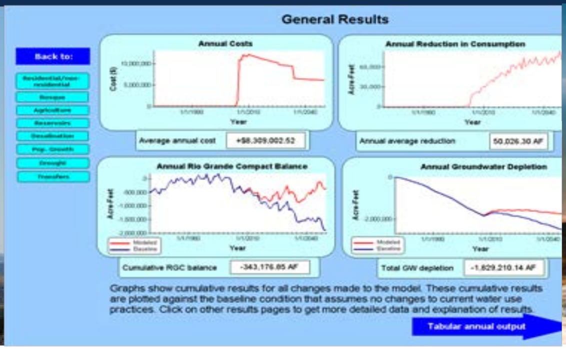
Exceptional service in the national interest

Sandia National Laboratories



Climate Adaptation Through Collaborative Modeling: Examples from the Rio Grande and Western Interconnection

Vincent Tidwell

Earth Systems Department

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

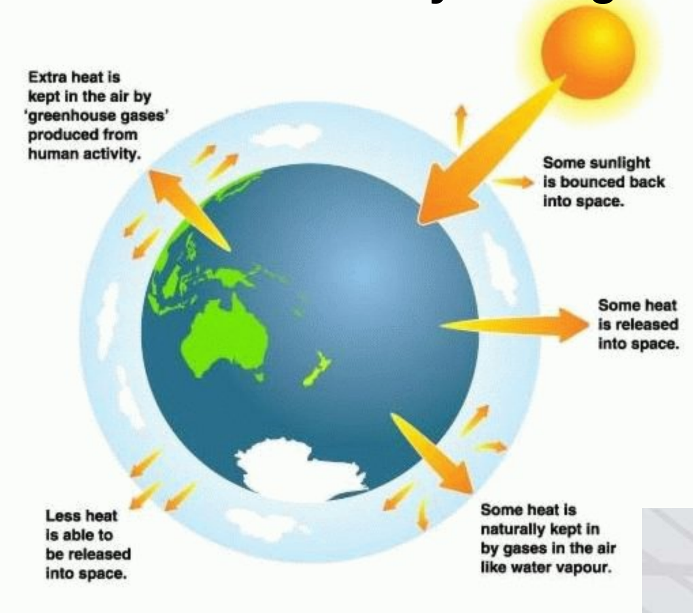
Collaborators

- Howard Passell
- Len Malczynski
- Tom Lowry
- Jesse Roach
- Beth Richards
- Marissa Reno
- Peter Kobos
- Will Peplinski
- Geoff Klise
- Ron Pate
- Barbie Moreland
- Stephanie Kuzio
- Ray Finley
- Erik Webb

Resource Planning Challenge

Sandia National Laboratories

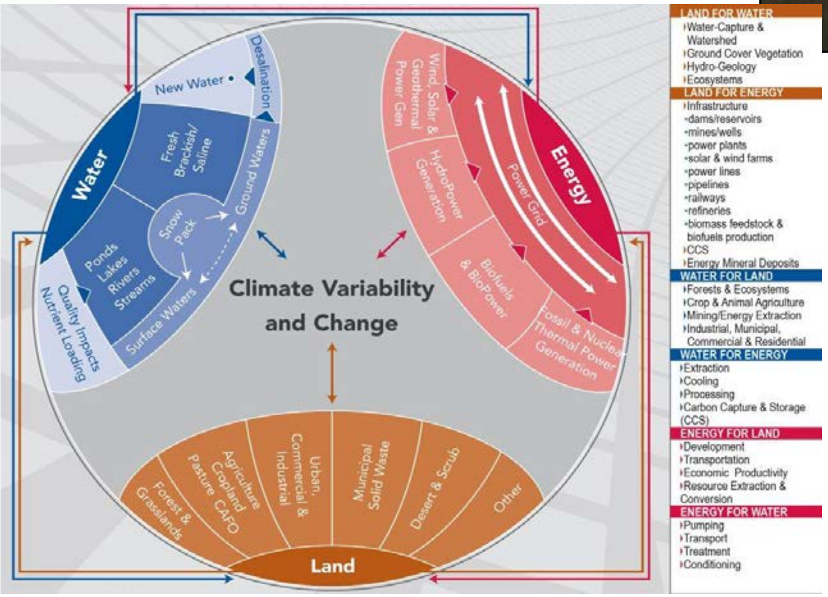
Climate Variability/Change



Growing Demand

Environmental Health

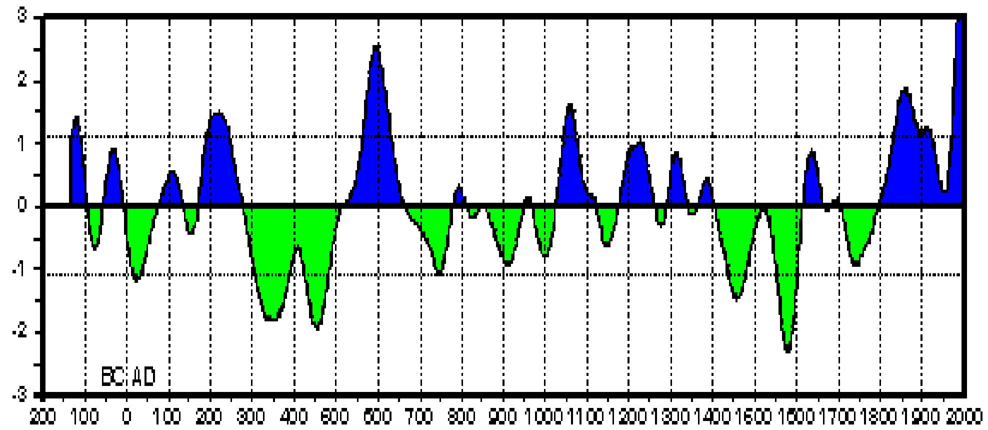
Competing Human Values

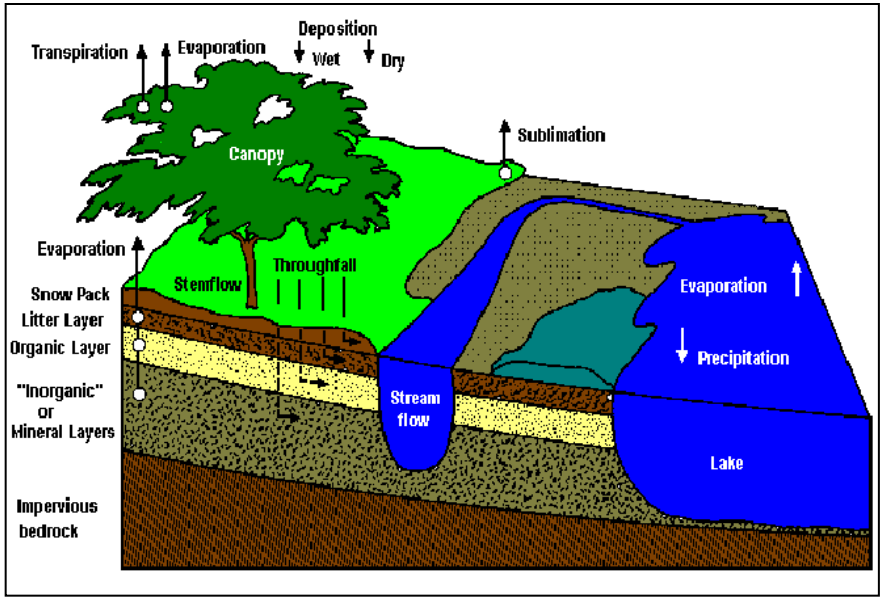


Energy/Water/ Land/….. Nexus

The Need

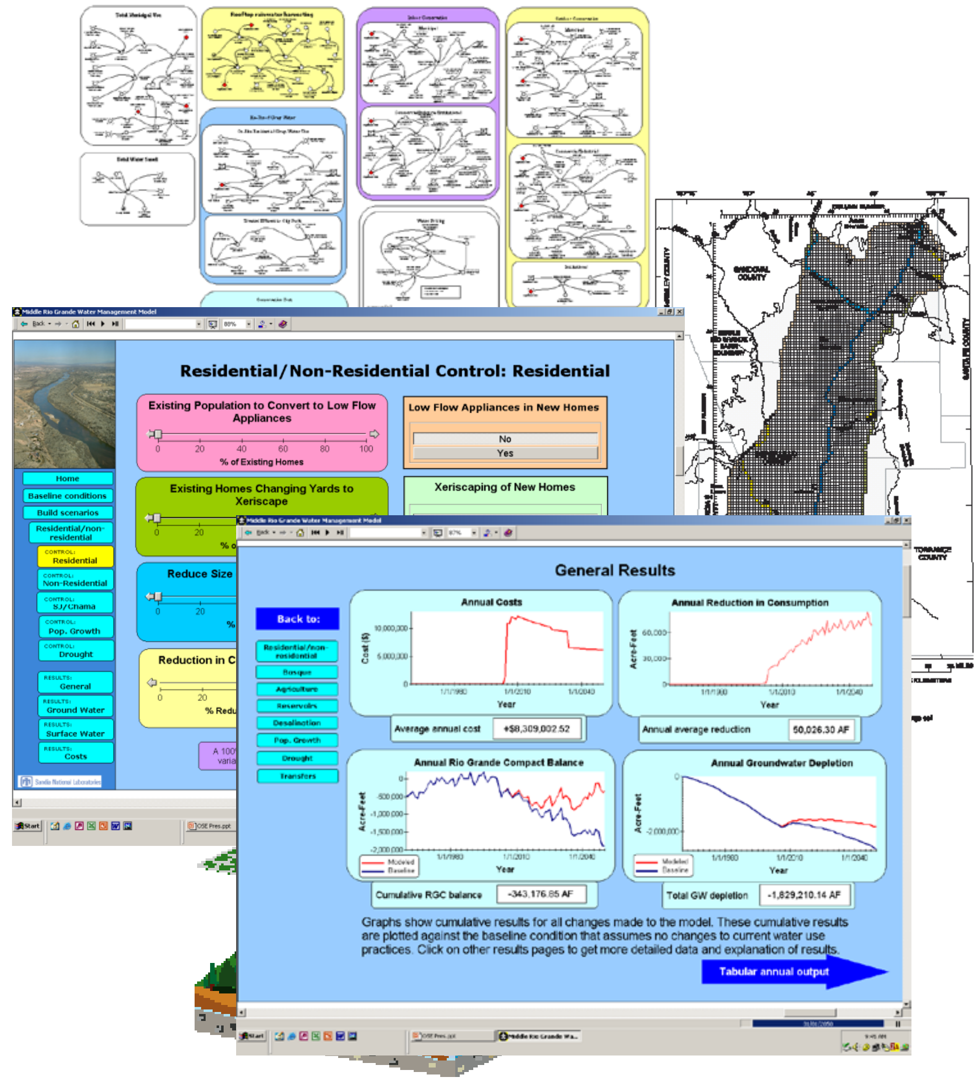
- ***Learn to speak the same language***:
  - Each person brings unique information and experience to the process.
  - No single person has the answer.
  - Need to develop a shared basis for decision making.





Integrative/Interdisciplinary Modeling

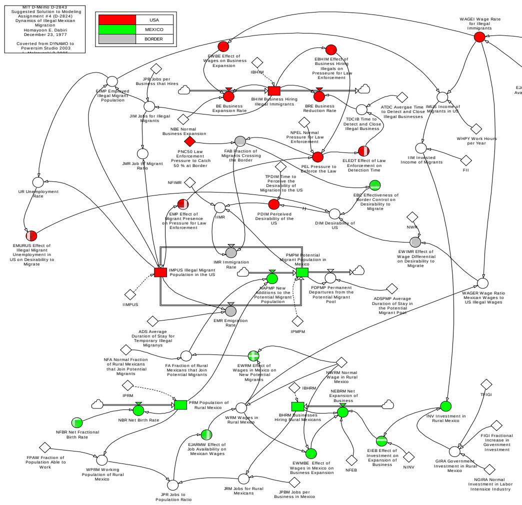
- System management,
  - High resolution,
  - Detailed physics,
  - Focused scope, and
  - Time intensive.
- System planning,
  - Low resolution
  - Scale appropriate physics,
  - Broad scope, and
  - Interactive.

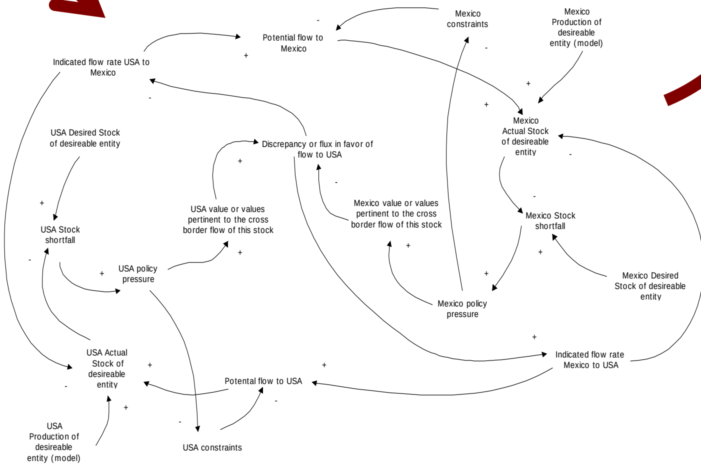


Fostering a Environment of Collaboration

Sandia National Laboratories

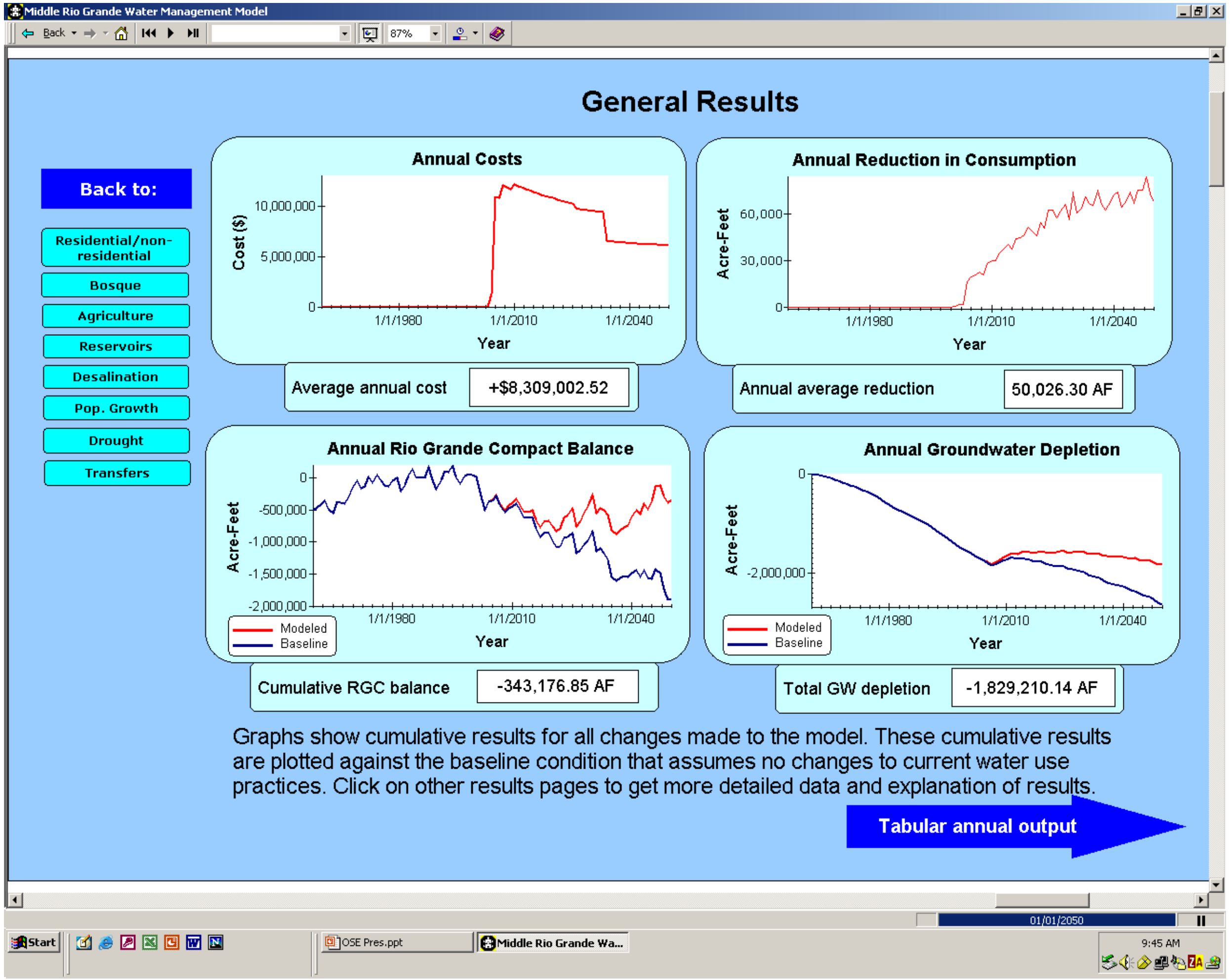
- Process of engaging decision-makers and stakeholders in:
  - Model development, and
  - Decision analysis.
- Purpose of broad input includes:
  - Expand knowledge base,
  - Structure group thinking/discussion,
  - Stimulate group learning, and
  - Ultimately lead to improved advocacy.





Visual/Interactive Environment for Analysis

- Broadly accessible
  - PC based
  - User friendly interfaces
  - Computations in seconds to minutes
- Provides interactive environment for scenario testing

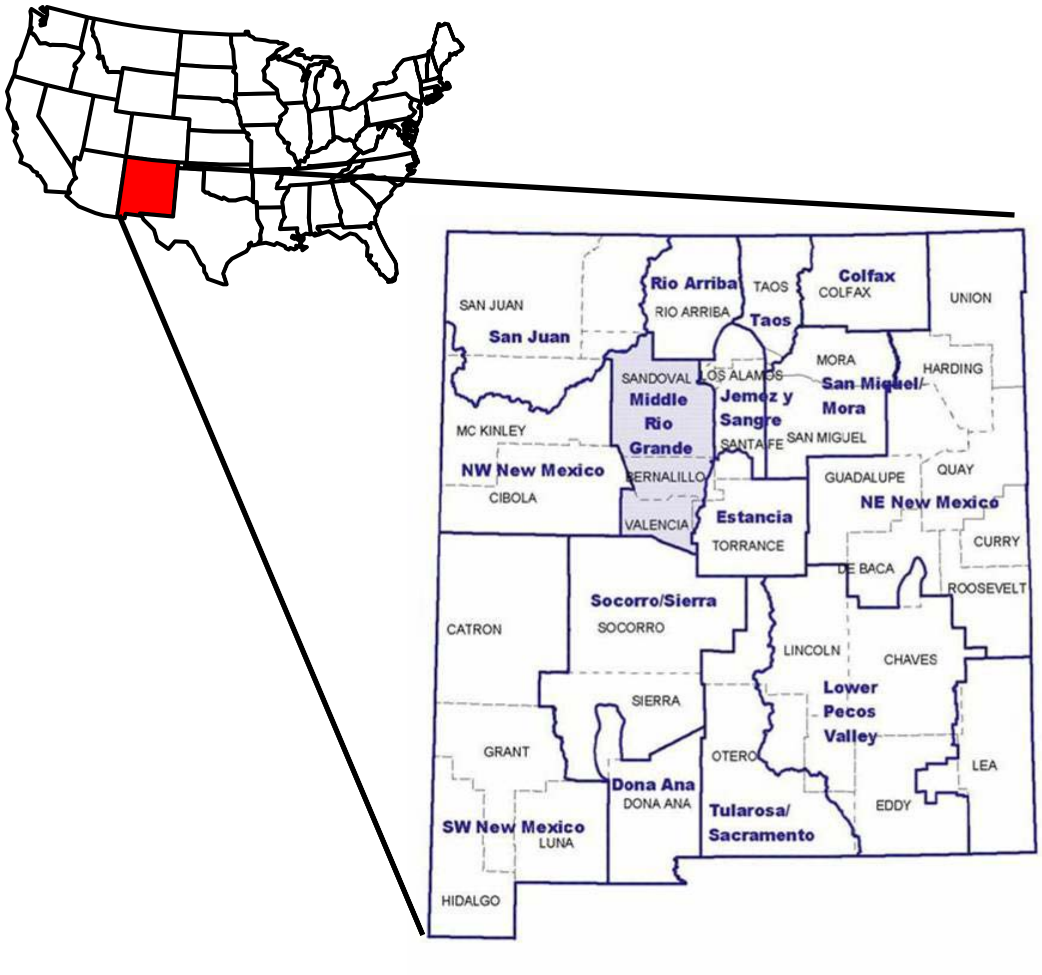


Motivation

People must be more afraid of the future than changes to the status quo

Example: MRG State Water Planning

- Three county planning region
  - Bernalillo
  - Sandoval
  - Valencia
- Total population of ~750,000 including Albuquerque, Rio Rancho, Belen, Bernalillo and Los Lunas



Planning Objectives

1. **What is the region's available water supply?**
2. **What is the region's future water demand?**
3. **How will the region balance supply with demand?**

- What actions can be taken?
- Which are acceptable to the community?
- How can they be implemented?

Planning horizon of 50 years!

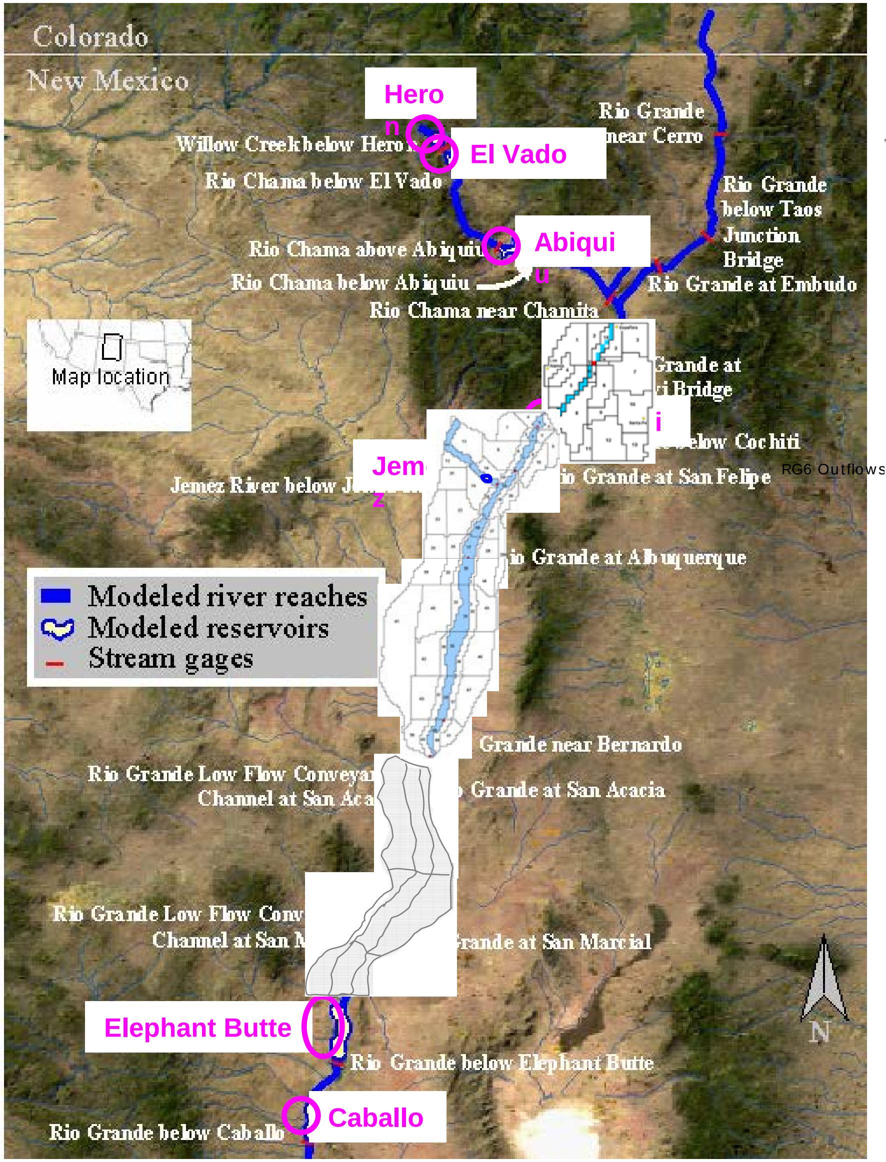
Model Development Process

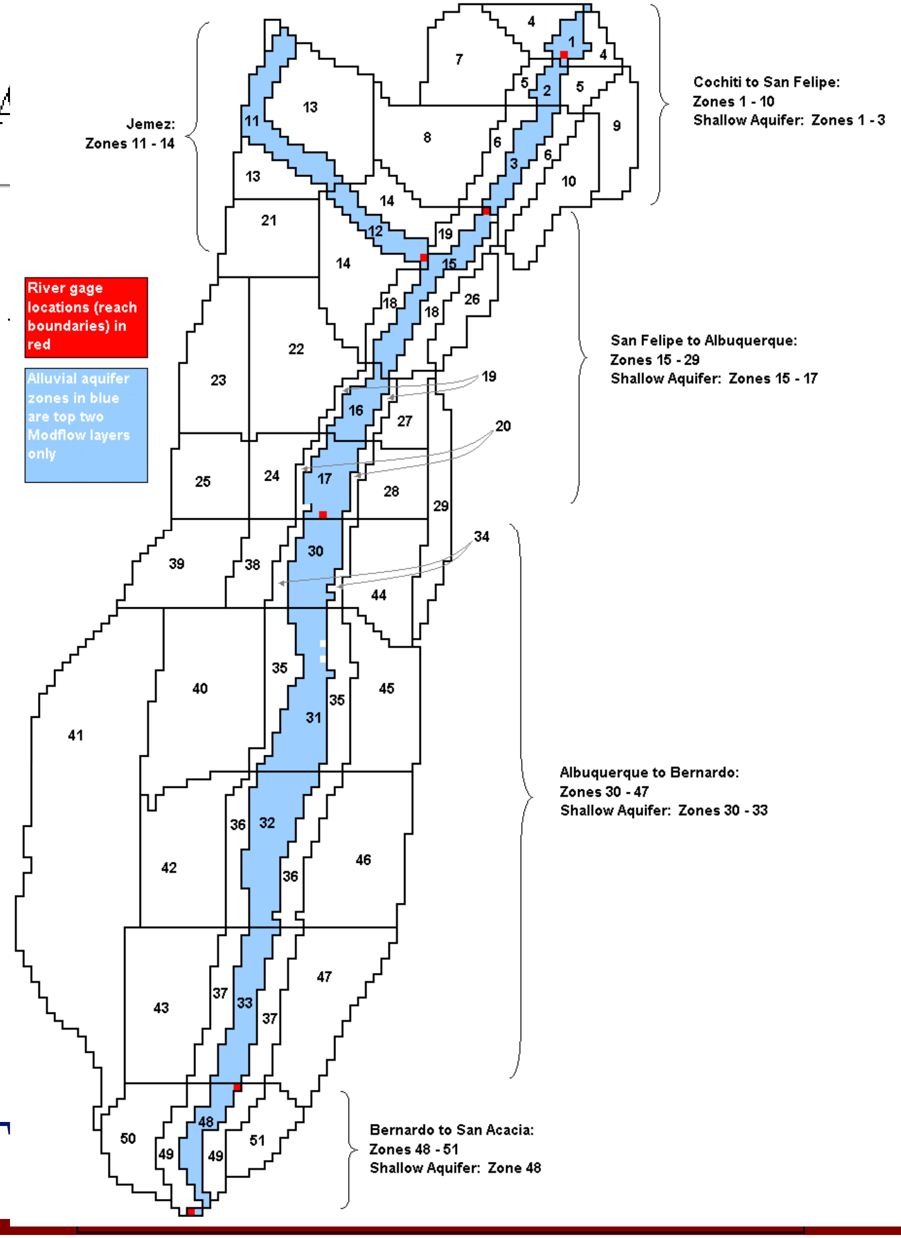
- Assembled a "Cooperative Modeling Team" including members from:
  - Each Water Assembly constituency group,
  - Middle Region Council of Governments (MRCOG), and
  - Utton Transboundary Resources Center, UNM
- Team meets every other week to:
  - Conceptualize model components,
  - Identify external sources of expertise and data, and
  - Review the model
- Community engagement
  - Expose community to model
    - Public forums,
    - Educational venues, and
    - Community events
  - Interactions with the professional community

MRG Operations Planning

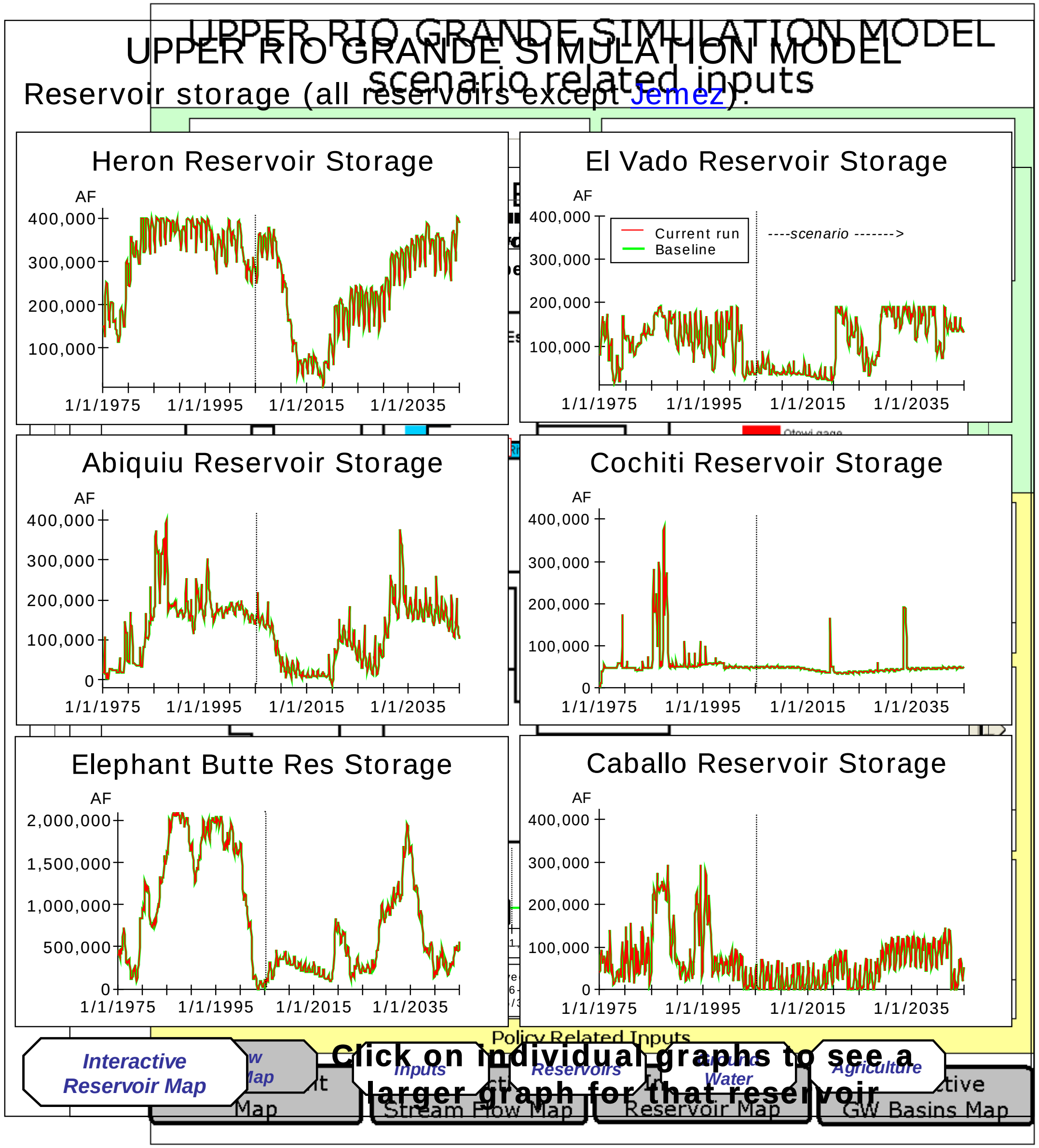
- Develop a decision support tool that is consistent with and complimentary to the Upper Rio Grande Water Operations Model (URWOM).
  - The primary purpose of the tool is to provide a platform for rapid scenario screening, and
  - Educate and engage the public and decision makers in water operations decision-making and planning.

Operations Model for the Upper Rio Grande



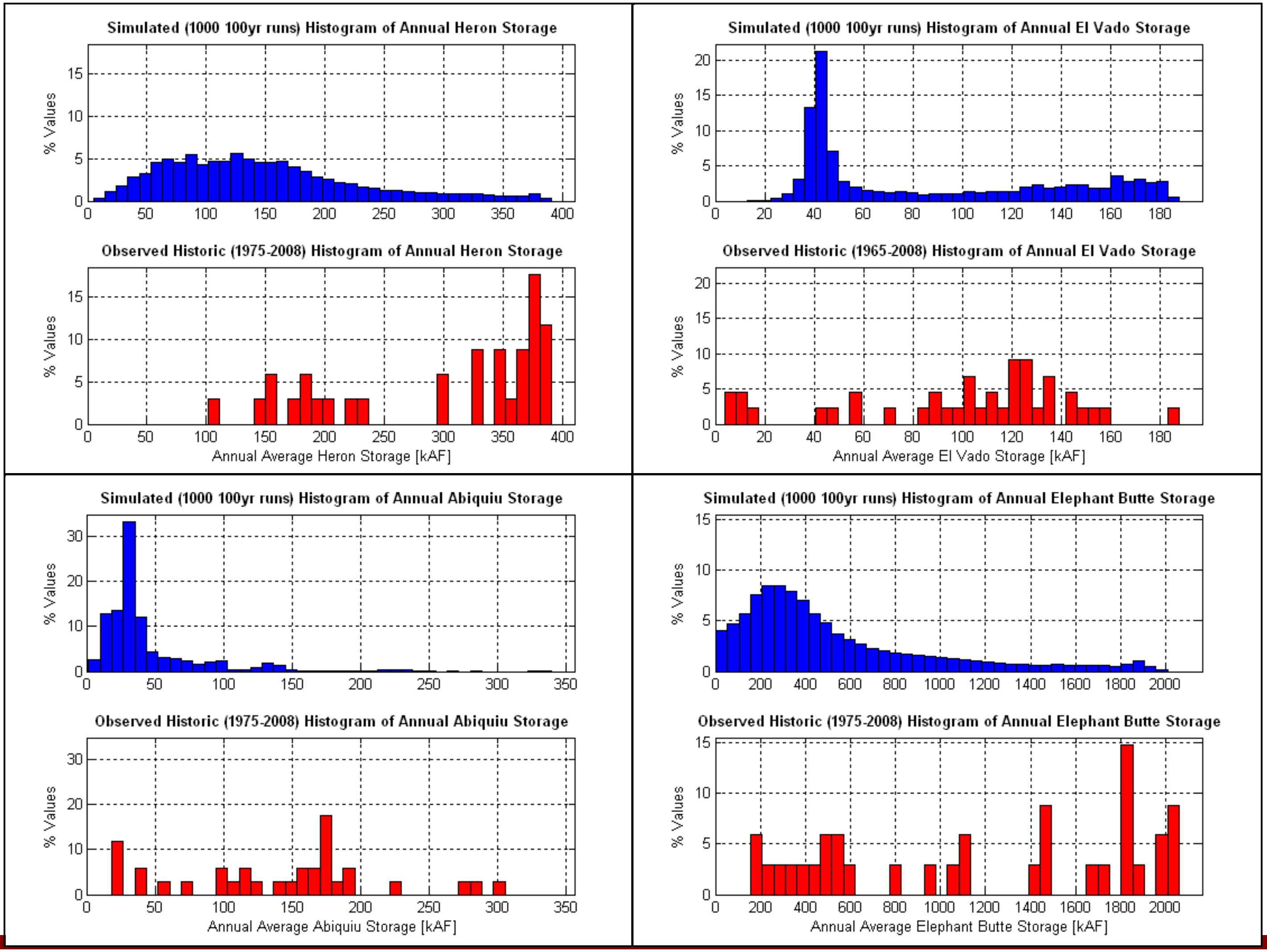


Operations Model for the Upper Rio Grande



Stochastic Reservoir Storage

Use the model to run 1000, 100 year long climate sequences based on 400 years of tree ring data:



Water Leasing Market Experiments

You are Cash Farmer 1 on Reach 1

What do you want to do?

- ( ) **Buy**
- ( ) **Sell**

1.00 AF units

For this Price: $

Cost per AF: $ / AF

Submit

YEAR	ROUND	TIME LEFT
1976	May of Year 1	03:05

CURRENT PAYOFF	
Water Balance (B)	4.35AF
Water Balance Value (V)	$0.0
Trading Cash (C)	$10.0
Year-end Earnings (C+V)	$10.0

Min. AF to get yield: 0.67

Refresh me

Previous Round Earnings

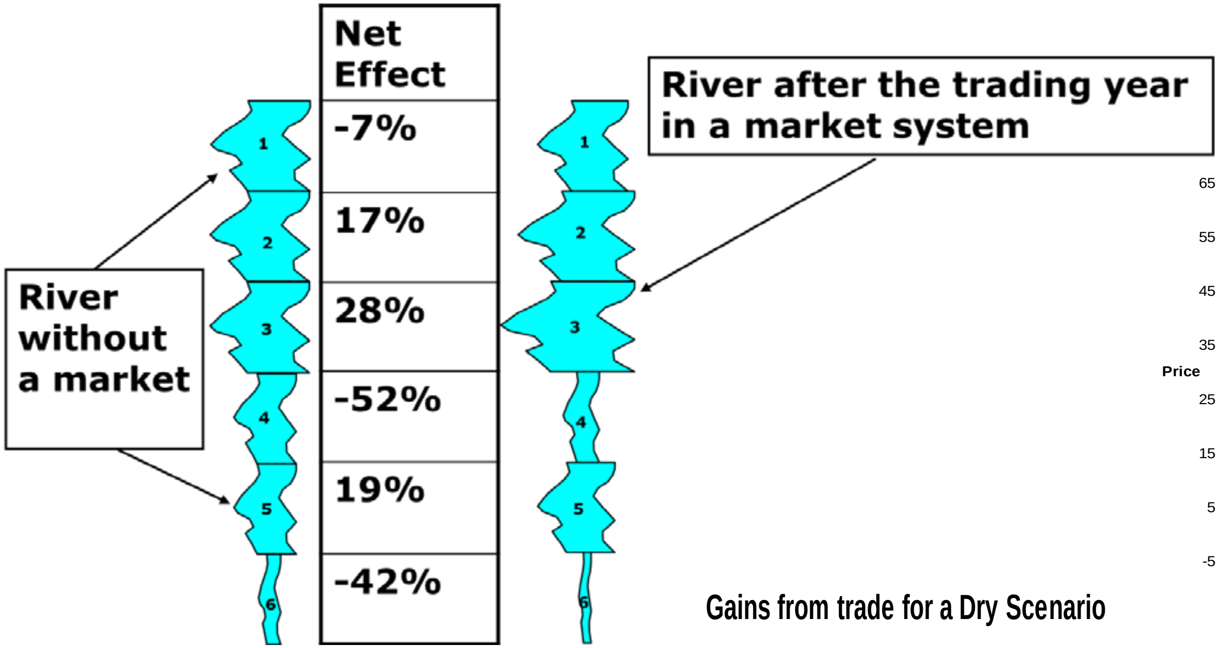
ALL TRANSACTIONS FOR EXPERIMENT

Player	Action	Player	Actual Units	Price	Price per AF
Cash Farmer 5	>>	Cash Farmer 1	1	$8	$8
Cash Farmer 6	<<	Env.	1	$5	$5
Cash Farmer 6	>>	Env.	1	$4	$4
Cash Farmer 6	<<	Cash Farmer 8	1	$2	$2
Cash Farmer 9	>>	Urban	1	$8	$8

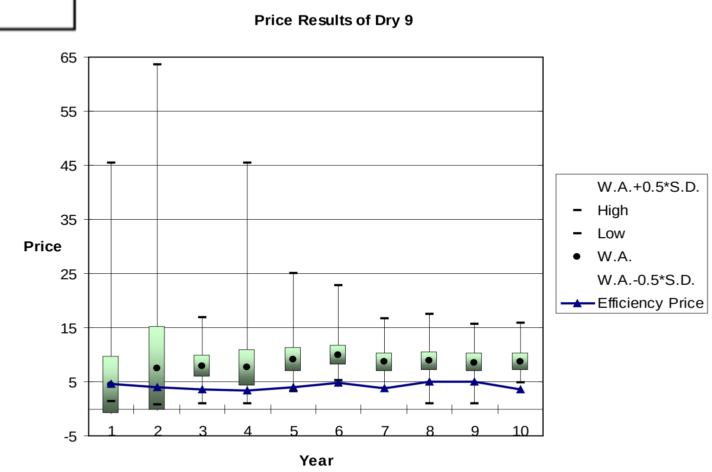
BIDS AND OFFERS (click on link to sell or buy)

Reach	Player	Click to Sell	Click to Buy
1	**Cash Farmer 1**		
1	Cash Farmer 3		0.7 AF @ $4.00 ($5.71/AF)
1	Cash Farmer 2		
2	Pecan Farmer 1		
2	Urban		
2	Cash Farmer 5		
2	Cash Farmer 4		
3	Pecan Farmer 2		
3	Cash Farmer 7		
3	Cash Farmer 6		
4	Pecan Farmer 3		
4	Cash Farmer 8		
5	Cash Farmer 9		0.79 AF @ $8.00 ($10.11/AF)
5	Cash Farmer 10		
0	Environmental		1.20 AF @ $7.00 ($5.50/AF)

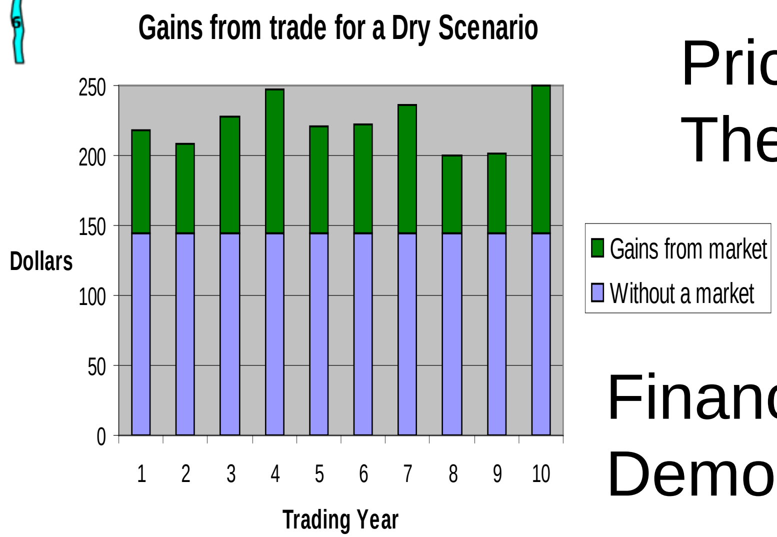
Water Leasing Market Experiments



Impacts on Distribution of River Flows



Prices Trend to Theory



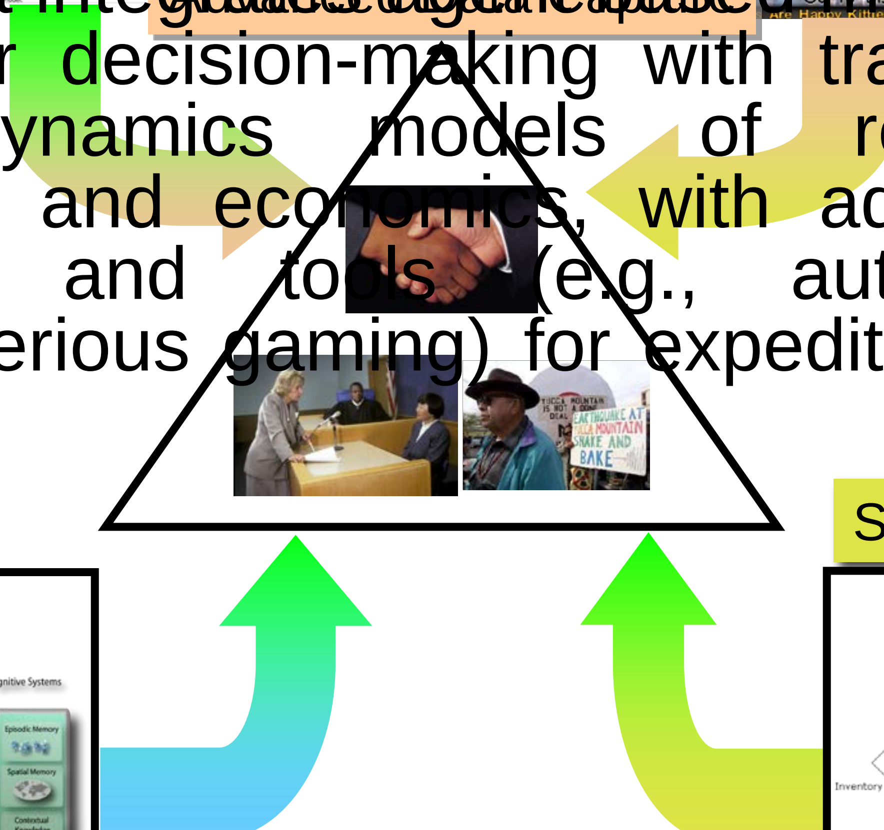
Financial Gains Demonstrated

Decision Insight into Stakeholder Conflict

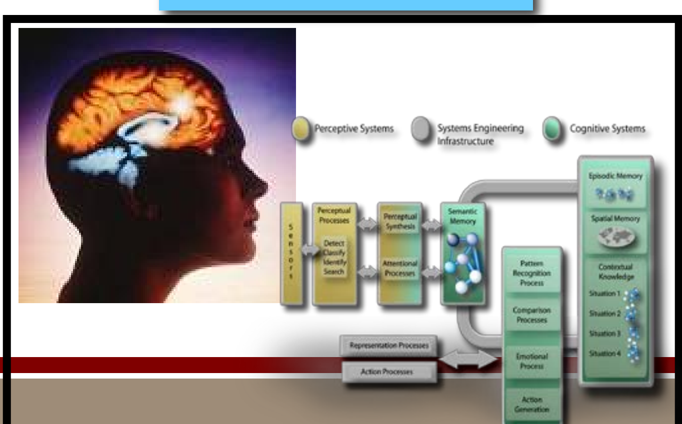
Sandia National Laboratories

Approach: Develop an decision support system that integrates agent based models of stakeholder decision-making with traditional system dynamics models of resource constraints and economics, with advanced processes and tools (e.g., automated learning, serious gaming) for expedited data capture.

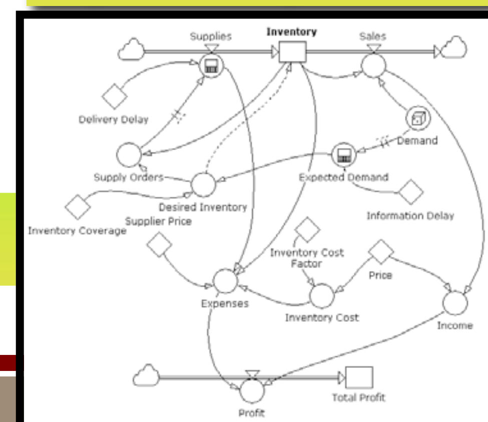
Advanced Data Capture



Agent Based Modeling



System Dynamics

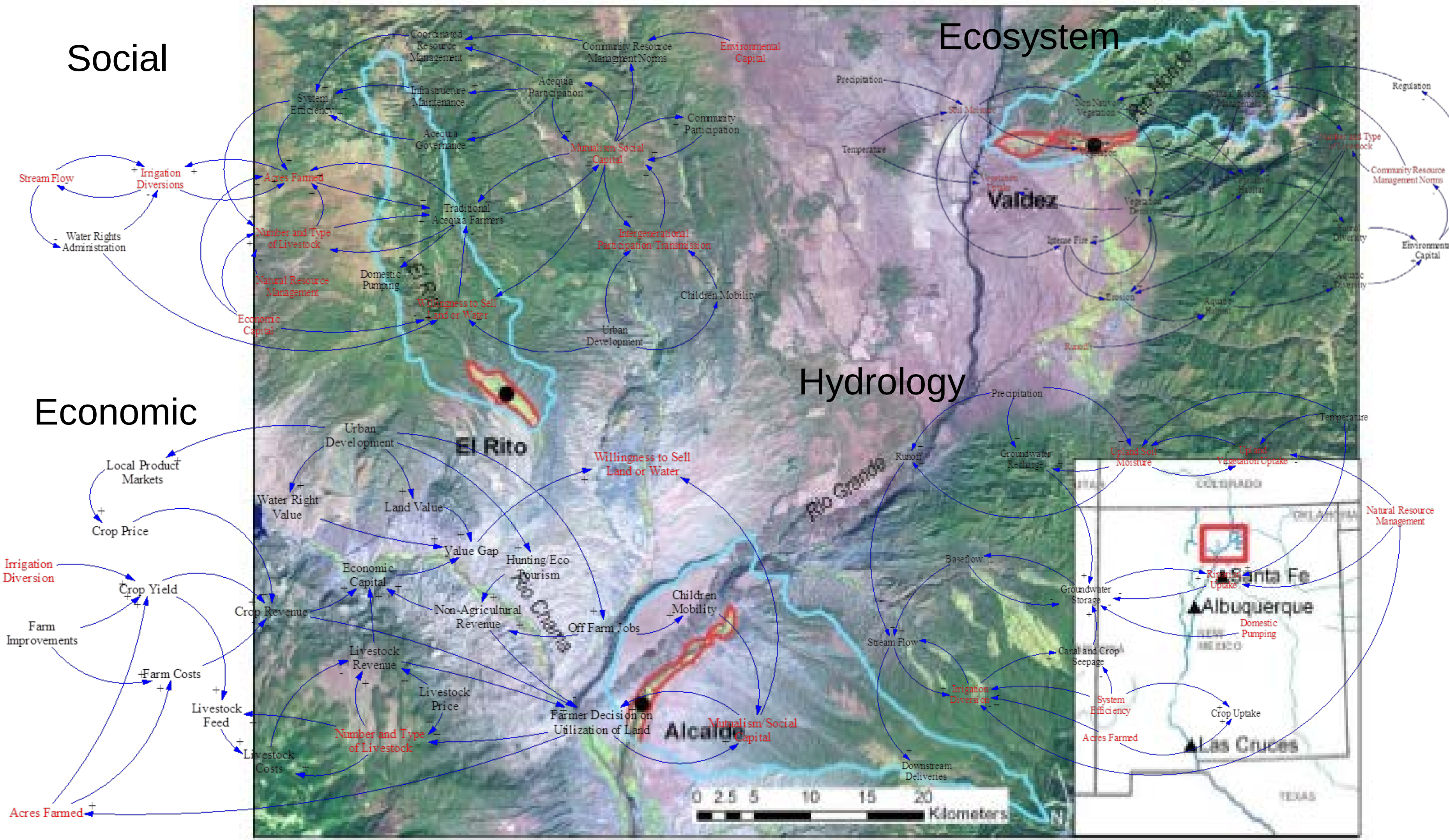


Serious Game Interface

- Water Wars Serious Game
  - SimCity style game
  - Built on Intel's Opensim gaming environment
  - SNL's integrated model serves as the "physics" to the game interface
  - Game is served over the web
- Game provides automated data capture on stakeholder behavior
- Game play controlled to expose desired action
- Game modes:
  - Multi player
  - Man against machine
  - Hybrid

Acequias vs. Climate Change and Urban Growth

Acequias vs. Climate Change and Urban Growth

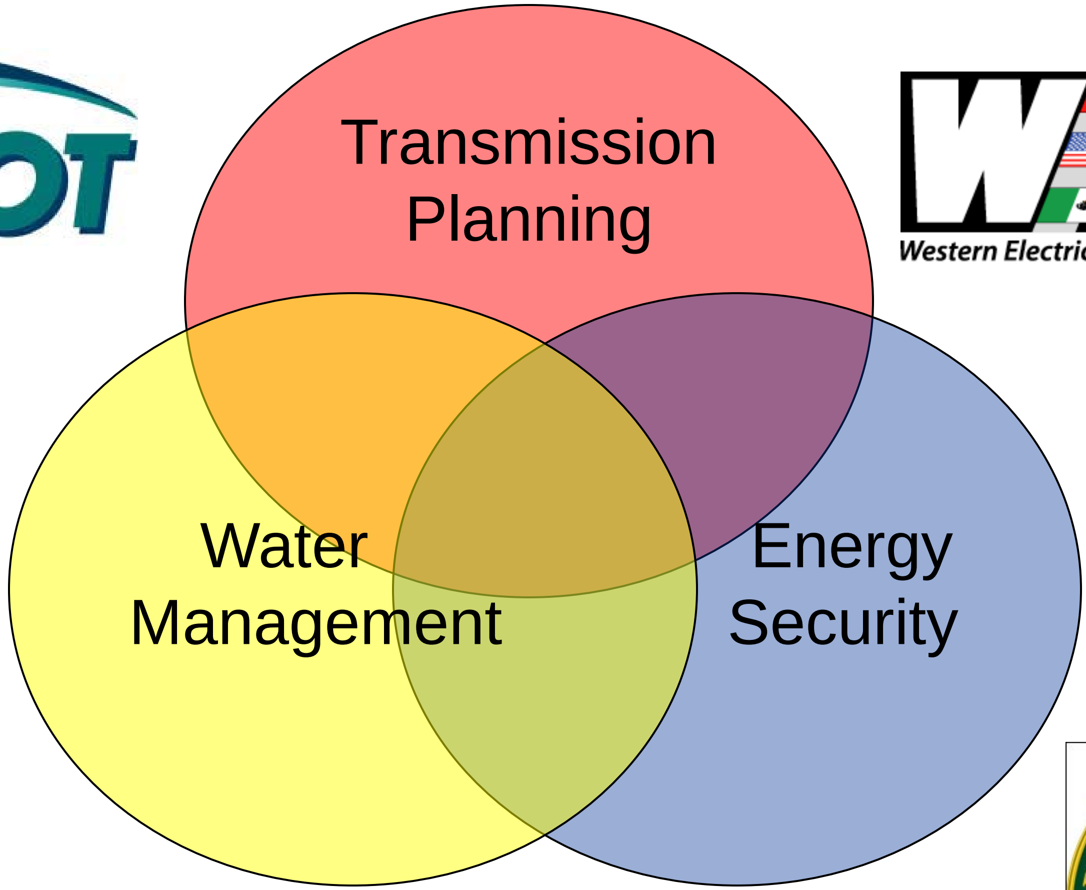


Energy and Water in the Western and Texas Interconnections

Sandia National Laboratories

ERCOT

WECC
Western Electricity Coordinating Council



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

WSWC
Western States Water Council

Department of Energy · United States of America

Project Objectives

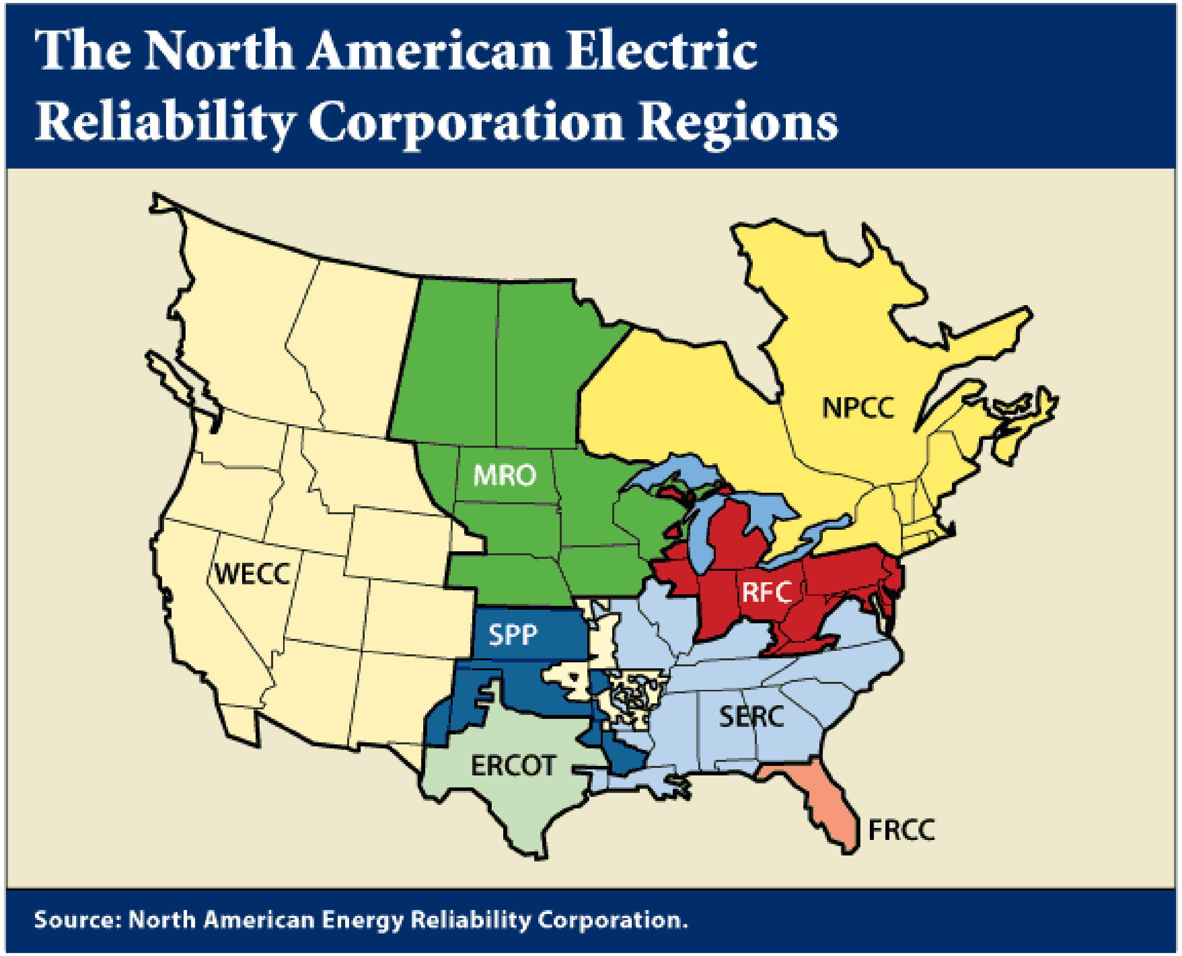
- Reduce the water footprint of electric power production in western North America:
  - Develop tools for quantitative assessment of the energy-water nexus,
  - Engage stakeholders across the energy-water spectrum, and
  - Evaluate water implications of alternative interconnection-wide transmission expansion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

Project Partners

- Sandia National Laboratories
  - Vincent Tidwell
  - Barbie Moreland
  - Howard Passell
- Argonne National Laboratory
  - John Gasper
  - John Veil
  - Chris Harto
- Electric Power Research Institute
  - Robert Goldstein
- National Renewable Energy Laboratory
  - Jordan Macknick
  - Robin Newmark
  - Daniel Inman
  - Kathleen Hallett
- Idaho National Laboratory
  - Gerald Sehlke
  - Randy Lee
- Pacific Northwest National Laboratory
  - Mark Wigmosta
  - Richard Skaggs
  - Ruby Leung
- University of Texas
  - Michael Webber
  - Carey King

Transmission Planning

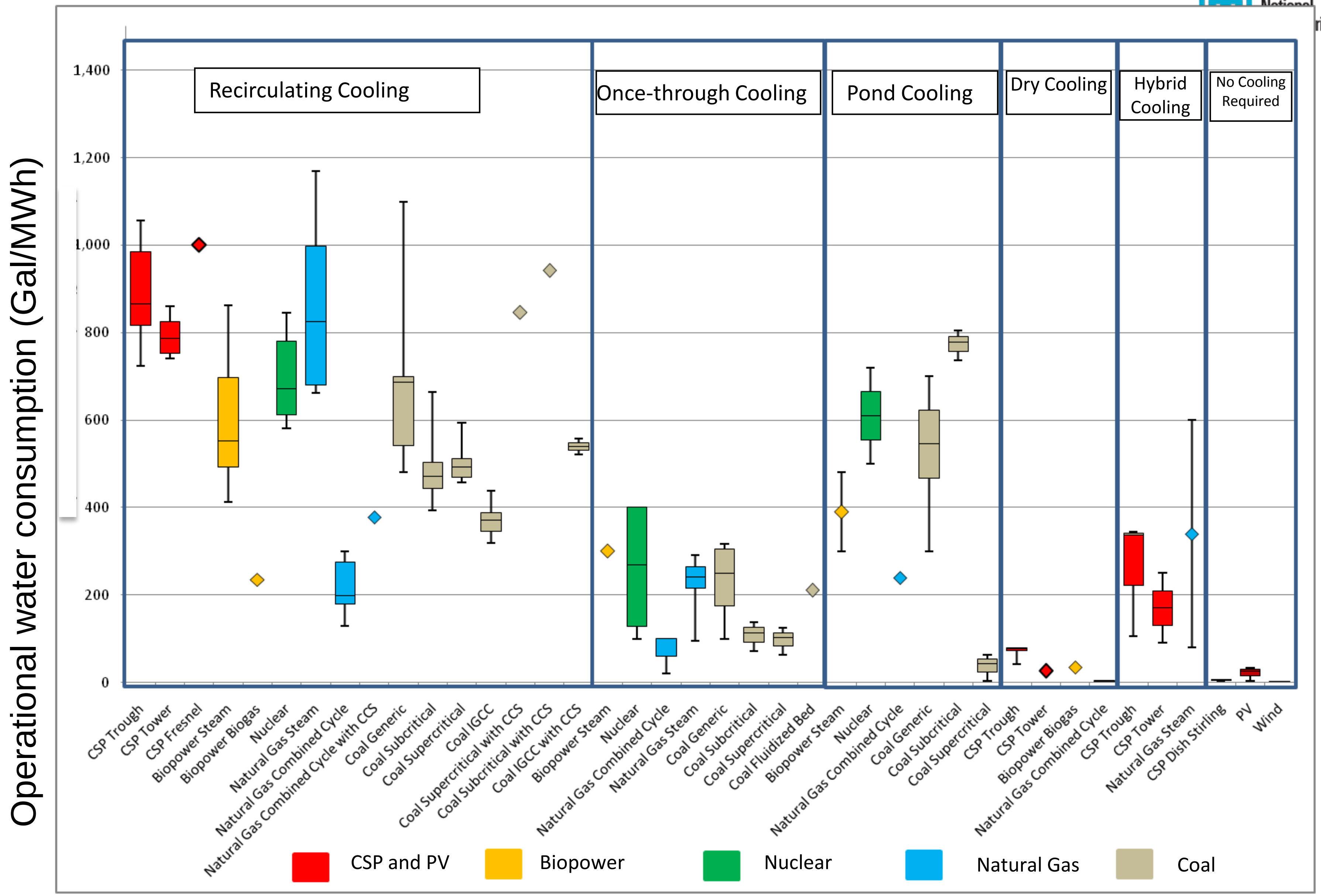
- WECC and ERCOT are conduction long-range transmission planning (20 yrs.)
  - Siting of new power plants
  - New transmission capacity



Power Plant Siting Decisions

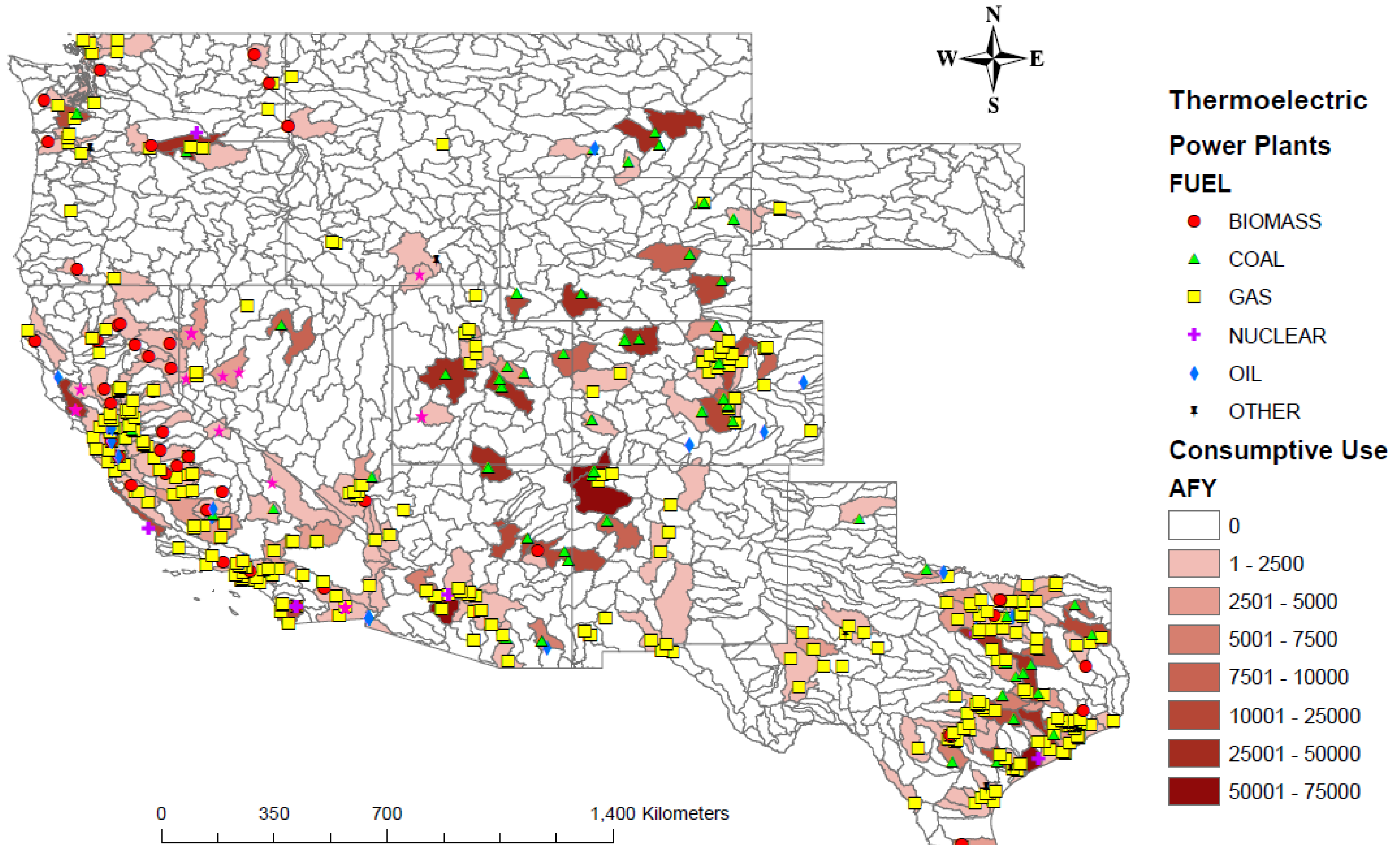
- West-wide objectives
  - Minimize cost
  - Maximize reliability
  - Maximize transmission capacity utilization
  - Limit exposure to policy change
  - ***Minimize stress over water***
- Power plant siting criteria
  - Fuel type
  - Cooling type
  - Capacity
  - Location
  - Water source

Operational water *consumption* factors for electricity generating technologies



Source: Macknick *et al.* 2011

Thermoelectric Consumptive Use and Power Plants (Current)



Key Water Sources

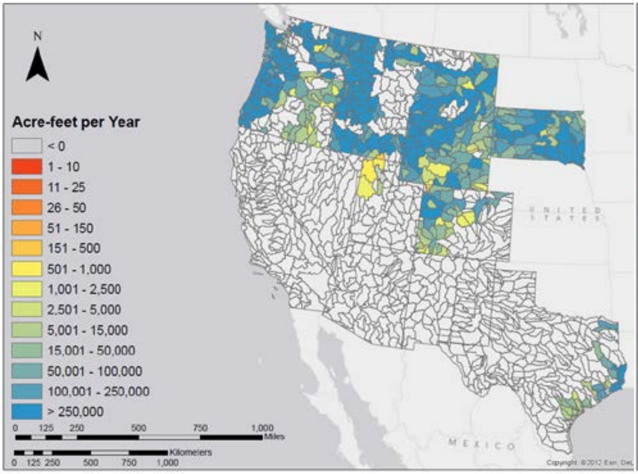
- **Potable Water**
  - **Unappropriated surface water**
  - **Appropriated surface water (rights transfers)**
  - **Groundwater**
- **Non-Potable Water**
  - **Municipal/Industrial wastewater**
  - **Shallow brackish water**
  - **Sea Water**

Relative Availability and Cost

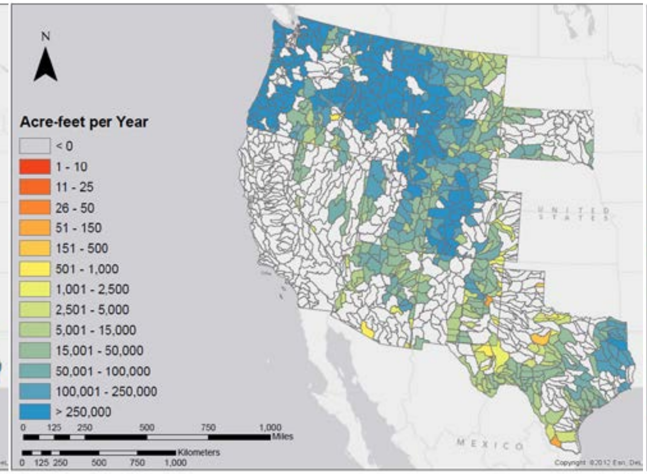
Water Availability

Sandia National Laboratories

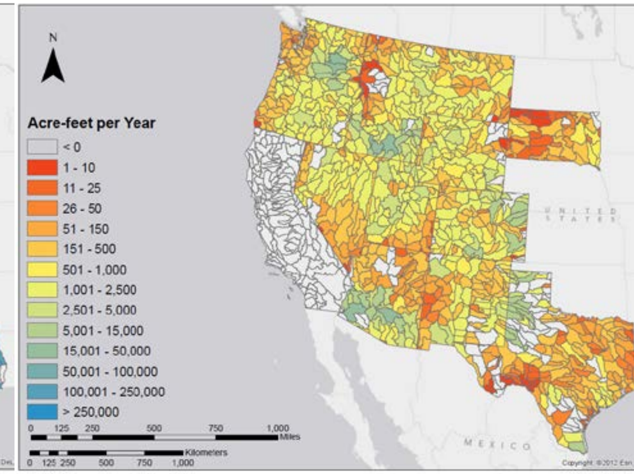
Unappropriated Surface Water Metric



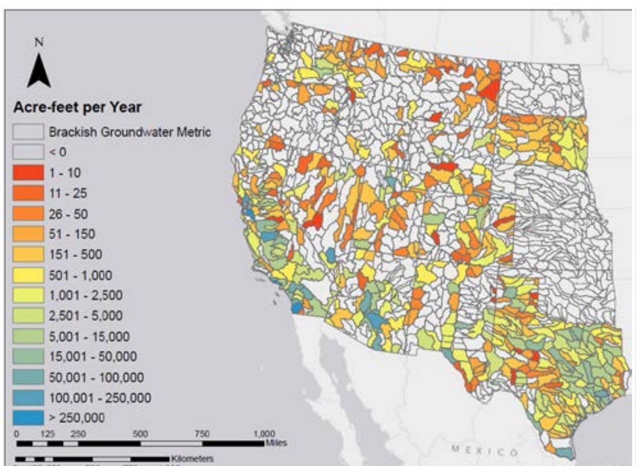
Potable Groundwater Metric



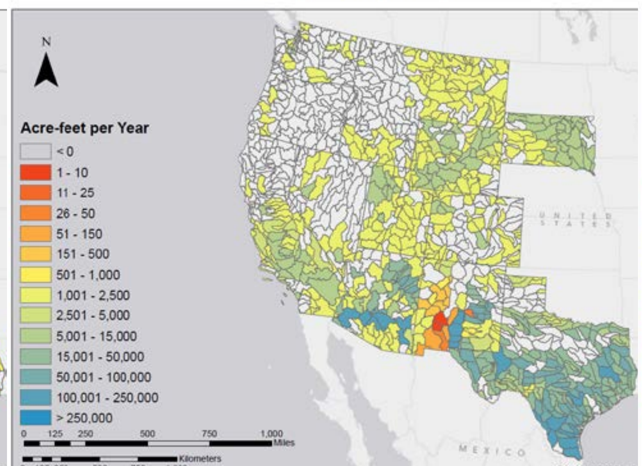
Appropriated Surface Water Metric



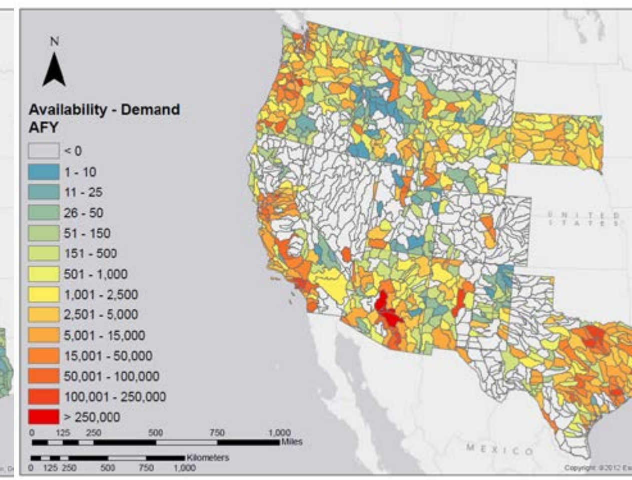
Wastewater Metric



Brackish Groundwater Metric

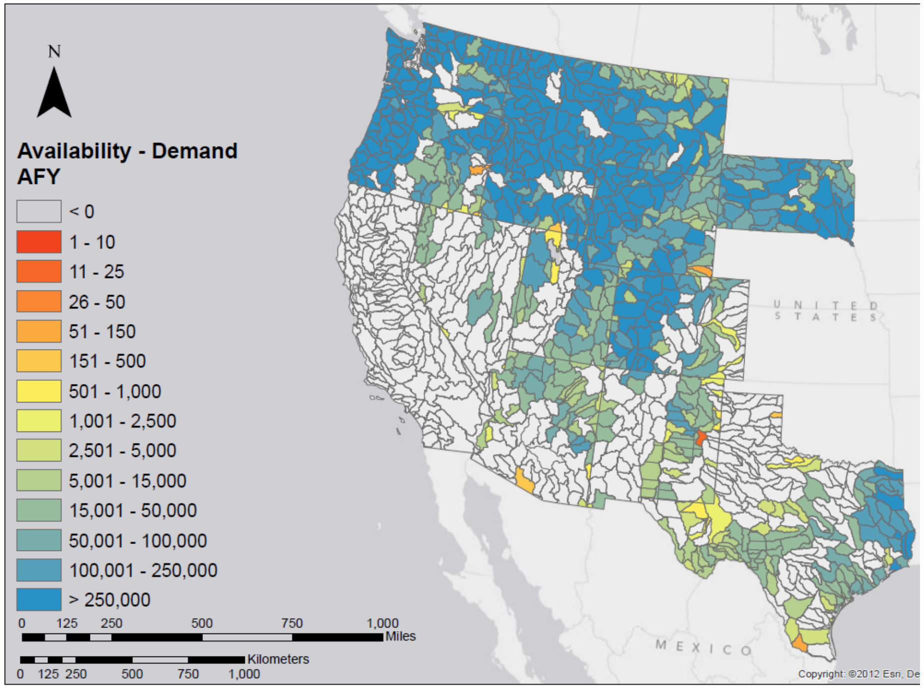


Change in Demand, Present - 2030

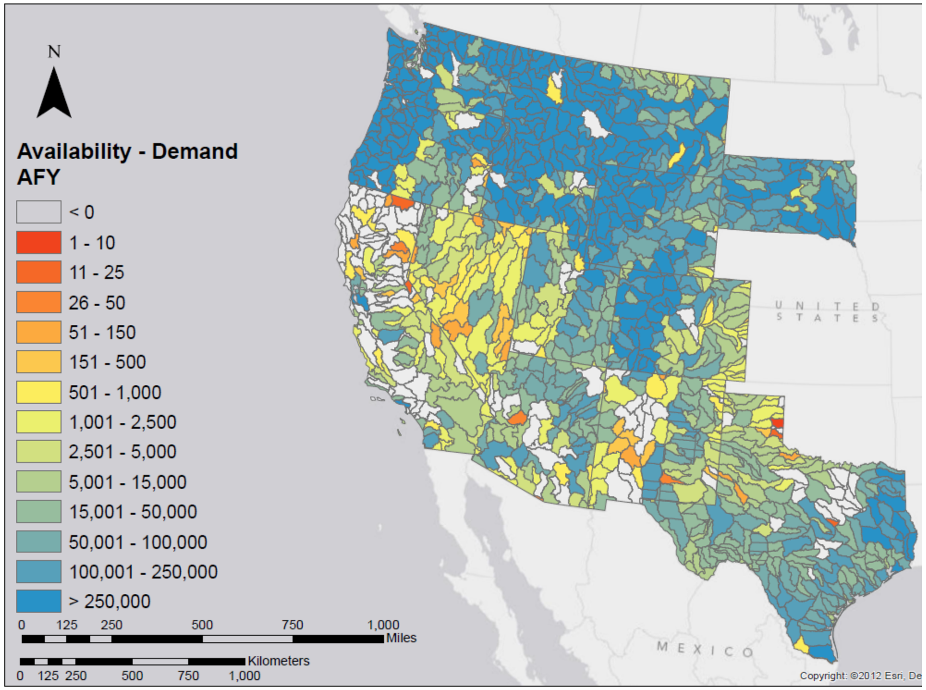


Water for Development

Unappropriated Water Sources Only
Availability - Demand, 2030

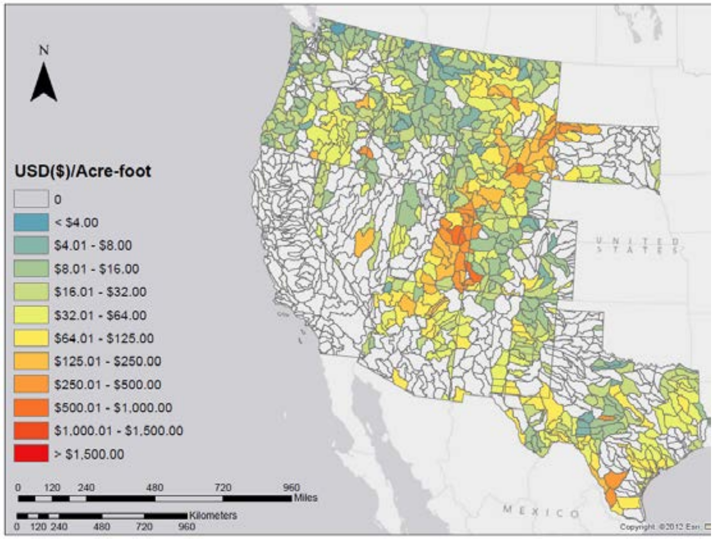


All Water Sources
Availability - Demand, 2030

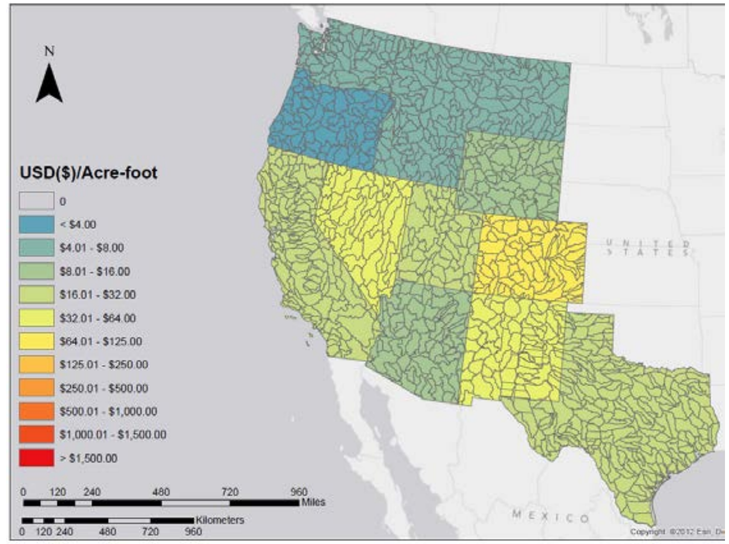


Relative Cost of Water

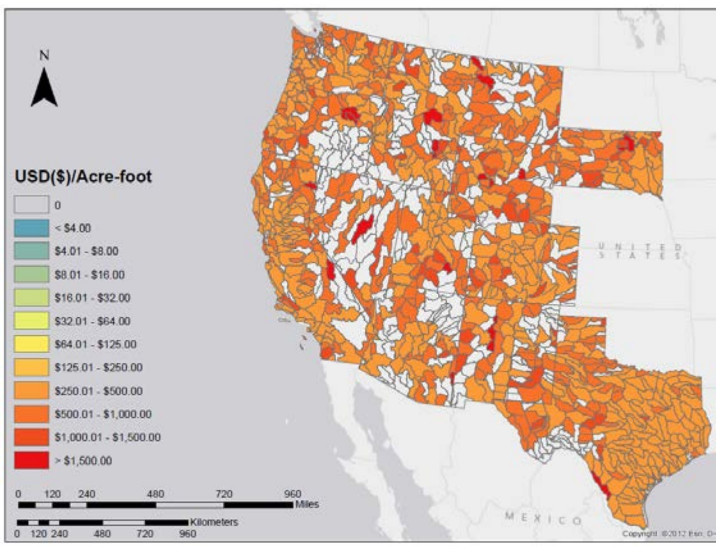
Potable Groundwater Cost



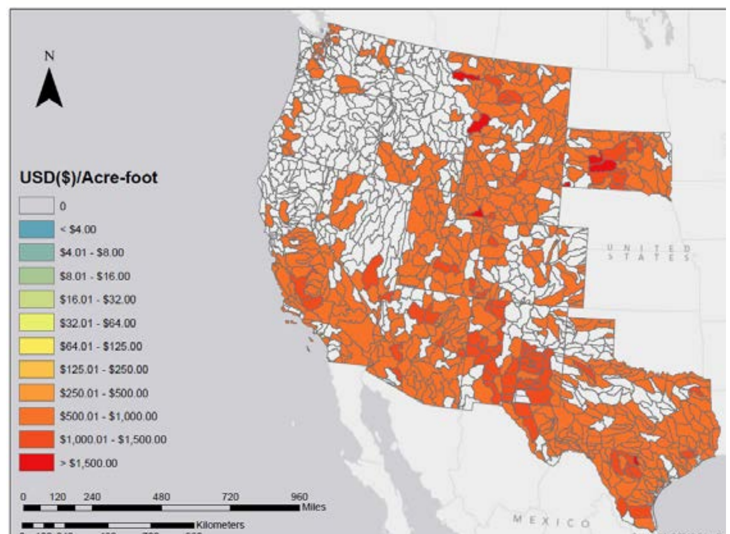
Appropriated Surface Water Cost



Wastewater Cost

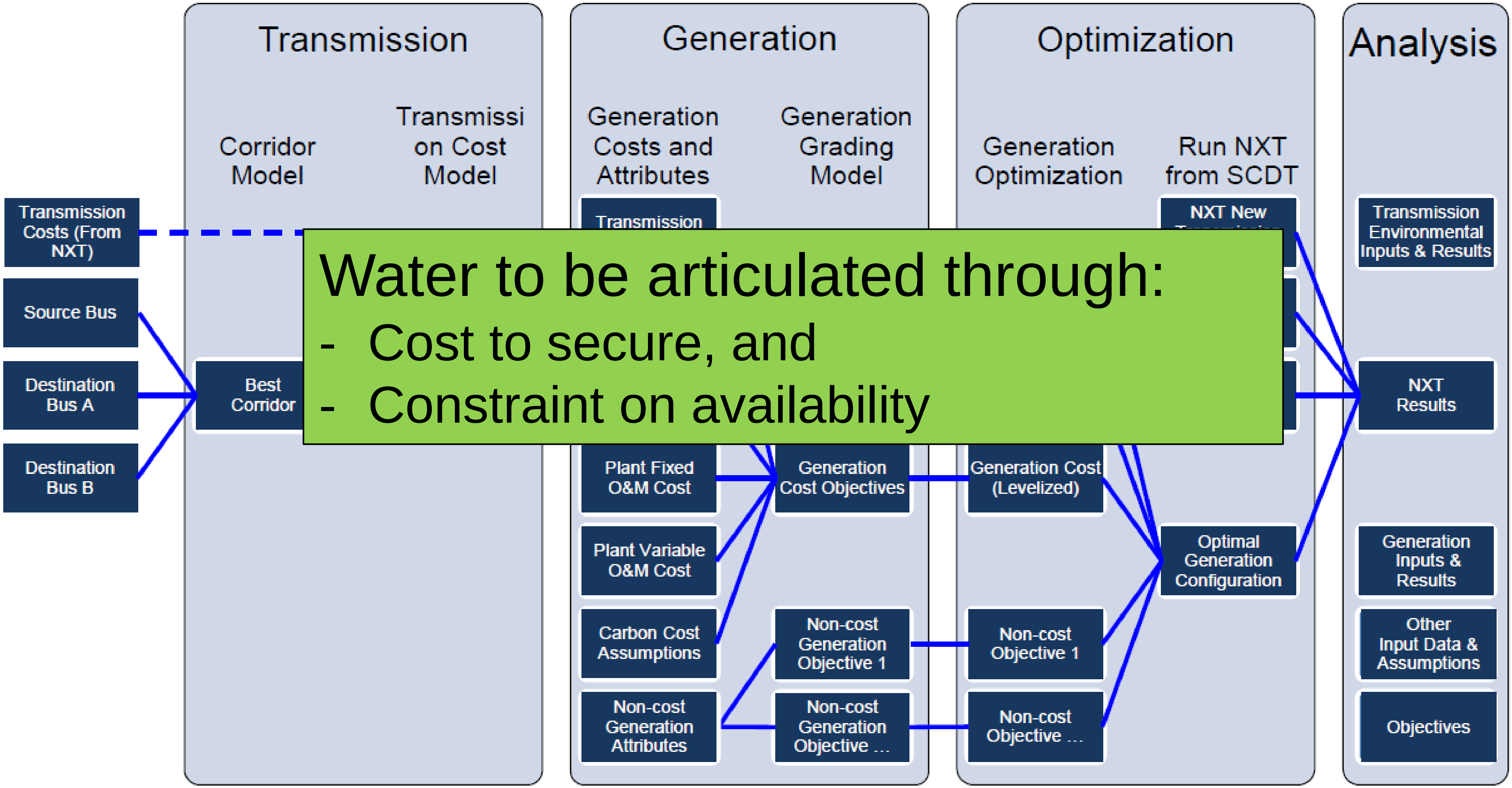


Brackish Groundwater Cost



Sandia National Laboratories

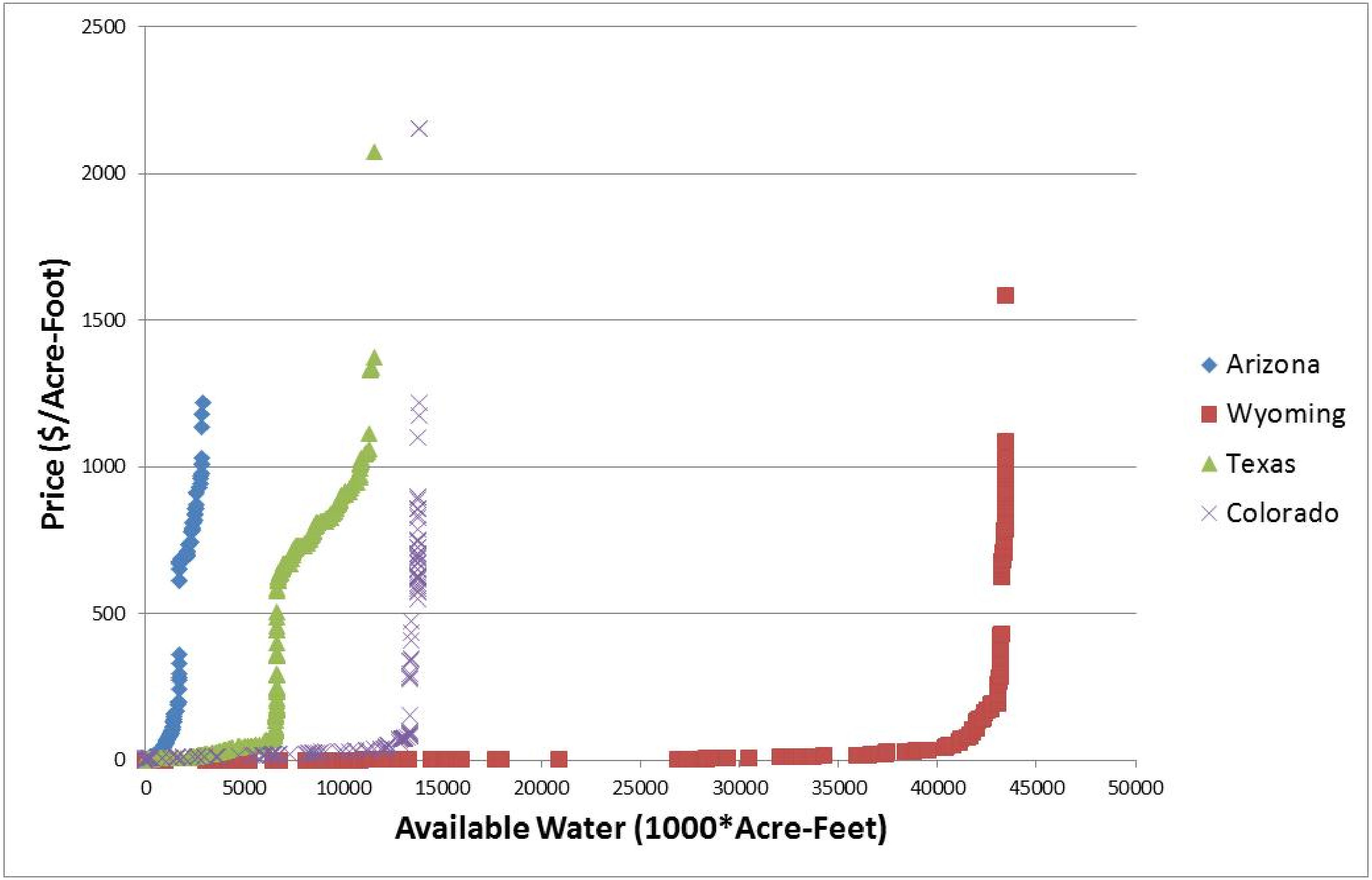
Long Term Planning Tool (LTPT)



Water to be articulated through:

- Cost to secure, and
- Constraint on availability

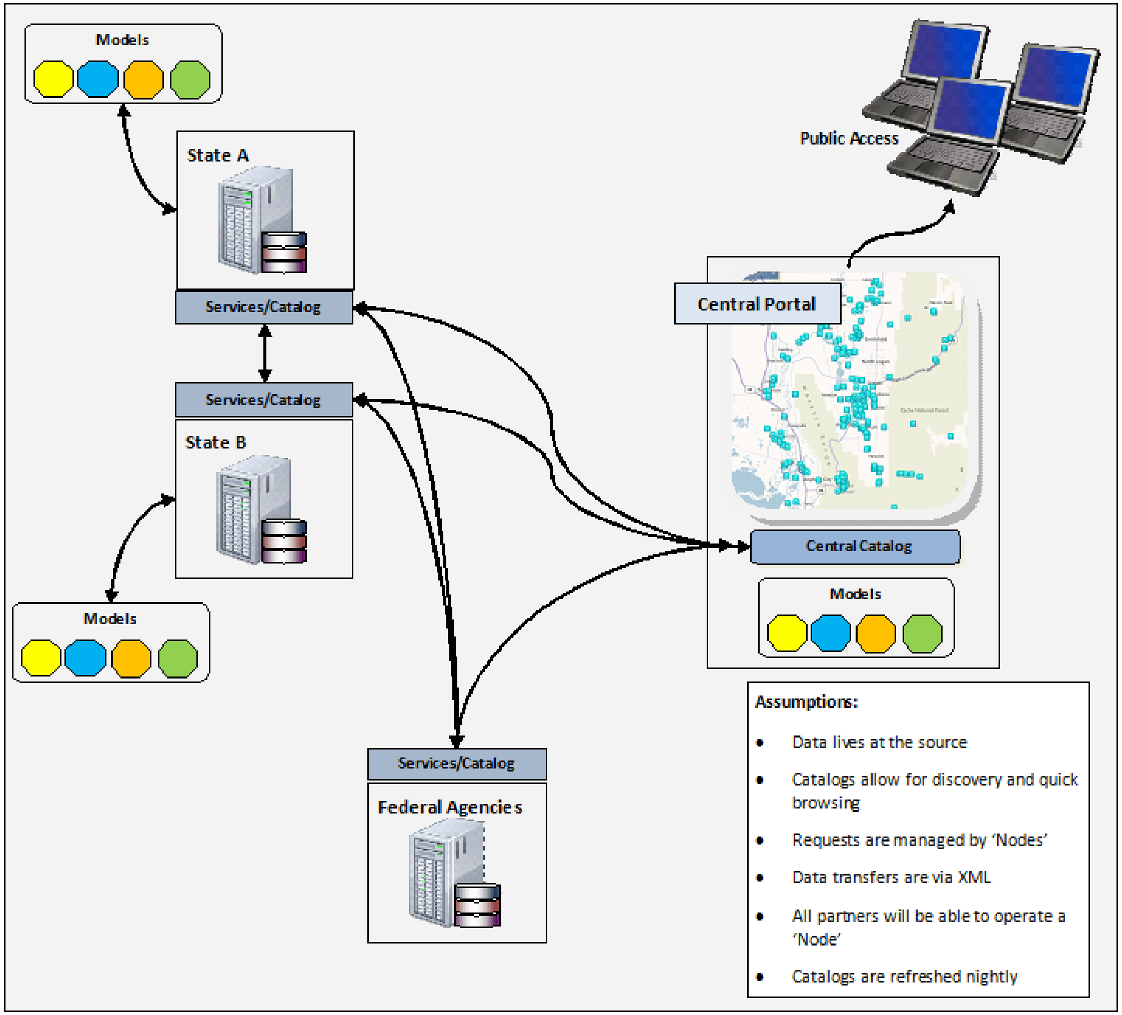
Water Supply Curves



Water Database Exchange (WaDE)

Sandia National Laboratories

- 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

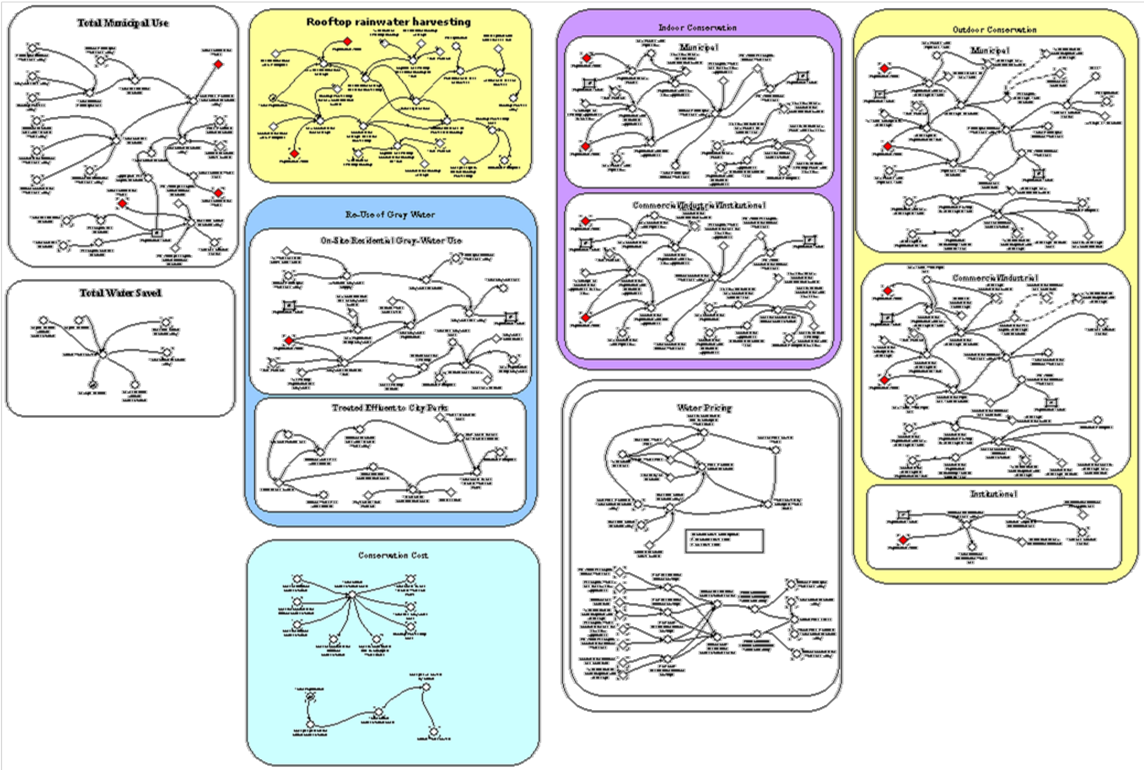


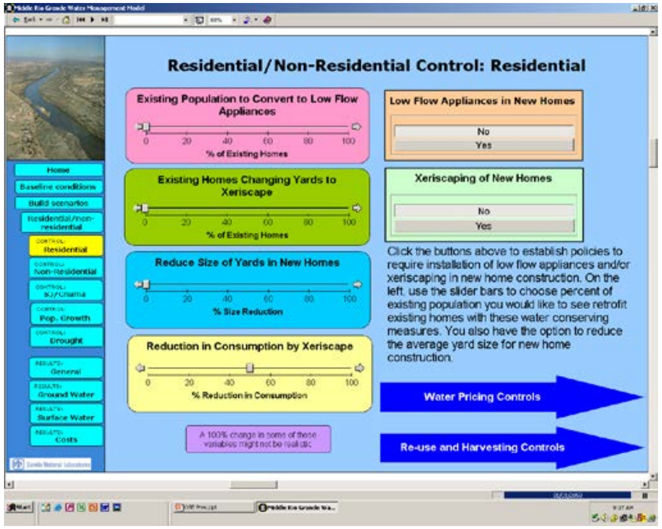
Collaborative Modeling

- Learning to speak the same language:
  - Integrated/interdisciplinary modeling,
  - Environment of collaboration,
  - Visual/interactive platform for analysis, and
  - Motivation.

Collaborative Modeling Community

- Conducted three conferences
- Produced published proceedings and book
- Tools of the trade:
  - Best practices,
  - Metrics of success,
  - Practitioners list/project survey.





Vincent Tidwell

vctidwe@sandia.gov

http://energy.sandia.gov/