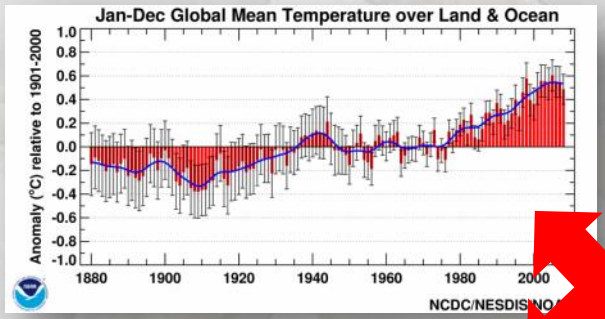
Development of Crowd-Sourced Stream Temperature Scenarios & Delineation of Climate Refugia for Preserving Native Trout

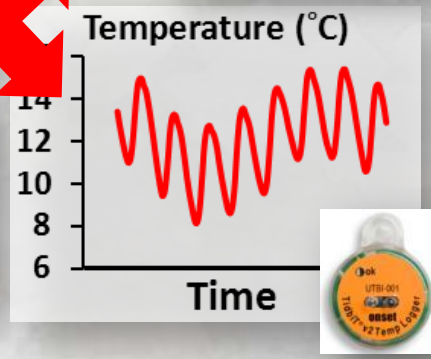
Dan Isaak, Mike Young, Seth Wenger[1], Erin Peterson[2], Jay Ver Hoef[3]
Charlie Luce, Steve Hostetler[4], Jason Dunham[4], Jeff Kershner[4], Brett Roper, Dave Nagel, Dona Horan, Gwynne Chandler, Sharon Parkes, Sherry Wollrab, Colete Bresheares, Neal Bernklau, Matt Groce

U.S. Forest Service
[1]Trout Unlimited
[2]CSIRO
[3]NOAA
[4]USGS



Climate Shield

NorWeST Stream Temp



Funding agencies:

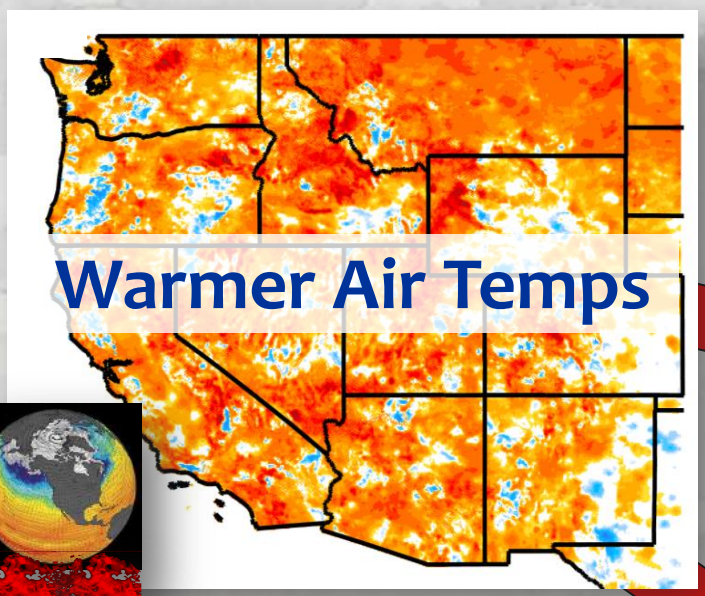
USGS science for a changing world

North Pacific Landscape Conservation Cooperative

Great Northern Landscape Conservation Cooperative

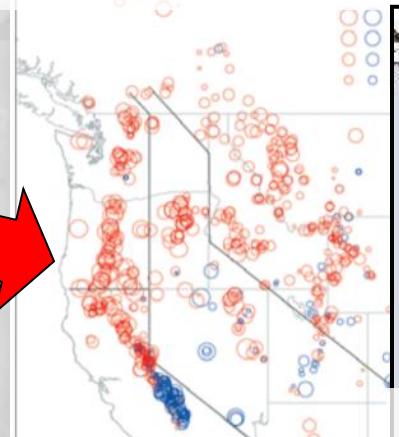
NASA

Environmental Trends Everywhere (1950-2009)

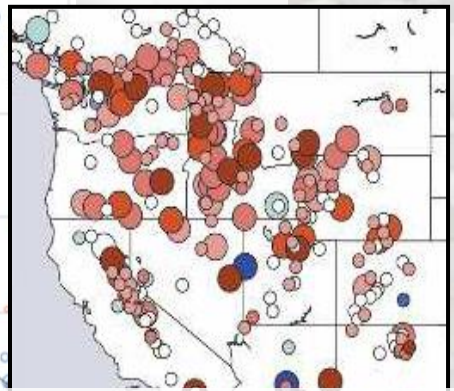


Warmer Air Temps

Less Snow & Earlier Runoff



Mote et al. 2005

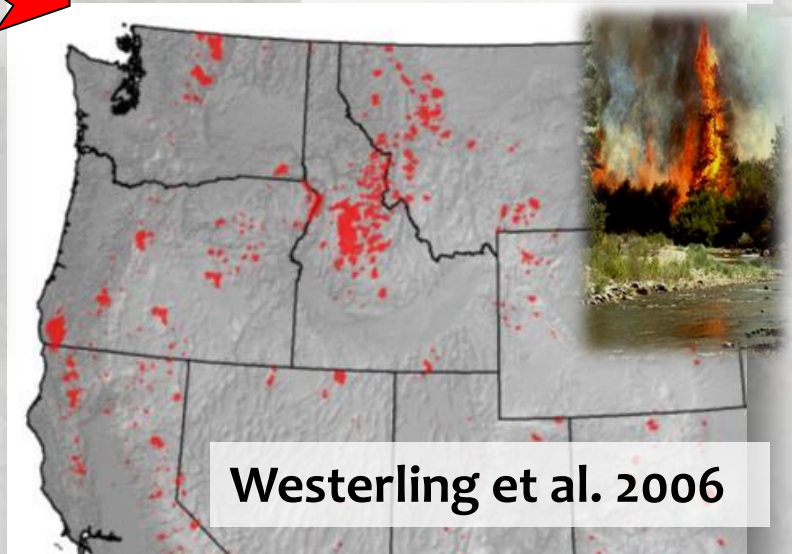


Stewart et al. 2005

Decreasing summer flows

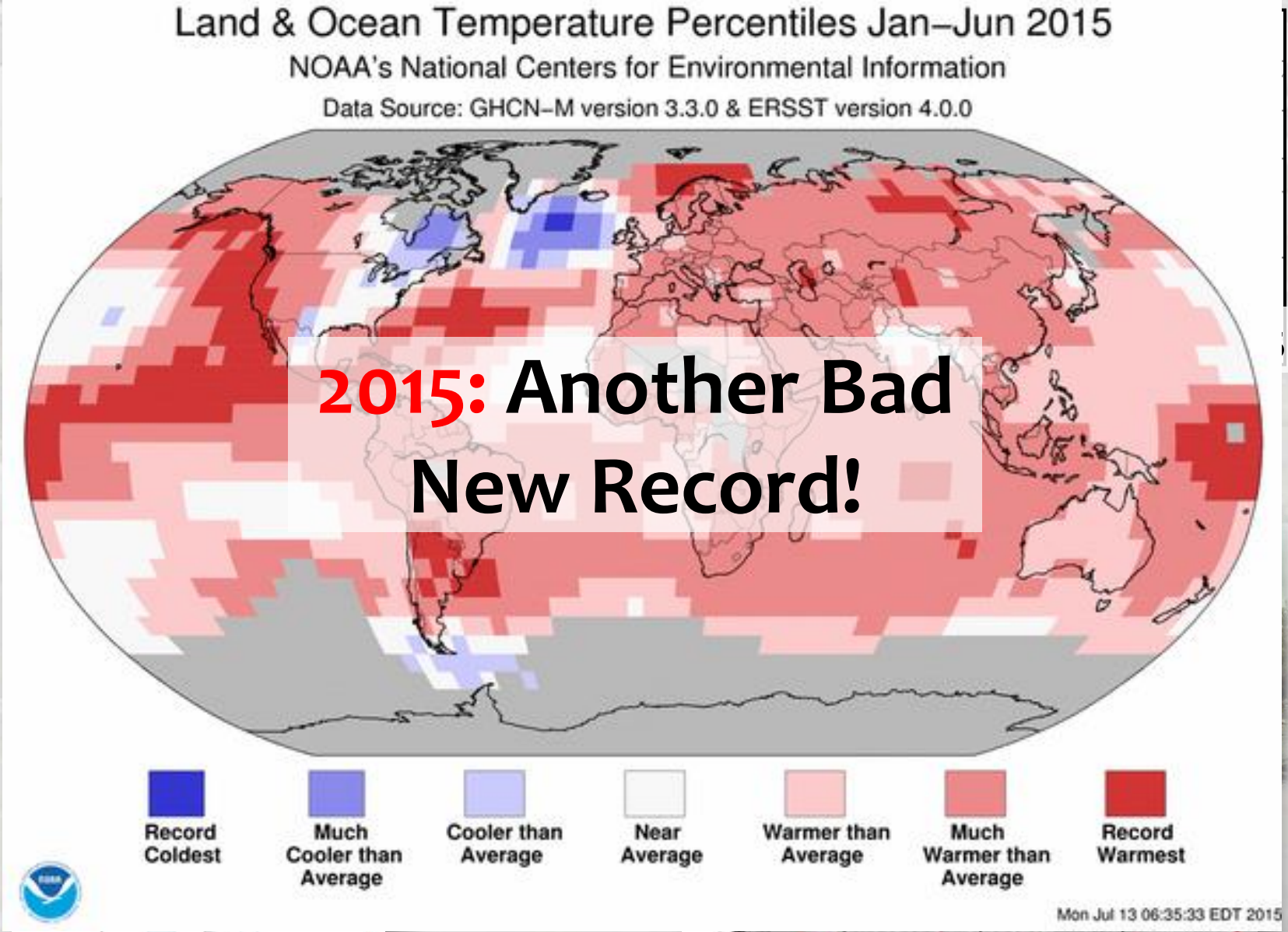
Leppi et al. 2011

Wildfire Increases



Westerling et al. 2006

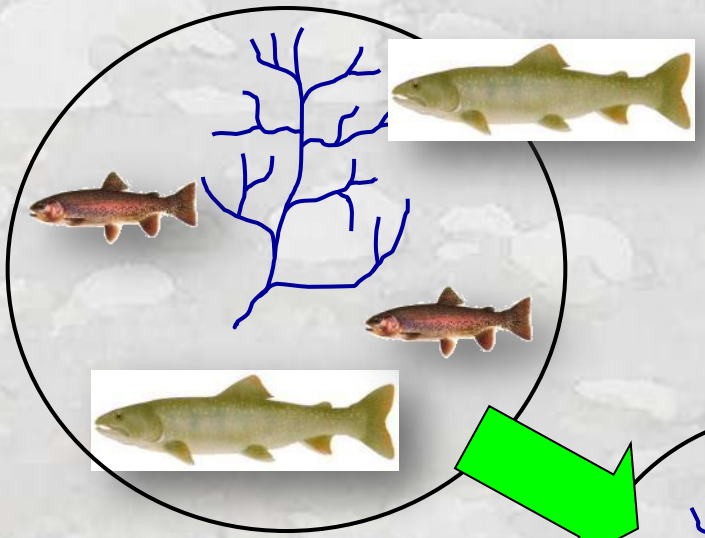
Environmental Trends Everywhere (1950-2009)

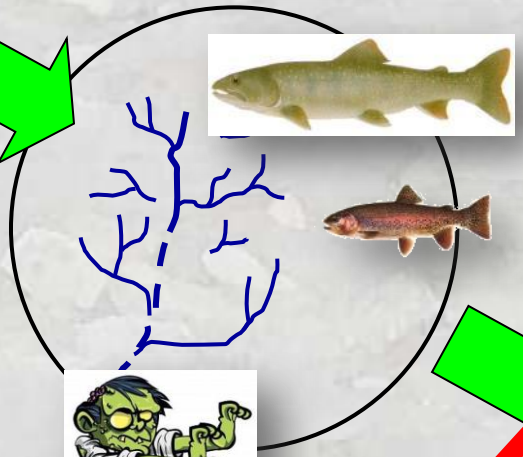


2015: Another Bad New Record!

Resistance Will Be Futile Sometimes

Not Everything Can be Saved



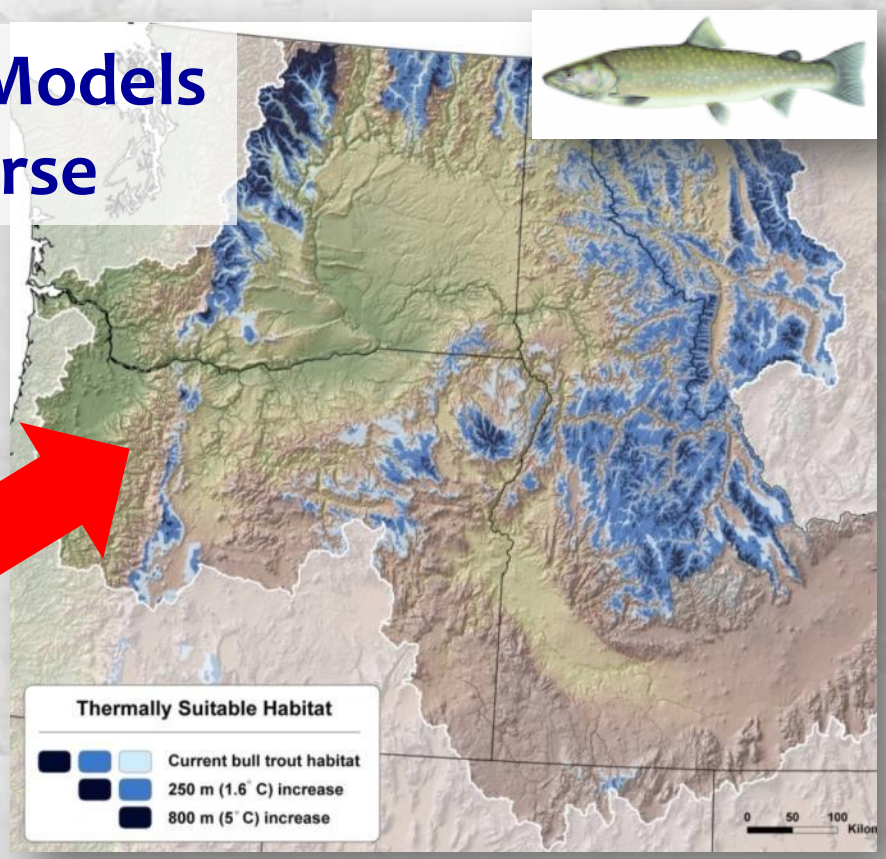


Sorry Charlie

Thresholds Beyond Which Populations Become "Walking Dead"

Precise Information Needed to Empower Local Decision Makers…

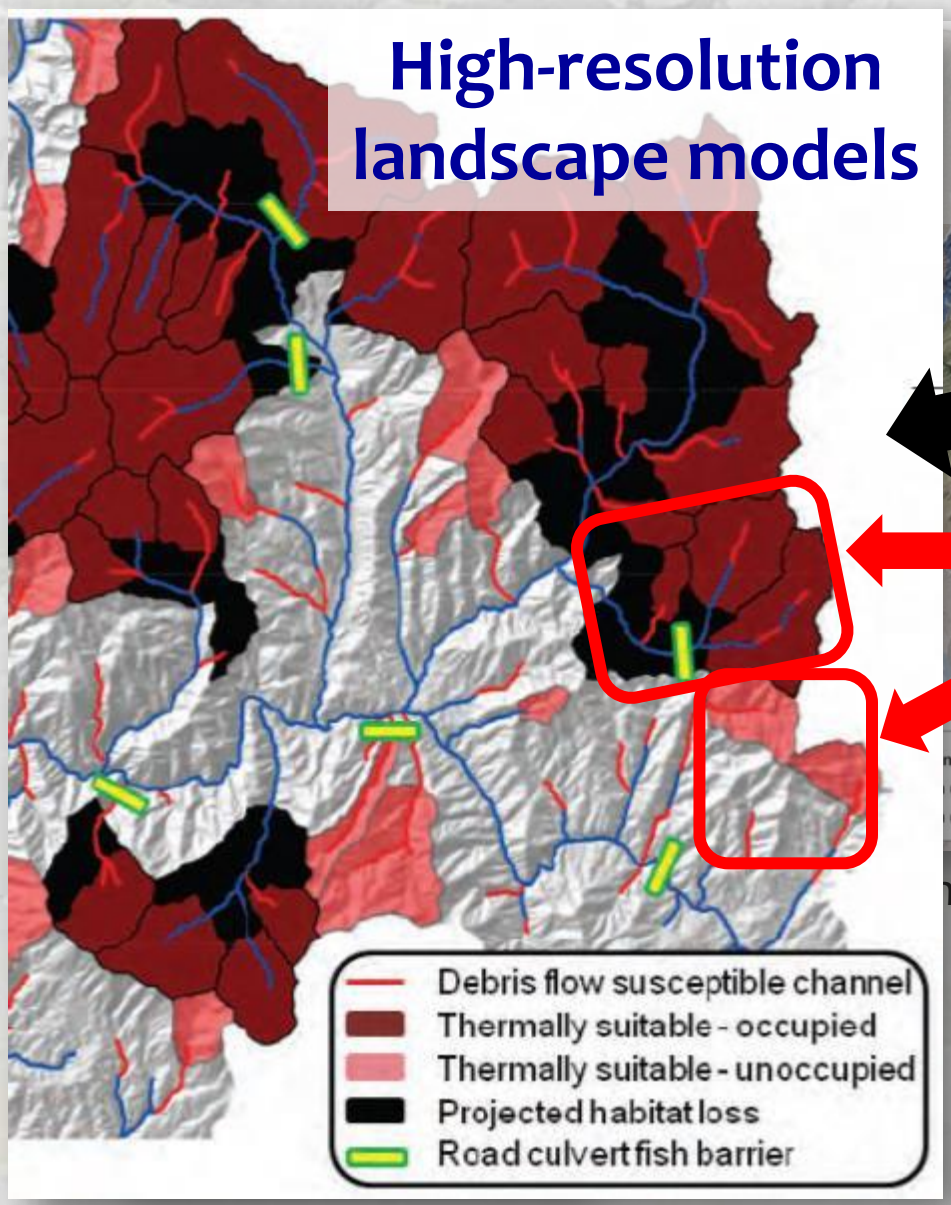
1st Generation Models are Too Coarse



Rieman et al. 2007. *TAFS* **136**:1552-1565

Not Good Enough for Zombie Detection

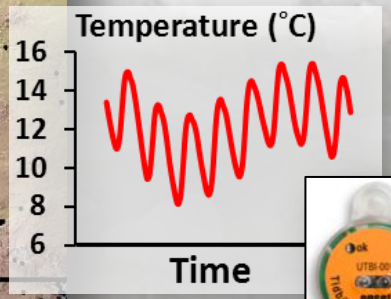
Precise Information Needed to Empower Local Decision Makers…



et al. 5

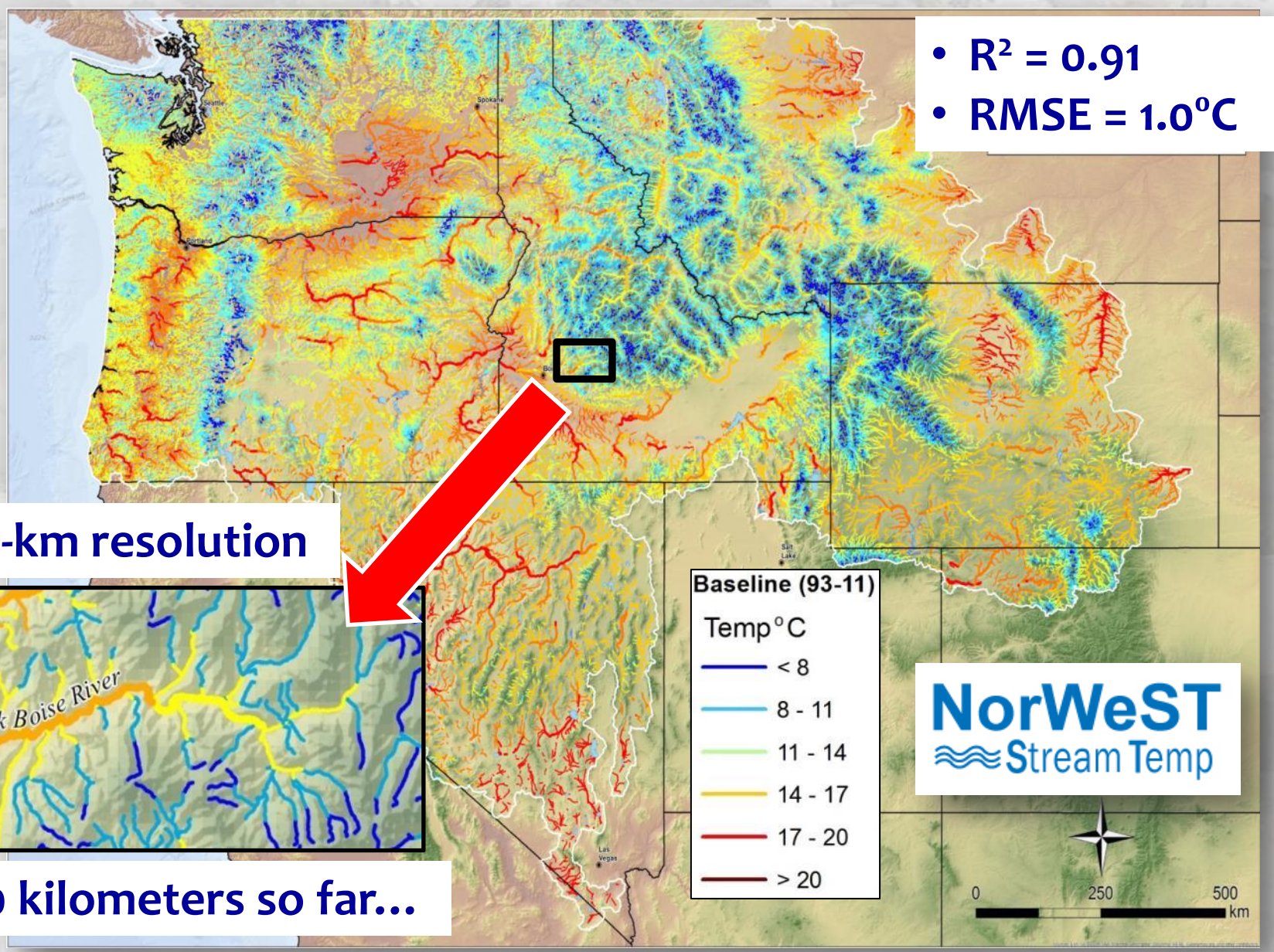
Lots of Temperature Data Exist…

>50,000,000 hourly records
>15,000 unique stream sites
>80 resource agencies



NorWeST
Stream Temp

…to Make High-Resolution Scenarios

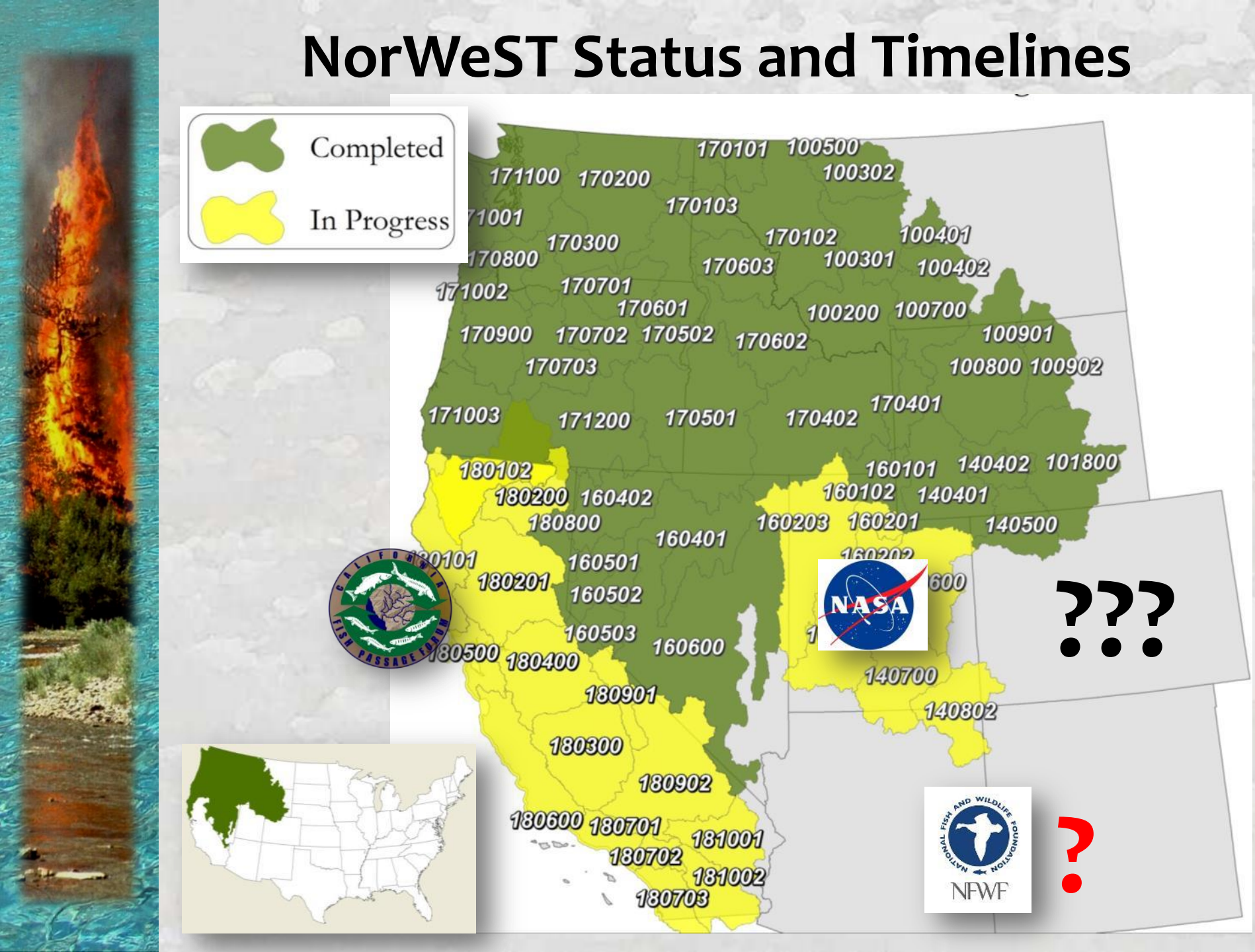


- R^2 = 0.91
- RMSE = 1.0°C

- 1-km resolution

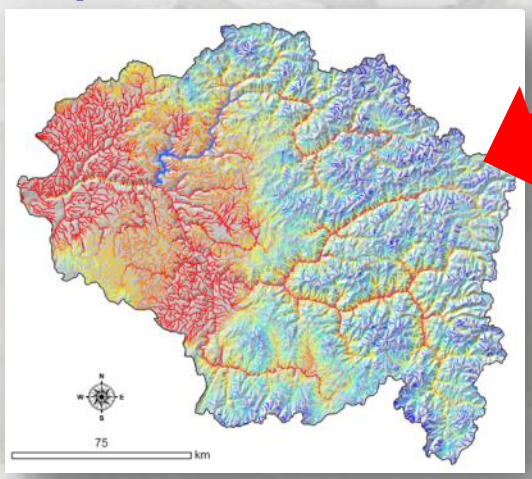
800,000 kilometers so far…

NorWeST Status and Timelines

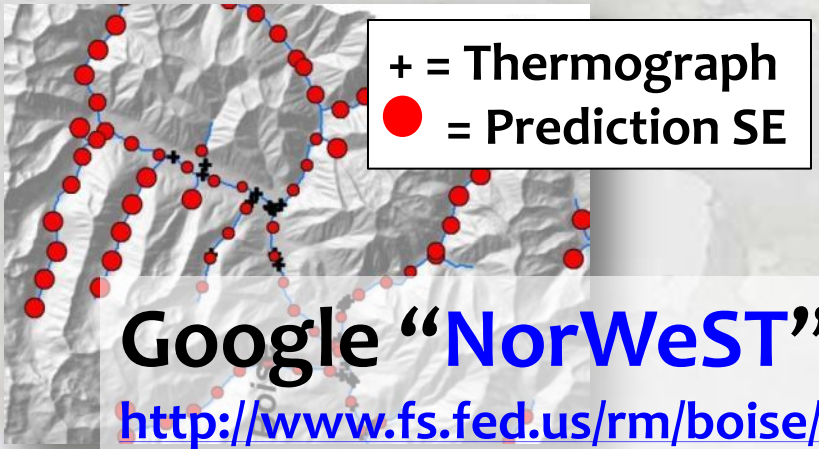


Website Distributes Scenarios & Data in User-Friendly Formats

1) GIS shapefiles of stream temperature scenarios



2) GIS shapefiles of stream temperature model prediction precision



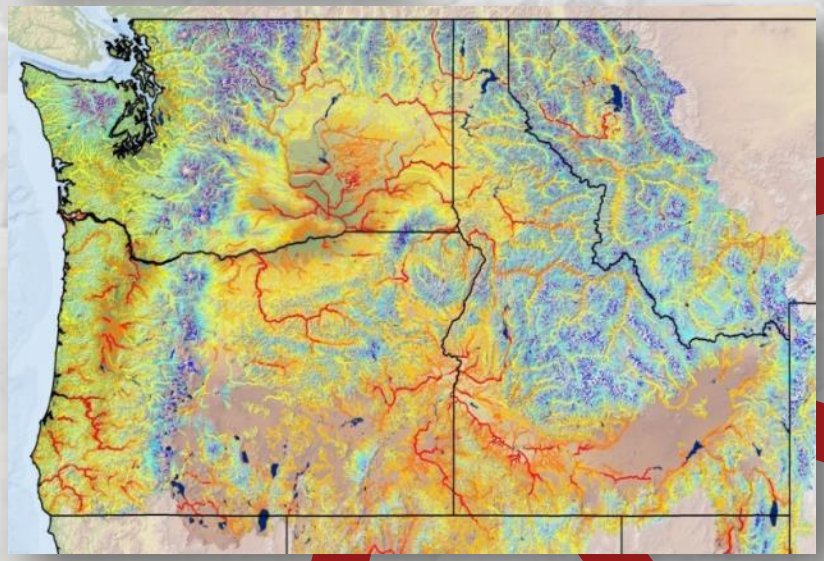
3) Temperature data summaries

Google "NorWeST" or go here...

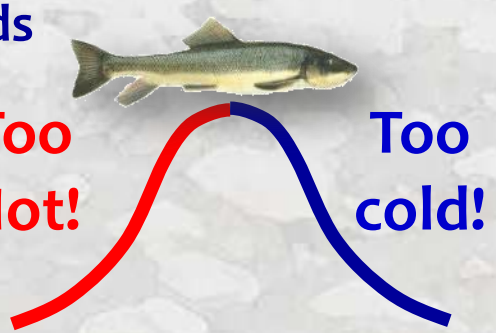
http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.shtml

NorWeST Stream Temp

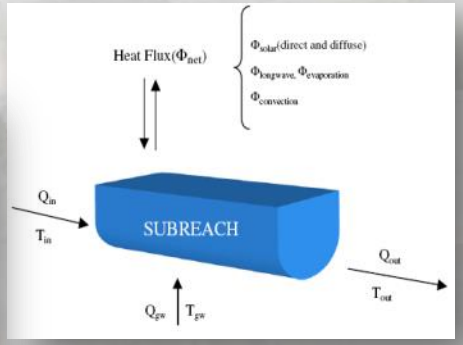
Temperature Applications

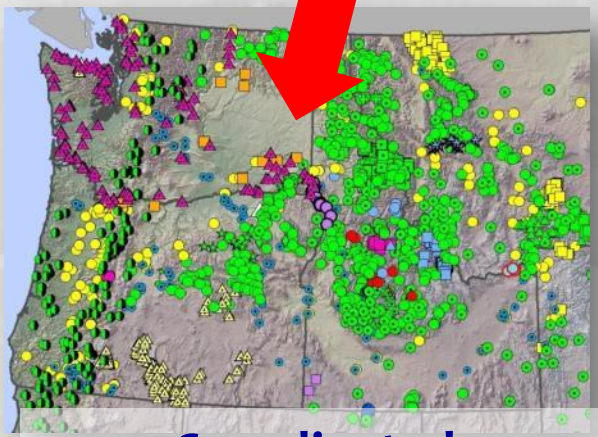


Regulatory temperature standards

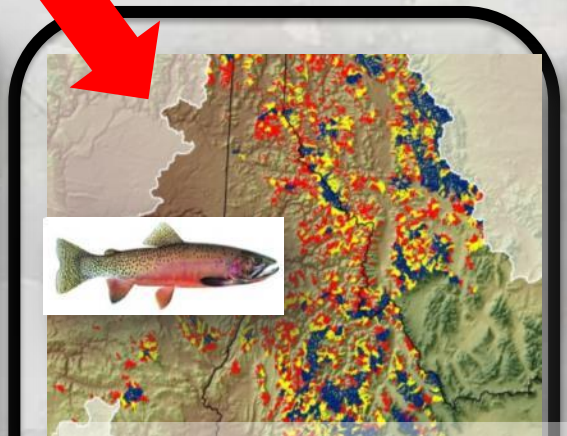


Data access accelerates temperature research





Coordinated Interagency monitoring



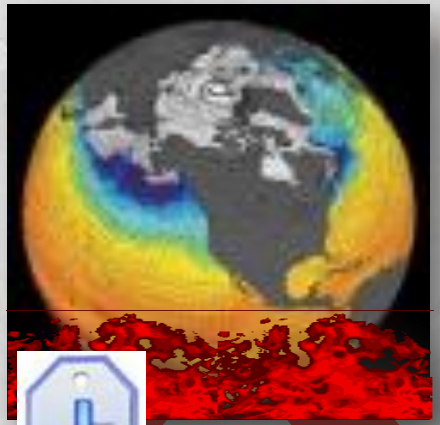
Species distribution models & climate assessments

The Cold-Water Climate Shield

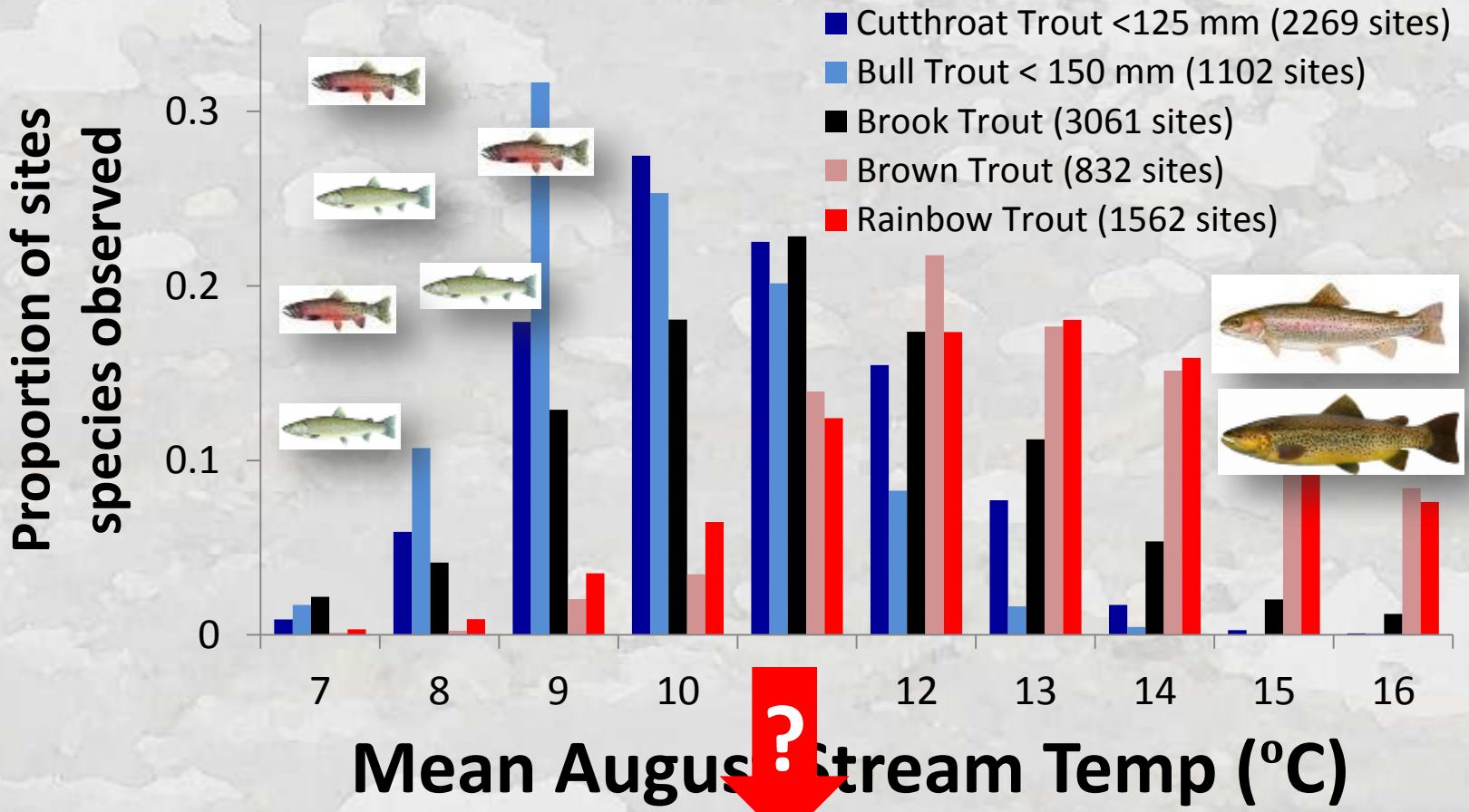
Delineating Refugia for Preserving Native Trout

Dan Isaak, Mike Young, Dave Nagel, Dona Horan, Matt Groce

US Forest Service - RMRS

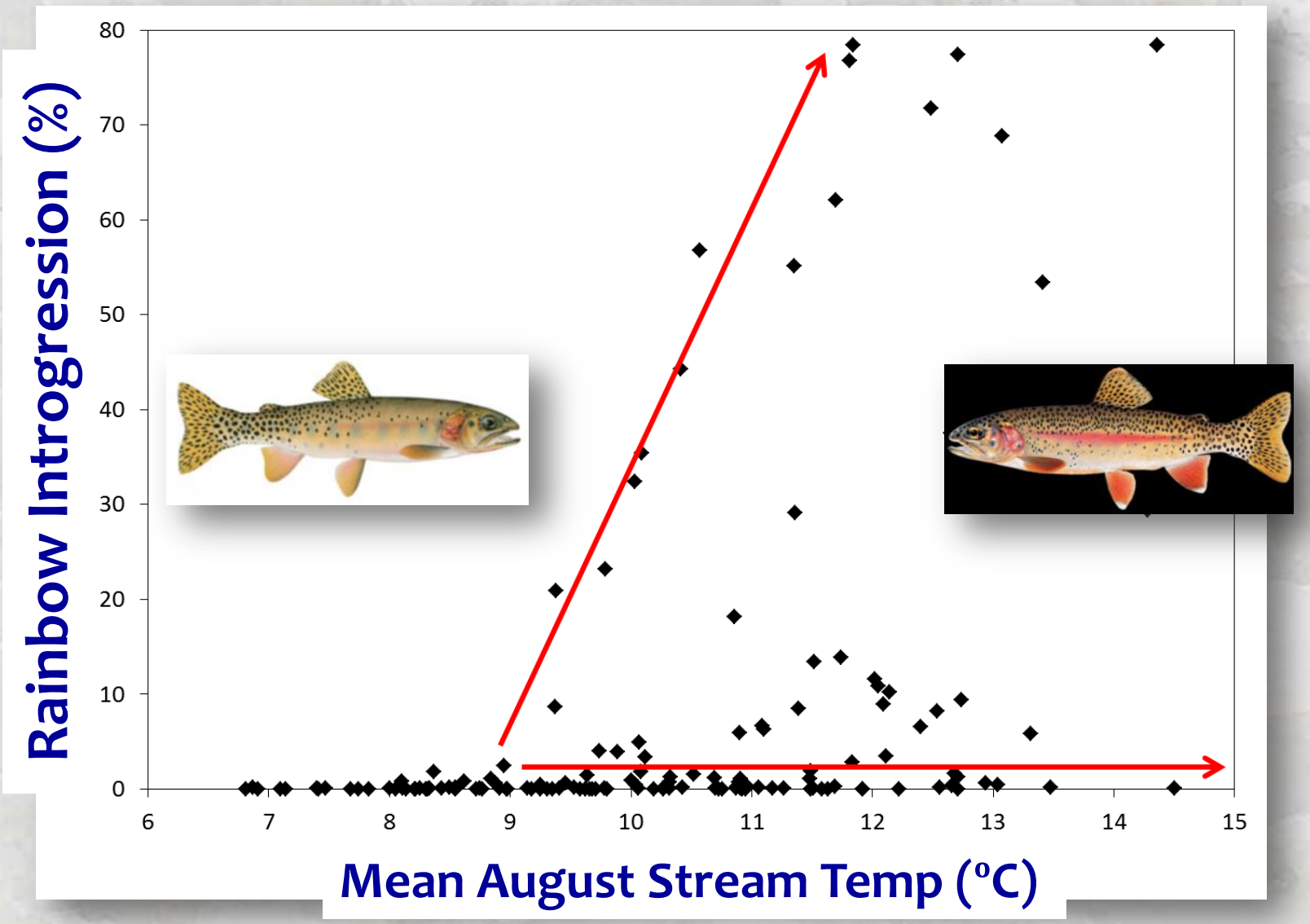


Cold Climates Exclude Most Invaders from Key Natal Habitats



BEWARE THE INVASION

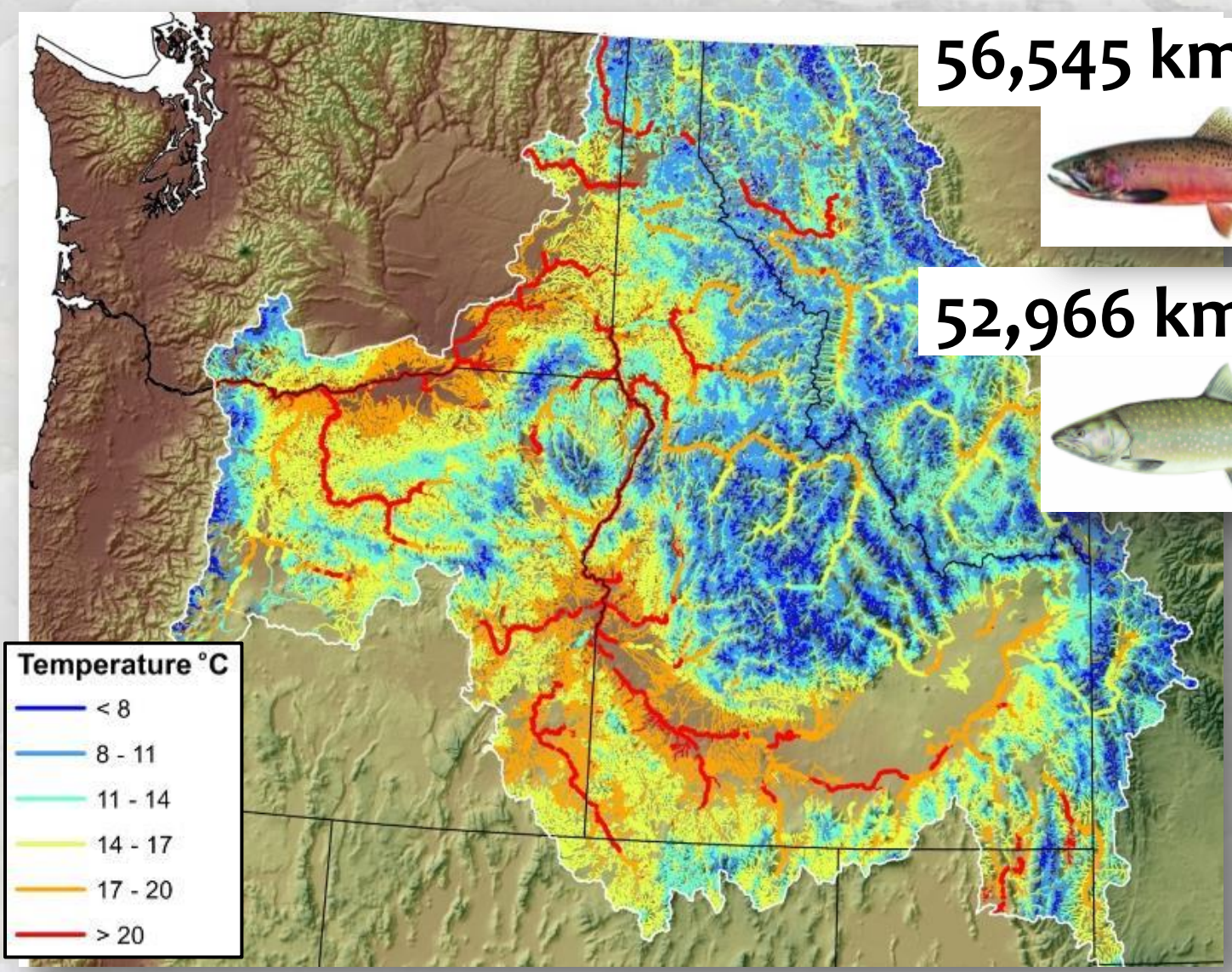
Cold Climates Exclude Most Rainbow Hybrids



McKelvey et al. In Review; Young et al., In prep.

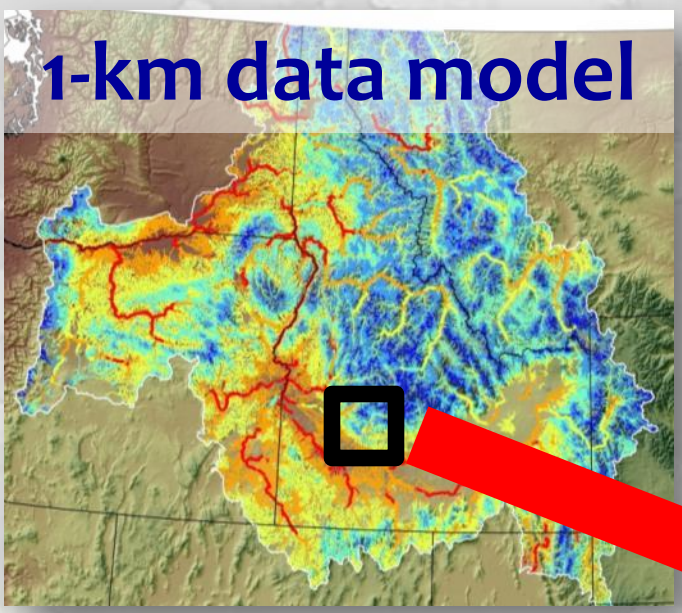
<11°C Streams (1980s) & <15% slope

70,335 / 259,052 stream kilometers in analysis area



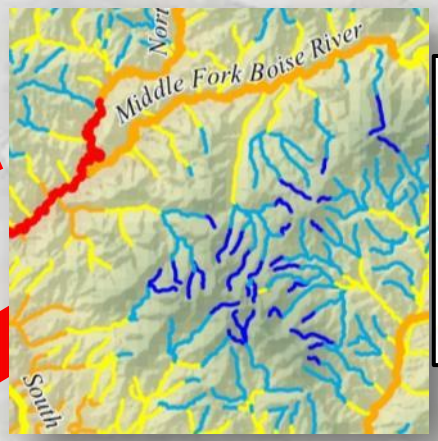
56,545 km

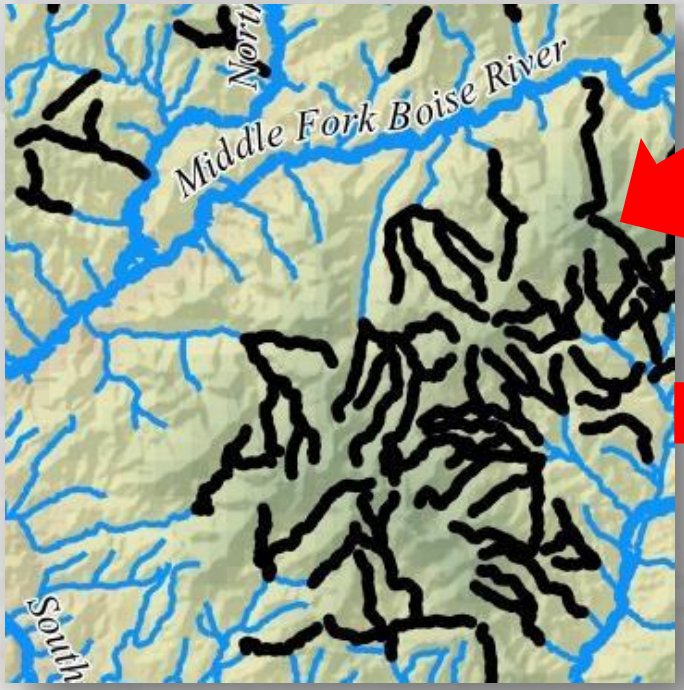
52,966 km



Additional Habitat Factors

- ArcGIS Python script aggregates discrete areas <11°C into "Cold-water habitats"





Predictor Variables…

- Habitat size (km <11°C)
- MeanTemp & MinTemp
- % Stream slope
- % Brook Trout

Fish Data for Species Occurrence Models

Present Absent

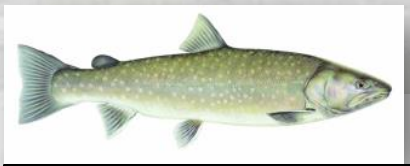
Fish sites = 3,655
Patches = 566

Fish sites = 4,506
Patches = 512

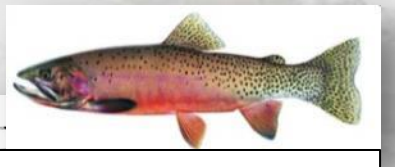
Fish data from published research & agency monitoring programs…

Species Response Curves from Logistic Regressions

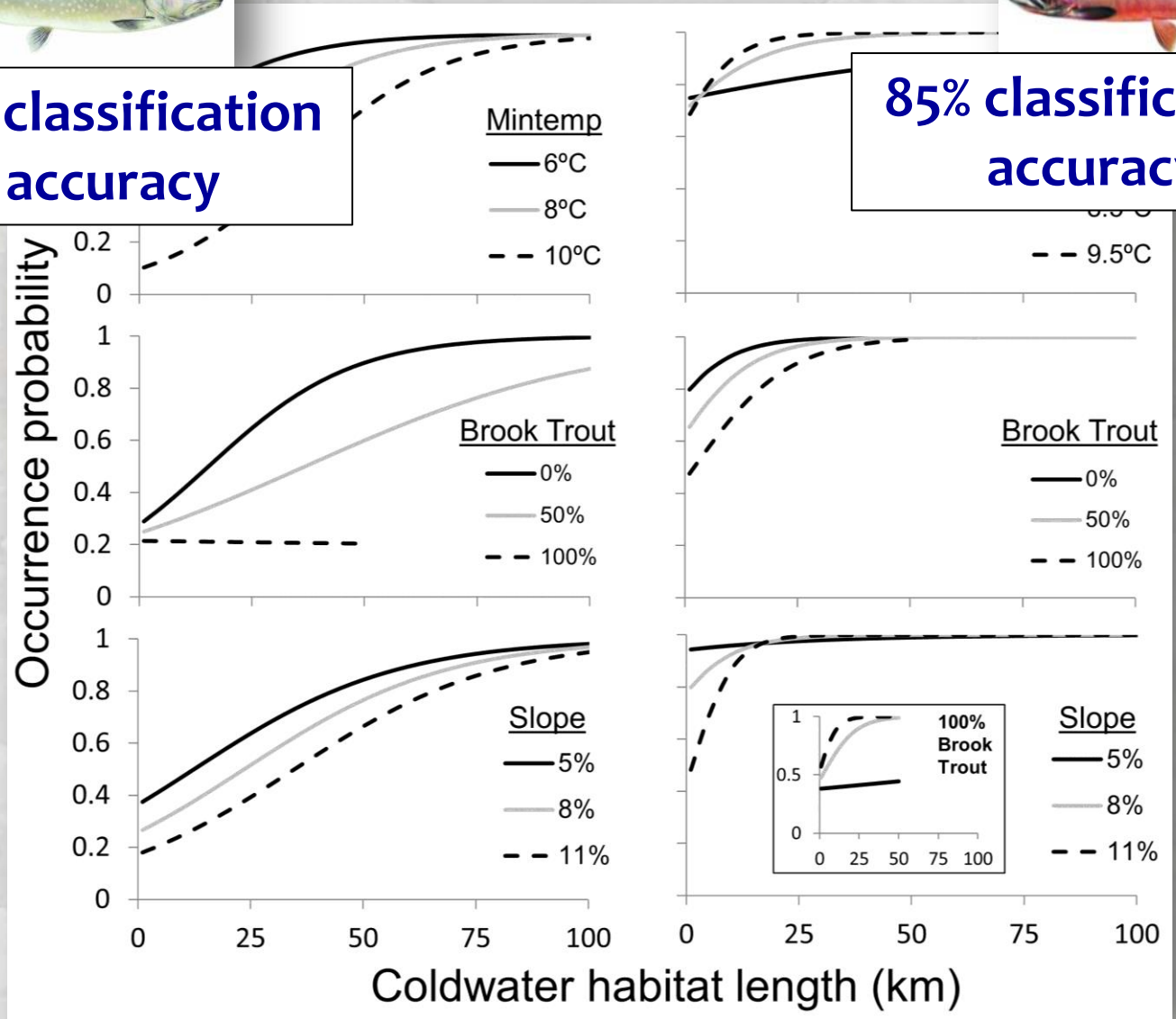
$$p = \frac{\exp(a + bx \ldots ny)}{(1 + \exp[a + bx \ldots ny])}$$



78% classification accuracy



85% classification accuracy



Bull Trout Probability Map

1980s

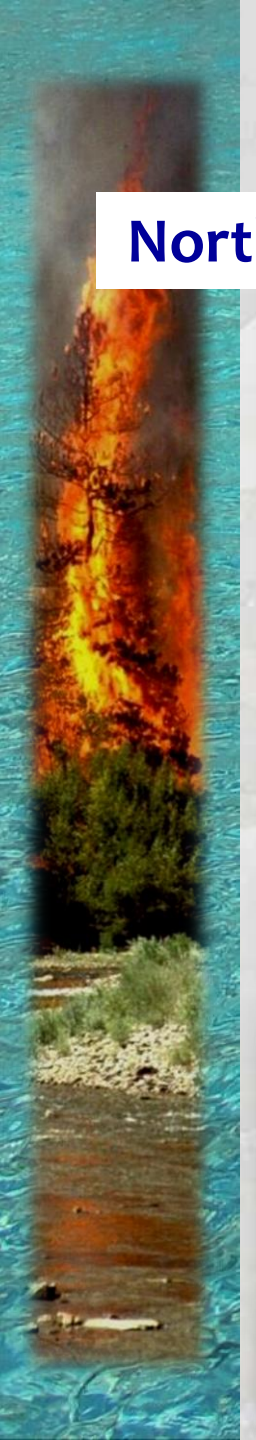
Stream scale predictions

>0.9 >0.5 >0.1

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

Bull Trout Probability Map

2080s



North Cascades

Flathead

Walla Walla

Metolius

Upper Salmon

>0.1

Worst case scenario!

2,712 >0.1 habitats

460 >0.5 habitats

62 >0.9 habitats

Cutthroat Probability Map

1980s

Cutthroat Probability Map

2080s

6,489 >0.1 habitats

5,181 >0.5 habitats

1,559 >0.9 habitats

>0.9 >0.5 >0.1

Cutthroat Probability Map 2080s

6,464 >0.1 habitats
5,137 >0.5 habitats
333 >0.9 habitats

>0.9 >0.5 >0.1

About that Brook Trout Effect…

Number & Size of Refugia >0.9

	Period	Median size (km)	Refugia
Cutthroat Trout 	1980s	11	3,089
		10	2,179
		9	1,559
Bull Trout 	2080s	51	348
		54	130
		53	62

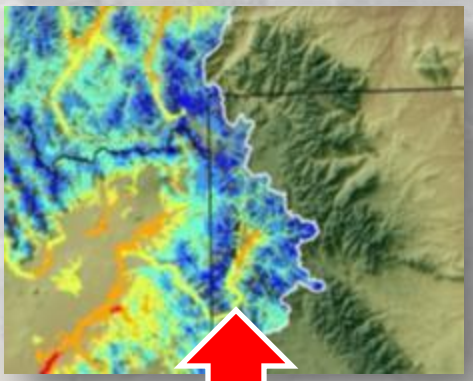
2x larger

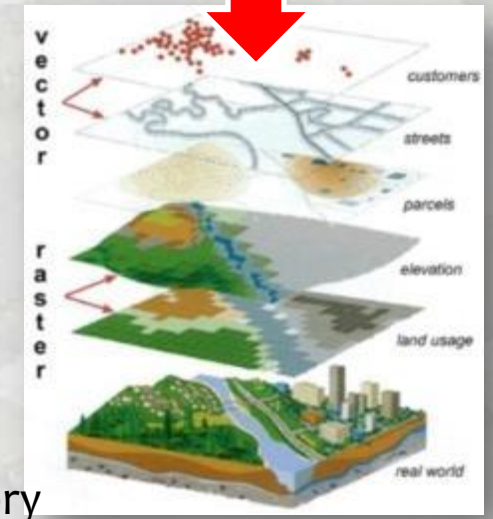
… but *steeper* streams are also invasion resistant

Land Administration GAP Analysis

<11°C streams in Bull Trout range

Land status	1980s	2080s
Private	5,580 (10.5)	1,099 (5.3)
Tribal	1,779 (3.4)	713 (3.4)
State/City	1,621 (3.1)	420 (2.0)
BLM	1,534 (2.9)	512 (2.5)
NPS	652 (1.2)	182 (0.9)
TNC	157 (0.3)	30 (0.1)
FS-wilderness	6,483 (12.2)	2,854 (13.8)
FS-nonwilderness	34,068 (64.3)	14,575 (70.2)
Other	1,093 (2.0)	367 (1.8)
Totals:	52,966	20,752





>90% on public lands

<15% protected in Wilderness or National Parks

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

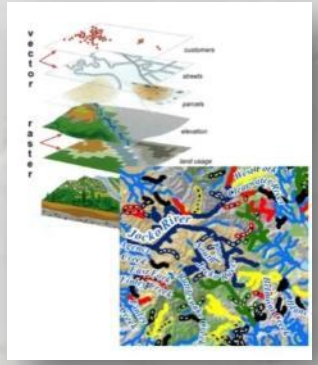
Open Access Information…

Climate Shield website:

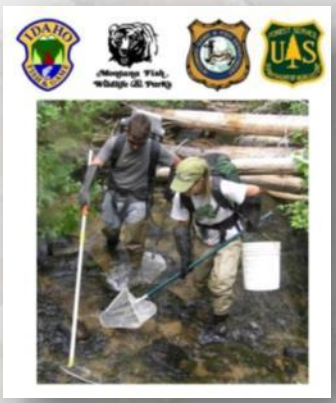
http://www.fs.fed.us/rm/boise/AWAE/projects/ClimateShield.html

Presentations & Publications

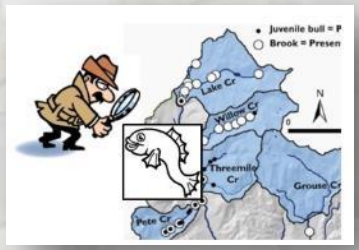
Digital Maps & ArcGIS Shapefiles



Fish Data Sources



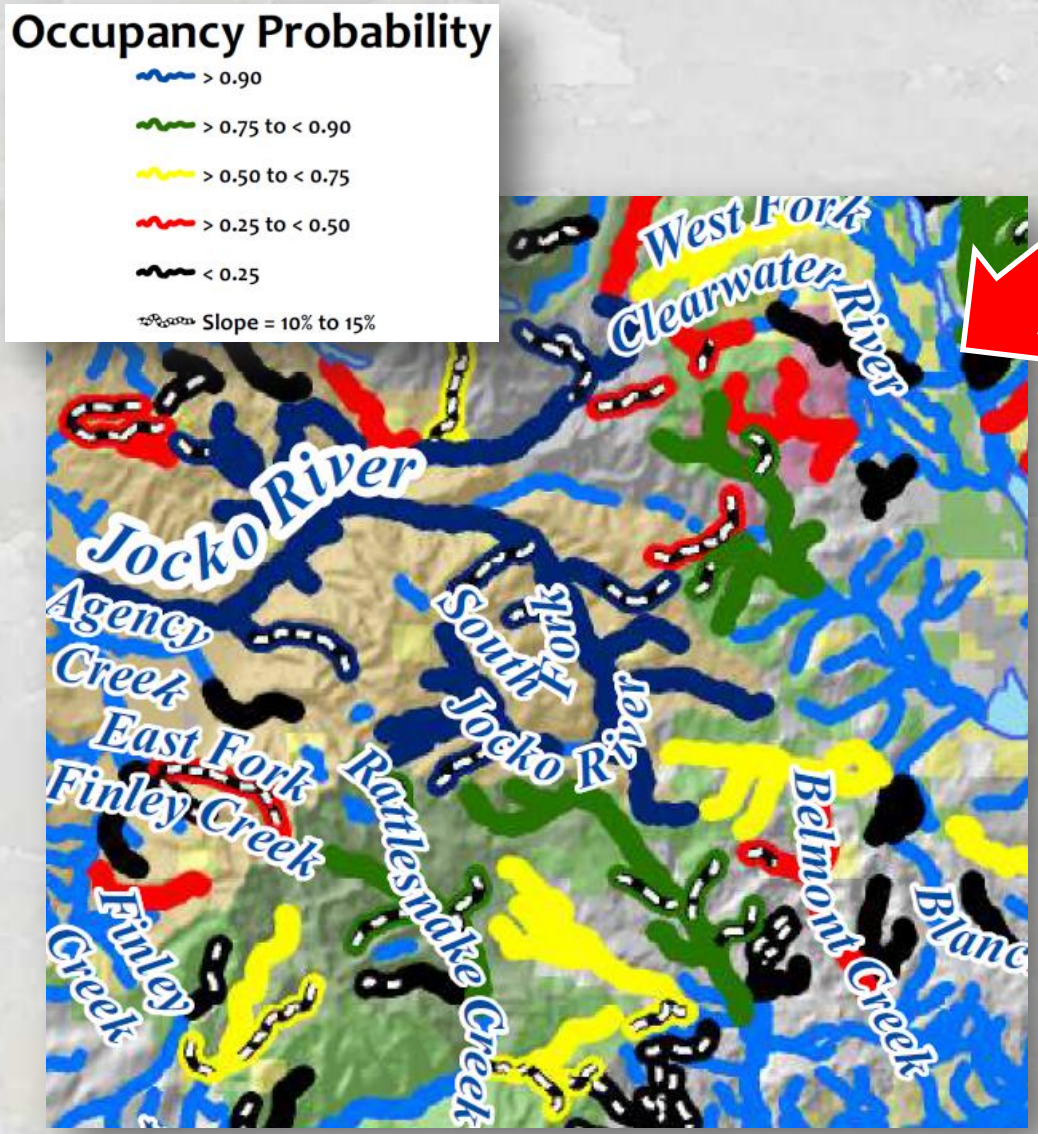
Distribution Monitoring

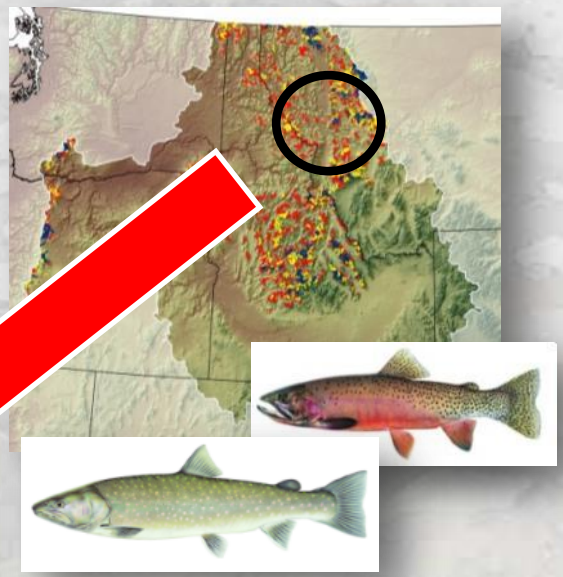


"User's Guide" (Peer-Reviewed Publication)

Isaak, D., M. Young, D. Nagel, D. Horan, and M. Groce. 2015. The cold-water climate shield: Delineating refugia for preserving native trout through the 21st Century. *Global Change Biology* **21** doi:10.1111/gcb.12879

High-resolution maps to empower local decision makers…





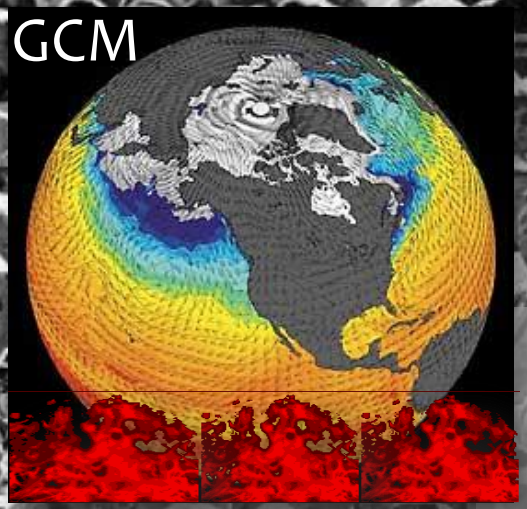
File formats:

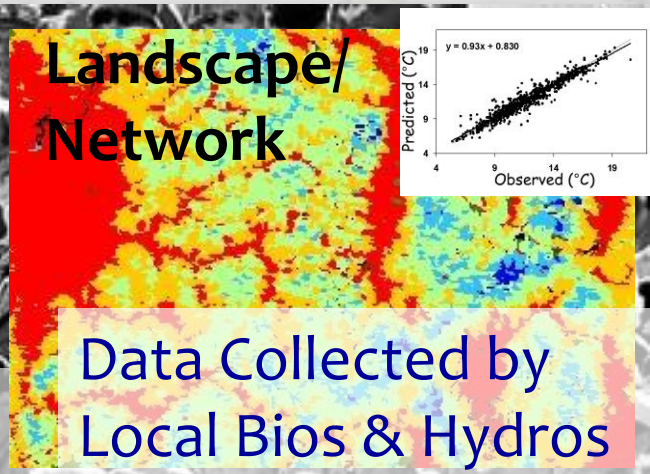
- ArcGIS files
- pdf files

15 Scenarios:

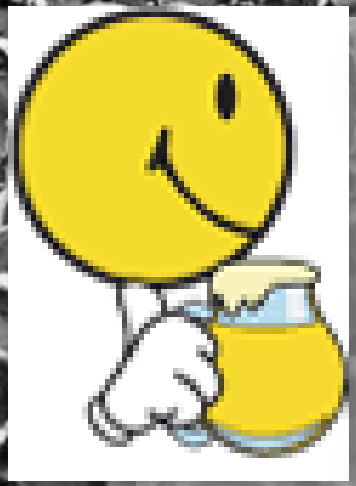
- 3 climate periods
- 5 Brook invasion levels

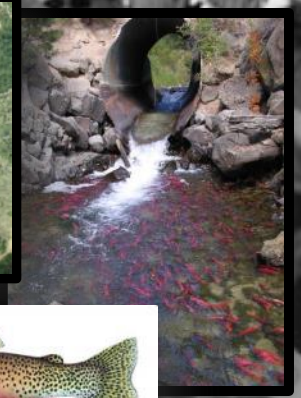
Crowd-Sourcing Helps Build Consensus & Social Networks for Effective Conservation





Coordinated Management Response





Management Decisions