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Integrated Energy-Water Planning in the Western and Texas Interconnections

ASME 2013 Power Conference
Boston, MA
July 29-August 1, 2013



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Energy and Water in the Western and Texas Interconnections

- Reduce the water footprint of electric power production in western United States:
 - Develop tools for a quantitative assessment of the energy-water nexus,
 - Engage stakeholders across the energy-water spectrum, and
 - Evaluate water implications of alternative interconnection-wide transmission expansion scenarios.

Technical Support Team

- Sandia National Laboratories

- Vincent Tidwell
- Barbie Moreland
- Howard Passell
- Katie Zemlick
- Barry Roberts



**Sandia
National
Laboratories**



- Argonne National Laboratory

- John Gasper
- Eugene Yan
- Chris Harto



- Electric Power Research Institute

- Robert Goldstein

- National Renewable Energy Laboratory

- Jordan Macknick
- Kathleen Hallett



- Idaho National Laboratory

- Gerald Sehlke
- Dan Jensen
- Chris Forsgren



Idaho National Laboratory

- Pacific Northwest National Laboratory

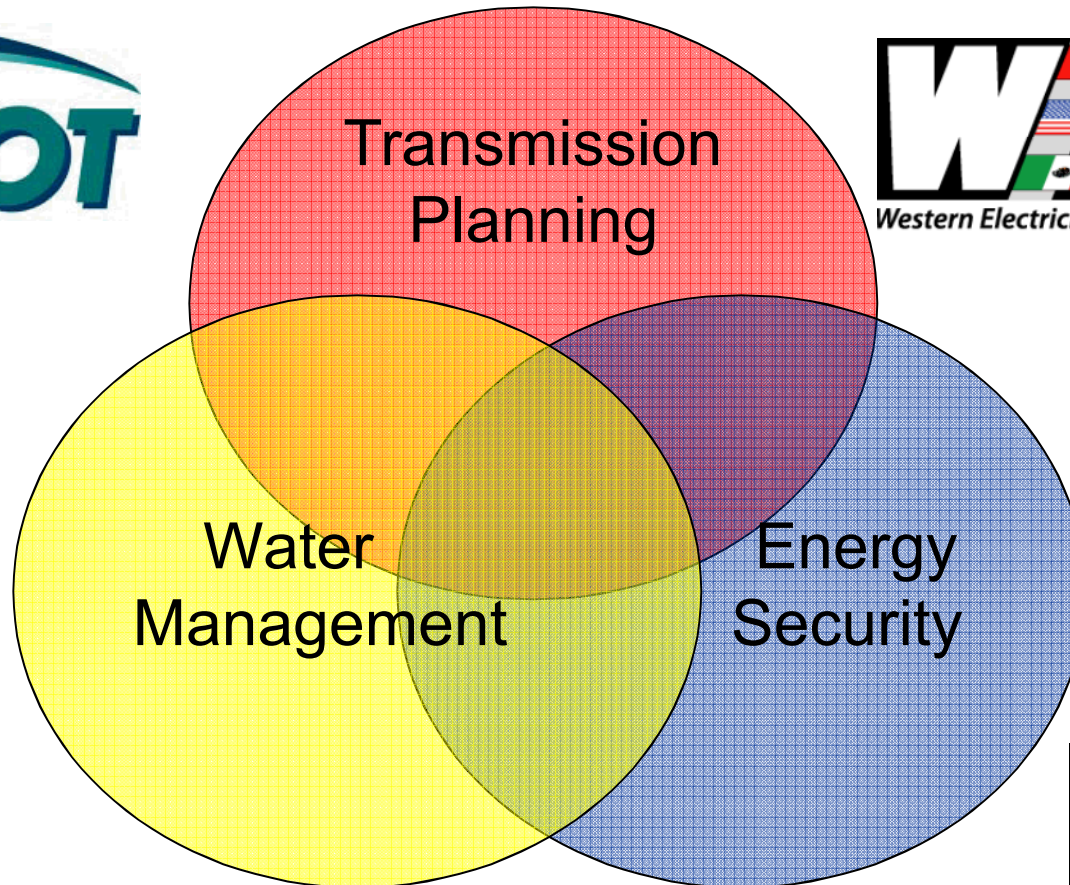
- Mark Wigmosta
- Ruby Leung

- University of Texas

- Michael Webber
- Carey King



Integrated Planning



**WESTERN
GOVERNORS'
ASSOCIATION**

Serving the Governors of 19 States and 3 US-Flag Pacific Islands



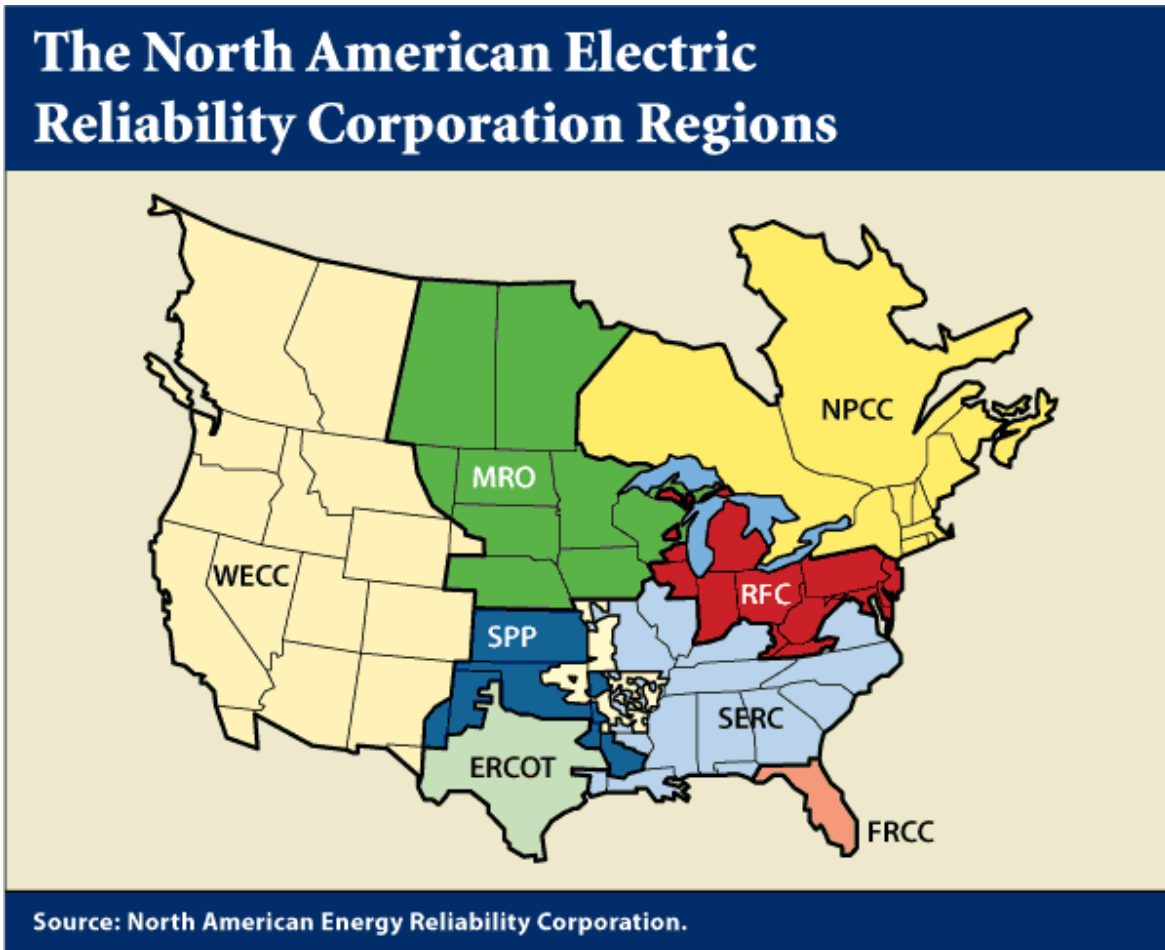
WSWC

Western States Water Council

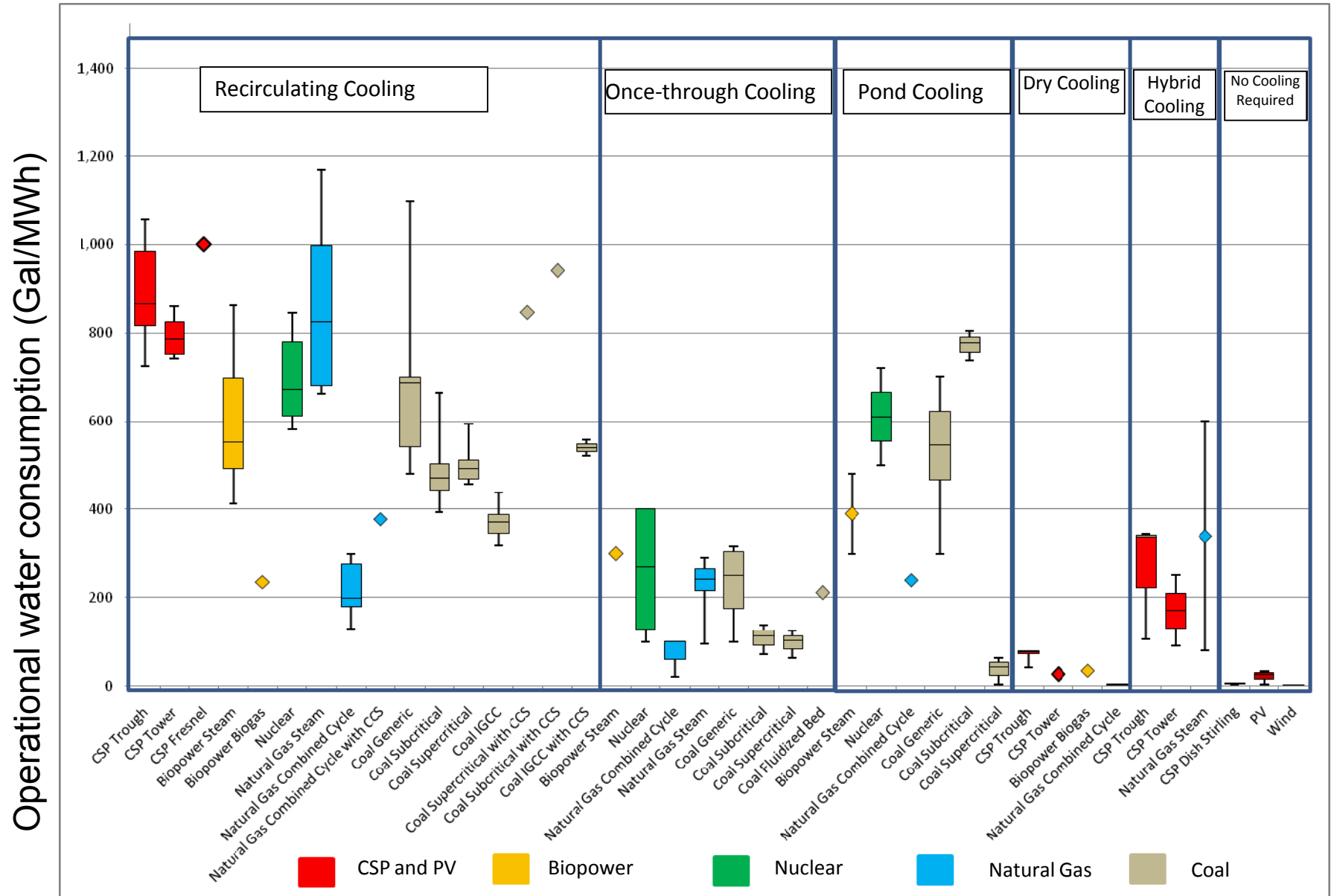


Transmission Planning

- WECC and ERCOT are conducting long-range transmission planning (20 yrs.)
 - Siting of new power plants
 - New transmission capacity

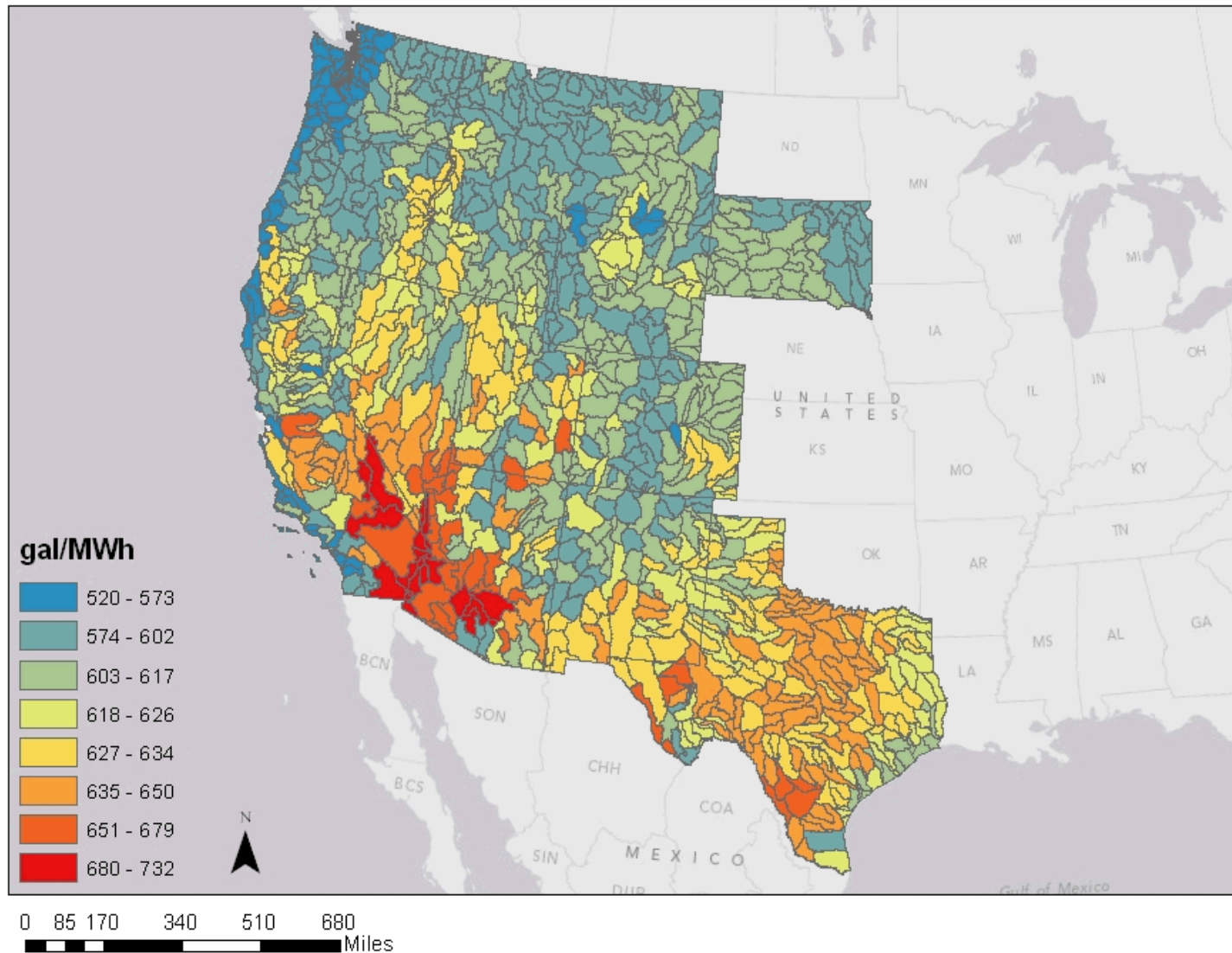


Operational water *consumption* factors for electricity generating technologies

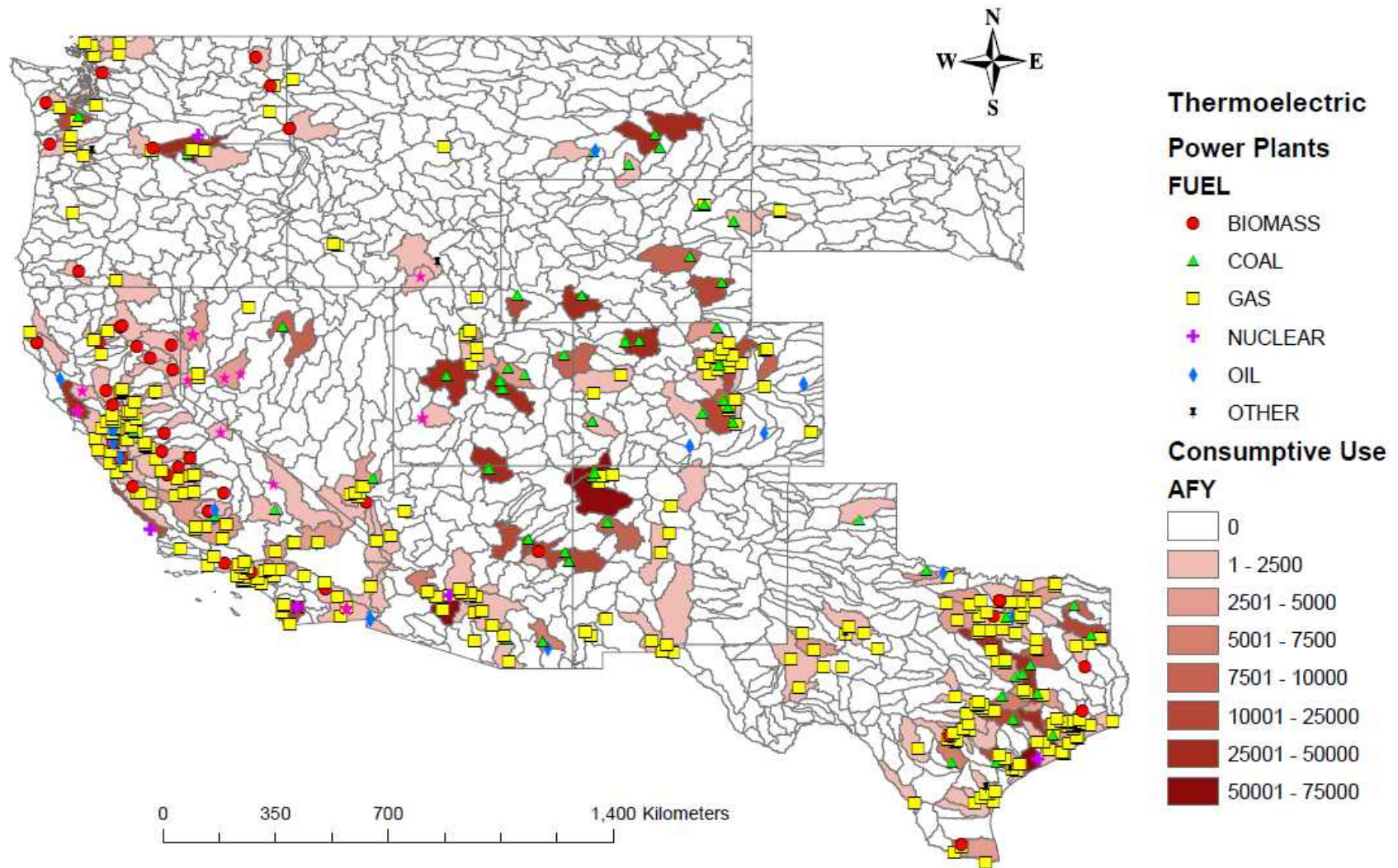


Source: Macknick *et al.* 2011

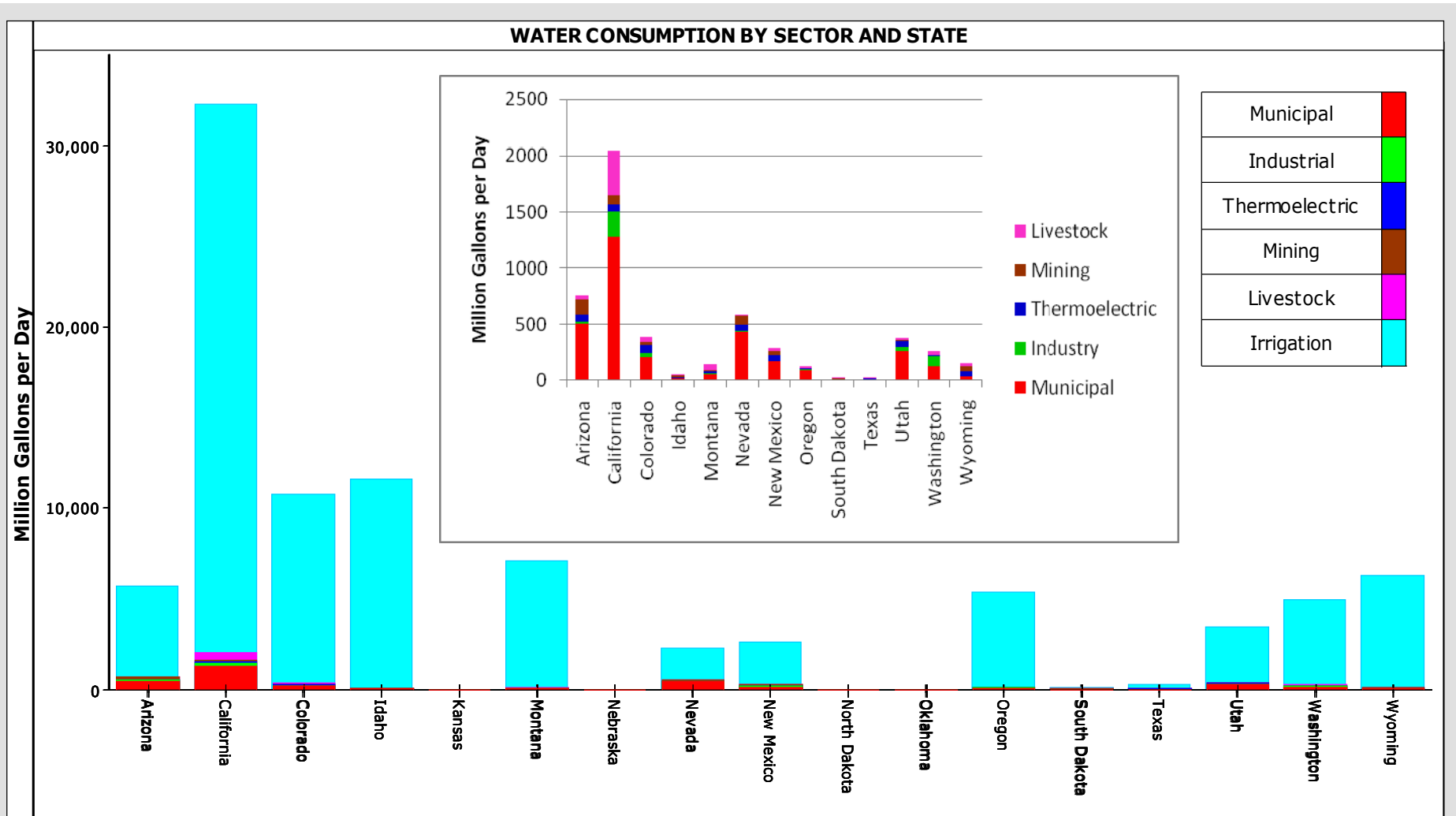
Coal Plant Water Use (gal/MWh)



Thermoelectric Consumptive Use and Power Plants (Current)

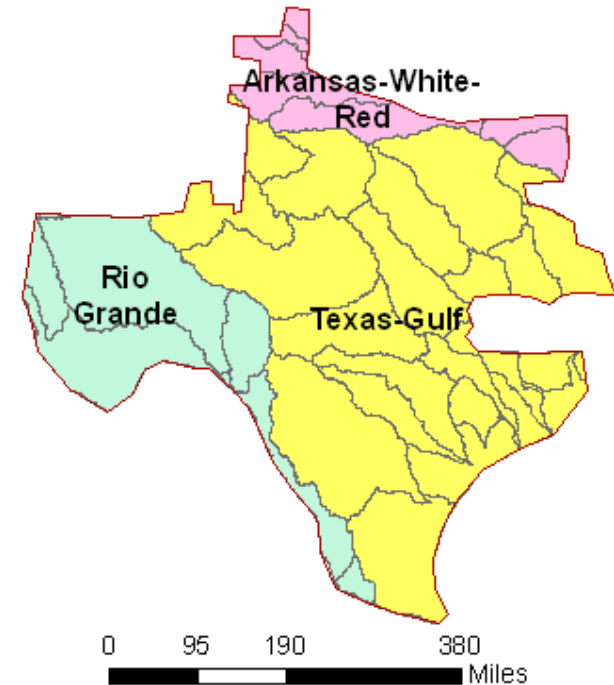


Water Consumption by State and Sector



Climate Modeling

- Texas Gulf Coast
- California
- *Pacific Northwest*



Power Plant Siting Decisions

- West-wide objectives
 - Minimize cost
 - Maximize reliability
 - Maximize transmission capacity utilization
 - Limit exposure to policy change
 - ***Minimize stress over water***
- Power plant siting criteria
 - Fuel type
 - Cooling type
 - Capacity
 - Location
 - Water source



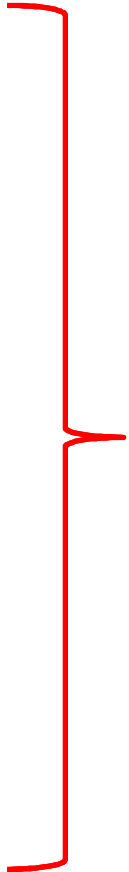
Key Water Sources

- **Potable Water**

- **Unappropriated surface water**
- **Unappropriated groundwater**
- **Appropriated water (rights transfers)**

- **Non-Potable Water**

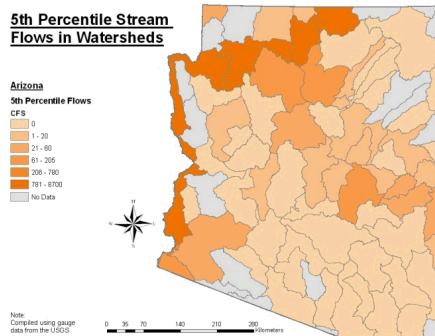
- **Municipal/Industrial wastewater**
- **Shallow brackish water**



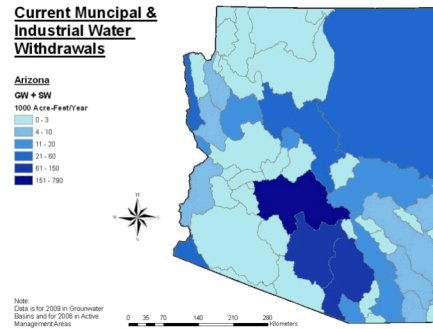
**Relative
Availability
and Cost**

Utilized State Water Data

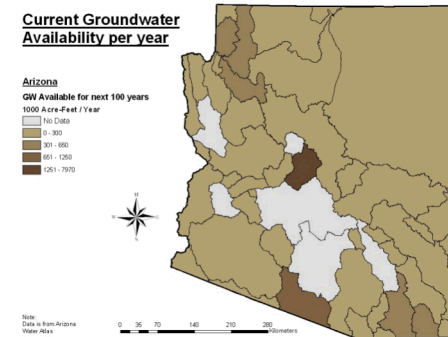
Water Supply



Water Demand



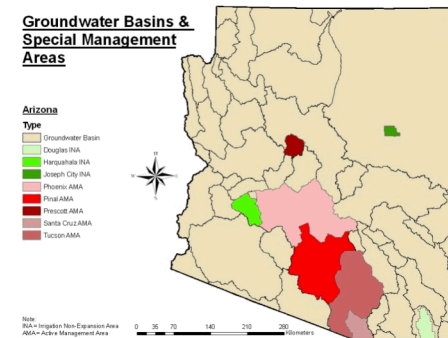
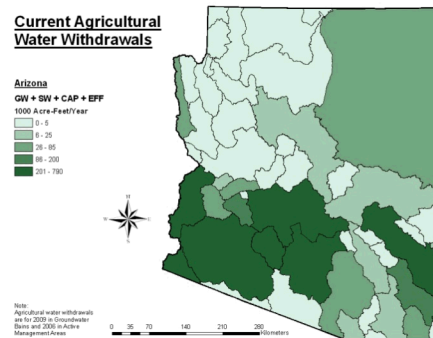
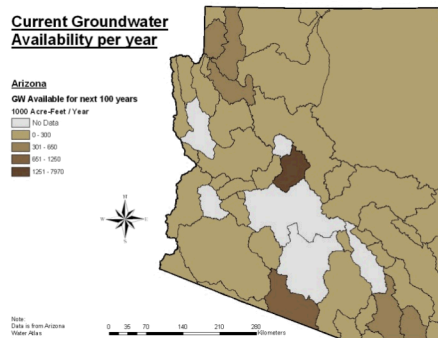
Water Institutions



Mean Gauged Streamflow

Municipal Demand

Unappropriated Water



Groundwater Depletion

Irrigation Demand

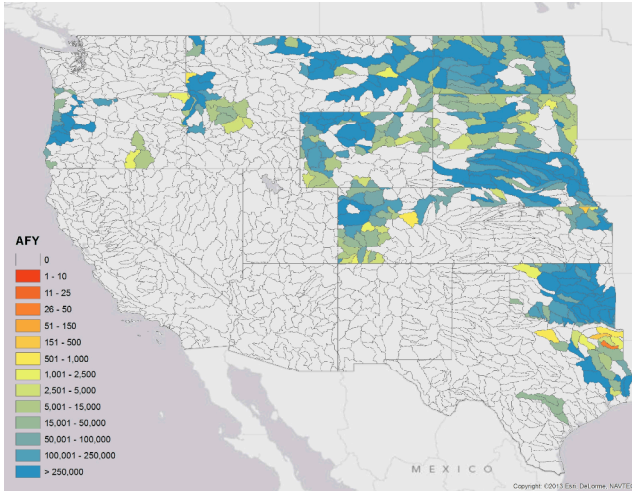
Administrative Control Areas

Metric Development

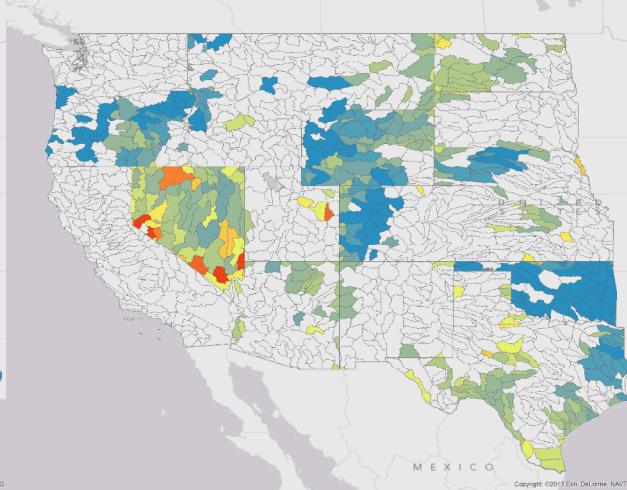
- **Data on “available water” are rare**
- **As such, metrics were estimated from available information**
- **Assisted by volunteer team from WSWC**
 - **Bret Bruce (USGS)**
 - **Dan Hardin (TX)**
 - **Sara Larsen (WSWC)**
 - **Dave Mitamura (TX)**
 - **Andy Moore (CO)**
 - **Ken Stahr (OR)**
 - **Todd Stonely (UT)**
 - **Steve Wolff (WY)**
 - **Dwane Young (WSWC)**

Water Availability

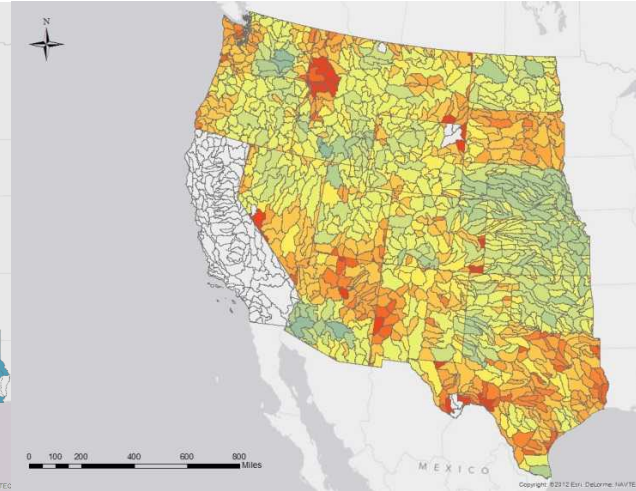
Unappropriated Surface Water



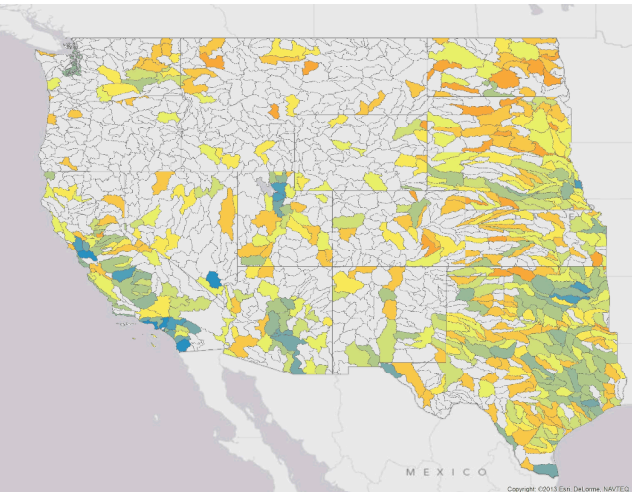
Unappropriated Groundwater



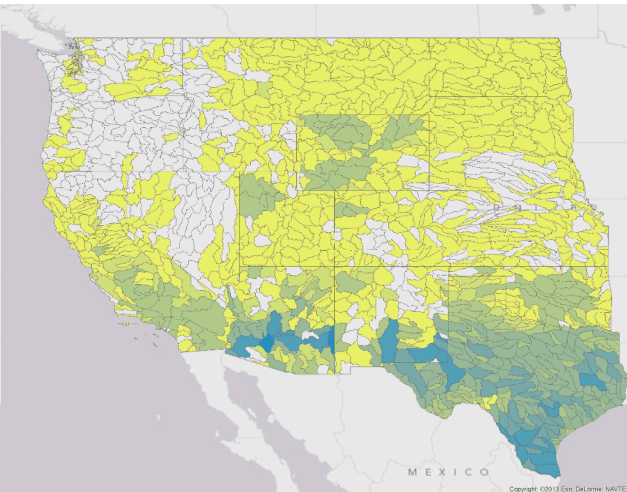
Appropriated Water



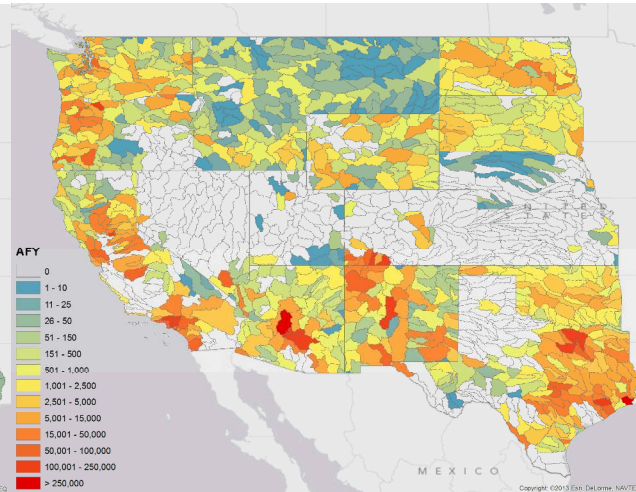
Municipal Wastewater



Brackish Groundwater

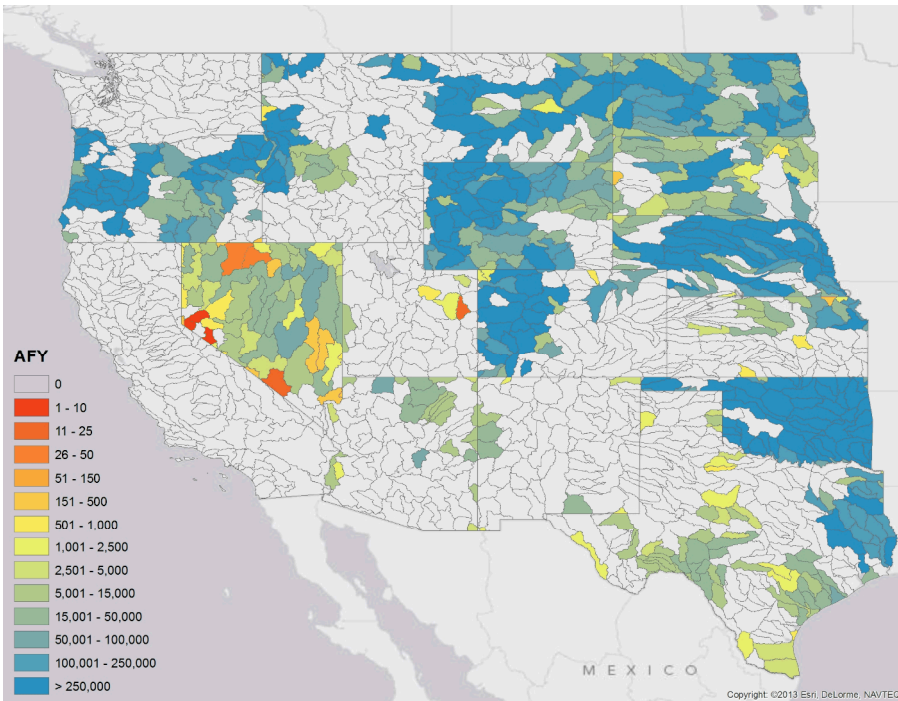


Consumptive Demand 2010-2030

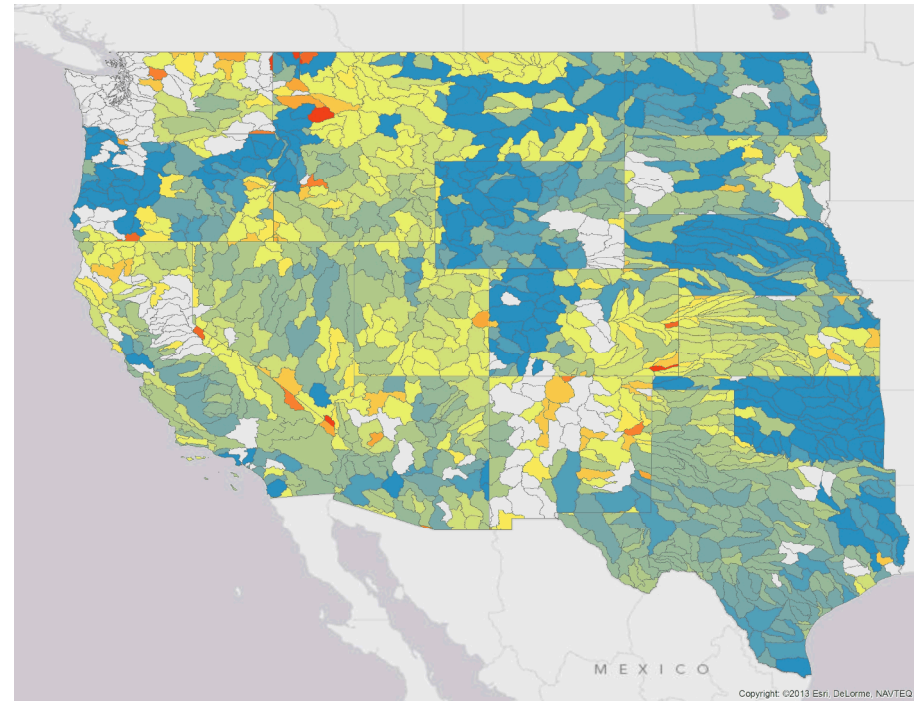


Water for Development

Unappropriated Water Sources – Change in Demand 2030

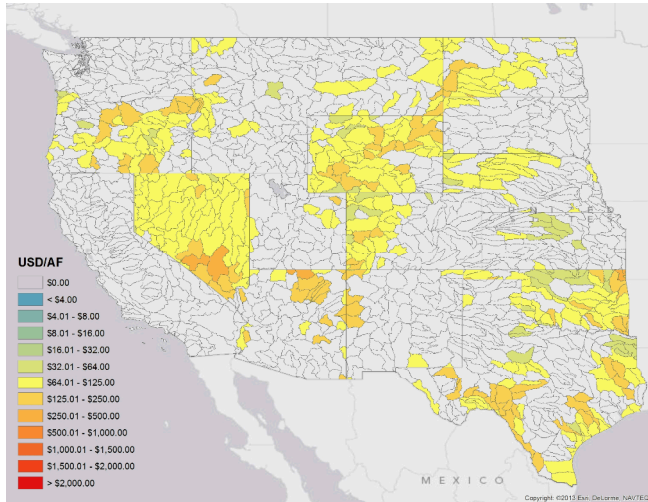


All Water Sources – Change in Demand 2030

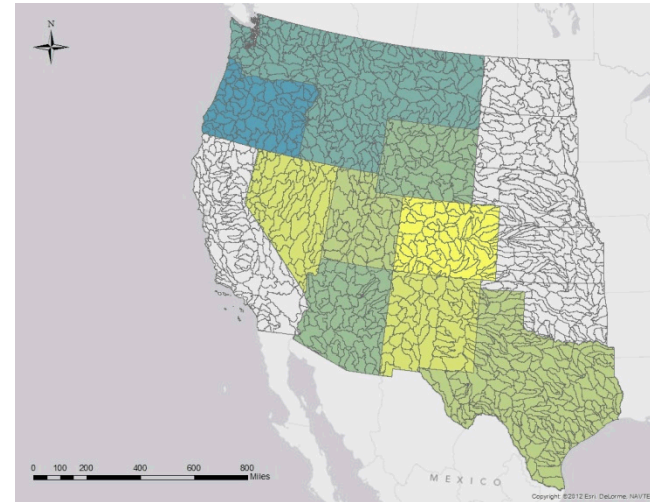


Relative Cost of Water

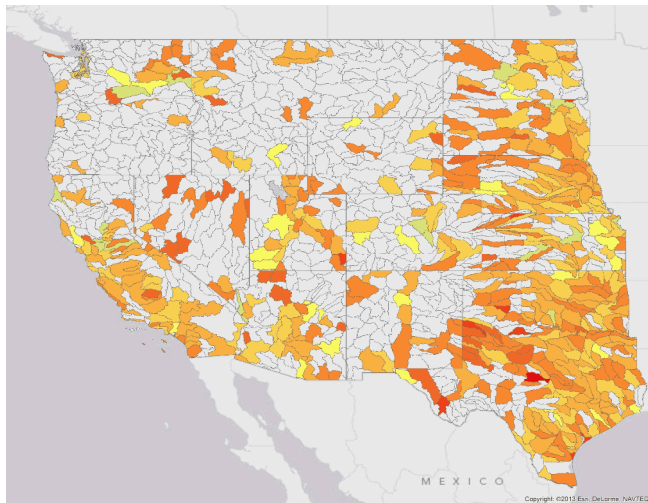
Unappropriated Groundwater



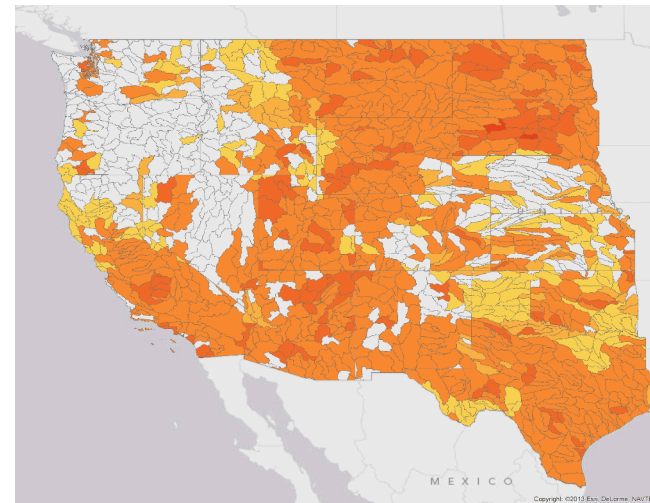
Appropriated Water



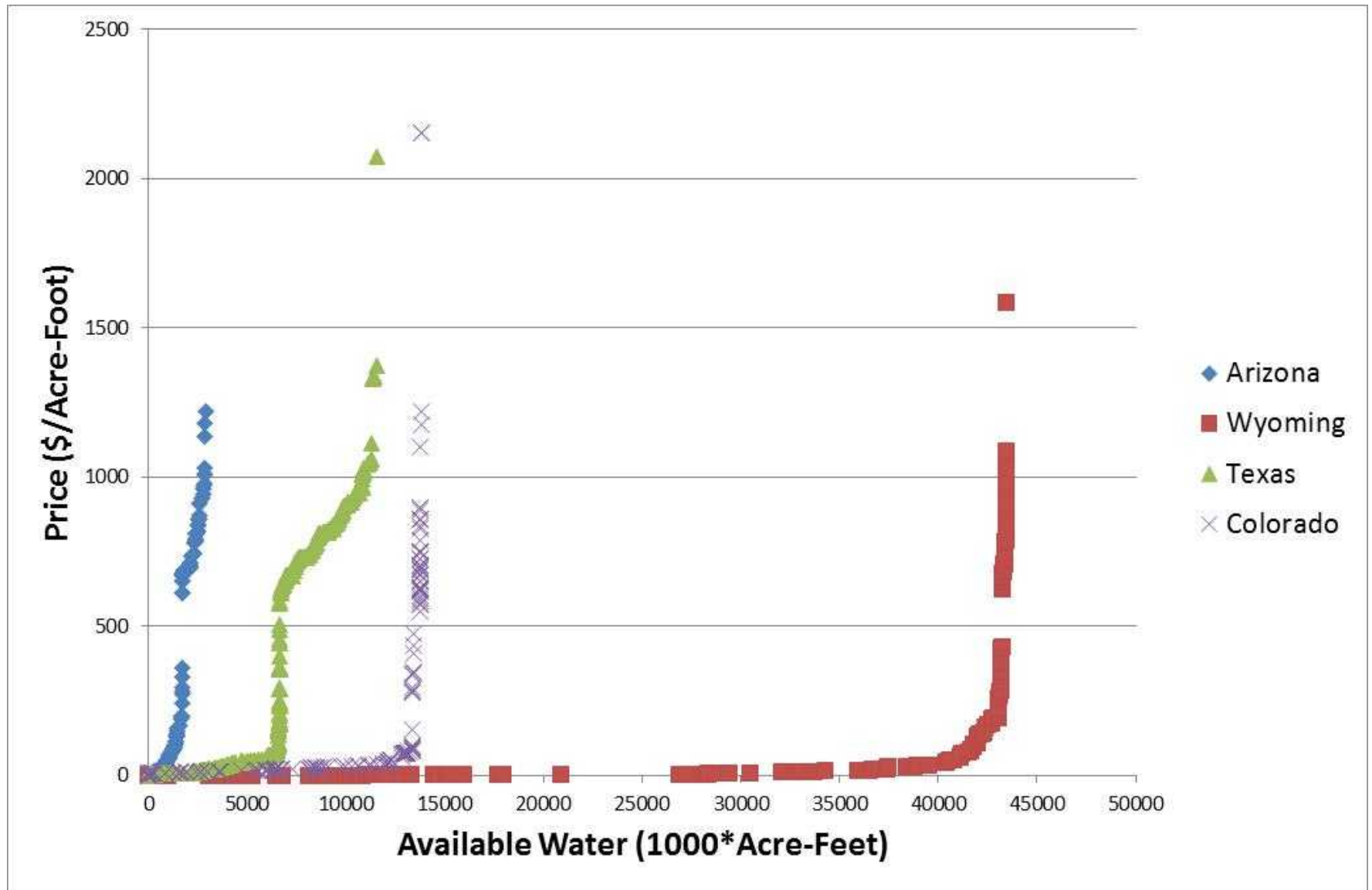
Municipal Wastewater



Brackish Groundwater



State-Level Supply Curves



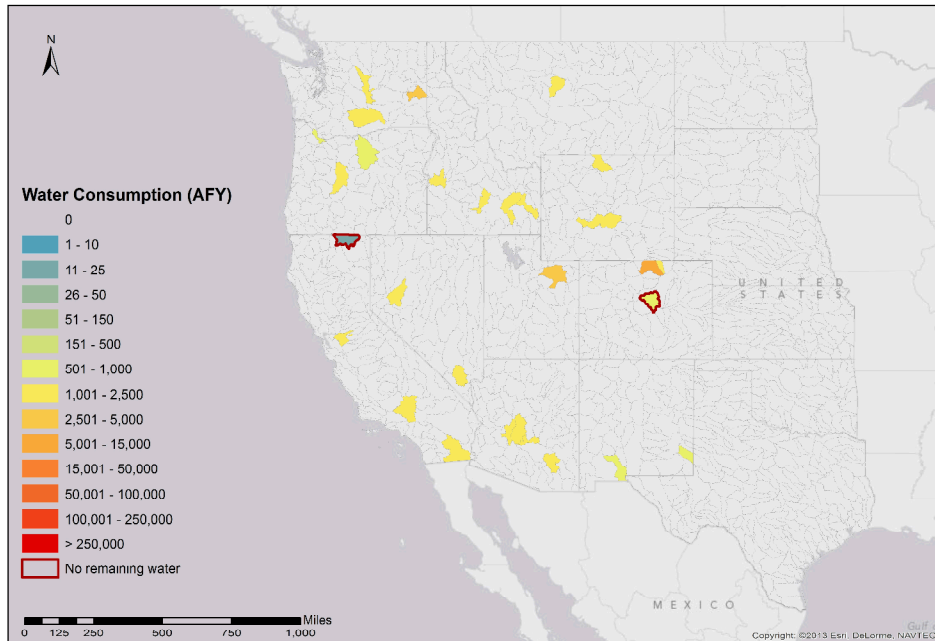
Long Range Planning Results

Case Description		Water Limited Watersheds	Number of New Units	Total Water Consumption (AFY)
Reference Case		2	59	53,128
Scenario 1 - Focus on Economic Recovery		3	106	106,808
Scenario 2 - Focus on Clean Energy		6	46	51,527
Scenario 3 - Focus on Short-Term Consumer Costs		2	108	108,203
Scenario 4 - Focus on Long-Term Societal Costs		1	43	38,637
Sensitivity - \$0/ton CO2 Tax		6	124	124,907
Sensitivity - \$2/MMbtu Natural Gas price		3	164	170,269
Sensitivity - \$12/MMbtu Natural Gas price		1	11	34,462
Sensitivity - \$75/ton CO2 Tax		5	131	133,674
Study Request - Enhanced Geothermal Breakthrough		4	20	19,230

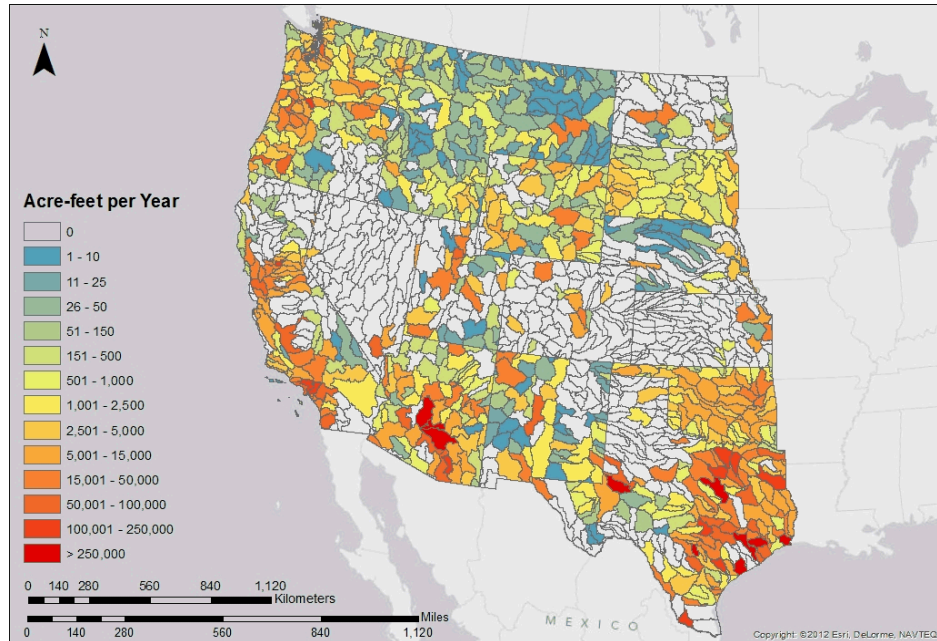
Long Range Planning Results

Reference Case

Total water demand (AFY) and areas where demand exceeds availability (red)



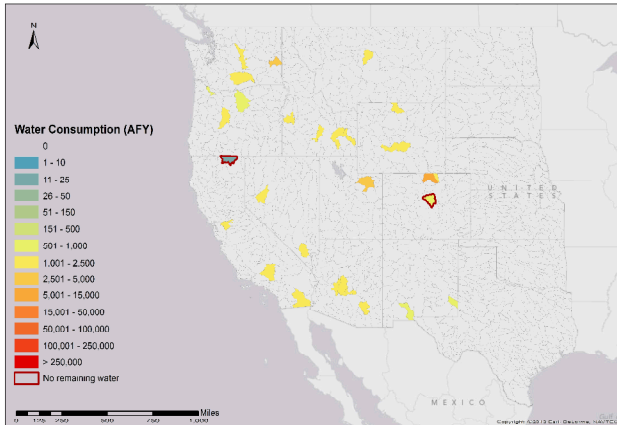
Change in Demand through 2030



Long Range Planning Results

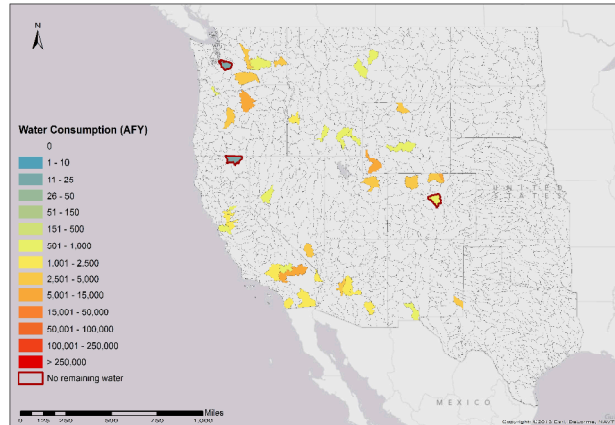
Reference Case

Total water demand (AFY) and areas where demand exceeds availability (red)



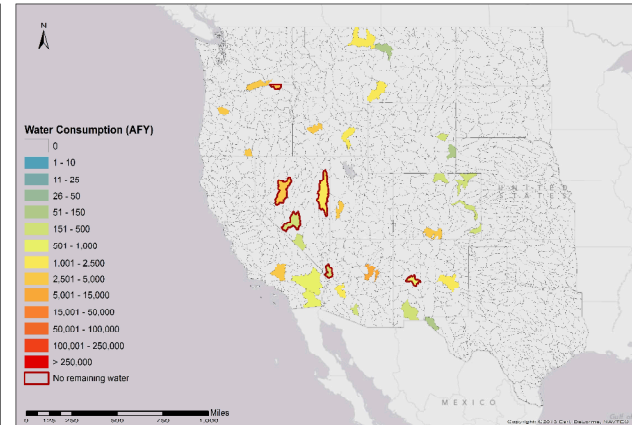
Scenario 1: Focus on Economic Recovery

Total water demand (AFY) and areas where demand exceeds availability (red)



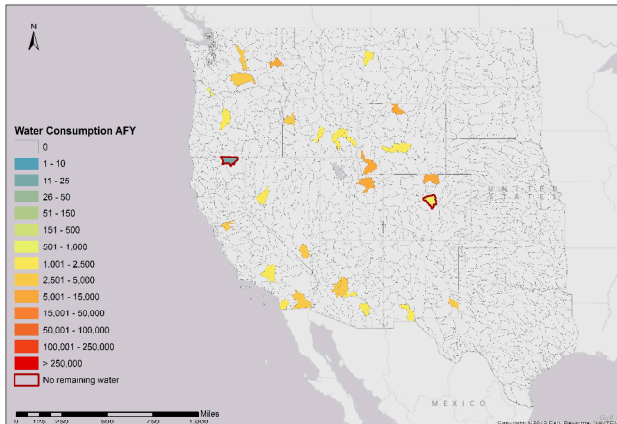
Scenario 2: Focus on Clean Energy

Total water demand (AFY) and areas where demand exceeds availability (red)



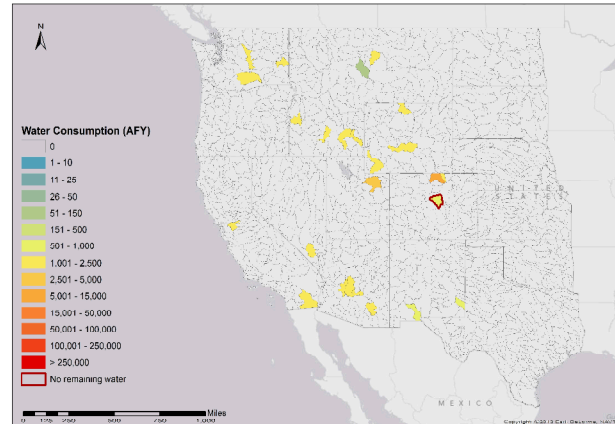
Scenario 3: Focus on Short-Term Consumer Costs

Total water demand (AFY) and areas where demand exceeds availability (red)



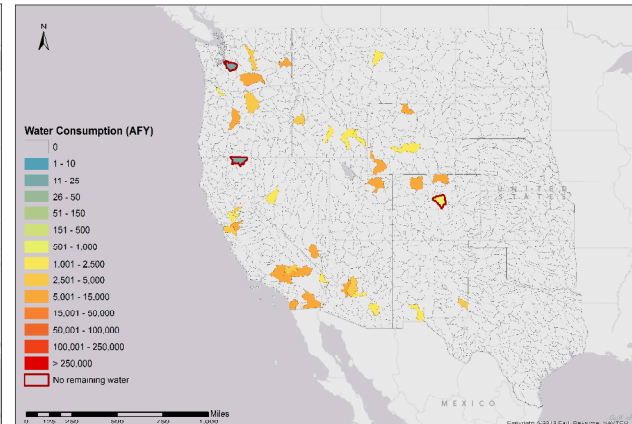
Scenario 4: Focus on Long-Term Societal Costs

Total water demand (AFY) and areas where demand exceeds availability (red)

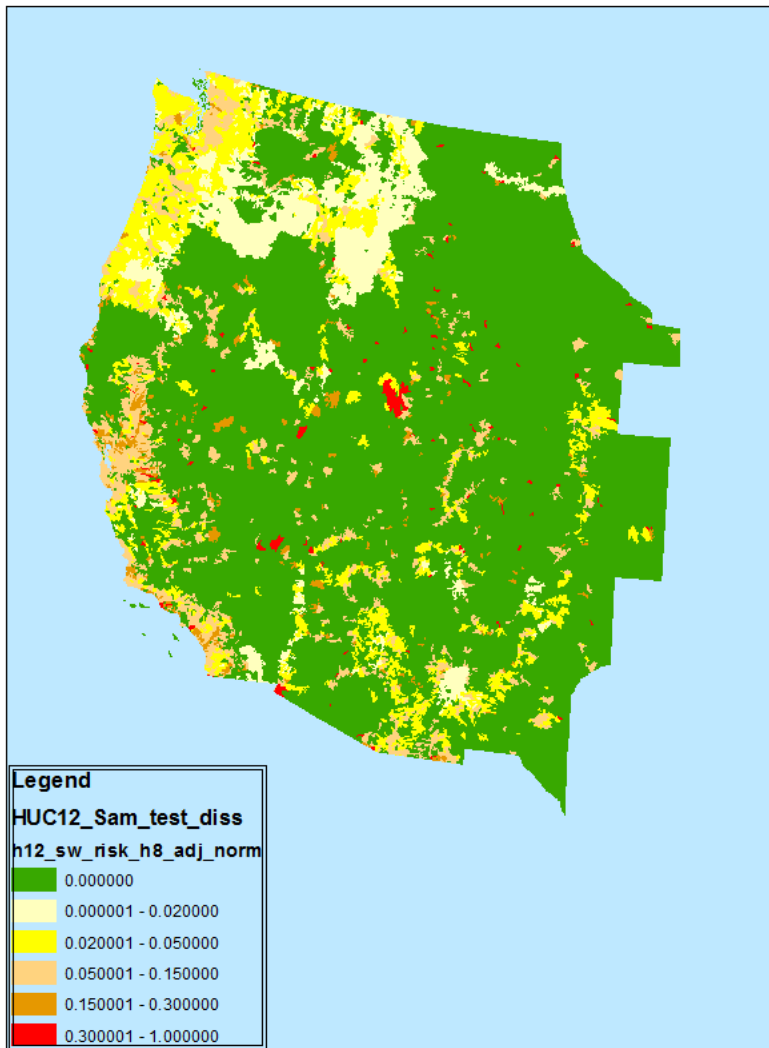


Sensitivity Analysis: \$2/MMbtu Natural Gas Price

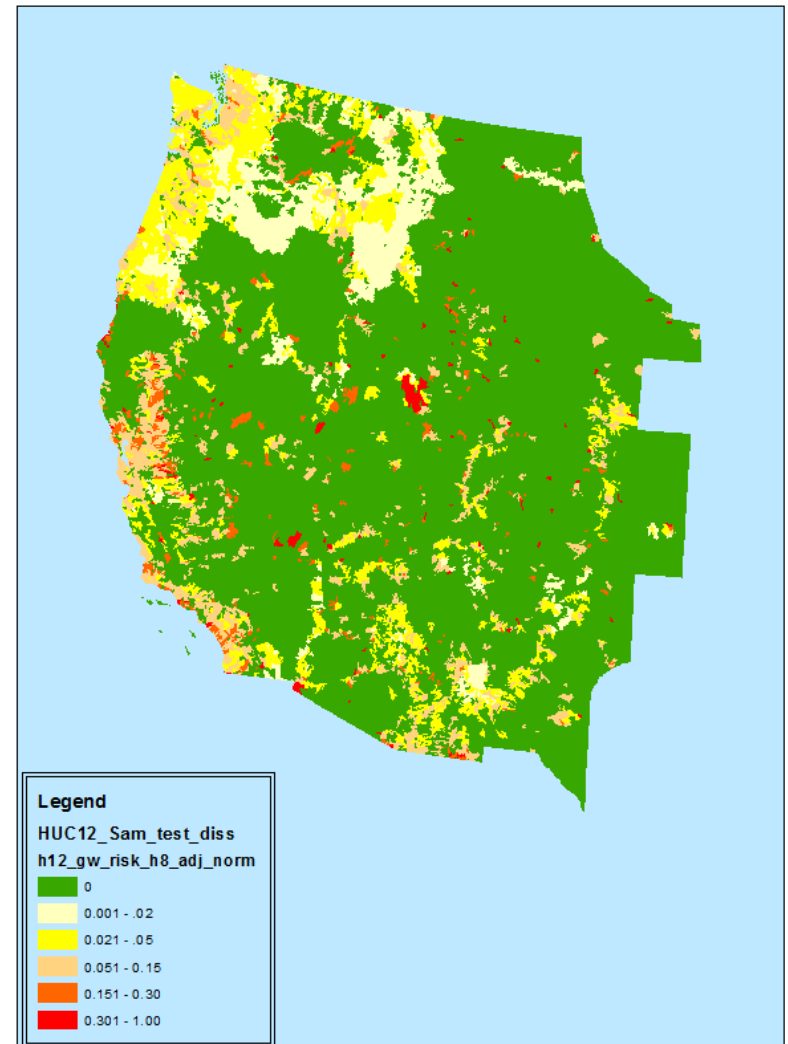
Total water demand (AFY) and areas where demand exceeds availability (red)



HUC-12 Risk Map (From Surface Withdrawals)

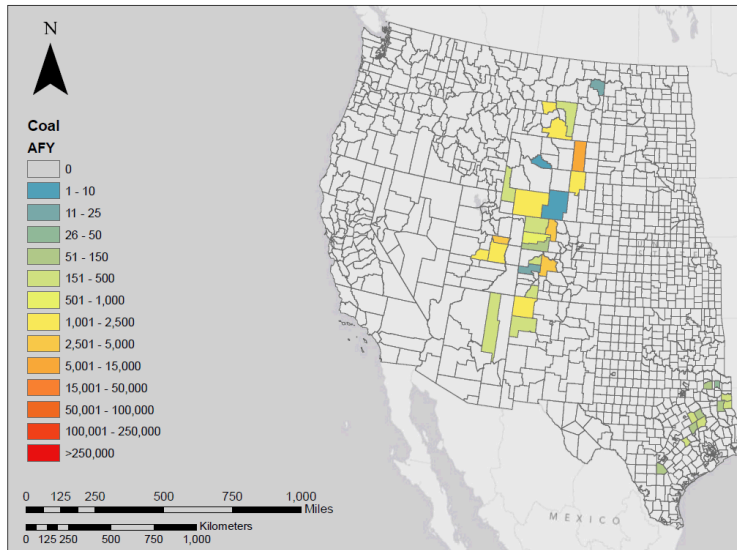


HUC-12 Risk Map (From Underground Withdrawals)

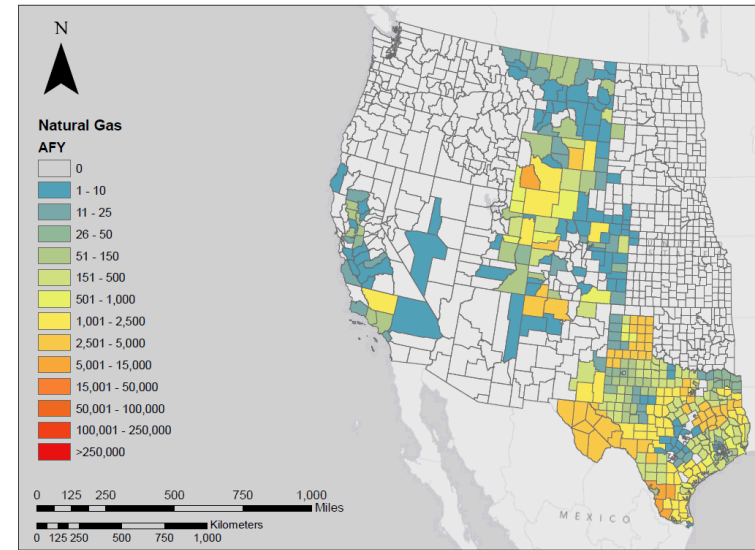


Water for Fuel Extraction

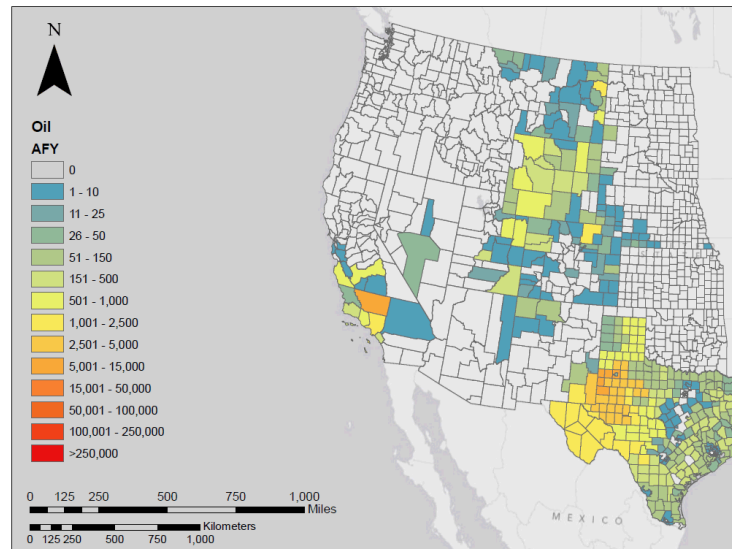
Water Use COAL



Water Use NATURAL GAS

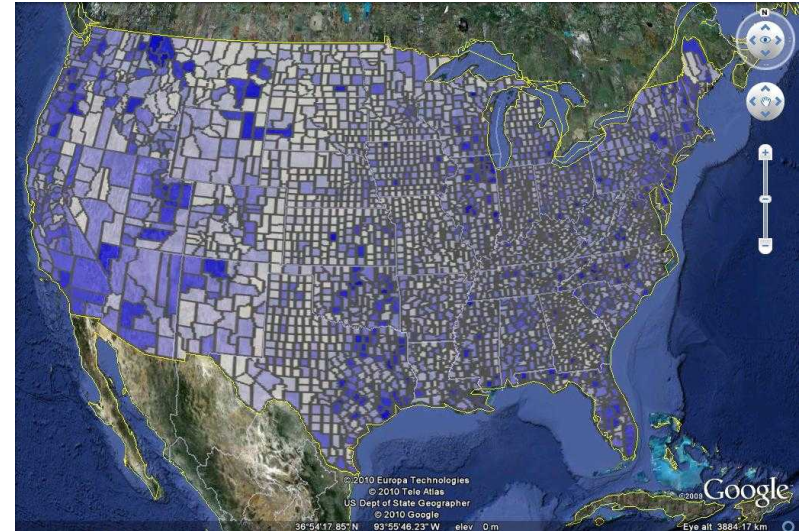
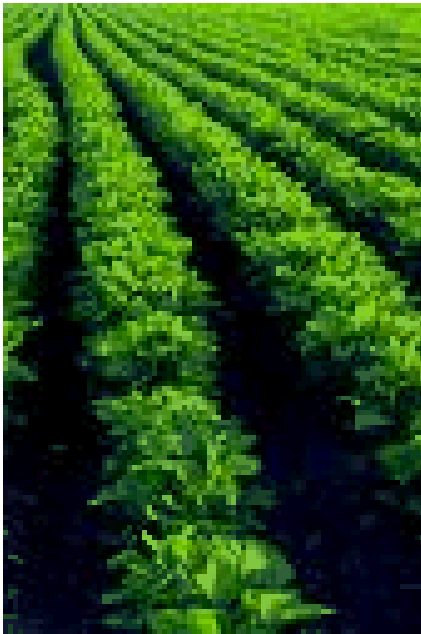


Water Use OIL



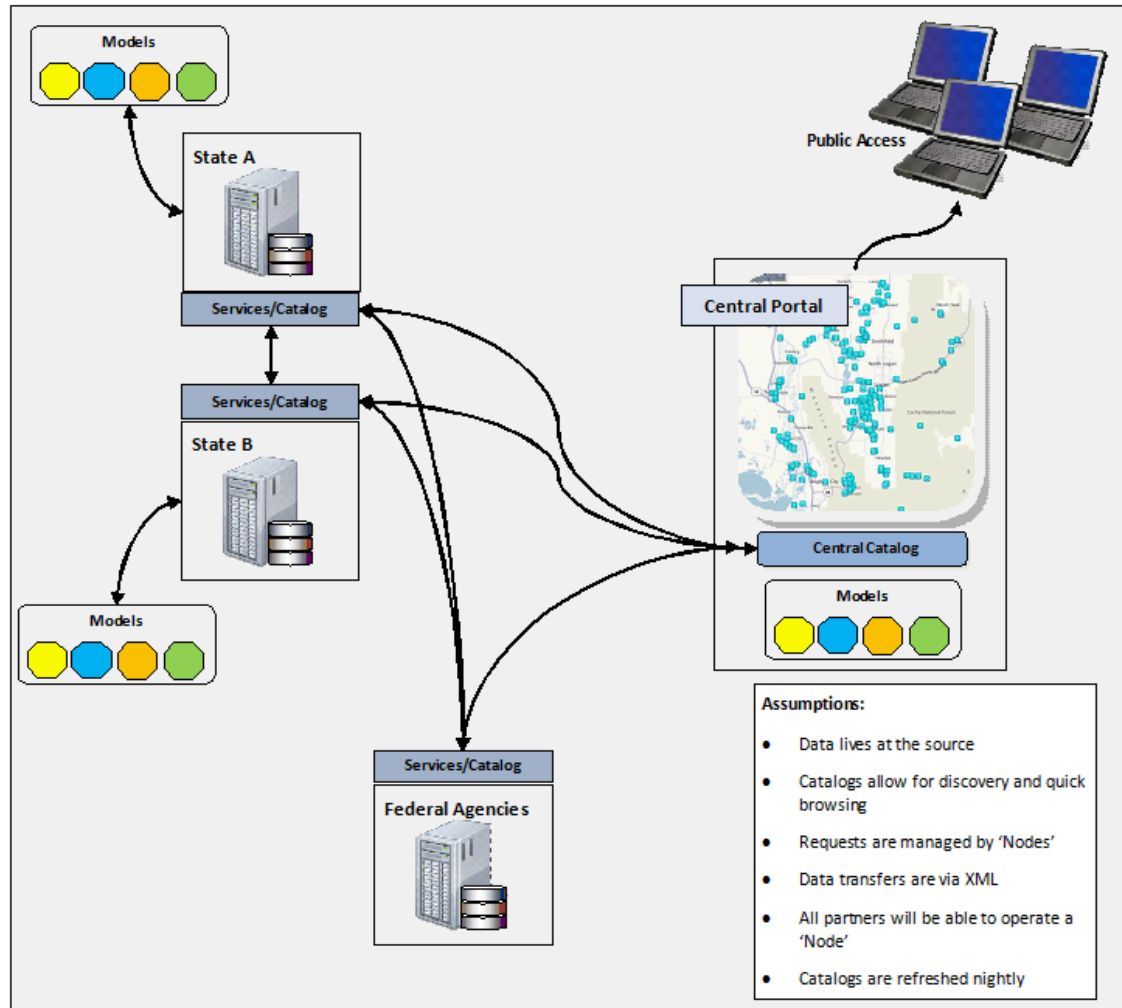
Energy for Water Calculator

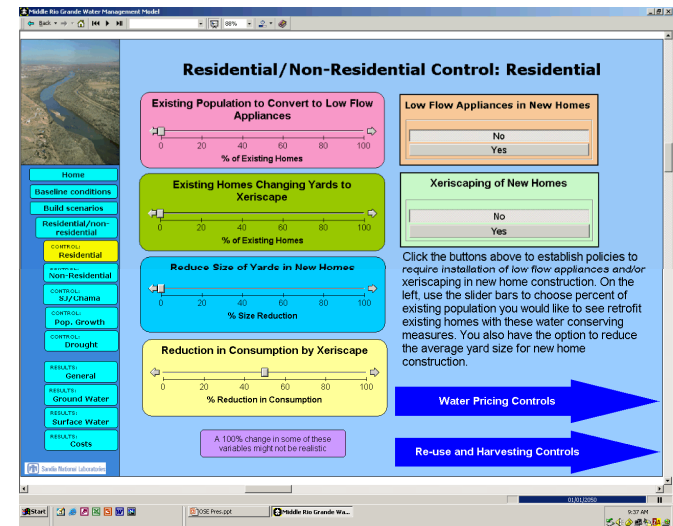
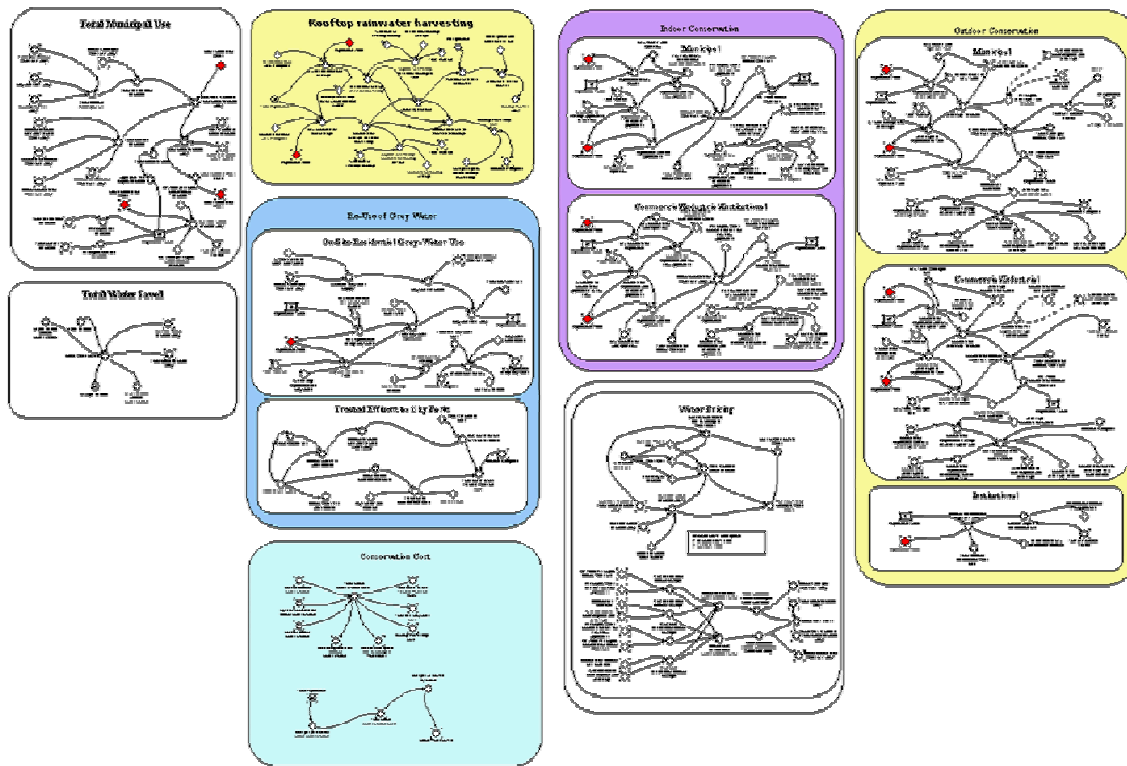
- ***Energy for Primary and Wastewater***
- ***Energy for Large Interbasin Transfers***
- ***Energy for Agriculture***



Water Use Data Exchange (WaDE)

- Use Web Services to transfer data
- Data Stay at the Source (i.e. the states)
- Provide transparent link between state data and integrated water metrics
 - Link to metadata
 - Changes in state data are automatically reflected in metrics





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