



Energy-Water-Land-Climate Nexus: Modeling Impacts from the Asset to the Regional Scale

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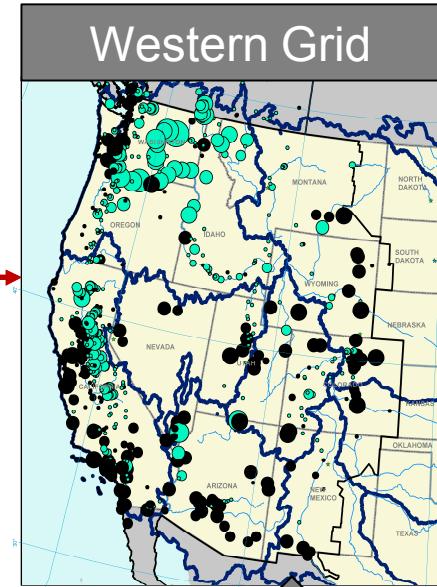


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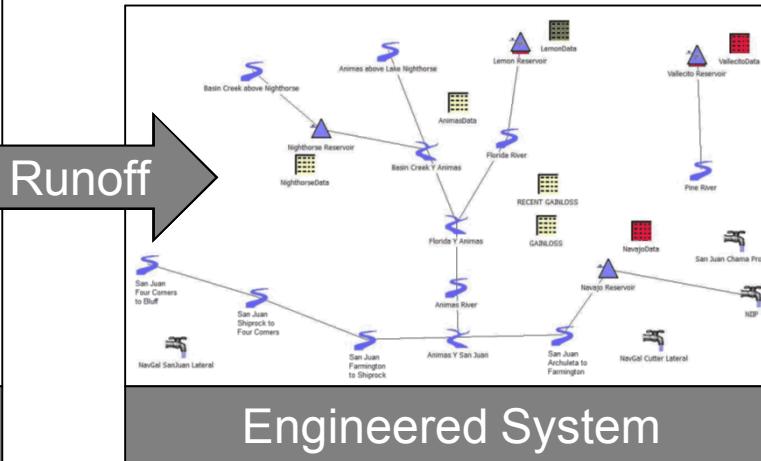
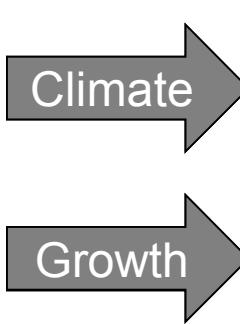
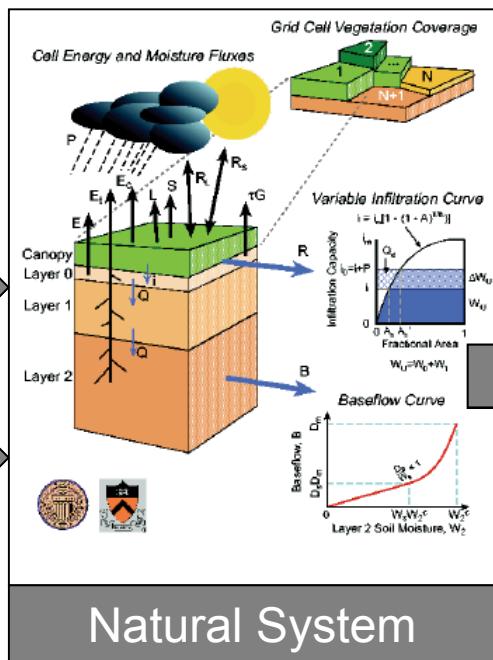
Objective

- Framework that links natural and engineered systems to evaluate climate vulnerabilities at the *asset level*:
 - Multiple interacting sectors,
 - Multiple forcings, and
 - Multiple interacting scales.

Next Speaker →



GC43C-1177
Katrina Bennett
Poster Thursday afternoon



Deliveries

- Electric Power
- Agriculture
- Environment

San Juan Basin

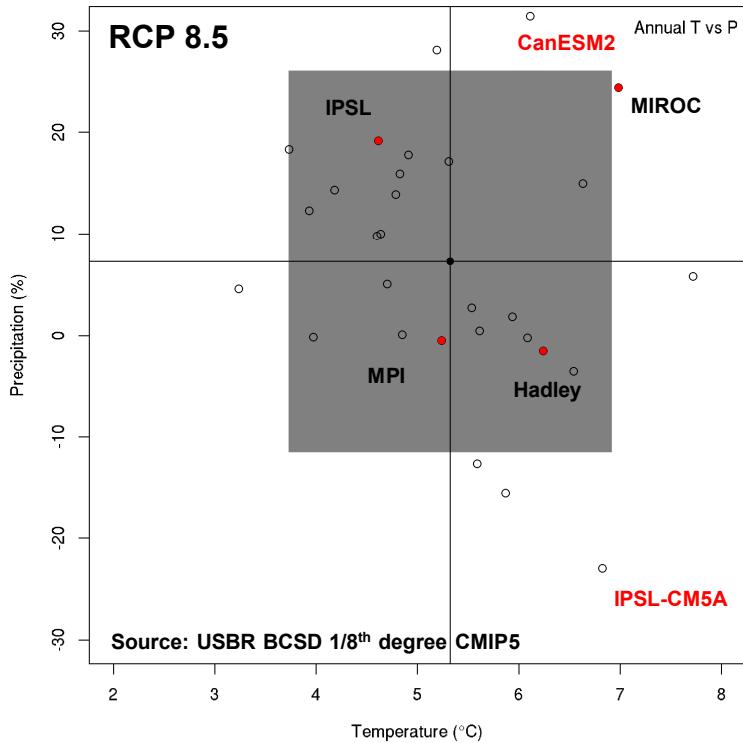


Four Corners Region

- Colorado River basin
- Snow melt dominated system
- Water Users
 - Native American
 - Irrigation
 - Multiple power plants and limited hydropower
 - Municipalities
 - Instream flows
 - Interbasin transfers

Model Scenarios

1. Six CMIP5 global climate models using scenario RCP 8.5



2. Climate Driven Vegetation Change (Fire, Infestation, Mortality)



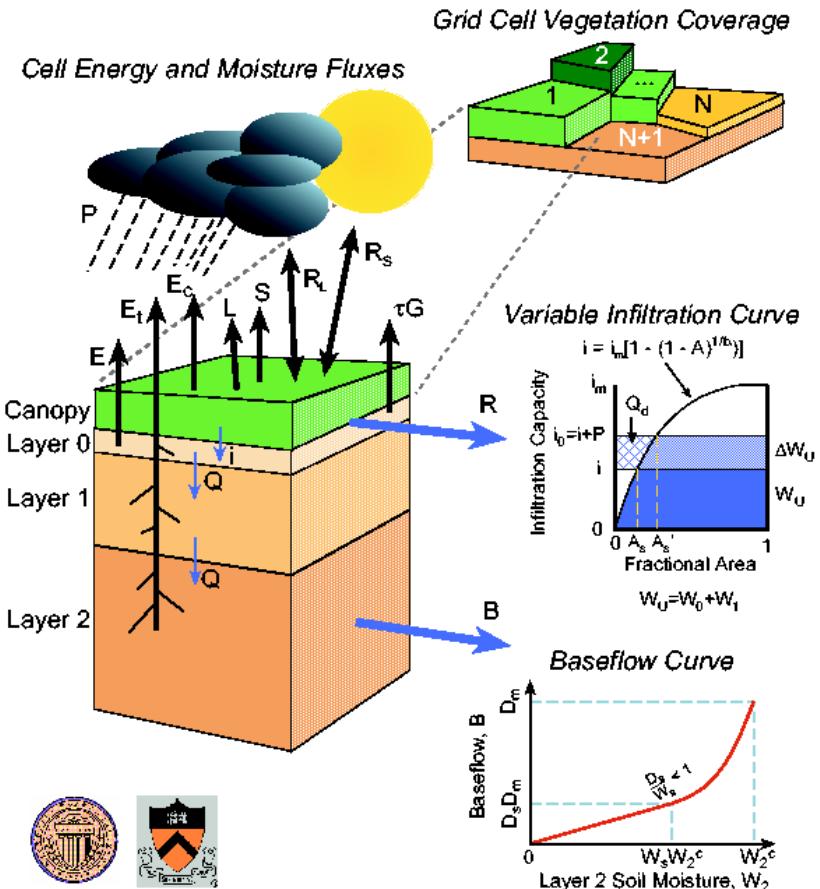
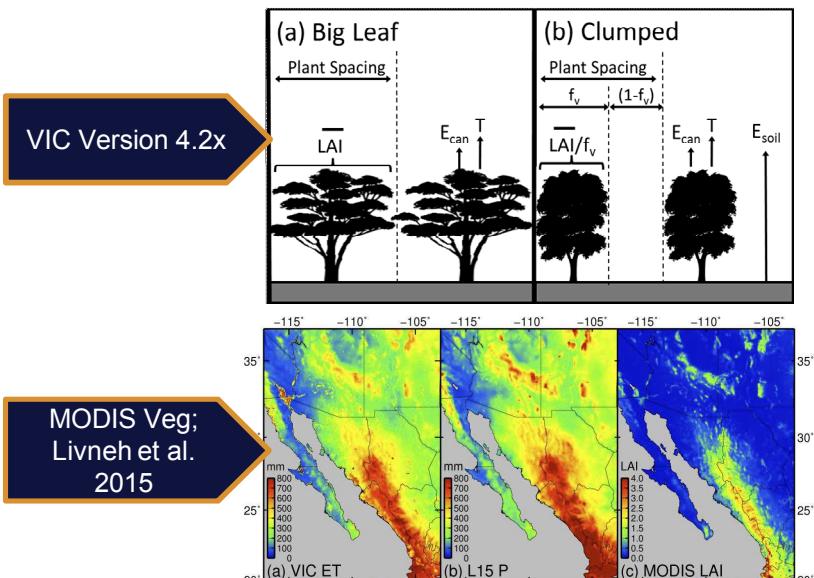
3. Growth Scenario



Navajo Indian Irrigation Project

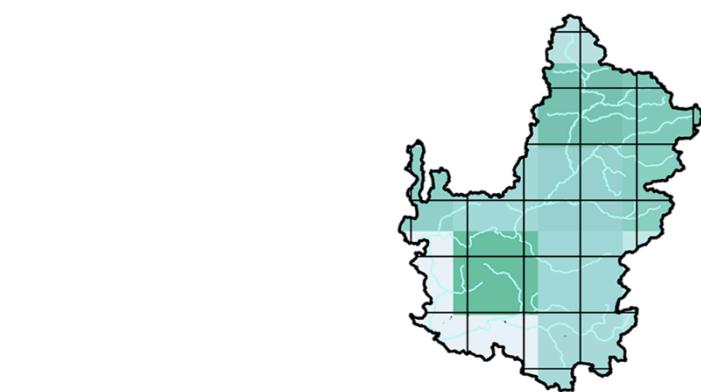
Methods: Hydrology

- Variable Infiltration Capacity (VIC) model at 1/16th degree
- New MODIS data, including time series for each grid cell for albedo, vegetation spacing and LAI
- Downscaling using Multivariate Adaptive Constructive Analogues (MACA) data set (Abatzaglou and Brown, 2011)

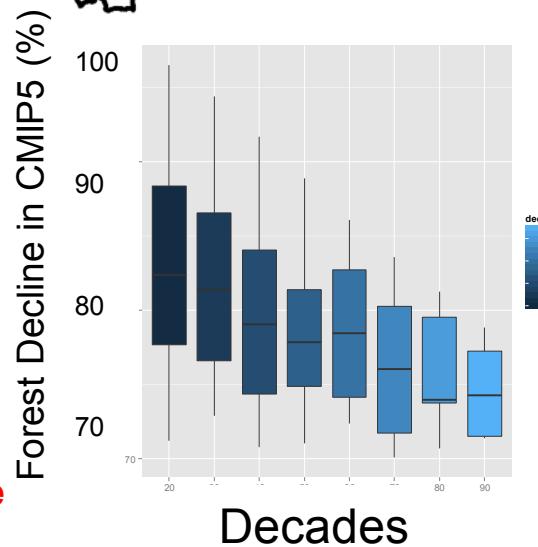
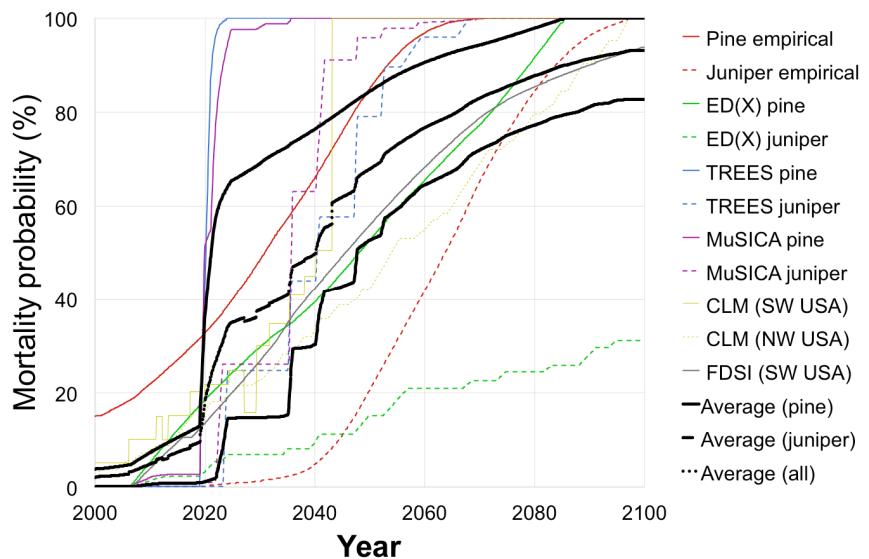
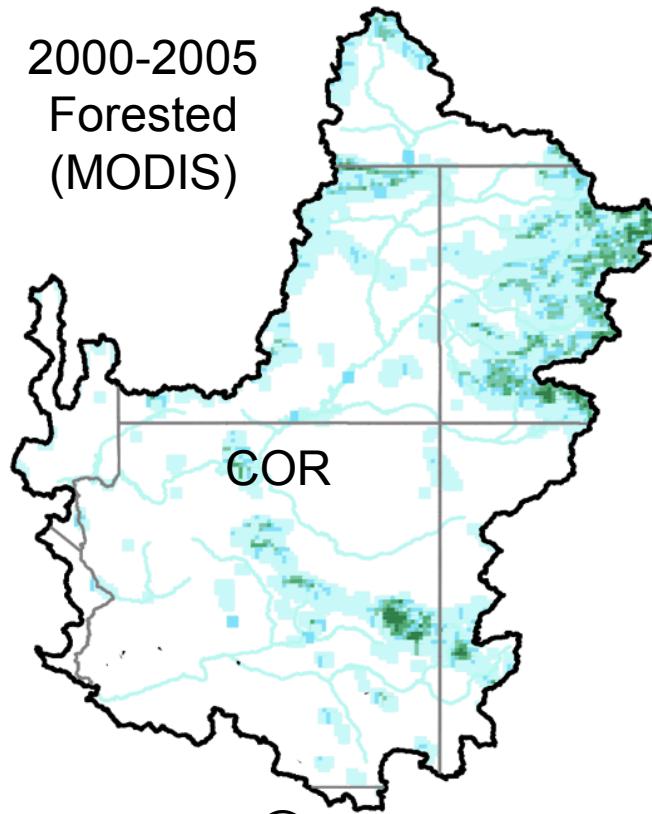


Bohn and Vivoni, 2015

Methods: Vegetation



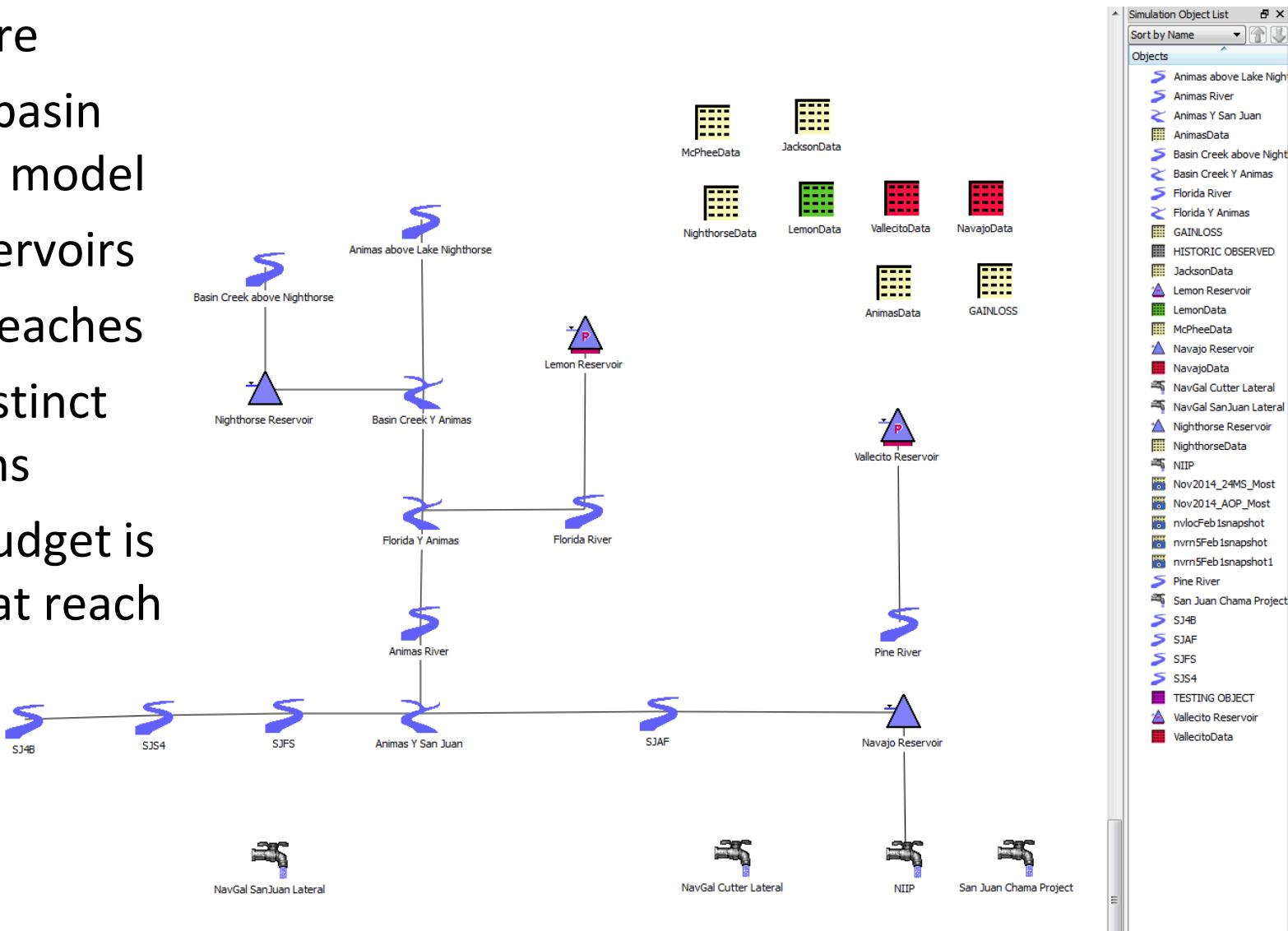
2000-2005
Forested
(MODIS)



McDowell et al. Convergent predictions of massive conifer mortality due to chronic temperature rise. *Nature Climate Change*. 2015.

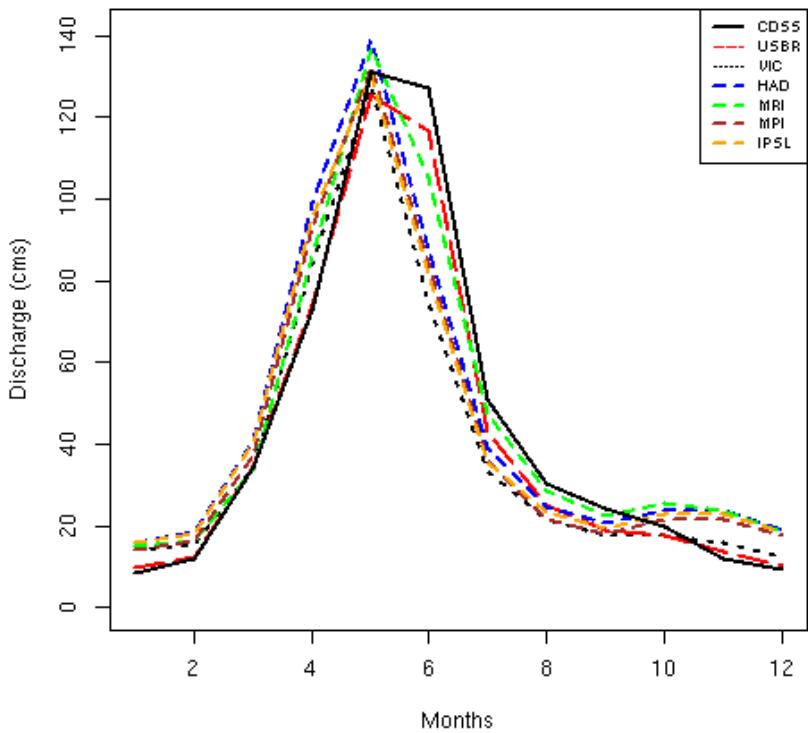
Methods: Reservoir Routing

- RiverWare
- Current basin planning model
- Four reservoirs
- Twelve reaches
- Three distinct diversions
- Water budget is lumped at reach level



History Matching

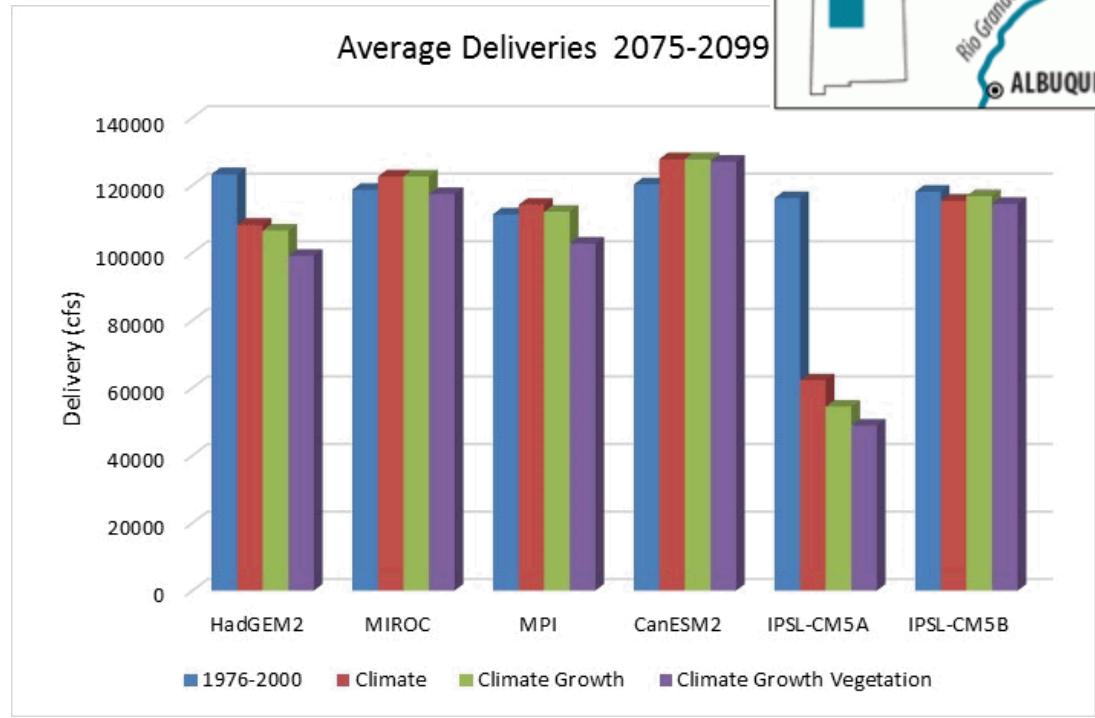
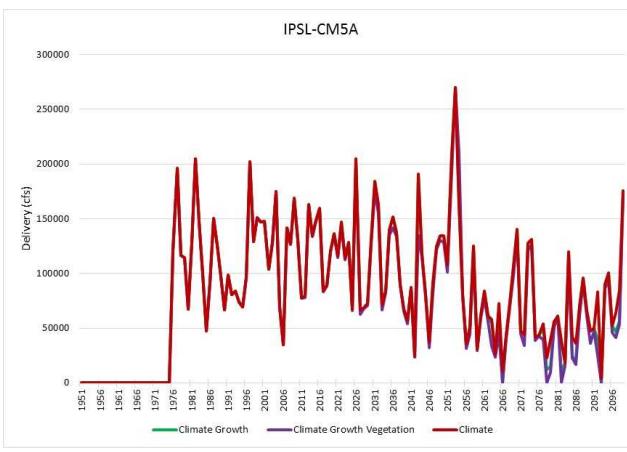
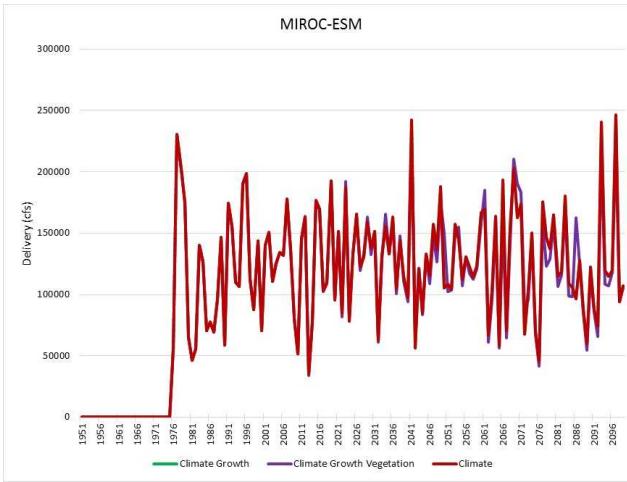
SJARN Monthly Average Flows (1974-2005)



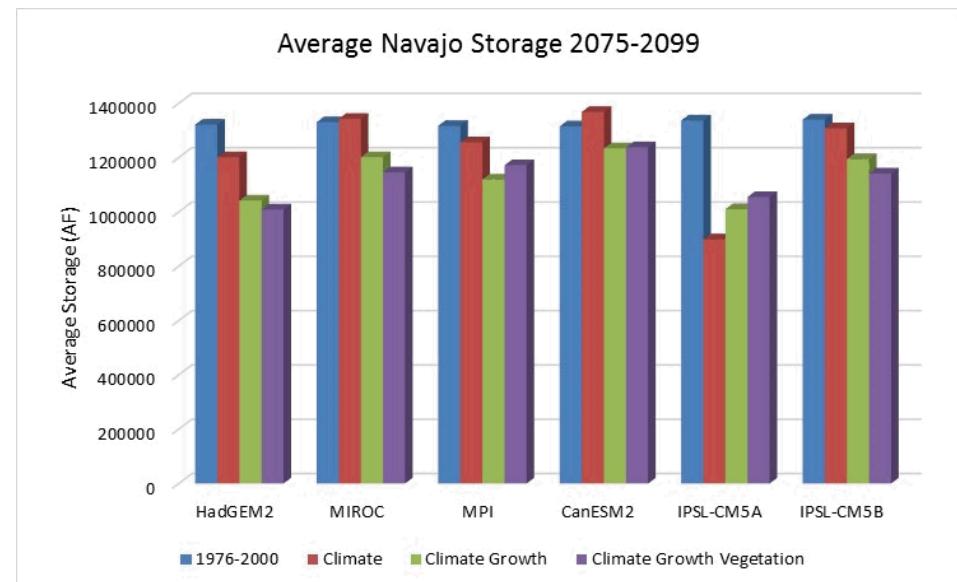
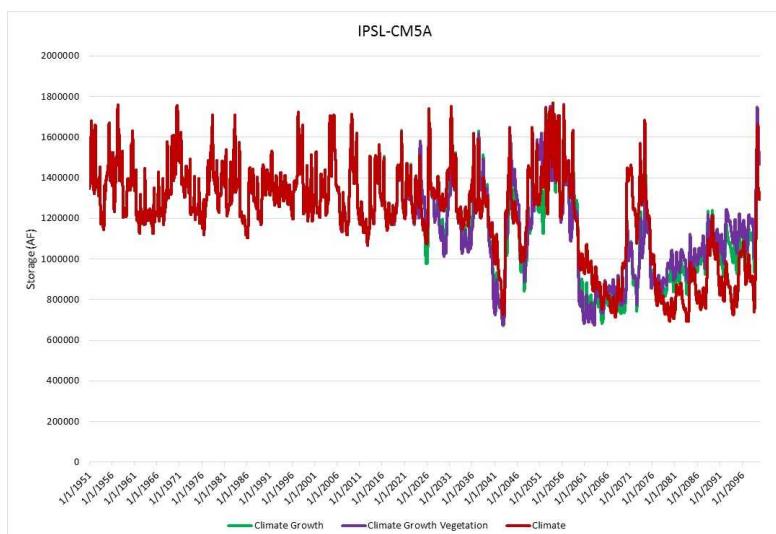
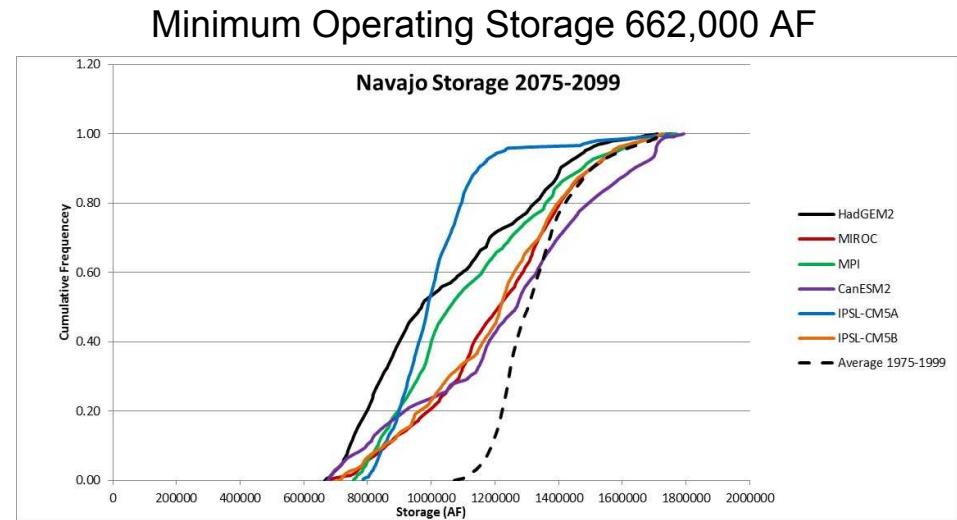
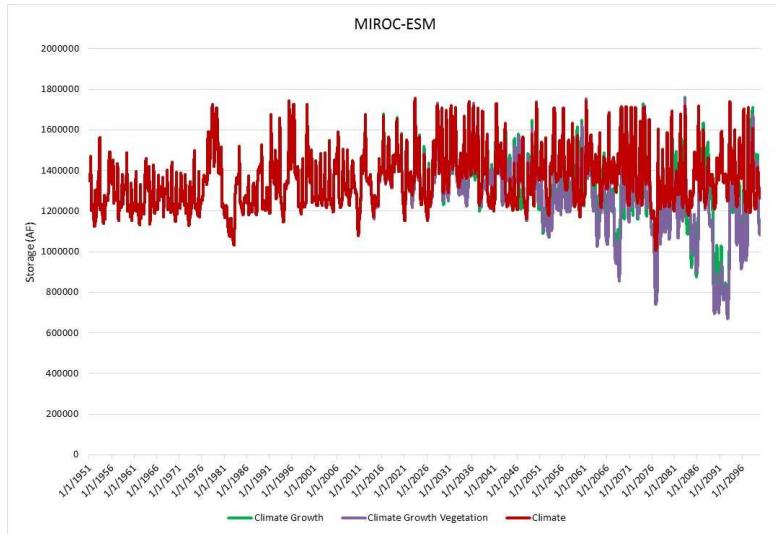
- Average monthly flows reproduced well except in June
- Calibration and validation accomplished at points just below Navajo Reservoir and the outlet to Lake Powell

Period of Analysis	Statistic	SJARN	SJNBU
Calibration (2006-2010)	Correlation Coefficient	0.91	0.90
Calibration (2006-2010)	Nash Sutcliffe	0.78	0.76
Calibration (2006-2010)	Nash Sutcliffe Log	0.77	0.75
Validation (2001-2005)	Correlation Coefficient	0.93	0.93
Validation (2001-2005)	Nash Sutcliffe	0.83	0.59
Validation (2001-2005)	Nash Sutcliffe Log	0.77	0.43
All (2001-2010)	Correlation Coefficient	0.90	0.91
All (2001-2010)	Nash Sutcliffe	0.81	0.67
All (2001-2010)	Nash Sutcliffe Log	0.78	0.58

San Juan-Chama Deliveries

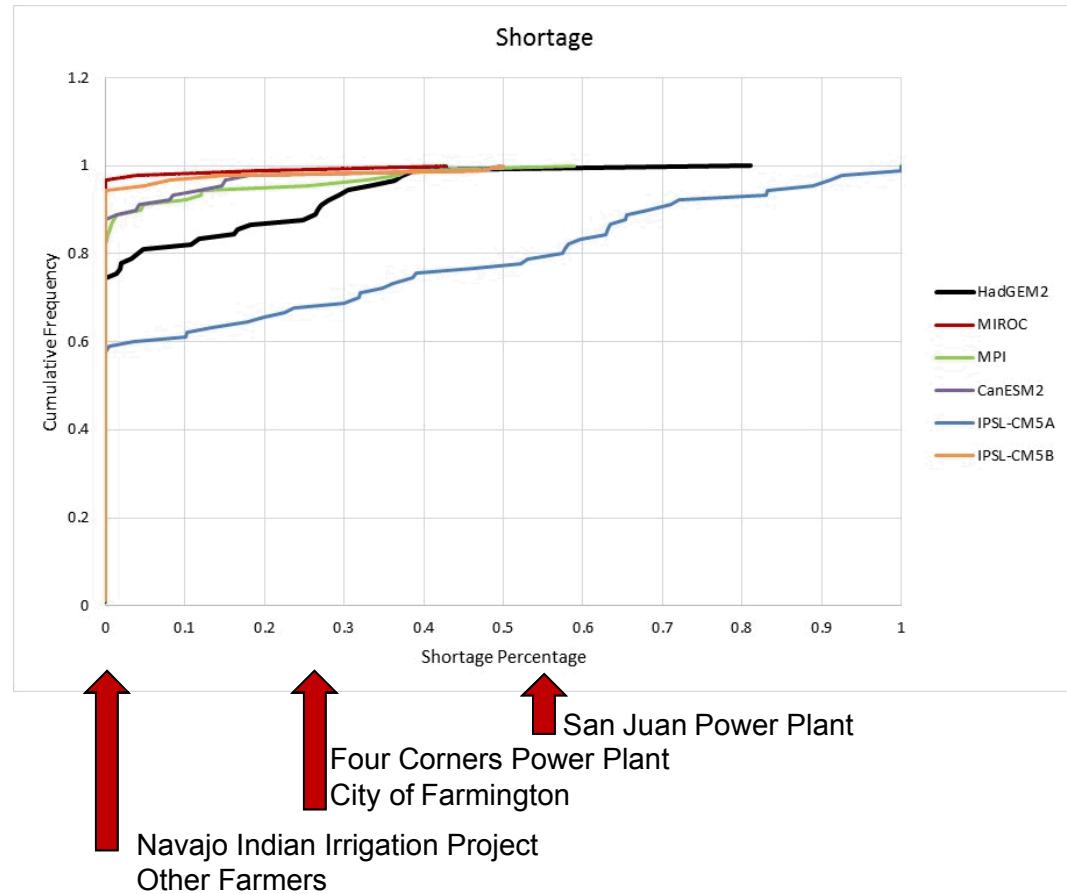
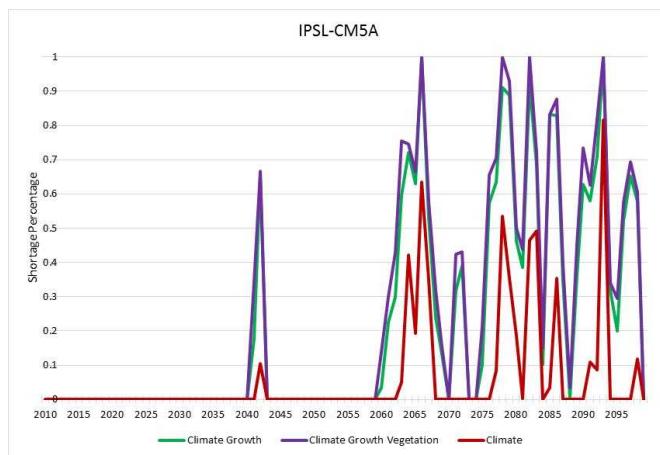
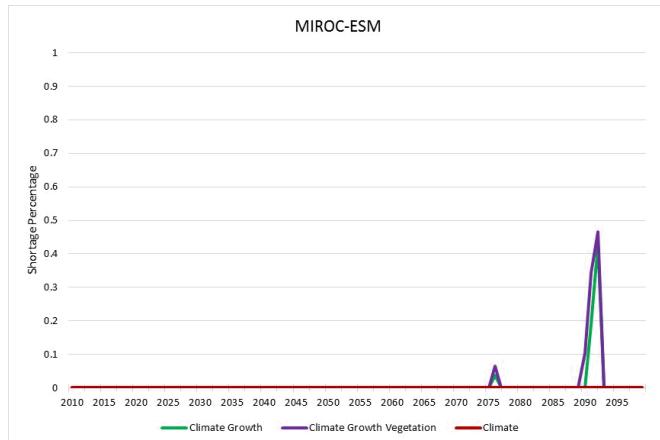


Navajo Reservoir Storage



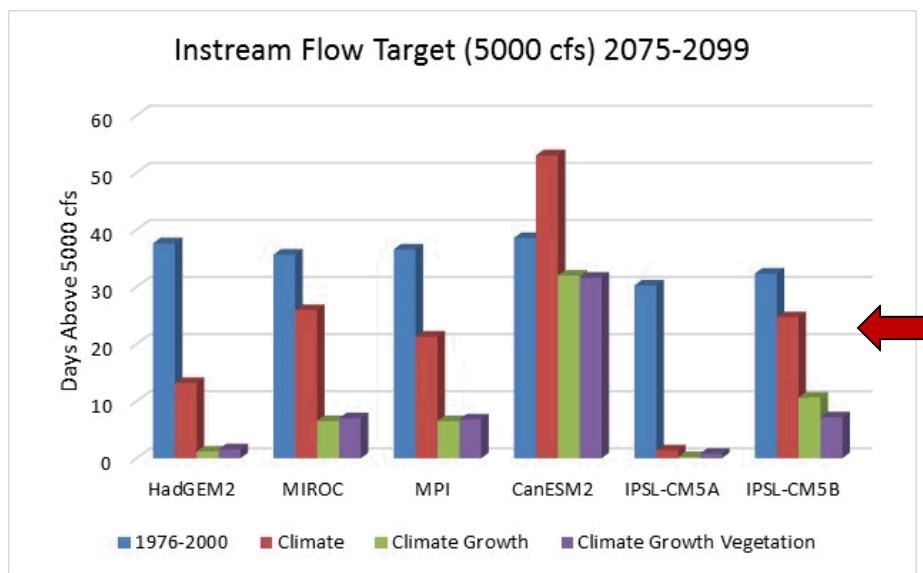
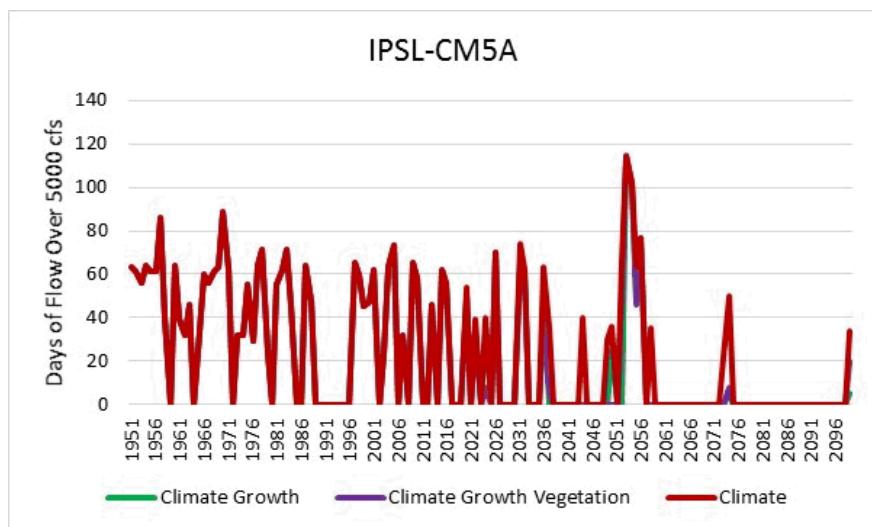
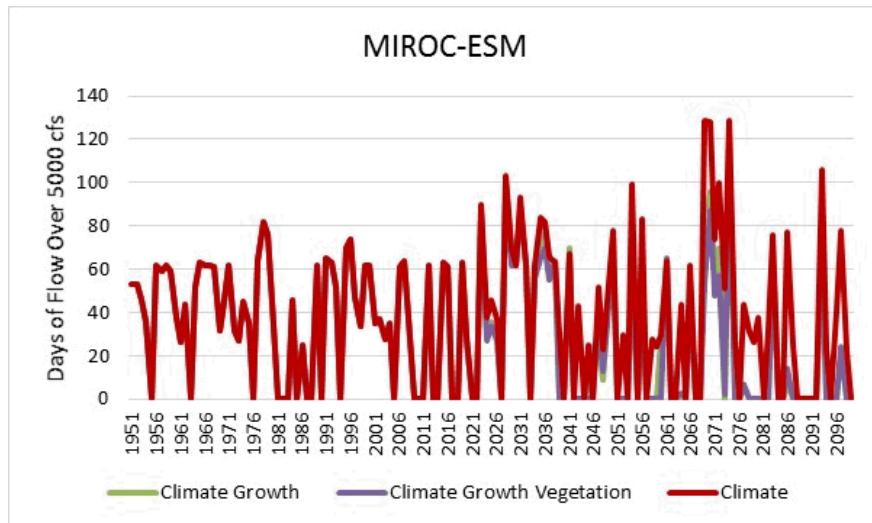
Water Deliveries

- Shortage sharing used to prioritize deliveries: all share equally in times of water shortage



Target Instream Flows

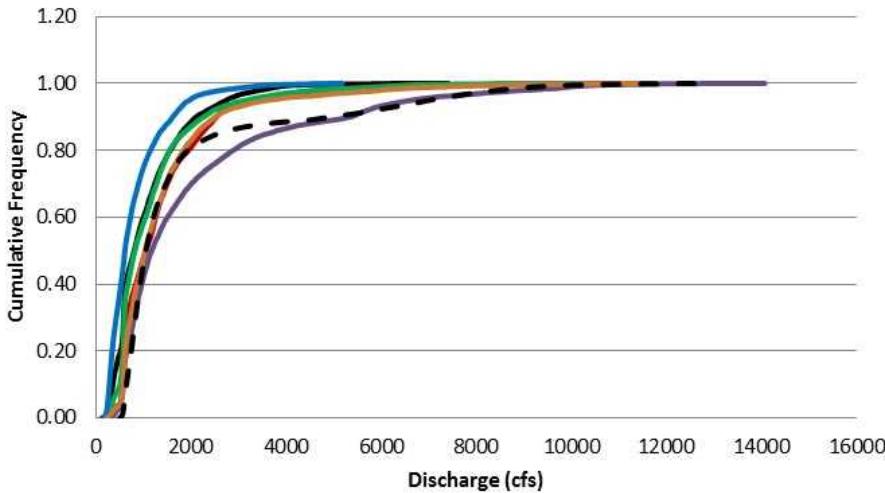
Days above 5000 cfs: March-July
Target is 21 days per year



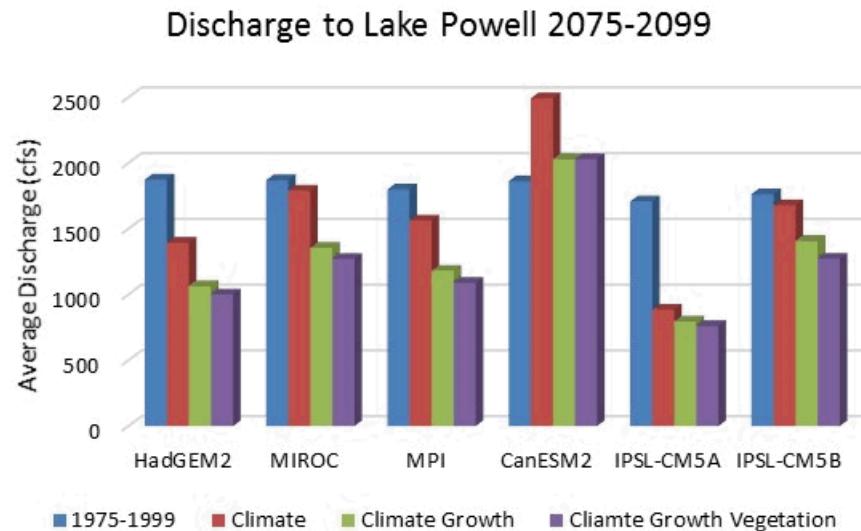
Deliveries on Colorado River

- One of three major upper basin tributaries to Colorado River
- Supplies about 18% of average annual flow

Discharge to Lake Powell 2075-2099



Discharge to Lake Powell 2075-2099



Summary

- ***Growth and Climate***: Only two models yielded delivery shortages under the climate only scenario; however when combined with growth all models registered multiple shortages.
- ***Uncertainty***: Significant differences in projected impacts were consistently evident across climate models and scenarios.
- ***Uneven Impacts***: Impacts differ significantly by metric due to position in basin and the institutional controls dictating its operations.
- ***Non-Local Impacts***: Local effects of climate change spilled over to other basins:
 - Lower Colorado River, and
 - San Juan- Chama diversion to Rio Grande Basin.

■ Project information:

<http://water.sandia.gov>

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Energy and Climate

RENEWABLE SYSTEMS CLIMATE/ENVIRONMENT ENERGY INFRASTRUCTURE ENERGY RESEARCH ABOUT EC

Energy and Climate • Climate/Environment • Water Security Program • Energy and Water in the Western and Texas Interconnects

Energy and Water in the Western and Texas Interconnects

Background Objectives Tasks Benefits/Outcomes Collaborators Links Documents Data Portal

Water Scarcity Impacts Energy Production

In the United States the energy sector accounts for approximately 41% of daily fresh water withdrawals and 49% of total overall daily water withdrawals for the following energy-related uses:

- Hydroelectric power generation
- Thermoelectric power plant cooling and air emissions control
- Energy-resource extraction, refining, and processing



The Energy Information Administration projects the U.S. population will grow by **70 million people** between 2005 and 2030, increasing electric power demand by **50 percent** and transportation fuel demand by **30 percent**. This will require more water. Unfortunately, this growth in water demand is occurring at a time when the nation's fresh water supplies are seeing increasing stress from:

- Limitations of surface-water storage capacity
- Increasing depletion and degradation of ground water supplies
- Increasing demands for the use of surface water for in-stream ecological and environmental uses
- Uncertainty about the impact of climate variability on future water fresh surface and ground water resources

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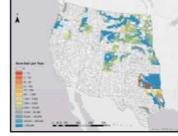
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Last Updated: August 7, 2014

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- Water Infrastructure Security
- Water, Energy, and Natural Resource Systems
- Energy and Water in the Western and Texas Interconnects
 - Energy and Water Data Portal
 - Electric Power Generation and Water Use Data
 - Water Availability, Cost, and Use

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