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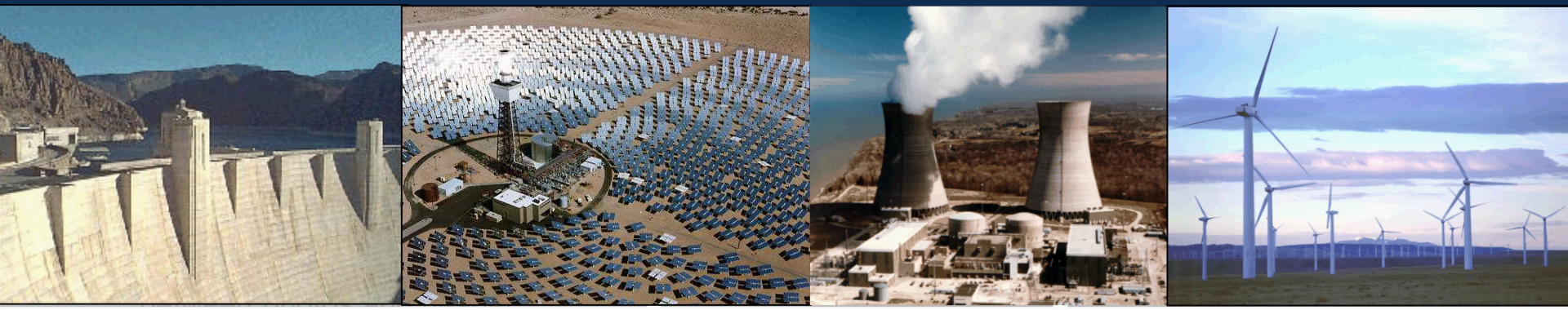

The Energy-Water Nexus and its Implications for Megacities in the Asia Pacific Region

Vincent Tidwell
Sandia National Laboratories

Food, Energy and Water Nexus in Sustainable Cities
Beijing, October 20, 2015

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Growing Interest in the Energy-Water Nexus

World Water Day 2014: Water and Energy

Azzizia desalination plant, Saudi Arabia - Flickr CC BY-NC-SA 2.0 by Waleed Alzuhair

Water and energy are closely interlinked and interdependent. Energy generation and transmission requires utilization of water resources, particularly for hydroelectric, nuclear, and thermal energy sources. Conversely, about 8% of the global energy generation is used for pumping, treating and transporting water to various consumers.

In 2014, the UN System – working closely with its Member States and other relevant stakeholders – is collectively bringing its attention to the water-energy nexus, particularly addressing inequities, especially for the 'bottom billion' who live in slums and impoverished rural areas and survive without access to safe drinking water, adequate sanitation, sufficient food and energy services. It also aims to facilitate the development of policies and crosscutting frameworks that bridge ministries and sectors, leading the way to energy security and sustainable water use in a green economy. Particular attention will be paid to identifying best practices that can make a water- and energy-efficient 'Green Industry' a reality.

Objectives of World Water Day in 2014

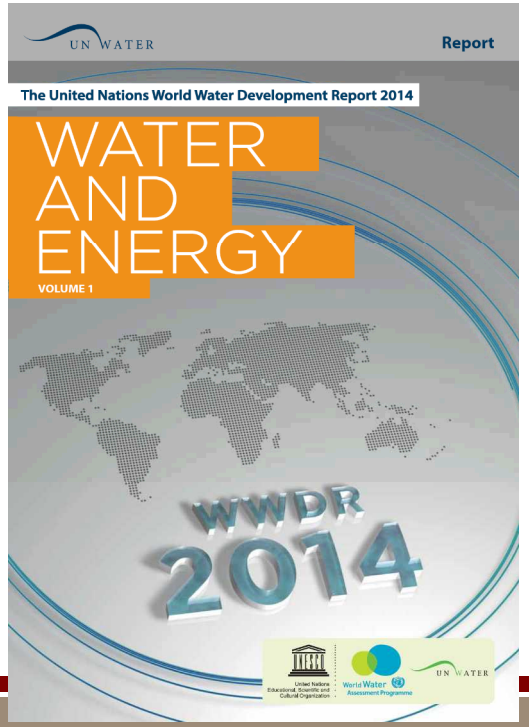
UN WATER WORLD WATER DAY 2014 &water energy 22.03.2014

WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

Global Agenda Council on Energy Security

The Water-Energy Nexus: Strategic Considerations for Energy Policy-Makers

May 2014



Energy-Water Quick Facts

- 90% of power production is water intensive
- The International Energy Agency estimated (2010) global water withdrawals for energy production at 583 billion m^3 representing some 15% of the world's total withdrawals.
- Thermal power generation accounts for roughly 80% of global electricity production .
- Hydroelectricity accounts for about 15% of global electricity production
- By 2035, global water withdrawals for energy are expected to increase by 20%, whereas water consumption for energy is expected to increase by 85%.

UN World Water Development Report 2015

Energy-Water and Megacities

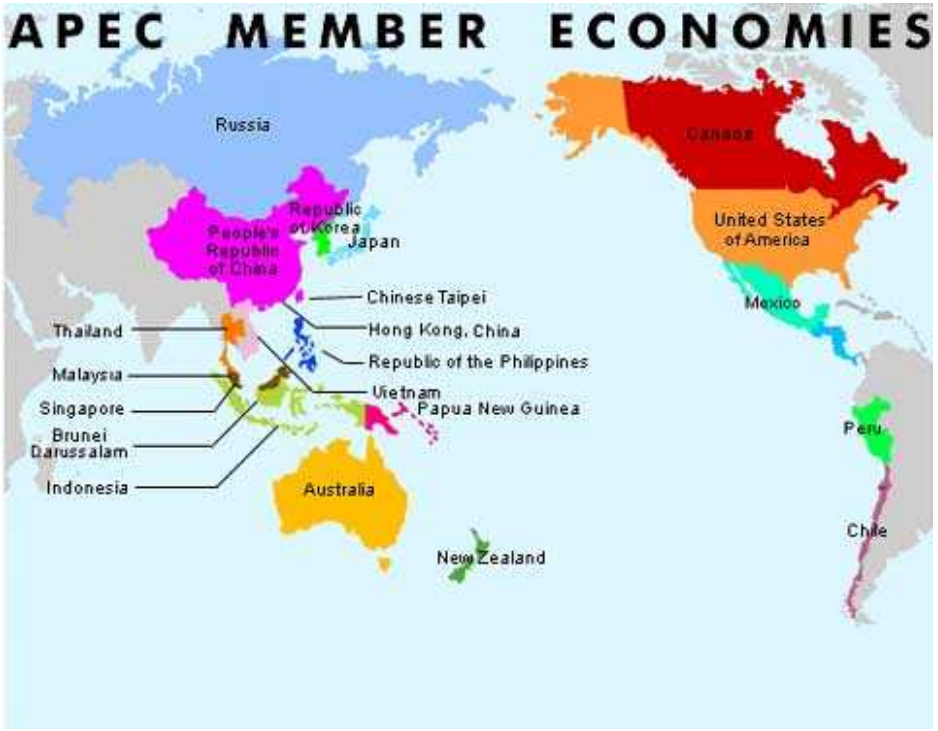
URBANIZATION

Every week, one million people move into cities requiring more energy and water!

UN 2015

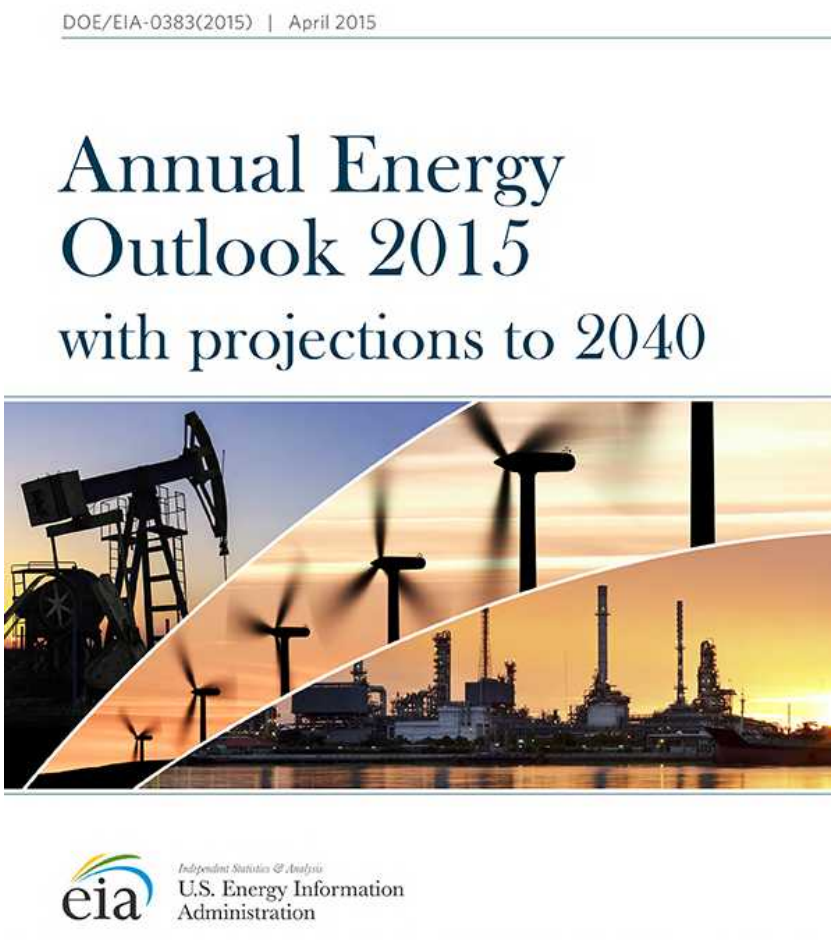
Objectives

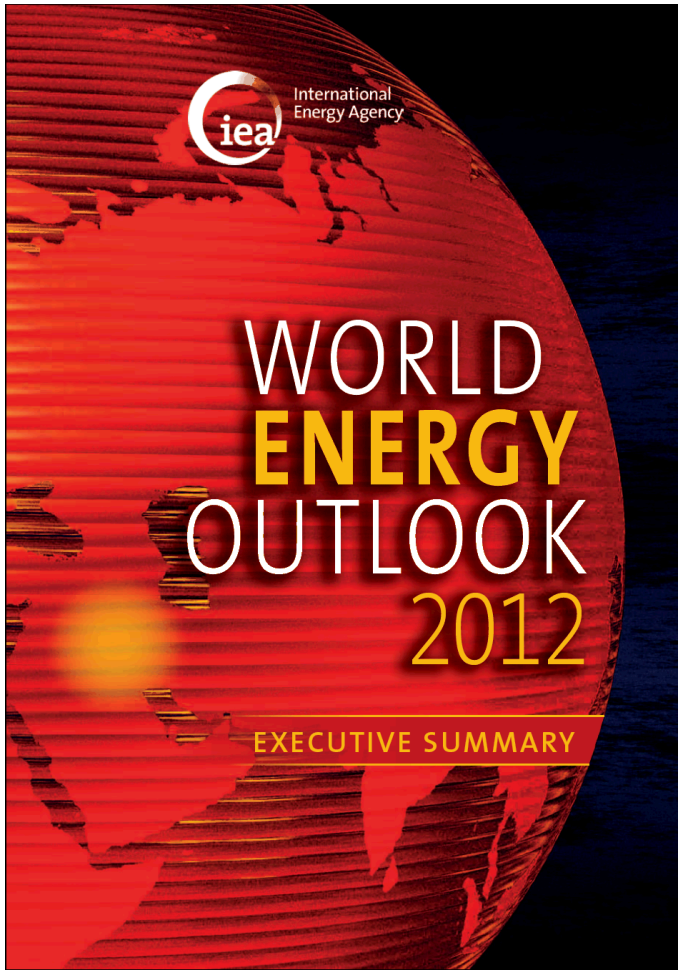
- Support the Asia-Pacific Economic Cooperation by investigating the Energy-Water Nexus in each member country:
  - Map water use for energy
  - Map energy use for water
  - Perform mapping at a regional level



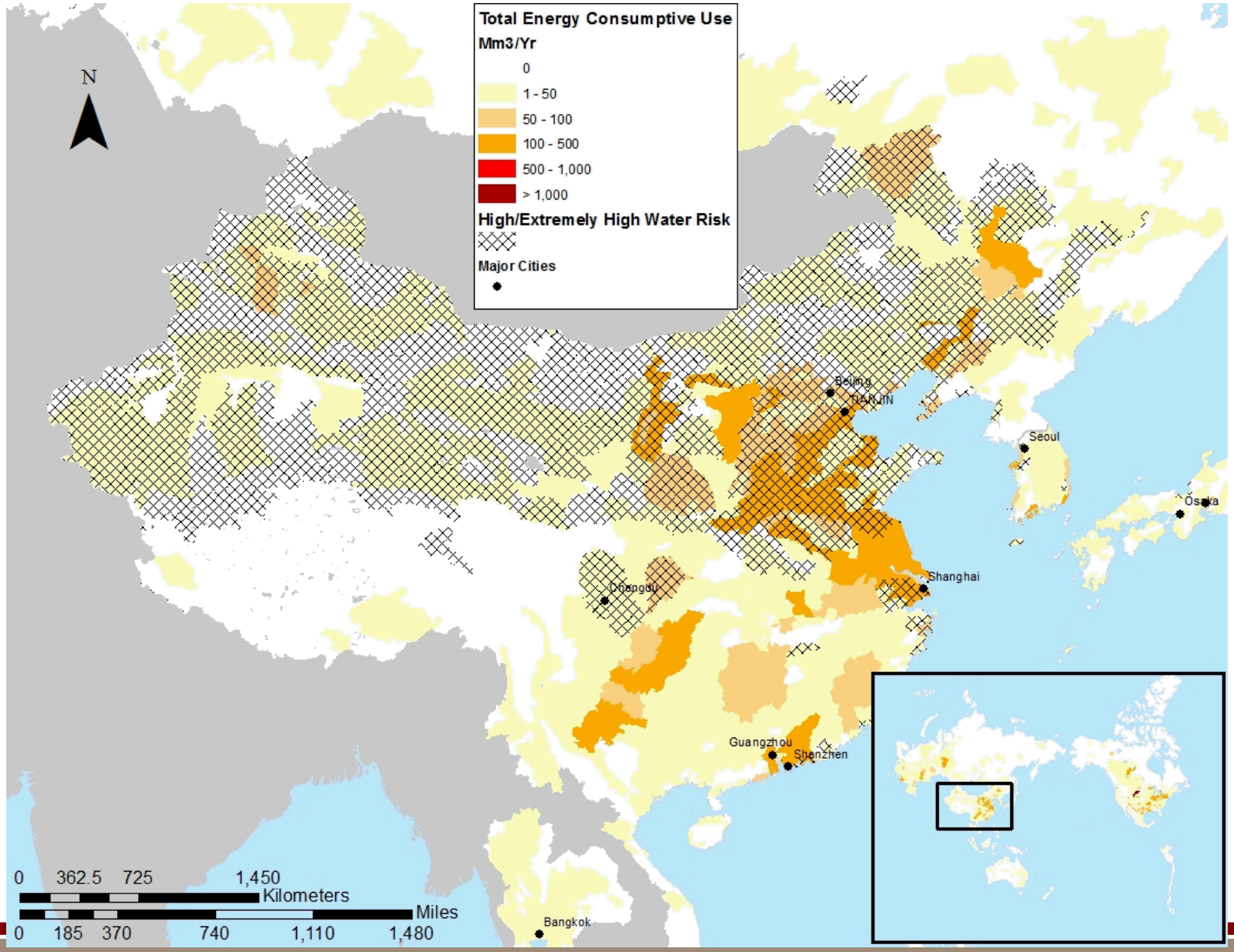
Methods

- Utilized publically available data

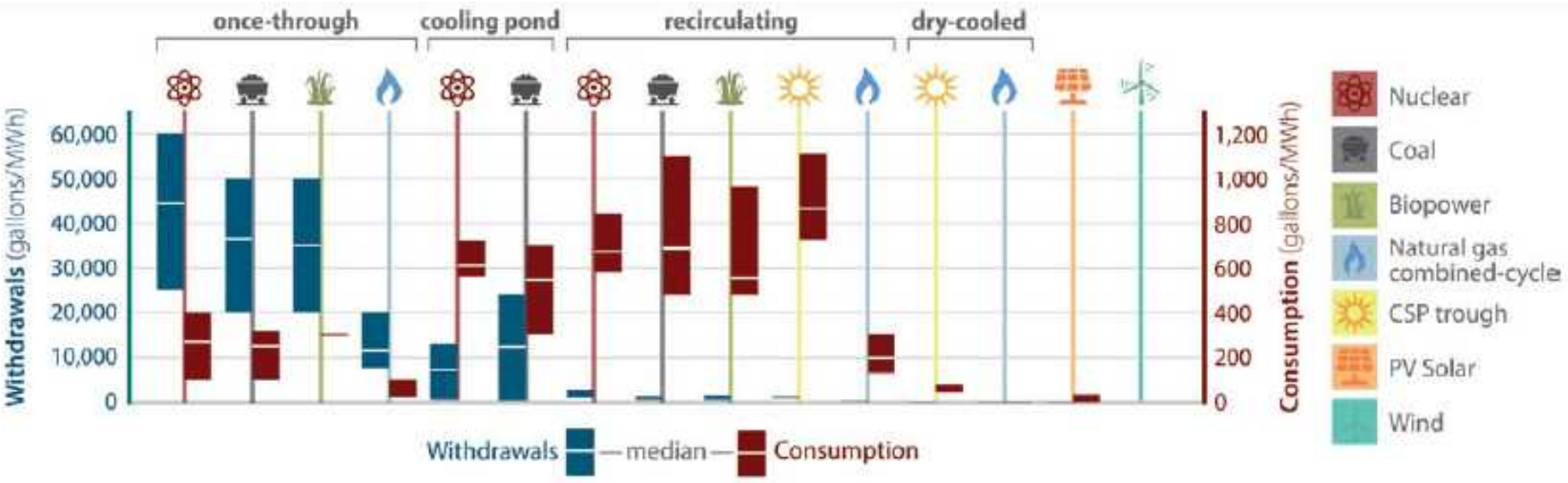




Water for Energy: Detail



Water and Energy Intensities



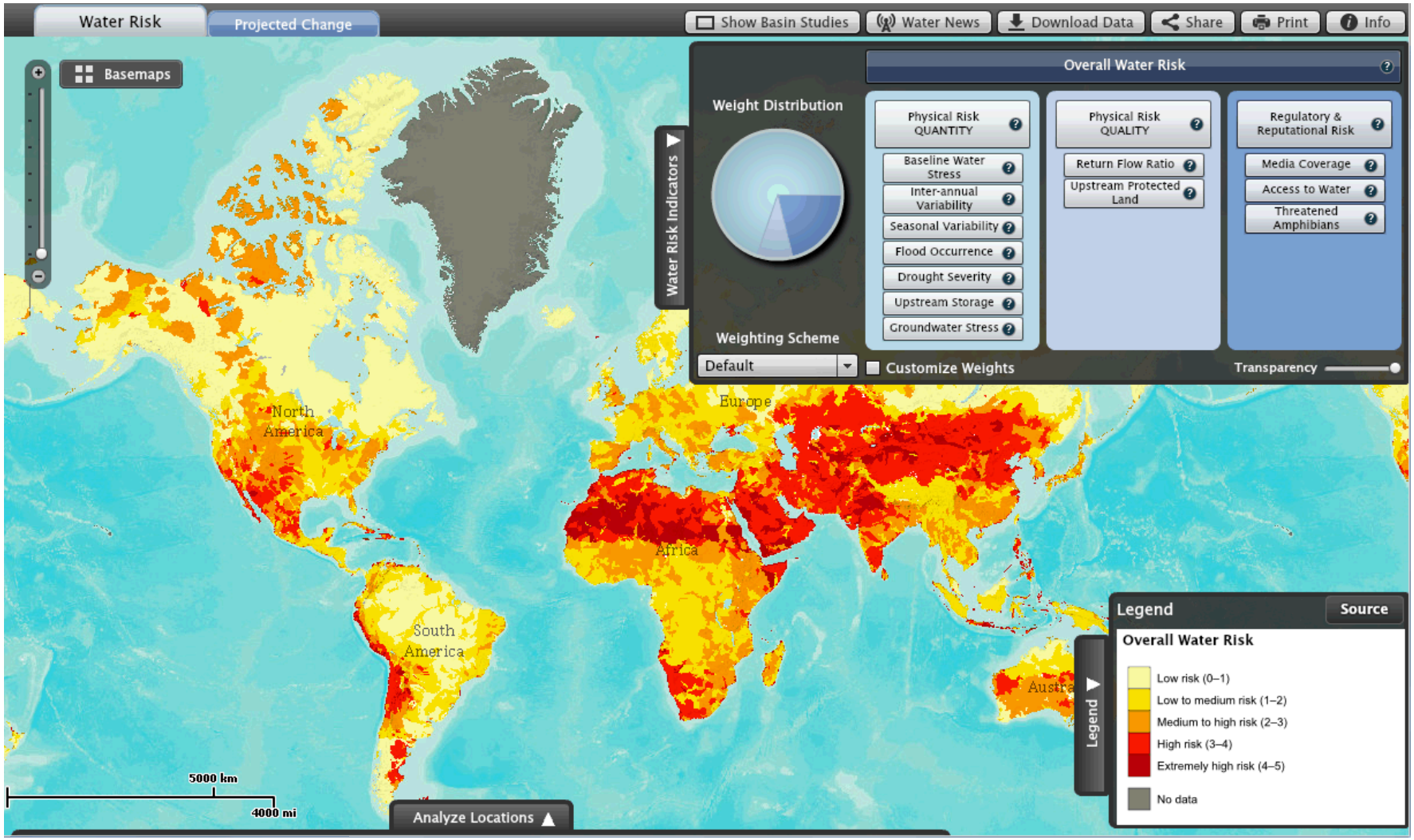
Averyt et al. 2011

Table 1. Fuel production categories with water consumption factors and data sources.

Energy category	Sub-category	Energy production source[a]	Water consumption factor (m^3 GJ^{-1})			
			Estimate[b]	Min	Max	Source[c]
Fossil fuel	Coal[d]	[1]	0.043	0.006	0.242	[7]
	Conventional oil[e]	[1]	0.081	0.036	0.140	[8]
	Oil sands[f]	[2], [3]	0.114	0.072	0.132	[8]
	Oil refining	[1]	0.040	0.026	0.048	[8]
	Conventional gas	[1]	0.004	0.001	0.027	[7]
	Shale gas	[4]	0.017	0.003	0.221	[7]
Nuclear fuel	Uranium mining[d]	[5]	0.033	0.000	0.252	[7]
	Milling	[5]	0.012	0.003	0.030	[7]
	Conversion	[5]	0.011	0.004	0.014	[7]
	Diffusion (enrichment)	[5]	0.037	0.034	0.039	[7]
	Centrifuge (enrichment)	[5]	0.004	0.003	0.006	[7]
	Fuel fabrication	[5]	0.001	0.001	0.003	[7]
	Fuel reprocessing	[5]	0.007	0.007	0.007	[7]
Biofuel processing	Ethanol	[1]	0.145	0.092	0.290	[9]
	Biodiesel	[1]	0.031	0.031	0.031	[9]
Biofuel cultivation	Sugarcane (ethanol)	[3], [6]	24.550	0.000	156.000	[10]
	Maize (ethanol)	[3], [6]	8.090	0.000	554.000	[10]
	Sugarbeet (ethanol)	[3], [6]	9.790	0.000	157.000	[10]
	Rapeseed (biodiesel)	[3], [6]	19.740	0.000	270.000	[10]
	Soybean (biodiesel)	[3], [6]	11.260	0.000	844.000	[10]
	Palm oil (biodiesel)	[3], [6]	0.000	0.000	0.850	[10]

Spang et al. 2014

Global Water Risk Mapping



AQUEDUCT

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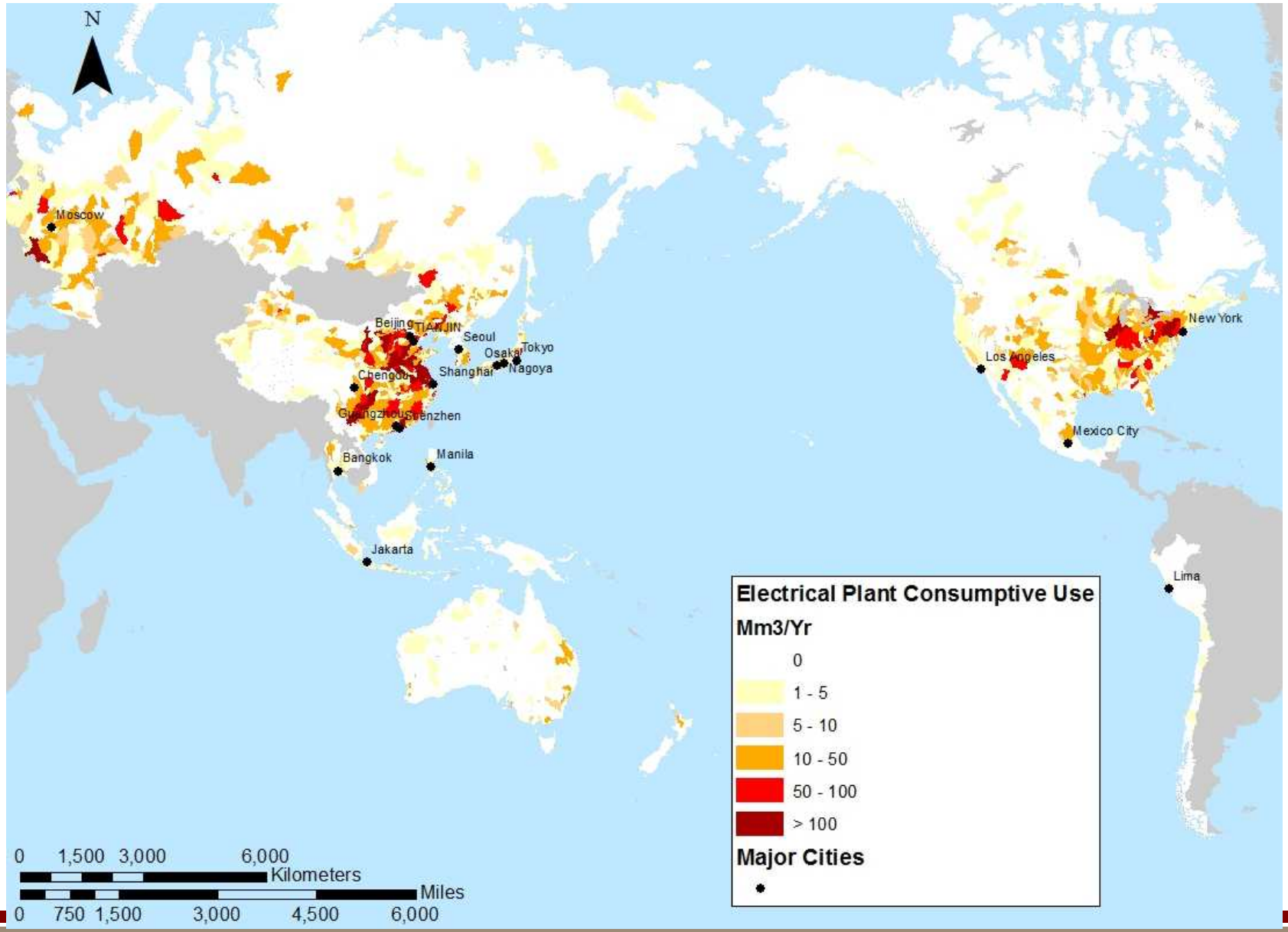
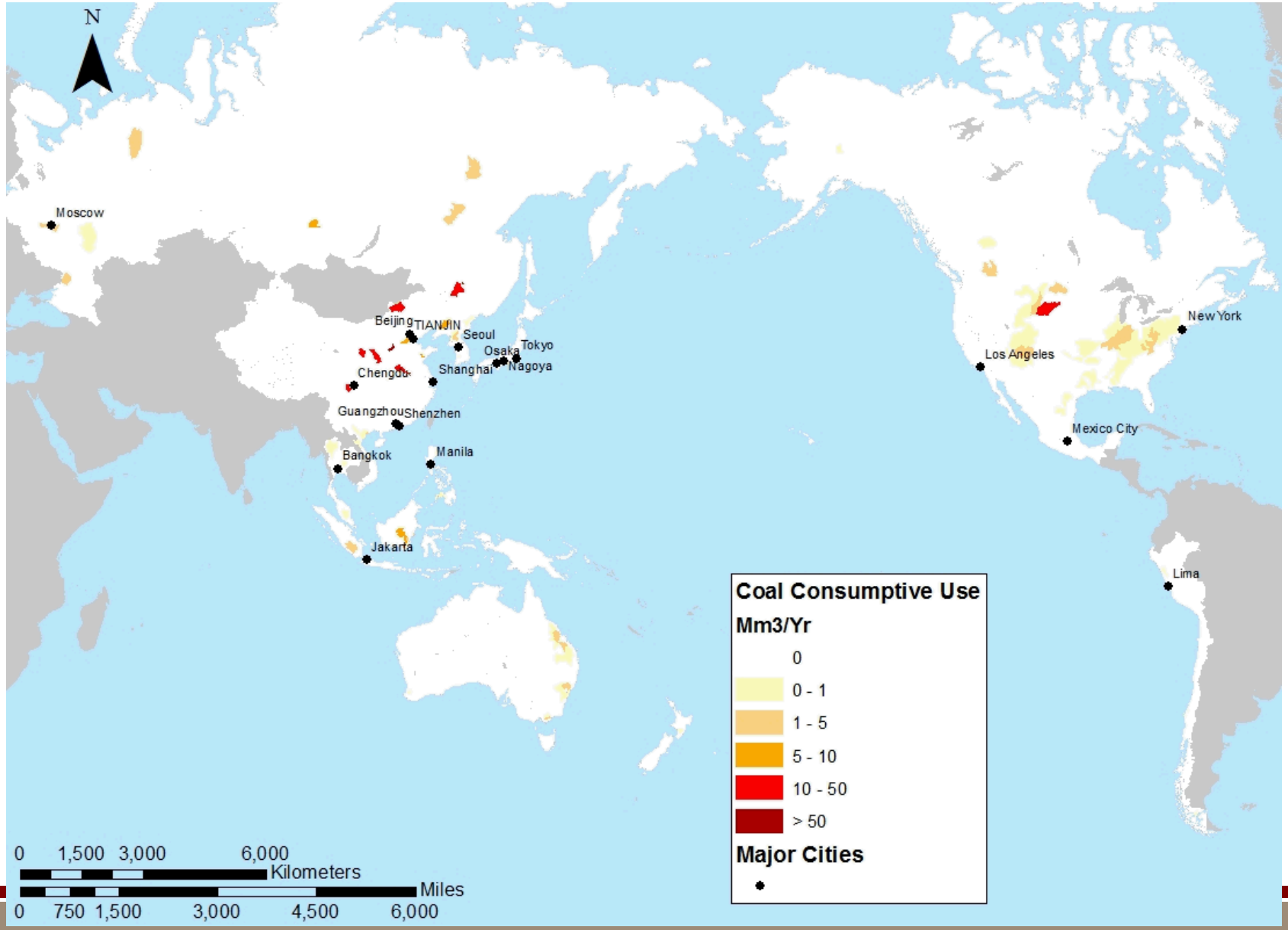
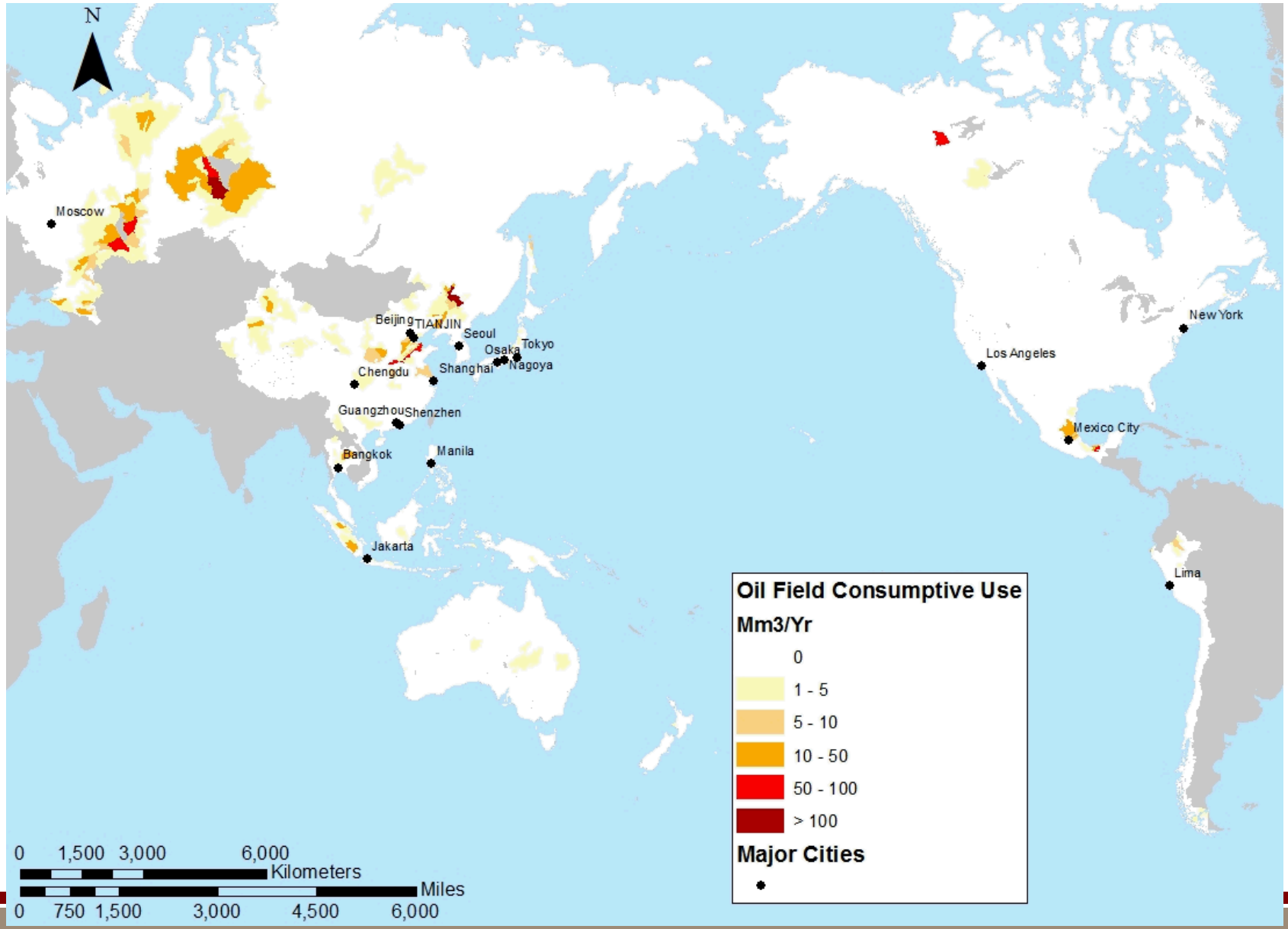
Water for Thermoelectric Power



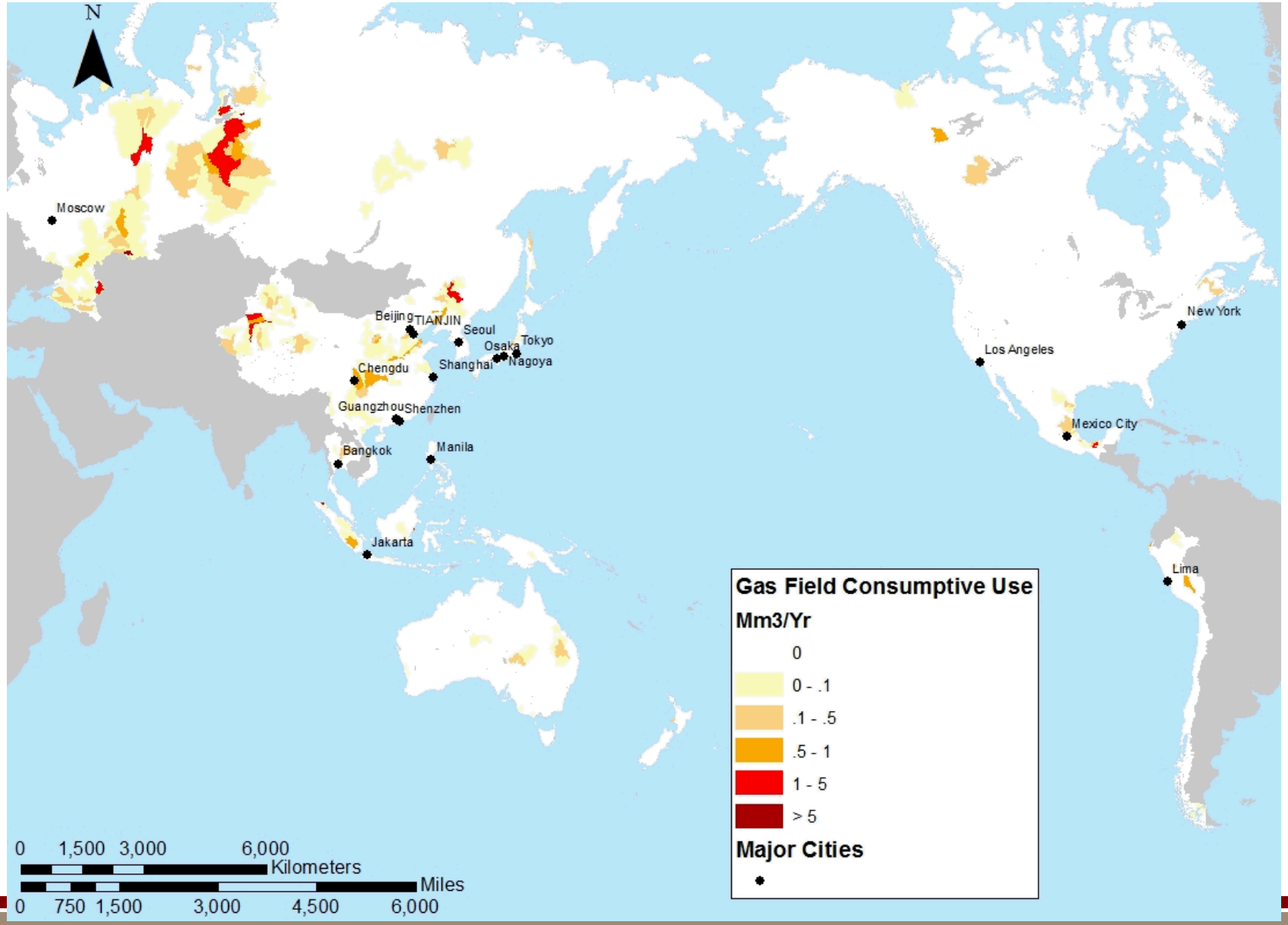
Water for Coal Extraction

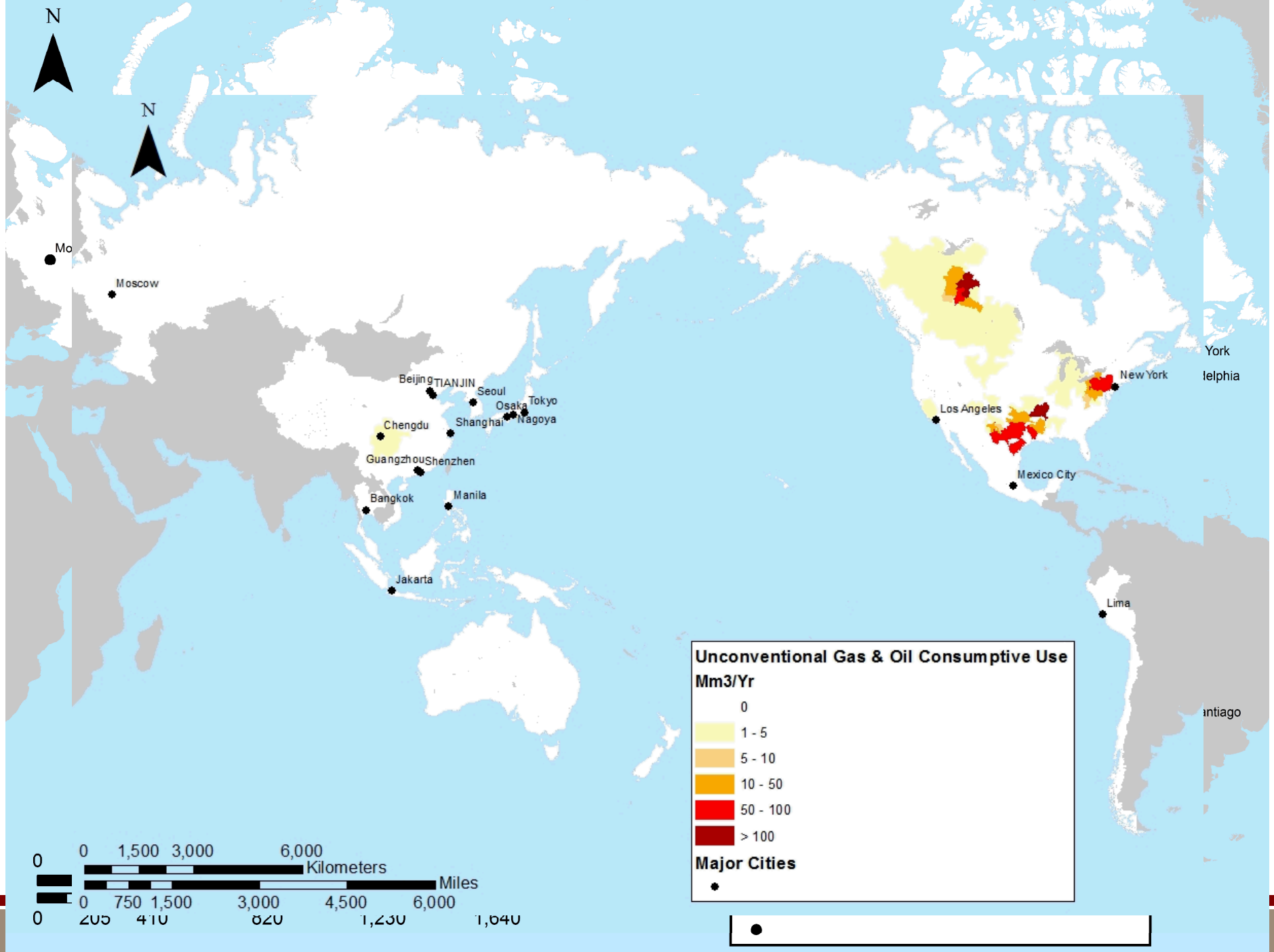


Water for Oil Extraction



Water for Gas Extraction

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10 - 50
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Miles
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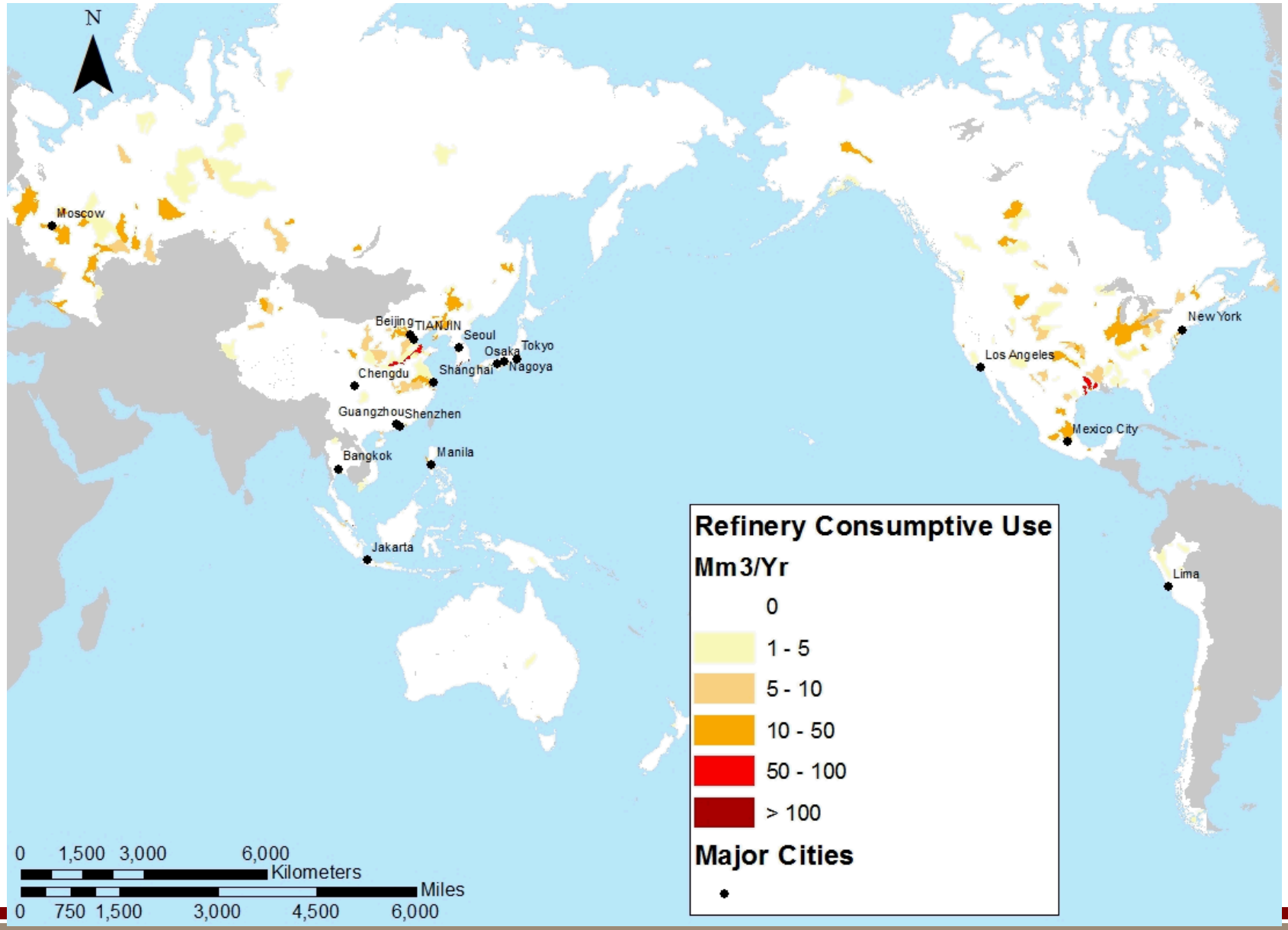
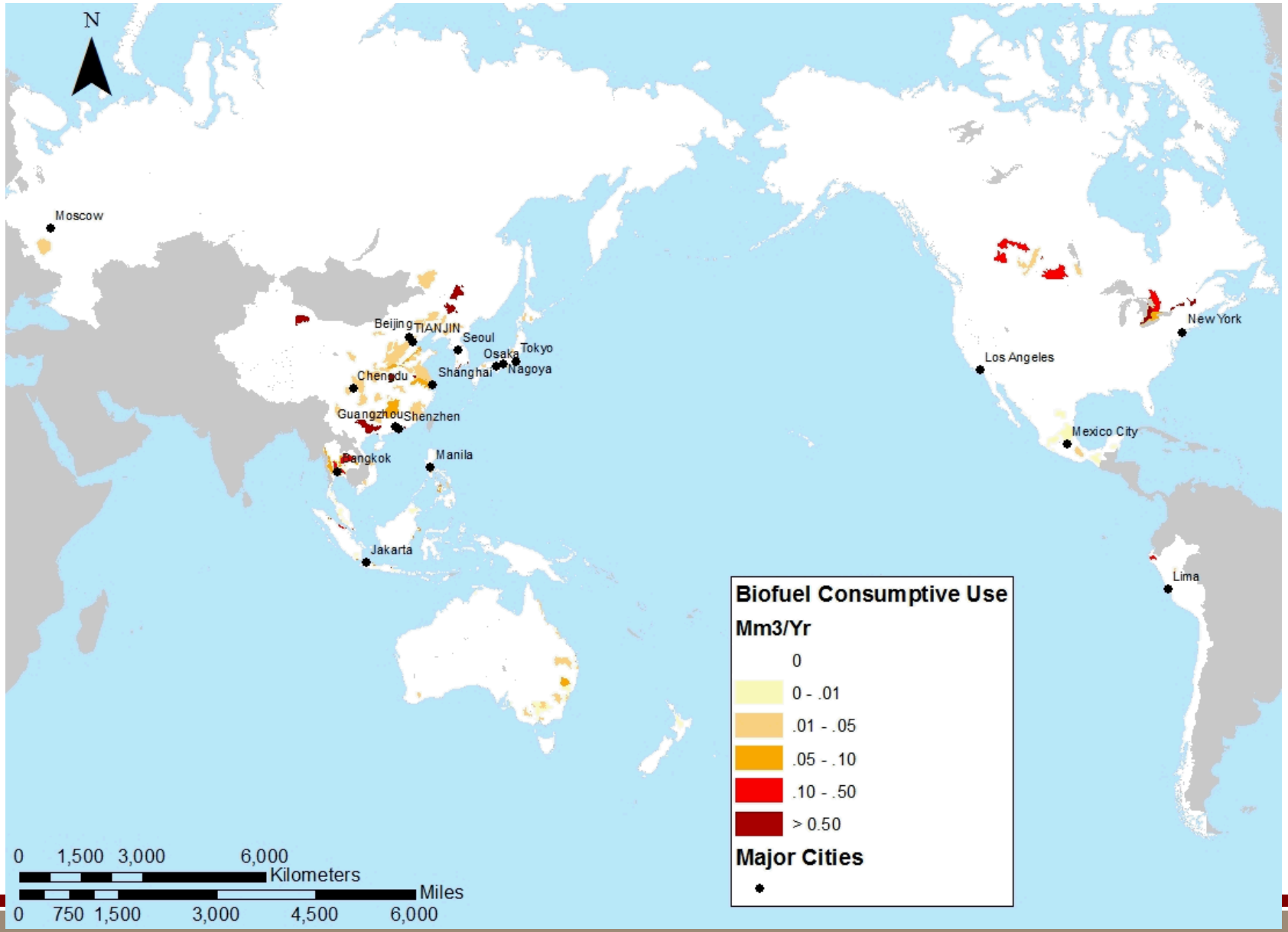
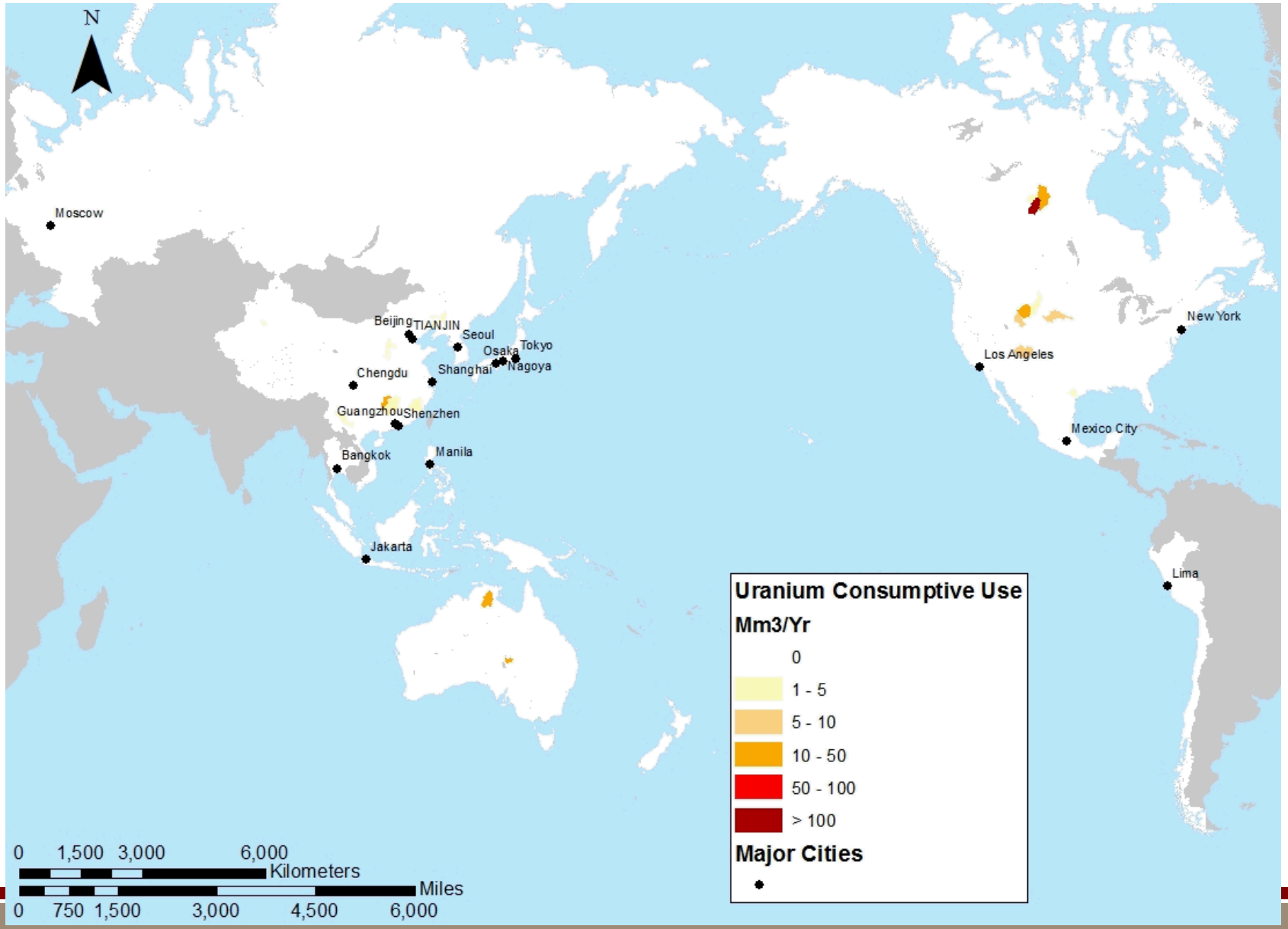
Water for Oil Processing



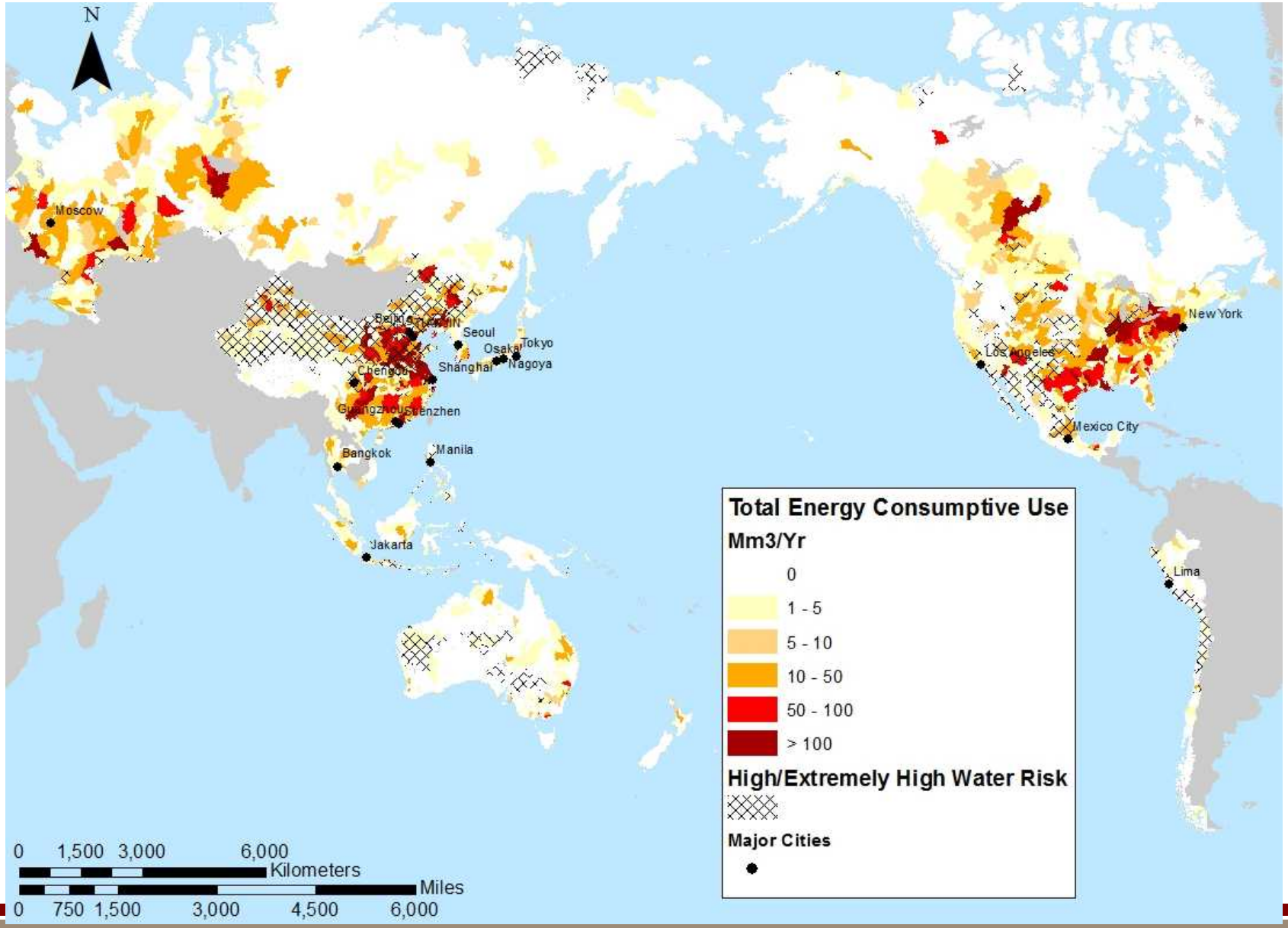
Water for Biofuel Refining



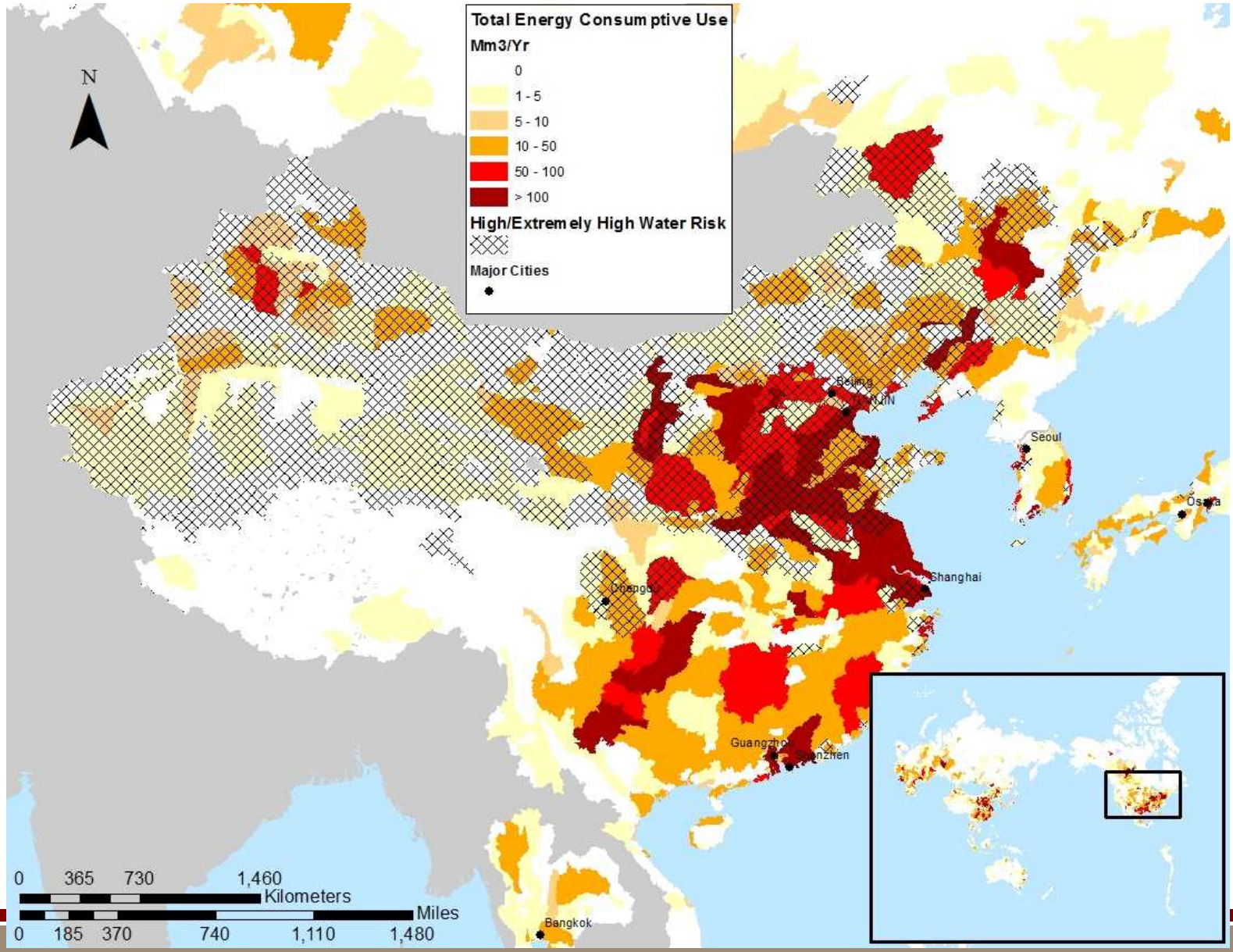
Water for Uranium Processing



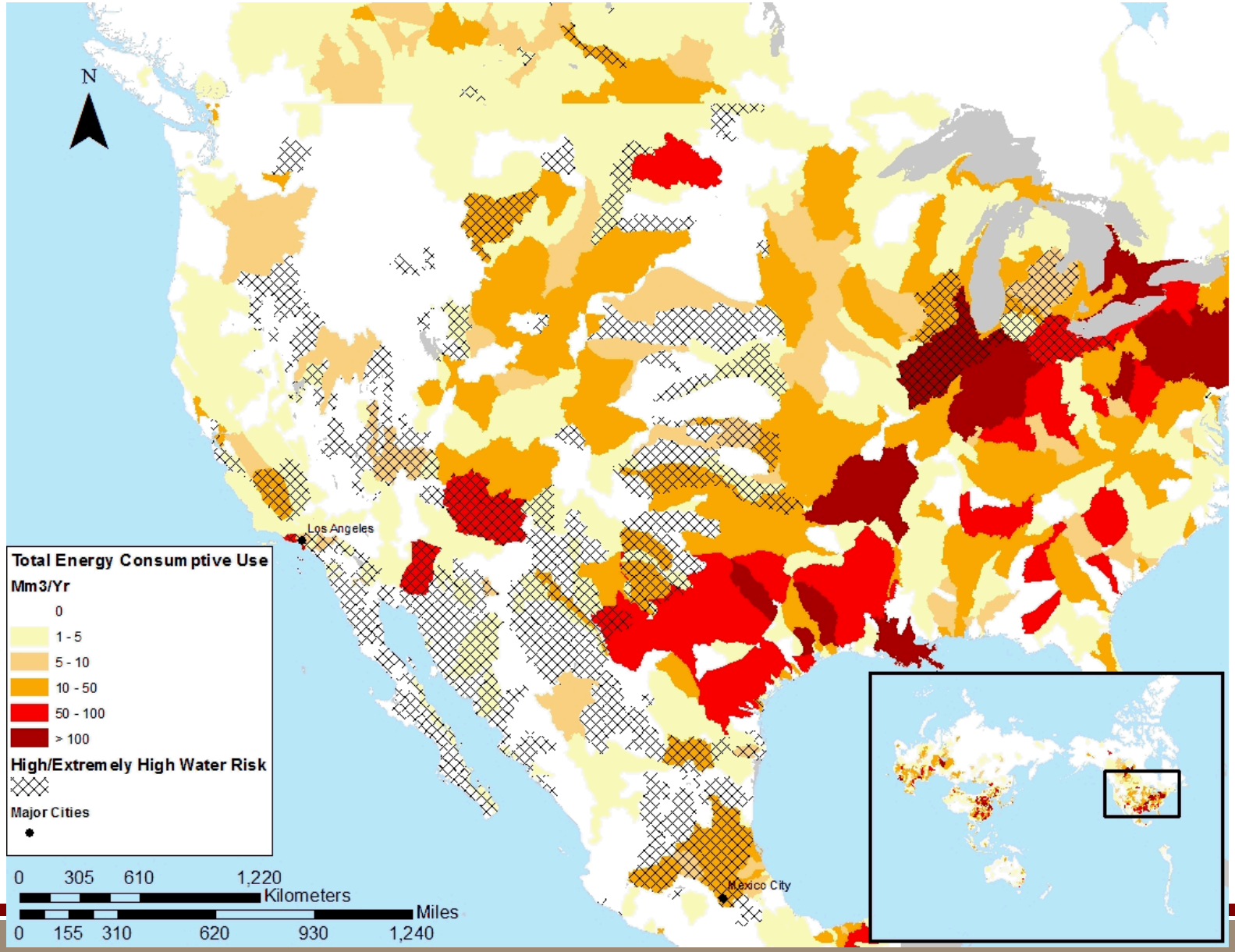
Water for Energy



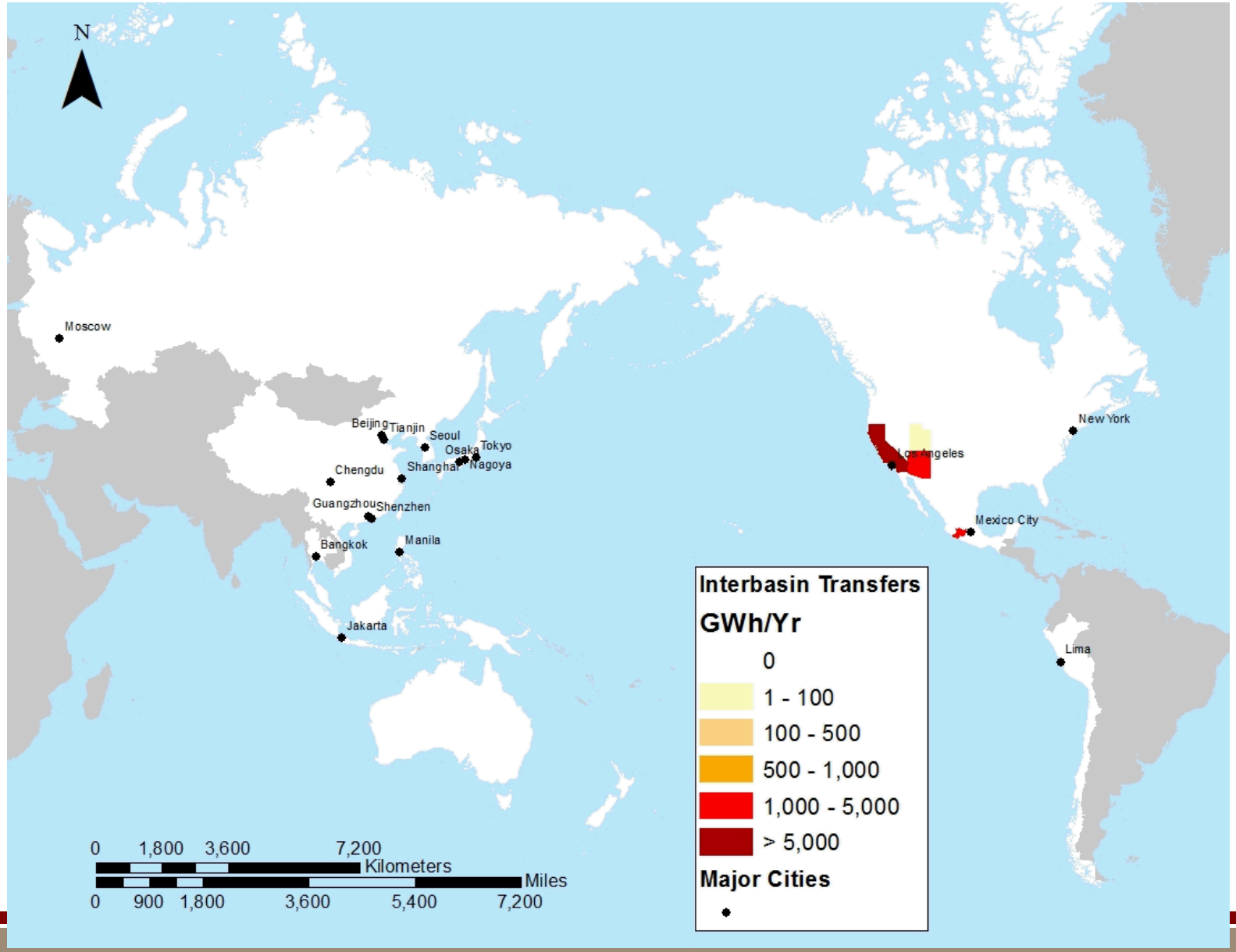
Water for Energy: Detail China



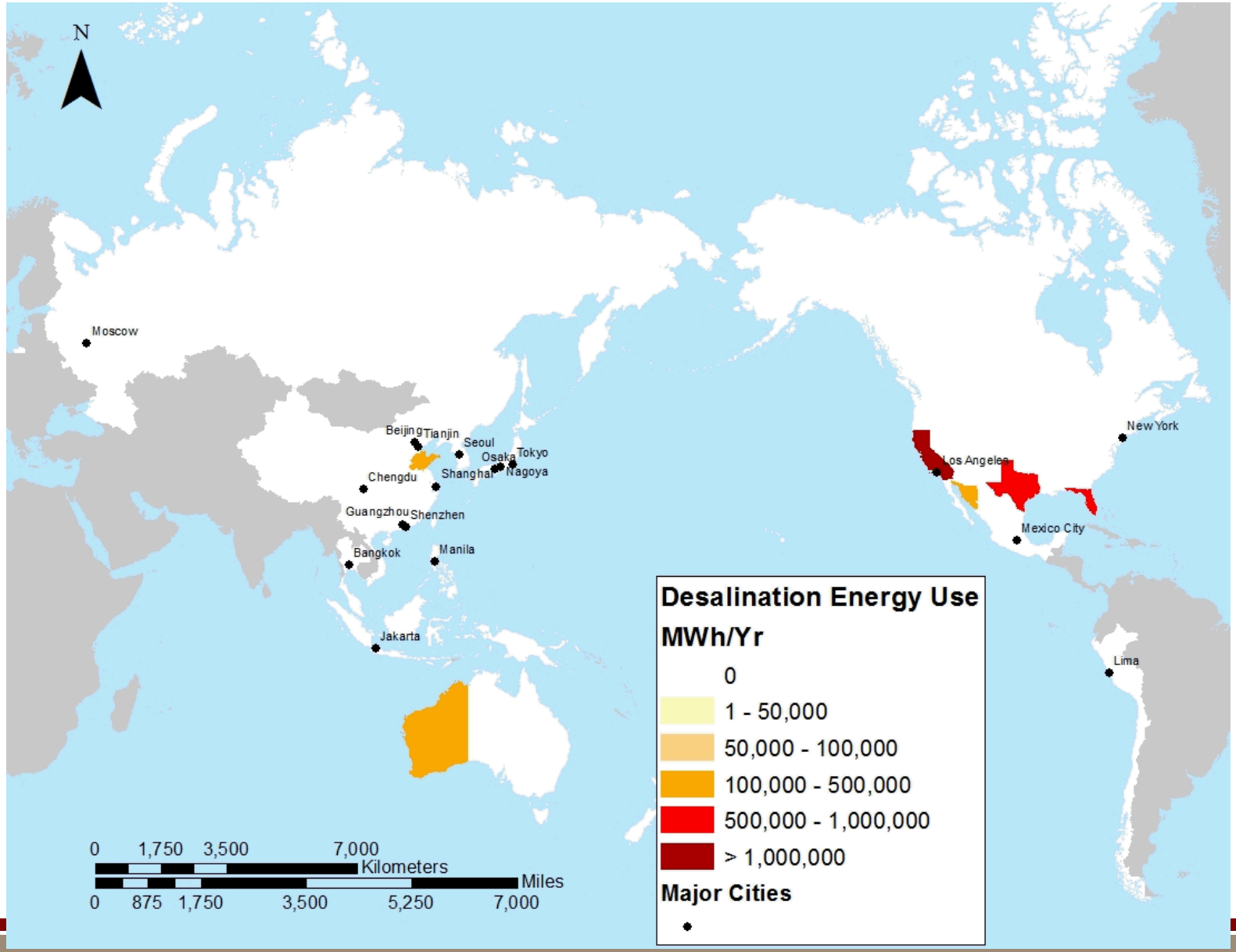
Water for Energy: Detail U.S.



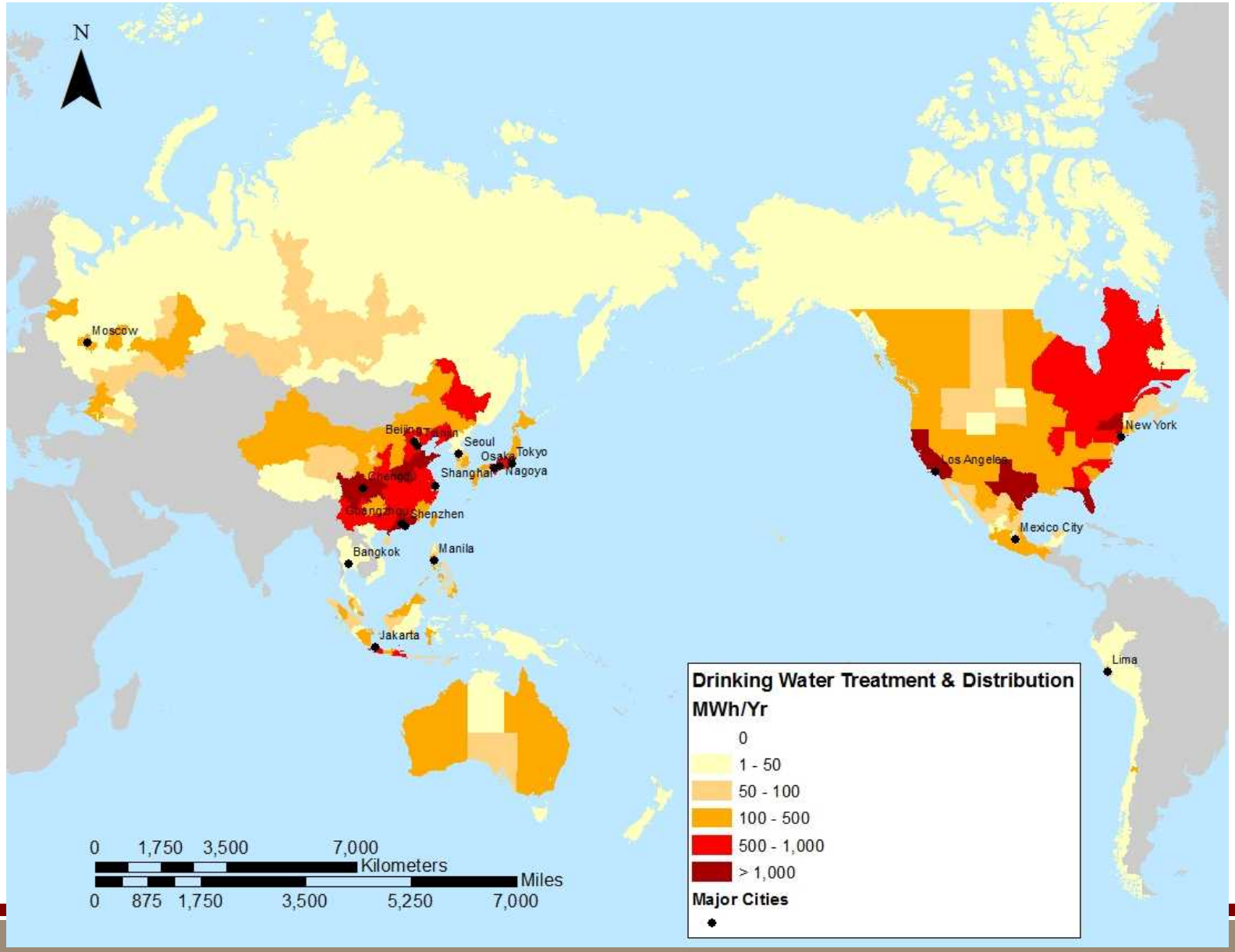
Energy for Interbasin Transfers



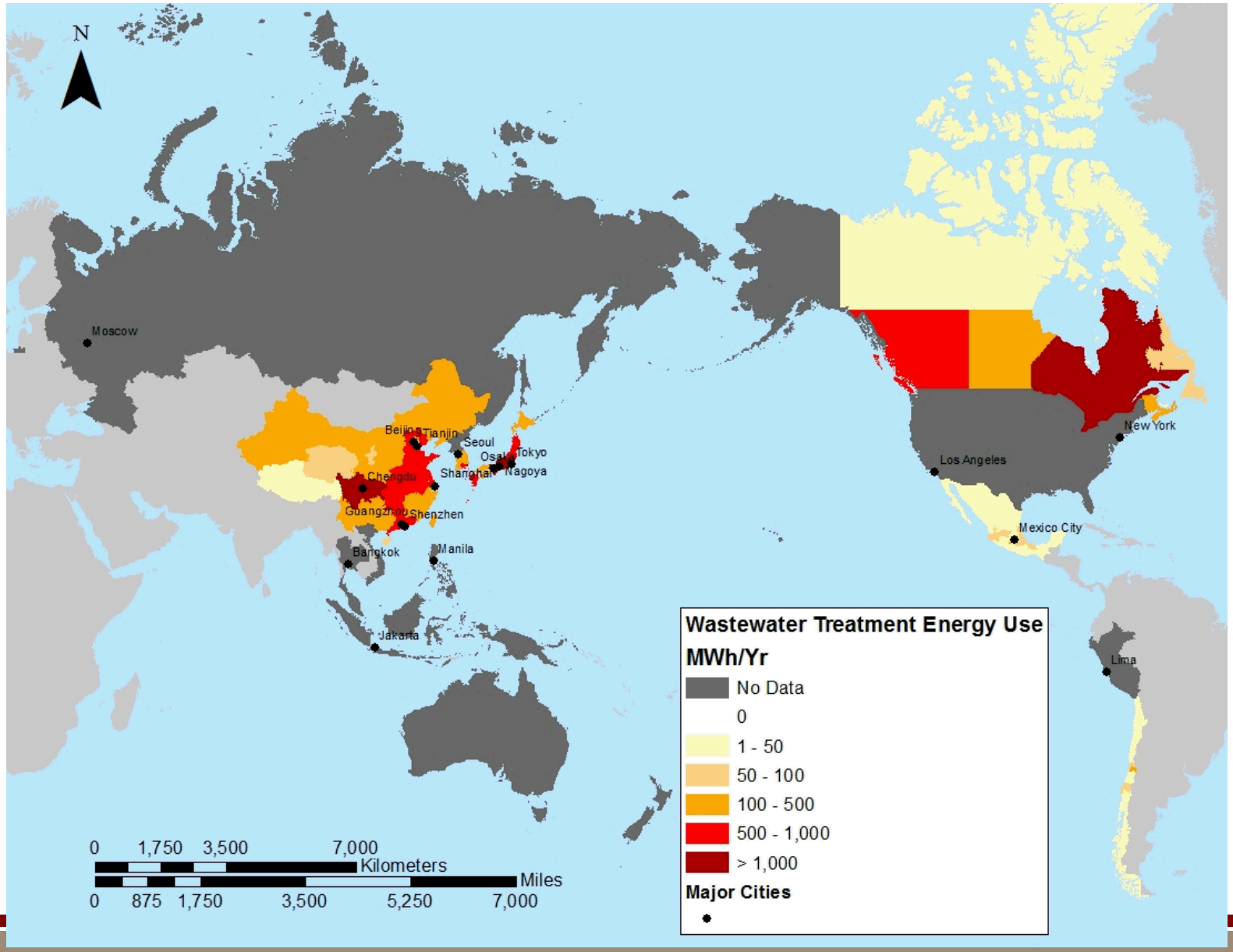
Energy for Desalination



Energy for Drinking Water



Energy for Wastewater Treatment



Summary

- Mapped *water for energy* and the *energy for water* for the APEC countries.
- Significant differences in the energy-water nexus are noted:
  - Among countries,
  - Regionally within countries, and
  - Across different unit processes.
- Numerous cases noted where high water use for energy and water stress coincide.
- The relation between megacity location and their related water- and energy-shed is clouded by transmission.