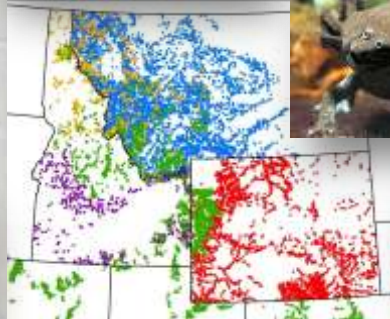
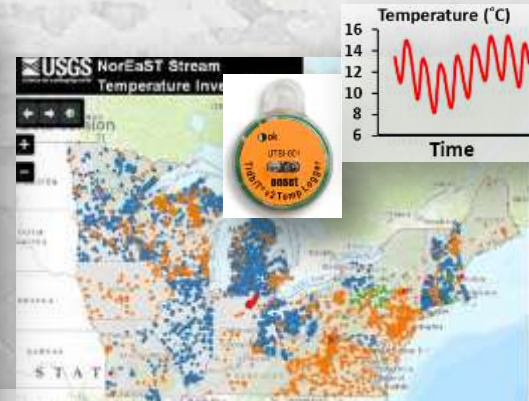
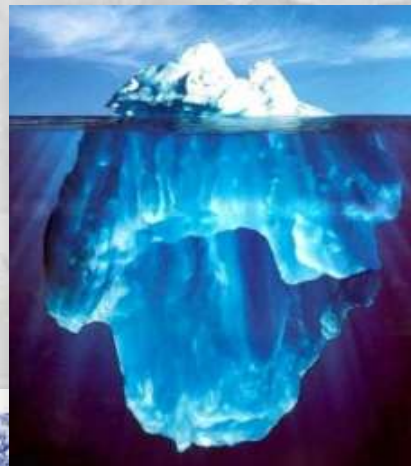


The National Stream Internet Project

BIG DATA = BIG POSSIBILITIES

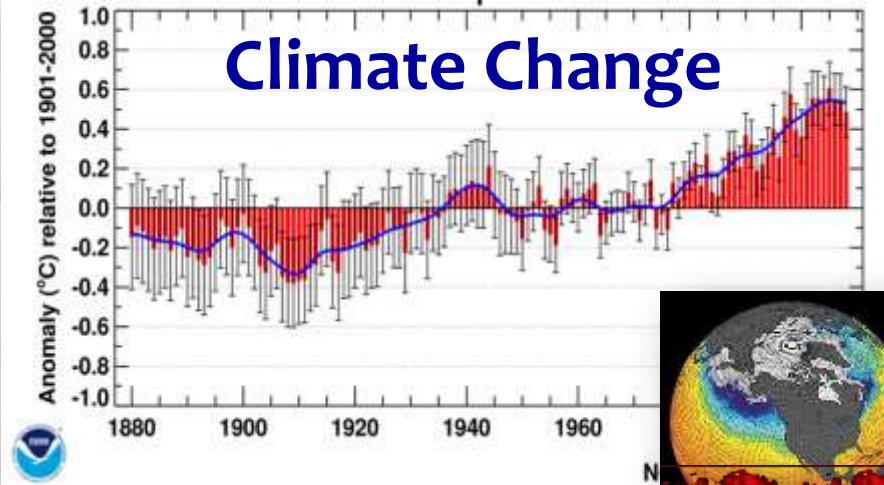


LANDSCAPE
CONSERVATION
COOPERATIVES

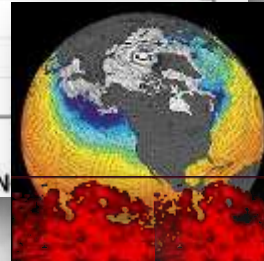


More Pressure, Fewer Resources

Climate Change



Urbanization & Population Growth



Shrinking Budgets



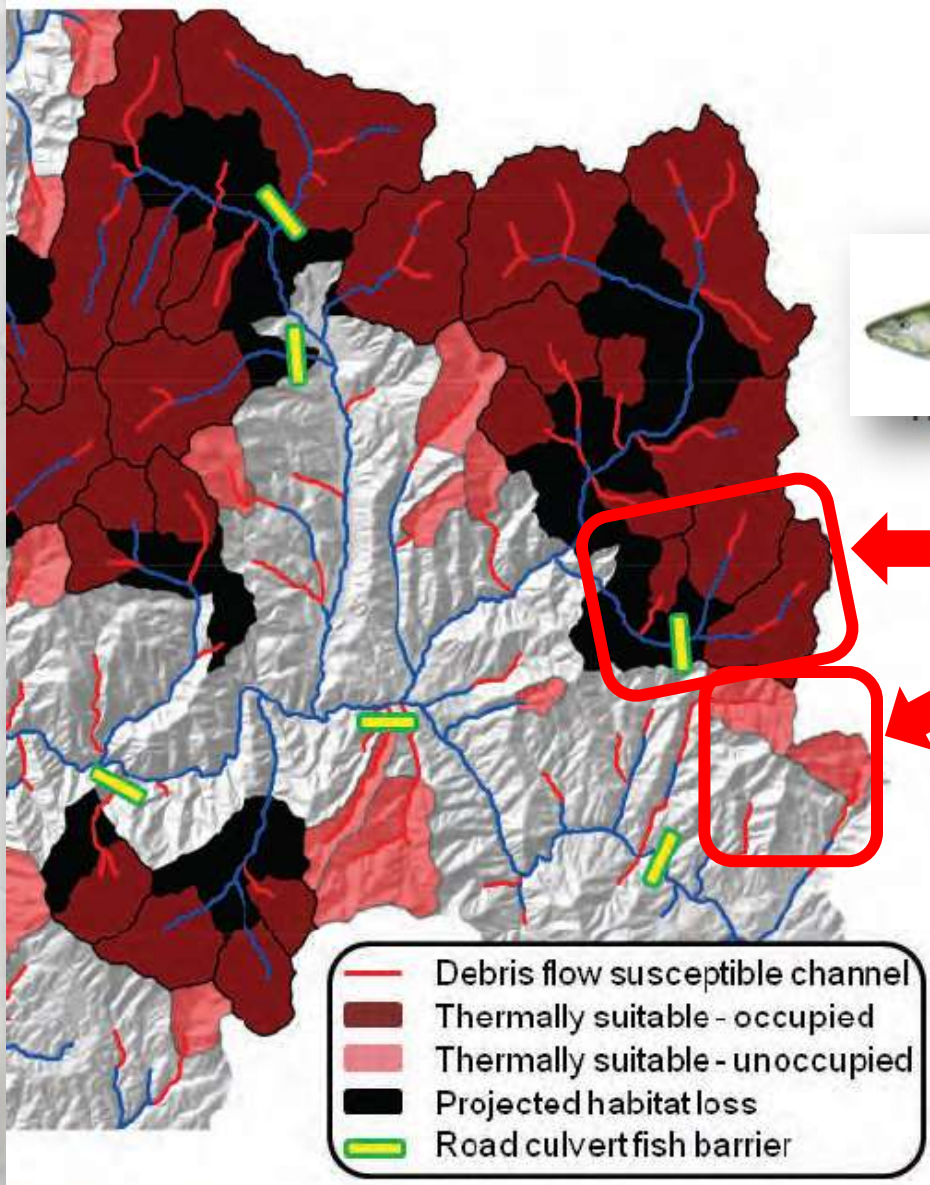
Need to do more with less



Strategically Consistent Information Across Broad Areas for Efficient Planning



Tactically Precise Information for Local Decisions & Project Implementation



I'm going to invest here...

... instead of here



A Stream Internet is...

A network of people, data, digital information systems & analytical techniques that interact synergistically to create & communicate massive amounts of “information” efficiently



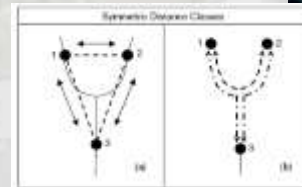
People on landscapes collecting data using standard protocols



Open access, comprehensive databases



Analysis & new information



Inter-Compatibility is Key...



Key Ingredient #1: NHD Streams

Nationally consistent geospatial database

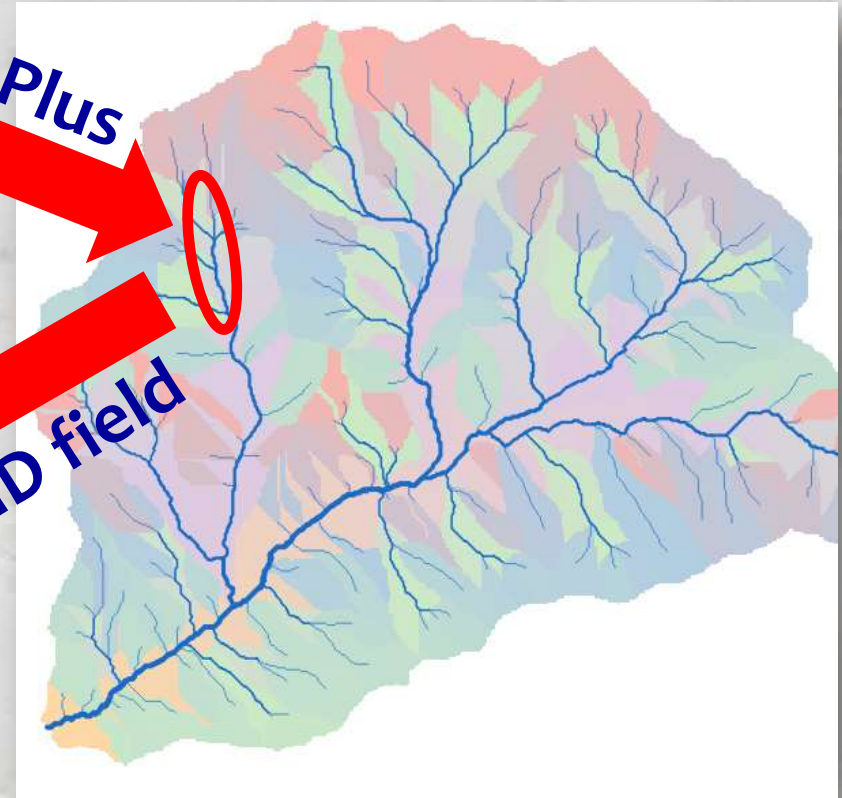


Cooter et al. 2010. A nationally consistent NHDPlus framework for identifying interstate waters: Implications for integrated assessments and interjurisdictional TMDLs. *Environmental Management* **46**:510-524.

Key Ingredient #2: The “PLUS” part of NHDPlus (Stream Reach Descriptors)



NHDPlus
COMID field



- 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.

#2. more "PLUSs" coming...

Environ Monit Assess (2009) 151:143–160
DOI 10.1007/s10661-008-0256-z

**Predicting the biological condition of streams:
use of geospatial indicators of natural and anthropogenic
characteristics of watersheds**

Daren M. Carlisle • James Falcone •
Michael R. Meador

COMID 1

COMID 3

COMID 2

Ecological Indicators 10 (2010) 264–273

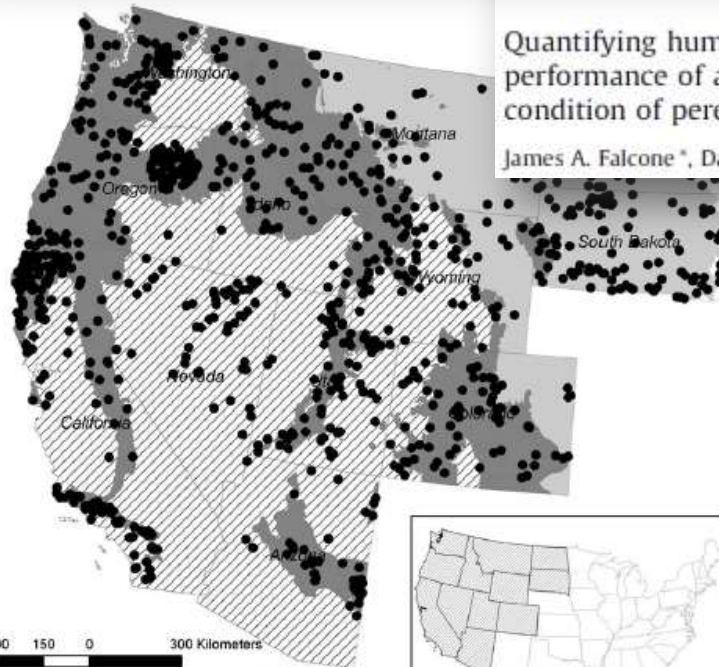
Contents lists available at ScienceDirect

Ecological Indicators

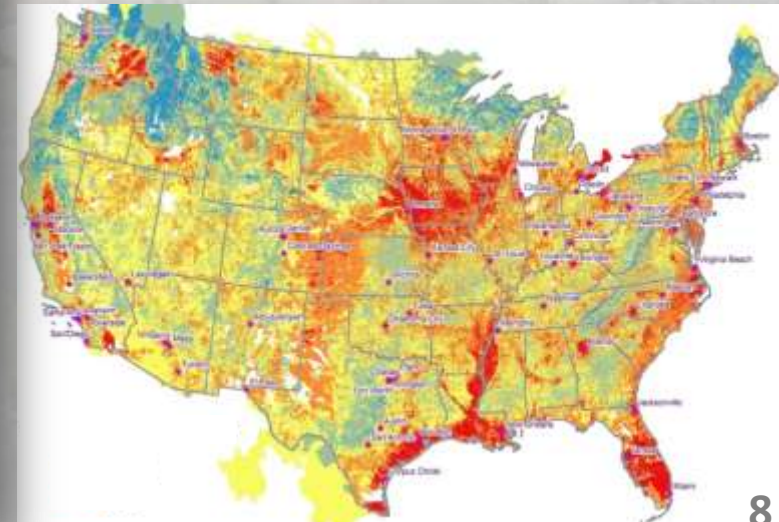
Homepage: www.elsevier.com/locate/ecolind

**Quantifying human disturbance in watersheds: Variable selection and
performance of a GIS-based disturbance index for predicting the biological
condition of perennial streams**

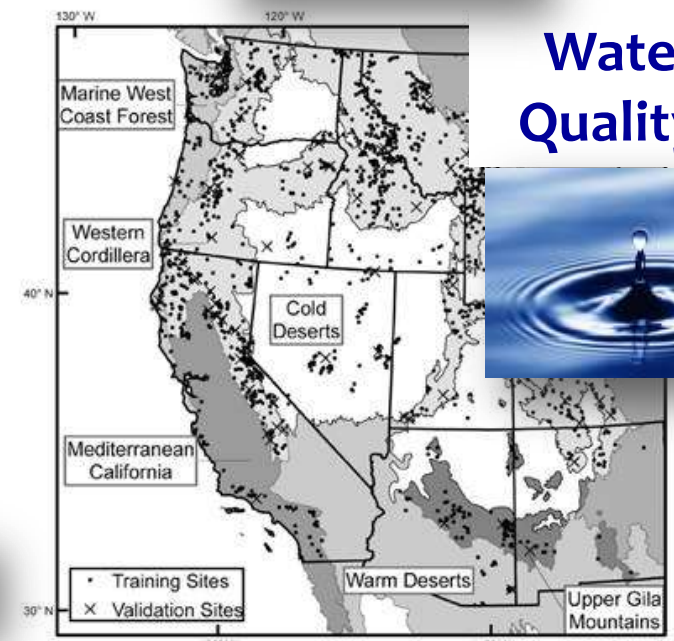
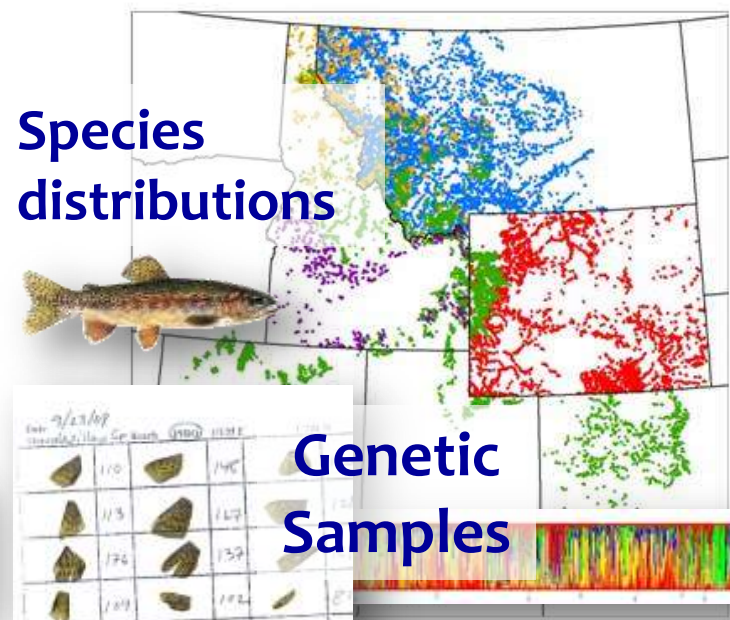
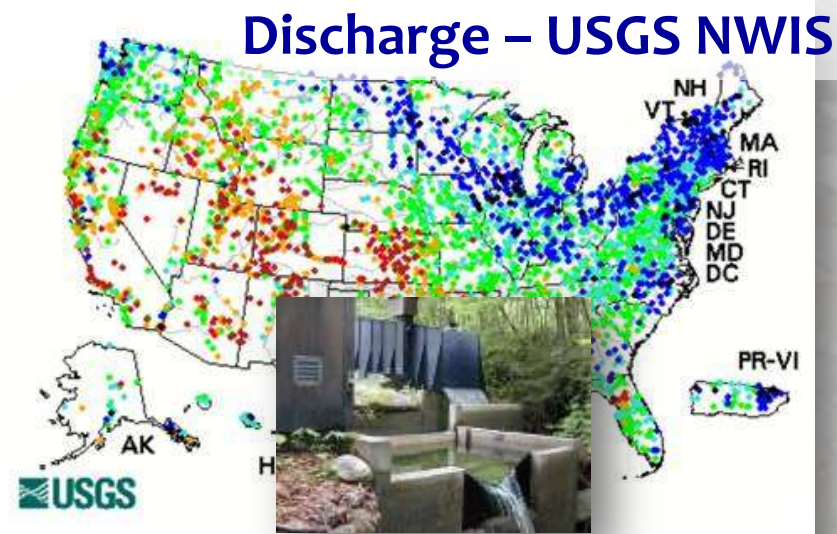
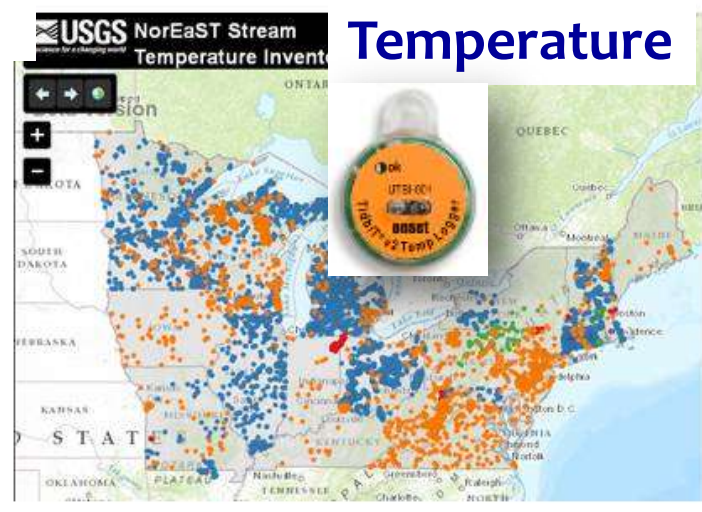
James A. Falcone*, Daren M. Carlisle, Lisa C. Weber



StreamCat



Key Ingredient #3: Mountains of Data Exist for Information Creation



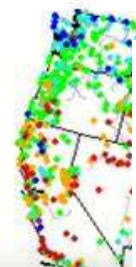
Genetic Samples



Key Ingredient #3: Mountains of Data Exist for Information Creation

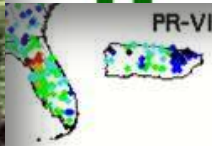
Free millions!

Temperature



Discharge - U

Free millions!



Sp
di

Free millions!



Water Quality



9/23/09

Sample ID	Genotype	Depth	Time
110	110	140	
113	113	117	
176	176	159	
169	169	142	

Genetic Samples



Free millions!



Key Ingredient #4: Statistical Models for Data on Stream Networks... FINALLY!

Environ Ecol Stat (2006) 13:449–464
DOI 10.1007/s10651-006-0022-8

ORIGINAL ARTICLE

Spatial statistical models that use flow and stream distance

Jay M. Ver Hoef · Erin Peterson ·
David Theobald



Journal of Statistical Software

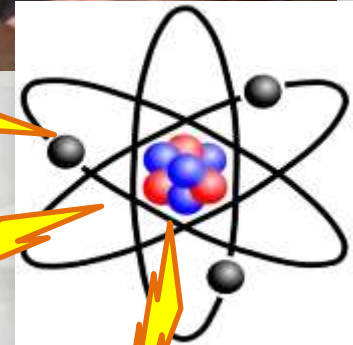
January 2014, Volume 56, Issue 3.

<http://www.jstatsoft.org/>

STARS: An ArcGIS Toolset Used to Calculate the Spatial Information Needed to Fit Spatial Statistical Models to Stream Network Data

Erin E. Peterson
CSIRO

Jay M. Ver Hoef
NOAA



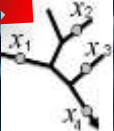
SSN: An R Package for Spatial Statistical Modeling on Stream Networks

Jay M. Ver Hoef
NOAA National
Marine Mammal Laboratory

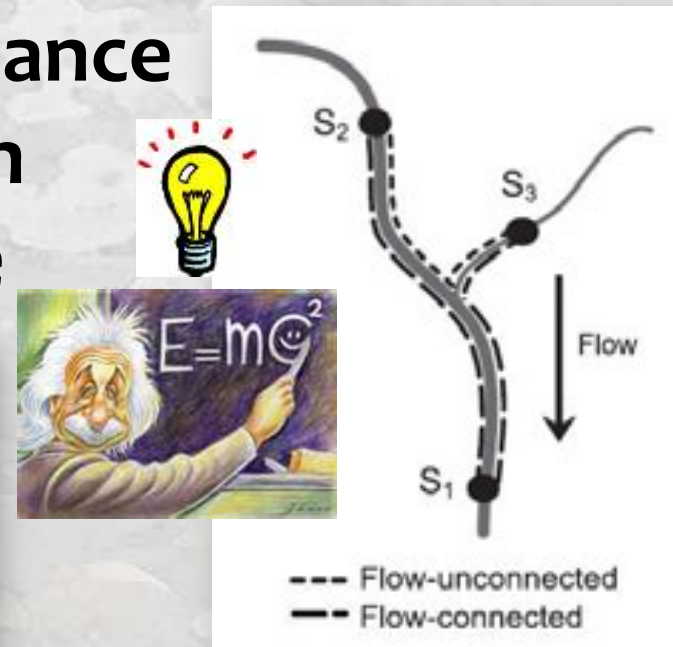
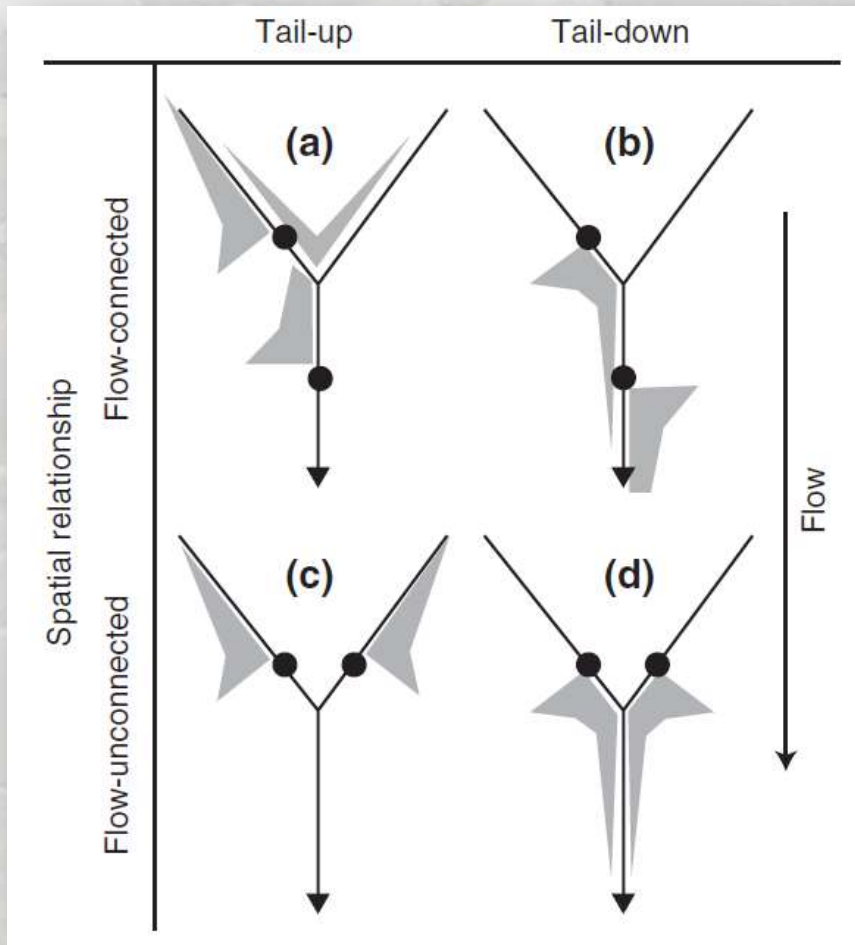
Erin E. Peterson
CSIRO, Brisbane

David Clifford
CSIRO, Brisbane

Rohan Shah
CSIRO, Brisbane



Key Innovation is Covariance Structure Based On Network Structure



- Models “understand” how information moves among locations
- Models account for spatial autocorrelation among observations

Peterson et al. 2007. *Freshwater Biology* 52:267-279;

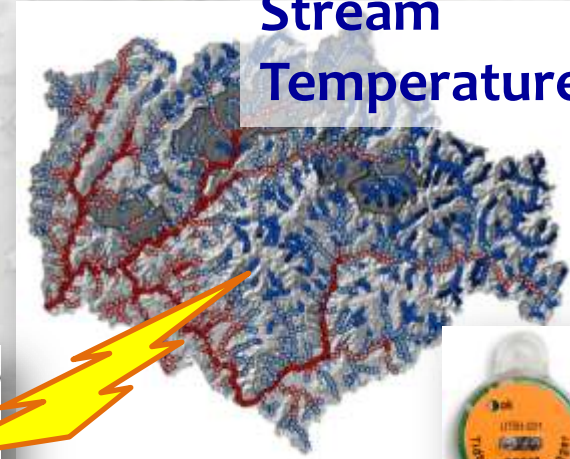
Peterson & Ver Hoef. 2010. *Ecology* 91:644-651.

Stream Models are Generalizable...

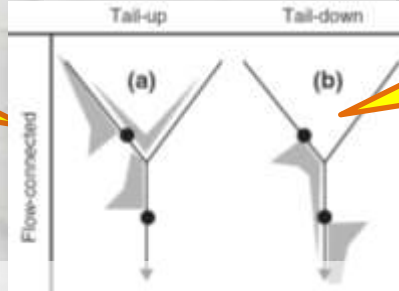
Response Metrics

- Gaussian
- Poisson
- Binomial

Stream Temperature

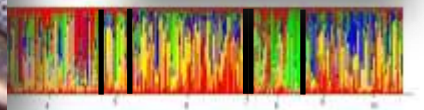
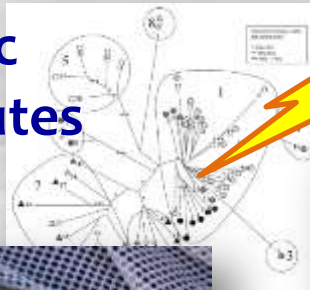


Distribution & abundance

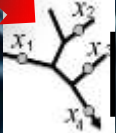


Statistical stream models

Genetic Attributes



Water Quality Parameters

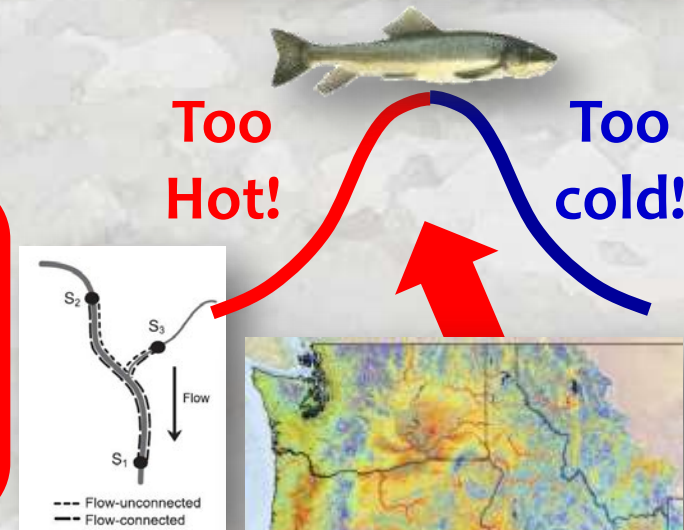


Applications of Stream Network Models

- Parameter estimation & prediction
- Status & trend assessments
- Efficient monitoring designs
- Block-kriging for reference site comparisons & fish population estimates



- Mining of BIG DATA databases
 - Climate scenarios
 - Temperature criteria
 - Species distribution models



$$Y = b_0 + b_1(x_1) + \epsilon$$

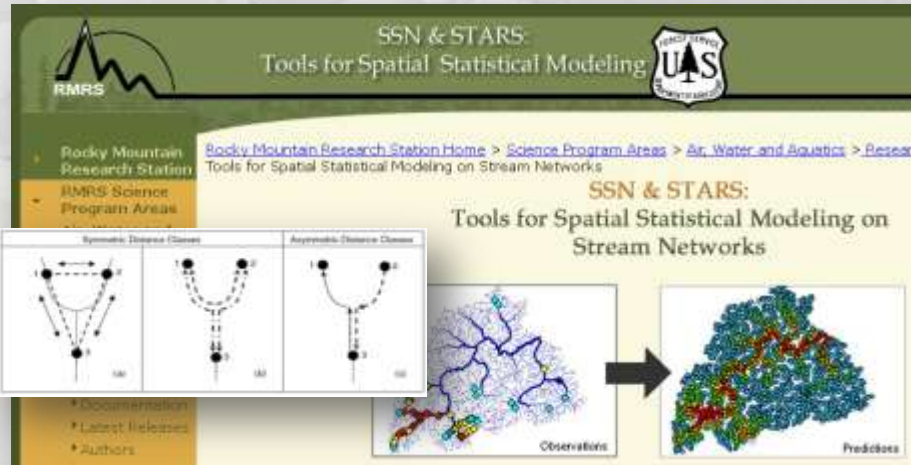
User Community is Growing Rapidly...

SSN/STARS Website

>20,000 website visits
in first 2.5 years

Free, high-quality
software

>600 software
downloads



Locations of visits to SSN/STARS website in last month

3rd Annual Stream Statistics Training Workshop in Boise

April 20 – 22

100 participants
~5 year waiting list...

3 day workshop

1st day: overview of spatial
stream models (webinar)

2nd/3rd days: work 1-on-1 with
Jay/Erin to model your data



3rd Annual Stream Statistics Training




stream

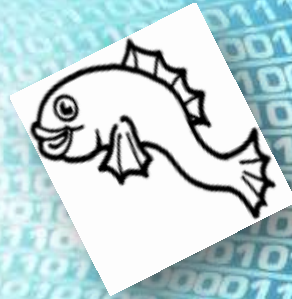
workshop

overview of spatial models (webinar)

days: work 1-on-1 with to model your data



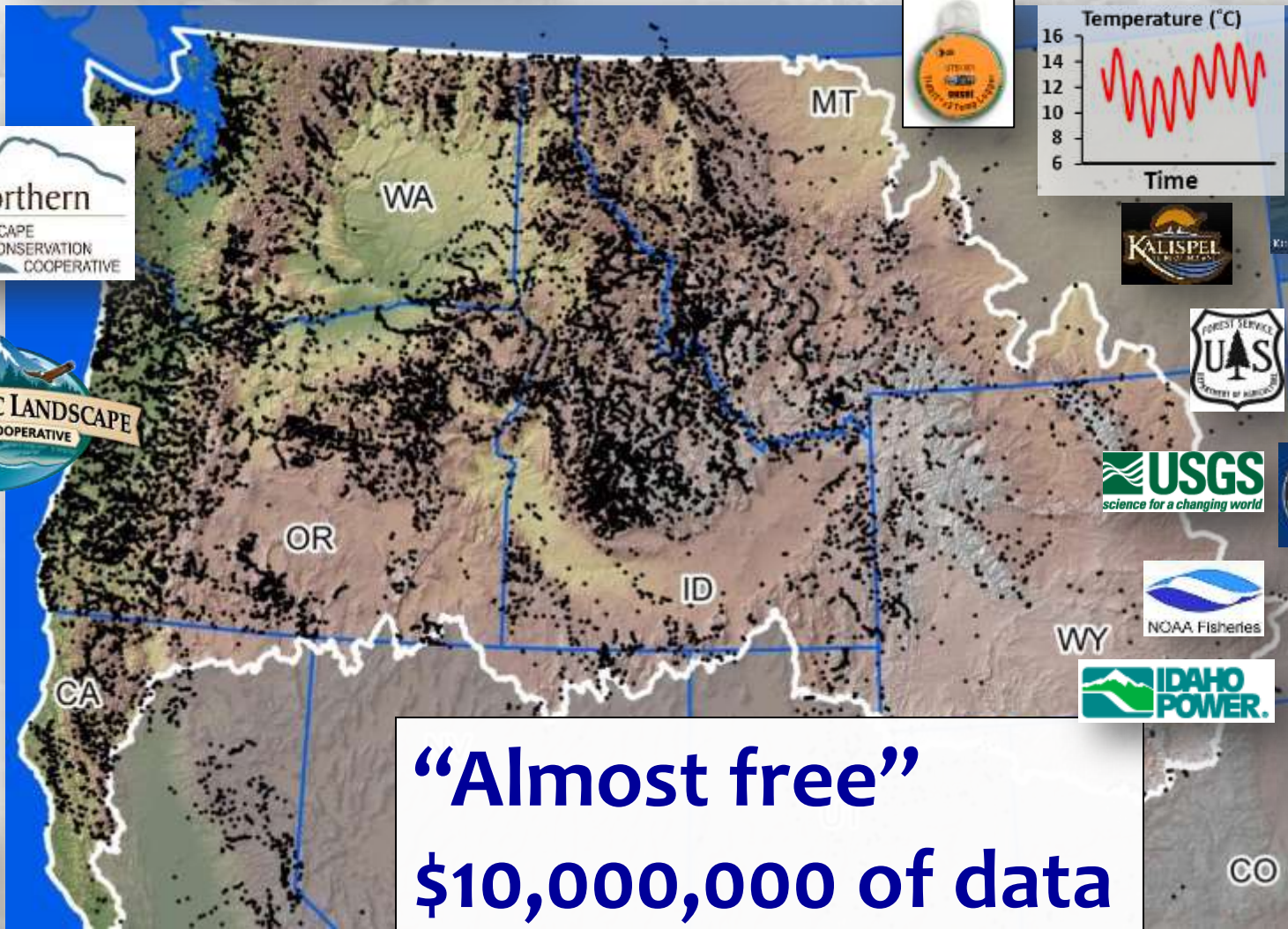
A BIG DATA Example of Stream Internet Technologies in Action



NorWeST

Stream Temp

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



**“Almost free”
\$10,000,000 of data**



NO

It's the MOTHER
LODE!



INFORMATION!



\$10,000,000 of data



Spatial vs Non-Spatial 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)

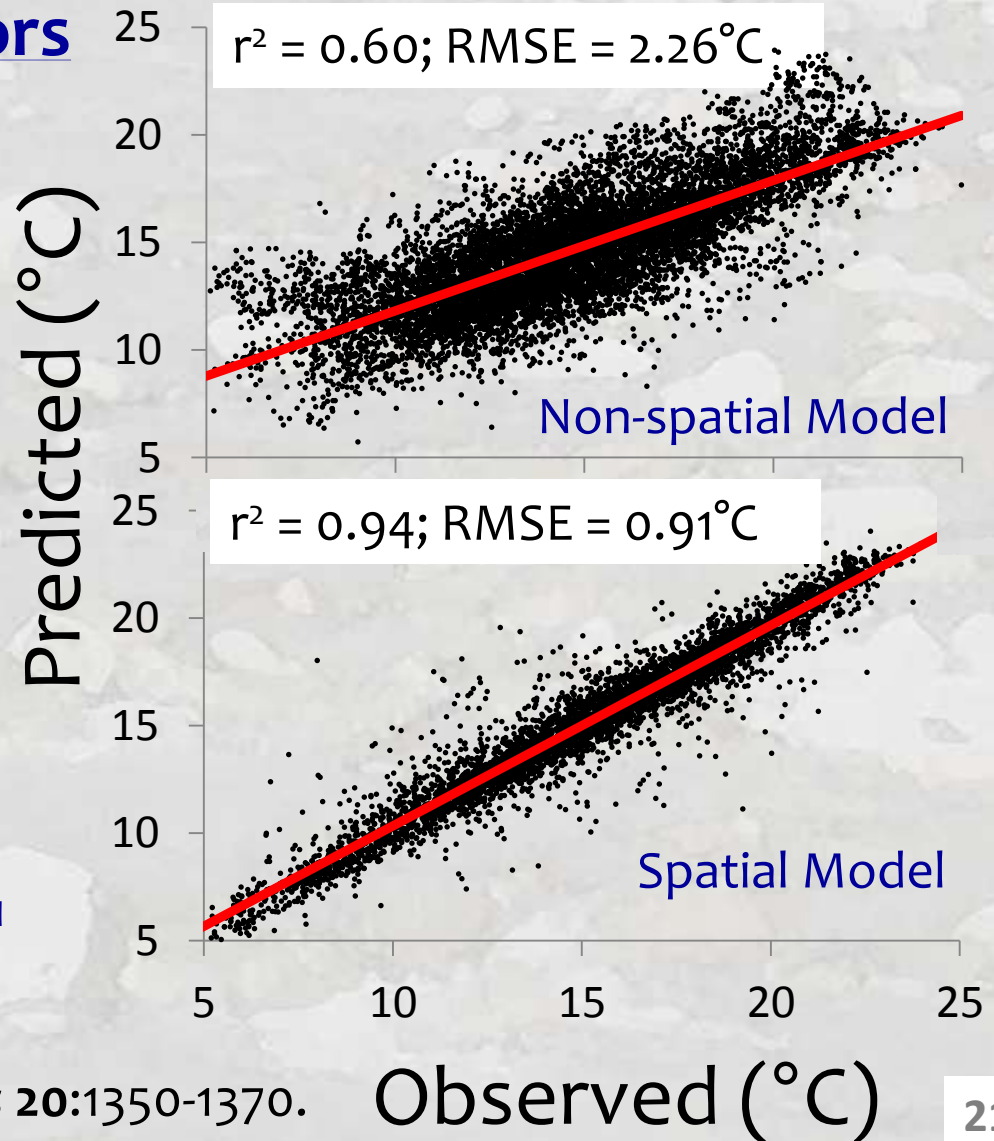
USGS gage data

11. Air Temperature (°C)

RegCM3 NCEP reanalysis

Hostetler et al. 2011

Mean August Temperature

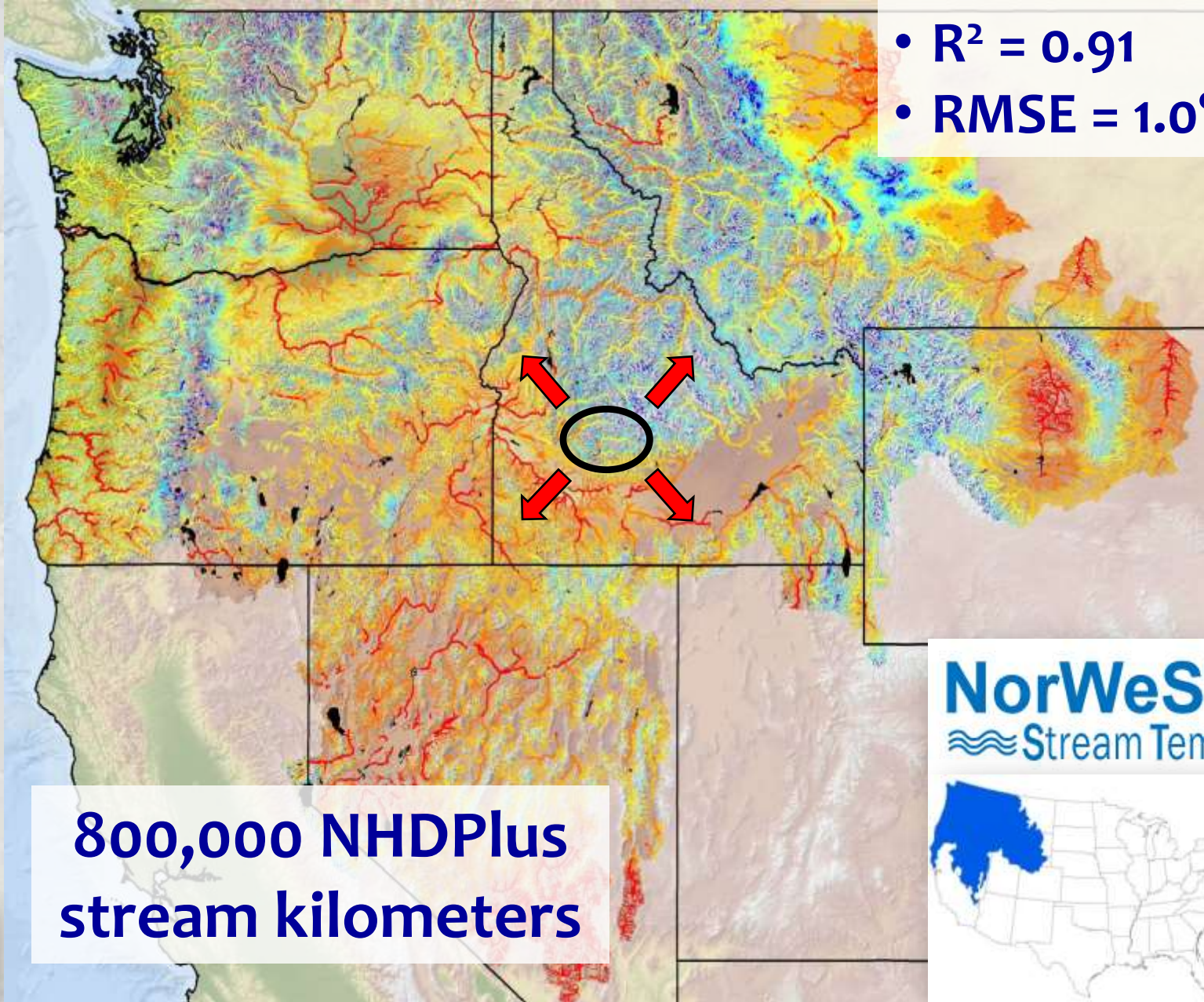


Isaak et al. 2010. *Ecol. Apps* 20:1350-1370.

Observed (°C)

High-Resolution Stream Scenarios

- $R^2 = 0.91$
- $RMSE = 1.0^{\circ}C$

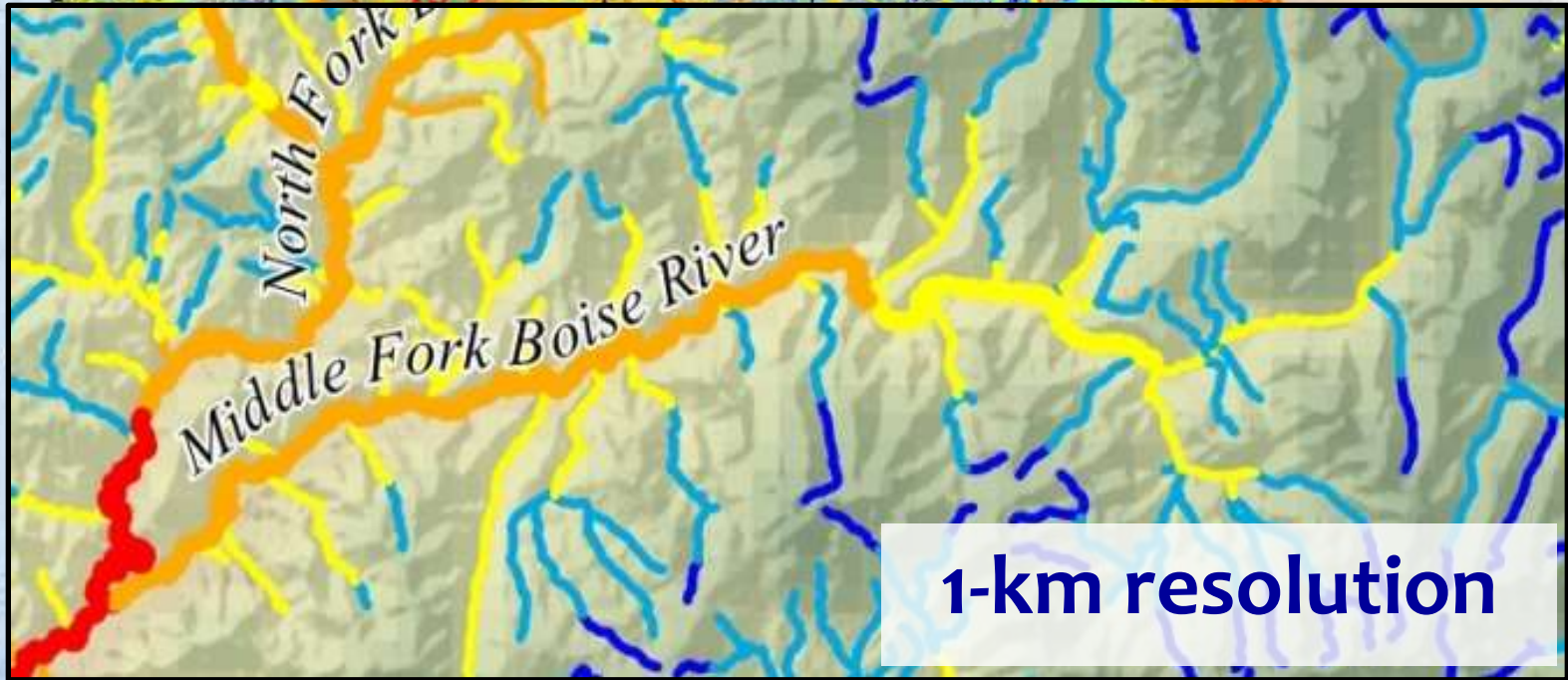
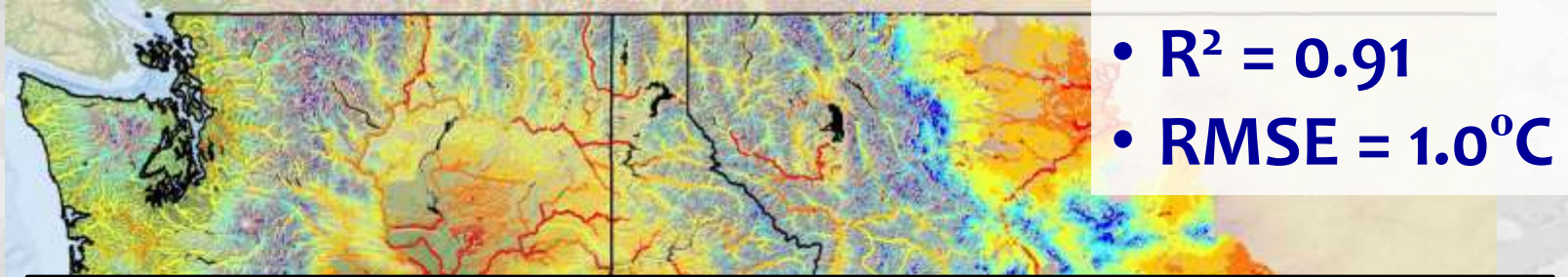


**800,000 NHDPlus
stream kilometers**

NorWeST
Stream Temp



High-Resolution Stream Scenarios

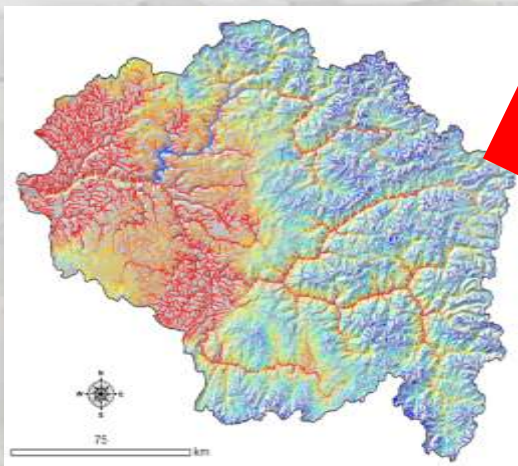


800,000 NHDPlus
stream kilometers

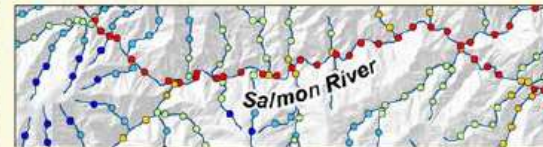


Website Distributes Scenarios & Temperature Data as GIS Layers

1) GIS shapefiles of stream temperature scenarios



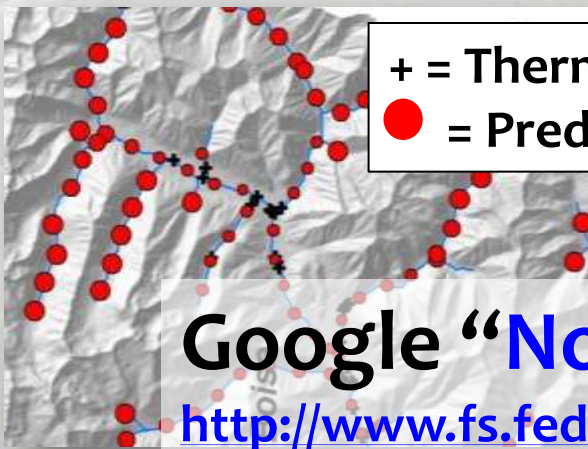
NorWeST
Stream Temp



Regional Database and Modeled Stream Temperatures

3) Temperature data summaries

2) GIS shapefiles of stream temperature model prediction precision



+ = Thermograph
● = Prediction SE



Google **NorWeST** or go here...

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

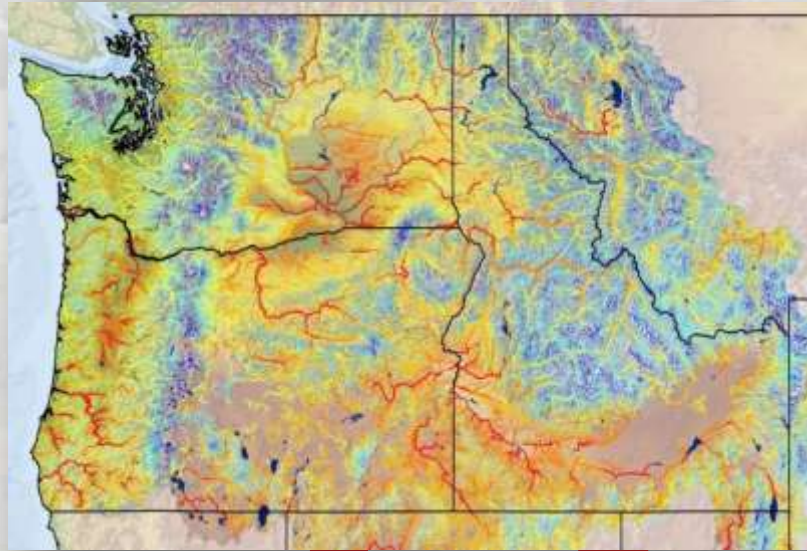
NorWeST User Community...

Website launched 3 Years Ago

- 10,000 visits/year
- 1,146 downloads last 6 months



Temperature Synergies...

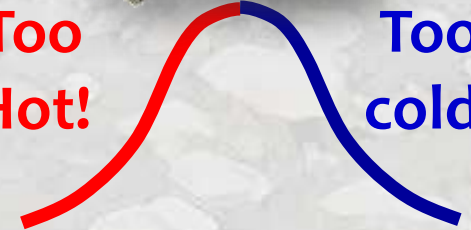


Regulatory temperature standards

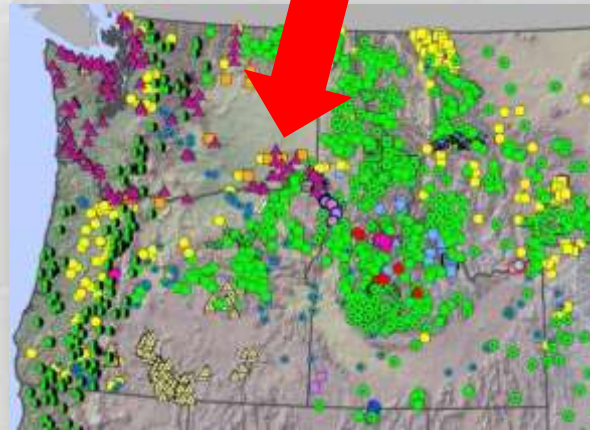


Too Hot!

Too cold!



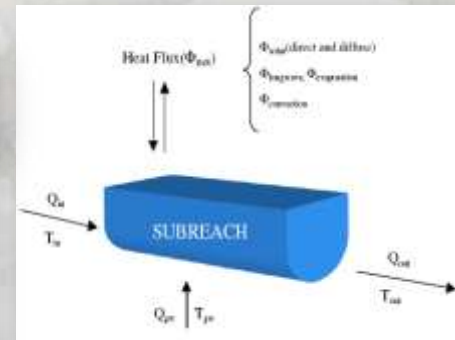
Data access accelerates temperature research



Coordinated interagency monitoring



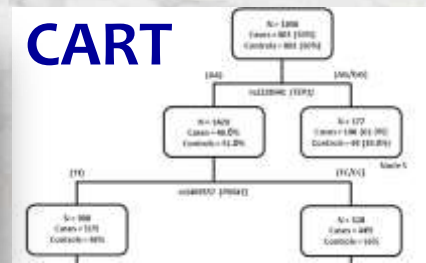
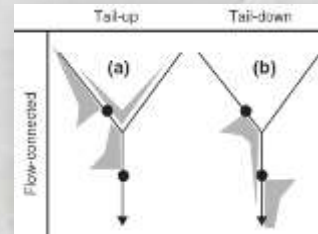
Species distribution models & climate assessments



Doesn't Matter How We Get There...

Many good models & designs...

SPARROW **GRTS**

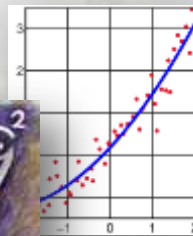
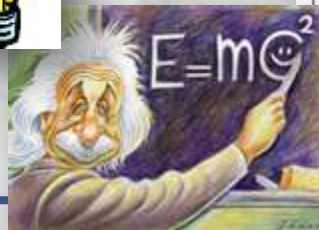


Many good programs...



The National Rivers and Streams Assessment

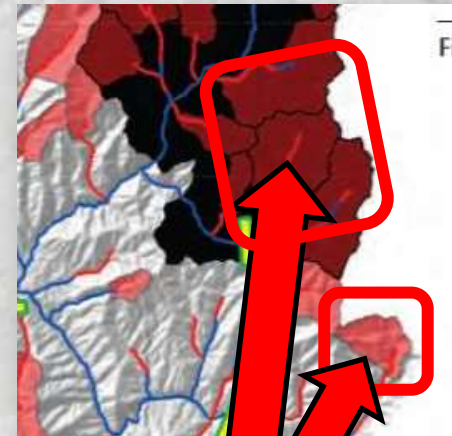
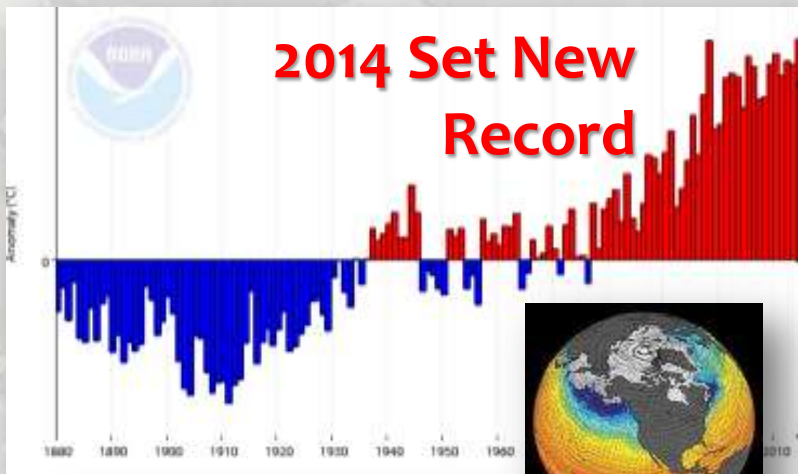
Needs for new models & programs...



“Information” & Efficiency Are Key

Good Information for Decision Making is Critical

The 21st-Century will Be
a Transitional One



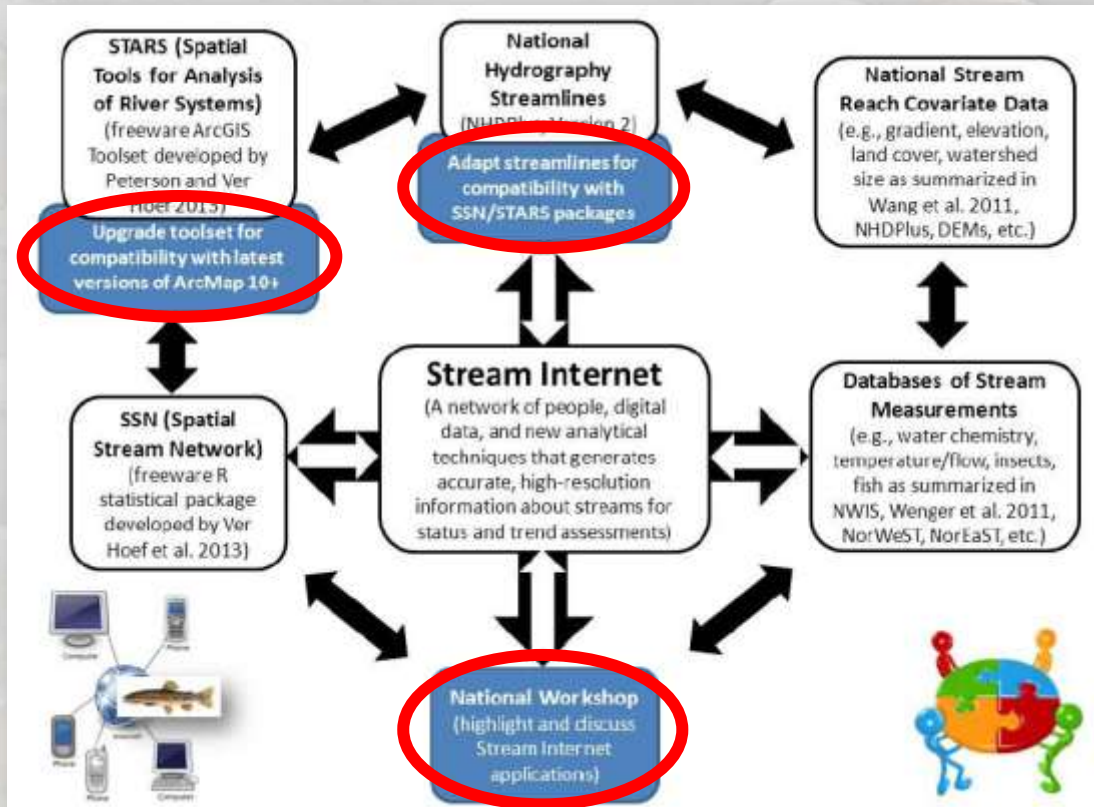
I'm going to invest here...

...not here



Stream Internet Project Tasks

- 1) Develop compatibility between spatial stream analysis tools and national hydrography layer (NHDPlus, v2)
- 2) Update STARS stream analysis tools to ArcMap 10.2
- 3) Host a workshop to brainstorm about possibilities that new analyses & databases provide to address key questions & information needs



Vision: TSI through the NSI

High-resolution space-time information for all stream things



3,000,000 stream kilometers

