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

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Food, Energy and Water Nexus in Sustainable Cities

Beijing, October 20, 2015



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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



Global Agenda Council on Energy Security

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

May 2014



securing energy in a water-constrained world



the energy-water challenge

Significant amounts of water are needed in almost all energy generation processes, from generating hydro-power, to cooling and other purposes in thermal power plants, to extracting and processing fuels. Conversely, the water sector needs energy to extract, treat, and transport water. Both energy and water are used in the production of crops, including those used to generate energy through biofuels. Population growth and rapidly expanding economies place additional demands on water and energy, while several regions around the world are already experiencing significant water and energy shortages.

Today, more than 700 million people lack access to potable water, and over 1.3 billion people lack access to electricity. At the same time, estimates show that by 2030, global energy consumption will increase by 35%, while water consumption by the energy sector will increase by 20%. Climate change will further challenge water and energy management by causing more water variability and intensified weather events, such as severe floods and droughts.

These interdependencies complicate possible solutions and make coordinating them to expeditiously improve integrated water and energy planning in order to avoid unwanted future scenarios.

will water constrain our energy future?

While a global water crisis could take place in the future, the energy challenge is present. Water constraints have already adversely impacted the energy sector in many parts of the world. In the U.S., several power plants have been affected by low water flows or high water temperatures. In India, a thermal power plant recently had to shut down due to a severe water shortage. France has been forced to reduce or halt energy production in nuclear power plants due to high water temperatures threatening cooling processes during heatwaves. Recurring and prolonged droughts are threatening hydroelectric capacity in many countries, such as Sri Lanka, China and Brazil.

Despite these concerns, current energy planning and production is often made without taking into account existing and future water constraints. Planners and decision-makers in both sectors often remain ill-informed about the drivers of these challenges, how to address them, and the needs of different stakeholders. The absence of integrated planning between these two sectors is socio-economically unsustainable.



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UN WATER

Report

The United Nations World Water Development Report 2014

WATER AND ENERGY

VOLUME 1



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 m³ 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%.

Energy-Water and Megacities



URBANIZATION

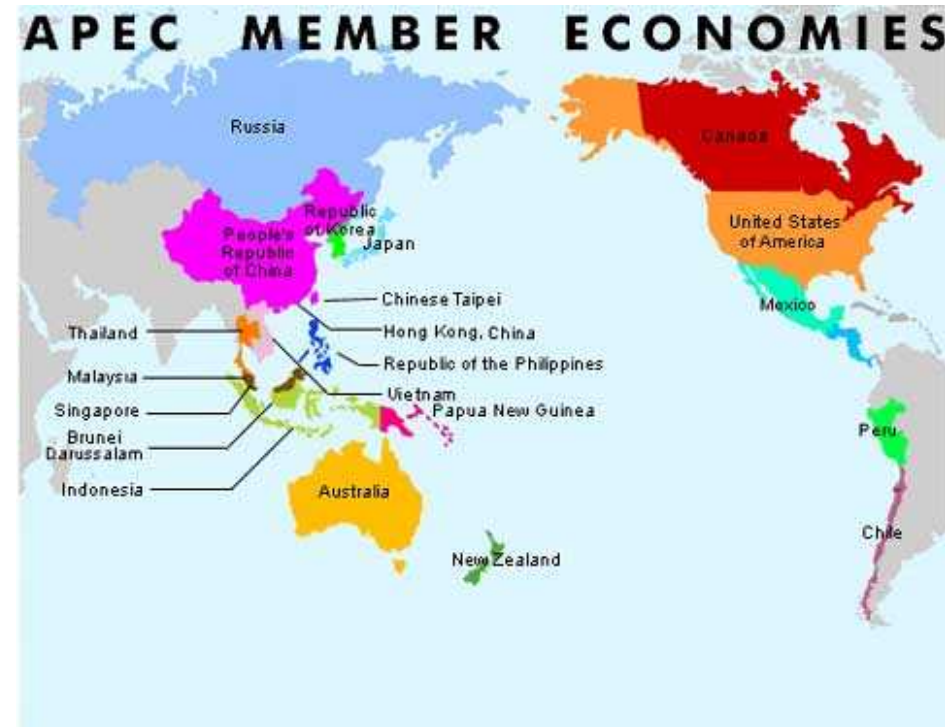
**Every week, one million people
move into cities requiring more
energy and water!**



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

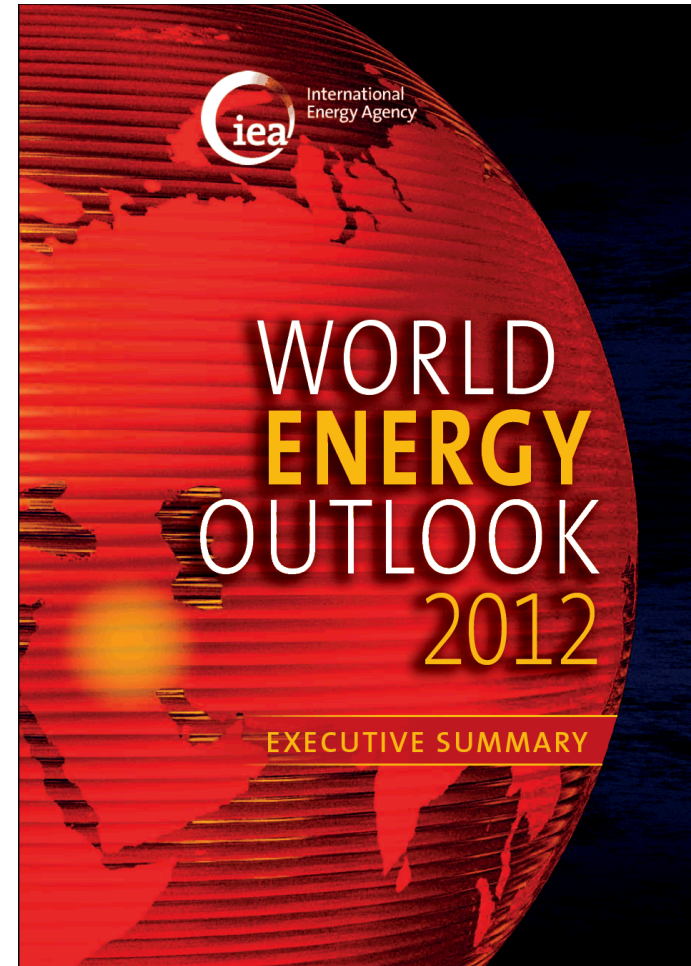
- Utilized publically available data

DOE/EIA-0383(2015) | April 2015

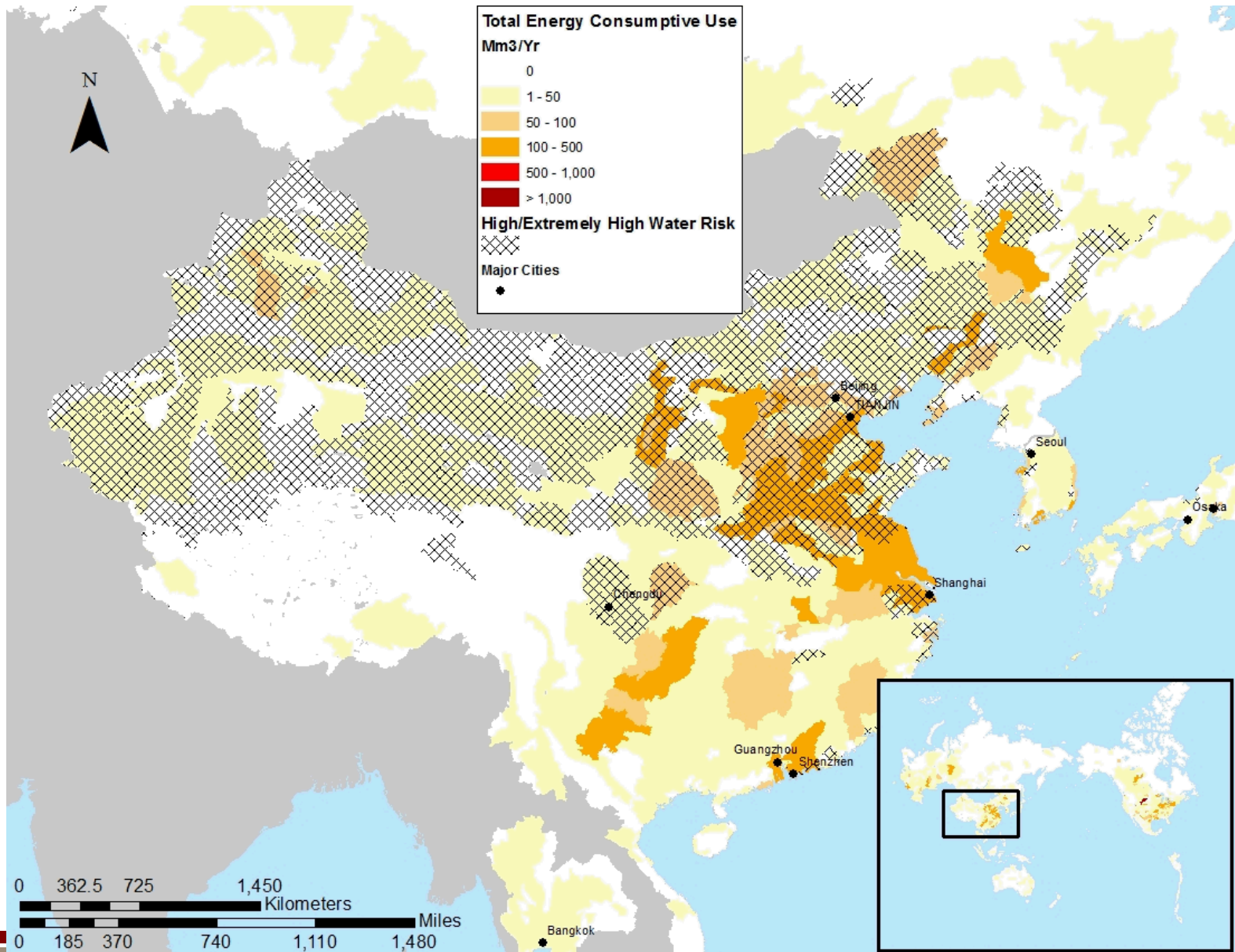
Annual Energy Outlook 2015 with projections to 2040



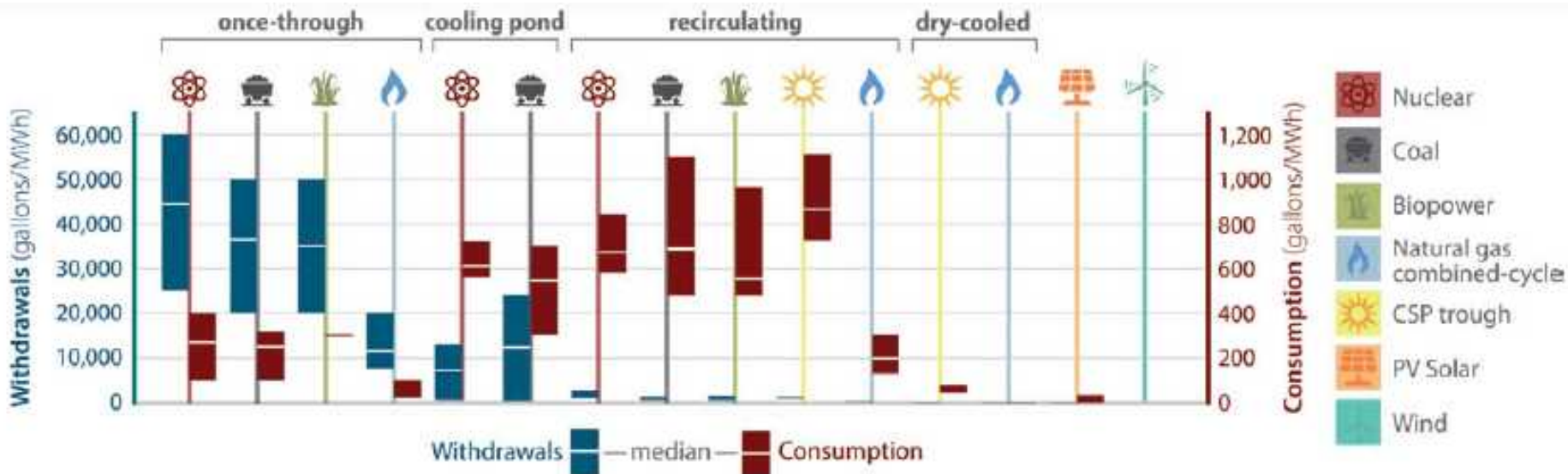
 *Independent Statistics & Analysis*
U.S. Energy Information
Administration



Water for Energy: Detail



Water and Energy Intensities



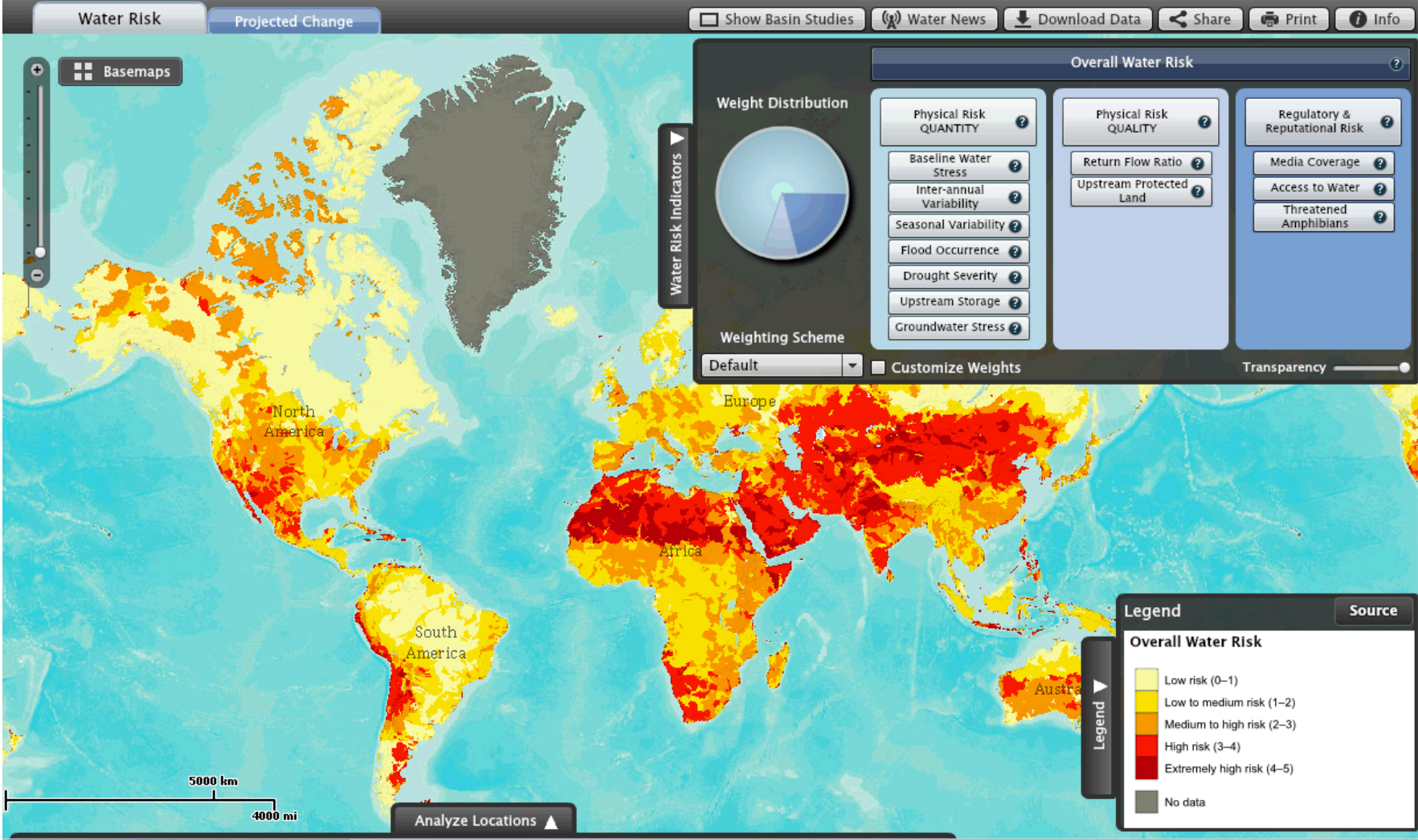
Averyt et al. 2011

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

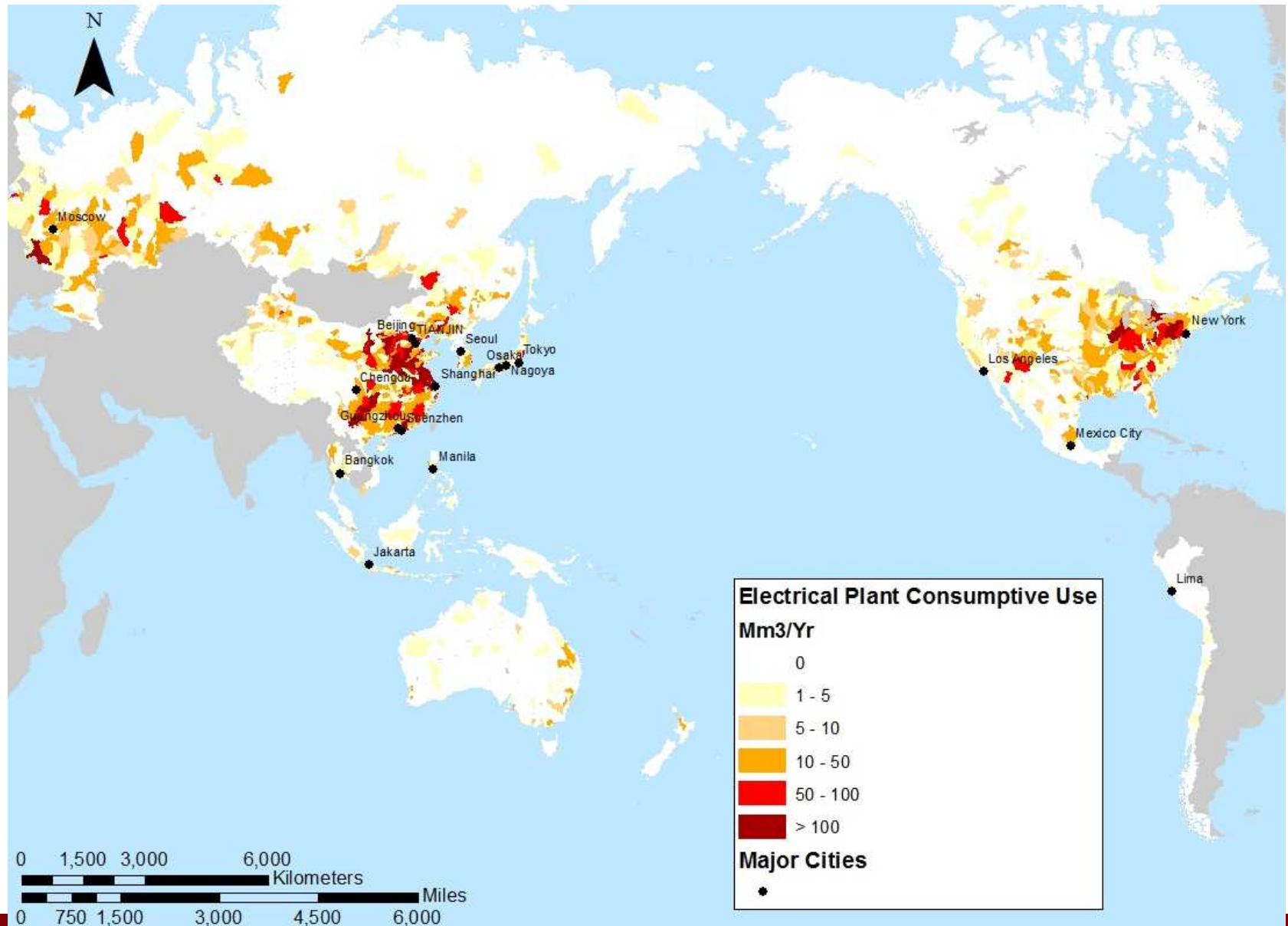
Energy category	Sub-category	Energy production source ^a	Water consumption factor ($\text{m}^3 \text{GJ}^{-1}$)			Source ^e
			Estimate ^b	Min	Max	
Fossil fuel	Coal ^d	[1]	0.043	0.006	0.242	[7]
	Conventional oil ^c	[1]	0.081	0.036	0.140	[8]
	Oil sands ^f	[2], [3]	0.114	0.072	0.132	[8]
	Oil refining	[1]	0.040	0.026	0.048	[8]
	Conventional gas	[1]	0.004	0.001	0.027	[7]
Nuclear fuel	Shale gas	[4]	0.017	0.003	0.221	[7]
	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]
Biofuel processing	Fuel reprocessing	[5]	0.007	0.007	0.007	[7]
	Ethanol	[1]	0.145	0.092	0.290	[9]
Biofuel cultivation	Biodiesel	[1]	0.031	0.031	0.031	[9]
	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

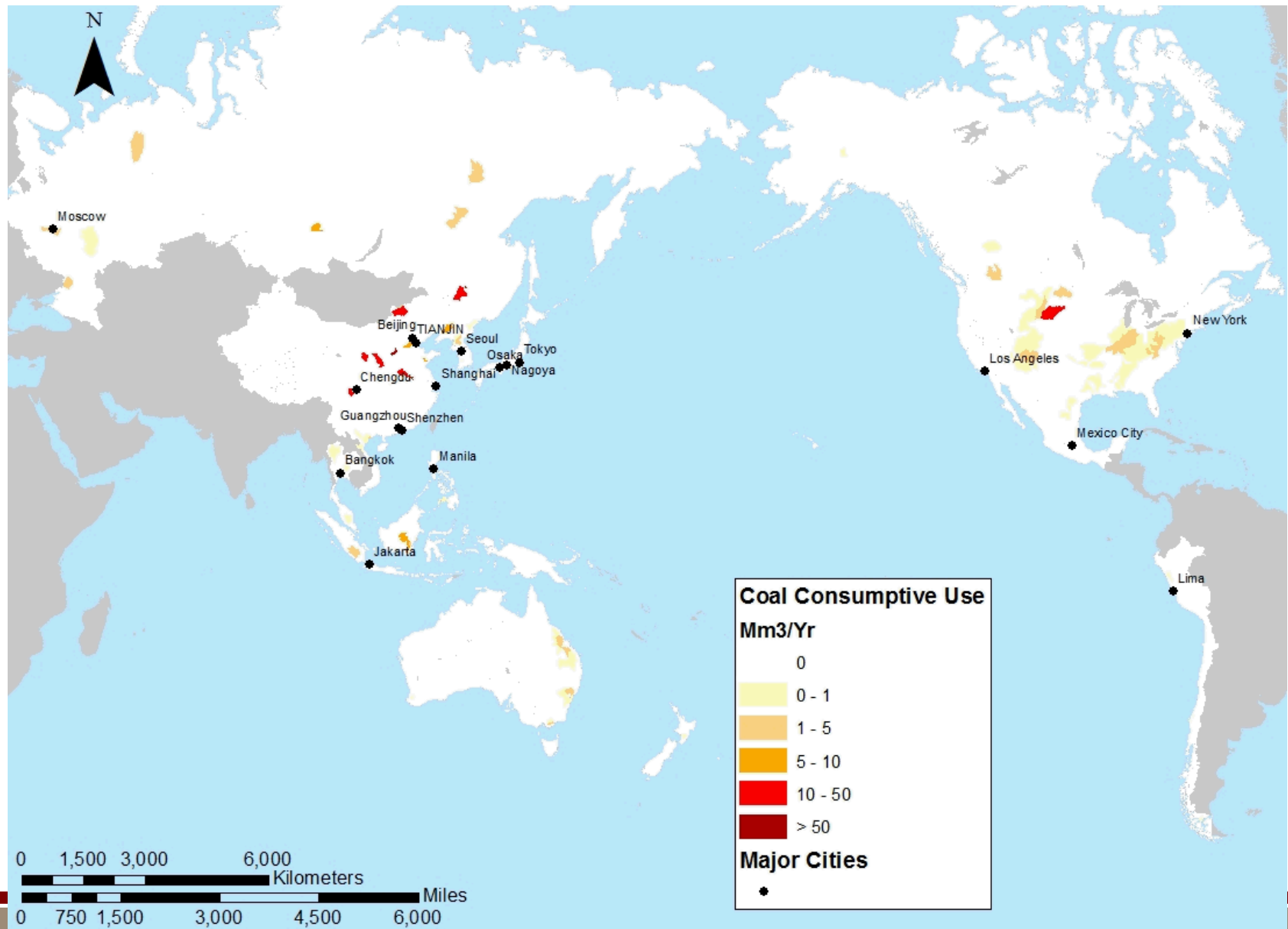
Global Water Risk Mapping



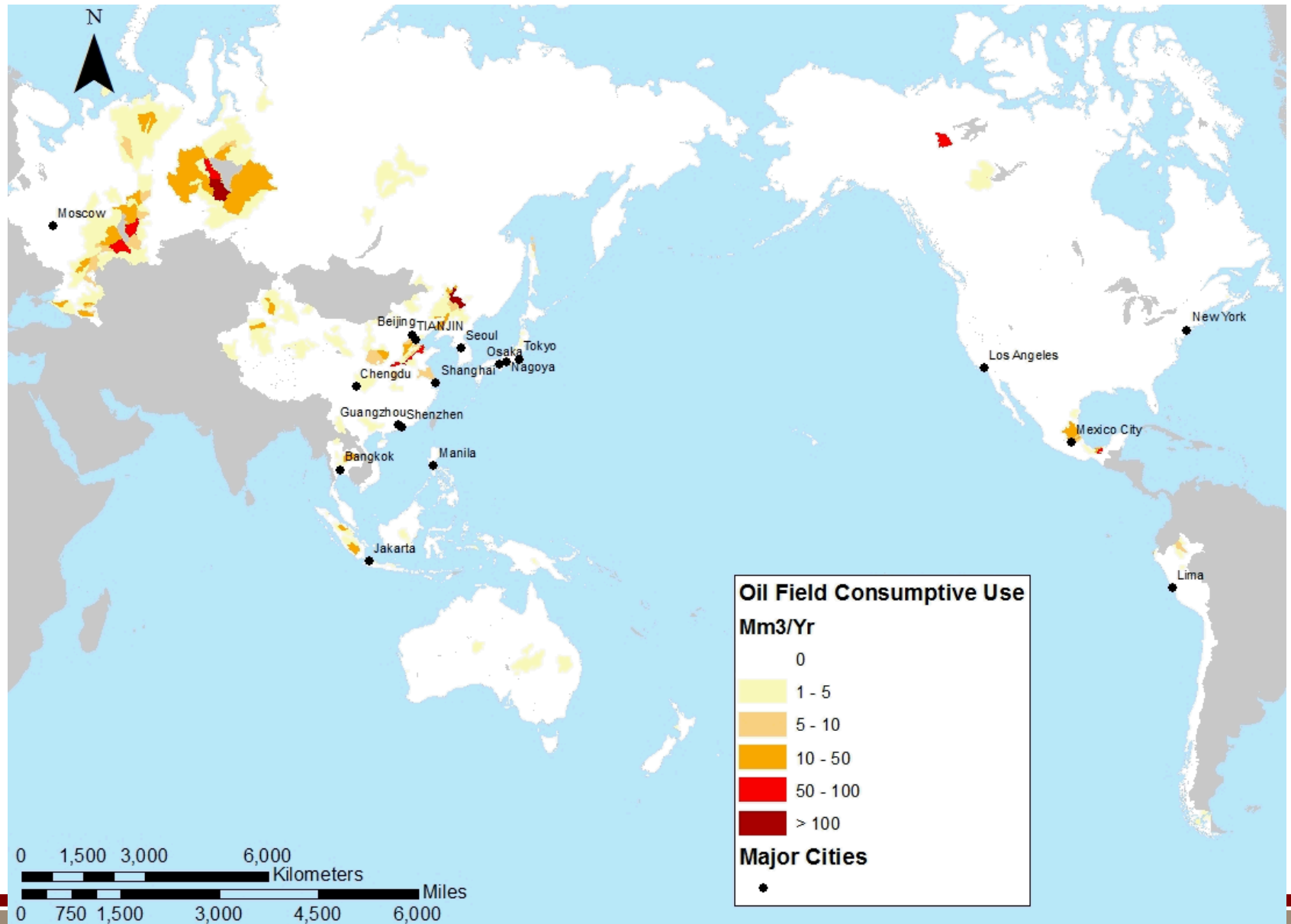
Water for Thermoelectric Power



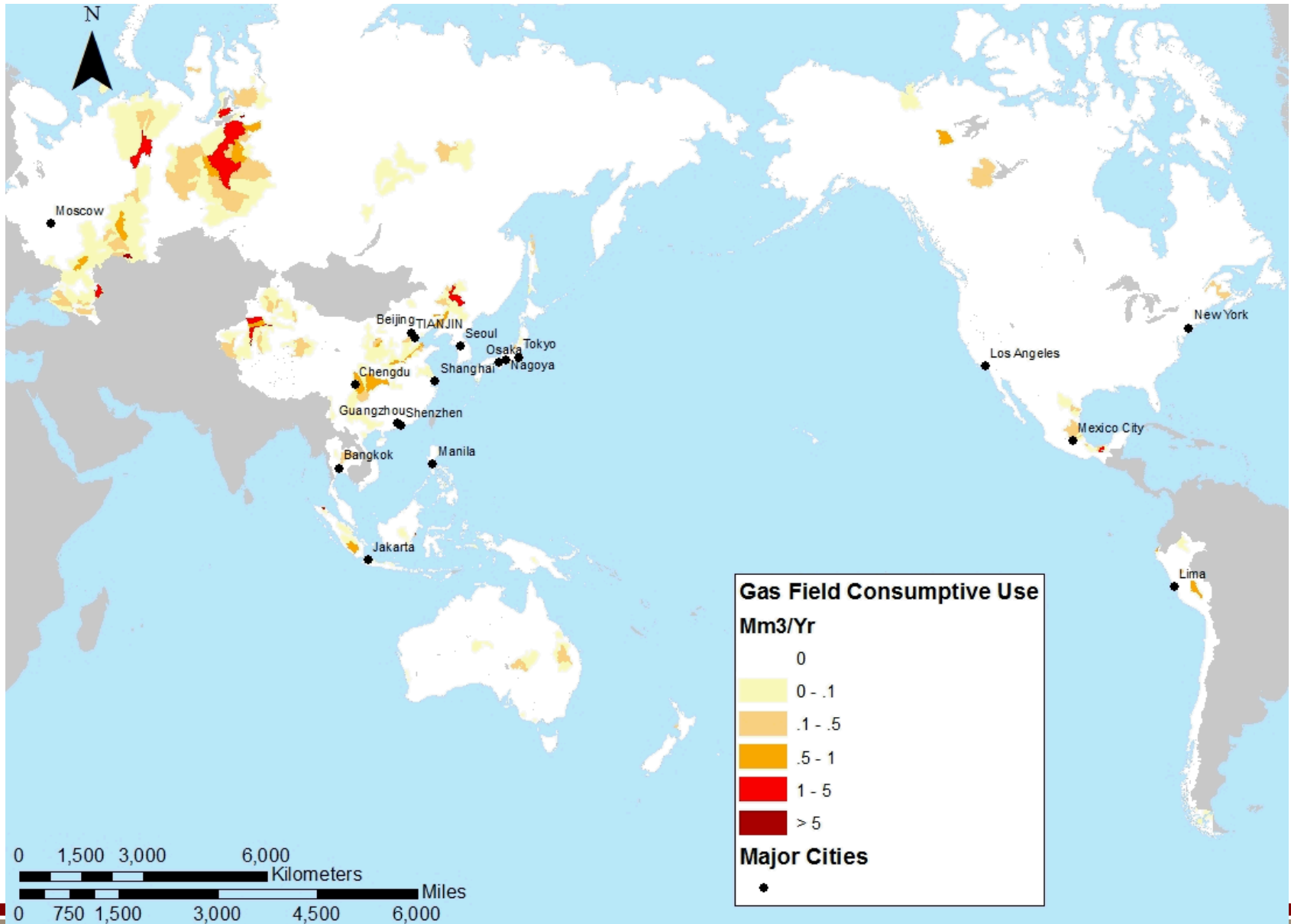
Water for Coal Extraction

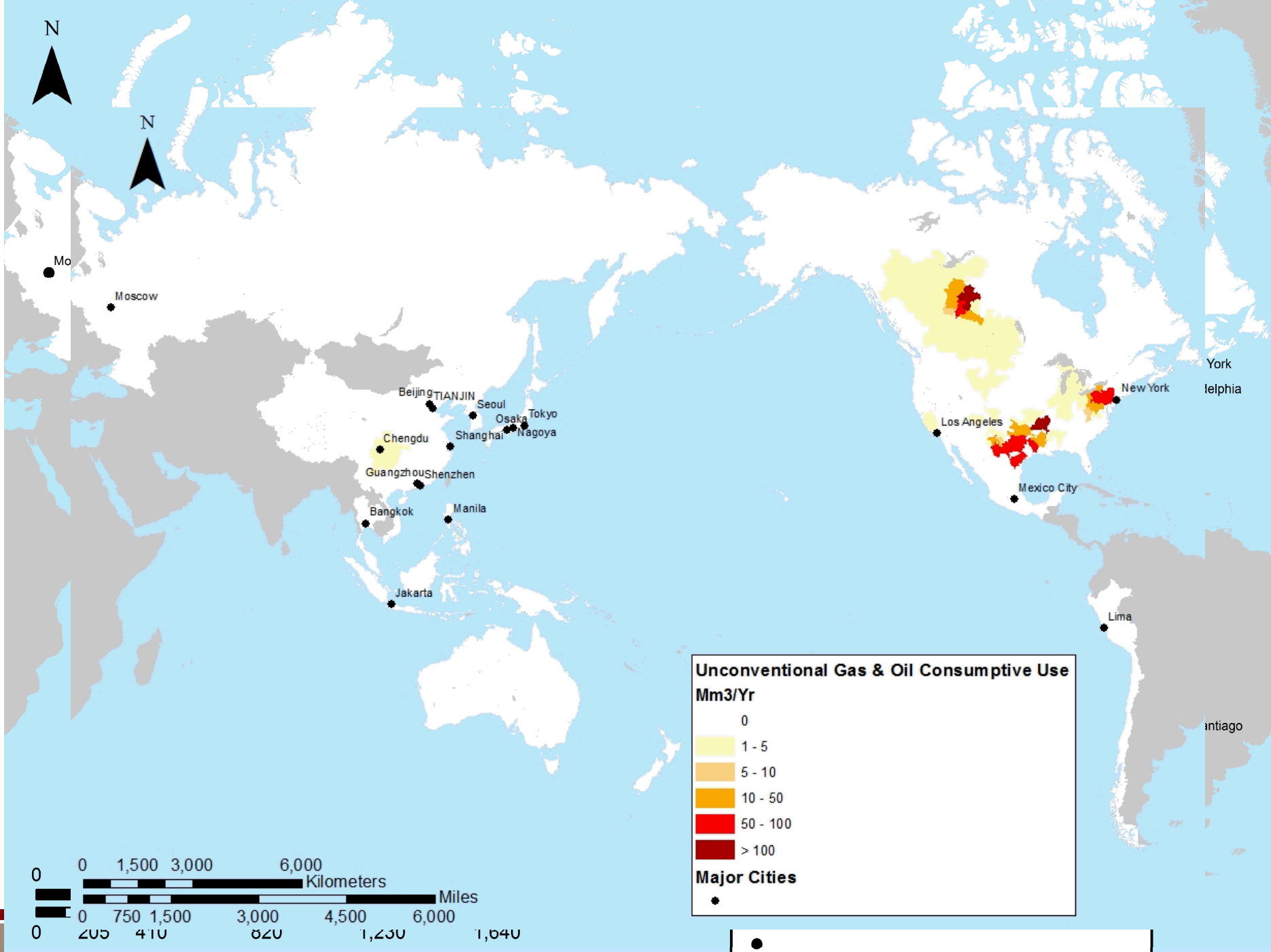


Water for Oil Extraction

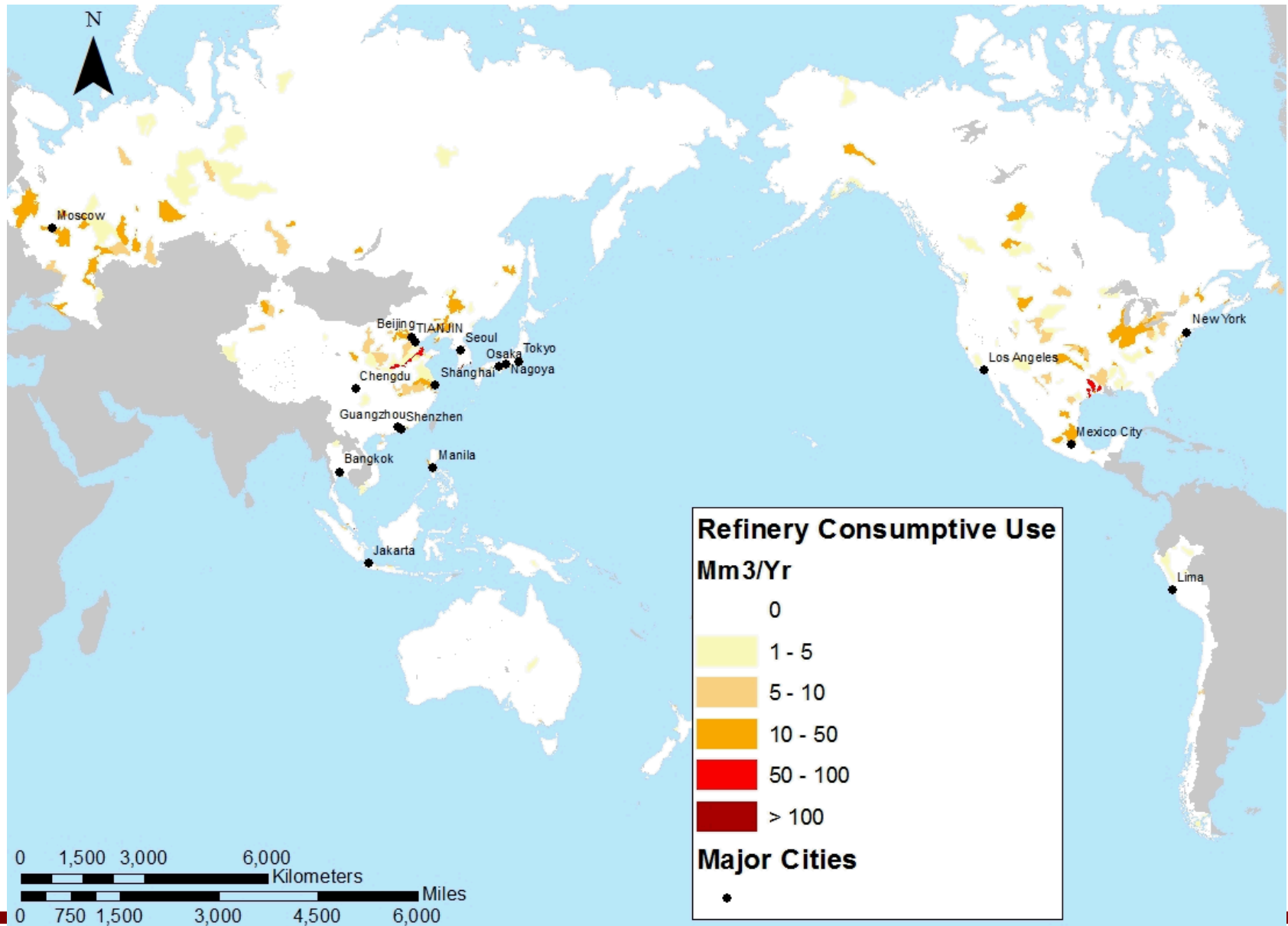


Water for Gas Extraction

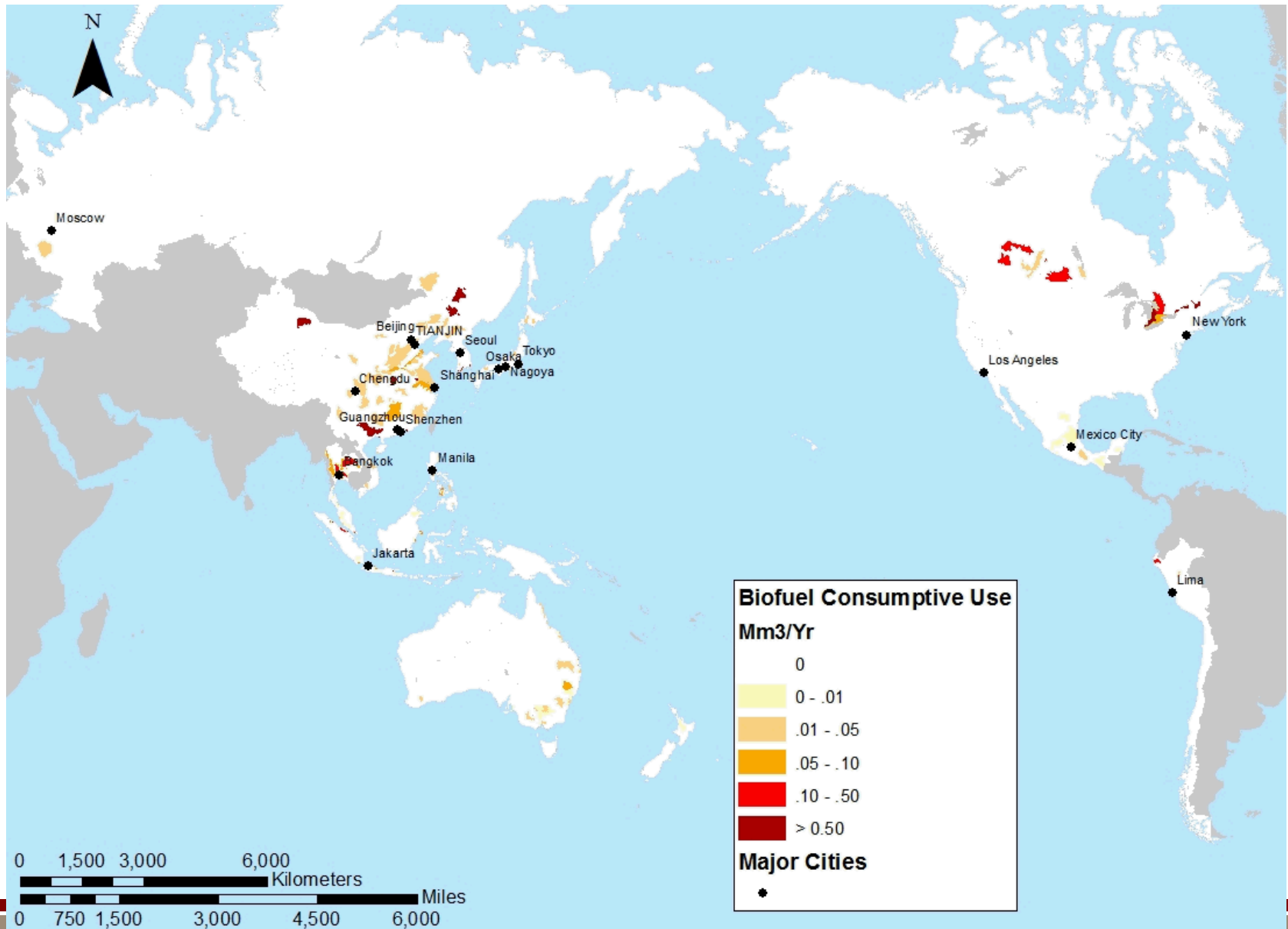




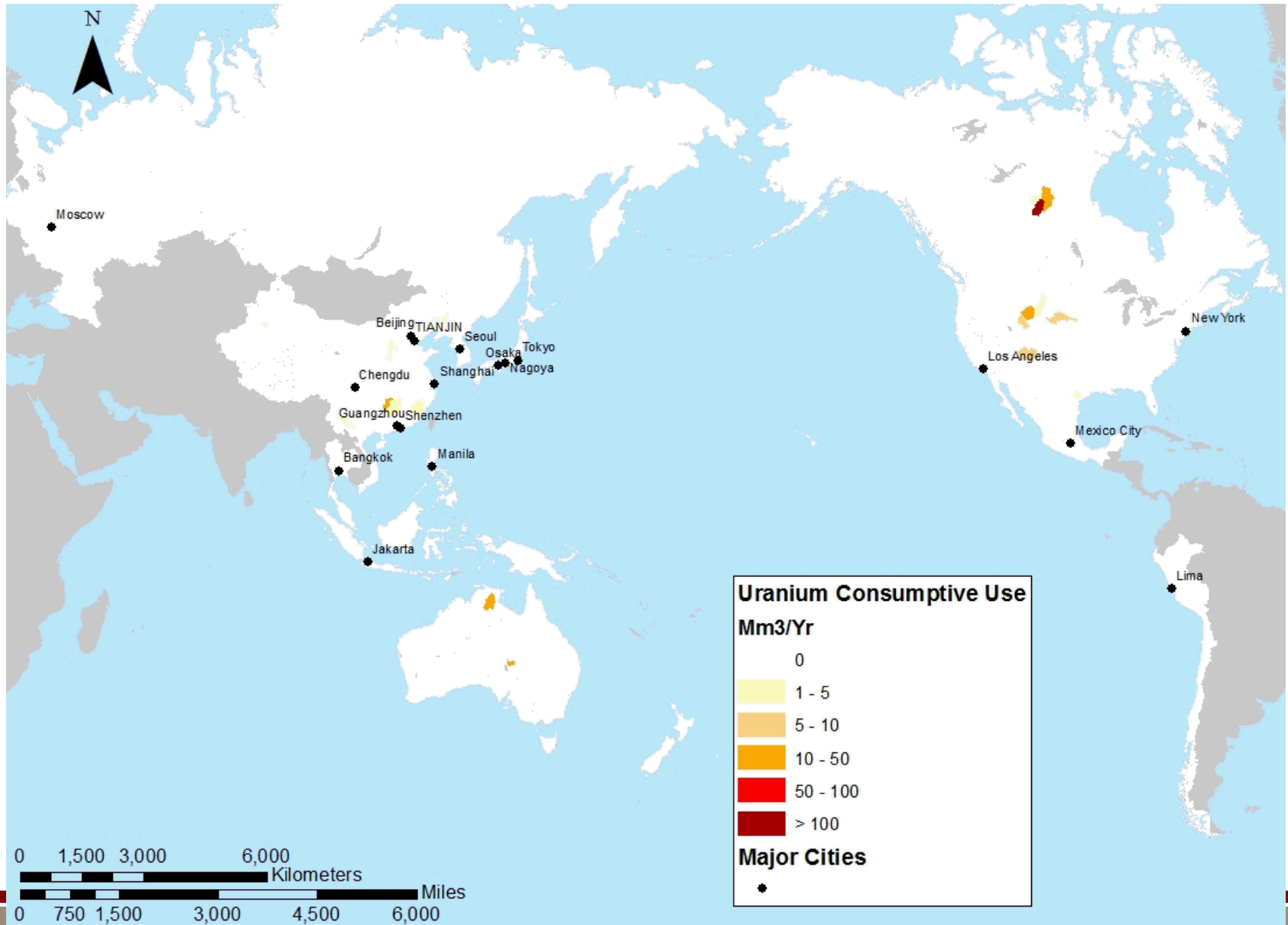
Water for Oil Processing



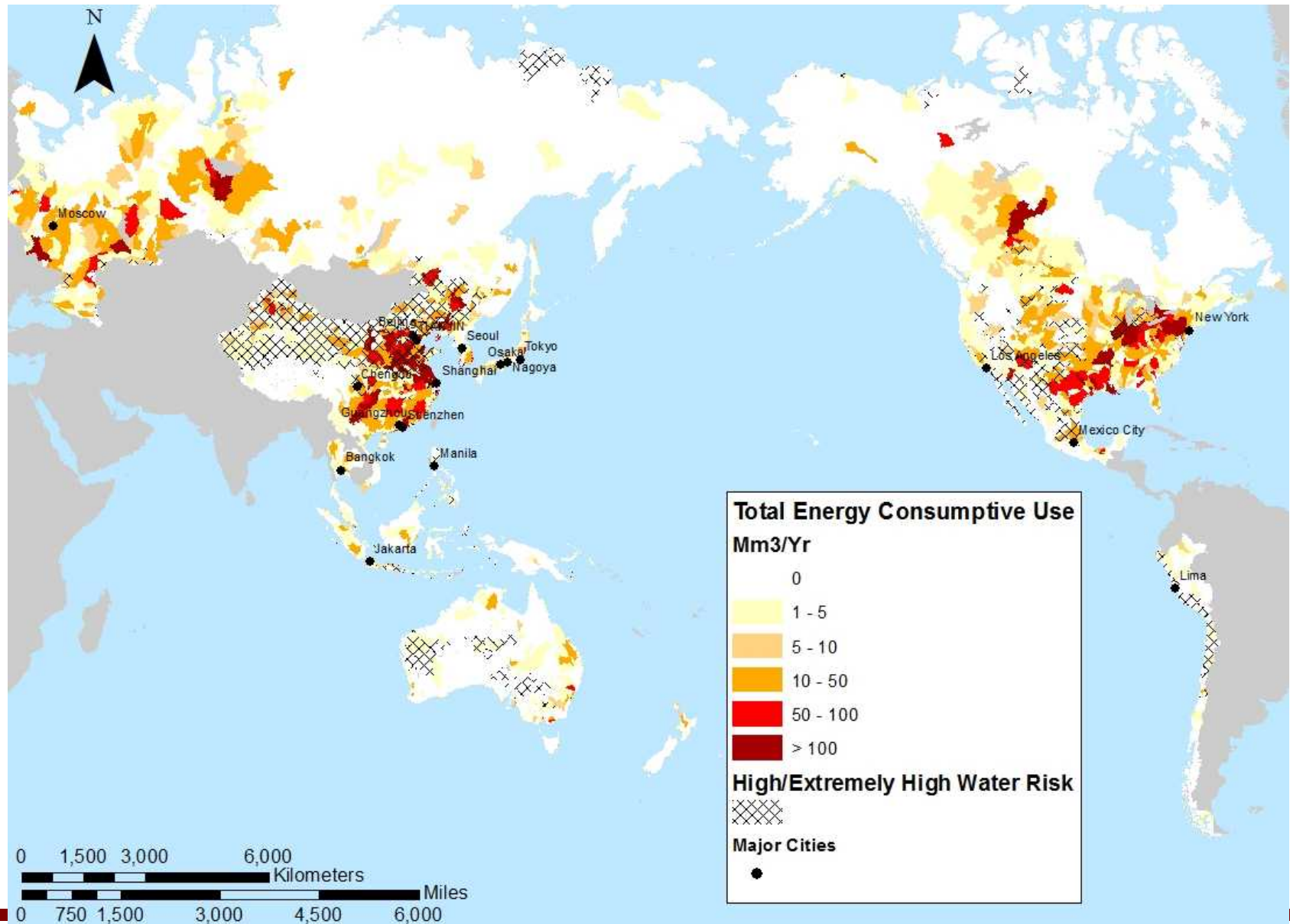
Water for Biofuel Refining



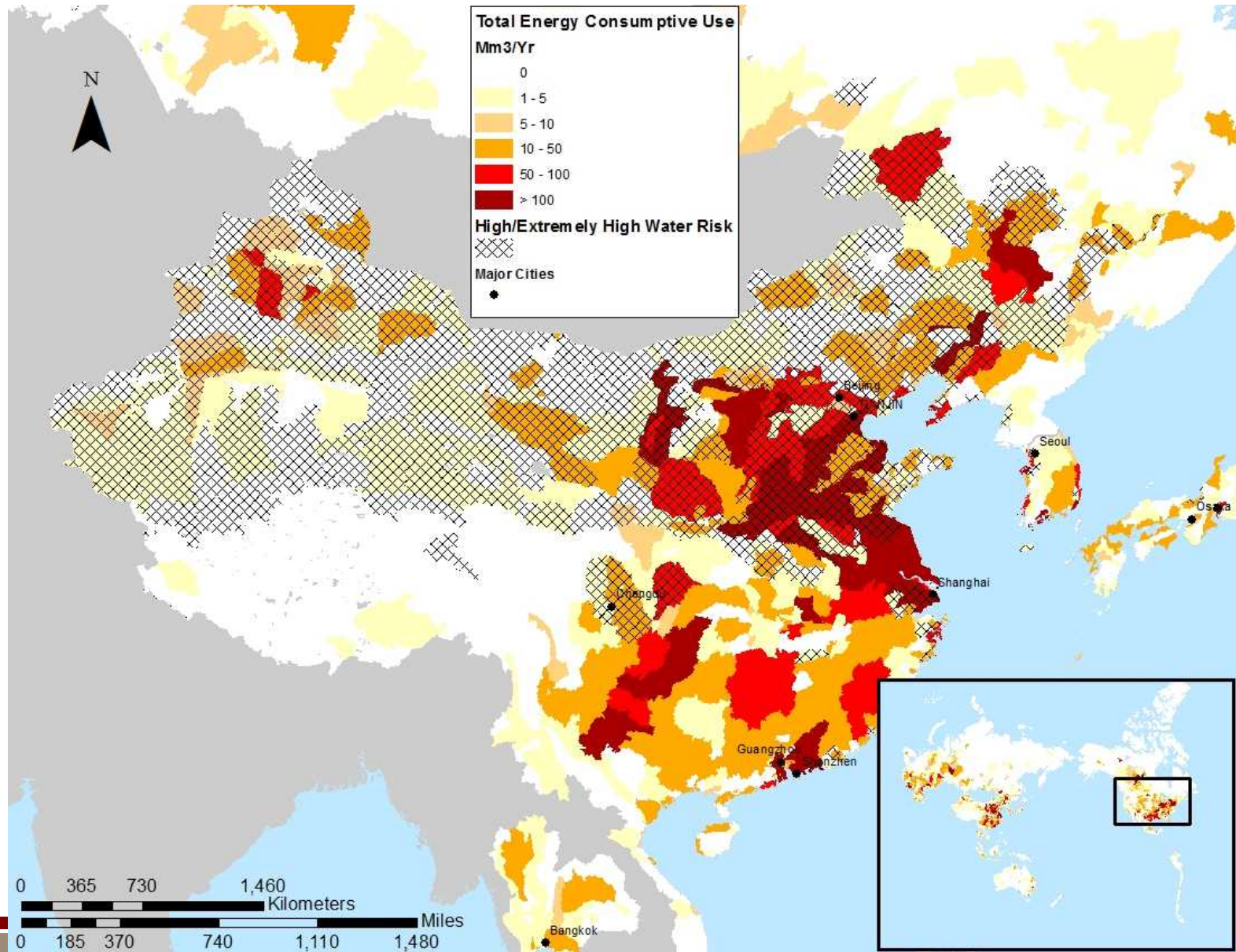
Water for Uranium Processing



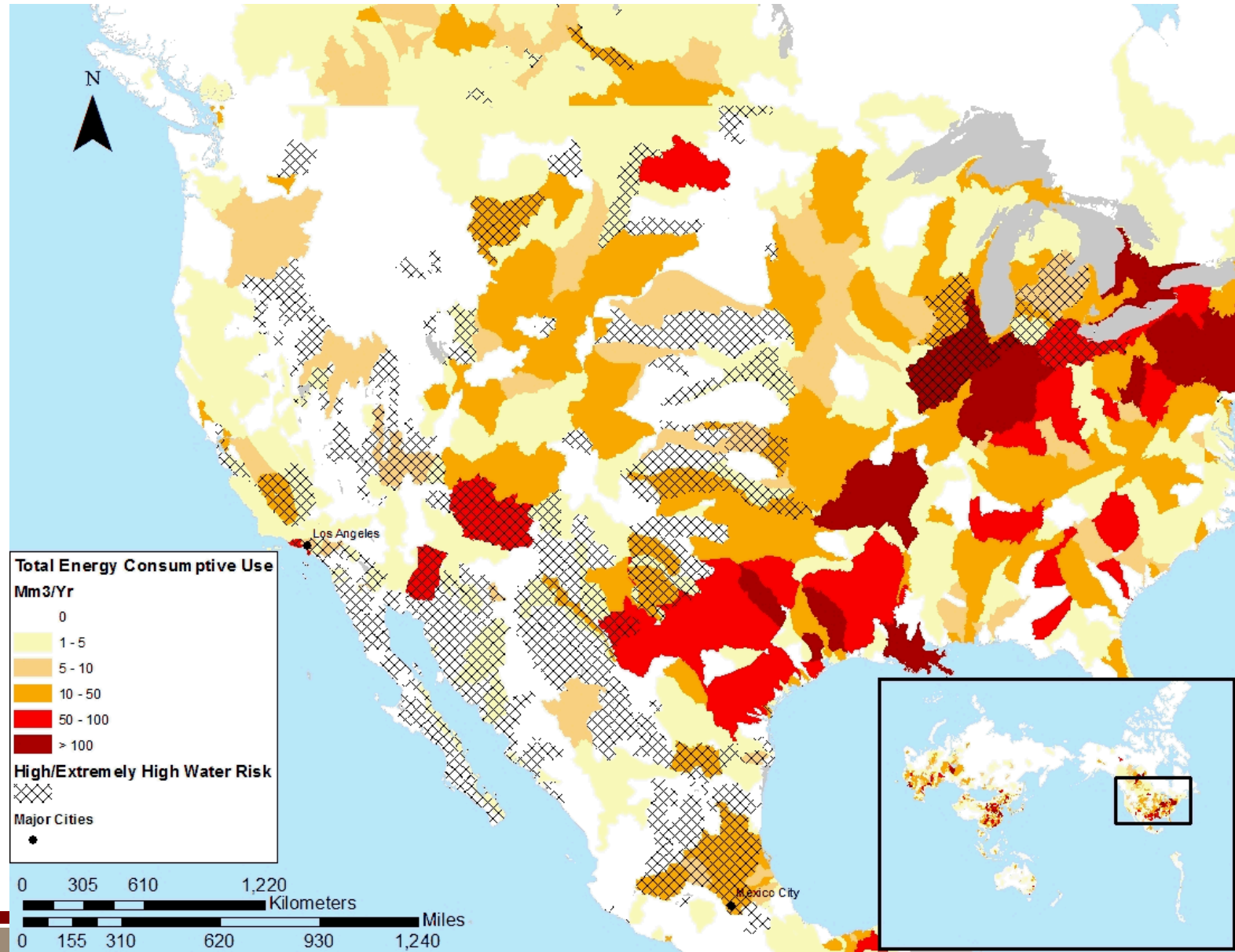
Water for Energy



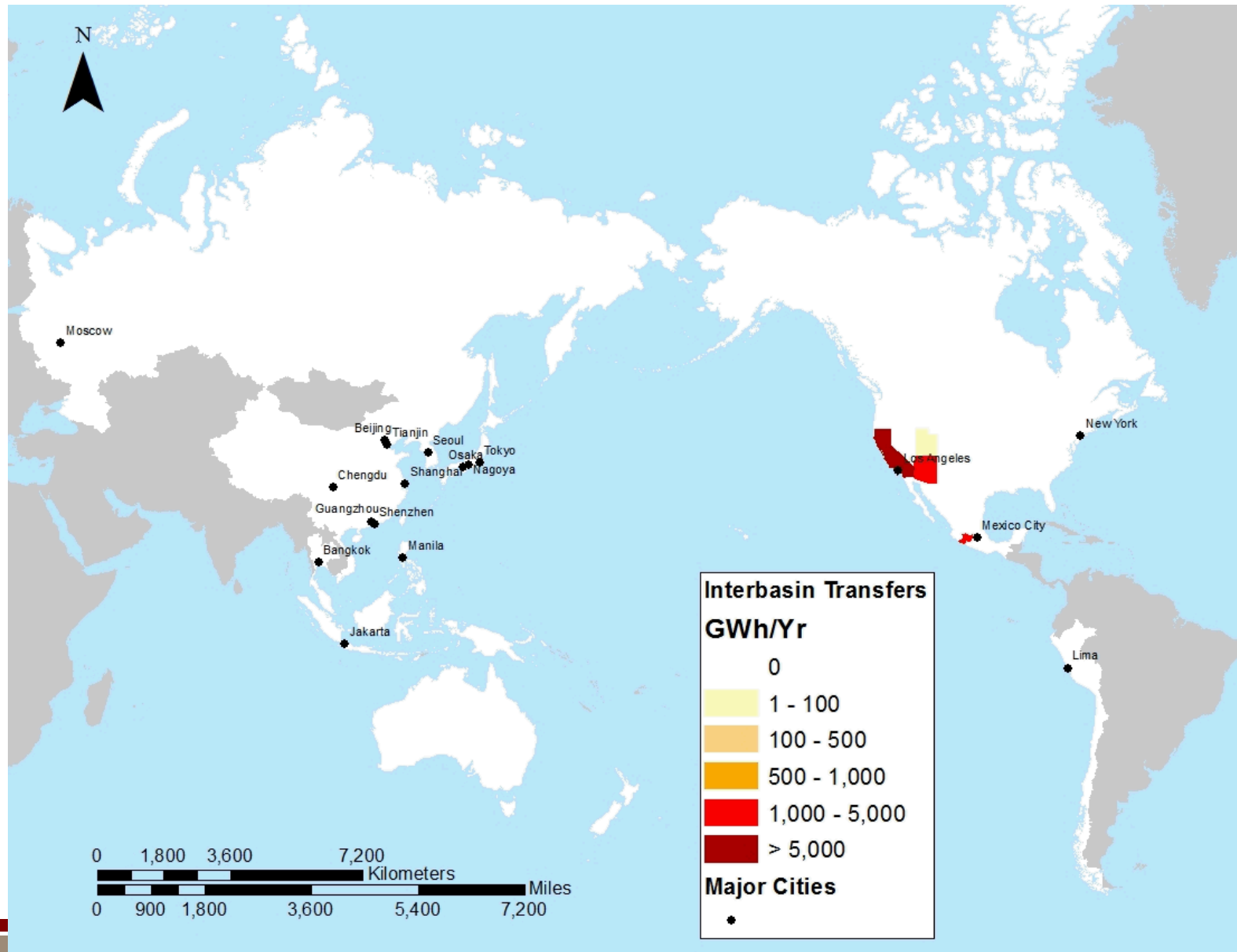
Water for Energy: Detail China



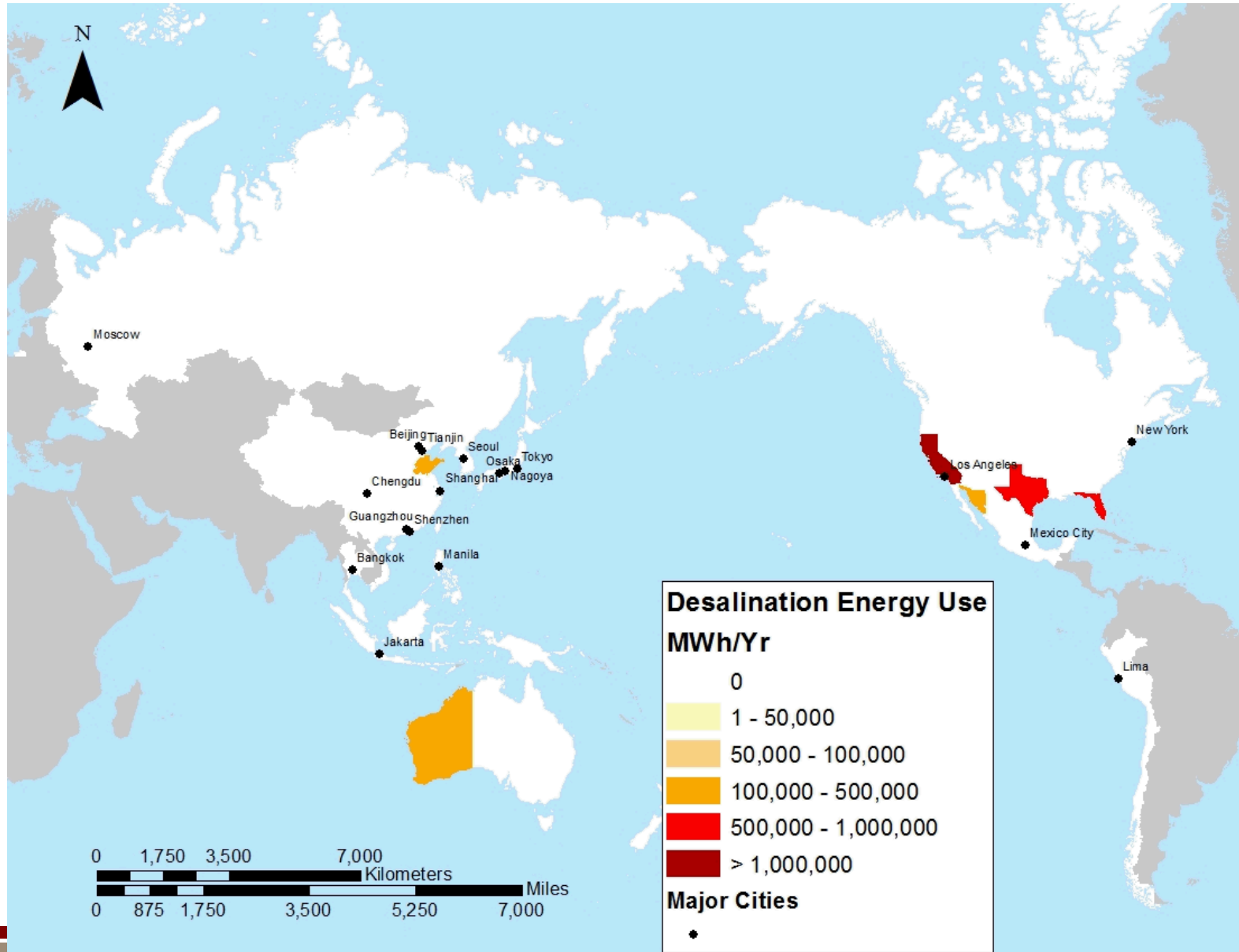
Water for Energy: Detail U.S.



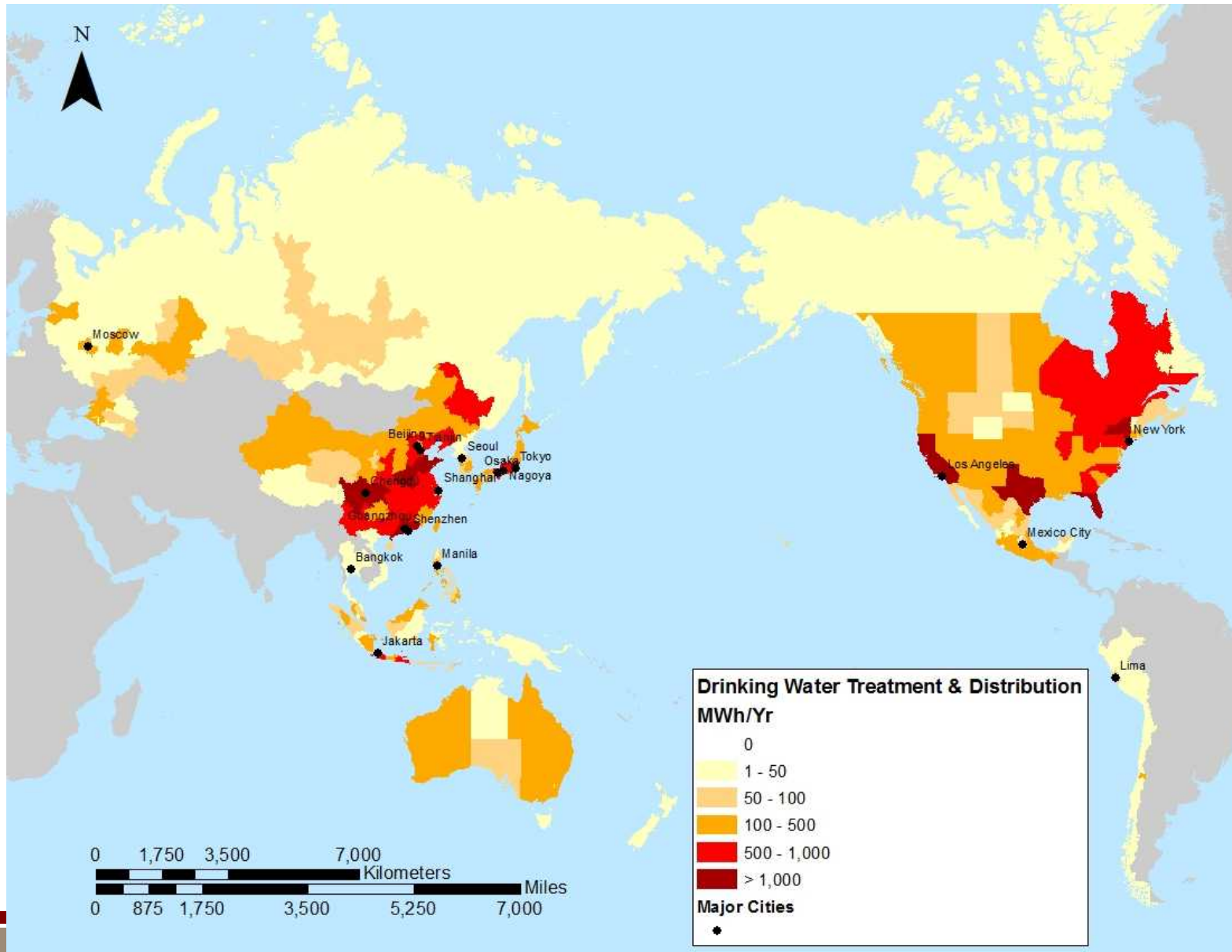
Energy for Interbasin Transfers



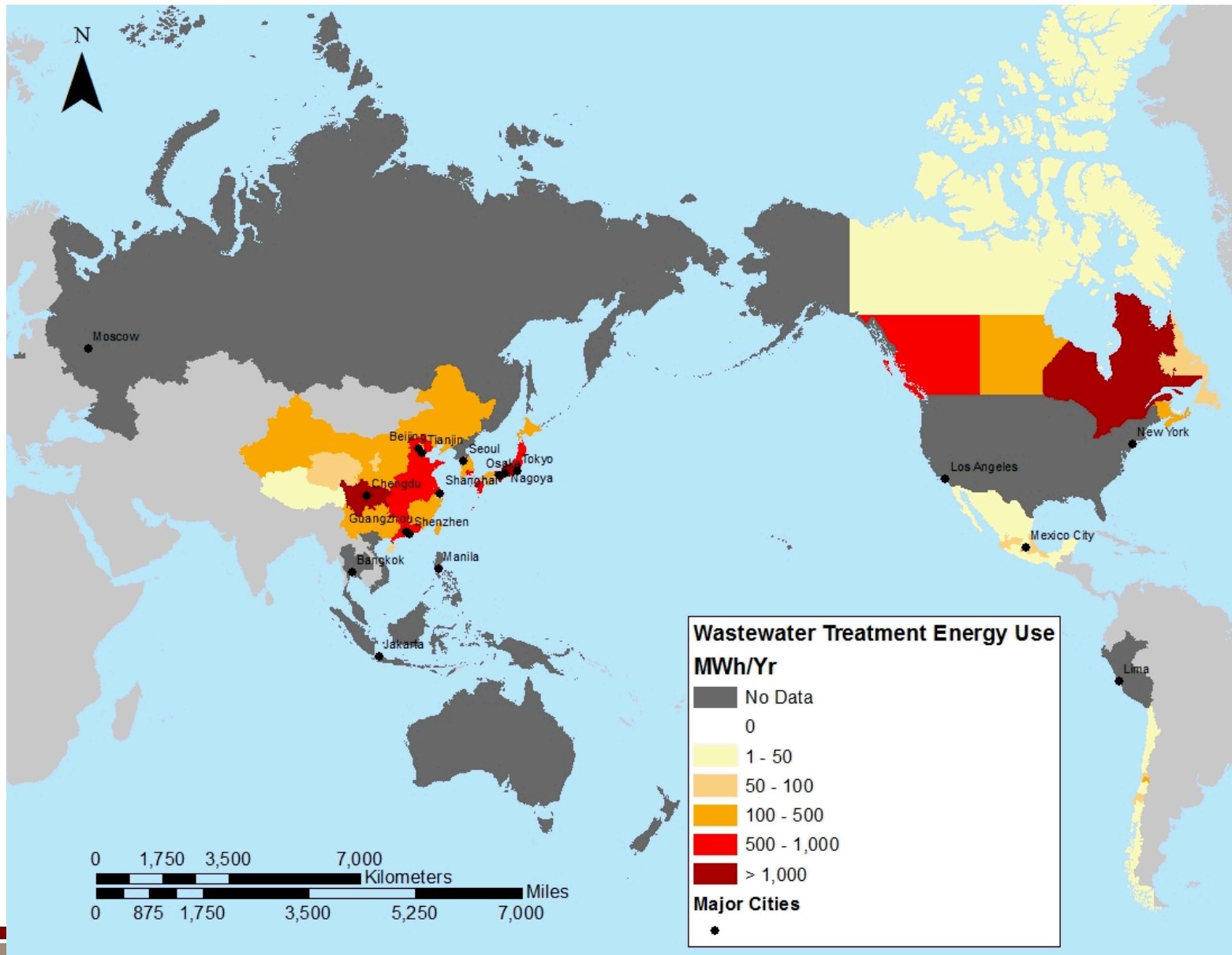
Energy for Desalination



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.