Cold Water as a Climate Shield to Preserve Native Trout through the 21st Century

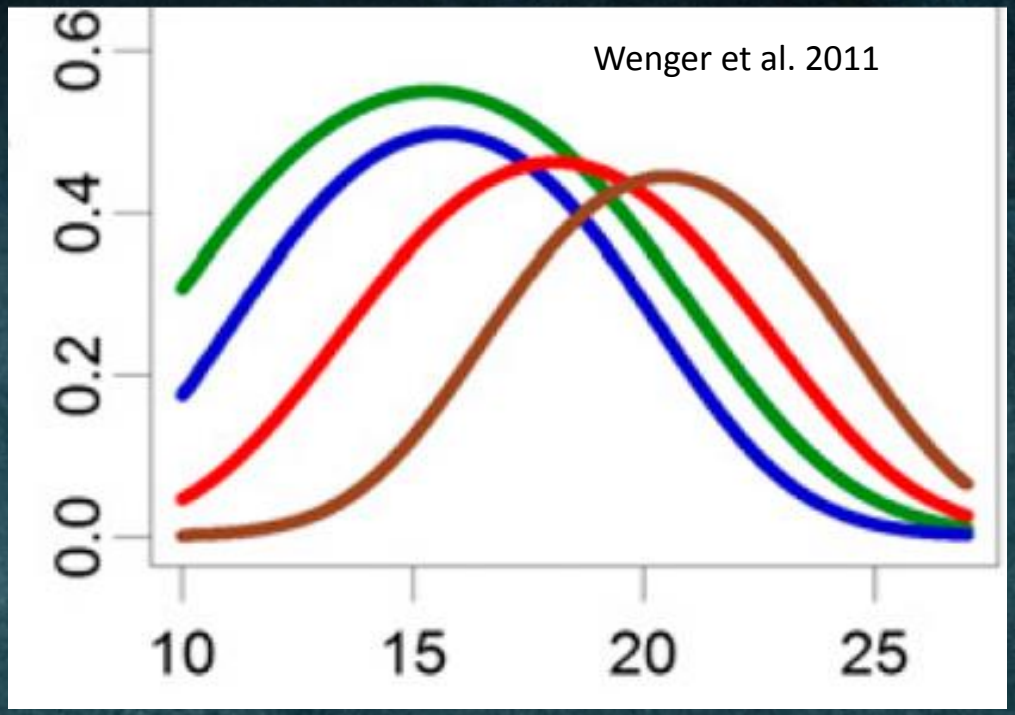
Michael Young, Dan Isaak, Dave Nagel, Dona Horan, Matt Groce
(with Scott Spaulding, Cam Thomas, Scott Barndt, and Brian Riggers)

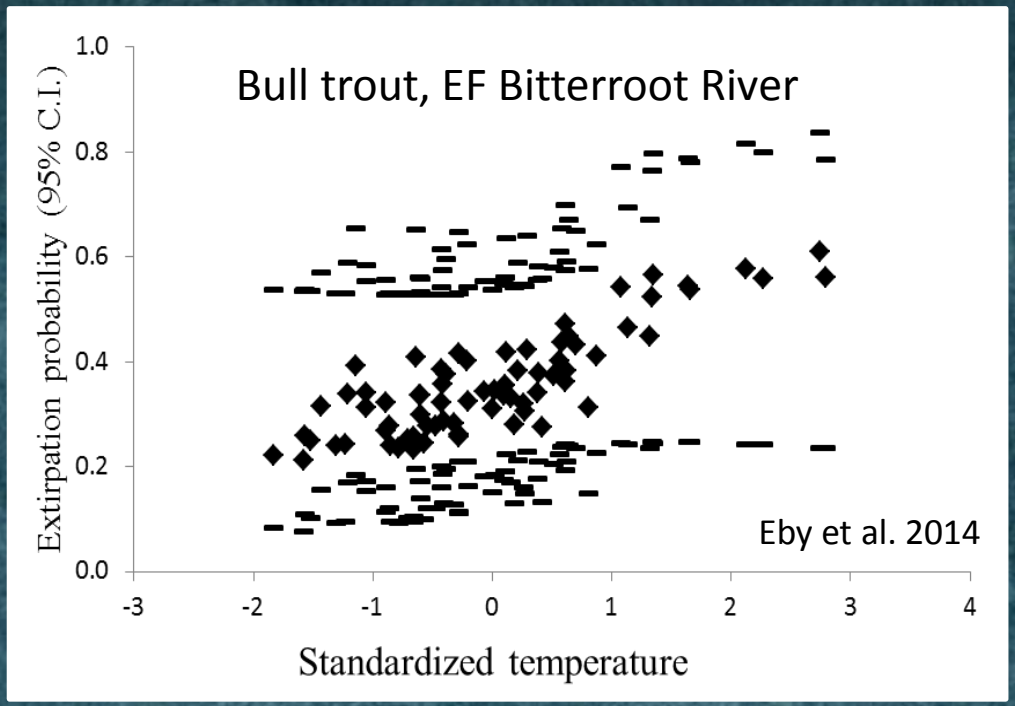
29 January 2015 – Missoula, Montana

Northern Rockies Adaptation Partnership

Climate and cold-water fishes

- Ectotherms
  - Temperature is destiny
- Climate change is already having an effect
- Elevation (= cold water) is a native trout refuge from invasions

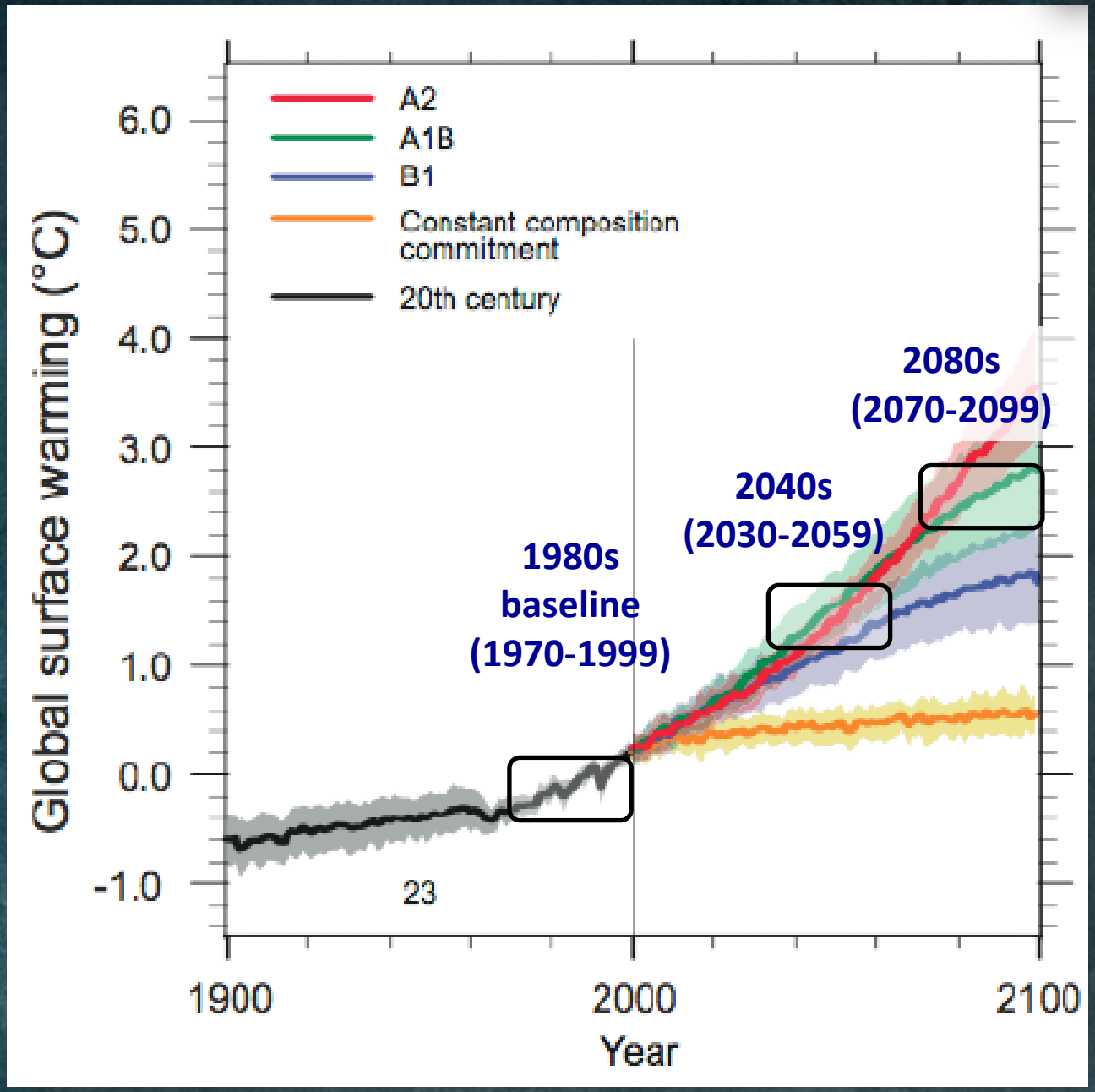




Temporal uncertainty: a future for cold-water fish?

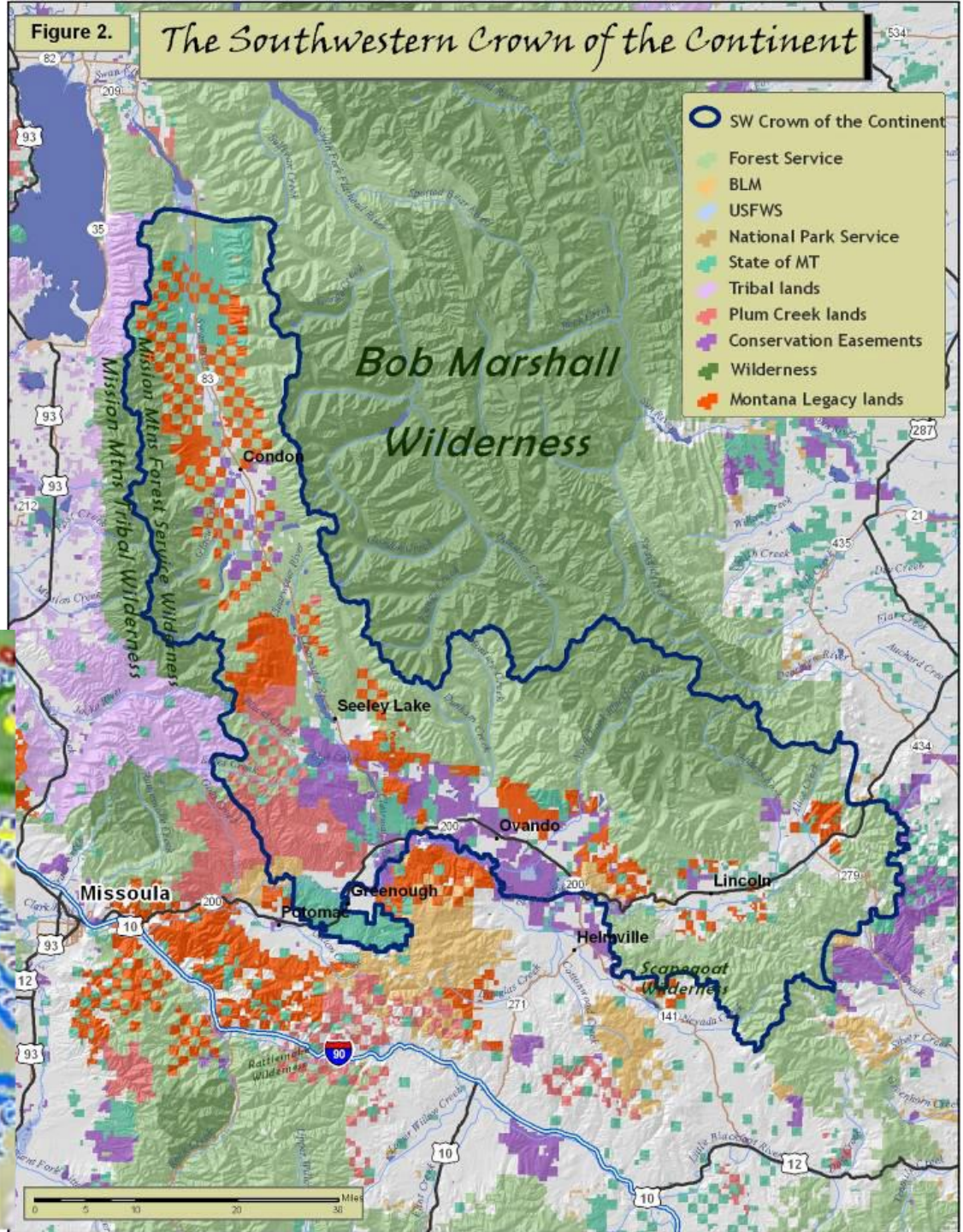
Hamlet al. 2013

- Most projections: 20—100% declines
  - Eaton & Schaller 1996
  - Reusch et al. 2012
  - Rahel et al. 1996
  - Mohseni et al. 2003
  - Flebbe et al. 2006
  - Rieman et al. 2007
  - Kennedy et al. 2008
  - Williams et al. 2009
  - Wenger et al. 2011
  - Almodovar et al. 2011
  - etc.
- Variable predictions
  - Emissions
  - GCMs
- Dates as surrogates
- 2040s = moderate change
- 2080s = extreme change



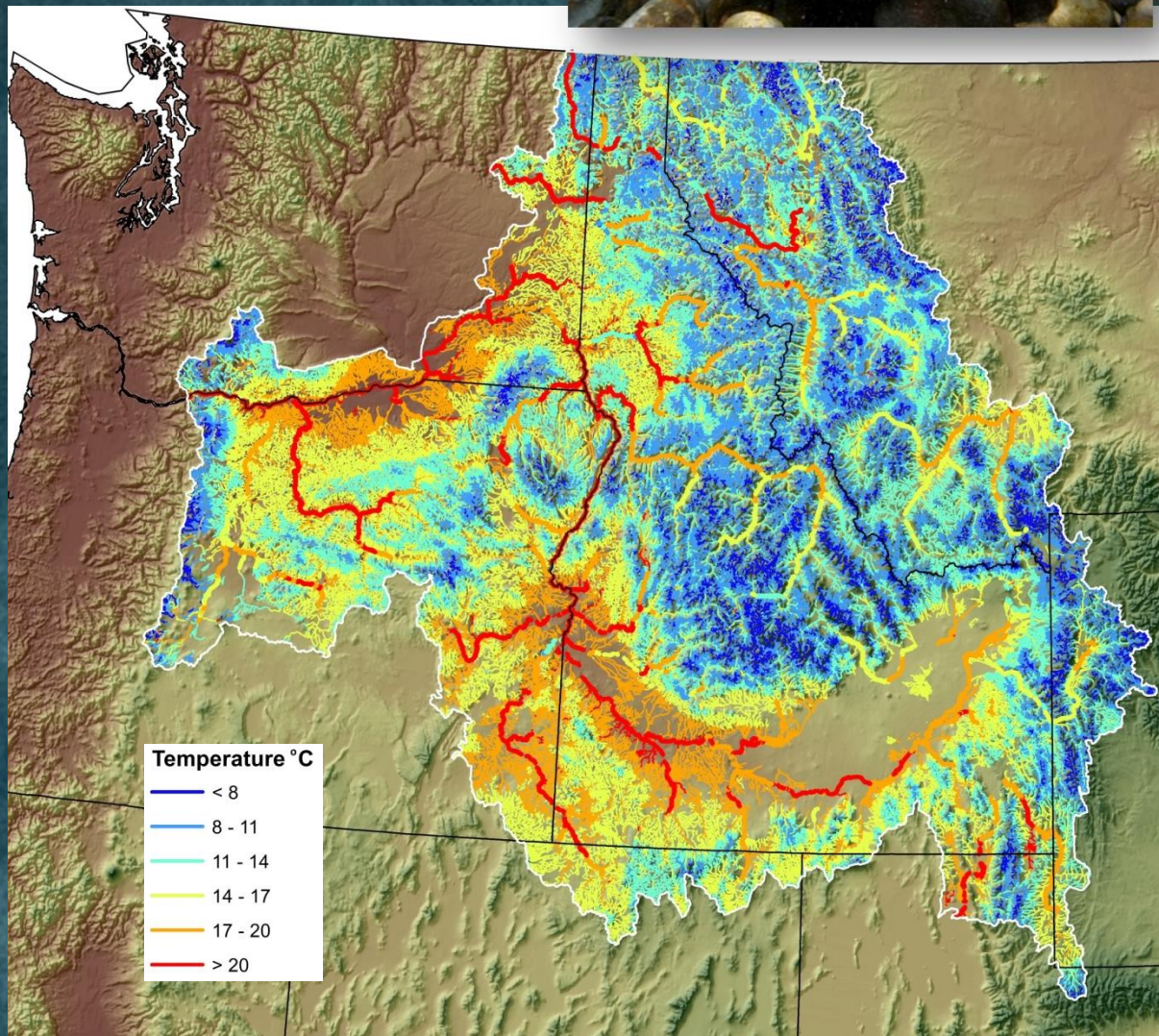
Overcoming spatial uncertainty: local decision makers need precise information

- Habitat improvement
  - SWCC
- Land exchanges
  - (Selway Creek)



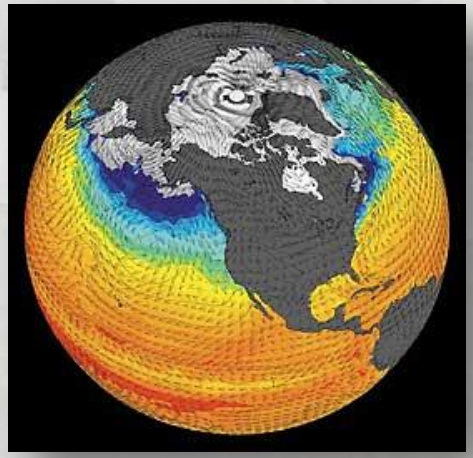
Building a climate shield for native trout – NRAP

- Climate to cold-water habitat
- Occupancy models
  - Accurate & sufficient
  - Consider invasive species
  - Empirical & broad
- Predictions and projections
  - Address climate change
  - Straightforward
  - Versatile in space & time
- <u>Identify climate refugia</u>

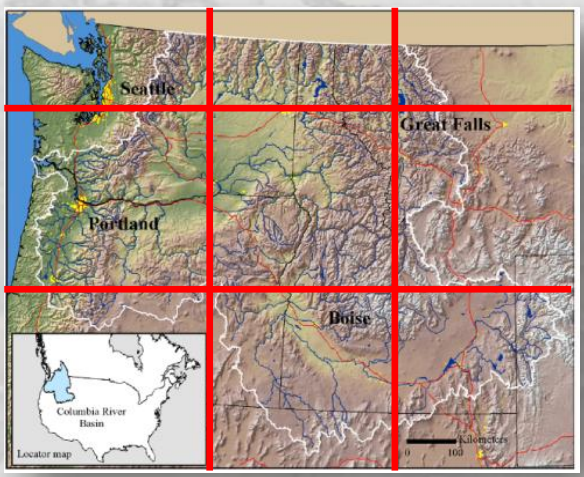


Taking climate into the water where fish live…

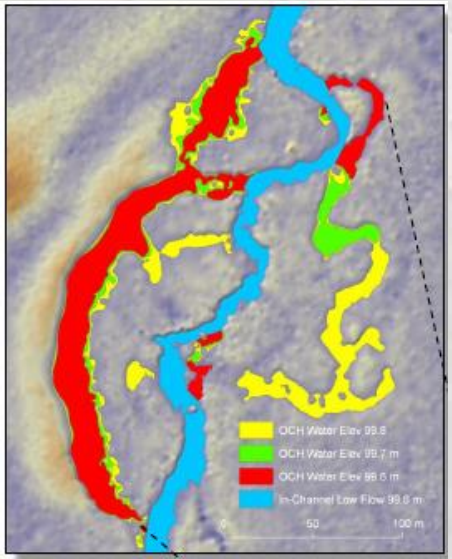
Climate model
(air temperature & precipitation)



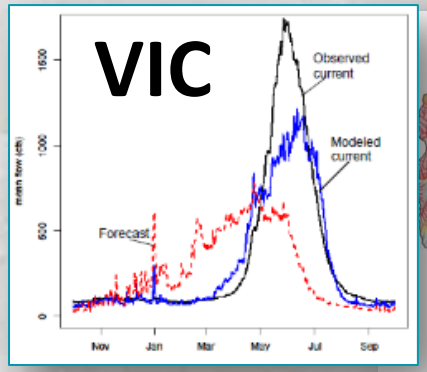
Regional patterns

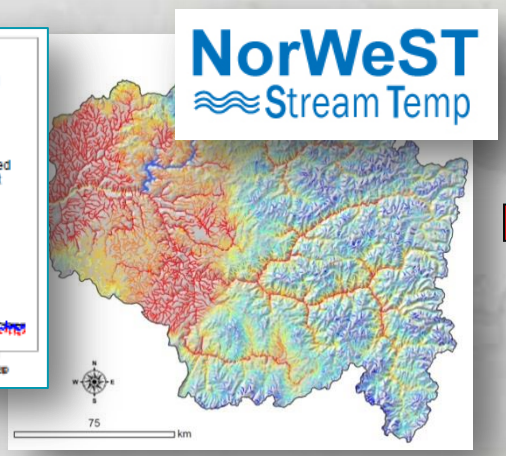


Stream reach patterns

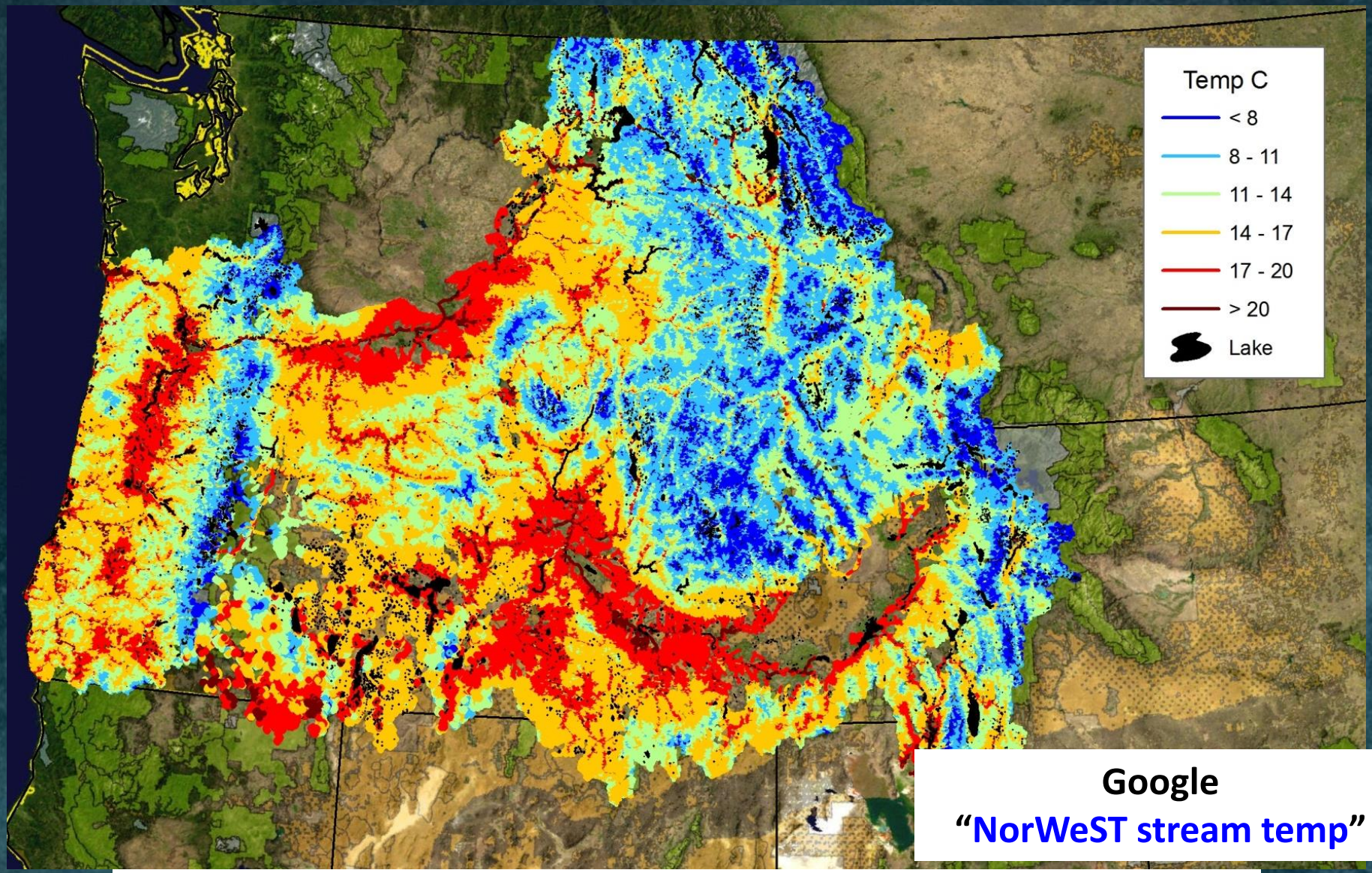


Stream temperatures & flow





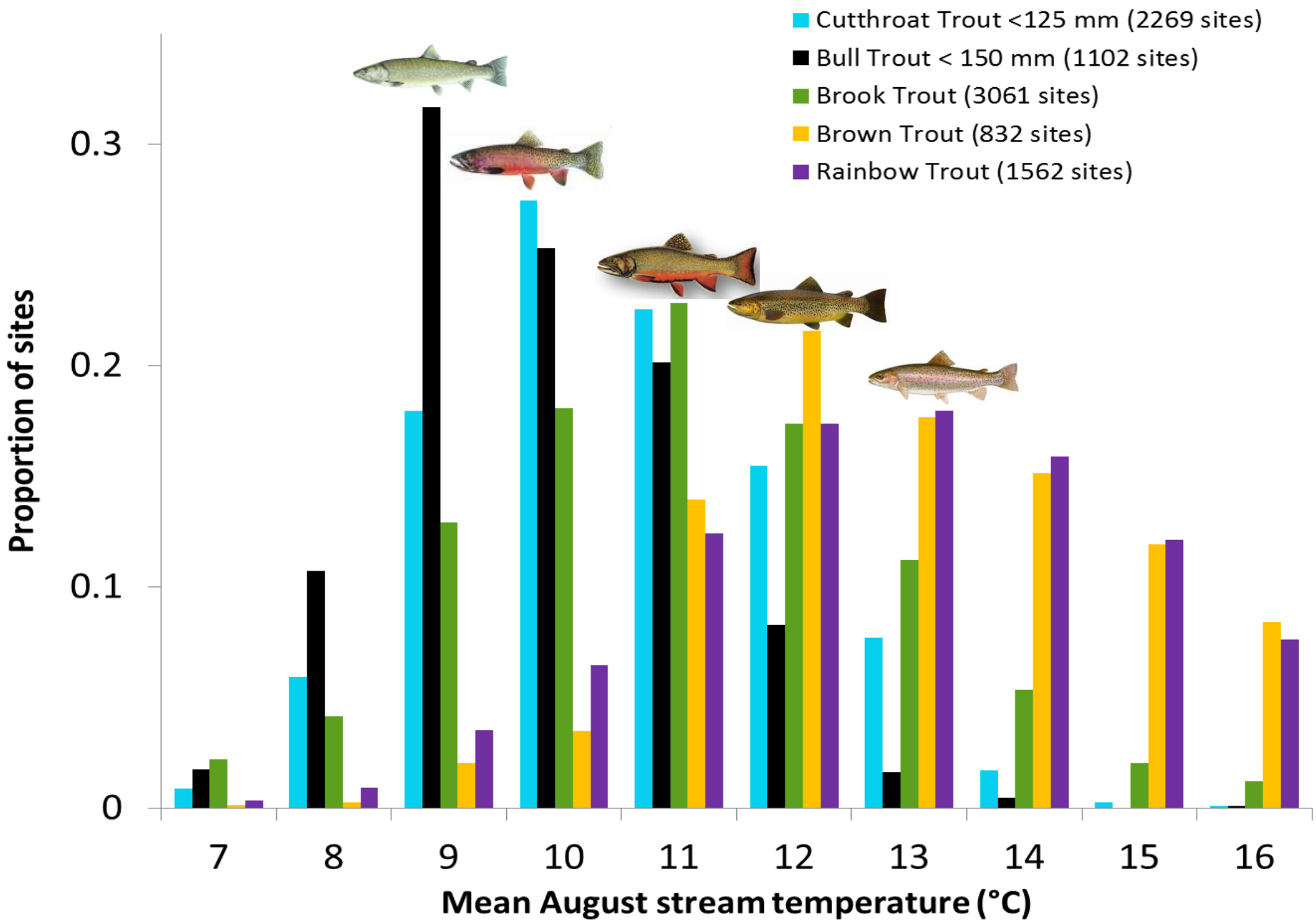
NorWeST: high-resolution stream temperature scenarios
40,397 summers of data - 380,000 stream kilometers modeled



Google
"NorWeST stream temp"

R^2 = 0.91; RMSE = 1.0°C; 1-km resolution

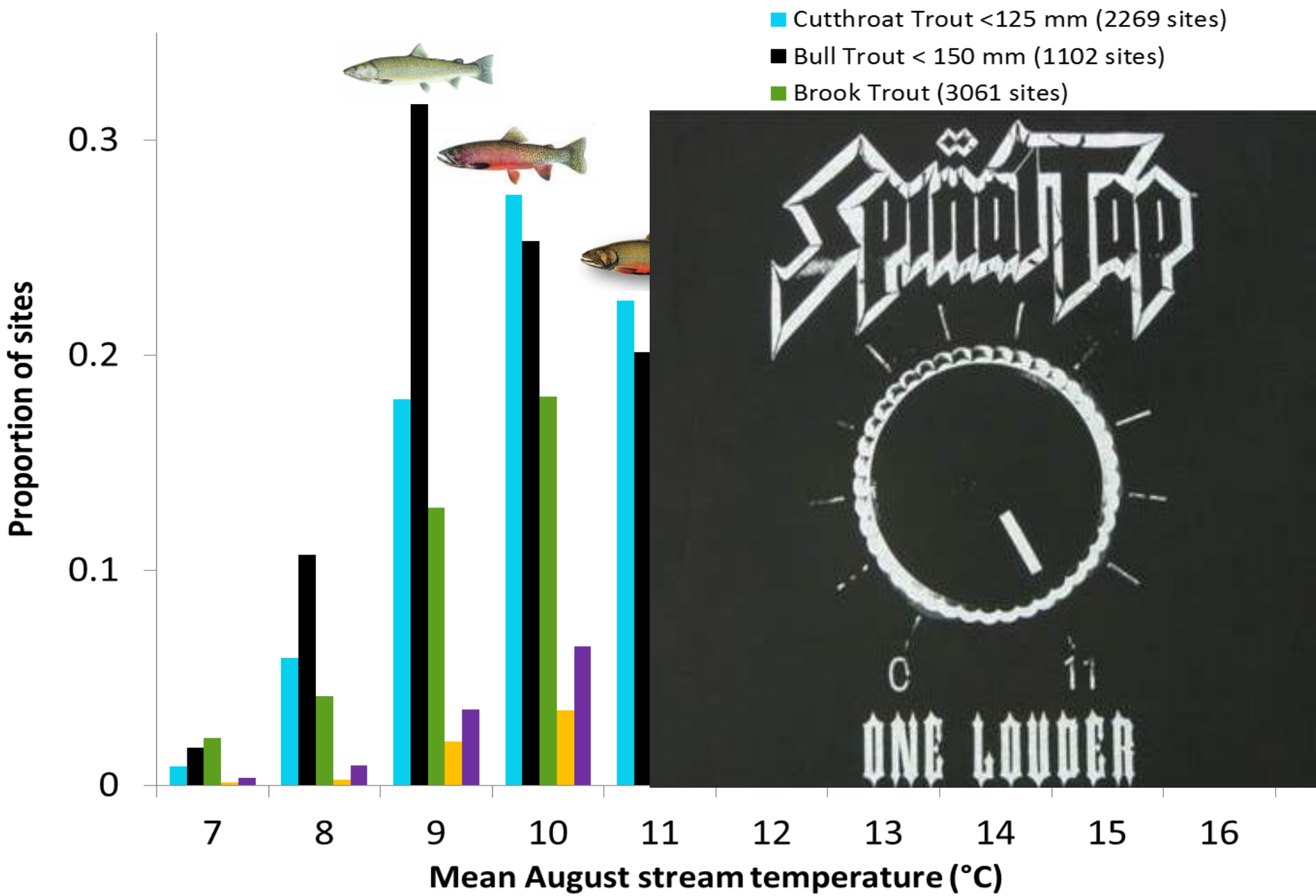
Cold-water habitats: choosing a thermal threshold

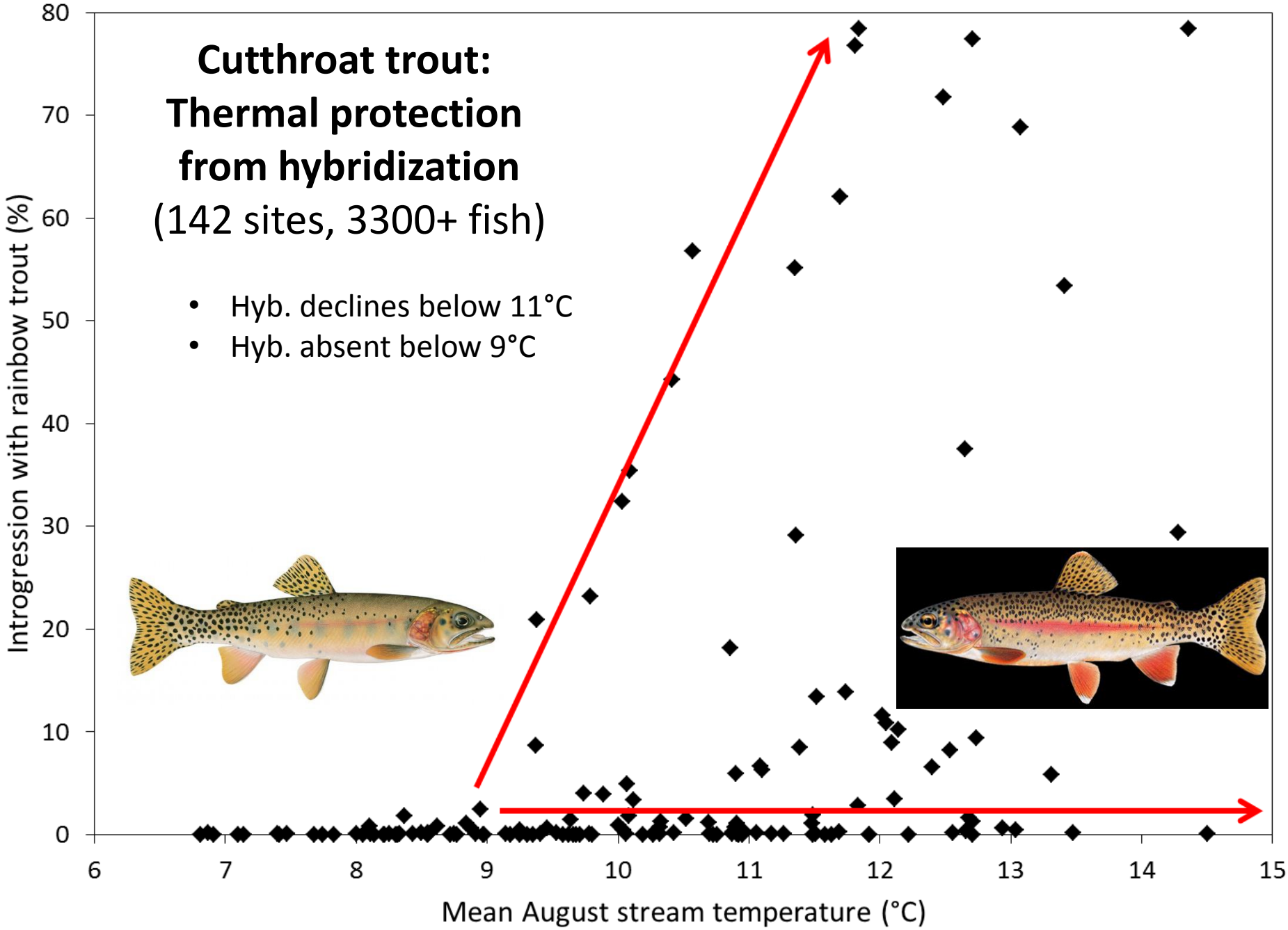


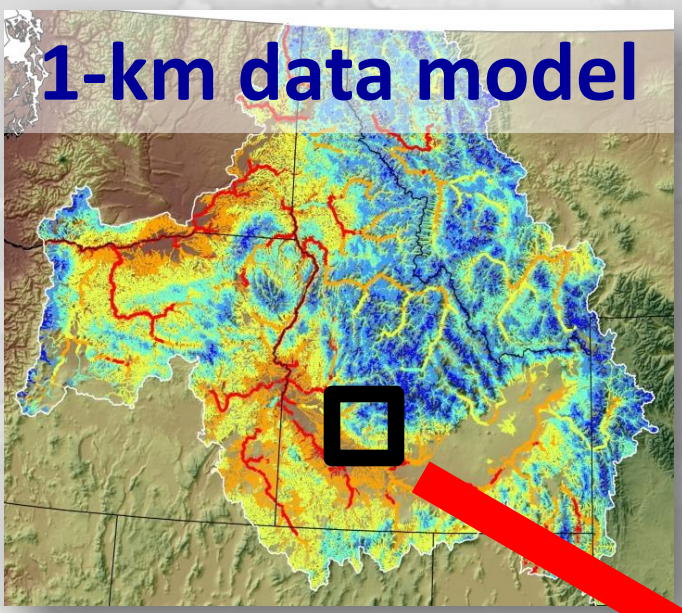
Cold-water habitats: choosing a thermal threshold

Mean August stream temperature (°C)

Cold-water habitats: choosing a thermal threshold

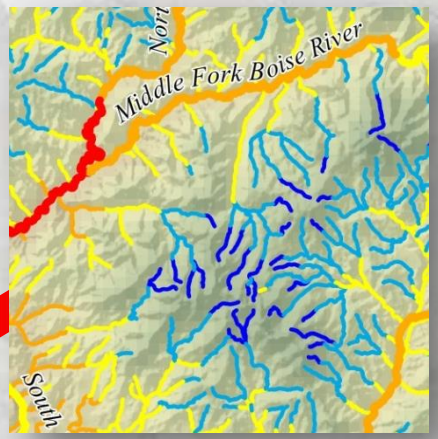


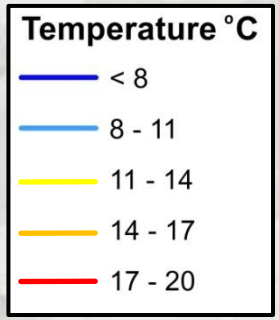

Cutthroat trout:
Thermal protection
from hybridization
(142 sites, 3300+ fish)
• Hyb. declines below 11°C
• Hyb. absent below 9°C
Introgression with rainbow trout (%)
Mean August stream temperature (°C)
0
10
20
30
40
50
60
70
80
6
7
8
9
10
11
12
13
14
15



Cold-water habitats: further refinements

- Additional filters
  - Gradient ≤ 15%
  - width ≥ 1 m
- Aggregated contiguous segments via an ArcGIS Python



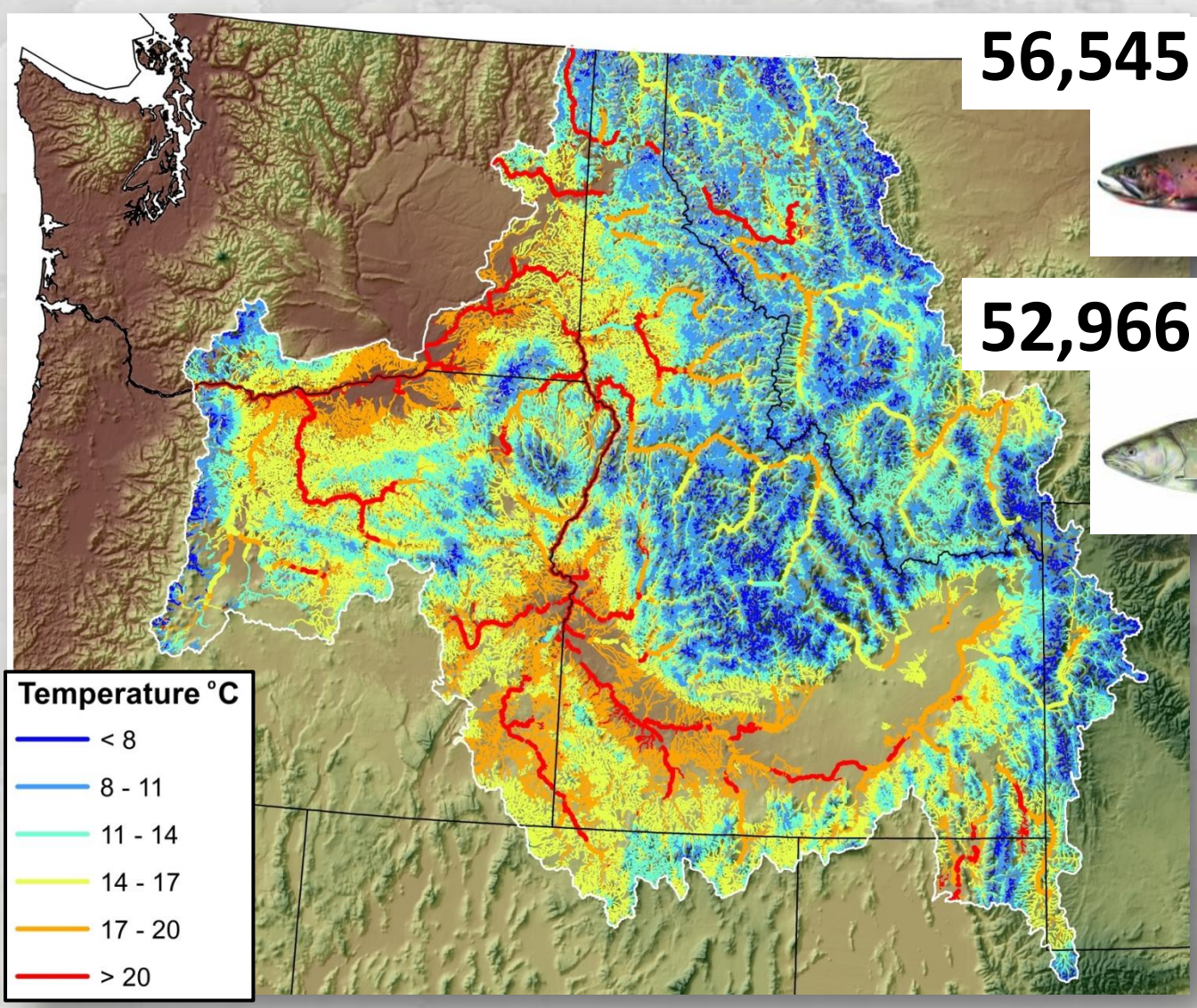


Assumed

- Trout populations >1 km
- Life history immaterial

Cold-water habitats (1980s)

70,335/259,052 stream km

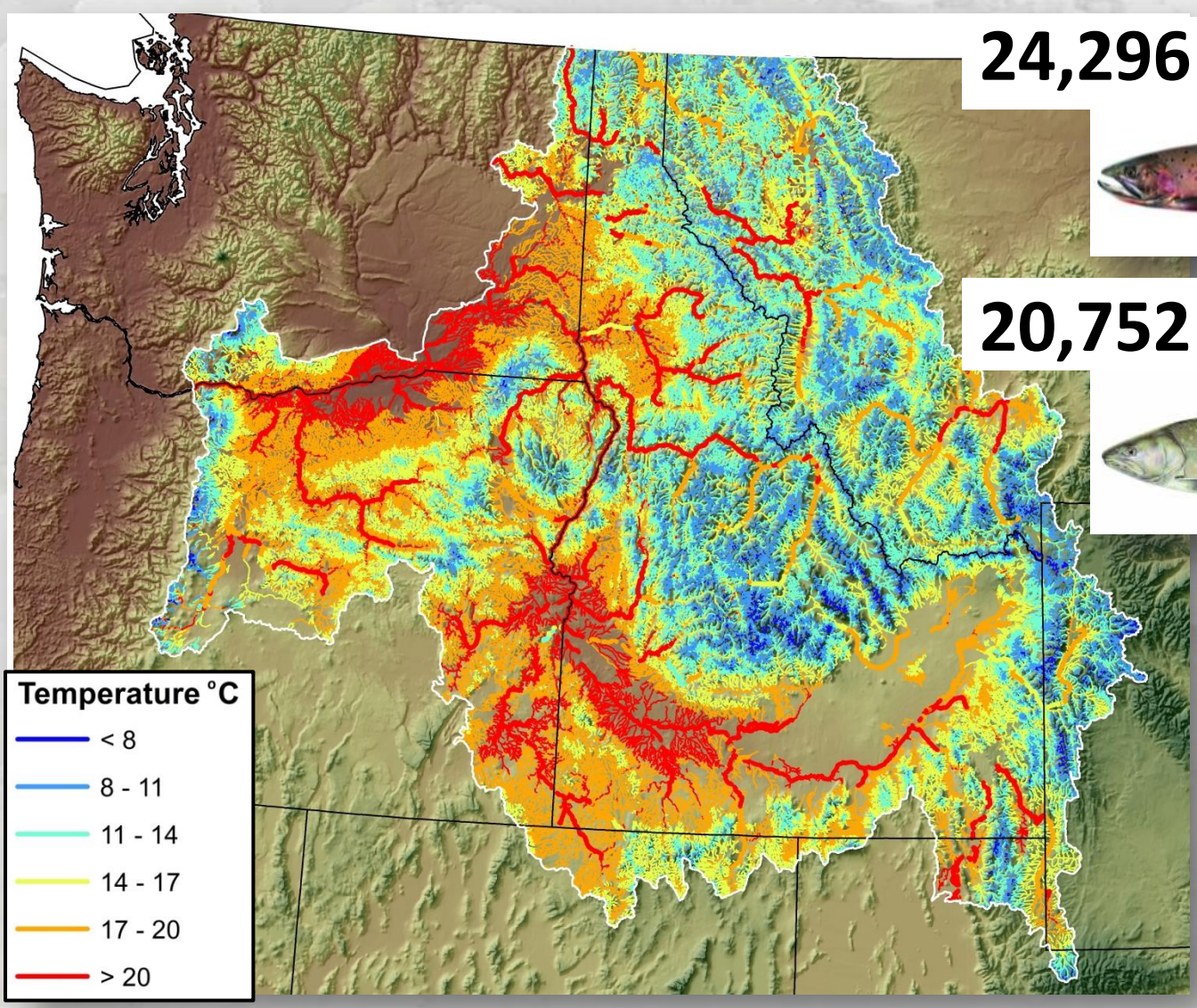


56,545 km

52,966 km

Cold-water habitats (2080s)

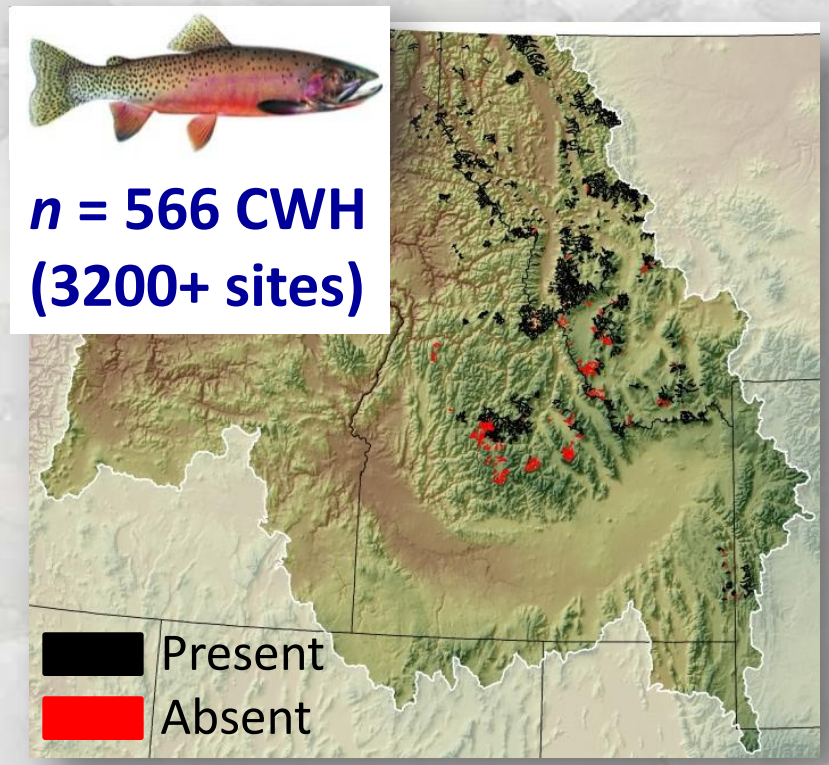
29,789/246,759 stream km

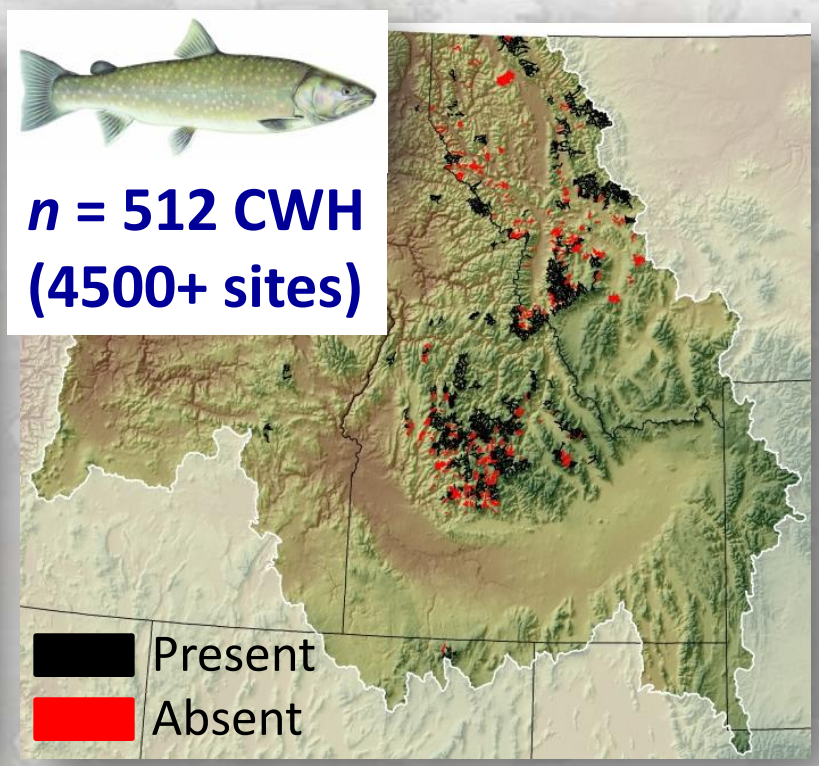


24,296 km

20,752 km

Occupancy: native trout in cold-water habitats





Fish data from literature & agency reports…

<u>Predictors (for juveniles)</u>

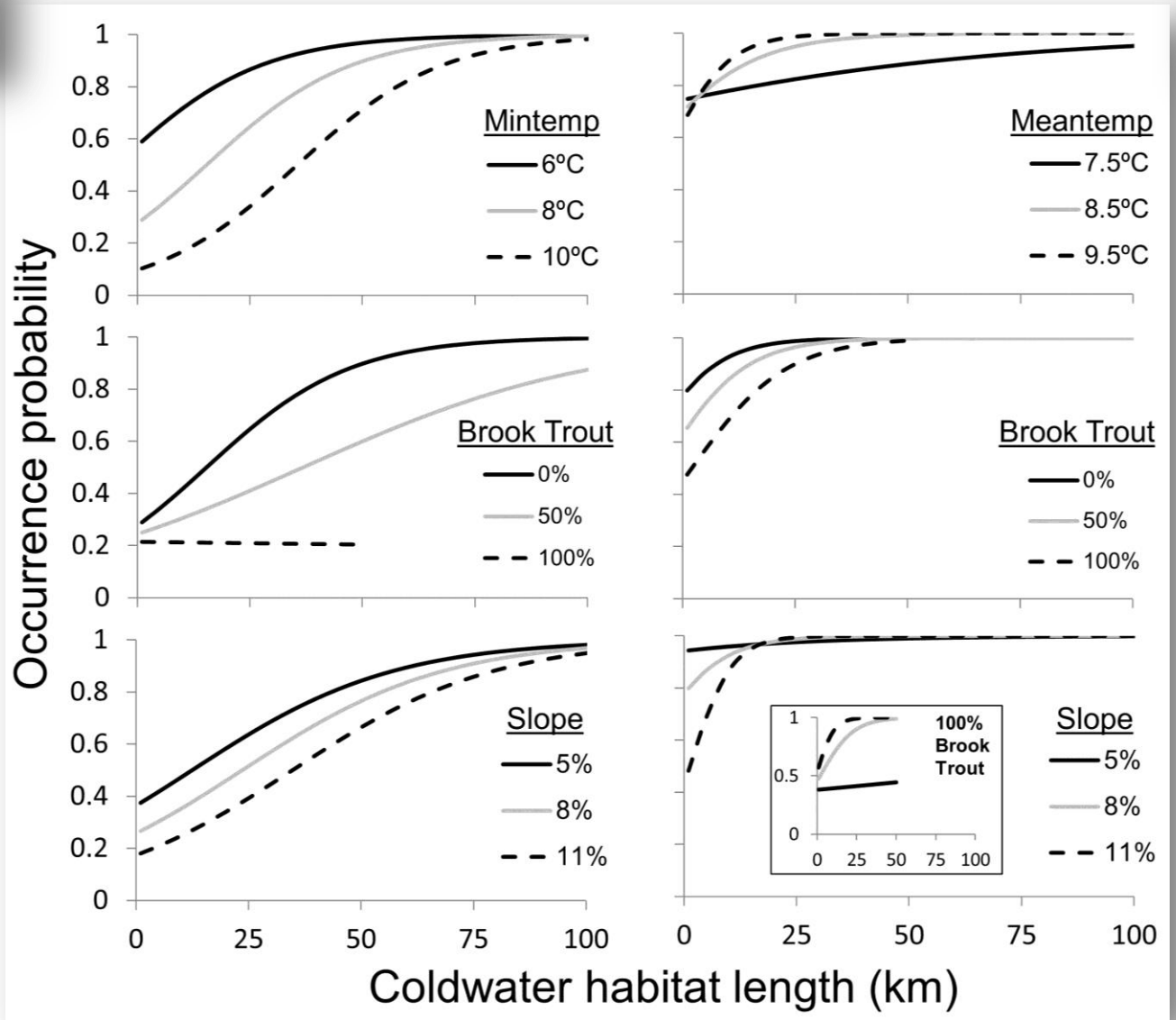
- **Habitat size (km ≤ 11°C)**
- **Stream slope**
- **Temperature**
  - **Mean**
  - **Minimum**
- **% Brook trout**

Rocky Mountain Research Station

Species Response Curves from Multiple Logistic Regression

Classification success

0.5: 78%
0.9: 96%



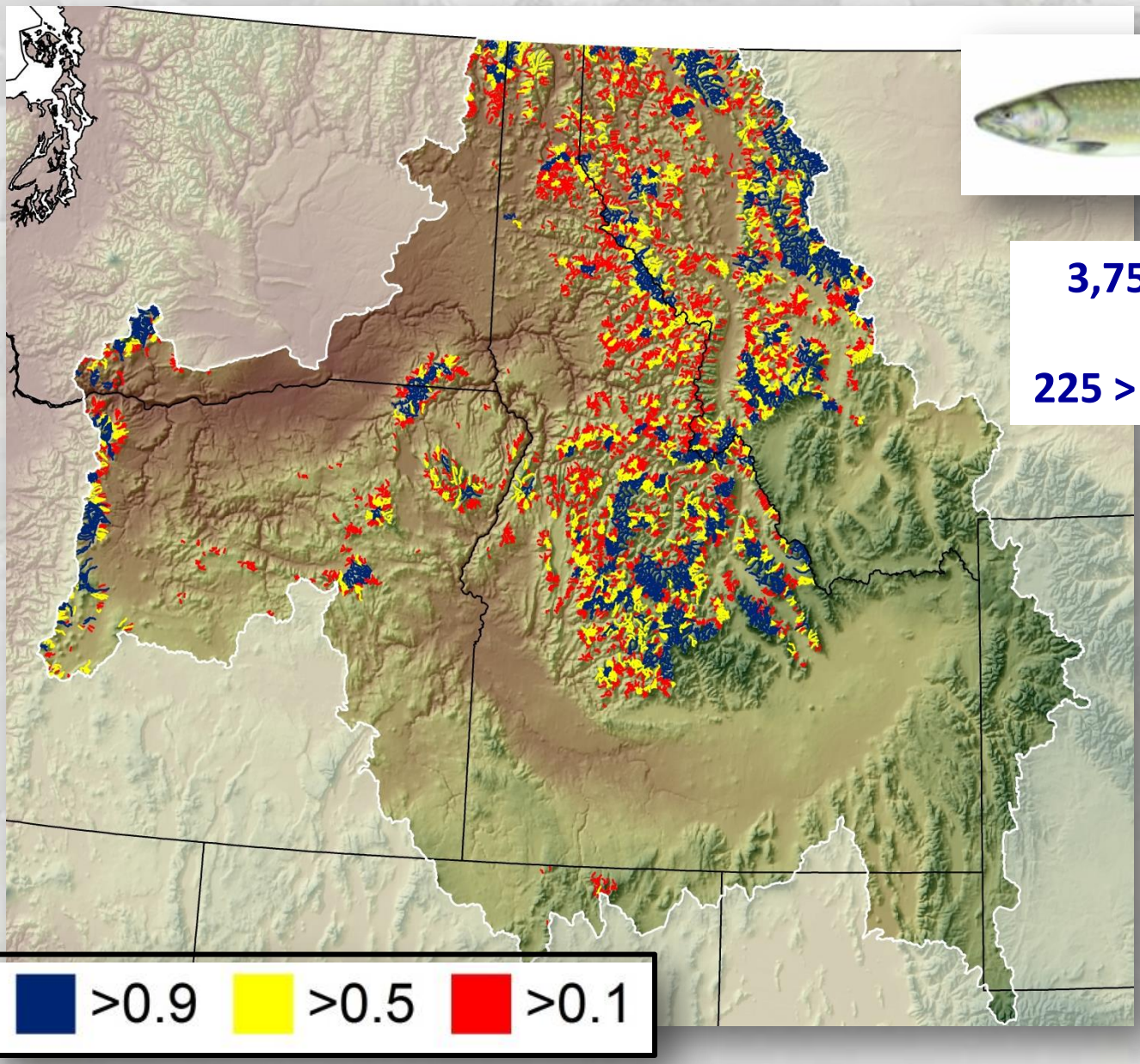
Classification success

0.5: 85%
0.9: 98%

Modeling occupancy: overall and in climate refugia

	Bull trout	Cutthroat trout
Given . . .	P(occupancy) . . .	P(occupancy) . . .
↑ Habitat size	↑ P(0.5): 17 km P(0.9): 65 km	↑ P(0.5): 1 km P(0.9): 13 km
↑ Stream slope	↓	↓, ↑
↑ Temperature	↓(minimum)	↑(mean) failure @ 8°C, displaced @ 11°C
↑ % Brook trout	↓ (@50%, CWH 2x)	↓

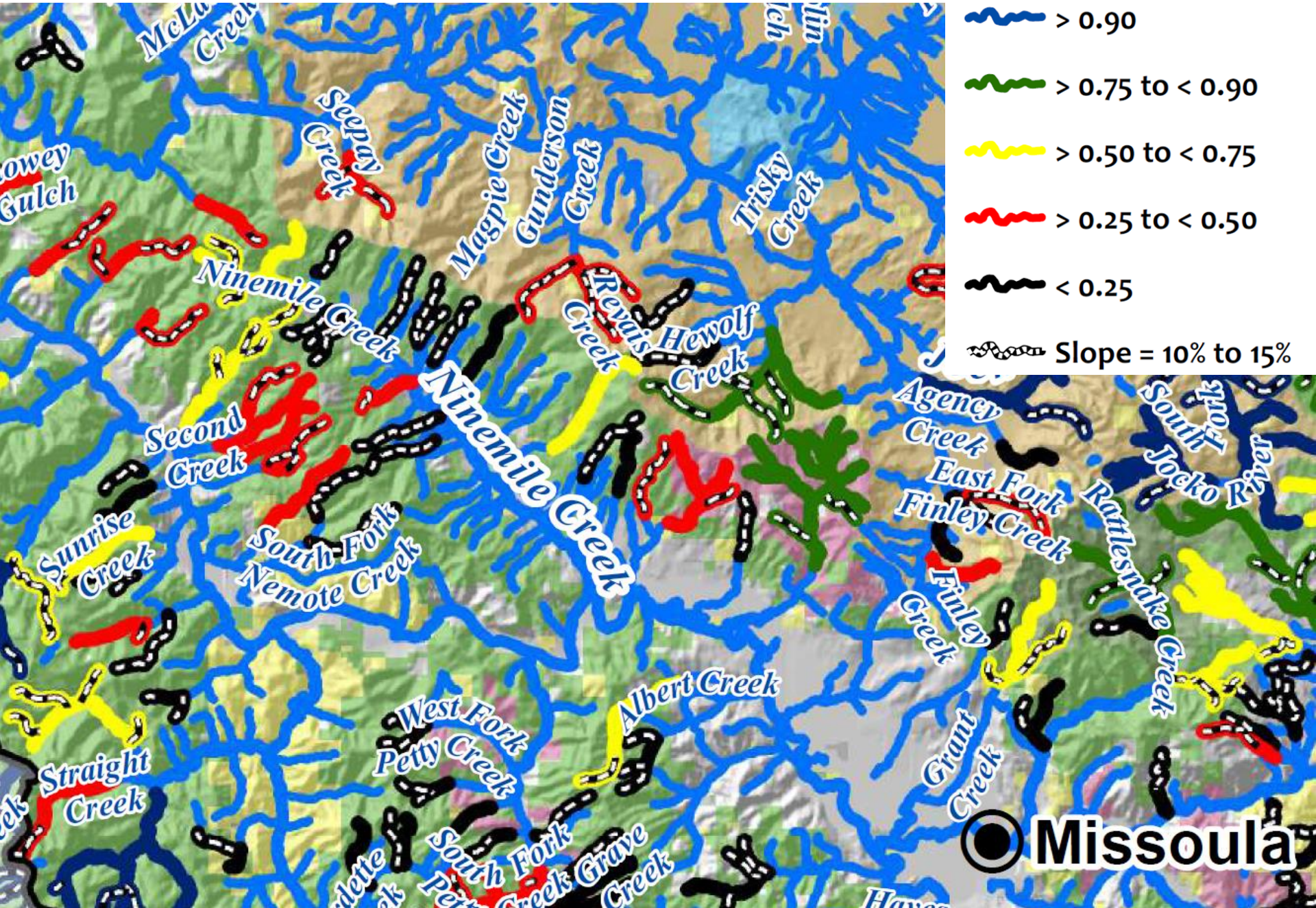
Occurrence Probability Map – 1980s



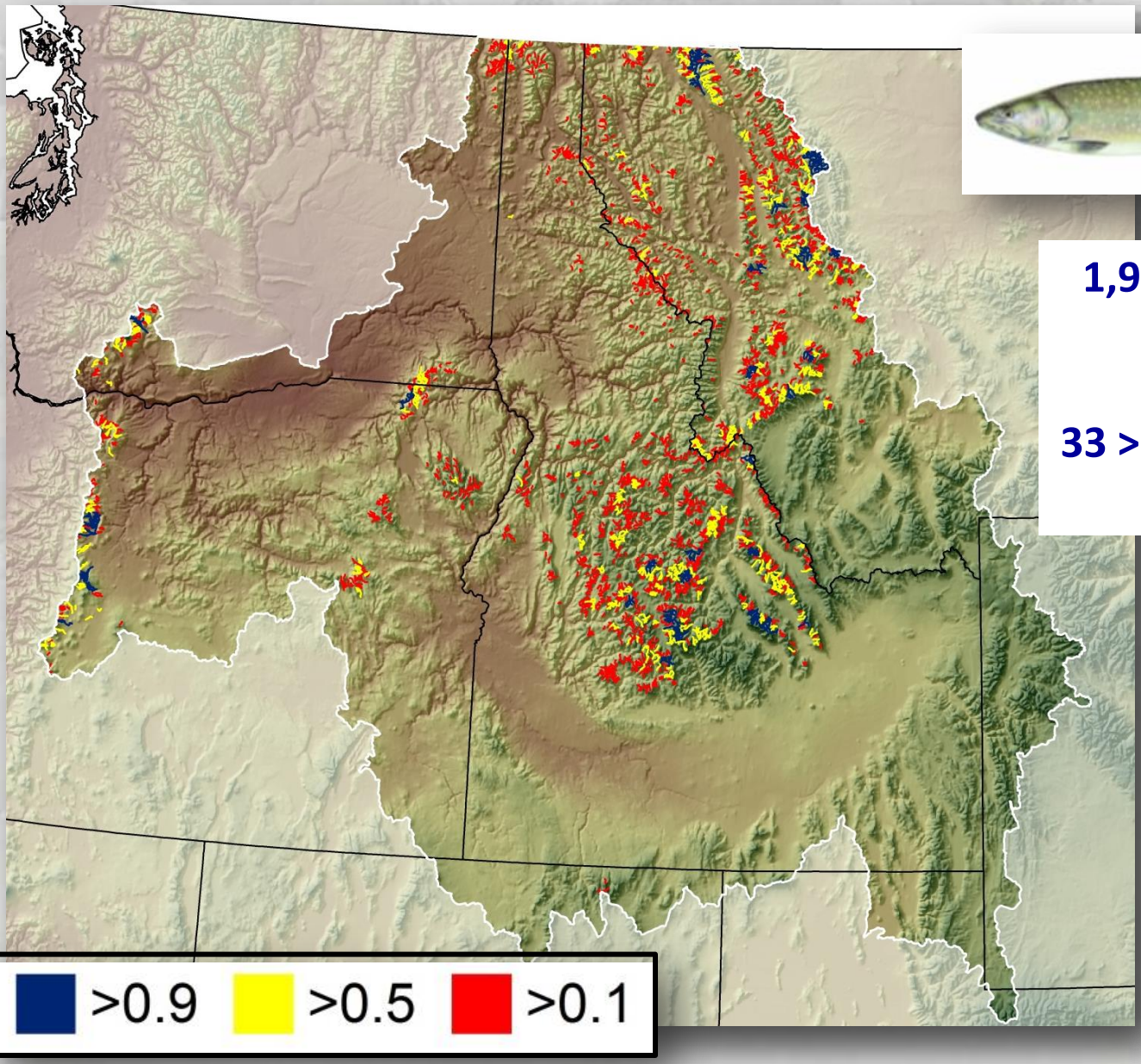
3,750 habitats

225 > 0.9 habitats

Occupancy probability: juvenile bull trout, 1980s, no brook trout



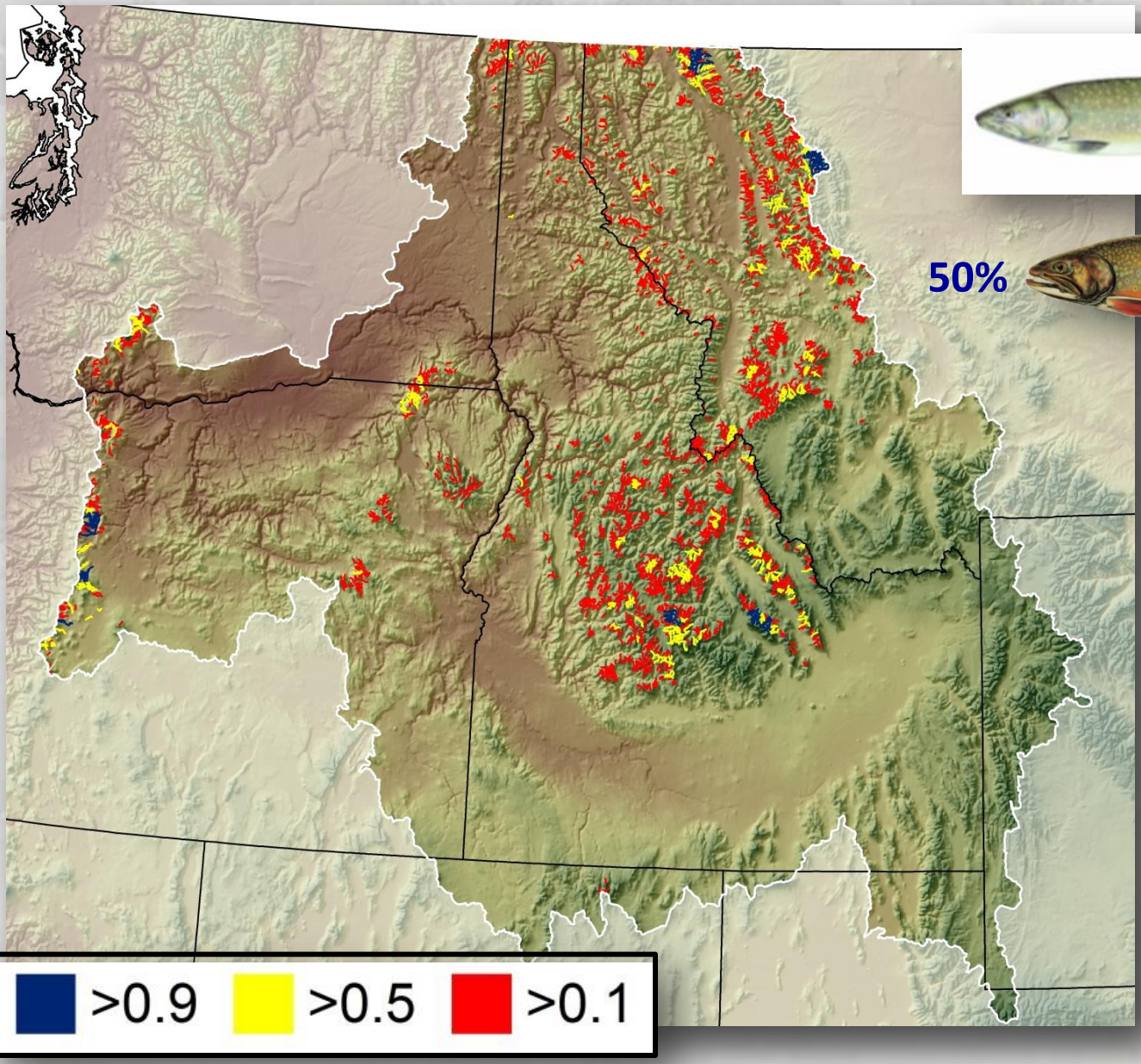
Occurrence Probability Map – 2080s



1,973 habitats (⇩47%)

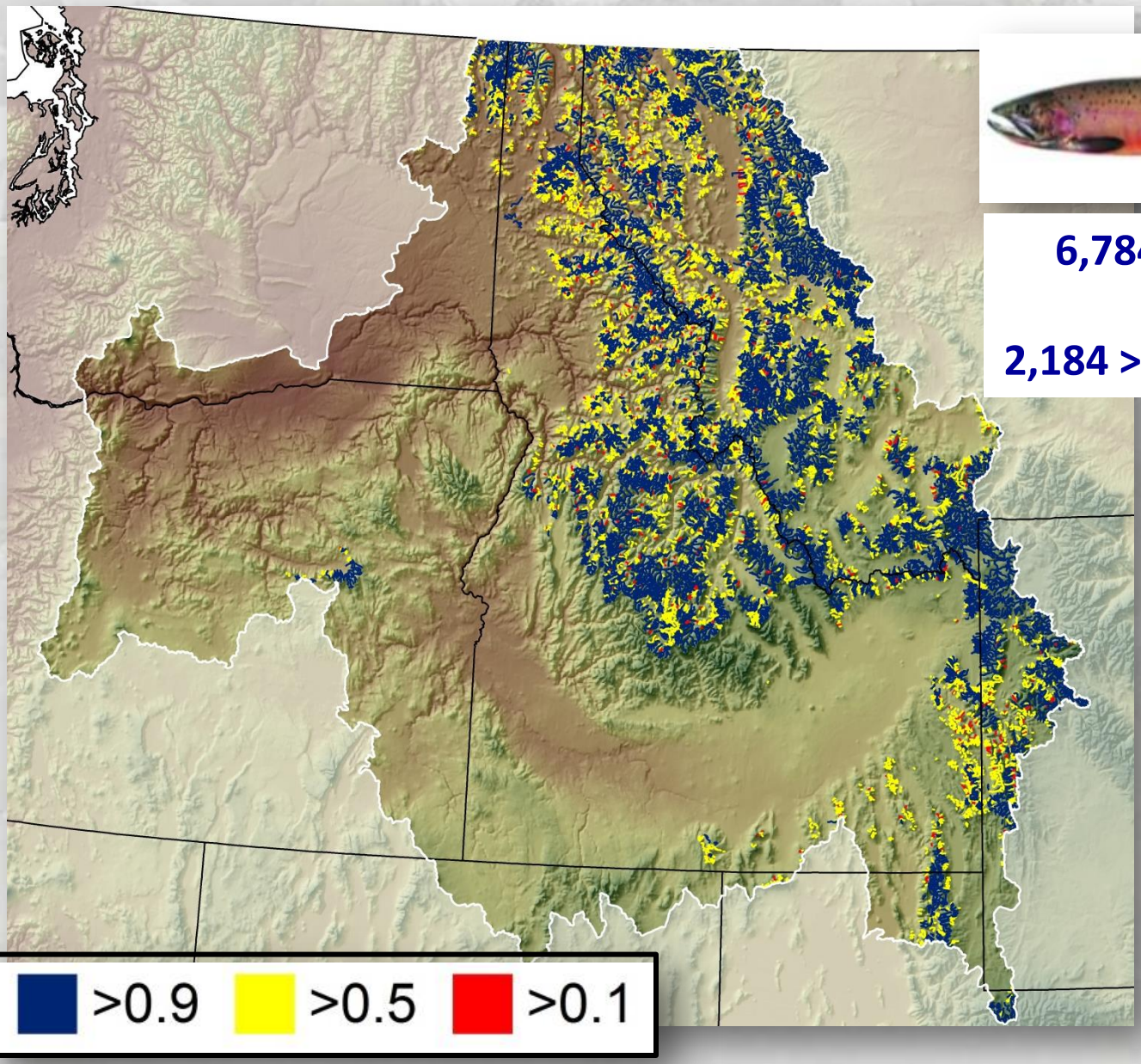
33 > 0.9 habitats (⇩85%)

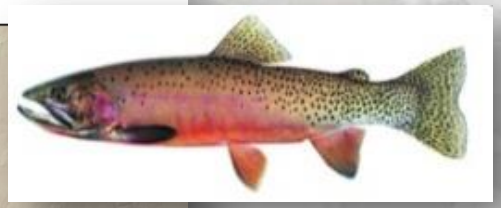
Occurrence Probability Map – 2080s



50%

Occurrence Probability Map – 1980s

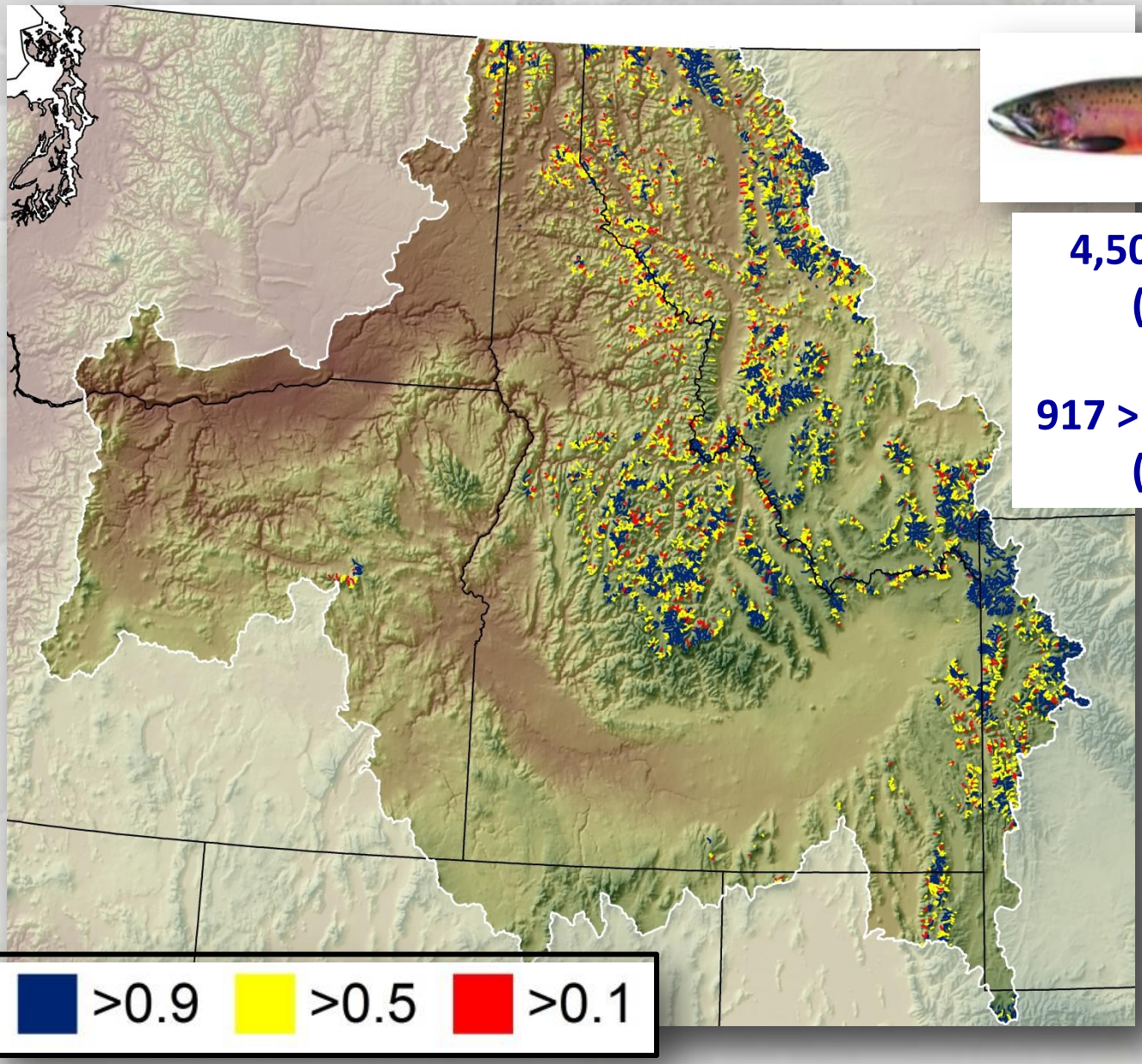


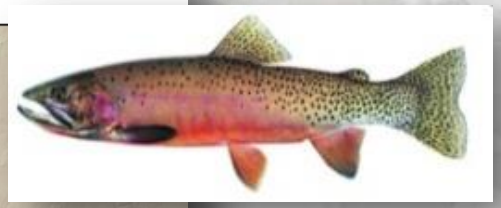


6,784 habitats

2,184 > 0.9 habitats

Occurrence Probability Map – 2080s

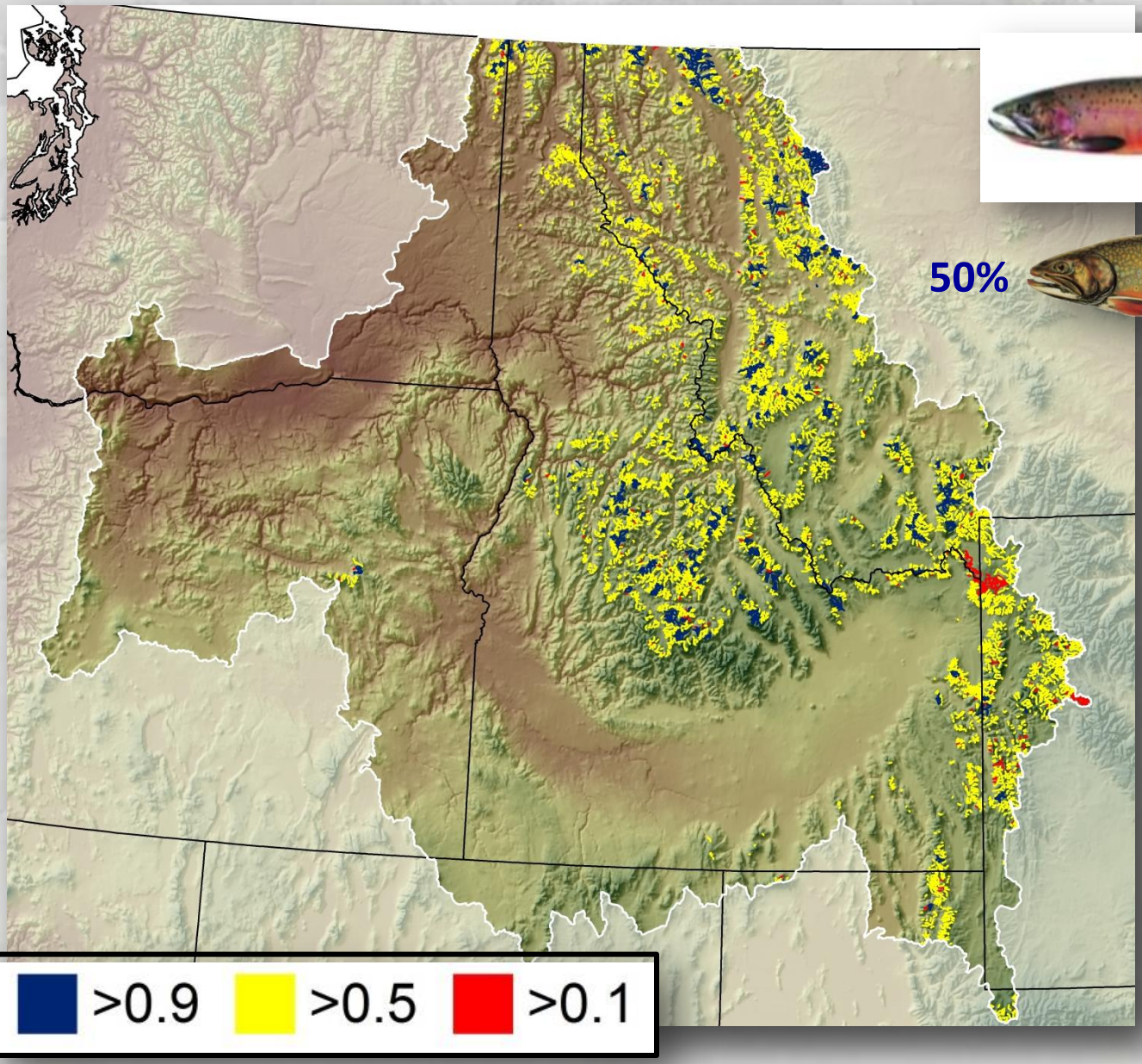




4,502 habitats (⇩34%)

917 > 0.9 habitats (⇩58%)

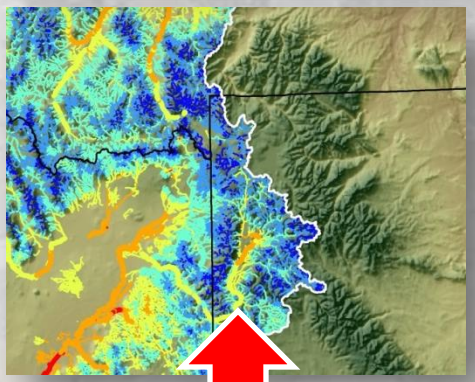
Occurrence Probability Map – 2080s

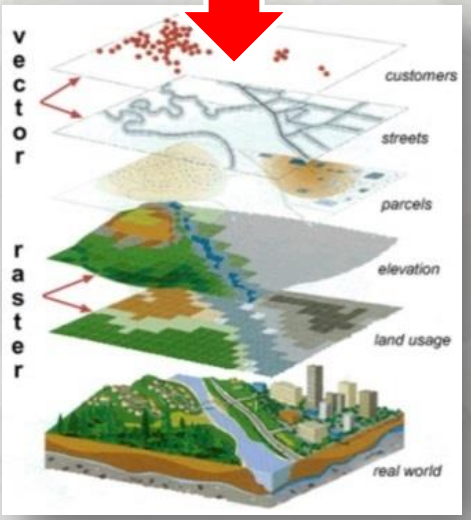


Land administration GAP analysis

<11°C streams in bull trout range

Land status	1980s	2080s
Private	5,580	1,099
Tribal	1,779	713
State/City	1,621	420
BLM	1,534	512
NPS	652	182
TNC	157	30
Other	1,093	367
FS-wilderness	6,483	2,854
FS-nonwilderness	34,068	14,575
Total:	52,966	20,752





- **~90% on public lands**
- **~75—85% on National Forests**
- **<15% protected**

Gergely and McKerrow 2013. PAD-US—National inventory of protected areas: U.S. Geological Survey. http://pubs.usgs.gov/fs/2013/3086/

Implications & adaptation for the future

- Prospects
  - Severe habitat losses & range contraction
  - Extinction debts & risky investments
  - Still some resilient habitats
  - Substantial habitat losses & range shrinkage
  - Still widely distributed
  - Many suitable habitats, but many at risk from nonnative species
- Actions (in situ)
  - Prioritize
  - Community conservation
  - Prioritize
  - Remove nonnatives
  - Isolate habitats?
- Actions (ex situ)
  - Translocation
  - Supplementation
  - Duplication
  - Refounding
  - Broodstocks

Feature:
FISHERIES MANAGEMENT

Native Fish Conservation Areas: A Vision for Large-Scale Conservation of Native Fish Communities

Jack E. Williams, Richard N. Williams, Russell F.

Áreas para la Conservación de Peces

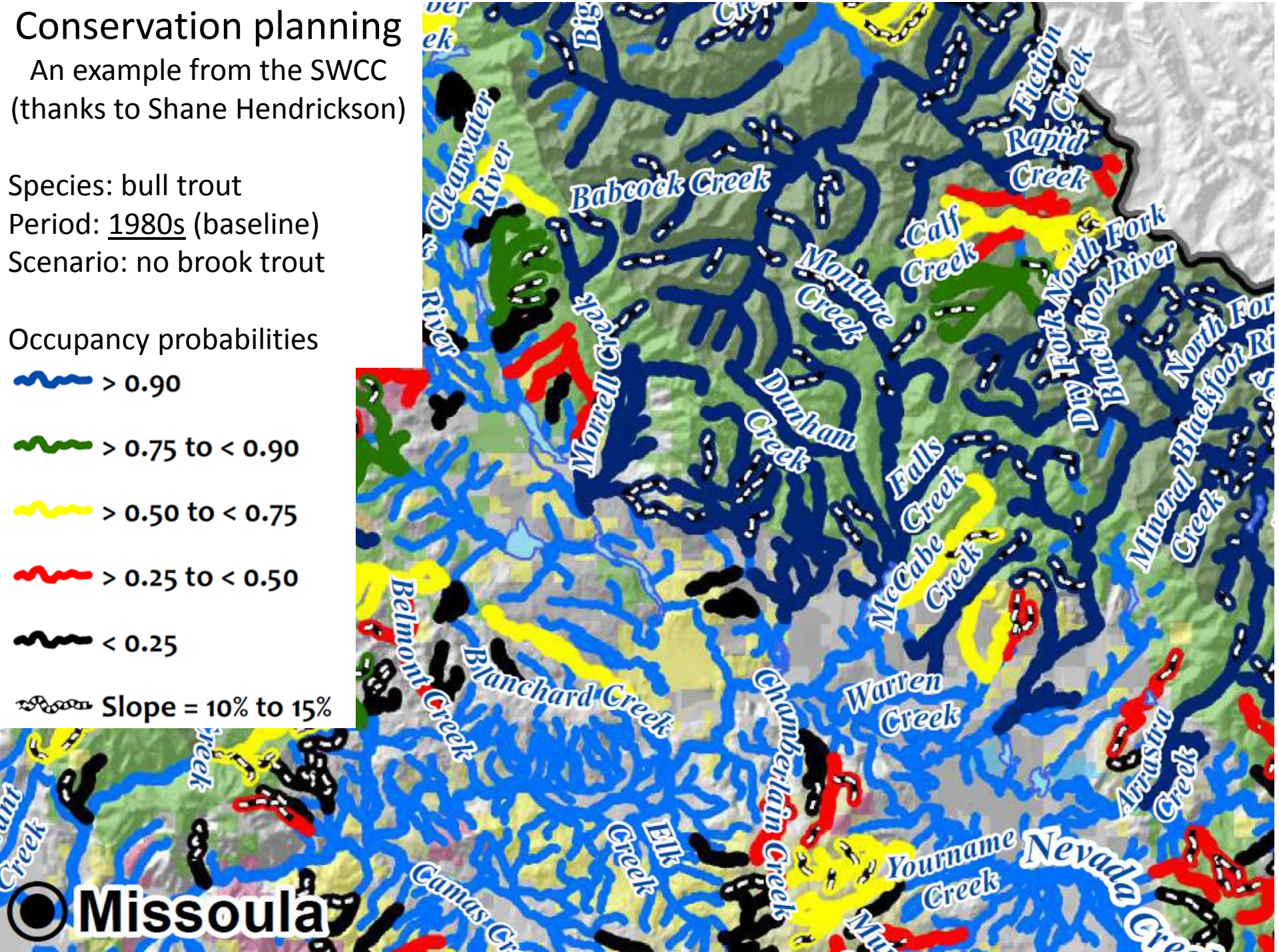
Conservation planning

An example from the SWCC
(thanks to Shane Hendrickson)

Species: bull trout
Period: 1980s (baseline)
Scenario: no brook trout

Occupancy probabilities

- > 0.90
- > 0.75 to < 0.90
- > 0.50 to < 0.75
- > 0.25 to < 0.50
- < 0.25
- Slope = 10% to 15%



Conservation planning

An example from the SWCC

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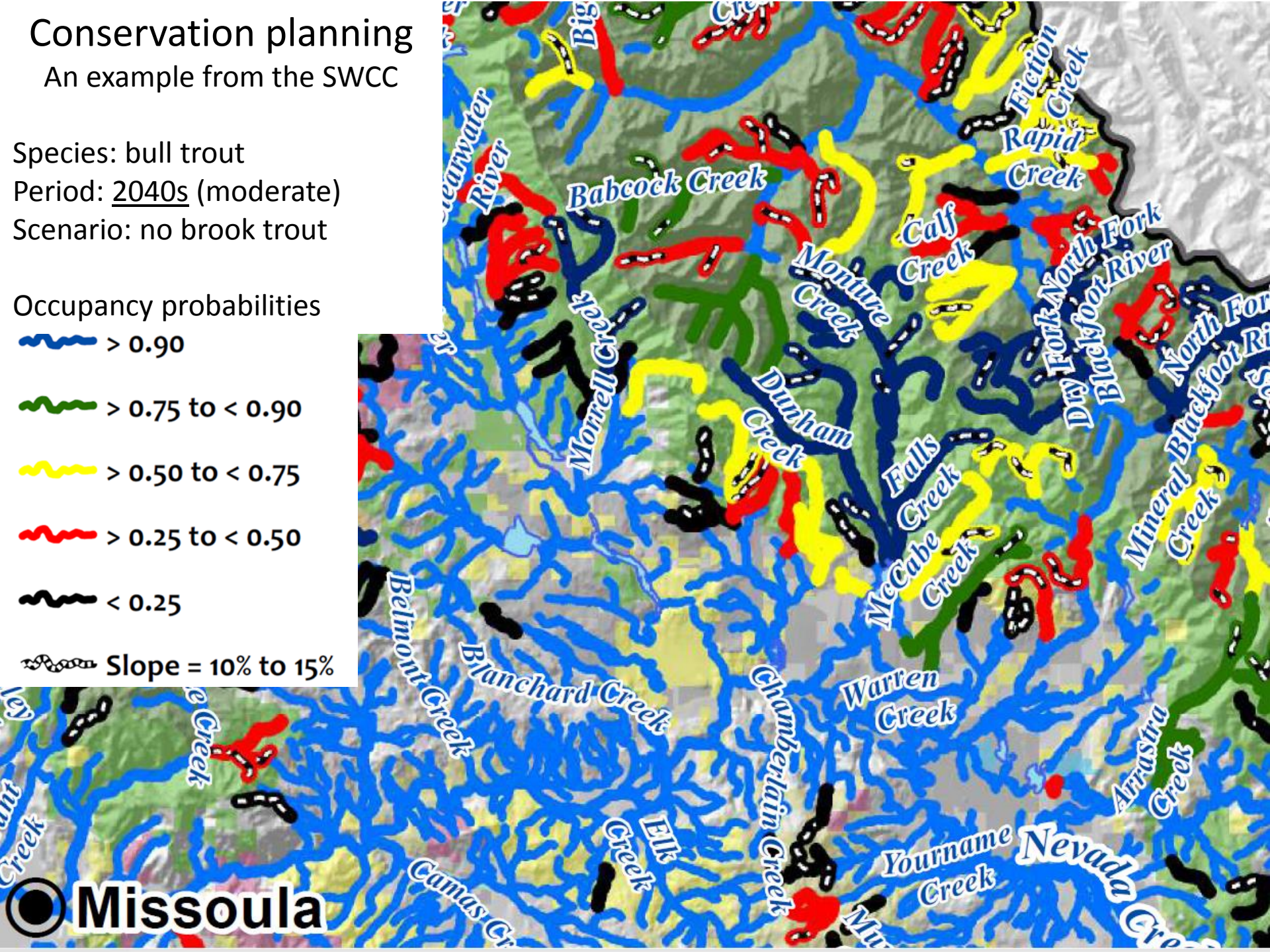
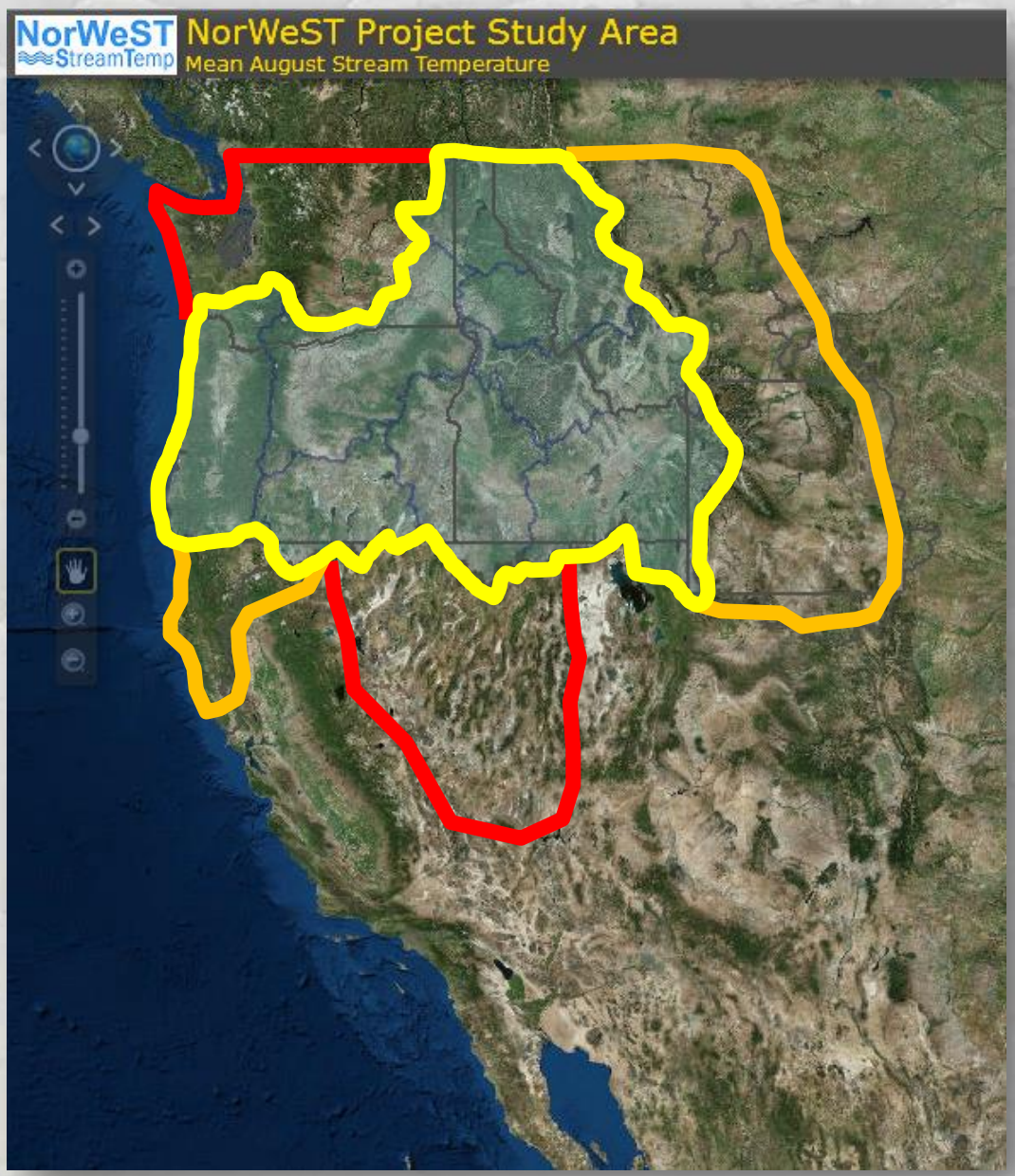


Cold-Water Climate Shield Expansion…



Added

Washington

Nevada

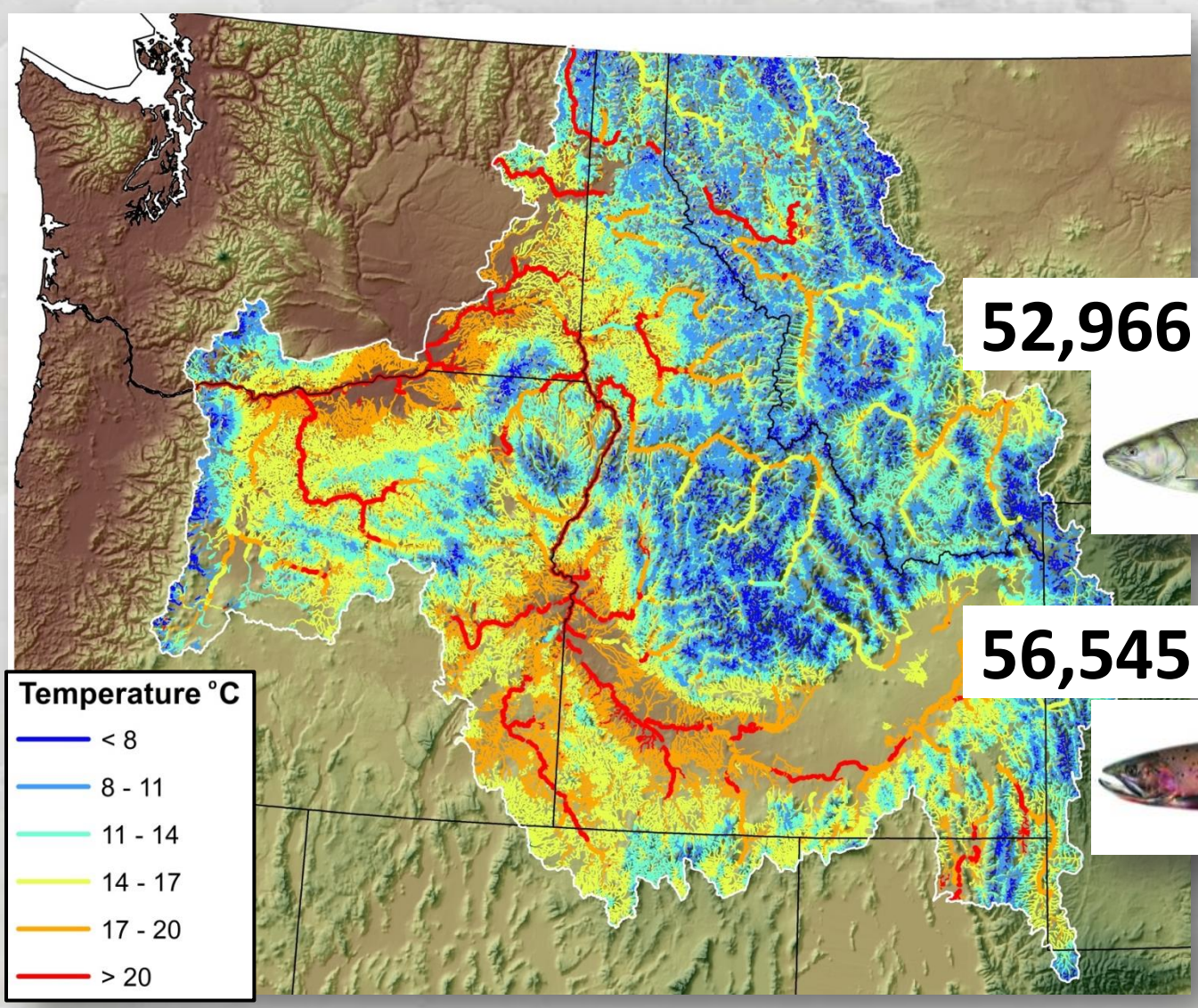
Underway

C. Montana

W. Wyoming

NW. California

The next challenge: assessment and monitoring at broad scales



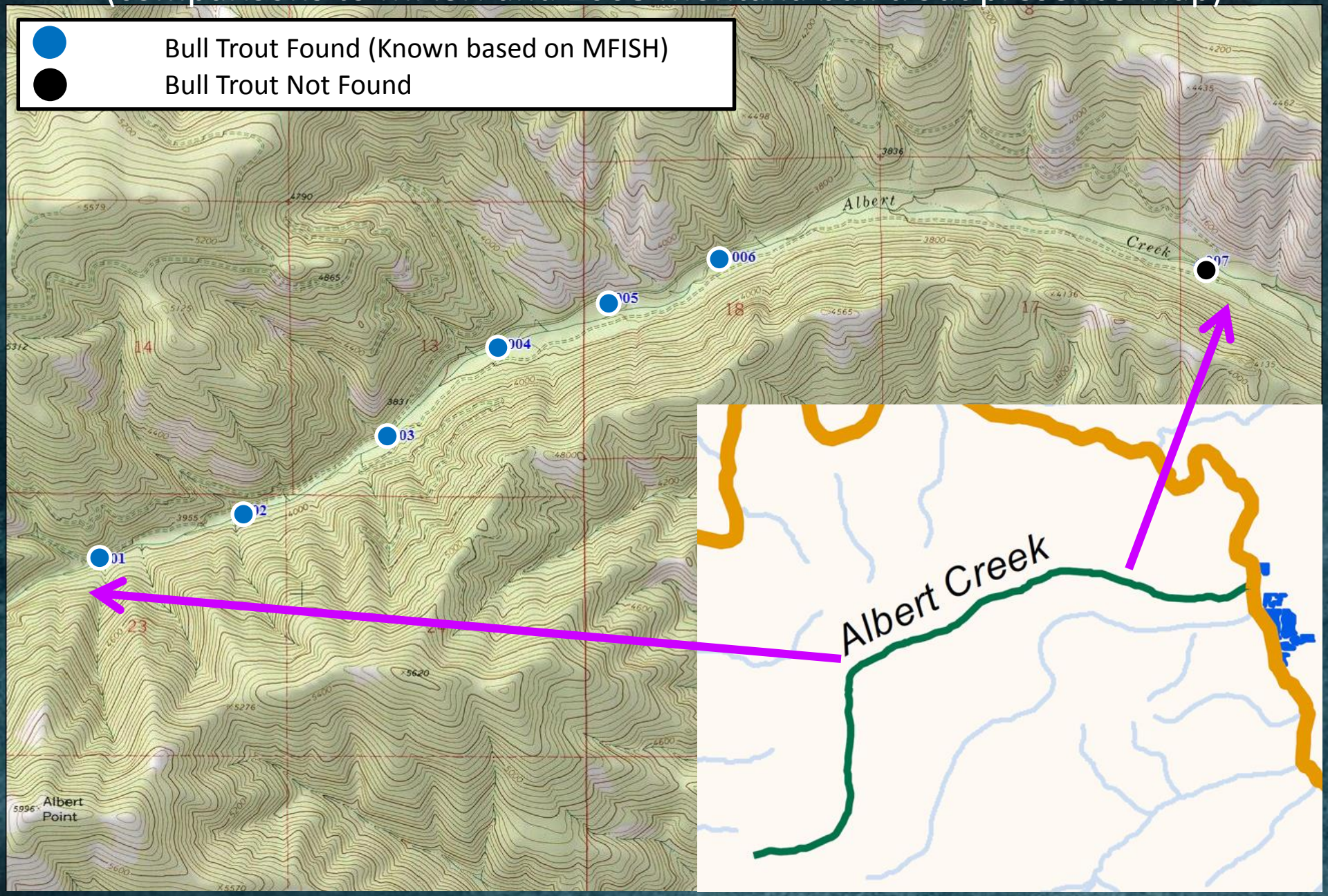
52,966 km

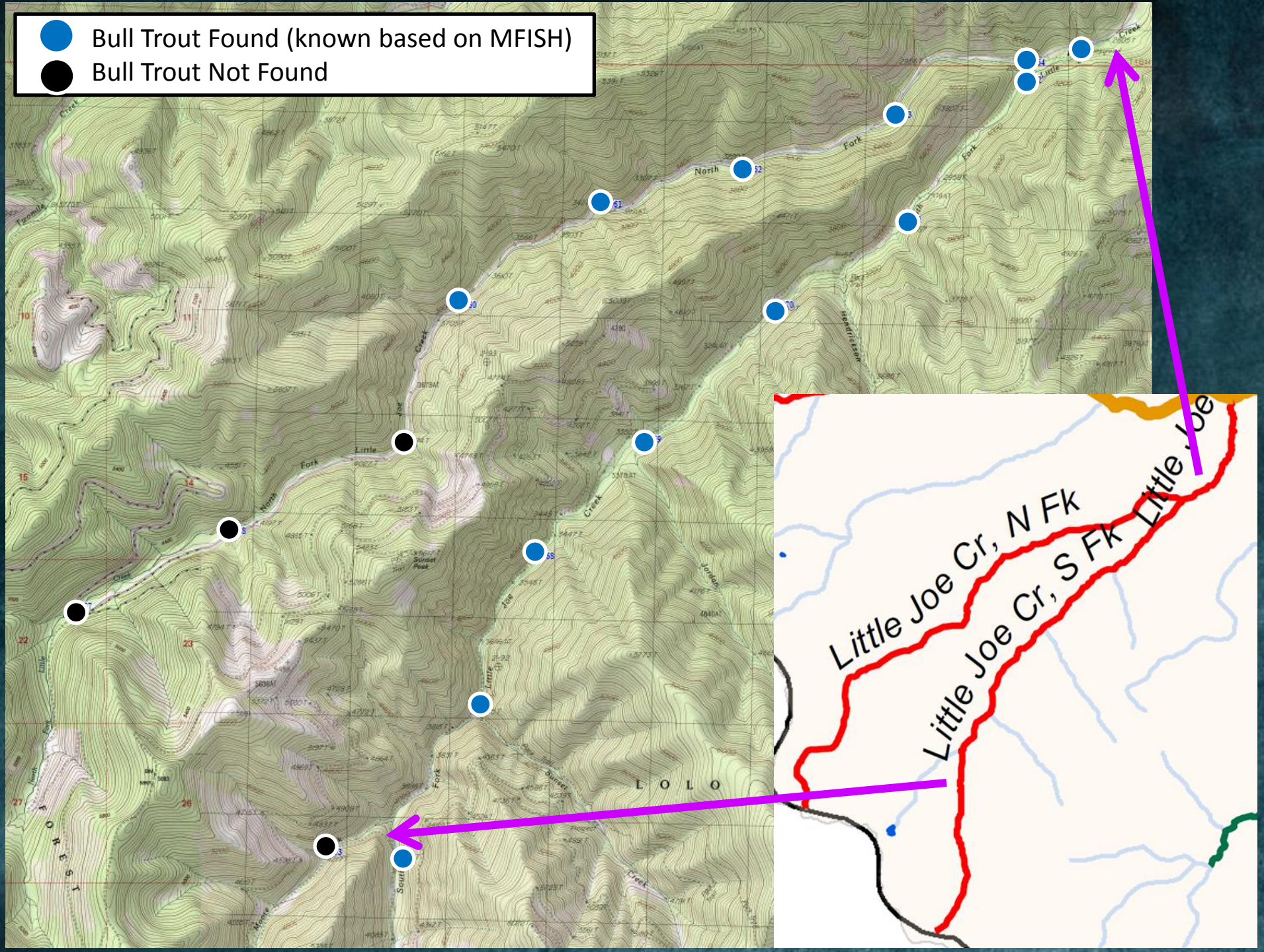
56,545 km

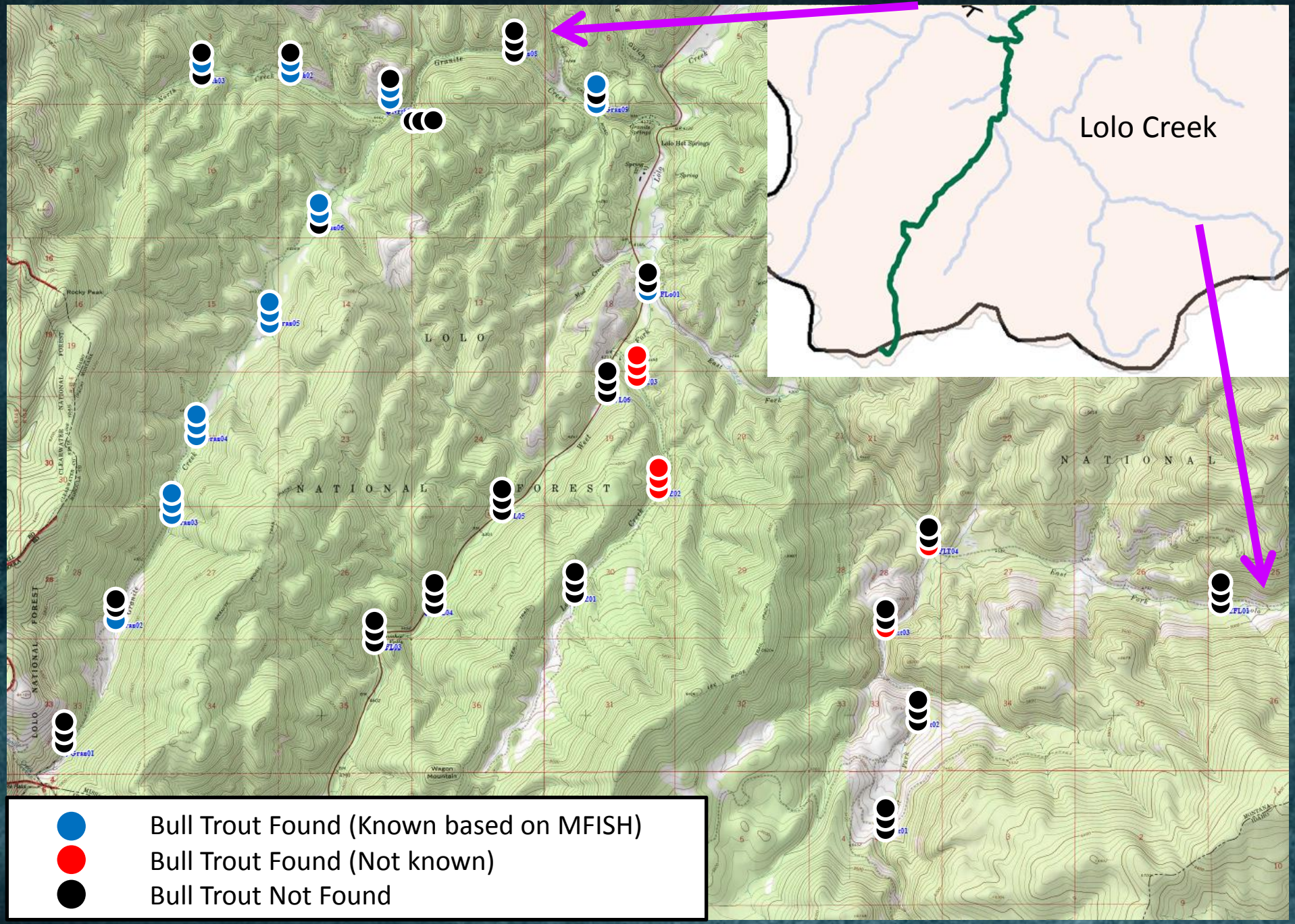
Monitoring the biodiversity portfolio: eDNA

- Pioneering this approach for species detection
- Costs: pennies on the dollar, minutes on the hour
- User-driven applications
- Optimizing for local to range-wide assessments

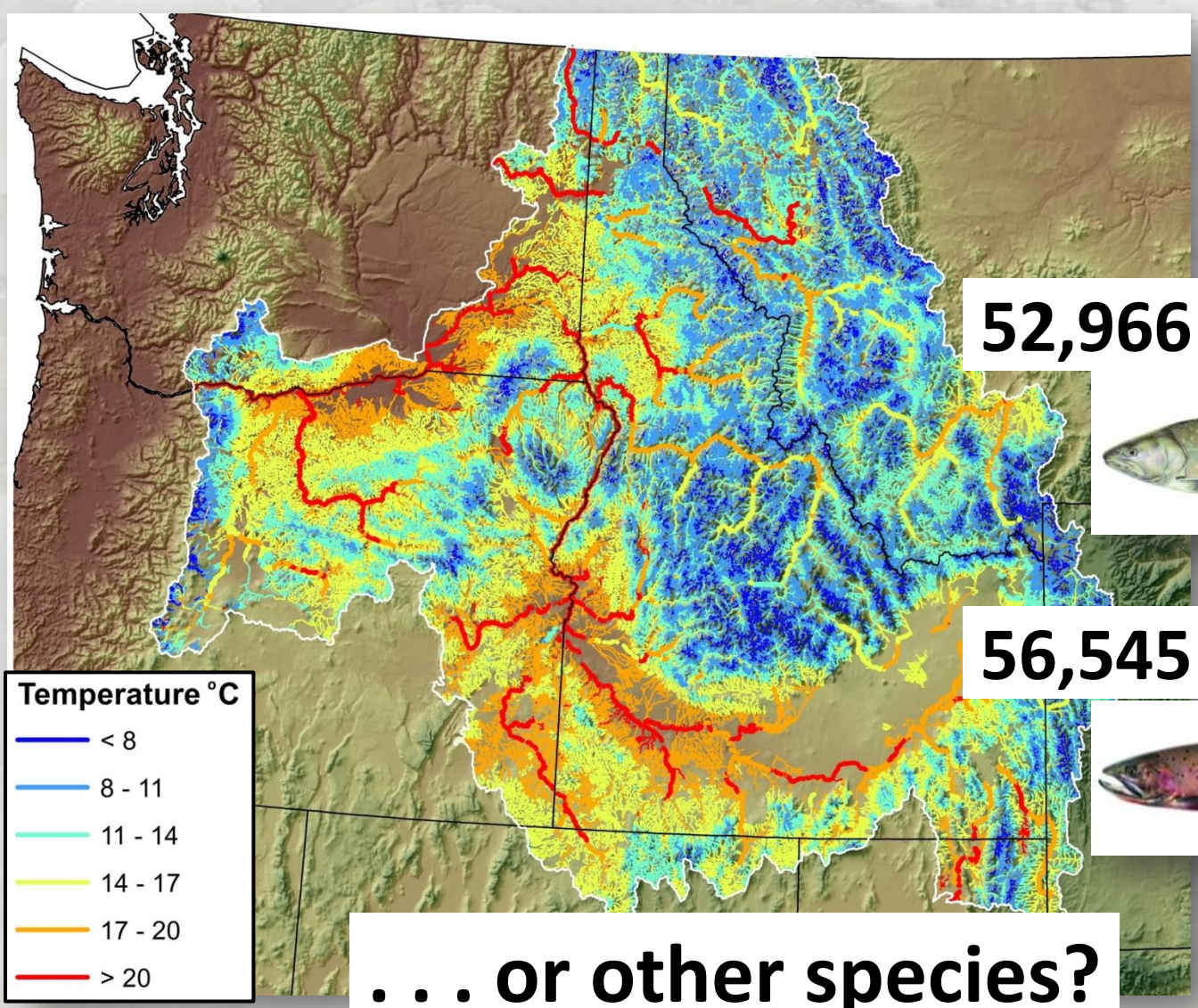
Using eDNA to delineate and discover bull trout populations (comparisons to MFISH and 2008 Montana bull trout presence map)




Bull Trout Found (known based on MFISH)
Bull Trout Not Found
Little Joe Cr, N Fk
Little Joe Cr, S Fk
Little Joe
LOLO


Lolo Creek
L O L O
N A T I O N A L
F O R E S T
N A T I O N A L
Bull Trout Found (Known based on MFISH)
Bull Trout Found (Not known)
Bull Trout Not Found

Why not a range-wide, eDNA-based assessment of bull trout occupancy?



52,966 km

56,545 km

. . . or other species?

Acknowledgements:

John Chatel & Scott Vuono - Sawtooth National Forest; Ralph Mitchell, Herb Roerick, & Mike Kellett - Boise National Forest; Bart Gamett - Salmon-Challis National Forest; James Brammer & Steven Kujala - Beaverhead-Deerlodge National Forest; Joan Louie - Lolo National Forest; Leslie Nyce - Montana Fish, Wildlife and Parks; Seth Wenger – University of Georgia; Kevin Meyer – Idaho Fish & Game; Phil Howell

Published Fish Literature Sources…

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Allen et al. 2010. Distribution and Movement of Bull Trout in the Upper Jarbidge River Watershed, Nevada. U.S. Geological Survey, Open-File Report 2010-1033.

Benjamin et al. 2007. Invasion by nonnative brook trout in Panther Creek, Idaho: Roles of local habitat quality, biotic resistance, and connectivity to source habitats. TAFS 136: 875–888.

Dunham & Rieman. 1999. Metapopulation structure of bull trout: Influences of physical, biotic, and geometrical landscape characteristics. Ecol. Appl. 9: 642–655.

Dunham et al. 2007. Influences of Wildfire and Channel Reorganization on Spatial and Temporal Variation in Stream Temperature and the Distribution of Fish and Amphibians. Ecosystems 10:335-346.

Eby et al. 2014. Evidence of Climate-Induced Range Contractions in Bull Trout Salvelinus confluentus in a Rocky Mountain Watershed, USA. PloS ONE 9: e98812.

Isaak & Hubert. 2004. Nonlinear response of trout abundance to summer stream temperatures across a thermally diverse montane landscape. TAFS 133: 1254-1259.

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