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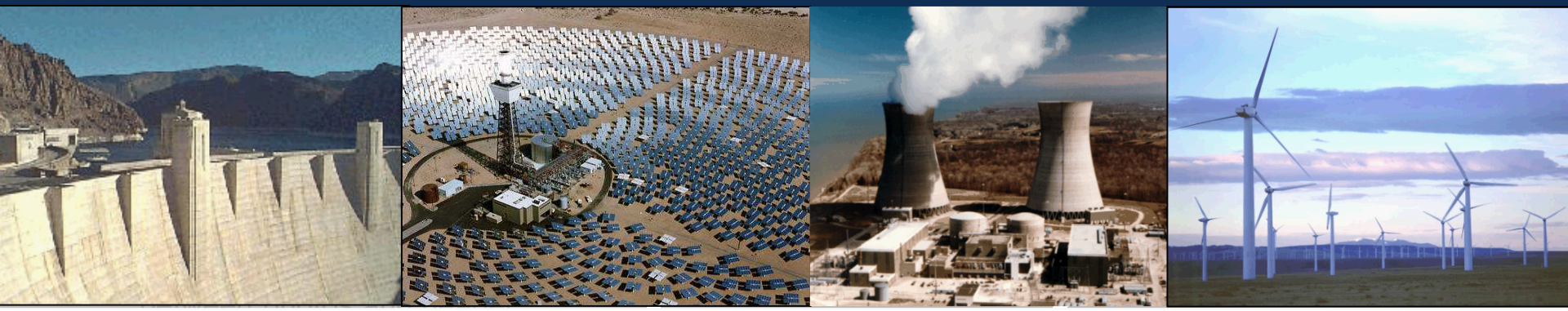

Integrated Energy-Water Planning

Vincent Tidwell
Sandia National Laboratories

APEC Water-Energy Nexus Expert Workshop
Atlanta, Georgia
October 31, 2017

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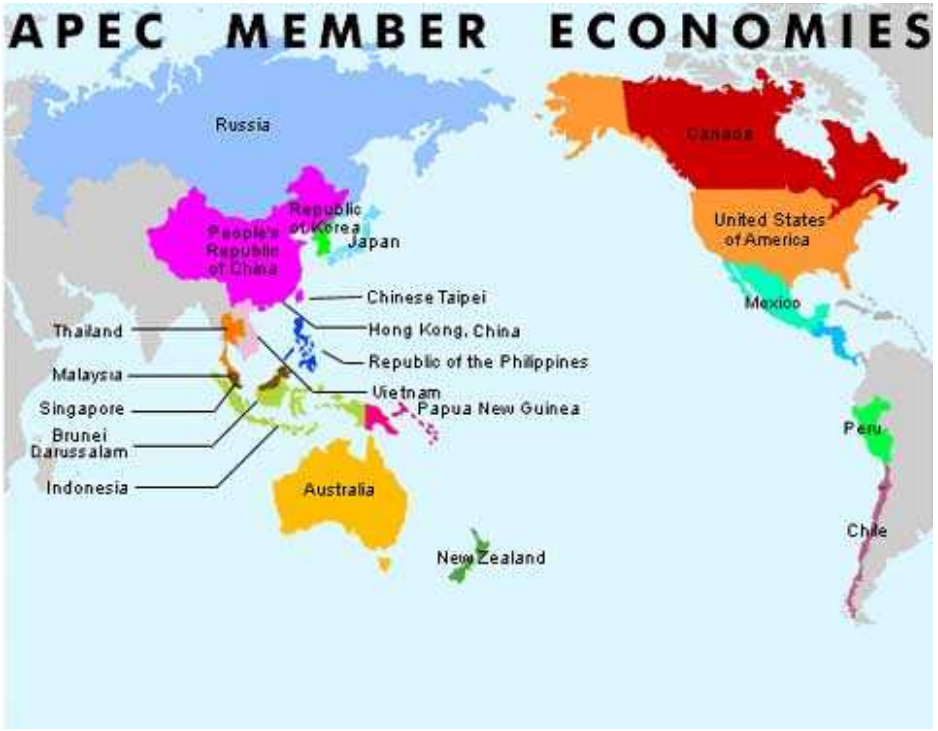
Take-Aways

- Modeling and analysis key to managing the Energy-Water Nexus
- Multi-modal, multi-scale approach is needed:
  - Multinational Scale: High-level analysis aimed at recognizing and communicating the problem,
  - Regional Scale: Moderate detail capturing linkages between energy and water supporting integrated planning, and
  - Asset Scale: Detail sufficient to model operations of key assets to quantify vulnerabilities and adaptive measures.

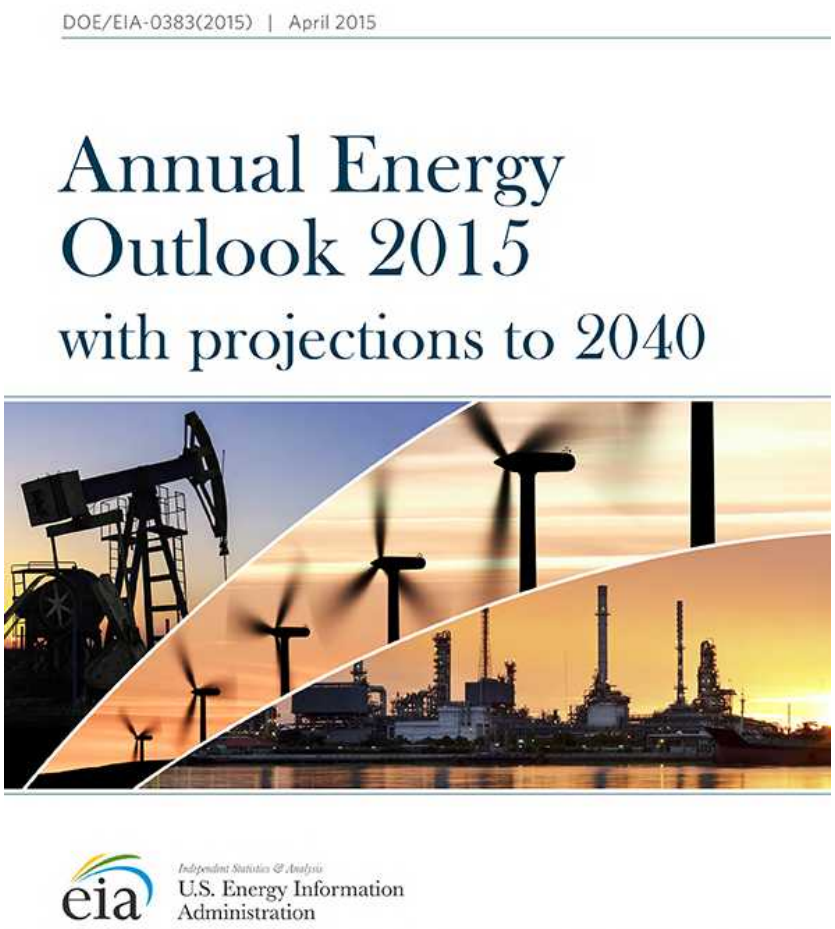
Multinational: Identifying Hot Spots

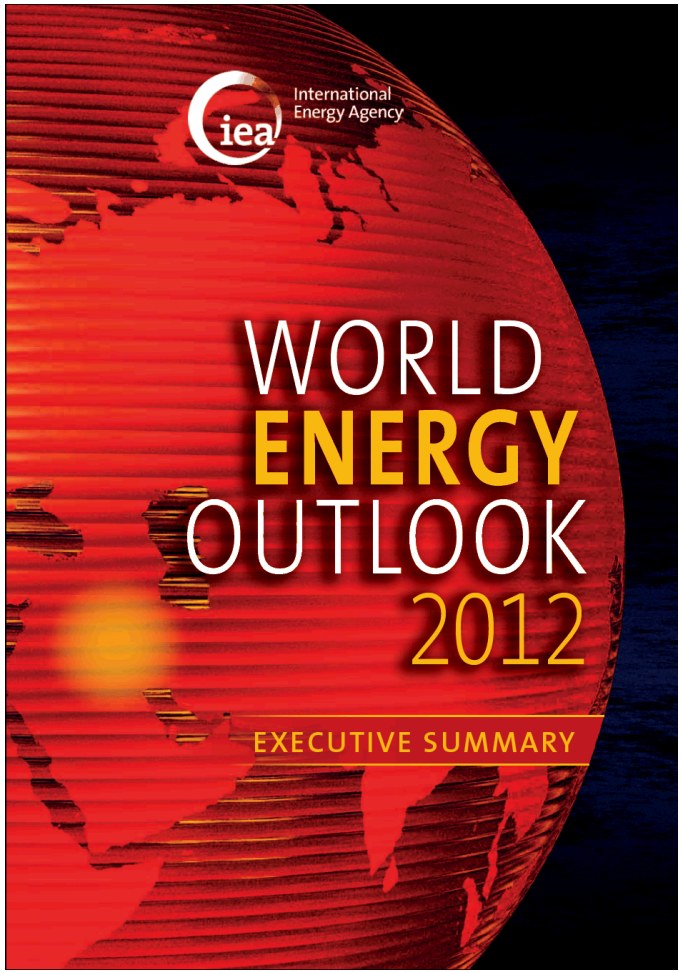
- Support the Asia-Pacific Economic Cooperation by investigating the Energy-Water Nexus in each member economy:
  - Map water use for energy
  - Map energy use for water
  - Perform mapping at a regional level
  - Compare to measures of water stress



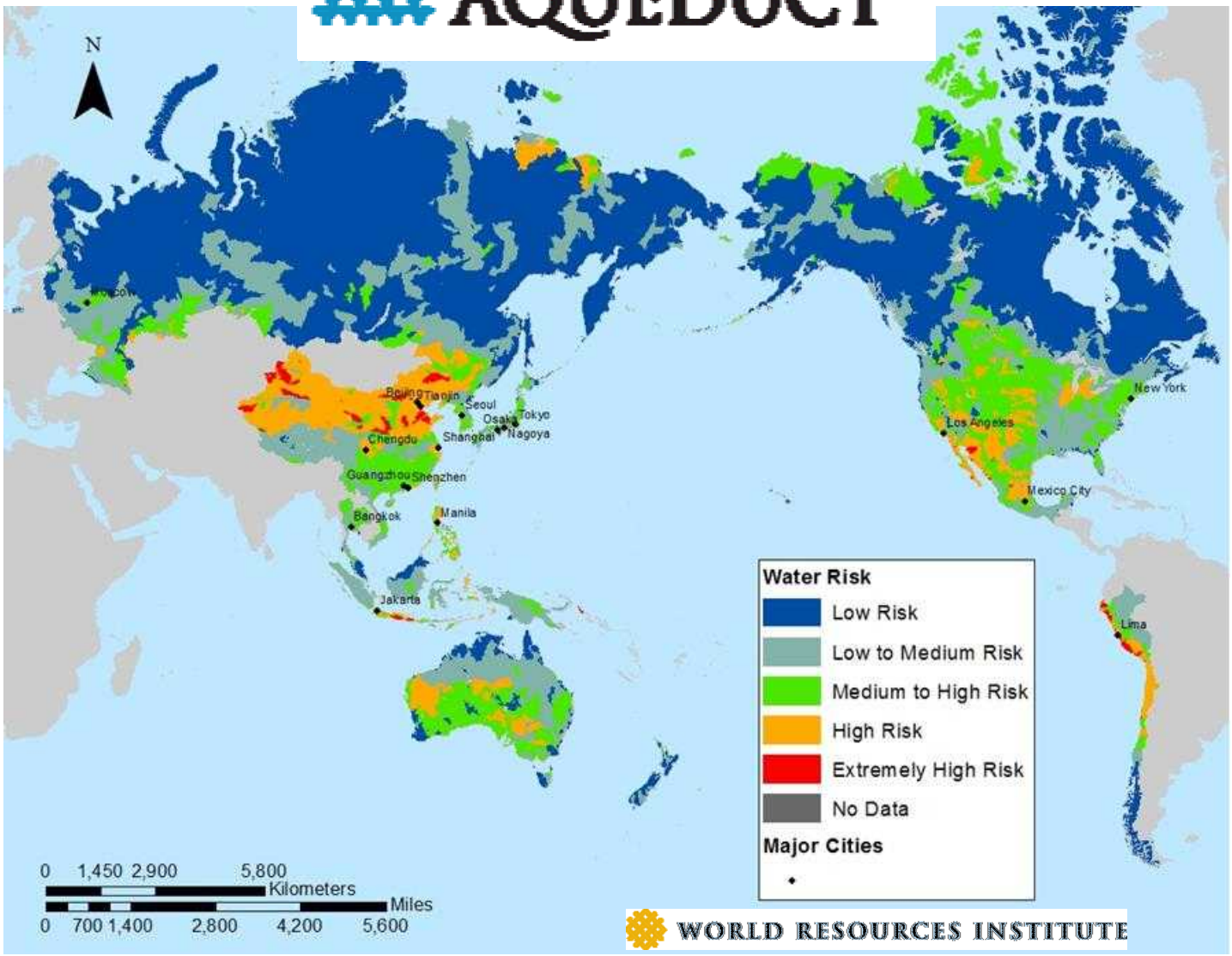
Methods

- Utilized publically available data

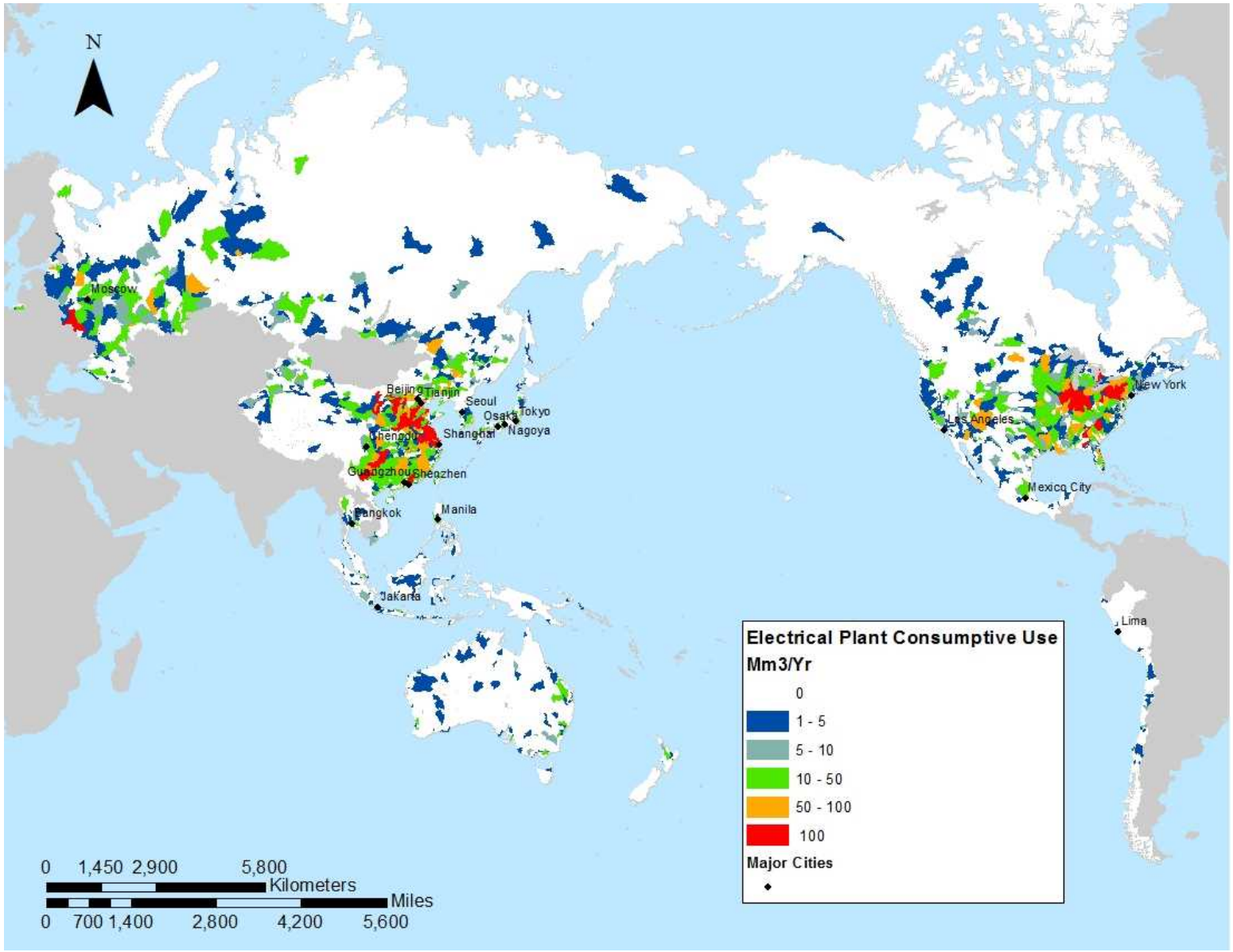




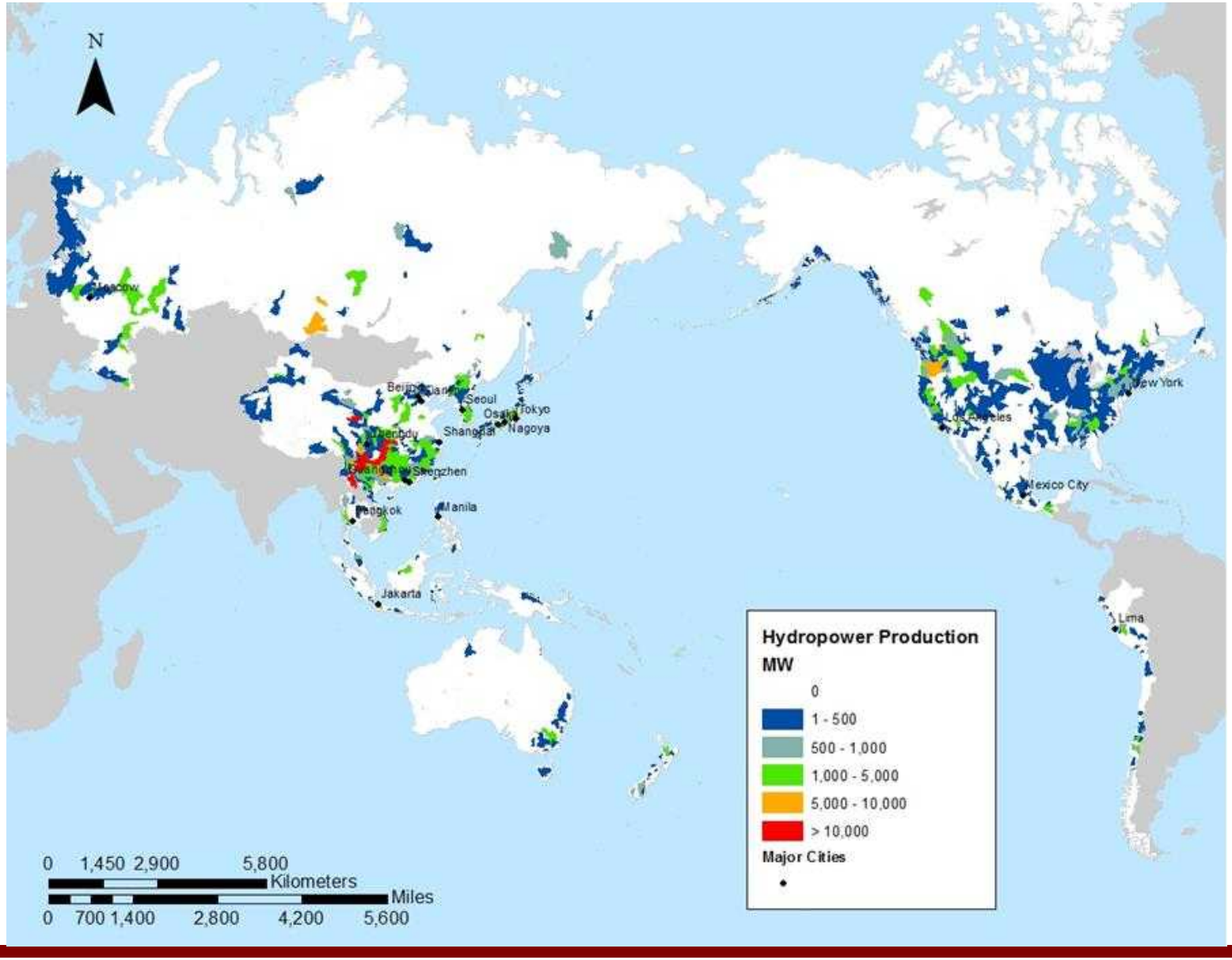
Global Water Risk Mapping



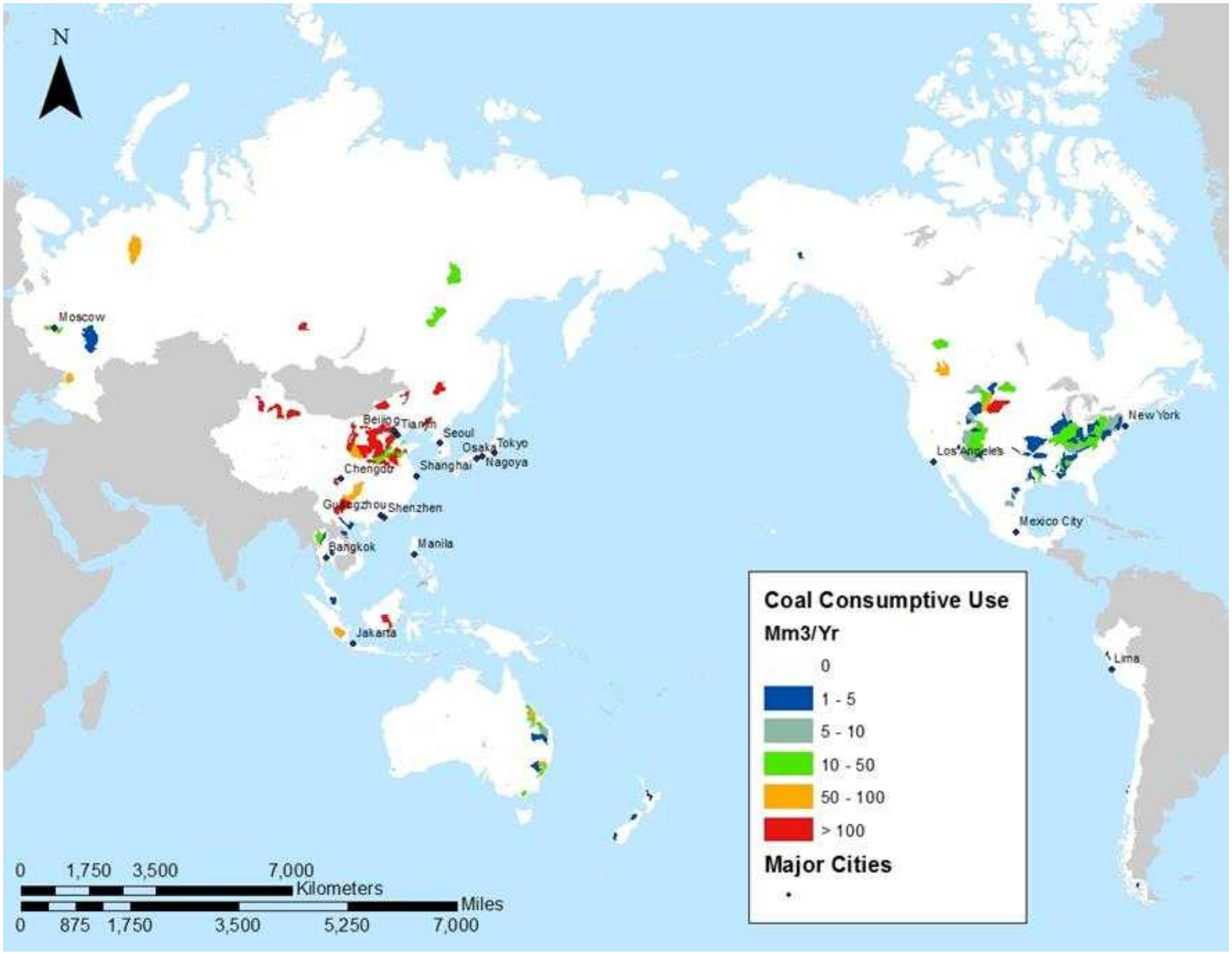
Water for Thermoelectric Power



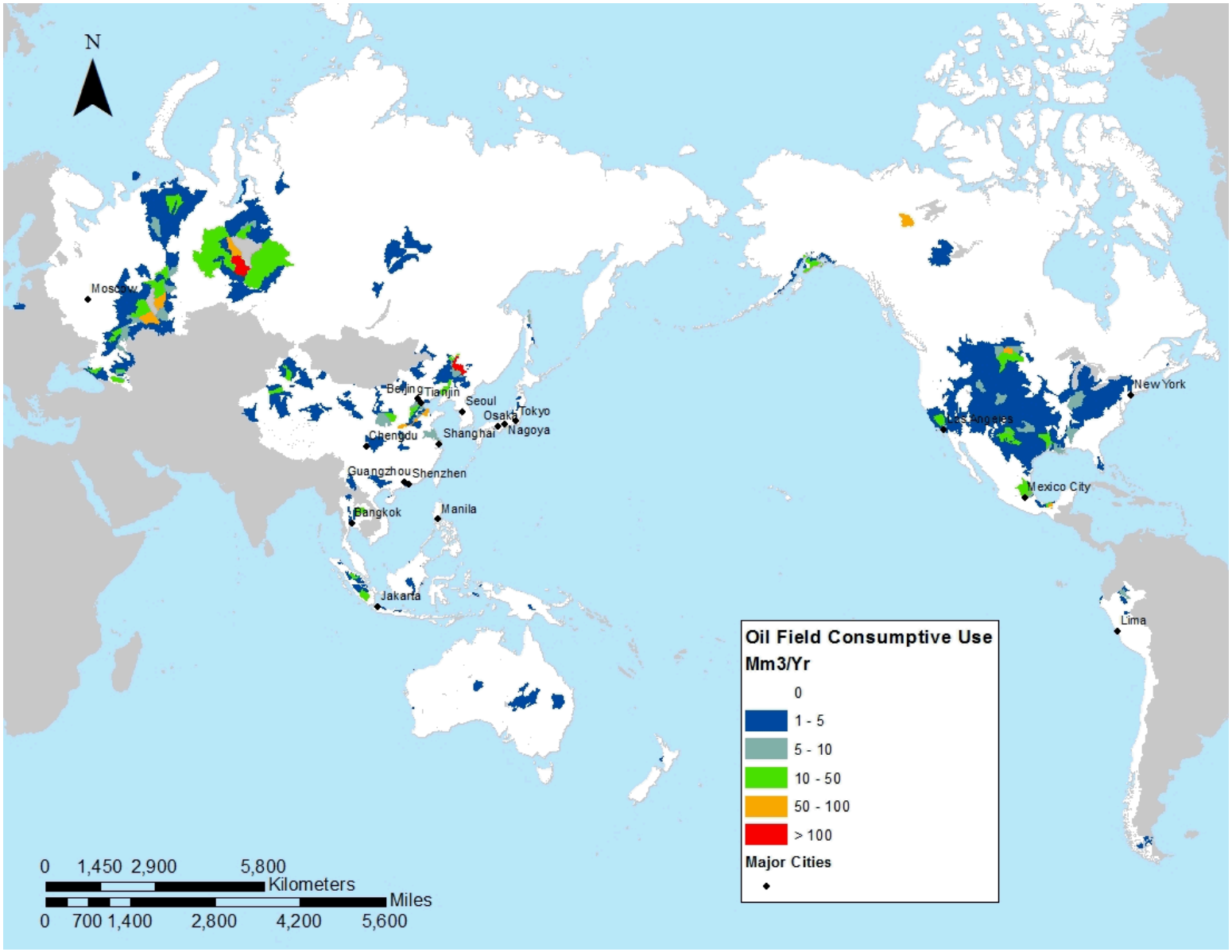
Hydroelectric Power (MW)



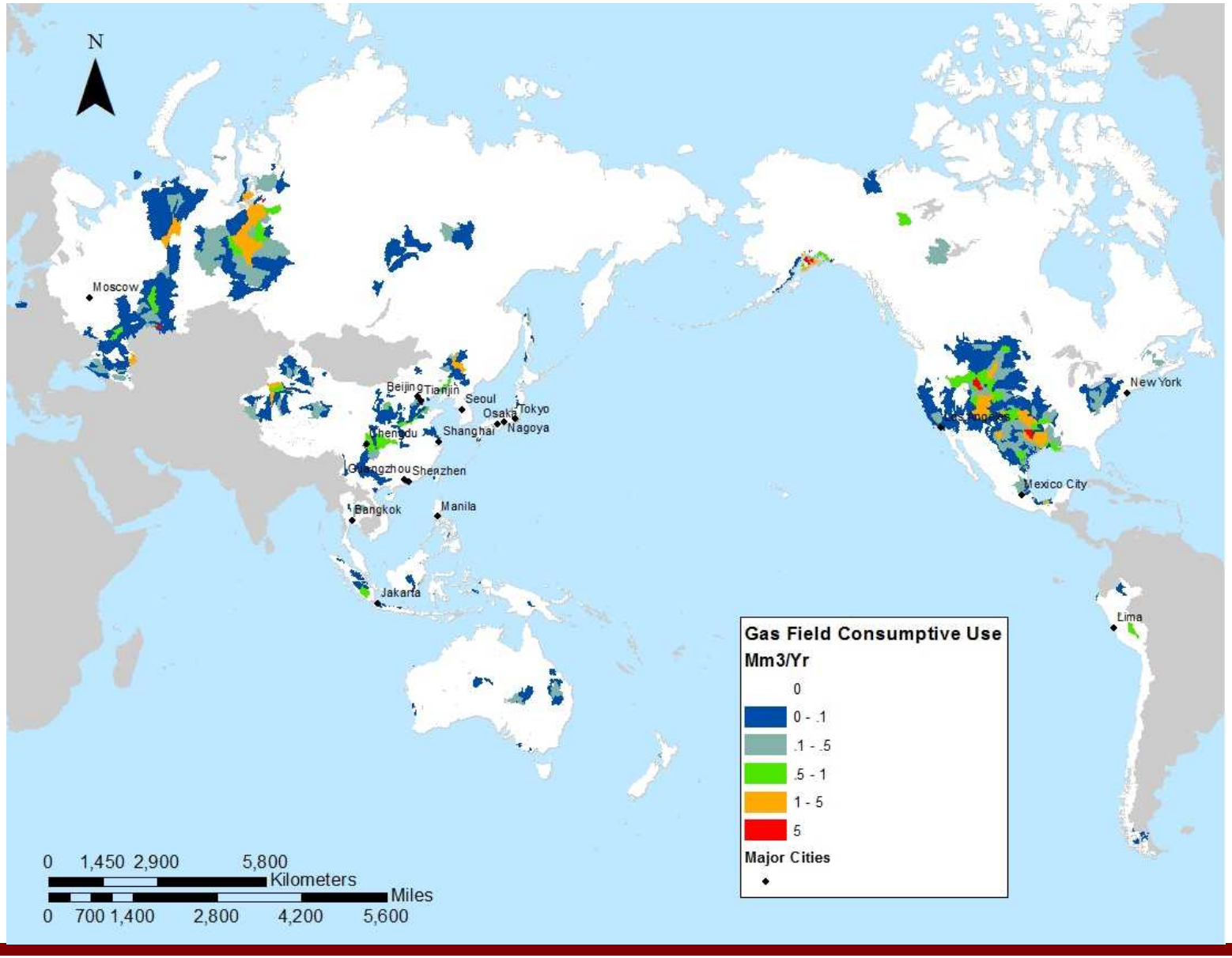
Water for Coal Extraction



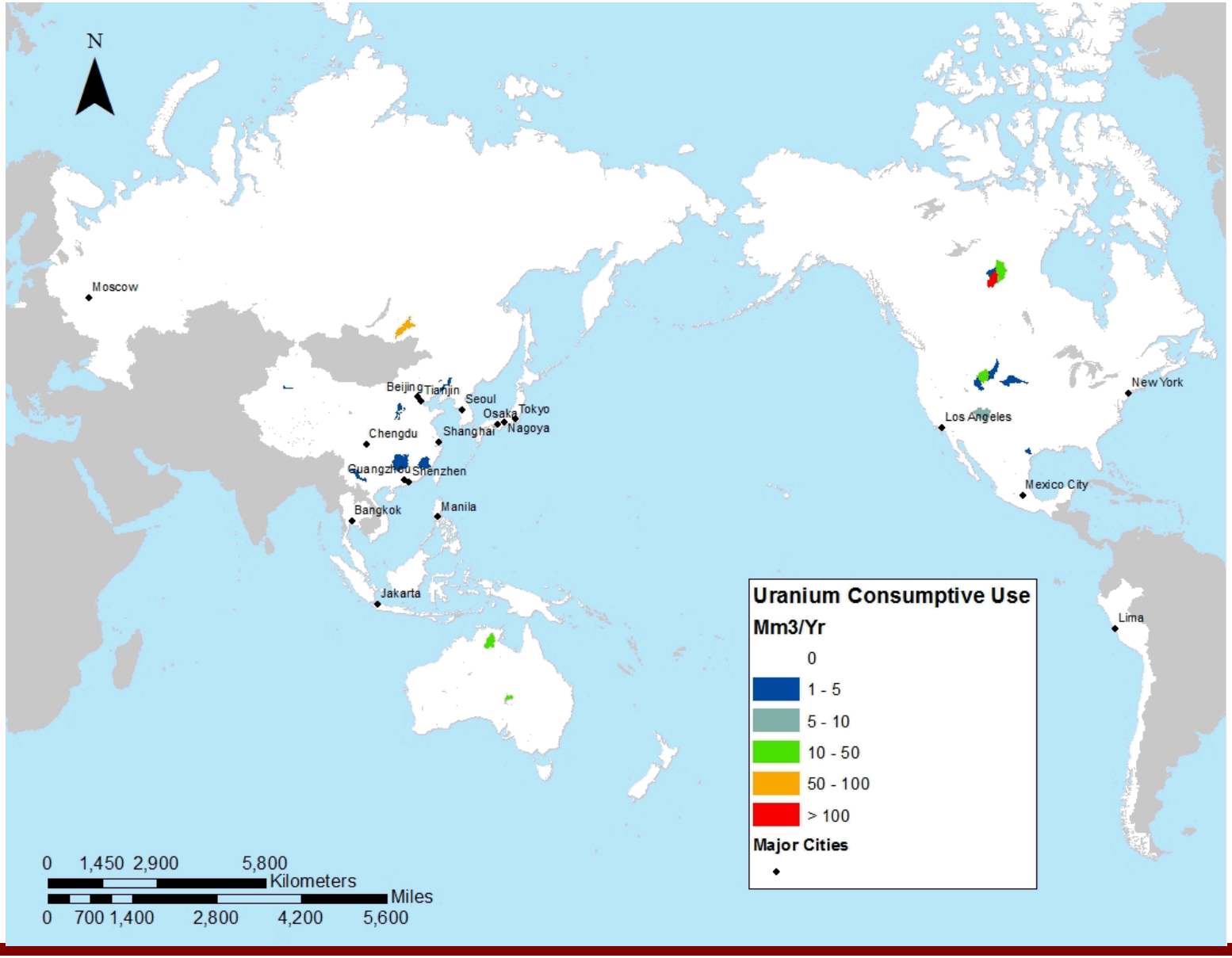
Water for Oil Extraction



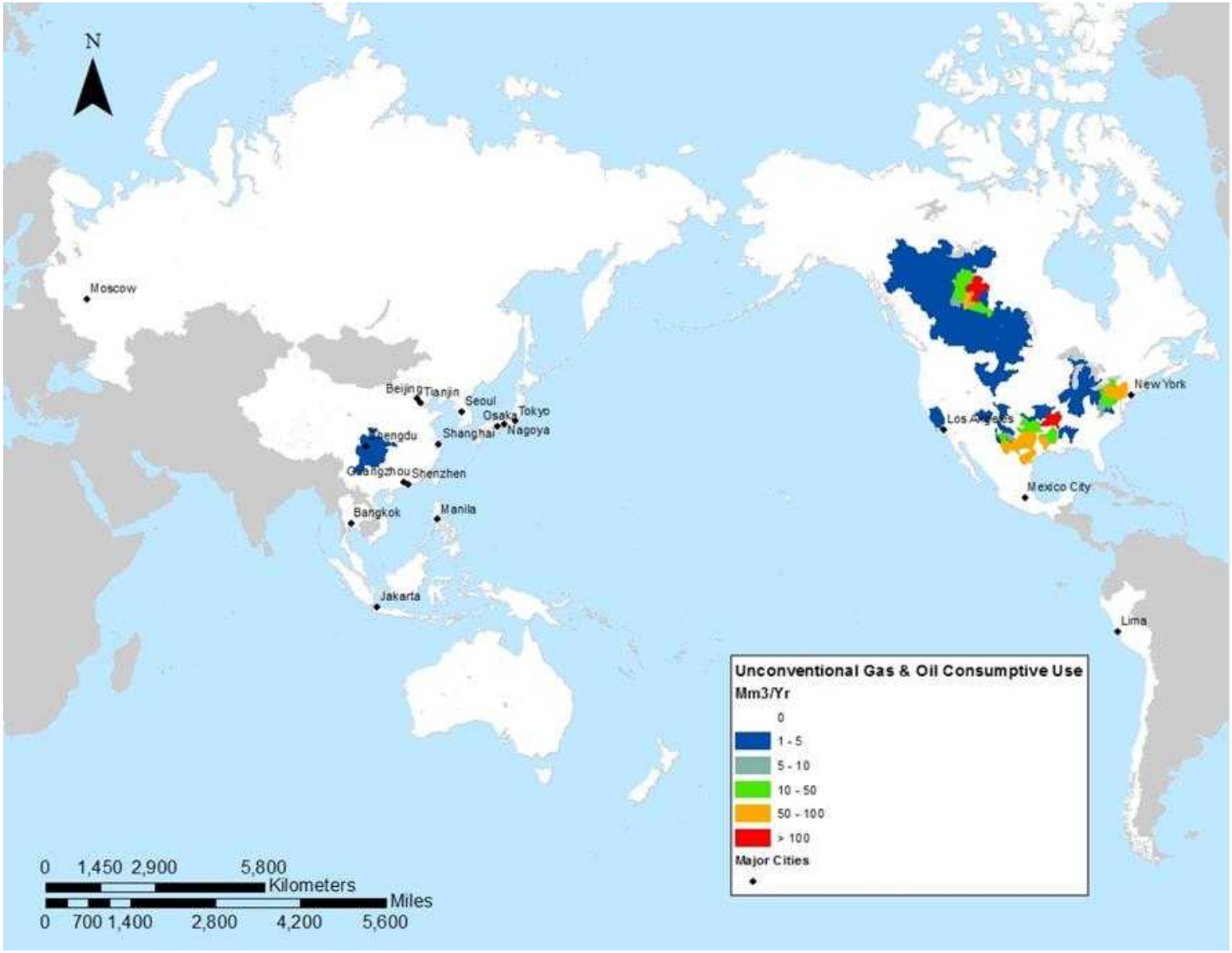
Water for Natural Gas Extraction



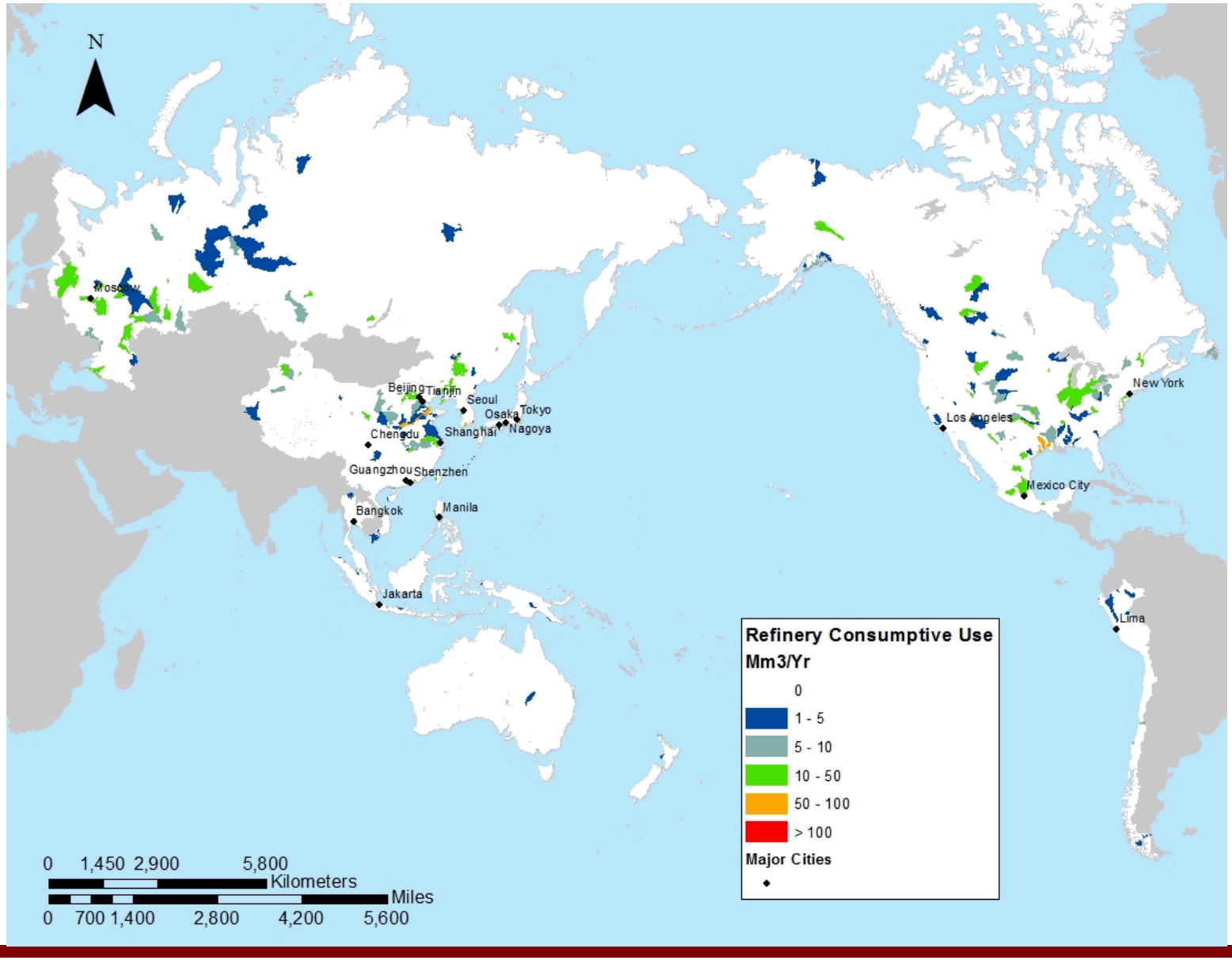
Water for Uranium Extraction



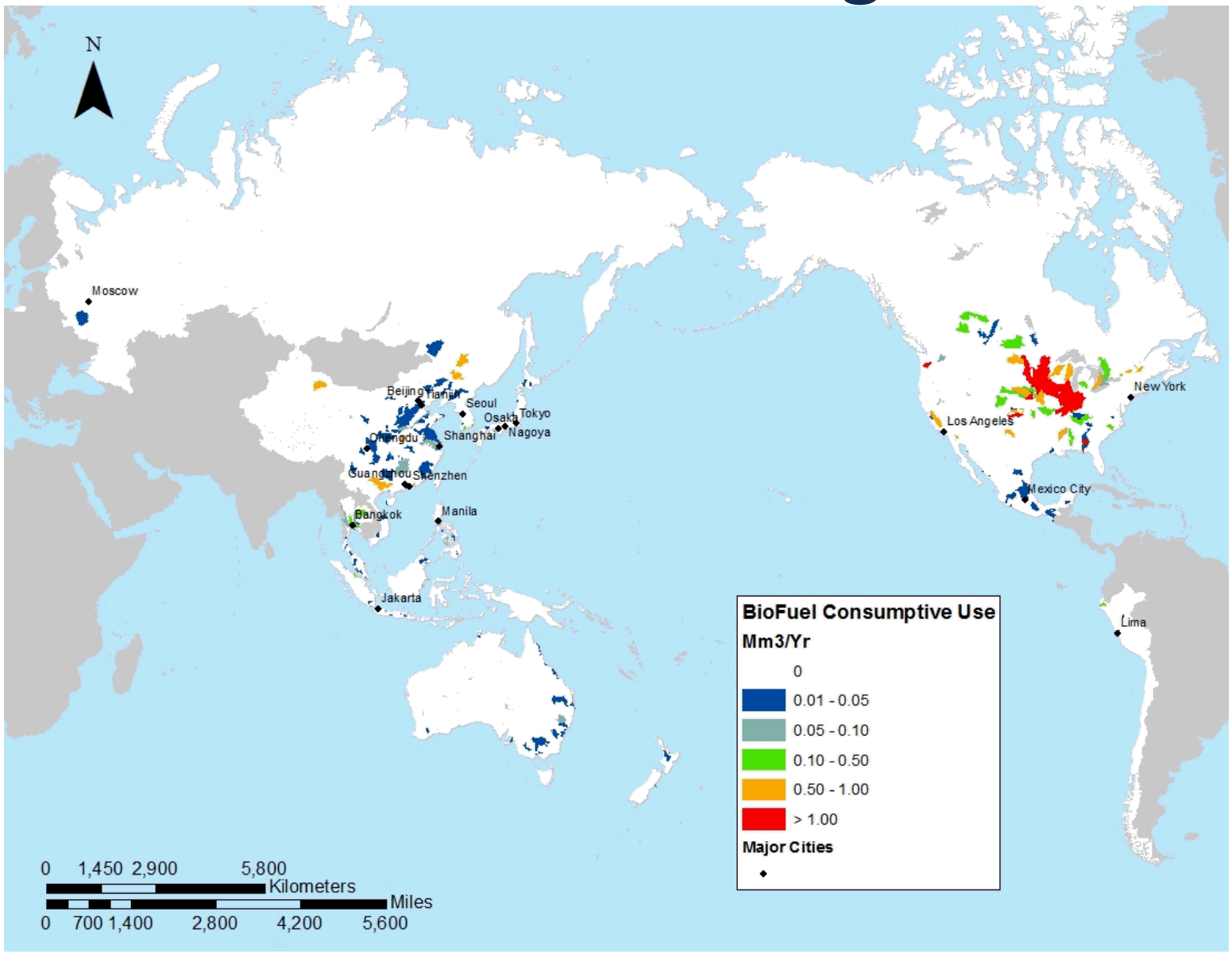
Water for Unconventional Oil and Gas



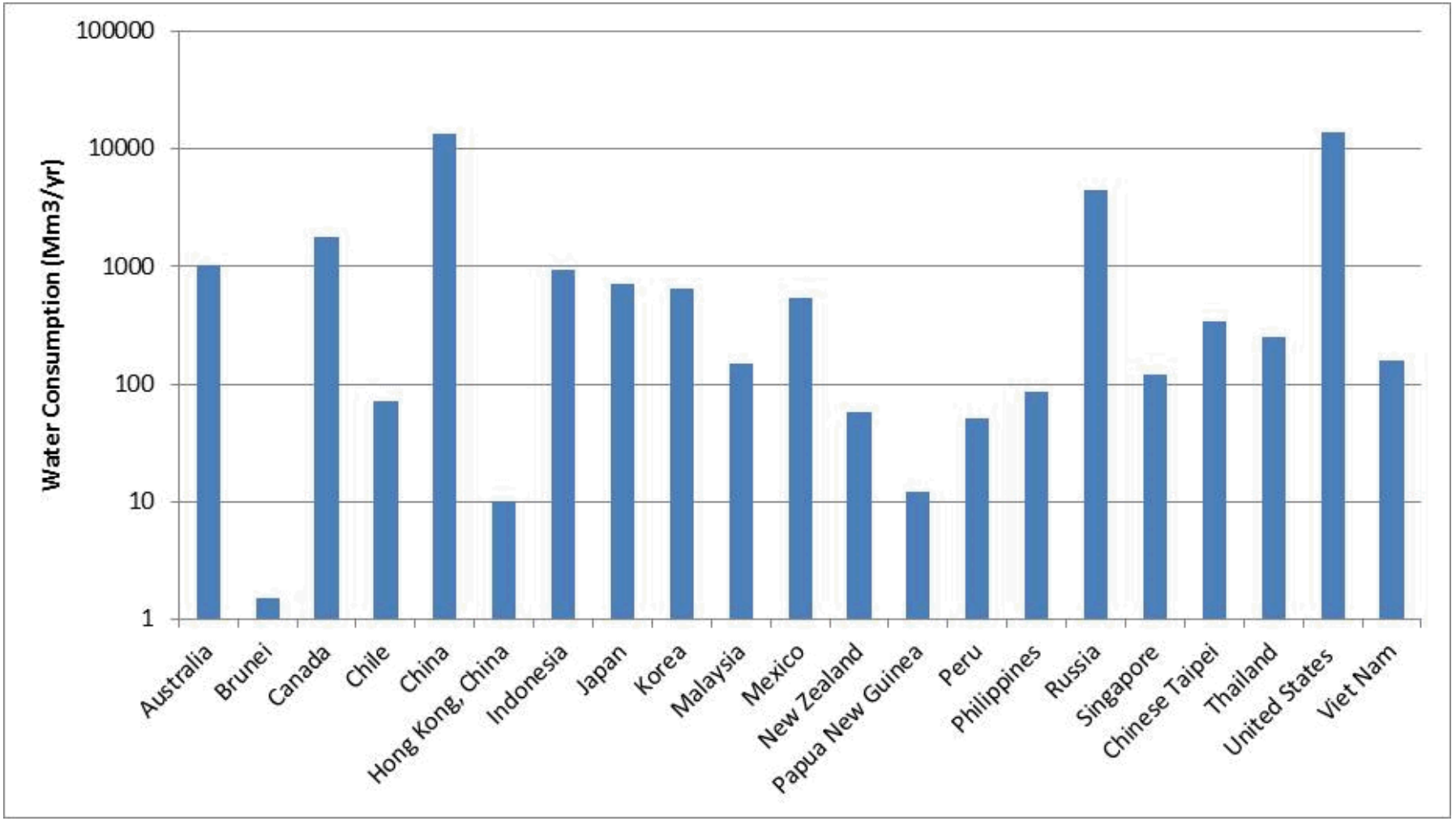
Water for Oil Refining



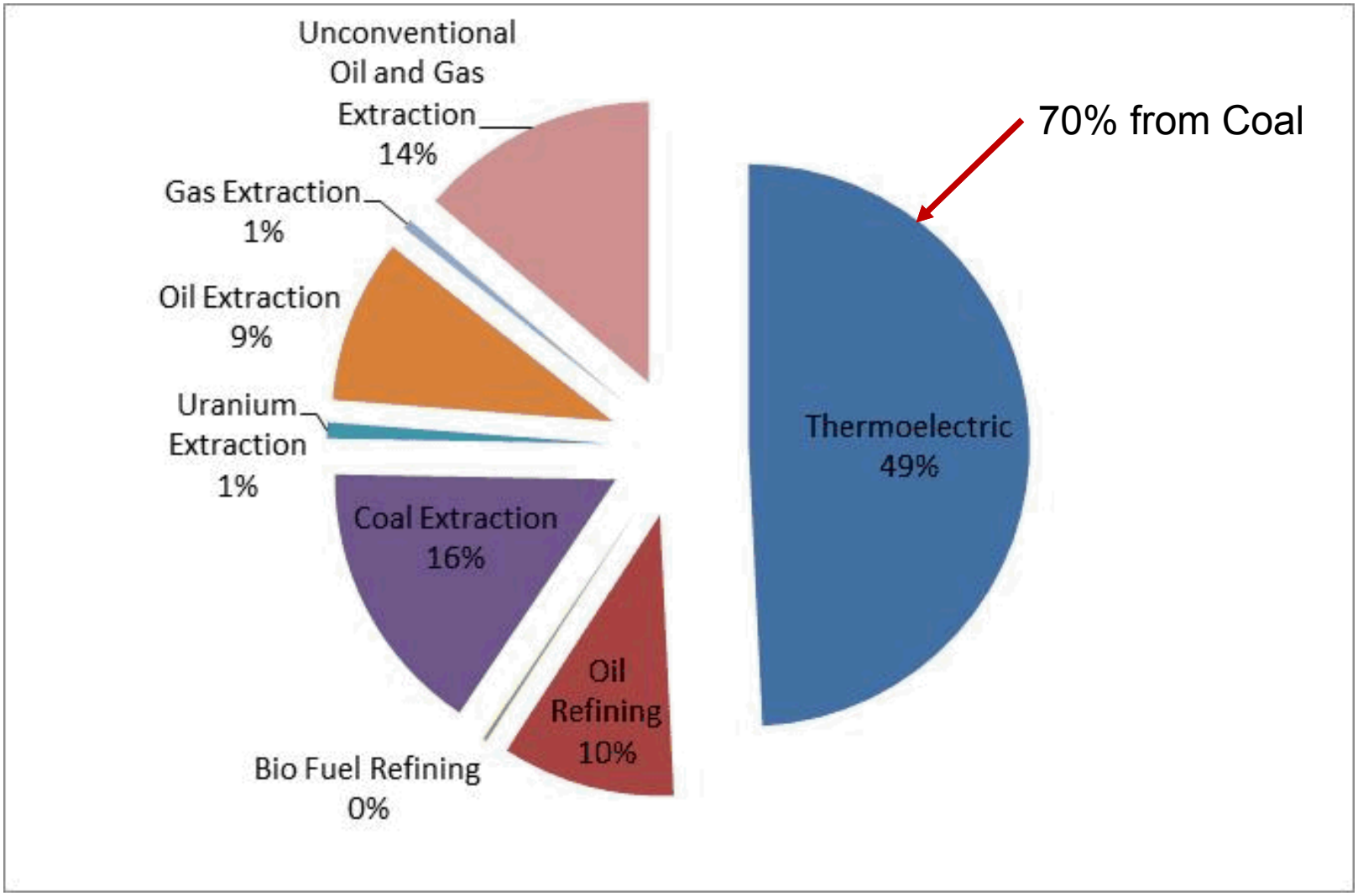
Water for Biofuel Refining



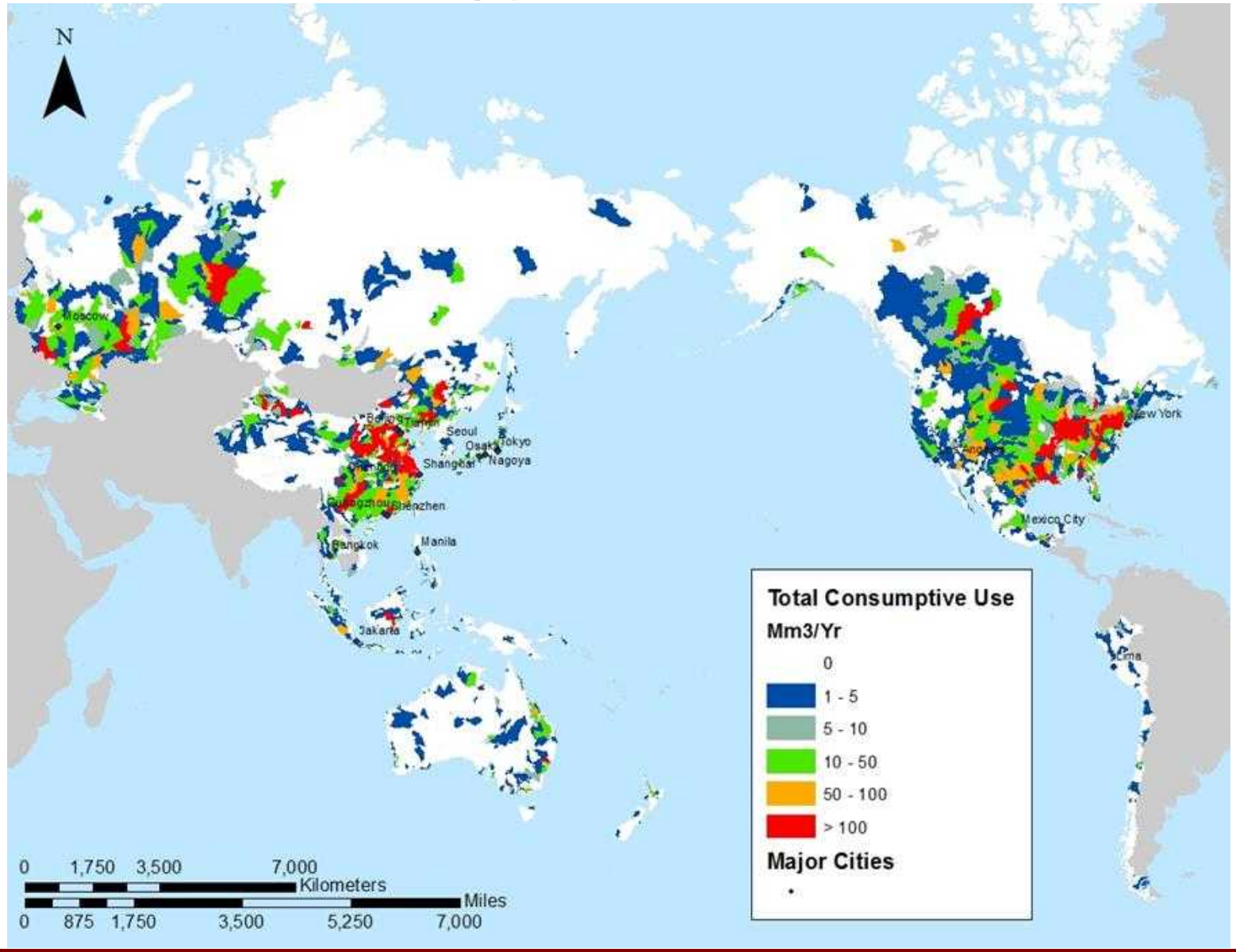
Water for Energy by Economy



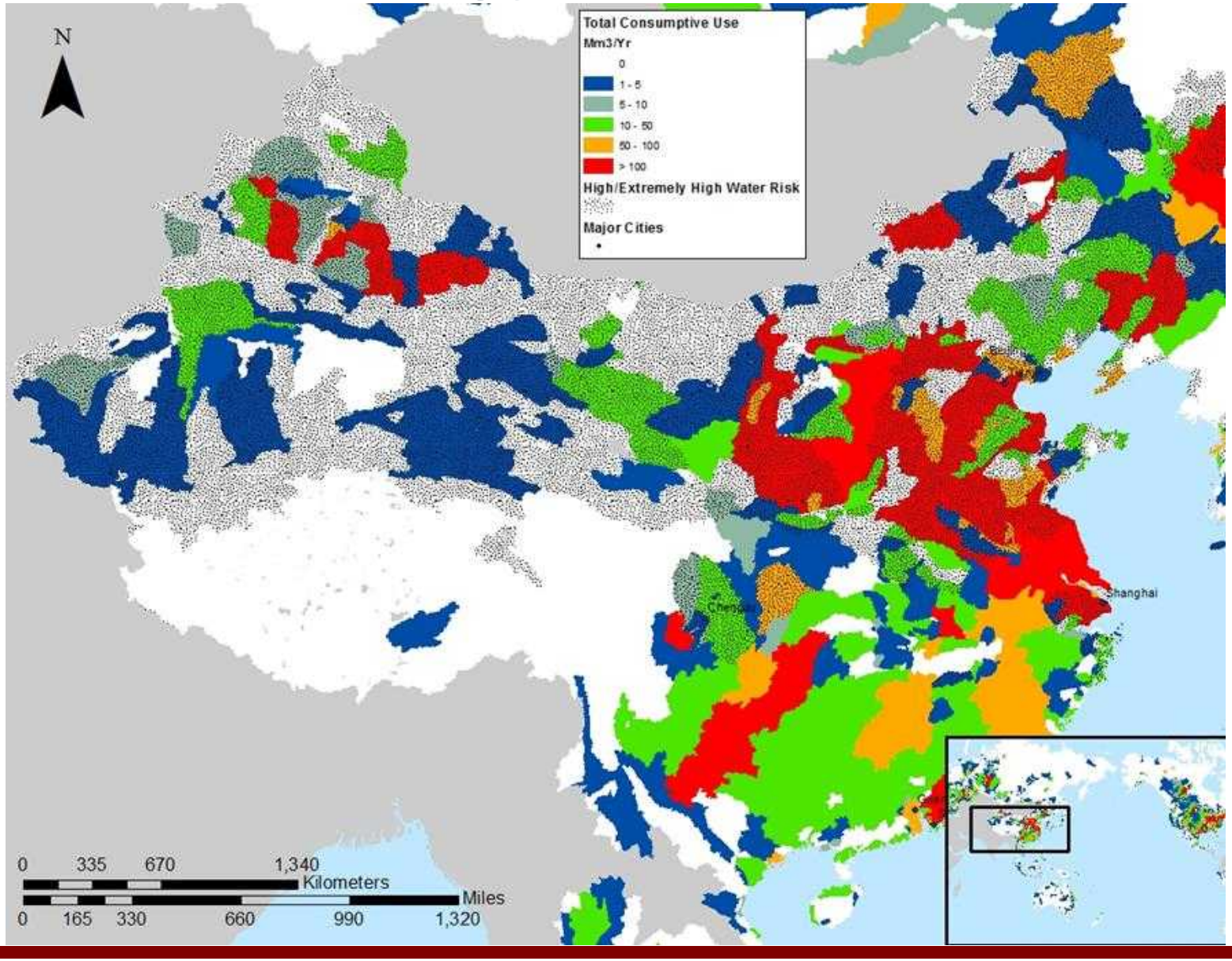
Water for Energy by Sector



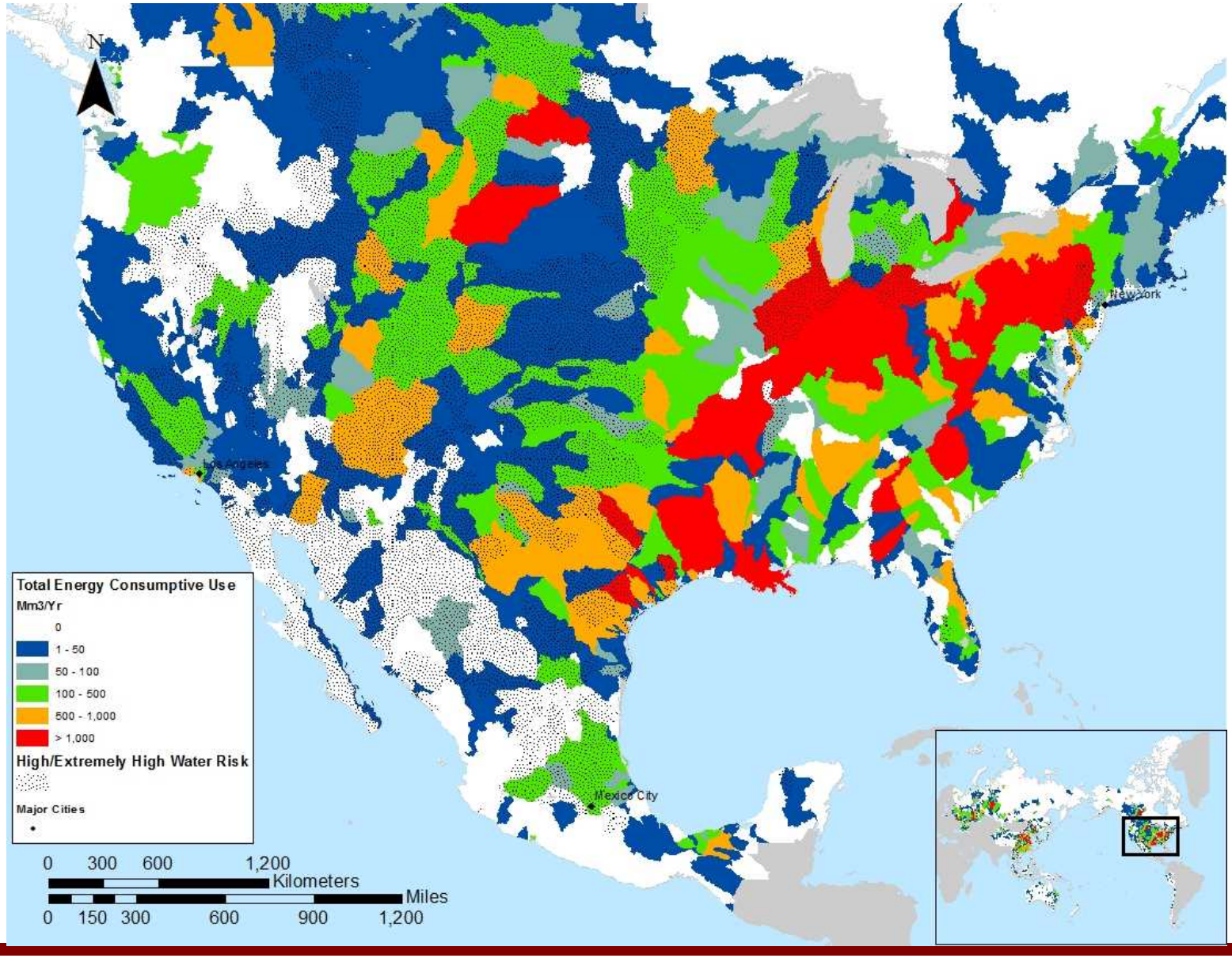
Water for Energy with Water Stress



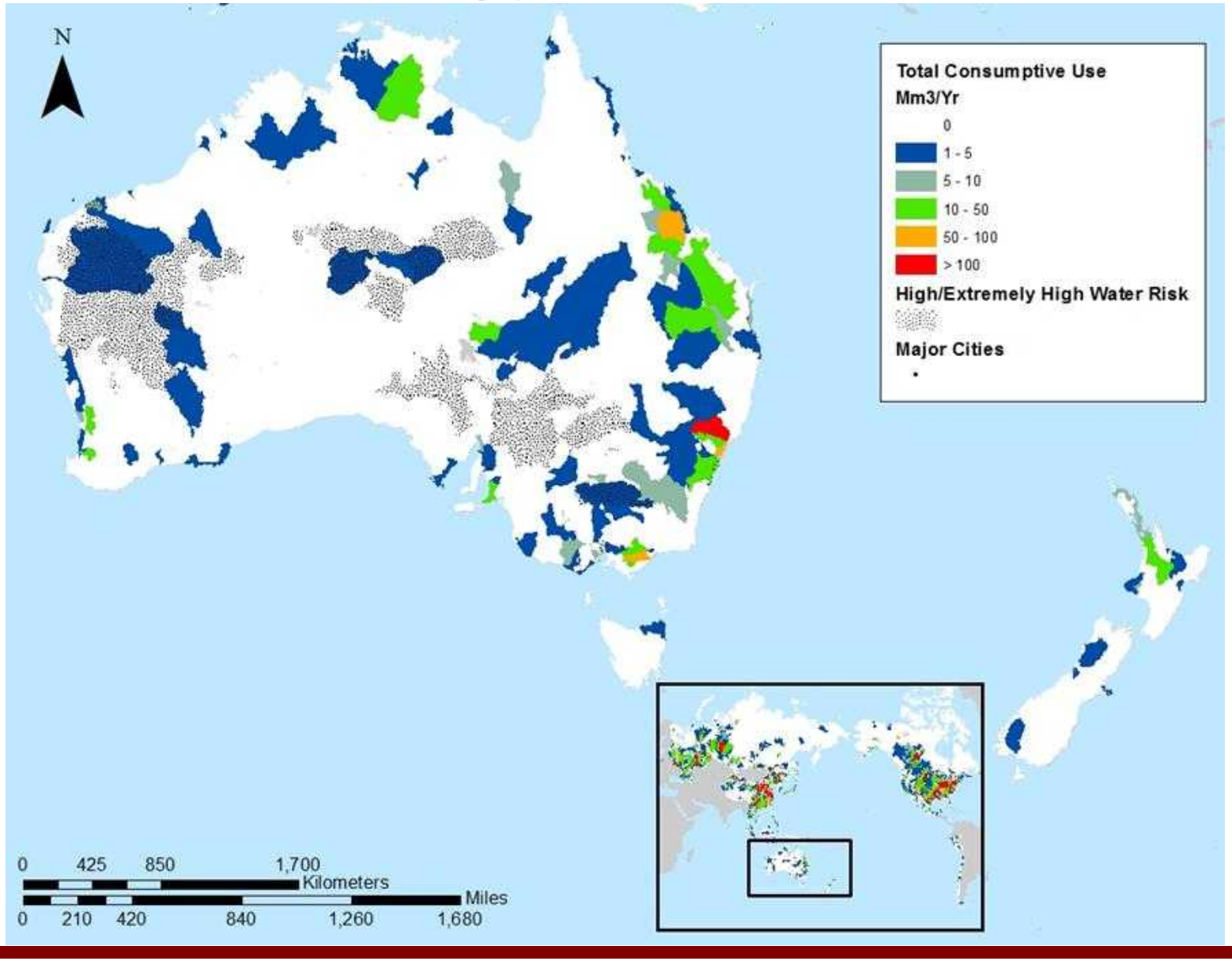
Water for Energy: Detail China



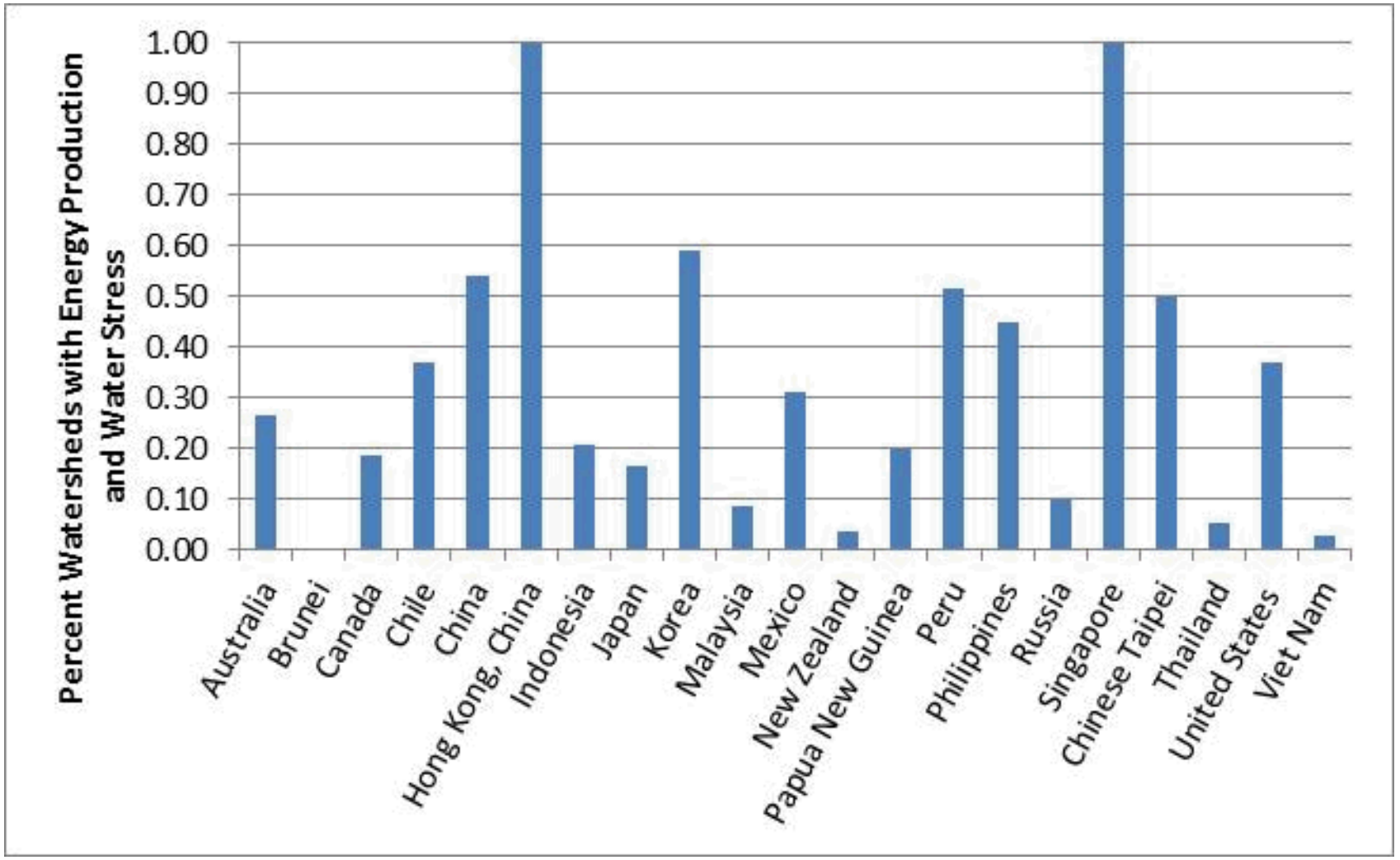
Water for Energy: Detail United States



Water for Energy: Detail Australia

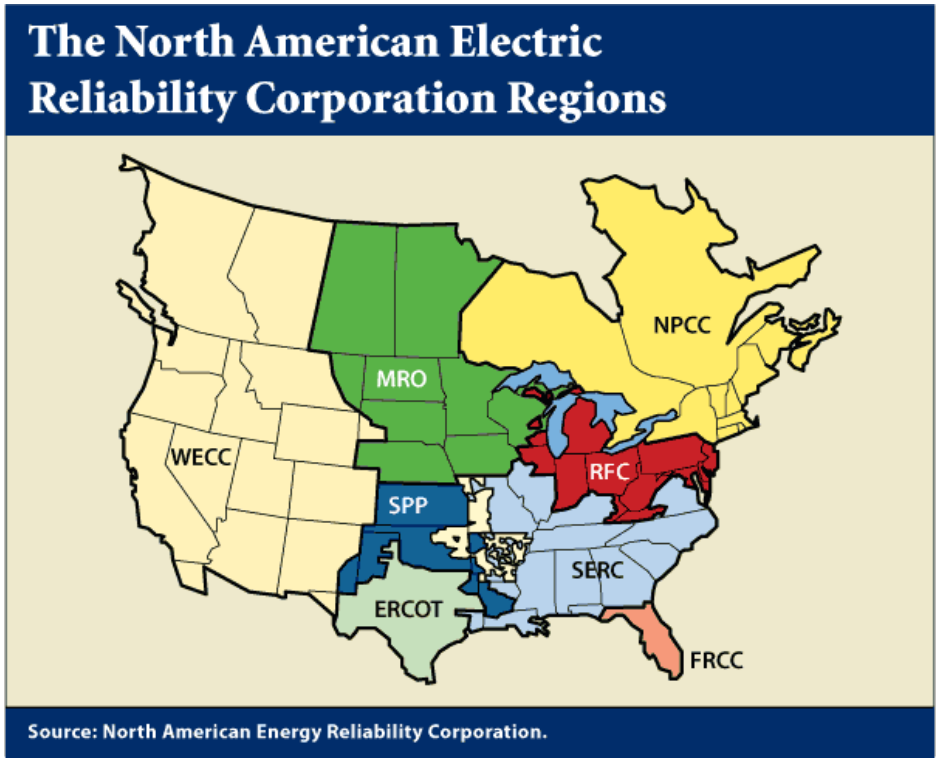


Energy-Water Risk



Regional: Integrated Planning

- Integrate water related concerns into long-range transmission expansion planning (20 yrs.) of WECC:
  - Siting of new power plants
  - New transmission capacity



WESTERN GOVERNORS' ASSOCIATION
Serving the Governors of 19 States and 3 US-Flag Pacific Islands

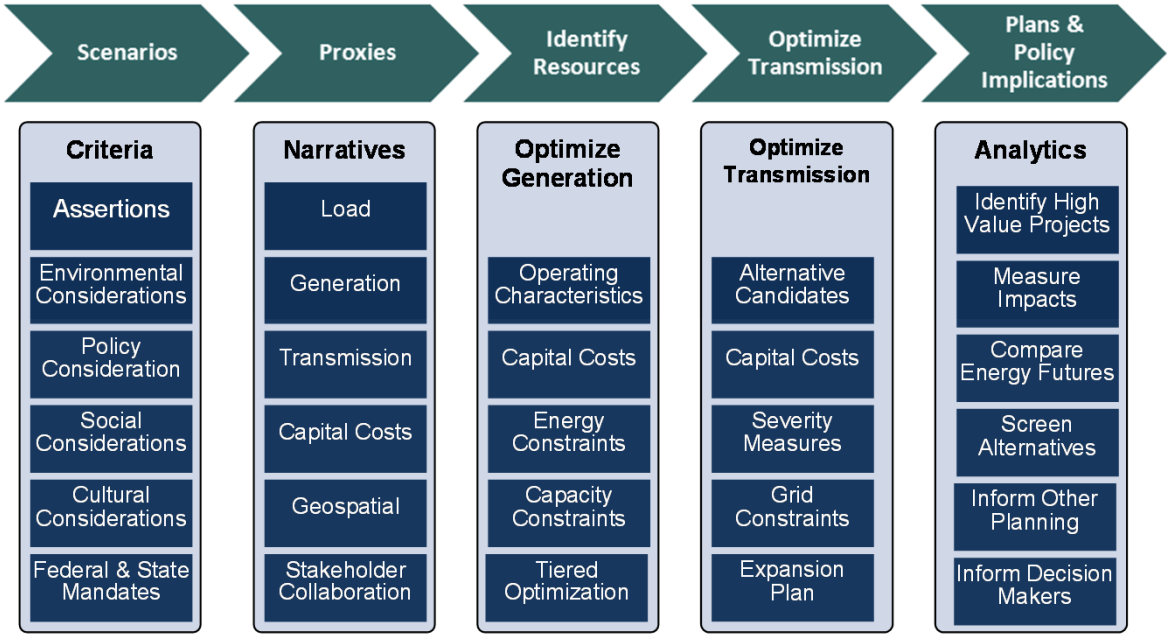
WECC

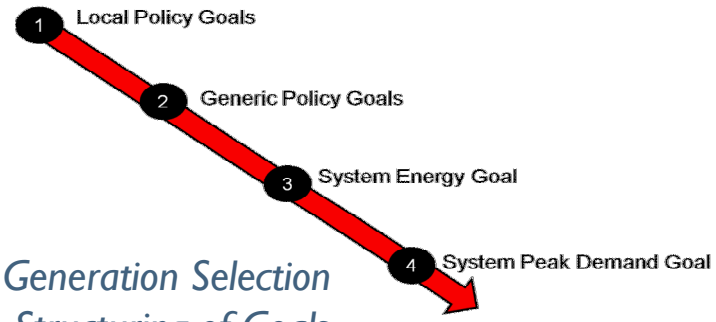
WSWC
Western States Water Council

Methods: Capital Expansion

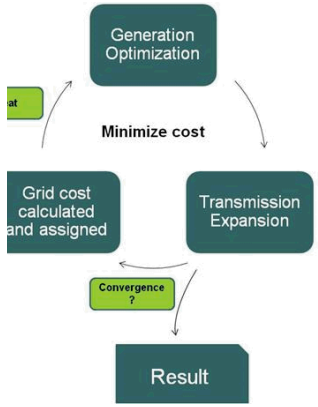
- Co-optimize generation and transmission additions.
- Least cost solution subject to goal related constraints:
  - Energy,
  - Policy,
  - Environmental, and
  - Societal conditions.
- Water is one of many considerations.

Source: WECC 2013





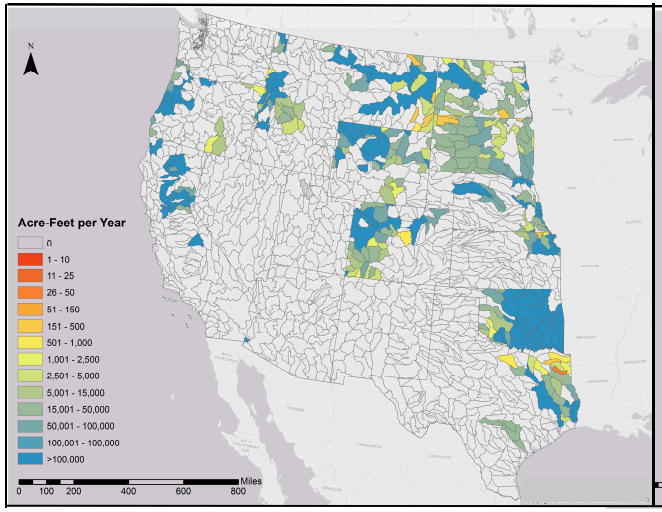
Generation Selection Structuring of Goals



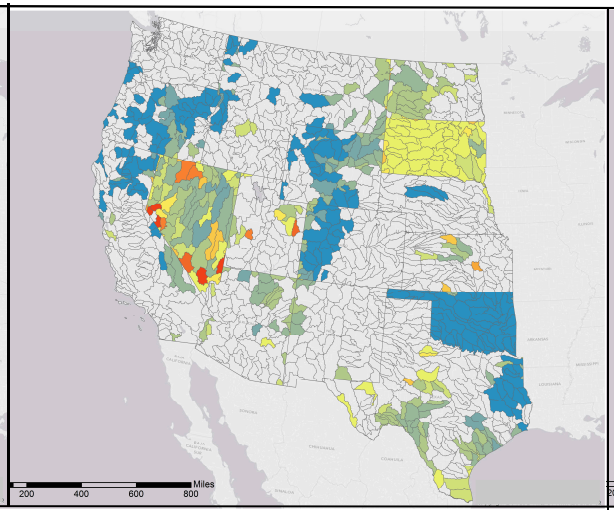
Optimization Iteration

Results: Water Supply Availability

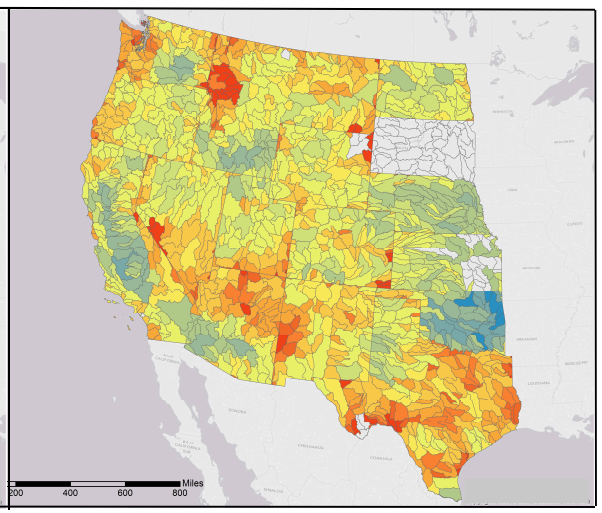
Unappropriated Surface Water



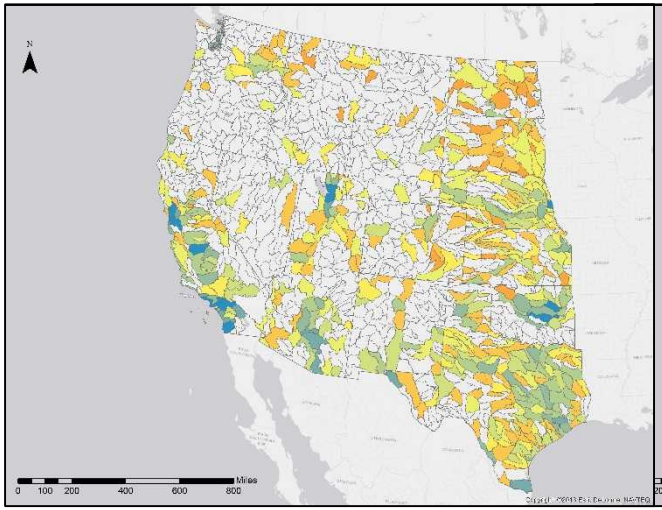
Unappropriated Groundwater



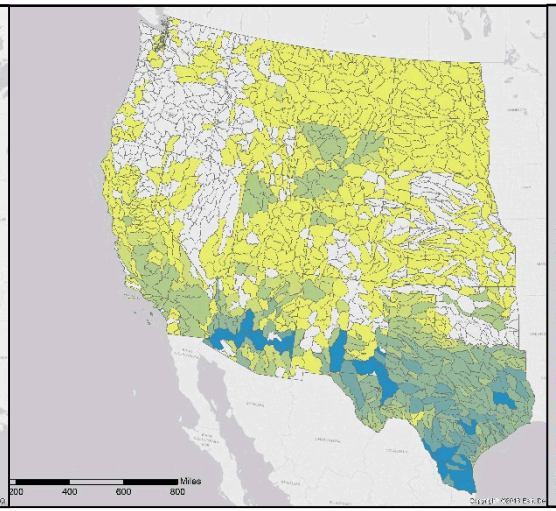
Appropriated Water



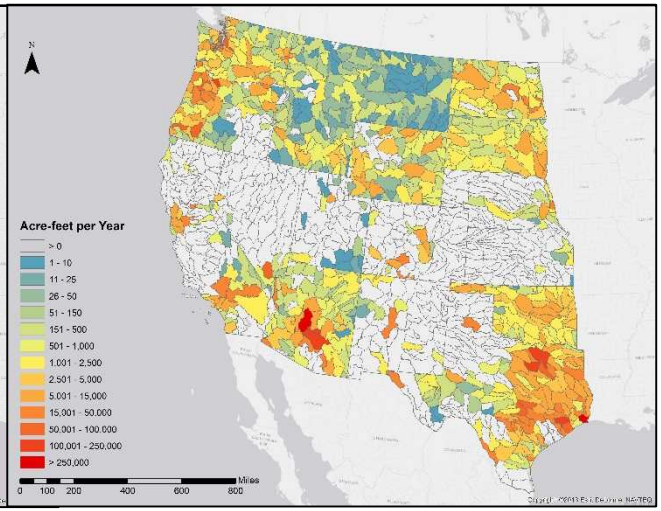
Municipal Wastewater



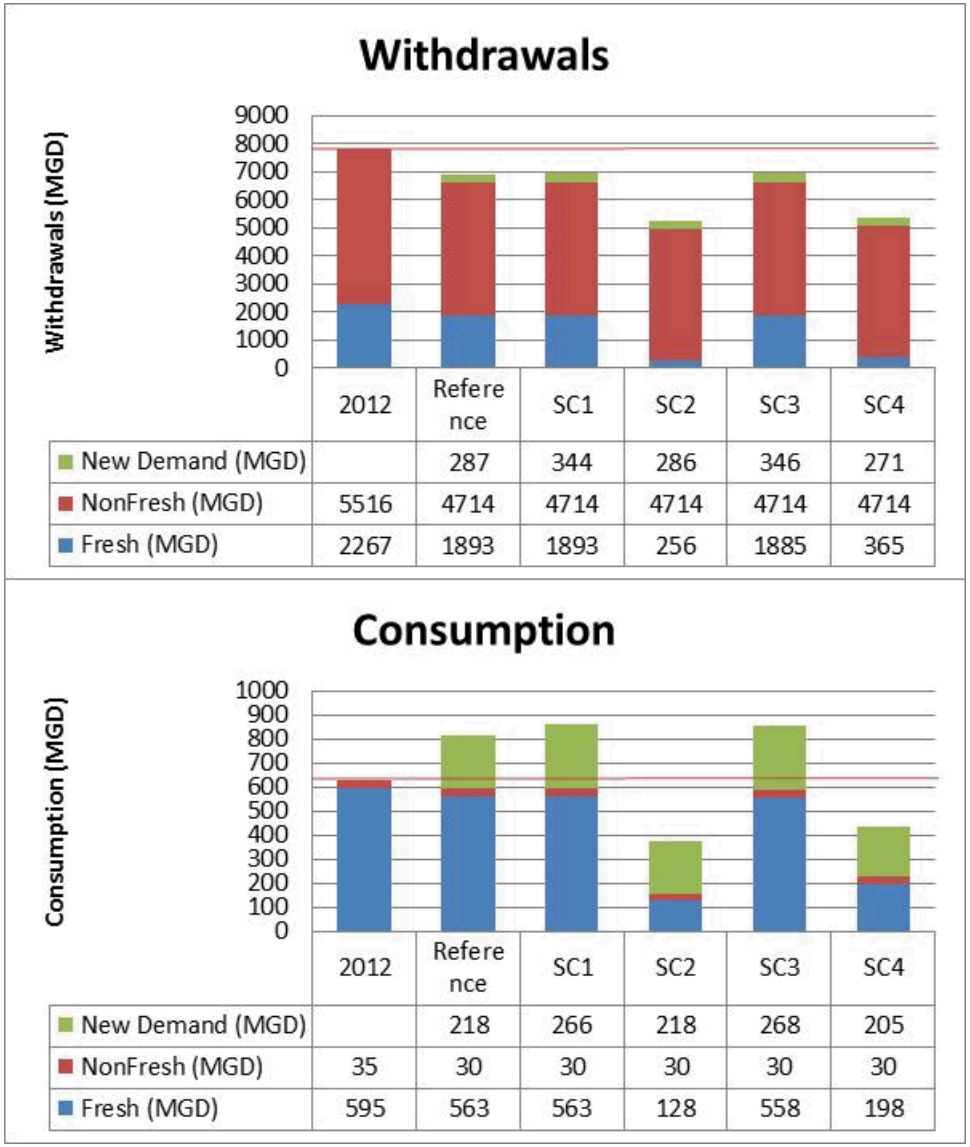
Brackish Groundwater



Consumptive Demand 2010-2030

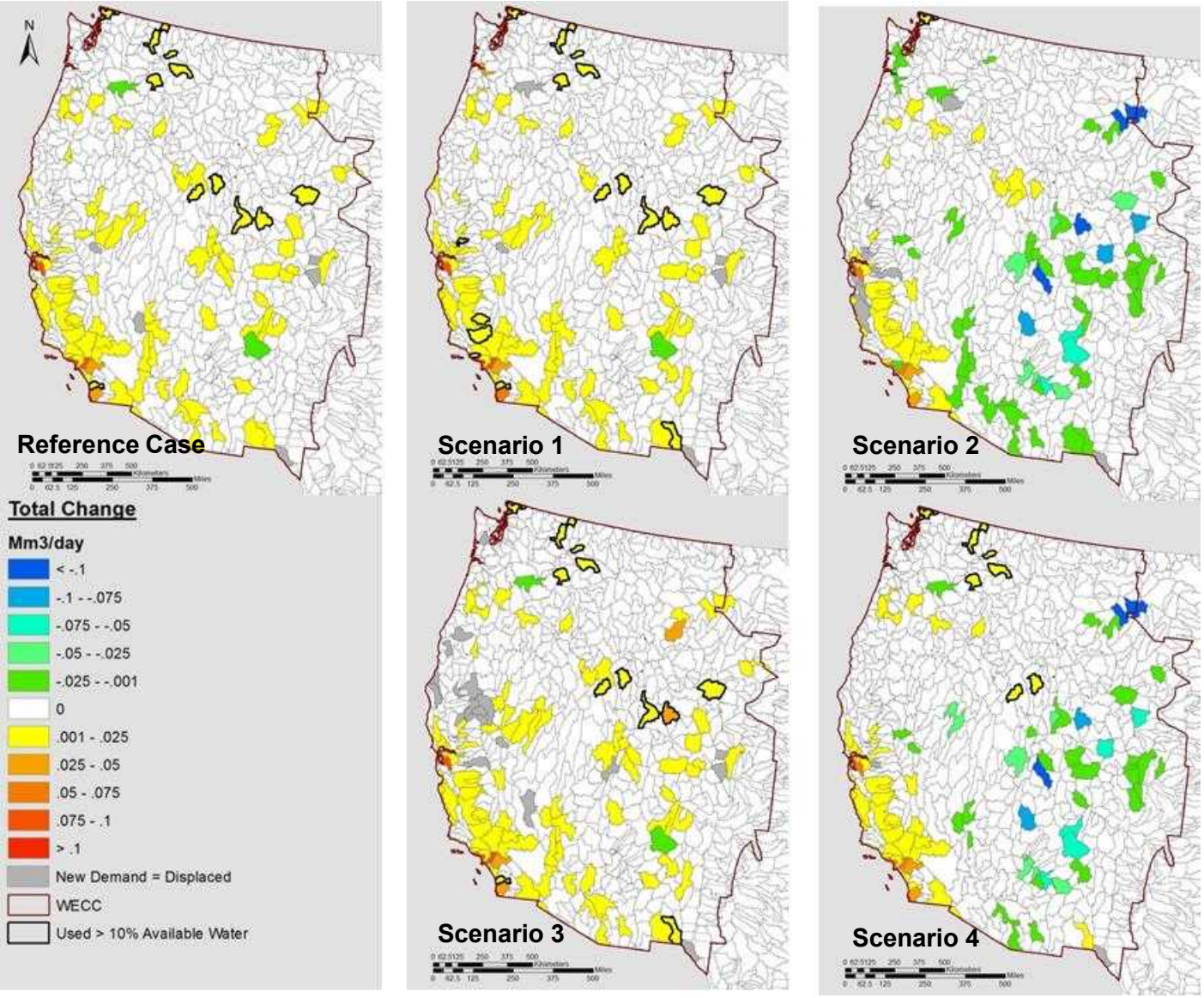


Results: Water Use



- Uniform reductions in withdrawals:
  - Similar additions across scenarios,
  - Retirements of 14% of seawater and 4 % freshwater withdrawals,
  - >70% displacement of freshwater withdrawal in scenarios 2 and 4
- Consumption varies by scenario:
  - Uniform additions,
  - >30% decrease for scenarios 2 and 4 (displaced coal)
  - >30% increase for other scenarios

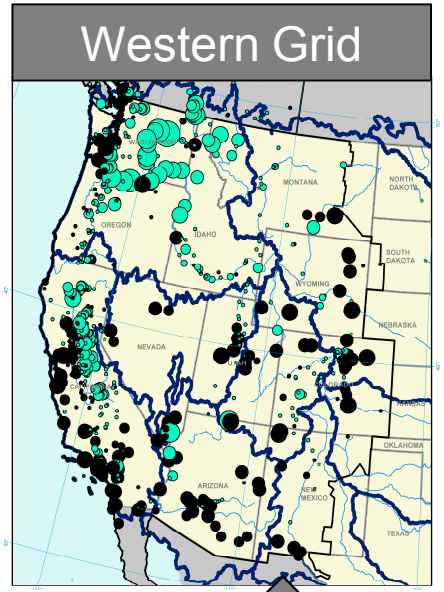
Results: Watershed Impacts



- Few instances where new demands exceed 10% of available water (outlined watersheds).
- Two scenarios free up considerable water (2 and 4).

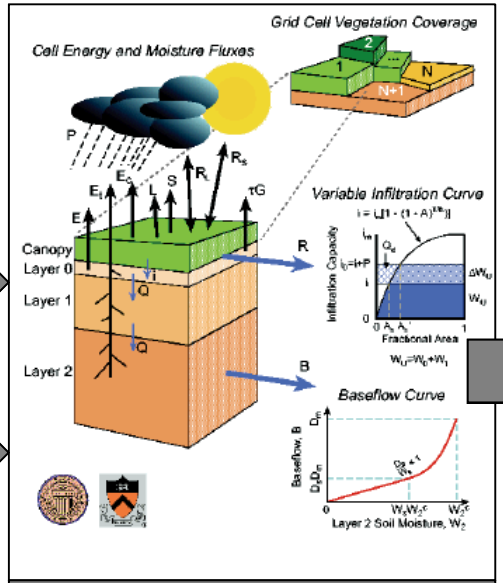
Asset-Level: Vulnerability Analysis

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



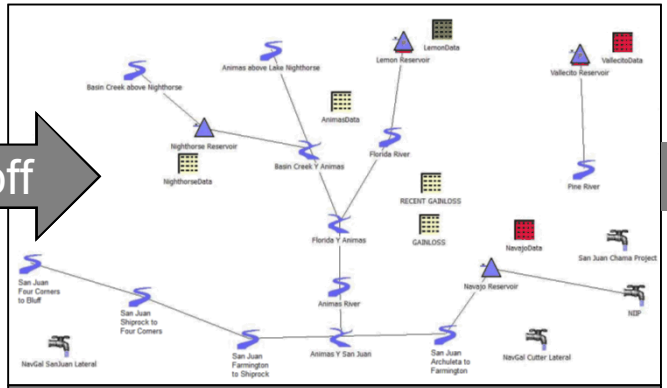
Climate

Growth



Natural System

Runoff

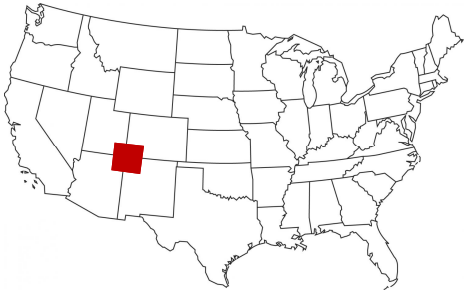


Engineered System

Deliveries

- Electric Power
- Agriculture
- Environment

San Juan Basin



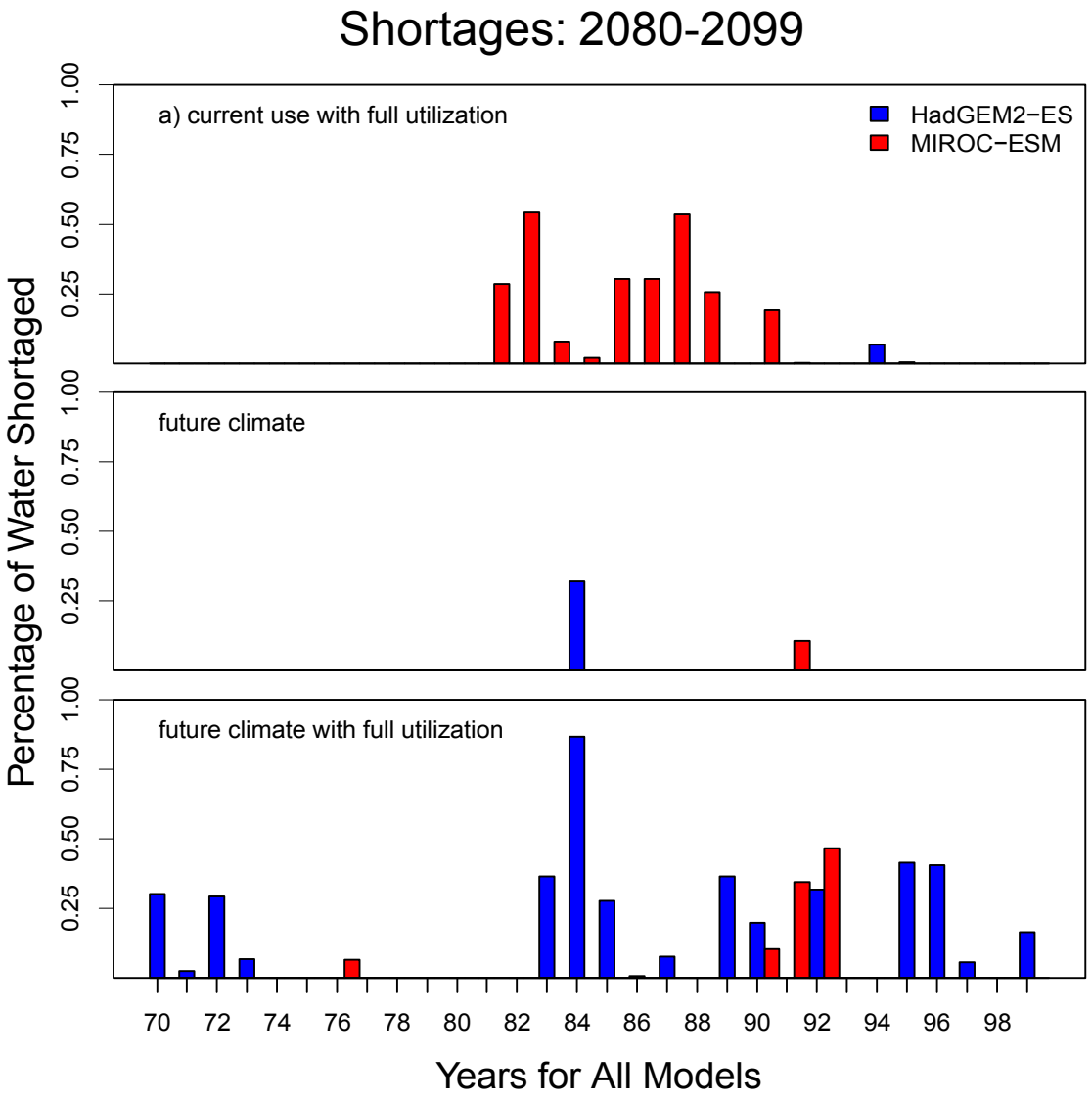
Four Corners Region

- Colorado River basin
- Snow melt dominated system

Water Users

- Native American
- Irrigation
- Multiple power plants and limited hydropower
- Municipalities
- Instream flows
- Interbasin transfers

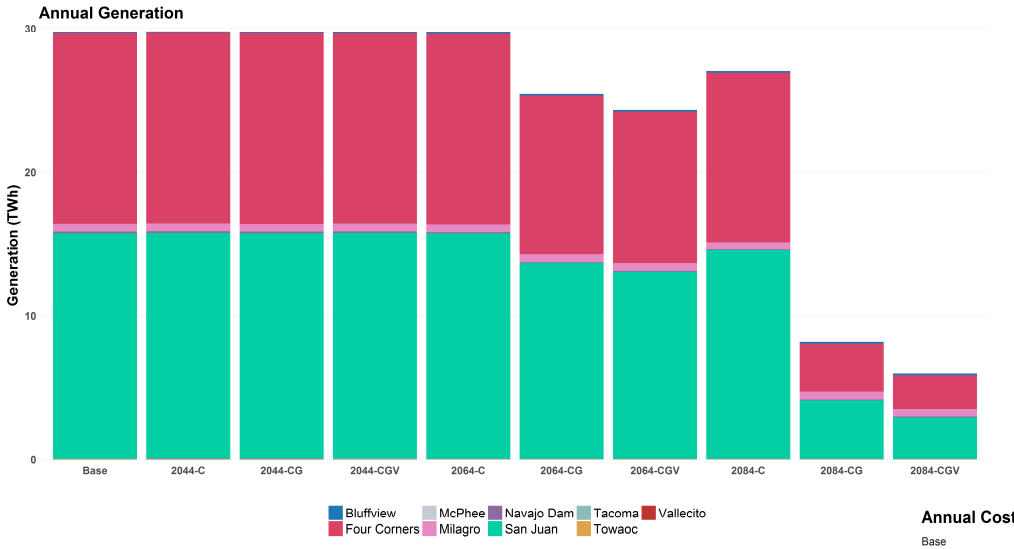
Water Delivery Shortages



- Expose vulnerabilities to climate change, growth and other forcings.
- Expose differences among assets.
- Basis for evaluating adaptive measures.

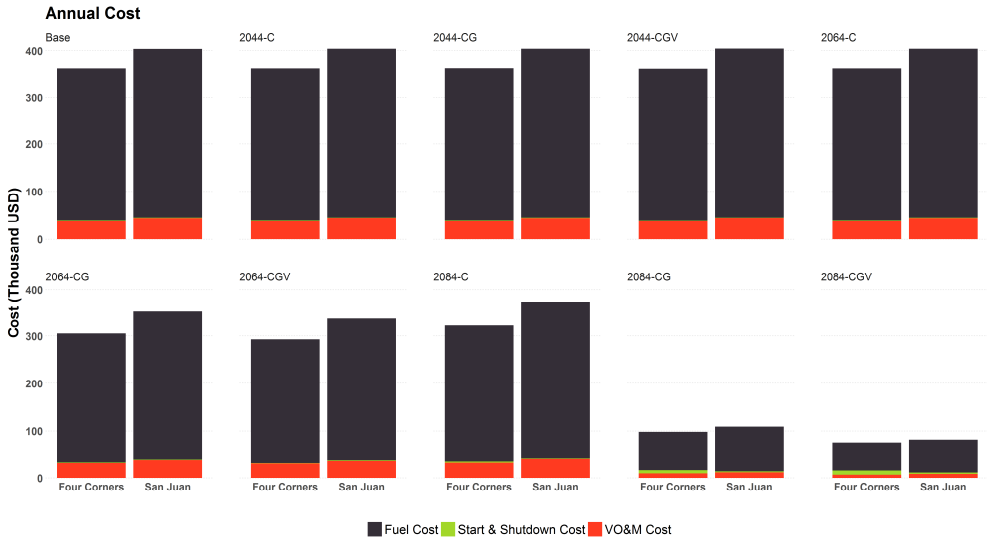
Generation Vulnerability

Impact on Generation by Year and Scenario



- Combined effects of climate on electricity demand and water supply.
- Impacts increase in time.
- Impacts to generation and costs to generate.

Impacts on Operational Cost by Year, Plant and Scenario



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- Project data available at:

http://energy.sandia.gov/?page_id=1741

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