

Exceptional service in the national interest



Energy and Water in the Western and Texas Interconnections

Colorado Public Utilities Commission
January 23, 2013

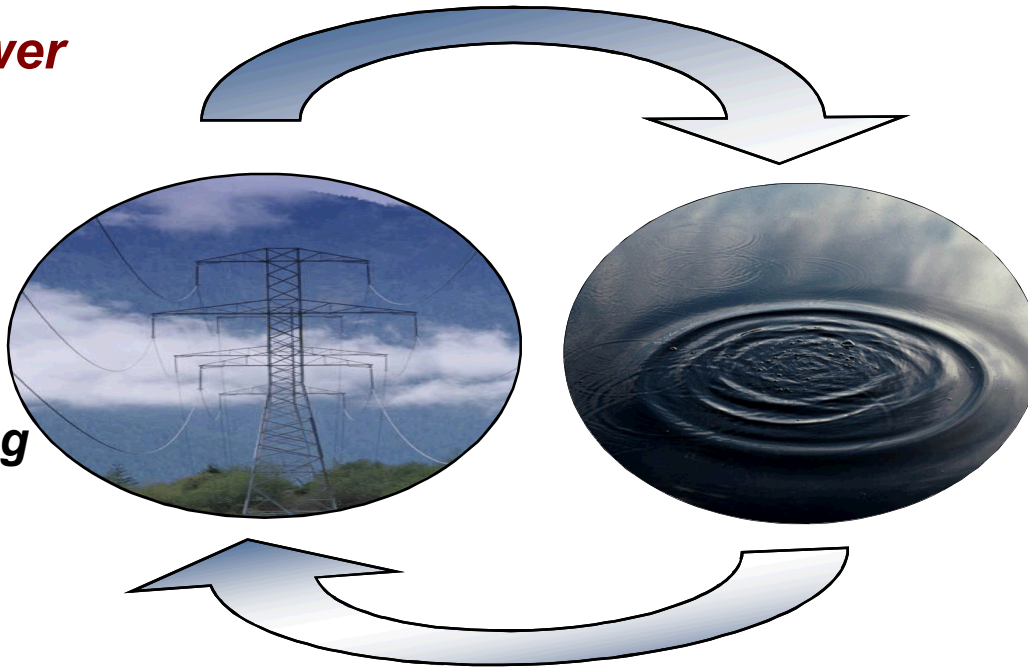


Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Water for Energy

Energy and power production requires water

- **Thermoelectric Cooling**
- **Energy Minerals Extraction/Mining**
- **Fuel Processing (fossil fuels, H₂, biofuels)**
- **Emission Control**

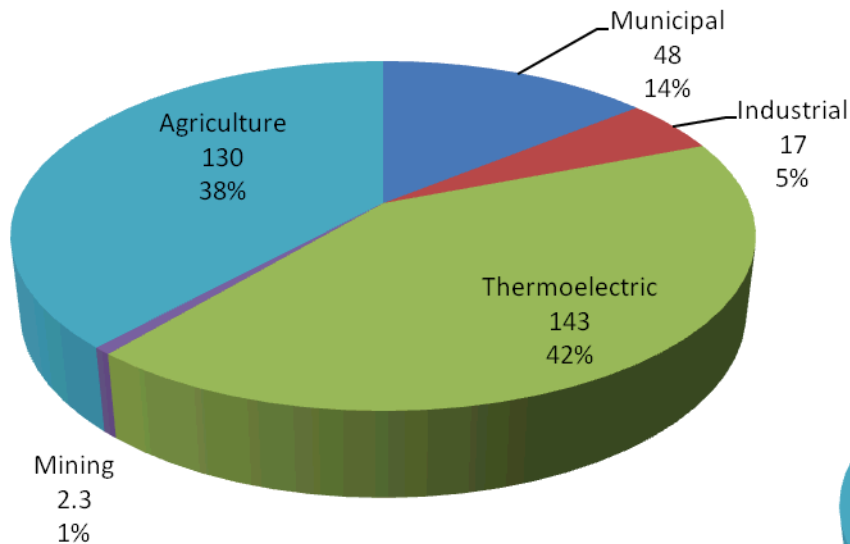


Water production, processing, distribution, and end-use requires energy

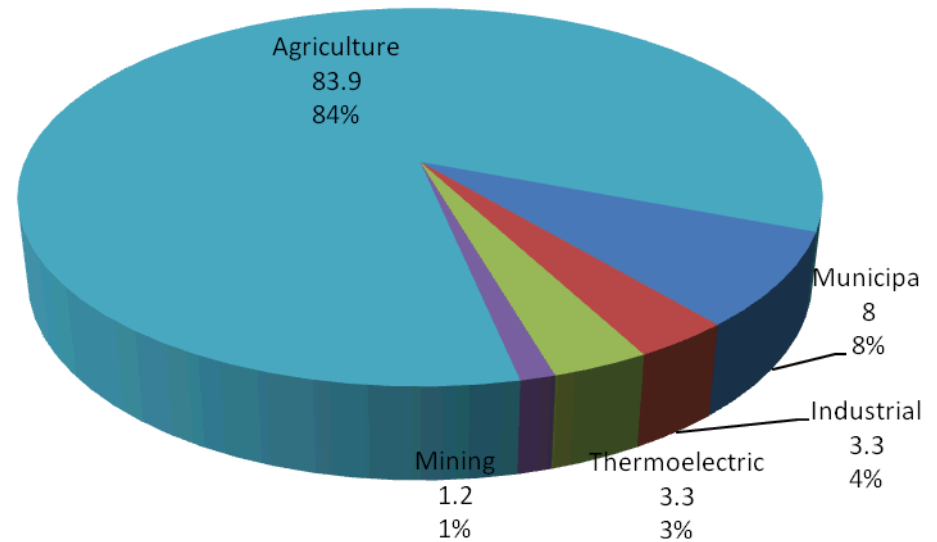
- **Pumping**
- **Conveyance**
- **Treatment**
- **Distribution**
- **Use Conditioning**

Water for Thermoelectric Power Generation

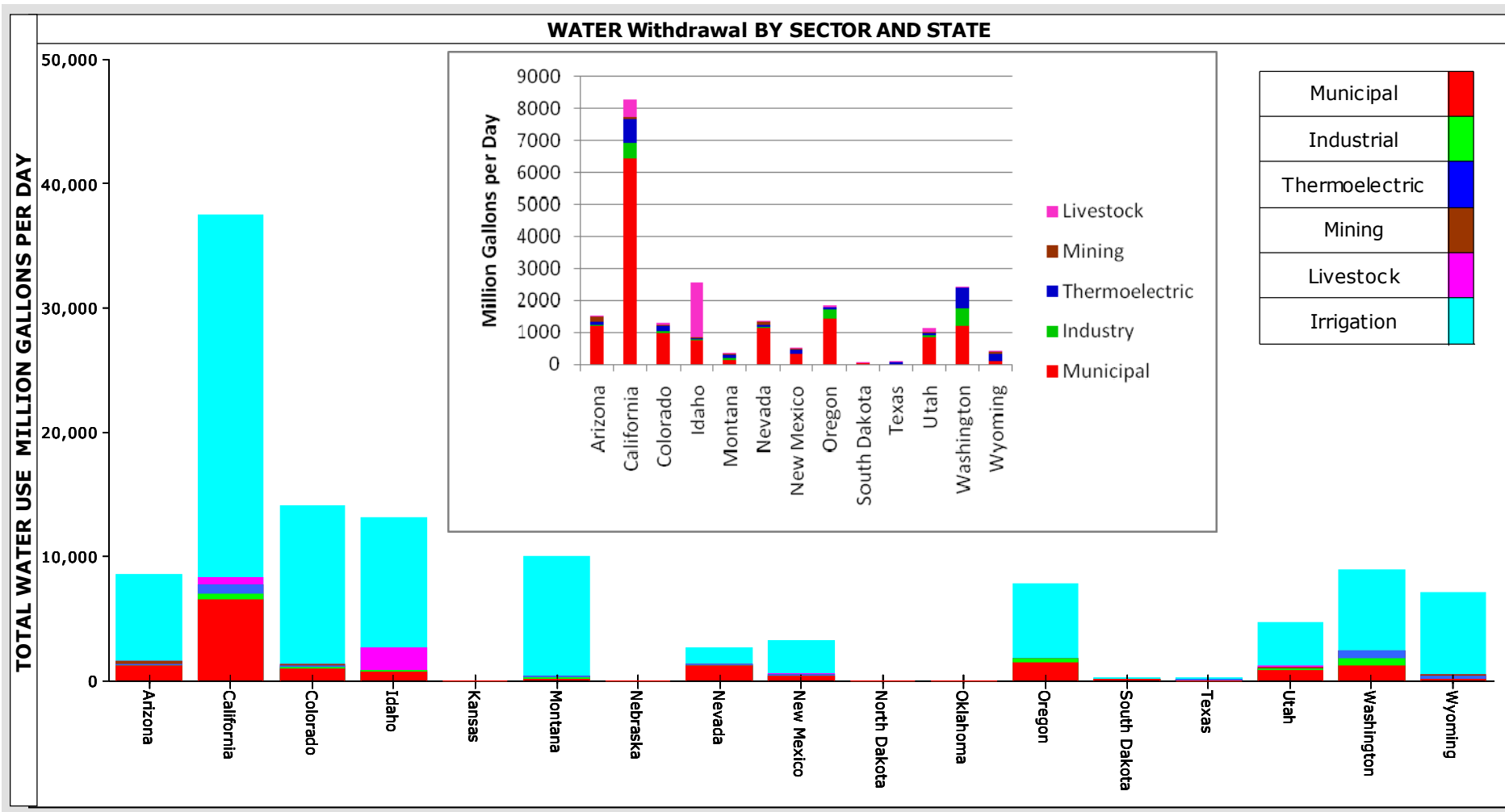
Water Withdrawal (BGD) 2005



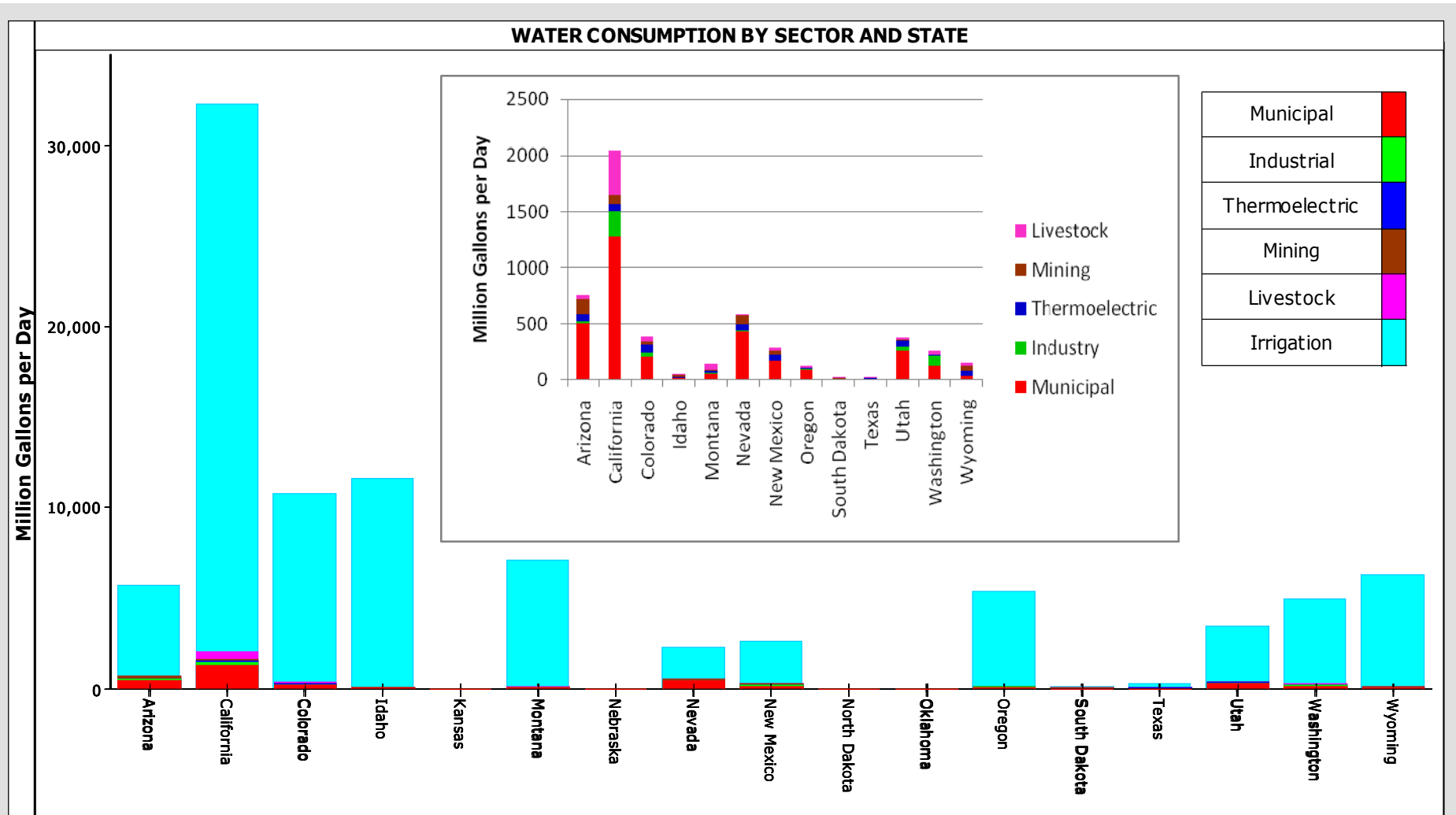
Water Consumption (BGD) 1995



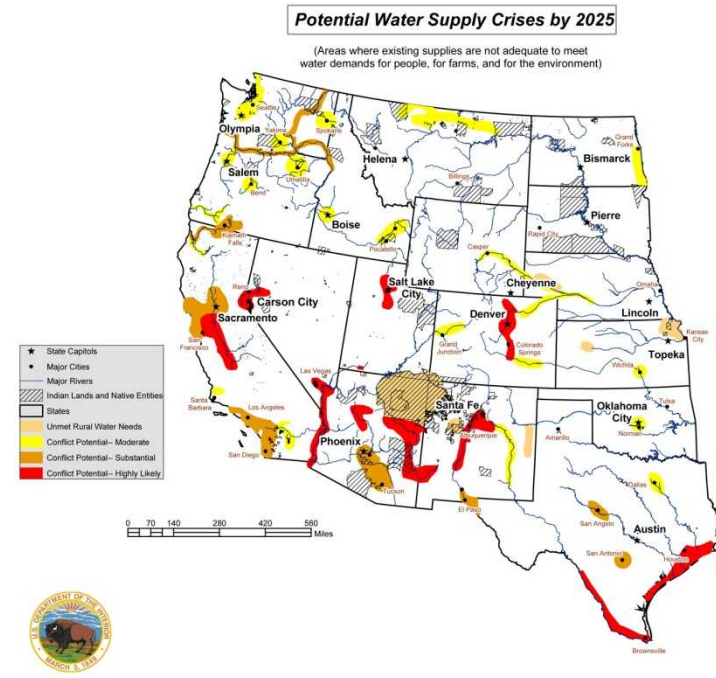
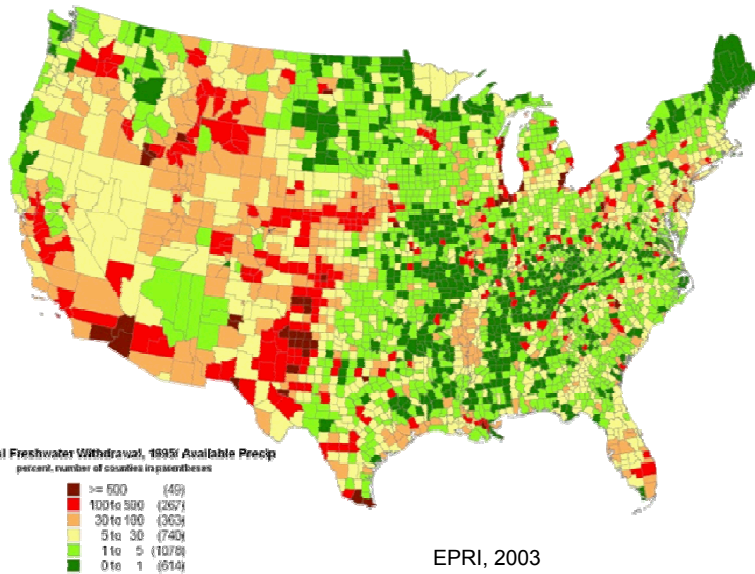
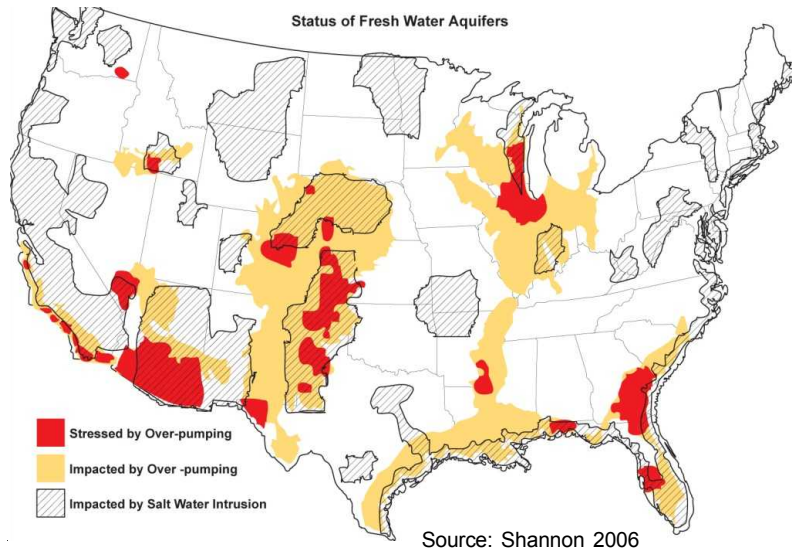
Water Withdrawal by State and Sector



Water Consumption by State and Sector

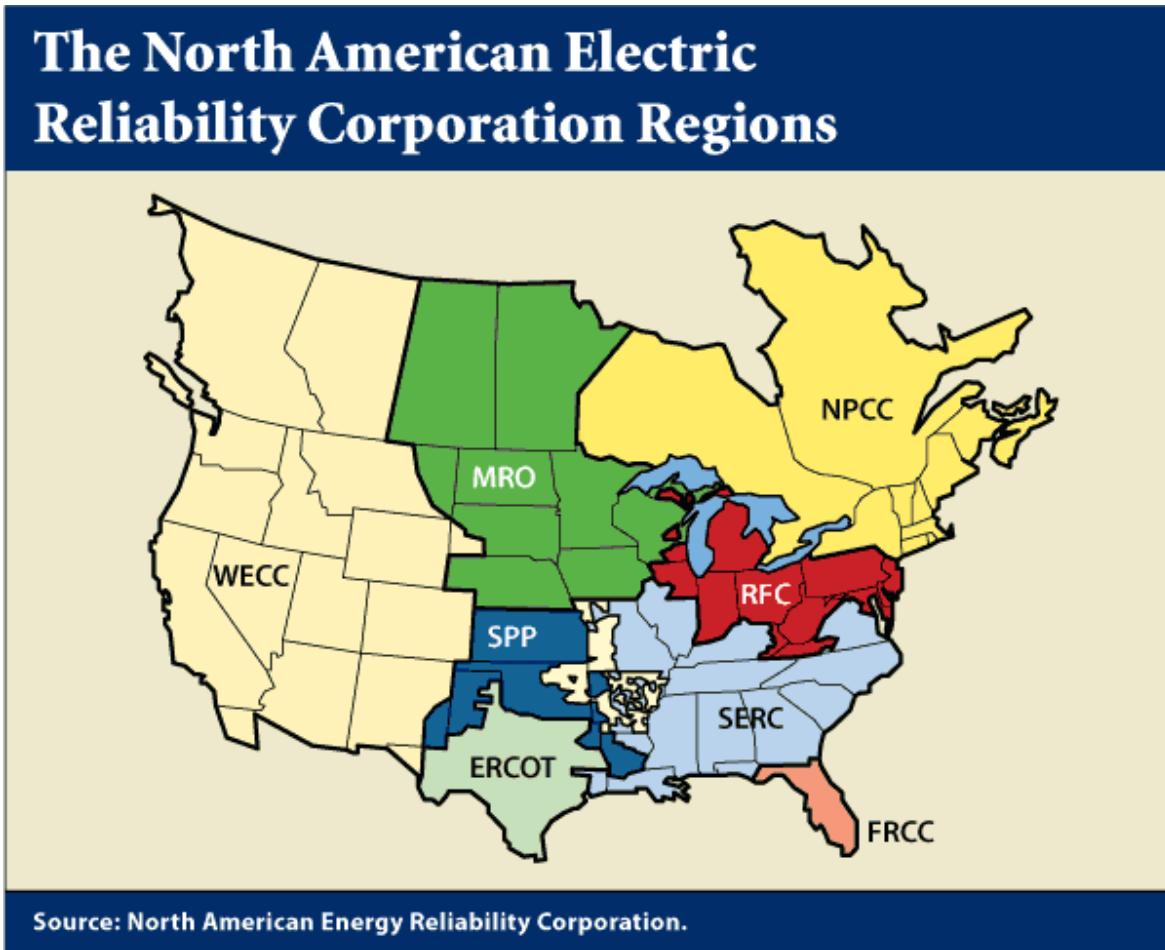


Indications of Water Stress

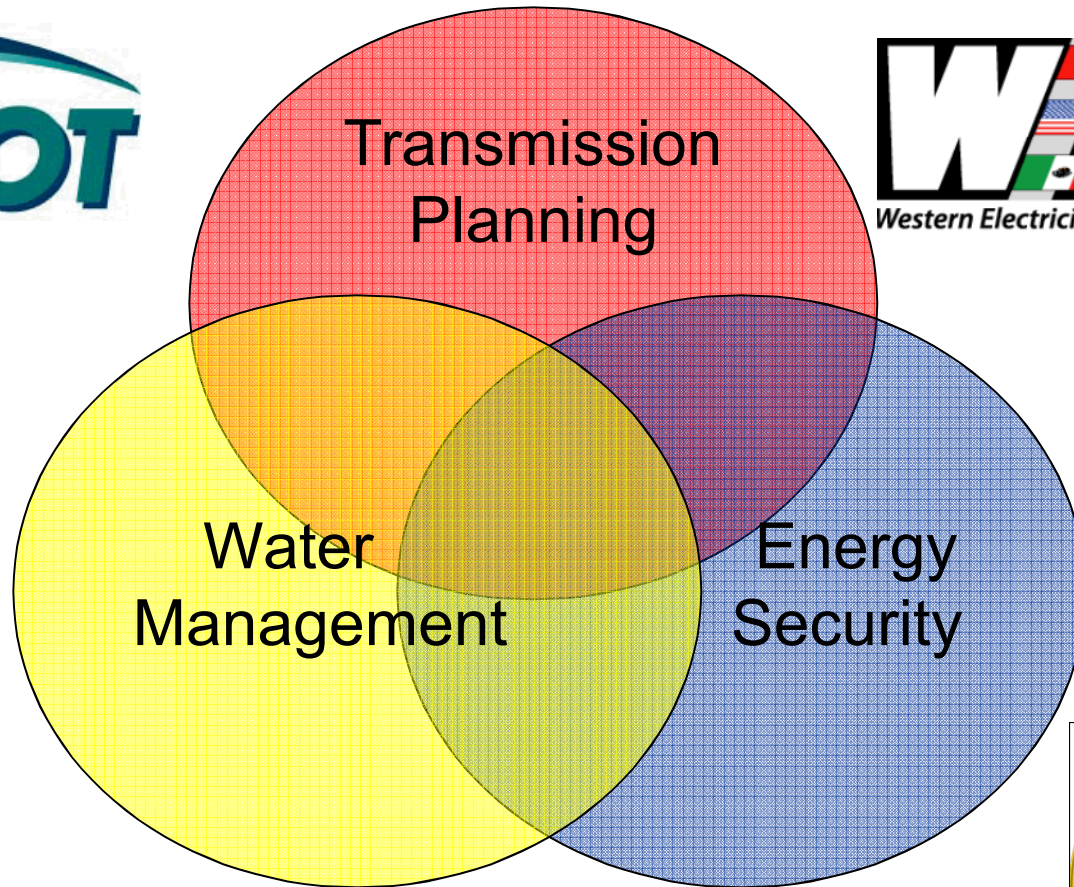


Transmission Planning

- WECC and ERCOT are conducting long-range transmission planning (20 yrs.)
 - Siting of new power plants
 - New transmission capacity



Integrated Planning



**WESTERN
GOVERNORS'
ASSOCIATION**

Serving the Governors of 19 States and 3 US-Flag Pacific Islands



WSWC

Western States Water Council



Technical Support Team

- Sandia National Laboratories

- Vincent Tidwell
- Barbie Moreland
- Howard Passell
- Katie Zemlick
- Barry Roberts



**Sandia
National
Laboratories**



- Argonne National Laboratory

- John Gasper
- Eugene Yan
- Chris Harto



- Electric Power Research Institute

- Robert Goldstein

- National Renewable Energy Laboratory

- Jordan Macknick
- Kathleen Hallett



- Idaho National Laboratory

- Gerald Sehlke
- Dan Jensen
- Chris Forsgren



Idaho National Laboratory

- Pacific Northwest National Laboratory

- Mark Wigmosta
- Ruby Leung

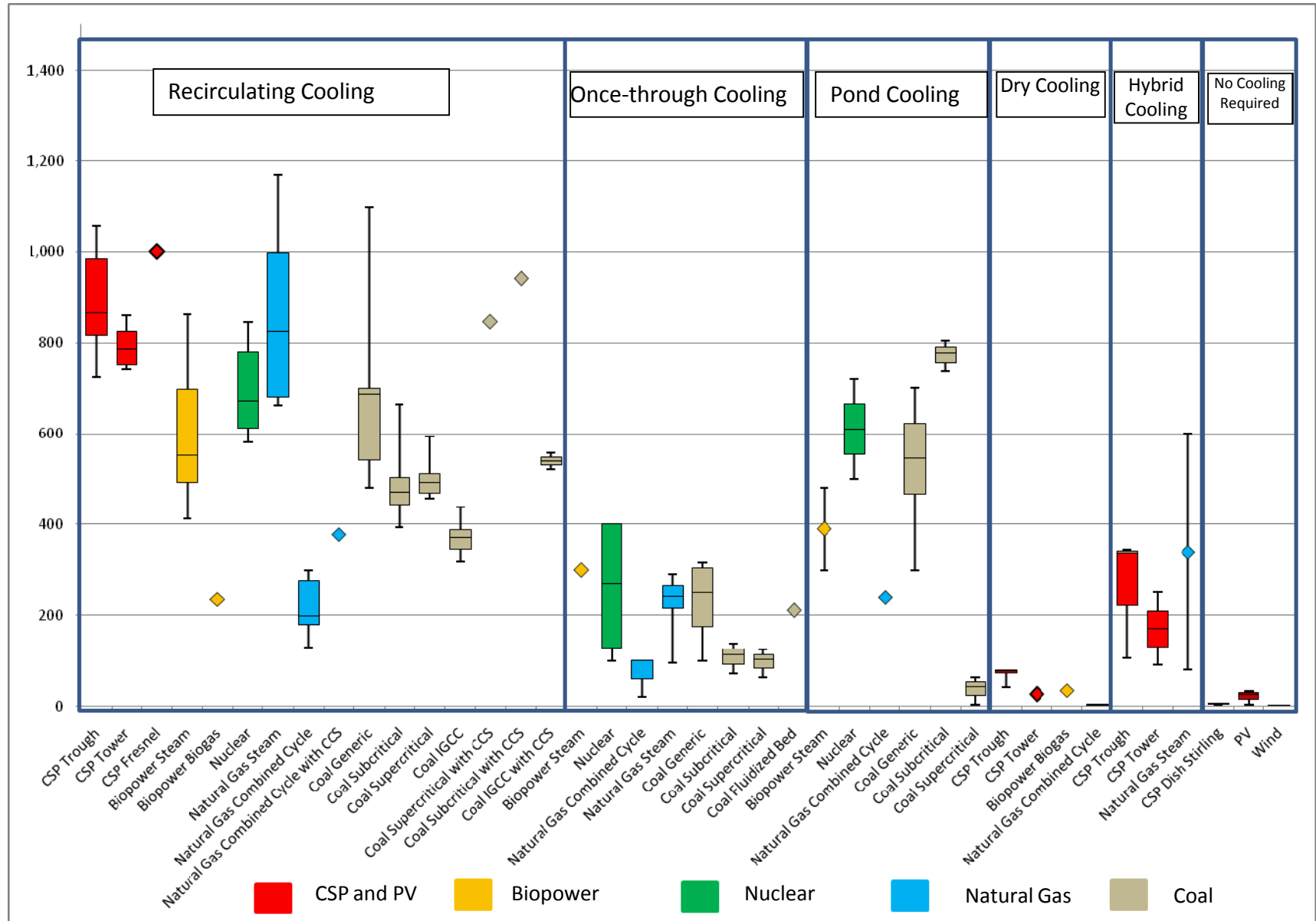
- University of Texas

- Michael Webber
- Carey King



Task 2: Thermoelectric Water Demand

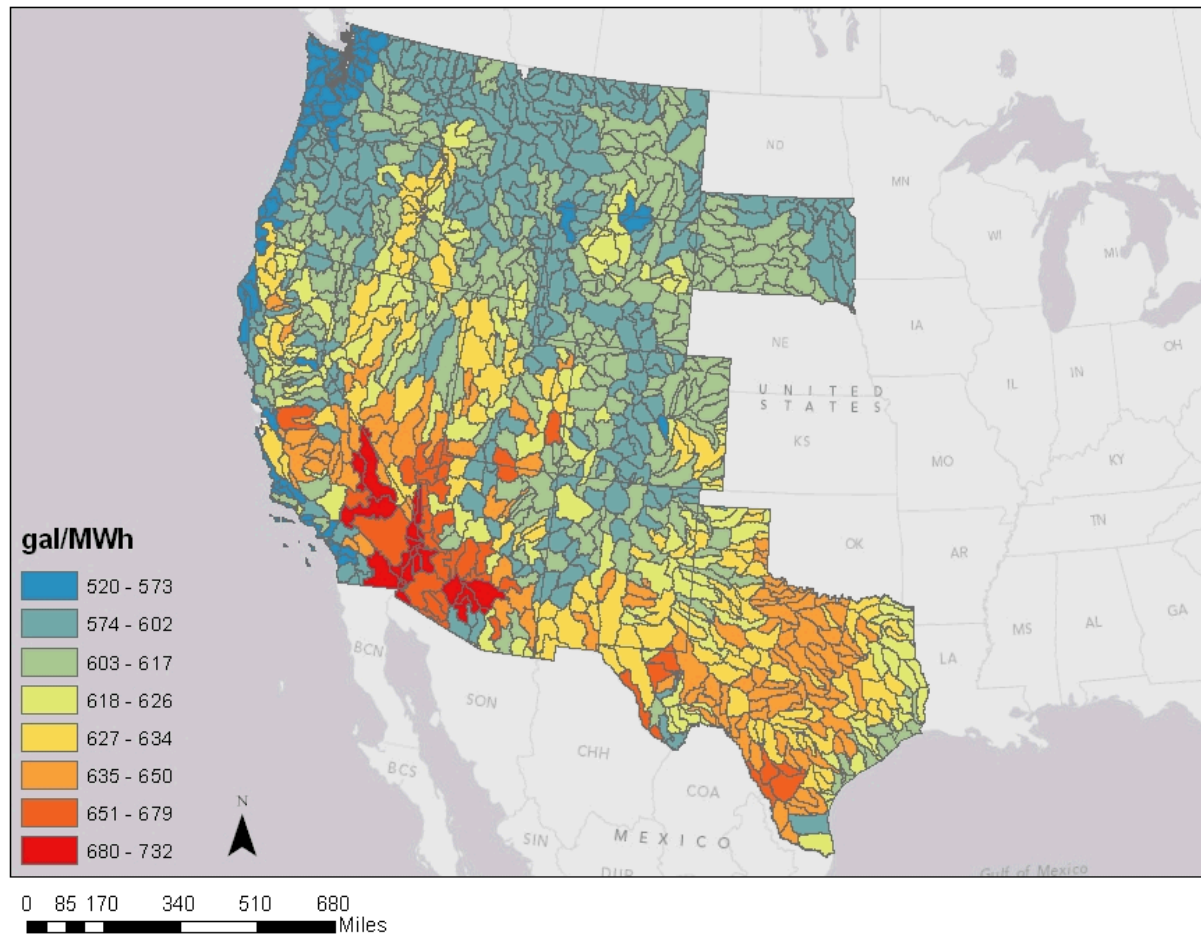
Operational water consumption (Gal/MWh)



Source: Macknick *et al.* 2011

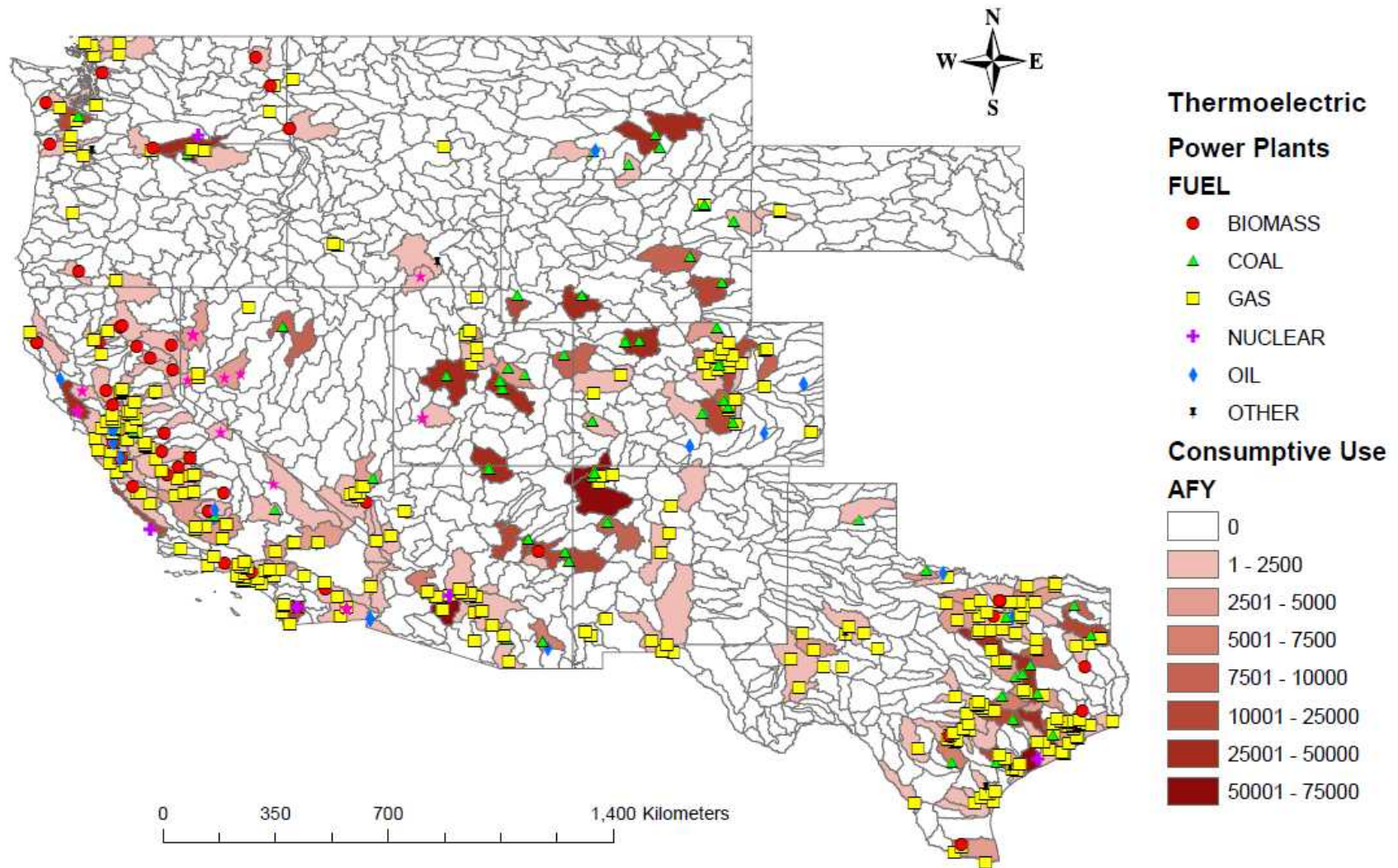
Task 2: Thermoelectric Water Demand

Coal Plant Water Use (gal/MWh)



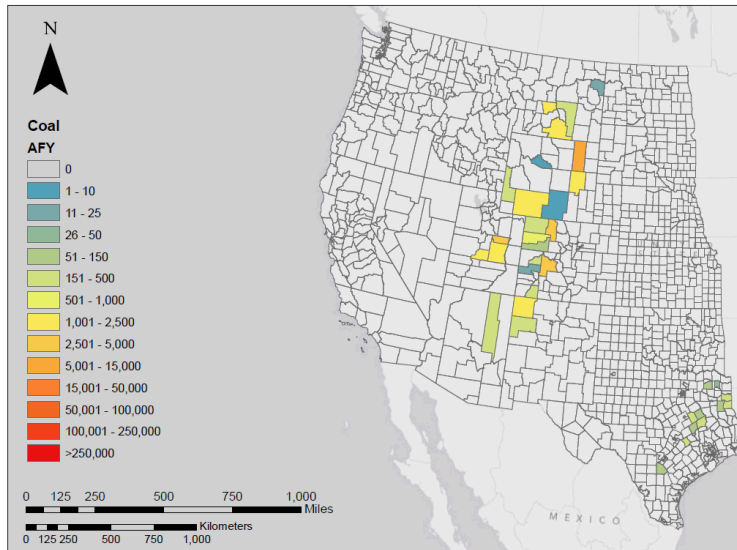
NREL 2012

Thermoelectric Consumptive Use and Power Plants (Current)

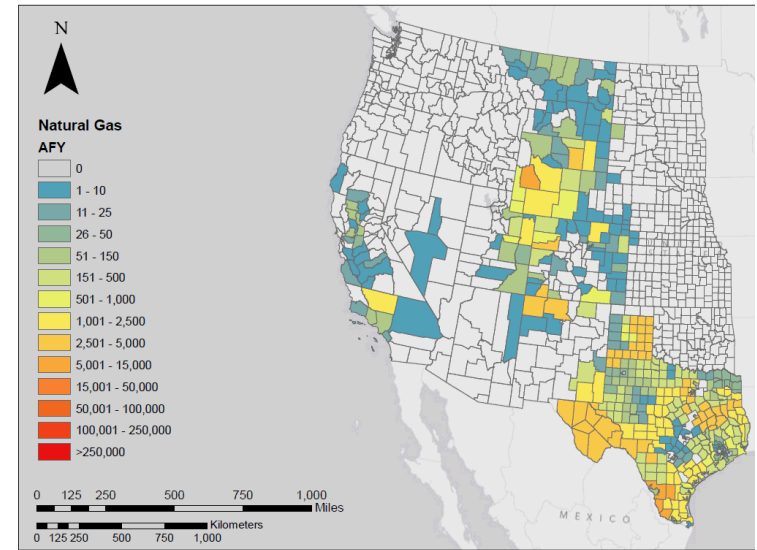


Task 3: Non-thermoelectric Water Demand

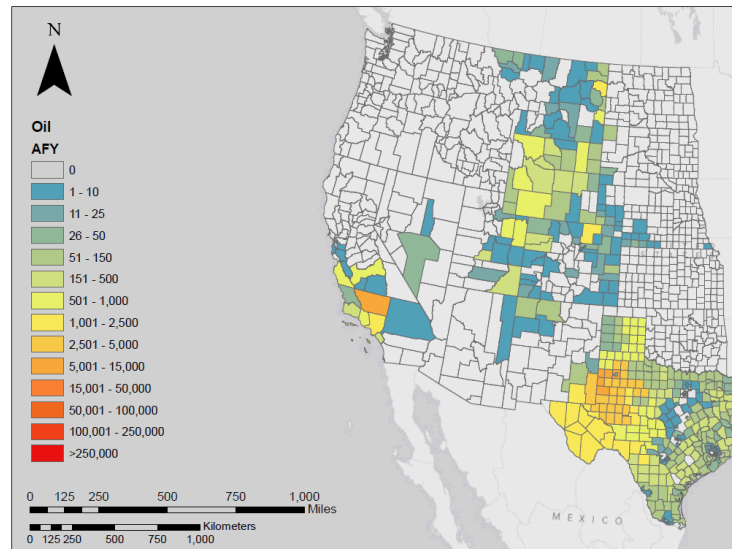
Water Use COAL



Water Use NATURAL GAS

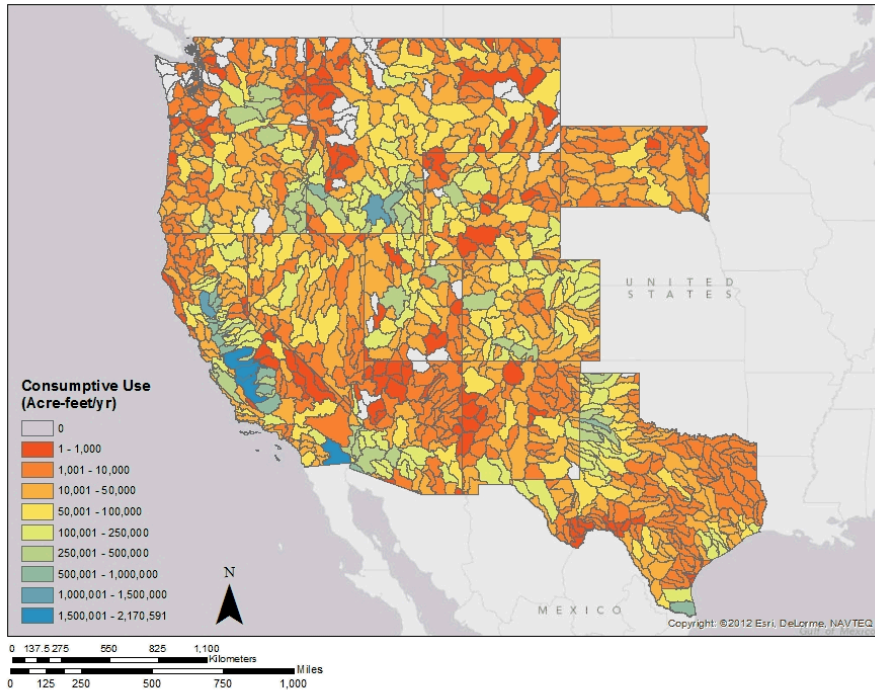


Water Use OIL

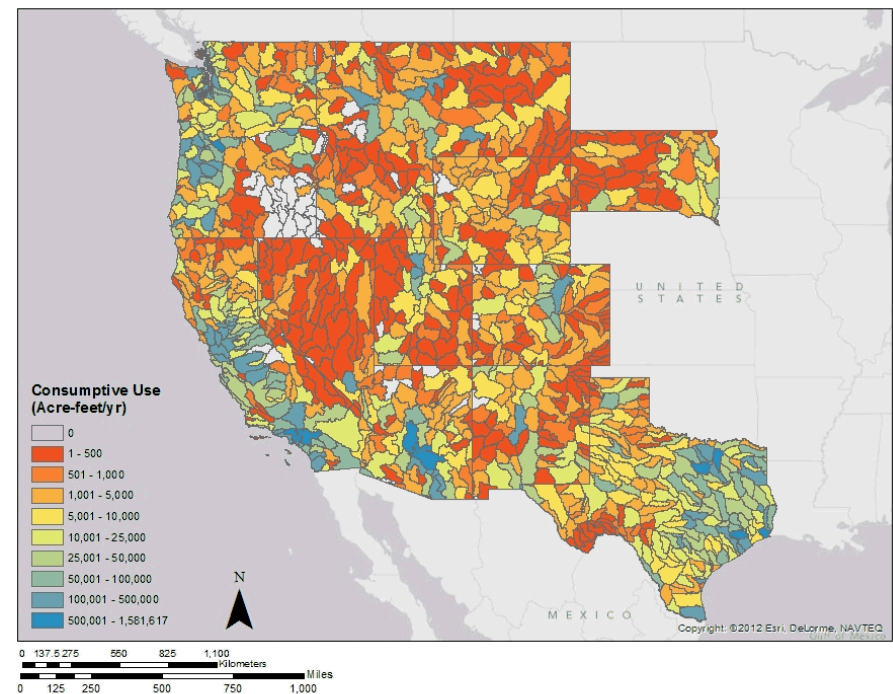


Task 3: Non-thermoelectric Water Demand

Irrigated Agriculture Current Consumptive Use

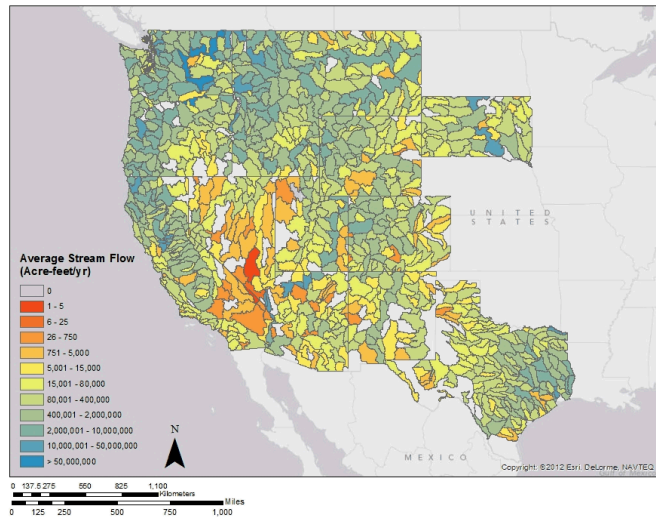


Municipal and Industrial Current Consumptive Use

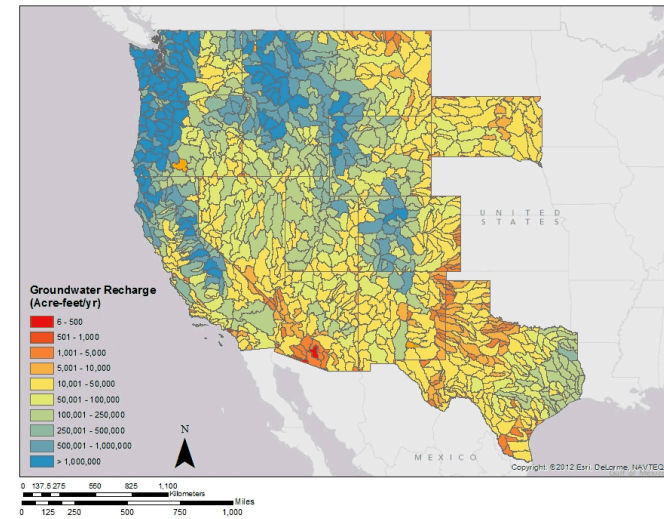


Task 4: Water Supply and Institutions

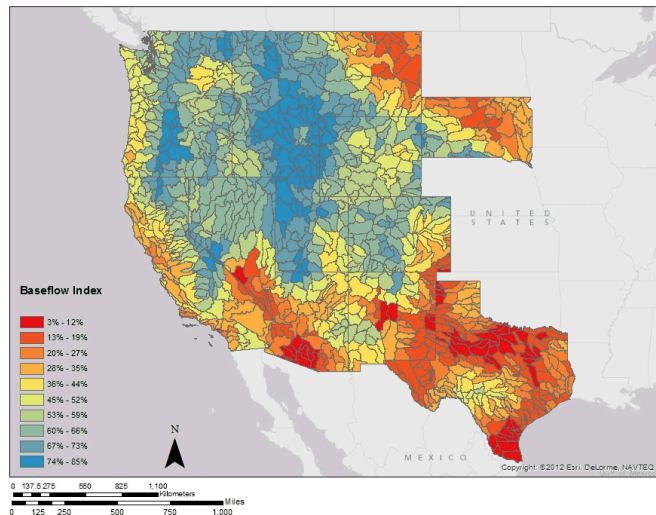
Average Stream Flow



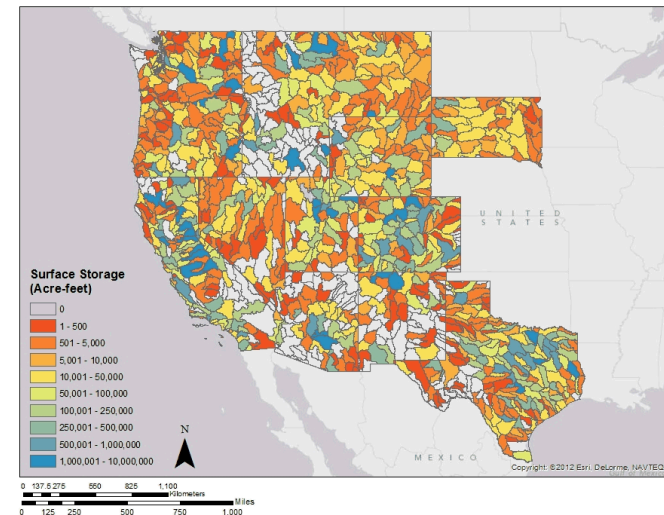
Mean Annual Groundwater Recharge



Baseflow Index

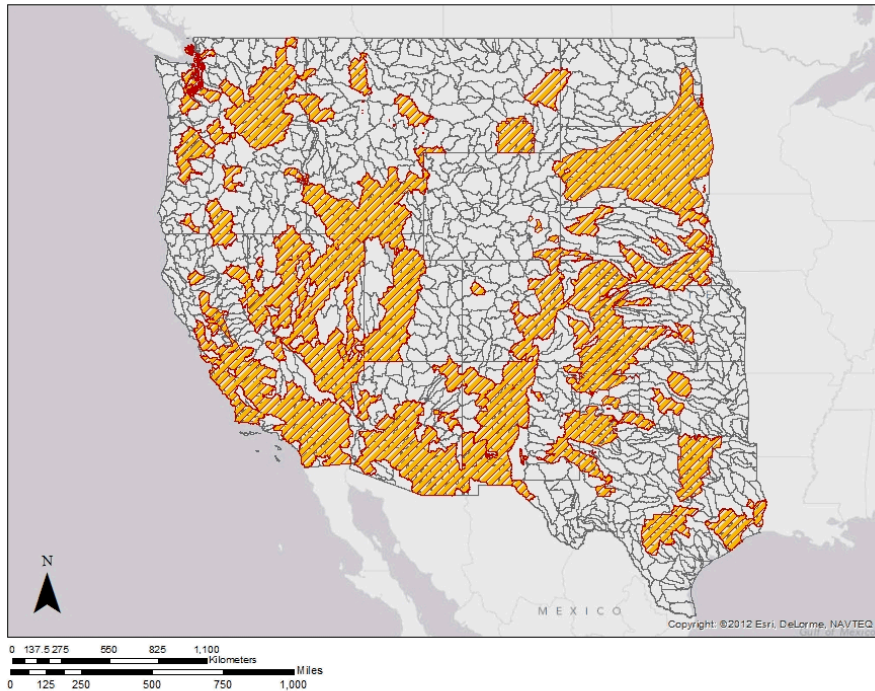


Surface Storage

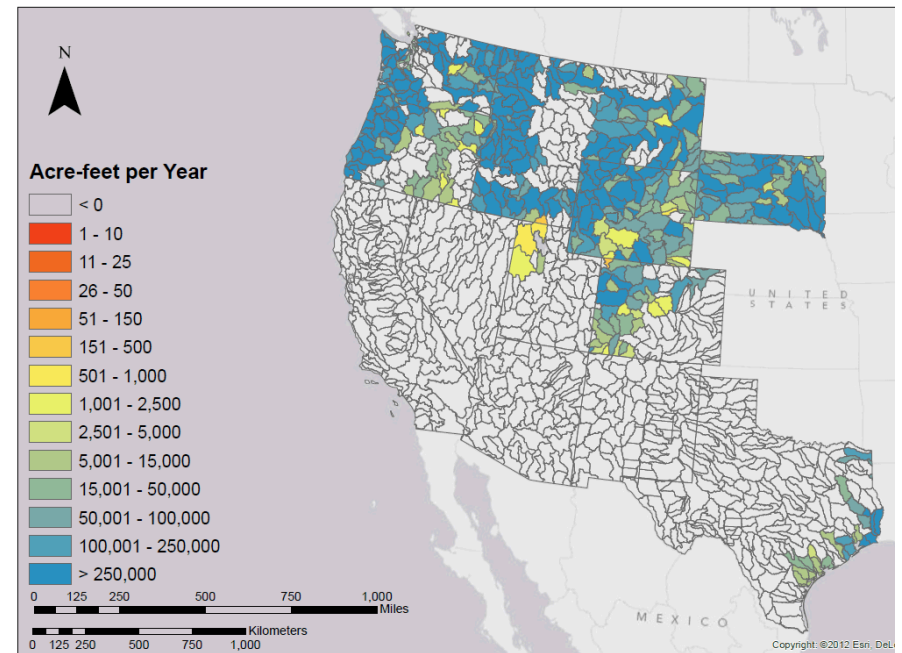


Task 4: Water Supply and Institutions

Groundwater Administrative Areas

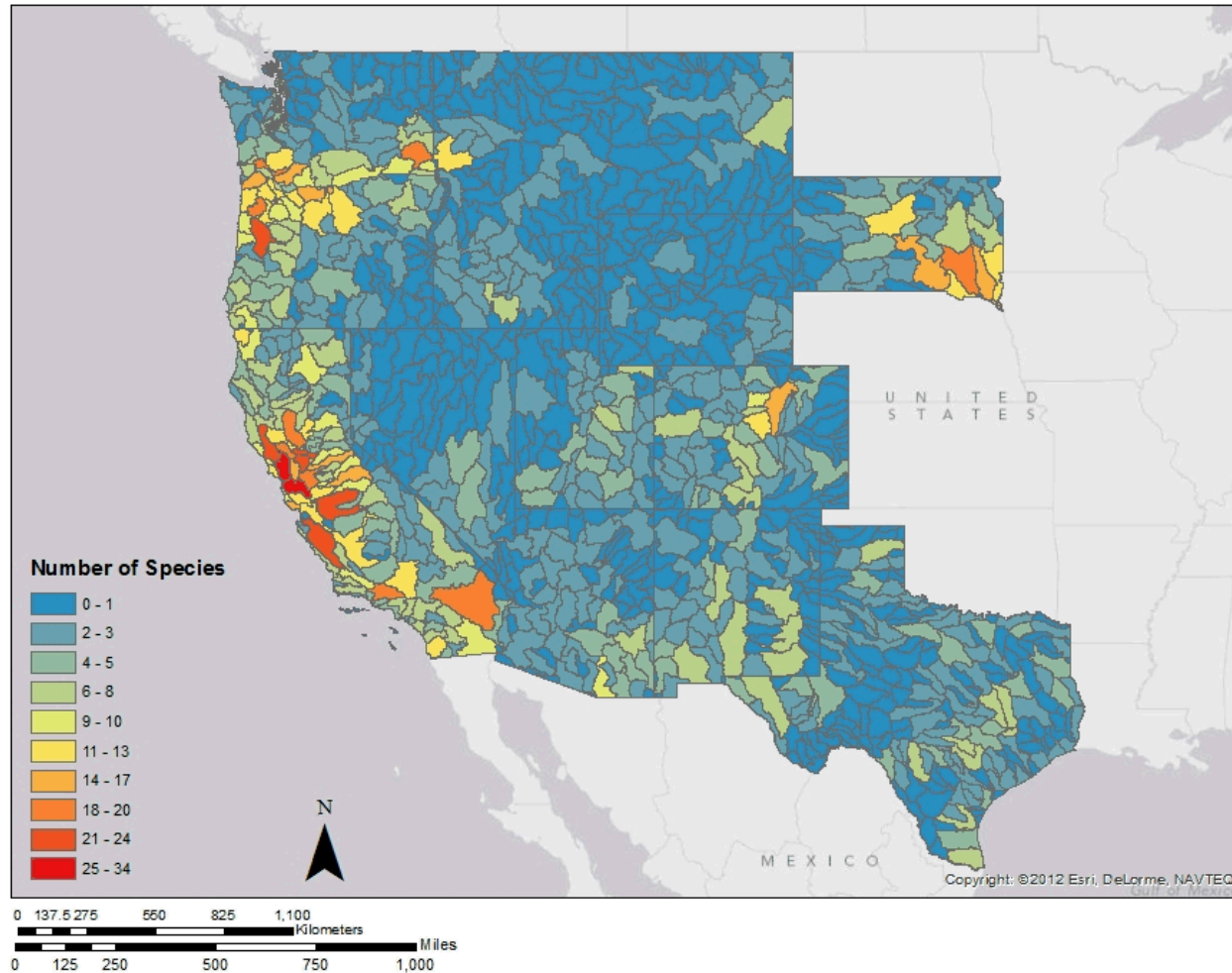


Unappropriated Surface Water



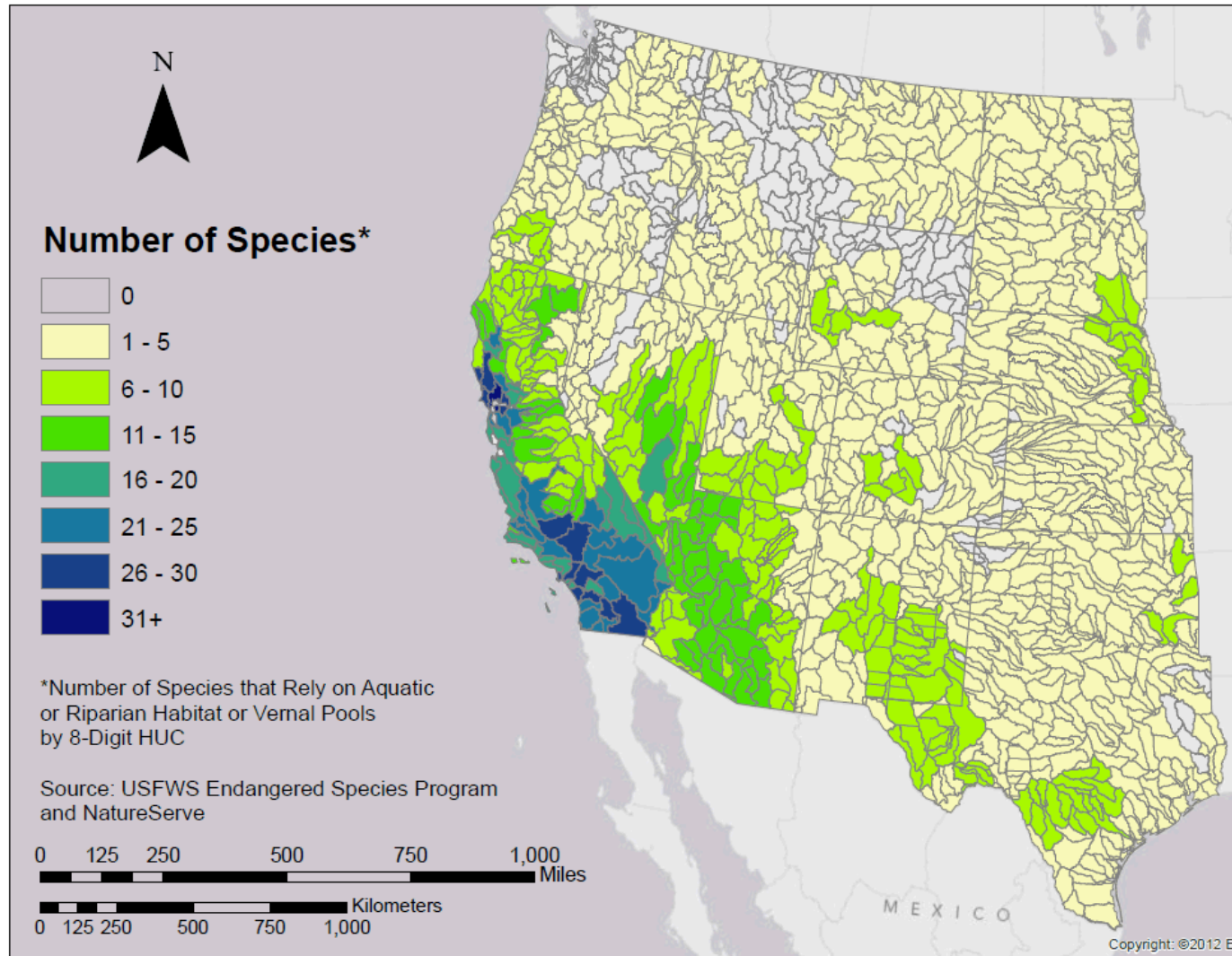
Task 5: Environmental Vulnerabilities

Number of Endangered Species



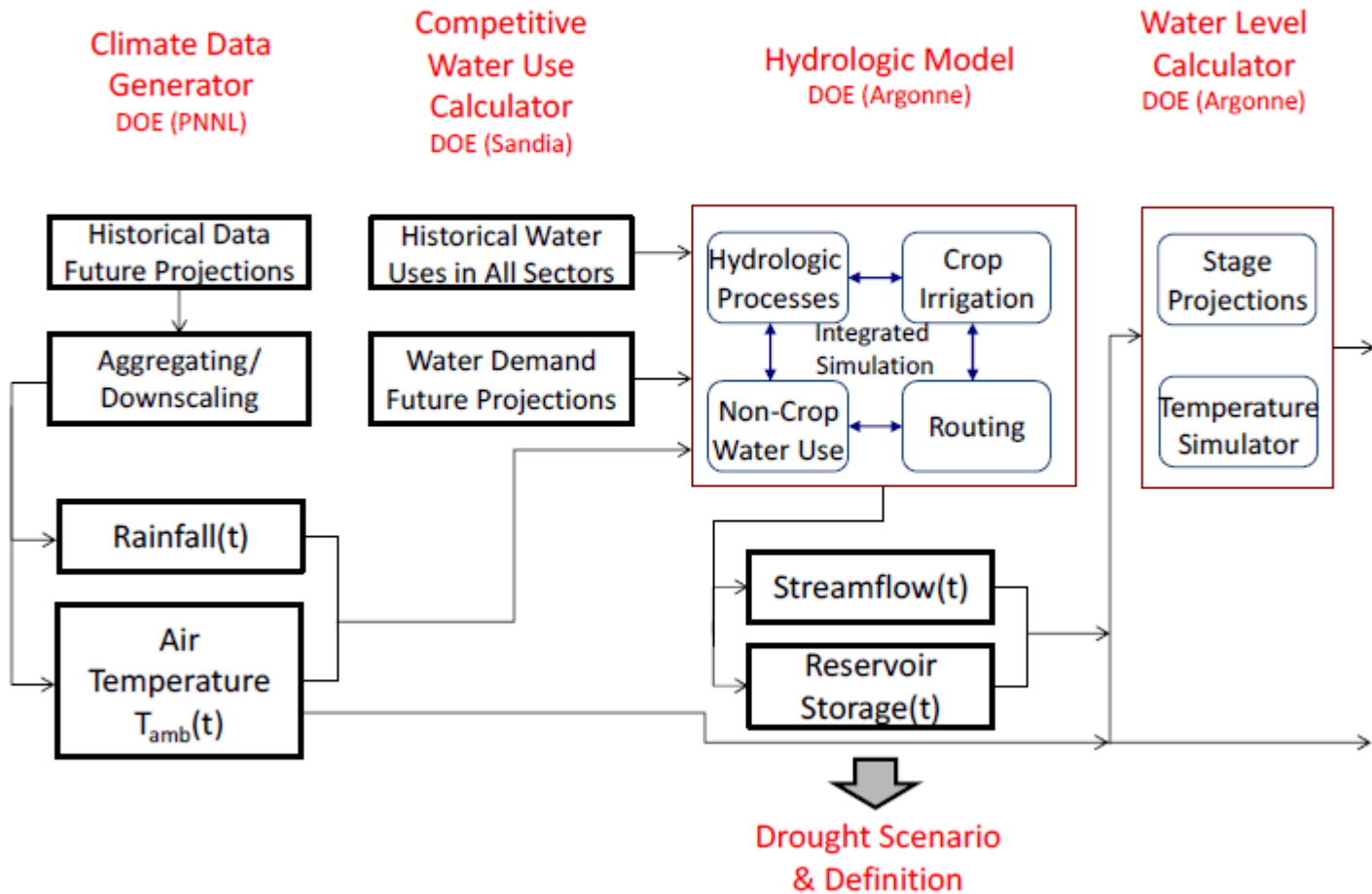
Task 5: Environmental Vulnerabilities

Endangered Species by 8-Digit HUC



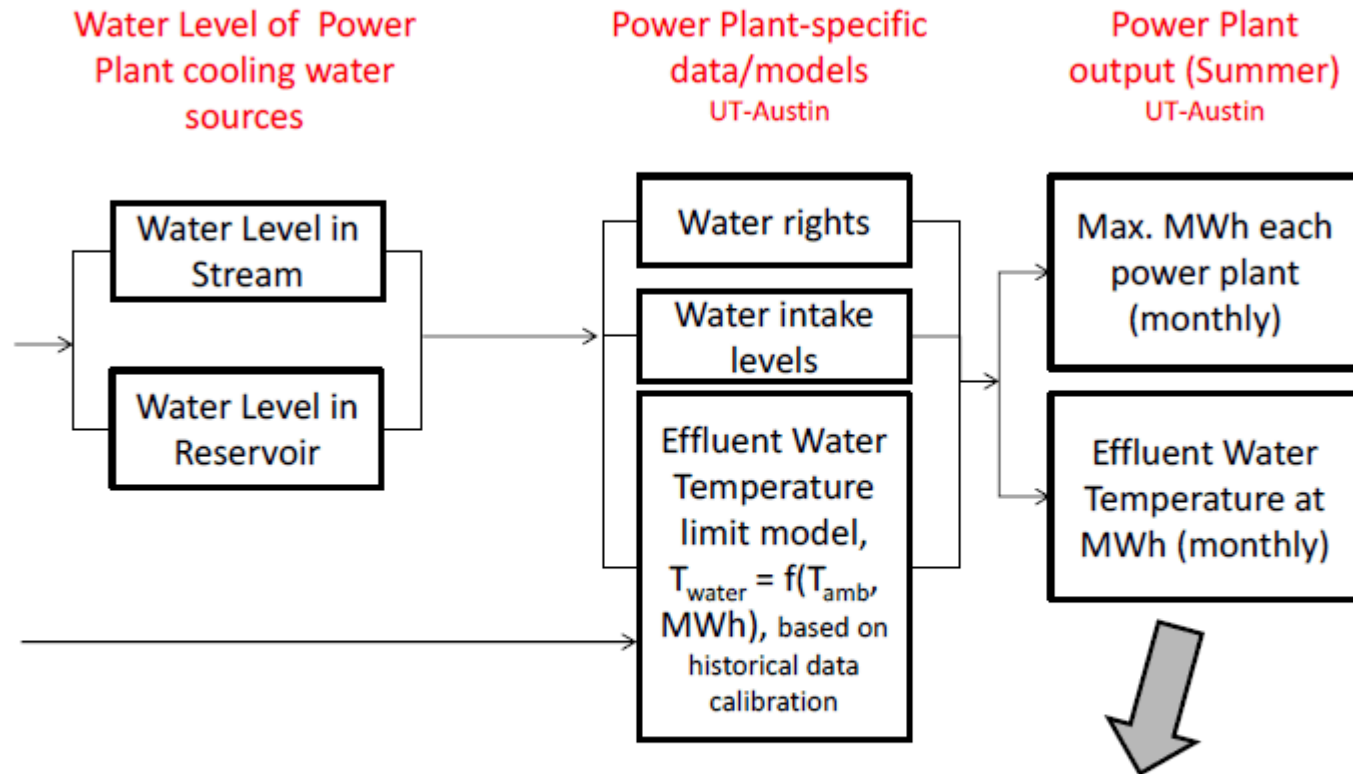
Task 6: Climate Variability

Regional Scale to HUC-8 Basins



Task 6: Climate Variability

Local Power Plants

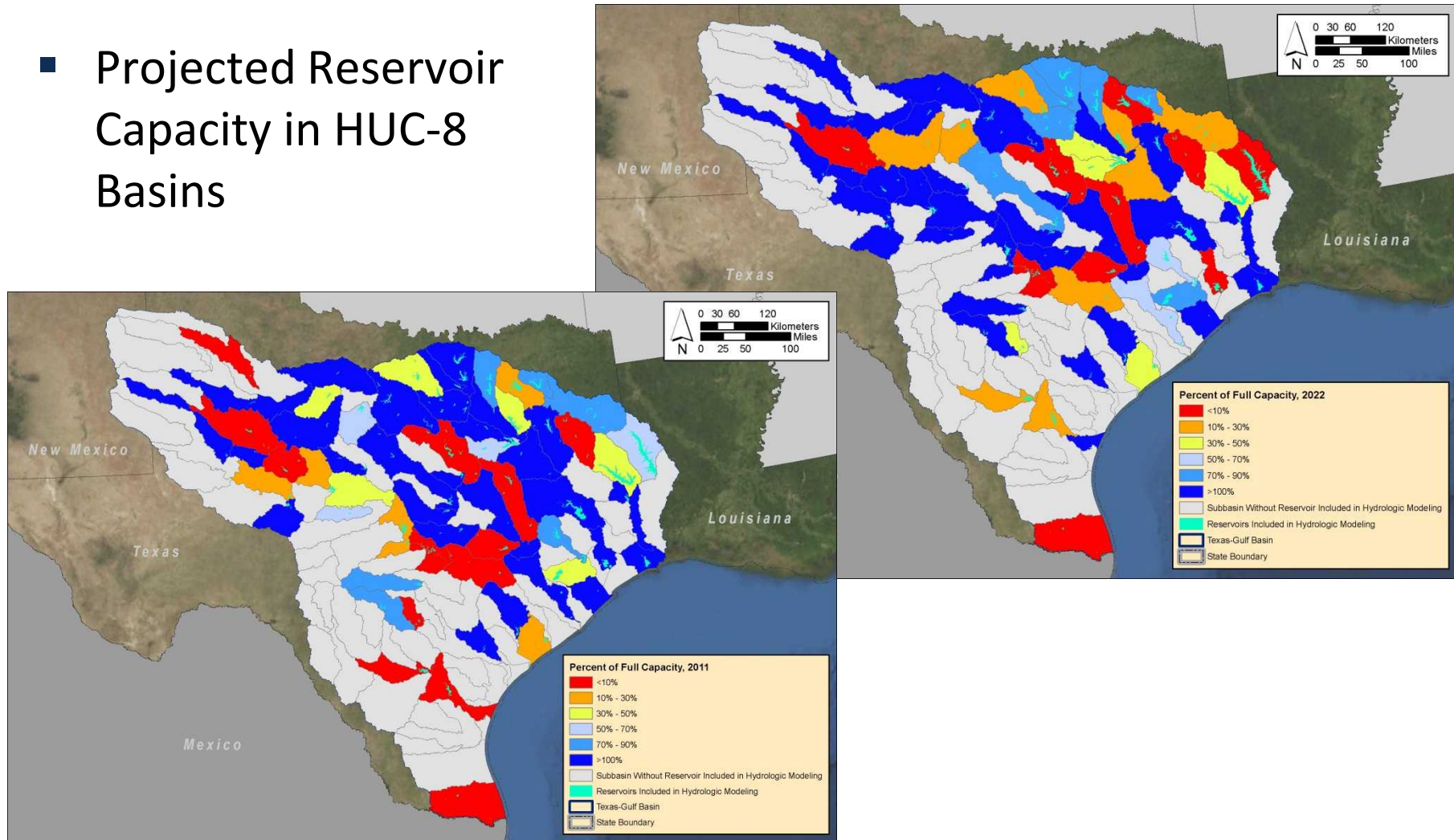


Determine if:

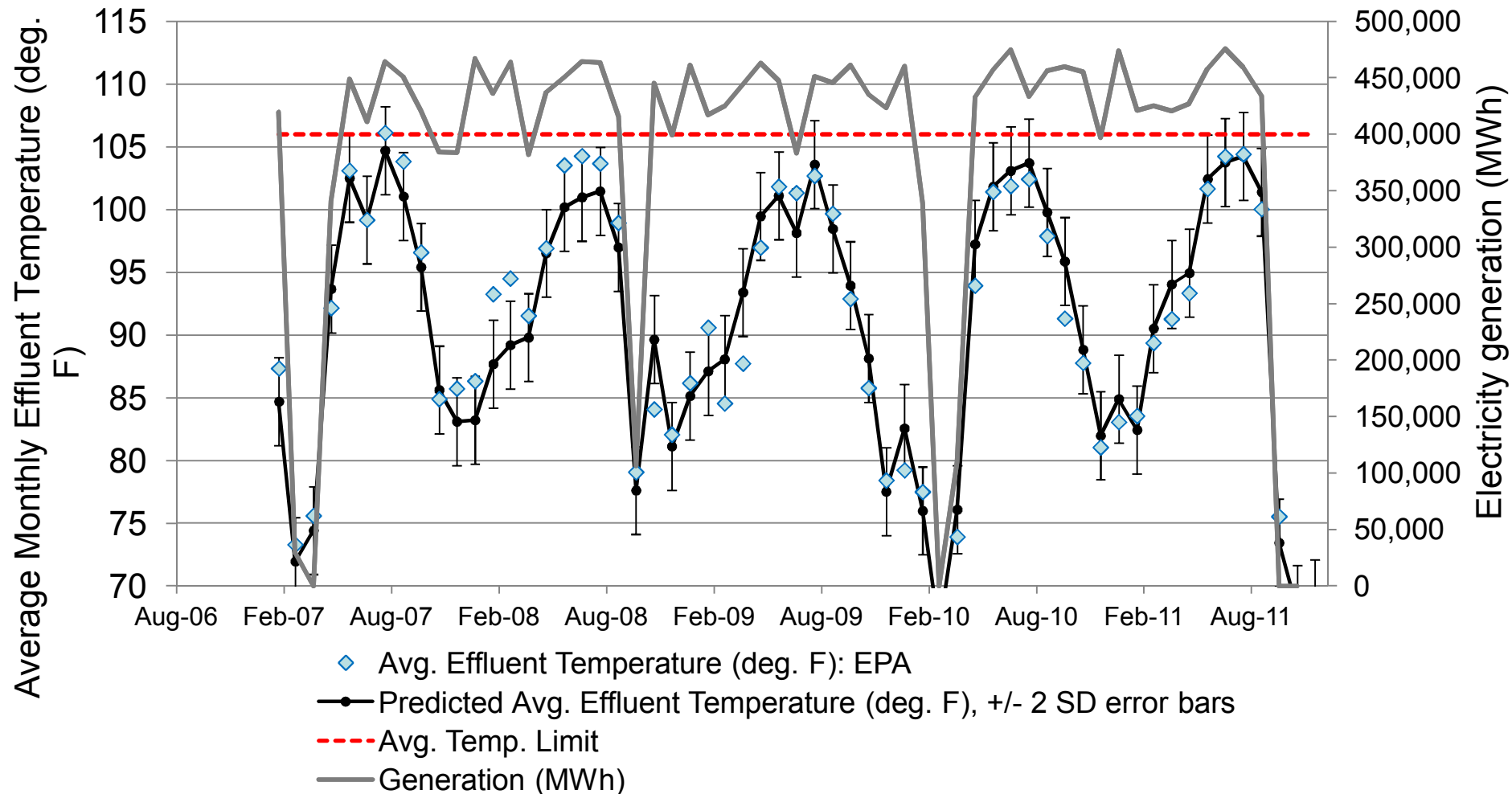
- (i) water effluent temperature permit limits can reduce power generation,
- (ii) intake levels constrain water intake, and therefore power generation

Hydrologic Modeling Results – *Single-Year Drought (Cont'd)*

- Projected Reservoir Capacity in HUC-8 Basins

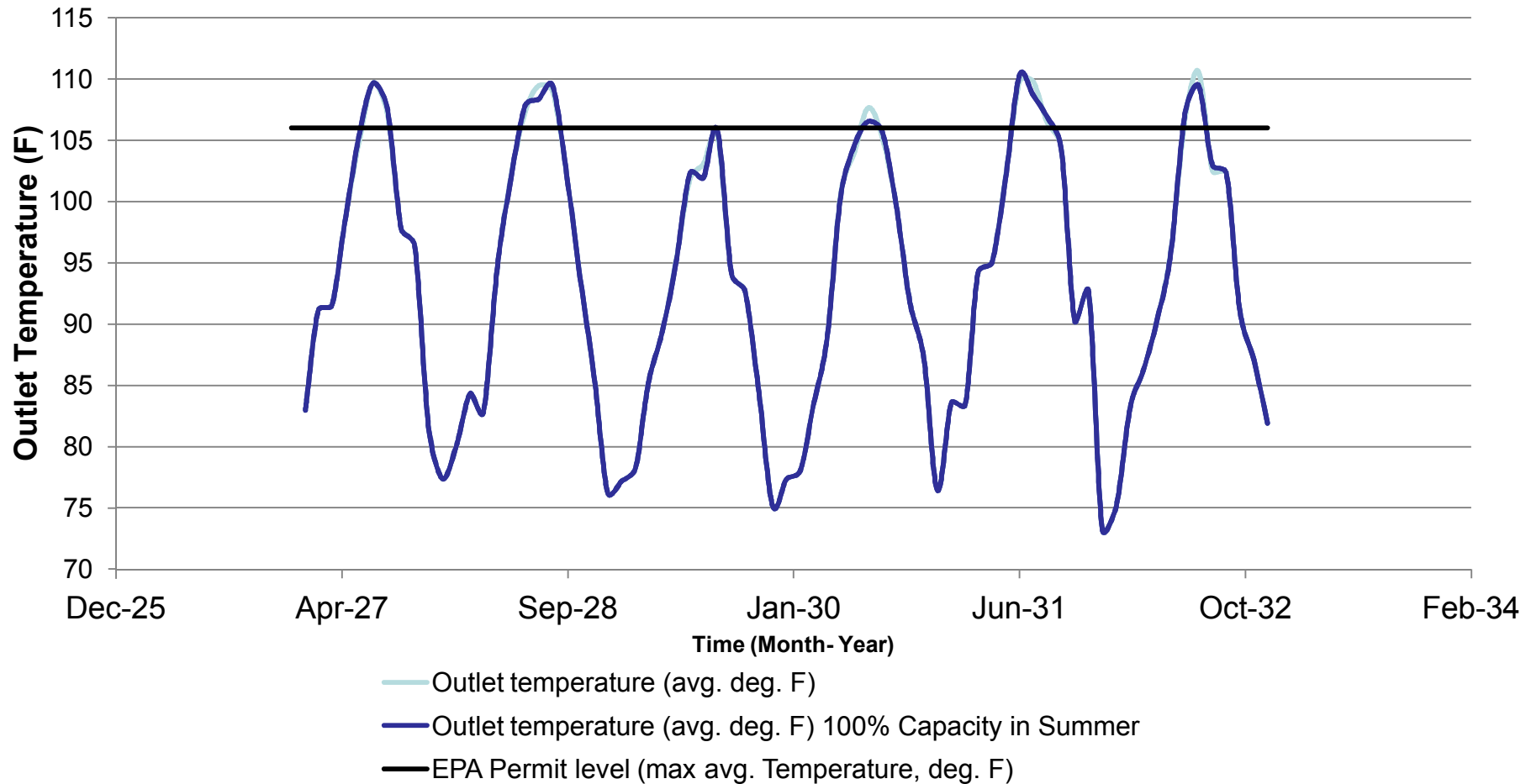


Operations near thermal limit



Operations near thermal limit in future summers

Assuming 2011 generation pattern



Task 7: Water Valuation

- Historic value of leased and sold water rights
- Economic value of water
- Cost of backstop technology



Current Agricultural Water Withdrawals

Arizona

GW + SW + CAP + EFF
1000 Acre-Feet/Year



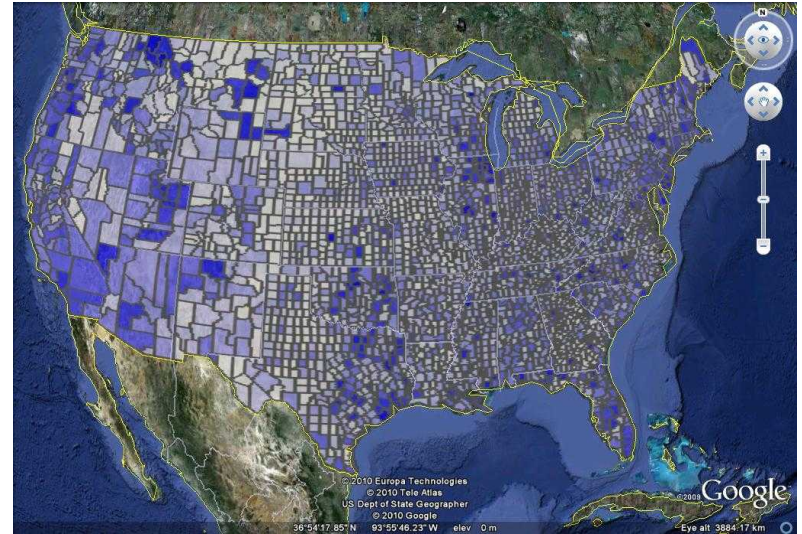
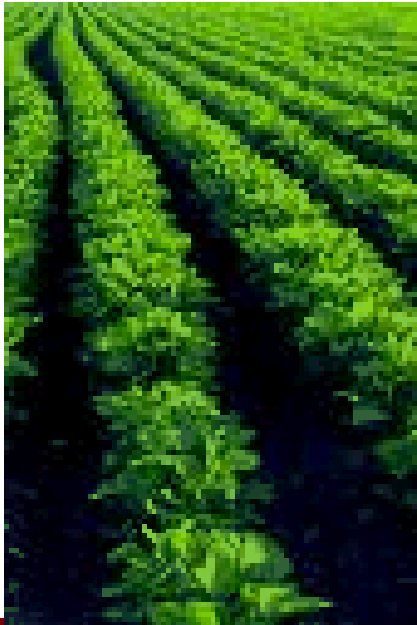
0 35 70 140 210 280 Kilometers

Note:
Agricultural water withdrawals
are for 2009 in Groundwater
Basins and 2006 in Active
Management Areas



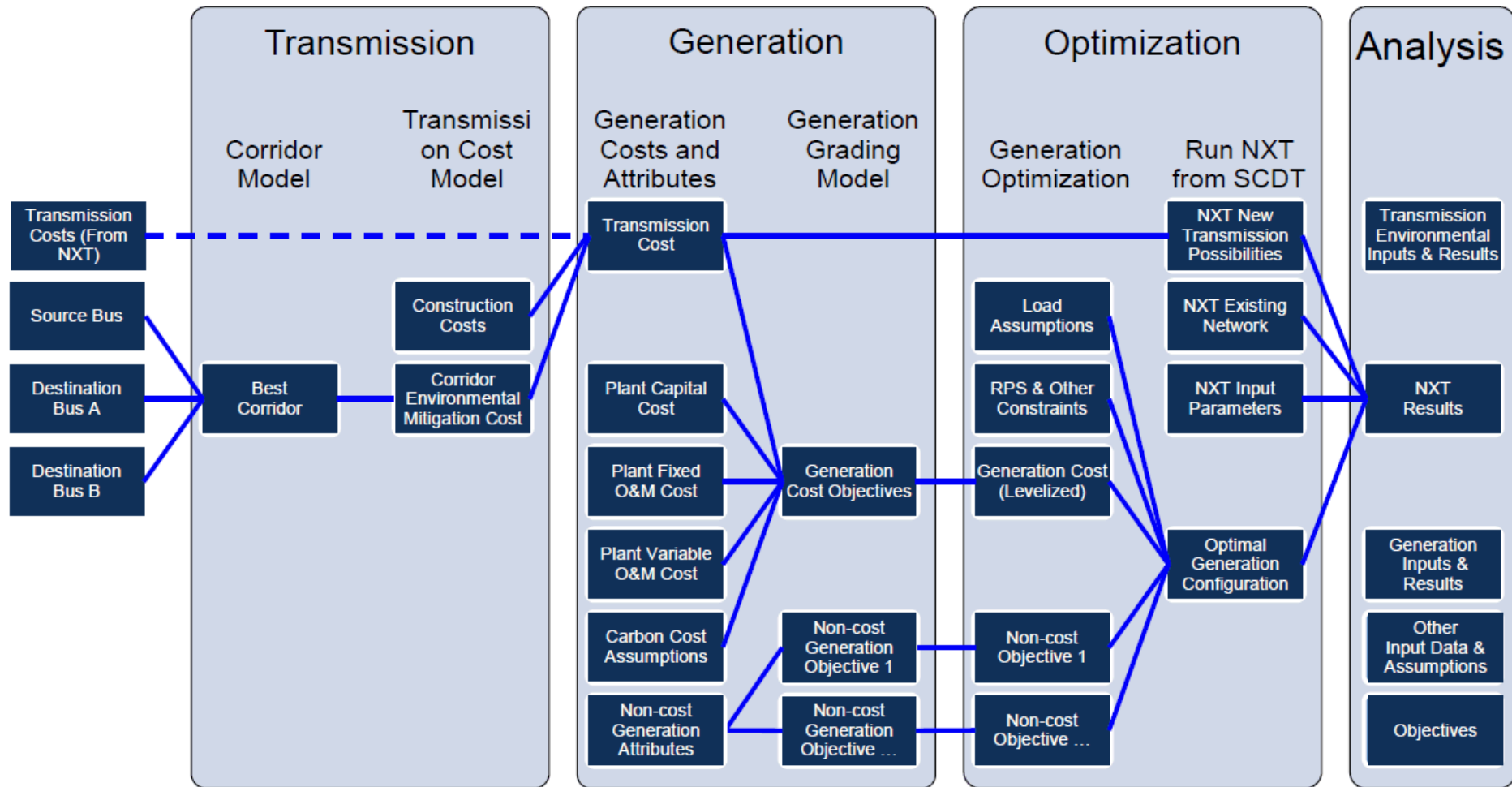
Task 8: Energy for Water Calculator

- ***Update Energy for Water Model***
- ***Energy for Large Projects***
- ***Energy for Agriculture***



Task 10: Planning Support

Long Term Planning Tool (LTPT)



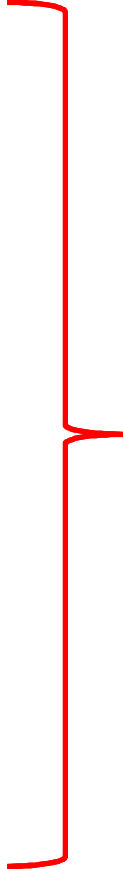
Key Water Sources

- **Potable Water**

- Unappropriated surface water
- Unappropriated groundwater
- Appropriated water (rights transfers)

- **Non-Potable Water**

- Municipal/Industrial wastewater
- Shallow brackish water

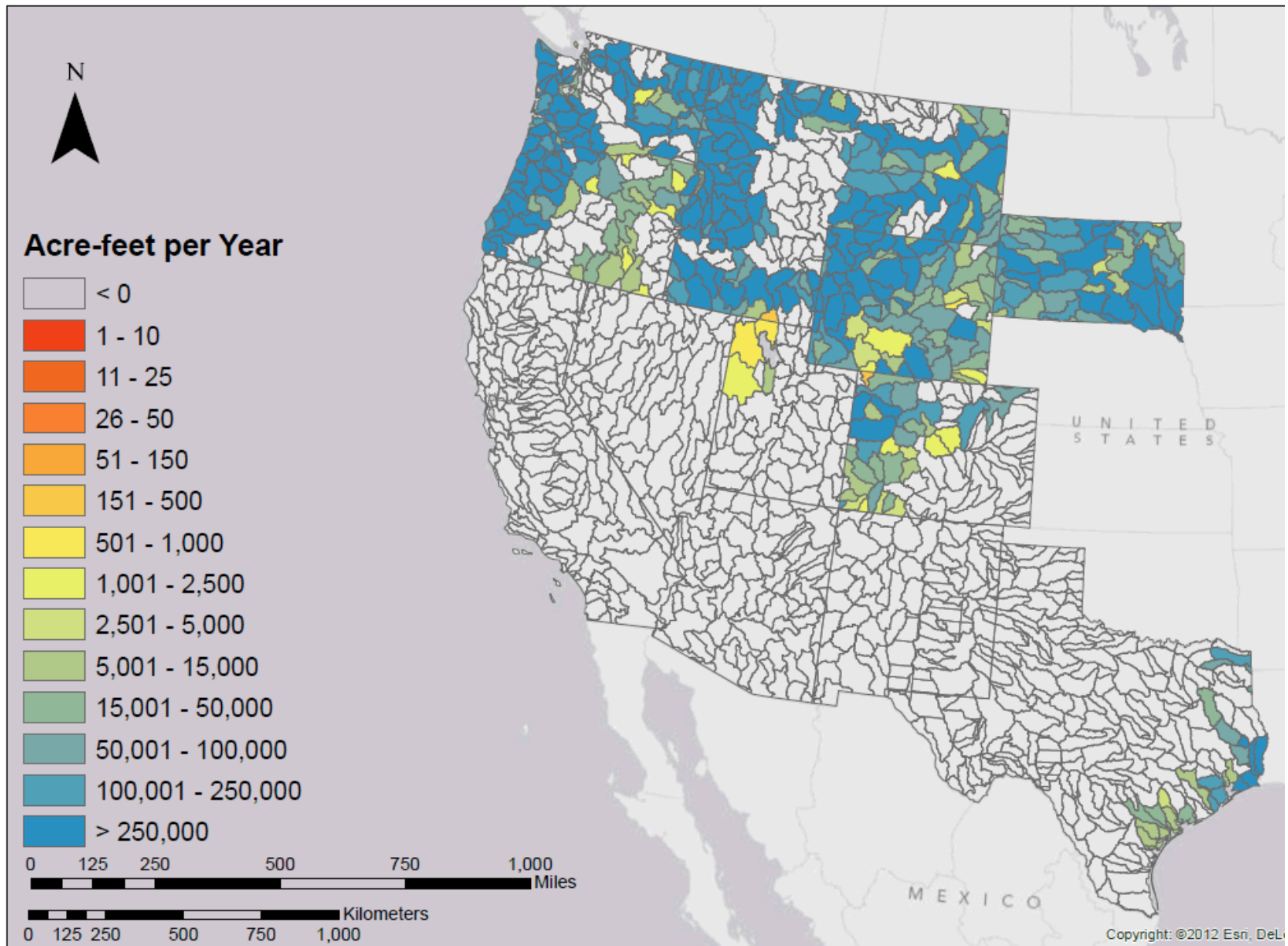


Relative
Availability
and Cost

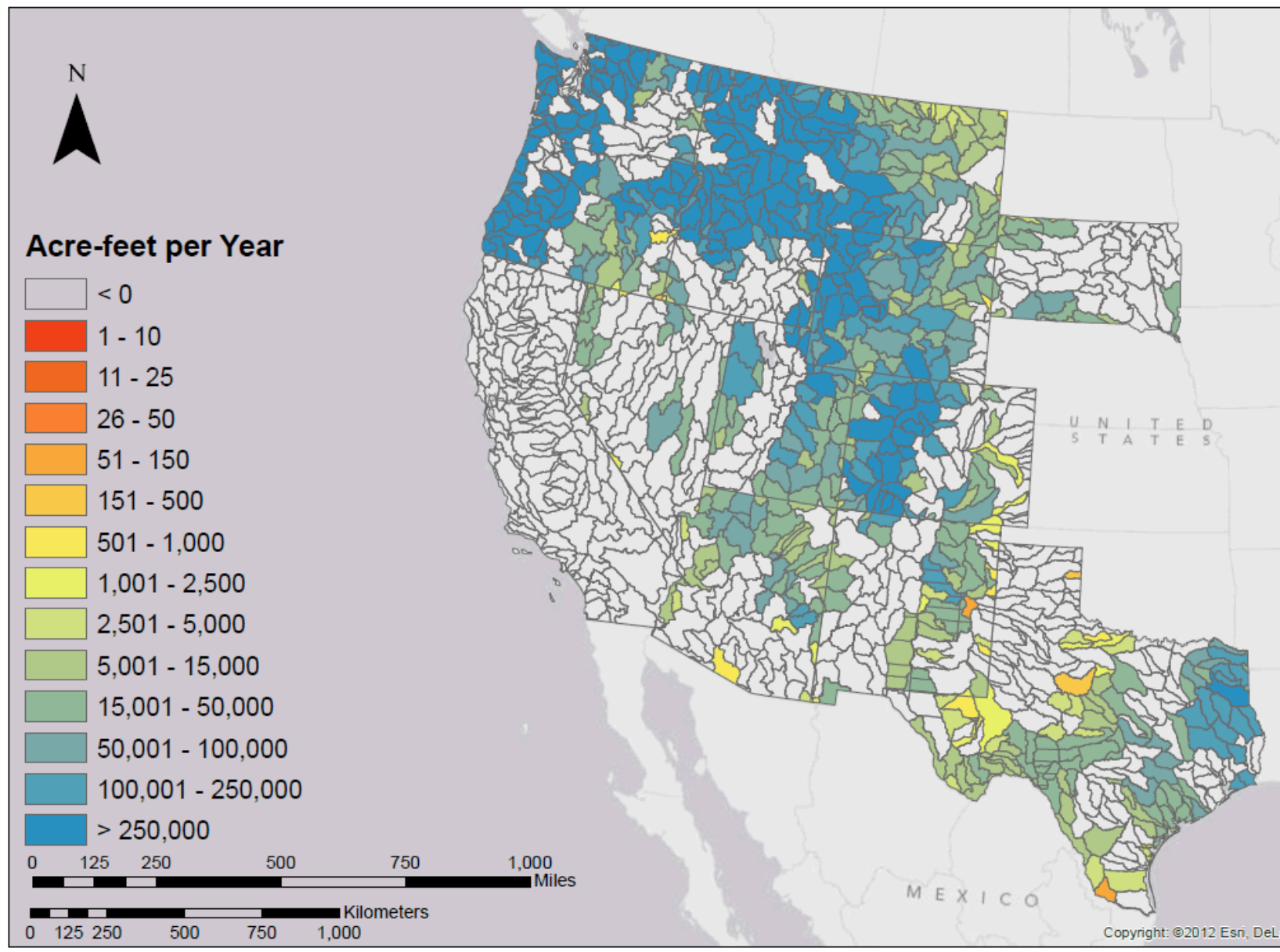
Metric Development

- **Data on “available water” are rare**
- **As such, metrics were estimated from available information**
- **Assisted by volunteer team from WSWC**
 - **Bret Bruce (USGS)**
 - **Dan Hardin (TX)**
 - **Sara Larsen (WSWC)**
 - **Dave Mitamura (TX)**
 - **Andy Moore (CO)**
 - **Ken Stahr (OR)**
 - **Todd Stonely (UT)**
 - **Steve Wolff (WY)**
 - **Dwane Young (WSWC)**

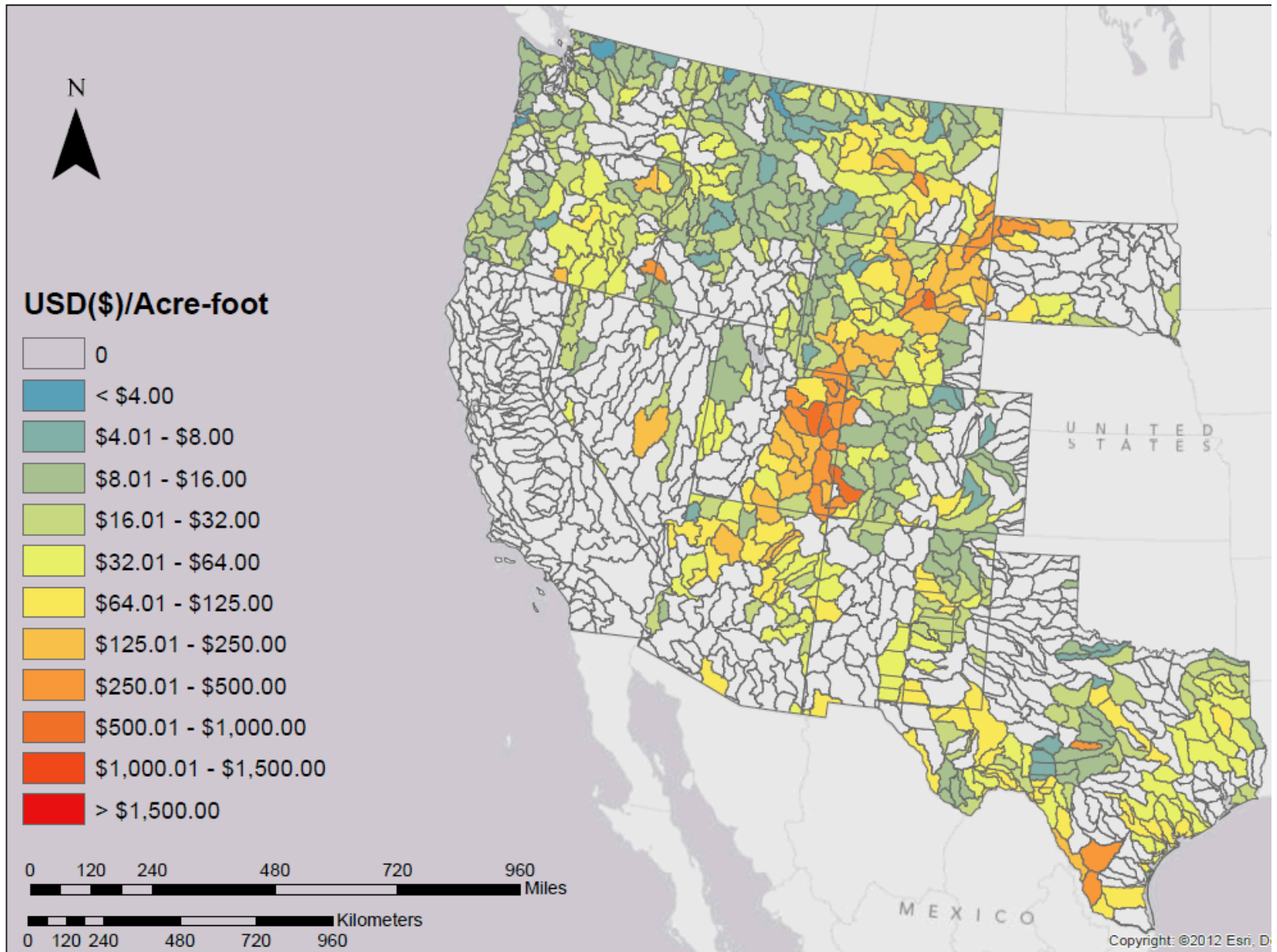
Unappropriated Surface Water Metric



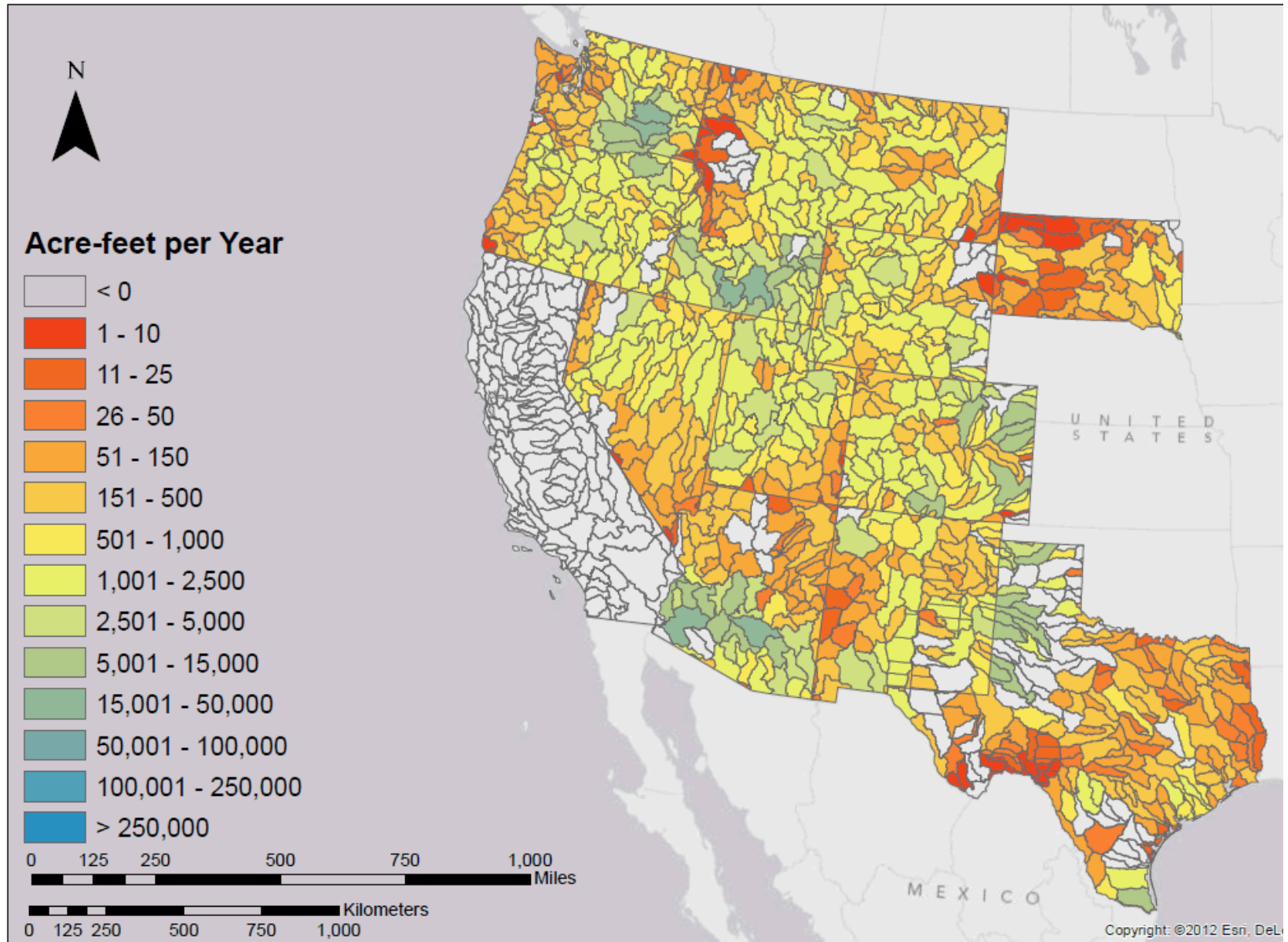
Unappropriated Groundwater Metric



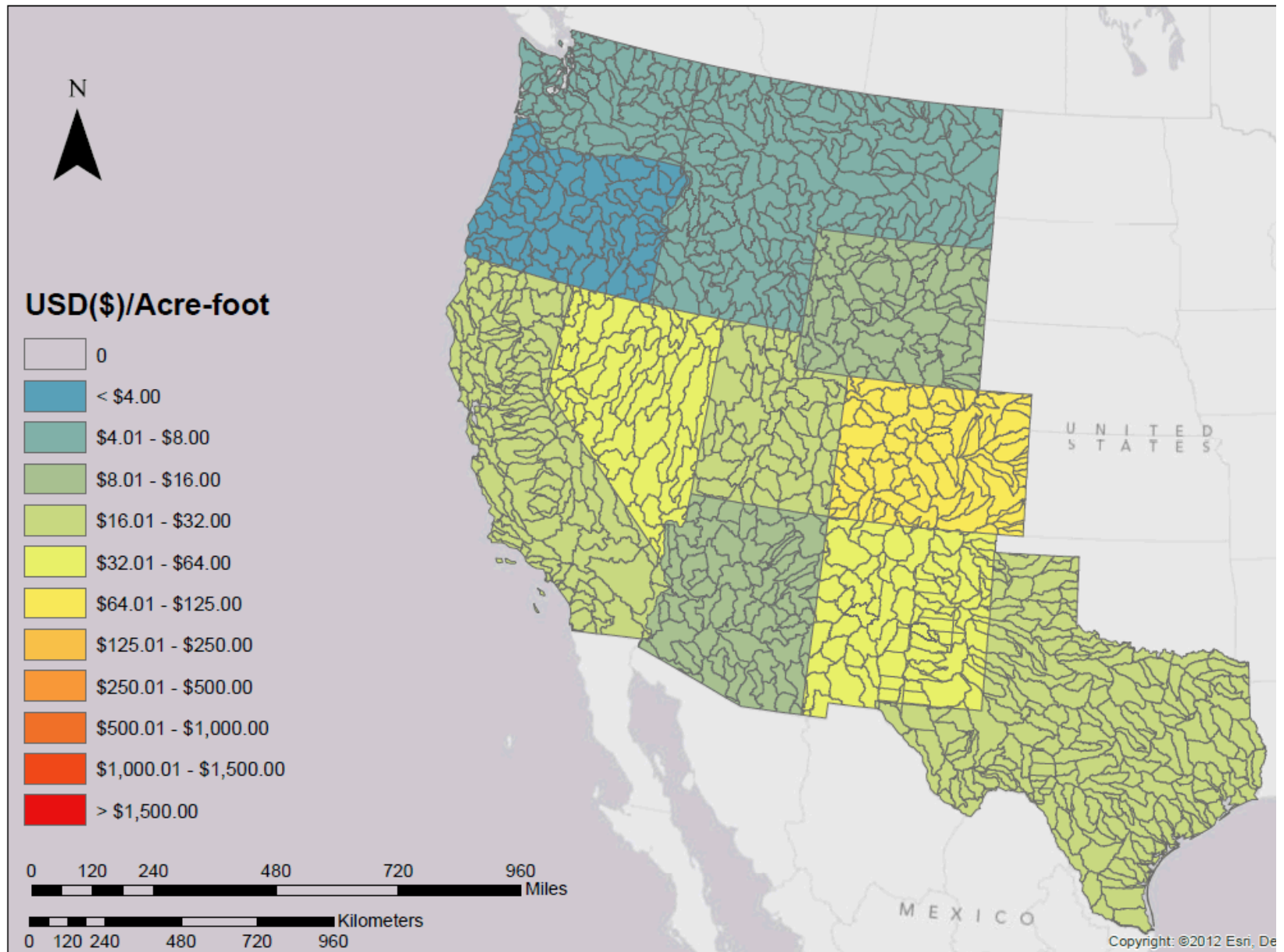
Unappropriated Groundwater Cost



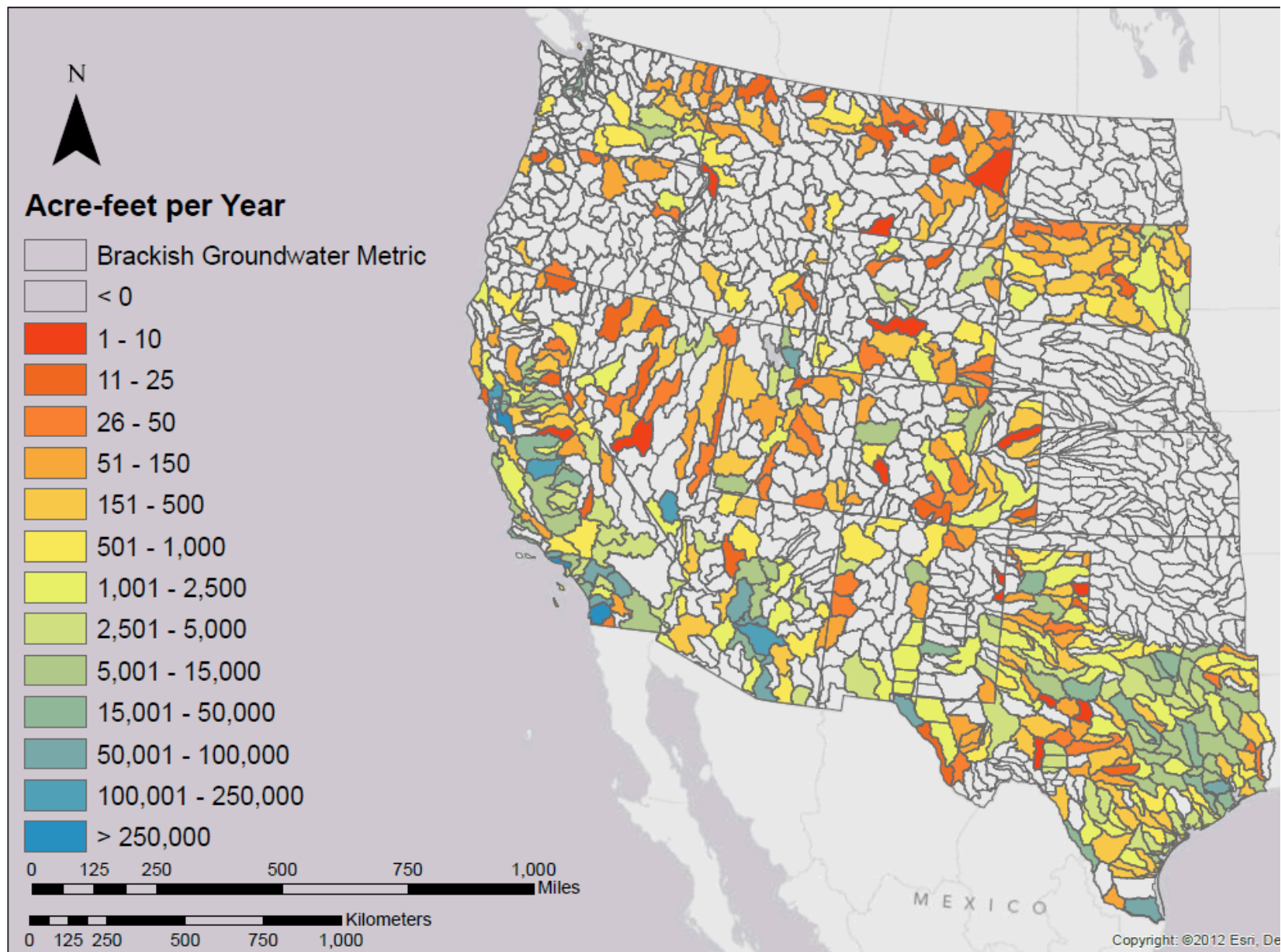
Appropriated Water Metric



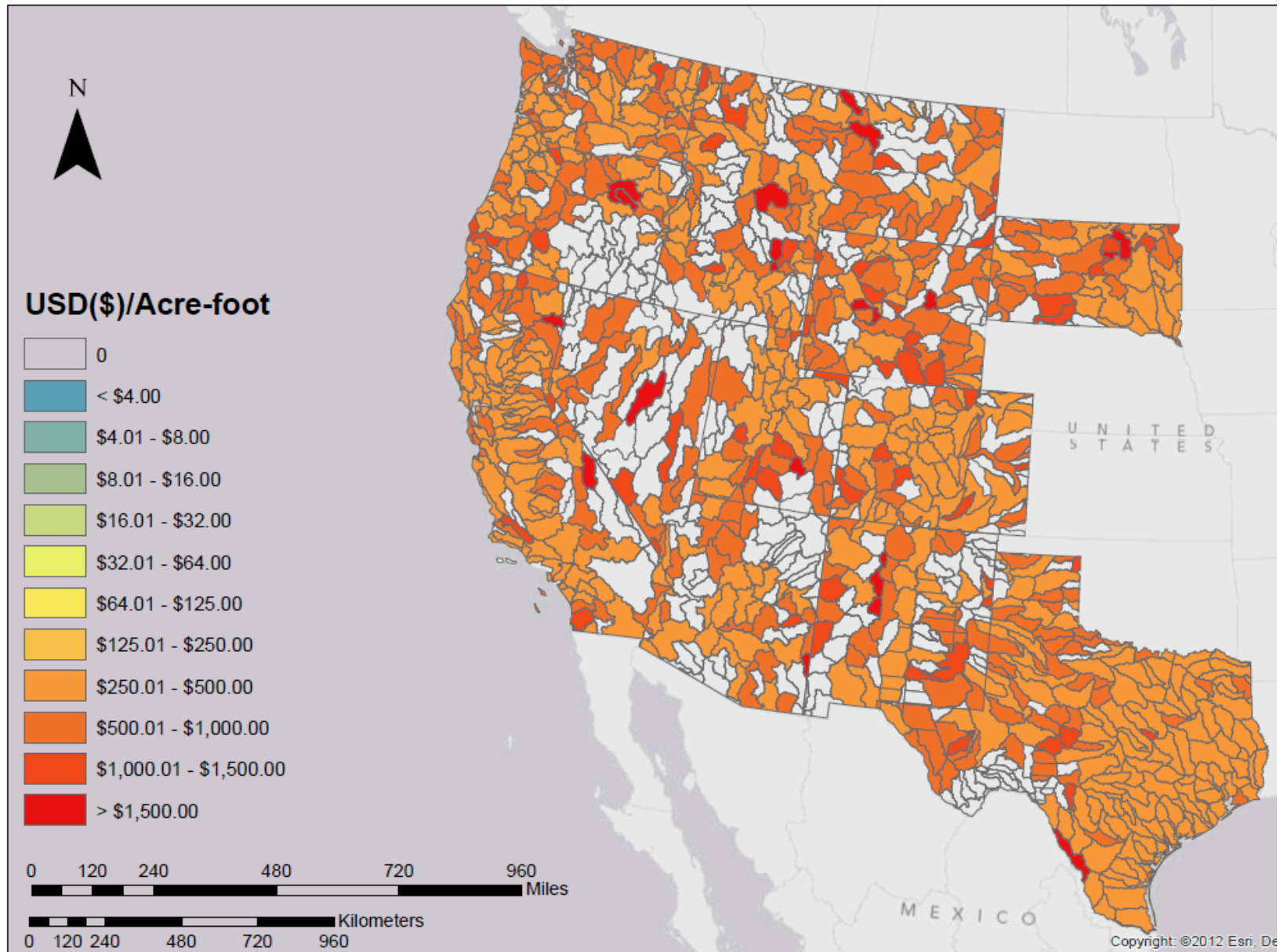
Appropriated Water Cost



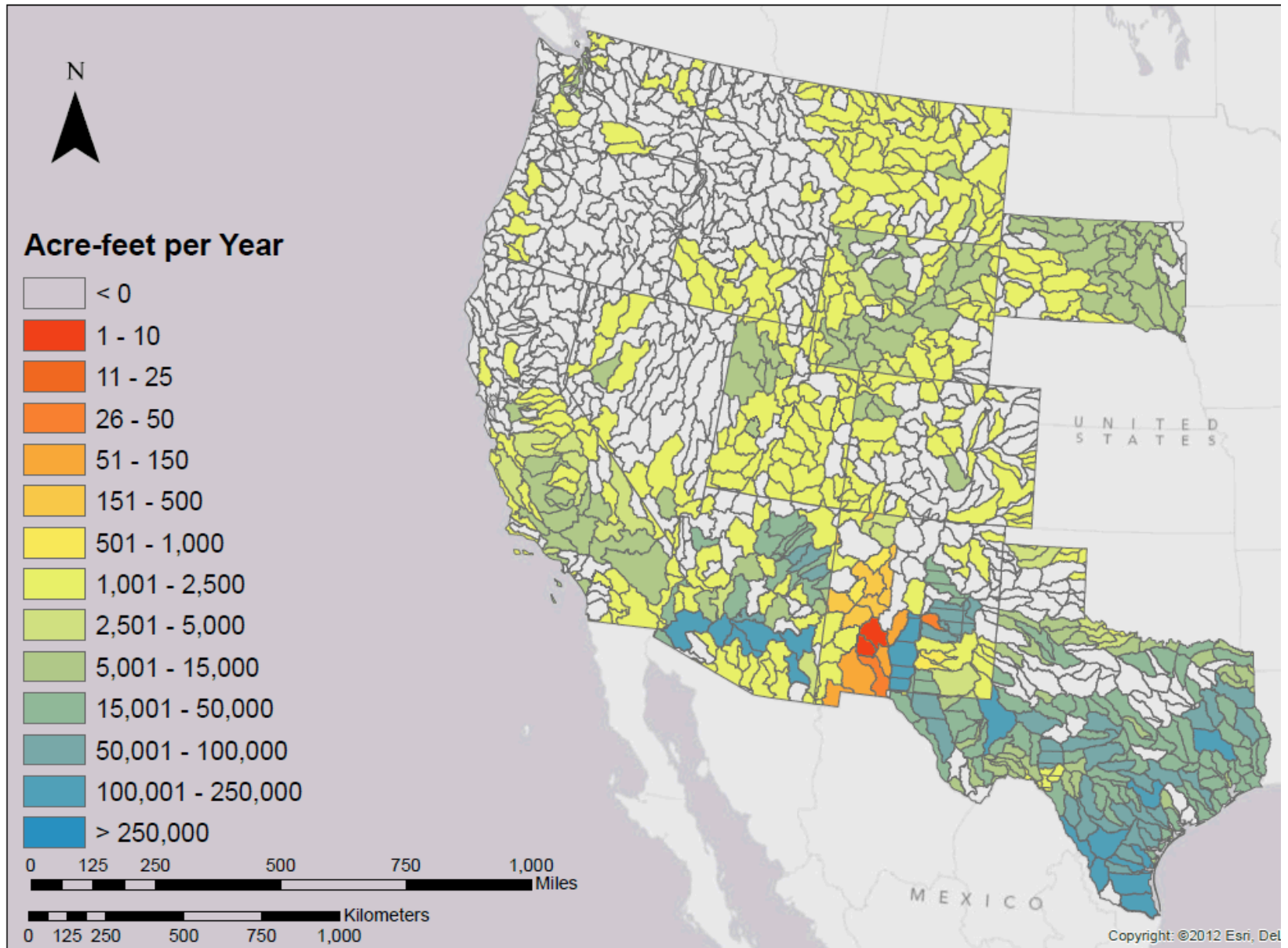
Wastewater Metric



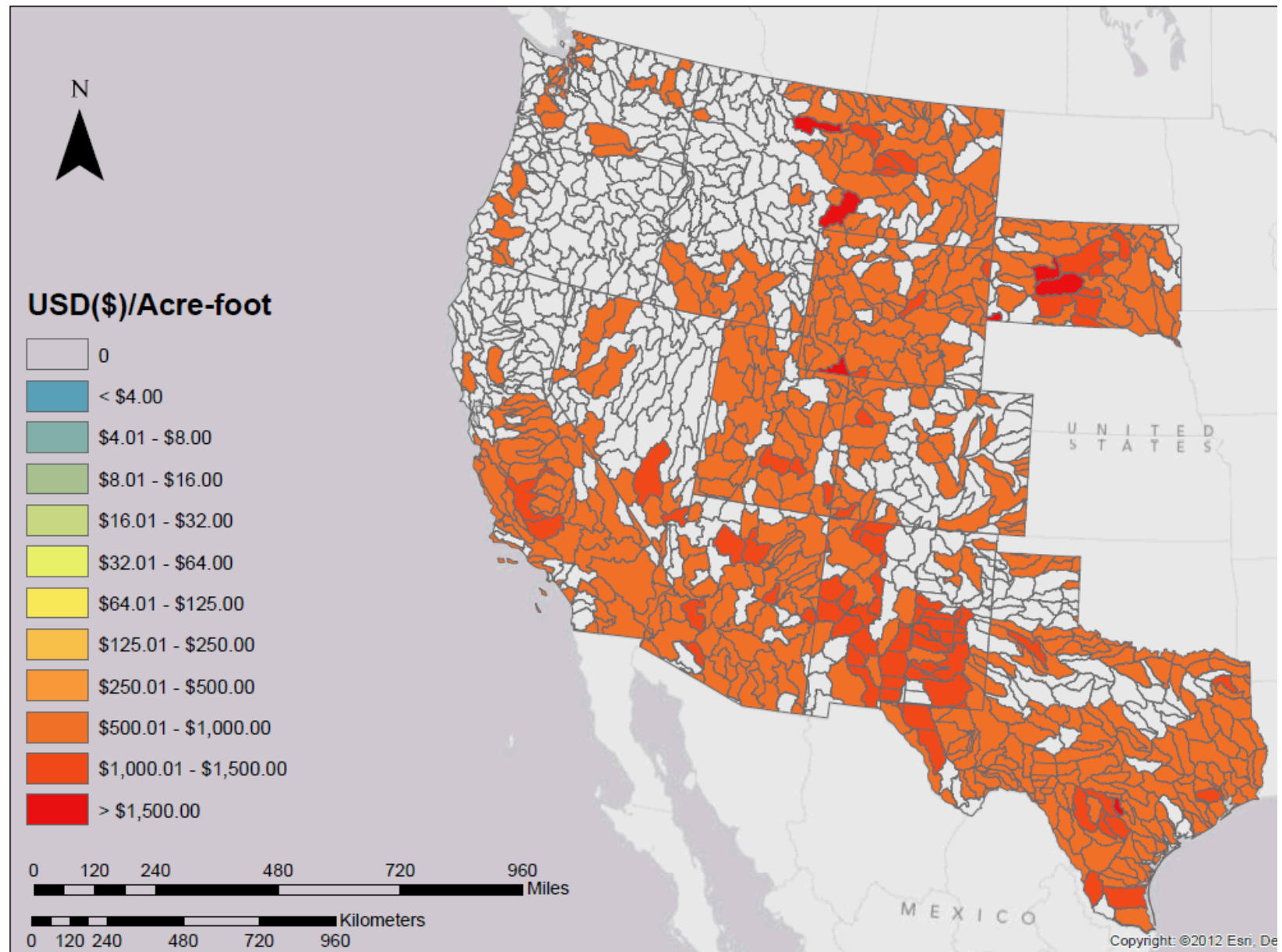
Wastewater Cost



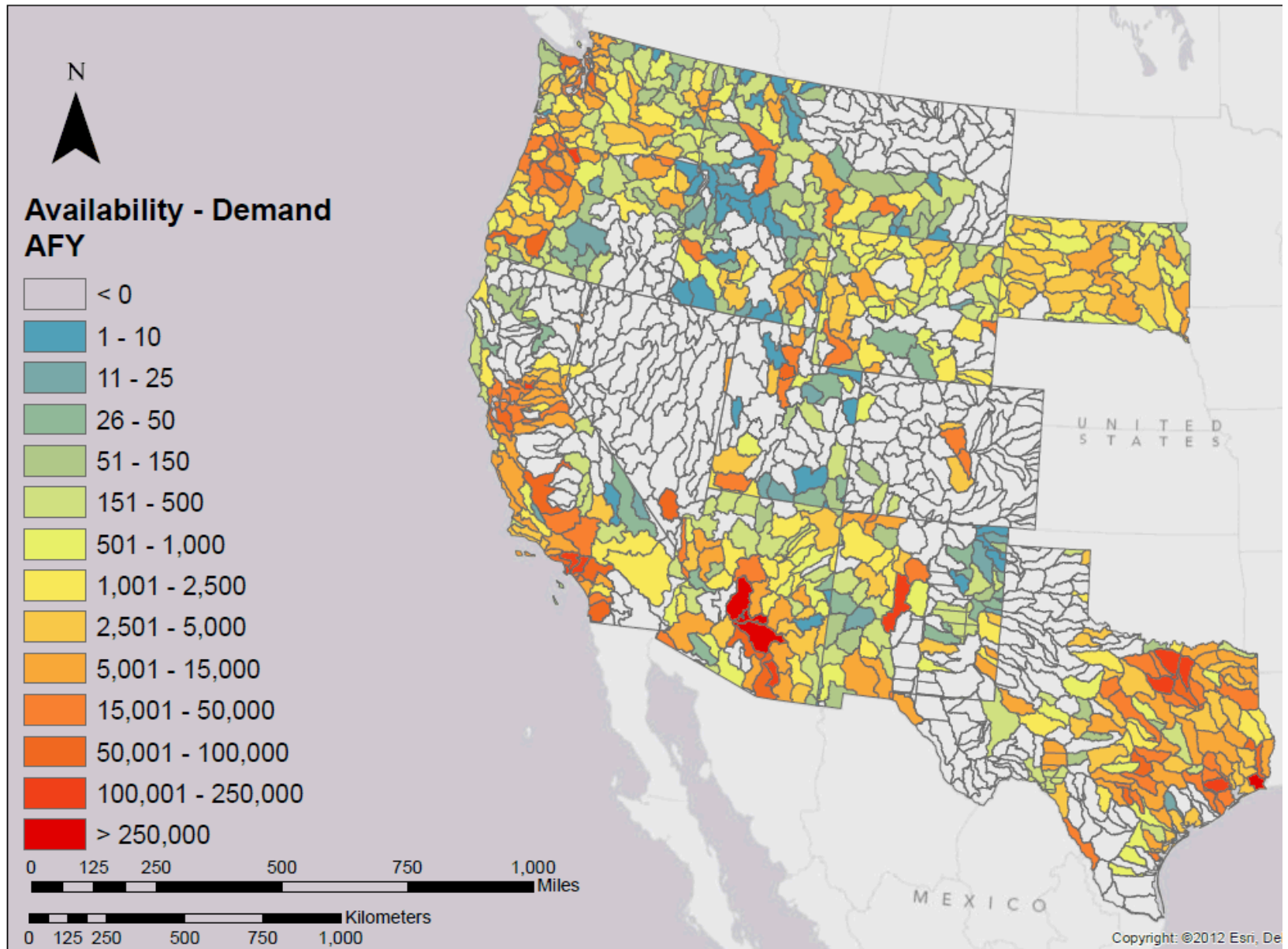
Brackish Groundwater Metric



Brackish Groundwater Cost

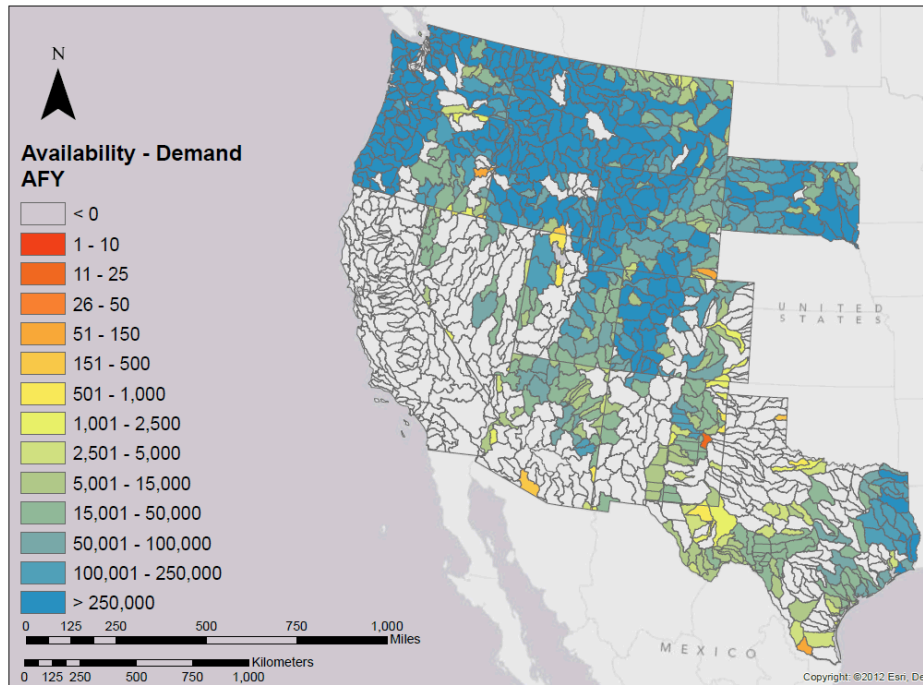


Change in Demand, Present - 2030

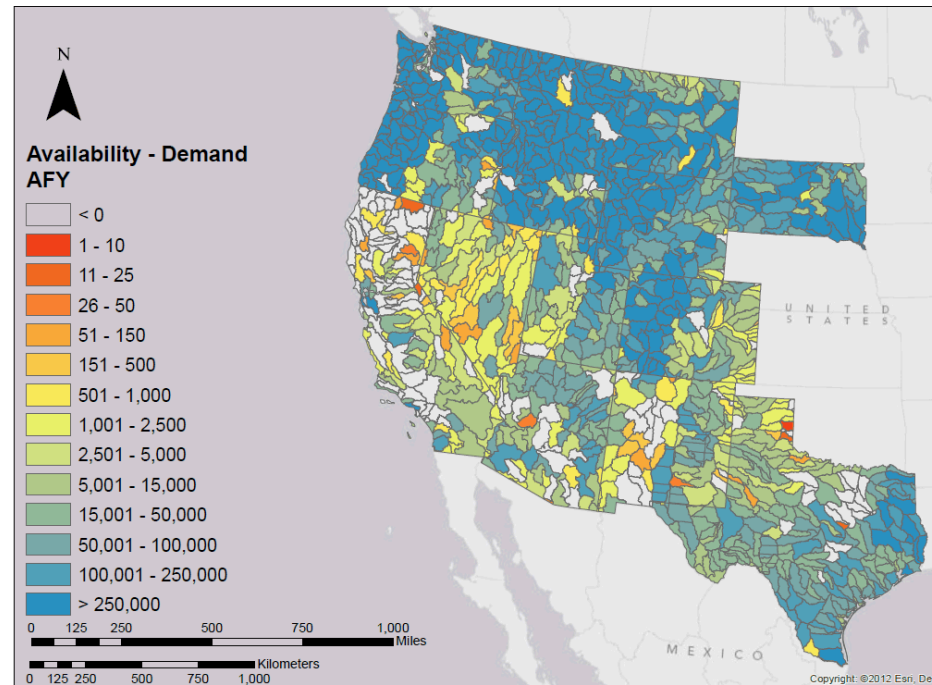


Water for Development

Unappropriated Water Sources Only
Availability - Demand, 2030



All Water Sources
Availability - Demand, 2030



Task 9: Decision Support System

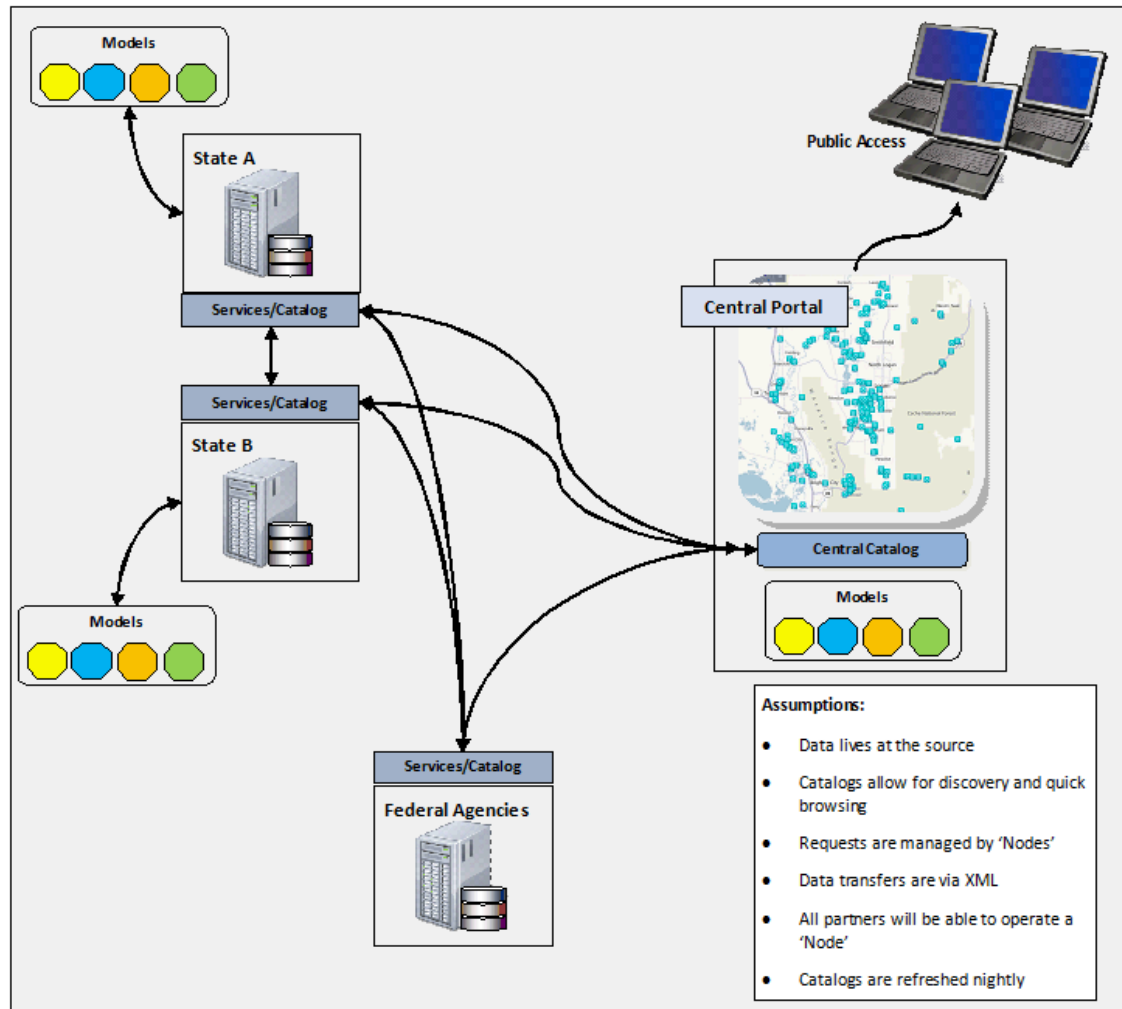


Water Use Data Exchange

- Western States Water Council

Task 9: Decision Support System

- Use Web Services to transfer data
- Data Stay at the Source (i.e. the states)
- Provide transparent link between state data and integrated water metrics
 - Link to metadata
 - Changes in state data are automatically reflected in metrics



Document Sources and GIS Data

Documents and GIS Sources

Source: SWSI (Statewide Water Supply Initiative) 2010, Appendix H: State of Colorado 2050 Municipal and Industrial Water Use Projections. *Labeled in data as SWSI 2010 App H*

Pdf Link: *Click anywhere in this box to link to source.*

Description of Source: Appendix H of the SWSI 2010 report is an update of a previous version created for the SWSI 2004 report. This appendix describes the current (2010) and future (2050) consumptive water use needs for the M&I (Municipal and Industrial) sector of the state of Colorado. The Municipal portion of the M&I sector consists of both municipal and domestic water use. Municipal use is defined as the amount of water consumed by entities (residential and commercial) that receive their water from municipal water providers. Domestic use refers to the rural areas of the state where entities rely upon individual wells or very small water supply systems.

The Industrial portion of the M&I sector is labeled in the Appendix as SSI or Self-Supplied Industrial. These are commercial or private entities that supply their own water either from groundwater pumping or surface water withdrawals without the aid of a municipal water supplier. This portion is composed of entities involved in Energy Development (such as mining for coal and renewable sources), Large Industry (large facilities such as the Coors Brewing Company in Jefferson County and the Colorado Steel Company in Pueblo County), Snowmaking (ski resorts) and Thermoelectric power generation. For the purposes of this project, the Thermoelectric portion is treated as a separate sector.

Source: Watershed Boundary Dataset (WBD), Natural Resources and Conservation Service. *Labeled in data as NRCS HUC 8*

Website: <ftp://ftp.ftw.nrcs.usda.gov/wbd>

Link: *Click anywhere in this box to connect to source.*

Description of Source: This dataset is a complete digital hydrologic unit boundary layer to the Subbasin (8-digit) 4th level for the entire United States. This dataset consists of geo-referenced digital data and associated attributes and provide a uniquely identified and uniform method of subdividing large drainage areas.

Source: US Counties *Labeled in data as Counties*

Description of Source: This shapefile was found in the service pack that was included with the ArcMap Version 9.3.0 Software. The shapefile represents the counties of the United States in the 50 states, the District of Columbia, and Puerto Rico. It provides detailed boundaries that are consistent with the census tract, block group, and state data sets and are effective at regional and state levels.

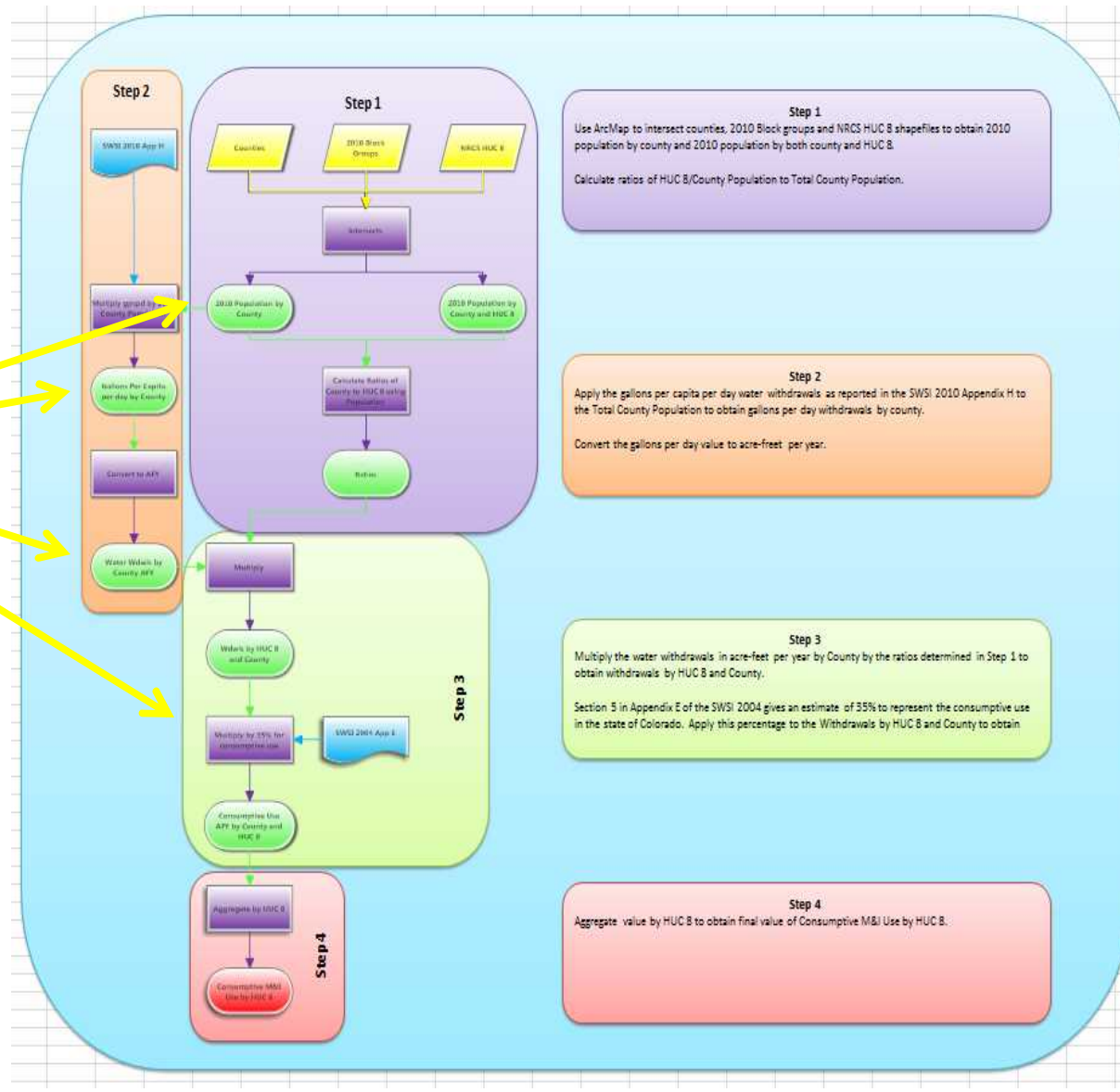
Source: U.S. Department of Commerce, U.S. Census Bureau, Geography Division, TIGER website, *Labeled in data as 2010 Block Groups*

Website: <http://www.census.gov/geo/www/tiger/tgrshp2010/poplu.html>

Link: *Click anywhere in this box to connect to source.*

Description of Source: This shapefile depicts the 2010 Census Blocks used by the U.S. Census Bureau. From the metadata of census blocks: "Census Blocks are statistical areas bounded on all sides by visible features, such as streets, roads, streams, and railroad tracks, and/or by nonvisible boundaries such as city, town, township, and county limits, and short line-of-sight extension of streets and roads. Blocks are the smallest geographic areas for which the Census Bureau publishes data from the decennial census."

Processing Schematic and Method Description

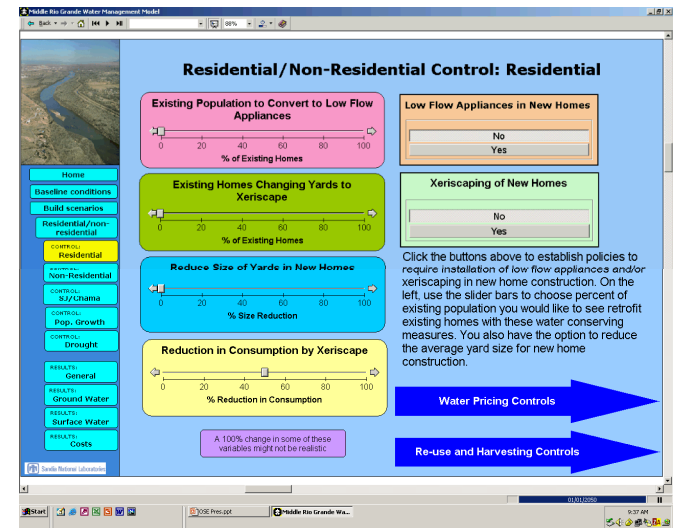
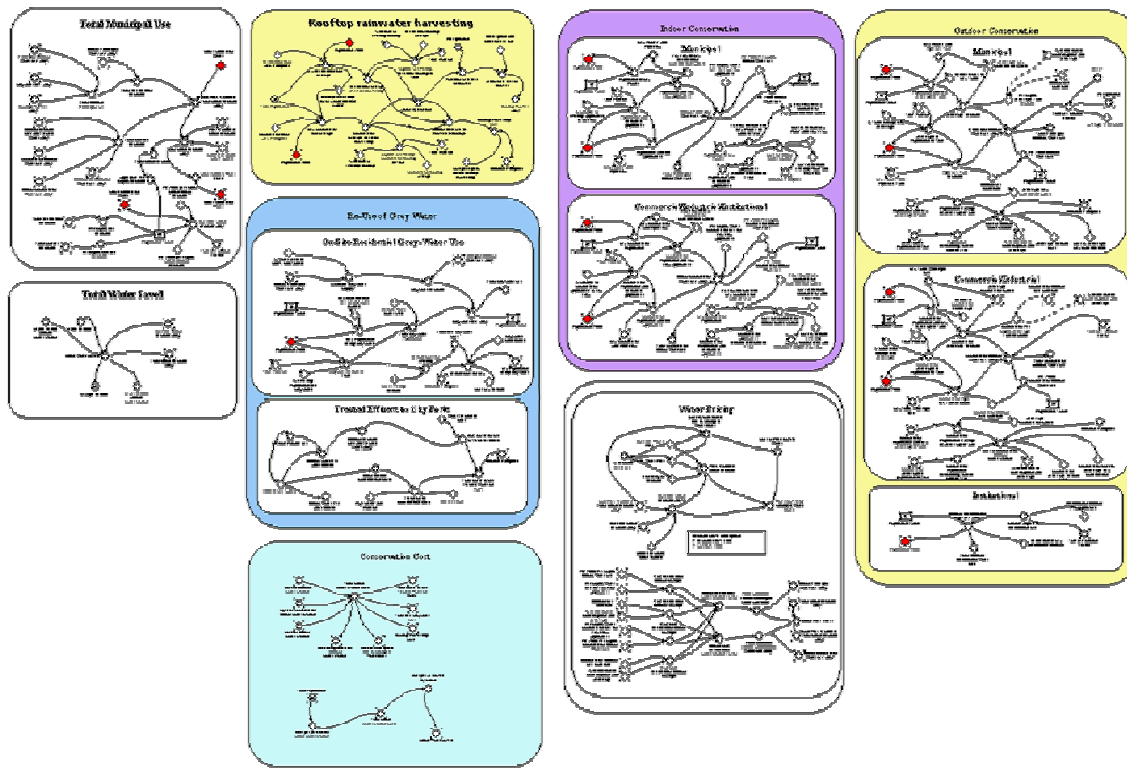


Data Processing

- Changes and updates provided by state can be added in the yellow highlighted areas by county. Any changes will iterate through the spreadsheet and be calculated in a new value in Step 4.

Colorado 2010 Municipal, Domestic and Municipal Supplied Industrial

Step 1					Step 2			Step 3			Step 4	
County	HUC 8	County Pop	County/HUC8 Pop (2010 Block Groups)	Ratio	Gpcpd by County (SWSI 2010)	Water Wdws gpd by County	Water Wdws AFY by County	Water Wdws AFY by HUC 8	Consumptive Use Percentage (SWSI 2010)	Consumptive Use AFY by County and HUC 8	HUC 8	Consumptive Use AFY by HUC 8
Adams	10190003	441204	387372	0.877988414	142	62650968	70203.54219	61637.89663	35.00%	21573.26382	10180001	167.4152125
Adams	10190004	441204	49080	0.11241059	142	62650968	70203.54219	7809.516348	35.00%	2733.330722	10180002	2.066854475
Adams	10190010	441204	4048	0.009174894	142	62650968	70203.54219	644.1106888	35.00%	225.4395241	10180010	3.420702985
Adams	10190011	441204	647	0.001466442	142	62650968	70203.54219	102.9494107	35.00%	36.03229375	10190001	619.645717
Adams	10190012	441204	48	0.000108793	142	62650968	70203.54219	7.6376688	35.00%	2.67318408	10190002	53423.79758
Adams	10190013	441204	9	0.000020399	142	62650968	70203.54219	1.4320629	35.00%	0.50122015	10190003	90879.54381
Alamosa	13010002	15356	13911	0.905899974	258	3961848	4439.448776	4021.696531	35.00%	1407.593786	10190004	15314.47981
Alamosa	13010003	15356	1445	0.094100026	258	3961848	4439.448776	417.7522455	35.00%	146.2132859	10190005	24200.78807
Arapahoe	10190002	540297	146836	0.271769046	164	88608708	99290.48775	26984.08109	35.00%	9444.428381	10190006	8620.932378
Arapahoe	10190003	540297	388160	0.718419684	164	88608708	99290.48775	71332.24083	35.00%	24966.28429	10190007	21246.08037
Arapahoe	10190010	540297	2362	0.00437167	164	88608708	99290.48775	434.0652124	35.00%	151.9228243	10190008	361.9740679
Arapahoe	10190011	540297	2932	0.005426645	164	88608708	99290.48775	538.8142264	35.00%	188.5849792	10190009	131.8896314
Arapahoe	10190012	540297	4	0.000007403	164	88608708	99290.48775	0.7350808	35.00%	0.25727828	10190010	880.9741688
Arapahoe	10190013	540297	3	0.000005553	164	88608708	99290.48775	0.5513106	35.00%	0.19295871	10190011	435.2642569
Archuleta	13020102	12061	4	0.000331647	182	2195102	2459.721546	0.8157604	35.00%	0.28551614	10190012	4532.73815
Archuleta	14080101	12061	5060	0.419534035	182	2195102	2459.721546	1031.936906	35.00%	361.1779171	10190013	653.6295893
Archuleta	14080102	12061	6997	0.580134317	182	2195102	2459.721546	1426.96888	35.00%	499.4391079	10190014	50.00454375
Baca	11020009	3786	15	0.003961965	329	1245594	1395.750357	5.52991425	35.00%	1.935469988	10190015	1.02126327
Baca	11020013	3786	34	0.008980454	329	1245594	1395.750357	12.5344723	35.00%	4.387065305	10190016	38.87568937
Baca	11040001	3786	26	0.006867406	329	1245594	1395.750357	9.5851847	35.00%	3.354814645	10190017	4.543942305
Baca	11040002	3786	148	0.039091389	329	1245594	1395.750357	54.5618206	35.00%	19.09663721	10190018	182.7358201
Baca	11040003	3786	374	0.098784997	329	1245594	1395.750357	137.8791953	35.00%	48.25771836	10250001	221.9091838
Baca	11040004	3786	958	0.253037507	329	1245594	1395.750357	353.1771901	35.00%	123.6120165	10250002	1398.155281
Baca	11040005	3786	2231	0.589276281	329	1245594	1395.750357	822.4825795	35.00%	287.8689028	10250003	501.9648276
Bent	11020005	6608	39	0.005901937	113	746704	836.7191672	4.93826385	35.00%	1.728392348	10250005	777.4204456
Bent	11020008	6608	20	0.003026634	113	746704	836.7191672	2.532443	35.00%	0.88635505	10250006	38.94785279
Bent	11020009	6608	6266	0.948244552	113	746704	836.7191672	793.4143919	35.00%	277.6950372	10250012	536.1514634
Bent	11020010	6608	283	0.042826877	113	746704	836.7191672	35.83406845	35.00%	12.54192396	10250013	98.89918273
Boulder	10190005	294854	294591	0.999108033	176	51894304	58150.16235	58098.29433	35.00%	20334.40302	10260001	43.63690632
Boulder	10190006	294854	263	0.000891967	176	51894304	58150.16235	51.8680184	35.00%	18.15380644	10260002	20.33949524
Broomfield	10190003	60547	52601	0.86876311	177	10716819	12008.73153	10432.74295	35.00%	3651.460032	10260004	49.45037575
Broomfield	10190005	60547	7946	0.13123689	177	10716819	12008.73153	1575.988583	35.00%	551.5960041	11020001	3215.111755
Chaffee	10190001	17813	9	0.000505249	297	5290461	5928.226074	2.99523015	35.00%	1.048330553	10200002	14721.98284
Chaffee	11020001	17813	17804	0.999494751	297	5290461	5928.226074	5925.230843	35.00%	2073.830795	10200003	41326.54423
Cheyenne	10260001	1834	608	0.331515812	183	335622	376.0812321	124.6768752	35.00%	43.63690632	11020004	1886.923615
Cheyenne	10260002	1834	37	0.020174482	183	335622	376.0812321	7.58724405	35.00%	2.655535418	10200005	1792.398556
Cheyenne	10260004	1834	689	0.37568157	183	335622	376.0812321	141.2867879	35.00%	49.45037575	11020006	456.3723339
Cheyenne	11020009	1834	3	0.001635769	183	335622	376.0812321	0.61518195	35.00%	0.215313683	10200007	102.4293074
Cheyenne	11020011	1834	422	0.230098146	183	335622	376.0812321	86.5355943	35.00%	30.28745801	10200008	271.3528922
Cheyenne	11020012	1834	50	0.027262814	183	335622	376.0812321	10.2530325	35.00%	3.588561375	11020009	1533.486402
Cheyenne	11030002	1834	25	0.013631407	183	335622	376.0812321	5.12651625	35.00%	1.794280688	10200010	1243.502013
Clear Creek	10190002	9476	2082	0.219712959	224	2122624	2378.506323	522.5886624	35.00%	182.9060318	10200011	594.8324819



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