Development and use of NorWeST Temperature Scenarios for Steelhead Assessments

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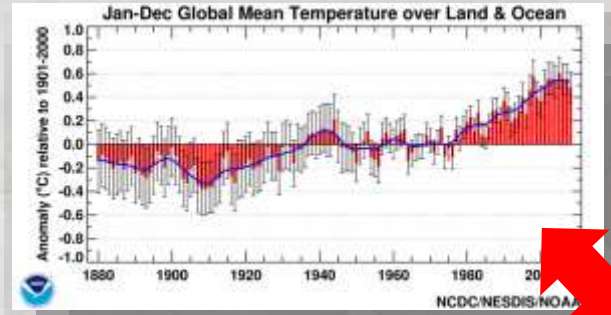
U.S. Forest Service

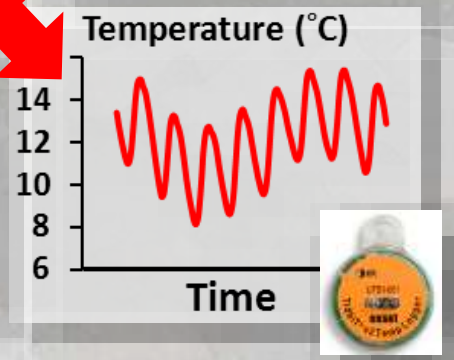
[1]Trout Unlimited

[2]CSIRO

[3]NOAA

[4]USGS

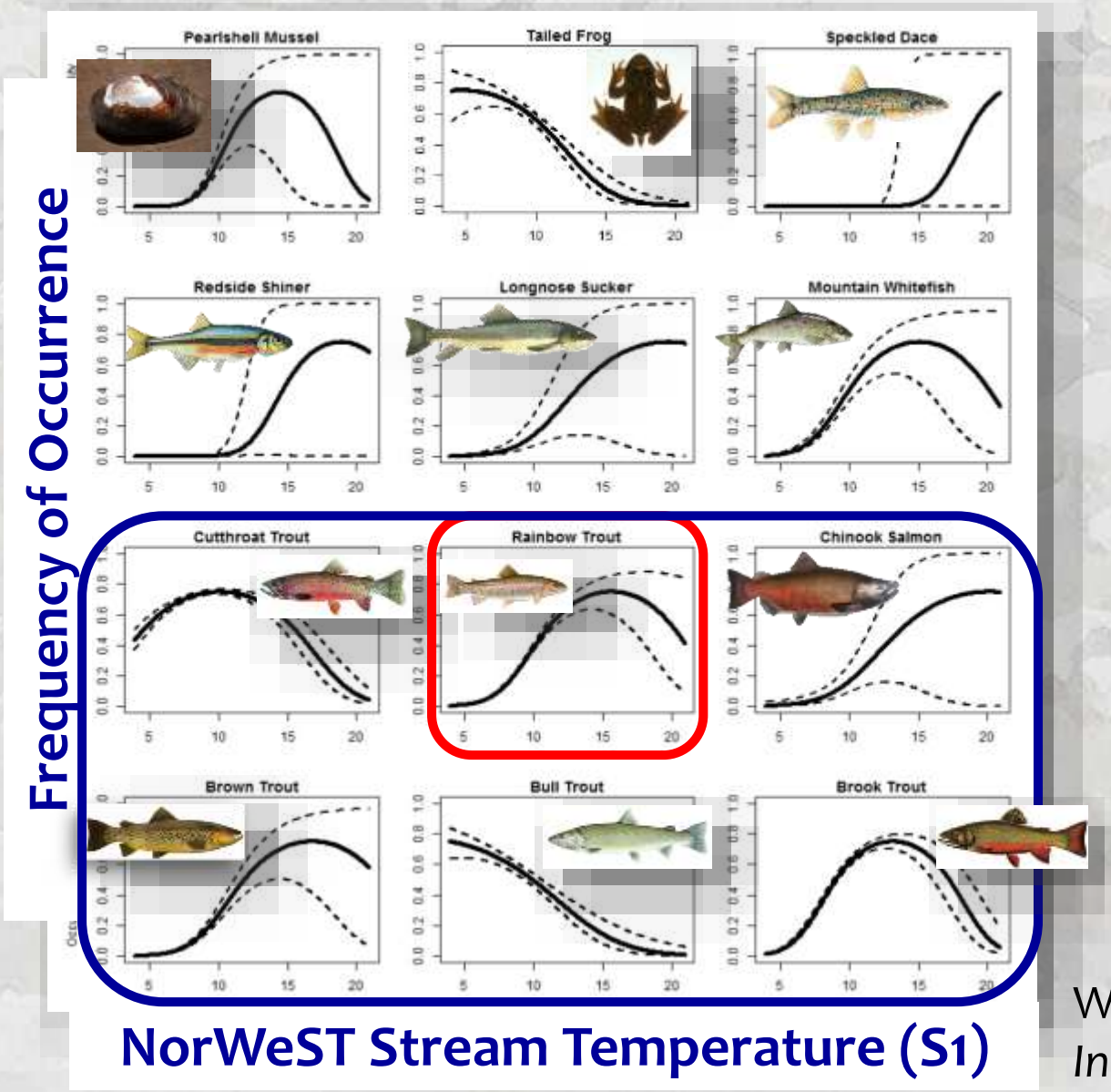




Funding agencies:

Temperature Affects Distribution & Abundance

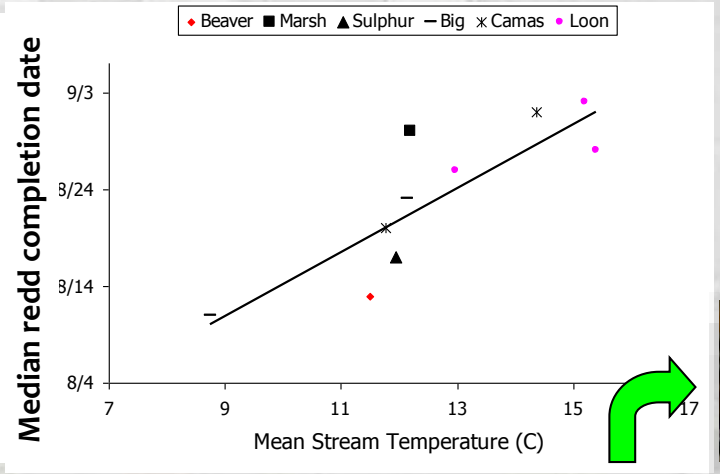
Thermal niches differ among species



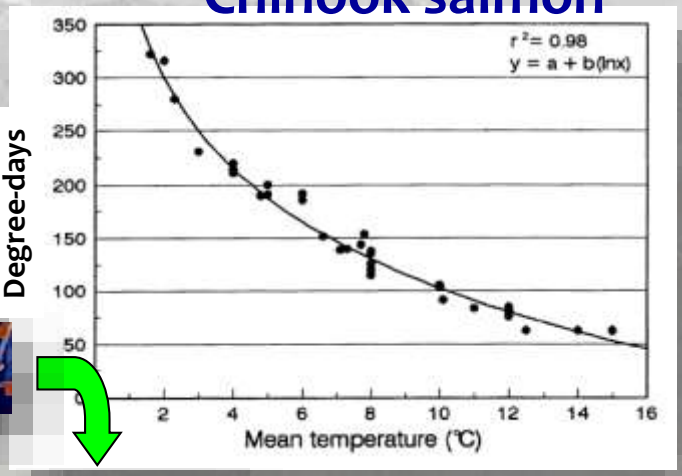
Wenger et al. *In Review.*

Temperature Affects Phenology

Spawn timing - Chinook salmon

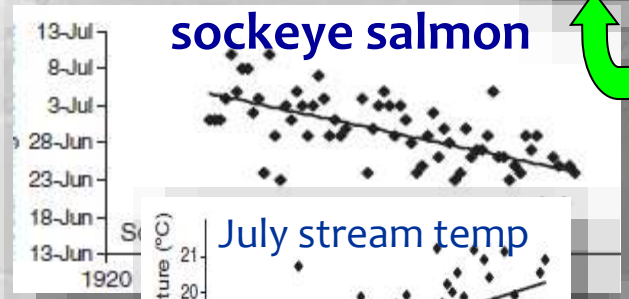


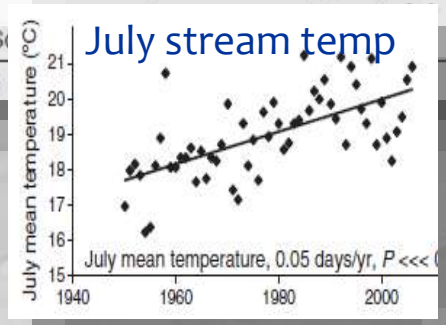
Incubation time - Chinook salmon



Brannon et al. 2004

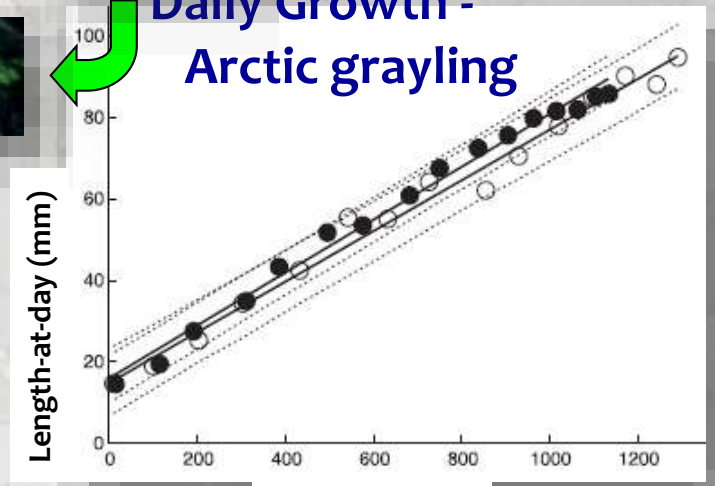
Migration timing - sockeye salmon





Crozier et al. 2008

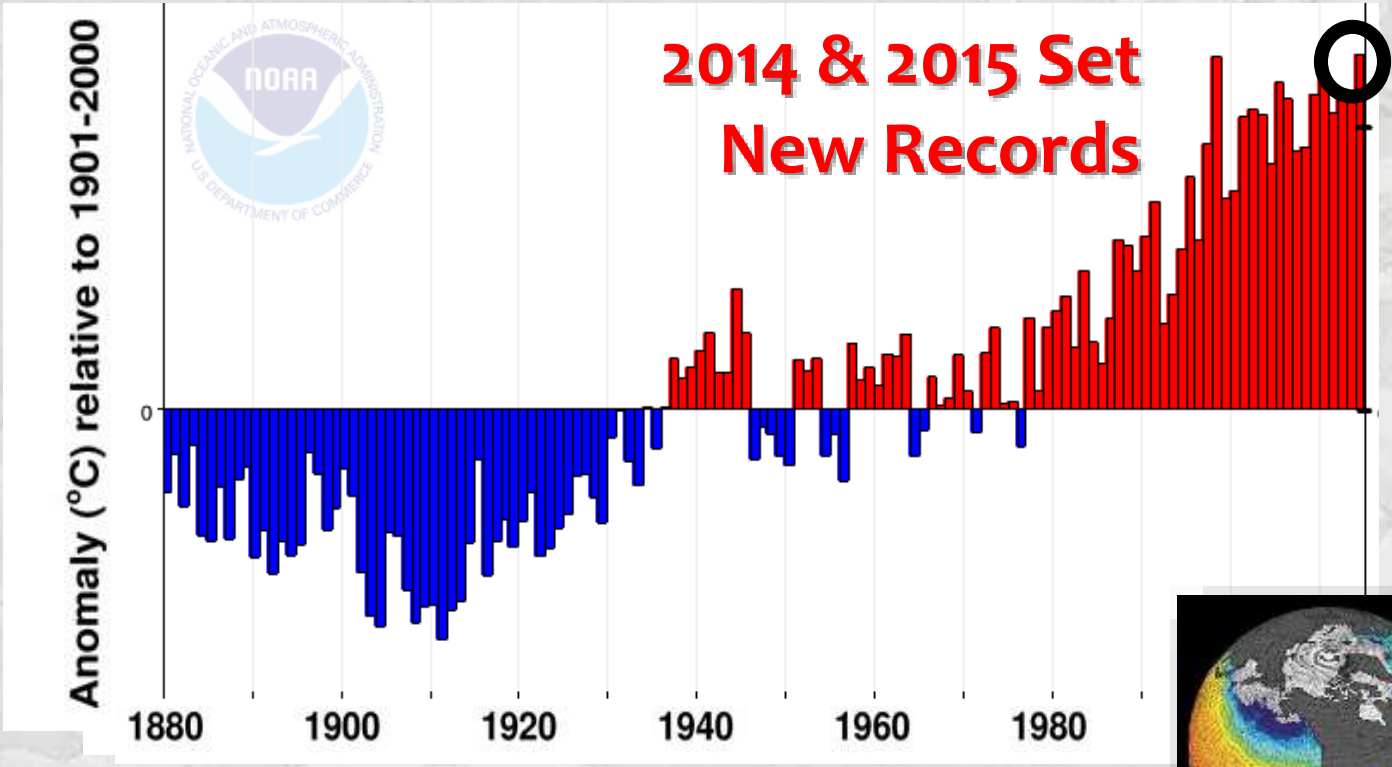
Daily Growth - Arctic grayling

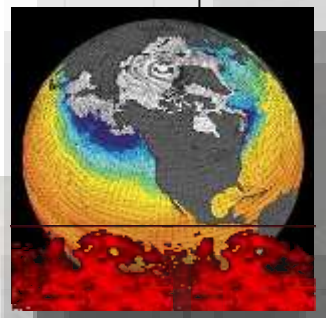


Dion and Hughes 1994

Temperatures are Getting Warmer…

1880-2014 Global Air Temperature Trend

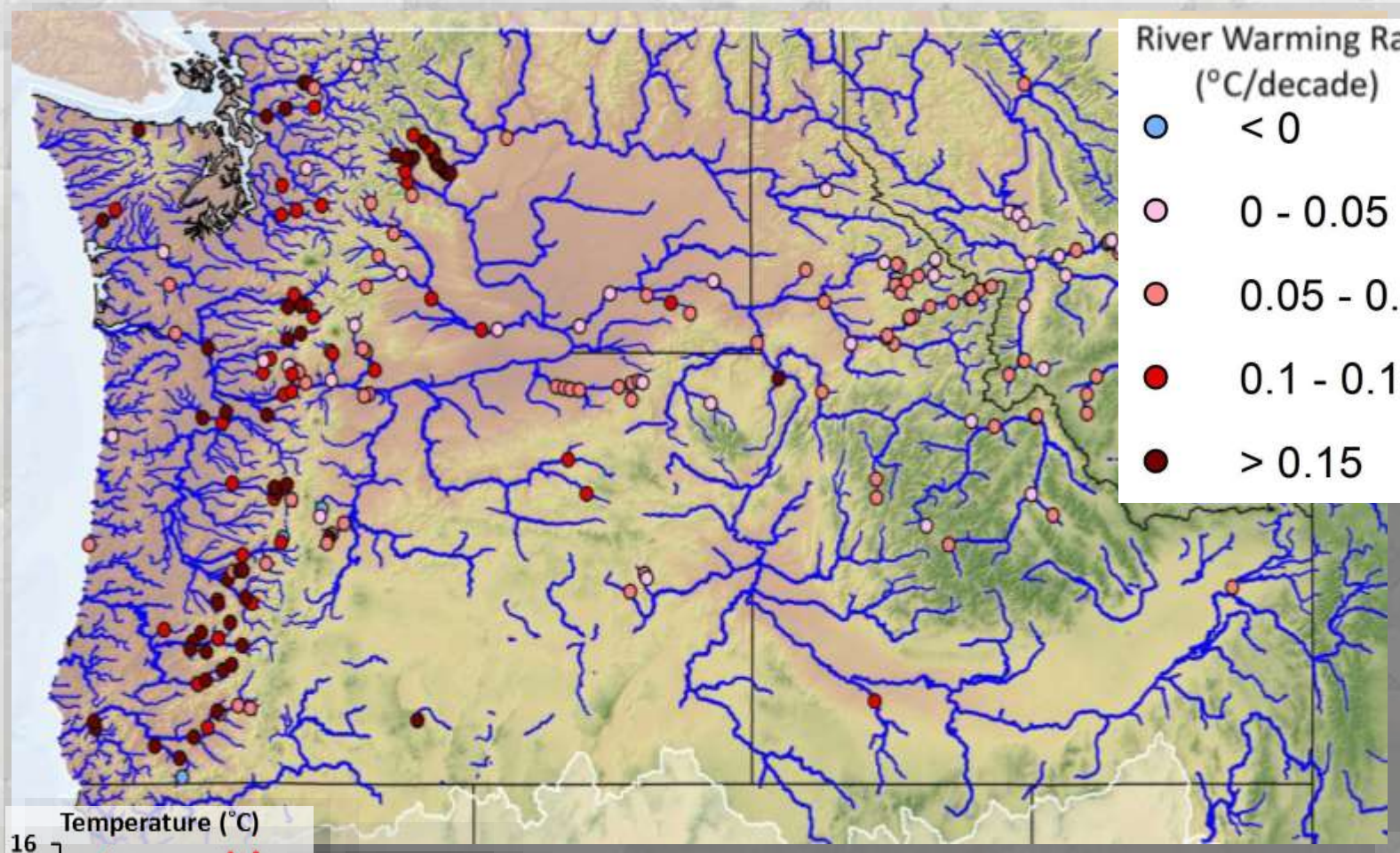




Plan on continued warming for decades…

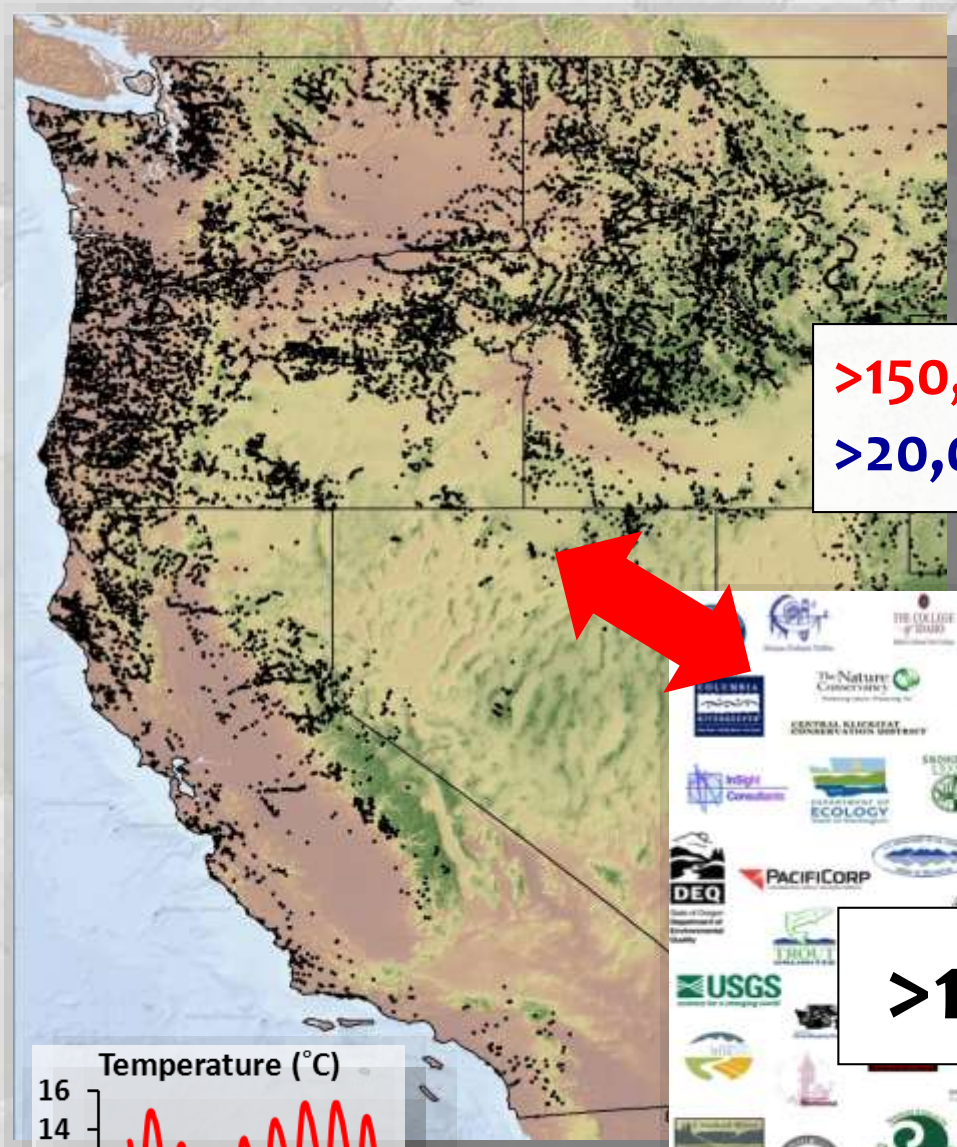
Summer River Temp Trends (1968-2011)

245 sites with >10 year monitoring records



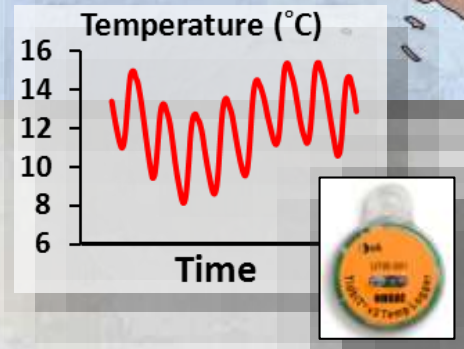
Isaak et al. In Prep.

Southern Steelhead Range = Lots of Temperature Data



>150,000,000 hourly records

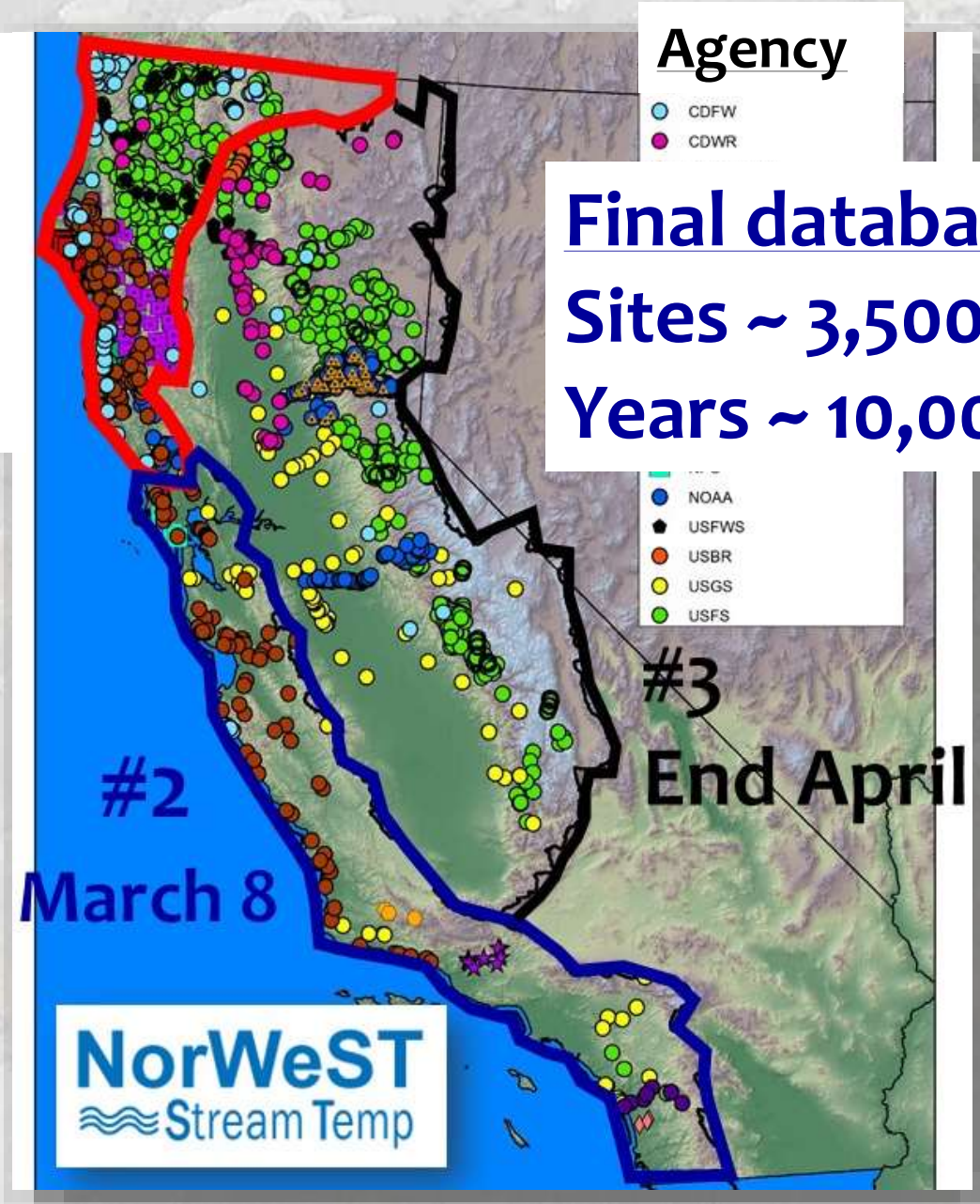
>20,000 unique stream sites



California Temperature Database

#1

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



Final database

Sites ~ 3,500

Years ~ 10,000

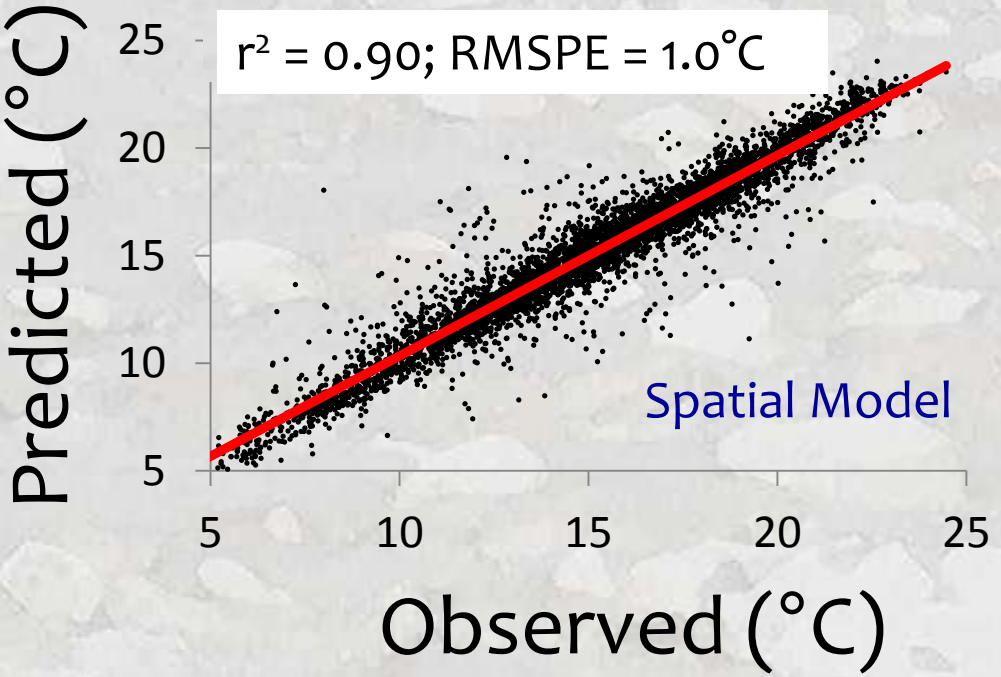
Predictive Accuracy of Temperature Model

Covariate Predictors

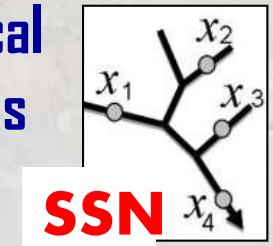
1. Elevation (m)
2. Canopy (%)
3. Stream slope (%)
4. Ave Precipitation (mm)
5. Latitude (km)
6. Lakes upstream (%)
7. Baseflow Index
8. Watershed size (km^2)
9. Glacier (%)

10. Discharge (m^3/s)
    USGS gage data
11. Air Temperature (˚C)
    RegCM3 NCEP reanalysis
    Hostetler et al. 2011

Mean August Temperature

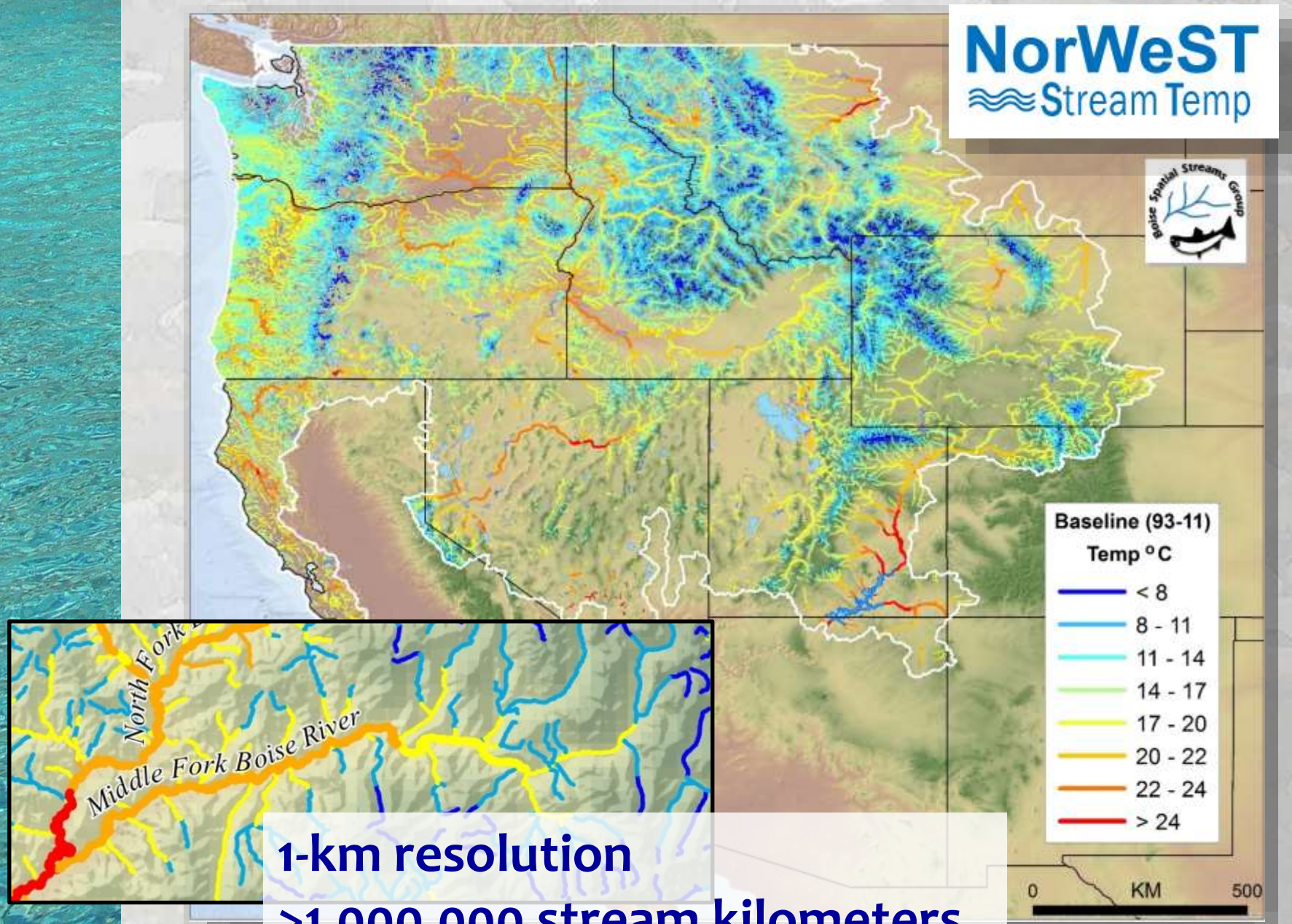


Spatial statistical network models



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

High-Resolution Stream Climate Scenarios

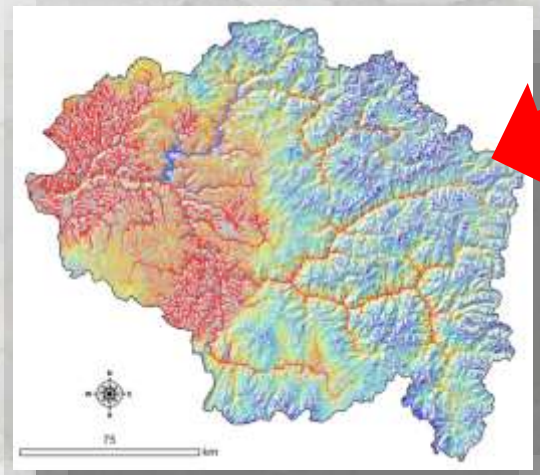


1-km resolution

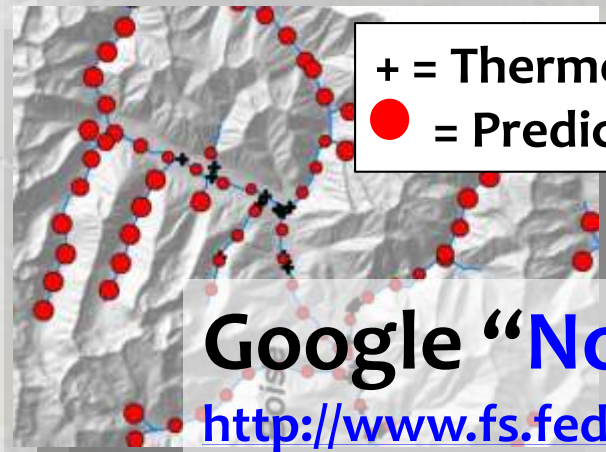
>1,000,000 stream kilometers

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

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

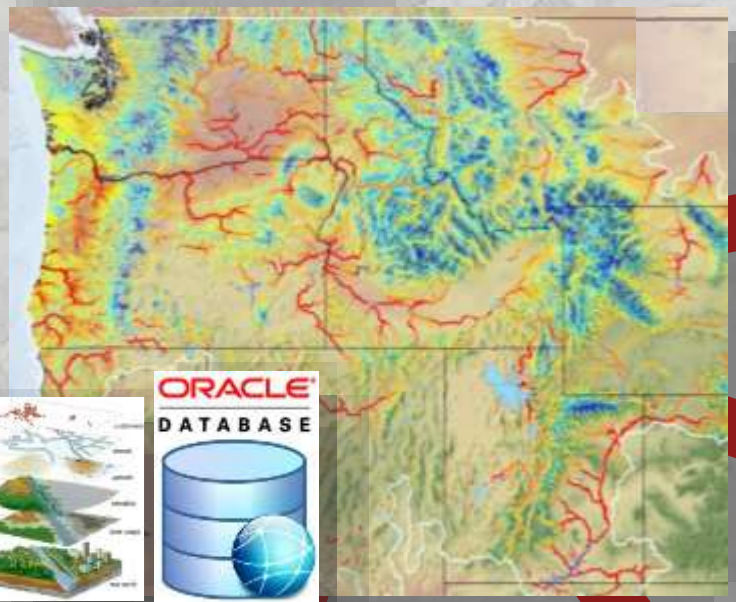
30 Climate Scenarios (Historic & Future)

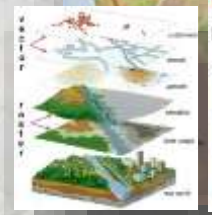
Scenario	Description
S1_93_11	Historical scenario representing 19 year average August mean stream temperatures for 1993-2011
S2_02_11	Historical scenario representing 10 year average August mean stream temperatures for 2002-2011
S3_1993	Historical scenario representing August mean stream temperatures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

***Extensive metadata on website**

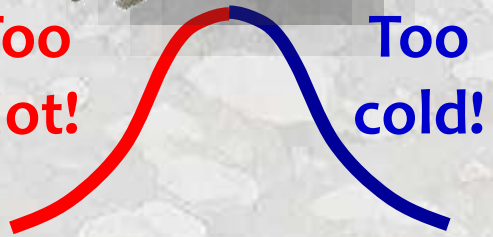
NorWeST Stream Temp

Temperature Applications

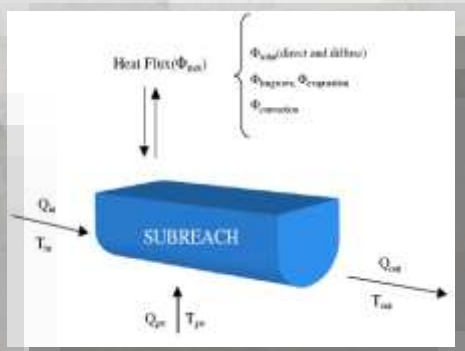




Regulatory temperature standards



Data access accelerates temperature research

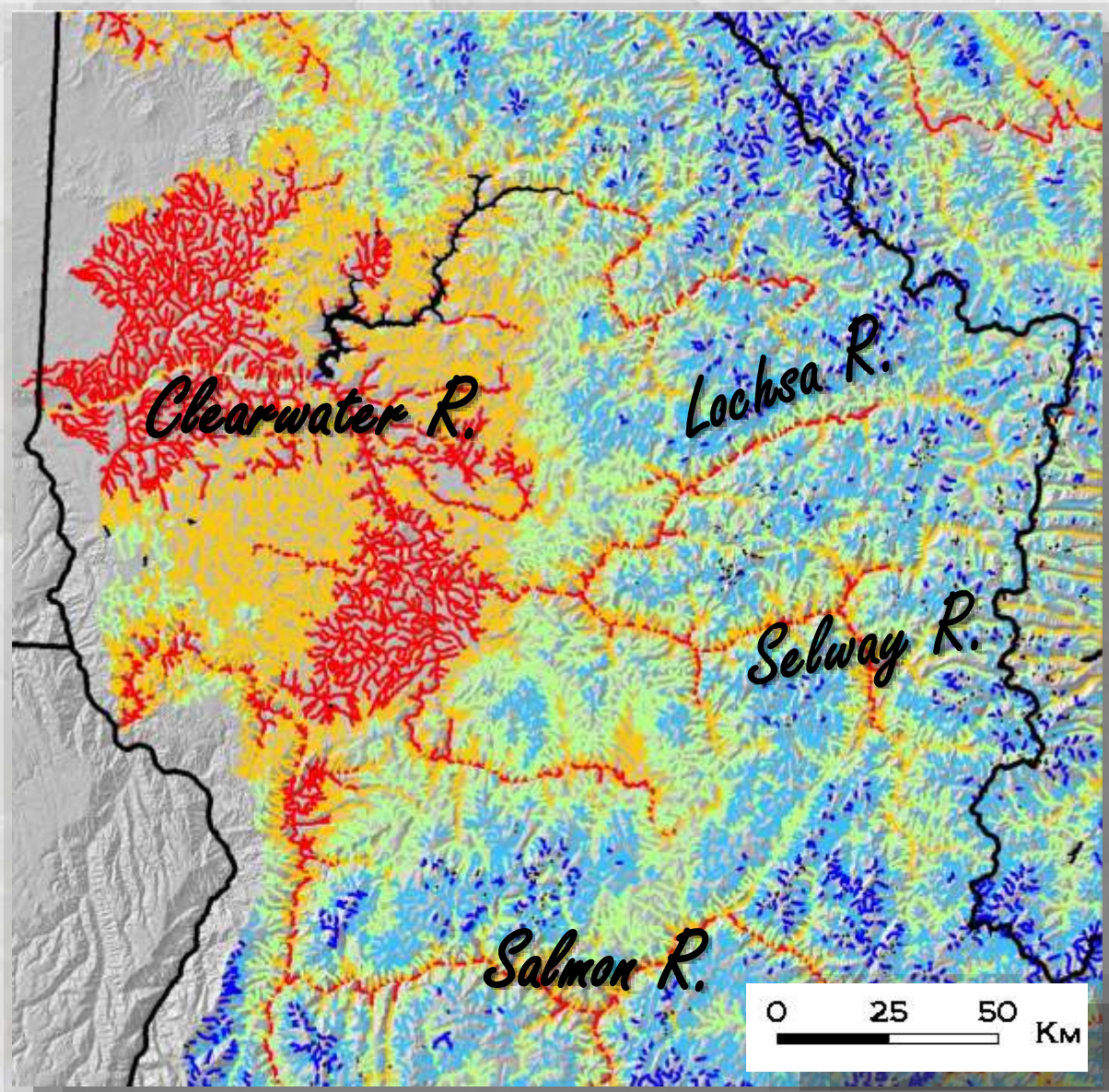


Coordinated Interagency monitoring

Species distribution models & climate assessments

Climate in North Idaho Steelhead Streams

Historic (1993-2011 Average August)



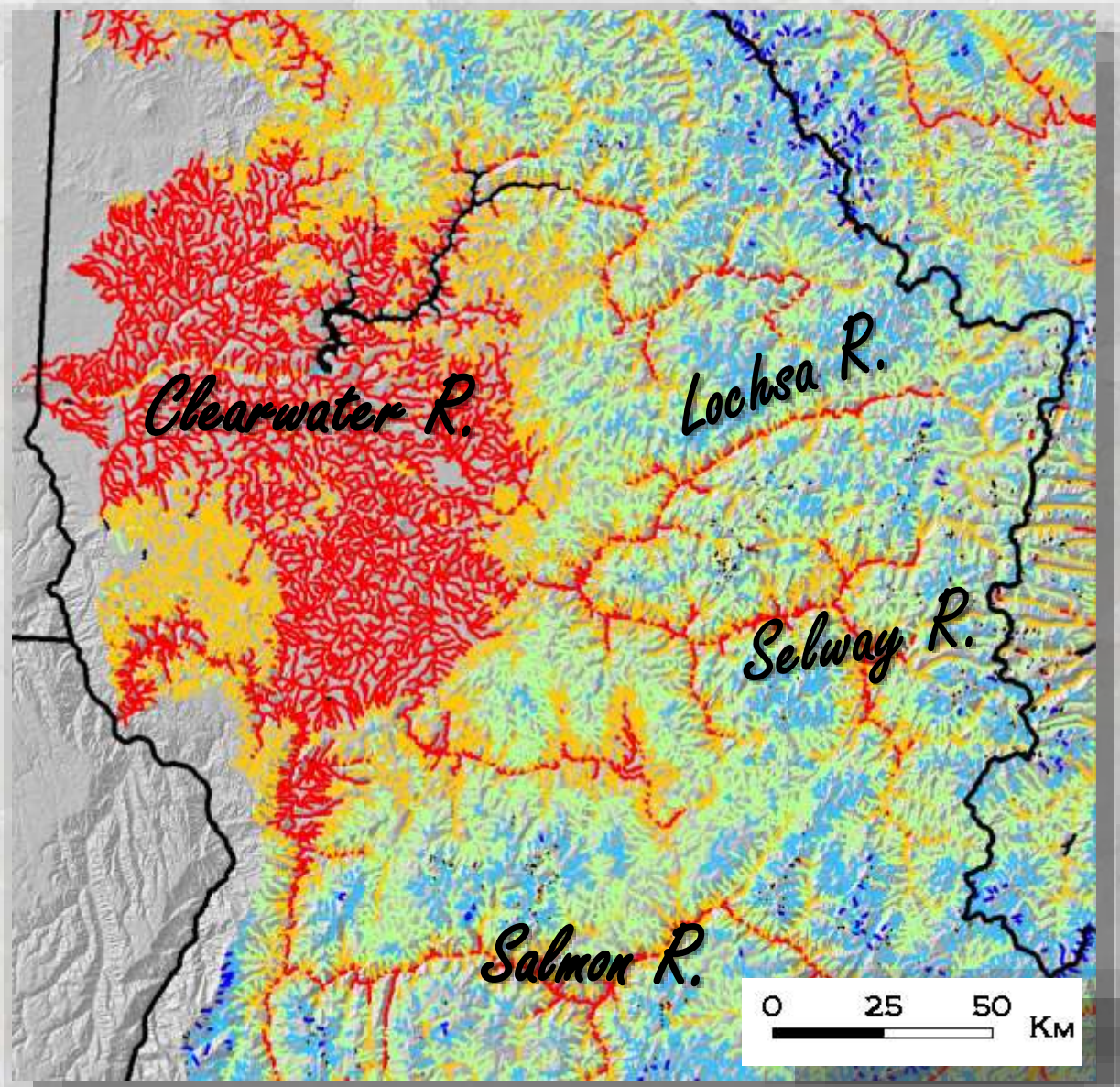
Temperature (°C)

- 0.0 - 8.0
- 8.1 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15

1 kilometer resolution

Climate in North Idaho Steelhead Streams

+1.00°C Stream Temp



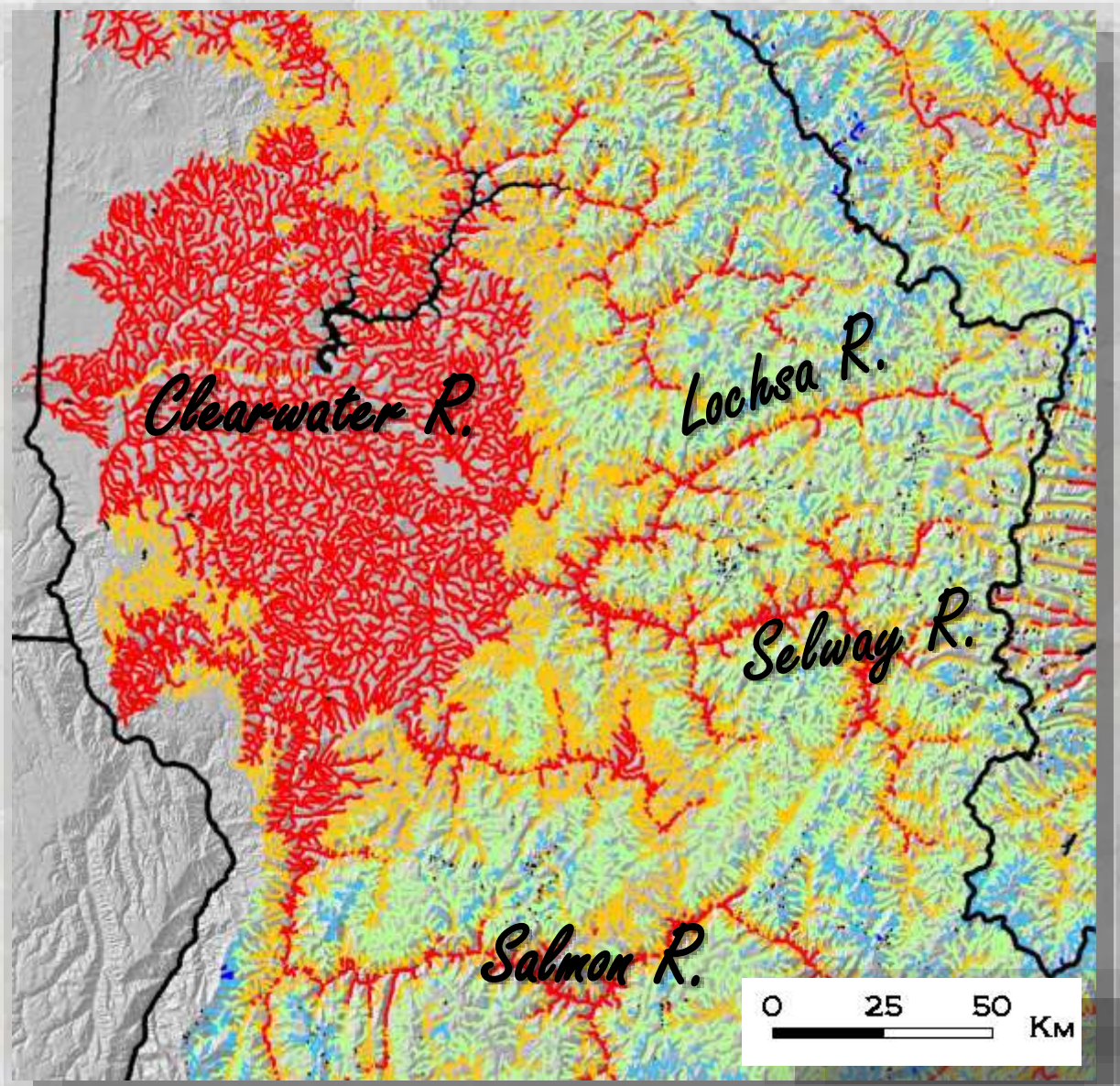
Temperature (°C)

- 0.0 - 8.0
- 8.1 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15

1 kilometer resolution

Climate in North Idaho Steelhead Streams

+2.00˚C Stream Temp



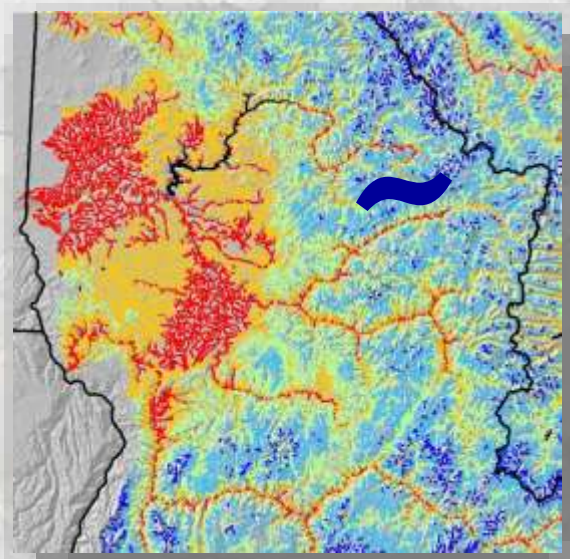
Temperature (°C)

- 0.0 - 8.0
- 8.1 - 10.0
- 10.1 - 12.5
- 12.6 - 15.0
- > 15

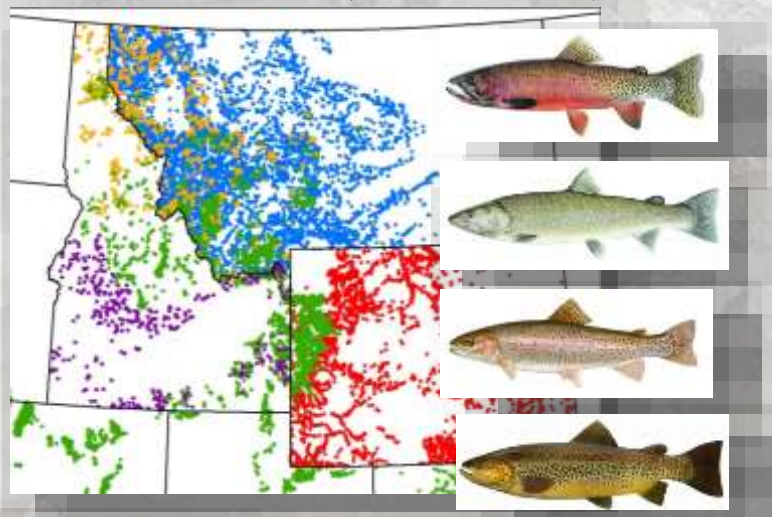
1 kilometer resolution

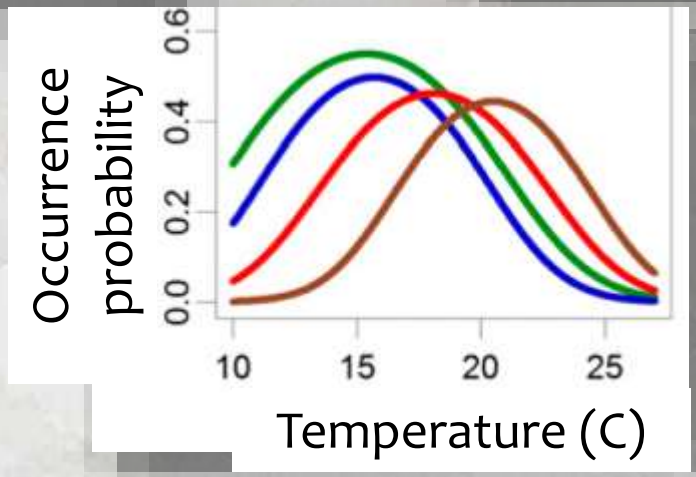
Fish Data Can be Used to Define Thermal Habitat Suitability

Stream temperature maps

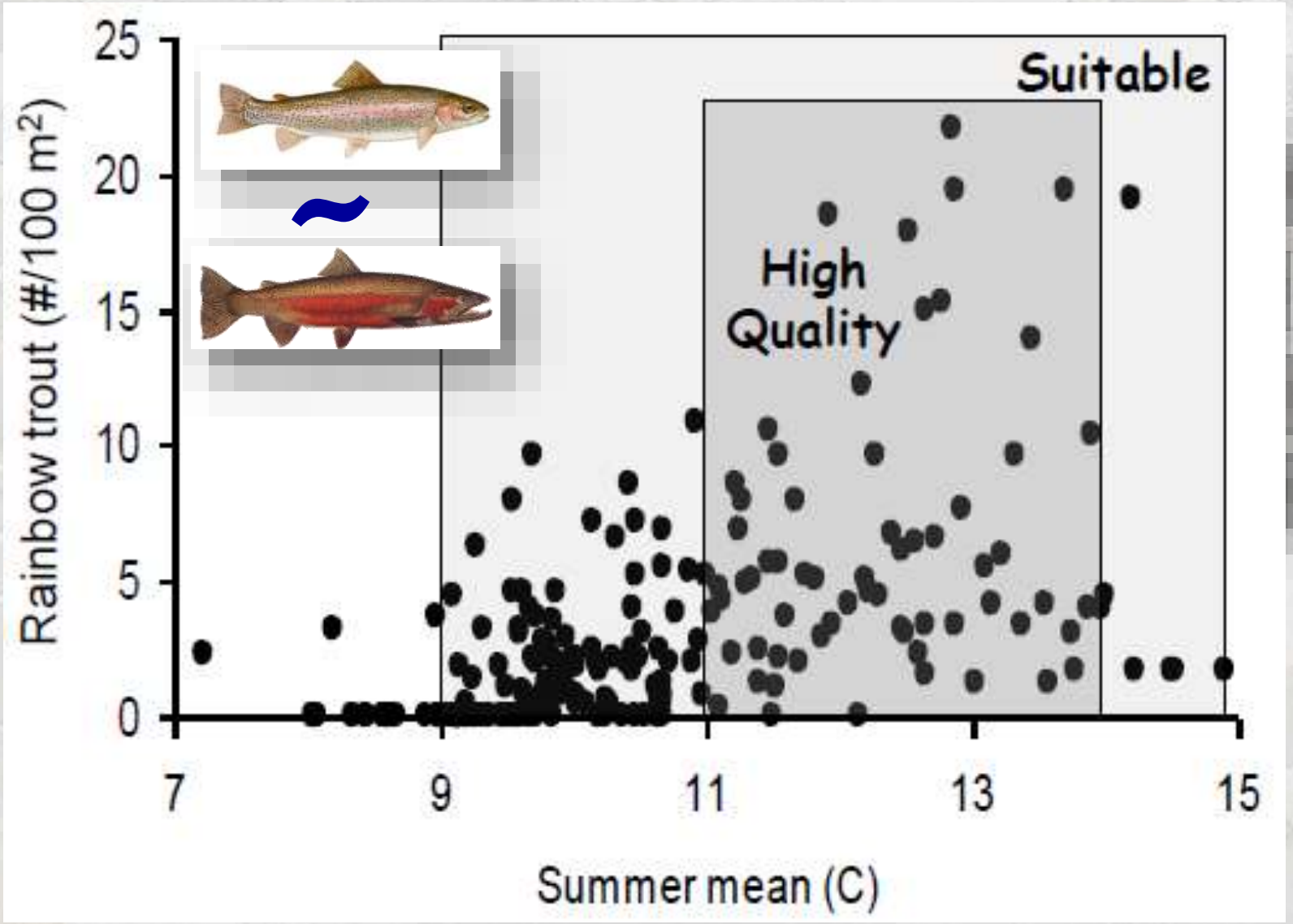


Regional fish survey databases (n ~ 20,000)



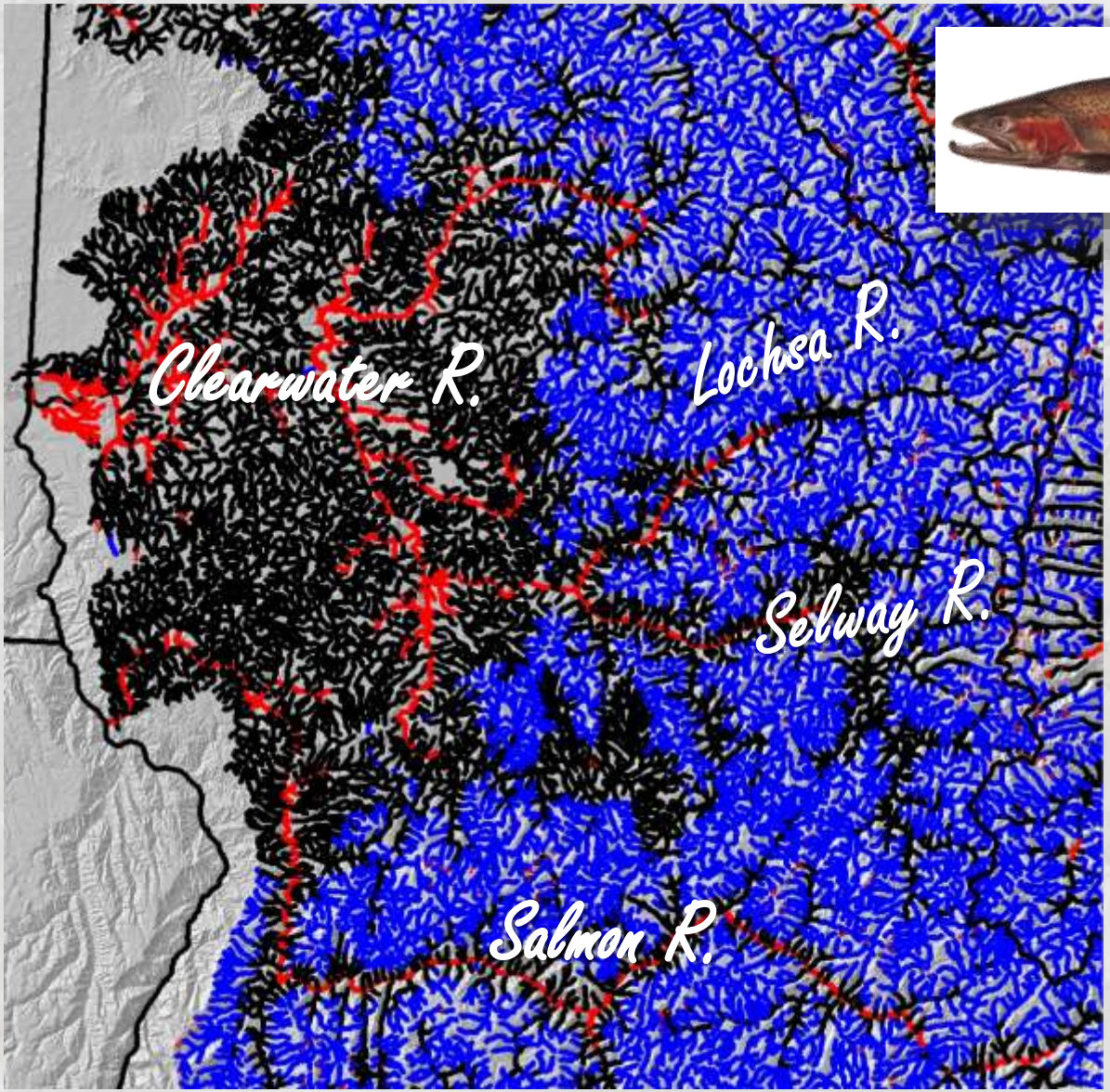


Fish Data Can be Used to Define Thermal Habitat Suitability



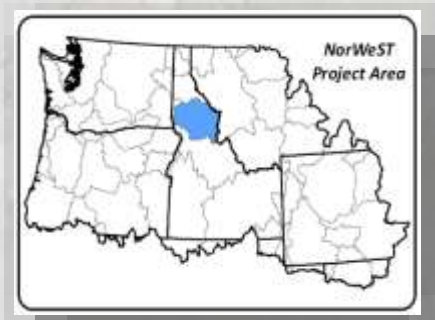
Steelhead/Rainbow Trout Habitat

Historic (1993-2011 Average August)



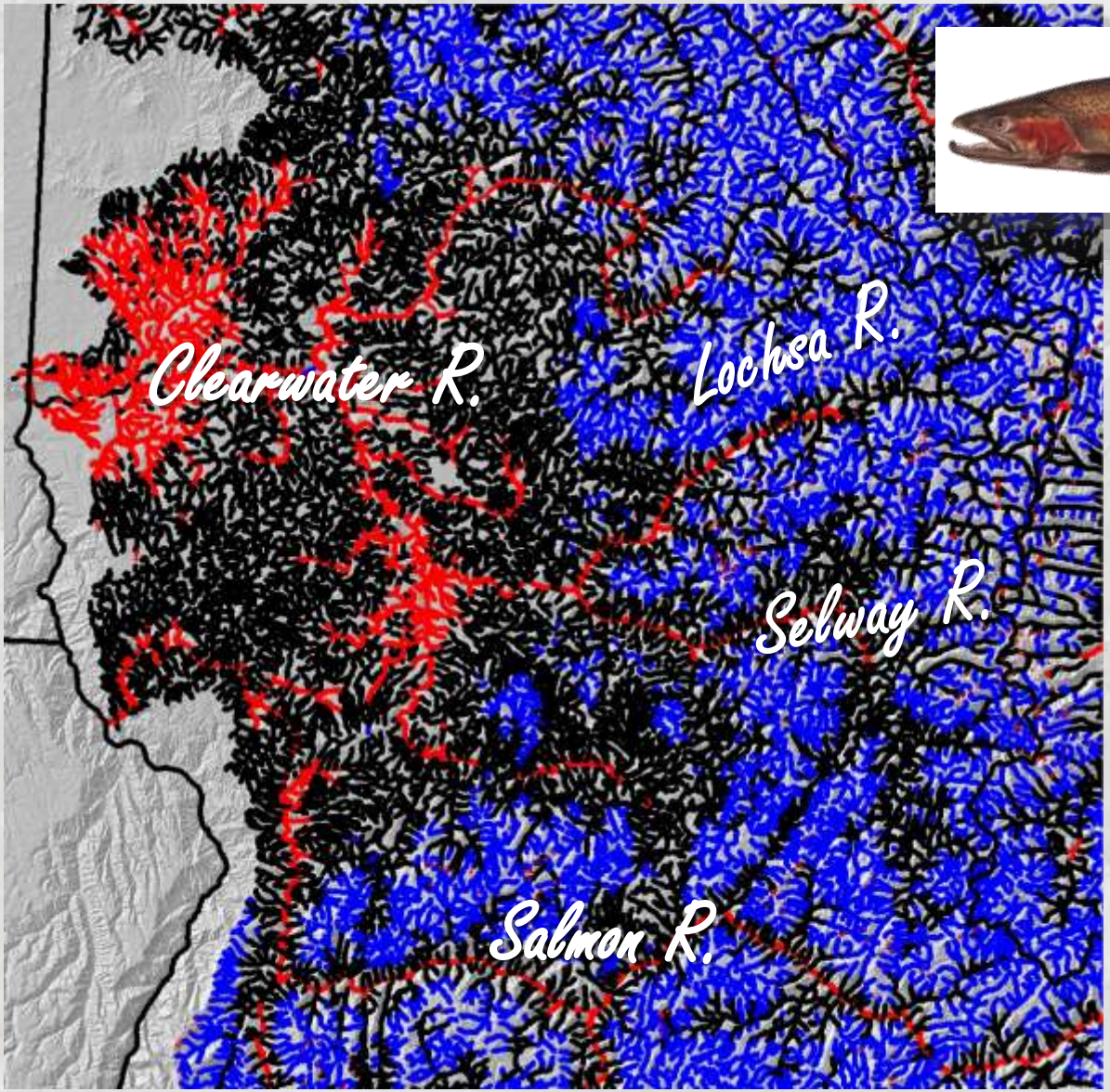
11°C – 14°C

- Optimal
- Suboptimal
- Suboptimal



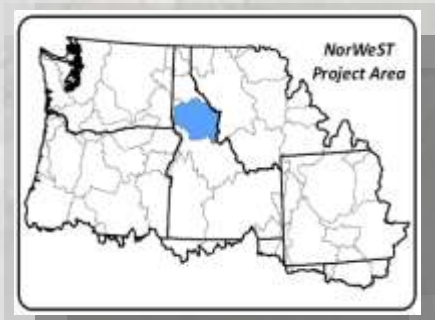
Steelhead/Rainbow Trout Habitat

+1.00°C Stream Temp



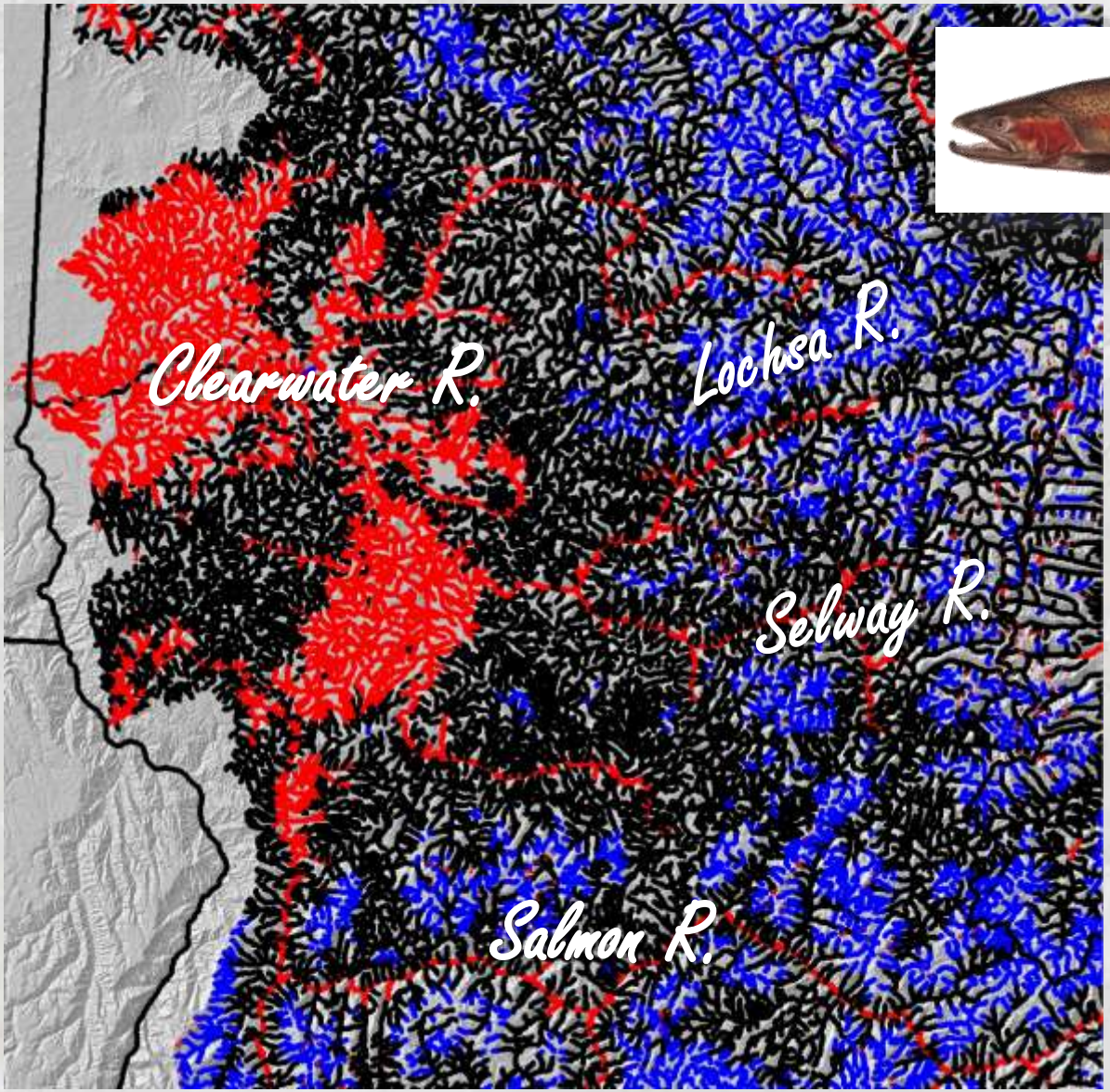
11°C – 14°C

- Optimal
- Suboptimal
- Suboptimal



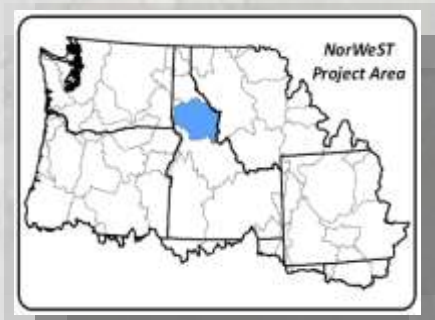
Steelhead/Rainbow Trout Habitat

+2.00˚C Stream Temp

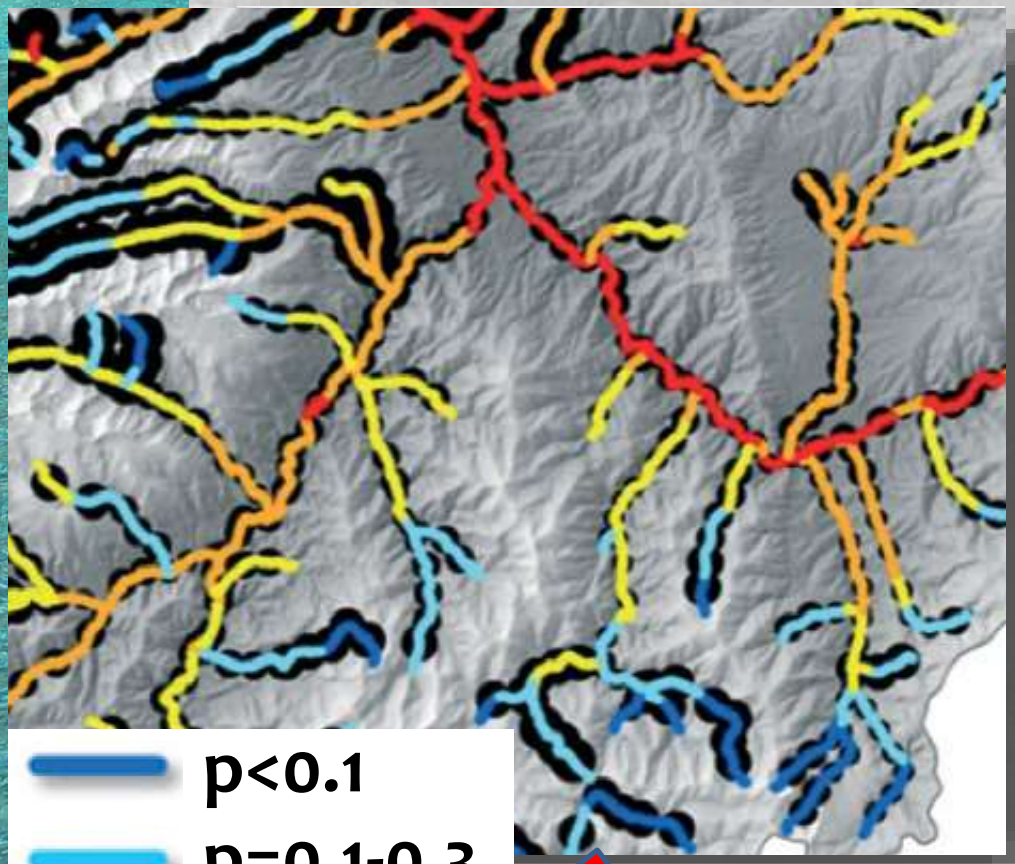


11˚C – 14˚C

- Optimal
- Suboptimal
- Suboptimal



Multivariate Models for More Accurate Predictions of Distribution & Abundance



p<0.1
p=0.1-0.3
p=0.3-0.5
p=0.5-0.7
p>0.7

Prediction maps

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

p(RBT occurrence) =
temperature +
reach slope +
stream flow

AUC = 0.8-0.9

r^2 ~ 80-90%

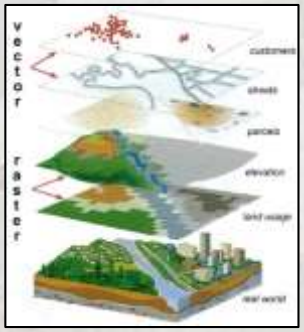
National Hydrography Dataset (NHD)

EPA

USGS
science for a changing world

NHDPlus

Arc GIS
ESRI

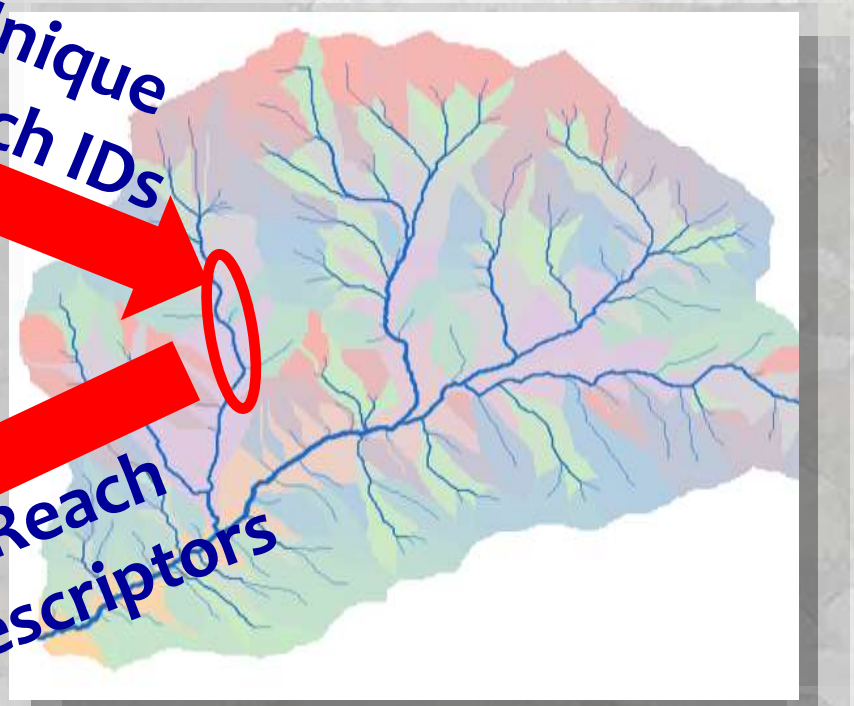


McKay et al. 2015. NHDPlus Version 2: User Guide.
Available at: ftp://ec2-54-227-241-43.compute-1.amazonaws.com/NHDplus/NHDPlusV21/Documentation/NHDPlusV2_User_Guide.pdf

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

Unique reach IDs



Reach descriptors

- Elevation
- Slope
- %Landuse
- Precipitation

100's more…

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

LANDSCAPE CONSERVATION COOPERATIVES

NOAA

ACEMS

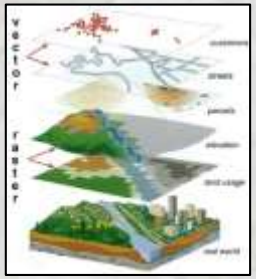
Boise Spatial Streams Group

FOREST SERVICE US

USGS

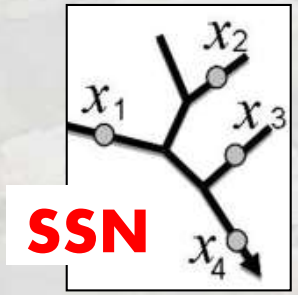
NSI Resources

NSI hydrography network (shapefiles)



Databases of stream reach descriptors

Databases of stream measurements



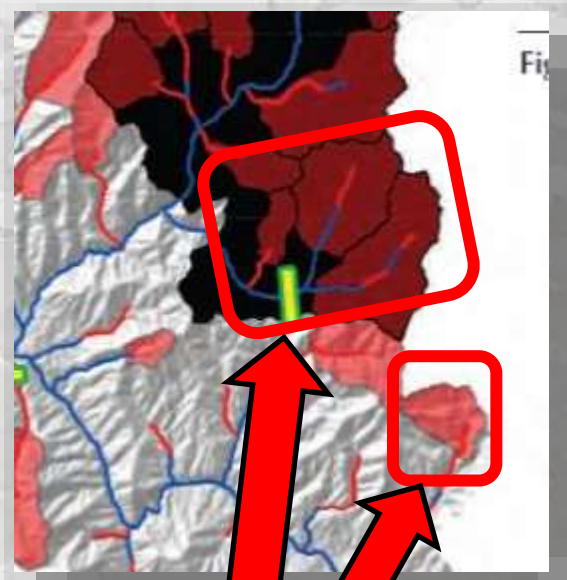
Spatial stream-network models

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