

Development and use of NorWeST Temperature Scenarios for Steelhead Assessments

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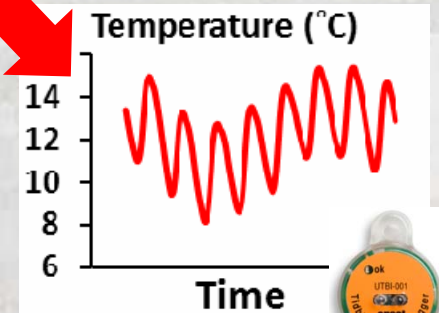
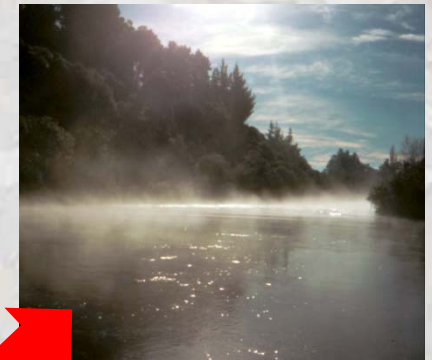
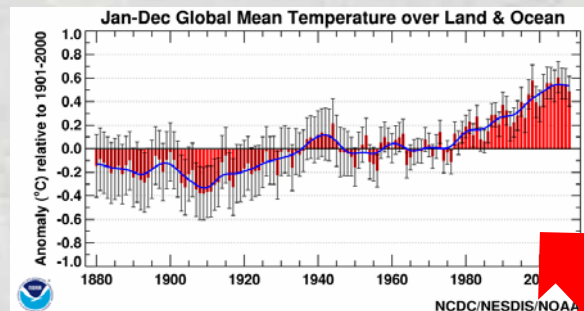
U.S. Forest Service

¹Trout Unlimited

²CSIRO

³NOAA

⁴USGS



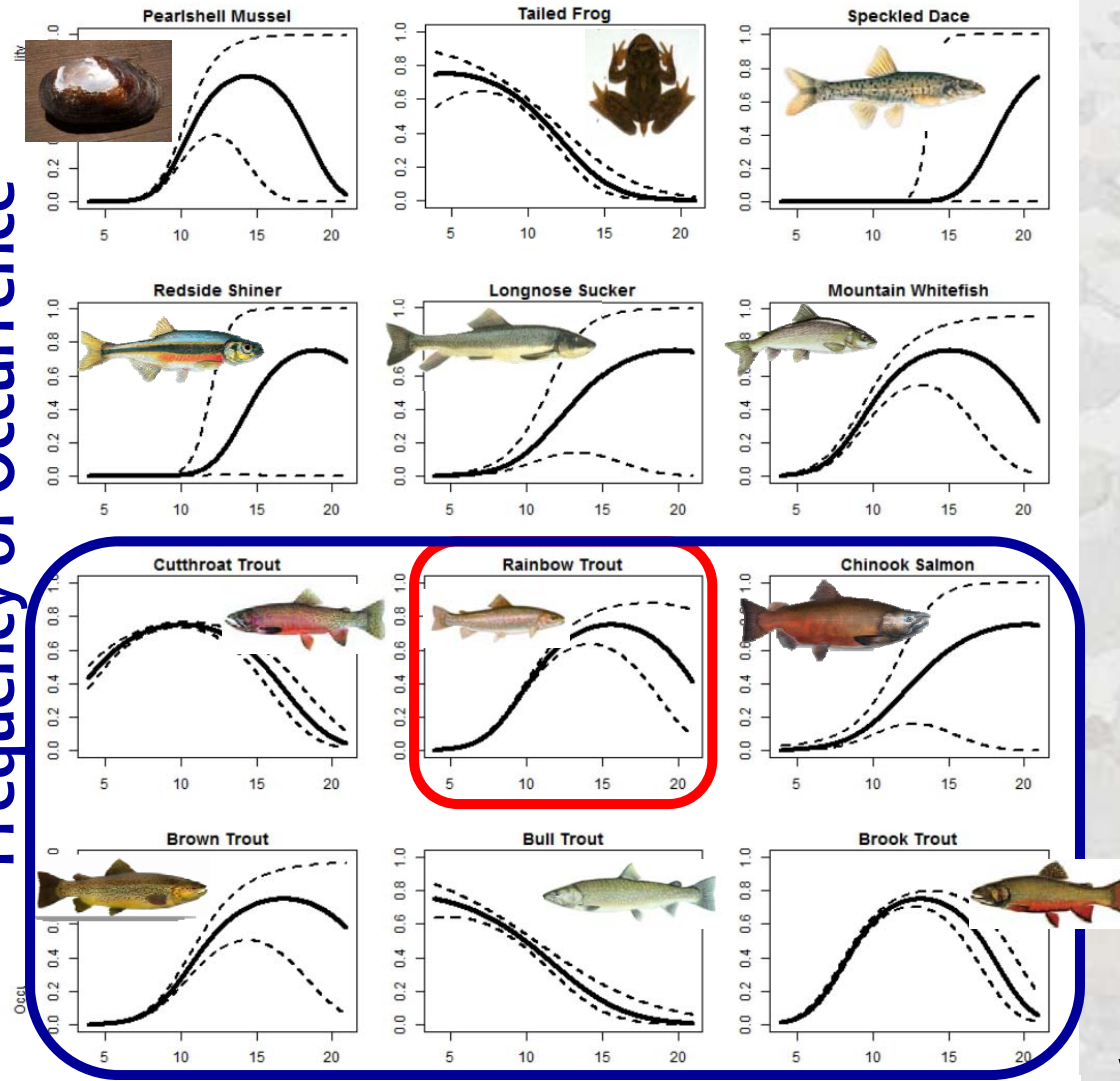
Funding agencies:



Temperature Affects Distribution & Abundance

Thermal niches differ among species

Frequency of Occurrence

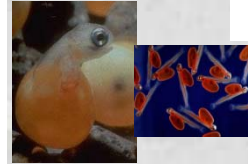
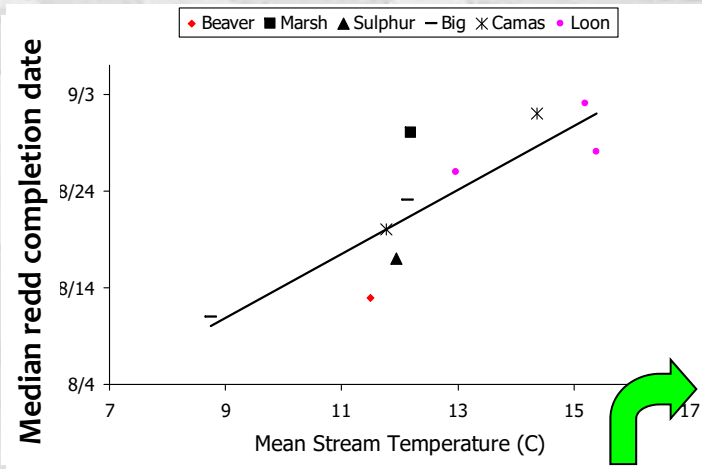


NorWeST Stream Temperature (S1)

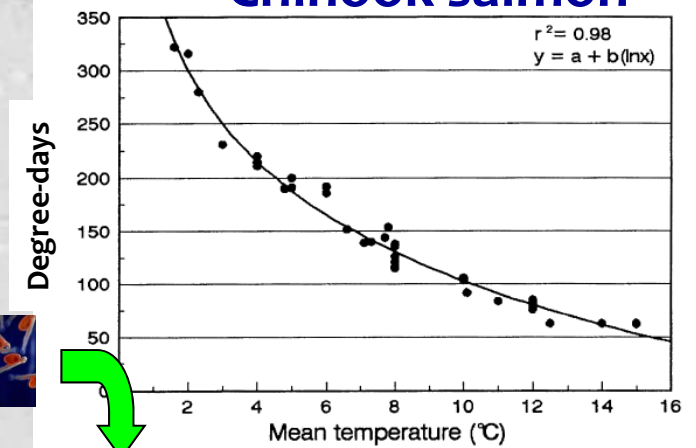
Wenger et al.
In Review.

Temperature Affects Phenology

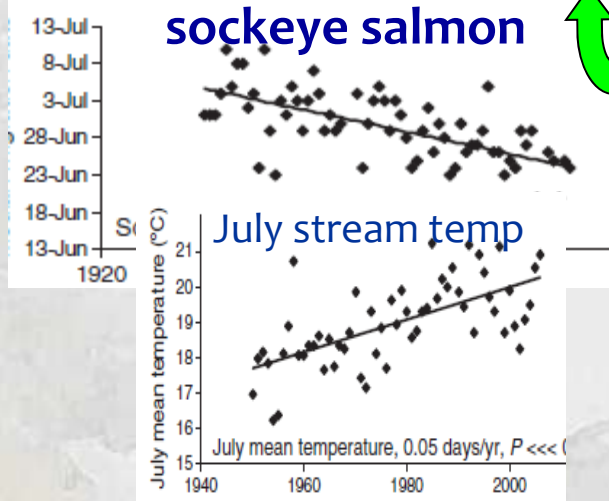
Spawn timing - Chinook salmon



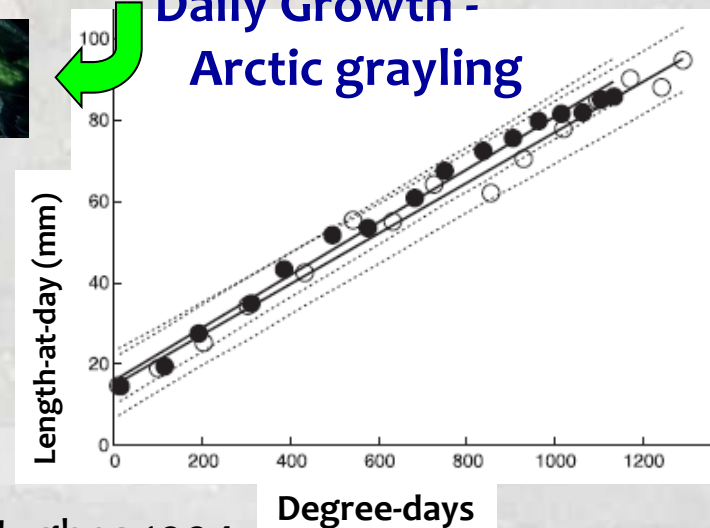
Incubation time - Chinook salmon



Migration timing - sockeye salmon



Daily Growth - Arctic grayling



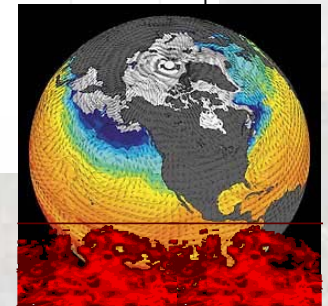
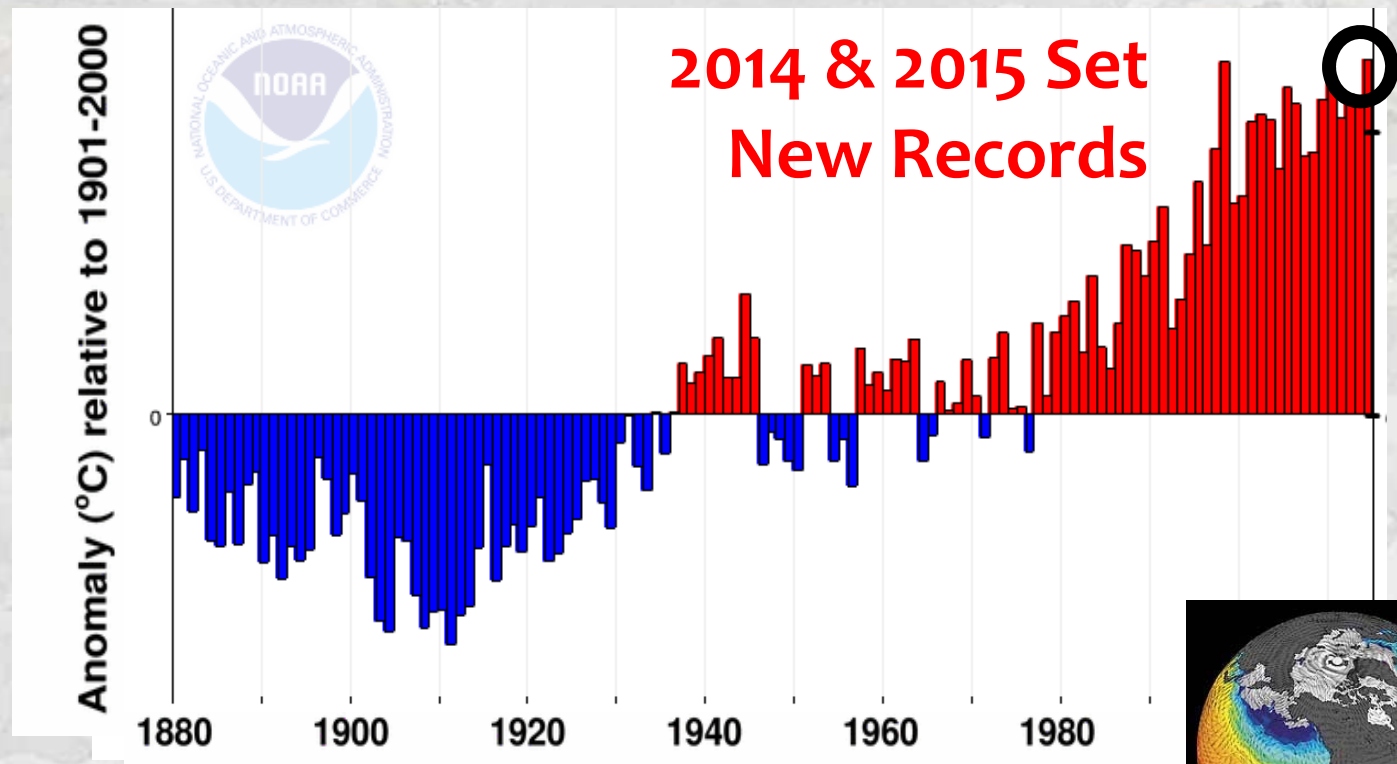
Crozier et al. 2008

Dion and Hughes 1994

Brannon et al. 2004

Temperatures are Getting Warmer...

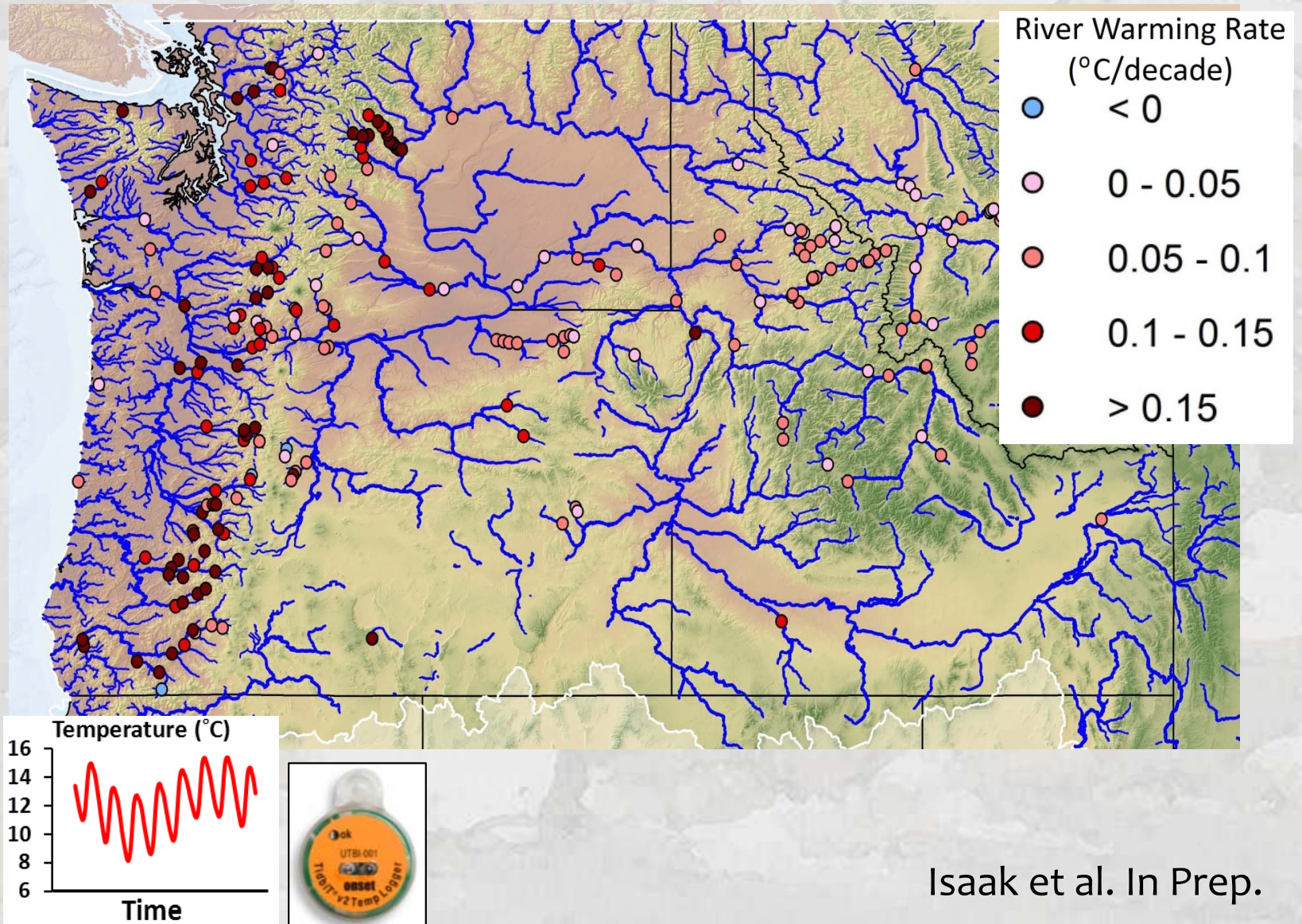
1880-2014 Global Air Temperature Trend



Plan on continued warming for decades...

Summer River Temp Trends (1968-2011)

245 sites with >10 year monitoring records

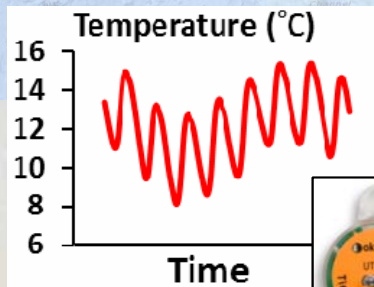


Isaak et al. In Prep.

Southern Steelhead Range = Lots of Temperature Data

>150,000,000 hourly records
>20,000 unique stream sites

>100 agencies



California Temperature Database

#1

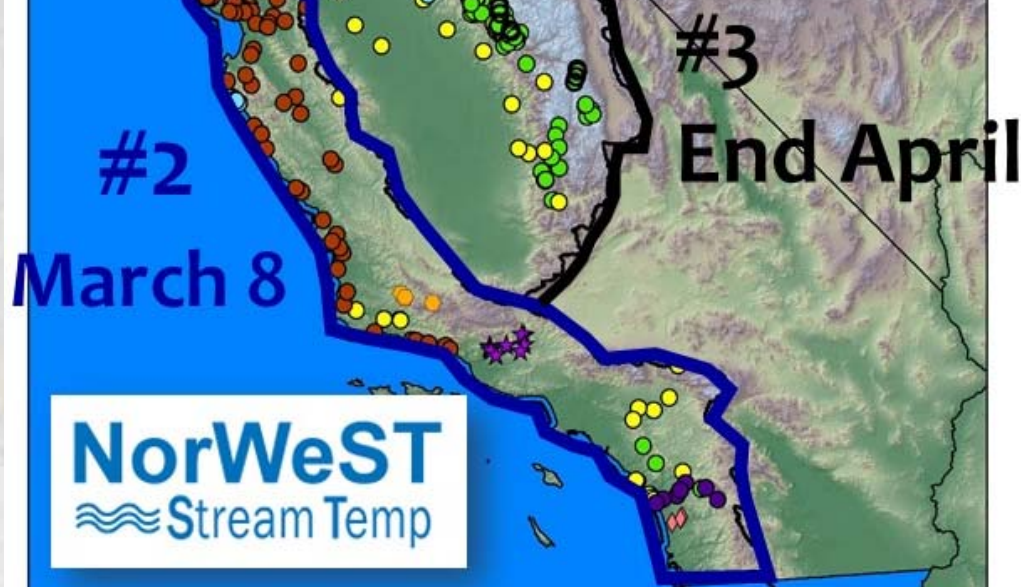
- Database & scenarios online
- More data coming
- Eli Asarian, Rich Fadness
- Refit model in fall

Agency

- CDFW
- CDWR

Final database
Sites ~ 3,500
Years ~ 10,000

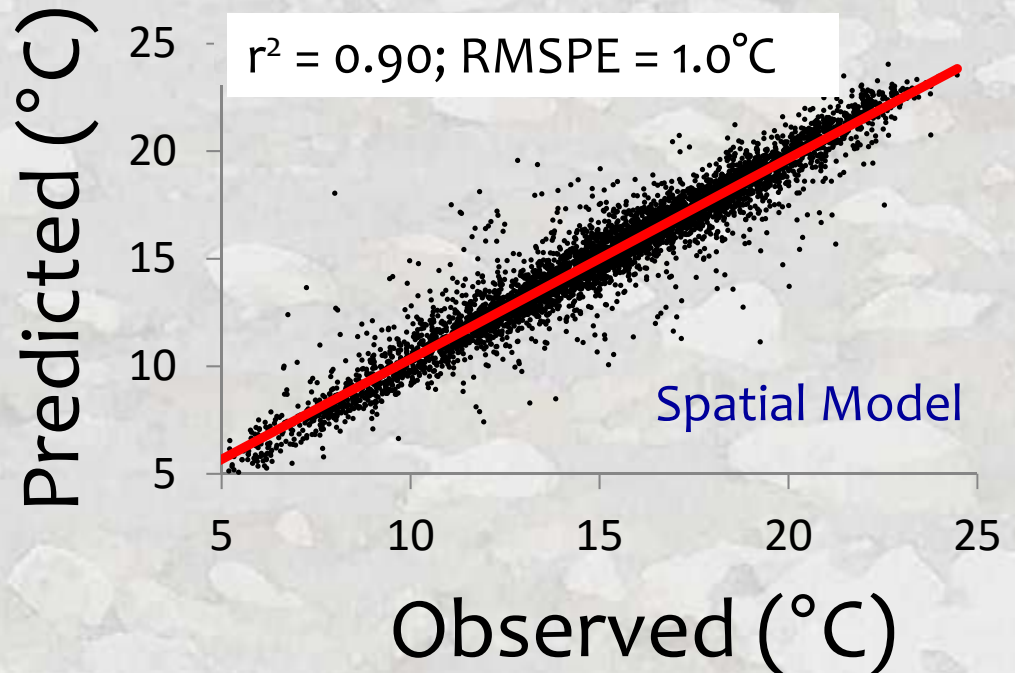
- NOAA
- USFWS
- USBR
- USGS
- USFS



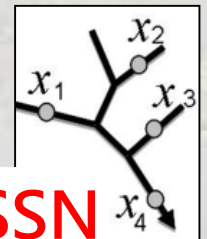
Predictive Accuracy of Temperature Model

Covariate Predictors

1. Elevation (m)
2. Canopy (%)
3. Stream slope (%)
4. Ave Precipitation (mm)
5. Latitude (km)
6. Lakes upstream (%)
7. Baseflow Index
8. Watershed size (km²)
9. Glacier (%)
10. Discharge (m³/s)
USGS gage data
11. Air Temperature (°C)
RegCM3 NCEP reanalysis
Hostetler et al. 2011

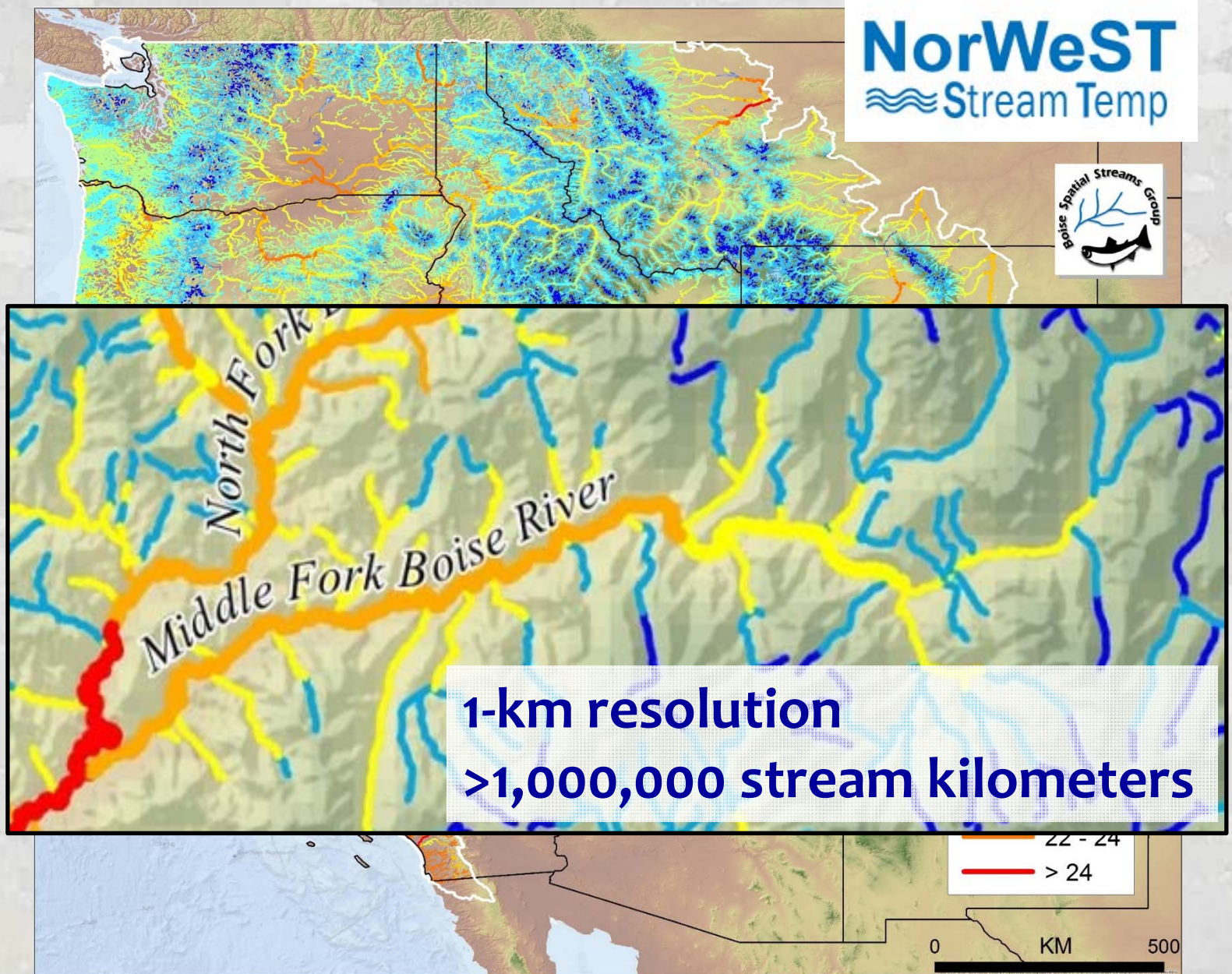


**Spatial statistical
network models**



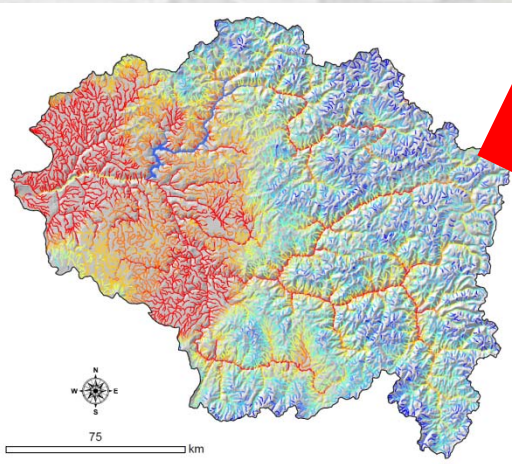
Isaak et al. 2010. *Ecol. Apps* 20:1350-1370.

High-Resolution Stream Climate Scenarios

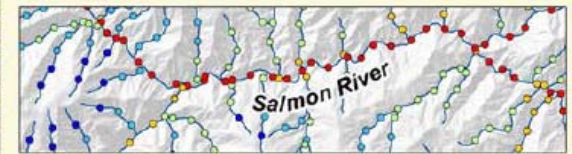


Website: Distributes Information in Useful Digital Formats (ArcGIS & .pdfs & Excel)

1) GIS shapefiles of stream temperature scenarios

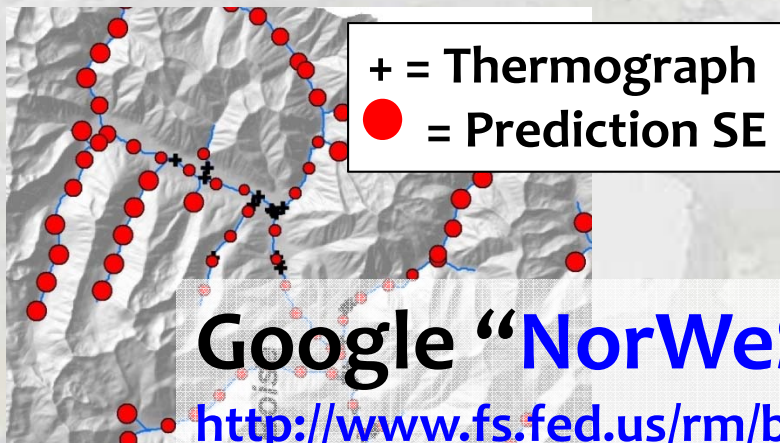


NorWeST
Stream Temp



Regional Database and Modeled Stream Temperatures

2) GIS shapefiles of stream temperature model prediction precision



3) Temperature data summaries



Google “**NorWeST**” or go here...

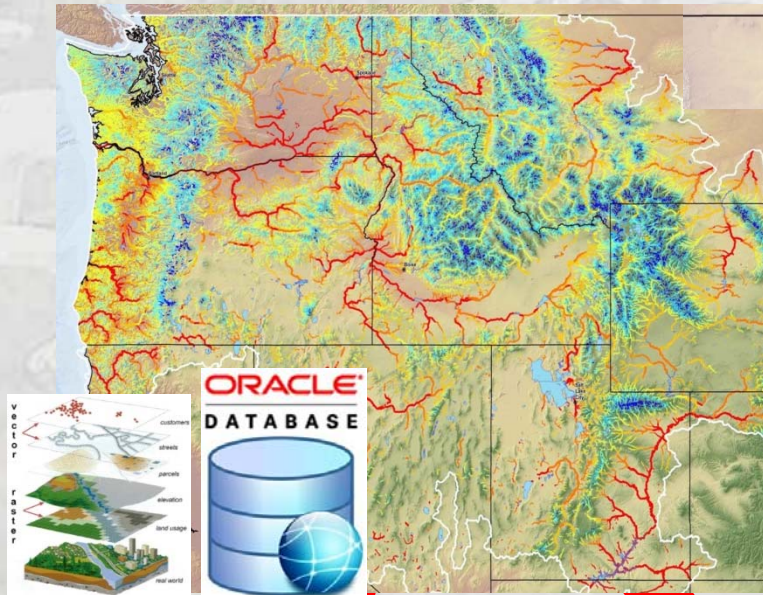
<http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.shtml>

30 Climate Scenarios (Historic & Future)

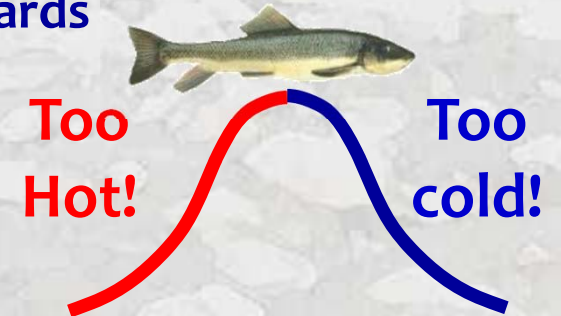
Scenario	Description
S1_93_11	Historical scenario representing 19 year average August mean stream temperatures for 1993-2011
S2_02_11	Historical scenario representing 10 year average August mean stream temperatures for 2002-2011
S3_1993	Historical scenario representing August mean stream temperatures for 1993
S4_1994	Historical scenario representing August mean stream temperatures for 1994
Etc...	
S23-33	10 Future scenarios...

***Extensive metadata on website**

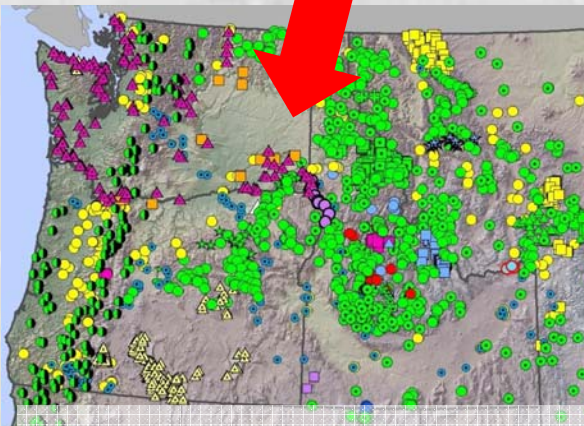
Temperature Applications



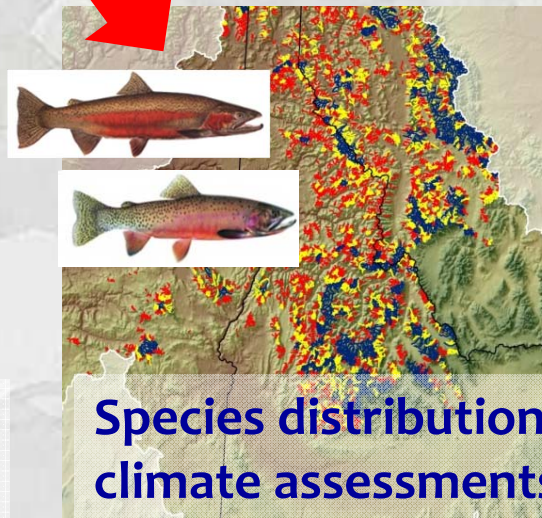
Regulatory temperature standards



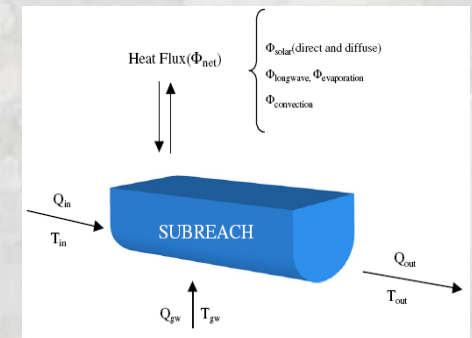
Data access accelerates temperature research



Coordinated
Interagency monitoring

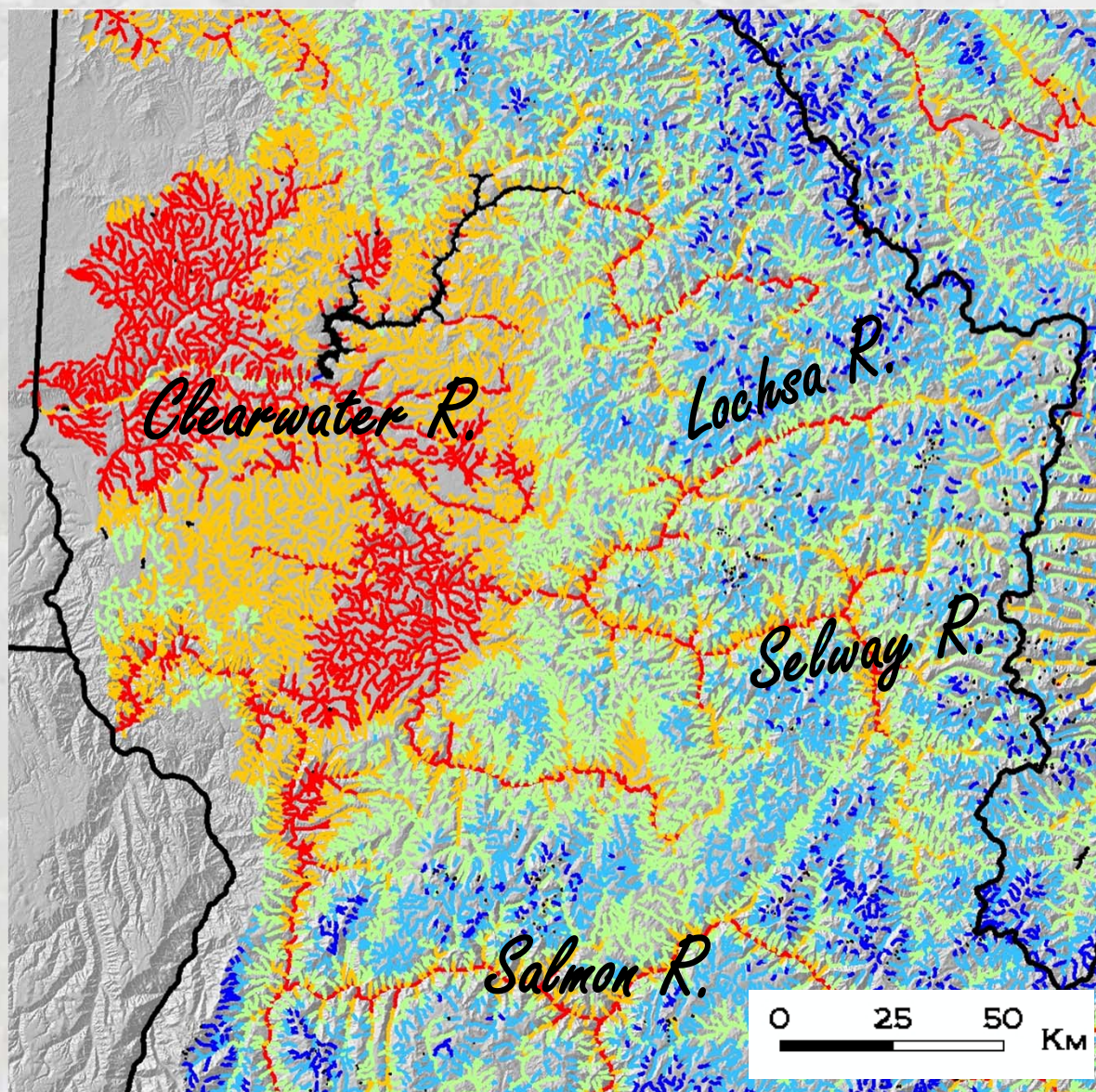


Species distribution models &
climate assessments



Climate in North Idaho Steelhead Streams

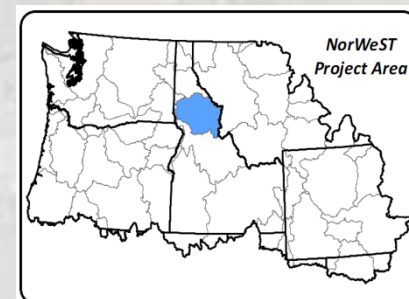
Historic (1993-2011 Average August)



Temperature (°C)

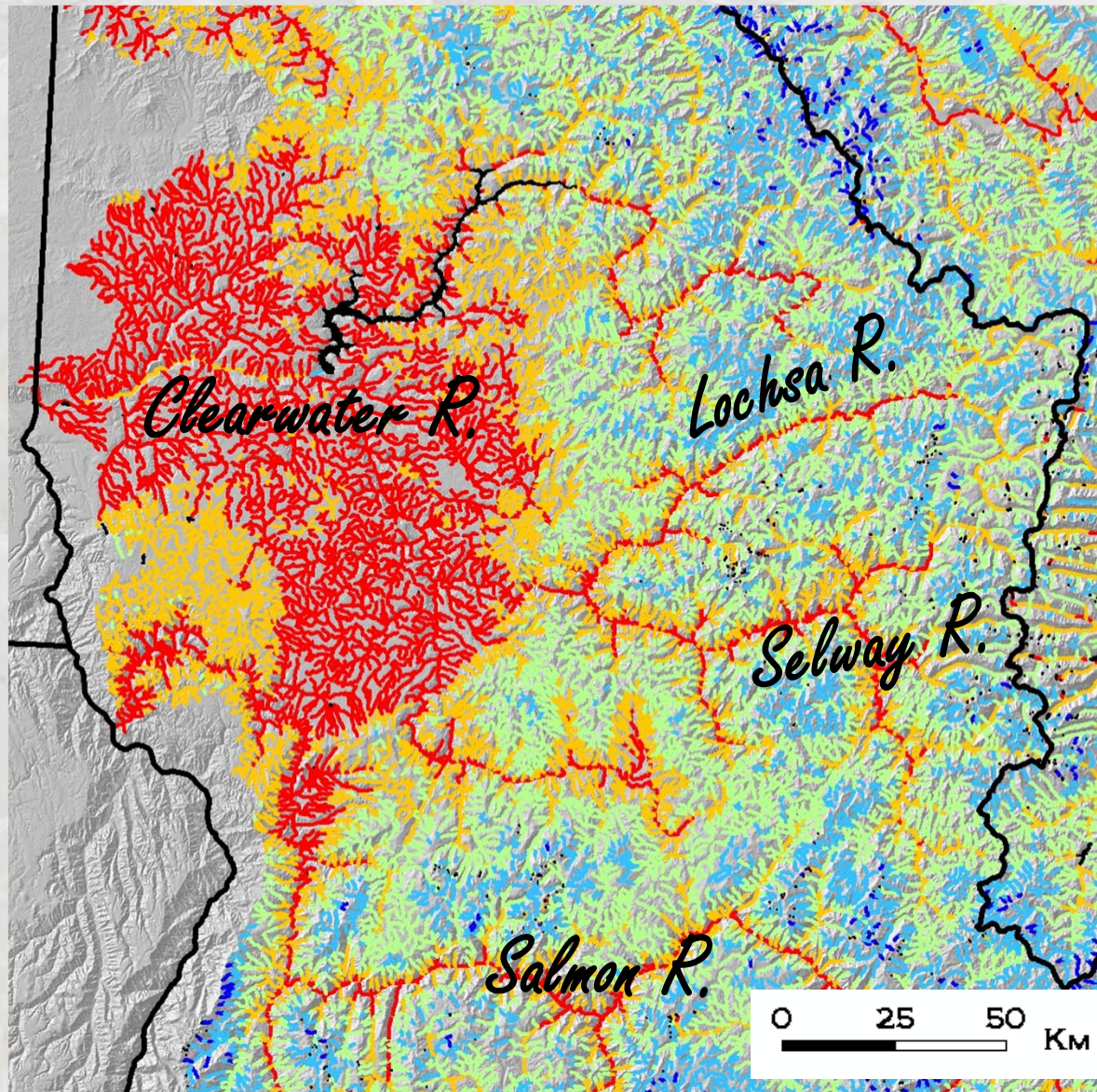


**1 kilometer
resolution**



Climate in North Idaho Steelhead Streams

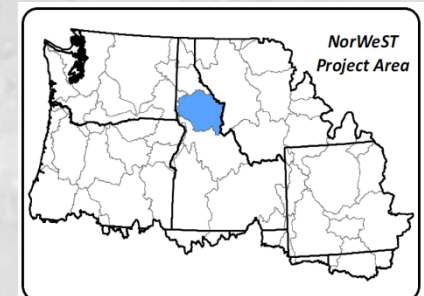
+1.00°C Stream Temp



Temperature (°C)

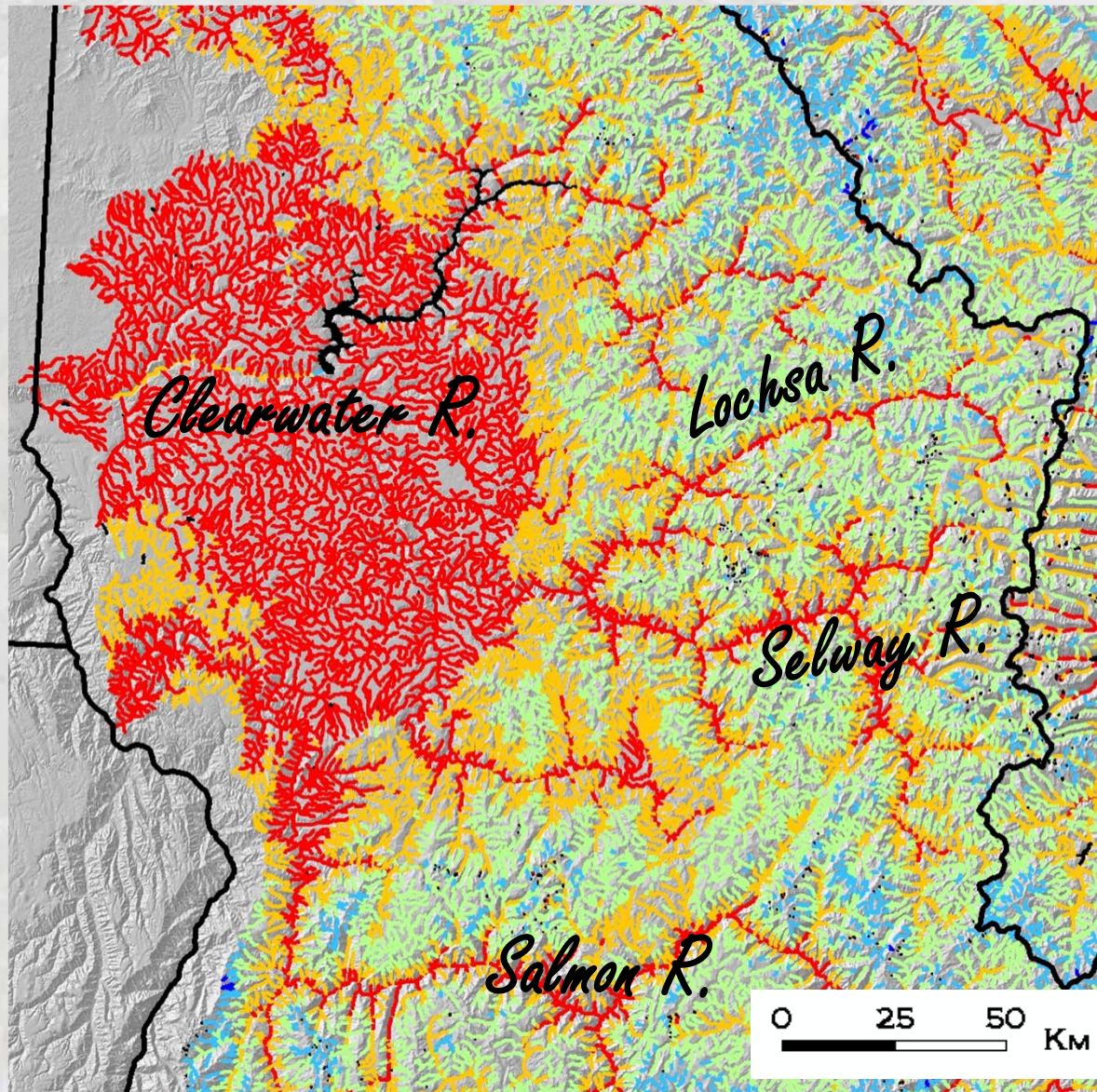


**1 kilometer
resolution**



Climate in North Idaho Steelhead Streams

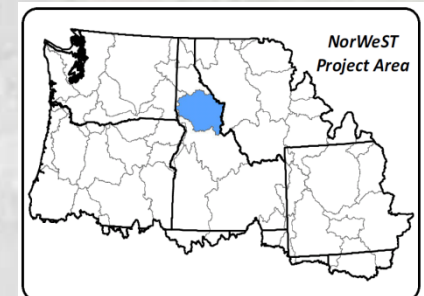
+2.00°C Stream Temp



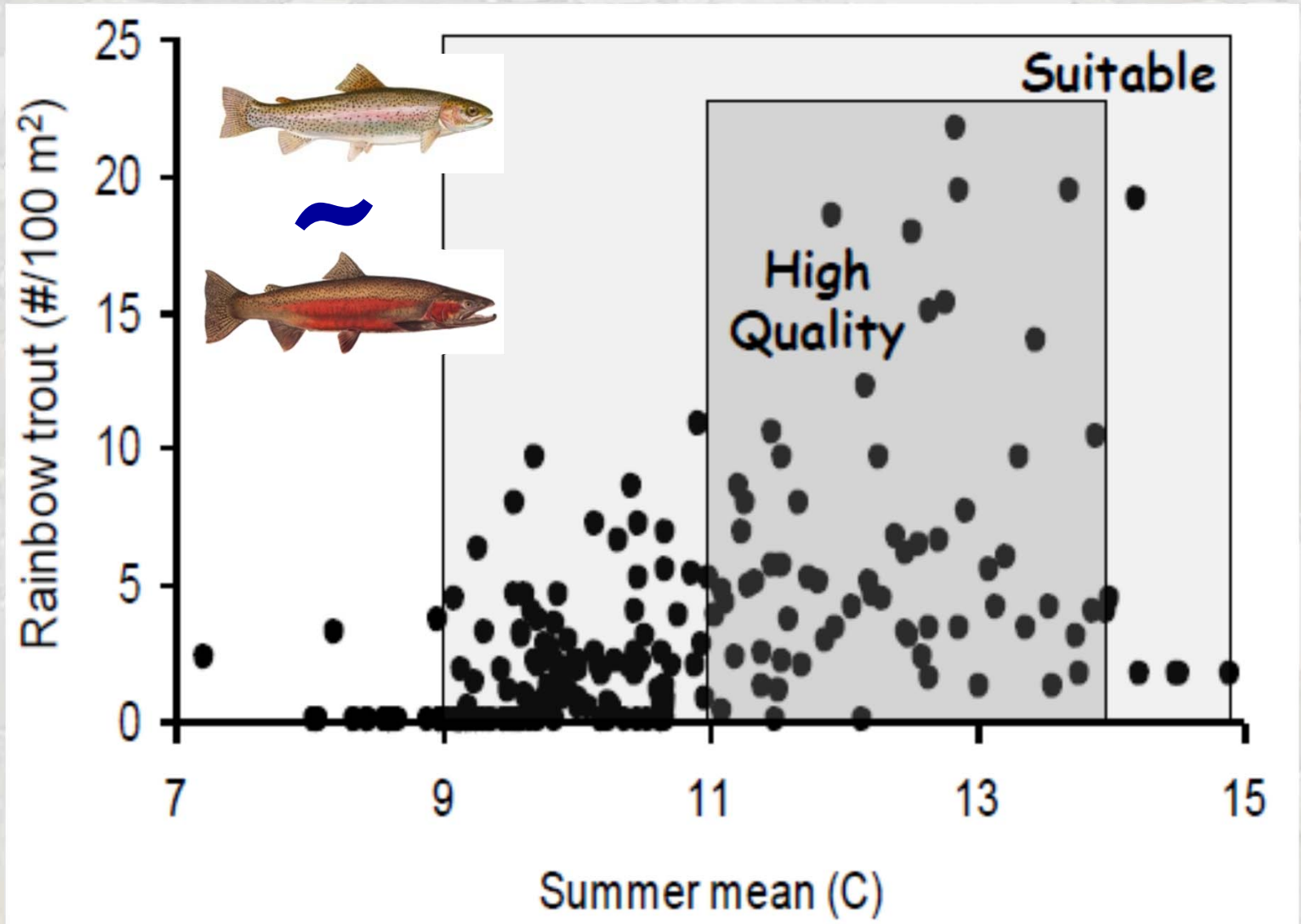
Temperature (°C)



**1 kilometer
resolution**

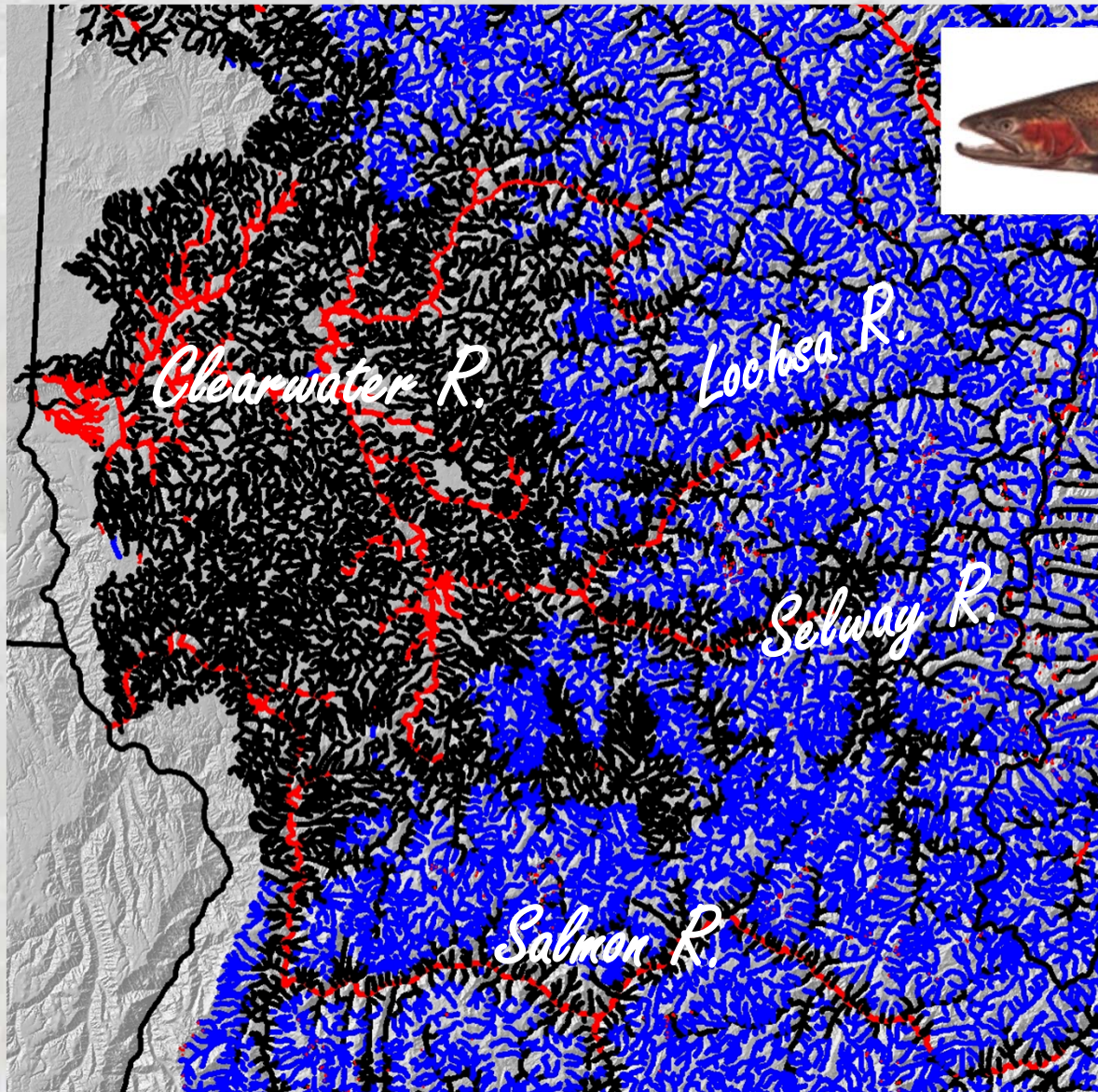


Fish Data Can be Used to Define Thermal Habitat Suitability



Steelhead/Rainbow Trout Habitat

Historic (1993-2011 Average August)

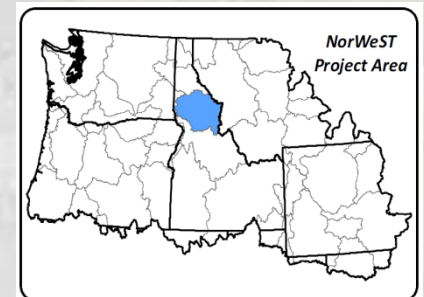


11°C – 14°C

■ Optimal

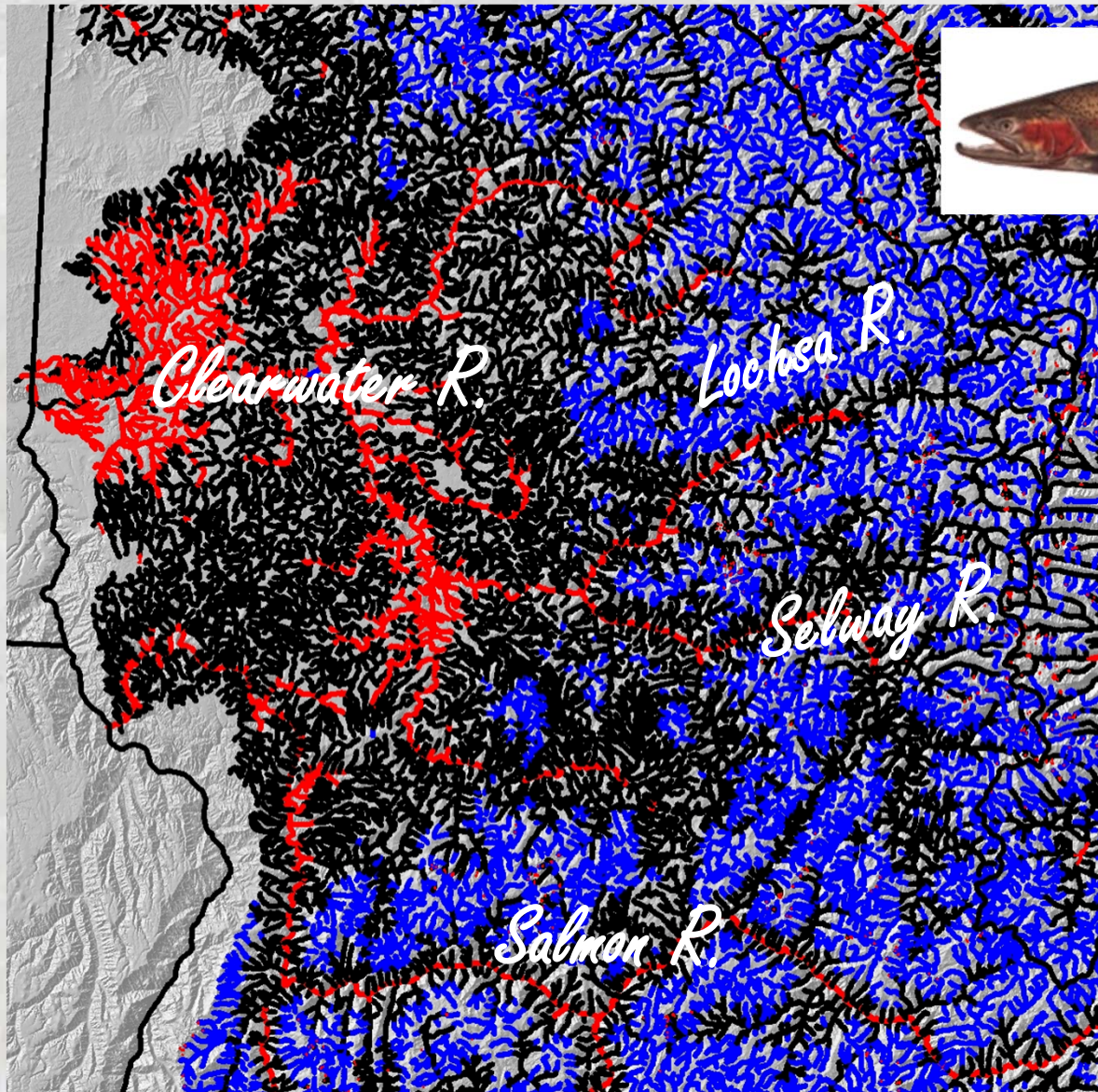
■ Suboptimal

■ Suboptimal



Steelhead/Rainbow Trout Habitat

+1.00°C Stream Temp

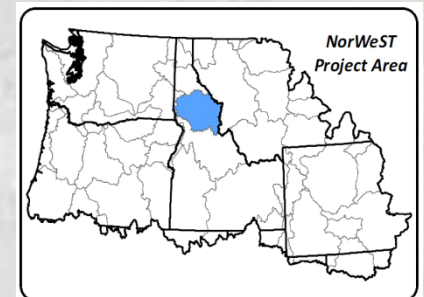


11°C – 14°C

■ Optimal

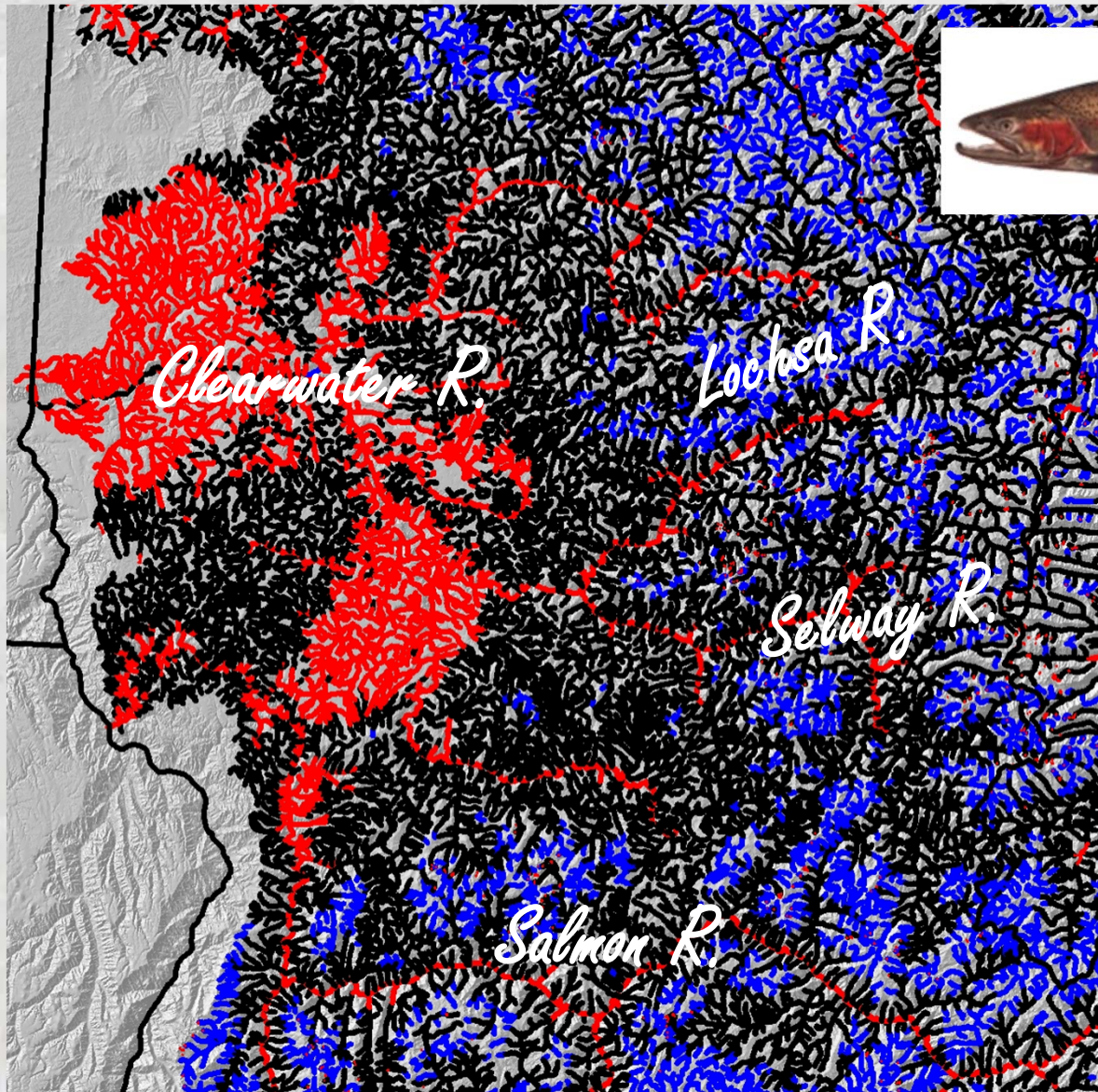
■ Suboptimal

■ Suboptimal



Steelhead/Rainbow Trout Habitat

+2.00°C Stream Temp

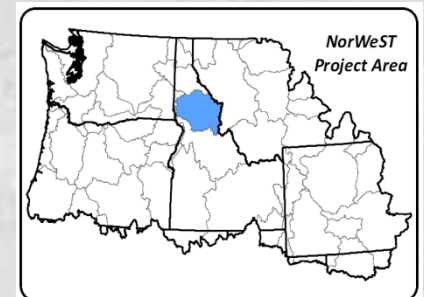


11°C – 14°C

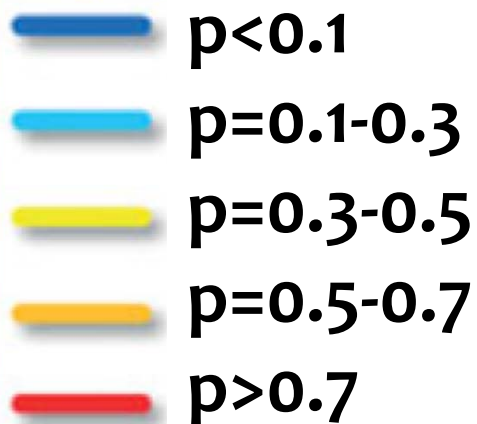
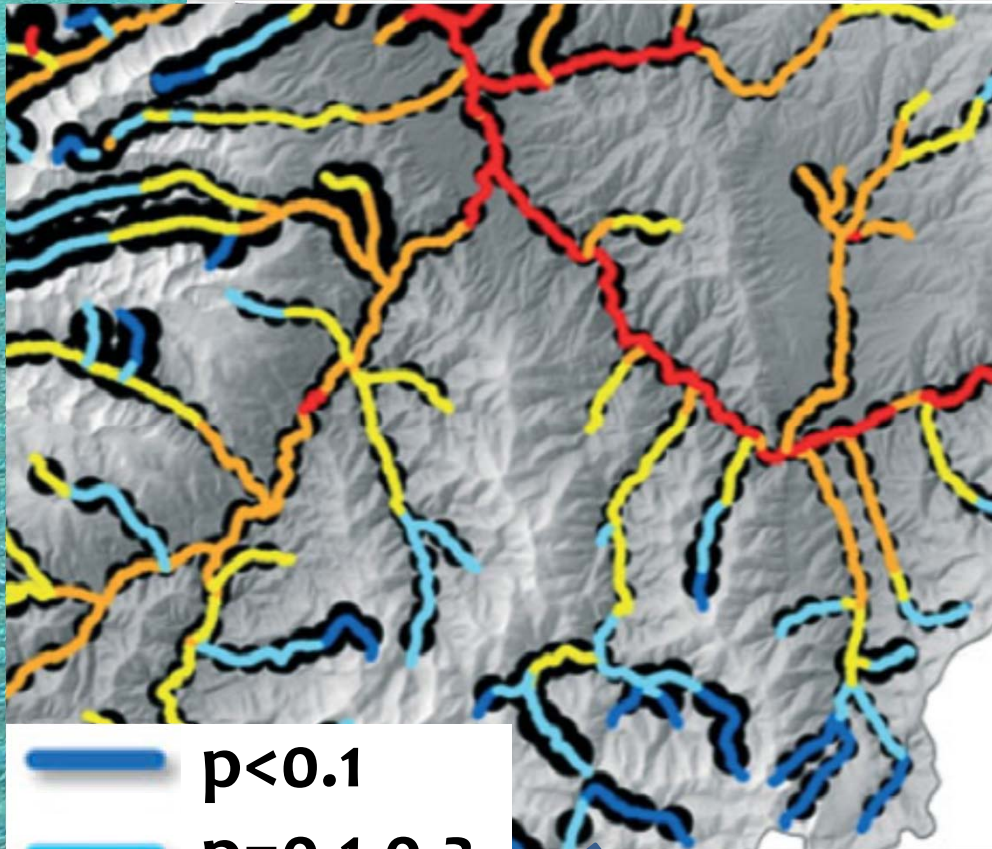
■ Optimal

■ Suboptimal

■ Suboptimal



Multivariate Models for More Accurate Predictions of Distribution & Abundance



- 13,769 fish survey sites
- 1,420 RBT occurrences

$p(\text{RBT occurrence}) =$
temperature +
reach slope +
stream flow

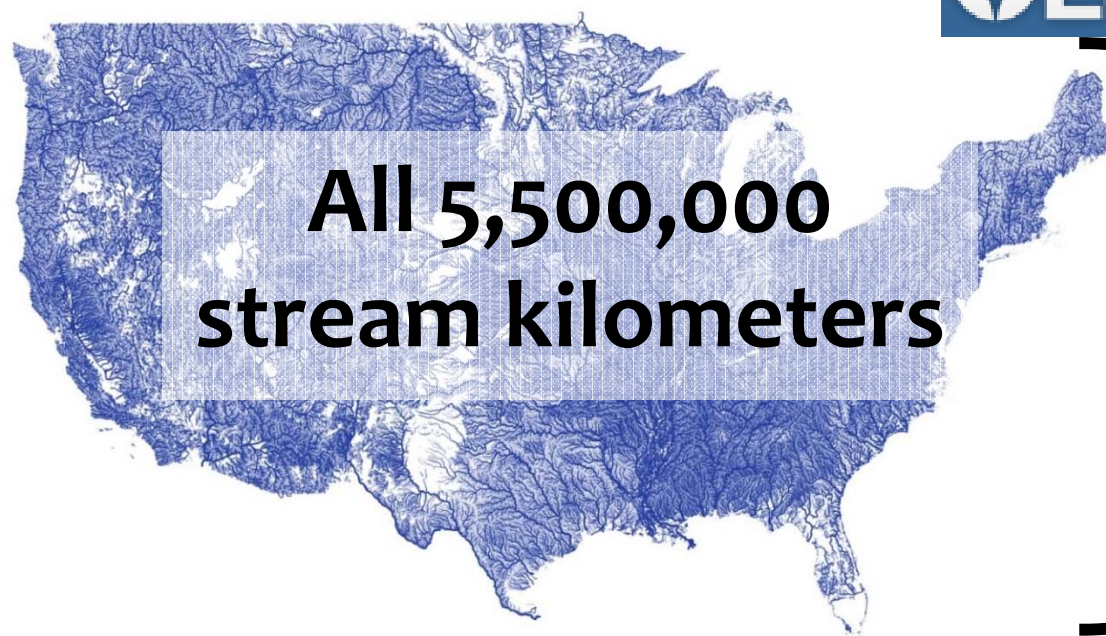
Prediction
maps



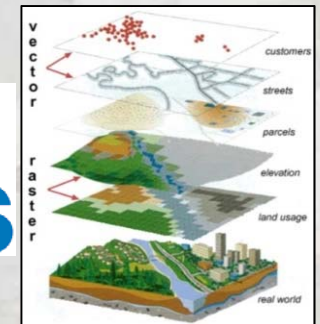
AUC = 0.8-0.9

$r^2 \sim 80-90\%$

National Hydrography Dataset (NHD)



All 5,500,000
stream kilometers

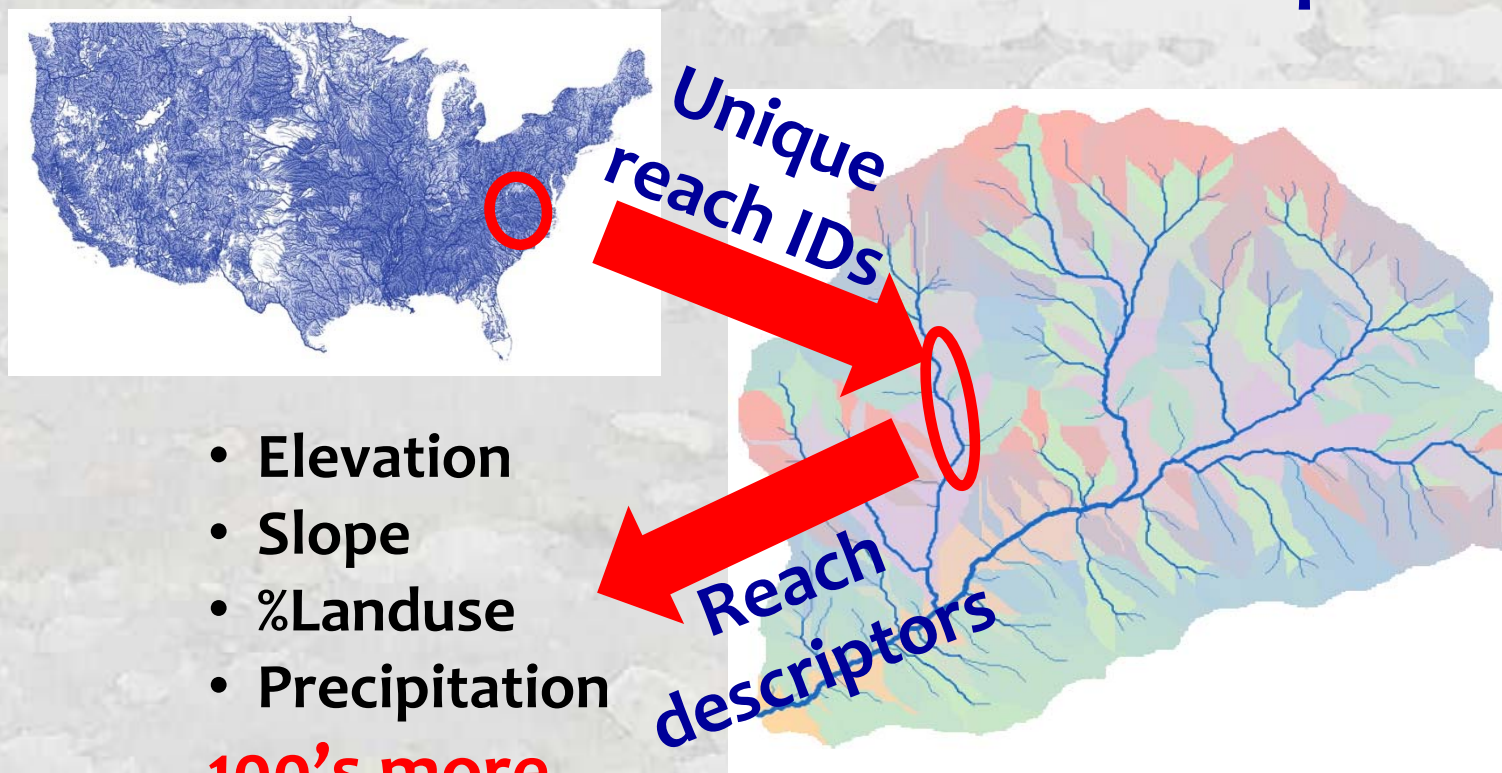


McKay et al. 2015. NHDPlus Version 2: User Guide.

Available at: ftp://ec2-54-227-241-43.compute-1.amazonaws.com/NHDplus/NHDPlusV21/Documentation/NHDPlusV2_User_Guide.pdf

Cooter et al. 2010. A nationally consistent NHDPlus framework for identifying interstate waters: Implications for integrated assessments and interjurisdictional TMDLs. *Environmental Management* **46**:510-524.

The “PLUS” part of NHD-Plus: Stream Reach Descriptors



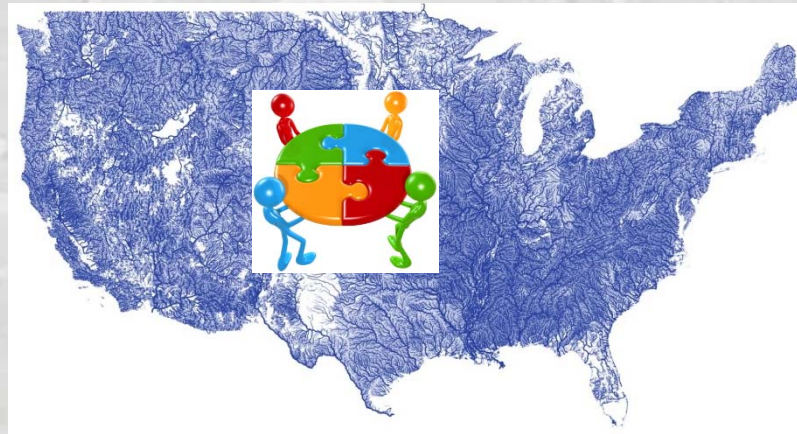
Wang et al. 2011. A hierarchical spatial framework and database for the national river fish habitat condition assessment. *Fisheries* **36**: 436-449.

Available at: https://www.researchgate.net/profile/Lizhu_Wang2

Hill et al. 2015. The stream-catchment (StreamCat) dataset: A database of watershed metrics for the conterminous USA. *The Journal of the American Water Resources Association*.

Available at: <http://www2.epa.gov/national-aquatic-resource-surveys/streamcat>

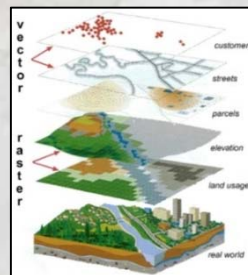
Website for 1-stop Shopping: The National Stream Internet



NSI Resources



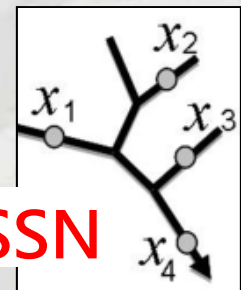
NSI hydrography network
(shapefiles)



Databases of stream reach descriptors



Databases of stream measurements



SSN

Spatial stream-network models

Ideas



Data



Analysis

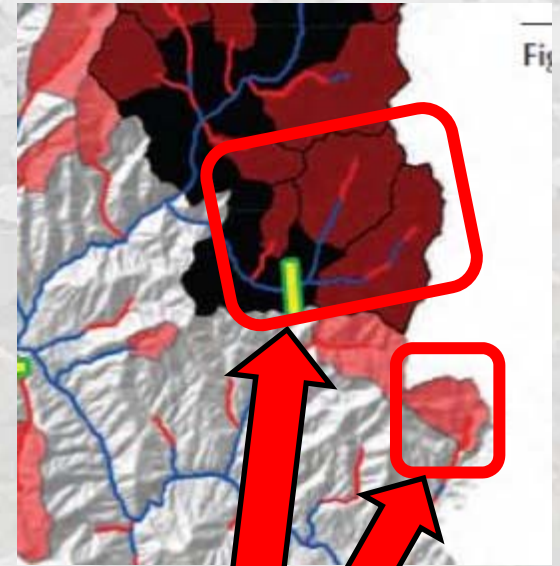


Information

High-Resolution, Spatial Information for Steelhead Decision Support is Possible

Fundamental Questions:

- How much steelhead habitat is in this river network?
- What are the spatial patterns in steelhead densities?
- What are the environmental constraints on fish density?
- Is climate change something to worry about for this population?
- Where should strategic conservation investments be made?



I'm going to invest here...
...not here





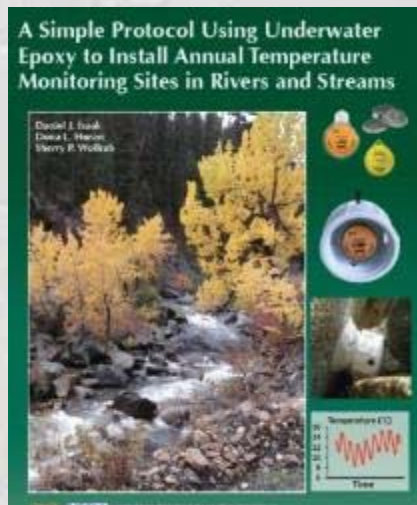
The End

Stream Temperature Related Websites

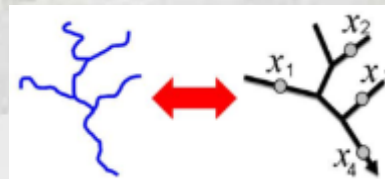
Google search on...

- 1) **NorWeST** – regional stream temperature database & climate scenarios
- 2) **Stream Temperature Modeling & Monitoring** protocols, modeling techniques, presentations, publications
- 3) **SSN/STARS** – tools for spatial statistical network modeling

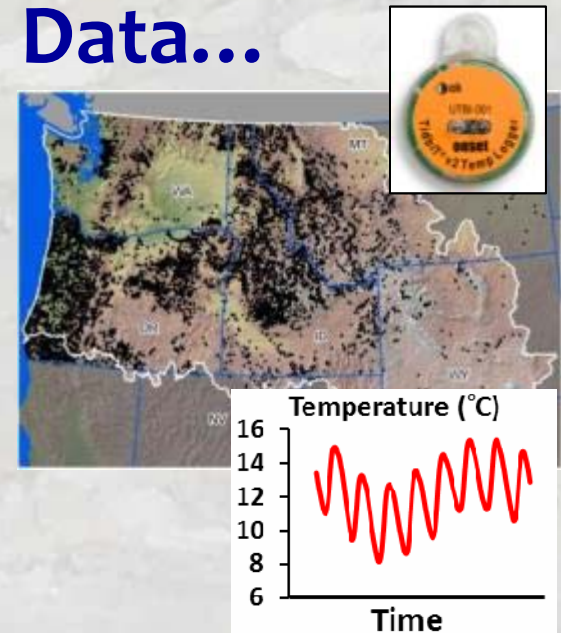
Publications...



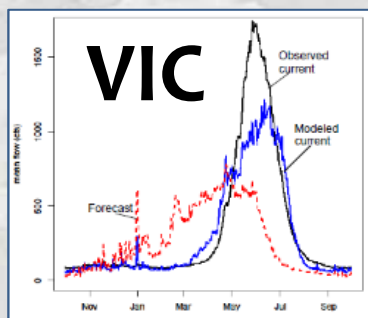
Software...



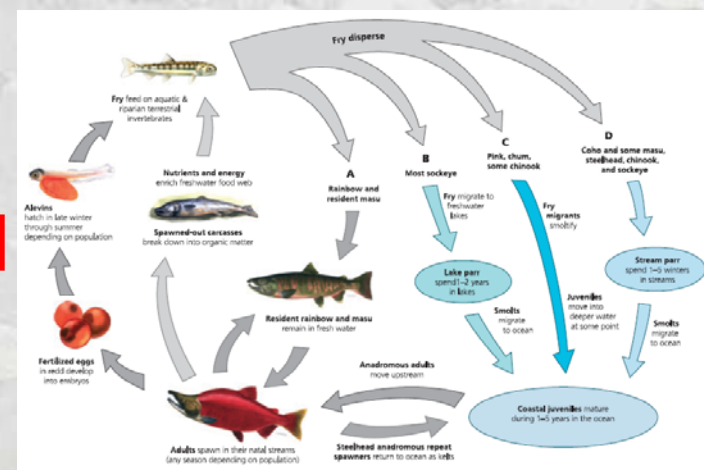
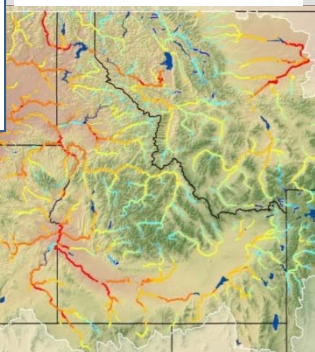
Data...



Integrate Salmon Models & Data with Stream Climate Scenarios



NorWeST
Stream Temp



Yes

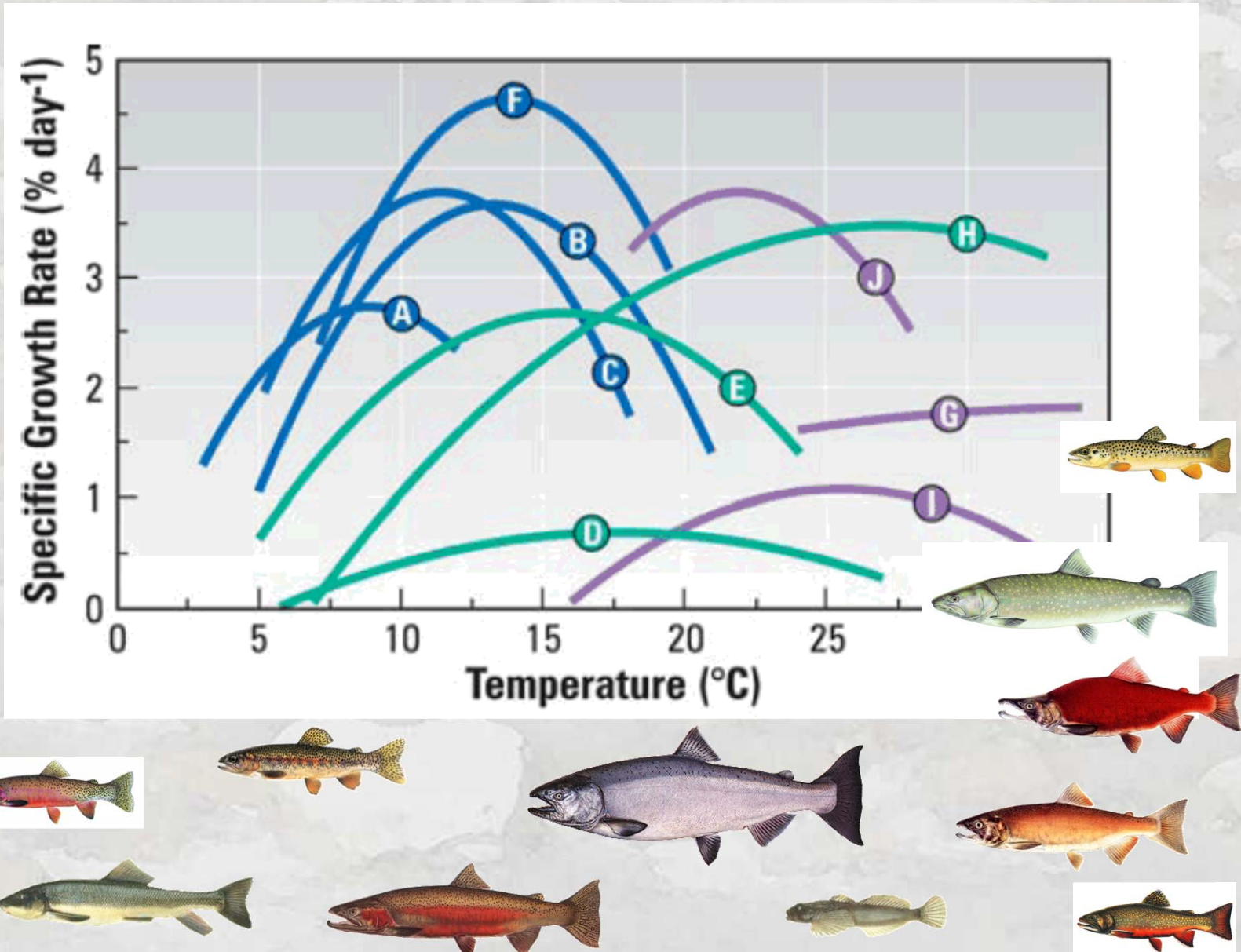


NO



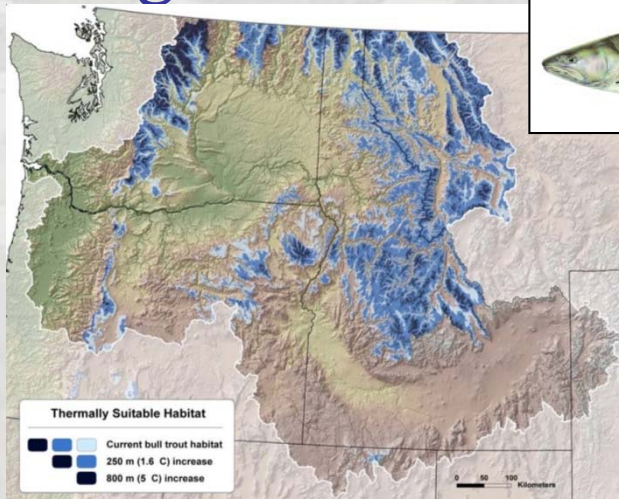
**Spatially explicit
predictions for
investment planning...**

Thermal Preferences Vary by Species

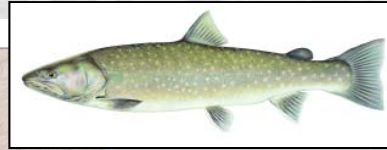


Temperature Regulation – Spatial Distributions

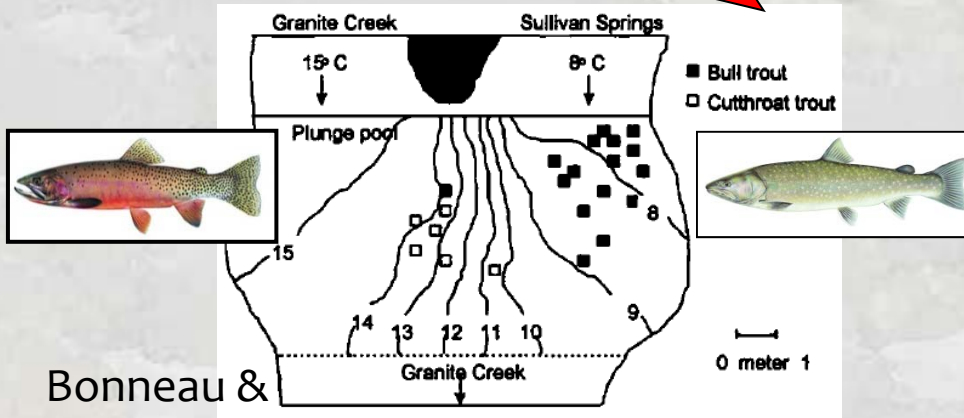
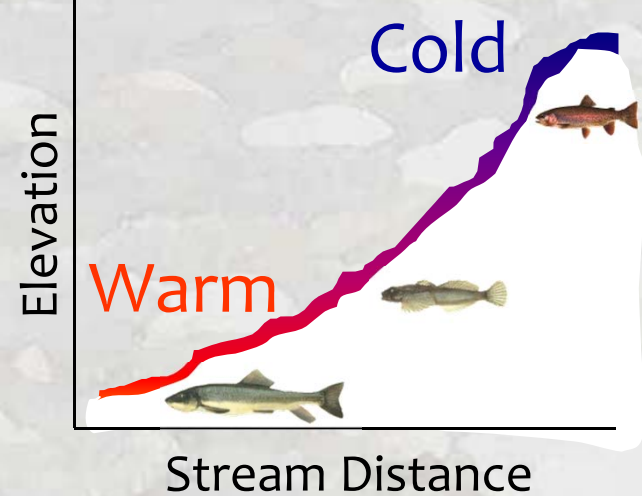
Regional Scale



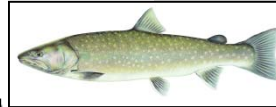
Rieman et al. 2007



Stream Scale



Bonneau &
Scarnecchia 1996



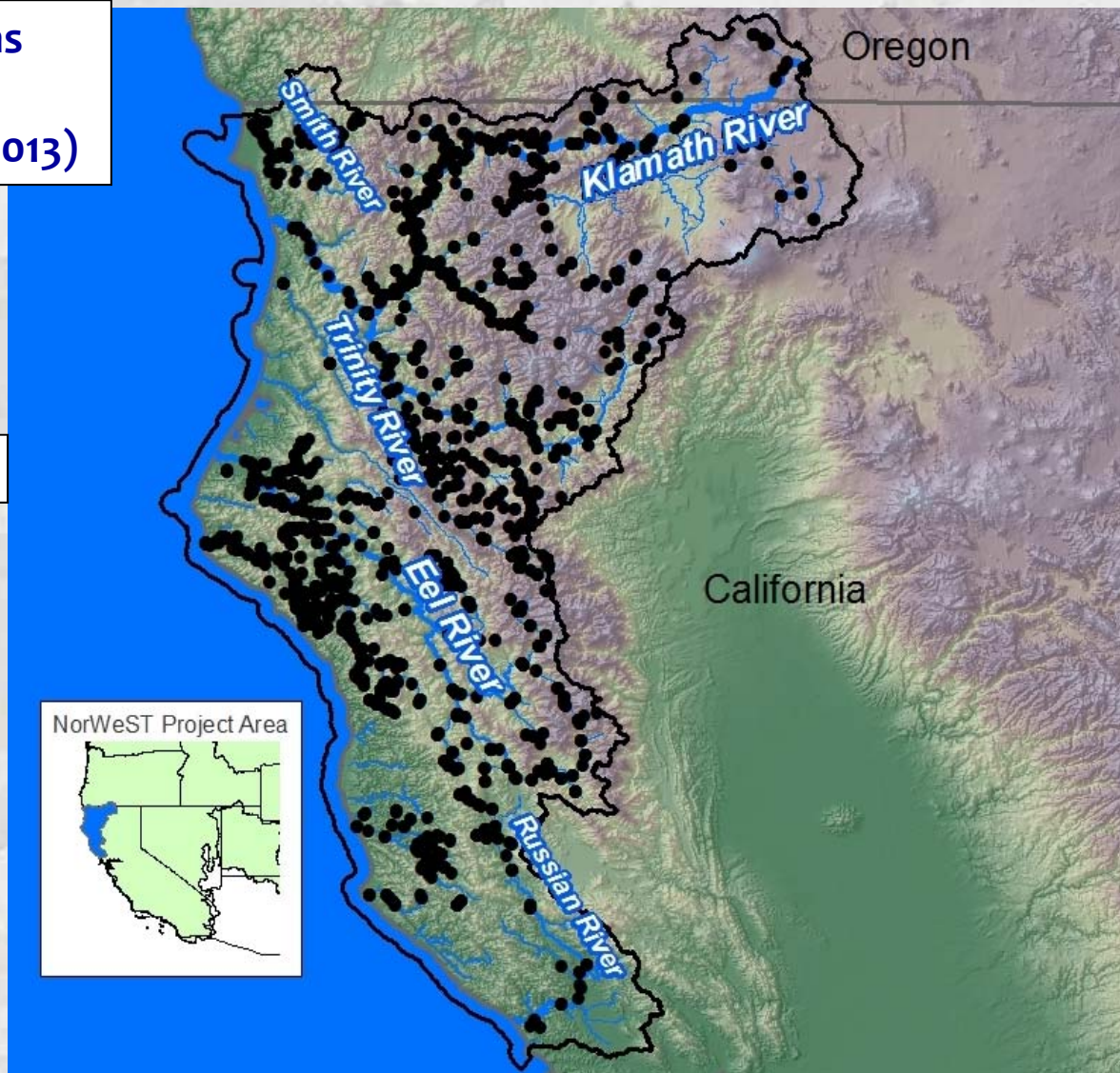
Northwest California Unit

Stream temp data aggregated across agencies

4,642 August means
1,506 stream sites
21 summers (1993-2013)



•Temperature site



California Coastal Unit

447 August means
163 stream sites
23 summers (1993-2015)



•Temperature site

