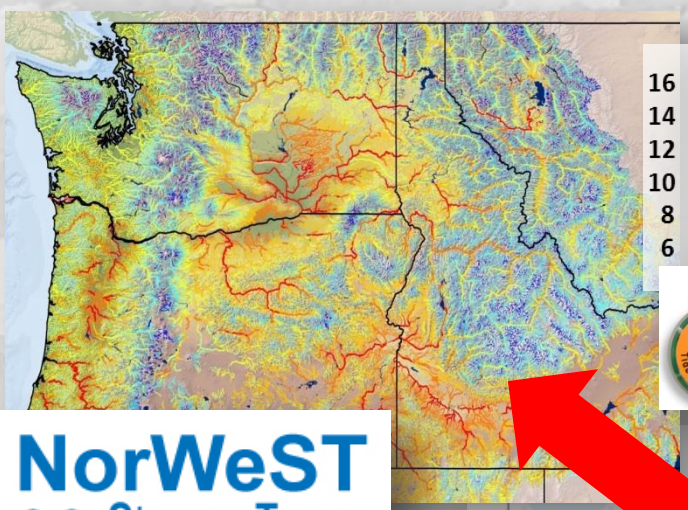
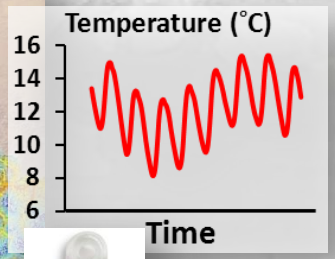
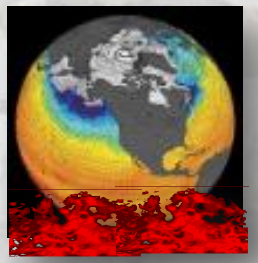
Recent Rapid Evolution of Stream Science in the Rockies

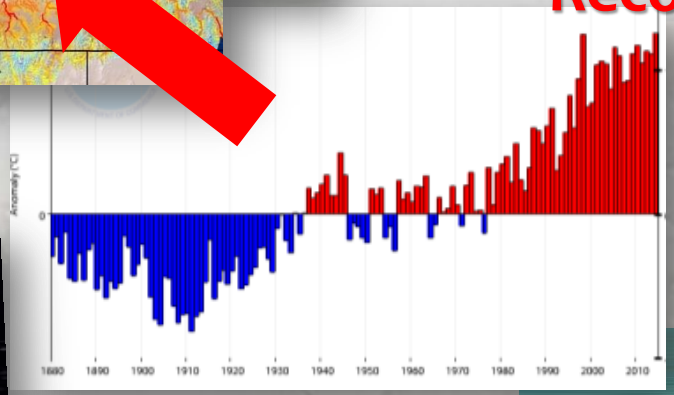






NorWeST
Stream Temp

2014 Set New Record



Early Research at Missoula Lab on the genomics frontier…

Review TRENDS in Ecology and Evolution Vol.22 No.1
Full text provided by www.sciencedirect.com
ScienceDirect

Genetic monitoring as a promising tool for conservation and management

Michael K. Schwartz[1], Gordon Luikart[2,3] and Robin S. Waples[4]

[1] USDA Forest Service, Rocky Mountain Research Station, 800 E. Beckwith Avenue, Missoula, MT 59801, USA
[2] Center for Investigation of Biodiversity and Genetic Resources, University of Porto, Campus Agrário de Vairão 4485-661, Portugal
[3] Division of Biological Sciences, University of Montana, Missoula, MT 59812, USA
[4] National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Boulevard East, Seattle, WA 98112, USA

Review TRENDS in Ecology and Evolution Vol.18 No.4 April 2003 189

Landscape genetics: combining landscape ecology and population genetics

Stéphanie Manel[1], Michael K. Schwartz[2], Gordon Luikart[1] and Pierre Taberlet[1]

[1]Laboratoire d'Ecologie Alpine, Equipe Génomique des Populations et Biodiversité, UMR CNRS 5553, BP 53, Université Joseph Fourier, 38041 Grenoble Cedex 9, France
[2]Rocky Mountain Research Station, US Forest Service, 800 E. Beckwith, Missoula, MT 59801, USA

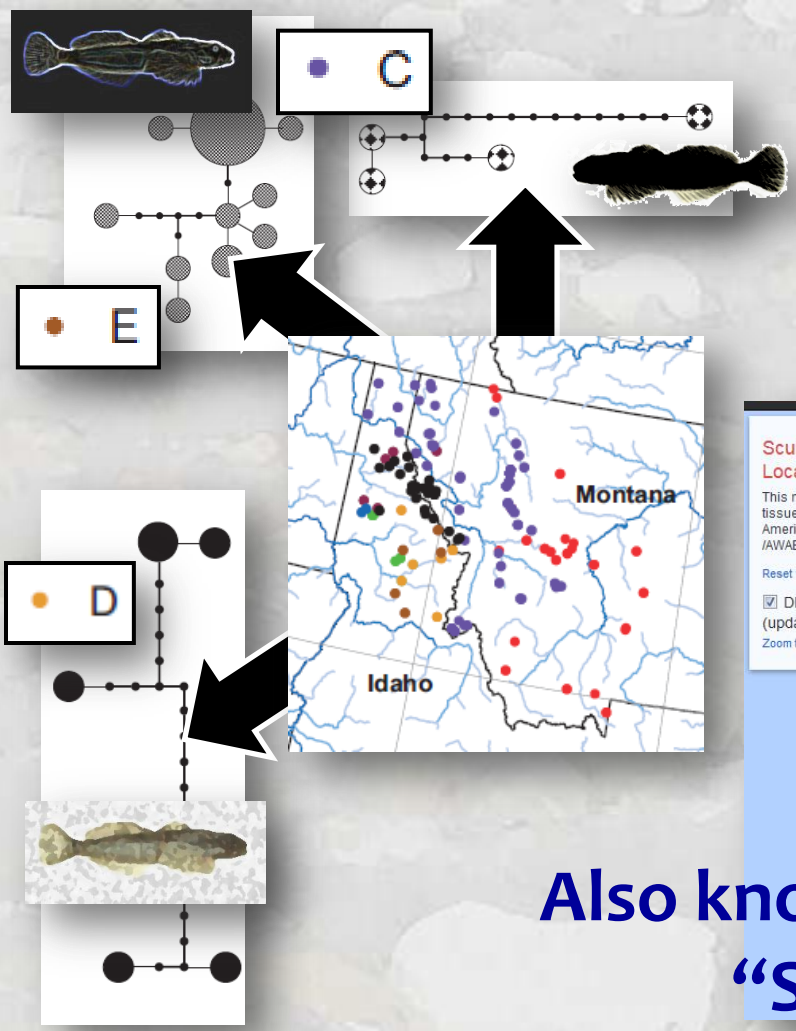
eDNA Revolution: Reliable biodiversity assessments

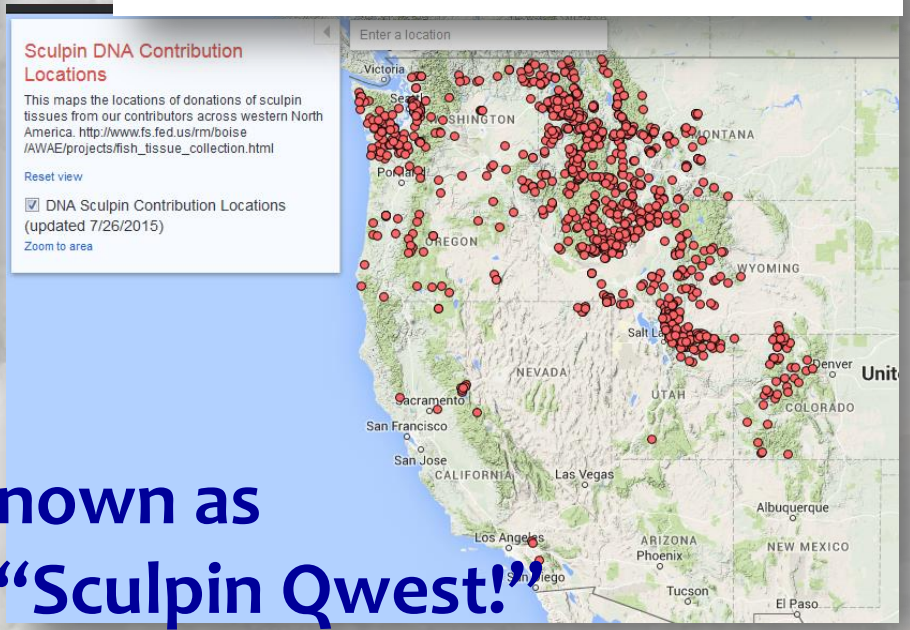
USFS National Genomics Center for Wildlife & Fish Conservation

- 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

DNA Barcoding: A few fin clips from a few fish in many places reveals evolutionary legacy & units of conservation

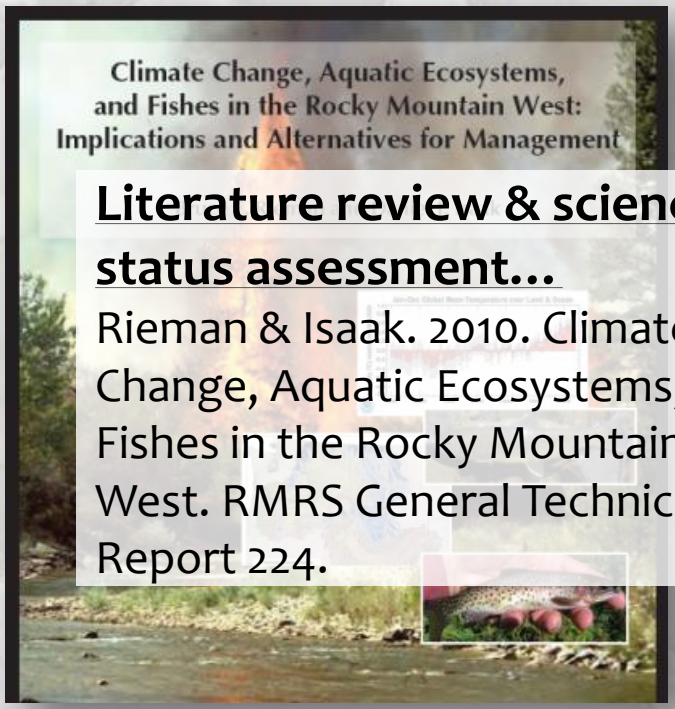




Also known as "Sculpin Qwest!"

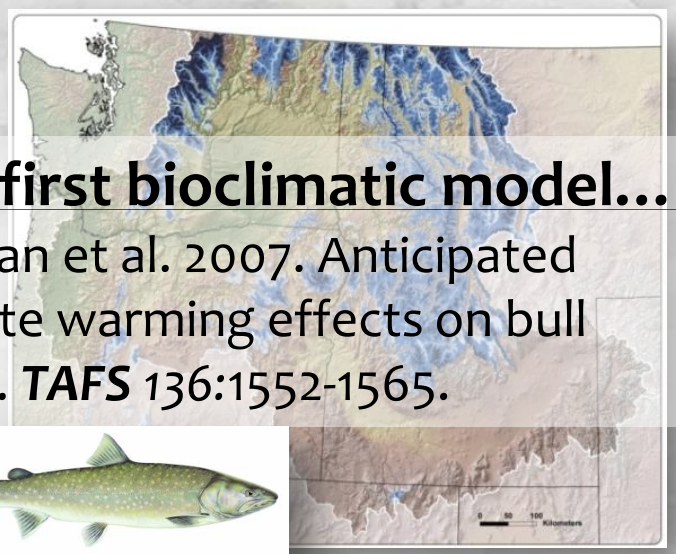
Young et al. 2013. DNA barcoding at riverscape scales: assessing biodiversity among fishes of the genus *Cottus* in northern Rocky Mountain streams. *Molecular Ecology* doi: 10.1111/1755-0998.12091

Early Climate Change Research at Boise Aquatics Sciences Lab…



Literature review & science status assessment…

Rieman & Isaak. 2010. Climate Change, Aquatic Ecosystems, and Fishes in the Rocky Mountain West. RMRS General Technical Report 224.

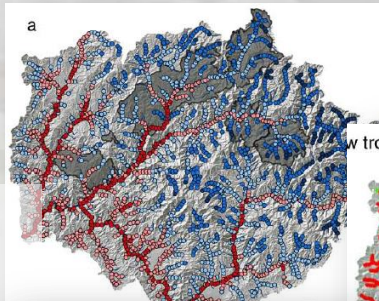


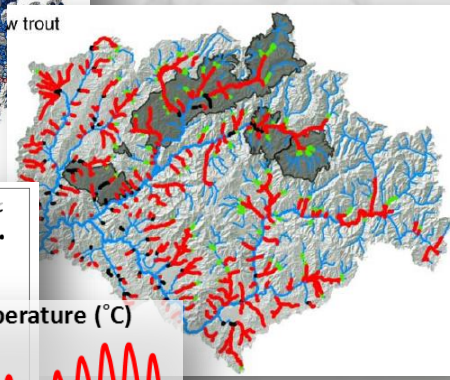
Our first bioclimatic model…

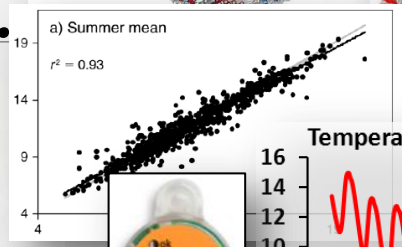
Rieman et al. 2007. Anticipated climate warming effects on bull trout. ***TAFS*** *136*:1552-1565.

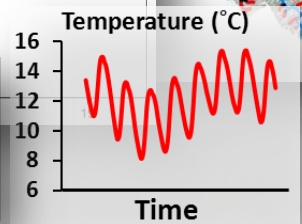
Protocol for "downscaling" climate to stream networks…

Isaak et al. 2010. Effects of climate change and wildfire on stream temperatures in a mountain river network. ***Ecol. Apps.*** 20:1350-1371.



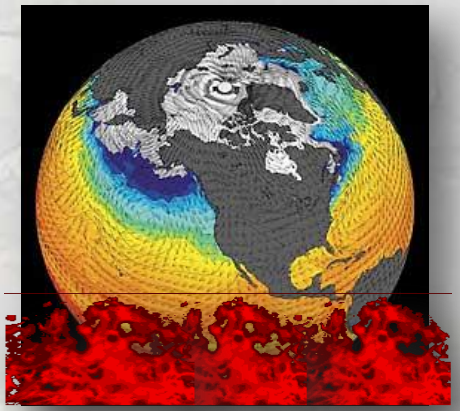




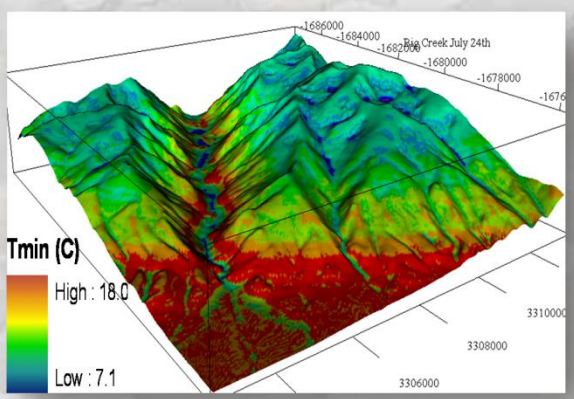


Need: High Resolution Stream Scenarios to Provide Management-Relevant Information

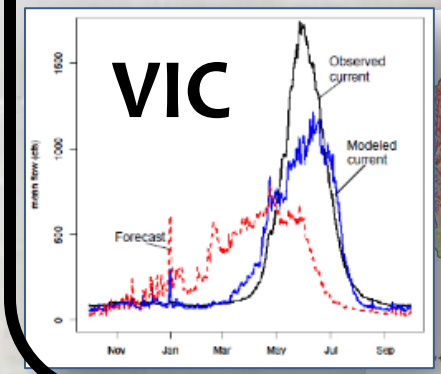
Global climate models
Resolution: 10000s of meters

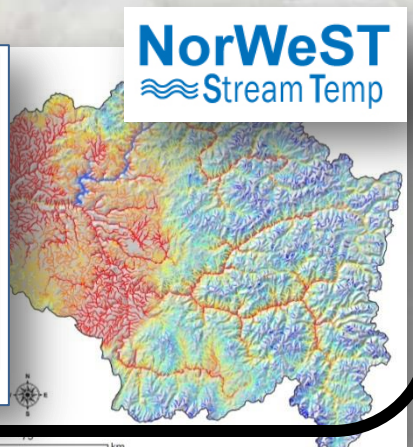


Landscape climate models
Resolution: 1000s meters

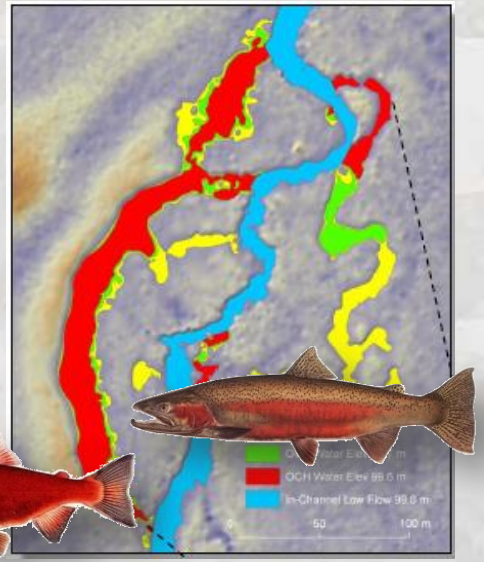


River network
temperature & flow





Stream reach

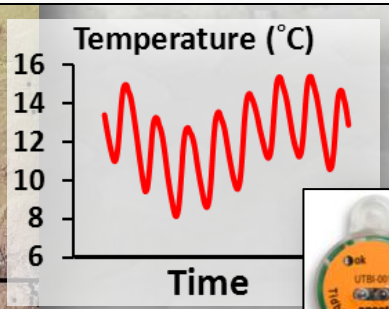


Step 1: Forge Disparate Data Into a Functional Database

Funded by:

NorWeST Stream Temp

>50,000,000 hourly records
>18,000 unique stream sites
>90 resource agencies



Great Northern Landscape Conservation Cooperative

North Pacific Landscape Conservation Cooperative

Forest Service USDA

California Fish Passage Forum

NASA

Kootenai Tribe of Idaho

Nez Perce Tribe Treaty of 1855

Idaho Department of Environmental Quality

NOAA Fisheries

Shoshone Bannock Fish and Game

U.S. Department of the Interior Bureau of Land Management

Kalispel Tribe of Indians

Oregon Fish & Wildlife

North Fork John Day Watershed Council

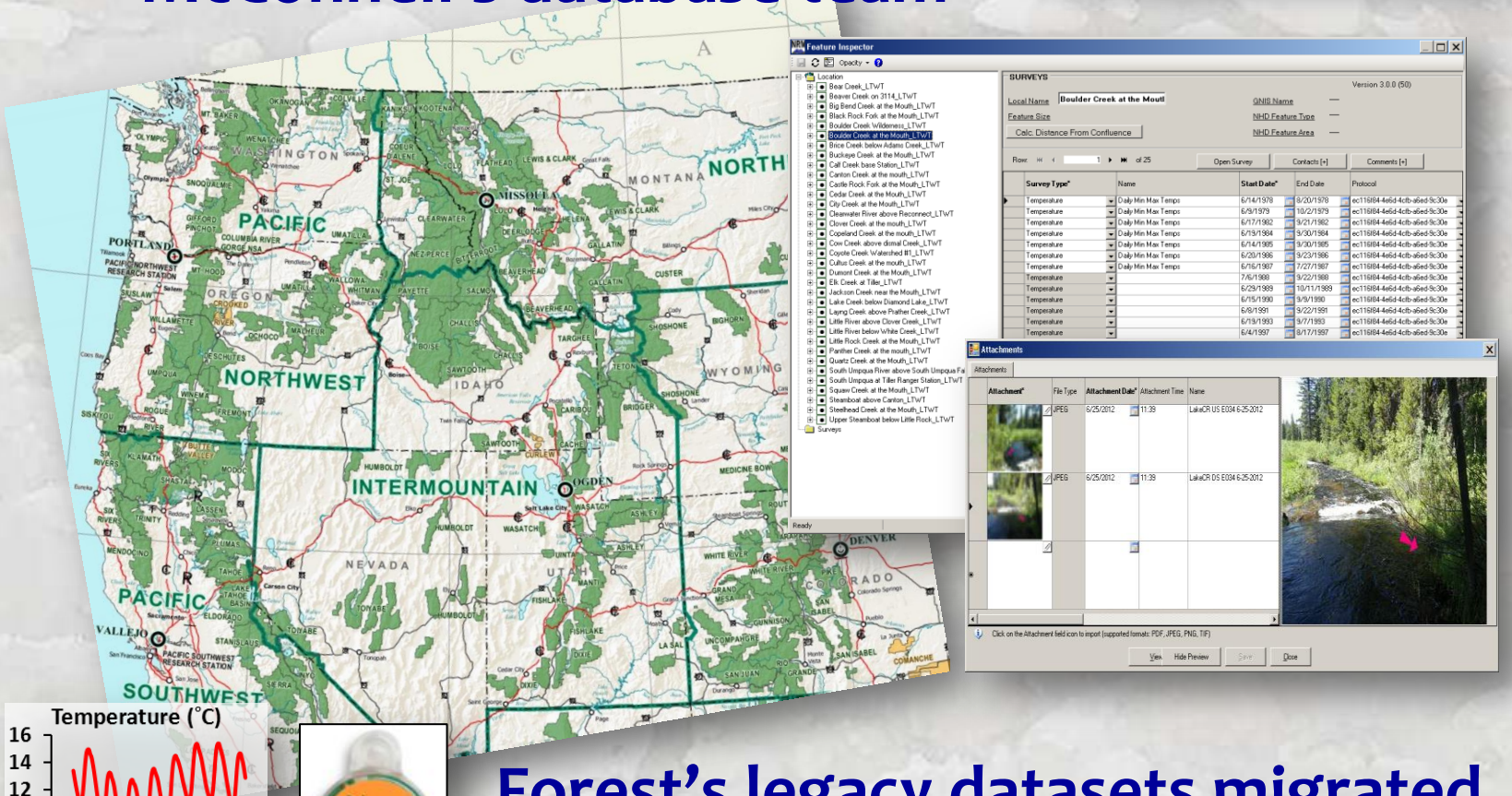
Idaho Fish & Game

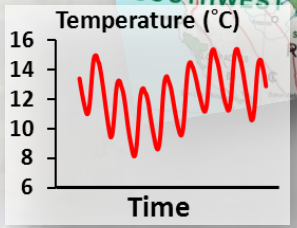
Idaho Power

USGS science for a changing world

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

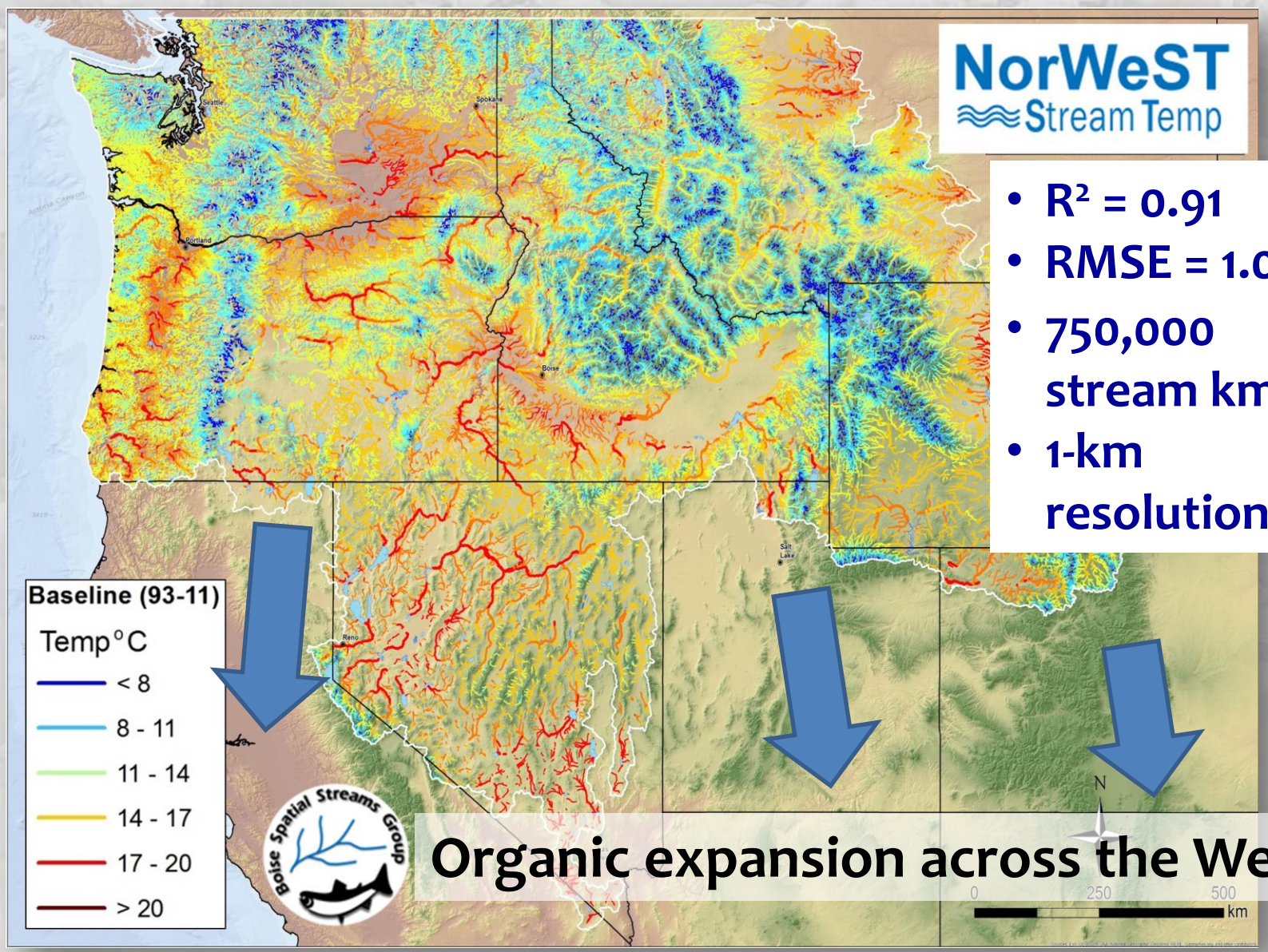
Work closely with Callie McConnell's database team





Forest's legacy datasets migrated into corporate database

Step 2: Model Accurate Stream Scenarios

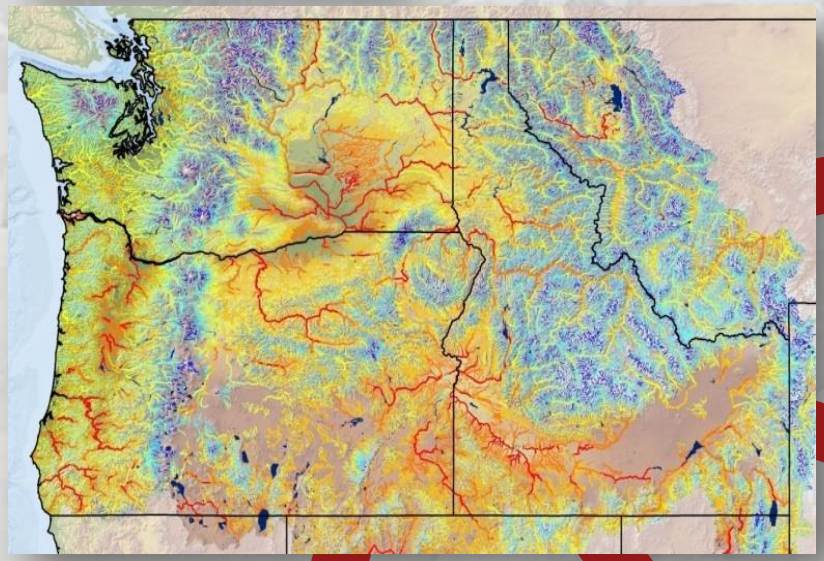


- R^2 = 0.91
- RMSE = 1.0°C
- 750,000 stream km
- 1-km resolution

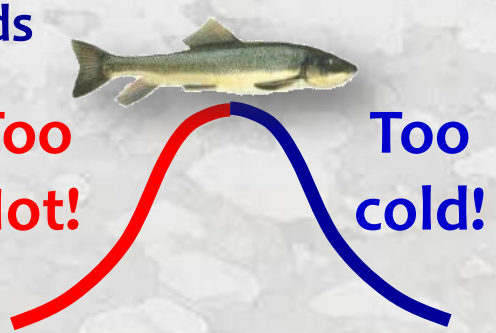
Organic expansion across the West

NorWeST Stream Temp

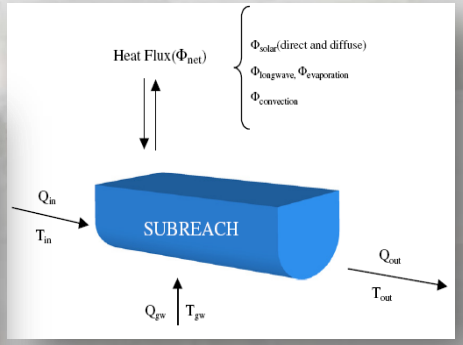
Temperature Applications

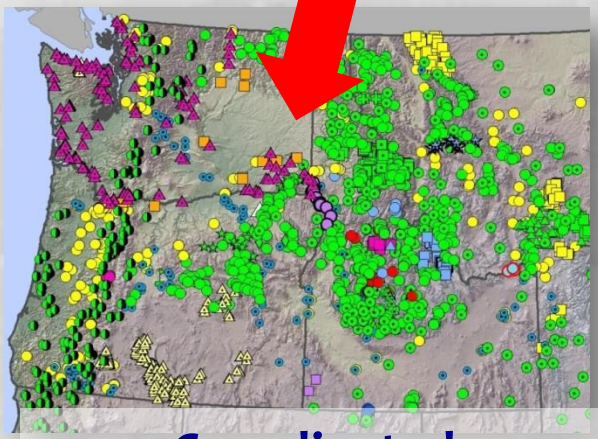


Regulatory temperature standards

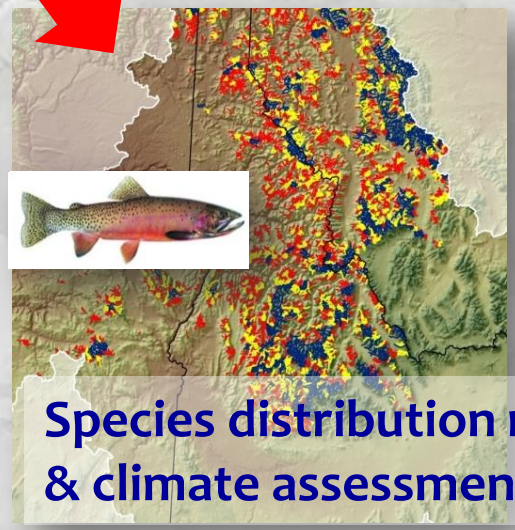


Data access accelerates temperature research





Coordinated Interagency monitoring

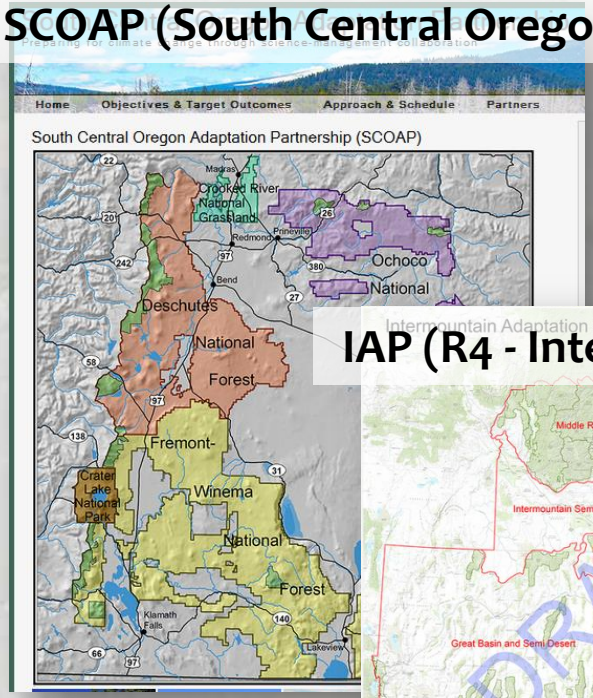


Species distribution models & climate assessments

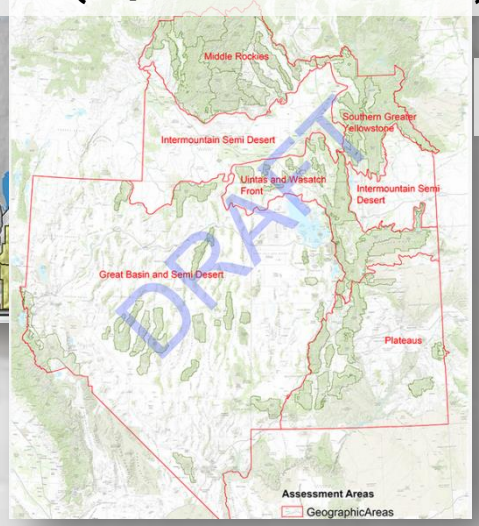
Climate Adaptation Partnerships (Dave Peterson – PNW Research)

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

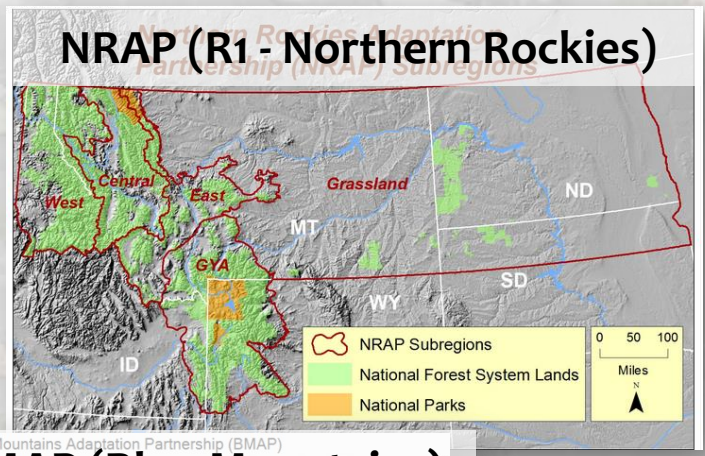
SCOAP (South Central Oregon)



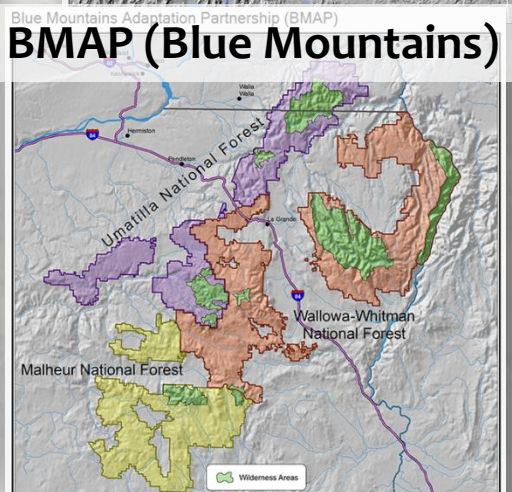
IAP (R4 - Intermountain)



NRAP (R1 - Northern Rockies)

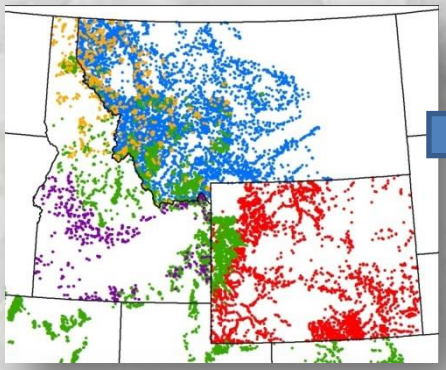


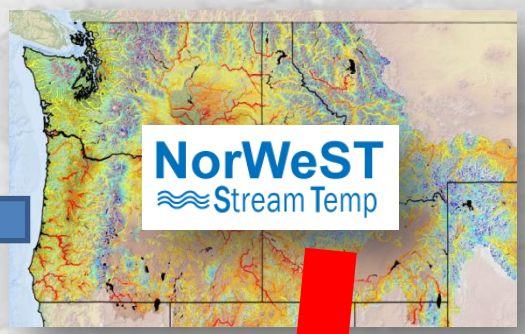
BMAP (Blue Mountains)

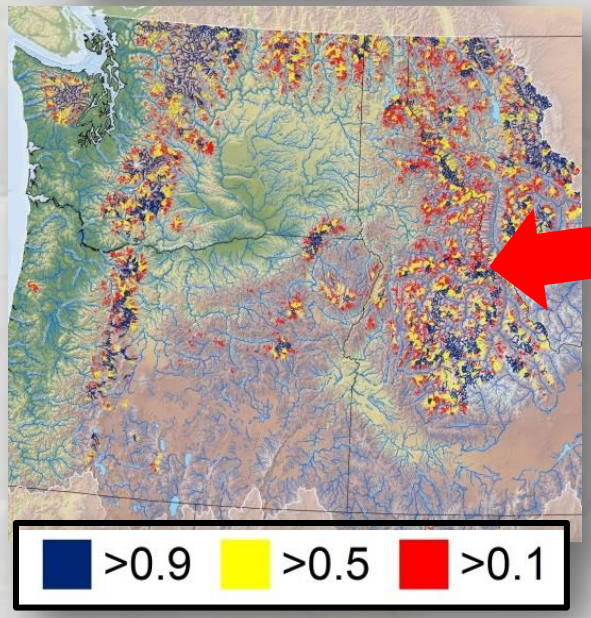


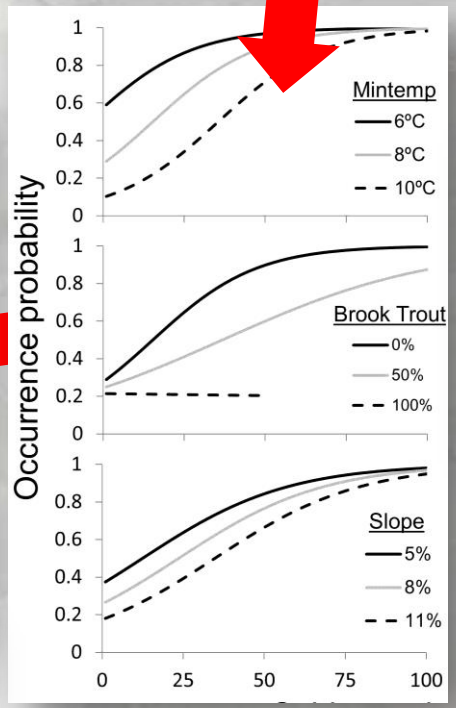
Cold-Water Climate Shield Project (NRAP)

BIG FISH DATA









78% - 85% predictive accuracy in 500+ validation streams

Isaak et al. 2015. The cold-water climate shield: Delineating refugia for preserving salmonids through the 21st Century. *Global Change Biology* **21** doi:10.1111/gcb.12879

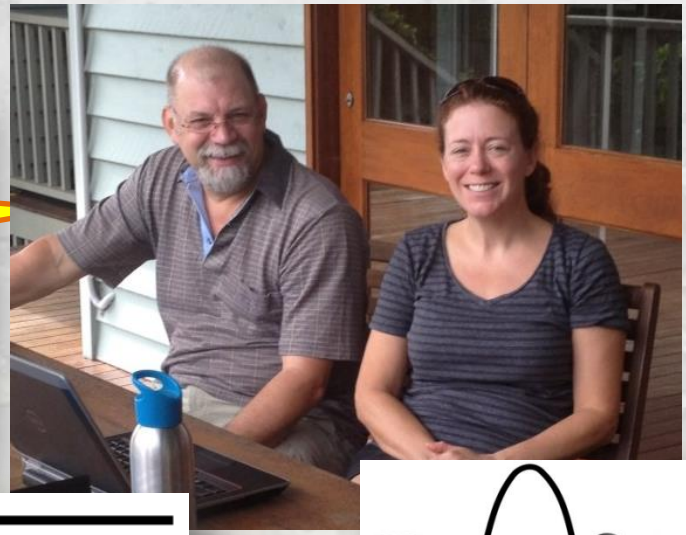
Ongoing Collaboration with Stream Statisticians: Models for Data on Stream Networks…FINALLY!

Environ Ecol Stat (2006) 13:449–464
DOI 10.1007/s10651-006-0022-8

ORIGINAL ARTICLE

Spatial statistical models that use flow and stream distance

Jay M. Ver Hoef · Erin Peterson · David Theobald

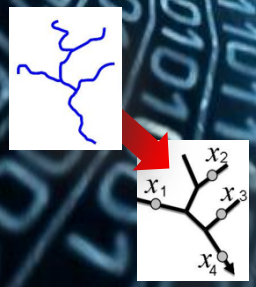


Freeware

Journal of Statistical Software
January 2014, Volume 56, Issue 3. http://www.jstatsoft.org/

SSN: An R Package for Spatial Statistical Modeling on Stream Networks

Jay M. Ver Hoef, NOAA National Marine Mammal Laboratory
Erin E. Peterson, CSIRO, Brisb
David Clifford, CSIRO, Brisbane
Rohan Shah, CSIRO, Brisbane



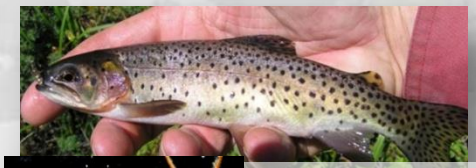
Functional Linkage of Watersheds and Streams (FLoWS)

- ArcGIS Geoprocessing Toolbox written in Python v2.5 for ArcGIS v
- Developed by Dr. Dave Theobald and John Norman at Colorado St

STARMAP
Space-Time Aquatic Resources Modeling and Analysis Program

EPA

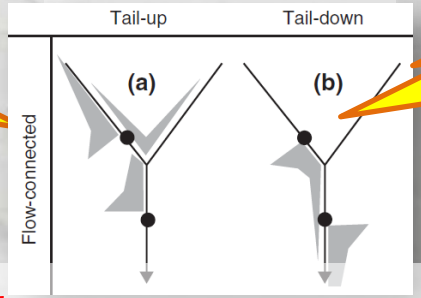
Stream Models are Generalizable…



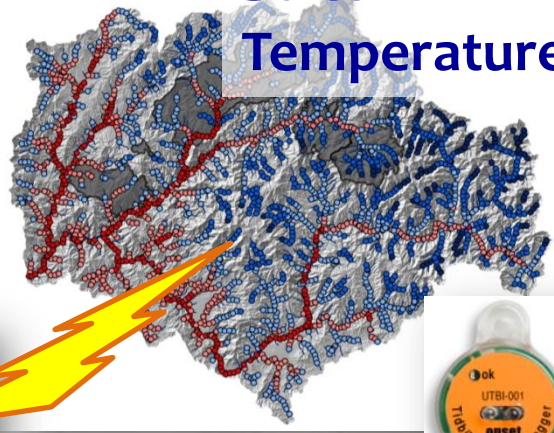
Distribution & abundance

Response Metrics

- Gaussian
- Poissan
- Binomial

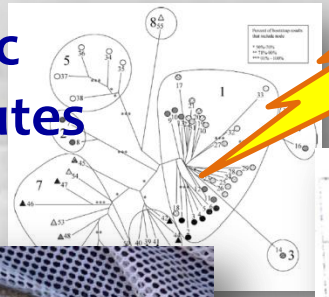


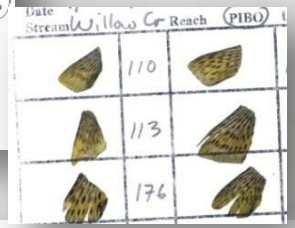
Stream Temperature

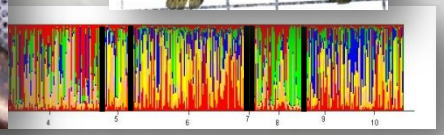


Statistical stream models

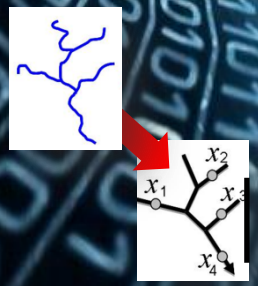
Genetic Attributes







Water Quality Parameters



Annual Stream Statistics Training Workshops in Boise (4th in Spring 2016)

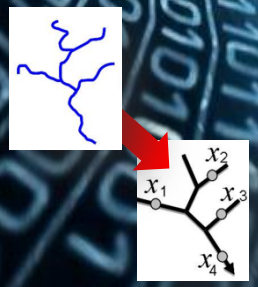
100 participants

~5 year waiting list…

3 day workshop

1st day: overview of spatial stream models (webinar)

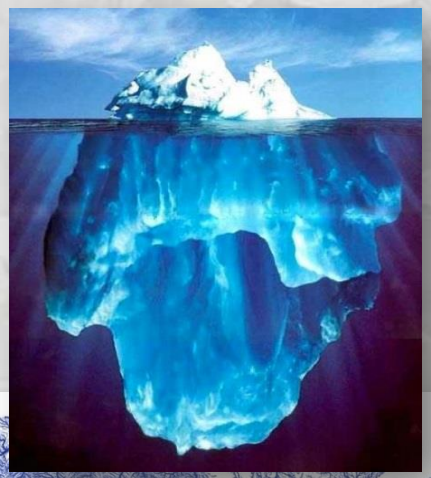
2nd/3rd days: work 1-on-1 with Jay/Erin to model your data

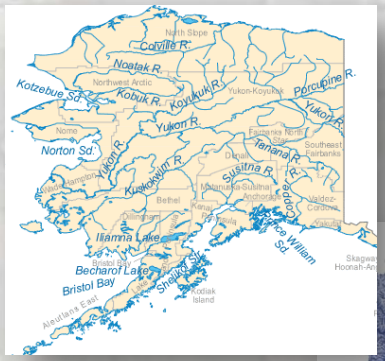


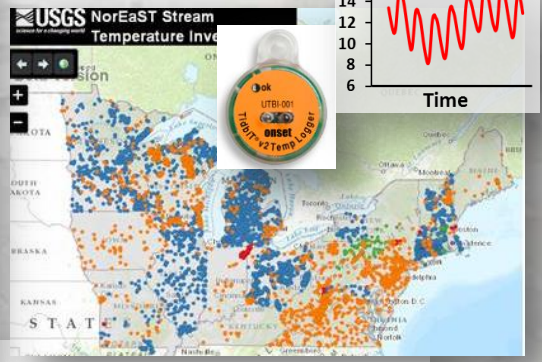
The National Stream Internet Project

BIG DATA = BIG POSSIBILITIES

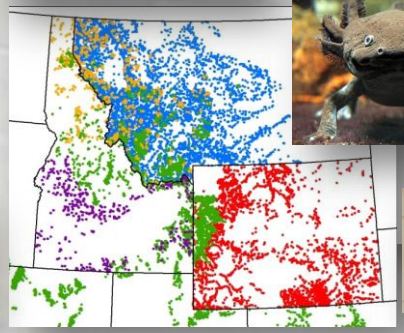
LANDSCAPE CONSERVATION COOPERATIVES

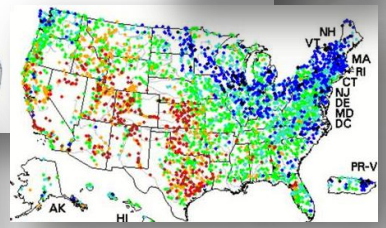


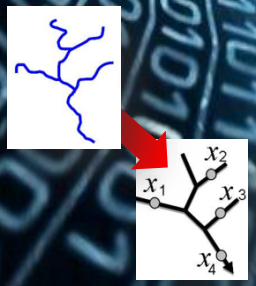




There are only 4,000,000 stream kilometers

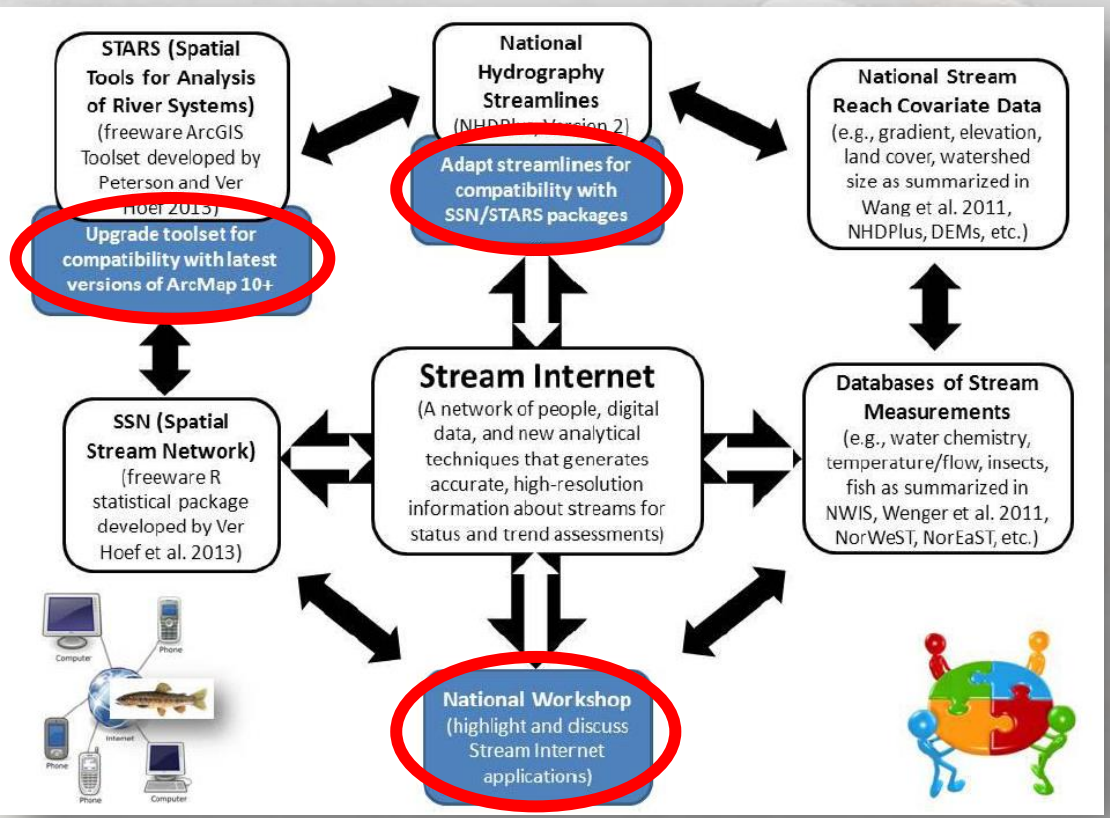


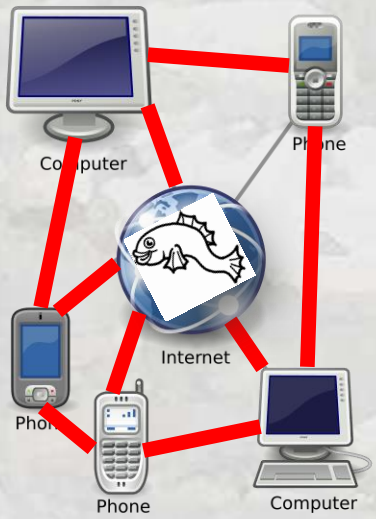




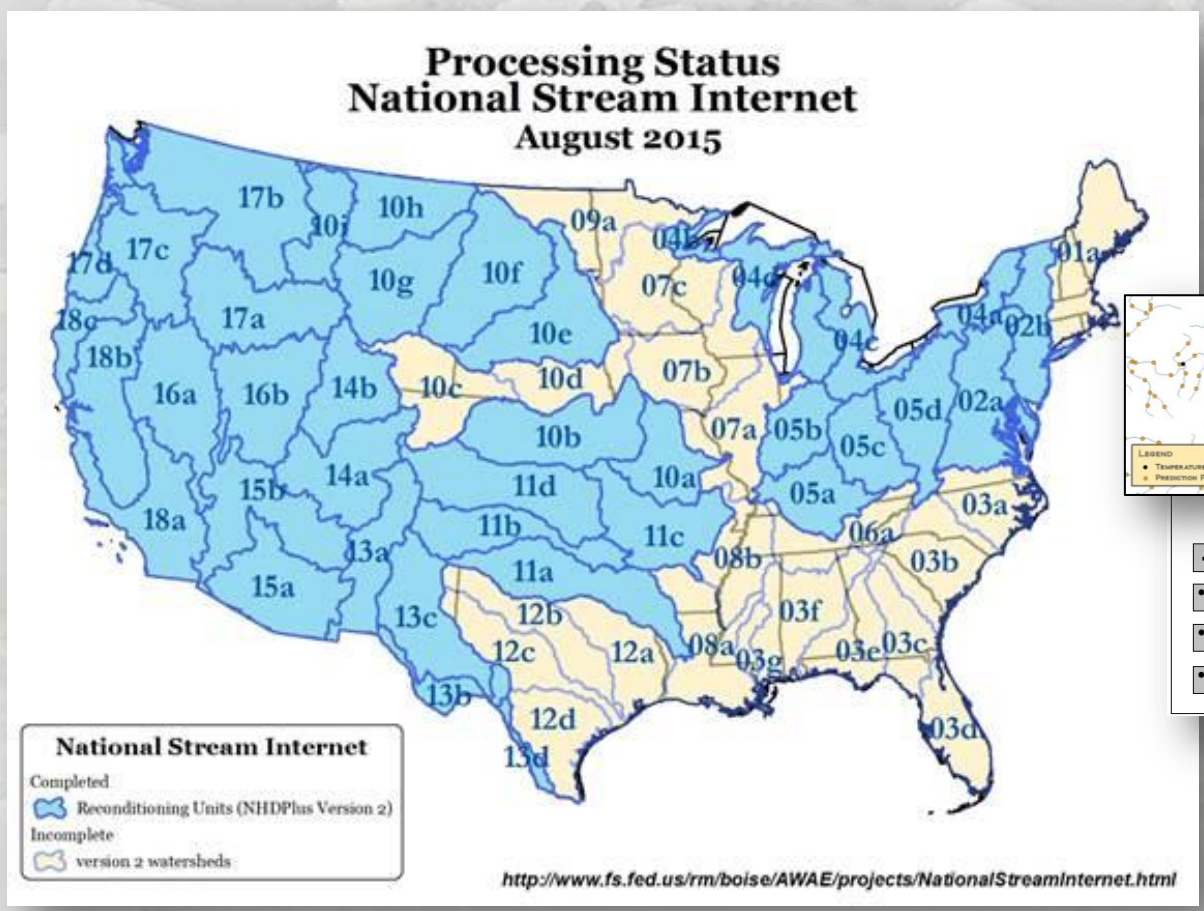
Stream Internet Project Tasks

1) Develop compatibility between spatial stream analysis tools and NHDPlus national hydrology database
2) Update STARS stream analysis tools to ArcMap 10.2
3) Host a workshop to brainstorm about possibilities that new analyses & databases provide to address key questions & information needs

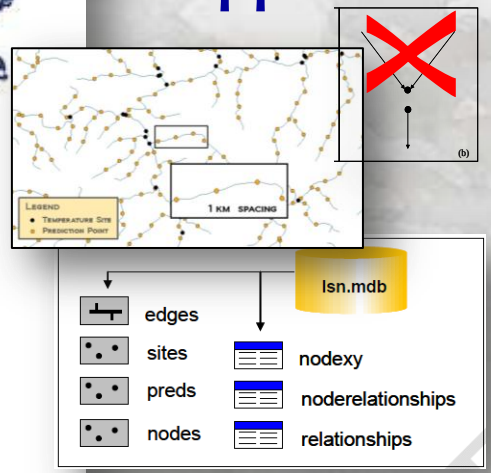




Stream Internet Processing Status



Geotechnical protocols applied



Coordinated with:

NHDPlus

EPA

USGS science for a changing world

NATIONAL FISH HABITAT PARTNERSHIP

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

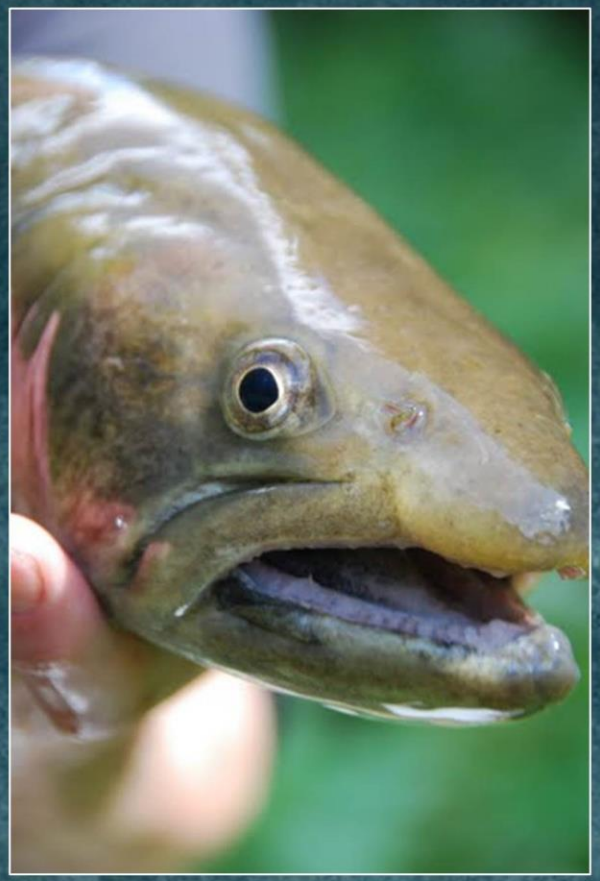
Michael Young, Kevin McKelvey, Michael Schwartz, Dan Isaak, Kellie Carim, Taylor Wilcox, Katie Zarn, Kristy Pilgrim, Dona Horan, Sherry Wollrab

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

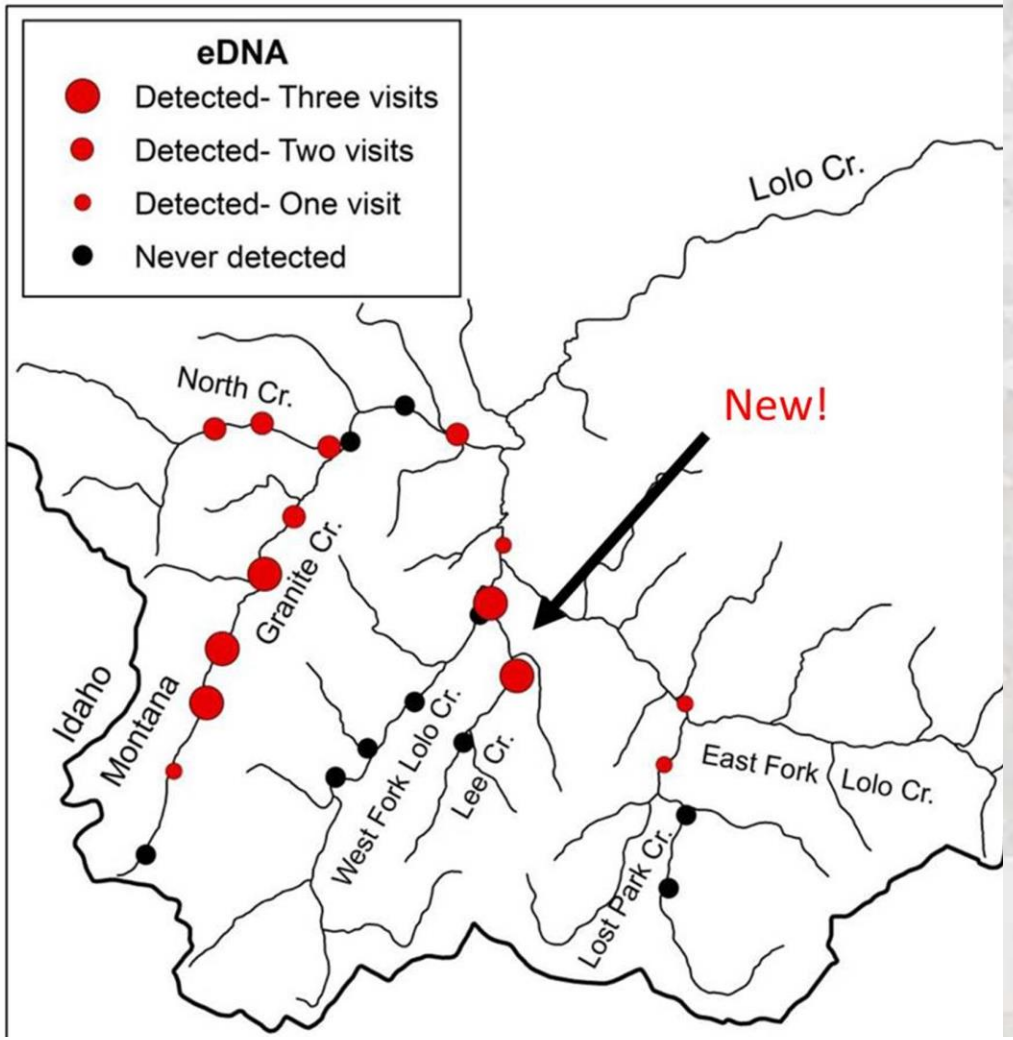
Forest Service Research & Development
National Genomics Center for Wildlife & Fish Conservation

Rocky Mountain Research Station

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

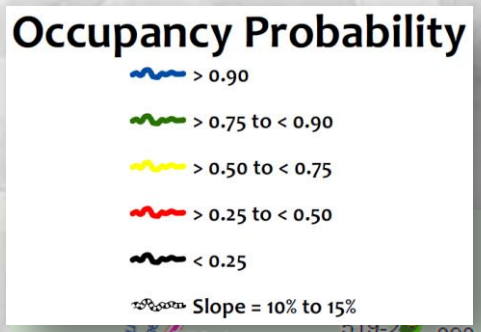


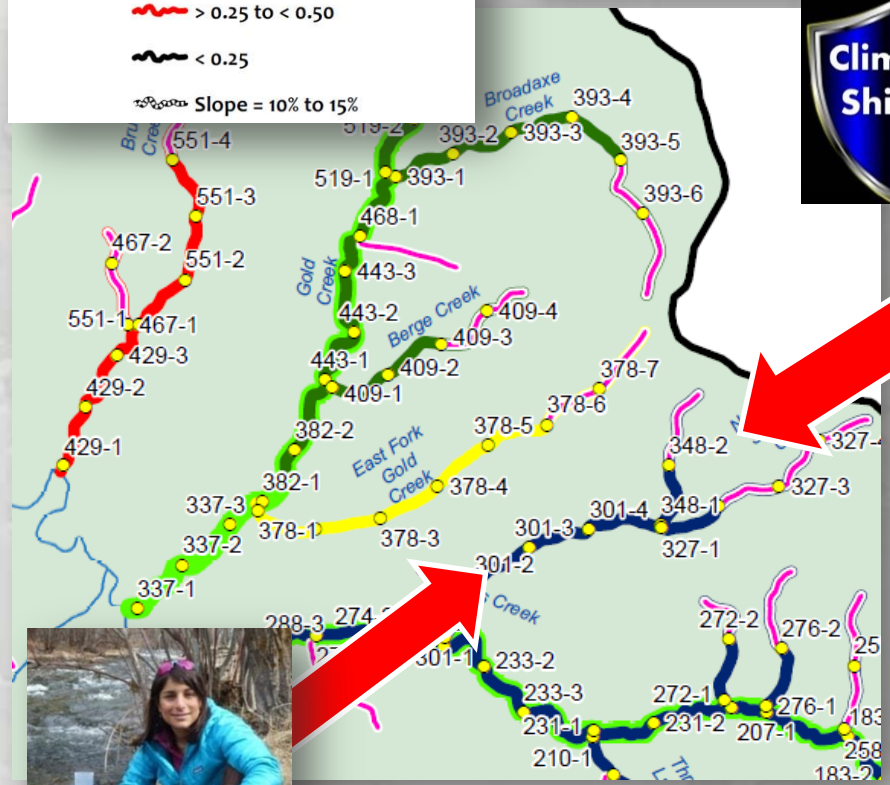
Carim et al. 2014. Protocol for collecting eDNA samples from streams. Version 1.5. USDA Forest Service, Rocky Mountain Research Station, Missoula, MT. 12 p.

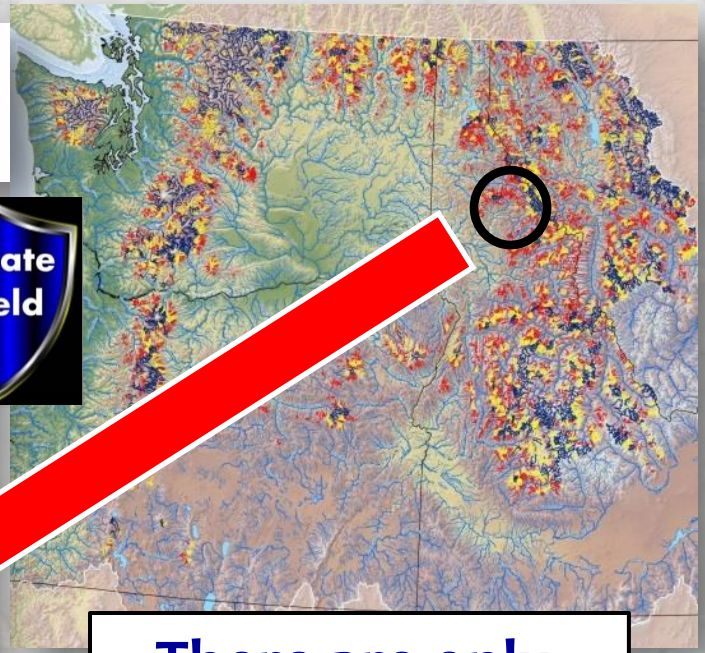
McKelvey et al. In review. Sampling large geographic areas for rare species using eDNA: a preliminary study of bull trout occupancy in western Montana.

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

Combine eDNA sampling with Precise Predictions from Climate Shield Model







Climate Shield

There are only…

5,332 >0.1 habitats

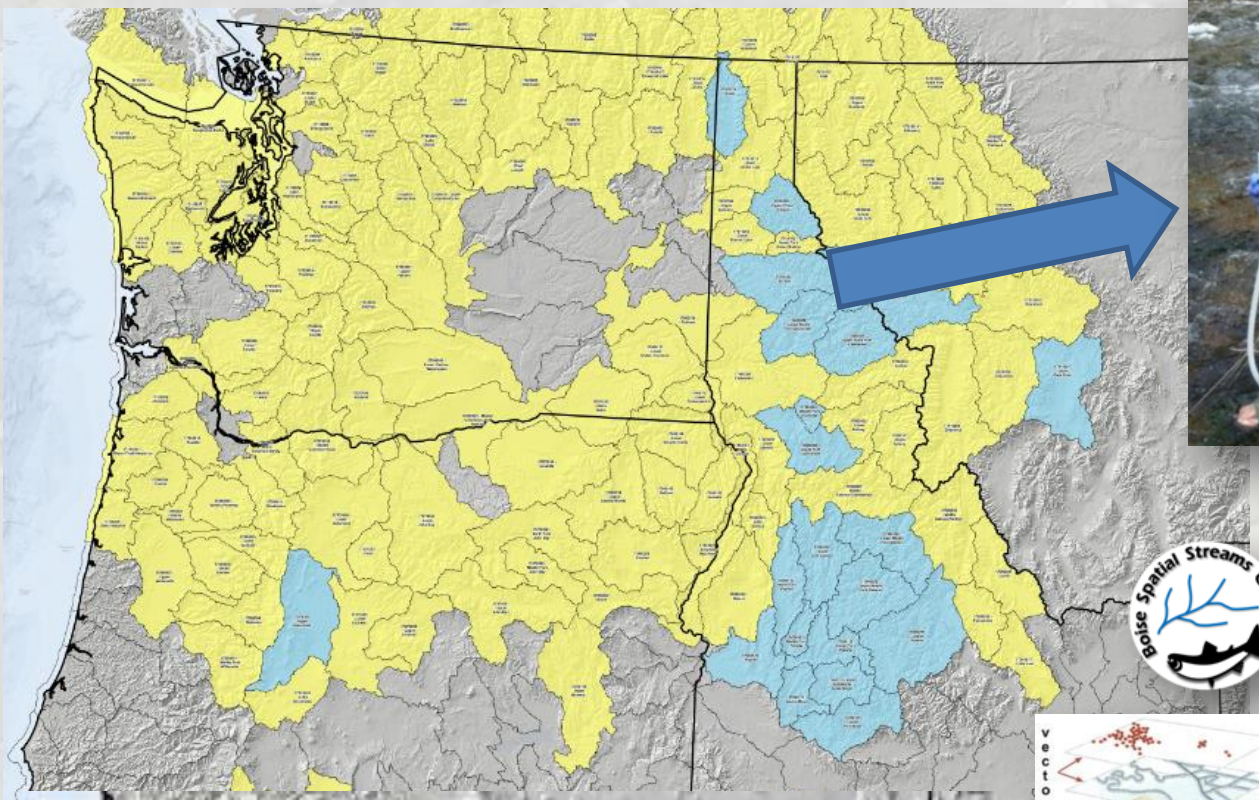
1,325 >0.5 habitats

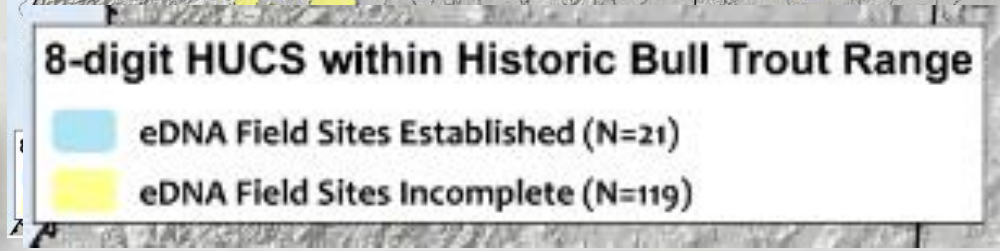
348 >0.9 habitats

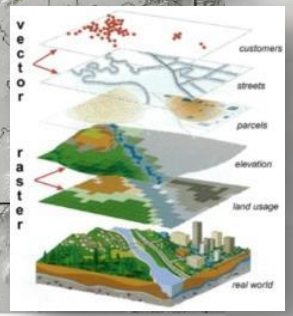
Target samples to resolve greatest uncertainty

Summers of 2015-2018: Industrial scale field sampling campaigns by FS & partner agencies

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





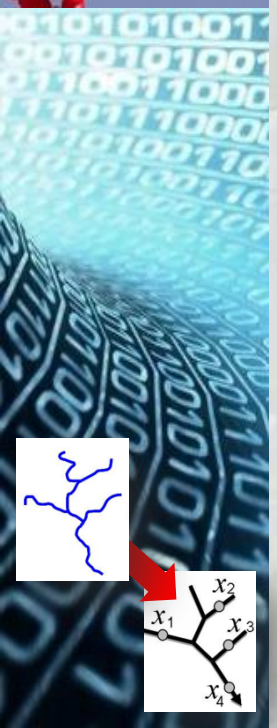


Boise Spatial Streams Group

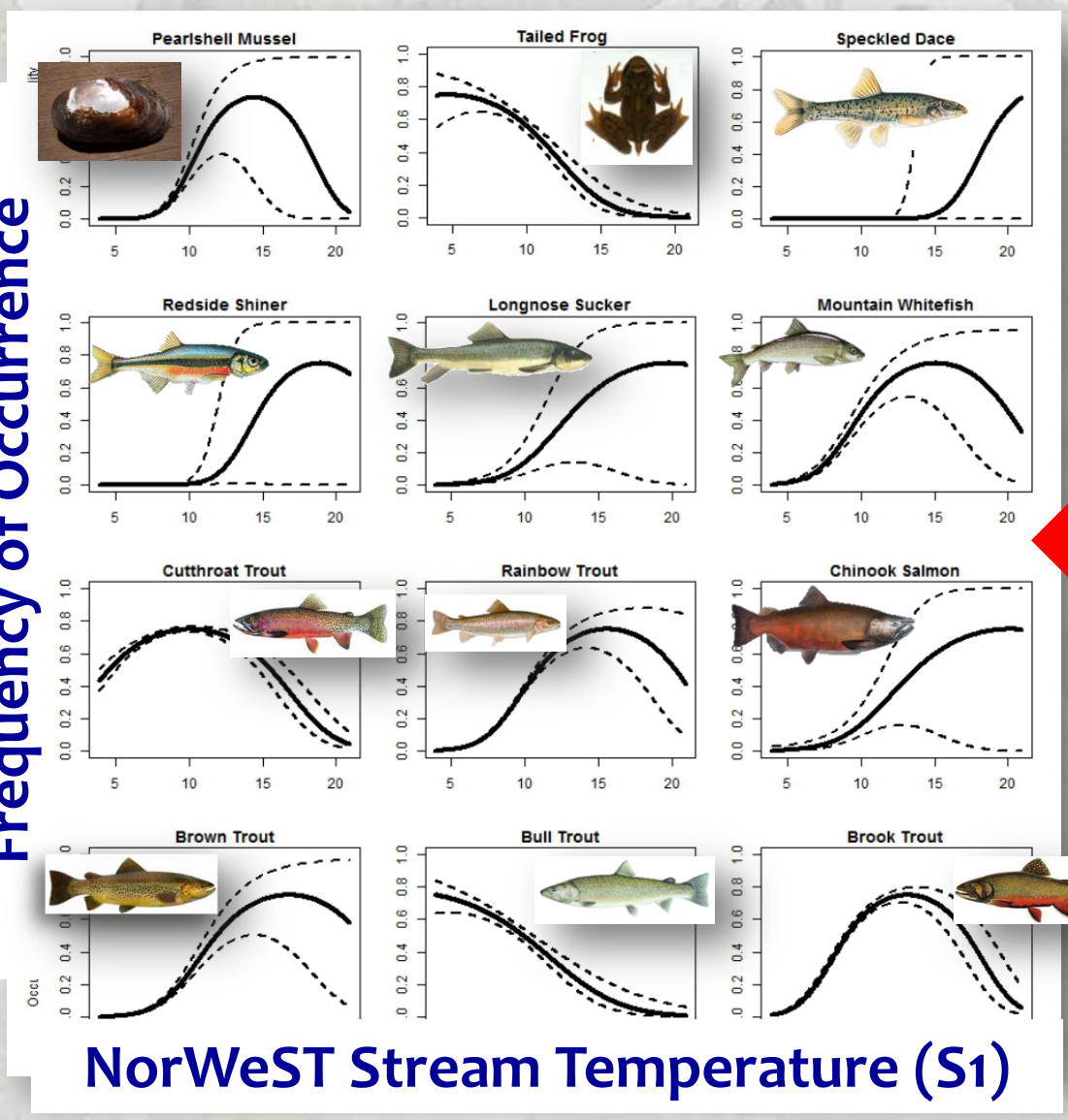
NGC

ORACLE DATABASE

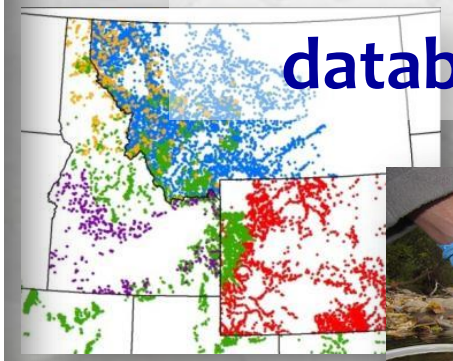
Bull trout samples contain eDNA for other critters to provide future biodiversity archive



Goal: Empower people with tools to develop high-resolution distribution/abundance/genetic information for all aquatic life…

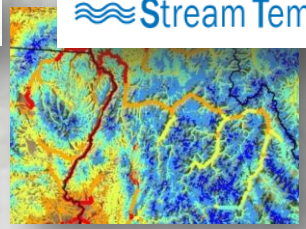


BIG biological databases



Geotechnical & analytical processing

NorWeST Stream Temp



SSN

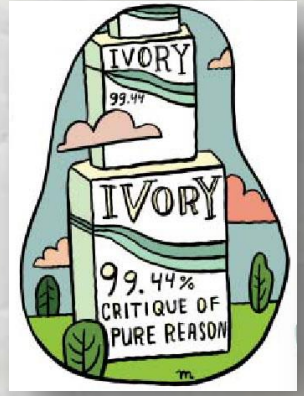
Climate Shield

e.g., Wenger et al. *In Review.* ***Diversity & Distributions***

Create a "Virtuous Cycle" of Information Creation

Many stakeholders

"Boots-on-the-Ground"

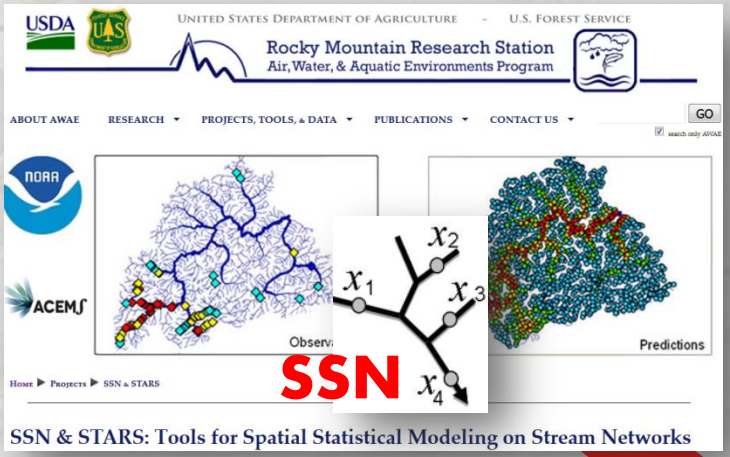


Research develops databases & relevant information

Mountains of data

Websites & Digital Media Distribute Information in Useful, User-friendly Formats (GIS databases, software, digital maps, manuscripts, videos, etc…

>35,000 web-visits/year & rapidly growing user bases



Locations of recent website visits