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science for a changing world

Water availability in the Upper Mississippi River Basin

USGS Water Resources Mission Area
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Do we have enough water?

How much water do we use?

How does water quality impact water availability?

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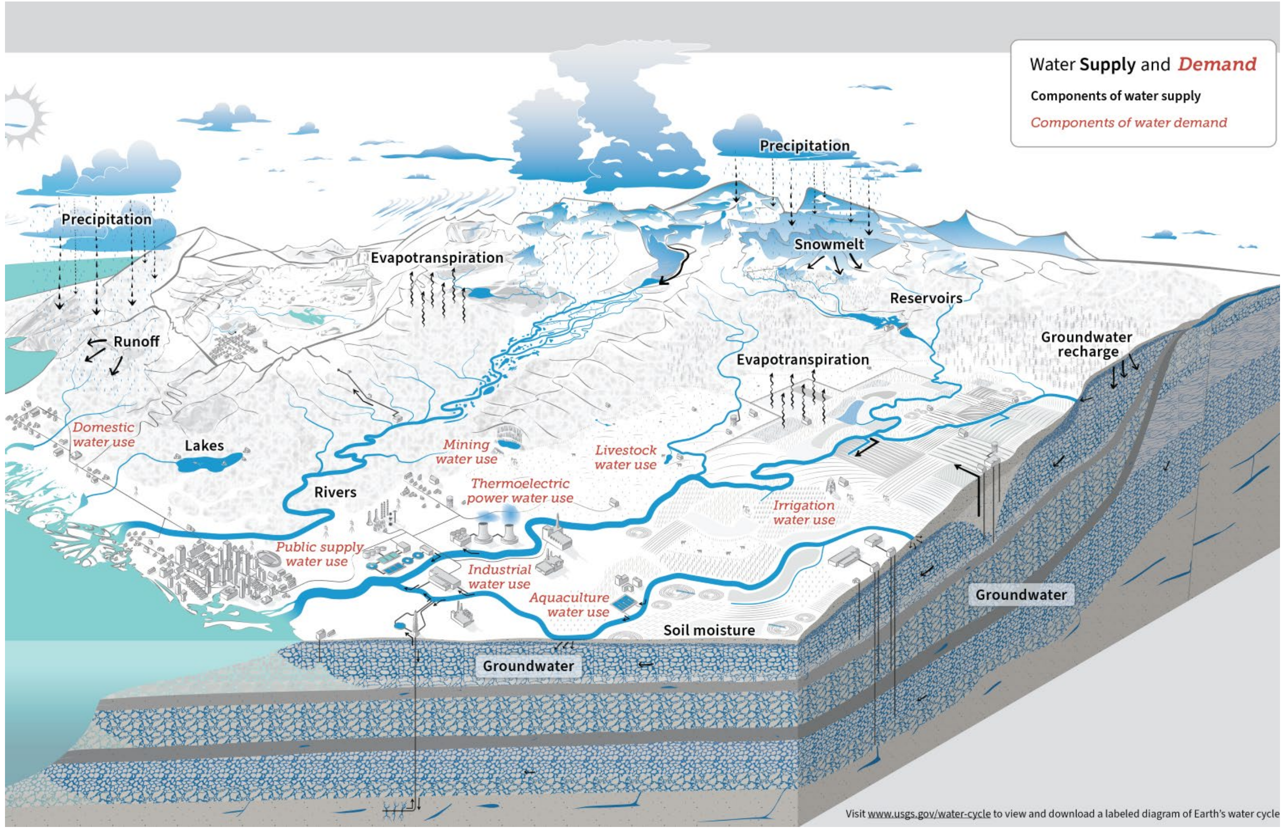
National Water Availability Assessment

Comprehensive, scientific assessment of water availability in the United States, integrating water quantity, quality, and use

First of its kind – provides **new water availability information**, including potential imbalance between water supply and demand

Complementary to forthcoming Regional Water Availability Assessments



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Water Supply

Water quantity

Water quality

Water Demand

Water use

Ecosystem health

Water Supply

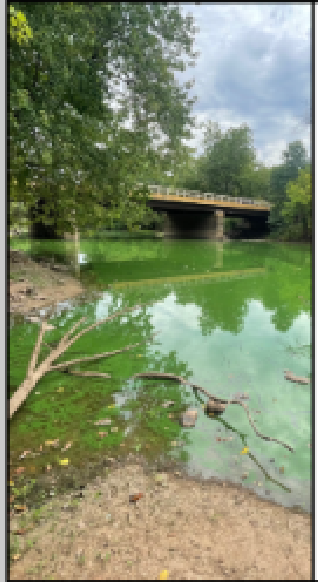
Water Quantity

Primary Components

Surface Water:
- streamflow
- runoff
- snow water equivalent
- precipitation
- evapotranspiration
- soil moisture
- storage

Groundwater:
- recharge
- storage

Reservoirs
- storage



Water Quality

Primary Components

Surface Water:
- salinity
- nutrients
- sediment
- water temperature

Groundwater:
- salinity
- nutrients

Secondary Components

- pesticides
- per- and polyfluoroalkyl substances (PFAS)
- harmful algal blooms
- metals
- geogenic constituents

Water Demand

Water Use

Primary Components

Withdrawal and consumption for:
- public supply
- irrigation
- thermoelectric power
- domestic
- industrial
- mining
- livestock
- aquaculture

Aquatic Community Health

Primary Components

- fish community health

Secondary Components

- invertebrates
- algae

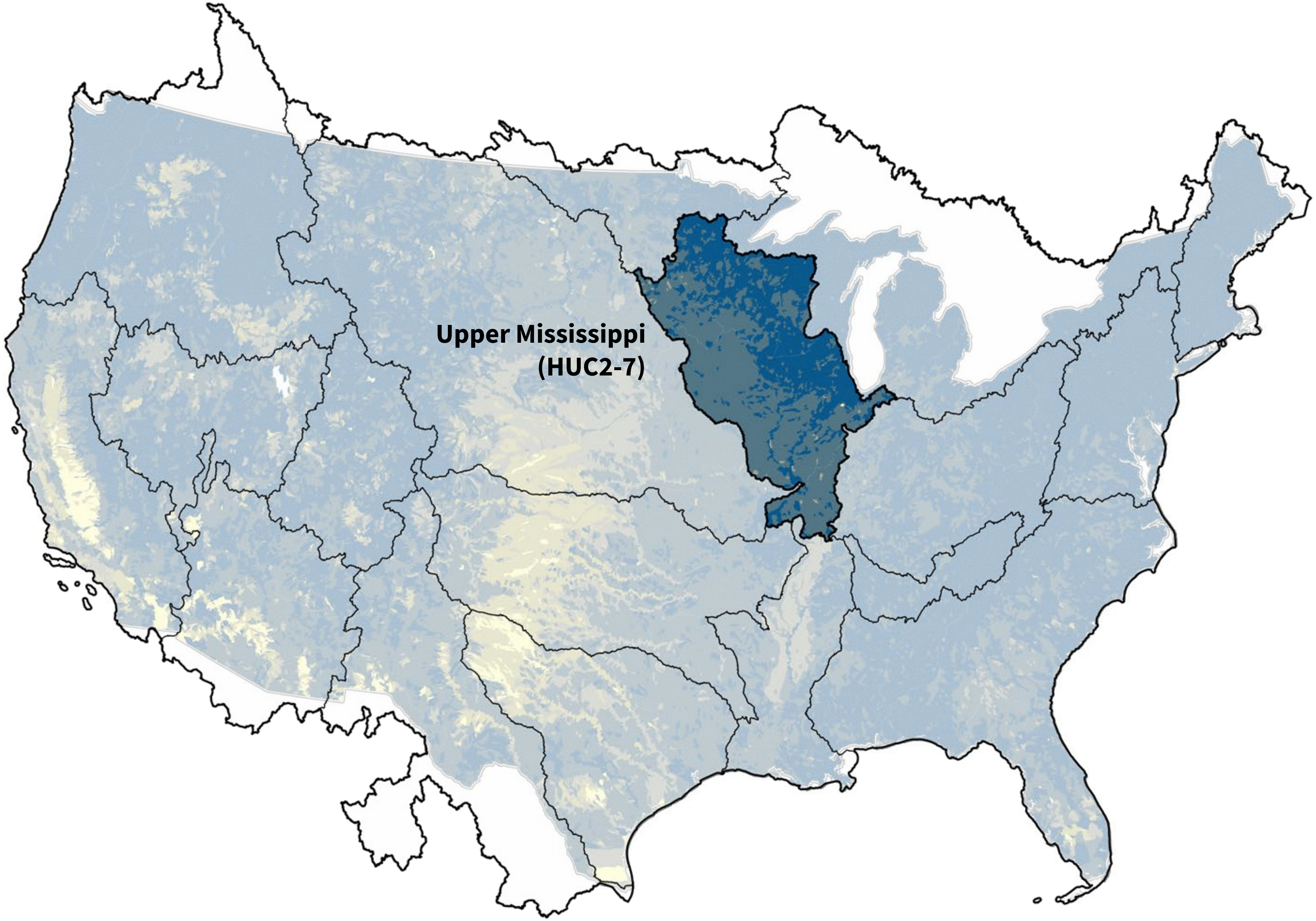
Do we have enough water?

Water limitation

Supply and Use Index (SUI)

- Severe (0.8-1)
- High (0.6-0.8)
- Moderate (0.4-0.6)
- Low (0.2-0.4)
- Very low (0-0.2)

SUI is the imbalance between surface water supply and water use.



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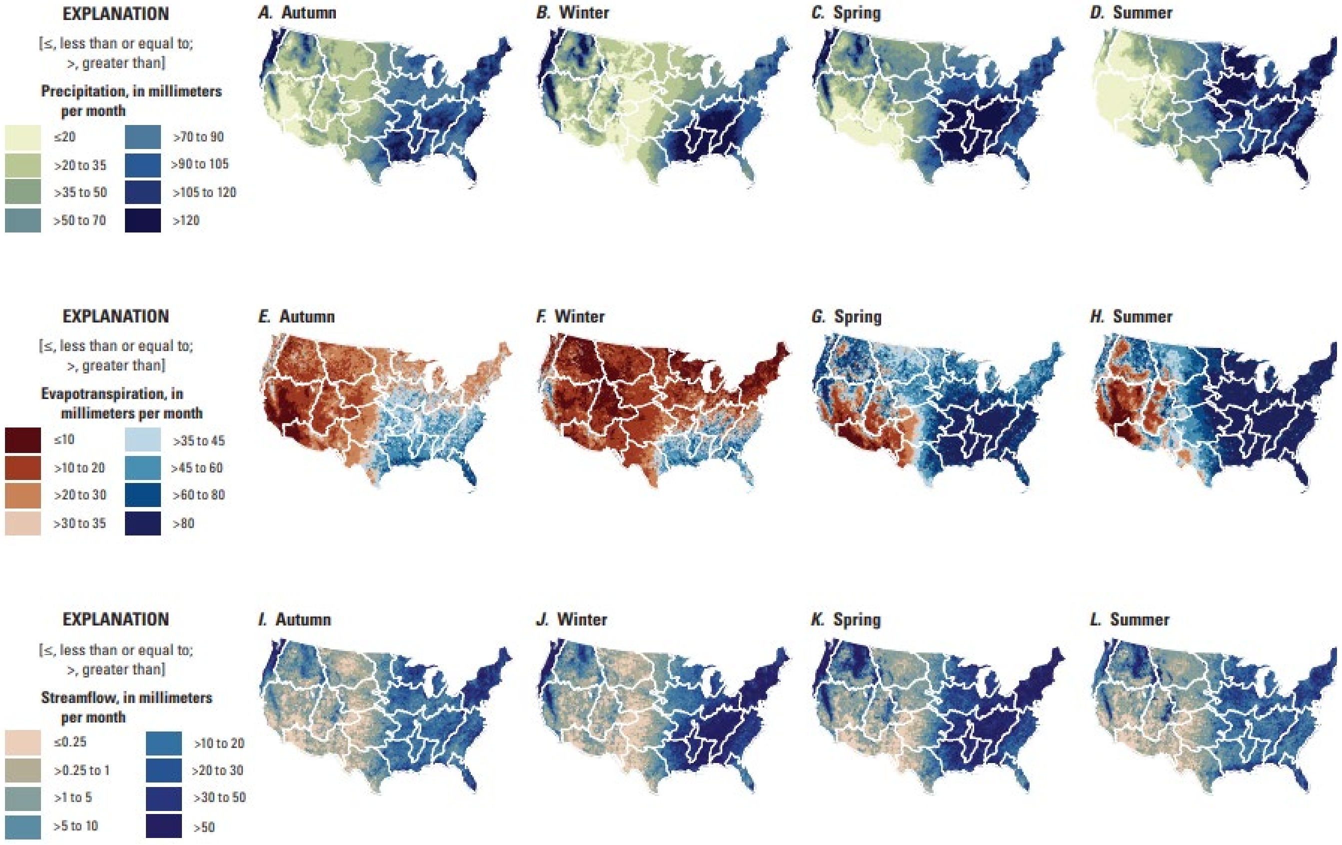
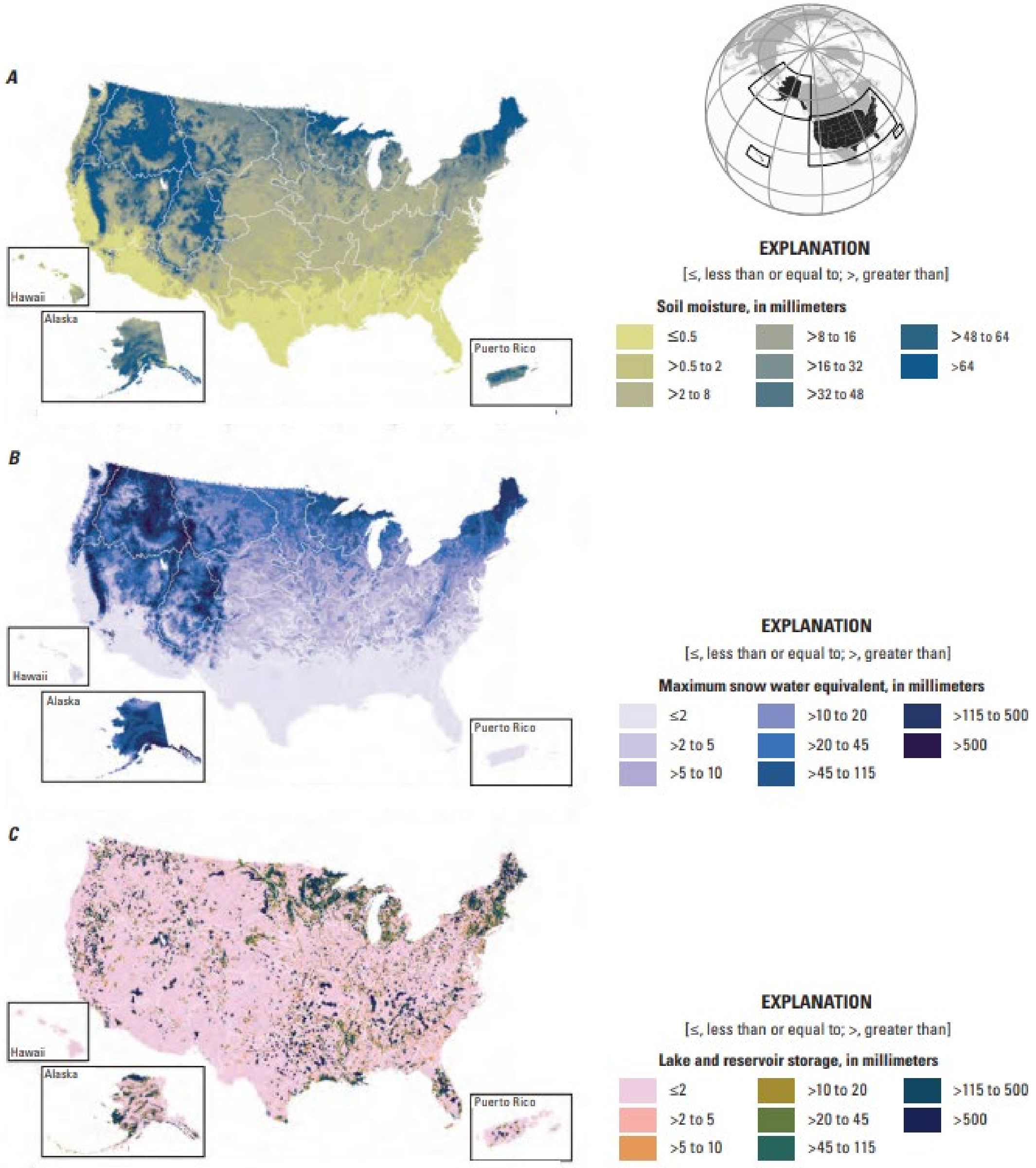
Surface Water Supply





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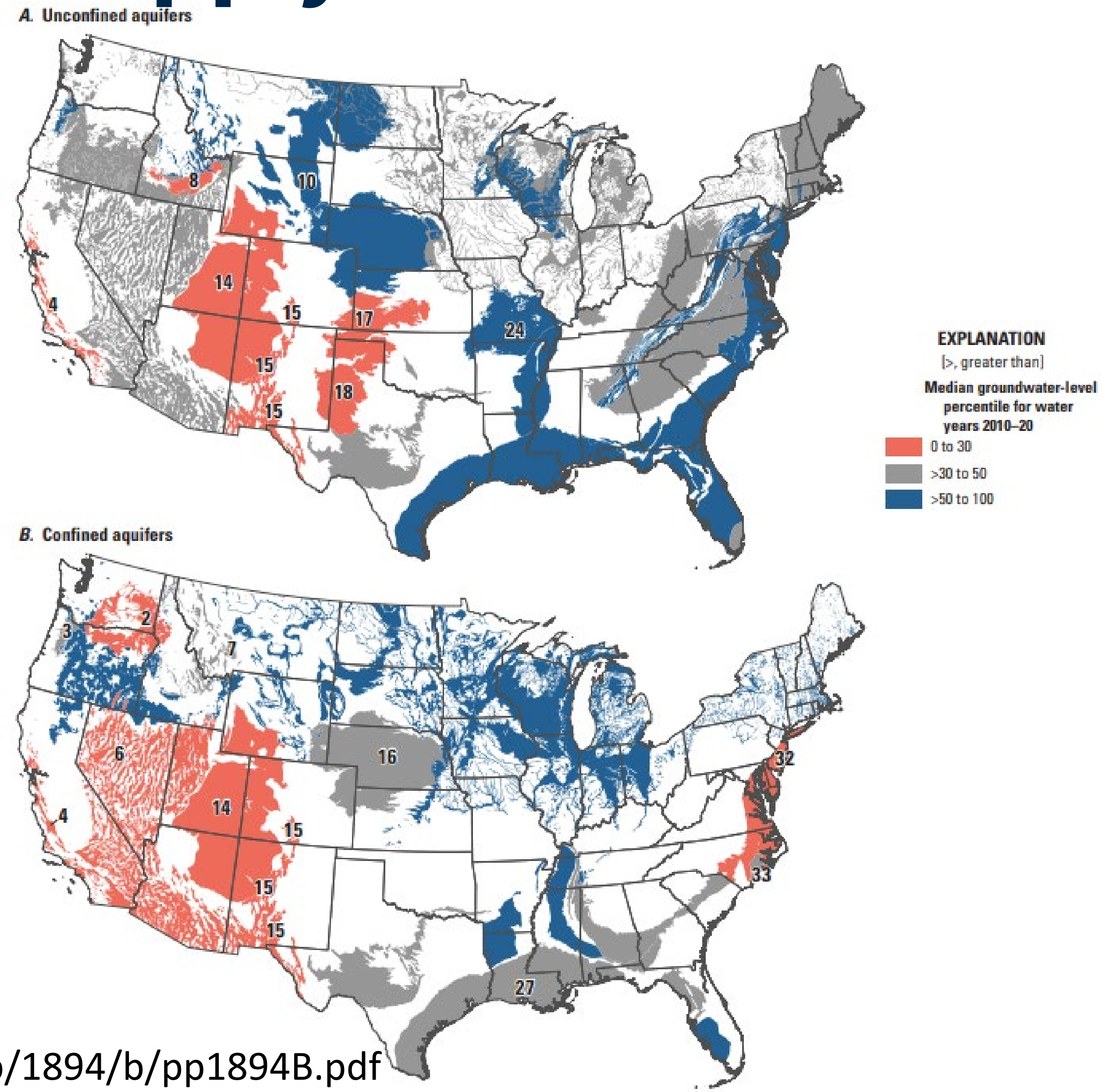
https://pubs.usgs.gov/pp/1894/b/pp1894B.pdf

Groundwater Supply



https://pubs.usgs.gov/pp/1894/b/pp1894B.pdf

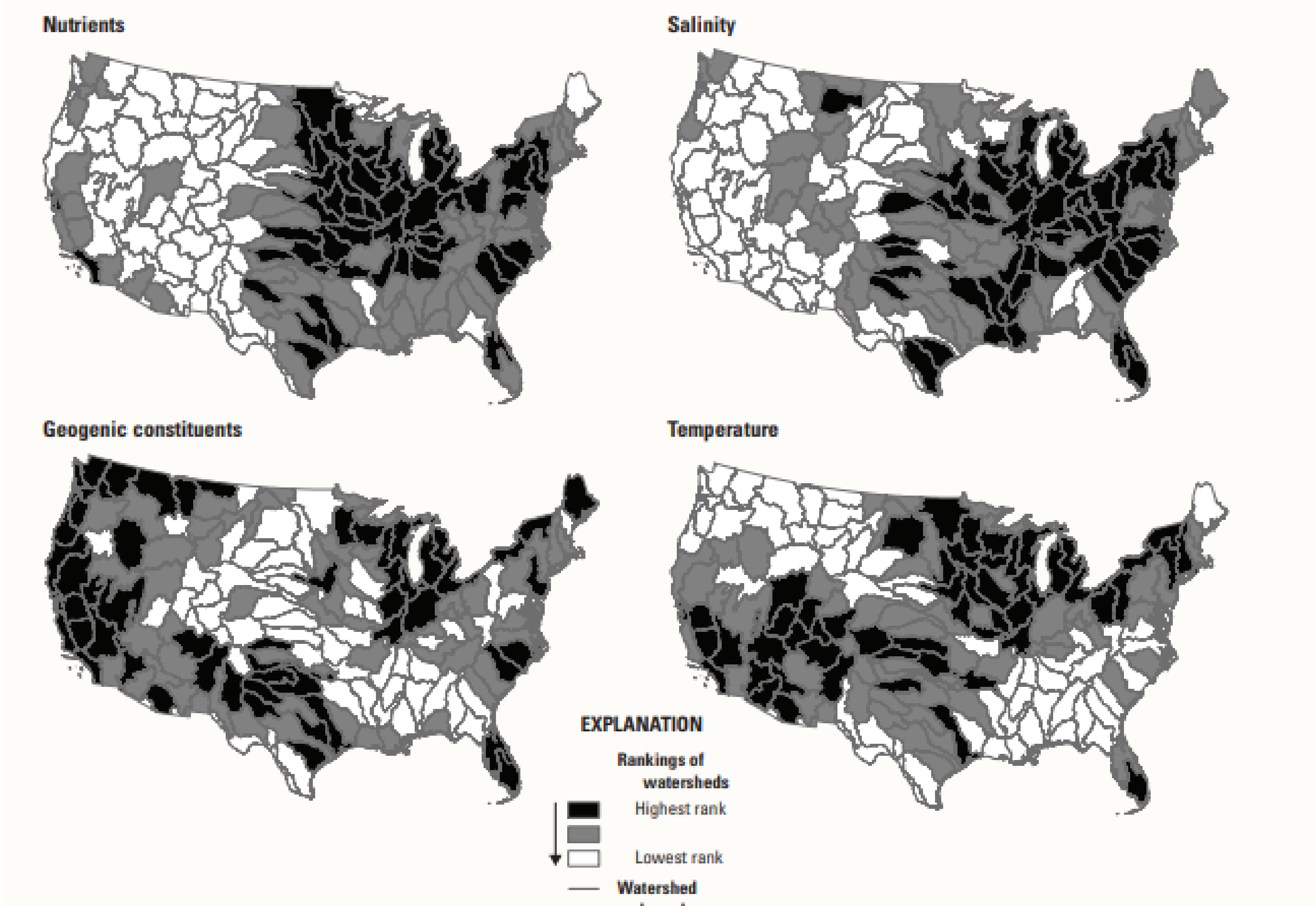
Data support

Martinez, A.J., Padilla, J.A., and Gorski, G., 2025, Monthly ensemble outputs from the National Hydrologic Model Precipitation-Runoff Modeling System and the Weather Research and Forecasting model hydrologic modeling system for the conterminous United States, Alaska, Hawaii, and Puerto Rico for water years 2010–2020: U.S. Geological Survey data release, https://doi.org/10.5066/P1RBMDUT.

- WRF-Hydro modeling application CONUS404 2009-2021
- NHM-PRMS modeling application CONUS404 1980-2021

Is the water of the right quality for humans and ecology?

Water Quality Gaps



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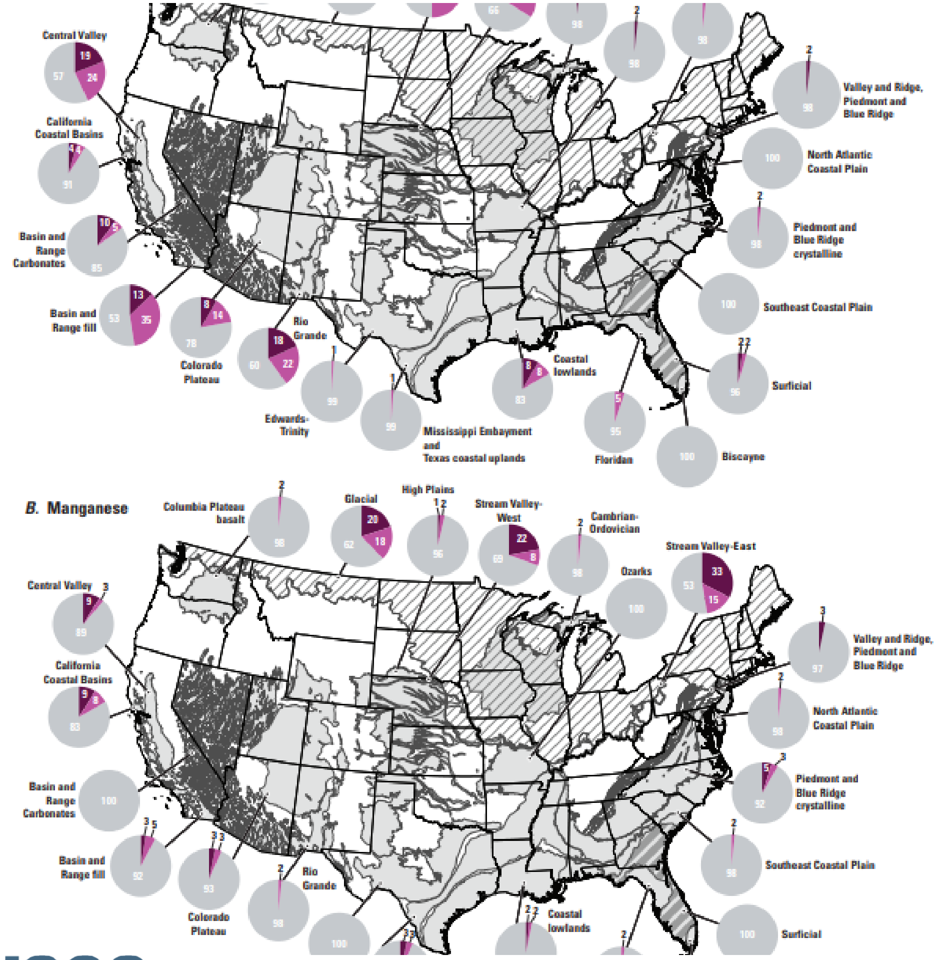
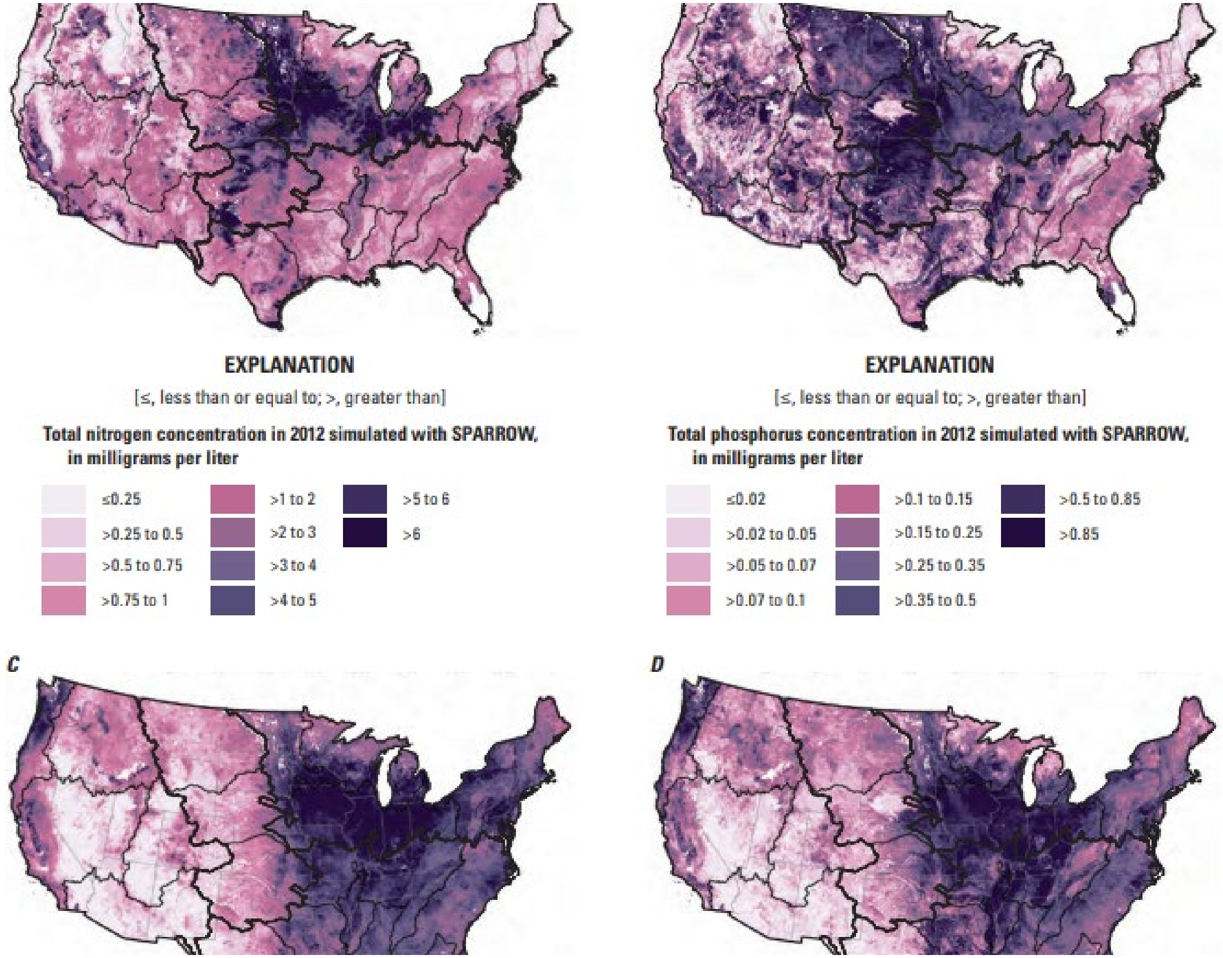
Water Quality (surface water and groundwater)



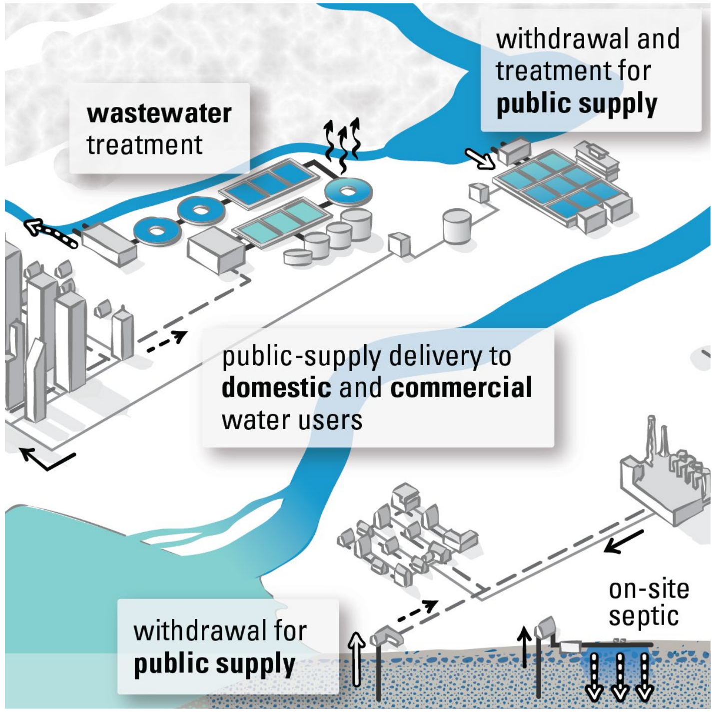


What volume of water are we withdrawing and consuming?

When are we using the water?

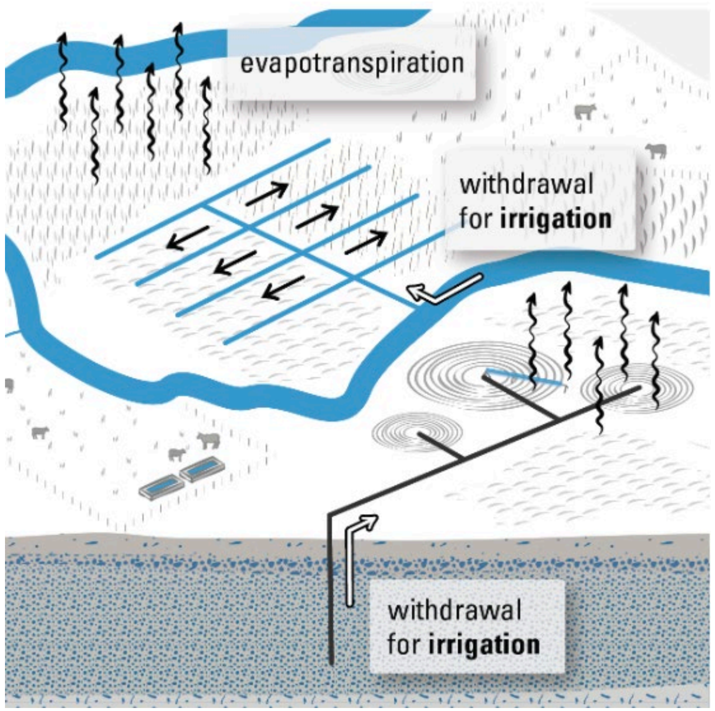
What are we using the water for?

Water Use (Demand)



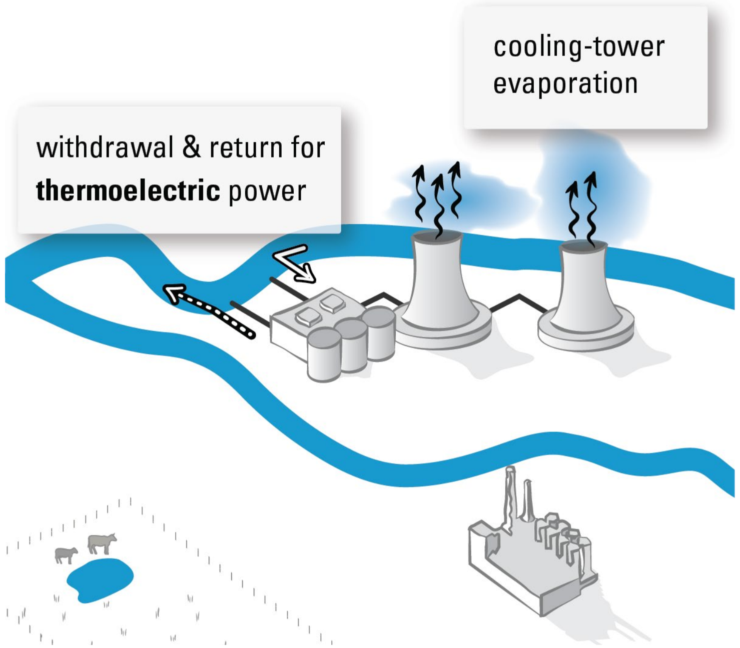
Public supply

7% of water consumptive water use



Crop irrigation

90% of consumptive water use



Thermoelectric power

3% of consumptive water use

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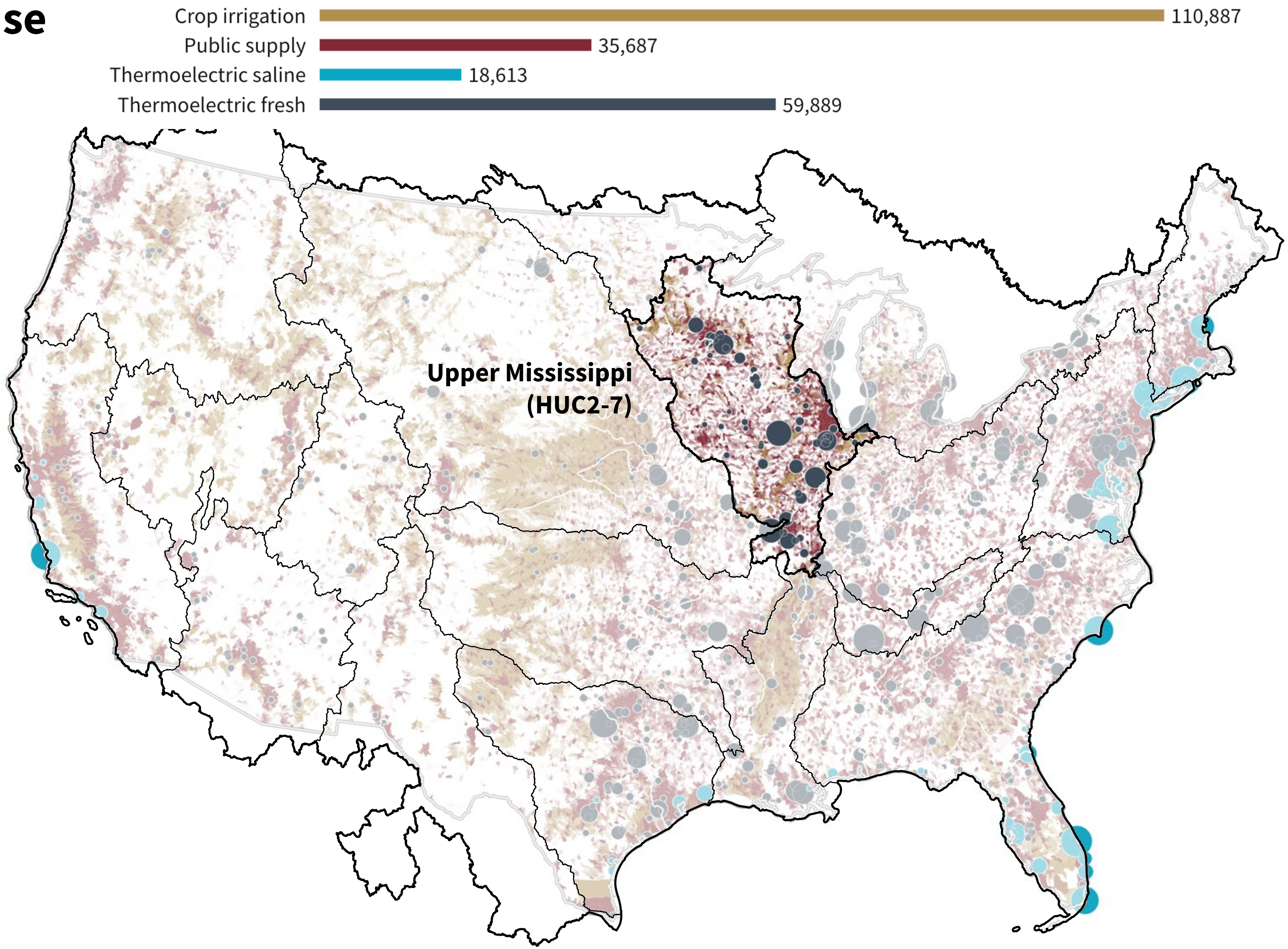
Average daily water use

Millions of gallons
used per day in 2020



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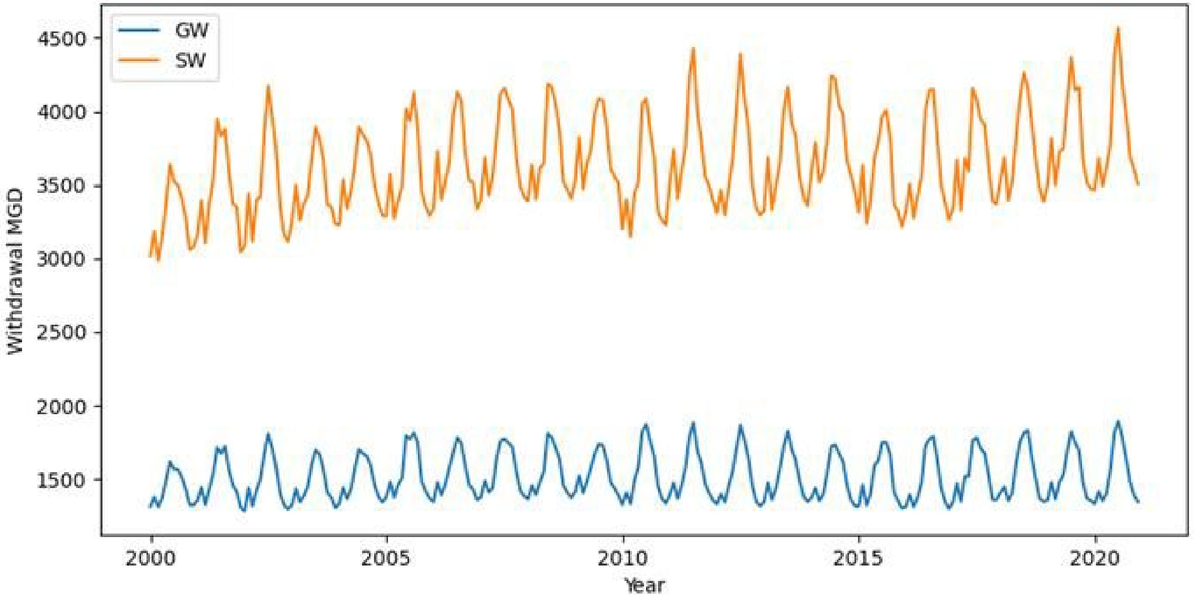
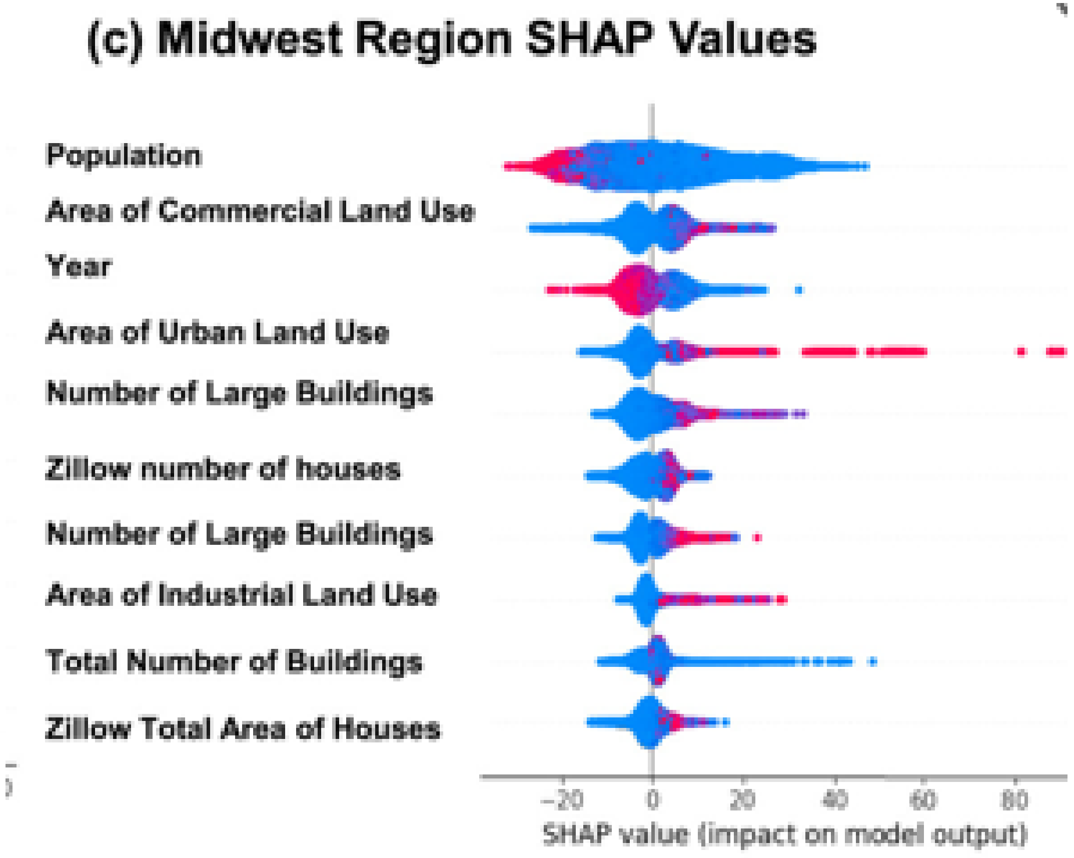
Public Supply





Luukkonen, C.L., Alzraiee, A.H., Larsen, J.D., Martin, D.J., Herbert, D.M., Buchwald, C.A., Houston, N.A., Valseth, K.J., Paulinski, S., Miller, L.D., Niswonger, R.G., Stewart, J.S., Dieter, C.A., and Miller, O.L., 2023, Public supply water use reanalysis for the 2000-2020 period by HUC12, month, and year for the conterminous United States: U.S. Geological Survey data release, (ver. 2.0, August 2024): https://doi.org/10.5066/P9FUL880.

Alzraiee, A., Niswonger, R., Luukkonen, C., Larsen, J., Martin, D., Herbert, D., et al. (2024). Next generation public supply water withdrawal estimation for the conterminous United States using machine learning and operational frameworks. *Water Resources Research*, 60, e2023WR036632. https://doi.org/10.1029/2023WR036632

Alzraiee, A. H., & Niswonger, R. G. (2024). A probabilistic approach to training machine learning models using noisy data. *Environmental Modelling & Software*, 179, 106133. https://doi.org/10.1016/j.envsoft.2024.106133

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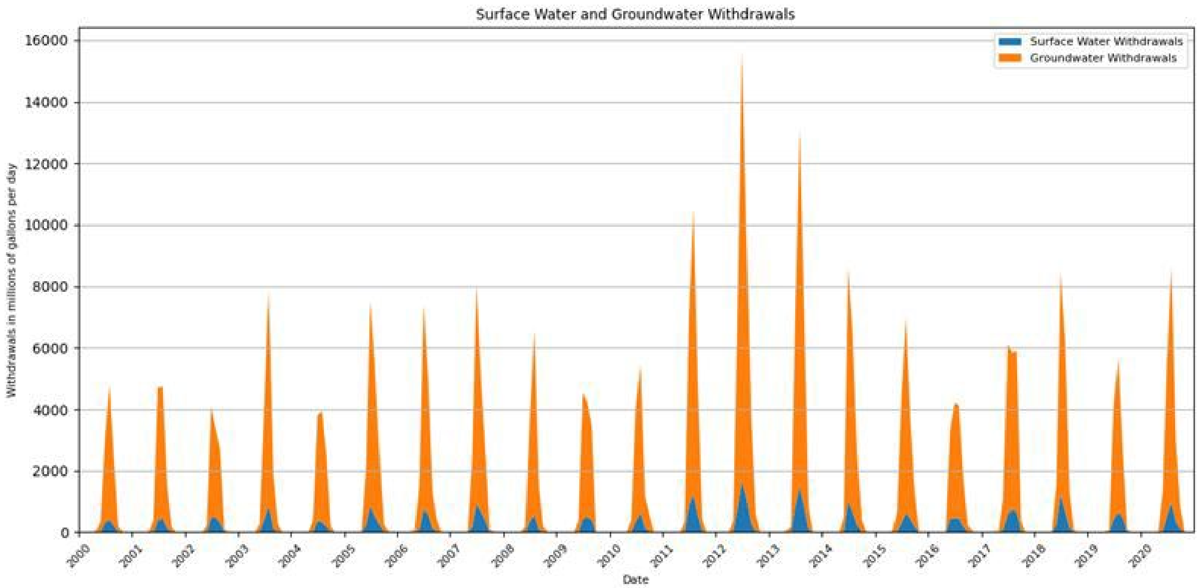

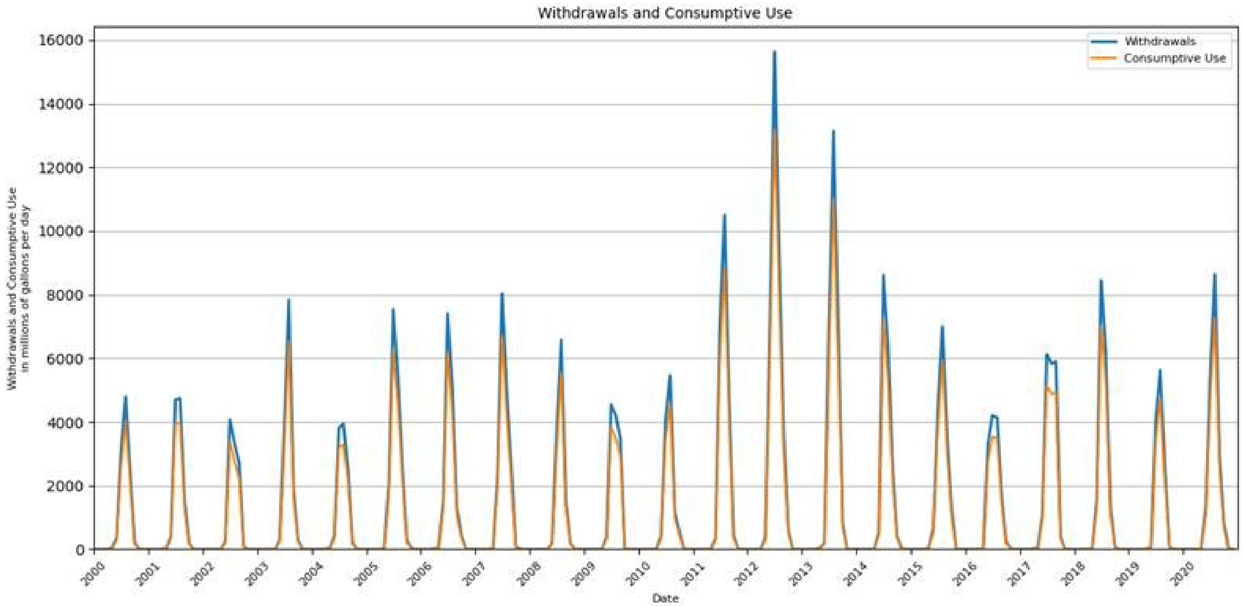

Figure 13. Model estimates of crop-irrigation water withdrawals by month by 12-digit hydrologic unit codes (HUC12s) for the conterminous United States, averaged for water years 2010–20. Black lines indicate hydrologic region boundaries. Model estimates for crop-irrigation water withdrawals are from Haynes and others (2024).

Irrigation

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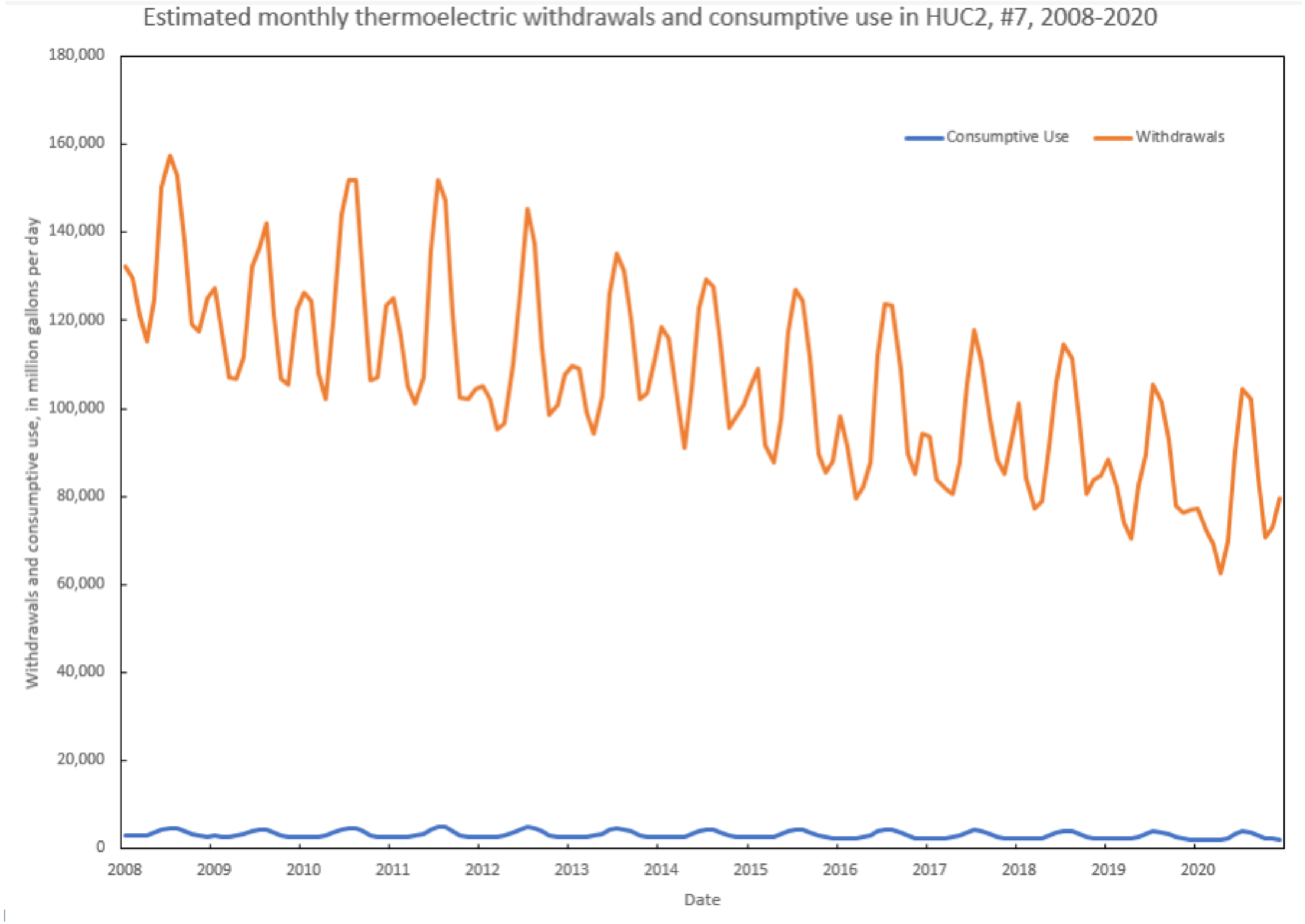
Martin, D.J., Regan, R.S., Haynes, J.V., Read, A.L., Henson, W.R., Stewart, J.S., Brandt, J.T., and Niswonger, R.G., 2023, Irrigation water use reanalysis for the 2000-20 period by HUC12, month, and year for the conterminous United States (ver. 2.0, September 2024): U.S. Geological Survey data release, https://doi.org/10.5066/P9YWR0OJ.
Haynes, J.V., Read, A.L., Chan, A.Y., Martin, D.J., Regan, R.S., Henson, W.R., Niswonger, R.G., and Stewart, J.S., 2023, Monthly crop irrigation withdrawals and efficiencies by HUC12 watershed for years 2000-2020 within the conterminous United States (ver. 2.0, September 2024): U.S. Geological Survey data release, https://doi.org/10.5066/P9LGISUM.

Thermoelectric



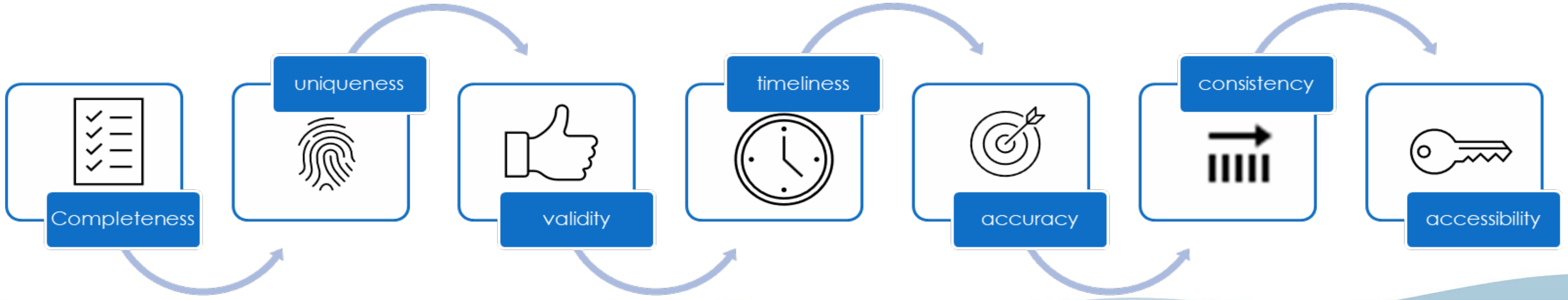
Gorman Sanisaca, L.E., Galanter, A.E., Skinner, K.D., Harris, M.A., Diehl, T.H., Halper, A.S., Mohs, T.G., Roland, V.L., Stewart, J.S., and Niswonger, R., 2023, Thermoelectric-power condenser duty estimates by month and cooling type for use to calculate water use by power plant for the 2008-2020 reanalysis period for the conterminous United States: U.S. Geological Survey, https://doi.org/10.5066/P9XG876W.

Galanter, A.E., Gorman Sanisaca, L.E., Skinner, K.D., Harris, M.A., Diehl, T.H., Chamberlin, C.A., McCarthy, B.A., Halper, A.S., Niswonger, R.G., Stewart, J.S., Markstrom, S.L., Embry, I., and Worland, S., 2023, Thermoelectric-power water use reanalysis for the 2008-2020 period by power plant, month, and year for the conterminous United States: U.S. Geological Survey data release, https://doi.org/10.5066/P9ZE2FVM.

M.A. Harris, T.H. Diehl, L.E. Gorman-Sanisaca, A.E. Galanter, M.A. Lombard, K.D. Skinner, C. Chamberlin, B.A. McCarthy, R. Niswonger, J.S. Stewart, J. Valseth Kristen, Automating physics-based models to estimate thermoelectric-power water use, *Environmental Modelling & Software*,2024,106265, ISSN 1364-8152, https://doi.org/10.1016/j.envsoft.2024.106265.

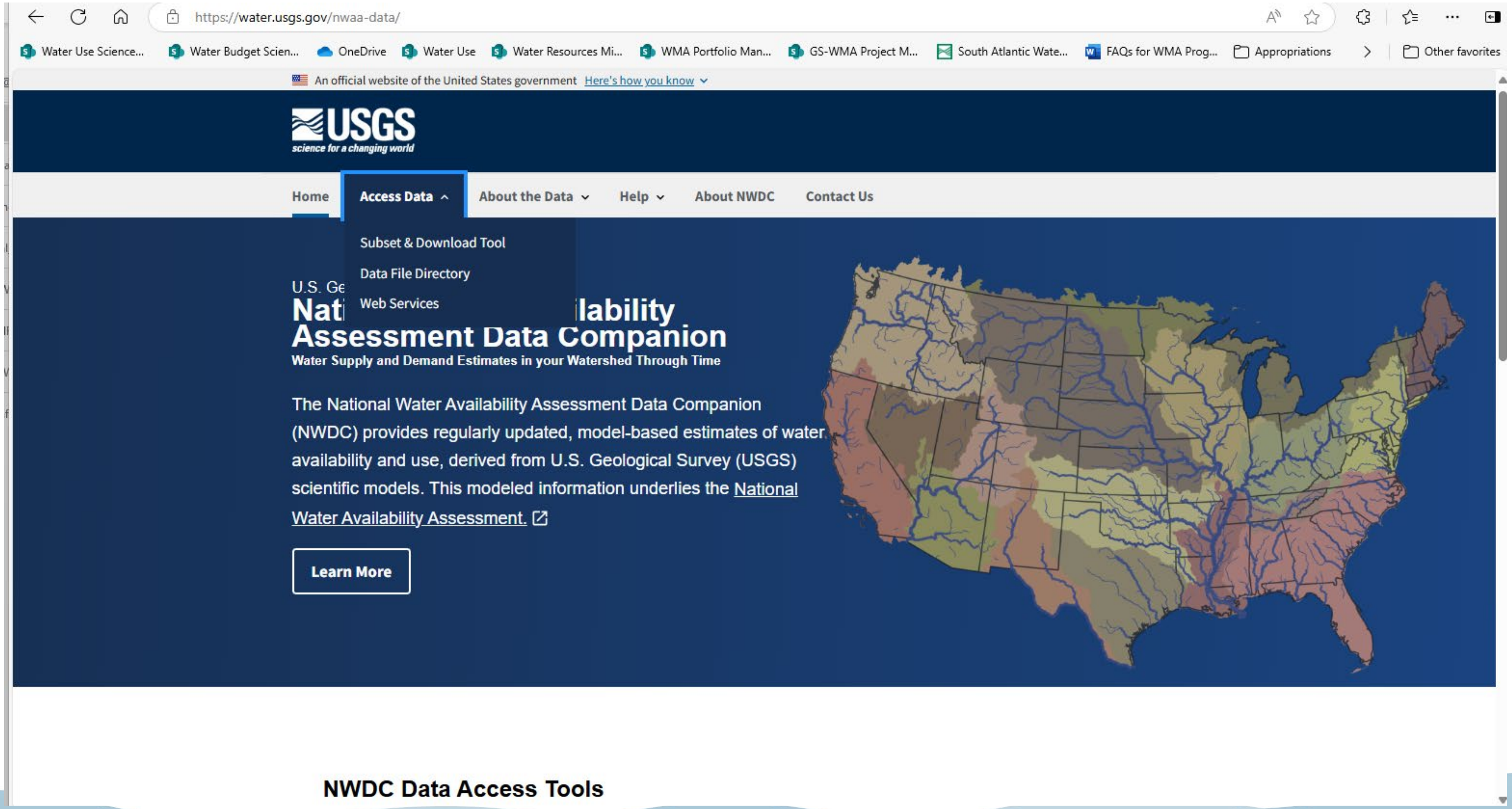
Water use to come

- Additional categories and more attributes associated with the withdrawal and consumptive use estimates
- Sub-category of use based on NAICs
  - NAICs codes, focusing on largest industries first.
  - Specifically working on adding Data Center
- Biggest limitation are available data to use for training and validation.



Data Companion

Get the data:
water.usgs.gov/nwaa-data



Insights for Upper Mississippi River Basin (Midwest hydrologic region)

- The combination of low precipitation and little annually renewable storage in soil moisture, snow, or lakes and reservoirs is a condition where water-availability concerns are likely to emerge or are already prevalent. These areas included the Midwest.
- Combined storage components across the CONUS constituted about 24 % of annual precip. with the remaining amount partitioned between streamflow and ET. The Midwest is 8.5%
- More consistent water supply compared to areas that are heavily reliant on precipitation from a single season to sustain water supplies for the remainder of the year
- Midwest hydrologic region had low precipitation totals in water years 2011 and 2012. The lack of rain resulted in low streamflow, ET, and soil moisture, and resulted in one of the most substantial droughts since the 1930s.
- Wettest soil-moisture conditions during 2019-2020
- Groundwater concentrations of nitrate and arsenic were elevated in a much smaller proportion of the CONUS, although areas with elevated concentrations can present risks to populations that depend on groundwater as a drinking-water source. Midwest- public supply is dominated by surface water
- Streams with nitrogen and phosphorus concentrations greater than reference conditions were widespread across the CONUS. More than 50 percent of the stream reaches in eight of the hydrologic regions including the Midwest were at least four times higher than ecologically relevant reference conditions.

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Insights for Upper Mississippi River Basin (Midwest hydrologic region)

- Streams with nitrogen and phosphorus concentrations greater than reference conditions were widespread across the CONUS. More than 50 percent of the stream reaches in eight of the hydrologic regions including the Midwest were at least four times higher than ecologically relevant reference conditions.
- Increasing salinity of surface waters pose a threat to water availability in the Midwest. Salinity has geogenic (natural) and anthropogenic sources, and yields are greatest in the Midwest.
- The Midwest is one of the hydrologic regions with the highest loads of suspended sediment.
- The Midwest hydrologic region has high pesticide concentrations, and leading to the greatest detection frequency in surface-water samples
- The Midwest has a high probability of exceeding HAB thresholds (yet regional variability is high)
- Elevated manganese, strontium concentration are commonly found in drinking-water aquifers in the Midwest.

Insights for Upper Mississippi River Basin (Midwest hydrologic region)

- Public Supply withdrawal seasonal variability is relatively low in the Midwest yet consumptive use has potential for variability due to outdoor water demand and evapotranspiration.
- Irrigation consumptive use is on average a larger percentage of withdrawals in the Midwest than other regions in the CONUS.
- Thermoelectric water withdrawals are decreasing in the watershed but consumptive use is generally consistent. That is due to the technology at the plant.

Contributors and acknowledgements

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