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Modeling the Hydrologic/Ecologic/Economic/Social Dynamics of Small Scale Community Irrigation Systems

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Acequias and the Future of Resilience in Global Perspective *Las Cruces, NM, March 5, 2013*



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Project Team

- Funding
 - National Science Foundation – Program on the Dynamics of Coupled Natural & Human Systems - #1010516
 - NSF NM EPSCoR - #0814449
 - New Mexico Agricultural Experiment Station
- Universities
 - New Mexico State University (Brian Hurd, Sam Fernald, Ken Boykin, Andres Cibils, Steve Guldan, Caiti Steele, Carlos Ochoa)
 - University of New Mexico (Jose Rivera, Sylvia Rodriguez)
 - New Mexico Institute of Mining and Technology (John Wilson)
 - University of Concepcion, Chile (J.L. Arumi)
- Collaborators
 - Sandia National Laboratories (Vince Tidwell)
 - New Mexico Acequia Association (Marquita Ortiz)

Key Questions

- What role do acequias play in:
 - Hydrologic buffering?
 - Community resilience?
 - Ecosystem health?
- How do climate change and urban population growth challenge these functions?
- What strategies are needed to assist in protecting these functions?

Need

- Tools to integrate knowledge and data developed as part of project
- Tools to evaluate alternative treatments in face of uncertainty.
- Tools that our stakeholders will trust to assist them in long-term planning.



Approach: Collaborative Modeling

- 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.



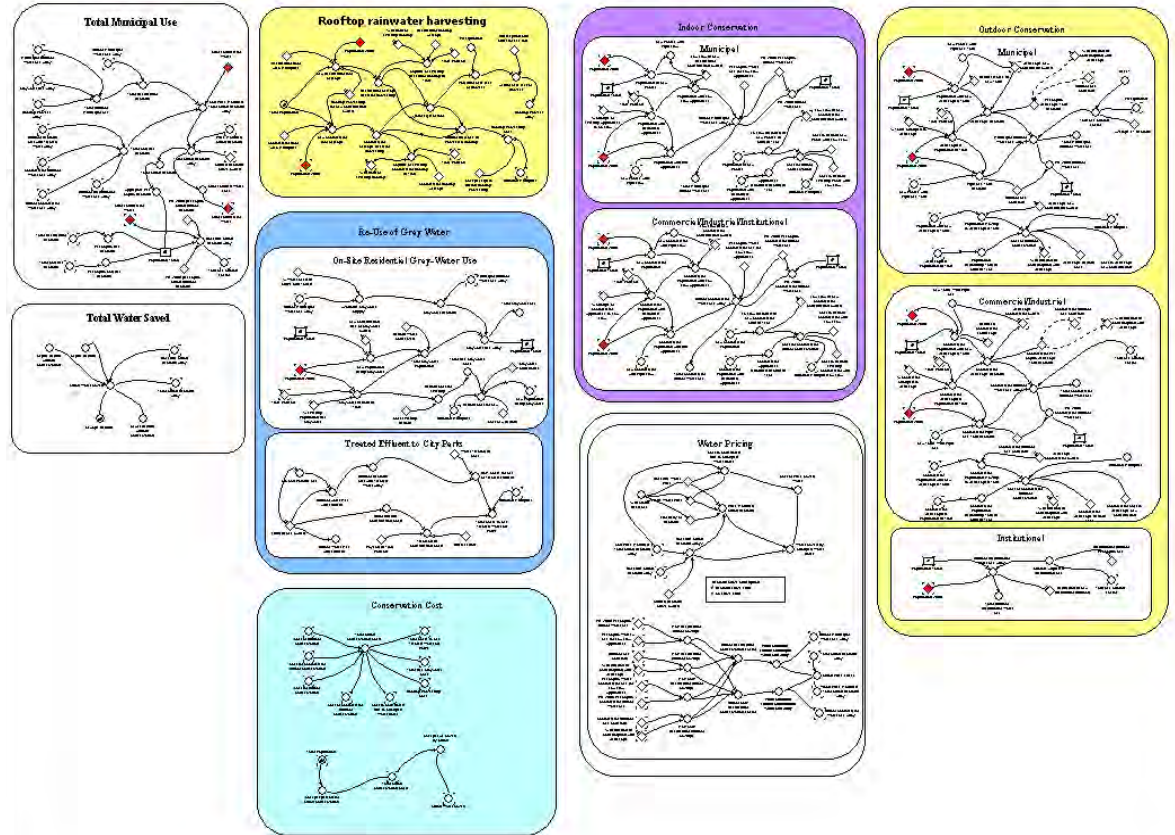
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Indicated flow rate USA to Mexico



System Dynamics

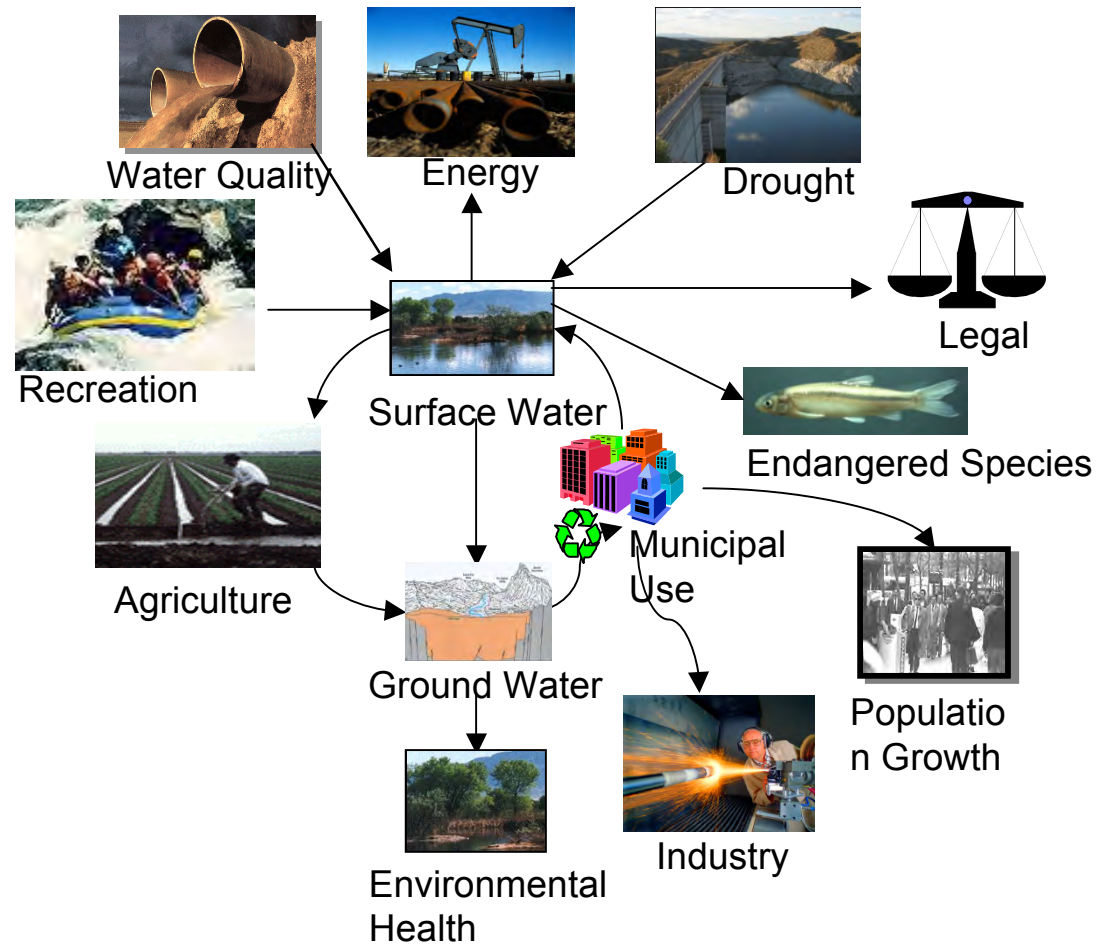
- We employ System Dynamics, which provides a formal framework for managing multiple interacting subsystems, each of which vary in time
- With system dynamics we are able to quantify feed-back, time delays, and coupling between subsystem components



Focus is on **Dynamic Complexity** rather than **Detail Complexity!**

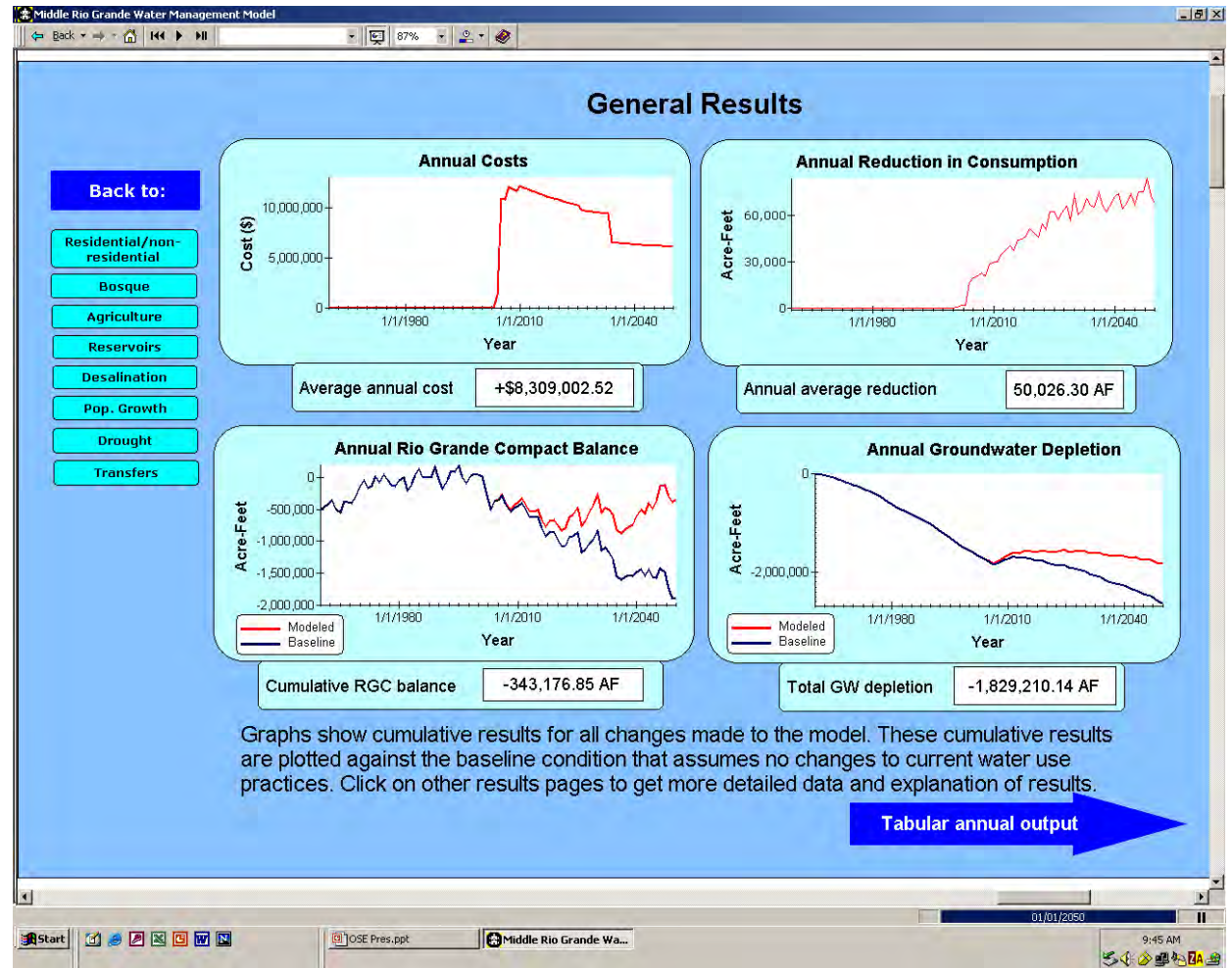
System Dynamics: Integrative Modeling

- Provides a framework for integrating over the broad range of factors influencing resource management

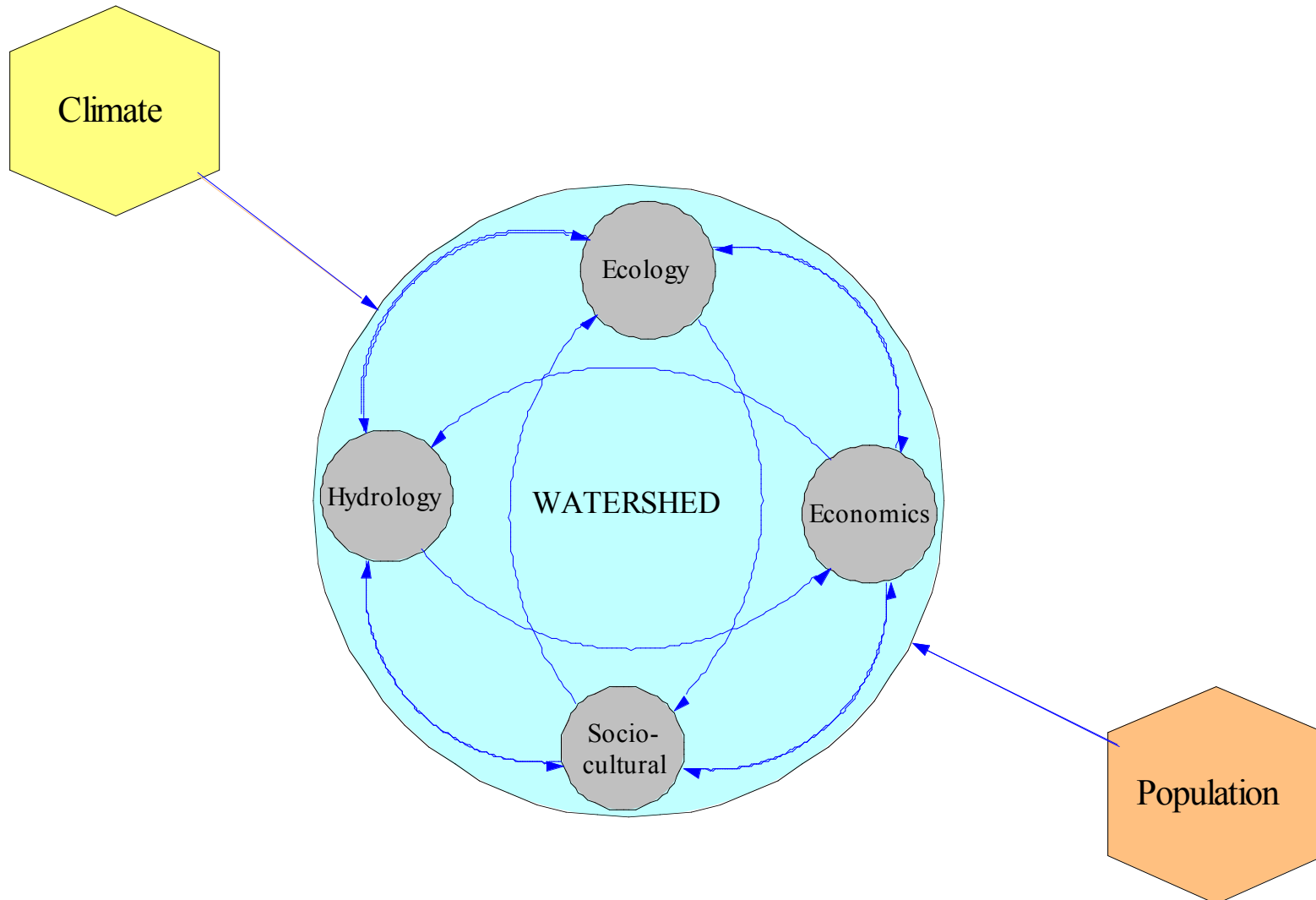


System Dynamics: Interactive Modeling

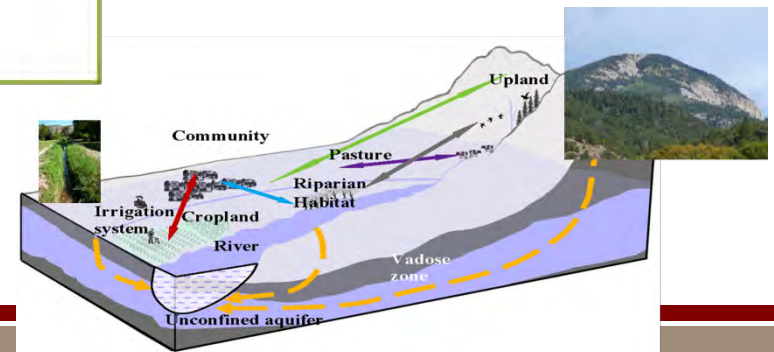
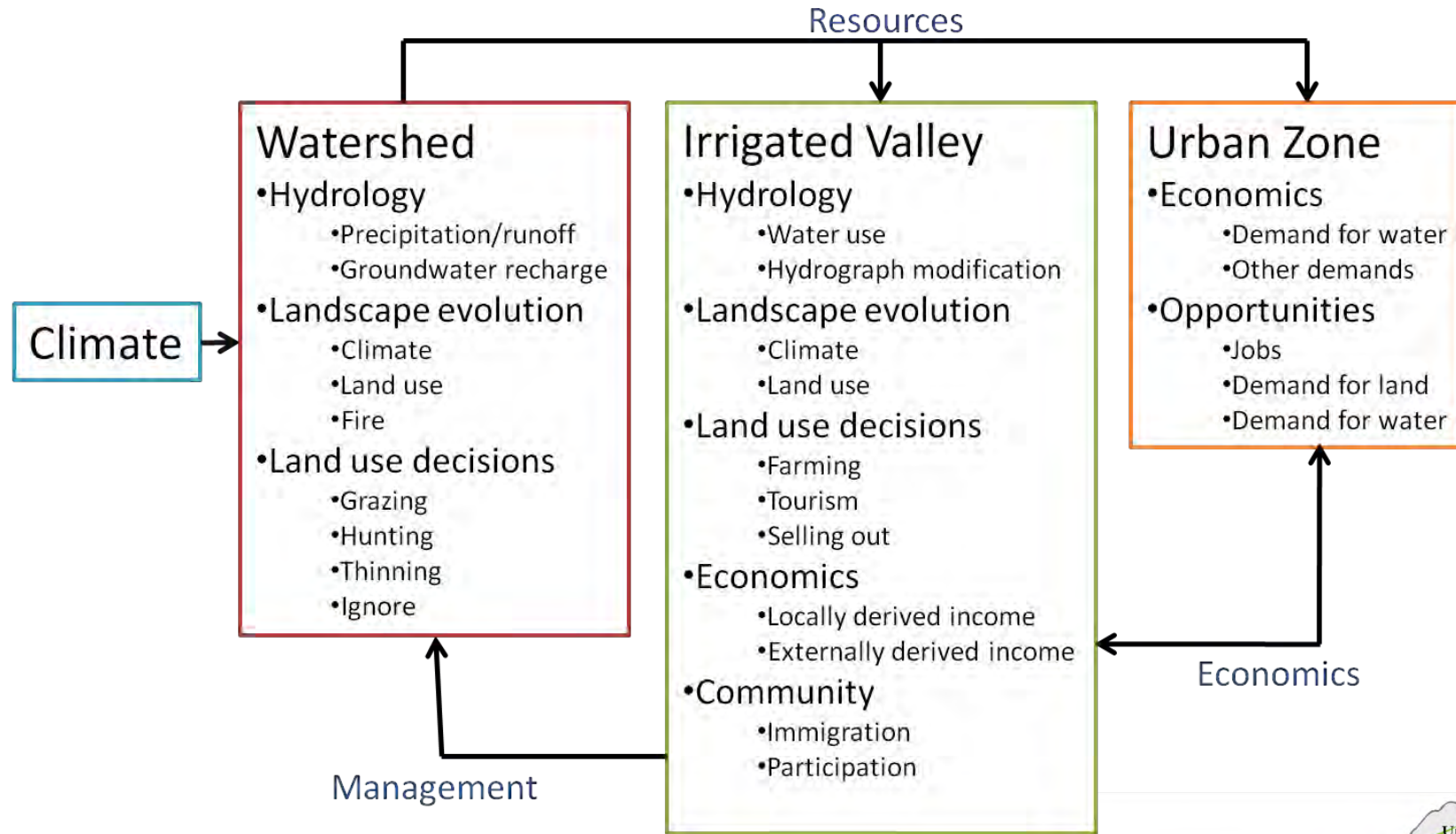
- Broadly accessible
 - PC based
 - User friendly interfaces
 - Computations in seconds to minutes
- Provides interactive environment for scenario testing



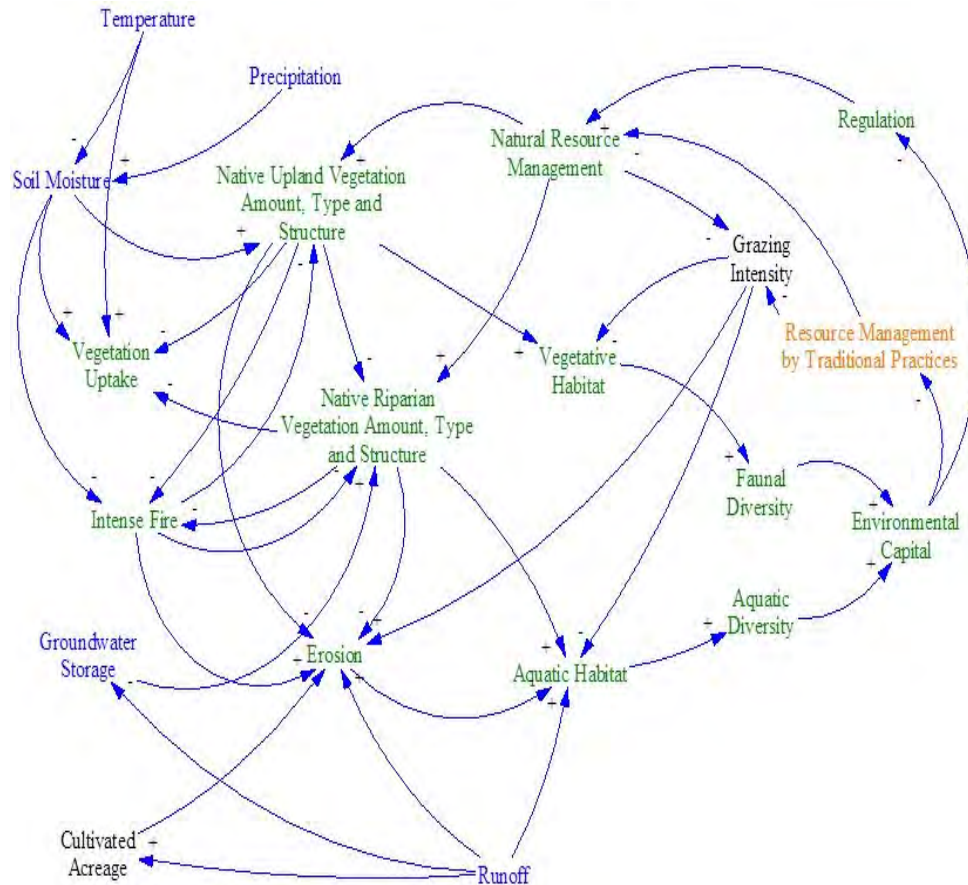
Integration Across Disciplines



Downstream Integration

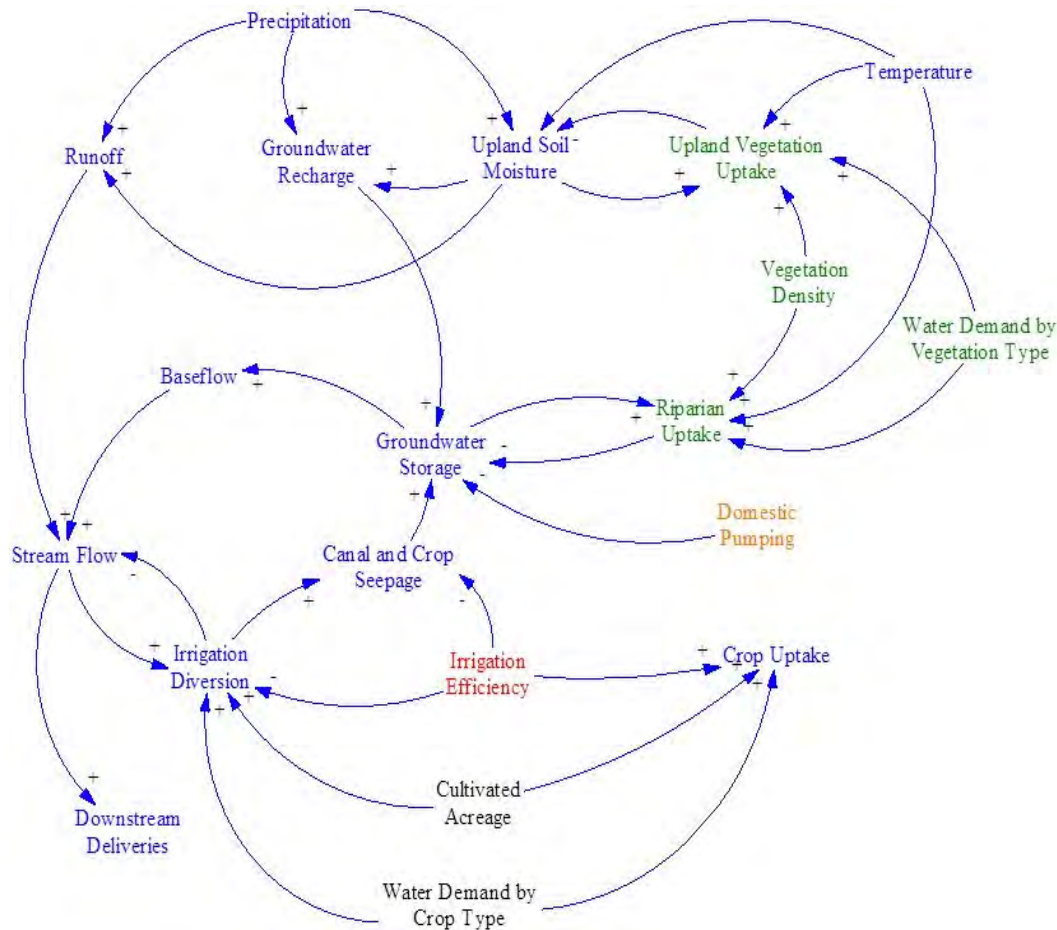


Ecologic Dynamics



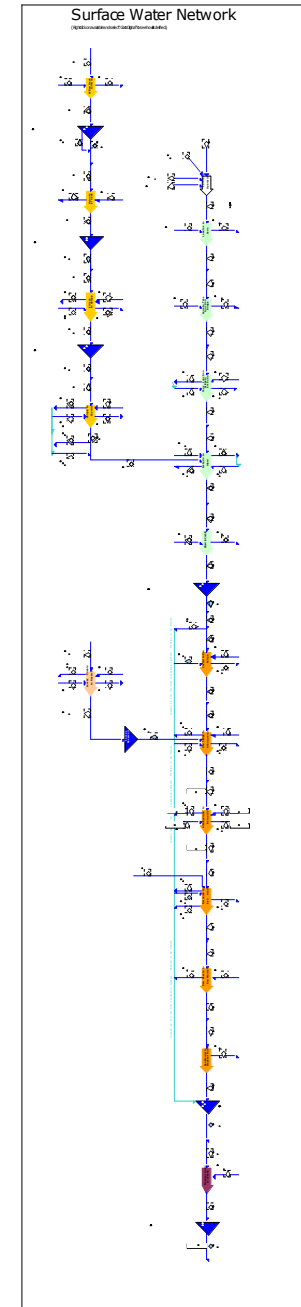
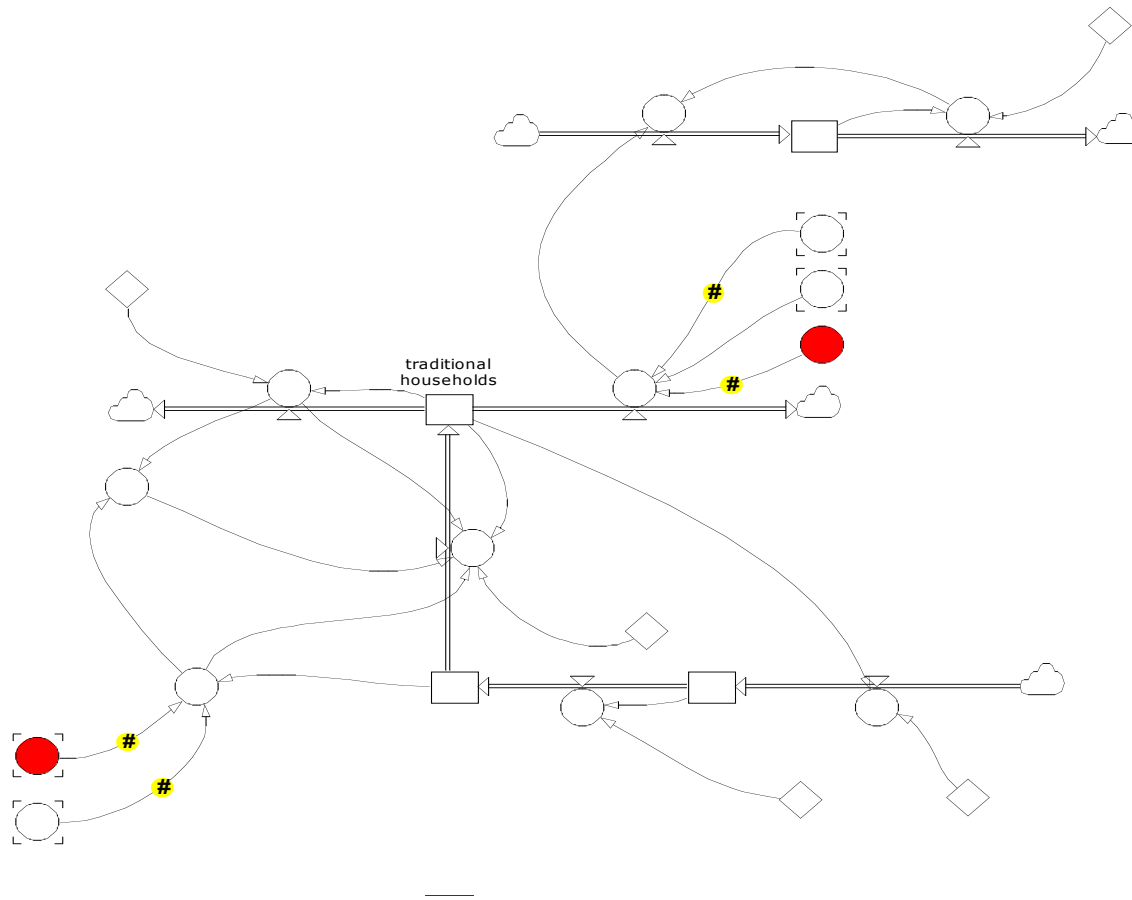
- How will climate impact:
 - Vegetation type and density,
 - Wildfire frequency,
 - Species diversity,
- How is ecology influenced by:
 - Grazing,
 - Hunting,
 - Fuels/wildlife management,
- How do climate and watershed management influence:
 - Stream flows,
 - Groundwater recharge,

Hydrologic Dynamics

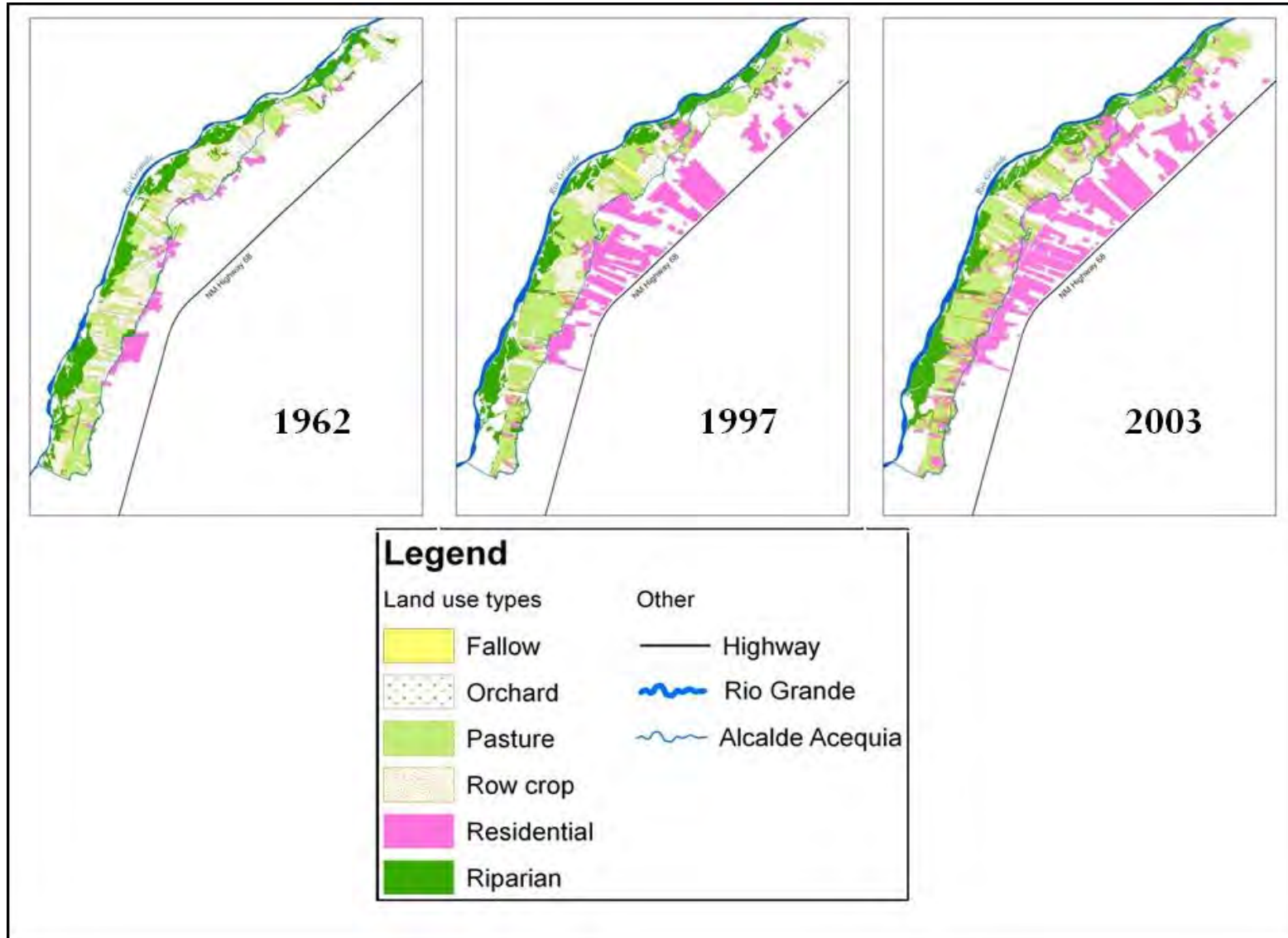


- How does water availability influence:
 - Irrigation practices,
 - Upland grazing decisions,
- How do irrigation practices influence the ecology:
 - Riparian habitat,
 - Hydrograph modification,
 - Water quality
- What steps can be taken to improve water availability:
 - Conservation,
 - Cooperative management,

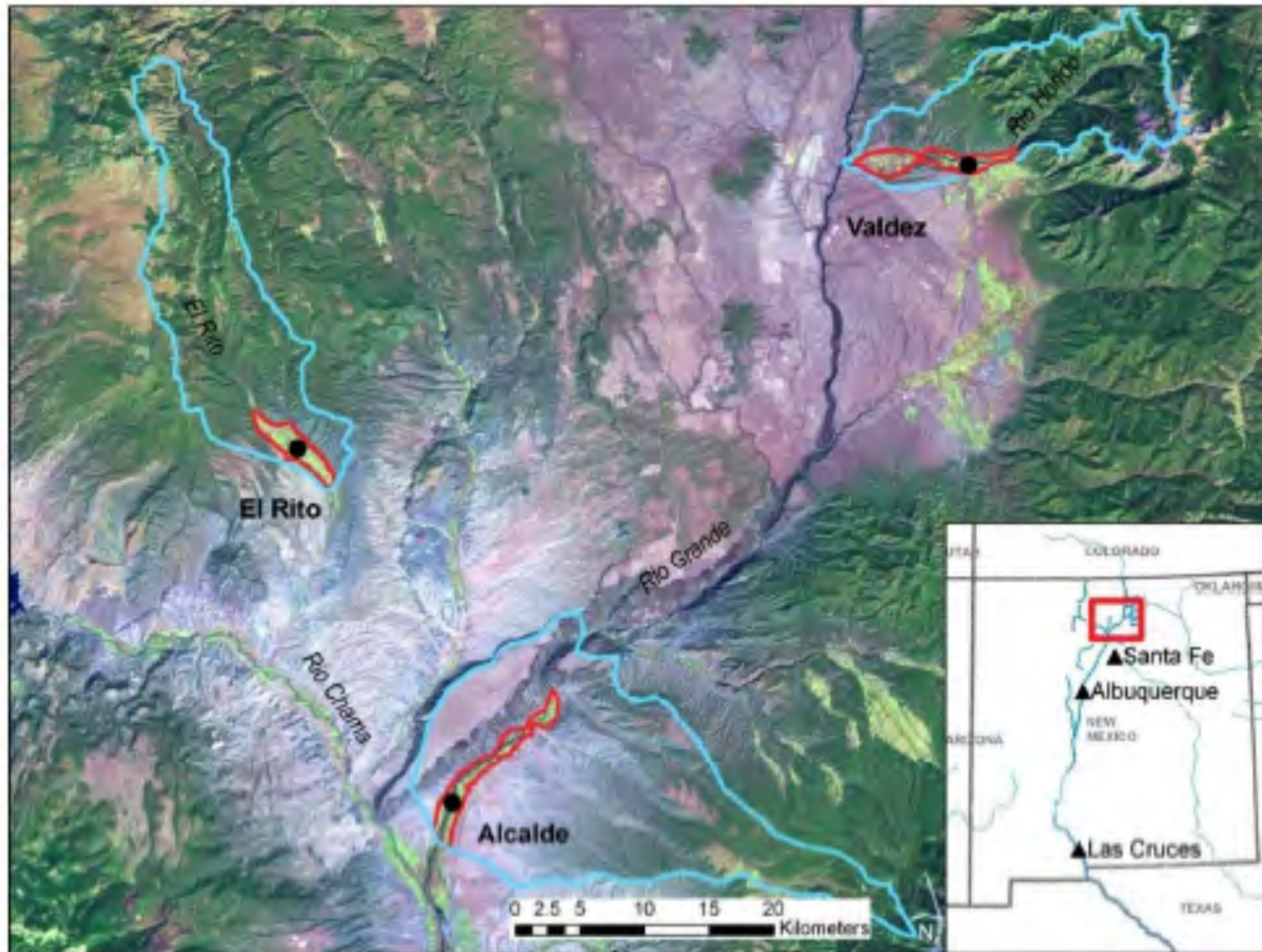
Model Development



Calibration



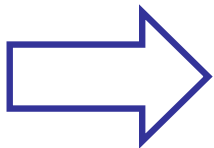
Extending Results Downstream



Middle Rio Grande

Data availability:

- Dominant historical data set is from USGS stream flow gages:

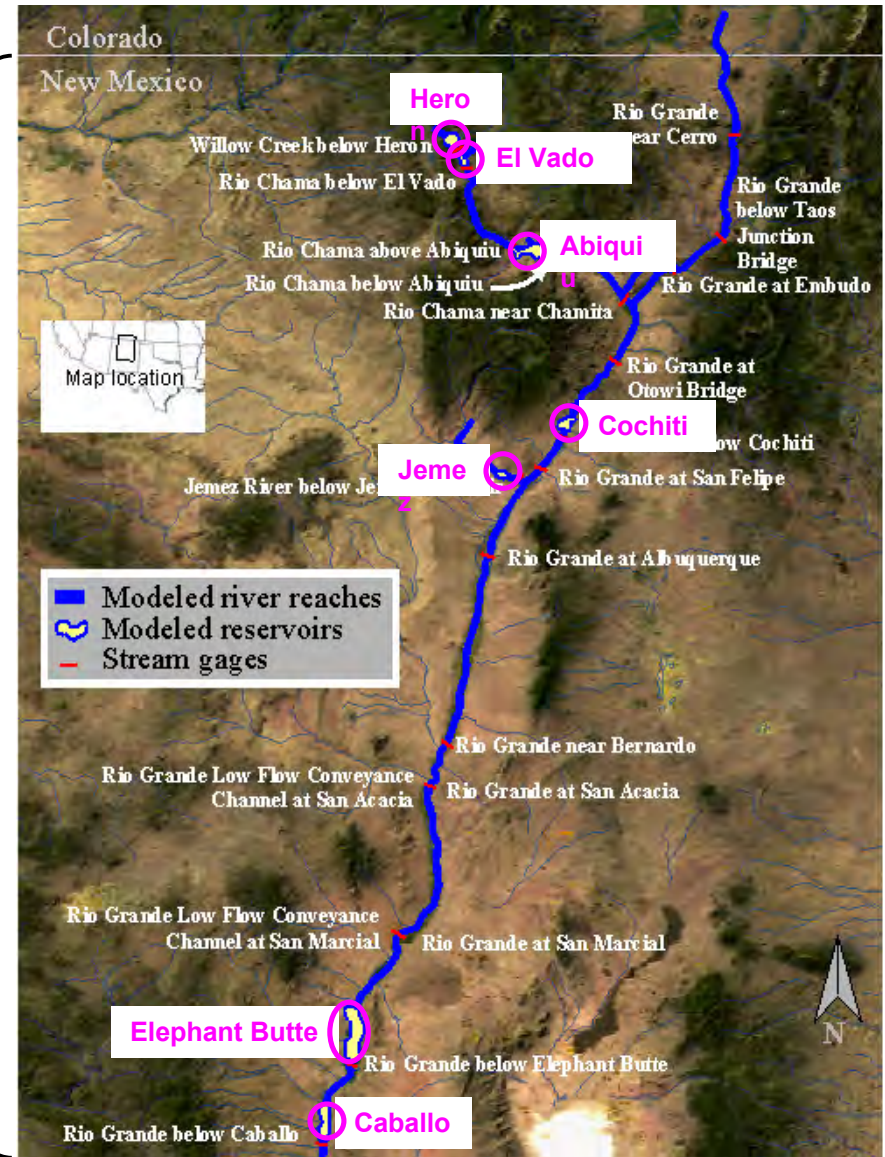


“River reach”: gage location based spatial unit of mass balance.

17 river reaches

- 12 Rio Grande
- 4 Rio Chama
- 1 Jemez River

In addition to river reaches, there are 7 spatial mass balance units representing major reservoirs



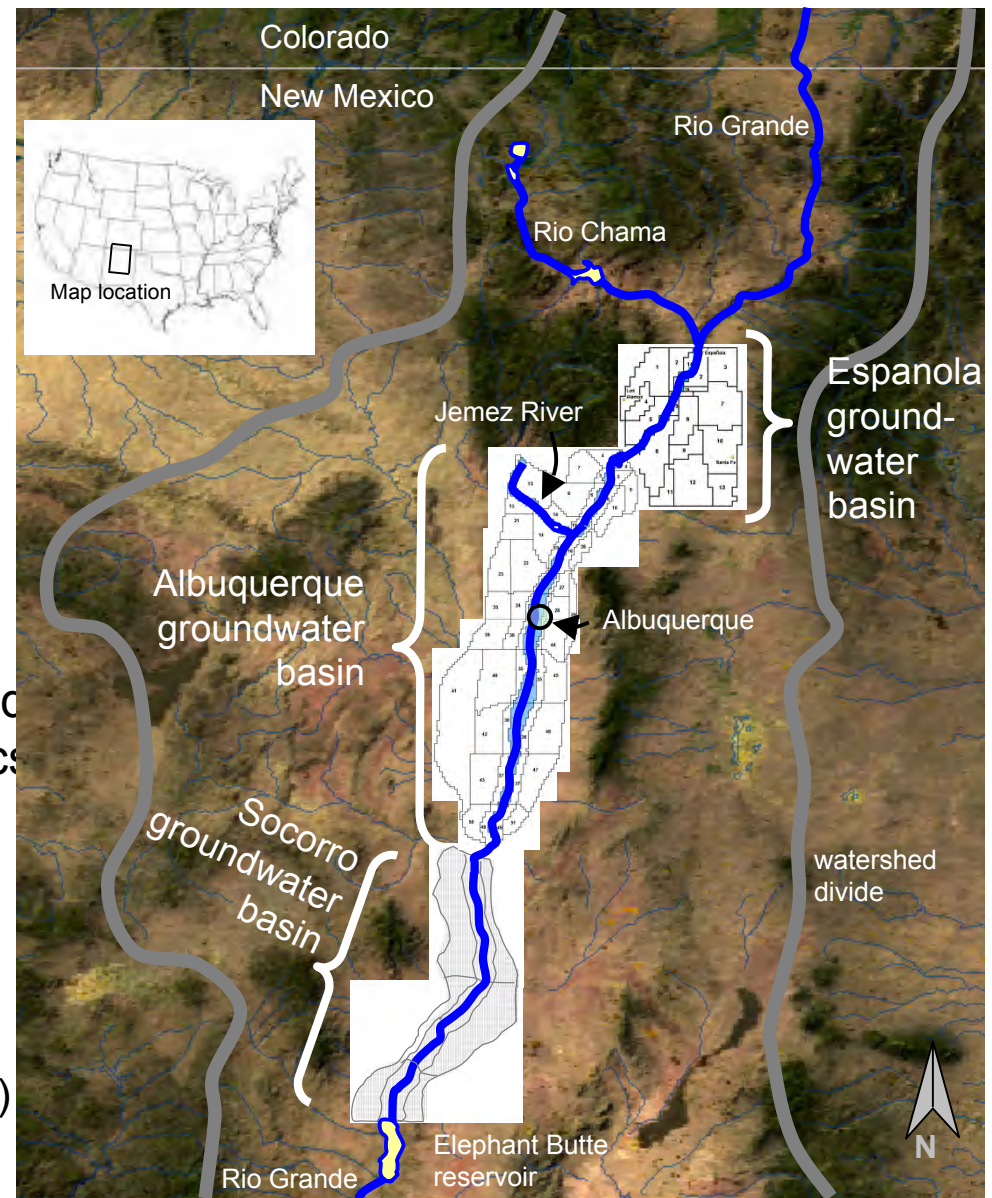
Middle Rio Grande

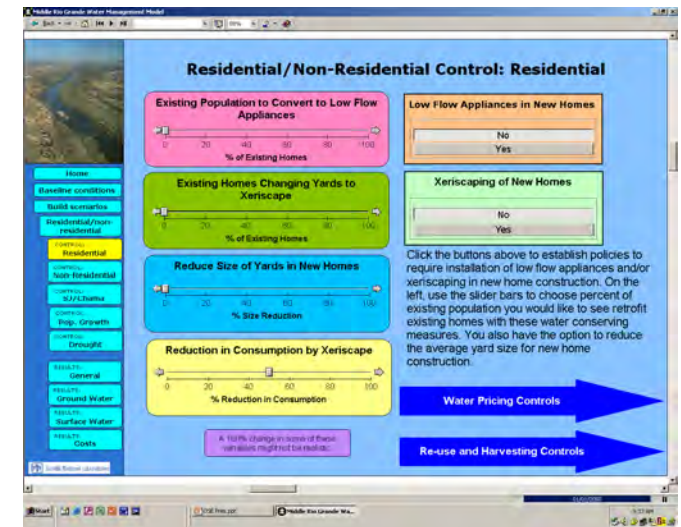
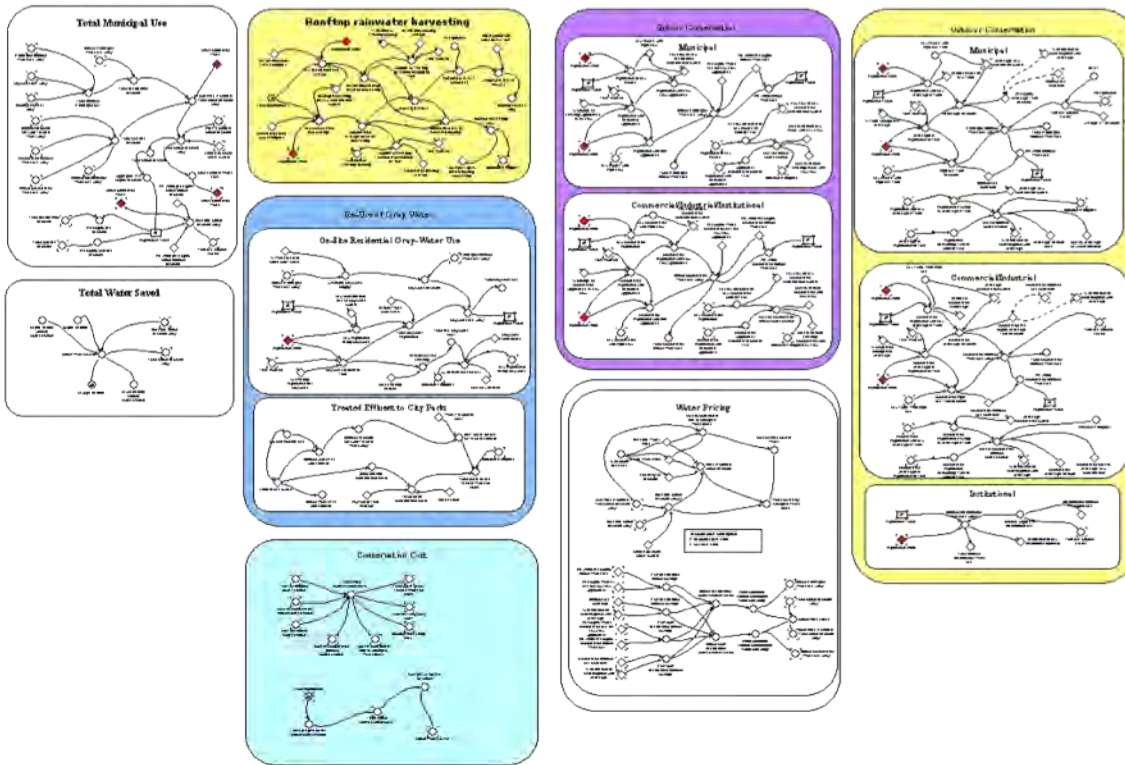
Goal:

- A rapid and physically based, dynamic representation of sw-gw interactions in Rio Grande river system coupled directly to dynamic surface water model.

Strategy:

- Use spatially explicit groundwater models to calibrate spatially aggregated versions in Powersim (system dynamics software).
- Three spatially explicit models of interest:
 - Espanola Basin (Frenzel 1995)
 - Albuquerque Basin (McAda et al 2002)
 - Socorro Basin (Shafike 2005)





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