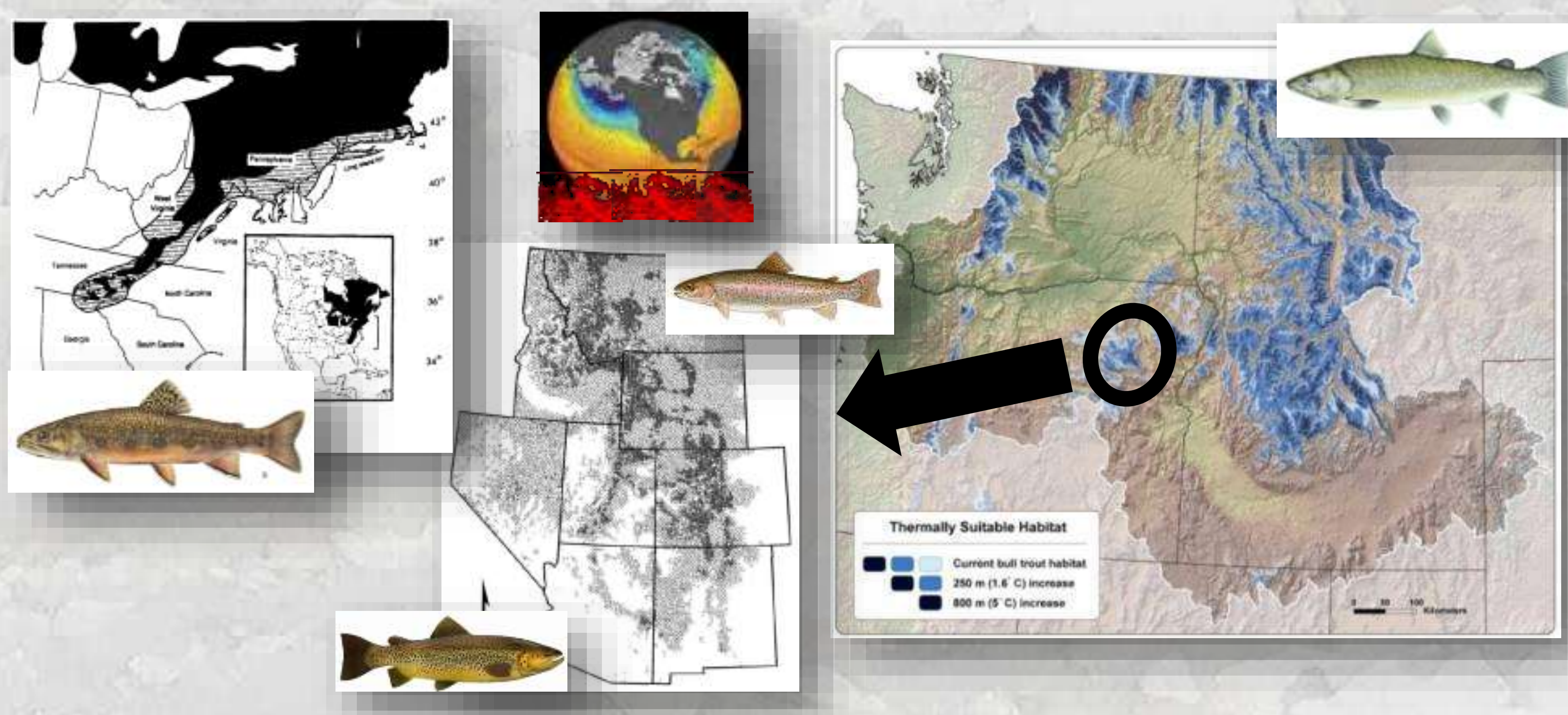
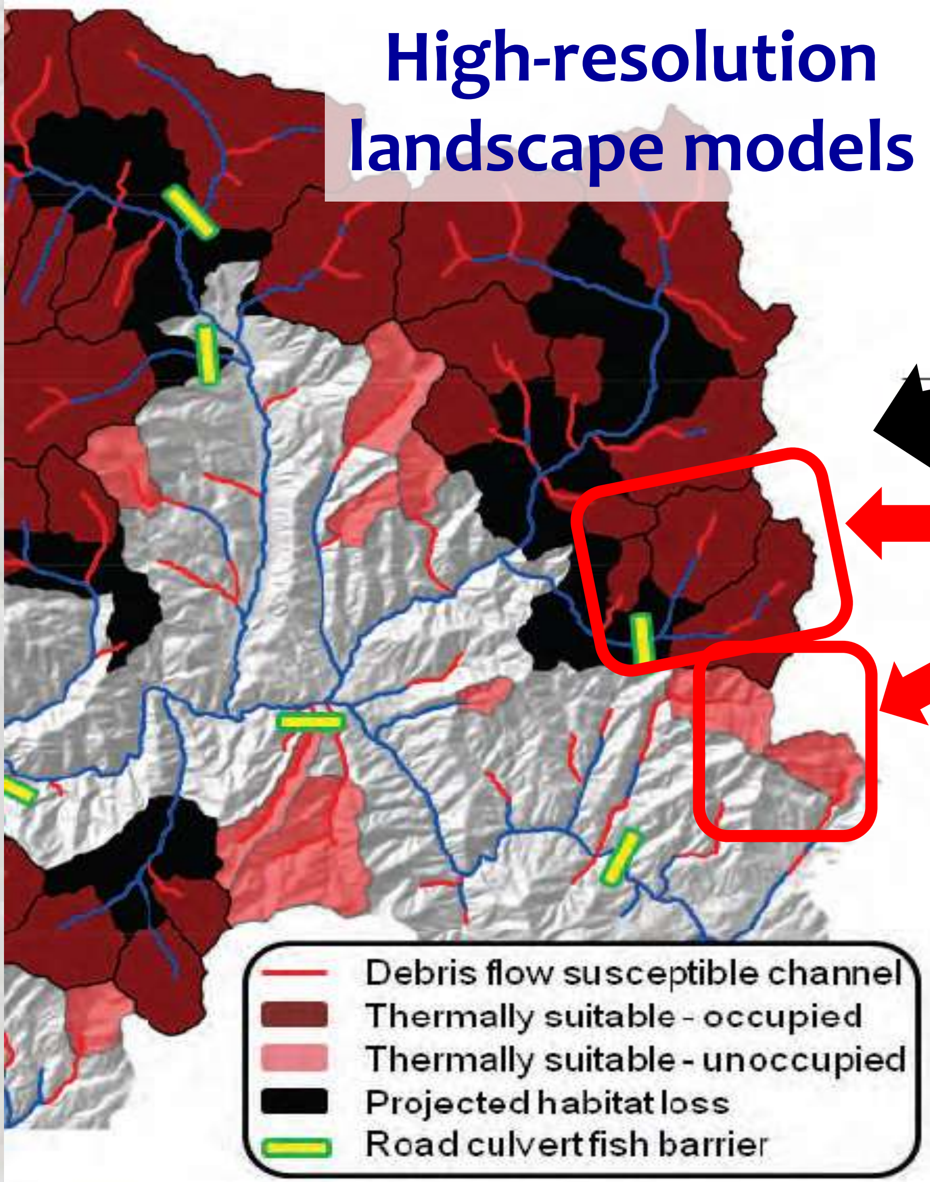
Macromodels & Data Products Provide Context BUT Local Precision Needed for Decision Makers



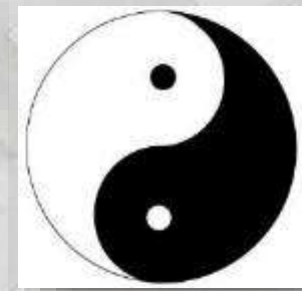
Macromodels & Data Products Provide Context
BUT Local Precision Needed for Decision Makers



Low Cost Sensors, Standard Protocols, & NHD Framework Can Significantly Improve Precision

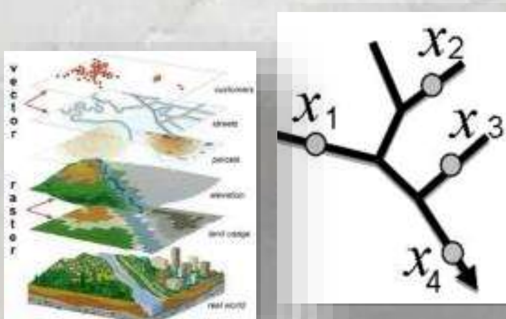
Many stakeholders "Boots-on-the-Ground"

Inexpensive sensors & standard data protocols



Open access databases

Models, analyses, & information



More Local Measurements = More Precision

Miniature Temperature Sensors

Vendor & Sensor model	Accuracy	Battery life & memory	Cost
Hobo Pro v2	+/-0.2°C	6 years	$123
Tidbit v2	+/-0.2°C	5 years	$133
iButton	+/-0.5°C	1 year	$20 – 40
Tinytag Aquatic 2	+/-0.5°C	1 year	$170

Discharge Pressure Transducers

Vendor & Sensor model	Accuracy	Battery life & memory	Cost
Onset Hobo	+/-0.05%	5 years	$300
Global Water WL16	+/-0.1%	1 year	$1,000
INW PT2X	+/-0.05%	1.5 years	$1,095
In-Situ Level TROLL	+/-0.05%	10 years	$1,170

Yet More Miniature Sensors

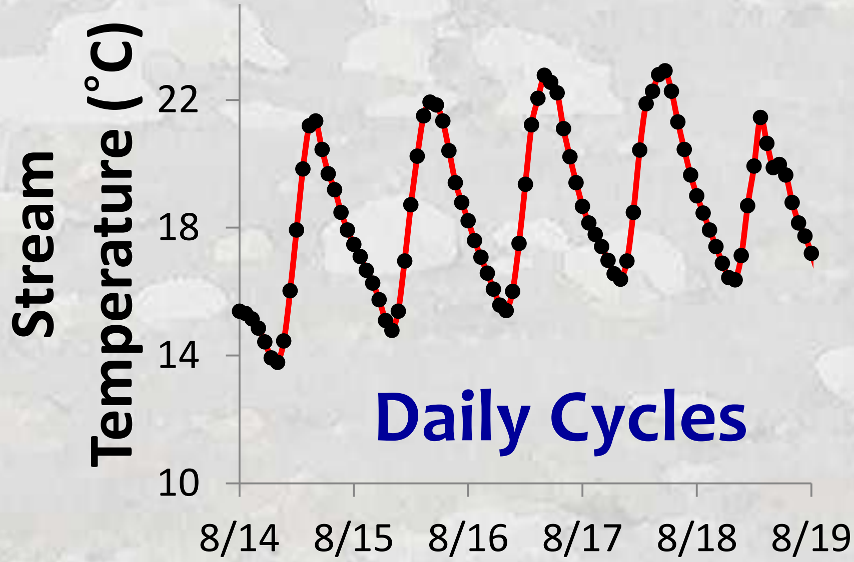
Conductivity

pH

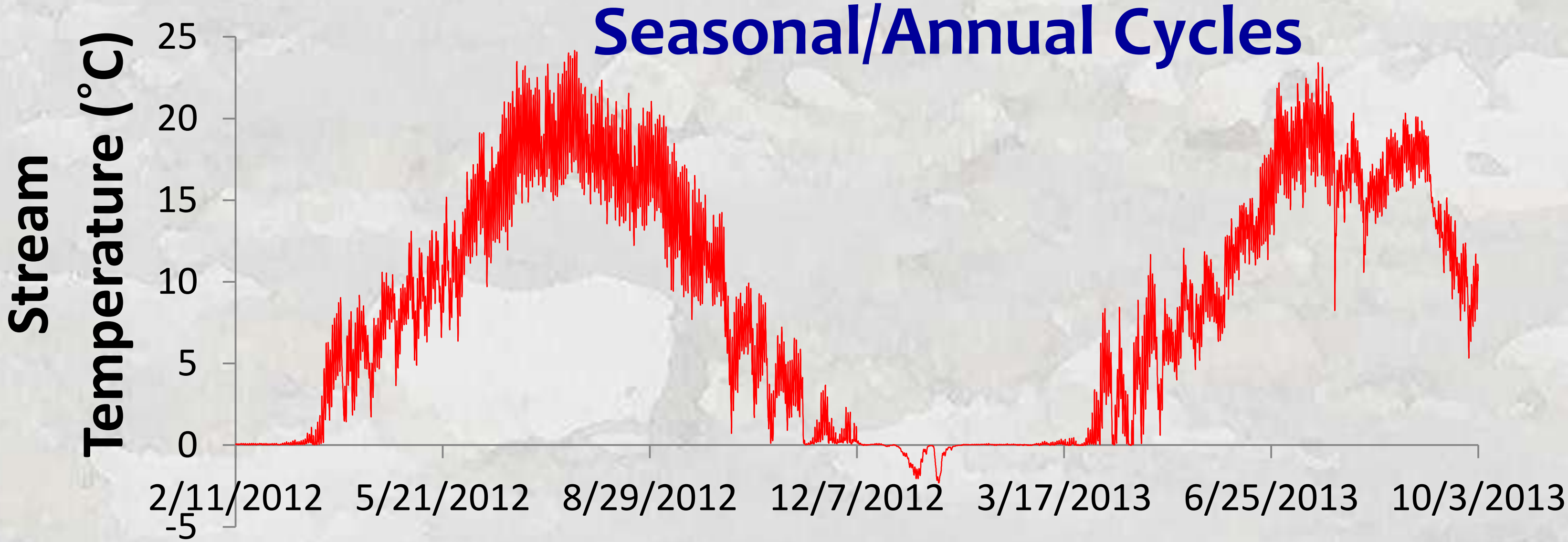
Light sensors

Oxygen

Sensors Yield Semi-Continuous Measurement Records with Time Stamps



	A	B	C	D	E
1	Date	Time	Site	Temperature	(*C)
2	7/15/2005	21:23	316	15.59	
3	7/15/2005	21:53	316	15.11	
4	7/15/2005	22:23	316	14.64	
5	7/15/2005	22:53	316	14.32	
6	7/15/2005	23:23	316	13.86	
7	7/15/2005	23:53	316	13.55	
8	7/16/2005	0:23	316	13.24	
9	7/16/2005	0:53	316	12.93	



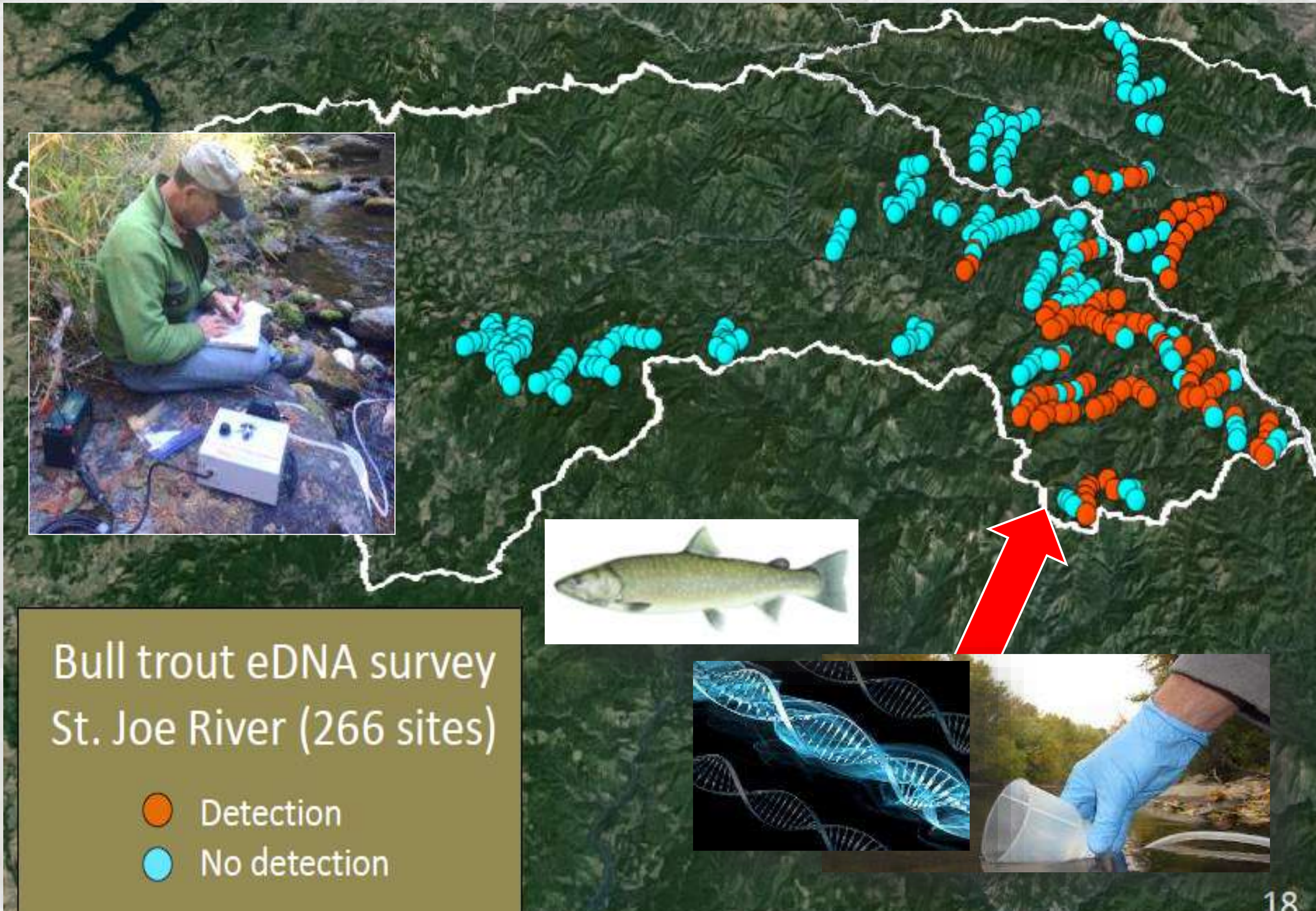
Biological Sensing: Traditional Methods

Biological Sensing: Environmental DNA (eDNA)

~$2,000 of equipment

One Person Can Sample Many Sites Rapidly

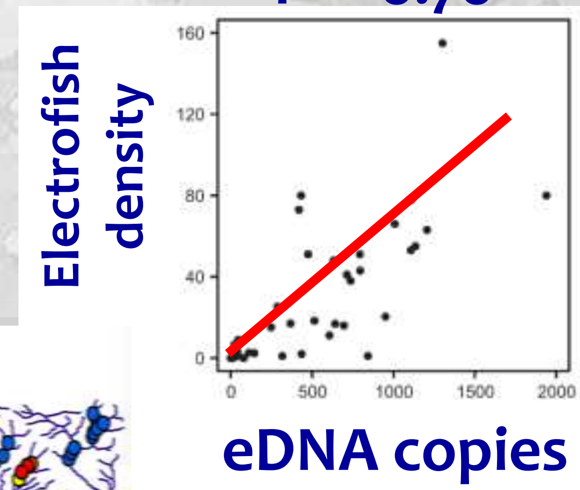
- **20 minutes to collect a sample**
- **Precise species distribution information**

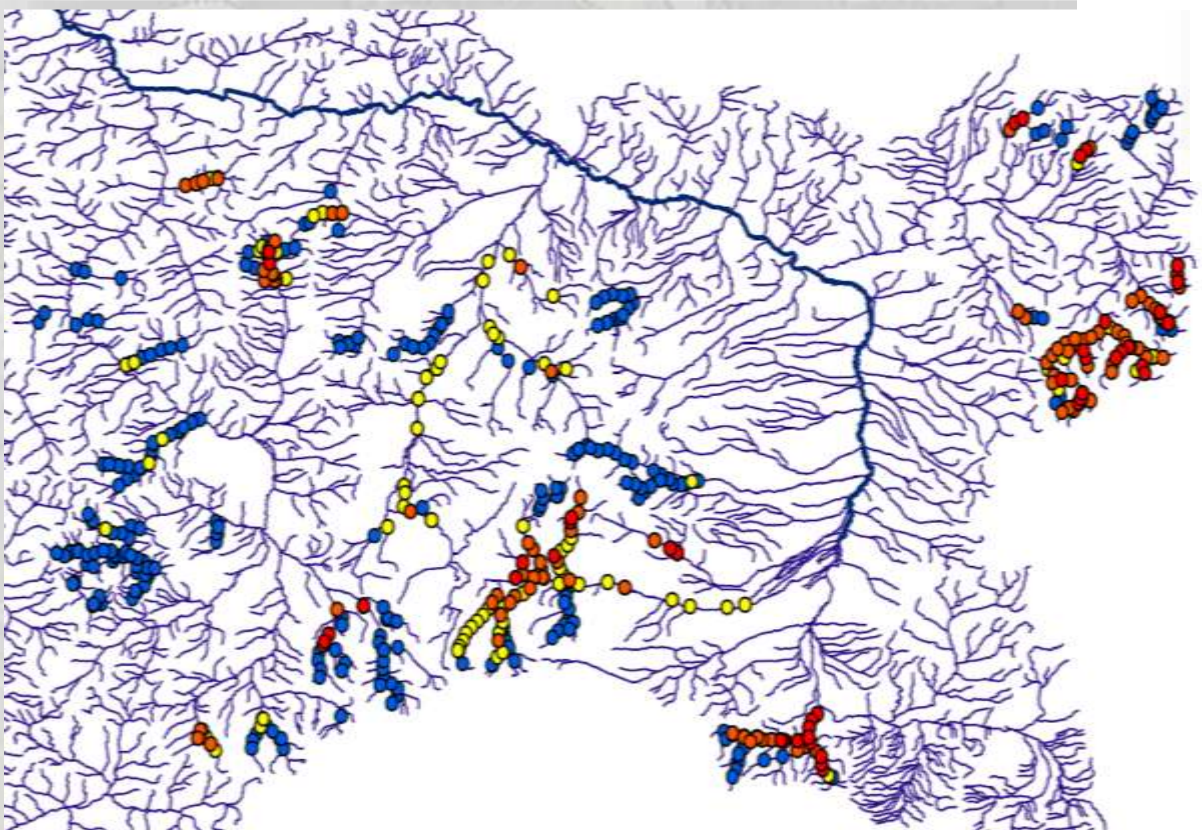


eDNA Density ~ Fish Abundance

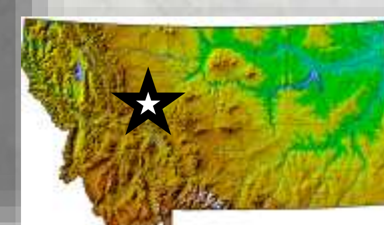
100%   50%   0%

$r^2 = 0.70$



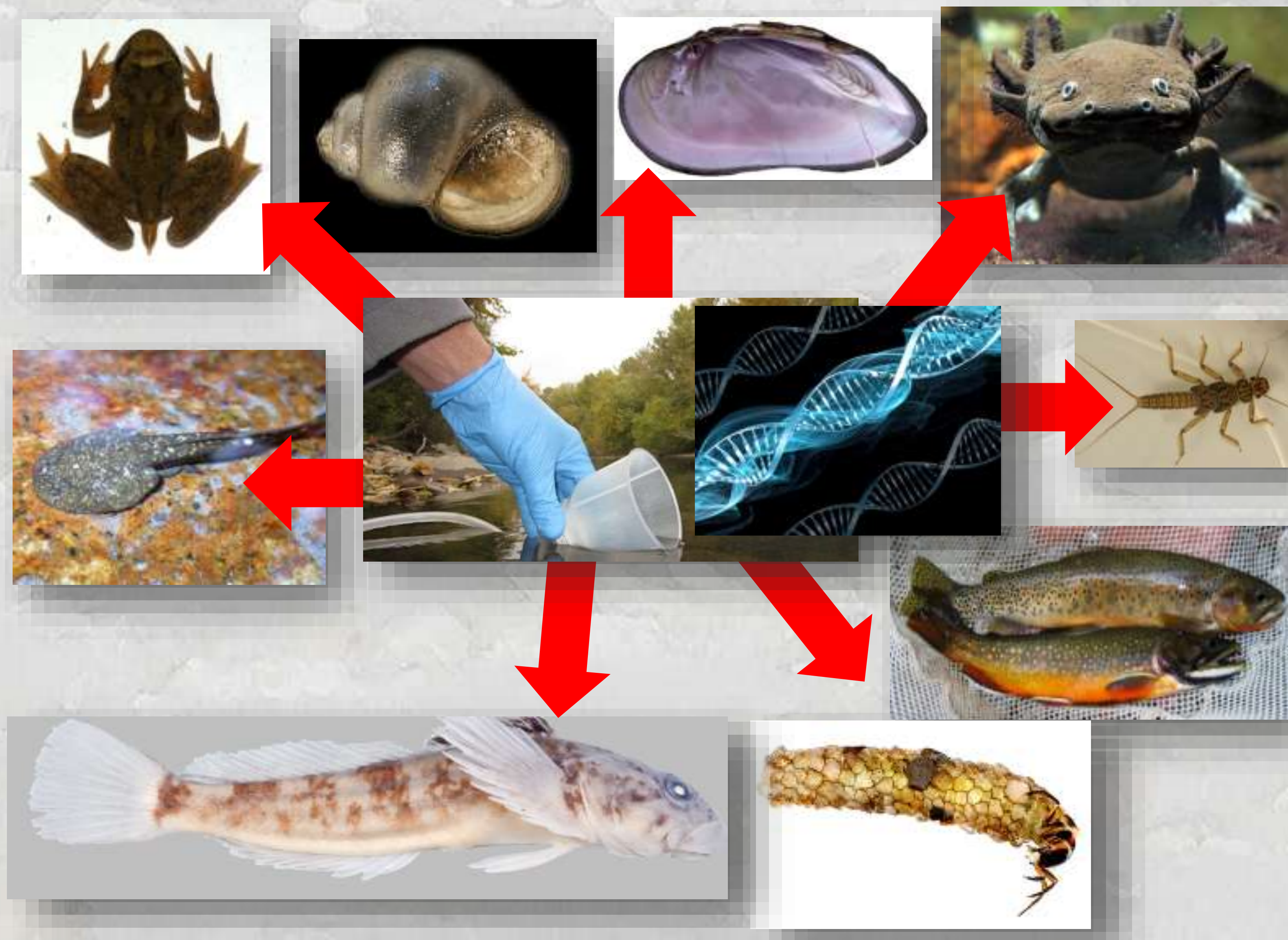


Wilcox et al. 2016. Biological Conservation 194:209–216



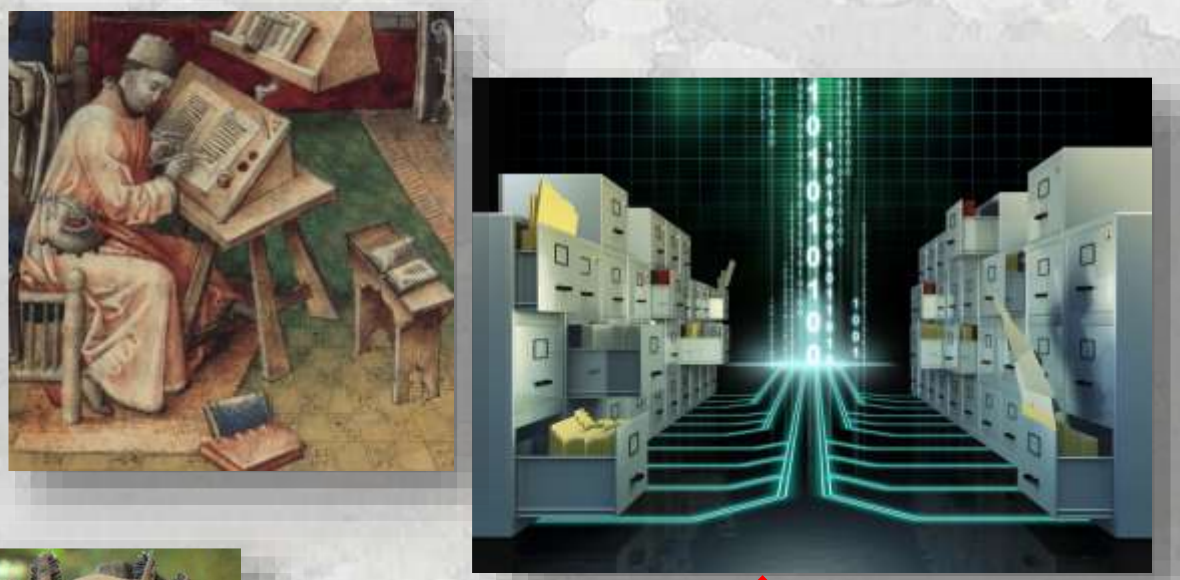
Samples Contain eDNA for All Critters

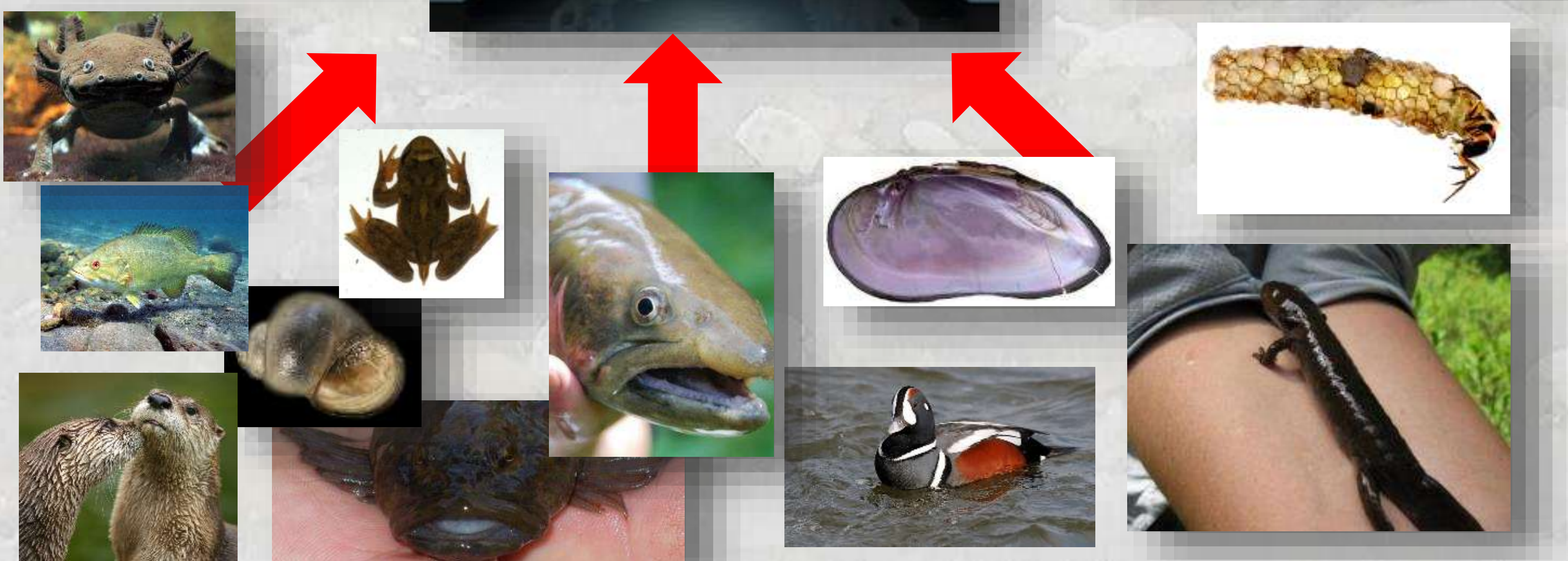
Comprehensive Biodiversity Assessments are Possible



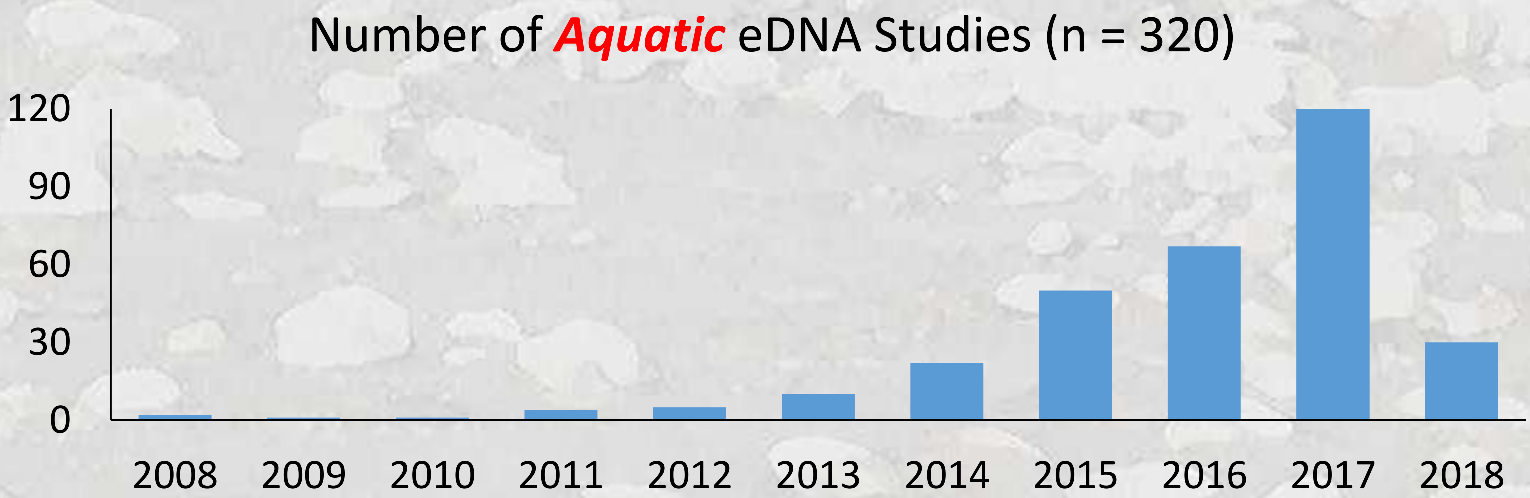
eDNA Samples Serve as a Long-term BioDiversity Archive

- Processing destroys only a small portion of a sample
- Samples can be dry stored in freezer or office
- Sample processing ~$100





eDNA Is a Nascent Field



Relevant publications

This list is updated periodically. Citation information is more easily accessed via the Mendeley En
group.

https://labs.wsu.edu/edna/references/ *List up*

WASHINGTON STATE UNIVERSITY

Adamson, E. A. S., and D. A. Hurwood. 2015. Molecular ecology and stock identification. Pages 811–829Freshwater Fisheries Ecology. John Wiley & Sons, Ltd, Chichester, UK.

Adrian-Kalchhauser, I., and P. Burkhardt-Holm. 2016. An eDNA assay to monitor a globally invasive fish species from flowing freshwater. PLoS ONE 11:e0147558.

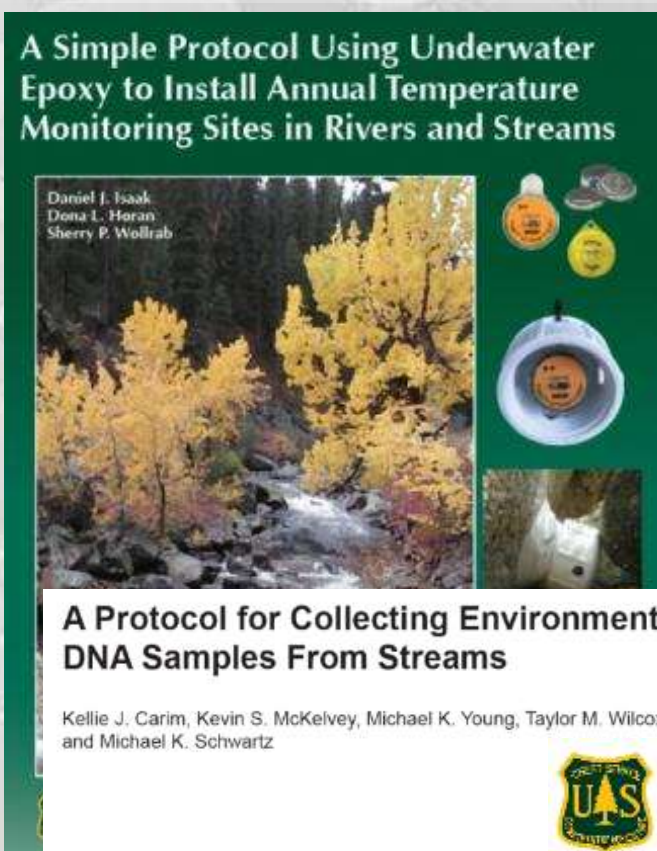
Agersnap, S., W. B. Larsen, S. W. Knudsen, D. Strand, P. F. Thomsen, M. Hesselsøe, P. B. Mortensen, Vrålstad, and P. R. Møller. 2017. Monitoring of noble, signal and narrow-clawed crayfish using envir DNA from freshwater samples. PLoS ONE 12:e0179261.

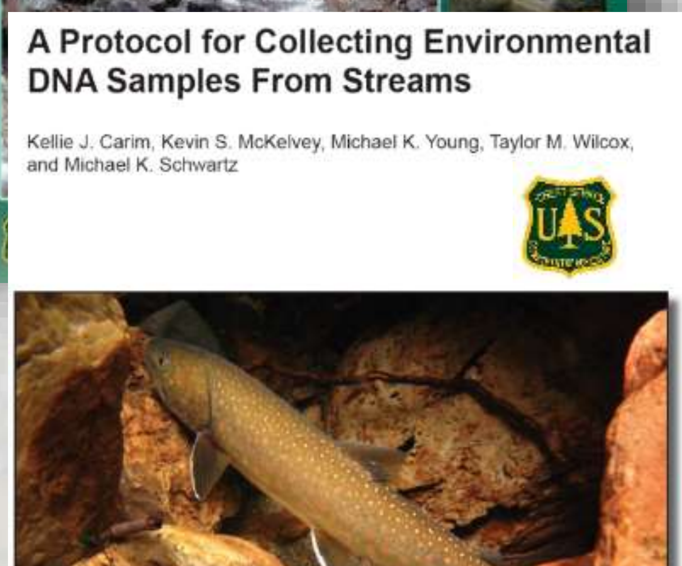
Aizu, M., S. Seino, T. Sado, and M. Miya. (n.d.). Environmental DNA metabarcoding with MiFish prim marine fish fauna of Tsushima Island, Nagasaki for establishing a marine protected area.

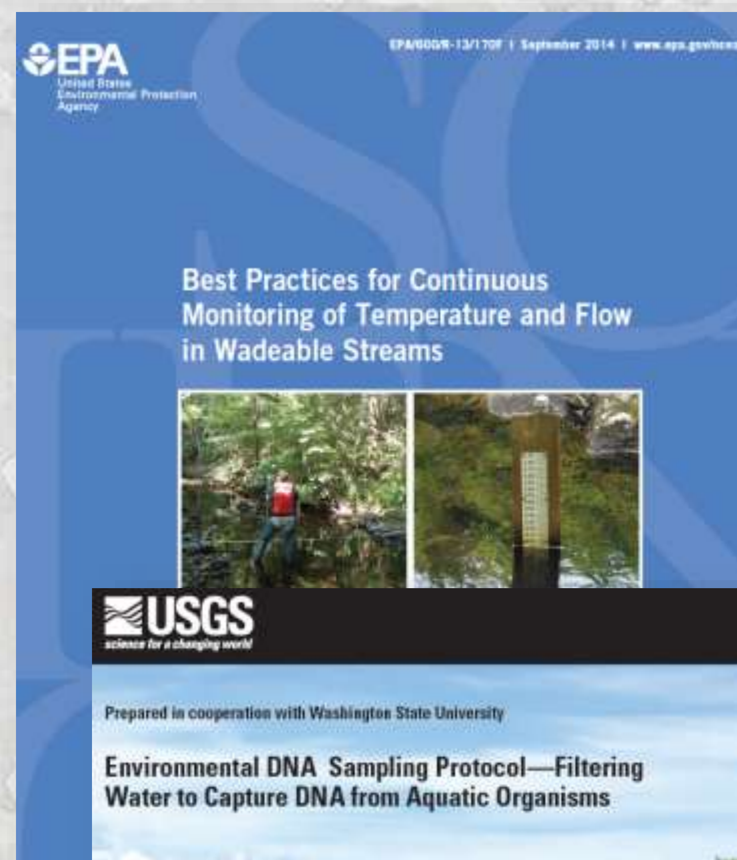
Alison A. Coulter*, D. K., J. J. Amberg‡, E. J. B. A. Reuben, and R. Goforth. 2013. Phenotypic plasticity spawning traits of bigheaded carp (Hypophthalmichthys spp.) in novel ecosystems. Freshwater Bio 58:1029–1037.

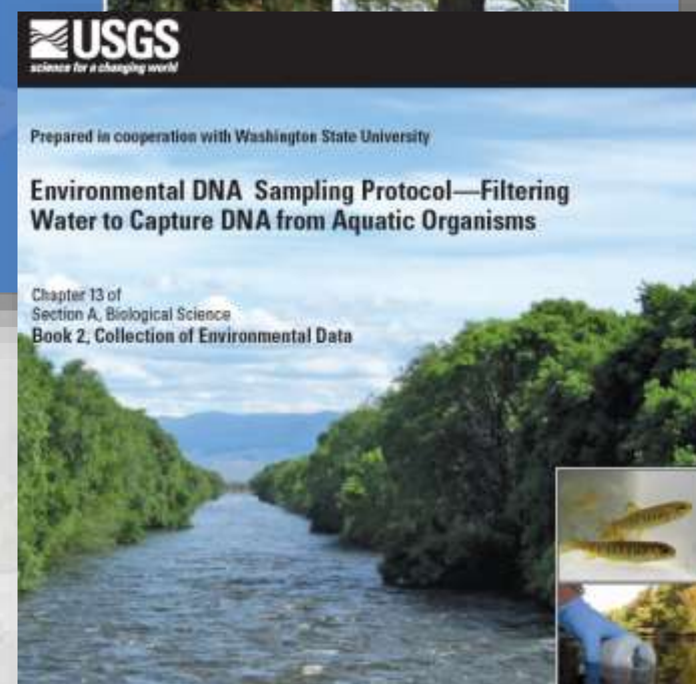
Costs will shrink

Standardized & Robust Data Collection Protocols Exist



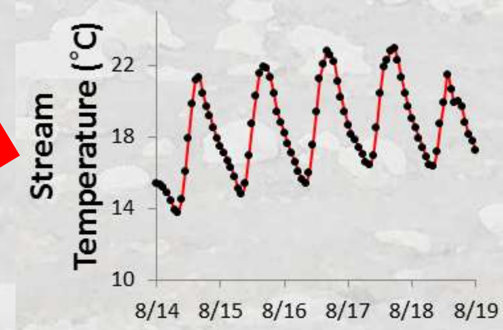


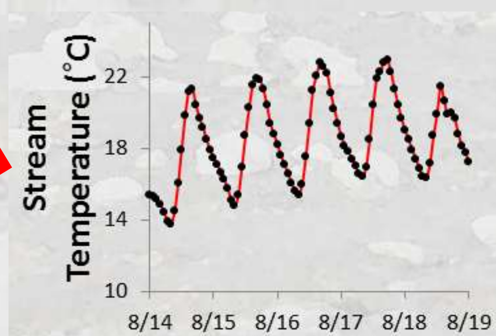




Example: BACI design to Measure Local Flow Restoration Effect

A) How much does flow alteration affect temperature?





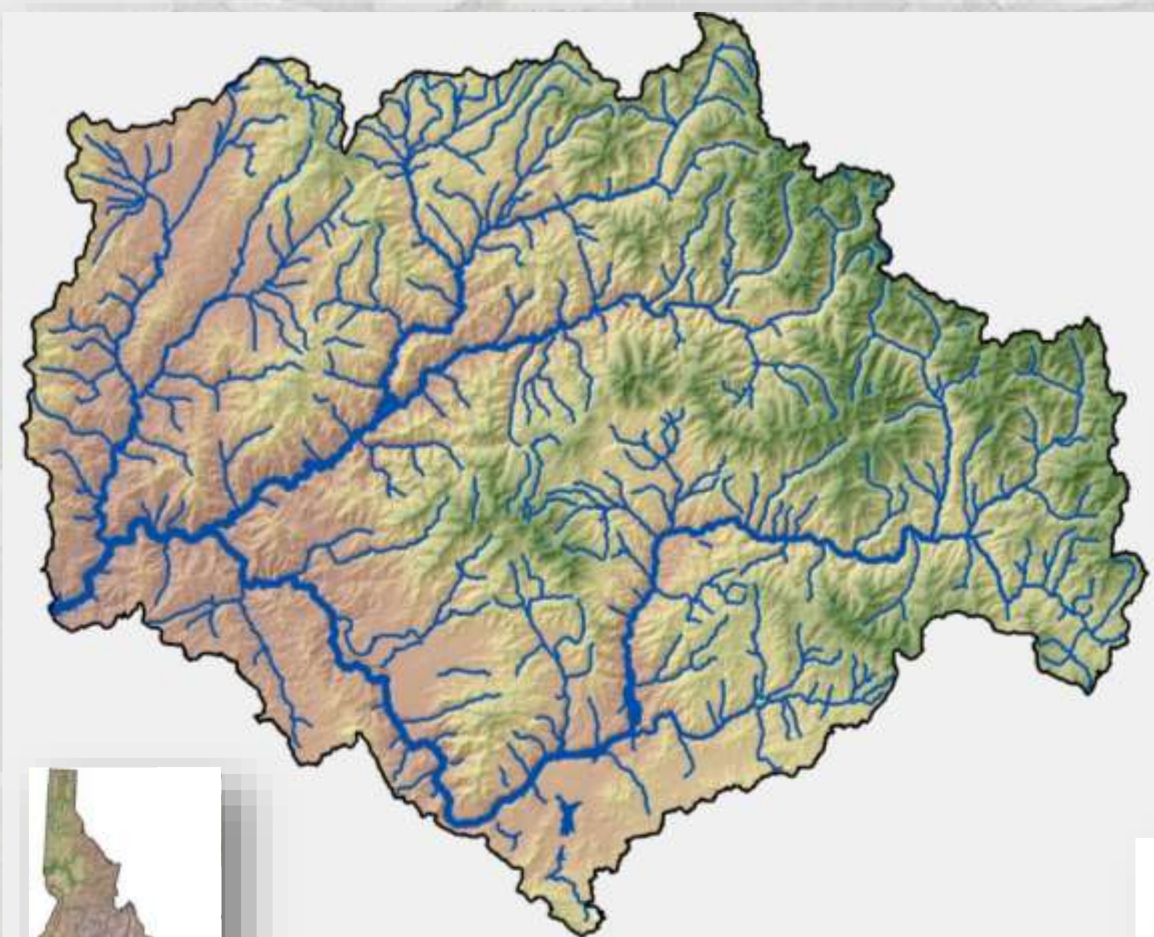
Example: BACI design to Measure Local Flow Restoration Effect

A) How much does flow alteration affect temperature?

B) Does better flow passage design result in dispersal?

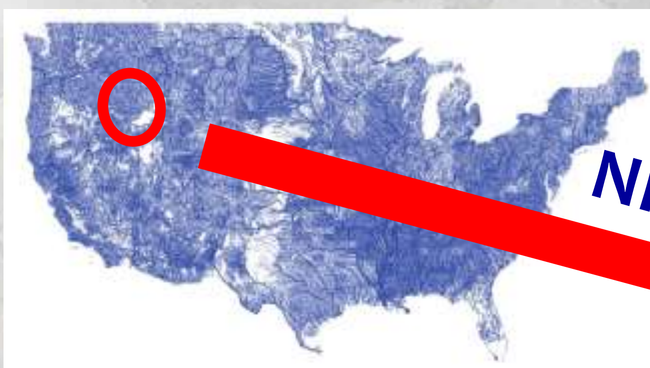
Example: NHD Guided Network Sampling Design

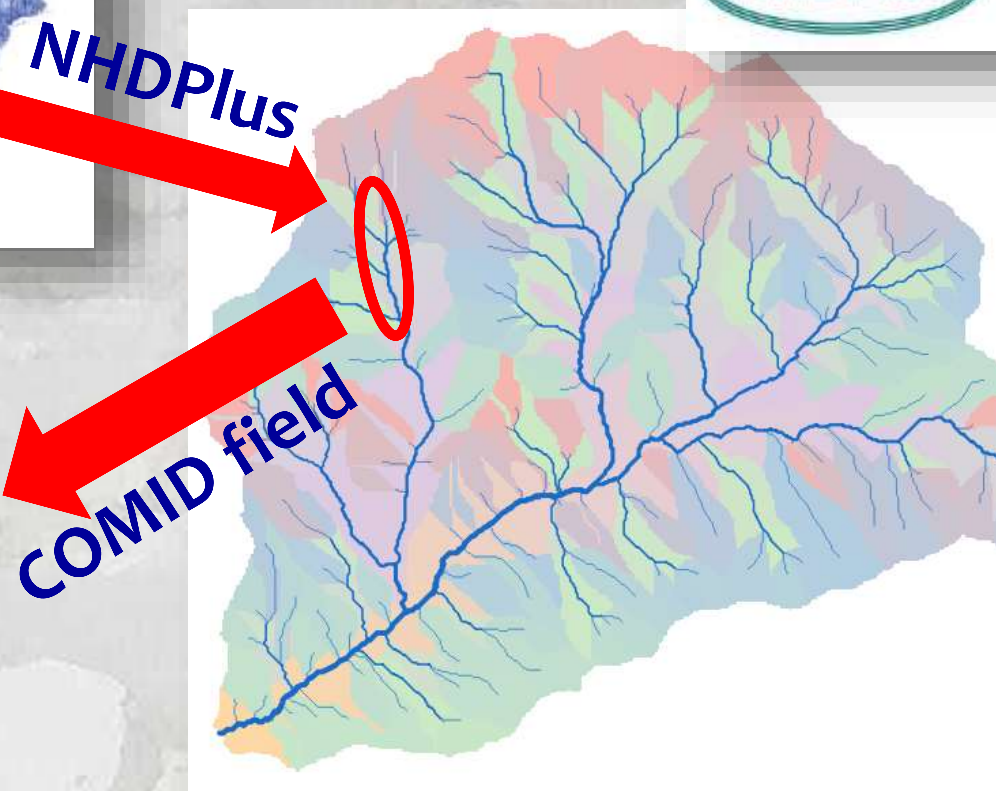
Monitoring network in central Idaho
7,000 hectares and 2,500 stream kilometers



Link Descriptors to NHD Reaches to Make Network Queries Possible

Easily done anywhere

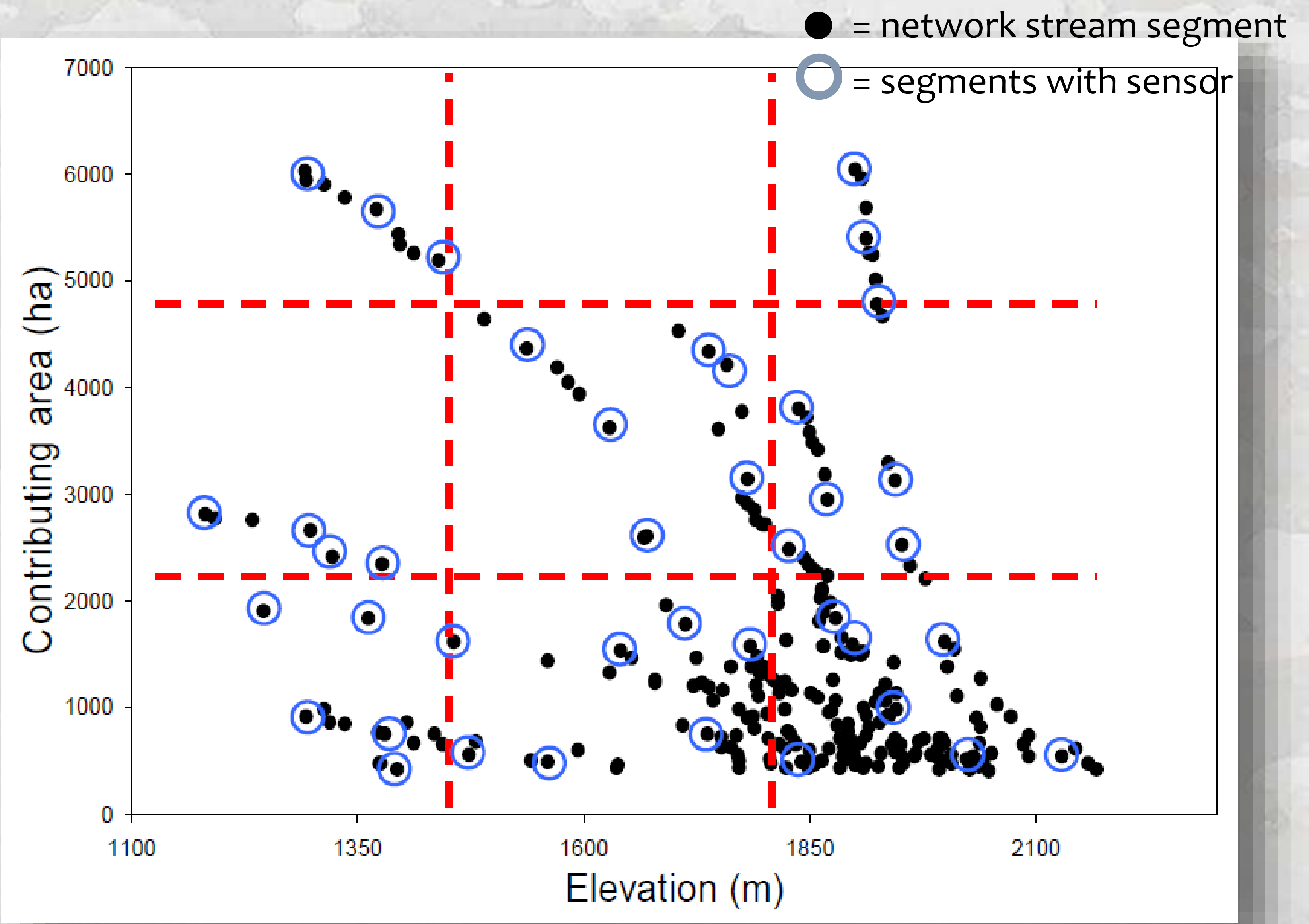




- **Elevation**
- **Slope**
- **%Landuse**
- **Precipitation**

10's more…

Summarize Network Gradients & Locate Sensors Based on Design Criteria (SRS, Systematic, GRTS, etc.)



Example: NHD Guided Network Sampling Design

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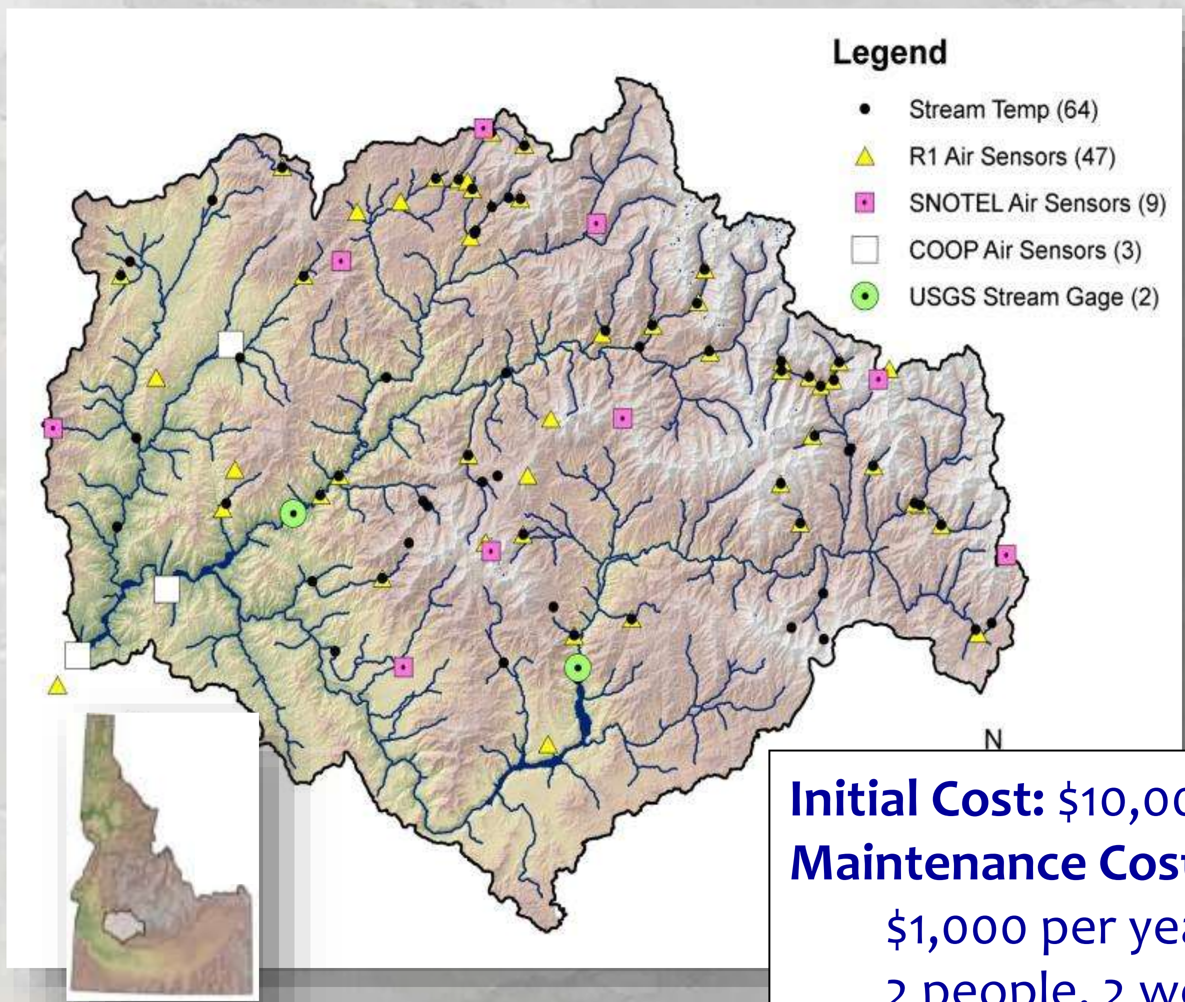


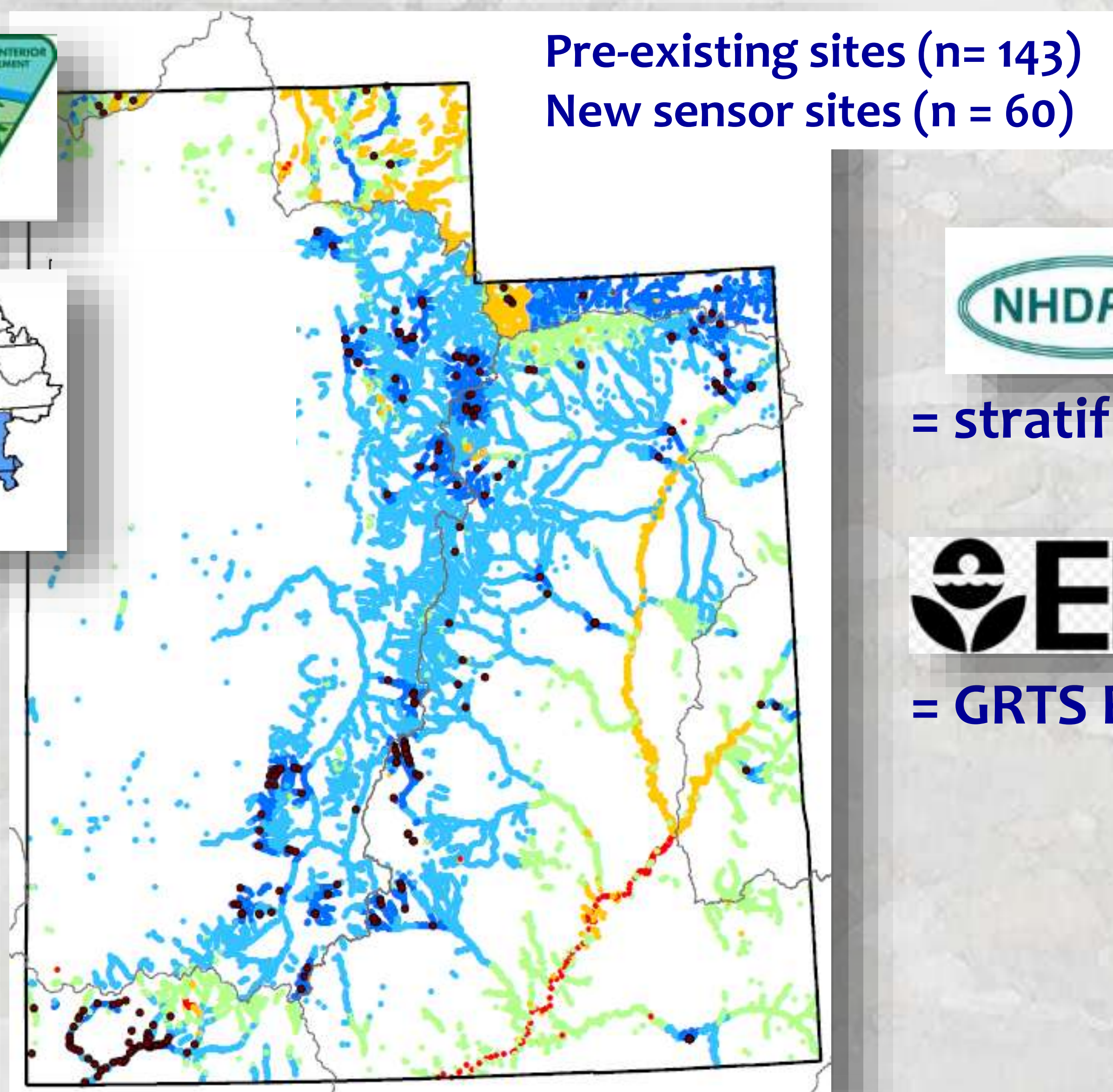
Stream sensors

Air sensors

Initial Cost: $10,000
Maintenance Cost:
$1,000 per year
2 people, 2 weeks to visit sensors (download & replace)

Example: NHD Guided Network Sampling Design

Utah Temperature Monitoring Enhancement



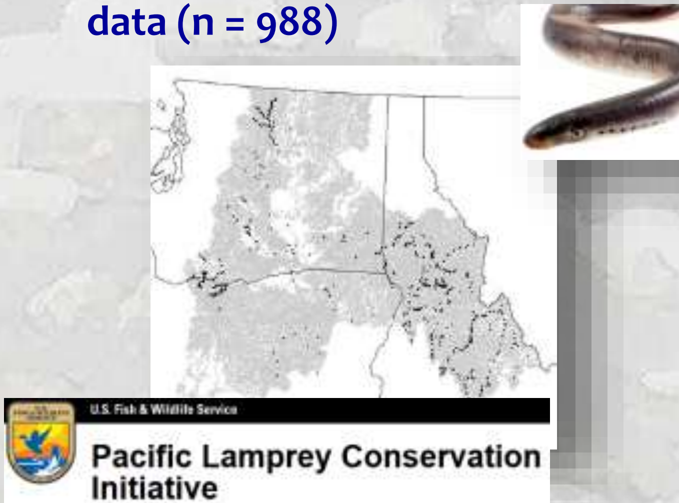
= stratification

= GRTS Random

Example: NHD Guided Network Sampling Design

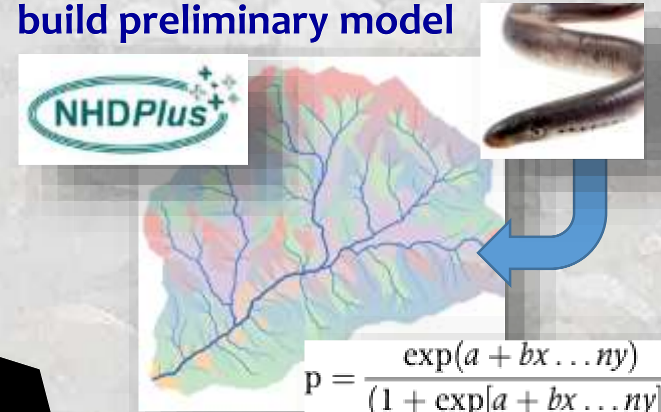
Pacific Lamprey Regional eDNA Sampling Design

Obtain existing biological survey data (n = 988)



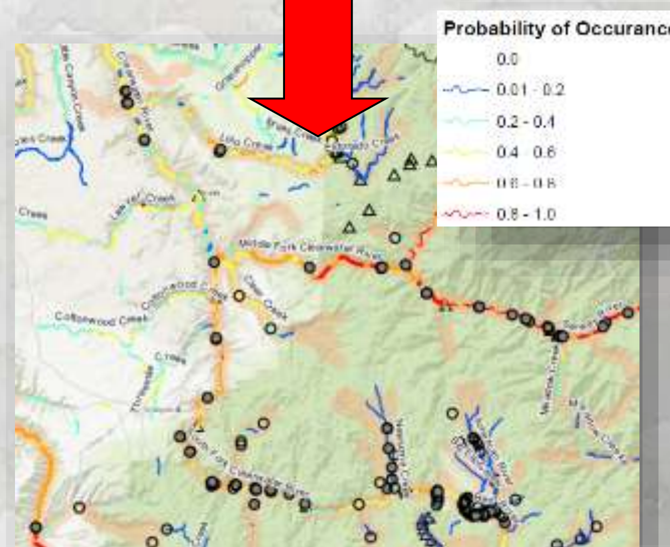
https://www.fws.gov/pacificlamprey/mainpage.cfm

Link data to NHD covariates & build preliminary model



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

Refit model

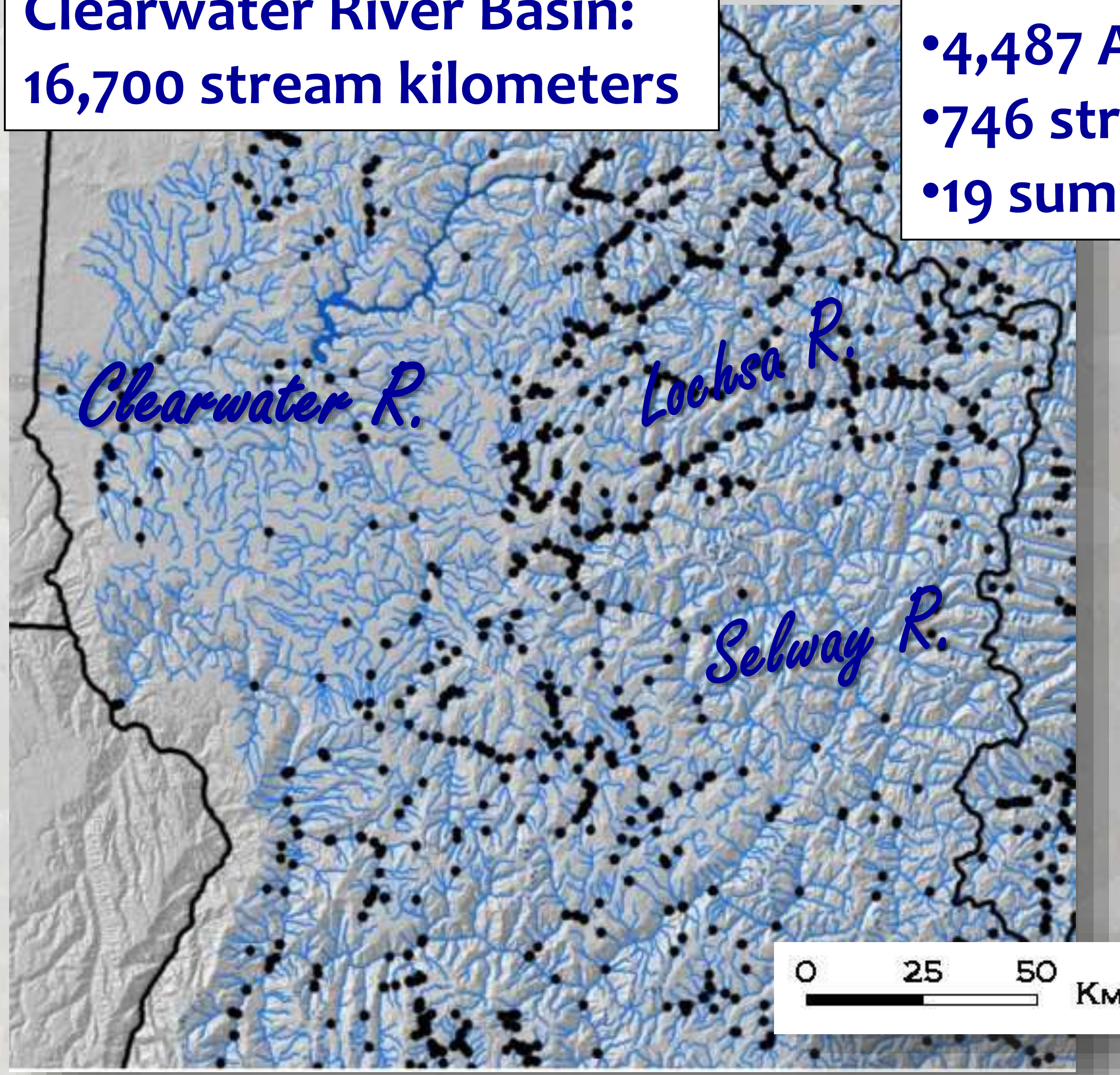


Use model to predict habitat suitability throughout study area network

Systematically eDNA sample potential habitat

Example: Network Scale Model of Drought Year Effects on Trout Thermal Habitat

Clearwater River Basin: 16,700 stream kilometers

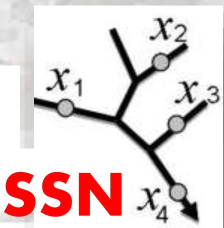


- 4,487 August means
- 746 stream sites
- 19 summers (1993-2011)

- Temperature site

Statistical Stream Temperature Model

$$\mathbf{y} = \mathbf{X}\beta + \mathbf{L}\gamma + \mathbf{R}\eta + \mathbf{z}_{TU} + \mathbf{z}_{TD} + \mathbf{z}_{EUC} + \varepsilon,$$



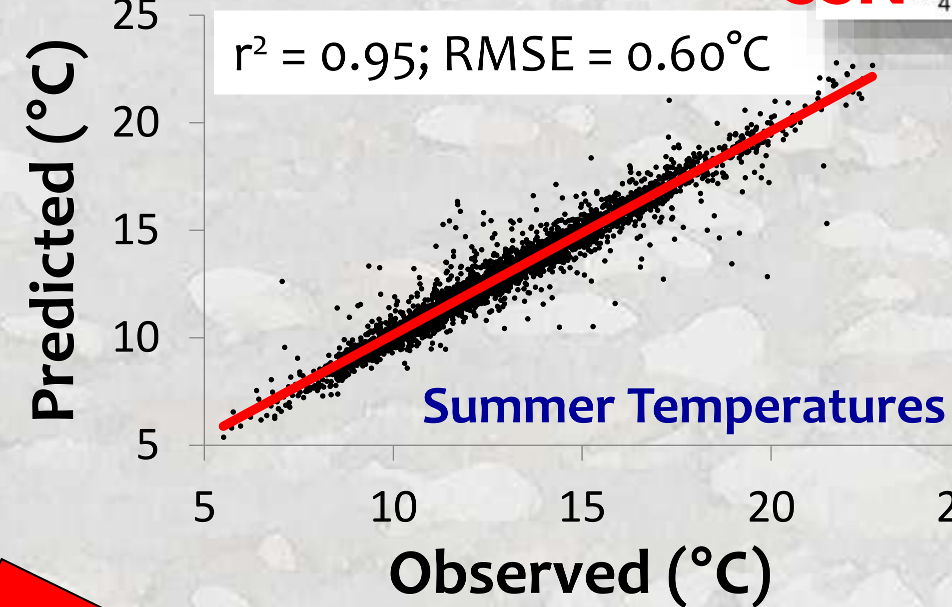
SSN

Covariate Predictors

1. Elevation (**DEM**)
2. Canopy (**NLCD**)
3. Stream slope (**NHD**)
4. Ave Precipitation (**NHD**)
5. Latitude (**GPS**)
6. Lakes upstream (**NHD**)
7. Baseflow Index (**USGS**)
8. Watershed size (**NHD**)

9. Discharge (**NWIS - USGS**)

10. Air Temperature (**USGS, COOP, many sources**)

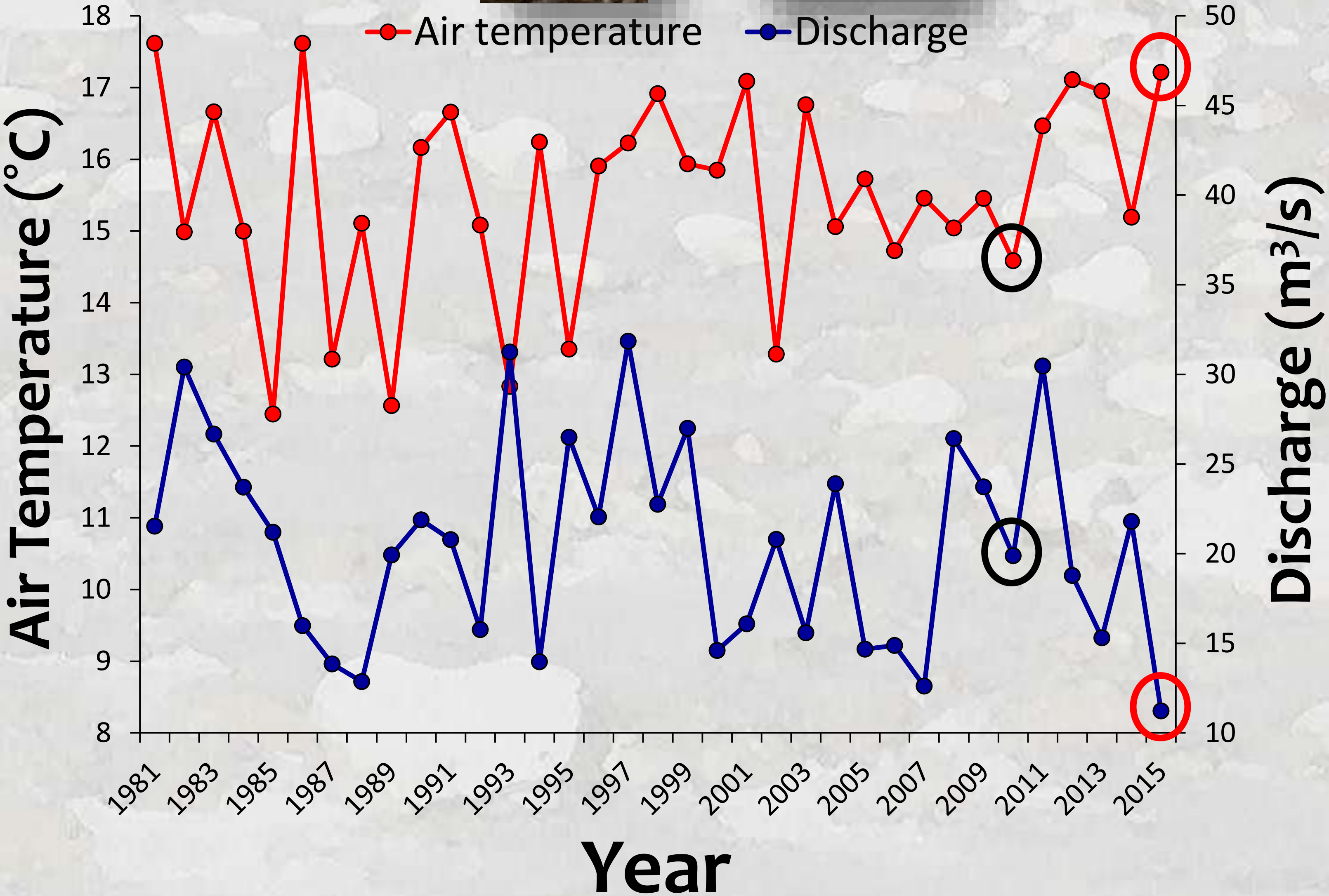


Isaak et al. 2017. The NorWeST summer stream temperature model & scenarios for the western U.S. *Water Resources Research* **53**: 9182-9205.

Summer Climate Variation (1981–2015)

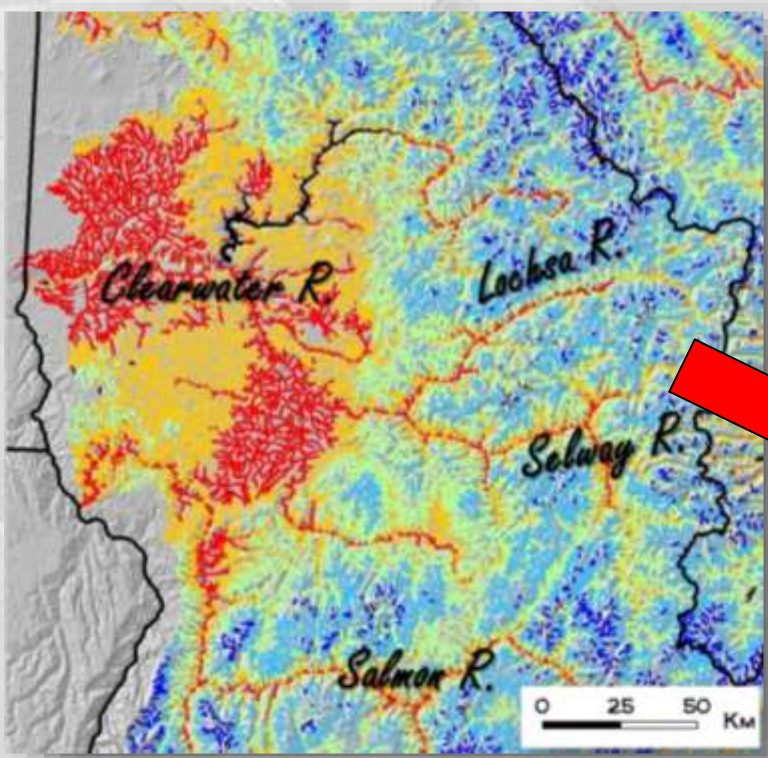
COOP Stations

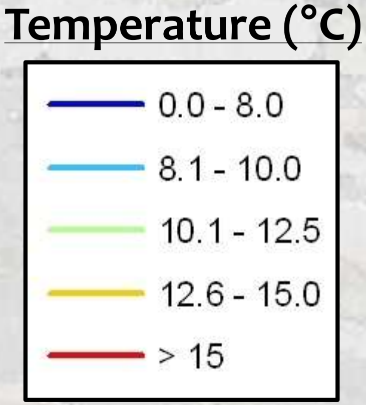
NWIS - USGS

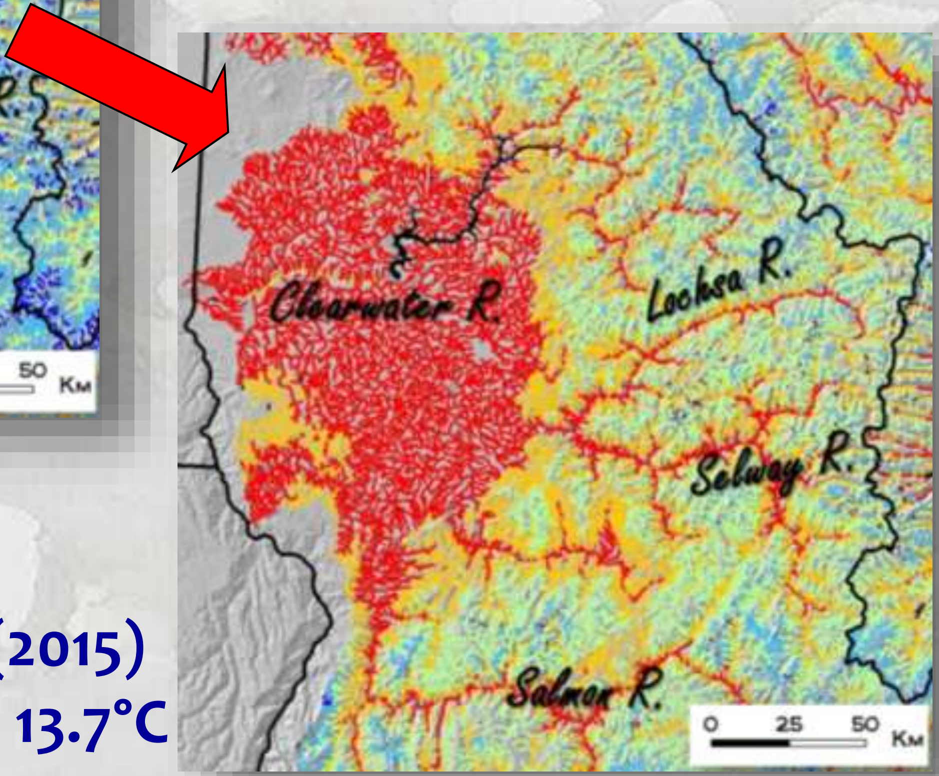


Prediction Maps for Summer Temperatures

Average year (2010)
temperature = 12.2°C



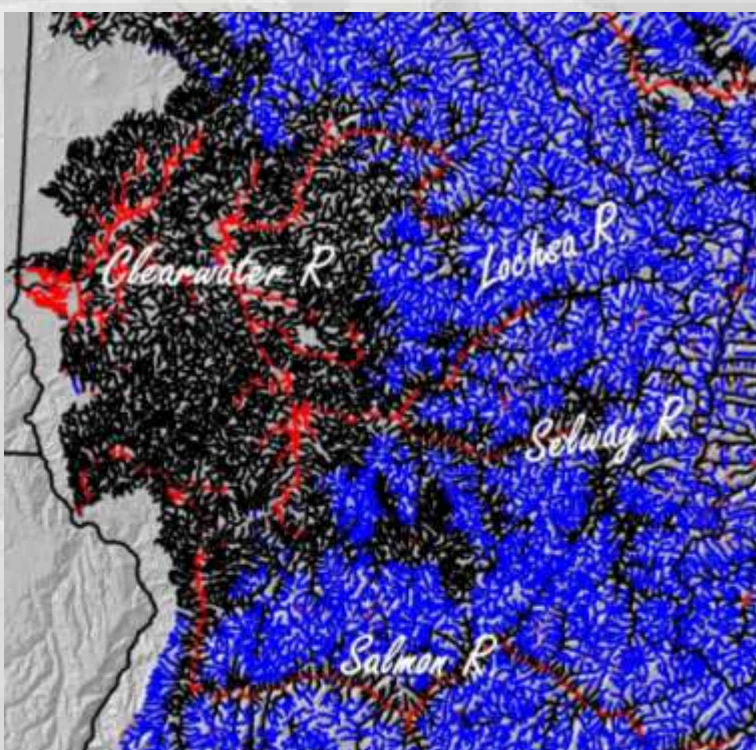




Drought year (2015)
temperature = 13.7°C

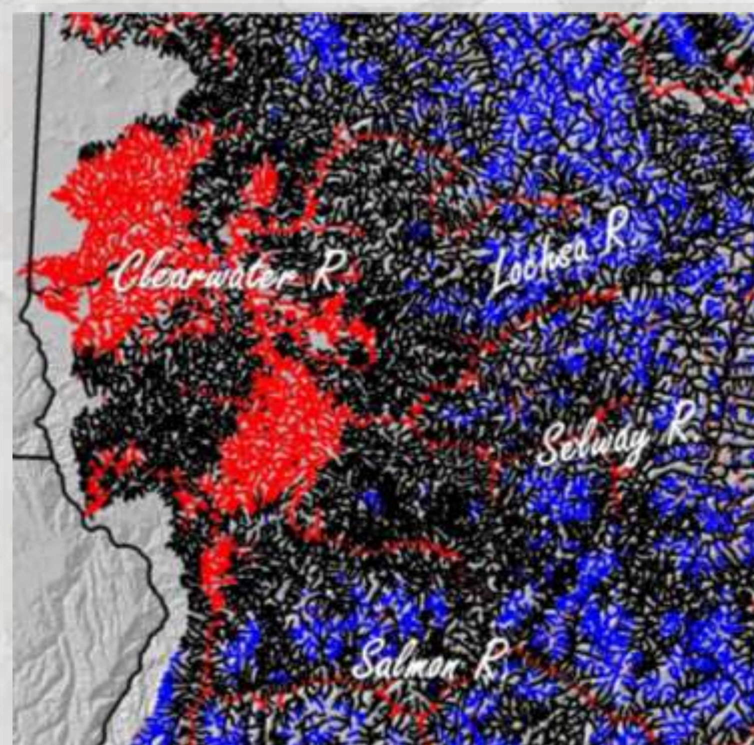
Where are Cutthroat Trout Negatively Affected?

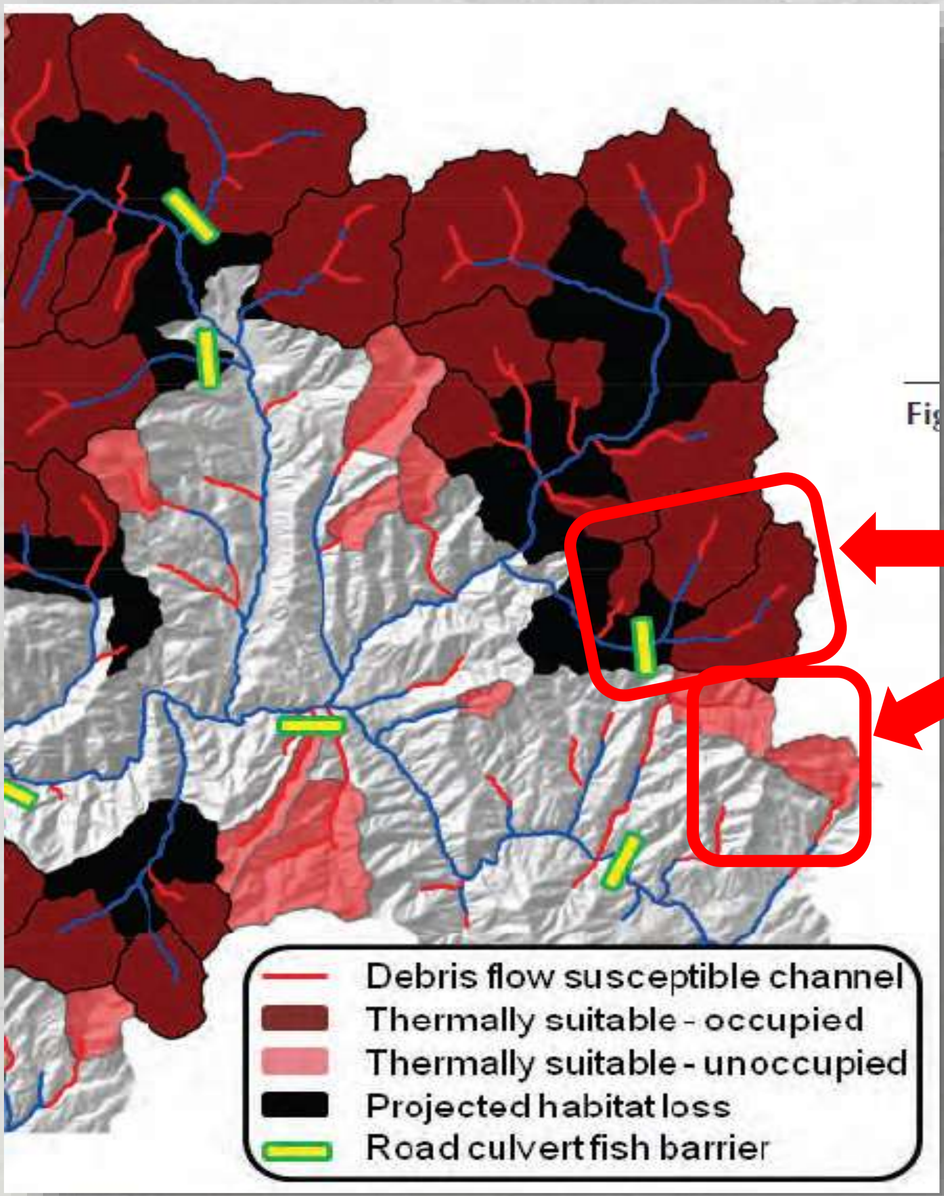
Average year (2010)



- Too Cold <11.0 °C
- Suitable <17.0°C & >11.0 °C
- Too Hot >17.0°C

Drought year (2015)





I’m going to invest here…

… instead of here