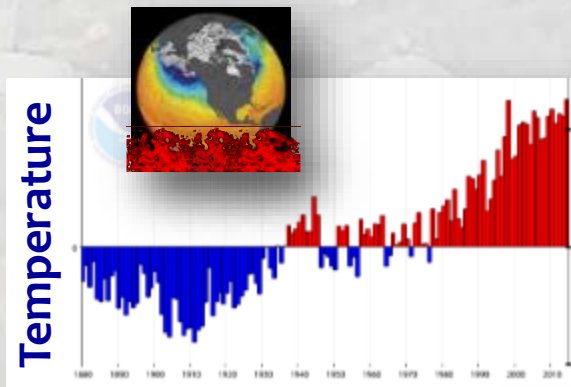


This Century's Bull Trout Forecast: Partly Sunny With Scattered Rain Showers

Dan Isaak and Mike Young

U.S. Forest Service, Rocky Mountain Research Station

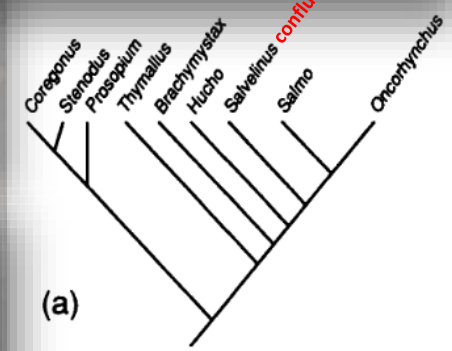
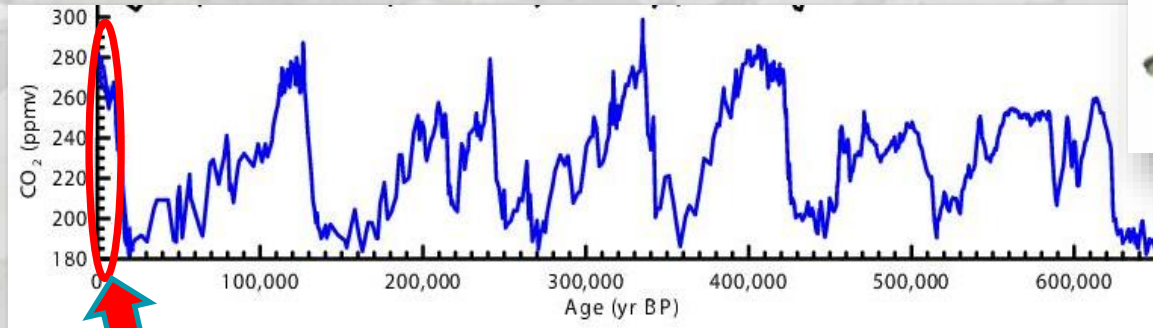


Before

After



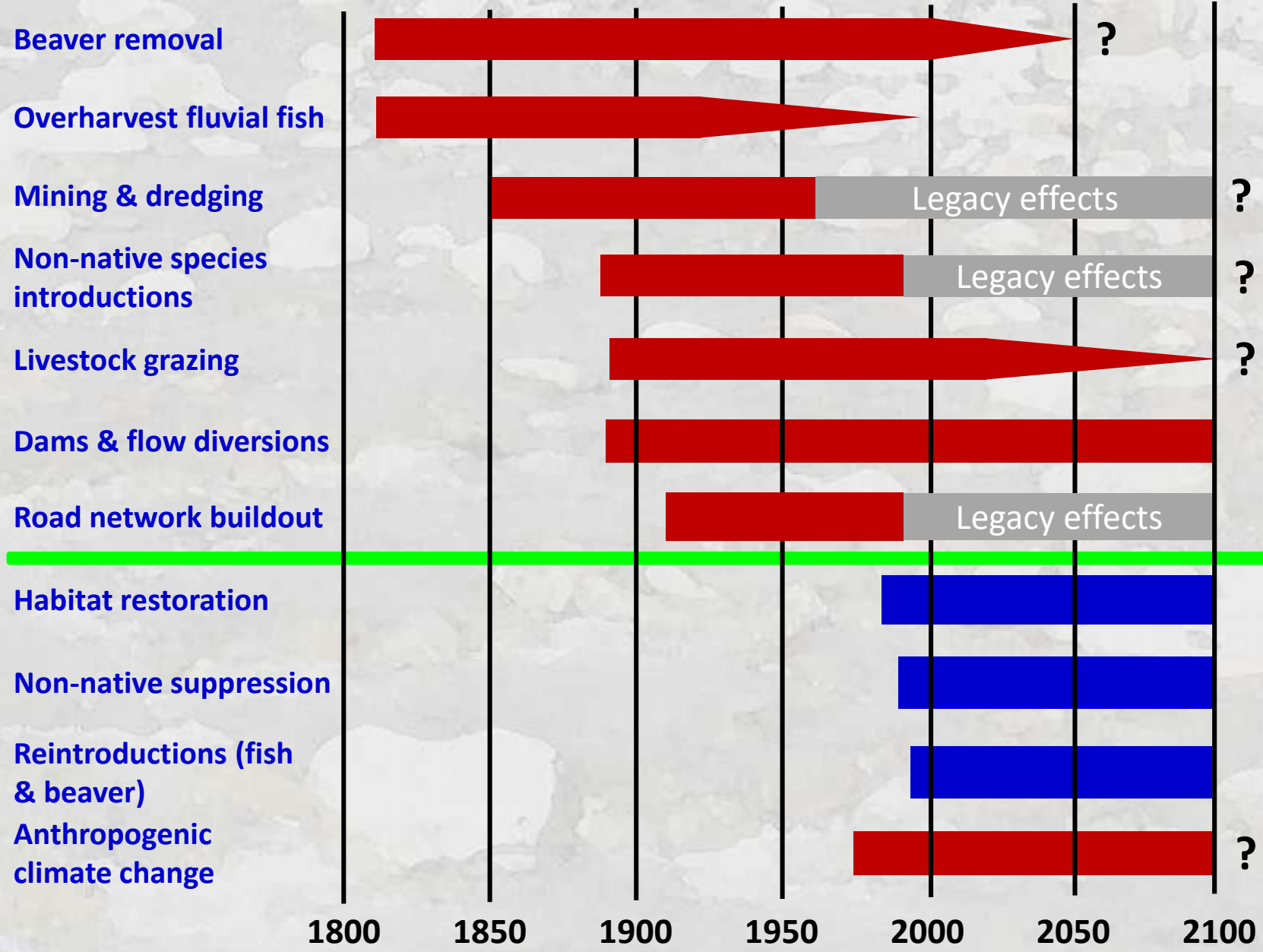
Much Has Transpired in the Bull Trout World Over Millions of Years...



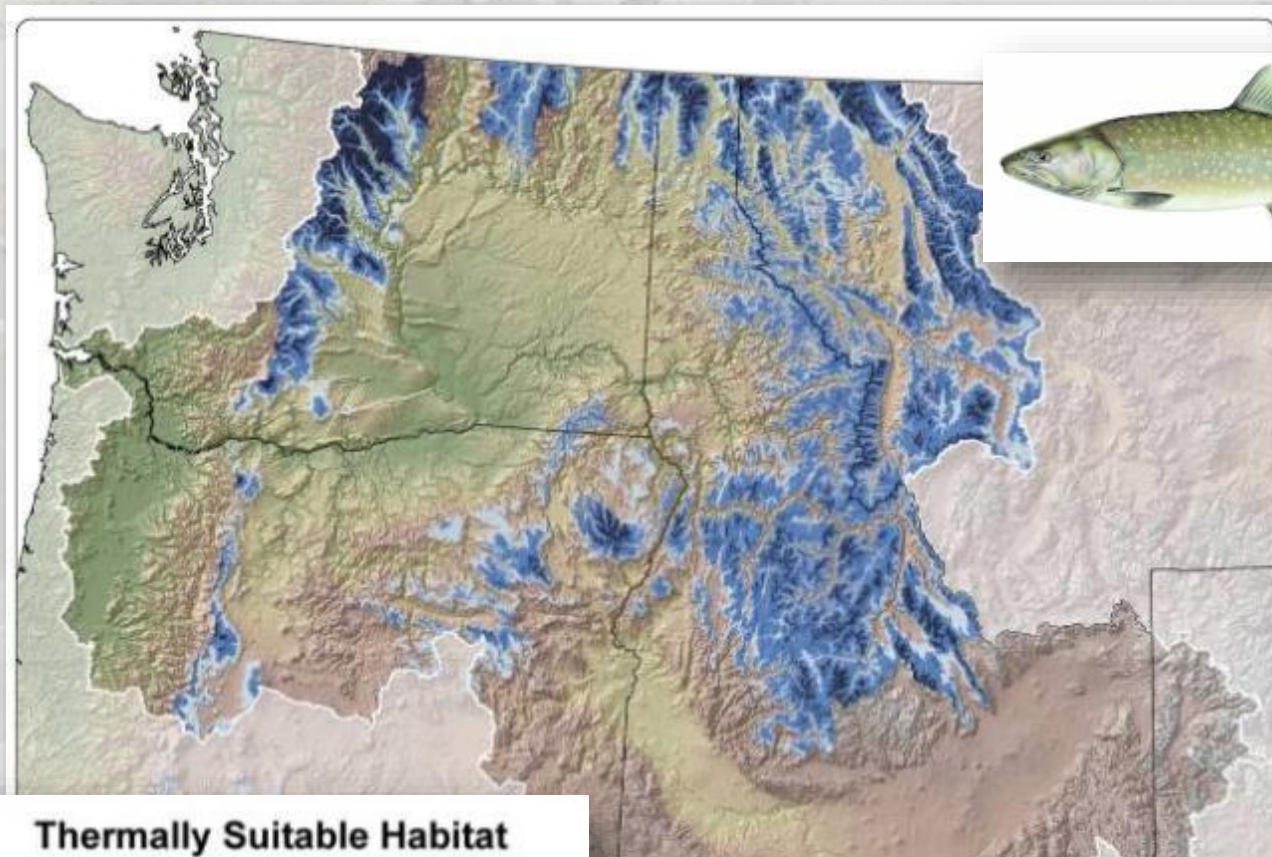
Human Civilization



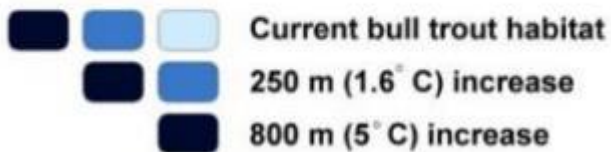
Novel Twists Last 200 Years...



1st-Generation Bull Trout Climate Model Predicts Large Habitat Reductions from Warming



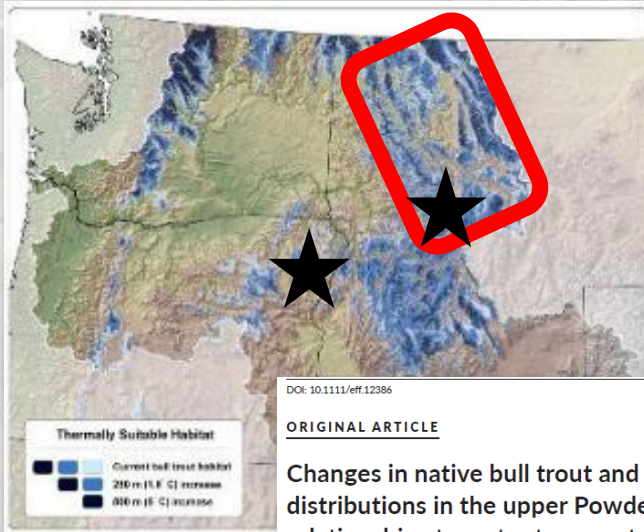
Thermally Suitable Habitat



+1.6° C AirT = 40% habitat loss
+5.0° C AirT = 92% habitat loss

Rieman et al. 2007. Anticipated climate warming effects on bull trout habitats and populations across the Interior Columbia Basin. *TAFS* 136:1552-1565

Subsequent Resurvey Studies Confirm Distributions are Contracting into Headwaters



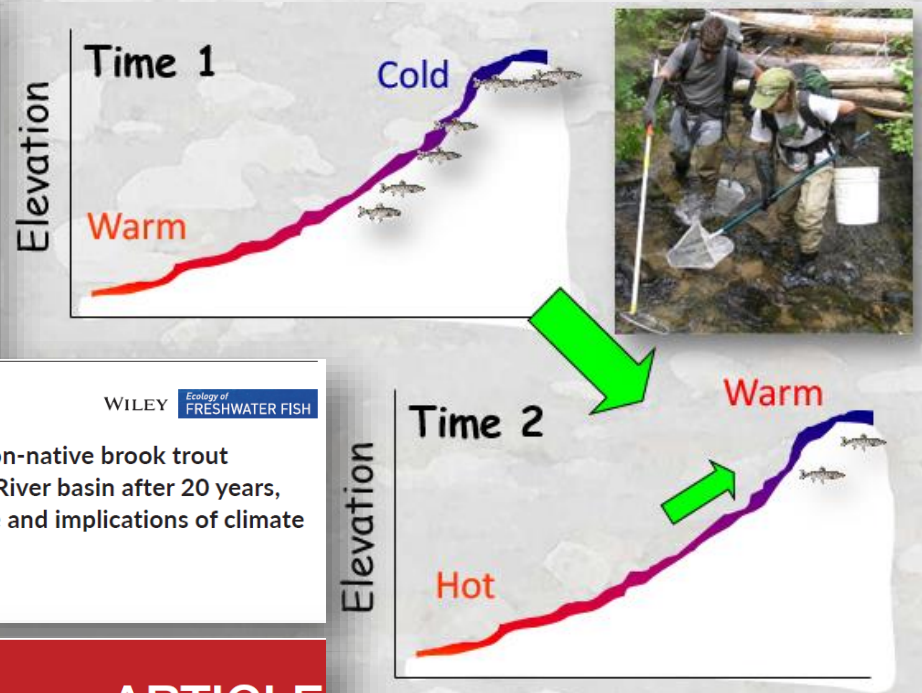
DOI: 10.1111/eff.12386

ORIGINAL ARTICLE

WILEY *Ecology of FRESHWATER FISH*

Changes in native bull trout and non-native brook trout distributions in the upper Powder River basin after 20 years, relationships to water temperature and implications of climate change

Philip J. Howell



ARTICLE

Are brown trout replacing or displacing bull trout populations in a changing climate?

Robert Al-Chokhachy, David Schmetterling, Chris Clancy, Pat Saffel, Ryan Kovach, Leslie Nyce, Brad Liermann, Wade Fredenberg, and Ron Pierce



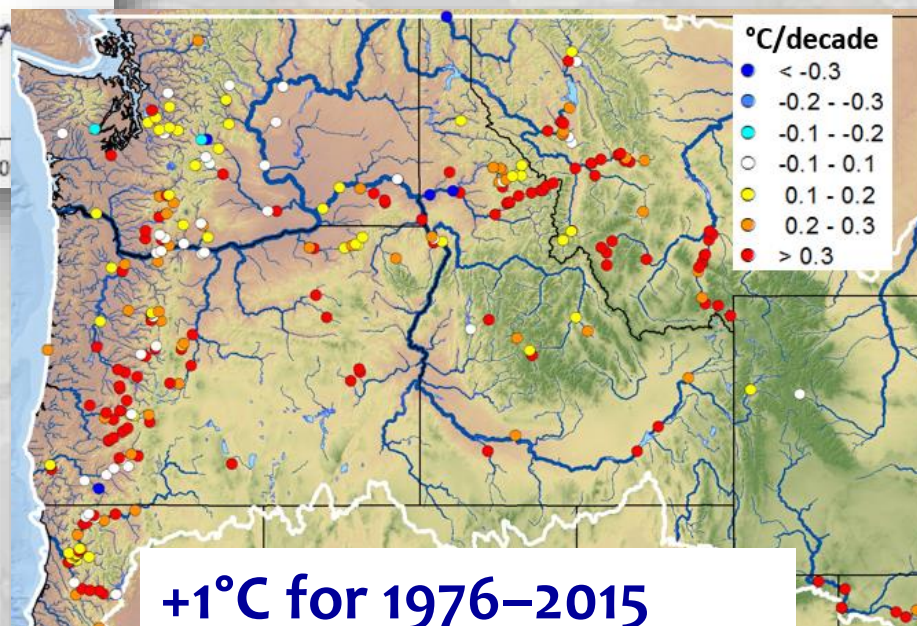
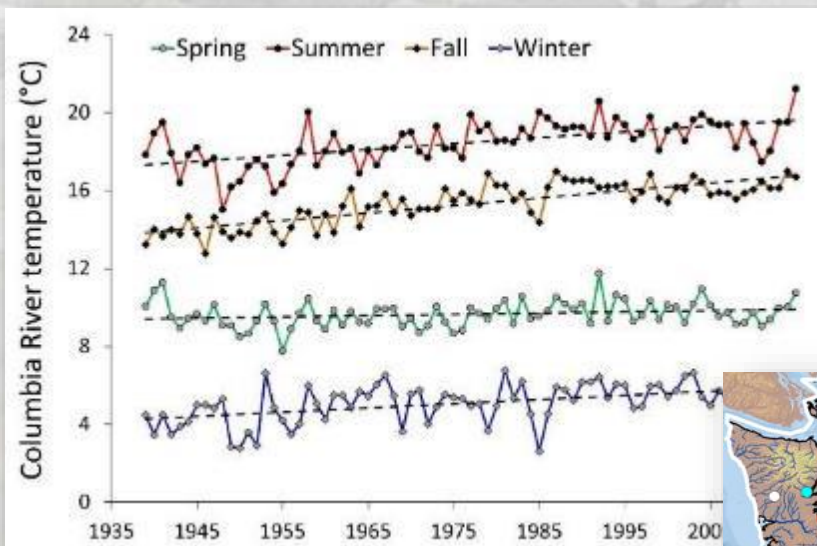
Evidence of Climate-Induced Range Contractions in Bull Trout *Salvelinus confluentus* in a Rocky Mountain Watershed, U.S.A.

Lisa A. Eby¹, Olga Helmy¹, Lisa M. Holsinger², Michael K. Young^{3*}

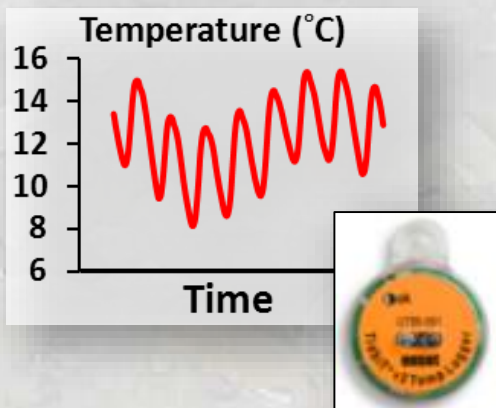
Expected Because Rivers & Streams are Getting Warmer...



**Bonneville Dam
Temperature Record**

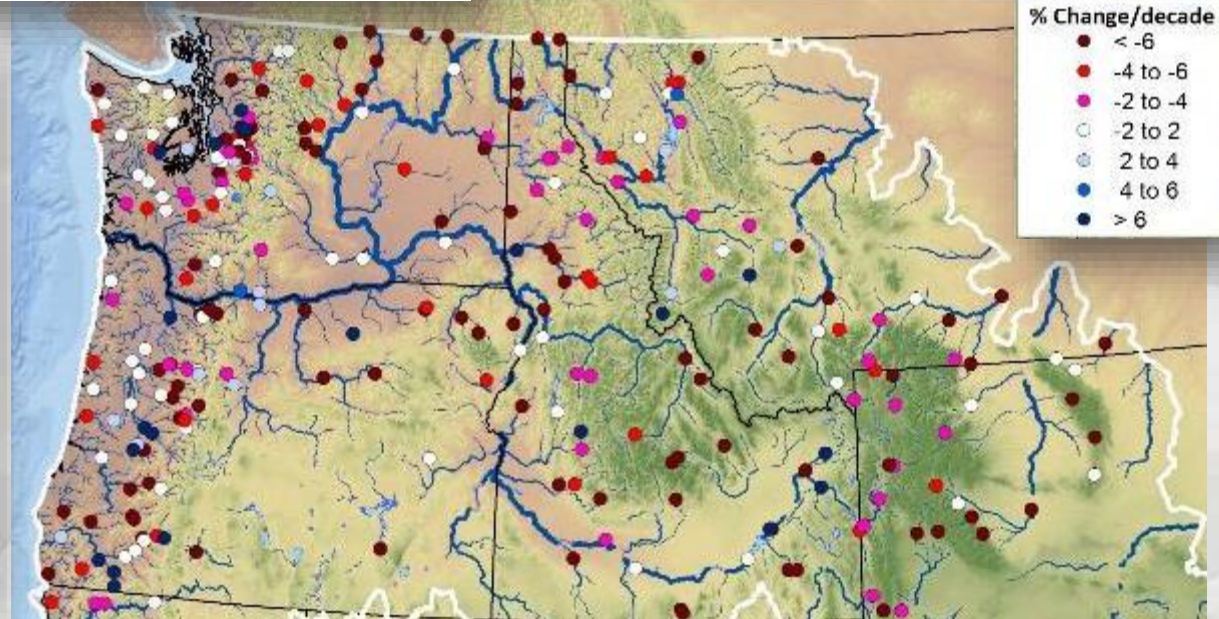
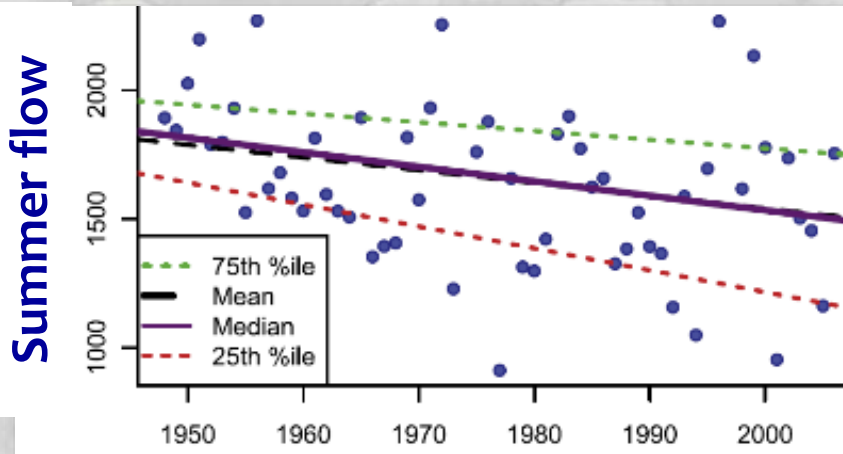


**+1°C for 1976–2015
Summer & fall months**



Isaak et al. 2018. Global warming of salmon and trout rivers in the Northwestern U.S. Road to ruin or path through purgatory? *Transactions of the American Fisheries Society* 147:566-587.

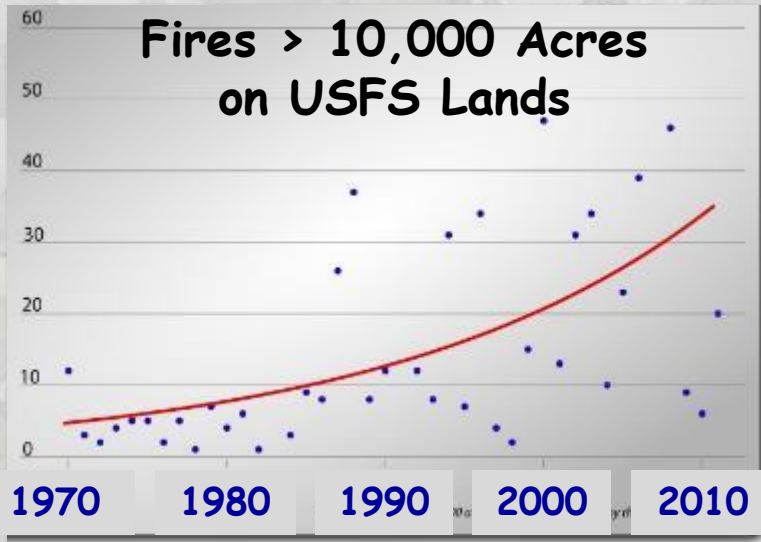
Summer Flows are Decreasing (1950–2015)



Luce and Holden 2009. Declining annual streamflow distributions in the PNW, 1948-2006. *Geophysical Research Letters* **36**: L16401.

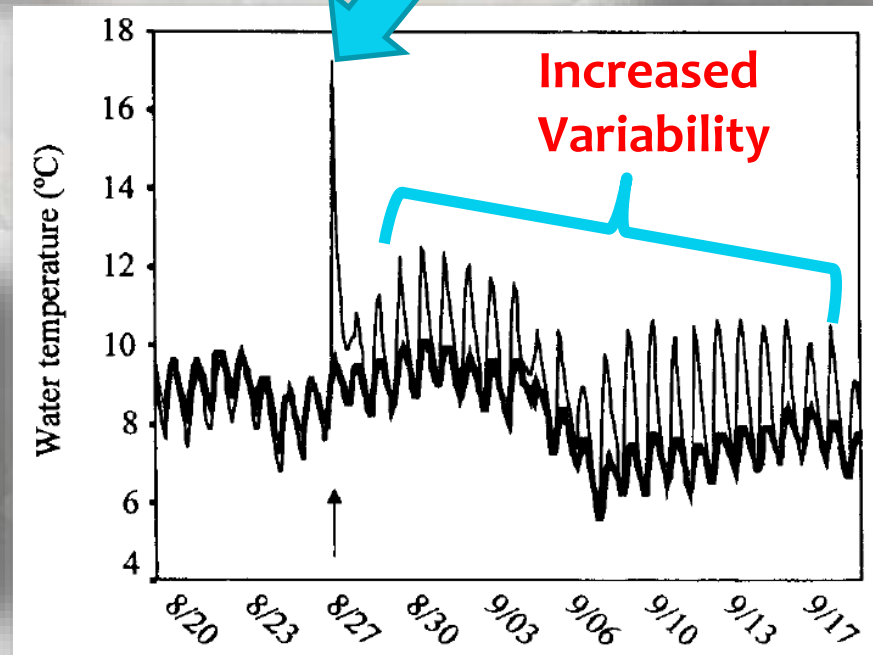
Luce et al. 2013. The missing mountain water. *Science* **342**: 1360-1364.

& Wildfires are Increasing



Fire

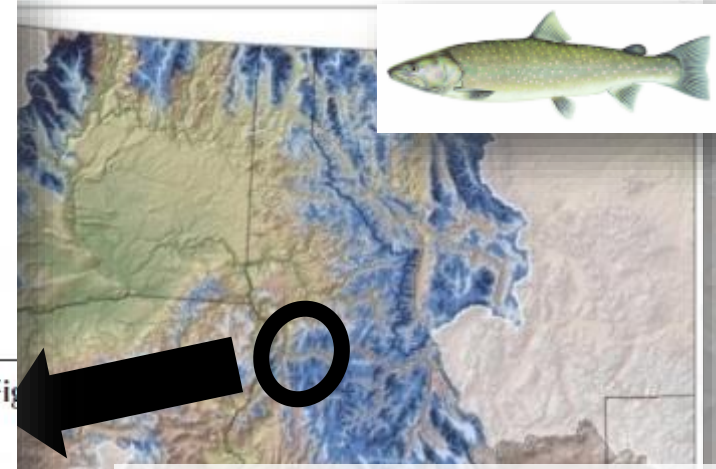
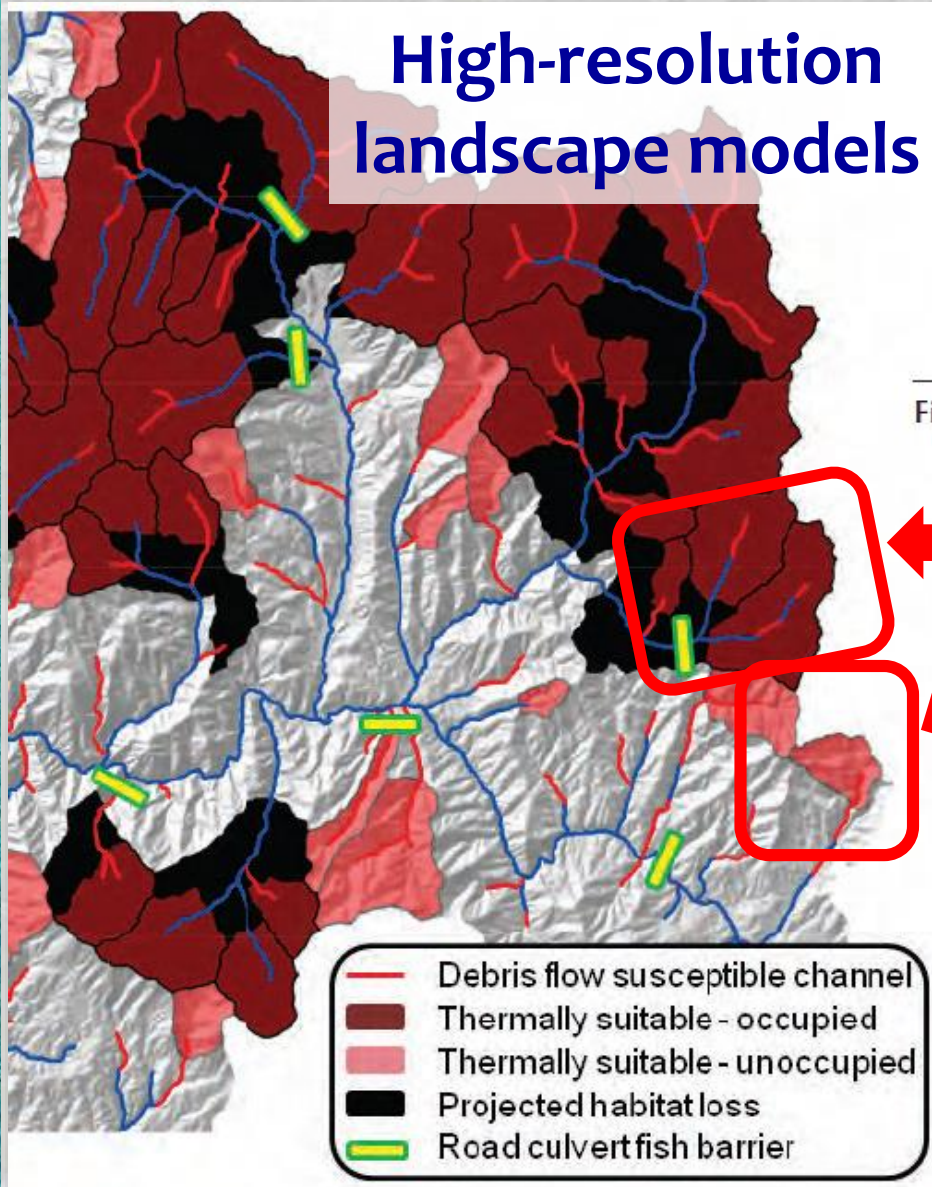
Exacerbates temperature gains & short-term disturbances



Fire

Increased Variability

Which Streams May Serve as Climate Refugia? Precision Forecasts Needed



I'm going to invest here...

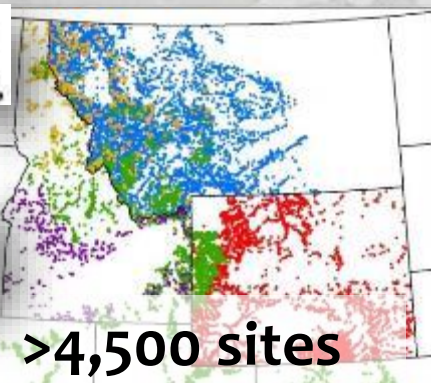
... instead of here



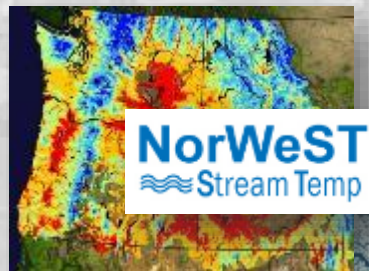
2nd-Generation Bull Trout Climate Model



BIG FISH DATA



>4,500 sites
>500 streams

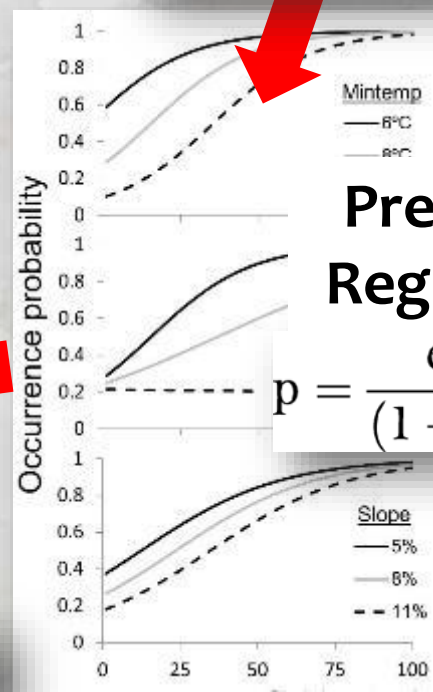
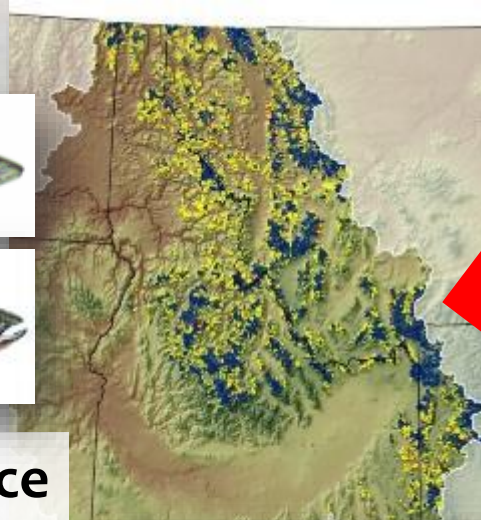


Variables

- Summer temp
- Patch size
- Gradient
- % Brook trout



Occurrence probability maps

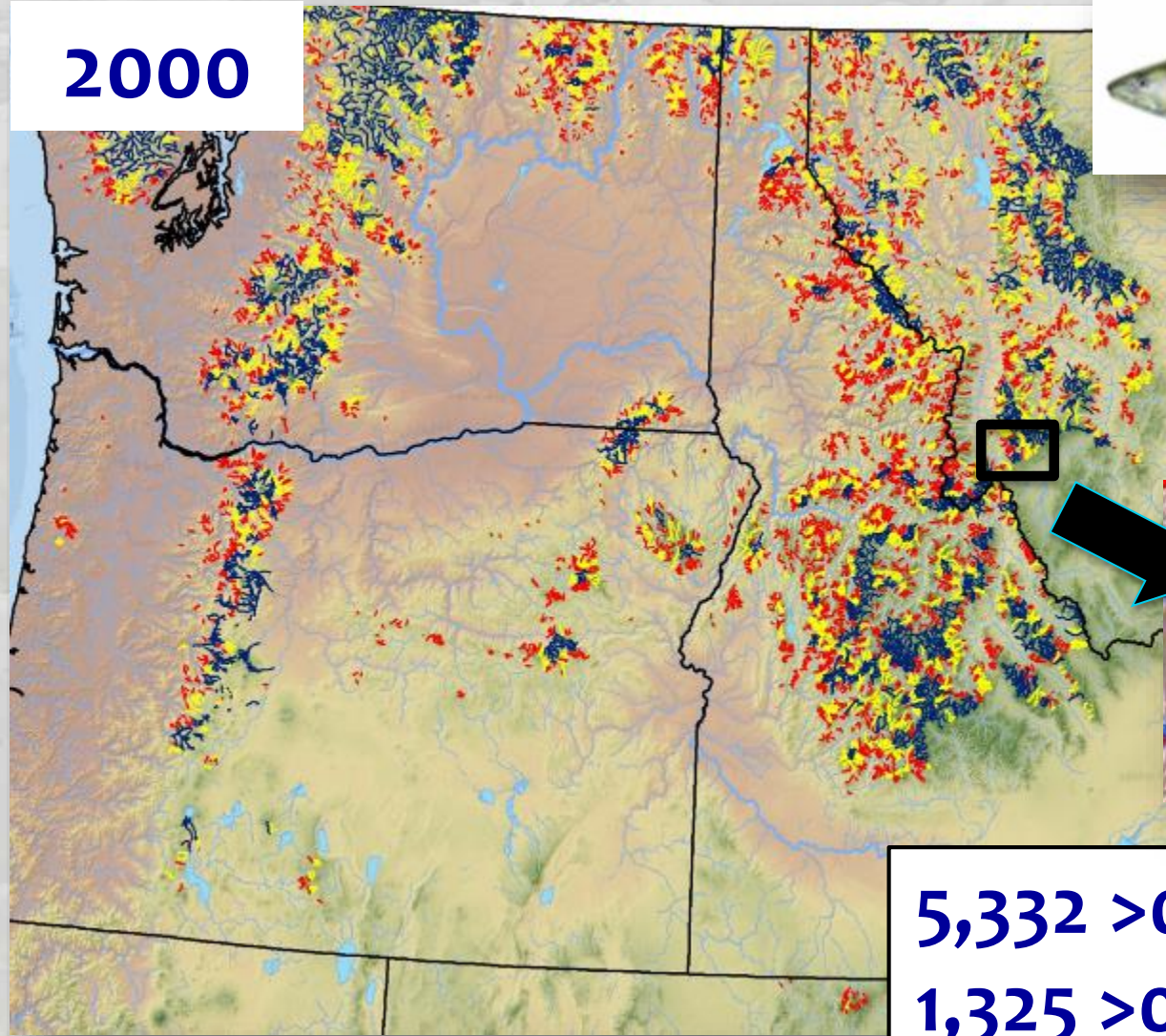


Predictive Logistic Regression Models

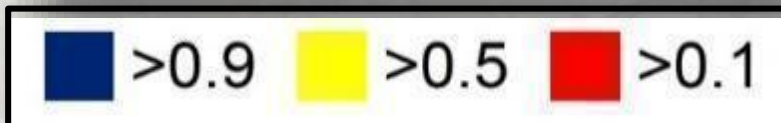
$$p = \frac{\exp(a + bx \dots ny)}{(1 + \exp[a + bx \dots ny])}$$

Bull Trout Population Occurrence Probability

2000



Stream
population scale
predictions

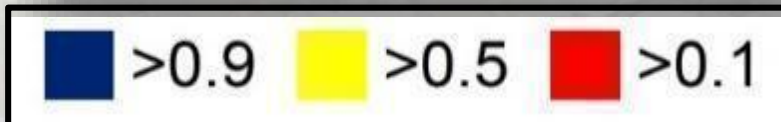
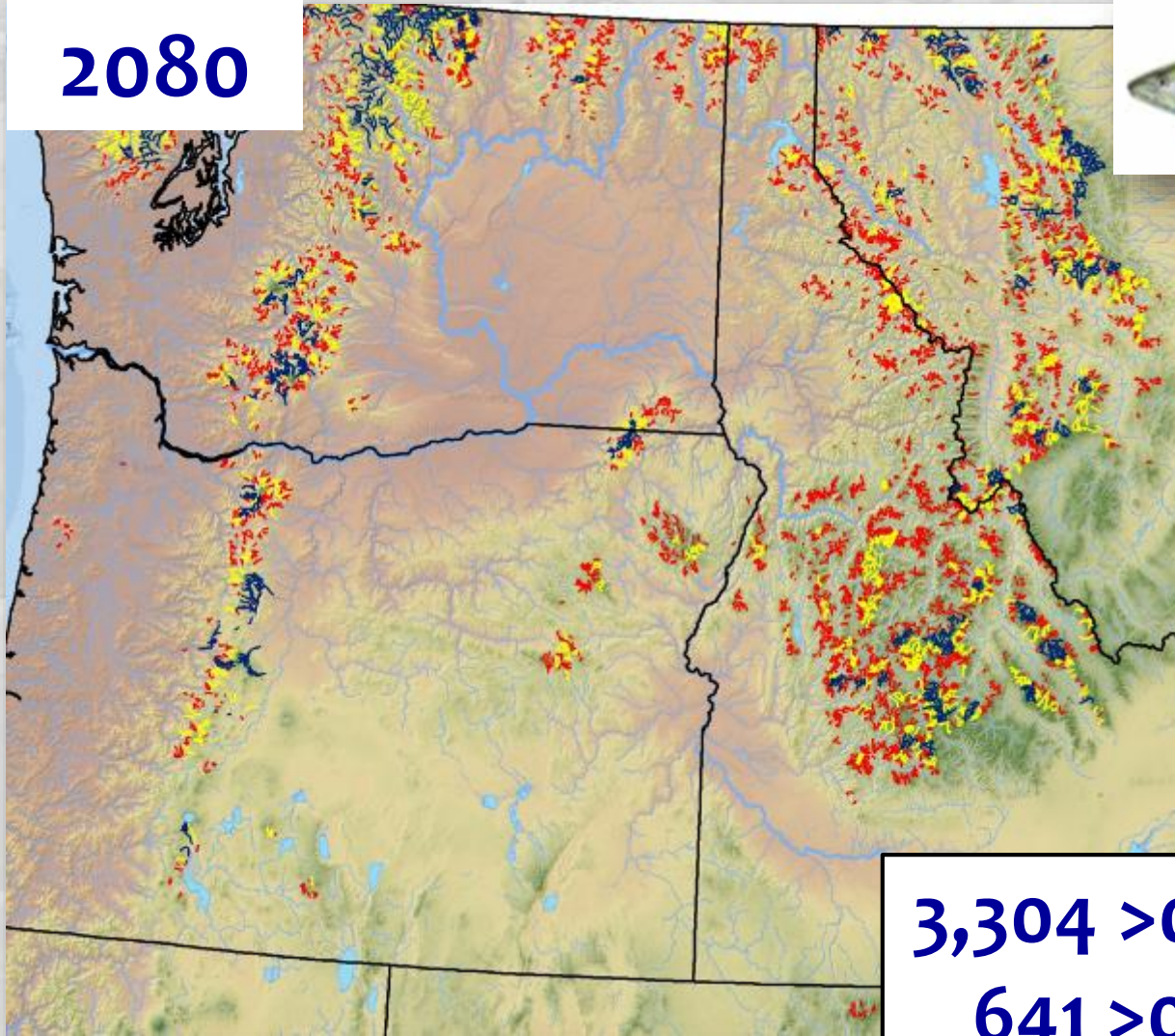


5,332 >0.1 habitats
1,325 >0.5 habitats
348 >0.9 habitats



Bull Trout Population Occurrence Probability

2080

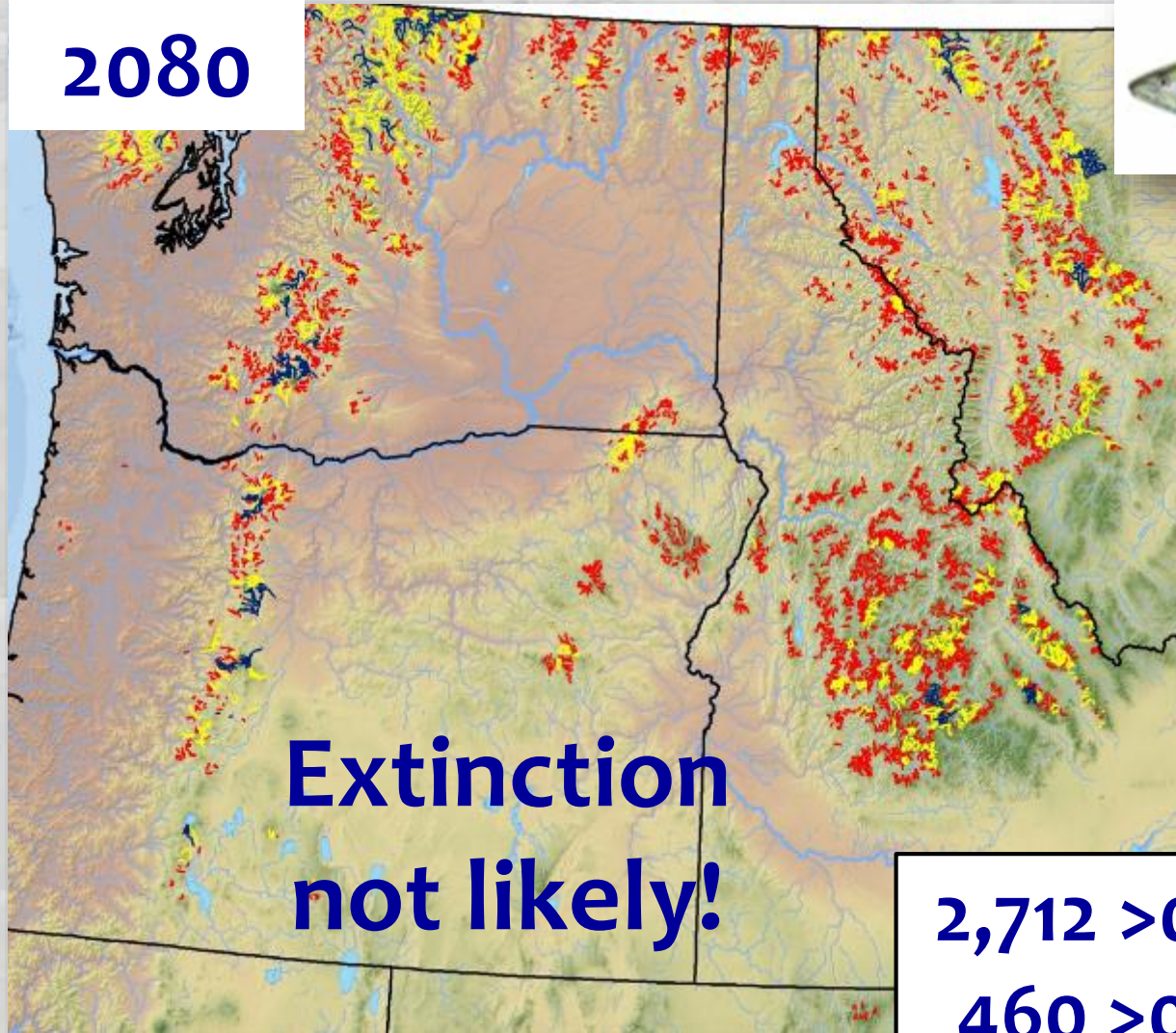


3,304 >0.1 habitats
641 >0.5 habitats
130 >0.9 habitats



Bull Trout Population Occurrence Probability

2080

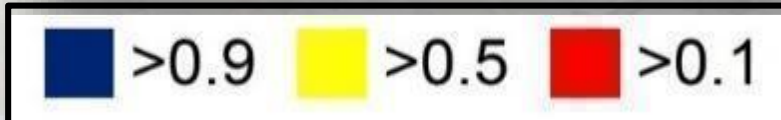


&



everywhere

Extinction
not likely!



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



Local Reversals of Negative Effects

Habitat quality & connectivity improvements

Technical Guide for Field Practitioners: Understanding and Monitoring Aquatic Organism Passage at Road-Stream Crossings

Nicholas Heredia
Brett Roper
Nathaniel Gillespie
Craig Roghair



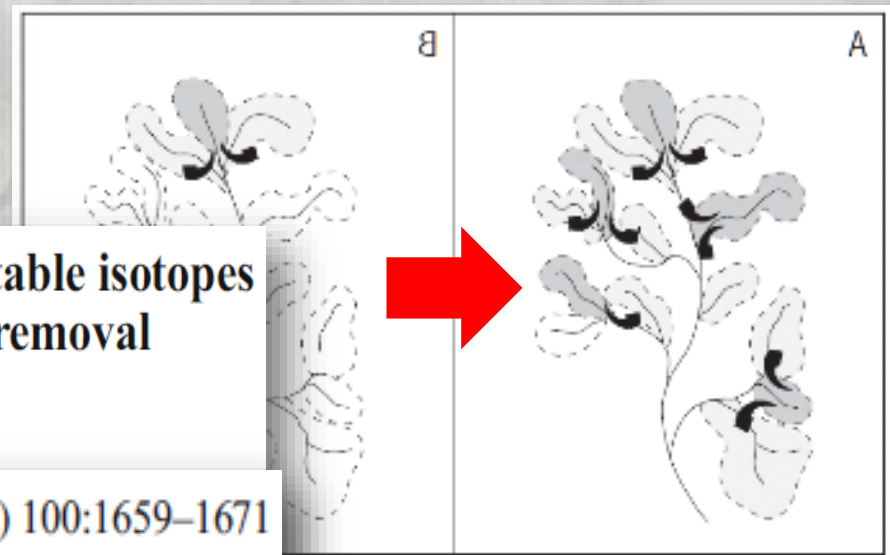
Before  After



Re-awakening dormant life history variation: stable isotopes indicate anadromy in bull trout following dam removal on the Elwha River, Washington

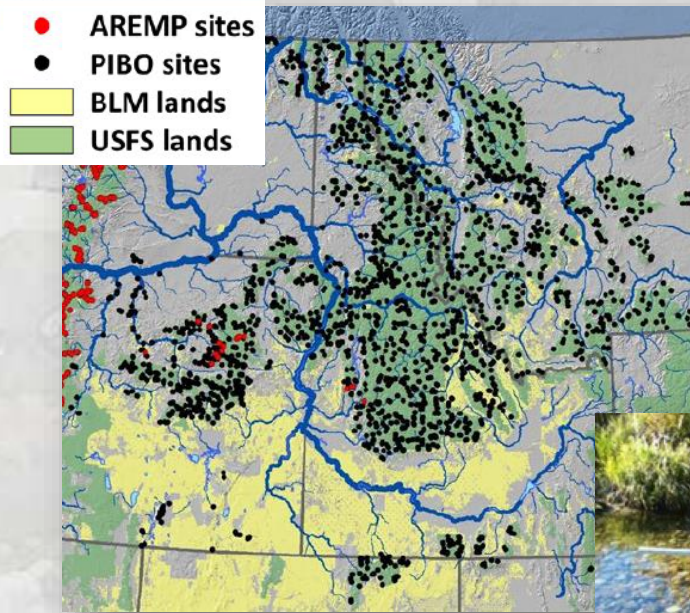
Thomas P. Quinn • Morgan H. Bond •
Samuel J. Brenkman • Rebecca Paradis •
Roger J. Peters

Environ Biol Fish (2017) 100:1659–1671
DOI 10.1007/s10641-017-0676-0

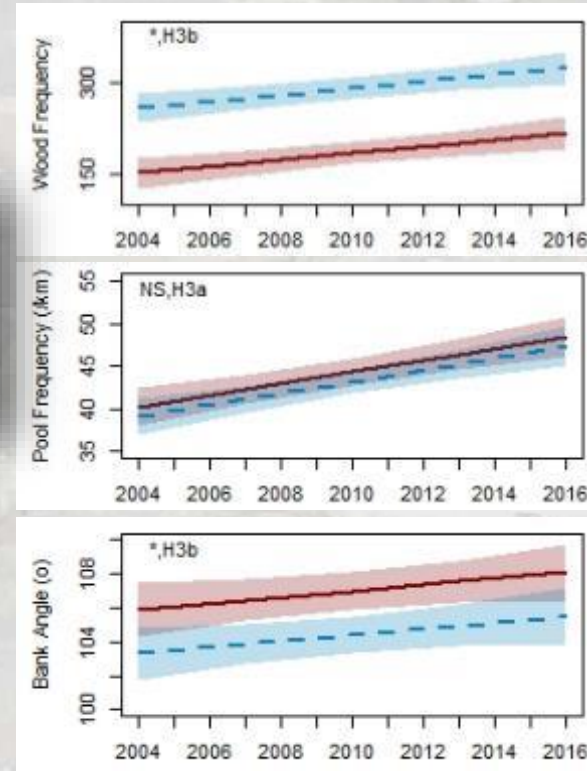


Local Reversals of Negative Effects

Habitat quality & connectivity improvements



- PIBO monitoring program 2004–2016
- Random sample of 1,250 sites in FS/BLM streams
- Trends: 1) more LWD, 2) more pools, 3) better banks

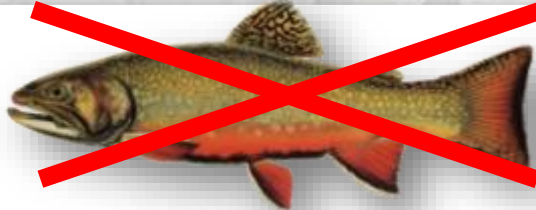


Roper et al., In review. Did changes in western federal land management policies improve salmonid habitat in streams on public lands within the Interior Columbia River Basin? *Environmental Management*

Local Reversals of Negative Effects

Eradication & suppression of brook trout

North American Journal of Fisheries Management 33:117–129, 2013
© American Fisheries Society 2013
ISSN: 0275-5947 print / 1548-8675 online
DOI: 10.1080/02755947.2012.747452

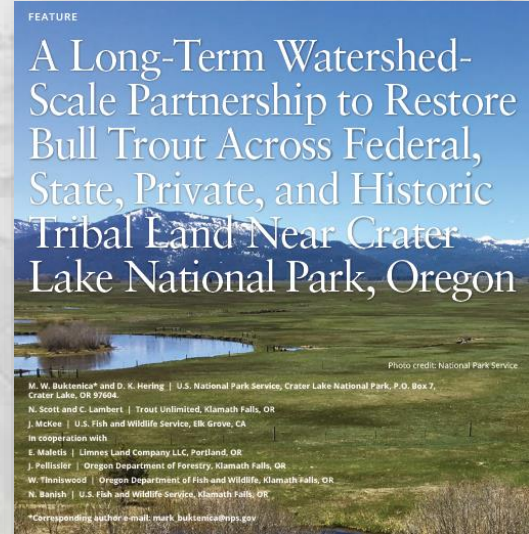


ARTICLE

Eradication of Nonnative Brook Trout with Electrofishing and Antimycin-A and the Response of a Remnant Bull Trout Population

Mark W. Buktenica,* David K. Hering, and Scott F. Girdner

U.S. National Park Service, Crater Lake National Park, Post Office Box 7, Crater Lake, Oregon 97604, USA



Costs could drop in the future

Survival and Reproductive Success of Hatchery YY Male Brook Trout Stocked in Idaho Streams

Patrick A. Kennedy,* Kevin A. Meyer, and Daniel J. Schill

Idaho Department of Fish and Game, 1414 East Locust Lane, Nampa, Idaho 83686, USA

Matthew R. Campbell and Daniel J. Schill
Idaho Department of Fish and Game

Simulated Effects of YY-Male Stocking and Manual Suppression for Eradicating Nonnative Brook Trout Populations

Daniel J. Schill* and Kevin A. Meyer

Idaho Department of Fish and Game, 1414 East Locust Lane, Nampa, Idaho 83686, USA

Michael J. Hansen

U.S. Geological Survey, Great Lakes Science Center, Hammond Bay Biological Station, 11188 Millersburg, Michigan 49759, USA



GMO



Local Reversals of Negative Effects

Reintroductions to historical habitats

Fish & Wildlife | Water | Ecotrope

Bull Trout Are Back In The Clackamas



Ecotrope Feb. 1, 2012 1:39 a.m. | Updated: July 10, 2018 1:28 p.m.



A bull trout reintroduction in Oregon proves what's possible

The ambitious effort brings a threatened predator back to the Clackama watershed.

Case histories
& institutional
knowledge are
increasing

| | | |
|---|---|-----------------------|
| Vol. 34: 191–209, 2017 https://doi.org/10.3354/esr00849 | ENDANGERED SPECIES RESEARCH Endang Species Res | Published September 5 |
|   | | |
| REVIEW | | |
| Translocation and reintroduction of native fishes: a review of bull trout <i>Salvelinus confluentus</i> with applications for future reintroductions | | |
| Molly F. Hayes, Nolan P. Banish* | | |
| U.S. Fish and Wildlife Service, Klamath Falls Fish and Wildlife Office, Klamath Falls, OR 97601, USA | | |

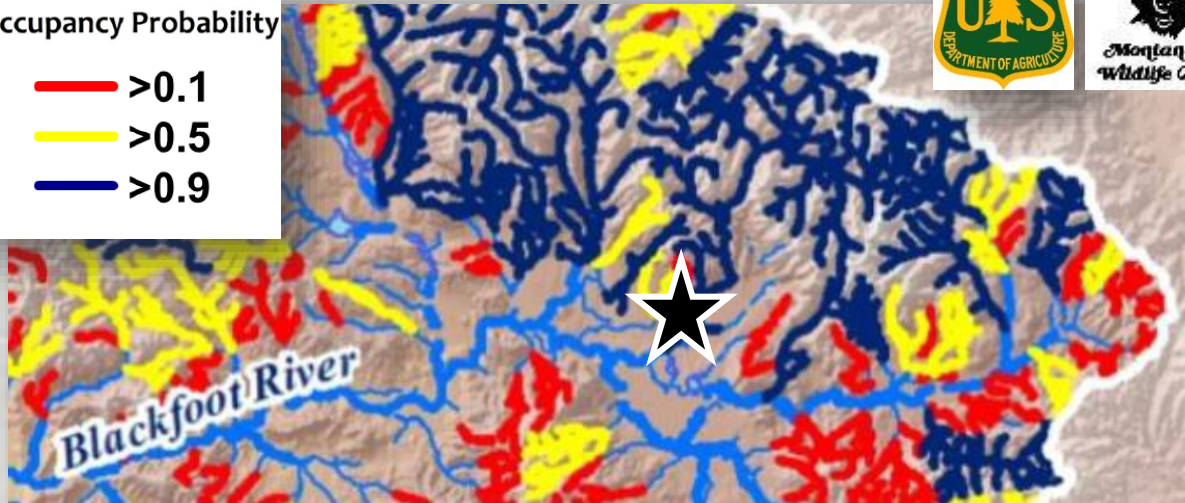
Local Reversals of Negative Effects

Assisted migration into long-term climate refugia



Occupancy Probability

- >0.1
- >0.5
- >0.9



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

Investing Strategically is Key

- Maintaining/restoring flow...
- Maintaining/restoring riparian...
- Restoring channel form/function...
- Prescribed burns limit wildfire risks...
- Non-native species control...
- Improve/impede fish passage...



Where to do them?

How to maximize bang for the



Investment Precision Improved by Better Distribution Information...

Rangewide eDNA Bull Trout Project ([Website](#))



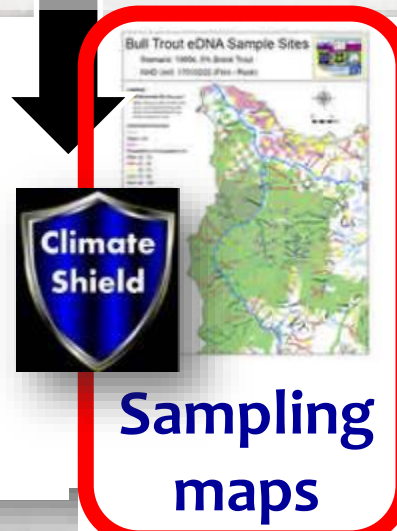
Many Resources



Supporting
Science



Protocols



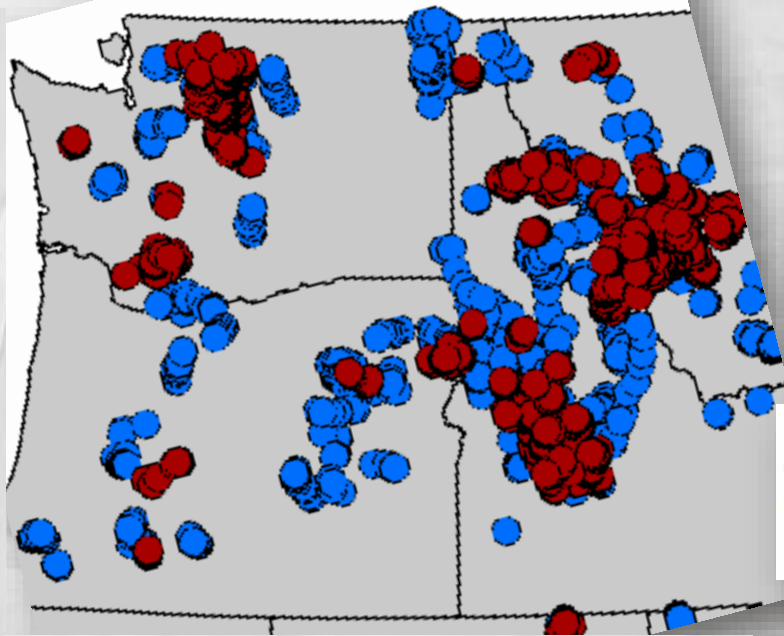
Sampling
maps



Results

Progress to date...

2015–2018 : ~7,000 sites sampled



Funded by



Crowd-sourced data collections
by many partner agencies



Dynamic Webportal Delivers Data in User-Friendly Digital Formats w/Metadata

The Range-Wide Bull Trout eDNA Project - USFS RMRS

Legend

Points

- eDNA Field Collection Sites (
 - not sampled
 - sampled, bull trout absent
 - sampled, bull trout present
 - sampled, being processed

Watershed Polygons

- Bull Trout Distribution Watersheds

Select up to 1000 records

- eDNA Field Collection Sites (9 ...
- eDNA Field Collection Sites (0 ...
- Climate Shield Natal Habitat Patches 0 ...
- USFWS Spawning and Rearing Critical H... 0 ...
- Bull Trout Distribution Watersheds 0 ...

eDNA sample metadata

| BT_Present | BTPresentT | Date_Coll | Datasou | GNIS_NAME | HUC8_Name | COMID | Site_ID | REACHCODE |
|------------|-----------------------------|-----------|---------|-------------------|------------|----------|---------|--------------|
| 2 | sampled, bull trout absent | 7/18/2016 | | Butte Cabin Creek | Flint-Rock | 24310459 | 873-1 | 170102020003 |
| 3 | sampled, bull trout present | 7/18/2016 | | Butte Cabin Creek | Flint-Rock | 24310455 | 885-4 | 170102020003 |

859 features 9 selected

Extract Points by Area of Interest

Feature Format*

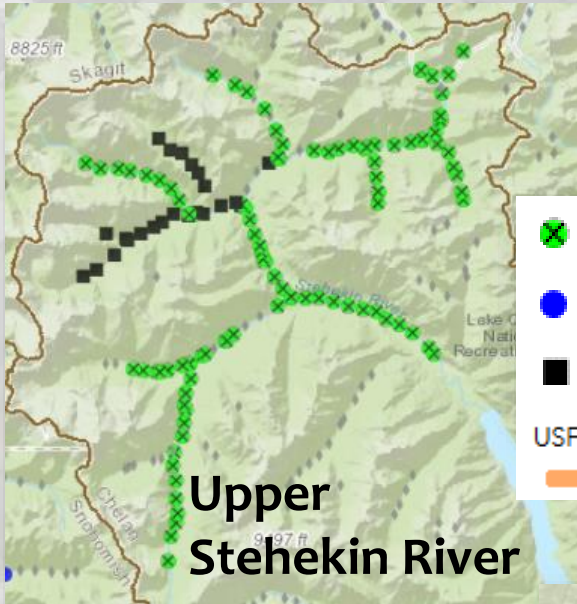
Shapefile - SHP - .shp

Execute

[Help](#)

eDNA Information Has Resulted in...

Confirmed absences

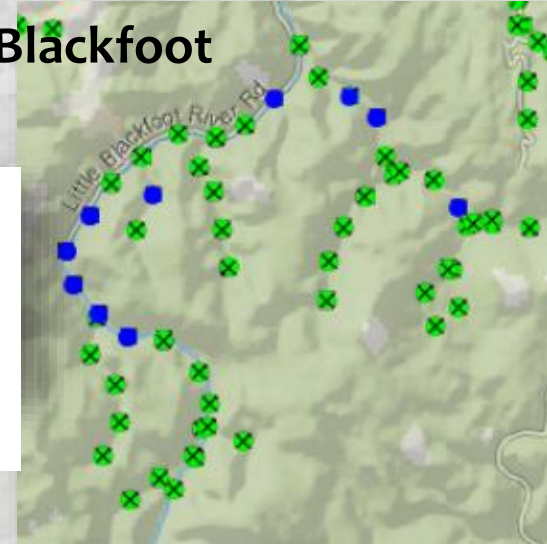


Upper Stehekin River

Discovery of new populations

Little Blackfoot River

- ✕ sampled, bull trout absent
 - sampled, bull trout present
 - sampled, being processed
- USFWS Spawning and Rearing Critical Habitat



Refinements of critical habitat?

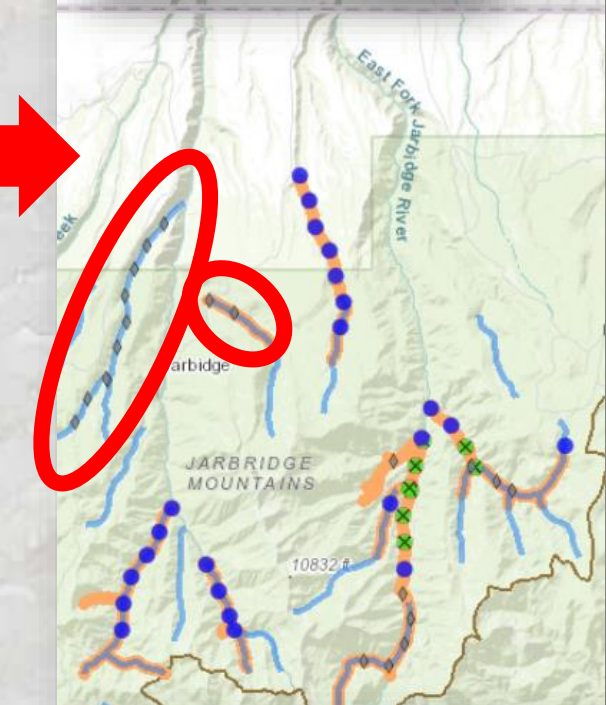
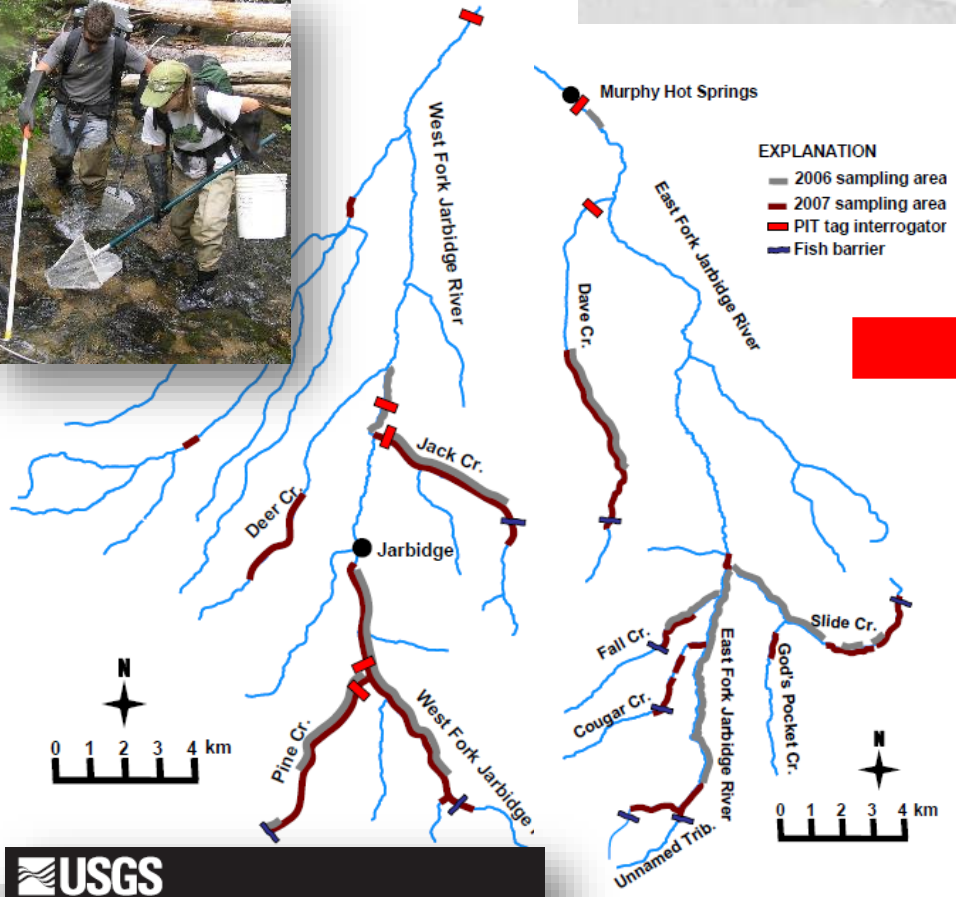


St. Joe tributaries

eDNA Trend Assessments from Repeat Samples

2006-2007 e-fishing surveys

2016 eDNA surveys



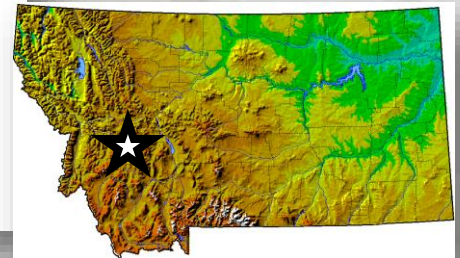
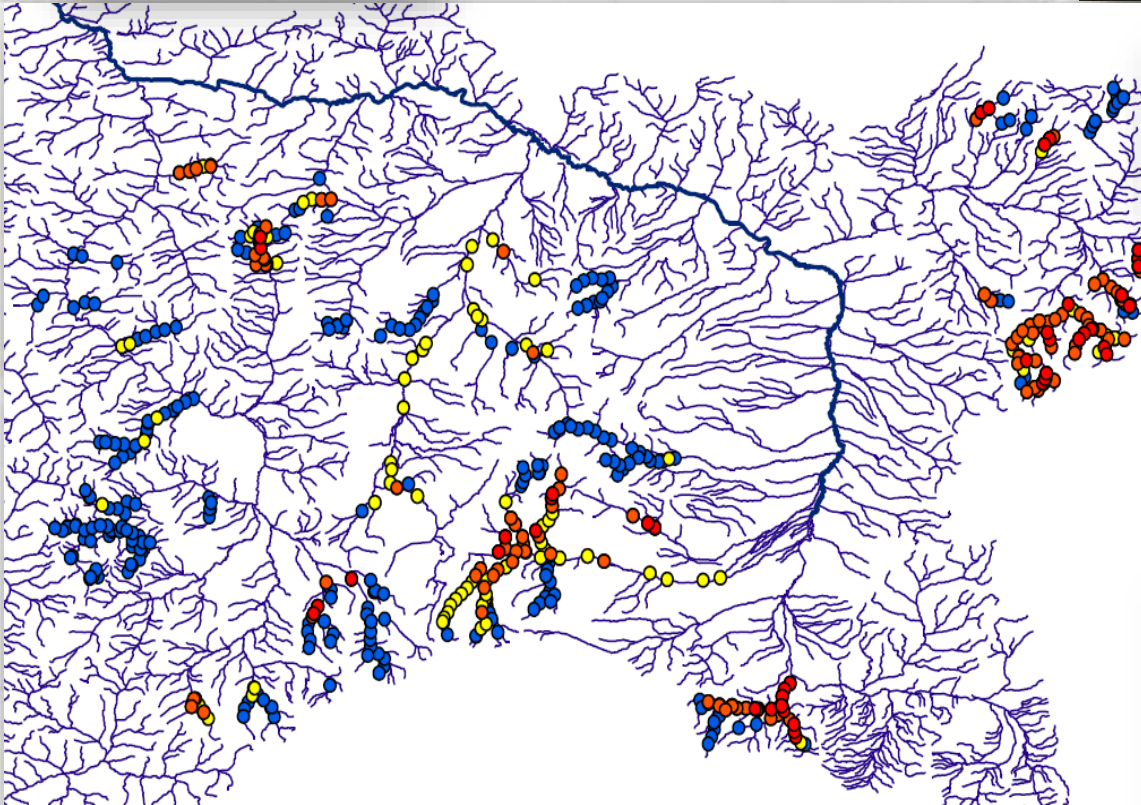
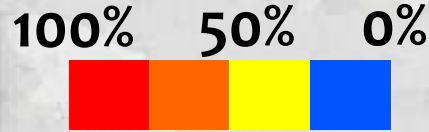
Prepared in cooperation with the U.S. Fish and Wildlife Service

Distribution and Movement of Bull Trout in the Upper Jarbridge River Watershed, Nevada



- sampled, bull trout absent
- sampled, bull trout present
- sampled, being processed

3rd-Generation Bull Trout Distribution Model: High resolution with species interactions



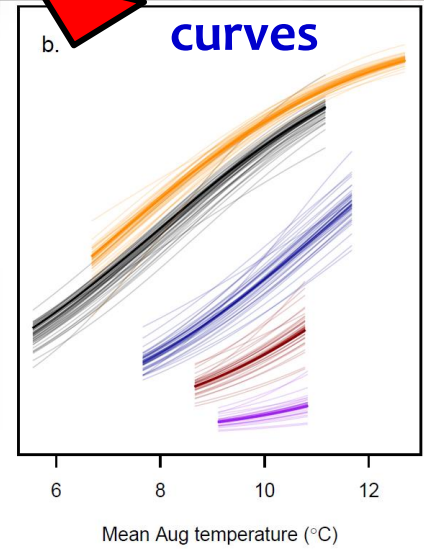
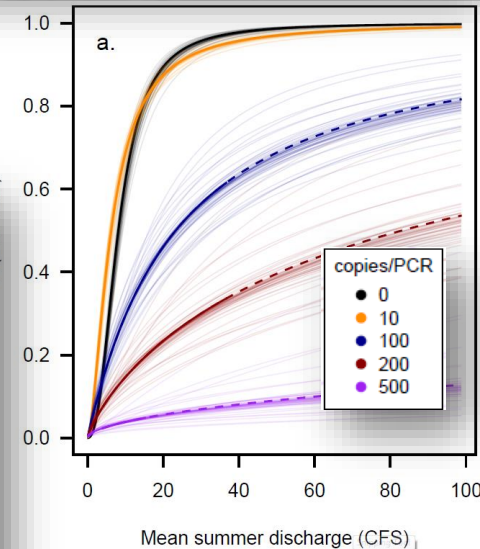
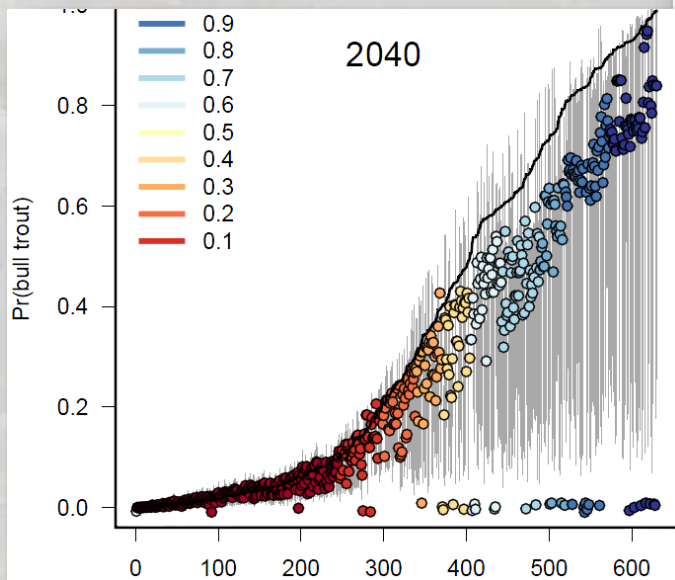
Wilcox et al. 2018. Fine-scale environmental DNA sampling reveals climate mediated interactions between native and invasive trout species. *Ecosphere* 9:e02500

3rd-Generation Bull Trout Distribution Model: High accuracy at reach scale

| | AIC | ΔAIC | AUC | Acc. |
|--|-------|------|-------|-------|
| FLOW + TEMP + BRK + BRK2 + BRK*FLOW | 464.0 | | 0.964 | 0.897 |
| FLOW + TEMP + BRK + BRK ² | 465.2 | 1.2 | 0.968 | 0.898 |
| FLOW + TEMP + SLOPE + BRK + BRK ² + BRK*FLOW | 465.2 | 1.2 | 0.965 | 0.898 |
| FLOW + TEMP + BRK + BRK2 + BRK*TEMP + BRK*FLOW | 465.6 | 1.6 | 0.964 | 0.900 |
| FLOW + TEMP + BRK + BRK2 + BRK*TEMP | 466.5 | 2.5 | 0.967 | 0.900 |
| FLOW + TEMP + SLOPE + BRK + BRK ² + BRK*TEMP + BRK*FLOW | 467.0 | 3.0 | 0.965 | 0.900 |
| FLOW + TEMP + SLOPE + BRK + BRK ² | 467.1 | 3.1 | 0.968 | 0.898 |

Model response curves

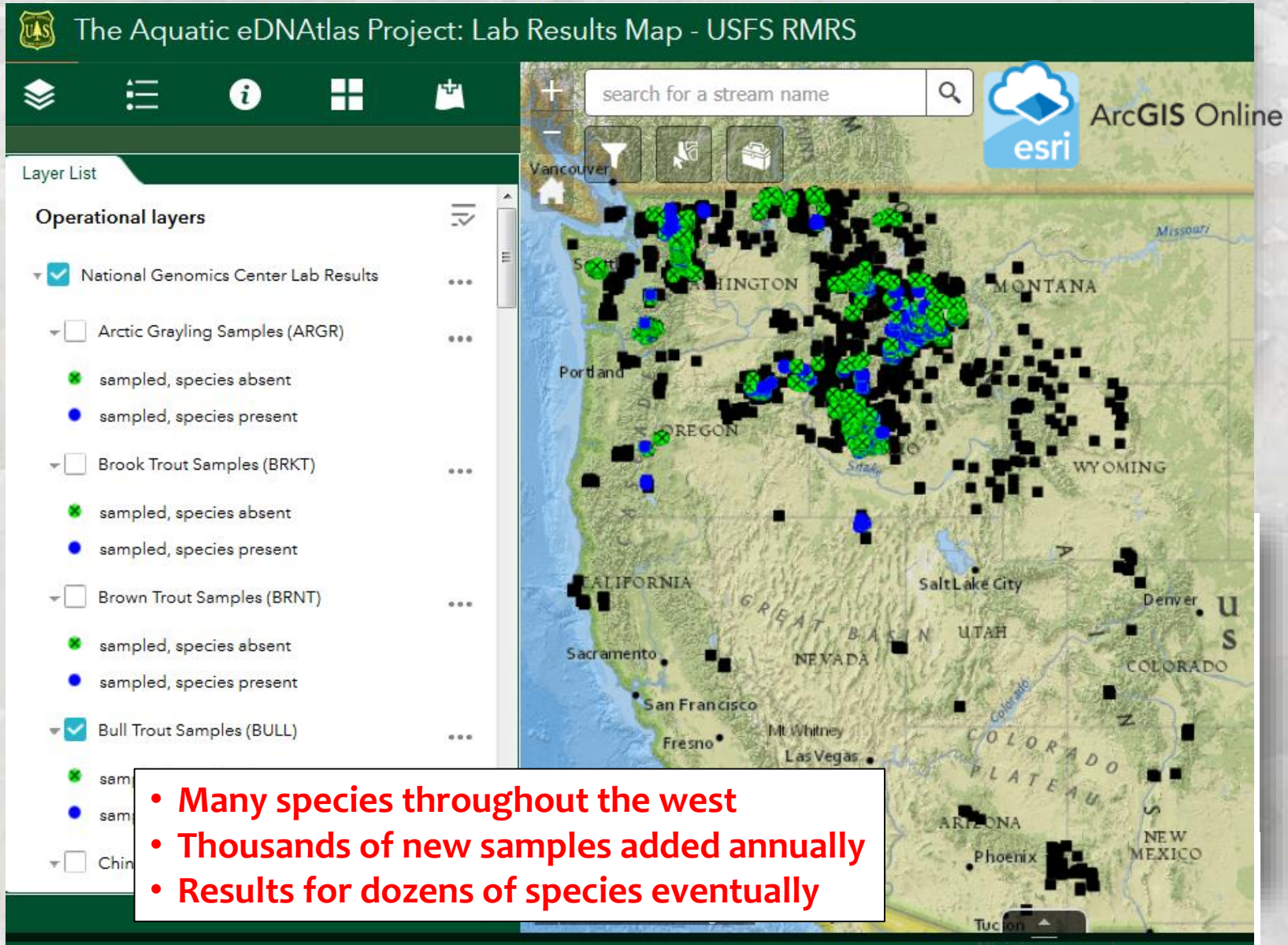
Predict reaches where bull trout are vulnerable to climate & brook trout



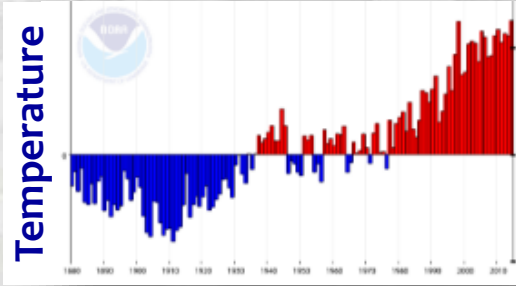
Wilcox et al. 2018. Fine-scale environmental DNA sampling reveals climate mediated interactions between native and invasive trout species. *Ecosphere* 9:e02500

Aquatic eDNA Atlas Project Website:

<https://www.fs.fed.us/rm/boise/AWAE/projects/the-aquatic-eDNAAtlas-project.html>



Many Different Factors Weigh Into this Century's Partly Cloudy Bull Trout Forecast

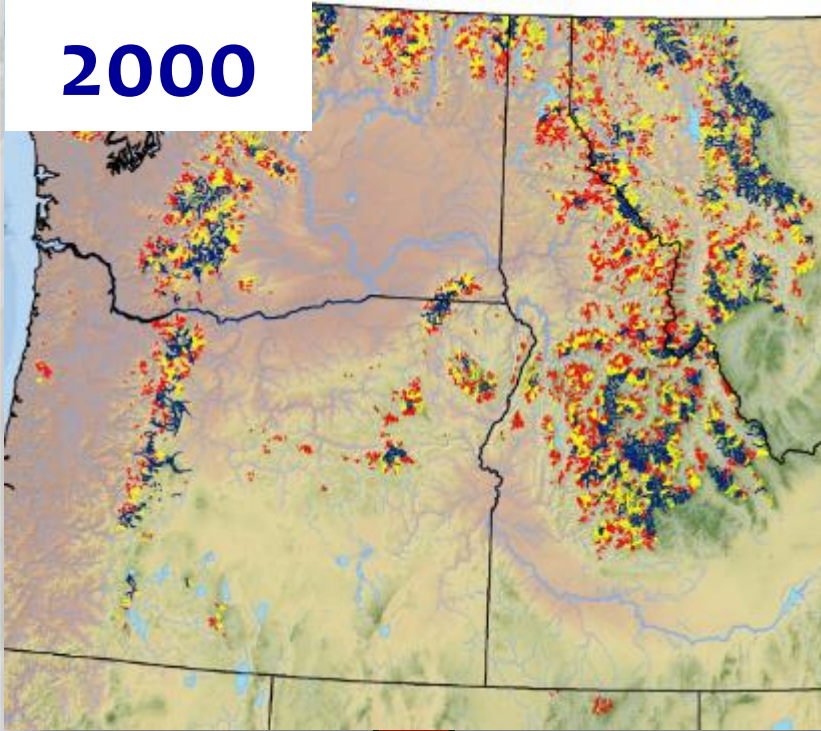


Before → After



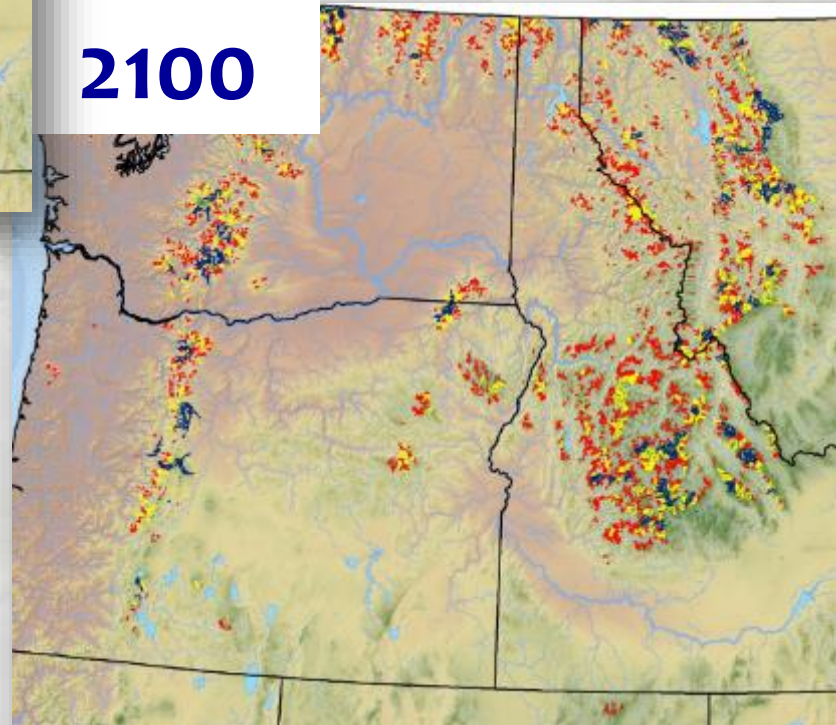
Regional Risk for Bull Trout Species is Low

2000



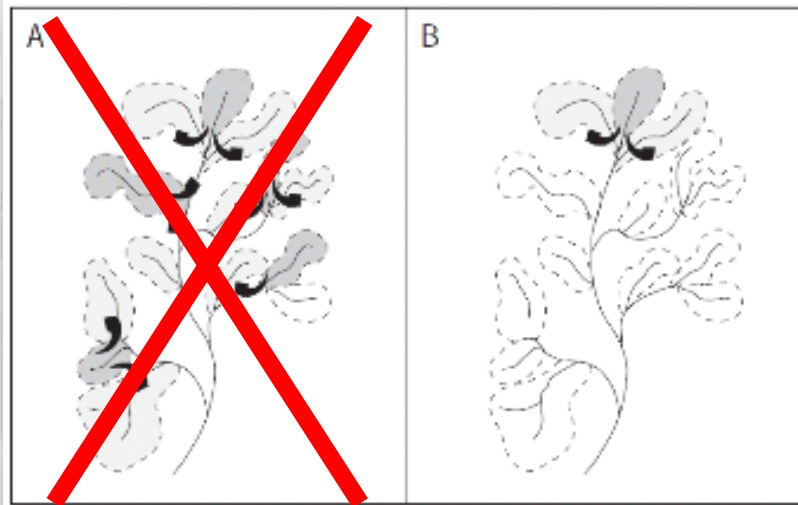
Many populations likely to persist

2100



High Risks for Some Individual Populations (e.g., Jarbidge populations)

Small, isolated, and alone...



Local Risks High for Some Individual Populations (e.g., Jarbidge populations)

Mitigate risks by:

1) Keeping brook trout out (eDNA monitoring program for early detection)



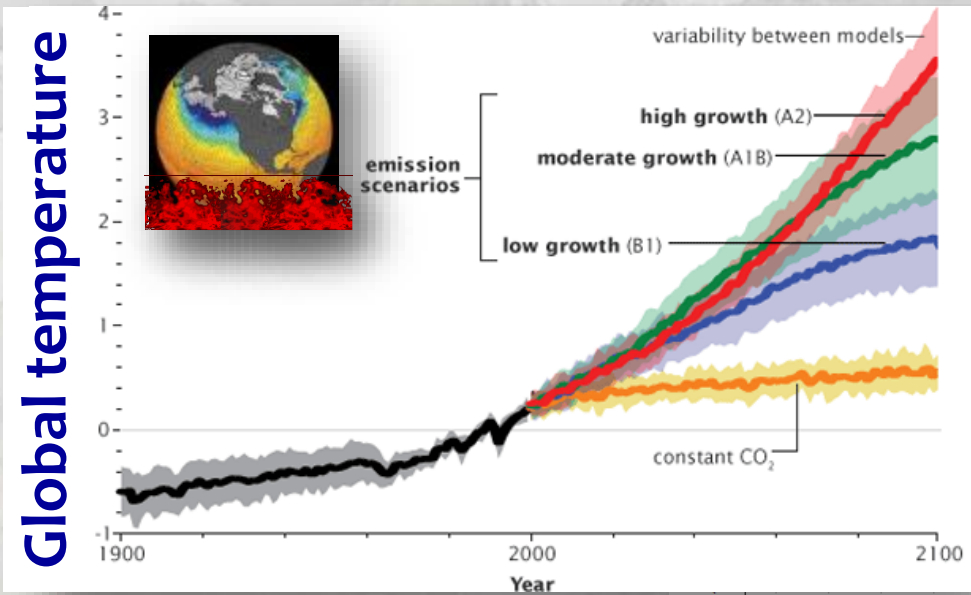
2) Proactively reduce wildfire risks (controlled burns to decrease fuel contiguity)



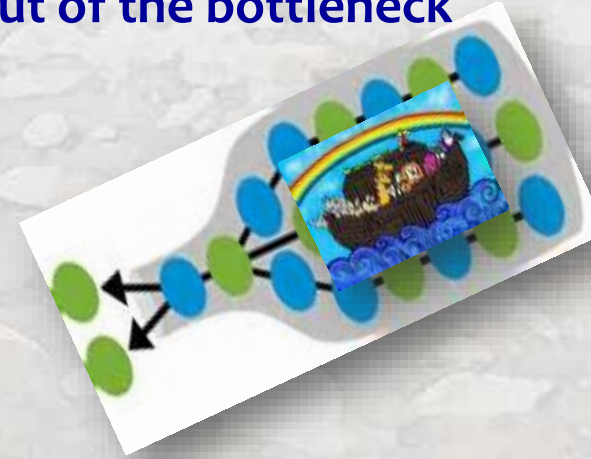
3) Enhancing habitat quality (grazing, stream shade, LWD)



Hang on For an Interesting 21st Century

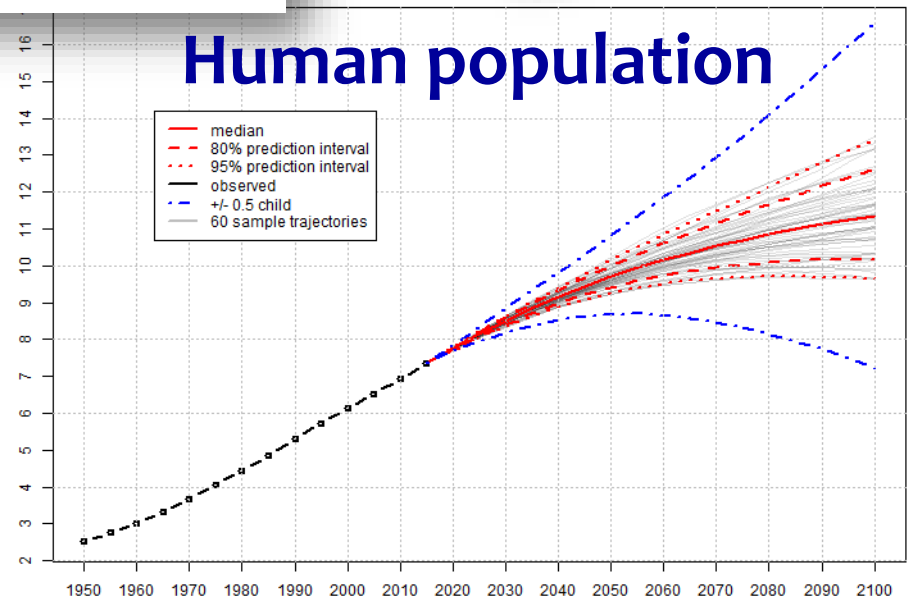


Something will come out of the bottleneck



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/>

The End

