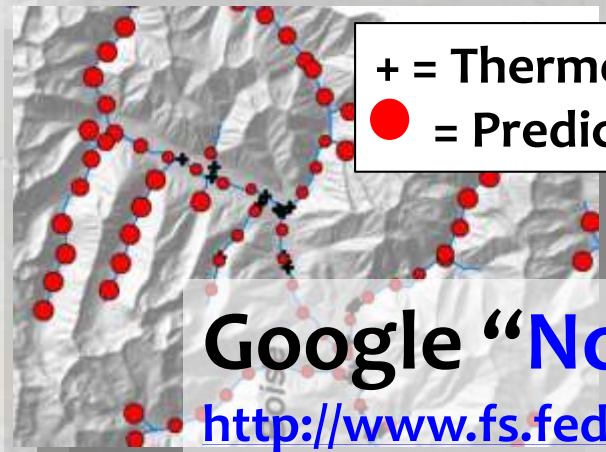
Water Quality Parameters

Step 4: Design Custom Website to Distribute Information in User-Friendly Digital Formats

1) GIS shapefiles of stream temperature scenarios



2) GIS shapefiles of stream temperature model prediction precision



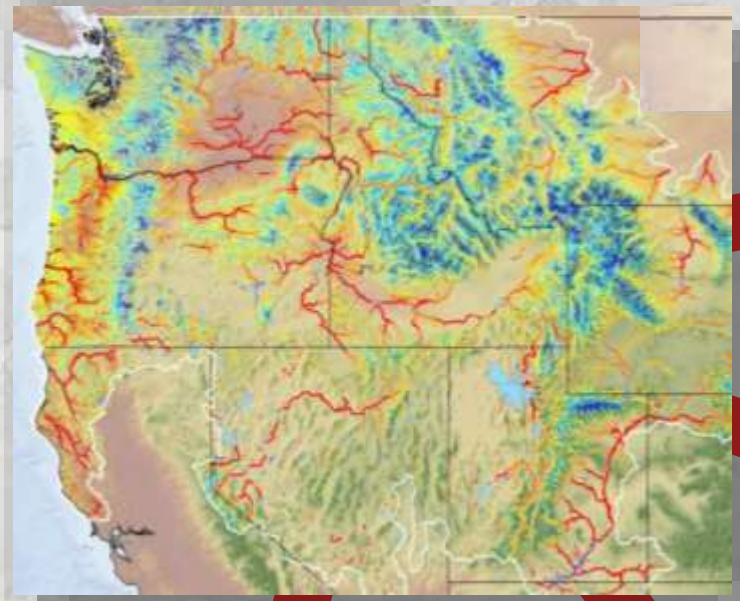
3) Temperature data summaries

Google "NorWeST" or go here…

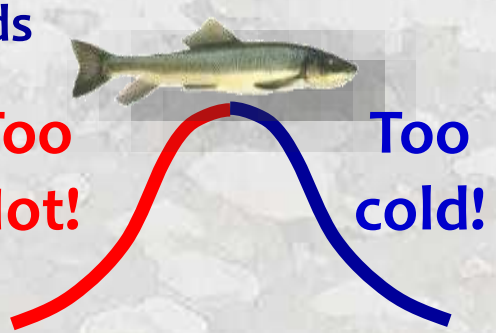
http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.shtml

NorWeST Stream Temp

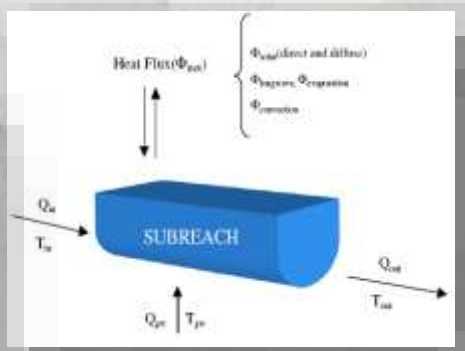
Temperature Applications



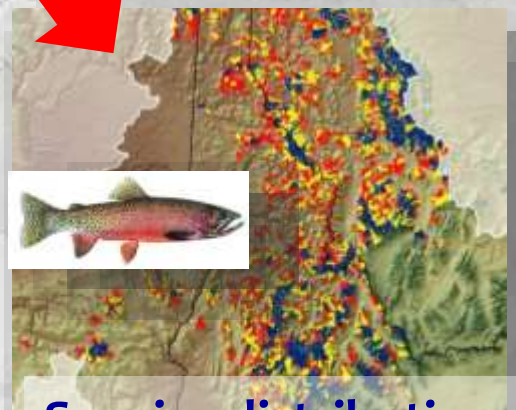
Regulatory temperature standards



Data access accelerates temperature research

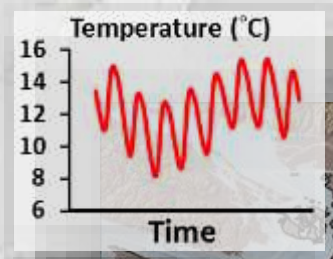


Coordinated Interagency monitoring



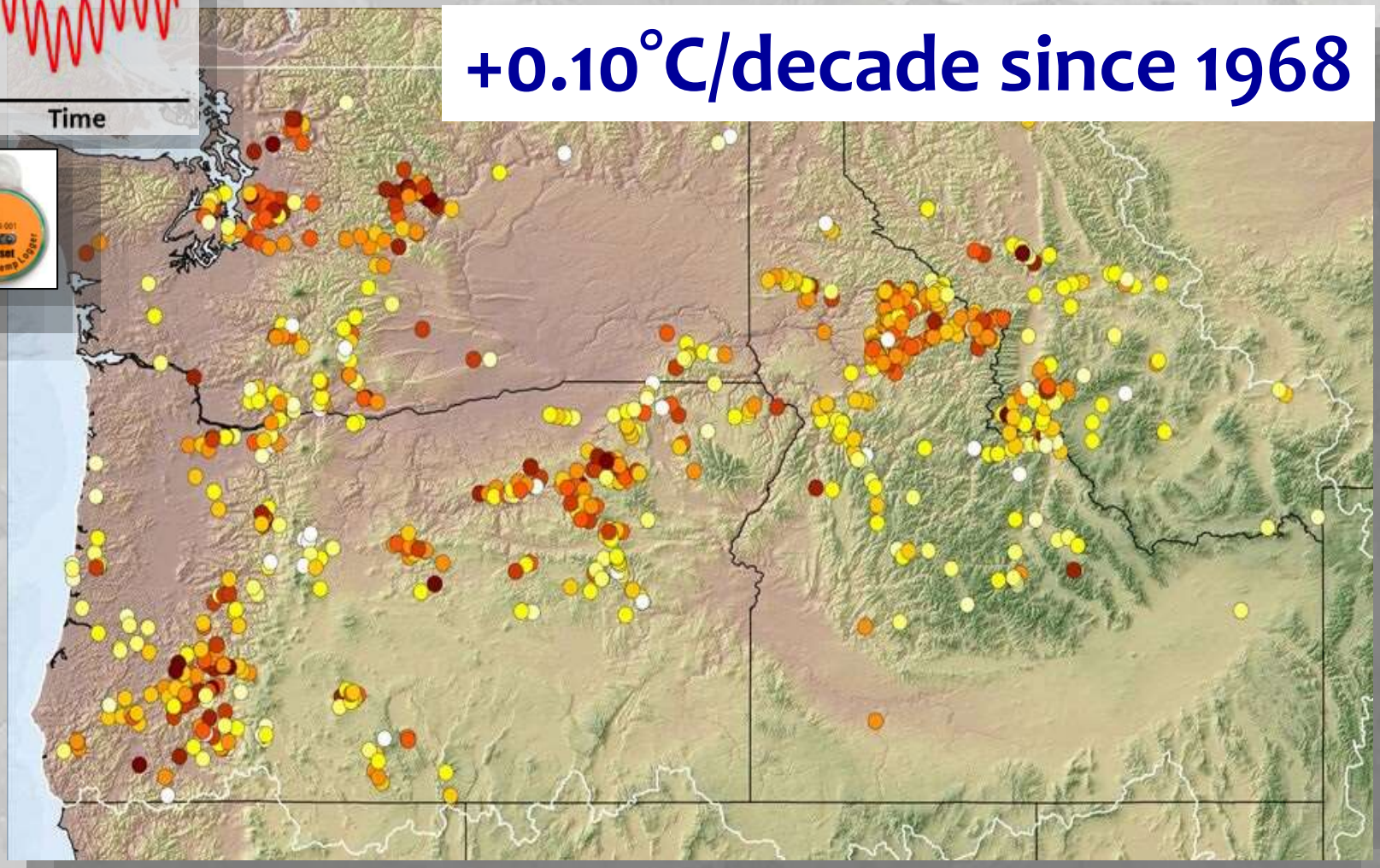
Species distribution models & climate assessments

Mountain Streams are Warming Very Slowly



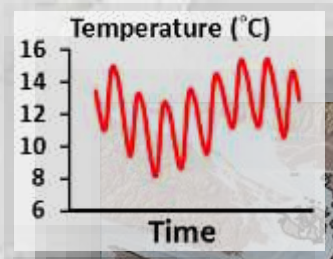
923 sites in NorWeST database with >10 year records

+0.10°C/decade since 1968



Isaak et al. 2016. Slow climate velocities of mountain streams portend their role as refugia for cold-water biodiversity. *Proc National Academy of Sciences*

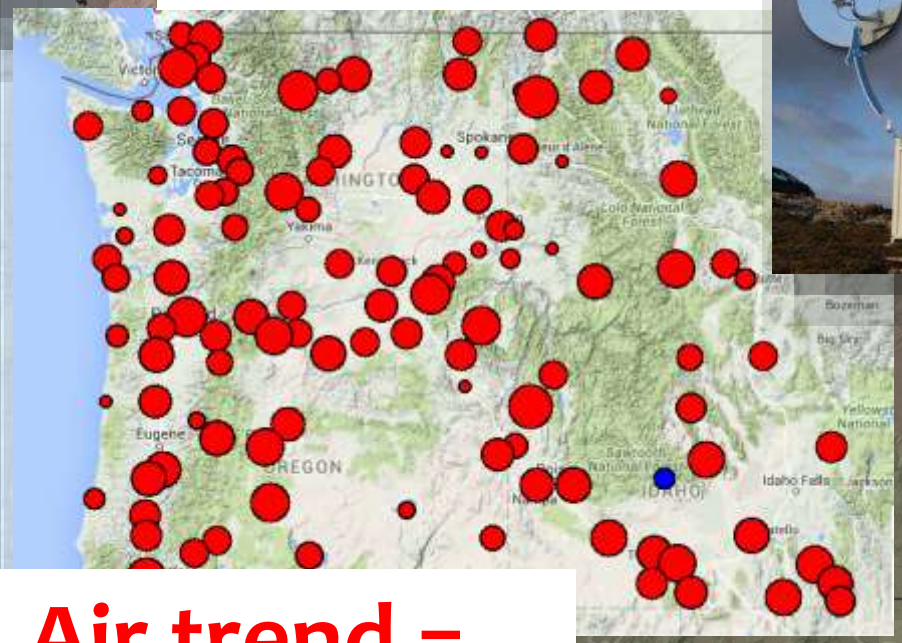
Mountain Streams are Warming Very Slowly

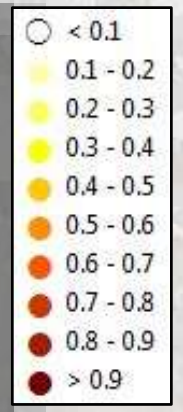


923 sites in NorWeST database with >10 year records

+0.10°C/decade since 1968

Weather Stations





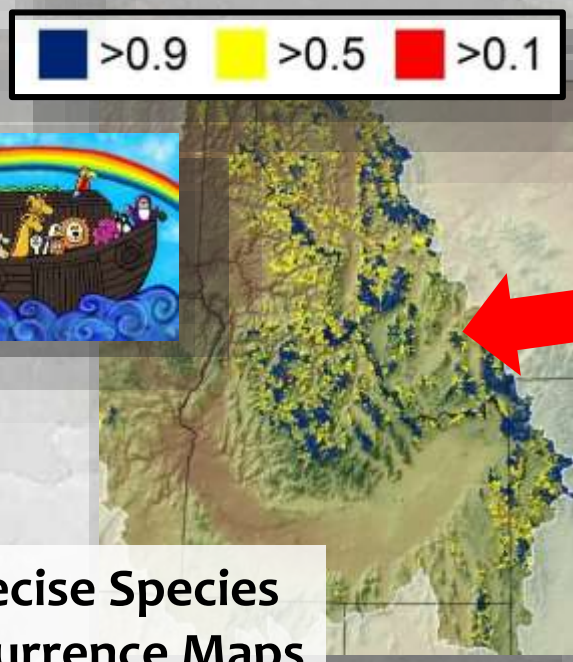
Air trend = 0.21°C/decade

e velocities of mountain streams portend their role as
er biodiversity. *Proc National Academy of Sciences*

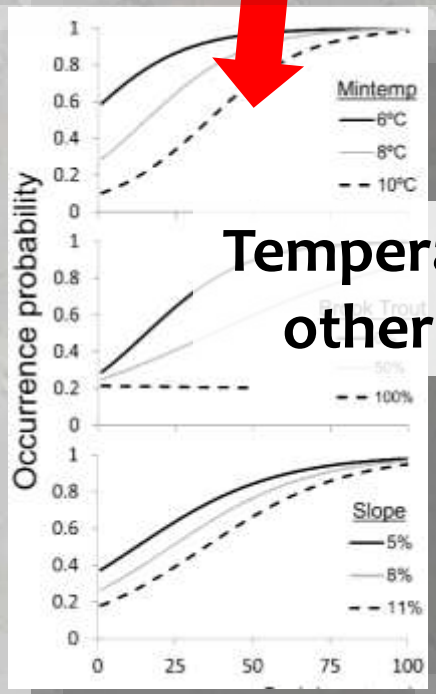
Mapping Climate Refugia for Native Trout

BIG FISH DATA

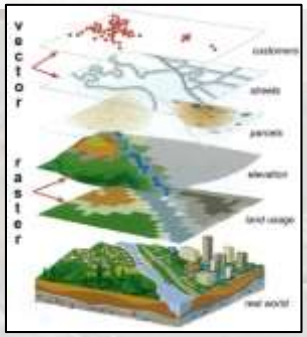
>10,000 sites



Climate Shield



Temperature, flow & other predictors



Precise Species Occurrence Maps

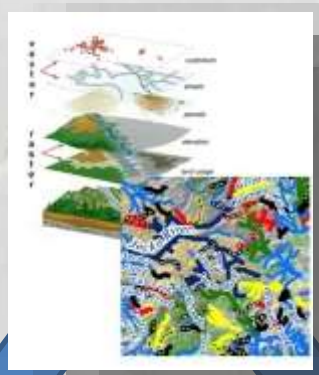
Isaak et al. 2015. The Cold-water climate shield. *Global Change Biology* **21**:2540-2553.

Website Provides Information in User-Friendly Digital Formats

Just Google "Climate shield trout"

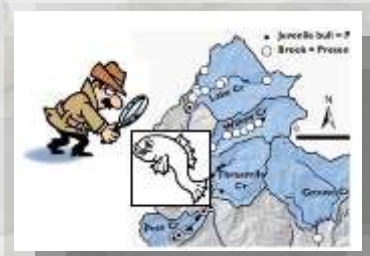
Presentations & Publications

Digital Maps & ArcGIS Shapefiles



Fish Data Sources

Distribution Monitoring



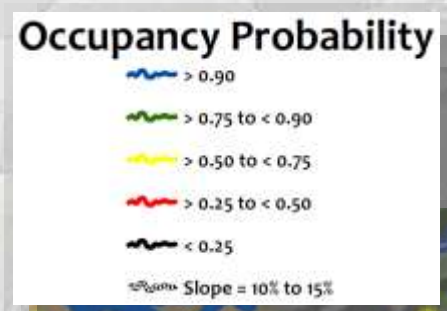
File formats:

- ArcGIS files
- pdf files

15 Scenarios:

- 3 climate periods
- 5 Brook invasion levels

High-quality Spatial Information Empowers Local Decision Makers…

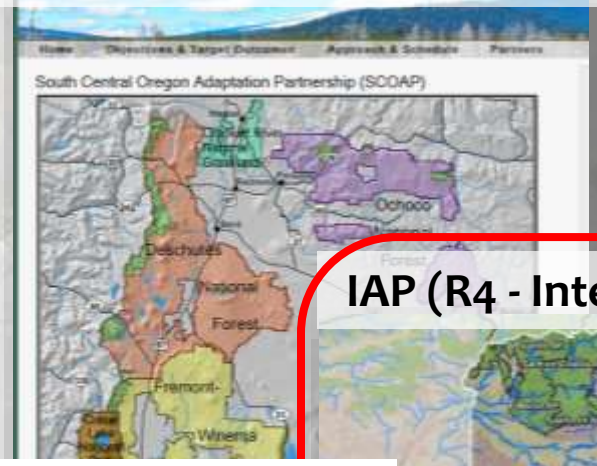


Highest priority conservation investment!

Climate Adaptation Partnerships (Dave Peterson – PNW Research)

- All Forests in Region 1, 4, & 6
- Stream climate scenarios & fish vulnerability assessments for ~40 NFs by end 2015

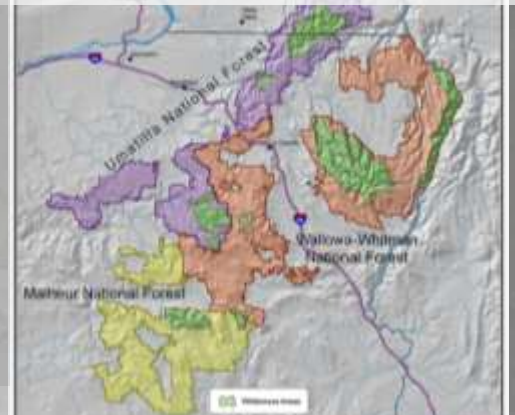
SCOAP (South Central Oregon)



IAP (R4 - Intermountain)

NRAP (R1 - Northern Rockies)

BMAP (Blue Mountains)



Aquatic Organisms

Dan Isaak, Mike Young, Cynthia Tait, Dan Duffield, Dona Horan, Matt Groce

eDNA Revolution: Reliable biodiversity assessments

USFS National Genomics Center for Wildlife & Fish Conservation

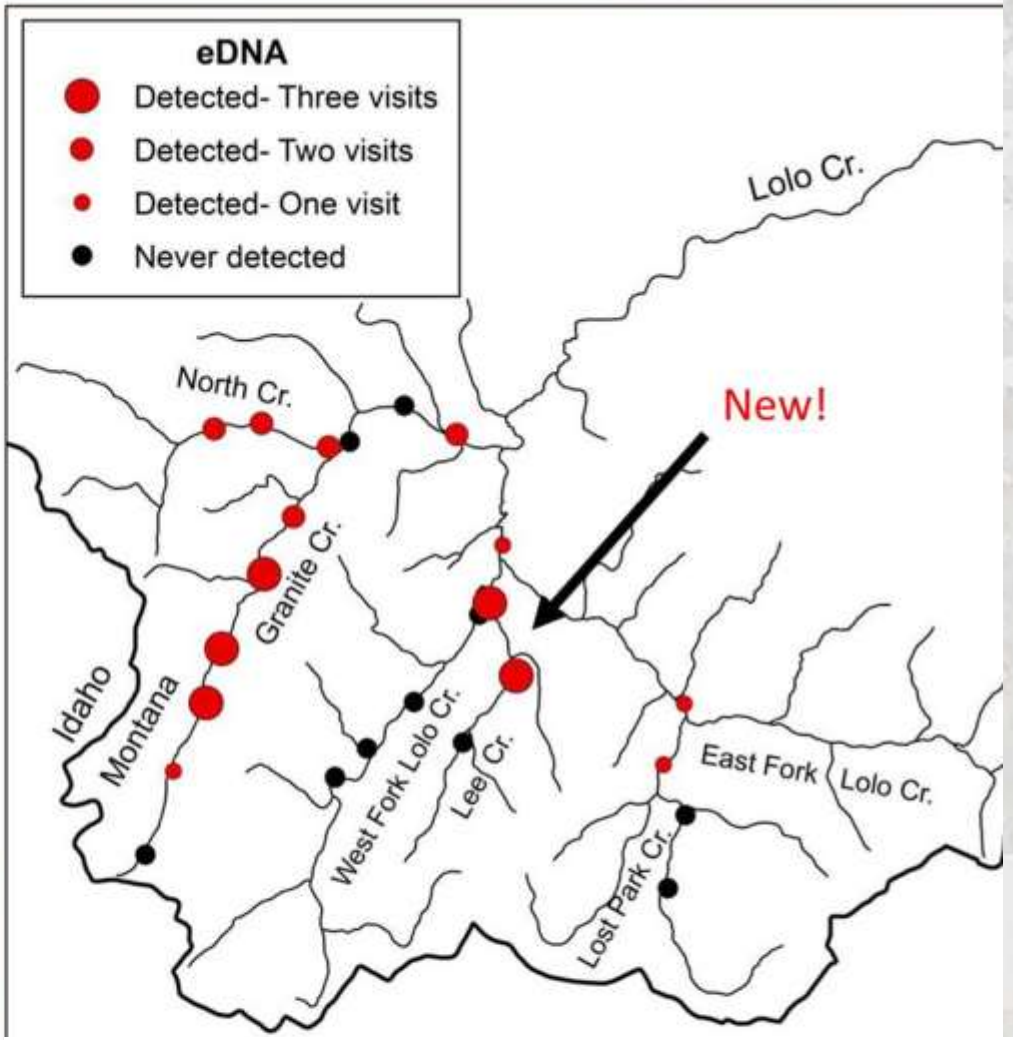
- Pioneered the technique for salmonids
- Species specific, highly reliable (1 trout / 100 m = 85% detection)
- Field-proven protocol
- Cost: $70 sample

Mike Schwartz
Mike Young
Kevin McKelvey

Using eDNA to detect bull trout

- Federally listed as threatened
- Dictates land management & planning
- Widespread, rare, & difficult to detect
- Ideal candidate for eDNA detection

- Pilot test: Montana 2014
- Confirmed known habitats
- Discovered new ones



Carim et al. 2014. Protocol for collecting eDNA samples from streams. Version 1.5. USDA Forest Service, Rocky Mountain Research Station, Missoula, MT. 12 p.

McKelvey et al. 2016. Sampling large geographic areas for rare species using eDNA: a preliminary study of bull trout occupancy in western Montana.

Wilcox et al. 2014. A blocking primer increases specificity in eDNA detection of bull trout. Conservation Genetics Resources, 1-2.

The rapid, range-wide inventory of bull trout: a crowd-sourced, eDNA-based approach with application to many aquatic species

Michael Young, Kevin McKelvey, Michael Schwartz, Dan Isaak, Kellie Carim, Taylor Wilcox, Katie Zarn, Kristy Pilgrim, Dona Horan, Sherry Wollrab

Great Northern Landscape Conservation Cooperative

Collaborators

Region 1

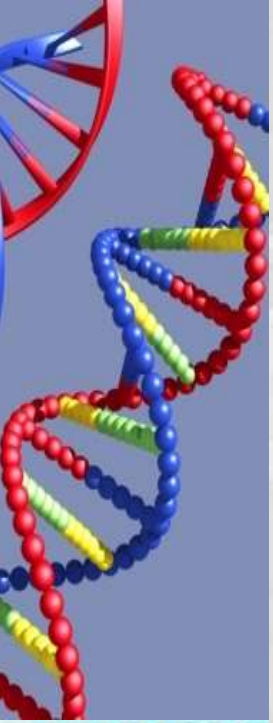
Bureau of Reclamation
Clark Fork Coalition
Clearwater Resource Council
Coeur d'Alene Tribes
Idaho Department of Fish and Game
Idaho Power Company
Montana Department of Natural Resources Conservation
Montana Fish, Wildlife & Parks
National Fish and Wildlife Foundation
The Nature Conservancy
Nez Perce Tribes
Oregon Department of Fish and Wildlife

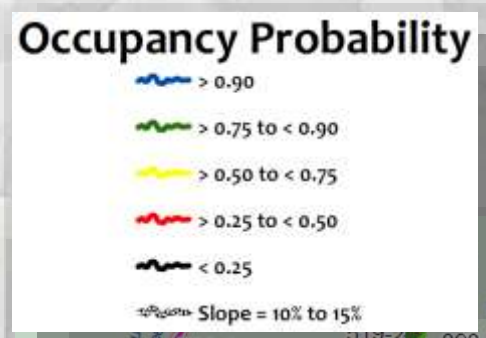
Trout Unlimited
U.S. Fish and Wildlife Service
USFS Beaverhead-Deer Lodge NF
USFS Boise NF
USFS Helena NF
USFS Idaho Panhandle NF
USFS Lolo NF
USFS Region 1
USFS Region 4
USFS Region 6
USFS Sawtooth NF
Washington Department of Fish and Wildlife
Yakima Nation

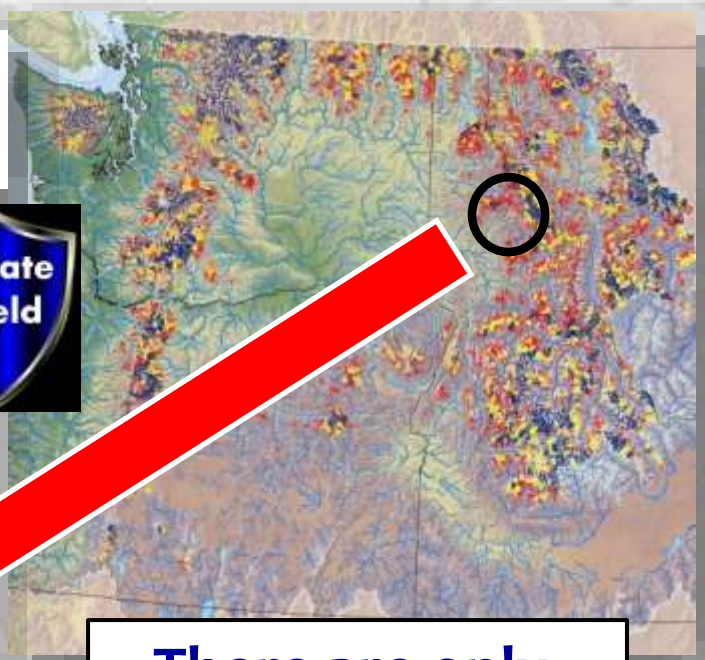
Forest Service Research & Development
National Genomics Center for Wildlife & Fish Conservation

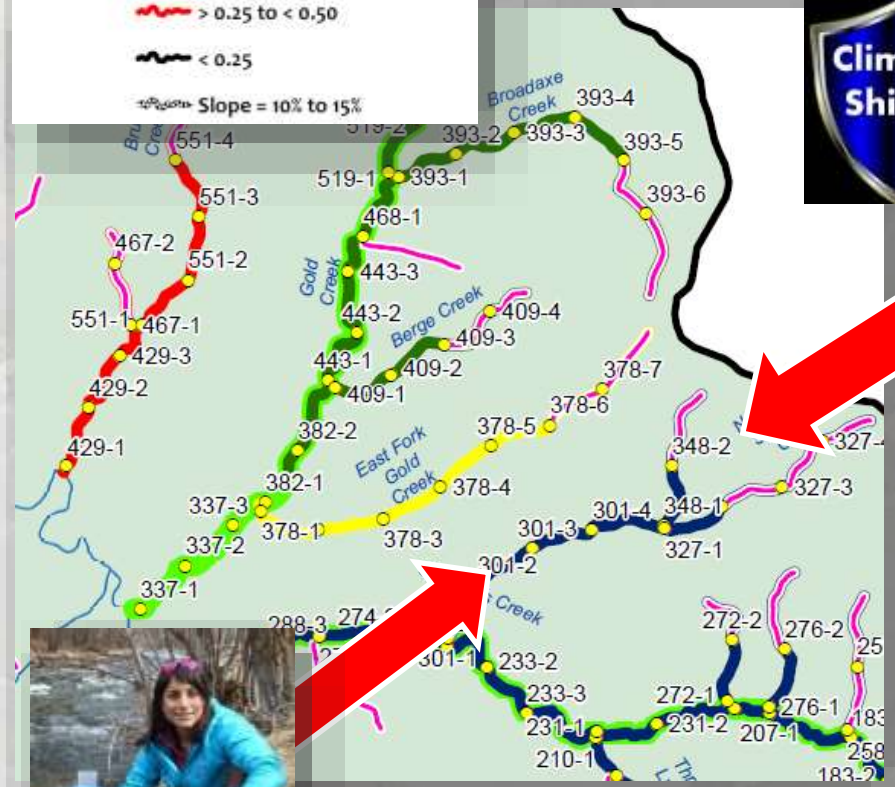
Rocky Mountain Research Station

Combine eDNA sampling with Precise Predictions from Climate Shield Model









There are only…

5,332 >0.1 habitats

1,325 >0.5 habitats

348 >0.9 habitats

Target samples to resolve greatest uncertainty

Website: Rangewide eDNA Bull Trout Project

Detailed field sampling maps

eDNA Sample Site

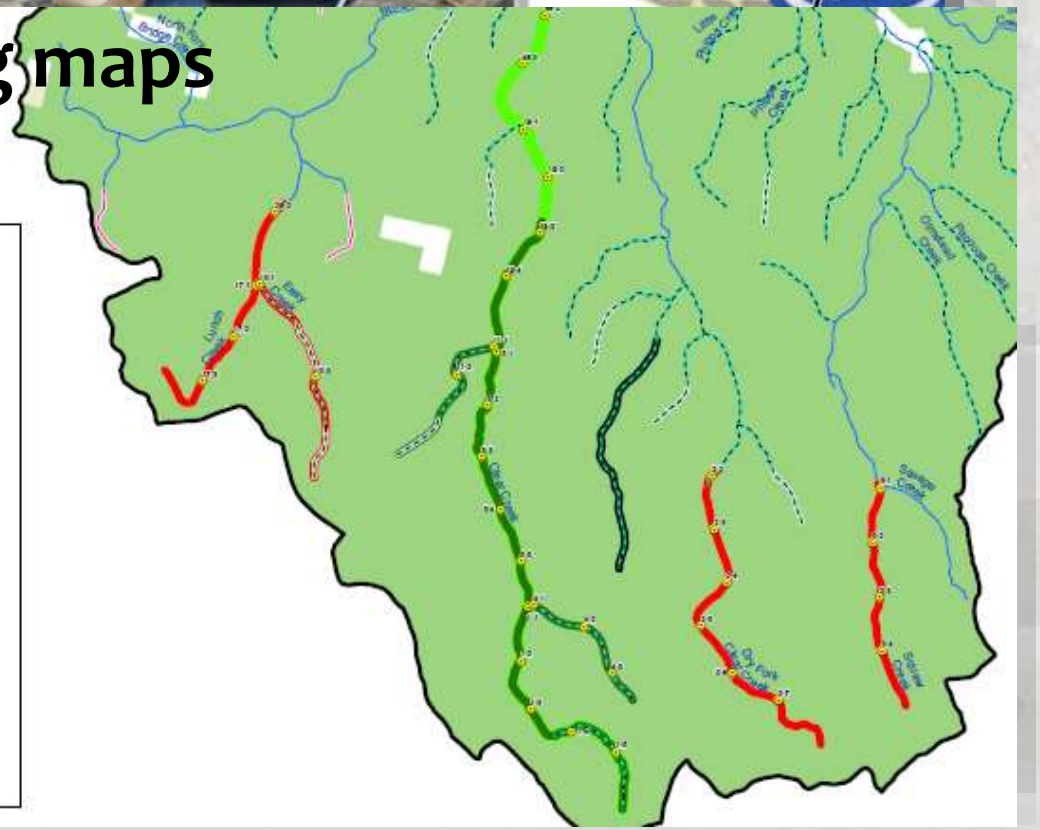
Note: The 93 sites on this map occur on streams having <10% slope and a probability of bull trout occurrence >25%.

Features

- Intermittent Flowlines
- Slope > 10%
- Probability of Occupancy (%)
  - 10 - 25
  - 25 - 50
  - 50 - 75
  - 75 - 90
  - 90 - 100
- Bull Trout Critical Habitat
- Waterfalls

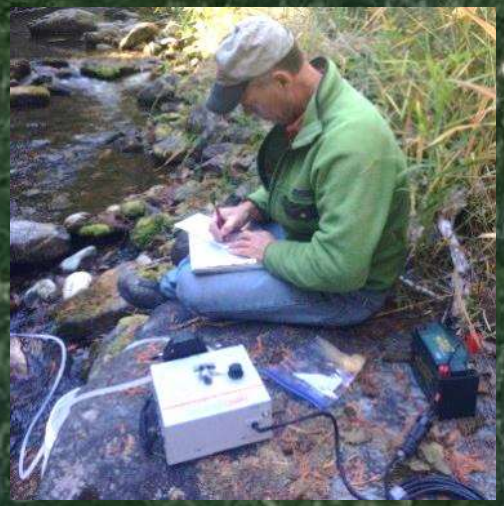
Land Ownership

- No Data
- BLM
- BOR
- USFWS
- USFS - Nonwilderness
- USFS - Wilderness
- COE
- NPS
- Other Federal
- Tribal
- State/City
- TNC
- Private
- Other/Unknown



Website: Rangewide eDNA Bull Trout Project

Rapid Results…



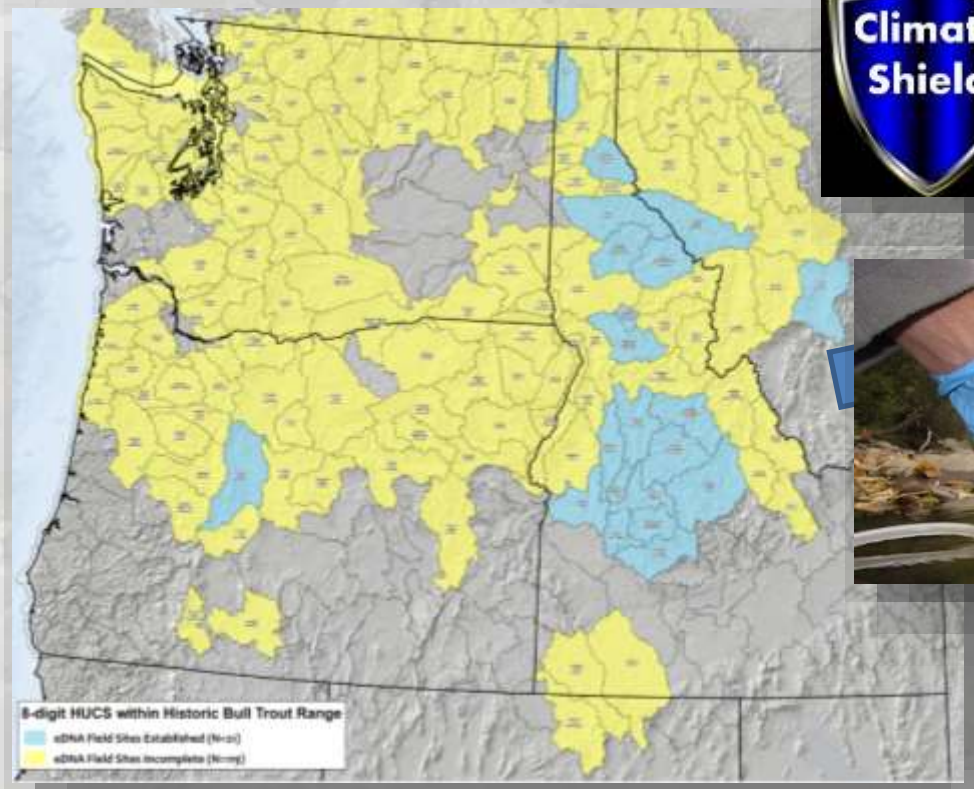
Bull trout eDNA survey
St. Joe River (266 sites)

- Detection
- No detection

Bull Trout Critical Habitat
Waterfalls
Private
Other/Unknown

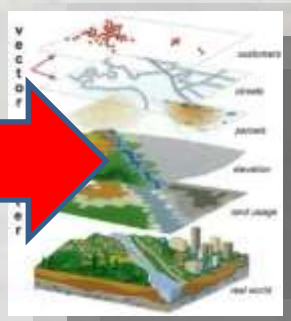
Rangewide eDNA Bull Trout Project:

Industrial scale crowd-sourced field campaigns



Climate Shield

Sample sites have unique IDs & are part of digital geodatabases from day 1!



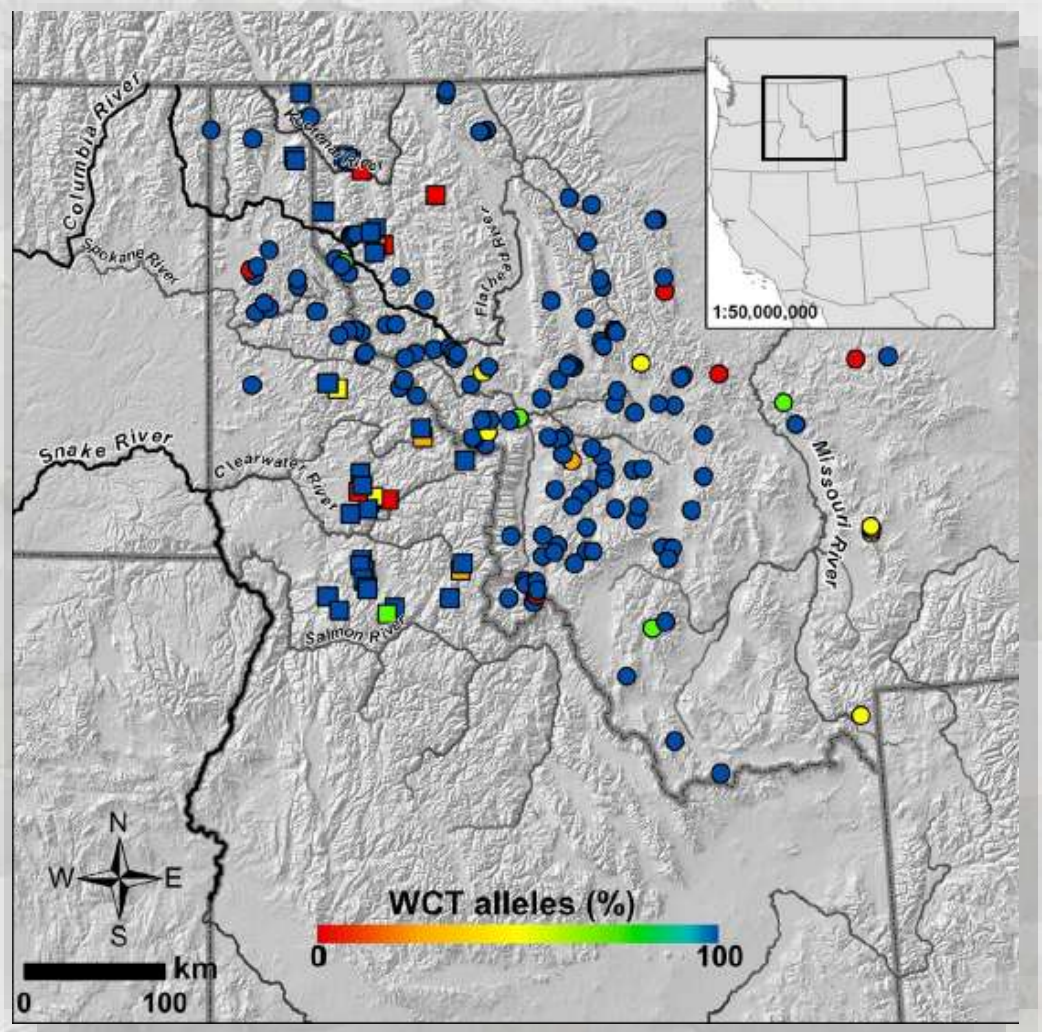
ORACLE DATABASE

Historical Occurrence Database to Improve Efficiency of eDNA Samples

Cutthroat - Rainbow Trout Hybridization

Less Prevalent Than Once Believed

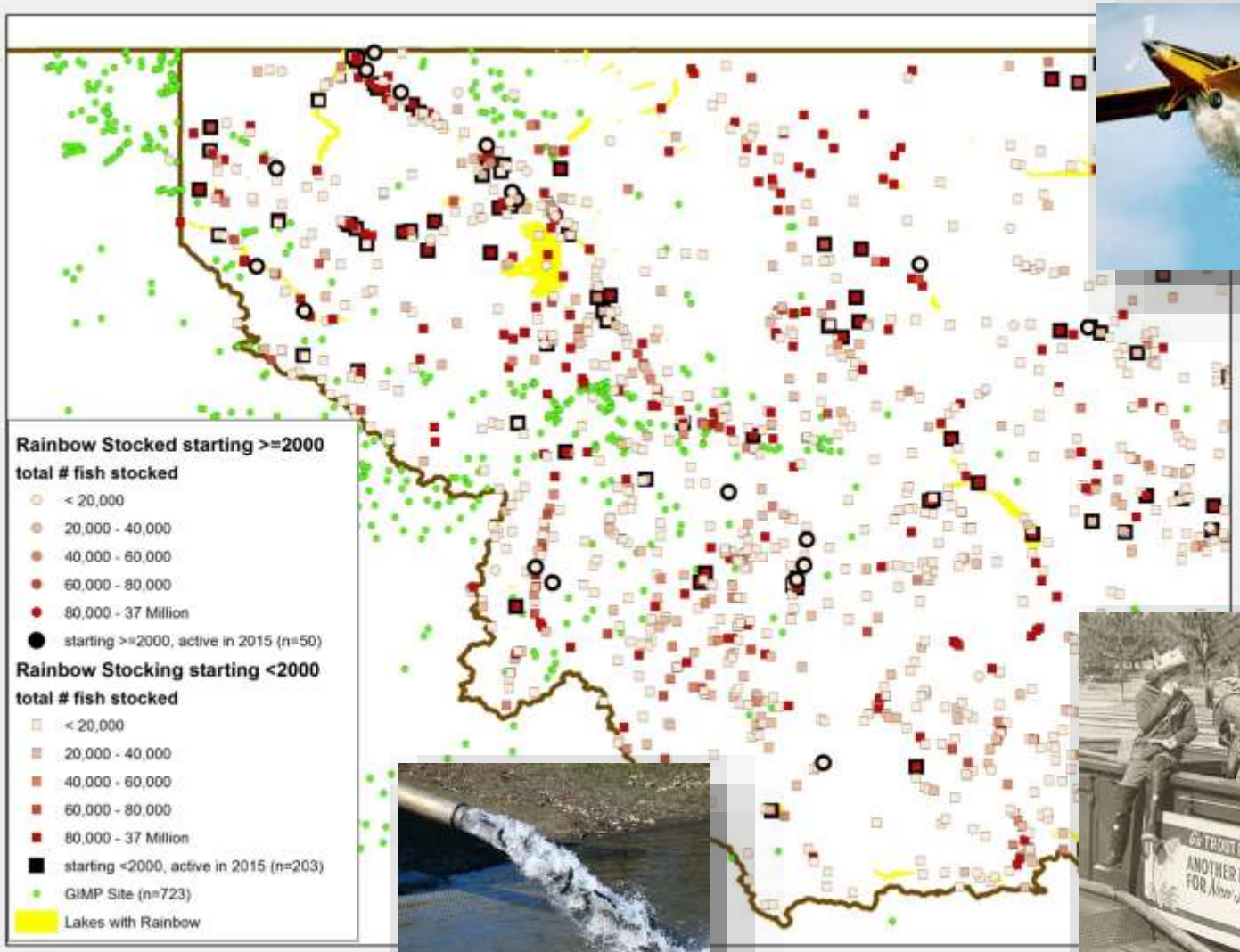
- 188 random PIBO sites



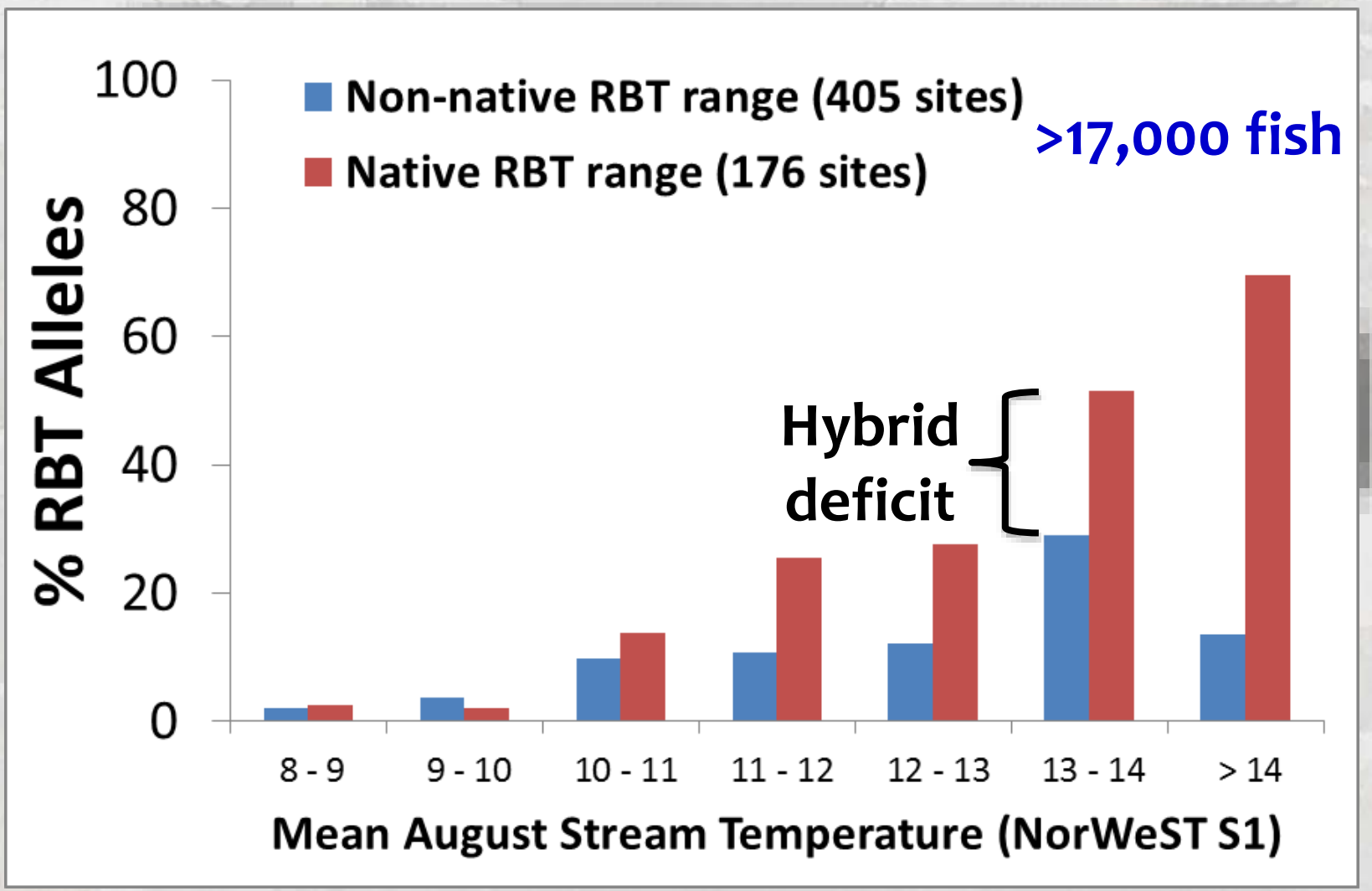
McKelvey et al. 2015. Patterns of hybridization among cutthroat trout & rainbow trout in northern Rocky Mountain streams. Ecology & Evolution

Rainbow Trout Stocking is Pervasive

Montana has stocked 400,000,000 in 60 years



Cold Climates Reduce Cutthroat-Rainbow Trout Hybridization



A Model to Predict Patterns of Cutthroat Hybridization this Century

Compilation of previously published datasets:

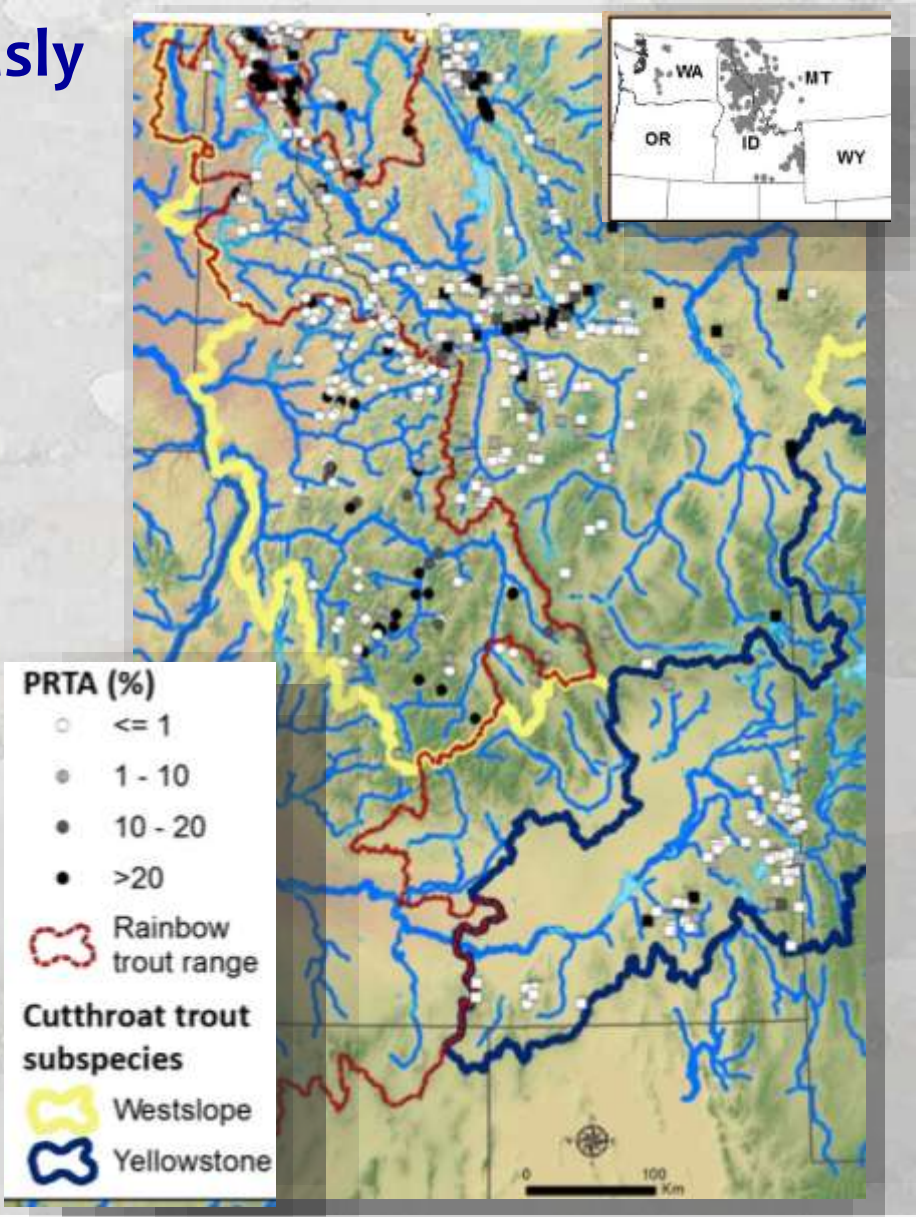
- 581 stream sites
- 17,000 fish

RBT%_Alleles =

AugTemp +
D_Source +
Mean Flow +
RBT_Range

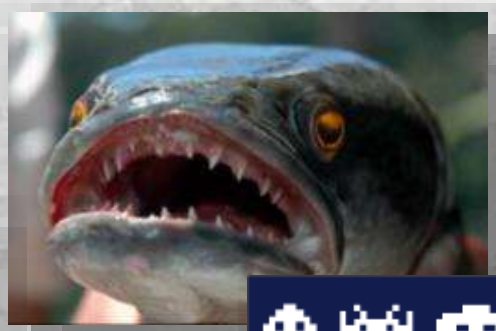
Prediction maps for all cutthroat streams & climate scenarios

Young et al., In prep.

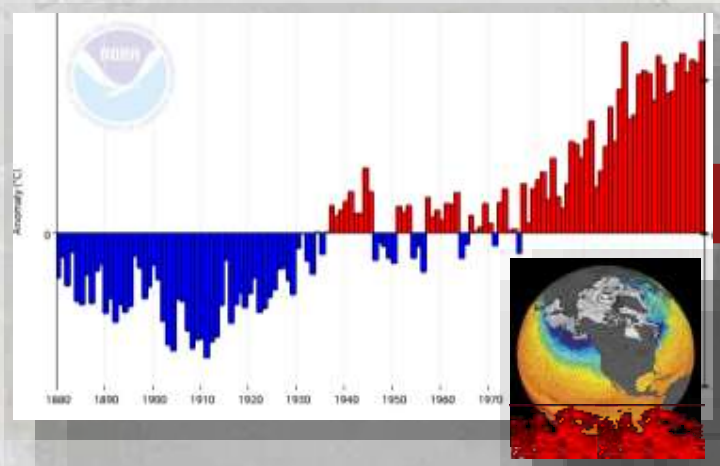


Mountain Streams & Communities are Relatively Resistent

100 years of non-native threats



>40 years of climate change



Yet many indigenous aquatic communities persist

Better Biological Baselines Needed

Who All Lives Here?

Bugs

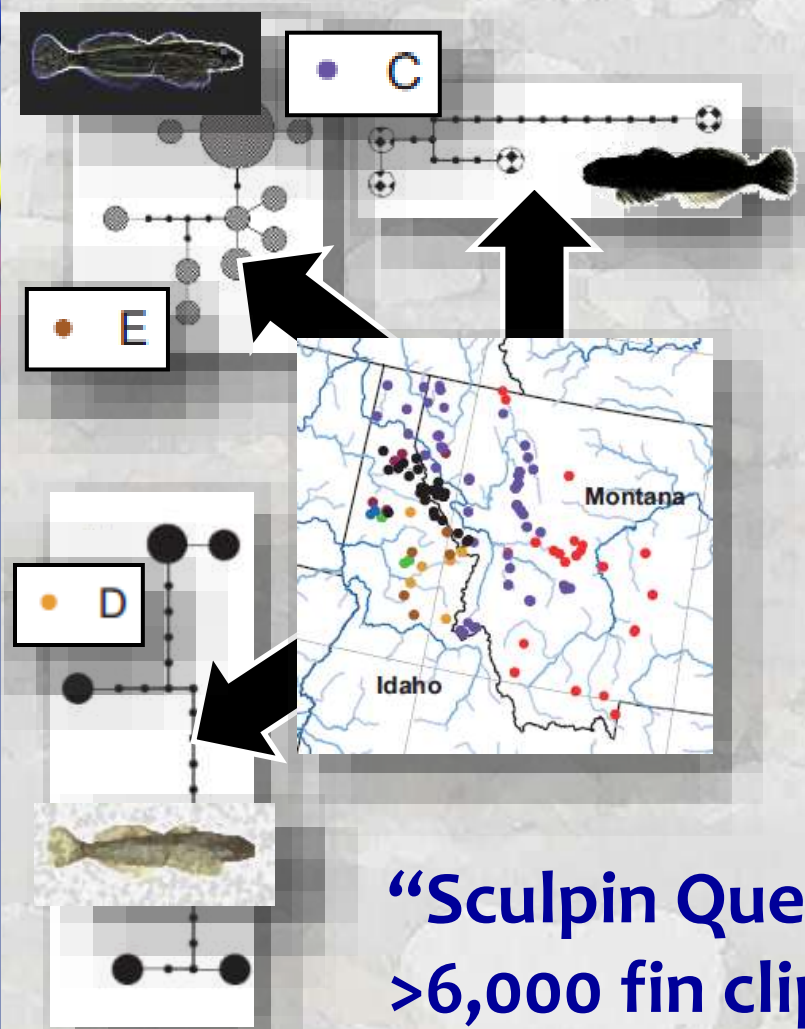
Mollusks

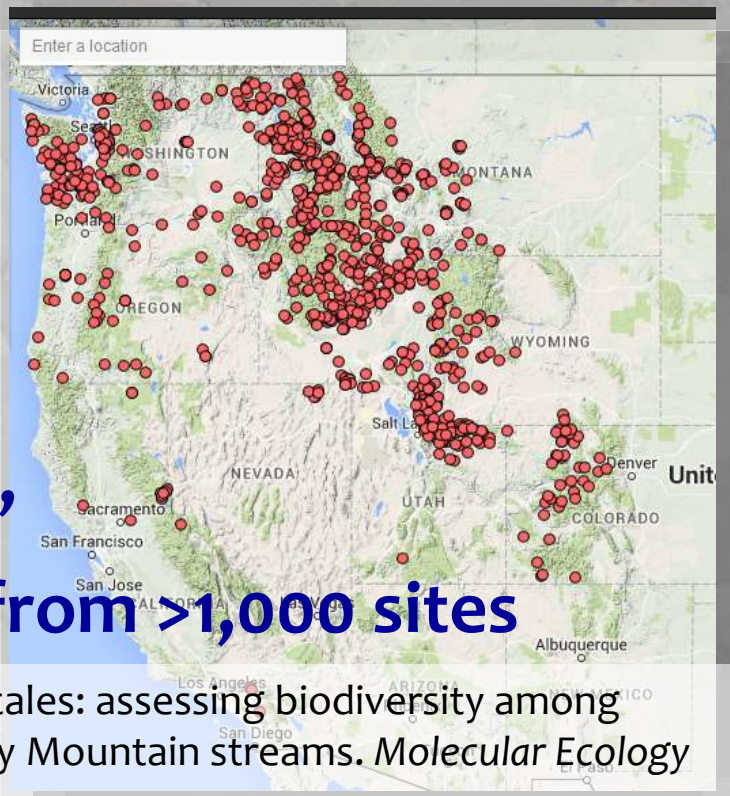
Amphibians

Non-game fish

Aquatic eDNA Revolution Will Change That

DNA Barcoding: A few fin clips from many places will reveal cryptic biodiversity & evolutionary legacy



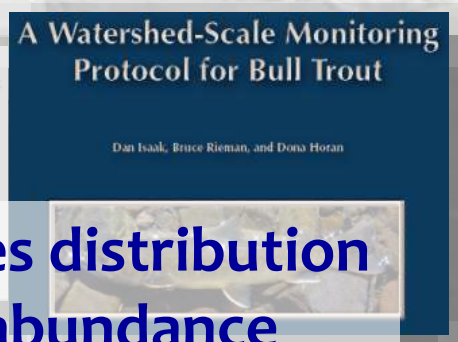


"Sculpin Quest!"
>6,000 fin clips from >1,000 sites

Young et al. 2013. DNA barcoding at riverscape scales: assessing biodiversity among fishes of the genus *Cottus* in northern Rocky Mountain streams. *Molecular Ecology* doi: 10.1111/1755-0998.12091

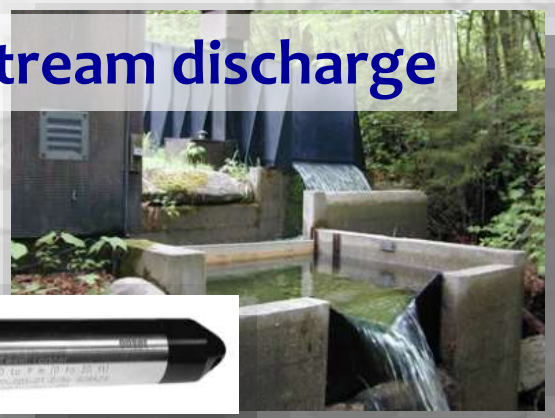
More Data Coming Faster…

Inexpensive, Standard Data Protocols

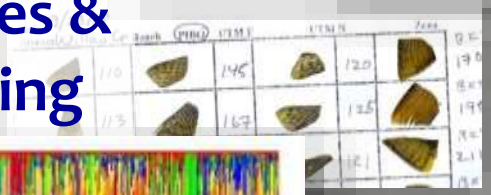


Species distribution & abundance

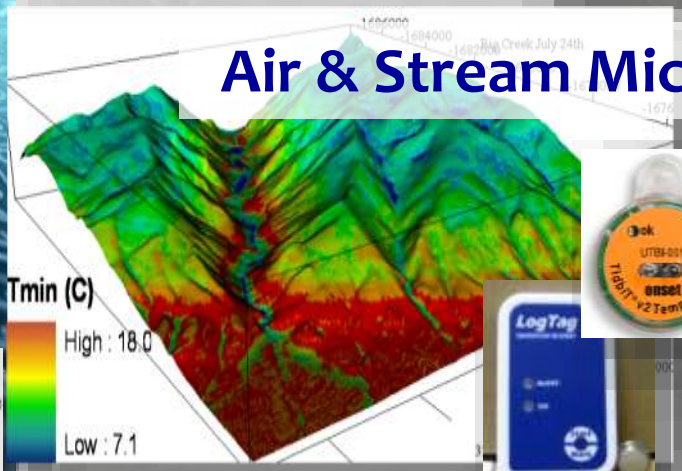
Stream discharge

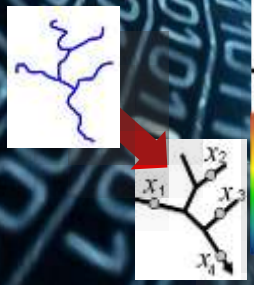


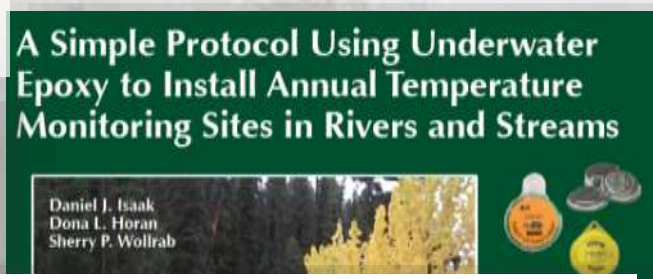
Tissue Samples & DNA barcoding

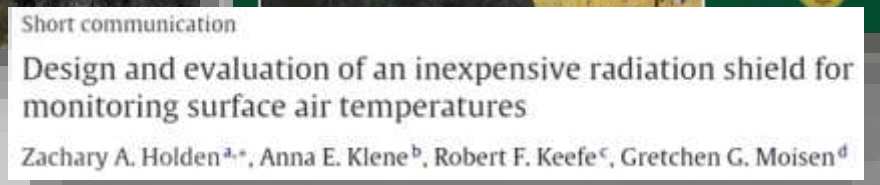


Air & Stream Microclimates

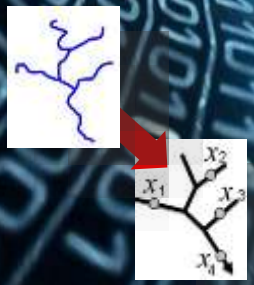








Data Are Smokey's Brain

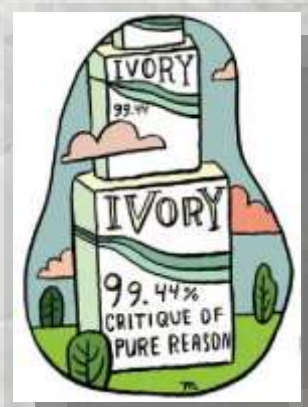


can Keep Smokey Smart!

Create a "Virtuous Cycle" of Information Creation

Many stakeholders

"Boots-on-the-Ground"

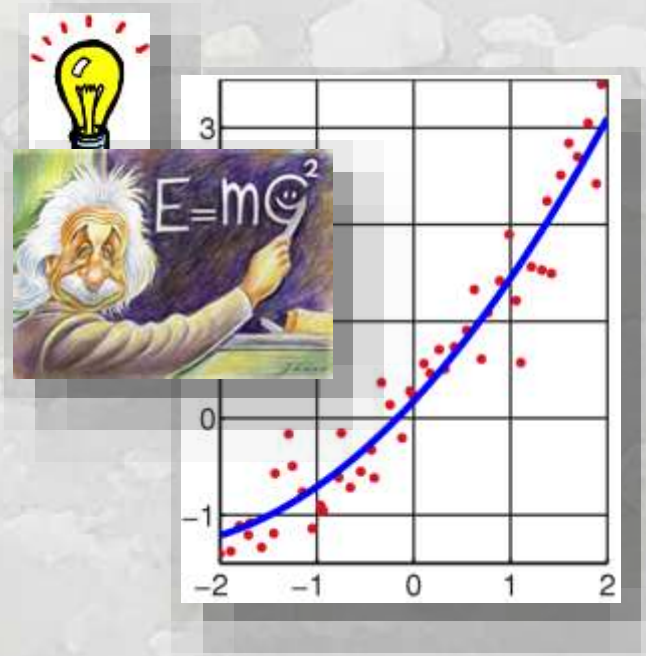


Research develops databases & relevant information

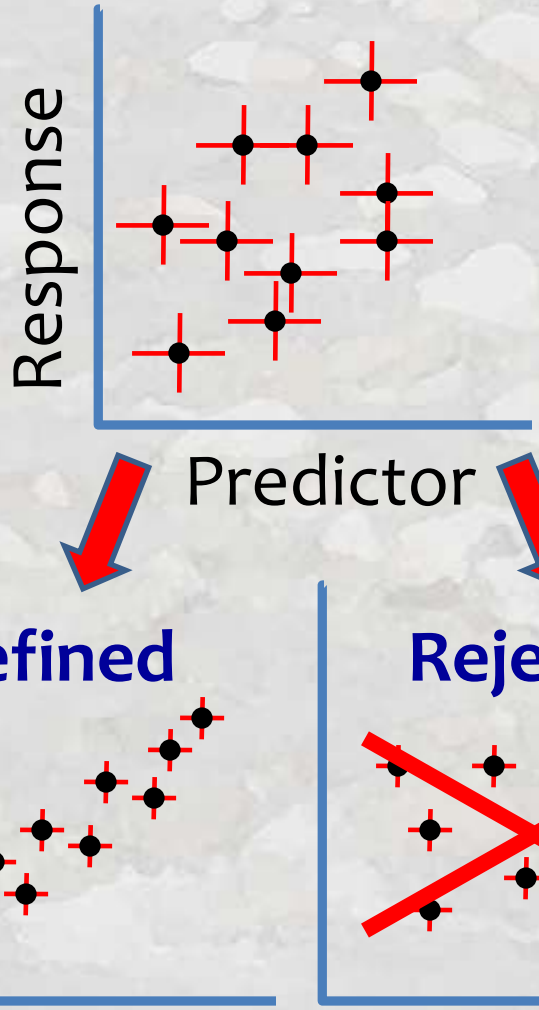
Mountains of data

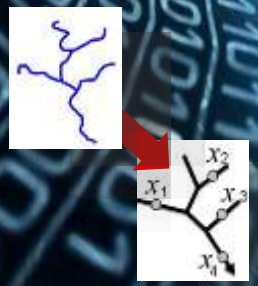
A New Era of Better Prediction & Understanding for Stream Things…

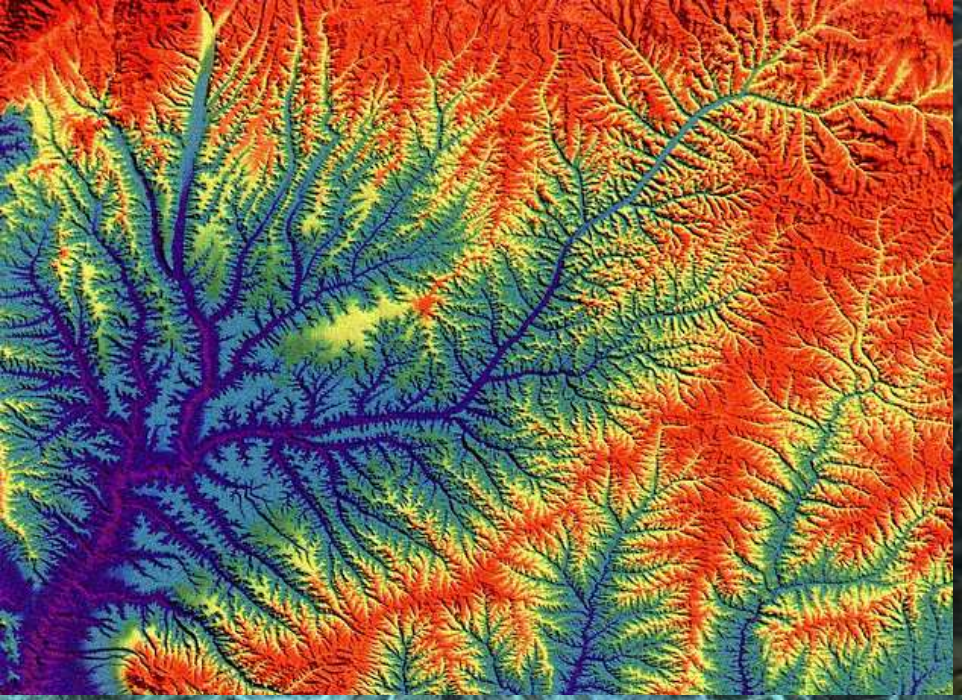
New relationships described



Old relationships tested







The End