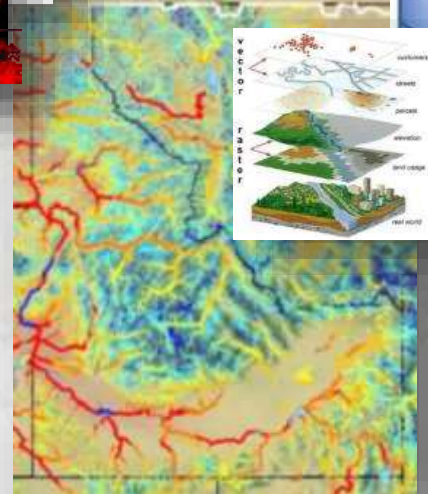
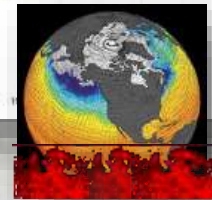
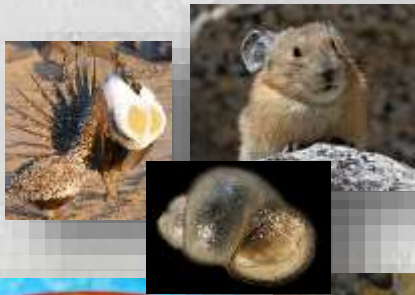
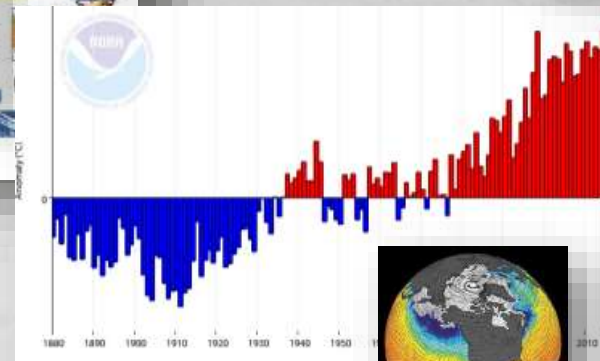
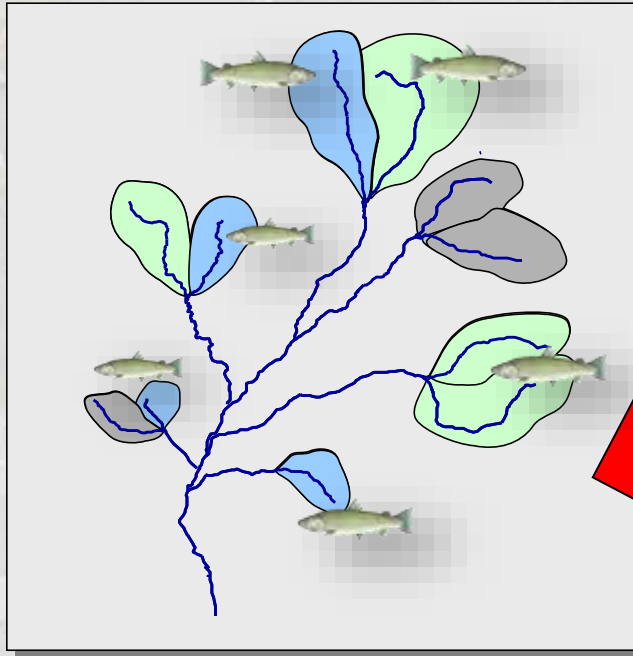


Using Big Interagency Databases to Identify Climate Refugia for Idaho's Species of Concern

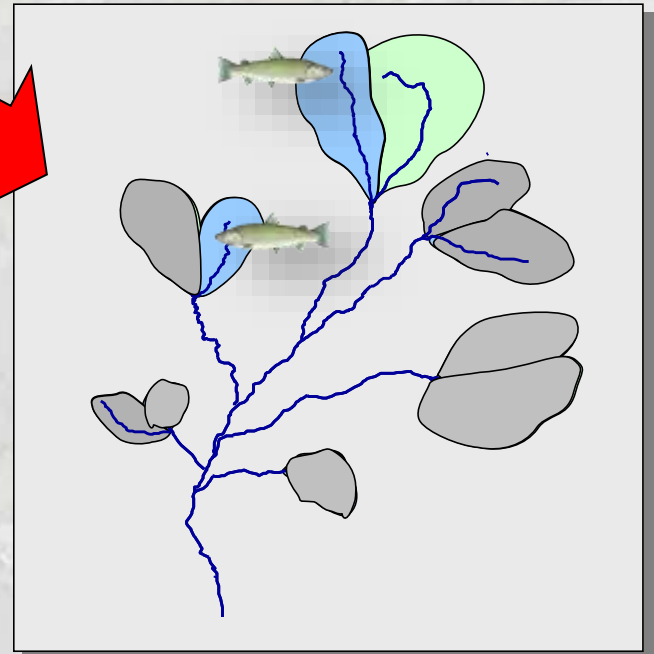


What is a Climate Refugia?

“...habitat that supports a locally reproducing population [or key life history stage] and has a high probability of doing so late this century”



Late century



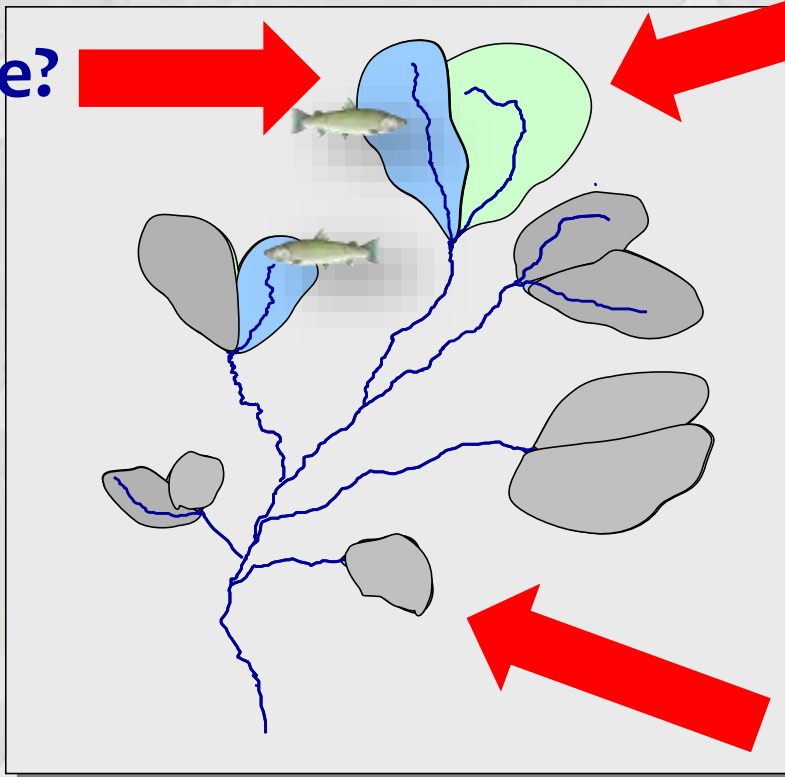
Identifying Refugia Facilitates Climate-Smart Planning & Conservation Investing

Late century

Invest here?



Or here?



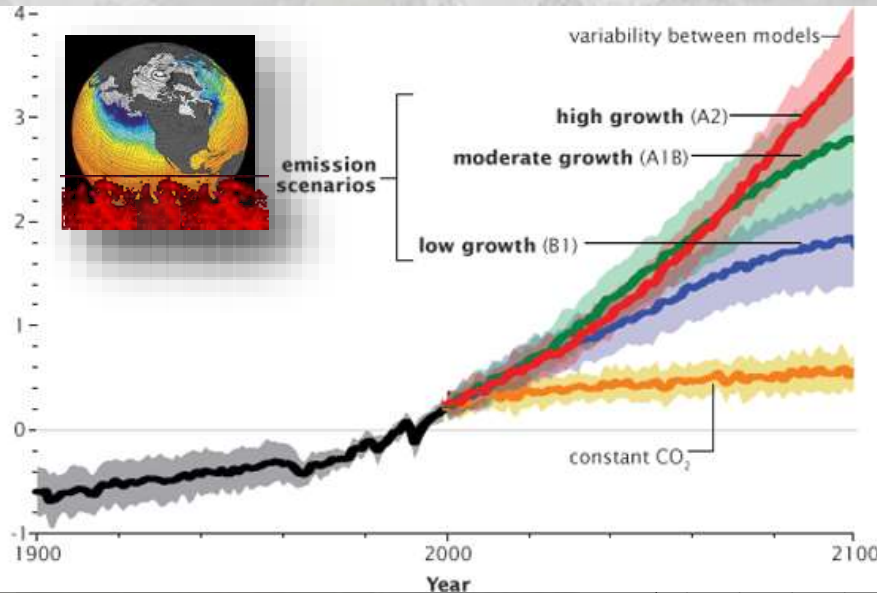
Invest here?



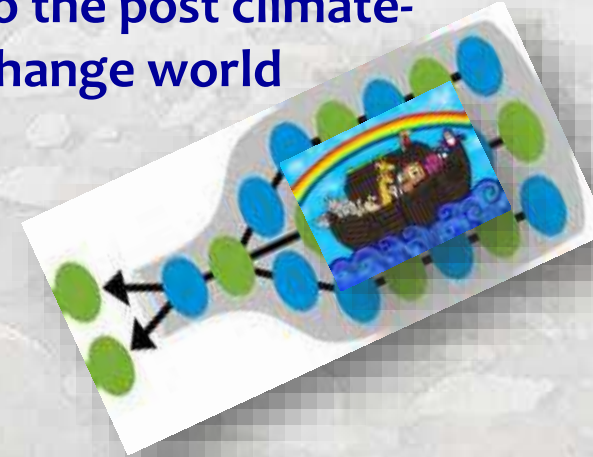
Identifying refugia may also allay fears of species extinction

21st Century – View it as a Bottle-Neck

Global temperature

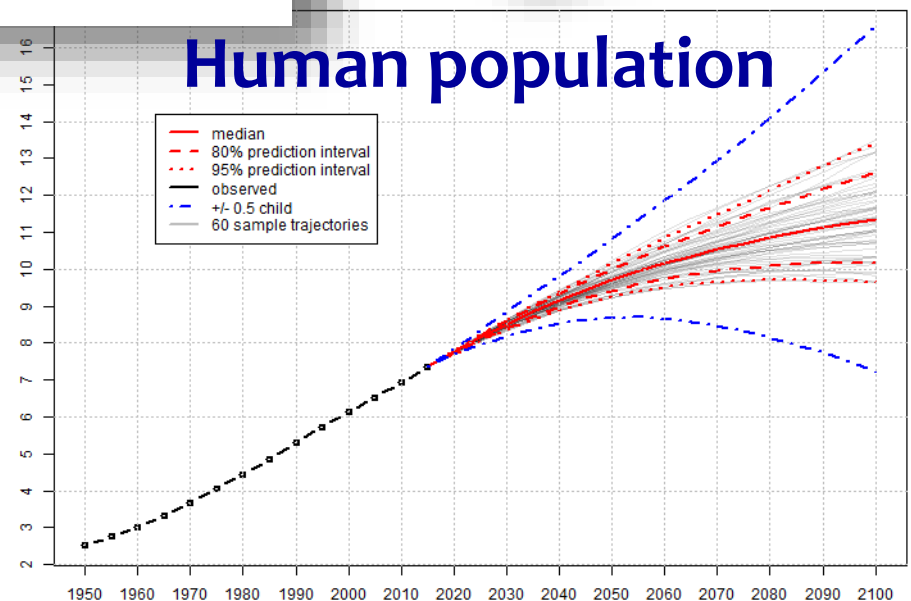


Refugia help navigate to the post climate-change world



Billions

Human population



Source: United Nations, Department of Economic and Social Affairs, Population Division (2015).
World Population Prospects: The 2015 Revision. <http://esa.un.org/unpd/wpp/>

Operationalizing refugia concept requires:

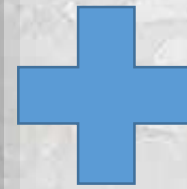
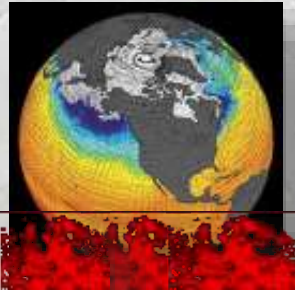
- 1) Ecological knowledge
- 2) Current status assessment of habitat conditions & population distributions
- 3) Climate scenarios of broad extent and fine resolution
- 4) Species distribution models built from #1, #2, & #3
- 5) Engagement of a conservation community that collectively acts on the information

Data & Models



Climate-Flagship-Umbrella Species

a.k.a. the “mules” of biodiversity conservation



- 1) Societally important (funding is possible)
- 2) Initially constrains the problem to something manageable
- 3) Database & model infrastructure for one species can be recycled for many species

Climate Boogeyman



Carpe diem!

1) Grant Funding



2) New technologies

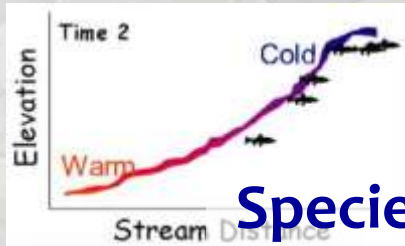


3) Interagency Coordination

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



Many Agencies Collect Similar Types of Data with Similar Protocols...



A Watershed-Scale Monitoring Protocol for Bull Trout

Dan Isaak, Bruce Rieman, and Dona Horan

Species distribution & abundance

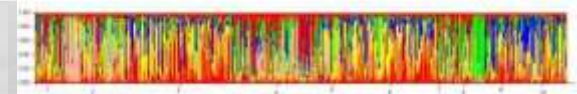


Stream discharge

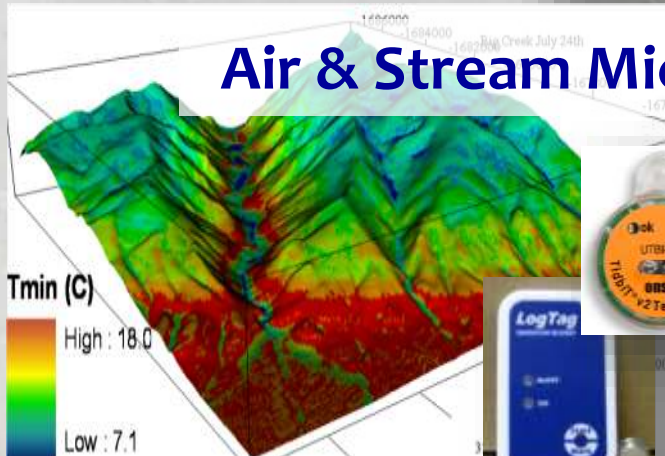


Tissue Samples & DNA barcoding

Depth	UTM E	UTM N	Zone	Q
110	145	120	18	13.0
115	147	125	18	18.0
		125	18	19.0
		121	18	21.0
			18	22.0



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. Wolrab



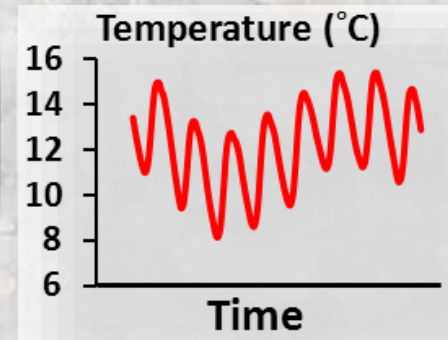
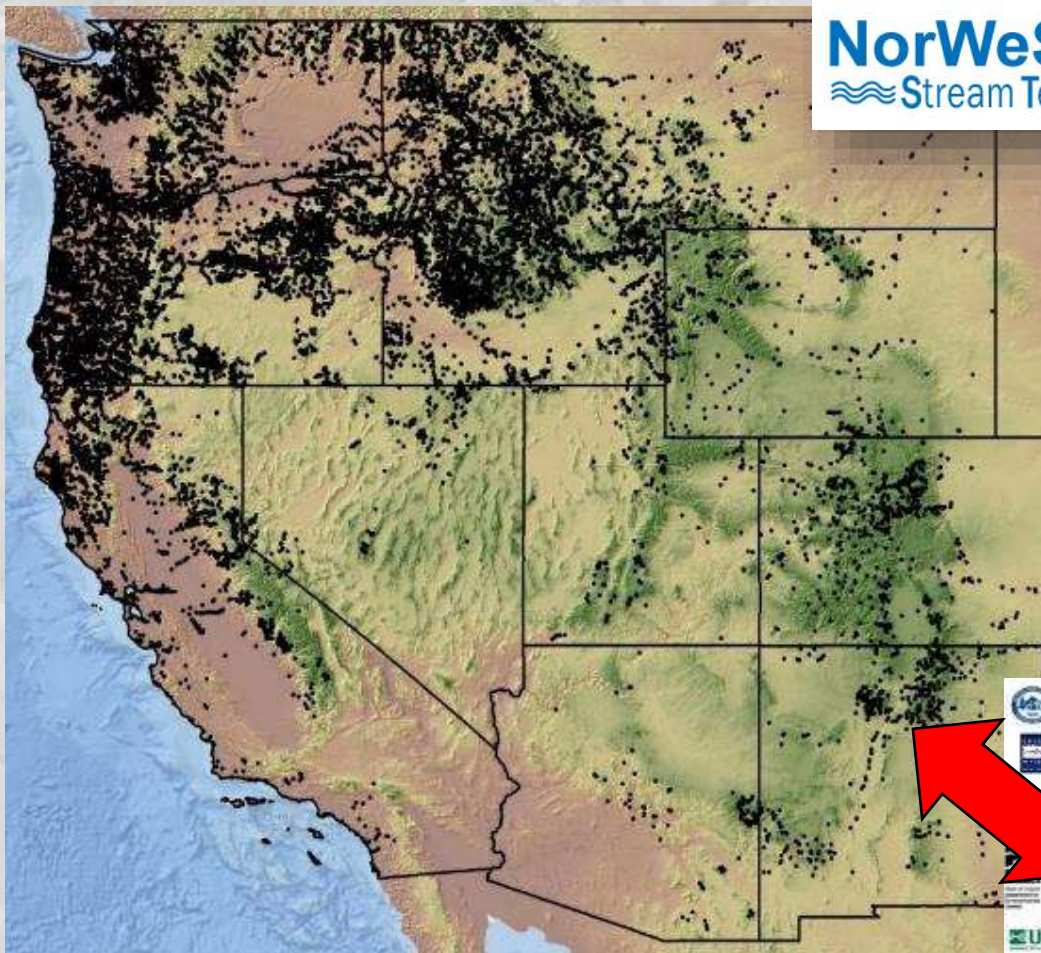
Short communication

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

Zachary A. Holden^{a,*}, Anna E. Klene^b, Robert F. Keefe^c, Gretchen G. Moisen^d

Huge Amounts of Data Already Exist

Western stream temperature sites



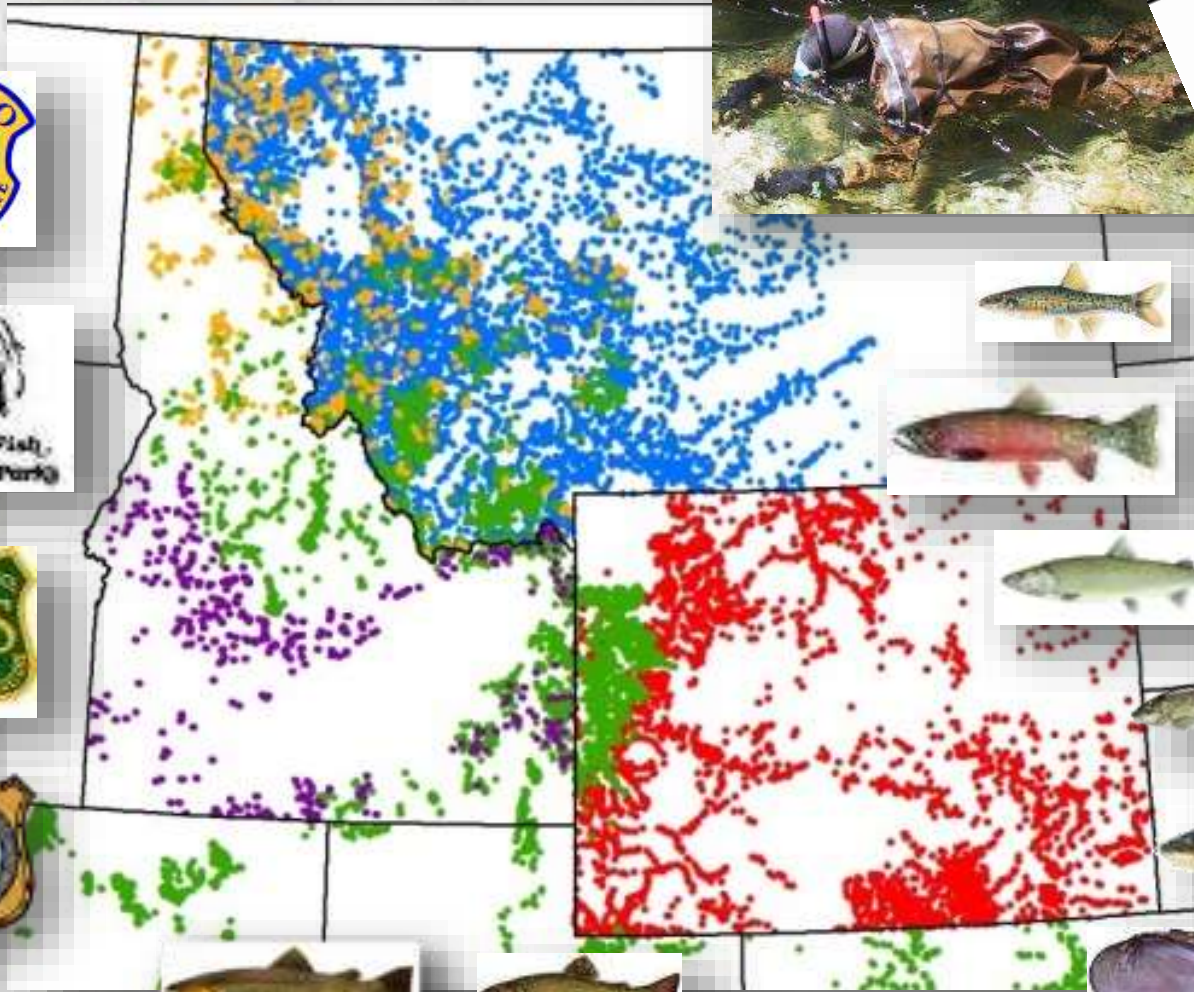
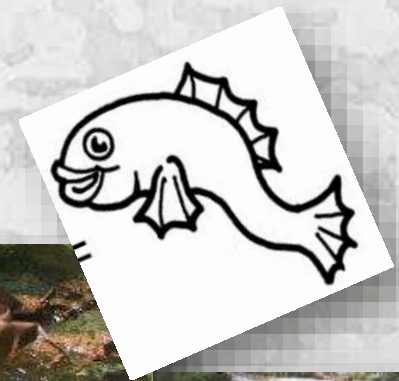
>100 agencies

>200,000,000 hourly records
>20,000 unique stream sites

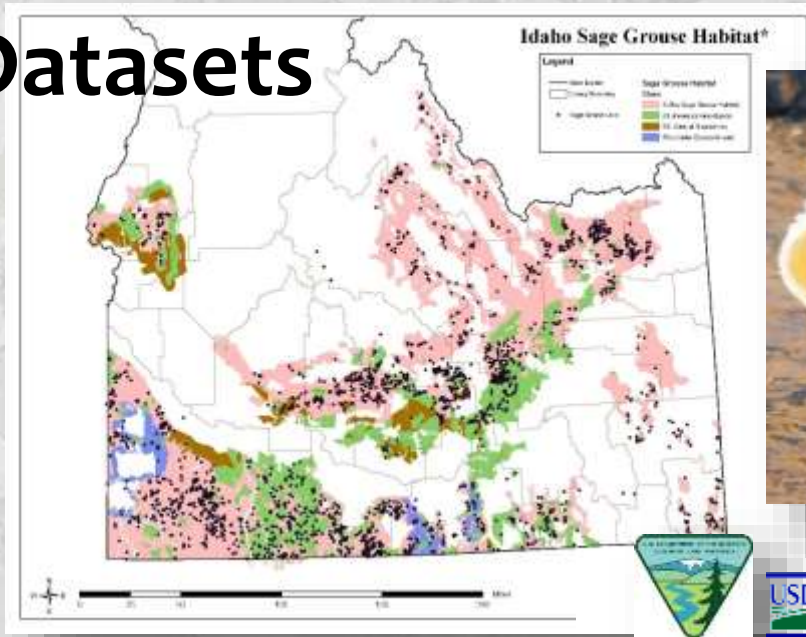


BIG FISH Datasets

>20,000 fish sample sites



BIG BIRD Datasets

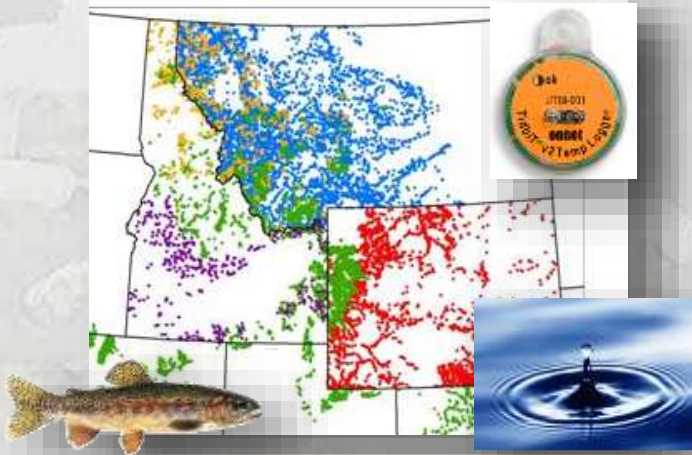


USGS BISON (Biodiversity Information Serving our Nation)
260,000,000 species occurrence records

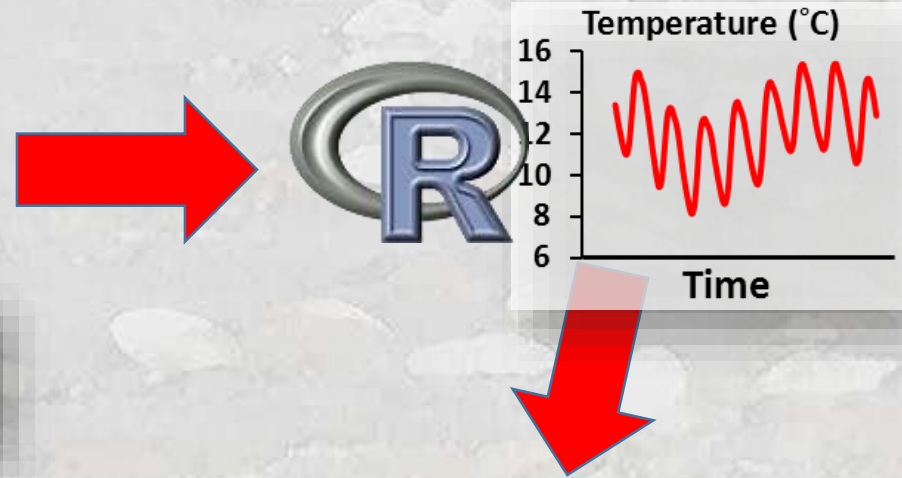


Data ≠ Database

Data Aggregation



QA/QC Data Cleaning



Metadata & digital archiving in user-friendly formats

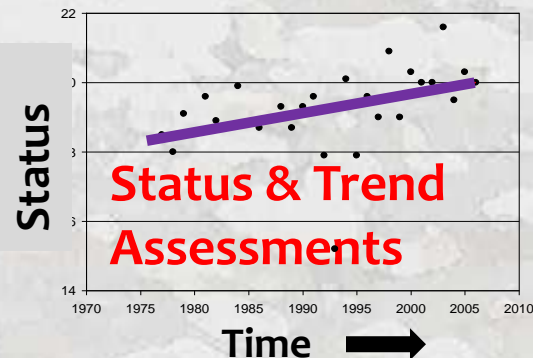
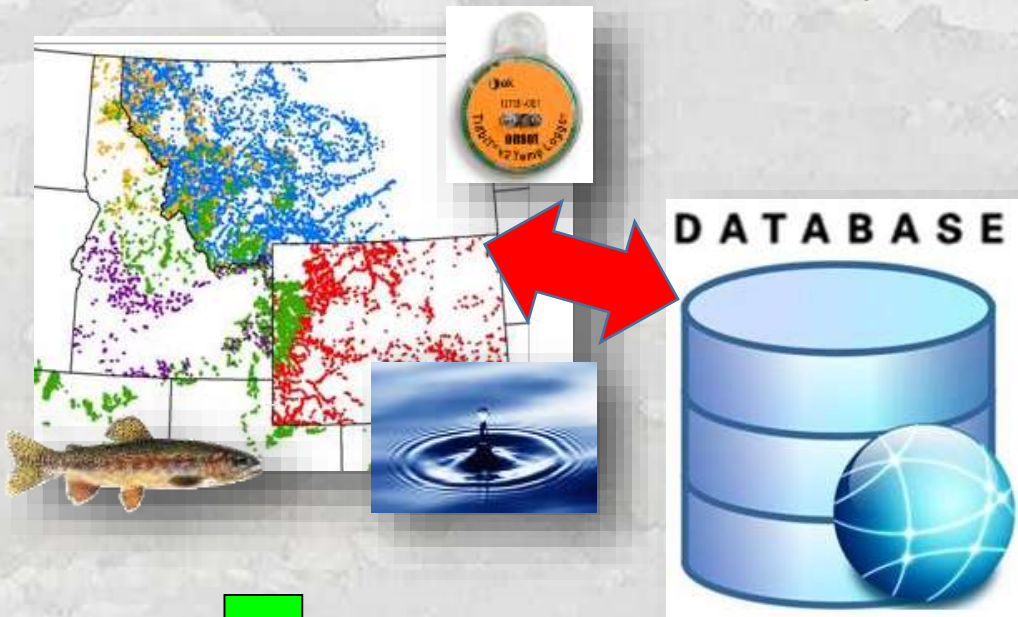


Data table structures & summaries

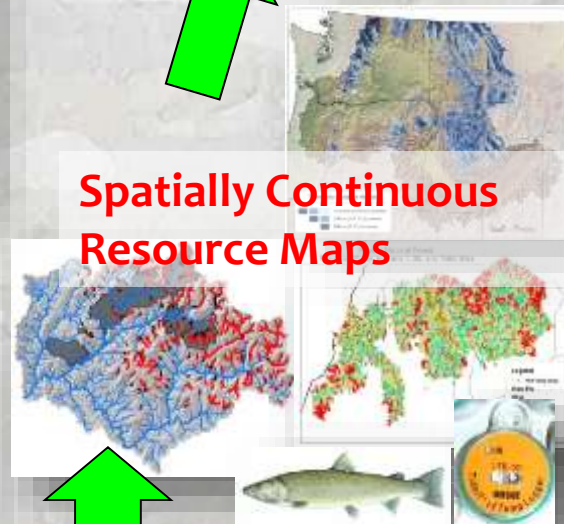
A blue database icon with a globe on top, labeled 'DATABASE'.

	A	B	C
1			
2	Stream:	Elk Creek	
3	Georeference:	610234 E, 4402546 W	
4			
5	Date	Time	Temp (°C)
6	7/15/2005	21:23	15.58
7	7/15/2005	21:53	15.11
8	7/15/2005	22:23	14.64
9	7/15/2005	22:53	14.32
10	7/15/2005	23:23	13.86
11	7/15/2005	23:53	13.55
12	7/16/2005	0:23	13.24

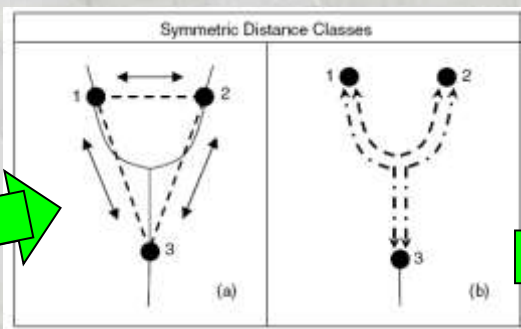
Databases Enable Efficient Queries, Summaries & Analyses



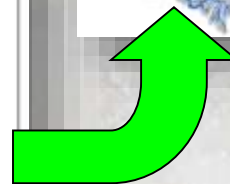
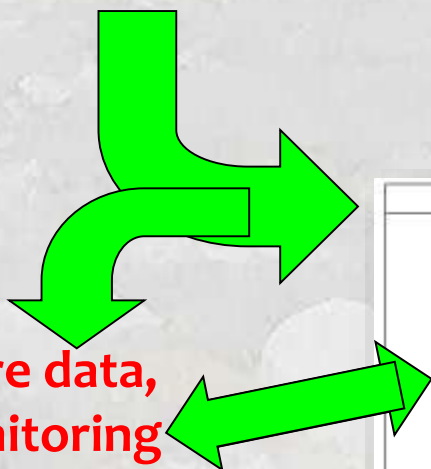
Spatially Continuous Resource Maps



Analysis



**More data,
monitoring
design**

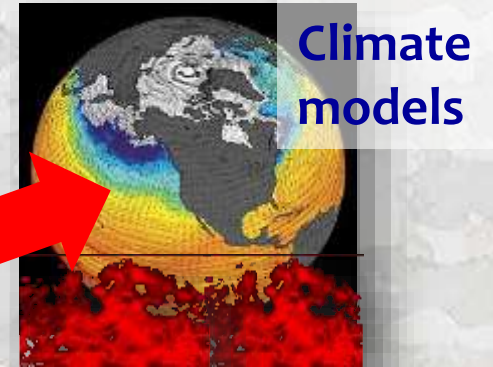
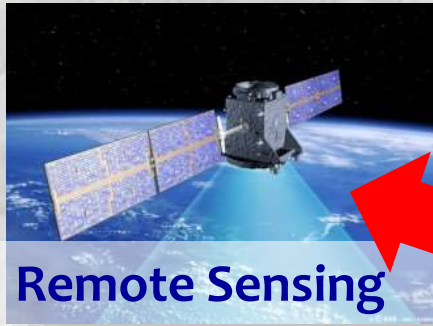


Creating & Maintaining Big Databases Are Full-Time Jobs for Technical Teams



Technology = Force Multiplier

Accurate models translated to “Real-World” Coordinates



GIS & Computing Capacity

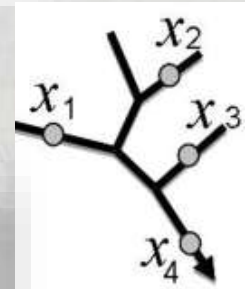
Miniature sensors



Nationally Geospatial Frameworks

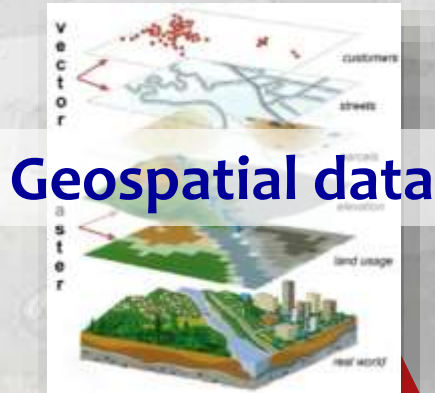


Spatial analyses



Technology = Force Multiplier

Information Dissemination & User-Communities



Email chat
& BLOGs



Workshops



Publication



Digitalmedia



**Conservation
Plans**

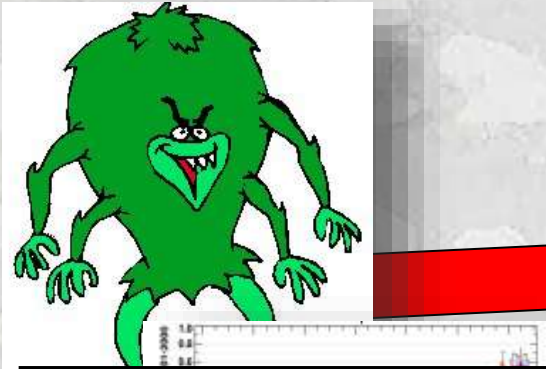
USDA United States
Department of
Agriculture

Forest Service
Northern Region
 March 2007

Land Management Plan
Clearwater National Forest

Real Fish-World Examples

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



**\$30 Billion on Fish & Wildlife
Recovery Efforts in PNW Since 1980**

Land Use & Water Development



ESA Listed Species



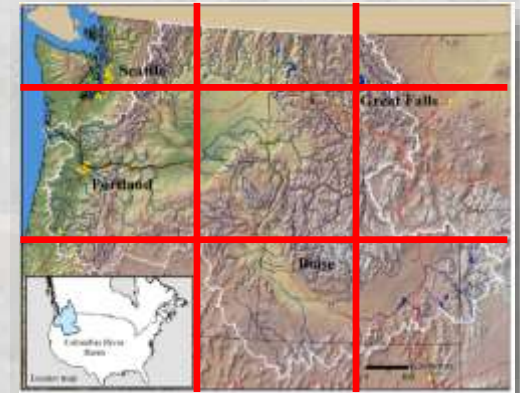
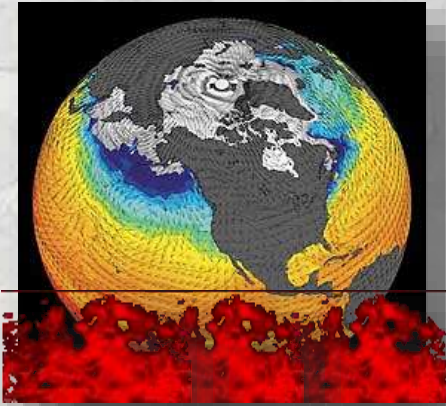
Need: High-Resolution Stream Scenarios

Global climate models

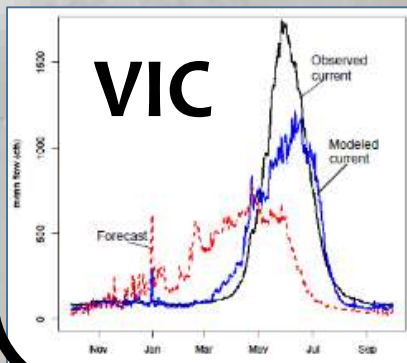
Resolution: 1000's of kilometers

Regional patterns

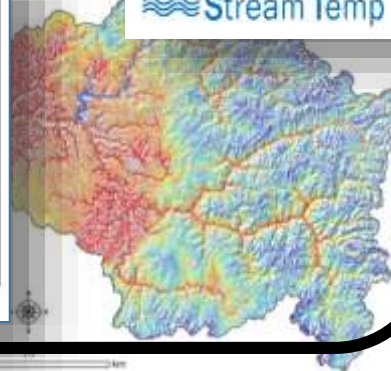
Resolution: 100's of kilometers



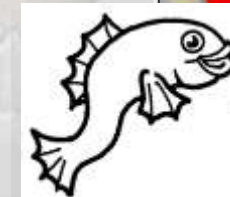
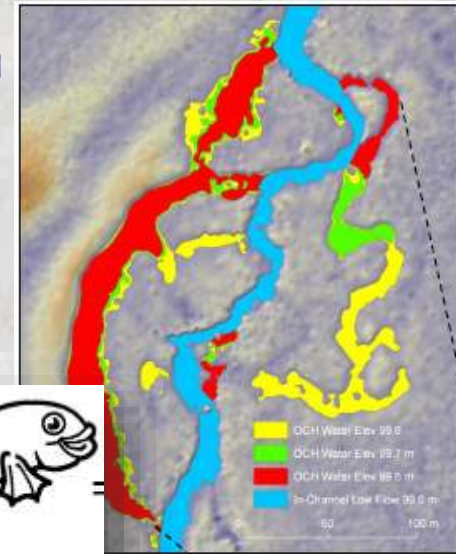
River network
temperature & flow



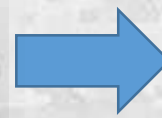
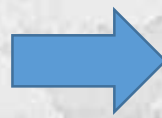
NorWeST
Stream Temp



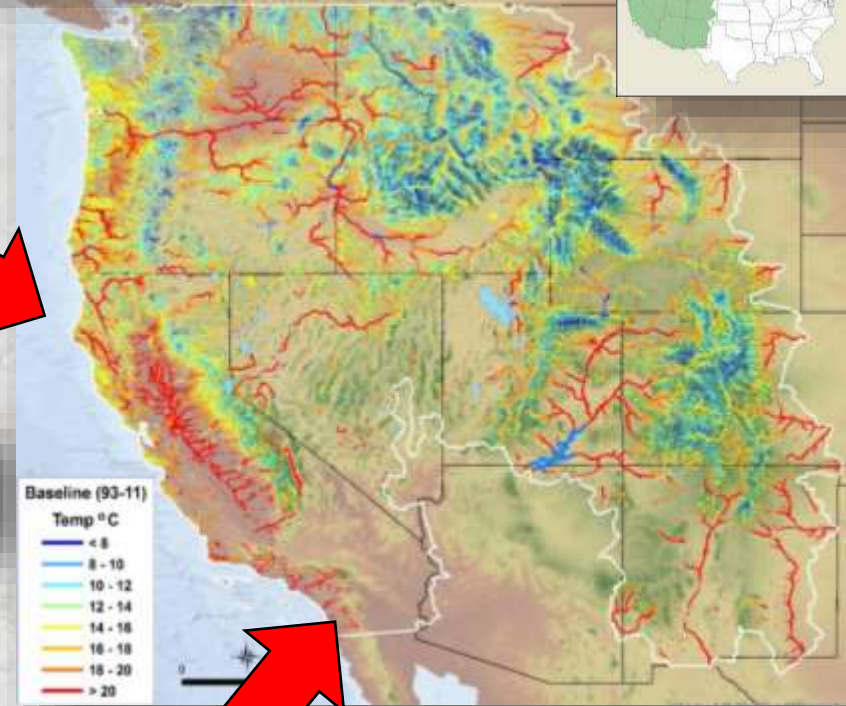
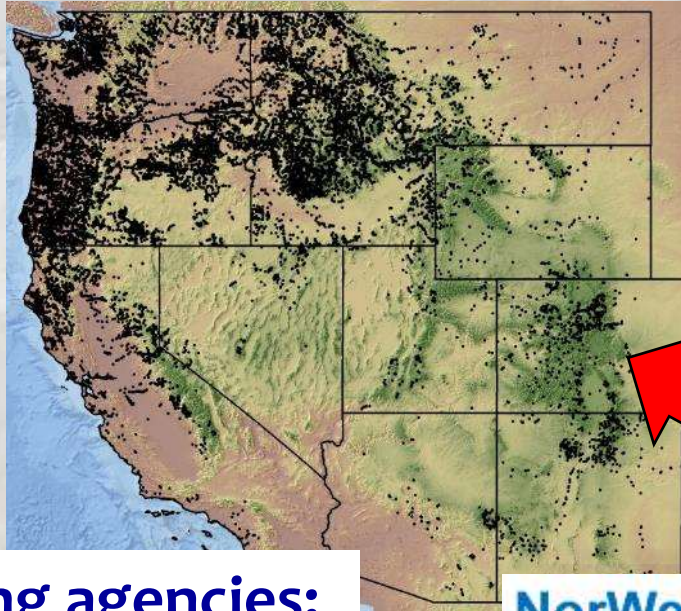
Stream
reach



Aggregate Data

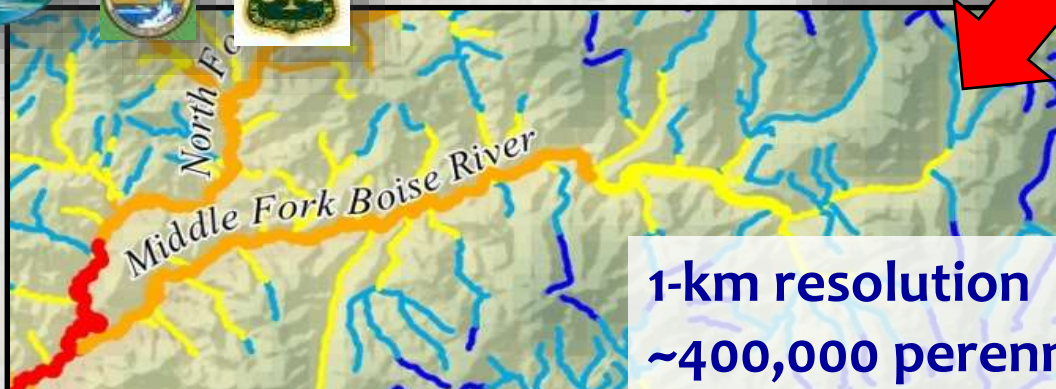


High-resolution Climate Scenarios



Funding agencies:

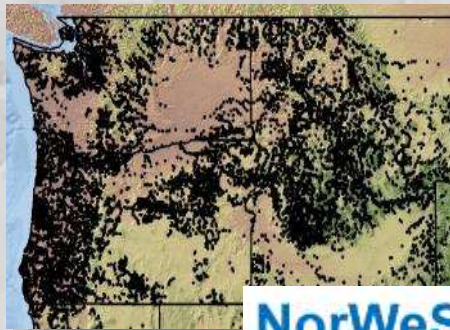
NorWeST Stream Temp



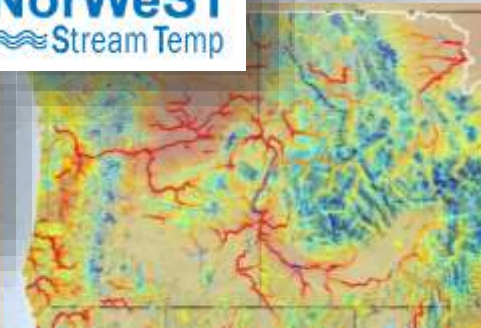
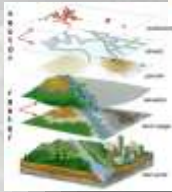
1-km resolution
~400,000 perennial stream kilometers



Database & Scenarios Create Synergies



NorWeST
Stream Temp

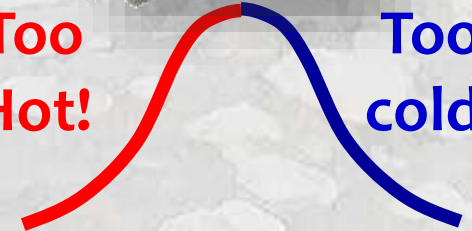


Regulatory temperature standards

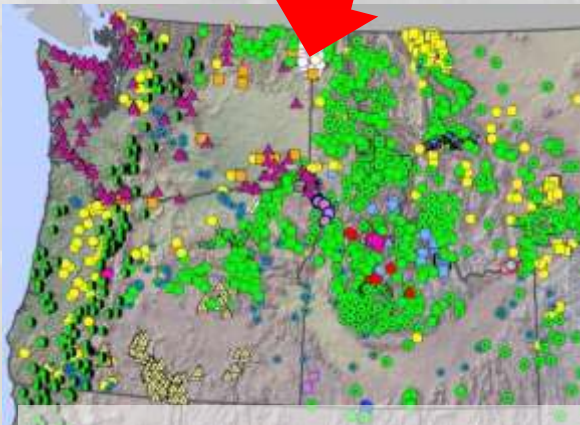


Too Hot!

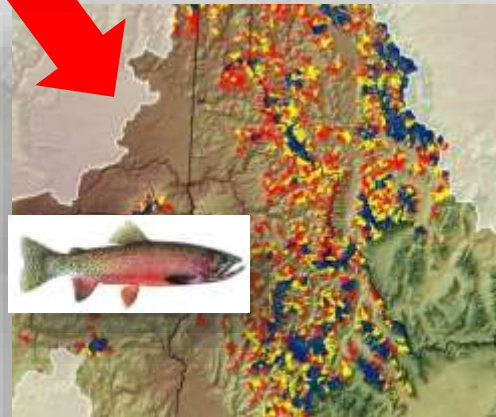
Too cold!



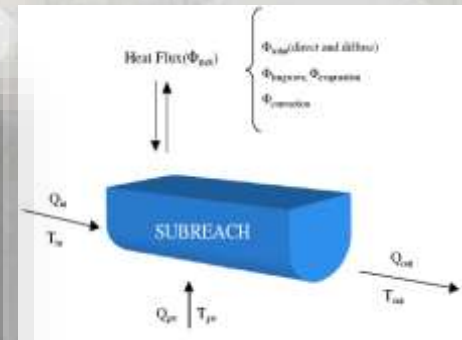
Data access accelerates temperature research



Coordinated
Interagency monitoring

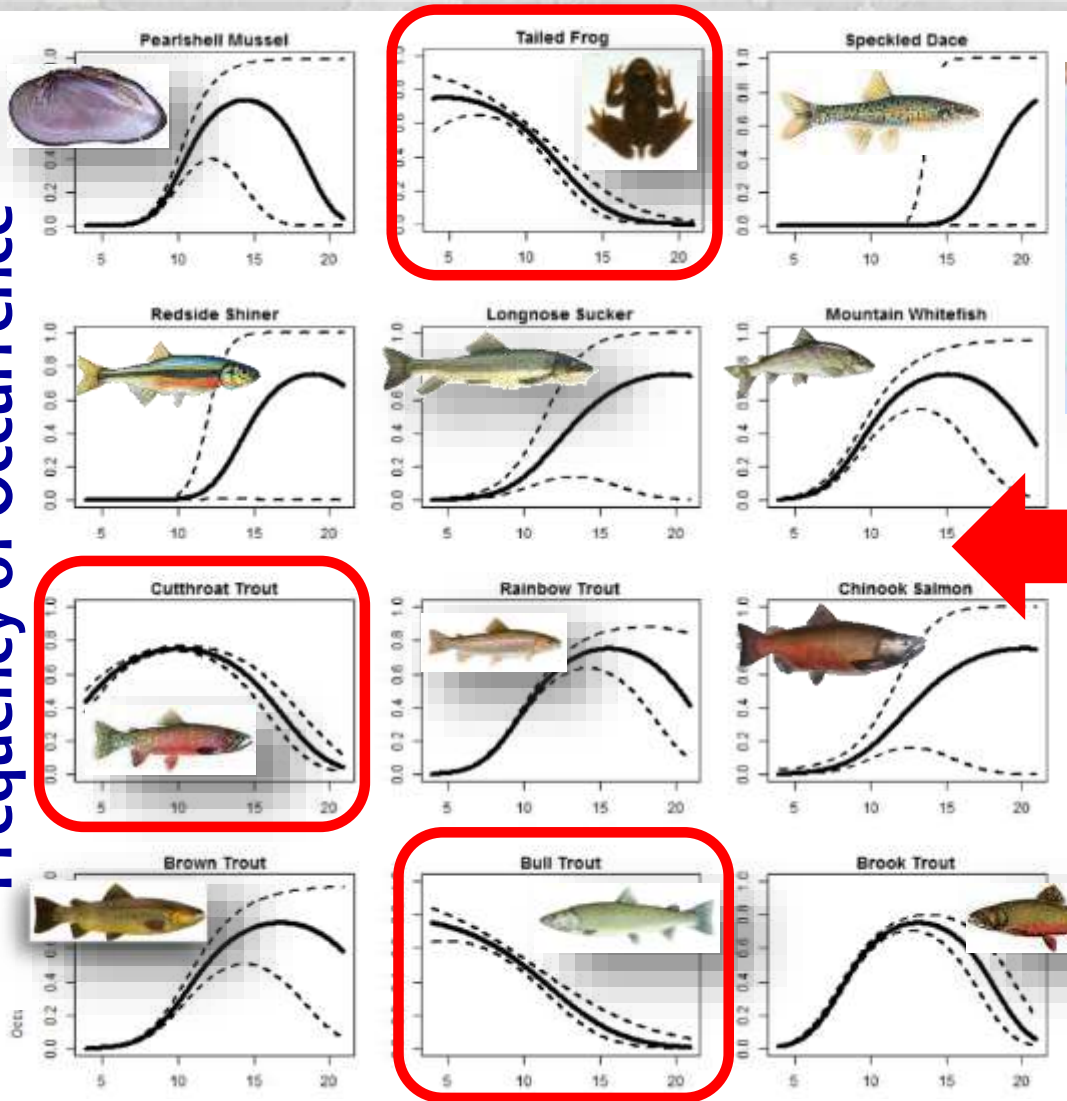


Species distribution models
& climate assessments

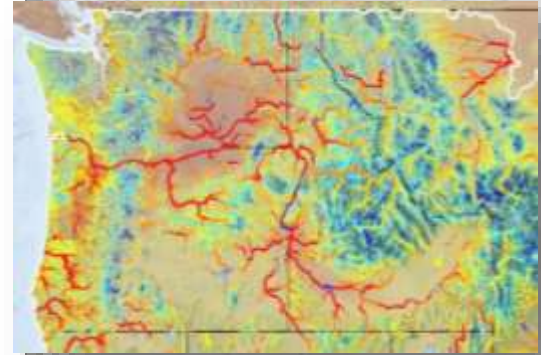


Climate Vulnerability Varies by Species

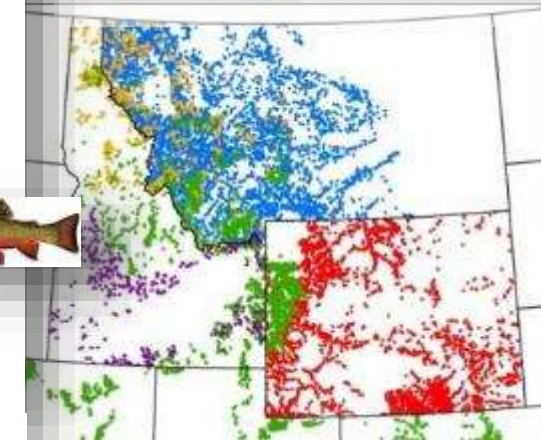
Frequency of Occurrence



NorWeST Stream Temperature

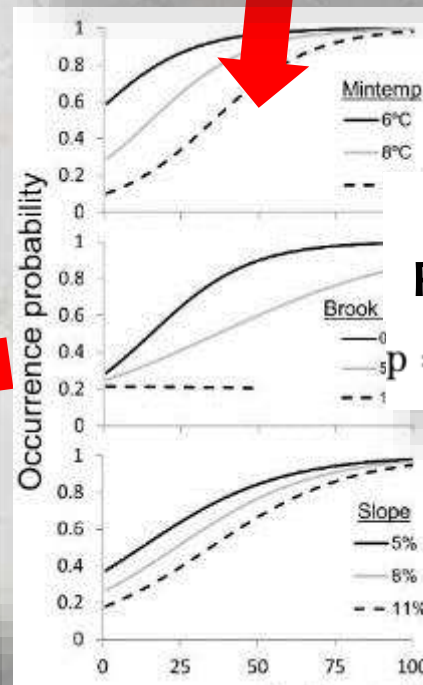
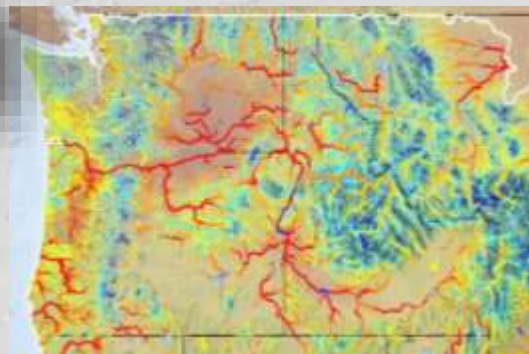
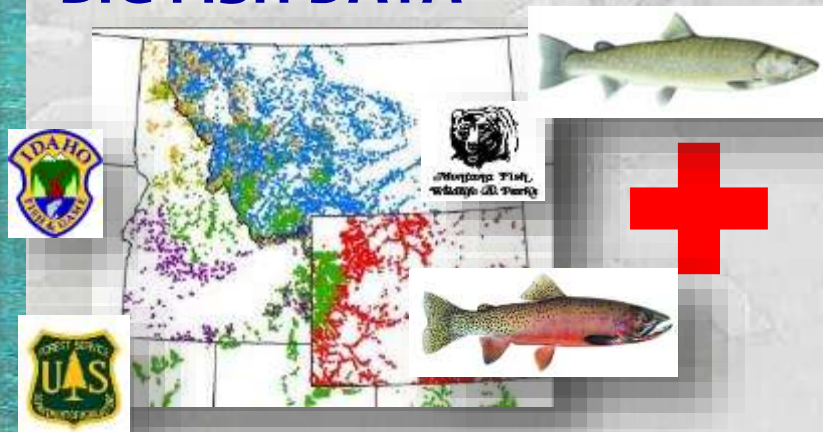


BIG FISH Data



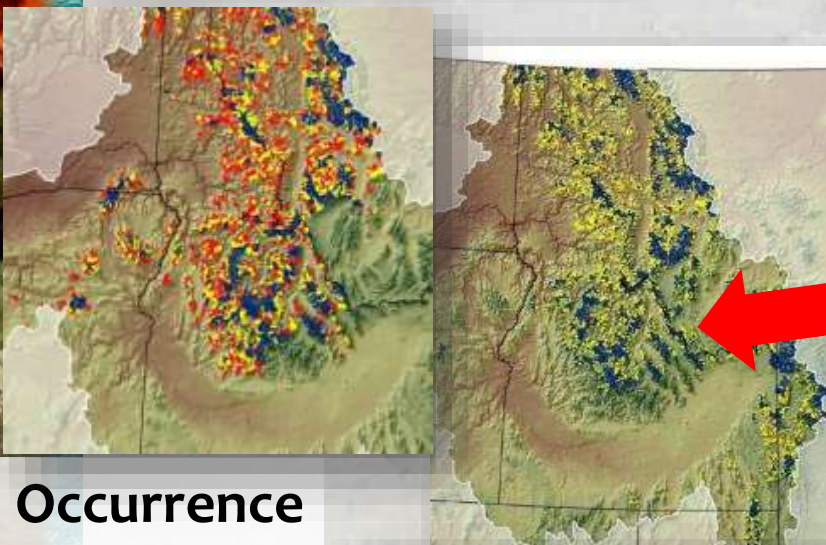
Precise Distribution Models for Sensitive Native Trout Species

BIG FISH DATA



Predictive Logistic Regression Models

$$p = \frac{\exp(a + bx \dots ny)}{1 + \exp[a + bx \dots ny]}$$

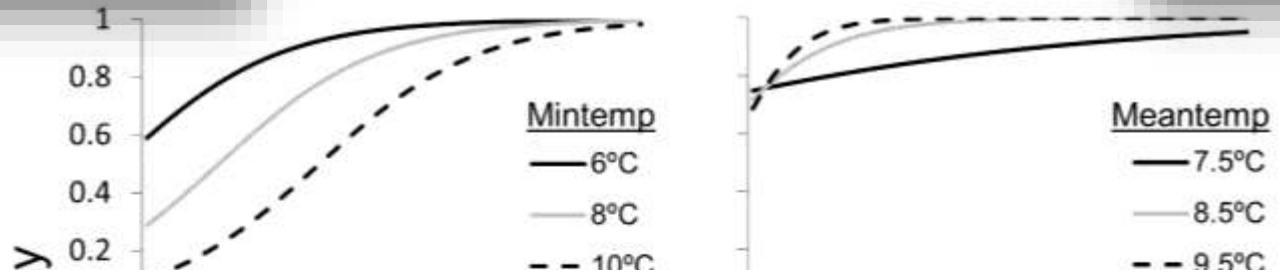


Occurrence probability maps

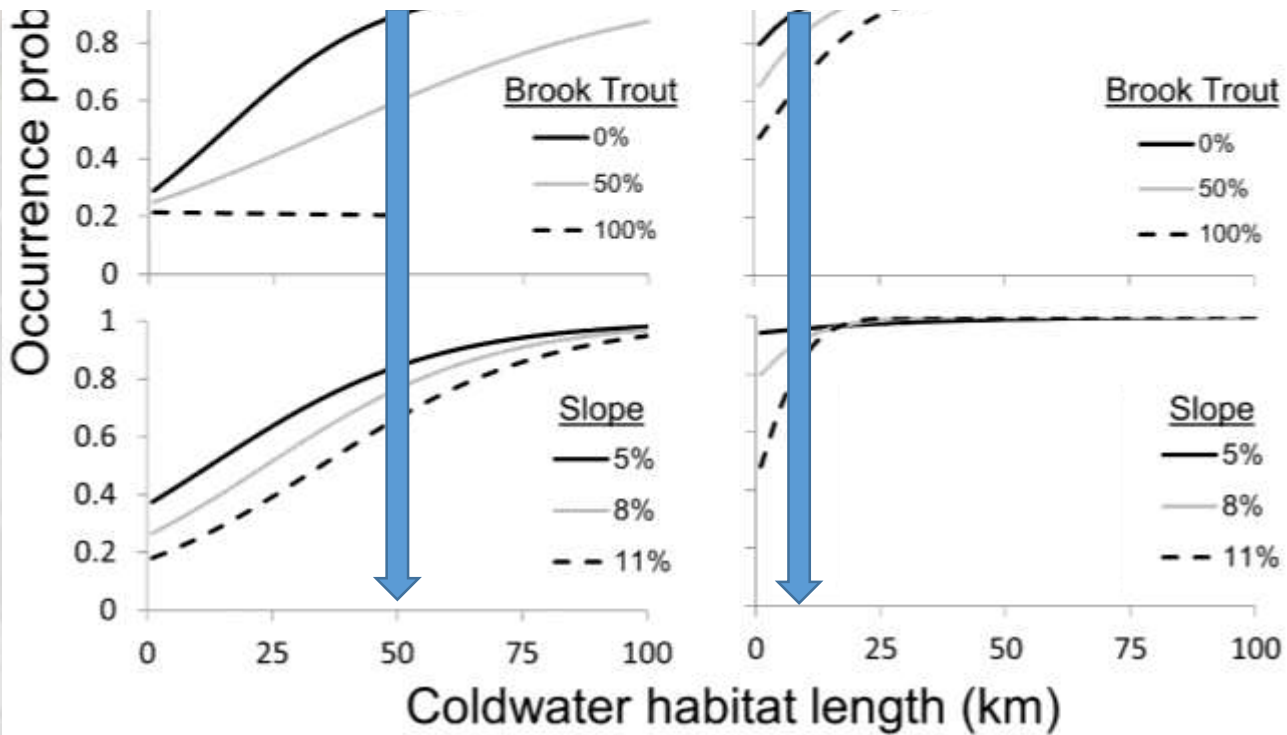


Isaak et al. 2015. The cold-water climate shield: Delineating refugia for preserving native trout through the 21st Century. *Global Change Biology* 21: 2540-2553

Models Yield Ecological Understanding

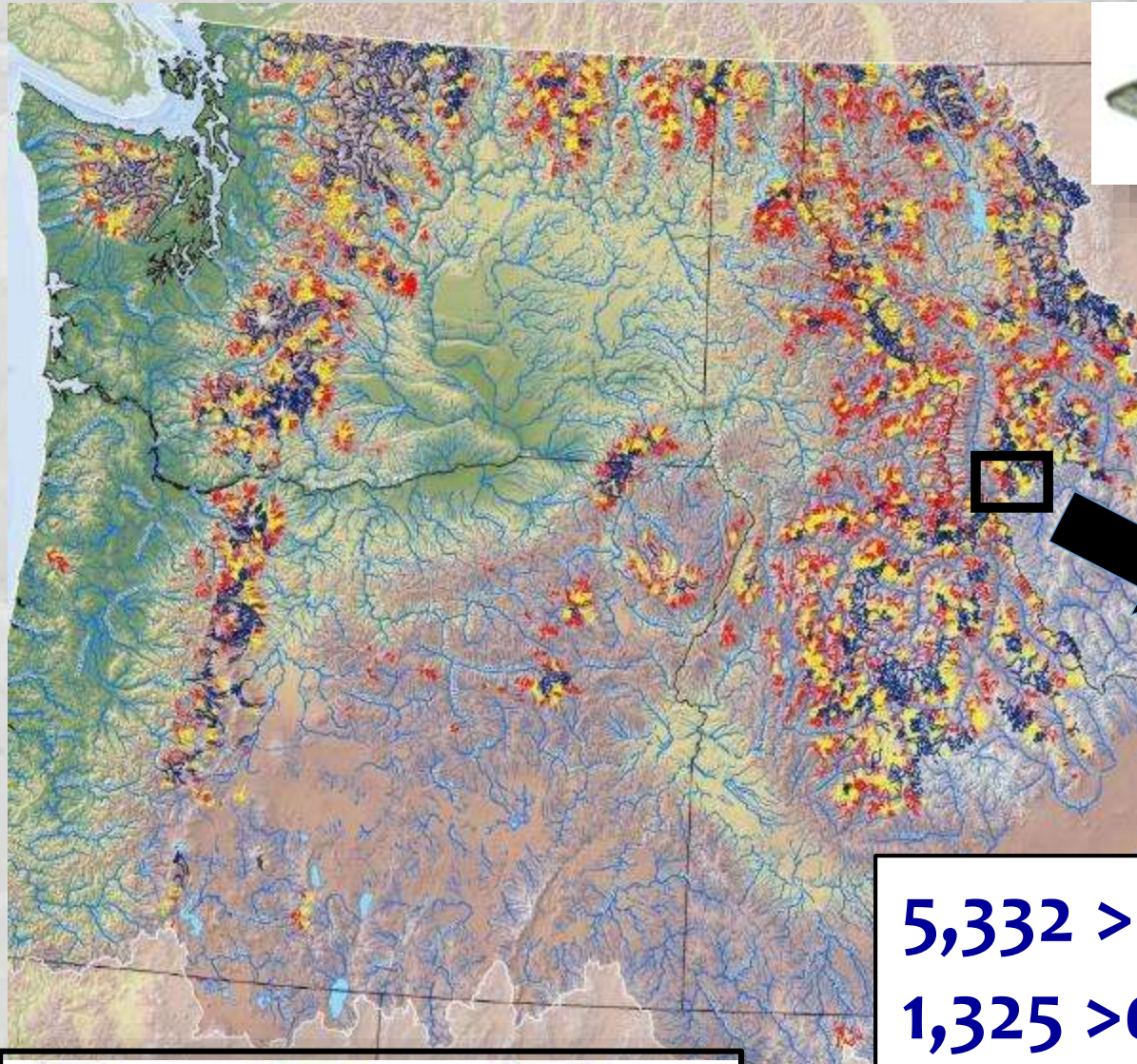


Differences in Habitat Size Requirements

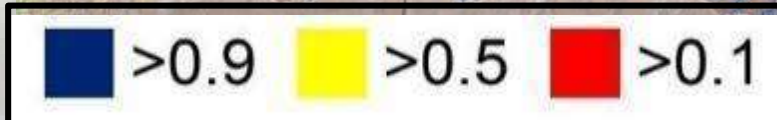
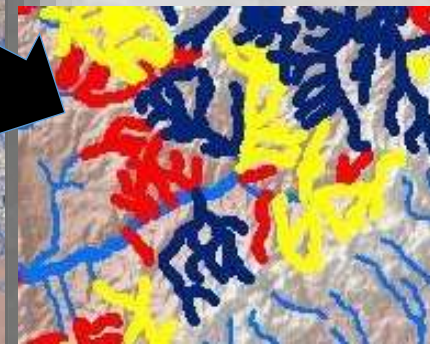


Bull Trout Probability Map

2000s



Stream
population scale
predictions

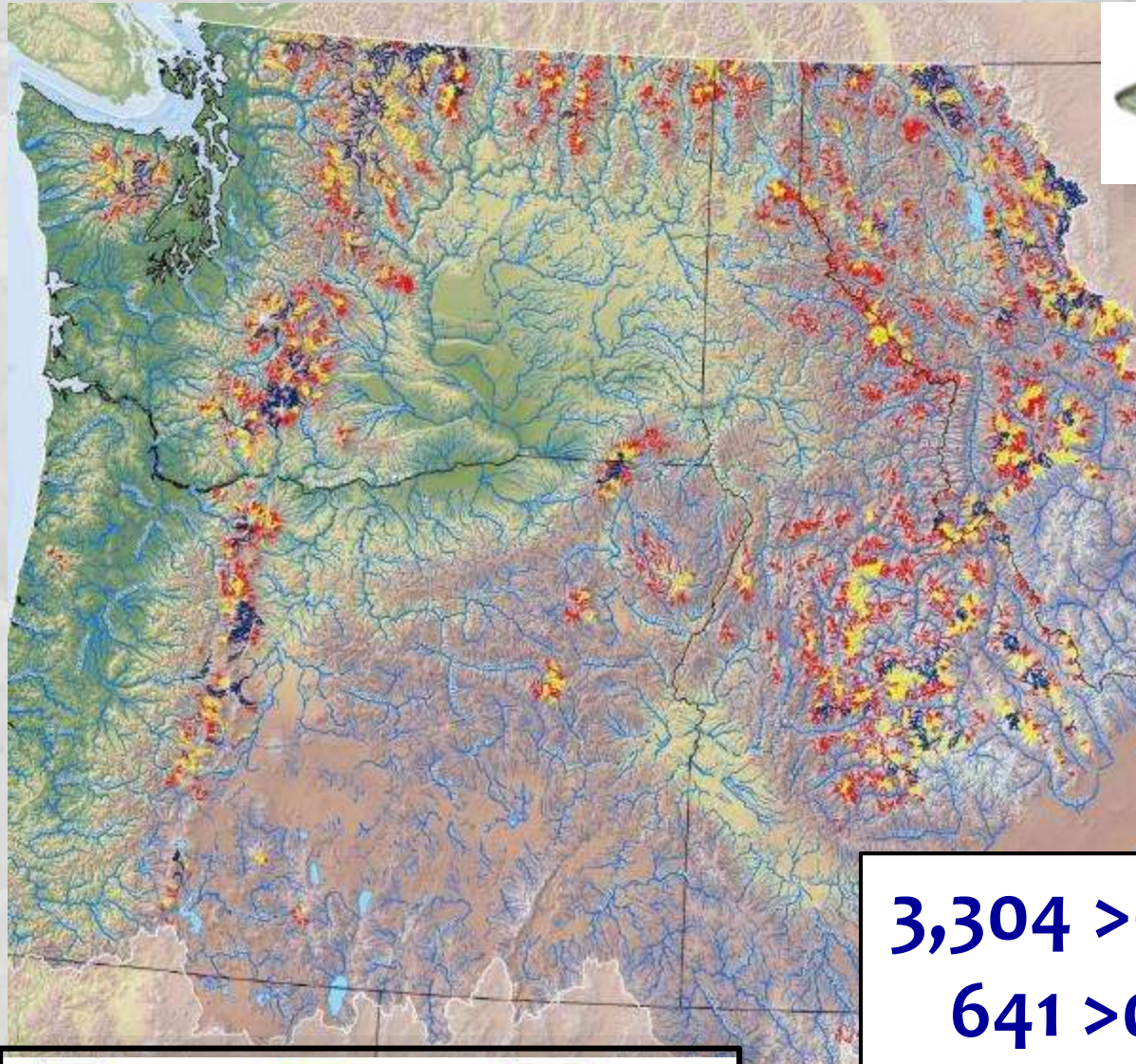


5,332 >0.1 habitats
1,325 >0.5 habitats
348 >0.9 habitats

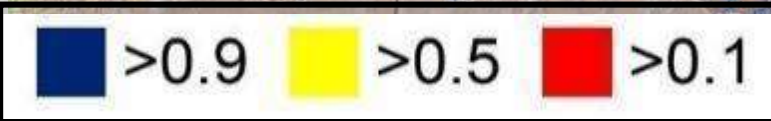


Bull Trout Probability Map

2040s



3,304 >0.1 habitats
641 >0.5 habitats
130 >0.9 habitats



Bull Trout Probability Map

2080s

North Cascades

Flathead

Walla Walla

Metolius

Central Idaho



Extreme scenario!
+5°C

Extinction not Likely

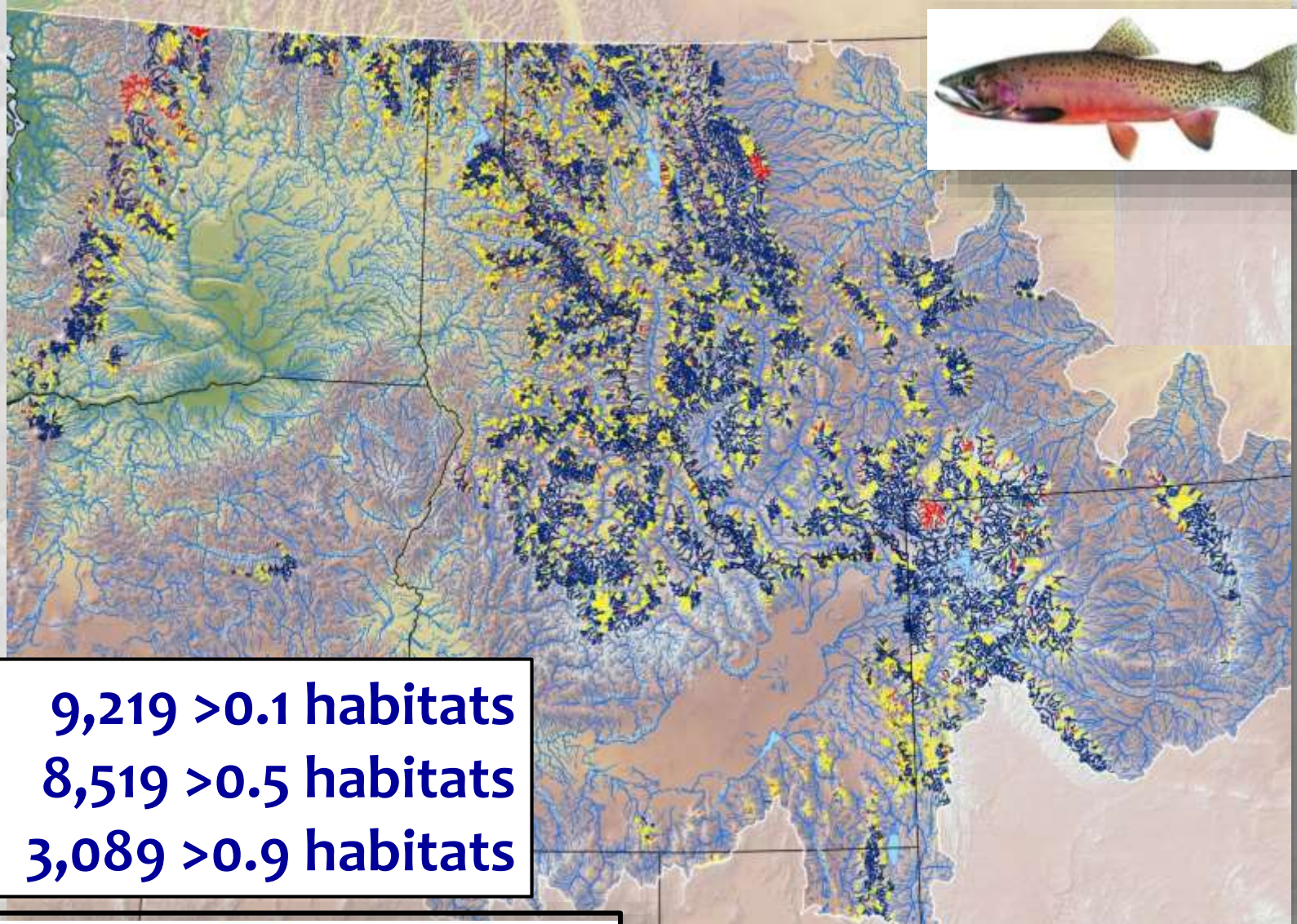
2,712 >0.1 habitats
460 >0.5 habitats
62 >0.9 habitats



>0.5  >0.1

Cutthroat Probability Map

2000s

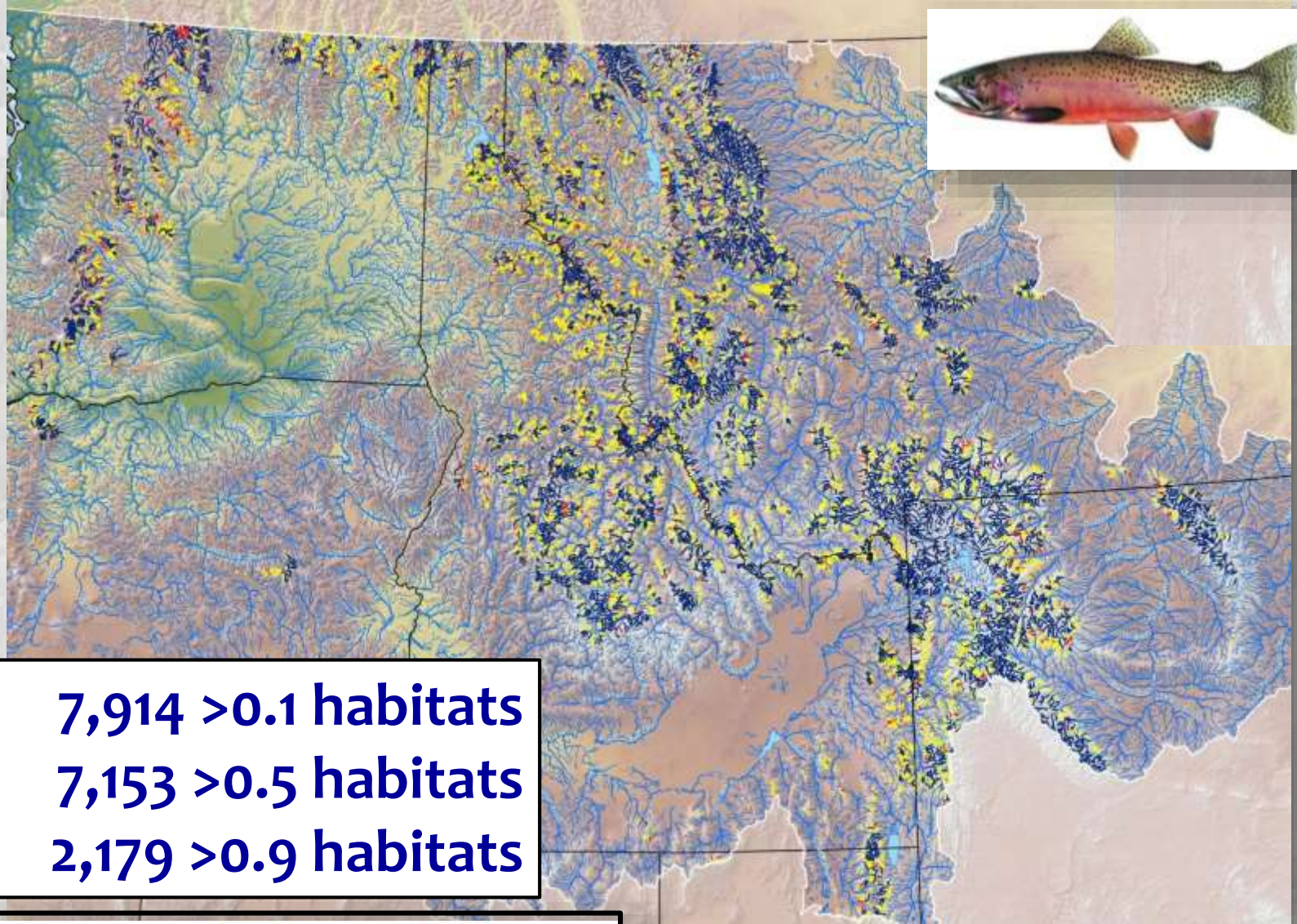





■ >0.9 ■ >0.5 ■ >0.1



Cutthroat Probability Map

2040s

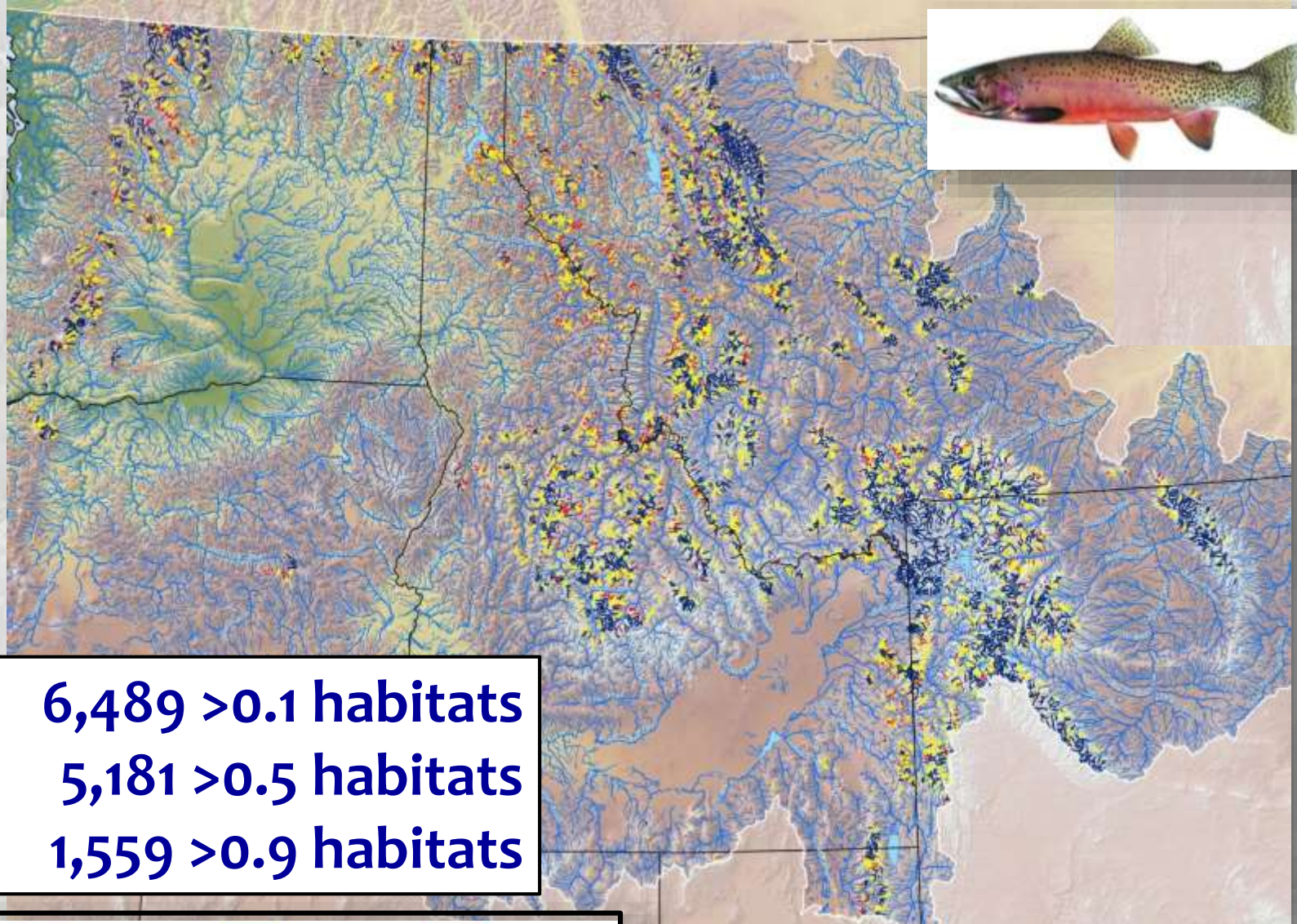





 >0.9  >0.5  >0.1



Cutthroat Probability Map

2080s



 >0.9  >0.5  >0.1





Website Provides Information in User-Friendly Digital Formats

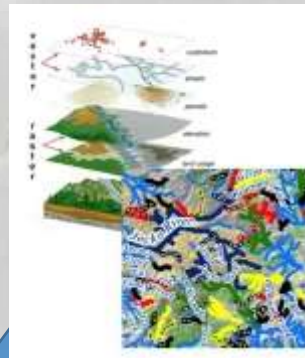


Just Google “Climate shield trout”

Presentations & Publications



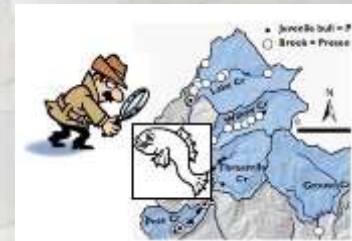
Digital Maps & ArcGIS Shapefiles



Fish Data Sources



Distribution Monitoring



File formats:

- ArcGIS files
- pdf files


15 Scenarios:

- 3 climate periods
- 5 Brook invasion levels


Precise Spatial Information about Refugia Empowers Local Decision Makers...

See both the
Forest & the Trees!

Occupancy Probability


 > 0.90

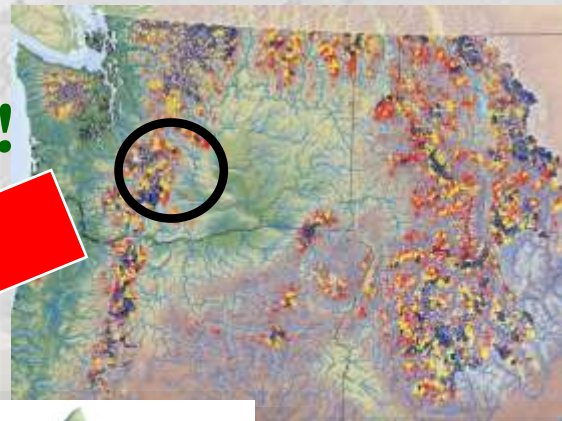
 > 0.75 to < 0.90

 > 0.50 to < 0.75

 > 0.25 to < 0.50

 < 0.25

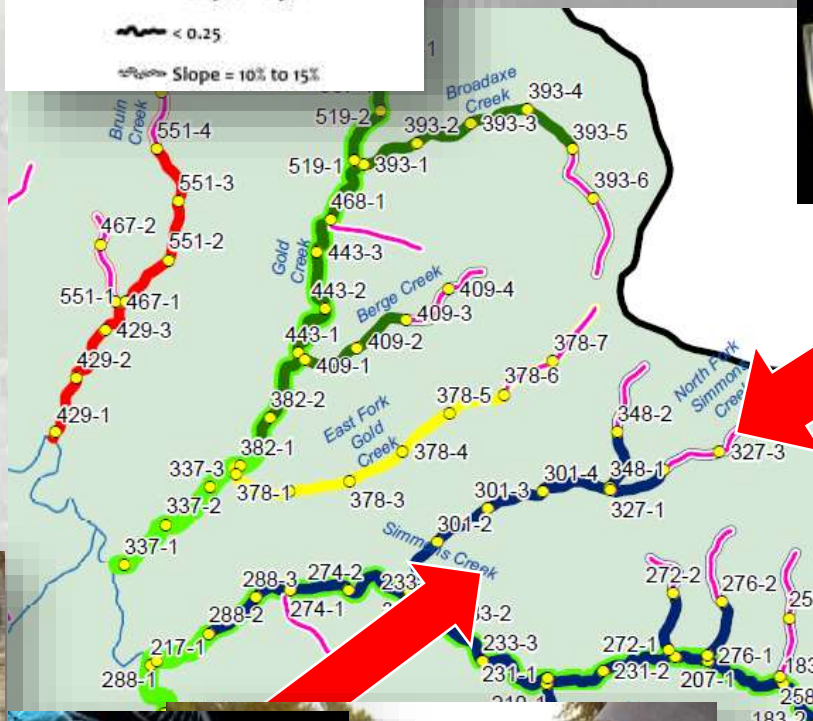
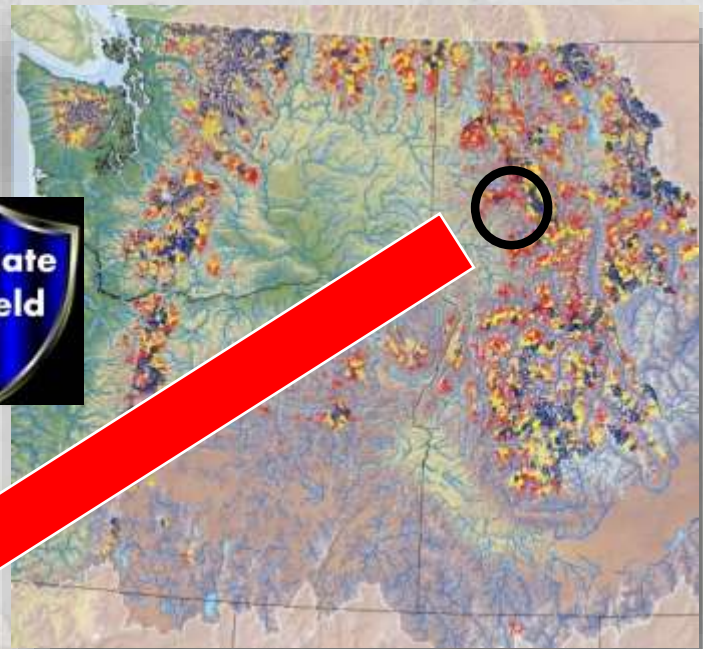
 Slope = 10% to 15%



Highest priority
conservation investment!

Precise Spatial Information also Guides Efficient Data Collection & Monitoring...

Occupancy Probability

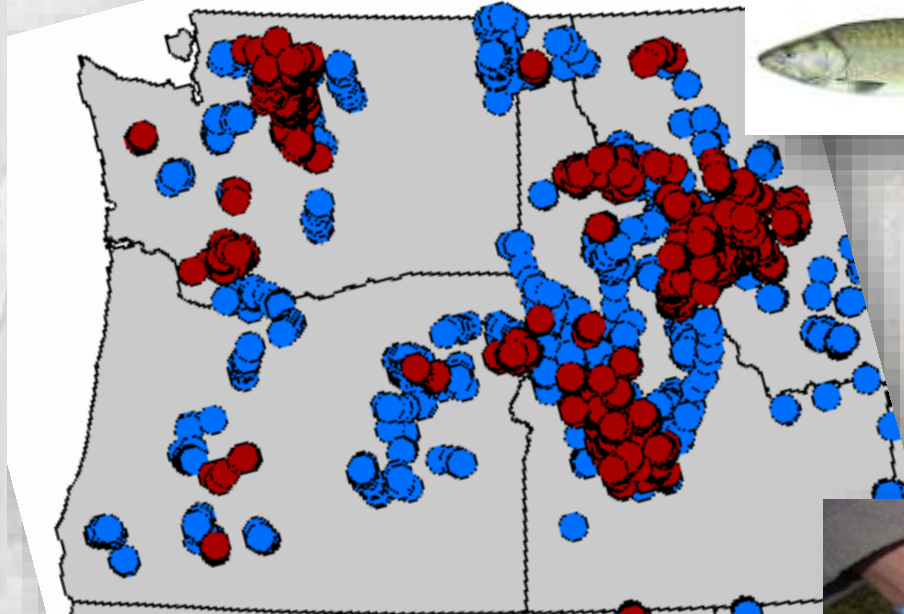


There are only...
~5,332 potential bull trout habitats
Why not census them all?



Uber Efficiency has Arrived:

Rangewide eDNA Bull Trout Project



Funded by:



Partners sampled...

2016: 3,000 stream sites

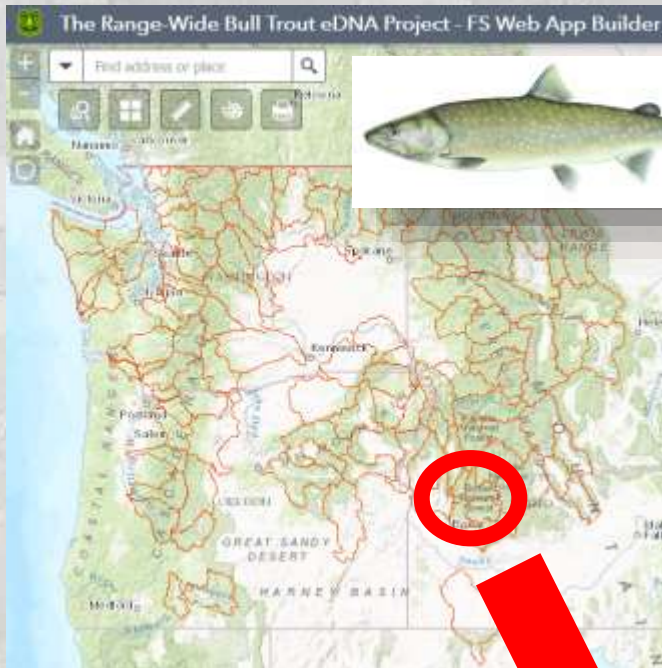
2017: 4,000 more site surveys planned

2018: 3,000 final site surveys

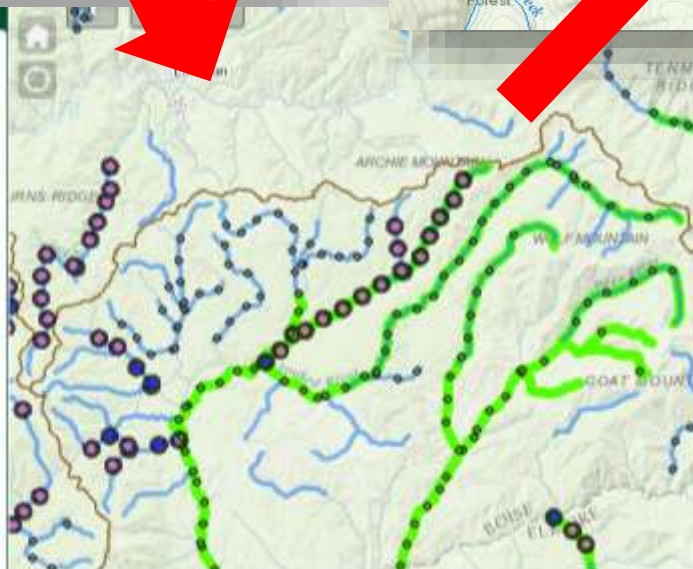
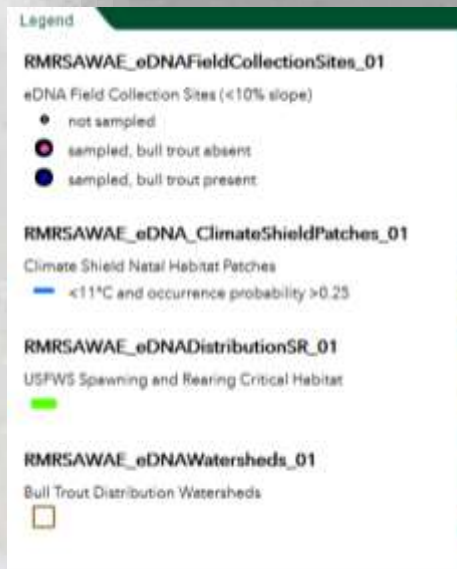
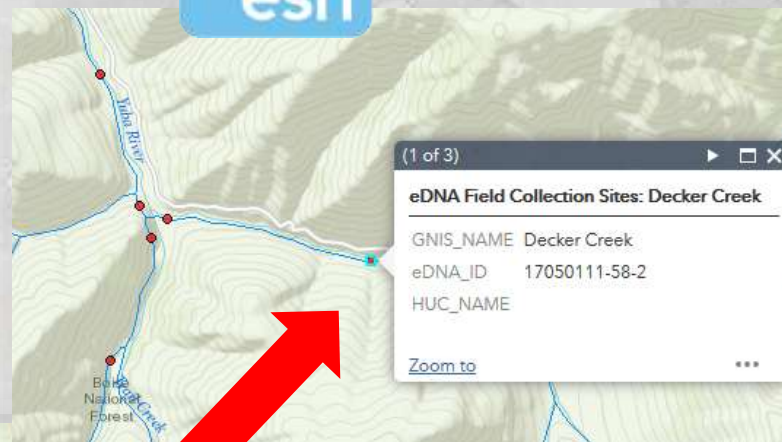
Sample sites are already organized in a database!



Dynamic Web-data portal Delivers Results at Website



ArcGIS Online



Query & download data by site, stream, HUC, DSP, species range

eDNA ByCatch is Important BiProduct...

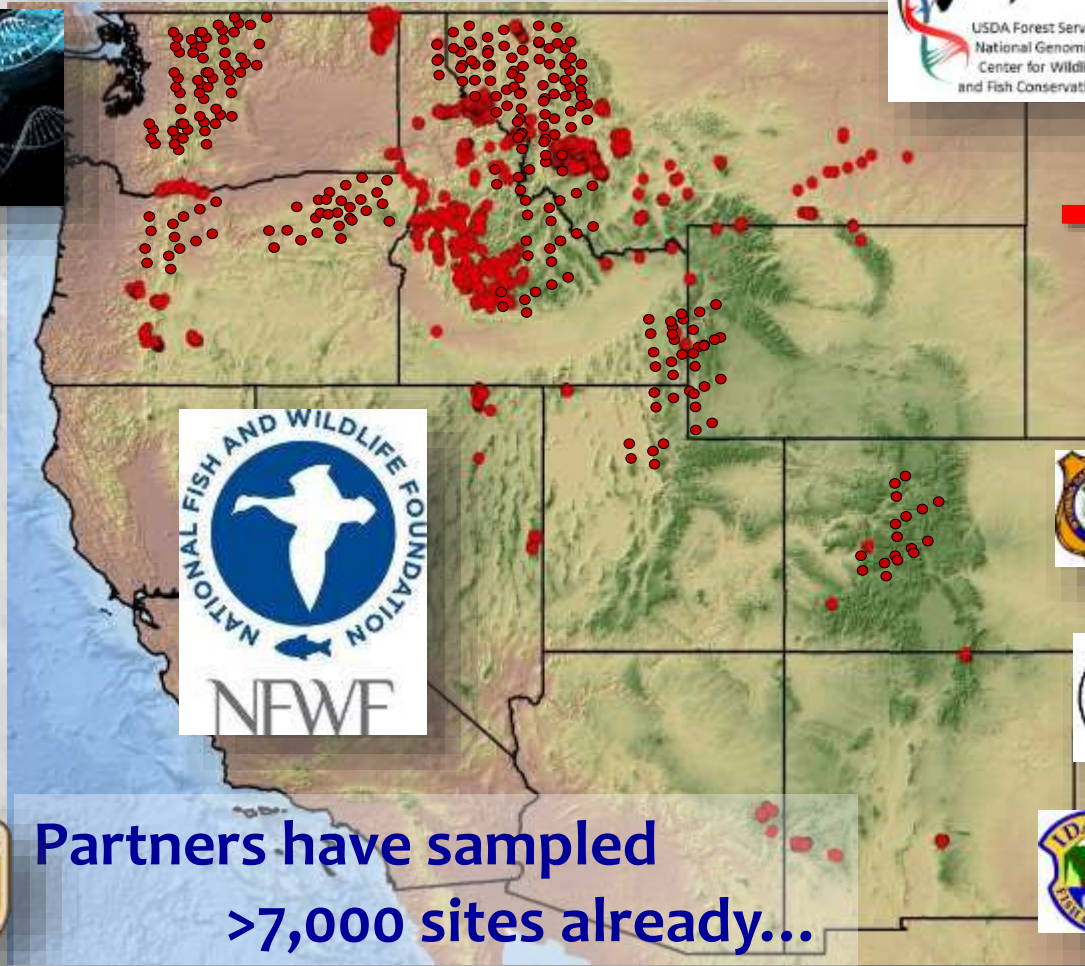


An Aquatic Biodiversity Archive

Aquatic eDNA Atlas Project: An Open-Access Database for all Species in the American West



National
Genomics
Center for
Wildlife & Fish
Conservation

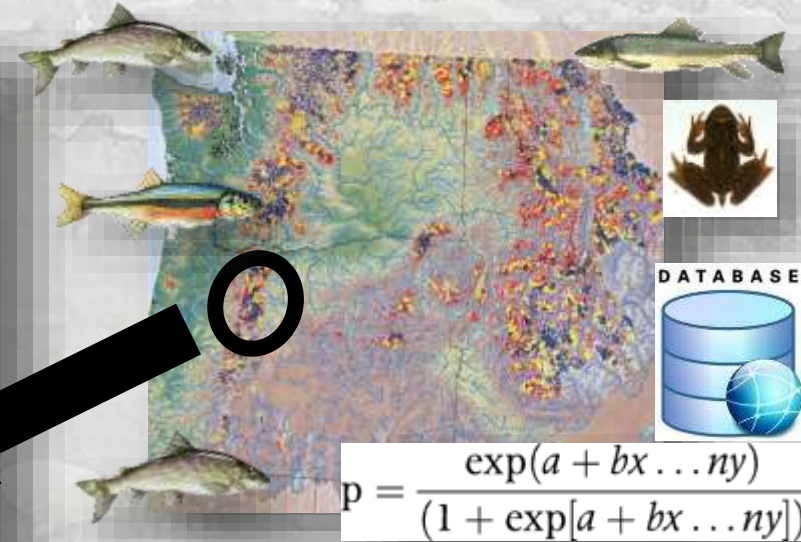
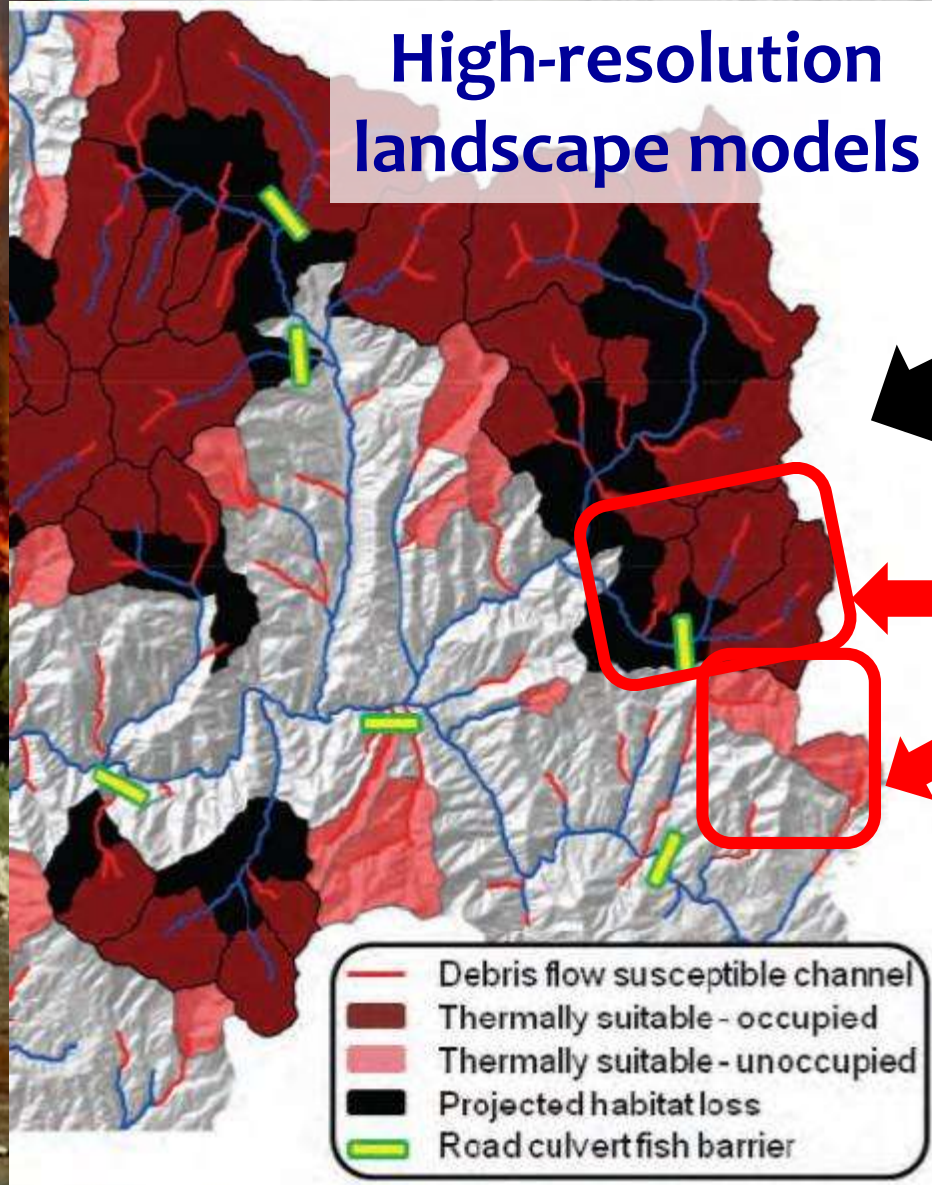


Partners have sampled
>7,000 sites already...



Goal: Precise Models & Databases for All Species

High-resolution landscape models

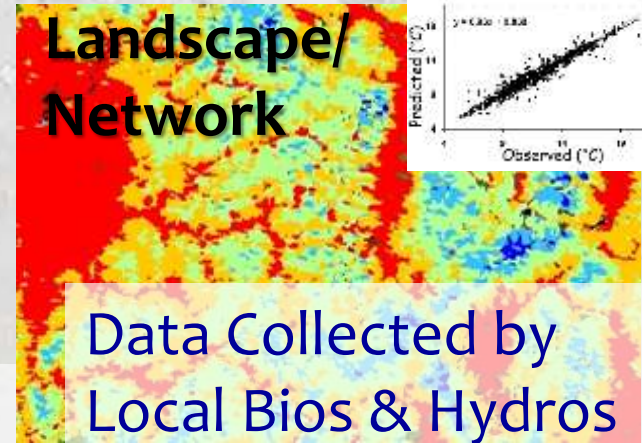
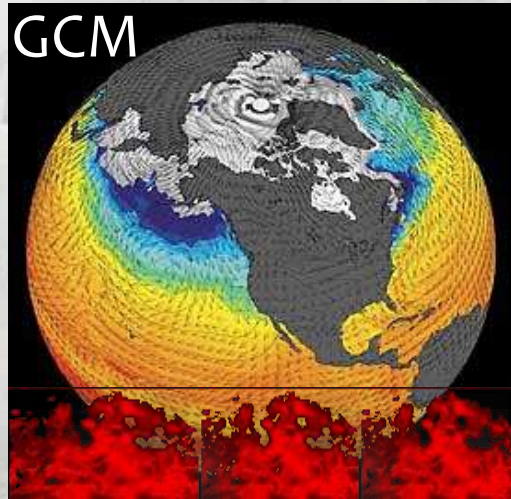


I'm going to invest here...

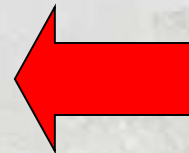
... instead of here



Inter-Agency Databases Engage Everyone & Strengthen Conservation Networks



Coordinated
Management &
Conservation



Management
Decisions



Better Inter-Agency Information Enables Efficiency on Many Fronts...

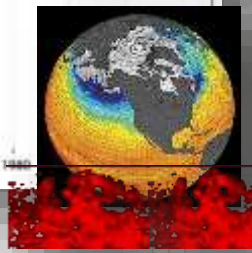
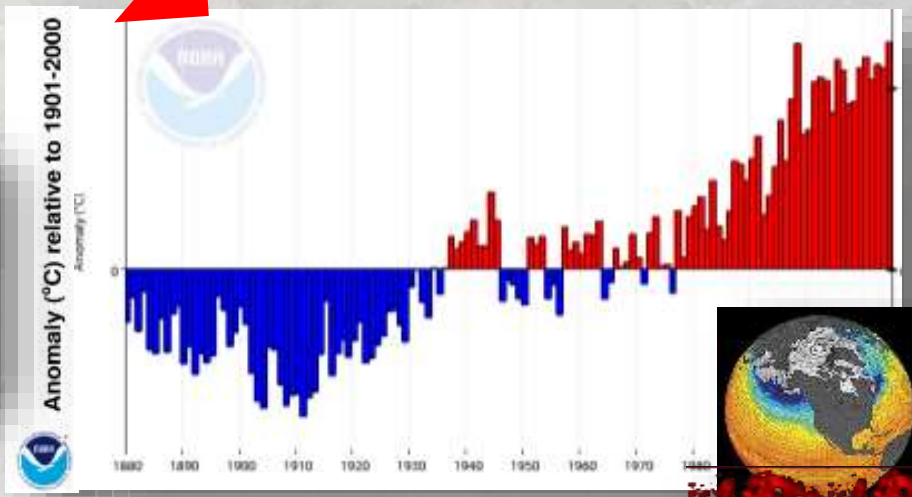


Urbanization & Population Growth



Climate Change

Habitat degradation



Climate Refugia put us on a Path to Preserve More Cool Critters in the Long-run

