

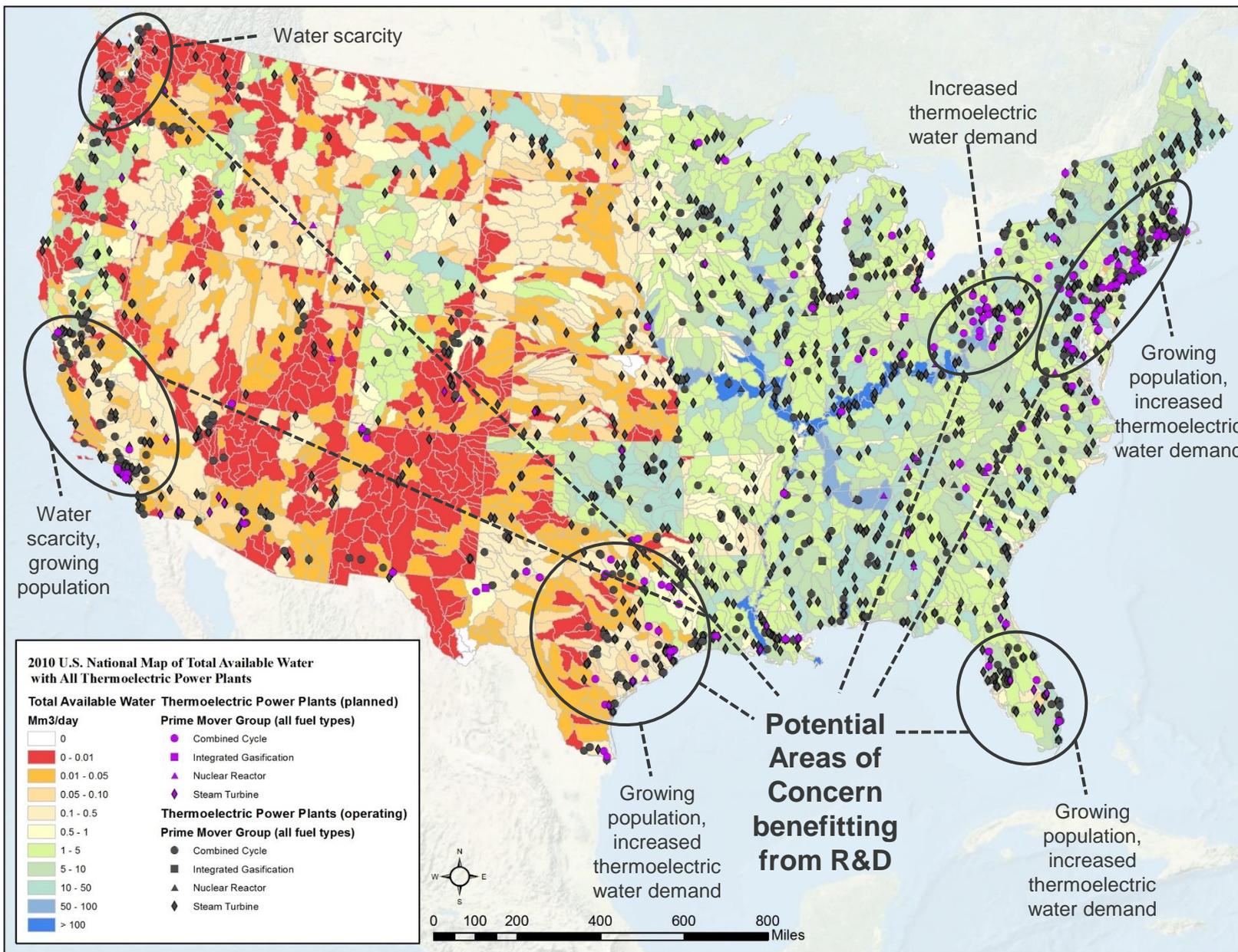
2018 Water Brief for Fossil Energy Applications

NETL Crosscutting—Briggs White



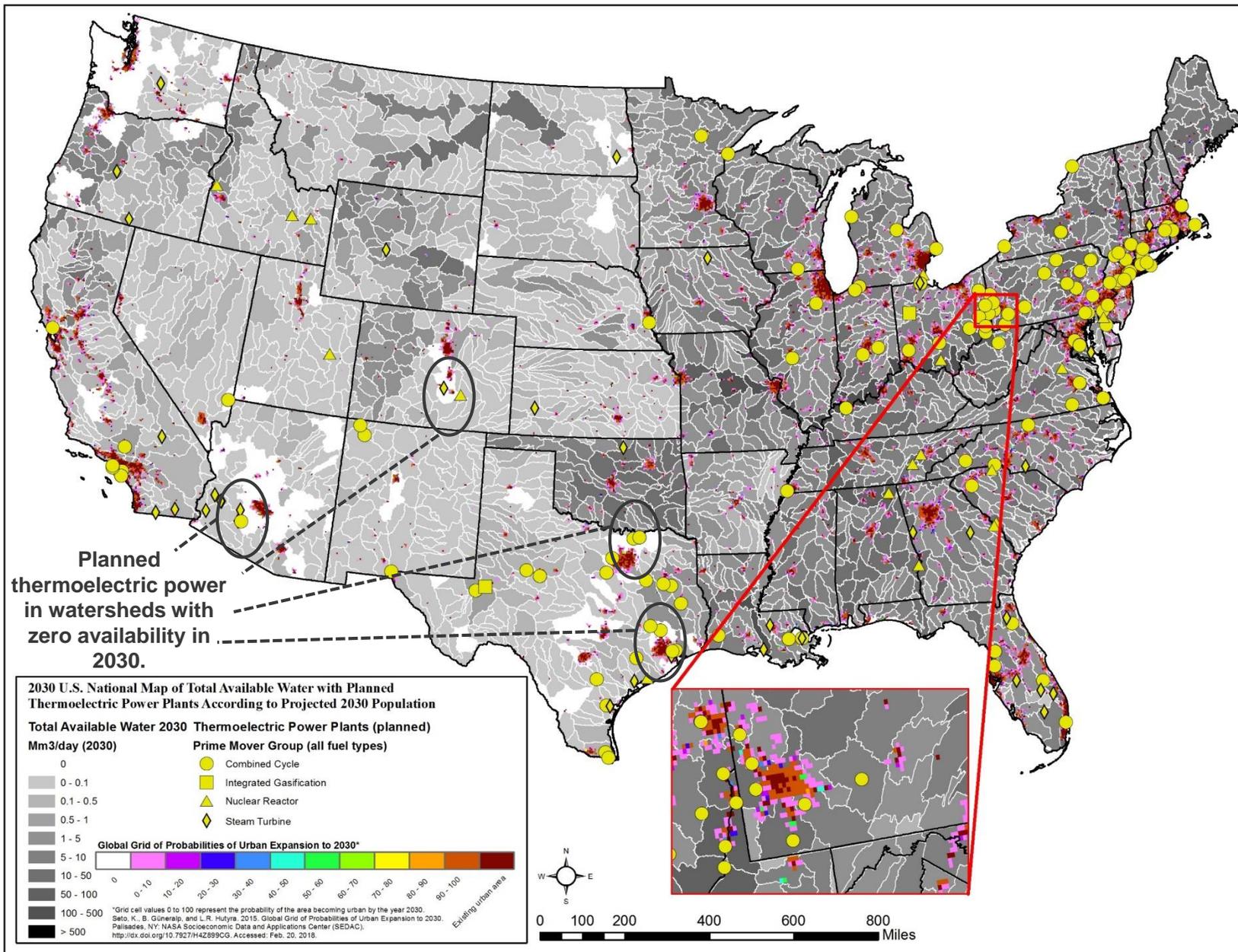
June 20th, 2018
Solutions for Today | Options for Tomorrow





Available Water and Thermoelectric Power Plants: R&D OPPORTUNITIES

- As thermoelectric power grows to keep up with demand in the east, more effective water management may help maintain low operating costs.
- In the water constrained west, thermoelectric power is looking to utilize technologies such as waterless plants employing dry cooling technologies to help alleviate current water stress.

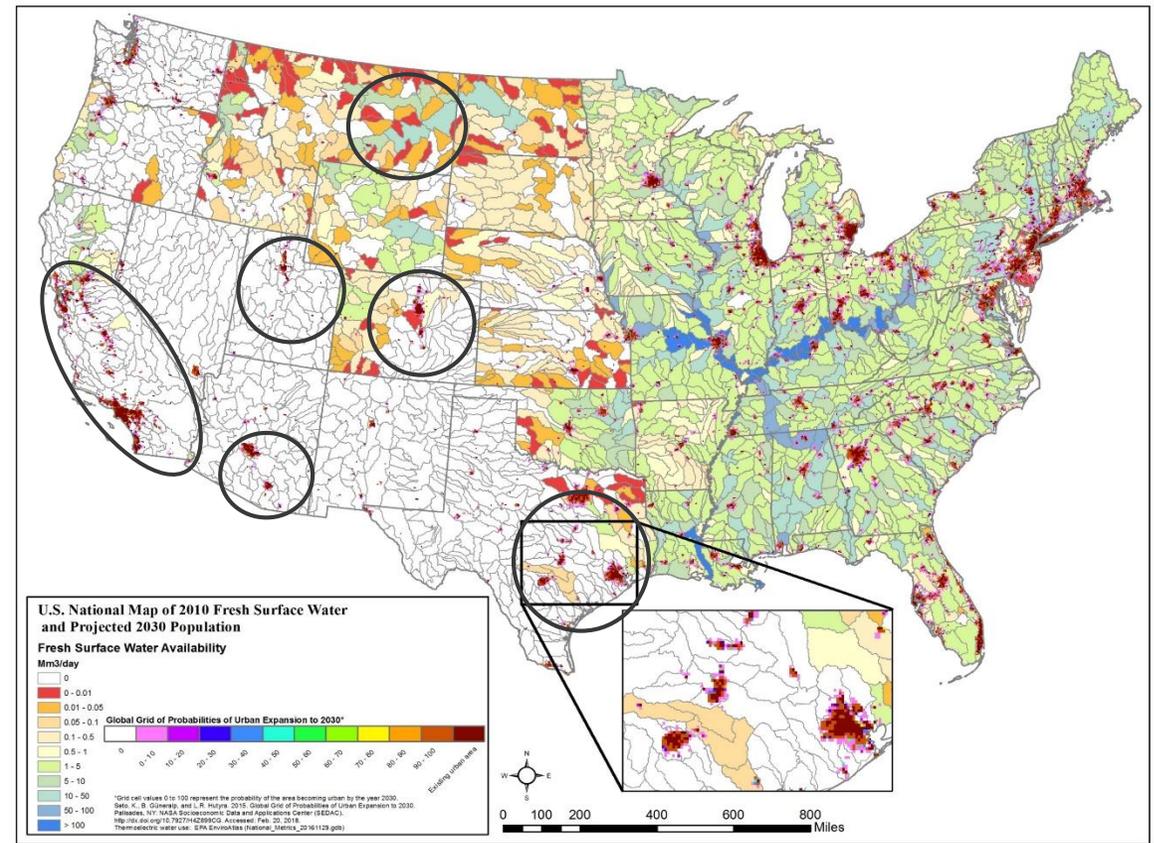
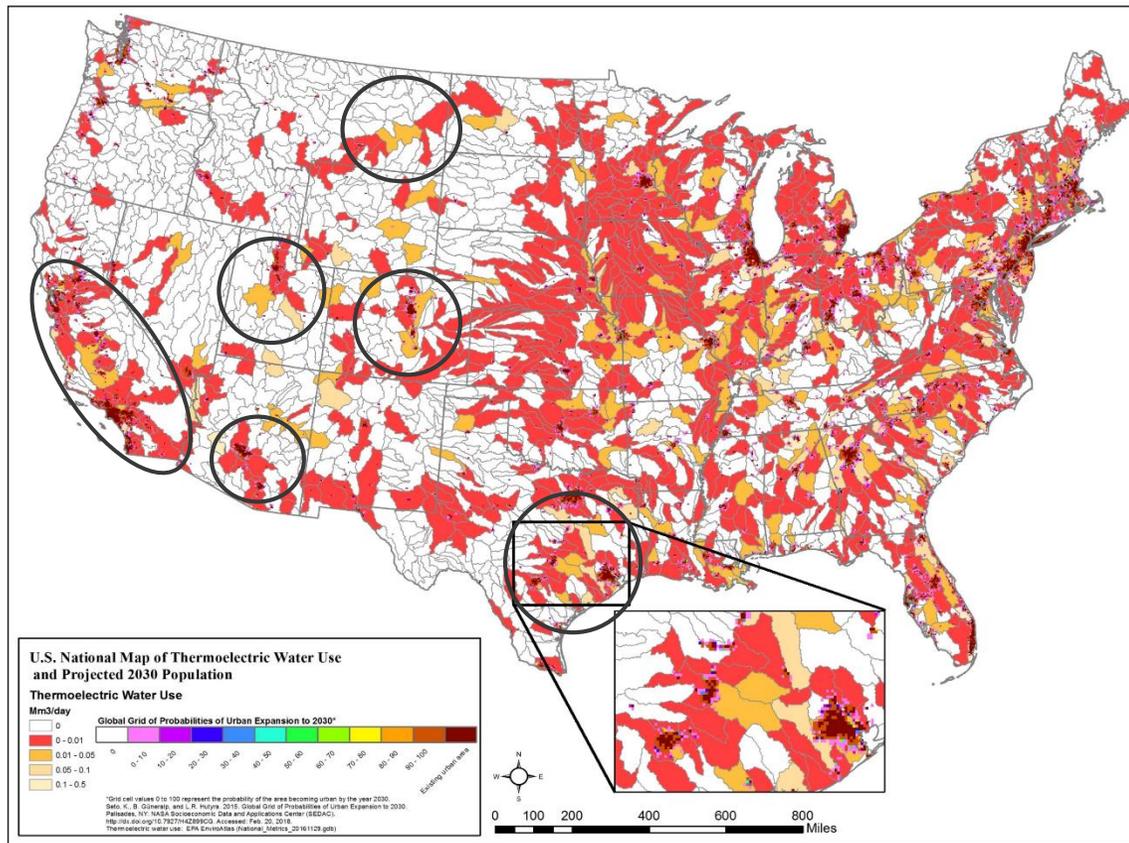


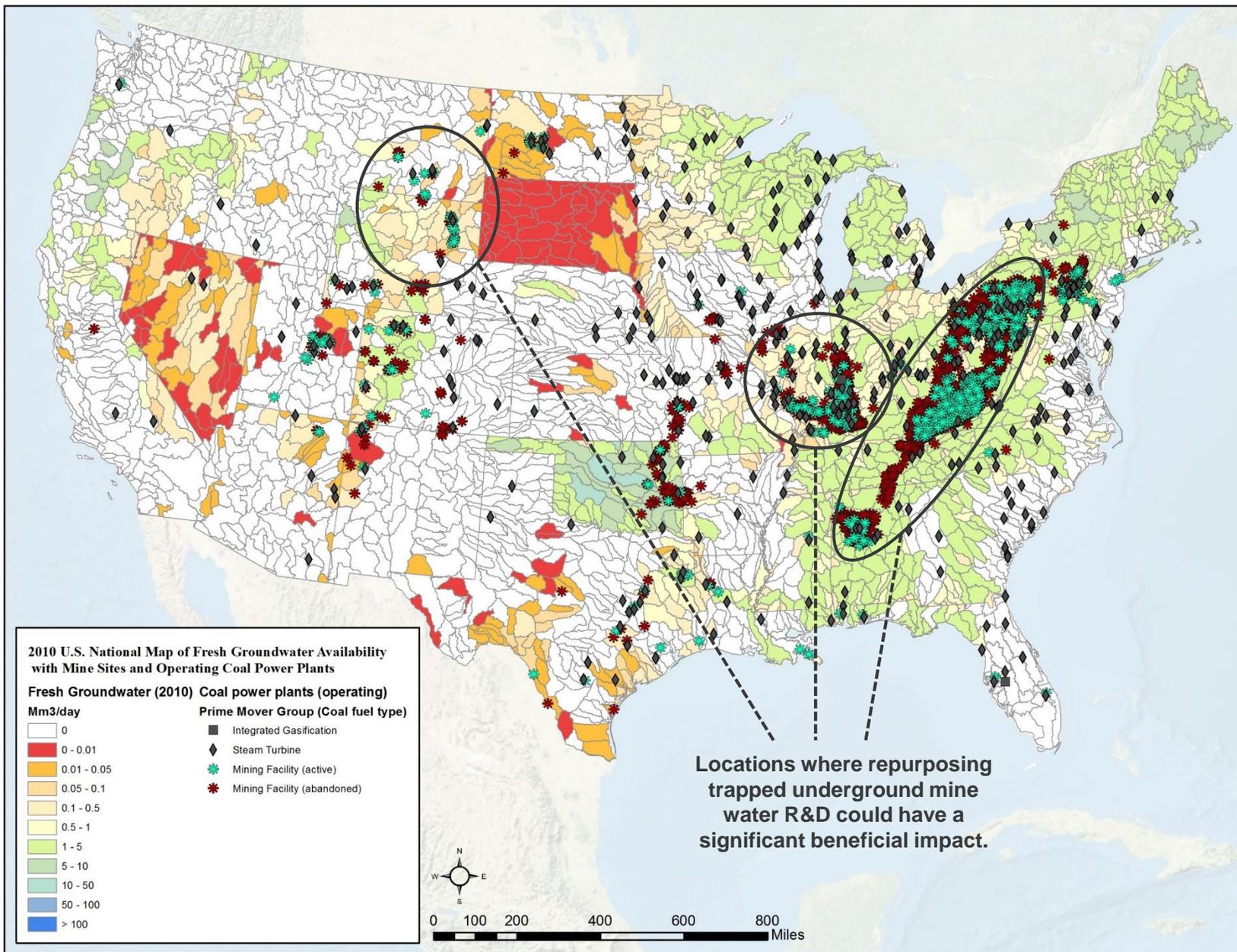
Projected 2030 Available Water and Urban Expansion: R&D OPPORTUNITIES

- In western locations of Arizona, Colorado, and Texas, planned thermoelectric power plants may want to consider effluent reuse technologies because several watersheds are expected to have limited availability by 2030.
- Advances in treating alternative sources of water, such as municipal gray water, will offset thermoelectric power plant's consumption of available freshwater in the western states.

Fresh Surface Water and Thermoelectric Water Withdrawal: R&D OPPORTUNITIES

- Six circled areas represent locations where thermoelectric water withdrawals (left map) nearly equal or exceed available fresh surface water (right map). These locations stress the need for advances in dry cooling and water management technologies to minimize water use throughout thermoelectric power generation.



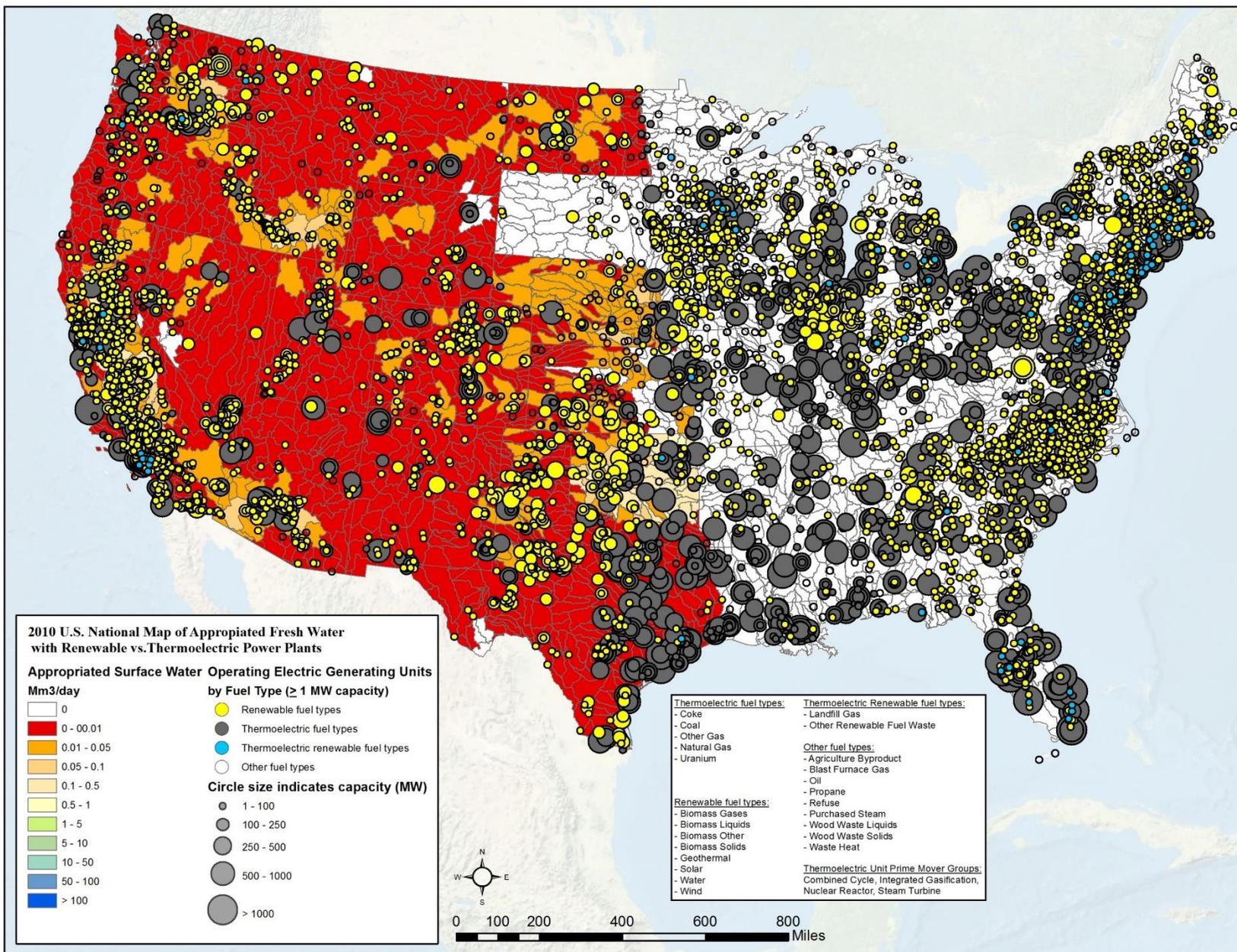


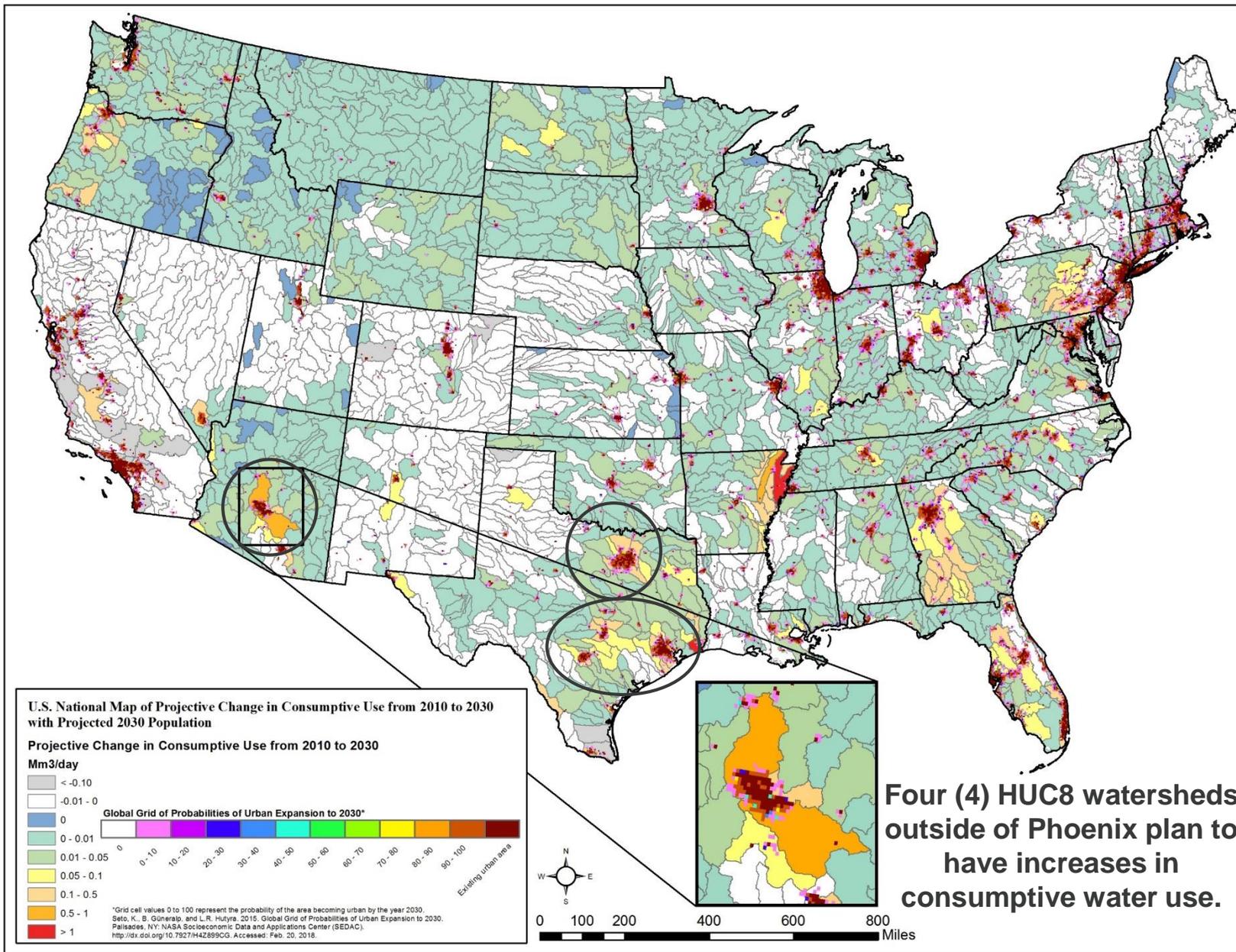
Fresh Groundwater, Mining, and Active Coal Power: R&D OPPORTUNITIES

- Water trapped in abandoned underground mines could become a source of freshwater for local thermoelectric power plants.
- Repurposing trapped mine water could remove the need for some thermoelectric power to utilize groundwater which is difficult to source and expensive to treat.

Appropriated Water and Power Sources: R&D OPPORTUNITIES

- In the west, renewable sources of power utilizing little to no water are more common (33% to 9% net generation), which may be partly due to water appropriation; flexible effluent and cooling technologies may help thermoelectric power plants when cycling due to renewable integration.
- Advanced water management techniques in the eastern states may help thermoelectric power remain cost-competitive.



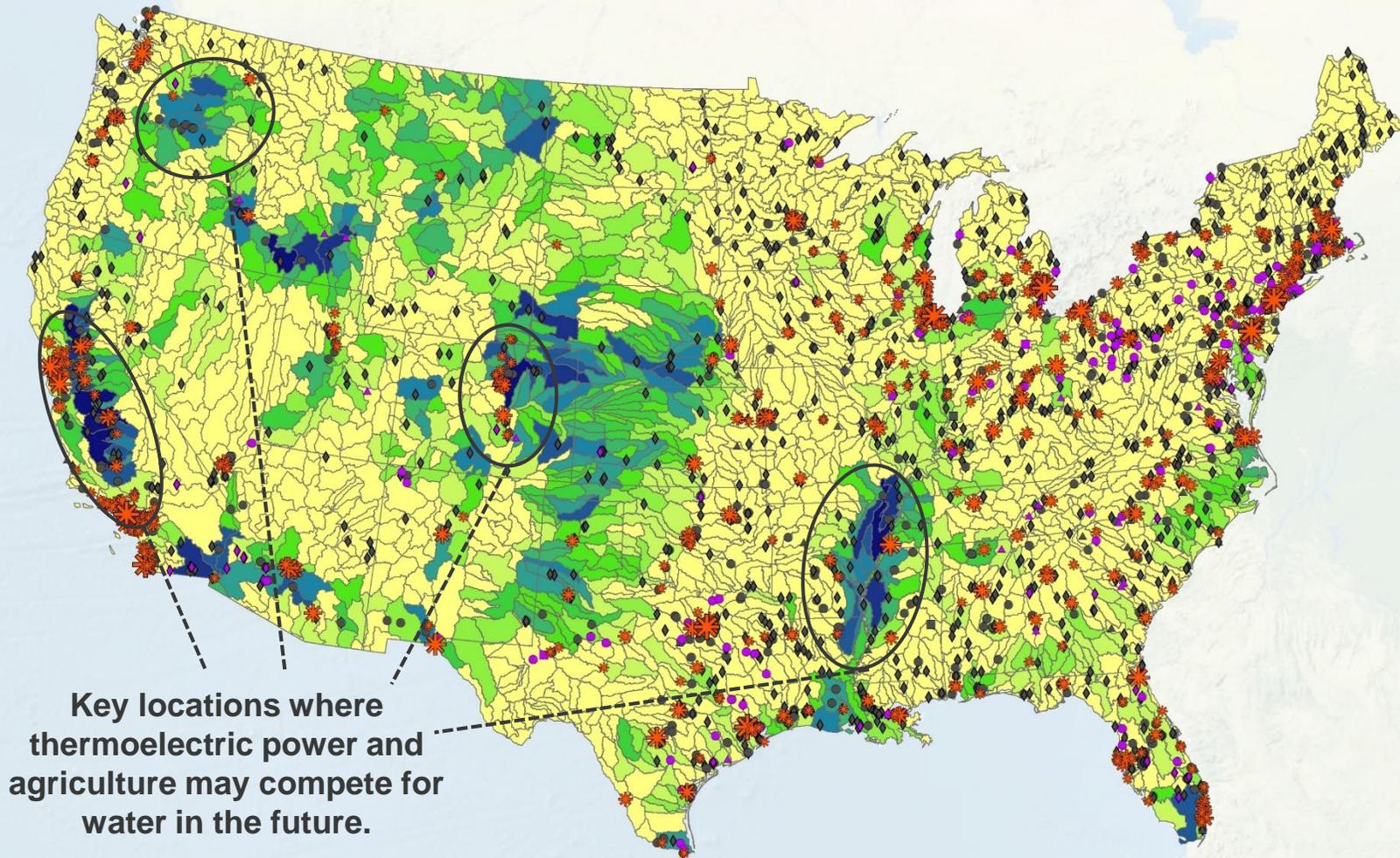


Change in Consumptive Use and Growth in Population: R&D OPPORTUNITIES

- As populations grow in the west, consumptive water use is projected to grow; to avoid water availability issues, thermoelectric power in these locations may look towards advances in dry cooling and hybrid technologies.
- In locations such as Phoenix, where consumptive use is projected to grow across all surrounding watersheds, thermoelectric power may actively consider effective automation technologies to use as little water as possible.

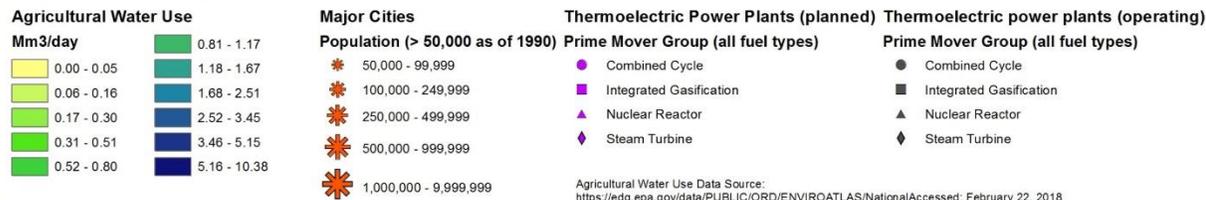
East vs. West: Agriculture and Thermoelectric Power: R&D OPPORTUNITIES

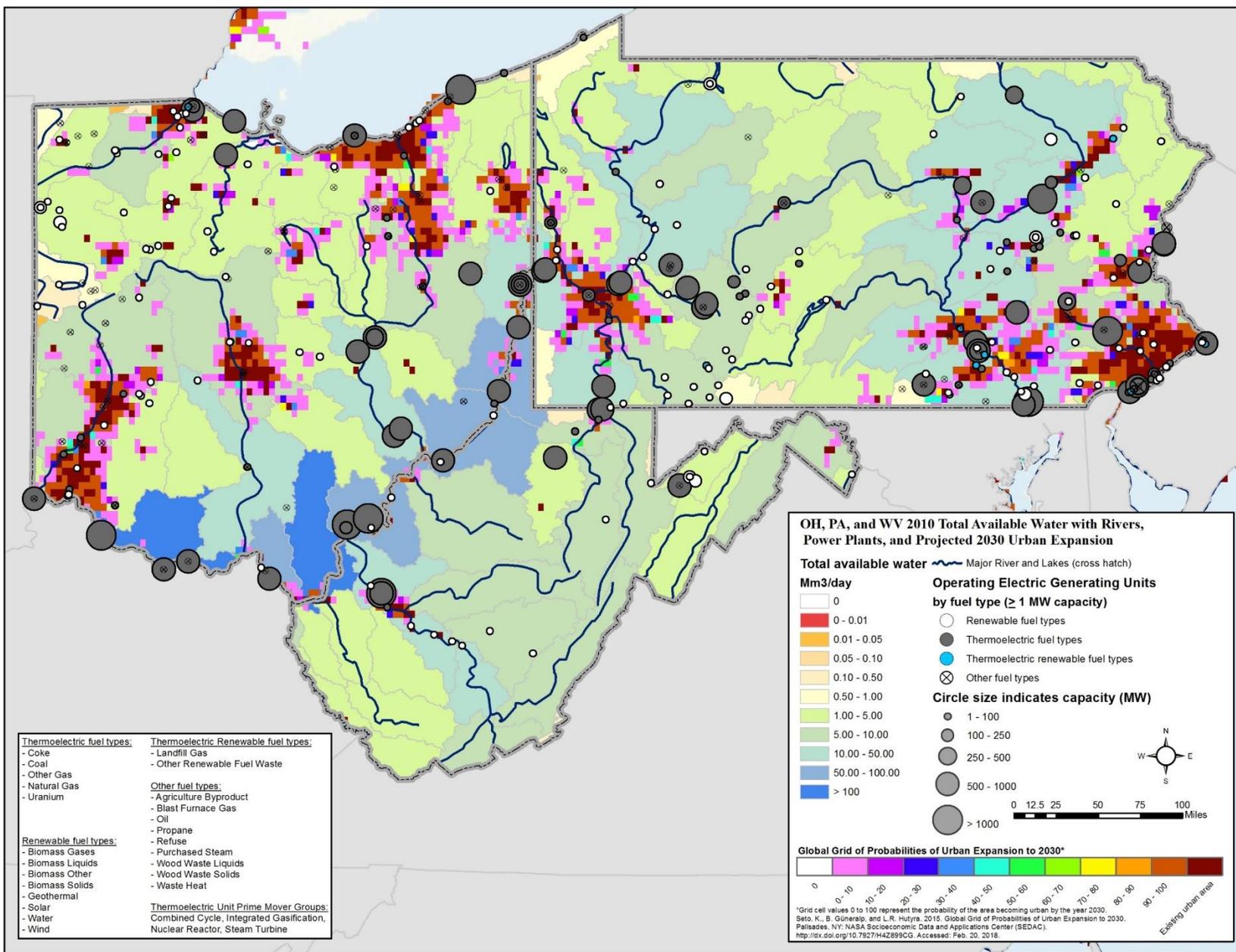
- Agriculture and thermoelectric water competition is a local issue that is difficult to decipher at the national scale; pinpointed advancements in water management and hybrid technologies may alleviate individual watershed stresses in Arkansas, Colorado, California, and Washington.
- Local thermoelectric power plant automation using sensors and controls may also limit the amount of water needed for electricity production.



Key locations where thermoelectric power and agriculture may compete for water in the future.

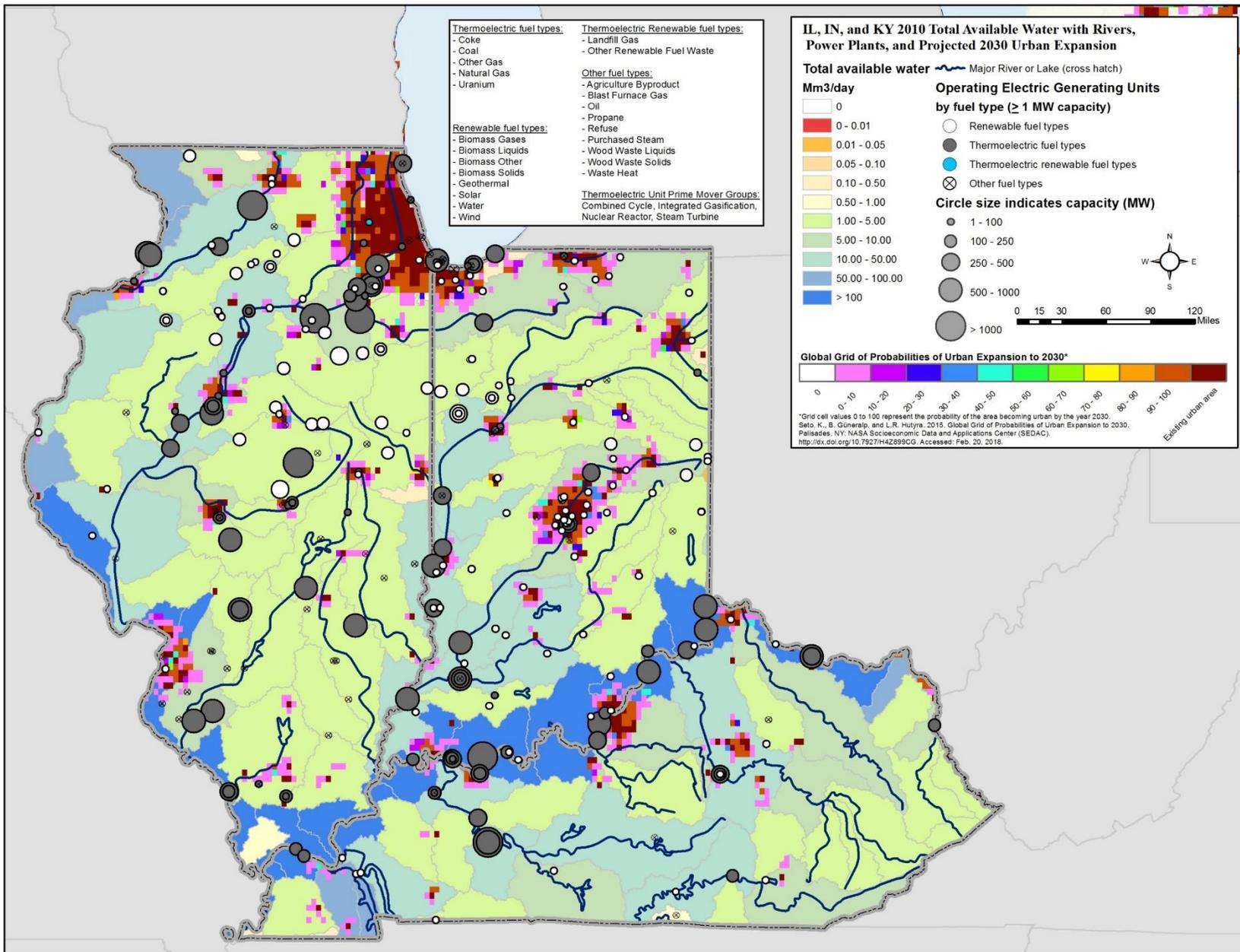
U.S. National Map of Agricultural Water Use with all Thermoelectric Power Plants





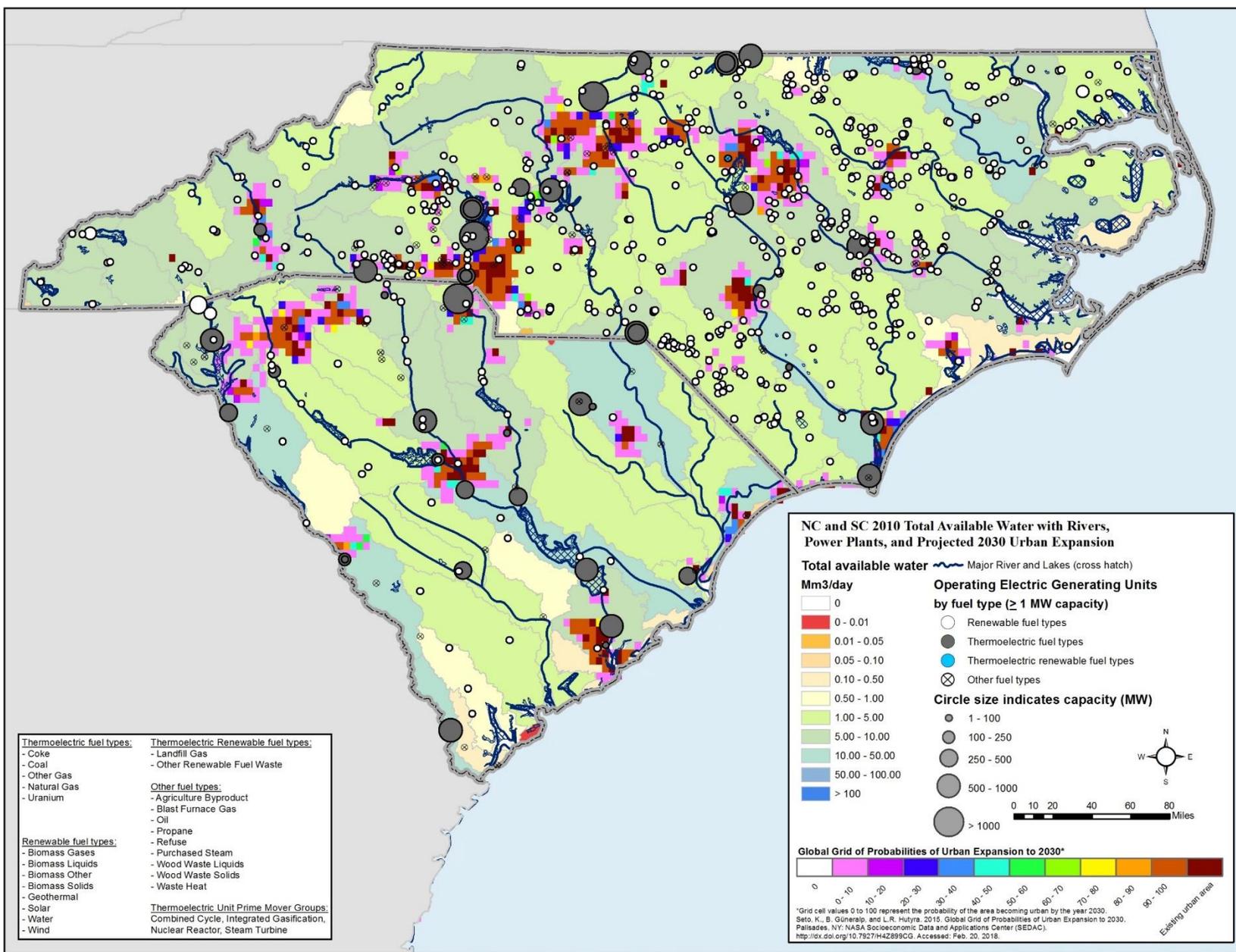
Northern Appalachia: Available Water and Thermolectric Power: R&D OPPORTUNITIES

- When multiple thermolectric power plants are placed upstream of one another, two issues impacting the ecosystem arise: increasing effluent water temperature and water quality.
- To ensure thermolectric power remains environmentally friendly, efficient cooling and water treatment detection technologies may benefit the Northern Appalachia region.



Midwest: Available Water and Thermoelectric Power: R&D OPPORTUNITIES

- Even though the Midwest region is water-rich and has a diversified energy portfolio, advancements in water quality detection may benefit the major cities in the region.
- Agriculture accounts for a significant portion of the Midwest's economy; designing effluent reuse techniques deployable in a drought may benefit both thermoelectric power and agriculture.

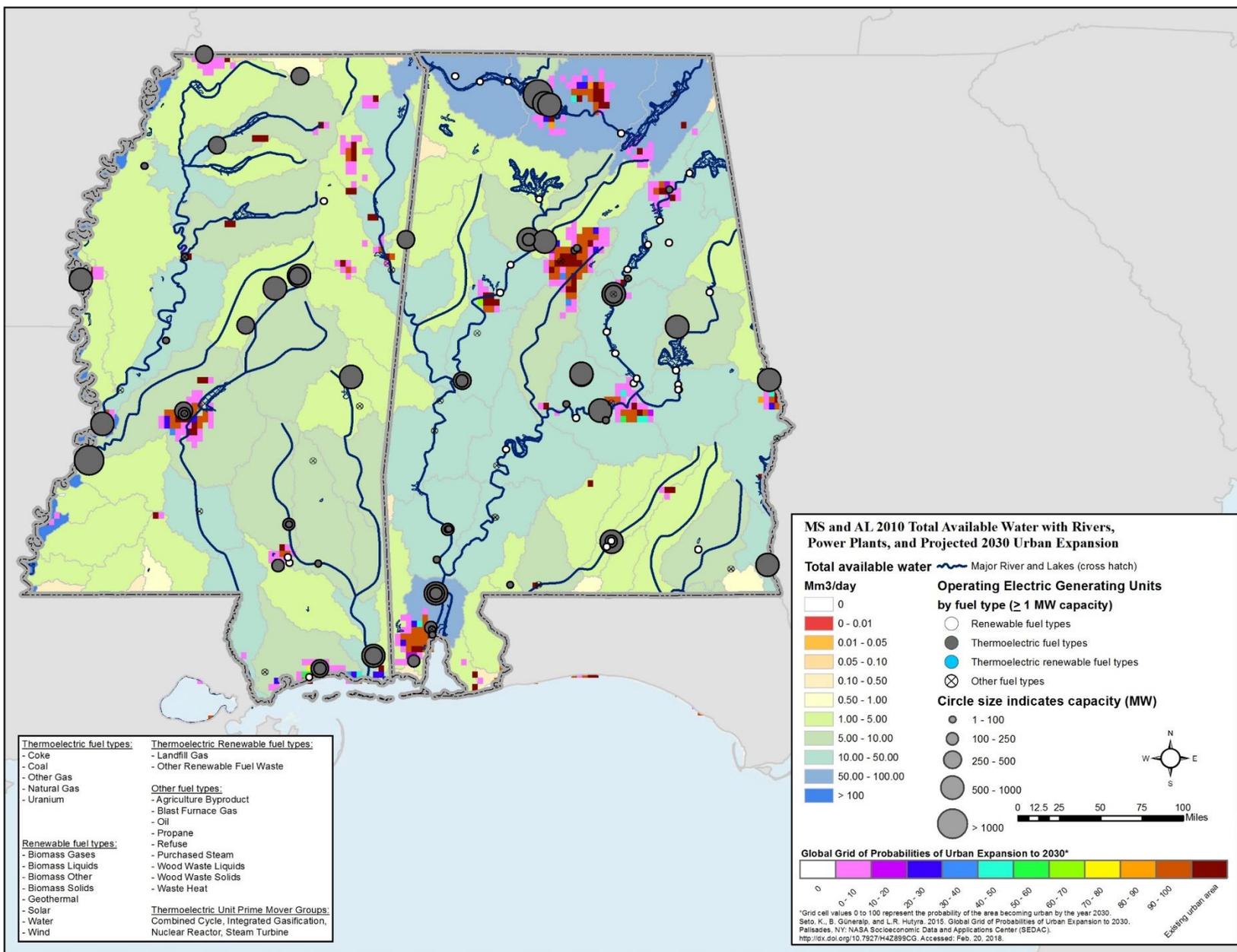


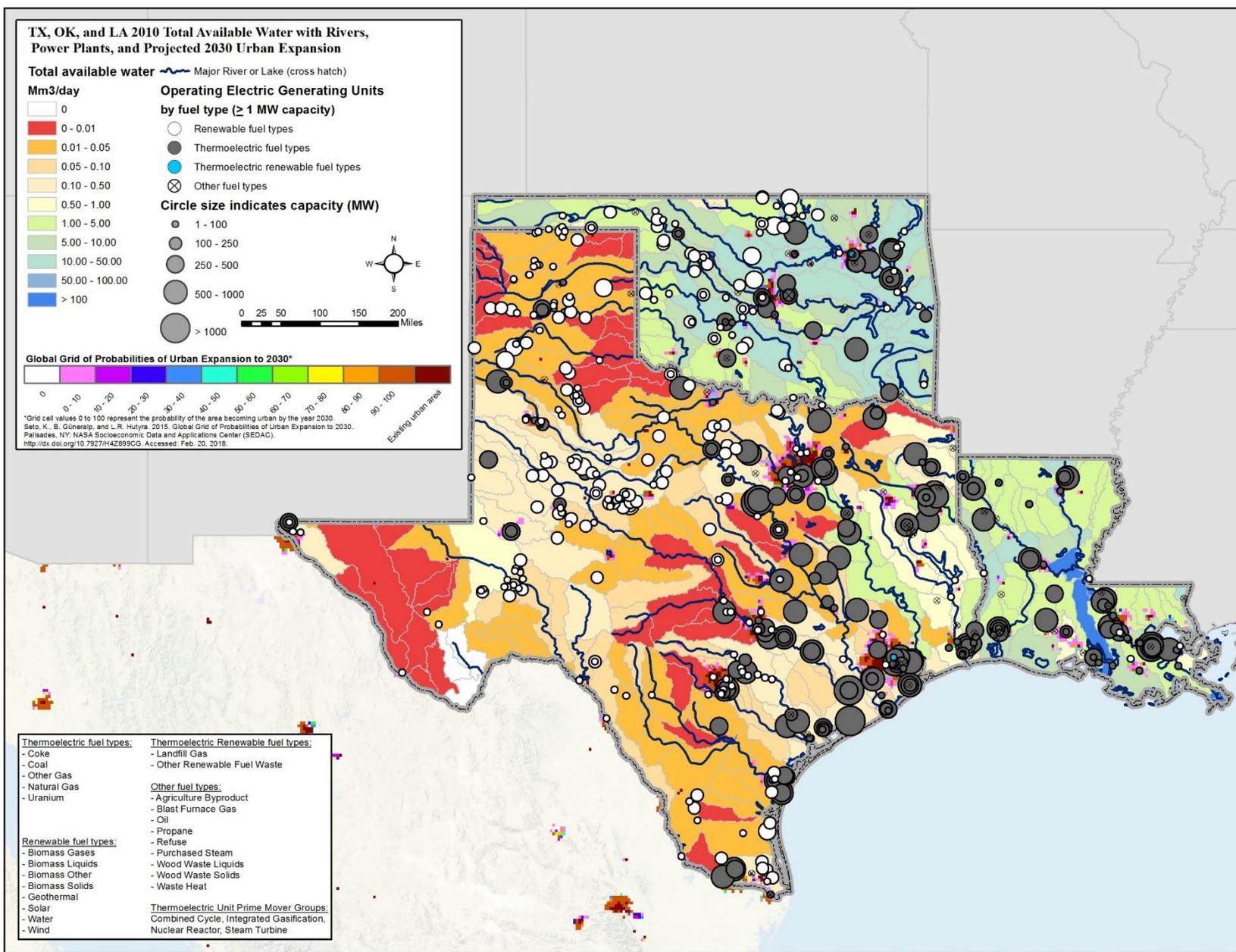
Southern Atlantic Coast: Available Water and Thermoelectric Power: R&D OPPORTUNITIES

- Due to potential cycling from distributed generation in this region, advancements in anti-corrosion materials, boilers, and load following may increase thermoelectric power efficiencies.
- The Carolinas are known for their unique estuaries; advancements reducing thermoelectric power effluent temperatures will help preserve these ecosystems.

Eastern Gulf Coast: Available Water and Thermoelectric Power: R&D OPPORTUNITIES

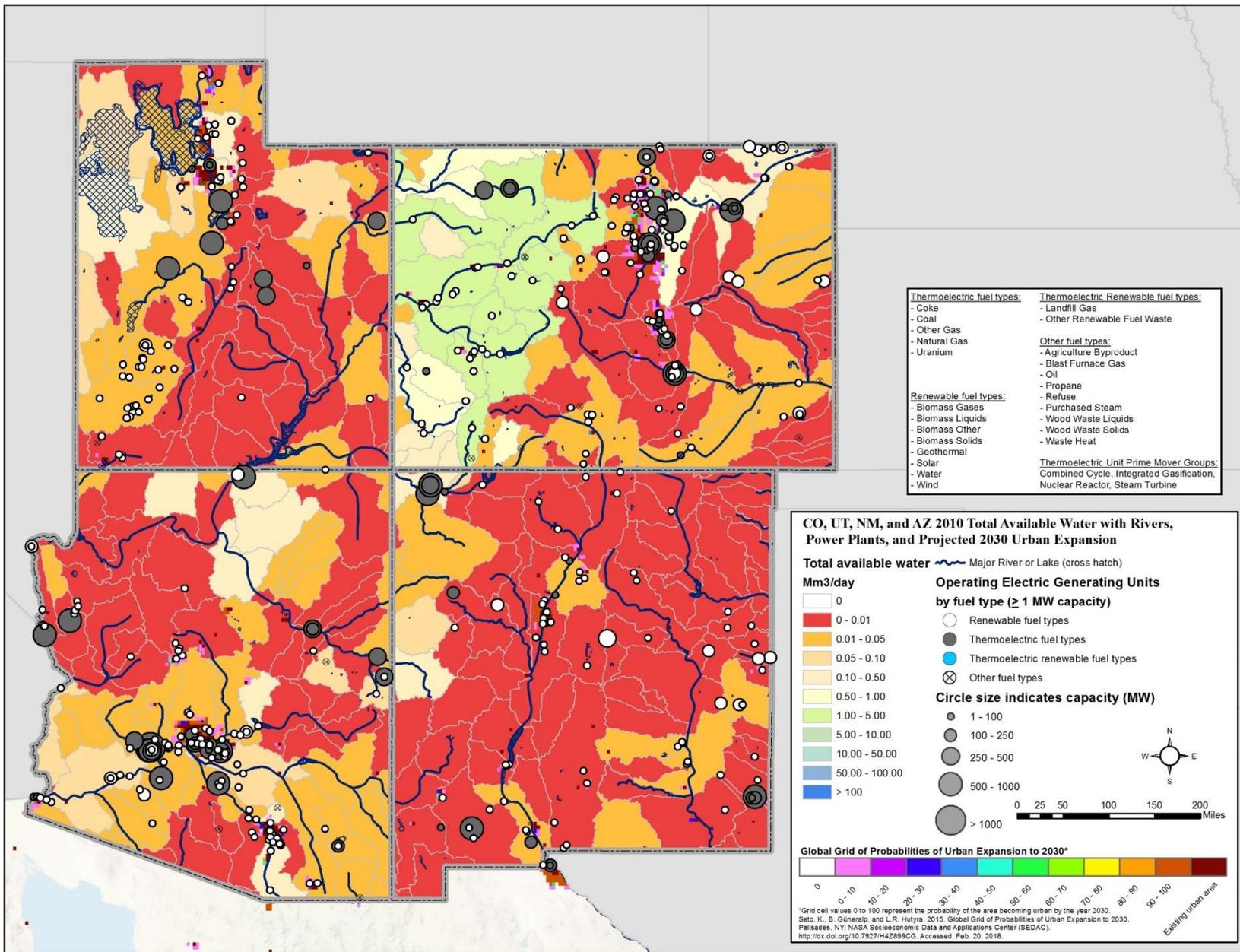
- Estuaries are common in the Gulf; alike the Carolinas, advancements reducing effluent temperatures will help preserve these ecosystems.
- Agriculture plays a major role in the Eastern Gulf Coast's economy; improvements treating alternative sources of water, such as brackish water, may alleviate future stresses between thermoelectric power and agriculture.





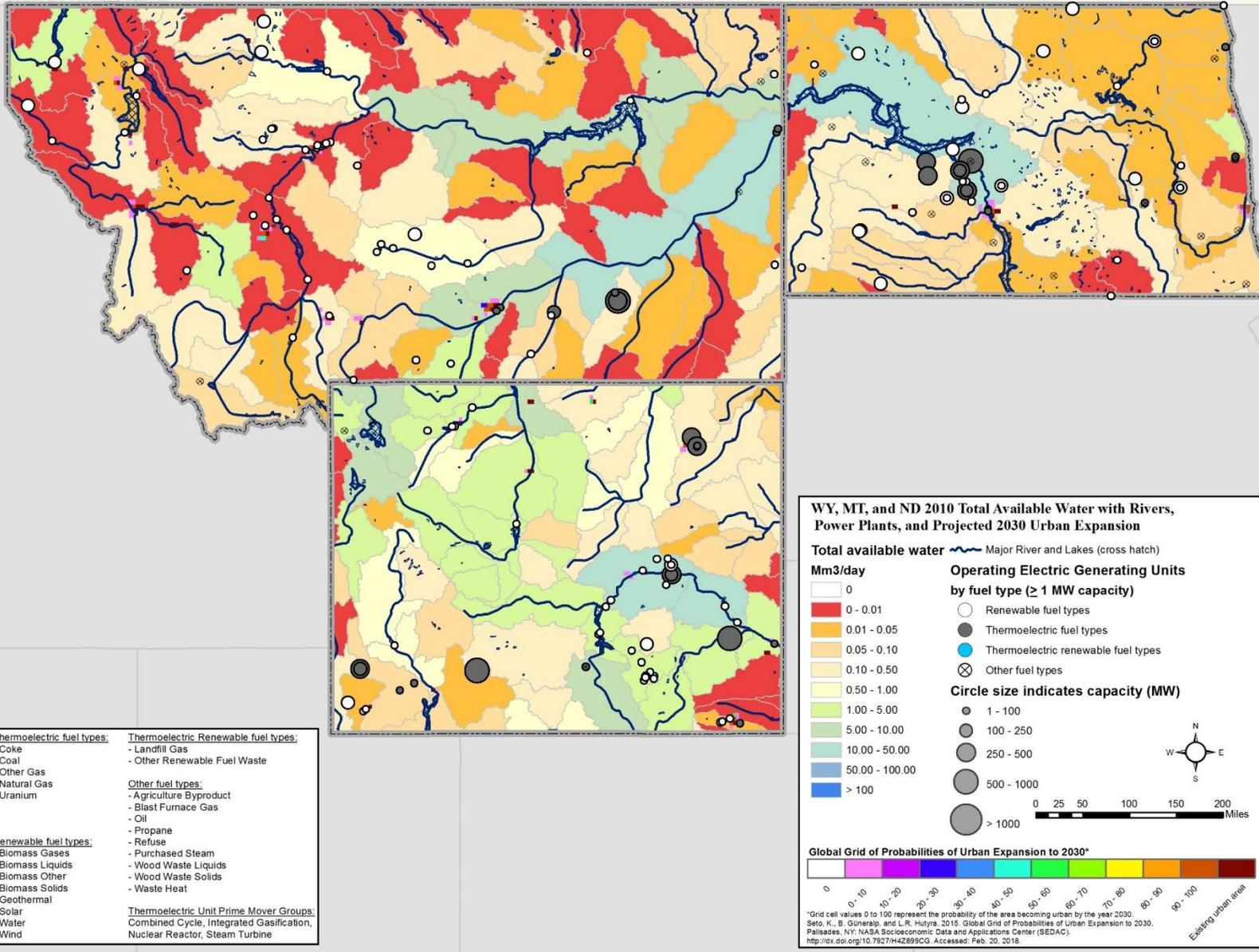
Western Gulf Coast: Available Water and Thermoelectric Power: R&D OPPORTUNITIES

- While Oklahoma and Louisiana in the Western Gulf Coast have moderate water availability, Texas is arid, and the region may benefit from advancements in dry cooling and hybrid technologies.
- Due to the high population density, improvements in water quality detection may also benefit the region and thermoelectric plants downstream of one another.



Mountain West: Available Water and Thermolectric Power: R&D OPPORTUNITIES

- The Mountain West is an arid region and may benefit from an array of advancements in thermolectric power production including: efficient water management practices, dry cooling, hybrid cooling, predictive maintenance, boilers, condensers, and anti-corrosion materials.
- The desert ecosystem is sensitive to environmental stimuli such as temperature fluxes, and reducing effluent temperatures will help preserve it.



Thermolectric fuel types: - Coke - Coal - Other Gas - Natural Gas - Uranium	Thermolectric Renewable fuel types: - Landfill Gas - Other Renewable Fuel Waste
Renewable fuel types: - Biomass Gases - Biomass Liquids - Biomass Other - Biomass Solids - Geothermal - Solar - Water - Wind	Other fuel types: - Agriculture Byproduct - Blast Furnace Gas - Oil - Propane - Refuse - Purchased Steam - Wood Waste Liquids - Wood Waste Solids - Waste Heat
Thermolectric Unit Prime Mover Groups: Combined Cycle, Integrated Gasification, Nuclear Reactor, Steam Turbine	

Northern Mountain West: Available Water and Thermolectric Power: R&D OPPORTUNITIES

- The Northern Mountain West is arid and may benefit from a similar array of advancements as the Mountain West: efficient water management practices, dry cooling, hybrid cooling, predictive maintenance, boilers, condensers, and anti-corrosion materials.
- The mountainous region is prone to extreme weather events and may benefit from modular power systems to prevent local outages.

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Acknowledgements

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Conversion factor: To convert from million meters cubed (Mm³) to acre foot, multiply by 810.714.