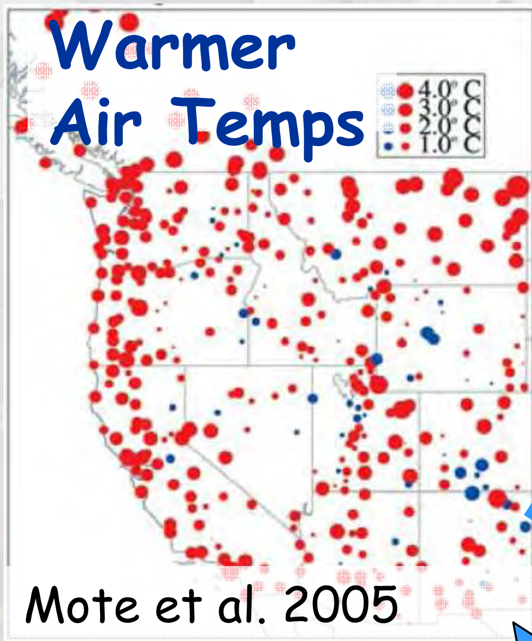
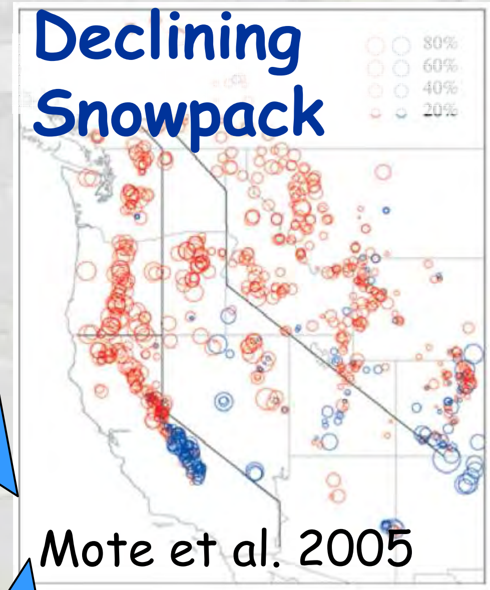
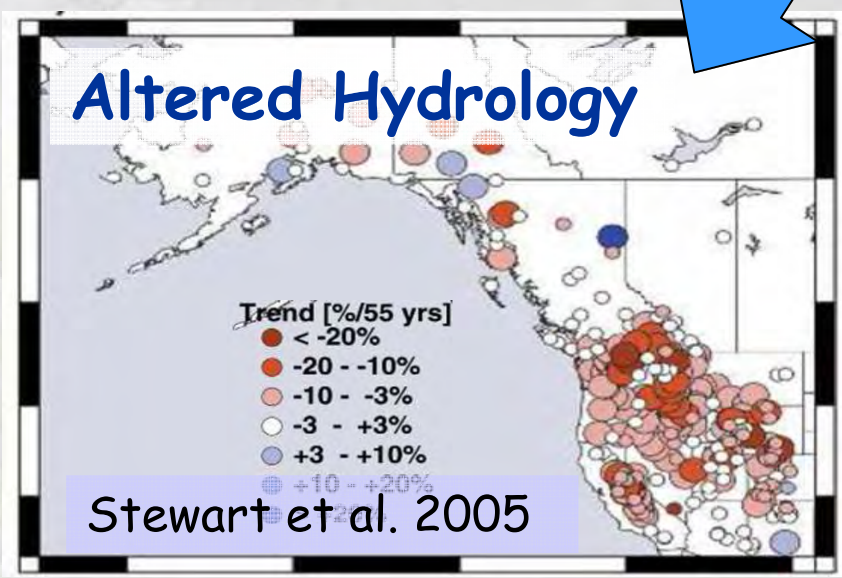
Western US – Observed Trends



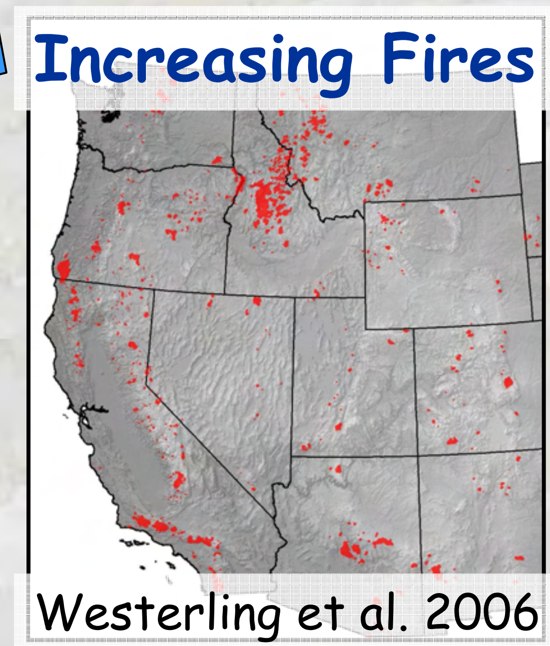
Mote et al. 2005



Mote et al. 2005

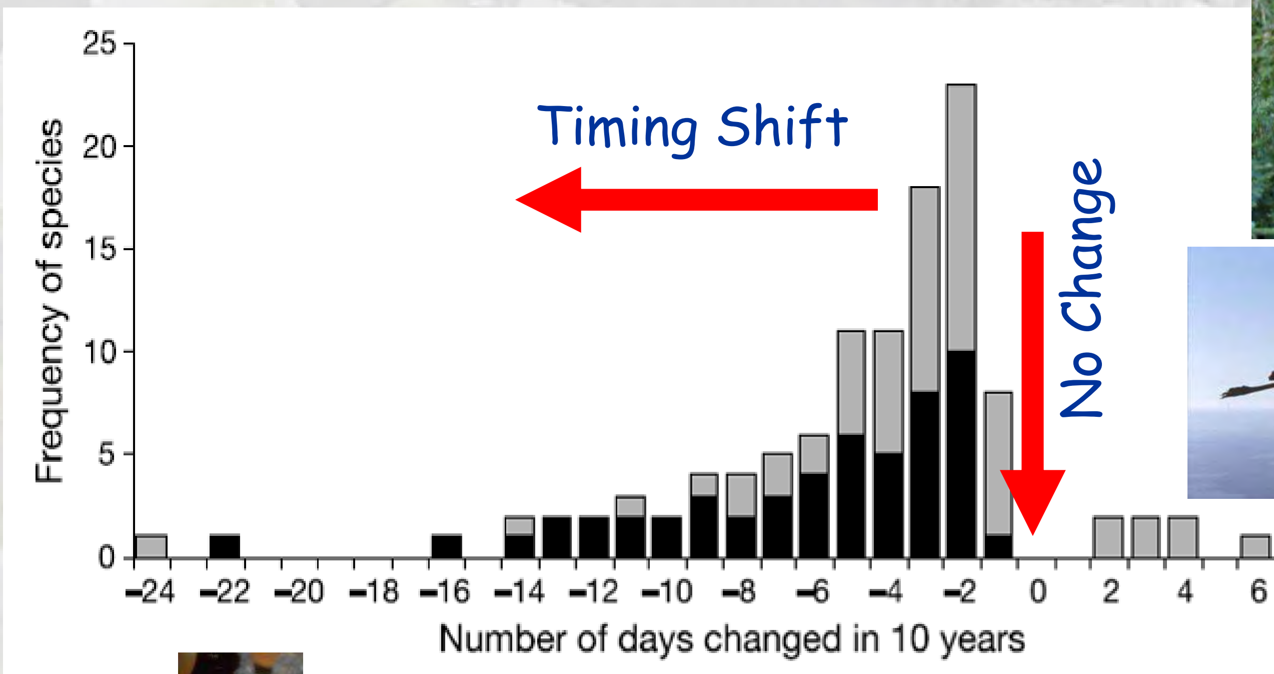


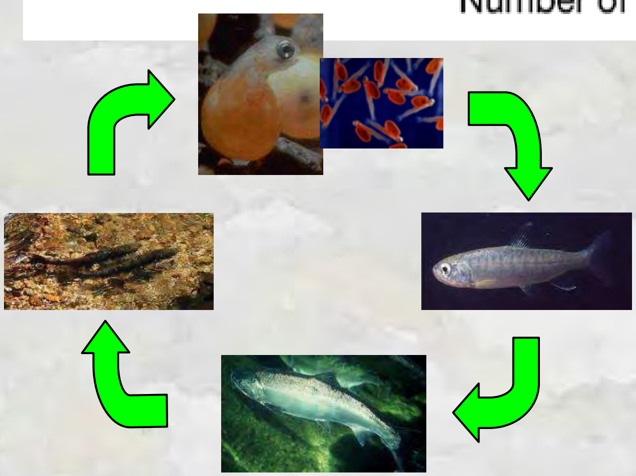
Stewart et al. 2005

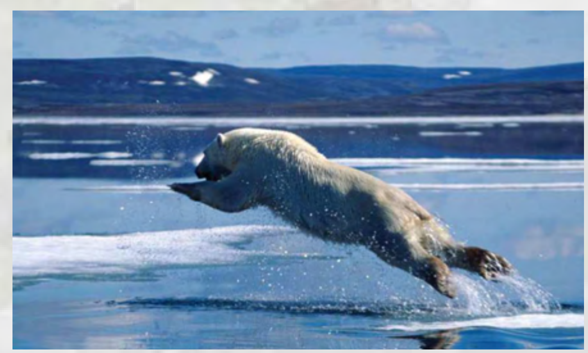


Westerling et al. 2006

Species Distributions are Shifting

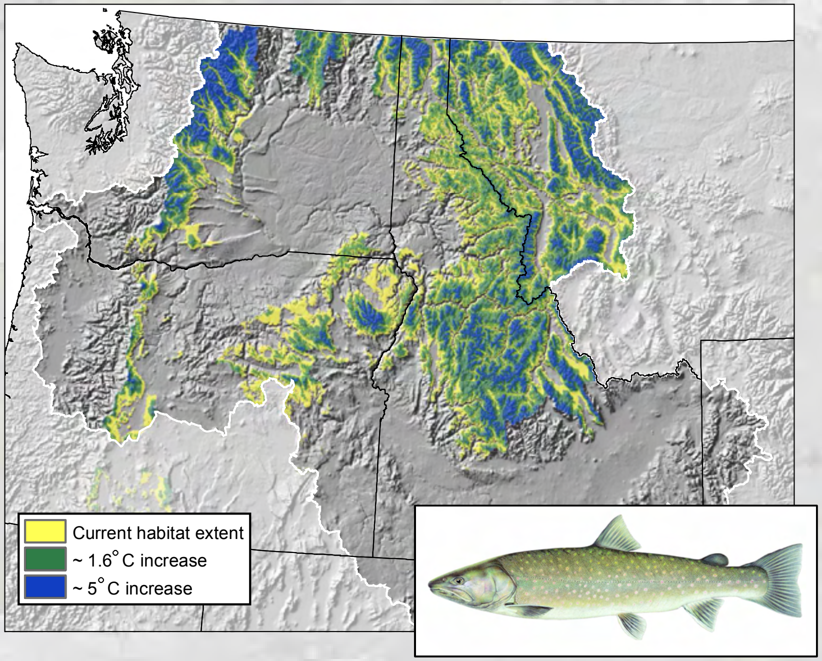




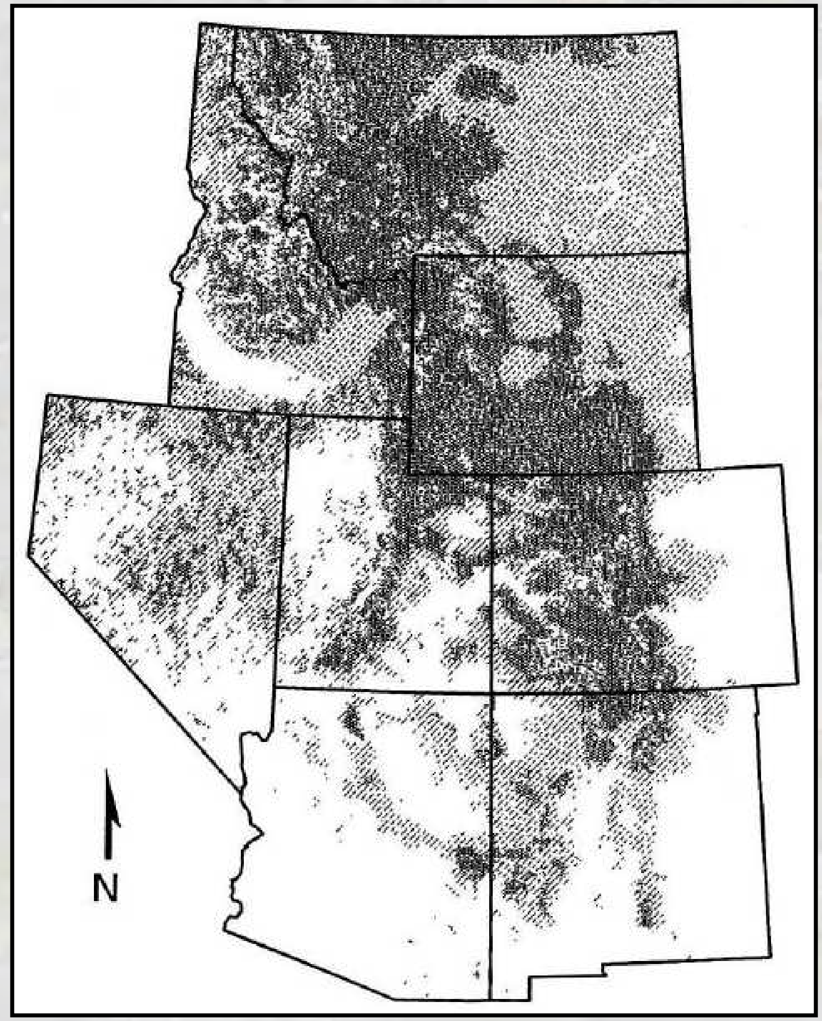


Root et al. 2003; Parmesan and Yohe 2003

Potential Changes in Salmonid Habitat

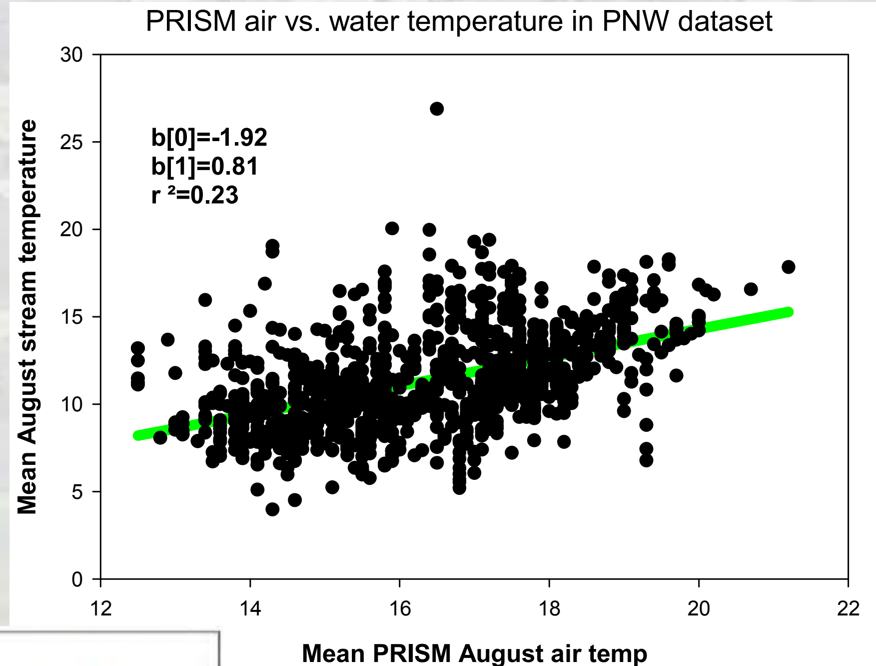


Rieman et al. 2007

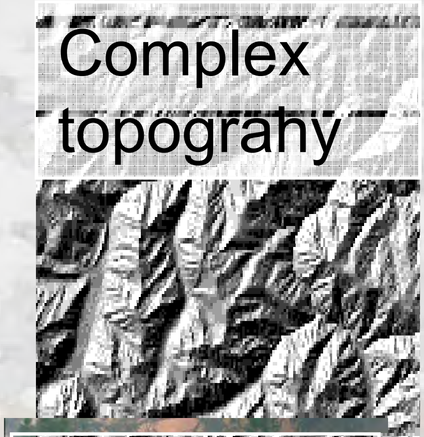


Keleher & Rahel 1996

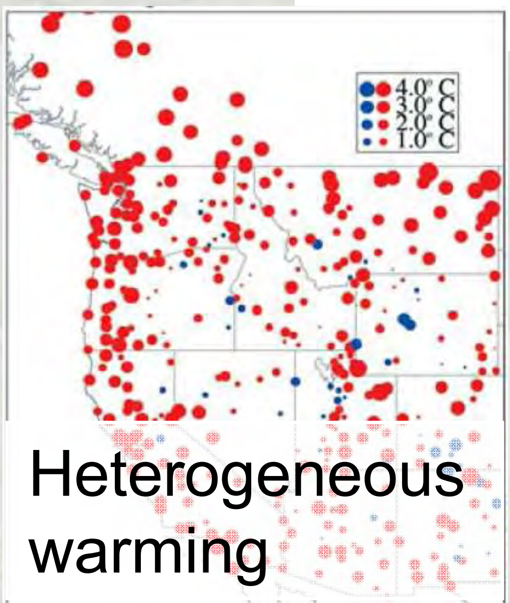
Air Temp ≠ Water Temp



Complex topograhy



Wildfires

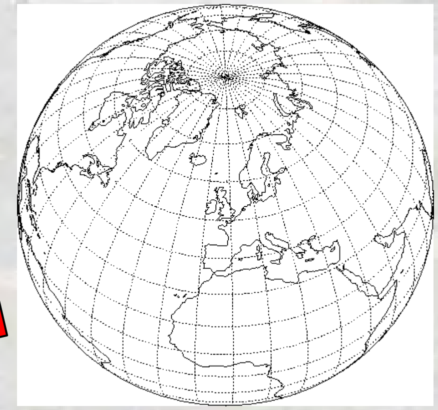


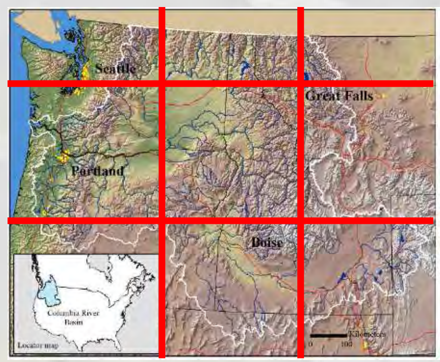
Heterogeneous warming

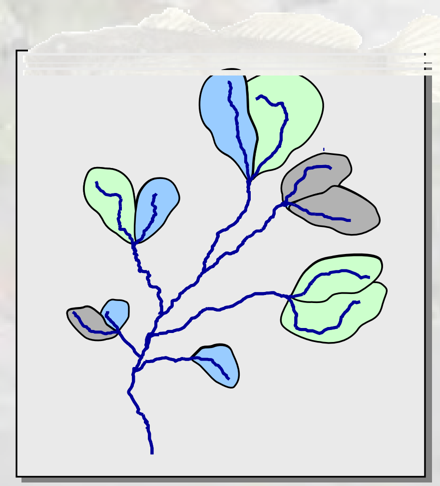
Riparian differences

Better Downscaling Needed

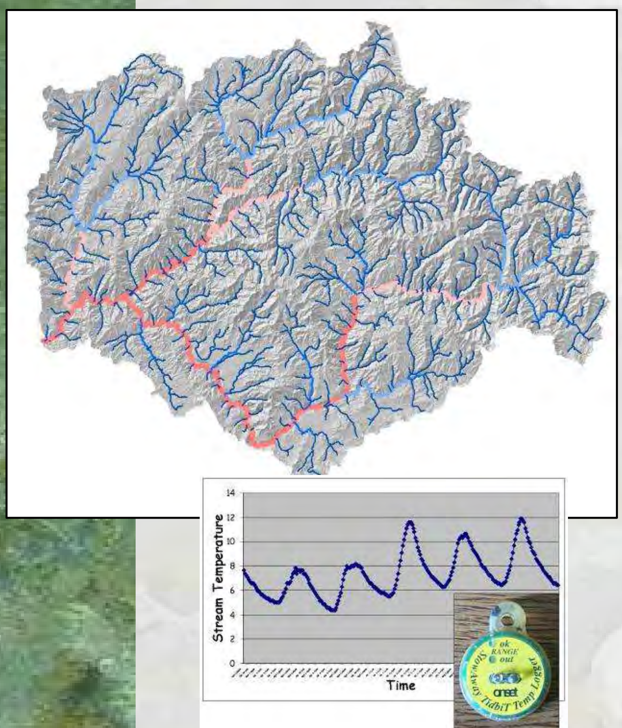
How will global trends affect my stream?







Downscaling climate and wildfire effects to assess thermal gains in stream networks



Dan Isaak, Charlie Luce, Bruce Rieman, Dave Nagel, Erin Peterson[1], Dona Horan, Sharon Parkes, and Gwynne Chandler

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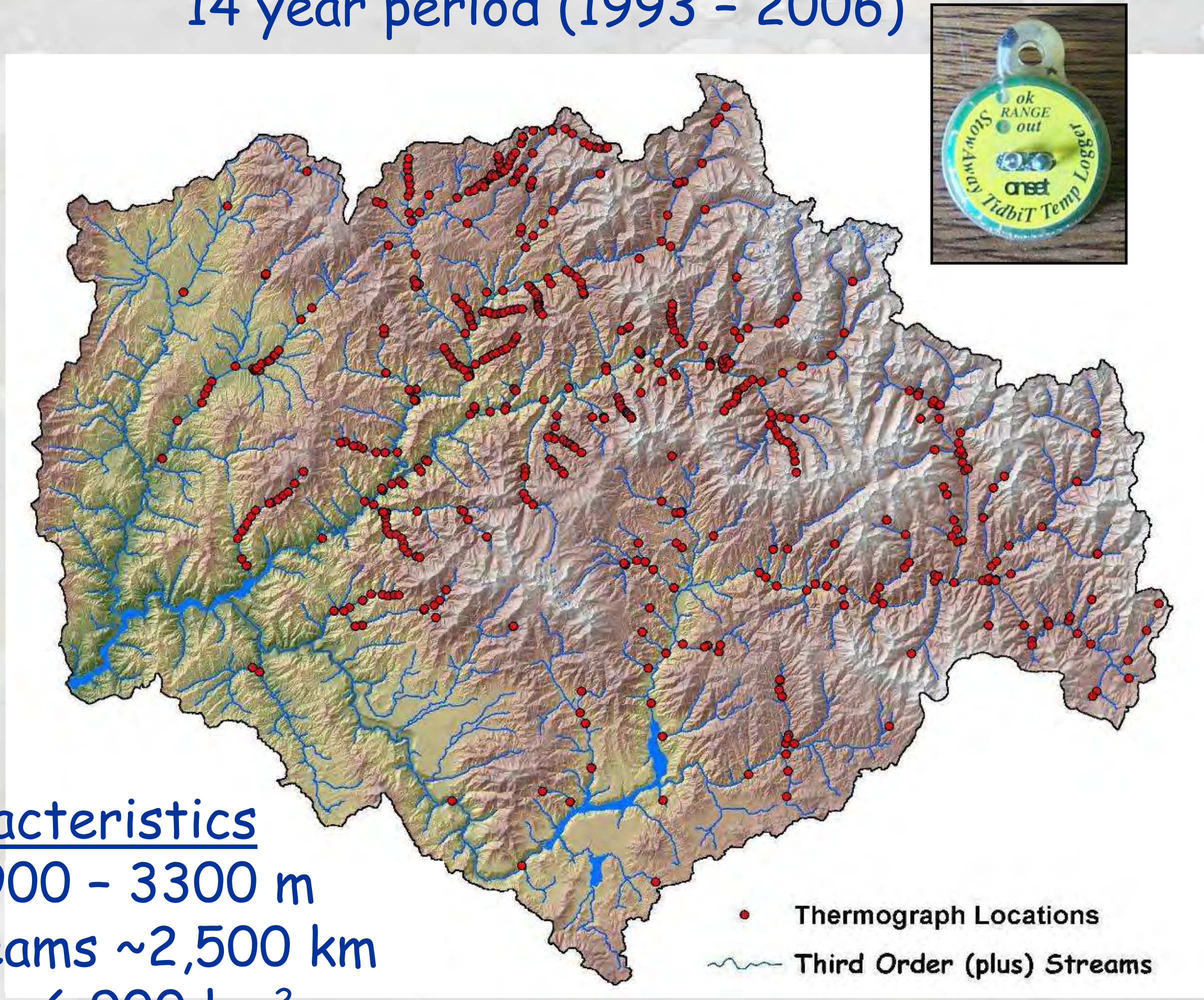
Indooroopilly, Queensland, Australia

Boise River Watershed

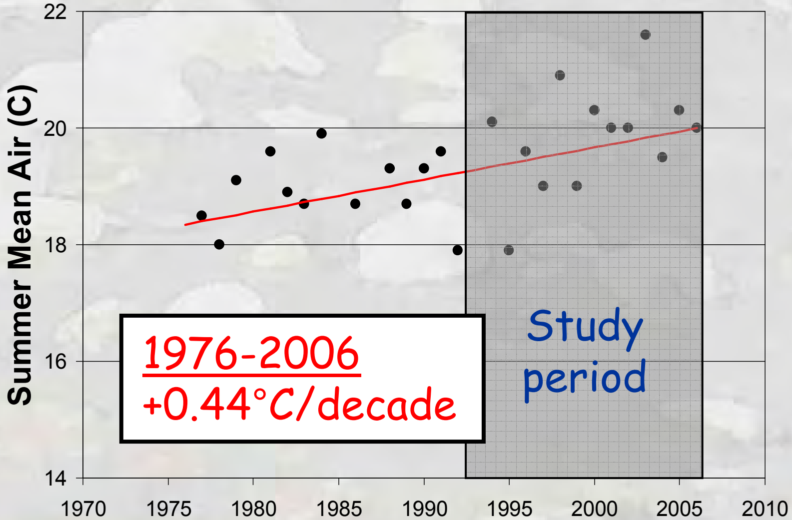
Stream Temperature Database
780 observations
518 unique locations
14 year period (1993 – 2006)



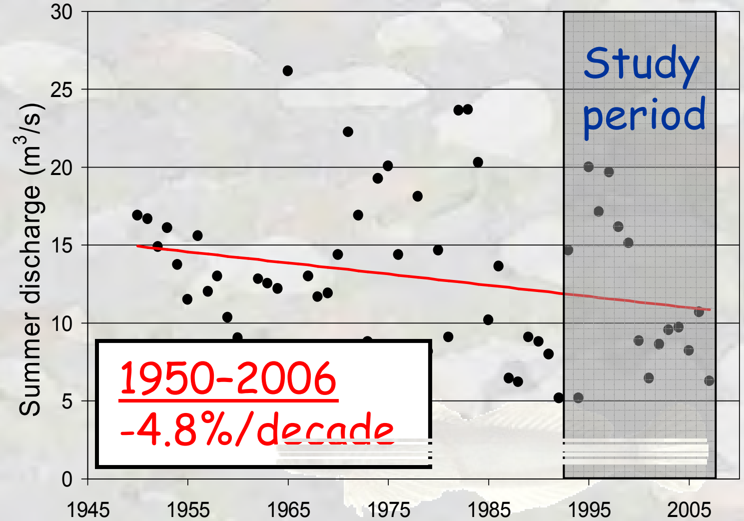
Watershed Characteristics
Elevation range 900 – 3300 m
Fish bearing streams ~2,500 km
Watershed area = 6,900 km^2

A Landscape Undergoing Change

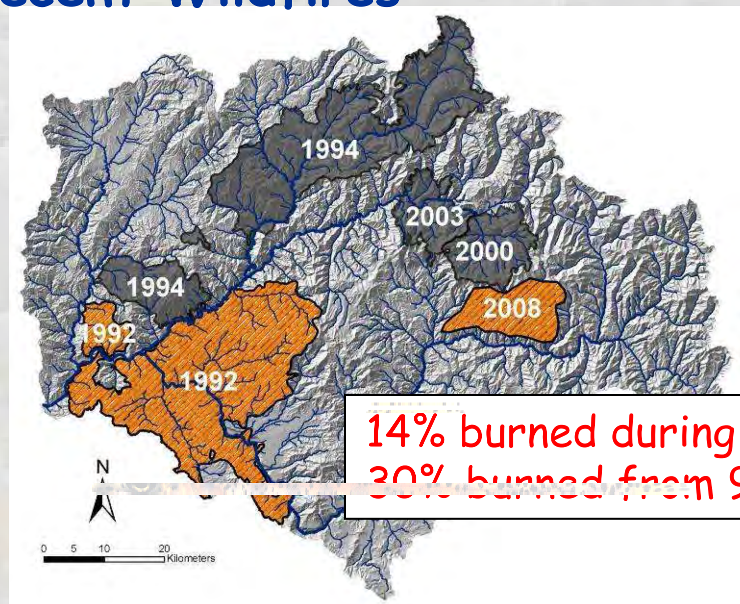
Air Temperature Trend



Stream Flow Trend

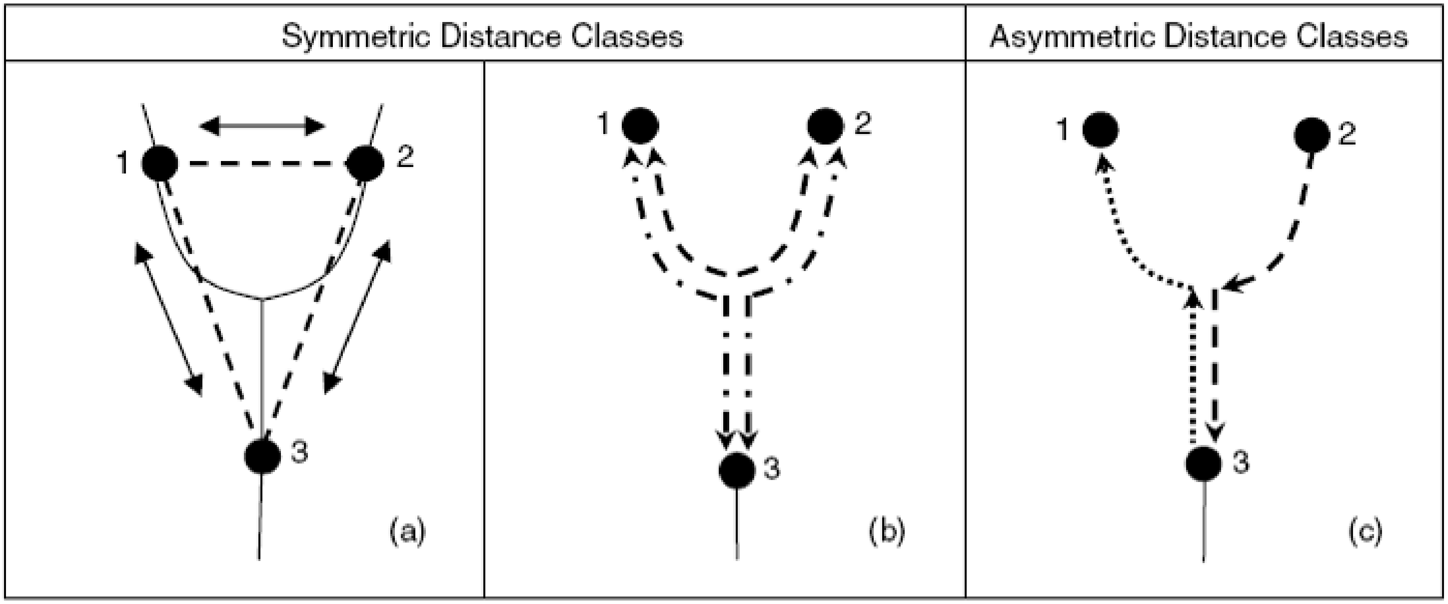


Recent Wildfires



14% burned during 93-06 study period
30% burned from 92-08

Spatial Statistical Models for Stream Networks



Advantages:

-flexible covariance structures account for different spatial autocorrelations

-weighting by stream size

-improved predictive ability & parameter estimates relative to non spatial models

Peterson et al. 2006; Ver Hoef et al. 2006

Response Variable

Summer Mean (average temperature July 15 – Sept 15)

Stream MWMT (highest 7-day moving average of the maximum daily temperatures)

Predictor Variables

Geomorphic attributes (DEM derived)

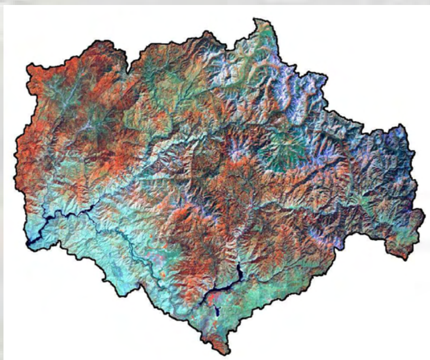
-basin elevation
-basin size
-reach slope
-glaciated valley extent
-alluviated/flat valley extent

Climate attributes (3 weather & 2 flow stations)

-annual summer mean discharge
-annual air mean & MWMT

Solar radiation (TM satellite imagery pre- & postfire)

Solar Radiation Estimates from Remote Sensing

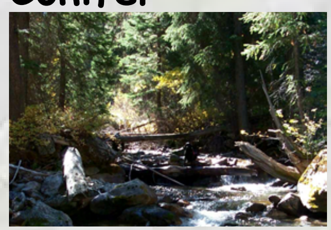


TM satellite imagery classifies riparian vegetation pre- & postfire into (open, shrub, conifer)

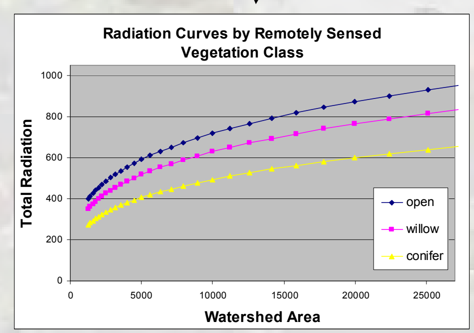
Open

Willow

Conifer



Canopy Photography estimates site-level radiation for each class (181 sites)



Radiation curves by vegetation class

Predicted annual radiation throughout network

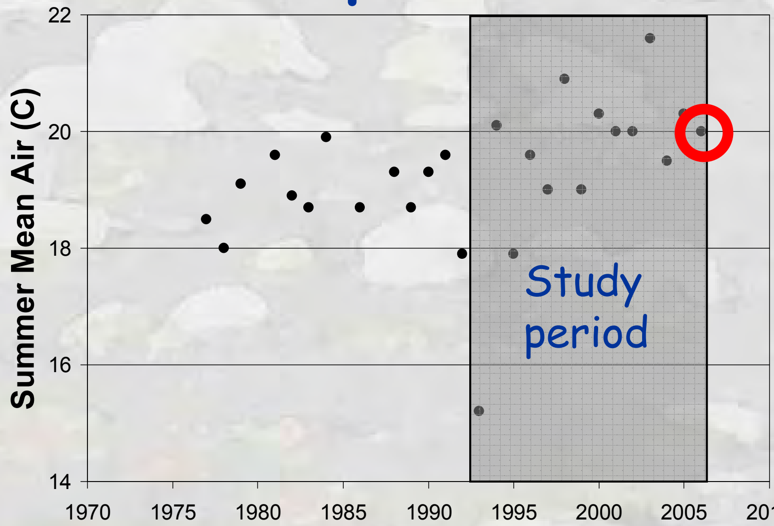
Model Results

Summer Mean Stream Temperature

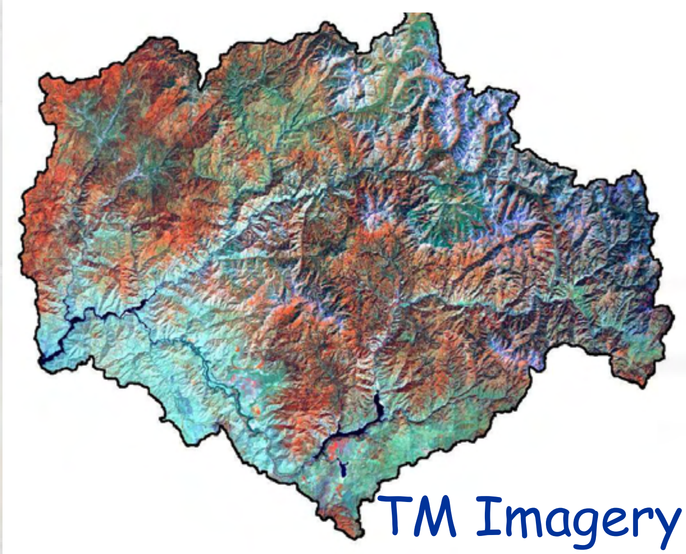
Model	Predictors	RMSE	ΔAICc	R^2	Variance Component: Fixed Effect	Variance Component: Spatial Error
Spatial	Elevation, Radiation, Air Temp, Flow	0.74	0	0.93	0.73	0.27
Non spatial	Elevation, Radiation, Air Temp, Flow	1.53	983	0.68	1.00	--

Predicting 2006 Stream Temperatures

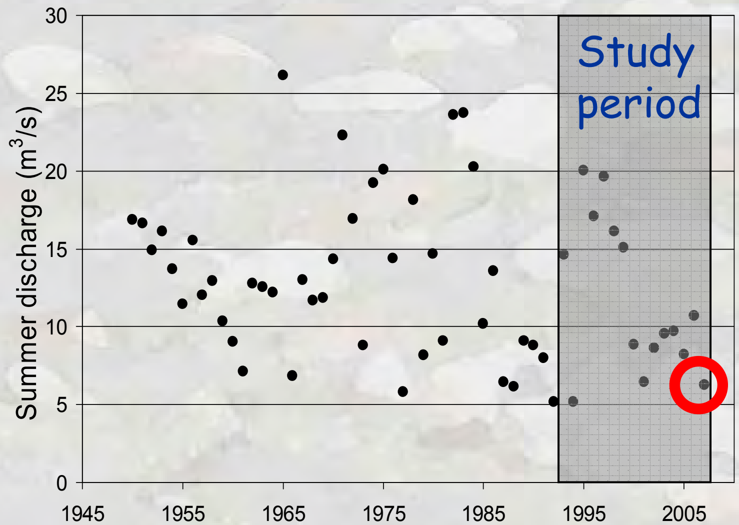
Air Temperature



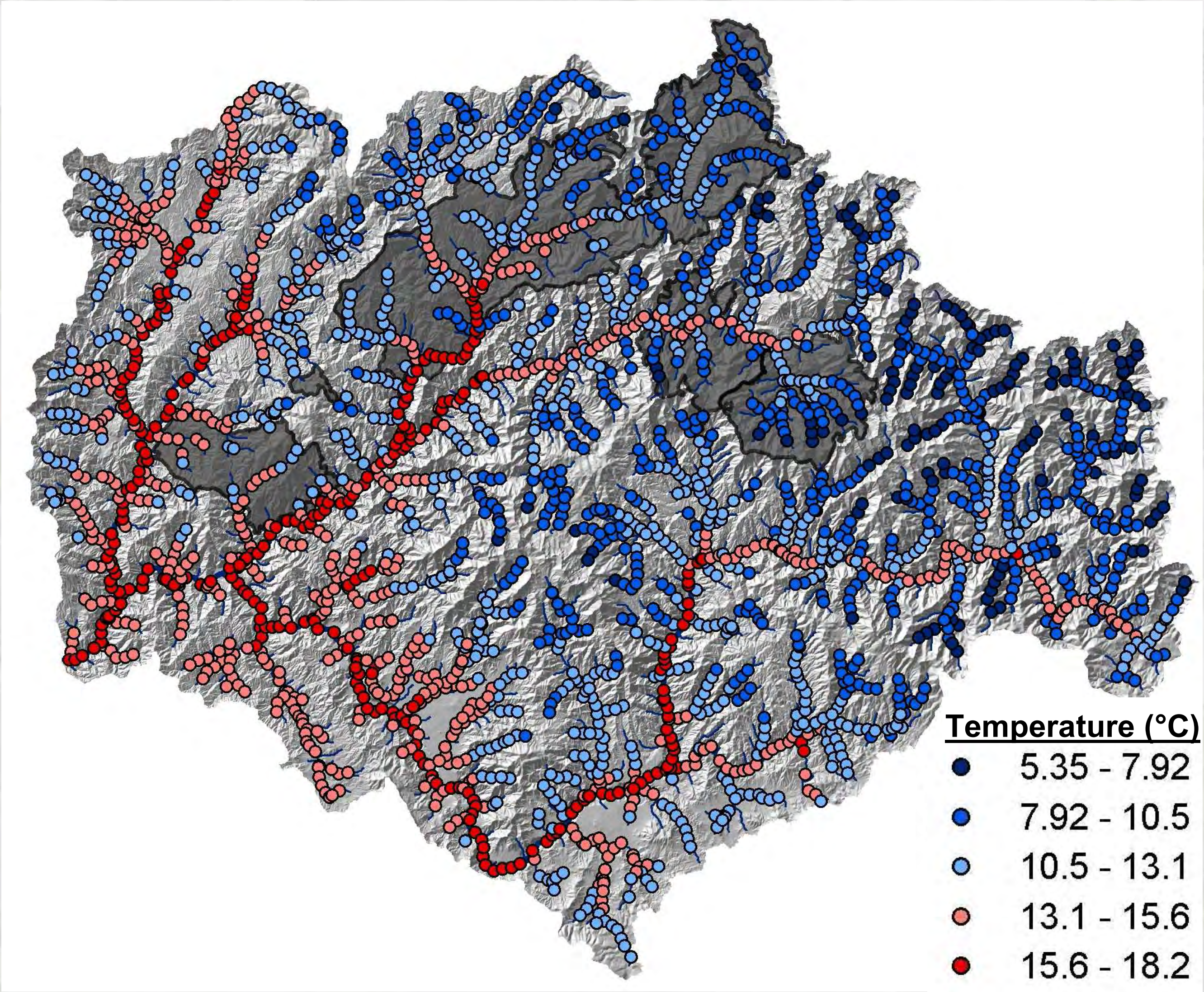
Radiation for 2006



Stream Flow

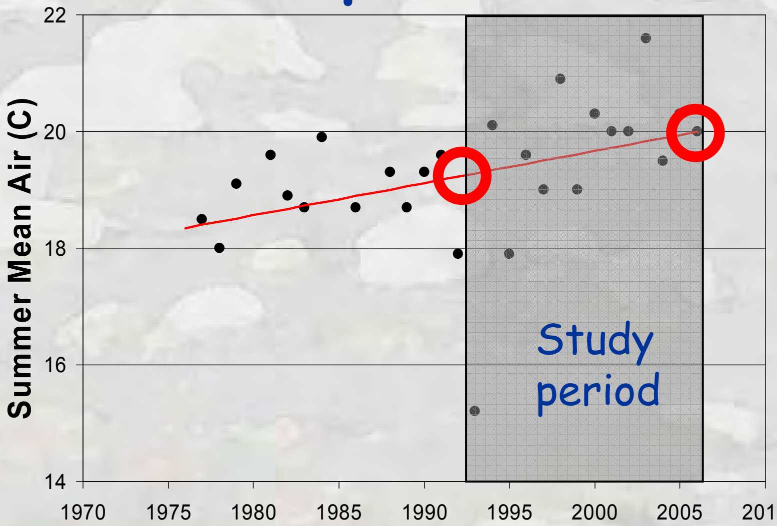


2006 Mean Stream Temperatures

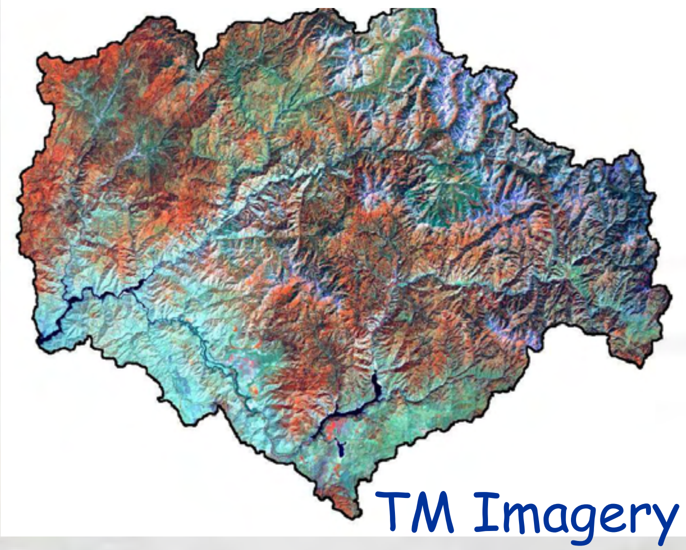


Determining Change from 1993-2006

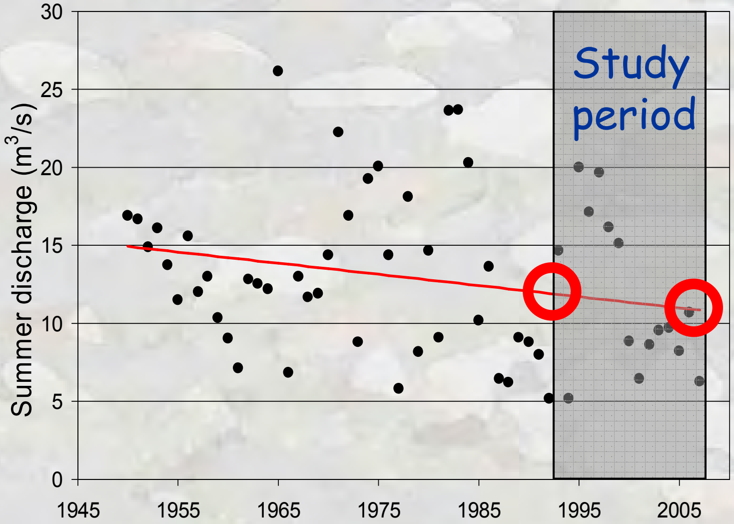
Air Temperature



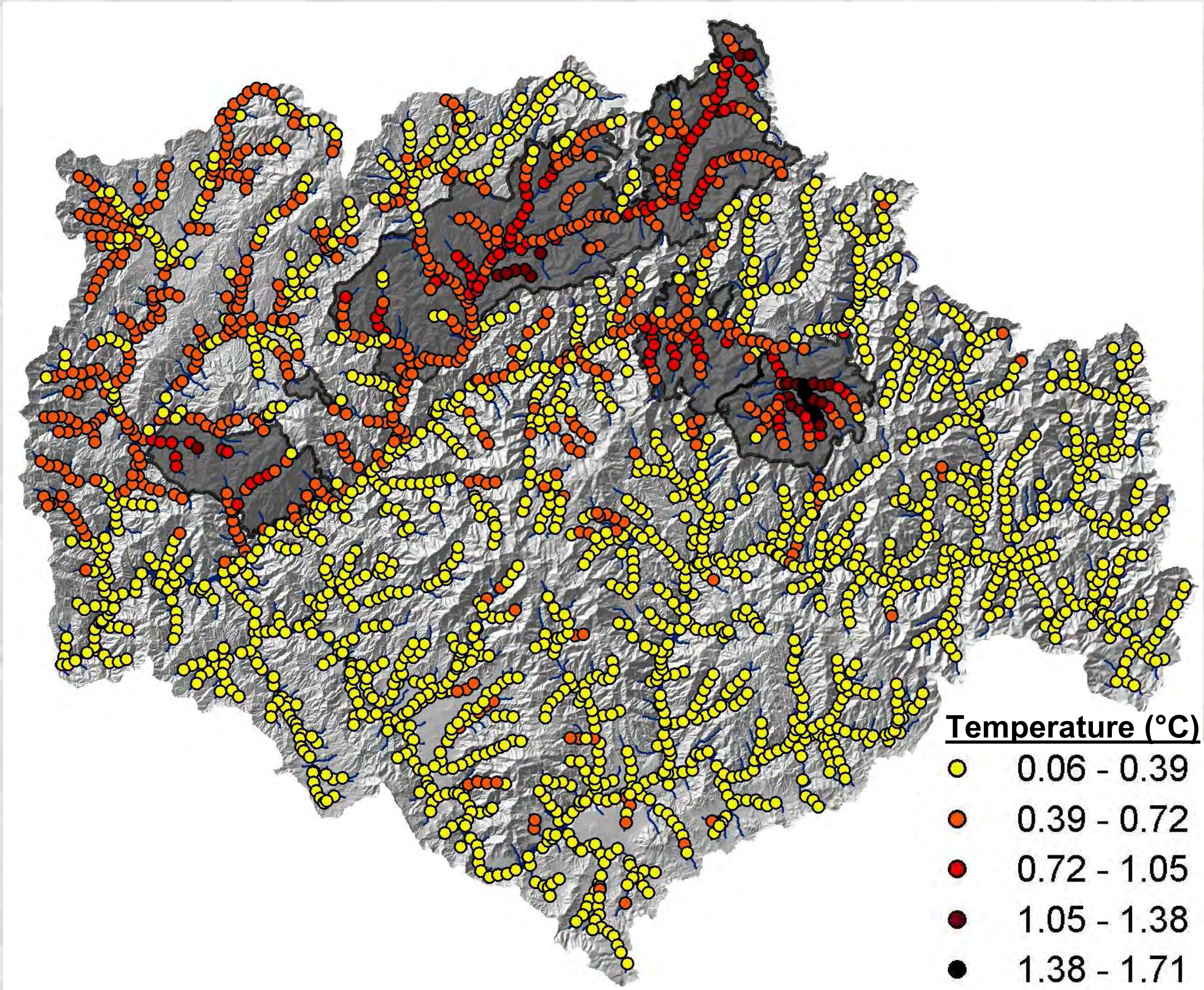
Radiation 93 - 06



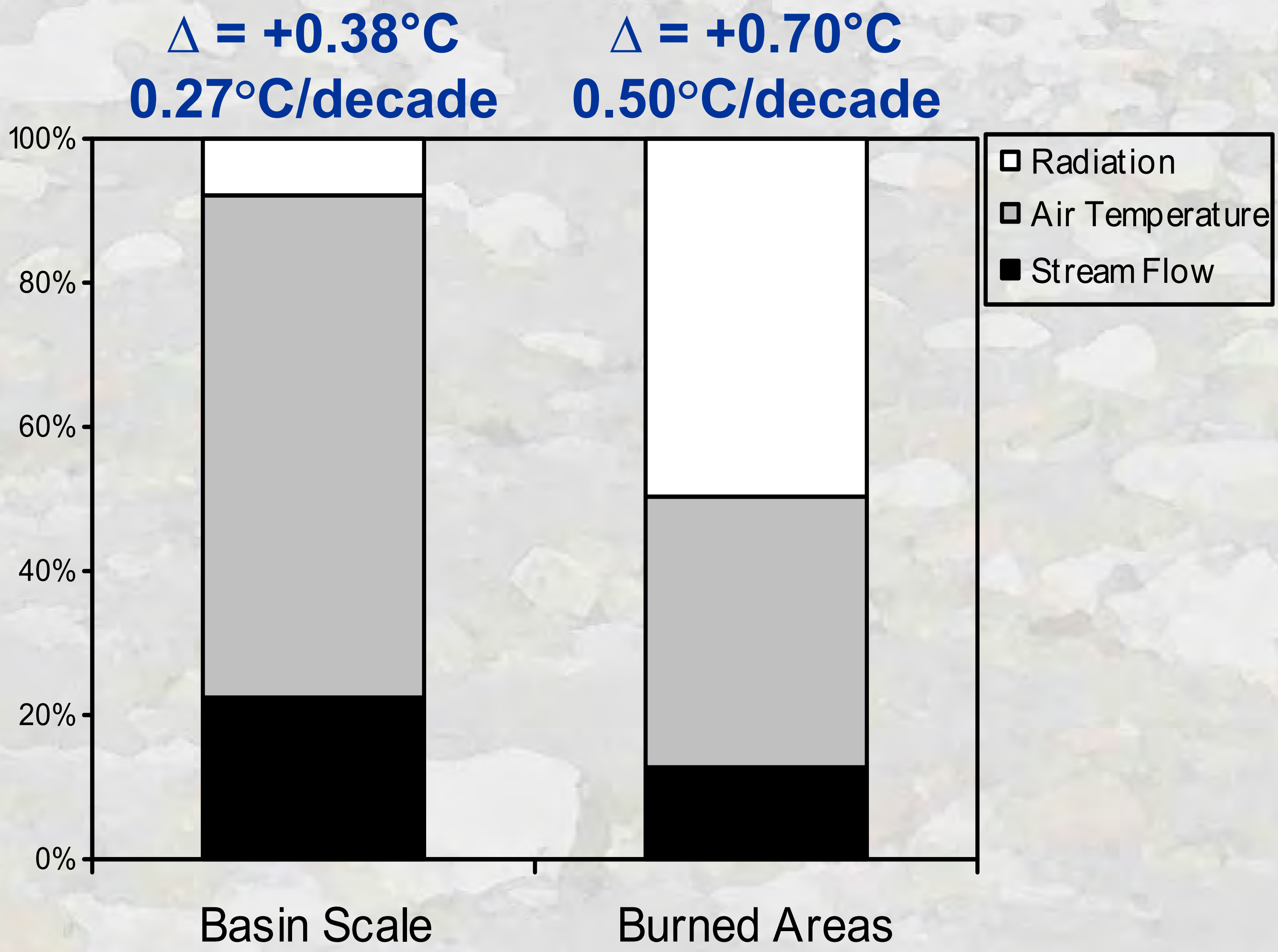
Stream Flow



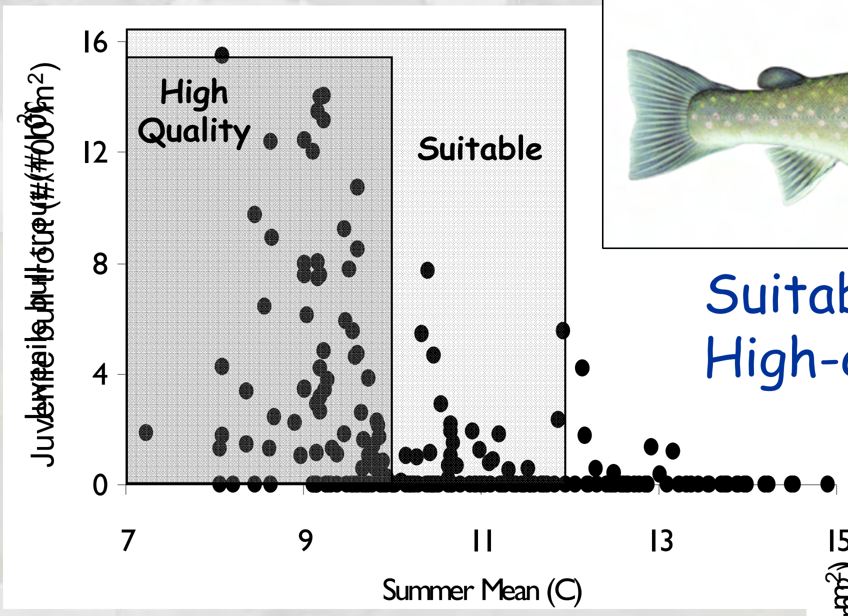
93-06 Stream Temperature Changes

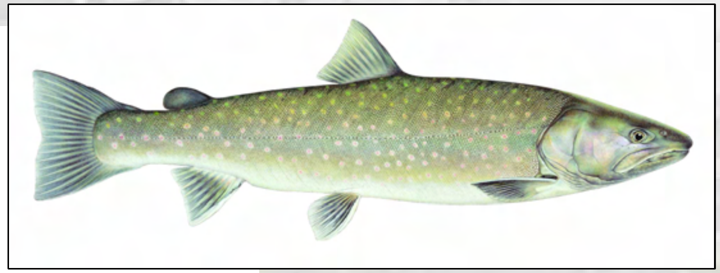


Basin-scale Temperature Increases

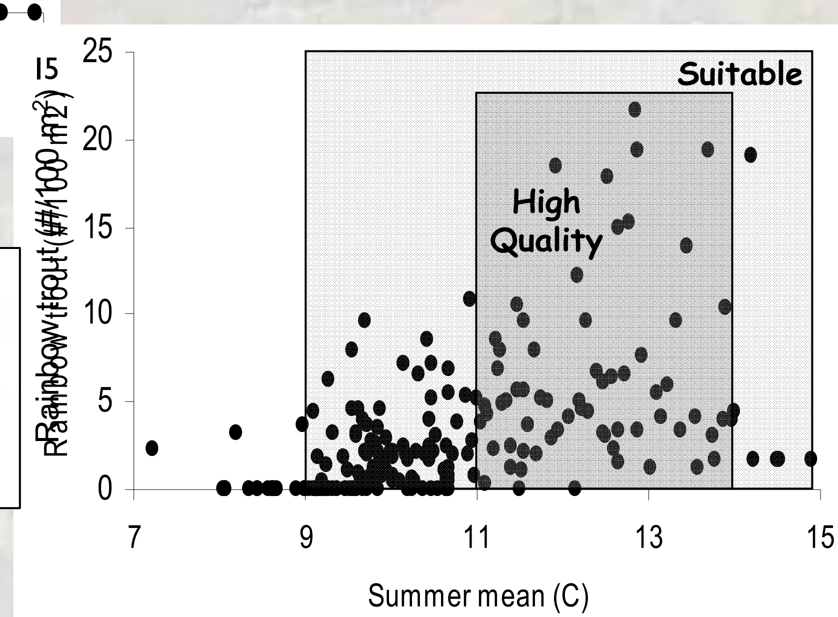


How Were Fish Habitats Affected?





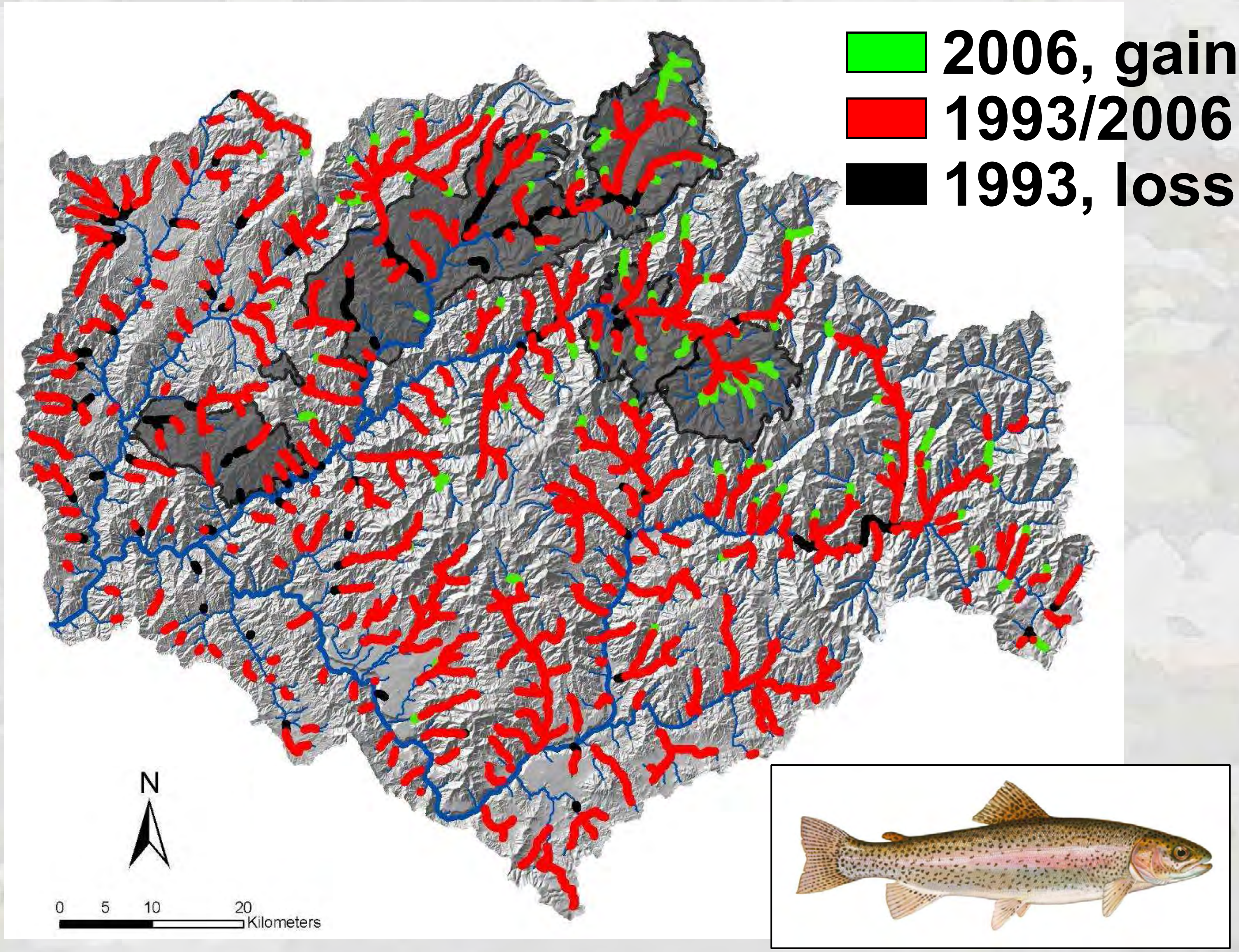
Suitable habitat < 12.0°C
High-quality habitat < 10.0°C



Suitable habitat = > 9.0°C
High-quality habitat = 11.0-14.0°C

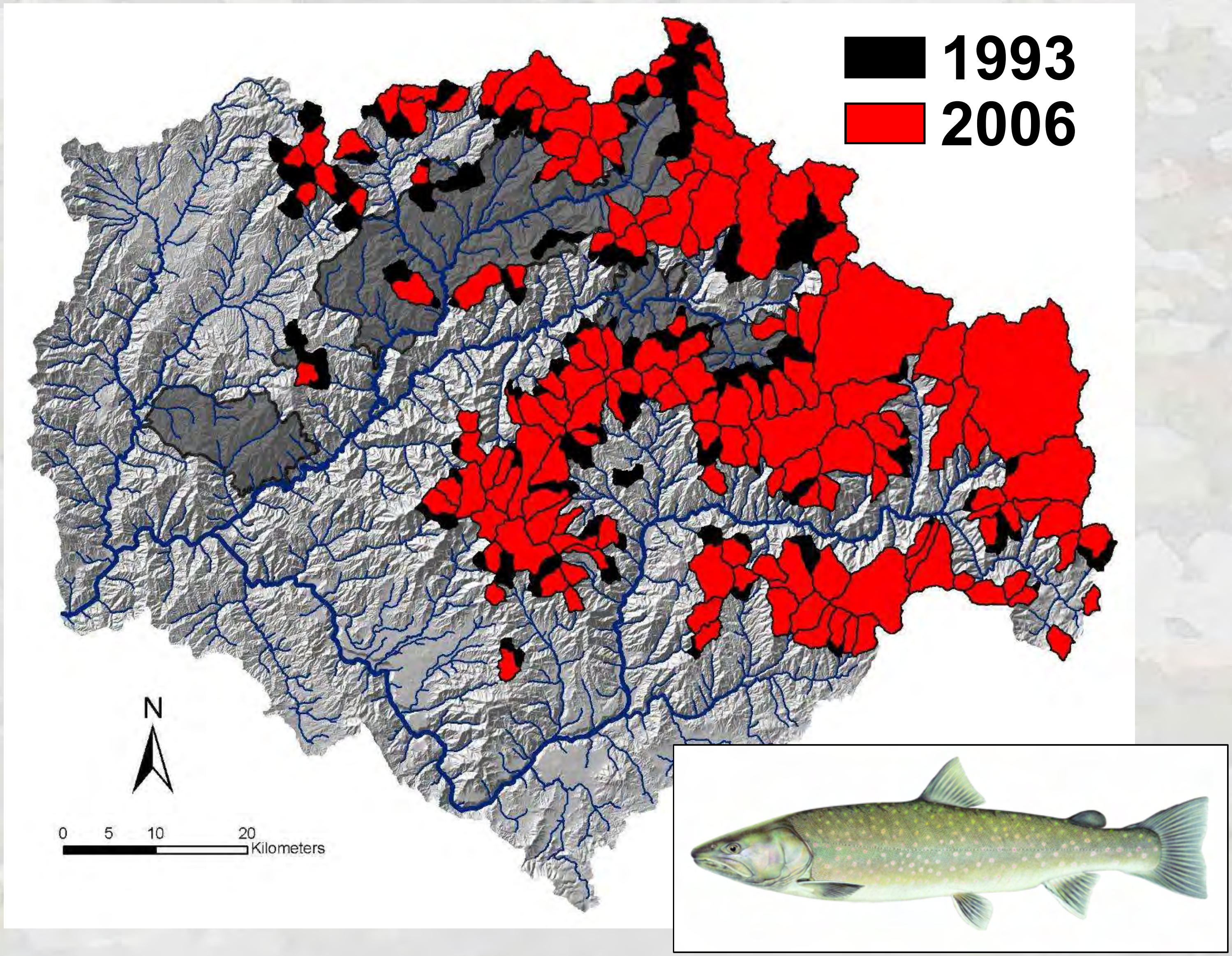
D. Isaak, unpublished data.

93-06 Rainbow Trout Habitat Changes



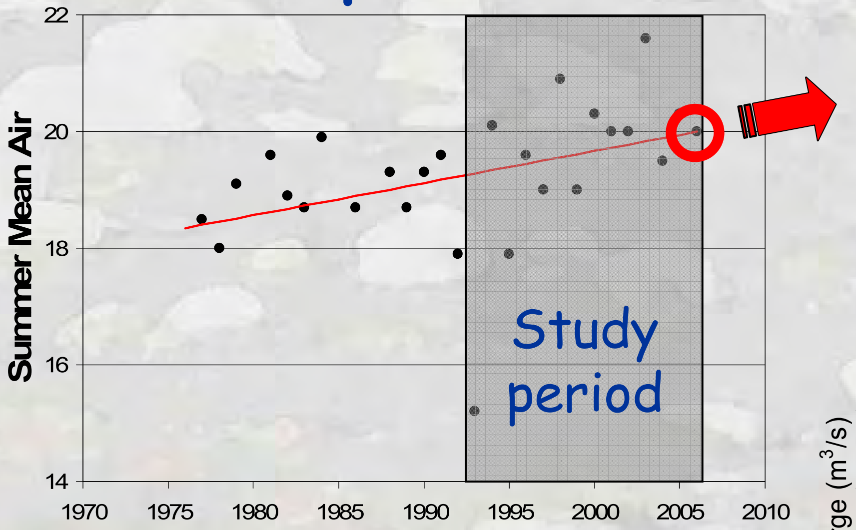
93-06 Bull Trout Habitat Changes

Habitat loss rate = 1.0 – 1.5%/year

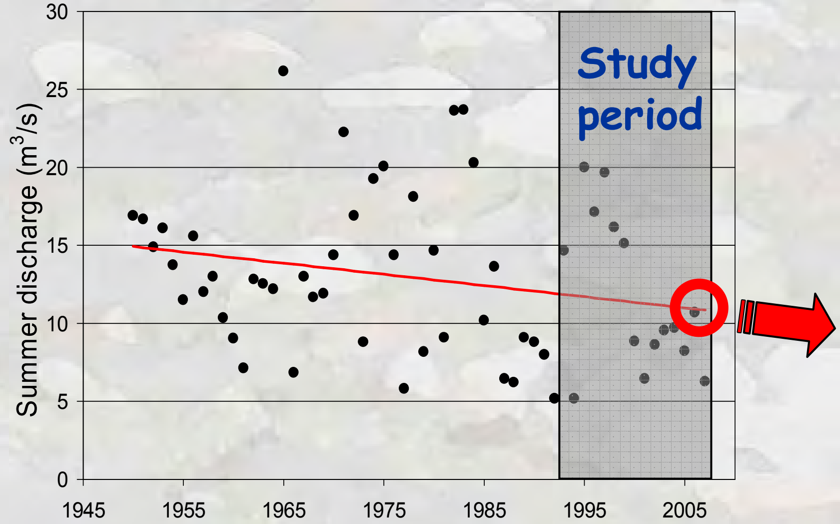


Predicting Future Changes

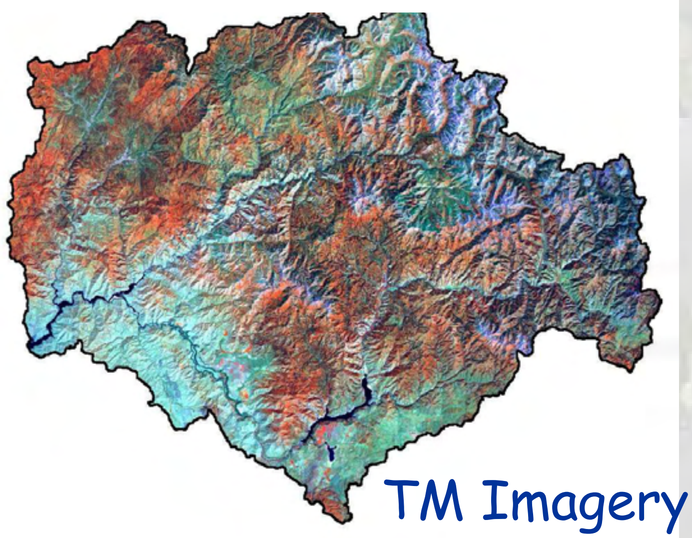
Air Temperature



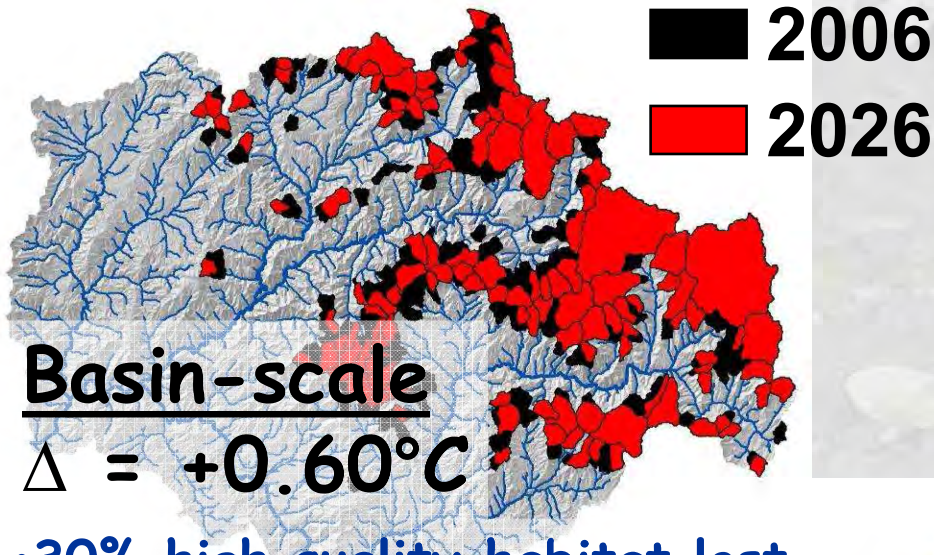
Stream Flow



Radiation for 1993



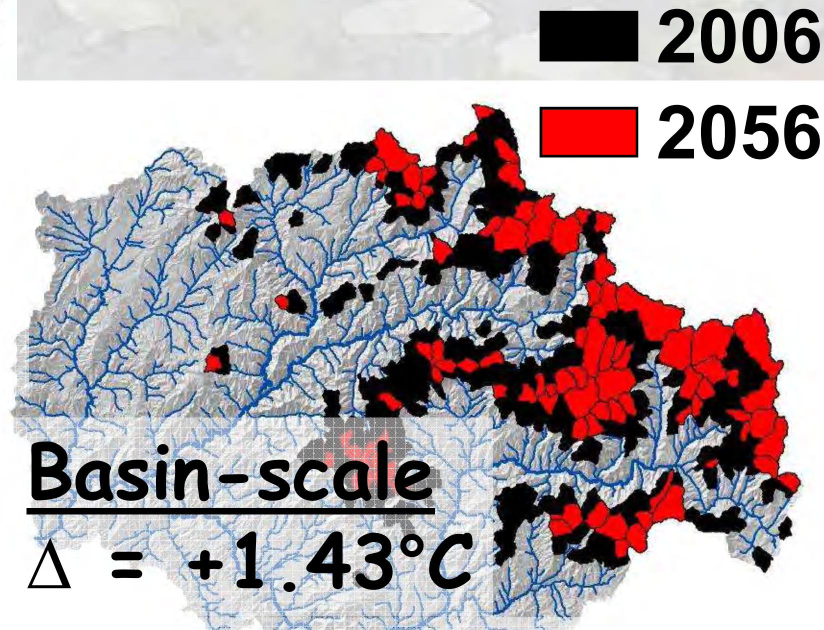
Future Bull Trout Habitat Changes



Basin-scale

Δ = +0.60°C

- 30% high quality habitat lost (1.5%/year)
- 16% suitable habitat lost (0.8%/year)

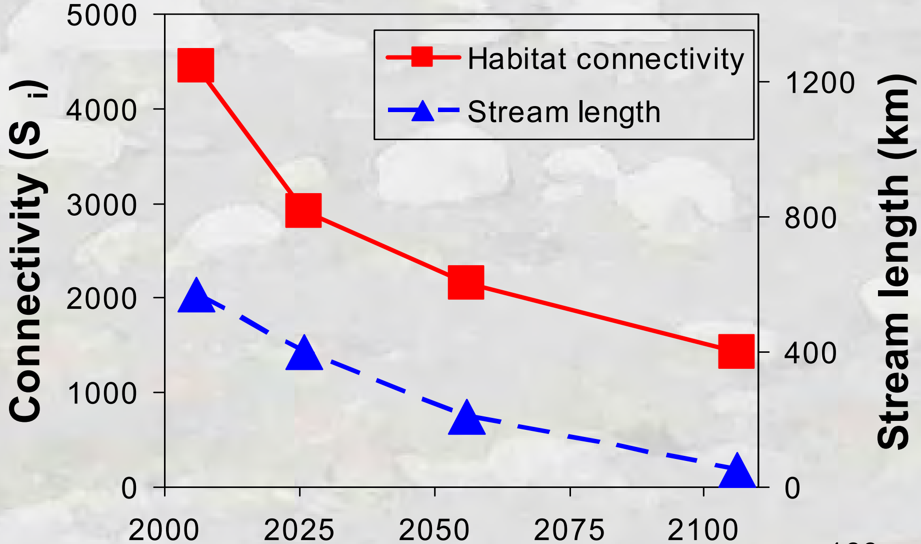


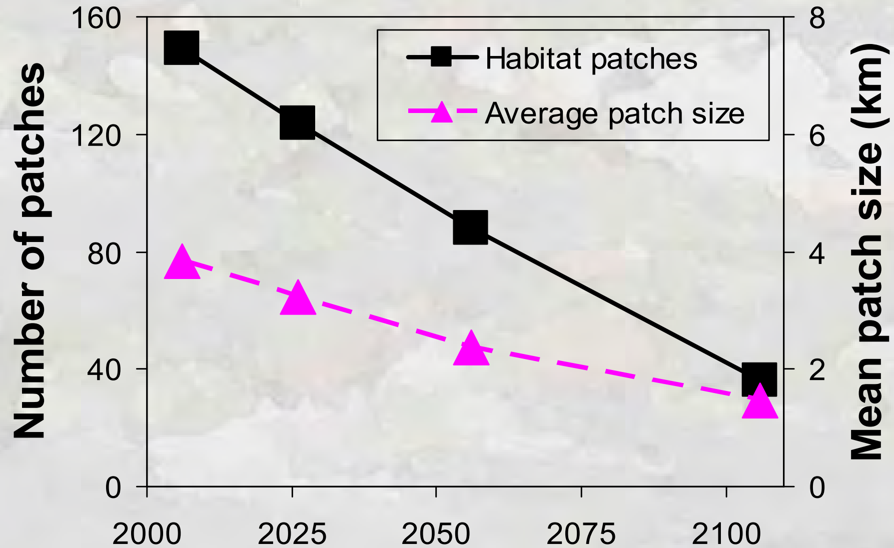
Basin-scale

Δ = +1.43°C

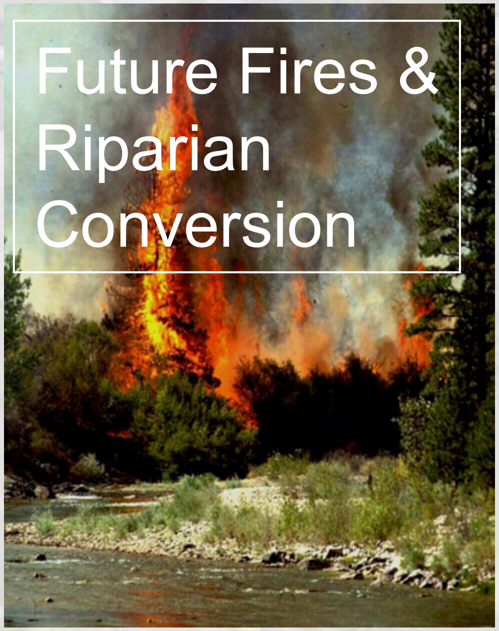
- 63% high quality habitat lost
- 39% suitable habitat lost

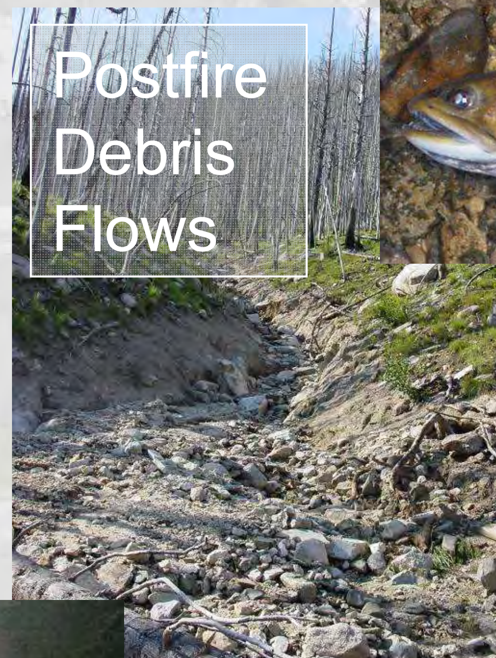
Future Bull Trout Habitat Changes

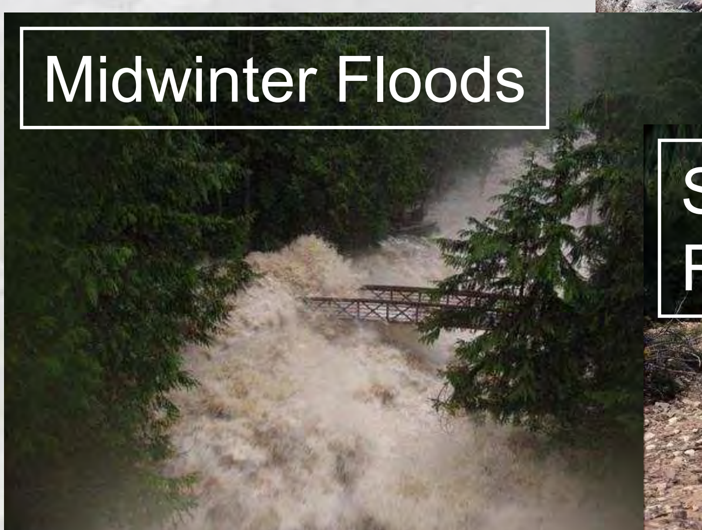


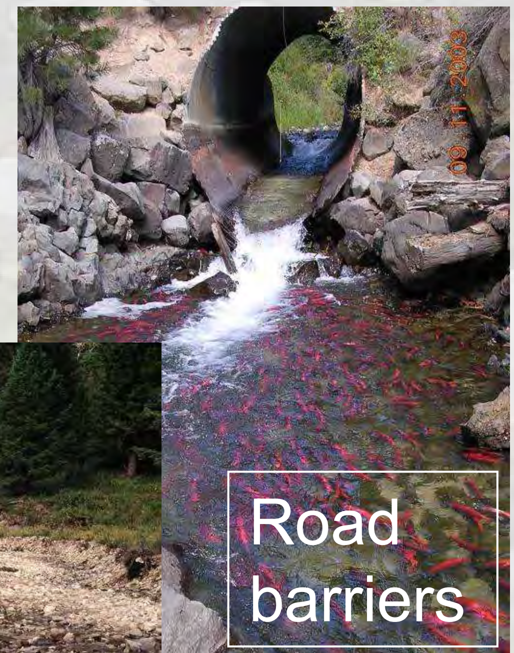


Are We Too Optimistic?









Mitigating Impacts of Temperature Increases

Thermal measures

•Maintain/restore riparian integrity, instream flows, & manage distribution/intensity of wildfires

•Heavily impacted streams may yield best results; 1 – 3°C temperature reductions could largely offset anticipated climate warming

Biological measures

•Barrier removals, assisted migrations

•Maintain diverse, productive habitats & populations

•Non-native species control

*****Strategic prioritization to be tactically smart & focus efforts where we can make a difference*****

Conclusions…

- Climate change is affecting thermal regimes & habitat distributions in western streams; Boise River network warming rate = 0.27°C/10y, primarily due to air temp increases & summer flow decreases.

- Thermally suitable habitats for bull trout in the Boise River network are being lost at 1% - 1.5%/y. Future changes in wildfire & other factors may make these estimates conservative.

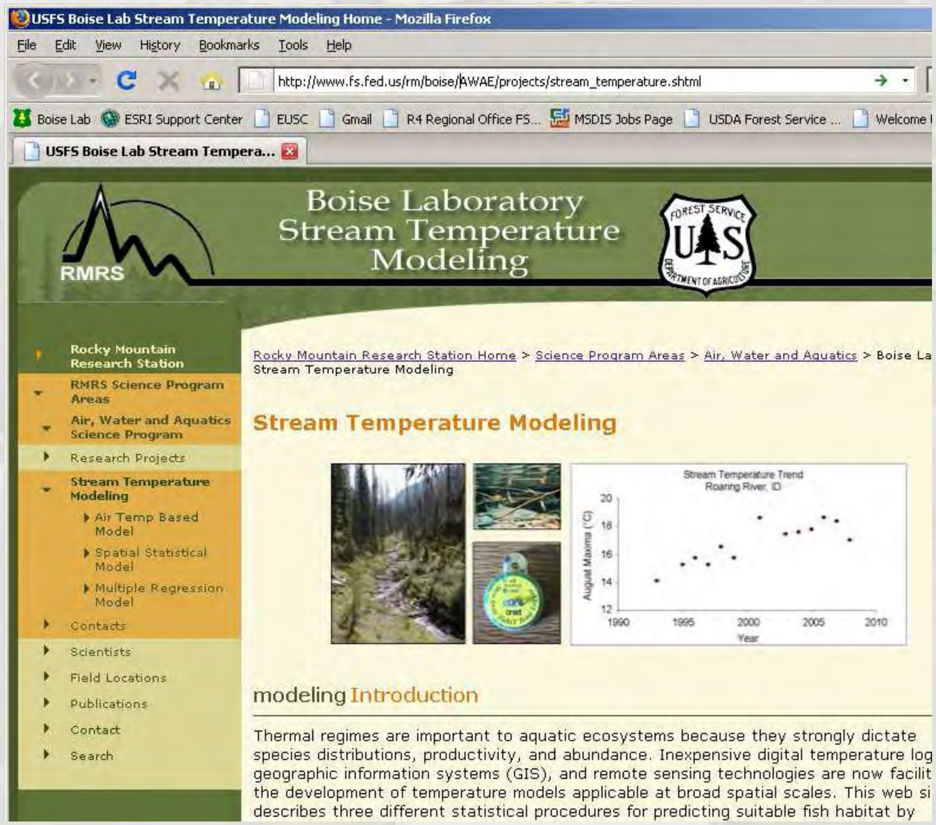
- Biological impacts will be species & context specific. Stenothermic species near their thermal maxima with fragmented distributions are most vulnerable.

- Biological validation & case histories of change needed to motivate decision makers and management agencies. Long-term time series of relevant biophysical attribute are invaluable.

- New spatial statistical models, GIS, remote sensing, and availability of stream temperature data make it possible to accurately predict thermal impacts of climate change on streams.

Stream temperature website:

www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml



- Stream temperature publications & detailed methodologies
- Spatial data layers for mapping results
- Processing macros for temperature data
- Online, searchable stream temperature database

US Forest Service

Rocky Mountain Research Station

BOISE AQUATIC SCIENCES LAB
RMRS